Geosci. Model Dev. Discuss., 4, C318–C320, 2011
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Geoscientific
Model Development
Discussions

# *Interactive comment on* "LANL* V2.0: global modeling and validation" *by* J. Koller and S. Zaharia

**P. OBrien (Referee)**

paul.obrien@aero.org

Received and published: 31 May 2011

I have experience with developing L* neural networks for the AE9/AP9 project. The development of fast L* networks is a vital step towards practical use of true adiabatic invariants to organize radiation belt data. I have some suggestions for improvements to this paper and the neural network. However, I believe for typical scientific use, the neural network and manuscript are acceptable with only minor revisions.

Typically, when one replaces a long calculation with a precomputed look-up table or fit, one aims to have the error in the replacement be smaller than the error in the original calculation. The authors have chosen that "error" to be described mainly by the uncertainty in L* itself (sometimes 50%), whereas I think it is more appropriate to target the error in the numerical algorithms that compute L* the long way. Thus,



the reported performance of delta-L* of approximately 0.1 RMS is adequate only in the former, not in the latter presentation. On the AE9/AP9 effort, we target 0.01 RMS (albeit we're using a much simpler field model), so that there is no question of the adequacy of switching from the long to the short calculation. Further, we often examine the maximum absolute error in L* as a means of putting an upper bound on how bad the fast calculation could be.

The discussion of the determination of Lmax is inadequate. Since alpha_eq is not a drift invariant, some explanation must be provided as to how this input relates to the calculated last closed drift orbit.

I am concerned (only a little) by the seeming redundancy of the inputs. Presumably this simply aids the neural network in fitting the data. But, there's risk of overfitting. Technically L* is a function only of the field state and the starting point/direction. I and Bm (or Lm and Bm) should be adequate to specify the relevant properties of the starting location, making the GSM coordinates redundant (a drift shell is composed of all those points/directions for which I and Bm are conserved in a static field).

The authors do not describe how they handle the drift or bounce loss cones. As with points with L>Lmax, the neural network will happily extrapolate into the loss cone. Perhaps the loss cone is defined as points where the Lm calcualtion fails or intersects the Earth. However, from experience on AE9/AP9, this is inadequate–it's is the bounce loss cone only. There is a region of points, the drift loss cone, for which Lm is defined, but L* is not. These points are by definition excluded from the training set. The neural network will extrapolate L* into that region and (as we learned on AE9/AP9) generate spurious L* values where particles are not trapped. The IRBEM-Lib documentation shows this as a region of "bad L*" over Indonesia.

It should be noted in section 2 that there is a more recent model, TS07D (geomag_field.jhuapl.edu/model), which is even slower to evaluate than the TS05 model, which is the subject of this paper. At this time, it does not appear to be practical to utilize TS07D for an L* neural network.

Toward the end of section 3 it is implied that the only input that depends on evaluating the full field model is Bmirr. In fact, Lm (and alpha_loc in the case of a specified direction of interest in an arbitrary coordinate system) also require evaluation of the field model. It is unclear to me what the authors intend by substituting for Bmirr but not also Lm with a simpler field model – presumably the savings comes in computing a simpler Lm, since that involves tracing the entire field line, whereas Bmirr can be computed from a single local field evaluation.

I was not very satisfied with the validation in LEO. The authors would do better to include an 800 km sun synchronous (e.g., POES) orbit in their validation set. The RBSP figure is the only one with much data below L=2, and it doesn't look very good. An investigation of LEO performance may show that special effort must be made to seed the training data with low altitude points. Perhaps the model is not intended for use in LEO, but that would make it unusable for a variety of data sets, including POES and SAMPEX.

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Interactive comment on Geosci. Model Dev. Discuss., 4, 575, 2011.