GOES N, O, P
Pre-launch Overview

Timothy J. Schmit

NOAA/NESDIS/ORA

Advanced Satellite Products Team (ASPT)

Madison, WI

and many others

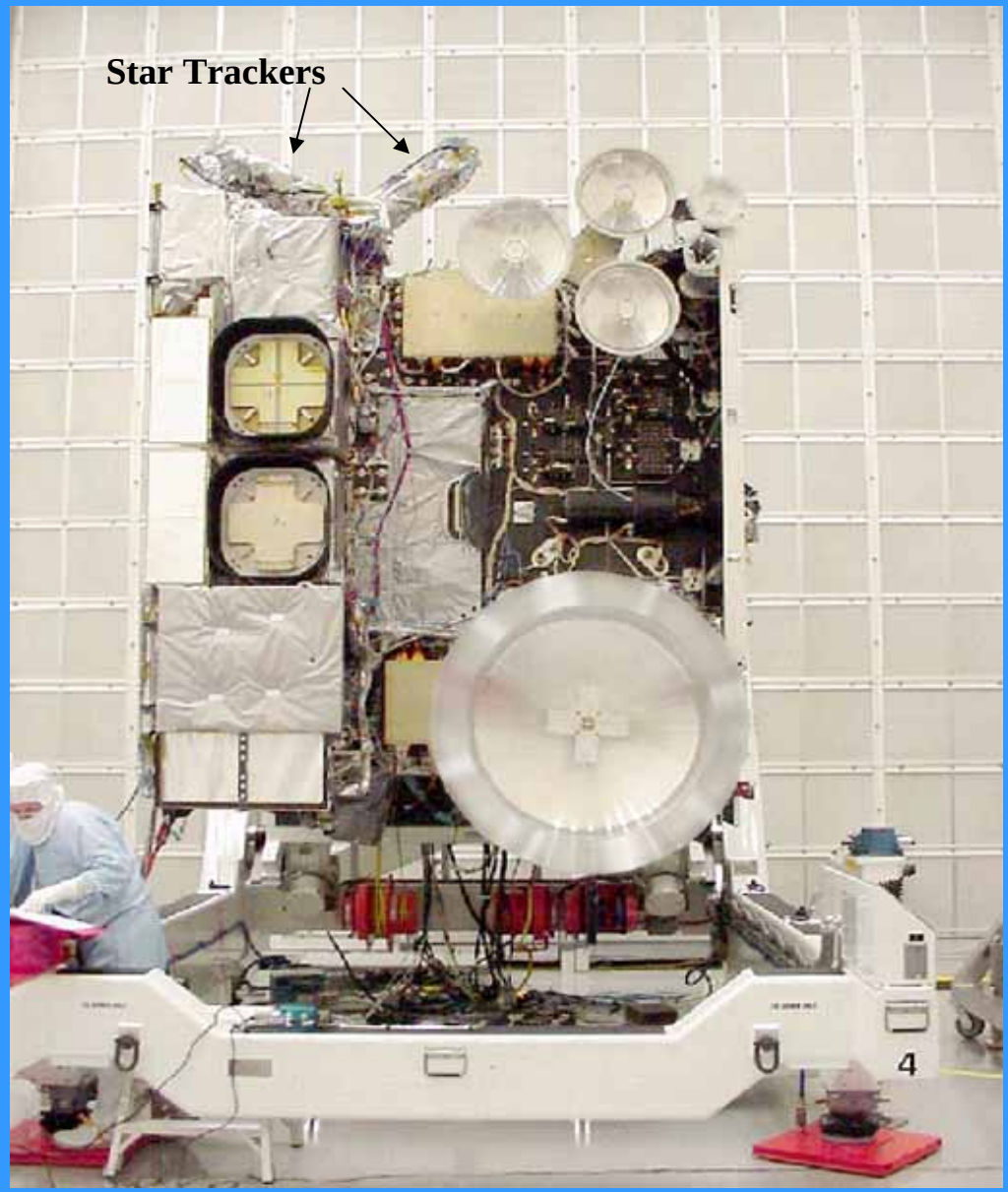
MUG Meeting
Madison, WI
October 2005

UW-Madison

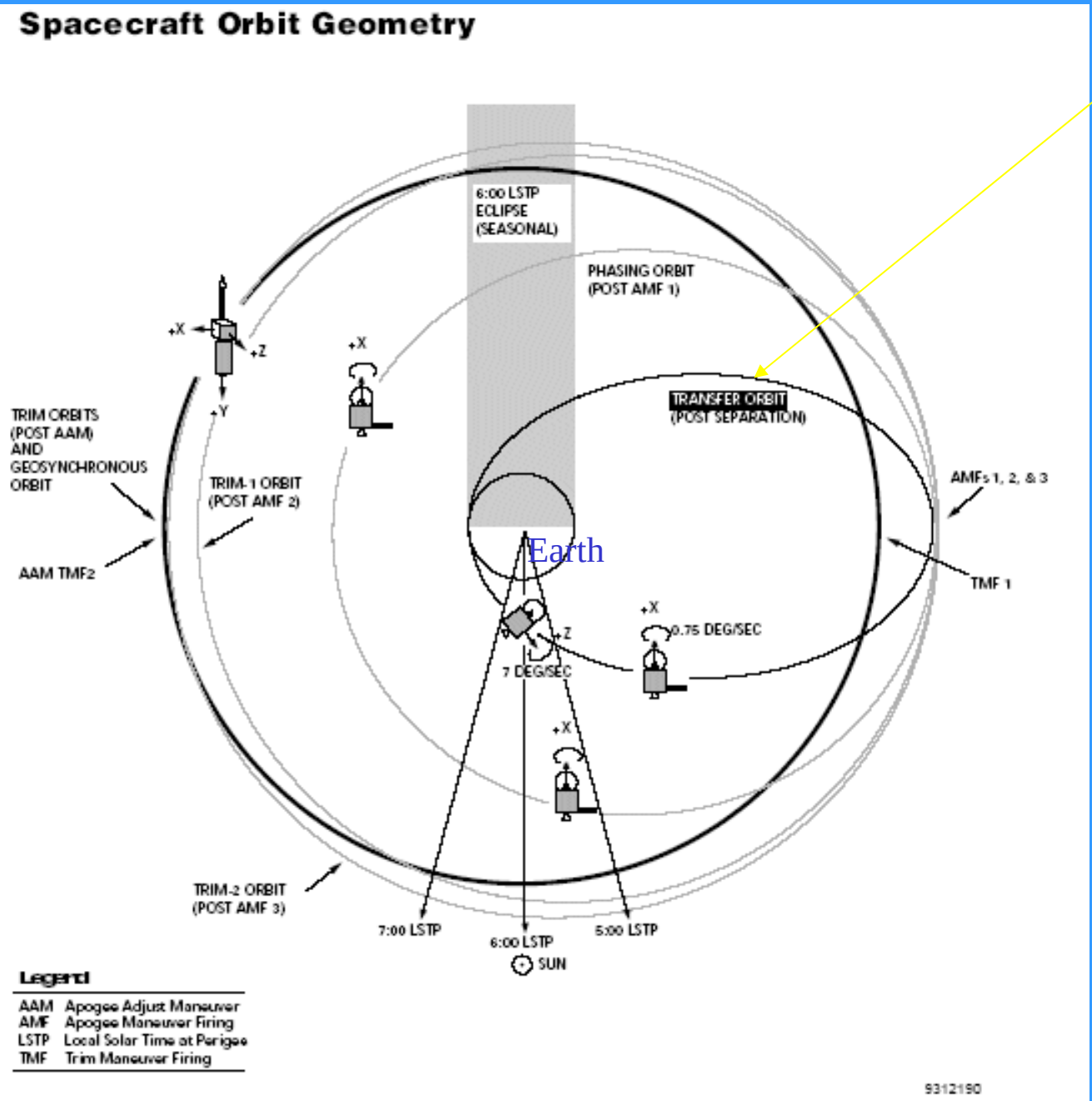
Subject Matter Experts

Tom Wrublewski, NOAA Liaison Office
Steve Kirkner, GOES Program Office
Mat Gunshor, CIMSS
Scott Bachmeier, CIMSS
Ed Miller, NOAA Liaison Office
Mike Weinreb, General Dynamics Advanced Information Systems
Sandy Ashton, Swales
Fred Wu, NOAA/NESDIS/ORA
Tim Walsh, NOAA/NESDIS/OSD
Don Hillger, NOAA/NESDIS/ORA
Tony Schreiner, CIMSS
SXI Group
GOES-N,O,P Booklet
Etc.

GOES-N Spacecraft



Images from NASA



Highly elliptical supersynchronous orbit;

48,789 km (30,316 miles) apogee radius;

6545 km (4067 miles) perigee.

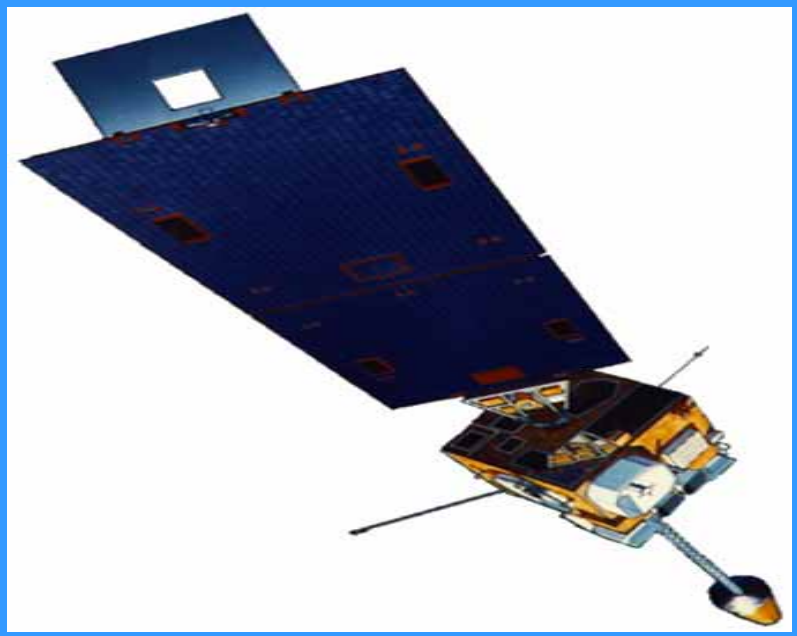
From GOES DataBook -- http://rsd.gsfc.nasa.gov/goes/text/goes.databook.html

GOES Schedules

- GOES-N is slated to be launched in **mid-November 2005** and operational in mid-2008. GOES-N will be called GOES-13 when it reaches geostationary orbit.

- GOES-O is slated to be launched in 2007 and operational in late 2009.

GOES-8/12



GOES-N/O/P will have similar instruments to GOES-8-12, but will be on a different spacecraft bus. The new bus will allow improvements both to the navigation and registration, as well as the radiometrics.

GOES-N/P

Position of the boom allows for colder detectors and hence less instrument noise

Limitations of Current GOES Imagers

- Regional/Hemispheric scan conflicts
- Low spatial resolution
- Missing spectral bands
- **Eclipse and related outages**

GOES-R (2012+) addresses the first 3 limitations, but GOES-N addresses the data outage issues!

What is a satellite eclipse period?

Since GOES is in a geosynchronous orbit, the sun will yearly traverse a +/- 23.5 degree angle perpendicular to the Earth's equator (GOES orbit plane). As a result, ***near the Vernal and Autumnal Equinoxes the Earth disk will periodically occult [block] the sun, from a GOES perspective***. Essentially, there are two eclipse seasons for each GOES spacecraft. Each GOES spacecraft utilizes a solar array that converts sunlight into electricity in order to power the satellite. Each day during the eclipse season the sun is blocked by the Earth and sunlight is not available to the GOES solar array. There is typically a 0-3 hour outage of imagery each day as GOES progresses through eclipse season. The maximum outage of 3 hours will occur at or near the equinox.

Nick Pinkine (NOAA/NESDIS)

What are Keep-Out-Zones?

Keep-Out-Zone (KOZ) is another term related to eclipse season operations. The ***GOES imager and sounder instruments have temperature constraints that prevent them from scanning an area too close to the sun***. If the GOES imager or sounder is allowed to scan an area near the sun, they could potentially overheat and become permanently damaged. Prior to and following each eclipse season as the sun is "close" to the Earth disk, image regions in the proximity of the sun will be deleted.

Nick Pinkine (NOAA/NESDIS)

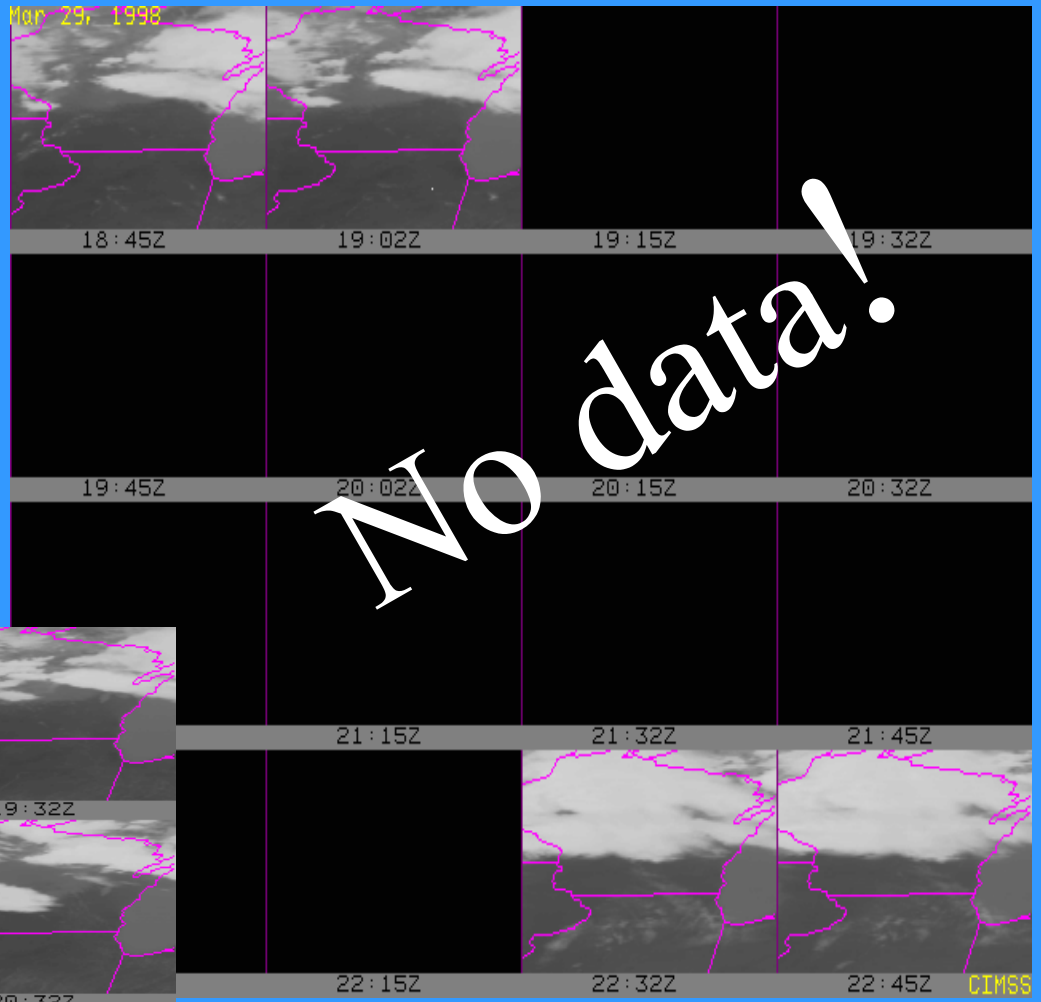
GOES-N/O/P will supply data through the eclipse periods. The spacecraft batteries are specified to be large enough to run through eclipse.

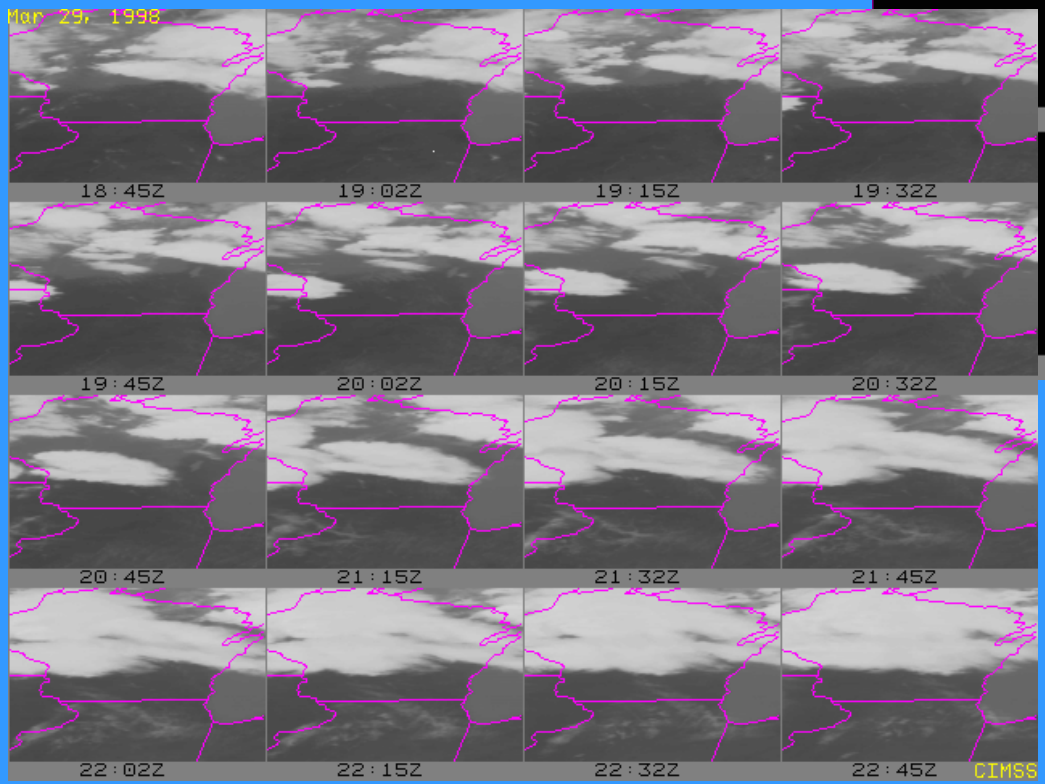
Shields have been added to the secondary mirror spiders. **Outages due to Keep-Out-Zones (KOZ) will be minimized.**

Outages due to Eclipse and the Keep-Out-Zone

GOES-8

(~3 hours of data outage)

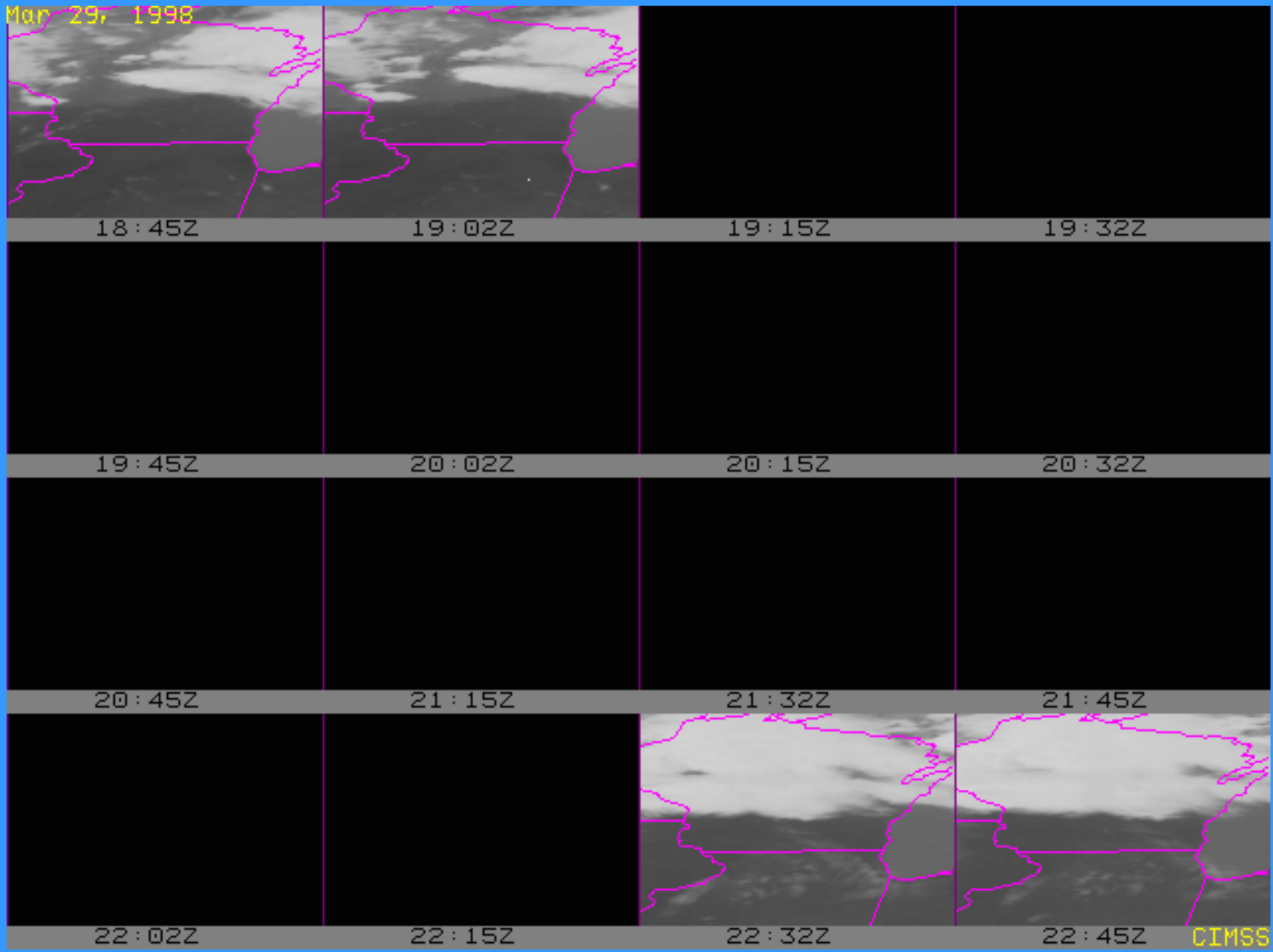




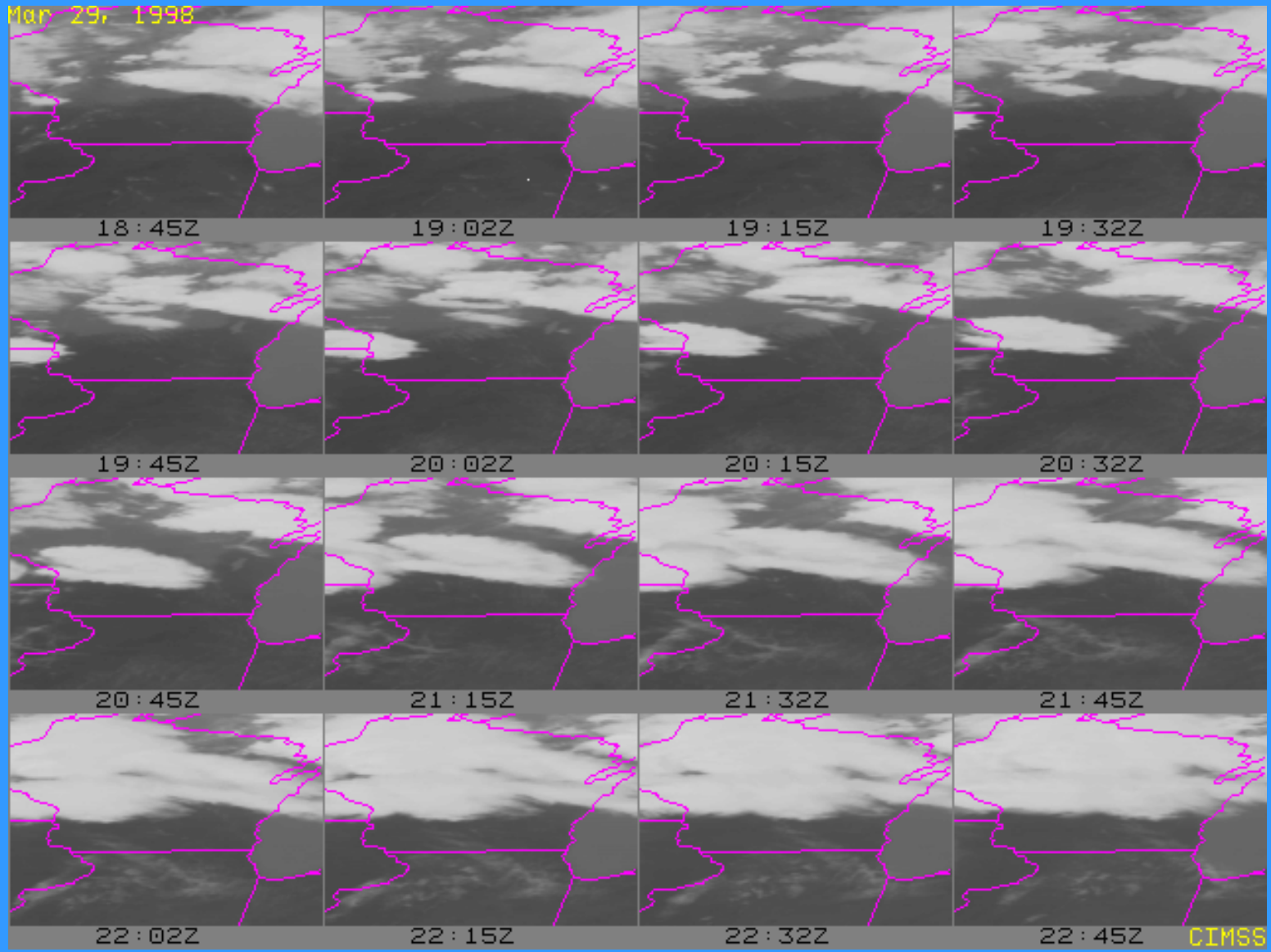
GOES-N+

(<<1 hour of data outage)

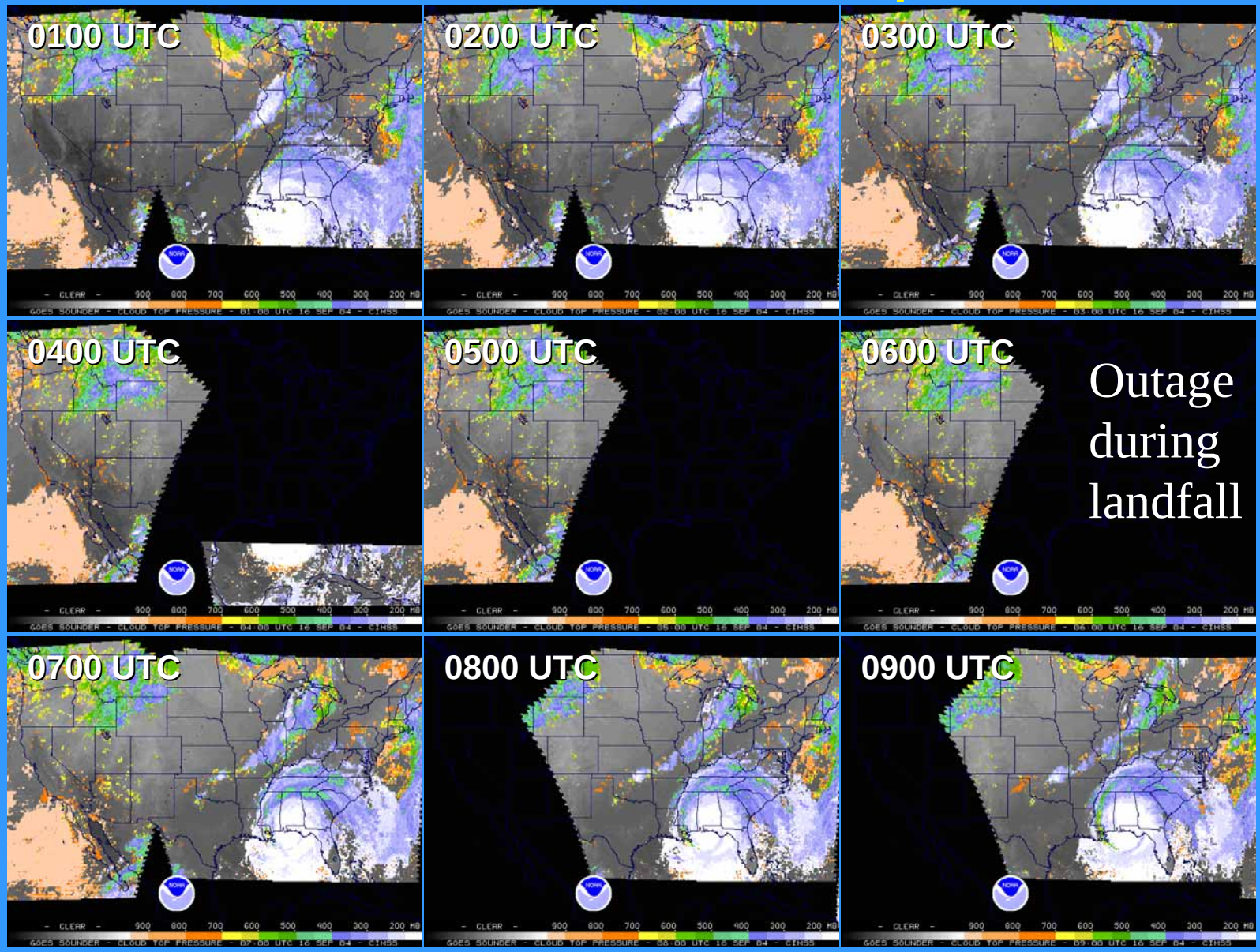
Sample of a 3-hr outage, not over the GOES-East eclipse time.



Sample of a 3-hr outage, not over the GOES-East eclipse time.



The Onset Of Hurricane Ivan: 16 September 2004



GOES-10 & -12 Sounder Cloud Top Pressure Coverage

Note satellite outage during landfall

Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

Note satellite outage during landfall

Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

Note satellite outage during landfall

Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

Note satellite outage during landfall

Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

Note satellite outage during landfall

Note: GOES-10 was taking images during this time.

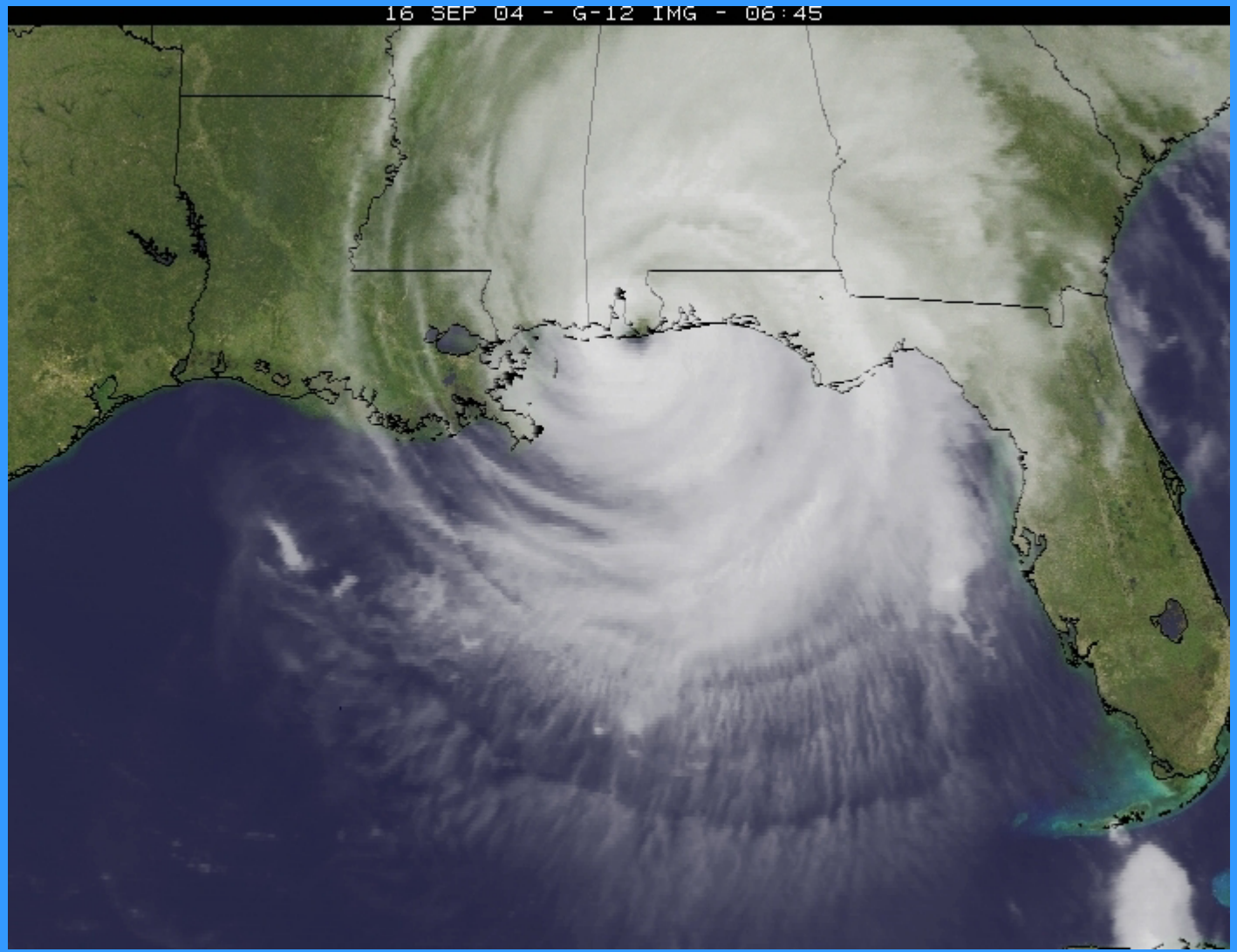
GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

Note satellite outage during landfall

Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

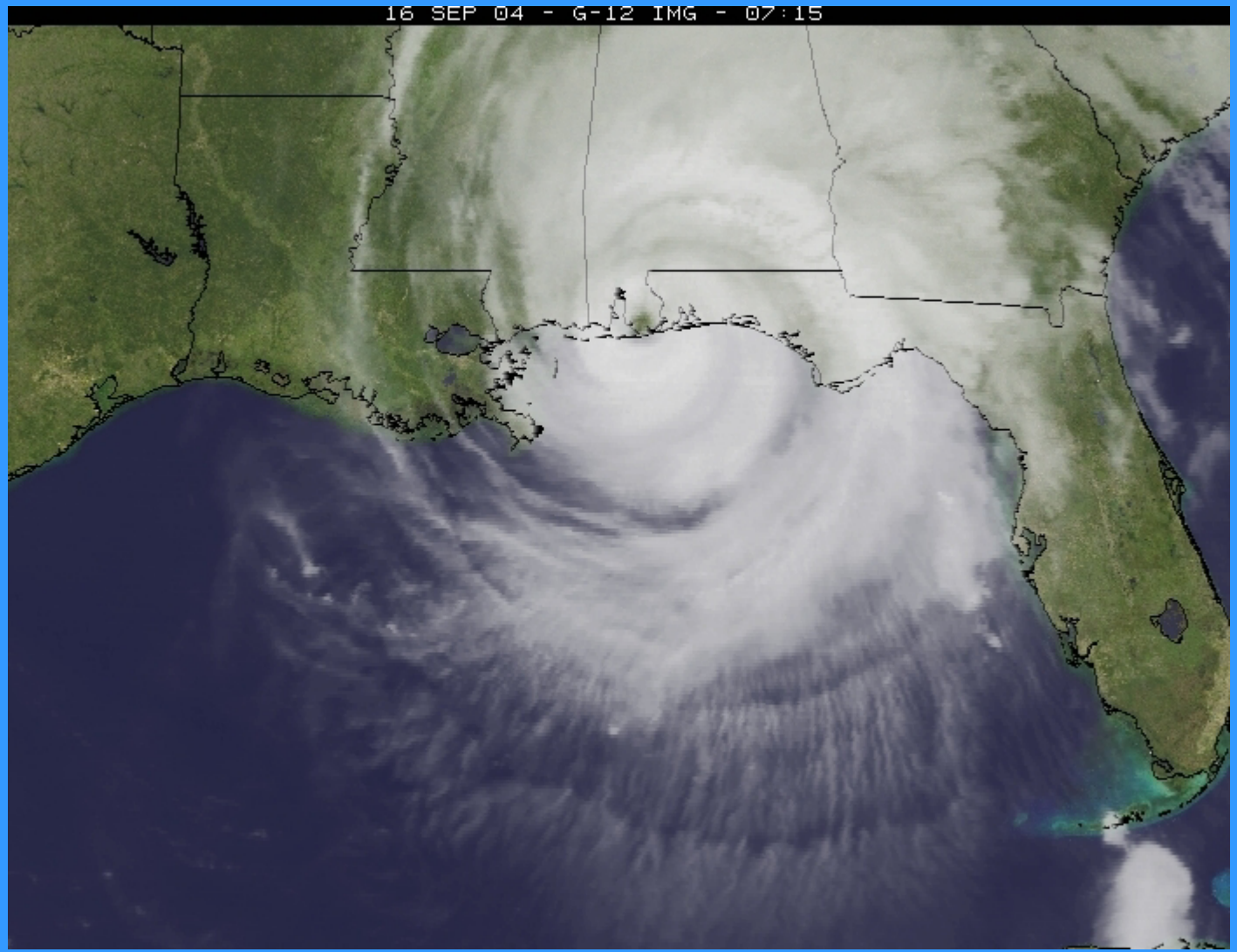
Note satellite outage during landfall



Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

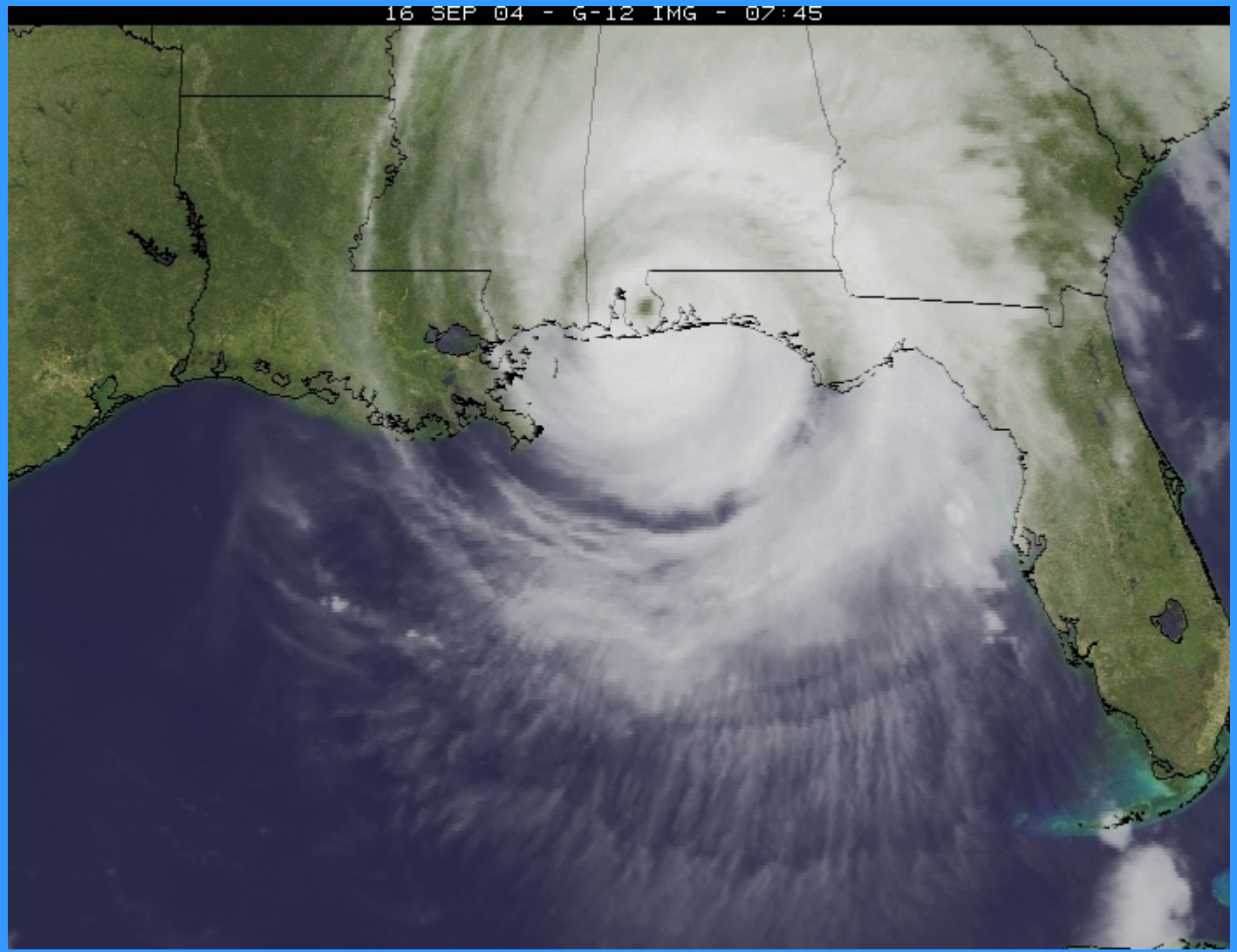
Note satellite outage during landfall



Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

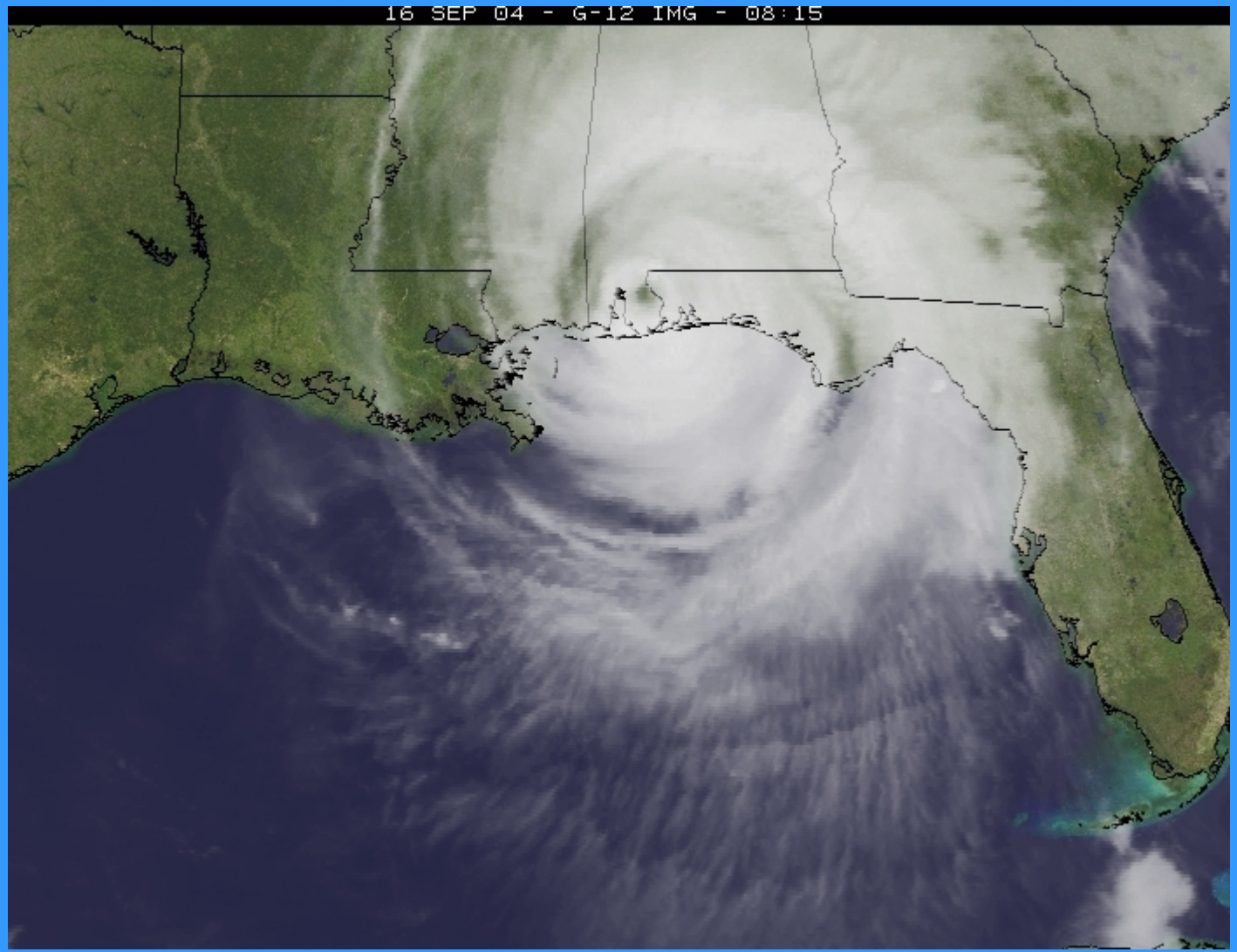
Note satellite outage during landfall



Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

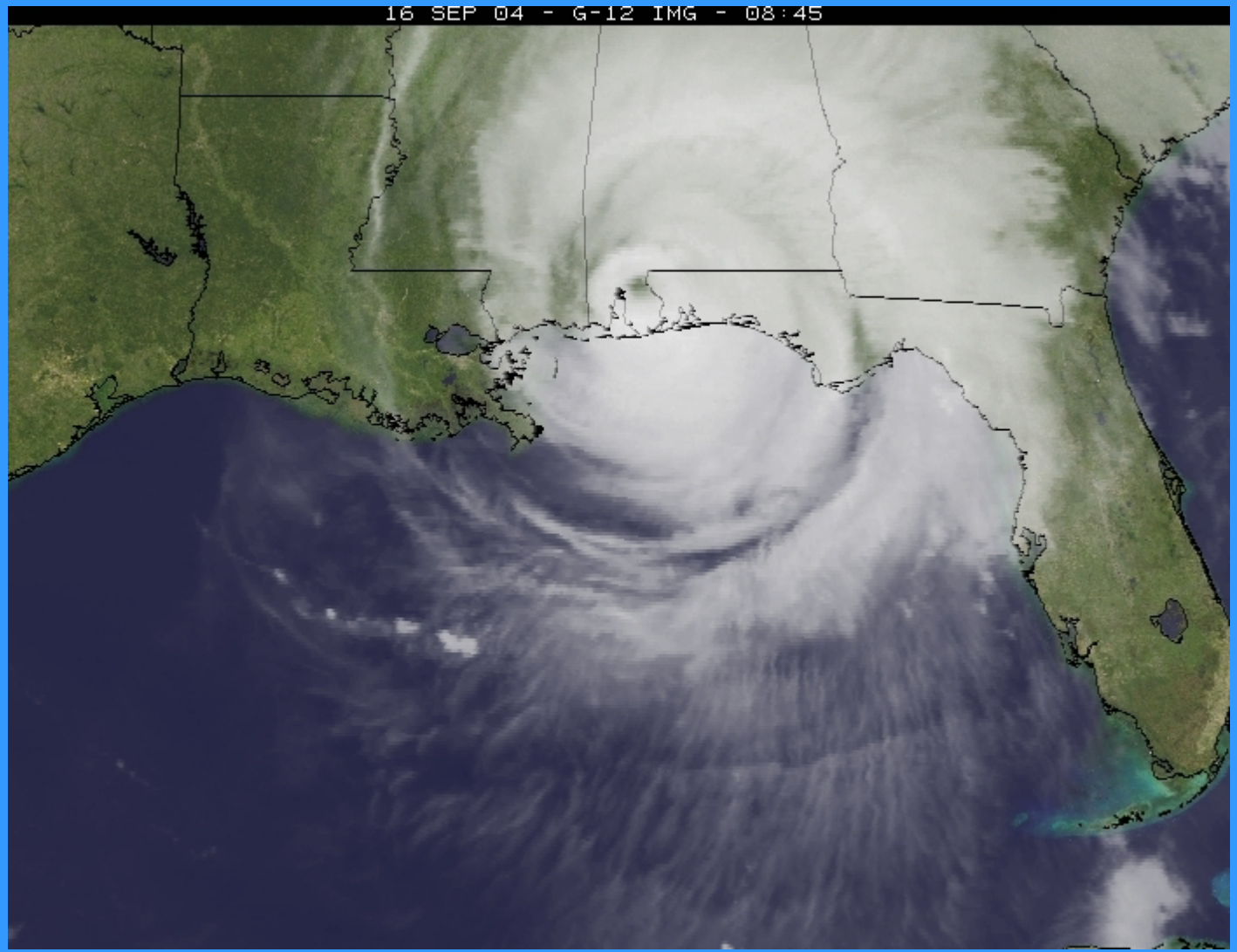
Note satellite outage during landfall



Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

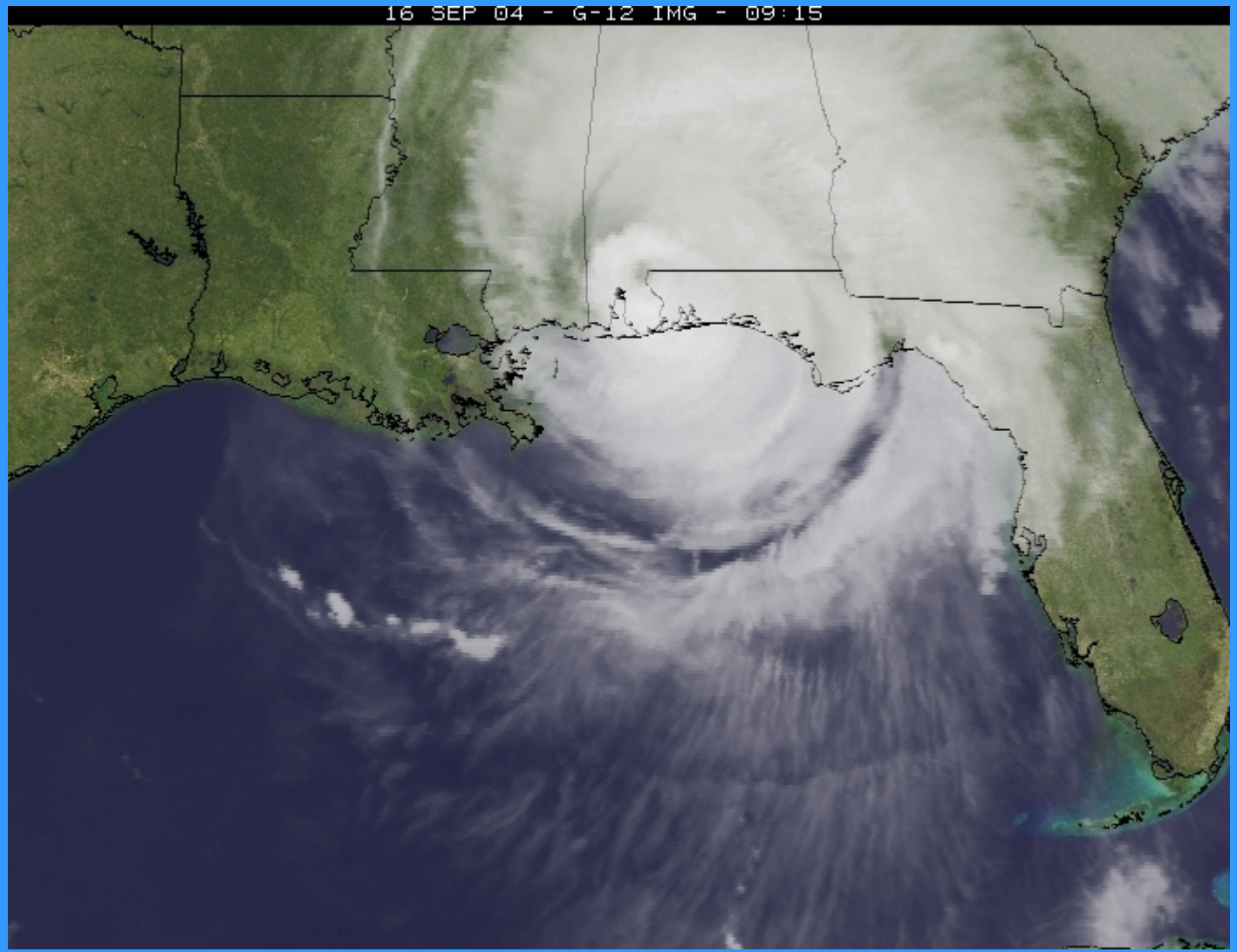
Note satellite outage during landfall



Note: GOES-10 was taking images during this time.

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

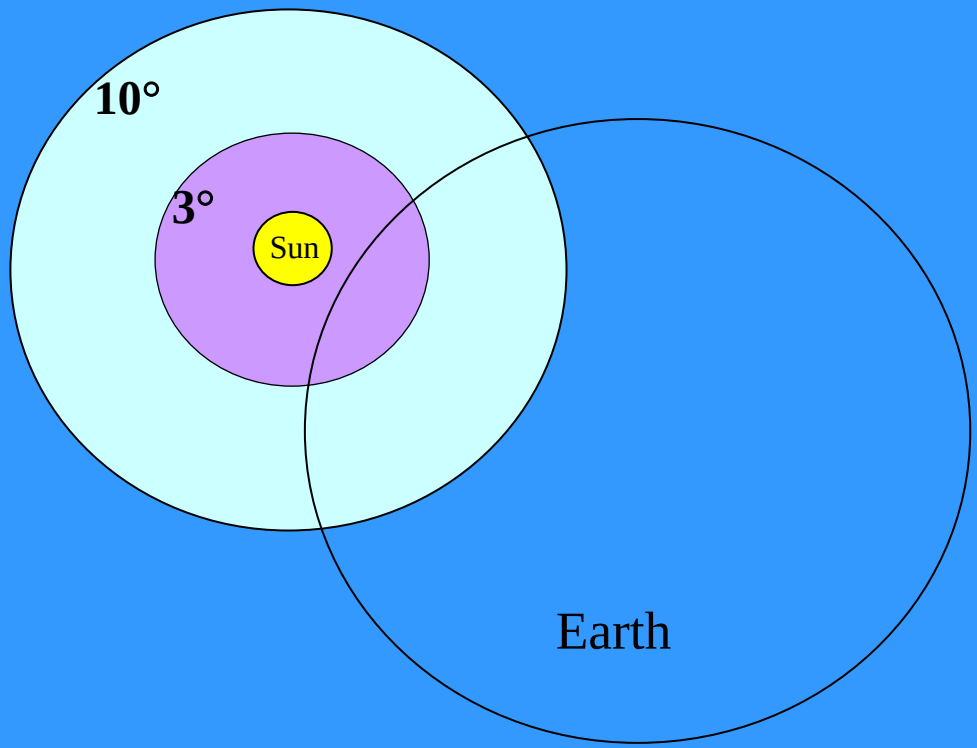
Note satellite outage during landfall



Note: GOES-10 was taking images during this time.

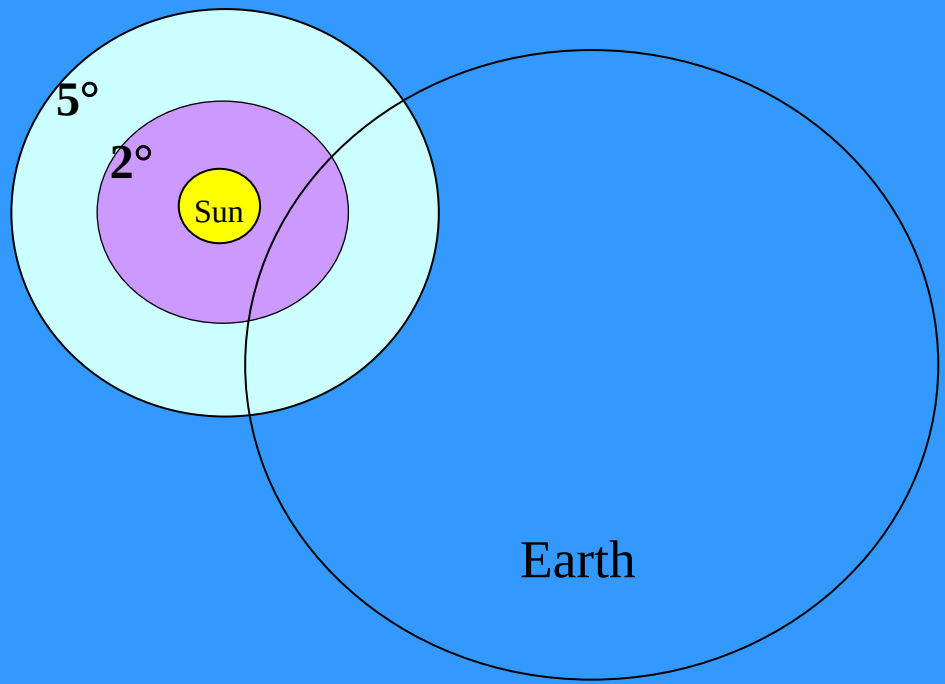
GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

Reduced KOZ



The values have not yet been defined for GOES-N operations

Reduced KOZ



The values have not yet been defined for GOES-N operations

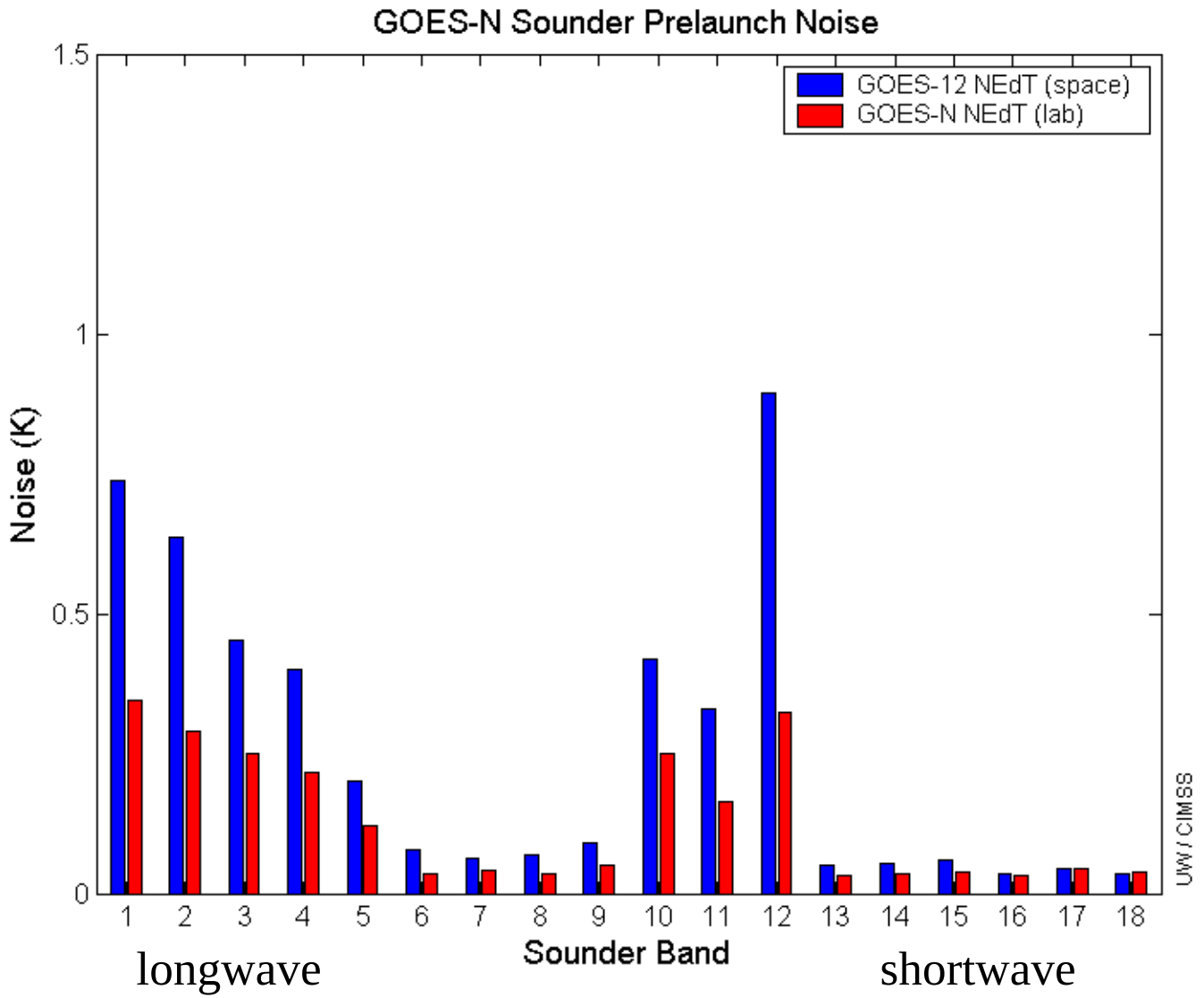
Improved **radiometrics** on GOES-N+

The **GOES-N+ instruments will be less noisy.**

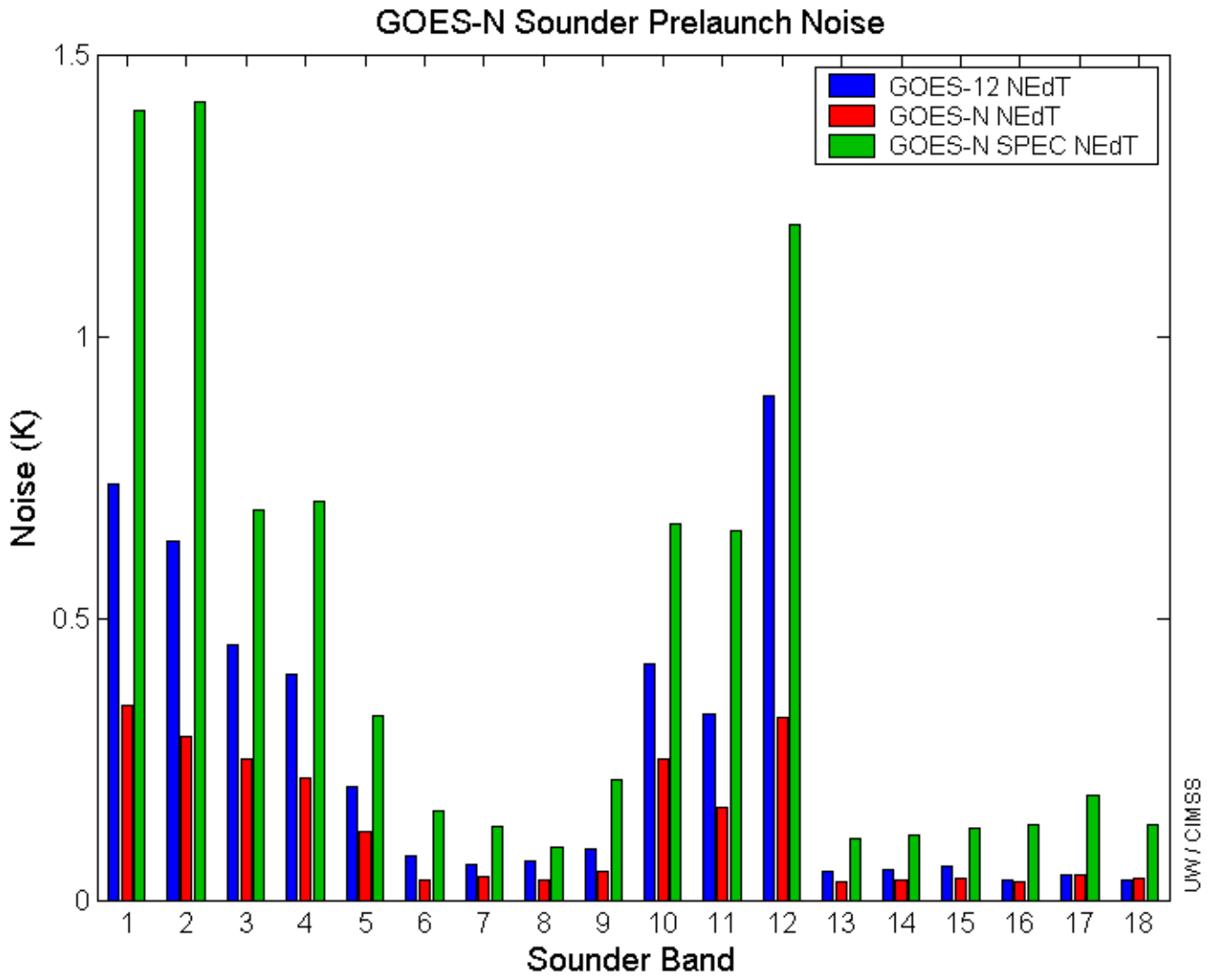
Lower (colder) patch (detector) temperature is the main driver.

Other modifications have been made to improve the noise performance on both instruments.

Improved GOES-N (Sounder) noise compared to GOES-12



Improved GOES-N (Sounder) noise compared to GOES-12



Improved **radiometrics** on GOES-N+

Imager: “Channel 4 (10.5 micron channel) ground test data showed a NEdT for the GOES-N instrument would be 0.05K. (The similar ground test value for the GOES-12 imager was 0.07K.)”

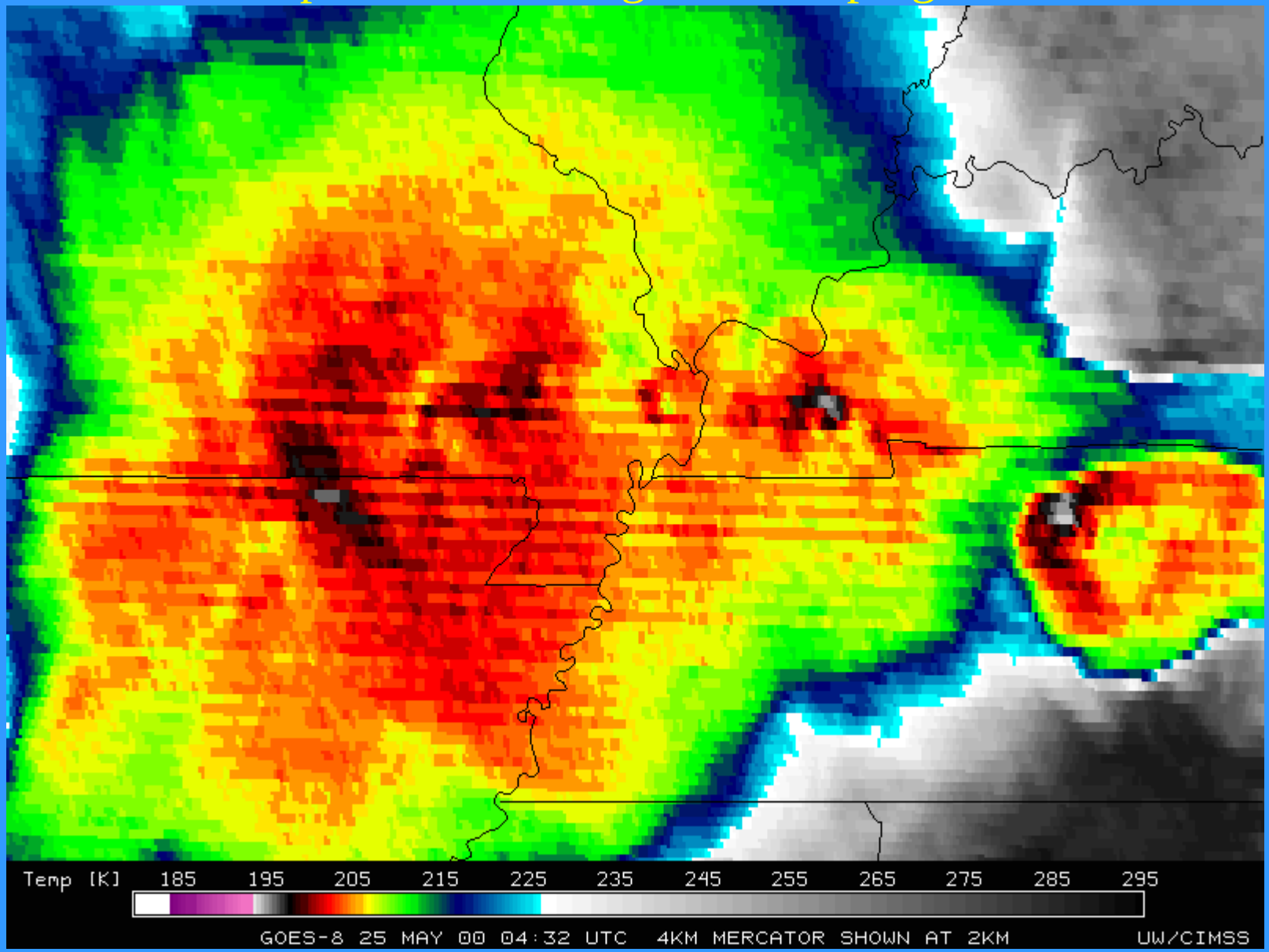
Sounder: “The GOES-N long and mid-wave channels show NEN's that are about 2/3 of the GOES-12 ground test. (Example: LW on GOES-12 ground test was 0.52mW/(m^2*Sr*cm^-1) compared to the 0.32 of the GOES-N instrument). SW channel NEN's will be about ¾ of the GOES-12.”

Improved **calibration** on GOES-N+

Reduction in striping to be achieved through increasing the Imager's scan-mirror's dwell time on the blackbody from 0.2 sec to 2 sec.

The more accurate blackbody characterization improves the calibration of the infrared detectors.

Example infrared image with striping:



Improved **calibration** on GOES-N+

Analysis shows that the blackbody noise will be reduced by about 13% in Imager channels 3-5, which should improve the precision of their calibration by approximately that amount and also reduce the striping by an unknown amount (since there are a lot of other factors besides uncorrelated blackbody errors that cause the striping).

This improvement begins with GOES-N ”

Improved **navigation** on GOES-N+

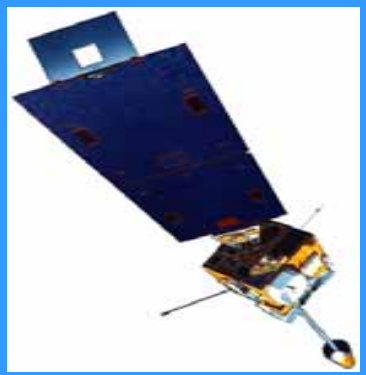
- The GOES-N navigation will be improved
  - New spacecraft bus
  - Use of star trackers
- GOES-N performance will be verified on-orbit

GOES-I/M Performance & GOES-N Expected Performance

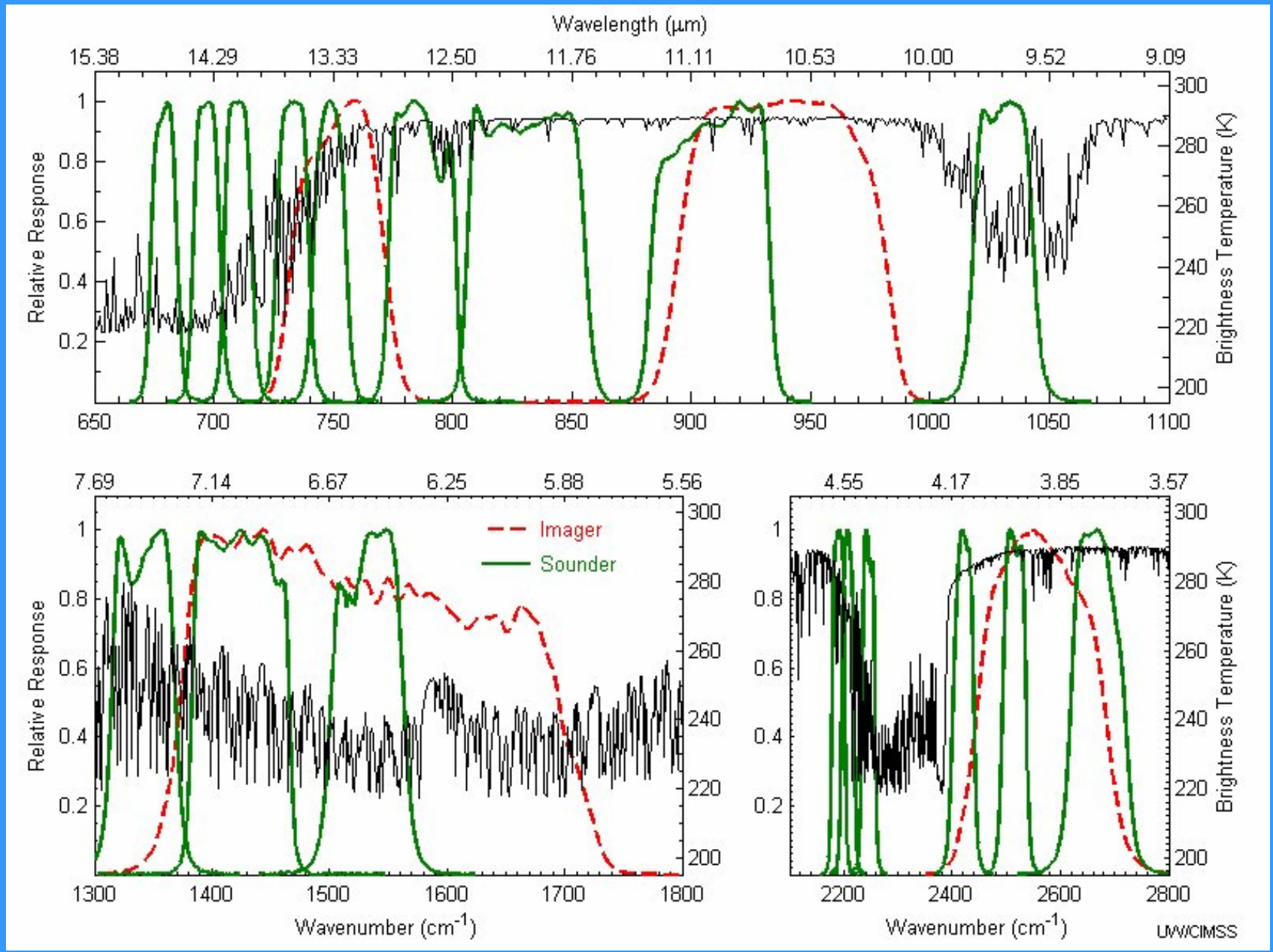
Navigation at Nadir	GOES-I/M	GOES-N+
Daytime (Visible)	112 urad = 4 km	53 urad (<2 km)
Nighttime (IR)	168 urad = 6 km	85 urad (~3 km)

The improved navigation and registration has many advantages. This includes:

- better quality image loops (the clouds will move, not the land);
- better estimates of atmospheric motion vectors (for better numerical model forecasts);
- better knowledge of fire locations (for better counting total number of unique fires), etc.

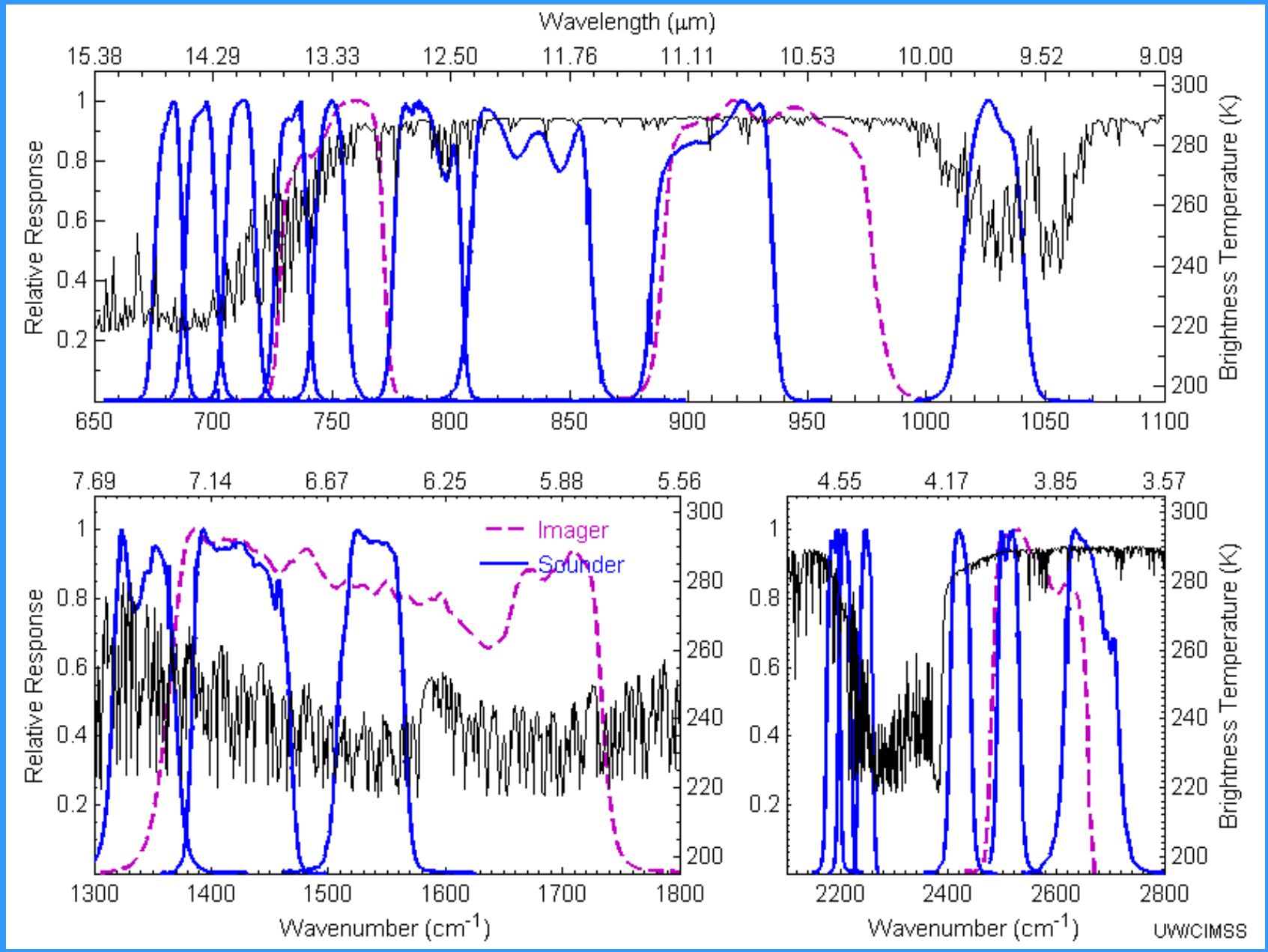


GOES-N Imager and Sounder spectral response functions.



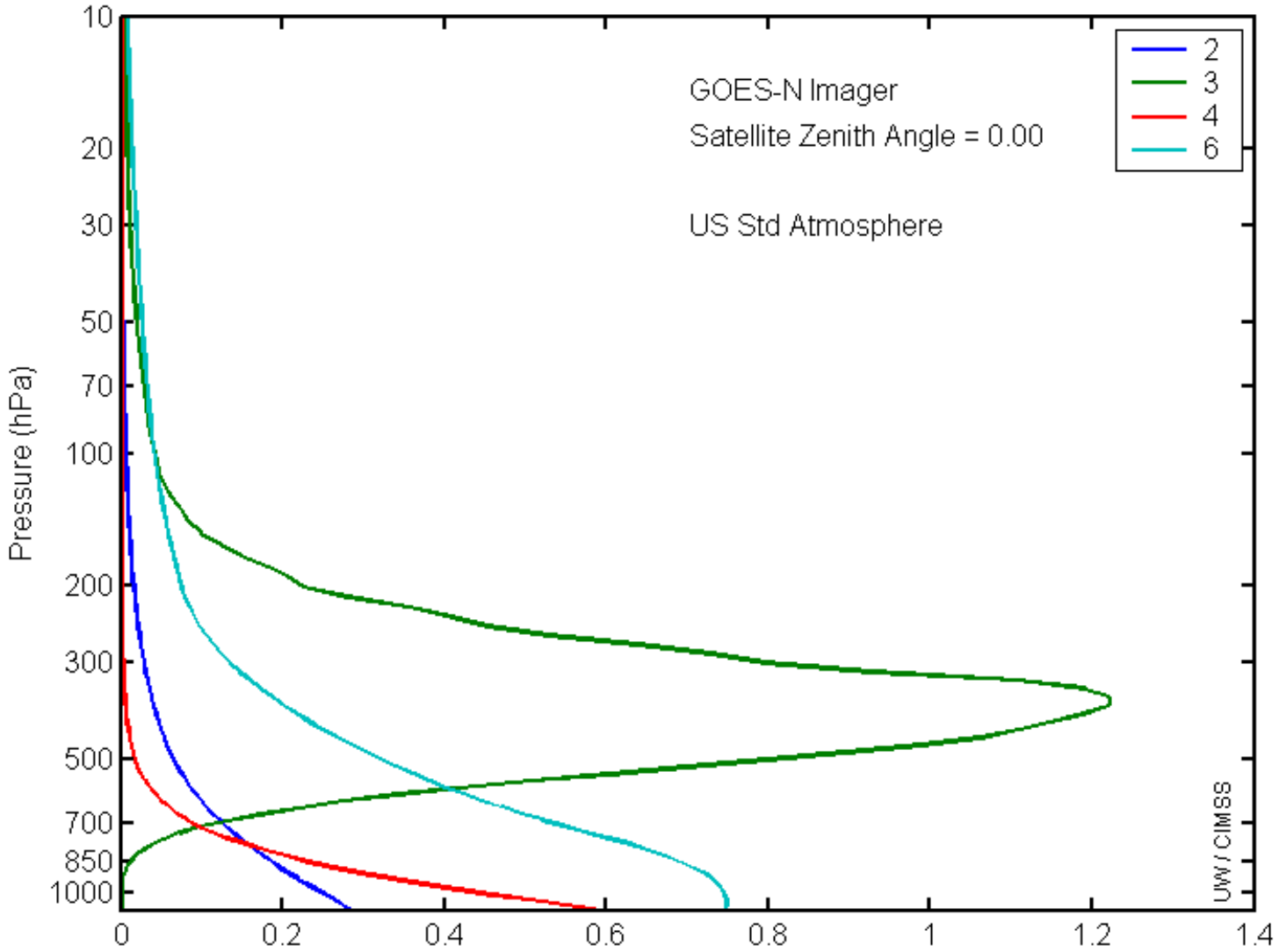
Note the imager band selection is similar to GOES-12.

GOES-12 Imager and Sounder spectral response functions.

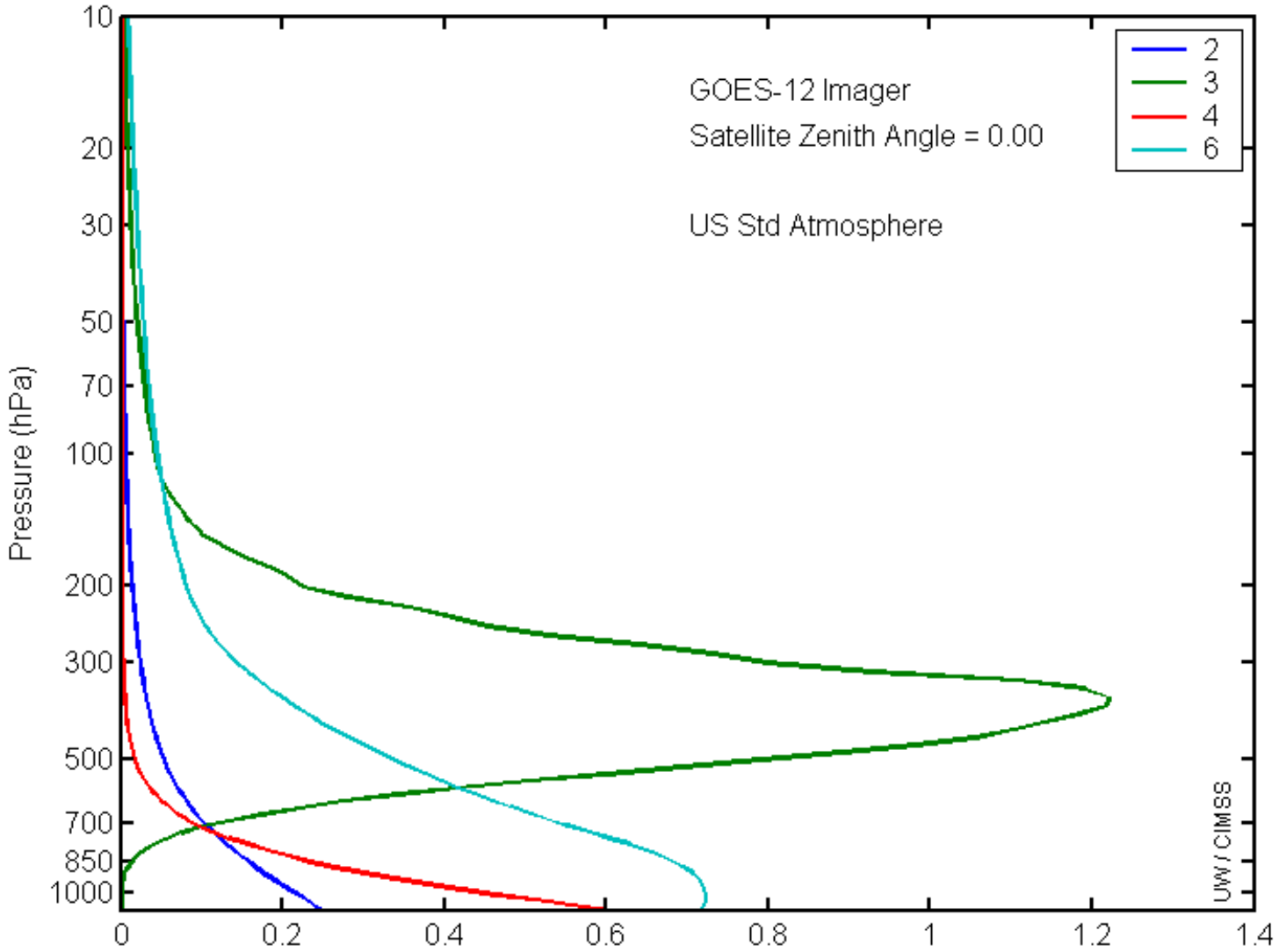


Note the imager band selection is similar to GOES-12.

GOES-N **Imager** Weighting Functions



GOES-12 **Imager** Weighting Functions



Columns are: band #, waveno, wavelength, rad, temp

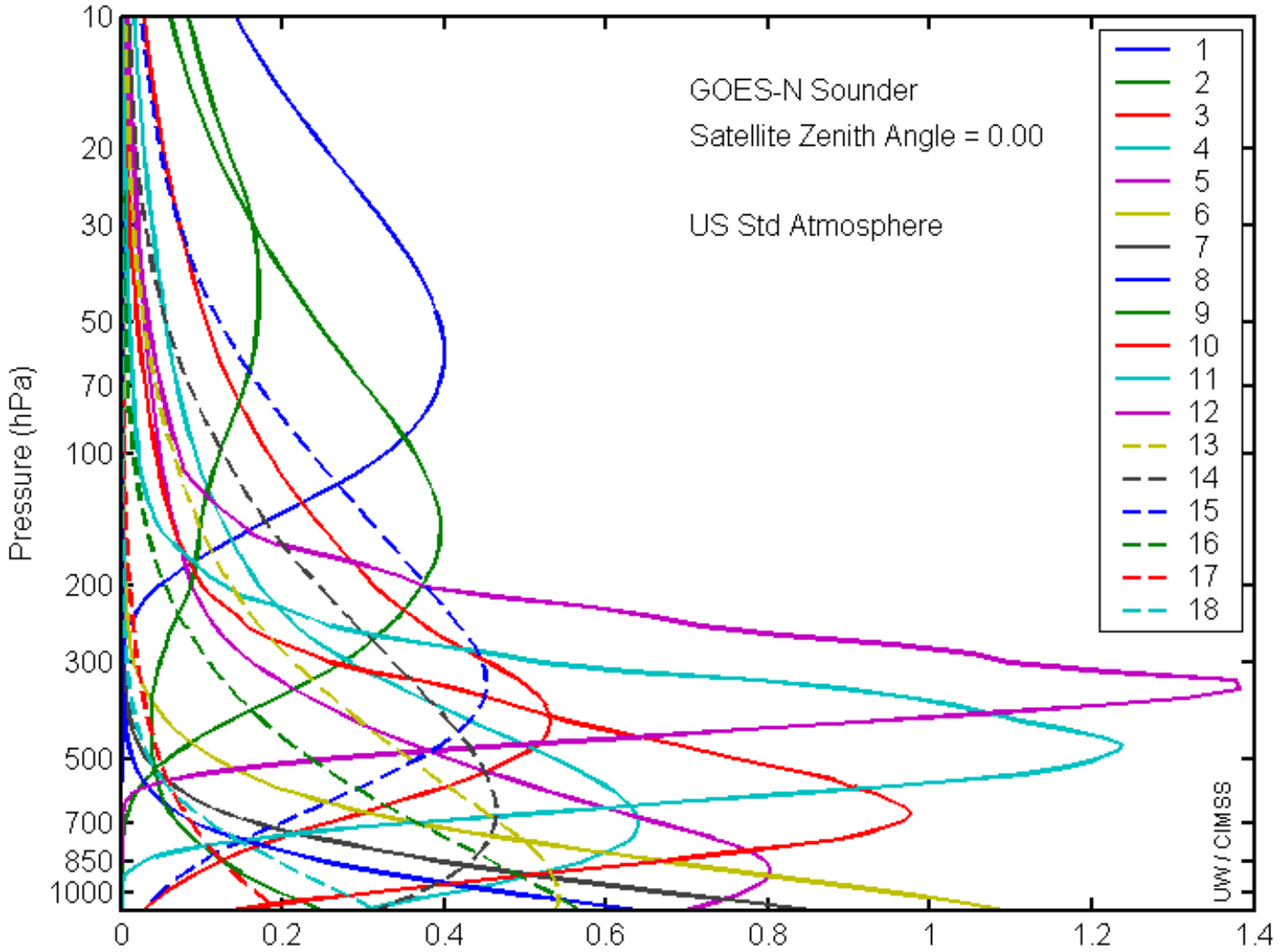
wf('GOES',13,22,26,'ZEN',0,'wmax',1.4,'label','legend',);

22	2563.91	3.90	0.6305	290.2464
23	1528.20	6.54	4.5668	238.7465
24	937.22	10.67	95.9120	290.8003
26	752.68	13.29	95.1700	271.0374

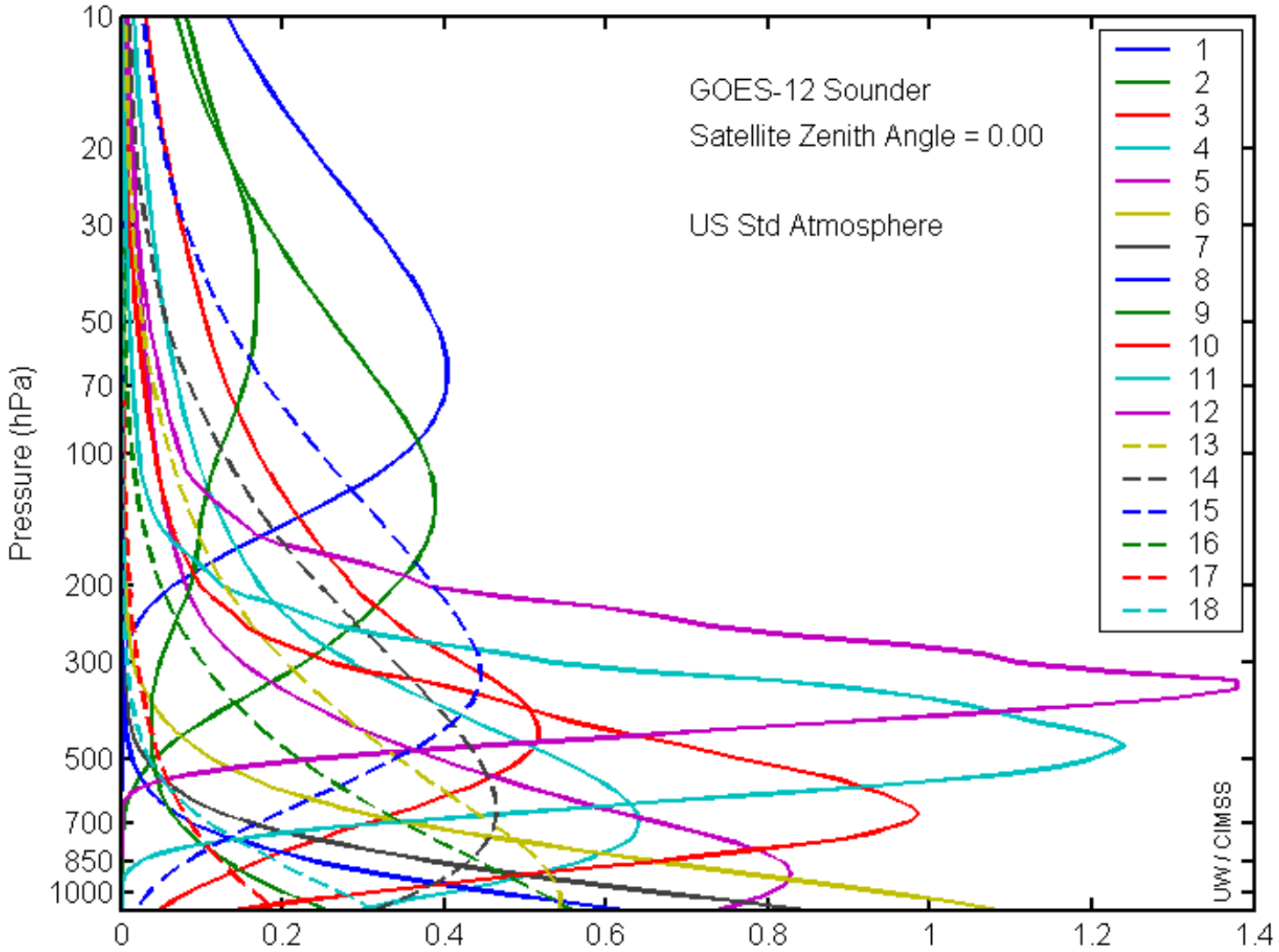
wf('GOES',12,22,26,'ZEN',0,'wmax',1.4,'label','legend',);

22	2564.82	3.90	0.6266	290.6531
23	1542.38	6.48	4.4045	238.7523
24	933.41	10.71	96.5968	290.8201
26	751.11	13.31	93.8555	269.9658

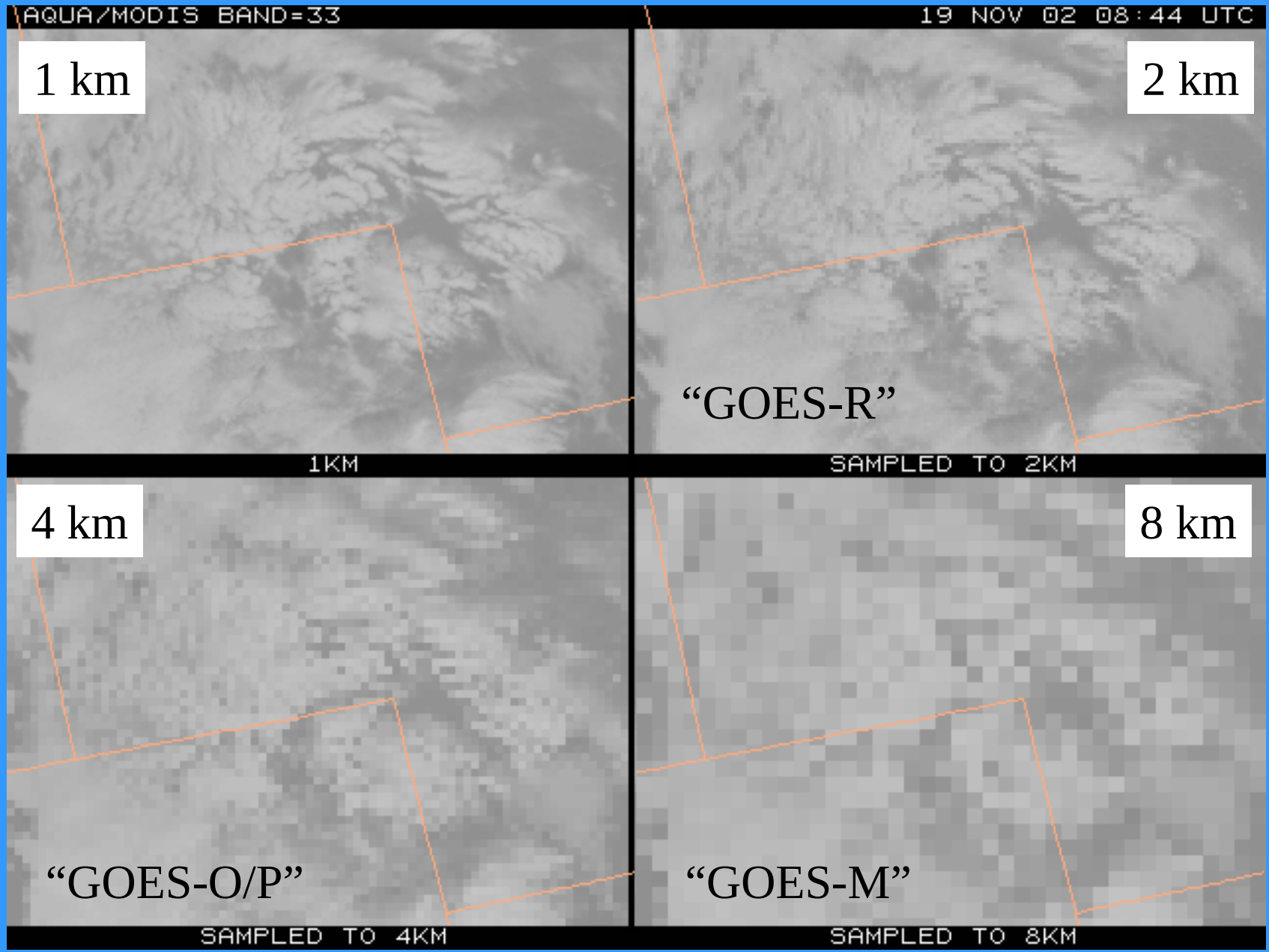
GOES-N **Sounder** Weighting Functions



GOES-12 **Sounder** Weighting Functions



GOES-O – improved spatial resolution of the 13.3 um band.



GVAR

- http://www.oso.noaa.gov/goes/goes-calibration/change-channels.htm
- Beginning with GOES-O, the imagers will have an additional infrared detector. In block 0, the amount of space for the drift correction coefficients will need to be increased by approximately 15% to accommodate the data for the 8th detector. To make room in block 0, **the factory coefficients will be removed and will be sent instead in a new type of block 11**.
- **The new "Imager Factory Coefficients" block 11 will be introduced early with the GOES-12 satellite**. This block 11 will be identified by the value "20" in words 5 and 6 ("Product ID") of the GVAR block header. However, the changes to block 0, including the removal of the Imager factory data and the addition of drift correction data for the eighth IR detector, will not become effective until GOES-O.
- The changes to GVAR outlined above will not be retroactive. **Data from GOES-8 through GOES-11 will always be transmitted to users with the current version of GVAR.** The revisions to GVAR described above will become effective with the GOES-12 satellite.

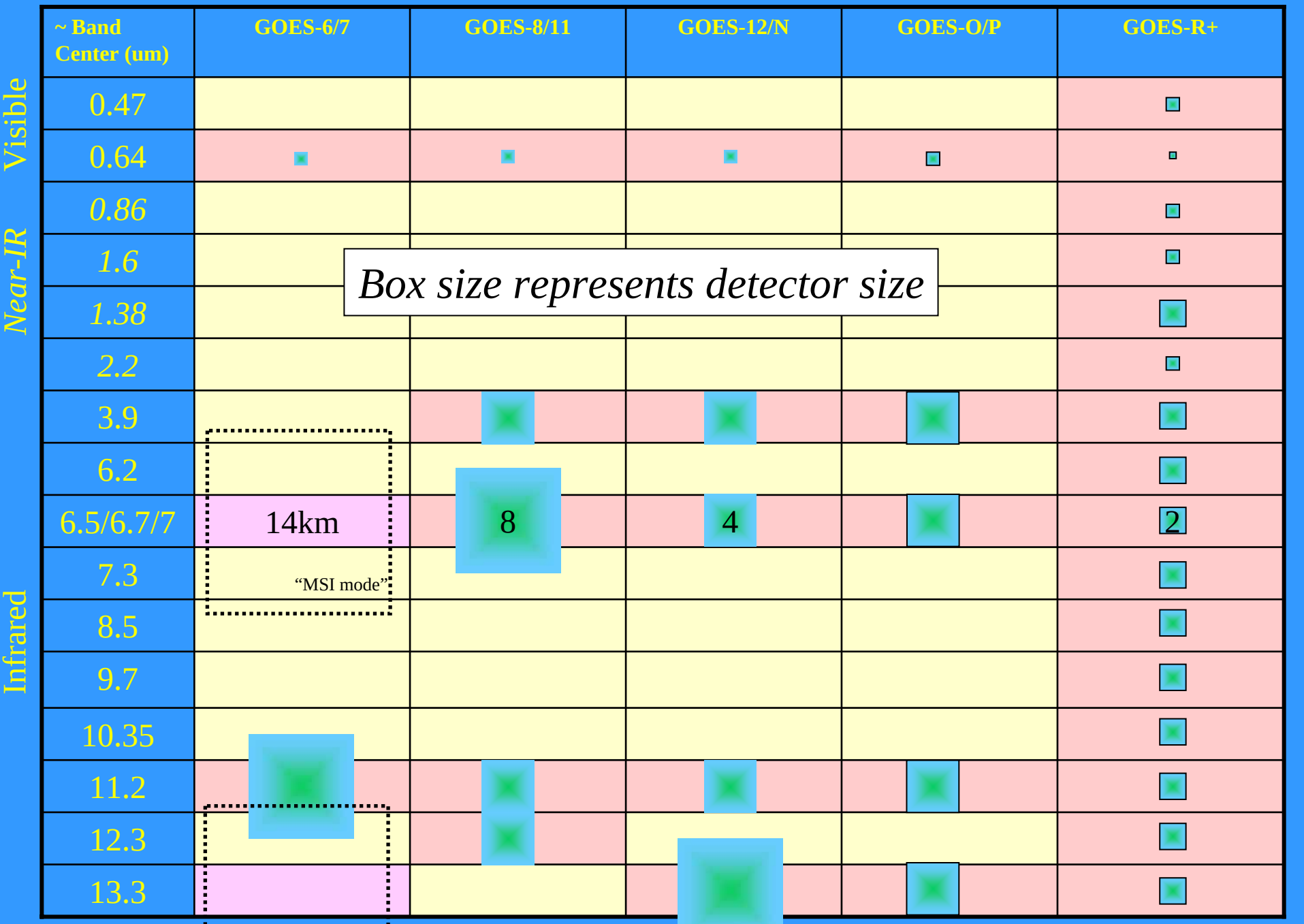
Visible “degradation correction”

- For comments or questions, contact:
  - Xiangqian Wu <Xiangqian.Wu@noaa.gov>

- To account for visible detector degradation over time, should “dynamic” visible calibration coefficients replace the “static” (pre-launch) values? Or should the “dynamic” values be placed elsewhere in the GVAR stream? In essence, should it be an “opt in” or “opt out” system?

- If so, on what satellite should this start?
  - GOES-11
  - GOES-N
  - GOES-O

Approximate spectral and spatial resolutions of US GOES Imagers



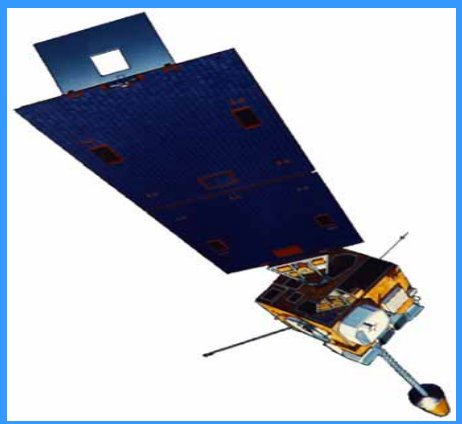
Summary:

GOES-N/O/P instrument changes

- **GOES-N post-launch check-out is upcoming**
- **better calibration (longer BlackBody looks)**
- **better resolution of the 13.3 um on GOES-O/P**

GOES-N/O/P bus change

- **no spring and fall eclipse outages**
- **reduced Keep-Out-Zone outages**
- **better calibration (colder detectors)**
- **better navigation (earth sensor -> star tracker)**

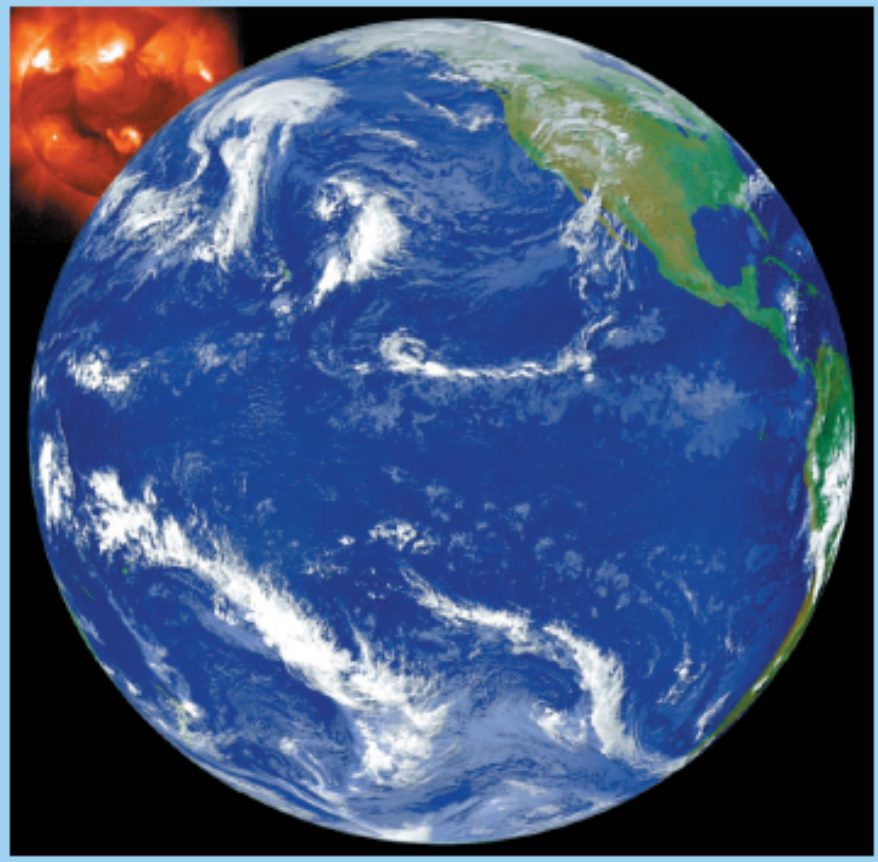


GOES-8/12

GOES-N/P

http://www.osd.noaa.gov/GOES/GOES_NQBooklet.pdf

GOES-N,O,P — The Next Generation



National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

U.S. Department of Commerce
National Oceanic and
Atmospheric Administration
National Environmental Satelite,
Data, and Information Service
Suitland, Maryland

Other Changes...

• A data product improvement has been provided with the development of the digital Low Rate Image Information Transmission (**LRIT**) system for distribution of data products that were distributed in an analog WEFAX format in the previous generation.

• The Data Collection System (**DCS**) has been enhanced.

• A dedicated transponder is being provided to support the Emergency Manager's Weather Information Network (**EMWIN**) data product service.

• There will be no "**boom snap**" navigation problems on the GOES-N,O,P satellites.

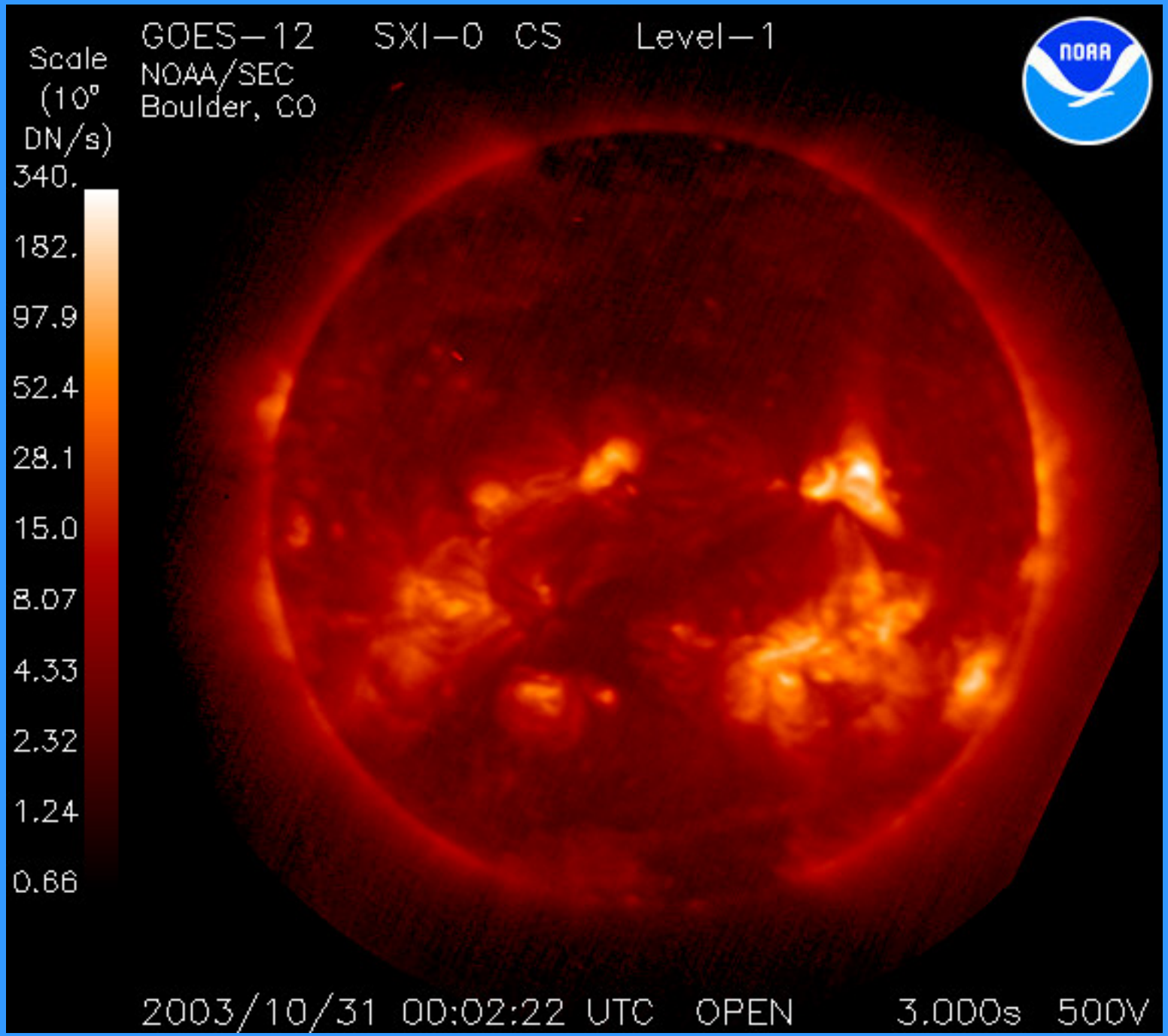
Other Changes...

• A new Solar X-Ray Imager (**SXI**) has been developed to permit the observation and collection of solar data products.

• The Space Environment Monitoring (**SEM**) subsystem has been enhanced. The EPS sensors have been expanded to provide coverage over an extended energy range and with improved directional accuracy.

• The Satellite design **life time** has been lengthened from 7 to 10 years.

• An optional operational "**yaw flip**" capability has been developed to permit optimum performance of the Imager and Sounder radiation coolers.


GOES-12 SXI-0 CS Level-1
NOAA/SEC
Boulder, CO
Scale
(10^ DN/s)
340.
182.
97.9
52.4
28.1
15.0
8.07
4.33
2.32
1.24
0.66
2003/10/31 00:02:22 UTC OPEN 3.000s 500V