Measurement of Ionospheric Scintillation with SAR

Christopher R Mannix*, David P Belcher, and Paul S Cannon
SERENE, EESE, University of Birmingham, Birmingham, United Kingdom.

Trans-ionospheric signals can be significantly affected by scintillation caused by electron density irregularities in the ionosphere. Measurement and monitoring of scintillation levels worldwide is typically accomplished using Global Navigation Satellite Systems (GNSS). Such data is naturally lacking in areas where GNSS receivers cannot be easily deployed, such as oceans and deserts.

Space-based synthetic aperture radar (SAR) systems are able to provide nearly complete imagery of the Earth's surface, and those operating at L-band and below are affected by scintillation. The effects of scintillation on the SAR images can be split into two categories – those due to phase scintillation (affecting the point spread function of the image) and those due to intensity scintillation (sometimes visible as streaking in the azimuthal direction of the image). Typically, these effects are problems to be mitigated, but Belcher and Cannon, (*IET Radar, Sonar Navig.* 2013, 2014) have suggested that it is possible to retrieve scintillation parameters from a SAR image by measuring these effects.

Two approaches to deriving scintillation information from SAR images were considered. The first benefits from only needing a single image but it requires homogeneous underlying terrain in order in order to differentiate the ionospheric effects. In the second pairs of images (one displaying the effects of scintillation, and one not) are compared to provide a measure of the effects of the ionosphere.

In this paper we present results from the analysis of several pairs of SAR images, all displaying the effects of phase and/or intensity scintillation.

The effects of phase scintillation can be visually observed as a 'blurring' of the image. Associated with this should be a change in the order parameter of K-distributed clutter intensity, and a change in the along-track autocorrelation function (relative to the undisturbed image). All three effects were observed for one of the image pairs. The change in the order parameter can be used to calculate the change in the strength of ionospheric turbulence C_kL between the two images (D.P. Belcher and P. S. Cannon, *IET Radar, Sonar Navig.* 2013).

The effect of intensity scintillation is apparent as azimuthal streaking in the image. This streaking is visible in all image pairs analyzed in this paper. If the contrast of the streaking can be quantified, the S_4 index can be calculated from the contrast, allowing the S_4 to be mapped across the image (D.P. Belcher and P. S. Cannon, *IET Radar, Sonar Navig.* 2014). To quantify the contrast of the streaking, the underlying terrain variation was removed using the undisturbed image of each pair. For all but one pair, this approach was successful, allowing the calculation of S_4 across the images. For the image that exhibited phase scintillation effects in addition to the azimuthal streaking, the 'blurring' of the image precluded the exact removal of the underlying terrain detail, making accurate estimation of S_4 difficult.