DSCOVR Magnetometer Observations
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Locations of the Instruments

- Omni Antenna
- Faraday Cup
- EPIC
- Star Tracker
- Thruster Modules
- Electron Spectrometer
- Magnetometer
- Digital Sun Sensor
Goddard Fluxgate Magnetometer

The Fluxgate Magnetometer measures the interplanetary vector magnetic field.

It is located at the tip of a 4.0 m boom to minimize the effect of spacecraft fields.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Value</th>
<th>Method</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>0.1-100 nT</td>
<td>Test</td>
<td>0.004-65,500 nT</td>
</tr>
<tr>
<td>Accuracy</td>
<td>+/- 1 nT</td>
<td>Measured</td>
<td>+/- 0.2 nT</td>
</tr>
<tr>
<td>Cadence</td>
<td>1 min</td>
<td>Measured</td>
<td>50 vector/sec</td>
</tr>
</tbody>
</table>
Pre-flight Calibration

• Determined the magnetometer zero levels, scale factors, and magnetometer orthogonalization matrix.

• Determined the spacecraft generated magnetic fields
  – Subsystem level magnetic tests. Reaction wheels, major source of dynamic field, were shielded
  – Spacecraft unpowered magnetic test in the GSFC 40’ magnetic facility
In-Flight Boom Deployment

- Nominal deployment on 2/15/15, seen as 4.4 rotations in the magnetometer components

![Graph showing magnetic field components with annotations.]
Alfven Waves in the Solar Wind

• The solar wind contains magnetic field rotations that preserve the magnitude of the field, so called Alfven waves.

• Alfven waves are ubiquitous and are possible to identify with automated routines.

• Systematic deviations from a constant field magnitude during these waves are an indication of spacecraft induced offsets.

• Minimizing the deviations with slowly changing offsets allows in-flight calibrations.
In-Flight Magnetometer Calibrations

- X axis Roll and Z axis Slew data is consistent with ground calibration estimates.

- Independent zero offset determination by rolls, slews and using solar wind Alfvenicity give consistent values.

- Time variation is consistent with yearly orbital change.

- Resulting magnetic field accuracy since LOI is ~0.2 nT, exceeding requirements.
• Orange curve shows the offset values provided to NOAA SWPC.

• Updates are provided at least monthly or when sudden changes are identified.
Intercalibrations with ACE and Wind

Require spacecraft separation <25 Re.

**ACE – DSCOVR:**
- June 8 – 19, 2015
- Sept 1 – 18, 2015
- Nov 27 – Dec 13, 2015
- Feb 24 – Mar 10, 2016

**Wind – DSCOVR:**
- May 12, 2015
- July 4 – 20, 2015
- Oct 6 – 23, 2015
- Dec 29, 2015 –
  - Jan 3, 2016
- Mar 23 – Apr 6, 2016
Comparison with Wind spacecraft measurements show good agreement. DSCOVR data is in black. The time shifted Wind data (to allow for solar wind propagation) is plotted in red. Small deviations are consistent with spacecraft separation.
Comparison with ACE spacecraft measurements also show good agreement. DSCOVR data is in black. The ACE data in red is not time shifted. Small deviations are consistent with spacecraft separation.

Interplanetary shock jump conditions at the beginning of the day agree as measured by the two spacecraft.
The 2015 Dec 31 – 2016 Jan 1 ICME was measured by both spacecraft with identical values.
DSCOVR Science: Small Structures

- DSCOVR and Wind separated by < 10 Re perpendicular to SW
• Inertial and dissipation ranges of magnetic turbulence
March 17, 2015 IP Shock

- A strong interplanetary shock was observed on March 17, 2015 at 04:05 UT.

- The shock was quasi-perpendicular ($\theta_{Bn} = 61$ deg) and had a fast mode Mach number of $M_f = 3.8$.

- The shock appeared to have textbook jump characteristics.
March 17, 2015 IP Shock

DSCOVR, 04:05:17.16–04:05:20.76, DoY 076, 2015

PSD, 04:05:17.16–04:05:20.76, DoY 076, 2015
March 17, 2015 IP Shock

- $2.0 \, \text{Hz} < f < 3.5 \, \text{Hz}$

\[ \lambda_{\text{INT}}/\lambda_{\text{MIN}} = 113.7 \]
\[ \lambda_{\text{MAX}}/\lambda_{\text{INT}} = 1.3 \]

\[ \theta_{\text{Bk}} = 17 \, \text{deg.} \]
\[ \theta_{\text{nk}} = 39 \, \text{deg.} \]
The same interplanetary shock was observed by DSCOVR and by the Russian Spektr-R mission.

The Czech BMSW instrument on Spektr-R provides 32 ms resolution solar wind flux measurements.

DSCOVR provide 50 vectors/sec (20 ms) magnetic field data.

Even though the spacecraft are separated by more than 100 Re, they observe the same frequency waves downstream of the shock.
Conclusions

• DSCOVR magnetometer data exceeds the Level 1 science requirements

• Unprecedented high-time resolution measurements already yielding new science results
  – Small spatial scale solar wind structures
  – Energy cascade and dissipation in the solar wind
  – Wave-particle interaction near interplanetary shocks

• Future DSCOVR studies will directly support Solar Probe Plus and Solar Orbiter inner heliospheric science objectives

• Once DSCOVR becomes NOAA’s primary space weather monitor, continuous data will be available through NOAA's National Centers for Environmental Information (NCEI)