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On the substorm-time variation of energetic electrons in the inner magnetosphere

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We studied spatial-temporal evolution of energetic electrons trapped in the inner magnetosphere (L<7.4) during an isolated substorm by using a four-dimensional drift kinetic simulation under the time-dependent electric and magnetic fields provided by a global magnetohydrodynamics (MHD) simulation. When the interplanetary magnetic field (IMF) turns southward, both the potential and induction electric fields start to increase in the inner magnetosphere, resulting in a gradual injection of low energy electrons (<51.9 keV) and deceleration of high energy electrons (>114 keV). The deceleration of high energy electrons results in a decrease in the phase space density (PSD) of the high energy electrons during the growth phase. After a while, an abrupt transition of phase state (a substorm onset) occurs in the magnetosphere, which triggers abrupt changes in the magnetosphere and ionosphere. The AL index decreases rapidly, and magnetic field lines become dipole-like. The dipolarization does not proceed smoothly in the inner magnetosphere because of significant force imbalance between the J x B force and the grad P force. As a consequence, the electric field oscillates with a period of 2-3 min, resulting in multiple injections of the low energy electrons. The low and high energy electrons are accelerated under the strong influence of the drift-betatron and gyro-betatron, so that the acceleration process is essentially non-linear. Our simulation results suggest that the force-induced processes play an essential role in the substorm-associated redistribution of energetic particles in the inner magnetosphere.

Keywords: Substorm, Inner magnetosphere, Energetic electrons