Correction of Ionosphere for InSAR by the Combination of Differential TEC Estimators

Jun Su Kim and Konstantinos Papathanassiou

Microwave and radar institute, German Aerospace Centre (DLR)

Low frequency spaceborne SAR configurations are favoured for global forest mapping applications and D-InSAR applications over natural terrain. Several missions have been scheduled to be launched / or proposed to be implemented in the next years: JAXA's ALOS-II (L-band), NASA's Destyni (L-band), DLR's Tandem-L (L-band) and ESA's BIOMASS (P-band) are some of them. A common challenge for all these missions is to control / compensate the disturbances induced by the ionosphere. At these lower frequencies the ionosphere effects several components of the SAR measurements performed: It delays the group velocity of the transmitting / receiving pulses, advances their phase(s) and rotates their polarisation state. Accordingly, it distorts not only intensity but also polarimetric, interferometric and polarimetric interferometric observation spaces.

The total electron content (TEC) is the most decisive parameter in the characterisation of the ionosphere. It is defined as the integrated electron number density per unit volume along the direction of propagation. Most of the free electrons are distributed within a relatively narrow altitude range allowing modelling the ionosphere as a thin layer at a fixed altitude. In this case the ionosphere can be characterised by a 2-D scalar field of TEC [1], [2].

Depending now on the SAR configuration and its observation space different correction approaches are possible leading to a wide range of calibration algorithms. In this paper we propose a concept towards the generalisation of ionospheric calibration methodology by integrating a number of individual approaches / algorithms. In this sense, a novel generic correction schema based on a combined (and improved) estimation of the 2-D TEC field (or the associated differential TEC field in the interferometric case) from a set of individual data based TEC and/or TEC gradient estimates is introduced and discussed.

As a special case a combined 2-D (differential) TEC field estimator based on (differential) TEC estimated from Faraday rotation measurements and (differential) TEC gradients obtained from the estimation of azimuth/range (differential) shifts is presented. Both observations are independent, allowing establishing an inverse problem for the (differential) TEC estimation. Geophysical knowledge as the anisotropic nature of the TEC distribution can be incorporated as *a priori* information in the "combined" (differential) TEC estimator.

The performance of the proposed approach is tested using ALOS quad-pol interferometric data sets over several test sites in Alaska. The achieved estimates are characterised by a significantly improved performance: While the FR based estimator suffers from the random granular deviation pattern of TEC after conversion, the proposed combined estimator effectively is free of such artefacts. Emphasis is given in the role of polarisation in the TEC estimation procedure [3] and on the calibration of Pol-InSAR data.

References

[1] Franz J. Meyer and Jeremy Nicoll, "Prediction, detection, and correction of Faraday rotation in full-polarimetric L-band SAR data", IEEE Trans. Geosci. And Remote Sensing, 46(10), Oct., 3076-3086, 2008

[2] Xiaoqing Pi, Anthony Freeman, Bruce Champman, Paul Rosen, and Zhenhong Li, "Imaging ionospheric inhomogeneities using spaceborne synthetic aperture radar", Jour. of Geophysical Research, 116, A04303, 2011

[3] Jun Su Kim, Konstantinos Papathanassiou, Shaun Quegan and Neil Rogers, "Estimation and correction of scintillation effects on spaceborne P-band SAR images", in Proceedings of IGARSS2012, 23-27. Jul., 2012