On the Use of Synthetic Aperture Radar (SAR) as a Tool for Ionospheric Irregularity Characterization

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Radio wave signals which propagate through the Ionosphere are vulnerable to scintillation caused by the existence of Ionospheric plasma irregularities. Scintillation, which is the temporal fluctuation in amplitude and phase of a signal, can result in severe channel fading and random phase variations that can interfere with the performance of global navigation satellite (GNSS), communication and radar systems. Synthetic aperture radar (SAR) data acquired in the equatorial and high latitude regions are often subjected to amplitude and/or phase scintillation, the impact of which is degraded image formation. While these effects are well known, and recent efforts have focused on using SAR data to improve the understanding of Ionospheric structures which may lead to scintillation (F.J. Meyer., et al., SAR and the Ionosphere: Challenges and Opportunities, 2014), the analysis of SAR data remains largely underutilized as a tool for Ionospheric research. In this paper, the potential for using SAR data analysis to estimate the shape of irregularities is investigated using the Satellite-beacon Ionospheric-scintillation Global Model of the upper Atmosphere (SIGMA) phase screen model. After performing the upgrades required for two-way wideband signal propagation, a range of Ionospheric conditions and irregularity shapes are simulated and the subsequent scintillation effects are introduced into an L-band linear frequency modulated (LFM) monostatic SAR signal model. The impact on pulse and azimuth compression is evaluated as a function of irregularity length, thickness and background total electron content (TEC) variation to determine the potential of using the analysis of SAR data to assist in bounding these critical irregularity parameters.