# Mapping Wave Variation in MARACOOS with SeaSonde Compact HF Radar

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## 1 Introduction

SeaSonde High Frequency Radars (HFR) radiate a signal at the ocean surface and process the returned sea echo for current and wave output [1]. While currents have been the primary SeaSonde product since the 1980s, the demand for wave output has steadily increased in the past decade. Wave parameter extraction has evolved from narrow beam second order inversion [2] to the well validated [4] [5] [6][7] [8] [9] broad beam model-fitting approach [3] used today. As recently as 2011, HFR-derived wave parameters were restricted to spatial scales of up to 40 km [5], but recent advancements have generated wind direction and wave height data that align with storm features at scales as granular as a 13 MHz radar range cell, or 3 km.

As part of an ongoing program with the U.S. National Weather Service, CODAR is partnered with Rutgers University to examine the wave climate and optimize HFR wave output along the New Jersey shore in the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS) Region. Output from three, 13 MHz SeaSondes during a winter cyclone show 3 km-scale shifts in the wind-wave regime consistent with storm progression and with data from two nearby National Data Buoy Center (NDBC) buoys.

## 2 New Jersey Wave Regime and Storm Grayson

Surface gravity waves along the New Jersey shore are driven by long period swell and by nearshore wind effects. Swell generates a homogeneous wave regime with relatively uniform wave height and wavelength. Winds that blow from land to sea (offshore winds) are also unusually common in this region.

Unlike fully developed sea swell, the properties of wind waves under development vary with time and space. As the fetch increases with distance from shore, the wave height builds.

Storm Grayson, a bomb cyclone, swept north-northeastward from Florida to Canada in the first week of 2018. The United States Weather Prediction Center's Daily Weather Maps depict the cyclone's low pressure center seaward of New Jersey on January 4 at 7 AM and north of Maine on January 5 at 7 AM. As the cyclone's upper limb crossed New Jersey shore, waves were pushed onshore, and as the lower limb passed, waves were pushed offshore.

## 3 SeaSonde Waves Software

SeaSonde Radial Suite Release 8® (RSR8) software fits cross spectra for each range cell to an ocean wave model [9]. The model is the product of a spectrum based on the Pierson Moskowitz (P/M) empirical model and a cardioid directional distribution around the dominant wave direction. If waves are onshore, then the dominant wave direction is defined by fitting the P/M model to the radar data. If waves are offshore, then the wind bearing as derived by the first order is used for the wave direction. RSR8 has a user-operated toggle to switch between conditions. In the newest beta software, the process is automated based on whether wave conditions are determined as onshore or offshore by the SO signal.

Significant wave height can be viewed in RSR8 as a single, filtered and averaged value for the waves coverage area (RC3-RC10 for this study), which is useful for evaluating onshore conditions. The averaged value typically compares well with nearby buoy values, reflecting a uniform ocean surface condition. RSR8 also plots wave output for each range cell for analysis of offshore conditions when significant wave height increases with range.

## 4 Results and Conclusion

HFR first order-derived wind direction at Seaside Park (SPRK), Bradley Beach (BRAD), and Sea Bright (SEAB) indicate onshore winds persisted from midnight until approximately 10 AM on January 4, 2018. A plot of RSR8's filtered, averaged, significant wave height at SPRK for this time period is shown with significant wave height from buoy 44091 (Figure 1), where HFR and buoy values fall within 0.7 meters of each other. Plots for other sites show similar results.

After 10 AM, winds began to turn direction to offshore, and an increase in significant wave height at RC3, RC5, and RC10 is seen at each HFR site (refer again to Figure 1 for SPRK results). Storm Grayson data exhibits the success of onshore and offshore SeaSonde waves algorithms in producing a cohesive signal across a 25-km wide, 90-km long patch of ocean at a spatial resolution ranging from 3 km for offshore winds and 24 km for onshore winds.

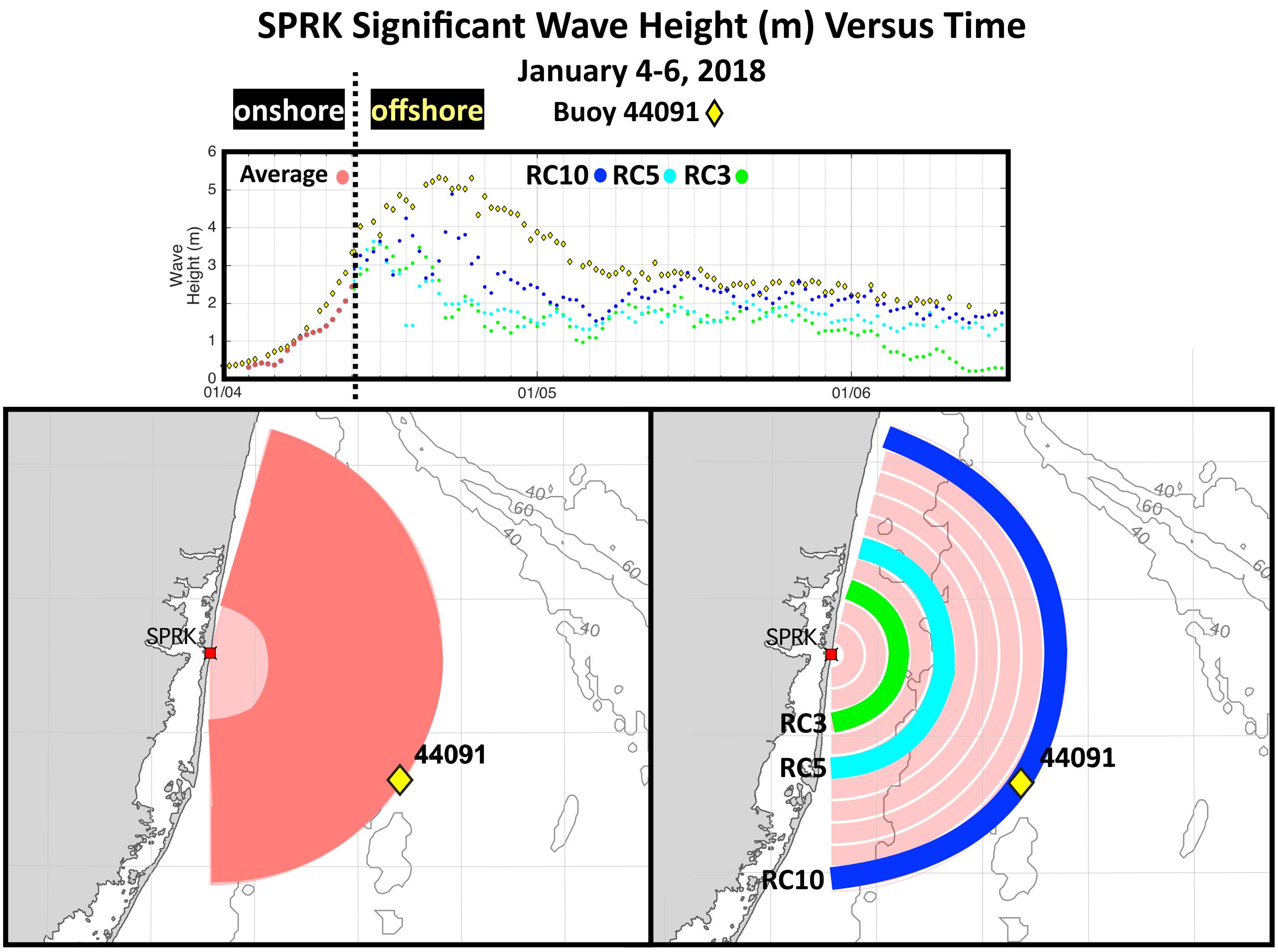


Figure 1: 13 MHz SPRK & buoy 44091: waves coverage area shaded (lower left); RC3, RC5, and RC 10 (lower right). Time series plot of: average wave height during onshore conditions (upper left); wave height for RC3, RC5, RC10 during offshore conditions (upper right).

## References


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