Large scale traveling ionospheric disturbances origin and propagation

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We investigate an origin, occurrence, and propagation of large-scale traveling ionospheric disturbances (LSTIDs) with an analysis of the total electron content (TEC) perturbation component deduced from the ground-based GPS and GLONASS observations. The high spatio-temporal resolution mapping approach provides a very detailed specification of the ionospheric small- to large-scale disturbances associated with two major sources of the LSTIDs generation: the solar terminator passage during the quiet time and auroral activity caused by auroral particle precipitation and field-aligned currents (FACs) intensification during geomagnetic disturbances. For the first time, the joint analysis of the ionospheric plasma irregularities, FACs, and LSTIDs reveals that a zone with the intense FACs and ionospheric irregularities occurred at the same region that represent the most probable source of LSTIDs excitation. The COSMIC RO electron density profiles confirm the E layer plasma density enhancement within LSTIDs excitation area. Such density enhancement leads to an increase of ionospheric conductivity, intensification of currents in the ionosphere, and release of energy by Joule heating into the lower thermosphere.
This approach was demonstrated for the case of the 19-21 December 2015 geomagnetic storm, when LSTIDs propagated over the European region were detected. During the main phase of the storm, the LSTIDs propagated equatorward from European high latitudes to middle latitudes (35-40N) with the horizontal velocities of ~700-800 m/s. The LSTIDs as deduced from the TEC-disturbed component had a much larger magnitude and propagate much longer distances during the daytime (sunlit part) than in the night. We found that an equatorward expansion of the strong ionospheric irregularities zone and an increase of the FACs magnitude led to a simultaneous intensification of the LSTIDs occurrence at high latitudes. The GPS ROTI (rate of TEC index) technique, a sensitive one for detection of the rapid ionospheric gradients and irregularities, could not recognize any signatures of the TIDs structures.

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