EVOLUTION OF THE USF/CMS CODAR and WERA HF RADAR NETWORK

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COMPS Observing Array System

The COMPS Program was implemented as a legislative initiative in 1997 with continuing support to date from various sources, including NOAA IOOS SECOORA support.

Initiated to improve our understanding of the workings of the coastal ocean for a variety of environmental applications, including hurricane storm surge along the West Coast of Florida’s West Florida Shelf (WFS).

COMPS program observing assets consist of arrays of offshore buoys and coastal stations for surface meteorology and in-water measurement of Temperature, Salinity, Currents, and Sea Level; along with HF Radar systems for offshore surface current velocity field measurements.
US HF Radar Network

- Operated by > 30 institutions and used by > 40 government/private entities for:
  - Coast Guard: Search & Rescue, Oil spill
  - Water Quality, Criminal Forensics
  - Commercial marine navigation
    - Off Shore Energy
    - Harmful algal blooms
    - Marine fisheries
  - Emerging – Tsunami, Vessel Tracking
National Data Management
HF Radar Data Management

Univ. of San Diego’s/Scripps Institution of Oceanography Coastal Observing Research and Development Center (CORDC)

- Quality control - Radar level
- Radial velocity level and Total vector velocity level
  - 1, 2, 6 km data
Existing Combined USF/CMS HF Radar Network

The USF/COMPS/Ocean Circulation Group (OCG) presently operates:

- Three (3) long range CODAR (1 RX and 1 TX Antenna, Direction Finding) systems [Redington Shores, Venice, and Naples, Florida], as well as;

- Two (2) WERA (12 RX antenna and between 1-4 TX antenna, Phased Array) systems [Ft De Soto, Venice] on the WFS.

- With the Venice site containing the only co-located and operational CODAR and WERA systems in the US.

The USF CODAR HF radar systems currently operate at 4.90 MHz and the WERA HF radar systems operate between 12.275 – 13.20 MHz, with a higher resolution coverage area within the larger CODAR footprint.
CODAR DF SeaSonde HF Radar

**Redington Shore (RdSr):**
- Located at 18200 Gulf Boulevard, Redington Shores, Florida (27° 49.937' N, 82° 50.032' W). Operation began on 9/24/03.
- Special “Flagpole” antenna. Typical of siteing issue difficulties from increased beachfront development.

**Venice (Veni):**
- Located at 1200 South Harbor Drive, Venice, Florida (27° 04.655' N, 82° 27.096' W) at US Coast Guard Auxiliary Station 86. Operation began on 4/27/04.

**Naples (Napl):**
- Located at 1301 09.729' N, 812° 48.632' W) within the City of Naples’ Loudermilk Park. Operation began on 04/20/05.
- All sites – “Hurricane Hardened” with much attention paid to lightning and grounding related issues. All cables in buried conduit and all antennas secured in poured concrete pedestals.
WERA PA HF Radar

**Ft DeSoto/Tierra Verde (FDS):**
- Located at the North Beach Pavilion at Ft DeSoto Park, Florida (27° 38.16' N, 82° 44.30' W). Operation began on 6/05/10.
- Twelve (12) 1m high RX antennas and a single 2m high roof top mounted TX antenna was used. RX antenna overdriving effects caused by TX direct path is mitigated through the 350 m TX to RX array separation distance decoupling.

**Venice (VEN):**
- Located at 1200 South Harbor Drive, Venice, Florida (27° 04.655' N, 82° 27.096' W) at US Coast Guard Auxiliary Station 86. Operation began on 6/13/10.
- Twelve (12) 1m high RX antennas and a standard 4-antenna beach mounted configuration was used – antenna separation distance is 220 m.
- All sites – cable in buried conduit with special low height, no guy wire design for aesthetics and to minimize sea turtle entanglement possibilities. Much attention paid to lightning and grounding related issues.
Co-Located CODAR/WERA – Aerial View
Co-Located CODAR/WERA

- Both systems operate on the same site but at different frequencies.
- Notch filters are placed on the WERA RX channel input locations to remove any in-band signal issues.
- The included image shows the relative positions of the CODAR TX antenna (taller) and WERA RX antennas 11 and 12.
Real-Time Performance – Sample CODAR Surface Current Field

- HF Radar observational challenges on the WFS are sometimes manifested in low data returns, especially in the summer, where the low energy environment and its corresponding lack of sufficient wave energy in the band necessary for Bragg scattering at the selected transmitted frequency.

- However, when energy is present like during a storm event, the returns are strong as shown in the following plots.
Example Real-Time Performance – WERA Surface Current and Significant Wave Height Field

<table>
<thead>
<tr>
<th>Site</th>
<th>COMPS Site</th>
<th>Possible Hours</th>
<th>Received Hours</th>
<th>% Received</th>
</tr>
</thead>
<tbody>
<tr>
<td>CODAR</td>
<td>RdSr</td>
<td>8808</td>
<td>8568</td>
<td>97.3</td>
</tr>
<tr>
<td>CODAR</td>
<td>Veni</td>
<td>8808</td>
<td>8767</td>
<td>99.5</td>
</tr>
<tr>
<td>CODAR</td>
<td>Napl</td>
<td>8808</td>
<td>8821</td>
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</tr>
<tr>
<td>WERA</td>
<td>FDS</td>
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<td>8443</td>
<td>95.9</td>
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<tr>
<td>WERA</td>
<td>VEN</td>
<td>8808</td>
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</tbody>
</table>

From - Univ. of San Diego’s/Scripps Institution of Oceanography Coastal Observing Research and Development Center (CORDC) Diagnostic Web Page
MESOSCALE FLOW FEATURES

• HF Radar systems have been used at USF/CMS in combination with moored ADCP’s in Observing the 3-D coastal circulation on the WFS.

• HF Radar surface current data has also been used at USF/CMS to compare with Altimetry-derived surface currents.

• Radial currents have also been assimilated into OCG FVCOM Coastal Ocean circulation modeling efforts at USF/CMS.

• Can now map, quantify and track features like eddies and jets.

• Active research continues with publications cited herein.
Recent HF Radar Publications

- Liu, Yonggang, Weisberg, R.H., Merz, C.R., “Assessment of CODAR SeaSonde and WERA HF Radars in Mapping Surface Currents on the West Florida Shelf”, Journal of Atmospheric and Oceanic Technology. Accepted with anticipated publication date of May 2014. DOI: 10.1175/JTECH-D-13-00107.1


HF Radar Publications Underway

- WERA MIMO - Synthetic Aperature Processing. Joint paper with Helzel in Oceans 2014, September
- WERA RFI External Noise Comparision Study
Future Needs/Opportunities

• Need more HF Radar site coverage along the Gulf of Mexico region to better support:
  • Ongoing Oil spill tracking and prediction efforts.
  • Ongoing HAB tracking and prediction efforts.
  • USCG Search and Rescue (SAR) Operations.
  • Commercial and Recreational Fishing needs.

• Expand existing USF nested CODAR/WERA HF Radar software/operational capabilities at the mouth of Tampa Bay to include ship tracking capabilities into/ out of Tampa Bay for improved Tampa Bay Port security.
Thank you.

Questions?
HF Radar systems derive estimates of the surface velocity, wave, and wind velocity from the gravity wave field via Bragg scattering of the HF Radar transmitted beam.

The reflected transmitted beam returns to the receiver Doppler shifted by a surface ocean wave equal to ½ the wave length of the transmitted signal.

The Doppler–frequency shift includes the theoretical speed of the wave PLUS the influence of the underlying ocean current on the wave velocity in a radial path (away from or towards the radar).

Significant wave height is derived from a scaled ratio of 2nd order to 1st order peaks from a single radar site.

Full directional wave spectra obtained from iterative inversion of Doppler spectra to match surface wave spectrum. Doppler spectra must be simultaneously observed from two overlapping stations.

Wind (short wave) direction measured from magnitude difference between the two peaks, Donelan’s \( \text{sech}^2(\beta(\theta)) \) where parameters are determined from Bragg ratios.

Barrick, Gurgel, Shay, Wyatt, et. al.