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On the differences between ionospheric scintillation indexes estimated over Antarctica by an SDR receiver and a commercial ISM receiver

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Since 2016, the Istituto Nazionale di Geofisica e Vulcanologia (INGV) has been operating a software-defined radio (SDR) Global Navigation Satellite Systems (GNSS) receiver in SANAE IV base (Antarctica) to monitor ionospheric scintillations resulting from irregularities in the ionospheric electron density, a phenomenon of interest for the scientific community to understand the dynamic Earth ionosphere and the threats it poses on L-band signals.

The SDR works in parallel to a commercial Ionospheric Scintillation Monitoring (ISM) Receiver that is considered the benchmark for evaluating the SDR. The two receivers share the same antenna and wiring assembly, and thus receive identical GNSS signals. However, scintillation indexes estimated by the two receivers are not always identical. This could be due to many factors related to their different signal conditioning at the radio-frequency front-ends, the characteristics of the analogue-to-digital converters, as well as their specific pre-correlation and post-correlation processing algorithms.

Using the SDR receiver, we recorded GNSS raw signals during periods when the scintillation index (S4) exceeded a pre-defined threshold. In this paper, we show results of evaluating the recorded GNSS signal samples using a GNSS fully-software receiver (MATLAB-based) with scintillation index computation capabilities that has been developed by the NavSAS group at Politecnico di Torino. This class of receivers is typically highly versatile, allowing us to modify parameters in the receiver or implement new architectures at any stage of the processing chain. This flexibility enhances our ability to adapt and optimise the GNSS signal processing for our specific research needs.

Furthermore, we show the results of analysing the occurrence of differences between the indexes estimated by the two receivers and sorting them according to space weather conditions. We use the data from 2016 to 2019, a period of low solar activity. We find that the two receivers gave comparable performance when the Planetary Kp-index indicated the occurrence of geomagnetic storms, proving the SDR receiver's performance under scintillation conditions. However, under quiet geomagnetic conditions, the SDR receiver indicates a higher occurrence of scintillation events at the edge of the climatological auroral oval, signalling that the SDR receiver could be an informative tool for ionospheric scintillation studies. Overall, this study encourages researchers to keep operating the SDR receiver at the SANAE IV station and to upgrade the SDR receiver to state-of-the-art multi-constellation multi-frequency GNSS technology.