

Relative Contribution of ULF Waves and Whistler-mode Chorus to the Radiation Belt Variation during the May 2017 Storm

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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 the Pc5 frequency range (2-7 mHz), and (2) the local acceleration caused by wave-particle interactions between whistler-mode chorus and radiation belt particles. Over the past decade, multi-point observations and numerical simulations have separately demonstrated evidence for the contribution of ULF waves and whistler-mode chorus to the relativistic electron flux enhancement. However, comparison of the contribution of ULF waves and whistler-mode chorus has not been extensively made yet. To the best of our knowledge, only few papers have demonstrated the global picture of the relative contribution of waves to the total radiation belt content.

In this study, we investigate when and where ultra-low-frequency (ULF) waves and whistler-mode chorus contribute to the net flux enhancement of relativistic electrons during the May 2017 storm. During the early recovery phase, ULF waves mainly contribute to the global enhancement of relativistic electron flux in the dusk sector. On the nightside, both waves are related to the flux variation. During the late recovery phase, both Van Allen Probe (RBSP)-B and Arase show that whistler-mode chorus contributes to the flux enhancement confined in L-value. The Comprehensive Ring Current Model (CRCM) coupled with Block-Adaptive-Tree Solar-Wind Roe-Type Upwind Scheme (BATS-R-US) simulation qualitatively reproduces the global evolution of ULF waves. Although the electron flux is underestimated by the simulation, we find the large anisotropy of hot electrons in the region where whistler-mode chorus waves were actually observed by satellites. In addition, the estimated magnetic field curvature on the dayside is small during the recovery phase.

We also investigate what controls the wave evolution. Both observations and simulation suggest that observed ULF waves in a frequency range of ~2-4 mHz are excited by the enhancement of the solar wind dynamic pressure. Observations also indicate that whistler-mode chorus on the nightside is predominantly excited by hot electrons with temperature anisotropy, whereas dayside chorus is enhanced by the change of the magnetic field line configuration. Estimated spatial distributions of electron anisotropy and magnetic field curvature give an explanation for observational results that enhanced whistler-mode chorus exists in the dusk sector, which is far from the ordinary location of wave generation.

