Inner Magnetospheric Whistler Waves (Chorus, Hiss, Lightning Whistlers): Statistics and Spatial Distributions For Radiation Belt Physics

David M. Malaspina[1,2], Jean-François Ripoll[3,4], Melanie Cosmides[3], Thomas Farges[3]
(1) Astrophysical and Planetary Sciences Department, University of Colorado, Boulder, CO, USA; email: David.Malaspina@colorado.edu
(2) Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA
(3) CEA, DAM, DIF, Arpajon, France; email: jean-francois.ripoll@cea.fr; melanie.cosmides@cea.fr; thomas.farges@cea.fr;
(4) UPS, CEA, LMCE, Bruyères-le-Châtel, France; email: jean-francois.ripoll@cea.fr

Whistler-mode plasma waves play several critical roles in the dynamics of the inner magnetosphere. Whistler-mode chorus waves drive electron energization in the heart of the radiation belts, as well as the electron scattering that produces electron precipitation. Whistler mode hiss plasma waves permeate the plasmasphere, scattering electrons and carving out the slot region between the inner and outer radiation belts. Hiss wave power also leaks out of the plasmasphere as exohiss. Terrestrial lightning strikes drive whistler mode plasma waves on magnetic field lines close to Earth, producing a persistent source of electron-scattering wave power. Characteristics of these whistler-mode waves (e.g. their wave normal angle, wave power, bandwidth, central frequency, spatial distribution, and geomagnetic driving conditions) are critical for determining the effectiveness of these waves for interacting with inner magnetospheric electrons (trapped and untrapped), including the relativistic electrons that pose a threat to spacecraft electronics. Each of these whistler mode wave types occurs with broad distributions of each wave property.

In this study, we seek to quantify the portion of the distribution for each whistler-mode wave property that contributes most to radiation belt electron acceleration and loss processes. This is accomplished by using observations of near-equatorial plasma wave power from the Van Allen Probes mission (2012-2019) to produce occurrence-weighted statistics of the power-weighted wave normal angle, wave frequency, and wave bandwidth for each whistler mode type. These statistics are further divided by spatial location and geomagnetic driving conditions (parameterized using the location of the plasmapause).

Occurrence-weighting and power-weighting reveal a narrow region of parameter space (in wave normal angle, bandwidth, and central frequency) where the most impactful electron energization and scattering occurs, for each whistler mode wave type. A close link between wave properties and the cold electron density in the plasmasphere and plasma trough is also demonstrated. These empirically determined wave property statistics are used to determine plasma wave diffusion coefficients that reflect the natural balance of whistler-mode wave occurrence, power, and central frequency that together determine key particle acceleration and scattering processes in the inner magnetosphere.