GNSS scintillation case studies at high latitudes following solar events of January 2014

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Solar events can perturb the ambient ionosphere by modulating the dynamics of the plasma and by increasing the electron density, which can result in TEC (Total Electron Content) gradients. The impact of the solar events is particularly important at high and low latitudes due to the interplay between solar wind, magnetosphere and ionosphere. The GNSS signals passing through steep TEC gradients can experience scintillation when received at ground level. In January 2014, a series of solar events acted as drivers of ionospheric scintillation of the GNSS signals received in the Arctic and in Antarctica. A giant sunspot erupted on January 7th producing a powerful X1-class solar flare at approximately 18:32 UT and launching a CME that hit the Earth's magnetic field on 9th January (around 20:00 UT). On January 12th the Earth entered a fast stream solar wind (solar wind velocity exceeded 800 km/s on January 13th).

This paper focuses on the observations acquired by high sampling rate (50 Hz) GNSS receivers deployed at sub-auroral, auroral, cusp and polar latitudes in both the northern and southern hemispheres. A comprehensive study of the effects in the ionosphere caused by solar events that occurred between January 7th and 13th is here presented and discussed by supporting the GNSS observations with SuperDARN and magnetometer data. Climatological analysis of GNSS data with the Ground Based Scintillation Climatology (GBSC) technique (Spogli et al., Climatology of GPS ionospheric scintillations over high and mid-latitude European regions. Annales Geophysicae, 27(9) 2009, Alfonsi et al., Bipolar climatology of GPS ionospheric scintillation at solar minimum. Radio Science, 46(3), 2011), supported by the comparison with SuperDARN observations, and scintillation proxies derived from GNSS data (Ghoddousi-Fard et al., GPS phase difference variation statistics: A comparison between phase scintillation index and proxy indices. ASR 52, doi: 10.1016/j.asr.2013.06.035), identifies the region in between the two convection cells as the most turbulent and the borders of the cells as the zone in which the fragmentation of the ionospheric plasma takes place. Magnetic observations, compared with the GBSC, helps in highlighting the relationship between scintillation and energy of the geomagnetic field as derived from the spectral behaviours of the H, D and Z components..

This study will address the objectives of the GRAPE (GNSS Research and Application for Polar Environment) SCAR Expert Group (http://www.grape.scar.org/).