Polar Ion Outflow - Is there enough to fill the Magnetosphere?
Ionosphere source sends a flow of low-energy (few eV to 10's of eV) plasma up into magnetosphere.

Plasma is made up of H+, He+, O+ from the polar wind, cleft ion fountain, polar cap and auroral zone.

The plasma flows up through the polar cap and the "empty" lobes of the magnetotail to the plasma sheet.
<table>
<thead>
<tr>
<th></th>
<th>Quiet</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$H^+$</td>
<td>$He^+$</td>
</tr>
<tr>
<td>Polar wind</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar maximum</td>
<td>15.0</td>
<td>1.1 (7.05 x 10$^6$)</td>
</tr>
<tr>
<td>Solar minimum</td>
<td>46.0</td>
<td>0.59 (3.85 x 10$^6$)</td>
</tr>
<tr>
<td>Cleft ion fountain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar maximum</td>
<td>0.33</td>
<td>1.6</td>
</tr>
<tr>
<td>Solar minimum**</td>
<td>0.63</td>
<td>0.73</td>
</tr>
<tr>
<td>Auroral zone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar maximum</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Solar minimum**</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Polar cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar maximum</td>
<td>0.24</td>
<td>0.24</td>
</tr>
<tr>
<td>Solar minimum**</td>
<td>0.43</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Each entry is to be multiplied by $10^{-5}$ ions s$^{-1}$.

*The numbers in parentheses represent the polar wind fluxes in ions per square centimeter per second that were used for the different solar and magnetic conditions.

**The Yau et al. [1985] DE data were taken in two sets: one near solar maximum and one about half way between solar maximum and minimum (see Figure 1).
QUIET PLASMA SHEET CONDITIONS

ACTIVE PLASMA SHEET CONDITIONS

Figure 3. A sketch of the magnetosphere showing the assumed size of the plasma sheet used in the calculations for (a) quiet and (b) active magnetic conditions. The dotted and dashed lines show the outer flow boundary for polar wind and cleft ion fountain ions, respectively, from a source located near the polar cusp.
TABLE 2. Parameter Summary

<table>
<thead>
<tr>
<th>Region</th>
<th>Volume, cm$^3$</th>
<th>Residence Time, s</th>
<th>Flux Range</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Flux $\text{ions s}^{-1}$</td>
<td>Density $\text{ions cm}^{-3}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(ions cm$^-2$ s$^{-1}$)</td>
<td>Calculated, ions cm$^{-3}$</td>
</tr>
<tr>
<td>Region I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inner plasmasphere</td>
<td>$6.97 \times 10^{27}$</td>
<td>$8.64 \times 10^4$</td>
<td>$8.0 \times 10^{26}$ (1.5 $\times 10^8$)</td>
<td>4930-1070</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$1.7 \times 10^{26}$ (3.25 $\times 10^9$)</td>
<td></td>
</tr>
<tr>
<td>Region II</td>
<td>$2.39 \times 10^{28}$</td>
<td>$4.32 \times 10^5$</td>
<td>$9.3 \times 10^{25}$ (1.5 $\times 10^8$)</td>
<td>850-180</td>
</tr>
<tr>
<td>Outer plasmasphere</td>
<td></td>
<td></td>
<td>$2.0 \times 10^{26}$ (3.25 $\times 10^7$)</td>
<td></td>
</tr>
<tr>
<td>Region III</td>
<td>$5.65 \times 10^{29}$</td>
<td>$2.16 \times 10^4$</td>
<td>$1.31 \times 10^{25}$ (3 $\times 10^6$)</td>
<td>5.1-1.1</td>
</tr>
<tr>
<td>Dayside plasma trough</td>
<td></td>
<td></td>
<td>$2.91 \times 10^{25}$ (6.5 $\times 10^6$)</td>
<td></td>
</tr>
<tr>
<td>Region IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a, Quiet plasma sheet</td>
<td>$3.75 \times 10^{20}$</td>
<td>$1.44 \times 10^4$</td>
<td>$1.9 \times 10^{26}$ (1.0 $\times 10^9$)</td>
<td>0.73-0.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$1.1 \times 10^{26}$ (3.25 $\times 10^7$)</td>
<td></td>
</tr>
<tr>
<td>b, Active plasma sheet</td>
<td>$3.75 \times 10^{20}$</td>
<td>$1.08 \times 10^4$</td>
<td>$2.2 \times 10^{26}$ (6.5 $\times 10^6$)</td>
<td>6.3-6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$2.1 \times 10^{26}$ (6.5 $\times 10^6$)</td>
<td></td>
</tr>
<tr>
<td>Region V</td>
<td>$7.0 \times 10^{20}$</td>
<td>$6.5 \times 10^3$</td>
<td>$8.4 \times 10^{25}$ (6.5 $\times 10^6$)</td>
<td>0.078-0.036</td>
</tr>
<tr>
<td>Tail lobe</td>
<td></td>
<td></td>
<td>$3.9 \times 10^{25}$ (6.5 $\times 10^6$)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Flux ranges are for different time periods.
Spacecraft Potential for typical agogee pass of POLAR
1997 August 6 15:00-20:00 UT

Spacecraft Potential for typical agogee pass of POLAR with PSI in operation
1997 August 15 11:00-22:00 UT

Example Polar Cap outflow to POLAR altitudes

Example Dayside Cleft outflow to POLAR altitudes
Particle trajectory categories for TIDE Observations - 1997 May 29 to June 11

- **Sunward**: 970606 13:45 UT
  - Deep Tail: 34 of 102 runs

- **Mid Tail**: 970529 17:31 UT
  - Mid Tail: 30 of 102 runs

- **Precipitating**: 970602 12:40 UT
  - Precipitating: 14 of 102 runs

- **Escaping**: 970611 03:45 UT
  - Escaping: 24 of 102 runs
Start parameters:
Kp level: 3
Local time: 9.173
Latitude: 80.510
Distance (Re): 8.181
Energy (eV): 11.03
Pitch angle: 179.900
Tilt angle: 33.310
start parameters:
Kp level: 1
Mass (amu): 1
Local time: 2.980
Latitude: 72.900
Distance (Re): 8.419999
Energy (eV): 4.77
Pitch angle: 179.900
Phase angle: 0.000
Tilt angle: -5.753
iback, bitilt, istop: 0 1 0
file: t970320-0100f.dat

Tue Nov 17 17:17:25 1993
start parameters:
Kp level: 1
Mass (amu): 1
Local time: 2.280
Latitude: 65.930
Distance (Re): 7.470000
Energy (eV): 7.40
Pitch angle: 179.900
Phase angle: 0.000
Tilt angle: -9.047
iback, itilt, istop: 0 1 0
file: t970320-0240f.dat
Ionosphere outflow correlations with solar wind plasma parameters

Normalized to 1000km altitude

#samples = 9899

ORIGINS OF THE HIGH ALTITUDE THERMAL PLASMA

Typical trajectory tracing

1997 June 9 01:10 UT

start parameters:
Kp level: 6
Mass (amu): 1
Local time: 19.100
Latitude: 80.270
Distance (Re): 7.989000
Energy (eV): 11.24
Pitch angle: 179.900
Tilt angle: 16.420

Footpoints of all trajectories

0 MLT
Figure 4. Schematic diagram showing the nonclassical processes that may affect the polar wind. From Schunk and Sojka [1997].
Figure 4. Convection trajectory of a representative flux tube of plasma during changing magnetic activity. At the start of the simulation the flux tube is located at about 1900 MLT and 67° magnetic latitude, as shown by the solid dot in Figure 3. The tick marks along the trajectory indicate the times in universal time hours.
Figure 3. Total H\(^+\) outflow rate (ions s\(^{-1}\)) versus time at selected altitudes. The outflow rate is obtained by integrating the H\(^+\) flux over the entire polar region at each altitude. From Schunk and Sojka [1997].
Ionosphere source sends a flow of low-energy (few eV to 10's of eV) plasma up into magnetosphere.

Plasma is made up of H+, He+, O+ from the polar wind, cleft ion fountain, polar cap and auroral zone.

The plasma flows up through the polar cap and the "empty" lobes of the magnetotail to the plasma sheet.