Validation of Ionospheric Measurements from the International Space Station (ISS)

Victoria Coffey¹, Joseph Minow¹, Kenneth Wright²
¹NASA Marshall Space Flight Center, ²University of Alabama in Huntsville

Introduction
The International Space Station orbit provides an ideal platform for in-situ studies of space weather effects on the mid and low-latitude F-2 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.

Probe Description
- **FPP** - Floating Potential Probe - gold-plated sphere of radius 5.08 cm isolated from chassis ground. Filmatic at a potential within a few kV of the plasma potential providing a reference for measuring the ISS potential.
- **PIP** - Plasma Impedance Probe - a short dipole antenna electrically isolated from the ISS that measures the electrical impedance at 256 steps from 100 kHz to 20 MHz in one second. Electron density derived from upper hybrid frequency.
- **WLP** - Wide-sweep Langmuir Probe - gold-plated cylinder of radius 5.08 cm. Performs a voltage sweep from -20 V to +80 V relative to chassis ground. Two different voltage step sizes (25 mV and 250 mV) are used. An internal heater allows surface cleaning.
- **NLP** - Narrow-sweep Langmuir Probe - a gold-plated cylinder with collector radius 1.43 cm and length 5.08 cm. Performs a voltage sweep from -4.85 V to +4.85 V about a reference potential determined by the FPP. A constant voltage step size of 12 mV is used.

Data Verification - Densities

**TIMED GUVI**
- Figure 5. Histogram of difference in densities between TIMED GUVI and WLP on 2006/217.
- Conjunction area ±15 min, ±12 ° lat, ±12 ° lon and ±25 km.

**DIAS Digisondes**
- Figure 6. Histogram of differences in densities between DIAS digisondes and WLP on several days in 2006.
- Conjunction area ±30 min, ±12 ° lat, ±12 ° lon and ±75 km.

**Conjunction area**

**Ultraviolet Imager**
- Figure 9 shows examples of deep density depletions during active geomagnetic conditions occurring on March 9, 2008. This data is consistent with Martinis et al. (2005) which suggests a linkage between equatorial spread F onset and the behavior of IMF Bz and E x B.

Intra-Probe Data Comparison

- The density and temperatures derived from the WLP and NLP Langmuir probes were compared to measurements from the incoherent scatter radar (ISR) at Millstone Hill, the European Digital Upper Atmospheric Server (DIAS) digisondes, and the TIMED Global Ultraviolet Imager (GUVI). Histograms of the differences between the WLP and the instrument measurements are shown. Difference = subtraction/mean of the two measurements to provide an even weighting (Coffey et al. 2008).

Summary and Future Operations

Since August 2006, the FPMU has been operated during several data campaigns and is providing measurements of the local ionospheric plasma and floating potential of the ISS. Potential science goals for interest to the T-Community that could be addressed by the FPMU include:
- Spread-F density perturbations - flight of light ion troughs and plasmaspheric boundary during geomagnetic storms.

References, Acknowledgements
We would like to thank the Space Environment Center, ACE, TIMED GUVI, Millstone Hill ISR, and DIAS Digisonde server community for supplying the data for our comparisons.

Keywords: Holes, Plasma, Ionosphere, ISS, Space Station, Spread-F, Electron Density, Temperatures, Conjunctions, Data Verification.

Table 1. Measured azimuth, range, and effective ranges for the FPMU.

<table>
<thead>
<tr>
<th>Sensor Measured</th>
<th>Effective Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scattering Radar</td>
<td>1.5 to 7.5 km</td>
</tr>
<tr>
<td>Ultraviolet Imager</td>
<td>2.5 to 10 km</td>
</tr>
</tbody>
</table>

Table 2. Operation dates of FPMU instrument suite.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPMU</td>
<td>2006/0762</td>
</tr>
<tr>
<td>PIP</td>
<td>2006/0762</td>
</tr>
<tr>
<td>WLP</td>
<td>2007/062</td>
</tr>
<tr>
<td>NLP</td>
<td>2007/062</td>
</tr>
</tbody>
</table>

Figure 1. FPMU layout (Wright et al., 2008)

Figure 2. Typical ISS ground track

Figure 3. Histogram of difference in densities between TIMED GUVI and WLP on 2006/217.

Figure 4. Sample data from each of the FPMU four probes from 2007/062.

Figure 5. Histogram of difference in densities between TIMED GUVI and WLP on 2006/217.

Conjunction area ±15 min, ±12 ° lat, ±12 ° lon and ±25 km.

Figure 6. Histogram of differences in densities between DIAS digisondes and WLP on several days in 2006.

Conjunction area ±30 min, ±12 ° lat, ±12 ° lon and ±75 km.

Figure 7. Histogram of difference in densities between WLP and Millstone Hill ISR and WLP on 2007/062.

Conjunction area ±15 min, ±12 ° lat, ±12 ° lon and ±25 km.

Figure 8. Histogram of difference in densities between Millstone Hill ISR and NLP on 2007/062.

Conjunction area ±15 min, ±12 ° lat, ±12 ° lon and ±25 km.

Figure 9. Several equatorial density holes observed sequentially by the FPMU as observed by TIMED-GUVI during active geomagnetic conditions.

Figure 10. Xp, and austral electrojet indices for March 9, 2008, Day 390.