WSRA Measurements of Ocean Directional Wave Spectra and Sea Surface Mean Square Slope

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Motivation: Measurement of the Ocean Wave

Installed on a NOAA WP-3D aircraft, the WSRA has routinely operated during research and reconnaissance flights into hurricanes over the past decade.

The WSRA directional ocean wave spectra—important information about the air-sea interface—are produced every 4 minutes and 16 seconds. This makes the WSRA a unique instrument that routinely documents the rapid spatial variation of sea surface inside the evolving hurricane.

WSRA data users:

Hurricane forecasting —
Real-time knowledge of the wave field parameters should improve the hurricane intensity forecast.

Ocean wave models —
Verification and improvements using WSRA observations of temporal and spatial evolution of wave field.

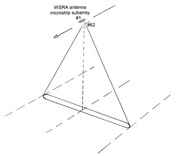
Storm Surge forecast —
Verification and improvements using WSRA measurement of storm surge of landfalling hurricanes. This WSRA me… to be feasible, but has yet to be implem…

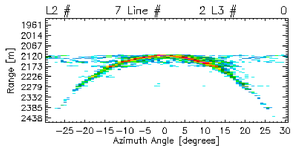
Technology:

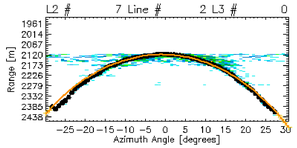
The WSRA is a digital beamforming radar with an antenna comprised of 64 narrow microstrip subarrays oriented in the along-track direction, and spaced at half wavelength intervals in the cross-track direction.

The radar returns from sequential transmissions on each of the 62 array elements are collected and coherently combined to produce 80 narrow beams spread over ±30º from the antenna boresight.

The width of WSRA swath is about 3.46 km at the typical 3 km (10,000 feet) aircraft altitude.



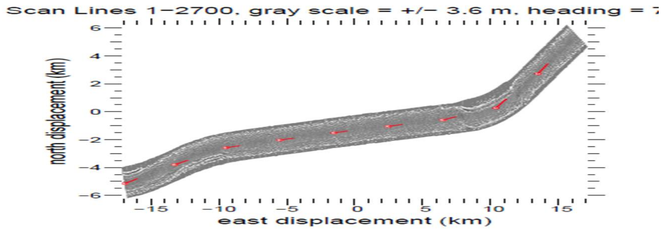




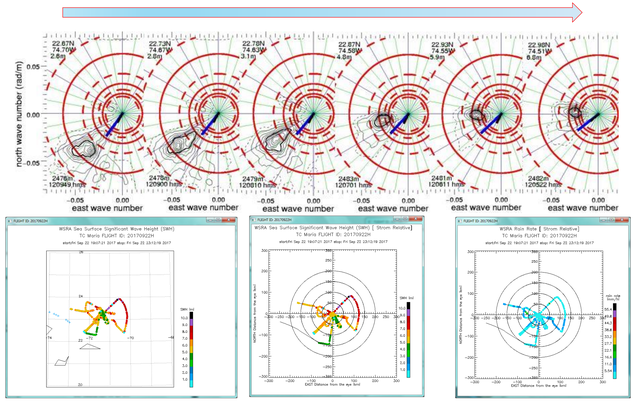
Measurement Methodology:

For each of its 80 narrow beams spread over ±30° in the plane perpendicular to the aircraft heading, the WSRA determines the range to the sea surface by computing the centroid range of the backscattered power. It uses those 80 ranges to determine the roll attitude of the aircraft more accurately than any of the aircraft systems. Multiplying each of the ranges by the cosine of the beam off-nadir angle determines the vertical distance to that point on the sea surface. Subtracting those values from their mean produces a topographic map of the sea surface which is then transformed by a two-dimensional FFT to produce first-order directional wave spectra.

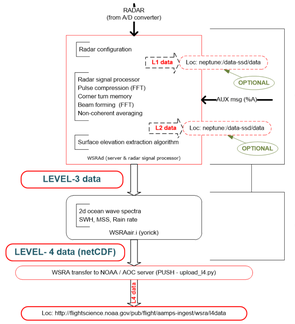
From the sea surface topographic maps and backscattered power, the WSRA estimates the directional wave spectra, sea surface mean square slope, and rain rate. The WSRA ocean directional wave spectra, along with other calculated sea surface parameters, are produced at about 4-minute intervals. These data products are calculated and transmitted in real-time to the National Hurricane Center and made available through the NAWIPS to Atlantic marine forecasters at NOAA's Tropical Analysis Forecast Branch.

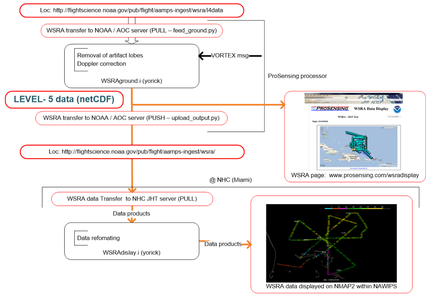


4.5 minutes



WSRA Data Flow: Processing, Transfer & Display => Real-time Reporting





WSRA Data Products

From the sea surface topographic maps and backscattered power, the WSRA produces the following data products: (1) the directional ocean wave spectra, (2) sea surface mean square slope, and (3) rain rate. From directional ocean wave spectra the following important parameters are extracted: (i) significant wave height, (ii) dominant wave parameters: direction, wavelength and height, and (iii) secondary wave parameters: direction, wavelength and height.

These data products are calculated and transmitted in real-time to the National Hurricane Center and made available through the NAWIPS to Atlantic marine forecasters at NOAA's Tropical Analysis Forecast Branch. The WSRA ocean directional wave spectra, along with other calculated sea surface parameters, are produced at 4-minute and 6-second intervals..

At the same time WSRA data are stored and archived for further post-flight analysis. Types of WSRA data stored are:

(1) Level 3 data of the centroid range, backscattered power and incidence angle for each of the 80 WSRA narrow beams, in addition to the aircraft flight parameters. The Level-3 data are stored in ASCII files on the WSRA server computer aboard the NOAA's WP-3d aircraft. The files containing Level-3 data are offloaded at the end of the hurricane season.
(2) Level 4 data of the output average directional wave spectra generated by the real-time processing with the artifact spectral lobes retained.
(3) Level 5 data same as Level-4 data but where the artifact spectral lobes have been deleted using a spatial/temporal integration of a hurricane wind field. The Level 5 data from measurements inside tropical cyclones are available within minutes after completion of the recon flights. For non-hurricane environments, removal of the artifact lobes would be done in post-processing by specifying an array of propagation directions for various ocean wavelengths, determined from a priori information in a non-hurricane environment, or an examination of the wave spectra themselves when the aircraft flight direction changed. The Level 5 spectral variance is also corrected for near-nadir reduction by the antenna footprint and off-nadir tilt-modulation enhancement by ocean waves.

WSRA Data Archives:

www.prosensing.com/wsradisplay