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# Analytical and Numerical Study of Formation of Sporadic E Layer with Taking into Account Horizontal and Vertical In-Homogeneity of the Horizontal Wind

**Authors :** Giorgi Dalakishvili, Goderdzi G. Didebulidze, Maya Todua

**Abstract :** The possibility of sporadic E (Es) layer formation in the mid-latitude nighttime lower thermosphere by horizontal homogeneous and inhomogeneous (vertically and horizontally changing) winds is investigated in 3D by analytical and numerical solutions of continuity equation for dominant heavy metallic ions Fe+. The theory of influence of wind velocity direction, value, and its shear on formation of sporadic E is developed in case of presence the effect of horizontally changing wind (the effect of horizontal convergence). In this case, the horizontal wind with horizontal shear, characterized by compressibility and/or vortices, can provide an additional influence on heavy metallic ions Fe+ horizontal convergence and Es layers density, which can be formed by their vertical convergence caused as by wind direction and values and by its horizontal shear as well. The horizontal wind value and direction have significant influence on ion vertical drift velocity and its minimal negative values of divergence necessary for development of ion vertical convergence into sporadic E type layer. The horizontal wind horizontal shear, in addition to its vertical shear, also influences the ion drift velocity value and its vertical changes and correspondingly on formation of sporadic E layer and its density. The atmospheric gravity waves (AGWs), with relatively smaller horizontal wave length than planetary waves and tidal motion, can significantly influence location of ion vertical drift velocity nodes (where Es layers formation expectable) and its vertical and horizontal shear providing ion vertical convergence into thin layer. Horizontal shear can cause additional influence in the Es layers density than in the case of only wind value and vertical shear only. In this case, depending on wind direction and value in the height region of the lower thermosphere about 90-150 km occurs heavy metallic ions (Fe+) vertical convergence into thin sporadic E type layer. The horizontal wind horizontal shear also can influence on ions horizontal convergence and density and location Es layers. The AGWs modulate the horizontal wind direction and values and causes ion additional horizontal convergence, while the vertical changes (shear) causes additional vertical convergence than in the case without vertical shear. Influence of horizontal shear on sporadic E density and the importance of vertical compressibility of the lower thermosphere, which also can be influenced by AGWs, is demonstrated numerically. For the given wavelength and background wind, the predictability of formation Es layers and its possible location regions are shown. Acknowledgements: This study was funded by Georgian Shota Rustaveli National Science Foundation Grant no. FR17-357.

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