

High Frequency Radar

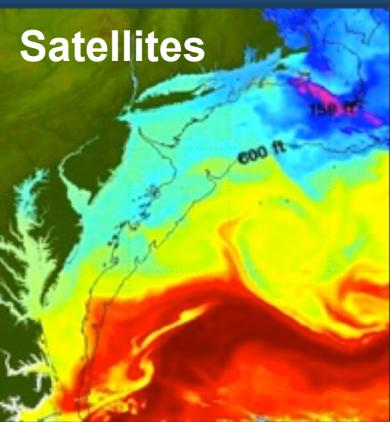
Hugh Roarty

7th Session of the JCOMM Observations Coordination Group

April 5, 2016

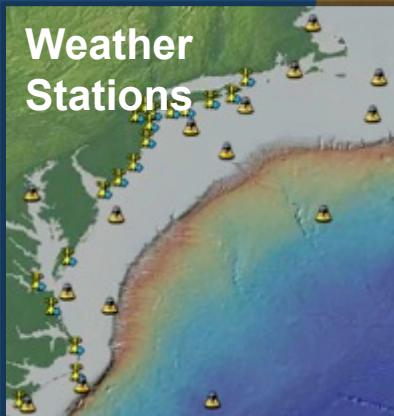
Mallorca, Spain

The logo for the Global Earth Observation System of Systems (GEO), featuring the letters "GEO" in a large, stylized, blue and green font.



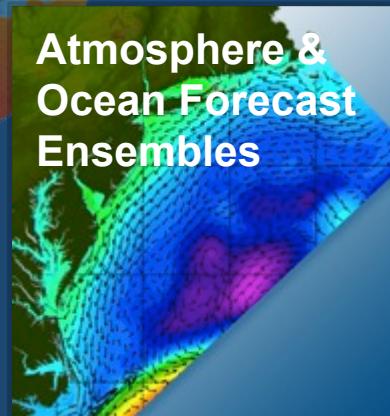
Population Density

To seek, discover & apply
new knowledge &
understanding
of our coastal ocean



MARACOOS
Ocean Information for a Changing World

Atmosphere &
Ocean Forecast
Ensembles



Rutgers University - Coastal Ocean Observation Lab 1992 - 2014

Center for Ocean Observing Leadership 2014 -



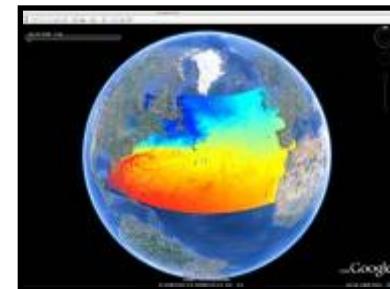
CODAR Network



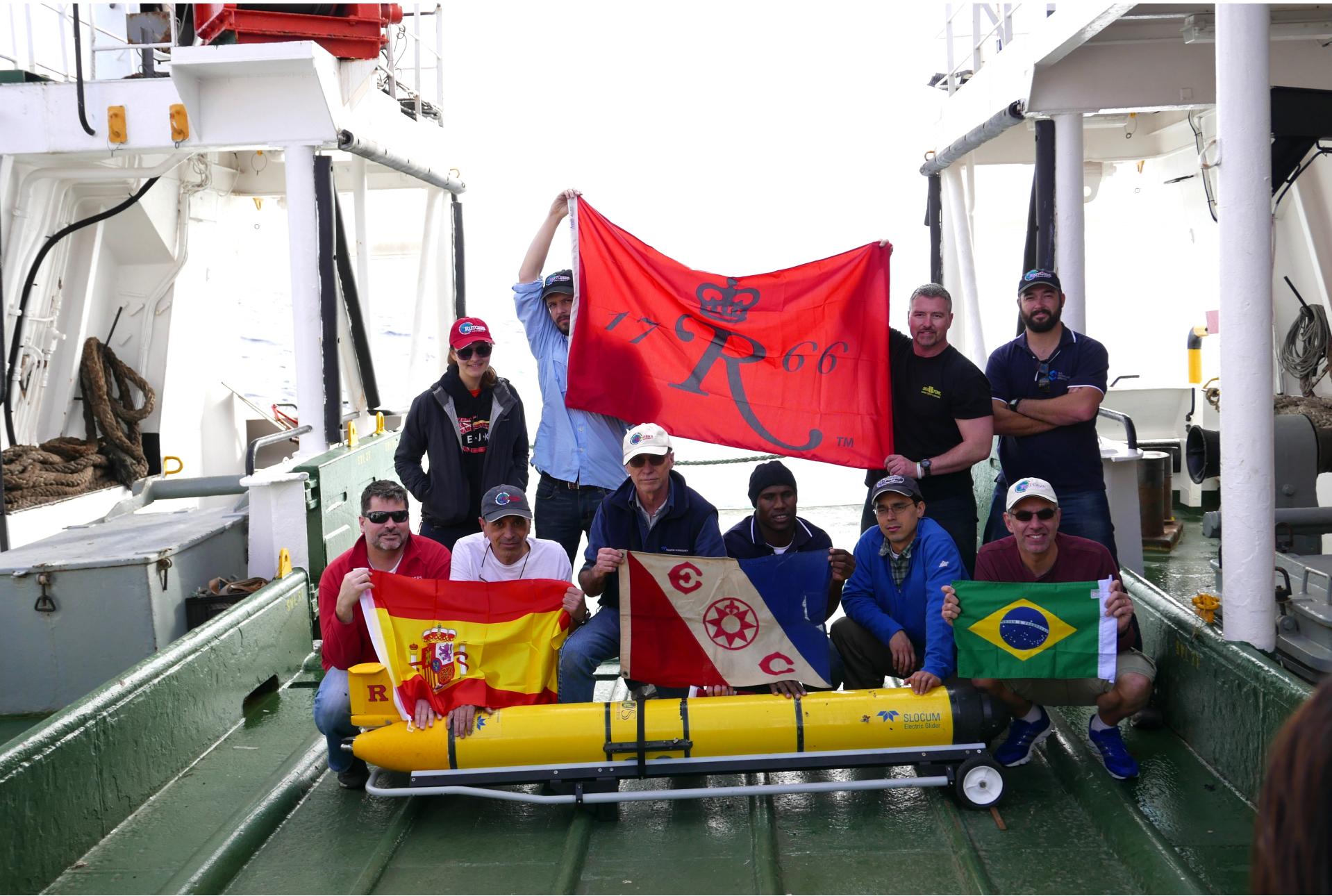
L-Band & X-Band Satellite
Receivers



Glider Fleet



3-D Nowcasts
& Forecasts



United Nations
Educational, Scientific and
Cultural Organization



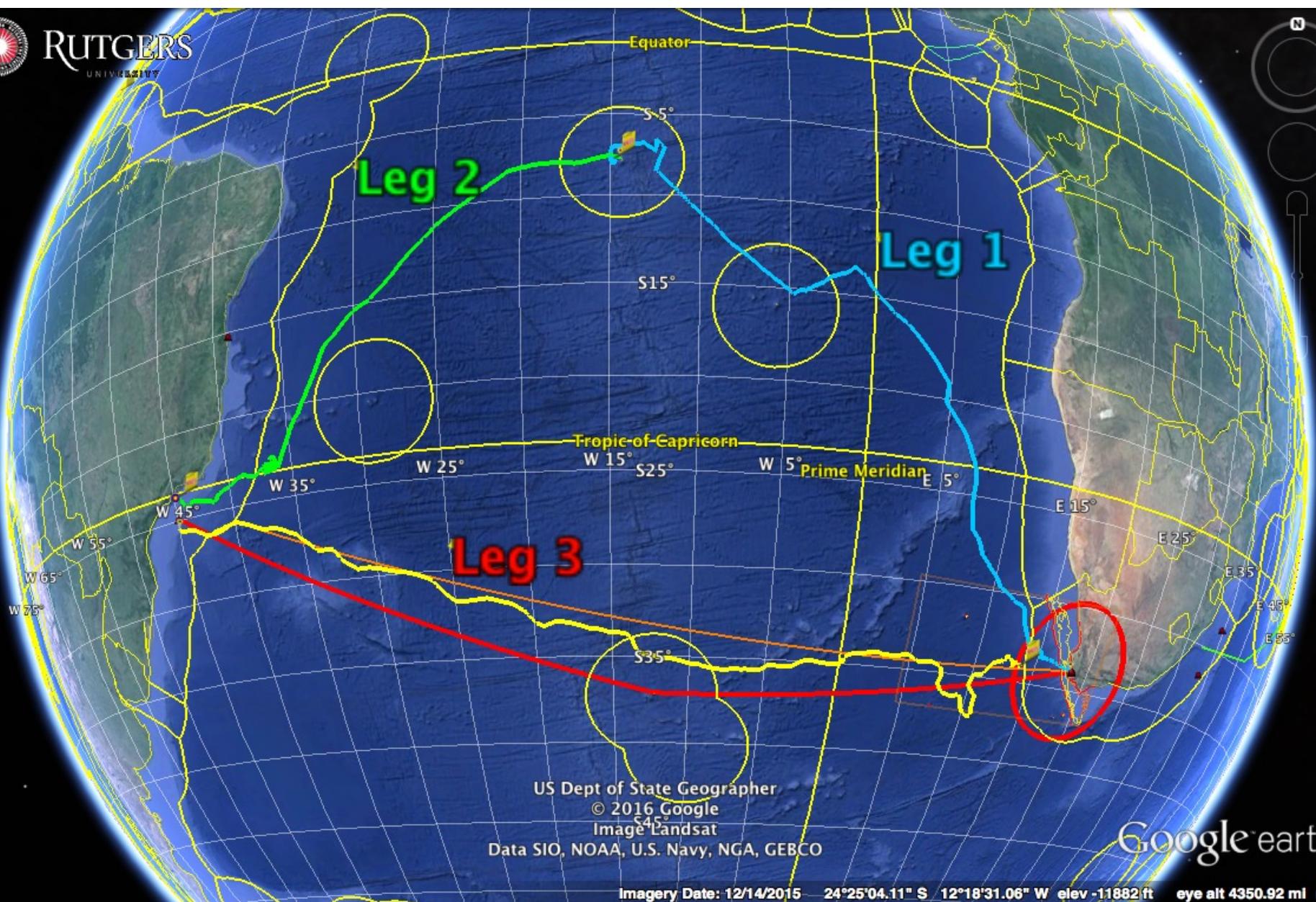
Intergovernmental
Oceanographic
Commission

RUTGERS
THE STATE UNIVERSITY
OF NEW JERSEY



RUTGERS
UNIVERSITY

N



United Nations
Educational, Scientific
and Cultural Organization



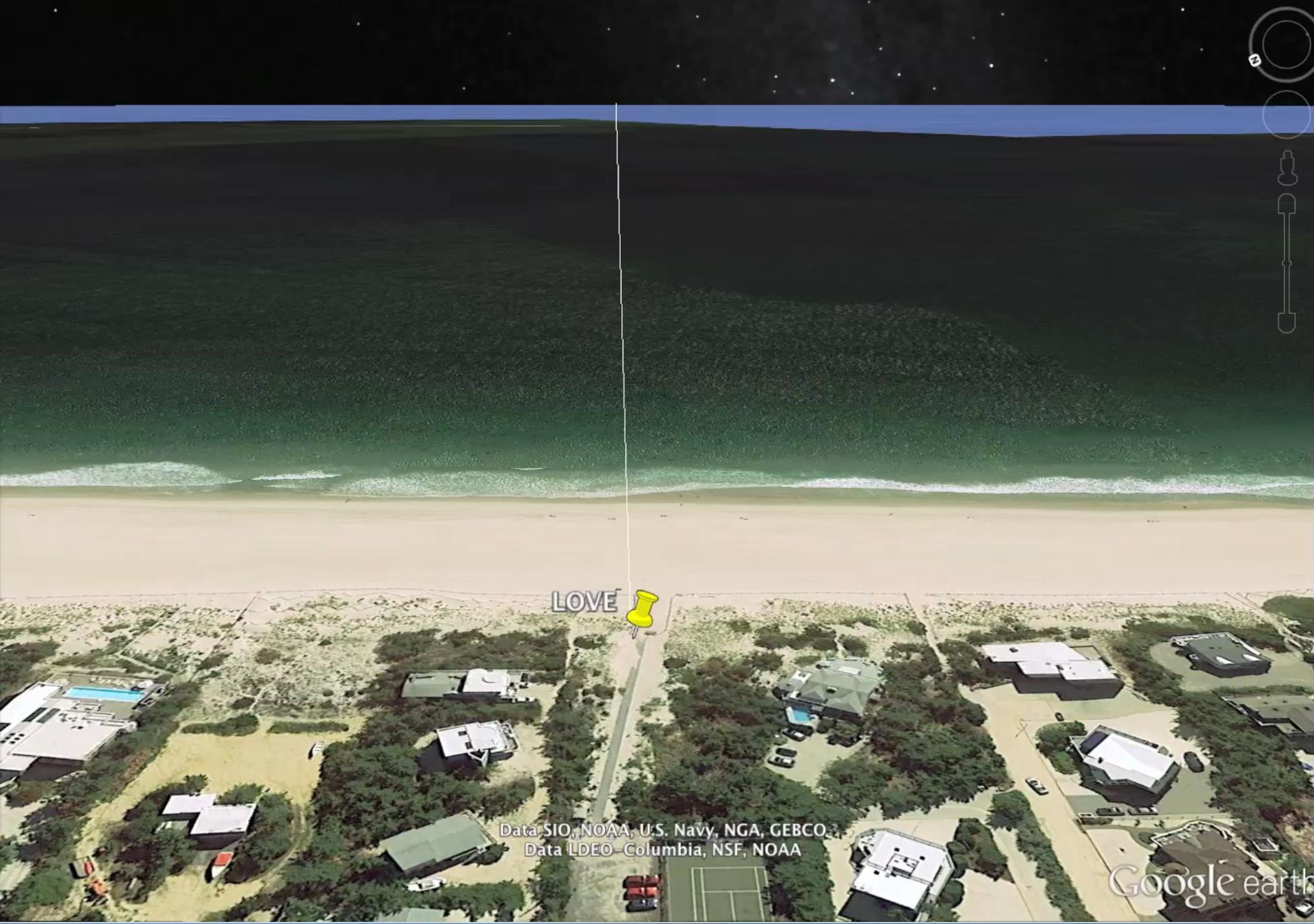
Intergovernmental
Oceanographic
Commission

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Talk Outline

- Introduction to High Frequency Radar
- GEO Global HF Radar Network
- Applications

INTRODUCTION TO HIGH FREQUENCY RADAR



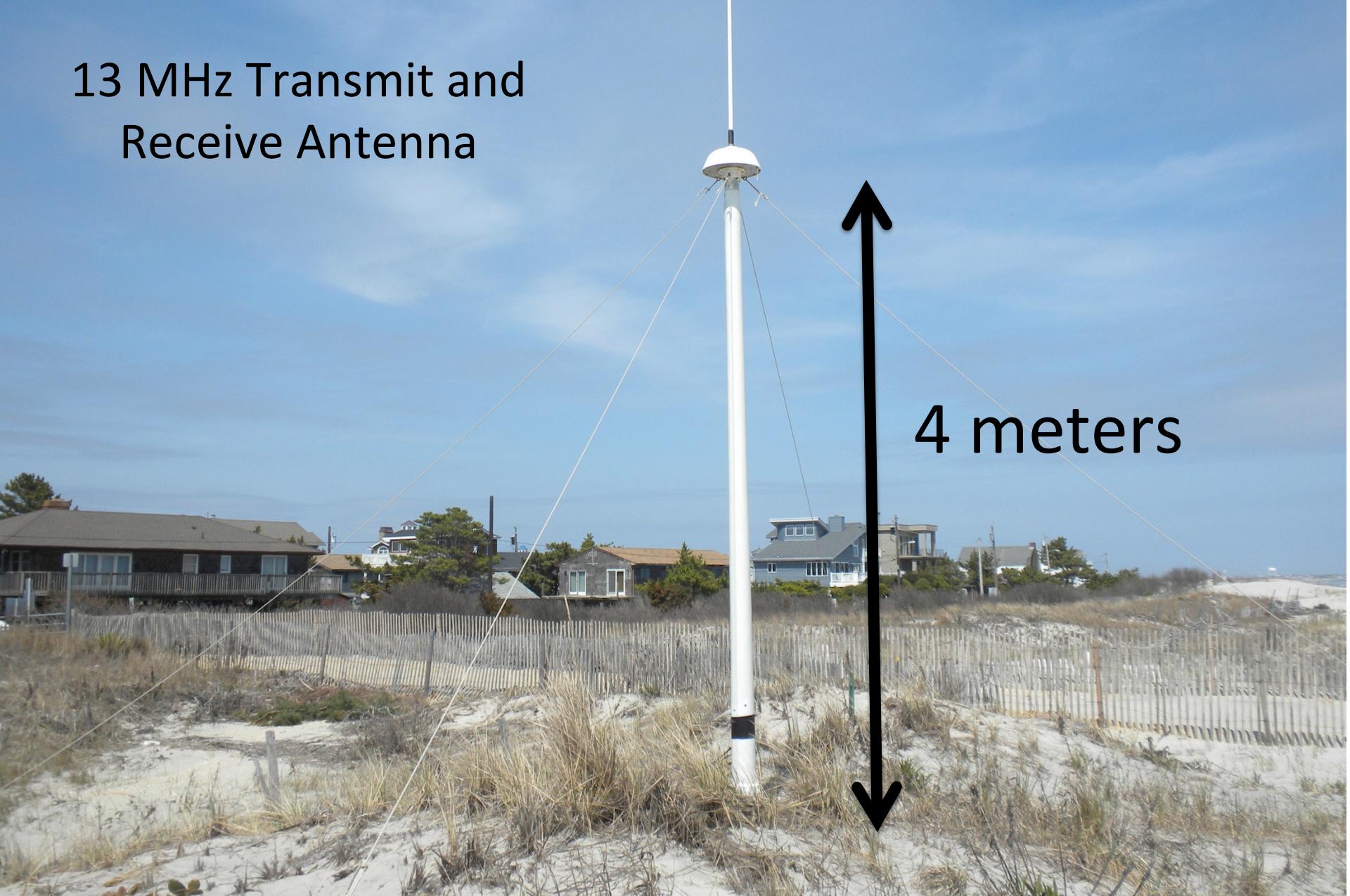
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data LDEO-Columbia, NSF, NOAA



MARACOOS

Ocean Information for a Changing World

13 MHz Transmit and Receive Antenna

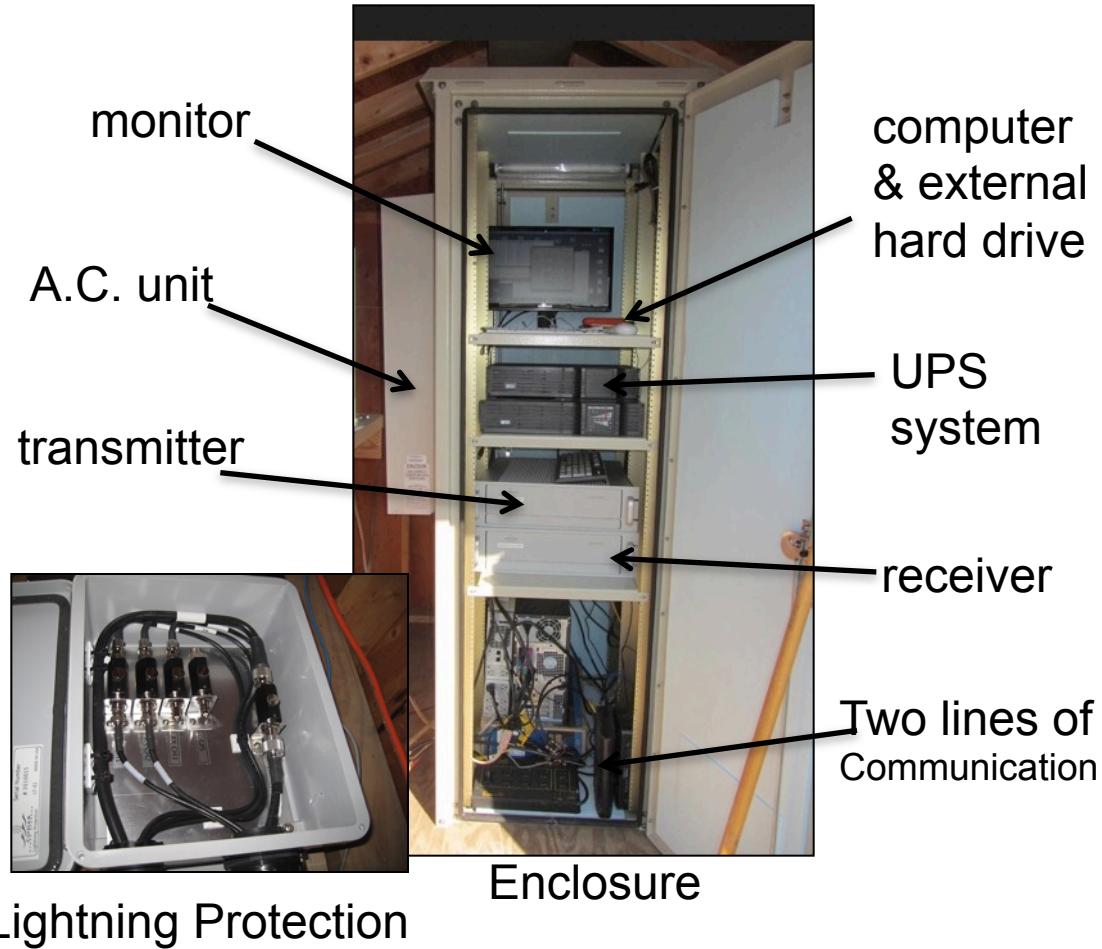


Standard HF Radar Shore Site:

Shed, Enclosure, Tx/Rx, Comms, Power, GPS, AIS



Shed

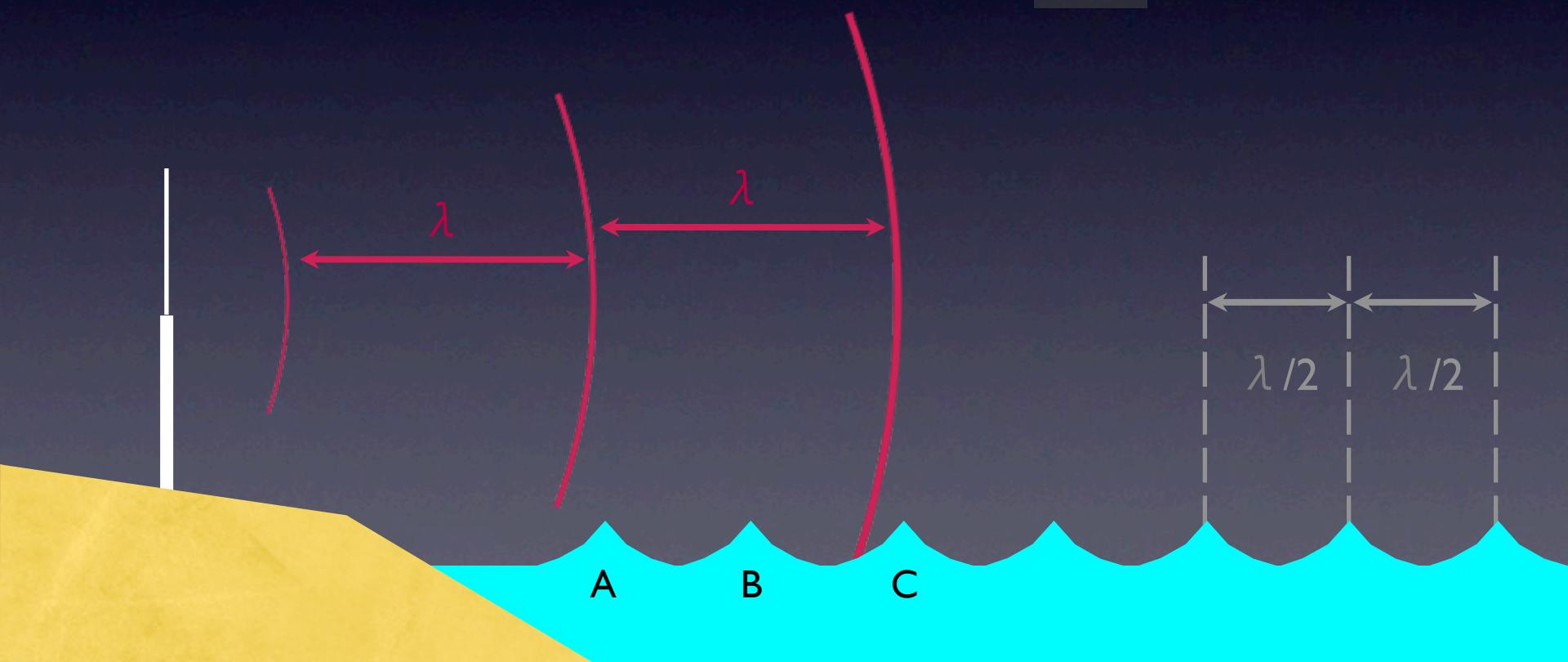


Lightning Protection

Enclosure

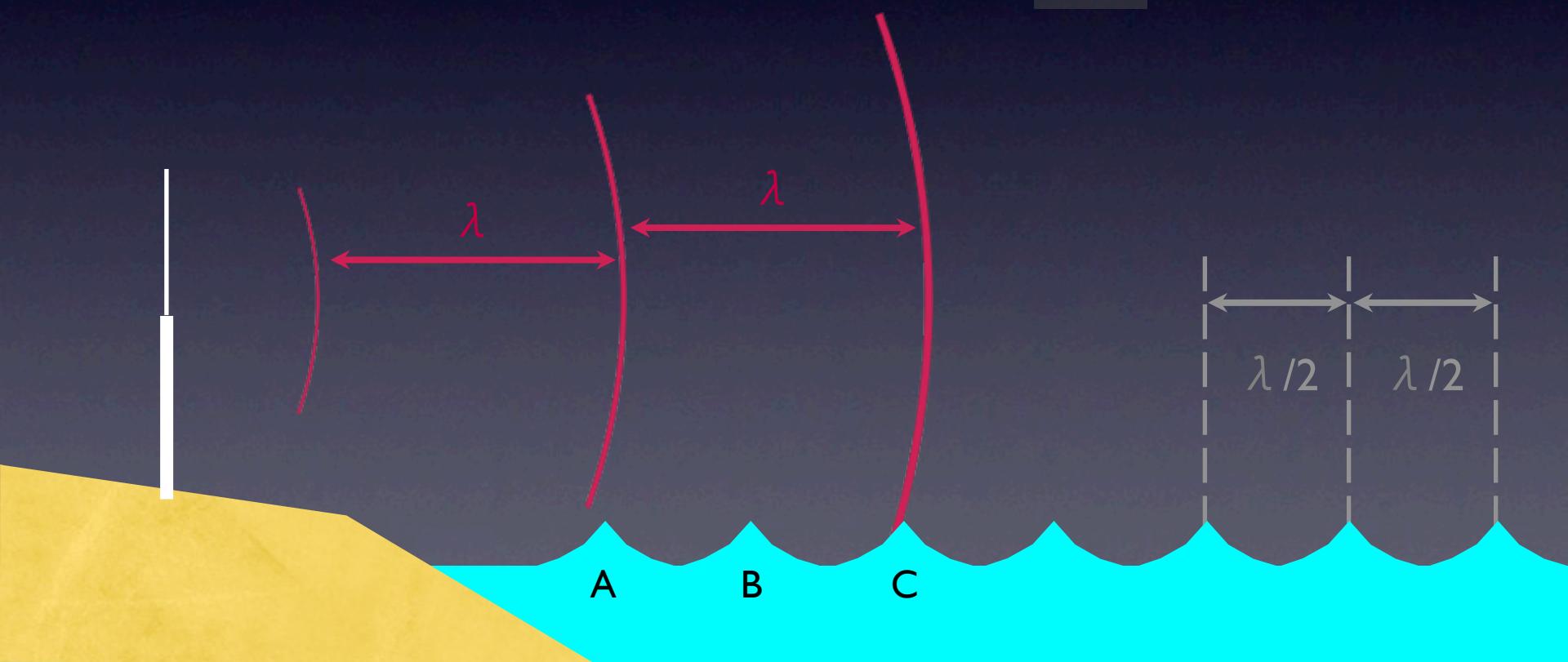
Bragg Sea Echo

Freq MHz	λ meters	$\lambda / 2$ meters	T seconds
5	60	30.0	4.4
13	23	11.5	2.7
25	12	6.0	2.0
42	7	3.6	1.5



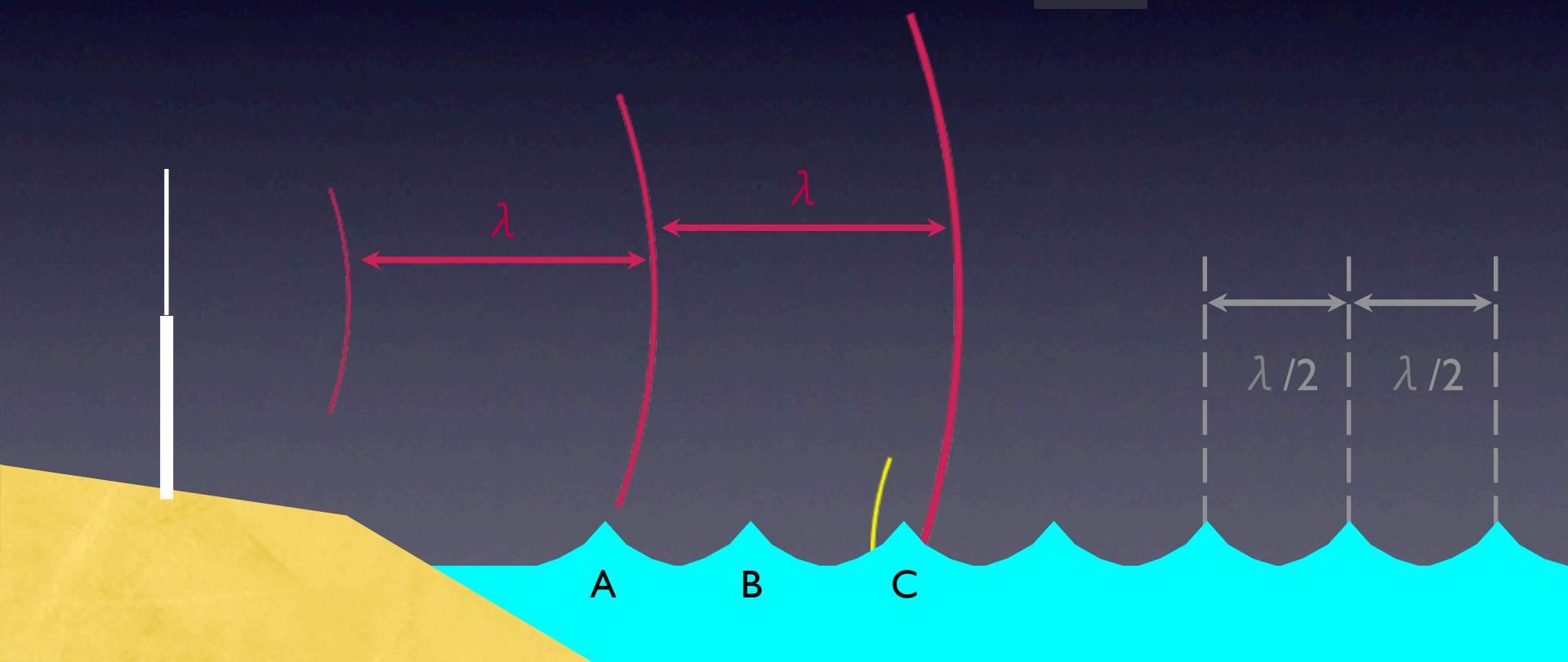
Bragg Sea Echo

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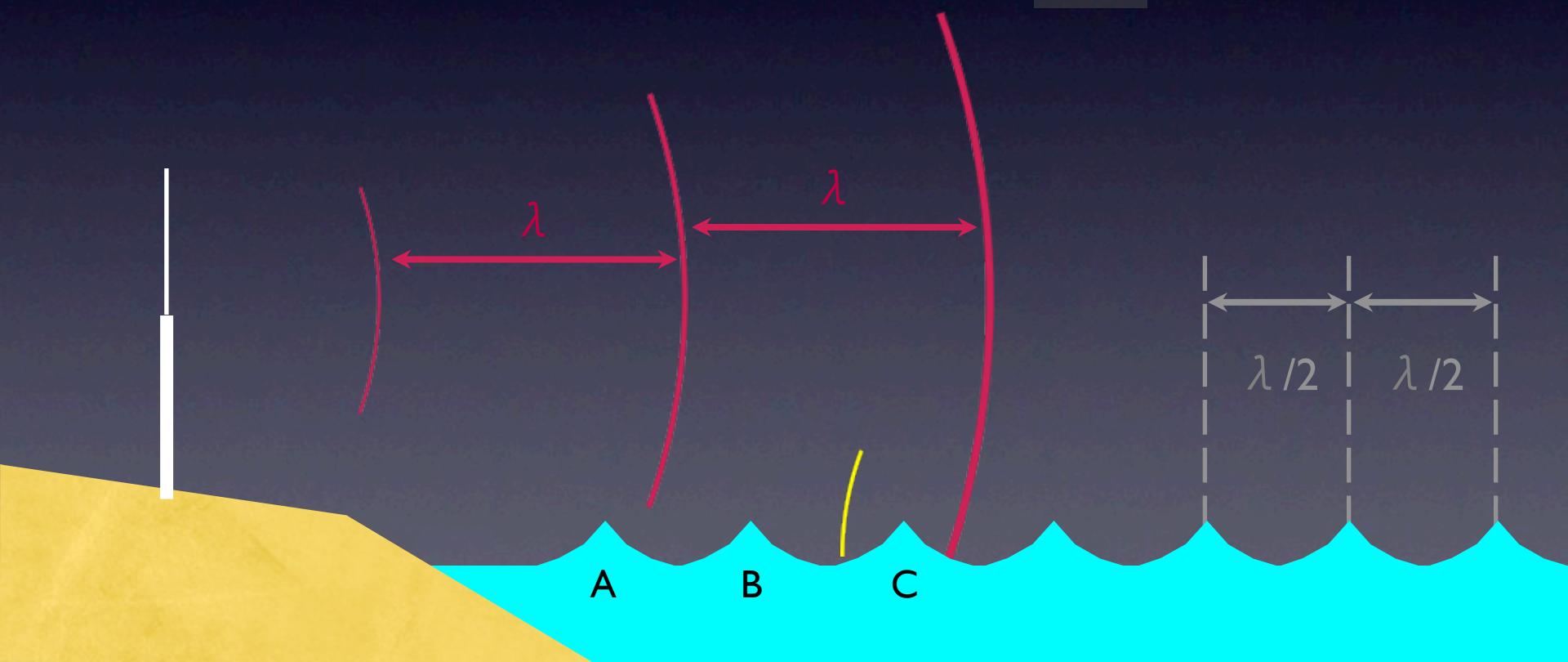
Bragg Sea Echo

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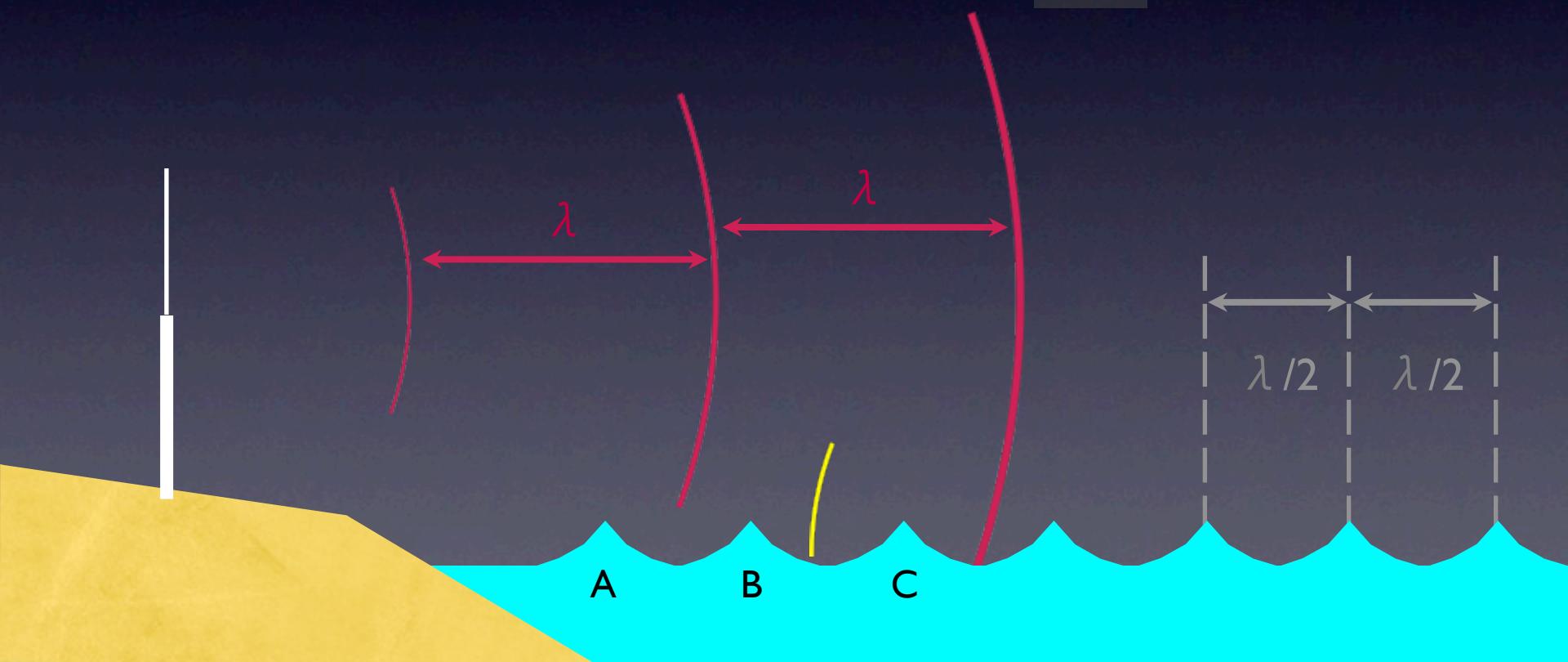
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Bragg Sea Echo



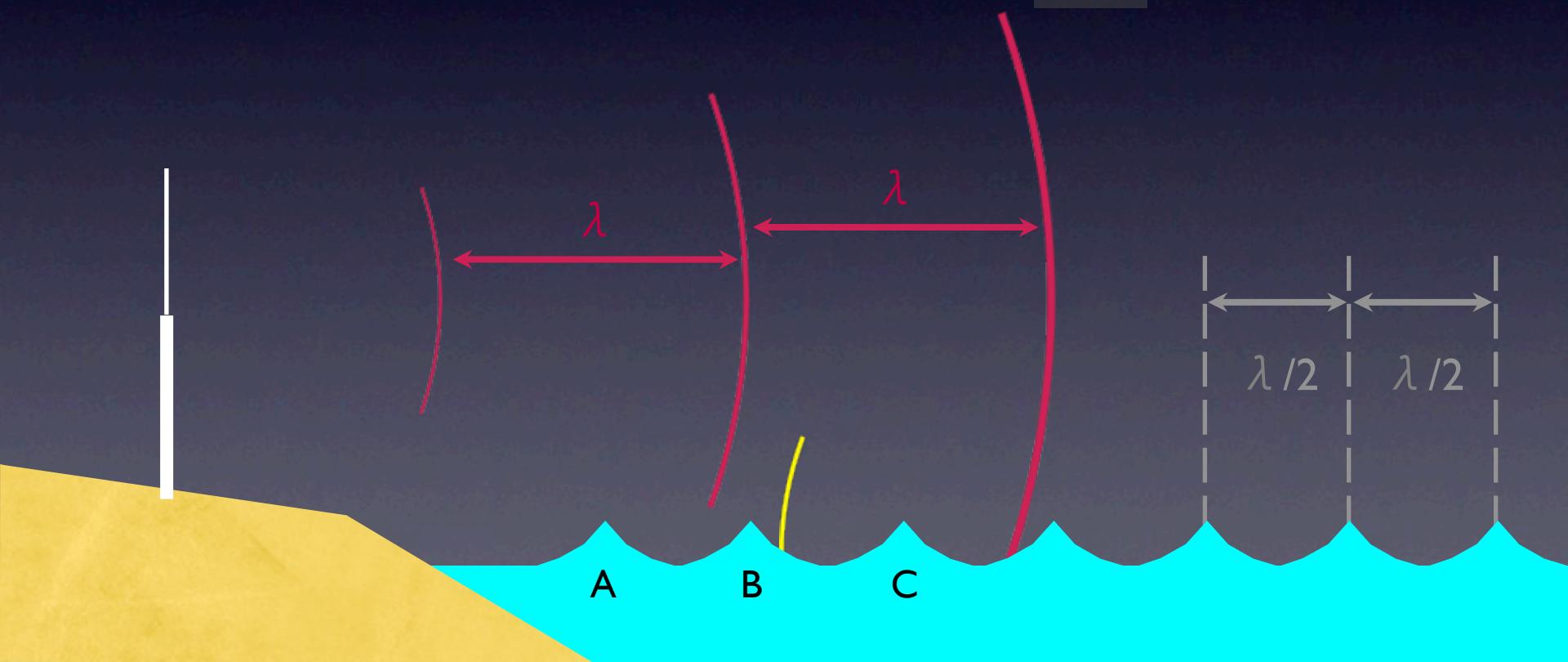
Bragg Sea Echo

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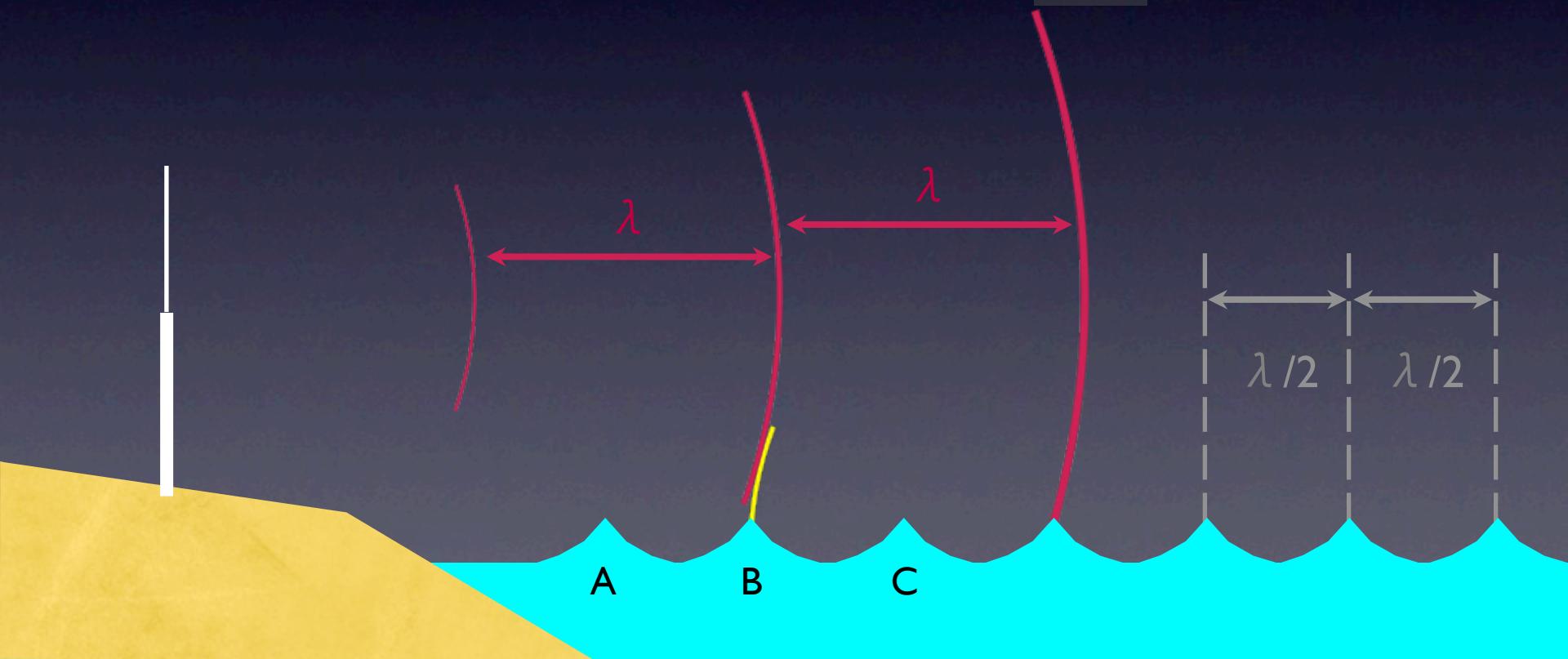
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Bragg Sea Echo



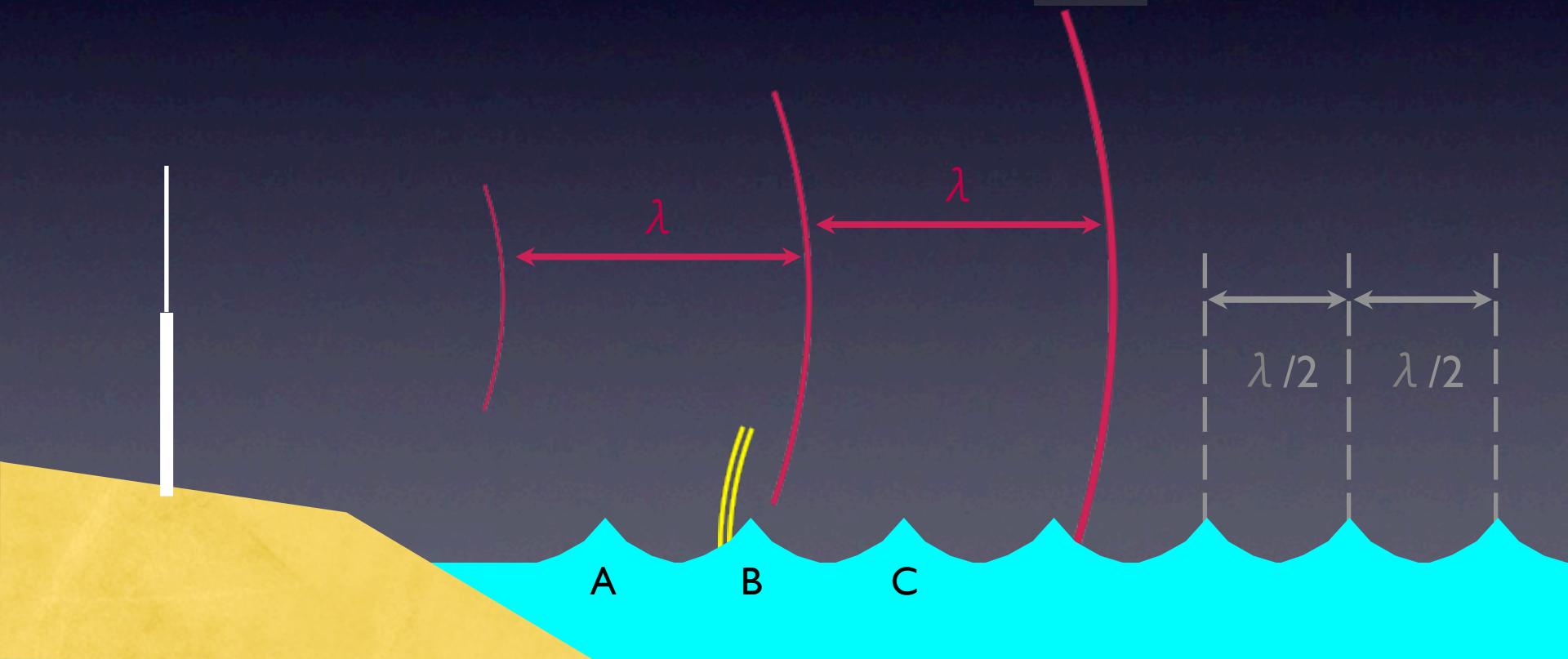
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Bragg Sea Echo

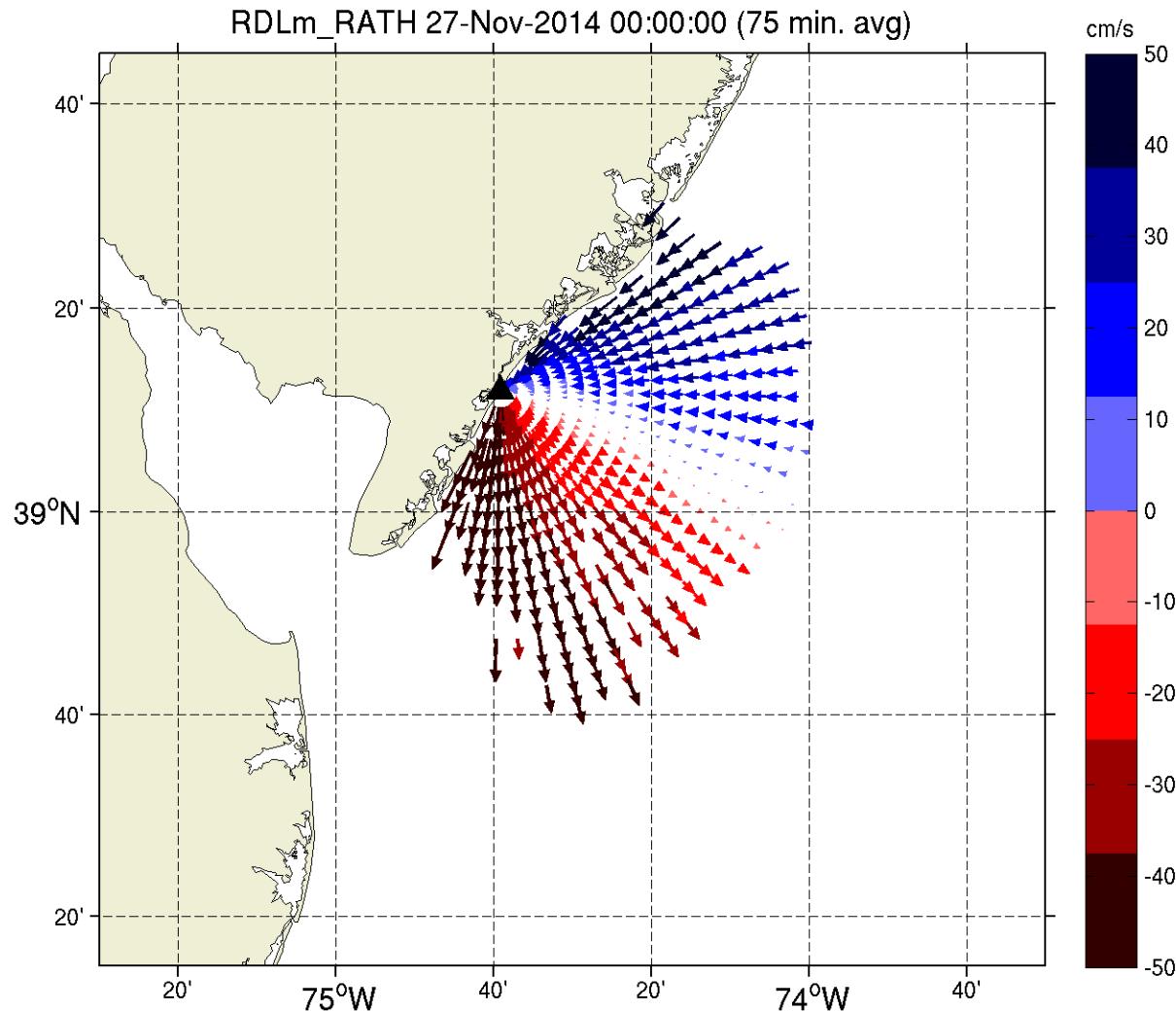


Bragg Sea Echo

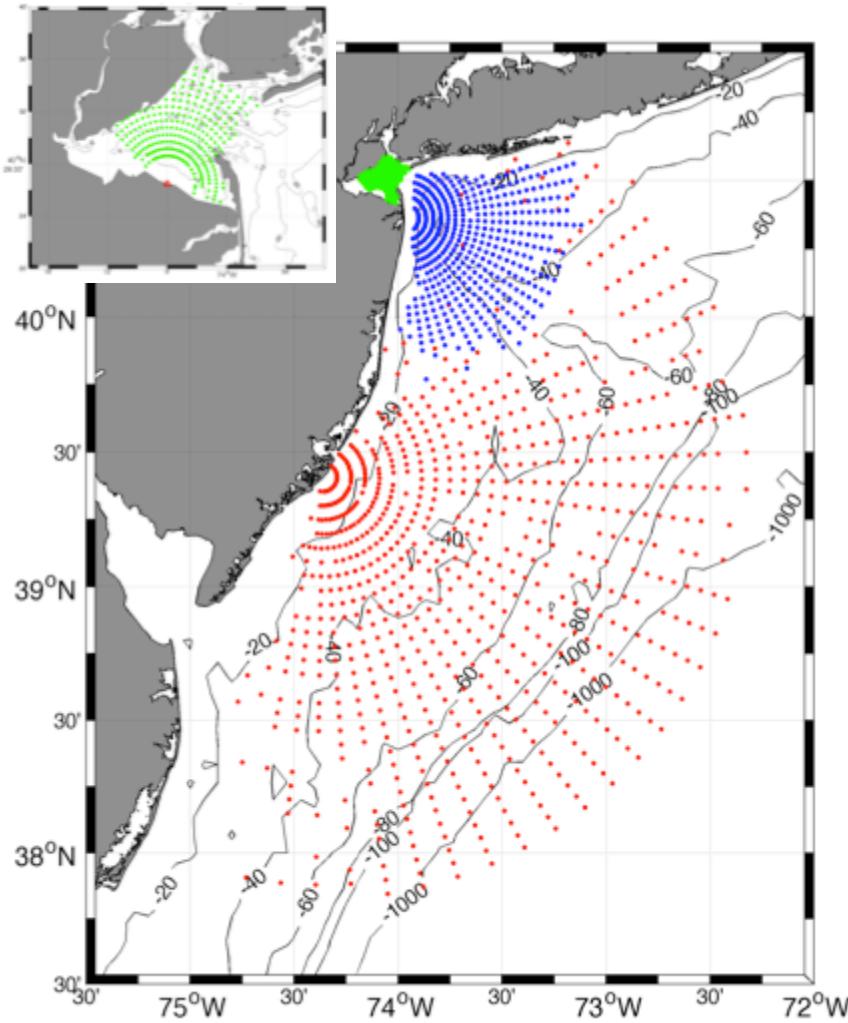
Freq MHz	λ meters	$\lambda / 2$ meters	T seconds
5	60	30.0	4.4
13	23	11.5	2.7
25	12	6.0	2.0
42	7	3.6	1.5



Radial Map of Currents



Surface Current Mapping Capability



25 MHz

Radar λ : 12 m Ocean λ : 6 m
Range: 30 km Resolution: 1 km

13 MHz

Radar λ : 23 m Ocean λ : 12 m
Range: 80 km Resolution: 3 km

05 MHz

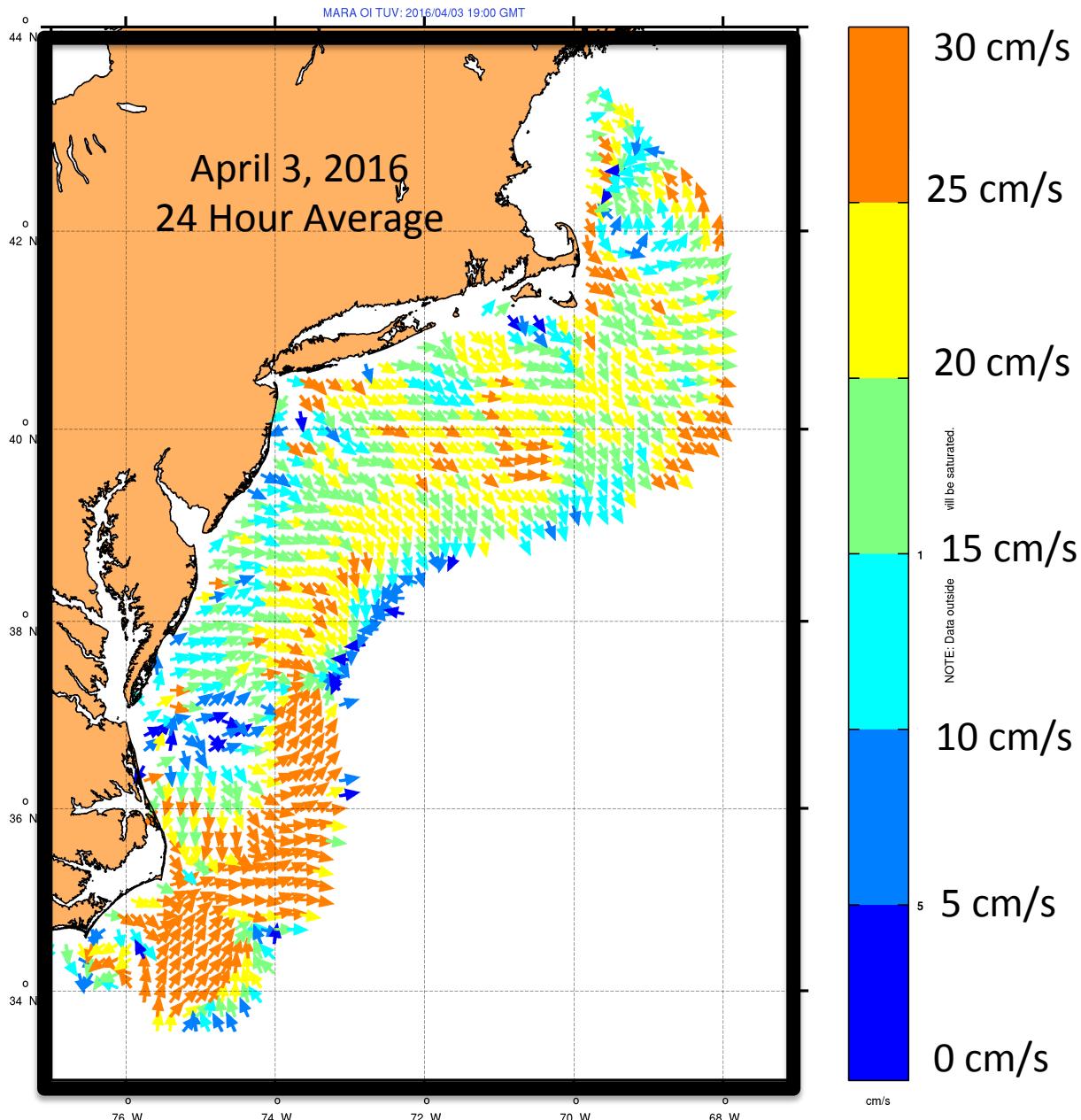
Radar λ : 60m Ocean λ : 30 m
Range: 180 km Resolution: 6 km

17 Sites

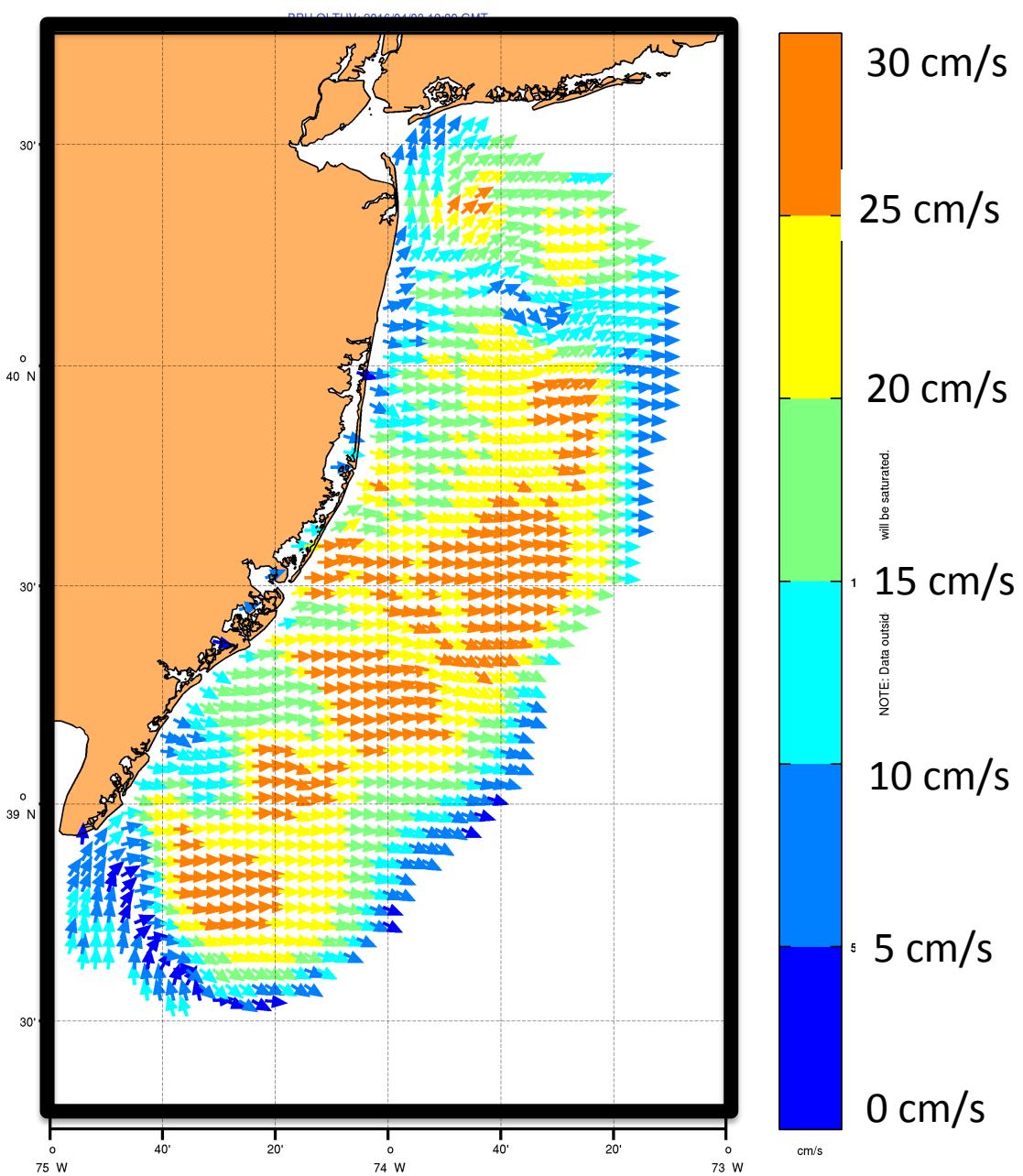
5 MHz

1000 km
coastline

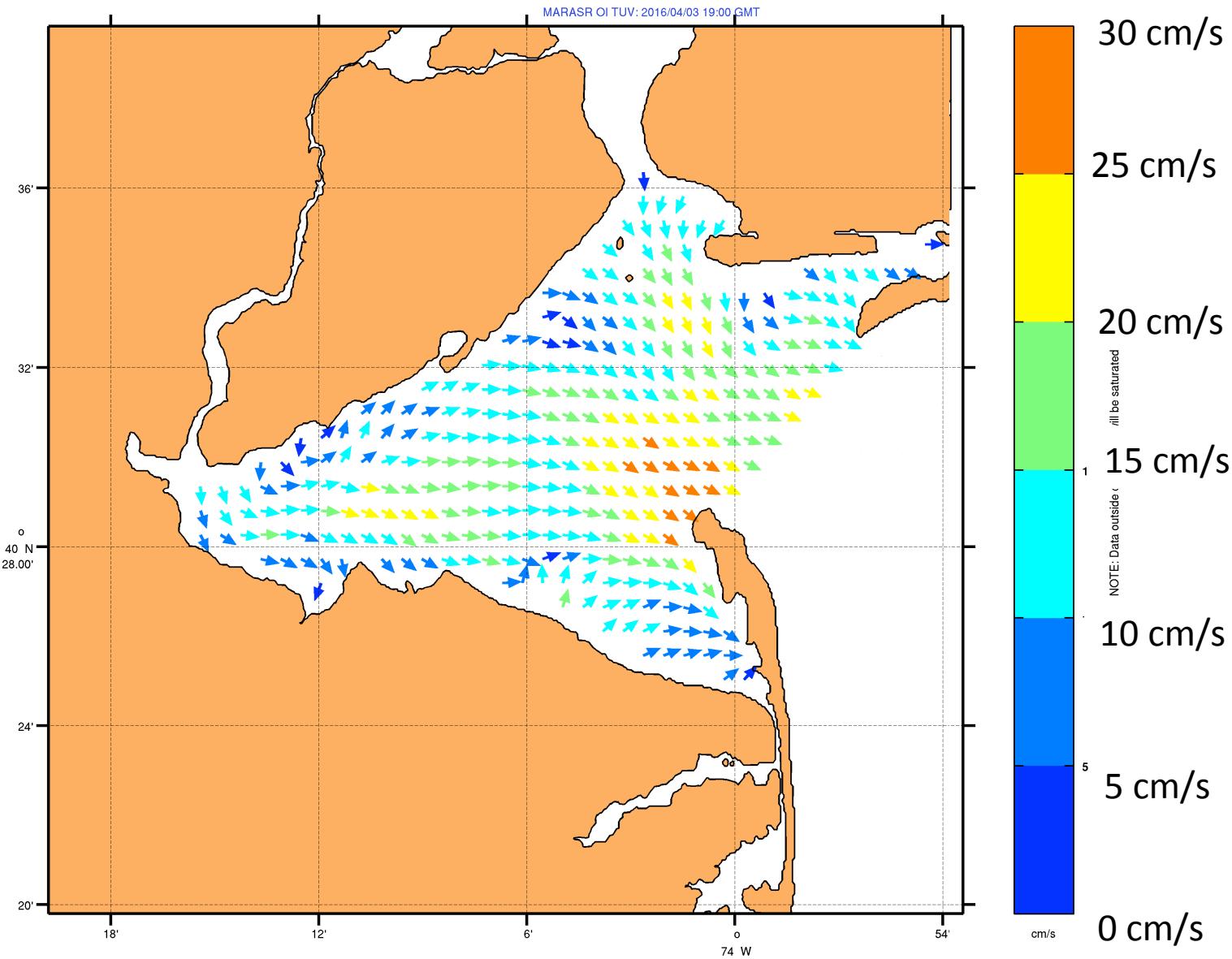
6 Km Spatial
Resolution



7 Sites
13 MHz
200 km
coastline
2 Km Spatial
Resolution



3 Sites
25 MHz
40 km
coastline
1 Km Spatial
Resolution



GEO GLOBAL HF RADAR NETWORK

Previous Meetings



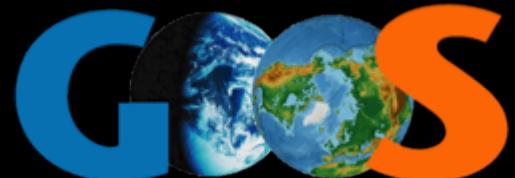
- England 2012
- Norway 2013
- Taiwan 2014
- Greece 2015



Fourth Meeting of the Global High Frequency Radar Network



September 22-23, 2015
Heraklion, Crete, Greece



Goals for Global HF Radar Network

- 1) Increase the number of coastal radars**
- 2) Ensure HFR data is available in a single standardized format in near-real-time,**
- 3) Assimilate data into ocean and ecosystem models**
- 4) A set of easy to use standard products**
- 5) Worldwide Quality Standards**
- 6) Develop emerging uses of HF radar**

Role of Global Network



ROW





 earthzine.org

<http://earthzine.org/2014/10/30/the-global-high-frequency-radar-network/>

The Global High Frequency Radar Network

Amanda
Lewan

By Dr. Hugh Roarty
Research Project Manager
Coastal Ocean Observation Laboratory
Rutgers University

Co-authors: Ms. Lisa Hazard, Dr. Lucy Wyatt, Dr. Jack Harlan and Dr. Enrique Alvarez Fanjul

The Global High Frequency Radar Network is a vision for a global operational system measuring ocean surface currents to support monitoring of marine and coastal ecosystems. The measurement of ocean currents is fundamental to ocean forecasting. High frequency (HF) radar has proven to be an efficient tool for the measurement of surface currents along the coast out to 200 kilometers.

GEO HF Radar Portal

Global HF Radar Network

9/20/15, 2:06 PM



Established at the GEO-VII Plenary in Istanbul, Turkey; the Global High Frequency Radar Network is a vision for a global operational system measuring ocean surface currents to support monitoring of marine and coastal ecosystems.



Home (index.html) References/Reports (references.html) IOOS GEO HF Radar Activities (activities.html) Network Members (members.html)
Contacts (contacts.html) Meetings (meetings.html)

Interactive Map of High Frequency Radar

This map shows all of the locations of the HF Radar sites all over the world.

<-1 Day -1 Hour 2015-09-19 23:00:00 +0:00 +1 Hour +1 Day [Bookmark View](#)

Control Panel UTC: 2015-09-20 18:06:40 Local: 2015-09-20 14:06:40

Participants

- Australia
 - ACORIN
- Canada
 - OCEAN NETWORKS
- Mexico
 - OCOMEX
- South Korea
 - KIOA
- Spain
 - ESTACIONES DEL ESTILO
 - SOCIB
- United States
 - IOOS

* Click a check box to view



Report a map error [Google](#)

For the full interactive map, click here (<http://cordic.ucsd.edu/projects/mapping/global/fullpage.php>)

Goals

Network Goals

- To increase the numbers of coastal radars.
- To ensure that HF radar data is available in a single, standardized format.
- To make/use a set of easy-to-use, standardized products.
- To assimilate the data into ocean and ecosystem modelling.
- To develop emerging uses of HF radar.

An International Effort

The Global HF Radar Network is a new international network of the combined efforts of research institutions, governments and companies to create a global system of measuring surface currents.

IOOS GEO HF Radar Activities (<http://www.ioos.noaa.gov/globalhfr/welcome>)

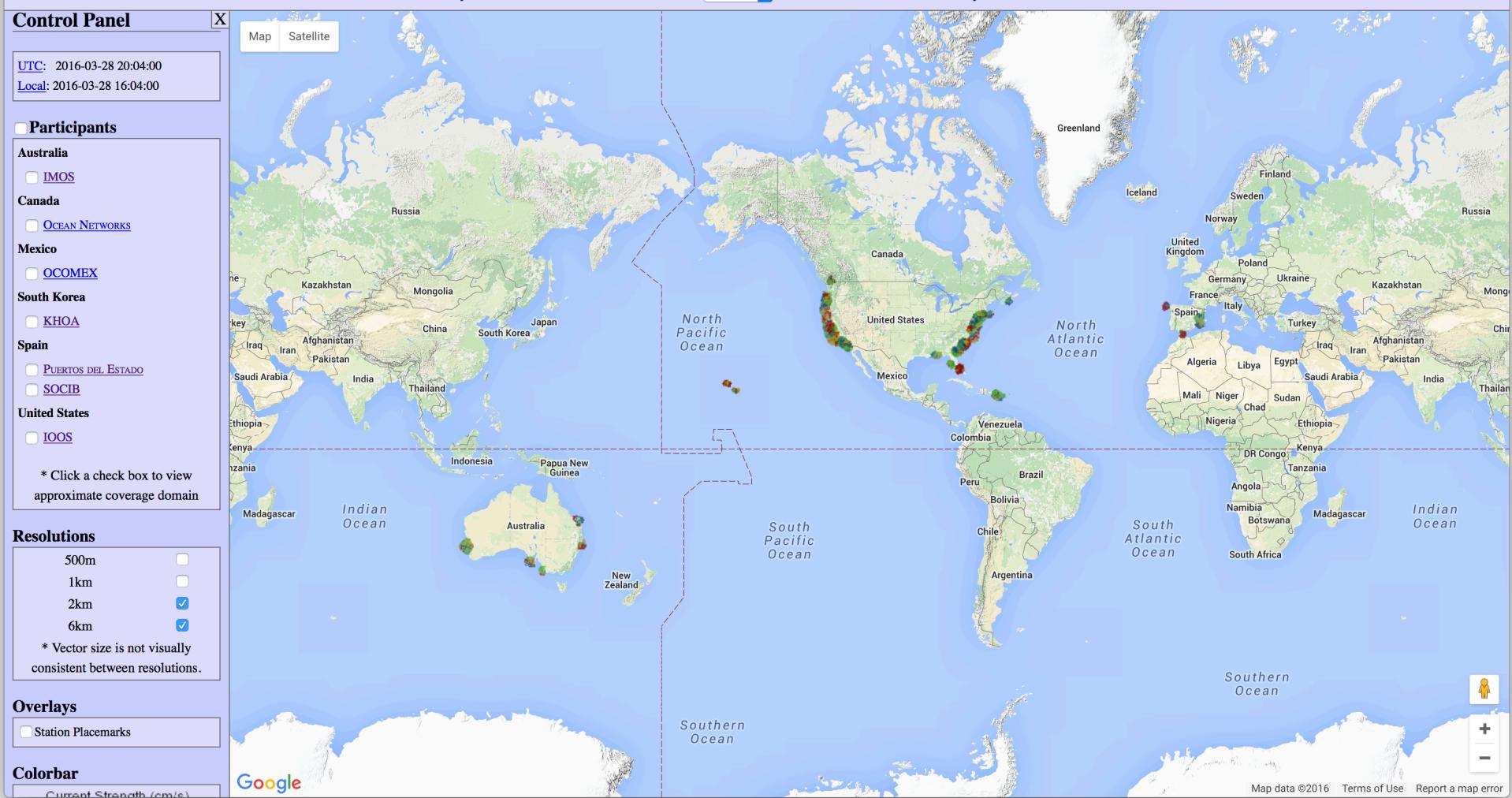
Global HF Radar (as of May 2014):
Co-Chairs:

- Hugh Roarty, HF Radar Project Manager, hroarty@marine.rutgers.edu (<mailto:hroarty@marine.rutgers.edu>)

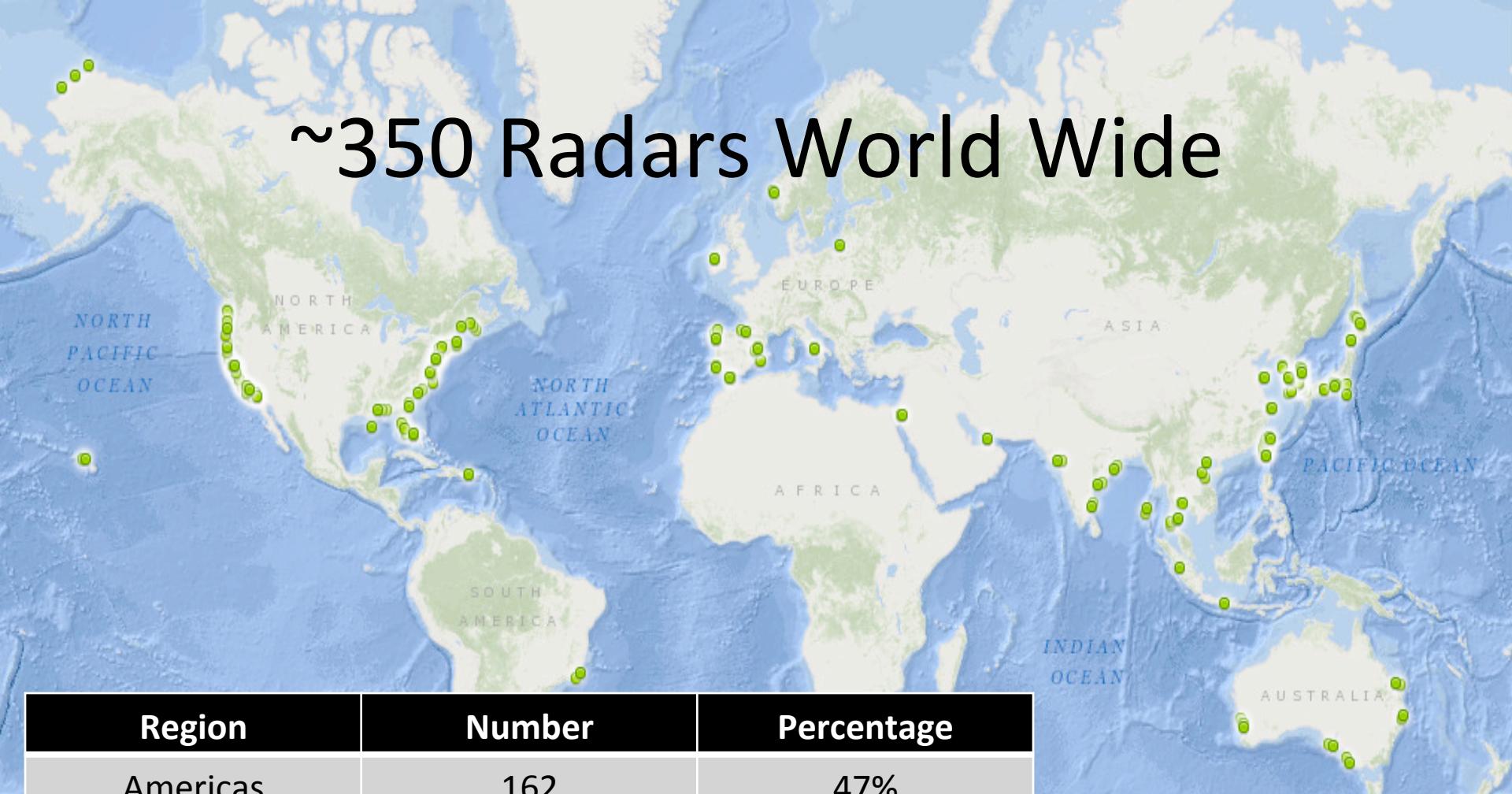
Global HF Radar Viewer

« -1 Day -1 Hour 2016-03-28 01:00:00 -04:00 from UTC +1 Hour +1 Day »

[Bookmark View](#)



~350 Radars World Wide



Region	Number	Percentage
Americas	162	47%
Europe	54	16%
Middle East	7	2%
Asia	122	35%



HF Radar

Task Team



EuroGOOS

European Global Ocean
Observing System



Global Inventory

349

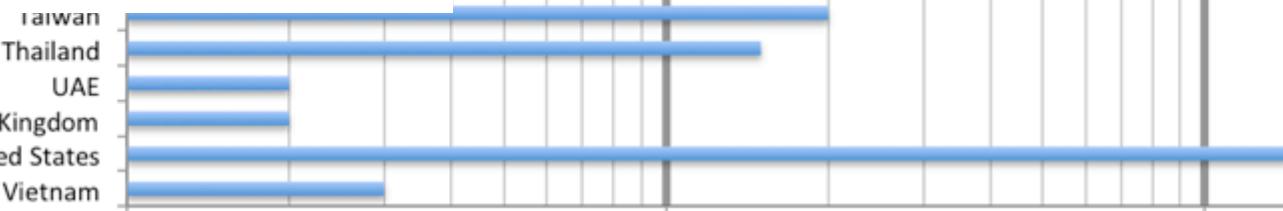
381



Morocco



Philippines



APPLICATIONS

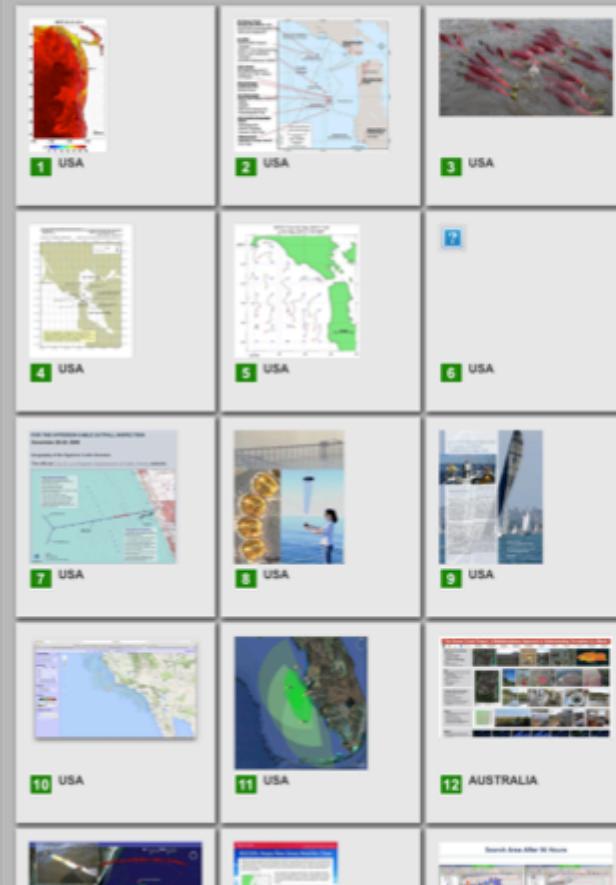


Application Success Stories

GEO Global High Frequency Radar Network

This map showcases the different applications of High Frequency radar measurements.

A story map   



Esri, GEBCO, DeLorme | Esri, GEBCO, IHO-IOC GEBCO, NGS

POWERED BY

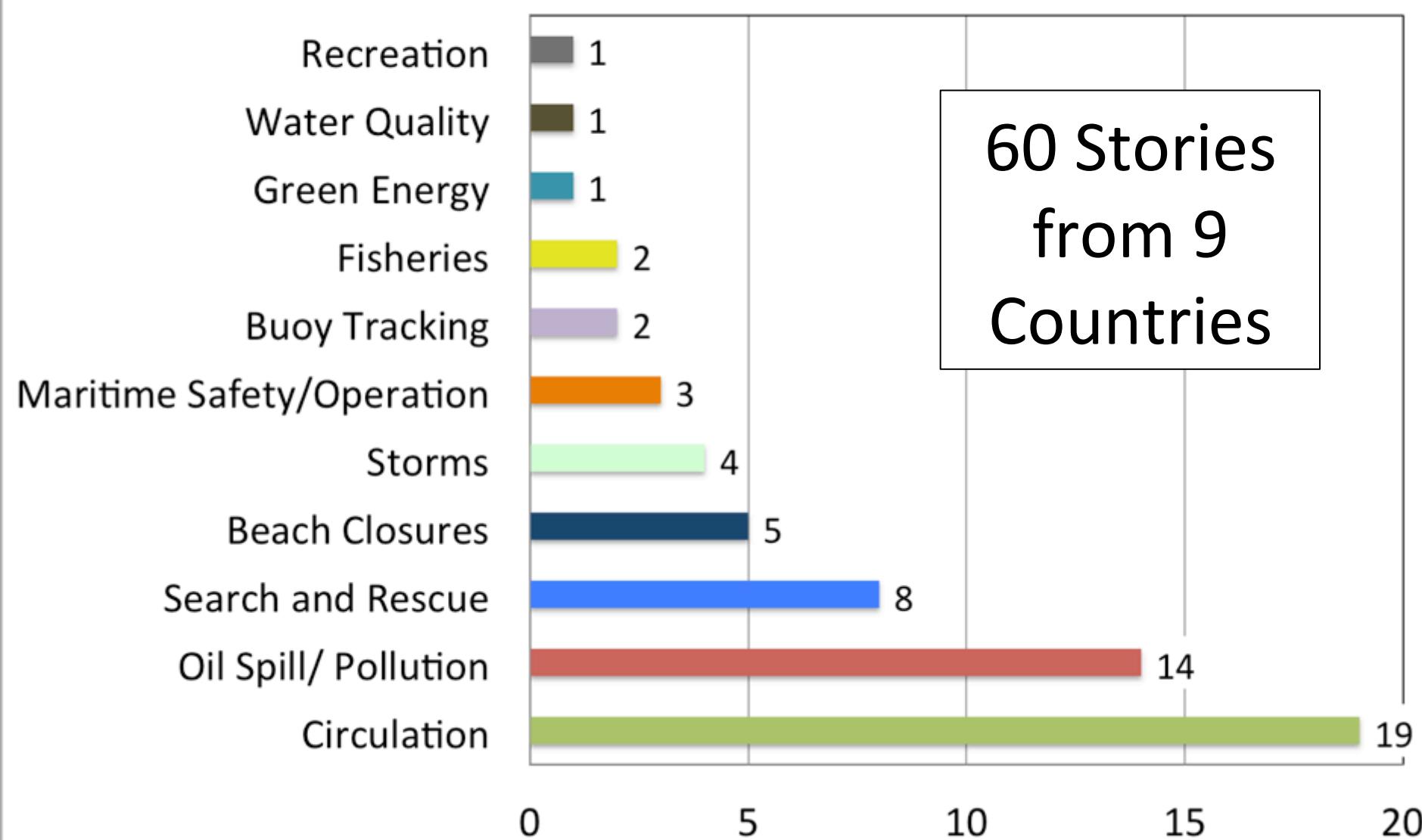

IOOS INTEGRATED OCEAN OBSERVING SYSTEM



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Application Stories of HF radar

60 Stories
from 9
Countries



HF Radar Application

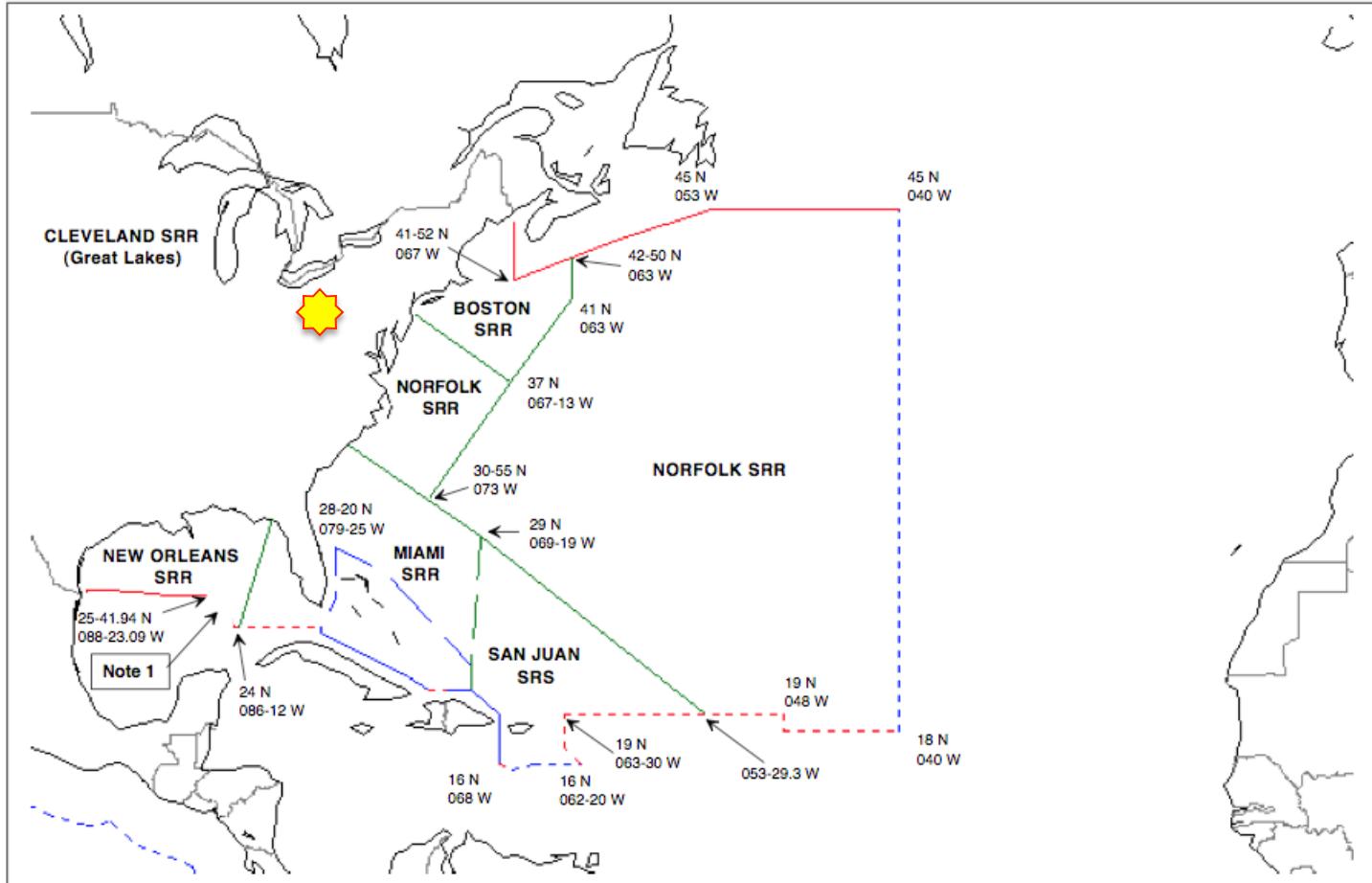


Search And Rescue

Dr. Hugh Roarty
Dr. Josh Kohut

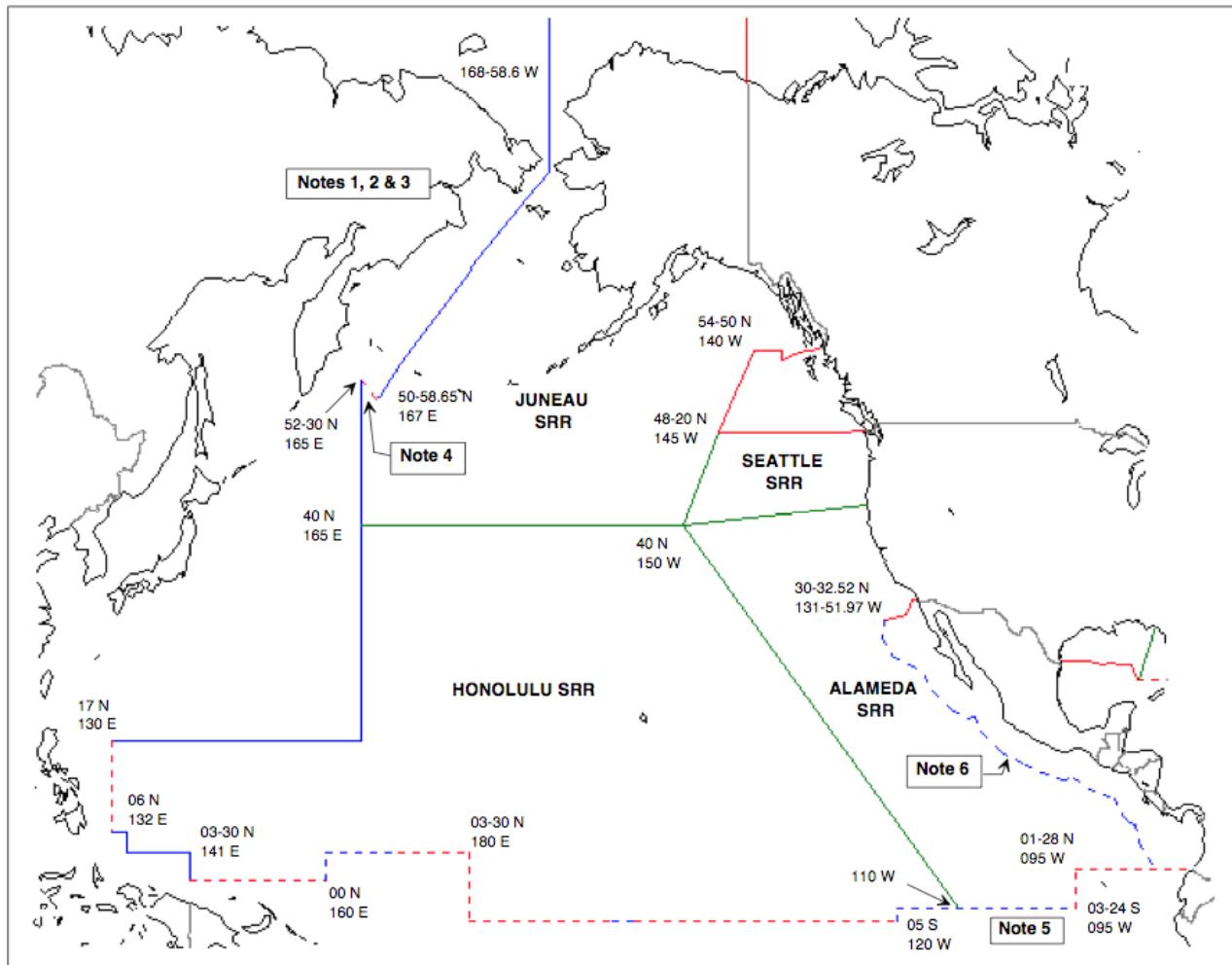


USCG Area of SAR Responsibility - Atlantic





USCG Area of SAR Responsibility - Pacific

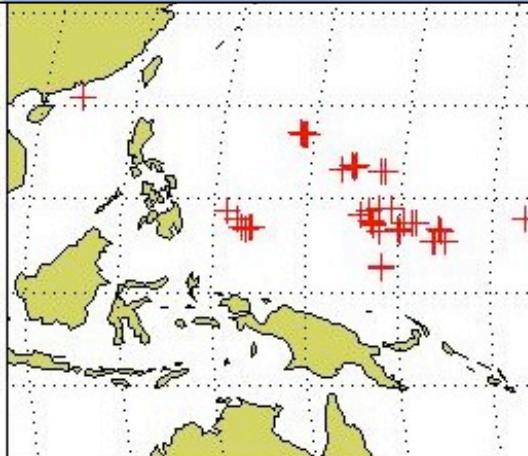
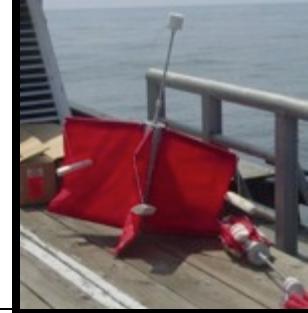




USCG Drifter Deployments

Self Locating Data Marker Buoys (SLDMB)
for Search And Rescue (SAR)

January 2006 – December 2007 (2 years)



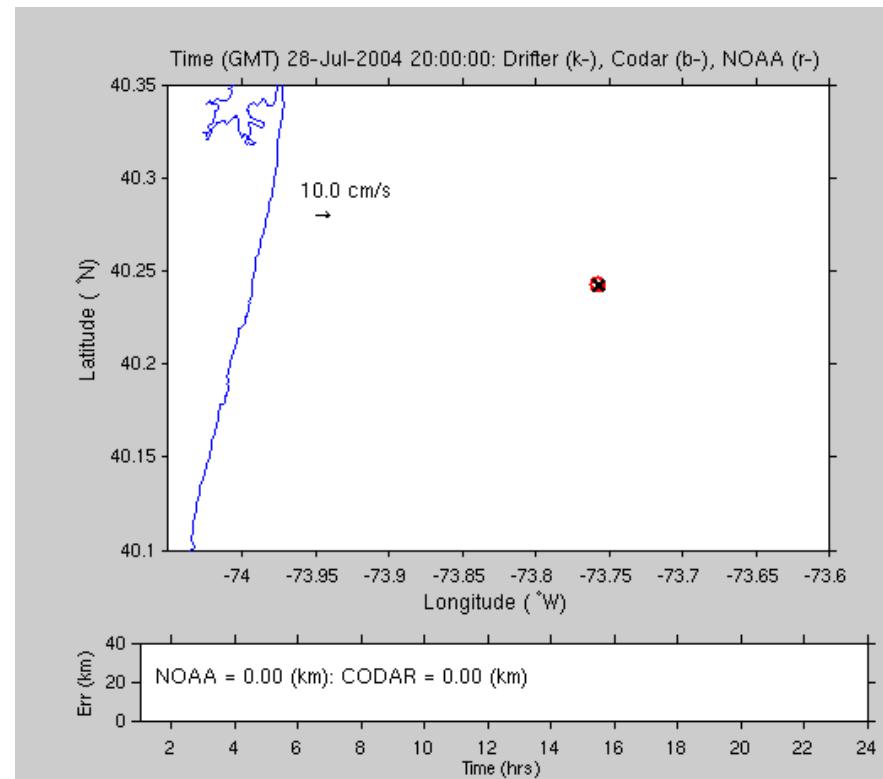
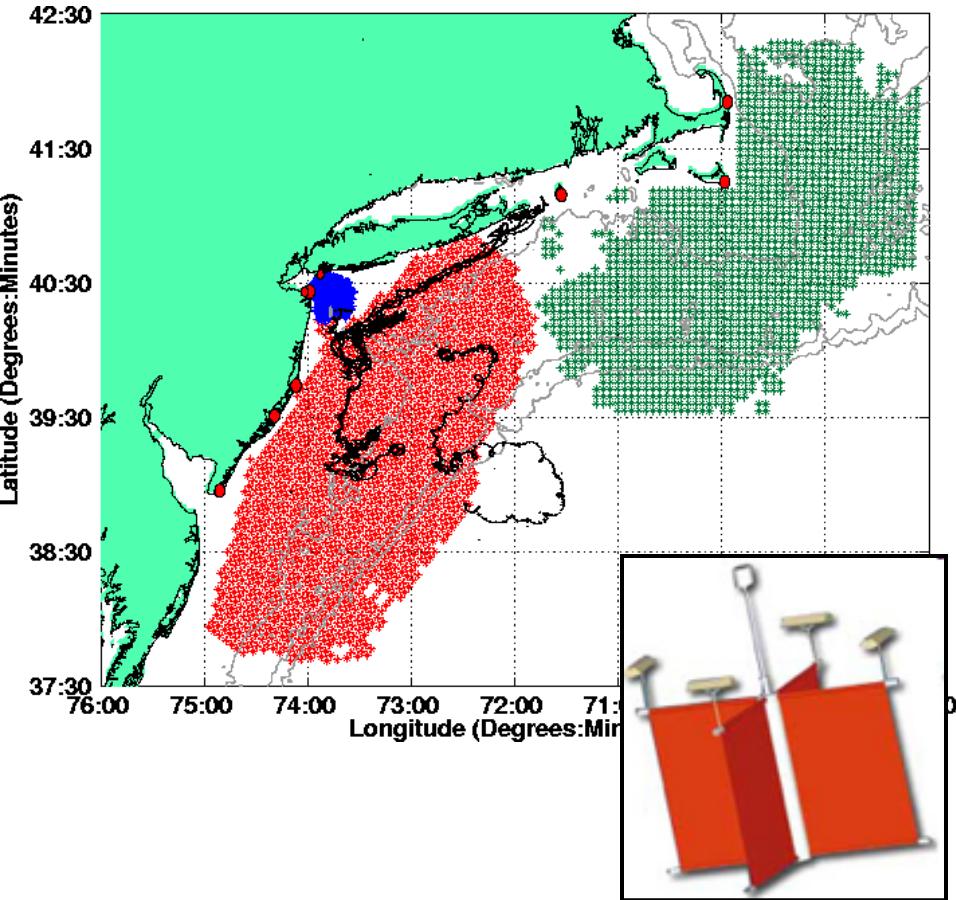
Most SAR cases occur in the envisioned HF Radar Network footprint

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Long Range 5 MHz

Year 2005



Drifter
CODAR
NOAA

Data Requests to EDS

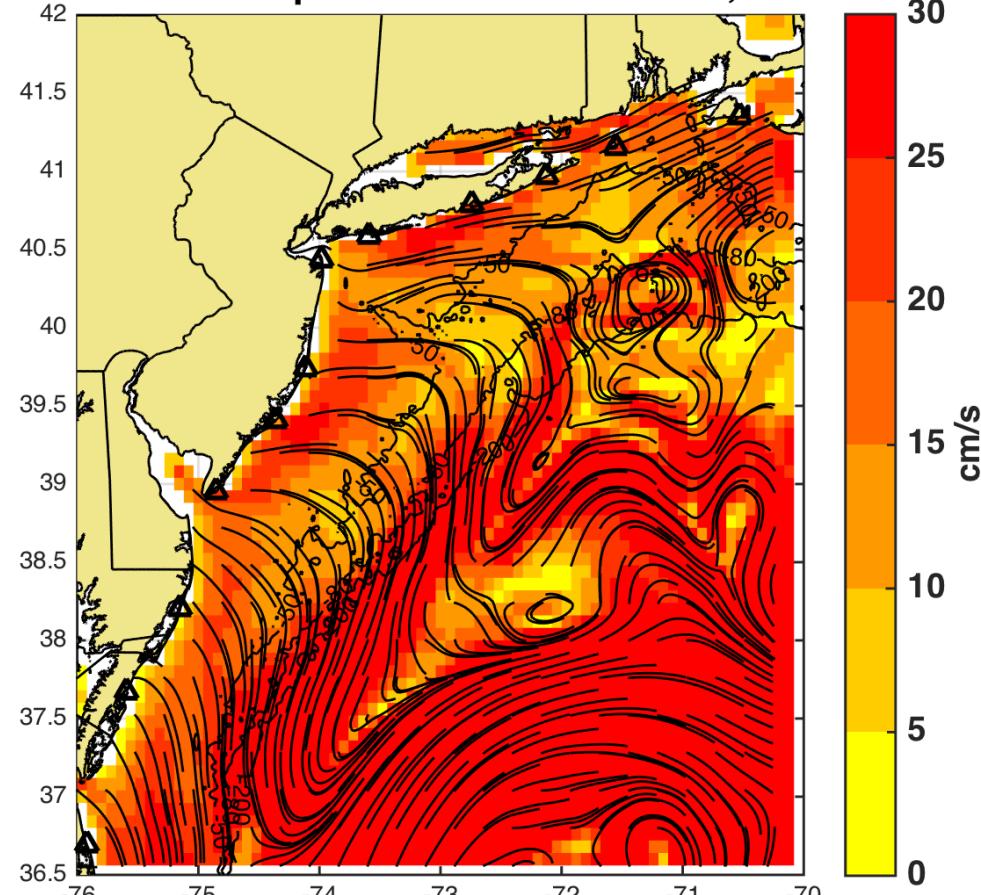
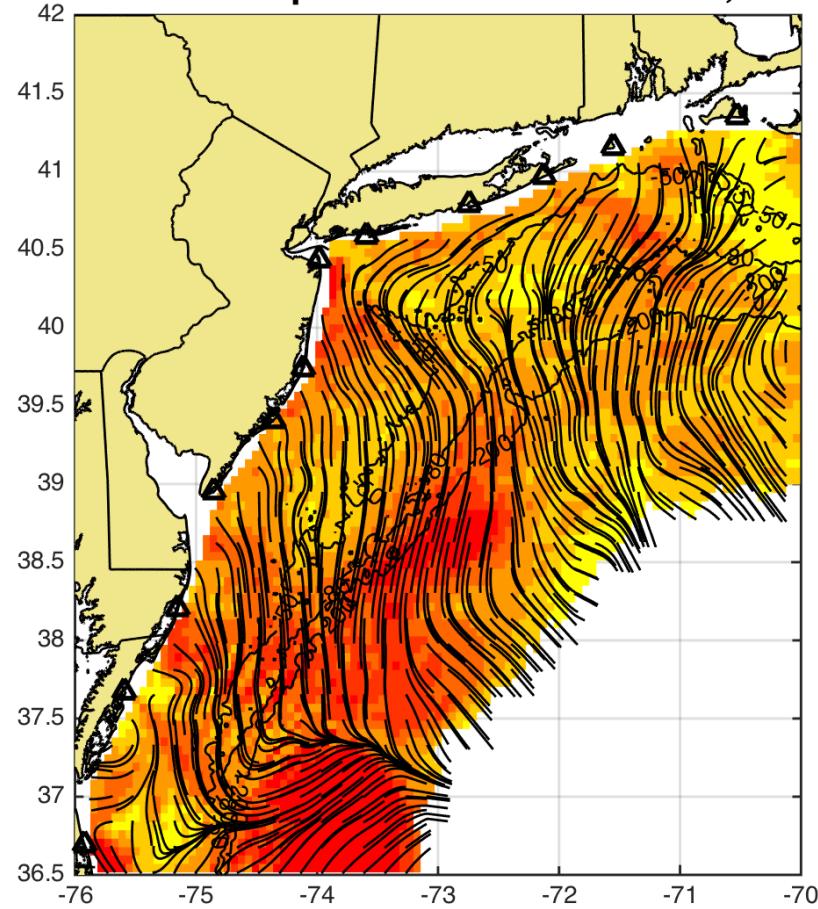
December 1, 2011 to March 15, 2014

Rank	Product	Requests	Percentage
1	NAM_CONUS_12km (NCEP)	41,679	26%
2	North Atlantic HYCOM (NCEP)	22,661	14%
3	NDFD CONUS (NWS)	15,794	10%
4	Aggregated ADCIRC Global HYCOM (NCEP)	13,494	8%
5	NAVGEM (Navy)	10,585	7%
6	Global HYCOM (NCEP)	8,978	6%
7	San Fran Bay tides (ASA)	8,367	5%
8	Chesapeake Bay (NOS)	7,538	5%
9	GFS (NCEP)	7,378	5%
10	Global NCOM (Navy)	6,762	4%
11	Aggregated ADCIRC NCOM	5,506	3%
12	National HF Radar Data and Predictions	4,501	3%
13	Global HYCOM (Navy)	2,720	2%
14	Tampa Bay (NOS)	1,699	1%
15	NY HOPS (Stevens Institute)	1,135	1%
16	Delaware Bay (NOS)	1,111	1%
17	NDBC - Buoys	902	1%
18	Mariano - Ship Drift	557	0%
19	Aggregated NCOM Tidal	527	0%
20	FVCOM Mass Bay (UMass)	498	0%
Total		162,392	100%

HF Radar

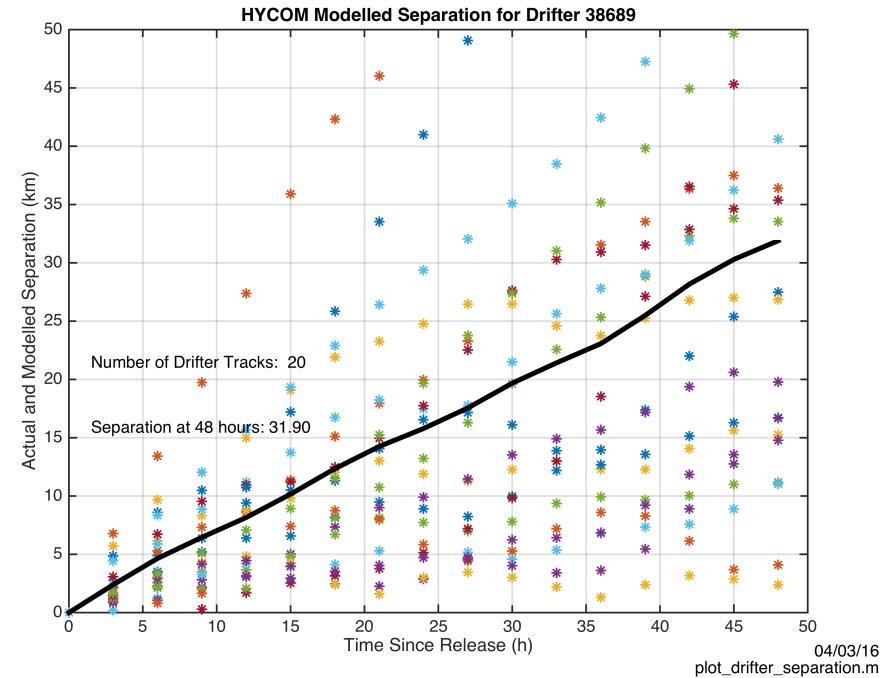
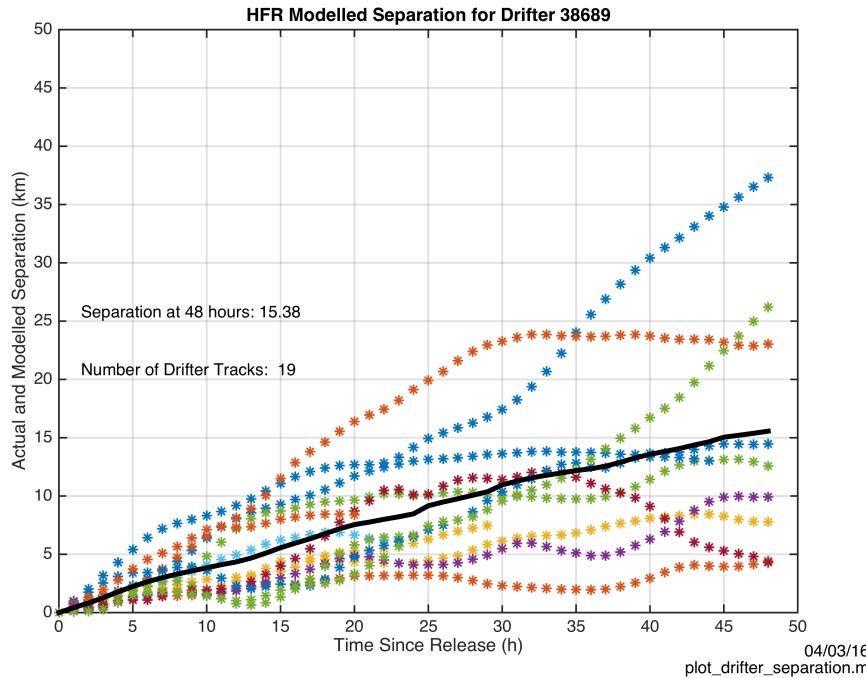
HYCOM

Surface Current Map 25 Hour Mean: Mar 28, 2016 face Current Map 25 Hour Mean: Mar 28, 2016 18:00



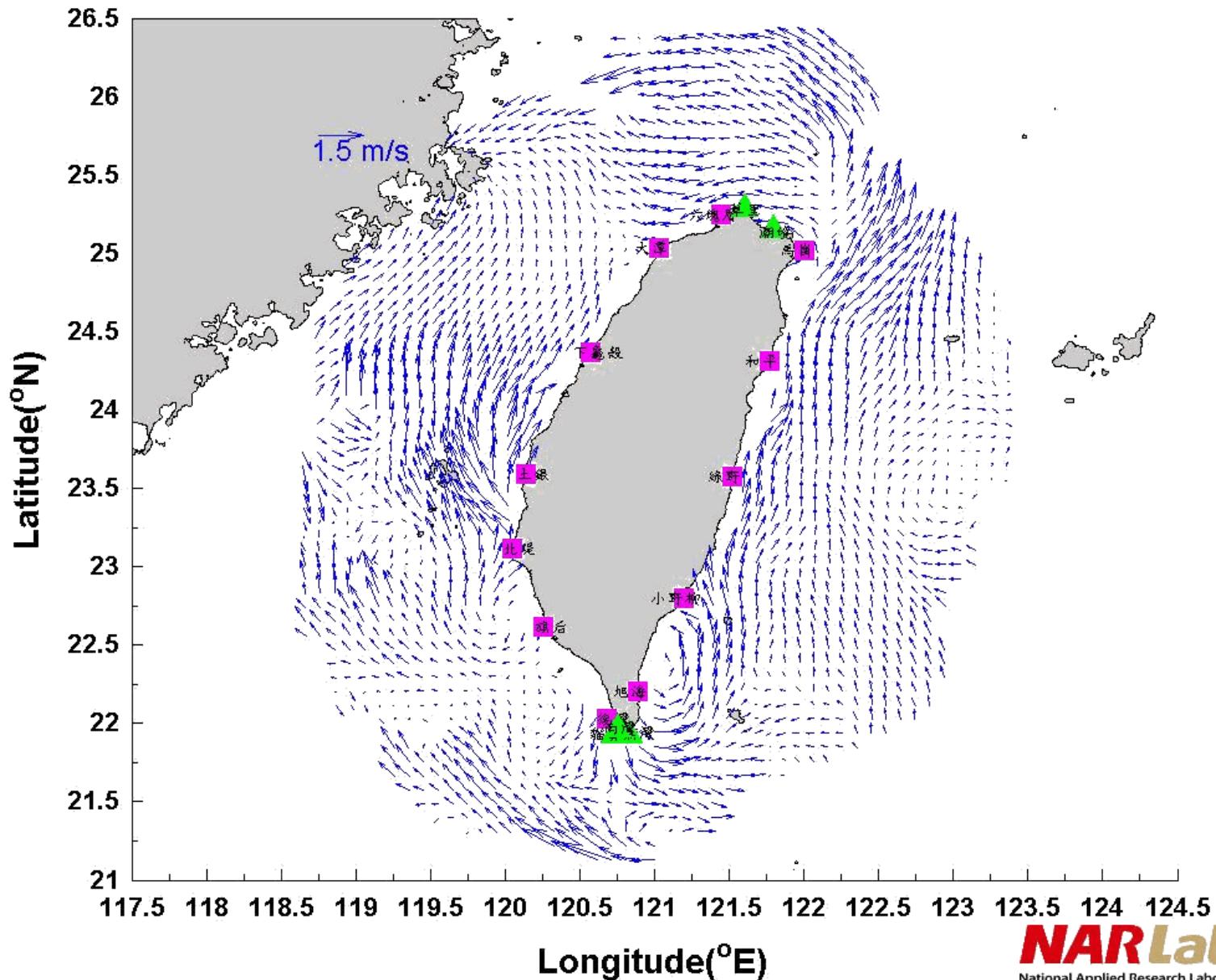
HF Radar

HYCOM



Separation (km) between actual and modeled trajectory after 48 hours

GMT Time: 2015/08/06 03:00



NARLabs
National Applied Research Laboratories



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Container Ship Breaks Apart, Causes Massive Oil Spill On Taiwan Coast

By [Jereal Cawis](#), Tech Times | March 28, 10:39 AM

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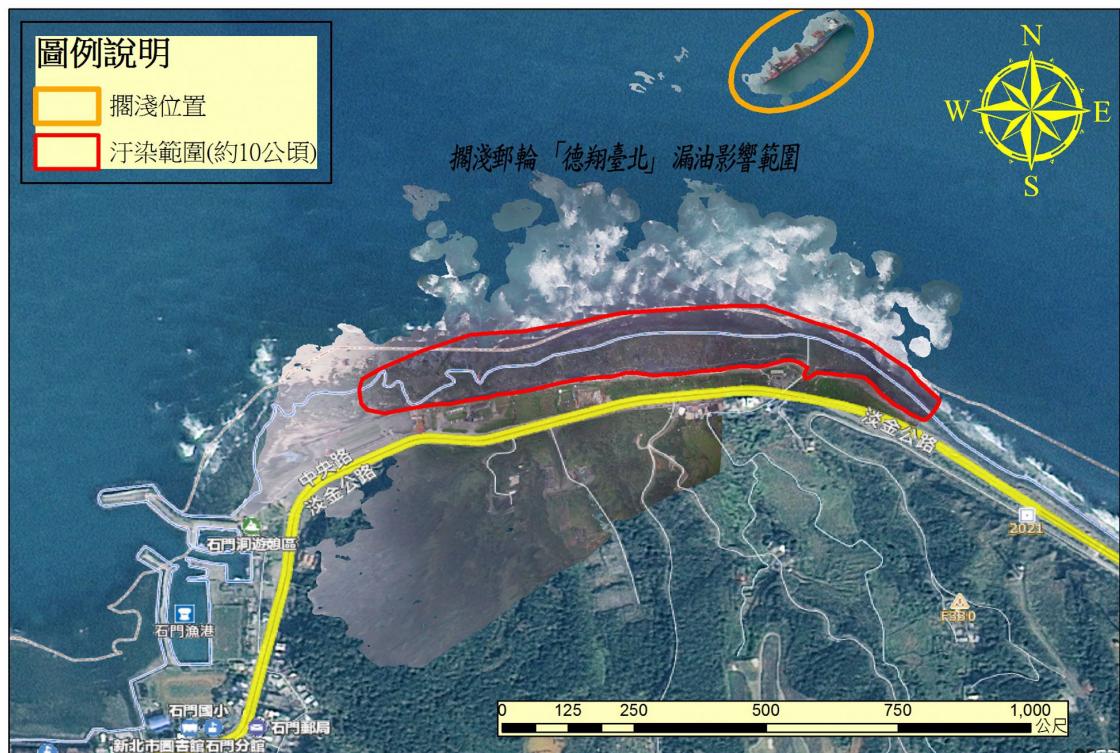
...

Subscribe



A shipwreck in New Taipei has caused oil to spill on the shore of Shihmen. The vessel also contains toxic chemicals that could damage the ecosystem.

(Photo : Billy H.C. Kwok | Getty Images)



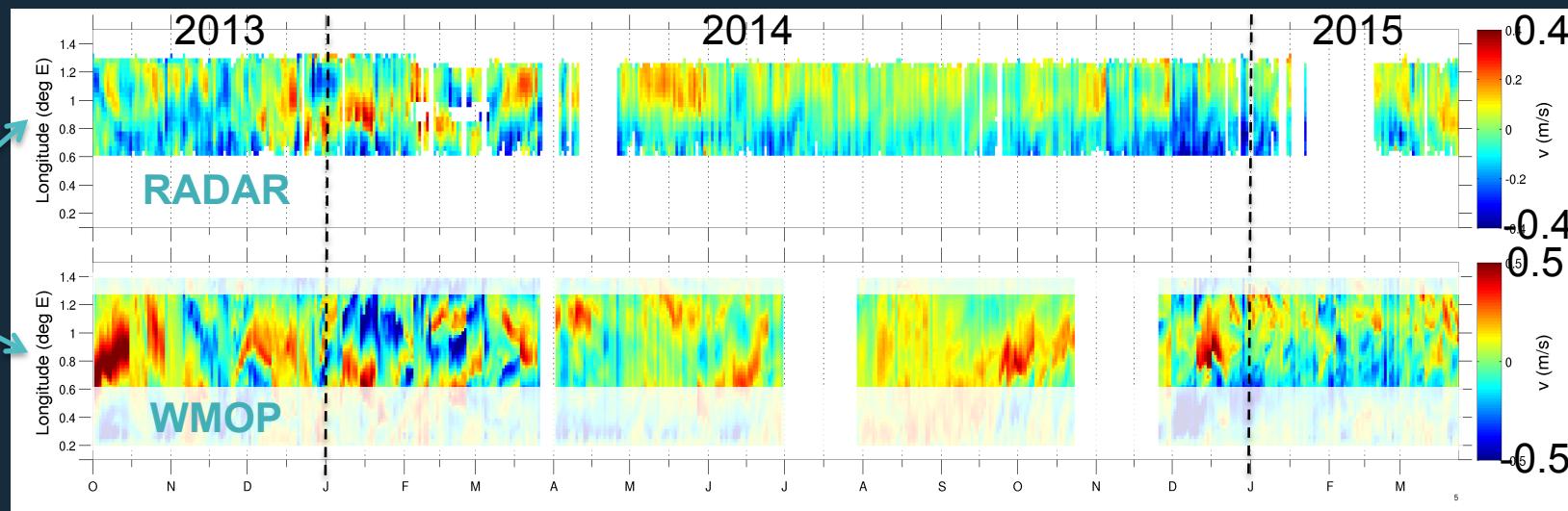
OTHER APPLICATIONS



MODEL VALIDATION

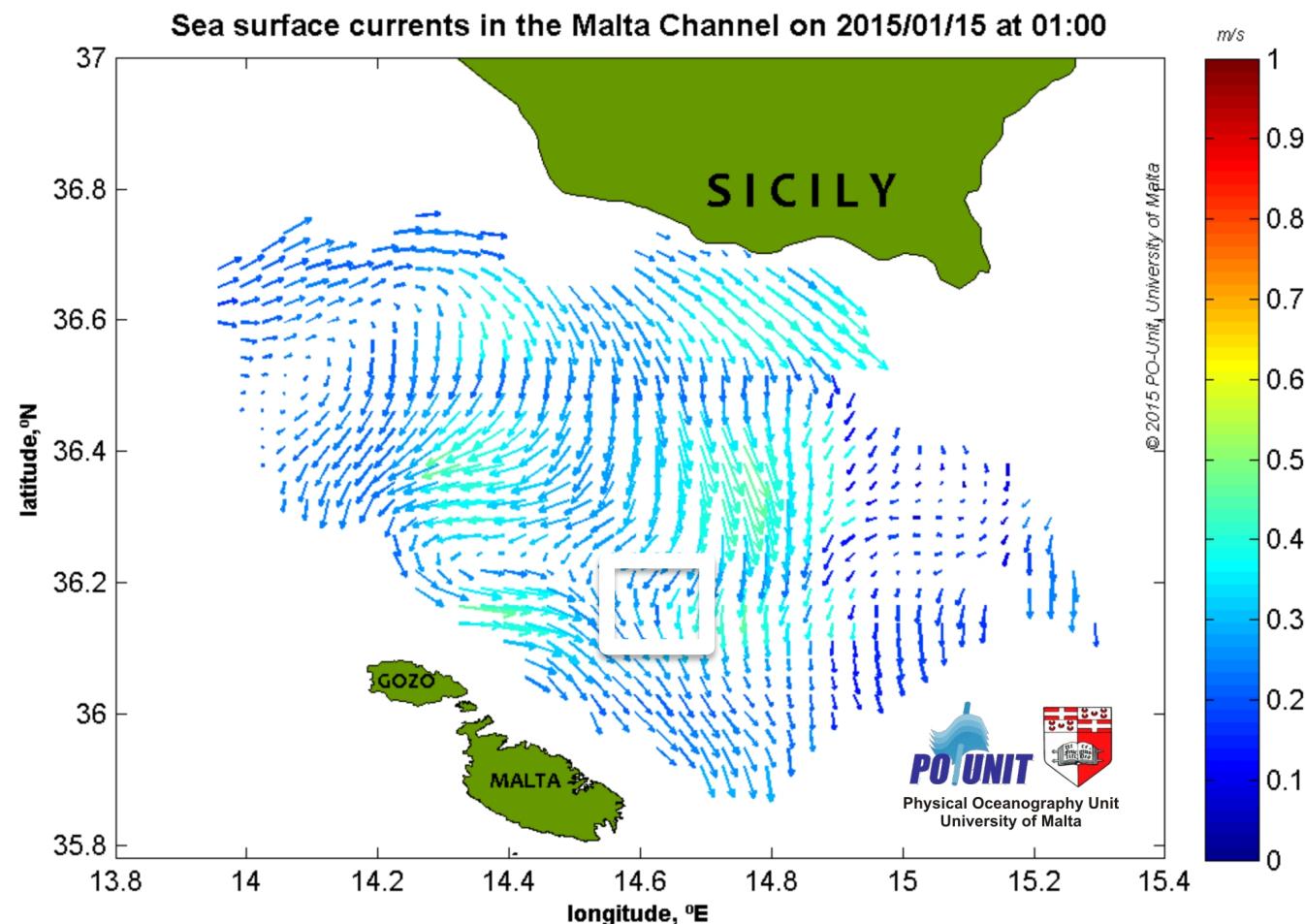
**WMOP: COMPARISON WITH HF RADAR DERIVED SURFACE CURRENTS
HOVMULLER DIAGRAM (38.7°N)**

V-component



- Seasonal variability for both data sets: high (low) variability in winter (summer)
- No permanent and synoptic patterns for WMOP
- Short spatial and temporal scales in winter in both model and radar, with poor pattern correspondence, except in case of strong wind events
- General overestimation of the current intensity in the model (maximum values approx. 30% higher).
- Higher variability for WMOP

Why CALYPSO in the Malta channel?

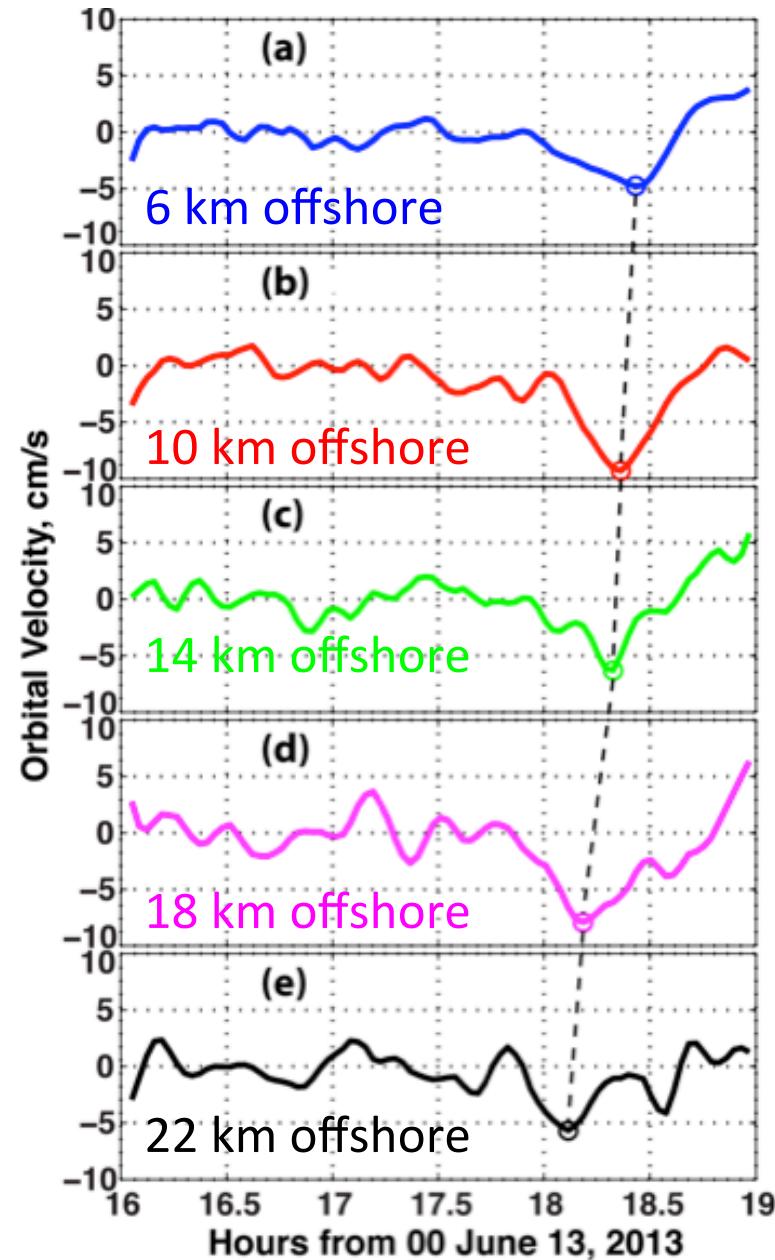


HF Radar Detects Tsunamis

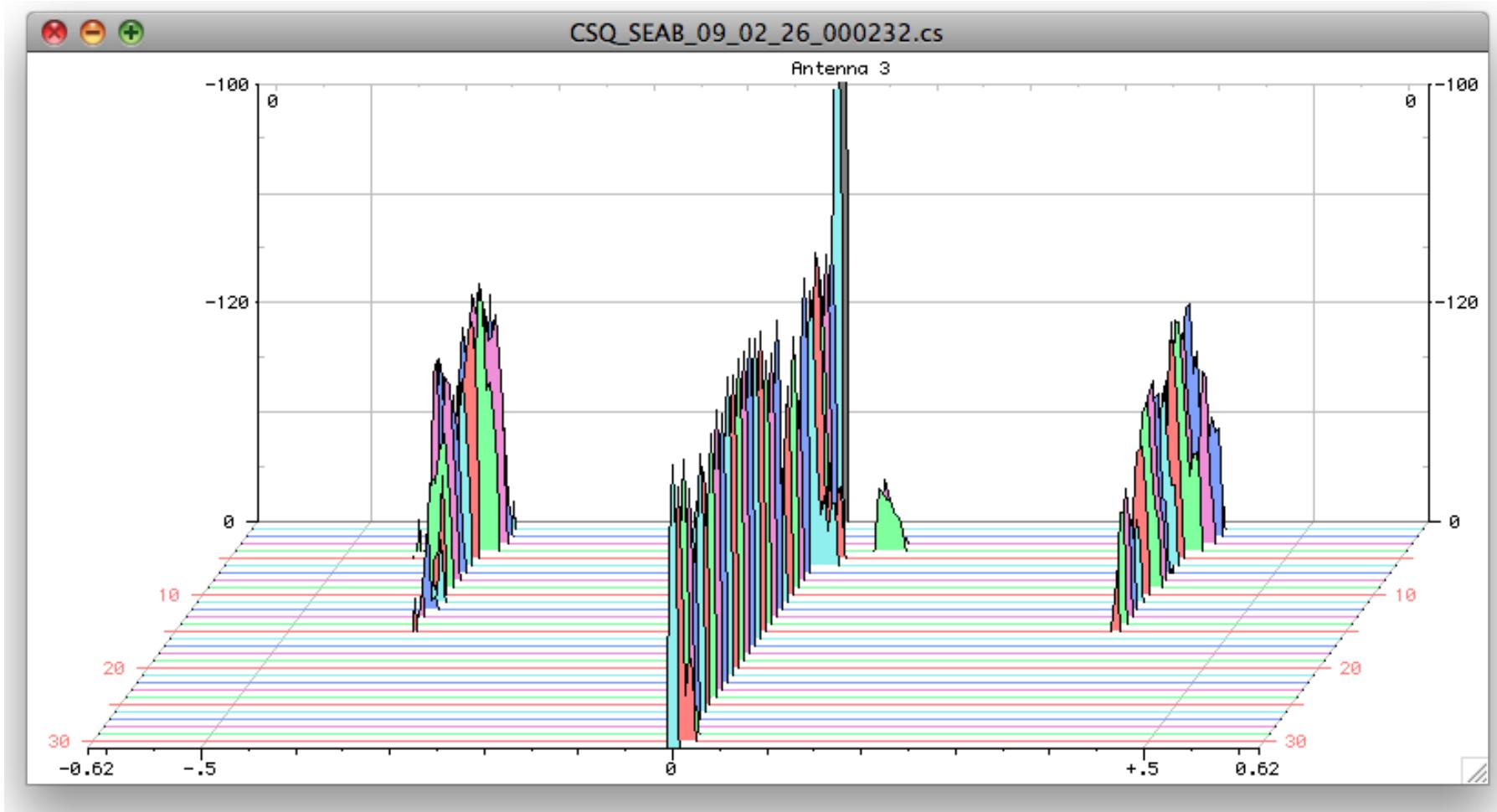


NOAA Tsunami Program Strategic Plan

2012-2021

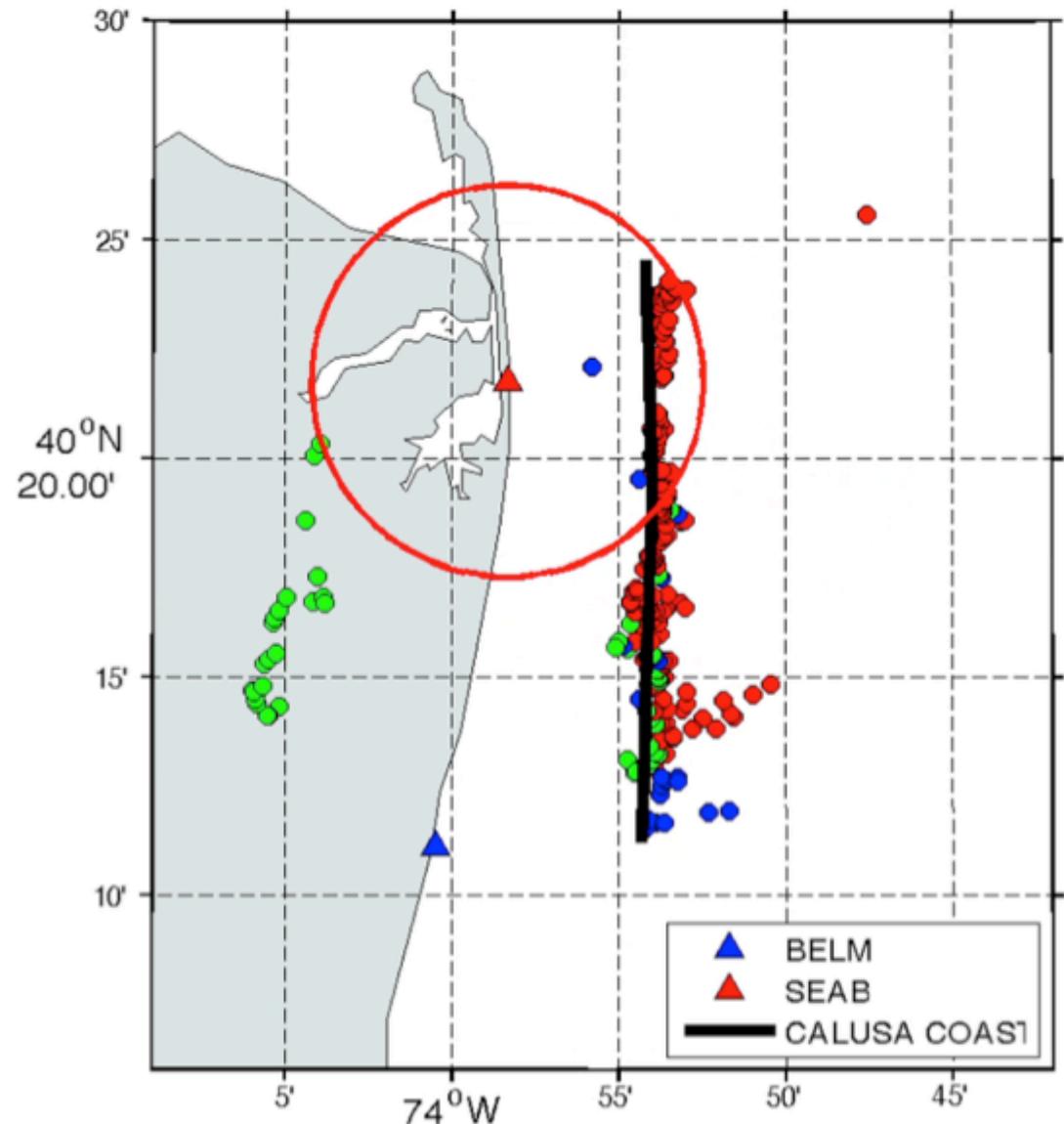


Ships in Spectra



Calusa Coast Comparison

11-Jun-2012 13:00:00 - 13:01:00



Calusa Coast Test Case

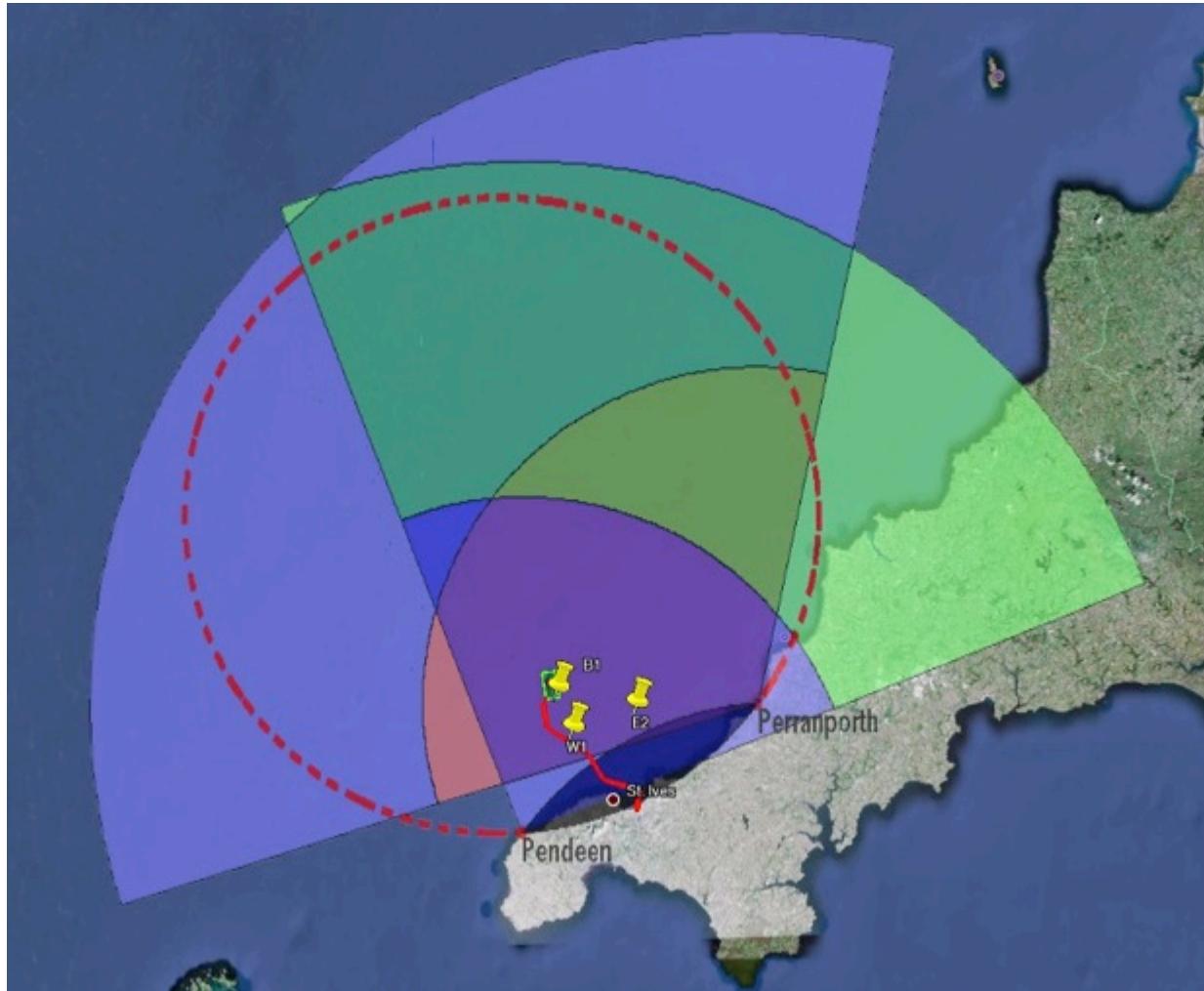


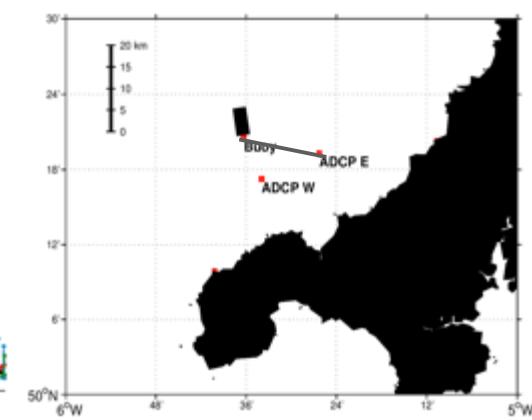
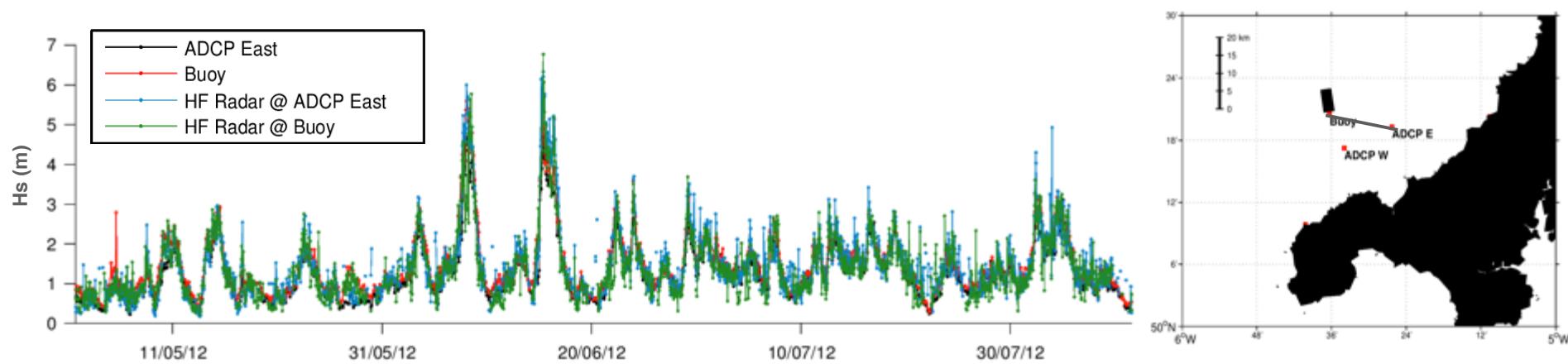
Wave Hub Radar Installation

Mean expected data coverage.

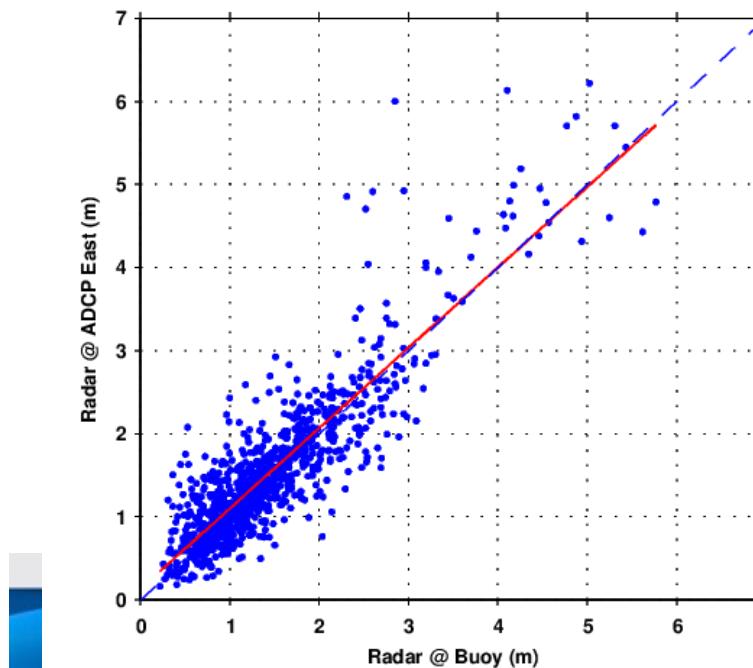
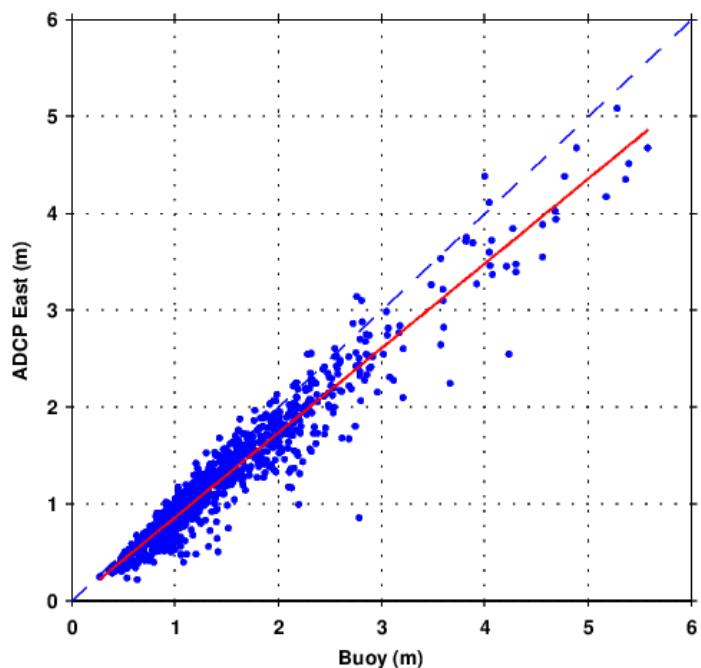
MARINE
RENEWABLE
ENERGY
WITH
PLYMOUTH
UNIVERSITY

- Directional estimates exist for intersections of colors.
- Wave coverage half of current coverage.
- Provides map of independent wave estimates with range resolution at 0.6km and azimuthal at 10% range





Location	R	RMSE	Bias	Obs
Buoy – ADCP East	0.96	0.19	0.20	1015
Radar@Buoy - Radar@ADCP East	0.88	0.43	-0.08	940



High Frequency Radar

Thank You



GEO

