The GOES-R Series:

The Nation’s Next Generation Geostationary Weather Satellites

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GOES-R Assistant System Program Director

32nd Space Symposium
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Colorado Springs, Colorado
A History of GOES Weather Satellites

40 Years of Geostationary Operational Environmental Satellites (GOES) Satellites (GOES-1 Launched Oct, 1975)
Why GOES-R?

The GOES-R series will provide significant improvements in the detection and observations of meteorological phenomena that directly impact public safety, protection of property, and our Nation’s economic health and prosperity.

Visible & IR Imagery  Lightning Mapping  Space Weather Monitoring  Solar Imaging

ABI  GLM  SEISS and MAG  EXIS and SUVI
GOES-R Spacecraft

- Extreme Ultraviolet and X-Ray Irradiance Sensor (EXIS)
- Space Environment In Situ Suite (SEISS)
- Magnetometer
- Advanced Baseline Imager (ABI)
- Geostationary Lightning Mapper (GLM)
- Solar Ultraviolet Imager (SUVI)
Advanced Baseline Imager (ABI)

- Primary instrument in GOES-R series
- 16 channel imager
- Measures radiances in the visible and near-infrared wavelengths
- Improves upon current capabilities in spectral information (3X), spatial coverage (4X), and temporal resolution (5X)
Three X More Spectral Information

GOES-13/14/15 Spectral Bands

GOES-R Spectral Bands

0.47 μm, 0.64 μm, 0.86 μm, 1.38 μm

1.61 μm, 2.26 μm, 3.9 μm, 6.19 μm

6.98 μm, 7.34 μm, 8.5 μm, 9.61 μm

10.38 μm, 11.2 μm, 12.3 μm, 13.3 μm
- Scan Mode 4: Full disk every 5 minutes
- Scan Mode 3: Full disk images every 15 minutes + 5 min CONUS images + 30 sec mesoscale

Forecasters can monitor the interactions between air masses, outflow boundaries and storms leading to increased situational awareness and confidence.
Geostationary Lightning Mapper (GLM)

Specifications

• Detects total lightning activity across the Western Hemisphere: in cloud, cloud-to-cloud, and cloud-to-ground
  ― Provides coverage over oceans and land
  ― Complements today’s land based systems that only measures cloud to ground (~15% of the total lightning)

• Improved forecaster situational awareness and confidence resulting in more accurate severe storm warnings (improved lead time, reduced false alarms) to save lives and property
Living with a star can be dangerous!
**Extreme Ultraviolet and X-ray Irradiance Sensors (EXIS)**

EXIS has two sensors to measure solar radiation:

- **Extreme Ultraviolet Sensor (EUVS):**
  monitors solar variations that affect satellite drag, and ionospheric changes impacting communication and navigation operations

- **X-Ray Sensor (XRS):**
  detects the beginning, duration, and magnitude of solar X-ray flares

Provides improved solar flare warnings for communications and navigation disruption

Provides input to models predicting severe impacts on satellites, astronauts, and airline passengers on polar routes, and provides input on possible impacts to power grid performance
• Improved detection of coronal holes, flares and coronal mass ejection source regions
• Improved geomagnetic storm forecasting
• Increased dynamic range, resolution, and sensitivity in monitoring solar x-ray flux

GOES-13 Solar X-Ray Imager: Current Capability

Future Capability: GOES-R Solar UltraViolet Imager (using Solar Dynamics Observatory data)
Space Environment in-Situ Sensor Suite (SEISS)

- SEISS consists of energetic particle sensors to monitor proton, electron and alpha particle fluxes to provide:
  - More accurate monitoring of energetic particles responsible for radiation hazards to humans and spacecraft
  - Better monitoring of low energy ionizing responsible for spacecraft charging
  - Improved warning of high flux events, mitigating damage to radio communication
Magnetometer

• The magnetometer measures the magnitude and direction of Earth's ambient magnetic field.

• Will provide the only operational measure of the impact of geomagnetic storms at geosynchronous orbit (key for interpreting solar radiation storm measurements by SEISS).

• Provides automated Magnetopause Crossing Detection and automated Sudden Impulse Detection.
GOES-R Unique Payload Services

- **Search and Rescue Satellite Aided Tracking (SARSAT)**
  - Relay distress signals from 406 MHz emergency beacons
- **Information Network (HRIT/EMWIN)**
  - Emergency Managers Weather Information Network services
  - Delivers selected imagery, charts, data products, and text messages (NWS Watches and Warnings) to users throughout western hemisphere.
- **Data Collection System (DCS)**
  - Relays data transmissions from over 20,000 in situ environmental data platforms from across the hemisphere
- **GOES-R Rebroadcast (GRB)**
  - Data from each of the GOES-R series instruments is processed on the ground, then bounced back through GOES-R satellites to users throughout the hemisphere.
GOES-R Integration
Assembled GOES-R Spacecraft
Flight Segment Progress

• GOES-R has completed thermal vacuum, mechanical, and acoustic testing

• GOES-S:
  • All instruments delivered; EXIS and SUVI installed on the sun-pointing platform
  • System Integration Review completed December 2–3
  • Module mate completed December 21
  • ABI and GLM mechanically integrated
Ground Segment Progress

- All GOES-R antennas at NOAA Satellite Operations Facility are complete
- W-1 and W-2 antennas at Wallops are ready to support current GOES and future GOES-R operations
- W-3 footing being installed for antenna construction
- R-1, R-2, and R-3 antennas at the Consolidated Backup completed System Certification Reviews
  - Five of six GOES-R antennas are ready to support launch
- Installation and checkout of all GOES-R & GOES-S processing & distribution hardware completed
- More than 75% of requirements verification complete
Operations Readiness

- End-to-End Testing:
  - ETE1a: Aug. 4, 2014
  - ETE1b: Apr. 15, 2015
  - ETE2: June 2, 2015
  - ETE3: July 28, 2015
  - ETE4a: Nov. 18–20, 2015
  - ETE4b: Apr-May, 2016

- Data Operations Exercises:
  - DOE 0: Nov. 1–4, 2014
  - DOE 1&2: June 15–30, 2015
  - DOE 4: Jul-Aug, 2016

- Ground Readiness Exercises
  - #1: Oct.5–Nov. 11, 2015
  - #2: Jan-Feb, 2016
  - #3: May-Jun, 2016
  - #4: Sep-Oct, 2016

- GOES-R Flight Operations Review Nov. 2–6, 2015
GOES-R: LAUNCHING OCTOBER 2016
Post-Launch Testing and Validation

- Launch: October 2016
- Launch and orbit raising: 14 days
- Post-launch checkout: 6 months post-LOR
- GOES-16 extended validation: 6 months post-PLT
- GOES-16 operational: after validation period at TBD orbit location
Training and User Education Materials

www.goes-r.gov

Online Training
• http://www.goes-r.gov/users/training.html (COMET, SPoRT, VISIT, WMO)

Printed Materials
• ABI Bands Quick Information Guides: http://www.goes-r.gov/education/ABI-bands-quick-info.html
• GOES-R Fact Sheets
• User Readiness Plan
• GRB Downlink Specifications and Product Users’ Guides
• Proving Ground Demonstration Final Reports and Annual Reports

Sample Data
• http://www.goes-r.gov/products/samples.html
Thank you!

For more information visit www.goes-r.gov

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# GOES-R Series Products

## L1b Products

<table>
<thead>
<tr>
<th>Radiances*</th>
<th>Cloud and Moisture Imagery (KPP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Imagery: EUV*</td>
<td>Rainfall Rate / QPE</td>
</tr>
<tr>
<td>Energetic Heavy Ions*</td>
<td>Legacy Vertical Moisture Profile</td>
</tr>
<tr>
<td>Magnetospheric Electrons and Protons: Low Energy*</td>
<td>Legacy Vertical Temperature Profile</td>
</tr>
<tr>
<td>Magnetospheric Electrons and Protons: Medium and High Energy*</td>
<td>Derived Stability Indices</td>
</tr>
<tr>
<td>Solar and Galactic Protons*</td>
<td>Total Precipitable Water</td>
</tr>
<tr>
<td>Geomagnetic Field*</td>
<td>Clear Sky Masks</td>
</tr>
<tr>
<td>Solar Flux: EUV*</td>
<td>Downward Shortwave Rad.: Surface</td>
</tr>
<tr>
<td>Solar Flux: X-Ray*</td>
<td>Fire / Hot Spot Characterization</td>
</tr>
<tr>
<td>Lightning Det: Events, Groups, Flashes*</td>
<td>Land Surface (Skin) Temperature</td>
</tr>
<tr>
<td>Aerosol Detection (including Smoke &amp; Dust)</td>
<td>Sea Surface Temperature (skin)</td>
</tr>
<tr>
<td>Aerosol Optical Depth</td>
<td>Reflected Shortwave Rad.: TOA</td>
</tr>
<tr>
<td>Volcanic Ash: Detection &amp; Height</td>
<td>Snow Cover</td>
</tr>
<tr>
<td>Cloud Optical Depth</td>
<td>Derived Motion Winds</td>
</tr>
<tr>
<td>Cloud Particle Size Distribution</td>
<td>Hurricane Intensity</td>
</tr>
<tr>
<td>Cloud Top Phase</td>
<td>Cloud Top Pressure</td>
</tr>
<tr>
<td>Cloud Top Height</td>
<td>Cloud Top Temperature</td>
</tr>
</tbody>
</table>

## Key Performance Parameter (KPP)

<table>
<thead>
<tr>
<th>Key</th>
<th>Performance Parameter</th>
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<tbody>
<tr>
<td>ABI</td>
<td>GLM</td>
</tr>
<tr>
<td>SEISS</td>
<td>EXIS</td>
</tr>
<tr>
<td>SUVI</td>
<td>Magnetometer</td>
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</tbody>
</table>

* Included in GRB

## L2+ Products

L2+ Products are remainder outside of oval.
### ABI Visible/Near-Infrared Bands

<table>
<thead>
<tr>
<th>Future GOES imager (ABI) band</th>
<th>Wavelength range (µm)</th>
<th>Central wavelength (µm)</th>
<th>Nominal subsatellite IGFOV (km)</th>
<th>Sample use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.45–0.49</td>
<td>0.47</td>
<td>1</td>
<td>Daytime aerosol over land, coastal water mapping</td>
</tr>
<tr>
<td>2</td>
<td>0.59–0.69</td>
<td>0.64</td>
<td>0.5</td>
<td>Daytime clouds fog, insulation, winds</td>
</tr>
<tr>
<td>3</td>
<td>0.846–0.885</td>
<td>0.865</td>
<td>1</td>
<td>Daytime vegetation/burn scar and aerosol over water, winds</td>
</tr>
<tr>
<td>4</td>
<td>1.371–1.386</td>
<td>1.378</td>
<td>2</td>
<td>Daytime cirrus cloud</td>
</tr>
<tr>
<td>5</td>
<td>1.58–1.64</td>
<td>1.61</td>
<td>1</td>
<td>Daytime cloud-top phase and particle size, snow</td>
</tr>
<tr>
<td>6</td>
<td>2.225–2.275</td>
<td>2.25</td>
<td>2</td>
<td>Daytime land/cloud properties, particle size, vegetation, snow</td>
</tr>
</tbody>
</table>

Schmit et al, 2005
# ABI Infrared Bands

<table>
<thead>
<tr>
<th>Band</th>
<th>Center Wavelength (μm)</th>
<th>Equivalent Wavelength (μm)</th>
<th>Resolution (km)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>3.80–4.00</td>
<td>3.90</td>
<td>2</td>
<td>Surface and cloud, fog at night, fire, winds</td>
</tr>
<tr>
<td>8</td>
<td>5.77–6.6</td>
<td>6.19</td>
<td>2</td>
<td>High-level atmospheric water vapor, winds, rainfall</td>
</tr>
<tr>
<td>9</td>
<td>6.75–7.15</td>
<td>6.95</td>
<td>2</td>
<td>Midlevel atmospheric water vapor, winds, rainfall</td>
</tr>
<tr>
<td>10</td>
<td>7.24–7.44</td>
<td>7.34</td>
<td>2</td>
<td>Lower-level water vapor, winds, and $\text{SO}_2$</td>
</tr>
<tr>
<td>11</td>
<td>8.3–8.7</td>
<td>8.5</td>
<td>2</td>
<td>Total water for stability, cloud phase, dust, $\text{SO}_2$, rainfall</td>
</tr>
<tr>
<td>12</td>
<td>9.42–9.8</td>
<td>9.61</td>
<td>2</td>
<td>Total ozone, turbulence, and winds</td>
</tr>
<tr>
<td>13</td>
<td>10.1–10.6</td>
<td>10.35</td>
<td>2</td>
<td>Surface and cloud</td>
</tr>
<tr>
<td>14</td>
<td>10.8–11.6</td>
<td>11.2</td>
<td>2</td>
<td>Imagery, SST, clouds, rainfall</td>
</tr>
<tr>
<td>15</td>
<td>11.8–12.8</td>
<td>12.3</td>
<td>2</td>
<td>Total water, ash, and SST</td>
</tr>
<tr>
<td>16</td>
<td>13.0–13.6</td>
<td>13.3</td>
<td>2</td>
<td>Air temperature, cloud heights and amounts</td>
</tr>
</tbody>
</table>

Schmit et al, 2005