Relative contribution of ULF and whistler-mode chorus waves to the radiation belt variation

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The Earth's radiation belt exhibits a dramatic variation during the active condition of the magnetosphere such as magnetic storms. The dynamic variation of the radiation belt is, in part, contributed by various wave-particle interactions, including: (1) the radial diffusion of electrons driven by ultra-low-frequency (ULF) waves in Pc5 frequency ranges (1.6-6.7 mHz) and (2) the local acceleration caused by wave-particle interactions between whistler-mode chorus waves and radiation belt particles. Over the past decade, multi-point observations have separately shown the evidence for the contribution of ULF and whistler-mode chorus waves to the relativistic electron flux enhancement. However, the relative contribution of ULF and whistler-mode chorus waves has not been extensively studied yet. In this study, we aim to address (1) when and where ULF and whistler-mode chorus waves contribute to the radiation belt dynamics and (2) what affects the wave growth.

We first investigate the temporal contribution of both waves to the relativistic electron flux enhancement during a specific magnetic storm. The target event is 27 May 2017 storm, which is triggered by coronal mass ejections. Both Arase (post-midnight) and Van Allen Probe (RBSP)-B (dusk) show global enhancement of ULF waves during the early recovery phase, which corresponds to the global increase of relativistic electron fluxes. Observed whistler-mode chorus waves are also enhanced, but their activity is small than the ULF wave activity. On the other hand, observed whistler-mode chorus waves are enhanced later on, during the late recovery phase when relativistic electron fluxes significantly increase around L~3.5–4, while ULF wave activity is weak. The large electron anisotropy at an energy level of ~20–50 keV is seen only during the late recovery phase.

To understand the spatial contribution of ULF and whistler-mode chorus waves, we perform Comprehensive Ring Current Model (CRCM) coupled with Block-Adaptive-Tree Solar-Wind Roe-Type Upwind Scheme (BATS-R-US) simulation. The simulation qualitatively reproduces the global evolution of ULF waves during the May 2017 storm. The estimated electron anisotropy is large at the energy of 10–40 keV, which is consistent with observations. The global distribution shows that the electron anisotropy is large in the dawn sector during the main phase. We find that the area where the electron anisotropy is large shifts toward dusk during the early and late recovery phases. Comparison between the simulation and observations indicates that eastward-drifting electrons excite whistler-mode chorus waves in the dusk sector. We will further discuss what affects the wave growth, i.e., the effect of magnetic field curvature.

