Geophysical Research Abstracts
Vol. 16, EGU2014-1176, 2014
EGU General Assembly 2014

Climatology of the relationship of cusp-related density anomaly with zonal wind and large-scale FAC based on CHAMP observations: IMF B_y and solar cycle dependence

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We present climatology of the relationship of cusp-related density enhancement with the neutral zonal wind velocity, large-scale field-aligned current (FAC), small-scale FAC, and electron temperature using the superposed epoch analysis (SEA) method. The dependence of these variables on the interplanetary magnetic field (IMF) B_y component orientation and solar cycle are of particular interest. In addition, the obtained results of relative density enhancement (ρ_{rel}), zonal wind, electron temperature and FAC are subdivided into three local seasons of 130 days each: local winter (1 January $\pm$65 days), combined equinoxes (1 April $\pm$32 days and 1 October $\pm$32 days), and local summer (1 July $\pm$65 days). Our investigation is based on CHAMP satellite observations and NASA/GSFC's OMNI online data set for solar maximum (Mar/2002-2007) and minimum (Mar/2004-2009) conditions in the Northern Hemisphere. The SEA technique uses the time and location of the thermospheric mass density anomaly peaks as reference parameters. The relative amplitude of cusp-related density enhancement does on average not depend on the IMF B_y orientation, solar cycle phase, and local season. Also, it is apparent that the IMF B_y amplitude does not have a big influence on the relative amplitude of the density anomaly. Conversely, there exists a good correlation between ρ_{rel} and the negative amplitude of IMF B_z prevailing about half an hour earlier.

In the cusp region, both large-scale FAC distribution and thermospheric zonal wind velocity exhibit a clear dependence on the IMF B_y orientation. In the case of positive (negative) IMF B_y there is a systematic imbalance between downward (upward) and upward (downward) FACs peaks equatorward and poleward of the reference point, respectively. The zonal wind velocity is directed towards west i.e. towards dawn in a geomagnetic latitude-magnetic local time (MLat-MLT) frame. This is true for all local seasons and solar conditions.

The thermospheric density enhancements appear half way between Region 1 (R1) and Region 0 (R0) field-aligned currents, in closer proximity to the upward FAC region. In our case R0 currents are systematically weaker than R1 ones. Also, around the cusp region we find no sign of Region 2 field-aligned currents. We can conclude that there is a close spatial relationship between FACs and cusp-related density enhancements, but we cannot offer any simple functional relation between field-aligned current strength and density anomaly amplitude. There seem to be other quantities (e.g. precipitating electrons) controlling this relation.

All the conclusions drawn above are true for the Northern Hemisphere. There may be differences in the Southern Hemisphere.