# COMPENSATION OF IONOSPHERIC EFFECTS INHERENT IN ALOS / PALSAR L-BAND POLARIMETRIC SAR IMAGERY

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## 1. INTRODUCTION

Correction of ionospheric effects in polarimetric SAR data can in principle present difficult problems. PALSAR microwave signals traverse the Earth's ionosphere twice. Thus the radar signals are affected by the spatially and temporally varying properties of the ionosphere. Faraday rotations, which affect SAR polarimetry, are proportional to the integrated free electron density along the path of the radar signal, the total electron content (TEC) of the ionosphere, and to 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 imagery, except possibly near the magnetic poles. However, TEC values can vary on length scales much smaller than the SAR image. Therefore, the spatial and temporal ionosphere variations preclude *a priori* compensation techniques.

Correcting for a uniform Faraday rotation across a SAR image is fundamentally similar to polarimetric calibration. Ionosphere induced effects affect the polarization state of the radar signal traversing the ionosphere. We first present the full non-linear solution to polarimetric SAR calibration in the presence of Faraday rotations and then investigate approximate calibration techniques. The approximate methods assume either zero cross-talk between polarimetric channels or a reciprocal (simplified) radar system. We test and compare the Faraday correction and polarimetric calibration procedures using both PALSAR imagery and simulated datasets that show effects due to localized TEC inhomogeneities.

Ionospheric inhomogeneities cause additional amplitude and phase distortions of the propagating signals which then distort the SAR image formation process. These ionosphere irregularities may appear at any length scale and therefore 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. These PALSAR observations of any point in the ionosphere last ~2 seconds, so the SAR image represents a 'snap-shot' of the TEC and its spatial variation. Verification of PALSAR observations of distorted ionospheric TEC values with simultaneous ground-based measurements of TEC values remains difficult to achieve. We have conducted experiments using the High-frequency Active Auroral Research Program (HAARP), located near Gakona Alaska, in conjunction with ALOS / PALSAR image collections to measure simultaneously ionospheric TEC values. These experiments rely on the capability of the HAARP high-power, high-frequency transmitter to distort the ionosphere TEC sufficient for simultaneous observation by the PALSAR L-band SAR.

## 2. SUMMARY

We will 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 polarimetric calibration and SAR image formation processing. We will present the results from our planned HAARP experiments and any serendipitous observations of ionospheric effects on PALSAR imagery.