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# Model for plasmaspheric mass loss during geomagnetic storm

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## Abstract

We estimate the total mass loss of plasmasphere for 4 events using theory and previous empirical models. As the electrical potential of Volland-Stern, the electrical potential of SAPS effect, the plasmapause position determined by the interchange instability mechanism and a model of electron density.

## 1. Introduction

The plasmasphere is a cold, dense torus of H+, He+, and O+ surrounding Earth and extending to distances of about 6 Earth radii ($R_E$) (Lemaire and Gringauz, 1998). During times of geomagnetic disturbance, sunward plasma convection plays a crucial role in plasmaspheric dynamics. Perhaps the most fundamental cause of inner magnetospheric convection is Dayside Magnetopause Reconnection (DMR). When the IMF(Interplanetary Magnetic Field) at the magnetopause is oriented opposite (southward) to the geomagnetic field, these oppositely-directed fields can undergo reconnection, a process that causes dayside geomagnetic field lines to become joined to the IMF lines, which then are dragged antisunward (along with the prevailing solar wind flow) into the stretched out magnetospheric tail (magnetotail). This magnetic flux transfer drives sunward convective flows in the inner magnetosphere. Associated with this sunward convection is a solar-wind electric (E) field that points from dawn to dusk, with magnitude given by the product of the solar wind speed and the Z-component of the IMF (Bz,IMF). The zero-order influence seems to be the polarity of Bz,IMF, which acts as a switch, turning convection on for southward IMF (Bz,IMF < 0) and off for northward IMF (Bz,IMF > 0). A significant modification of DMR convection is a phenomenon that to be called the subauroral polarization stream (SAPS) (Goldstein, 2006).

The plasma experiences gravitational and centrifugal forces. The latter arises due to corotation. The gravitational force decreases with altitude and there is a limit beyond which gravitational force is balanced by centrifugal force. The limit is called Zero Parallel Force Surface (ZPFS) (Pierrard and Stegen, 2008). During intense geomagnetic activity the convection electric field intensifies leading to enhanced centrifugal effects and as a consequence blocks of plasma may be detached in the night local time sector due to the development of plasma interchange instability. The electric conductivity of the lower ionosphere limits the growth rate of plasma interchange instability.

In order to estimate the mass loss, first be calculated the convection electric field (section 2), later be determinated the plasmapause position (section 3) and then use a model of density to get the mass loss (section 4). The section 5 is for the results.and comparsions.

## 2. Convection Electric Field

The convection electric filed used in this model is the result of the Volland-Stern electric convection potential plus SAPS electric potential derived by Goldstein et al., 2005, on basis of a previous study of average characteristics of SAPS (Foster and Vo, 2002).

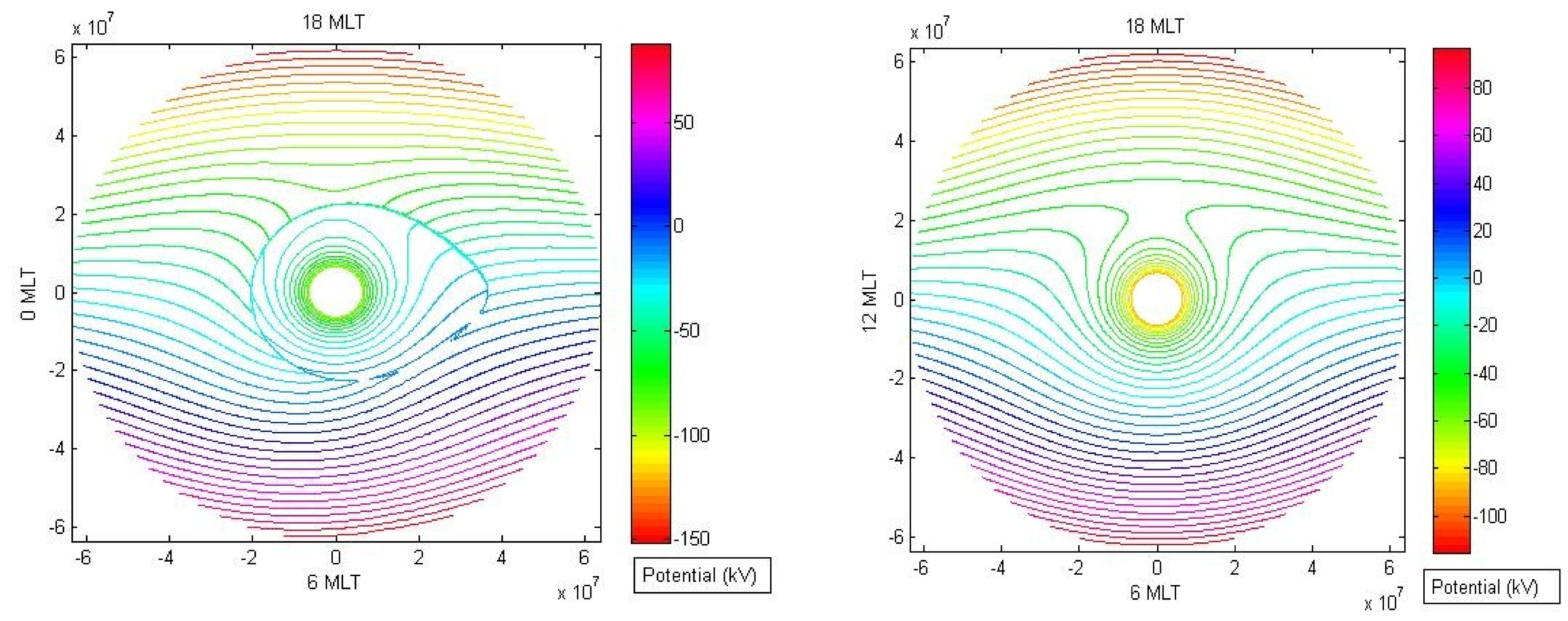


**Figure 1.** Equipotential map of electric field with SAPS (left) and without SAPS (right) for Kp = 7

## 3. Plasmapause Position

To determinate the plasmapause position was considered that the plasmapause is the result of the interchange motion becoming unstable along the innermost geomagnetic field lines tangent to the ZPFS [Lemaire, 1989].The plasmapause develops first in the equatorial region, and subsequently at lower altitudes along the magnetic field lines tangent to the ZPFS. Inward shifts of the ZPFS occur during substorm events, when the magnetospheric convection velocity is significantly enhanced in the midnight and postmidnight MLT sectors (Pierrard and Stegen, 2008). The Kp-dependent empirical electric field model of the section 2 is used to determine the convection velocity, and ultimately the position of the plasmapause.

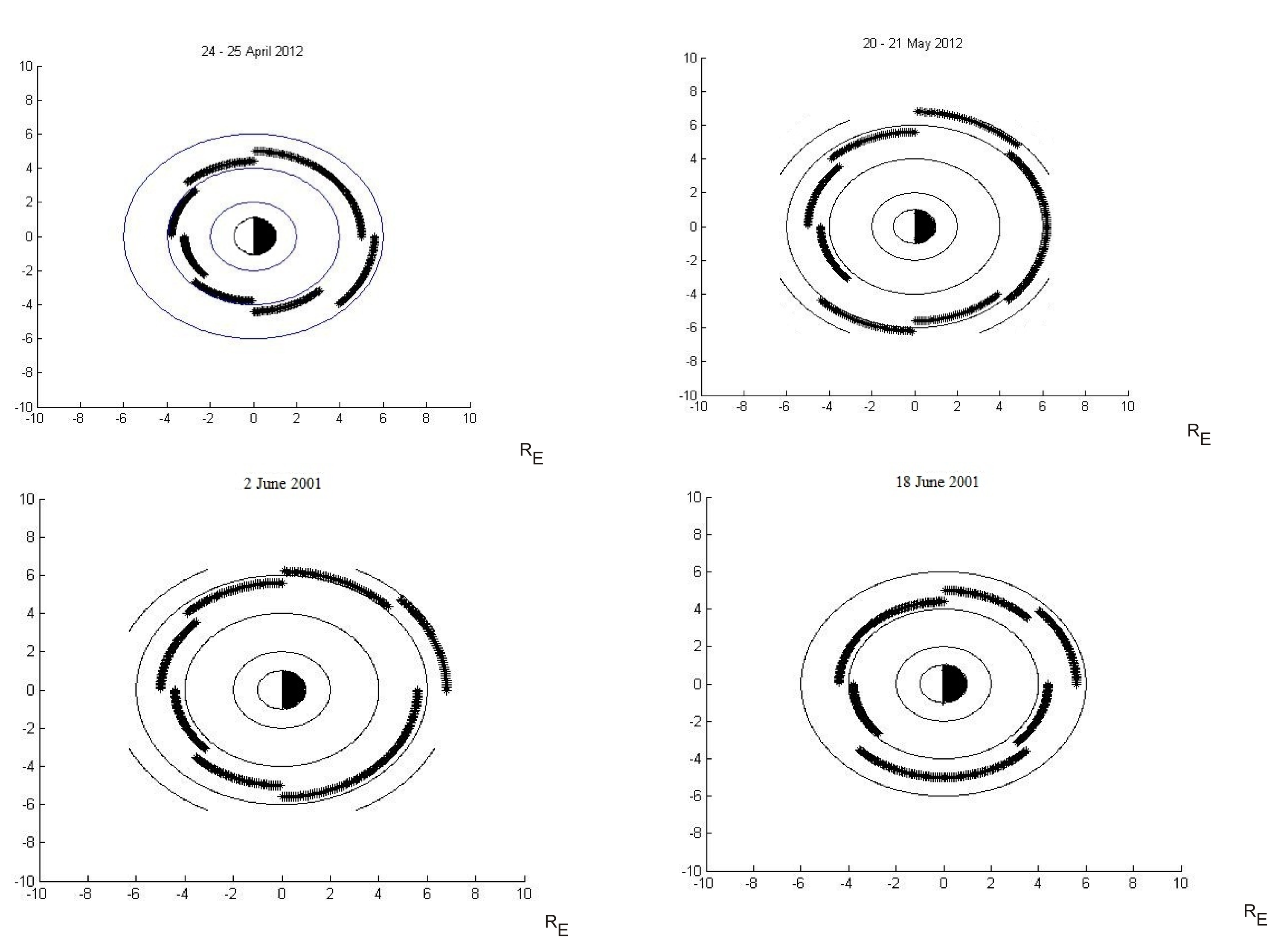


**Figure 2.** Plasmapause position for 24 -25 April, 20 - 21 May 2012 and 2 June, 18 June 2001.

## 4. Mass Density

Once you have the plasmapause position, was used the power law form for electron density given by Denton et al., 2002. The equatorial electron density, ne0, used is the empirical model of Carpenter and Anderson (1992). With this calculates the integrated number of electrons in the plasmasphere depending of L shell.

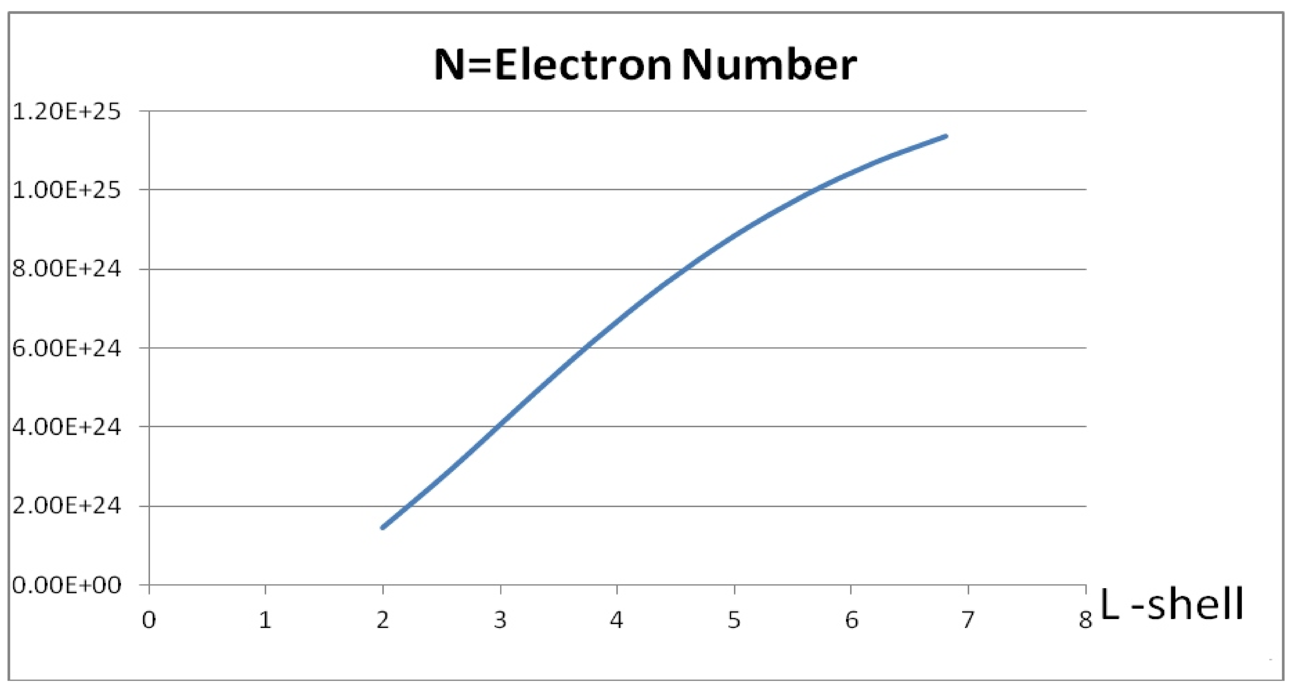


**Figure 3**. Integrated total number of electrons in the plasmasphere

Once it has the number of electrons can estimate the number of ions assuming the quasi-neutrality of plasma in the plasmasphere and the invariability of percentages of ions present in the plasmasphere .

## 5. Total mass of material loss for 4 events

Were taken into account 4 events: 1) 24 -25 April 2012, 2) 20 - 21 May 2012, 3) 18 June 2001 and 4) 02 June 2001.

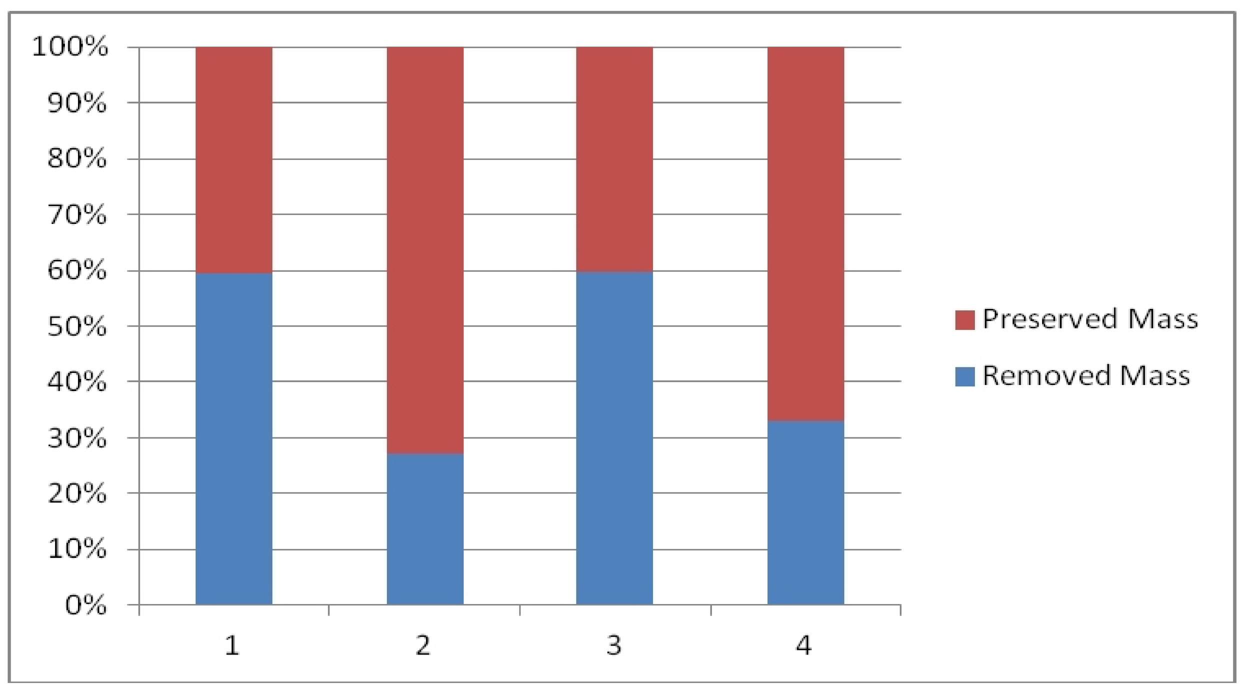


**Figure 4**. Total estimated mass removed versus the preserved mass

## 6. Summary and Conclusions

The study of the plasmasphere is an example of use of several research techniques. Approaching theoretical, empirical models and measurements and in situ observations. All this leads to a more complete understanding of what is round us. In this case the Plasmasphere.

We used previous research tools available, perhaps not use the optimum but yes the best adapted to solve the problem. And comparing the results of Section 5 with the results obtained by M.Spasojevic and Sandel 2010 are not very different, although they may improve if the simplifications made here are replaced by more realistic data for example the magnetic field, the density model, the percentages of composition, etc.

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