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Interactive comment on "Verification of SpacePy's radial diffusion radiation belt model" *by* D. T. Welling et al.

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Summary:

The authors present the RadBelt model of radial diffusion in Earth's outer electron adiation belt, which is part of the greater SpacePy library being developed by colleagues at LANL. Since the RadBelt model is being built upon to include energy and pitch angle diffusion, which greatly enhances its complexity, verification of RadBelt at this early stage is critical. The method of manufactured solutions (MMS) is detailed and employed for verification of RadBelt. Two analytical solutions are tested, and RadBelt performance is quantified for various diffusion rates, time steps, and grid sizes. From these results, the authors conclude that the RadBelt solution to the radial diffusion equation has been correctly implemented and is sufficiently accurate. I think this paper

will prove useful to the radiation belt modeling community for its detailed presentation of his useful verification technique. I also commend the authors for providing details on the numerical form of the diffusion equation shown in Equation 5. I recommend this paper for publication subject to the authors addressing the comments listed below.

Specific details, comments, and questions:

This work presents excellent details and examples of a powerful verification technique (i.e., MMS) that many radiation belt modelers may be unfamiliar with. This will be beneficial to the community. However, there are some points in the paper for which additional clarification and/or revisions may be beneficial to readers; these are detailed here:

- Page 2167, line 8: regarding the 3rd invariant, it is not really the case that this invariant is "especially important" when compared to the other two. All three invariants are important and necessary conditions for fully adiabatic dynamics. The third invariant is, however, most easily broken since it is associated with the drift motion, which has the longest period. This makes it the easiest to model (it allows for longer time steps) and often responsible for non-adiabatic dynamics.

- Page 2168: The authors may also want to mention Xiao et al. [JGR, 2010] on 3-D diffusion modeling including mixed-diffusion terms and/or Subbotin et al. [JGR, 2010 or 2011] on the VERB code, which is also a 3-D code with mixed terms (the 2011 publication also includes the additional complexity of coupling to a source population of electrons with the Rice Convection Model).

- Page 2169, Equation 2: Why did the authors decide on this form for a source of PSD? There should be some justification or explanation of why this source model is used. Also, how were the parameters in this equation determined?

- Page 2169, line 21: Loss is discussed, though no explicit loss model is defined. How is PSD loss (to the magnetopause, as mentioned, and/or due to scattering loss to the atmosphere) implemented in the RadBelt model?

- Page 2170, line 3: Why did the authors select the Tsyganenko 2001 storm model over more recent and accurate models (Tsyganenko-Sitnov 2005 or 2007, for example). Some explanation or justification for this choice is recommended.

- Page 2170, line 15: L* is referred to as "L*" here, though throughout the rest of the paper it is referred to as L.

- Page 2170, line 11 concerning Figure 1: More details should be provided for the results shown in Figure 1. Is the outer boundary L=10 or LMax? If it is L=10, why is there no rapid diffusion across the sharp PSD boundary at LMax? By the nature of the radial diffusion equation, such a sharp gradient in PSD, especially at high-L, should result in very rapid diffusion that would smooth the gradient and reduce PSD throughout much of the rest of the belt. What are the boundary conditions and initial condition used for these results? Also, there is uncharacteristically little variation in PSD throughout the majority of the belt in the results. This seems unphysical and should be noted and/or explained in the text. After the dropouts during storm main phases, the PSD returns immediately to high levels (10e9 on the color scale); this too seems unphysical. These features and model conditions should be discussed in the main text.

- Page 2173, line 11 concerning Figure 3: In the bottom panel of Figure 3, how is this solution possible considering that the outer boundary condition is set to 0?

Typographical corrections:

- Page 2169, line 6: "...flexibility and capability- ..." should read "...flexibility and capability; ..."

- Page 2178, line 2: "in to consideration" should read "into consideration"

Interactive comment on Geosci. Model Dev. Discuss., 4, 2165, 2011.