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Comment on angeo-2021-56

Anonymous Referee #1

Referee comment on "The “SafeSpace” database of ULF power spectral density and radial diffusion coefficients: dependencies and application to simulations " by Christos Katsavrias et al., Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2021-56-RC1, 2021

Summary: The work deals with improving the quantification of one of the main processes acting in the radiation belts: radial diffusion. It provides a variety of content of potential importance: It briefly describes how electric and magnetic field measurements from the three THEMIS inner probes (A, D, E) were processed to compute products equated with radial diffusion coefficients, DLLs. It discusses several dependencies of the database related to spatial location and magnetic activity. It compares and contrasts the database outputs with various published models. It also shows two numerical simulations of outer radiation belt dynamics: one where radial diffusion is parameterized by the data products introduced in this manuscript, and the other where radial diffusion is parameterized by the published model that best compares with the database (l.261-262). One of the main findings is that “all models underestimate the DLL during quiet times and at low L* values, while they overestimate the DLL during high levels of geomagnetic activity and at high L* values” (l.279-281).

General Comments: The work claims to provide a database of “accurately calculated” radial diffusion coefficients (l.4, l.12, l.71, l.216, l.246, l.265). Yet, it fails to be convincing. A much more rigorous treatment of both data processing and scientific presentation is required to demonstrate the validity and significance of the work.

Specific Comments:

Major comments:

1. The database does not provide radial diffusion coefficients:

A radial diffusion coefficient quantifies the long-term phase-averaged effect of small electromagnetic fluctuations on trapped particles' third adiabatic invariant (e.g., Schulz and Lanzerotti, 1974). Thus, a radial diffusion coefficient is independent of magnetic local time by definition. In this work, the products resulting from THEMIS data processing present significant variations with magnetic local time (section 3.2, Figure 4). This feature is enough to demonstrate that the database does not provide a time series of radial diffusion coefficients.

2. THEMIS data processing, and its presentation, need improvement:

- Quantifying radial diffusion using satellite measurements is a challenging task. For instance, it requires differentiating spatial and temporal variations from a time series of field measurements sampled along spacecraft trajectory, often in the presence of strong spatial gradients. How this is achieved remains unclear.

- Fei et al. formulas apply at the magnetic equator only. Yet, THEMIS probes do not necessarily sample the magnetic equator. The manuscript does not explain how this feature is taken into account in the data processing.

- Not all choices made during data processing are well explained or well justified. For instance, why the equation (4)? Why "cdelta" =0.76? What is the definition of "dj"?

3. The claim that the data products are accurate is not justified:

Before being able to make any claim regarding the accuracy of the approach, it seems necessary to discuss the extent to which the outputs depend on the variety of choices made during data processing. Yet, this has not been done.

Minor comments:

* Table 1: Units are missing. The list of limitations provided is incomplete.

* While Falthammar's (1965) framework was developed in the non-relativistic case, the extension to relativistic particles is straightforward (e.g. Schulz and Eviatar, 1969). Thus, the claim that Falthammar's formulation is "valid for sub-relativistic particles, only" (l.32) is misleading.

References:

Schulz and Eviatar (1969), Diffusion of equatorial particles in the outer radiation zone, https://doi.org/10.1029/JA074i009p02182

Schulz and Lanzerotti, 1974, Particle Diffusion in the Radiation Belts, https://doi.org/10.1007/978-3-642-65675-0