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# GOES-R Baseline Instruments


James J. Gurka
NOAA/NESDIS GOES-R Program Office, GSFC, Greenbelt, Maryland

Timothy J. Schmit
NOAA/NESDIS, STAR, Madison, Wisconsin


## 1. INTRODUCTION

Since the launch of the GOES-8 in April of 1994, the current series of Geostationary Operational Environmental Satellites (GOES) has performed well, providing nearly uninterrupted coverage of the earth's environment and near earth space environment. In order to meet the more demanding future user requirements the instruments on GOES-R, scheduled for a 2015 launch include an Advanced Baseline Imager (ABI), a Geostationary Lightning Mapper (GLM), and advanced space and solar observing instruments. The GOES-R instruments will monitor a wide range of phenomena, including applications relating to: weather, climate, ocean, land, cryosphere, hazards, solar and space with much improved spatial and temporal resolution. Prior to the GOES-R Series GOES-N (-13), O, and P will also offer some significant improvements over the current GOES satellites. The information from the GOES-R series can be combined for a better depiction of the current state of the earth-atmosphere. This should allow for greatly improved communication and visualizations including products from the ABI and GLM with high temporal and spatial resolution.

## 2. GOES I-P Imager

The GOES I-M series and N-P series imagers have 1 visible channel and 4 Infrared channels. The visible channel with a central wavelength of 0.65 µm has a spatial resolution of 1 km. The infrared channels have wavelengths ranging from 3.9 µm to 13.3 µm. As of June 2009, GOES-11 was the operational west satellite (135 W); GOES 12 was the operational east satellite (75 W); GOES 13 was the spare (105 W); and GOES 10 was providing South American coverage (60 W).


*Corresponding author address*: James Gurka, NOAA/ GSFC GOES-R Code 417 Bldg 6, Greenbelt MD 20771; e-mail: James.Gurka@noaa.gov


The instruments on the I-M series are very similar to those on the N-P except for improved spatial resolution of the 13.3 µm channel on GOES O and P. The new spacecraft bus on the N-P series provides several improvements over the earlier series: the improved batteries eliminate the loss of data during the spring and fall eclipse periods; the use of onboard star trackers provides much improved navigation; and the data are less noisy due to colder detector temperatures (Hillger and Schmit, 2007).

### 3.1 GOES-R Advanced Baseline Imager (ABI)

While the GOES N-P series provides some significant improvements, the changes are relatively small compared to the major changes coming with the GOES-R series, no earlier than 2015. Every imager product currently produced will be improved and there will be a host of new products available. The ABI will be 5 times faster than the current imager and will provide more than 3 times the spectral channels with a four-fold improvement in spatial resolution. A comparison of the capabilities of the GOES I-M series to the GOES N-P series to the GOES-R series is summarized in table 1.

| Performance Capability | GOES I-M | GOES N-P | GOES R |
|---|---|---|---|
| Imaging | | | |
| Visible Resolution | 1 km | 1 km | 0.5 km |
| IR Resolution | 4-8 km | 4-8 km N<br>4 km O/P | 1-2 km |
| Full Disk Coverage Rate | 30 min | 30 min | 5 min |
| # of Channels | 5 | 5 | 16 |
| Solar Monitoring | GOES-M only | Yes | Yes |
| Lightning Detection | No | No | Yes (8km) |
| Operate through Eclipse | No | Yes | Yes |
| Ground System Backup | Limited | Limited | Limited |
| Archive and Access | Limited | Limited | Yes |
| Raw Data Volume per spacecraft | 2.6 Mbps | 2.6 Mbps | 75 Mbps |

Table 1. Comparison of the GOES Series Capabilities

The ABI channels include 2 visible bands, 4 near IR (infrared) channels and 10 IR channels. The visible bands are centered at 0.47 µm, and 0.64 µm. Examples of applications in these bands include daytime aerosols over land and coastal water mapping (0.47 µm); and daytime clouds and fog, insolation and winds (0.64 µm). The near IR bands and sample applications include, 0.865 µm: daytime vegetation/ burn scars, aerosols over water, and winds; 1.378 µm: daytime cirrus clouds; 1.61 µm: daytime cloud-top phase and particle size, and snow; and 2.25 µm: daytime land/cloud properties, cloud particle size, vegetation, and snow. The IR bands and sample applications include, 3.90 µm: surface and clouds, fog at night, fires, and winds; 6.19 µm: high-level atmospheric water vapor, winds, and rainfall; 6.95 µm: mid-level atmospheric water vapor, winds, and rainfall; 7.34 µm: lower-level water vapor, winds and sulfur dioxide (Ackerman et al 2008); 8.50 µm: total column water vapor for stability, cloud phase, dust (Li et al 2007), sulfur dioxide, and rainfall; 9.61 µm: total ozone, turbulence, and winds; 10.35 µm: surface and clouds; 11.2 µm: imagery, sea surface temperatures, clouds, and rainfall; 12.3 µm: total column water vapor, ash and sea surface temperatures; 13.3 µm: air temperature (Schmit et al 2008), cloud heights and amounts. For more details on the ABI channels and their applications, see Schmit et al (2005, 2009).

See figure 1 for an example of the improved spatial resolution of the ABI over the current GOES imager. MODIS imagery is used a proxy for the ABI product. Figure 2 shows a comparison of the resolution of the fog and low cloud product in GOES-10 (4 km) versus a proxy ABI product from MODIS.

The 16 channels on ABI provides almost limitless possibilities of image combinations to enhance features of interest (Hillger 2008). Figure 3 shows MODIS images of smoke from brush fires over the Los Angeles basin. The image on the left is true (or 'natural') color, produced from the combination of the blue, red, and green channels. While ABI will have a blue and a red channel, it will not have a green channel. However, Miller (2009) and Hillger (personal communication) have shown that a look-up table generated from the red and near IR channels can be used to simulate the green channel and thus provide a reasonable approximation to a true color image. Initial results show that these pseudo true color images, that can be produced from ABI channels are very close to reality over land, but over water there are some significant differences.

Figure 4 shows a red, green, blue (RGB) multi-channel combination image from Meteosat Second Generation (MSG) highlighting blowing dust over Africa.

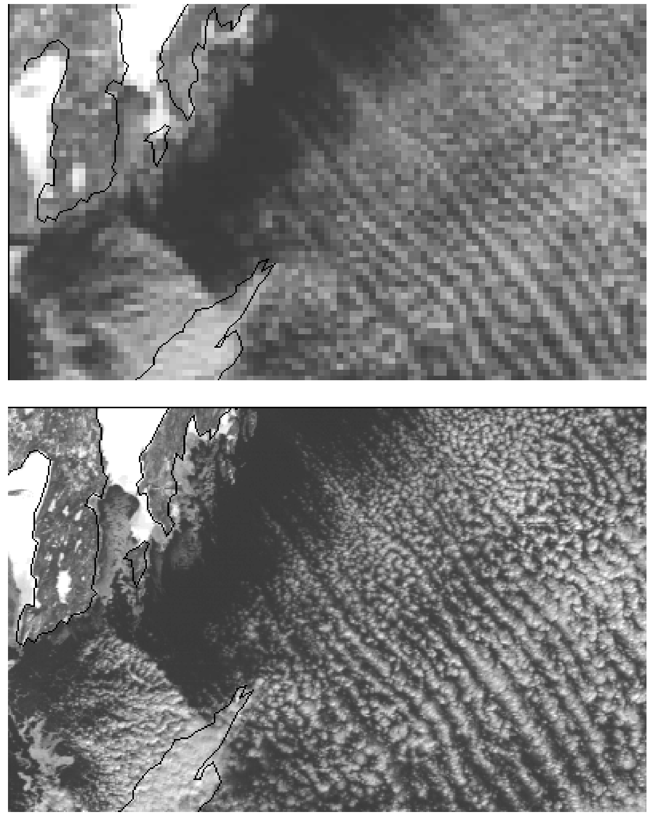

Fig. 1. Lake effect cloud bands over Lake Superior at 1720 UTC 19 jan 2001 in MODIS visible band (bottom) at 0.5 km spatial resolution, compared to GOES-East (top) at 1.0 km spatial resolution.

**3.2 Geostationary Lightning Mapper (GLM)**

The new GOES-R Geostationary Lightning Mapper (GLM) on the GOES-R Series is a single channel, near-IR transient detector that will continuously measure total lightning activity with near-uniform spatial resolution of 8-12 km over the full-disk. The GLM will detect total lightning flash rate and changes in flash rate over both land and water. Total lightning activity is related to the updraft strength and the amount of ice in the mixed phase region of thunderstorms. By monitoring lightning frequency, one can infer storm kinematics and microphysical structure and, therefore, changes in storm severity. Also, while land-based lightning detection networks typically provide limited coverage over ocean areas, the GLM will provide widespread coverage over the Atlantic and Pacific for more efficient flight route planning and significant fuel cost savings.

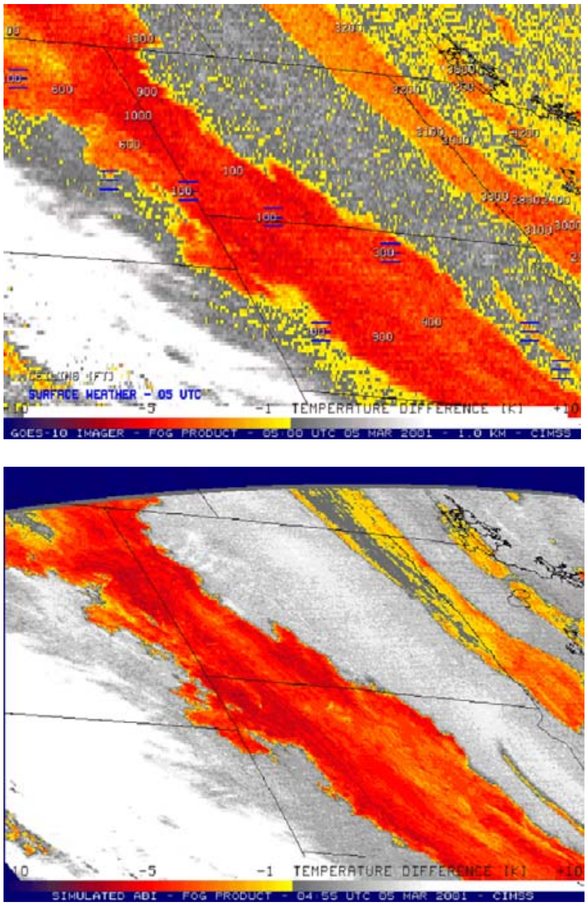


Fig. 2 Fog detection with 4-11 µm for the simulated ABI (bottom) and the GOES-10 Imager (top). Both images are from 5 Mar 2001. Note the better depiction of the fog (orange) in the simulated ABI image.

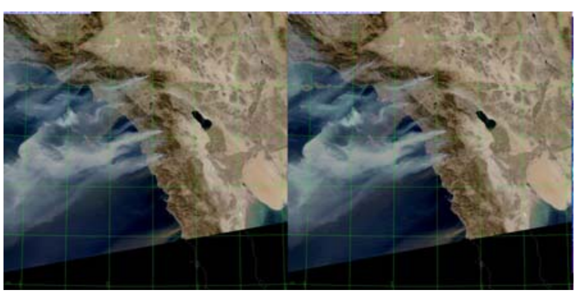

Fig. 3. MODIS images of Smoke from fires near Los Angeles. True color image on left. Simulated true color from visible and near IR on right.

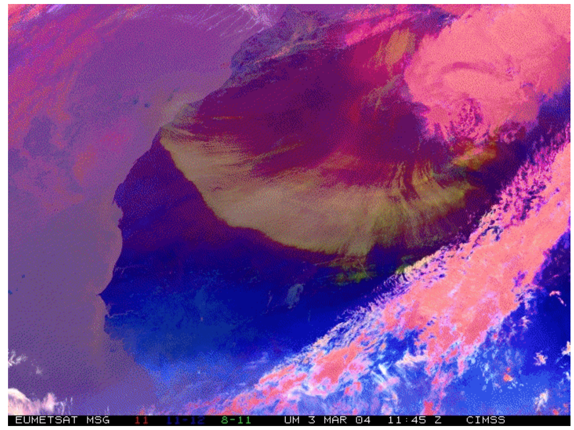


Fig. 4 MSG multi-channel image showing a large areo of blowing dust over Africa.

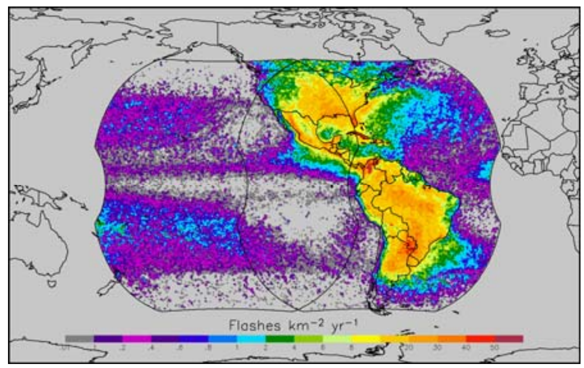


Fig. 5 Coverage area from GOES-R and GOES-S GLM with lightning climatology

Figure 5 shows the combined lightning climatology from the lightning Imaging Sensor (LIS) and the Optical Transient Detector (OTD) from 1997 through 2005 over the coverage area for the GLM from GOES-R and GOES-S. The GLM will offer Broadcasters a rich new source of information to use in combination with the high spatial and temporal resolution imager data and radar data to alert the public of hazardous weather events.

### 3.3 Space Weather Instruments

According to NOAA's Space Weather Prediction Center (SWPC), space weather refers to the conditions in space that affect Earth and its technological systems. Space weather is a consequence of the behavior of the Sun, the nature of Earth's magnetic field and atmosphere, and our location in the solar system. As our society becomes more dependent on electronic systems, telecommunications and navigation systems, such as LORAN and GPS, and as space travel and the number of trans-polar flights increase, an awareness of Space Weather continues to grow in importance. The instruments on the GOES-R series to help observe space weather include: The Space Environment in-situ Suite (SEISS), for detecting energetic particles, the Solar Ultra Violet Imager (SUVI), for observing activity on the sun, and the Extreme Ultraviolet and X-ray Irradiance Sensor.

## 4. SUMMARY

For the Broadcast Community, the advent of the GOES-R era offers the potential of a host of new visually appealing products to help the public better understand rapidly changing hazardous weather (and other) events. The rapid refresh rate of the ABI and the GLM will provide more timely information and show a smooth transition of rapidly changing cloud systems. The four-fold improvement in spatial resolution will provide more visually appealing imagery with greater scientific value. The 0.5 km resolution of the 0.64 µm visible channel will approach the "neighborhood scale" for cloud observations. There will be more channels for a host of new products, including near true color imagery, and channel combination RGB products to highlight dust, aerosols, air quality, cloud properties, cloud versus snow etc. A totally new instrument on GOES-R, the Geostationary Lightning Mapper (GLM) will provide a new warning tool that will be ideal for using in conjunction with the ABI and radar data. While the GOES-R Series holds great promise for improving our ability to provide better short-range forecasts and to communicate that message to the public, it also holds challenges in preparing for a fire hose of data. The data rate for the GOES-R series will be close to 40 times the rate of the current GOES series. To effectively tap into the GOES-R potential, effective advanced planning and budgeting is essential to ensure that communications and display systems are in place to use the new products prior to launch.

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## 6. ACKNOWLEDGEMENTS

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