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# A level 2 wind speed retrieval algorithm for the CYGNSS mission

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The NASA EV-2 Cyclone Global Navigation Satellite System (CYGNSS) is a spaceborne mission focused on tropical cyclone (TC) inner core process studies. CYGNSS consists of a constellation of 8 microsatellites, which will measure ocean surface wind speed in all precipitating conditions, including those experienced in the TC eyewall, and with sufficient frequency to resolve genesis and rapid intensification. It does so through the use of an innovative remote sensing technique, known as Global Navigation Satellite System-Reflectometry, or GNSS-R. GNSS-R uses signals of opportunity from navigation constellations (e.g. GPS, GLONASS, Galileo), scattered by the surface of the ocean, to retrieve the surface wind speed. 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, make GNSS-R ideal for the CYGNSS goals. Here we present an overview of a Level 2 (L2) wind speed retrieval algorithm, which would be particularly suitable for CYGNSS, and could be used to estimate winds from GNSS-R in general. The approach makes use of two different observables computed from 1-second Level 2a (L2a) delay-Doppler Maps (DDMs) of radar cross section. The first observable is called Delay-Doppler Map Average (DDMA), and it's the averaged radar cross section over a delay-Doppler window around the DDM peak (i.e. the specular reflection point coordinate in delay and Doppler). The second is called the Leading Edge Slope (LES), and it's the leading edge of the Integrated Delay Waveform (IDW), obtained by integrating the DDM along the Doppler dimension. The observables are calculated over a limited range of delays and Doppler frequencies, to comply with baseline spatial resolution requirements for the retrieved winds, which in the case of CYGNSS is 25 km x 25 km. If the observable from the 1-second DDM corresponds to a resolution higher than the specified one, time-averaging between consecutive observables is also applied, to reduce further the noise in the observables. The observables are correlated with wind speed, allowing one to develop an empirical Geophysical Model Function (GMF) that relates the observable value to the ground truth matchup winds, using a training dataset. The empirical GMF can then be used to estimate the winds from a generic dataset of observables, independent from the training one. In addition to that, the degree of decorrelation existing between winds retrieved from DDMA and from LES leads to the development of a Minimum Variance (MV) estimator, which provides improved wind estimates compared to those from DDMA or LES alone. The retrieval algorithm is applied in this study to GNSS-R synthetic data simulated using an End-to-End Simulator (E2ES) developed for CYGNSS, and using the true wind speeds that constitute the input to the simulations, as the ground-truth matchups. The performances of the retrieval algorithm will be presented in the form of Root Mean Square (RMS) error between the true and retrieved winds, highlighting that, for those specular points acquired with high enough gain of the receiver antenna, the RMS error meets the CYGNSS requirements on the wind speed uncertainty, which must be the greatest between 2 m/s or 10% of the measured wind.