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Probing sea surface with L-band Doppler radar

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This study has been motivated by the development of a coherent L-band radar, designed and manufactured by Degréane Horizon. It allows one to measure the properties of short surface waves, and its 50 m resolution is useful to capture small-scale changes in a coastal environment.

We present and interpret an original set of full-polarized data, including cross-polarization. L-band Doppler spectra for light winds exhibit a morphology that is consistent with interaction processes of Bragg type between electromagnetic waves and surface gravity waves. The shift of the maximum from Bragg wave velocity can be explained by surface current effects. The data, recorded under a great variety of meteorological conditions, exhibit significant sensitivity to current and wind [1], which justifies the development of a forward model describing accurately the behaviour of the backscattered electromagnetic field with respect to geophysical parameters related to wind, current, fetch, swell, ...

The key point consists in taking properly into account non-linear hydrodynamic interactions between waves to generate a realistic moving sea surface. Here, a linear surface is first generated and higher order corrections are obtained from expansion of hydrodynamic equations. However, if a classical semi-empirical model is used as first-order spectrum, this approach implicitely assumes that higher order terms do not significantly modify the part of the surface spectrum that contributes to the radar echo. This is verified up to the VHF radar frequency range, but not in L-band. Therefore, the spectrum describing the linear part of the surface has to be 'undressed' such that adding higher order terms leads to the chosen semi-empirical surface spectrum.

From the electromagnetic point of view, since standard low-frequency approximations no longer hold at L-band, a small-slope approximation has been implemented to compute the backscattered field [2]. An approximate integral equation is thus solved with the help of a fast numerical method and the statistical average results from a Monte-Carlo process. This approach requires a lot of computation time but takes multiple scattering into account and provides estimation of the cross-polarized cross-section. Numerical results show that for light winds (say less than 5 ms^{-1}) the model correctly predicts the behaviour of the data with respect to wind speed and direction [3].

This 3D model and the data behave in the same way with respect to wind speed and direction, and Doppler spectra present very similar shapes at low wind, whatever the polarization.

References

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