# MEASUREMENTS AND CORRECTIONS OF IONOSPHERIC EFFECTS IN INSAR IMAGERY

Xiaoqing Pi, Bruce Chapman, Anthony Freeman, and Paul Rosen
Jet propulsion Laboratory, California Institute of Technology

## Abstract

Spaceborne interferometric synthetic aperture radar (InSAR) operating at L-band and lower frequencies is susceptible to inhomogeneous ionosphere with spatial structures on scales comparable to targeted remote sensing features, i.e., from hundreds of kilometers to meters. The concerned ionospheric variations include medium-to-small scale electron density or total electron content (TEC) structures associated with auroral arcs, plasma bubbles and patches, traveling ionospheric disturbances (TID's), large horizontal gradient, and irregularities. These ionospheric inhomogeneities can cause phase, power, and polarization changes of the radio signal within a radar scene. The effects can produce distortions in InSAR images if not detected and removed [e.g., Freeman and Saatchi, 2004; Chapin et al., 2006; Shimada et al, 2008; Meyer et al., 2009].

While the ionospheric variations have been measured using various radio and optical techniques from ground and space for many decades, recent effort has been made to use radar techniques to derive Faraday rotation in calibration of spaceborne polarimetric SAR (POLSAR) measurements [e.g., Freeman et al., 2008, 2009], and to measure ionospheric inhomogeneities associated with auroral arcs, plasma bubbles, scintillation, and mid-latitude trough [e.g., Pi et al, 2008; Meyer et al., 2009; Shimada et al, 2009; Pi et al., 2009]. Attempts to correct ionospheric effects in PALSAR InSAR imagery have also been made using polarimetric techniques [e.g., Freeman et al., 2008; Ainsworth and Lee, 2009], a split-spectrum processing (SSP) technique [e.g. Paul Rosen et al., 2009; Rosen, et al., 2009], and a GPS-based technique [e.g., Peng and Sandwell, 2009]. The SSP technique makes use of radar measurements with limited transmission bandwidth to derive TEC difference between received repeat-pass radar signals, which is applied to minimizing the ionospheric effects in the interferograms.

While these new capabilities are being developed for imaging ionospheric variations using SAR and mitigating ionospheric effects on InSAR, much remain to be explored such as sensitivity of polarimetric measurements to relatively weak ionospheric perturbations yet still contaminating InSAR images, best ionospheric imaging resolution that a SAR can achieve, effectiveness and accuracy of correction methods under various conditions, and quantitative characterization of InSAR distortions due to ionospheric effects.

The ALOS Ionospheric Data Acquisition (AIDA) campaign is dedicated to further studies, which involves efforts by JAXA, Jet Propulsion Laboratory, University of Alaska, Air Force Research Laboratory, Naval Research Laboratory, etc. The campaign will utilize multi-diagnostic instruments, such as PALSAR, GPS satellites and receivers, ground-based incoherent scatter radars, and all-sky airglow imagers. The radio and optical measurements will be used to characterize ionospheric effects and to assess the robustness of correction methods.

In this paper, we will describe our effort in the AIDA campaign and present initial campaign study results. In our study, GPS measurements collected from ground-based networks are used to identify ionospheric variations, such as medium-scale ($10^2$ – $10^1$ km) TID's at middle latitudes or ionospheric TEC perturbations associated with auroral arcs. Co-located polarimetric observations collected using ALOS PALSAR around the same time are processed to derived 2D Faraday rotation and TEC images for the perturbed region. These images are then applied to not only assessing the sensitivity of L-band polarimetric measurements to various levels of ionospheric perturbations, but also correcting ionospheric phase distortion in repeat-pass InSAR images. The SAR-derived TEC images are compared with GPS measurements, and ionospheric corrections are compared with results obtained using the split-spectrum processing technique to assess the different correction techniques. Further campaign activities will also be discussed that calls upon collaboration among interested parties.

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