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"Satellite Studies of Ionospheric Electric Fields and Neutral Winds"
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1. INTRODUCTION

We have studied mid- and low-latitude electrodynamic and neutral thermospheric dynamic processes using measurements on board the AE-E, DE-2, and UARS satellites, and global convection and general circulation models. These studies have determined the morphology of the equatorial zonal electric fields [*Scherliess and Fejer*, 1999], the response of equatorial plasma irregularities to magnetospheric disturbances [*Palmroth et al.*, 2000], and the time dependent response of the mid- and low latitude electric fields to magnetospheric disturbances [*Scherliess and Fejer*, 1998, 1999; *Fejer and Scherliess*, 1998, *Scherliess et al.*, 2000]. We have also used extensive *F* region zonal and meridional wind data obtained by Wind Imaging Interferometer (WINDII) instrument on board the Upper Atmosphere Research Satellite (UARS) to study the latitudinal dependence of daytime disturbance winds during magnetically disturbed periods and the general characteristics of the global thermospheric disturbance wind system during geomagnetically active periods [*Fejer et al.*, 2000; *Emmert et al.*, 2001]. This project has supported the PhD thesis research of John Emmert [2001].

2. SUMMARY OF RESULTS

Low and Mid Latitude Ionospheric Electrodynamics. We have completed our studies of equatorial electric fields using Ion Drift Meter (IDM) data from the AE-E satellite together with radar observations from the Jicamarca incoherent scatter radar by developing the first season, solar cycle, and longitude dependent quiet-time ($Kp < 3$) F-region vertical plasma drift model [*Scherliess and Fejer*, 1999]. This model highlights the large longitudinal variation of the evening prereversal enhancement and reversal time with longitude which play important roles on the generation of equatorial spread F and radiowave scintillations.

Palmroth et al. [2000] used data from the IDM and Vector Electric Field Instrument (VEFI) on board the DE-2 satellite to examine the longitudinal occurrence of large scale plasma depletions in the equatorial ionosphere. They showed that the effect of magnetic activity on the occurrence of these plasma depletions is in good agreement with the results of *Fejer et al.* [1999] obtained using Jicamarca incoherent scatter radar data.

Scherliess and Fejer [1998], *Fejer and Scherliess* [1998], and *Scherliess et al.* [2000] have studied the time dependent response of mid-latitude zonal plasma drifts measured by the DE-2 satellite and Millstone Hill, Saint-Santin, and Arecibo incoherent scatter radar to magnetospheric disturbances. These studies have shown a good agreement between the storm time electric field patterns measured by the satellites and incoherent scatter radars, and indicate significant leakage of high latitude steady-state electric fields to upper mid-latitudes. The empirical electric field patterns are in good agreement with results from the Rice Convection Model (RCM).

Mid- and Low-Latitude Disturbance Thermospheric Winds. *Fejer et al.* [2000] presented the initial results on the latitudinal variation of daytime *F* region zonal and meridional disturbance winds obtained using vector wind measurements from the 557.7 nm $O(^1S)$ green line and 630.0

nm O(^{1}D) red line emissions measured by the WINDII instrument on board the UARS satellite since 1991. Following the experimental procedure described in our disturbance electric field studies [*Fejer and Scherliess* 1997, 1998; *Scherliess and Fejer*, 1998], the perturbation winds were obtained by subtracting the local time, latitude, altitude and season dependent quiet time (Kp < 3) wind values along the trajectory of the satellite. The use of orbital coordinates ensures an even sampling and, more importantly, removes known bias associated with the orbital configuration of the satellite (i.e., the data from the ascending and descending trajectories give somewhat different quiet time average *F* region wind values).

The top panel in Figure 1 shows a sample of the orbits during December solstice (November-February) magnetically quiet (average Kp=1.8) conditions; the bottom panels present the scatter plots of the quiet time zonal and meridional winds measured along the darkened orbits shown in the top panel. The perturbation winds derived from the green and red line data, which were analyzed separately, gave essentially identical results and were combined to improve statistics.

The latitudinal profiles of the meridional and zonal disturbance winds are essentially season independent, which is consistent with the model results presented by *Fuller-Rowell et al.* [1994]. The left panels in Figure 2 illustrates the latitudinal variations of the average meridional and zonal disturbance winds obtained by combining the perturbation values from all seasons. The average solar local times are about 7.4 h, 10.5 h, and 14.5 h, respectively. The solid curves correspond to least squares fits of the perturbation winds using cubic B-splines [e.g., *Fejer and Scherliess*, 1997] for the zonal component, and a linear fit for the meridional component.

The DE-2 zonal winds measured by the WATS intrument during August 1981 and February 1983 were studied using the same experimental procedure (only a relatively small number of meridional wind observations were made by this satellite). The right panel in Figure 2 shows the excellent agreement between the latitudinal profiles of the zonal disturbance winds derived from measurements by the UARS and DE-2 satellites.

Emmert et al. [2000a] presented a detailed study of the local time, seasonal, solar cycle, and latitudinal variation of the mid- and low-latitude *F* region neutral winds measured by the UARS satellite using the experimental procedure described in *Fejer et al.* [2000]. They also developed analytical models for the disturbance winds as a function of local time, latitude, and Kp, and compared the satellite results with data from ground based observations and theoretical and empirical numerical models. *Emmert et al.* [2000b] presented the initial results of the longitudinal variation of the UARS and DE-2 *F* region winds. These results will be discussed later.

Figure 3 shows the local time variation of the *F* region winds measured by WINDII for moderate solar flux (solar decimetric flux index of about 120) conditions. The UARS meridional disturbance neutral winds are in good agreement with disturbance winds derived from Saint-Santin (42°N, 3°E) incoherent scatter radar measurements published by *Duboin and Lafeuille* [1992]. The UARS *F* region meridional disturbance winds decrease by a factor of about 1.5 to 2 with the increase of the solar flux index from 90 to 150, but the zonal winds are largely unchanged.

Figure 4 shows the comparison of the longitudinally averaged UARS disturbance winds with results from the Horizontal Wind Model (HWM-93) [*Hedin et al.*, 1996] and with the NCAR TIEGCM [*Richmond et* al., 1992] as a function of latitude at three local time sectors. The TIEGCM results were provided by C. Fesen. Figure 4 indicates that the TIEGCM zonal disturbances agree with the satellite results except for the early morning sector. The TIEGCM meridional disturbance winds do not agree with the WINDII results except in the afternoon sector. The HWM-93 meridional and zonal disturbance winds are not consistent with the WINDII results. It is interesting to note that the first version of this empirical model (HWM-87) is in slightly better agreement with the UARS disturbance winds.

3. REFERENCES

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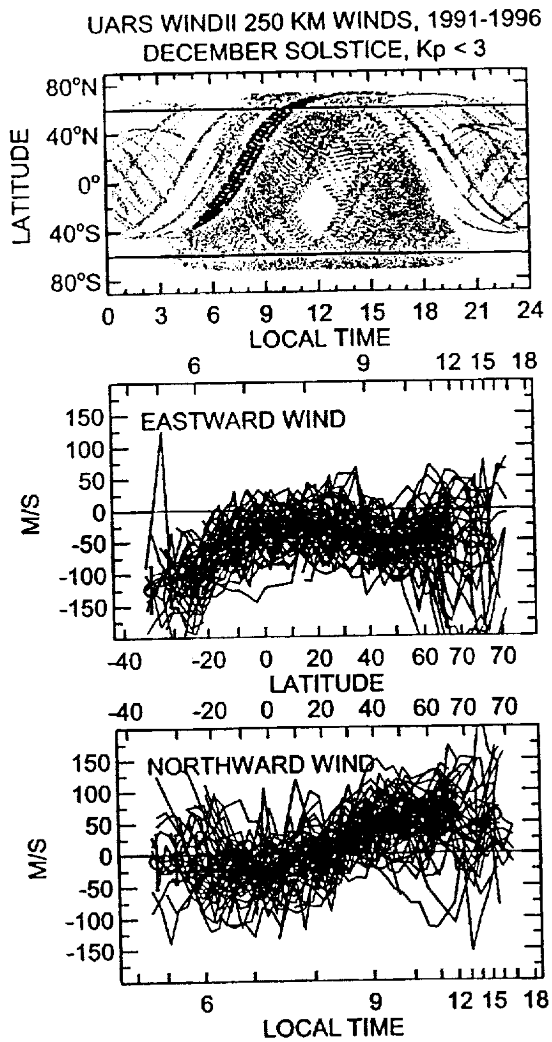

Figure 1. Top panel: UARS orbit during December solstice quiet time periods. The local time scale corresponds to the equatorial crossing. Bottom panels: Scatter plots of the quiet time eastward and northward winds measured along the darkened orbits shown in the top panel. The unusual local time scale in the bottom panel results from the satellite orbital velocity [after *Fejer et al.*, 2000a]

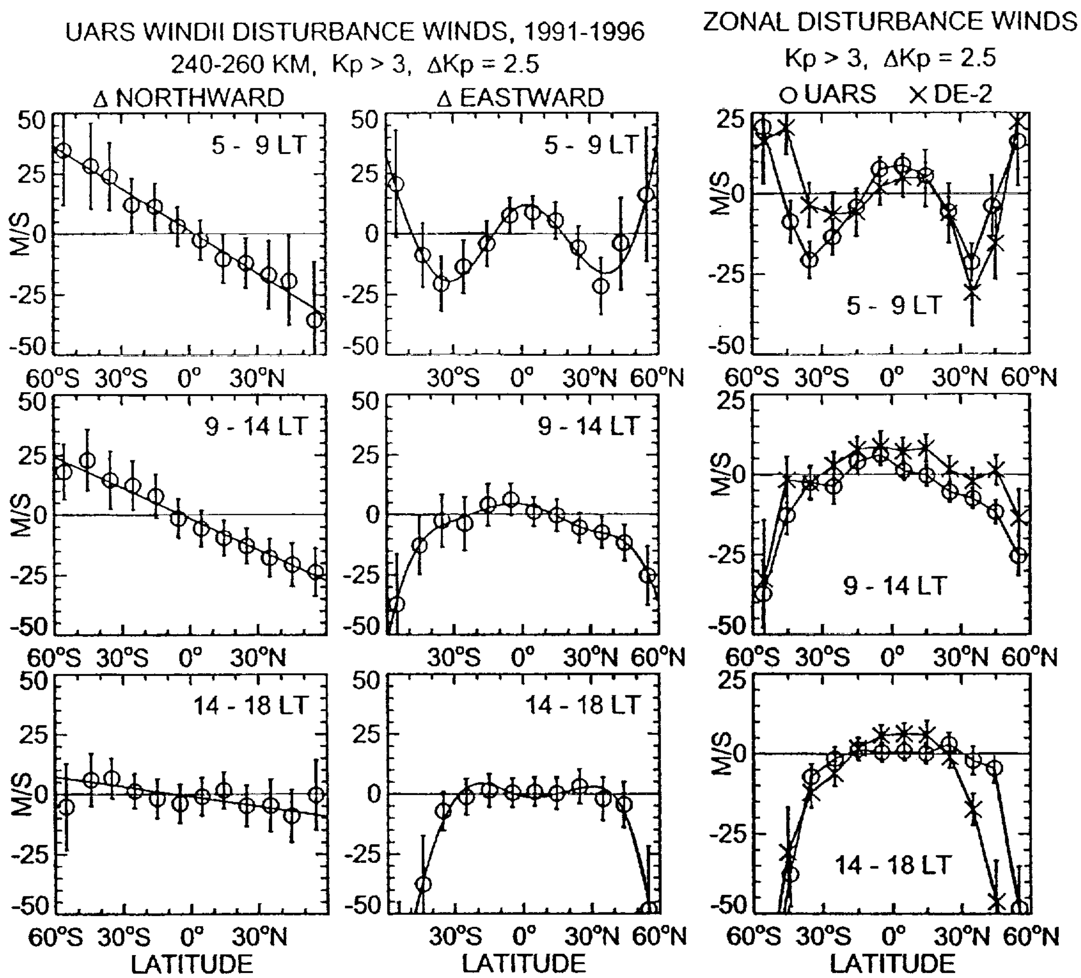

Figure 2. Left and center panels: Latitudinal profiles of the longitudinally and seasonally averaged northward and eastward disturbance winds for an increase ΔKp =2.5. Right panel: Comparison of zonal disturbance wind patterns derived from measurements on board the UARS and DE-2 satellites. The scatter bars denote the standard errors of the means [after *Fejer et al.*, 2000a].

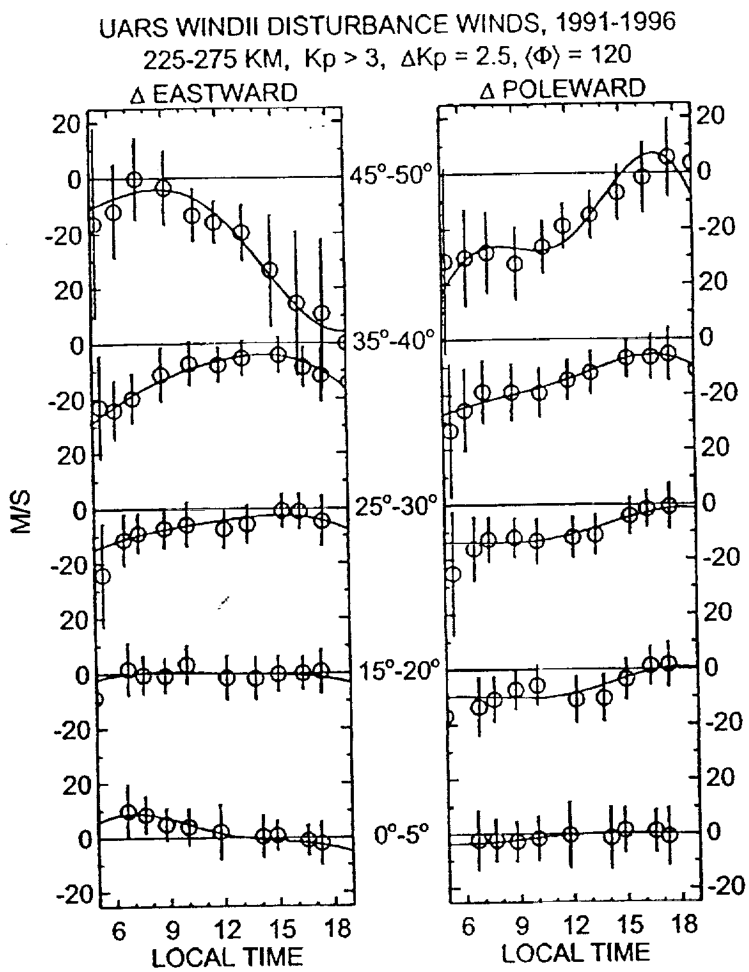

Figure 3. Local time variations of the *F* region daytime disturbance winds measured by WINDII in five latitudinal sectors [after *Emmert et al.*, 2001a].

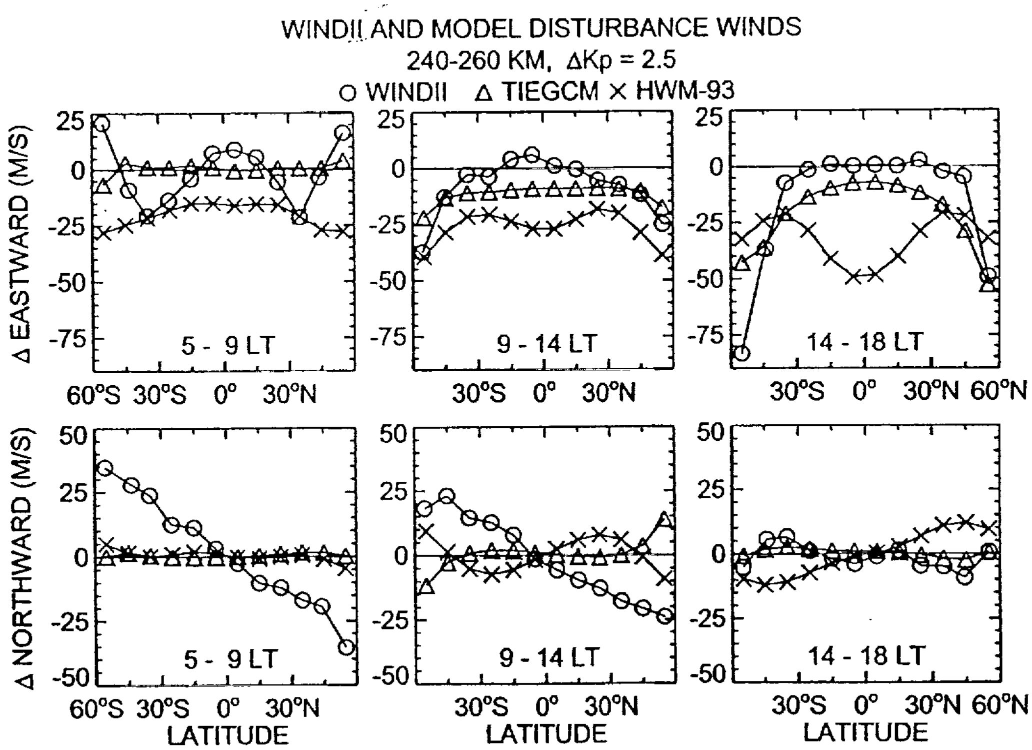

Figure 4. Comparisons of the latitudinal profiles of longitudinally averaged *F* region neutral disturbance winds measured by WINDII and results from TIEGCM and HWM-93 [after *Emmert et al.*, 2000a].