Coastal HF Radar Theory and Applications

A Presentation for

The Oil Spill Technology Symposium

Hank Statscewich

March 29, 2018

UAF University of Alaska Fairbanks

AOOS Alaska Ocean Observing System

BOEM Bureau of Ocean Energy Management

NSF

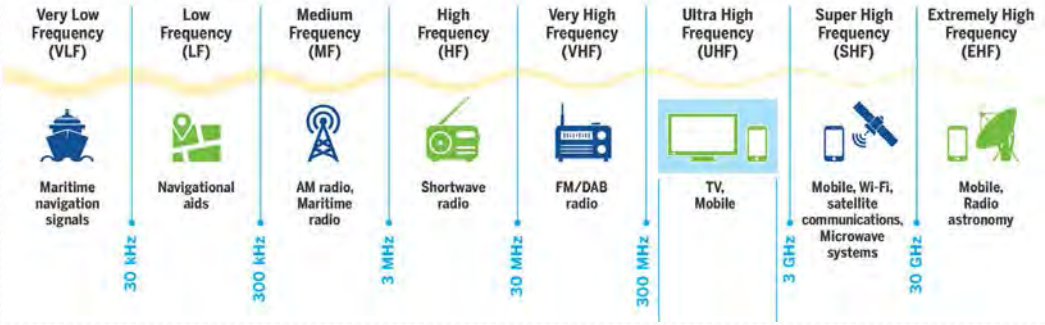
ConocoPhillips

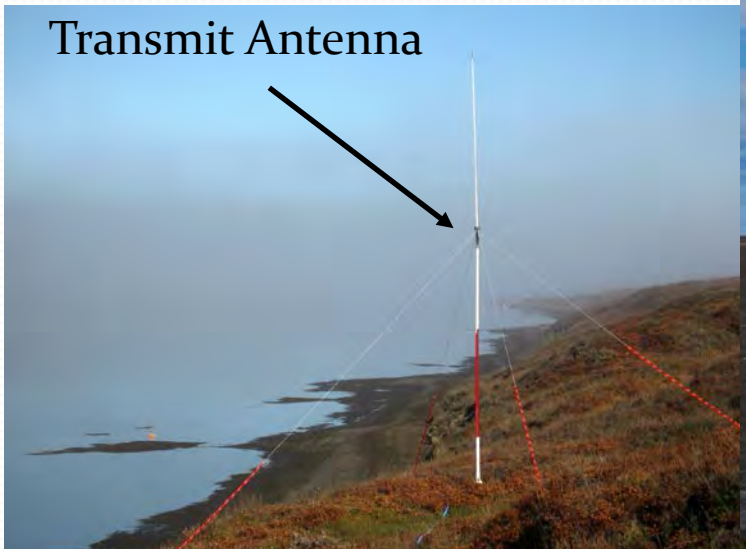
Integrated Ocean Observing System

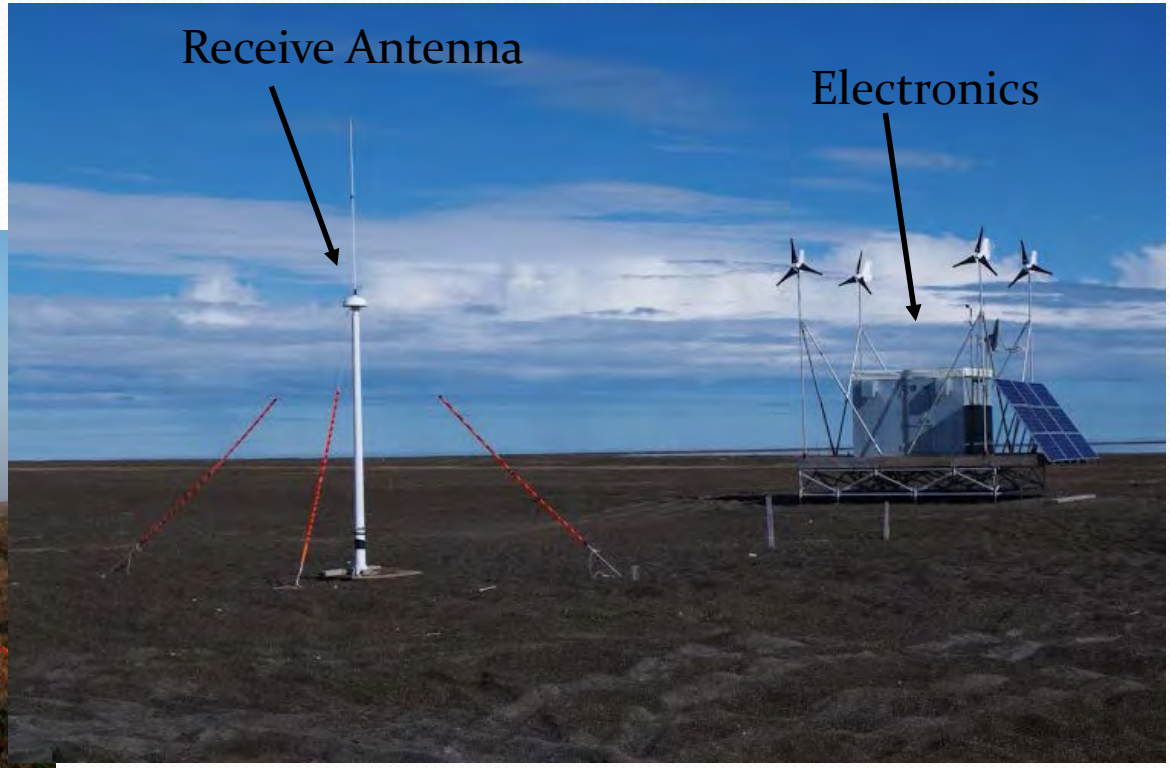
U.S. Department of Homeland Security

What Is HF Radar?

- HF = High Frequency
- Radio Station



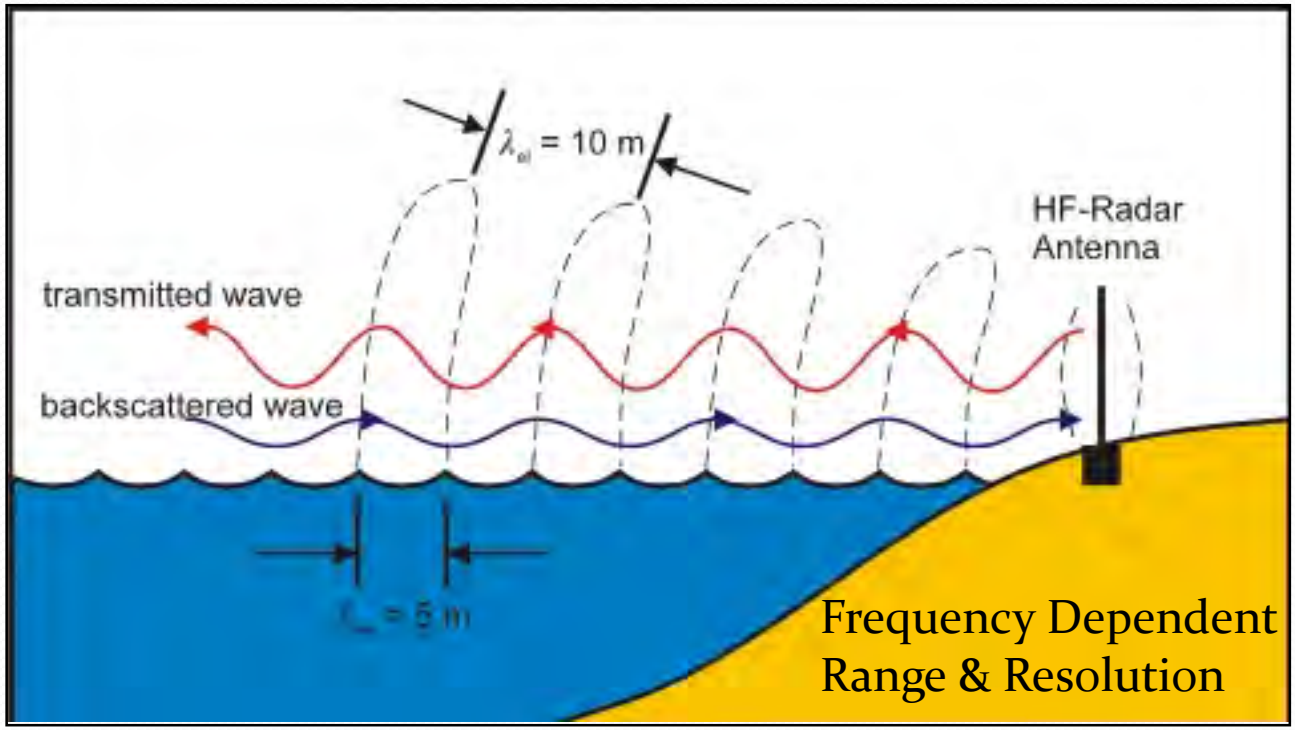




What does it sound like?

How Does it Work?

Bragg Scattering: wavelength of **scattering waves is ½ transmit wavelength**



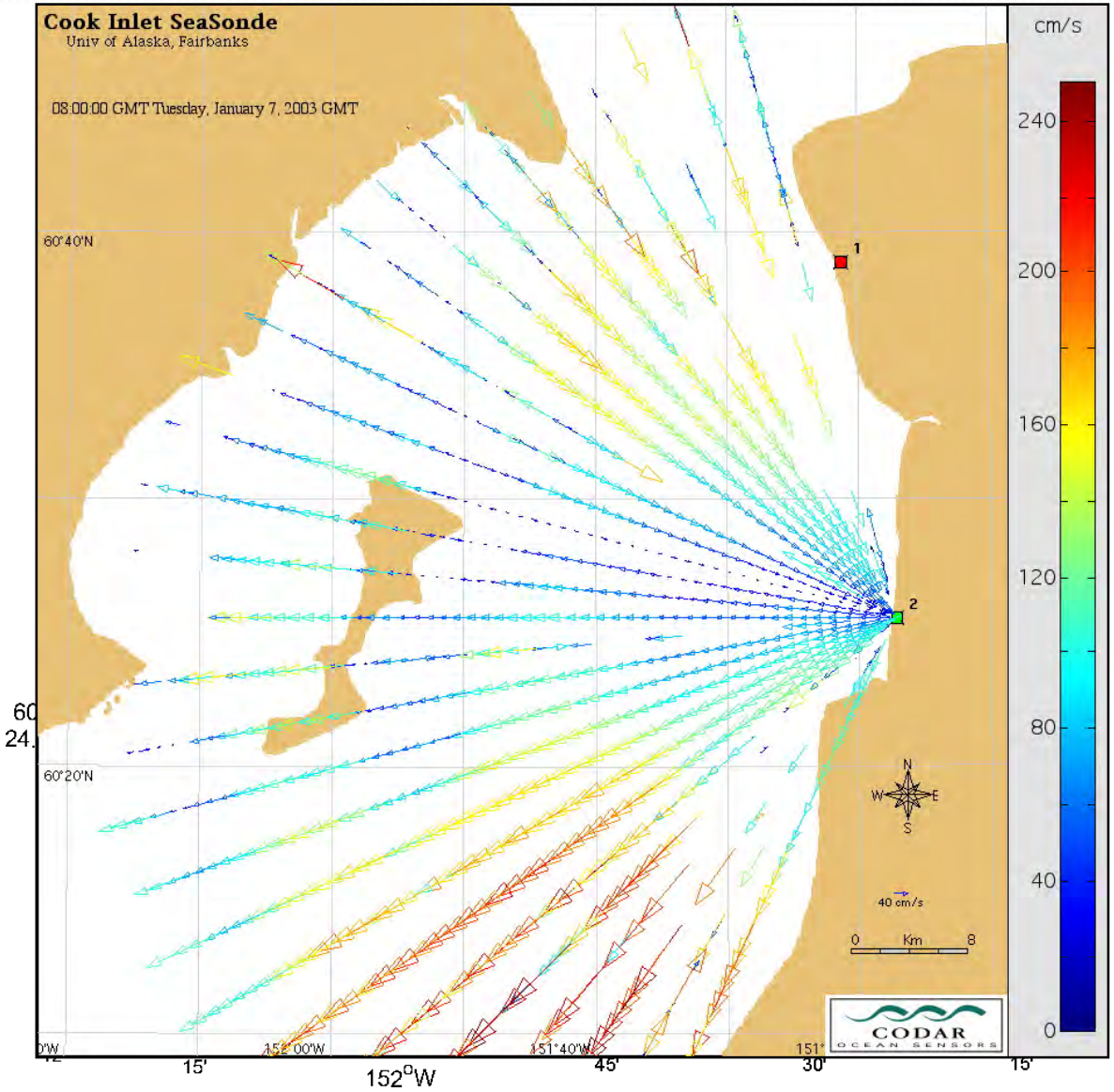
5 mHz = 30 m Waves	180 km Coverage at 5 km Resolution
12 mHz = 12.5 m Waves	80 km Coverage at 1 km Resolution
25 mHz = 6 m Waves	40 km Coverage at 0.25 km Resolution

Wave Periods are between 1.5 – 5 seconds

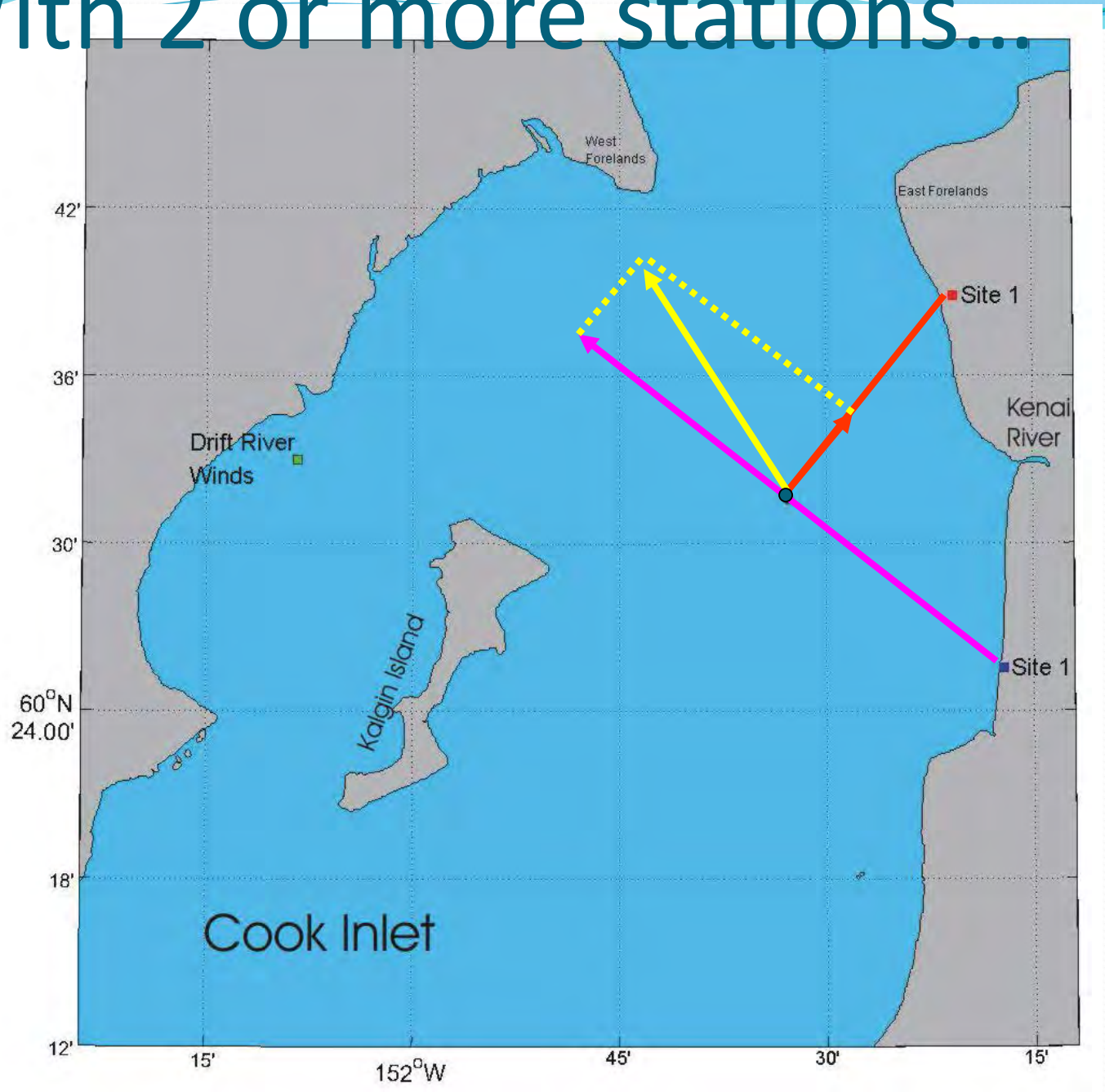
Example Raw Data: Doppler Spectrum from a Radial Site

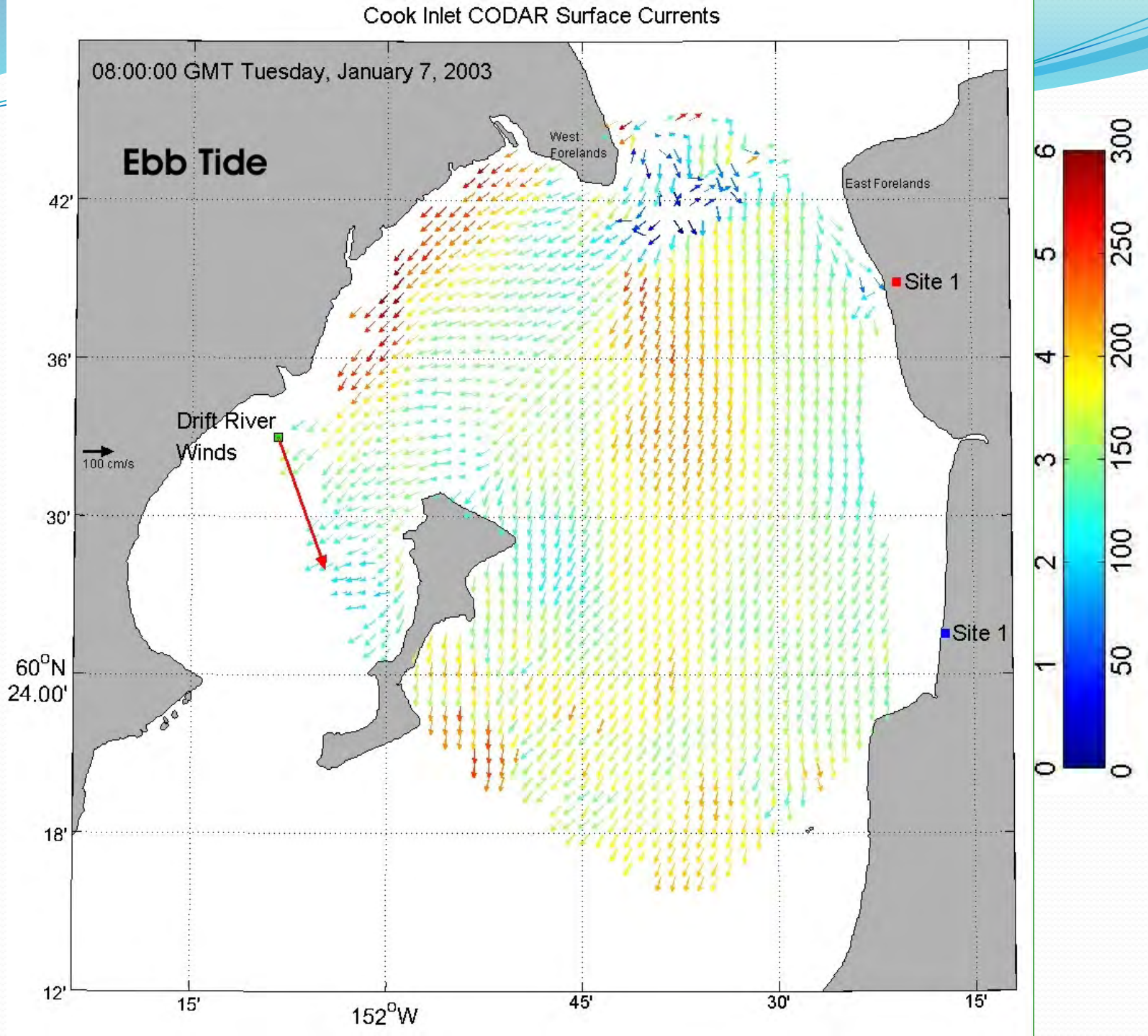
- The shift in Doppler spectrum represents moving ocean waves plus the surface currents carrying the ocean waves.
- Ocean wave speed is known via dispersion relation so the velocity of the surface current can be back calculated.

What does it do?



With 2 or more stations…



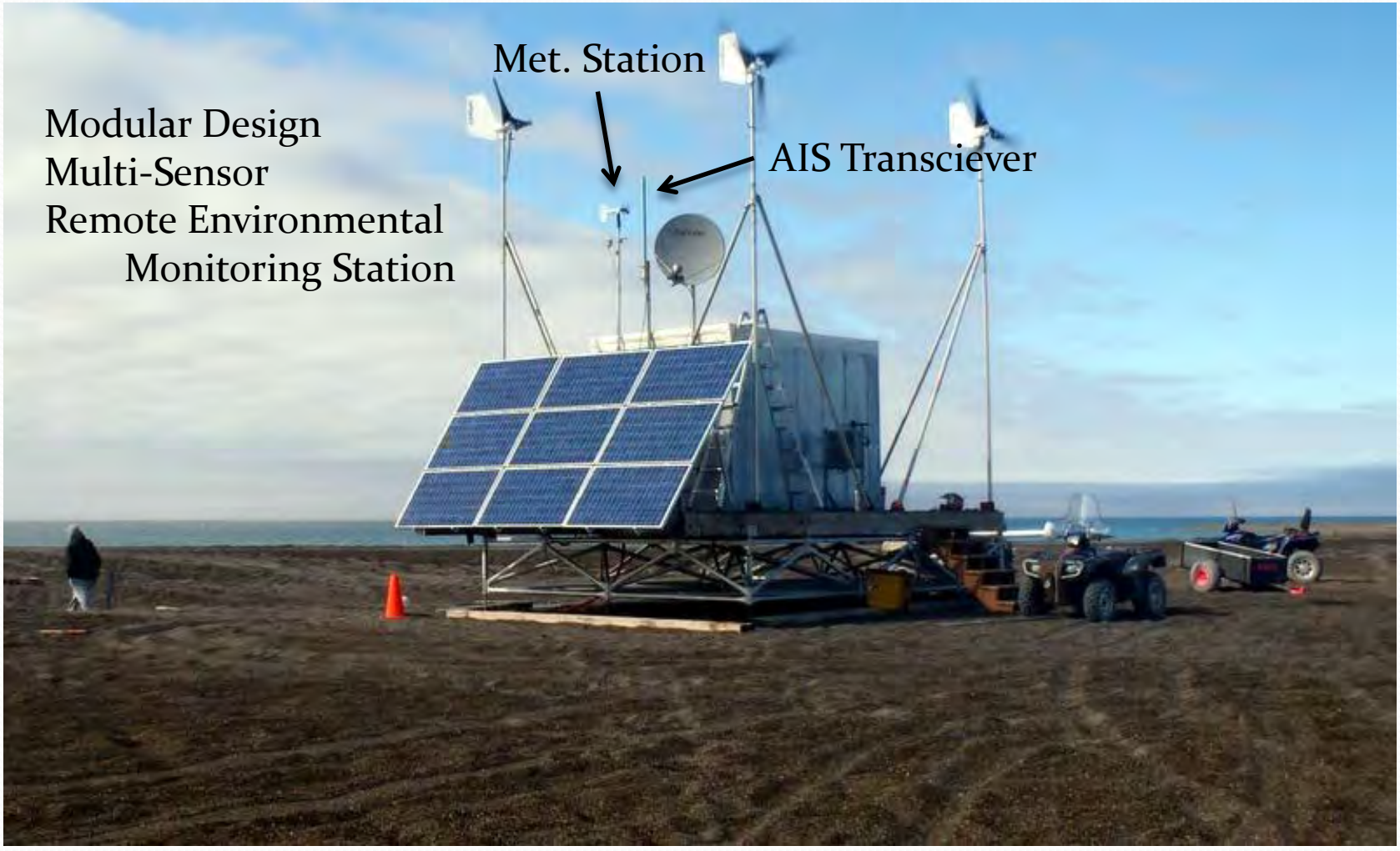

Cook Inlet CODAR Surface Currents
08:00:00 GMT Tuesday, January 7, 2003
Ebb Tide
West Forelands
East Forelands
Site 1
Site 1
Drift River Winds
100 cm/s
42'
36'
30'
18'
12'
60°N
24.00'
15'
152°W
45'
30'
15'
0
1
2
3
4
5
6
0
50
100
150
200
250
300
cm/s

350+ Global HF Radar Installations


Prudhoe Bay
(United States)
PWS
Outer Gulf Coast (OGC)
CHUKCHI SEA
ALASKA
BROOKS RANGE
Point Barrow
Cape Lisburne
Point Hope
Kotzebue Sound
SEWARD PENINSULA
Norton Sound
Saint Lawrence Island
Cape Romanzof
Saint Matthew Island
Nunivak Island
Bristol Bay
Saint Paul Island
PRIBILOF ISLANDS
Saint George Island
ALASKA PENINSULA
Kodiak Island
SHUMAGIN ISLANDS
Unimak Island
Unalaska Island
FOX ISLANDS
ALEUTIAN ISLANDS
GULF OF ALASKA
ALEXANDER ARCHIPELAGO
QUEEN CHARLOTTE ISLANDS
Dixon Entrance
Mackenzie Bay
Cape Dalhousie
Barter Island
Mount McKinley
Mount Sanford
Yukon
Kuskokwim
Anadyrskiy Zaliv
Mys Dezhneva
DIOMEDE ISLANDS
Bering Strait
RUSSIA
UNITED STATES
SUNDAY
MONDAY

Remote Power Module (RPM): 2010 - Present
8 Years of Continuous Operations

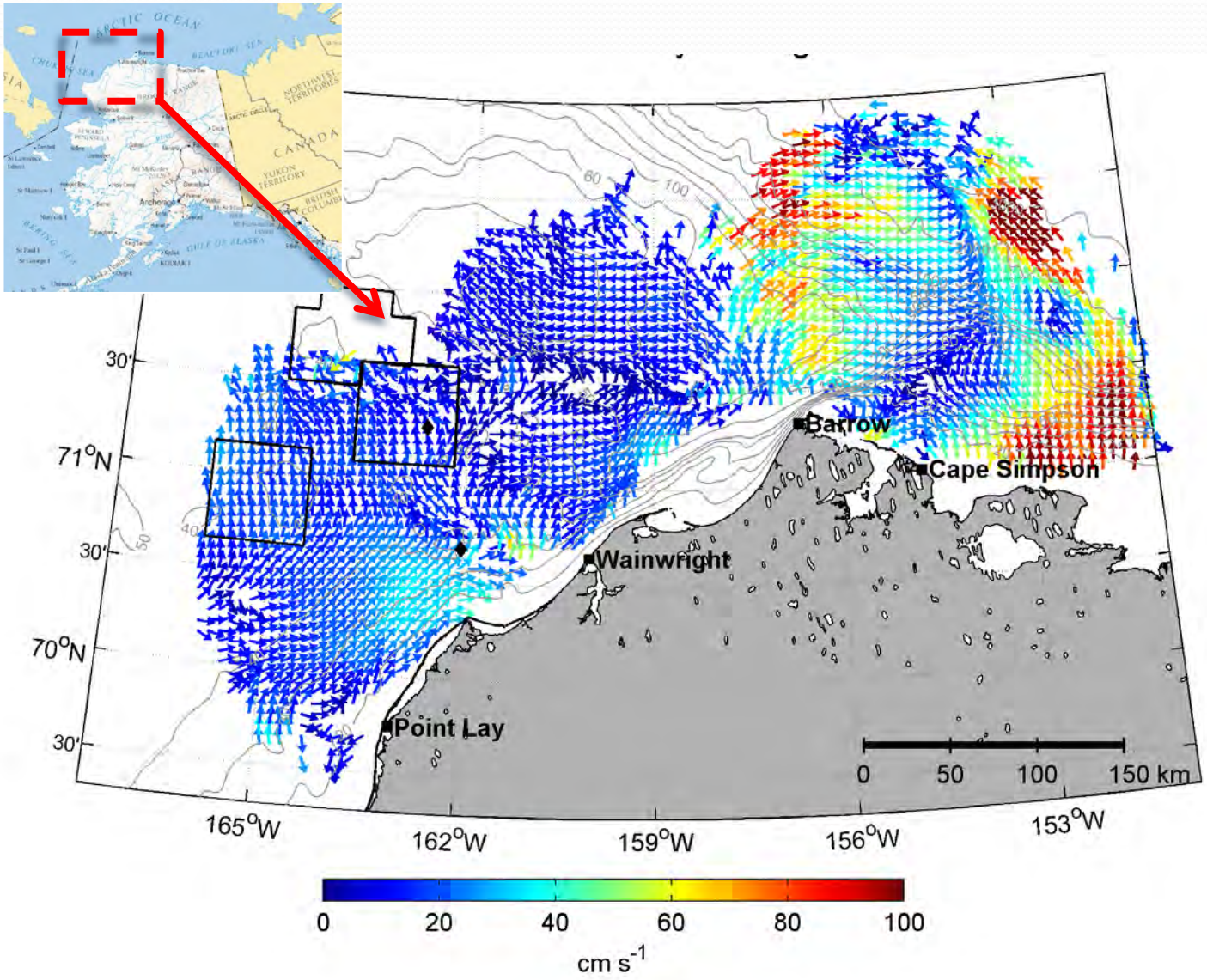
Fully-automated, arctic hardened and tested, renewable (solar and wind) hybrid power station provide power & realtime telemetry to HF radar, AIS and other environmental sensors.



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

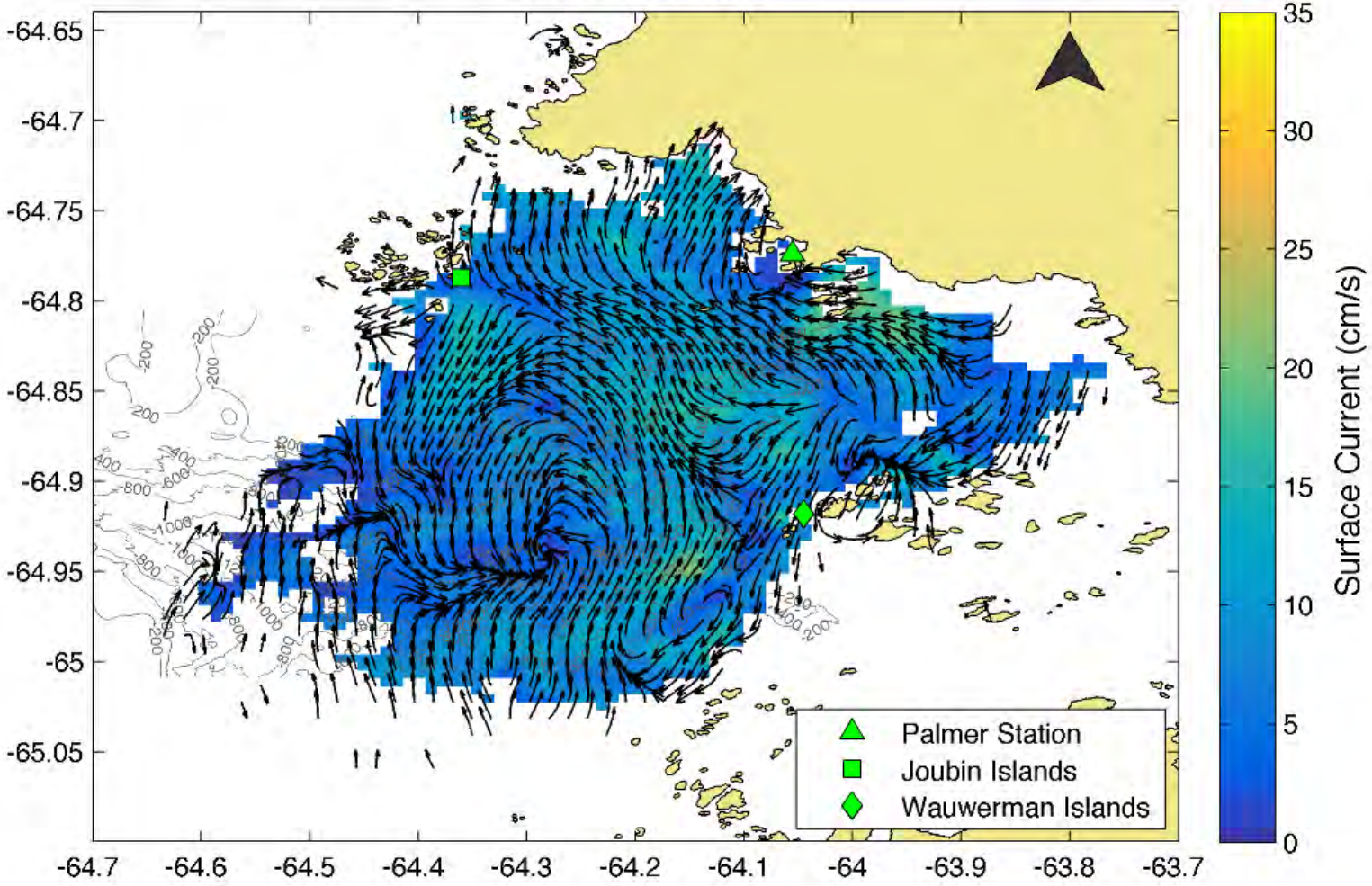
6-km Grid Covering 80,000 km^2

Hourly Measurements in real-time

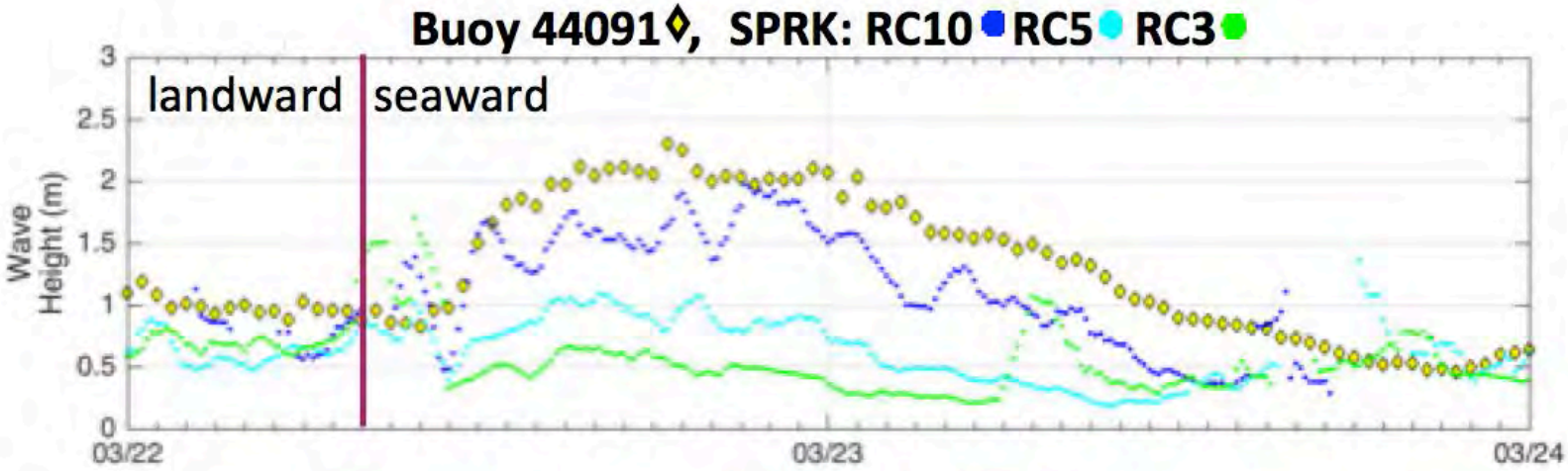
Already incorporated into NOAA'S Arctic ERMA

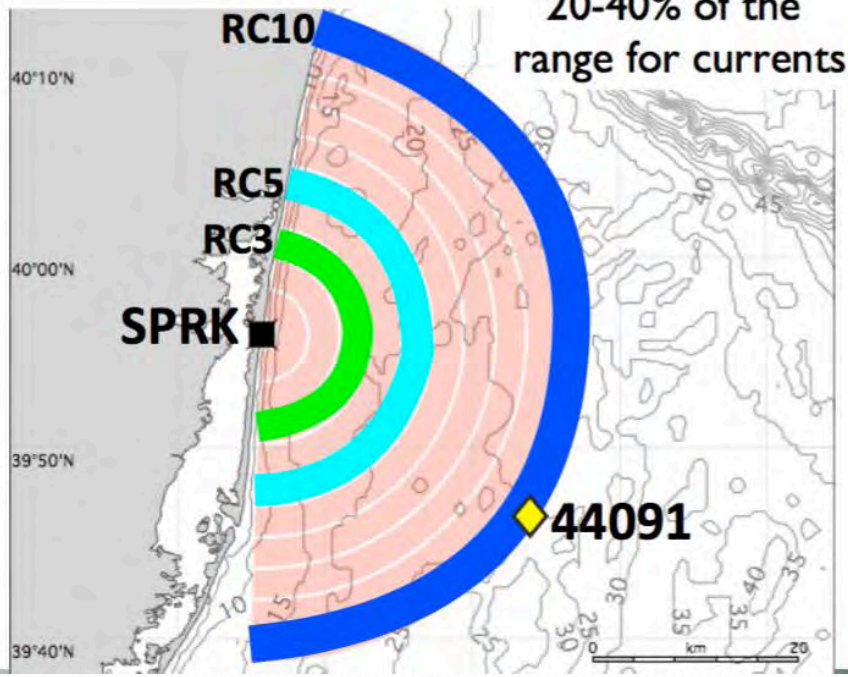
Does it Work In Ice?

Ocean Circulation Measurements

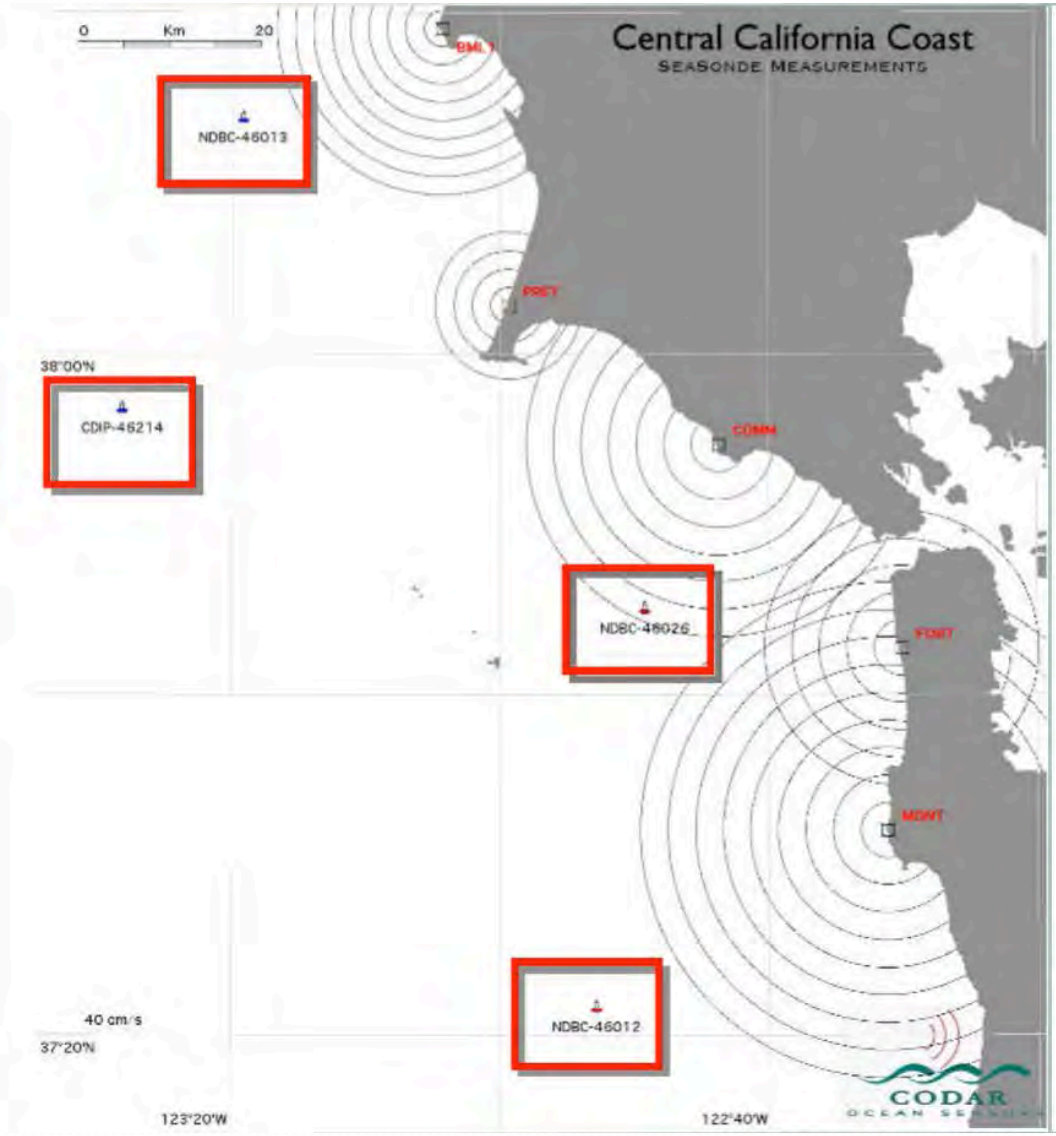


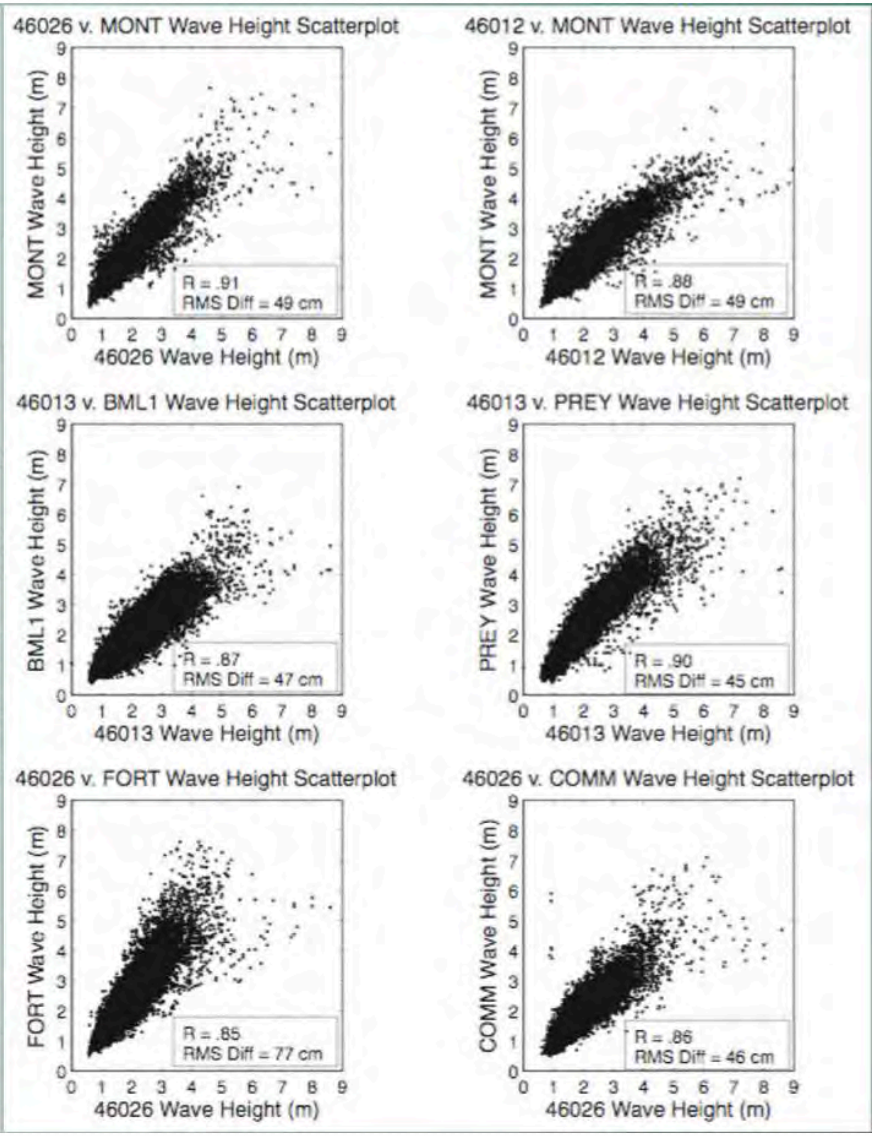
Wave Measurements





Wave Measurements

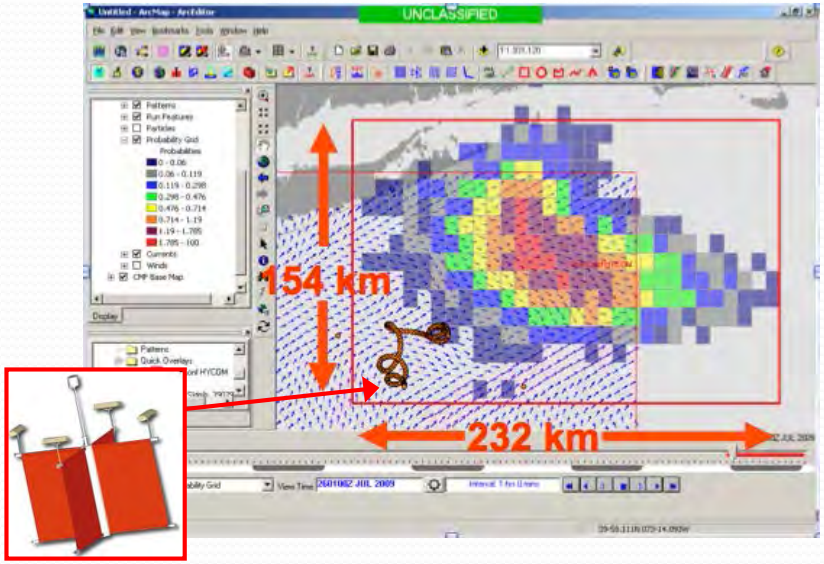




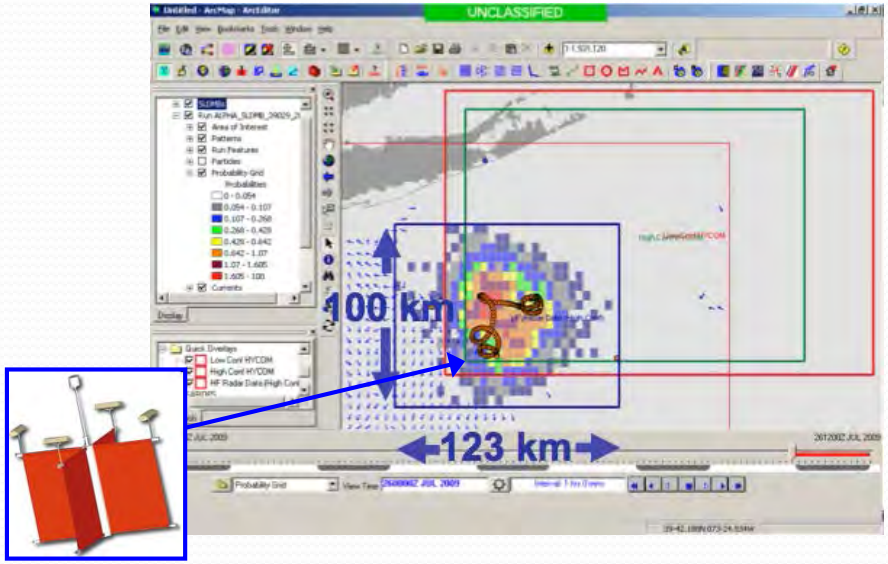
Search and Rescue

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

East Coast HF Radar Network – 15 Sites



Mid-Atlantic Operational Data Flow to SAROPS

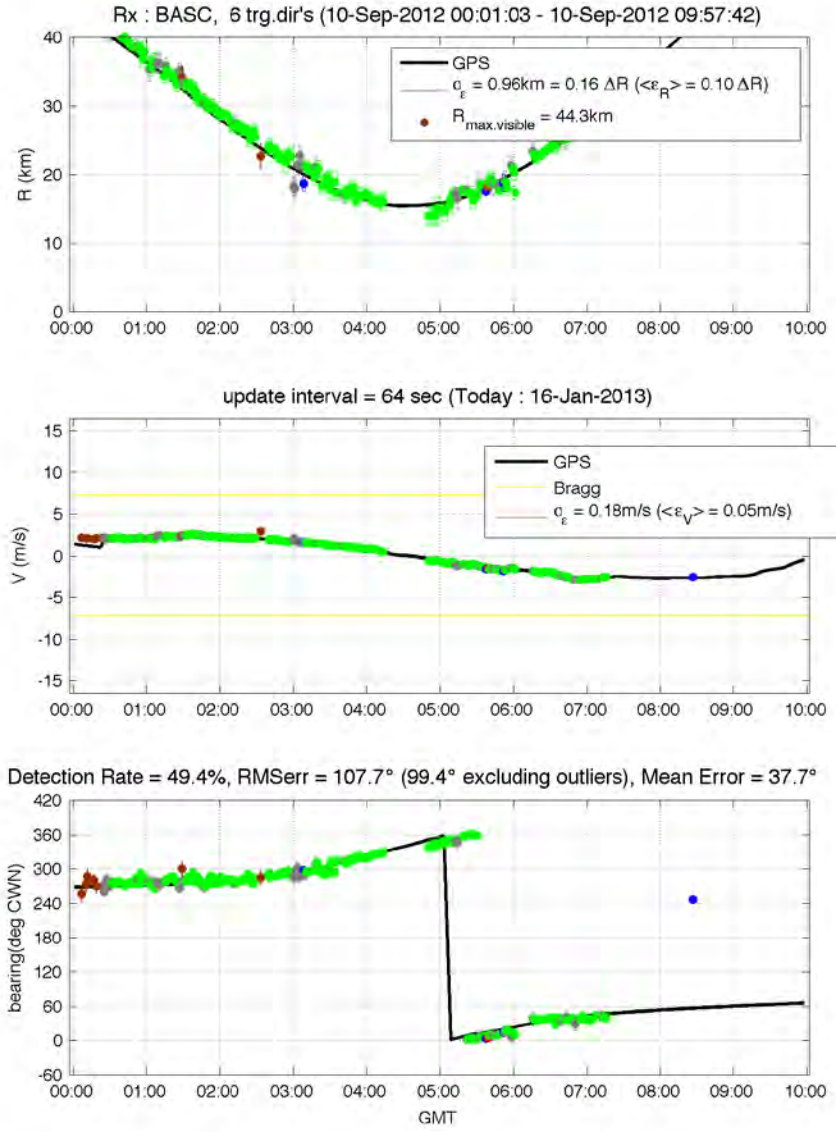


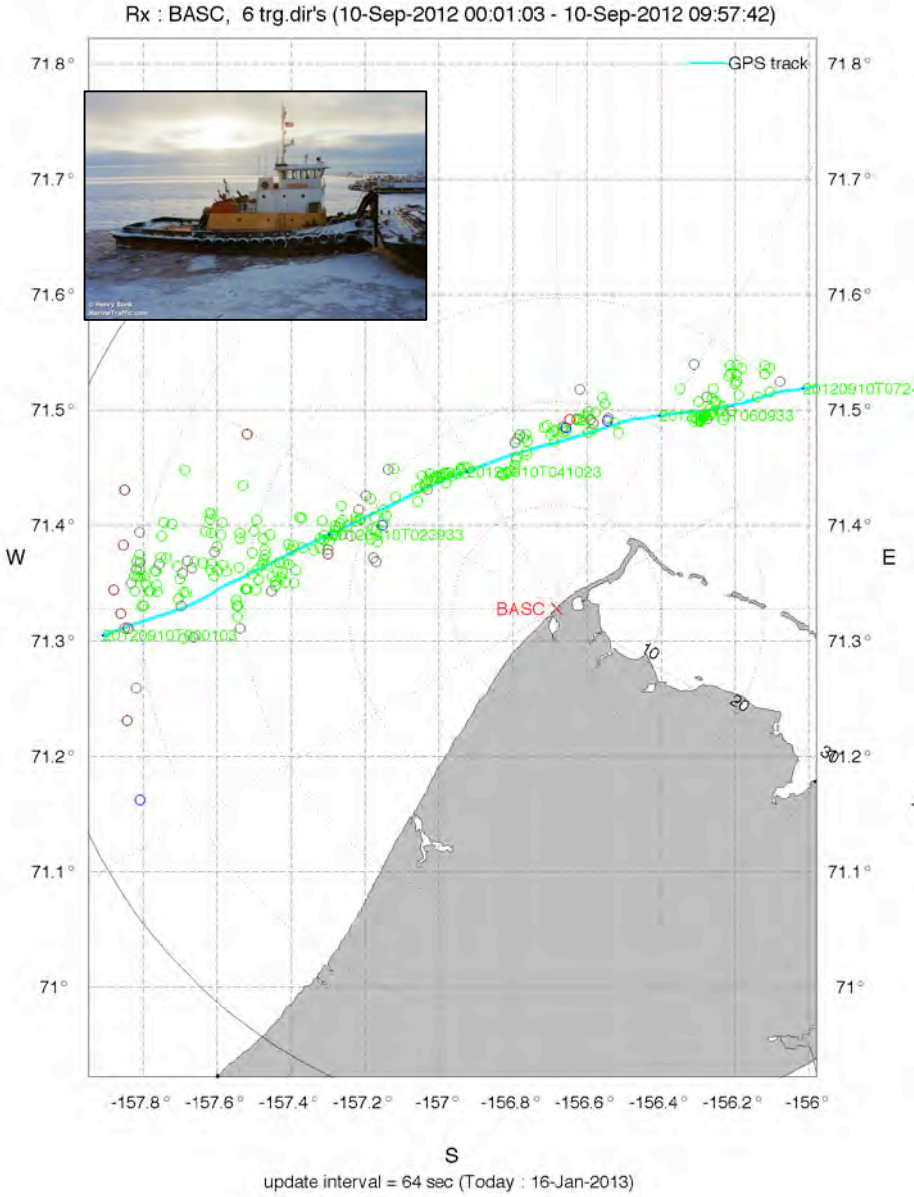
SAROPS 96-Hour Search Area: **HYCOM = 36,000 km²**

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

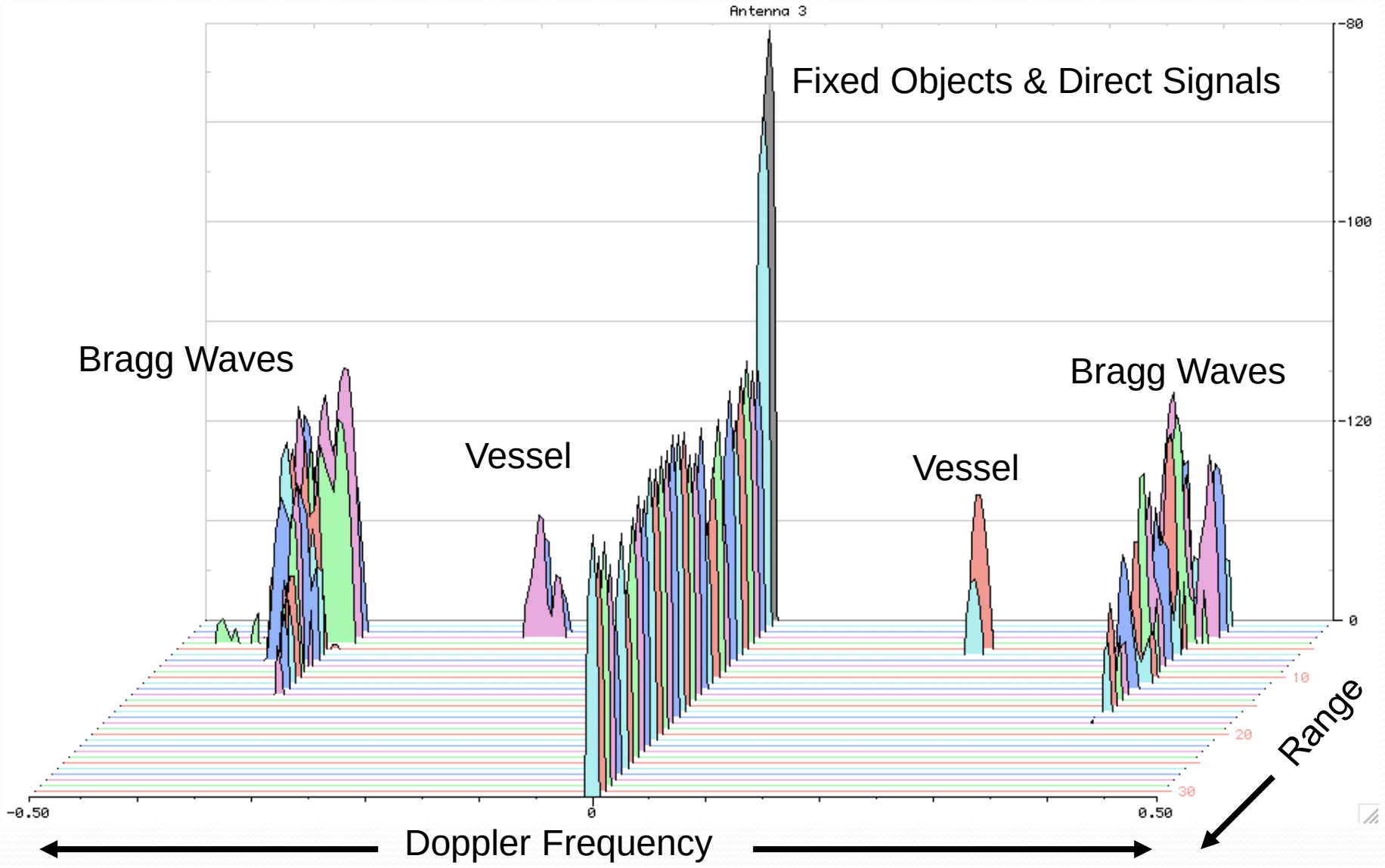
Search area was reduced by 66%

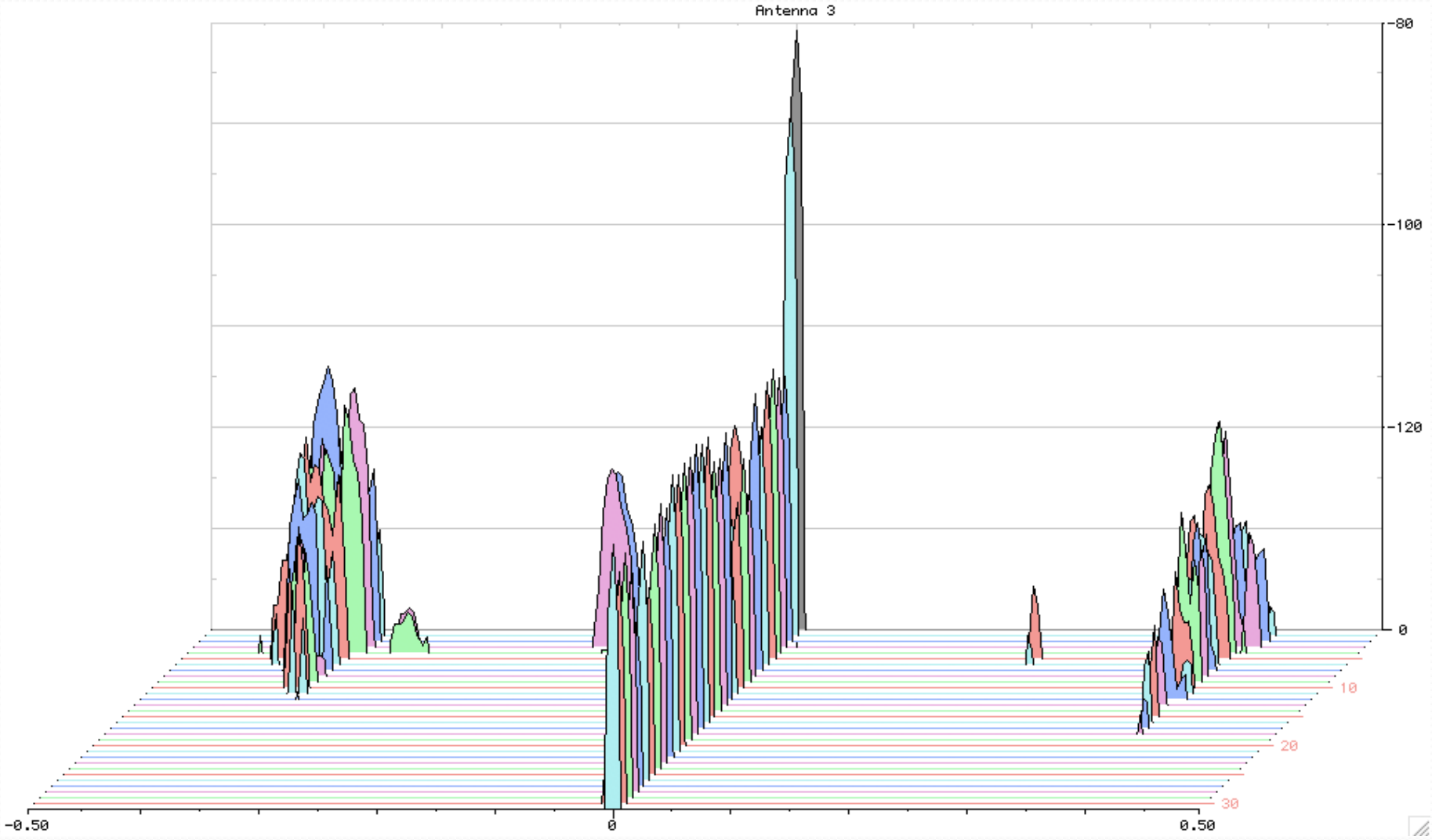
Vessel Tracking

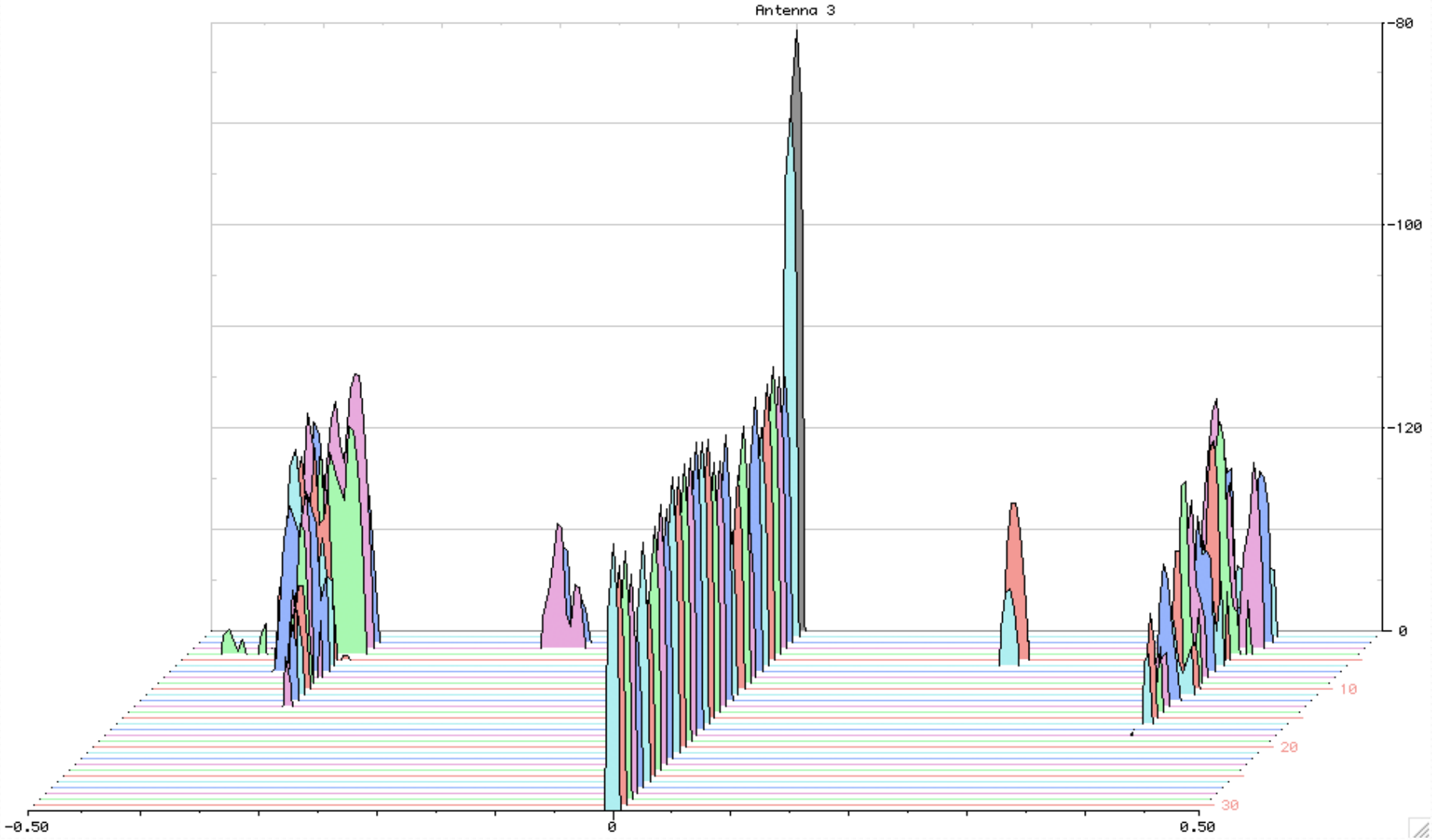




Doppler Spectra from all Range Cells with Detection Algorithm Applied




Antenna 3
-80
-100
-120
0
10
20
30
-0.50
0
0.50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-0.50
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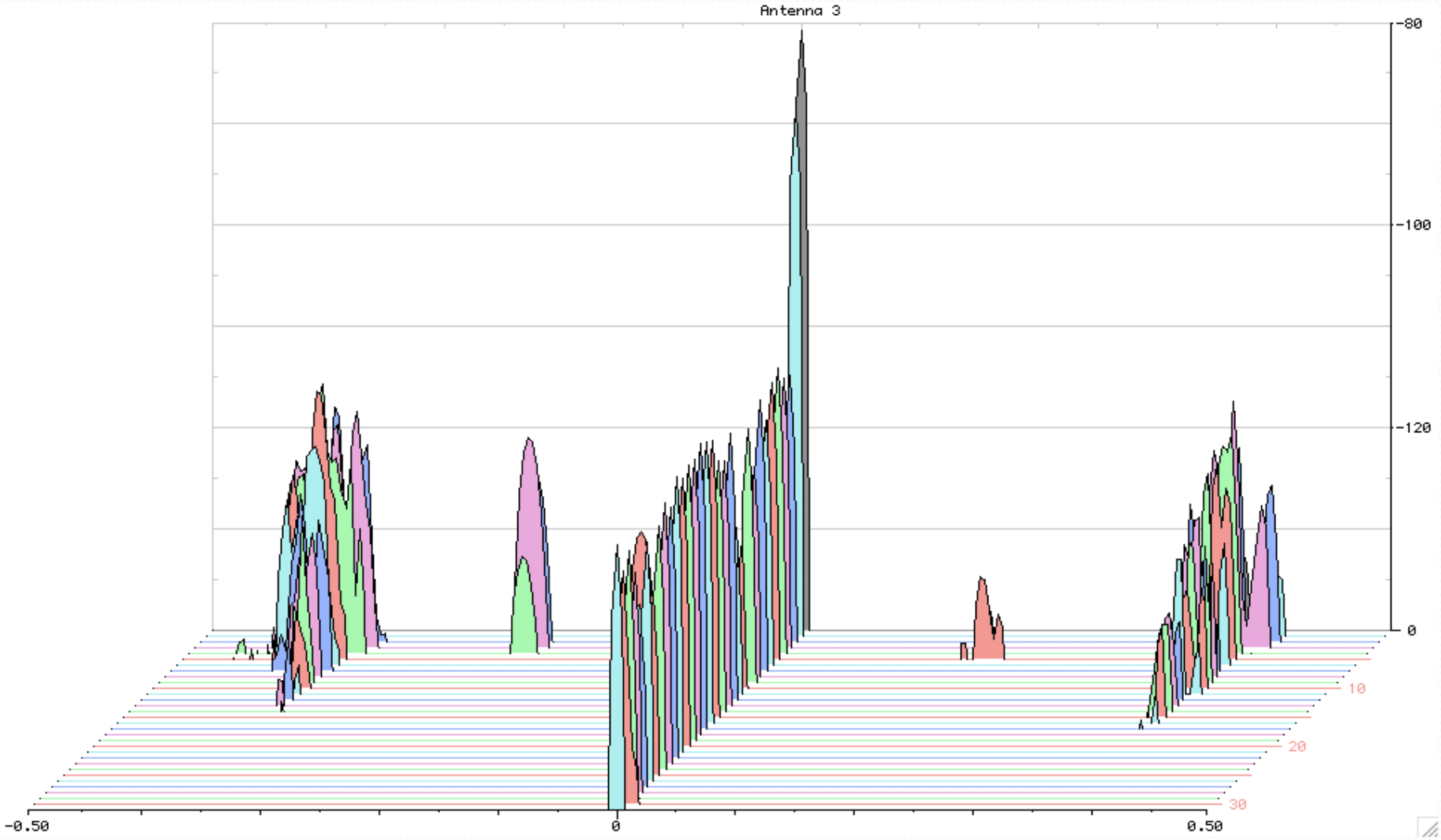
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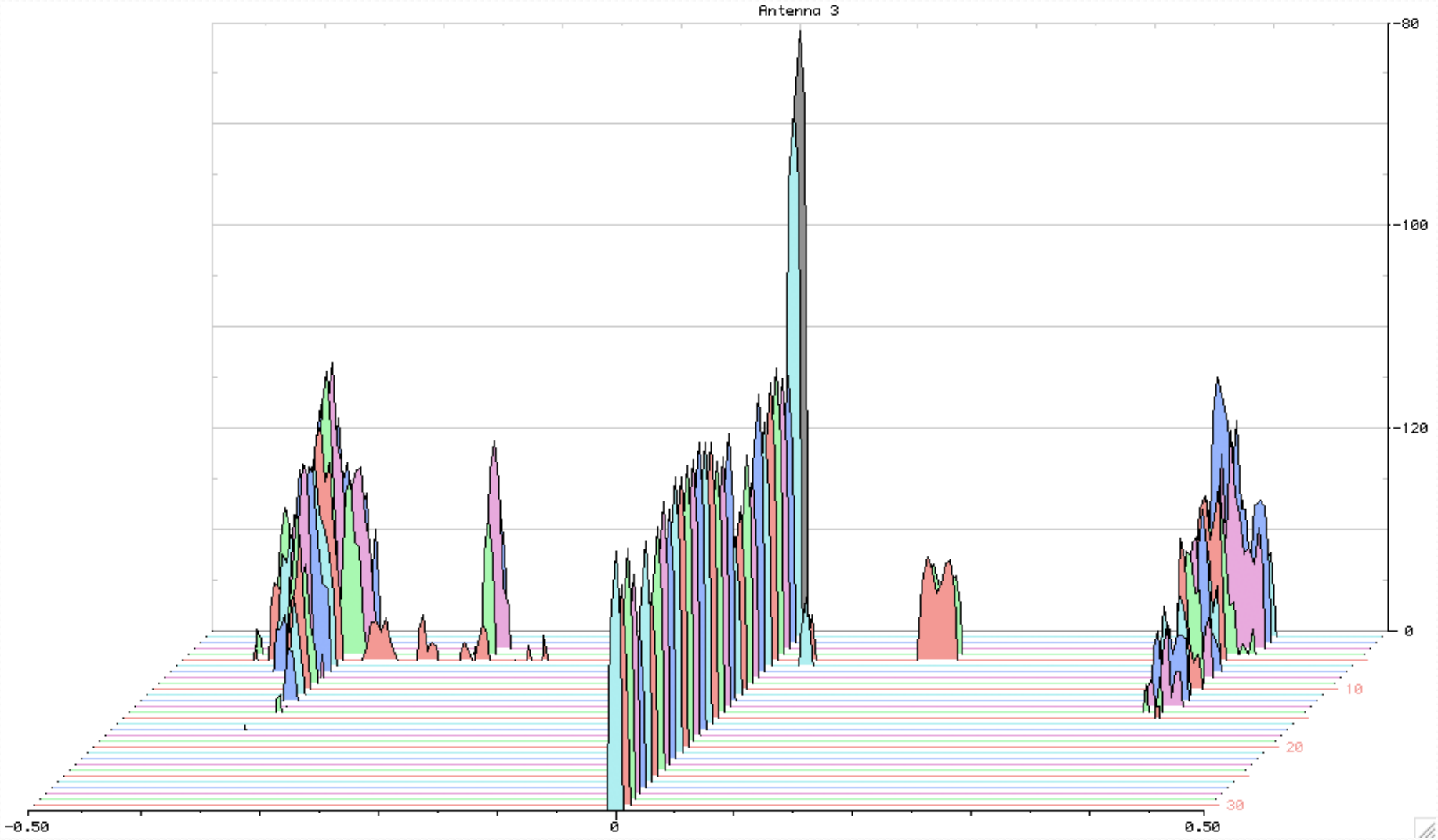
Antenna 3
-80
-100
-120
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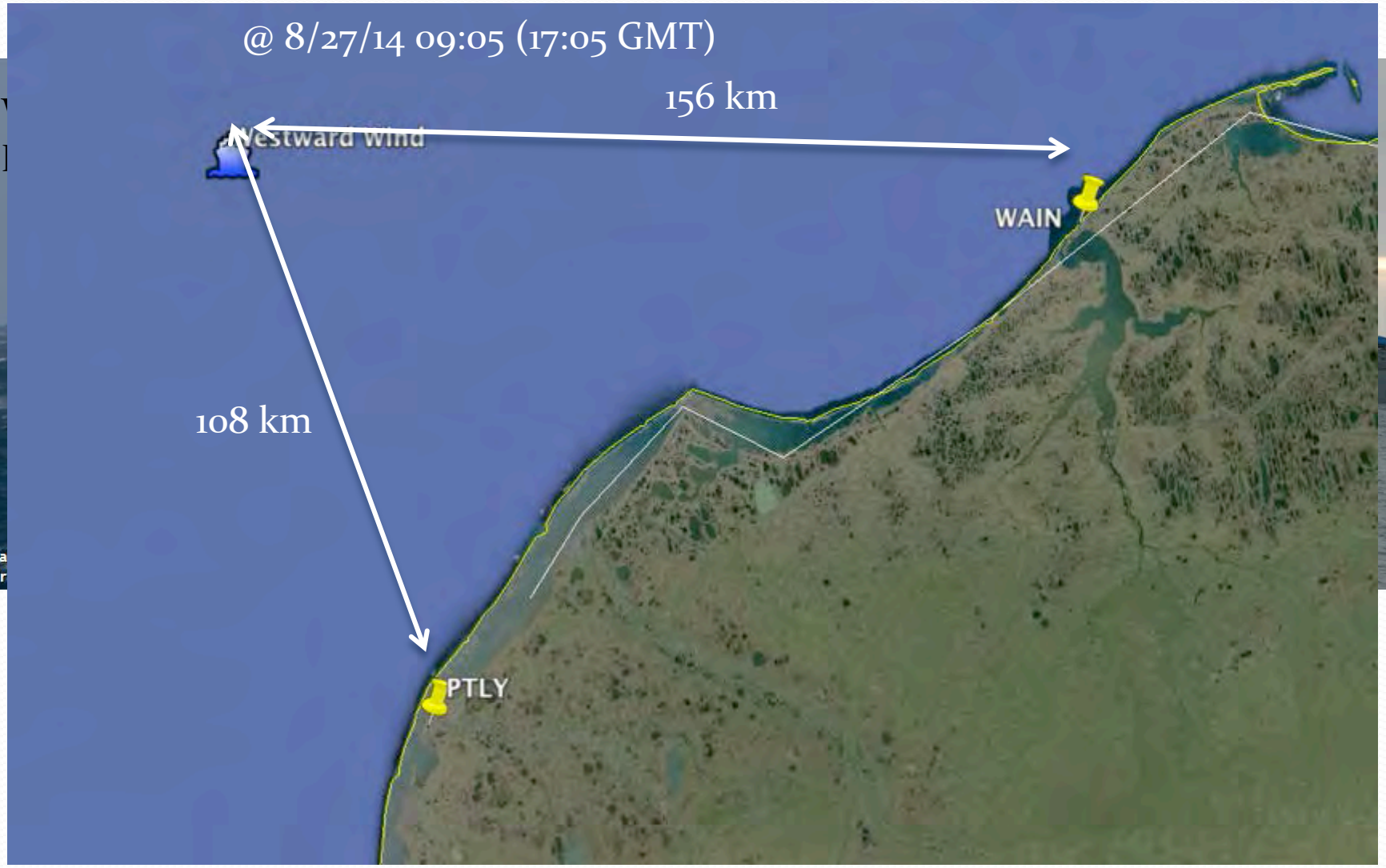
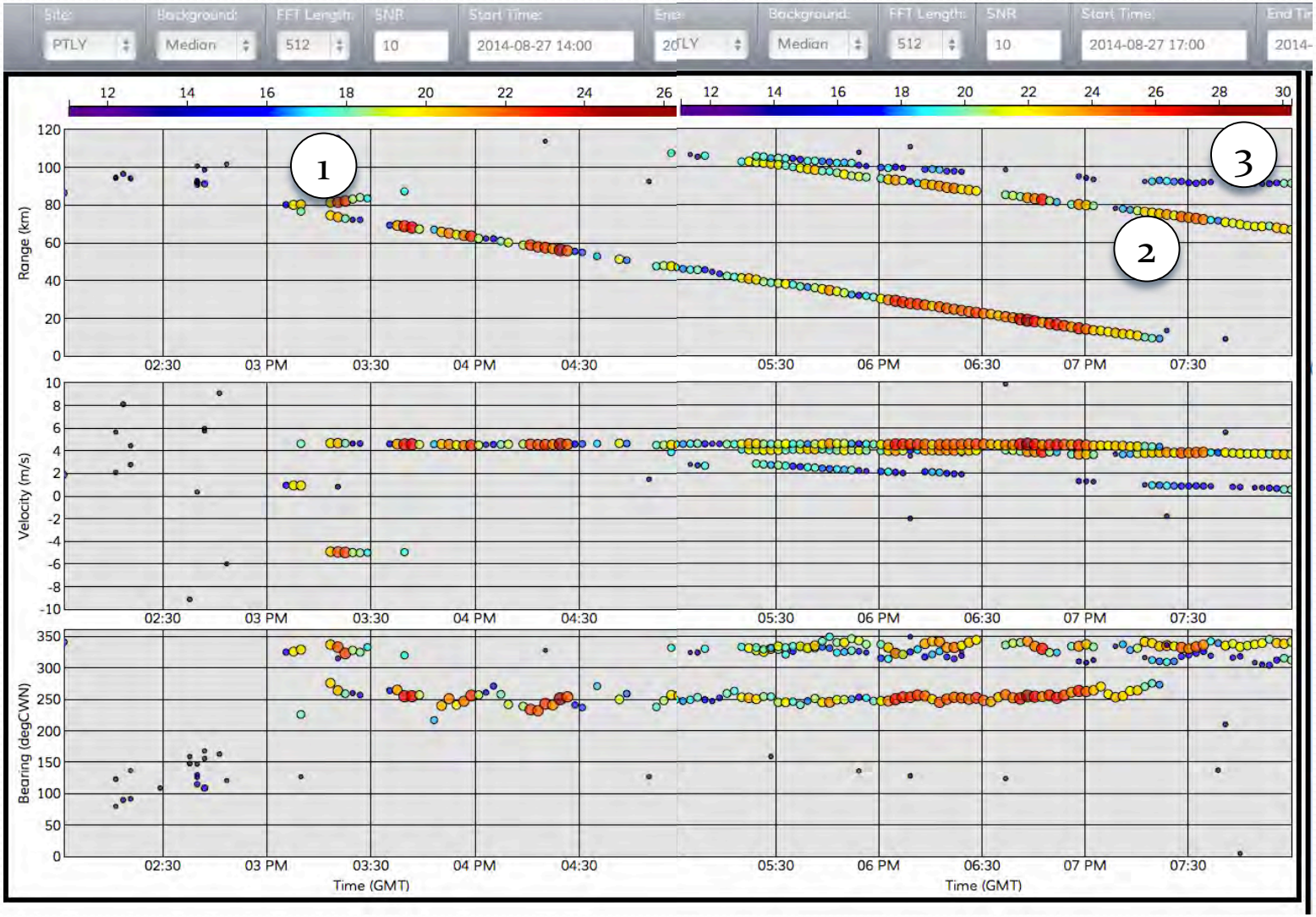
20
30
-0.50
0
0.50

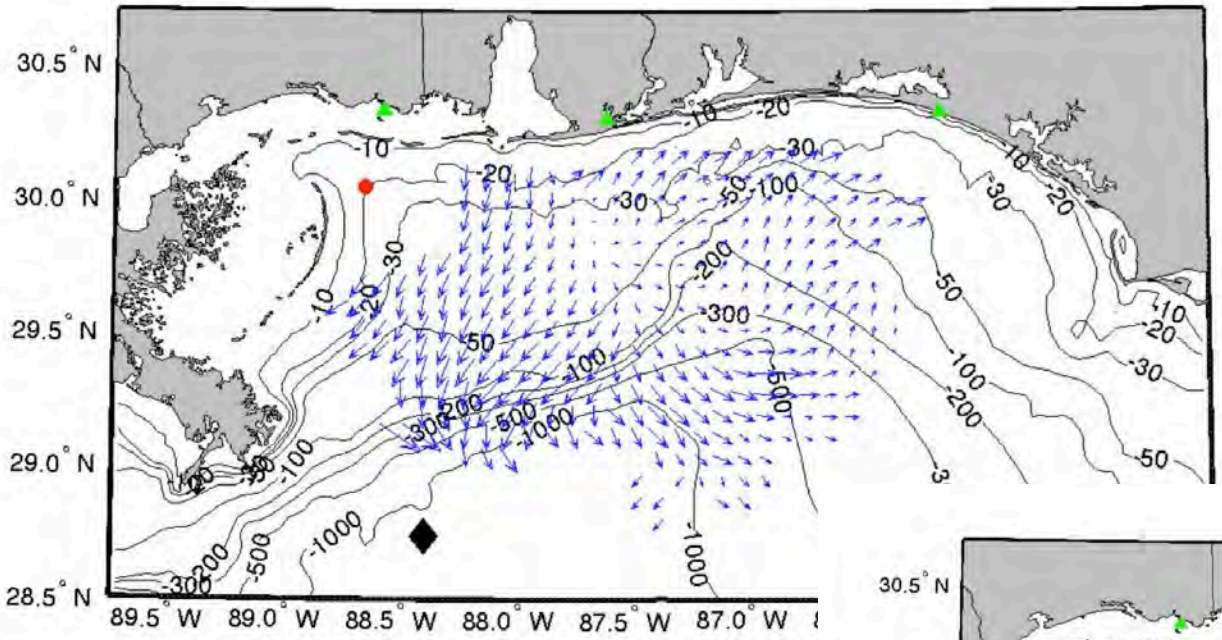
Vessel Detection: Case Study

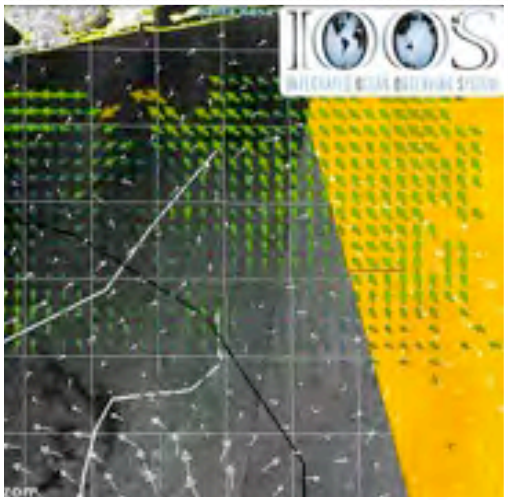


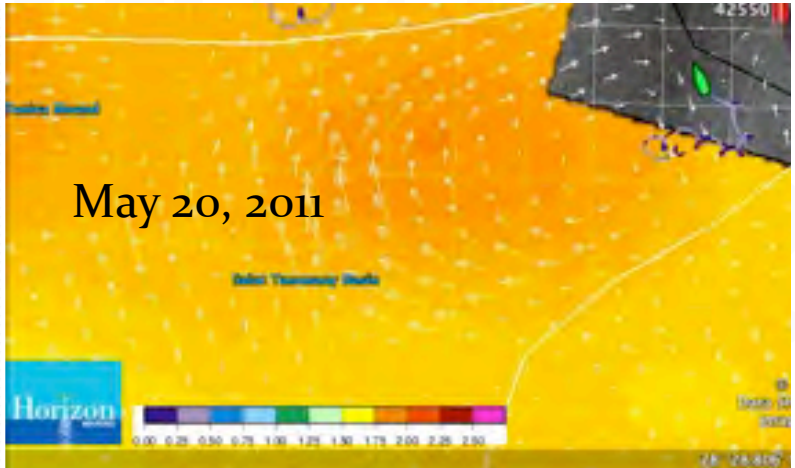
Detections by HF Radar at PTLY 14:00 -20:00 GMT

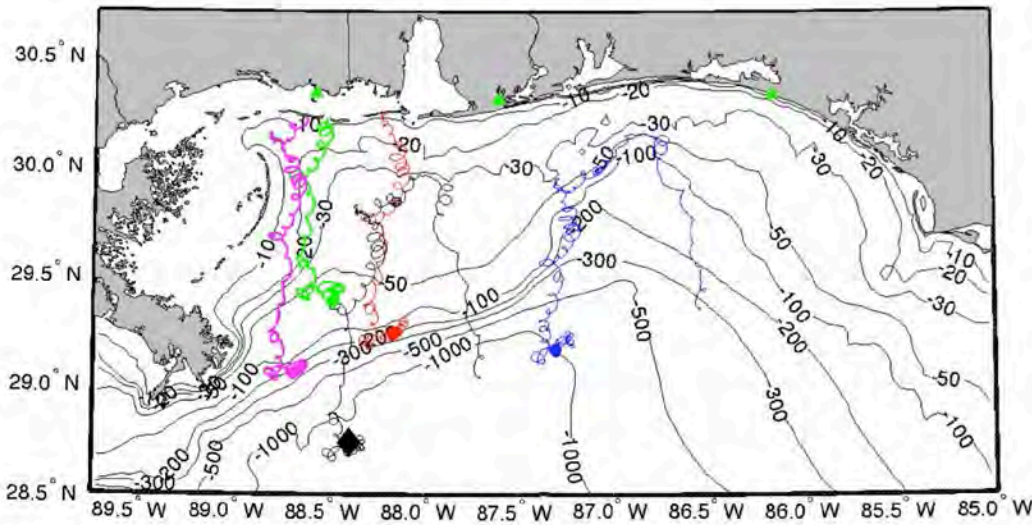


Oil Spill Dispersion Mapping



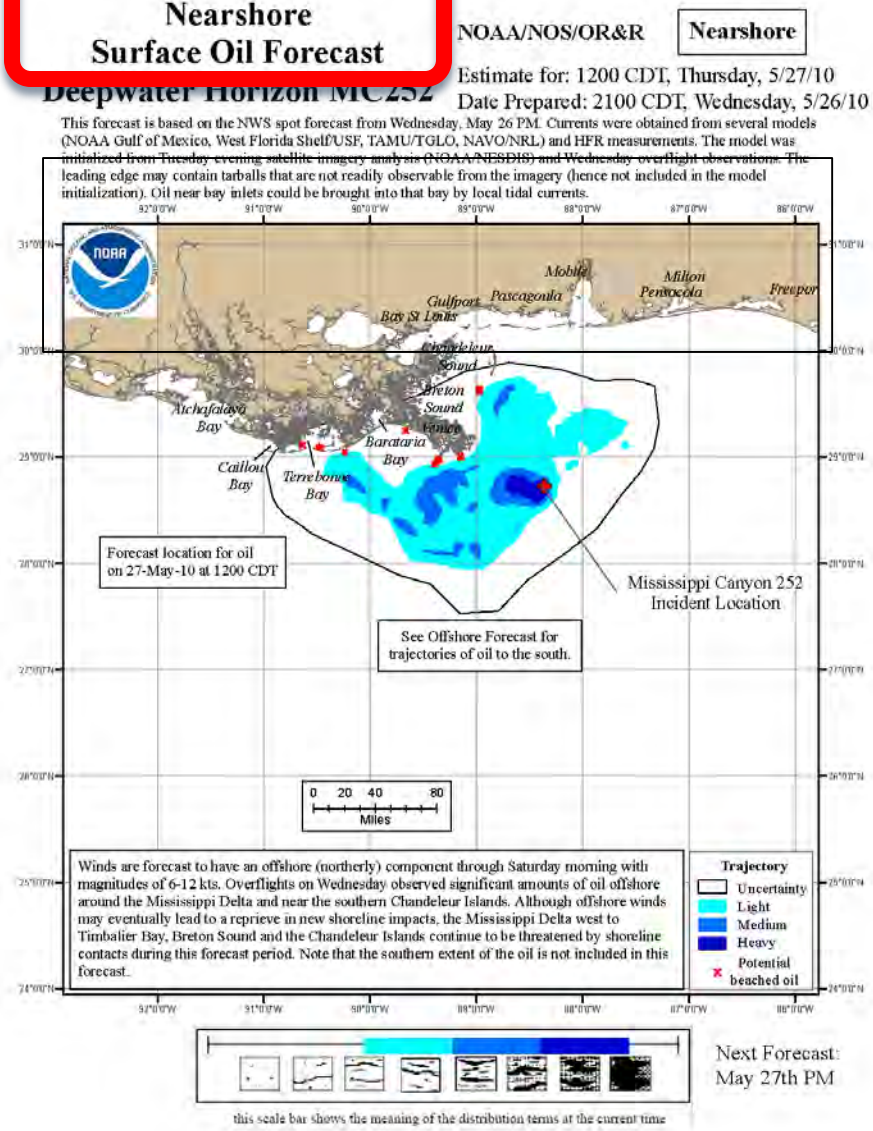




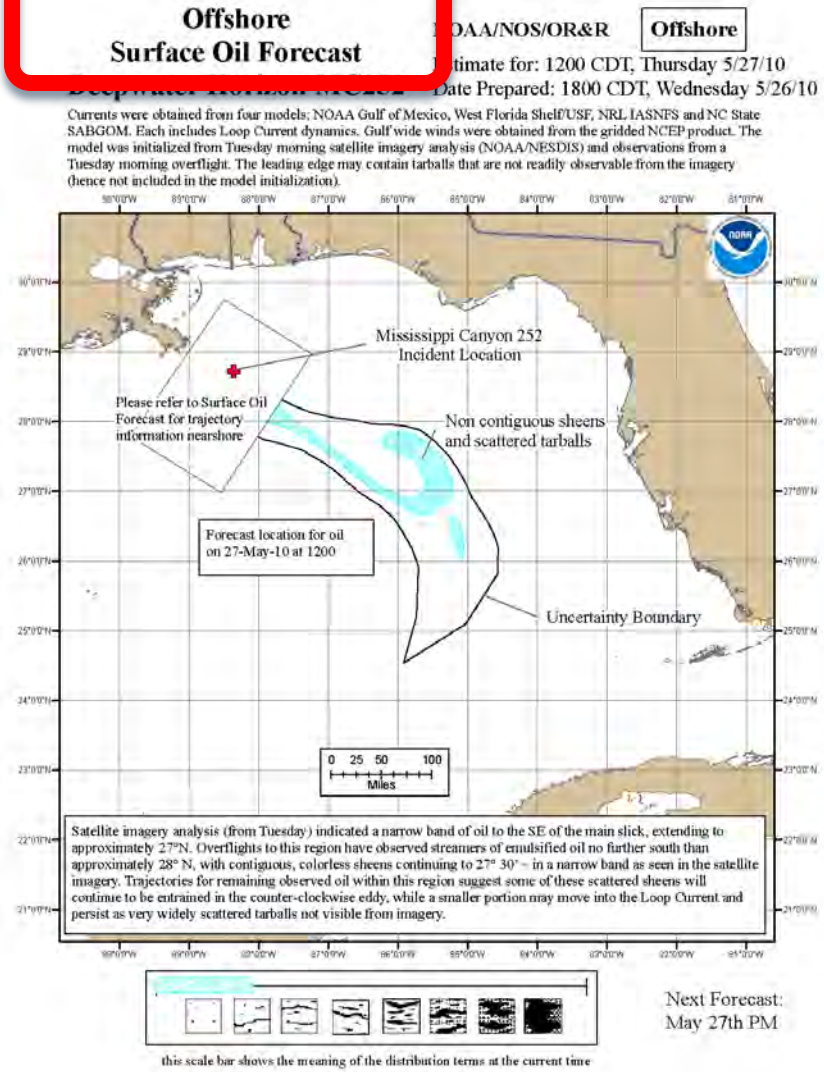


Oil Spill Status : NOAA Guidance

Nearshore Surface Oil Forecast



Offshore Surface Oil Forecast



Enhanced Wave and Oil Spill Trajectory Modeling

Journal of Coastal Research | 26 | 5 | 789–797 | West Palm Beach, Florida | September 2010

REVIEW ARTICLE

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.

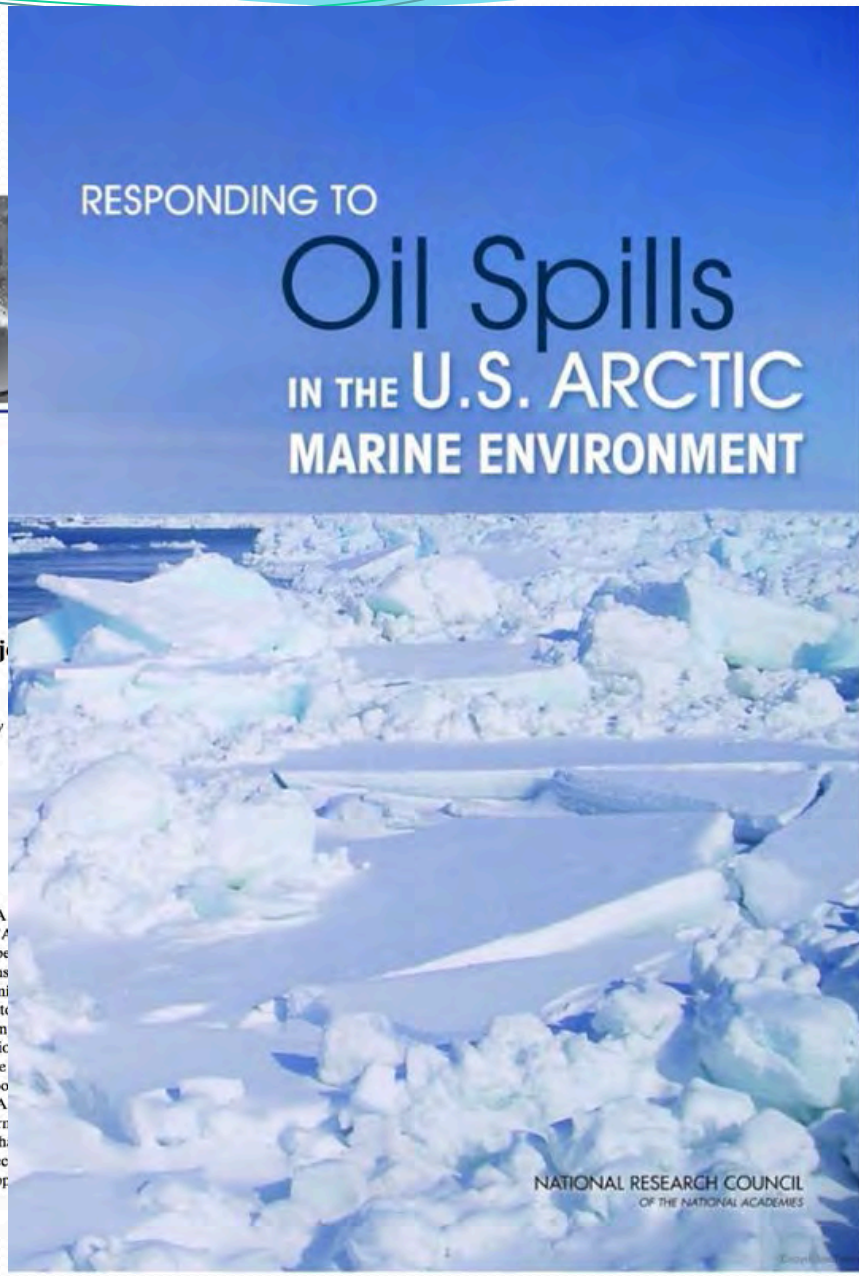
ADDITIONAL INDEX WORDS: *Oil spills, oil remote sensing, tracking oil spills, oil spill response, remote sensing.*

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



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?

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