Implementation of GNSS-Reflectometry for sea surface wind remote sensing

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Abstract

Global Navigation Satellite System-Reflectometry (GNSS-R) is an innovative Earth observation technique that exploits signal of opportunity from Global Navigation Satellite System (GNSS) constellations after reflection on the Earth surface. There are ocean remote sensing capabilities of GNSS-R include the retrieval of sea surface heights, moisture of soil, wind speed and wind direction. Although GNSS-R is considered as a potential source for estimating sea state parameters, researches on this field is still lacking. The National Space Organization (NSPO) of Taiwan has plan to send FORMOSAT-7/COSMIC-2 into space by 1st quarter 2017. The FORMOSAT-7 program calls for 12 mission specific satellites plus one NSPO-built satellite. The 12-satellites are planned to be launched and deployed in two clusters of 6-satellites into the designated low and high inclination orbits.

The level 1 product from the GNSS-R receiver is a map of GPS signal power scattered from the sea surface, as a 2D function of delay and Doppler frequency, which is known as a Delay-Doppler Map, or DDM. In presented study, the sensitivity of the DDM to the sea state parameters is tested. Based on the 3rd generation wave models, many cases of sea surface simulations are carried out with respect to different surface wind speed, different wave direction and different directional spreading parameters. Relying on Zavorotny-Voronovich model (Z-V model), the DDM is retrieved with respect to simulated Directional Mean Square Slope (DMSS). The sensitivity of DDM to DMSS exhibited in both the range of power values and shape.

Sea state parameters can be retrieved from a given DDM based on the sensitivity of direction and DMSS to the DDM shape and magnitude. Two mentioned observables – DDM Average (DDMA) and Trailing Edge Slope (TES) are derived from GNSS-R Delay-Doppler Maps (DDMs). Regression-based wind retrievals are developed for each individual observable using empirical geophysical model functions. The wind speed retrieval in case of Dujuan typhoon from those observables show good agreement with the data from numerical model.

Additionally, the first observed DDM data from aircraft have been analysed to estimate wind speed using observables algorithms. On the other hand, truth wind data from buoy and tested flight configurations are also used to simulate DDM. The retrieved wind speed from simulated Z-V DDM are compared to wind speed from observed DDM to verify the algorithm.

Further study is needed to test the simulation for higher wind condition. The expectation is to simulate the ocean wave surface based on roughness spectra in high wind, then develop the algorithm with more realistic DDMs.

Key word: GNSS-R, DDM, wind speed, Z-V Model