Modelling Ionospheric Faraday Rotation for a 435 MHz Radar Satellite and the Selection of Calibration Transponder Sites

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In 2021 the European Space Agency will launch the Biomass satellite, a synthetic aperture radar (SAR) to measure the distribution of biomass density in the world's forests. Its uniquely low operating frequency of 435 MHz enhances foliage and ground penetration of the radio waveform but also amplifies the effects of the ionosphere, which introduces both scintillation (scattering from irregularities) and Faraday rotation (FR). The Biomass SAR will be fully polarimetric, transmitting and receiving radar chirps in orthogonal (H and V) planes. On-orbit calibration of the H and V transmit and receive channels (determining cross-talk and channel imbalances) requires a ground-based transponder located near the geomagnetic equator so as to minimise the impact of FR on the calibration.

This paper describes how models of ionospheric electron density and predictions of the future geomagnetic field are combined with the geometry of the radar beam and the sun-synchronous orbit to select candidate transponder sites with FR of less than 1.8°. The effects on FR of varying geophysical parameters (solar activity, secular geomagnetic field variations, seasonal variations, etc.) are determined for a range of beam look-angles. The effects on FR of varying the satellite yaw angle to minimise the SAR Doppler centroid are also assessed, and the feasibility of adding a further yaw steer designed to minimise FR is investigated. Of eight candidate locations, it is determined that a site near Porto Velho, Brazil is optimal (at least for dawn-side ascending satellite passes), since here the FR will be consistently less than 0.5° and has a low variation with increasing look angle (i.e. across the radar swath). Yaw steering to minimise FR provides limited benefit and would necessitate a high yaw rate as the satellite crossed the equator.