Scatterometer Instrument Competence Centre (SCIRoCCo)

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Final Report

Research activity	Comparison of ERS-2 ESCAT sea backscattering coefficients with electromagnetic models of sea surface scattering and other empirical models under challenging geophysical conditions
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The research activity was carried out in a master's degree thesis in Electronic Engineering. This work started in October and ended in May. The first part was developed at the University "La Sapienza" in Rome, while the second part was carried out at the Royal Netherlands Meteorological Institute (KNMI) in The Netherland.

The aim of this work was to analyse the rain effects on the scatterometer signal, since they can distort the signal and cause errors in the wind retrieval [1]. In fact, rain modifies the measured radar cross section in several ways and the most important rain effects are the splash effects and the atmospheric effects [2]. Rain modifies the ocean surface by impinging on it with an increasing of the surface roughness due to the generation of the ring waves and with an induced wave damping due to the generation of an upper turbulence layer. Meanwhile rain modifies the scatterometer signal when it passes through the atmosphere by attenuating it and by increasing the signal due to volume scattering [3].

The electromagnetic model Small Slope Approximation up to the second order (SSA2) [4], that simulates the ocean surface backscattering coefficient, has been modified by including these rain effects. The splash effects, i.e. generation of ring waves [5] and rain-induced wave damping [6], that modify the ocean surface roughness, have been considered by modifying the Elfouhaily sea wind wave spectrum [7] in the region of the capillary waves. These phenomena cause an increasing of the signal both for VV and VH signal. Such increasing is due to the increasing of the rain rate, but it also influenced by the wind speed. In particular, the higher is the wind speed, the lower is the increasing. The atmospheric effects, attenuation and volume scattering, have been also included in this electromagnetic model. These phenomena instead cause a decreasing of the signal with the rain rate for both VV and VH signal.

These models have been compared by using two different data set: 19 RADARSAT-2 dual-polarized SAR images acquired during some hurricanes [8] and SFMR measurements by NOAA's hurricane – hunter aircraft [9]; ERS-2 scatterometer data [10] and the TRMM rain rate data [11].

For the first data set the SAR images have been corrected, using the ECMWF wind field, by the large scale dependences: incidence angle, wind speed and wind direction. After these corrections a comparison between the dual polarized signals and the collocated, in space and time, rain rate data has been made along several tracks through the hurricanes.

On the ERS-2 scatterometer data an analysis of the distance (Maximum likelihood estimator: MLE) [12] of the measured triplets from the cone surface, given by the Geophysical model function plotted in the three-dimensional measurement space of the σ^0s of the fore, mid and aft beam, has been performed. An analysis of the correlation between the MLE distance of some ERS-2 images during some cyclones acquisitions and the TRMM rain rate data has been performed.

CONCLUSION

The electromagnetic model that simulates the precipitation effects has been validate on two different data-set. From these comparisons it has been found out that in extreme conditions, with high wind speeds and high rain rate, the dominant rain effect is the atmospheric effect and in particular the atmospheric attenuation. In fact a decreasing of the signal has been observed in both the data in presence of precipitations, and the electromagnetic model of the atmospheric effects seems to follow the measured backscattering coefficient.

The RADARSAT-2 data give information in co-polarization and in cross-polarization and it results that the cross-polarized signal (VH) decreases with the rain rate more than the co-polarized signal (VV), as it happens also in the electromagnetic model of the atmospheric effects.

The ERS-2 data give information on the signal azimuth pattern (thanks to sigma nought triplets measured by the aft, mid and fore beams) and it results that rain causes a loss of anisotropy of the radar signal, as confirmed by the electromagnetic model of the atmospheric rain effects.

The fact that the atmospheric effects are the dominant effects in hurricanes, happens because in extreme conditions, the sea spray and the wave breaking complicate the air-sea interaction and the wave characteristics, therefore the splash effects can't be considered. They should be tested in standard conditions.

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