Equinoctial Asymmetry of the Vertical Drift in Pre-reversal Enhancement

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Abstract

The height of the post-sunset equatorial F-layer, which is the most important parameter in controlling the generation or inhibition of equatorial spread F (ESF), is largely driven by the equatorial vertical plasma drift (E×B) velocity. Occurrence of ESF in different longitudes shows asymmetry between March and September equinoxes especially during solar minimum years. The asymmetry is also simulated by using NCAR Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM). In order to investigate the phenomenon, we examine the lower thermospheric tidal forcing which is driven by the Global-Scale Wave Model (GSWM) in the TIEGCM during the pre-reversal enhancement (PRE) under high and low solar activity. The occurrence time and magnitude of maximum PRE vertical drift show high dependence on the magnitude and phase of migrating tides in both equinoxes under low solar activity condition (F10.7=80) but no significant effects under high solar activity (F10.7=200). These results suggest that the tidal effects from the lower thermosphere (E region) may contribute to ionospheric F region PRE vertical drift especially during low solar activity period.

Introduction

A unique feature of the low latitude ionosphere is the pre-reversal enhancement, a sharp upward spike in the vertical ion velocities that occurs shortly after local sunset, superimposed in the typical diurnal variation of daytime upward and nighttime downward drifts. The phenomenon is mainly driven by eastward electric fields and can significantly change the height of ionosphere. The equatorial electric field and plasma drift vary with longitude at a given local time and affect the growth rate of the Rayleigh-Taylor instability through the gravitational and electrodynamics drift terms and by controlling the electron density gradient in the bottomside of the F layer after dusk.

Lots of observations show the asymmetry between equinoxes in different longitudes. It is found that GPS scintillation and eastward ion drift is much stronger during March equinox than September equinox in post-sunset period in longitude 100°E. However, occurrence of spread F is much more frequent in September than March equinox at 200°E. In order to figure out the causal mechanism, we simulate the PRE vertical drift by using

NCAR TIEGCM in geomagnetic quiet condition under both solar minimum and solar maximum year. TIEGCM self-consistently calculates neutral and ion densities, composition, velocities, temperatures, along with electric fields and currents, between 97 and 700 km depend on different solar activity. Inputs are solar radiation, auroral precipitation, high-latitude electric field, propagating atmospheric tides. The lower and middle atmospheric migrating tidal forcing, like temperature and neutral wind velocity are simulated by GSWM. GSWM is a two-dimensional, linerized, steady state numerical tidal and planetary wave model which extends from the ground to the thermosphere.

The model results show up the existed asymmetry between equinoxes in longitude 100°E. But simulation does not produce reverse results in longitude 200°E. Which indicate that migrating tides may play important roles on controlling the strength and occurred time of PRE. By changing the tidal parameters, we confirm that tidal effects can significantly alter the magnitude and phase of PRE and cause the asymmetry in equinoxes, especially under solar minimum condition. In solar maximum case, the asymmetry is much smaller in normal run. With changing tides, the PRE only shows slightly difference. The results reveal that during post-sunset period, beside the F region dynamo, lower thermosphere (E region) tidal effects can also contribute to the PRE vertical drift.

Reference

Fesen, C. G., G. Crowley, R. G. Robel, A D. Richmond, and B. G. Fejer, Simulation of Pre-reversal enhancement in the low latitude vertical ion drifts, *Geophys. Res. Lett.*, 27, 1851-1854, 2000

Fejer B. G., L. Scherliess, and E. R. de Paula, Effects of the vertical plasma drift velocity on the generation and evolution of equatorial spread F, *J. Geophys. Res.*, 104, 19859-19869, 1999

Hagan, M. E., R. G. Roble, and J. Hackney, Migrating thermospheric tides, *J. Geophys. Res.*, 106, 12739-12757, 2001

Millward, G. H., I. C. F. Muller-Wodarg, A. D. Aylward, T. J. Fuller-Rowell, A. D. Richmond, and R. J. Moffett, An investigation into the influence of tidal forcing on F region equatorial vertical ion drift using a global ionosphere-thermosphere model with coupled electrodynamics, *J. Geophys. Res.*, 106, 24733-24744, 2001

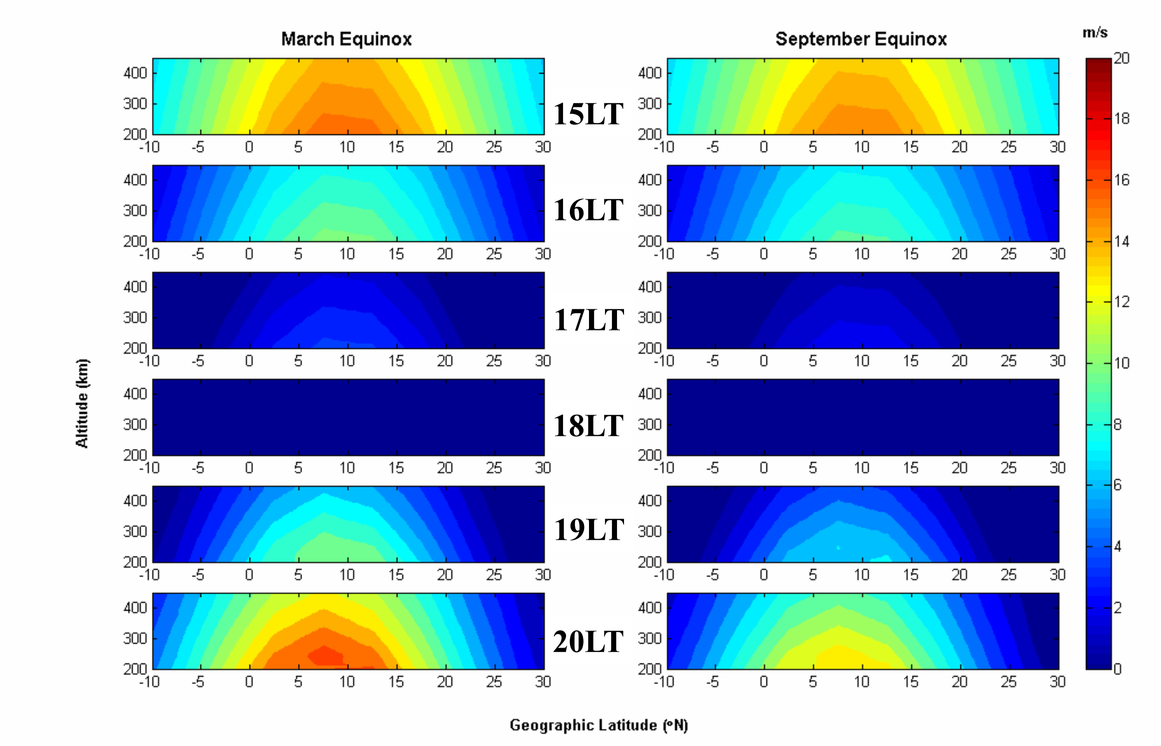

Figure 1. E×B vertical drift at different local times in March and September equinoxes in longitude 100°E

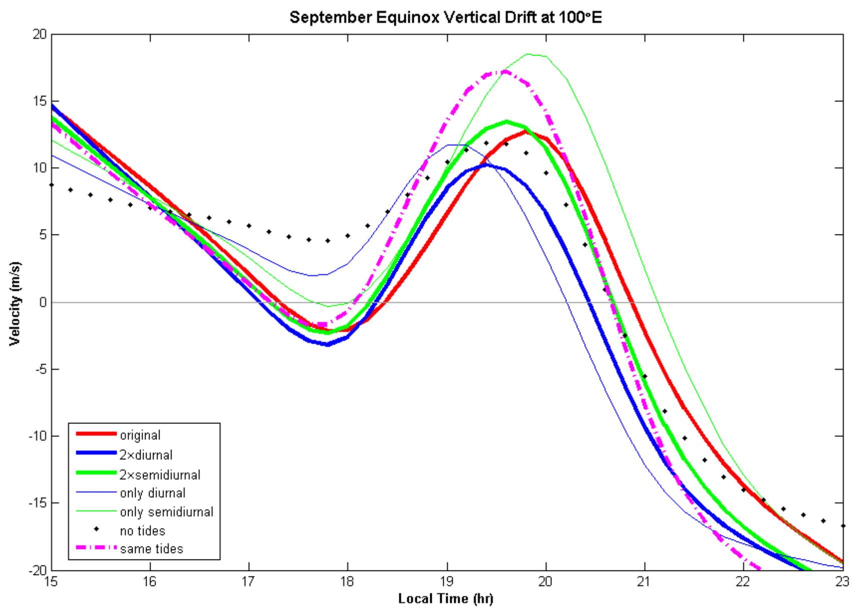

Figure 2. Equatorial vertical drift velocity at 300km under baseline run (red thick line), doublded diurnal migrating tides (blue thick line), doubled semi-diurnal migrating tides (green thick line), only diurnal migrating tides (blue thin line), only semi-diurnal migrating tides (green thin line), no tides (black dot line), and set the tides on day 80 (magenta dash-dot line) in March equinox in low solar activity.

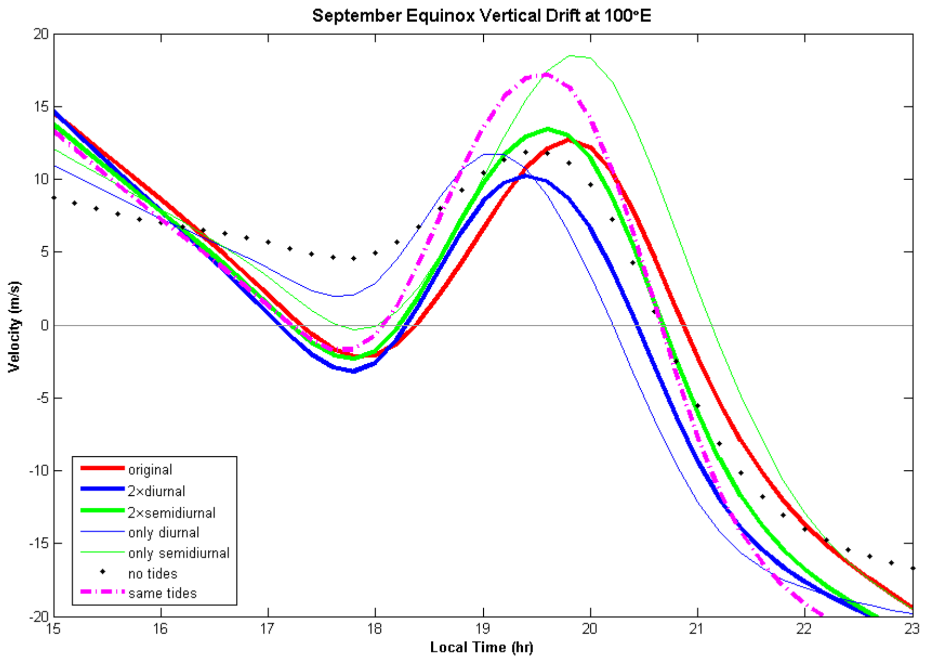

Figure 3. As for Figure 2, but in September

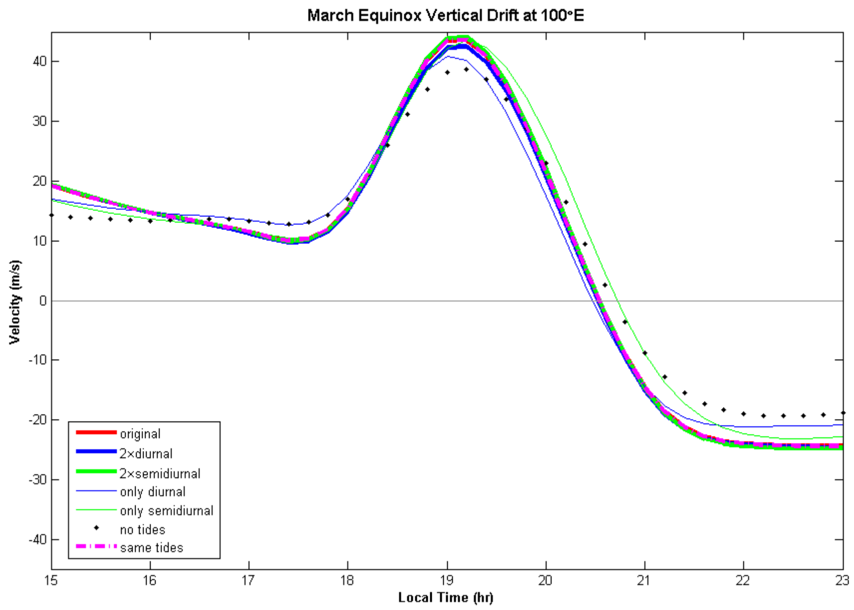

Figure 3. As for Figure 2, but for solar maximum conditions