

Stratospheric Gravity Waves as the Seeds for E-F Coupling

A well-known phenomenon within the mid-latitude ionosphere is the appearance of southwestward-directed traveling ionospheric disturbances (TIDs), predominantly in summer nighttime. While the Perkins instability has long been suspected to play a role in the generation of these waves, it has also been consistently demonstrated that the growth rate of this instability is too slow to produce such TIDs. Some have speculated that a similar instability within sporadic-E layers couples to the Perkins instability within the F-region via polarized electric fields, yielding a significantly larger combined growth rate. Indeed, there is significant observational evidence that these TIDs occur in conjunction with the appearance of sporadic-E.

Here, the results of a study of TIDs during summer nighttime in the southwestern United States are presented using data from 2015 from a radio-frequency telescope and an array of 20 nearby GPS receivers. The telescope, the Very Large Array (VLA) in New Mexico, measures gradients in total electron content (TEC) toward bright cosmic radio sources and is sensitive to relatively small-scale TIDs (~tens of km wavelength). The GPS receivers are all within 200 km of the VLA and are better at characterizing medium-scale disturbances (~hundreds of km). Both datasets preferentially showed evidence of southwestward-directed TIDs when the ionosonde in Boulder, Colorado detected sporadic-E. While the TIDs had significantly different wavelengths (16 km for VLA-detected waves; ~100 km for GPS), they were traveling in roughly the same direction with the same speed (~150 m/s). This implies that the two instruments were sampling two different portions of a spectrum of F-region waves associated in some way with sporadic-E.

Examination of wind data from the NOAA North American Regional Reanalysis (NARR) showed that when southwestward-directed TIDs were detected with either GPS or the VLA, there was a localized acceleration in the jet stream, or "jet streak," near the Great Lakes to the northeast of the VLA. This correlation was stronger for the smaller, VLA-detected waves and existed whether or not sporadic-E was present. However, the TIDs were substantially stronger when sporadic-E was detected. This supports a hypothesis within which the summer nighttime TIDs, at least those over the continental United States, are primarily the result of jet streak-induced gravity waves whose impact is greatly enhanced by the E-F coupling instability.