Model Coupling between BATS-R-US - CIMI and GEMSIS-RC for study of ULF waves in the inner magnetosphere

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Radiation belts are regions of enhanced population of relativistic electrons with energies over MeV in the Earth’s inner magnetosphere. The outer radiation belt electrons exhibit significant variations during geomagnetic storms. There are two major candidates of the acceleration mechanism: the radial transport from external source and local acceleration within the inner magnetosphere. Previous observations have used radial profiles of the phase space density (PSD) to distinguish two mechanisms [e.g. Reeves et al., Science, 2013]. While the local acceleration creates a localized peak in the PSD radial profile, the radial transport has been considered as a diffusive process that reduces gradient in the PSD profile. However, under certain conditions, the radial transport process can also produce localized peaks in the PSD profile [e.g. Degeling et al., JGR, 2008]. Therefore, it is important to have another observable measure to distinguish the two acceleration mechanisms to understand the relativistic electron variations in the outer radiation belt.

Pc5 Ultra-Low Frequency (ULF) waves in the inner magnetosphere are observed as electromagnetic fluctuations with frequencies of 1.67-6.67 mHz and considered as a driver of the radial transport of relativistic electrons in the outer radiation belt. In our previous study, we showed that interaction with continuous monochromatic Pc5 waves can form characteristic butterfly pitch angle distributions of the relativistic electrons in specific regions in the outer radiation belt determined by the drift-resonance condition [Kamiya et al., submitted to JGR, 2018]. This result suggests a possibility that the characteristic pitch angle distributions can be a measure to distinguish the radial transport driven by the Pc5 waves. On the other hand, the formation of the butterfly pitch angle distributions depends on the latitudinal distribution of the wave power and spectrum of the Pc5 waves. In order to model more realistic spatial distributions of the ULF waves for investigation of its interaction with relativistic electrons, we need to improve the outer boundary conditions in our global simulation of the inner magnetosphere to more realistic ones.

For this purpose, we have developed a model coupling method between two models, i.e., Global MHD-based simulation of the magnetosphere, Brock-Adaptive-Tree Solar-Wind Roe-Type Upwind Scheme –Comprehensive Inner Magnetosphere and Ionosphere (BATS-R-US - CIMI) and a 5-D drift-kinetic global inner magnetospheric simulation, GEMSIS-Ring Current (RC). The BATS-R-US - CIMI model solves the ideal MHD equations for the regions from the sunward boundary to the inner boundary at L=2.5 including the ring current pressure gradient [Glocer et al., JGR, 2013; Fok et al., JGR, 2014]. The GEMSIS-RC model solves the ring current ion PSD in the 5-D phase space together with time evolution of the electromagnetic fields self-consistently, which include the ULF waves in the inner magnetosphere ($3.6 < L < 6.6$) by calculating the drift-kinetic equations and Maxwell equations simultaneously [Amano et al., JGR, 2011]. We adopted time-dependent boundary between two models, which is located on the last closed

field line in the GEMSIS-RC simulation domain. In the presentation, we will report on the validity assessment of the model coupling method and the initial result of the ULF wave simulation in the inner magnetosphere with realistic boundary conditions.

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