

## Storm-Substorm Relationship: Controversies and Recent Development

## TOMOAKI HORI

National Institute of Information and Communications Technology

The storm-substorm relationship (SSR) is one of the oldest and most controversial issues in Solar-terrestrial physics. A considerable amount of arguments have existed regarding this issue since 1960's when the idea, a magnetic storm consists of successive occurrence of multiple substorms, came out. Later on a different paradigm called enhanced convection paradigm, was proposed to explain the ring current development during a storm main phase. This paradigm postulates that particle injection to the ring current is driven directly by the solar wind electric field and thus the total energy content of the ring current varies in close association with the solar wind condition. Such a direct driven process is supported by a number of recent studies using numerical simulations and/or energetic neutral atom (ENA) imaging of the storm-time ring current, which we have achieved during this past decade, as powerful tools to diagnose the ring current dynamics. Those works strongly indicate that the existence of the enhanced convection induced in the magnetotail is a must for the storm-time ring current buildup. On the other hand, a bunch of observational evidence show with no doubt that substorm injections do generate a significant amount of energetic particles and concurrently transport them into the very region of the ring current. In addition to the injection from the magnetotail, it is well known that substorm promotes the supply of oxygen ions of the ionospheric origin, which can dominate the energy budget of the ring current during relatively intense storms. Accordingly, it seems that the SSR argument has recently shifted its focus to the question of whether substorm injection is dispensable to the buildup process of the ring current, or the combination of substorm injection and enhanced convection is essentially responsible for the ring current injection. In the presentation the results of the studies addressing these questions are reviewed carefully for an attempt to clarify how our current understanding on the ring current injection is summarized. We also discuss some recent results regarding the SSR argument which can be important clues to elaborating the current model of the storm-time ring current evolution.