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On the influence of ocean waves on simulated GNSS-R delay-doppler maps

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Global Navigation Satellite System-Reflectometry (GNSS-R), is an established technique that exploits GNSS signals of opportunity reflected from the surface of the ocean, to look primarily at the ocean surface roughness. The strength of this technique, and the primary motivation to carry it forward, is in the fact that GNSS signals are available globally, all the time and over the long term, and could help dramatically improve the monitoring of ocean wind and waves. GNSS-R offers the prospect of high density global measurements of directional sea surface roughness, which are essential for scientific purposes (i.e. quantifying the air-sea exchanges of gases), operational weather and ocean forecasting (i.e. prediction of high winds, dangerous sea states, risk of flooding and storm surges) and to support important climate-relevant Earth Observation techniques (IR SST, or surface salinity retrieval).
The retrieval of ocean roughness from GNSS-R data has now been demonstrated with a reasonable level of accuracy from both airborne [1] and spaceborne [2] platforms. In both cases, Directional Mean Square Slopes (DMSS) of the ocean surface have been retrieved from GNSS-R data, in the form of Delay-Doppler Maps (DDMs), using an established theoretical scattering model by Zavorotny and Voronovich (Z-V) [3]. The need for a better assessment of the way the ocean waves influence the scattering of GPS signals has recently led to a different approach, consisting of simulating the scattering of such signals, using a more sophisticated large-scale scattering model than Z-V, and explicit simulations of realistic seas.
Initial results produced from these simulations have been recently published in [4], where the emphasis has been put on the effects of different sea states on Radar Cross Section (RCS) and Polarization Ratio (PR) in space domain. Linear wind wave surfaces have been simulated using the Elfouhaily wind wave spectrum [5], for different wind speeds and directions, and with or without a superimposed swell. Then, the scattering from such surfaces has been computed using the innovative Facet Approach (FA), which approximates the surface through a number of rectangular facets, differently oriented, and calculates the surface scattering as the ensemble of the signals scattered from all the facets.
Here we proceed with the next step of the GPS-Reflectometry simulator, through investigation of the results in Delay- Doppler (DD) domain. Changes and variations of the DDMs, computed using the FA scattering model, are investigated for a variety of wind and wave conditions of the underlying sea surfaces simulated. Results are analysed for changing wind speed and direction of the waves, presence of a swell component superimposed on wind waves, and changing parameters (wavelength, amplitude, direction) of the swell, revealing some degree of sensitivity of these maps to different sea states. The effect of polarization is also taken into account, through an analysis of PR in DD domain. Finally, an initial investigation into the effect of nonlinearities on the sea surface in DD domain is carried out, by looking at DDMs of the signal scattered from non linear non gaussian sea surfaces explicitly simulated.

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