On the Accuracy of Scatterers LOS Rotation Estimation Procedures in Radar Polarimetry

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Different procedures for the estimation of the rotation angle of scatterers around the radar Line-Of-Sight using polarimetric data have been proposed in the literature. In [1], a deep analysis of the fundamentals of the procedures has been carried out and some common aspects among the procedures were demonstrated. Particularly, it has been shown that many procedures are in fact the same and can be divided into just two classes. The two classes are fundamentally different based on two different principles: The Rotation Transformation Based Routines (RTBR) and the Consimilarity Transformation Based Routines (CTBR). For a certain group of scatterers the two classes lead to the same rotation angle, but for most general scatterers the two classes of LOS rotation estimation procedures lead to different rotation estimation.

In [2], the effects of LOS rotation as well as of Faraday rotation on polarimetric differential interferometry have been investigated. It has been shown that both rotations may generate a bias if just single polarization is used in differential interferometry. A procedure has been thus proposed, in order to mitigate/eliminate the bias effect when full polarimetric data are available. In both cases, the rotations have to be estimated and compensated from the data. This suggests a dependence of the procedure on the accuracy of the rotation estimation.

In this work, the accuracy of LOS rotation estimation procedures of general scatterers using the radar polarimetric scattering matrix is assessed. It is demonstrated that the accuracy is not only dependent on the Signal-to-Clutter-Ratio (SCR) of the scatterer resolution cell. The scatterer type, in the polarimetric sense, determines as well the accuracy of the scatterer rotation estimation procedures. For certain type of scatterers, the estimation of the rotation angle may be even impossible, independently of the SCR. This dependence of the LOS rotation estimation on the scatterer type is of high importance and has to be taken into account when estimating LOS rotation.

We further define a polarimetric measure which directly expresses the accuracy of LOS rotation estimation procedures in determining the rotation of a general scatterer. The polarimetric measure is defined for both classes of routines, RTBR and CTBR. The measures are general and it is demonstrated that they can be evaluated for scattering matrix expressed in every arbitrary polarimetric basis. The polarimetric measures are also independent of the actual scatterer LOS rotation, which has to be required. In addition, the influence of the SCR of the scatterer resolution cell is also taken into account in the RTBR and CTBR accuracy expressions.

Emphasis is given for the coherent scattering case (quasi-deterministic scatterers as the so-called Coherent Scatterers - CSs [1, 3]), although the incoherent scattering case (distributed scatterers) is also analyzed. Throughout the paper, the analysis is carried out theoretically and supported by simulations and by the application of the proposed methods to real full polarimetric L-band data from the E-SAR system of the German Aerospace Center (DLR).

[1] Zandona-Schneider, R., "Coherent Scatterers in SAR Polarimetric and Interferometric Data", PhD Thesis, 2008.

[2] Zandona-Schneider, R., Papathanassiou, K. P., "Pol-DinSAR: Polarimetric SAR Differential Interferometry using Coherent Scatterers", IGARSS 2007, Barcelona 2007.

[3] Zandona-Schneider, R., Papathanassiou, K. P., Hajnsek, I., Moreira, A., "Polarimetric and Interferometric Characterization of Coherent Scatterers in Urban Areas", *IEEE Trans. Geoscience and Remote Sensing*, vol. 44, No. 4, pp. 971-984, April 2006.