A POSTERIORI POLARIMETRIC CALIBRATION: COMPENSATING FOR FARADAY ROTATIONS AND IONOSPHERE IRREGULARITIES

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1. INTRODUCTION

Correction of Faraday rotation effects in polarimetric SAR data can in principle present a difficult problem. Space borne SAR systems transmit and receive signals that traverse the Earth's ionosphere. Thus the radar signals are affected by the local properties of the ionosphere. Two critical properties of the local ionosphere are the free electron density and the direction of the Earth's magnetic field with respect to the radar propagation direction. The 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 50km, except possibly near the magnetic poles where the field lines are strongly curved. However, TEC values vary on length scales smaller than the SAR image size.

For a uniform Faraday rotation across a SAR image, the problem is fundamentally similar to polarimetric calibration, but complicated by the absence of a small parameter. Typical polarimetric SAR calibration methods depend both on linearization of non-linear calibration equations and, in practice, on the small magnitude of the crosstalk and channel imbalance corrections. Faraday rotations can become large enough to rotate vertical polarizations to horizontal, and vice versa. We present a simple description of the effects of Faraday rotation on polarimetric SAR imagery. We also provide a method to compensate for Faraday rotation precisely because it is, or can be a large correction with respect to standard crosstalk and channel imbalance corrections. We will test the results from combining Faraday corrections with polarimetric calibration by employing both simulated and actual data. The full polarimetric calibration and Faraday correction method greatly simplifies when, for example the polarimetric cross-talk corrections can be ignored, or the SAR is known to be a reciprocal system.

The ionosphere induced effects initially affect the polarization state of the radar signal traversing the ionosphere. However ionospheric inhomogeneities may cause additional amplitude and phase distortions of the signals which then distort the SAR imagery. These ionosphere irregularities may appear at any length scale and therefore may affect the individual SAR pulses. Some ALOS L-band PALSAR images show the effects of localized ionospheric variations that induce variable Faraday rotation across the scene. This implies that PALSAR has observed ionosphere variations on length scales much smaller than the PALSAR image. One approach to correct these ionosphere irregularities incorporates a simple phase screen to compensate for the local TEC variations. The strength of the phase screen adjusts so as to zero the observed Faraday rotation across the image. By necessity this is a bootstrap approach; the SAR observes a region of the ionosphere for at most a few seconds and observed variations occur over length scales less than 1 km. The SAR data is likely the only available data that can be employed to estimate the local TEC variations.

2. SUMMARY

We will present a general polarimetric calibration and Faraday correction technique, and show the simplification possible under different calibration assumptions. We will assess the phase screen correction idea by applying the technique to PALSAR L-band imagery.