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Two distinct types of chorus wave activity in Earth's outer radiation belt distinguished by their spatiotemporal variation

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Earth's magnetosphere is home to a wide variety of plasma waves from a wide variety of sources. One important benefit of studying plasma waves in the near-Earth plasma environment is that it provides us an excellent opportunity to observe ELF, VLF and ULF waves "in the wild". In Earth's magnetosphere (and other planetary magnetospheres), electromagnetic waves exhibit spatiotemporal variability that is likely controlled by factors related to the dynamics of the wider system, e.g. magnetospheric convection, substorms, and geomagnetic storms. There may also be spatiotemporal variability linked to the generation mechanism of the waves, the propagation of the waves away from their source region, and the variability of the free energy source driving the waves.

The wave activity throughout the magnetosphere is fascinating from a plasma physics point of view. Many electromagnetic waves supported by the plasma undergo significant diffraction in the magnetic field and density gradients of Earth's magnetosphere, and there are important wave-particle interactions throughout the system between the waves and different plasma species. Additionally, wave-particle interactions are an important factor that control the dynamics of the high-energy electrons in the outer radiation belt. We therefore seek to understand the wave activity, and the strength of the wave-particle interactions, in order to improve numerical models of outer radiation belt behavior for use in operational space weather applications. We have previously demonstrated that the spatiotemporal variability of bounce- and drift-averaged wave particle interactions in Earth's outer radiation belt is important; different time- and length-scales of variability change the outcomes of the Fokker-Planck equation that describes changes in the high energy electron flux trapped in the outer radiation belt [1-3]. Statistical models of the underlying spatiotemporal variability of wave activity and plasma parameters in the outer radiation belt are therefore vital to determine the temporal variation of bounce- and drift-averaged diffusion coefficients for use in numerical models.

In this work, we use a large statistical database of observations from the NASA Van Allen Probes to investigate the spatiotemporal variations in chorus wave activity in Earth's outer radiation belt. We demonstrate that there are two distinct types of chorus wave activity. The first is a dayside population of low frequency chorus waves that is almost always present, exhibiting relatively small spatiotemporal variability, and whose occurrence diminishes with geomagnetic activity. The second wave population is a post-midnight sporadic population of low-mid frequency chorus waves with large spatiotemporal variability, whose occurrence and amplitude increases with increasing geomagnetic activity. Each wave population exhibits a different probability distribution of wave power. We suggest that different models should be constructed for each type of waves, reflecting their different properties and relationships to the wider system.

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