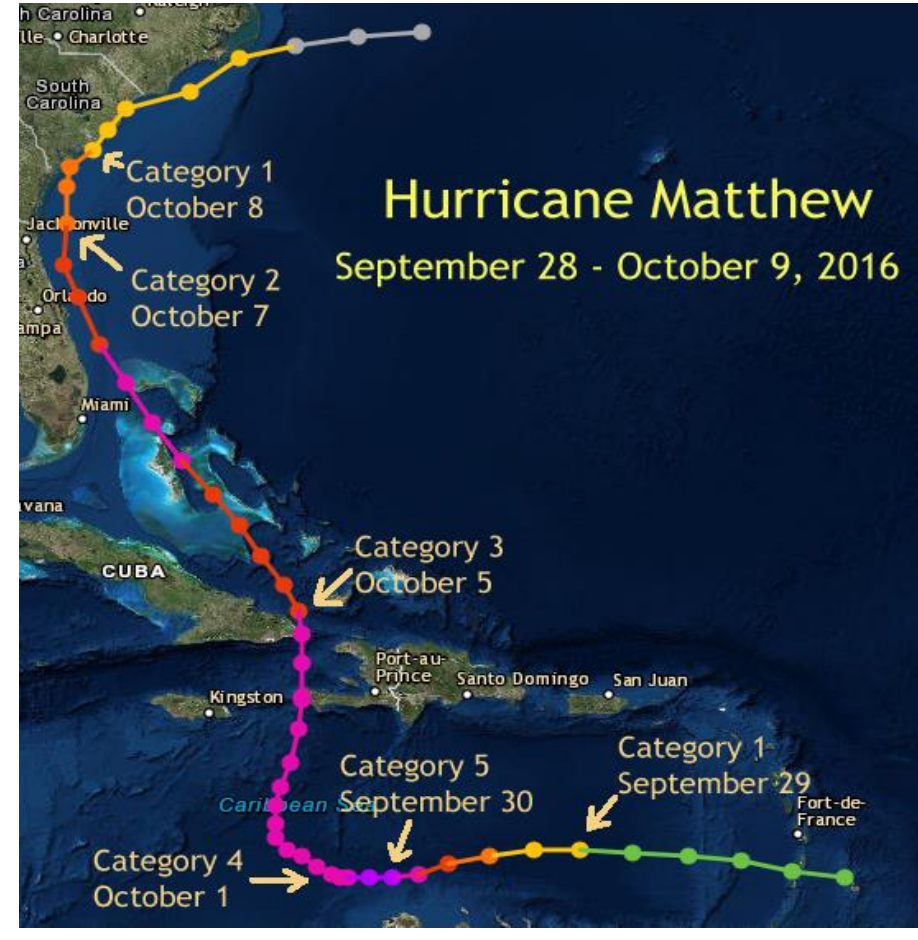
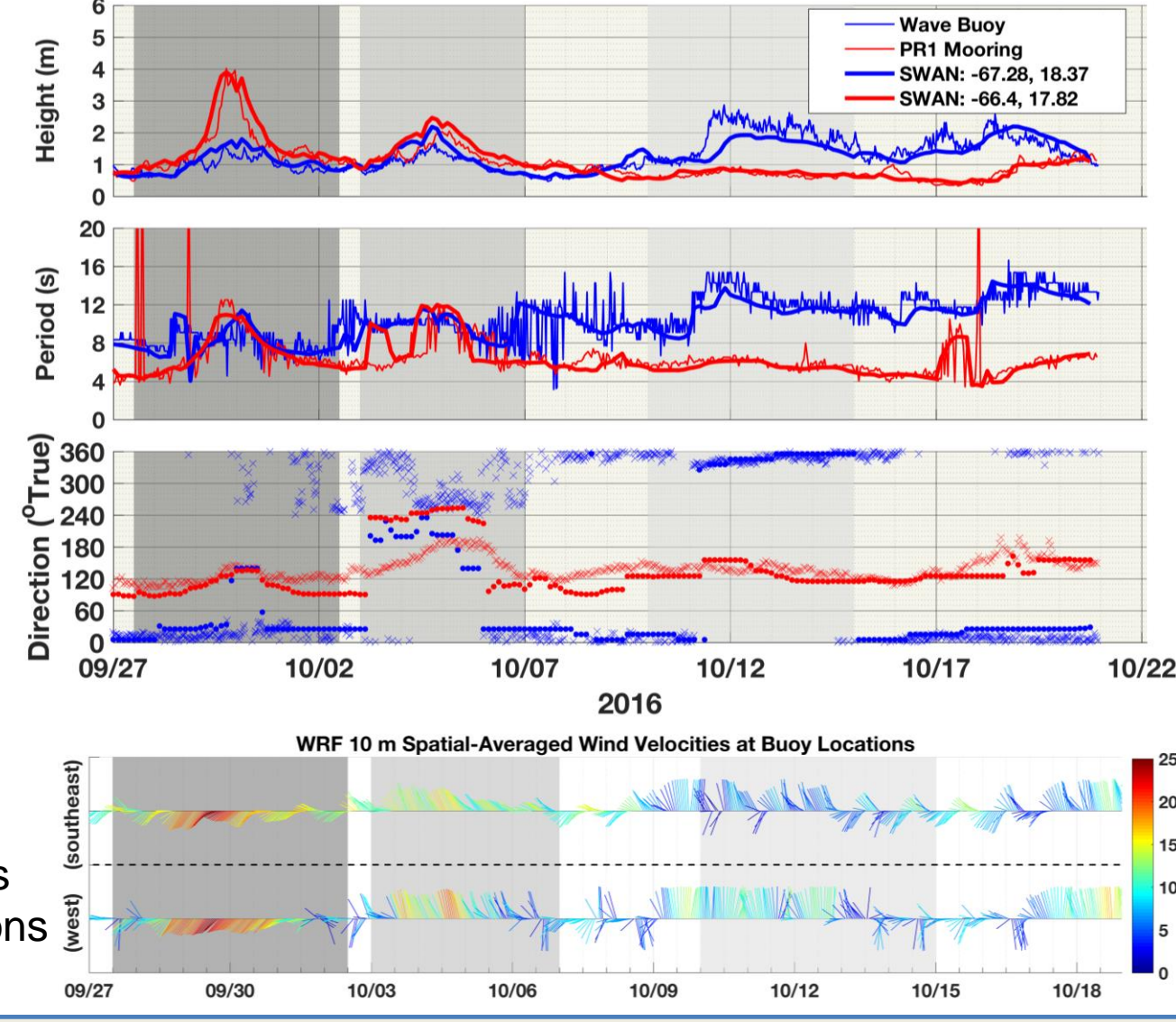


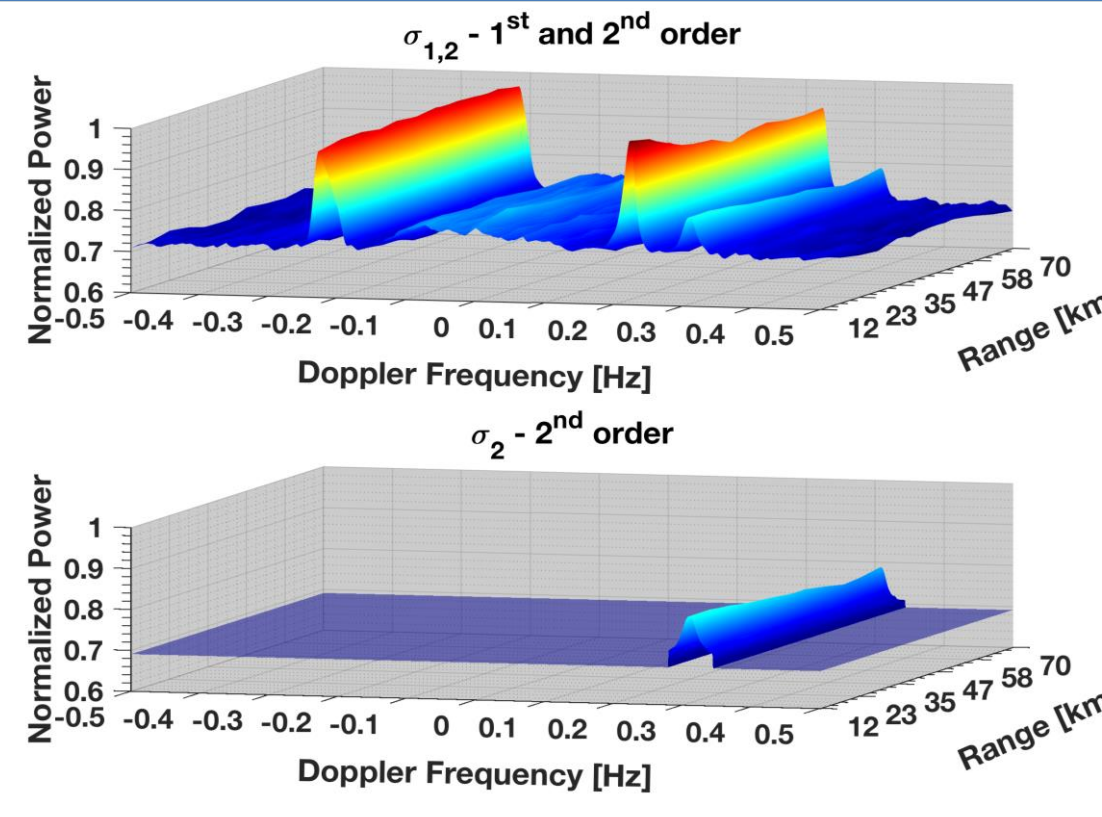
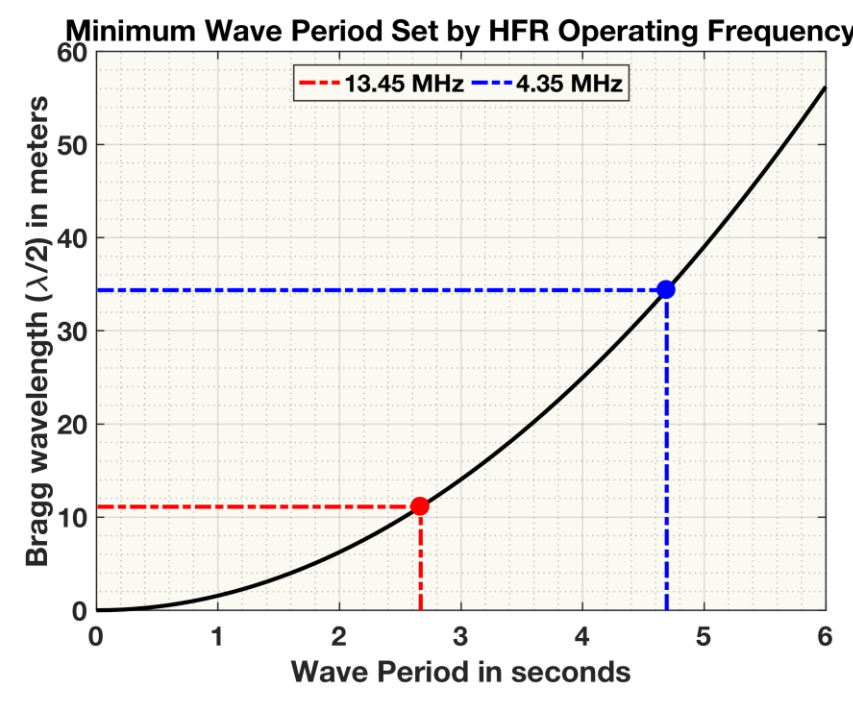
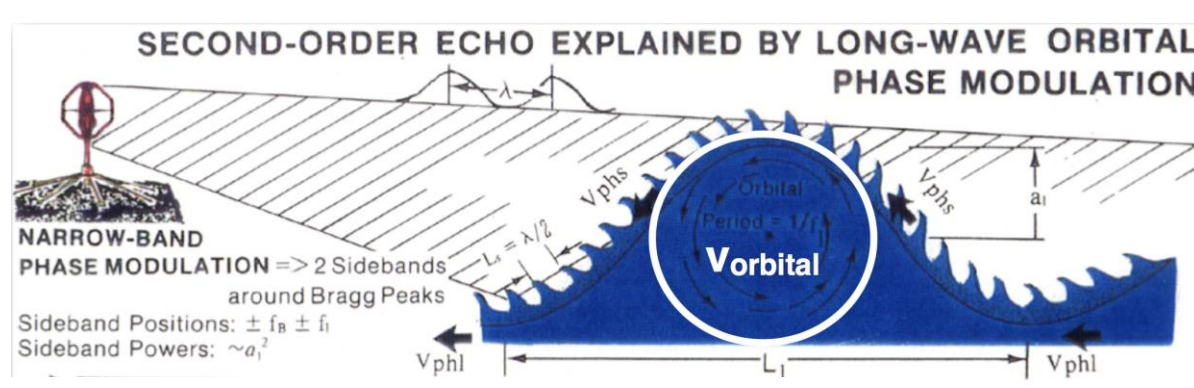
Overview



Hurricane Maria produced 3 complex wave events off the west and southeast coasts of P.R. Validations of HFR-derived wave parameters are presented.



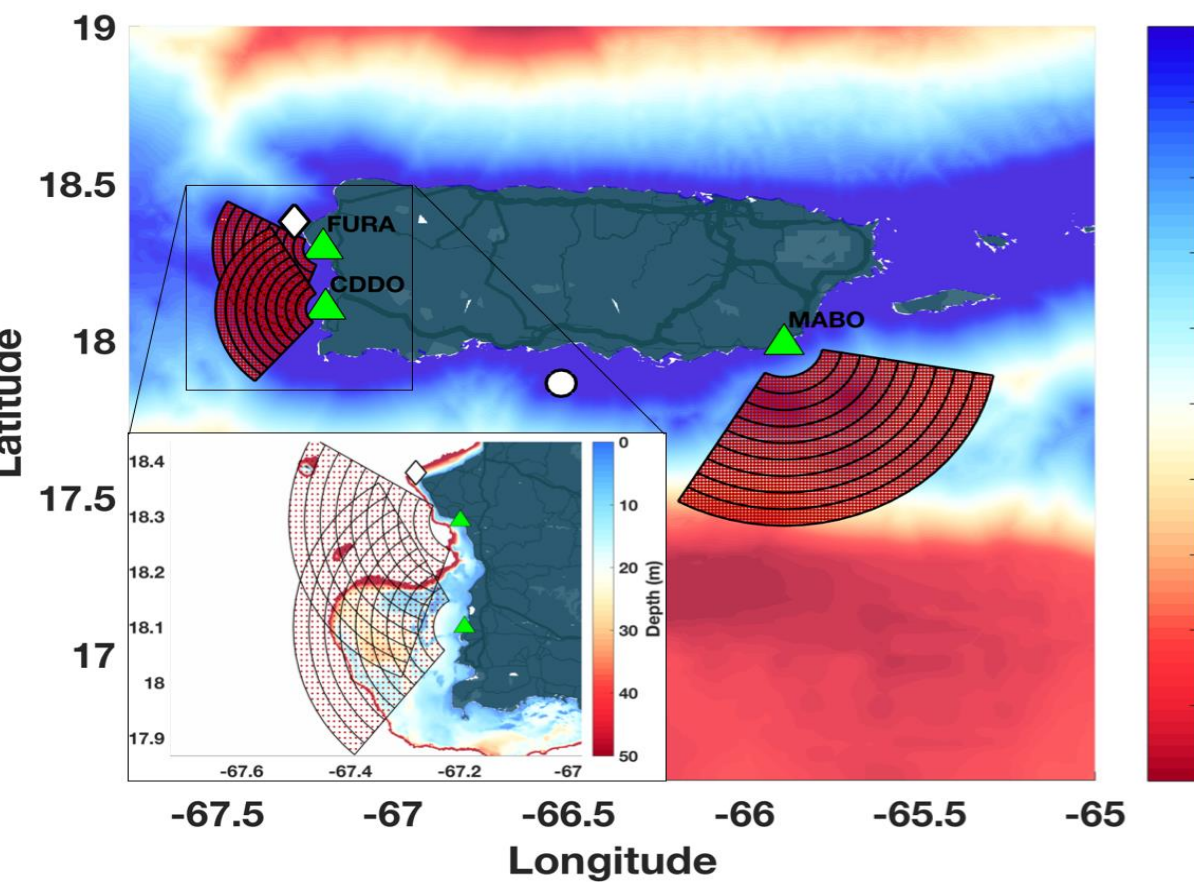
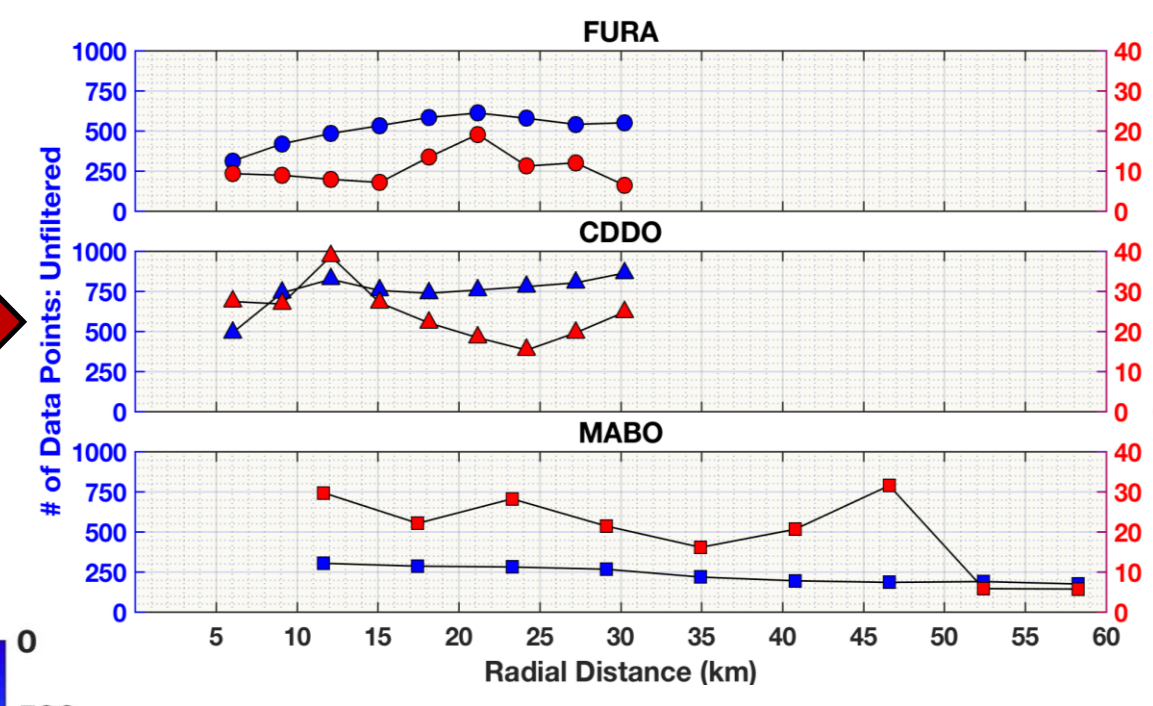
HFR Spectrum and Wave Derivation



The interaction between the underlying long wave orbital velocities with the short, Bragg wave motion induces a secondary side-band displaced from the 1st order peak. Because higher order wave energy is normalized by the Bragg energy, the shortest period waves the HFR can detect are the Bragg waves themselves.

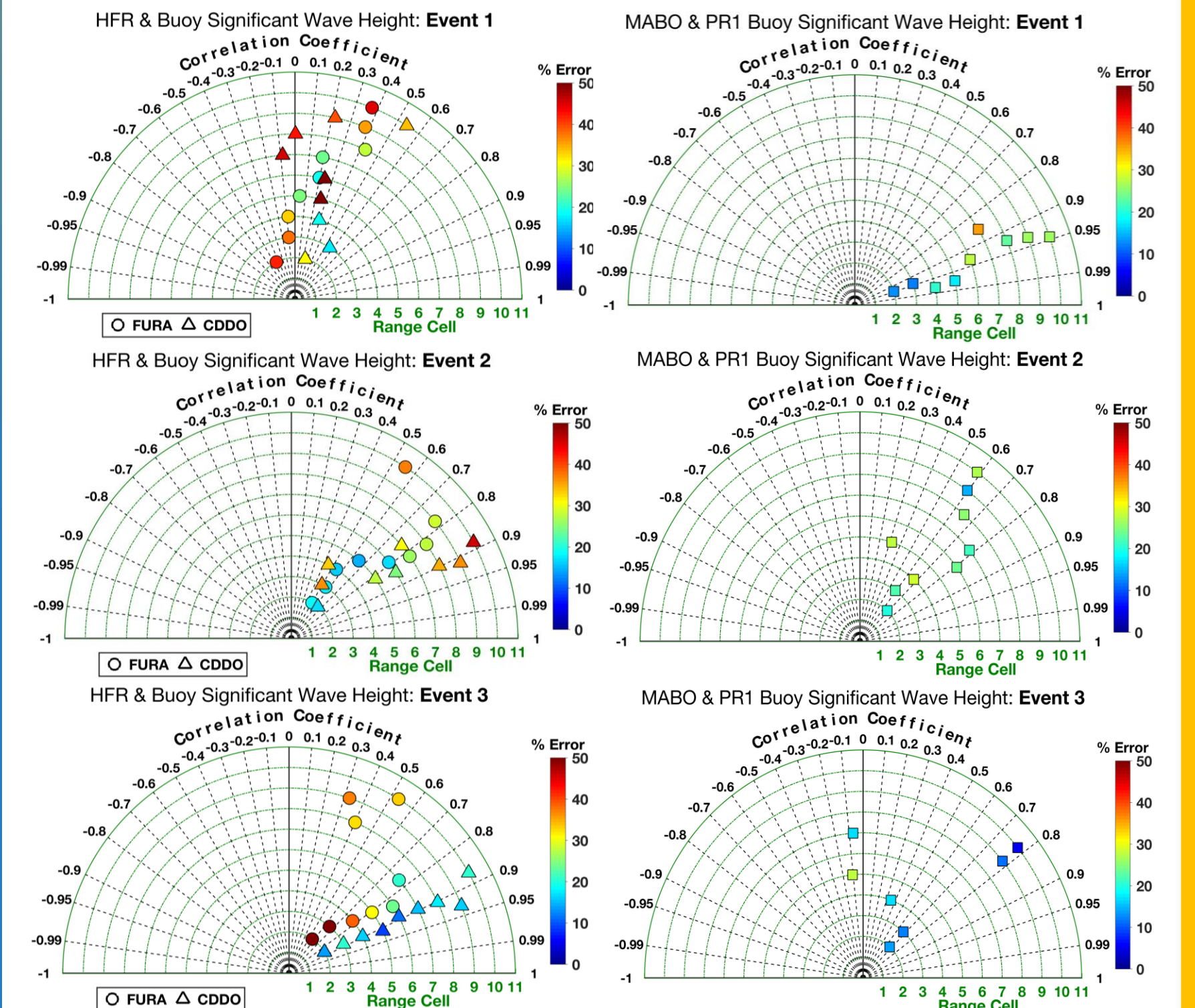
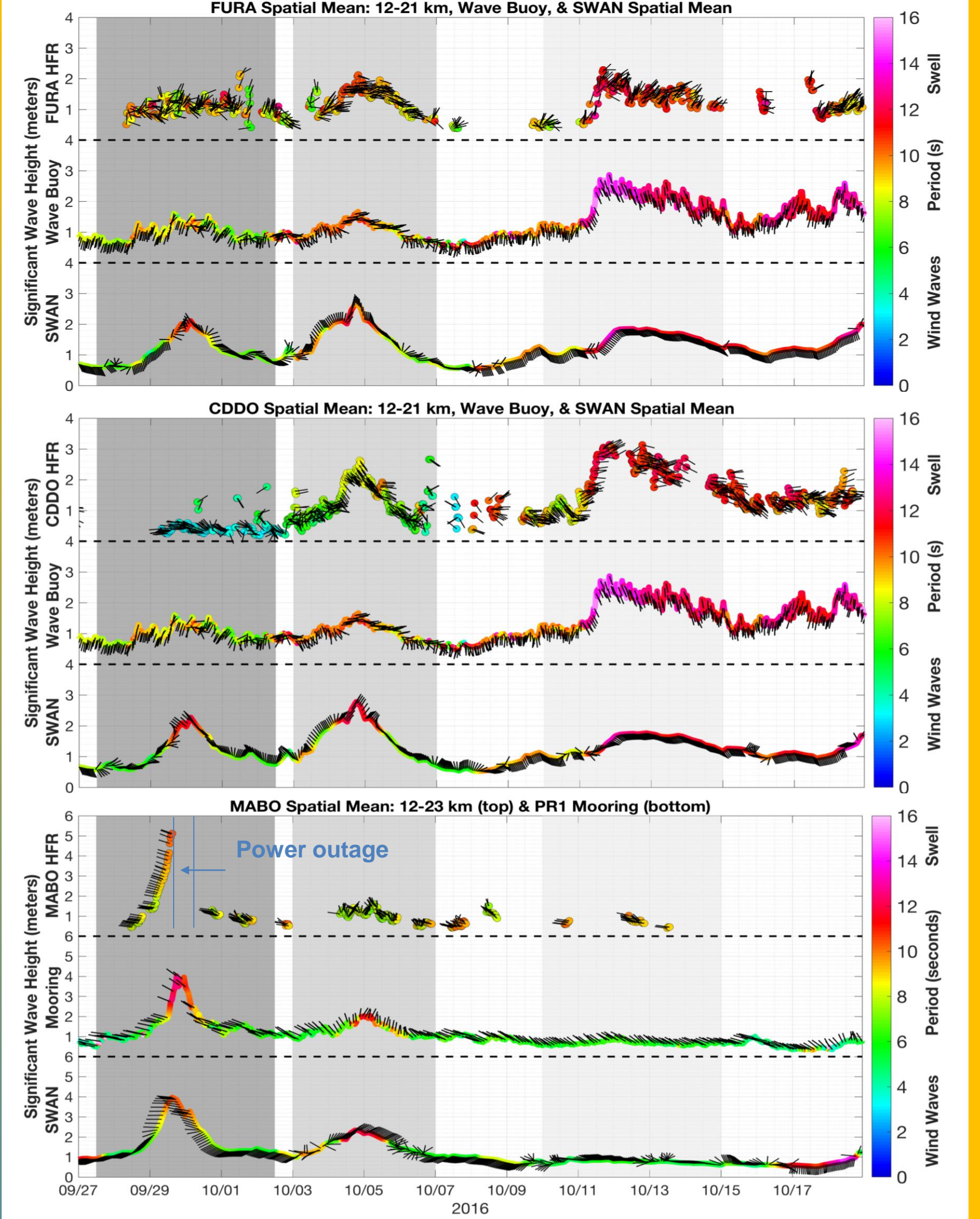
Methodology

| HFR Filtering Methods | | | |
|-------------------------------|--------|--------|--------|
| Filter | FURA | CDDO | MABO |
| Hs maximum | 5 m | 5 m | 7 m |
| Td maximum | 20 s | 20 s | 20 s |
| ΔH_s hr ⁻¹ | 2 m | 2 m | 4 m |
| ΔT_d hr ⁻¹ | 4 s | 4 s | 3 s |
| Spatial ΔH_s | 0.75 m | 0.75 m | 1.75 m |
| Spatial ΔT_d | 2 s | 2 s | 1.5 s |
| Hs σ factor | 2.75 | 2.25 | 3.5 |
| Td σ factor | 2.5 | 1.75 | 2 |
| Hs moving σ factor | 2 | 1.75 | 3.5 |
| Td moving σ factor | 2.25 | 1.75 | 1.5 |
| Spatiotemporal Min. Points | 60% | 60% | 60% |
| 2-pass filter | Yes | Yes | Yes |



Noise contamination is a common issue with remote sensing. The post-processed wave parameters from each HFR station were subjected to additional filtering criteria to eliminate outliers in the dataset. The filtered HFR wave parameters were validated with nearby buoys and the regional SWAN (Simulating Waves Nearshore) model spatially-averaged over the radar range-cell polygons.

Validations

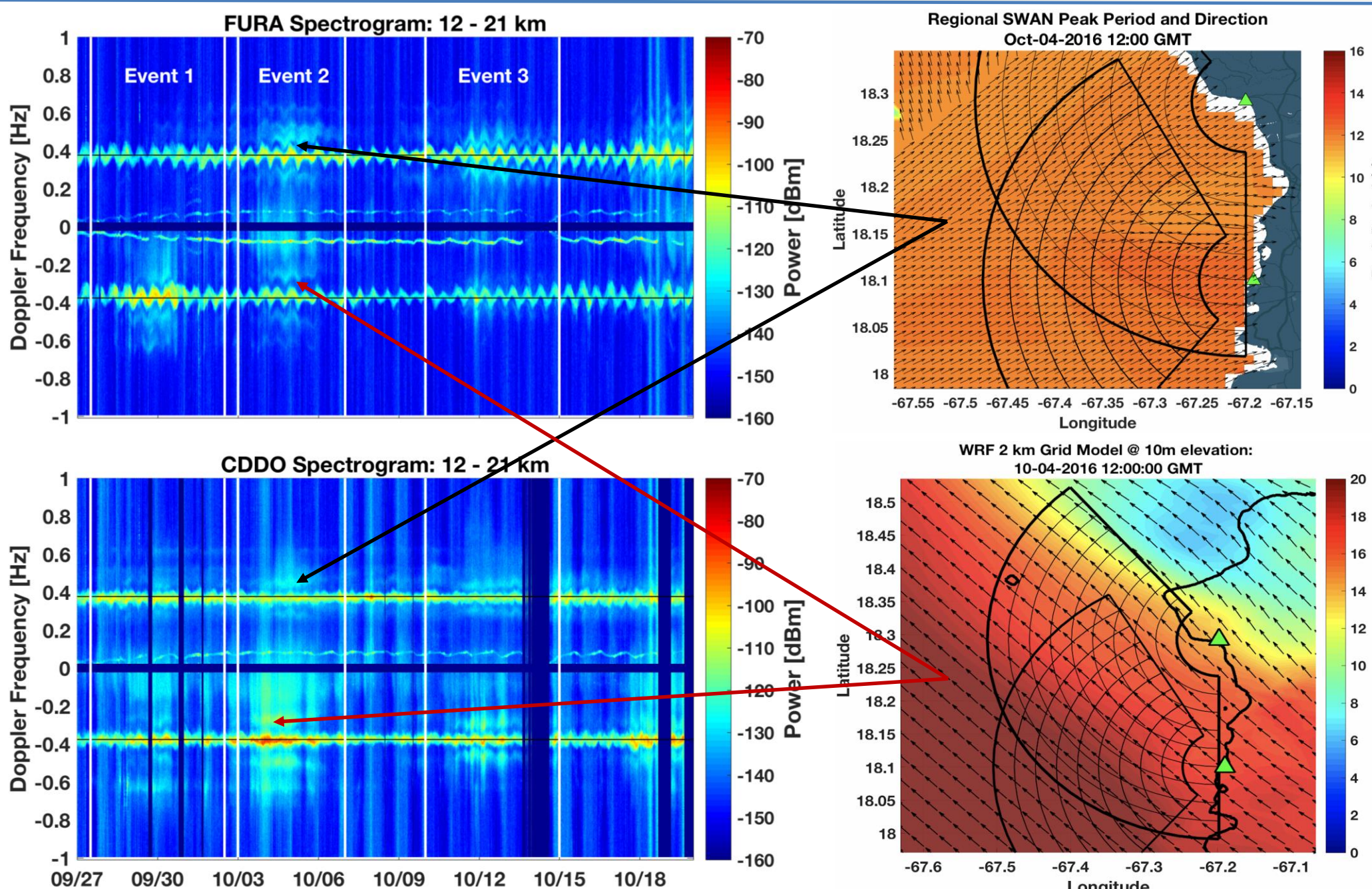


Onshore conditions with respect to the HFR locations resulted in better agreement in Hs with nearest buoy measurements.

Cross-correlation between MABO & PR1 to correct for time lag:

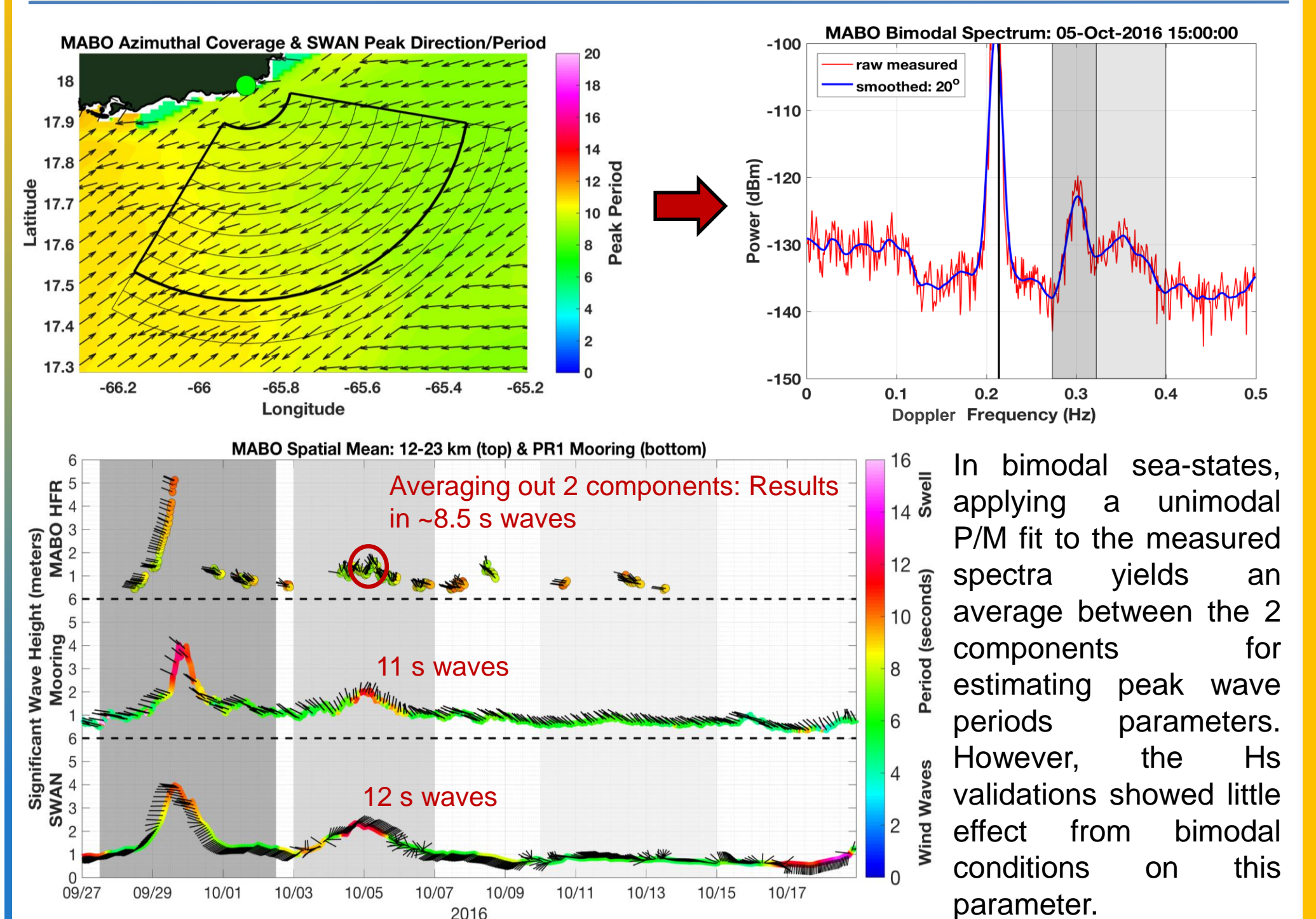
$$R_{HFR, Buoy}(m) = \sum_{n=0}^{N-m-1} HFR_{n+m} + Buoy_n^*$$

Analysis – Mona Passage



Winds are offshore in the (-) Doppler frequencies, shown in the CDDO 2nd order power spectrum. The wave amplitudes measured by CDDO increase with fetch, but the wind direction is more cross-shore with respect to the FURA coverage area. The SW swell energy was captured by FURA and CDDO, shown by the surrounding continuum nearest to the Bragg peaks.

Analysis – Southeast



In bimodal sea-states, applying a unimodal P/M fit to the measured spectra yields an average between the 2 components for estimating peak wave periods. However, the Hs validations showed little effect from bimodal conditions on this parameter.

References

- Barrick, D. E. (1977) "Extraction of wave parameters from measured HF radar sea-echo Doppler spectra", Radio Science, doi: 10.1029/RS012i003p00415.
- Lipa, B.J. and D.E. Barrick (1986), "Extraction of Sea State from HF Radar Sea Echo: Mathematical Theory and Modeling", Radio Science, Vol. 21, 81-100 (1986)
- Lipa, B. and Nyden, B. (2005) "Directional wave information from the SeaSonde", IEEE Journal of Oceanic Engineering, doi: 10.1109/OJEE.2004.839929.