THE FEASIBILITY OF A COMPACT POLARIMETRIC SYNTHETIC APERTURE RADAR FOR POLSAR AND POLINSAR APPLICATIONS

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Nowadays it is widely recognized that SAR polarimetry (POLSAR) and polarimetric SAR interferometry (POLINSAR) add a valuable contribution to promising applications in many fields of remote sensing. SAR polarimetry uses the information embedded in the polarization state of electromagnetic waves scattered by the target; as an example, this technique has been used for vegetation mapping, classification and bio-physical parameters retrieval. POLINSAR technique combines SAR polarimetry and SAR interferometry and associates a scattering phase center to each resolution cell. The interferometric phase at different polarizations can yield information on the height of the target in the cell through suitable scattering models [1, 2]. With reference to forested areas, promising applications of this technique are biomass estimation and multilayer topographic information retrieval [3]. Both POLSAR and POLINSAR require full polarimetric (FP) SAR sensors and interferometric acquisitions. Full polarimetry from space implies system constraints to cope with data downloading rate, size of the processed swath and power consumption. To overcome these limiting factors, a new approach for SAR polarimetry, called compact polarimetry (CP), has been proposed. In the CP architecture, the SAR transmits either a circularly polarized wave ($\pi/2$ mode) or a linearly polarized one oriented at 45 degrees ($\pi/4$ mode), and receives at both horizontal and vertical polarization. A central issue in remote sensing is to assess the performance of a CP SAR sensor with respect to a fully polarimetric configuration.

Based on a new approach to compact polarimetry simulation, we discuss the feasibility of CP in terms of system design, SAR processing and performance, with focus on forest remote sensing. The required simulated CP data are commonly synthesized from FP single-look complex (SLC) data, i.e. after focusing raw data. A novelty of the present work is in an alternative method of simulating compact polarimetric and compact polarimetric and interferometric datasets: on the basis of electromagnetic theory, we argue that the synthesis of compact polarimetry from raw data, i.e. before the focusing process, is more appropriate. By this approach we are also able to study the effects of the SAR receiver on the simulated CP data. Indeed, when CP is synthesized from fully polarimetric SLC data, it is implicitly assumed that the CP signals have passed through a classical H/V dual-channel SAR system without any distortion. This is not true in the real operation of a compact polarimetric system. In the case of CP signals, some system components can affect the dual-channel signals differently from FP signals. In particular, attenuators and analogic-to-numeric converters are adapted to different dynamic ranges, hence the effects of quantization noise on real CP signals needs to be inverstigated.

To investigate the effects of real system components, we consider the characteristics of the ALOS-PALSAR receiver and its SAR processor. We compare the outputs of the SAR processor in the case of conventional CP synthesis (i.e. from SLC data) and in the case of the proposed CP synthesis from the signals arriving at the SAR antenna. We note that outcome of this study are a more accurate method for simulating compact polarimetric backscattering and guidelines for designing a CP SAR system and processor.

Once provided reliable simulated CP data, the next step is the assessment of the performance of POLSAR/POLINSAR algorithms using compact polarimetric and interferometric datasets. These algorithms primarily exploit the information embedded in the covariance matrices. One way to compare CP and FP is by reconstructing the pseudo full polarimetric covariance matrix. A reconstruction algorithm and the associated performance in POLSAR classification have been presented in [4].

We have extended that theoretical formulation to the compact POLINSAR information [5]. Here we present a FP reconstruction algorithm of the POLINSAR covariance matrix. The reconstruction of the pseudo full POLINSAR covariance matrix is based on the symmetry properties of some natural media. By assuming reflection symmetry plus an additional constraint, the complex degree of coherence of the vegetation is preserved. We show the performance of the reconstruction algorithm when applied to an example of H/A/α decomposition and to the retrieval of forest height [2] from POLINSAR information. The results obtained by ALOS-PALSAR data acquired over vegetated and forested areas are reported and discussed.

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