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Observation and analysis of the formation of the ionospheric sporadic E layer over European middle latitudes

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The Earth's lower ionosphere is significantly influenced by processes in the neutral atmosphere, the upper ionosphere, the magnetosphere and the entire geosphere. Sporadic *E* (*Es*)-layers are irregular structures in the lower ionosphere with a central peak height of about 90-150 km and have a significant impact on the wireless communications, navigation and satellite remote sensing. The *Es* layer can have higher electron densities than the regular *E* region, and it tends to be more frequent and more intense in the summer [1]. The literature suggests that there are several mechanisms involved in forming *Es*. Some of the proposed mechanisms include planetary waves [2], tides [3] sudden stratospheric warming events due to zonal wind reversals affecting the propagation of lunar tides, transport of the metal ions through the neutral wind shear instabilities [4], meteor ablation, particle precipitation, internal gravity waves, local electric field fluctuations or strong electric field associated with thunderstorms/lightning. Understanding the morphological characteristics of *Es* behaviour and the underlying theories is crucial for the study of coupling processes in the Earth's atmosphere and for further ionospheric predictions.

Gravity waves, tides and planetary waves contribute significantly to the energy budget of the neutral atmosphere and ionosphere. Traveling ionospheric disturbances (TIDs) are oscillating disturbances or waves propagating through the ionosphere. In most cases they are generated by acoustic gravity waves (AGWs) or the Perkins instability. TIDs have an oscillating horizontal polarised electric field in the direction of propagation. This is mapped down along the magnetic field lines. The medium scale traveling ionospheric disturbances (MSTIDs) could be generated by instabilities when the electric field of the *Es* layer polarisation is mapped into the *F* region [5].

Using the European Digisonde network and GPS radio occultation data, we analysed the spatial and temporal distribution of sporadic *E*-layers over Europe and investigated their occurrence and evolution in relation to lower thermospheric dynamics, solar activity and magnetic field parameters. In this study, we focus in particular on the virtual height variation of the *Es*-layer when MSTIDs propagate over the *F* region.

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