

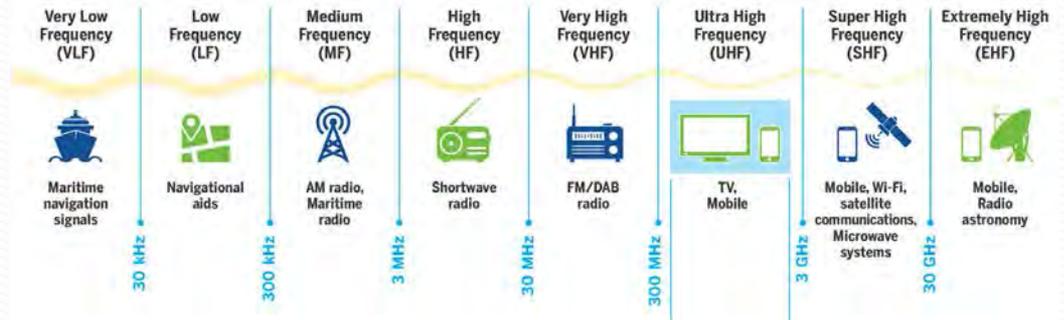
Coastal HF Radar Theory and Applications

A Presentation for
The Oil Spill Technology Symposium
Hank Statscewich
March 29, 2018



What Is HF Radar?

- HF = High Frequency
- Radio Station



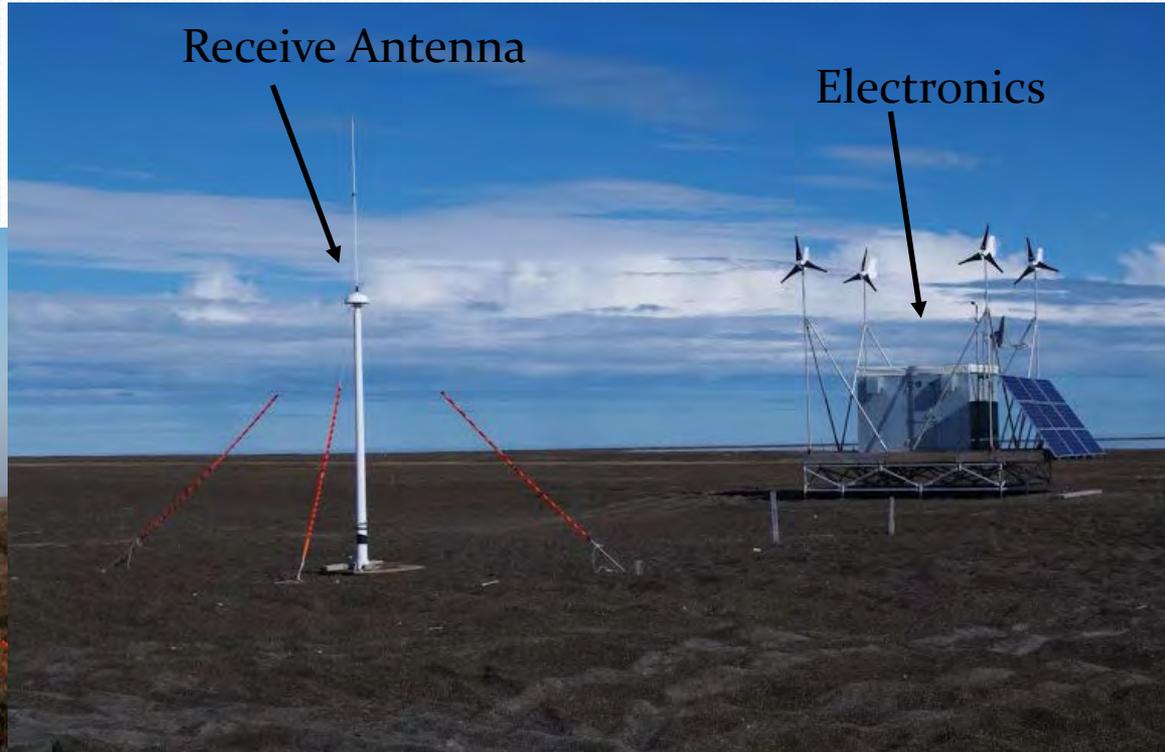
Transmit Antenna



Receive Antenna



Electronics

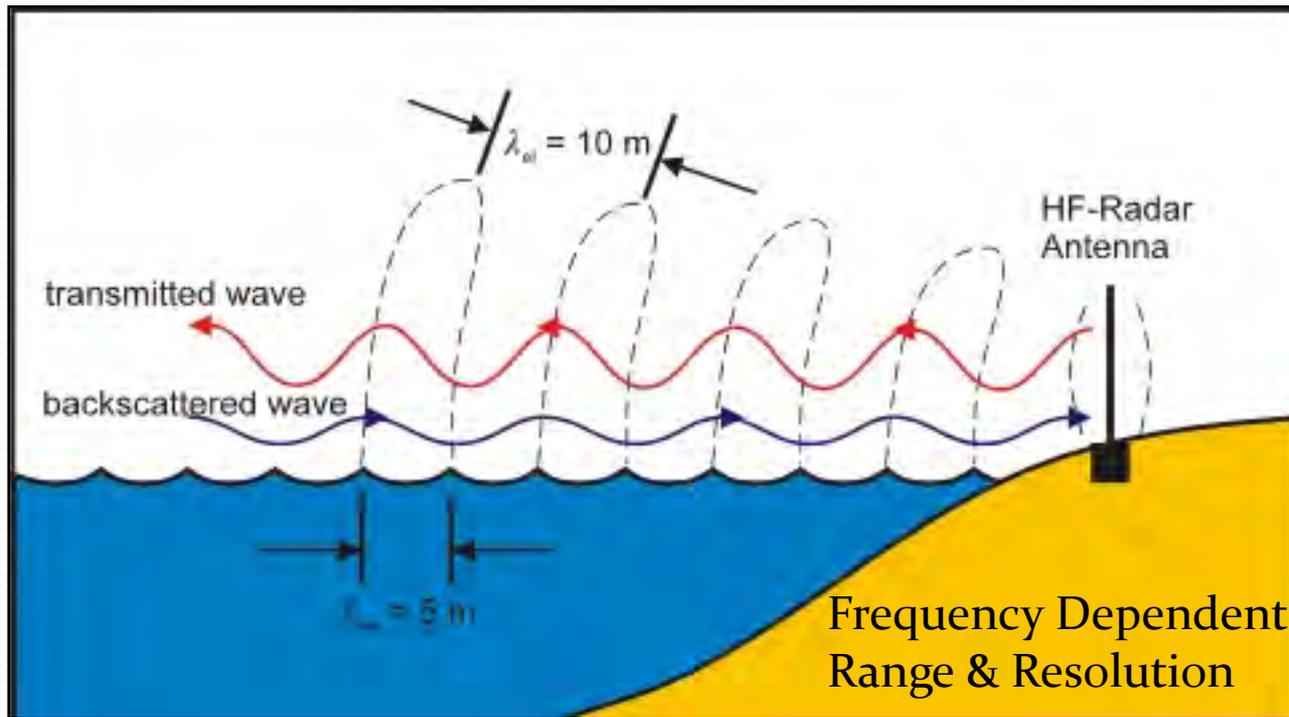


What does it sound like?



How Does it Work?

Bragg Scattering: wavelength of scattering waves is $\frac{1}{2}$ transmit wavelength



5 mHz = 30 m Waves

12 mHz = 12.5 m Waves

25 mHz = 6 m Waves

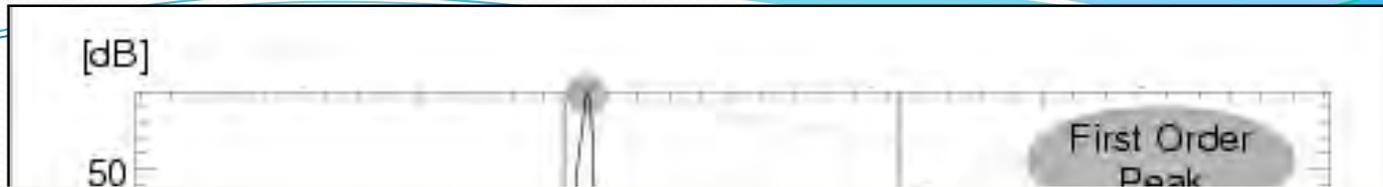
180 km Coverage at 5 km Resolution

80 km Coverage at 1 km Resolution

40 km Coverage at 0.25 km Resolution

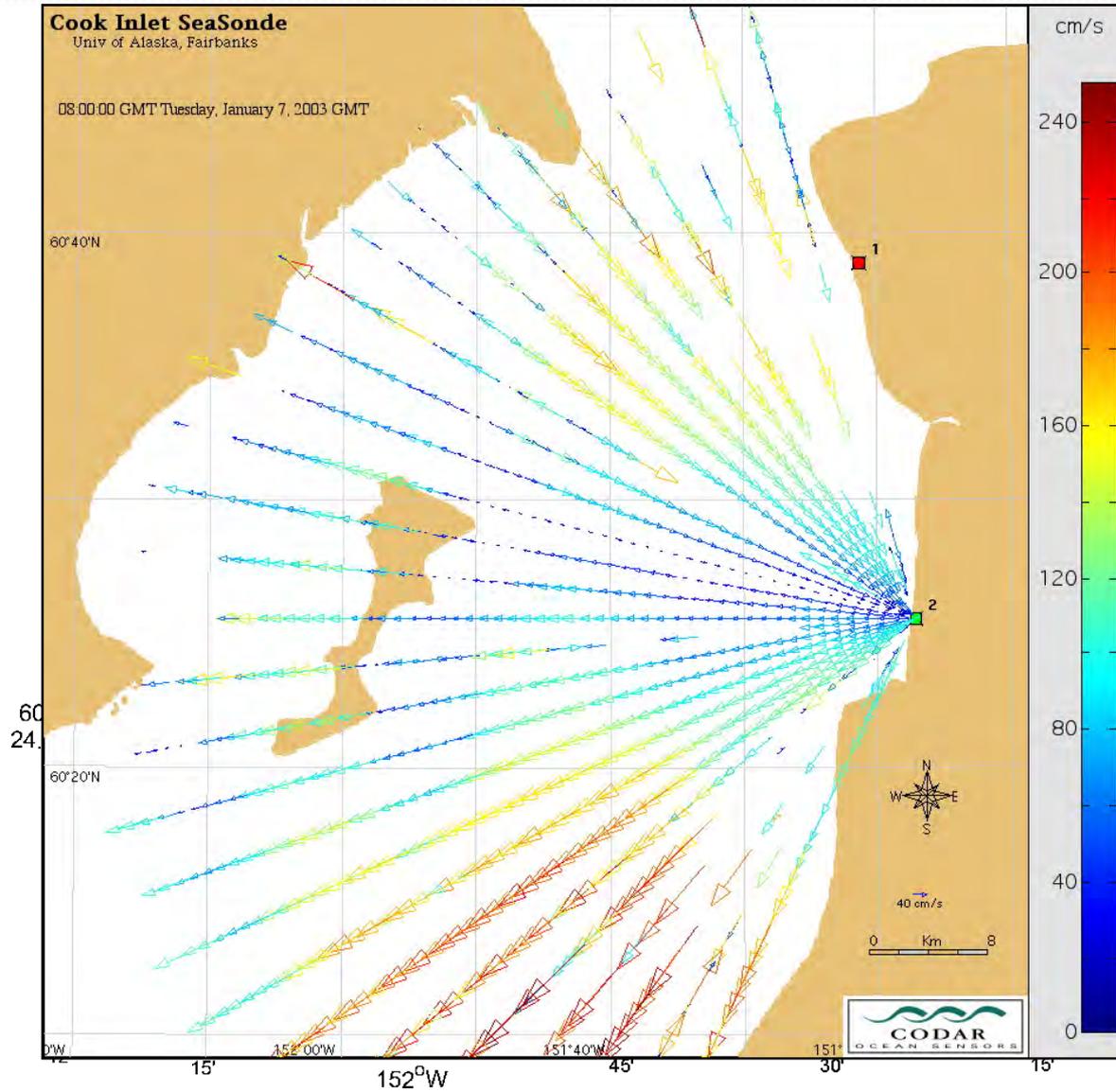
Wave Periods are between 1.5 - 5 seconds

Example Raw Data: Doppler Spectrum from a Radial Site

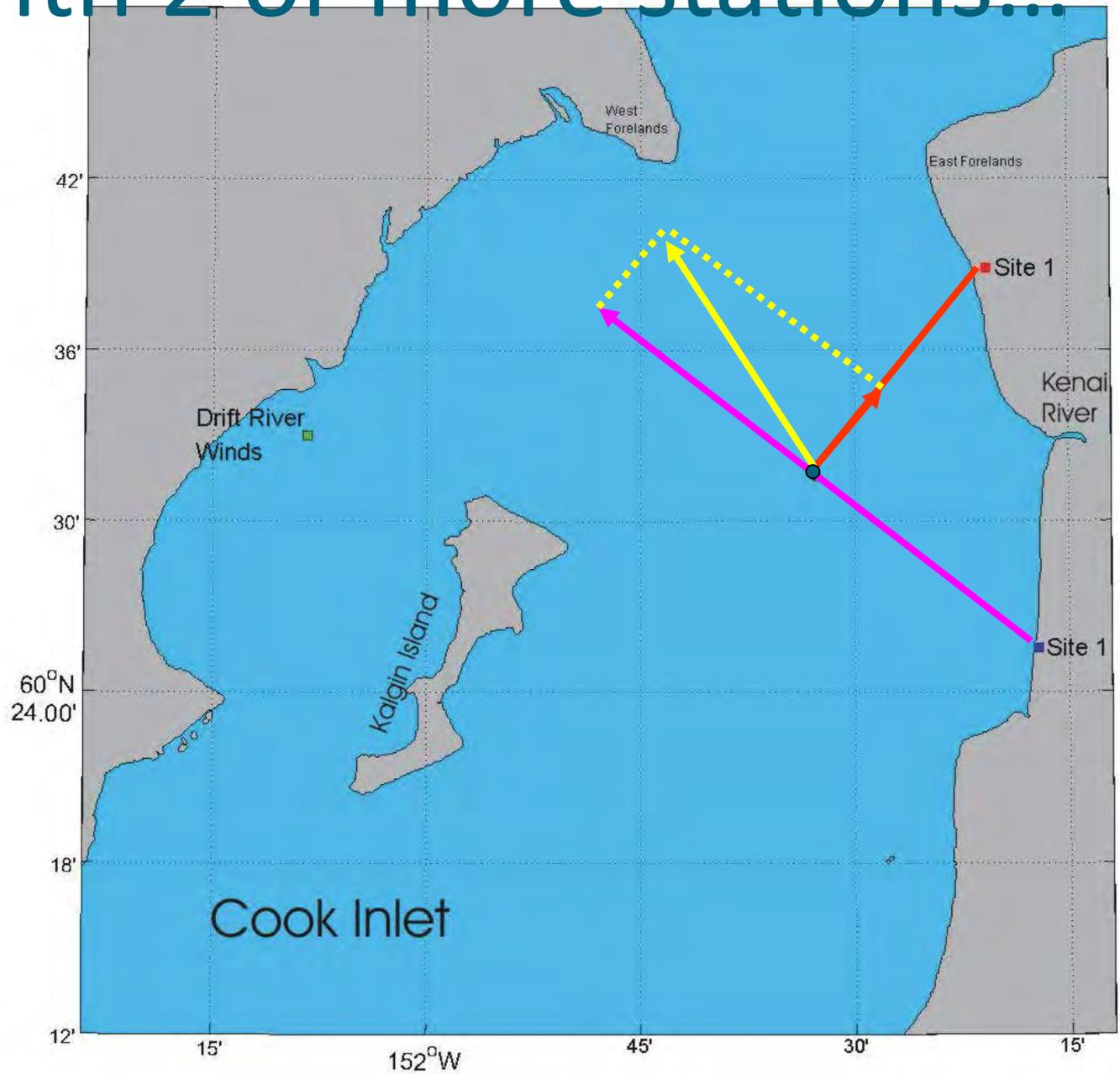


- The shift in Doppler spectrum represents moving ocean waves plus the surface currents carrying the ocean waves.
- Ocean wave speed is known via dispersion relation so the velocity of the surface current can be back calculated.

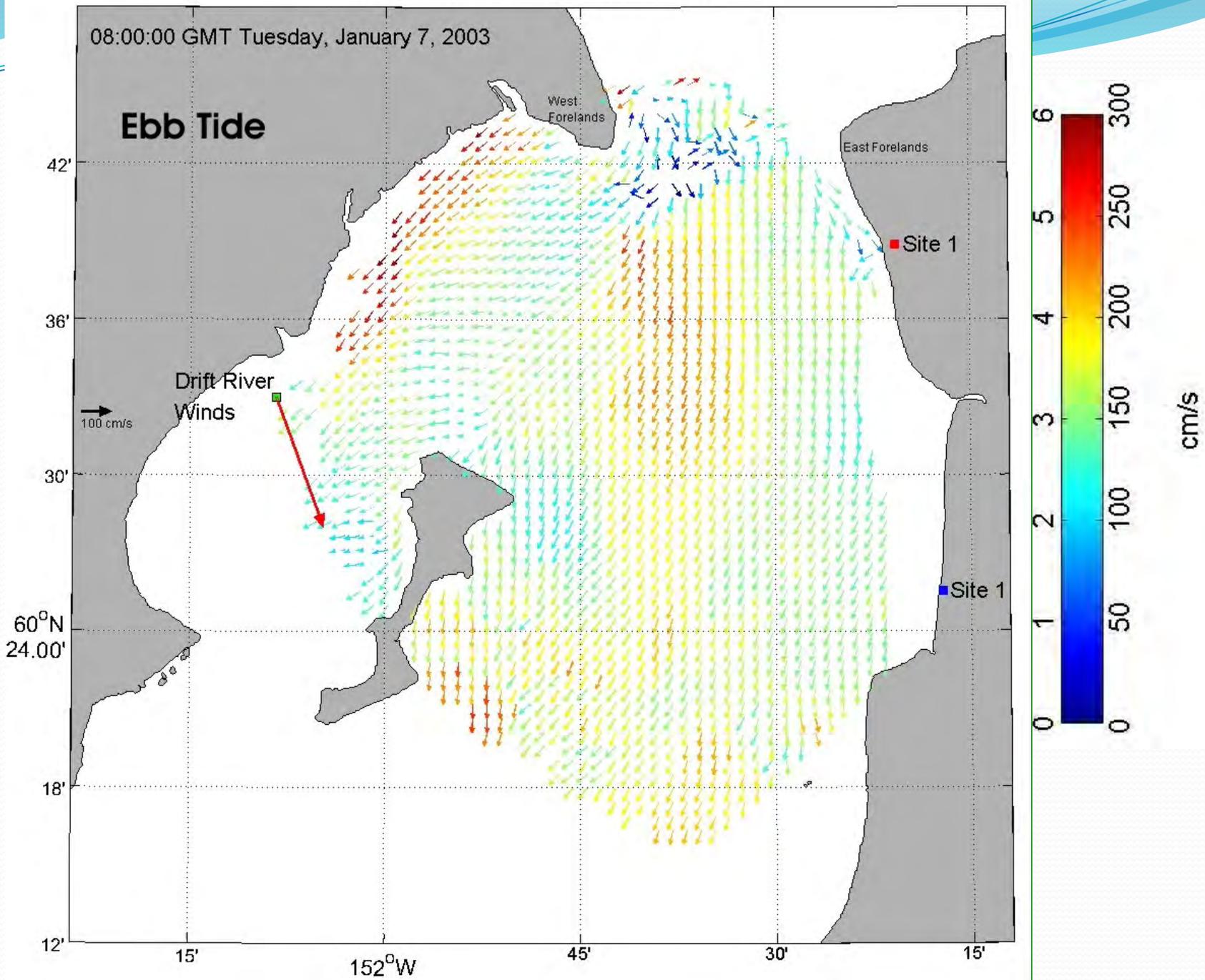
What does it do?



With 2 or more stations...



Cook Inlet CODAR Surface Currents



350+ Global HF Radar Installations





Prudhoe Bay

ALASKA

(United States)

PWS

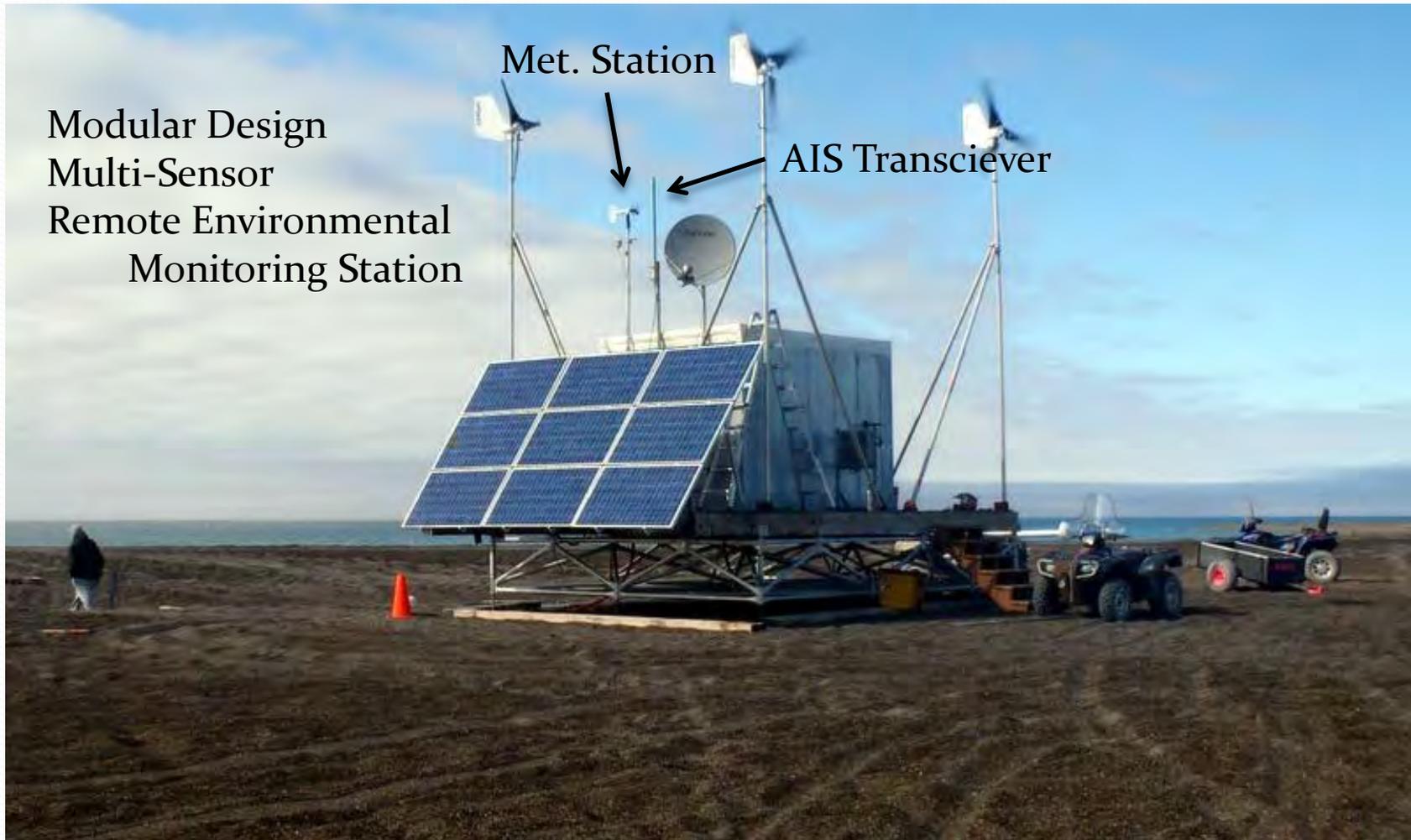
Outer Gulf Coast (OGC)

Remote Power Module (RPM): 2010 - Present

8 Years of Continuous Operations

Fully-automated, arctic hardened and tested, renewable (solar and wind) hybrid power station provide power & realtime telemetry to HF radar, AIS and other environmental sensors.

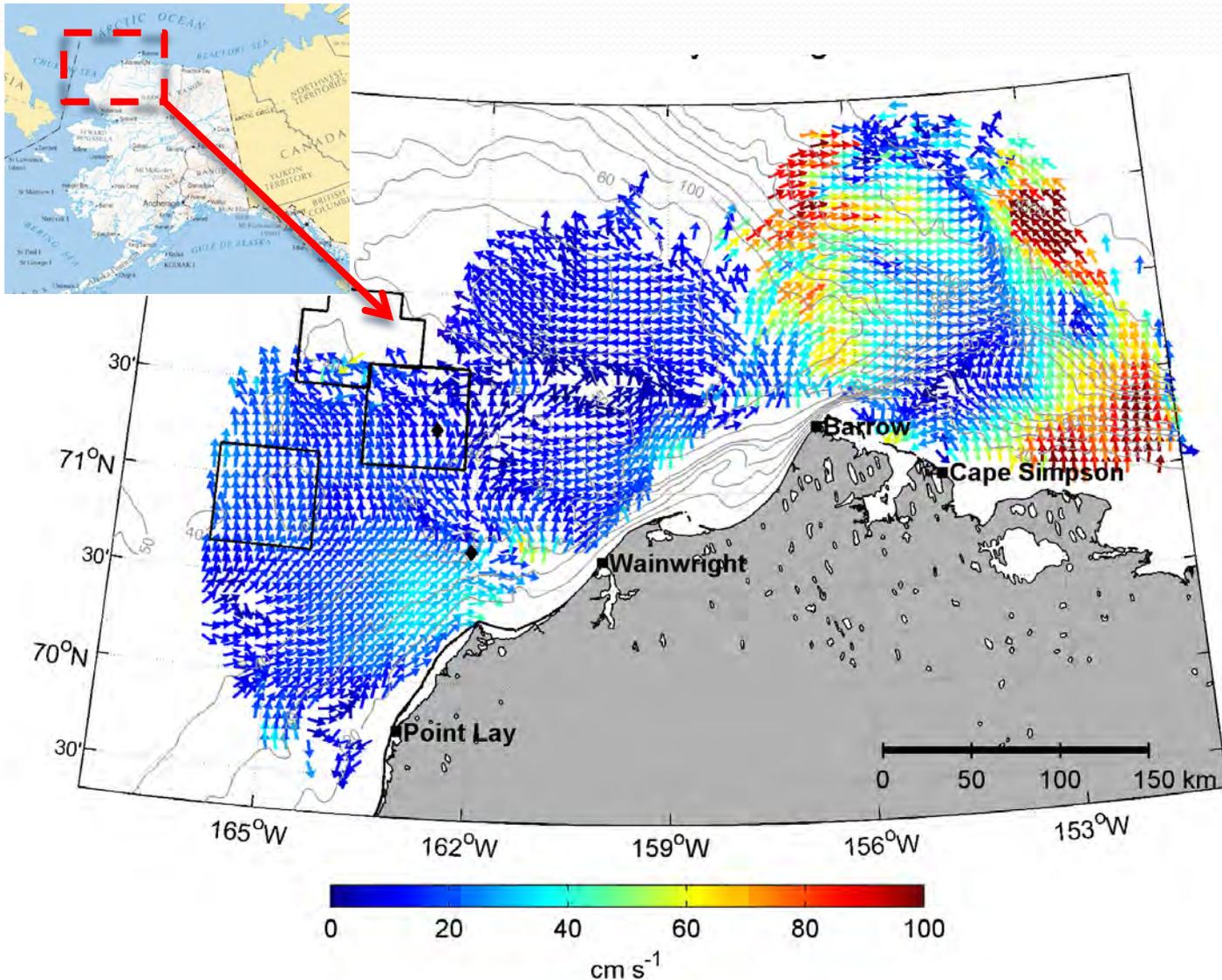
Modular Design
Multi-Sensor
Remote Environmental
Monitoring Station



Applications?

- Ocean Circulation
- Waves
- Search and Rescue
- Vessel Tracking
- Contaminant Spills
 - Particle Tracking
 - Higher Accuracy Trajectory Modeling
- Marine Navigation
- Marine Ecosystem/Fisheries Applications

Ocean Circulation Measurements



5 MHz Long-Range Network

6-km Grid Covering 80,000 km²

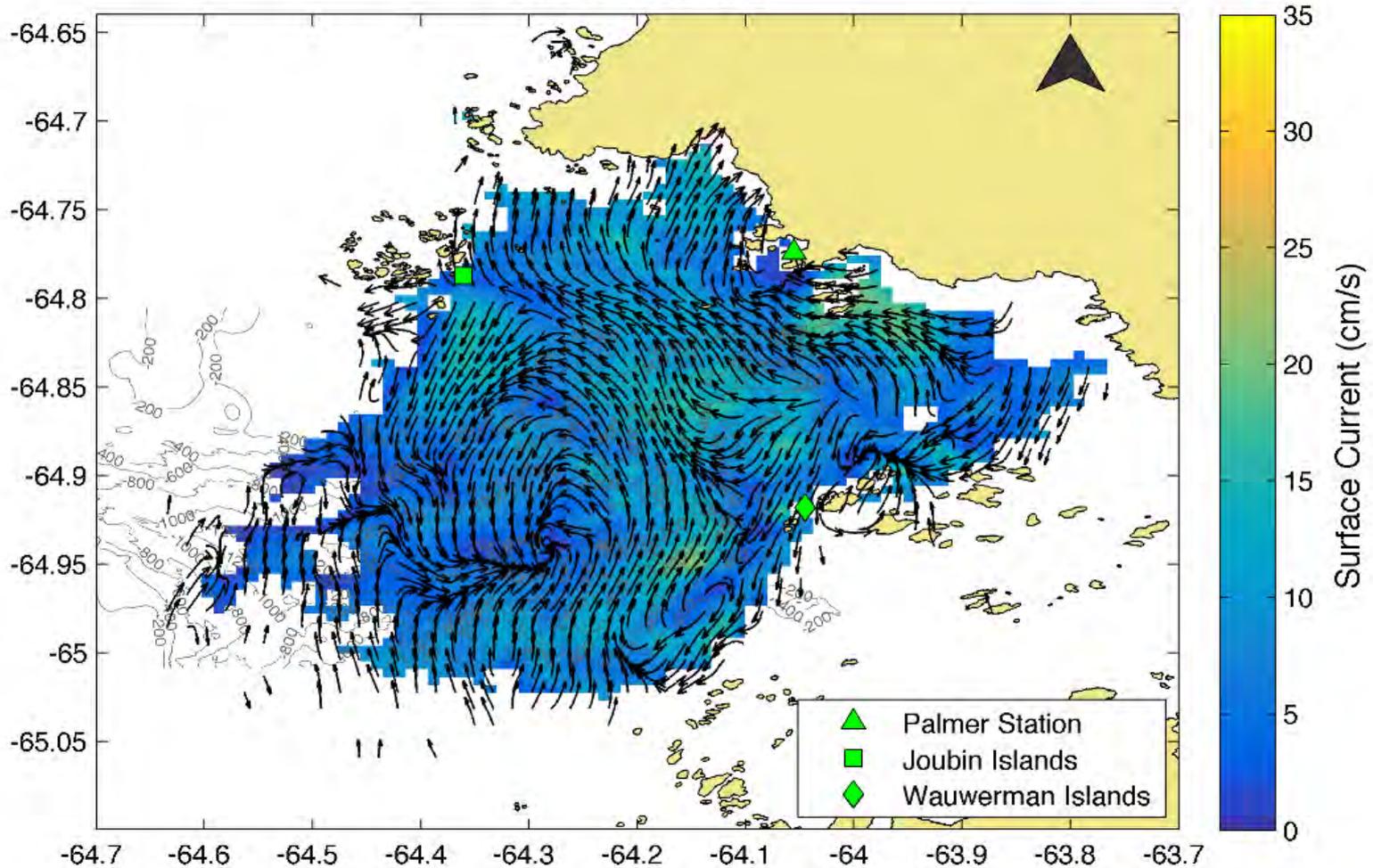
Hourly Measurements in real-time

Already incorporated into NOAA'S Arctic ERMA

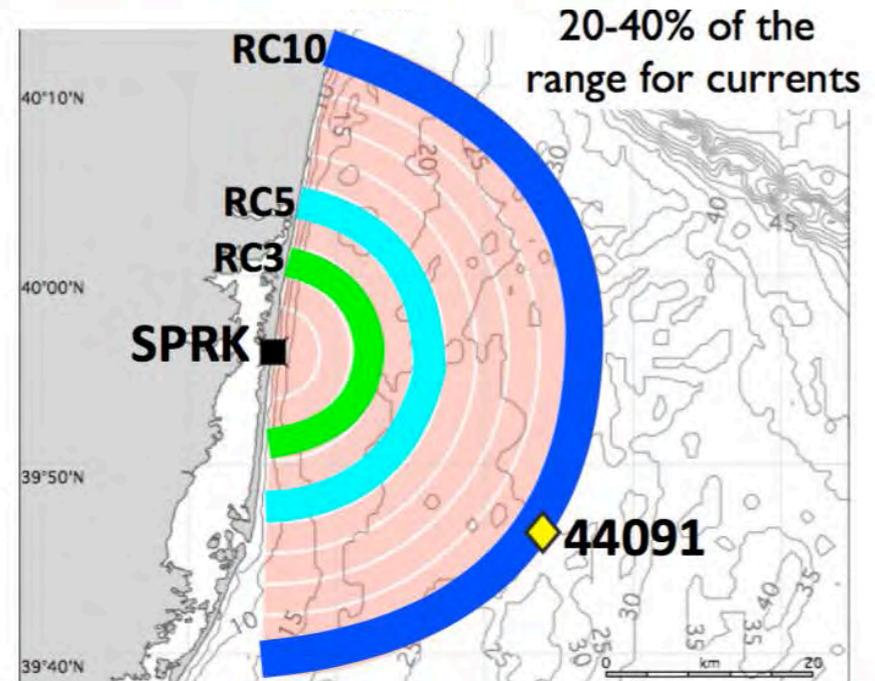
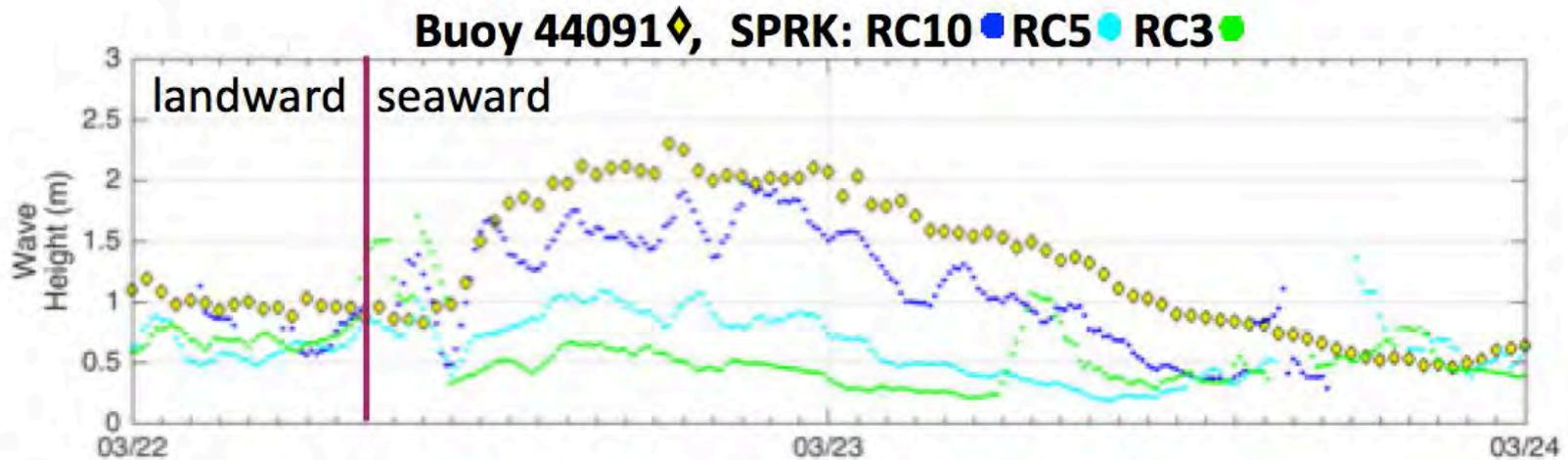
Does it Work In Ice?



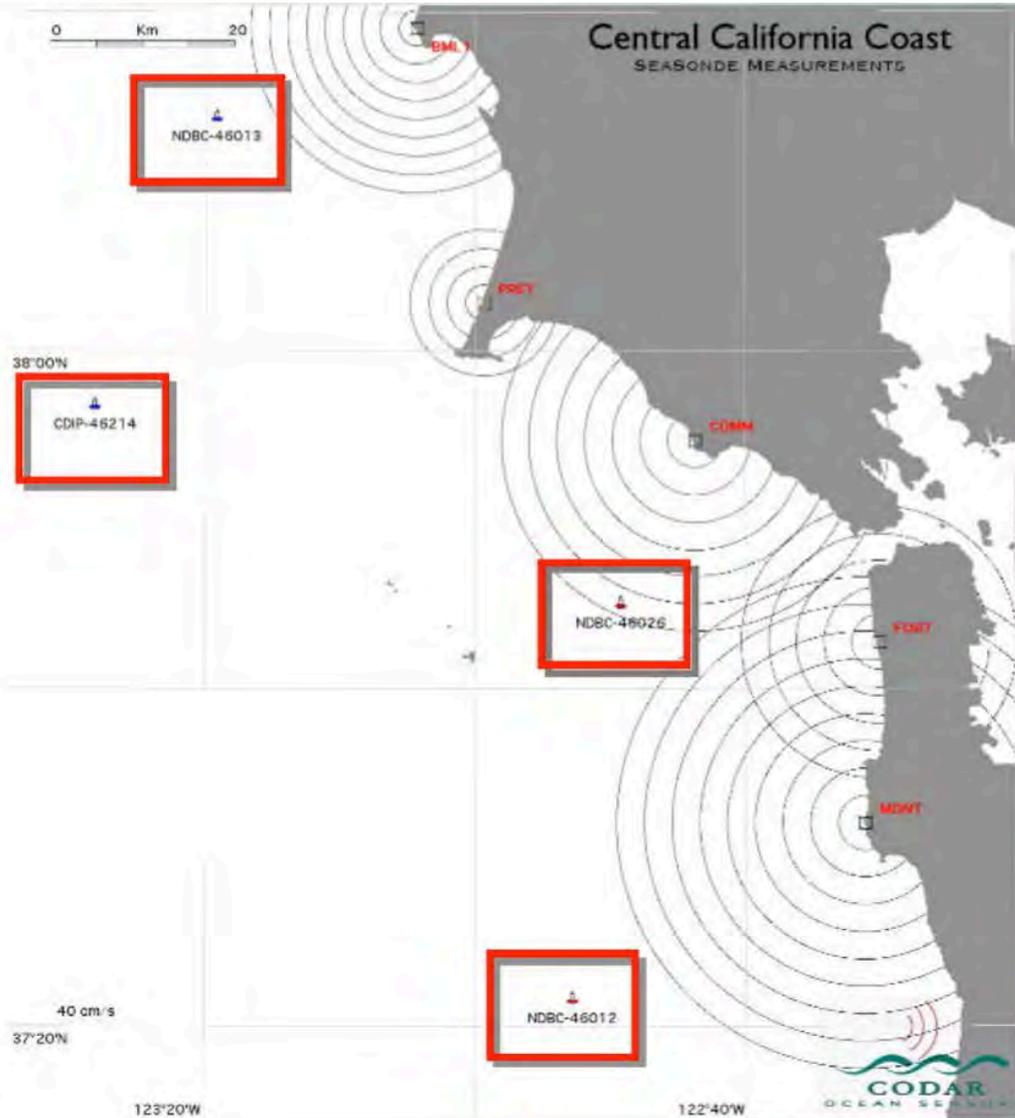
Ocean Circulation Measurements



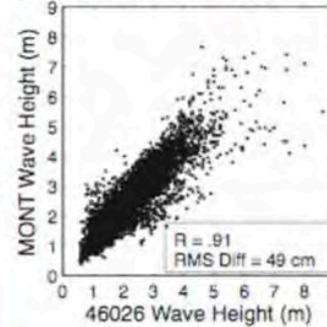
Wave Measurements



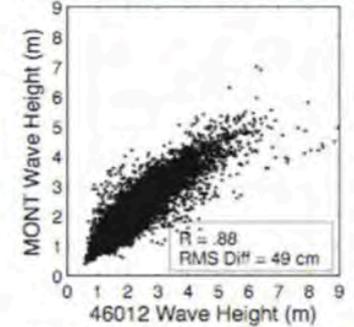
Wave Measurements



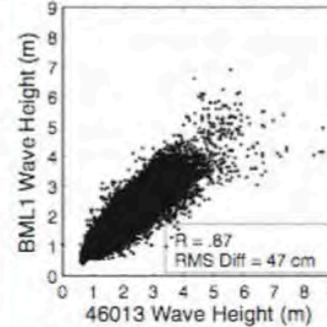
46026 v. MONT Wave Height Scatterplot



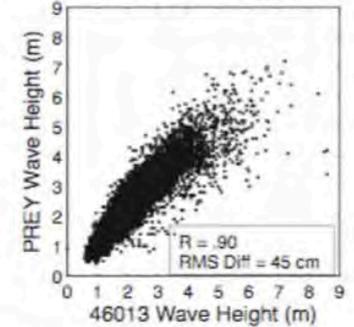
46012 v. MONT Wave Height Scatterplot



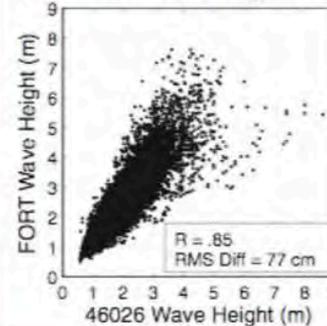
46013 v. BML1 Wave Height Scatterplot



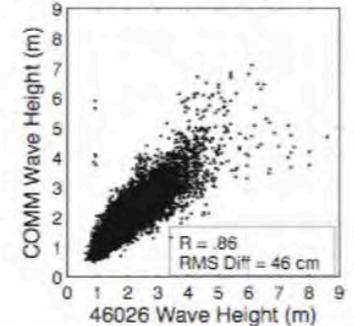
46013 v. PREY Wave Height Scatterplot



46026 v. FORT Wave Height Scatterplot



46026 v. COMM Wave Height Scatterplot



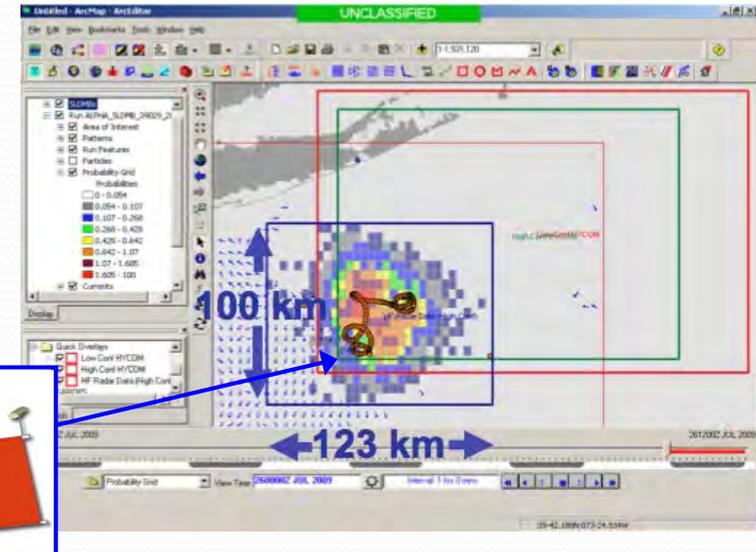
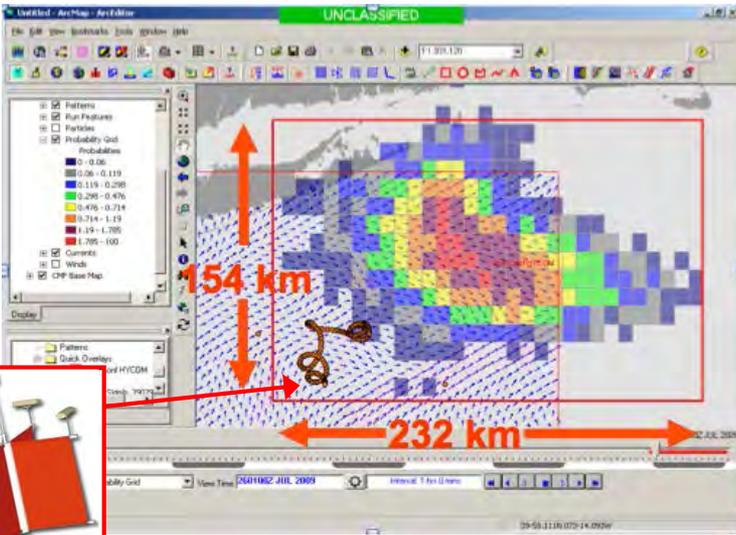
Search and Rescue

U.S. Coast Guard: Search And Rescue Optimal Planning System



East Coast HF Radar Network – 15 Sites

Mid-Atlantic Operational Data Flow to SAROPS

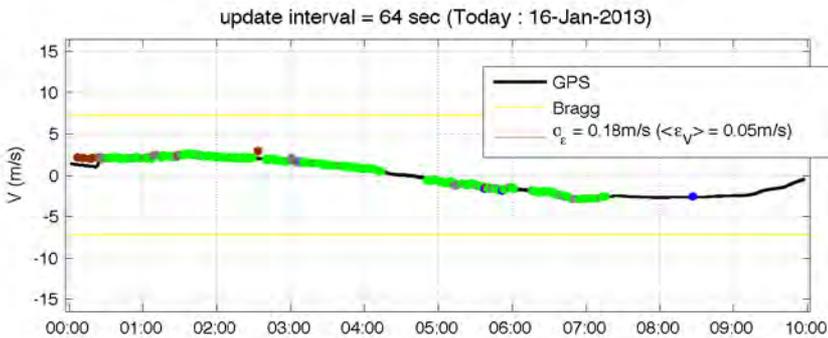
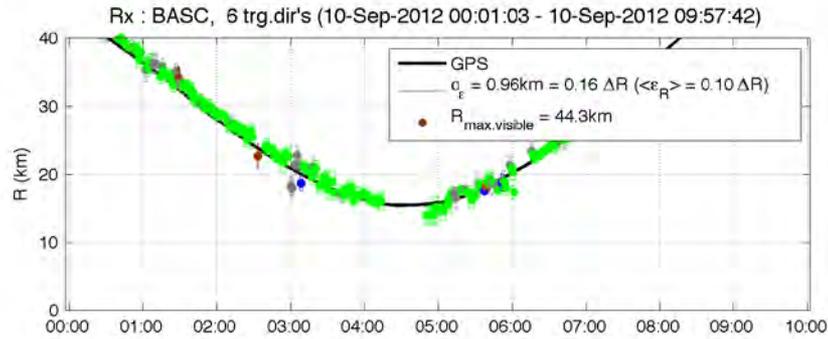


SAROPS 96-Hour Search Area: **HYCOM = 36,000 km²**

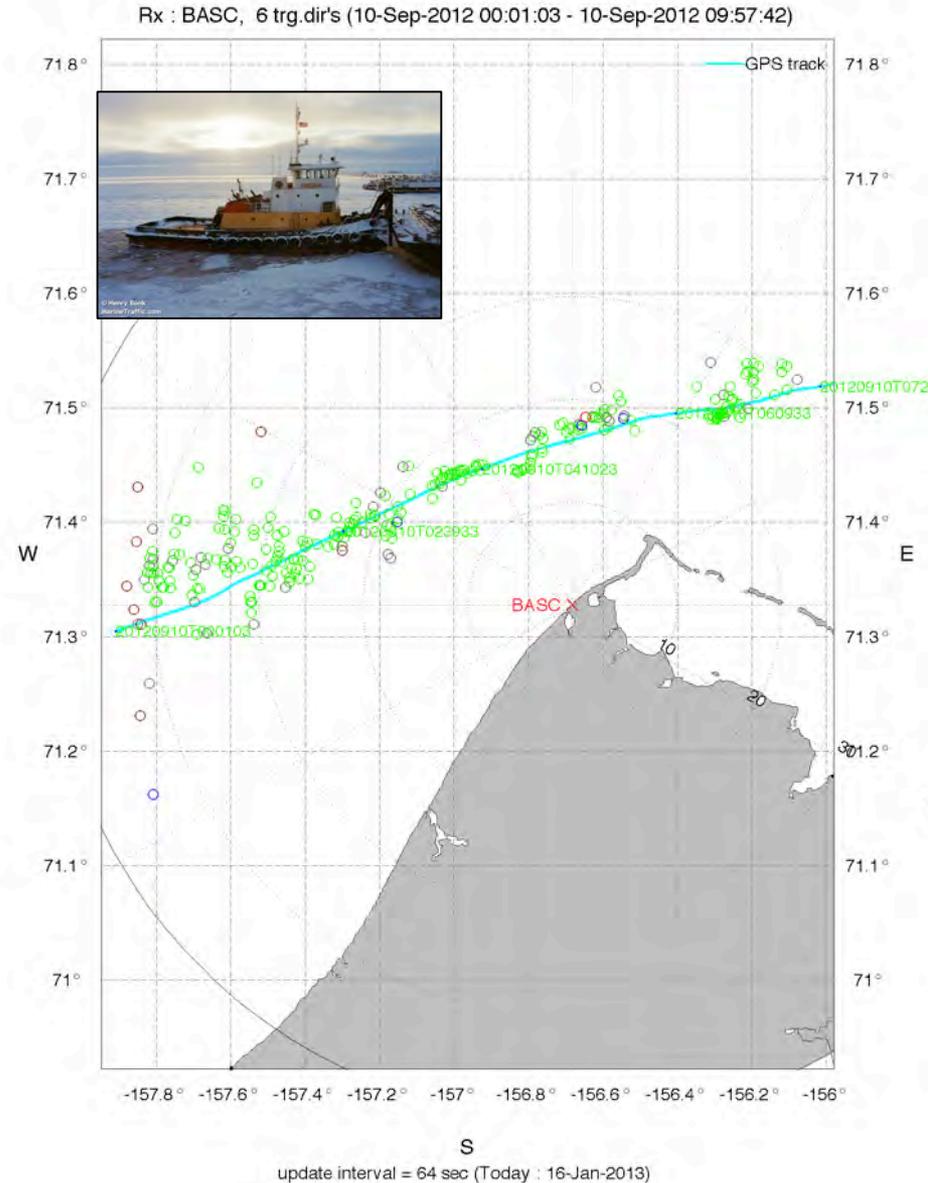
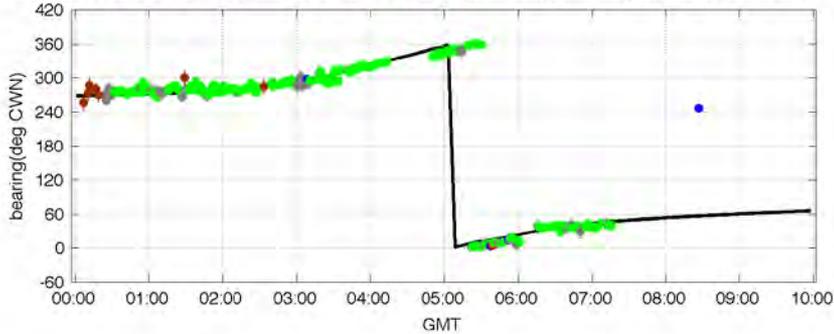
SAROPS 96-Hour Search Area: **HF Radar = 12,000 km²**

Search area was reduced by 66%

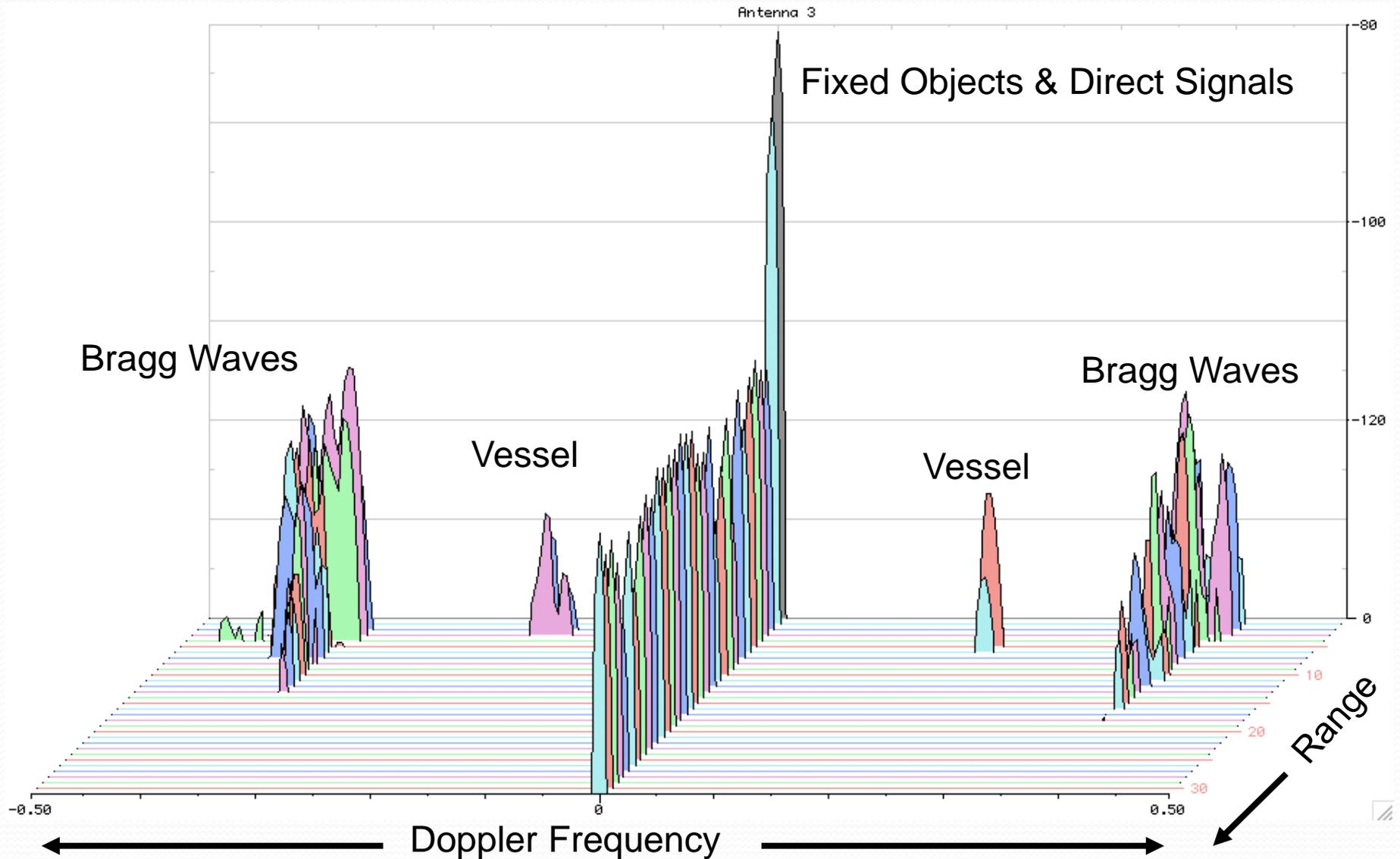
Vessel Tracking

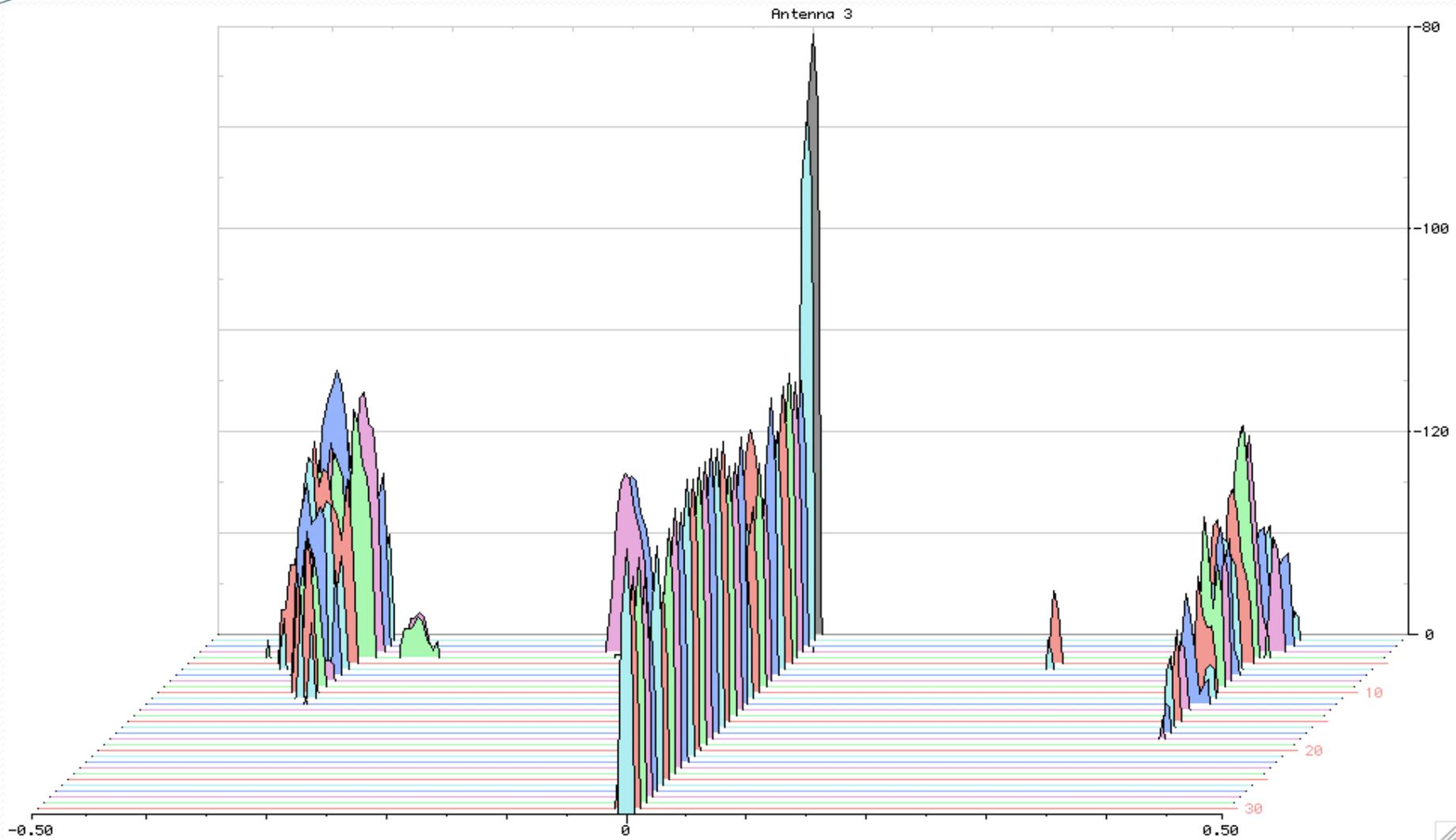


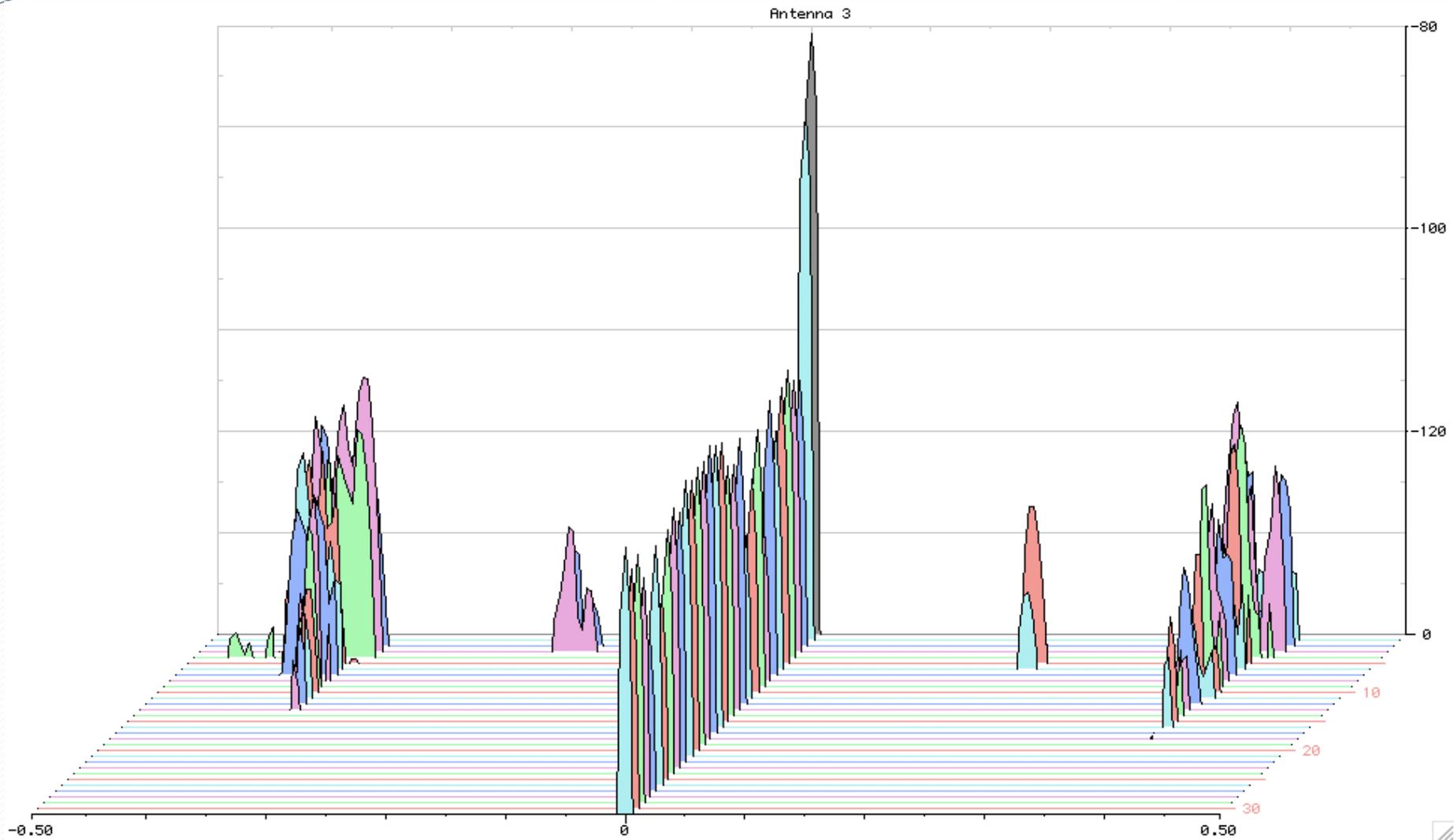
Detection Rate = 49.4%, RMSerr = 107.7° (99.4° excluding outliers), Mean Error = 37.7°

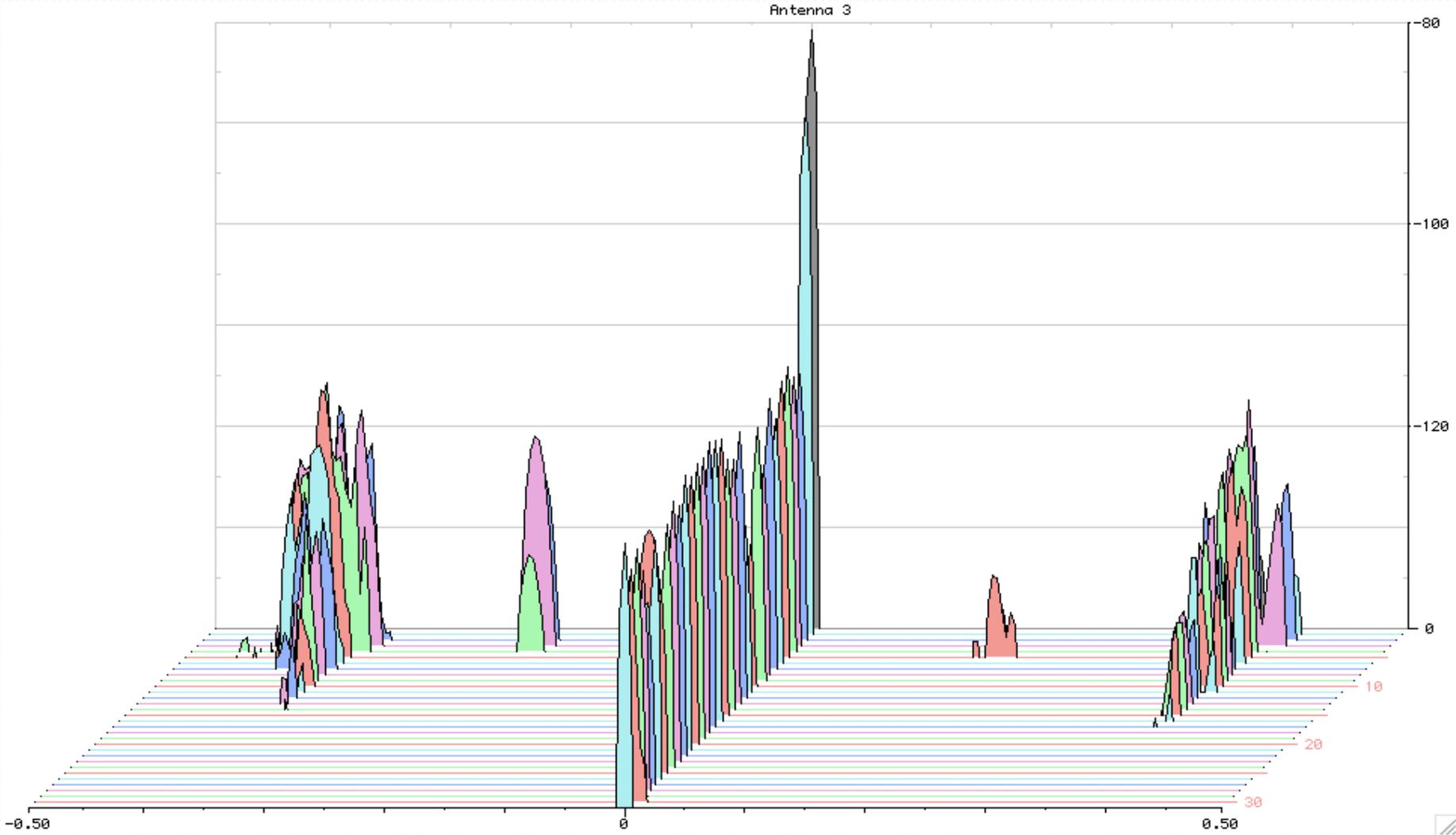


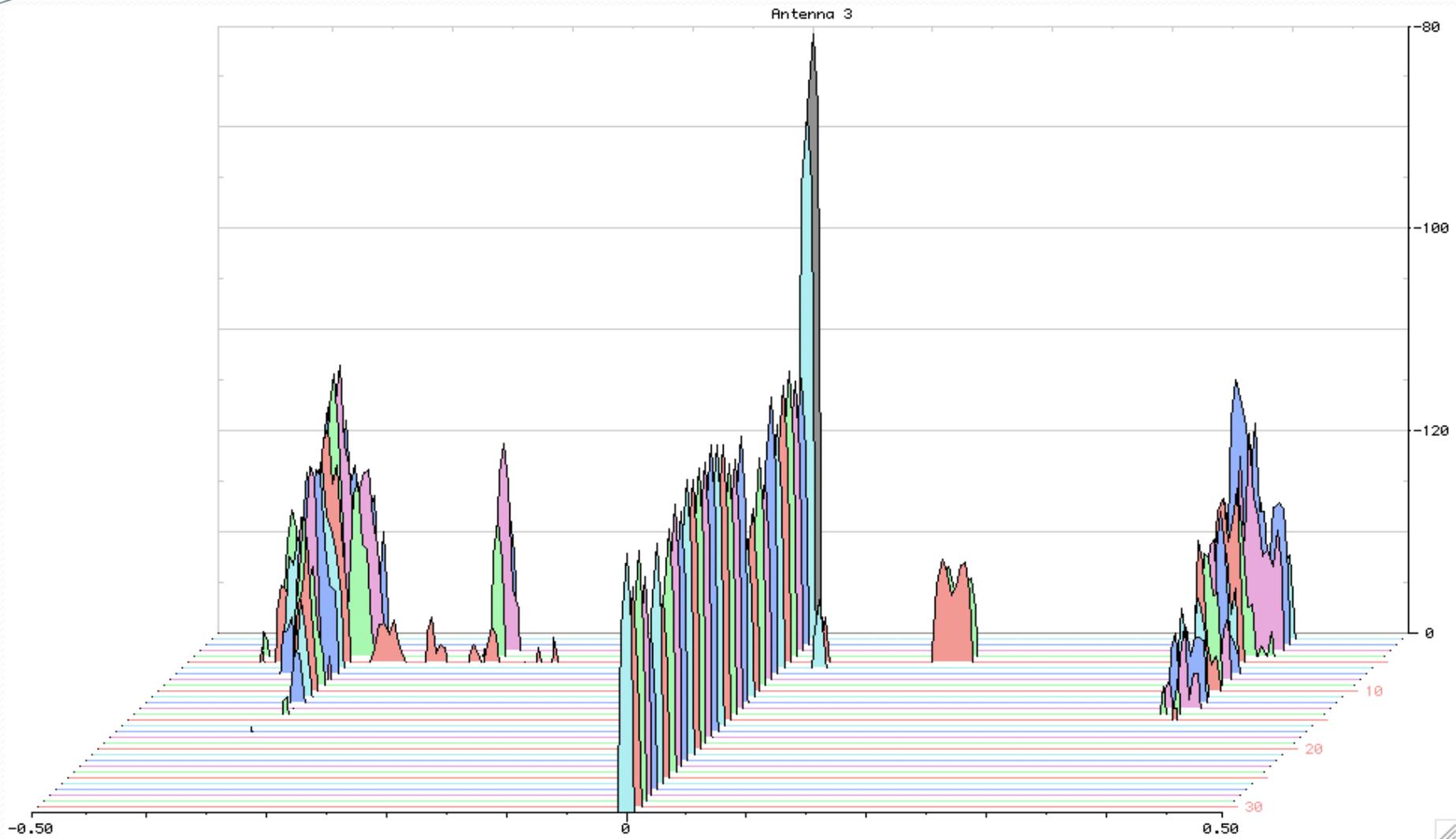
Doppler Spectra from all Range Cells with Detection Algorithm Applied



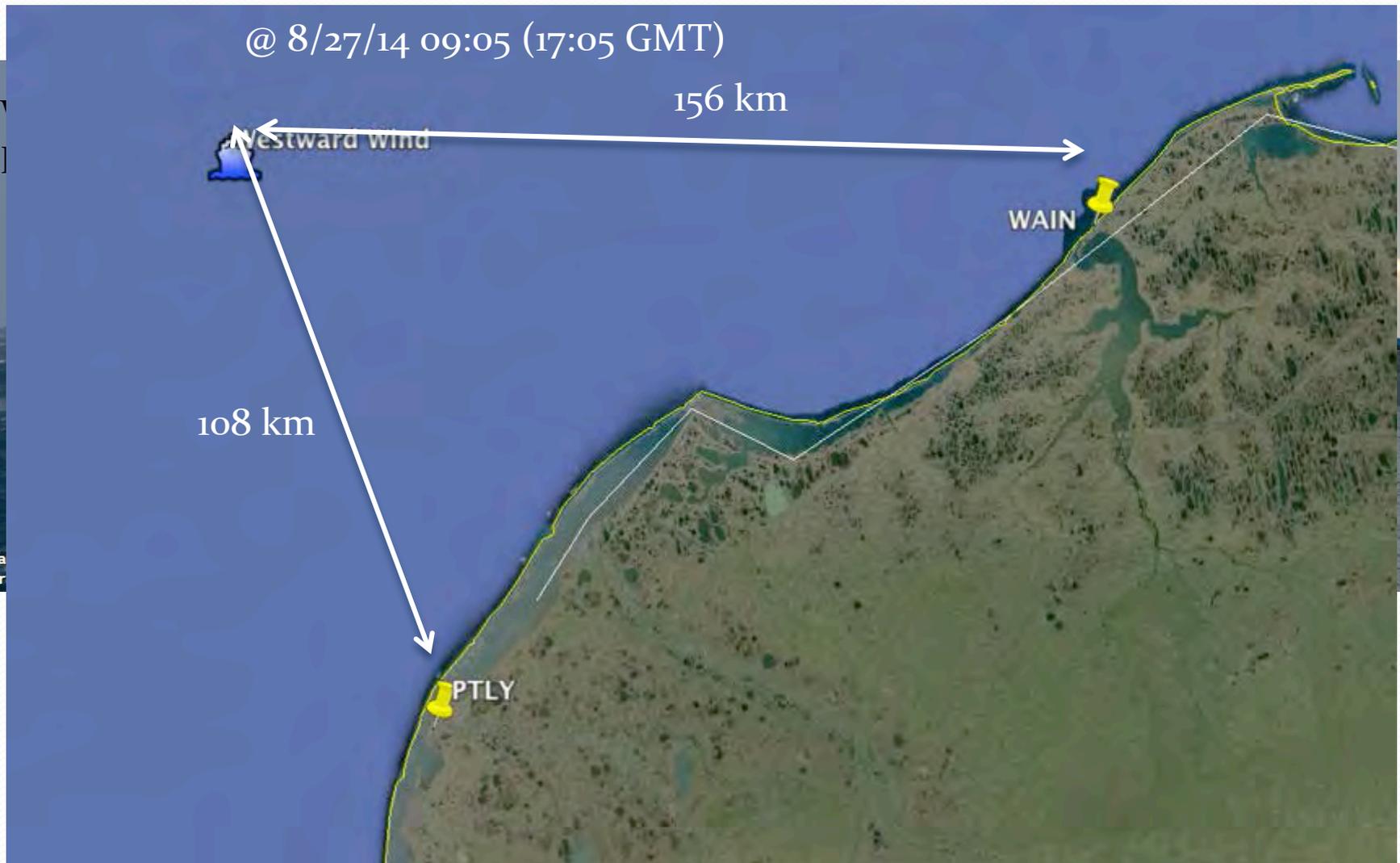




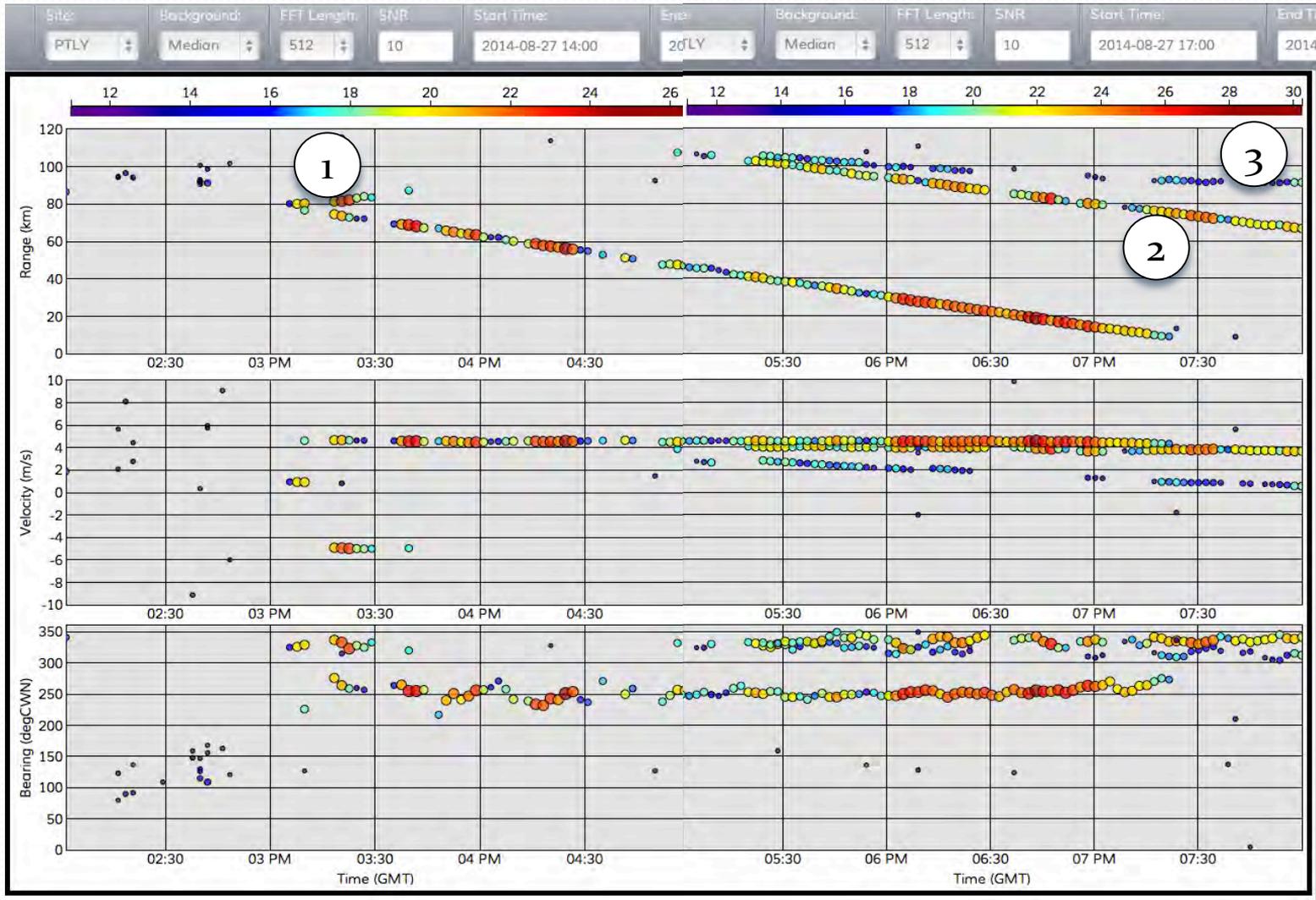




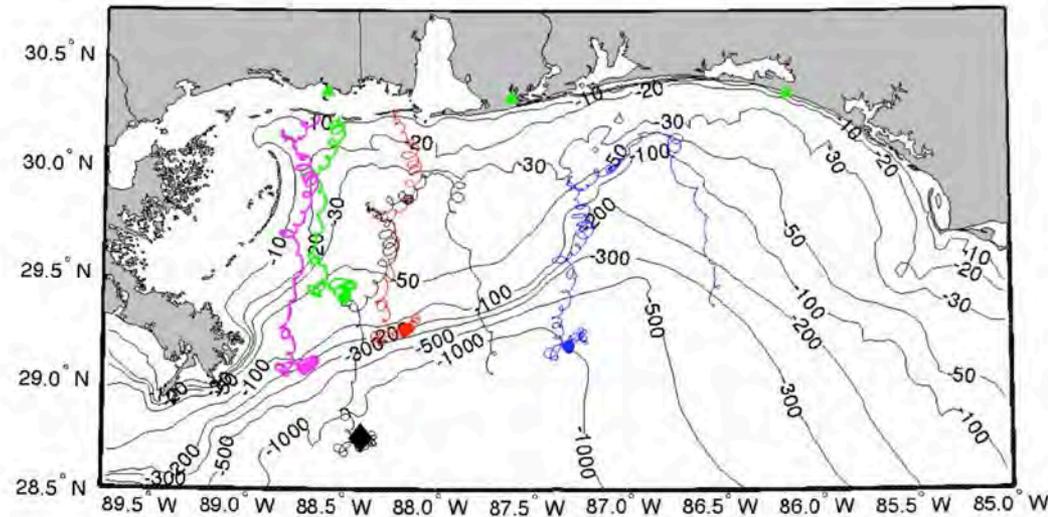
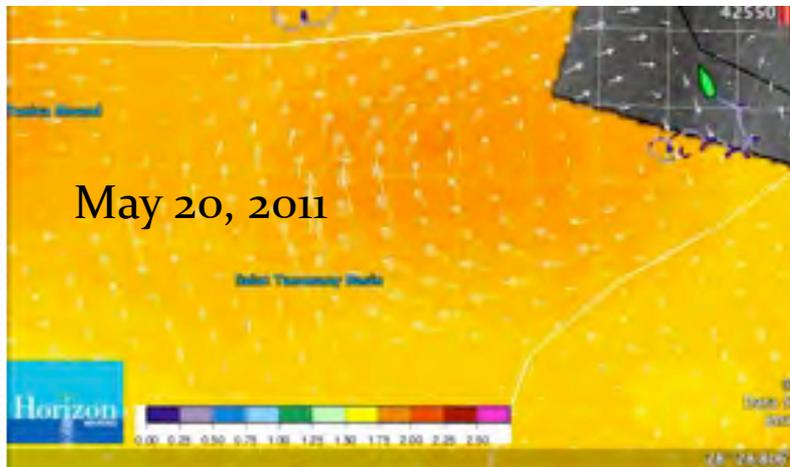
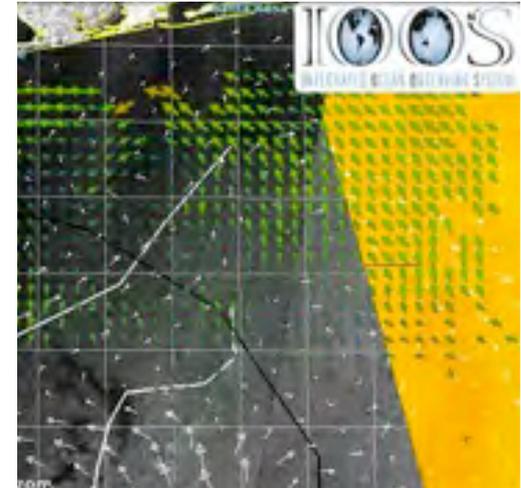
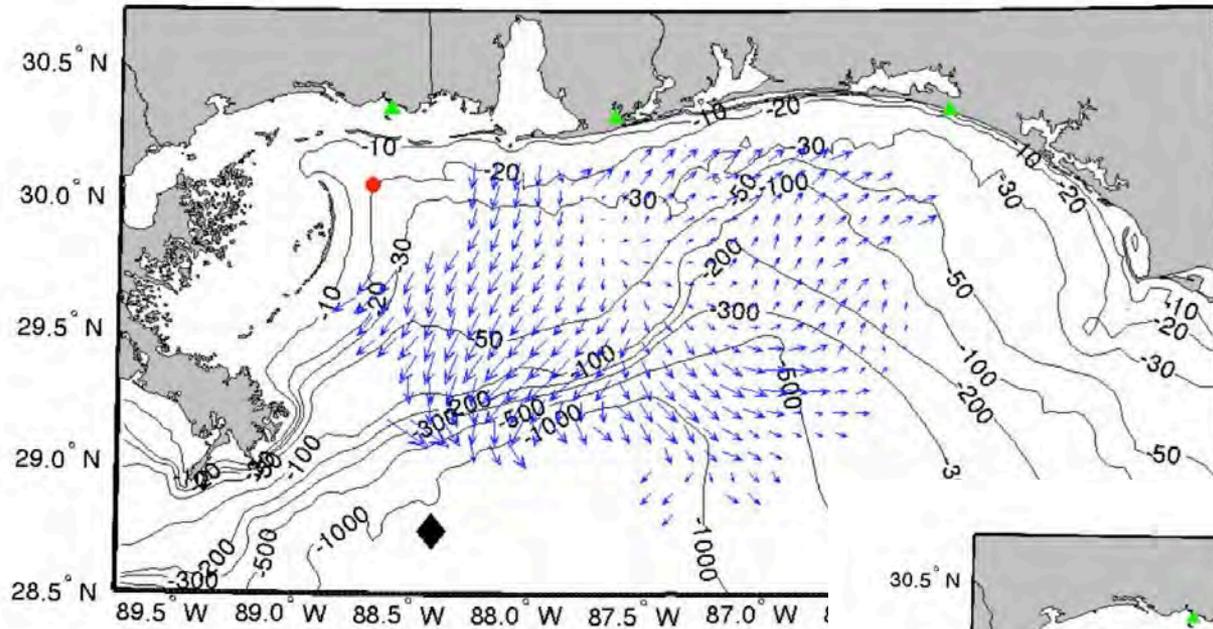
Vessel Detection: Case Study



Detections by HF Radar at PTLY 14:00 -20:00 GMT



Oil Spill Dispersion Mapping



Oil Spill Status : NOAA Guidance

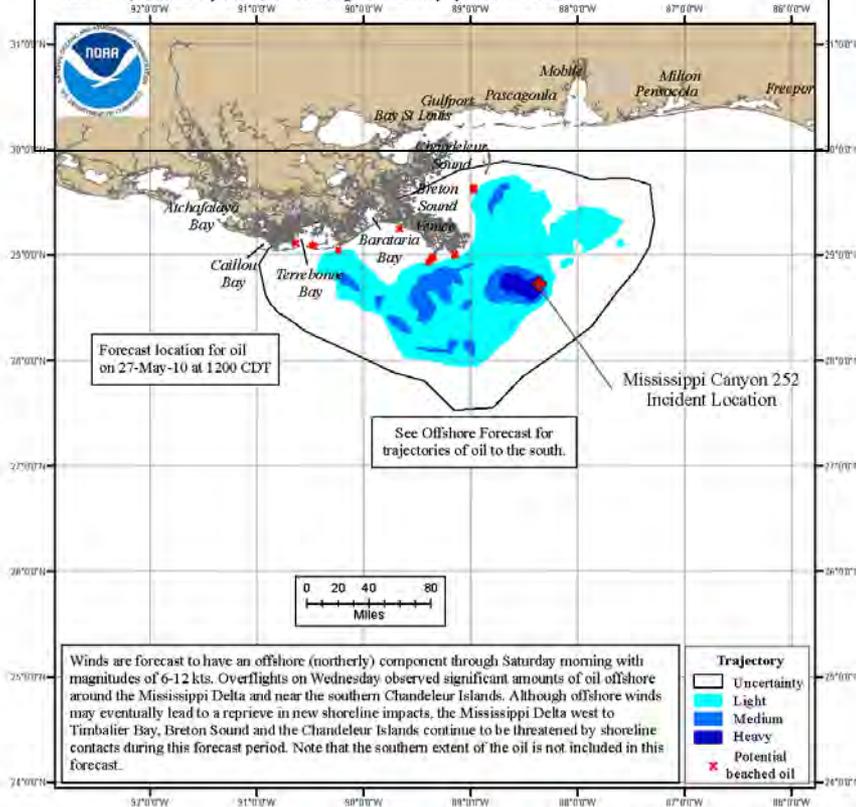
Nearshore Surface Oil Forecast

NOAA/NOS/OR&R **Nearshore**

Deepwater Horizon MC252

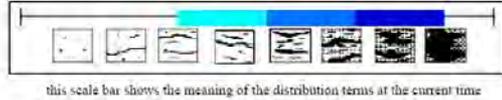
Estimate for: 1200 CDT, Thursday, 5/27/10
Date Prepared: 2100 CDT, Wednesday, 5/26/10

This forecast is based on the NWS spot forecast from Wednesday, May 26 PM. Currents were obtained from several models (NOAA Gulf of Mexico, West Florida Shelf/USF, TAMU/TGLO, NAVON/NRL) and HFR measurements. The model was initialized from Tuesday evening satellite imagery analysis (NOAA/NESDIS) and Wednesday overflight observations. The leading edge may contain tarballs that are not readily observable from the imagery (hence not included in the model initialization). Oil near bay inlets could be brought into that bay by local tidal currents.



Winds are forecast to have an offshore (northerly) component through Saturday morning with magnitudes of 6-12 kts. Overflights on Wednesday observed significant amounts of oil offshore around the Mississippi Delta and near the southern Chandeleur Islands. Although offshore winds may eventually lead to a reprieve in new shoreline impacts, the Mississippi Delta west to Timbalier Bay, Breton Sound and the Chandeleur Islands continue to be threatened by shoreline contacts during this forecast period. Note that the southern extent of the oil is not included in this forecast.

Trajectory
 □ Uncertainty
 □ Light
 □ Medium
 □ Heavy
 x Potential beached oil



Next Forecast: May 27th PM

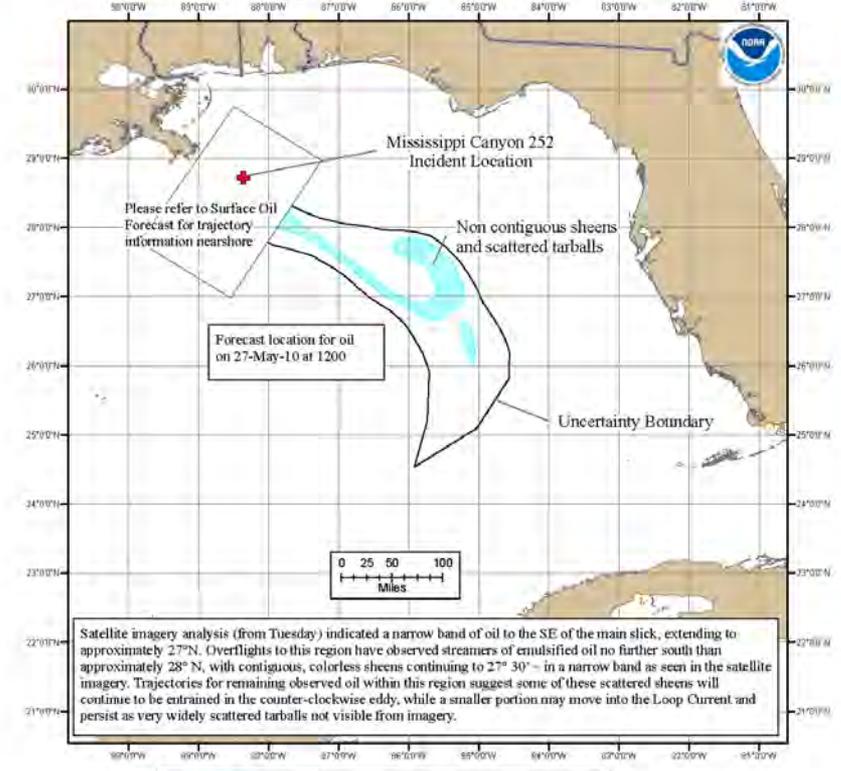
Offshore Surface Oil Forecast

NOAA/NOS/OR&R **Offshore**

Deepwater Horizon MC252

Estimate for: 1200 CDT, Thursday 5/27/10
Date Prepared: 1800 CDT, Wednesday 5/26/10

Currents were obtained from four models: NOAA Gulf of Mexico, West Florida Shelf/USF, NRL IASNES and NC State SABGOM. Each includes Loop Current dynamics. Gulf wide winds were obtained from the gridded NCEP product. The model was initialized from Tuesday morning satellite imagery analysis (NOAA/NESDIS) and observations from a Tuesday morning overflight. The leading edge may contain tarballs that are not readily observable from the imagery (hence not included in the model initialization).



Satellite imagery analysis (from Tuesday) indicated a narrow band of oil to the SE of the main slick, extending to approximately 27°N. Overflights to this region have observed streamers of emulsified oil no further south than approximately 28° N, with contiguous, colorless sheers continuing to 27° 30' - in a narrow band as seen in the satellite imagery. Trajectories for remaining observed oil within this region suggest some of these scattered sheers will continue to be entrained in the counter-clockwise eddy, while a smaller portion may move into the Loop Current and persist as very widely scattered tarballs not visible from imagery.



Next Forecast: May 27th PM

Enhanced Wave and Oil Spill Trajectory Modeling

Journal of Coastal Research

26

5

789-797

West Palm Beach, Florida

September 2010



REVIEW ARTICLE



www.jcr.org

Tracking Oil Slicks and Predicting their Trajectories Using Remote Sensors and Models: Case Studies of the Sea Princess and Deepwater Horizon Oil Spills

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ABSTRACT

KLEMAS, V., 2010. Tracking oil slicks and predicting their trajectories using remote sensors and models: case studies of the Sea Princess and Deepwater Horizon oil spills. *Journal of Coastal Research*. 26(5), 789-797. West Palm Beach (Florida), ISSN 0749-0208.

Oil spills can harm marine life in the oceans, estuaries, and wetlands. To limit the damage by a spill and facilitate cleanup efforts, emergency managers need information on spill location, size and extent, direction and speed of oil movement, and wind, current, and wave information for predicting oil drift and dispersion. The main operational data requirements are fast turn-around time and frequent imaging to monitor the dynamics of the spill. Remote sensors on satellites and aircraft meet most of these requirements by tracking the spilled oil at various resolutions, over wide areas, and at frequent intervals. They also provide key inputs to drift prediction models and facilitate targeting of skimming and booming efforts. Satellite data are frequently supplemented by information provided by aircraft, ships, and remotely-controlled underwater robots. The Sea Princess tanker grounding off the coast of Wales and the explosion on the Deepwater Horizon rig in the Gulf of Mexico provide good examples for studying the effectiveness of remote sensors during oil-spill emergencies.

ADDITIONAL INDEX WORDS: *Oil spills, oil remote sensing, tracking oil spills, oil spill response, remote sensing.*

INTRODUCTION

Oil spills can destroy marine life as well as wetland and estuarine animal habitat. To limit the damage by a spill and facilitate containment and cleanup efforts, the shipping operators, oil companies, and other responsible agencies must rapidly obtain information on spill location, size and extent of the spill, direction and speed of oil movement, and wind, current, and wave information for predicting future oil drift and dispersion.

Most of the large oil spills in the oceans stem from tanker groundings, break-ups, and collisions, resulting in a large fraction of the oil spreading along the surface of the ocean and

wide range of remote sensors have provided the required data for tracking and predicting the future movement of the spilled oil in a timely and reliable manner, helping guide rescue and defensive efforts, including the deployment of skimming vessels and protective booms. Users of remotely-sensed data for oil spill applications include the Coast Guard, environmental protection agencies, oil companies, shipping/insurance/fishing industries, and defense departments.

Deepwater oil spills during offshore drilling operations are not as numerous as tanker breakups, but they can cause more long-term damage to the environment, as the Deepwater Horizon oil spill proved. Also the sizes of oil spills stemming from tanker accidents can be calculated knowing the holding

RESPONDING TO

Oil Spills IN THE U.S. ARCTIC MARINE ENVIRONMENT

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NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Future Advancements

Rapid Deployment

On the shelf – ready to deploy
Target time frame = 6 hrs



In Conclusion

Coastal HFR Instrument Platforms Provide (in Near Real-Time):

- Ocean current speed and direction data over a wide area
- Information on ocean wave heights
- Information of vessels operating in the area
- Wind Speed and Direction Data
- Key inputs to drift prediction models
- May facilitate targeting of local assets (skimmers and boom deployments)

Thank You
Questions?

