Evaluation of High Frequency Radars (HFR) wave data using Nearshore Wave Prediction System (NWPS)

Ali Salimi Tarazouj[1,2], Ali Abdolali[2,5], Saeideh Banihashemi[1,2], Hugh Roarty[4], Chad Whelan[5] , Brian Zelenke[3] , Mathew Masarik[1,2] , Jessica Meixner[1] , Avichal Mehra[1]

[1]NOAA/NWS/NCEP/EMC
[2]Lynker
[3]NOAA/NOS/IOOS
[4]Rutgers University/MARACOOS
[5]CODAR Ocean Sensors. Inc

Introduction

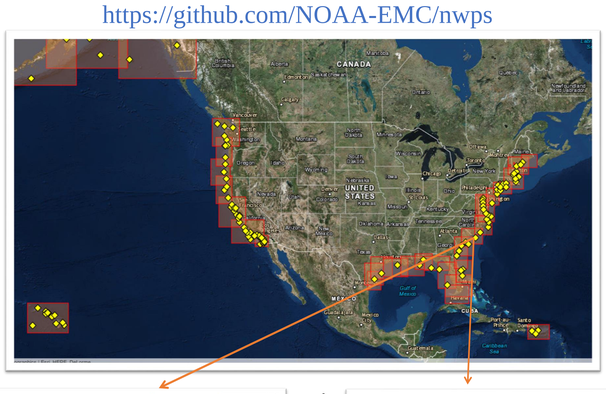
- The National Weather Service's (NWS) National Centers for Environmental Prediction (NCEP) use the Nearshore Wave Prediction System (**NWPS**) to provide high-resolution wave modeling along the U.S. coast. This modeling is crucial for predicting coastal weather conditions and hazards. The NWPS uses the wave model SWAN and obtains boundary conditions from the National Oceanic and Atmospheric Administration's (NOAA) modeling systems. While traditional validation methods have used stationary buoys and satellite altimeters, recent studies have shown the potential of using coastal high frequency radars (**HFR**) to sample wave properties. This study aims to evaluate and verify the accuracy of HF radar wave data by comparing it with NWPS model results. This evaluation is essential for operational use in nowcasting and forecasting.

Nearshore Wave Prediction System (NWPS)

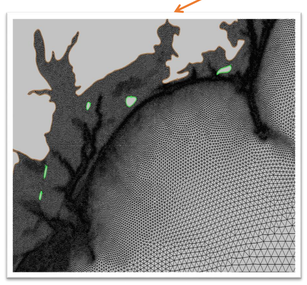
- 36 On-demand model domains, covering coastal WFOs.
- Core model is SWAN, including wave partitioning.
- Primary forcing is GFE wind fields prepared by forecasters.
- Additionally water levels from ESTOFS/P-Surge (200 m coastal res), RTOFS surface currents (e.g. Gulf Stream), and Global WW3 (GFS wave) offshore wave BCs.
- Run length = 144 h, 2-8 cycles/day, on-demand.
- Structured and Unstructured meshes with 5 km–100 m resolution, with 36 directions / 37 frequencies (0.05-1.5 HZ).

https://github.com/NOAA-EMC/nwps

a)



b)



c)

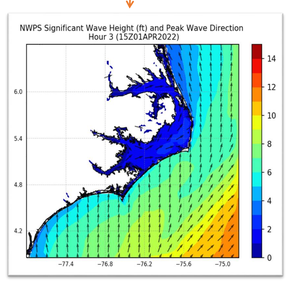


Figure.1: NWPS domain coverage (a), mesh (b), forecast output (c)

https://polar.ncep.noaa.gov/nwps/viewer.shtml

High Frequency Radar (HFR)

- High Frequency Radar (HFR) is used to measure ocean waves from 2nd-order Bragg Doppler spectra generated via the reflected signals from the water surface.
- The radar Doppler spectrum is used to determine wave parameters at range rings from the HFR, which are then consolidated into a spatial average represented by a single value.
- The radar can measure the amplitude, direction, and frequency of ocean waves in real-time.
- The spatial average and temporal resolution of the measurements depend on the operating frequency of the system, with ranges of 3-50 kilometers offshore and 15-60 minutes.
- Check out **"Nearshore Wave Climatology of the New Jersey Shelf "** poster by Roarty et. al.

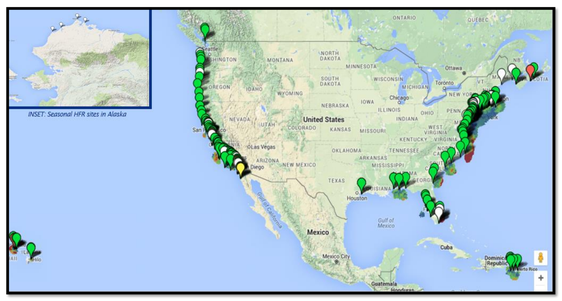
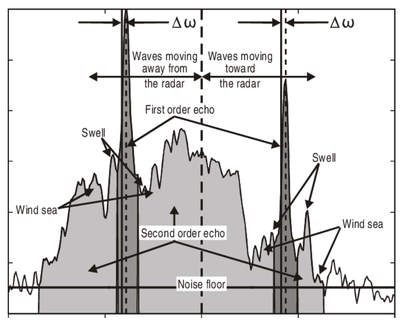


Figure2: Map of approximately 130 HFR sites which measure surface current actively. Few of them are enabled for the surface wave measurement.

a)



b)

Figure3: a) Main characteristics of a typical Doppler spectrum (Toro, et al, 2014). b) HFR transmit/receiver antenna.

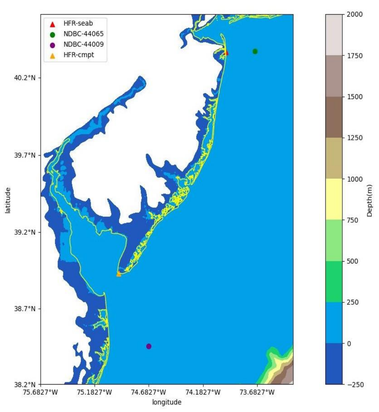


Figure4: Study area showing the location of HFR & NDBC buoys

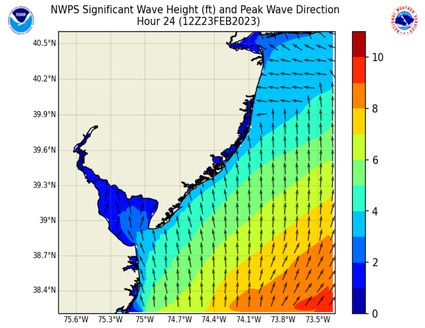


Figure5: Snapshot of the NWPS significant wave height in the study area

NWPS data are extracted at the location of NDBC buoys and also different distances from the HFR station.

Results

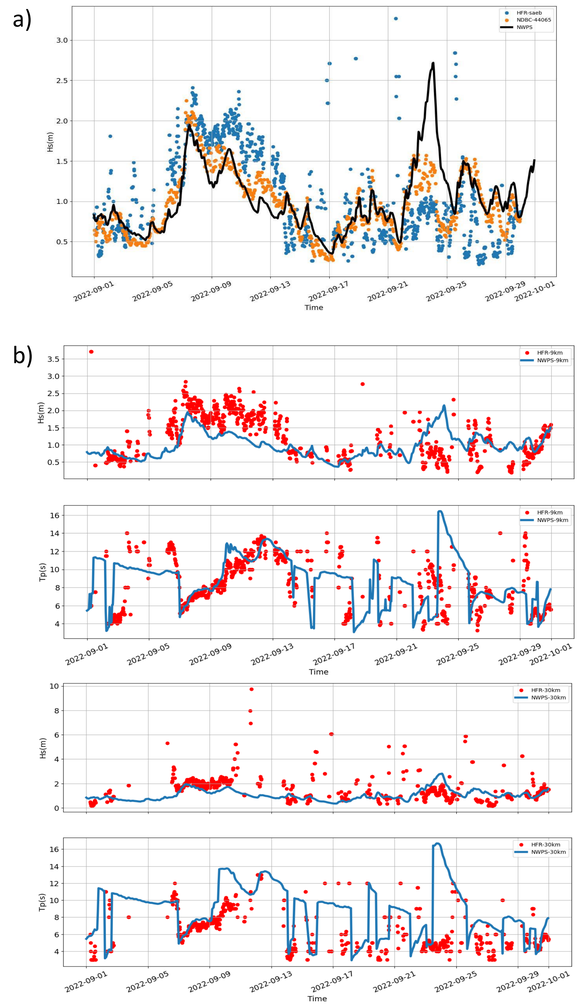


Figure6: a) comparison of the HFR, NDBC, and NWPS significant wave height for the spatial averaged single value. b) HFR range data comparison against the NWPS data for 9km (top panel) and 30km (bottom panel).

- **Overall the NWPS is underestimating the significant wave height compared to the HFR meassurments.**
- **The discrepancy between the HFR and NWPS is decreasing with the distance away from the HFR station.**
- **The difference between the wave periods, measured by HFR and the NWPS simulation, is small compared to the significant wave height.**

Summary and Discussion

- The comparison between the wave parameters measured by HFR against the NDBC buoy and NWPS model shows promising results.
- The comparison is conducted for only one month, however to include the seasonality effect and different significant events, the comparison should be extended.
- Although the representative wave parameters (Hs, Tp, …) have good agreement, it is necessary to compare the results in the energy spectral level.

Contact

Ali Salimi-Tarazouj, Ph.D.

Physical Scientist, Lynker at NOAA/NWS/NCEP/EMC

5830 University Research Court

College Park, Maryland, 20740

ali.salimi@noaa.gov

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