Probabilistic ULF models: how do they improve our understanding of the physics?

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Probabilistic modelling is used heavily in weather and climate models to accurately represent the full range of possible physical states, thereby improving forecasts and capturing the uncertainty inherent in a complex system. Here, we begin to apply probabilistic modelling to ULF waves. Eventually, we aim to better determine the impact of ULF waves on Earth's radiation belts; by representing the full probability distribution of radial diffusion coefficients we will represent physical reality more faithfully than solely using the mean or median.

However, to construct such a model, we first need to determine the probability distributions of the radial diffusion coefficient, which varies with the power in the underlying ULF waves. Therefore we present an analysis of the distributions of wave power spectral density for both ground-based magnetometers (CARISMA) and the corresponding in situ observations. We compare these distributions, examine the relationships between them and comment on the new physical insights this probabilistic approach reveals. Differences between distributions seen on the ground and in space give us new insights into the generation and propagation of ULF waves in the magnetosphere. We comment on the consequences of these types of distributions for probabilistic modelling. We also discuss how these distributions change with the driving solar wind; in particular, whether upper and lower bounds of power at the ground determined by the solar wind are seen in space. These bounds may indicate a limit to the ability of the magnetosphere to support ULF waves, and therefore limits on the resulting radial diffusion.