Abstract

Atmospheric gravity waves (AGWs) play an important role in the dynamics of the Earth´s middle and upper atmosphere. Propagating through the thermosphere and interacting with the ionospheric plasma, AGWs produce Travelling Ionospheric Disturbances (TIDs). Investigation of TIDs nowadays is an important task in geophysics and radiophysics, as TIDs produce refractive distortions of transionospheric radio signals and influence radio wave propagation within the broad radio wave range from hundreds of meters to tens of centimetres used in radiocommunication, radiolocation, and radioastronomy and are among the most typical sources of the Global Navigation Satellite System (GNSS) errors. Specification of the main TID drivers in the geospace and the Earth's atmosphere, hemispheric/interhemispheric circulation of TIDs and their impact on ground-based and space-borne communication/navigation technologies are among the major challenges of the Project TechTIDE supported by the European Commission Horizon 2020 Research and Innovation Program that will advance our scientific understanding of the TID formation and propagation mechanisms and will support the identification, verification and early warning systems.

The paper presents results of the TID activity monitoring and analysis carried out in the frame of the Project using selected methodologies and special tools. We focused on the TIDs triggered by the most efficient drivers - Coronal Mass Ejection (CME)- and High Speed Solar wind Streams coming from the Coronal Holes (CH HSSS)- related magnetic storms. CMEs are spontaneous solar/coronal ejecta that usually occur more frequently around the maximum of the solar cycle and induce non-recurrent storms. During the declining phase of the solar cycle, coronal holes tend to dominate, expanding from the polar regions to equatorial location. Solar wind HSS, originating from CH located at or near the solar equator, and the associated CIRs formed in front of HSSs then become the considerable source of the recurrent disturbances of the Earth´s magnetosphere and ionosphere. While CMEs typically produce greater *Dst* excursions, CIR/CH HSS seems to be more geoeffective in the sense of greater overall energy output than are the CME events mainly due to their longer duration. Comprehensive observations of the effects during CME-induced magnetic storms usually show changes in main ionospheric parameters and Total Electron Content Perturbations (TECP) caused by the ionospheric fluctuations associated with the Large Scale TIDs (LSTIDs) moving equatorward. The LSTIDs are launched from the auroral zones and have long horizontal wavelength and high speeds. The LSTIDs could be multiple when associated with a series of quasi-periodic substorms. LSTIDs of CIR/HSS-related storm origin have not been widely monitored and analysed in details. Our results indicated that during the magnetic disturbances associated with CIR/CH HSS the TID activity is considerable and has longer duration when comparing with CME-related events.

The other aspects we are focusing on are specification of the impact of TIDs on EGNOS system availability degradation through statistical correlation of the performance data recorded from system operators and of TID detection results and hemispheric/interhemispheric circulation of the TIDs. In order to obtain quantitative information on the likeliness and morphology of interhemispheric circulation of TIDs 38 events from the project catalogue were examined. We used exclusively GPS-based detection methods, specifically information on TEC, TEC deviations in space and time from a background reference (dTEC), and the Rate of TEC change

in time (ROT), all inferred from GPS receiver networks in Europe and Africa. Under the constraint that our data sample was heavily biased toward geomagnetic storm time events we conclude that hemispheric conjugacy of LSTID is highly probable while interhemispheric circulation rather unlikely but still occurring during some periods.