GPS&GLONASS Observations of the Large Scale Travelling Ionosphere Disturbances during Severe Geomagnetic Storms

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Travelling ionospheric disturbances (TIDs) are generally considered as ionospheric signatures of atmospheric gravity waves (AGWs) in the thermosphere. Using a comprehensive database of ~5300 ground-based Global Navigation Satellite Systems stations we have investigated large-scale travelling ionospheric disturbances (LSTIDs) during severe geomagnetic storms of March, June and December 2015. For the first time, the high-resolution, two-dimensional maps of the total electron content perturbation were made using not only GPS but also GLONASS measurements. This allows us to reach unprecedented spatio-temporal resolution for LSTID parameter estimation on a global scale. Several LSTIDs originated from the auroral regions in the Northern and Southern Hemispheres were observed simultaneously over Europe, North America, South America and Australia. In particular, during the St. Patrick's Day storm we report that (1) intense LSTIDs propagated equatorward in North America and Europe, (2) convergence of several LSTIDs originated from the opposite hemispheres in the interference zone over geomagnetic equator in South America, and (3) "super" LSTIDs with the wavefront length of more than 10,000 km observed simultaneously in North America and Europe. LSTIDs observed in these sectors had wavelength of ~1200–2500 km and wave periods of ~50–80 min. During the recovery phase on the background of the negative ionospheric storm developed over North America we detect signatures of the stream-like structures elongated within the latitudinal range of 29°N–42°N across the U.S. These structures persisted through the nighttime to the early morning from 04 UT to 13 UT on 18 March 2015, and they were associated with the subauroral polarization stream-induced nighttime ionospheric flows and significant poleward surge in thermospheric winds at subauroral and midlatitudes. Special attention was drawn to the investigation of the TIDs dynamics at auroral latitudues of the Northern and Southern hemispheres using ground-based GPS/GLONASS and the Swarm constellation in situ measurements.