A Study of Plasmaspheric Refilling during Recovery Phases of Moderate Magnetic Storms using Cross-Phase Measurements

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Measurements of eigenfrequency of geomagnetic field lines can provide information on the plasma mass density near the equatorial plane of the magnetosphere. Data from an extended meridional array of ground magnetometers therefore allows the radial density distribution, and its temporal variation, to be remotely monitored. Using cross-phase analysis of magnetometer array data, we determined the equatorial mass density during geomagnetic storms. In each case the eigenfrequency for field lines increased markedly, corresponding to reductions in mass density and indicating that the plasmapause moved Earthward and these flux tubes were depleted. The time taken to refill depleted flux tubes was estimated for event in March 2004 and depends on L value and is 2-3 days at L = 2.3, 3 days at L = 2.6, and more than 4 days for flux tubes with L-shell of more than 3.3. This is in good agreement with Park [1974]' s observation, but longer than Reinisch et al. [2004]' s observation. Plasmaspheric refilling progresses with a clear diurnal variation associated with supply of plasma from the ionosphere on the dayside and downward loss of plasma on the nightside. Plasma refilling rates in the daytime were calculated from the hourly variation of plasma mass density. These ranged from ~250 amu.cm^{-3}.hr^{-1} at L = 2.3 to ~13 amu.cm^{-3}.hr^{-1} at L = 3.8. The resultant upward plasma flux at the 1000 km level is 0.9-5.2 x 10^{8} amu.cm^{-2}.s^{-1}. These values are in reasonable agreement with daytime upward ion and electron fluxes determined by previous authors. The refilling rate shows an increasing from the first refilling day to the second. The increasing rate is 1.2-2 and in good agreement with the increasing rate shown in Wilson' s simulation which suggested a two steps refilling process. The loss rate in the nighttime was roughly estimated using night-to-day gaps or short time decreasing of the mass density. It varies in the range of 7-208 amu. cm^{-3}. hr^{-1}.with a typical value of 50 amu. cm^{-3}. hr^{-1}.We found the daily averaged refilling rate at L = 2.3 and L = 2.6 was about 420 amu.cm^{-3}.day^{-1} and this agrees reasonably well with previous measurements [Chi et al., 2000 and Sandel and Denton, 2007]. We will discuss these results in the context of (i) the location of plasma boundaries such as the plasmapause and flow topological boundary, (ii) the refilling rate as a function of L, time, and value of mass density itself, (iii) the movement of heavy ions, and (iv) consequences for model representations of the plasmaspheric refilling.