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
What does it sound like?
How Does it Work?

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

Drift River Winds

Site 1

Winds

cm/s
350+ Global HF Radar Installations
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 km²
- Hourly Measurements in real-time
- Already incorporated into NOAA’S Arctic ERMA
Does it Work In Ice?
Ocean Circulation Measurements
Wave Measurements

Buoy 44091, SPRK: RC10, RC5, RC3

landward seaward

Wave Height (m)

03/22 03/23 03/24

20-40% of the range for currents
U.S. Coast Guard: Search And Rescue Optimal Planning System

East Coast HF Radar Network – 15 Sites

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

Rx : BASC, 5 trg.dir's (10-Sep-2012 00:01:03 - 10-Sep-2012 09:57:42)

- GPS
- $\sigma = 0.96$ km
- $\Delta R = 0.16$ km
- $\langle R \rangle = 0.10$ km
- $R_{max,vis} = 44.3$ km

update interval = 64 sec (Today : 16-Jan-2013)

- GPS
- Bragg
- $\sigma = 0.18$ m/s
- $\langle v \rangle = 0.05$ m/s

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

update interval = 64 sec (Today : 16-Jan-2013)
Doppler Spectra from all Range Cells with Detection Algorithm Applied

- Bragg Waves
- Fixed Objects & Direct Signals
- Vessel

Doppler Frequency
Range
Vessel Detection: Case Study

Westward Wind
Length 49 m

Photo taken from the Westward Wind at approximately 8/27/14 08:55 (16:55 GMT)

Russian Naval Vessel Pribaltica

156 km

@ 8/27/14 09:05 (17:05 GMT)

108 km
Detections by HF Radar at PTLY 14:00 -20:00 GMT
Oil Spill Dispersion Mapping

May 20, 2011
Tracking Oil Slicks and Predicting their Trajectories Using Remote Sensors and Models: Case Studies of the Sea Princess and Deepwater Horizon Oil Spills

Victor Klemas

College of Earth
Ocean and Environment
University of Delaware
Newark, DE 19716, U.S.A.
klemas@udel.edu

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 space 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 boom deployment. 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 Alaska 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, 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 remaining above the surface of the ocean and a 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 response 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 size of oil spills stemming from these accidents can be calculated based on the holding capacity and...
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?