gmd-2014-135

Calculations of the Integral Invariant Coordinates I and L in the Magnetosphere and Mapping of the Regions where I is conserved, using a particle tracer (ptr3D v2.0), LANL*, SPENVIS, and IRBEM

Author's response

We thank the reviewers for the very careful evaluation of the manuscript. We have implemented all recommendations and corrections that the reviewers have suggested. In addition, in response to the 2nd reviewer comments, we have added a new plot, Figure 12, which is a global map for different conditions (quiet and disturbed), showing in a much clearer way the regions where I can be assumed to be constant. This has been done for both 30° and 60° initial equatorial pitch angles, for particle starting distances 4 - 8 RE. This recommendation for the addition of the figure greatly enhances the paper, making it useable for more practical applications as a systematic global visualization of the regions that I can be considered to remain constant.

Below we list the replies to each of the reviewer comments.

1st referee

This manuscript describes a systematic examination of the second and third adiabatic invariants I and L* calculated with two models available to the community as well as a particle-tracing model written specifically for the study. The results are interesting and highlight the importance of utilizing adiabatic invariants with care.

The authors have addressed my concerns with a previous version and assuming the following minor issues are addressed, the manuscript is suitable for publication.

Minor Comments/Technical Corrections

1) Line 8: "adiabaticity" → "conservation". I think this may be more precise, but if the authors feel strongly about it adiabaticity is fine.

"Concervation" has been used instead.

2) Line 15: Insert "ptr3D," before "a 3D particle tracing code…".

"ptr3D" Inserted

3) Line 16: "purpose" → "study".

Implemented

4) Line 18: "starting" → "initial".

Implemented

5) Line 22: Ibid.

Implemented

6) Line 27: Insert "line" after "magnetic field".

Implemented

7) Line 28: Ibid.

Implemented

8) Line 31: “associated with each” → “defined”.

Implemented

9) Lines 33 and 39: Either capitalize second invariant or don’t.

Second invariant is capitalized

10) Equation 1: make the upper or lower integration limit s’m, so it can’t be thought that the integration is over a null range.

Implemented

11) Line 44: I is NOT just the length of the field line (i.e., $\int ds$). The radical factor is important! The wording should be changed to reflect that it has units of length and depends on the path length, but isn’t approximately that!

*The following text has been added: “I is expressed in distance units (km or R**E**) and depends on the length of the particle trajectory along a field line between the two mirror points.”*

12) Lines 48—49: See comment 9.

Implemented

13) Line 81: IRBEM-lib or IRBIM-LIB, pick one.

IRBEM-ib is used throughout

14) Line 87: “integrant” → “integrand”.

Corrected

15) Line 88: See comment 13.

Implemented

16) Line 107: “purpose” → “study”.

Implemented

17) Line 109: Omit “the” before “TS05”.

Corrected

18) Line 120: “, for 4” → “. Four”.

Implemented

19) Line 121: “(4—8 RE).” → “(4—8 RE in steps of 1 RE) were used.”

Implemented

20) Line 123: Insert “in a” before “static magnetic field)”.

Implemented

21) Line 128: Insert “UT” after “17:55” (Assuming this is in UT).

It is indeed UT; has been inserted.

22) Line 130: Ibid.

Implemented

23) Line 143: “0 MLT” → “midnight MLT”.

Implemented

24) Line 159: Ibid.

Implemented

25) Line 169: Omit “(L-star-max)”.

Deleted

26) Line 173: Omit “For” and “the calculated maximumL*”).

Deleted

27) Line 190: See comment 1.

Implemented

28) Line 222: insert “(p.a.)” after “initial eq. pitch angle” (or otherwise make clear the use of “p.a.” in the subsequent lines).

Implemented

29) Line 230: “attempted to quantify” → “quantified”.

Implemented

30) Line 284: Omit “in this paper”.

Deleted

31) Lines 286—291: This casts doubt on the entire study. What is meant by “tuned”? Why can’t you just release it, with that caveat?

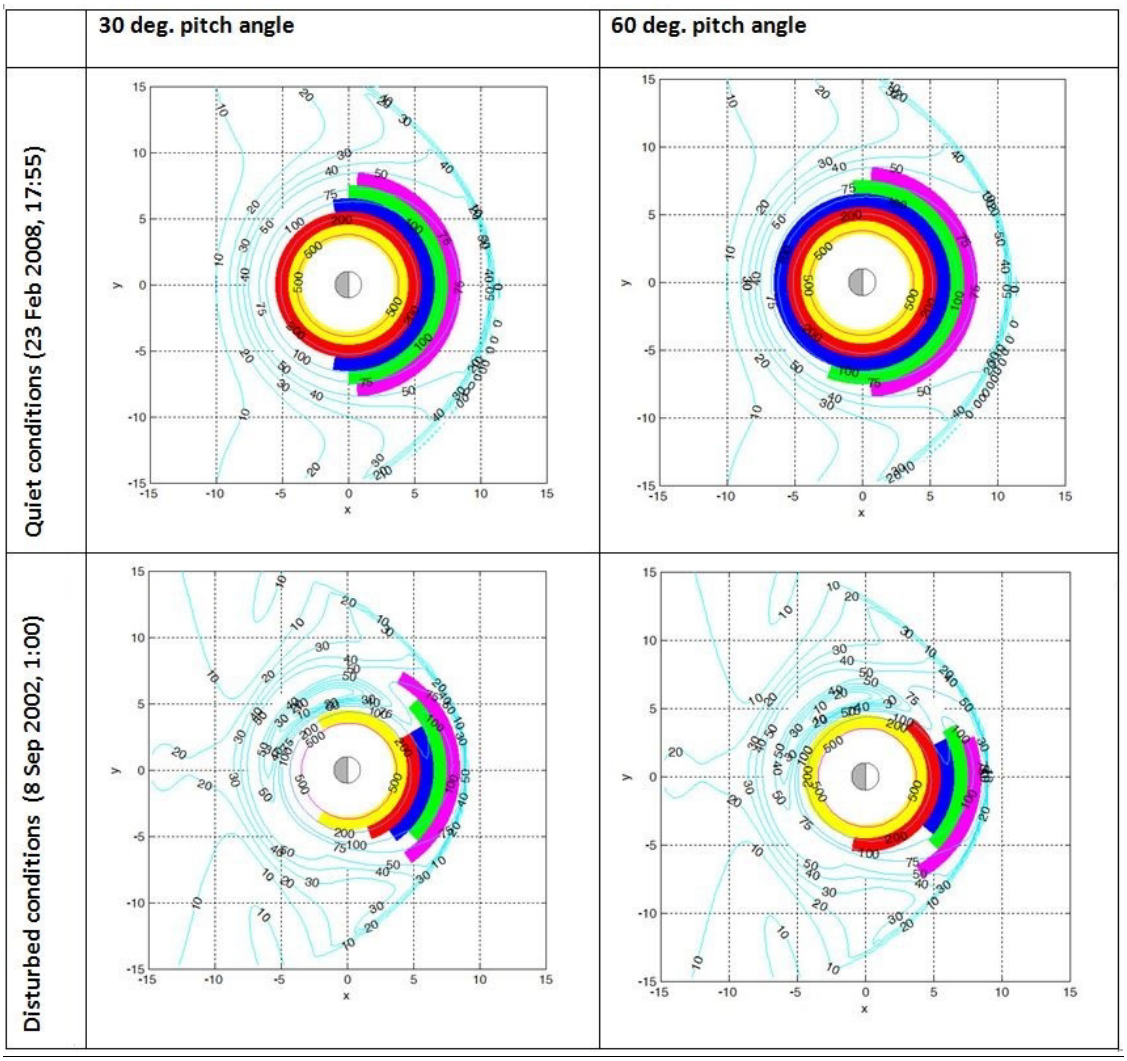
The particle tracing code uses an adaptive time-step integrator, in which the limits of time-step variation are determined by the min and max variations in particle velocity magnitude and velocity vector. These limits of maximum and minimum allowed variation are dependent on particle energy, and need to be calculated and introduced in the code before running the entire set of particles. An improper use of the code for higher or lower energy particles with the same limits of velocity mag and vector variation would introduce numerical errors, and thus it might not ensure conservation of the particle energy. It is envisioned that the next version (ptr3D V3.0) will contain an automated calculation of these limits of maximum and minimum allowed variation, and will be released to the modelling community.

2nd referee

The revised version has been significantly improved, given its additional discussion on the motivation and implication from their results. The mapping regions of the constants are very important and useful to the community. I therefore recommend the publication of this new manuscript after the authors address the following minor suggestions:

1. As shown in Figure 10 and 11, it is just an example for pitch angle at 30 degree and L of 8, which is understandable for a demonstration. What about for other pitch angles and locations? Since the purpose is to generate a global map for practical application, it would be quite nice if the authors could provide more systematic global visualization for different conditions (i.e., quiet and disturbed)

   We thank the reviewer for this recommendation, which greatly enhances the paper. The following figure has been added, Figure 12, containing plots of the regions of constant I for quiet and disturbed solar wind conditions, and 30° and 60° initial equatorial pitch angles, for particle starting distances 4 - 8 RE. The corresponding text has been added in Section 5.



2. For the LANL* software, in addition to Josef and Zaharia [2011], there is a new version:

Yu, Y., J. Koller, S. Zaharia, and V. Jordanova (2012), L* neural networks from different magnetic field models and their applicability, Space Weather, 10, S02014, doi:10.1029/2011SW000743.

The reference has been added in the LANL section, Line 79*