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Geomagnetic storm of March 17, 2015: global RT-IGS GPS phase irregularities and effects in the Canadian auroral region

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ABSTRACT

High-speed solar wind and coronal mass ejection events are the major causes of ionospheric disturbances that can affect GNSS positioning solutions. As a result of a halo coronal mass ejection followed by a high-speed solar wind stream from a coronal hole, March 17, 2015 experienced one of the strongest geomagnetic storms of the current solar cycle. The onset of GPS phase scintillation in the auroral oval coincided with a southward turn of the interplanetary magnetic field (IMF) about 2 hours after the shock that was associated with a strong northward IMF. The GPS scintillation intensified and extended into the polar cap under the influence of southward IMF in the magnetic cloud. This study evaluates GPS inter-frequency phase rate variations (Ghoddousi-Fard et al., 2013) derived from real-time IGS (RT-IGS) global network GPS data as well as GPS phase scintillation measurements in the Canadian Arctic monitored by the Canadian High Arctic Ionospheric Network (CHAIN) (Jayachandran et al., 2009) during the event.

Effects of March 17, 2015 storm on precise point positioning solutions are also studied over Canadian auroral region by correlating epoch solutions with solar wind speed and auroral electrojet (*AE*) index, as representatives of driving sources of phase scintillations in auroral zone.

Keywords: Geomagnetic storm, GNSS, Scintillation.

1. Geomagnetic storm of March 17, 2015

A coronal mass ejection ahead of a high-speed plasma stream from a coronal hole lead to a geo-effective configuration in the solar wind (Kataoka et al., 2015) that resulted in a strong geomagnetic storm on March 17, 2015. Solar wind data were obtained from the Goddard Space Flight Center Space Physics Data Facility CDAWeb and OMNIWeb (King and Papitashvili, 2005). The OMNIWeb data set of interplanetary magnetic field (IMF) and solar wind plasma parameters combine the data from available solar wind monitors, propagating the solar wind measurements to the nose of the Earth's bow shock to accommodate for propagation delays from the spacecraft. The geomagnetic response was characterized by a *Kp* index reaching a value of 8, the *AE* index exceeding 2000 nT, and the ring current *Sym-H* index dipping below -200 nT.

2. Global RT-IGS GPS phase rate measurements

Inter-frequency GPS phase rate variations from RT-IGS stations over stormy day of March 17, 2015 and rather quiet day of March 16 are studied. Results are calibrated for receiver specific background inter-frequency phase rate noise through evaluation of daily mean variation of inter-frequency phase rate at each group of stations operating the same receiver type during quiet and storm conditions. Global maps of GPS phase irregularities (sDPR) derived at each ionospheric pierce point are presented in a UT hour and geomagnetic latitude coordinate system for comparison against common geomagnetic indices. Figure 1 shows GPS phase irregularities during 24 hours of March 17, 2015 from RT-IGS stations as compared with real-time *AE* index.

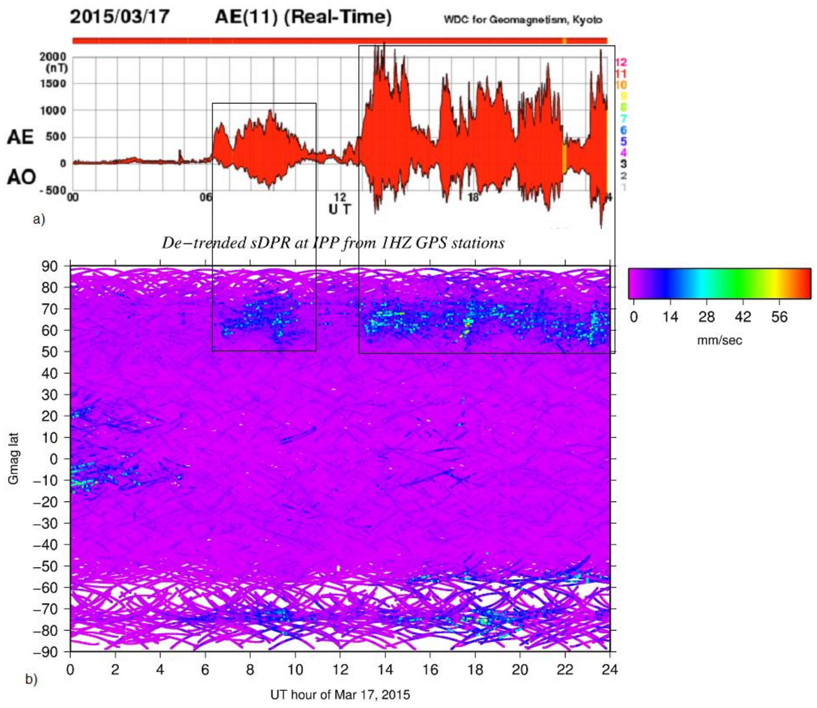

Figure 1- Real-time *AE* index (a) and de-trended sDPR at IPP from RT-IGS stations (b) during March 17, 2015.

3. Ionospheric irregularities over Canadian auroral region and their effects on GPS positioning

Further studies carried out on the effect of storm over Canadian auroral zone revealed sensitivity of the GPS phase rate variations for storm detection. Precise point positioning (PPP) epoch solutions over a number of GPS stations in the Canadian auroral region are also studied during the storm day. Positioning solutions by means of challenges in cycle slip detection and repair are discussed in comparison with geomagnetic indices during the storm period.

4. References

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