Exploring Offshore Wind Energy:

Why is it important and what is being done at Rutgers?

Greg Seroka

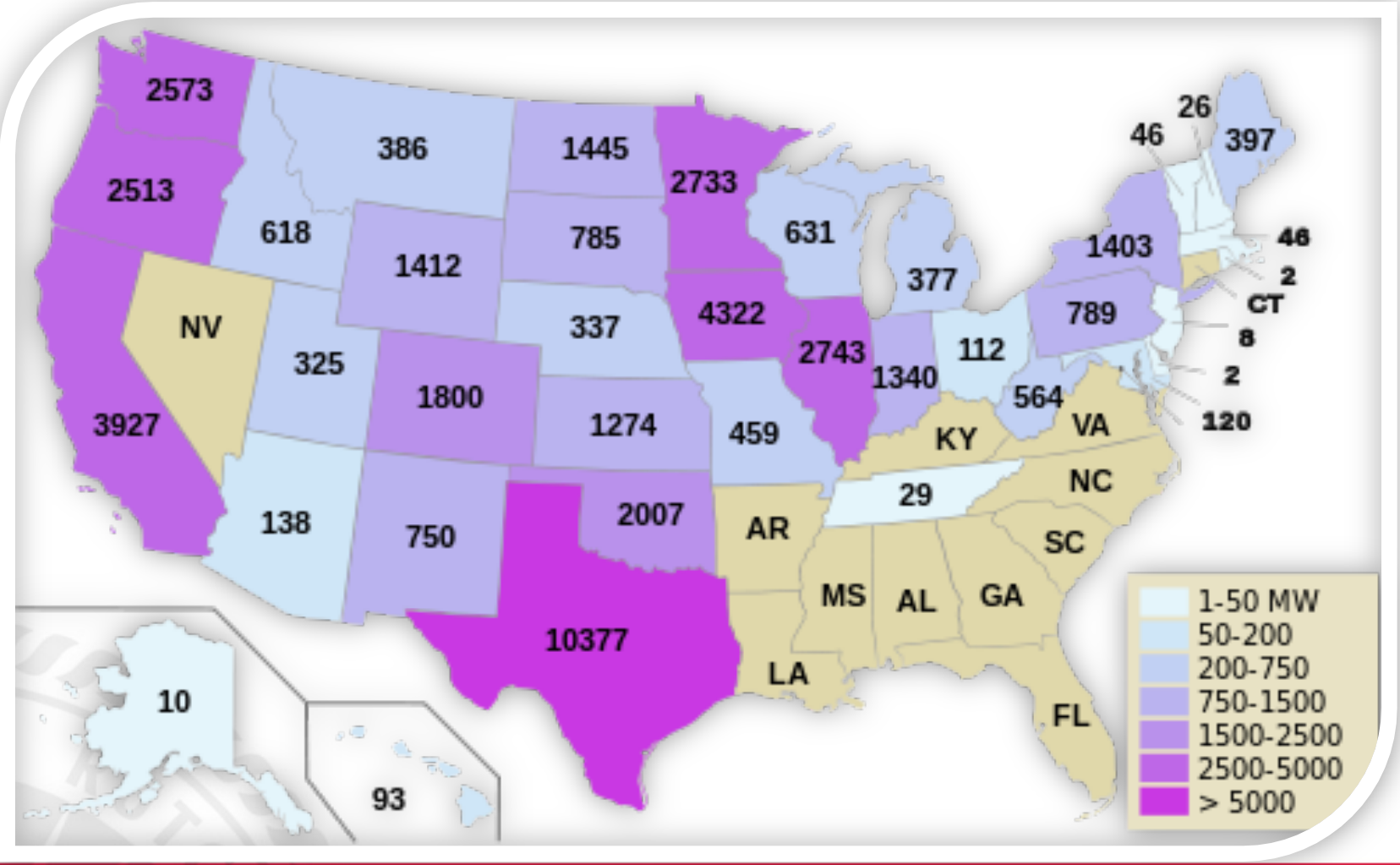
NJ Governor's School: Energy and Sustainability Course

July 10, 2012

Renewable Energy, Non-fuels

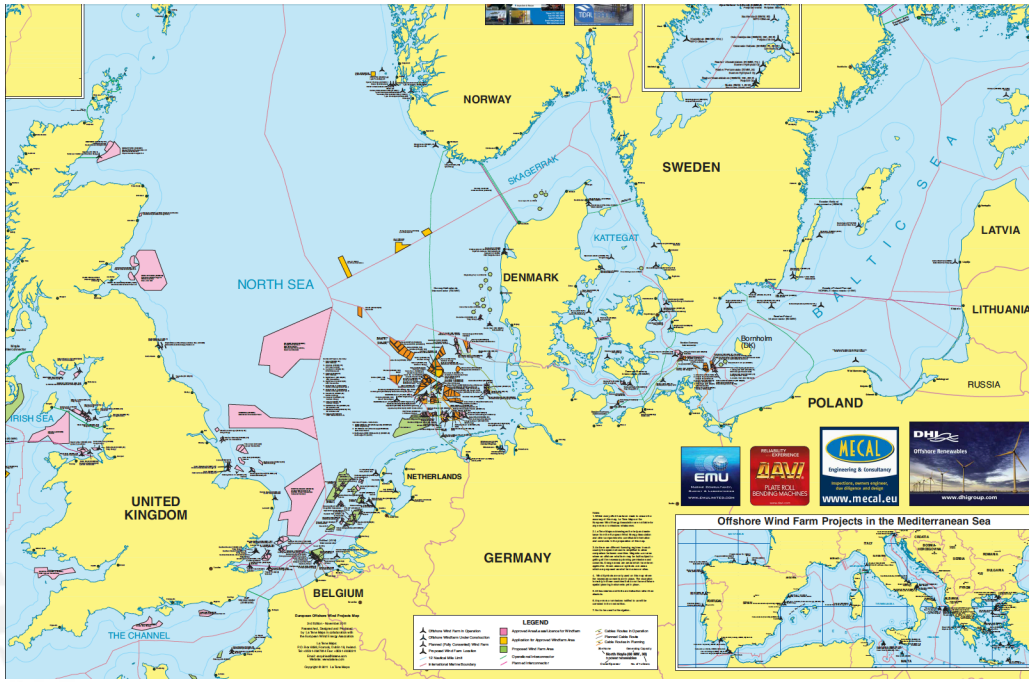
- Obama: 20% renewable by 2030
- Diversified energy solution critical for success
- Renewable energy sources (non-fuel):
  - Hydropower
  - Geothermal
  - Solar (variable)
  - Wind (variable)
- Compare to coal, oil, natural gas, and nuclear

Installed U.S. Wind Capacity (as of end 2011)



Current US Status and Future Needs

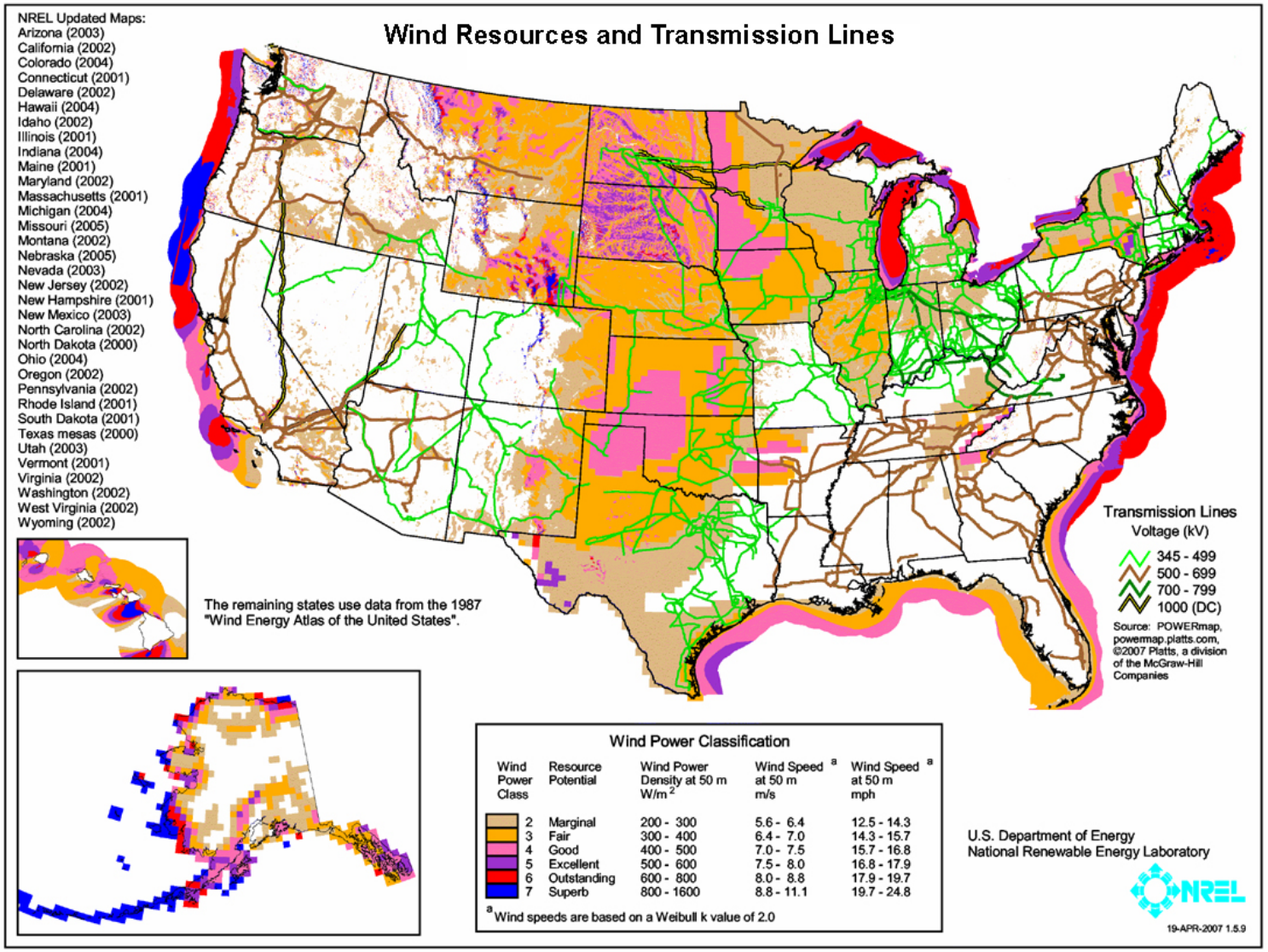
- To achieve 20% renewable by 2030, expansion is obvious and needed (currently, 14.6%)
- Northern Europe has over 50 offshore wind farms, while U.S. has **ZERO**



Why will offshore wind be an area of growth for US?

- More wind power potential offshore than onshore

U.S. Wind Resource Potential



Why will offshore wind be an area of growth for US?

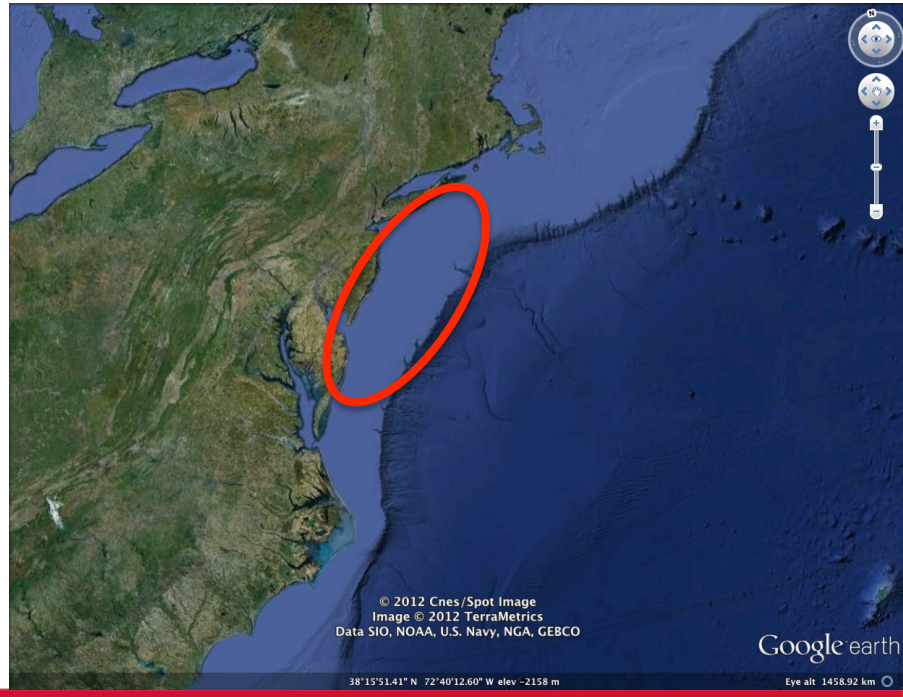
- More wind power potential offshore than onshore
- Closer to population centers (coastal cities)
  - Less transmission needed
- US energy security
- Growth esp. along East Coast because:
  - Proximity to I95 corridor
  - Shallow waters

National Renewable Energy Lab (NREL)

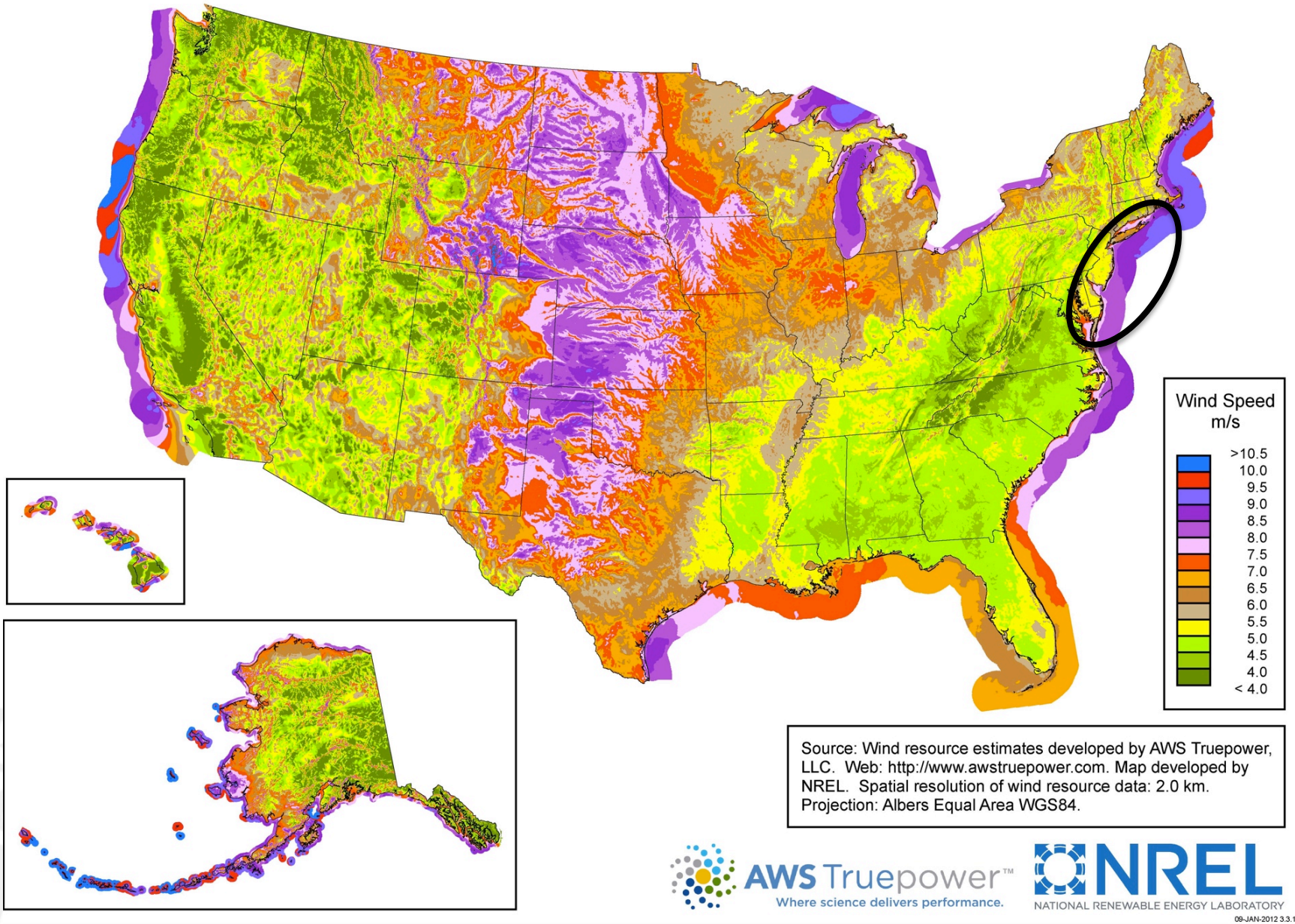
- Map of Transformation of the Electric Sector:
  http://rpm.nrel.gov/refhighre/expansion/expansion.html

Why New Jersey?

- State government support
  - Offshore Wind Economic Development Act (2010), ORECS
- Continental shelf (shallow waters)
- Good wind resource



United States - Land-Based and Offshore Annual Average Wind Speed at 80 m



Source: Wind resource estimates developed by AWS Truepower, LLC. Web: http://www.awstruepower.com. Map developed by NREL. Spatial resolution of wind resource data: 2.0 km. Projection: Albers Equal Area WGS84.

AWS Truepower™
Where science delivers performance.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

09-JAN-2012 3.3.1

Wind Variability

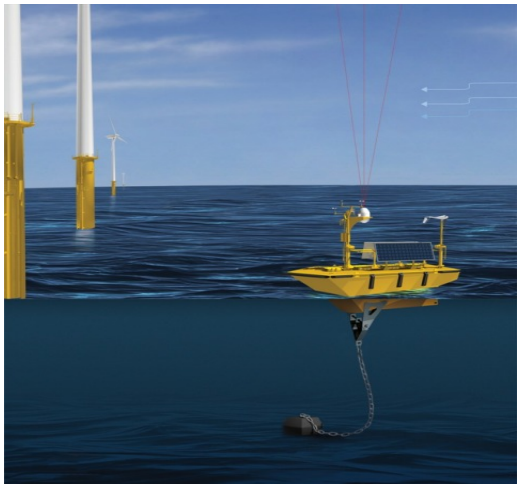
- Wind (and solar) are variable renewable energy (VRE) sources
  - Non-fuel, no storing (still in research phase)
- Critical to understand, characterize, and quantify major sources of variability
- Scarce oceanic observations limit efforts toward this goal

Coastal/Offshore Monitoring

Meteorological Tower

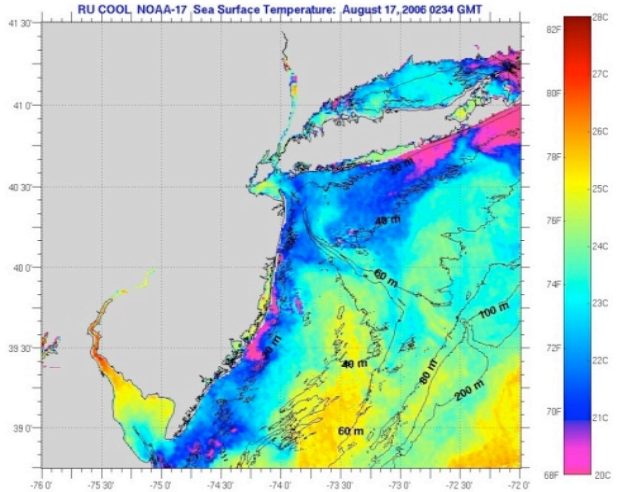
Meteorological Buoy

Offshore vertical LIDAR

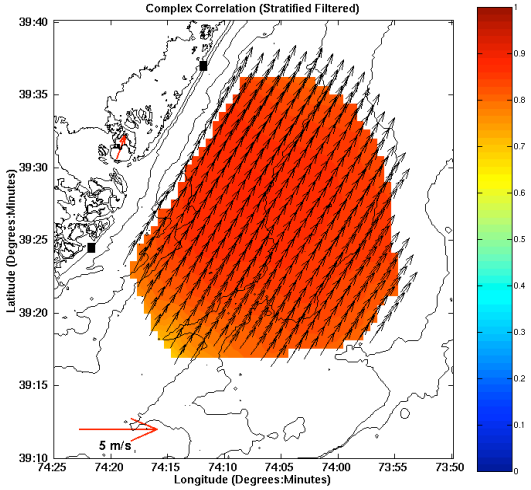


Coastal/Offshore Scanning LIDAR

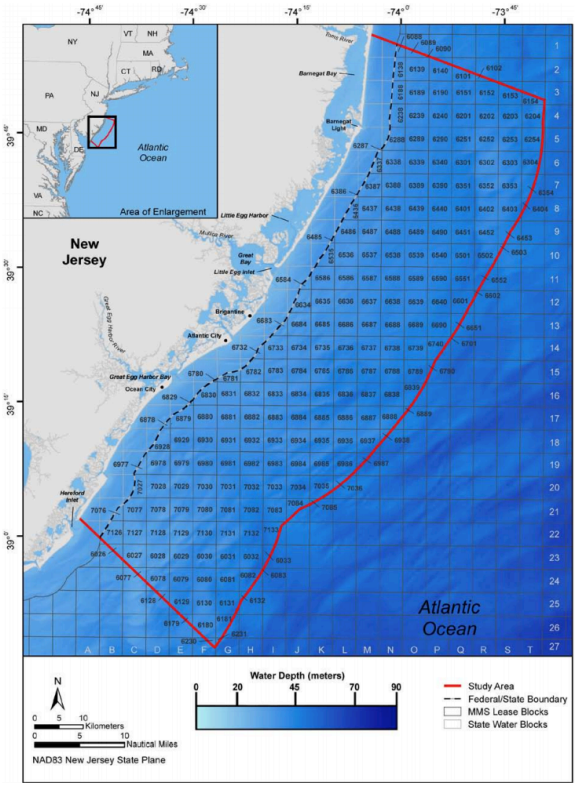
Infrared Satellite



Coastal Radar (CODAR)



- Ecological baseline studies of offshore wind power already performed (shown to left)
  - Avian species
  - Fisheries
  - Marine Mammals
  - Sea turtles



- This project is the state's physical baseline study

NJ Board of Public Utilities (NJBPU): a current RUCOOL project

- NJBPU asked RUCOOL to evaluate wind resource as a sort of “consultant”
- Use modeling to achieve these goals, complement ecological baseline study

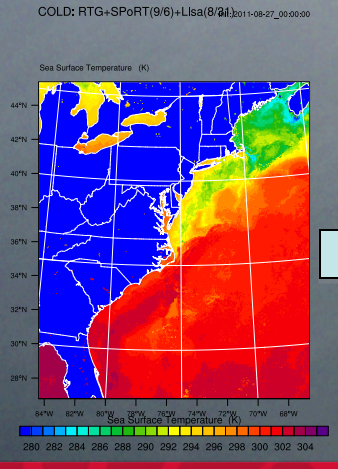
State of New Jersey
New Jersey Board of Public Utilities (NJBPU)

An Advanced Atmosphere/Ocean Assessment Program: Reducing the Risks Associated with Offshore Wind Energy Development

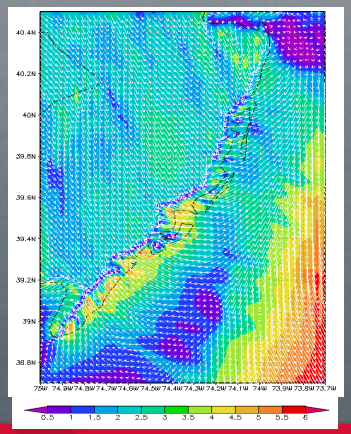
As Defined by The NJ Energy Master Plan and
The NJ Offshore Wind Energy Economic Development Act

Principal Investigators: *Dr. Scott Glenn and Dr. Rich Dunk, CCM*
Team Members: *Dr. Josh Kohut, Dr. Hugh Roarty, Louis Bowers, Greg Seroka, John Kerfoot, Laura Palamara, Mike Crowley, Ethan Handel, Colin Evans*

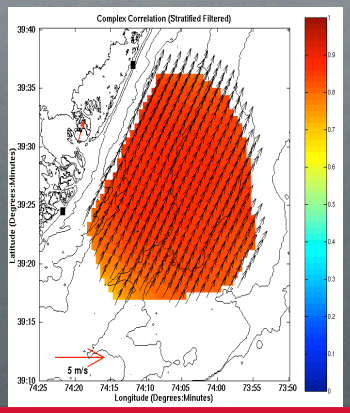
New Ocean Data



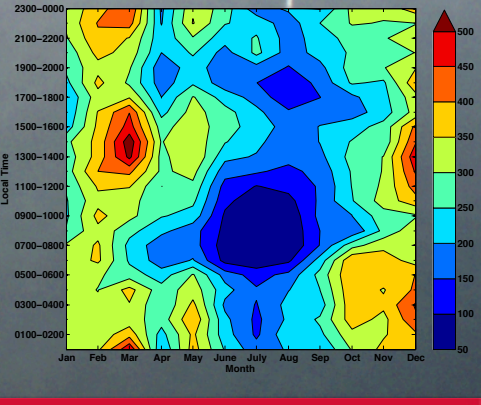
Hi-Res Weather Model



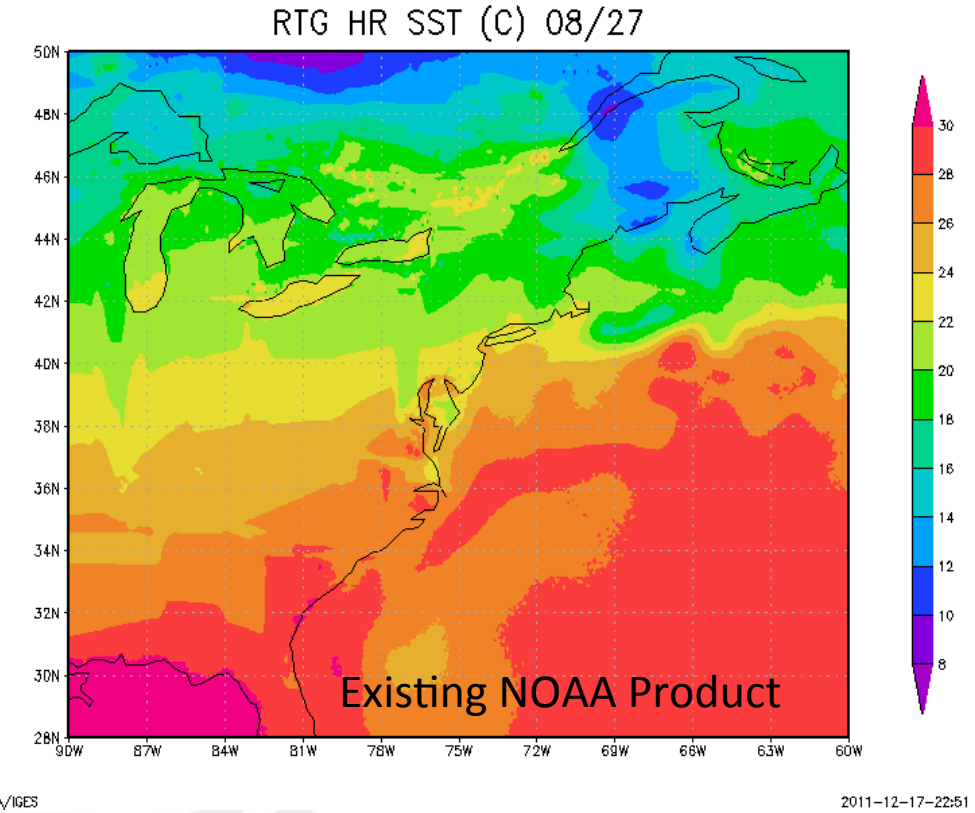
Spatial Validation Data

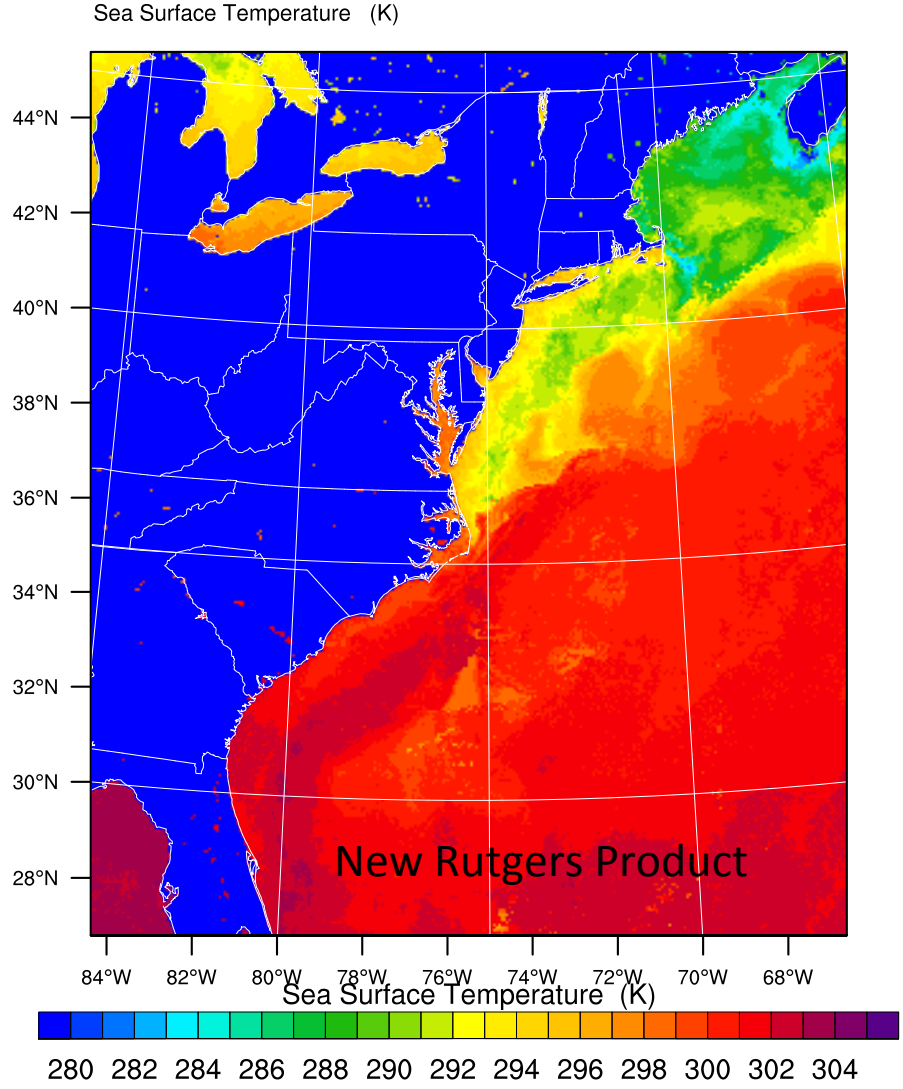


Wind Power Statistics



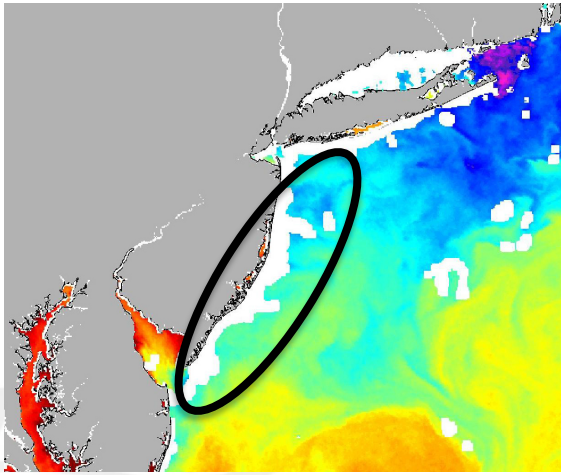
New Rutgers Satellite Product



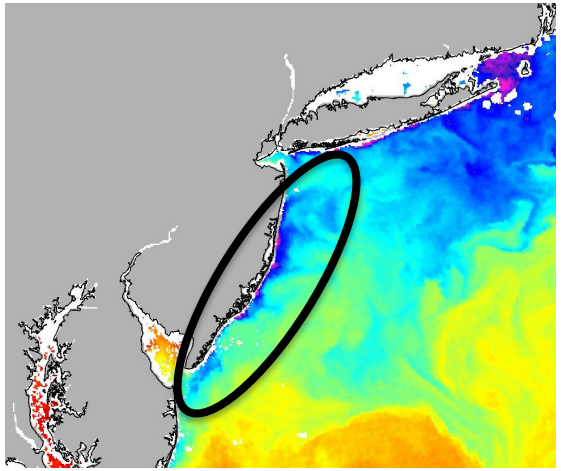


We can now resolve upwelling using satellites…

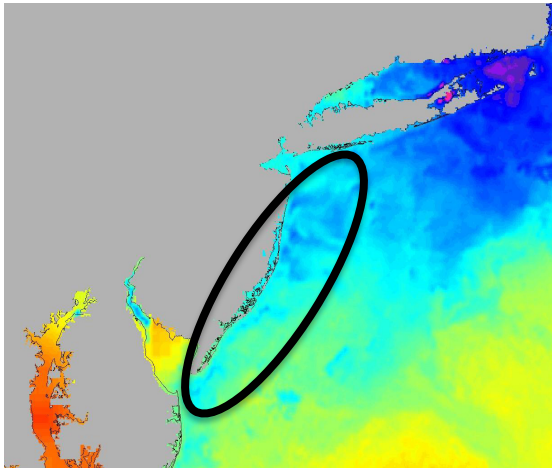
Cloud Masking
(old method)



Cloud Masking
(new method, unique to Rutgers)



MODIS 7-day
(old method)



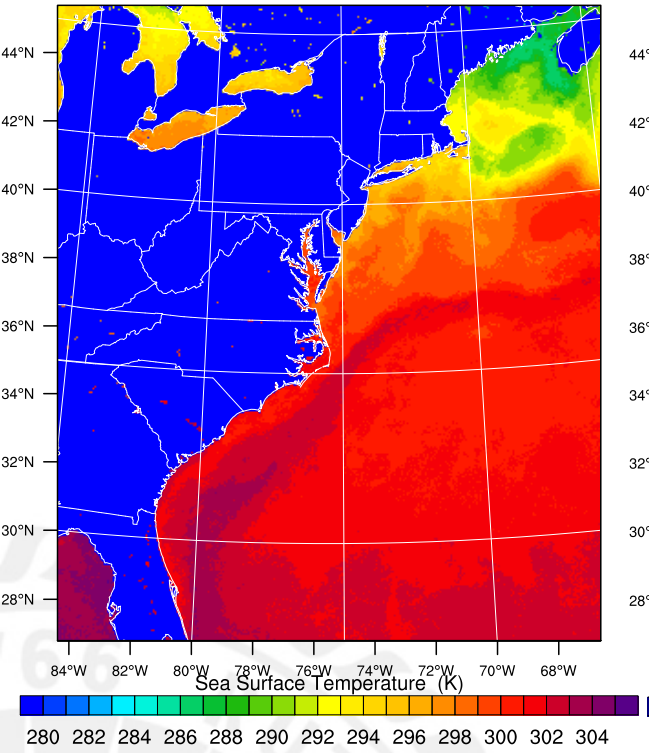
…and SST for hurricane simulations:

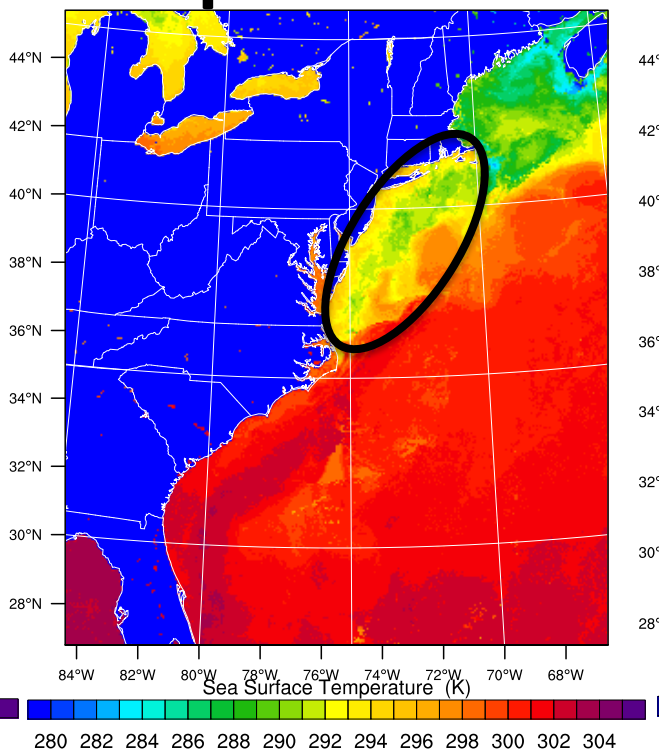
e.g. *Hurricane Irene*

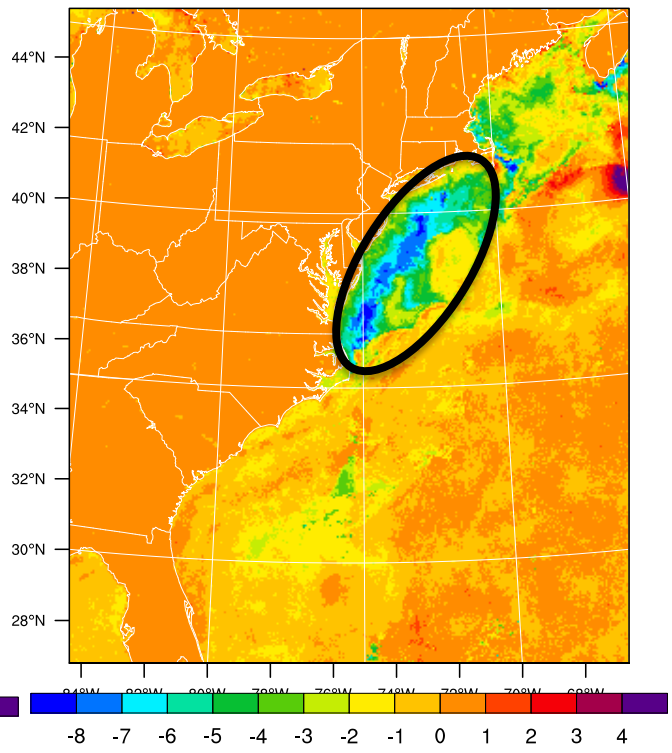
SPoRT + RTG

RU declouded product

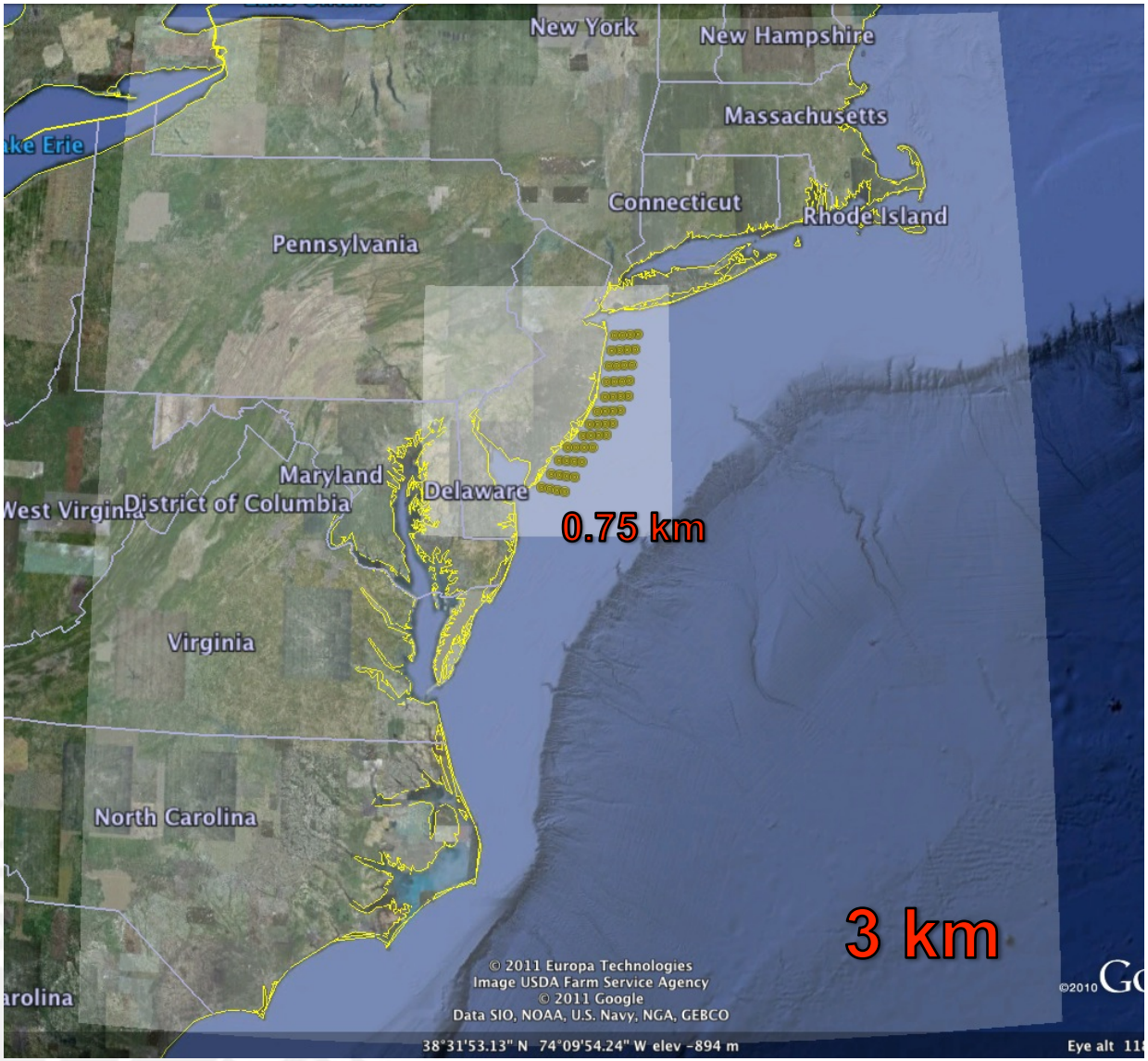
Difference







RU-WRF domains



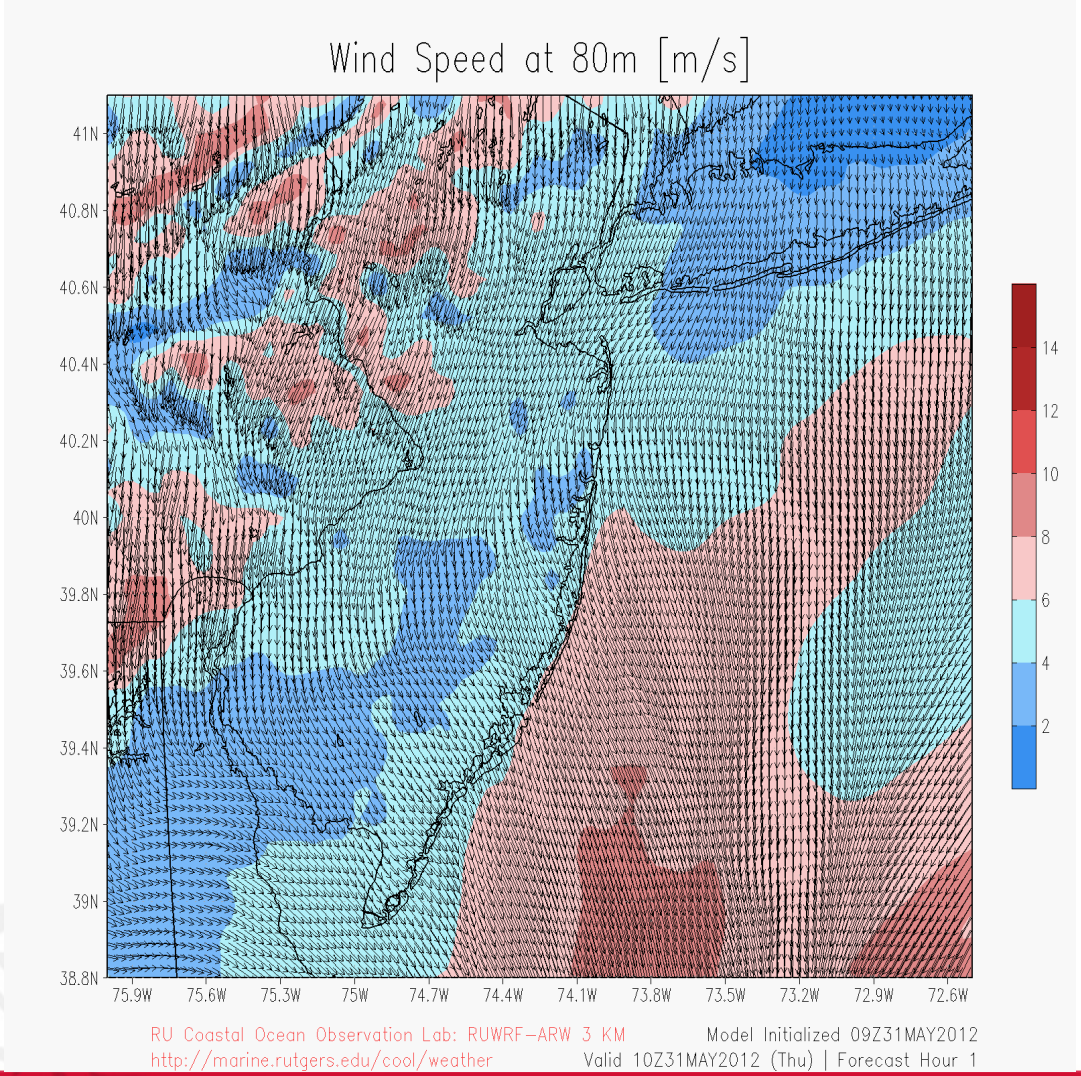
- ***3 km*** **horizontal resolution over NY Bight**
- ***0.75 km*** **horizontal resolution over study area**
- **By comparison, North American Mesoscale (NAM) Model from NOAA is 12 km horizontal resolution**

Model is being run in real-time, for precise comparison to onsite met towers

Data is currently being extracted from the model at a selected array of grid points within the study domain producing several **"Virtual" Meteorological Towers**.

Sea breeze animation:

RU-WRF 3km run with RUSST



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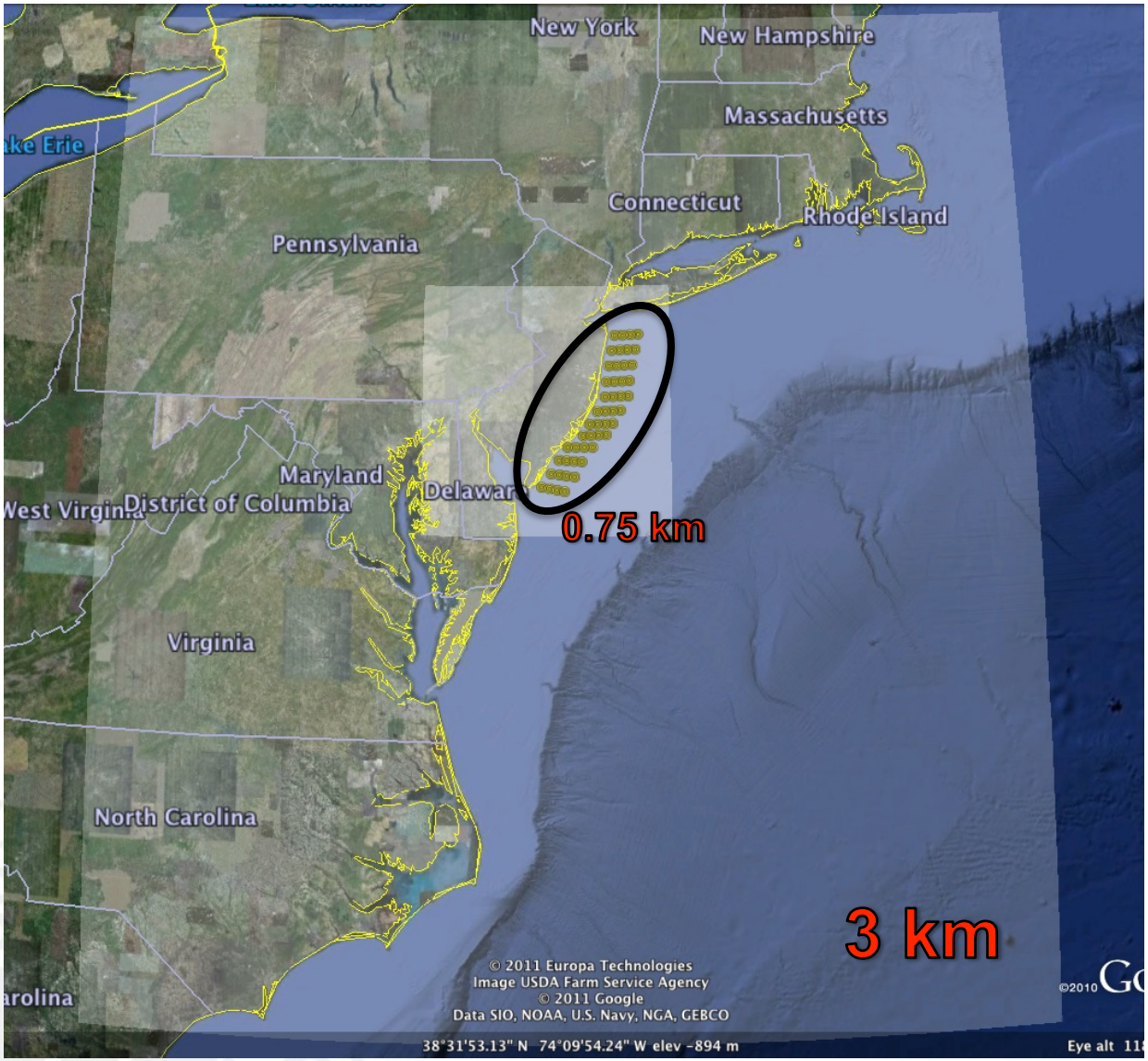

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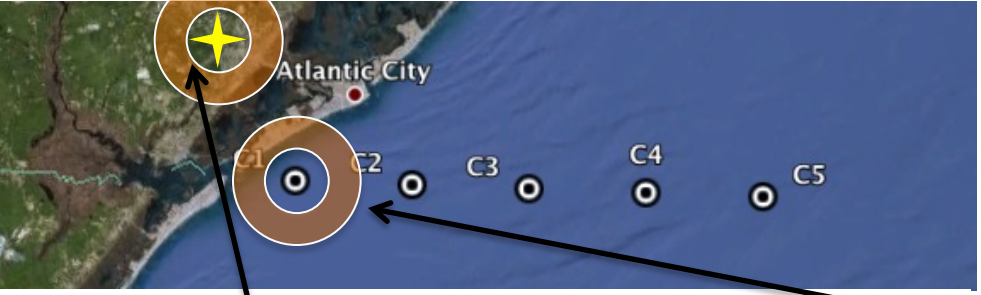
Virtual Met Tower Examples

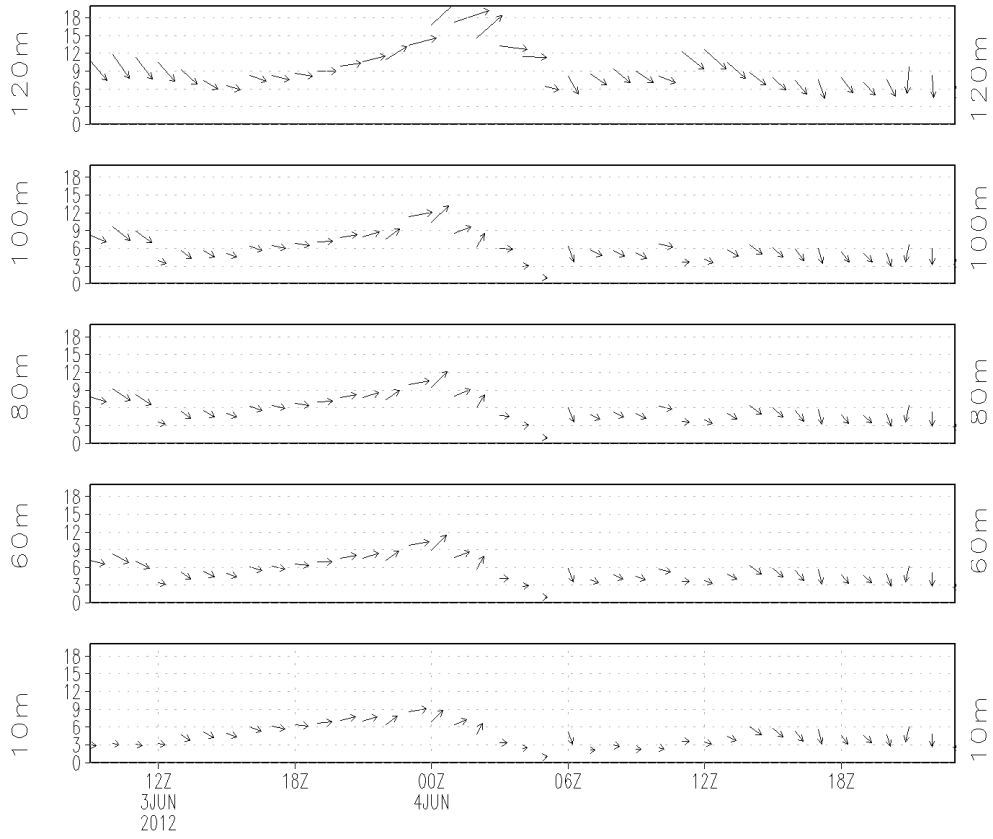


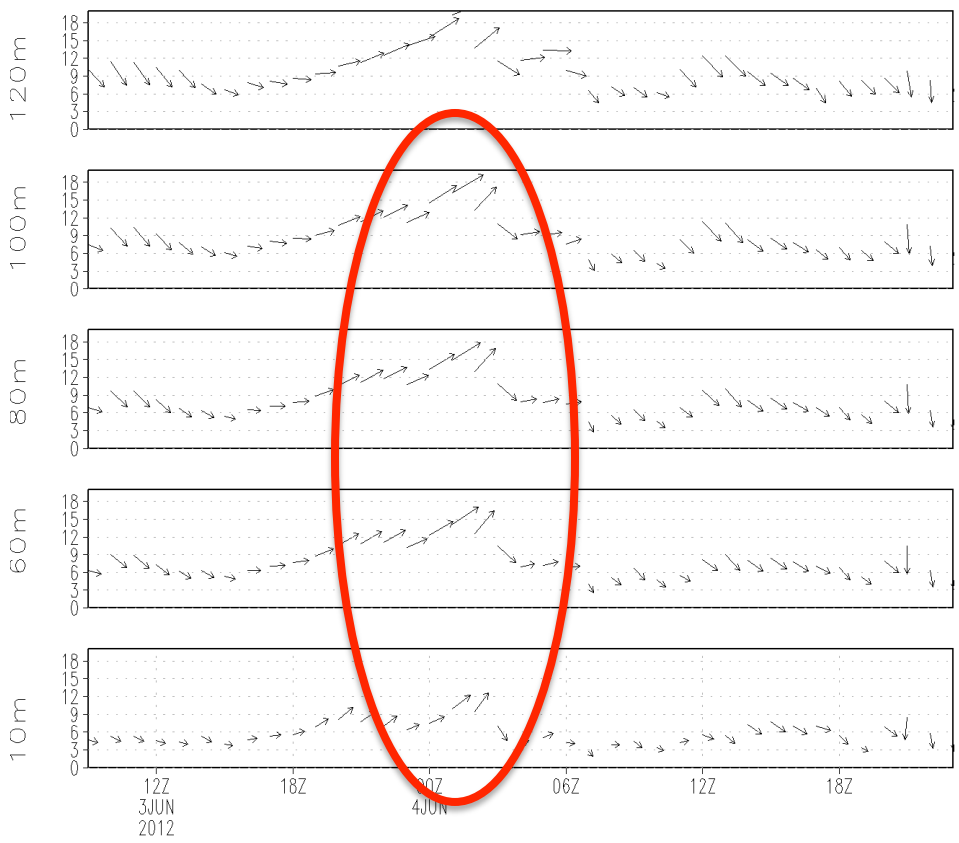
Virtual Met Tower ACY 39.45999533,-74.57000266

Virtual Met Tower C1 39.29821073,-74.47812373

Onshore (KACY)

Offshore



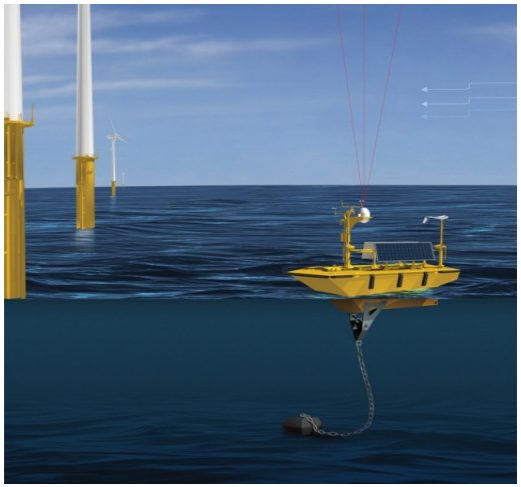


Model Validation

Meteorological Tower

Meteorological Buoy

Offshore vertical LIDAR



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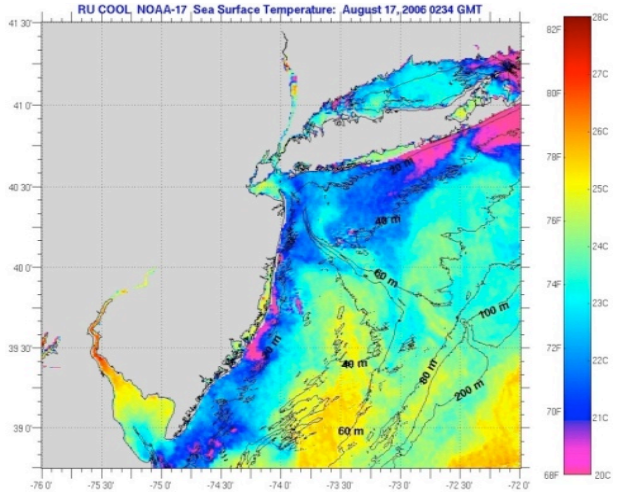

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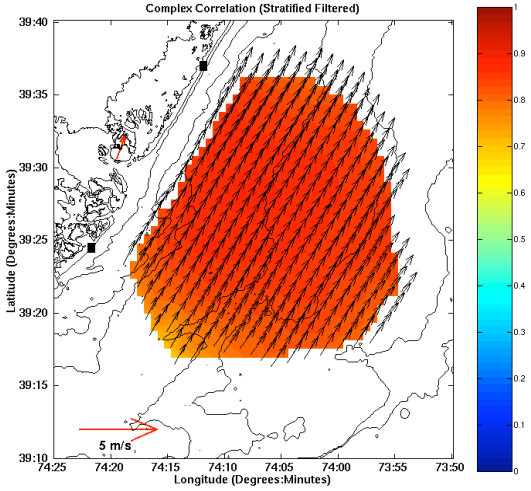

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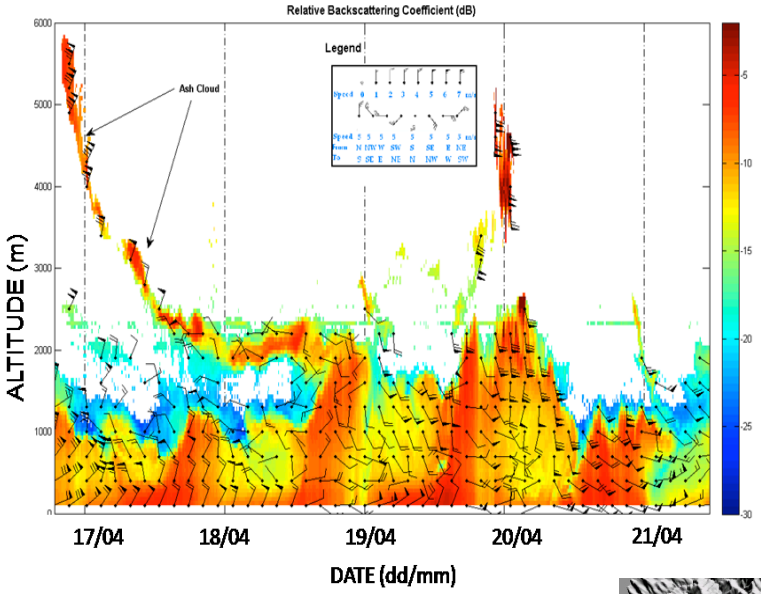
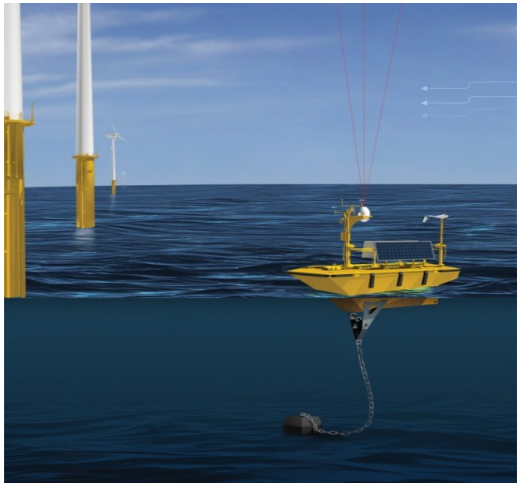
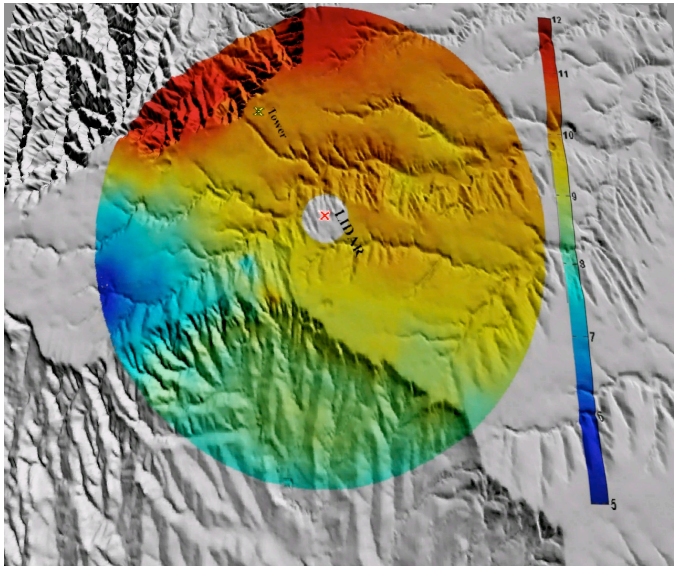


Offshore vertical LIDAR



Coastal/Offshore Scanning LIDAR



Enhanced High Resolution Coverage

13 MHz CODAR

25hr Surface Current Field (5MHz): 2012-Jun-03 23:00 (+/- 12 hours)

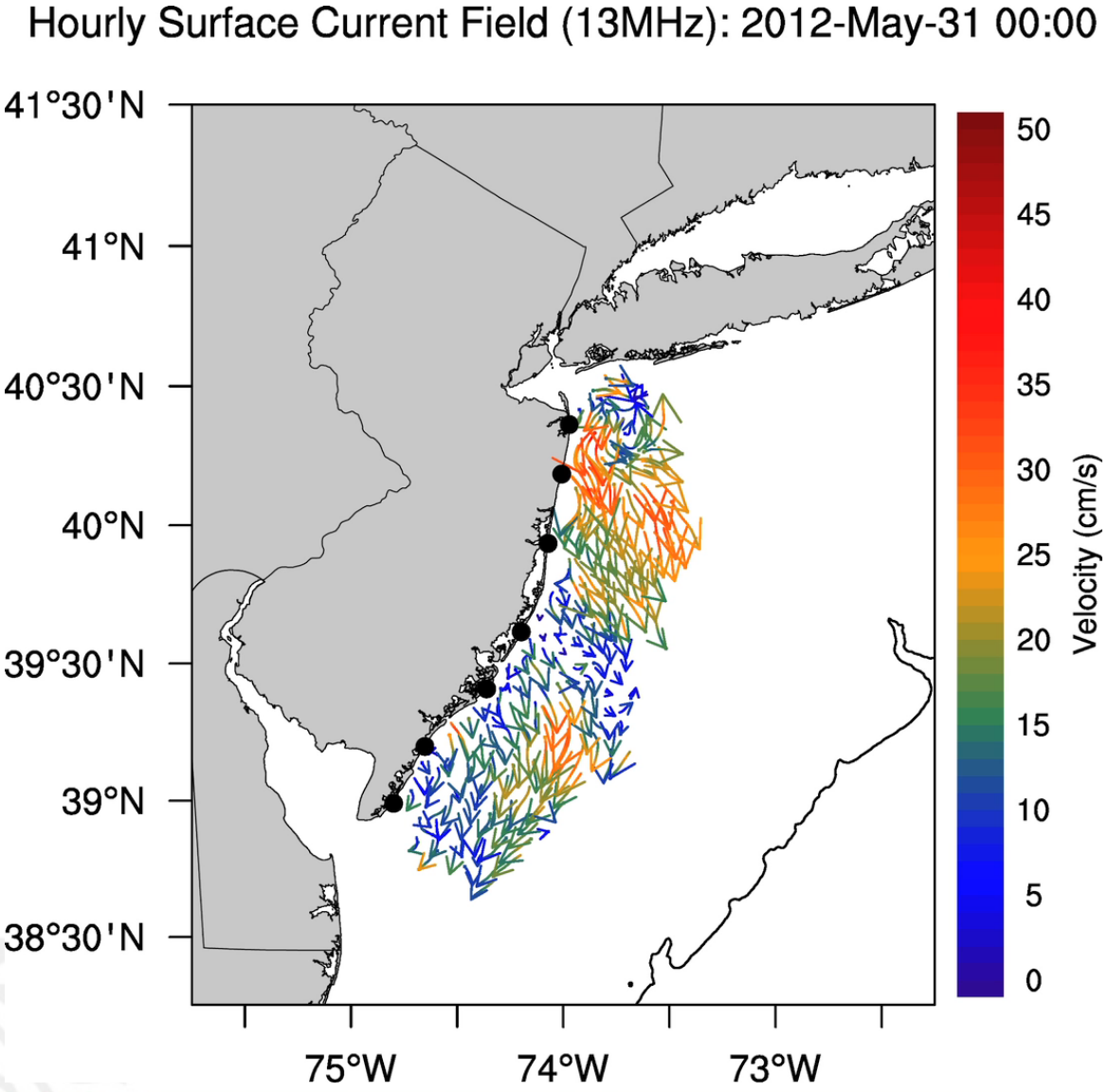
42°N
40°N
38°N
36°N
34°N
76°W
74°W
72°W
70°W

25hr Surface Current Field (13MHz): 2012-Jun-03 23:00 (+/- 12 hours)

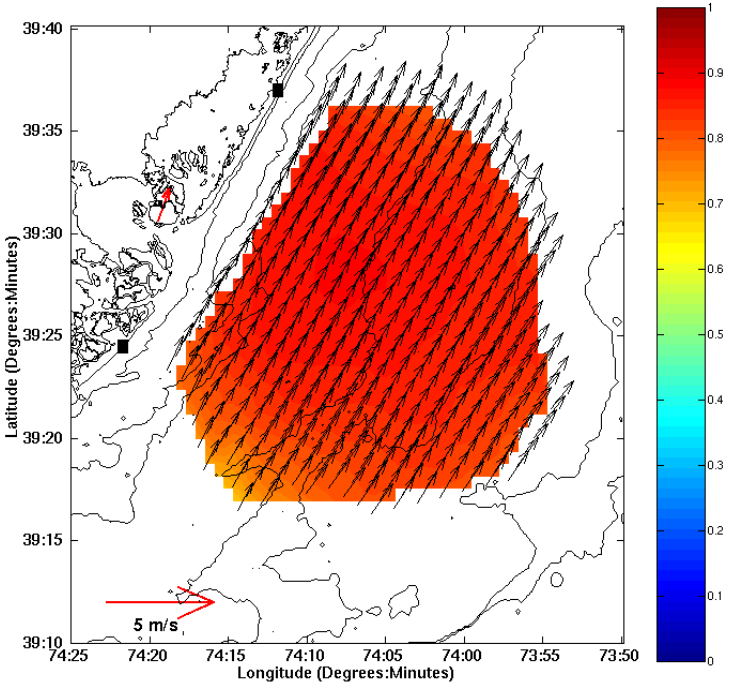
41°N
40°30'N
40°N
39°30'N
39°N
38°30'N
75°W
74°30'W
74°W
73°30'W
73°W

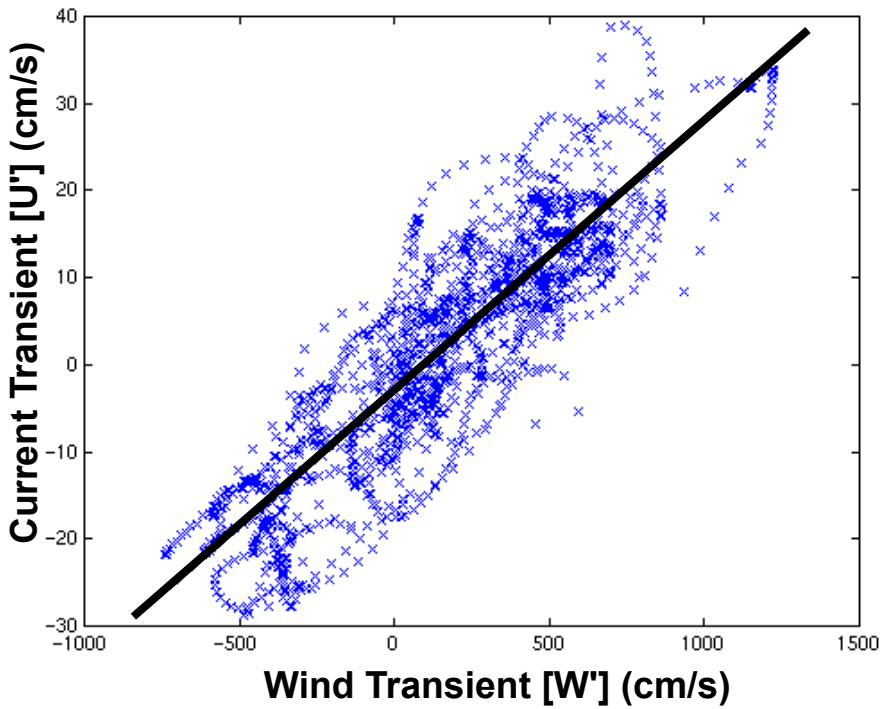
0.6
0.5
0.4
0.3
0.2
0.1
0
Current Velocity m/s

CODAR seabreeze animation



HF Radar Derived Linear Wind Model

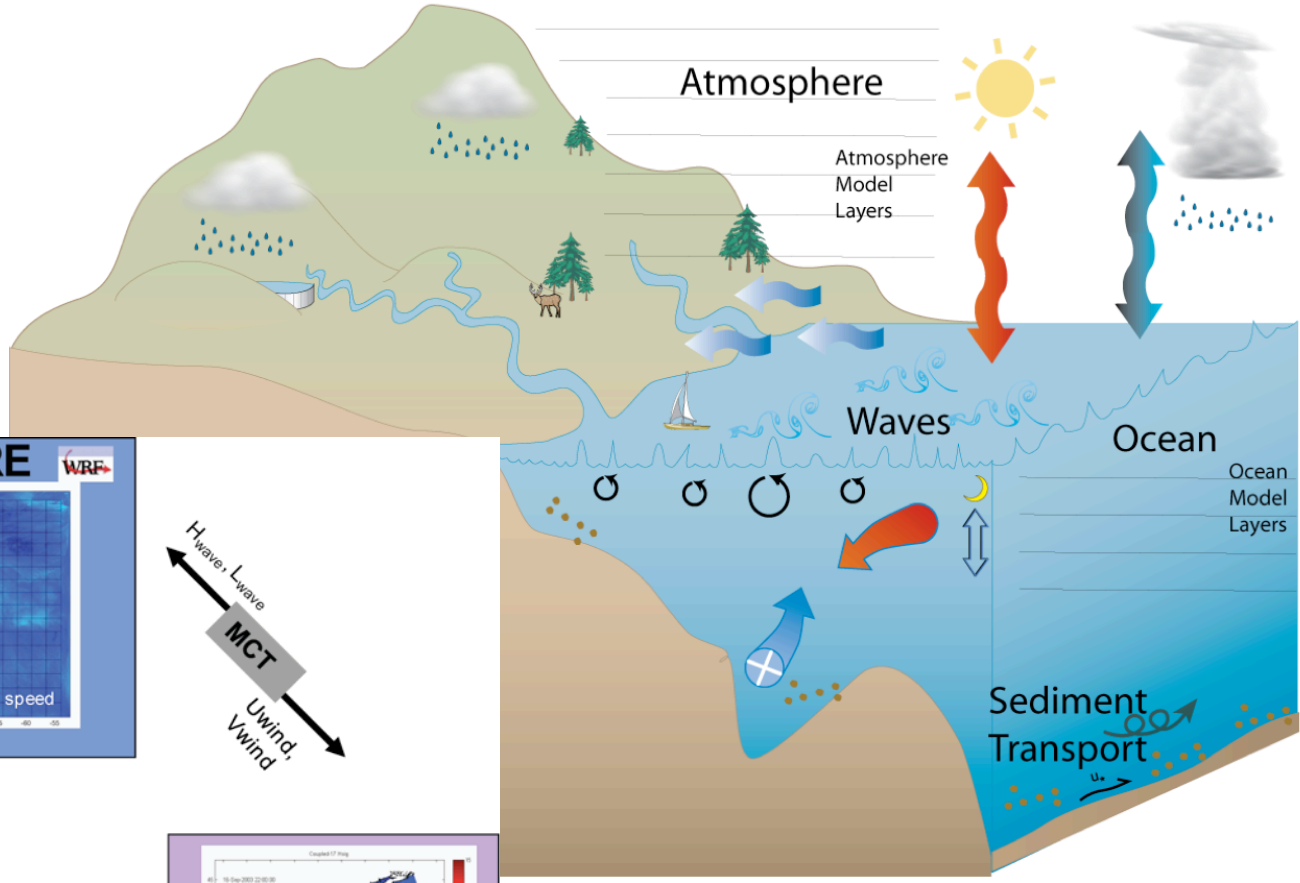


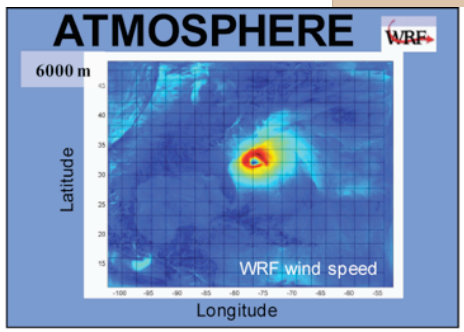


- Rotate wind vectors according to complex correlation
- Calculate the slope and intercept of best fit line

$$U'_c(x,y,t) = slope(x,y)*W'(t)$$

Atmosphere-Ocean-Wave Coupling





Uwind, Vwind, Patm, RH, Tair, cloud, rain, SWrad, LWrad

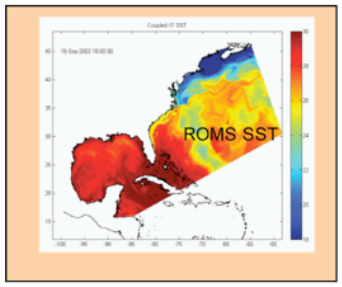
MCT

SST

H_{wave}, L_{wave}

MCT

Uwind, Vwind

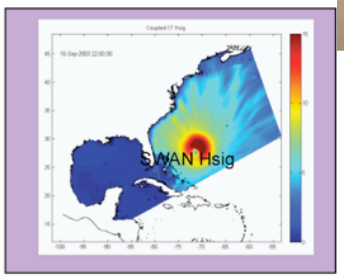


OCEAN ROMS

H_{wave}, L_{wave}, D_{wave}, T_{surf}, T_{bott}, Q_b, W_{dissip}, U_b

MCT

u_s, v_s, η, bath



WAVE SWAN

Future Possibilities

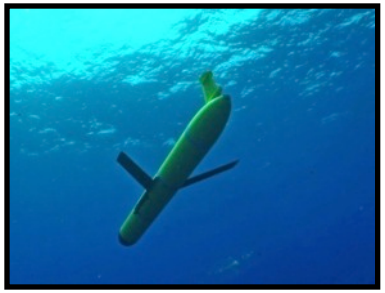
- This work can be used as a basis for a representative forecasting/predicting program
- Show economic viability of offshore wind
- Most efficient integration into grid
- Day ahead bidding of energy by utilities
- Construction, operation, maintenance

Rutgers University - Coastal Ocean Observation Lab

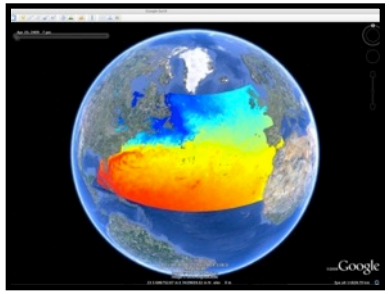
Operations, Research & Education Center

Satellite Data Acquisition Stations

CODAR Network



Glider Fleet



3-D Forecasts