Modeling and Data Assimilation of the Ring Current, Relativistic and Ultra-relativistic Electrons in the Inner Magnetosphere

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Dynamics of energetic and relativistic particles have received a lot of attention in recent years. Significant efforts have been focused on the understanding of the acceleration and loss processes of relativistic electrons and their dynamic evolution, as well as the understanding of ring-current injections in variable magnetic and electric fields. More recently, observations have been used systematically with the aid of data assimilation tools that allow to reconstruct the state of the system by blending models and various observations, and also allow to infer unknown physics and quantify various physical processes. In this study, we present an overview of recent modeling efforts with the VERB-3D and VERB-4D codes. We also show data assimilation from ring current to multi-MeV energies. We present a systematic comparative analysis of the dominant acceleration and loss processes for ring current, relativistic, and ultra-relativistic electrons and compare them. In particular, modeling and data assimilation reveal the missing physical processes at these three ranges of energies. Sensitivity simulations show that the background plasma density, location of the magnetopause, accurate description of electric and magnetic fields, and the description of the not well sampled high latitude wave environment play a crucial role for the dynamics of various electron populations in the inner magnetosphere. In summary, we present the recently funded EU Horizon 2020 project led by GFZ that will produce a chain of probabilistic modeling forecasts from the Sun to the inner magnetosphere.