

## **2003 Halloween storm EUV Plasmopause Data: Directory Structure**

In each event directory, you will find a "movies" directory and a "ppa" directory.

The "movie" directory contains some animations and movies of EUV plasmasphere data.

The "ppa" directory contains the actual plasmopause data, as described below.

### **MOVIE DIRECTORIES INFORMATION**

In each event folder there is a "movie" directory. The movie directory contains three sub-folders: "mapped movies", "raw movies", and "indices".

**EUV\_raw\_movies:** These are the movies of "raw" images downloaded from the EUV instrument, with minimal processing. (These movies are obtainable via anonymous FTP from <http://euv.lpl.arizona.edu/euv/>.)

#### **EUV\_mapped\_movies:**

These movies contain "mapped images." A mapped image is created by taking the pixels of the raw EUV image, and assigning L and phi values to the vertices of each pixel. The L-value is assigned using the "minimum L" routine of *Roelof and Skinner [2000]* (see reference below). Thus, the pixels of the raw EUV image are mapped to the magnetic equator (in SM coordinates), presumably removing much or most of the perspective effects from the raw images.

#### **EUV\_ppa\_movies:**

These movies show the extracted plasmopause data contained in the ***".ppa" files*** (see next section). The view is of the equatorial plane (SM coordinates) with the Sun to the right. The dots are the manually extracted points (SEE NEXT SECTION). The line is the Fourier expansion of those points (SEE NEXT SECTION for limitations of this Fourier expansion!).

**indices:** This directory simply contains a .GIF picture file of Provisional Dst obtained for the event by WDC Kyoto.

### **PPA FILES INFORMATION: Information about EUV plasmopause files**

The following is a very brief description of the primary plasmopause location files, the "ppa" files.

They contain multiple points that represent the plasmopause as manually extracted from global snapshots of the plasmasphere obtained by IMAGE EUV.

#### **Not Always Just "Plasmopause" Data.**

It's worth noting that these points are not always purely "plasmopause" data. In most cases, the points do indicate a best guess for the outer edge of the plasmasphere. But there are two exceptions.

**(1) No Steep Outer Gradient.** If there is no clear outer boundary (e.g., the plasmasphere density has a gradual roll-off rather than a single steep well-defined density gradient), an attempt was made to represent the plasmasphere shape by clicking. ***For the 2003 Halloween event, it is generally the case that the plasmopause is not represented by a steep, well-defined density gradient.*** In cases where there was no sharp density gradient, the click points do not define a single curve, but rather make up a scattered "band" (intended to represent the thickness of the poorly-defined outer edge), or in some cases, the click points indicate some degree of structure to the outer boundary.

**(2) Multiple Edges or Interior Structure.** In cases where there are multiple sharp edges, or some kind of interior structure, the click points do not define a single curve.

## 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).

## File Contents

In each file, you will find all the plasmopause location points corresponding to a single EUV image. That is, all the points in a given file are simultaneous global "measurements" of the plasmopause.

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

L = L-shell location (defined as the radial distance in the magnetic equator in Earth radii RE).

phi = angular location in radians, defined so that phi=0 at 1200 MLT (noon), phi=pi at 2400 MLT, etc.

At the end of the .ppa file, you will find a Fourier expansion of the (L,phi) points. This Fourier expansion is useful in cases where one wishes to determine electric fields from the plasmopause motion (as described in Goldstein et al., [2004]; see reference below.). It is not advised that you use this Fourier expansion without **first consulting with Jerry Goldstein (jgoldstein@swri.edu)**. The reason for this warning is that the Fourier expansion is only a good representation of the plasmopause under certain restrictive circumstances. Probably the most important requirement for a "good" Fourier expansion is that the plasmopause (L vs phi) curve must be single-valued. If there is a drainage plume, for example, it is most likely that the plasmopause curve is *NOT* single-valued. A secondary consideration is that the Fourier expansion is only really good inside a range of MLT (i.e., phi) values for which there were actually extracted points. For example, if there are only plasmopause points extracted on the nightside, one should not expect, in general, the Fourier expansion to be accurate on the dayside. *Improper use of the Fourier expansion can provide a very innaccurate plasmopause!*

## Notes on Manually-Extracted Plasmopause Location: "Click Points"

### **THESE DATA ARE UNSORTED!!!!**

The click points are not single-valued and are not monotonic, in either MLT or L-shell. When using a given .ppa data file, you may want to sort the data points by MLT before you plot them or use them. Also, when you plot the plasmopause data, *it is strongly advised that you use discrete symbols (filled circles or dots) to plot the points rather than connecting the points with lines.*

### **SUBJECTIVE ERROR**

Something to keep in mind is that the (L,phi) points have been manually extracted. There is inescapably some subjectivity to the extraction, although comparison with in situ data has shown that the manually extracted plasmopause is reasonably accurate (within a few tenths of an RE) under most circumstances.

Many extractions show not a single well-defined plasmopause, but rather a "band" of scattered or staggered points. In these cases, the error can be crudely estimated as the radial thickness of the band, or as the scatter in plasmopause location within some given range of MLT, say 0.5 hours to 1 hour of MLT. If a well-defined plasmopause does exist, it probably has 0.3-0.7 RE uncertainty, due to the high background noise in this 2003 Halloween event.

### **Why are we still using manual extractions?**

A common question raised is, "Why hasn't anyone devised a routine for automated plasmopause extraction? Wouldn't an automated routine be better? One argument is that the automated extraction might be described as "not subjective" (since a computer isn't usually thought of as subjective). Another is that the automated routine would be quicker, not so labor intensive. The answer to this question is that the human eye does as well, or better, at recognizing the plasmopause location, when compared to any automated routine developed at the present time. It's a challenging problem to design an automated routine that can ignore

shadows, noise, sunlight contamination, etc. So for now, the best we have is manual extraction, and we do our very best to minimize the subjectivity.

#### **IMPORTANT NOTE ON USING PLASMAPAUSE DATA**

In cases where a well-defined plasmopause edge existed, single plasmopause location points can be trusted. However, in cases where the click points were intended to represent a gradual density gradient, or interior features, care must be exercised in interpreting single points. In fact, the best way to use the EUV extracted "plasmopause" data is to plot the data and do a global "by eye" assessment of the overall plasmopause shape and size.

If you have any **questions** about how to use EUV plasmopause data, *please contact **Jerry Goldstein** ([jgoldstein@swri.edu](mailto:jgoldstein@swri.edu))*.

#### **Linux Compatibility**

For users of Linux or UNIX, some may have problems with the .ppa files that were created using IDL 5.3 for Mac OS 9.1. Specifically, the Mac OS 9.1 IDL "carriage return" may not contain the "line feed" command that Linux expects. If this problem interferes with your use of the data, please contact **Jerry Goldstein** ([jgoldstein@swri.edu](mailto:jgoldstein@swri.edu)).

#### **References**

Goldstein, J., R. A. Wolf, B. R. Sandel, and P. H. Reiff, Electric fields deduced from plasmopause motion in IMAGE EUV images, *Geophys. Res. Lett.*, 31(1), L01801, doi:10.1029/2003GL018797,386, 2004.

Roelof, E. C., and A. J. Skinner, Extraction of ion distributions from magnetospheric ENA and EUV images, *Space Sci. Rev.*, 91, 437, 2000.