MAPPING WAVES, CURRENTS AND BATHYMETRY WITH SHORE-BASED COHERENT MARINE RADAR: NEARSHORE VALIDATION

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BACKGROUND

Reliable, cost efficient, and continuous observations of nearshore hydrodynamics are often required for the design and maintenance of coastal structures as well as to understand coastal change. In the last decades, advances in digitization and computational efficiency for signal processing have led to an increased use of marine radars as a tool for hydrographic applications, such as the retrieval of bathymetry, surface currents, winds and sea state. Many marine radar products are based on a three dimensional fast Fourier transformation (3D-FFT) of the image sequences obtained from a scanning radar. These methods have been extensively validated in deep to intermediate water depths. In the nearshore, and increasingly shallow waters, validation studies are rare and the available studies mainly focus on the retrieval of bathymetry. Validated radar measurements of spatially varying wave and current fields are not yet available. The present study is thus focussed on the assessment of the limitations of radar hydrography in a nearshore environment.

VALIDATION DATASET

We use data obtained at the U.S. Army Corps of Engineer's Field Research Facility (FRF) in Duck, North Carolina, where the coherent-on-receive marine radar of the Helmholtz-Zentrum Hereon (Hereon) was installed for the During Nearshore Event Experiment (DUNEX) in September 2021, and collected data until December 2021. It was later relocated on the FRF property to be better aligned with in-situ sensors and recorded data from January to August 2022. Combined with available in-situ data from the FRF's long-term monitoring network and the frequent bathymetric surveys, this data set opens unprecedented opportunities to assess the accuracy of radar retrieved products in the nearshore.

TRADITIONAL AND MODERN RETRIEVAL METHODS

For our analysis, we use both traditional 3D-FFT based methods based on the backscatter intensity and modern methods based on the Doppler velocity to estimate two-dimensional wavenumber spectra together with currents and water depths. To increase spatial resolution, we also apply localized bathymetry retrieval techniques based on wave phase gradients, and a recently developed method to obtain wave and roller dissipation from the Doppler velocity measured by the radar (Streßer et al., 2022). Our early results show that, as expected, the 3D-FFT methods perform well outside the surf zone, but are failing further inshore due to the influence of wave breaking and increased spatial inhomogeneity. The spatial resolution of the 3D-FFT method is ≈ 500 m, which is not enough to cover the high spatial variability of the nearshore wave and current field. From the observed roller dissipation, the transformation of wave height can be estimated at the scale of the radar resolution of roughly 7.5 m (see Fig. 1). Therefore, a combination of the traditional backscatter intensity based and modern Doppler velocity based methods is proposed to make progress in nearshore radar hydrography. The relative directionality of the wave field is estimated from the backscatter intensity via 3D-FFT and the energy scaling for the wave spectra is derived via assimilation of the radar derived dissipation rate into the cross-shore wave and roller energy flux balance equations.

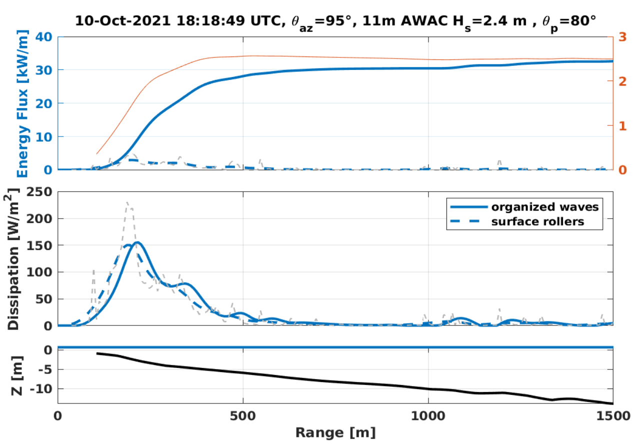

Figure 1 – Transformation of wave height and energy flux (top), wave and roller dissipation (center) and beach profile (bottom) estimated from the radar data.

REFERENCES

Streßer, Horstmann, Baschek (2022). Surface wave and roller dissipation observed with shore-based Doppler marine radar. Journal of Geophysical Research: Oceans, 127, e2022JC018437.