2010-2015 ACCOMPLISHMENTS PART 2

Image Credit: Pedro Matos-Llavona

BROAD FIELD REMOTE MEASUREMENTS HF-RADAR

SECOORA
Southeast Coastal Ocean Observing Regional Association

IOOS
INTEGRATED OCEAN OBSERVING SYSTEM

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Broad field Remote Observations – HF Radar Team

Operating and Maintaining IOOS Priority High Frequency Radars In SECOORA (Mapping surface current fields in real time at 15 priority sites using CODAR and WERA).

Primary Investigator (PI) : Lynn K. (Nick) Shay, UM

Co-Investigators (Co-PIs): Harvey Seim, UNC-Chapel Hill

: Dana Savidge, SkIO

: George Voulgaris, USC

: Robert Weisberg, USF

Approach: Each of these institutions operate at least 2 HF radars in the SECOORA footprint.

Broad field Remote Observations – HF Radar

Goal: Operate HF radar surface current measurement systems and provide the data in near-real time to identified user-groups. Key objectives are:

1. Maintain HF radar systems to provide the surface current data in near-real time;

2. Document operating characteristics, performances and interoperability issues;

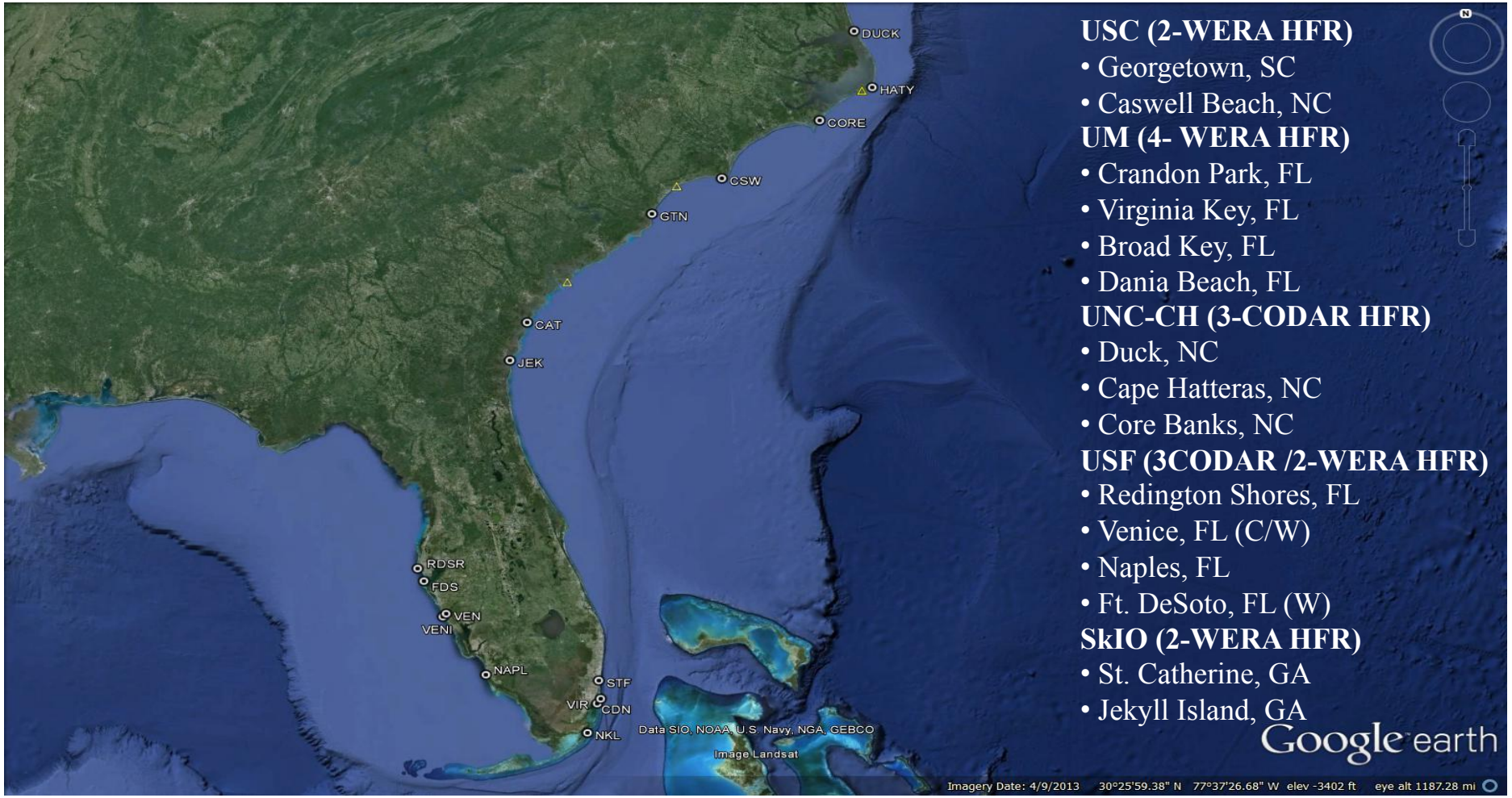
3. Build new products for winds and waves to address stakeholder needs;

4. Analyze various data sets for seasonal, annual climate related signals; and,

5. Coordinate activities with adjoining regions such as GCOOS-RA and MACOORA.

Wish: Add one site per year to the existing SECOORA network to narrow the gap subject to the availability of funds.

Broad Field Remote Observations – HF Radar Sites



USC (2-WERA HFR)
- Georgetown, SC
- Caswell Beach, NC

UM (4- WERA HFR)
- Crandon Park, FL
- Virginia Key, FL
- Broad Key, FL
- Dania Beach, FL

UNC-CH (3-CODAR HFR)
- Duck, NC
- Cape Hatteras, NC
- Core Banks, NC

USF (3CODAR /2-WERA HFR)
- Redington Shores, FL
- Venice, FL (C/W)
- Naples, FL
- Ft. DeSoto, FL (W)

SkIO (2-WERA HFR)
- St. Catherine, GA
- Jekyll Island, GA

Broad field Remote Observations – HF Radar

Applications:

HF radar provides near-real time surface currents, significant wave heights and wind directions from first and second order returns. Phased Array technology can also provide the directional aspect of the wave spectrum.

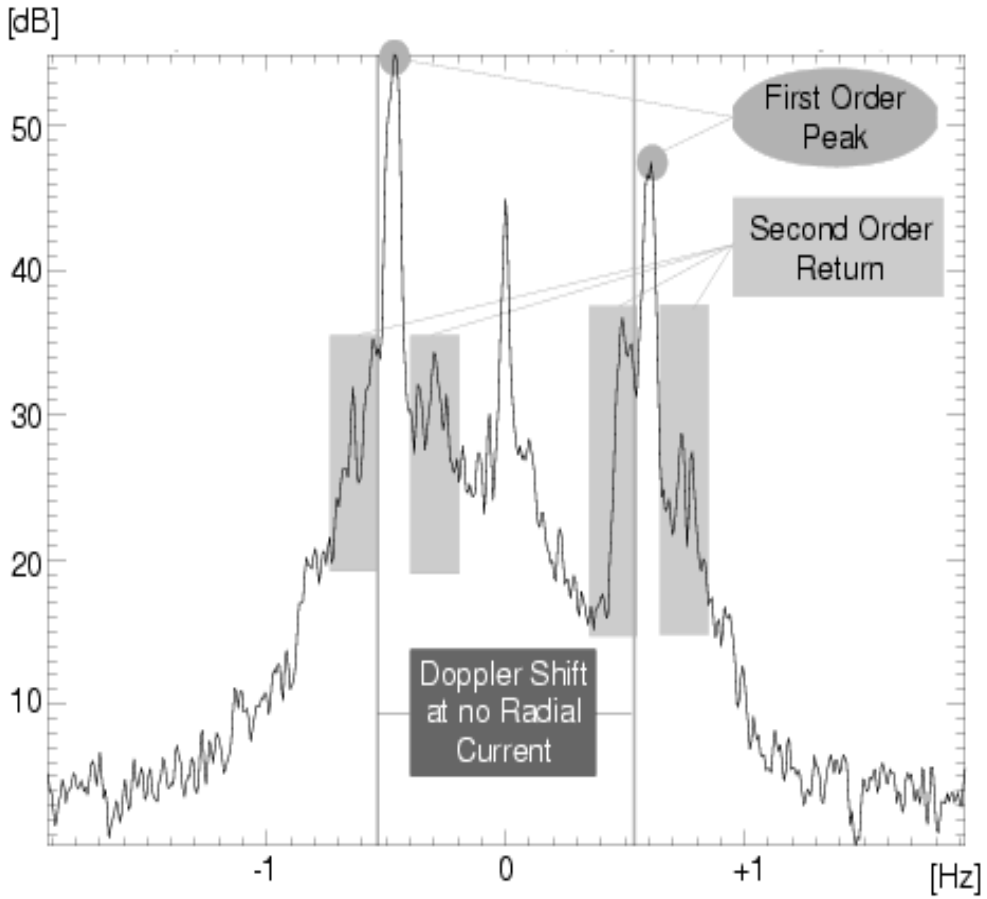
Benefits:

Network provide valuable data : search and rescue operations, oil spills and toxins (e.g. beach closures); weather prediction current and wave forecasts; marine transportation; surge prediction models; and ship tracking for security issues .

Stakeholders:

USCG, NWS, DHS, Port Officials, State and County Emergency Managers, Local Police Departments, County and State Park Managers.

Broad field Remote Observations: HF Radar **Measurement**



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

Wave spectra is obtained from iterative inversion of Doppler spectra to match the surface Wave spectrum. Doppler spectra must be simultaneously observed from two overlapping stations [*Wyatt*, IEEE-JOE, 1990].

Accomplishments (2011-2015) – HF Radar

- Operating HF Radars with up times > 75 to 80% often extending to the maximum ranges of 80 (MR) to 200 (LR) km.
- Training grad students be the next generation HF radar scientists for the IOOS network (that's one of our primary goals at Universities)
- Providing data to the NWS to improve marine forecasting in areas Florida Current and Gulf Stream (UM).
- Building a climatology to understand monthly, seasonal and annual surface current variability (USC) and north wall of the GS (UNC).
- Implementing and testing ship tracking software at sites in support of DHS (SkIO, UNC, USF).
- Participating in CODAR AIS Automated Antenna Pattern Measurement (APM) Pilot Project Participant operating at the USF Venice site.
- Assessing algorithms for SWH from an AWAC buoy deployed in the Florida Straits as part of the WHARF project (UM).
- Added a third radar site in North Carolina using state funds (UNC).

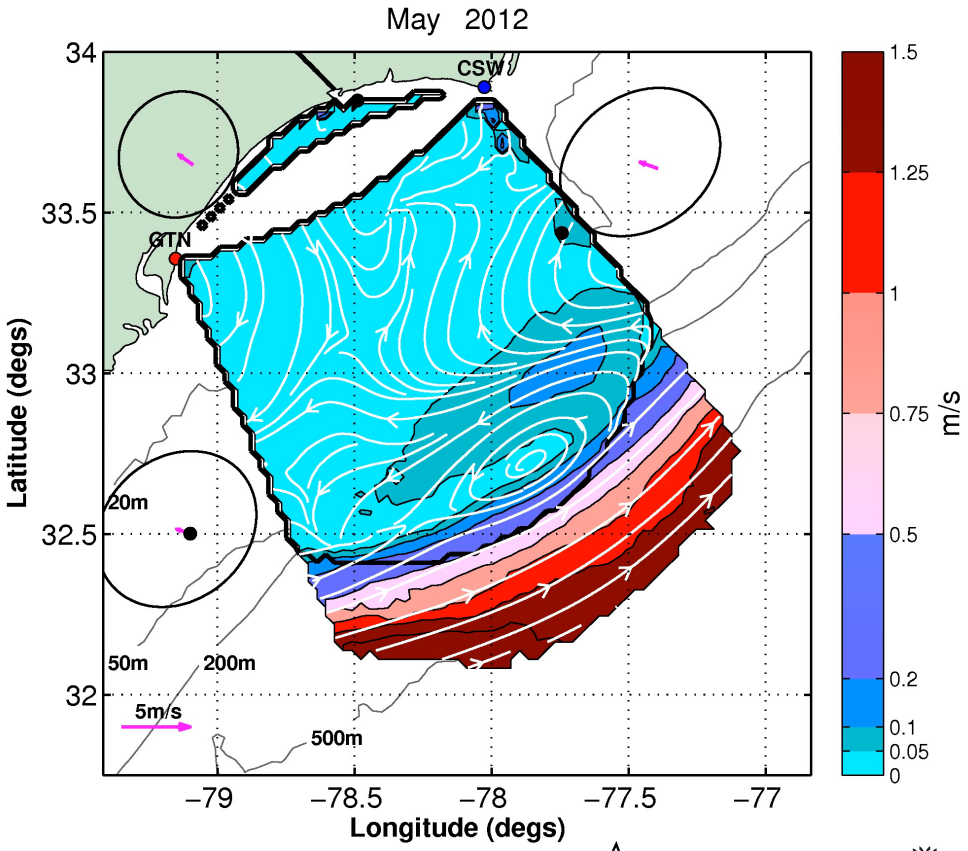
Broad field Remote Observations – HF Radar

Example of an USC HF Radar product:

Monthly Climatology of see surface flow and wind forcing in Long Bay, SC

- See differences in streamlines from month to month
- Some of them are due to differences in wind forcing
- Others due to differences of Gulf Stream position

Climatology estimated at the end of each month following an intensive QA/ QC re-analysis of the data



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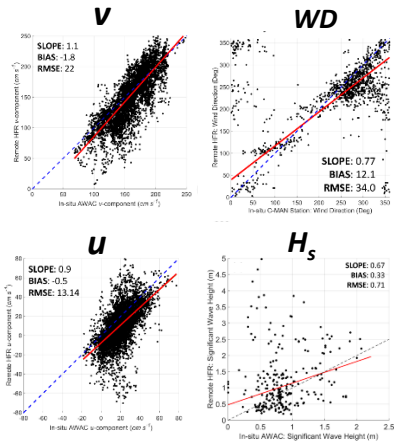
Broad field Remote Observations – HF Radar

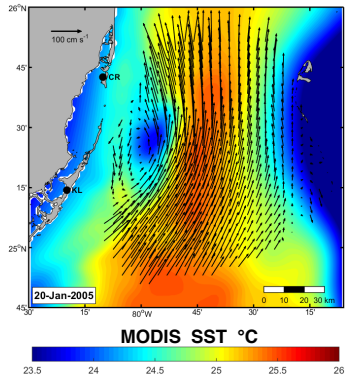
W H A R F Experiment (Student Project): Evaluation of HF radar measurements.

- Concurrent *in situ* measurements of **surface current velocity**, **wave height** and **wind direction.**
- Improving **operational wave height algorithms**.
- Only 20% of the time series was useful for wave heights due to the FC moving over AWAC mooring - <u>needed a 300 kHz unit.</u>



Investigation of cyclonic frontal eddies using HF radar, MODIS SST and subsurface ADCP data (*towards a value added product*).

- Submesoscale frontal eddies **drive divergence**, **upwelling**, and **particle dispersion** at the surface.
- Barotropic current structure suggests full water column **cross-shelf exchange** at the 80 m isobar.



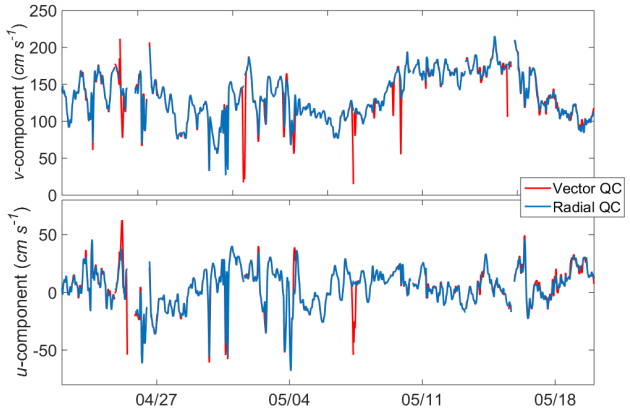
Broad field Remote Observations – HF Radar

Lessons Learned

- Equipment needs to be upgraded (cables, coils, antennae, power supply) at 6 to 8-year intervals to keep quality data flowing…..Spares are essential.
- Communications with State, County officials *providing real estate is critical* (keep websites active).
- Must hurricane proof all sites in Southeast and Gulf (GCOOS-RA).

- PIs do their own data management (acquisition, quality control and archiving).

- For **improved operations** as well as research and student projects reprocess radial vice vector currents earlier in the process (internal codes) as part of QA/ QC.



Broad field Remote Observations – HF Radar

Coastal Erosion increases SNR (antennas close to water line)

... but collides with the need for marine turtle conservation efforts.

… so antennas need to be relocated …

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Lessons Learned

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Summary and Recommendations

- Several priority sites have been operational since 2003 and spares to replace worn parts are needed. In last five years only CORE site added (UNC) with *state* funds.
- Only RA using WERA and CODARs and they can work together (USF, UM).
- HF radar groups providing value added products (climatology USC), combining with satellite and buoy measurements)…..more could be done.
- SECOORA (and GCOOS-RA) have **broad gaps in coverage (Georgia to South Florida is glaring)** despite DwH (2010) emphasizing the value of HF radar to understand movement of surface oil plume.
- HF radars are providing valuable data to various stakeholder groups through the HF radar net (Rutgers and SIO), SECOORA Websites, and each groups website.
- All radar groups continue to leverage (cannot continue to do this) to keep radars running 24/7/365 (HF radar network is an IOOS requirement).
- SECOORA needs Education and Outreach to help sell potential products to John Q. Public and stakeholders.

Broad field Remote Observations – HF Radar

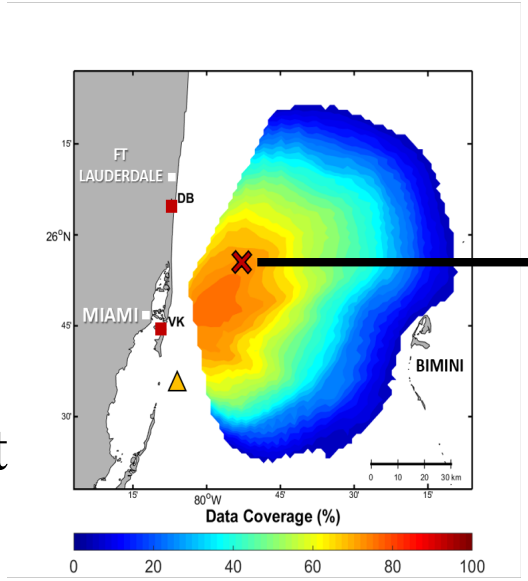
Evaluate operational capabilities of HF radar:

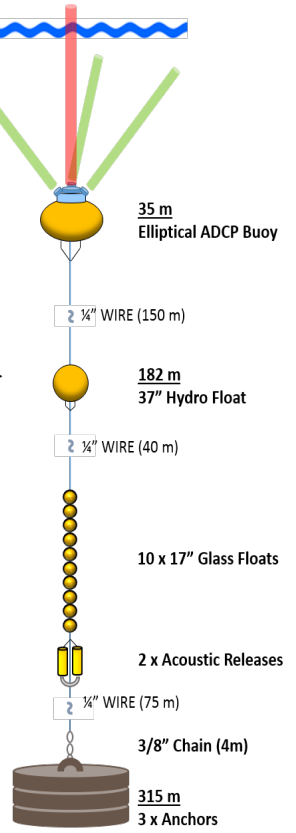
- Current velocity
- Wind Direction
- Significant Wave Height

Subsurface Mooring Deployment

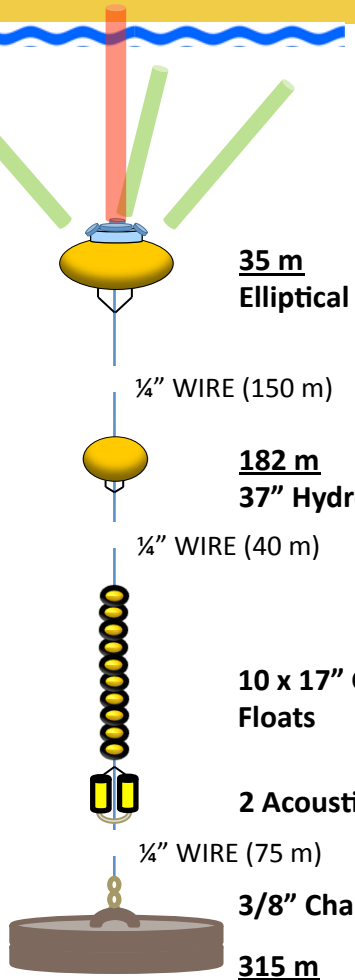
Nortek's acoustic wave and current (AWAC) profiler (600 kHz)

- current velocity profiles
- waves





Broad field Remote Observations – HF Radar



35 m
Elliptical ADCP Buoy

¼" WIRE (150 m)

182 m
37" Hydro Float

¼" WIRE (40 m)

10 x 17" Glass Floats

2 Acoustic Releases

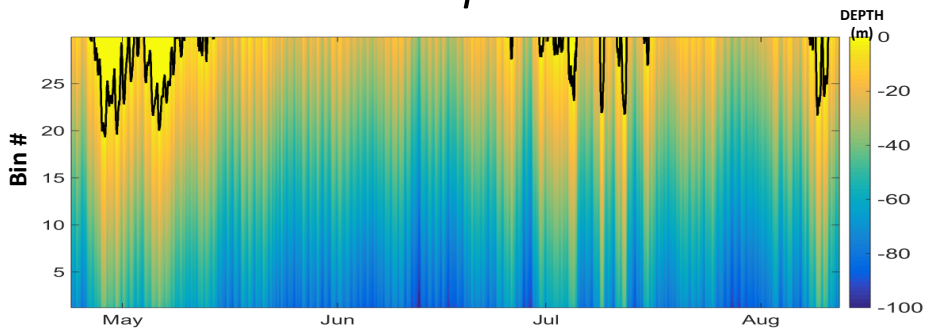
¼" WIRE (75 m)

3/8" Chain (4m)

315 m
3 x Anchors

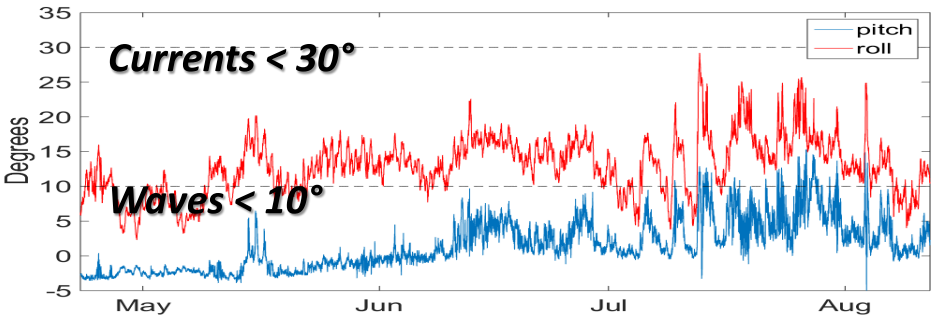
Wave Accuracy Thresholds

Depth



60 m *depth threshold*

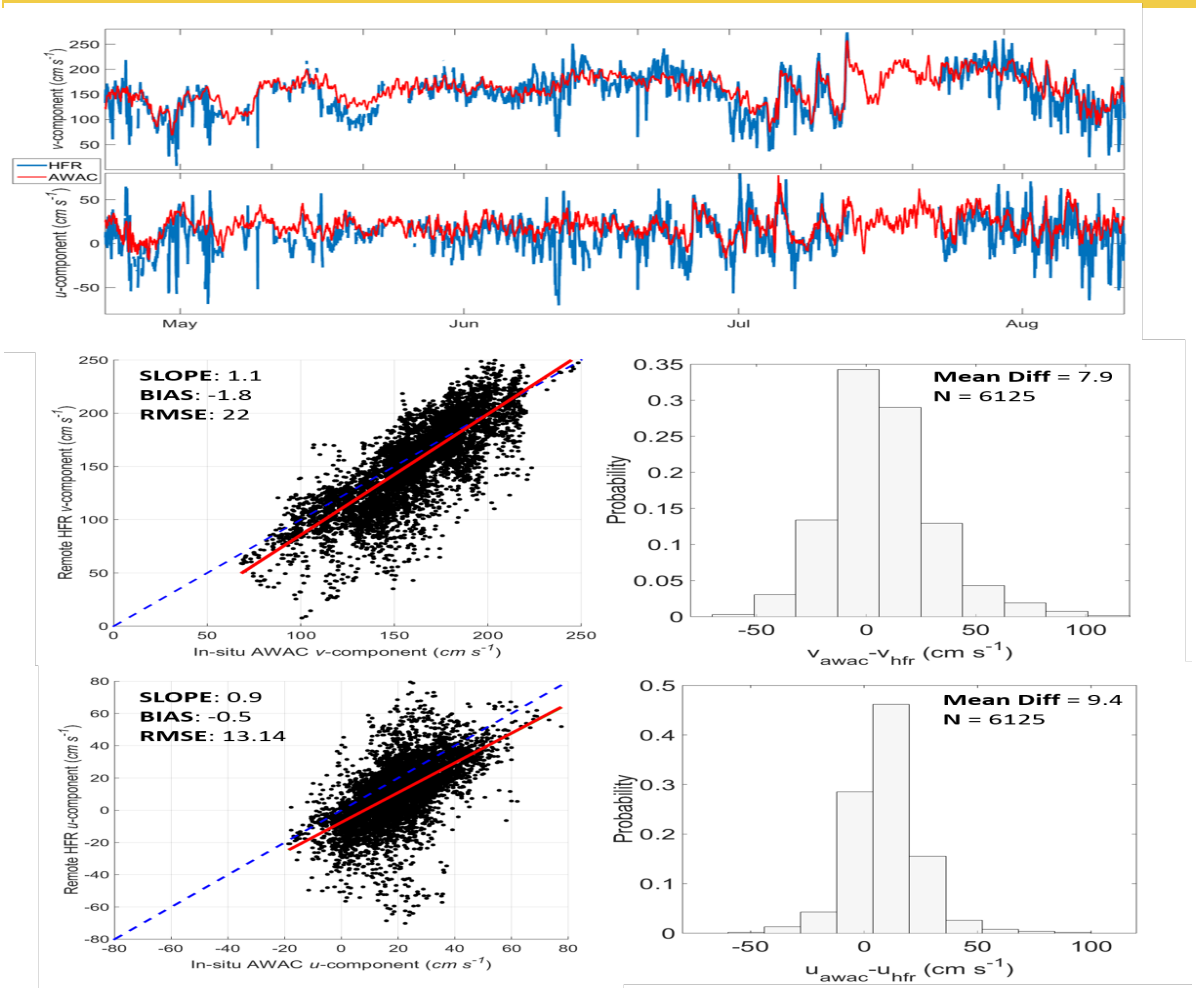
Pitch & Roll



10° *tilt threshold*

17.7% Coverage →**18 days**

Broad field Remote Observations – HF Radar



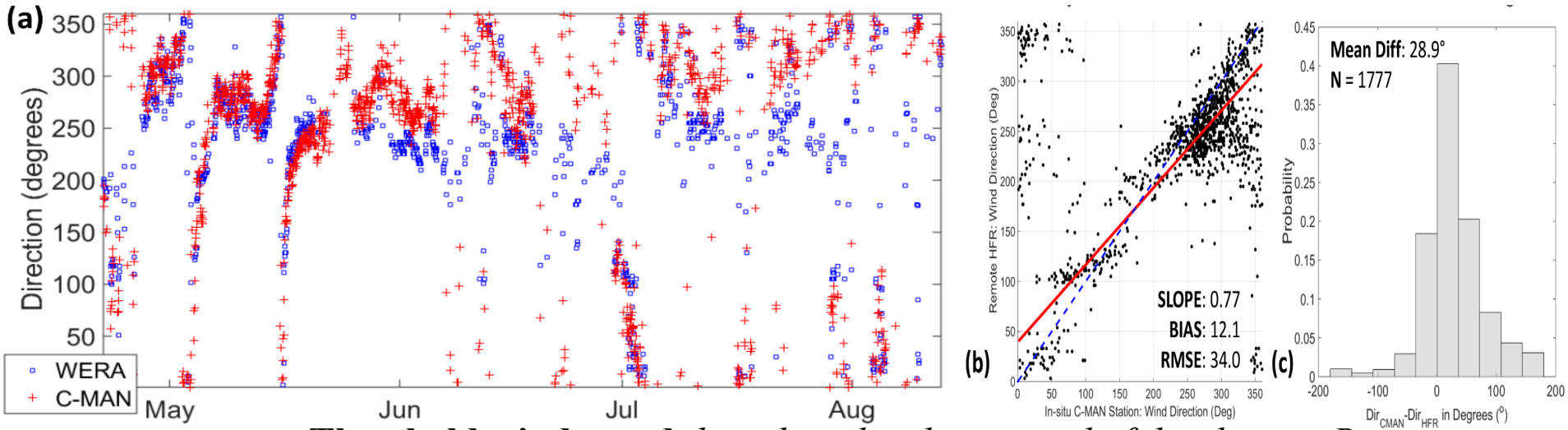
Overall RMS difference consistent with previous studies in the Florida Straits (*Shay et al.*, 2002; *Parks et al.*, 2009):

u : *17 cm s^{-1}*

v : *22 cm s^{-1}*

Broad field Remote Observations – HF Radar

Comparison to Fowey Rocks C-MAN station for Wind Direction

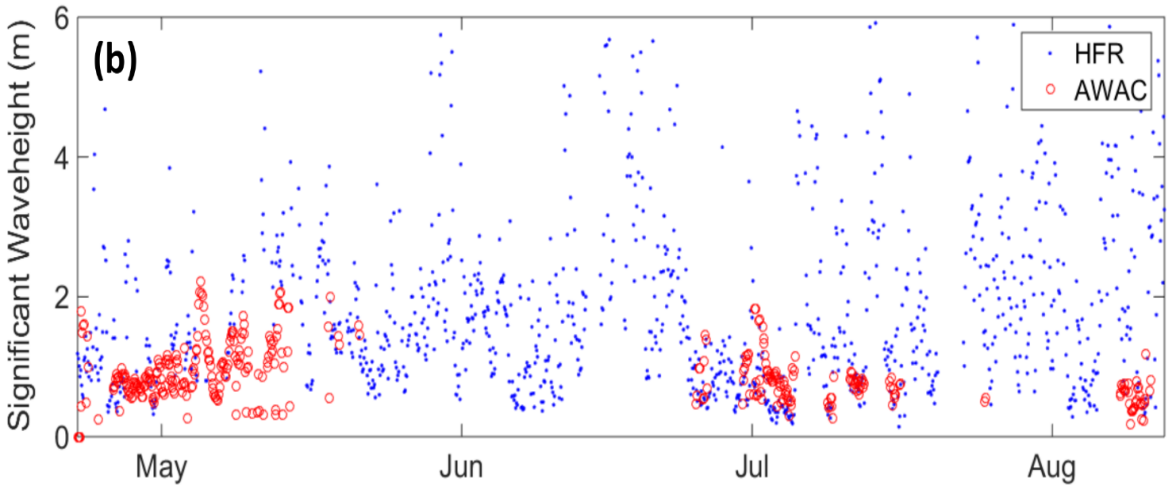


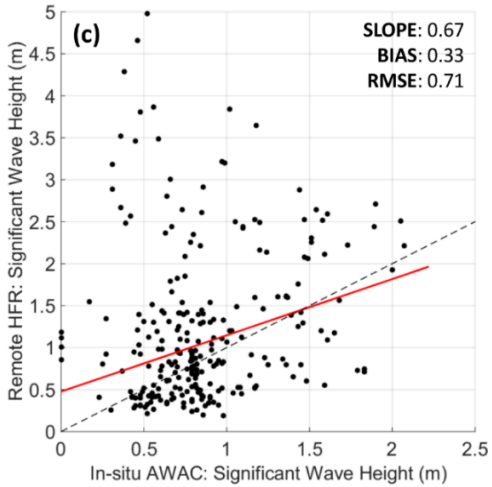
Threshold wind speed, *based on the phase speed of the shortest Bragg wave (12 m) and Pierson-Moskowitz theory ($c = 1.17 \times U_{10}$):*

3.8 m s^{-1}

For wind speeds < 3.8 m s^{-1} the remotely-sensed Bragg waves were not generated locally

Broad field Remote Observations – HF Radar





Following e.g. *Heron and Heron* (1998), we removed times when wind direction was close to orthogonal with beam angle (we tried 15° and 30°) → *but no significant improvement*

Explanations:

- Scattered *in situ* coverage in time
- Higher accuracy HF radar measurements for $H_{rms} > 0.1/k_0 \rightarrow H_s \geq 1.6$ m
- AWAC pushed to threshold of accurate returns

Some Recent Publications

Archer, M., L. K. Shay, B. Jaimes and J. Martinez, 2015: Observations of an ocean front using High Frequency Radar: anticyclonic shear zone instability of the Florida Current In *: Coastal Ocean Observing Systems: Advances and Synthesis*, Elsevier Press, 179-209.

Archer, M., L. K. Shay, J. Martinez, 2015: Evaluation of Remote HF Radar Observations using In-situ Measurements: Currents, Winds and Waves. IEEE/OES 11th CWTW, St. Petersburg, FL, 12 pp (in press)

Dzvonkovskaya, A., Merz, C.R., Helzel, T., Liu, Y., and Weisberg, R.H., 2014: Initial results of ship detection and tracking using WERA HF ocean radar with MIMO configuration. *Radar Symposium (IRS), 15th International - IEEE Xplore,* Gdansk, Poland, doi:10.1109/IRS.2014.6869265.

Liu, Y., Weisberg, R. H., and Merz, C. R., 2014: Assessment of CODAR Seasonde and WERA HF Radars in Mapping Surface Currents on the West Florida Shelf. *J. Atmos. Oceanic Technol.*, 31, 1363–1382, doi:10.1175/JTECH-D-13-00107.1.

Martinez-Pedraja, J., L. K. Shay, B. K. Haus and C. Whelan, 2013: Interoperability of Sea-sonde and Wellen Radars in mapping surface currents. *J. Atmos. Oceanogr. Tech.,* **30**, 2662-2675.

Merz, C. R., Liu, Y., Gurgel, K.-W., Petersen, L., and Weisberg, R.H., 2015: Effect of Radio Frequency Interference (RFI) Noise Energy on WERA Performance Using the 'Listen Before Talk' Adaptive Noise Procedure on the West Florida Shelf. *Coastal Ocean Observing Systems*. Elsevier (in press).

Shen, W., K-W. Gurgel, G. Voulgaris, T. Schlick and D. Stammer, 2012. Wind-speed inversion from HF radar first-order backscatter signal. *Ocean Dynamics*. doi 0.1007/s10236-011-0465-9.