IONOSPHERIC PATH DELAY ESTIMATES FOR SPACEBORNE SAR DATA: PROSPECTS AND LIMITS

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1. INTRODUCTION

The influence of the atmosphere on an electromagnetic wave traversing the ionosphere and troposphere has becoming increasingly important for recent and upcoming low-frequency but also high resolution spaceborne synthetic aperture radar (SAR) systems. SAR satellite measurements of the Earth's surface with electromagnetic waves are subject to atmospheric path delays that can affect geolocation, particularly given high range resolution. Although these atmospheric effects on radar signal propagation modify the signal velocity and direction, they can be modeled and corrected [1], [2].

In order to increase the geolocation accuracy of spaceborne SAR applications, it would be helpful if the status of the ionosphere for a specific observation geometry could be determined immediately before or during an acquisition. In the case of strong ionospheric activity this information could then be used to compensate the Faraday rotation effect by pre-rotating the transmitted radar signal. Defocusing effects in range and azimuth could also be handled more accurately.

We use reference spaceborne L – and P- band sensor configurations to model and demonstrate the effect of the ionosphere on the radar signal propagation. The SAR raw data is generated using a standard SAR simulator, extended to include the signal propagation effects caused by the ionosphere.

As a proper reconstruction of a SAR image subject to strong ionospheric effects significantly depends on accurate matched filtering during range compression, we place emphasis on optimizing the synthetic reference chirp.

To test the quality of range compression, we use the signal return of an arbitrarily positioned corner reflector. Within the range compression step we use autofocusing techniques to evaluate the possibility of extracting ionospheric total electron content (TEC) from single-pol SAR acquisitions using the pulse degradation and phase distortion of a corner reflector. This information is then used to propose an optimised matched filter, estimated using the current status of the ionosphere during the data take. As the feasibility significantly depends on the sensor configuration, we address the limits of this technique with respect to TEC levels [3]. We analyse the signal return of corner reflectors at a range of TEC levels and varying chirp bandwidths. Inclusion of Faraday rotation and common noise terms helps improve estimation of the method's limits.

Results are compared with techniques estimating the TEC and Faraday rotation from quad-pol PALSAR "PLR" data [4]. Conclusions for an operational correction of ionospheric effects in SAR data are modeled and evaluated as well in an integrated scheme. Contributions to calibration and geolocation accuracy improvements are discussed. Possibilities for an advanced and more accurate technique of an on-board TEC estimation are outlined.

The work describes techniques that could be used to estimate the ionospheric status during a spaceborne SAR acquisition in (nominally) single polarization mode, whereby "quad-pol" calibration pulses would be periodically inserted into the radar transmission timing – low resolution evaluation of FR and by extension derivation of TEC levels is possible without azimuth compression.

The comparison to existing methods calculating the TEC and the Faraday rotation from polarimetric data allows evaluation of the feasibility of the methods using real spaceborne measurements. Depending on the sensor's central frequency and the system bandwidth, the prospects and limits for the detection and correction of ionospheric path delay and pulse defocusing effects are quantified and discussed.

11. REFERENCES

[1] Z.-W. Xu, J. Wu and Z.-S. Wu, "A Survey of Ionospheric Effects on Space-Based Radar", *Waves in Random Media*, pp. 189-272, Apr. 2004.

[2] A. Freeman, "Calibration of Linearly Polarized Polarimetric SAR Data Subject to Faraday Rotation", *IEEE Transactions on Geoscience and Remote Sensing 42*, pp.1617-1624, Aug. 2004.

[3] F. Meyer, R. Bamler, N. Jakowski and Thomas Fritz, "The Potential of Low-Frequency SAR Systems for Mapping Ionospheric TEC Distributions", *IEEE Geoscience and Remote Sensing Letters 3*, pp. 560-564, Oct. 2006.

[4] M. Jehle , M. Rüegg, L. Zuberbühler, D. Small and E. Meier, "Measurement of Ionospheric Faraday Rotation in Simulated and Real Spaceborne SAR Data", *IEEE Transactions on Geoscience and Remote Sensing*, in print.