Decades of Data

Results from a BEDI Project to Create High--Resolution GOES Magnetometer Data

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Presentation Outline

● Uses of GOES MAG Data
● History of GOES 8 through GOES-R Series
  Magnetometer Data
● BEDI Accomplishments
● Further Work
Earth’s Magnetic Field Reacts to Solar Disturbances

93 million miles
Earth’s Magnetic Field Reacts to Solar Disturbances 

Geostationary Orbit 

93 million miles 
(8 minutes light time)
Uses of GOES MAG Data

- Detecting solar wind shocks, which can indicate problems for spacecraft electronics (both single-particle events and dielectric charging)
- Providing the coordinate reference frame for interpreting charged particles (electrons and ions)
- Predicting aurorae
GOES Magnetometer Data -- Recent History

- Spring 1994: First GOES 8-12 Series launched (high res)
- Spring 2006: GOES 13-15 Series launched; operational
- November 2016: GOES-16 launched; operational

<table>
<thead>
<tr>
<th></th>
<th>GOES 8-12</th>
<th>GOES 13-15</th>
<th>GOES R-U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Rate</td>
<td>2 Hz</td>
<td>2 Hz</td>
<td>10 Hz</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>0.5 Hz</td>
<td>0.5 Hz</td>
<td>2.5 Hz</td>
</tr>
<tr>
<td>Boom Length</td>
<td>3 m</td>
<td>8.5 m</td>
<td>8.5 m</td>
</tr>
</tbody>
</table>

The GOES-R series covers more spectral bandwidth, important for studying radiation belt dynamics and creating new operational and research products.
BEDI Accomplishments

- Fuelled rescue of GOES 8-12 high-resolution data from old CDs
- Standardized file formats so files dating back to 1994 use latest formats (netCDF-4) and common variables
- Added new geophysically useful coordinate frames
  - Unified with GOES-R algorithms - e.g., added a new frame that is aligned with Earth’s magnetic field
- Corrected issues introduced by attitude control system
BEDI Accomplishments--Coordinate System Example

EPN -- Classical:
Local spacecraft, pseudo geographic
E: Earthward
P: Poleward
N: Eastward
E x P = N
This is ok, but community desperately needed a magnetic frame

VDH -- New and improved → Aligned with Earth’s Magnetic Field
Earth magnetic field aligned
V: Radial
D: East
H: Dipole North
V x D = H
BEDI Accomplishments--Archive and Access

- First time any GOES 8+ magnetic field data has been archived
- First time GOES 8-12 high resolution data is publicly available
  - Full resolution was previously only useless telemetry on old CDs
  - Spinning disk only offered low resolution files (i.e. averaged magnetic field over time)
- Complete ISO collection-level record created for L2 products
- Archive done via NCEI-NC; to our knowledge, first remote data set to be archived this way.
- Immediate access to the new 20-year archive is provided via spinning disk
GOES-16 Early Light

- **Electrons**
  - T4-0degN
  - 59-855 keV

- **Protons**
  - T2-35degS
  - 100-860 keV

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**B**

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Direction</th>
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<tr>
<td>( B_{\text{radial}} )</td>
<td>radial</td>
</tr>
<tr>
<td>( B_{\text{az}} )</td>
<td>azimuthal</td>
</tr>
</tbody>
</table>

**Dose**

- \( >1.2 \text{ MeV} \)

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1. Magnetic field
2. Protons
3. Electrons

The magnetic field (top) and charged particles are oscillating at same frequency, like particles on a jump rope.

The magnetic field provides the coordinate frame for interpreting electrons and protons.

*Preliminary data – See disclaimer on last slide.*
Further Work

- Create complete documentation
- Peer reviewed journal article (JGR Space Physics)
- Finish data archival, L0 and L1b metadata records
Acknowledgements

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Disclaimer for pre-operational data:

At the time data were taken, NOAA's GOES-16 and GOES-17 satellites had not been declared operational and their data were preliminary and undergoing testing. Users receiving these data through any dissemination means (including, but not limited to, PDA and GRB) assume all risk related to their use of GOES data and NOAA disclaims any and all warranties, whether express or implied, including (without limitation) any implied warranties of merchantability or fitness for a particular purpose.
Backup Slides
GOES Magnetometer Data - Part of the full picture

Space Environment Overview: 1983-01-01 - 2014-12-31

- Sunspot
- Cosmic Rays
- Flares
- Ion Storms
- Geomag. Storm
- B (nT)

Chart: D. Wilkinson
GOES-17 Outboard MAG: First Light

- Plasma waves ride on top of Earth’s main field.
- Plasma waves control the levels of energetic particles that cause damage to satellites and harm astronauts
- Wave frequency is important (bottom panel)
  - Some frequencies accelerate particles to high radiation levels
  - Other frequencies scatter the particles, rendering them less harmful

Preliminary data -- See disclaimer on last slide.