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Identification of Radial Diffusion Parameters for the Earth's Radiation Belt through Bayesian Inference

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The determination of the phase space density of energetic particles trapped in the Earth's radiation belts is a crucial component of Space Weather modeling. A widespread approach to study the particle dynamics is to employ a reduced model in terms of a Fokker-Planck diffusion equation. In one-dimension, this approach captures the radial diffusion of particles due to interaction with ULF waves. The wave-particle interactions are encoded in the diffusion coefficient, and all other un-modeled physical processes enter through a loss term, and variable boundary conditions. Obviously, accurate results strongly depend on a correct characterization of these parameters.

In this work, we derive a data-driven probabilistic description of the diffusion coefficient and of the electron loss timescale, based on Bayesian statistics. In particular, we identify the coefficients of the 1-D radial diffusion model based on a standard Markov Chain Monte-Carlo, where uncertainties in the input parameters are propagated either through a forward or a surrogate model. The identification data is based on the measurements of the Van Allen probes, and the informed coefficients are able to provide accurate phase space density predictions in agreement with experimental observations.