Ring current and magnetosphere-ionosphere coupling during the super storm on 20 November 2003

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We have investigated the major impacts, on the terrestrial ring current, of a coronal mass ejection (CME) and the associated magnetic cloud that severely disturbed the earth's magnetosphere on 20 November 2003. Data from DMSP F13, DMSP F16, NOAA 17 and a constellation of LANL satellites show unique characteristics of this storm: the polar cap potential increased at least to 200 kV, the polar cap boundary moved as low as about 60 MLAT, the plasma sheet density increased to 5 cm^{-3} at L=6.6 near the Dst minimum, and the inner edge of the plasma sheet ions originating from the plasma sheet penetrated deep into L=1.5 or less. We performed a ring current simulation that computes self-consistently the evolution of the phase space density of the ring current ions and the closure of the electric current between the magnetosphere and the ionosphere. Major results are summarized as follows. (1) During the main phase, the ring current can be developed by the enhancement of the convection electric field with modeled polar cap potentials. (2) Dense geocoronal neutral hydrogen or a large coefficient of pitch angle diffusion (greater than $10^{-4} s^{-1}$) is probably required to account for a rapid motion of the inner edge of the plasma sheet (or the ring current) population to higher L-value during the recovery phase. (3) Both the simulated and observed field-aligned current distributions show multiple current sheets, rather than just two current sheets. Fluctuations in the polar cap potential and the plasma sheet density are believed to be the cause of the multiple FAC sheets. (4) The equatorward edge of the Region 2 type field-aligned currents were observed to be expanded as low as 40 MLAT, which is consistent with the simulation. (5) The convection pattern can be much more complicated than averaged one due to the strong Region 2 FAC. A noticeable feature is a reversal of zonal ionospheric plasma flow that emerged on the dawnside. The flow reversal is thought to result from the relatively strong shielding electric field.