Coordination Group for Meteorological Satellites

• CGMS - is the group for global coordination of meteorological satellite systems.
  • Includes protection of in orbit assets, contingency planning, improvement of quality of data, support to users, facilitation of shared data access and development of the use of satellite products in key application areas.
  • Coordination is pursued from an end-to-end perspective between meteorological satellite operators and user communities such as WMO, IOC-UNESCO and others.

• High-level space weather goals:
  • Improve the near-real-time access to and global exchange of space weather data from instruments on meteorological satellites
  • Identify baseline space-based space weather observational system for the WMO 2040 vision for global observing system
  • Establish coordinated spacecraft anomaly reporting
  • Evaluate operational space weather products in support of CGMS spacecraft operations, and recommend needed services
2018 CGMS Space Weather Update

- **New Terms of Reference for Space Weather.** Approved by the Plenary and now be called the Space Weather Coordination Group giving this group permanent status for the first time.

- **CGMS Baseline and Contingency Plan.** The updated Baseline and Contingency Plan were approved by the Plenary. The Baseline now designed to reflect the commitments of CGMS Members and captures space weather observations and measurements for the first time.

- Space Weather Calibration

- Space Weather Anomalies
## Current and Planned Capability

<table>
<thead>
<tr>
<th>Capability</th>
<th>Orbit</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>25</th>
<th>26</th>
<th>27</th>
<th>28</th>
<th>29</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solar Disc Imaging</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Disc Imaging</td>
<td>L1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Disc Imaging</td>
<td>1AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Disc Imaging</td>
<td>GEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Disc Imaging</td>
<td>LEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coronal Mass Ejection Imaging</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronal Mass Ejection Imaging</td>
<td>L1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronal Mass Ejection Imaging</td>
<td>1AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronal Mass Ejection Imaging</td>
<td>GEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronal Mass Ejection Imaging</td>
<td>LEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Magnetic Field</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic Field</td>
<td>L1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic Field</td>
<td>1AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic Field</td>
<td>GEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic Field</td>
<td>LEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Solar Wind</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Wind</td>
<td>L1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Wind</td>
<td>1AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Wind</td>
<td>GEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Wind</td>
<td>LEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Energetic Particles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energetic Particles</td>
<td>L1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energetic Particles</td>
<td>1AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energetic Particles</td>
<td>GEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energetic Particles</td>
<td>LEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ionospheric Conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ionospheric Conditions</td>
<td>L1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ionospheric Conditions</td>
<td>1AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ionospheric Conditions</td>
<td>GEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ionospheric Conditions</td>
<td>LEO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Observations and Measurements

- **Low-Earth Orbit**: In-situ measurements provided by instruments on LEO satellites, and GNSS radio occultation measurements providing total electron content, produce the current state of ionosphere.

- **Geostationary Orbit**: In-situ measurements of the space environment and the magnetic field of the magnetosphere provide advanced warning of space weather events. Imaging of the Sun in the x-ray and ultraviolet bands allow detection of solar flares, which supports forecasting; Coronagraph imaging of the Sun for CMEs provides 1-4 day advanced warning of geomagnetic storms.

- **L1**: In-situ measurement of the solar wind speed and magnetic field provides 15-60 minutes of advanced warning of arrival at Earth; Coronagraph imaging of the Sun for CMEs provides 1-4 day advanced warning of geomagnetic storms.

- **L5**: Enhanced performance may be obtained by a potential ESA L5 mission that support forecasting and complementary measurements by providing an “off-axis” view of the Sun. Mission gives visibility of the propagation of plasma clouds from the Sun towards Earth as well as view of the solar disk before it rotates into view from Earth.
CCOR: NOAA’s first operational coronagraph

Presently using NASA/ESA SOHO CME images to define the inner boundary of the CME propagation code WSA/Enlil (1-4 day warnings of Earth arrival)

CCOR Optical Testbed- Initial Illumination Test
CCOR In Phase B; NRL Preliminary Design Review 9/28/18
Possible deployment on GOES U 2024
Current GOES-R Configuration

Area for CCOR
NOAA Space Weather Follow On Plan Summary

• Establish and sustain a foundational set of space-based observations and measurements (i.e., CME imaging and solar wind measurements)

• Ensure continuity of critical data
  • Complete the Compact Coronagraph (CCOR) with Naval Research Laboratory (NRL) as NOAA partner project.
  • Host CCOR on the GOES-U spacecraft planned for launch in early 2024
  • Establish new acquisition of Space Weather Instrument Suite (SWIS)
  • Establish new acquisition of NOAA spacecraft and NOAA/NASA partnership for launch rideshare to L1 with NASA’s Interstellar Mapping and Acceleration Probe (IMAP) late 2024. NOAA L1 spacecraft will have SWIS, CCOR and instruments of opportunity
  • NOAA Satellite Observing System Architecture (NSOSA) calls for sustained Space Weather in-situ and CME capability

• Maintain archives for space-based data which are essential for model development and benchmarking
DOC Space Traffic Management

- **Space Policy Directive-3**: “Department of Commerce should be the new civil agency interface for space traffic management (STM) and space situational awareness (SSA)”

- Space Weather situational awareness is critical when assessing the natural environment occupied by the increasing government and commercial space activity, which will soon include space tourism

- Space weather services contribute to the following goals of STM:
  - Mitigate the effect of orbital debris on space activities (actionable collision avoidance warnings require space weather information)
  - Encourage and facilitate U.S. commercial leadership in S&T, SSA, and STM
  - Provide U.S. Government-supported basic SSA data and basic STM services to the public
  - Improve SSA data interoperability and enable greater SSA data sharing
Space Weather

Space Weather: The impact of solar wind and solar storms on Earth’s environment

Causes of space weather:
• Radio and X-Ray flux
• Coronal Mass Ejection (CME)
• Variation in Solar Wind

Impact of Space Weather:
• Navigation and timing interference (including GPS)
• Geomagnetically induced currents in electric power grid, rail systems, and pipelines
• Satellite drag, interference, and degradation
• Radiation exposure to astronauts and to passengers and crew in aircraft
Department of Commerce, through NOAA, provides 24/7 space weather services for the Nation.

NOAA Space Weather Warnings are based on the NOAA Space Weather Scales:

**Geomagnetic Storms (G-scale)**
(Magnetic field)

**Solar Radiation Storms (S-scale)**
(Energetic charged particles)

**Radio Blackouts (R-scale)**
( Electromagnetic radiation)

DoD services provided by USAF 557th Weather Wing at Offutt AFB, NE.
Uses of Space Weather Products

Space Operations
- Postpone launch of satellite
- Turn off/safe instruments and/or spacecraft in orbit

Electric Power Grid
- Adjust/reduce system load
- Disconnect components
- Postpone maintenance

Airlines
- Divert polar flights
- Change altitude

GPS/Navigation
- Postpone activities
- Redo survey
- Use backup systems