# Large- and medium-scale traveling ionospheric disturbances over Europe induced by solar eclipse as inferred from dense GPS network data

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The irregularities having different scales are omnipresent in the ionospheric plasma. Of particular interest are traveling ionospheric disturbances (TIDs). They are thought to be manifestations of acoustic-gravity waves (AGWs) or caused by electromagnetic forces and electromagnetic coupling between E and F-regions. TIDs are originated by many natural and artificial high energy sources and responsible for energy and momentum coupling of different atmospheric and ionospheric regions.

Solar eclipses are considered to be one of the most important sources of ionospheric perturbation. They enable the studies of atmospheric and ionospheric processes during short-term day-to-night transition and vice versa covered wide altitude range (from the Earth’ s level till topside ionosphere). The identification of TIDs generated by lunar shadow moving is complicated. It is by the fact that the solar eclipses, especially total, are relatively infrequent events over definite region. In addition, it is often difficult to separate TIDs induced by solar eclipse from those caused by continuously existing other natural sources. Simultaneous observations over many different regions are needed to trace TID generation and propagation characteristics. Using the data from dense GPS networks all over the word for joint analysis is a promising approach to better understand this issue.

We have analyzed the data acquired by dense regional networks of GPS receivers located in Western and Northern Europe during the total solar eclipse of 20 March 2015. This event occurred near the vernal equinox during the recovery phase of severe geomagnetic storm. The comprehensive study of TEC variations using spectral and statistical methods as well as band-pass temporal and spatial filtrations was conducted. We detected the prevailing TID periods to be of 50 –60 minutes. In addition both large-scale TIDs (LSTIDs) and medium-scale TIDs (MSTIDs) having close periods occurred during this solar eclipse.

Over Western Europe, the LSTIDs exhibited northeast propagation direction and had average horizontal phase velocity $V_m$ = 900 m/s. At the same time, the MSTIDs propagated southeastward with $V_m$ = 140 m/s. The absolute amplitudes of TEC variations were equal to about 0.17 and 0.07 TECU for LSTIDs and MSTIDs respectively.

As for TIDs over Northern Europe, both LSTIDs and MSTIDs had prevailing southeast horizontal phase velocities. Their average value was of 770 m/s for LSTIDs and of 100 m/s for MSTIDs. The TID amplitudes were larger at high latitudes. The LSTID and MSTID amplitude values reached of 0.6 and 0.4 TECU respectively.

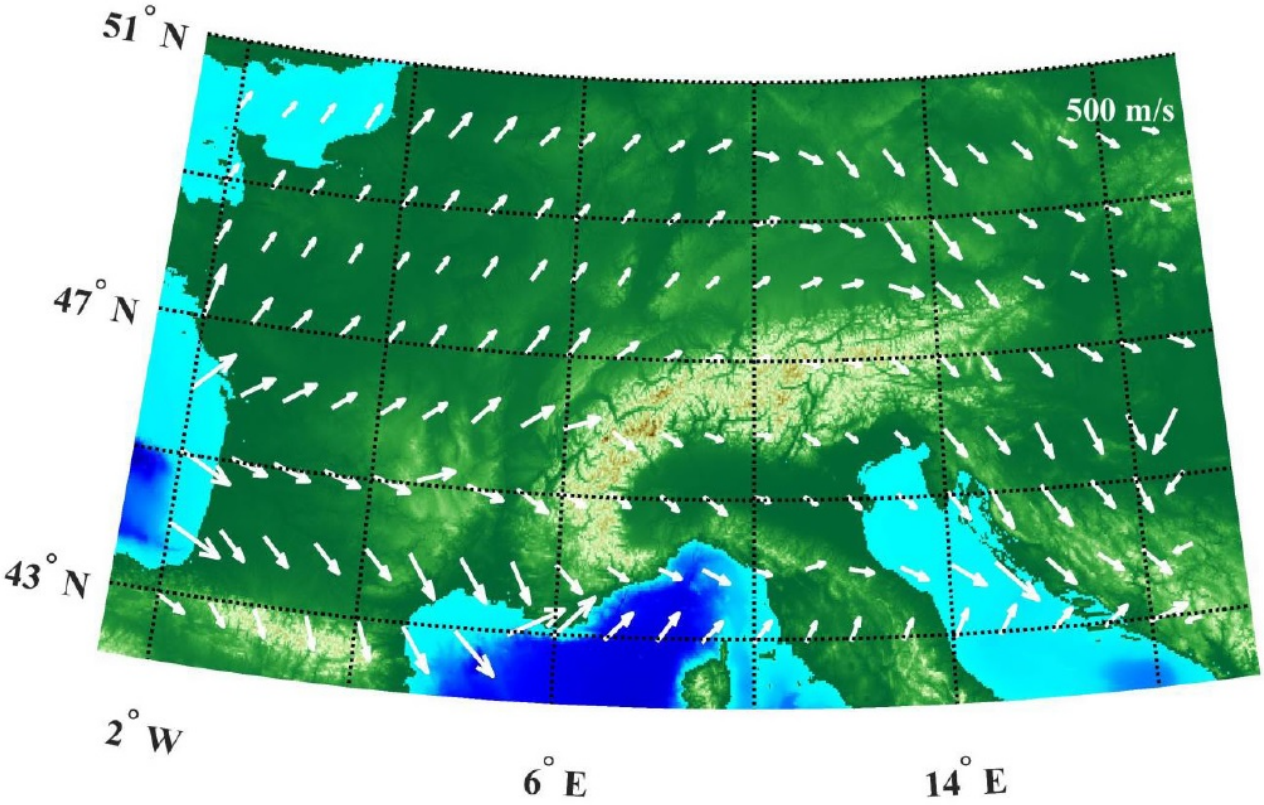
We created a map of LSTIDs' horizontal phase velocity vectors demonstrating the main features of large-scale wave propagation.

Used approach and developed methods will be applied to specify and forecast the characteristics of TIDs

observed during other solar eclipses occurred at different space weather conditions.

Keywords: ionospheric disturbances, solar eclipse, GPS network data




Velocity vector field showing the directions of LSTIDs' horizontal phase velocities over Europe during the total solar eclipse of 20 March 2015