

How to Use Plasmapause Test Particle (PTP) Simulation Output

J. Goldstein (JGoldstein@swri.edu)

1. OVERVIEW

This document provides brief instructions for using PTP simulation output [from the 60-storm study](#).

The PTP simulation reproduces Van Allen Probes plasmapause observations to within 0.4 RE [Goldstein et al., 2014b]. The model represents the time-varying global plasmapause as an ensemble of cold test particles subject only to ExB drift. The convection electric (E) field is driven by solar wind data and the Kp geomagnetic index.

For more information about this simulation method, see *Goldstein et al.* [2003, 2005a, 2005b], *Goldstein and Sandel* [2005], and *Goldstein et al.* [2014a, b] (references listed below). The update by *Goldstein et al.* [2014b] includes a simple treatment of refilling.

2. Van Allen Probes ONE-MONTH SIMULATIONS

The plasmapause model results are available covering 60 storms from the 5 year period September 2012 to September 2017. Each 4-day simulation run's output is saved at a 15-min cadence.

The download for each simulation run is a zip file. When you open the zip file, you will see a master folder called "**s_VAP_[YYYYMMDD]_storm_study**", where [YYYYMMDD] is the start date for the 4-day simulation run. The folder includes:

- (a) **Instructions (PDF)**, a.k.a., a "Readme" file: That instruction PDF is the same as this file, and is stored in the folder "**0_INSTRUCTIONS_README**".
- (b) **Movie**: In QuickTime format, this movie shows virtual Van Allen Probes flythroughs of the simulated plasmasphere. The movie also shows you what the data should look like when correctly plotted. See **Figure 6.1** for an example frame from one movie. The movie is stored in the folder "**1_MOVIE**".
- (b) **Output Data Files**: There should be ~385 files in the master folder, one per 15-min time step. **Section 3** (below) describes how to read and use them.

3. ASCII FILES INFORMATION: Information about PTP plasmapause (".ppa") files

The output of the PTP simulation is found in a sequence of ".ppa" files, described herein. Please note that these are pure text files. If you "double click" you might find your OS interprets the ".ppa" suffix as a Powerpoint. You may need to drag and drop into a text file editor program.

Each file contains a table of points (L and phi values) that represent the plasmapause as simulated by an ensemble of ExB-drifting cold test particles.

3.1 File Naming Convention

Each file is named according to the convention YYYYDDDHHMM.ppa, where

YYYY = 4-digit year

DDD = 3-digit day of year (e.g., day 1=Jan 1)

HH = 2-digit UT hour

MM = 2-digit UT minute

".ppa" = 3-letter extension ("ppa" = shorthand for plasmopause).

3.1 File Contents. Each file contains all the plasmopause location points corresponding to a single time snapshot of the simulation. Each file depicts a different time in the simulation.

The .ppa file consists of ASCII text, 2 columns:

- **L** L-shell location (radial distance in the magnetic equator in Earth radii RE).
- **phi** angular location (radians); phi=0 at 1200 MLT (noon), phi=p at 2400 MLT, etc.

At the end of the .ppa file is a Fourier expansion of the (L,phi) points. This expansion is useful for E-field analysis [as described in *Goldstein et al.*, 2004]. The Fourier expansion is only a good representation of the plasmopause when the plasmopause (L vs phi) curve is (rarely) single-valued. Use of the Fourier expansion can provide a very innaccurate plasmopause!

4. QUESTIONS ABOUT USING OR INTERPRETING THESE RESULTS

If you have any **questions** about how to use or interpret PTP plasmopause model data, *please contact **Jerry Goldstein** (jgoldstein@swri.edu).*

4.1 Farmer's Wife Algorithm. These results use the simulation code described in *Goldstein et al.*, [2014b], but with the added inclusion of an algorithm dubbed "Farmer's Wife" (named for the character in the song "Three Blind Mice" who chops off mouse tails). Farmer's Wife truncates plumes when they get too narrow. Occasionally, the algorithm removes too many points, in which case the "fail-safe" in the code is to revert that timestep to an *O'Brien and Moldwin* [2003] empirical plasmopause. So, if you see the plasmaspheric configuration change suddenly from one time step to the next, it is probably because of Farmer's Wife. If this happens mid-event and it poses a problem for your research study, please let me know and I can create a custom run for you.

4.2 Simple Filter. For some month-long simulations, Farmer's Wife did not perform well, and I ran a simpler filter: if the number of test particles exceeds 1024, this simple filter resets the plasmopause to *O'Brien and Moldwin* [2003]. Again, if you see a discontinuous jump to a circle, it is because the simulation has reset itself. If this happens mid-event and it poses a problem for your research study, please let me know and I can create a custom run for you.

4.3 Model Validity. The model has only been validated (using IMAGE EUV) at or inside of geostationary orbit. The plume location outside 6.6 RE is purely qualitative. Similarly, the model magnetopause is static, with standoff distance at 10 RE, so for large events interpret carefully.

5. References

- Goldstein, J., M. F. Thomsen, and A. DeJong (2014a), In situ signatures of residual plasmaspheric plumes, *J. Geophys. Res.*, 119, 4706, doi:10.1002/2014JA019953.
- Goldstein, J., S. De Pascuale, C. Kletzing, W. Kurth, K. J. Genestreti, R. M. Skoug, B. A. Larsen, L. M. Kistler, C. Mouikis, H. Spence (2014b), Simulation of Van Allen Probes plasmopause encounters, *J. Geophys. Res.*, doi:10.1002/2014JA020252.
- Goldstein, J., and B. R. Sandel (2005), The global pattern of evolution of plasmaspheric drainage plumes, in *Inner Magnetosphere Interactions: New Perspectives from Imaging*, edited by J. L. Burch, M. Schulz, and H. Spence, p. 1, American Geophysical Union, Washington, D. C., doi:10.1029/159GM01.
- Goldstein, J., B. R. Sandel, M. F. Forrester, T. F. Thomsen, and M. R. Hairston (2005b), Global plasmasphere evolution 22–23 April 2001, *J. Geophys. Res.*, 110, A12218, doi:10.1029/2005JA011282.
- Goldstein, J., J. L. Burch, and B. R. Sandel (2005a), Magnetospheric model of subauroral polarization stream, *J. Geophys. Res.*, 110, A09222, doi:10.1029/2005JA011135.
- Goldstein, J., R. A. Wolf, B. R. Sandel, and P. H. Reiff (2004c), Electric fields deduced from plasmopause motion in IMAGE EUV images, *Geophys. Res. Lett.*, 31(1), L01801, doi:10.1029/2003GL018797.
- Goldstein, J., B. R. Sandel, P. H. Reiff, and M. R. Hairston (2003), Control of plasmaspheric dynamics by both convection and sub-auroral polarization stream, *Geophys. Res. Lett.*, 30(24), 2243, doi:10.1029/2003GL018390.
- O'Brien, T. P., and M. B. Moldwin (2003), Empirical plasmopause models from magnetic indices, *Geophys. Res. Lett.*, 30(4), 1152, doi:10.1029/2002GL016007.

6. Figures

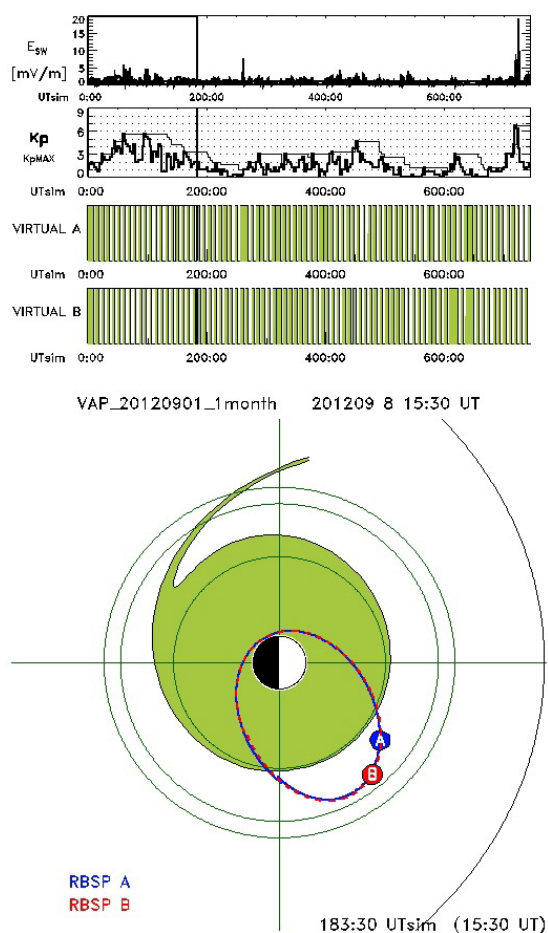


Fig 6.1 Example frame from PTP Movie of 2012 Sep simulation ("VAP_20120901_1month").