On the Electrodynamic Variability of the Evening Low Latitude F-Region

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Equatorial electric fields and plasma drifts play fundamental roles on the morphology of the low latitude ionosphere. The quiet and disturbed vertical ExB drifts (driven by zonal electric fields) are small, but they determine the daytime distribution of ionization over a large area of the Earth through the fountain effect. Furthermore, the evening prereversal enhancement of the upward drift plays a important role on the occurrence of equatorial irregularities with a large range of scale sizes. A typical characteristic of the low latitude electrodynamic vertical and zonal plasma drifts is their strong variability during both geomagnetically quiet and disturbed times. The understanding of the temporal and spatial variations of these parameters is essential for the development of realistic ionospheric models.

The equatorial vertical and zonal F-region plasma motions have been studied in detail using extensive measurements from the Jicamarca incoherent scatter radar (11.9°S, 76.8°W; magnetic dip 2°S), near Lima, Peru, ionosonde observations from Brazil and India, and more recently with in-situ Ion Drift Meter data from a number of satellites. In this paper we use incoherent scatter radar and satellite measurements to examine the long- and short-term variability of the equatorial F-region.

The quiet-time equatorial F-region electrodynamic plasma drifts are driven by neutral wind generated E-region dynamo and F-region polarization electric fields. The low latitude thermospheric winds and plasma drifts are highly variable as a result of large changes in the global tidal forcing, and effects of irregular winds, planetary, and gravity waves. They can also be affected by the dynamic conditions at the base of the thermosphere, and by long- and short-term changes in the efficiencies of the E- and F-region dynamos. Incoherent scatter radar data indicate that the daytime average upward drifts do not vary much with solar activity, but the evening upward and the nighttime downward drifts increase from solar minimum to solar maximum, and that their quiet-time variability is local time, seasonal, and solar cycle dependent. The variability of the daytime vertical drifts is largest in the dawn-noon sector and during March equinox solar minimum periods. The amplitudes and reversal times of the evening vertical plasma drifts are significantly more variable during solar minimum than during solar maximum. In the Peruvian equatorial region, the largest variability of the evening vertical and zonal plasma drifts occurs during December solstice.

During and after magnetically disturbed conditions, enhanced leakage of high latitude electric fields to lower latitudes and large perturbations in the global wind system are important additional sources of strong equatorial plasma drift and ionospheric current variability. Extensive statistical and case studies have indicated that most of the large plasma drift perturbations associated with magnetic activity can be explained as resulting from the combined effects of prompt penetration electric field and disturbance dynamo electric fields. The average equatorial empirical disturbance patterns associated with the prompt penetration electric field and disturbance dynamo electric fields are in excellent agreement with results from global convection and disturbance dynamo models, respectively. The fundamental unresolved questions in this area deal with the variability of the evening prompt penetration, ionospheric wind driven disturbance dynamo electric fields, and also with the possible effects of other neutral atmospheric wind and conductivity driven dynamo processes. This variability is expected to be largest near dawn and dusk.

There are a large number of effects that can modulate the low latitude evening prompt penetration electric fields. Recent numerical simulations indicate that both the initial time response and the steady state leakage of high latitude electric fields to the evening low latitude ionosphere is solar cycle dependent. These evening prompt penetration electric fields seem to be highly affected by the reconfiguration of the Earth's magnetic field following sudden changes in geomagnetic activity. In addition, convection enhancements and substorms produce clearly different evening equatorial electric field perturbations.

The characteristics of evening dynamo electric fields driven by storm time driven winds are still not fully understood. At equatorial latitudes disturbance dynamo drifts near dusk show strong seasonal and solar cycle effects. The evening disturbance dynamo vertical drifts are downward and have largest amplitudes during equinox solar maximum conditions. The low latitude thermospheric disturbance winds and ionospheric dynamo electric fields should also be strongly dependent on the longitudinal sector where the bulk of the high latitude energy deposition takes place, but the longitudinal dependence of disturbance dynamo drifts still remains to be determined. There are also other potentially important sources of evening disturbance dynamo drifts. These include traveling atmospheric disturbances (TADs), and changes in the ionospheric conductivity due to changes in the ion composition are common features of the mid- and low-latitude ionosphere during and after magnetically active times.