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Analysis of the Ship-Sea Contrast using Quasi Simultaneous Space-borne Single and Quad Polarization Data

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Polarimetric SAR (PolSAR) technology has been proven to be very effective in many areas of Earth Observation (EO) including several maritime applications. Firstly developed for airborne platforms, PolSAR has been later adopted also in space-borne missions, e.g. RADARSAT-2, TerraSAR-X, etc. There are certainly a number of technical and hardware constraints in the space-borne case, such as limited power and antenna size, which limit the radar performances. Spatial resolution, signal to noise ratio, azimuth ambiguity to signal ratio and spatial coverage of a space-borne SAR system are characteristics that affect the capability to effectively detect and classify ships in the sea environment. Compared to single-pol acquisitions, where only one polarization state is transmitted and only one is received at a designed pulse repetition frequency (PRF), a PolSAR system record the 4 linear combinations of Horizontal (H) and Vertical (V) linear polarized pulses, hence, the system has to operate with an ideally doubled PRF. As consequence: a) the Doppler bandwidth per channel is reduced, which causes a loss in azimuth resolution, b) the ambiguous range region increases, which causes the across-track swath to be narrowed down and c) the azimuth length of the antenna is halved in reception, which causes a wider main lobe and higher side lobes. In the past, the performances of space-borne PolSAR system for the detection of maritime targets have been assessed be direct comparison among the channels acquired. Although this comparison strategy is quite fair, it has never been possible to compare the ship-sea contrast of a target imaged by PolSAR with the contrast resulting from a conventional single-pol SAR that observes the same target with the same acquisition geometry. This is the fairest comparison one can imagine since it does include on one side the unprecedented scattering details coming from a PolSAR acquisition; however, on the other side, it accounts for the lower spatial resolution that characterizes PolSAR acquisitions. It is obvious that such experiment conducted in space requires two twins' satellites operating simultaneously (or close to be simultaneous). We have taken the unique opportunity provided by the pursuit monostatic configuration of the TanDEM-X mission to accomplish such experiment. In such a configuration, the twin satellites TerraSAR-X (TS-X) and TanDEM-X (TD-X) can operate independently by each other while flying in a close formation with the two orbits separated of circa 76km (that would correspond to approximately 10sec). Operating the first satellite in the standard StripMap single-pol mode and the second satellite with the experimental Dual Receive Antenna (DRA) quad-pol mode, it has been possible to observe the same scene with the same geometry and almost simultaneously. This paper summarizes the results obtained in the ship-sea contrast and discrimination, processing real SAR data and collocated ship ground truth information provided by automatic identification system on board the ships present in the selected geographical region.

Keywords: polarimetry, target detection, validation