In-Situ F2-Region Plasma Density and Temperature Measurements from the International Space Station

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Introduction

The International Space Station orbit provides an ideal platform for in situ studies of space weather effects on the mid and low-latitude F2 region ionosphere. The Floating Potential Measurement Unit (FPMU) operating on the ISS since Aug 2006, is a suite of plasma instruments: a Floating Potential Probe (FPP), a Plasma Impedance Probe (PIP), a Wide-sweep Langmuir Probe (WLP), and a Narrow-sweep Langmuir Probe (NLP). This instrument package provides a new opportunity for collaborative multi-instrument studies of the F-region ionosphere during both quiet and disturbed periods. This presentation first describes the operational parameters for each of the FPMU probes and shows examples of an intra-instrument correlation. We then show comparisons with the plasma density and temperature measurements derived from the TIMED/GUVI ultraviolet imager, the Millstone Hill ground-level incoherent scatter radar, and DIAS digisonde. Finally, we show one of several observations of right-time equatorial density holes demonstrating the capabilities of the probes for monitoring mid and low latitude plasma processes.

Probe Description

The FPMU operation is autonomous with either an on or off state. The only control is over the operation of a heater in the WLP. The FPMU is mounted to a camera port and its data is transmitted via the Ku-Band. The camera interface allows for high bandwidth - 6.776 12-bit words each second. For 2007 the AOS for the Ku-Band is ~69%-65%.

Table 1. Measured parameters, duty cycle, and position changes for the FPMU

<table>
<thead>
<tr>
<th>Probe</th>
<th>Duty Cycle</th>
<th>Effective Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPP</td>
<td>1</td>
<td>N 5 1.0-1.1 GHz</td>
</tr>
<tr>
<td>PIP</td>
<td>1</td>
<td>N 5 1.2 GHz</td>
</tr>
<tr>
<td>WLP</td>
<td>0.4-1.6</td>
<td>N 3 0.5 GHz</td>
</tr>
<tr>
<td>NLP</td>
<td>0.2-0.4</td>
<td>N 5 5 MHz</td>
</tr>
</tbody>
</table>

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Figure 1: FPMU mounted on the ISS (Stanley et al., 2005)

Figure 2: Typical ISS ground track

Table 2. Operation dates of FPMU instrument suite

<table>
<thead>
<tr>
<th>Date</th>
<th>FPMU Operation</th>
<th>WLP Operation</th>
<th>NLP Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>On</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>2008</td>
<td>Off</td>
<td>On</td>
<td>Off</td>
</tr>
</tbody>
</table>

Figure 3. Sample data from each of the FPMU: four probes from 20/02/02.

Since operation started in 2006, the FPMU plasma probes, WLP, NLP, and PIP have observed several nighttime equatorial holes extending to densities below 1 x 10^4 m^-3. Figure 9 below shows continuous examples of deep density cavities during active geomagnetic conditions occurring on March 9, 2008. Panels in Figure 10 present the geomagnetic indices for this day.

Independent Data Verification

The density and temperatures derived from the WLP and NLP Langmuir probes were compared to measurements from the incoherent scatter radars (ISR) at Millstone Hill, the European Digital Upper Atmospheric Server (DIAS) digisonde, and the TIMED Global Ultraviolet Imager (GUVI). Differences between the WLP and these instruments are given below where the difference = differences between the two measurements. (Coffey et al., 2008).

Figure 4. Sample data from each of the FPMU: four probes from 2002/02/02.

Figure 5. Difference in temperature between the WLP on March 9, 2008 and the ISR on March 10, 2008.

Figure 6. Difference in density between the WLP and the ISR on March 9, 2008.

Observations of Nighttime Equatorial Holes

Since operation started in 2006, the FPMU plasma probes, WLP, NLP, and PIP have observed several nighttime equatorial holes extending to densities below 1 x 10^4 m^-3. Figure 9 below shows continuous examples of deep density cavities during active geomagnetic conditions occurring on March 9, 2008. Panels in Figure 10 present the geomagnetic indices for this day.

Summary and Future Operations

As of August 2008, the FPMU has been operated during several data collection campaigns and is meeting its primary requirement of providing floating potential measurements of the ISS and its secondary requirement of providing measurements of the local ionospheric plasma. It will continue to operate during in-situ data collection campaigns at least through 2008 and possibly through 2010. Potential science goals of interest for the FPMU include:

- The study of F-region plasma density and temperature transitions in equatorial anomaly regions.
- The study of F-region plasma density and temperature transitions in auroral anomaly regions.
- The study of F-region plasma density and temperature transitions in mid-latitude F-region ionosphere.
- The study of F-region plasma density and temperature transitions in auroral anomaly regions.

Future plans include the extension of the FPMU campaign to the low-latitude F-region ionosphere, the study of F-region plasma density and temperature transitions in auroral anomaly regions, the study of F-region plasma density and temperature transitions in mid-latitude F-region ionosphere, and the study of F-region plasma density and temperature transitions in auroral anomaly regions.

References, Acknowledgments

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Figure 7. Difference in temperature between the WLP and the ISR on March 9, 2008.

Figure 8. Difference in density between the WLP and the ISR on March 9, 2008.

Figure 9. Several equatorial density holes monitored using the FPMU on March 9, 2008. Day 85 - showing active geomagnetic conditions.

Figure 10. Summary of in-situ and remote sensing observations for March 9, 2008.

Figure 11. Summary of in-situ and remote sensing observations for March 9, 2008.

Figure 12. Summary of in-situ and remote sensing observations for March 9, 2008.