ASSESSEMENT AND COMPENSATION OF IONOSPHERIC EFFECTS ON LOW-FREQUENCY POLARIMETRIC SAR DATA

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1. INTRODUCTION

Correction of Faraday rotation effects in polarimetric SAR data can in principle present difficult problems. SAR microwave signals traverse the Earth's ionosphere twice. Thus the received radar signals are affected both by the local properties of the ionosphere, and the scatterers in the scene. The critical properties of the local ionosphere that affect microwave propagation are the free electron density, and the strength and direction of the Earth's magnetic field with respect to the radar propagation direction. Faraday rotations are proportional to both the integrated free electron density along the path of the radar signal, the total electron content (TEC) of the ionosphere, and the component of the magnetic field along the propagation path. The strength and direction of the Earth's magnetic field remains fairly constant over the length scales of SAR images, say 50 km, except possibly near the magnetic poles where the field lines are strongly curved. However, TEC values can vary on length scales much smaller than the SAR image. Therefore, localized TEC inhomogeneities cause Faraday distortions that vary across the image.

2. COMPENSATING FOR FARADAY ROTATIONS

Correcting for a uniform Faraday rotation across a SAR image is fundamentally similar to polarimetric calibration, but complicated by the large correction factors. General polarimetric SAR calibration methods depend on linearization of the non-linear calibration equations and, in practice, on the small magnitudes of the crosstalk and channel imbalance corrections. We present the general non-linear solution to polarimetric calibration incorporating Faraday rotations and then investigate approximate methods assuming either zero cross-talk between polarimetric channels or a reciprocal radar system. These calibration techniques apply to quad-pol imagery where the non-reciprocal backscatter, e.g. HV ≠ VH, indicates an ionosphere propagation distortion of the polarimetric returns.

Dual-pol imagery requires a known target in the scene to estimate the Faraday rotation. We will investigate the imaging and in-scene target requirements that permit polarimetric calibration of dual-pol imagery in the presence of Faraday rotation effects. We will illustrate dual- and quad-pol calibration techniques using both PALSAR imagery and simulated datasets.

3. FARADAY CALIBRATION REQUIREMENTS FOR POLARIMETIRC SAR

Correction of ionospheric effects in dual- and quad-pol SAR data is, in principle, possible. Quad-pol imagery provides a direct measurement of the Faraday rotation via the complex phase difference between the LR and RL circular polarizations. Dual-pol presents further complications and requires known scattering targets to estimate the Faraday correction. While uncorrected Faraday rotation distorts the polarimetric data and thus derived polarimetric products, the underlying question is: How accurately must we compensate for Faraday rotations to preserve the polarimetric information?

We address the general issue of the required accuracy of polarimetric calibration [1]; here restrict the analysis to an assessment of miss-calibration arising from uncompensated Faraday effects. The Faraday distortions affect various target types and polarimetric decompositions differently. The impact of uncompensated distortions depends upon the specific remote sensing application. Our analysis employs a general metric to assess miss-calibration effects on polarimetric SAR imagery. We illustrate the technique by evaluating standard targets, e.g. random volume, dihedrals, etc., and polarimetric decomposition and classification methods.

4. SUMMARY

We review the general polarimetric calibration and Faraday correction technique, and show simplifications possible under different imaging / calibration assumptions. We will use both PALSAR imagery and simulated data to assess ionospheric compensation techniques for dual- and quad-pol SAR imagery. We present a quantitative assessment of the Faraday calibration accuracy required for polarimetric analysis and the magnitude of polarimetric errors introduced by uncompensated ionosphere effects.

REFERENCES

[1] Wang, Y., T. L. Ainsworth and J.-S. Lee, “Evaluation of System Polarization Quality for Polarimetric SAR Imagery and Target Decomposition,” submitted to *Proc. IGARSS’10*, Honolulu, 2010.