On the Use of Multi-Squint for the Ionospheric Calibration of SAR Images: The Biomass Case

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The Biomass mission from the European Space Agency (ESA) is a response to the current need to measure environmental variables that assess the state of the planet in its fight against climate change. With measuring the aboveground biomass (AGB) at a global scale as its primary objective, this ambitious Synthetic Aperture Radar (SAR) mission will be the first to operate a fully polarimetric P-band (435 MHz central frequency) system from space. This mission concept poses several challenges that require innovative solutions. Given the low frequency, the ionosphere is expected to introduce significant degradation in the observations related to phase errors (defocusing, azimuth shifts and phase screens in the interferograms), intensity scintillation and Faraday rotation. All the effects directly relate to the Total Electron Content (TEC) between the satellite and the imaged scatterers. For this reason, the ionospheric calibration of the system and high-resolution ionospheric imaging and the extraction of geophysical parameters are closely linked.

The SAR principle is based on the synthesis of a very long antenna by coherently adding echoes as a platform (a satellite in this case) moves past the targeted scene to generate high-resolution 2-D complex images. As the platform moves past the targeted scene, it looks at it with different squint angles in the along-track (azimuth) coordinate. The varying squint angle is the angle between the direct look direction and the center of the beam. Most current calibration algorithms assume this squint angle is very small, neglecting variation of the ionospheric and system effects inside the beam (beam-center approximation). This assumption, at first, seems to hold for Biomass (with a 3-degree azimuth beam aperture).

In this talk, we discuss this approximation and show that this assumption might leave considerable errors in the calibration, ionospheric imaging and the extraction of parameters that can benefit from appropriate squint angle accommodation. In particular, state-of-the-art Faraday rotation calibration in quad-pol data and TEC estimation is made using the Bickle and Bates approach. The transformation from Faraday rotation angle and TEC is done with the angle between the line-of-sight and local geomagnetic field vector ($\vec{B} \cdot \hat{k}$). This estimation is highly sensitive to system calibration residuals and the knowledge of the geomagnetic field and geometry. We will show what, with an efficient multi-squint Bickle and Bates, it is possible to accurately account for the $\vec{B} \cdot \hat{k}$-variation inside the beam and cancel residuals characteristic of the beam-center approximation. Likewise, we will discuss how this approach helps detect errors due to the local magnetic field uncertainty and further system calibration errors. The results are shown with simulated data from the Biomass End-to-End Performance Simulator (BEEPS) and with real Biomass data (if available by the time of the presentation).