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Characterization and assessment of different algorithms for retrieval of mean square slopes from GNSS-R measurements

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Global Navigation Satellite System-Reflectometry (GNSS-R) exploits signals of opportunity from navigation constellations (e.g. GPS, GLONASS, Galileo), scattered by the surface of the ocean, to retrieve the surface wind and wave fields. GNSS-R represents a true innovation in remote sensing, and it is receiving a growing interest from the scientific community. Its main advantages lie in the dense space-time sampling capabilities, the ability of L-band signals to penetrate well through rain, and the possibility of simple, low-cost/low-power GNSS receivers. These recognized strengths of GNSS-R recently led to the approval of the NASA EV-2 Cyclone Global Navigation Satellite System (CYGNSS), a spaceborne mission focused on tropical cyclone (TC) inner core process studies. CYGNSS attempts to resolve the problem of inadequate observations and modeling of the inner core, which represents the principal deficiency with current TC intensity forecasts, and which can be overcome with GNSS-R. The present study focuses on the information content about the sea surface roughness and wind speed, that is contained in spaceborne GNSS-R Delay-Doppler Maps (DDMs).

A number of algorithms for the retrieval of Mean Square Slopes (MSS) - representative of the surface roughness - are analyzed. These include existing algorithms based on least-square fitting procedures (e.g. 2D least-square fitting of DDMs, using the Zavorotny-Voronovich DDM theoretical model), or based on direct observables (e.g. DDM volume), as well as "new" algorithms, which make use of waveforms derived from the DDM, which have thusfar been unexploited (e.g. integrated delay and Doppler waveforms). The analysis is carried out using simulated DDMs generated by the mature forward model end-to-end simulator developed for CYGNSS. A comparison of the results obtained for different retrieval algorithms will be presented.

In particular, the performance of the algorithms considered is investigated and characterized for the case of significant non-uniform wind field across the scattering area, such as will be encountered in and near tropical cyclones. The impact of each algorithm, as well as of other parameters (e.g. the extent of the DDM), on the sensitivity of the results to non-uniform winds will be presented. The results are directly relevant to CYGNSS, where the ultimate objective is to produce standard gridded maps of retrieved wind fields from raw DDM measurements.

The value of this research is twofold, in that it addresses the choice of the best algorithms to retrieve MSS and ultimately wind speed in extreme and non-uniform wind conditions, and also provides a first assessment of the data compression requirements and strategies that will be applied to DDMs for the CYGNSS mission.