Ionospheric Corrections for High Frequency Line of Sight Satellite Observations During Solar Minimum

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As the Earth's low orbit region becomes increasingly crowded, the ability to track and identify orbiting objects is becoming increasingly important. High frequency line of sight (HF LOS) radar systems are an important tool for the tracking of objects in low Earth orbit (LEO). However, with the use of HF radar comes the necessity to account for the effects of the Earth's ionosphere, which causes retardation and refraction of the radio waves. This introduces range, elevation and azimuthal biases to the satellite observations, and is a significant hindrance to tracking and identifying orbiting objects to a high degree of precision.

In this study, we analyzed radar detection data collected from an experimental HF LOS system operated by Defence Science and Technology Group during the Australian Defence "SpaceFest" Space Situational Awareness experiment in late 2020. This system operated over a period of approximately 7 days and made many LEO object observations, which were later compared with two-line element (TLE) propagations. The numerical ray-tracing package PHaRLAP was then used together with a climatological ionospheric model (IRI2016) to calculate ionospheric corrections to the radar detection data.

The results showed that during "SpaceFest", which has held during solar minimum conditions, the ionospheric corrections to the satellites' elevation and azimuth were not statistically significant, while those to the range were of the order of 5-8km. Applying these range corrections to the radar peaks data reduced the average range-error between the detections and TLE to well within 1km. The developed algorithm can be easily applied during any phase of the solar cycle when ionospheric corrections are expected to be larger, or to any other radar system, which is able to produce range, elevation and azimuth data.