Investigating Cell Phone GNSS for Ionosphere Remote Sensing

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Over the past several decades, Global Navigation Satellite System (GNSS) signals have been increasingly exploited for ionosphere remote sensing. As GNSS signals propagate through the dispersive ionosphere they experience refractive effects dependent on electron density along the signal path, with multi-frequency GNSS signal combinations providing estimates of total electron content (TEC) along the signal path. In Canada, ionospheric phenomena of interest for safety-critical operational systems include the aurora, polar patches, traveling ionospheric disturbances and storm enhanced density – all readily observed using ground-based GNSS receiver networks. Space weather models have become increasingly reliant on assimilation of such GNSS observations to enhance prediction capability and gain insight into physical drivers. In this paper we explore opportunities to further enhance global coverage and spatial resolution of GNSS ionosphere remote sensing through recent technological advances in mass-market GNSS receiver technology.

In May 2018 the GNSS community welcomed the first release of an Android multi-frequency smartphone, with a Broadcom chip providing unprecedented L1 measurements from four GNSS constellations (GPS, Galileo, GLONASS and Beidou) and L5/E5 frequency observations for GPS and Galileo. The new Google Android GNSS raw measurement API allows access to the embedded chips' multi-frequency raw data for user processing, analysis and application development. Initial studies have shown improved navigation accuracy and precision over other smartphone devices and potential exists for ionospheric observation capabilities. This non-traditional sensing method is inexpensive and easily deployable, and potential exists to explore new approaches for GNSS TEC estimation.

We present first results for TEC estimation using dual-frequency cell phone GNSS and we analyse the major challenges and limitations for this approach. Low-cost antenna characteristics and RF interference from internal electronics are quantified and the magnitude and stability of system biases is estimated. Our testing includes controlled experiments using a GNSS hardware simulator and real-world validation in our Transition Region Explorer (TREx) network – a dedicated ground-based network to study high-latitude ionospheric phenomena in Canada. Simultaneous TREx observations from GNSS RF front-end samplers and geodetic GNSS receivers provide truth comparisons, while complementary auroral imager and riometer data provide information about ionospheric phenomena and the RF propagation conditions. Analysis focuses on case studies during late 2018 using the latest device upgrades.