Numerical simulation of modulation of midlatitude ionospheric E-region by atmospheric gravity waves

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The quasi-periodic (QP) radar echoes of ionospheric irregularities in the E-region was first observed with the MU radar and studied for more than a decade. Just after the discovery of QP echoes, they were thought to be associated with the deep modulation of sporadic-E (Es) layers by atmospheric gravity waves. Although this idea turned out not to be true from the two rocket experiment in 1996 and 2002, it is true that the characteristics of QP echoes are actually similar with gravity waves. We similated the effects of gravity waves on the E-region plasma by combining two numerical simulation models for the neutral atmosphere and the E-region plasma.

Since amplitude of gravity waves increases with altitude, gravity waves can strongly modulate plasma in the E-region. When the zonal wind shear that can accumulate plasma exists at the lower thermosphere, there is a possibility that gravity waves with eastward phase velocity are filtered out due to the eastward wind below the shear node. Gravity waves with westward phase velocity can remain in the lower E-region, and generate polarization electric fields. The phase alignment of the gravity wave maps along the geomagnetic field, and generate structures of the E-region plasma from northwest to southeast on the horizontal plane. The results are consistent with the typical structure of QP echoes. If such structures propagate following the neutral wind, spatial quasi-periodicity of QP echoes can be observed with radars as temporal quasi-periodicity.