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RUTGERS

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19 may

The Dedication - Doug Webb

Edit Posted by: Scott in: Across the Pond Edit

As tradition now has it, the first blog entry is our dedication. Today we dedicate Rutgers Glider Mission #138, our second mission under the I-COOL banner, to Doug Webb, the inventor of the Slocum autonomous underwater glider.

> I-COOL Mission Blogs

Across the Pond
Antarctic LTER
Antarctic LTER: Palmer Logistics
Antarctic LTER: Palmer Station
Espresso & Biospace
Ligurian Sea 2008
Middle Atlantic Bight
Middle Atlantic Bight: MURI
RU27 Atlantic Crossing Preflight

> Student Blogs

North Atlantic Weather
Ocean Methods 2009
Passion Puddle Observatory
Power Savings
Power Savings: Fin Control
Undergraduate Operations

Historic Blogs

Flight to Halifax
Spain Summer 2008

January 2009

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« Dec

Doug's accomplishments span a 50 year career in ocean technology development. His company, Webb Research Corporation, already builds over 80% of the world's ARGO drifters. Doug and his company are now enabling the growing global legacy of the Slocum electric and thermal gliders. The science fiction we read in 1989 is now the way we go to sea. Now we hear world renowned scientists describe the inexpensive robotic gliders as the future of oceanography. When it comes to transforming how we observe and study the ocean, Doug Webb's vision of the future, his long-term dedication to making that vision a reality, his perseverance in problem solving, and his willingness to share his invention with others, stands as an inspiration to all scientists and students of the sea.

Previously at Rutgers, we recognized Doug's influence on us through the dedication of one of our labs, naming it in his honor. Here we dedicate to Doug the most ambitious Slocum Glider mission we have ever undertaken. We have chosen this mission since we are deploying our first glider that, at least in theory, has the capacity and endurance to potentially fly across the Atlantic. But this is no virtual study. We are going to sea, and at sea we will encounter unexpected events and situations. We are far from certain that we will make it across, but we do know we will learn more by trying than by staying home. We also know that with uncertainty lies adventure, and it is that sense of adventure that will inspire others. Regardless of what happens over the next several months, we will achieve our primary goal, that of entraining students in a voyage of inspiration.

We are grateful to Doug for taking us in, and allowing us to be part of the development of this magnificent new tool that will span the distances between countries, and help us all realize that yes, just like we teach in school, there really is only one ocean on which we all depend.

Thanks Doug,

The R.U. COOL Team

1 Comment

21 **may**

The journey begins

Edit Posted by: Oscar in: Across the Pond Edit

Following on the dedication to Doug Webb, without whom we would not be trying this, I am so excited that we start. To echo Scott, we might not be successful, but I would rather die at sea, then to die on land. So with quiet enthusiam, lets wish RU17 a successful journey. First I raise a beer to Scott Glenn, who is smart and stubborn enough to make this work. I also want to THANK Hugh, Dave, and Bob for their efforts of the last few weeks. Finally, we are sending this robot out to sea, it has several large obstacles. The first is crossing the fishing areas, where drift nets signal glider doom. For that run silent, run deep…..

The Slocum glider, was named after Joshua Slocum. He was the first man to sail around the world solo. He described this journey in his book, "Sailing alone around the world" by Capt. Joshua Slocum {highly recommended for sailors, fisherpeople, or anyone who sleeps better in a deep ocean swell}. He set sail July 1, after waiting. "In fact, many weeks of bad weather had prevailed. On July 1, however, after a rude gale, the wind came out nor'west and clear, propitious for a good run. On the following day, the head sea having gone down, I sailed from Yarmouth, and let go on my last hold on America." Capt. Slocum passed Cape Sable at 4:30 PM at a distance three cables from land. Well the Scarlett Knight glider now begins its journey, it surfs tonight offshore heading for the shelf break.

2 Comments

COOL Web Links

- Active Glider Navigation Page
- Active Gliders Transects
- Atlantic Crossing Students Page
- Atlantic Glider Track w/SST
- Atlantic Mission Public Site
- East Coast Enhanced SST
- Gulf Stream Forecast
- HYCOM Data
- National Hurricane Center
- North Atlantic SST
- Northeast SST
- RU COOL Data Page
- RU COOL Web Site
- RU17 Segment Imagery
- Waves and Ship Reports

COOL KMZ Files

- Active Deployments KMZ file
- Gulf Stream SST KMZ 1km
- Justin's Live Google's KMZ file
- North Atlantic SST KMZ 1km
- Western Atlantic SST KMZ 1km

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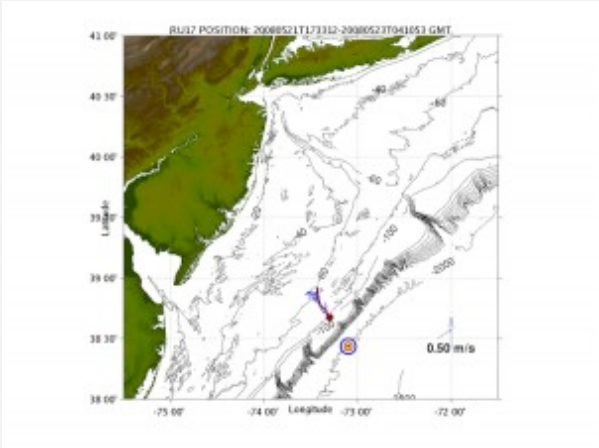
Ken Branson on Glider Recovered

21 may

Godspeed RU17 - The Scarlet Knight

Edit Posted by: Scott in: Across the Pond Edit

Today, Wednesday, 5/21, at exactly 1:25 pm, Dave and Bob launched RU17, christened The Scarlet Knight by President McCormick, from a trusted friend, the SeaTow Hatteras, a veteran of the amazing Shallow Water 2006 days. RU17 has a Digifin tail, a stretch payload bay, a full stock of batteries, no altimeter (to make more space for batteries), a smooth coat of paint and more stickers than we've seen in a long time. On monday we took RU17 out for a short test run at sea. We only left it deployed for about an hour. It was a good shake test with the waves. Dave and Bob brought it home, opened it up, checked all the electronics, soldered connections that could be soldered, hot glue gunned the others. Hugh loaded several letters in the message bottle. They checked final weight and balance. The balance is critical. If the glider is too stable, it sinks and floats like a submarine instead of flying. If its too unstable, it can't stay on its glidepath, and it expends all its energy moving the batteries back and forth to keep it on glidepath.

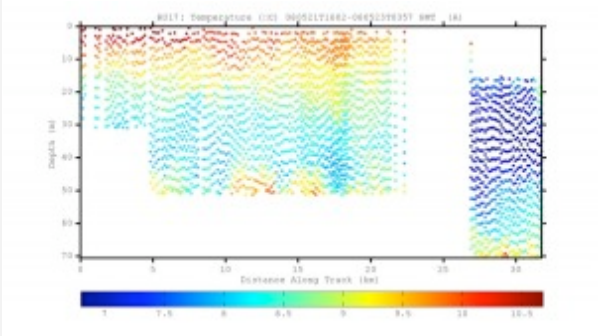


Dave and Bob left the dock this morning at 10:10 am, and headed out to the 60 m isobath, deploying at 1:25 pm. Dave started the usual 15 minute test missions. By about 2:00 pm, Dave let go of the Freewave communications link from the boat and handed over control to Hugh in the COOLroom via Iridium Satellite.

Geno Olmi (right) from the NOAA Coastal Services Center views today's launch of RU17 from the COOLroom.

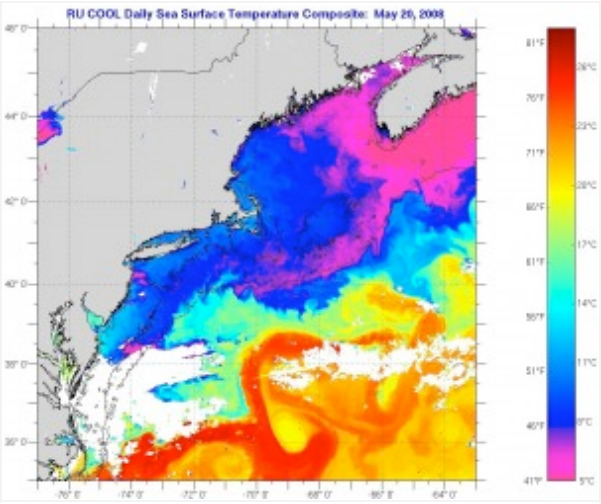
Hugh continued running through a series of short tests, one of which included looking at the flight control data. Josh said it was one of the best performing gliders he had ever seen. Dave and Bob took extra time getting the balance of the glider just right yesterday before the final seal. H-Moment was about 6.1, pretty close to the 6.0 target. We anticipated a good performing glider, and the test showed we did. Its getting on to glidepath quite well, with little prolonged movement of the forward batteries. We may try running the RUgain mission in the morning to see if mucking with the gains gets the batteries in position even faster. Initially we were running 1 hour missions from 3 m to 30 m depth. Dave saw some boats in the region, so we dropped the climb to depth to 5 m. With good performance to 30 m, the dive to depth was extened to 50 m. With that switch looking good, John just now (about 9:30 pm) switched to 3 hour missions for the rest of tonight. We hope to be up to 6 hour missions by tomorrow afternoon.

Resultant temperature section is shown below.



Veterans of previous glider flights will see the difference above. We cut the CTD sampling back from once every cycle to once every 10 cycles. Less data to transmit. We also are collecting data on downcasts only, turning the CTD off on the upcasts. Tomorrow morning we'll test a new script that we've run on the simulators that turns the ctd on for one 6-hour segment then leaves if off for the next three 6-hour segments. Plan is to sample the midnight to 6 am shift, and get the data home and up on the web in time for the morning satellite SST passes. Then we turn the CTD off for the rest of the day.

We'll spend the rest of tonight and tomorrow morning on the outer shelf testing flight controls and energy savings settings. Then sometime tomorrow afternoon as we approach the shelf break, we switch to a stay deep behavior and fly under all the surface activity at the shelf break. The objective is to get off the shelf and into the slope water before the Memorial Day boating activity begins. Our buddy Big Mahi and his tuna club will be out there and we want to be out of his way before the fishing starts this weekend.



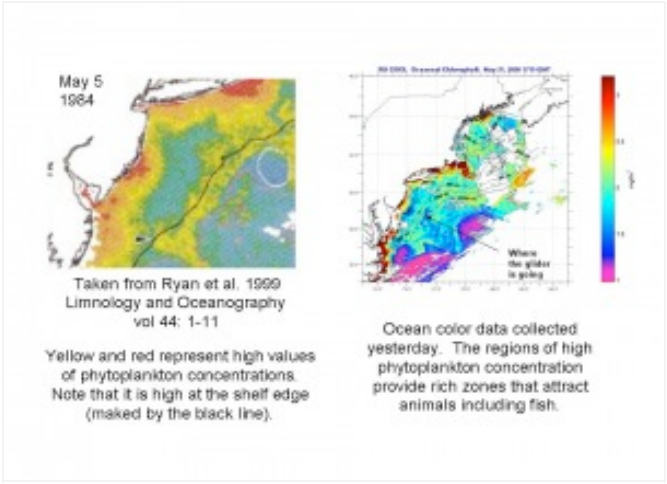
The above image shows where we are heading - the portion of the Gulf Stream the runs south to north along 70 W. We are going to try for the crest near 38 N. That Cold Eddy centered near 36 N, 69 W is doing us a great service. Its interaction with the Gulf Stream has halted the downstream propagation of the meander crest, allowing the crest to grow out towards the northwest. It must know we are coming, and is reaching back to grab us.

2 Comments

22 may Hitting the shelf edge

Edit Posted by: Oscar in: Across the Pond Edit

The glider is heading to the shelf edge. Our first obstacle is the fishing nets and the dramamtic ammount of human activity. This activity will only be magnified with the start of the Memorial day weekend. The acitivity is linked to presence of big fish. The shelf edge represents a very productive region of the ocean. The turbulence found at the shelf edge results in major regions of phytoplankton growth.



To get through the net region, we will keep RU17 deep and we will minimize the number of the times that the system will surface. For those who don't believe that there is alot of fishing activity off New Jersey & New York, we offer as proof a

photo from one of our local fishing legends "Big Mahi". Here he shows the first tuna he caught recently.

0 Comments

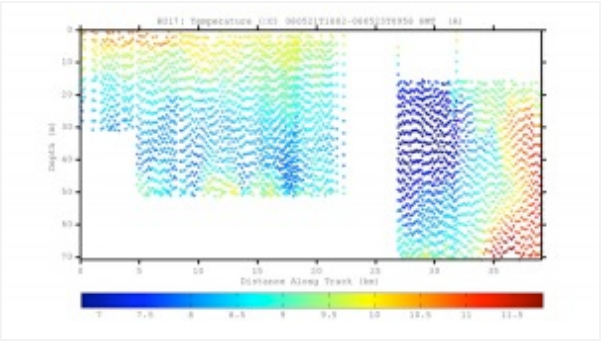
23 may

Fly Deep

Edit Posted by: Scott in: Across the Pond Edit

RU17, otherwise known as The Scarlet Knight, completed its engineering tests thursday afternoon. Hugh ran it through a series of short missions. CTD on and off works fine. The agressive and passive flight control test missions were run. Josh Graver from MIT phoned in on the flight control. Josh got his Ph.D. at Princeton in glider flight control, did his Post-doc at Rutgers, and is now at MIT getting his business degree. Flight control data was downloaded, and showed this glider is so well ballasted it almost doesn't matter which extreme we use. We'll tune to something in the middle and send it out to RU17 next week. Before we do we'll send it to RU06. Antarctic fans will recognize RU06 as the first robot to cross the Antarctic circle. The certificate is on the wall in the COOLroom. RIght now RU06 is sitting out in the Rutgers parking lot serving as a simulator. Before we send anything to RU17 at sea, we first test it on RU06. This morning we are also working with the Navy using RU06 to simulate satellite phone calls into their control center for an upcoming mission with RU01.

Back to The Scarlet Knight.



The initial temperature record is shown above. You can see how we stepped this glider down, with dives first to 30 m, then 50 m, and now to 70 m. Near 25 km, the CTD (conductivity, temperature and depth) sensor was turned off. After turning the CTD back on, we started flying deep, keeping the glider below 15 m as we approach the shelf break. At midnight the segment duration was increased to 6 hours. We'll use 6 hour subsurface flight segments throughout this extended mission. After sampling from midnight to 6 am, Hugh switched the ctd off. We'll leave it off for the next 3 segments, turning it on to sample in the midnight to 6 am segment. This makes the data available for comparison to the morning NOAA satellite overpasses.

Next entry discusses the morning satellite data.

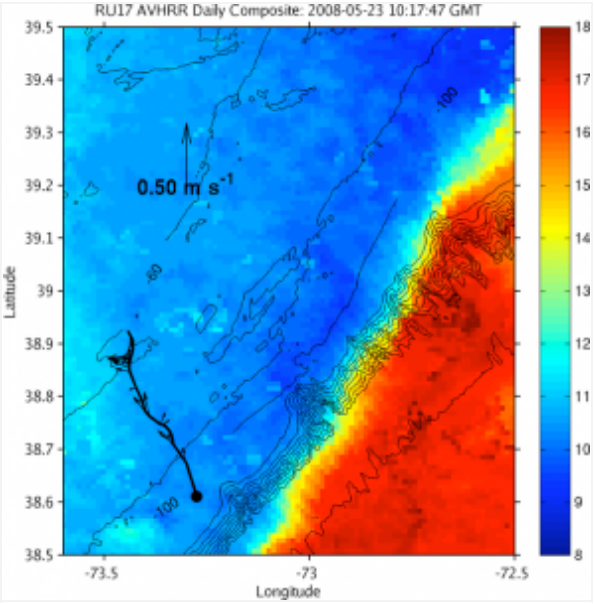
0 Comments

23 may The View from Space - Its a Big Pond

Edit Posted by: Scott in: Across the Pond Edit

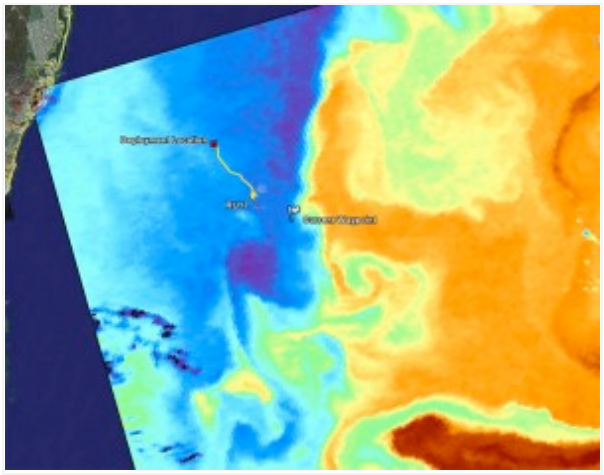
The next 5 images show the view from space acquired by the operational NOAA polar-orbiting satellites. Everytime they pass over Rutgers, we use a satellite dish to track it as it flies overhead. We acquire the high resolution direct broadcast data from the satellite, map the data onto standard projections, and convert the data to Sea Surface Temperatures (SST). Its then posted to our website http://marine.rutgers.edu/cool/sat_data/?nothumbs=0

The first 4 images are the high resolution (1 km) local data downloaded from the Rutgers website. The final image is from the same satellites, but from the lower resolution (4 km) global coverage. This we obtain from the NASA website http://oceancolor.gsfc.nasa.gov/ . We use the Data by FTP access, and regularly download the SST data, and map it to the North Atlantic.

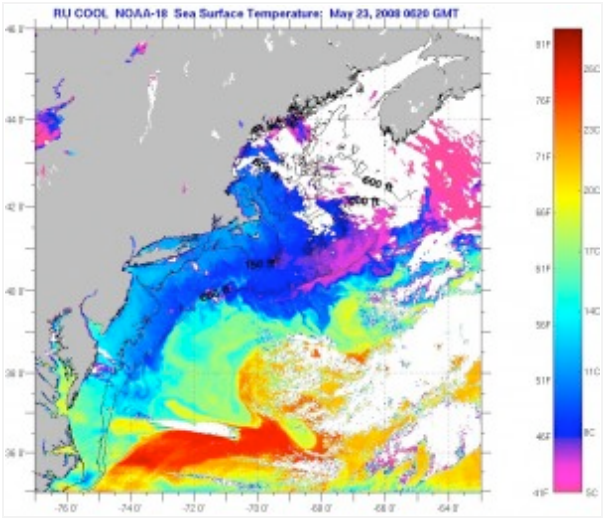


The above image shows the track of RU17 as the thick black line. The present

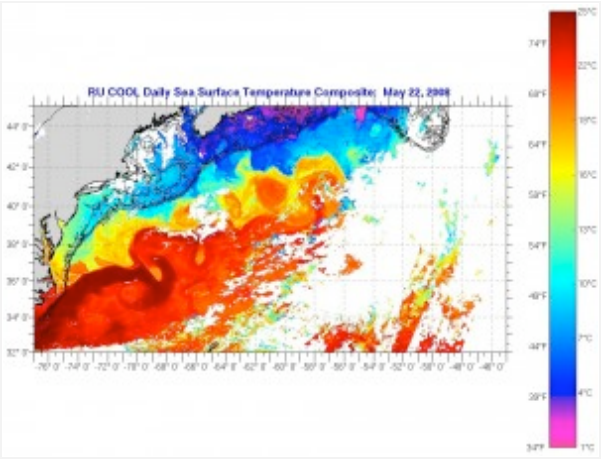
location of the glider is the round dot. Current vectors measured by the glider along the track are shown. The bathymetry is contoured with the thin black lines. Located just offshore the shelf break is a strong SST front. The surface water temperature changes from 9 C to 16C. This is the shelf slope front. We are staying deep until we get on the offshore side of this front.



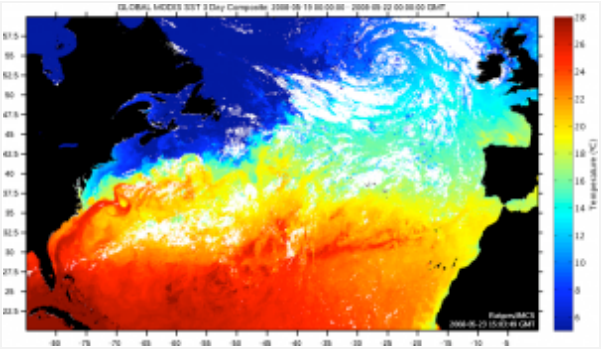
Above is an enhanced image of the Slope water between the shelf break and the Gulf Stream. There are a series of small eddies we will use to get us across the shelf break.



Above is the Northeast image, showing the large Gulf Stream meander near 38 N, 70 W. Here is our target.



Now we zoom out to the full Gulf Stream. May is an excellent time for satellite imagery of the Gulf Stream.



Above is the image of the full North Atlantic. The Gulf Stream running to the Grand Banks of Newfoundland is about 1/3 of the way across.

0 Comments

23 may A View of the Gulf Stream

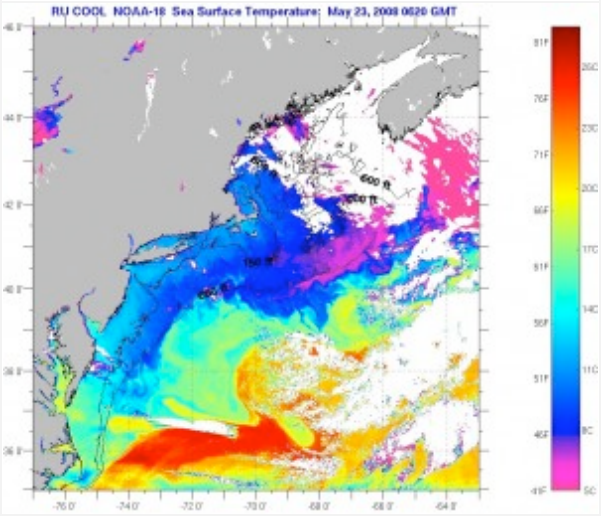
Edit Posted by: pathfinder in: Across the Pond Edit

Last night, as the last clouds associated with our last week of showers dissipated from the region, we were fortunate to gather a satellite image of sea surface temperature that reveals many of the dynamic features that will effect RU17s trip across the slop waters and entry to the Gulf Stream.

For the weeks, the Gulf Stream has maintained a meander ridge over the a cold core eddy near 36 15N 68 30W. Spinning counter clockwise below the axis of the gulf stream, this eddy has drawn warm Sargasso sea water to the north to reinforce this meander (through May 19). Warmer water flows towards, and around these depressions in the sea surface. As the eddy slowly drifted towards the west, towards the mouth of the Gulf Stream, the eddy began to draw water from the Gulf Stream Southward, where it slowly piled, depriving the meander crest of strength. The deflection of water by the cold core eddy caused the GS to form a meander around it (~May 21). Now, water making it around the cold core is surging back to the interface with slope water, pushing the eddy back towards the slope sea!

This mornings SST shows the cold core eddy crawling up the trough of the Gulf Stream that descended to erase it, and the entire system begins to turn counterclockwise. Since the cold core eddie continues to spin counterclockwise (and RU17 is to the west of it), this cold core should help us out by deflecting currents towards the S/SW. However, this morning's image also reveals a meander ridge developing near 36 30N 71 45W. This ridge is holding those helpful currents to the east, and using the cool core eddie to close itself off as a warm core eddie. This feature is beginning to dominate the currents that will affect our entry to the stream. Is this the warm core that will bring us through the Grand Banks?

With this knowledge of the currents, it's time to run the path planning model. Do we chance taking a premature signature of warm water and eastward currents, and try to ride the right? Do we keep heading east until the currents draw us south? It does look the the ring is reaching right out for us.



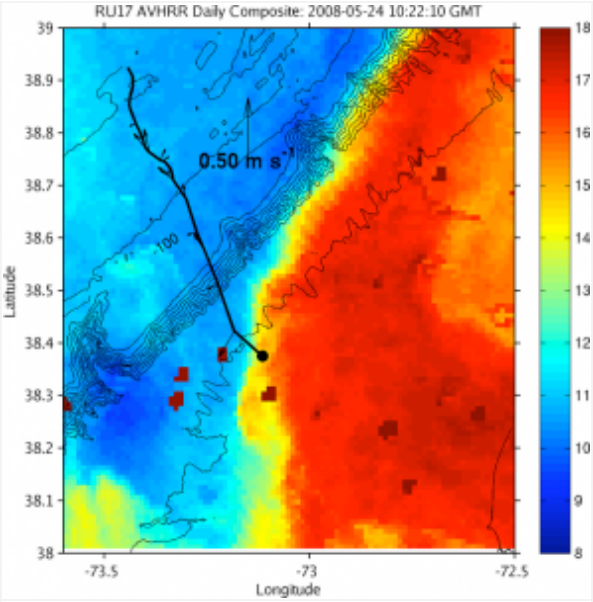
-Justin.

1 Comment

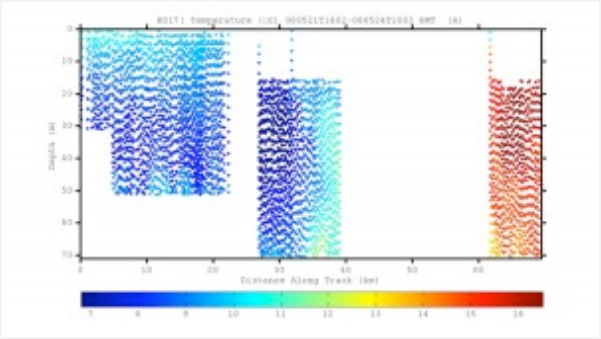
24 may Deep Flight Across the Shelfbreak

Edit Posted by: Scott in: Across the Pond Edit

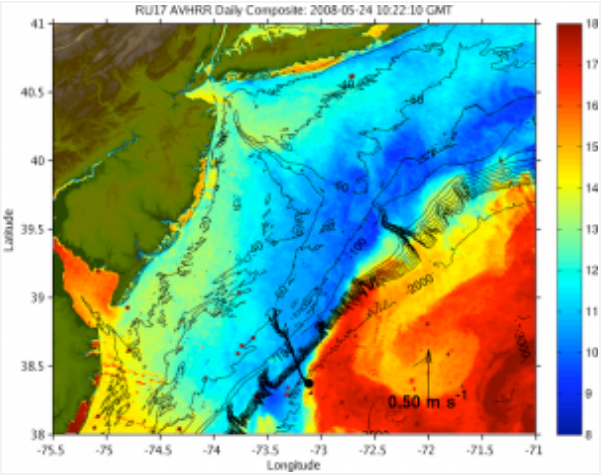
Zoomed in image below shows the 6 am surfacing location of RU17. It is flying deep, and made it across the shelf break. This is the first known danger point of any international mission, and only the second time we tried this method to cross the shelf break. If only we knew this might work in the Shallow Water 2006 experiment.The data assimilative modelers urged us weekly to try to cross, but the ships in the experiment said the fishing activity was too intense at the break, and they had to pull their towed gear out of the water to cross, redeploying on the other side.



We have left the cooler blue water (8C) and are now at the edge of the warmer red 15 C water. Overnight we turned to fly essentually due east to get into the eddy to try for a boost. Well stay deep for this next 6 hour interval - the 6 am to noon, and switcht to full water column flight, our most efficient mode, at noon today. An important point is that we made it off the shelf before the Memorial Day boating activity kicks in.



Above is the temperature section on the CTD for RU17. You can see we left the cold 8C water of the shelf and have entered the warm 15C water of the slope. CTD is now on for one 6 hour segment, and off for 3 6 hour segments. We run the data collection segment from midnight to 6 am, so the data is ready for the morning NOAA satellite shots.

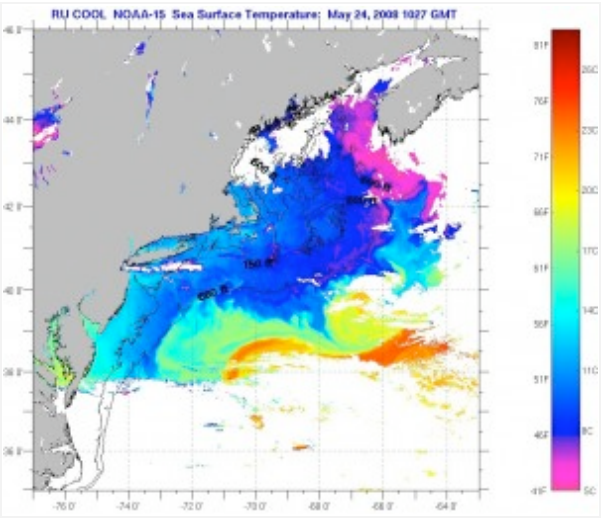


The above image shows the situation for the next few days. The direct route to the Gulf Stream has an eddy in the way. If we cross directly through the eddy, we save 100 km. If the edy currents are against us, we loose time, if they are with us, we gain time. 3 days into it and we already have our first gamble. In most eddies you can tell the circulation from the SST imagery. This one reminds me of the SHAREM 150 exerices back in 2005. We were working in the Sargasso with the Navy, and both we were trying to get 4 gliders to meet in the center of the box. Oceaongraphers at Rutgers and Stennis had to guess the direction of all the eddies in the field based on the SST imagery only. We were pretty good at the relative motion across fronts, but not always on the absolute. We learned caution the hard way. We'll learn something new again over the next two days.

0 Comments

24 may Gulf Stream Meander Crest Grows

Edit Posted by: Scott in: Across the Pond Edit



Sometime last night Justin noticed the interaction between the Gulf Stream and the Cold RIng was well underway. The image above was just acquired and posted on our website. The warm (red) Gulf Stream meander crest near 38 N, 70 W is growing, bulging out to the northwest. It is now a full degree of Longitude closer to

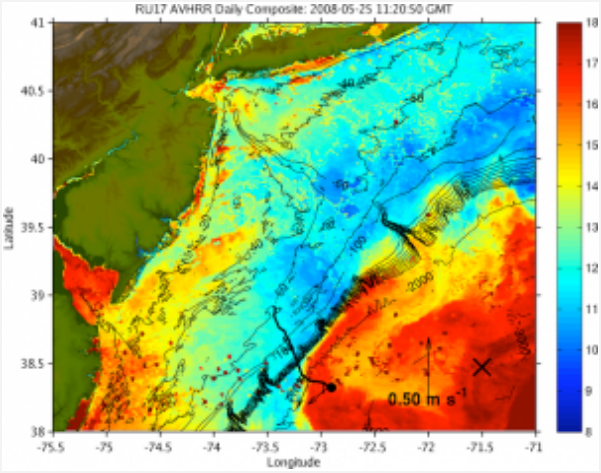
us, reaching to 71W. The Gulf Stream is approaching RU17 faster than RU17 is approaching it. The race is on. We need to find the favorable currents in Lisa's eddy from yesterday, grab that meander creast and shoot off to the west before the large meander system breaks apart into rings.

0 Comments

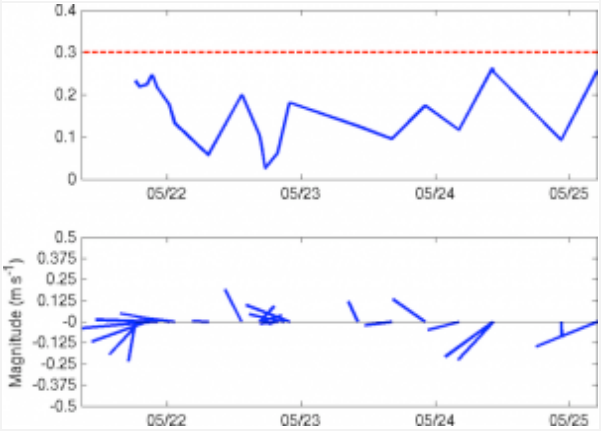
25 may Weekend Update - Local

Edit Posted by: Scott in: Across the Pond Edit

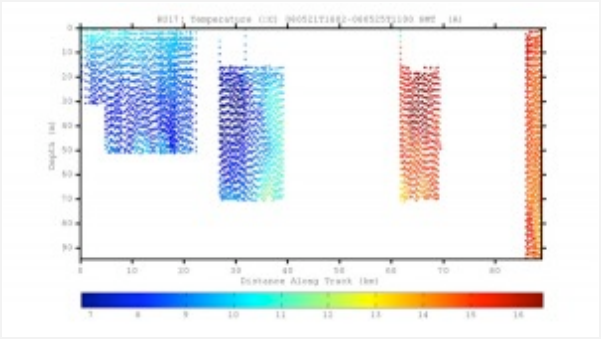
The Scarlet Knight (RU17) is heading towards the east (X marks the spot), crossing a band of warm water as it heads into the slightly colder filament that starts up near the Hudson Canyon, heads south parallel to the shelf break to about 38.5 N, then cuts east. We want to ride that flow to the east.



Current speeds (in meters/second) are just about at the threshold (red dotted line) from where we switch from being a ship to being a drifter. Looks like currents in the warm band are to the southwest, parallel to the shelf break.



Now that we are in the warm water, away from the danges of the shelf break, we switched to full water column yo's (as the call them). This will increase our speed and be our most efficient flight configuration for the majority of this mission. We are doing 6 hour surfacings, CTD on for 1, off for 3.



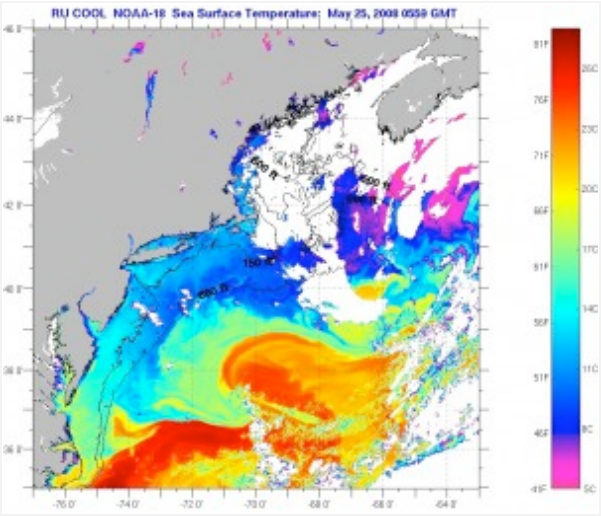
Time to go catch that Gulf Stream. Check out the regional weekend news for some amazing Gulf Stream imagary of a major ring formation.

0 Comments

25 may Weekend Update - Regional

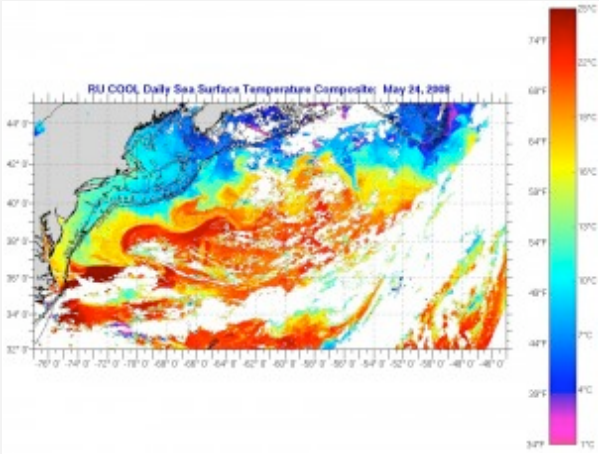
Edit Posted by: Scott in: Across the Pond Edit

Sea Surface Temperature Image below shows the start of a major "S" shaped (Gulf Stream meander system (wam red water) centered near 69 W. Between 74W and 68 W, the Stream heads due east along 36N. It then cuts back sharply around that Cold Core Ring it just absorbed, and heads northwest to 38N, 73W. It then makes another sharp turn and heads back east, but now along 38 N. The area covered by the two hairpin turns measures 300 km east-west (about the distance from New York City to Washington, DC) and 200 km north-south. This is a major feature for the Stream.



The first thing I thought of when I saw this image this morning was spring of 2006. We were preparing for the ONR Shallow Water 2006 summer experiment on the New Jersey outer shelf. We were tracking the Warm Core Rings that propagate along the shelf break, and influence exchange between the shallow shelf water and the deepwater of the Slope Sea. Back in 2006, I saw the biggest ring formation event I have ever seen since I began looking back in 1983. The event prompted us to start this series of blogs. You can read about the big ring of 2006 if you go to our blog page at http://rucool.marine.rutgers.edu/index.php/COOL-Blogs/ and

click on the New Jersey Shelf Research link. You have to scroll down to the March through May events to see the big ring story. The cool thing was that one of our ONR partners in Shallow Water 06, Glen Gawarkiewicz from the Woods Hole Oceanographic Institution, was reading the blog and took his gradute student class out on a Woods Hole research vessel to sample it. Students used the blog to provide a regional context for their shipboard measurements. We'll be do the same thing with this 2008 event. Only difference is, we won't need a boat. We'll send a robot.



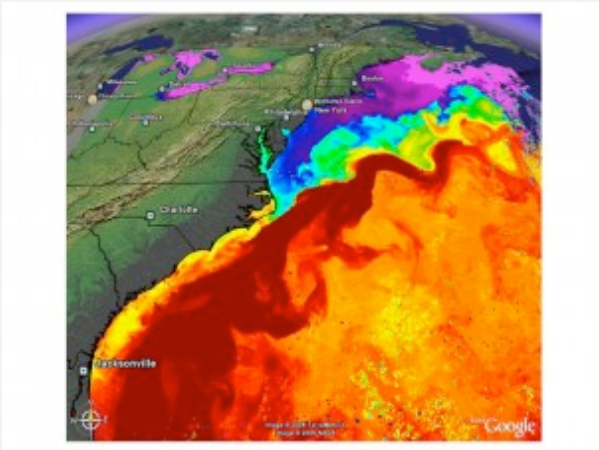
Above sea surface temperature composite image from yesterday shows the overall situation for the Gulf Stream. West of the big S-curve, the Stream is flowing due east along 36 N. West of the S-curves, the Stream is flowing due east along 38 N. The S is where it makes the jump from the southern route to the northern route.

0 Comments

25 may May 25 " Why The Gulf Stream"

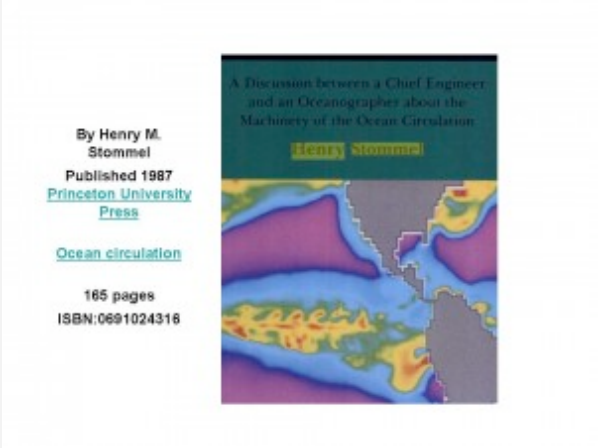
Edit Posted by: Oscar in: Across the Pond Edit

The Scarlett Knight glider is heading offshore and it will enter the Gulf Stream. The Gulf Stream upon which we will hop onboard will be critical to the successful crossing of the Basin as we need to use as much of the ocean's power as possible. The glider will transverse the Gulf stream and then enter into the North Atlantic Drift much like many ocean explorers of the past. European knowledge of the Gulf Stream dates to the 1513 expedition of Juan Ponce de Leon, and once it was discovered was used by Spanish ships sailing from the Caribbean to Spain. The Gulf Stream is a western-intensfied current largely driven by wind stress. Currents on western boundaries are intensified by the Coriolis effect which exterts force. This can explain western boundary currents (the Gulf Stream) are stronger the currents on the eastern boundarys. Henry Stommel (pictured here sitting in his office at WHOI), who ALSO envisioned networks of autonomous instruments such the ocean glider, is credited with describing this effect. To put it mildly, for oceanographers Stommel is one of the "Gods". If Stommel was a rock band, he would be the Beatles and Led Zepplin combined! Anyway, I digress. The Gulf Stream transitions into the North Atlantic Drift which in contrast from the Gulf Stream is a thermohaline circulation. The net effect however is that copious ammounts of warm ocean water is transported towards Europe. This is cirtically important as it funnels heat, alot of it, which keeps those outside cafes as spectacular destinations for most of the year by keeping Europe warmer then it would be without a Gulf Stream and North Atlantic Drift.



The Glider will use the monetum provided by the Gulf Stream which is extremely strong. It carries 1.4 petawatts of heat (note this 100 times the world energy demand, see a great article by Jonathan Leake, The Australian, December 5, 2005). The current transports water at a rate of 30 million cubic meters per second (30 Svendrups) through the Florida Straits. It passes Cape Hatteras along the Eastern seaboard of the Unted States, and the rate increases to 80 million cubic meters per second. The figure above shows the extremely warm sea surface temperatures (red color) hugging the southern eastern seabaord of the United States. Using the Gulf Stream as a potential source of energy for humanity has long been hypothesized however this remains currently a dream. For the Glider, its goal will be to use as much of the energy to help it complete its long and lonely journey. To harvest the energy the Glider, and its pilots, must keep it in the Gulf Stream. This will be a consuming mental adventure for six months as wrong turns and poor choices could result with us outside the Gulf Stream and in a precarious predicament of not having enough energy to complete its journey.

For those who want to dig deeper, start in Wikipedia, and access some of the great literature about many of the issues dicussed above. Also there is a great book by Stommel himself (below) which is a great read. Actually the Stommel book below is one of my all-time favorite books,,, but i am a nerd.



Fernandez-Armesto, Felipe (2006). *Pathfinders: A Global History of Exploration*. W.W. Norton & Company, p. 194.

Wunsch, Carl (November 8, 2002). "What Is the Thermohaline Circulation?". *Science* **298** (5596): 1179–1181. doi:10.1126/science.1079329.

Seager, Richard (July–August, 2006). "The Source of Europe's Mild Climate". *American Scientist Online*.

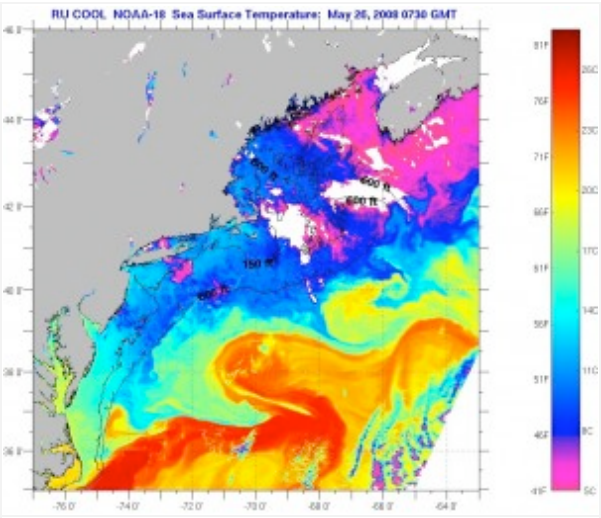
Phillips, Pamela. The Gulf Stream. USNA/Johns Hopkins.

1 Comment

26 may A Growing Meander

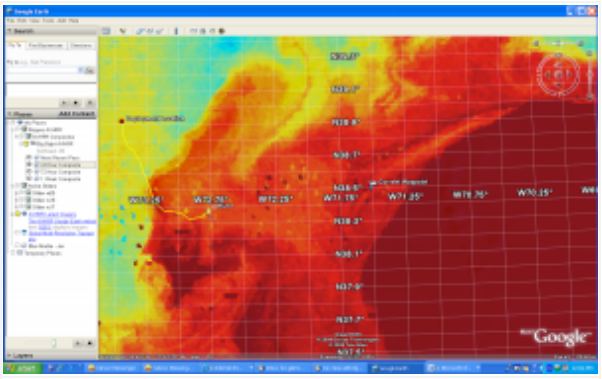
Edit Posted by: Scott in: Across the Pond Edit

The S-curve in the Gulf Stream below continues to grow. You can still see the stretched out remnants of the cold core ring on the southern side of the meander crest. They crest continues to grow back to the west towards us.



RU17 made slow progress to the east last night, encountering a head-current for much of the night. Based on the enhanced image from last night (below), we think it is associatd with that warm filament (dark red)that extends to the south of

RU17's present location. Rather than try to fly through it to the south, we are giving RU17 a new waypoint that flies it to the northeast, perpendicular to the current that is it presently in. Here we hope to find the more favorable currents that were advecting the colder shelf water far out to sea.



Efficiently crossing the Slope Sea without a major Warm Core RIng to ride is our first challenge.

0 Comments

26 may History 101 -The Slocum Glider goes to Sea

Edit Posted by: Scott in: Across the Pond Edit

Above photo from Tuckerton, NJ and the first at-sea deployment of a Slocum Glider. Clayton Jones is on the left, Doug Webb is on the right.

One thing we occassionally get to do is tell our students stories of our history, especially of the people we have met, have gone to sea with, and through our common interests, both on and off the boat, have become lifelong friends. Meeting Doug was a turning point in that history, is one of those friends, and part of that story. Here is my version.

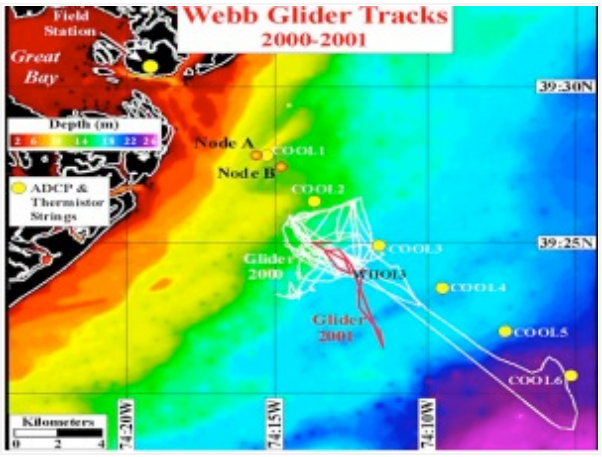
I first introduced myself to Doug Webb a decade ago. I already knew Doug from my days in the early 1980's as a student at Woods Hole. I don't think Doug knew me. So it was 1998, and we were both at a coastal observation and modeling

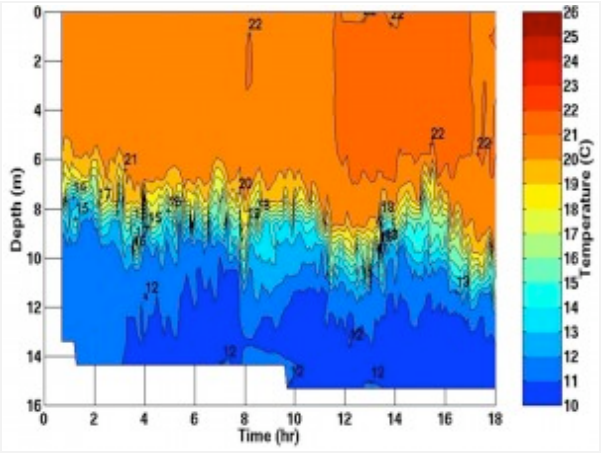
conference at MIT. It was sponsored by the MIT SeaGrant office to pull in more people working with AUVs. I gave a talk about the coastal predictive skill experiments we were planning offshore Tuckerton, NJ. It was part of the new National Ocean Partnership Program (NOPP). My talk included slides on a new REMUS Autonomous Underwater Vehicle that Chris von Alt was building at WHOI.

At this same conference, Doug gave a talk on an AUV that I had not seen before. In fact, it was very different from any AUV I had ever seen. Doug's AUV first had wings, and when you looked closer, it had no propeller. It was instead driven by a buoyancy engine that would cause it to alternate between floating and sinking. It used wings to glide horizontally both on the way up and on the way down. Unlike the propeller driven vehicles, with typical durations measured in hours, Doug's plans for the Glider included having it deployed for weeks, months and eventually years at a time. At that very moment I knew I needed one. It could provide the continuous spatial context for all the shipboard measurements we had planned. And it could patrol the outer edge of our region of interest, so that the models would be on track when the ships went in. I invited Doug to join us in Tuckerton in the annual Office of Naval Research (ONR)-sponsored Coastal Predictive Skill Experiment. We all wrote another NOPP proposal together, and a new partnership between Rutgers and Webb Research was born.

The next year, 1999, with NOPP funding, Doug brought one of his gliders down to Tuckerton for some initial testing (see above photo). It was the first time a Slocum was to be deployed at sea, and we tied a rope to the tail just to make sure. Clayton Jones would be on shore and would talk to the glider via a Freewave Radio Modem. Doug Webb would go out on one of our local SeaTow vessels for the deployment. Clayton said Doug would need some help, since typically 2 people deploy the glider. We chose a first year grad student, Josh Kohut, to accompany Doug on that historic test. Once deployed for the first time in the open ocean, the glider was told to dive, return to the surface, and phone home. It did. All on its own. We didn't even need the rope. We called it a year.

Doug and Clayton came back to the Coastal Predictive Skill Experiments again in 2000 and 2001. The white line below shows the track of the first x-shelf section in 2000. Clayton flew the glider out to the edge of the Freewave Modem range and back. Temperature data from the flight is on the right. We couldn't leave the approximately 30 km watch circle of the freewave antenna mounted on the 64 meter Meteorological tower at Tuckerton. Next step was global satellite communications, but that would have to wait for 2003.





We now run 17 gliders, and Josh is a Professor of Marine Science at Rutgers.

1 Comment

29 may Greetings From Tallinn, Estonia

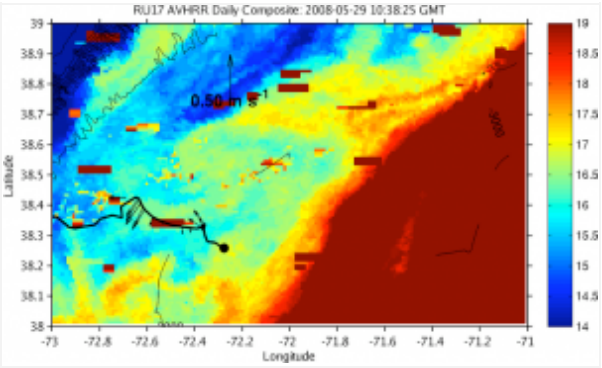
Edit Posted by: Scott in: Across the Pond Edit

Today we are giving talks at the UNESCO Baltic Sea conference in Estonia. While here we also met the Navy White Ship the Pathfinder to visit RU01, our oldest glider, just before they deploy it in the Baltic in a couple of weeks. You can see the number 01 on the tail fin. The blue sticker on the front section indicates it was picked up at least once by Harvey Seim as one of our IOOS runs between New Jersey and North Carolina.

Tom Austin and his REMUS group from Woods Hole was aboard the pathfinder with several REMUS vechiles they will use to try to find a downed Estonian aircraft from the pre-WWII days. We met for dinner and traded memories of the Coastal Predictive Skill Experiments, and where both of our groups have gone in the past 10 years. The number of parallels is eyeopening. REMUS 6000 is shown below.

Yesterday (wednesday, Estonia time) was a great day for RU17. Since Sunday of Memorial Day Weekend (U.S. Time) RU17 has been weaving its way through a series of warm filaments that are being shed by the large "S-shaped" Gulf Stream. Each of those warm filaments has currents counter to the direction we want to go - east. Just like a person caught in a rip current, the glider can't swim against these flows. The best we can do is swim perpendicular to the currents to try to get out of the infavorable currents and get into the favorable. Over the last few days we have had multiple course changes. One filament in particular was especially strong to the southwest, so we just flew southeast and were out of it in a day. But without a warm core ring to carry us across the slope sea, its a extended series of filament crossings. This can be frustrating this early in the mission, but it is also good training. We'll encounter uncertainties like this again and again in this mission. If anything, it has actually increased our confidence in the rip current beavior model. If the currents are against you, swim perpenidicular until time or space changes it for you.

The below image was just downloaded. It shows where we are. Across all the visible filaments and in the cooler water, about 60 km from the outer fringes of the Gulf Stream. We are heading east.



Current time series below shows the conditions. Two days of strong currents to the west, the wrong direction. RU17 finally fought throug these, and is now in the slower cooler water thats between us and the stream.

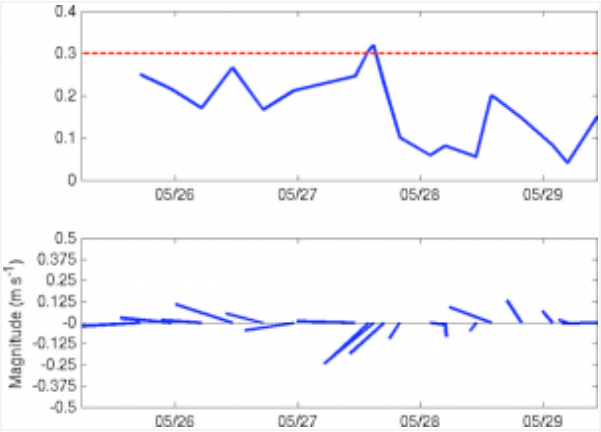
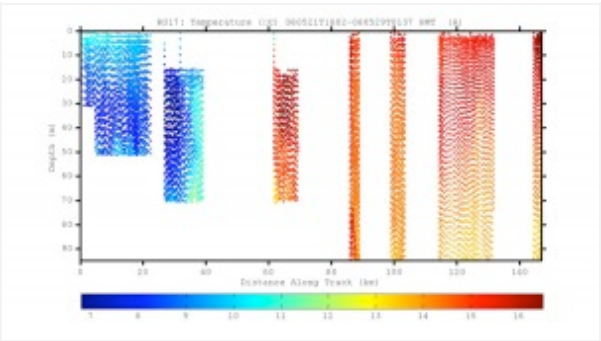
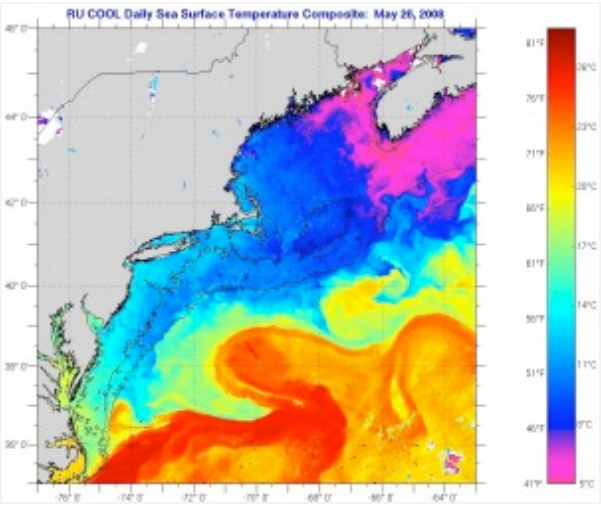


Image below shows we are still turning the CTD on and off to save power, but with all the course changes over the last 2 days, we put less time into worrying about the ctd. If it was on, we left it on till we got out of trouble, minimizing our time at the surface where we are getting advected rapidly in the wrong direction.



Here is our target, the growing "S-shaped" Gulf Stream meander shown in this composite image below. We are aiming for the Gulf Stream anywhere near the bulge that extends westward along 38 N. We are about 60 km west of this bulge, and are heading into it. We should be back from Estonia on Friday night, and RU17 should be getting close to the Gulf Stream about Saturday. Thats good. Once in the stream, we will again assume active control of the glider to maximize our distance across.

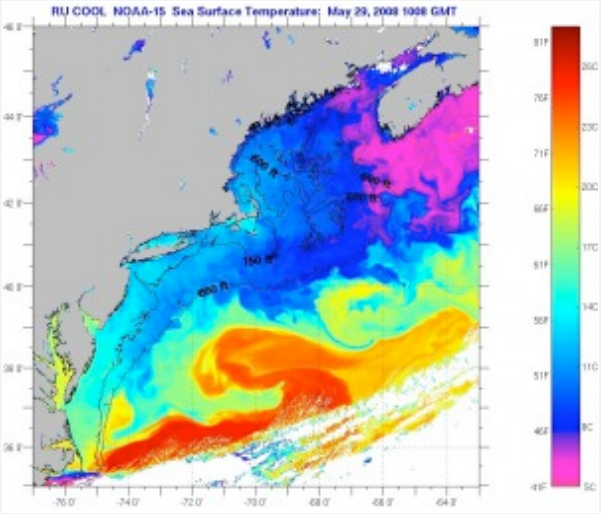


1 Comment

29 may Another Warm Filament

Edit Posted by: Scott in: Across the Pond Edit

Just when you start thinking you've crossed the hardest part of the Slope water, the clouds clear, and what do you see, the Gulf Stream spinning off another warm filament an pulling away from us. The warm filament extends to 72 W along 38 N, but the stream only etends weste to 71 W.



Ok, its not like we haven't done this before. Lets cross another.

0 Comments

29 may Finding the Gulf Stream in the Old Days

Edit Posted by: Oscar in: Across the Pond Edit

Well Scarlett Knight is slowly trying to get to stream. The we will try to get the glider to remain in the stream as long as possible! But as we enter the Gulf Stream it is great to look back to the giants before us. While Ben Franklin was acknowledged to have mapped the stream, scientific focus on mapping the stream to understand its dynamics was a major focus in the 1950's and 1960's. In June 1950, the synoptic path between Cape hatteras and the Grand Banks of Nefoundland was mapped by Fuglister and Worthington. He is pictured with some oceanographic giants (pictured are Worthington, Bumpus, Fuglister and Riley). The efforts to map the Stream was very labor intensive, requiring many ships, many people, opertating under very rough conditions.

Given this, there was much effort to improve technology to make life better. Simple advances were invaluable!! For example, one classic paper in the 1960's showed that using a towed thermometer looking at the temperature changes at 200 m depth could track the Gulf Stream. The scientists could then use the data to adjust where the ship was moved, and this allowed them studied the spatial variability in this undulating Gulf Stream. The glider by virtue of its undulating behavior represents the next generation of this approach. The BIG advantage is that now instead of going to sea i get to sit now in really exciting committee meetings, fill out lots of progress reports, and answer my phone…… wait a minute, maybe the new future has some downsides……..

A NEW METHOD OF TRACKING THE GULF STREAM[1]

F. C. Fuglister and A. D. Voorhis

Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

It has been found possible to map the path of the Gulf Stream rapidly over long distances by towing a temperature sensor at a depth of 200 m. The strategy is to steer the ship along the 15C-isotherm, which approximates the middle of the horizontal temperature gradient characteristic of the Gulf Stream at 200 m and represents a position close to the maximum surface current.

F. C. FUGLISTER AND A. D. VOORHIS

Limnology and Oceanography 1965

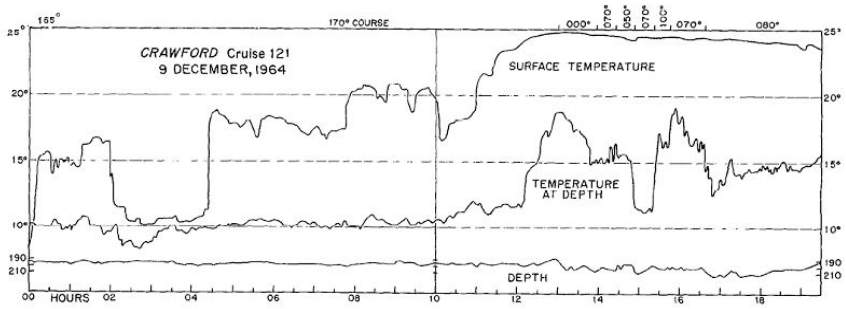


FIG. 4. Surface temperature from the bow thermistor and V-FIN temperature and depth for the first 20 hr of *Crawford* cruise 121.

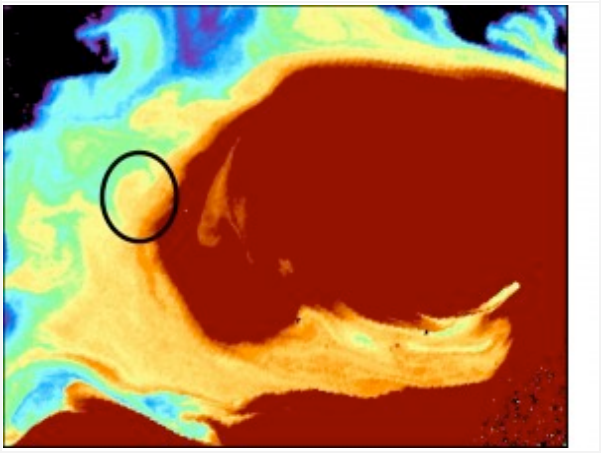
0 Comments

30 may Lisa finds an eddy

Edit Posted by: Scott in: Across the Pond Edit

We were just finishing up the US-EU Baltic 2008 International Symposium at Tallinn, Estonia yesterday. John gave us a call during the last speaker. RU17 was encountering a current to the west, and we needed to go east into the Stream. Satellite imagey had just cleared and revealed the new warm filament. So we had to make a decision, we could not continue flying east. So do we turn northeast or southeast. Lisa enhanced the most recent satellite image and posted on the blog web links on the right. We picked it up in Estonia, and found that RU17 was in a very small eddy off the western side of the new filament (see black oval below). The decision was made. Fly to the northeast, and follow the eddy around. John gave it the new waypoints, and we headed off for an evening of team building with our NOAA & Navy partners, and scientists from around the Baltic. John found us later that night with another phone call. RU17 was whipping around the eddy, increasing its speed, and making up for the time we lost in the westerly currents over Memorial Day weekend. We are back up to the average speed we need of

about 1 km/hour to get through this phase of the deployment and not exceed our quota of battery time.



0 Comments

30 may

A Happy Welcome Home

Edit Posted by: Scott in: Across the Pond Edit

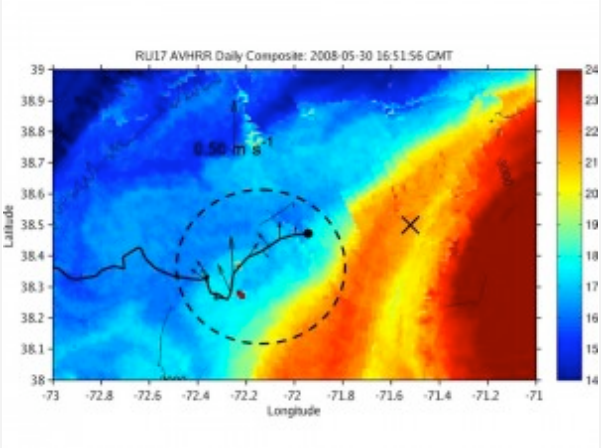
After sending RU17 on its way around the eddy Lisa found in the previous entry, we walked around Tallinn. Eventually we were left with two hours to kill waiting for our plane. Harvey Seim, a University of North Carolina partner in our Mid-Atlantic Coastal Ocean Observing System, suggested a walk up the hill to the castle walls at the top for the best views of the city and the port. The city was amazing - buildings dating back hundreds of years and, as advertised, the east meets west architecture.

http://www.flickr.com/photos/rutgers_cool/sets/72157605344234105/

We ended the trip with a quick meal at the Burrito Bus with some new found friends from Estonia, and a cab to the airport.

The image below is what we found when we landed in the U.S. We spun around the eddy with the strong currents to the north, following that finger of slighty

warmer water as it curved around to the northeast.



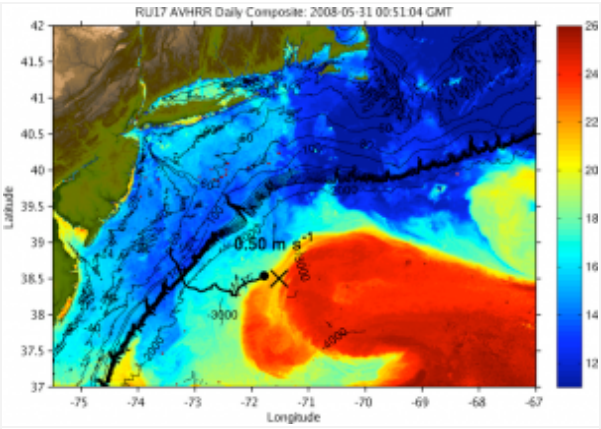
Amazing how a making some distance over the ground can change the mood in the operations center. We left Rutgers early in the week with RU17 flying into head-currents, as we zig-zagged through a complex field of eddies and filaments. We returned with some serious kilometers being clocked, and smiles all around.

0 Comments

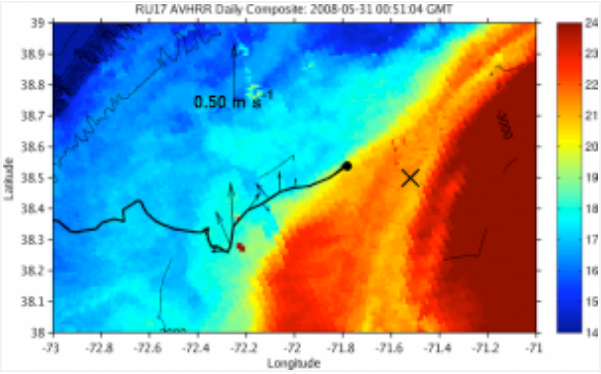
30 may Approaching the Big Warm Filament

Edit Posted by: Scott in: Across the Pond Edit

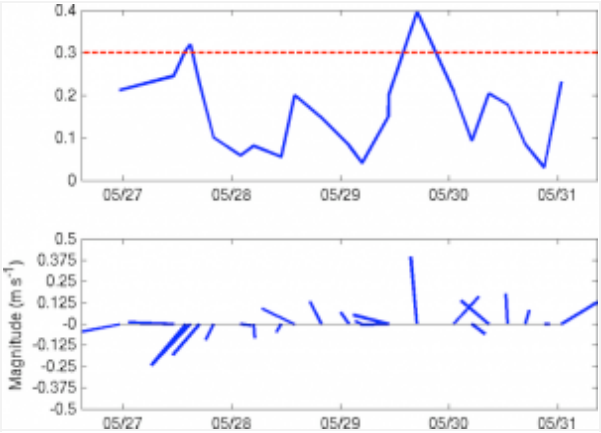
Below image shows the S-shaped Meander system (red colors around 24C) and how RU17 is approaching the Gulf Stream.



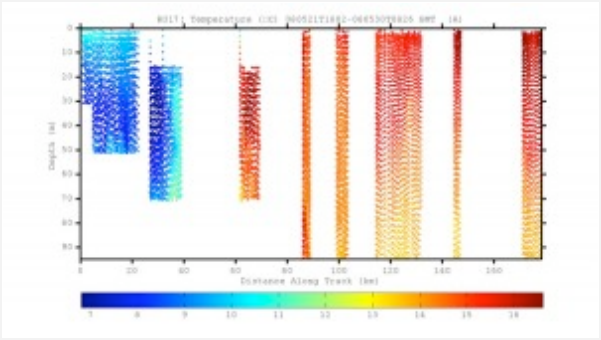
Zoom in on the glider and it is just at the edge, hitting the 20C isotherm. The gap seperating the large warm filament that we found yesterday in Tallinn when the clouds cleared appears to be narrowing. A more traditional warm filament is forming in the dark red waters about 24C. Here the filaments start small and tend to grow opposite the main flow with time.



The fast kick to the north on 5/29 certainly helped our cause. Now we are getting currents to the northeast, a good sign as we try to enter the Gulf Stream.



Last time CTD was turned on (early today), temperatures where about 17 C. We should start to see these increase as we cross the big warm filament. We'll keep an eye on this as we cross. Its not the traditional warm filament that forms as a near surface feature, so we are not sure how deep to this feature will turn out to be.

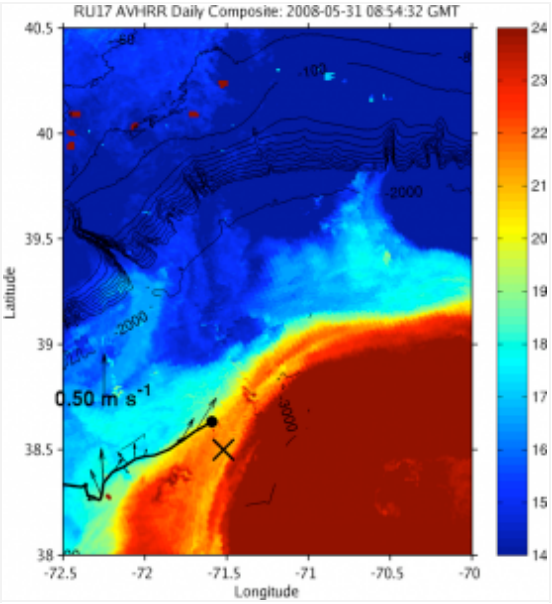


0 Comments

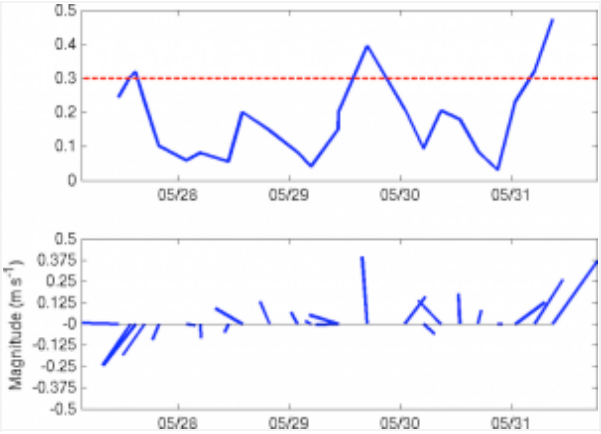
31 An Overnight Approach to the Gulf Stream

may | Edit Posted by: Scott in: Across the Pond Edit

Below is the early morning image from May 31. RU17 whipped around with the eddy and approached the Gulf Stream overnight. Currents where to the northeast, and increasing. We kept RU17 on a perpendicular course, heading to the southeast, using the glider velocity to get us into the Gulf Stream.



Currents are increasing above the glider speed (the dotted red line). When currents are above the red line, we behave more like a drifter. Below the read line, we are more like a boat.



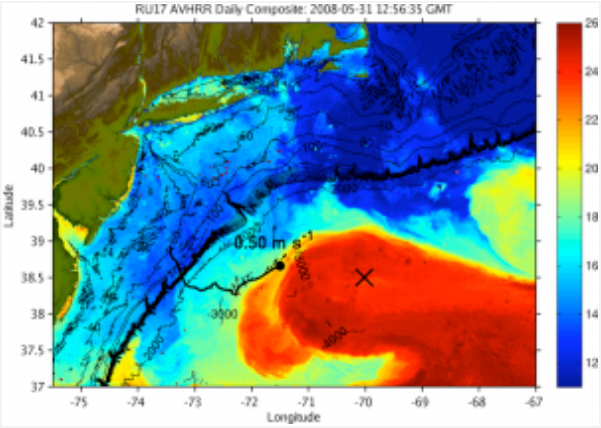
With the 9 am surfacing this morning we switched to a new mode of flying. We are now focused on using the glider velocity to get us into and keep us in the strong currents. We'll also switch the enhancements on the satellite images that appear on the google earth plots and the "Atlantic Glider Track w/SST" COOL Web Links on the right.

0 Comments

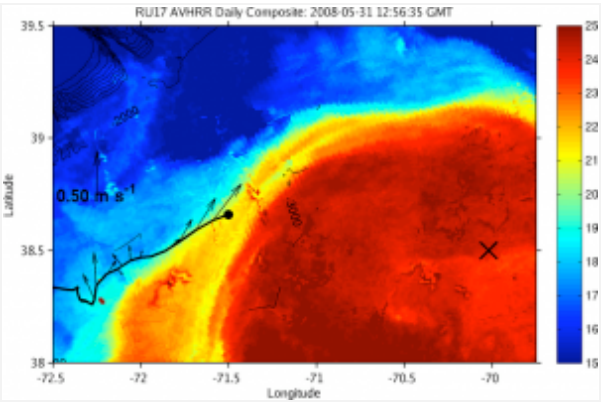
31 may Racing the Ring Formation

Edit Posted by: Scott in: Across the Pond Edit

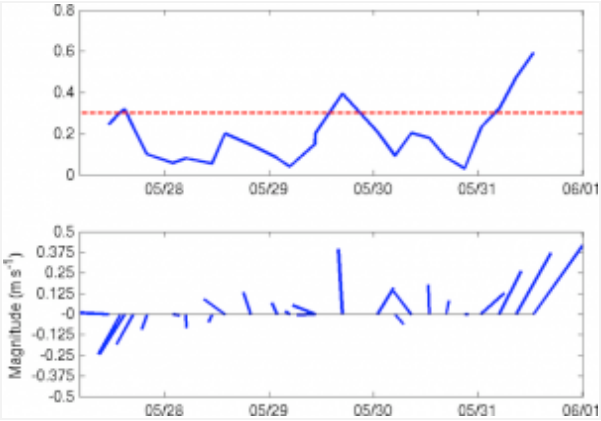
The satellite-derived Sea Surface Temperature (SST) maps have been modifed to now enhance the structures within the Gulf Stream. The crest of the S-Shaped meander system is clearly now enhanced. The structure is on its way to pinching off to form a new Warm Core Ring that will be centered about 38 N, 70 W. We need to get deep into the Gulf Stream and shoot quicky downstream to beat the ring formation process. But deep into the Gulf Stream makes it hard to get out if we get caught in a new warm ring. The ring will be pretty big, about twice as big as New Jersey, so its a lot of distance to cover if we need to swim out. We need to get past about 68W to keep from getting spun around like we did on the flight to Halifax.



Below is the new zoom in on RU17 as it enters the Gulf Stream. The warm filament continues to diminish in size in this image. Currents are to the northeast. We set the waypoint (X) to the east and deep in the Gulf Stream. We will continue spinnig around this point over the next 24 hours.



Current speeds below are increasing. Up to 60 cm/sec. We want to get these well over 100 cm/sec over the next day.



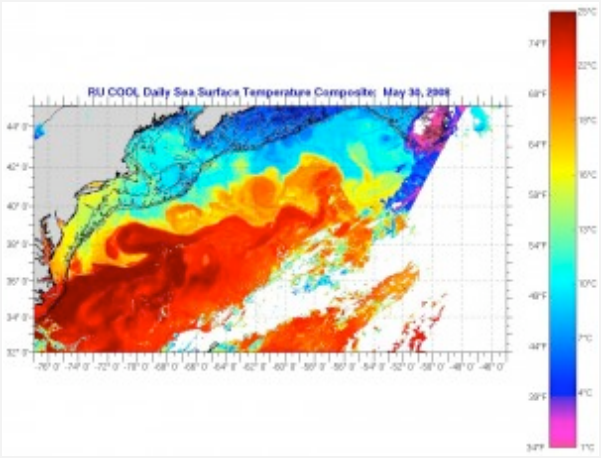
0 Comments

31 may Back to the Big Picture

Edit Posted by: Scott in: Across the Pond Edit

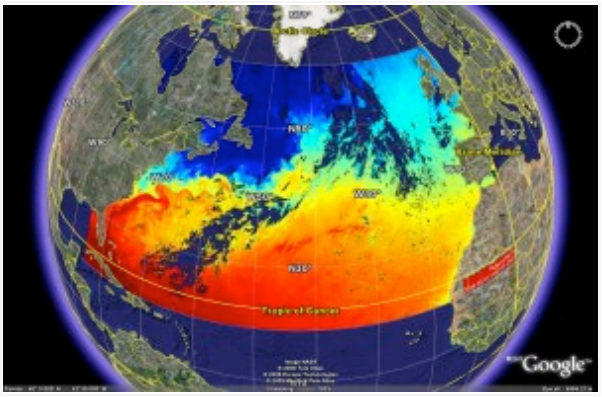
So why am I here blogging on a saturday night? RU17 is due to surface in less than an hour, and is just about to enter the Gulf Stream. Its a major transition in how we fly. Also, its just really cool to watch. This is only our second time to fly into the Stream, so it still carries with it an awesome sense of accomplishment. Especially after we had to cross the Slope Sea without the aid of a major warm core ring. Should we have waited for the large meander near 70W to break off and propogate westward to the shelf break? We could have our destination was again Halifax. But we couldn't wait. We need to get far to the east before the stormy weather of winter sets in. So we had to go as soon as we were ready, and live with whatever conditions the ocean gave us.

Below is a snapshot of those conditions downstream. Once we get into the Stream near 71W, we'll rind down the eastern side of that meander crest and try to beat the warm ring formation. After that we have two gentle meanders with crests near 64W and 60 W to follow. Then there is the warm ring formation event we see going on now at 57W. Hopefully this event is complete by the time we get there so we can go straight across than all the way around.



After that we zoom out to the North Atlantic farfield. Here the big transition occurs at 50 W. West of 50W, there is a lot of cold water of Titantic fame extending far to the south to about 40 N. East of 50W, you see the Gulf Stream Extension Region,

and the bifurcation of the warm currents. Some of the warm water heads northeast to about 50 N, 40W. Some of it heads straight across towards Spain. If we get that far, we are shooting for the southern route that goes straight across. One of the main reasons is simply to keep the batteries as warm as possible for as long as possible. Cold batteries die faster.

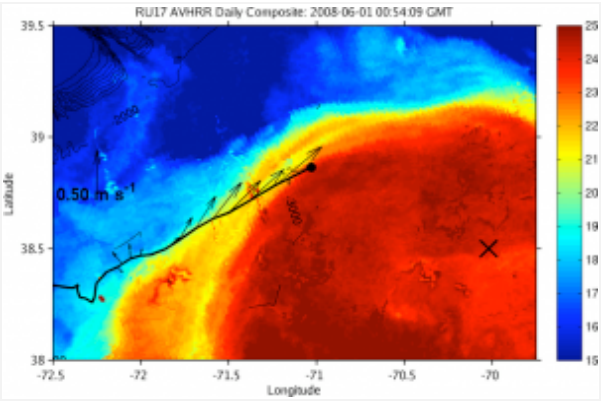


0 Comments

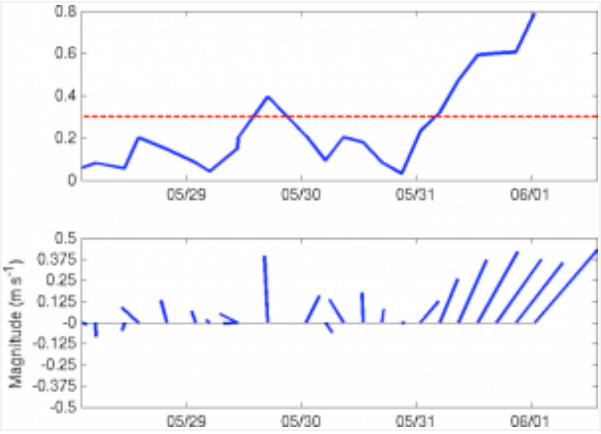
31 may Good Night Scarlet Knight

Edit Posted by: Scott in: Across the Pond Edit

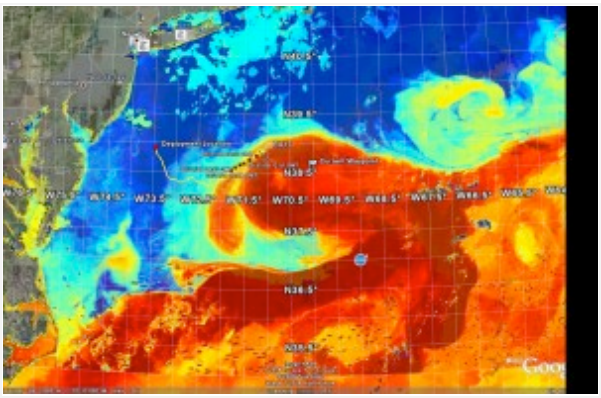
RU17 enters the warmest waters of the Gulf Stream in the early morning (GMT) hours of June 1.



Currents are picking up, reaching 80 cm/sec, running towards the northeast. RU17 is heading southeast, perpendicular to the drift to get deeper into the Stream overnight.



The google earth view below. That northern part of that large warm filament that appeared in Tallinn on thursday is almost entirely gone. The southern part is just sitting there. We hit the good side of this event.



We are done for the night. RU17 position and health checked, the CTD was turned on. For those of you still up, you can follow along by checking the web links on the right and clicking on Atlantic Glider Track w/SST. RU17 should be back at the surface at 1 am local and 5 am local (east coast) time. It's only instructions are to download the new CTD data and continue swiming deeper into the Gulf Stream. We'll move the waypoint during the 9 am surfacing and turn the CTD back off.

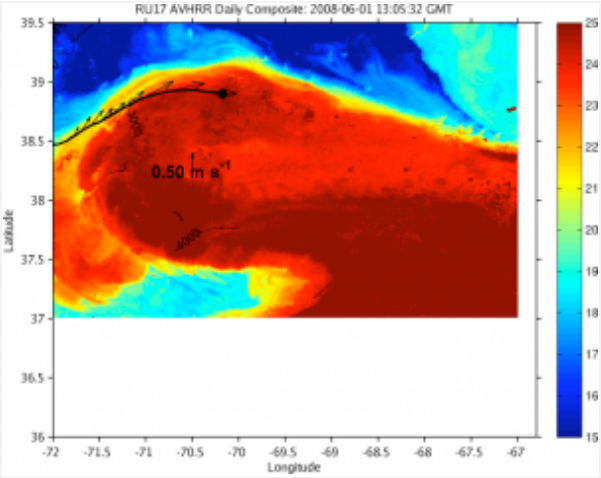
Good work by all. We are in the Stream.

0 Comments

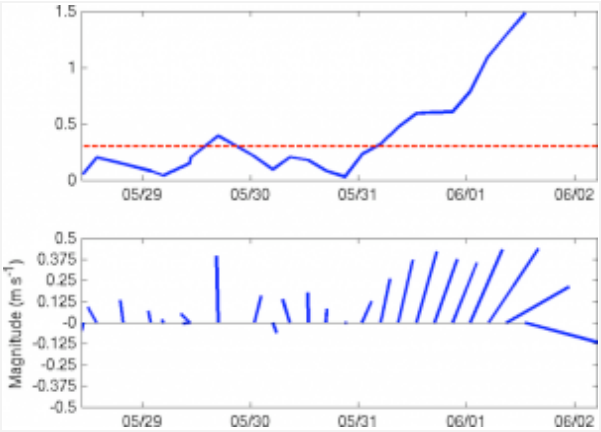
01 jun Rounding the Meander Crest

Edit Posted by: Scott in: Across the Pond Edit

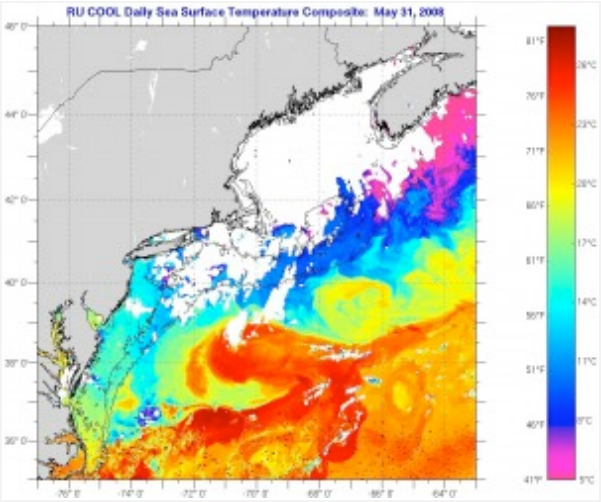
RU17 rounded the top of the meander crest near 70W, and is heading down into the trough near 67.



Currents have increased to 148 cm/sec, or 1.48 m/sec on the speed plot below. The vector current plot shows the direction has turned to the southeast. We'll be heading in this direction down into the trough.



Next environmental condition to deal with is the cold core eddy seen below to be between 37-38N, 65-66 W. Partial imagery from today looks like it is starting to interact with the Gulf Stream to the north. If the interaction strengthens, it could pull us out of the Stream to the south. We want to be in the high speed core to maximize distance over the ground, but we'll need to hug the northern side to get by this cold core ring if it gets too close. We'll keep an eye on this one.

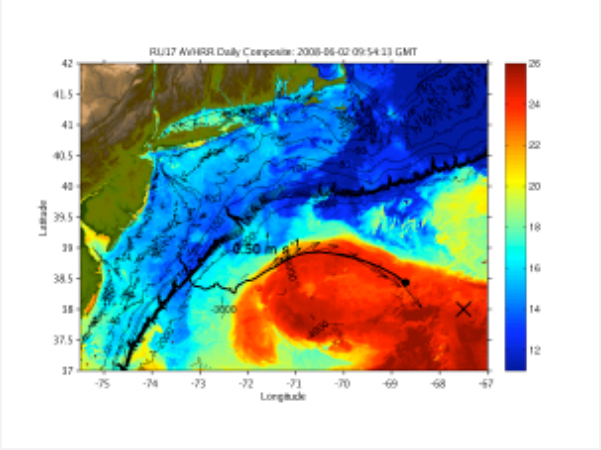


0 Comments

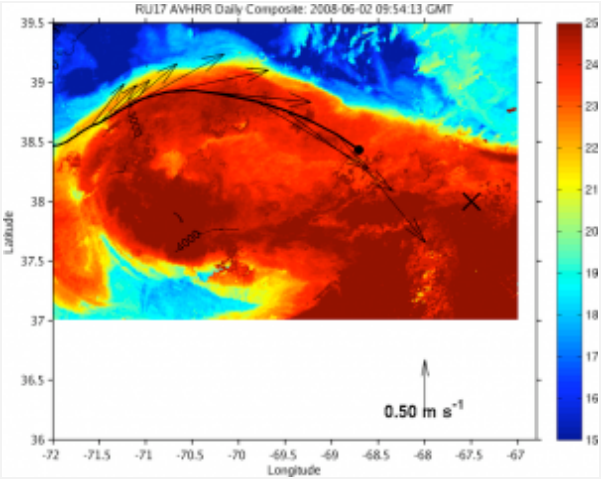
02 jun Finding the Core of the Gulf Stream

Edit Posted by: Scott in: Across the Pond Edit

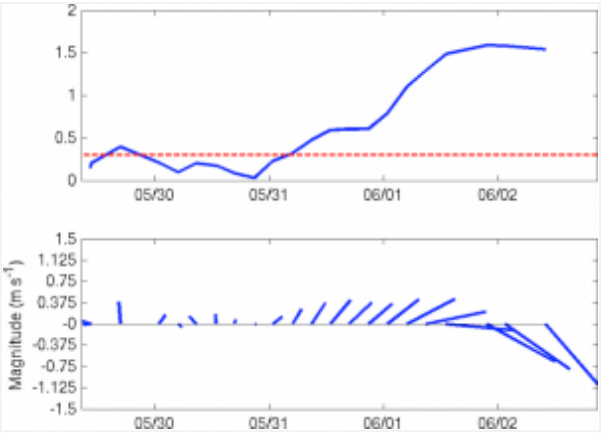
The Scarlet Knight did another fine job, letting us all sleep through the night. It continues to fly down the meander creast and towards the trough. The concern today will be to ensure that we make it by the region where the warm ring formation will take place.



The zoomed image below shows the situation. Our objective was to find and explore the maximum velocity core of the Gulf Stream. During our first trip into the Gulf Stream with RU15 on the way to Halifax, we were more concerned with getting in and getting out again. We did not purposefully venture all the way into the core. In this case, with RU17, when we were still outside the Stream, we made the Glider velocity perpendicular to the flow, using the glider to get us closer to the core as fast as possible. As we approached the core, we slowly turned RU17 into the flow, using less and less of the glider speed to move towards the middle. This allowed us to more finely sample the increasing velocities, find the core, and define its structure. The clear SST imagary from May will enable us to relate that structure to the north wll of the Gulf Stream. The north wall is the sharp temperature gradient between the warm (red) and cold (blue) waters. We'll use that structure to help us better navigate the maximum velocity region as we head downstream.



Currents below show we are starting to see a decrease in speed, indicating that we may be close to the maximum velocity core of the Gulf Stream. We'll see what the currents are at the 9 am surfacing, and for the first time in about a week, give RU17 a bit of northward velocity to try to pull it back into the highest velocities we have found.



0 Comments

02 jun Looking back

Edit Posted by: Oscar in: Across the Pond Edit

Many peers have provided inspiration, friendly competition, and joint support in developing the capacity to conducting similar long journies in the ocean. Like we acknowledge Joshua Slocum, we also acknowledge our peers in the modern era of oceanography. For tonight, I highlight a prior "AWESOME" journey of the Spray, which crossed from the East coast to Bermuda. Breck Owens (WHOI) and Russ Davis (SCRIPPS) get the credit for this mission which was a great journey showing

the potential to maintain active control of robots throughout a sustained mission. The Spray is another glider system similar in concept as the Sloccum Webb glider. Much like us at Rutgers and Webb Research, Breck Owen aptly captures our views where "We envision having fleets of gliders in operation in a few years," "It could change the very nature of the kinds of questions we can ask about how the ocean works." On this night as RU17 navigates the Gulf Stream, we raise a toast to Breck and Russ.

For a nice description of that Spray mission, go to the link:

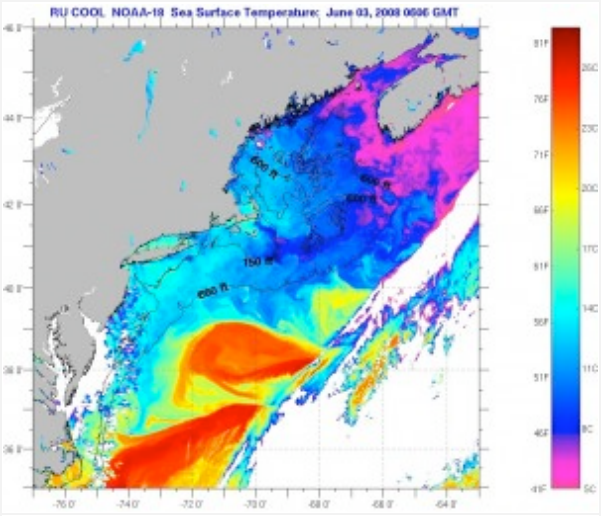
http://www.sciencedaily.com/releases/2004/11/041108012708.htm

0 Comments

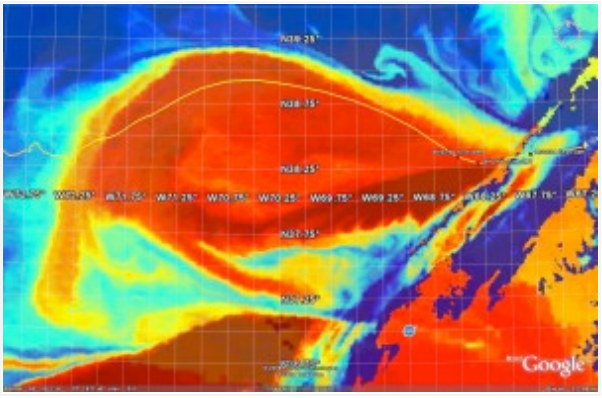
03 jun Squeezing By the Warm Core Ring Formation

Edit Posted by: Scott in: Across the Pond Edit

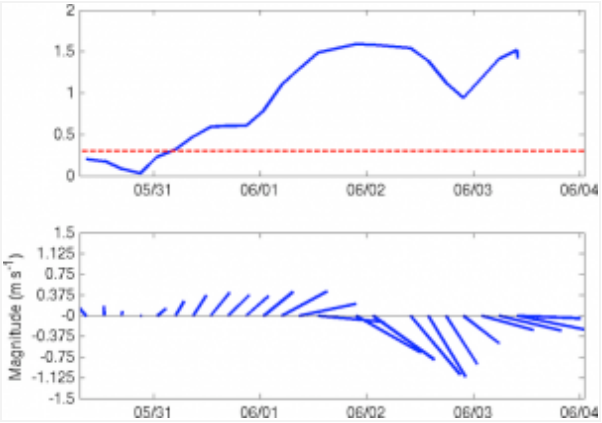
The bank of clouds (white) that was over the Gulf Stream the last couple of days is moving rapidly westward. The clearing skies over the S-shaped meander revealed that we are very close to the warm ring formation event. It is hard to separate the partial cloud cover at the edge of the cloud front from the cold water from the cold water that now extends eastward along 37 N to almost 69 W. But the warm water of the Stream that is now moving westward along 38 N is clear.



Below is the track of RU17 across the top of this feature. Our most southerly point yesterday stopped about 2 km north of where the westward moving warm water is today. Our switch to a course more to the northeast to get back in the maximum velocity core of the Gulf Stream appears to have been a good move. Looks like we managed to pull away from the advancing warm ring formation event by a matter of hours.



Below is the current time series measured by RU17. On June 1 we crossed approached the maximum velocity core of the Stream from the north, and slowly made our way across, sampling the velocity field along the way until we crossed out on the southern side late in the day on June 2. With concern for the unknown status of the warm ring formation and the known location cold core ring just downstream, we crossed back into the maximum velocity core early on June 3 to get as far north as possible to avoid the cold ring, and to get back into the highest velocities of the Stream to get as far away from the warm ring formation as possible.

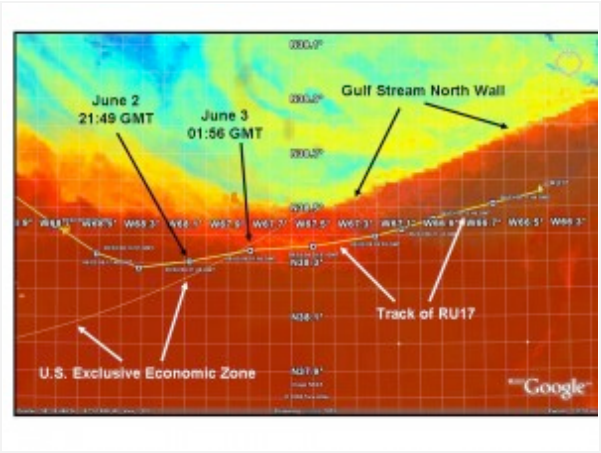


0 Comments

03 jun Leaving the U.S. EEZ

Edit Posted by: Scott in: Across the Pond Edit

The Scarlet Knight left the U.S. Exclusive Economic Zone today, June 3, sufacing at 01:56 GMT on the western side of the line.



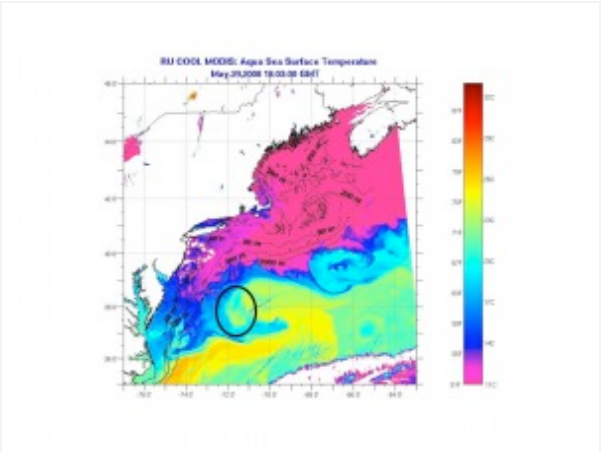
The above Google Earth display is a Sea Surface Temperature image of the Gulf Stream zoomed into the track of RU17 (thick yellow line). Each surfacing is marked with a day and time. The north wall of the Gulf Stream is the sharp temperature change between the warm (red) Gulf Stream waters and the cooler (yellow, green) Slope Sea. RU17 is riding the maximum velocity core of the Stream located about 15-30 km to the south of this sharp temperature gradient. As we know from both Hank Stommel and Mike Crowley, the Stream curvature modulates the distance between the north wall and the maximum velocity axis. The changing centrifugal force squeezes the north wall closer to the maximum velocity axis in the meander troughs, and seperates the two in the meander crests. The thin yellow line is the U.S. Exclusive Economic Zone. When RU17 crossed out earlier today, we were exactly 200 nautical miles southeast of the Rutgers CODAR site on Nantucket.

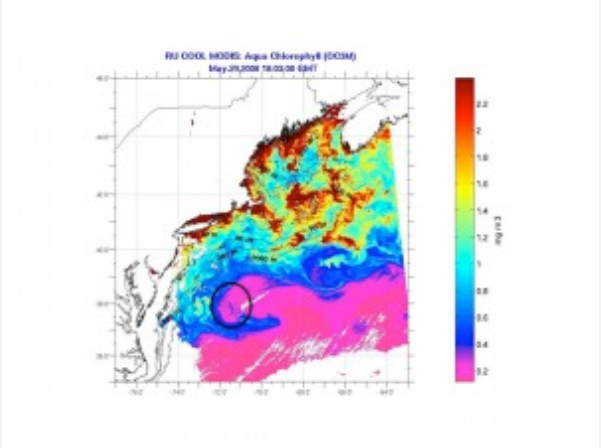
0 Comments

03 jun Ocean Optics Explains the Mystery of the Filament

Edit Posted by: Scott in: Across the Pond Edit

Steve will be happy with this one.





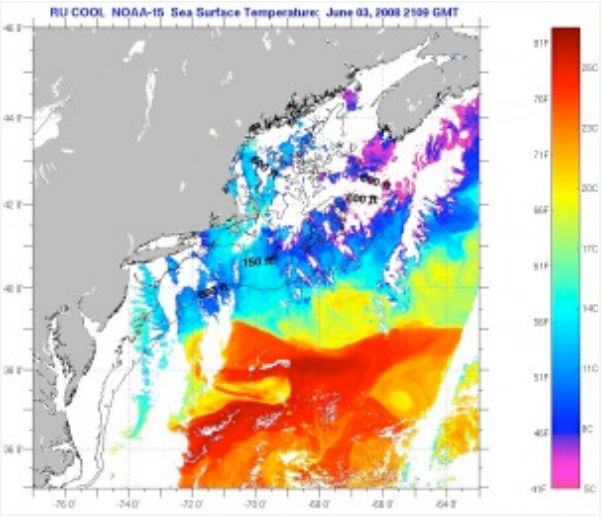
Remember that big warm filament that suddenly appeared between RU17 and the Gulf Stream on Thursday afternoon while we were still in Estonia? The filament is circled in the Sea Surface Temperature (SST) image on the left (or top, depending on viewer). We were left wondering which way the circulation was going in that filament. But from the SST, its really hard to tell. Thats when you turn to ocean optics. The image on the right (or bottom) is the ocean color converted to Chlorophyll. The structure is now clearly visible inside the circle in the ocean color. A thin line of Slope water (blue) is seen running west to east just below 38 N and ending in a classic hammerhead shape at 71 30' W. The optics indicates the filament has separate northern and southern sections. RU17 was heading into the northern section that was eventually absorbed into the Stream. The southern half just sat there for days. Now we know why.

0 Comments

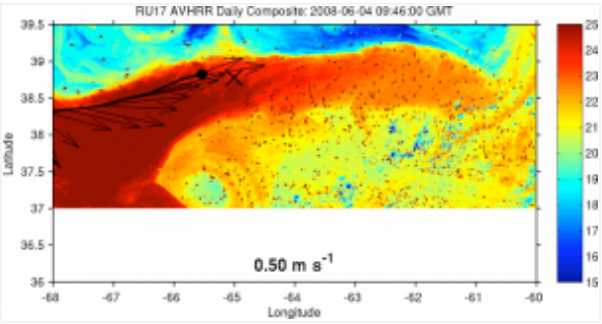
04 jun Into UTM S20 (What does that mean?)

Edit Posted by: Scott in: Across the Pond Edit

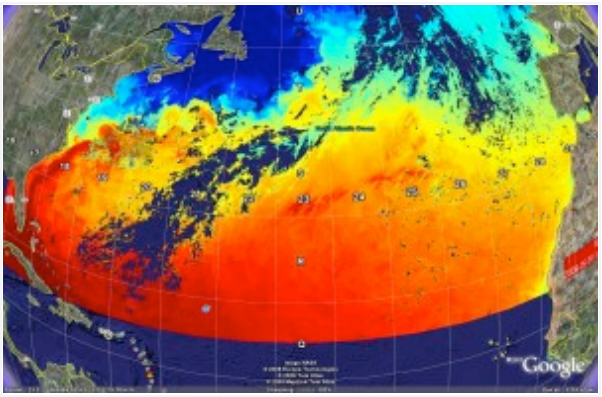
The image below shows the favorable situtation for RU17. As the warm (red) Gulf Stream waters leave Cape Hatteras, emerge from under the clouds, and head east between 36 N and 37 N, they hit 69W and turn 180 degrees back to the west. At the top of that turn you can see the very warm water (dark red) splitting into two pieces along 38 N. One piece heads west along 38 N and around the developing warm core ring. The other piece is pulled to the east along 38 N and downstream with the same section of the Gulf Stream carrying RU17.



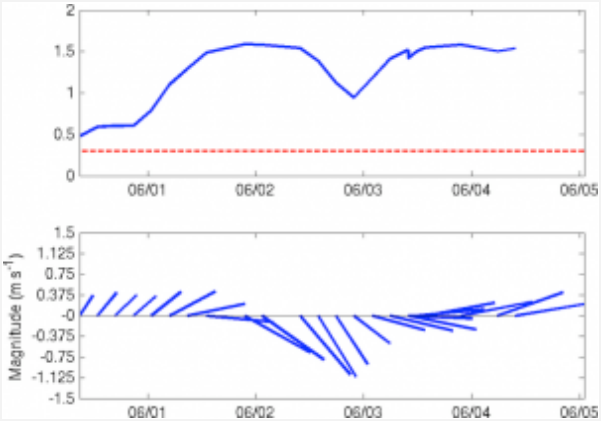
RU17 hugged the northern side of the Gulf Stream to get past the interaction with the Cold Core Ring seen at 37 N between 65-66W. It has now past 66 W and has a straight shot out to about 62 W. Crossing 66W is significant because it is the border of another UTM zone. UTM stands for Universal Transverse Mercator. The UTM zones are important because the gliders navigate using local X-Y coordinates within each zone. Each time you cross into a new zone, you restart your navigation grid.



The UTM zones can be displayed on Google Earth by going under the Tools section, clicking on options and playing with the Show Lat/Long settings. The zones are shown below, labeled by number (east-west) and letter (north-south). We just crossed from zone S19 to S20. The numbers change every 6 degrees of Longitude. T29 is still a long ways away.



RU17 is doing a fine job of staying in the maximum velocity core of the Gulf Stream. Speed is up around 153 cm/sec, almost due east. Its almost a straight shot across this UTM which ends at 60 W.

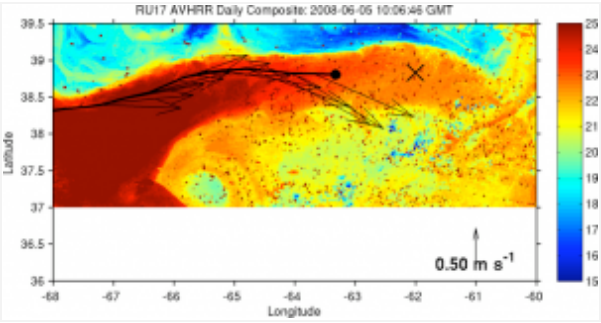


0 Comments

05 jun Fastest Glider on Earth

Edit Posted by: Scott in: Across the Pond Edit

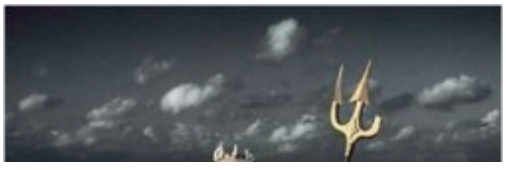
RU17 is in the maximum velocity core of the Gulf Stream. Gulf Stream velocities are up to 185 cm/sec. Add to that the glider velocity, and we are screaming along at 222 cm/sec over the ground on the straight away. Cisco emailed in and said the speed is probably peeling off the paint.



0 Comments

05 jun Listening to Joshua Slocum

Edit Posted by: Oscar in: Across the Pond Edit



As Captain Slocum sailed his journey, he captured many of the feelings encountered during extended times at sea. Here he describes his journey in a

location close to where RU17 is tonight.

"The fog lifting before night, I was afforded a look at the sun just as it was touching the sea. I watched it go down and out of sight. Then i turned my face eastward, and there, apparently at the very end of the bowspirit, was the smiling full moon rising out of the sea. Neptune himself coming over the bows could not have startled me more. "Good evening, sir," I cried: "I'm glad to see you." Many a long talk since then I have had with the man in the moon; he had my confidence on the voyage." *from Sailing Alone Around the World by Capt. Joshua Slocum*

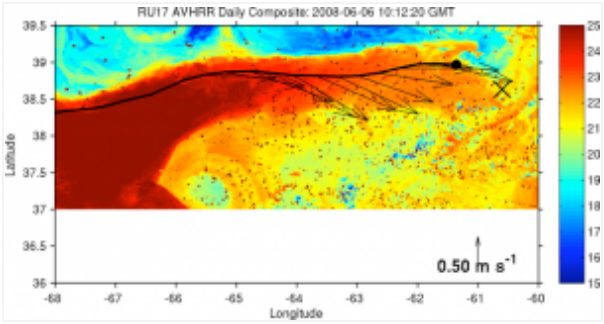
Artwork from: http://www.ba-reps.com/artist/olaf/portfolio/2030/image/87343?c

0 Comments

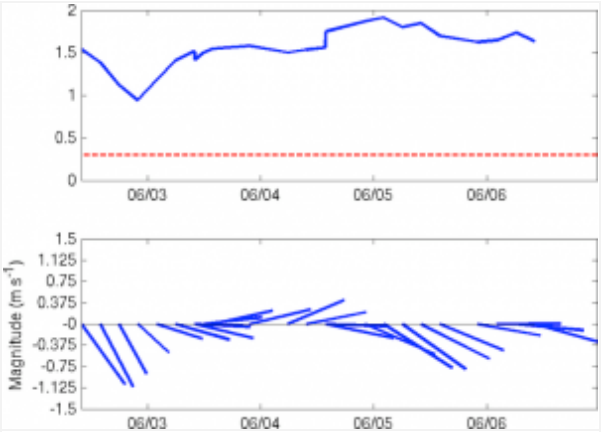
06 jun Straight Shot across the UTM zone

Edit Posted by: Scott in: Across the Pond Edit

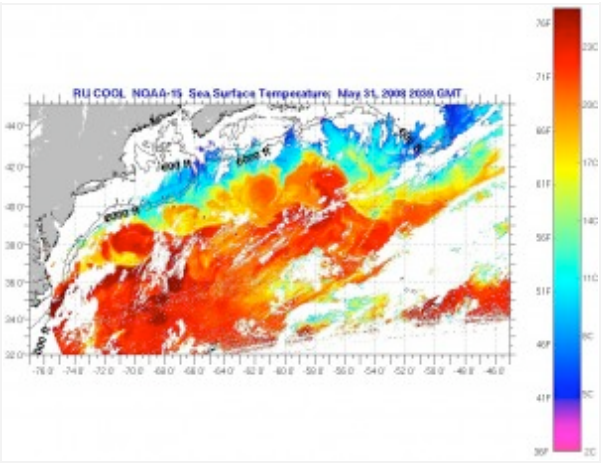
RU17 has completed the straight east run and is turning down into the rapidly propagating meander trough. We'll hug the northern side of the trough, then head into the southern side of the crest that is further downstream.



Gulf Stream velocities are down a bit from the peak. We are currently finding 164 cm/sec. Still higher than our crossing back on June 2.



Sometime tomorrow we should be finished crossing this UTM zone. The border is at 60 W. It was a relatively easy straight shot. We'll cross 60 W and set up for the next one, a much more difficult navigation along a meander crest that is interacting with a Warm ring to the north (see below between 56-58W), and a cold ring to the south observed in the satellite altimetry but not in the Sea Surface temperature. We'll be setting up for that over the next few days.



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07 jun

Transitions

Edit Posted by: Scott in: Across the Pond Edit

RU17 just passed 60 W and into the next UTM zone, S21. It is now east of Nova Scotia, our first safety port on this trip. (Thanks Marlon and Scott!) Maps were reset this morning for the new UTM region. We'll be in this one from 60 W to 54 W. Two satellite Sea Surface Temperature (SST) images are displayed in the Google Earth interface. The large scale north Atlantic image is acquired from NASA. In the northwest Atlantic, we have layered over a locally acquired SST image of the Gulf Stream. People following along will note that we have now switched from the Northeast image on the Rutgers page, the one we used to get to Halifax, and the full Gulf Stream image used here.

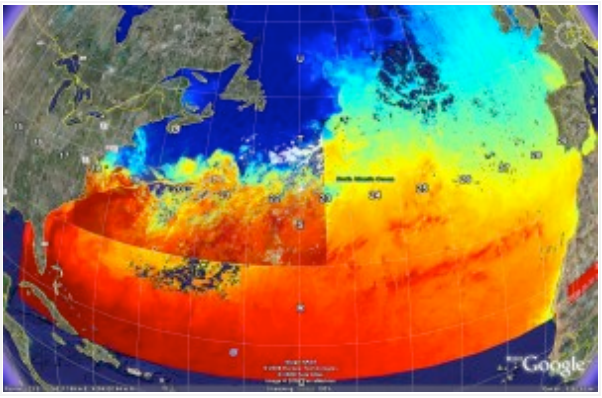
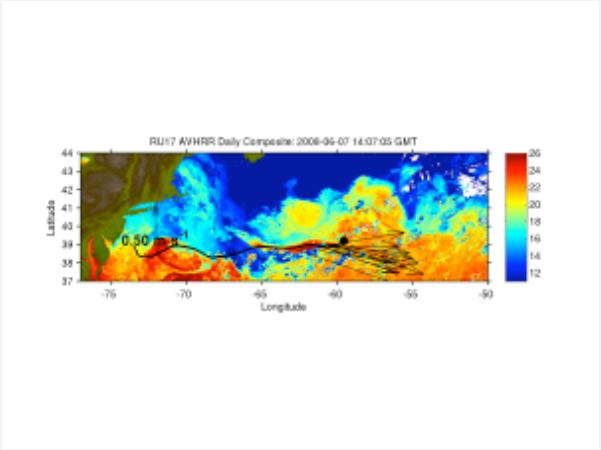
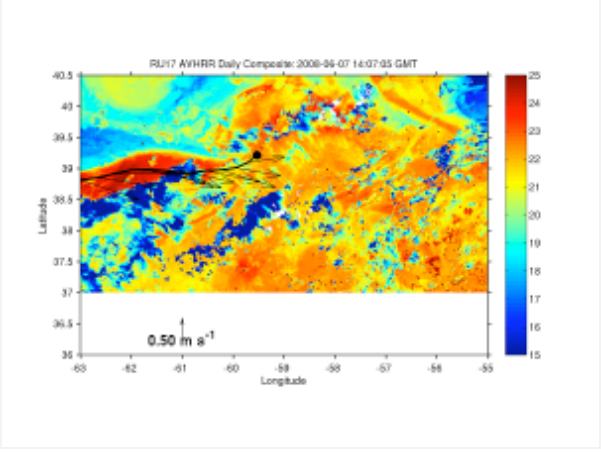


Image below shows the full track of RU17 from the NJ shelf to its present location in International waters. That large meander system back at 70W is starting to look like a Warm Core Ring. Everybody is waiting for a cloud-free image.



Zooming in on RU17, we are heading up into the small meander crest. A bit downstream, we see the southern edge of a Warm Core Ring between 55 and 57 W. But there are persistant scattered clouds over the region, causing all those blue spots in the region and masking the actual location of the Gulf Stream.

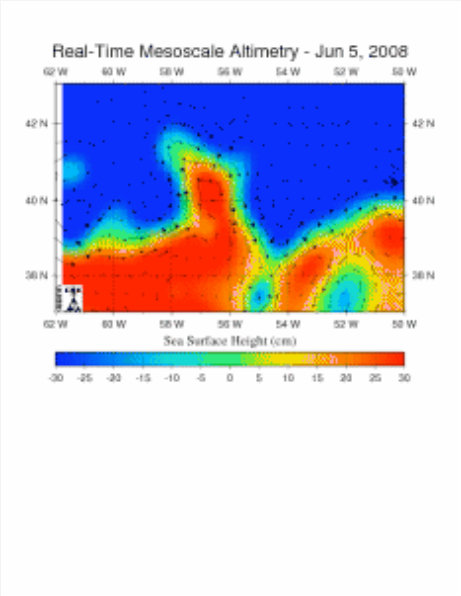


So that means we turn to satellite altimetry that we download from the University

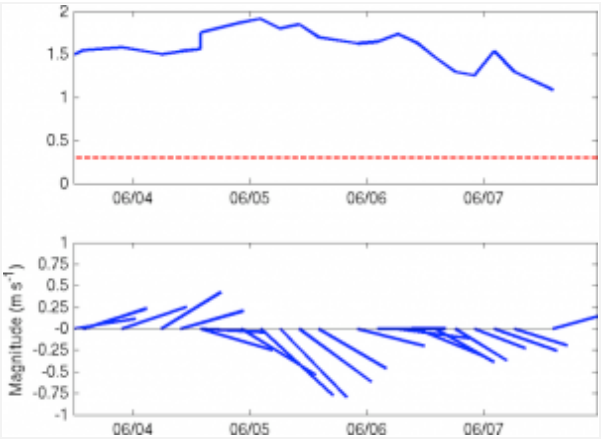
of Colorado.

http://argo.colorado.edu/~realtime/global_realtime/geovel.html

They merge the satellite altimetry into a gridded product and calculate the geostrophic velocities. In the plot below, the colors now represent Sea Surface Height (SSH), not temperature (SST). Some interesting points are that the altimetry indicates a broadening of the Gulf Stream near 60 W, and a subsequent reduction in currents. It also indicates there is a strong interaction with the Warm Core Ring between 56 W and 57 W. We want to try to find a way across the southern side of this interaction rather than all the way around.



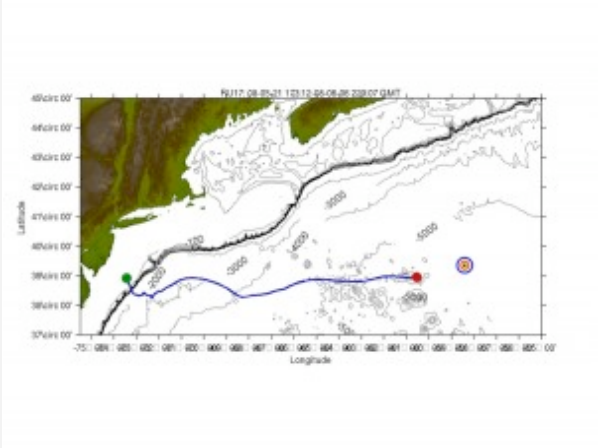
The current speed time series also indicates the velocity is dropping. Is this because we moved out of the maximum velocity core or because the core has slowed down? We can't be sure at this point with the existing partly cloudy SST imagery. So we'll have to start moving RU17 back and forth across the region we think has the maximum velocity to answer this question. The other options is to hope for clear weather. The vectors in the stick plot below show the Gulf Stream velocity now has a northerly component to it. We are heading up into the meander crest.



The last image below shows the track of RU17 relative to the bottom topography.

We are now crossing the New England Seamounts, a chain of extinct volcanoes.

http://en.wikipedia.org/wiki/New_England_Seamount_chain



0 Comments

07 jun Transition Photos

Edit Posted by: Scott in: Across the Pond Edit

Several Rutgers Undergraduates from Josh's (standing on right) Atlantic Crossing class are spending the summer working on the transatlantic crossing. Here Justin (the Pathfinder, seated) and Anthony (the Pilot, standing), take control of RU17 for the first time through the new interactive Google Earth interface. Previous blog entries show how we have been using Google Earth for some time now for the display of the datasets and the glider tracks. John has now added a feature where you can click on new waypoints in Google Earth, automatically translate the positions into glider-speak, and send the message to glider's email inbox where RU17 checks for new instructions each time it surfaces. In the backgroud is the first NOAA IOOS glider, RU21, fresh out of the shipping box from Webb Research. Also in the background hanging on the wall on the right above the chart table is the brown map of Ben Franklin's Gulf Stream. The map was discovered by Phil Richardson in France back when I was a student at WHOI. I managed to snag one of the copies they made for the celebration.

Tomorrow we head to Spain with Evan (image below, back row, red Rutgers Oceanography t-shirt), another undergradaute from the Atlantic Crossing class. Evan is a double major in Marine Science and Spanish. He'll be spending the

summer in Spain helping prepare the potential landing zone for RU17. On his last day in the office before leaving for Spain, Evan brought his Grandfather's Astronomy Club through the lab for a tour. Just the day before at our first Center for Ocean Science Education Excellence (COSEE) advisory board meeting, it was suggested that we develop opportunities for more retired people to be involved in the education activities of the Coastal Ocean Observation Lab. But who is that guy on the far right?

John Delaney (standing in front of the glider Dockserver computer) stopped by the COOLroom on his way back to the University of Washington from a conference in Europe. In the COOLroom, John took manual control of RU17, foregoing the Google Earth interface shown on the bottom left. Chip (center), a seasoned world traveler for glider deployments, copilots as John downloaded some datafiles, turned off the CTD for the night, and sent RU17 back on its way into the meander crest. The new IOOS glider is in the foreground.

Below John is typing glider-speak on the Dockserver computer directly to RU17 while it is at the surface east of the New England Seamounts. RU17's words are in the large window in the middle of the screen, John's replies in the the small window along the bottom. It looks like RU17 is winning this discussion.

John stopped by Rutgers for much more than an evening of guest glider piloting. Janice has a weekend workshop with K-12 teachers from around the country. The teachers are providing feedback on their in-class pilot studies with the new COOLclassroom webpages. John has long been a strong supporter of scientist-educator partnerships, and felt Janice's workshop was important enough for him to stop in New Jersey for a weekend on his way home. After dinner on Friday night, John gave the short version of one of the talks he just presented in Europe. It is a truly inspirational tour of history, art and science. He shows us the link between the oceans and life on earth, the need to better understand the ocean as the flywheel of our planet's climate, and provides his vision for the future of ocean observing so we can develop that understanding. About 2 jaw dropping hours later, everyone rushed the stage to get a closer look at John's HDTV images from his latest trip to the underwater hydrothermal vent communities.

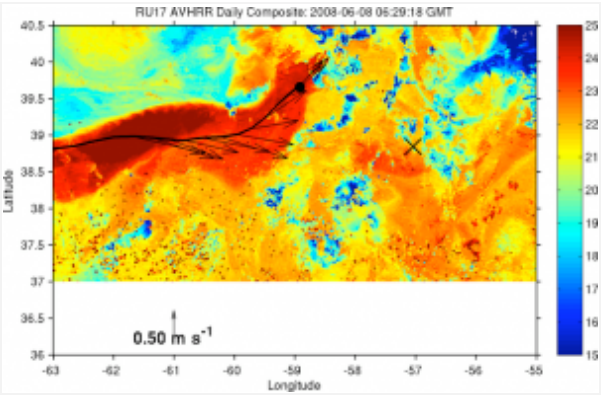
Shown below on the left, Ravit, one of the primary Rutgers professors working on the COOLclassroom, is talking to John (white shirt) about his presentation. On the right you'll see Laura and Steve. Laura is my teacher buddy, as they are called in the COOLclassroom world. Laura used to be in the Navy. Back when I was at Harvard forecasting the Gulf Stream for the Navy, I would send the forecasts to Laura, and Laura would send them out to the U.S. subs at sea. Now Laura is a teacher in New Jersey. Next to Laura on the far right is Steve, a teacher from Washington state. Steve was at Rutgers a couple summers ago for an Earth teachers workshop conducted by Monterey Bay Aquarium Research Institute. While George from MBARI was at Rutgers with the teachers, we took them all out to sea to deploy a few gliders. One of the gliders we brought along was the initial version of RU17. It was still stock - not even a stretch payload bay. It was the first time RU17 was in the ocean, so we tied a rope to its tail to make sure it came back. We had plans for that robot, and we didn't want to take a chance. And as usual, we always try to involve the teachers. Steve volunteered to put the wings on. Steve has a picture of himself attaching the wings to RU17 hanging in his classroom. That same glider, with a few modifications, is now flying east of the Seamounts in international waters. The community grows.

0 Comments

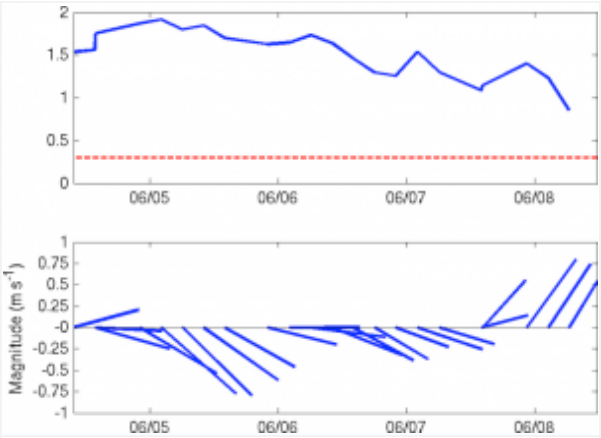
08 jun Navigating the patchy satellite data

Edit Posted by: Scott in: Across the Pond Edit

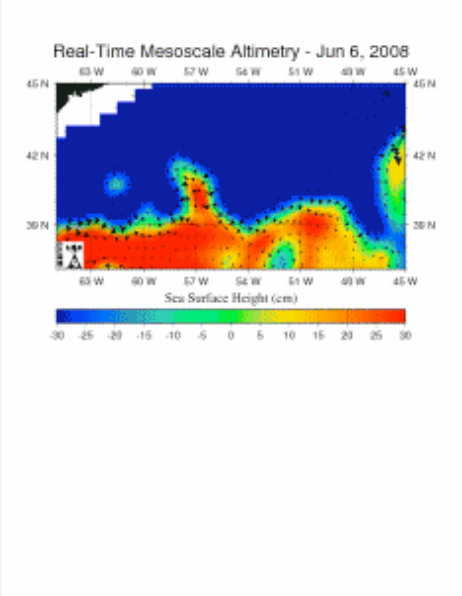
RU17 is moving up into the small meander crest and will be spending much of the next 24 hours flying perpedicular to the current to pull it south of the interaction with the warm eddy near 57 W. Much of this region is still obscured by clouds, so we are working off of composites assembled from the satellite Sea Surface Temperature data we do see in the small breaks in the clouds.



RU17 is seeing a reduced current speed as we pull it to the southern side of the Stream. Faster downstream currents appear to be to the north, but so is a warm eddy we don't want to get caught in.



The satellite altimetry from last night indciates the Cold rings to the south are moving away from the Stream, but the warm ring to the north is closer. So RU17 is moving to the southern side of the Stream for a few days.



0 Comments

08 jun Phewww!

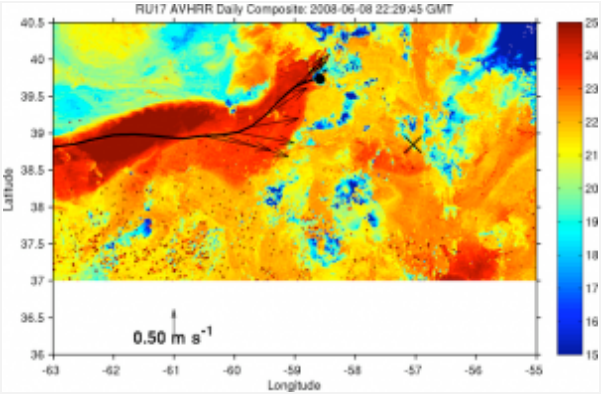
Edit Posted by: Scott in: Across the Pond Edit

My 17 year old daughter is out with the car, and she doesn't call in at a prearranged time. I know she is fine, but still I worry.

RU17 called in fine at 2 am today, but skipped the 6 am call. No big deal. The Iridium system is not perfect. It may be close to 100%, but its not unusual to occassionally miss a call. The first thing you do is check on the receiving side. A power surge from a lightning storm could have taken out the modem in the lab. The Dockserver computer could have locked up and needs to be reset. But Hugh and Chip both logged in and found everything on our side was good. So maybe its bad weather at the glider site. Maybe RU17 is in a big storm. A quick check of the Oceanweather.com website indicates that there was a storm, but it was farther east around 40 N. Forecast waves in the vicinity of RU17 were only running 10

feet. Ship reports from the area where saying the winds were 10-15 knots. Certainly not a reason to expect a droppout in the Iridium. RU15 ran fine through a storm with 25 foot waves. So it must be just one of those glitches. It'll probably call in at 10 am. But it didn't. We now had 2 missed calls in a row and no contact for 8 hours. Thats when the worrying began. I had to physically drive (in a car) away from the computer. 4 hours later, Josh called me on my cell phone. RU17 called in at 2 pm. I drove back around the block and ran into the house, popping the image up on google earth. Josh downloaded the files, checked that everything was fine, and we set it back down. RU17 was still heading up into the meander crest, and the existing waypoint was fine. Josh sent it back down.

Josh, Evan and I then met at Rutgers for the trip to Spain. RU17 called in at 6 pm, right on schedule. It was making it to the top of the meander crest. I small break in the clouds confirmed this. We were on the southern side of the Gulf Stream. We would know have the full width of the Gulf Stream between us and the warm core ring to the north. We gave RU17 a new waypoint, and headed it downstream to the east. We hit the turnpike to the airport. Next stop Spain.



0 Comments

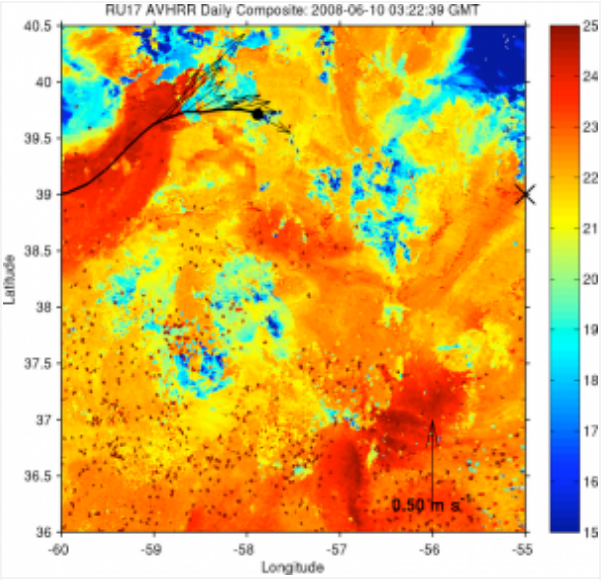
10 jun 1492 km - Good Morning from Spain

Edit Posted by: Scott in: Across the Pond Edit

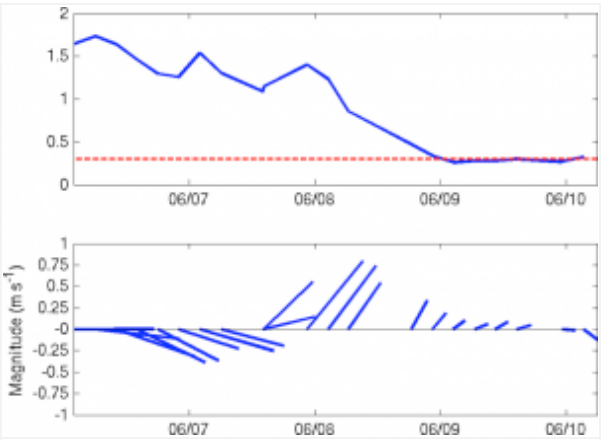
RU17 surfaced 45 minutes ago and clicked off kilometer 1492. We are in Madrid, visiting Puertos del Estado, the government agency that provides operational oceanographic and meterological data and forecasts. Our host is Qualitas Remos, an industry partner, that is developing and operating the High Frequency (HF) Radar networks in Spain and around Europe.
http://www.qualitasremos.com/index_en.html

Our undergraduate student, Evan, will be spending a 10 week summer internship at Qualitas Remos.

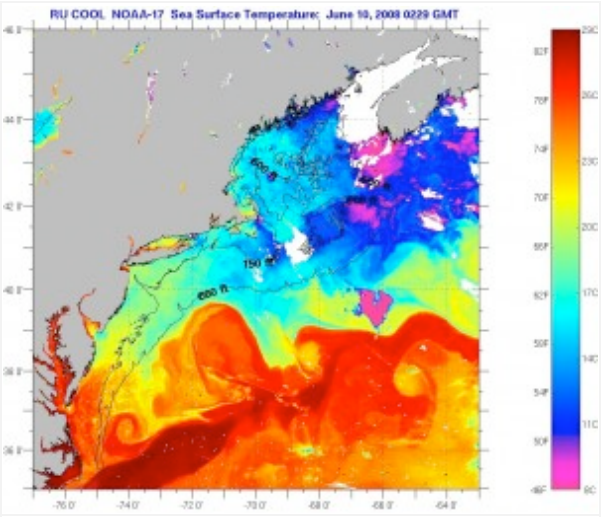
RU17 is now rounding the top of the meander crest, staying on the southern side, and turning to head southeast. We are staying on the southern side of the stream to avoid a warm core ring we occassionaly see pieces of in the satellite imagery, but is well defined in the satellite altimetry.



Currents remain low on the southern side of the Gulf Stream.



If we get a better satellite image of the warm ring, we would feel better about moving a bit more to the north and into the faster currents. Clear weather may be on the way. The entire Gulf Stream west of 62W just became visible this morning. That large meander system we used a couple weeks ago is now essentially a large warm core ring that extends from the 2000 m isobath near the shelf break to the Gulf Stream. Now would be a good time to launch from Wendell Brown's glider lab at UMass Dartmouth.



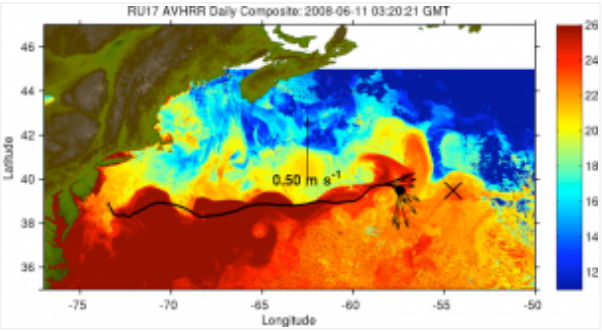
To finish up from yesterday, Hugh downloaded and checked the Mission Log files (the MLGs) from RU17 for the times surrounding the two missed Iridium calls. At the 2 am surfacing, RU17 took the usual 2 minutes of housekeeping and getting a GPS fix, and then phoned home, connecting to the Iridium system the first time. At 6 am, RU17 surfaced, and managed to get the GPS about 10 seconds faster, so it doesn't appear to be bad waves preventing the glider from seeing the satellites. RU17 then tried to call home, and could not get the Iridium carrier signal. Like any smart user of a modern electronic device that isn't doing what you want, RU17 turned the Iridium phone off, flipped it back on, and tried again. It tried cycling the power and recalling 5 times before finally giving up and heading back down to continue its mission. At the 10 am surfacing, the same thing happened. No problem getting the GPS, but 5 tries on the Iridium phone again produced no carrier. Finally at the 2 pm surfacing, the Iridium call went through on the first try. I guess I should also listen more to my daughters when they tell me that they are going to be fine.

1 Comment

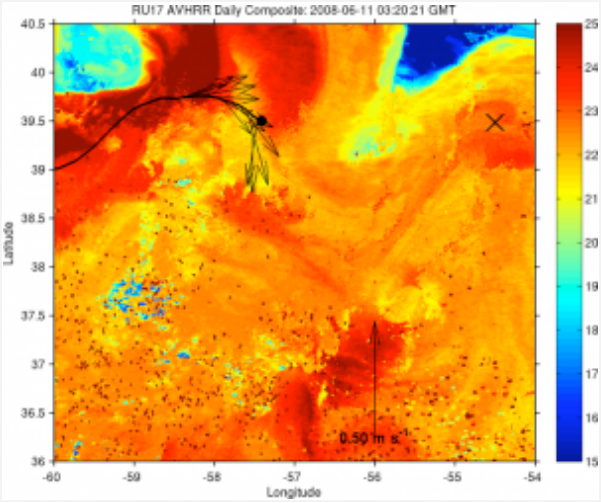
11 jun Cutting the Meander Crest.

Edit Posted by: Scott in: Across the Pond Edit

The wished for clear satellite imagery appeard today. RU17 cut across the bottom of the meander crest, avoiding the shingle formation on the western side and the warm core ring interaction on the western side.



With clear imagery, we can go back to some precision flying. We'll head the glider east, using the eastward velocity of the glider to get us back into the maximum velocity core of the Stream.

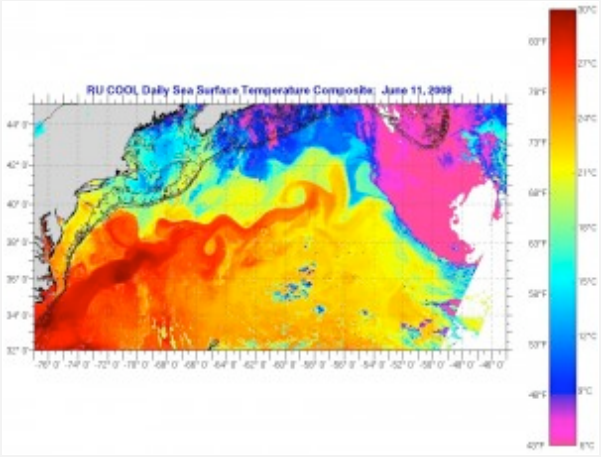


0 Comments

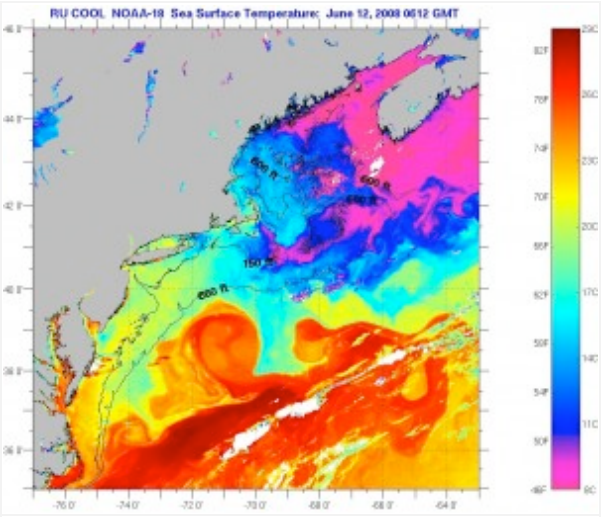
12 jun A Clear Skies Celebration

Edit Posted by: Scott in: Across the Pond Edit

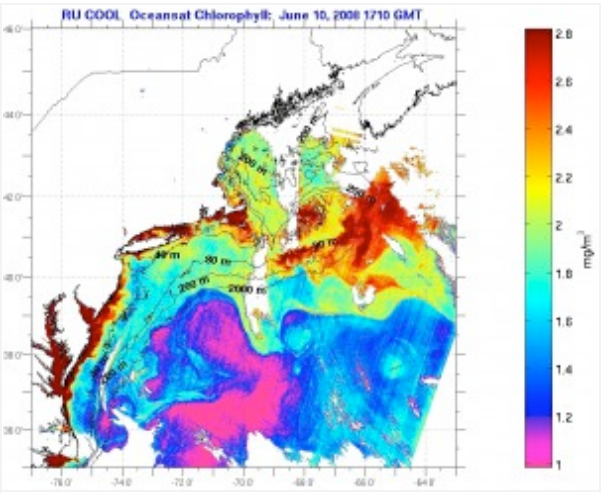
Lots of satellite imagery this morning. Nothing like clear skies to make your day. Below is a yesterday's SST composite of the Gulf Stream showing clear coverage of the full Stream out to 53W. First we'll zoom in on the western half.



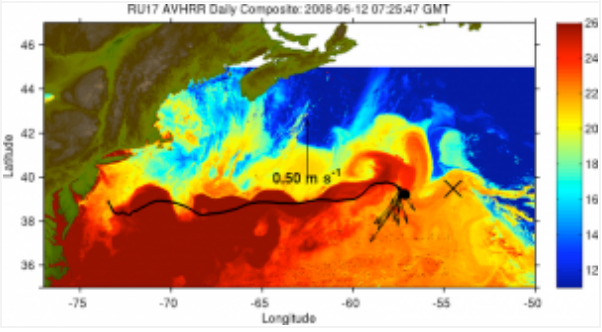
First we zoom in on the Sea Surface Temperature image from the NOAA satellites. The large (about 200 km across) warm core ring centered at 39 N, 73 W, nearly spans the Slope Sea between the shelf break and the Gulf Stream. Colder water from the shelf is being pulled offshore across the Slope Sea along the eastern side.



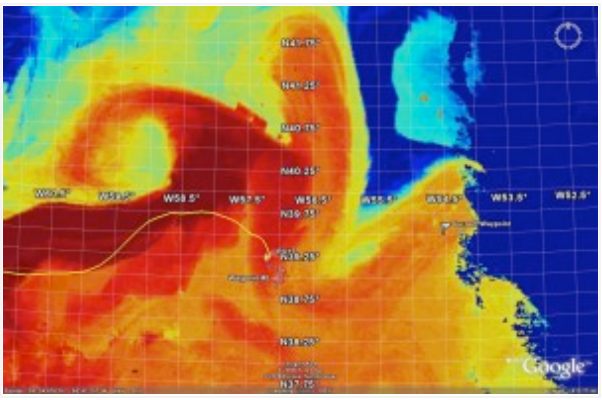
Below is the Chlorophyll image of the same location from India's Oceansat. The effect of the large warm core ring on the phytoplankton is significant. The large blooms we often see near Georges Bank often run in a continuous strip south along the shelf break along the shelf-slope frontal jet. Here the warm ring interupts that distribution, with about half of the Chlorphyll running along the shelf break, and half heading offshore.



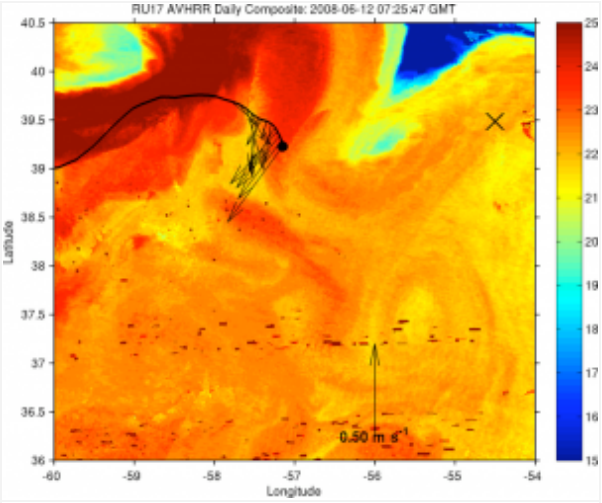
Moving over to the location of RU17, we see the complicated ring-stream interactions occuring between 50 W and 60 W.



Zooming in to the interaction zone, we now see what we avoided by cutting RU17 across the bottom of the meander crest. The meander crest is propagating in a typical warm core ring formation event. The forward face of the crest on the eastern side stalls. The rear face on the western side propagated rapidly to the east, closing the distance at the base and cutting of a ring. The ons is complicated by the large counterclockwise circulation on the western side of the crest, and the warm core ring absorption on the eastern side. Both of these events we wanted to avoid. Hitting either one would have caused several days of delay.



Zooming in further, we see that RU17 is making its way back into the strong currents of the Gulf Stream, and will soon be heading into the downstream meander trough. We'll move the waypoint to the bottom of the trough on the next surfacing to improve our efficiency.

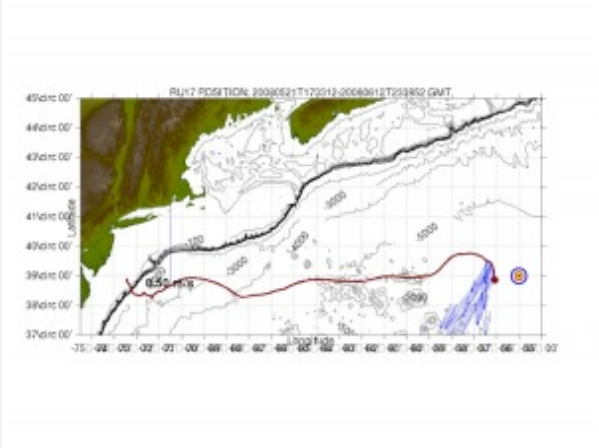


2 Comments

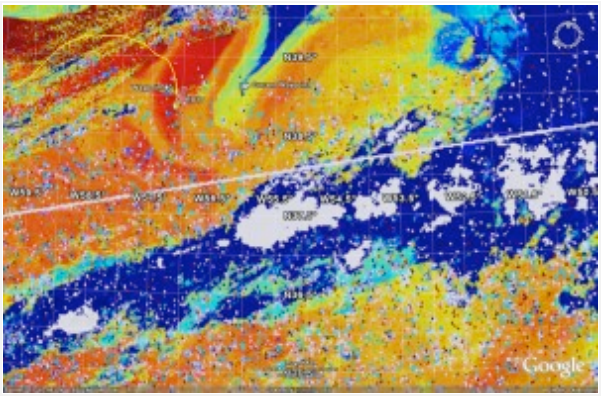
12 jun That Explains It - The Trough Deepens

Edit Posted by: Scott in: Across the Pond Edit

All the currents reported by RU17 today are towards the southwest. And we have been waiting for the currents to start turning, expecting it to occur each time it surfaces.



The image that just came in shows why. That meander trough near 56 W is rapidly deepening. We'll move the waypoint south at the next surfacing to help spin RU17 around the meander.



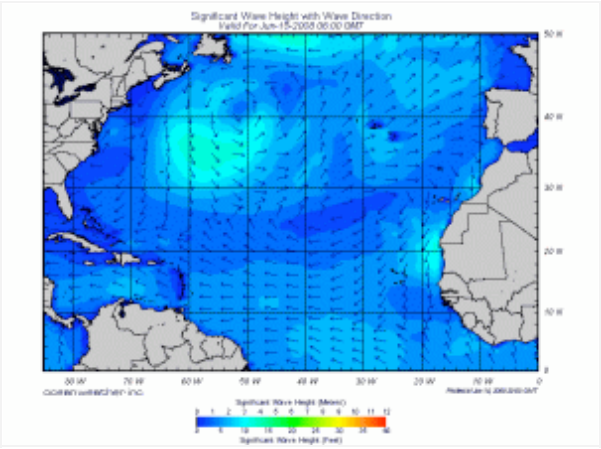
0 Comments

15 jun

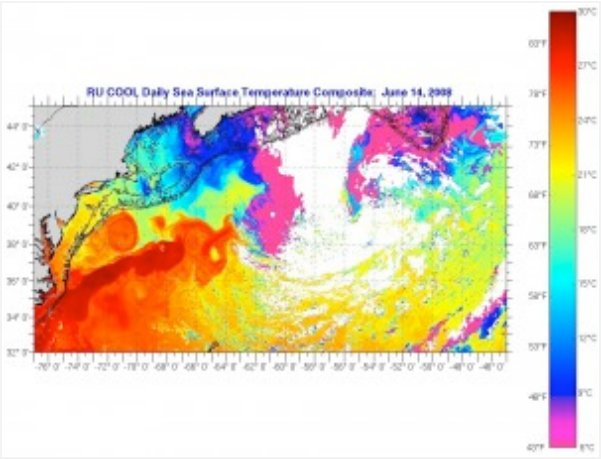
Searching for the path east.

Edit Posted by: Scott in: Across the Pond Edit

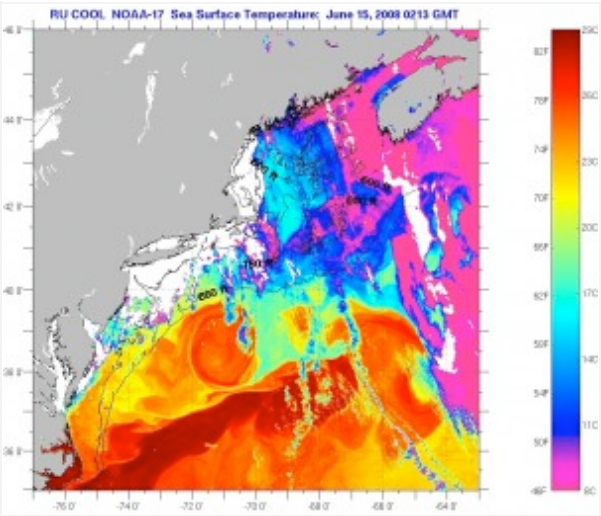
We have a nice storm in the Atlantic in the vicinity of RU17. Oceanweather's waves are up to about 20 ft significant just to our south. Winds are from the northeast.



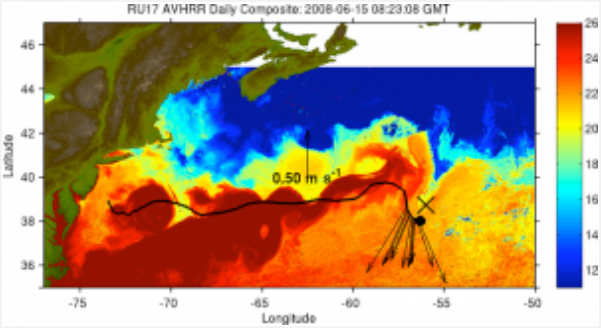
SST is very clear to the west of the storm, but RU17 is under the clouds. We can't see the Gulf Stream and eddies we are trying to steer around.



We can see that huge freshly formed Warm Core Ring centered near 71 W. This is the first SST image you can see the cold filament looping all the way around. This is a very large ring for this region, spanning the entire Slope Sea from the shelf break to the Gulf Stream.

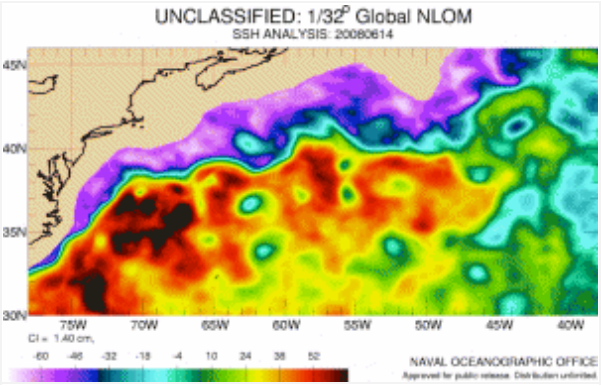


Back to the location of RU17, heres the situation with the present glider locations and the composite satellite image from before the storm. We left the meander crest, and its interactions with the two warm rings, behind us, and tried to shoot the gap between the Gulf Stream north wall and the Cold Core ring to the south. One problem is you can't see the cold core ring in the satellite imagery, even though we know it is there.

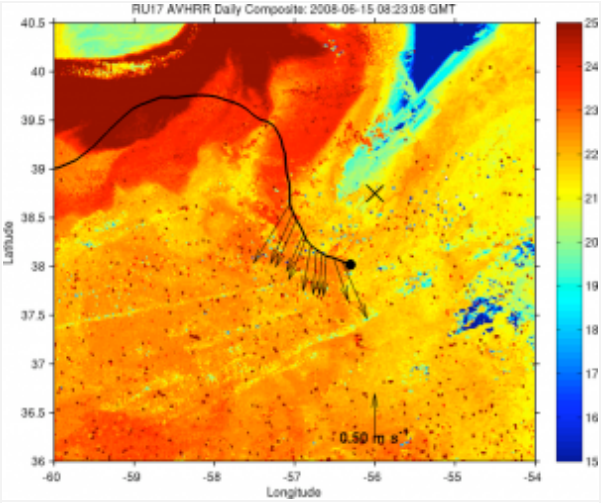


So we have been relying heavily on the NRL NLOM nowcasts and forecasts.
http://www7320.nrlssc.navy.mil/global_nlom32/gfs.html

The SSH analysis below indicates the Gulf Stream is definitely interacting with the cold core ring near 56W, as it has for the last several days in their nowcasts and forecasts. But the SSH analysis also reflects a lot of what is going on in the deep field.



The currents we had thursday and friday last week were all to they southwest, indicating the model was doing a very good job. We were very likely to have to take the longer route east that travels all the way around the cold eddy. But the SST is the very upper-most layer of the ocean,and it indicates there may still be a way through the gap up by the surface. So we reduced the depth of RU17's dives. Instead of diving between 5 m and 100 m, late friday night we switched to dives from 5 m to 50 m, keeping us even higher in the water column. The winds from the storm are also from the west or northwest, so they will help drive us in the easterly direction we want if we stay up closer to the surface. With this strategy we managed last night to find some currents that have now turned to the southeast.



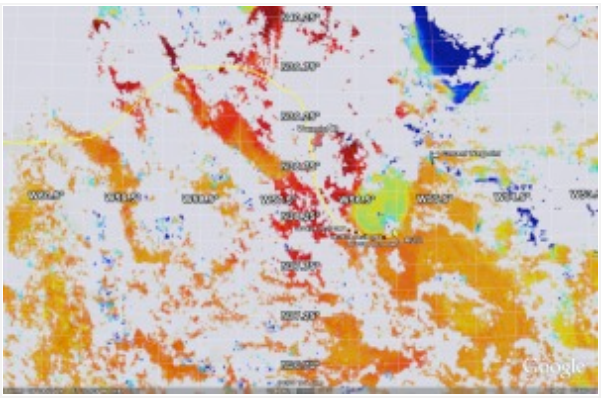
With this sign that there may still be a way through the gap in the upper water column, we'll keep RU17 in the top 50 m for at least another day. We'll move the waypoint a bit to the east so we keep drawing RU17 as best we can away from the Cold RIng. And as the storm heads east, it should leave a clear SST image behind it so we can figure out how we did while the lights were out.

0 Comments

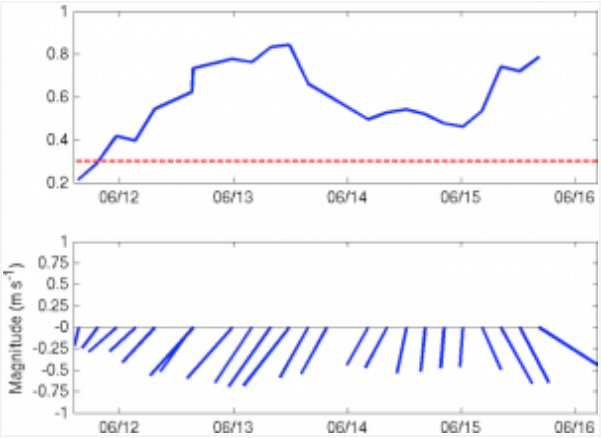
15 jun An SST image only a parent could love

Edit Posted by: Scott in: Across the Pond Edit

There it is - a small break in the clouds and RU17's bright yellow face. We are in the Gulf Stream, just south of the north wall, and well to the northwest of the troublesome cold core ring. The current waypoint is nicely placed downstream.



The currents are rotating counterclockwise to the east. RU17 is finally rounding the bottom of this meander trough.



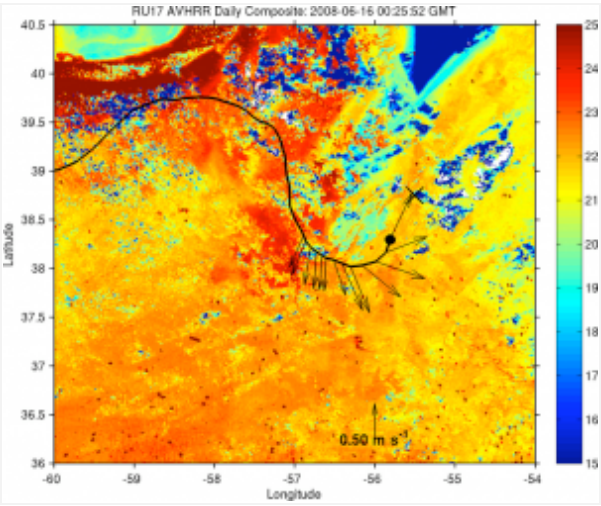
At 3 days of flying blind through a meander-ring interaction zone guided only by old satellite imagery and our own currents, this is a great treat. Happy fathers day!

0 Comments

15 jun Back in the Stream

Edit Posted by: Scott in: Across the Pond Edit

RU17 has spun around the trough of the meander, and is heading up the eastern side into the next meander crest. The currents have spun around, and we are finally heading downstream with the wind at our backs. The long straight Gulf Stream in the previous UTM zome was so much easier than these large scale meanders.



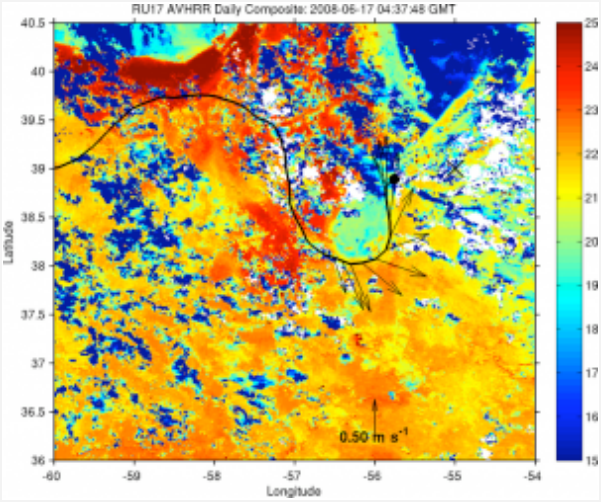
So what happened during the storm when the clouds covered the Stream? How did the meander trough deepen so quickly, and why after 3 days of trying, we were suddenly able to shoot east? The answer tomorrow. Check in with your favorite Navy modeler for a clue - Thats how we'll unravel the mystery.

1 Comment

17 jun Spun Into the Center & Flying Out

Edit Posted by: Scott in: Across the Pond Edit

Growing consensus is RU17 sat on the western side of the interaction of the meander trough and the cold core ring until the interaction was complete with a rapidly deepening trough, then spun around the bottom. Wizard score for the Navy model goes up. RU17 then kept spinning around the eastern side till it was spit out into the cold still water in the center of the trough. So Justin and Anthony, while working up their plan for the next UTM zone, turned it back east and are heading straight back into it. Already the currents are picking up to the northeast, at least in the surface dialog RU17 sends back to my email box. We added a few new diagonostics over the weekend that haven't made it into the plotting code yet, so RU17 just emails them.



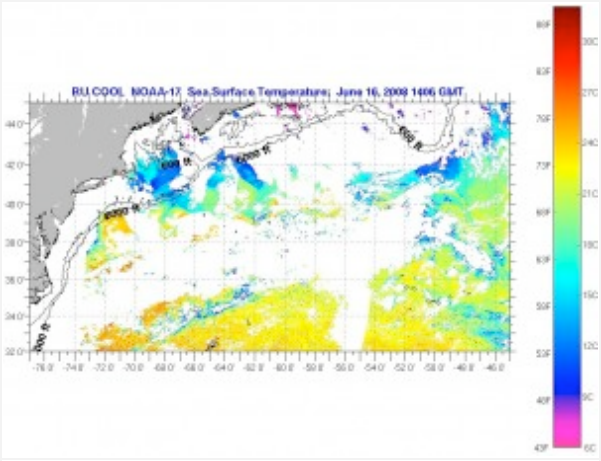
This has been a time consuming UTM, but our most educational. Looking forward to the next one. Fewer rings - at least the ones we know about.

0 Comments

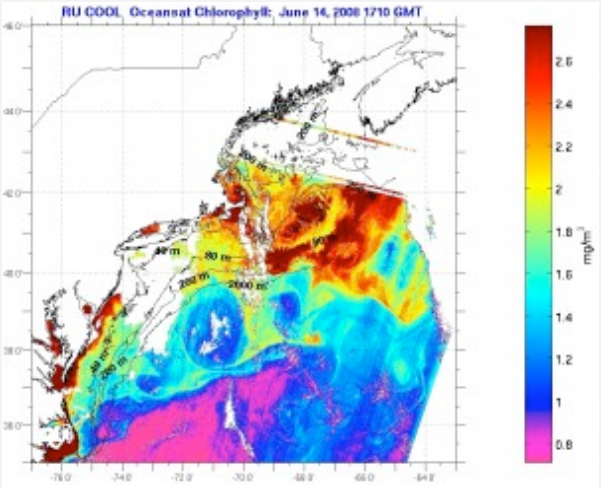
17 jun Clouds Everywhere

Edit Posted by: Scott in: Across the Pond Edit

A cloudy day on the Gulf Stream. Clouds (white) cover its entire length. A difficult day for Gulf Stream forecasters.



Looking back a couple days, India's Oceansat still provides a good look at the phytoplankton. Lots of stuff over Georges Bank, and a big spinning desert of a warm eddy in the Slope Sea.



0 Comments

17 jun Glider Speak

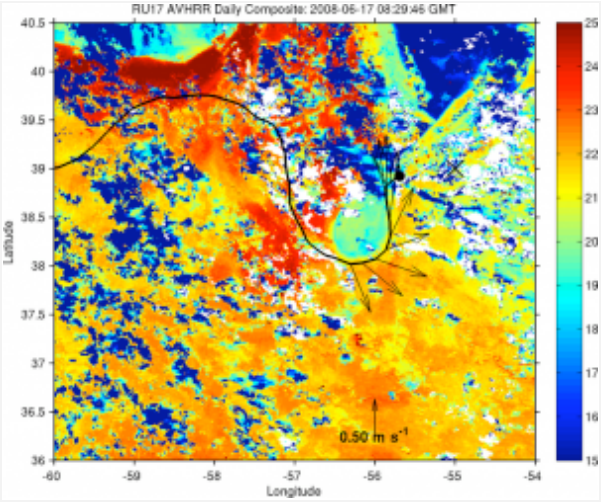
Edit Posted by: Scott in: Across the Pond Edit

Clouds everywhere. But RU17 is doing fine. Here is the important segment cut and pasted from its 4:27 am email:

sensor:m_water_vx(m/s)=0.183506119284393 158.303 secs ago
sensor:m_water_vy(m/s)=0.158799262502452 158.389 secs ago

m_water_vx is the east component of velocity in meters/sec. m_water_vy is the north component. Both are positive, indicating the components of the current vector are to the east at 0.18 m/s, and to the north at 0.15 m/s. Anytime we see positve east currents dominating, we are happy. Currents are also increasing and heading to the northeast, indicating we are heading back into the Gulf Stream. Some cloud-free imagery would be very useful.

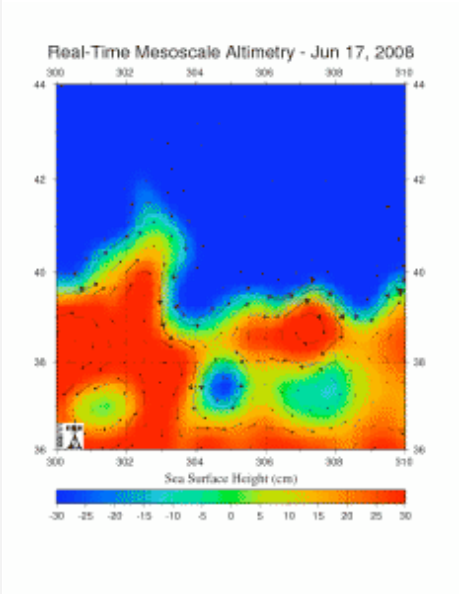
Below is the most recent version of the track. You can see how we turned sharply to the east to get back in the Stream. Beware of the SST imagery - it is a couple days old, and the region is changing rapidly.



0 Comments

18 jun Waiting for clear weather

Edit Posted by: Scott in: Across the Pond Edit

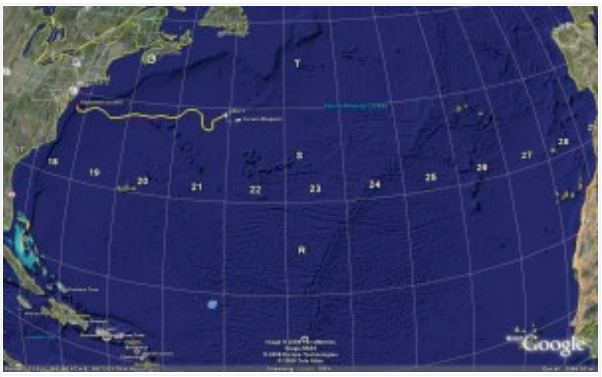


Still cloudly over RU17. We turned to altimetry (above, from Colorado), and the altimetry says turn to the southeast for faster currents. So we'll give that a try. A least until morning or the clouds clear again.

0 Comments

19 jun 2000 Kilometer Mark

Edit Posted by: Scott in: Across the Pond Edit

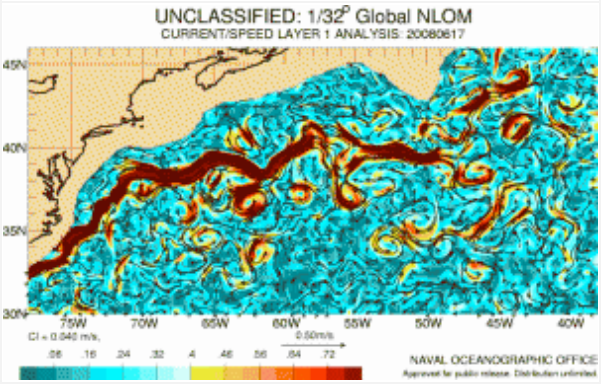


This morning RU17 crossed the 2000 km mark. Tonight it crosses into S22, its 5th UTM navigation zone. We are 29 days into this mission.

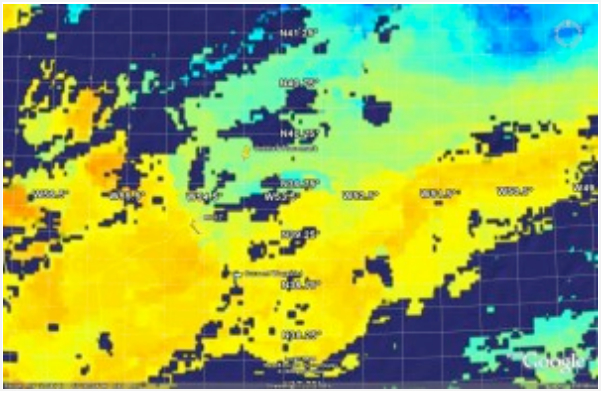
0 Comments

19 jun There is no Gulf Stream at 55 W

Edit Posted by: Scott in: Across the Pond Edit

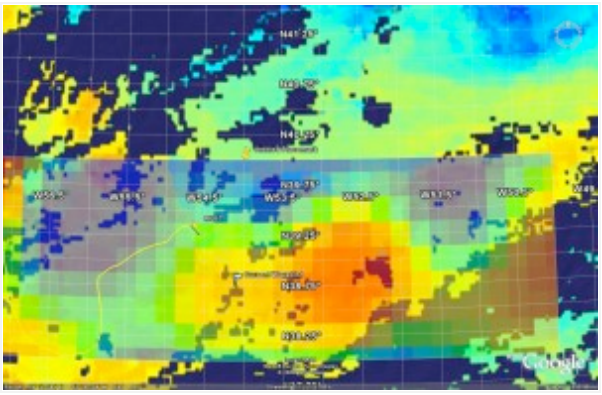


I think the above NLOM model run describes the situation best. The Gulf Stream spliters into numerous filaments between about 56 W and 54 W where it is interacting with numerous rings, warm and cold. It reforms east of 54 W in this forecast.

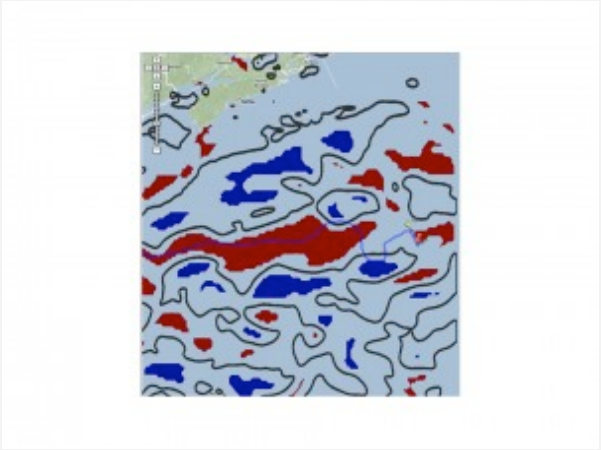


The above picture is the best satellite image of Sea Surface Temperature we have seen in the last few days. It appears there is a stronger front to our southeast.

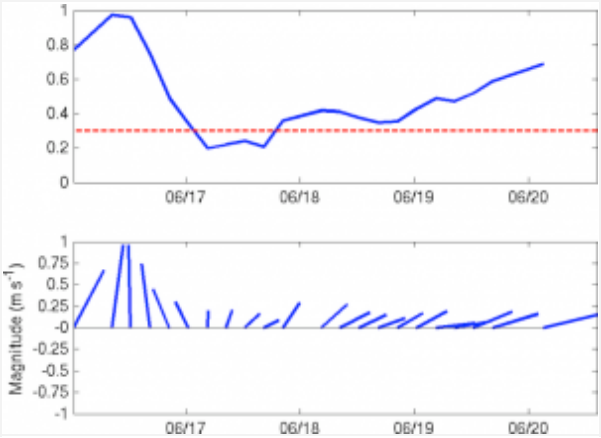
Below is an overlay of the Satellite derived altimetry. There is a strong sea surface height front shown as the region between the high (red) and low (green), also to our southeast.



Below is a plot we made from today's NCOM model forecast. Here we plot only the east-west component of the velocity. Red is greater than 30 cm/sec to the east. Blue is greater than 30 cm/sec to the west. Head for the red. Blue is bad. The track of RU17 is the thin blue line. Here the model output from NCOM says that the best eastward velocities are just to our south and run east to the edge of of the display domain.



So earlier this morning we decided to head southeast to see if we could find some stronger currents.



Since turning to the southeast, the currents are slowing increasing. We are close to 70 cm/sec, almost all to the east. Not sure if its because we are flying southeast into stronger currents, or if we are drifting east into the region where the Stream reforms. Either way, strong currents to the east always feel good.

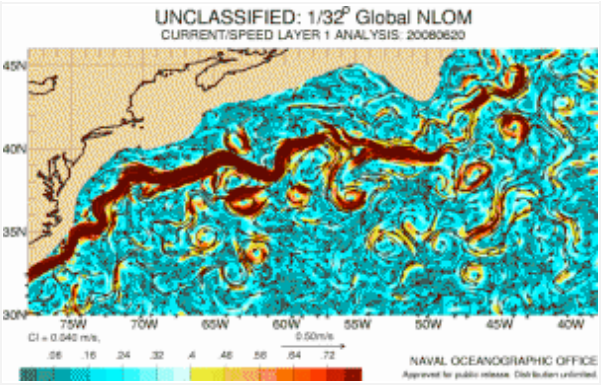
0 Comments

21 jun Remote Access

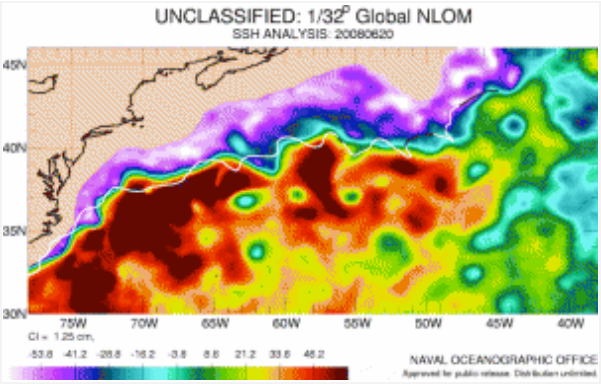
Edit Posted by: Scott in: Across the Pond Edit

Today's RU17 update is brought to you by the WiFi folks at McDonalds.

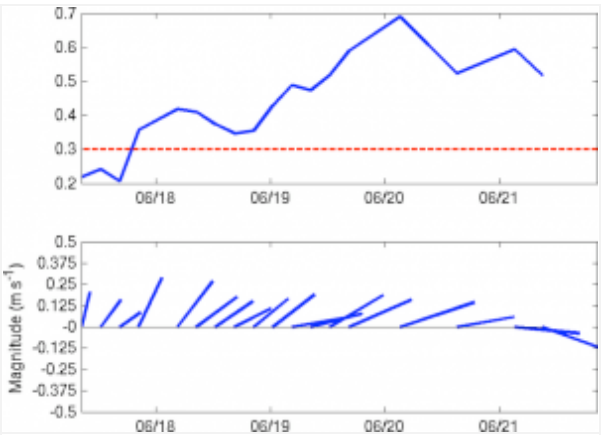
RU17 is near 53W. Navy forecast below has a broad eastward flow in this region, located between 39 N and 40 N



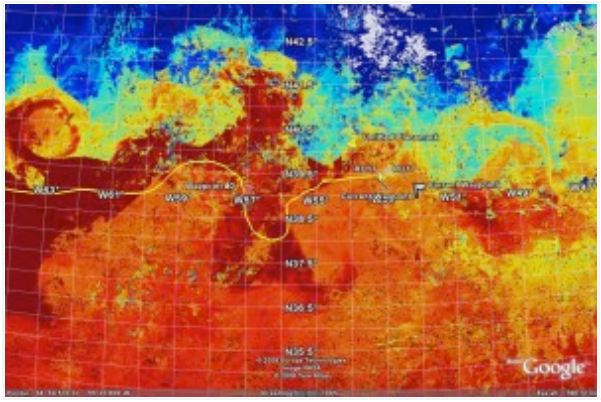
But their frontal analysis shows some small amplitude meanders. Near 53W, the Stream is heading southeast.



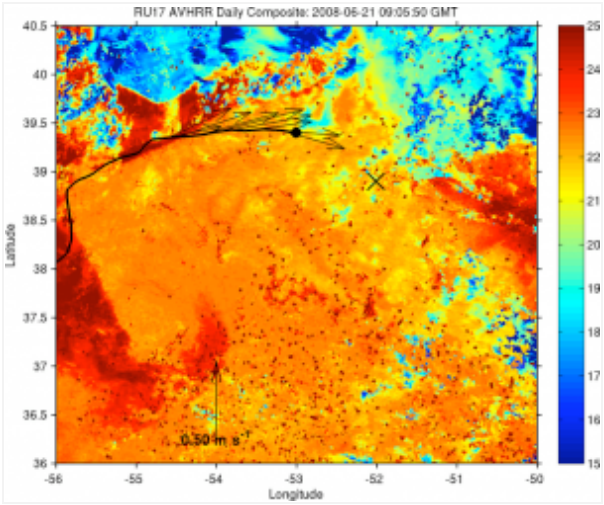
The Frontal analysis agrees with the turning currents in RU17. We went up into the meander crest (the northeast currents, across the crest (east currents), and are now heading southeast. Looks like a very good analysis product. Did we get all the way into the top of the crest? I'm not sure. I think we cut across the bottom a bit.



So we are now approaching the trough, and we will try to cut this one right at the northern edge. We moved the waypoint east to 39 N, 51 W. There is some very spotty SST imagery that says this point is near the north wall. it is nothing that you would believe if you did not have other info, but it is the best we have. If this is the north wall, it will cut RU17 across the stream from the southern side to the northern side. The concept is the same cross-Stream exploration that we did when we first entered the stream back around 70W. We want to do the same on this side of the Gulf Stream region before it starts to filament. This will help us for next year's journey. If you look at the Navy forecast near the top, and head down along 50 W south of the tail of the Grand Banks, you'll see that the Stream starts to filament into numerous jets and eddies.



Above picture shows the general situation, but it is a 7 day composite of SST, and a 2 week length of glider track, and a very dynamic region. Composites move the north wall of the stream to its most northern location during the interval. Use caution with any conclusions you draw from this image.



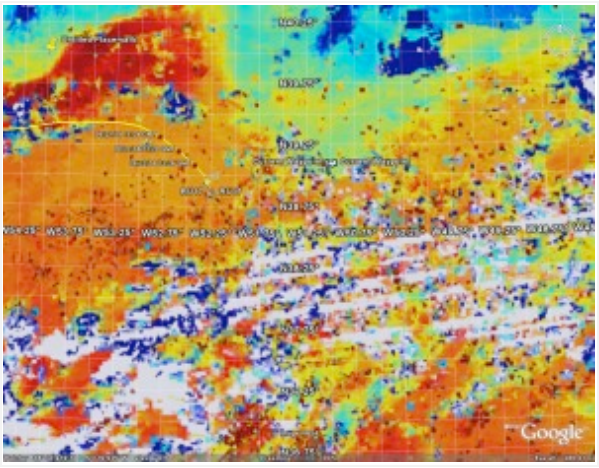
John just made the new panel for the zoomed in imagery and currents. It sure does look like the Stream's north wall was north of us as we crossed the crest. A good reason to redo the cross-stream survey.

0 Comments

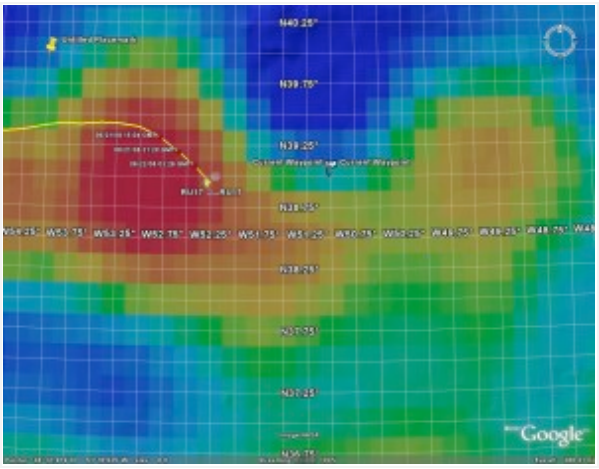
22 jun Building the road as we drive it

Edit Posted by: Scott in: Across the Pond Edit

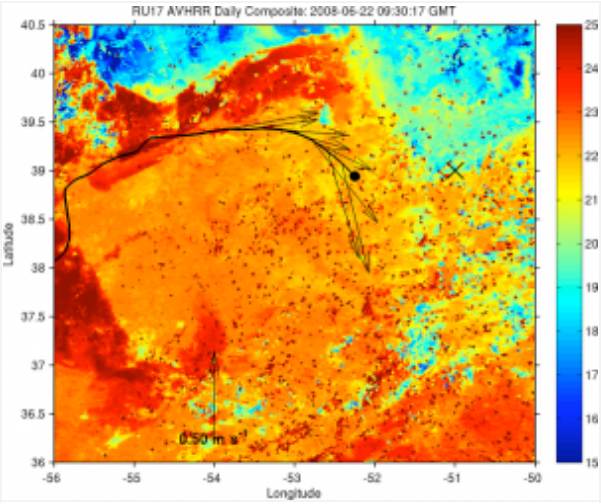
Below is the satellite-derived Sea Surface Temperature (SST) displayed in google earth. Looks like we did a lousy job of flying around the meander crest located between 52 W and 54 W.



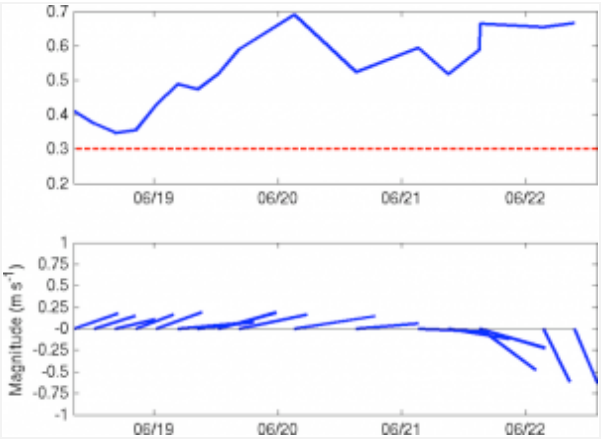
Below is the same view, but now with the satellite-derived Sea Surface Height (SSH) from the altimeter displayed. One of the undergrads just completed this new view over the weekend. The Gulf Stream shows up as a high (red) in the sea surface height. Wow, looks like we did a pretty good job of flying around that meander crest.



At least both the SSH and SST above agree on the location of the meander trough we are now heading into. In the SST image below, RU17 is seen heading into the trough and currents are turning to the south.



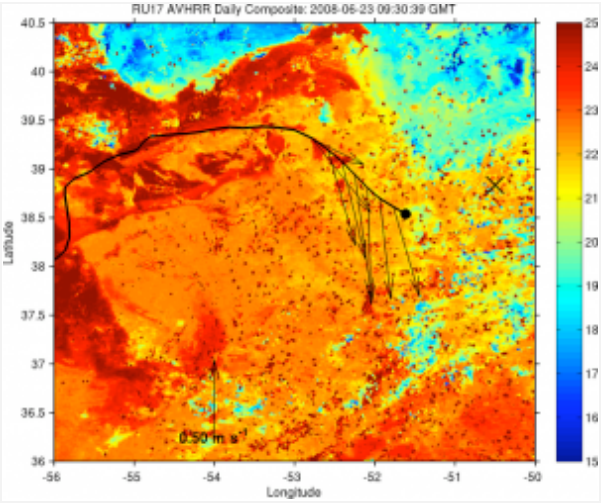
Below is the time series of current speed and direction. We are using the glider velocity to fly across the Gulf Stream towards the north wall to do a cross-Stream survey of the Stream's surface velocity field.



0 Comments

23 jun Approaching the next meander trough.

Edit Posted by: Scott in: Across the Pond Edit



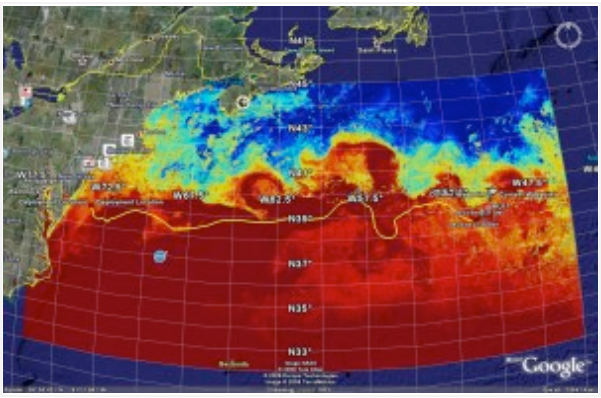
RU17 is rounding the bottom of the well defined trough in the Gulf Stream meander. Currents are rotating to the east, and are expected to continue rotating as we round the bottom. We'll keep trying to pull RU17 closer to the north wall on a cross-Stream current survey.

0 Comments

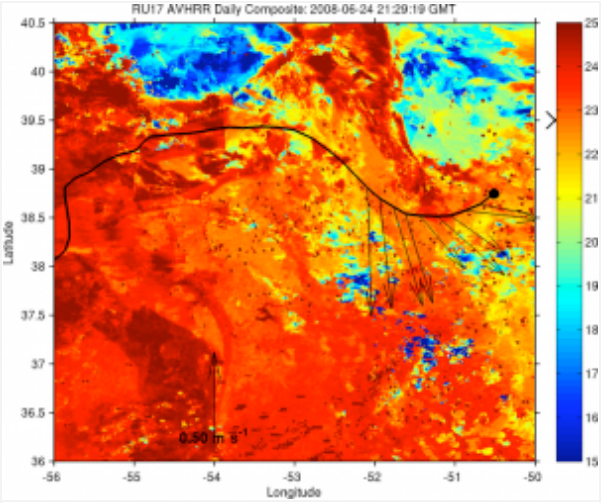
24 jun Entering the last meander system in our satellite coverage

Edit Posted by: Scott in: Across the Pond Edit

RU17 is approaching the easternmost limit of satellite coverage from our receiving station at Rutgers. Between 50 W and 45 W, we have one meander crest and trough system to navigate. After that we leave our own coverge and head into regions where we must rely on global datasets. To get there, the students are building us new google earth tools. Several are being tested now in the lab before they release them to the likes of me. I guess they want to make sure they work so I don't end up calling them for help in the early morning hours of my usual watch.



Below is the plot of the current vectors observed by the glider overlayed on the satellite Sea Surface Temperature. We have passed the trough near 51 W, and are heading up into the crest wtih a somewhat uncertain northern side. Luckily Justin has the altimetry products in google earth, and just like the last meander crest, we learned to fly by the altimetry.



0 Comments

24 jun As we head out of the Gulf Stream

Edit Posted by: Oscar in: Across the Pond Edit

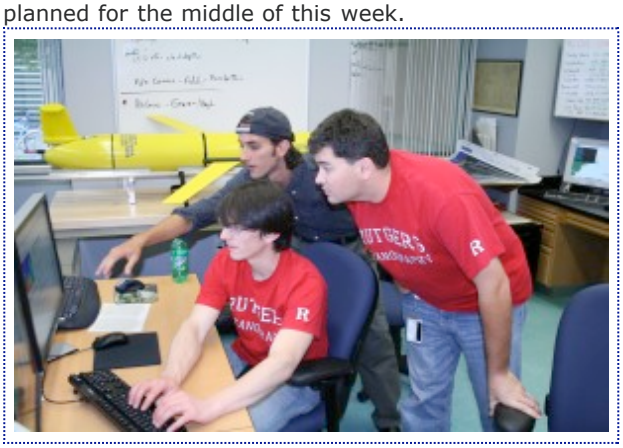
As the Glider starts to head into the dreaded eddy field along its path to Spain after the surfing the Gulf Stream, we continue our focus on the some of the great impacts the Gulf Stream has on Northeast Atlantic. There was a great article published in March 2008, in Nature by Minobe et al. (2008). This authors in this article used a combination of weather analyses, satellite data and an atmospheric general circulation model to show that the Gulf Stream's influence extends into the atmosphere. The Gulf Stream contributes theat and mositure to the upper troposhpere which then in turn fuels local rain patterns. This allows the Gulf Stream to impact the local climate. This was a illustrated in a very graphic on the cover of that issue of Nature that illustrates the Gulf Stream surface current speeds in blue-white colours (white is the fastest) and upward wind velocities in yellow-red colours (red for stronger winds). The graphic was produced by F. Araki and S. Kawahara, ESC JAMSTEC

0 Comments

24 jun New Undergraduate Student Blog

Edit Posted by: Scott in: Across the Pond Edit

As we approach 50 W, we are starting to rig RU17 for the next phase of flight. We already switched over to the longer 6 hour missions, and have some flight tests planned for the middle of this week.



The undergrads have started their blog (see Undergraduate Operations http://www.i-cool.org/?cat=9), to keep track of what they are doing. The three main people working on the daily glider flight decisions are Justin, Anthony and Eric. Justin is working on the path planning, Eric on the flight characteristics and Anthony on the piloting. They are looking for new datasets and models to improve our navigation, and ways to save energy and fly more efficiently. Justin is spending his last few months with us before he heads down to Georgia to grad school with their new AUV group. Right now Eric is simulating some new behaviors on a glider in the lab before we upload them to RU17. Anthony is working on getting a ride on the daily NJ DEP beach survey plane to help us interface our ocean datasets with their aircraft data. Evan continues to report in from Spain on the set up of the CODAR network for the potential landing zone, but people seem to look forward to his food reviews the most. Danielle and Emily are working on the CODAR network back here in our MACOORA home, so what we do here can be transferred to Evan in Spain. Shannon and Dakota remain our outreach specialists, touring high schools and appearing on NJ TV stations. Garzio (don't call him Mike) thinks we're all crazy and is heading to Antarctica with his glider instead. Erick finished his GIS interface and is heading down to UDel to work with Matt Oliver, another Rutgers grad, on his new gliders and remote sensing data. Ethan is in the Caribbean working on a NOAA project for the summer. Ethan had a tough decision, the Caribbean for 2 months on a NOAA project or Hawaii for 1 month on a Navy project. Ethan is in the Caymans. Dave and Bob, the RU17 build and deploy team, just left for Hawaii today. Check out the undergraduate photos at
http://rucool.marine.rutgers.edu/index.php/People/People-Undergrads.html

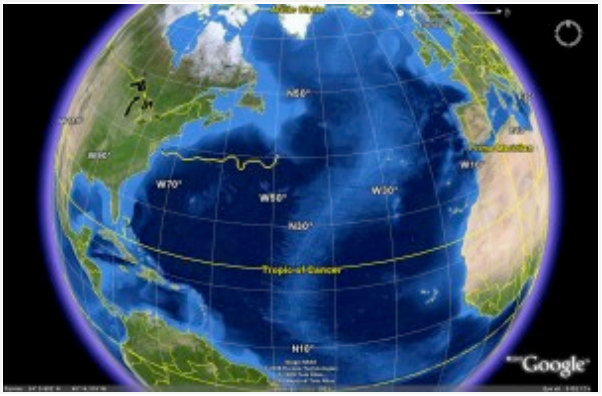
0 Comments

26 jun Milestone 50 W

Edit Posted by: Scott in: Across the Pond Edit

RU17 is now south of the Grand Banks of Newfoundland. The map below give the location names. The Tail of the Grand Banks is the part that extends south. The nose of the Bank heads east to the Flemish Cap. You'll read about these places in fishing books like the Perfect Storm.

Below is the yellow line shows the track of RU17 from the New Jersey shelf to just south of the tail of the Grand Banks. Yesterday evening we just crossed the 50 W line, an important milestone. Our path planning gurus estimated it would take us about 1 month for us to fly into and across the Gulf Stream RIng and Meander region, and reach the Tail of the Grand Banks at 50 W. RU17 was deployed on May 21, and crossed 50 W on June 24, 1 month and 3 days later. A 10% difference. Thats a bullseye in oceanography. RU17 has now flown over 2500 km. We are now about 1250 km from Halifax, 1550 km from the Azores. Continuing east we cross the abyssal plain toward the Mid-Atlantic Ridge.



We will be flying RU17 differently for the rest of the trip based on the oceanography. The Tail of the grand Banks is considered the end of the Gulf Stream Ring and Meander Region. From the FLorida Straits to Cape Hatteras, NC, the Gulf Stream flows almost northward up the edge of the countinental shelf. Here the Gulf Stream has small amplitude meanders that form small frontal eddies on the west wall that propagate swiftly downstream. At Cape Hatteras, the Gulf Stream turns eastward towards the tail of the Grand Banks. In this region we see the second type of Gulf Stream behavior, with large meanders that break off to form warm core rings to the north and cold core rings to the south. Once we pass the east of the Tail of the Grand Banks, the Gulf Stream enters its thrid behavior zone. Here it begins to filament, forming branchs that head northest toward Norway and branches that head east towards Spain. The region is filled with short jets and a rich eddy field.

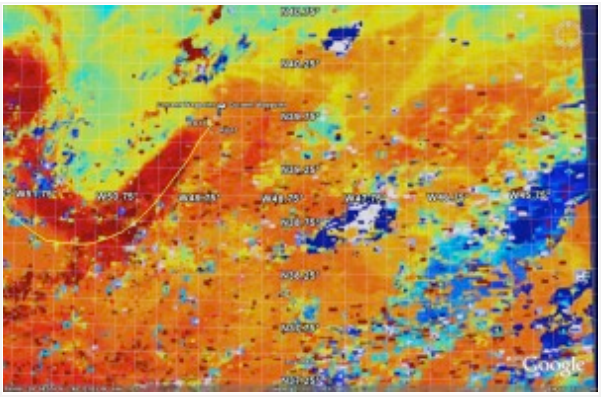
We will soon be entering the next phase of operations for RU17. Our datasets will change, becoming more global and loosing the detail we get in the coastal datasets. Our uncertainty about the environment will grow, and we will rely more and more on model forecasts. We'll be looking to Gregg Jacobs at NRL and Frank Bub at NAVO, our Navy forecasting gurus, a lot more in the future.

0 Comments

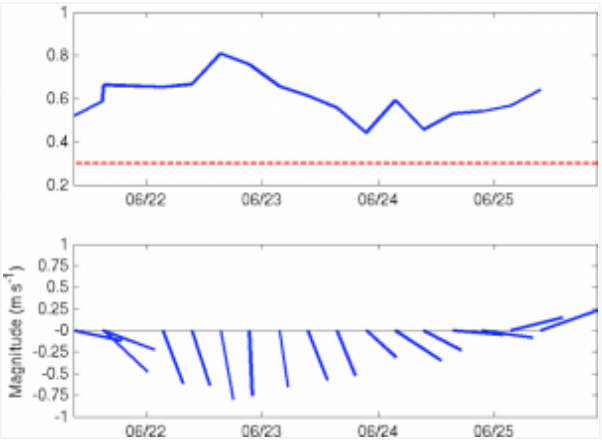
26 jun Today's Local Plan - riding the meander crest

Edit Posted by: Scott in: Across the Pond Edit

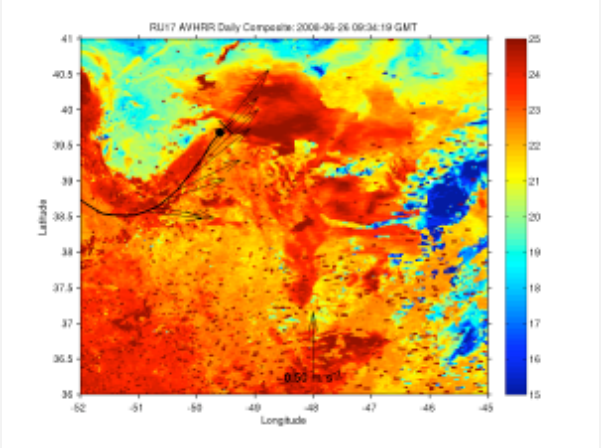
RU17 is moving up the meander crest toward the top, which appear to be a line along 40 N. As it heads north, we are drawing it closer and closer to the north wall of the Gulf Stream.



Gulf Stream current speeds continue to increase, and are turning to the northeast.



RU17 (black dot with long track tail) is heading right at the current waypoint (X in the plot). When we get there sometime this morning, we'll switch to a waypoint to the east to moave across the top of the crest.



0 Comments

26 jun Biologically Inspired Behaviors - Following the Turtles

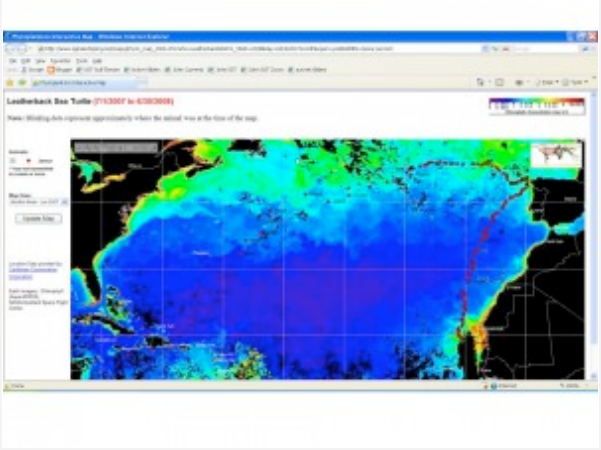
Edit Posted by: Scott in: Across the Pond Edit

Ok, so Wikipedia says remoras sometimes hitch a ride on turtles. So where to the turtles go? Sage found us a couple of links.

Here's one website: http://seamap.env.duke.edu/datasets/detail/316 . You can see the turtles leaving the east coast and heading east in the Gulf Stream. After rounding the tail of the Grand Banks, the tracks bifurcate.

Here's another. The track of a Leatherback Sea Turtle named Jamur.

http://www.signalsofspring.net/maps/phyto_map_2006.cfm?who=Leatherback&DATA_YEAR=2008&day=06302007month&open=yes&NAMES=Jamur,second



Jamar travelled from the Tail of the Grand Banks to Spain in about 4 to 4.5 months. Do they swim faster than gliders? Here's the link to a paper on the Leatherbacks they instrumented in the Caribbean.

http://jeb.biologists.org/cgi/reprint/205/23/3689.pdf

Scott Eckert found that the Leatherbacks rarely stopped swimming, that their second most common behavior was a high speed sustained swim for hours at a time at speeds around 75 cm/sec. Looks like a Turtle is about 2.5 times faster than a Glider.

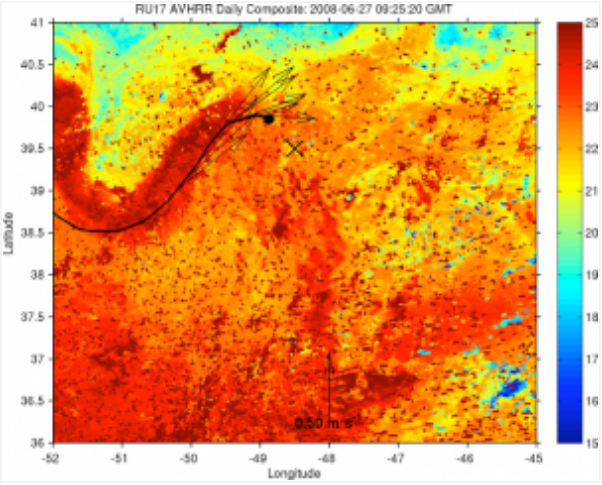
The image above also plots the turtle track on the ocean color image, with Jamur appearing to like that Chlorophyll front. Guess we'll start plotting the global Chlorophyll and try to follow the turtles.

0 Comments

27 jun Trust your Altimeters

Edit Posted by: Scott in: Across the Pond Edit

RU17 is moving across the top of the meander crest. Gulf Stream currents turned to the east and are continuing to swing around with a small southward component, indicating we are getting near the eastern side of the meander crest. We used the altimeter data to keep placing the waypoint just ahead of RU17 along the edge of the Stream in the Colorado altimetry product. Score one for the altimeter. Thats good, we are going to need it a lot more in the next phase of the flight.



0 Comments

27 jun

Remora remora vs. RU17

Edit Posted by: Anthony Lund in: Across the Pond, Undergraduate Operations Edit

Remora remora could be responsible for the glider's unusual behavior yesterday.

Cultivating in the warm and pelagic waters of the North Atlantic, Remora form commensal relationships with larger animals because it lacks a swim bladder and cannot travel alone. Therefore, it attaches itself, with its powerful suction disc on its head, to a host's skin. It feeds by detaching from its host and consuming its scraps.

Remora remora locations

A remora could easily mistaken a glider as a larger animal to support it for food and transportation. Since the remora has such a strong suction disc, the glider could not support the remora and it was forced to sink. In addition, since the remora feeds off of its host's scraps, it detached realizing that there was nothing to consume. Because of the detachment and weight loss, the glider was able to fix itself.

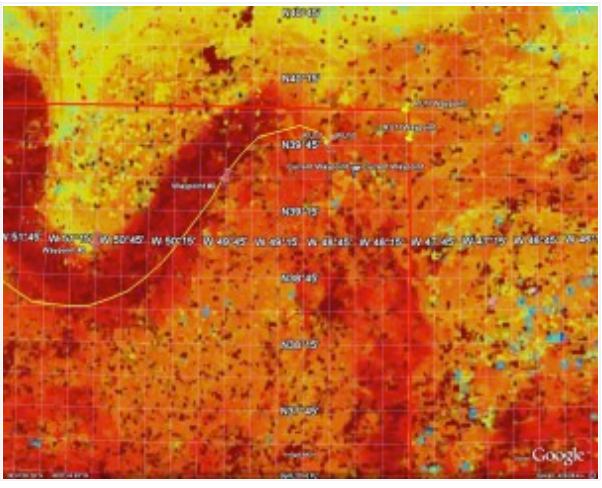
-Danielle Holden

0 Comments

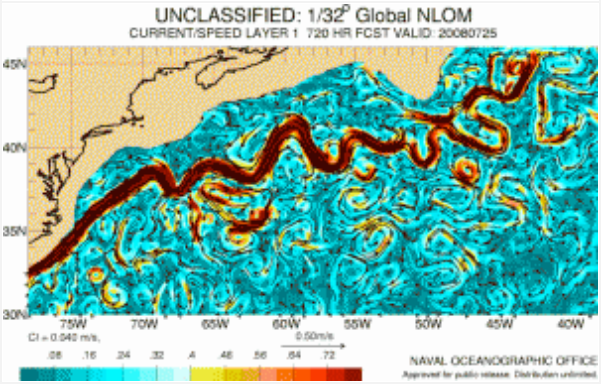
27 jun The Pathfinder steers a hard left.

Edit Posted by: Scott in: Across the Pond Edit

Here is the picture we had in the morning after the 5:30 am surfacing. We made it to the top of the meander crest, and we were heading SE. But which way to Spain? Northern route, southern route? All we see is warm water.

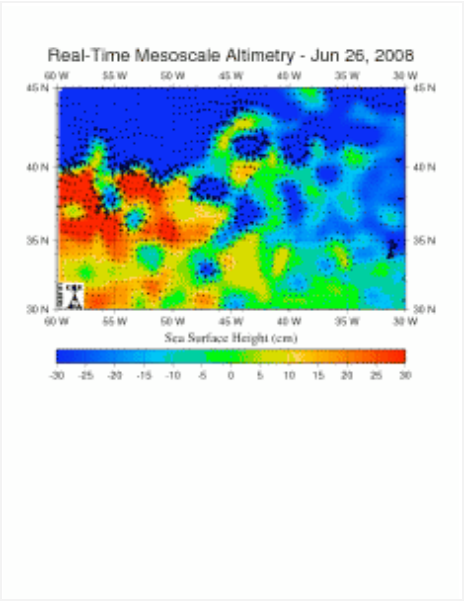


Below is the Navy forecast. We see a long stretch of continuous current running to the southwest between 50 W and 45 W. Looks like a good route to there, but then it dead ends, turning back on itself and heading to Norway.

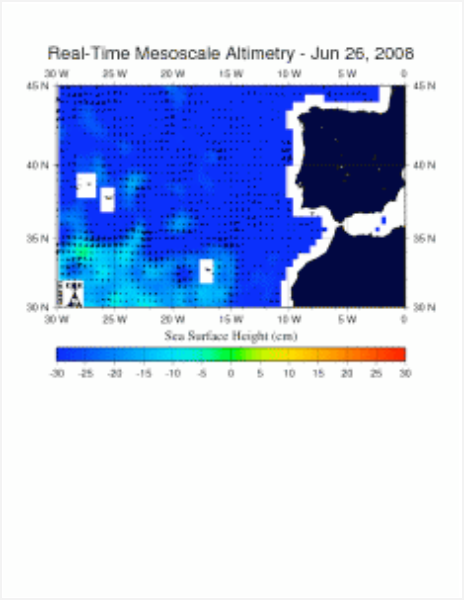


Still with some uncertainty in our next move, all the facutly and senior staff headed to the conference room for our montly call with the MARCOOS network. MARCOOS is the Mid-Atlantic Bight Coastal Ocean Observtion System. It is the Regional onserving system for the Mid Atlantic Coastal Ocean Obseving Regional Association known as MACOORA. It is part of the U.S. Integrated Ocean Observing System (IOOS). The undergrad remained behind, searching for a path. The MARCOOS call was running long today. Our plan for the HF radar network was due today, and we were discussing the final tweaks to the last 2 weeks of work. While we were on the call, we get an email from Justin, our undergraduate pathfinder. All he said was the satellite Sea Surface Temperature and altimetry agree, and he was turning RU17 to follow a developing ridge in the sea surface height. In the google earth display we saw he had made a sharp left hand turn, 90 degrees to the current, exactly the move you pull in an emergency when you have to make progress in the face of a strong current. Where was Justin suddenly taken us?

Below are a couple shots of the satellite altimetry data showing the sea surface height in color with red being the high and blue the low. Between 50 W and 45 W we see the strong current to the southeast, simialr to the Navy forecast. There is the low blue oval centered about 38 N, 48 W, and several filaments heading north. The altimetry picture says the the filaments on the north extend east to nearly 30 W. The strong current to the southeast just ends, dropping you at 45 W. So the southern route is faster the 45 W, but then what?



Below is the satellite altimetric measurement of sea surface height from 30 W to Spain. Its flat. Nothing there. We get no help beyond 30 W, just a slow, steady slog. So the goal becomes the fastest route to 30 W, and thats the northern route. Justin's hard left in the morning was our attempt to find that route north in that featureless Sea Surface temperature image.



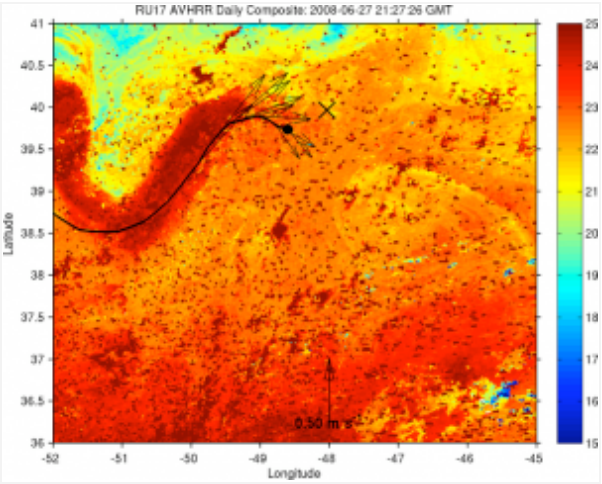
0 Comments

27 jun

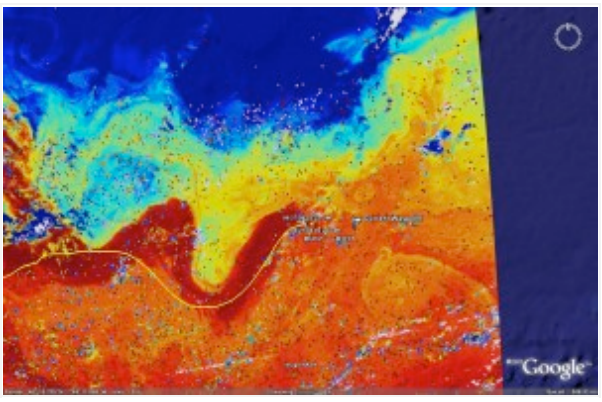
OMG - There it is!!

Edit Posted by: Scott in: Across the Pond Edit

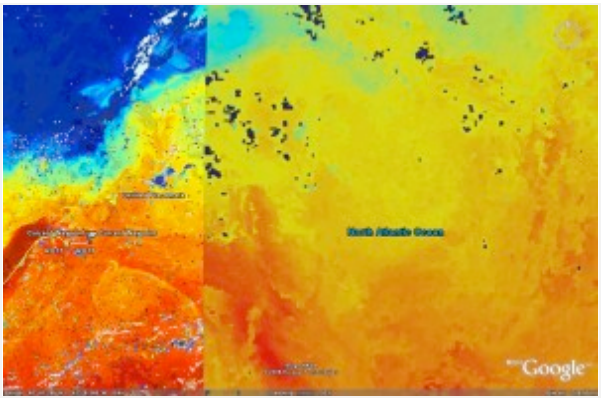
We left RU17 with a bit of a plan, we knew we wanted to go northeast, but the exact way to get there was still uncertain. There are lots of different current patterns you can encounter on the way northeast, and we were feeling our way through these based on the glider velocity measurements alone. The problem with this approach is that you never know when you'll hit a dead end. Then right after dinner this image pops up. Wow. There is the oval ring we saw in the altimetry. Its faintly visibile between 45 W and 48 W. And there is a route north. My favorite part about Satellite Sea Surface temperature is that it is synoptic. That means it is a clear snapshot at a single time, not a smeared average over some time interval. Its not always representative of the true subsurface currents, but when it is, there is nothing better to to steer a glider by.



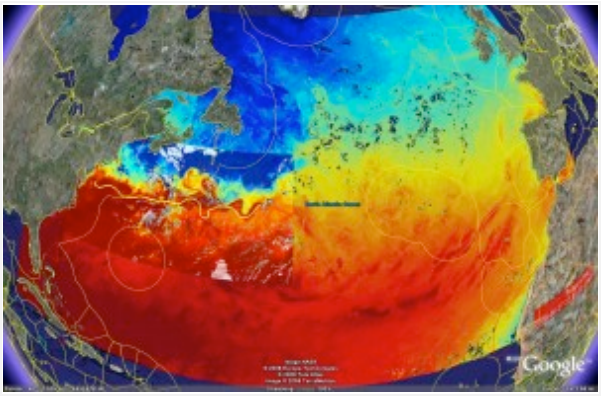
Below we zoom out a bit on the google earth image. Again you can see the oval eddy, with one branch going south of the oval eddy, and the other branch of warm water turning to the north.



Now lets insert the global 4 km dataset over the blue area at the right of this image. This shows the interface between our locally acquired 1 km data and the global 4 km data. The northern branch of the Stream heads north and turns east towards Spain, running just above 40 W.



Now lets zoom out to view most of the hemisphere. We are right in that bifurcation zone of the Gulf Stream. We are trying to take the northern branch that them heads all the way across with the maximum gradients near 40 N. Thats the latitude we saw the strong altimetric signals extending the farthest to the east. Thats the zone we need. Strong fronts and Sea surface height gradients mean strong currents. The thin yellow lines, many of which look like circles around the islands, are the boundaries of the Exclusive Economic Zones, the EEZs. This route will skim along the northern side of the Azores EEZ, staying in international waters until Spain.



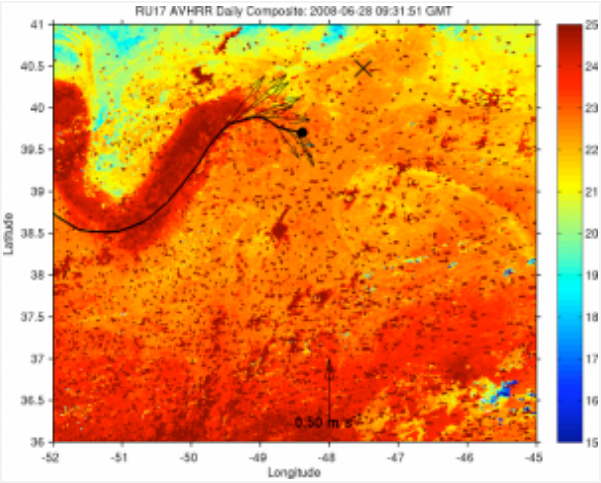
Looks like The Pathfinder earned his keep today.

0 Comments

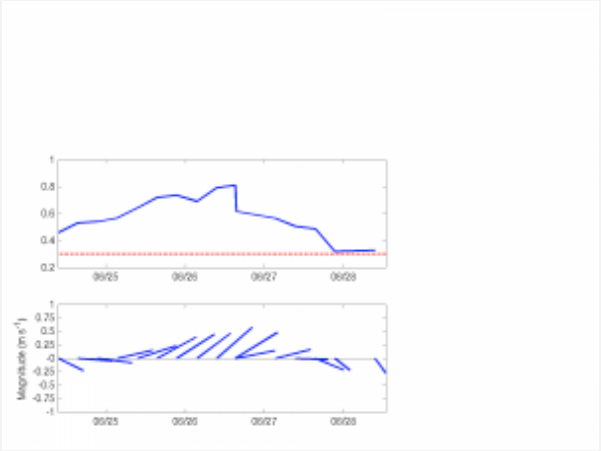
28 jun The Transition to a New Regime

Edit Posted by: Scott in: Across the Pond Edit

RU17 is making slow but steady progress towards the northern branch of the Gulf Stream we discussed last night. RU17 is steering toward the X in the plot. We have very quickly transitioned into a new type of environment.



Current speeds have dropped significantly in the last day. The time series of current speed indicates we dropped down nearly to the line where we can just about navigate like a ship rather than move like a drifter.



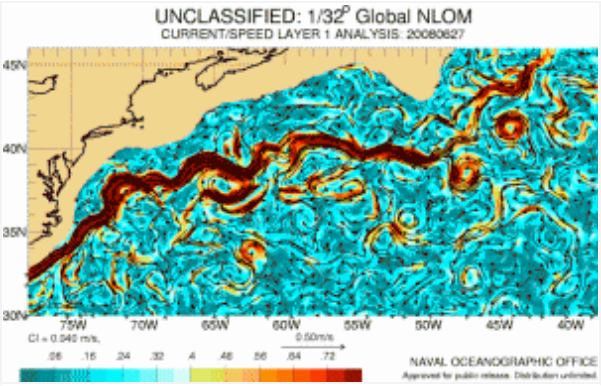
So we are still trying to not fight this current, still treating it like a swimmer swimming perpendicular to a rip current. Right now the glider is flying on a bearing of 58 degrees, so we are heading 58 degrees measured clockwise from north. The depth averaged current is flowing towards 148 degrees, again measured clockwise from north. The difference between the two is exactly 90 degrees, meaning RU17 is flying exactly perpendicular to the current. This is the most efficient path to get out of the area we are now in, and move towards the northern branch of the Gulf Stream where we want to be. All we can do now is sit back and wait for the magic to happen.

0 Comments

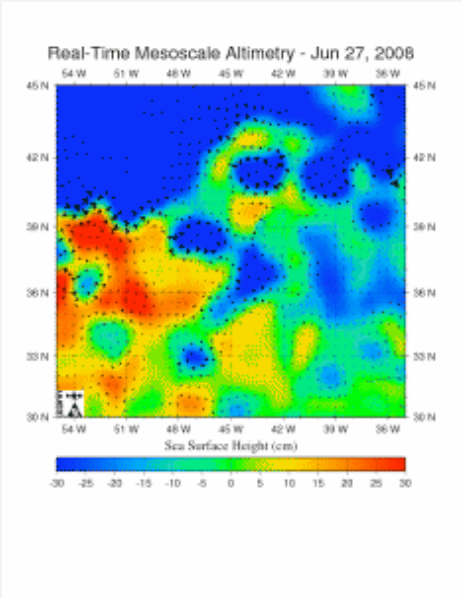
29 jun I always liked Plan B

Edit Posted by: Scott in: Across the Pond Edit

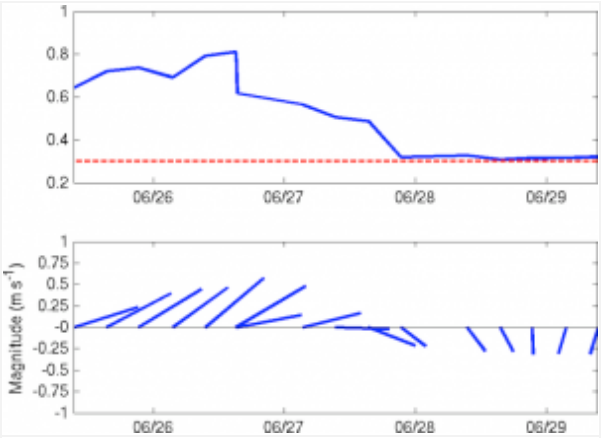
That large cold eddy centered near 39 N, 47 W (see forecast below) continues to grow more distinct and is dominating the oceanography in the vicinity of RU17. It is the strongest local feature here in the model forecast. The forecast still has a smaller route northeast, but it looks like it heads off toward Norway.



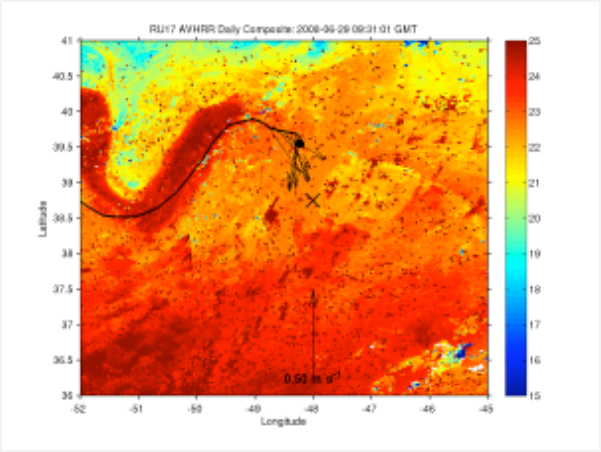
A quick check of the satellite altimetry (below) and we see that the route to the northeast no longer exists. The region is pretty much dominated by the cold core eddy that is located between 45W and 48 W, just south of 39 N.



We spent a day (friday night through saturday night) with RU17 searching for the route northeast, but all we found was steady currents about 30 cm/sec to the south (figure below). This is consistent with the Trust Your Altimeter philosophy we learned in the previous two Gulf Stream meander crests. Now we see it applied to the very first eddy we encounter in the Gulf Stream extension region. Since RU17 can only fly about 30 cm/sec, continued searching for the potential route northeast becomes an exercise in station keeping and waiting for something to happen. But we don't have time to wait. So lets trust the altimeter, assume the northeast pathway is shut down, and follow an alternative path to the same eventual location.

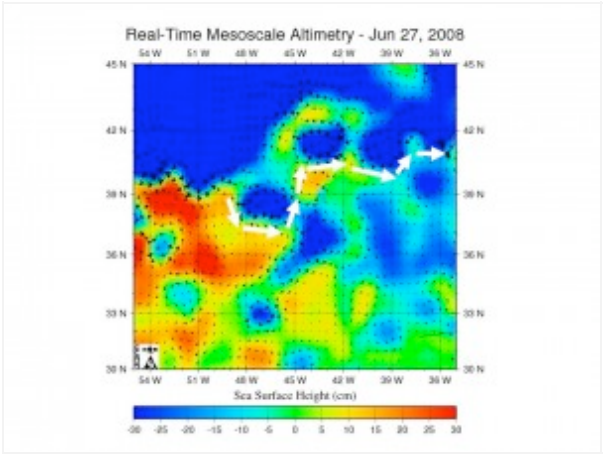


So last night we turned RU17 into the currents and began heading south, starting a loop around the southern side of the cold eddy. In the Sea Surface temperature image below, you can faintly see the eddy in the surface temperatures. Its the oval you see between 46 W to 48W, just around and below 39 N.



The advantage of this route is that it uses the dominant oceanographic feature in the region as the route east, even if it may be a bit less direct. If we want to use the oceanography to help us get across, we should probably start by using the dominant features that the models, satellite altimetry, and satellite surface temperatures all agree on. Its always more comfortable flying these things when you know your enviroment based on the models and remote sensing data than if you are flying blind.

So below is the proposed route forward, flying eddy to eddy based on the altimeter field. Our objective is to get into the 40 N to 41N band where the larger altimetric signals are found all the way east to 30 W. With the northern route shut off, we turn into the southern route, loop around the southern side of the alpha-eddy, then back up the eastern side between the cold eddy's low height (blue) and the adjacent high (red) in the sea surface topography. So we fly counterclockwise around the low and clockwise around the high, following what is known as the geostrophic currents. We then spend some time on the southern sides of the next two cold eddies (blue). We then see a small clockwise high that can boost us to a bigger clockwise high that is just off to the east of the image plotted here. Just like the atmospheric weather, this ocean weather will evolve over the time as we travel along this route. We will be increasingly relying on the broader oceangraphic community to monitor the ocean weather conditions in this region as we continue our journey.

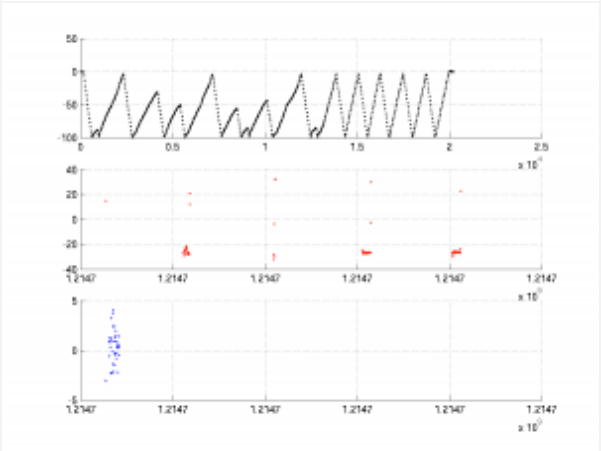


0 Comments

29 jun What Was That? II - Return of the Remora remora Behavior

Edit Posted by: Scott in: Across the Pond Edit

Whatever it is, it came back and left again. Below is the time series plot of the glider depth (y-axis) as a function of time (x-axis). You can see the glider move up and down in the watercolumn in a sawtooth pattern. We now call it the Remora remora behavior till we figure it out. Same behavior as last time, we suddenly switch to fast descents and slow ascents, sometimes not making it to the top of the yo. It lasts for two 6 hour underwater segments, then goes away just as suddenly, returning to a normal series of approximately equal dives and climbs. This time the oddity (as RU17 calls them when it reports back) of stopping RU17's upward motion occurred 7 times, causing RU17 to return to depth and try the ascent again. Luckily a robot never gets tired of trying again and again.



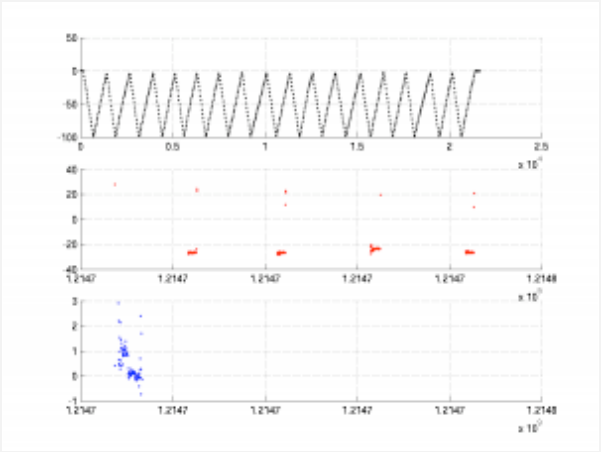
The puzzling thing is that there is not a thing that moves, or even thinks of moving, on RU17 without being sensed and recorded. We'll download these engineering files again, just like we did last time. Last time we found several related behaviors that occured in response to oddities, but nothing that appears to have caused the oddities. We'll keep looking.

0 Comments

29 jun That looks better

Edit Posted by: Scott in: Across the Pond Edit

Now thats what a glider segment is supposed to look like. Nearly identical ascents and descents, all yos to the same depth, all returning to the near surface depth of a few meters.



So we know what to do. Monday morning tiger team. Lets download the engineering files and look again.

0 Comments

30 jun weather behavior; eastern atlantic

Edit Posted by: rogalsky in: Across the Pond, North Atlantic Weather Edit

Scott asked me to find the weather patterns for the eastern portion of the Atlantic Ocean and the coast of Spain, this is what I found.

The Mercator website allows you to view zonal maps.

- While looking at the zonal maps if you observe areas D it shows the portion of the gulf stream.
- Area B and E show the coast of spain
- Area C narrows in on the coast of Spain

Also while in the Mercator website if you click on the "sections" tab next to the zonal maps you will find cross sections of the different oceans. Cross section 7 and 4 seem to be around the area that we want to observe. Make sure that the date is adjusted…you can go as early as the prediction for July 9. These maps will give you temperature, salinity, and vectors.

http://www.stormsurf.com/page2/links/atlane.html

This is a link the Stormsurf.com which is a link off of NOAA. This site will give you the wave height and period for the Atlantic ocean.

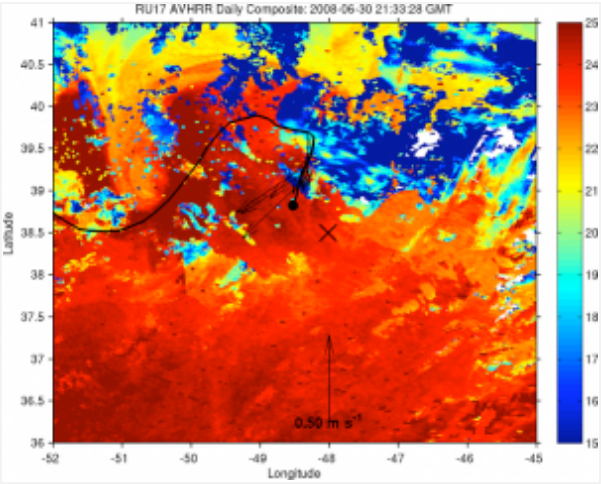
I will post if i find more

0 Comments

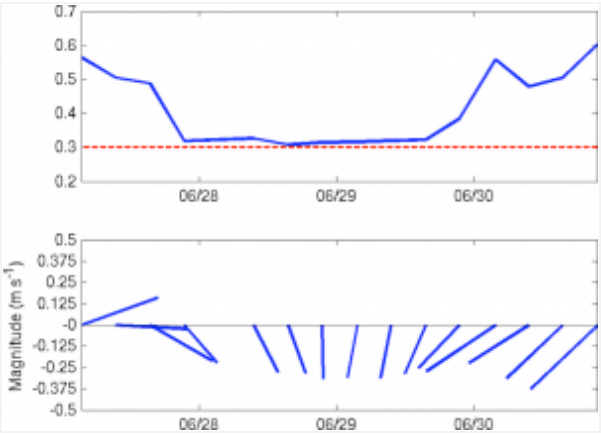
30 jun Score one for the Altimeter

Edit Posted by: Scott in: Across the Pond Edit

I think it was Saturday night we gave up on heading north trying to get into the segment of the Stream heading northest. We based that decision on the satellite altimetry. Tonight we have a clear spot in the clouds that shows the northern side of that meander crest just ends around 40.5 N, and everything turns south. All we kept seeing all friday and saturday was currents to the south.



So score another one for the altimeter guru's. Thats two days it saved us, which is really good. People are looking at the glider velocities and seeing that westward component, wondering why we are going the wrong way. I keep telling myself its based on the altimeter, and F still equals m*a, so it has to come around. Guess we will know in a couple days how that decision plays out. But in this case, the model, the altimeter, and the sea surface temperature all agree. Its a big eddy out there. Currents are increasing rapdily. Some of the strongest we have seen in this part of the Stream.



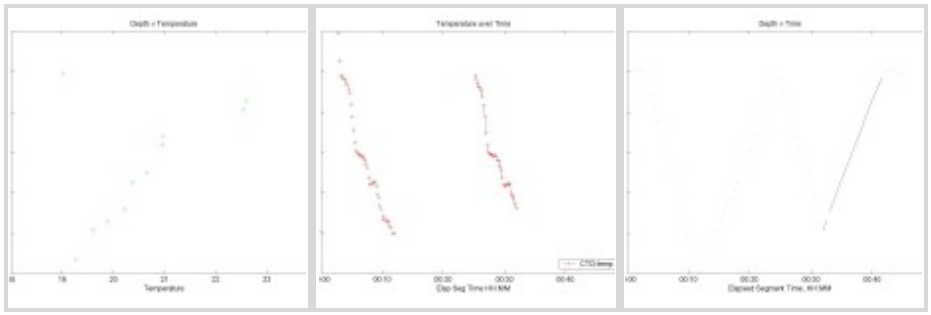
0 Comments

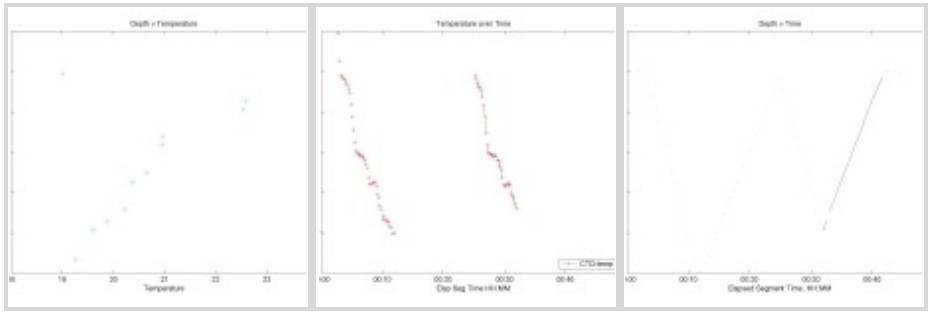
01 Altimetry Is Our Best Bet

jul | Edit Posted by: Anthony Lund in: Across the Pond Edit

Judging from these plots, especially depth verses temperature, we noticed shallow surface temperatures. At about 40 meters, the temperature drops off significantly. So far the altimetry has been reliable for forecasting, I think we should continue to have faith in this data.

We did a one hour segment with the CTD on, unfortunately, we did not get reliable CTD pressure readings. Glider pressure readings are consistent, however, the plot did not reproduce as well as I would have liked.





Clearer plots and CTD data will be coming soon.

Anthony

0 Comments

02 jul The biggest eddy east of the Grand Banks

Edit Posted by: Oscar in: Across the Pond Edit

Posting for Scott, he is somewhere on the interstate cruising towards Ohio. Scott says

"The biggest eddy east of the Grand Banks
Currents continue to increase in a surprisingly strong eddy. We are starting to loop around the southern side. In this location the models have a lot of southward velocity slinging water off the eddy to the south. We don't want to be thrown into that.

So we are making our way east, trying to stay towards the core.

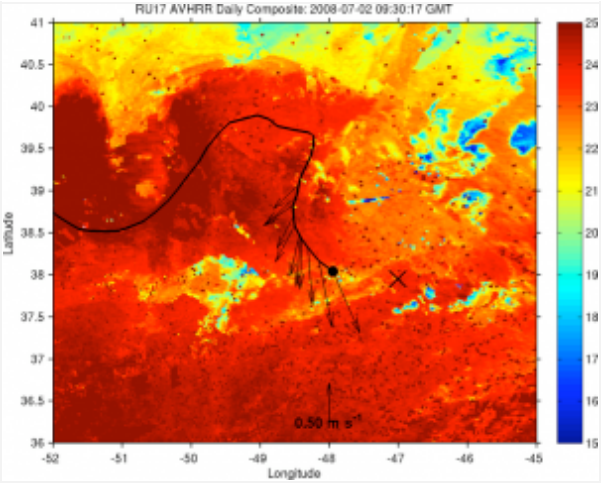
Somewhere between 47 W and 48 W, the strong southward velocities end.

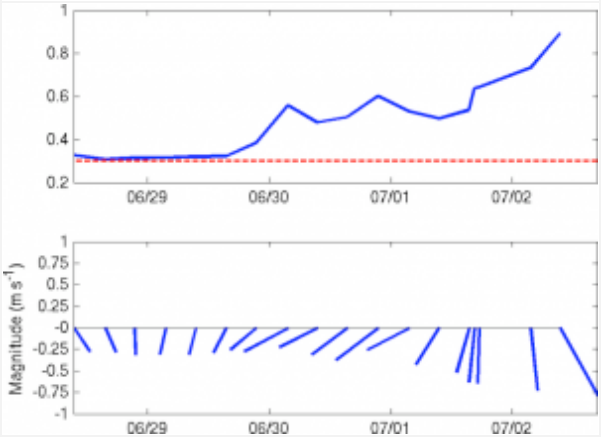
We should see a turning to the east of the velocity vector.

At that point we need to do the opposite and work on getting out of the eddy.

You'll see a switch in our flight planning from flying towards the center to flying towards the out edge.

Center seeking to center fleeing behavior."





0 Comments

02 jul The biggest eddy East of the Grand Banks

Edit Posted by: Scott in: Across the Pond Edit

Currents continue to increase in a surprisingly strong eddy. We are starting to loop around the southern side. In this location the models have a lot of southward velocity slinging water off the eddy to the south. We don't want to be thrown into that.

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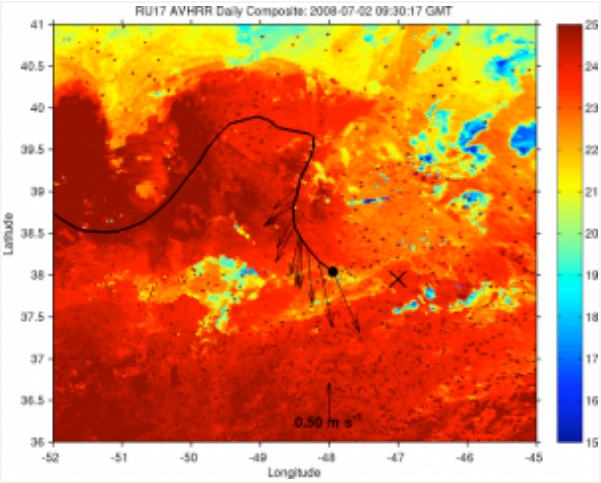
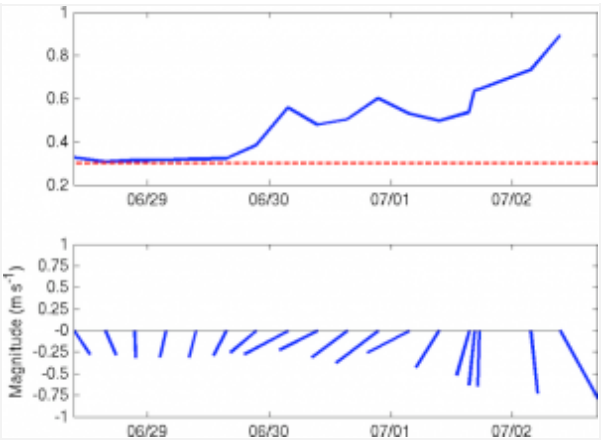




0 Comments

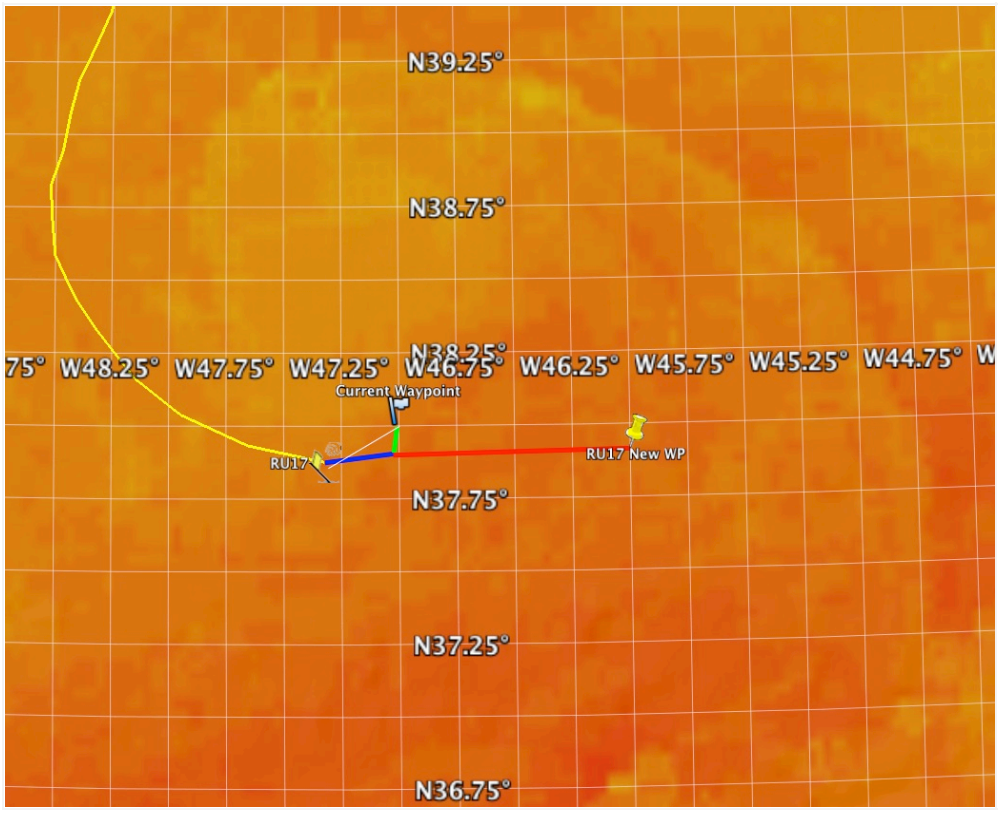
02 jul Ride the Wave into a 100km Day?

Edit Posted by: pathfinder in: Across the Pond, Undergraduate Operations Edit

RU17 has reached the east side of a large cold core eddy. At long last, we should regain northern velocities during the next segment before they swirl towards the center of the eddy (turning counter clockwise). Since we really don't want the glider to fly into a trap that it has a difficult time getting out of, I will choose way points that send the glider towards the outside edge of the eddy. The glider should not get to the edge for several days, but we've got to start heading for there now. It's all about time, distance, energy and pushing east. The glider's speed through the water is fixed (+/- the weight of remora remora).

GMT	Elapsed Time (hrs)	Mission	Surface Reason	Segment	Position	Waypoint	Range (km)	Bearing	Speed/ Heading	Heading Offset	Depth Averaged Current	Segment Distance (km)	Battery Voltage	Vacuum (in Hg)
2008-07-02 22:06:40	6:31	ATLANTIC.MI	timeout expired	2008-183-0-0	37° 52.58' N 47° 19.22' W	38° 00.00' N 46° 45.00' W	31.33	94°	1.28 m/s 102°	8°	1.06 m/s 139°	30.07	11.32	7.75
2008-07-02 15:34:42	6:03	ATLANTIC.MI	timeout expired	2008-172-0-93	37° 56.02' N 47° 39.30' W	37° 56.95' N 47° 00.28' W	57.56	103°	1.29 m/s 114°	11°	0.89 m/s 152°	28.18	11.36	7.94
2008-07-02 09:30:17	5:48	ATLANTIC.MI	timeout expired	2008-172-0-92	38° 02.34' N 47° 56.83' W	37° 56.95' N 47° 00.28' W	83.57	113°	1.08 m/s 126°	15°	0.89 m/s 152°	22.55	11.32	8.58
2008-07-02 03:41:12	6:08	ATLANTIC.MI	timeout expired	2008-172-0-90	38° 09.85' N 48° 08.98' W	37° 56.95' N 47° 00.28' W	103.35	120°	1.04 m/s 141°	21°	0.73 m/s 173°	22.92	11.35	8.60

Right now, I am choosing the next WP for RU17. Checking the water velocities over the past few surfacings, we can see that the water has begin moving more EAST than SOUTH. By tomorrow morning (between 11:30PM and 5:30AM surfacings), water velocities will be to the NORTH. Since we don't know that RU17 is currently in water moving NORTH, the WP that I choose needs to fly RU17 towards the center of the circulation (NORTH) in case velocities to the SOUTH have become stronger, but should help RU17 fly perpendicular to the current, towards the outside of the circulation (EAST). So, RU17 must cross the line connecting the new waypoint with the center of the circulation. Since velocities should increase to the north, and we want to go EAST, our new WP will be just N of the glider, more importantly, further EAST. When the currents turn towards the NE, as they should over night, we will swim perpendicular to them. Since we would likely begin to drift ENE, our WP will become increasingly SE. We don't know how strongly those velocities are going to be, so it is important to choose a point with the intended heading, but a good ways off. Between the last two phone calls 6hr, we traveled 30km (not too shabby). I hope we do that again, and I'll chose a point ~80km off just in case. In either event, a new WP will be needed for the 11:30 surfacing.



Below, the background colors (orange/red) show the water temperature near RU17. Notice how this reveals the circulation of the water. The blue line segment shows where RU17 should surface, the green line shows RU17's bearing when it surfaces, and the red line shows its new heading. The yellow pin is where the new waypoint is located, and the yellow glider tail shows RU17s last know position (just before its

last phone call).

0 Comments

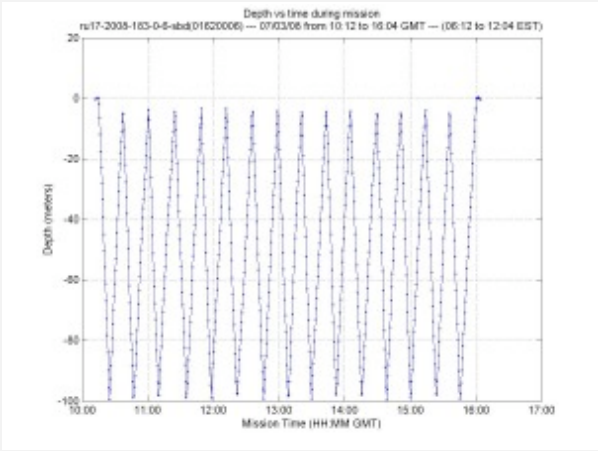
03 jul Segment Looks Good

Edit Posted by: Anthony Lund in: Across the Pond Edit

In our last segment (the 6:00-12:00 EST) our depth plot looks normal. However, there are a few climbs where we were a little slow. Possible biology, algae or jellyfish? Maybe the remoras didn't clean 17 throughly? In any event, the normal dive behavior for this time of day is not unexpected. As more information regarding remora behavior becomes available, then it might be possible to figure out how to fly 'evasive maneuvers.'

More important for today is to continue path planning to fly out of the eddy, and conserve energy. Hopefully, the remoras take the 4th of July weekend off!

Everyone enjoy the Holiday and weekend!



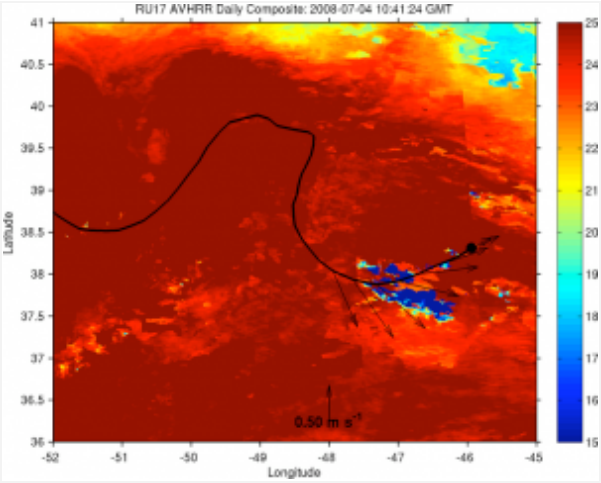
Anthony

0 Comments

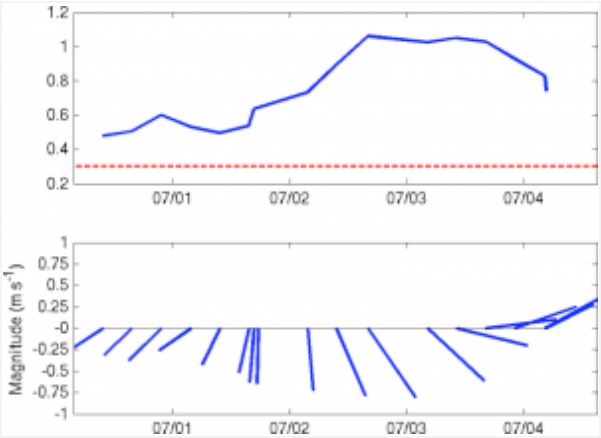
04 jul Navigating the eddy field

Edit Posted by: Scott in: Across the Pond Edit

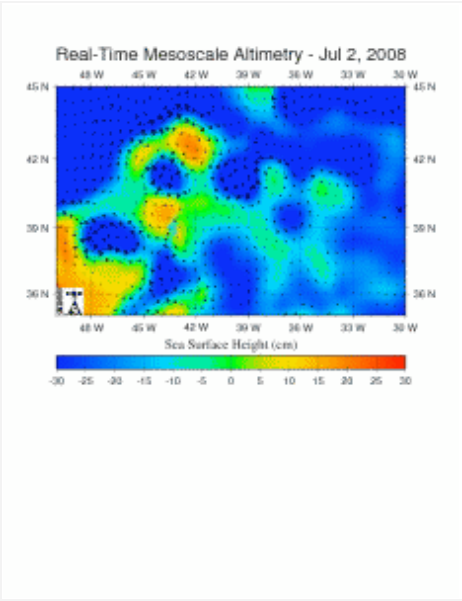
RU17 is rounding the southern side of the large cold eddy. We are working our way out.



Currents are decreasing - thats good.



Altimetry says the edge of the ring is at about 45 W. We'll keep flying east for 6-12 hours before turning north to catch the warm eddy.

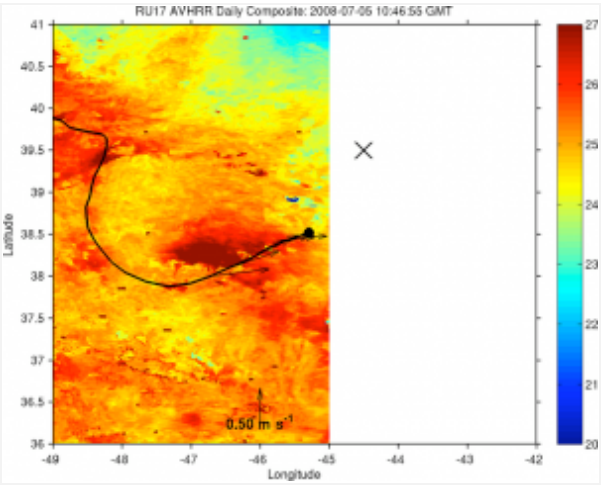


0 Comments

05 jul Dealing with Uncertainty

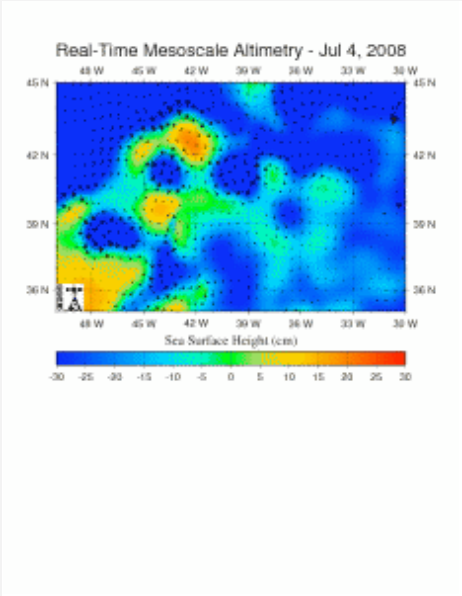
Edit Posted by: Scott in: Across the Pond Edit

RU17 is about 20 km from the edge of our locally acquired satellite sea surface temperature imagery. We have currents running generally to the east, and we are making about 12-15 km every 6 hour segment. We will close most of this distance by the noon surfacing, so by about 6 pm today we will have left our satellite coverage. From now on we will be relying on our firends for data and forecasts to help us navigate.

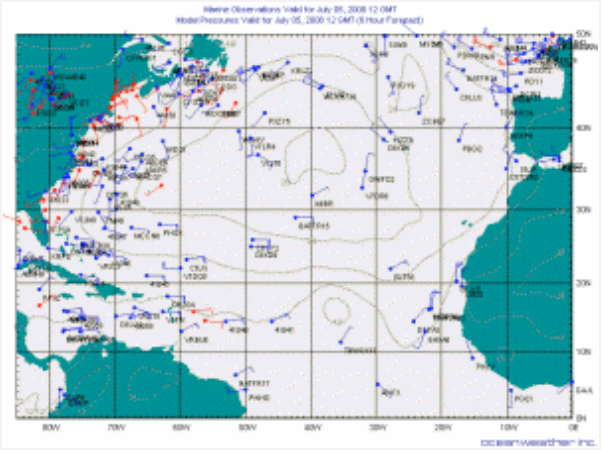


Today's Sea surface temperature image (above) does not help us much as we try

to define the fronts and eddies of the Gulf Stream extension region. We'll start using postings from the google earth viewer for the 4 km MODIS imagery we get from NASa Goddard's Ocean Color Web. Checking the altimetry (below) from U. Colorado, we see RU17 should be approaching that high (red) in the sea surface height centered near 39.5 N, 44W, but we are not seeing any of the currents to the west that we would expect. We are instead getting currents to the east. Quite likely the sea surface high is still there, its just displaced to the north of where it appears in this composite data product.



So on to the models. First a quick check of the weather (below). I like this image because it has the ship observations combined with the pressure contours. The entire North Atlantic is dominated by a single high pressure system. A classic summer image, Just like the text books. Guess we save this one for fall classes. With this high pressure over the North Atlantic, we should not be hoping for much help from the SST. The sunny weather of a high pressure system just heats up the surface and blurs the features. One reason ocean feature analysts really like storms is because as soon as the storm clears the area, the ocean is mixed vertically and the horizontal fronts show up like the lights just got turned on.



So then we move on to the Navy ocean forecast model. The model results have a band of eastward velocities that are running from the location of RU17 to the northeast to about 40 N, 40 W. The band is nearly a full degree wide. RU17 is in this band, and it is heading east, just like the model.

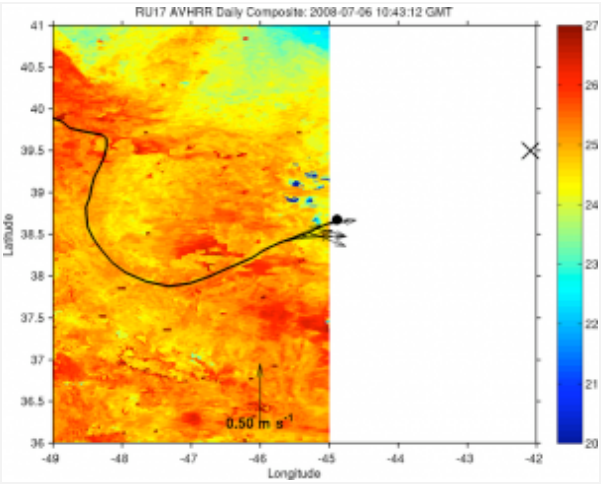
Nothing like a glider on the scene to help you deal with uncertainty. We have three sources of information. One says nothing is happening, the second says the currents are to the west, and the third says the currents are to the east. The glider tells us which one to believe today. We also know that it could change as fast as tomorrow, depending on when the altimeters pass overhead, when the winds stir up the ocean so the sea surface temperature looks like the deep field, and how the model's data assimilation scheme is pulling in the new data and dealing with it. But today, its the Navy modeler's wizzard score that goes up by one.

0 Comments

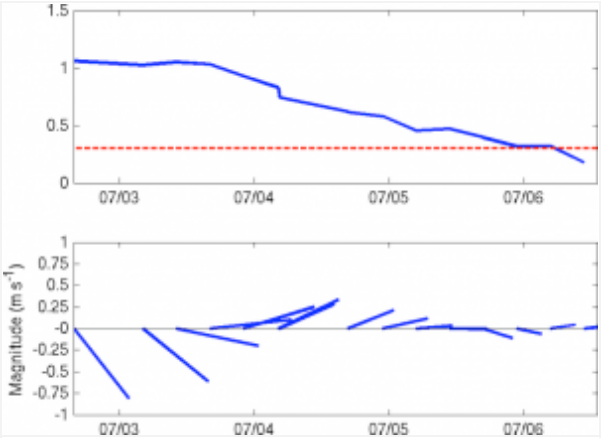
06 jul Following the Navy's Ocean Forecast

Edit Posted by: Scott in: Across the Pond Edit

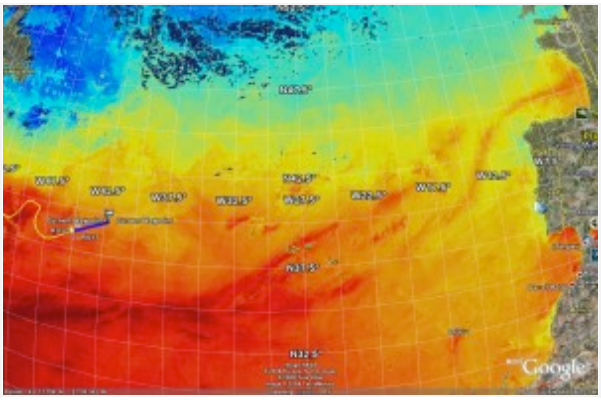
RU17 officially flew off the map yesterday, leaving guidance from our own satellite receivers behind. The Scarlet Knight has clocked 3,143 km to get to this point.



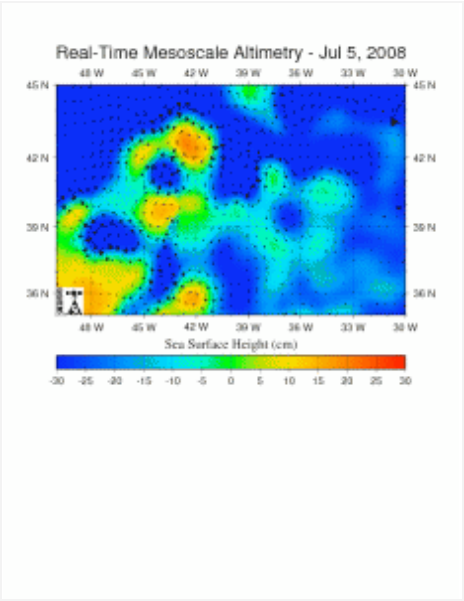
Currents are steadily decreasing on the way out of the cold eddy we just left behind. Not a bad exit. We were hoping to leave the ring as currents hit NE, a heading of 45 degrees. Looks like we got to a heading of about 60 degrees. Not bad at all. Currents from the last reported surfacing are heading ENE - so are we. Nothing like a tailwind.



Switching to the global Sea surface themperatures, we need to work on a new product over the coming week. The existing product show below is designed for long-range planning. We'll put together a new enhanced zoom for the local glider area. Satellite imagery is nice like that. Multiple scales are easy.



Altimetry is still a bit perplexing. That high (red) centered near 40N, 44W should be giving us currents to the northwest based on our present position, 38 40'N, 44 53'W. But RU17 is still seeing currents to the northeast, just like the Navy model forecast. Paraphrasing a 1980's quote from Alan Robinson, thats the power of dynamical interpolation that you get from a model. F=ma is still a powerful constraint.



So we will continue on this path for a bit. We are flying in what the Navy model says is a region of favorable (eastward) currents in between to regions of unfavorable (westward) currents. if the altimtry eventually proves right, possibly by a displaced high, we are also in a good position to follow it around to our destination, the general area of 40 N, 40 W.

0 Comments

10 jul Stuck in a corner - Altimetry to the rescue

Edit Posted by: Scott in: Across the Pond Edit

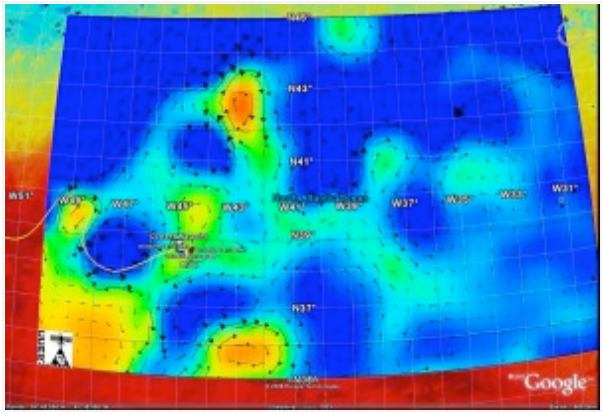
So where have the bloggers gone? - no entries since monday. Yep, something was awry. You can usually tell how the day is going based on the number of blog entries. Here we had a string of 4 days with no entries - our longest string yet. We were all pretty busy trying to unravel this puzzle while simultaneously building the new tools we needed to unravel it. It took us till yesterday, when a combination of new tools and new altimetric data from Colorado showed us that we had flown into a corner, and the only way out was to circle around and try again farther north.

The story begins Sunday, where RU17 was heading northeast through a gap between two westward flows based on the Navy model. The uncertainty issue was the eastern side of Romora Ring, the strong cold eddy we had just left. None of the spatial datasets we had (satellite SST, SSH or forecasts) agreed on the shape or location of the eastern side of that ring. We had planned on being advected north by the eddy on the eastern side, but the northward currents never appeared. Instead the currents stayed to the northeast, continuing to decrease as we left the eddy early on monday. We continued in this direction, but by monday evening, the currents flipped, and were slowly increasing against us. By tuesday, the currents to the southwest had inceased, turning into a headwind that stopped us dead. By evening we where being pushed backwards. The Navy model said the gap we were shooting for was closing, but it didn't really matter how big the gap was, we couldn't fight this current.

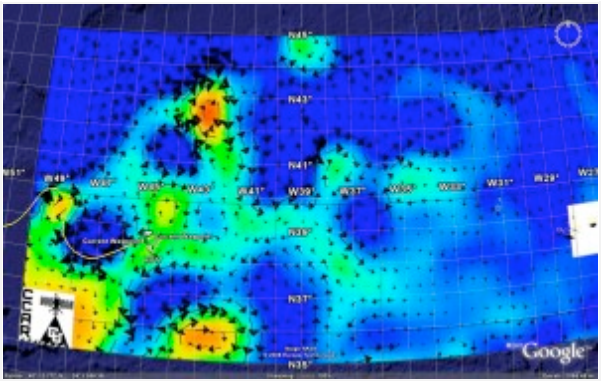
So we needed a way out. Glider exit strategies from a strong current are well

known. Just like a swimmer caught in a rip current, you swim perpendicular to the current until time or space results in a change. So which way do we turn? RIght or left? Usually we would choose the direction perpendicular to the current that had at least some component towards the east, towards the Azores or even Spain, our ultimate destination. But in this case we had the Navy model saying we would encounter even stronger currents in the wrong direction if we chose the direction to the east. So on tuesday we decided we had to trust our models, and we turned RU17 from northeast, heading it first to the north, then the northwest, and finally to the west as the currents were pushing us due south. It really hurts to give up hard fought ground like that, but we had no choice, we had to find a favorable current ride or spend valuable energy just station keeping at best.

Then on wednesday, as we were trying to fly out of the southward current, some new altimetry came in. We did not check were the satellite overpasses where that day, we didn't have to. The large oval cold ring we had just left was now a perfect circle in the altimetric data, and was now in agreement with the model. The discrepancies of the last few days went away with the new data, features were in the same locations, and the currents being experienced by the glider matched what was being seen from space. Finally, we had a roadmap with a way out (see below). And not only did we have a roadmap, we now had the roadmap displayed in our google earth interface. For the last few days we had been staring at tiny images on computer screens, or printing out hardcopies, trying to plot glider positions and velocity vectors by eye. Now we had an interface that did all this automatically, allowing us to zoom in and out as we needed.

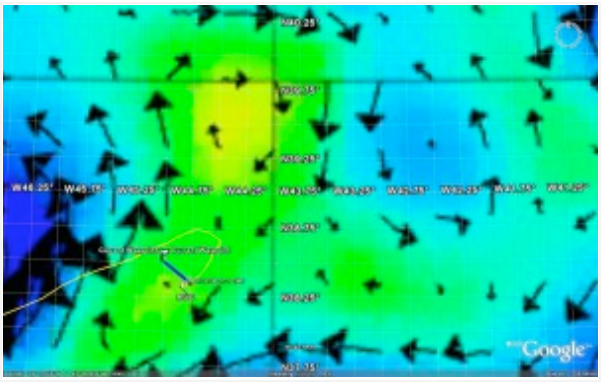


With the new roadmap, we charted a course to the west that would take us into a strong region of northward velocities that we would use to slingshot us around the high in the sea surface height that is presently blocking our path east.



Below is the zoom in of the path of RU17. It looks like strong currents to the north

are about a days run to our west, and nothing but trouble is found to our east. For the first time on this mission, we have had to turn west to get to water flowing east.

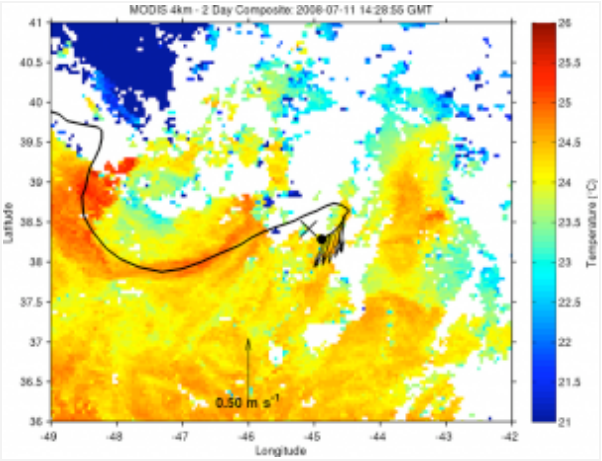


0 Comments

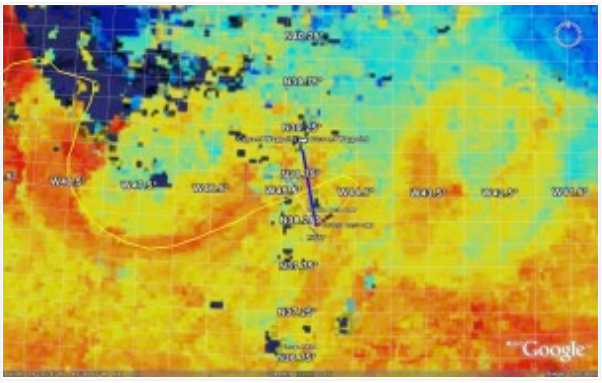
12 jul Building the road as we drive it

Edit Posted by: Scott in: Across the Pond Edit

We love our satellites! Nothing like multiple satellites showing you a clear path forward. Thursday night we saw the updated altimetry from Colorado. This morning John and I worked on the MODIS Sea Surface Temperature imagery we get from NASA. John is home in NJ. I find myself spending another weekend morning at a McDonald's WiFi hotspot, this time in Sturbridge, MA. We found an enhancement that shows that big cold ring from last week, the one with the remoras, and we now have two satellites and a model all agreeing on the location of the eastern edge of this ring. We are heading for a known favorable current, a very good feeling when you are battling a strong headwind and all the models say the route east is blocked. We are even now seeing the currents turning from flowing to the south (the difficult headwind) to southwest, meaning we are approaching the more favorable current region.



We'll adjust the waypoint for RU17 at the 10:30 am (EDT) surfacing so that it is more perpendicular to the current, just like a swimmer in the rip current. This will maximize our speed towards the region of known favorable currents.



We are pretty encouraged by all this, despite the delay of a few days we had earlier in the week dealing with the data uncertainty and the headwind. Those that have followed along know we have left the region we cover with our own data. We can only reach part way across from this side of the pond. We are now reliant on our national and international colleagues for the data we use for guidance. We have new datasets from a broadly distributed network that we are now getting into our google earth interface, and the new tools are being used for pathplanning. Partners in Spain and the Canary Islands have sent us their first test datasets that reach out across the Atlantic from their side of the pond. We'll be adding those in the next few weeks.

The great Antarctic explorer Shakleton once said, "If you can't find a way, you build a way." The NJ version is here in action, we are buidling the road as we drive it.

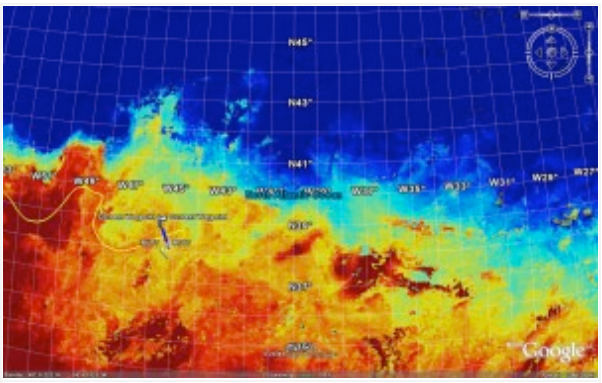
0 Comments

13 jul Satellites tell all

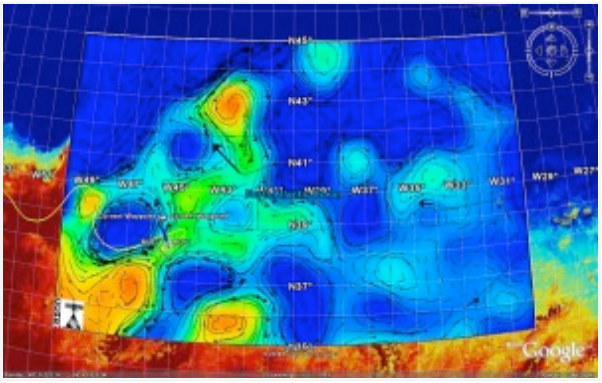
Edit Posted by: Scott in: Across the Pond Edit

Today's thanks go out to our friends keeping the satellites flying. A weekends worth of work on the satellite Sea Surface Temperature (SST) and Sea Surface Height (SSH) has really paid off. We still have some cleaning up of the details, but the path is clear, and we now know how close we came to breaking through this past week before we were turned around by the currents.

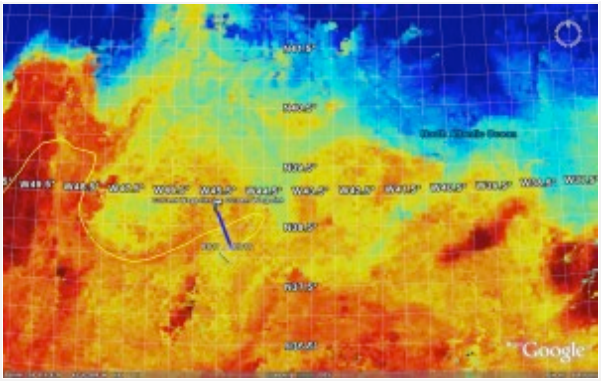
First is the satellite Sea Surface Temperature image below. It is gives us the general conditions between RU17's present location and the Azores, located about 1200 km to our east. We are working this front we have enhanced in the SST imagery to show temperatures between 21C and 26 C. The front is not clean like the mighty Gulf Stream. But it is a front the large sea turtles seem to like on their trips to Spain. John got these images working over the weekend.



The satellite altimter fills in the complex eddy field between RU17 and the Azores by mapping the Sea Surface Height. The highs (red) and lows (blue) in the sea surface height are very similar to the high pressure and low pressure systems you see in your NOAA atmospheric weather maps. The currents swirl around these highs and lows, and our job is to use this maps to find the best path east. These are the interstate highways of the ocean. Sometimes to get east, the best way is to fly west for a bit to pick up the interstate. Justin got these maps working over the weekend.

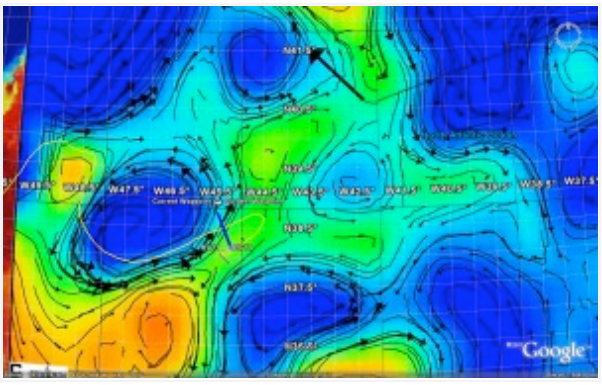


Now we zoom in on the temperature map to see the features in the eddy field in the immediate vicinity of RU17. You can see near 47W our loop around the southern side of the cold eddy where we found what we think are remoras. We exit the eddy on the eastern side, and suddenly were turned around to the southwest by strong currents.



Zooming in on the Sea Surface height map, we see the local access to the highways. The clockwise circulation around the cold eddy with the remoras is

clearly seen near 47 W. We were flying in the green colors, trying to cross that high region in the sea surface height when the currents to the southwest got too strong for us. The new feature in the field we did not see before is the small cold eddy we see as a low located near 39 N, 42W. Where did that come from? its a new feature for me. But the southwest currents proved too much for us, and we where turned back. At least we now know why. We were so close to reaching those eastward currents along 39 N, but with a glider, you only have about 25 cm/sec of forward speed to work with. Currents have been running near this speed or higher against us, so no matter what we do, that path is blocked.



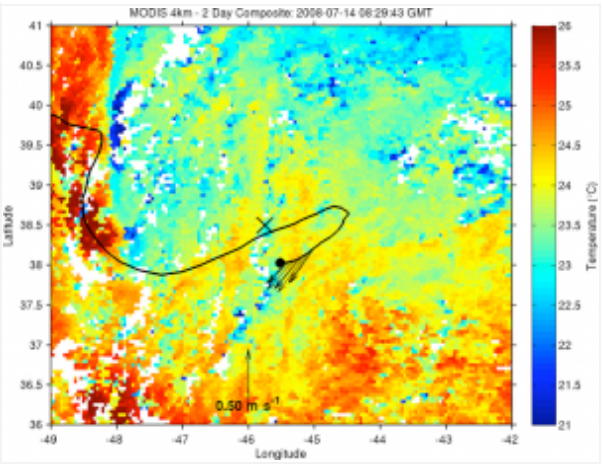
So based on the above roadmap, which we also know is constantly changing, we can see that the best way east is to first travel west. We moved the next waypoint for RU17 to 38 30'N, 45 45'W so we can fly perpendicular to the southwest currents, just like a swimmer in a rip current. We will fly northwest till we get into the outer edges of that cold eddy and ride it north. Hopefully the remoras leave us alone.

0 Comments

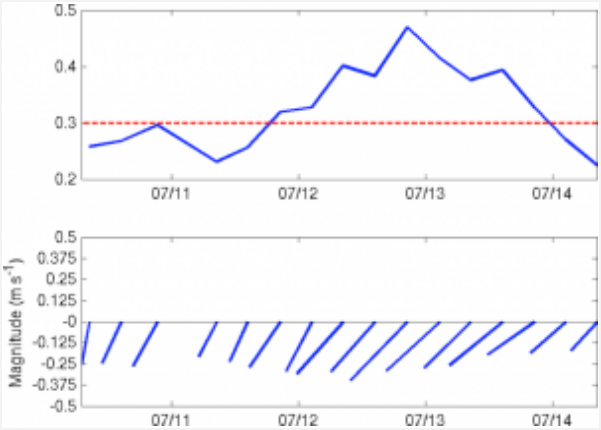
14 jul Exiting the jet

Edit Posted by: Scott in: Across the Pond Edit

Sea surface temperature image below has the glider track and the observed current vectors overlaid. RU17 is making the turn towards the eastern side of the cold eddy (difficult to see in this image).



As shown in the time series plot below, current speeds are decreasing as we leave the strong jet to the southwest that has blocked our path forward for a few days now. Current direction from the most recent surfacing (4 am, not shown here) is even more favorable, continuing to decrease and turn to the west.



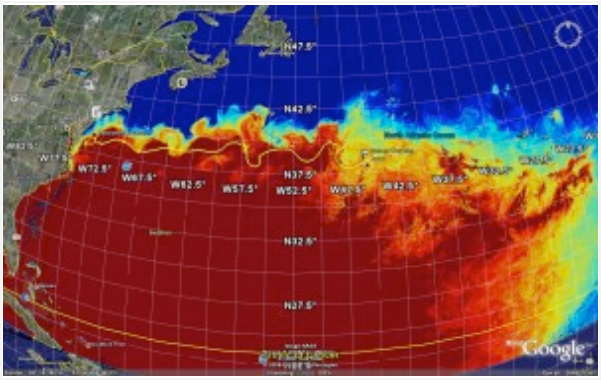
We expect this trend to continue over the next day. Currents should continue turning clockwise, first to the west, then to the northwest, and finally to the north.

1 Comment

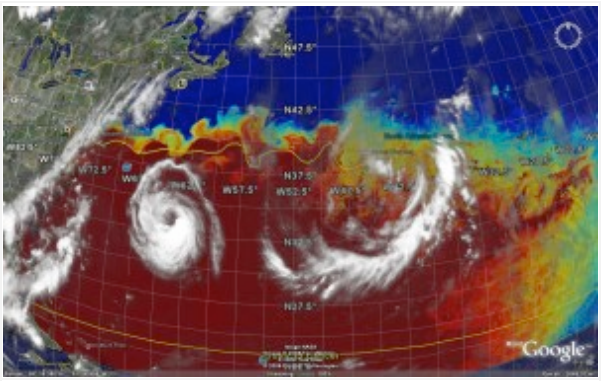
15 jul Tropical Storm Bertha

Edit Posted by: Scott in: Across the Pond Edit

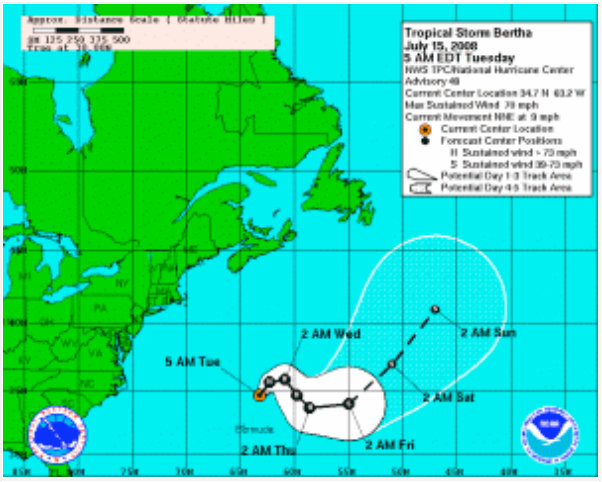
Sea surface temperature over the North Atlantic shows that RU17 is about half way across.



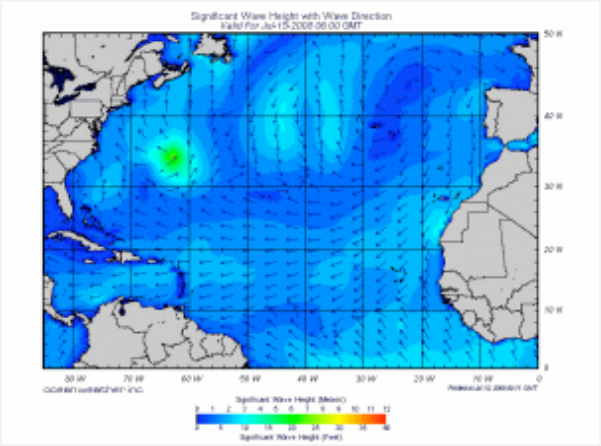
Turn on the clouds from the satellites, and you see that RU17 is currently in a nice break in the clouds, but Tropical Storm Bertha is over by Bermuda.



The NOAA 5-day forecast cone indicates that Bertha is forecast to pass to our west about Sunday afternoon. That means we will be on the right hand side of the Tropical Storm, the most severe for wind and waves.



Ocean weather currently has the waves from Bertha running about 20 ft.
We hit 26 ft significant wave heights on the trip to Halifax.
Nevertheless, we'll take a few precautions.



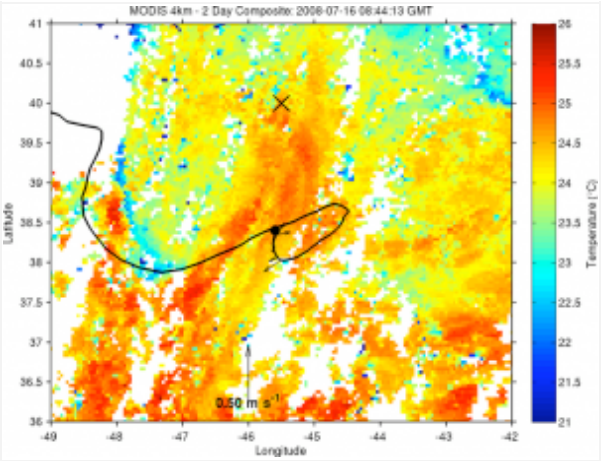
1 Comment

16 jul

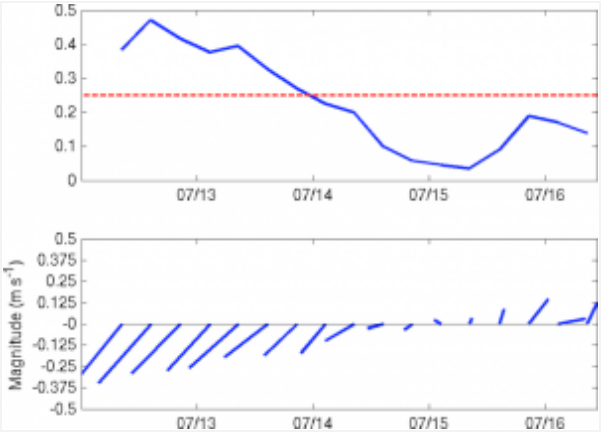
Back in the cold eddy

Edit Posted by: Scott in: Across the Pond Edit

Yesterday RU17 made great progress out of that strong jet to the southwest, and is now picking up currents from the eastern edge of the cold ring - the one with the remoras. We moved the waypoint north to where the currents turn west in the satellite altimetry.



Here's the current speed and direction time series plot. You can see how the currents switched direction on July 15th, a very happy day for all of us. We will next try moving RU17 a little deeper into the ring to try to speed things up a bit on this segment that gets us to 40 N, and a better path east.



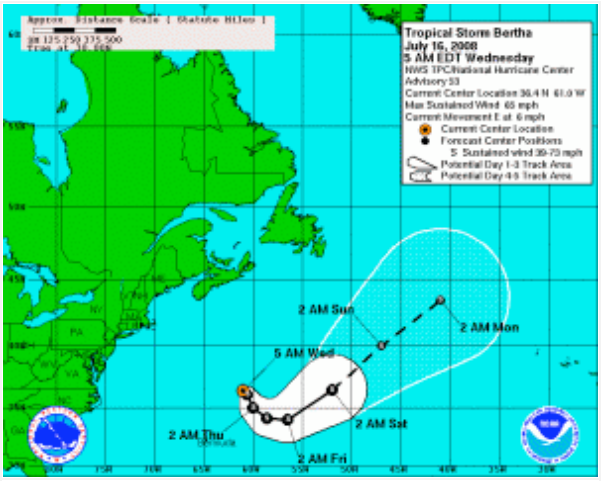
0 Comments

16 jul

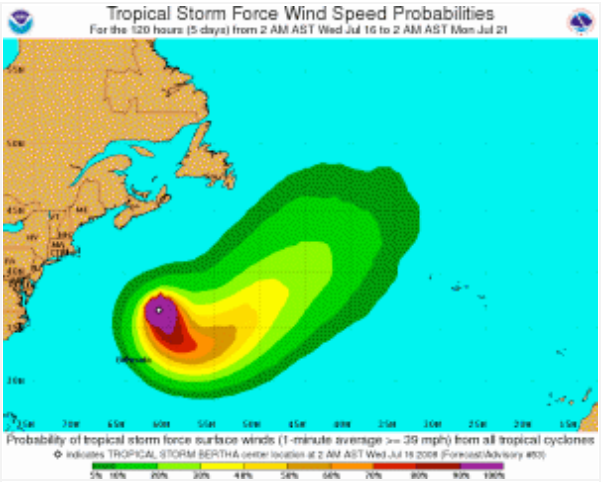
Tropical Storm Bertha Update

Edit Posted by: Scott in: Across the Pond Edit

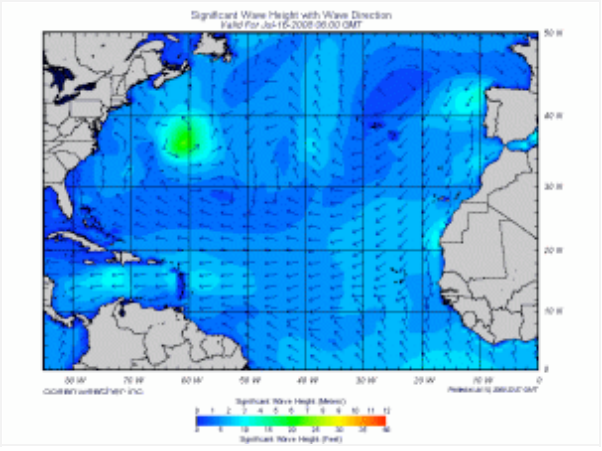
NOAA National Hurricane Center has tropical storm Bertha passing RU17 located near 40 N, 45W sometime on Sunday morning. The forecast track has it passing to our west.



Below is the forecast probilities for Tropical Storm speed winds from Bertha. RU17 is located on the right side of the track, the side with the most severe winds. If you find 40 N, 45 W on the wind probability map below, you'll see that the worst of Bertha's winds are heading right at RU17.



Below are the North Atlantic forecast waves for today from Oceanweather. Significant wave heights in the green spot associated with Bertha look to be about 20 feet high.



So a Tropical Storm is heading right at us. What do we do? Actually, there is very little we need to do. While surface vessels usually steer away from storms, gliders are robots that we typically steer into storms. When Tropical Storm Ernesto shot up the New Jersey coast back in 2006, we turned 6 gliders and headed them into the worst part of the storm. With Jim Moum from Oregon State University, we are building a hurricane hunter glider for an Office of Naval Research project. He was at Rutgers yesterday with his crew as we continuing to assemble RU10. His group installed the accelerometers that will measure waves, we talked of future modifications to the nose for turbulence sensors, and how we will want to mount an acoustic current meter for next year. Next year we'll be using the same stretch payload bay design we are test flying on RU17 right now. But this year, we'll strap all the sensors to the outside, and have RU10 sitting ready on the Jersey coast, waiting for a hurricane to come our way.

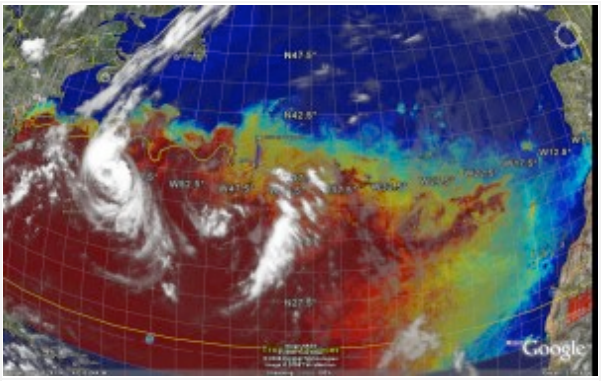
0 Comments

16 **jul**

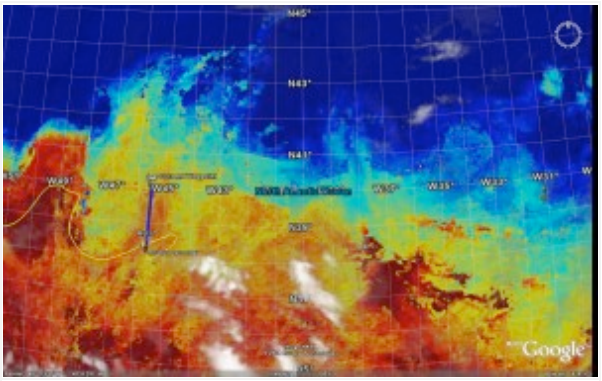
Google Earth tour of new path planning data

Edit Posted by: Scott in: Across the Pond Edit

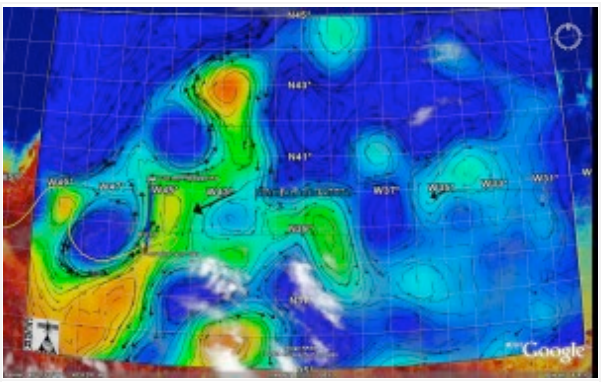
We are in the process of switching over to new data products for RU17 path planning. Here is a quick tour. Below is the gobal MODIS 4 km Sea surface temperature product from NASA enhanced for the region around RU17. We have layered the clouds from the visibile satellite sensors to show that it is clear over RU17, but Bertha lies to our west and is heading our way.



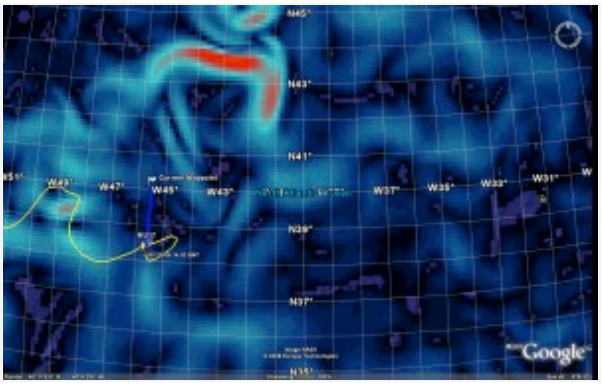
Below we zoom in to the region around RU17 and get a closer view of the sea surface temperature near RU17. the center of the cold eddy we are now in is visible. We are shooting northward along its eastern side.



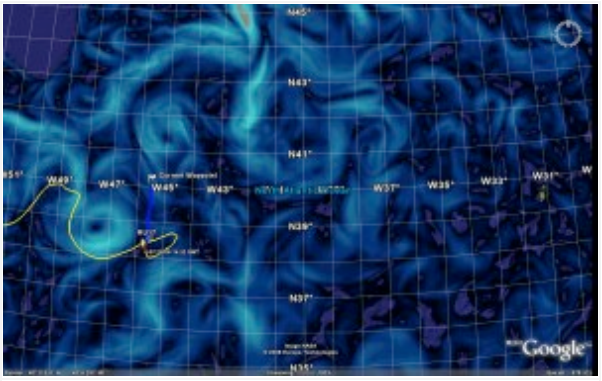
Below we flip on the sea surface height and geostrophic currents derived from the satellite altimeters by Colorado. The cold eddy appears as a stong low (blue), just like a storm in the atmosphere. RU17 is riding the easter edge north, following the currents to about 40 N where we turn east.



Below is the Navy's NCOM model. It is the lower resolution model that is used to give the larger scale feastures of the flow. Here we have contoured current speed only. We have other plots for speed and direction.



Now we zoom in to the higher resolution Navy NLOM model. Here the cold eddy appears as a strong circular motion that the model resolves. Most of the daily decision making will be made off this high resolution NLOM model.



Next we will add some new products from our friends in Spain and the Canary Islands.

0 Comments

17 jul History 102, 2003-2008

Edit Posted by: Scott in: Across the Pond Edit

The previous blog entry on our glider history (History 101) focused on the NOPP/ONR years (1998-2002) and the Coastal Predictive Skill Experiments we conducted down at Tuckerton, New Jersey in a local 30 km x 30 km box. This was before we had global communications operational on our gliders, so we used line-of-sight radio modems. This was the time period during which Tom Curtin at ONR said our mission at Rutgers was to work with Webb Research and get gliders into the operational Navy. We've been working that mission ever since.

So here we pick up our story in the early summer of 2003. Through ONR we purchased our first set of 3 Slocum gliders, and they were beginning to arrive at Rutgers. We were on our own and we had a lot to learn. The first thing to learn was how to communicate with these gliders globally. We all knew there was just not that many more years we could spend in the line-of-sight shadow of the Tuckerton Meteorological Tower before we ran out of sponsors. And there were a lot of interesting research problems out there in the world beyond Tuckerton summer upwelling eddies. Leaving our 30 km x 30 km footprint required global satellite communications, and we chose Iridium.

The problem in 2003 was that the Iridium phones, like your cell phone, could drop calls right in the middle of a conversation with your robot. You would loose all the work you had completed, and have to try to reestablish the connection. If you couldn't get a good connection, and get the required commands across, you would risk loosing your glider. Back then the Iridium cell phones we used were real phones that were disassembled and installed in the glider. RU01, our oldest glider, still has the original Iridium cell phone with the key pad still in place. We had to make them work.

Steve Ackleson from ONR visited us in May, and I felt pretty bad presenting the news. I had to tell our sponsor we had a problem, that it was critical to our development of a global glider fleet, and that I was not even close to a solution. Steve asked how long it will take to fix. I told him it would take a month, not because I knew what to do, but because I knew we had a good group we could apply to the problem. There was also one thing I learned at MIT that would help. It was simply an approach we used everyday in our work back in school. A simple three step process. Define the problem. Devise the solution. Implement the solution. Surely not rocket science. But my office-mate Steve

Koch repeated it often. Maybe the most important lesson I learned at MIT. We formed a tiger team and went after the problem, meeting early every morning to define the daytime tests and late every afternoon to define the overnight tests.

But one barricade to progress was the cost of the Iridium calls. We had hours of testing over days and days planned, and we were running up quite an Iridium bill. Iridium satellite phone time runs about $1.50 a minute. At the time, Ocean.US was running a program called the Iridium Pioneers. The program provided free Iridium phone cards for researchers developing new communication systems for ocean platforms. We went to Dave Martin, Director of Ocean.US, and explained our situation. Gliders were still a very unproven platform at the time, but somehow we managed to get Dave to take a chance on us. He managed to find one free Iridium card, but that's all we needed. I don't know if Dave even knows what a critical role he played in the early days of glider development.

Back at Rutgers we managed to set up a communication test system that monitored every character we sent to the glider as it passed by, and also monitored every confirmation of that character that came back. By testing various communication protocols over days and days, we finally concluded that you have to send information 1 character at a time, and until you see that character return, you have to keep resending it. One discovery led to another, and we finally established a way to talk to the gliders, and a Z-modem program that Tom Campbell from Dinkum Software rewrote for the gliders. Combining all these pieces resulted in a communication protocol that checked its transmissions, and if the phone connection was dropped, picked up the transmission where it left off when the connection was reestablished. In a month we were good to go.

We followed this with as series of short nearshore tests in the water with ropes attached to the glider, and everything seemed to work. By October we were ready to go. On that day we decided we were going to attempt something never attempted before. We were going to take our glider and fly it from Tuckerton all the way across the shelf to the shelf break, turn it around and fly it back. A round trip journey of 250 km. We also decided we would not just do this once. We would do it every opportunity we had, starting something that we would end up calling the Tuckerton Endurance Line. We have been flying that line for 5 years now. Data from the Endurance line can be found in papers with time scales ranging from storm events to seasonal climatologies. We continue to work with Steve on ocean optics research problems around the world.

In December of 2004, at the annual American Geophysical Union meeting in San Francisco, Terri Paluszkiewicz took Oscar and me aside to talk about our glider future. Terri wondered if we wanted to get involved with the Navy flying gliders in deepwater for assimilation in models. Even though the water was deep, gliders in the upper 200 m possibly could provide assimilation data for the more rapidly changing upper layer of the ocean that was influenced by the atmosphere. Of course we agreed. We needed the work. The catch was that SHAROM 149, as it was called, was taking place in the Pacific in January, and we would have to work over Christmas break to prepare. The other catch is the Navy did not want just a single glider, they wanted a fleet. Even on Christmas day I found myself on the phone with Clayton Jones from Webb Research, working on the details of assembling the fleet.

But then on December 26, the Tsunami hit. What had happened to our colleagues in Indonesia that just spent the fall semester with us and had recently returned home? We still don't know for sure. I remember talking to Clayton on New Years Eve. We were beginning to realize that every available Navy ship in the Pacific had been diverted to Indonesia for Tsunami relief. Our ships were gone, and without ships, we figured our exercise would be cancelled. Within a few days everyone's thoughts had been officially confirmed, and the mission was scrubbed. But after seeing the events on TV in Indonesia,

missing a bit of Christmas did not seem like such a big deal anymore.

That put us on tap for SHAREM 150, which was to take place in the spring in the Sargasso Sea. Our mission was to assemble a fleet of four gliders, deploy them for the first time from the big Navy research ships from the four corners of a large box, and fly them into the center from over the horizon, rendezvousing in the middle and clustering for pick up. We needed four gliders to work, so as usual, we sent 5. The extra glider is there in case one is lost, for whatever reason, and is also the simplest way to ship a complete set of spare parts in case they are needed.

The mission was a game changer for the Navy. The models that assimilated the data performed better than expected. A severe storm occurred that caused the surface ships to divert, suspending their mission to leave the area, while the 4 gliders continued flying and sampling the ocean, sending their data back to Navy for assimilation in the models. They kept us there longer than expected, not allowing the Navy white ship return to port before the exercise was over. At one point we even transferred control to NAVO at Stennis Space Center, letting their glider pilots send one of the gliders whipping around an eddy they could see in the altimetry to speed its progress towards a central recovery point.

Now that we had the Navy's interest, we had to make the gliders more robust, more rugged. The Navy envisioned fleets 10 times the size of our simple fleet of 4, and that would require robust gliders that requires minimum maintenance to deploy, pilot and recover. In response, Terri started the ONR Glider Consortium, made up of the top groups working with the Slocum, Seaglider and Spray gliders. Many of the improvements that were made and tested as part of the Glider Consortium are now installed on RU17. Probably one of the most significant, and certainly the most noticeable improvement, is the new short Digifin tail on the gliders. We had several failures based on the old design that have now been eliminated with the new fin. And the fin is no longer a delicate failure point. In one Digifin test, we appear to have been dragged by a fishing vessel near the shelf break. The dragging snapped off one of the wings, but the fin remained intact. The glider flew back to shore with 1 wing and a tail fin to compensate. On recovery we found scratches over the entire body, but a perfectly intact Digifin. Our electrical engineer, Dave Aragon, said the digifin is the most important improvement that has been made to the Slocum Glider to enable long-duration flights.

The NSF Coastal Ocean Processed (CoOP) program then came along and funded the Lagrangian Transport and Transformation Experiment (LaTTE) in the Hudson River Plume. Our experiment was to inject dye in the plume, and follow it downstream, observing the transformations of the biology and the chemical properties of the water as it flowed through a highly instrumented coastal ocean observatory. In each of the spring field seasons of 2004, 2005 and 2006, Oscar deployed a glider from the biology boat that we then controlled from shore in the COOLroom. In the COOLroom we used the satellite, CODAR, and Glider data to provide a 3-D context for the two ships at sea, coordinating their activities through daily briefings and 24/7 access to data. Oscar, Josh and I talked about the coastal observatory and the LaTTE program at the U.S.- E.U. Baltic Oceanography meeting in Lithuania in May 2006, 1 week after we were out of the water.

Rick Spinrad, one of the Assistant Administrators at NOAA, saw our talks, and new exactly what buttons to push to get us going. He sat us down, and said he has something for us to do for the good of our country. He first wanted us to read the Gathering Storm document prepared by our nations economic leaders about the need to entrain more students in Science, Technology, Engineering and Math (STEM) careers. He then gave us three grand challenges. First was to demonstrated flying gliders in coordinated fleets. Second was to fly the gliders into hurricanes to gather data in the interface between ocean and atmosphere in severe conditions. The third was a long-distance flight of inspiration.

Rick asked us to take one of our gliders, modify it, and fly it across the Atlantic on a mission that would inspire the public and entrain students in STEM careers. Wow. We had a lot of work to do.

We checked the first box in an ONR project, the Shallow Water 2006 Joint Experiment to be conducted on the NJ coast in the summer of 2006. Terri managed to increase the size of our glider fleet with 9 new ONR owned gliders. We flew a formation of 6 gliders along parallel cross-shelf lines where we would assemble then sweep across the front to the other side, providing data for assimilation in the models and information for the daily reports to coordinate up to 6 ships that were operating in the area. The experiment was 2 months long, plus spin up and spin down. This experiment required us to switch from our LaTTE model of 24/7 coverage in the COOLroom for 1 week to distributed coverage from anywhere in the country that could be sustained for 3 months. In trying to solve this problem, Hugh Roarty came up with the brilliant idea of letting McDonalds provide the internet infrastructure. McDonalds and Starbucks all over the country provide access to WiFi. All we needed to do was provide the capability to browse the observatory datasets from a laptop, and we had the problem solved. We managed to coordinate the whole experiment from my laptop, running the glider fleet and sending out the daily morning reports from whatever McDonalds I could find.

SW06, shorthand for the Shallow Water 2006 Joint Experiment, also provided us the opportunity to check off the second item. We had a single glider that was on the Endurance line get hit by Hurricanes and Tropical Storms before, but we never did a purposeful deployment. During SW06, Hurricane Ernesto propagated up the U.S. east coast, was downgraded to a Tropical Strom, and then in the Mid Atlantic, transitioned into a sever extratropical storm. We saw it coming, and when the surface ships diverted, we turned the glider fleet and flew it straight into the storm. The dataset was amazing, especially related to the turbulent mixing. With ONR funding, we are now working on a Hurricane Hunter glider with Oregon State University. The glider will use the stretch payload bay, have turbulence sensors, acoustic profiling current meters, accelerometers for waves, and optical sensors for sediment transport. We assemble the system every summer and sit it on the New Jersey shore, waiting for a hurricane to come by.

That brings us down to Rick Spinrad's final grand challenge. To fly a glider across the Atlantic in a way that inspires young people to take up math and science. This was a bit more difficult, because no glider actually existed that was capable of this. The other issue was funding. The Glider Fleet was funded by ONR. The Storm Glider was funded by ONR. But what agency would fund something as risky as an attempt to cross the North Atlantic with underwater robot? Turns out no one would do this with public money. But private money, that's different. Through the generous support of Rutgers Alumni, we were able to acquire sufficient funds to purchase a new glider to dedicate, and potentially loose, to this mission. NOAA also needed the Lithium batteries tested to support one of Reg Beach's NOPP projects to put some high powered biological sensors in the extended glider payload bays. The new sensors likely will require the high power density of Lithiums to meet the sampling requirements. We needed to test the batteries, and Reg said we should do something exciting with the battery test. So now we had a vehicle, provided by private donations, and a need to test batteries, provided by NOAA. The long-duration mission was a go. It would be enabled by the experience gained through numerous short-duration coastal missions in foreign waters including the Mediterranean, the Baltic, the Irish Sea, the Sargasso Sea, off Australia, and finally, off Antarctica. Oscar and Josh will tell those stories. Now it was time to build, test and deploy RU17.

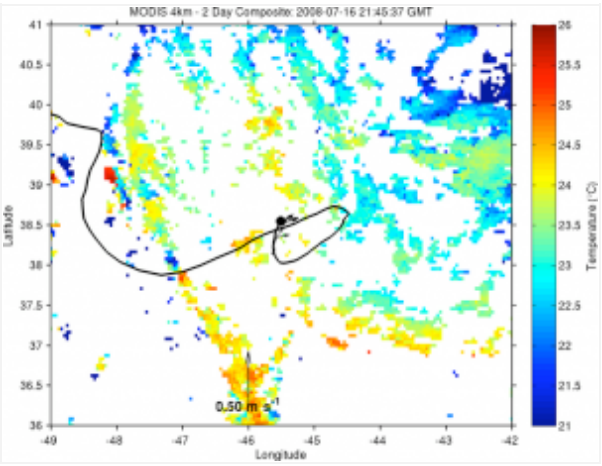
0 Comments

17 jul

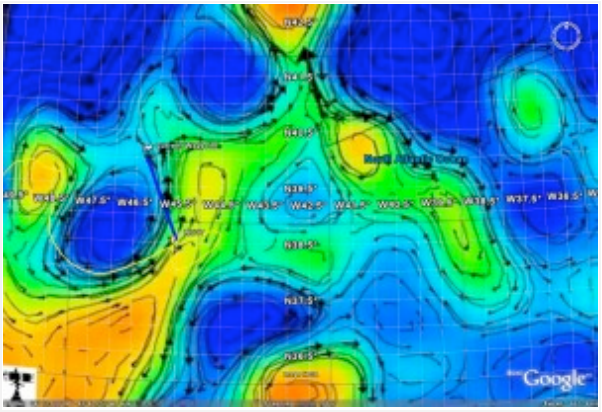
Heading to 40 N on the NLOM highway.

Edit Posted by: Scott in: Across the Pond Edit

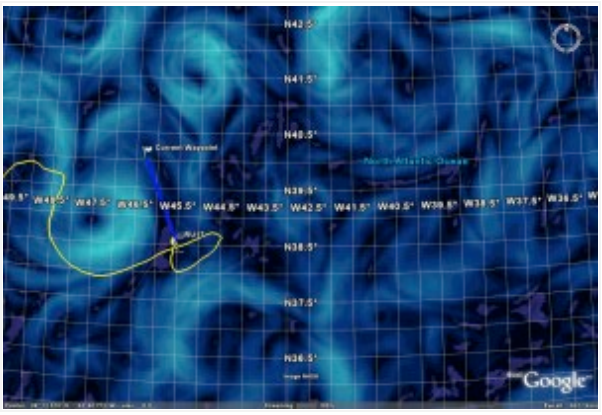
Below is the satellite sea surface temperature data from the last 2 days. White is clouds. Colors are ocean. There are lots of clouds. Currents at location of RU17 are to the norteast. We are looking for the northward currents associated with the cold ring.



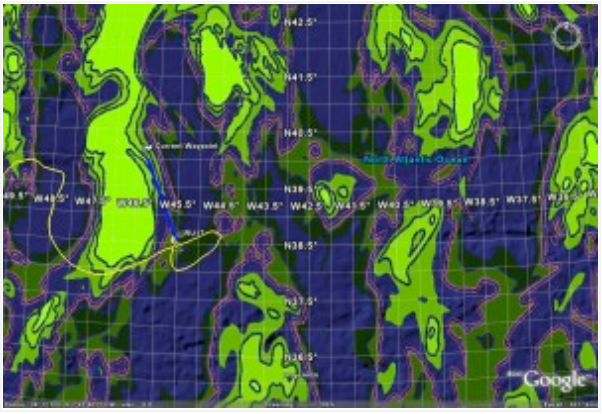
Satellite altimetry says we are on the outer edge of the cold ring (the blue low in the sea surface height to our west). We should be seing increasing currents to north. The idea is to ride this current north till we see the currents heading east around 40 N.



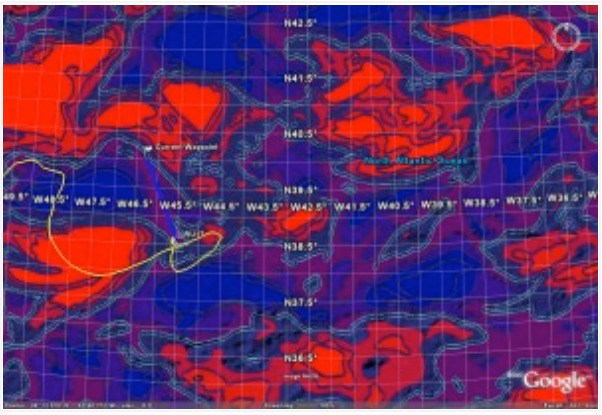
Below is the Navy NLOM model, with current speed plotted. Strong currents are lighter colors. In the model the cold eddy is farther west, and we are not quite in it yet. Either way, we are moving the next waypoint for RU17 to more aggressively seek these stronger currents. Yep, that means a turn to the northwest. I know how much everyone hates to hear us talk about heading west to go east.



Below we plot the north/south component of the current from the Navy NLOM model. The model has strong currents to the north shown as the bright green just to our west. This is our highway to 40 N.



Why 40 N? The Navy model also has strong currents to the east up there. Here is a plot of the east-west components of the navy model velocities. At 39 N. currents are heading west. Along 40 N, there is a long band of bright reds indicating currents to the east. That is where we are headed.



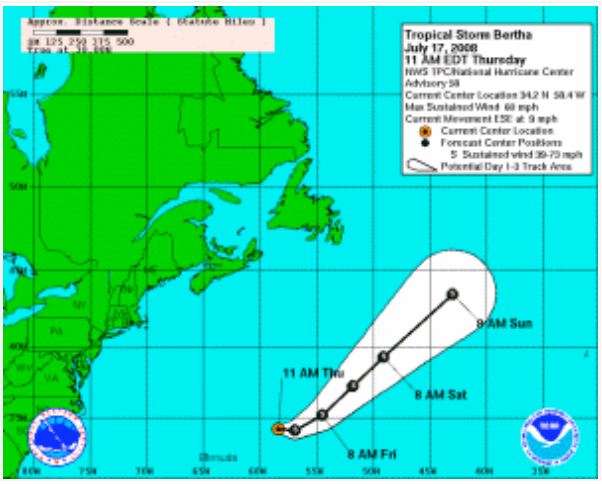
0 Comments

17 jul

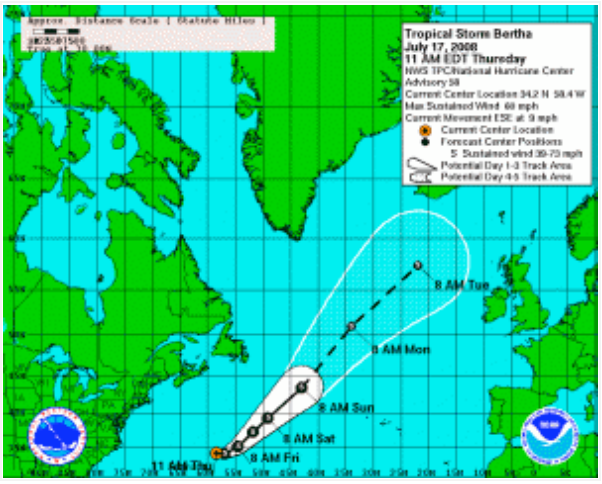
Tropical Storm Bertha - Sooner than expected

Edit Posted by: Scott in: Across the Pond Edit

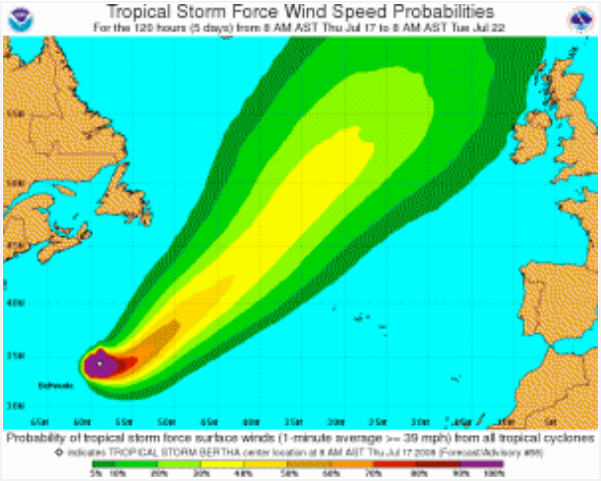
This morning's NOAA forecast has Bertha increasing its speed to the northeast. It now looks like it will arrive near RU17, about 40 N, 45 W, sometime between 8 am Saturday and 8 am Sunday.



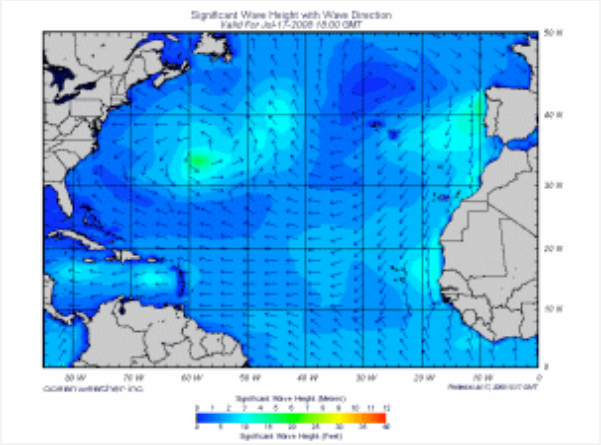
5-day forecast cone has it continuing Northeast between England and Iceland.



Tropical storm winds below still have the worst winds heading right at us.



Waves in near that 20 ft high mark in Bertha, but are starting to pick up in the vicinity of RU17. We are up to 10 ft significant waves. We also have clouds.



The main precaution we will take with RU17 will be to change its dive behavier. We were going to do that on saturday, but now it looks like we'll do it earlier, likely friday morning. We don't want to wait too long in case the waves get high and we have problems communicating. Then it too late. The modification is simple. This is not our Hurricane Hunter glider, RU10, so we have no real need to go all the way to the surface unless we want to communicate. Instead of rising to a depth of 5 m for each undulation, we will turn RU17 at a deeper depth, likely 25 m. This will let the worst of the storm blow over out top. We will also shorten up the bottom of each undulation. No need to take a chance on the extra pressure forcing from waves. Instead of stretching ourselves to our 100 m limit to stretch our power, we will only dive to about 90 m, giving us a 10 m margin of safety at the bottom.

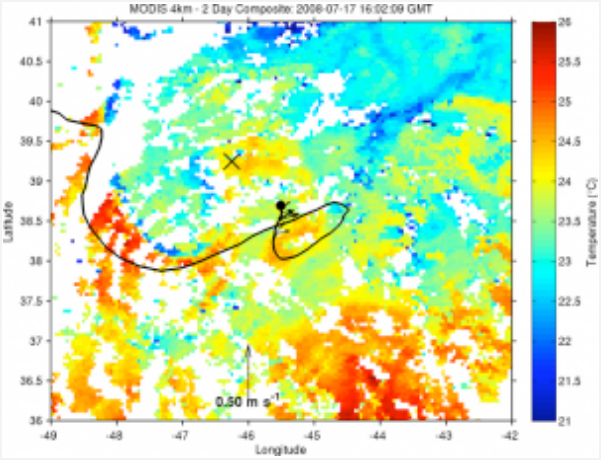
0 Comments

17 jul New SST Imagery - NLOM was Right!

Edit Posted by: Scott in: Across the Pond Edit

Check it out! New Sea Surface temperature data just in, and the cold ring is clearly visible! Justin, you know what to do. Get us into the northward currents. We have

a good plan for the night.



Meanwhile, we are back at a small, unmarked yellow warehouse somewhere near Pearl City. Chip recovered RU05 yesterday, and is replacing the attitude sensor. The problem child is the small board Chip is holding. We had an intermittent on it, and we can't really fly efficiently if the attitude sensor is flipping on and off on its own.

The radio in the background sitting on the wall beam is playing essential songs of the 80's for the guys working the forklifts in the warehouse. But we are getting a lot of Peaceful Easy Feelings coming across. We're working to get RU05 fixed up and back in the water tomorrow. Bad weather for small boats is coming on Saturday, so we need to get back out tomorrow before the wind kicks up.

Meanwhile we set up a couple of laptops on top of an overnight shipment of Viking life saving equipment. My laptop is checking on RU17 as we transfer all the mission logs from RU05 back to Rutgers. All from a simple phone modem connection. Chip is linked to RU05 via a radio modem to check out his fix.

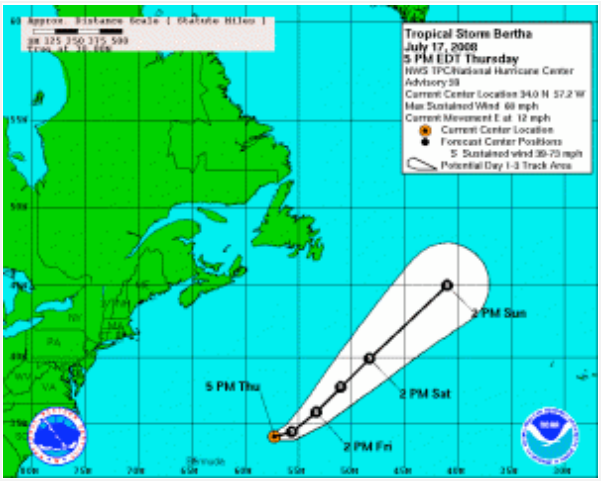
0 Comments

17 jul

The Scarlet Knight meets T.S. Bertha - 2 pm Saturday

Edit Posted by: Scott in: Across the Pond Edit

5 pm update from the Hurricane Center. Tropical Storm crosses 40 N about 2 pm Saturday. Thats when we'll be seeing some strong winds. We'll be making ready Friday morning, 24 hours in advance.



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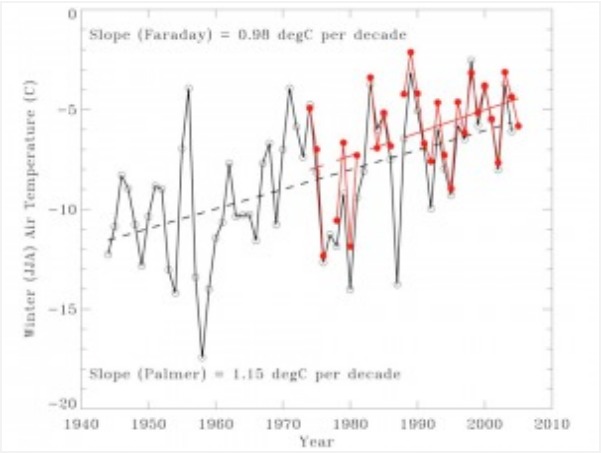
17 jul

History 103, Where did RU17 come from?

Edit Posted by: Oscar in: Across the Pond Edit

The voyage across the ocean highlights the ability of the gliders extending from our backyard offshore New Jersey to now feeling confident to send them to extreme ocean environments which historically are difficult to work in. During my graduate school years I was lucky to join a host of labs (Drs. Barbara Prezelin, Raymond Smith, Langdon Quetin, Robin Ross) working in the Antarctica along the West Antarctic Peninsula. This region of Earth is characterized by major zones of sea ice, icebergs, and extremely large storms that produce epic waves. It was descibed by early explorers as the land of gods, and it is. This region is also changing. As the world warms, ecosystems are changing. Understanding the ecological consequences is critical as the magnitude and pace of the predicted warming will produce novel climate conditions. The Western Antarctic Peninsula (WAP) is undergoing the most dramatic climate change on Earth .

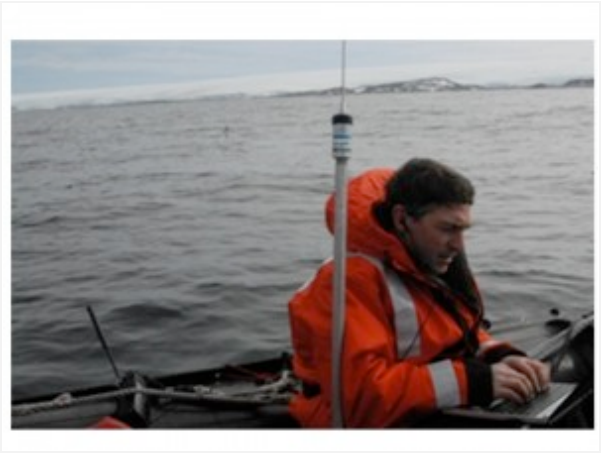
The WAP region has experienced a significant winter warming during the past half century (5.4 times the global average). The figure below shows the air temperature changes at two different stations. over the last 50 years. This warming has shortened the sea ice season and perennial sea ice is gone. The maritime system of the northern WAP is expanding southward, displacing the continental, polar system of the southern WAP while 87% of the glaciers are in retreat. Associated with this warming has been a climate induced migration in the WAP ecosystem spanning the plankton all the way up to the penguin populations. We do not understand what is driving the temperature changes or the most dramatic factors driving the ecosystem changes. We know the decline of ice is driving one of the largest and most rapid climate induced shifts in a marine ecosystem on Earth . A project, the Long Term Ecosystem Research (LTER) has been conducted in the WAP for over 18 years. The project was just starting as I was finishing graduate school, and was ongoing when I eventually joined Rutgers in 1995. The history of the next period was highlighted in the blog "History Lesson 102". The Palmer LTER is dedicated to study the processes underlying these changes and its impact on the ecosystem. In summer 2006, i was asked to attend a conference in Washington DC a steamy August. I was lucky to joined by some old friends, Mark "Bull Dog" Moline (an old Antarctic buddy and part of the immediate COOL family) from Cal-Poly, Doug "Bam Bam" Martinson from LDEO, Gary "Nice Guy" Kirkpatrick, and Clayton "Sloccum" Jones. After hanging with a bunch of smart people, when we were waiting for cabs to the airport in the hotel lobby we were encouraged to submit a small exploratory grant to test Glider tecnology in WAP. It successful it might provide a unique tool to study the WAP climate change.



We submitted a grant to the National Science Foundation, and were very lucky to be funded. By December 2006, two gliders were shipped to Antartic, traveling by frieght from New Jersey, to California (the Navy base in Port Hueneme), to Punte Arenas in Chile where they placed aboard the Research vessel Gould, and shipped to Antarctic. The person drafted for the field deployment was Clayton Jones from Webb Research. Arriving in Palmer just after the new year in 2007. While he was preparing the glider for the deplyment, Scott and Oscar was joining a team to provide a series of talks to the University of Tianjen and the Port of Tainjen in China. On the 7th of January, a glider was launched from Palmer Station by Clayton, working Josh Kohut in the COOL room in New Jersey. A picture of him contorlling the glider of Palmer is shown below.

The glider data was processed in near real time, and Scott and I were shipped data over the web. This data collected in the Southern ocean was less than an hour old, when it was placed into our talks for the officals from Tianjen. The idea that a data was being transported across the world was truly mind boggling for us old crusty oceanographers. The glider was also recieving press in the Philadephia Enquier, the Asbury Park Press and other papers. Unbeknowst at the time, a benefactor read these articles about Josh, a former Rutgers graduate student conducting a global climate change robotic experiment, and with great kindness contacted us on what would be a great next journey. Scott, Oscar, and Josh had already recieved the pep talk and challenge from Dr. Spinrad from NOAA, and we suggested a glider to cross oceans to inspire the next generation of the scientist and engineers. This was sufficient to gain the confidence of this donor, and we were graciously given the funds to acquire a glider, which is ru17 which now is deep in the Atlantic alone this evening,,, not even a remora for company.

For those interested in the Southern ocean, how did it work out? The glider was the first robot to cross Antarctic circle, it collected over 1200 vertical profiles (the LTER had despite heroic efforts has collected just over 2400 profiles in 18 years using traditional techniques), and has found interesting information related to the why penguins feed where they do offshore Palmer Station. This coming year the COOL team joins the LTER and we will focus on suing gliders to provide a more sustained presence in the Southern Ocean. The long duration journey and new battery technologies in Ru17 will be critical to allowing the gliders to achieve the scientific potential we hope for. Given that, the we toast ru17 tonight, its history of where it came, and the future it will usher in in the coming years.



0 Comments

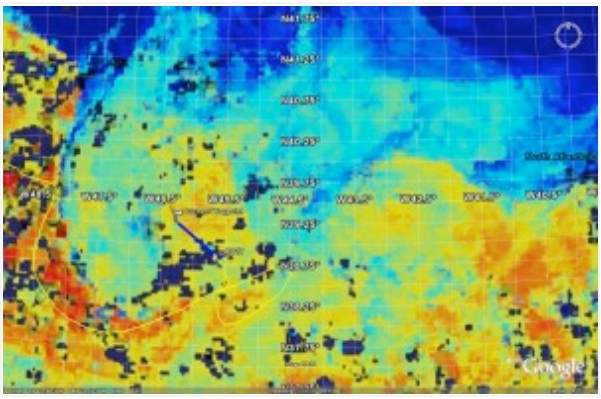
18 jul

The Google Earth Morning Report

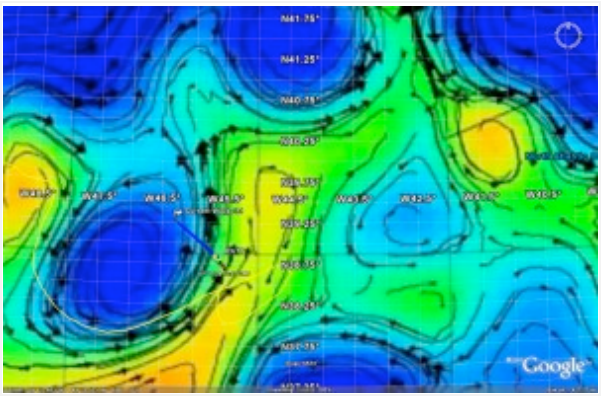
Edit Posted by: Scott in: Across the Pond Edit

Its still morning in Hawaii.

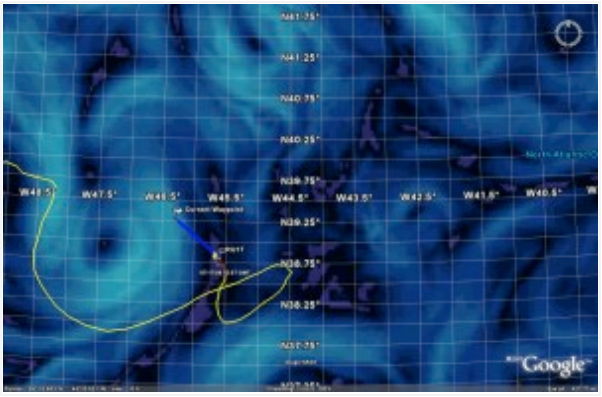
Satellite Sea Surface Temperature (below) shows the cold eddy centered along 47 W - a big bonus we found last night. We are heading across the warm waters that are being pulled counterclockwise around this strong feature.



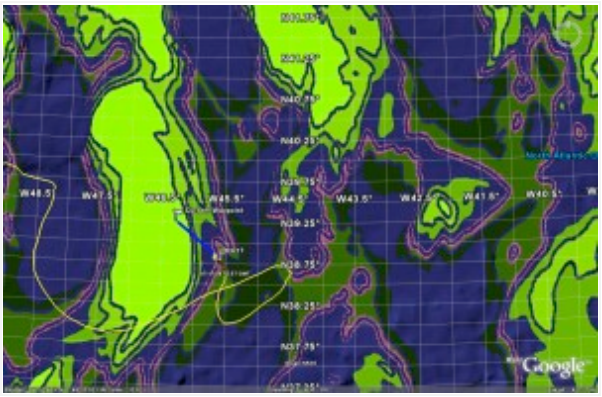
Altimetry (below) has us already in the eddy, but currents are slow. its that space-time thing with altimeters. The data makes a big difference when the satellite passes overhead, but then you have to wait several days for another overpass.



So the models do the space-time interpolation for you. Below in the current speed plot the NLOM model says we are heading into the fast swirl velocities associated with the ring. We have to be a bit cautious, we don't want to fly to deep into the eddy and repeat the events on the trip to Halifax. On the trip to Halifax, we made a second loop around an eddy, partly because we wanted to try it and we knew we had the battery power to spare. Here we don't want to do any extra loops we don't have to. We have already had our eastward progress stopped twice by unfavorable currents on this trip. In each case we had to find a different route around an eddy. We will have more of these that we don't expect, so we don't want to do any additional loops on purpose.

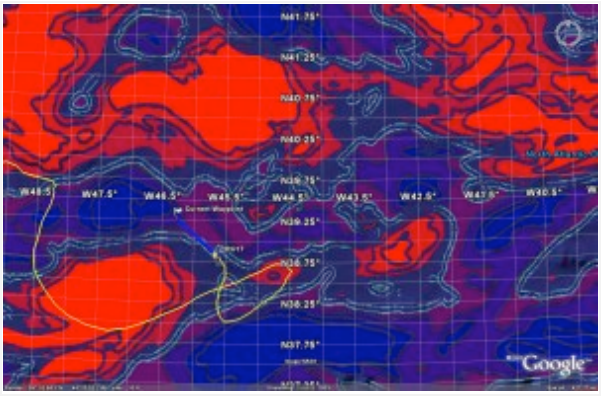


Below is contoured the north/south component of the NLOM currents in green. That strong band of currents to the north in bright green is out target.



Once in that green region, we head north to 40 N, we we see a lot of red spots in

the image below. The bright reds are strong currents to the east. That is where we want to be.

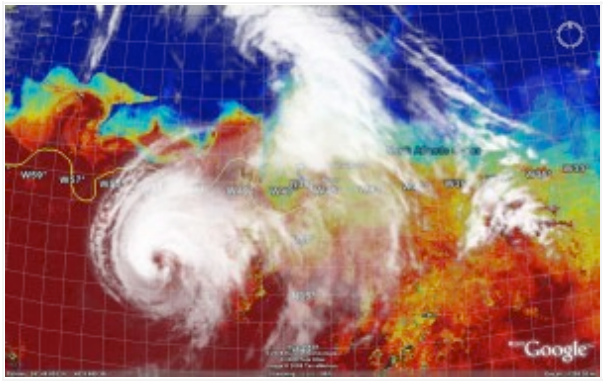


0 Comments

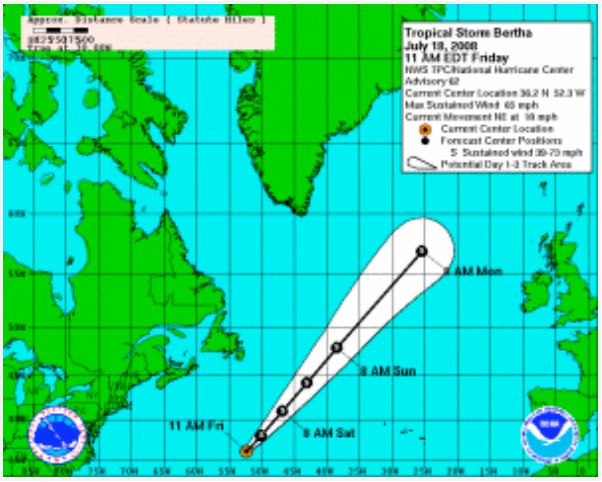
18 jul Bertha Approaches

Edit Posted by: Scott in: Across the Pond Edit

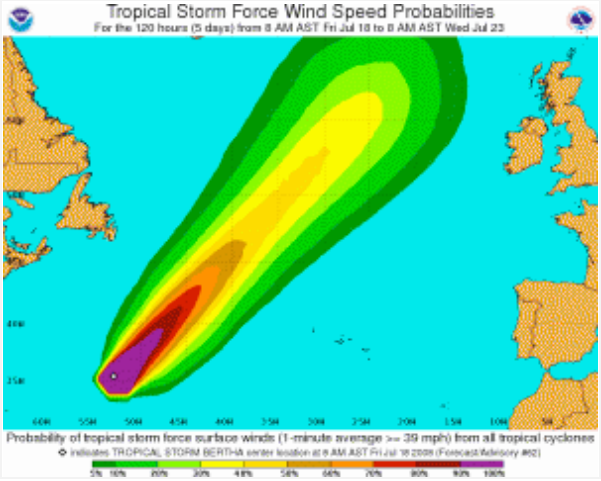
Below image shows RU17 flying in the break in the clouds just to the northeast of Tropical Storm Bertha. In this image, the colors represent sea surface temperatures. White are the clouds that we can't see through. RU17 is barely visible in the break, but the break was clear enough to give us a good look at the cold eddy described in the previous posting.



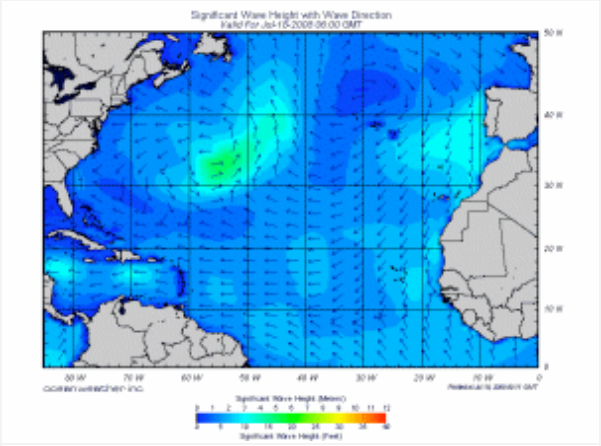
NOAA National Hurricane Center has Bertha forecast to track straight to the northeast, right at us. We should start feeling the effects of Bertha early Saturday morning.



The track is narrowing, with the very highest probability of Tropical Storm winds just a bit to our west. We are essentially directly in the path of storm.



The waves are picking up in that region between Bertha and that band of couds to RU17's north.



Hugh completed rigging RU17 for the storm this morning, sending the new flight

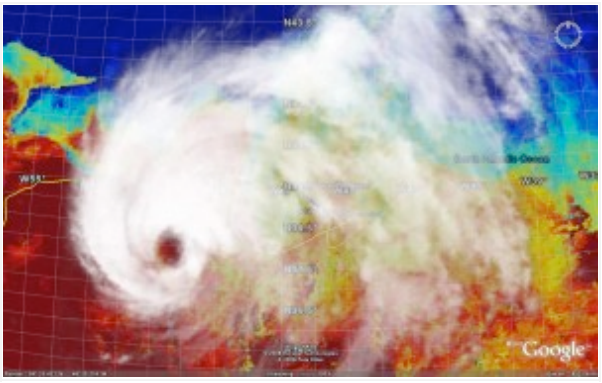
pattern to the glider at the noon surfacing. We will fly between 25 m depth and 90 m depth till the storm passes. Then will go back to our more energy efficient pattern after it passes.

0 Comments

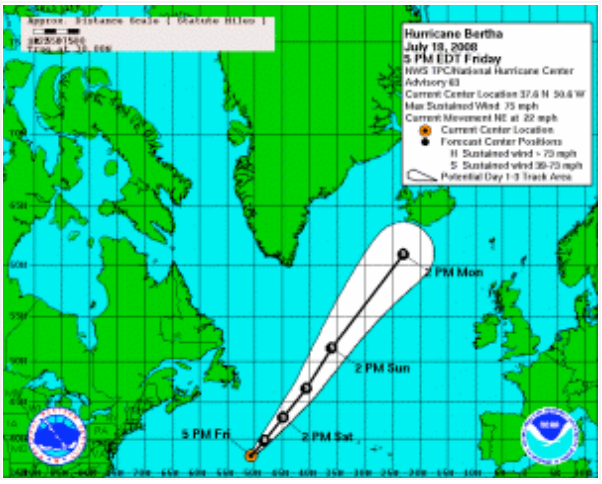
18 jul Getting to know Bertha

Edit Posted by: Scott in: Across the Pond Edit

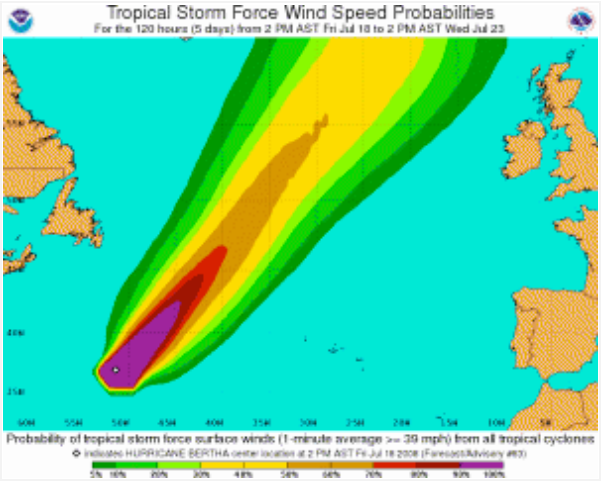
Tropical Storm Bertha's outer cloud bands are starting to pass over RU17.



Bertha's eye should pass by RU17 early tomorrow.



RU17 is pretty much assured of getting tropical storm force winds.



RU17 is already rigges with a modified flight plan with a standard stay deep behavior, the same one we ised to avoid the fishing gear as we crossed the shelf break a couple months ago. Tonight, at the 12 midnight surfacing, Hugh will turn RU17 to the north. We'll run north with the currents, the winds and the waves. A following sea. If we are on the wrong side of the storm for the winds, we are on the right side of the ring for currents. The currents on this side of the ring are the same direction as the waves. Just ask anyone here in Hawaii what happens when the currents are opposing the waves. We just saw it firsthand with today's RU05 deployment.

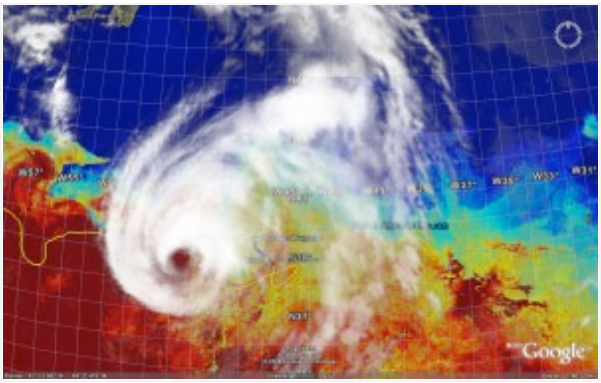
0 Comments

18 jul Eye to Eye

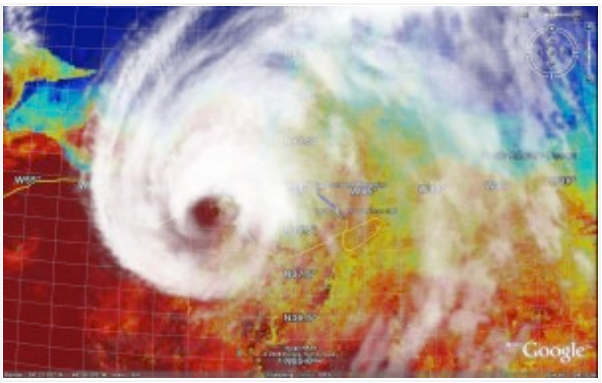
Edit Posted by: Scott in: Across the Pond Edit

Rick:

When we talked about crossing the Atlantic and flying into Hurricanes 2 years ago, I was originally thinking they would be separate missions.



Now a close-up of the Scarlet Knight and Bertha, side by side.



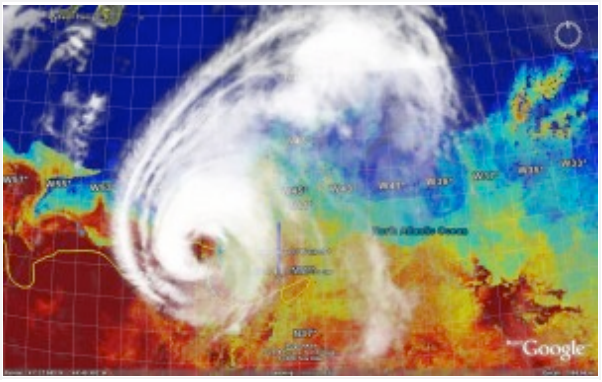
0 Comments

19 jul

Rigged and Ready

Edit Posted by: Scott in: Across the Pond Edit

Hugh sent RU17 straight north. Justin's blue line indicates RU17's course. We are on the right side of the Tropical Storm, the side with the most intense winds. RU17 reported increasing currents to the north.



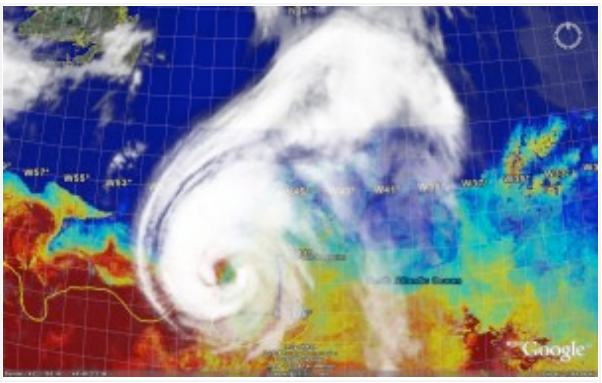
0 Comments

19 jul

Bertha crosses our track

Edit Posted by: Scott in: Across the Pond Edit

Bertha is moving northeast, crossing the track of RU17. We are just to the right of this propagation direction, about 200 km from the eye wall, in the outer cloud bands. Looking down through the eye, Bertha will soon cross into the colder water to our north.



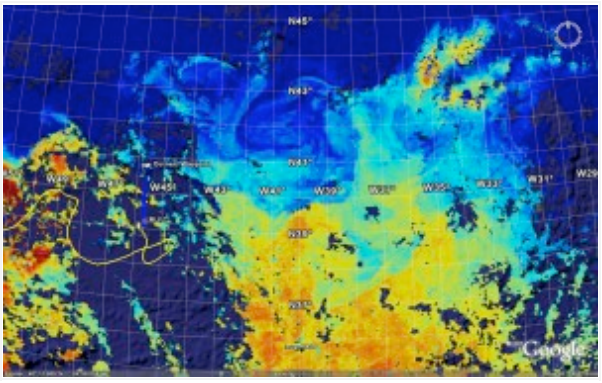
0 Comments

19 jul

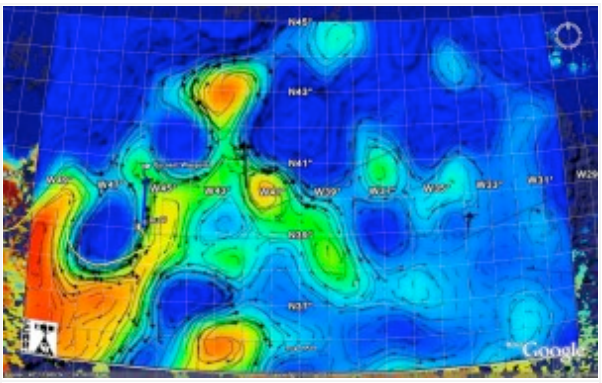
Weathering the Strom, Riding the Rings

Edit Posted by: Scott in: Across the Pond Edit

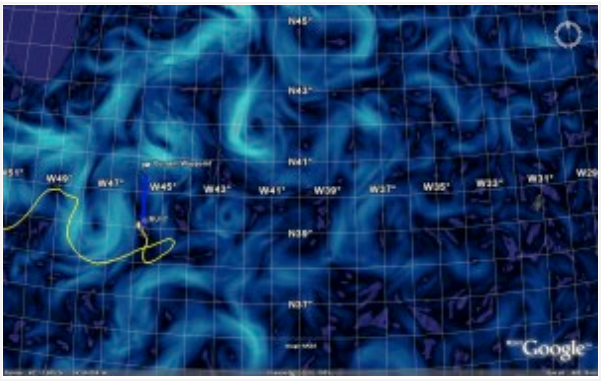
Gulf Stream forecasters love storms. The storms mix up the surface layers, and instead of looking at a uniformly warm but thin surface layer, you get to see the horizontal gradients associated with the deeper flows. In the case below, the eddy structure is clearly visible in the sea surface temperature image. When you get images like this, they are very valuable, because they are instantaneous. They show the actual shape of the features. Our eventual goal is that strong cold eddy near 42 N between 40 W and 43 W. We want to ride its southern side. You also can see some of the warmer eddy to the northwest of the cold eddy. RU17 is in clouds (the black regions in this enhancement).



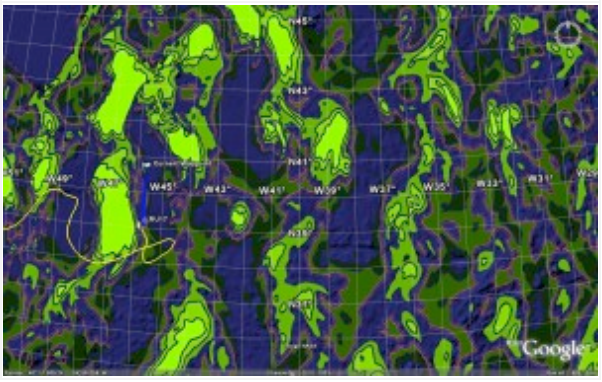
Below the altimetry is in excellent agreement with the satellite sea surface temperature The cold eddy (low in blue) we are going for is clearly outlined, and we see the warm eddy (high in red to the northwest). The problem here is that the cold eddy RU17 is trying to use today is located under the clouds near 39 N,47 W. According to the altimetry, RU17 is crossing through the strongest nortward currents associated with that eddy. We know that is not the case. RU17's currents remain below 20 cm/sec, very week. So the altimetry, a several day composite, is smearing this feature and we need to wait for another overpass to refine our current estimates in this region.



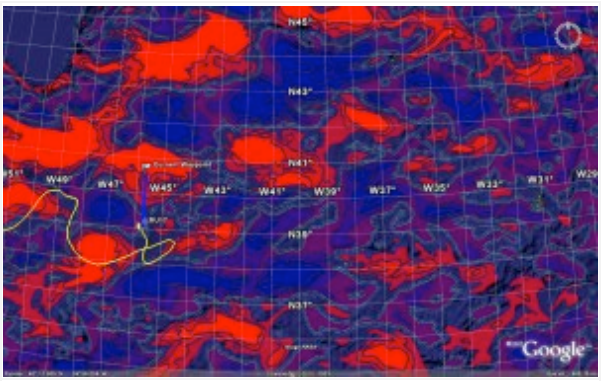
Once refinement is to use a dynamical model, in this case the Navy's NLOM model that does the dynamic interpolation of the altimetric field to try to eliminate the smearing in time and space you get from raw altimetry. The dynamic constraint is the the interpolation requires F=m*a, a significant constraint since the apple hit Newton on the head. In this dynamically constrained interpolation (current speed contoured below), the eddy we are looking to ride is still to our east.



Below is the countours of north/south velocity, and we still want to steer into those strong currents to the north.



And find those strong currents to the east (bright red) we see here associated with that eddy.



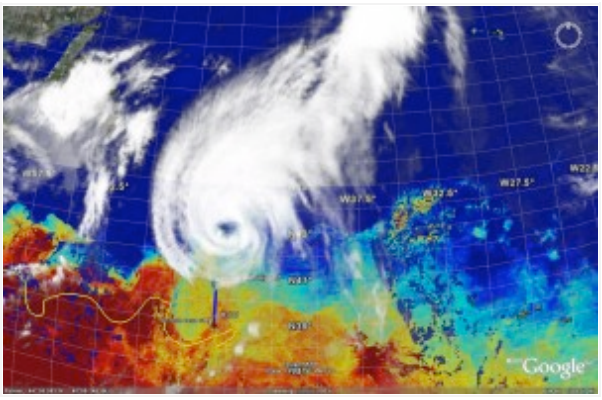
0 Comments

19 jul

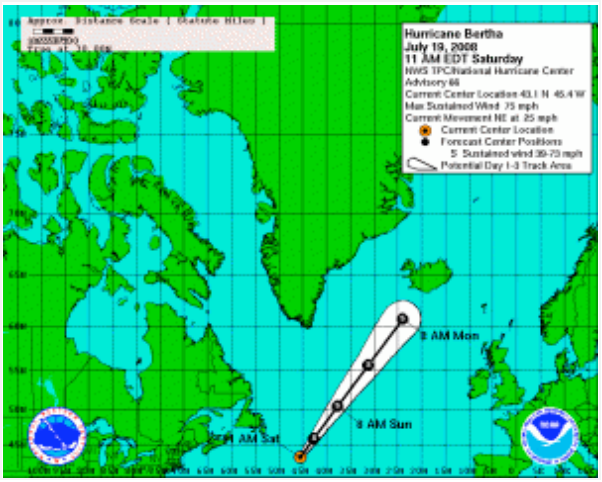
Hurricane Bertha heads off to the Northeast

Edit Posted by: Scott in: Across the Pond Edit

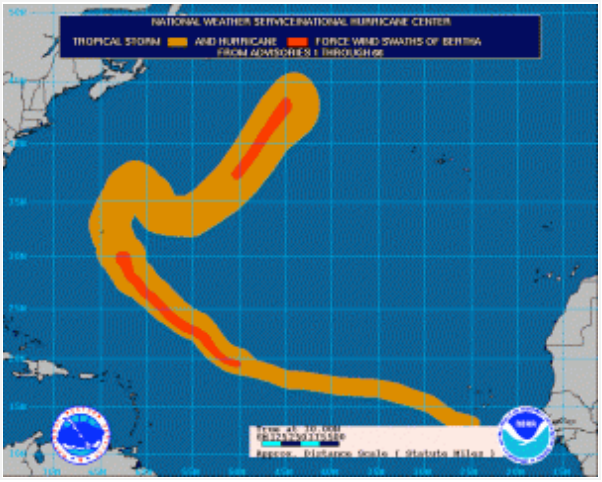
That was fast. Hurricane Bertha is now over the colder waters to the north of RU17.



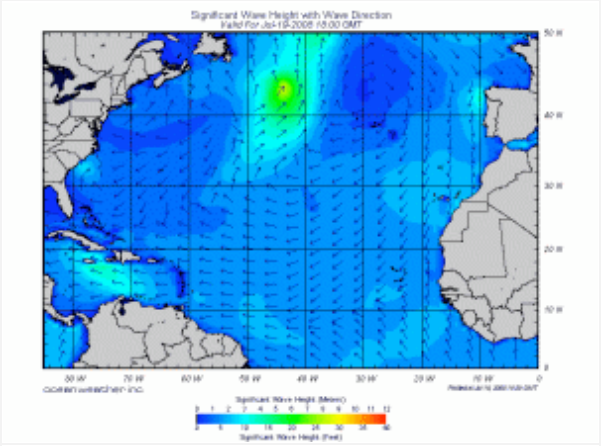
The forecast below shows the hurricane is going to continue tracking rapidly to the northeast



Amazing how as it was approaching us, Bertha dediced to reintensify, going back to Hurricane force winds. RU17 was in the region with the tropical storm winds (orange), with the hurricane winds just to our west (red).



Waves are now peaked at about 30 foot significant wave height. Wow. We were in 10 foot waves during yesterday's glider deployment in Hawaii. 30 footers in the North Atlantic, hard to imagine.



With the storm now past, we can go back to our more efficient flight pattern, and head into those stronger currents we see in the Navy NLOM model. Justin loves to take the wheel. Lets see where he takes us.

0 Comments

19 jul

Riding out a Storm on the Open Sea

Edit Posted by: Oscar in: Across the Pond Edit

The Scarlett Knight is being impacted by the storm, given its slow speed there are only a few strategies, such as sling shotting forward in favorable currents, etc., but for the most it is just a time of riding out the storm. Whether you read the Perfect Storm, Sloccum's diary, or experincing it live, there are few things as epic as being at sea during large storms. These are violent and quite often organic experiences. Along those lines, i found a few passages from Captain Joshua Sloccum's mission around the world, that can captures exerpeince in fine form as we relax knowing we are not in the North Atlantic being buffted by Bertha.

Passages from the "Sailing alone around the world" by Capt. Joshua Slocum (Sheridan House Publishers). The Scarlett Knight is a Webb Glider named after Joshua Slocum. The passage starts after taking his provisions at the Azores.

"Plums seemed the most plentiful on the *Spray* and these I ate without stint. I had also a Pico white cheese that General Manning, the American consul-general had given me, which I supposed was to be eaten, and of this I partook with the plums. Alas! by night-time I was double up with cramps. The wind, which was already a smart breeze, was increasing somewhat, with a heavy sky to the sou'west. Reefshad been turned out, and I must turn them in again somehow. Between cramps I got the mainsail down, hauled out the earings as best i could, and tied away point by point, in the double reef. There being sea-room, I should, in strict prudence, have made all snug and gone down at once to my cabin. I am a careful man at sea, but this night, in the coming storm, I swayed up my sails, which, reefed though they were, werre still too much in such heavy weather; and i saw to it that the sheets were securely belayed. In a word, I should have laid to, but did work. I gave her the double-reefed mainsail and whole jib instead, and set her on her course. Then i went below, and threw myself upon the cabin floor in great pain. How long i lay there I could not tell, for I became delirious. When I came to, as I thought, from my swoon, I realized that sloop was plunging into a heavy sea, and looking out the companionway, to my amazement I saw a tall man at helm. His rigid hand hand, grasping the spokes of the wheel in a vise. One may imagine my astonishment. His rig was that of a foriegn salior, and large red cap he wore was cockbilled over his his left ear, and all was set off with shaggy black whiskers. He would have taken been taken as a pirate in any part of the world. While I gazed upon his threatening aspect I forgot the sotrm, and wondered if he had come to cut my throat. This he seemed to divine. "Senor" said he, doffing his cap, " I have come to do you no harm." And a smile, the faintest in the world, but still a smile, played on his face, which seemed no unkind when he spoke. I have sailed free," he said, "but was never worse than a contrabandista. I am one of Columbus's crew," he continued. "I am the pilot of the *Pinta* come to aid you. Lie

quiet, senor captain," he added, "and i will guide your ship to-night. You have a *calentura*, but you will be all right to-morrow." I thought waht a very devil he was to carry sail. Again, as if he read my mind, he exclaimed: "Yonder is the *Pinta* ahead: we must overtake her. Give her sail; give her sail! *Vale vale muy vale*!" Biting off a large quid of black twist, he said: "You did worng captain to mix cheese with plums. White cheese is safe unless you know whence it comes. Quien sabe it have been from leche de Capra and becoming capricious—"

"Avast there" I cried. "I have no mind for moralizing."

I made shift to spread a mattress and lie on that instead of the hard floor, my eyes all the while fastened on my strange guest, who, remarking again that I would only "only pains and calentura," cuckled as he chanted a wild song:

High are the waves, fierce, gleaming,

High is the tempest roar!

High is the sea-bird screaming!

High the Azore!

I suppose I was now on the mend, for I was peevish, and complained" "I detest your jingle. Your Azore should be at roost, and would have been were it a respectable bird!" O begged he would tie a rope-yarn on the rest of the song, if there was more of it. I was still in agony. Great sea were boarding the *Spray*, but in my fevered brain I thought they were boats falling on deck, that careless draymen were throwing from wagons on the pier to I imagined the *Spray* was now moored, and without fender to breast her off. "You"ll smash your boats!" I called out again and again, as the sea crashed on the cabon over my head. "You'll smash your boats, but you can't hurt the *Spray*. She is strong!" I cried.

I found, when my pains and calentura had gone, that the deck, now as white as a shark's tooth from sea washing over it, had swept of ervything moveable. To my astonishment, I saw now at broad day that the *Spray* was still heading as I had left her, and was going like a race-horse. Colombus could not have held her more exactly on her course. The sloop had made ninety mile in the night through a rough sea. I felt grateful to the old pilot that I marveled some that he had not taken in the jib. The gale was moderating, and by noon the sun was shining."

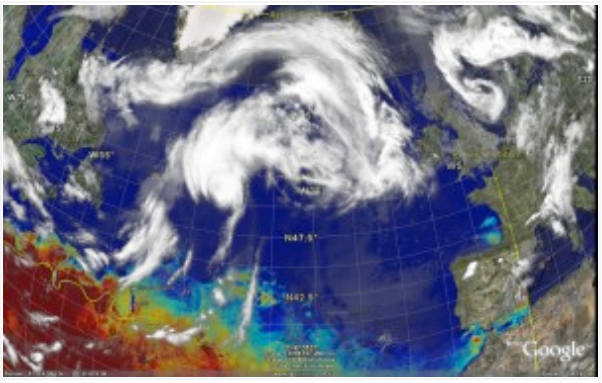
So in the spirit of Captian Slocum we hope the wayward spirit of the Pinta is with the Scarlett Knight today riding out the remnant of Bertha. If the ghost pilot of Columbus is not available, well we will be happy having the Rutgers undergraduate glider pilots!

0 Comments

20 jul Bertha's Inertial Tail

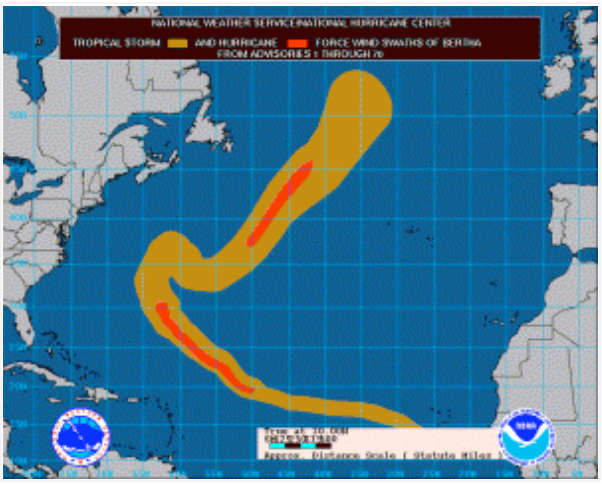
Edit Posted by: Scott in: Across the Pond Edit

The cloud image below overlaid on the Sea Surface temperature image shows that Bertha no longer looks like a tropical storm. It is over cold water and the clear eye is gone. Wikipedia lists it as the longest lived tropical storm in July on record. http://en.wikipedia.org/wiki/Hurricane_Bertha_(2008)

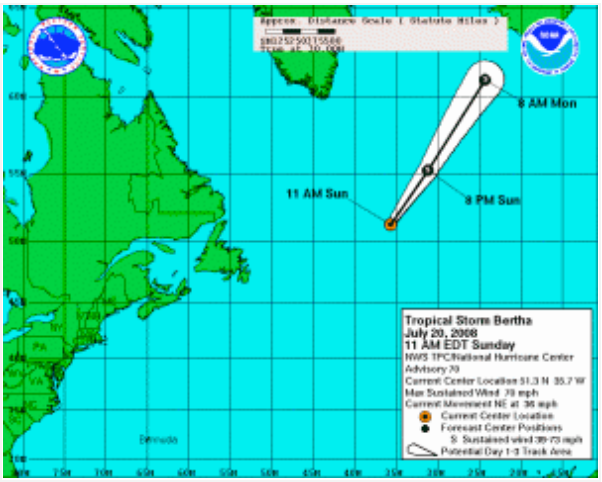


The NOAA National Hurricane Center has declared Bertha "Extratropical" over the far North Atlantic, officially ending its record breaking run. Tropical storms have that well defined eye and a nearly symmetric circulation. Extratrpoical storms look more like the storm fronts we get with Northeasters on the east coast of the U.S., very assymetric. NOAA NHC sent out their last advisory this morning. http://www.nhc.noaa.gov/index.shtml

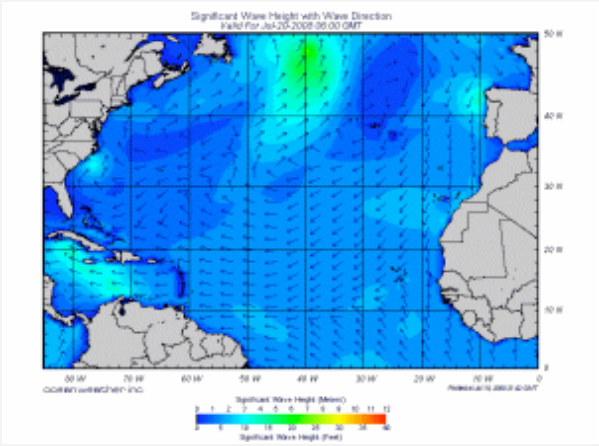
Below is the wind history along its path. The strengthening back into a hurricane after passing over Bermuda was what we were watching as it approached RU17.



Below is the last advisory for Bertha as a tropcial storm. Heading northeast.



Below is a snapshot of the present ocean surface waves from Oceanweather. The larger waves are to our northeast, and are declining in the vicinity of RU17. We are down to about 10 ft waves in the vicinity of the glider.

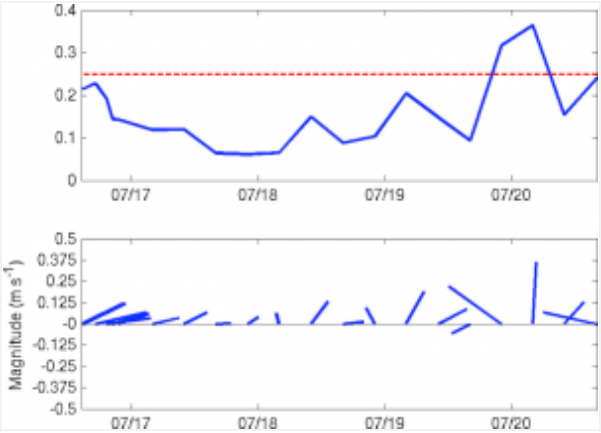


Below is what a 6 foot glider looks like climbing a 10 foot wave. But its not RU17 in the North Atlantic. Its RU05 in the Pacific right off Diamond Head in Hawaii. The photo was taken from a 32 foot boat right after it was deployed. Just Chip and I went on this deployment. I left my kids on shore. We took two waves over the bow that came over the cabin and drenched us on the back deck. The strong currents opposing the waves really stack up the seas - very steep waves and a bumpy wet ride was the result for the humans. The robots don't seem to care. One reason we liked RU17's position during Bertha on the eastern side of the eddy was the currents were running to the north with the waves instead of against them. This reduces the steepness of the waves.

Be

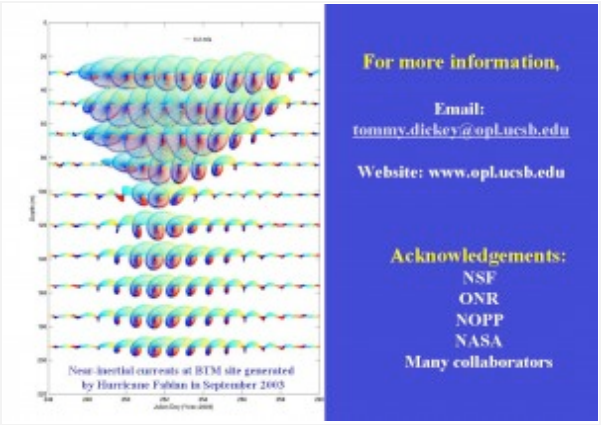
Below is a time series plot of the currents observed by RU17 after the passage of Bertha. It looks very confused. Thats because the currents we report are averaged over a 6 hour subsurface segment. As the storm is passing, there are three main contributors to the current, all of which are changing in space and time as RU17 flies through the ocean. One component is the geostrophic currents we see in the altimetric sea surface height plots from Colorado. The second is the wind driven currents from the tropical storm itself. The third component is called the inertial currents. Inertial currents are the ocean responding at its natural frequency to a strong change in forcing. Just like a bell rings at its natural frequency when you bang it with a hammer, a tropical storm is a mighty big hammer, and when it

strikes the ocean, the ocean rings. The period of the ringing at this latitude is something like 18 hours. The ringing response is the currents rotating around in a circle. They turn clockwise with time. In the time series below, we see all those effects, but they are not well resolved by the glider's sampling.



Surprisingly, Wikipedia has no entry for Inertial Currents. Inertial currents are one of the most commonly observed types of currents in the world ocean, and we did not even make Wikipedia. Hmmm. The top return from google is http://oceanworld.tamu.edu/resources/ocng_textbook/chapter09/chapter09_01.htm

The best example of inertial currents I have ever seen are from Tommy Dickey. Below is his poster of the inertial ringing of the ocean by BTM, the Bermuda Testbed Mooring, as Hurricane Fabian passed overhead. With the time series data from this mooring, you can sample much more often in time, and dramatically resolve the clockwise rotation of the inertial currents as the ocean rings from Fabian's hammer.



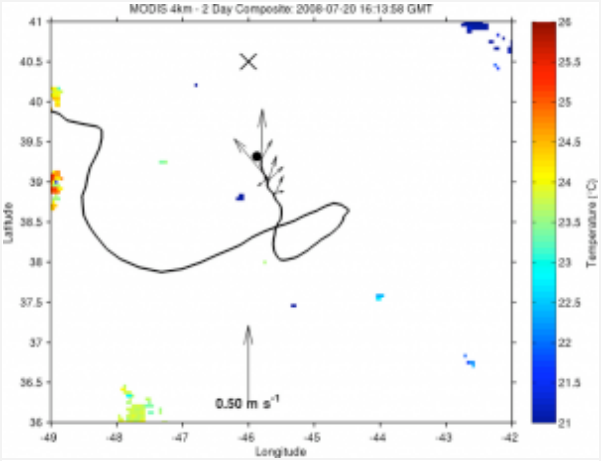
0 Comments

20 jul Waiting for the global dataset.

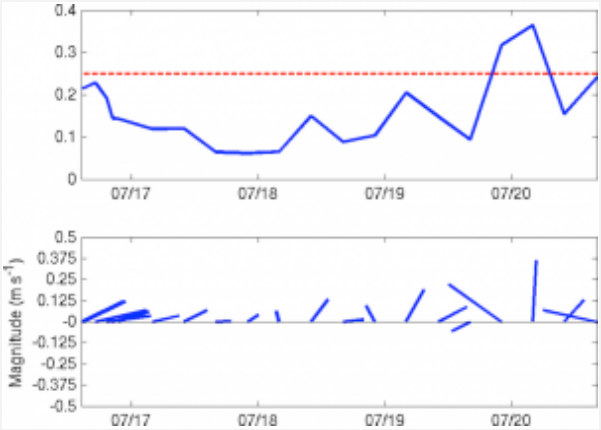
Edit Posted by: Scott in: Across the Pond Edit

Wow, strong currents to the north. That was a nice surprise this morning. The sea surface temperature map is blank - all white because of the cloud cover from Bertha. The global data lags by a day - a good reason to have a local acquisition site where you get instintaneous access. We should have that near 35 W, the western most extent of the Canary Island satellite receiver. But we should have a

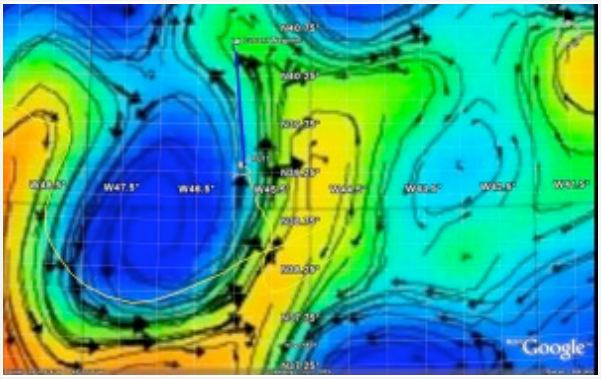
good global SST maps sometime tomorrow.



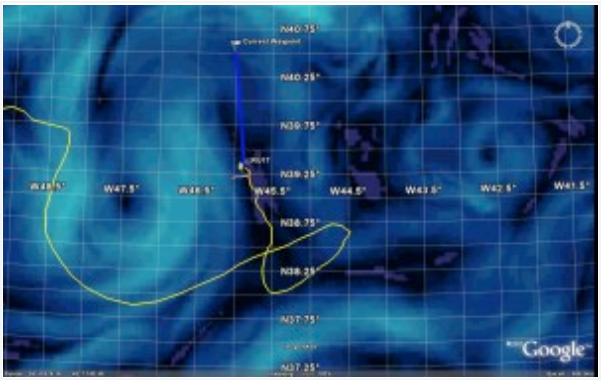
But the current time series is confused due to the inertial waves from Bertha (see previous post).



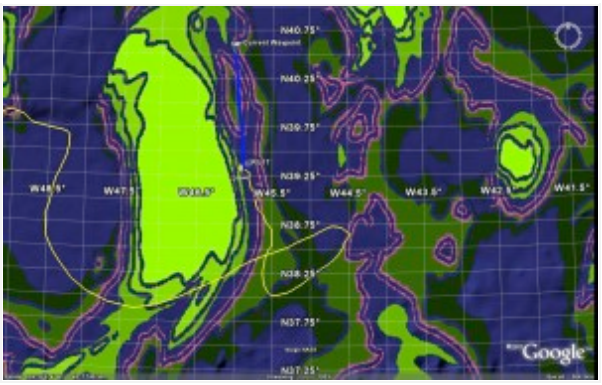
The Altimetry product is still waiting for a recent overpass in our region. Based on the altimetry, we have already crossed the strongest currents associated with the cold ring (blue color in the Sea surface height map below).



So we move on to the Navy forecast product below, here plotted as speed. The eddy is just to our west.



Below we plot the northward component of the velocity as green, with the brighest green being the fastest velocities. The stronger currents are a mere 20 km to our west in this forecast.



Our plan today is to follow the Navy forecast, fly to the northwest, into the forecast region for the stronger currents, and wait for the next round of global Sea Surface Temperature data to come in.

0 Comments

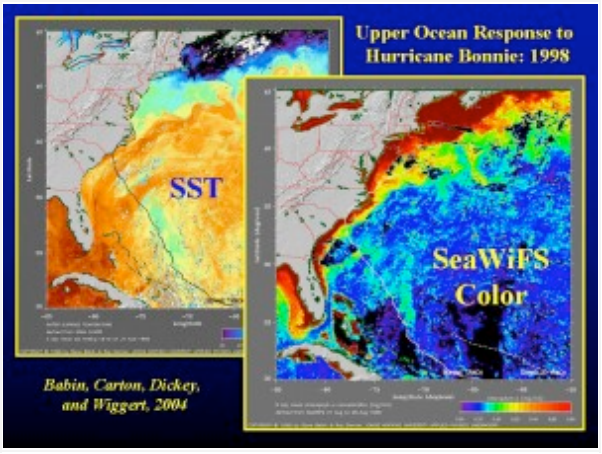
20 jul Final thoughts on Bertha and praise for Hurricane Researchers

Edit Posted by: Oscar in: Across the Pond Edit

Scott showed some beautiful imagery showing the big interial currents associated with big hurricanes. The large events are also known to have impacts on the chemistry and biology of the ocean, even if we can rarely sample during these violent events. In the deep ocean during hurricane season, warm waters are straitified above the colder waters at depth. These warm waters generally have low nutrients, as they have been used up by phytoplankton at a previous time. The large storms can disrupt this straitification, and the net result is that the nutrient rich water at depth can be supplied to the surface. These nutrients that can stimulate new blooms of phytoplankton. Thus the storms as they pass can leave a trail of enhanced ocean phytoplankton productivity in its wake. Some of the images below show this effect, and once the clouds clear we will assess if we can see this effect has happened with Bertha. The figure below was produced by Babin et al. (2004). The upper back panel shows the track of Hurricane Bonnie and the sea surface temperature. Along the track (black line) there are green colors, indicating lower temperature water then the surrounding waters which are red/orange. The lower front panel, shows the ocean image, and coincident with the

low temperature waters along the path of Hurricane Bonnie are enhanced phytoplankton concentrations. With luck clear imagery will allow us to see what the biological impact of Bertha was.

Babin, S.M., J.A. Carton, T.D. Dickey, and J.D. Wiggert, 2004, Journal Geophysical Research, 109, C3, C03043, doi:1029/2003JC001938.

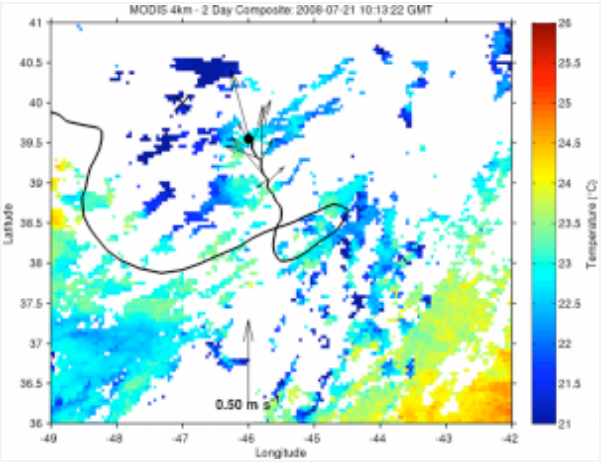


0 Comments

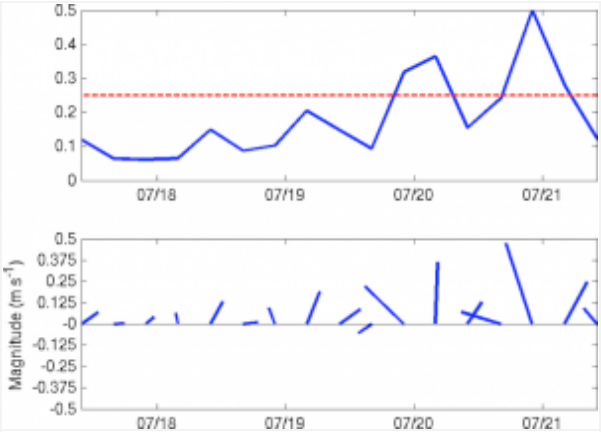
21 jul Post-hurricane SST imagery shows us the path

Edit Posted by: Scott in: Across the Pond Edit

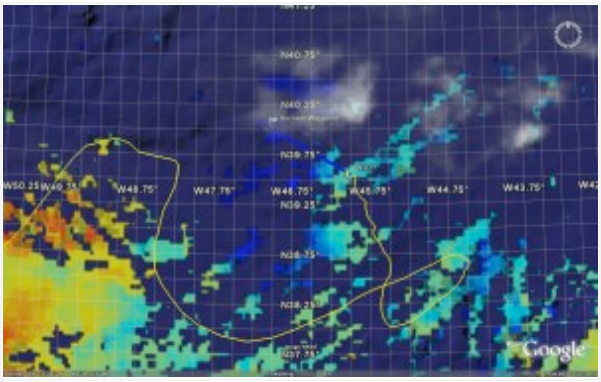
The post hurricane Sea Surface Temperature shows the eastern edge of the cold eddy, RU17 is smack in the middle of the warmer filament wrapping around the outer edge. This is a very good place to be. Currents will be to the north. The glider track shows the serrated edge typical of strong interial waves. We have many examples of buoys drifting in the ocean that show this behavior. The move in one direction with the ambient currents but also spin in a small circle due to the intertial waves.



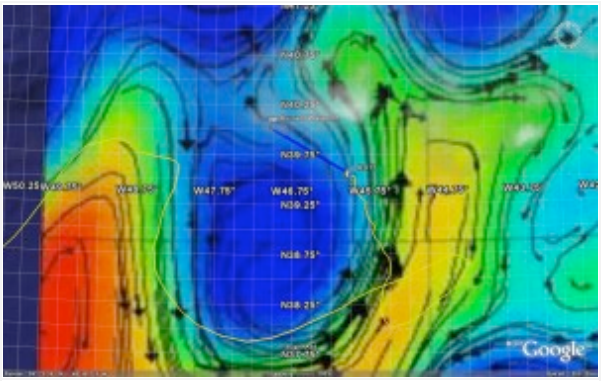
Below we see the general trend is an increasing velocity to the north with the inertial oscillation superimposed.



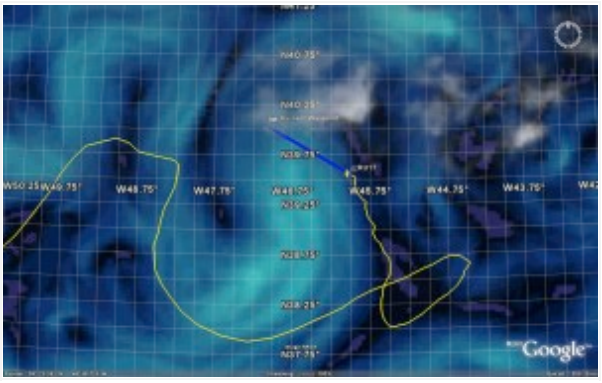
Putting the SSt image in google earth shows we are inside the warm filament wrapping around the ring that is heading north. This has been our target for several days. Its good to finally be there.



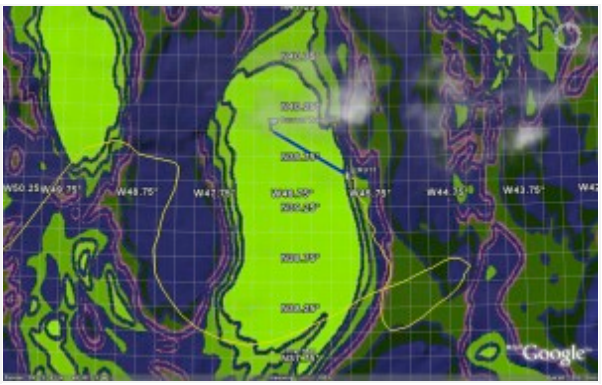
The altimetry below says we already flew through our target, and the the stronger currents are back east.



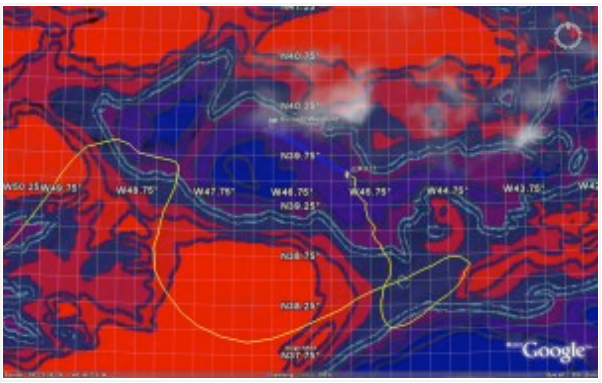
The model forecast says we are about to hit the target, and the stronger currents are to the west.



It is a nice patch of northward current in the model. Based on the satellite SST, we are already in the bright green northward velocities shown below.



We can ride these currents up to about 40 to 41 N where we pick up a nice patch of water heading east (bight red).



RU17 will be turned to swim due north at the 12 noon local time surfacing.

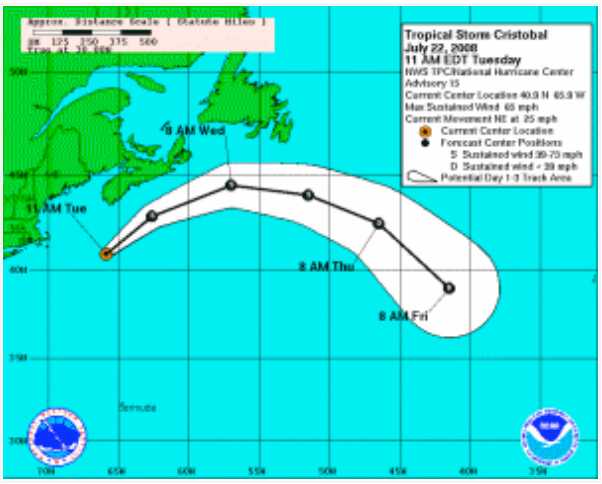
0 Comments

22 jul

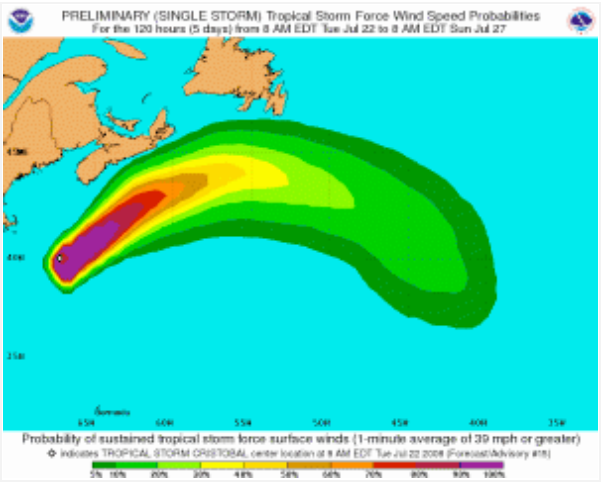
Now its Cristobal from the north

Edit Posted by: Scott in: Across the Pond Edit

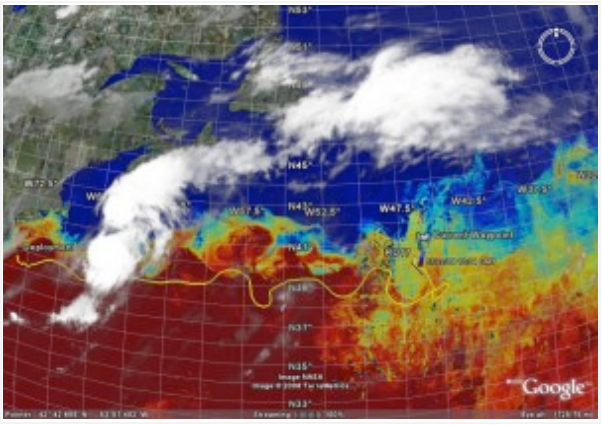
Now its Tropical Storm Cristobal that is heading for RU17. Its due to arrive late thrusday to early friday. We are again forecast to be on the more severe right hand side of the storm track, but this time the approach is from the north. A great combination punch - Bertha from the south, Cristobal from the north.



NOAA National Hurricane Center has Tropical Storm Cristobal north of the Gulf Stream, over the cold water, and undergoing the extratropical transition. Extratropical transition often weakens the winds, but also often increases the area of high winds. People living in the Middle Atlantic Bight often experience these Extratropical Transitions first hand, the most recent example being Tropical Storm Ernesto, which underwent the transition while over Pennsylvania, Maryland, Delaware and New Jersey.



In the cloud/SST image below we don't see the nice eye wall structure in Critobal like we did in Bertha, but I really like the clear view of the ocean surface we get in the SST after each storm. The cold eddy RU17 is in right now is clearly visible in this image made possible by the passing of Bertha.



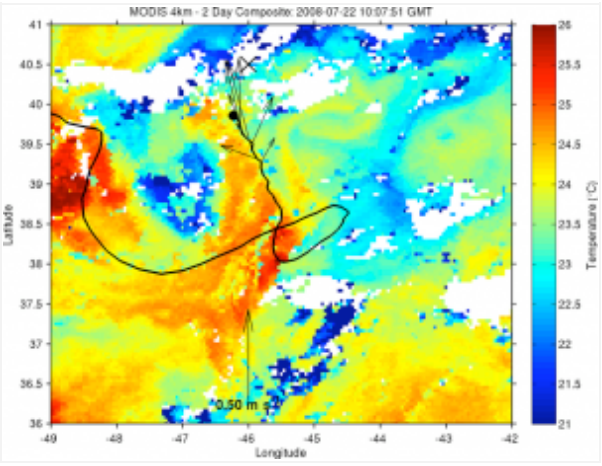
So if we are looking for the silver lining in this one-two punch, this is about the best thing that can happen to us in terms of using the satellite Sea Surface Temperature for path planning. Each passing storm wipes the slate clean of the summer surface warming, giving us a good view of the deep ocean structures that define our velocity field. A couple of weeks after Crisobal we'll be into the intense summer surface heating of August, and we'll be hoping NOAA can send another tropical storm our way.

0 Comments

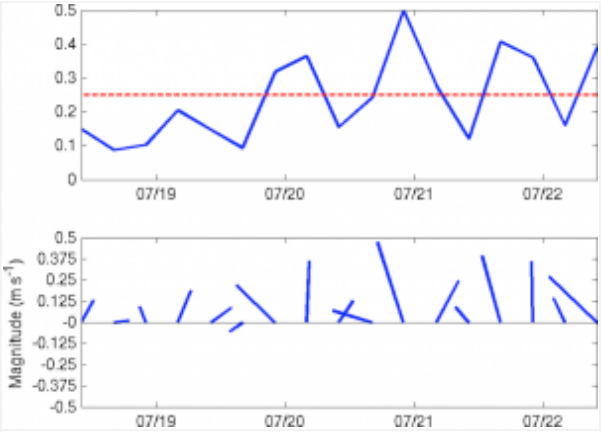
22 jul A bright & sunny day on Google Earth

Edit Posted by: Scott in: Across the Pond Edit

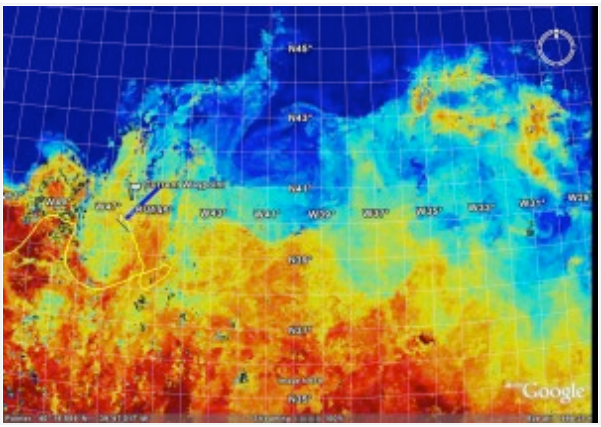
RU17 is making rapid progress to the north, running up the eastern edge of the ring in the satellite Sea Surface temperature (image below). The inertial waves are still visible in the last few days of its track. Now we will be making the turn to the northeast. The SST says the ring is open to the north, so we don't have to worry about being swept around. But just in case, lets start flying northeast.



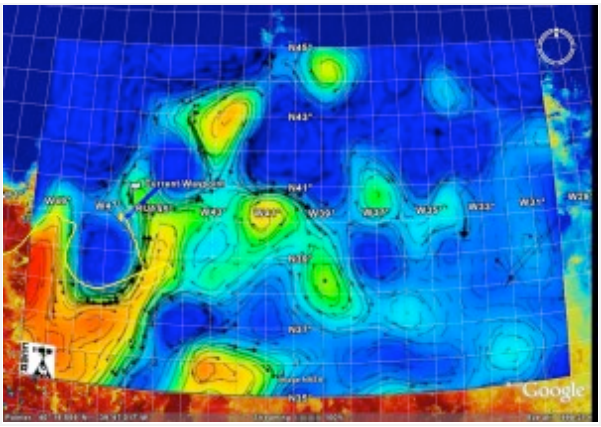
The below time series shows the effect of the inertial oscillations superimposed on the current to the north. These inertial currents should start to fade away, just about the time Cristobal comes to bang on the ocean again.



Below are the great google earth series of images showing agreement between all of our data sources and models. This is truly a great day. First is another version of the Sea Surface temperature image showing us riding the currents to the north on the eastern side of a ring.

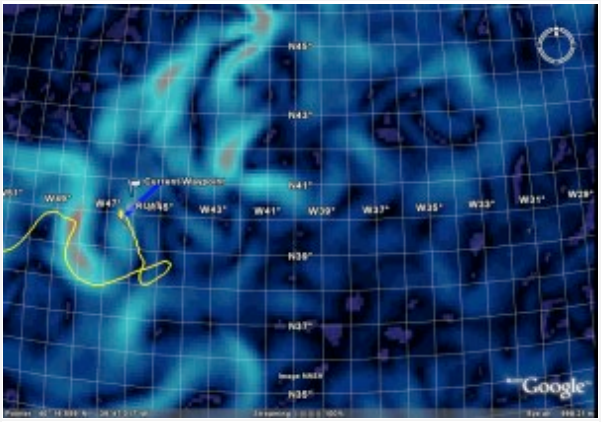


More altimetry must have come in because we see a definite change in the local altimetry Sea Surface Height product. We are circling a low (blue) and heading north with the currents into a region that will soon start to turn us to the east. To aid the currents in that turn, we have asked RU17 to start flying to the northeast across this region where the current is turning.

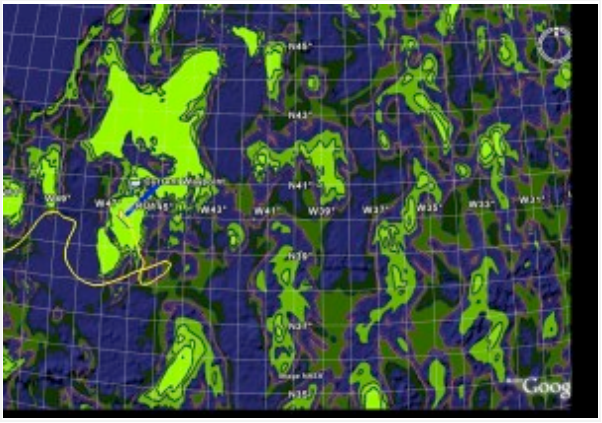


Below is the NCOM forecast (yep, NCOM, not NLOM) that shows the ring in exactly

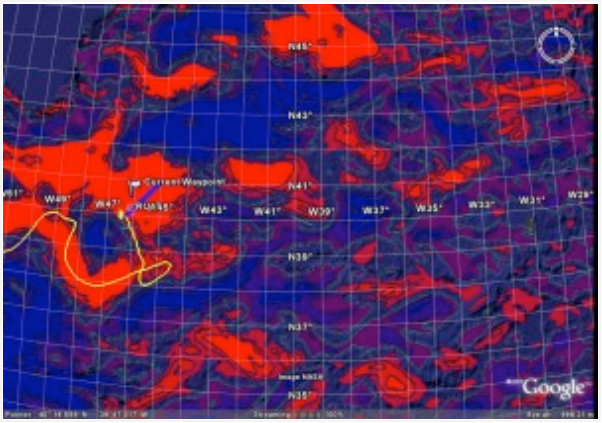
the right place with its mouth open to the north, just like the satellite SSt and SSH. Remarkable agreement. So today we choose the NCOM model.



Below is the north-south component of the current. Green is to the north. We are smack in the middle of the strong northward bright green currents. This is what we need. A ride to 41 N.



Below are the east,west currents. Red is to the east. Once we get to 41 N, we have a long series of eastward velocity segments running to 33 W. Thats our target.



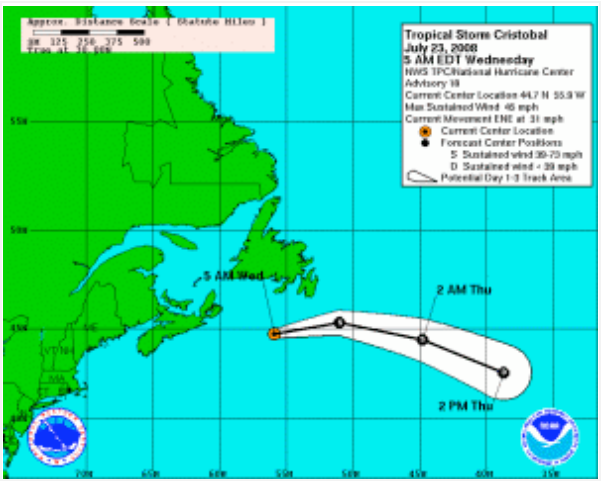
0 Comments

23 jul

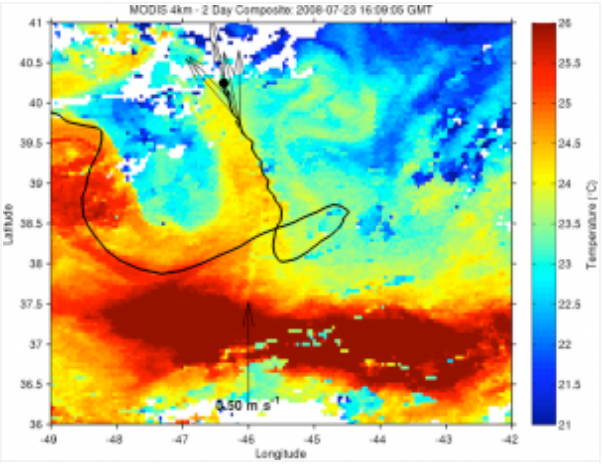
Starting the turn to the east

Edit Posted by: Scott in: Across the Pond Edit

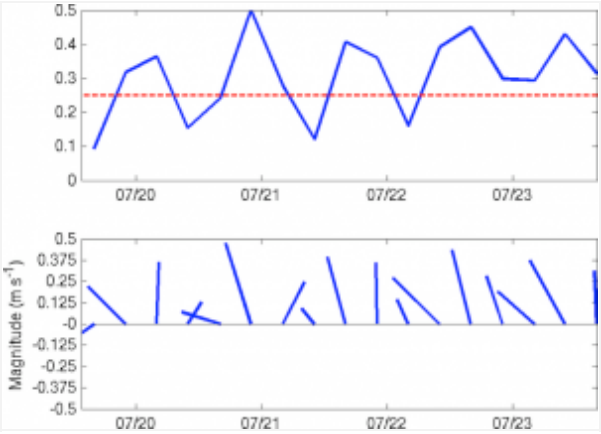
Tropical Storm Cristobal is now forecast to stay well north of RU17.



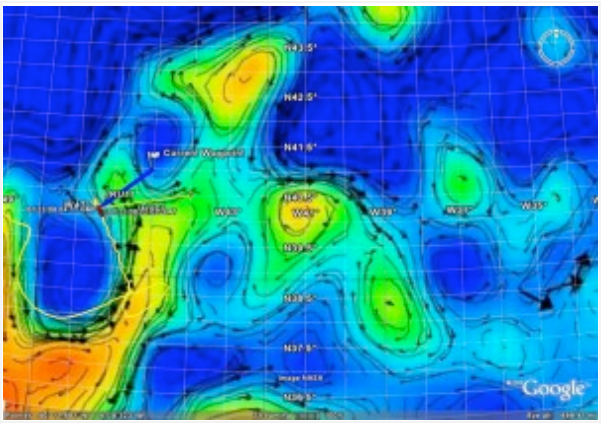
RU17 is riding the eastern side of the cold eddy. Heading northwest along that warm band of water.



Intertial currents are slowly fading, and we have a current that is due north. Something we have not seen in a couple of days. So the current is turning, and we can start turning RU17.



We will turn RU17 from its present NE course to a new course to the ENE. The new waypoint will be 40.5 N 44W. We will use RU17's velocity to try to center us in that eastward flowing current we see in the altimetry below. Eric just sent RU17 on a 1 hour CTD sampling mission that he will also use to verify his tuning of its flight characteristics. Once Eric completes his mission, he will be sending RU17 to the new waypoint.

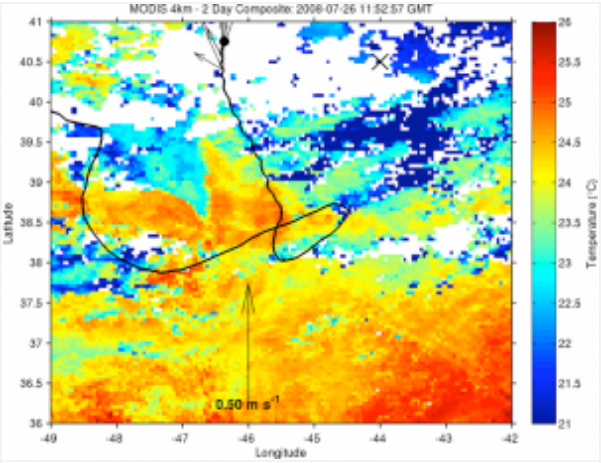


0 Comments

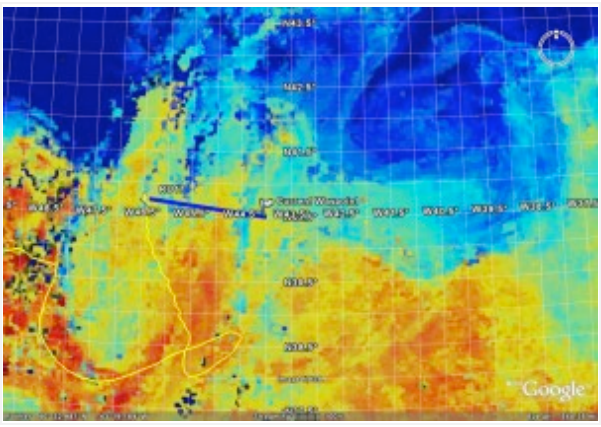
26 jul At the Target Latitude - Finally.

Edit Posted by: Scott in: Across the Pond Edit

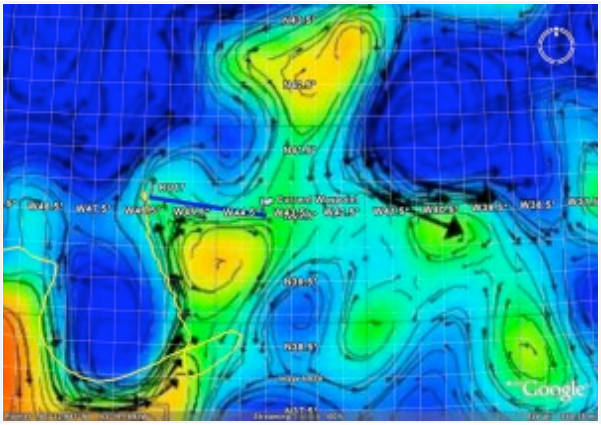
RU17 is traveling north and making the turn to the east. We are approaching 41 N, our target latitude. This has been a long wait. We have forecasts of eastward currents along this latitude that we hope to catch.



Below is a 72 hour composite SST image. We followed the eastern side of the cold eddy centered near 39 N, 47W, staying in the warm water and riding the current north. We are now turning toward the cold eddy we see in the imagery between 40-43 N, 38-42W. We want to fly along the southern side of this eddy.



Below is the satellite altimetry. We are trying to circle a high (orange) in the sea surface height field located near 40 N, 45 W. The hope is to whip around this high to the east, and cross the saddle point near 40.5N, 43.5 W into the southern side of the intense low corresponding to the cold eddy discussed in the above SST image. The danger area is the saddle point. Here it is quite easy to get pushed the wrong way. We have already experienced trouble trying to cross one of these regions before. Maybe this time we will be more lucky.



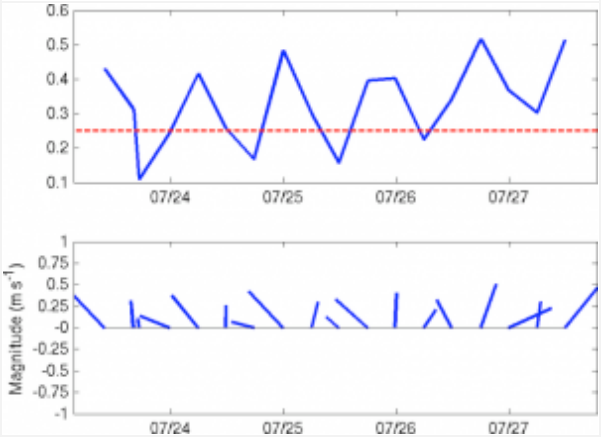
0 Comments

27 jul

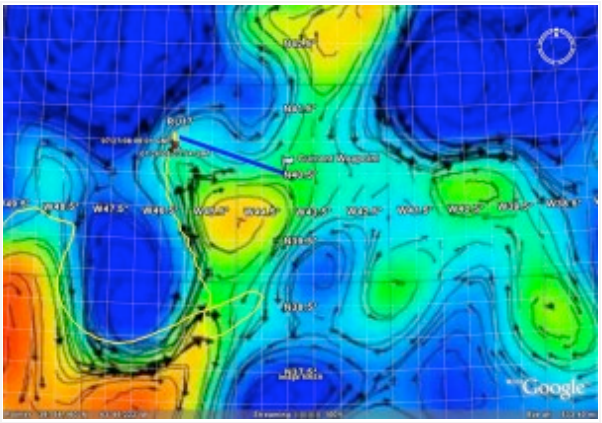
Currents Good - Waypoint Good

Edit Posted by: Scott in: Across the Pond Edit

Currents continue to swing clockwise. Last night as we left the lab, Josh and I stopped one last time to check on RU17. It had just surfaced, and we wanted to see the currents. We had a positive vx (velocity component to the east) and it was bigger than vy (the north-south velocity component). We had not seen that in a couple weeks. A great way to close out a Saturday night.



Altimetry is still our best roadmap at this point. We continue circling around the high (orange in plot below), and continue heading the glider to that waypoint between the eddies. There are three possible routes to the large cold eddy (blue) we see centered near 42 N, 41 W. The northern route that goes around the high located at 43 N, 43W. The southern route goes around the low near 39 N, 43W, and the route straight across. The southern route is one we don't want. That low already gave us a problem once, stopping us dead in our tracks and whipping us south into the influence of another low. The northern route is much safer, but much longer. We'll have to try for the straight across 41 N route, and do our best not to get pulled into the southern route. To accomplish this, we'll keep the waypoint as it is for a day or so to get deeper into this northward current. The altimetry says we should then start experiencing an eastward flow. We'll be watching for that. Then as the current starts pushing us north along 44 W, we try to shoot straight east into the current that is going south, hoping to catch the big cold ring near 42N, 41 W. Its about a 4 to 5 day flight across this region with currents switch from north to south. A couple days drifting north, followed by a couple days drifting south. Wow, lots to look forward to.



0 Comments

28 jul

MSU Summer Robotics Camp Presentation

Edit Posted by: pathfinder in: Across the Pond, Undergraduate Operations Edit

On Friday, July 25, I had the opportunity to spend the morning at Montclair State University, in Montclair, NJ, to visit the MSU Gifted and Talented Summer Robotics Camp. I made the visit hoping to introduce the students to Slocum gliders and the data that we use to fly them, provide the students with a real world context for the computer logic and circuit design that they're learning in class and to give them a glimpse of what it is like to be a glider pilot for a Transatlantic Glider Mission. Many of the campers heard news snippets about the Transatlantic Mission and brought their questions to one of their teachers, Norm Sutaria. Norm who forwarded them along to Sage. The students needed to know more about RU17, what goes on behind the scenes to support the endeavor, and what it's like to be behind those scenes. Sage asked me to respond to their questions. Seeing a perfectly justified opportunity to spend a work day out of the lab, I volunteered to visit camp.

Truth be told, I really enjoy doing outreach. It's a lot of fun to bring the kind of experiences that turn into 'everyday life' around the cool room, and share them with an interested, engaged and excited audience. Most of the campers were gifted and talented students, so they came with much the interest and excitement, all I simply had to share stories. The spiraling nature of engineering/design may not be everyone's favorite story, but the cooperative work of Webb Research Company and Rutgers University is a great example for students building their first robots, right there is class. It's important to know that things don't always work out perfectly at first and that success almost always follows many 'near successes'.

I would like to thank Norm for having me over to MSU, getting me some excellent directions, and helping to steer my presentations towards each class, Dave Aragon for helping me check out and load up a glider early that morning, and Chuck for helping me put RU01 back in the cage room at the end of the day.

-Justin.

Favorite question of the day:

Student: So…what's it like?

Me: To do what?

Student: Well….the whole robot….

Me: Flying a robot across the ocean?

Student: Yea, like do you ever get to sleep?

PRESENTATION SUMMARIES from email to RUGLIDEROPS

Presentations went really well. What was planned as a 15 minute

presentation for two classes turned into three class periods (8:30-12:30)

with a total of 5 classes of students attending,

First presentation was completely inquiry/question driven. ~15 students 10-11 yrs old.

Walked in with glider at 8:35, and the questions started. Spent most of the time on the

floor with the students, showing them around the glider.

Second presentation class of 3 13-14 year olds. Combination of inquiry based,

motivated by their teacher, and guided by independent student interest (on or off the topic of Slocums). The

teacher

motivated activity was reading some glider code, so I walked them through the surfac20.ma

and goto_l10.ma to introduce them to behavior space of the glider. Showed them the

combined datasets in Google Earth and web tools (Glider Navigation Page, and Glider Ops

Home page).

Third class, combination of user driven and power point. ~25 students, 10-12.

Some students worked on their own robot kits, which they showed off to me before

the presentation while a second class joined. Spent more time describing the COOL

room and what we do, than in the previous. Ended up being largely user based and

I only used about half of the slides that I assembled. The slides made it feel a little too

lecturey for me especially with the pre-lunch vibe starting to kick in, but they were

useful to answer questions.

3 Comments

28 What else crosses a ocean way better than a

jul

nerd?

Edit Posted by: Oscar in: Across the Pond Edit

While RU17 struggles as it *finally* heads east again after a too long period battling, we look to those critters that always live at sea. While we at COOL can feel great about ourselves for kinda making it 1/2 way across the ocean, the reality is that ocean crossings are buisness as usual for many organisms in the sea. So tonight, more in spirit of humility, we toast one of those organisms, the Leatherback turtle.

The leatherback turtle (Dermochelys coriacea) is the largest of all living turtles, but unfortunalety is is critically endangered. As a sea turtle, the leatherback is the largest and heaviest. The leatherback turtle has global range spanning from Alaska to New Zealand. Leatherback turtles like the deep ocean ocean (one was tracked from Indonesia to the U.S. over 13,000-miles!!!!!). They cross the oceans faster than the glider and they serve as an inspriation to those of us trying to doing it for the first time. Check out the links below to view their amazing capabilties! We have much too learn……

http://www.topp.org/species/leatherback_turtle/

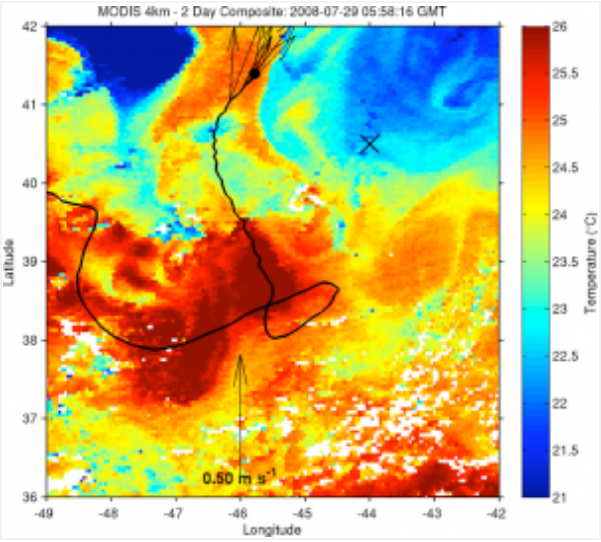
0 Comments

29 jul

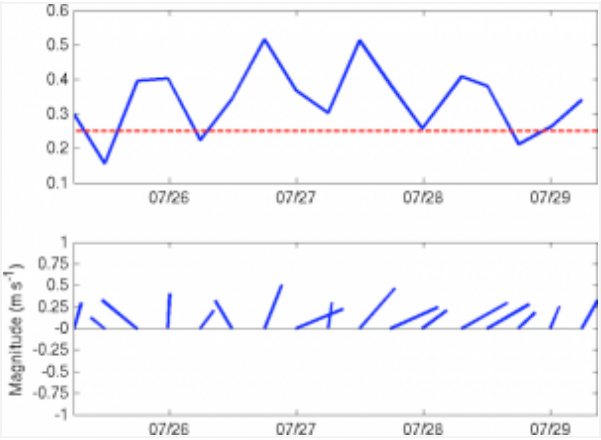
All in slow motion

Edit Posted by: Scott in: Across the Pond Edit

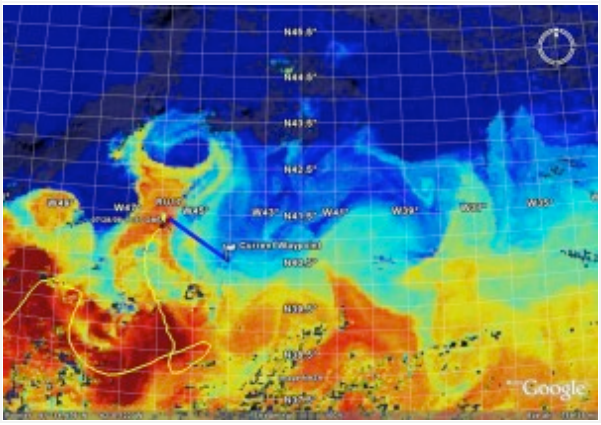
RU17 continues to head in towards the center of a large loop it is now making to the north. We are in a band of warm water that runs north-south. We are using the glider velocity to head east, across this band.



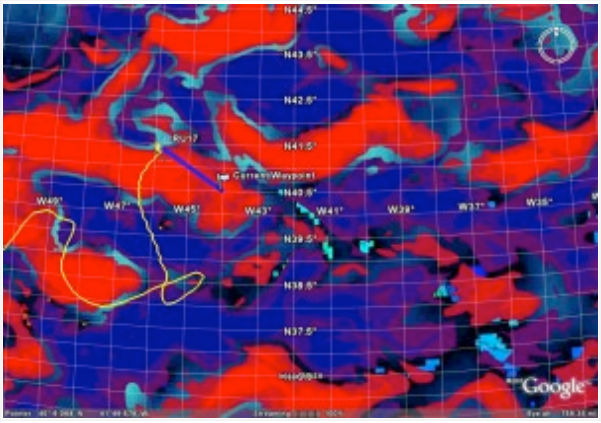
Currents (below) have that consistent eastward component. A good thing. Altimetry says if we keep going east, we get into a patch of currents to the south and east.



We continue to make progress trying to cross that front from the warm water into the cold. The southern side of that cold region is believed to have strong currents to the east.



We are learning the value of a good forecast. Everything happens slowly in the world of gliders, and the ocean changes in the mean time. Trying to puzzle out the exact circulation in that cold region remains difficult. We have altimetry and two models. We can see features that are similar in all three, but the locations are shifted. Hard to say what that colder water has in store for us. Guess we won't know till we get there. Uncertainty - a difficult one today. My favorite image of them all is below. It is the east-west component of the current in the NLOM model. Reds are east, blues are west. On this northward run of RU17. you can see how the track was drifting west in the blue, and as soon as it hit the read, it started drifting east. We hope to stay in these eastward velocity filaments for a bit.



0 Comments

02 aug We're Flying Again!!!

Edit Posted by: Scott in: Across the Pond Edit

Sometimes at sea, everything goes wrong at once. At least this time it was on a weekday.

On Wednesday during our normal weekly CTD casts (inspired by the Argo program that profiles once every 10 days), we noticed RU17 did something very unexpected. On one of its regular climbs, it decided, on its own, to pull a full 360 degree turn. The total process took about 10 minutes. It then went on its way like normal.

But why would it do that? We checked that the actual fin position matched the commanded fin position, and that through the turn the fin was actually pointed in the opposite direction. The fin was trying to counteract the turn, but the compass was telling us RU17 would have no of that, and just continued around till it completed its donut.

At the same time we noticed that the currents RU17 were reporting were heading to the east. And that our navigation said RU17 was flying to the southest. So why did it surface to the southwest? The velocity of the water (the wind in the atmosphere) plus the velocity of the glider relative to the water (the airspeed of an aircraft) are supposed to add up to the total velocity over the ground (the ground speed of the aircraft). it wasn't. Somewhere there was an error in the navigation.

To top this off, we noted we were spinning around in a very large circle, and were not sure of its source. Where they real ocean currents, or was our navigation just wacked.

As we were looking through this, Josh was on the phone with the folks in Spain. They were wondering if we thought we would need to stop at our third alternate landing zone (the Azores), or would we be continuing all the way to Spain. Just like the Space Shuttle, we always have alternate landing zones in mind for long trips. Our first alternate site is UMass Dartmouth, second is Halifax, and our third is the Azores. As we passed both Massachusetts and Halifax, in each case RU17 was doing fine, so the decision was made to continue. But at this point I was thinking not about the big question we face - do we have enough power for Spain, or do we rebattery at the Azores. I was worried if we could even make the Azores.

But there is nothing like a robot at sea that needs your help to motivate people.

We had experienced navigation errors before. RU06 was flying off Antarctica. And it also had to do with crossing the UTM zones. But tests during the flight to Halifax indicated that although a navigation error is being reported, the glider is actually doing what it is supposed to be doing, and all you have to do is reset the computer and all the problems go away. But this time was different. There was no reported navigation error, but we knew we had a real one.

Everytime I have a problem with my Dell laptop, the first thing our IT guys ask is did you try rebooting? Using this wealth of accummulated computer troubleshooting knowledge, we decided to give it a try. We pulled RU17 out of its mission, reset all the points so they were in the same UTM, and restarted the mission. We switched over to 1 hour missions so we could recheck the navigation, resolve the current variations, and see if we were still doing donuts.

RU17 surfaced in 1 hour and out came the calculators. We were checking all the reported navigation information by hand, and everything was in agreement. At least now we knew where we were, and where we wanted to go. Now the task of getting there.

Over the next day and night we continued running a series of flight tests, some short 1 hour segments while we were awake, some longer 6 hour segments while we slept. The circles we were spining in turned out to be inertial in nature. The time average current we were in was relatively small, so the interial waves were just spinning us in a circle. So why weren't we flying relative to the circle, and stretching them out? Why were we looking more like a drifter than a glider?

Did we loose our wings? No, the pitch was moving from -26 to +26 degrees on dives and climbs, so we had at least one wing. And the roll was only varying by a couple degrees between dives and climbs, so that meant we had both wings.

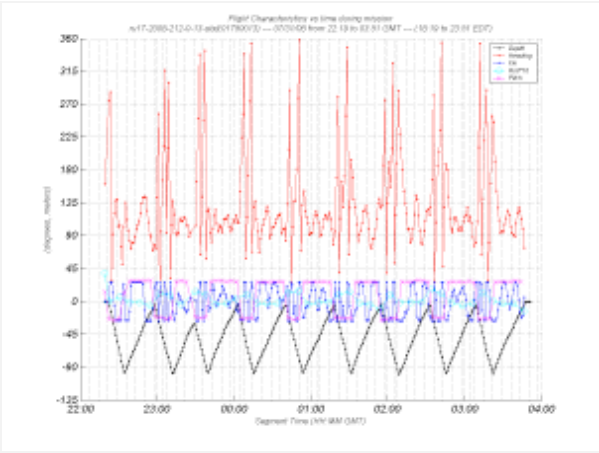
That brings us back to the donut story. Instead of stopping for an hour to download a full engineering file every time we wanted to look at flight characteristics, we added a few of the key flight parameters, heading, pitch, roll to the science data file, and sent the glider a new format for what we want sent back. The results told a story that puzzled us for days.

RU17 seemed to like the donuts it just learned, and was doing more and more of them. Instead of 1 donut during the entire subsurface mission, we began seeing 360 degree turns every downcast. Then two turns every downcast. By the end we were up to 3 turns per downcast. We had an budding olympic gymnast at sea. Spinning circles on every descent really cuts down on the distance you can fly, and makes you look a lot more like a drifter than a glider.

So what was it? Something snagged on the CTD? We often think this is one of the most likely places to snag something, since it has a profile that requires it to stick out into the sampling volume. All the other pieces of the glider, the wings and tail, are designed to try to shed snags. We even thought of removing the CTD just for this long trip in case we did snag something. But all the turns were to the right, and the CTD is on the left side of the glider tucked under the wing. So if it was

drag, it had to snag on the snag-shedding wing.

Then we saw this plot. The red line is the heading, the black line is the depth. When the depth increases from 0 to -100 m, you are diving, flying on a downcast. Every downcast has a double or triple turn, and every upcast is fine, sticking to the intended heading with a little bit more noise than usual, but at least sticking to it.

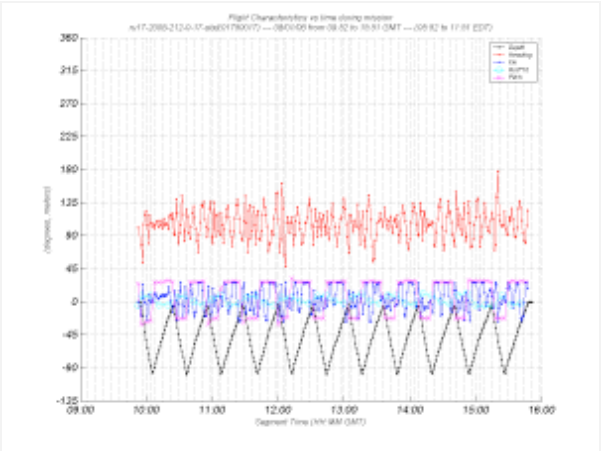


Look at the second climb. Something stopped it. RU17 tried climbing towards the surface, its progress was halted, and it decided it was better just to go back down at try it again. Could this be Remora remora? This is the exact same behavior we saw before that suddenly stopped as soon we left the eddy.

Well, we were pushed back into that same eddy where we saw these before. Could they be back? Maybe. Still we got ready for a battery of engineering flight tests. We were going to grab RU17 at the 6 pm Friday surfacing and run it through a series of tests to see if something was wrong with the compass.

Maybe we were tilting the compass too much on the downcast, and it was giving a faulty reading. We planned on shallowing up the dives and see if we could change the compass behavior. Instead of descending at 26 degrees, we shallowed to 20 degrees, getting near the stall angle of the glider. We planned to see if we held the fin fixed at zero, would it steer a straight path, or would it turn independent of the fin. If nothing worked, and we thought we had a snag, we were going to try to fly the glider backwards. We would try to sink with the batteries all the way back, resulting in a nose up descent. We have a lot of extra through on the battery, so if something was snagged on us by our foward motion, maybe the backward motion would pull it off.

So RU17 surfaces at 6 pm. John pulls over the diagnostic file and starts downloading the first test file. Eric grabs the test file, and plots it. Our jaws drop.



RU17 is flying perfectly. Eric averaged the red headings to find 107.6 degrees, within the round off error of our intended 108 degree heading. Instead of the slow 9 yos per 6 hour interval, we where back up to 11 yos in 6 hours. We had sped up, we were no longer doing donuts. We knew we were in strong inertial currents. We knew where we were, and we knew were we were going. All on a friday evening.

Since we all already made the commitment to miss dinner at home, and it was already loaded on the glider, we thought we would at least run our first test. We flew for an hour at a shallower dive angle. The compass still worked, but the flight control got a little wobbly, since we where near stalling and the flow over the fin was reduced. We set everything back to normal dives and climbs, plus or minus 26 degrees.

In a matter of seconds, our mission switched from a rescue mission (use whatever power you need to save yourself) back to the sustained low-power mission for trying to push past the Azores to Spain. Justin ran his path planning algorithm on the 4-day Navy current forecasts. Continuing with the current to the northwest was going to take us on a wide loop to the north. trying to fly east was into the current, and just make us do the same thing, only slower. Southeast was directly into the current, so that was out. Trying to push it to the northeast caused Justin's path to swing around the east. That was our out. We switch to 6 hour missions, and John gave it a new waypoint to the northeast, 42 30 N, 42 30 W, an interesting combination of lats and lngs.

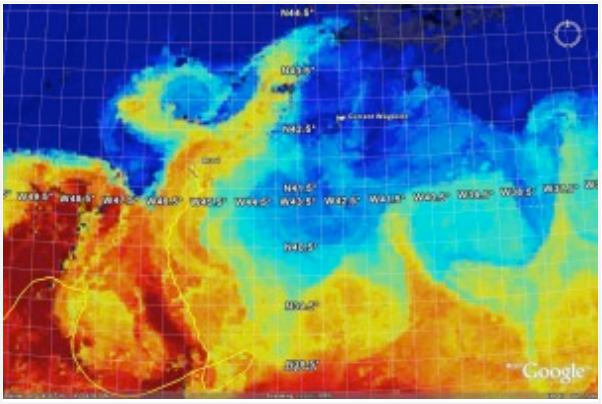
Our job was done. Our robot was back on track after 2 days of unexpected behaviors. We headed home to see our families.

0 Comments

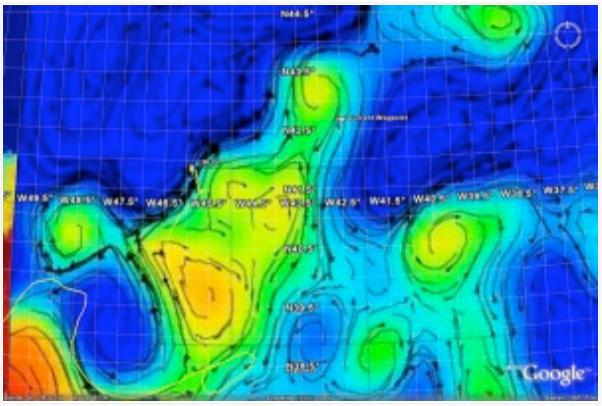
03 aug A filament shoots north

Edit Posted by: Scott in: Across the Pond Edit

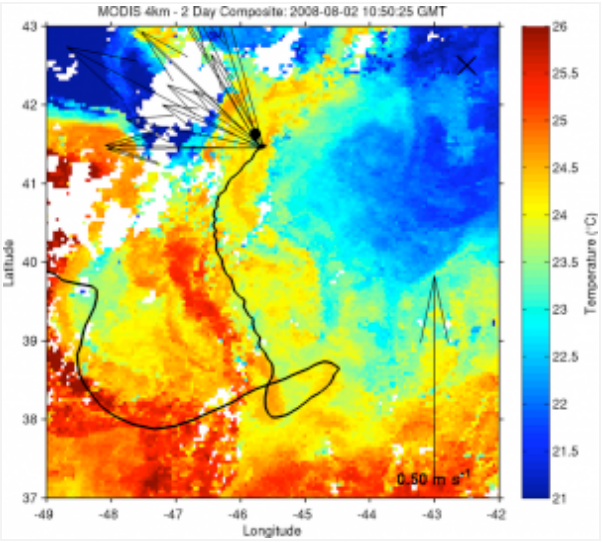
RU17 is riding this warm filament north. Since friday night, the currents have been to the northwest, pulling us toward that small cold eddy near 42 N, 47 W. We have been flying perpendicular to this to the northeast to try to get to stick to the eastern side. The currents started turning to the north early this morning, so maybe it is working. It also means we can change our waypoint. Perpendicular to the current is now a waypoint that is due east.



The Colorado altimetry product looks real good this morning. It shows the warm filament we are in, and the currents to the north. The altimetry says we should soon reach that curve where we turn to the east. We'll use the glider velocity to help it along.



Below is our traditional plot of the current vectors over the last few days. Lots to the northwest.



0 Comments

04 aug 8/4 Movie

Edit Posted by: goodwin in: Across the Pond, Spain Summer 2008 Edit

Let me try to insert the movie that i made…

movie

i hope it works

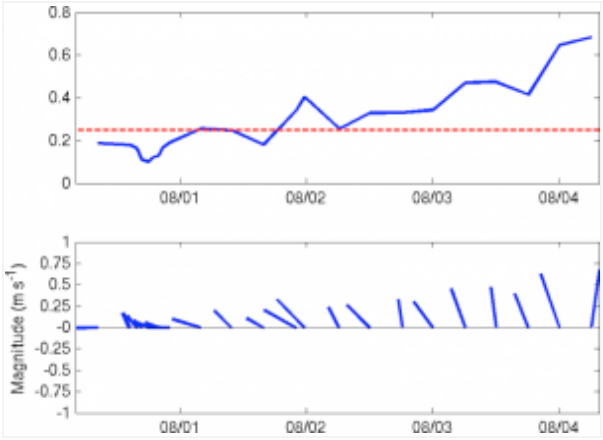
It shows the currents (blue arrows) and the drifter path(starts with green dot then black line and ends with red dot). They are supposed to match up. You be the judge.

0 Comments

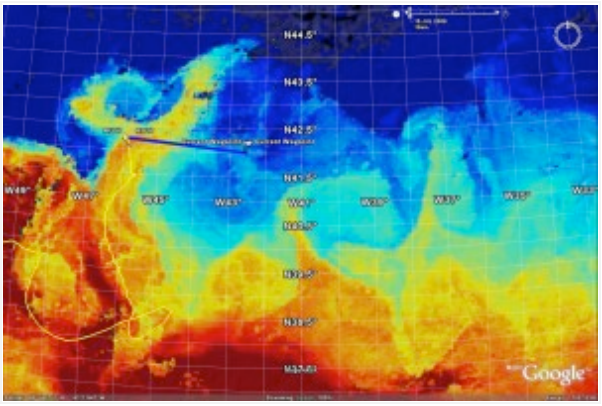
04 aug Navigating the eddy field - growing confidence in the models

Edit Posted by: Scott in: Across the Pond Edit

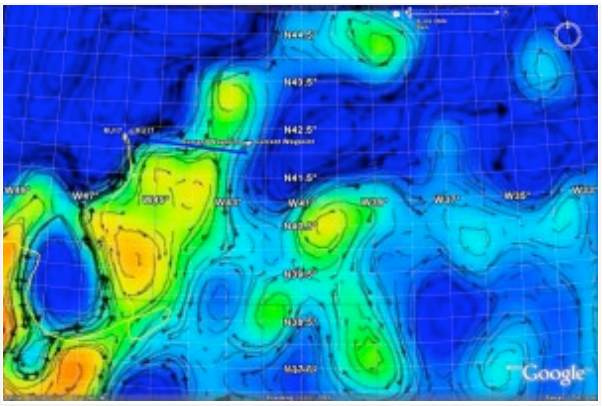
Water velocities observed by RU17 are streadily increasing (plotted below as a time series). Direction is much more consistent. Looks like the intertial waves have finally spun themselves out, dropping in magnitude well below the background currents. We have been hoping for the currents to start turning to the east, and here is the first evidence. A small piece of vx, only 6 cm/sec, to the east. We hope this piece increases. The satellite data below shows what we fear, and the altimetry shows what we hope.



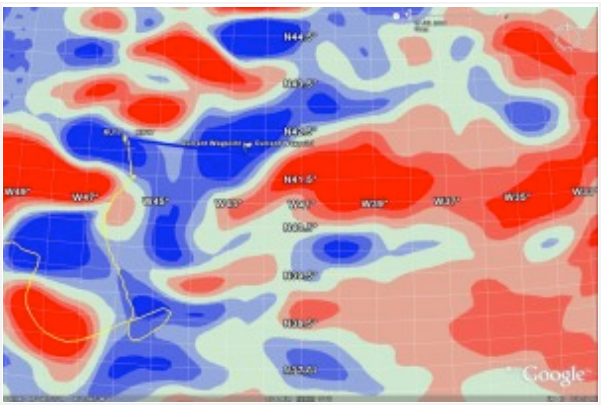
The satellite image below shows we are doing fine moving up in this warm filament. The problem on wednesday when we were in the low current region and had trouble flying did not help us get out of this warm water. We tried flying east, but went nowhere because of the possible biological drag event. And we were so close to the edge. We are now moving rapidly north, and there is a cold eddy up there. If we hit this eddy, the only way around it is clockwise. So west, then north, then east, then south again.



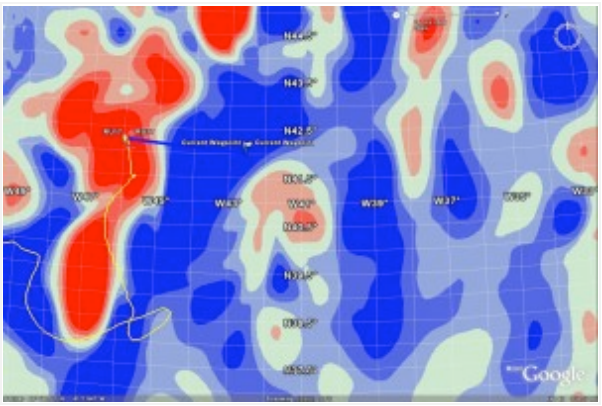
Below is the altimetry image of sea surface height we are much happier with. The Sea Surface high (yellow/orange) near 40 N, 45-46 W does an excellent job of explaing the path of RU17. it followed this high around as intended until we reached 41.5 N, we stalled with the strange glider behavier, and just spun in a few intertial circles as the glider said it was doing slow but tight 360s instead of flying to the east. We are now heading north with these geostrophic currents, and we are hoping they takes us to the east around the high located at 41.5 N. Our objective shown by the waypoint is that sea surface low (blue). This water is flowing south and makes a strong turn to the east. But either way, we deal with it. Its simply another day of navigating the intense eddy field of the Gulf Stream extendsion region. There is no such thing as a direct path for a glider in locations like these.



Below is the NCOM forecast of the east (red) and west (blue) component of the velocity. it clearly shows our objsective, that band of red water heading east between 40 N and 42.5 N. It has been an elusive objective. The problem has been trying to cross that band of blue westward velocity that runs from north/south between us and those nice eastward currents we need. The NCOM forecast also has eastward currents just to our north. The amazing thing about the figure below is the agreement between the track of the glider and the NCOM forecast of east (red) and west (blue) velocity components. The glider is heading north starting about 38.5 N. It moves through a patch of blue (west) and heads northwest. it hits the red (east) patch near 40.5 N, and heads northeast. It then hits another blue patch near 41.5 N, and is heading northwest. And now we are about to enter another patch of red (eastward) at about 42.5 N. Now I do realize we have that space-time thing going on, and someday we should go back and resample the model alont the glider track and time for the true test, but this is amazing. The Navy model is assimilating remote sensing data for the surface and the subsurface data from the Argo profilers. it can combine all that with a bit of F=ma and give us guidance this good. Wow.



The below image of the north (red) and south (blue) components of the NCOM velocity forecast explains the strategy. We are in a long band of northward velocities - everyone agrees here - which is a pretty good day at sea. We continue to ride this northward current till we hit that patch of eastward flowing water. We ride that east to about 43 or 42W, till we hit the patch of southward flowing water that brings us to our desired route in the big red band running between 40 N and 42.5 N in the above plot of eastward velocities.



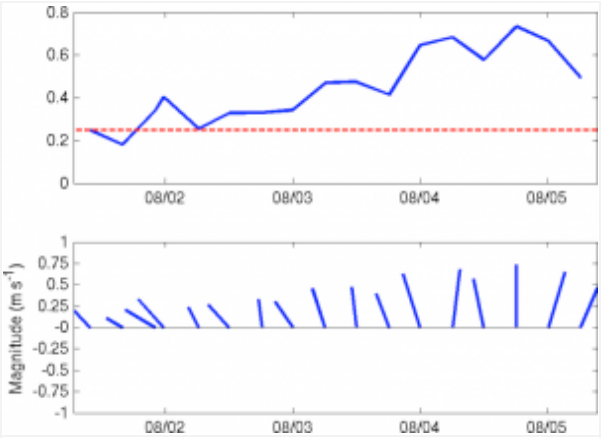
Lots of work still to do to get where we want - that red band in the east-west velocity, but we are getting a lot of help from both sides of the ocean, and the folks back at Webb that build the gliders. Its a team effort, and the team is growing. Everyone wants to help the robot.

1 Comment

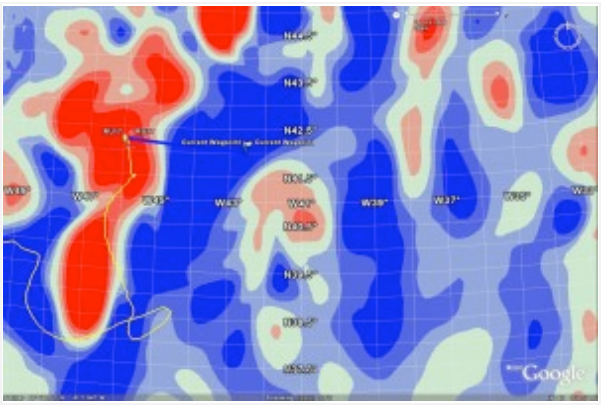
05 aug The models called it right

Edit Posted by: Scott in: Across the Pond Edit

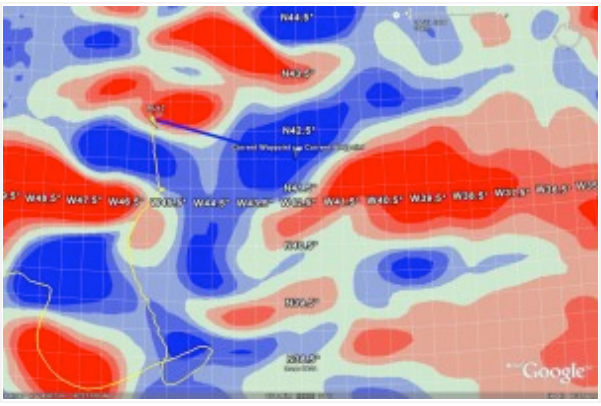
RU17 is moving into an area where the currents are still predominantly to the north, but the east-west component has shifted to the east. Speeds are coming down.



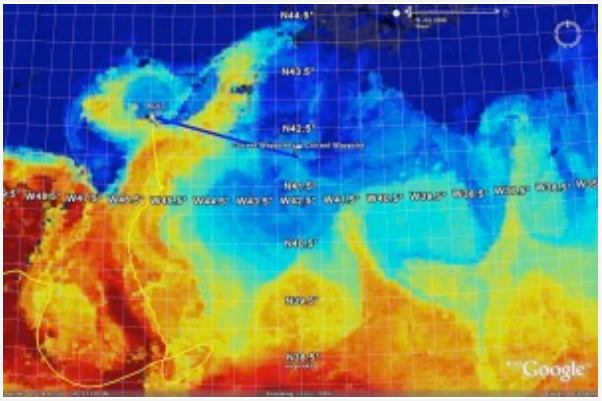
Below is today's NCOM forecast for the north (red) -south (blue) component of the current. Way back when during the loop that drove us south in the blue, we flew west to get into this band of northward current, giving us a very favorable current to get us farther north.



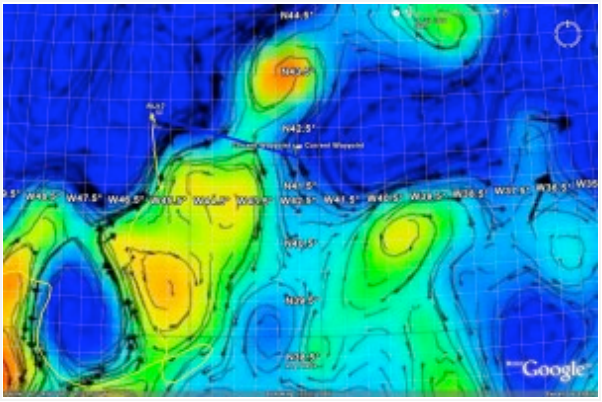
Below is the east (red) -west (blue) component of the NCOM forecast currents. Yesterday we talked about approaching 42.5 N so we could get into that red region just to our north. From RU17's GPS position, it looks like we are in the red, and from RU17's reported currents, the currents have switched to an eastward component.



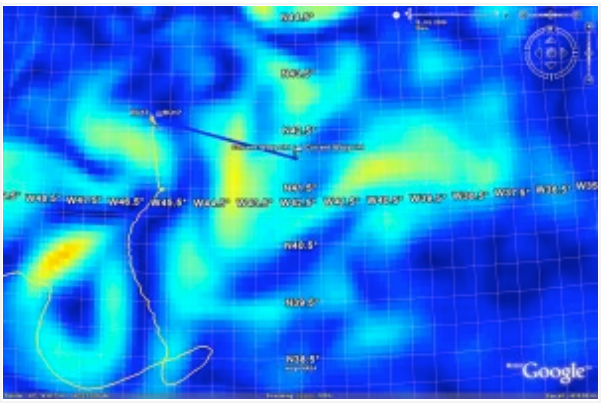
The satellite sea surface temperature (below) is 72 hours old, but indicates we have approached the bottom of that cold eddy feature centered near 43N, 47 W. Even so, we seem to be curving around to the east.



Altimetry says we are in a current that is heading to the north and turning to the east.



We have a pretty good idea of where we are. Still a bit of clean up to do on the processing, and with the data from Spain to get it into the operational data stream. They are providing nice products like MODIS SST and geostrophic velocities. Below is a quick teaser. The geostrophic currents. We need to turn them into east-west and north-south components just like the NCOM forecast above.



But right now we have to focus on our flight characteristics. It looks like we are

moving into a new water mass, and that will be good. We had a lot of trouble with what appears to have been external influences. We know we are flying slower than we were earlier, and thats hurting us. It makes it harder to jump from eddy to eddy. With this update of where we are going, we can now spend the time today on how we are getting there.

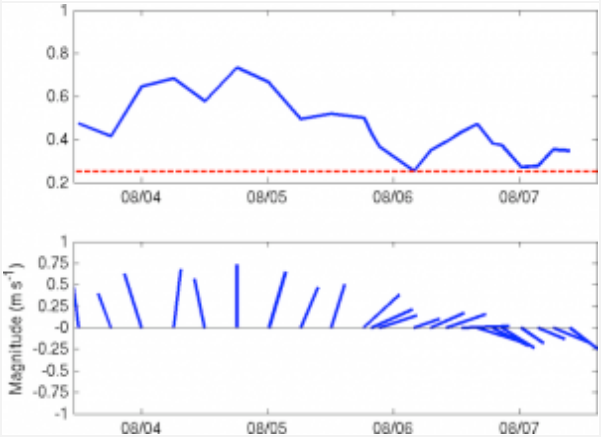
0 Comments

07 aug

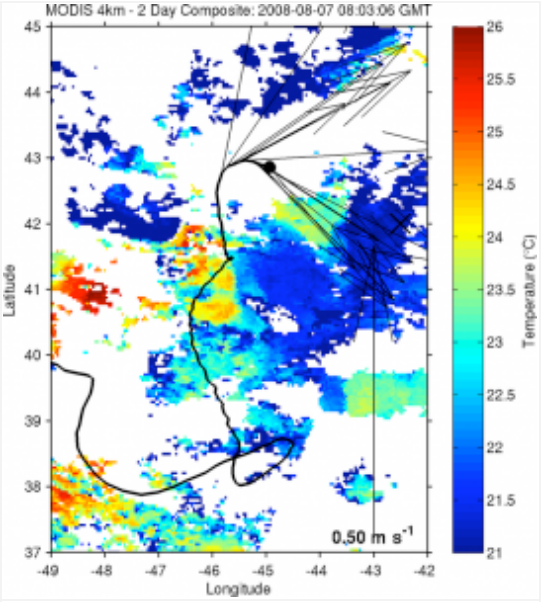
A clear path - but do we have the speed to take it?

Edit Posted by: Scott in: Across the Pond Edit

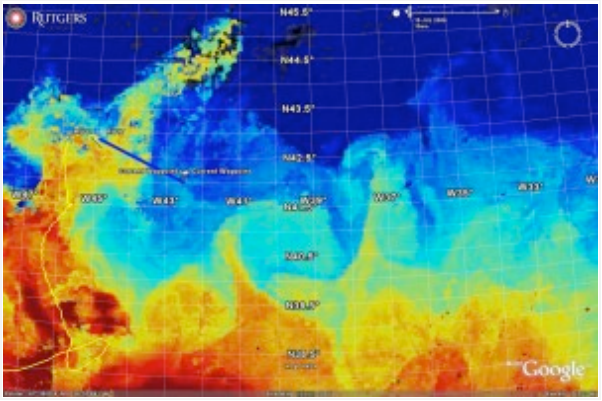
Ocean current time series from RU17 shows that the northward currents that brought us to this latitude first turned to the northeast for about a day, and now have been steady to the southeast for another day.



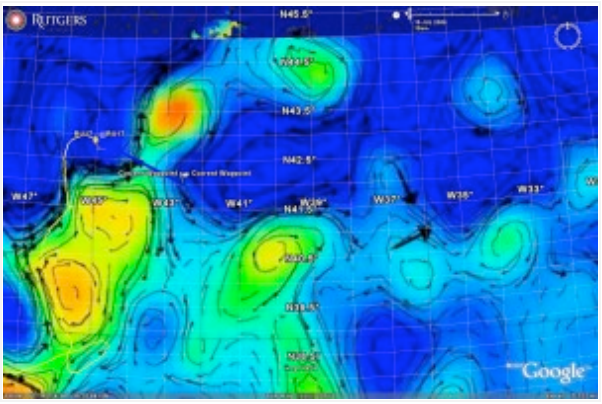
RU17 has made a loop with a steady eastward component. The SST image below here is a small piece of warm water we are heading into.



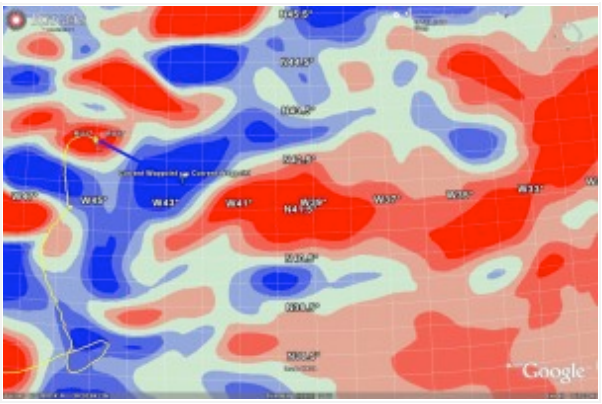
In the image below, we use a 1 week composite to try to place the above small patch of warm water in a broader context. There is a front just to our north that runs parallel to this track. If this warm front is representative of the currents, as we continue eastward, we should start seeing first currents to the north in that warm filament that extends to 45 N, followed by currents to the south in the colder water. Our goal is to cross this region to get to 42 W. We are looking to run in between two eddies - the warm eddy centered near 41 N, 40 W and the cold eddy centered near 42 N, 41 W.



Both of these eddies are well resolved by the altimetry shown below. There is a strong low (blue) near 42 N, 41 W, and a strong high (yellow/orange) near 41 N, 40W. The strong jet between these eddies leads to a meandering current that runs generally eastward nearly all the way to the Azores.



The NCOM model shows this region very well below. Here we have contoured the east (red) and west (blue) components of the model forecast. Lots of red eastward velocities are seen between 40.5 N and 42.5 N. The hard part remains crossing this persistent band of westward velocity (blue) we see that stands between us and the route east. We tried crossing this band further south, and were pushed back, heading into a southward flowing current that would have taken us the eastward flows that head toward the north African coast. Luckily, we had that ring we could go back to and shoot north for an attempt at the northern route.



So we have a good plan to get where we need to. A plan that brings us close to the Azores if we need to stop for repairs, batteries, or cleaning before we continue the journey to Spain. But we still have that problem with what appears to be an external influence slowing us down night after night. Eric is an NSF RIOS undergraudate student this summer, and his results clearly demonstrate that something is slowing us down at night. As a result, we are trying to test different flight behaviors. Does it help if we fly faster or slower, steeper or shallower, surface more at night, etc, etc. Most of our work will be focused on trying to get our horizontal glider velocities back up so we can improve our navigation in the eddy fields. This will be especially important as we try to cross that band of westward flowing water.

0 Comments

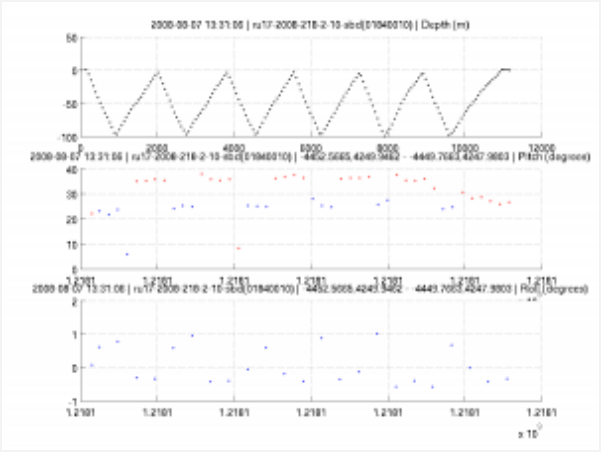
10 aug Much to say on a sunny summer weekend

Edit Posted by: Scott in: Across the Pond Edit

We spent much of last week working on flight characteristics of RU17. Something was slowing down our ascents, especially at night. One of our partners from across the pond, Antonio Ramos from the University of Las Palmas de Gran Canaria said it

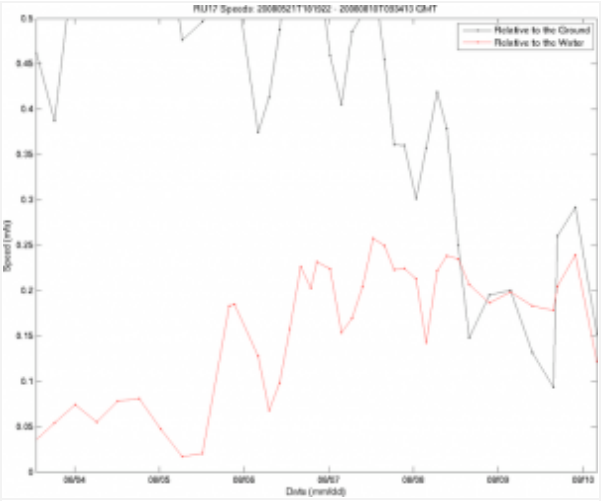
reminded him of his echosounder work, where he found patchy layers of biomass that moved up and down in the water column with the day night cycle. His examples show how these layers may be in the upper 100 m at night, and dive back down below us during the day. The patchiness of his biological observations certainly match the patchiness of the effects on Ru17. We also have two unexplained behaviors in the glider flight characteristics Antonio's hypothesis may help us with. We occassionally get kinks in our climbs when the glider slows down for a bit, then speeds up. is it going through a layer of larger biomass. It was occuring on our slower climbs. On our faster dives, we occasionally see something that spins RU17 in a complete circle, the fin correctly opposing the turn the entire way, indicating either the compass can break and fix itself, or that there is an external influence causing some drag. To look further into Antonio's hypothesis, we'll look more closely at the day-night cycles of all these behaviors. Thanks again to our friends on the other side, and thanks to Eric Vowinkel, one of the NSF RIOS students spending the summer with us. Eric just presented his poster on tuning the flight characteristics of RU17 on Friday at the final RIOS open house.

For RU17, one of the most interesting observations was that the day night cycle had a significant effect on our slower climbs, but had little effect on our faster dives. We decided to try speeding up the climbs, trying to fly at a steeper pitch to move faster through the water column, and see if we could minimize the day-night impact. We moved the climb pitch angle from an energy savings 26 degrees to a bit more costly 35 degrees that would also maximize (theoretically) our horizontal speed. The first plot below of the time series of dives and climbs shows we have evened up the speed of ascents and descents for most of the record, but we still need to work abit on the final ascent after a timeout is experienced.

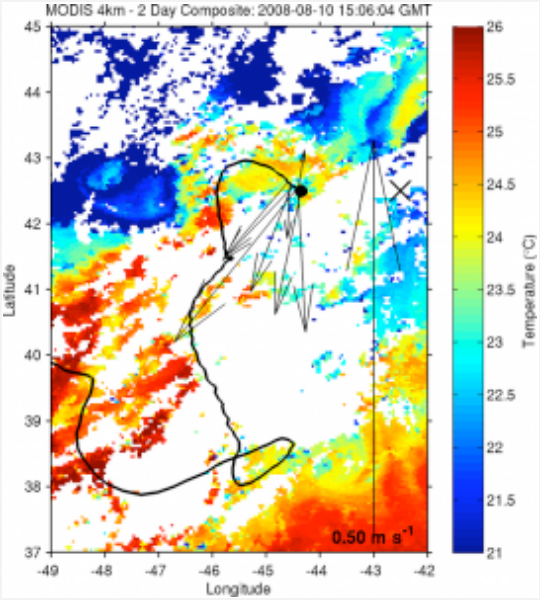


The ulitmate test, however, is not whether we can move up and down, but whether we can use the wings to translate that vertical motion into horizontal motion. It also would put to bed a secret fear that we had - maybe we had lost both of our wings, and that was why our forward motion was so slow. RU16 just proved that even after a shark attack that possibly removed both wings, a glider can still make some forward progress even with just the stubs that are left behind. The plot below brought smiles to everyone's face. Here we take the velocity over the ground, subtract from it the velocity of the water, and get the resulting velocity of the glider relative to the water. Below the red line shows the plots of the magnitude of the velocity of the glider relative to the water. We started making the change about mid-day on August 5. A bit of tuning and we are now averaging somewhere around 20 cm/sec. That a respectable speed for any glider. its not the 25 cm/sec we like, but its pretty close. Talk about a spirit lifter. There clearly is still a diurnal cycle we need to sort out, but we have been averaging a good speed relative to the water since Wednesday. With this good news, we switched from the 3-hour dive

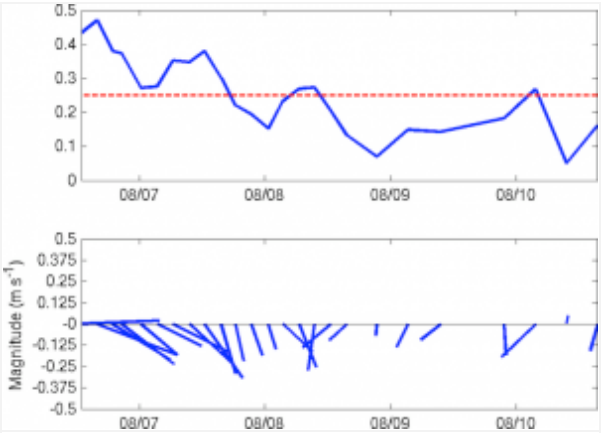
segments we used for testing to the energy saving 6-hour segments for the weekend.



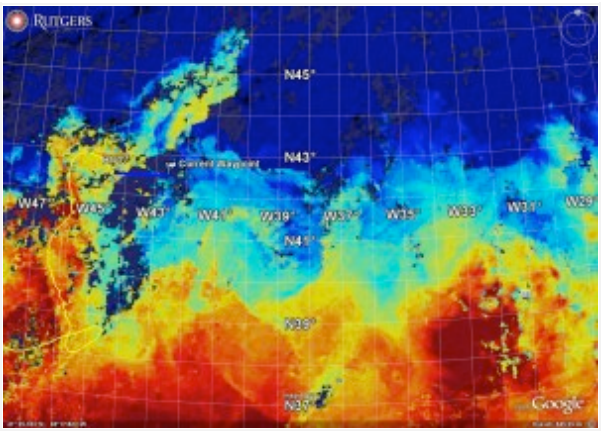
Now that we have created some speed relative to the water, lets check what the water is doing. RU17 is finding currents to the south to southwest, that combined with our glider speed flying to the east, has resulted in the nice loop to the east.



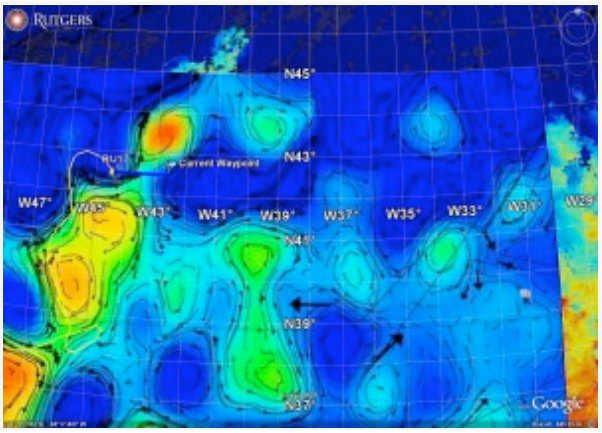
The current speeds are decreasing over time as we swing to the east. We even had a short reversal to the north for one segment. But most currents have a southerly component. We'll use that to compare with the various products we use for path planning.



Below are a series of google earth images we use for path planning. John did the Sea Surface temperature plot first, then Justin followed up with a series of products that he is now finalizing in the last few days before he heads off to grad school in in Georgia. In the imagery below, we see the warm filament heading north from RU17's current postion, and the cold water just to the east. Somewhere in that cold water is the eddy that we want to catch. We hope that it will whip us around, first to the south, then to the east. the trick is, we are not exactly sure where that eddy starts.

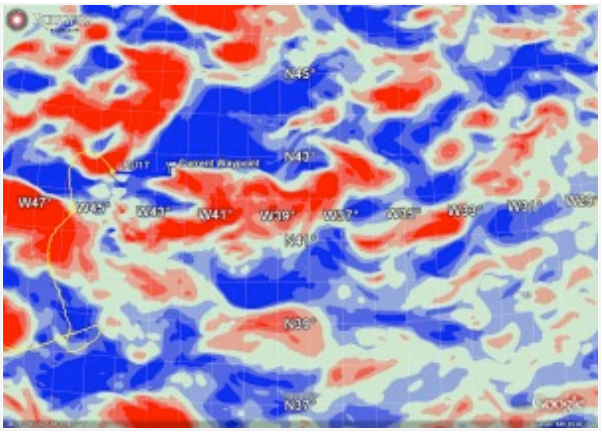


Colorado Altimetry. The geostrophic currents from the altimetric sea surface height provide some clues. It has the edge of the cold eddy (low SSH, blue) as far east as 43W. This is very good, since we have been watching this eddy for some time now, and it is propagating west. Its center is at 42.5 N, 41 W. The northeast side of the eddy in the altimetry corresponds to a front we see in the SST. Its good when datasets agree. That means based on this image, all we have to do is cross this region from our present location at 44.5 W to get to 43W, and we will be in the eddy. The problem is the southerly currents that we see flowing along 43.5 W. if we get stuck in these, we get advected south away from this eddy. It suggests that the safer way to cross is to go further north and hit that saddle point between the two highs. The high near 43.5 N, 43 W is also in the SST, so that gives us confidence in its location. The problem with this image is that is says the current velocities should be to the east, and they aren't. They are predominately to the south. And as we continue east, we should see first a current to the north, followed by a current to the south. So if the southerly danger region is there, we also have a northerly current to cross first. The conclusion here is to head east and see what happens. We can't trust the geostrophic currents locally, but we can keep trying to reach that cold eddy that is propagating west.

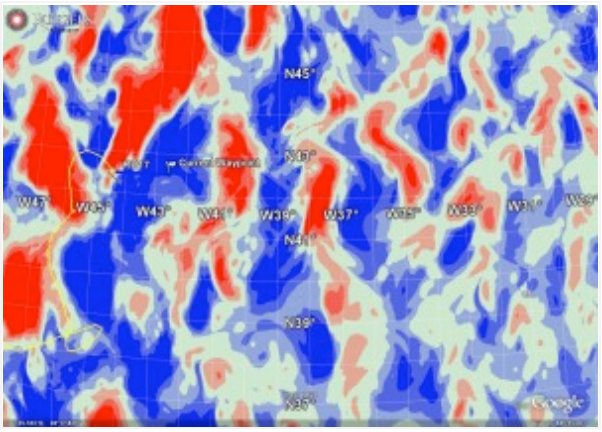


Now come the series of plots that are various combinations of models and assimilated data, with the altimeter playing a major role. Justin has contoured the East (red) -West (blue) component of the predicted current, followed by the North (red) - South (blue) component. Grey is anything in the range of +/- 5 cm/sec. Every shade of red or blue corresponds to another 10 cm/sec increment.

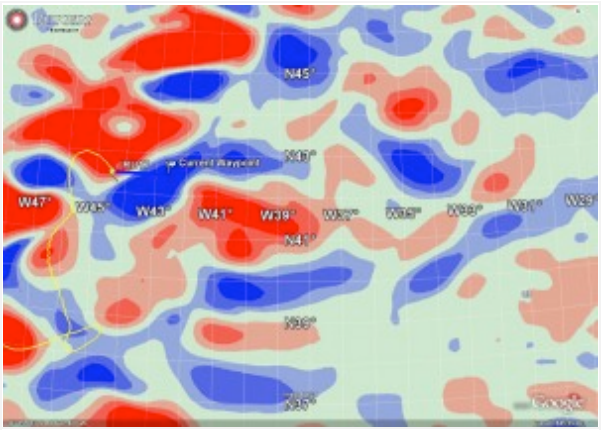
NLOM E-W (below). There is a broad band of Eastward velocity between 41 N and 43 N. it continues off the plot to the Azores. This is our target. if we can get into that cold eddy, it will sweep us into this current. The good thing about this forecast is that the eastward velocity band extends all the way to 44.5W, just to our south. If we do get forced south, this forecast says we'll catch this region and still get into the target region.



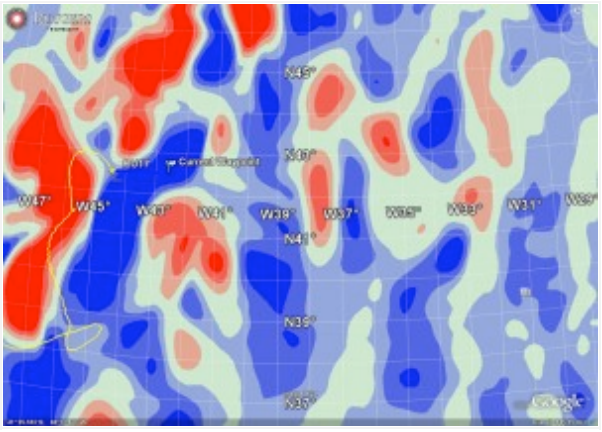
NLOM N-S (Below). The band of southward velocity that we need to cross has breaks in it to our south. Again, this is the good news forecast. We are entering a region of southward velocity in this forecast that could get us to 43 W when combined with the eastward velocity. The problem locally is that we have already had southerly currents for some time.



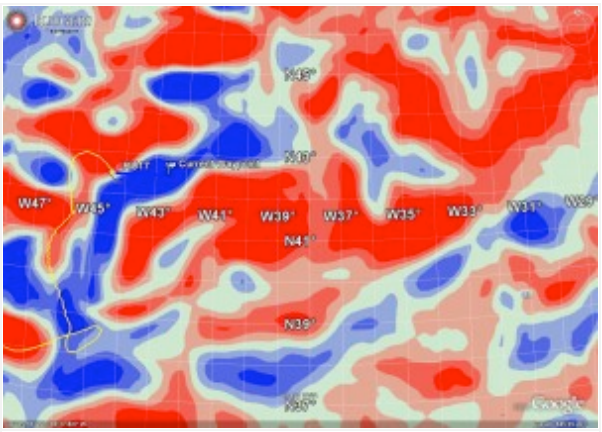
NCOM E-W (below). This is voted the most improved forecast since yesterday. Not because we have any more validation data, but because of the changes on the east-west velocity to our south. yesterday that band of blue water extended way to our south. If that forecast was right, it said there was no possible way for us to cross this region and get to the ring. This caused severe stress yesterday morning, at least for me. The NCOM forecast said the only way east was to continue on the north and go around. As I told Hugh before we even started this mission, the most stressful times are going to come when we want to fly against the current (we wanted to go NE, and the current was SW), so you had to go perpendicular to the current, but you did not know should you go perpendicular to the right or perpendicular to the left. So yesterday morning I decided to turn left 45 degrees and head north. If NCOM was correct in saying that the only path was too the north, we would be on it. If the altimetry was correct, we could use the extra distance to the north to help us cross those southerly currents and not miss the eddy. But now we see the eastward velocities wrapping around us to the south, again extending to 44.5 W. So by yesterday evening, right about the time that Mike Phelps was swimming for the gold, we heading RU17 back east.



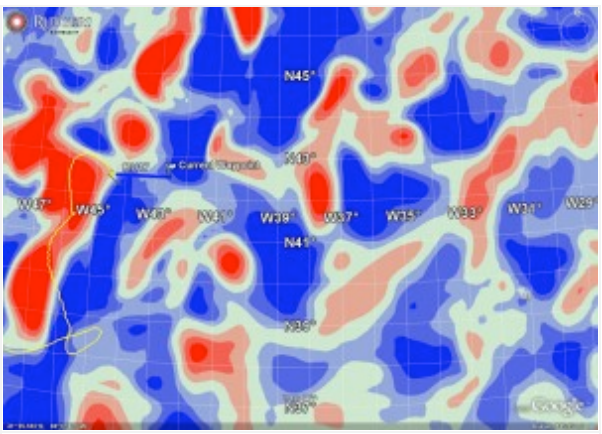
NCOM N-S (below). Again we see currents to the south, but the eastward currents we will encounter will bring us back to the east and to the northward currents we need to stay in that eddy.



Spain Altimetry E-W (below). the broad band of eastward velocity is again seen between 41 N and 43 N. Everyone agrees on this. With that much agreement, its where I want to be. Avoiding days like yesterday will be a lot better for me. This product has the easterly current region extending to 44 W, but all the way north to 41.5 N. This dataset remains with the area of unbroken westward water between us and our goal, and it says the only way around is to the north. But we also have a day delay between this product and the above forecasts. As this product is updated tomorrow, we hope to see that blue band decrease in size, especially to our south.



Spain Altimetry N-S (below). All altimertic derived products agree we are heading into a region of southerly velocity. So we know what is coming. The question is, as we move south, can we make it across into the eddy.



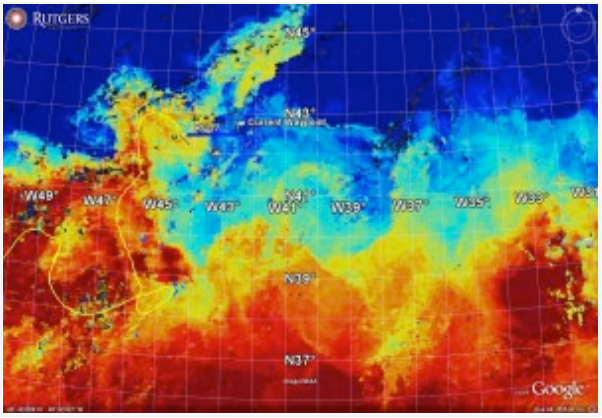
0 Comments

11 aug

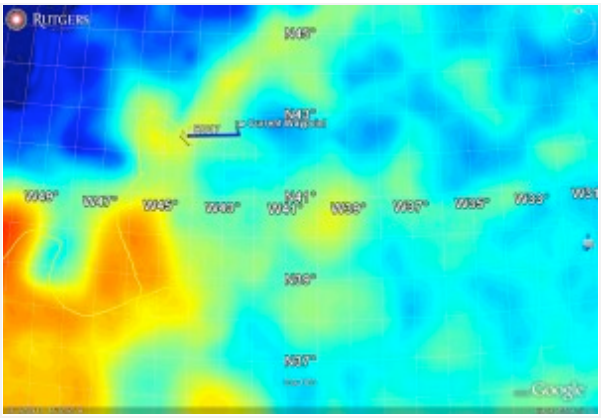
New Altimetry tells the story

Edit Posted by: Scott in: Across the Pond Edit

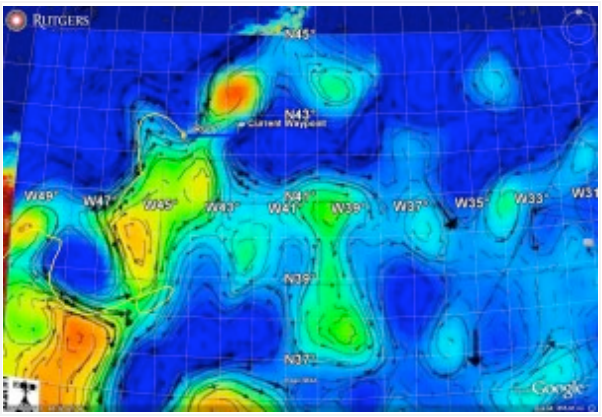
Below SST image shows that between 41 N and 43 N, RU17 moved Northward in a warm current and then turned southeast. The weeks worth of composite satellite imagery shows that it appears to be following a warm current.



The NLOM forecast of sea surface height showed it first. RU17 was spinning around a newly developed high (yellow) in the NLOM forecast of SSH.



The Colorado altimetric product now shows it clearly. There is a bump in the high that was not there in yesterday's product, and RU17 is spinning around that high, moving towards the saddle point between the larger highs to the east.



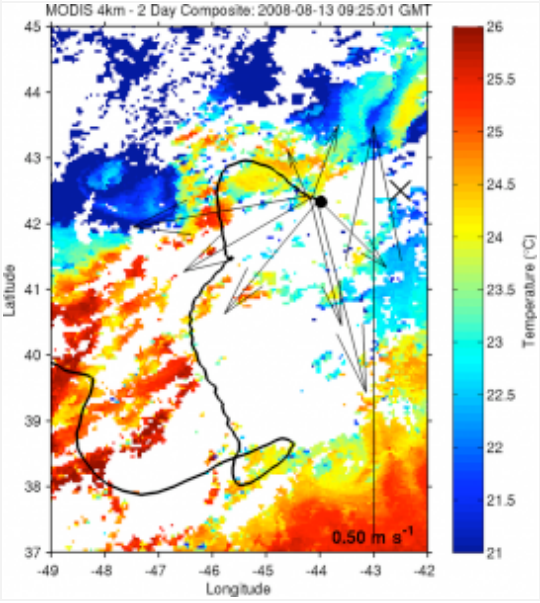
In fact, the above image is an excellent summary of Ru17's course for the last month. It shows us getting pushed back by that low below 38 N, how we turned back to the northwest, and rode the western side of the high north, and how we are continuing to rind this feature around.

0 Comments

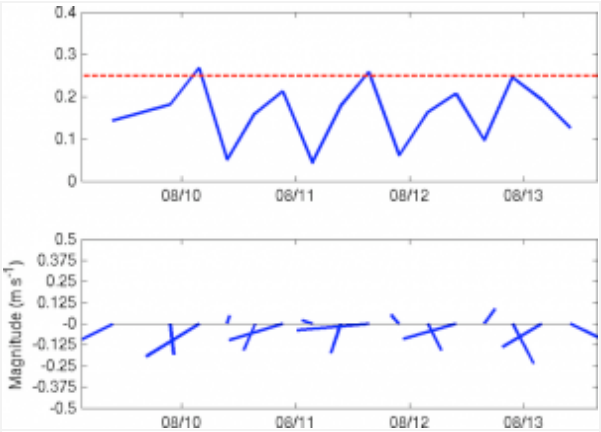
13 aug Closing the gap to the cold ring.

Edit Posted by: Scott in: Across the Pond Edit

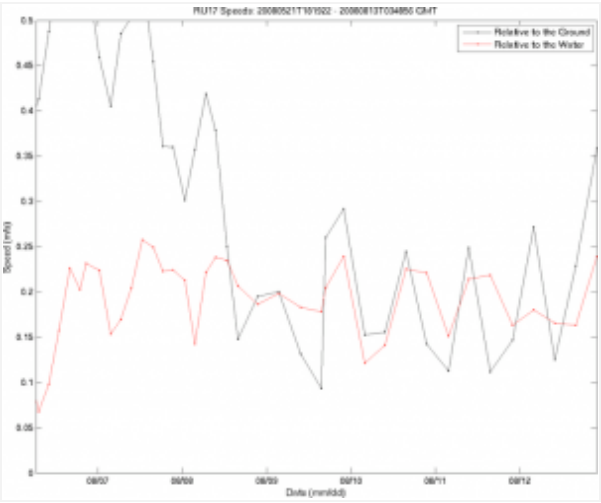
RU17 is making steady progress to the east towards our target cold ring. Currents are going everywhere. Why?



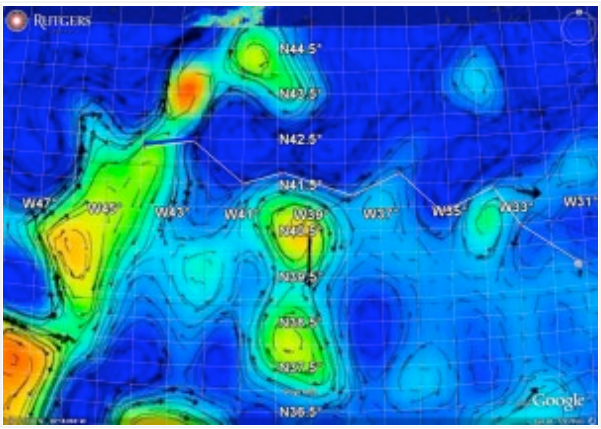
TIme series show they are inertial, but poorly resolved by our 6 hour sampling. Vectors almost look like the hands of a clock.



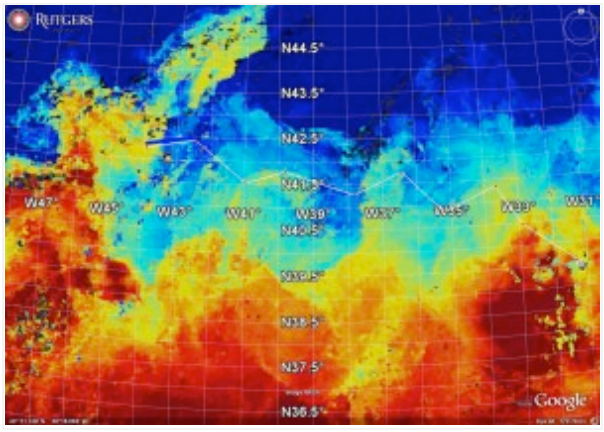
RU17 has been making a good horizontal flight speed at a reasonable rate for the last 5 days. We are averaging nearly 20 cm/sec relative to the water. This is a great achievement.



Below is the Sea Surface Height field, and how we want to fly eddy to eddy as soon as we get deep enough into the first cold eddy to not get advected south. The good news is that the eddy is moving west while we move east, closing the gap from both sides. The zig-zag path length is about 1250 km to the first island in the Azores.



Below is the SST field with the Zig-zag path overlayed. We are staying in the frontal region between the warmer water to the south and the colder water to the north. We always like to keep our batteries above 15C. Cooler temperatures sap the energy.



0 Comments

13 aug Latest Flight Plot Using Eric's Scripts

Edit Posted by: Hugh Roarty in: Across the Pond Edit

5 large bearing deviations. Will look at previous segments.

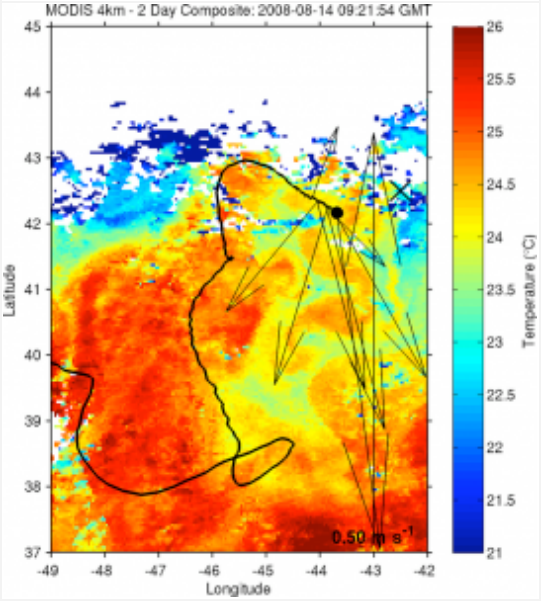
0 Comments

14 aug Moving into the southward flowing jet

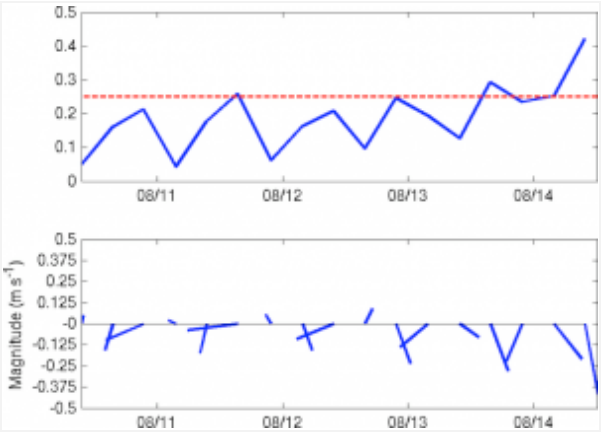
Edit Posted by: Scott in: Across the Pond Edit

New satellite Sea Surface Temperature (SST) shows we are in a meandering filament with southward currents. This is the region we need to cross. The filament

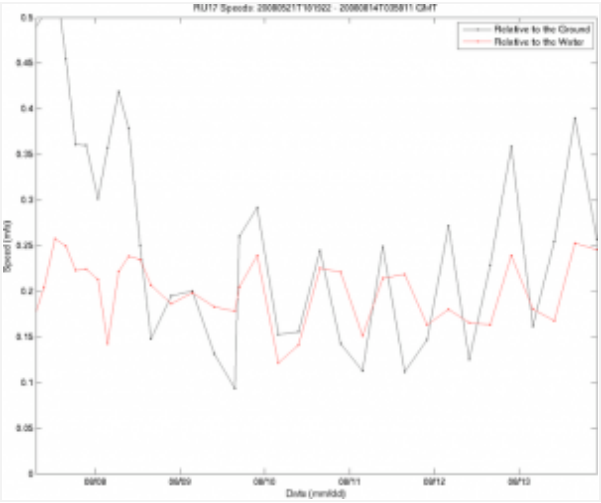
in the SST image appears to be thinner, but with more meanders, than it does in the altimetry.



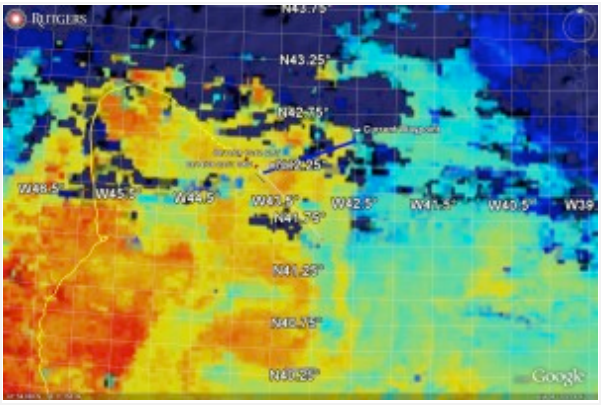
Currents are increasing steadily as we head into this southward flowing filament.



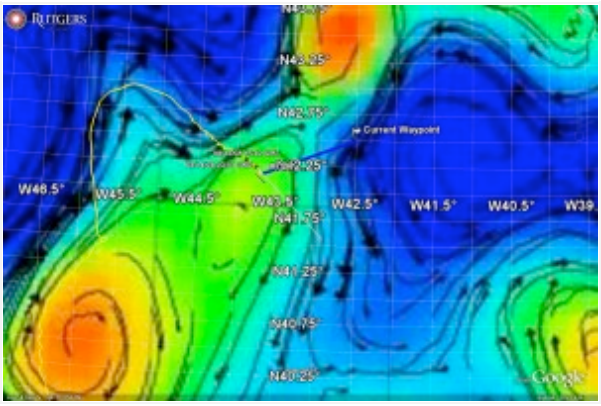
We are maintaining our glider speed, so that is good news.



Below is the SST in google earth. Yellow line is our track. Blue line shows the direction RU17 is flying. White line shows where we end up if we continue on this track to the other side of the filament.



Below is that same track and white line on the altimetry. If we can maintain this track, it looks like we can get across the southward flowing jet and into the part of the eddy that turns east rather the part that keeps heading south.



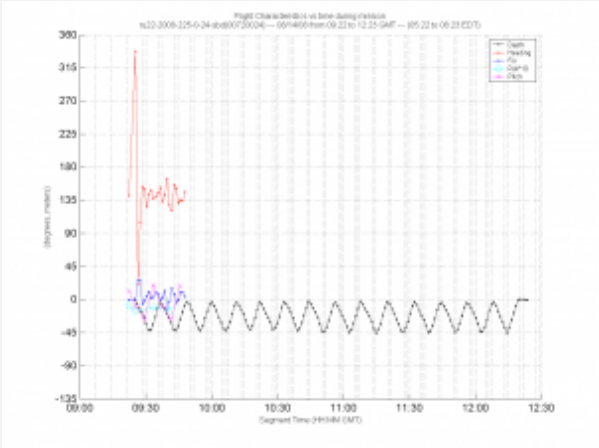
Wish us luck!

0 Comments

14 aug August 14 Flight Metrics

Edit Posted by: Hugh Roarty in: Across the Pond Edit

ru17 5 large bearing deviations same as yesterday

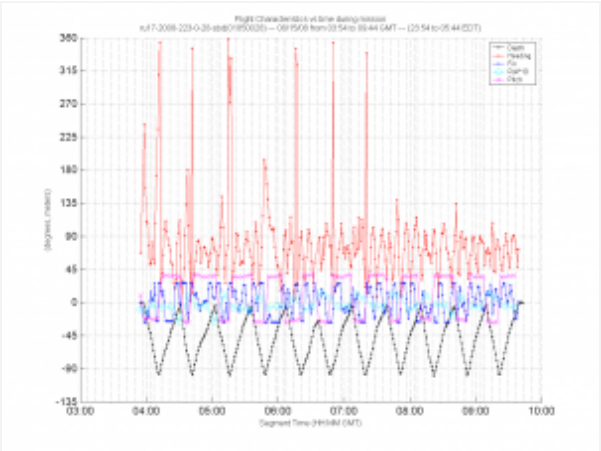


ru22 only have heading from the first 2 yos but the range isn't as large as 17 so we'll need to investigate.

0 Comments

15 aug August 15 flight metrics

Edit Posted by: Hugh Roarty in: Across the Pond Edit



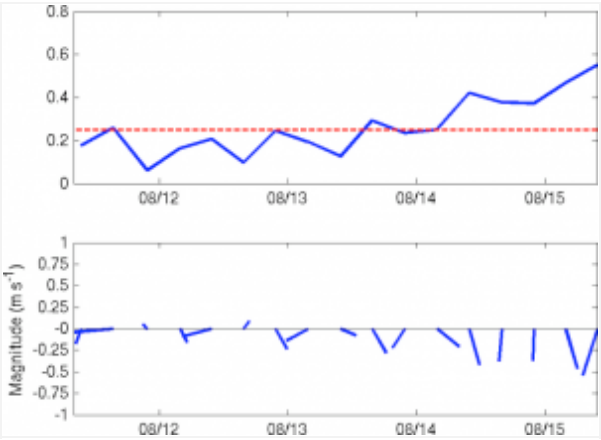
7 large bearing swings. I had noticed them only on dives. Now it appears that 2 of them happen on climbs. Close to the inflection. Wonder if this has anything to do with swimming normal to the current.

0 Comments

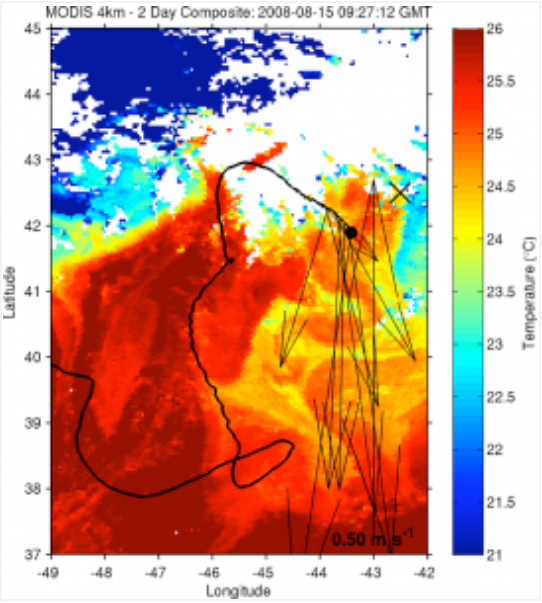
15 aug Flying for the eddy's edge.

Edit Posted by: Scott in: Across the Pond Edit

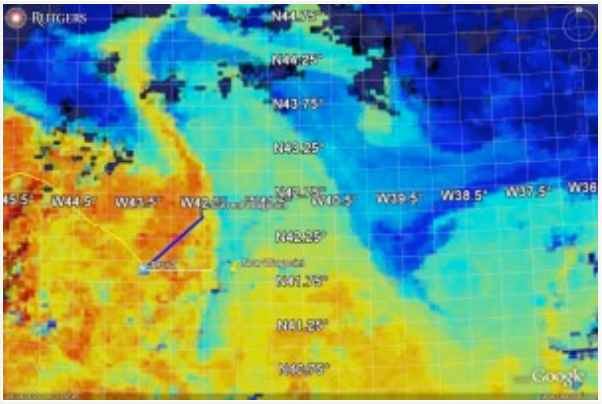
Currents are heading south and inrceasing in macnitude, climbing to about 55 cm/sec.



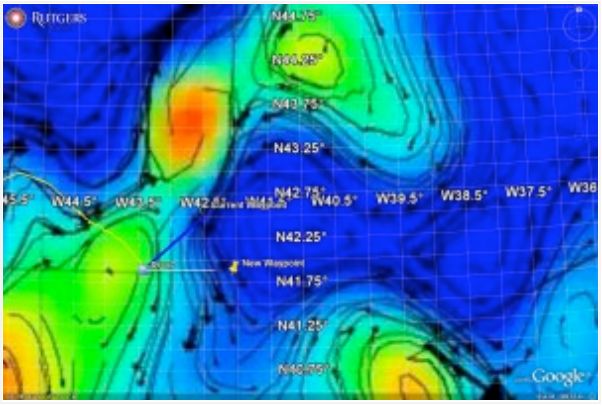
RU17 is being advected south and is flying east, hoping to cross the filament of warm water into the cold eddy to the east.



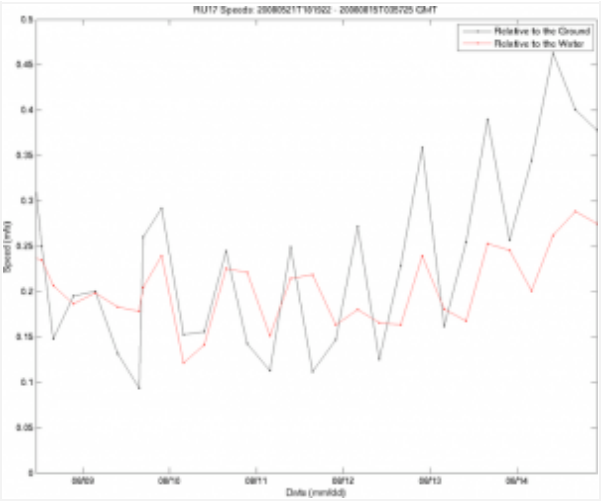
This zooms in on the cold eddy. That coldest water near 42 N, 40 W is the northeast side. The western side of the eddy is near 42.3 degrees, about 90 km to our east along the white line. We'll start steering RU17 towards the new waypoint that is due east at the 11:30 am surfacing.



Below is the altimetric SSH product. if we can make it about half way out on that 90 km long white line, we will be far enough into the eddy to be swept around to the east rather than pushed south away from the eddy.



Looks like RU17 is still making good horizontal speed even with the course deviations that are occasionally hit us.



Time to fly. Good luck RU17.

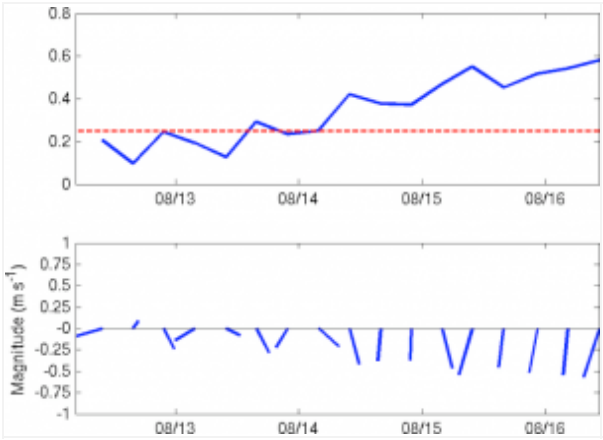
0 Comments

16 aug

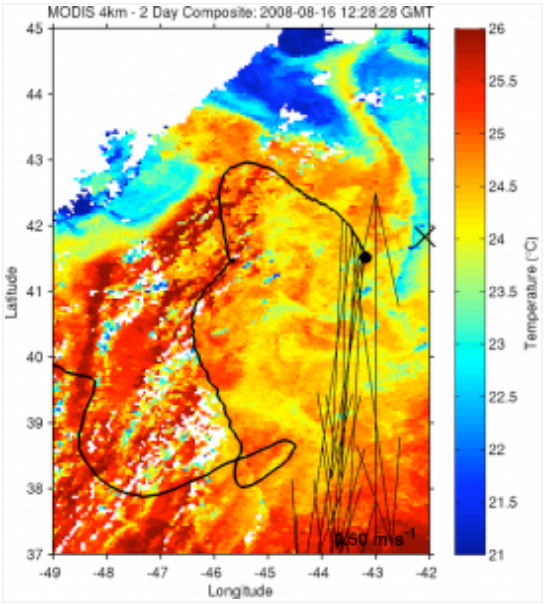
The Race

Edit Posted by: Scott in: Across the Pond Edit

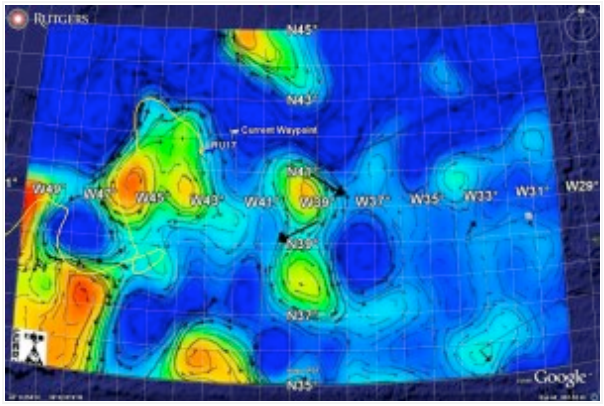
Currents in the vicinity of RU17 are running relatively steady, near 55-60 cm/sec and mostly to the south.



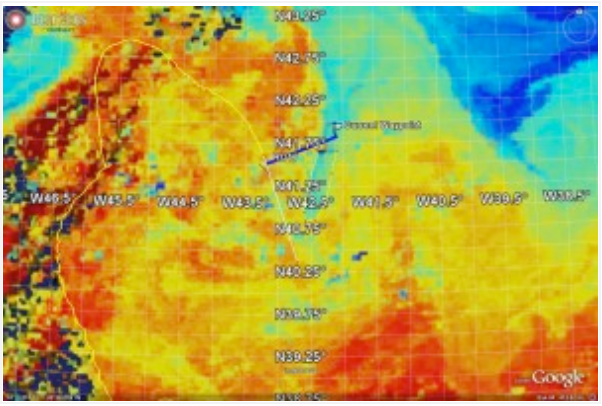
Overlaying it on the standard SST projection below shows that we are in the warm water, and we are trying to get into that tongue of cold water that is heading south along the edge of the map.



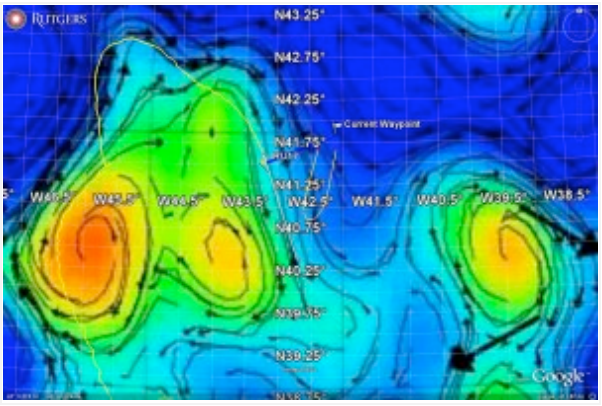
But its the new altimetry below that really tells the story. There must have been new passes in the region that are incorporated into this mornings product. All the individual sea surface highs (organe) that RU17 has been looping around near 44-45W have merged into one very large high region. Its about 450 km across, greater than the distance between New York Harbor and Chesapeake Bay. The challenge of us is to fly RU17 out of the sea surface high with its clockwise circulation, and into the sea surface low (blue) just to the east with its counterclockwise circulation. The counterclockwise circulation of the low puts us on the meandering path to the east. The clockwise circulation of the high will spin us around this large system for another lap.



Zooming in on the SST image below, we have drawn a white line showing where we end up with the present trajectory. And we have outlined that tongue of cold water just to the east with a yellow line. RU17 is currently about 55 km from the cold tongue, and the present trajectory takes it to within about 25 km of the bottom of the cold tongue. Clearly we want to fly east as fast as we can.



In the zoom in of the altimeter product below, the need to fly east is even more clear. If we continue on the present trajectory, we will remain in the high and go around the big clockwise loop again. if we can move RU17 about 25 km east, we can pick up the counterclockwise circulation of the low.



Will we make it? Many uncertainties remain. How accurate is the present sea surface height map in the region we are flying into. There are places along the track of RU17 where the observed currents are very close to what we see in the altimetric product. Then there was last saturday, exactly 1 week ago, when none of the guidance products agreed, either with each other or with what the glider was seeing on the ground. We have been able to increase RU17's horizontal speed by adjusting the pitch of the climbs, but it is still wounded, and not flying at the full speed we had early in the flight. The best we can do now is continue to move our waypoint to the south, traking RU17's progress and continuing to head it east. As we continue east, we hope to get into more favorable currents that will also tweak our trajectory and help us exit the eddy. So we are dependent on both the speed of RU17, and its ability to cross the streamlines, and the change in the streamlines we get as we move east.

This is going to be very close. We are in a game measured in smoots.

1 Comment

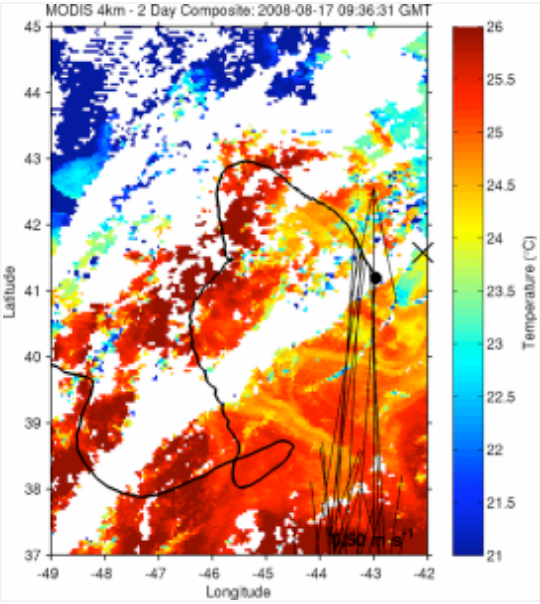
17 aug

Too Close to Call

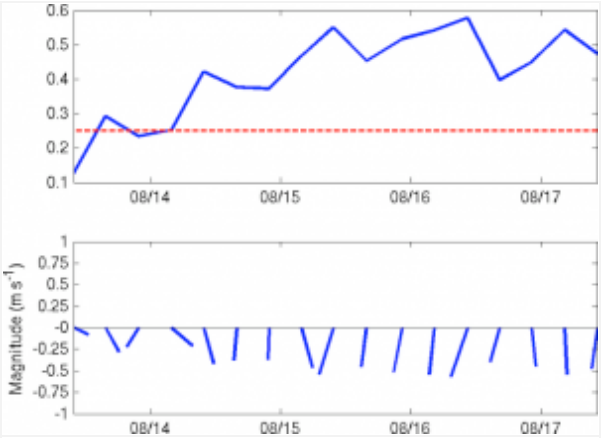
Edit Posted by: Scott in: Across the Pond Edit

RU17 continues its race against the currents. RU17 is flying east. The currents are flowing south. We are aiming for that cold tongue of water just visible on the

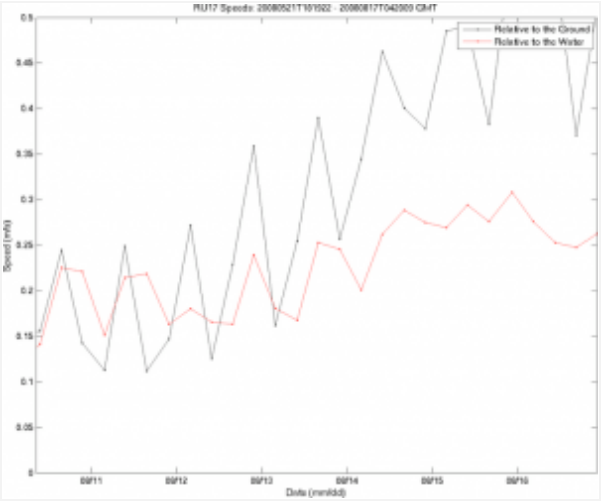
eastern side of this SST image.



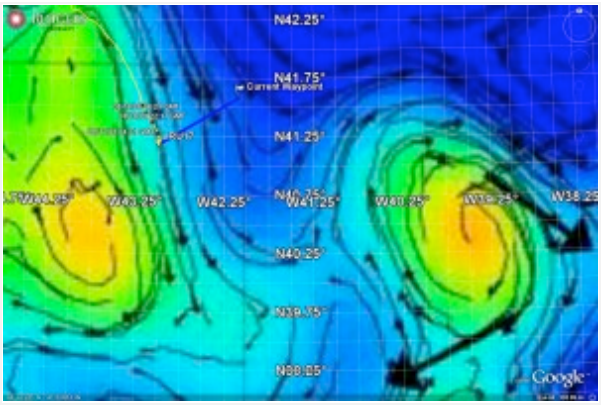
Current time series tell the story on the ocean side. Currents are relatively steady to the south, hovering around 50 cm/sec, with a bit of wobble in direction. Maybe inertial currents causing the wobble.



Time series of horizontal glider speed below tell the glider side. Looks like we are maintaining a decent forward velocity despite the steering problems.



And finally, below, the roadmap. We are trying to fly away from the High (orange) near 44W and into the Low (blue) near 42 W. If the ocean currents win, we stay in the High get whipped around for another loop. Same thing that happened on the flight to Halifax. If the glider wins, we get into the Low and get whipped around to the east. RU17 continues to make progress across the streamlines towards the vectors that are heading around the low. But remember, there are still uncertainties in the roadmap. The altimetry says the currents should be mostly south with a little bit of east. We are seeing mostly south, as predicted, but more occurances of west than east. So the roadmap has error bars, the glider speeds have error bars, the current estimates have error bars, and the result - it remains to close to call. Our job is to keep RU17 flying east, and see what happens.

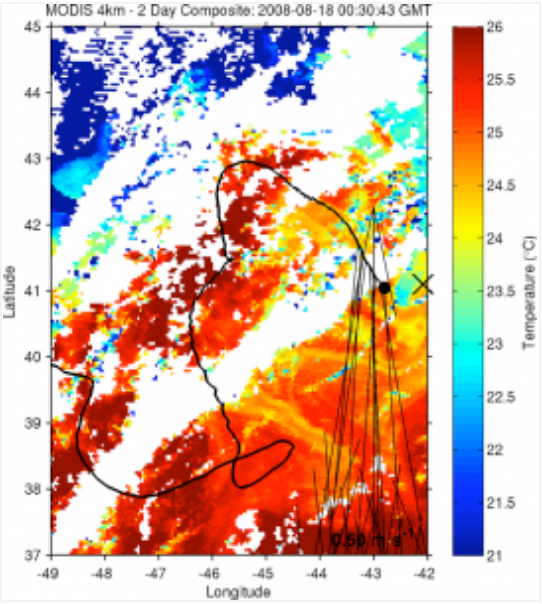


0 Comments

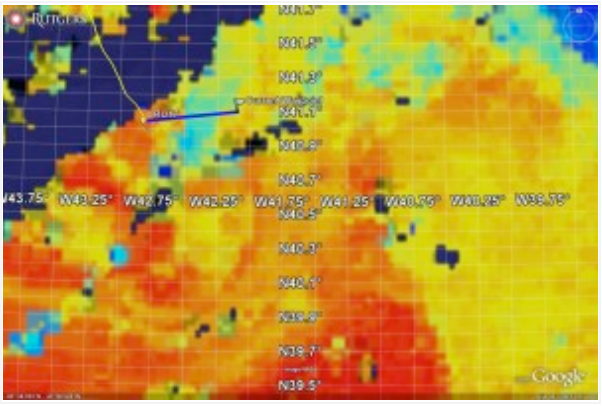
17 aug Setting up for a photo finish

Edit Posted by: Scott in: Across the Pond Edit

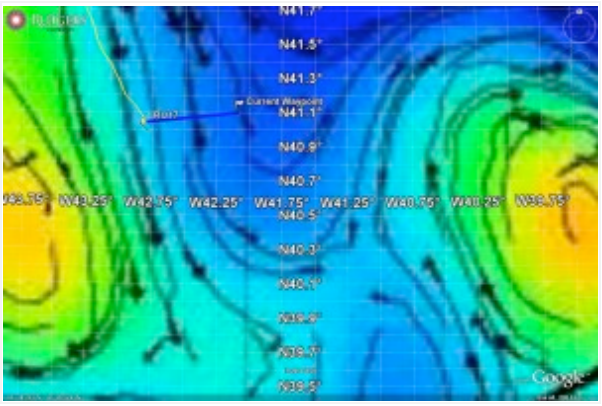
3 quick images below. First shows RU17 approaching the southern end of the cold tongue we set as a target.



Imagge below zooms in on the track and the tongue. We'll know if we make it by morning.



Below is the sea surface height image showing RU17 trying to cross into the reagion that spins back to the east rather than getting pulled further south.



It will be a photo finish in the morning.

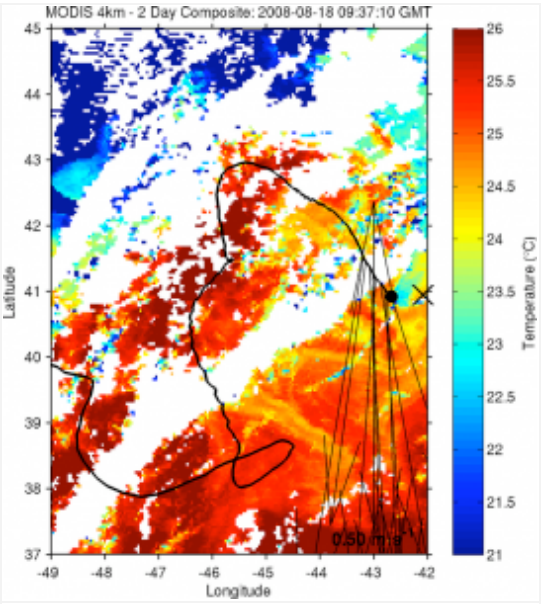
0 Comments

18 aug

One more stroke

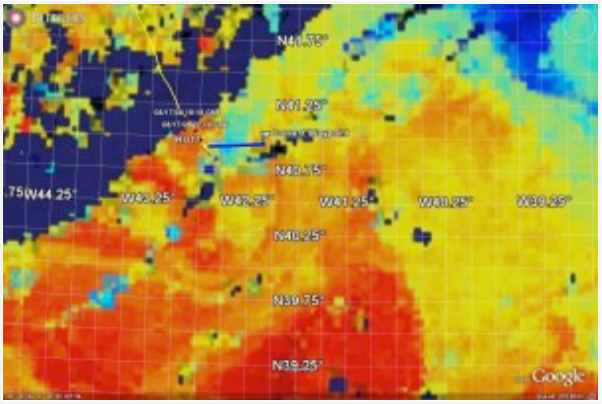
Edit Posted by: Scott in: Across the Pond Edit

Image below has the 6 am EST location of RU17. Just on the edge of that cold water in the SST image below. We'll have to zoom in for a closer look.

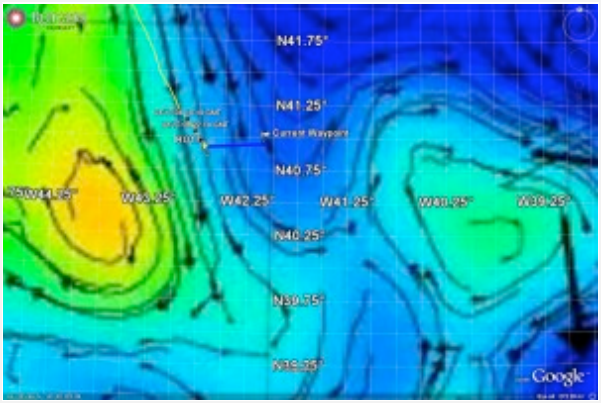


There is a significant change in the current direction. The direction line is more to the east than in the previous 4 days. Will this trend continue?

Zooming in on the SST, we are about 5 km from the edge of the cold water. We typically traveling 8-12 km every 6 hour interval. It all depends on the angle we can make to the east.



Based on the morning altimetric road map, we continue to make progress across the streamlines towards the Low (blue) in the sea surface height. The observed currents from the last segment above are now more in line with currents on the map below, increasing our local confidence in the map.

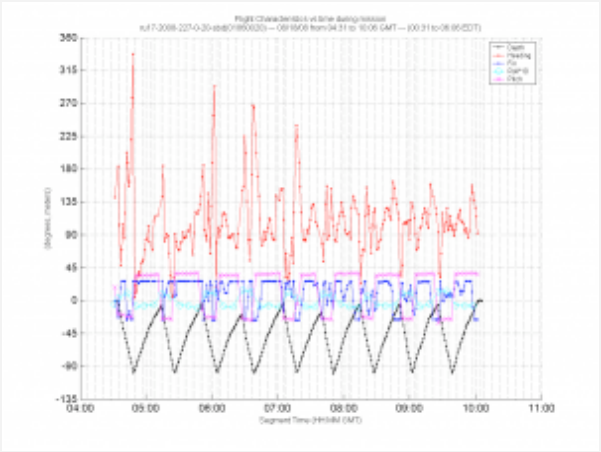


0 Comments

18 aug

August 18 Flight Metrics

Edit Posted by: Hugh Roarty in: Across the Pond Edit



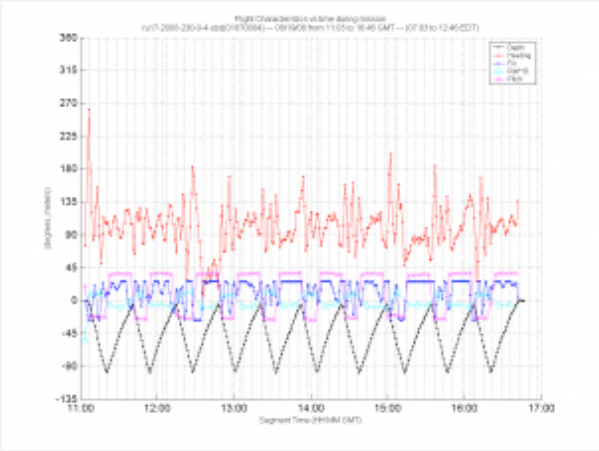
The fin was really getting a work out on this segment. 4 large bearing deviations.

Less than before. Did not make it to the surface on 2 yos.

0 Comments

19 aug August 19 flight metrics LOOK GOOD?!

Edit Posted by: Hugh Roarty in: Across the Pond Edit

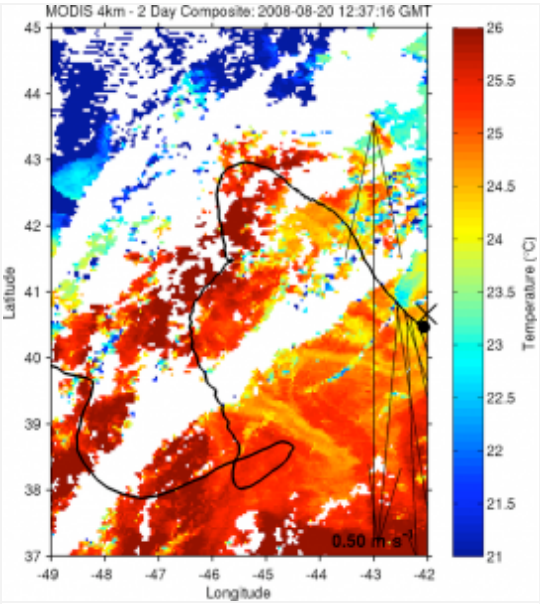


0 Comments

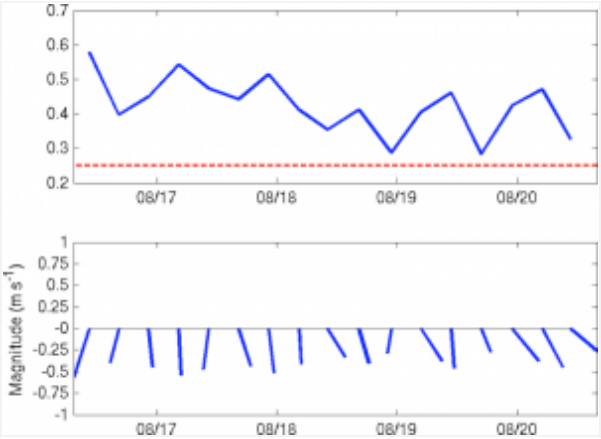
20 aug Keep going RU17

Edit Posted by: Scott in: Across the Pond Edit

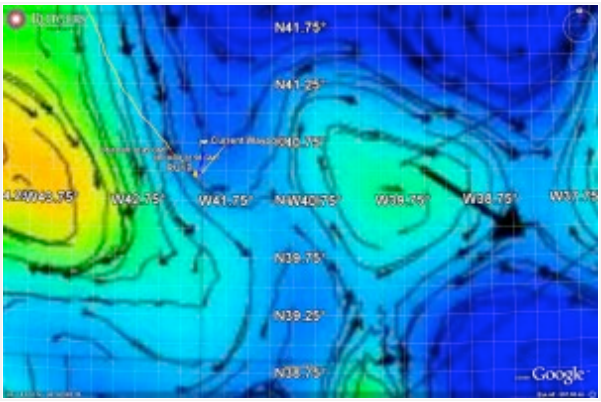
RU17 is about to cross in the next UTM boundary at 42W, skirting along the southern tip of that target cold tongue.



Ocean currents are more consistently to the southeast. A good sign.



The roadmap below says we should start seeing those currents turn east soon. We'll continue to swim perpendicular to the current to try to get into that current spinning around the High to our east.



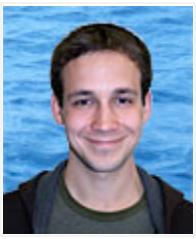
0 Comments

20 aug A tip of the hat to the glider pilots!!!

Edit Posted by: Oscar in: Across the Pond Edit

Ru17 reached 50.1% across the Atlantic today. It has been a painful few weeks navigating around westward moving bulges of water and roving bands of biological obstacles mobbing the Glider at night. Also as the first half of the journey ends, so does the summer break. 2 of the key pilots this summer were undergraduates. One of them Justin Shapiro, graduated Rutgers in the spring and is now transitioning into graduate school at Georgia Tech. A second undergraduate was Eric Vowinkel from U. Maryland who was conducting a summer RIOS internship in the lab this summer. Despite just starting out oceanography, they anchored much of this leg and have more underwater glider kilometers then maybe just a handful of people on Earth. We thank them for their efforts!!! Also we need to tip the hats to the operations group of the COOL room. Hugh, Dave, John and Josh have been scanning glider specifics with lots of great help from Webb research. Without them along with Bob, Chip, Igor and Lisa, none of this the observatory would work. We finally need to bow in front of the god father and head honcho, Scott Glenn. Even while on break, he worked remotely help guide ru17 using the wireless connection he could find at the local McDonalds. Scott is th hardest working person in oceanography and seems to thrive on 3 hours of sleep a night, much to the chagrin of the rest of us. So while we still have long journey

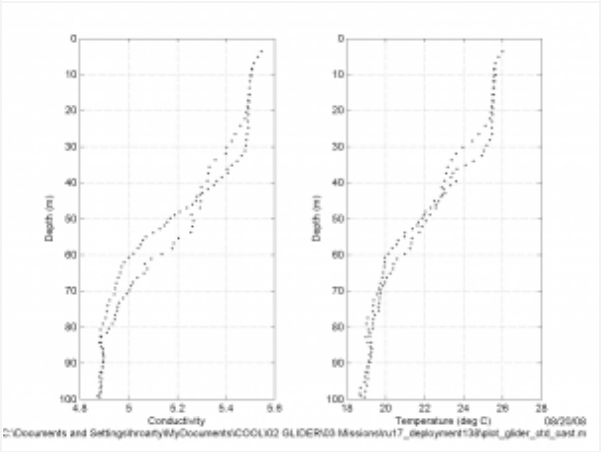
left, today for a moment, let's stop and salute those who have got us this far!



0 Comments

20 aug CTD cast from today

Edit Posted by: Hugh Roarty in: Across the Pond Edit



Thermocline present at 30 m.

density 1023.5 at surface 1026 at bottom

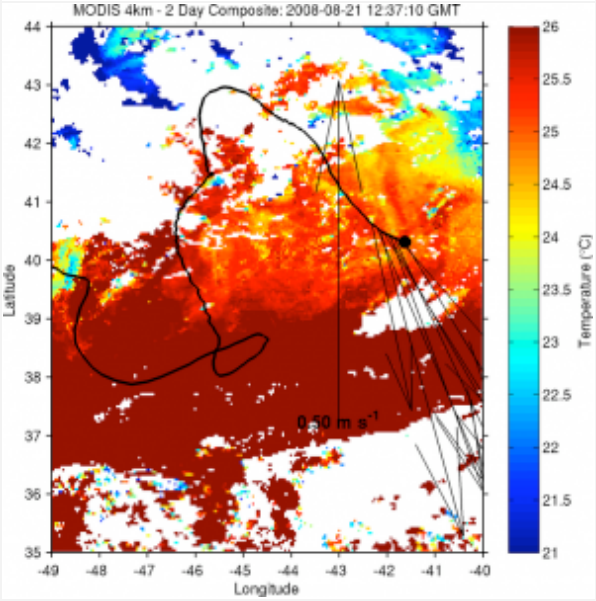
0 Comments

21 aug

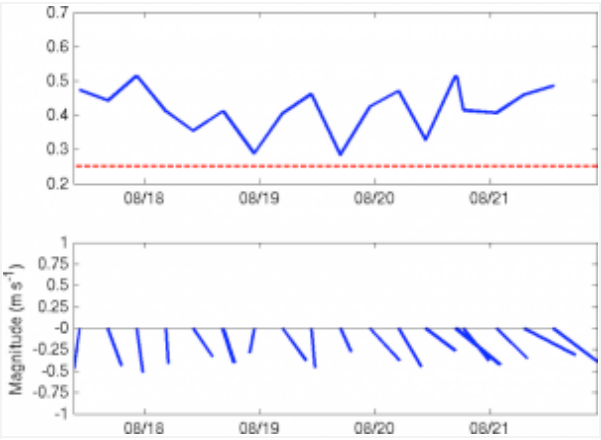
Heading Downstream

Edit Posted by: Scott in: Across the Pond Edit

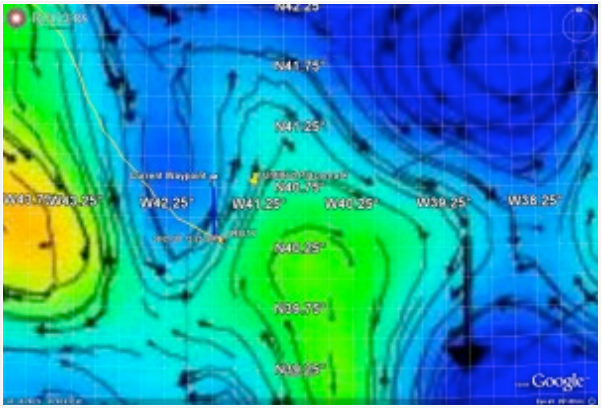
RU17 is making the turn to the east.



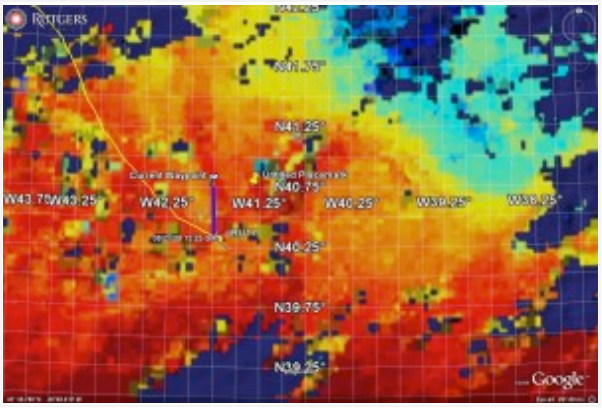
Currents are turning from the southerly direction more towards the east. They presently are heading SE at about 50 cm/s.



The altimetry says we are squarely in the middle of the jet moving northeast, but our currents are running southeast. Locally, it looks like the altimetry needs another satellite overpass. But downstream, the altimetry agrees very well with the sea surface temperature.



Below the SST shows a curving meander crest to our east, and then the sharp front as you head down into the next trough. That part of the SST is in very good agreement with the altimeter. So lets try flying off the SST front today. We made our next waypoint, shown by the yellow pin, right at the edge of the less extreme SST front on the western side of the meander approaching the crest. Altimetry says we should be seeing the currents turn northeast soon.



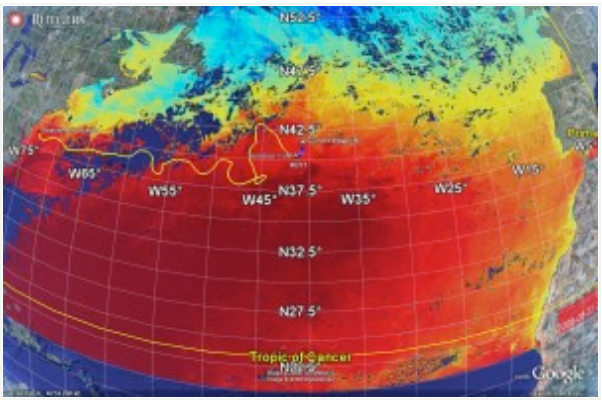
0 Comments

22 aug

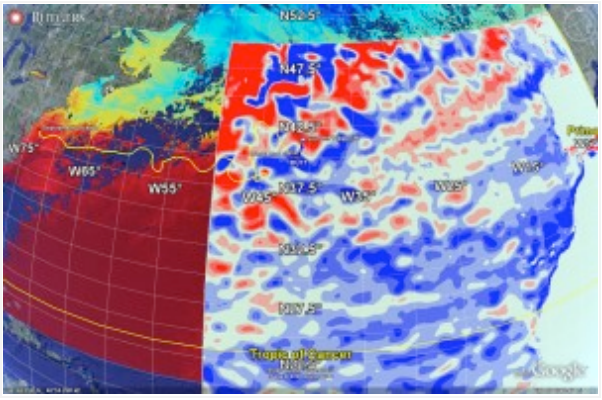
Milestones

Edit Posted by: Scott in: Across the Pond Edit

Two days ago, on Wednesday, August 20, RU17 crossed 42 degrees West longitude - the half way point. Yesterday was Thursday, August 21, exactly 3 months after RU17 was deployed on the New Jersey shelf on May 21. During these three months, RU17 has flown 4470 km. Sometime late tomorrow we should hit 4500 km.



On the way we flew under the fishing activity to cross the shelfbreak. We crossed the slope water without the help of a warm core ring. We jumped into the Gulf Stream and raced an giant warm core ring formation event, beating it by about a day. We followed the Gulf Stream meanders past the tail of the Grand Banks, leaving the coverage area of our own satellite data so that we are now solely dependent first on global datasets (see SST image above) and now on data generated in Spain (see Spanish Altimetry product below with east (red) and west (blue) velocities contoured). We said goodbye to Halifax, hello to the Azores as the next closest safety port.



After passing the Grand Banks, navigation changed from riding a jet to flying eddy to eddy in an effort to head east. We tried going wide around the northern side of a large cold eddy, only to be stopped by unfavorable currents and forced to go around the southern side. We exited the cold reddy near the southern side and tried to make our way east in favorable currents, only to be repelled by another cold ring that appeared in the satellite altimetry. Rather than getting pushed south, forcing us to take the southern route to Africa, we backtracked, headed back into the cold ring and rode it north. The ride north required us to circle three warm rings that merged into one the size of the Mid Atlantic. We raced our way out of this eddy as it pulled as back south, getting us to where we are today.

Along the way we were hit by the more intense right hand side of hurricane Bertha, the longest living hurricane in recorded history. And we learned the difficulty of fighting the unknown biology. For about two weeks as we tried to fly around that complex of three warm rings, all we could do was drift. We weren't able to make any forward progress beyond a few cm/sec even though the glider was moving up and down through the water column. All evidence points to something external causing some drag that would slow us down and spin us in circles with a clear day-night cycle. With no end in sight, we re-learned how to fly RU17, changing flight parameters until we found we could increase the pitch we

would dive and climb at, enabling us to regain our forward speed and start flying again, but at a cost of more energy expended.

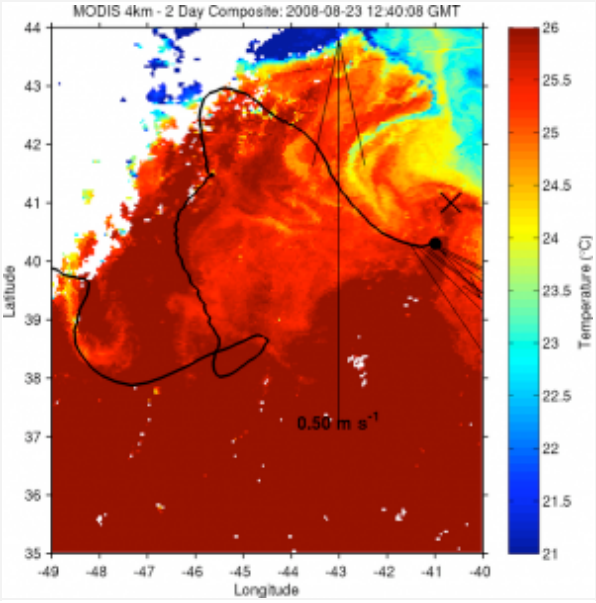
We still have a long way to go. We have flight characteristics we continue to tune. And we have to re-evaluate our energy usage. But we are still flying, and as long as we can fly, we'll keep going.

0 Comments

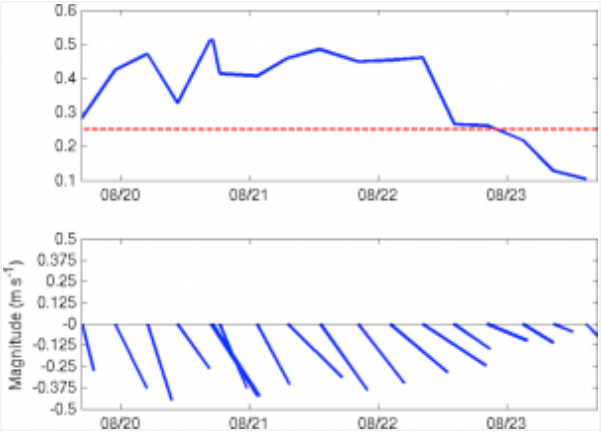
23 aug Eddy to Eddy - The Saturday Hand Off

Edit Posted by: Scott in: Across the Pond Edit

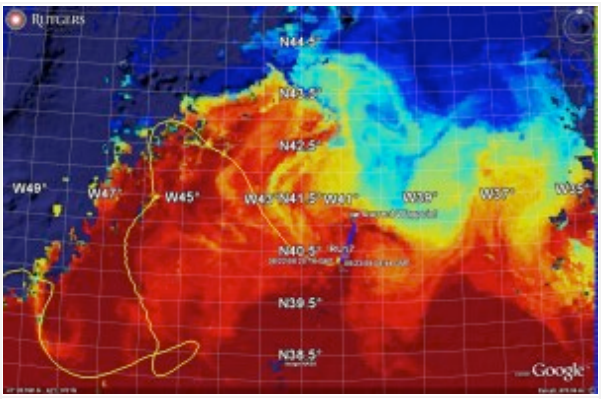
The SST image below has a clockwise circulation centered near 41.5 N, 41.5W that is pulling that thin cold filament of water around its western side. The track of RU17 shows how it rode the western outer edge of this eddy, flying closer and closer to the eddy as it was advected downstream to the SE. RU17 is now entering a warm filament that originates further south, and is starting to make the turn back towards the NE.



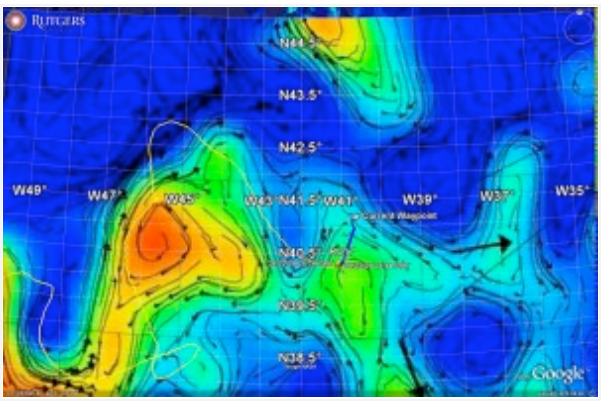
Currents have decreased substantially as the glider approaches the warm filament. Current directions have turned to SE. We are watching to see if this current starts turning to the NE with the warm filament.



Here is the same SST from today shown in the google earth interface. You can see the clockwise circulation feature centered near 40.5 N, 40 W, with the warm filament spinning around its outer edge. The trick is to ride the outer edge of these eddies, jumping in for a push, but not getting too deep so you can jump back out again in time to catch the next eddy. So the edges are really important to define.



The sea surface height (SSH) and geostrophic currents derived from the altimeter below show many places where the currents derived from the satellite altimeter, and the SST fronts derived from the satellite infrared imagers agree. You can see the cold filament near 48W in the SST agreeing with the SSH. The elongated warm feature near 37W in the SST is also reflected as a high (yellow/green) in the SSH. But that is not always the case due to the different sampling patterns and resolutions of the satellites. The both agree there is a warm feature with clockwise circulation around a sea surface high (green) centered near 40.5 N, 40 W, and that there is a very distinct outer edge on the northeast side. However, the satellites do not agree on the location of the western side of this eddy. The SST image shows we are just approaching it, and the SSH images says we have already passed through it. This illustrates the value of the data set back by RU17. The currents clearly show that we are just approaching an area with a change in currents, and have not flown through a region with strong currents to the northeast. Nothing like data from the field to help decide which satellite is right.



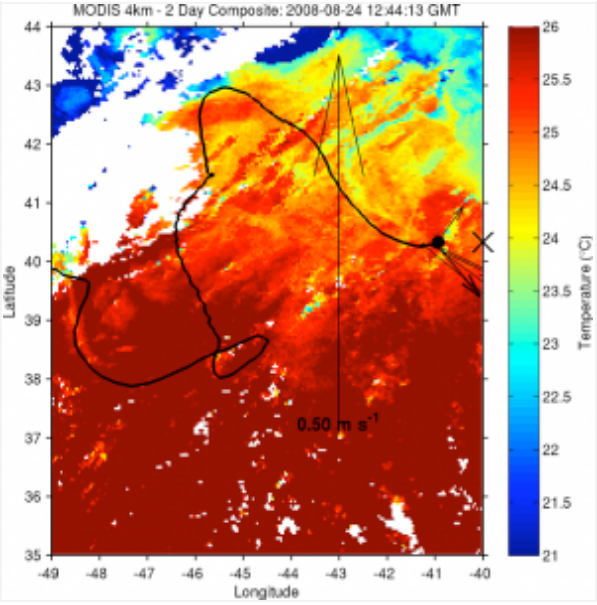
1 Comment

24 aug

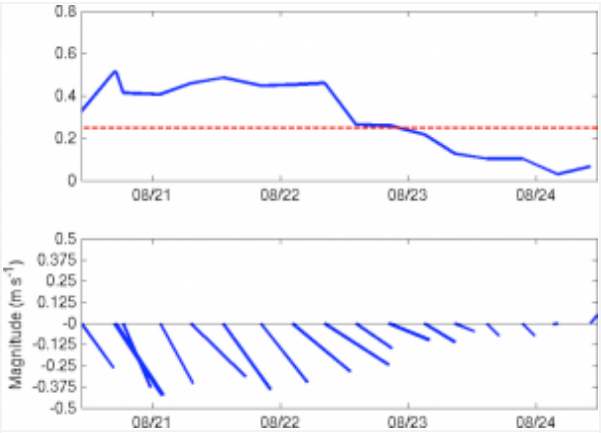
Finding the change in the currents.

Edit Posted by: Scott in: Across the Pond Edit

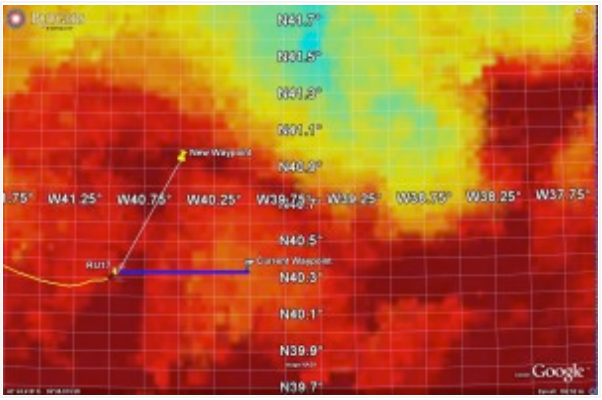
Yesterday we decided to fly due east to try to jump into that warm filament heading north. Wow, what a fast change in the current direction.



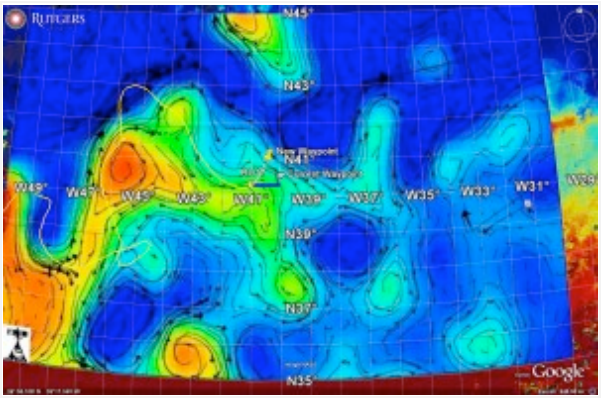
Time series below shows the currents steadily decrease in speed over 2 days, then suddenly flip direction by about 90 degrees from southeast to northeast.



Zooming in on the SST data, we will switch to a new waypoint that crosses the warm filament at about a 45 degree angle. Why don't we continue due east?



Altimetry below says we want to start thinking about heading north. New data was received in the region, and the high (green/yellow) we are using now is merging with the highs (red/orange) that we just left. We need to ride the boundary of the present high so we can still get out of it as we swing around its northern side. Even if we don't make it out, the consequences are not nearly as great this time as the last time. There is a pair of counterclockwise eddies located along the 38W meridian. Either of these lows (blue) will send us east.



As we are now getting used to, the altimetry seems to do a good job of explaining how we got to where we are (compare the yellow track heading southeast with the currents), but has some difficulties matching the currents where we are. But overall, it is pretty good guidance.

1 Comment

27 aug Getting Humans to the Azores

Edit Posted by: Anthony Lund in: Across the Pond Edit

After an exhaustive search, I was able to figure out a few ways to get to the Azores. Unfortunately, the only direct flight (which may be canceled) leaves from Logan International Airport in Boston, Ma. However, there are multiple direct flights from Newark Liberity International Airport, NJ to Lisbon International Airport, Portugal. Continental and TAP (Portugal National Airline).

Airline Travel

Newark to Lisbon via continental depart 8:15 pm arrive 8:20 +1day (Non-stop

flight)

Lisbon to Flores FLW Airport via TAP (Portugal National Airline) Depart 6:30 Arrive 12:30-Flores Airport

OR

SATA Airline Depart 8:00 arrive 12:30

http://www.wego.com/flights/schedules/search/LIS-FLW/2008-09-17/2008-09-21/?wgz=104f4

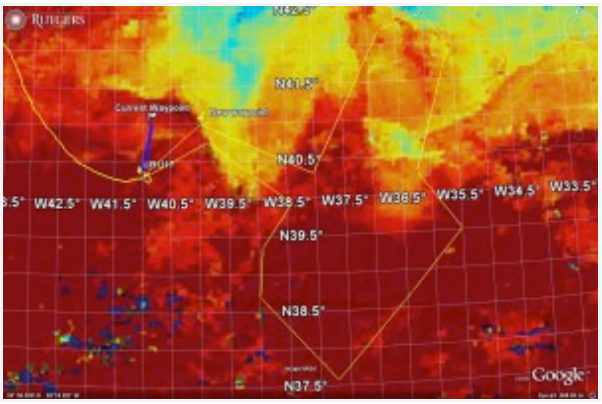
Next we have to find boat and car rentals. That's another search for another day!

3 Comments

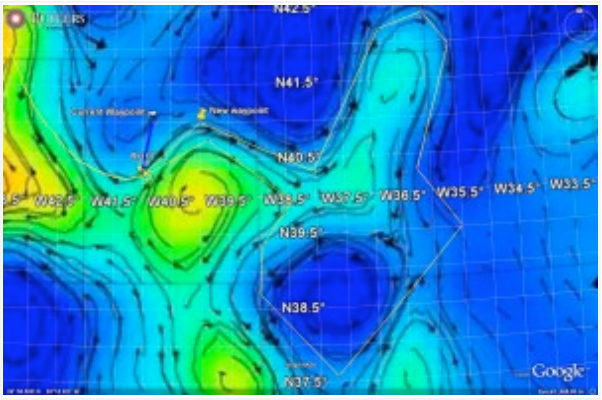
30 aug Turning Downstream - Flight Restored.

Edit Posted by: Scott in: Across the Pond Edit

Back to the blog. You know the routine. No blog entry, something must be up. We'll zoom into that story in the next entry. The few days of small yellow circles in the glider track near 40.25 N, 41 W are a preview. You can probably guess the story … Didn't we just go through that same thing about a month ago? When we did get out of it, altimetric products said we were only about 12 km southeast of the stronger currents on the outer edge of eddy. Barely a days run when you are flying. We headed for hit, and it the edge around 1 pm yesterday. We continued heading north till this morning, crossing into the stronger northeast currents. This morning well change the waypoint and, for the first time in a while, head downstream with them. We are heading towards that strong Sea Surface temperature front to our Northeast. We then have 2 potential paths to our next destination.



The Altimetry image below shows the two paths we can take. We are looking to get to about 36 W (the eastern edge of our present UTM navigation zone), somewhere between 39 N and 40 N. One route follows the currents around to the north, the other follows the currents around to the south. The south route is warmer, better for the batteries. The northern route is colder, which we hope is better for the biology. Everyone wants to try the northern route to see if we can catch a break on the biology. If we do, it will have important implications for the next glider we fly across.

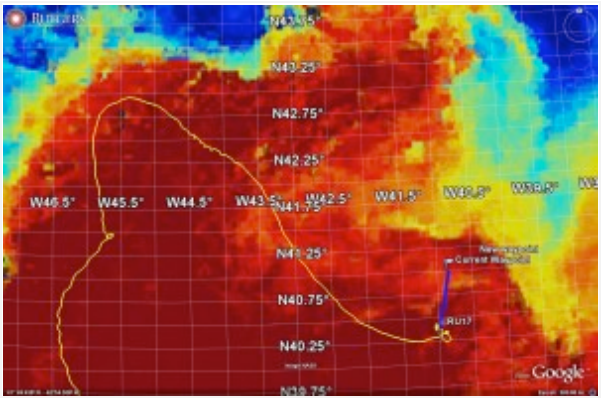


0 Comments

30 aug Moonwalks & the New Moon.

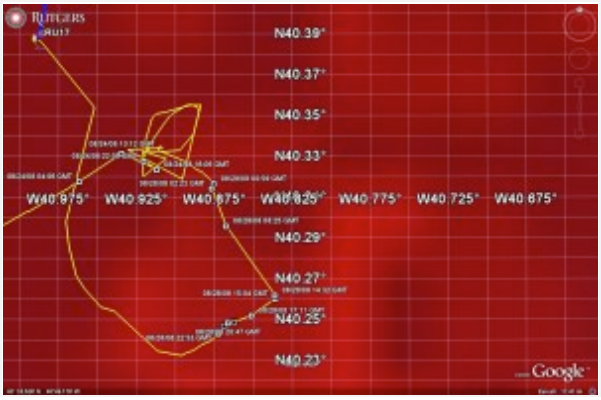
Edit Posted by: Scott in: Across the Pond Edit

The SST image below shows that the track of RU17 over the past month and a half. Most of the time the glider is flying fine, yes a bit slower that the start, but still flying. Then there are those two periods where the glider went nowhere. All RU17 did was spin in inertial circles for a period of a few days. Looking at the details of the glider flight, the glider itself was spinning in 360 circles, turning to the right, so even thought it was moving up and down, and flying forward, it wasn't going anywhere but in small circles. This caused huge concern the first time, since we didn't know what was causing it, if it would end, or if we could make it go away. We tried numerous manuevers, and even designed a new behavior, the moonwalk, where we would fly the glider backwards. But we never got to the point of trying it, since whatever we managed to free ourselves of whatever we had snagged, and were flying again.

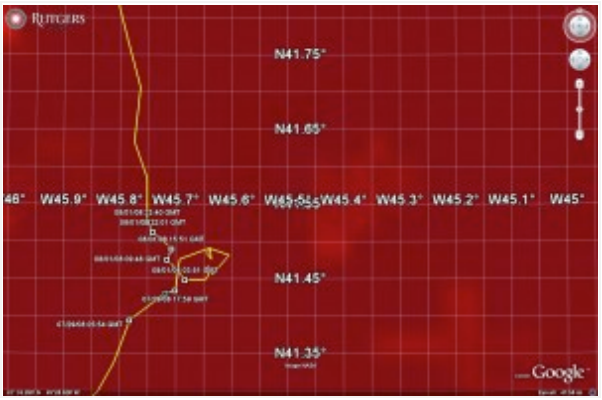


Then comes the second event where we zoom into the glider track. This time the glider was spinning in tight circles to the left - opposite of before. So maybe we snagged something on the other wing this time. The tight circles turn you into an Argo drifter that just moves up and down in the water column, and we again spent several days spinning in inertial circles. We had seen it before, and we had new beviors ready. We flew with shallow pitches and and slow. We held the fin steady on zero, and saw the glider spin in a constant counterclockwise circle as it ascended and descended. We continued to notice the day night cycle. It all got worse at night, and would improve during the day. Sometimes the improvement was a lot,

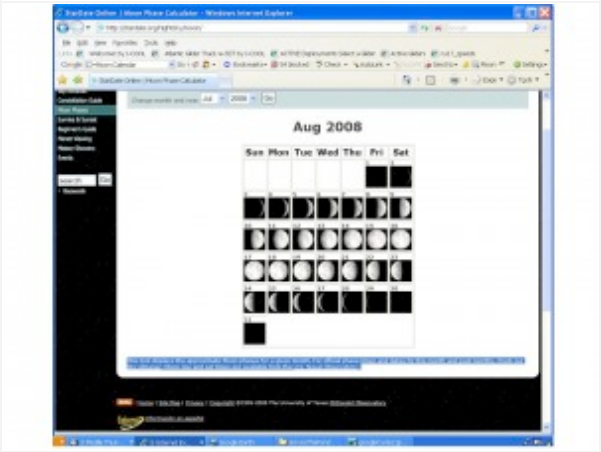
sometimes very little. We looked for ways to see if we can clean the glider every morning. We flew steep and fast. Not much help. So we tried the moonwalk. When we are at the surface and we want to descend, we pull water in the nose with the buoyancy pump, and just like the sailors in Das Boat, we through all the batteries as far forward as possible. This gets the nose down fast and instead of just sinking down, we fly down. But for the moonwalk, we didn't through the batteries forward. Instead, when we pulled in the water with the buoyancy pump, we pulled the batteries all the way back so the tail was heavy. Instead of heading down nose first, we were flying RU17 down tail first. Our first moonwalk was only to a depth of 35 m. We never tried it before, and people were worried we'd tear off a wing flying backwards. But we returned to the surface, and convinced ourselves we looked cleaner than when we left (wishful thinking perhaps, but the moods in the room were noticably improved, so we left it at that). We then tried different behaviors to try to make it through the night. The CTD cast said the thermocline was about 30 m deep. We tried staying shallow, flying above the thermocline overnight. No help. The enxt day we did a double moonwalk, making sure we were as clean as possible. The second night we tried to fly deep, again staying away from the thermocline. If that didn't work, we were going to try drifting for the night. But by this time, we were a few days into the event, and we were seeing improvement. We found ourselves a mere 12 km to the southeast of what the altimetry said were some good currents. Instead of continuing east as we were tryin to get out of this region, we turned northwest (west, everyone hates when we turn west). Luckily it most of it was during the night so it took people a while to notice. And to our amazment, the guidance turned out to be correct, and we were heading into a favorable current to the northeast.



The most recent event above prompted many discussions on the biology. The National Marine Fisheries Service folks from Sandy Hook stopped by the COOLroom with their collaborators from the fish acoustics world. We talked of what fish could be out there, migrating up and down with the day night cycle, what they would find interesting with the glider or if they were just packed that tight. And we wondered if we could hear them. What if we had a acoustic listening device on the glider that we could turn on when we wanted to listen to fish? The preoposal for the test flight was submitted on Friday by 5 pm.



Oscar also talked on biolumenescence as a potential attractor. If we are flying through layers of plankton that are bioluminescent, maybe we are glowing at night. Meanwhile Hugh was working on the flight characteristics. Hugh takes a lot of notes. He couldn't help but notice that the last time he was writing about these flight characteristics was one month ago. Zooming into the first cycle just above, we went into the inertial circles on July 29, and left them August 1. Zooming into the second cycle (two figures above), we went into the inertial circles Aug 24, and left them behind Aug 28. So what could be happening at sea linked to the moons cycle. Jorge Corredor from Univeristy of Puerto Rico provided the answer. Jorge is one of our NOAA IOOS partners. We started flying gliders with him last October. And while we were there, we talked about the bioluminescence arounf Puerto Rico. Jorge said it was pretty azing to see, but that you have to wait for a new moon for it to be really impressive. We googled the moon calender.



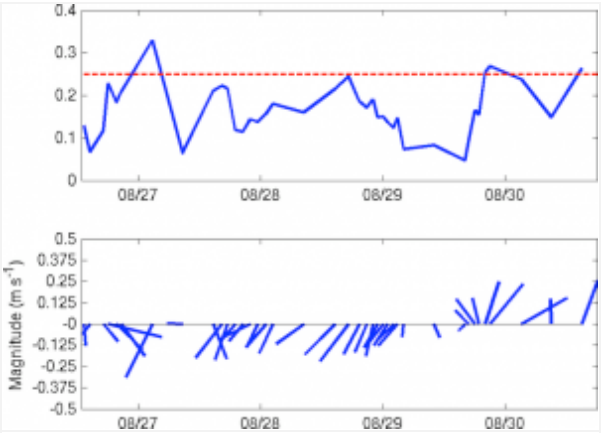
August 1 was the new moon. So was August 31. We checked the waves from the Oceanweather website. The waves were low. So just before or during the new moon, when the waves are low, we saw problems with biology. Maybe its also time to learn more about bioluminescence.

0 Comments

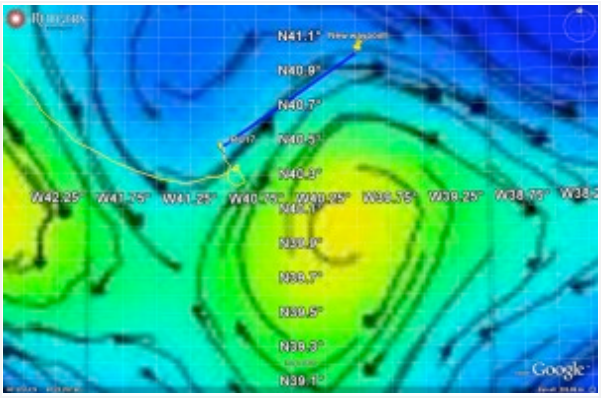
30 aug Heading Northeast to the cooler water.

Edit Posted by: Scott in: Across the Pond Edit

RU17 surfaced at 11, reported currents are heading northwest at 25 cm/sec.



Altimeter says the geostrophic currents are the same direction. We have turned the glider northeast, heading to the SST front we talked about earlier today.

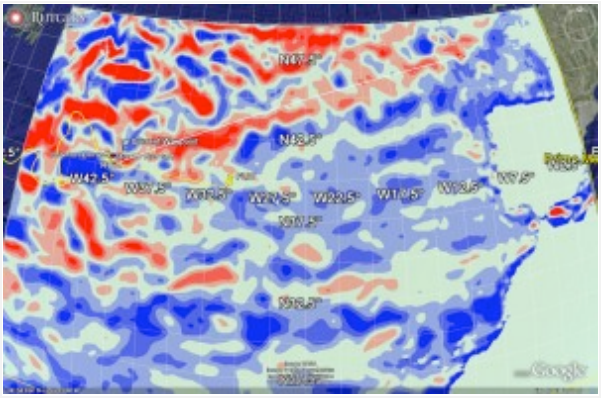


0 Comments

01 sep The Big Picture - September 1st.

Edit Posted by: Scott in: Across the Pond Edit

The Spanish altimetry product shows the big picture nicely. The plot below shows the east (red) and west (blue) components of the velocity. The brightest reds are velocities with an eastward component greater tahn 25 cm/sec. RU17 is in an excellent position. The white line shows us a straight path along eastward flowing (red) colors to 10 E longitude. A distance of 2600 km. The yellow line shows the direct 800 km route to Flores Island Airport (FLW), the most western island the Azores chain.



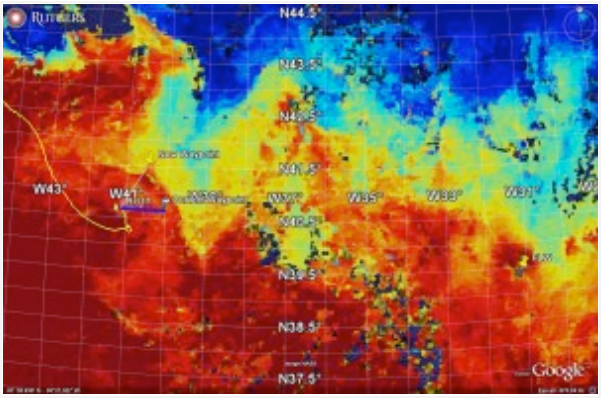
Our plans for the next week are to focus on flight characteristics. We'll be focusing on things that improve our steering during the day, while minimizing the drag effects that push us off course at night.

0 Comments

01 sep The Little Picture - September 1st.

Edit Posted by: Scott in: Across the Pond Edit

RU17 is heading slowing northwest. We have been flying eastward, but the eastward component of the current is stronger than us. The result is the slower drift to the northwest. WIth the strong current in this direction, our best bet is to fly perpendicular to the currents till we find a more favorable drift. So we'll try flying to the northeast for a day or so, seeing if we can get closer to the front in the Sea Surface temperature image below. If you follow this front between the warmer (red) and colder (green/blue) water to the east, it takes you directly to the Azores Island of Flores (FLW marks the Flores Island Airport.

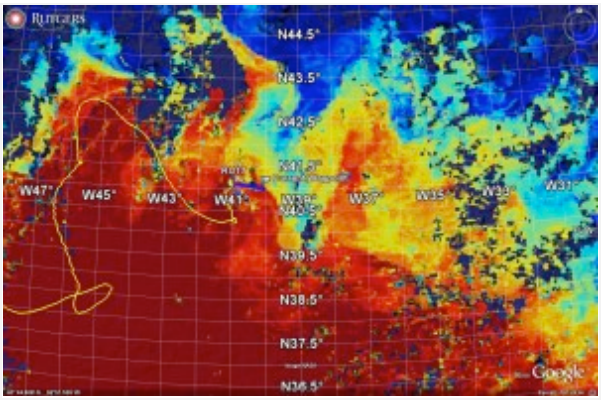


0 Comments

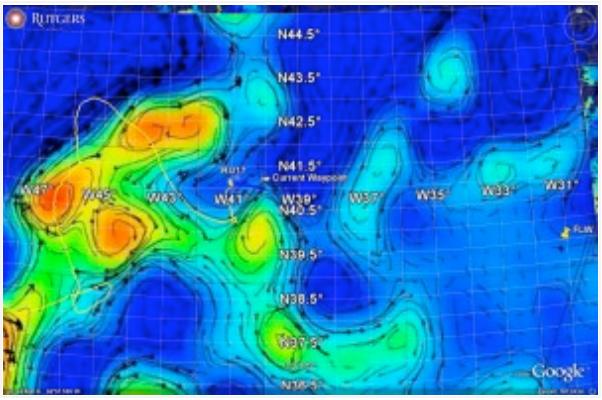
04 sep Northeast to the SST front

Edit Posted by: Scott in: Across the Pond Edit

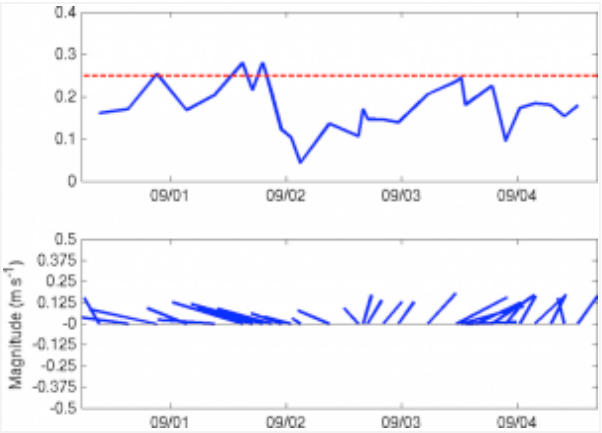
RU17 has turned and is heading northeast toward the SST front.



The Altimeter explains the currents. In the SSH image below, the currents show we are running up the western side of a sea surface high. We will head into it.



Currents observed by the glider below agree with the altimetry - its a good day.

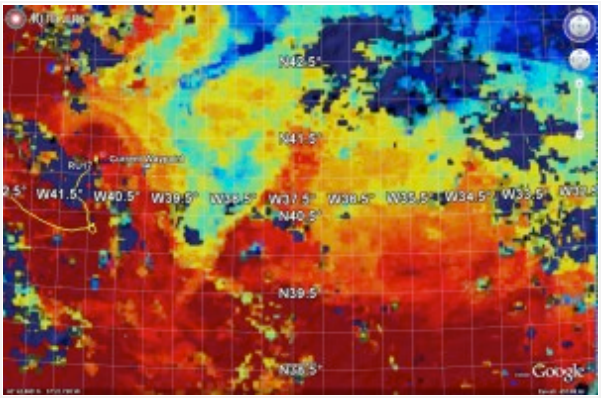


0 Comments

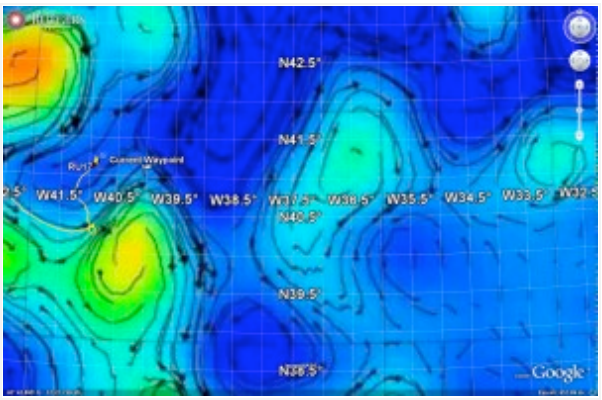
05 sep A deepening meander trough in our future.

Edit Posted by: Scott in: Across the Pond Edit

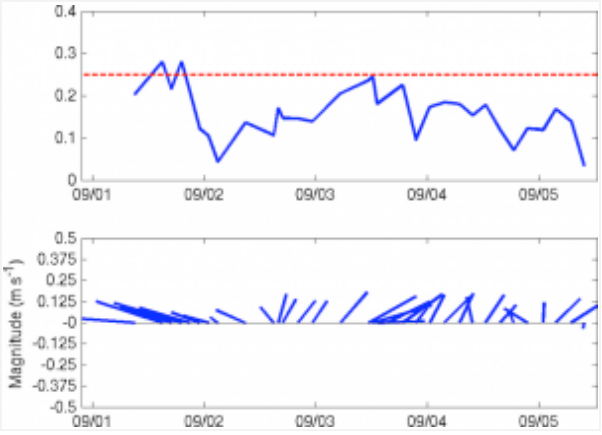
The SST front to our east continues to sharpen ad the cold trough deepens. We continue heading toward this front.



Altimeter shows the deepening trough and the interaction with a cold eddy to the south. The worry hear is that this makes a wall of southward flowing water that we cannot cross.



Currents are generally to the northeast. Again, in good agreement with the altimeter, and we have now have 2 good days in a row.



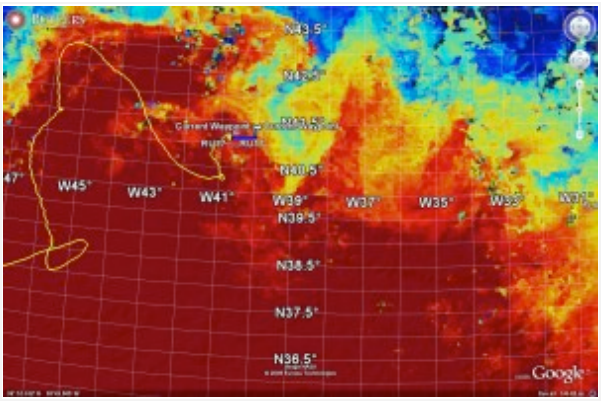
Back to our focus on flight characteristics.

0 Comments

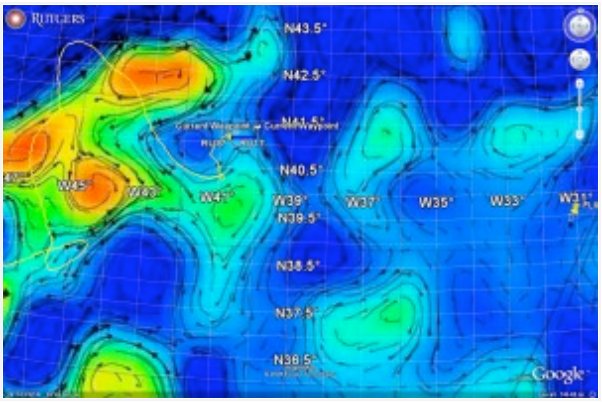
07 sep This week's race.

Edit Posted by: Scott in: Across the Pond Edit

RU17 is heading due east to the sharp sst front to our east. Currents are slow, so it is making steady progress under its own power. We are typically travelling 2-4 kilometers every 6 hour interval, about half the speed of a glider when it is newly deployed.



And once again we find ourselves in a race. Our goal is to cross over the pointed top of this warm eddy located near 39.75 N, 40.5 W (the green in the sea surface height plot below) before it interacts with the larger and stronger warm eddy (red) o the north. The larger warm eddy has strong currents to the southwest that we want to stay away from.

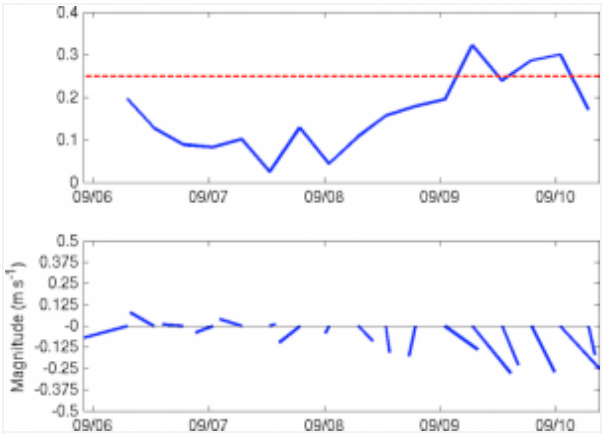


0 Comments

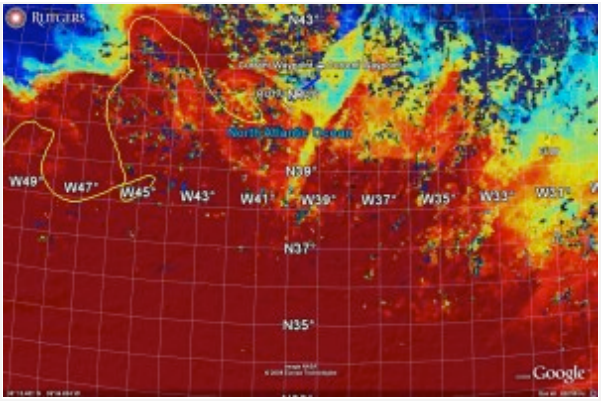
10 sep Heading southeast - trough or cold eddy - the race continues

Edit Posted by: Scott in: Across the Pond Edit

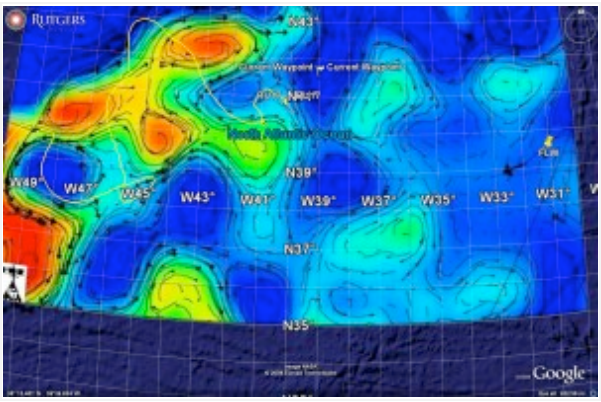
Currents have increased and are not heading southeast. We rounded the top of the warm eddy.



Still heading toward that SST Front



Altimetry gives the story. Do we have enough speed to make it perpedicular to the current and into the trough that only goes as far south as 40 N, or do we have to ride the cold eddy all the way south to 38 N and come back around. Both put us in the same place, but one is much faster.



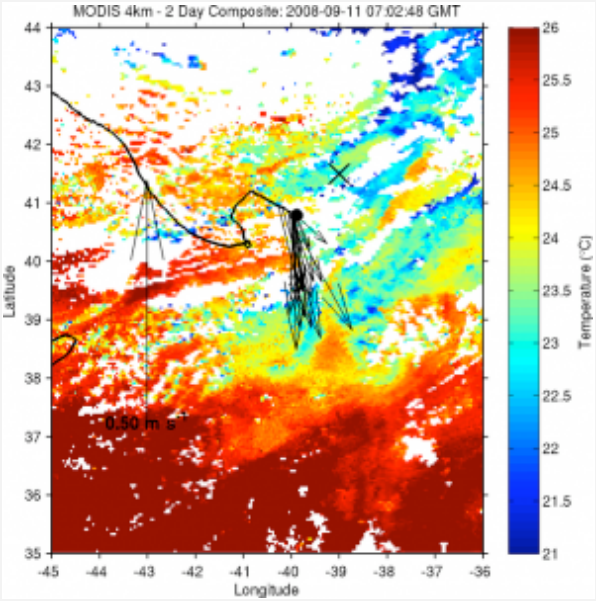
0 Comments

11 sep

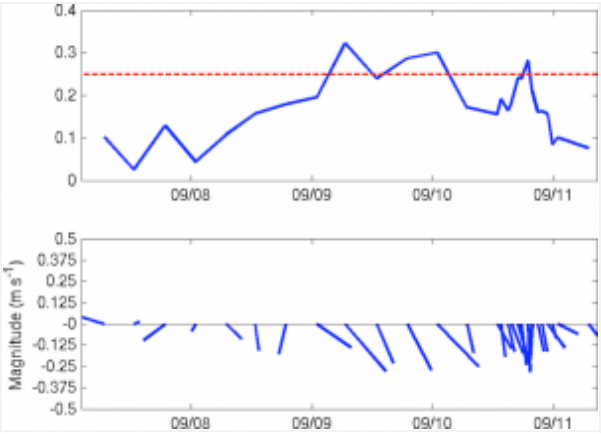
Crossed the SST Front

Edit Posted by: Scott in: Across the Pond Edit

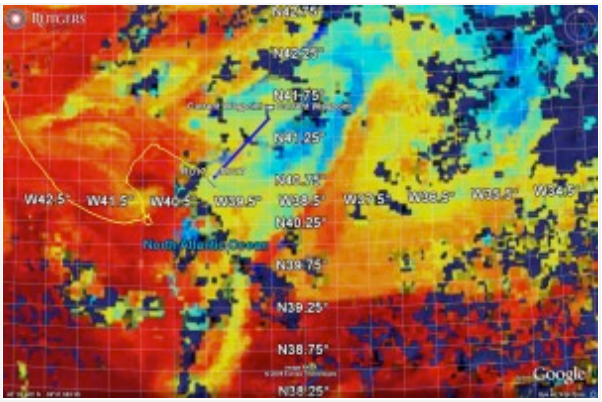
RU17 crossed the SST front into the colder water last night. Lots of current vectors to the south on the warm side, cross the front, and currents drop and turn southeast.



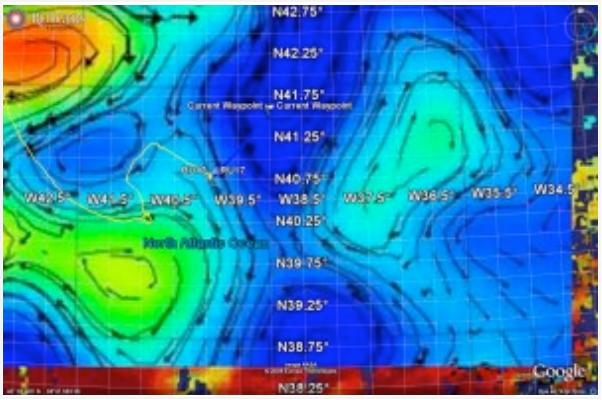
Here is is in time series. The currents where hourly during the day since we had RU17 on hourly missions. We were doing tests on the gain for the integrated heading error and how it effect the fin control. We have a new setting we'll try for the rest of today.



Here is the SST in the google world. We want to cross this cold eddy we are now in to the warm front on the other side without getting pulled south into that cold filament that shoots straight down along 40 W to 38N.



Heres the altimetry. Looks about like yesterday. We are crossing the streamlines towards the center of the cold eddy centered near 42 N, trying to avoid the cold eddy centered near 39 N.

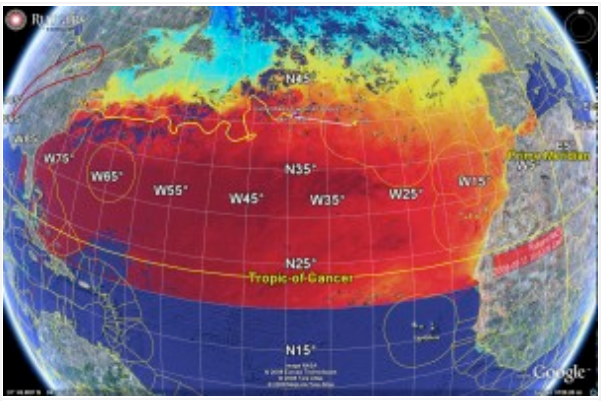


0 Comments

13 sep RU17 - East of 40W

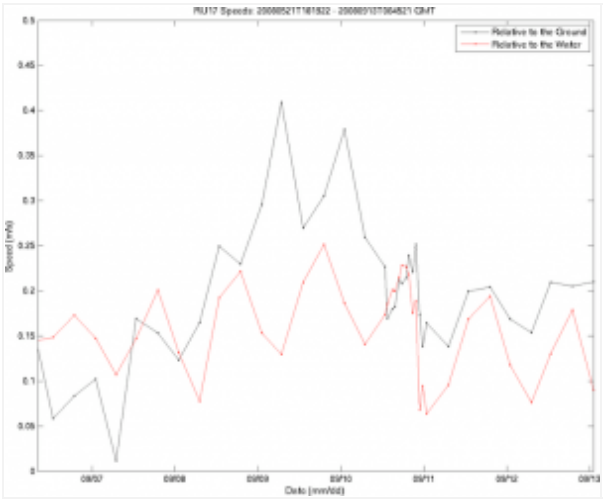
Edit Posted by: Scott in: Across the Pond Edit

RU17 just flew east of the 40 W longitude line. Our longitudes started in the 70's, and now we are in the 30's. We are 115 days into the mission, and have traveled 4800 km. In that time, RU17 only missed 3 phone calls that I know of - certainly setting an excellent example for my daughters as they begin their world travels.

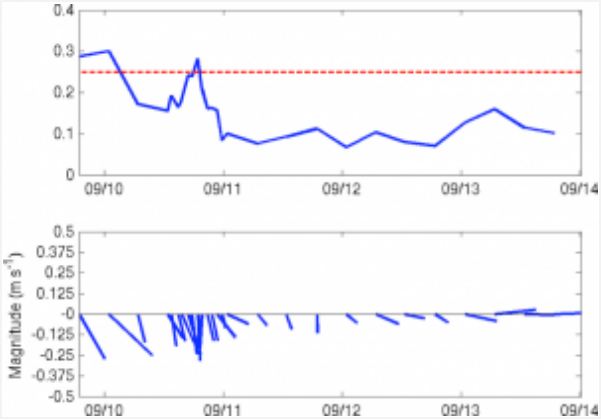


40 W is significant because of the Coast Guard. The half way point is about 42 W. But 40W is the eastward extent of the Coast Guard's area of responsibility. it extends way past the Exclusive Economic Zone lines (yellow) of the U.S. It amazes me that they can cover such a vast area. When at sea, it is always comforting to know that if trouble occurs, the Coast Guard is there. Today we leave their area of operations as we continue east, and they continue their important job of saving lives both before, during and in the wake of Hurricane Ike. Good luck to my friends in Houston. I spent 4 years on the beaches of Galveston with fellow oceanographer George Forristall, and used to fly small aircraft into the Galveston Airport, elevation - 6 ft.

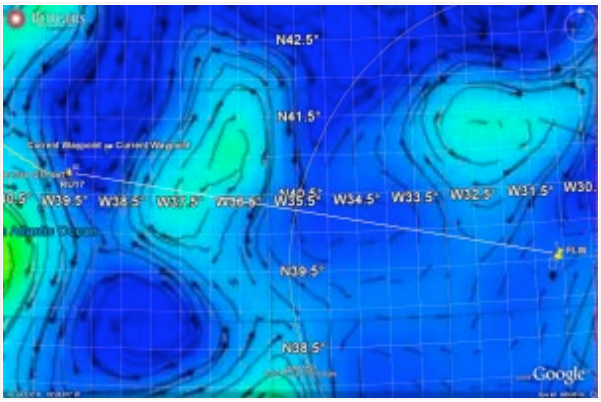
Back to RU17. Below is the plot of glider speed (red line) relative to the water. Our estimates have large error bars, but one thing is clear, we have a daily cycle in the glider's ability to fly relative to the water. On 9/10 and 9/11, we switch from the usual 6 hour surfacings to 1 hour surfacings for the flight tests we talked about. We need to re-tune the flight parameters because the glider that left the dock is not the same as the glider we are now flying. Something is different, and we don;t know what. For the glider geeks out there, the biggest thing we did was change u_hd_fin_ap_igain from 0.03 to 0.00003. Reducing this gain by a factor of 1000 essentially turned off all adjustments to steering based on the integrated heading error. We are now steering based almost entirely on the instantaneous heading error. But don't try this at home with your own glider. A normally responsive glider will respond with lots of fin motor motion, potentially resulting in a loss of battery power.



Now we look below at the ocean currents observed by the glider. The top panel is speed in m/s, the bottom panel is the current vectors. Speeds are steady around 10 cm/sec, and the direction has turned from south during the tests on 9/10 to east. East is good. Its the way we want to go. But where did these currents come from?



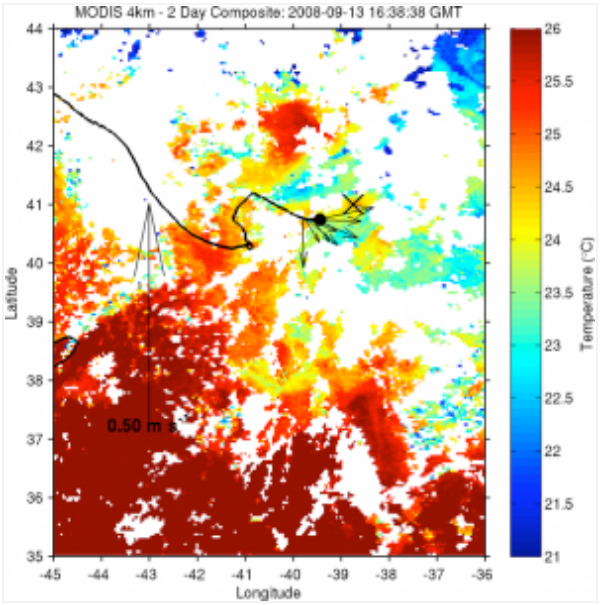
Looking back at the altimetry data showing us the sea surface height and the resulting geostrophic currents below, we see that we are supposed to be crossing a current that is heading south, potentially sweeping us into a cold ring (blue) centered near 39 W. Instead the glider says the currents are to the east, not the south. The difference here is usually associated with the repeat interval of the altimeter and the spacing between the tracks. We are finding a lot of smaller scale oceanography is occuring in between the spacing and timing of the altimeter coverage. Thats why we have models.



Another point on the image above is that we are now 700 km away from the Island of Flores in the Azores as the crow flies. RU17 clearly has little use for crows. For us, the route to Flores involves spinning around two warm eddies (yellow) shown in the Sea surface height image above. The centers of the two eddies are lined up along 41 N. Our objective is to use these eddies to swing RU17 around and down into Flores. If we get close to Flores, it will be hard to resist the temptation to hop a quick flight to the Azores and rent a boat for a visit. Our glider is different, and we don't know how. The sooner we see what is different, we can begin designing the work around that will improve the next flight across. But back to the currents, why are the currents heading east?

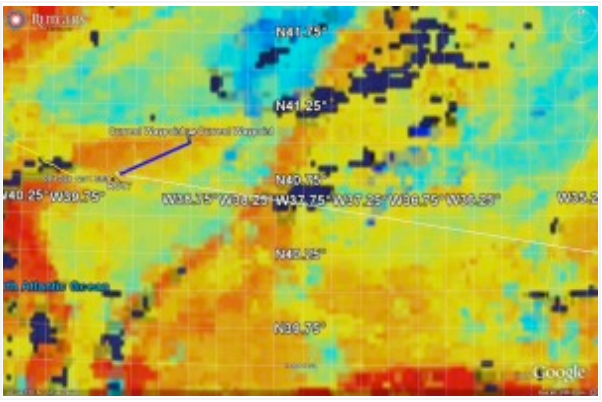
The Sea surface temperature image below shows why. There is a thin warm filament reaching across the cold water on either side, and we are in it. The currents in this filament are to the east, and we are going to stay in that filament

to take us across the cold water to the warm eddy on the other side.



A

Below we zoom into this feature in google earth. We are in the warm filament, flying towards its northeast corner, and drifting with its eastward currents. The warm filament nearly makes it all the way across the cold water gap to the warm front on the other side. That warm front is the edge of the first warm eddy we need to catch for our approach to Flores.

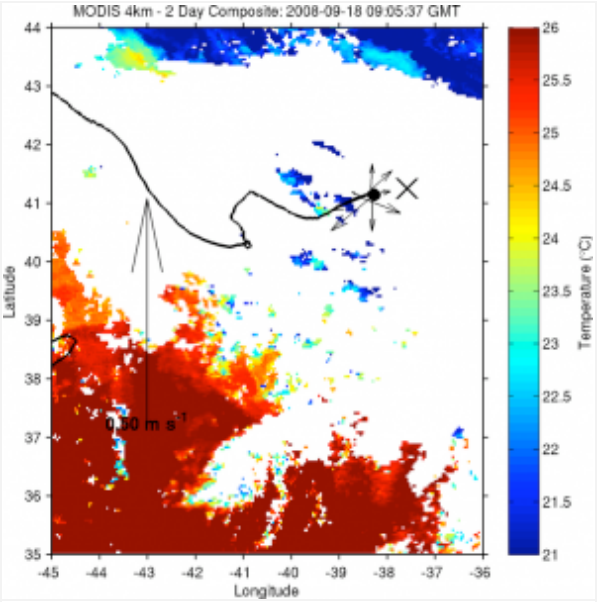


0 Comments

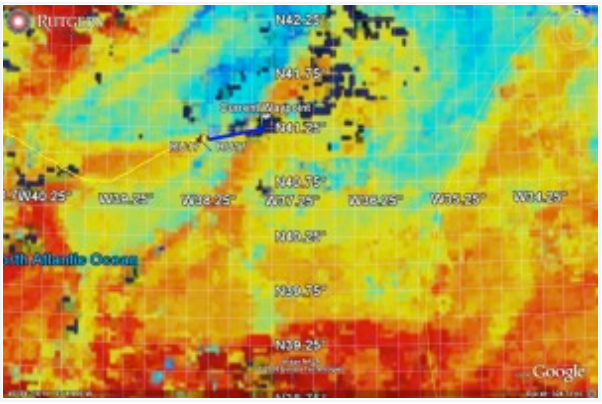
18 sep End of the Warm Filament - Back in the Cold.

Edit Posted by: Scott in: Across the Pond Edit

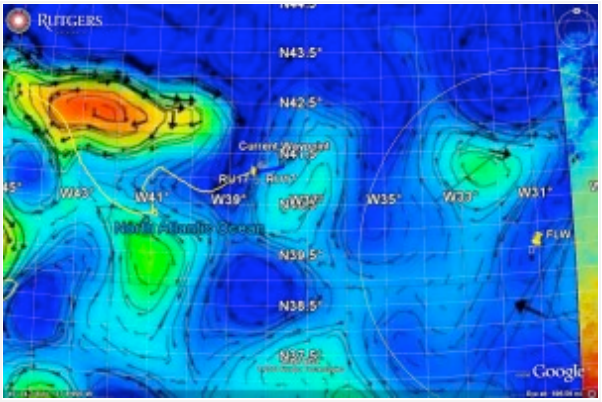
After several days of favorable currents, RU17 has run into a counter current. That single arrow to the southwest is the most recent observation. We have been flying quite well to the northeast. The white in the image indicates there are clouds overhead for the last 2 days.



Below we look at the 1 week composite of Sea Surface Temperature and the track of RU17. The glider was running east with the currents in a warm filament. As soon as RU17 approached the nose of that filament, currents dropped to near zero. After crossing this current front, we find currents to the southwest, consistent with the cold water heading south and around the front of the filament. Our goal is to cross this cold water into the warm front less than 25 kilometers to the east. A simple day's run for a new glider, but we are a bit slower now after nearly 4 months at sea. But we know exactly what to do. Make our waypoint perpendicular to the current, and head towards the warm front as best you can.



The altimetery image below shows why we are heading for the warm front. it is the western edge of a warm eddy centered near 40.5 N, 37 W. If we can spin around the northern edge of this eddy, we follow the current around to a second warm eddy, and that gets us close to Flores.

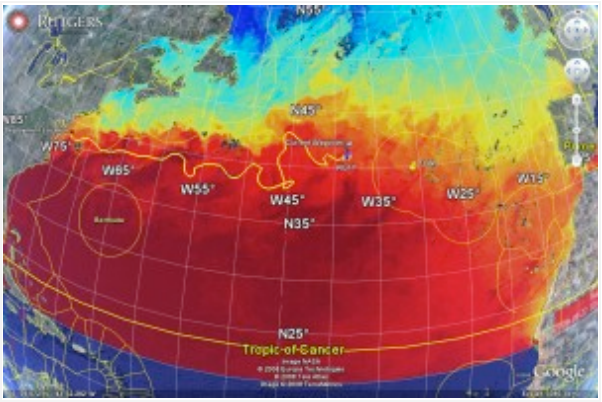


2 Comments

22 sep 4 Months & 5,000 km Later ……

Edit Posted by: Scott in: Across the Pond Edit

The Rutgers Scarlet Knight Glider, often known by its number RU17, has just completed another set of milestones. Yesterday, September 21, 2008, The Scarlet Knight completed its 4th month at sea. Today, it crossed the 5,000 km line.



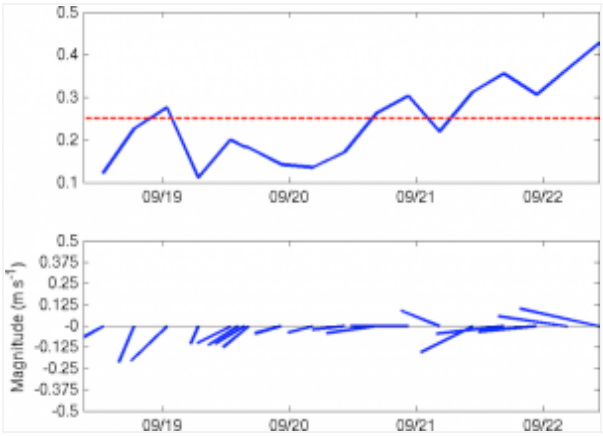
At this point, we are 650 km away from the Azores Island of Flores, marked on this map by its airport call letters, FLW. Our plan is to fly RU17 as close to Flores as we can so we can then go out in a small boat for a look. We expect that we'll pull RU17 on board, give it a thorough cleaning and check out on shore, then send it back on its mission to the European mainland.

0 Comments

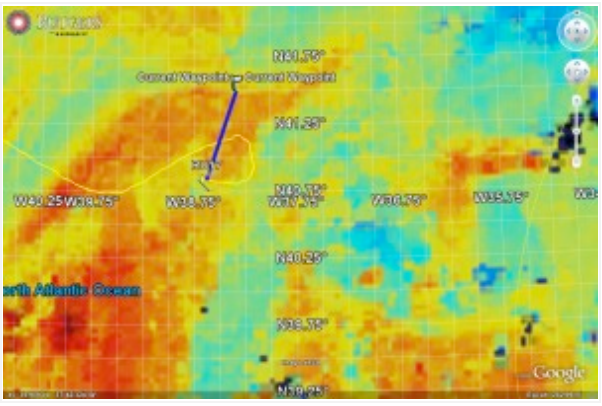
22 sep Around an Eddy

Edit Posted by: Scott in: Across the Pond Edit

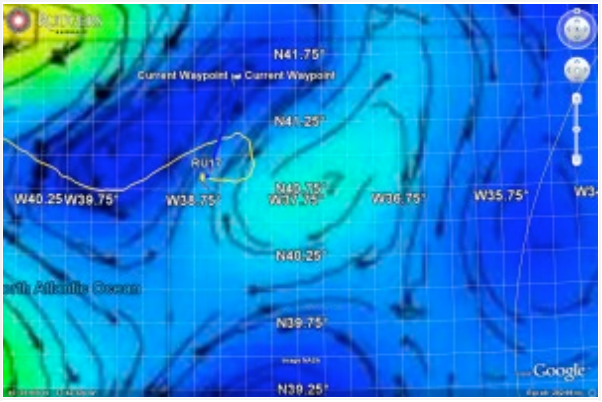
Currents over the weekend starting pushing us do west. Where did they come from? We knew there was cold water on the eastern side of the warm filament from last week, but we expected those currents to be to the Southwest, not directly west. So with west currents we cannot fly against, we turned north. Altimetry said the westward currents would just increase if we turned south.



The Sea Surface Temperature image from this morning explains why. At the end of the warm filament, we see a clockwise circulating eddy forming. RU17 is on the southern side of the core, spinning around in a clockwise motion. The image tells us what we need to do. Start our center fleeing behavior. You should see the waypoint we fly to start looping around the outside of this eddy as we use the glider velocity to fly out and the eddy swirl velocity to spin us around.



The Altimeter data shows the general trend of the water is flowing to the northeast, but it does not resolve the eddy we are now in.



This seems to be a recurrent theme. The currents do something we don't understand, and a day or two later it is explained by the remote sensing data. We need the models.

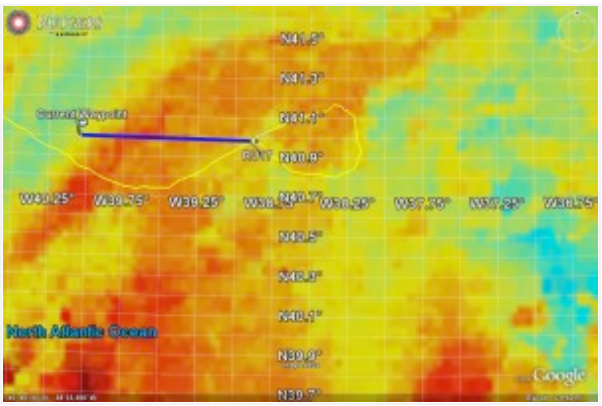
0 Comments

23 sep

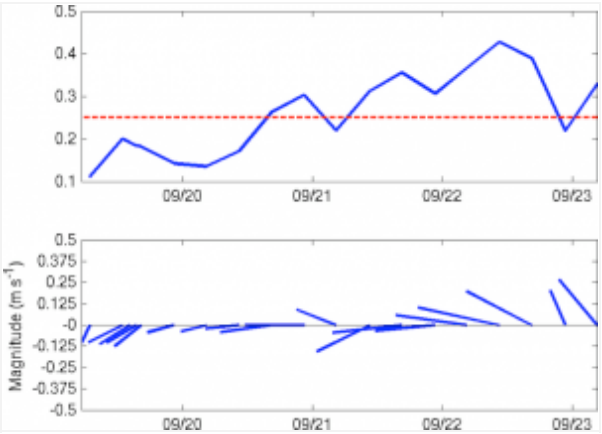
My favorite days at sea.

Edit Posted by: Scott in: Across the Pond Edit

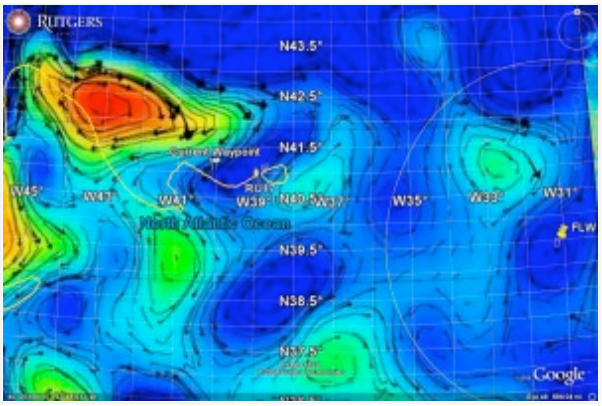
Its always a good day at sea when the view from space is the same as the view from underwater. This dealing with uncertainty thing can make your hair fall out. Satellite sea surface temperature shows a clockwise circulating eddy at the end of the warm filament, the glider track shows us spinning around the center, and the waypoint looks like we are heading west. The concept here is that we are just fleeing the center, and as the glider moves around the eddy, we'll move the waypoint around with it. I suppose we could to a little math someday to automate this.



Currents reported by the glider are also spinning around in direction as the glider goes around the eddy center, all as expected.



Altimeter currents are not in agreement, simply demonstrating that the size of the eddy we are in is not something resolved by these satellites. it has the larger scale flow to the northeast, but not all the smaller swirls and eddies that impact our 6 foot long glider on its daily travels.

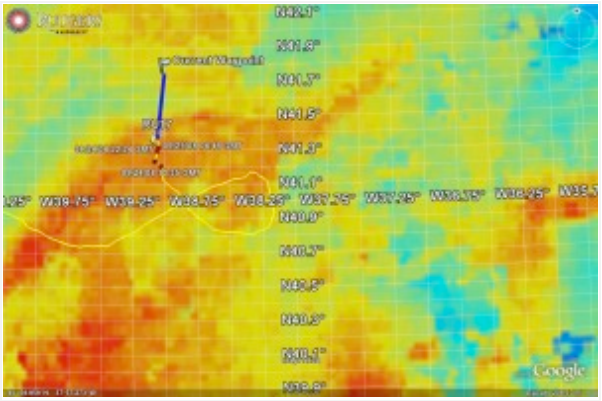


0 Comments

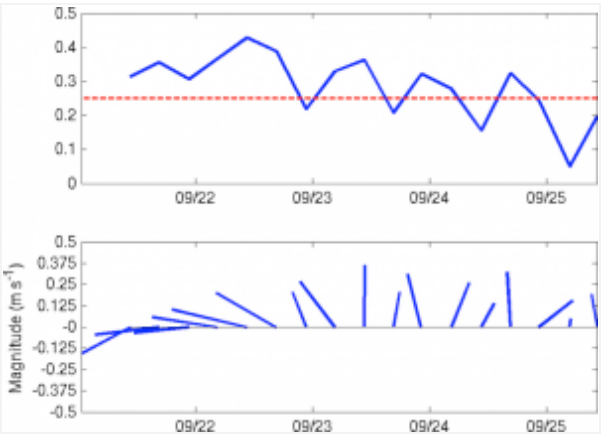
25 sep Around to the top and out

Edit Posted by: Scott in: Across the Pond Edit

Below is the sea surface temperature image showing RU17 spinning around the eddy up to the northern side. But this satellite image is now several days old. Its been pretty cloudy new 40 N, 40W.



Currents vectors show the turning, the nortward trend, and the decrease to very small speeds last night. We must be near the edge. Can't tell for sure. Time to turn back east and head along what we think is the northern side of this eddy.



0 Comments

25 sep Flight info to the Azores -Shannon

Edit Posted by: student in: Across the Pond, Passion Puddle Observatory Edit

AZORES FLIGHT & HOTEL INFORMATION

- Flights to anywhere in the Azores from the US only leave on Tuesdays and Fridays out of Boston.
- good website about azores travel: http://www.azoresweb.com/travel.html#flights

We would have to leave on a Tuesday and the least amount of travel time is around 9 hours…(it's better then the most common 35 hour trip)

- Each flight has one or two stops but you end up in Horta (which is the town with the marina and Oceanography University) on Faial Island.

Flights from BOS to HOR range from $849 pp up to over $2,000 pp (long flights w/ 2+ stops)

- These are the flights that I found (they seem to be the cheapest and shortest): http://www.orbitz.com/App/ViewFlightSearchResults?retrieveParams=true&z=9cb4&r=gd&z=9cb6&r=gf&lastPage=interstitial

If we need to get to Flores we can take another short flight. (Ferries to Flores and Corvo are rare)

- A flight from Horta to Flores roundtrip would cost about $316 pp at the most (the price depends on what day you fly)
- http://wftc2.e-travel.com/plnext/sata/Override.action

Hotels range from $51 to $145 a night depending on where you stay

- The cheapest hotel on Horta seems to be around $104 a night
- http://www.azores.com/travel/hotels.php?id=6
- There is only one main hotel on Flores (it runs around $51 a night), but there are Bungalows =]
- http://www.azores.com/travel/hotels.php?id=9

OK so say we want to fly into Horta (Faial), and stay one night to get settled in and talk to the University people. Then the next day fly to Flores and make our plan for the glider and stay there for 3 nights and then head back to Horta for a day before flying back home. This would cost about $1,526 per person using the cheapest flights and hotels.

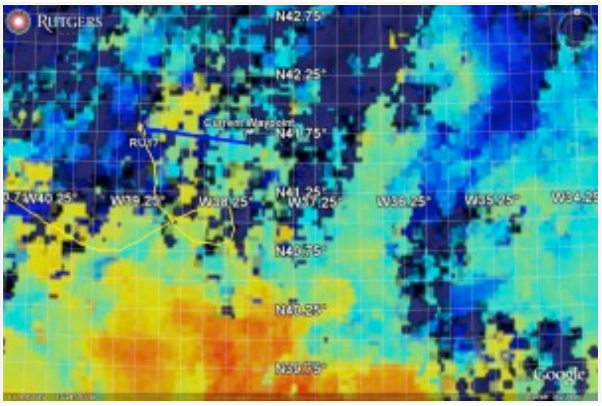
2 Comments

28 sep A Week of Clouds

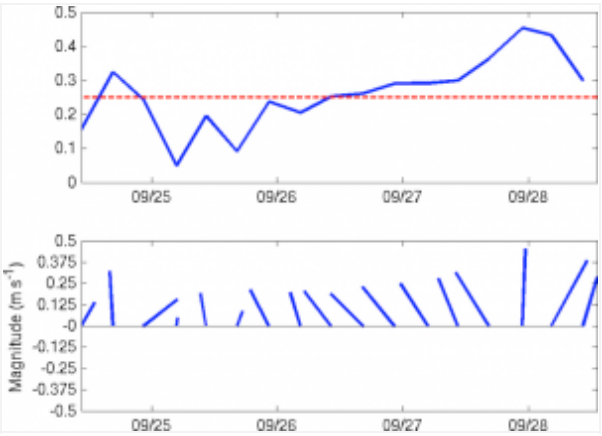
Edit Posted by: Scott in: Across the Pond Edit

Last week we found our route east ended in an eddy that spun us back to the west. We were able to fly out of that eddy, but found the boundary on the northern side to be sharp. Currents inceased to the northwest, as we tried to pull

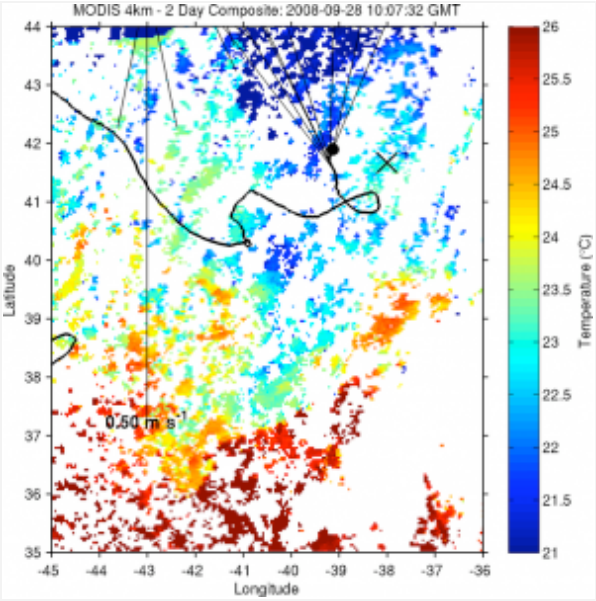
ourselves back east. Satellite imagery is extremely patchy. The week composite below shows some warm water to our east, and cold to our west. So it appears we have a warm eddy we are heading around.



The currents we see to the north are consistent with this patchy evidence of a warm eddy. Currents are rotating over last few days - northwest, then north, then northeast.



You can see the vectors rotate when we plot them on the map below. This time with a 2-day composite image.



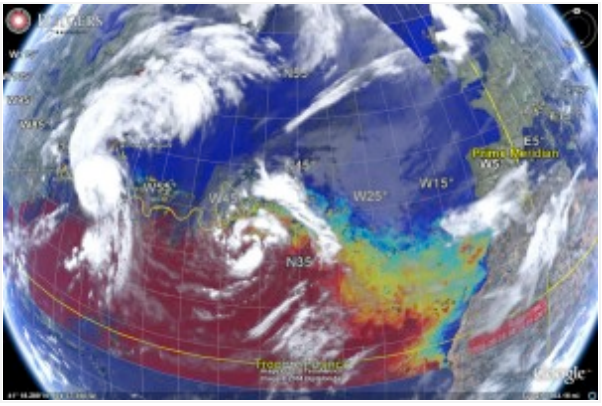
We will continue to fly into this eddy, and get some of its push to the east. Then we find out what is on the other side. At this point, we don't know. Looking forward to some clearing on the other side.

0 Comments

28 sep Global View of the Glider Fleet

Edit Posted by: Scott in: Across the Pond Edit

RU10, RU18 and RU22 are deployed on the Mid Atlantic Continental Shelf on ONR, DoD and NOAA missions, respectively, coordinated with two NOAA fisheries cruises. They are getting hit by the outer cloud bands and waves from Hurricane Kyle today. RU17 is under the clouds in a storm in the middle of the Atlantic. But RU01 and RU16 are having a sunny day in the Mediterranean, specifically the Ligurian Sea off Italy. RU01 always gets the best jobs. Its seen a lot of the world. We'll be joining it next month at the European Glider Organization meeting.

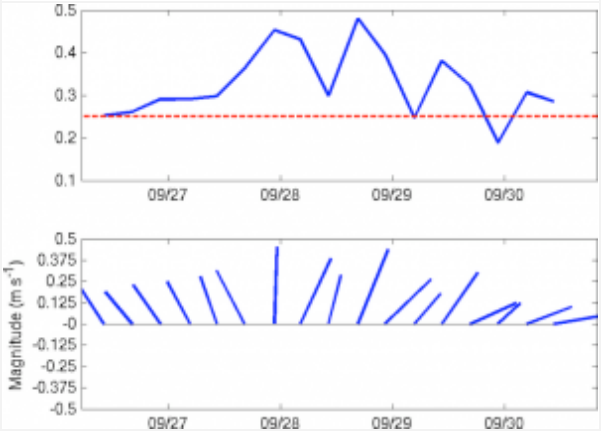


0 Comments

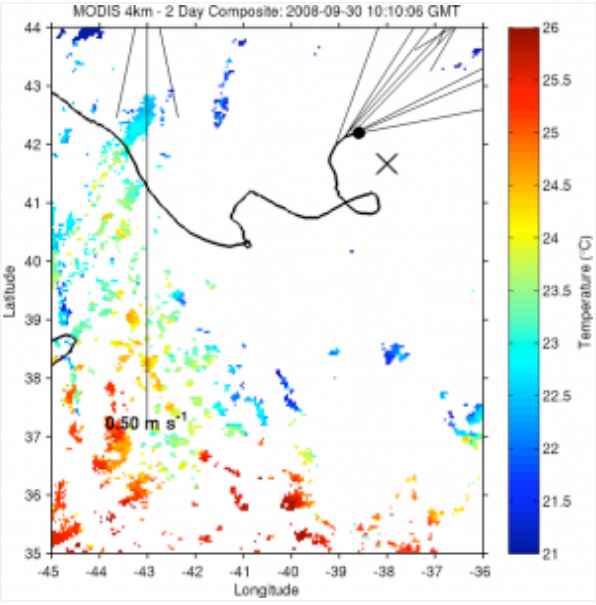
30 Altimetry Back Online - A Great Day at Sea

sep | Edit Posted by: Scott in: Across the Pond Edit

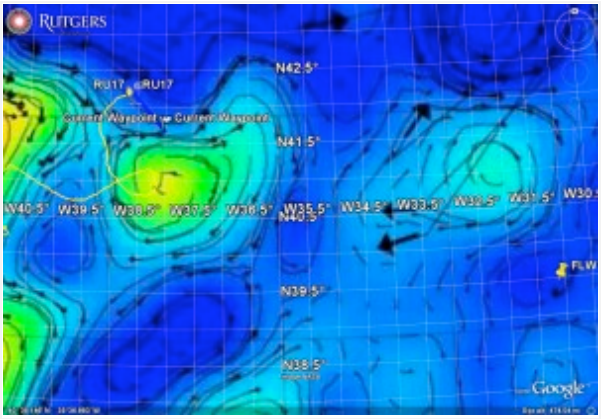
Time series of currents observed by RU17 where to the north for a few days and are now turning east. Was this a warm eddy to our north that had merged with the warm filament we were riding east?



Satellites looking at Sea surface temparature are still obscured by cloud cover. No clue as to whats happening except from RU17 itself.



Until Bob Leden at Colorado restored access to the altimetry dataset over the weekend. Justin logged in from his new grad school, Georgia Tech AUV lab, and restarted the google earth scripts. What a great shot! A large warm eddy centered near 41 N, 38 W. We are on the northern side. And the RU17 observed currents are consistent with the satellite view from space. We are heading east, and we know why. It is a good day at sea. 700 km to Flores (FLW on map).

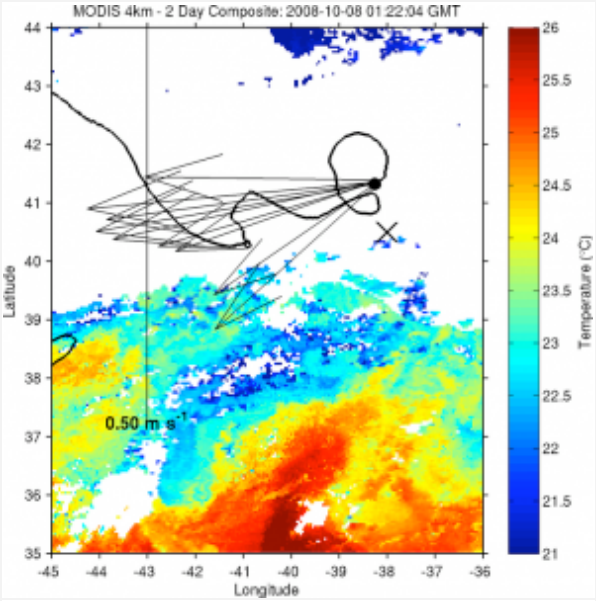


0 Comments

07 oct Lap 2 ?

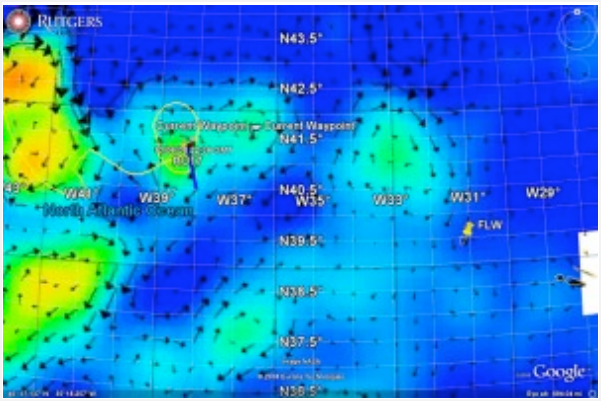
Edit Posted by: Scott in: Across the Pond Edit

Shannon said it best today in class. I liked eddies when I first learned about them, but now I hate them. Shannon is part of the undergraduate crew prepping for the trip to the Azores. Over the last day or so, we started on our second lap heading around this eddy. We've been in this stituation before - the trip to Halifax. But several differences. On the Flight ot Halifax, we had good SST imagery of the eddy. The picture below shows that once again, it is cloudy over RU17. We had that one day last week where we saw warm water to the north and our warm filament appear to merge. The altimeter said we had a bigger eddy than we started with, also talking merger. The other difference is that on the way to Halifax, we had a fully healthy glider. Here we are flying slower, and its going to take us longer to fly out in the radial direction than RU15 did on the Halifax flight. So we'll just keep moving the waypoint around and moving to the outer edge.



Below is the new altimetry product from Colorado. It shows the eddy extended much farther north than when we entered this area. Again, merger is the likely scenario, and we definitely have a bigger eddy to fly out of. And that's just what

we'll keep doing as we come around the southern side. Hopefully we come out above 42 N on the northern side. if we can get across this eddy, we got another one to grab, and we start getting close to Flores.

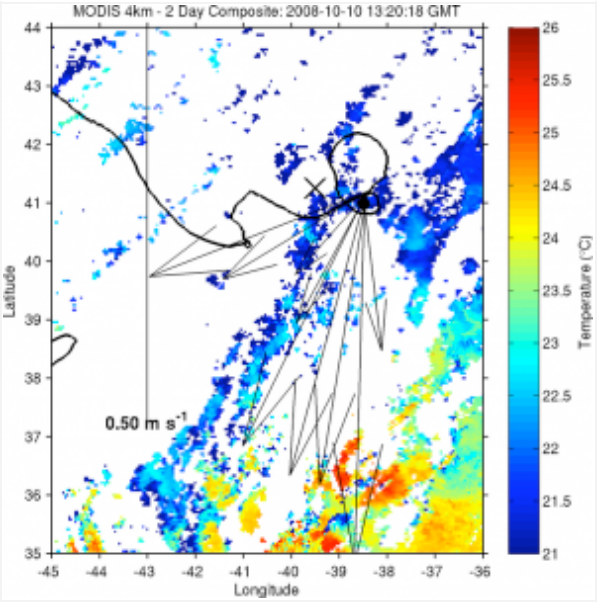


0 Comments

10 oct Now it makes sense

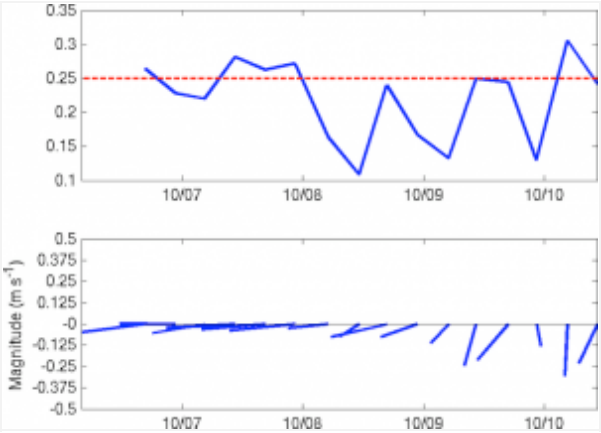
Edit Posted by: Scott in: Across the Pond Edit

Image below shows the sea surface temperature imagery around RU17 is still cloudy. Seen a lot of that lately. Generally southerly flows.

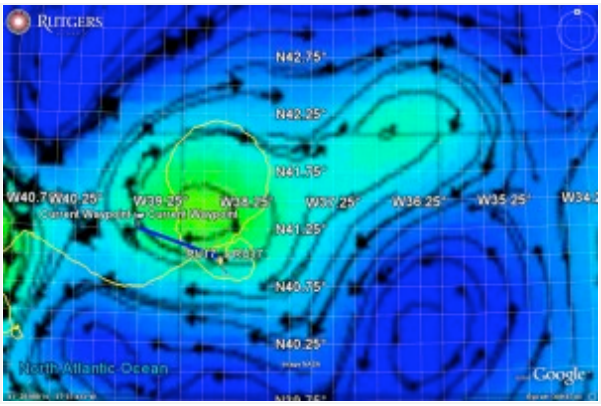


Current time series has been a bit distressing. Currents drop in speed and then head to the south. But all the currents in the altimetry are to the west. Did we exit the eddy on the southern side? If so we better get back inside, since everything south of this eddy is to the west. All the currents to the east are up around 42N. Without any additional guidance and only two datasets that disagreed, we had a big question in front of us, do we continue with the plan of going around the eddy on a second lap, which meant flying west, or do we ignore the altimetry and just head east. Either direction is consitent with our usual practice of flying perpendicular to the current. One goes for immediate gain based on what the market is doing right now, the other for long term gain based on historical

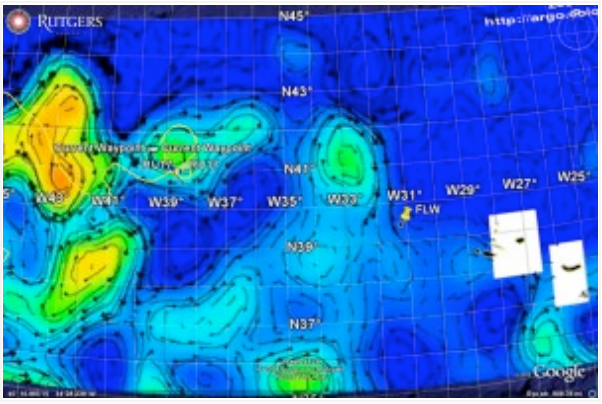
performance. We opted for historical performance and turned west. The details may be missing, but the general flow from the altimeter is usually right. We also find the discrepancies tend to clear themsleves up if you wait a day or so for new data.



So we waited until morning. In my case, I waited all night on a plane flight from Honolulu to Newark. The waiting is sure made easier with no connection to the internet possible. The new configuration for the eddy is shown below. Our track makes perfect sense now. We are spinning around this eddy, and on the first time around we were too close to the center to make the jump to the smaller eddy just to the east. This time around we will try to stay more to the outer edge.



If we look downstream, we see a series of three warm (green) eddies, one near 39 W, one near 37W, and the third near 33W. If we can fly this glider up to around 42 N, we can follow this current across the norther sides of these eddies then turn south down to Flores. If the current stays as is, it will even send us southeast to the central islands in the Azores.



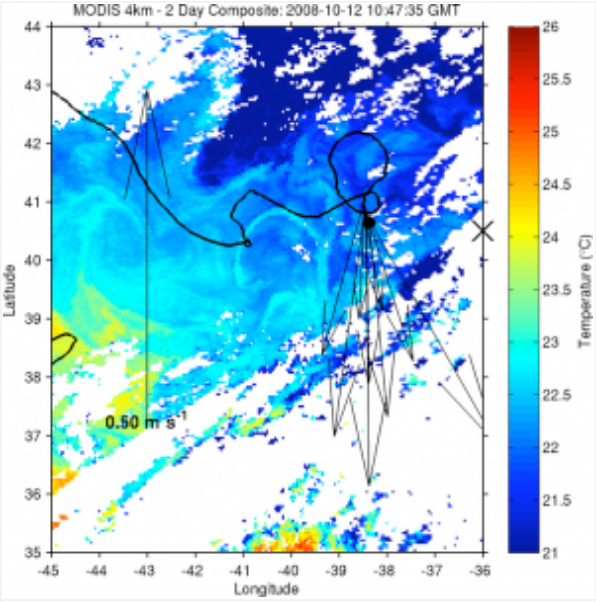
So after a couple days of wondering what was going on, we again have good agreement between what the altimeter sees from space and what RU17 sees on the ground. Once again, it is a good day at sea. Enjoy the weekend.

0 Comments

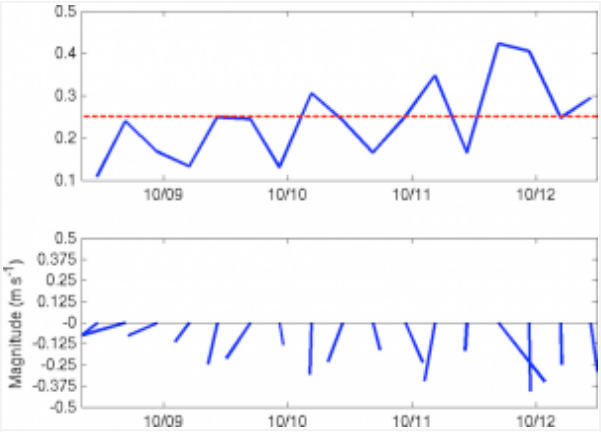
12 oct What we know, and what we don't know

Edit Posted by: Scott in: Across the Pond Edit

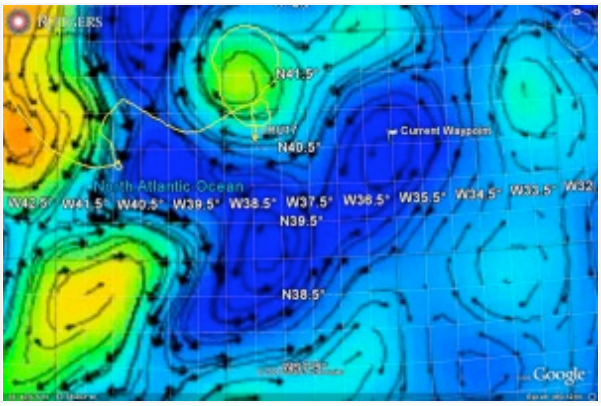
Wow, some clear satellite imagery! That was a bit of a wait. Lets see what we can make of it. The main thing that jomps out at you is the filament of warmer (light blue) water swirling around a cold eddy centered near 40 N, 40 W. RU17 is just east of this eddy, and is experiencing strong currents to the south. Since the currents on the west side of the cold eddy should be to the north, we clearly are not in the circulation associated with the one eddy we can really see.



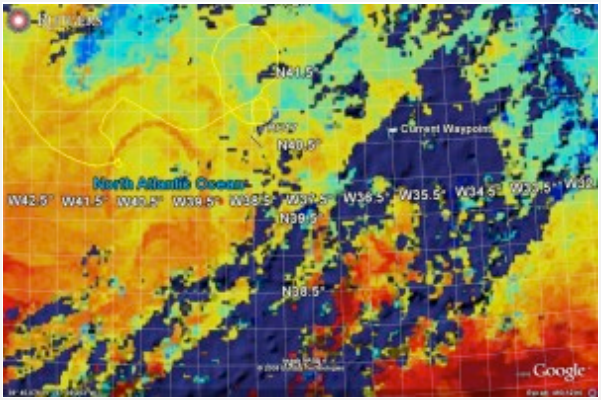
Below is the time series of currents, again steady south for 3-4 days. The altimetry said we should be in a warm eddy and the currents should be to the west. We should be going around for a second lap. Clearly we are not.



So lets go back over the analysis products and see where we stand. What do we know, what don't we know. First, back to the altimetry. Here we see a warm eddy centered near 41.5N, 38.5 W. Then a band of 3 cold eddies to the south, one centered near 40 W, the next near 38 W, and the third near 36 W. Altimetry may get the exact shape of these eddies wrong, and may misplace them slightly, but it hardly ever gets the number of eddies wrong. The challenge becomes finding the same number of eddies in the satellite sea surface temperature imagery.

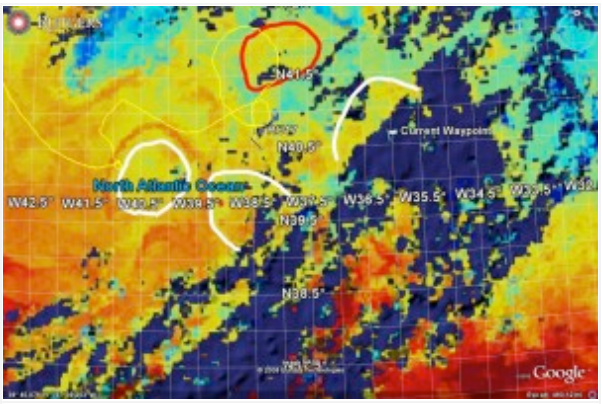


The SST image is shown below with a different enhancement to emphasize the fronts in this region. The cold eddy near 40 W is clearly visible. There is a warm patch to our north that could be warm ring we are supposed to be in. There is a curved front to our east. And something to our south.

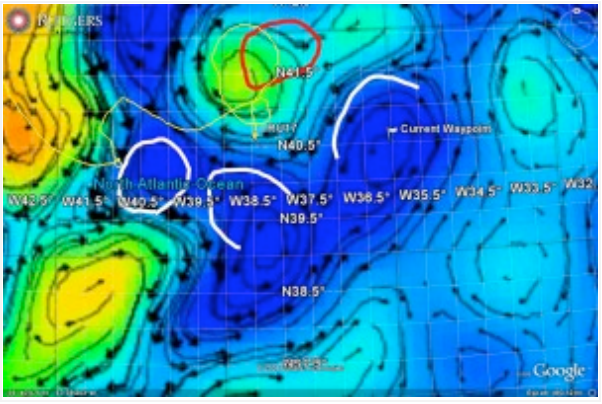


We can draw these lines on the satellite image as shown below. The red line is the

outline of what cold be the warm eddy in the imagery. It is consistent with the glider track. As soon as we left the red circle, the glider stopped spinning in a loop and headed south. The three white lines show what may be the three cold eddies. The western most eddy is pretty certain. The central eddy may be wishful thinking, but if I have to have an eddy somewhere, its the closest feature I can find.



Now we go back and overlay those same lines back on the altimetry product. Starting with the warm eddy, it looks like the instantaneous SST shot from today says the warm eddy is displaced to the northeast of its location in the altimetry product. Ok, that happens, and it is consistent with why the glider currents differ in direction from the expected altimeter currents by 90 degrees. In contrast, the western cold eddy shown by the white line is perfectly lined up in both the altimetry and the SST. So we have a lot of certainty there, and we are also certain we are not in it. The cold eddy to our east also appars to line up with the SST front. The cold eddy to our south appears to line up with the front on its western side. It looks like we have established our general eddy field, something we can use for path planning. The biggest uncertainty however is found in that region between the cold eddy to our south and the cold eddy to our west. This is precisely the region RU17 is in, and precisely the area that the strong southward currents are pushing us.



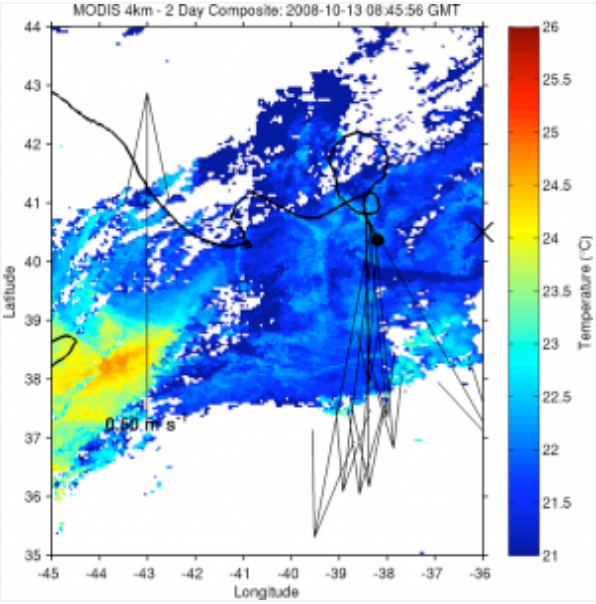
With the strong currents, this is where we are heading, like it or not. Since that is the case, we will try to head into the cold eddy to our east. If we catch it, we whip around the southern side and head north to the warm eddy that gets us to Flores. Wish us luck and good satellites.

0 Comments

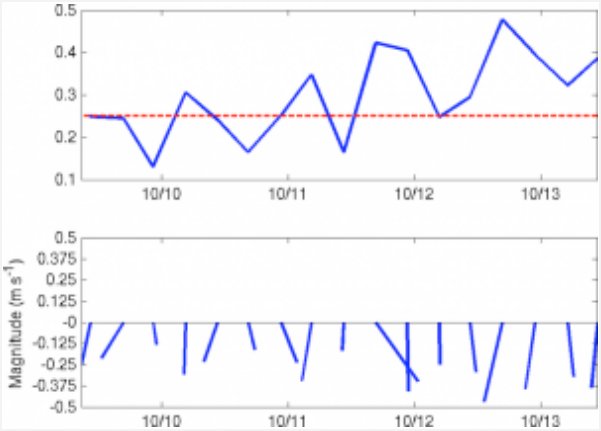
13 | Shooting South

oct | Edit Posted by: Scott in: Across the Pond Edit

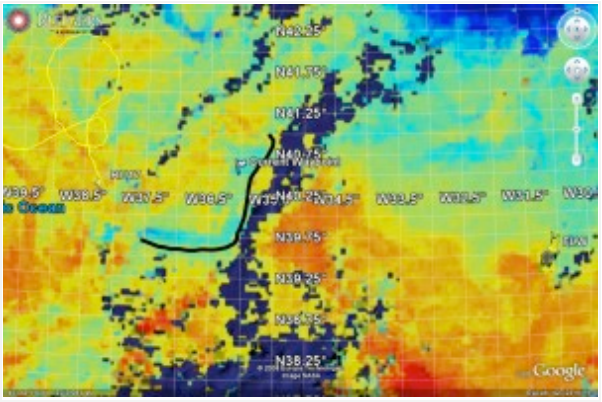
RU17 is moving rapidly to the south in strong currents between 35-50 cm/sec. We have had 4 days of persistent southward currents since leaving the warm ring. The disturbing part is that the altimetry says the currents should be to the east. The good part is that eventually we will hit a cold eddy. We know which one we want to hit, the one to our east, and thats the one we are heading for.



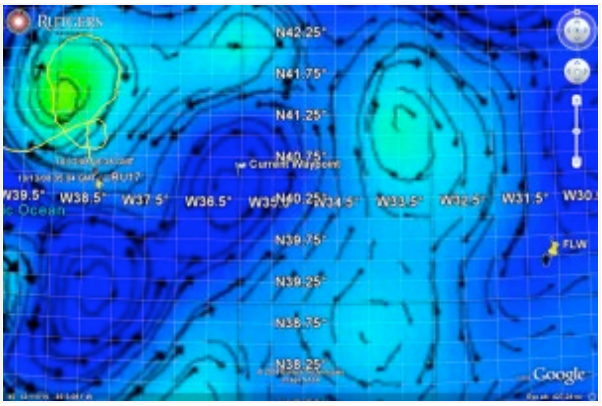
Time series below shows the 4 days of southerly currents.



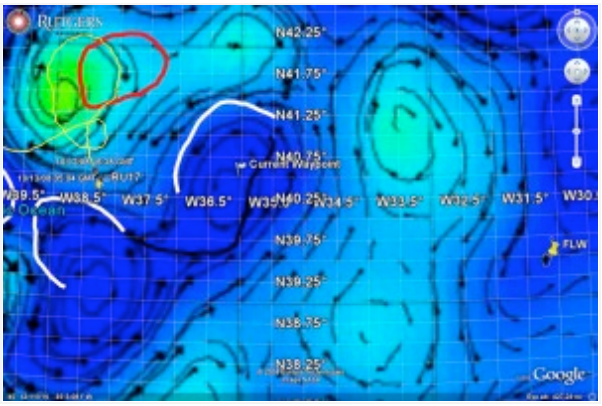
SST imagery is clear again today, so we see some of the same features. The new piece is the cold water that runs east-west near 39.5 N and turns north at 36W. I've drawn a black line along its eastern side. Is it clouds or is it real, yeah, the common question. The difference here is the curvature, clouds are curving with the concave side to east, this has the concave side to the west.



Back to the altimetry. We know the eddies are real, but may ne in slightly different positions. The biggest issure for us is that the altimeter says the currents at RU17 are to the east, and they clearly are not. As long as we are going south, we are going to try to head towards the eddy to our east, and loop around its southern side.



Below is the same alitmeter image with the lines from the SST overlaid. Red and white lines are from yesterday. The black line is from today. Clouds or ocean, or clouds interacting with ocean fronts, its on the southern side of this eddy. Its where we are heading.



One other interesting point, see how the glider track is curving to the east even though the currents are mostly south and a bit west? We suddenly noticed a doubling of the glider speed relative to the water over the last day. Where did that come from. I did notice a near full moon last night. Something to investgate

today.

0 Comments

13 oct

Info On the Azores trip

Edit Posted by: Katie in: Across the Pond, Passion Puddle Observatory Edit

Azores Trip:

Important people

- Luis Sebatiãno - (l.sebastiao@gmail.com)

Works at DSOR Lab at Insitute for Systems and Robotics- based in Lisbon

Has contacts in FAIAL island

-Renato Bettencourt

-Mr. Toste

Has contact at: Oceanography Fisheries Department of the University (at FAIAL island)

-Dr. Ricardo Santos-(Director of department)

- Renato Bettencourt

Part of the staff that works with AUV and ASV operations

- Mr. Toste

Not quite used to handling AUVs but a reliable and capable person (acc. L. Sabatiãno)

Runs a hotel- see below

Has a diving center

-Bigger boat (RIB type) is about 7m long

- John Wilkin- (wilkin@marine.rutgers.edu)

Has contact Alvaro Peliz

-Alvaro Peliz

Friend of Ocean Modeling Group

Can propose oceanographic scientists who could help with logistics on ground and at sea

Travel and Lodgings

-Travel

EWR to

- "Ponta Delgada" airport (at "Sao Miguel" island) -approx. $1,300-$2,200

- "Horta" airport (at "Faial" island) -approx. $1,300-$2,600

- "Terceira" airport (at "Terceira" island) -approx. $1,300-$2,300

With TAP airline

- http://www.flytap.com/USA/en/Homepage/

Then take an international flight between islands with SATA Airline

- http://www.sata.pt/EUA/en/Home/

OR BOS directly to the Azores via SATA airline

-MUCH CHEAPER that flying TAP -$400-$500 one way

-Lodgings

Mr. Toste's Hotel

-http://www.azores.com/travel/hotel.php?id=67

-http://www.hotelocidental.com/ (Portuguese) or http://translate.google.com/translate?u=http%3A%2F%2Fwww.hotelocidental.com&hl=en&ie=UTF-8&sl=pt&tl=en (google translation to english)

- Tel: +351-292590100

- Fax: +351-292590101

- E-mail: hotelocidental@hotmail.com

0 Comments

13 oct

Map of the Azores with Names

Edit Posted by: Hugh Roarty in: Across the Pond, Passion Puddle Observatory Edit

0 Comments

15 oct More info about Azores trip.

Edit Posted by: Katie in: Across the Pond, Passion Puddle Observatory Edit

10/15

-Recieved another contact from John Wilkin, Ana Martinsfrom the University of the Azores dept. of oceanography and fisheries www.horta.uac.pt

-Recieved an e-mail from Raquel Toste (Hotel Manager), and replied asking about more information on lodgins, boat rental, and air travel

A more detailed map of Flores:

http://en.wikipedia.org/wiki/Image:Flores_Azores.png

The airport is on the east side of the island in Santa Cruz and Tostes hotel is just north of that also on the east coast.

The next island to the east is Faial, over 150 km away so the possibility of hitting any islands if we fly the glider to the east side of Flores is slim to none.

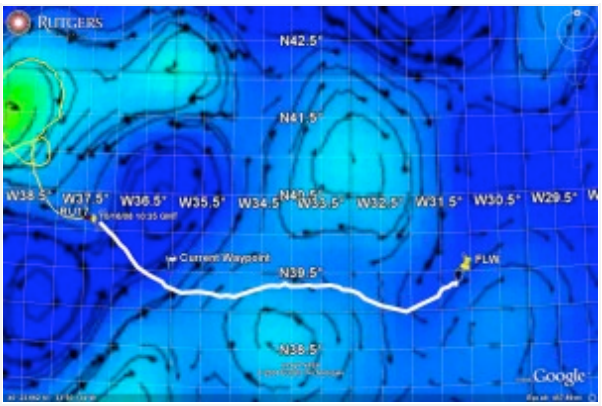
0 Comments

16 oct Shannon & Dakota take the Wheel

Edit Posted by: Scott in: Across the Pond Edit

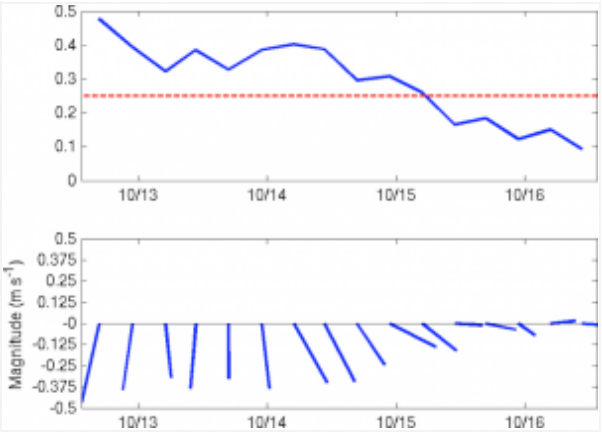
Yesterday was one of those days a teacher never forgets. Shannon and Dakota walked into my office in the afternoon just before heading off to class. They said they were looking at the data, and they found a better way to the Azores, and they wanted to fly it there themselves. They were freshman when this flight started. Now they are sophomores, part of the experienced crew. They had been learning

more about the flight characteristics of RU17 this past week, and they noticed its speed had suddenly increased - after all, it is the full moon. They also were looking at the satellite altimetry-derived current product, with its local uncertianties but generally correct features. They drew the white line on the image. They figured they could use the new found speed to shoot the gap between two cold eddies, hugging the eddy to the northeast for a push to the east, but staying as far south as they could to catch the next set of warm eddies between 32-34 W. They would shoot the warm eddy gap, this time hugging the warm eddy to the south for an eastward push. Instead of approaching Flores from the north, the long term plan, they would approach Flores from the south. The plan would cut weeks off the trip. This was important for the students. They want to go the Azores for the pick up and turn around, so they have to get it there before finals. Saving time was critical.



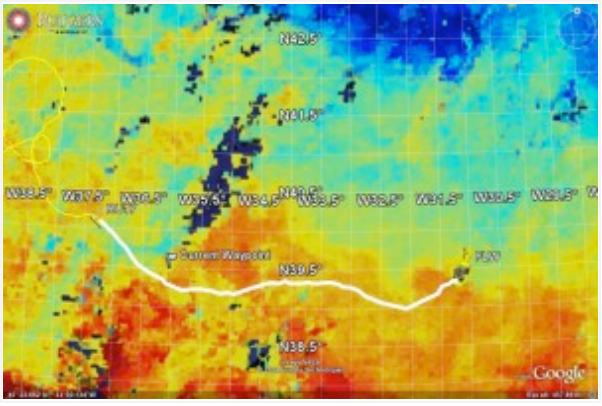
We all loved the plan. Shannon and Dakota said they would take over driving and watching, just like Justin, Anthony and Eric did this past summer. They were seniors and juniors. Shannon and Dakato are going to show us what the sophomores can do.

The time series below shows the currents have decreased, but they are remaining to the east. It looks like they are going into a region with lower currents, and a hugging the northern ring as intended.



Recent sea surface temperature maps are mostly cloudy, so we forced to go to a 7 day conposite. But when we do and we trace that same white line, we are staying

in the warm water (red) south of the front. Thats good for a few reasons. Most of the currents on the cold side of the front (green colors) are flowing to the west. The warmer water also extends battery life.



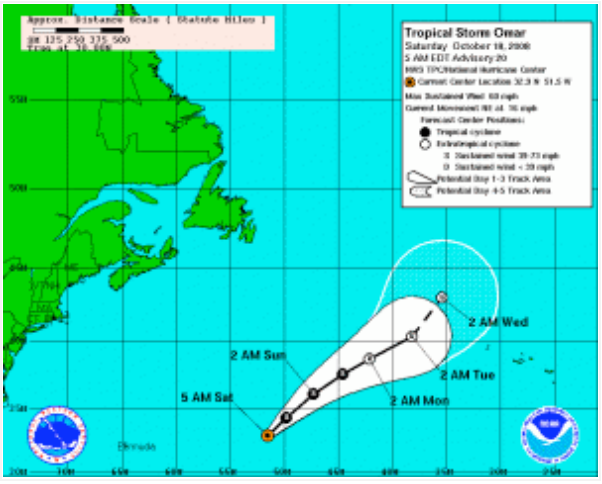
Battery life is something we always think about, but something that becomes even more important as winter comes. We are a few days away from 5 months at sea. We have flown over 5,500 km. We have less than 550 km to go to get to Flores. 9/10 of the way there.

1 Comment

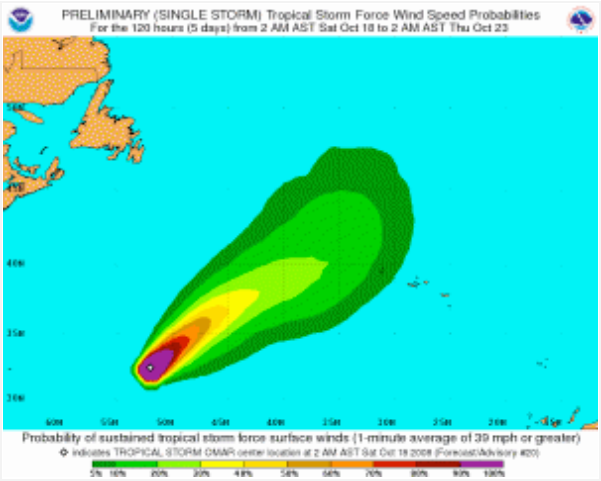
18 oct Tropical Storm Tuesday

Edit Posted by: Scott in: Across the Pond Edit

RU17 is currently located near 40 N, 37 W, heading east. Tropical Storm Omar is at 34 N, 51 W, moving northeast at 13 knots. Yep, Omar is heading directly at The Scarlet Knight, due to arrive about tuesday. Our third tropical storm this trip.

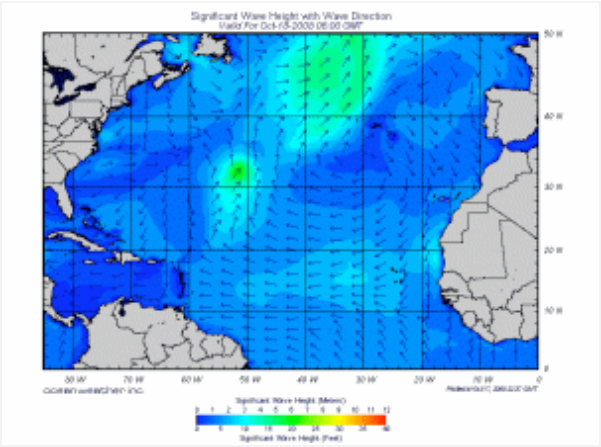


Tropical Storm force winds are likely in our region. Forecast Discussion on the NOAA National Hurricane Center website has the highest winds concentrated on the southeast side of of the storm, the side that will hit RU17 if Omar continues on this path.

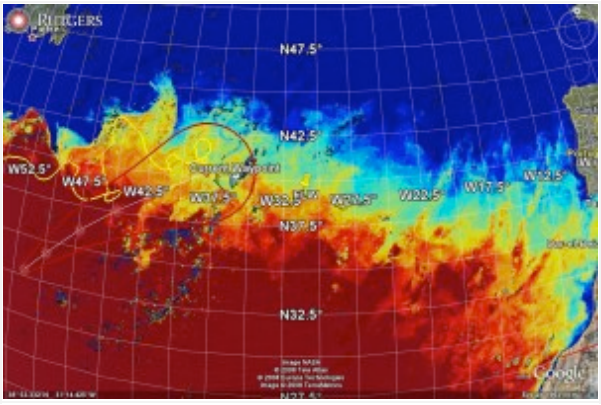


\

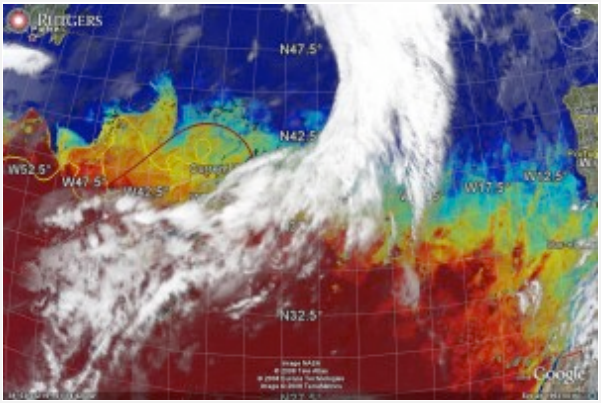
Signficant Wave hieghts in Omar right now are running in the 15-25 foot range. Big waves again. We'll do the usual rigging for storms - stay a littler deeper on our top inflection points. Unlike the many gliders we purposely fly into storms and hurricanes, we like to keep RU17 away from the rough treatment. We have little idea what RU17 actually looks like 5 months into this voyage, so we are minimizing risk where we can.



Below is the track of RU17 and the forecast track of Omar overlaid on the satellite Sea Surface Temperature. Now we have 2 reasons to run to the east as fast as possible, first to avoid Omar, and second to get ourselves out to the Azores and back before final exams.



Below is the cloud front that OMAR is running along. We hope this front moves east and clears the skies over RU17. We are right on the edge of the cloud front, and Omar looks to be running along it.

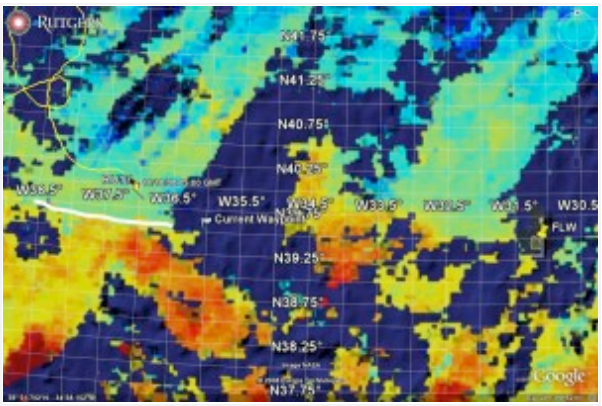


0 Comments

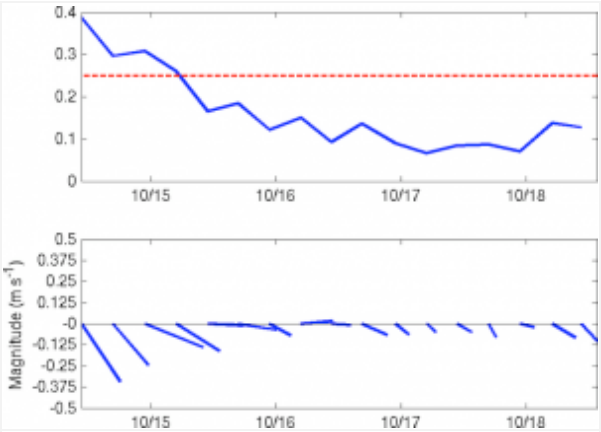
18 oct 500 Kilometers to the Azores

Edit Posted by: Scott in: Across the Pond Edit

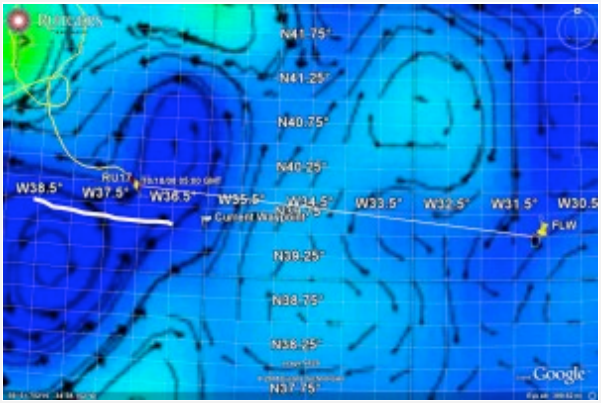
RU17 is flying southeast just north of a front in the Sea Surface Temperature. We've outlined the front with a white line.



Currents are slowly increasing in speed and are still running to the southeast.



The two pieces of evidence we have above indicate that RU17 is likely on the southern side of the cold eddy centered near 40.5 N. 36.5 W in the satellite altimetery below. The SST front could be associated with the other cold eddy to our southwest. Our objective is to fly eastward between these two cold eddies, staying in the northern cold eddy to take advantage of its currents to the east.



We'll likely continue on this heading for the weekend, crossing through the interaction zone and staying in the northern eddy. Once across the center, we'll start heading south as far as we can in anticipation of crossing the northward flowing currents between 36 W and 35 W. The thin white line is the google earth ruler. It says the distance to Flores just dropped below 500 km. Everyday, the ocean gets a few kilometers smaller.

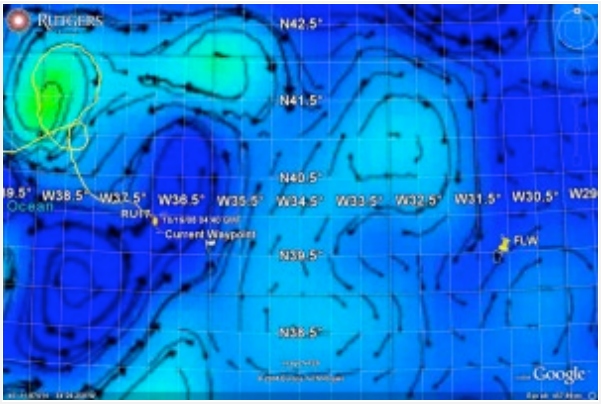
1 Comment

19 oct

The calm between the eddies.

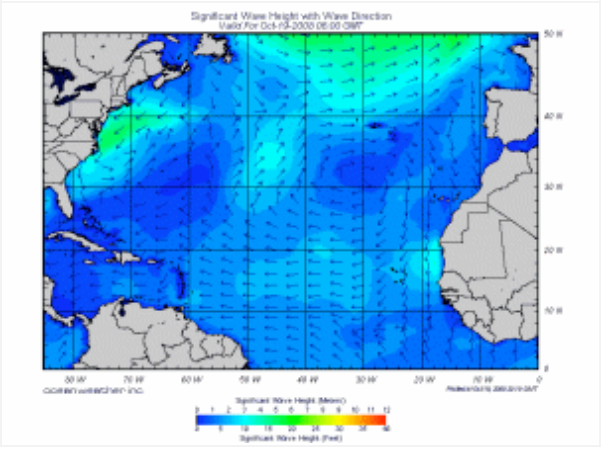
Edit Posted by: Scott in: Across the Pond Edit

RU17 is now located in the middle of the interaction zone between the two cold eddies, one centered to our northeast, the other centered to our southwest. The eddy to the northeast, the one we are closer to, is weakening.



Currents reported by RU17 in this region are week, and changing direction over the last day and a half. The changing direction is likely due to the rotating inertial currents. The inertial currents mostly just loop you in a circle, while the glider uses its own speed to make progress toward the waypoint.

National Hurricane Center dropped Tropical Storm Omar from its tracking webpage. Waves from Omar are down today. The look to be running about 10 ft.



0 Comments

20 oct To call the Azores

Edit Posted by: Katie in: Across the Pond, Passion Puddle Observatory Edit

So here is the process to call internationally from a Rutgers phone.

To call outside the RU campus-99

To call internationally-011

Country code for the Azores-352

Then area code and number

So saying the number we wanted to call was area code 123 and number 456-789, the full number would be

99-011-352-123-456-789.

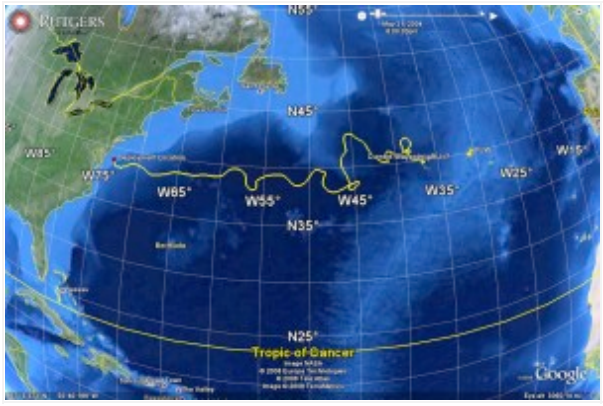
(The numbers in the azores only have 6 digits as opposed to our 7)

2 Comments

21 oct 5 Months at Sea

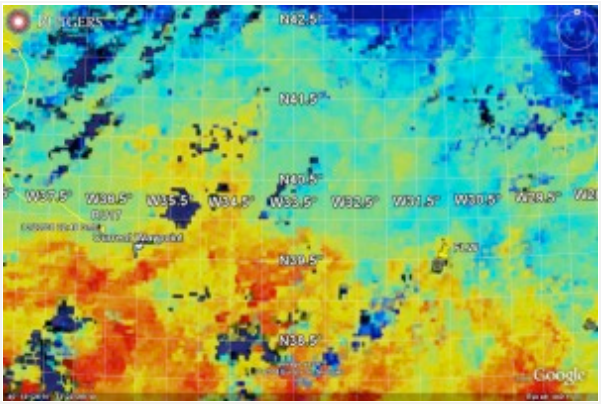
Edit Posted by: Scott in: Across the Pond Edit

RU17, named The Scarlet Knight for good luck, has now spent 5 months at sea, traveling 5600 km in the process. We started these student missions with the Flight to Halifax (also one of our blog sites) back on March 7, 2008. Backed up by a world-class ocean observatory, the students ranged from Seniors to Freshman. Some have graduated and are on to jobs with NOAA or graduate school, and the Freshman that started with us are now the Sophomores steering us from eddy to eddy to the Azores. The plot below shows how RU17 is crossing the vast abyssal plain of the Atlantic and is approaching the Mid-Atlantic Ridge. The Azores is on the ridge, with Flores, our target island, on the western side. This morning we are 450 km from Flores.

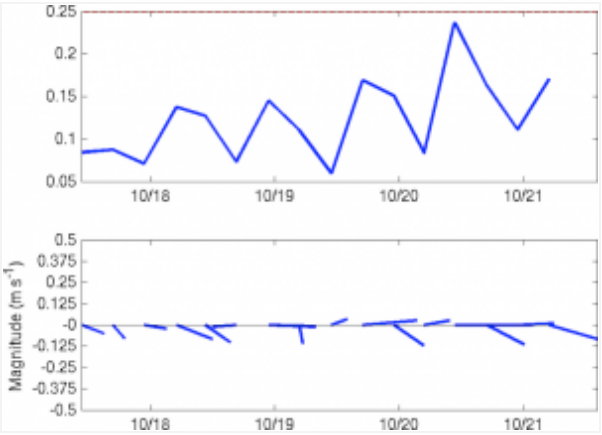


Zooming in on the track and the satellite Sea Surface Temperature image, we are

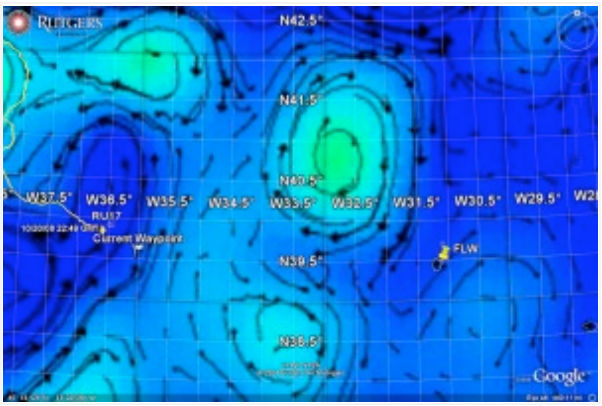
running parallel to a front that lies to our southwest. Our objective has been to stay north of this front as we crossed between the two cold eddies.



Current speeds are oscillating but with in increasing trend, and are to the east or southeast, consistent with RU17 being on the southern side of the northern cold eddy.



Below is the satellite altimetry showing RU17 flying between the two cold eddies, staying closer to the northern eddy. The really good news is the two warm eddies that lie to our east between 34 W and 32 W. On Sunday, these two eddies were strongly interacting, and had formed a wall that RU17 would have to go around. On monday they started pulling apart, and today, they look like distinct warm eddies. It gives us a clear path to Flores. We head southeast and pick up a push from the southern warm eddy. Students will make the change after class this morning.



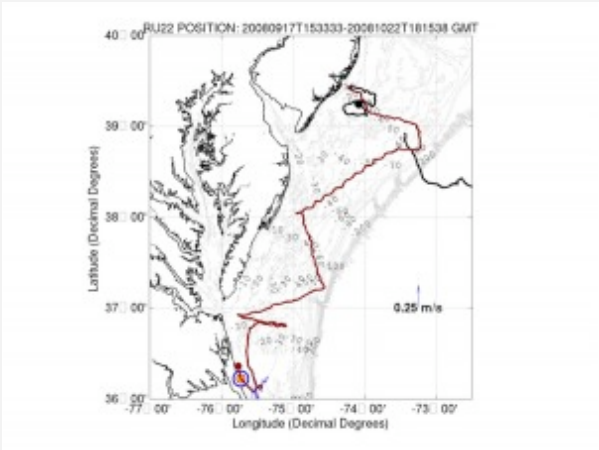
0 Comments

22 oct

The Recovery of RU22

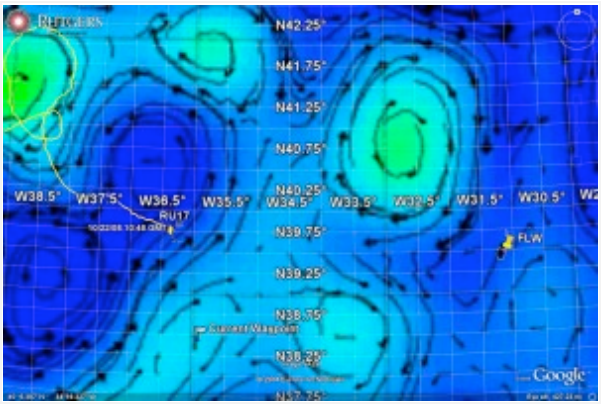
Edit Posted by: Scott in: Across the Pond Edit

Missed my usual morning rounds of RU17 today. But no worries, the students are driving. Veterans of the Flight to Halifax are on the job.

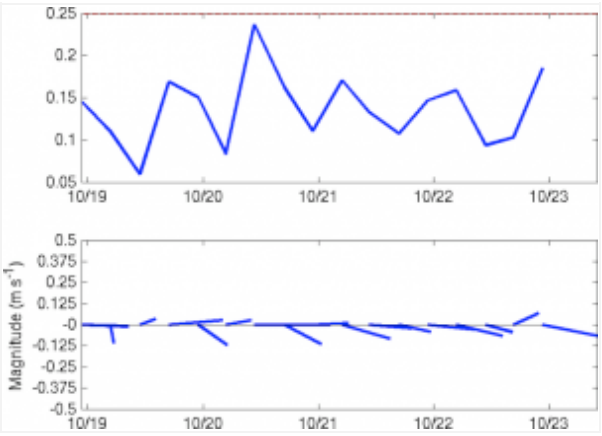


Today we were more concerned with RU22 (above). It was offshore Virginia. It just completed the Fall sampling run for the southern half of our Mid-Atlantic region for IOOS. We were running low on batteries, currents where pushing us south towards the Gulf Stream faster than we could fly, and a low over Nova Scotia was sending big waves our way. The forescast was bad as far forward as they forecast. Tom (UMaryland) and Mike (UNC) rented a bigger boat (they are both fans of the small, fast recovery vessels), and were heading out for retrival today, the best of the all bad weather days this week. Many of us were at the annual meeting of our IOOS Regional Association in Fall River, Massachusetts, looking out the window at gray skies and strong winds. Tom and Mike were going to head down the coast close to shore until they reached the same latitude as the glider, then head out into the waves. We watched on our blackberry's while they took the hits all morning. Just after lunch, the code message was sent. RU22 - Bear in the Igloo! Glider-speak for RU22 was recovered and safe on deck. At the IOOS meeting, the UMass, RU, and UMaryland glider teams were all smiles. The IOOS glider sampling was successfully coordinated with the fall NOAA Fisheries surveys, and the last glider was coming home. We had our assimilation dataset for a winter of hindcast model experiments. While we celebrated, Tom and Mike had to battle back against even bigger waves to get back home. We heard the story later in the day at dinner. We owe them new Mustang suits.

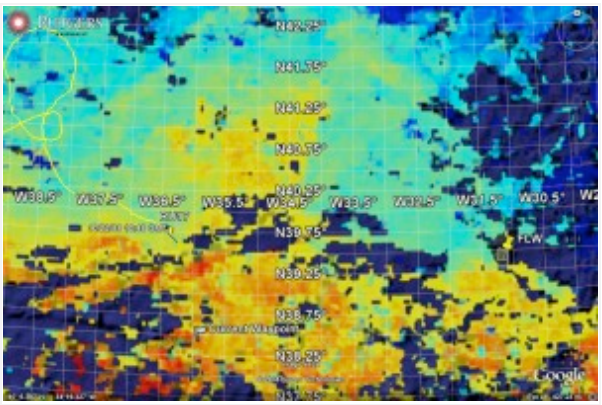
Meanwhile, way out in the North Atlantic, RU17 is in the cold eddy centered near 40.5 N, 36.5 W, now crossing over to the eastern side of that eddy. Our next target is the warm eddy to our southeast centered near 38.5 N, 33.5 W.



The Altimetry above says we should already be feeling the currents to the north, but the glider current time series plot below says thats not the case. The glider says the currents are still running to the east. So our students have the waypoint set to the south. The combination of the eastward current and the southward glider velocity gives us the desired path to the southeast.



When will we hit the northward flowing side of the eddy? From the Satellite Sea Surface Temperature map below there is a band of warm water extending to the north alont 35 W. That is probably the northward currents we see in the altimetry. if we measure the distance, we are about 30 km from the edge of this warm band. We should close that distance in a couple of days. Farther to the east, between 34 W and Flores (FLW), we see colder water to the north of 39.5 N is likely associated with the clockwise eddy circulation centered near 40.75 N, 32.75 W. So we will want to stay south of that front.



About 435 km to Flores.

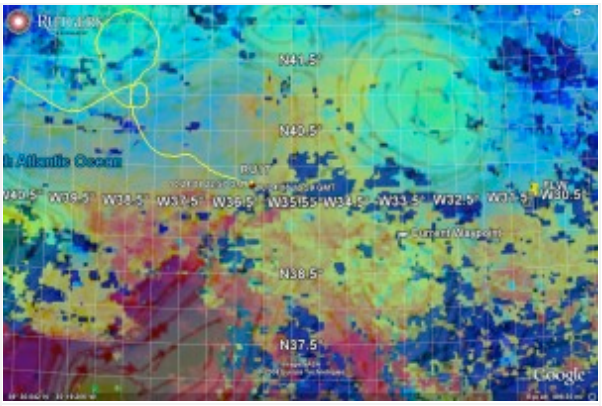
0 Comments

25 oct Off to La Spezia

Edit Posted by: Scott in: Across the Pond Edit

Tonight we hop the pond to Italy. We are heading to the European Glider Organization meeting. Glider talks, glider training. We'll work on plans for the RU17 turn around in the Azores, and the continuation of the trip to Spain.

RU17 is in a low velocity region, but the current is heading north. You can see the warm water in between the two eddies heading north. The currents seen by the glider are smaller than what we expect from the altimetry. The smaller currents mean we need to use our glider velocity to head east. So we turned RU17 to the ESE. We hope the small southward component will get us into the target eddy that is to our southeast. The new waypoint is on the northern edge of this eddy. The SST front says the western edge of this eddy is about 135 km away. And the point we are heading to is about 245 km away. We are flying slow now, down to about 10 cm/sec. Usual trouble at night, we don't always make it to the top of our undulations and have to head back down. But its real cloudy in the area, and the moon is going into is final phases before the new moon, so we always see a deterioration in performance with the new moon.



We'll keep working these eddies, trying to get to the Azores before finals. If we don;t beat finals, we may have to wait for the intercession between semesters.

0 Comments

01 nov A Great Mission Comes to an End

Edit Posted by: Scott in: Across the Pond Edit

We just spent the last week at the European Glider Organization (EGO) meeting in La Spezia, Italy. It was early Monday morning, the day after we arrived, that RU17 woke us up in the middle of the night with a call to our blackberries. Dockserver had just sent us the warning "Glider: ru17 Event: ABORT".

A glider abort doesn't necessarilly mean the sky is falling. What it does mean is that the glider figured out that something is not right, and rather than trying to deal with the problem alone, the glider decides to come to the surface so we can work on it together. But the message Dockserver was relaying to us from RU17 wasn't good. In glider-speak, RU17 sent the following line with the abort:

ABORT HISTORY: last abort cause: MS_ABORT_LEAK

One of RU17's internal sensors had detected a leak, and it was aborting the mission to return to the surface until we told it otherwise.

Now the leak detect sensors are very sensitive, and with good reason. Any small amount of seawater can cause electrical systems to short and fail. We have seen leaks before, and have continued to fly the glider, adjusting the flight characteristics to shallow up the dives and climbs to keep whatever water drops that were rolling around inside away from the electronics. In the past we have been able to keep a glider flying towards its recovery point by this method. It all depends on your glider's location when you find the leak and how much risk you are willing to accept. If it is a local deployment, we just keep the glider at the surface and send a boat out the next day - minizing risk. If it is far away, you sometimes have to accept the risk and fly towards a pickup point that is within range. In the process of doing this, we have learned the flying tricks of monitoring the vacuum and leak detect voltages to minimize impact on the electronics.

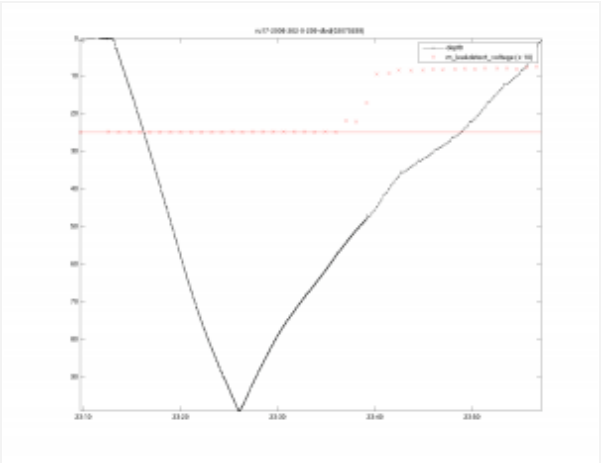
RU17 then sent us a second message from the surface that included the following lines.

```
sensor:m_vacuum(inHg)=8.12776288306713           5.158 secs ago
sensor:m_leakdetect_voltage(volts)=1.05079366266727     52.628 secs ago
```

The good news was the internal vacuum was holding. That meant the airbag was holding. The airbag has to inflate and deflate for every surfacing. Thats a lot of motion over 5 months with the potential for wear points. If we have a leak, the airbag is always the first suspect. But the internal vacuum was holding, so the airbag was likely intact. That's very good, because the airbag is also our life ring. Just like your lifejacket, it gives you that extra added buoyancy to keep your head (in our case the communication antenna) above water.

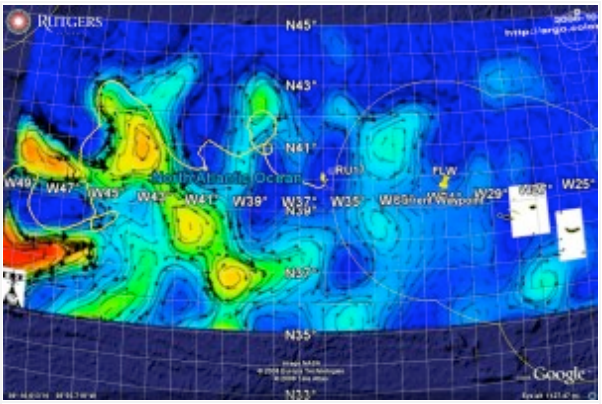
The bad news was the leak detect voltage was down to 1.05. Usually the voltage on the leak detect sensor is rock solid around 2.48 volts. Any rolling drop of water may move it a few hundreths or even a few tenths. But here it was already down to 1.05. Even though we know there is no direct correlation between the amount of water inside and the magnitude of the voltage drop, and that by definition, any leak in a submarine at sea is bad, the severity of this drop in voltage stopped me dead. That one number spelled trouble.

Since we now had RU17 at the surface, we may as well spend a little Iridium money and start downloading the engineering files to determine what happened, and when the leak detect was triggered. The crew at Rutgers downloaded the most recent "dbd" file from RU17 with all the engineering data. Here is the plot they sent to us in Italy. It shows a trace of depth (black) and leak detect voltage in red. Note that the leak detect is multiplied by 10 so it can be displayed on the same axis. The plot indicates that as RU17 started this segment, it was heading down towards 100 m depth and the leak detect voltage remained constant at 2.48 volts. RU17 hit the inflection point at about 98 m, and started heading back up. About 11 minutes into the ascent, at a depth of about 47 m, the leak detect voltage changes, and within 2 minutes drops to about 1.1 to 1.05. RU17 triggers a leak detect abort, and heads to the surface.



With this news the rescue mission was on. It was now monday in Europe and we could not have been in a better place. The entire European glider community was assembled in Italy. Clayton Jones from Webb Research was with us. We downloaded more data from RU17 to try to get a better handle on why we were leaking. Nothing in the previous records looked odd. Emanuel Coelho from NRL Stennis was with us in Italy, and he helped us with contacts in the Azores. The University of the Azores research vessel, the R/V Arquipelago (http://www.horta.uac.pt/) was perfect and was available. It was a 1.5 day steam from its home port to RU17's present position.

RU17 was drifting north. The altimtery below showed the situation. It was in the northward currents between a warm eddy to the east and a cold eddy to the west. It would continue to drift north and then whip around one of these eddies. If it stayed with the warm eddy, it would whip around closer to the Azores. If it stayed with the cold eddy, it would drift farther away. So drift was setting a time frame for us. We had about a week before RU17 would drift to the northern side of these eddies and turn east or west. Since RU17 looked to be favoring the cold eddy and the turn to the east, we wanted to be out there before it made that turn. Chip was in the U.S. and could fly out to the Azores to meet the boat. Dave was in Italy with us and a full load of glider recovery gear for the EGO glider school. He could leave from Italy and head to the Azores. Whoever got there first would head out.



That left us on shore to monitor the trends. But the news was not good. The leak detect was not holding steady. Instead it continued to drop. By tuesday it was down to 0.42 volts. We were getting very good at coming up with scenarios that could explain the continuing drop in voltage that did not include the obvious explanation that more and more water was somehow getting in. We were at dinner on tuesday night when Hugh called from Rutgers. We had lost

communications with RU17. Oscar and Josh later told me that in that one second, they watched me age 10 years. RU17, my constant companion for 5 months, had gone silent. And we were quickly running out of tricks.

Our next hope was the emergency ballast weight. If RU17 looses both communications and gps signals, it assumes it is somehow stuck underwater, and it blows its emergency ballast weight. 500 grams of lift. In a world measured in grams, this provides a big push to the surface. If the seawater had not damaged RU17's electronics, and it could still think, in 16 hours it would eject its ballast weight and return to the surface.

It was a restless night for most. Email traffic persisted through the night. People would wake up, trade emails, and try to get back to sleep. No sign.

The 16 hour time period without communications was set to expire the next day, Wednesday, just before the lunch break at the EGO meeting in Italy. We all gathered around the Dockserver station we set up for NATO for use in the glider training school. 16 hours came. no comms from RU17. 17 hours came. no comms. We went to lunch.

There were still several scenarios that could have RU17 at the surface, but with a damaged Iridium satellite phone so it could not call us. In this case the emergency ARGOS location system is on a separate circut, and the next time a satellite passed overhead, we could get an emergency transmission with a location. We have also found gliders by this method in the past. The Argos system gives you an approximate location within a few kilometers with a few hour delay. Anyone trying to find something in the ocean with this information knows how difficult it is. But once you get close, we have something called a Gonio. Its a direction finding antenna that you tune to the ARGOS broadcast frequency that you can then use to steer the boat in to close the last few kilometers on the glider. We keep 2 Gonios in the lab for just this purpose. They have paid for themselves many times over. But after another full day of monitoring ARGOS, still no reports from RU17.

The EGO meeting and glider school ended yesterday, and now we are back home in the States. We'll continue to watch and wait through the weekend. Yes, stranger things have happened. We always keep in mind the Oregon State experience where a lost glider suddenly reappeared several days later and phoned home. We'll let these next few days pass, and see if we get anything. If nothing new happens, we'll likely close out this mission sometime early next week. At that point we'll celebrate RU17's many successes, and start the build on the next glider that our students will launch towards Europe in 2009.

1 Comment

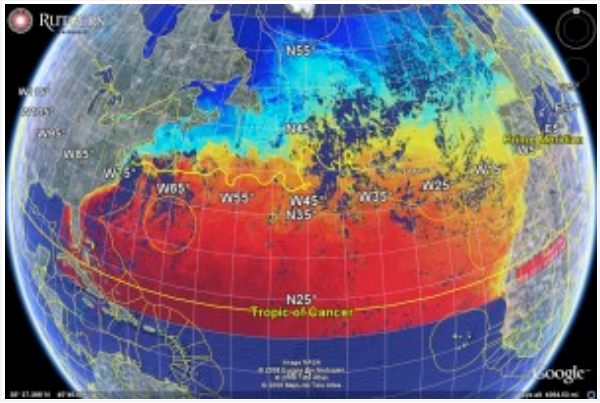
06 nov

RU17 Accomplishments

Edit Posted by: Scott in: Across the Pond Edit

Tale of the Tape

RU17 was deployed on May 21, 2008 and was within 20 km of the Azores EEZ line when we lost communications on October 28, 2008. The Rutgers students, technical staff and scientists flew RU17 a record breaking distance of 5,700.59 km. We spent 160 days at sea, which translates to 22 weeks and 6 days, or 5 months and 1 week depending on your preferred measure of time. There is no Guinness Book for glider statistics, so we have to rely on the public websites we can find. Based on that search, it looks like we share the duration/distance records with our friends at the University of Washington. Glider RU17 now holds the world record for the longest distance mission for an autonomous underwater glider – 5,700 km. A University of Washington Seaglider holds the world record for the longest duration mission – 7 months.



Education

The primary purpose of this flight was education. We where challenged by NOAA to fly a glider across the Atlantic on an inspirational flight that entrained students. Funding for this purpose was provided through donations from Rutgers Alumni. The private funds were used to build RU17, which was christened The Scarlet Knight by the Rutgers President in honor of the Rutgers-wide involvement that not only crossed campuses, schools and departments, but also crossed generations of students in the Rutgers family.

Over the course of building RU17, the test Flight to Halifax, and the Across the Pond experience, undergraduate involvement in the Coastal Ocean Observation Lab has increased by an order of magnitude. We typically had 1 or 2 undergraduates in the Lab on a regular basis, including a record setting 3 undergraduates in 1994. Now, depending on how you count, we have been 10 and 20 undergraduates working in the Lab.

We see the undergraduate students are seeking new opportunities earlier in their careers. In the past the majority of students came to us during their Junior year. Occasionally we would entrain the rare Sophomore, a lucky break because we would both benefit from the opportunity to spend two summers together. Now, attracted by the grand scale of international glider missions, we are even pulling in Freshmen through the various Intro to Oceanography courses and Freshman seminars that we use as feeders. Workstudy students are seeking us out during the school year. Traditional summer internships are being used to attract students from outside Rutgers, and to send Rutgers students abroad. Some Seniors are staying with us through the summer after graduation before they move on. Some of the new Freshman will have spent 4 years working with us in the Lab over

the course of their undergraduate careers. The students are seeking both the hands-on research opportunities and the camaraderie of a group project that RU17 provided. They are prompting us to teach more mid-level undergraduate courses. Our traditional capstone courses, for example, the first year graduate course in Physical Oceanography, are still being taken, but the capstone course I now recommend for their final semester is Communicating Ocean Science, an NSF sponsored class developed by Lawrence Hall of Science. The course introduces them to modern educational theory, it provides hand-on opportunities to practice what they learn at Liberty Science Center, and they use that experience as a basis for mentoring the younger multi-disciplinary students in the lab. Even after graduation, we see that the students use the new tools available to them, like video IM and Skype to stay in touch, and to field questions from younger students that are just starting out.

What did the students do during this project? We had several small teams or sometimes individuals contributing to a common goal. Two students helped with the glider build itself. Two worked on determining and improving the flight characteristics of RU17, including work on the flight characteristics of the extended payload bay, energy savings on communications and trim battery movements, and optimizing the gains on the Digifin for improved steering. Two worked on the CODAR network in the U.S. as the take off point, one went to Spain to work on their CODAR network as a potential landing point. One worked on path planning and the new Google Earth and Google Maps interfaces. Another worked on the webpage interface describing what we are doing. During the summer, the more senior level students took full control of the flight planning and waypoint changes. During the fall semester, the younger students came in and filled their shoes.

Science

The most interesting scientific discovery of this mission has been the interaction of the glider with the upper ocean biological communities of the central North Atlantic. After leaving the Gulf Stream region and heading east of the Grand Banks of Newfoundland, we noted a decrease in glider speed on both upcasts and downcasts, resulting in fewer undulations per 6 hour segment. The suspected cause is biofouling, since the speed decrease was slow and steady for a period of about a month before it leveled off at a slower but steady speed.

The new discovery for us was the difference in the day-night behavior of the upcasts and downcasts. The upcasts were sensitive to the day night cycle, downcasts were not. There were many times when the upcast speed at night was much slower than the upcast speed during the day. Many times at night we would have trouble making it to the top of an undulation. The glider would be slowed to a stop, and would have to turn around and go back down before trying again to ascend. Yet throughout the mission, downcast speeds showed no day-night variation. Interactions with either remoras and squid were suggested as possible explanations. We have seen Remoras attached to gliders in the past, and we know they are negatively buoyant, which could explain the glider's reluctance to climb if a remora was attached. Remoras also use their vision to hunt for food, so its been suggested that they may prefer hitching a ride on a glider at night when they have nothing better to do.

The other interesting part was that the occurrence of slow nighttime upcasts appeared to vary in space and time. There was one eddy in particular that we saw the slow upcasts whenever we were in it. Another cycle we noticed followed the new moon. There were two new moons that RU17 started flying in a tight circle as if something had grabbed onto one side or the other. During one full moon it circled to the left, the other it circled to the right. It was suggested that bioluminescence was making the glider very visible during the

new moon, and the glowing glider was attracting squid. Assuming something was attached to the glider, we tried a new procedure to fly the glider backwards, pulling water in the nose to make it heavy but shifting the batteries all the way back so that it sank tail first.

Partnership

The flight of RU17 was conducted in the enduring spirit of the National Ocean Partnership Program. In effect, it launched an unfunded International Ocean Partnership Program that united a community within the U.S. and across the Atlantic. Having a glider deployed at sea motivated collaborations that may otherwise have taken years to develop. Path planning for RU17 required data and forecasts, and operational centers with existing products were eager to contribute to the success of the mission. The University of Maine provided a link to their satellite data when the Rutgers acquisition system went down and required repairs. A similar satellite receiving station in the Canaries provided local coverage on the European side. The NASA Ocean Color Web provided access to the global MODIS dataset for SST and Chlorophyll that filled the gap between the higher resolution direct broadcast data acquired on either side of the Atlantic. The Altimetry products generated by the University of Colorado, especially the geostrophic currents, were in constant use. Ocean model forecasts were provided by the Naval Oceanographic Command and by our partners in Spain. The NOAA National Hurricane Center and Oceanweather websites provided wind and wave forecasts. The international Argo program provided subsurface temperature and salinity profiles for ballasting and flight planning.

All the above datasets were combined in a Google Earth interface that was built by students and hardened by research programmers at Rutgers. The purpose was to overlay datasets and glider positions for mission planning and waypoint selection. Software was developed to go directly from the Google Earth mouse clicks to the glider waypoint files that sit in the glider's Dockserver mailbox waiting to be sent at the next surfacing. The Google Earth interface proved to be extremely popular with bloggers and pilots. It has already been transferred to other glider operators throughout the U.S. It was especially well received by the NAVO glider pilots at Stennis Space Center. They used the interface to mission plan for gliders deployed in two Navy Exercises, BALTOPS with NATO and RIMPAC in the Pacific. At the recent Integrated Ocean Observing System (IOOS) Mid Atlantic Coastal Ocean Observing Regional Association (MACOORA) annual meeting, the interface was one of three adopted by the data management team for implementation during year 2 of MACOORA's Mid Atlantic Regional Coastal Ocean Observing System (MARCOOS).

Training

As part of our IOOS Mid-Atlantic Regional Coastal Ocean Observing System (MARCOOS), we started glider flights that ran from state to state in the Mid-Atlantic. Regular gliders flights are now maintained between the U. Massachusetts-Dartmouth and Rutgers, and between Rutgers and U. Maryland / U. North Carolina. At the semi-annual MARCOOS meeting in the fall of 2007, it was determined that an advanced glider training course was required to maintain this network. Rutgers developed the Glider School 102 as a follow-on to the Webb Research Glider 101 course. It was first taught in the intersession before the start of the Spring 2008 semester so that all the undergraduates preparing for the upcoming test Flight to Halifax and the eventual flight across the Atlantic could take the course. They were joined by our IOOS partners, a few glider pilots from NAVO, and some glider operators from Plymouth, England. One of the

undergraduates from the U. Maryland that participated in the course later applied for a NSF RIOS summer internship and ended up spending the summer with us flying RU17.

Interest in the Glider Training 102 course also expanded with the Flight to Halifax and the subsequent flight of RU17. The course was given twice more, once in the spring and again in the summer, as training for additional NAVO glider pilots. During the class, the NAVO pilots started using the same Google Earth interface to fly RU01 in the Baltic that we were using to fly RU17 in the Atlantic. With our growing connections in Europe, we were invited by the European Glider Organization (EGO) to join them in a European Glider School conducted in Italy at the NATO facility in the fall.

With the rapid expansion of glider operations in the U.S., Europe and Australia, the community is going to need more people training in the operation, maintenance and use of gliders for ocean research and operations. Last year two seniors graduated from our lab. One went to work in the Caymans on NOAA projects. The other went to Georgia Tech to work with a young faculty advisor starting a new glider lab. On their last visit, NAVO posted job advertisements in the lab. They are developing a significant glider capability, and they will be needing new people. They are especially interested in the students that graduate from our lab, and are willing to pay for their Masters degrees if they head down to NAVO after they finish the undergraduate program at Rutgers.

Technology

RU17 served as a test case for three major changes on the Standard Slocum Glider. Any of these changes could be tested with dedicated flights in our Mid-Atlantic testbed. With RU17 we were able to leverage the tests into one long-duration mission.

This was the longest duration test to date of the new Digifin developed as part of the glider hardening work for ONR. The earlier style fins were more susceptible to damage. The Digifin design is more compact and strong enough to be grabbed without breaking. It performed well the entire trip, continuing to call in even during the highest seas, and remained tunable throughout the mission as flight characteristics changed.

The Lithium Batteries were tested for a NOAA NOPP project to install a kinetic Fluorescence, Induction and Relaxation (FIRe) sensor on a glider. For the techno-folks, the FIRe sensor measures the quantum yield of stable charge separation at photo system II. For the rest of us, this provides an extremely sensitive proxy for phytoplankton physiological status. In other words, are the forests of the sea healthy. Light sources used by the FIRe sensor require a lot more power than most sensors, so Lithium batteries are strong option for envisioned long-term deployments of the FIRe.

The extended payload bay was tested for future deployments at the NSF LTER located on the Antarctic Peninsula. The distance between the U.S. station in Palmer and the British station in Rothera is to far for a standard glider on Alkaline Batteries. Lithiums are difficult to ship and don't like the cold. Using the space inside the extended payload bay for additional Alkaline batteries, it is now theoretically possible to cover the full distance between Palmer and Rothera with a single deployment. The flight of RU17 demonstrates that the extended payload bay is a viable option when longer duration missions are required.

In the process of conducting this mission, engineering observations were continuously

shared with Webb Research, the designer and manufacturer of Slocum gliders. This feedback helped Webb identify and prioritize software and hardware upgrades that impact all gliders. Specific examples include positive control of the buoyancy pump when a downward inflection is initiated at depth (this prevents the high water pressure from generating heat by pushing the pump in faster than intended), additional energy savings modes and a range of new gain values for the control of the Digifin, the ability to cross UTM navigation zones without restarting a mission, the design of new wing rails for attaching the wings to extended payload bays, etc, etc. This feedback loop is how we have operated with Webb Research as a NOPP partnership initiated in 1998. Electrochem, the manufacturer of the Lithium Batteries, has now joined this partnership.

Public Outreach

Our students serve as ambassadors for Rutgers and for ocean science and technology. They brought gliders to high schools around the state and explained how young students at Rutgers can get involved. They flew the gliders in the pond on campus during the public Agricultural Field Day, attracting news media coverage. The Flight to Halifax attracted coverage in the U.S. and Canada, and the midway point in the flight across the pond produced an Associated Press article that was printed in hundreds of newspapers around the world. Chip and I were at the RIMPAC exercise in Hawaii, walking a glider down the public dock to a deployment vessel. We were surprised that everyone knew what it was, commenting how it looked just like the one that was trying to cross the Atlantic. In another example, we were at the Liberty Science Center, teaching a class in their Delta Lab, a lab set up to look like the Rutgers COOLroom. The middle school students we met that day told us Rutgers was famous for football, basketball and gliders.

Conclusion

This was a risky mission. Everyone knew that. We also knew that we would learn a lot more by trying than by staying at home.

We tried once. We learned a lot. We'll try again in the Spring.

1 Comment