MODELING OF SPORADIC-E STRUCTURES FROM WIND-DRIVEN KELVIN-HELMHOLTZ TURBULENCE

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Abstract:

Atmospheric wind shears control the irregularity structure in the E-region. Near 100 km altitude, where the ion collision frequency is much larger than the ion cyclotron frequency, the degree of shear turning and the direction of maximum shear gradient determine the location of the E-layer peak. With a large degree of shear turning, a non-zonal speed-shear produces an E-layer that is offset from the node in the neutral shear. This node marks the region where Kelvin-Helmholtz (KH) turbulence in the neutral atmosphere has the largest amplitude. In the case of non-zonal, turning shears the induced irregularity structures will reside on the top or bottom of the offset E-layers. Also, larger horizontal ion drift currents will be induced into the ion layers because of their offset from the node of the wind shear. Both the enhanced irregularities on the top or bottom of the layers and the increase in ion drift velocity will promote the growth of field-aligned irregularities (FAI\'s) by the gradient drift mechanism. Proper modeling of the FAI amplitude requires inclusion of the three-dimensional wind shear structure.The effects of combination turning and speed shears on the three-dimension structure of the E-layer are modeled using a system of coupled equations for continuity and momentum that describes both the neutrals and plasma. In the model, the large amplitude components of the neutral wind shear drives the neutral atmosphere unstable and produces Kelvin-Helmholtz (K-H) billows. At the same time, the three-dimensional structure of the same wind shear compresses the ions vertical profile that is not necessarily centered on the node of the wind shear. The speed shear component is the source of Kelvin-Helmholtz turbulence and it produces quasi-periodic (Q-P) irregularities in the layer along the horizontal direction of the speed shear. The location of the turbulence in the ions is dependent on the offset lifting or lowering by the turning shear component of the neutral wind. In the absence of a turning component, the speed shear introduces K-H structures at the peak of the layer [Bernhardt, JASTP, 105, 1487-1504, 2002]. The radar scans of the E-region [Miller and Smith, JGR, 83, 3761-3775, 1978] show K-H structures on the topside of the ion layers. The numerical results of the model study are consistent with these observations.