Estimating $C_k L$ from Space Based Synthetic Aperture Radar Images

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ABSTRACT

Synthetic aperture radar (SAR) is widely used in applications that require all weather imaging. SARs utilise the forward motion of the radar platform to produce high resolution imaging at long-ranges, without requiring impractically large antennas. Space-based (SB) SARs are increasingly popular for remote sensing applications such as surveillance, measurement of the Earth's biosphere, and disaster response.

A typical SB-SAR operates in low Earth orbit (LEO) and thus the SAR signals must pass through the ionosphere on their way to and from the satellite. The ionosphere affects the operation of these radars [1], with those operating at L-band (1-2 GHz) and below at risk of being seriously compromised by the ionosphere [2].

Previous studies of the impact of the ionosphere on SAR systems have primarily addressed Faraday rotation e.g. [3], however, the impact of small scale ionospheric irregularities on the operation of the radar has also been addressed [4-8]. Rather than look at the impact of the irregularities on the radar, this paper will address the inverse problem of using the radar to estimate the strength of turbulence.

Belcher and Rogers [7] proposed a theory linking the shape of the ionospherically disturbed SAR point spread function (PSF) with conditions in the ionosphere, as measured by the height integrated strength of turbulence, $C_k L$. This paper will review that theory and its application in this context. It will follow this with an evaluation of the technique using estimates of $C_k L$ derived from PALSAR-2 satellite images of Ascension Island and specifically a 5m corner reflector. The $C_k L$ values produced will be compared with independent measurements of ionospheric conditions made using GNSS.

The PSF approach has a significant limitation – the requirement for a point target (such as a CR) to be present in the image. Belcher and Cannon [6] recently suggested different technique to measure the ionosphere using measurements of the statistical properties of natural clutter. The paper will also describe this technique and its testing against a large dataset of PALSAR-2

images. The C_kL values will be compared to those derived from the PSF measurements of the CR.

Early analysis has been previously published in [9].

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