Future GOES

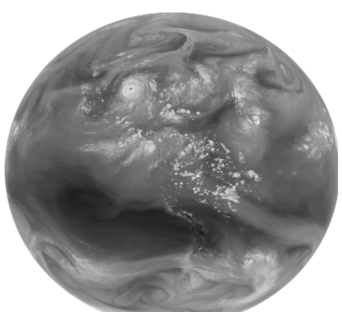
Timothy J. Schmit

NOAA/NESDIS/Satellite Applications and Research

Advanced Satellite Products Branch (ASPB)

Madison, WI

and Many Others



Cachoeira Paulista -
São Paulo, Brazil
November, 2007

Outline

- GOES-13 (on-orbit storage)
- GOES-O/P
  - 13.3 µm change
- GOES-R
  - Schedule
  - ABI
  - Intro GLM

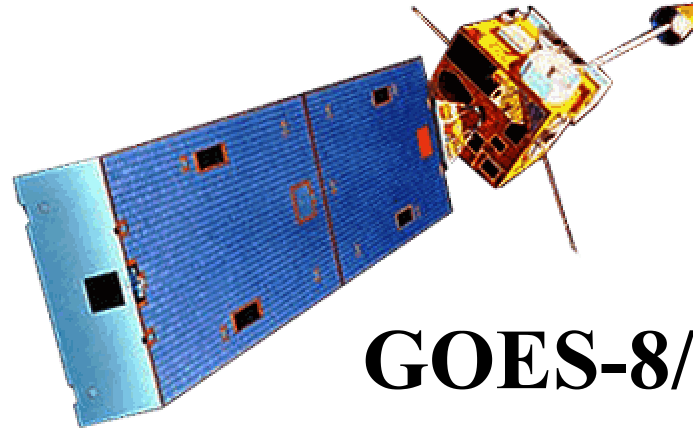
GOES-13

GOES-13/O/P will have similar instruments to GOES-8-12, but on a different spacecraft bus.

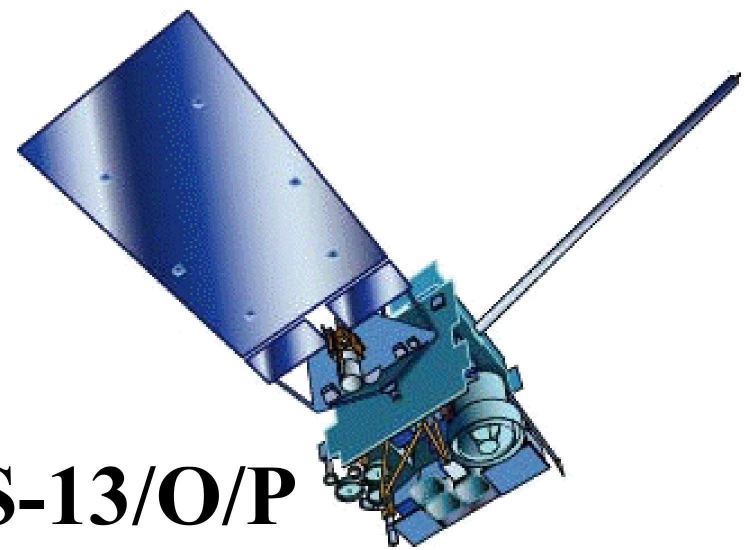
Spring and fall eclipse outages will be avoided by larger onboard batteries.

Improved navigation

Improved radiometrics

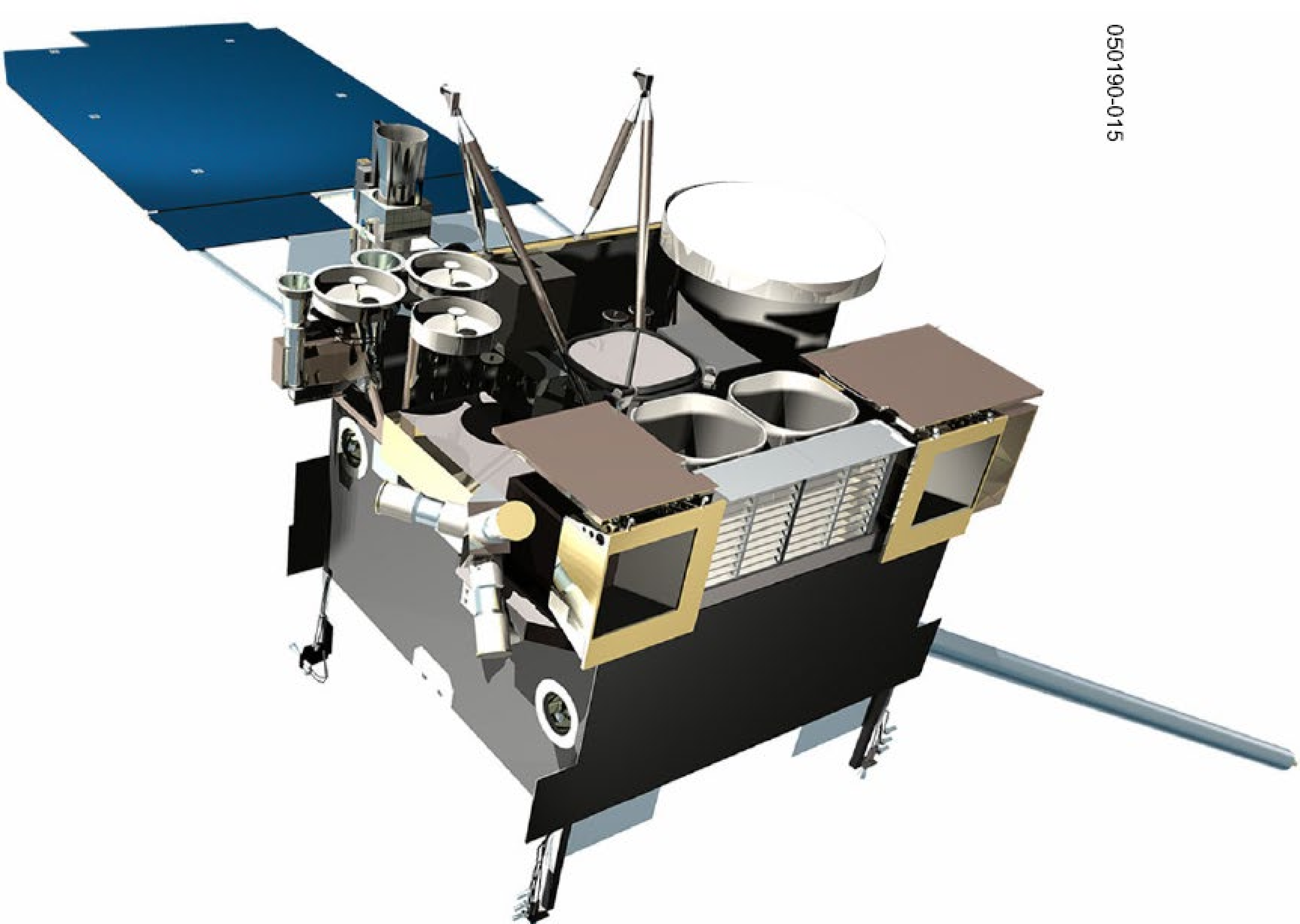


GOES-8/12

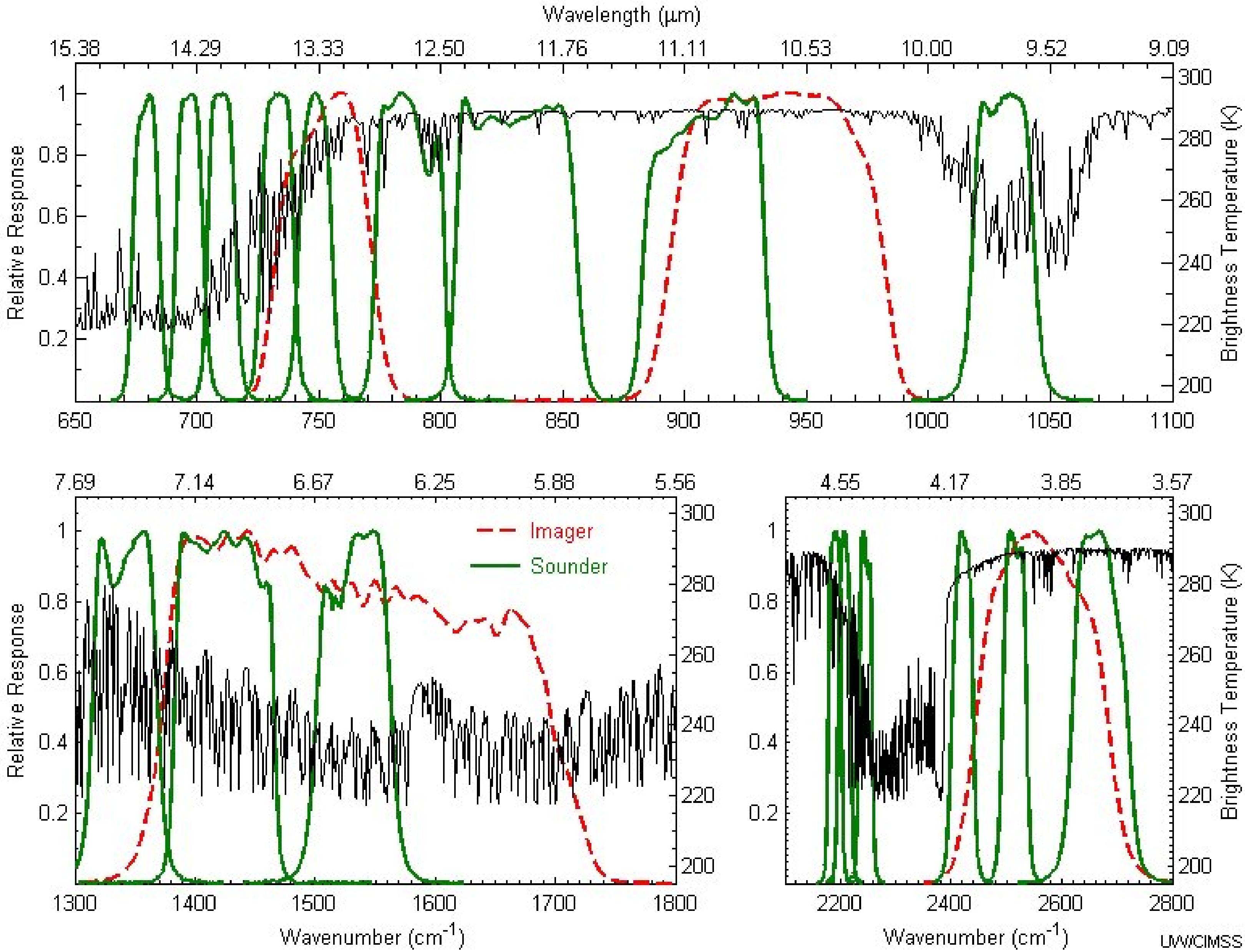


GOES-13/O/P

GOES-N Spacecraft

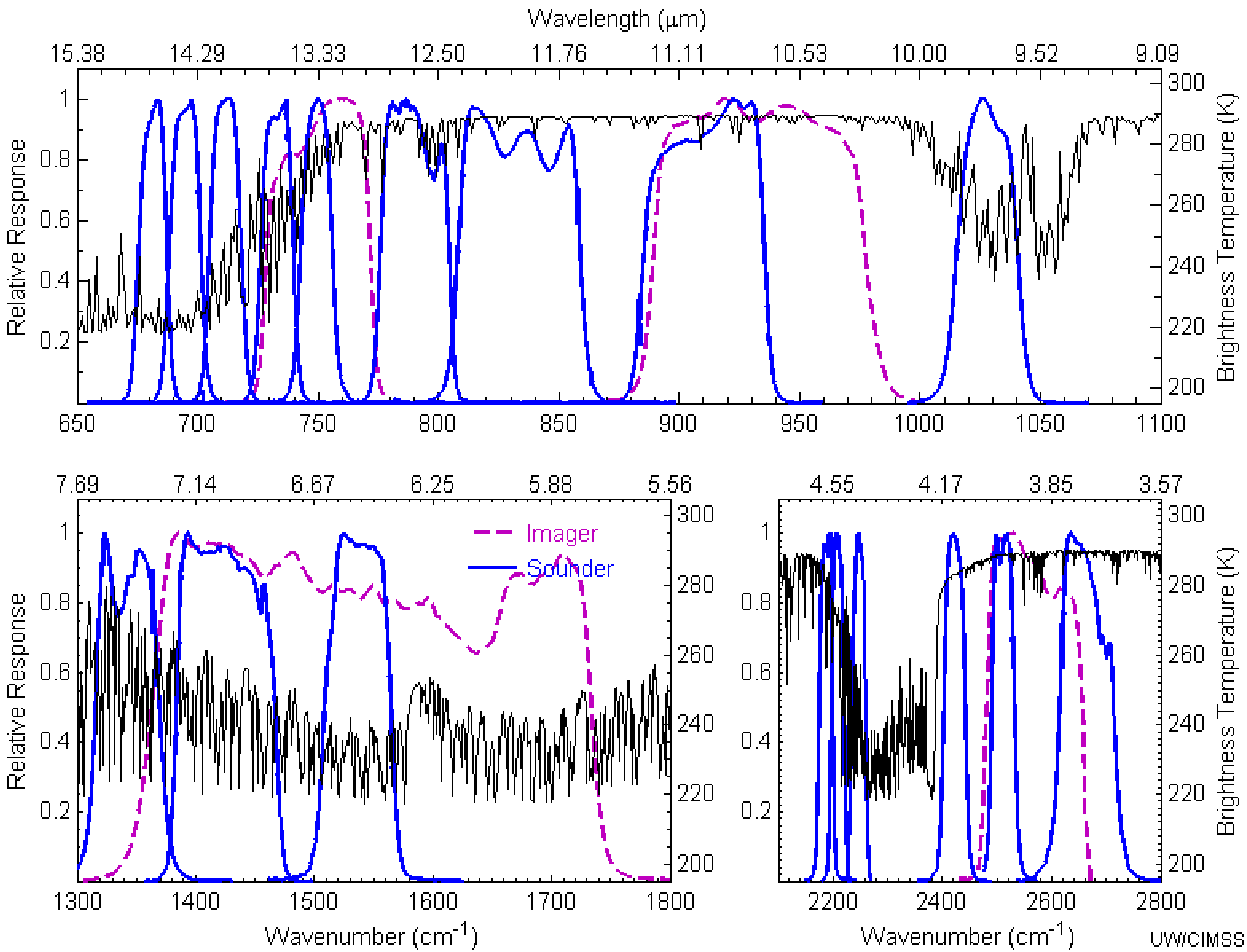


GOES-N Imager and Sounder spectral response functions.



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

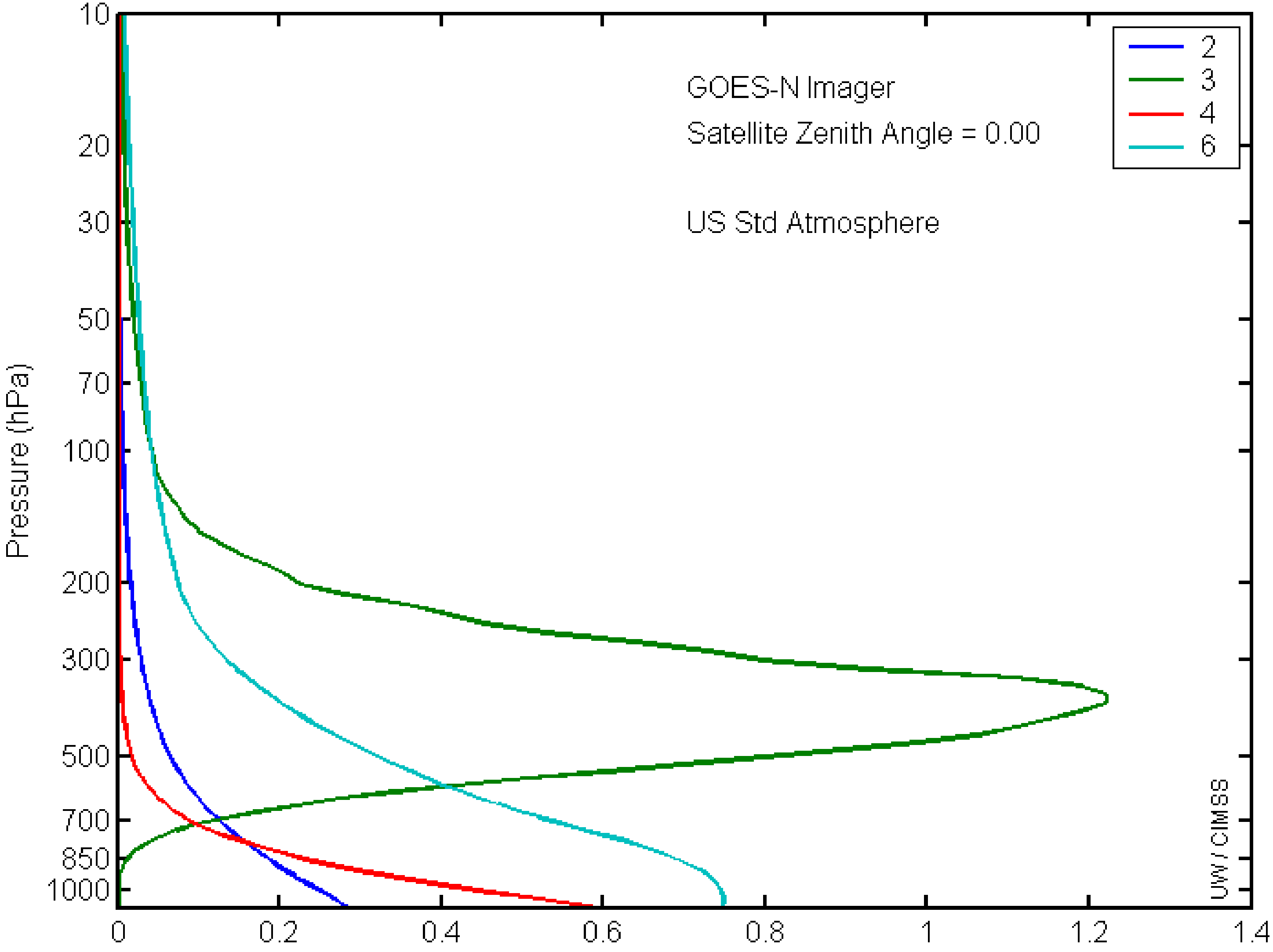
GOES-12 Imager and Sounder spectral response functions.



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

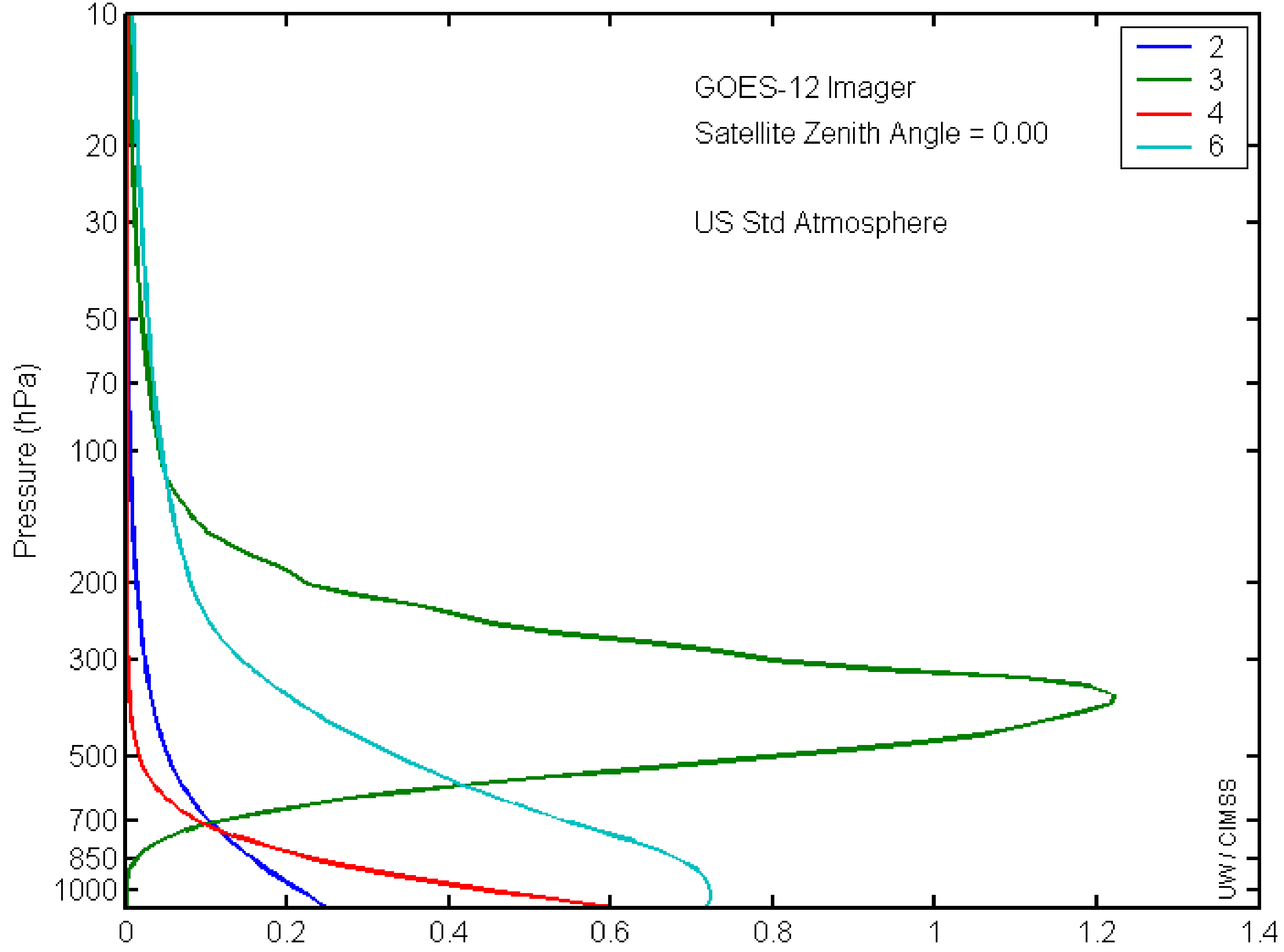
GOES-N **Imager** Weighting Functions

Pressure

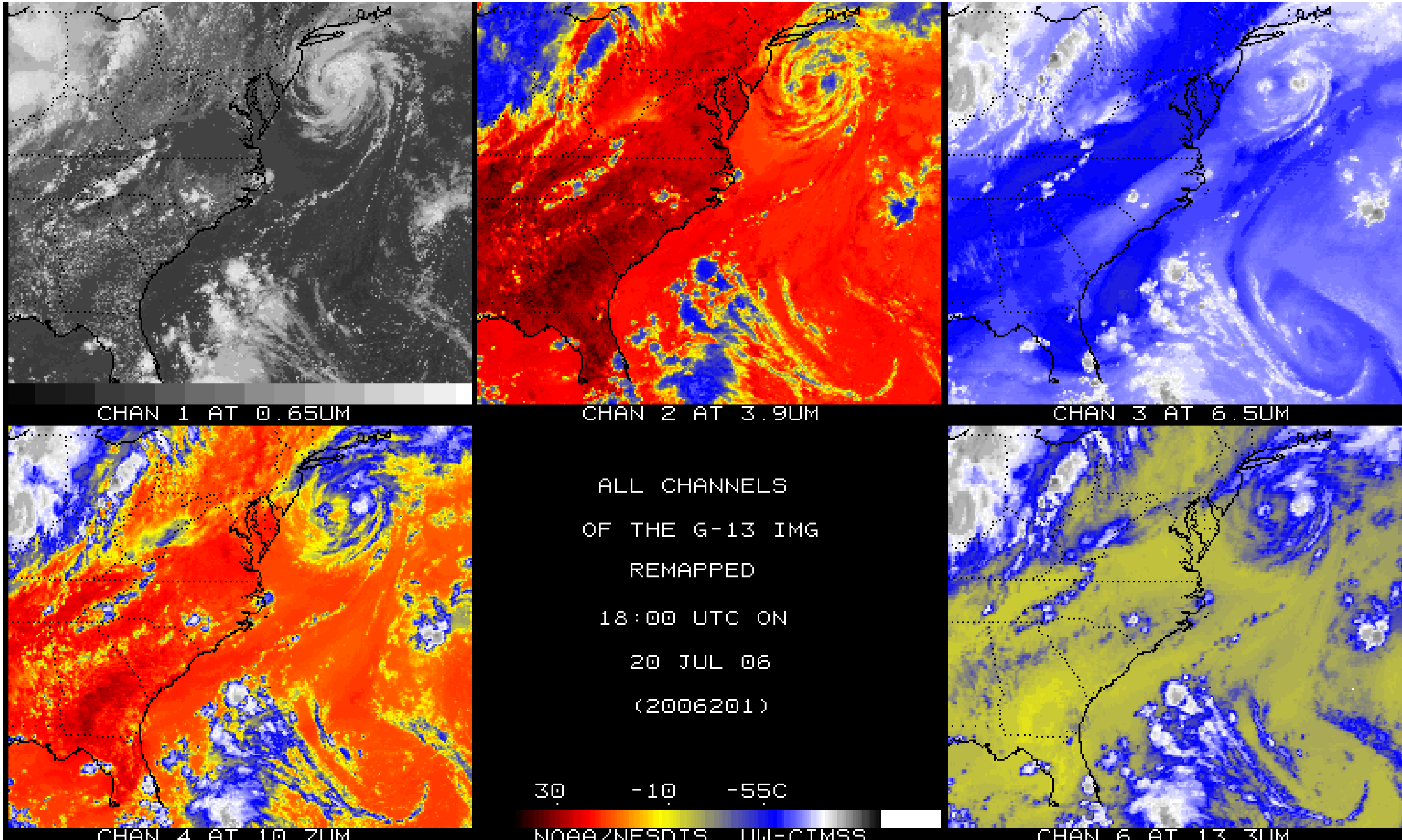


GOES-12 **Imager** Weighting Functions

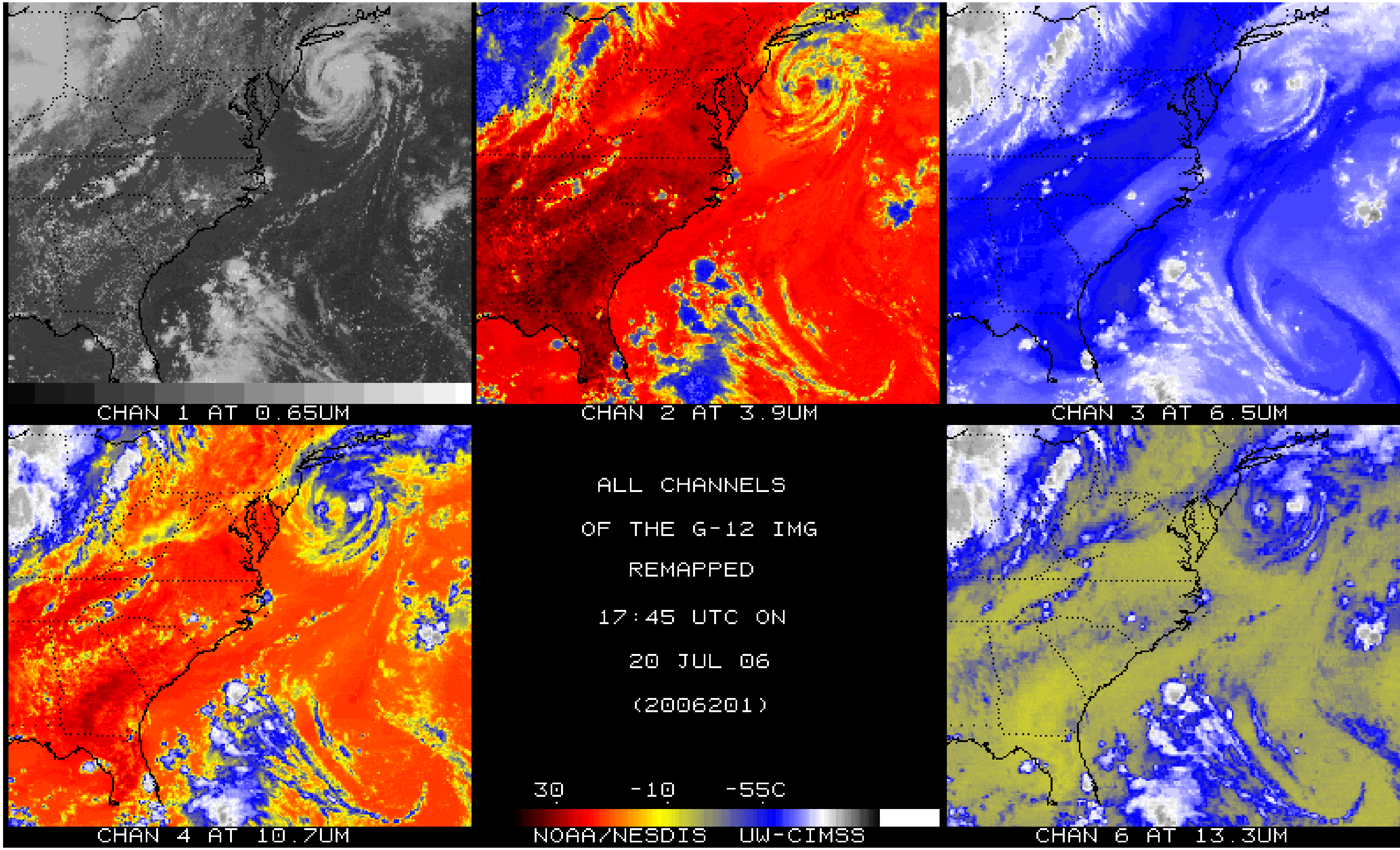
Pressure



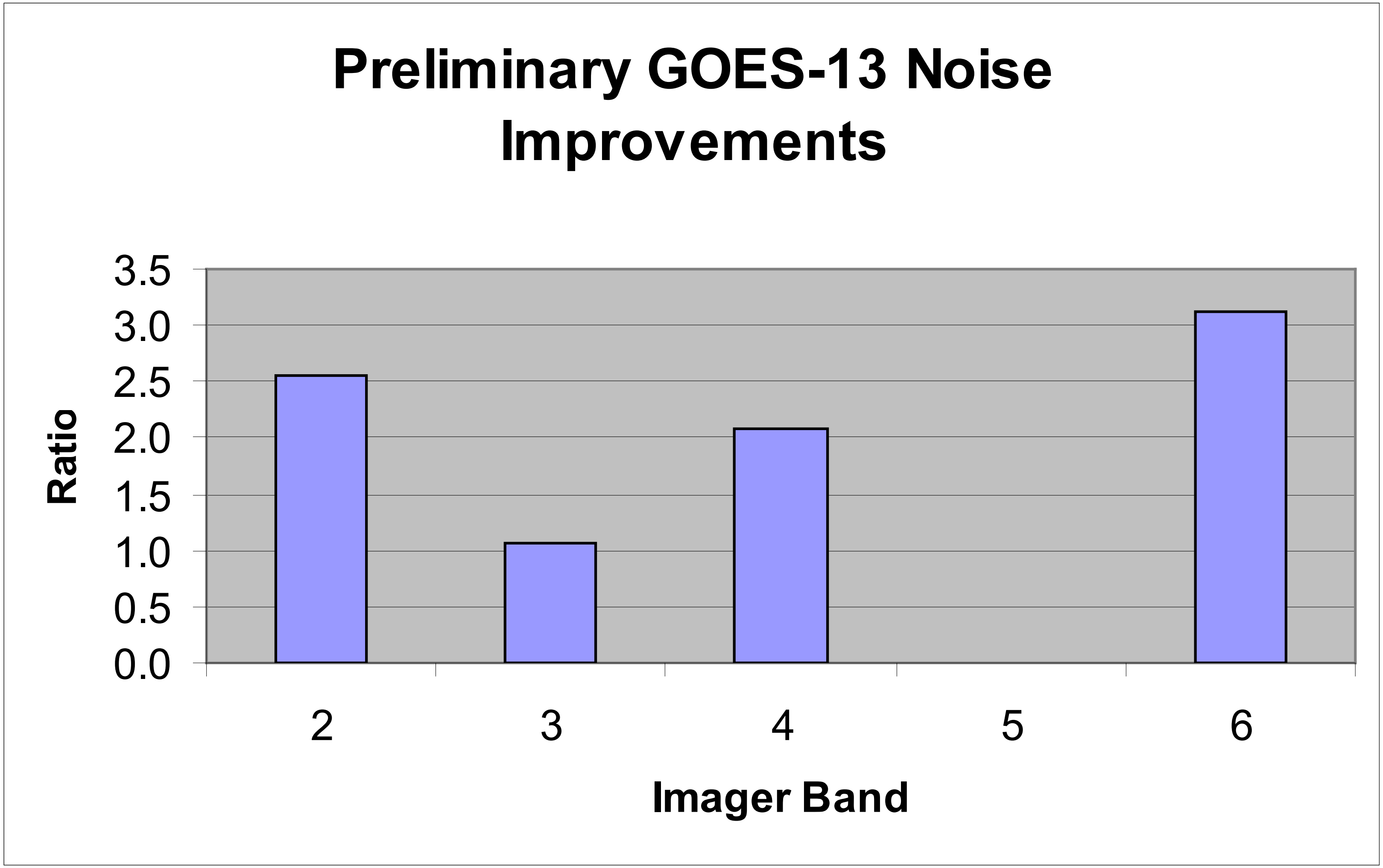
GOES-13 Imager



GOES-12 Imager



Preliminary GOES-13 Imager noise improvements over GOES-12

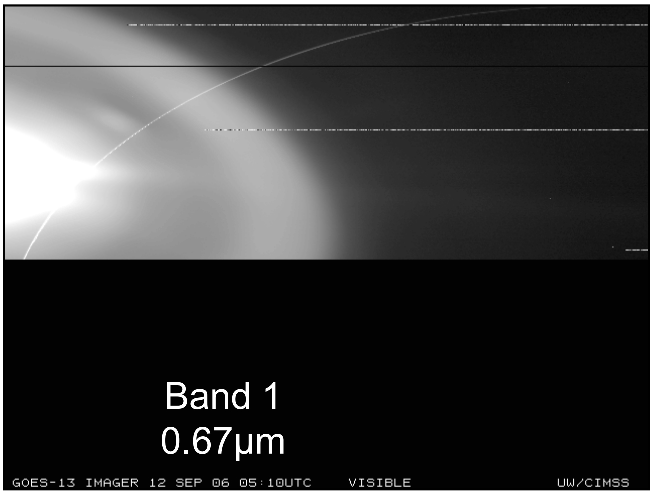


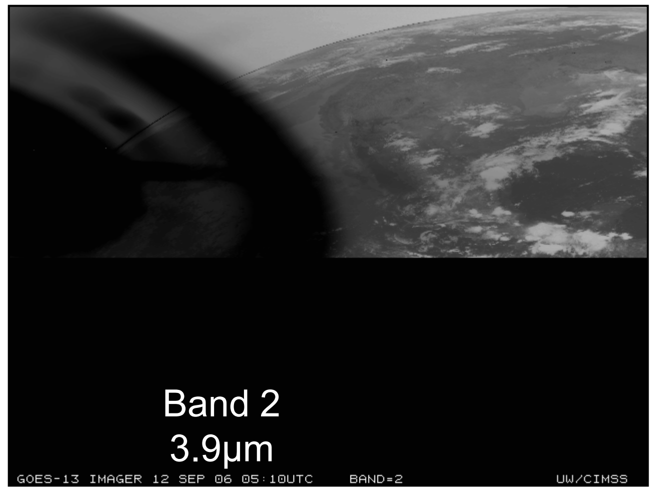
GOES-13 imager shows a factor of up to 3 times less noise

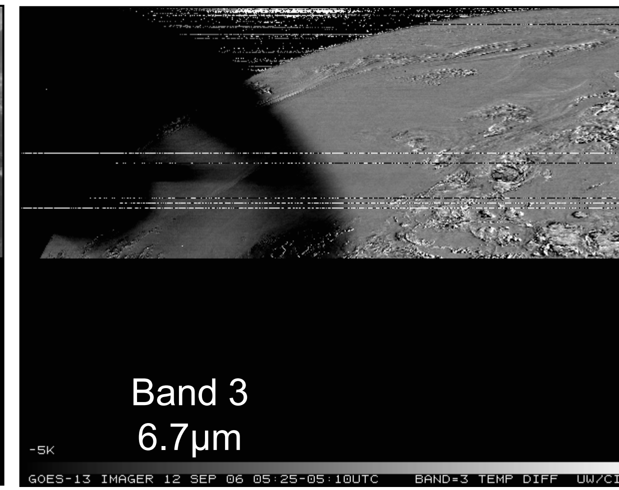
Testing of GOES-13 Keep-Out-Zone

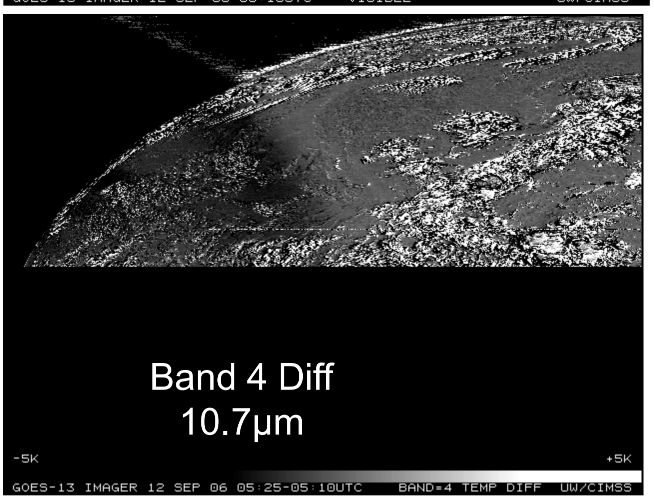
Courtesy of M. Gunshor, CIMSS, T. Schmit, ASPB

Ignore the bad lines due to ingest
Note that even the 13.3 um band (6) is affected



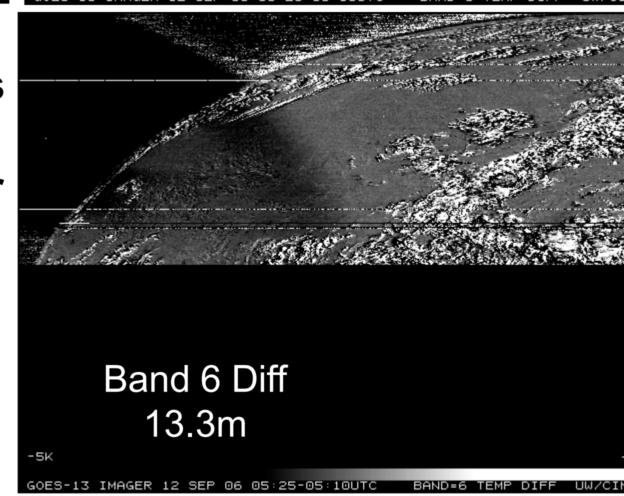


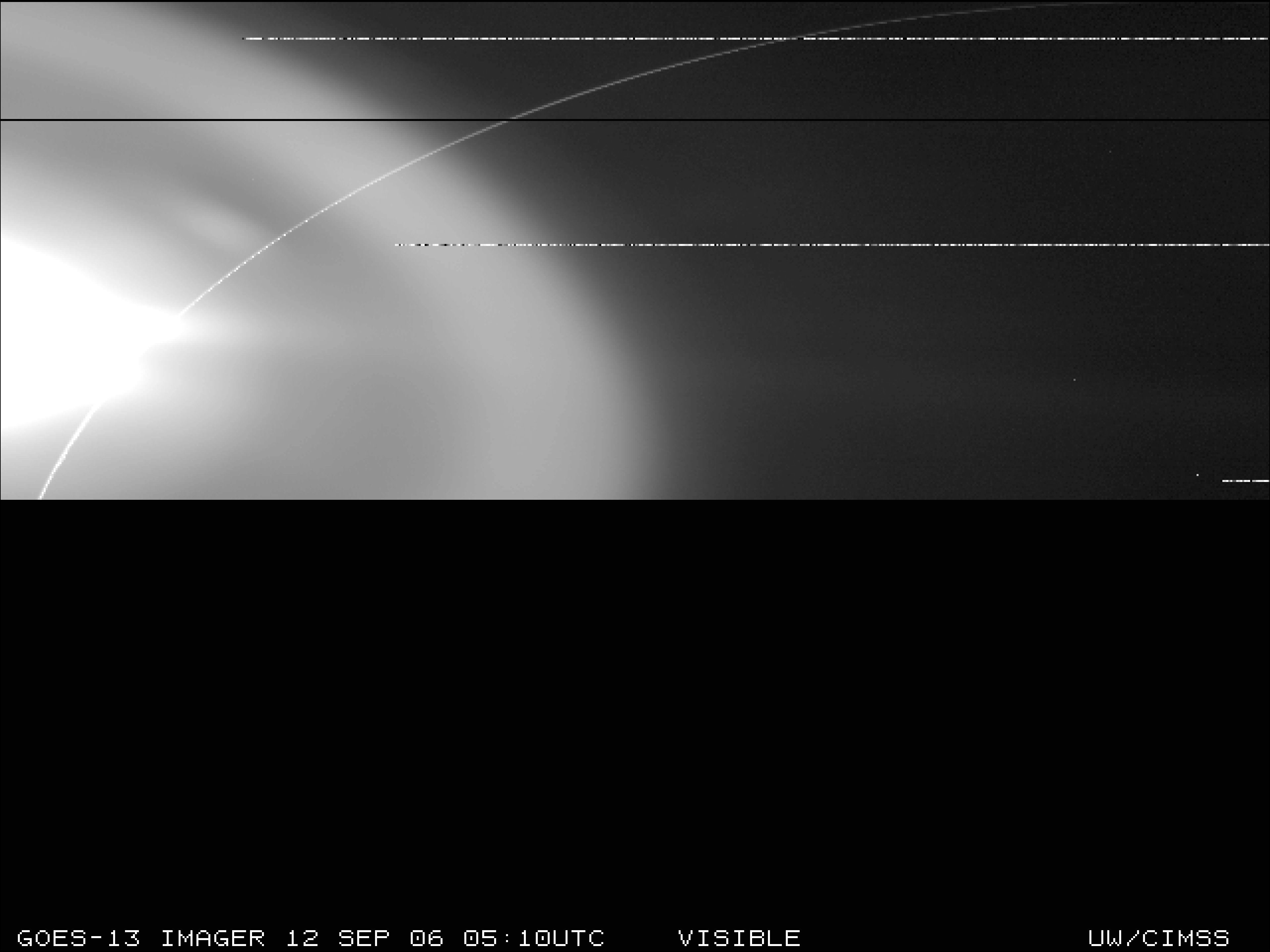


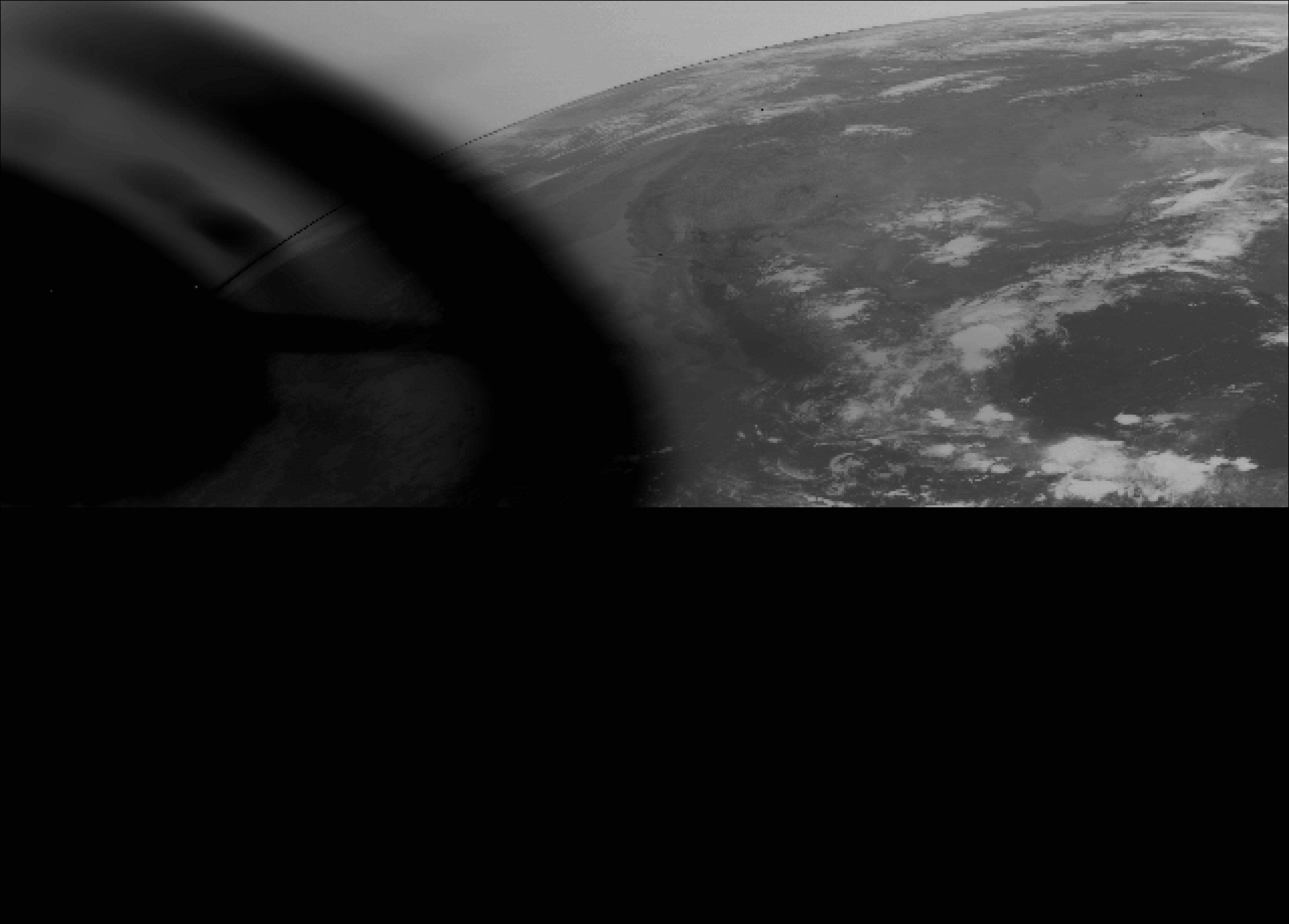


Should the GOES-13/O/P series provide full images, partial images (of unaffected areas) or no images during KOZ?

What impacts to products and operations would be realized with such imagery?

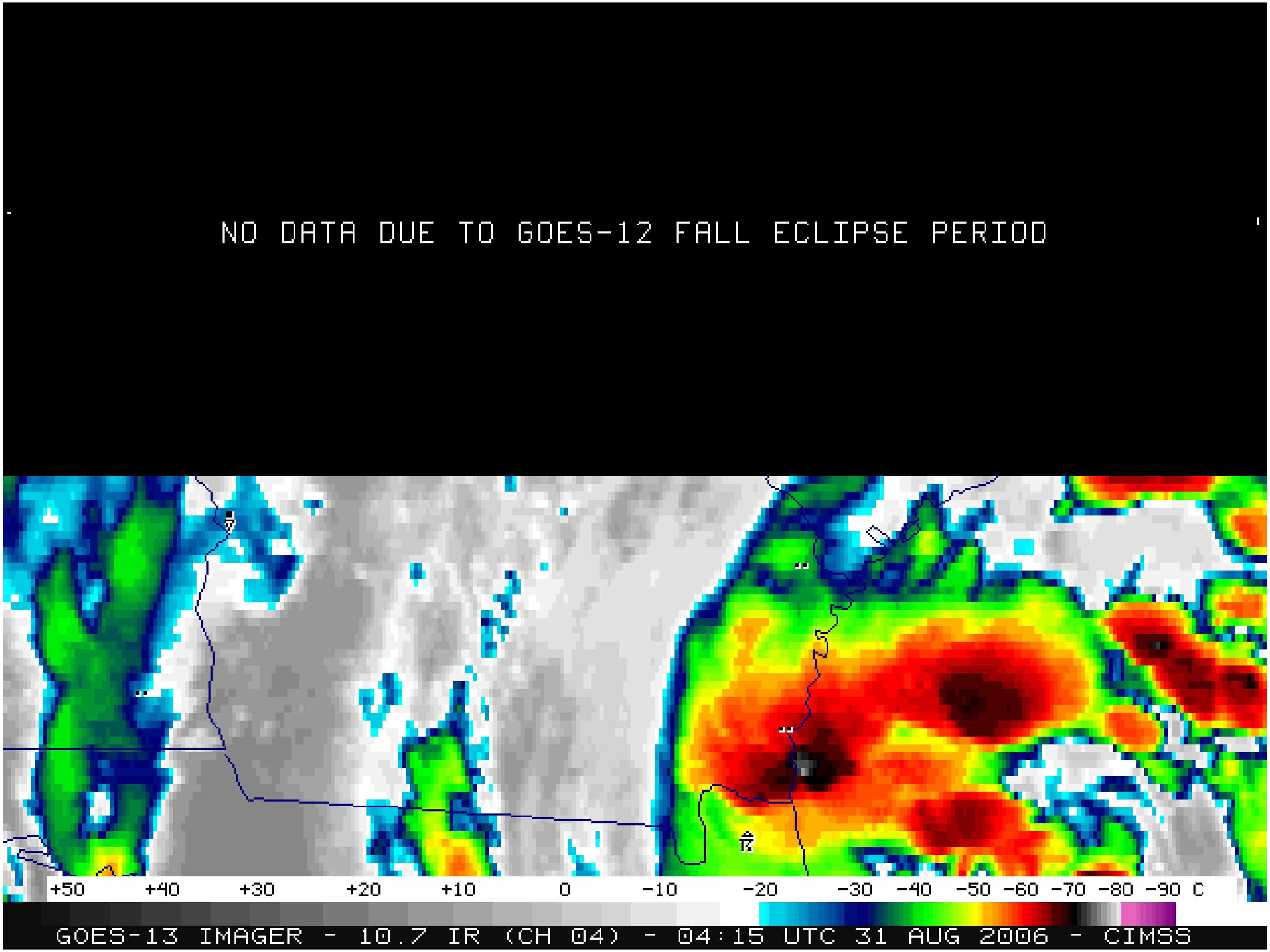



GOES-13 IMAGER 12 SEP 06 05:10UTC
VISIBLE
UW/CIMSS

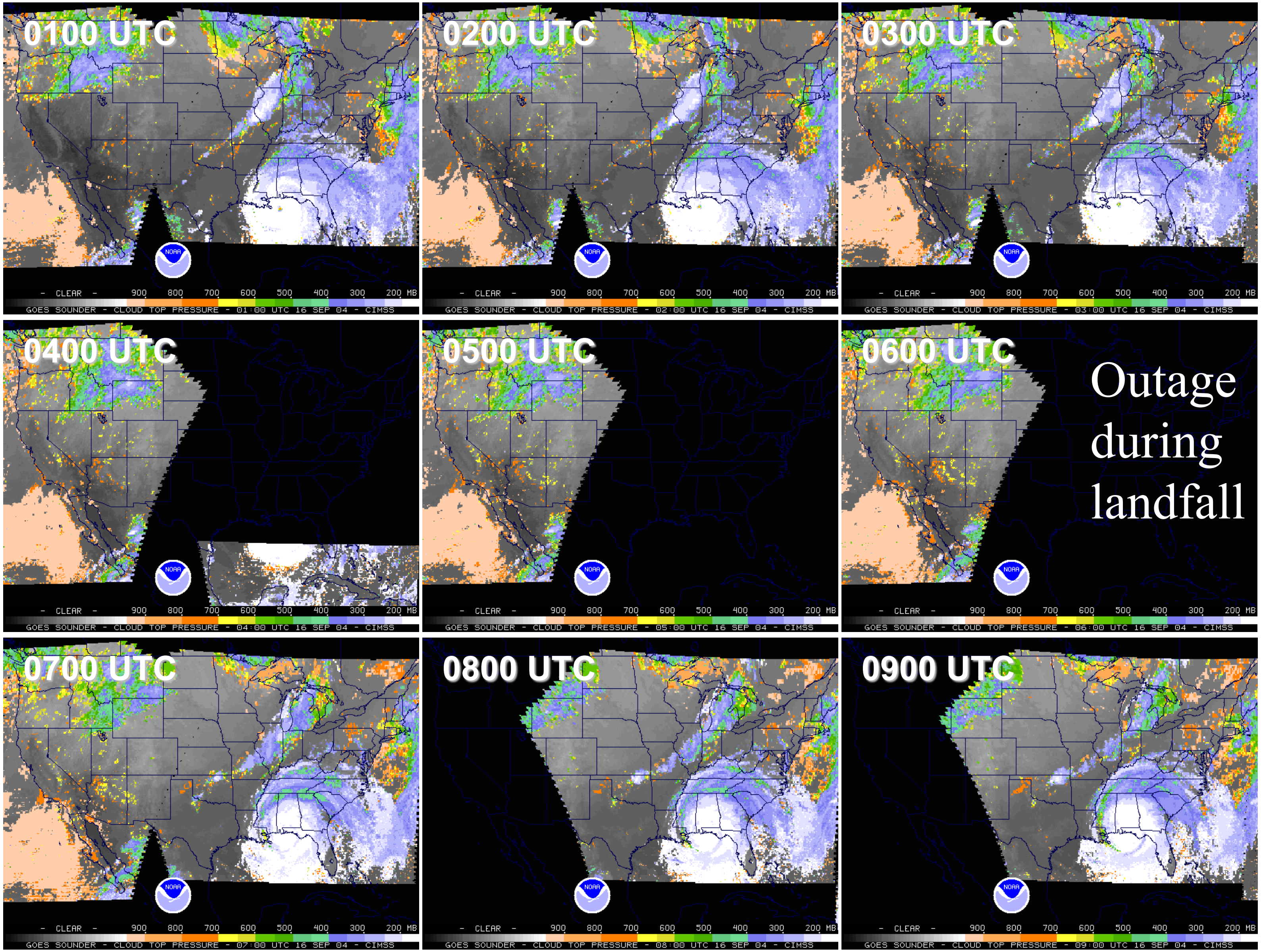


GOES-13 IMAGER 12 SEP 06 05:10UTC BAND=2 UW/CIMSS

GOES-12/13 (During eclipse)

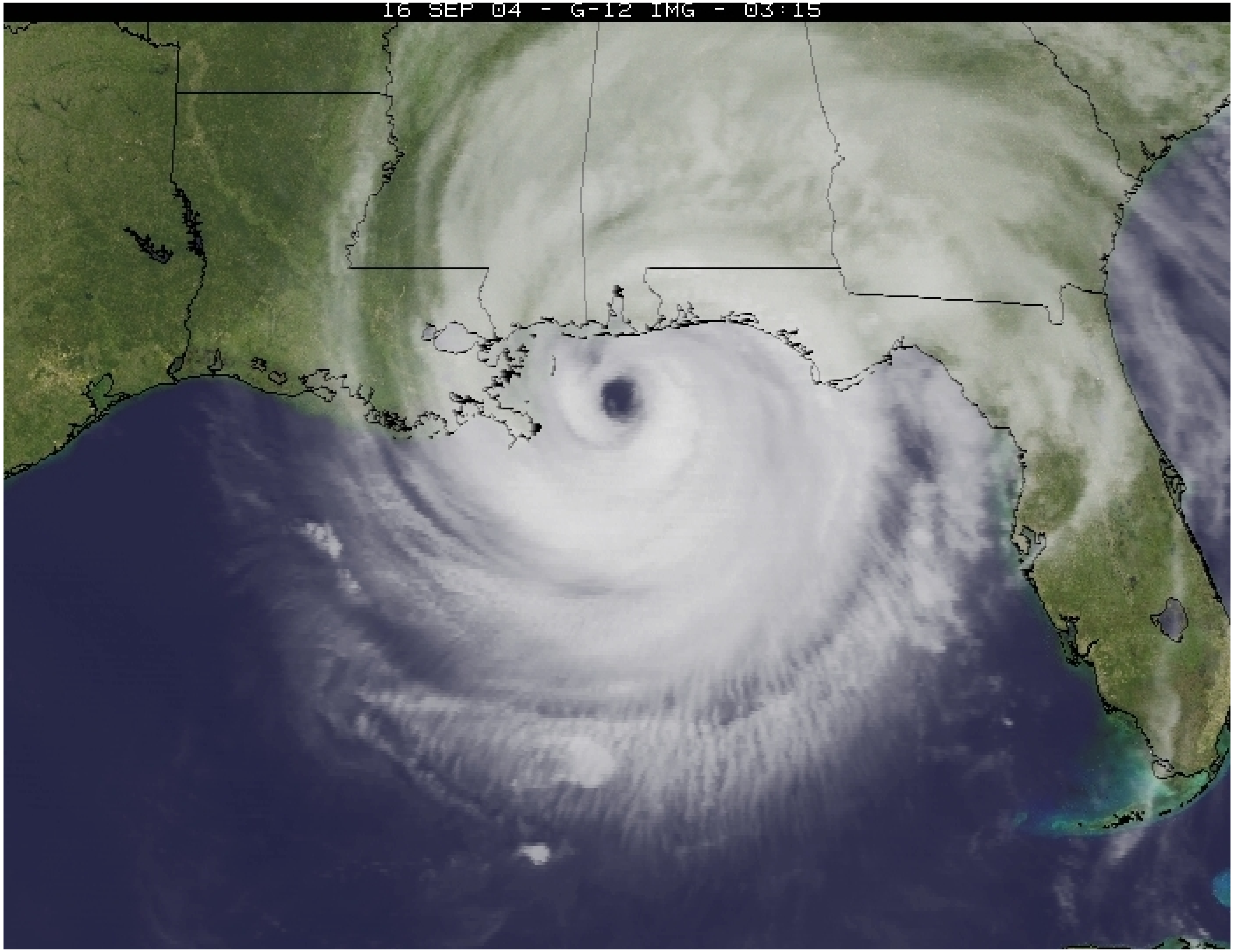


The Onset Of Hurricane Ivan: 16 September 2004



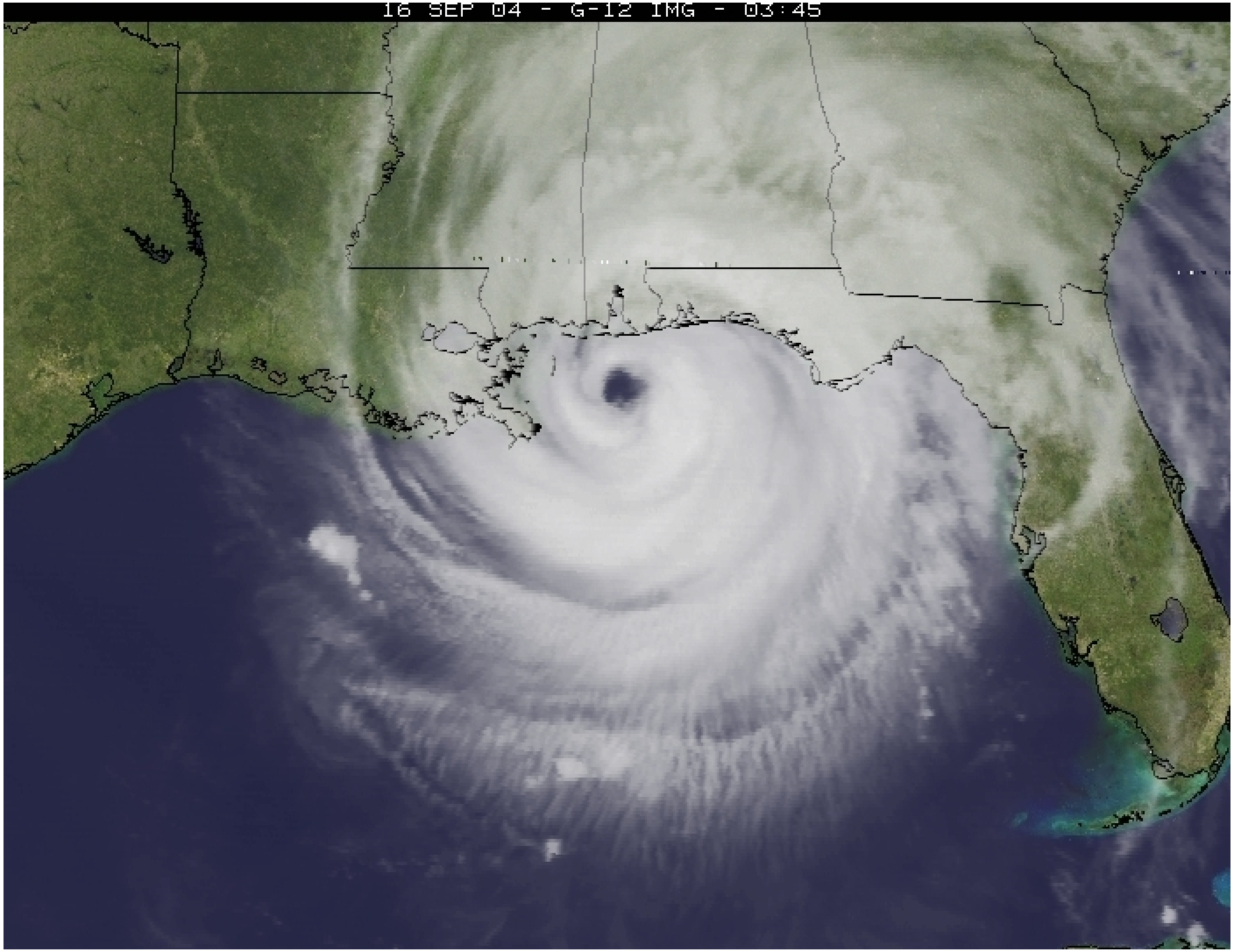
GOES-10 & -12 Sounder Cloud Top Pressure Coverage

Note satellite outage during landfall



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

Note satellite outage during landfall



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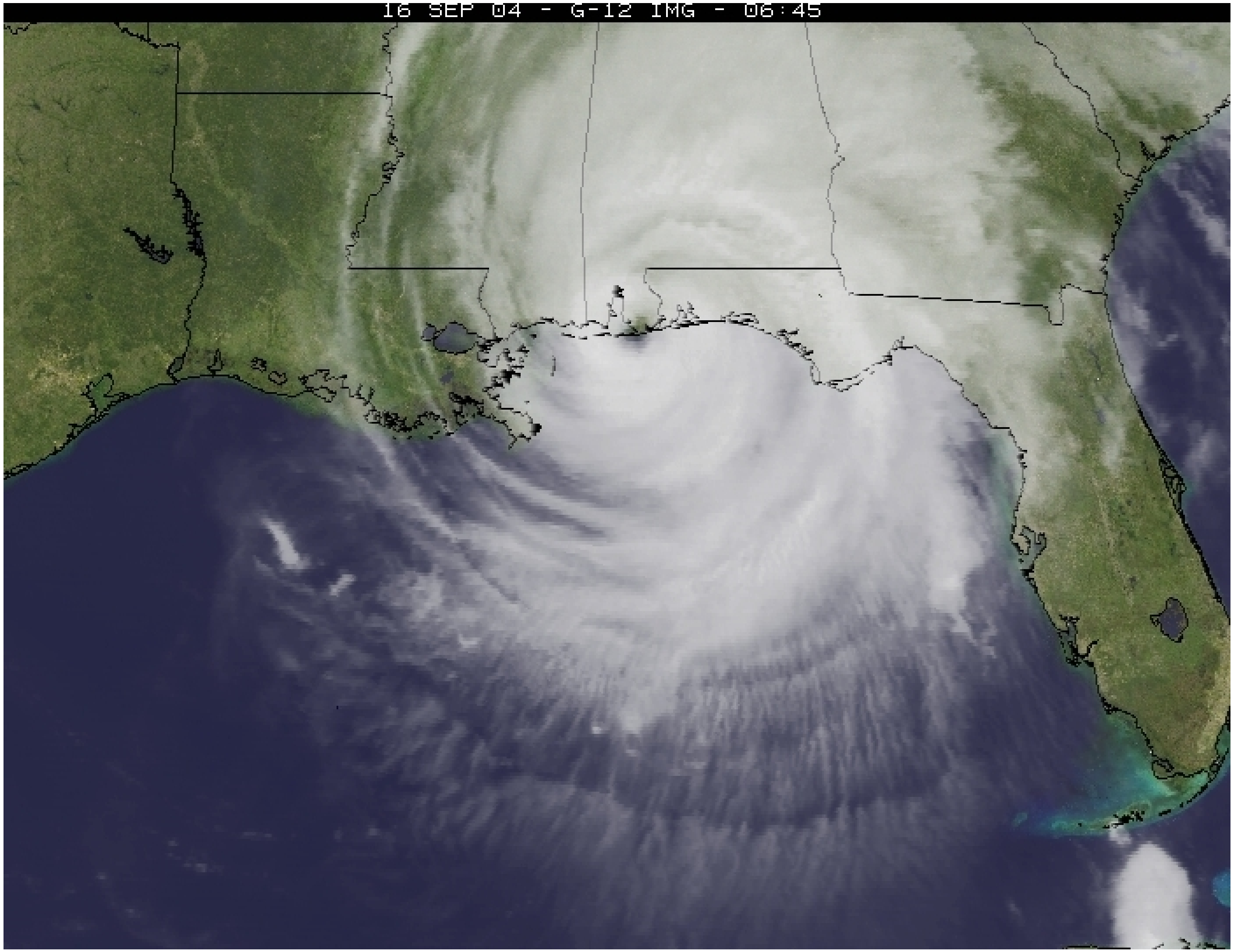

GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

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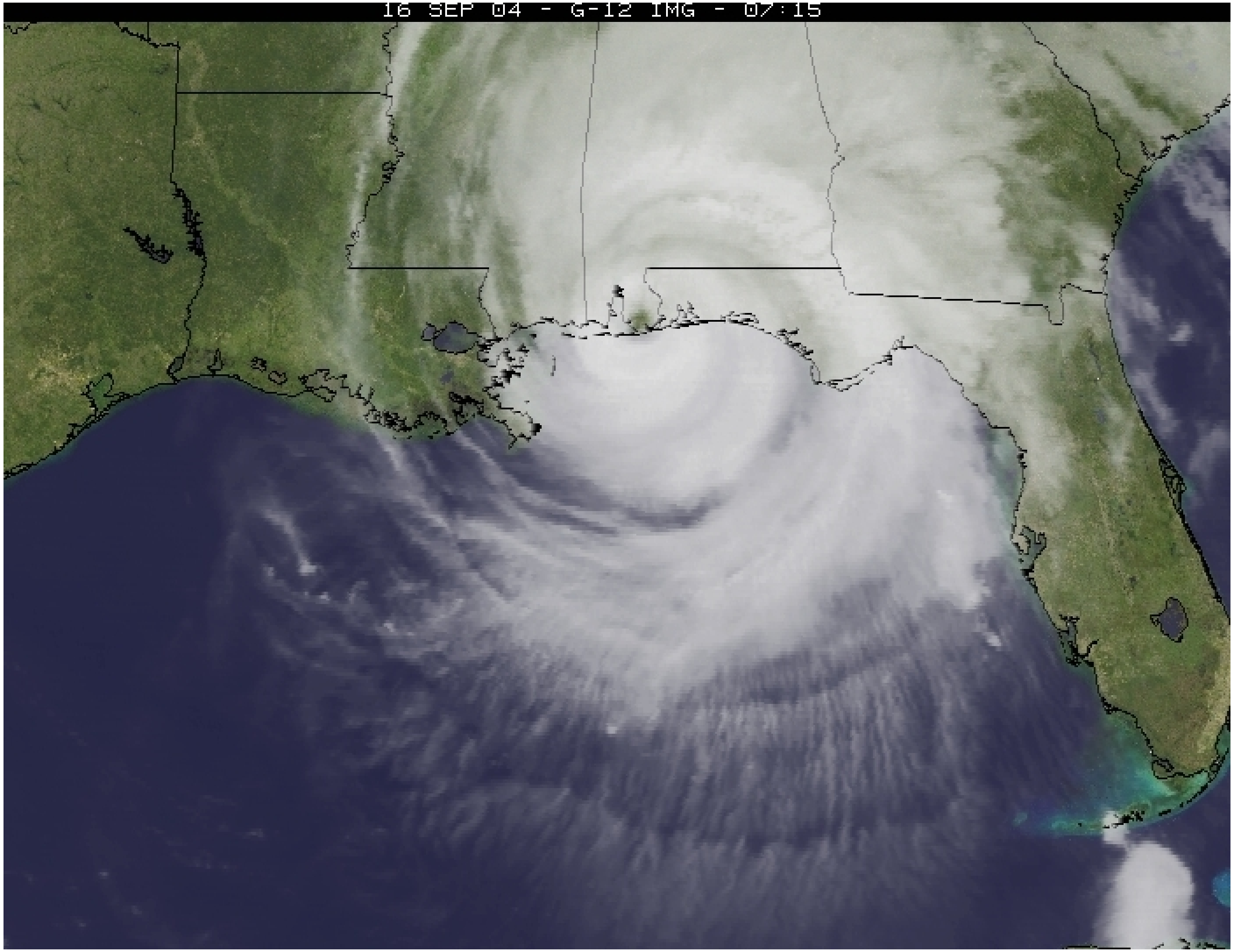
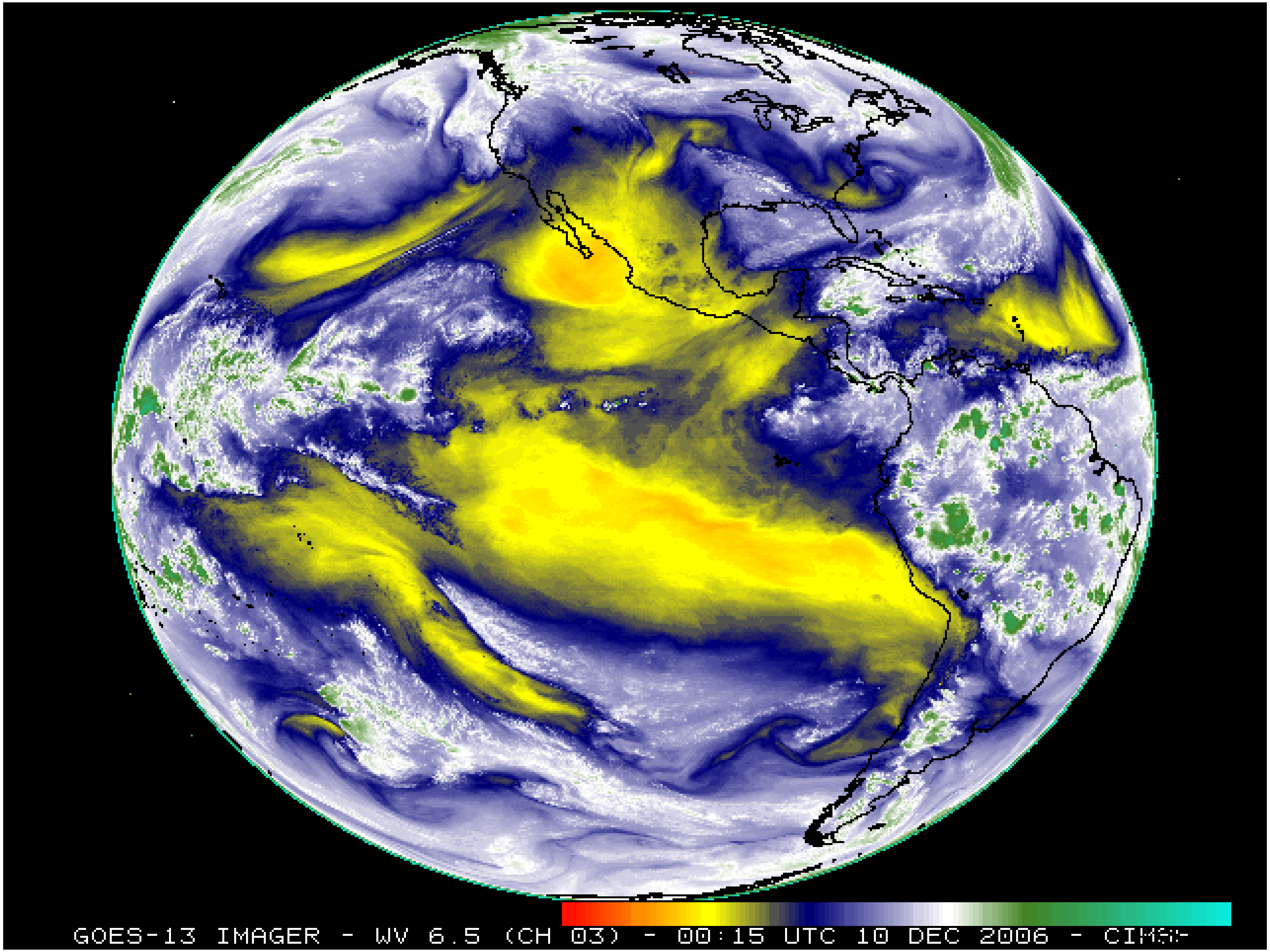


GOES satellite loop: http://www.ssec.wisc.edu/~rickk/eclipseivan.html

GOES-13 (Full Disk)

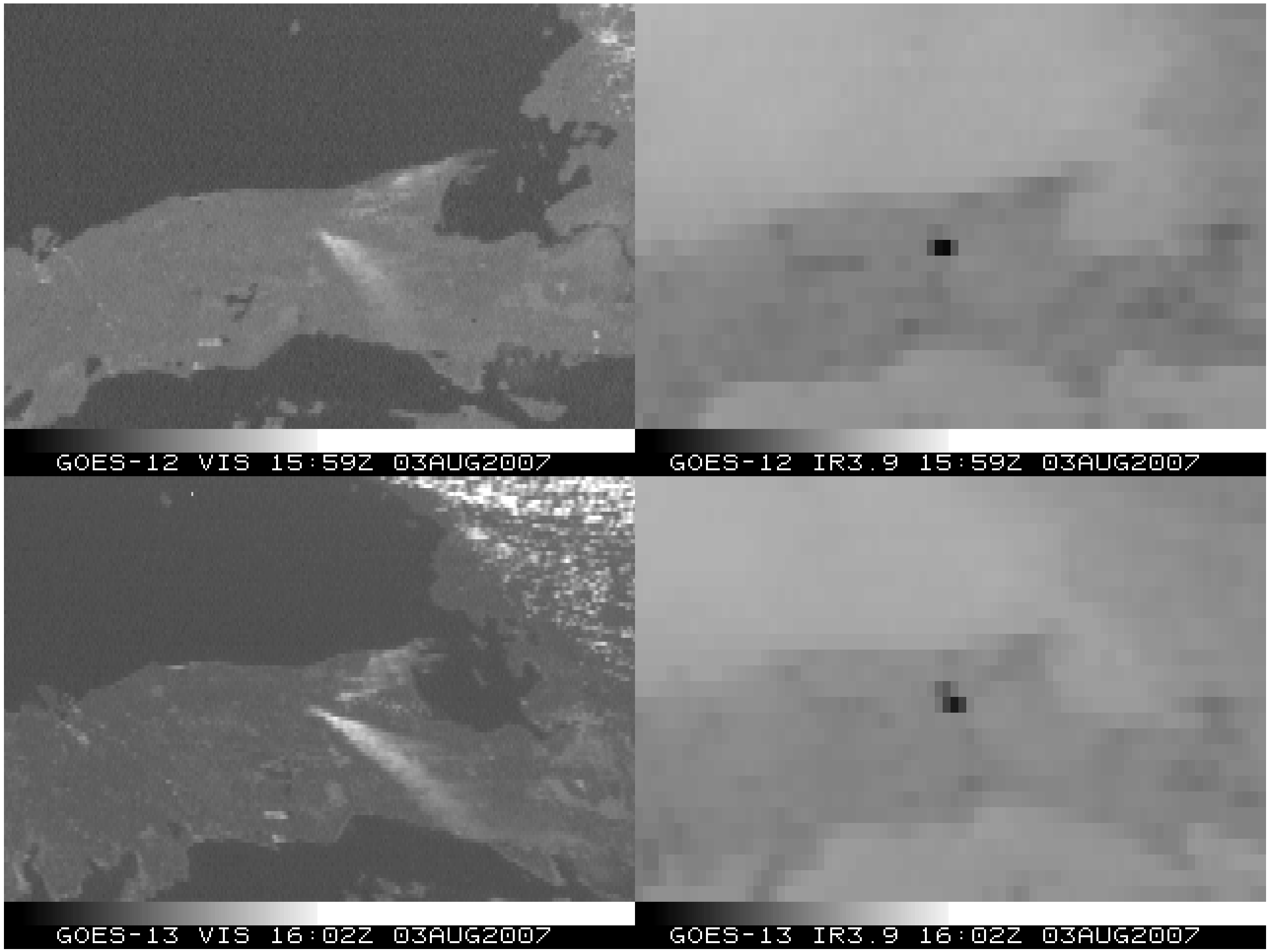


MI Fires

Visible | Shortwave Window

GOES-12:

GOES-13:



3-Aug-2007

S. Bachmeier, CIMSS

Outline

- GOES-13
- **GOES-O/P (GVAR change)**
  - 13.3 µm with ~4km IGFOV
- GOES-R
  - Schedule
  - ABI
  - Intro GLM

GOES-0

- To become GOES-14
- Launch date *may* be Spring of 2008
- Followed by a post-launch check-out and on-orbit storage.

Outline

- GOES-13
- GOES-O/P
  - 13.3 µm change
- **GOES-R**
  - Schedule
  - ABI
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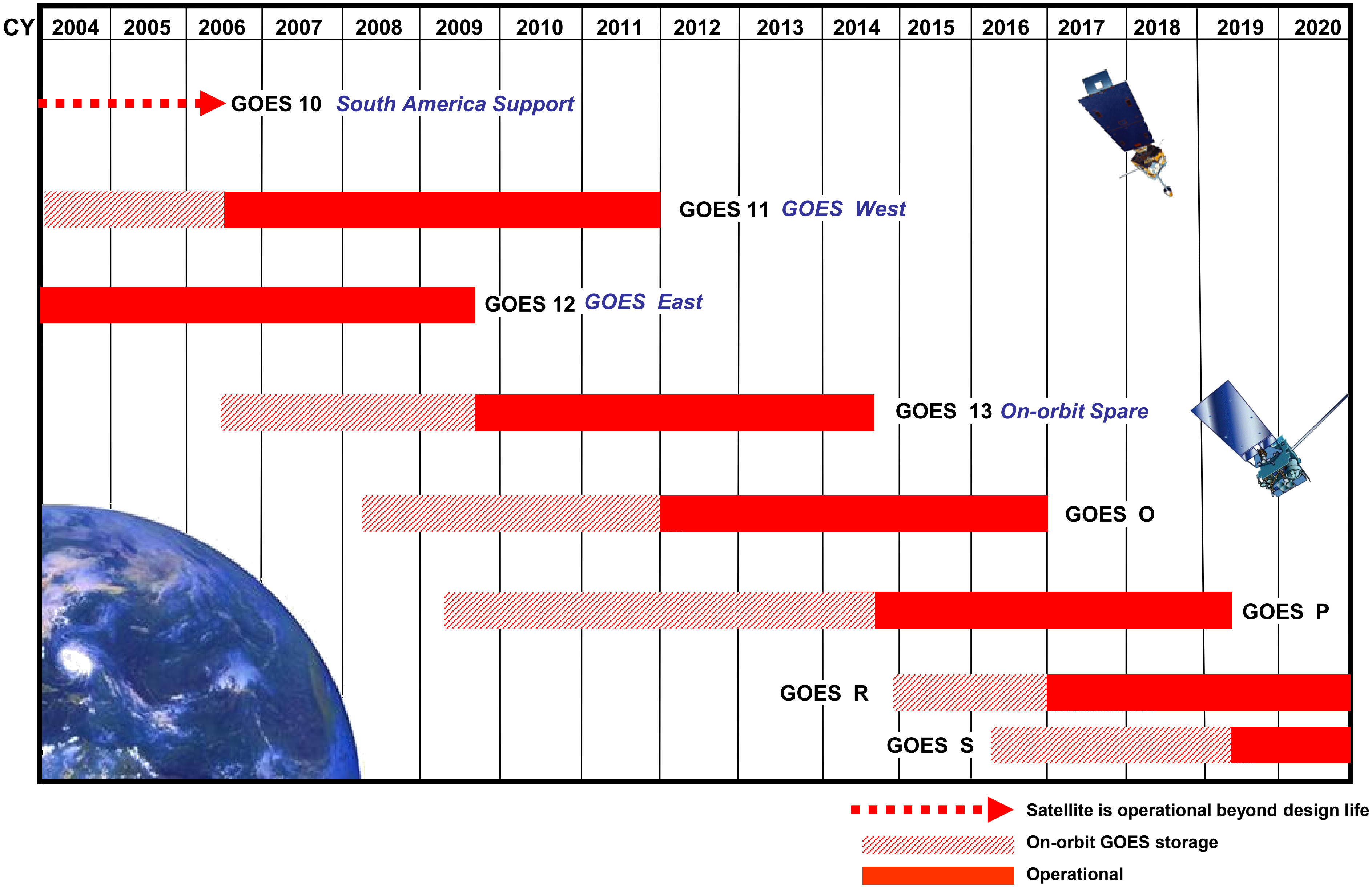
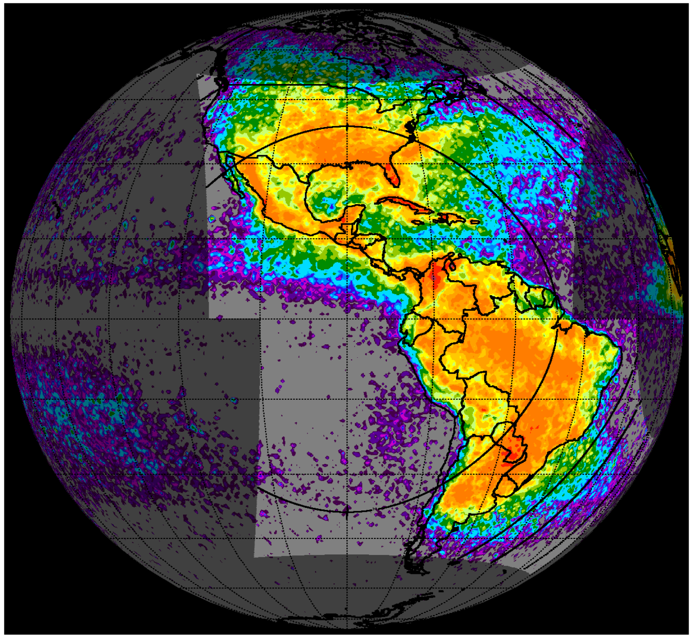
Continuity of GOES Operational Satellite Program



Critical Products to the Nation

- **Advanced Baseline Imager (ABI)**
  - Monitors and tracks severe weather, winds, hurricanes, hazards, etc.
  - Images clouds to support forecasts
  - Aerosols for Air Quality & Climate Applications
  - Volcanic ash tracking, fire and smoke detection, winds and icing detection
- **Hyperspectral Environmental Suite (HES)**
  - Provides atmospheric moisture and temperature profiles to support environmental models, forecasts and climate monitoring
  - Monitors coastal regions for ecosystem health, water quality, coastal erosion, harmful algal blooms, sea surface temperature
  - Geostationary sampling of ocean color allows coastal resource management
- **Geostationary Lightning Mapper (GLM)**
  - Detects lightning strikes as an indicator of severe storms
  - Previous capability only existed on polar satellites
- **EXIS – (EUV and X-Ray Irradiance Sensors) and Space Environmental In-Situ Suite (SEISS)**
  - Images the sun and measures solar output to monitor solar storms (SUVI/EXIS)
  - Measures magnetic fields and charged particles (SEISS)
  - Enables early warnings for satellite and power grid operations, telecom services, astronauts, and airlines
- **Unique Payload Services**
  - Environmental Data Relay
  - Search and Rescue

Geostationary Lightning Mapper (GLM)



- **Detects total strikes: in cloud, cloud to cloud, and cloud to ground**
  - **Compliments today's land based systems that only measures cloud to ground (about 15% of the total lightning)**

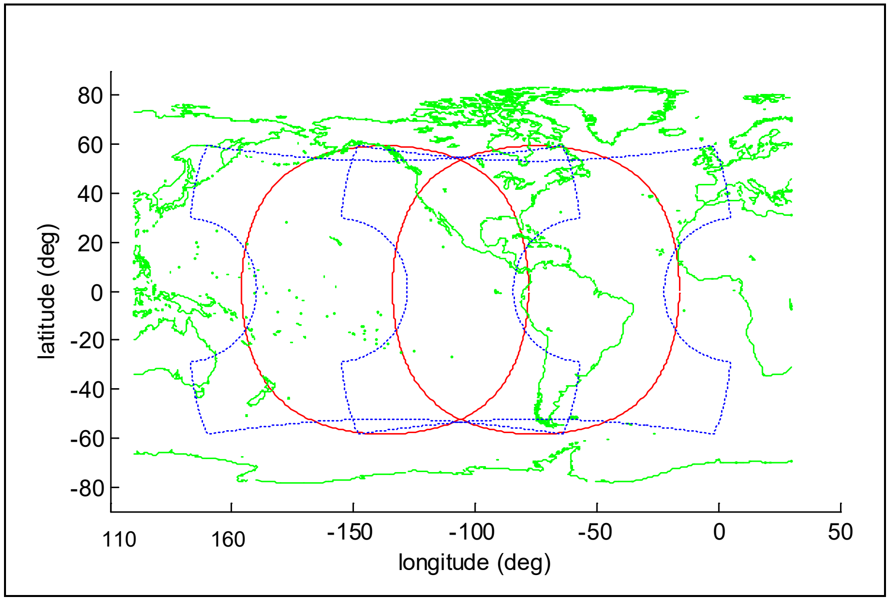
- **Increased coverage over oceans and lands**
  - **Currently no ocean coverage, <u>and</u> limited land coverage in dead zones**

GLM Objectives:

Provide continuous, full-disk lightning measurements for storm warning and nowcasting.

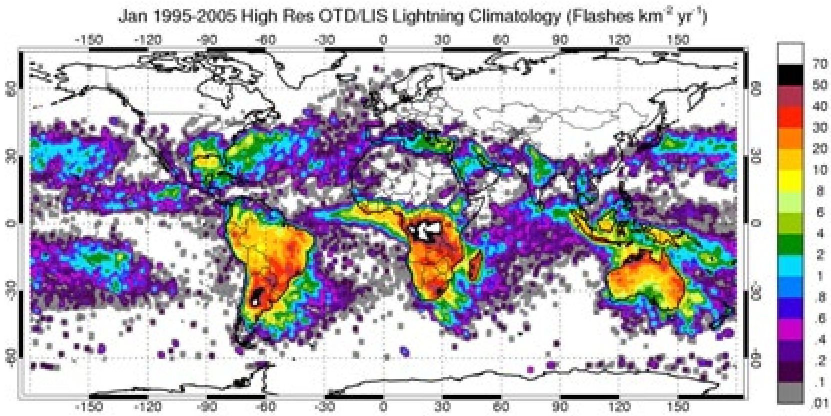
Provide early warning of tornadic activity.

GOES-E and GOES-W GLM View of CONUS and Adjacent Oceans

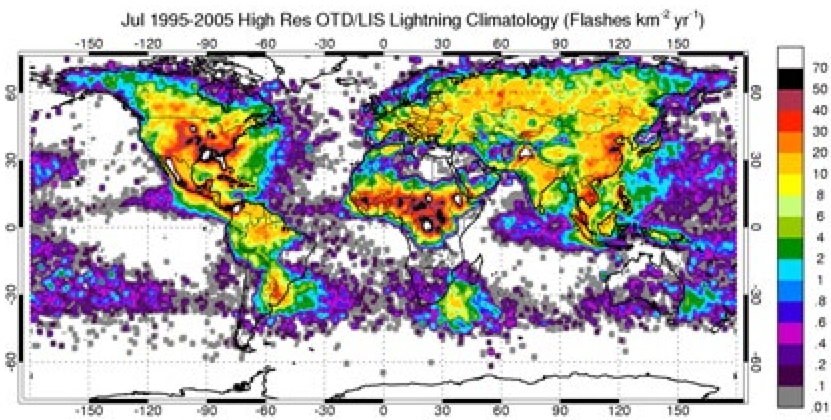


The GLM full-disk is defined as the intersection of circular and square Earth-centered fields-of-view having minimum diameter 16.0º and minimum length 15.1º respectively.

First geostationary LM!

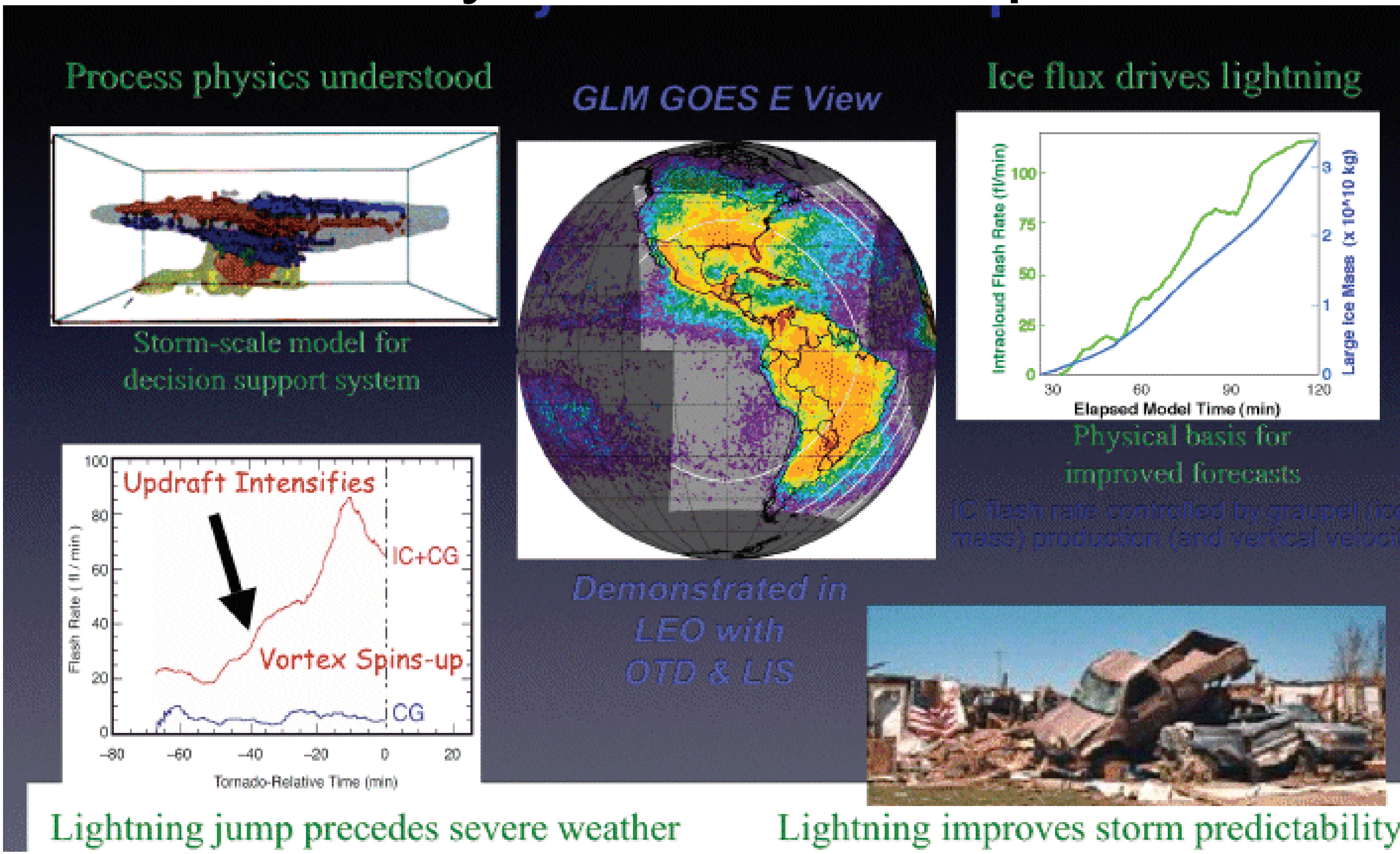


Combined 10-yr LIS/OTD for January



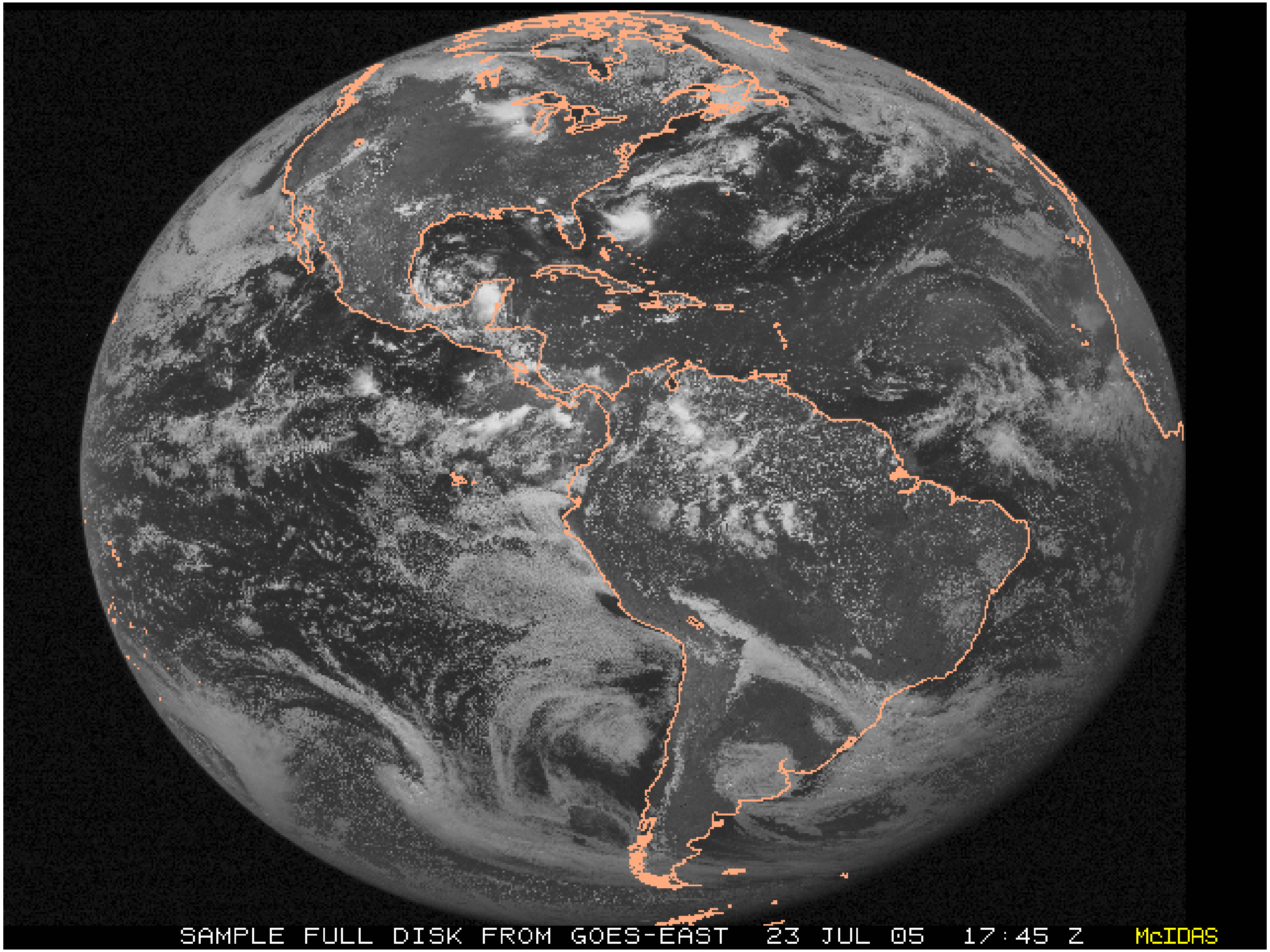
Combined 10-yr LIS/OTD for July

Continuous GEO Total Lightning will identity severe storm potential



The Advanced Baseline Imager:

	ABI	Current
Spectral Coverage		
	16 bands	5 bands
Spatial resolution		
0.64 μm Visible	0.5 km	Approx. 1 km
Other Visible/near-IR	1.0 km	n/a
Bands (>2 μm)	2 km	Approx. 4 km
Spatial coverage		
Full disk	4 per hour	Every 3 hours
CONUS	12 per hour	~4 per hour
Mesoscale	Every 30 sec	n/a
Visible (reflective bands)		
On-orbit calibration	Yes	No

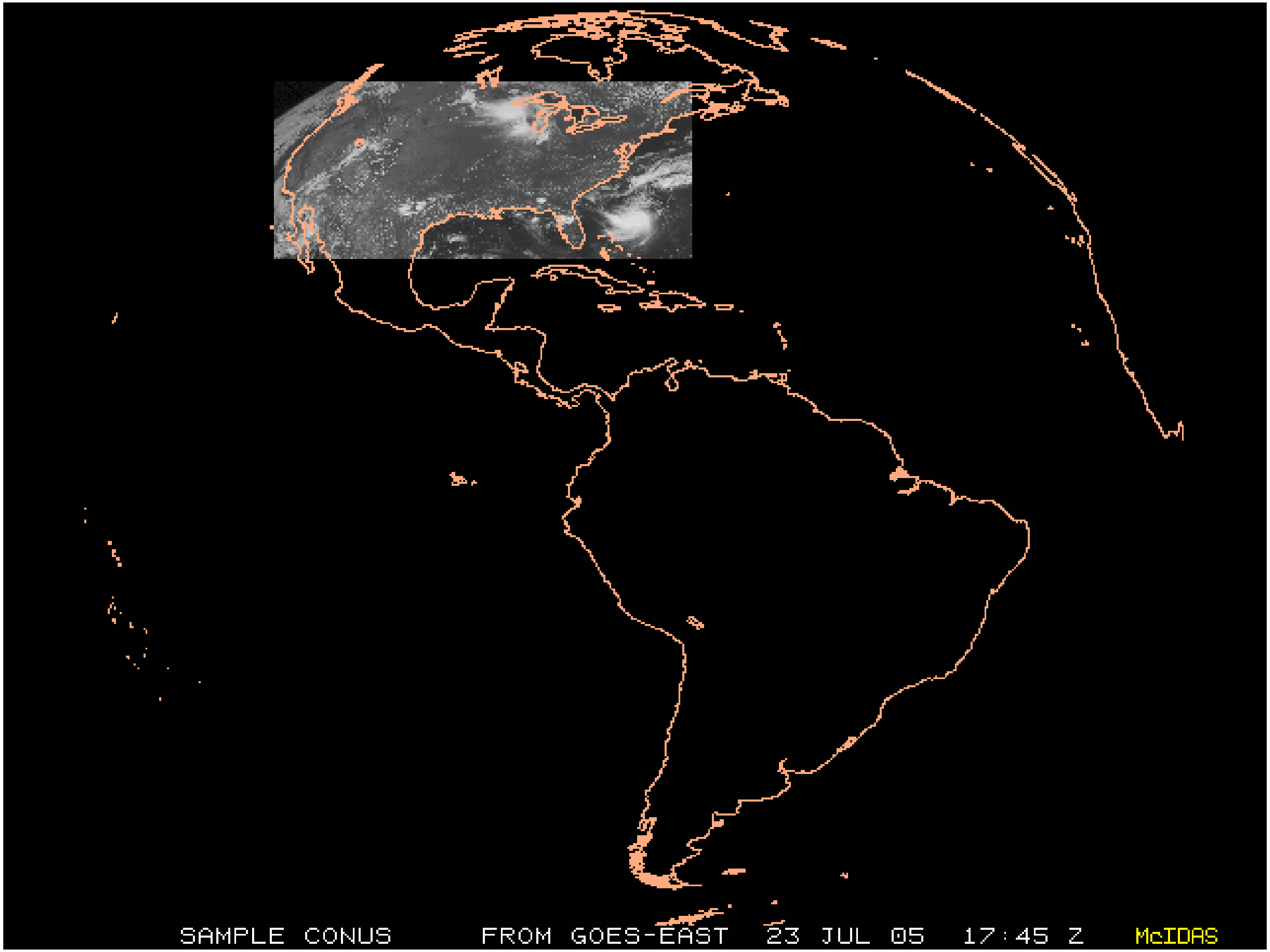


ABI scans about 5 times faster than the current GOES imager

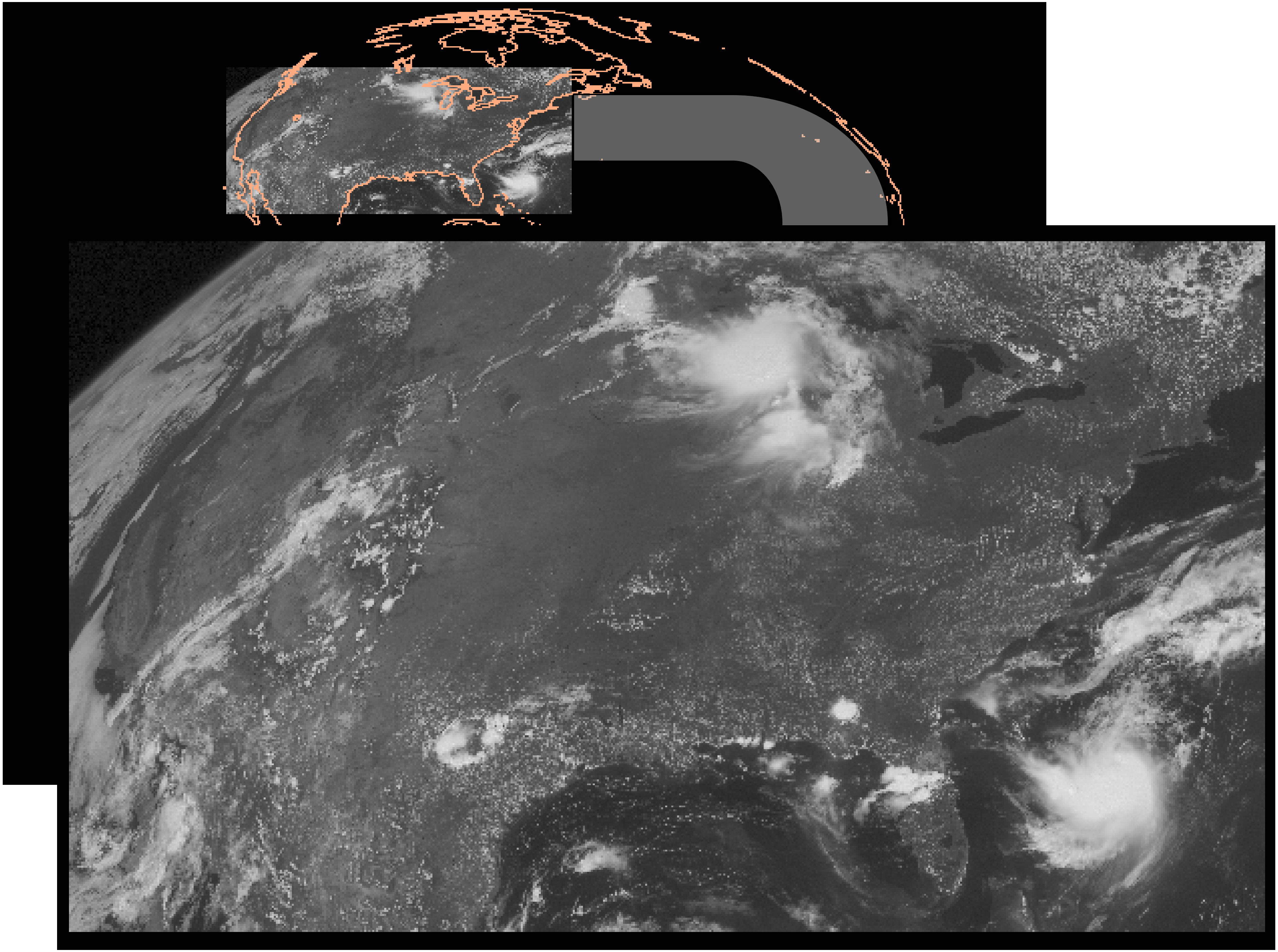
There are two anticipated scan modes for the ABI:

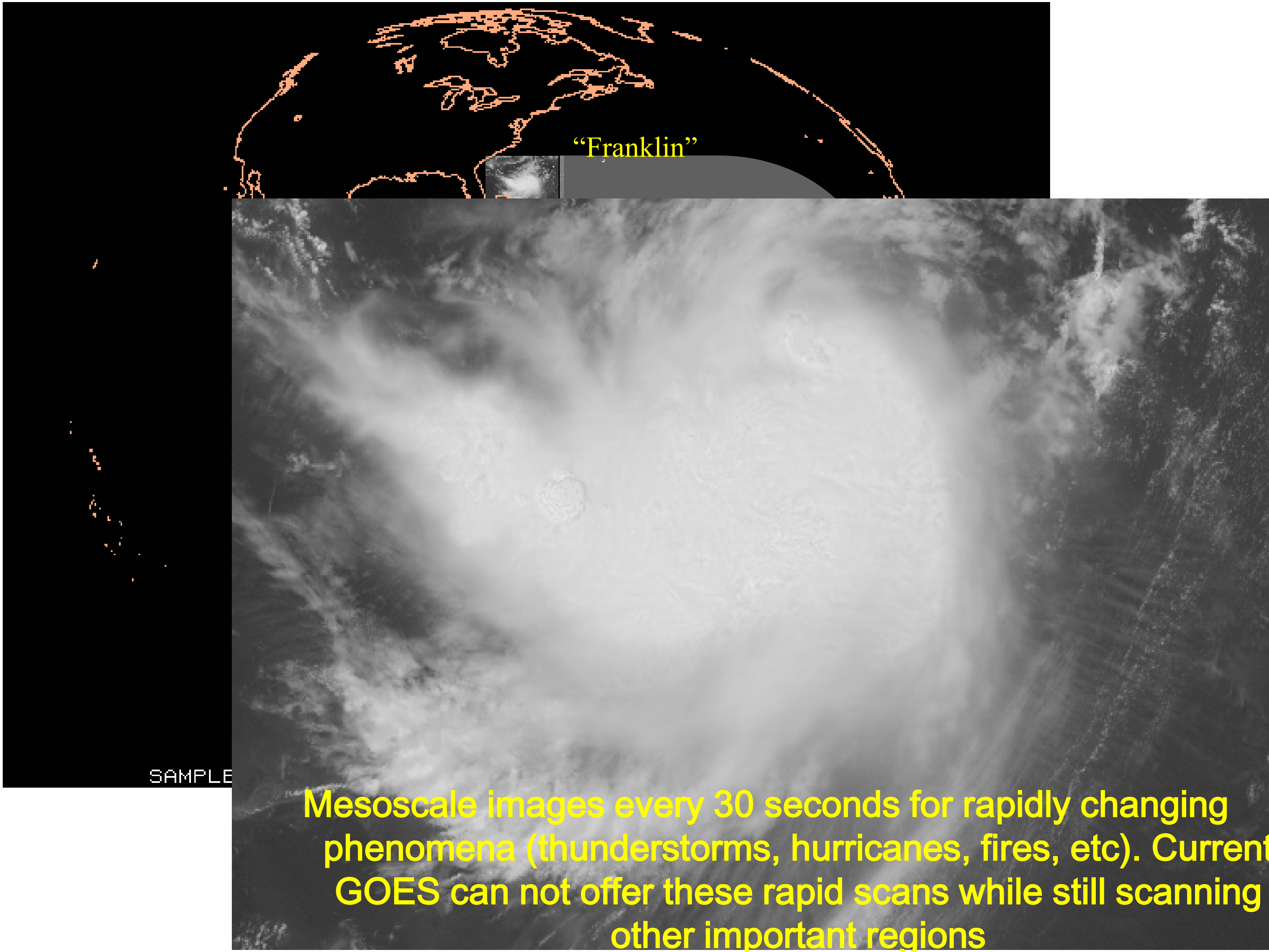
- Full disk images every 15 minutes + 5 min CONUS images + mesoscale.

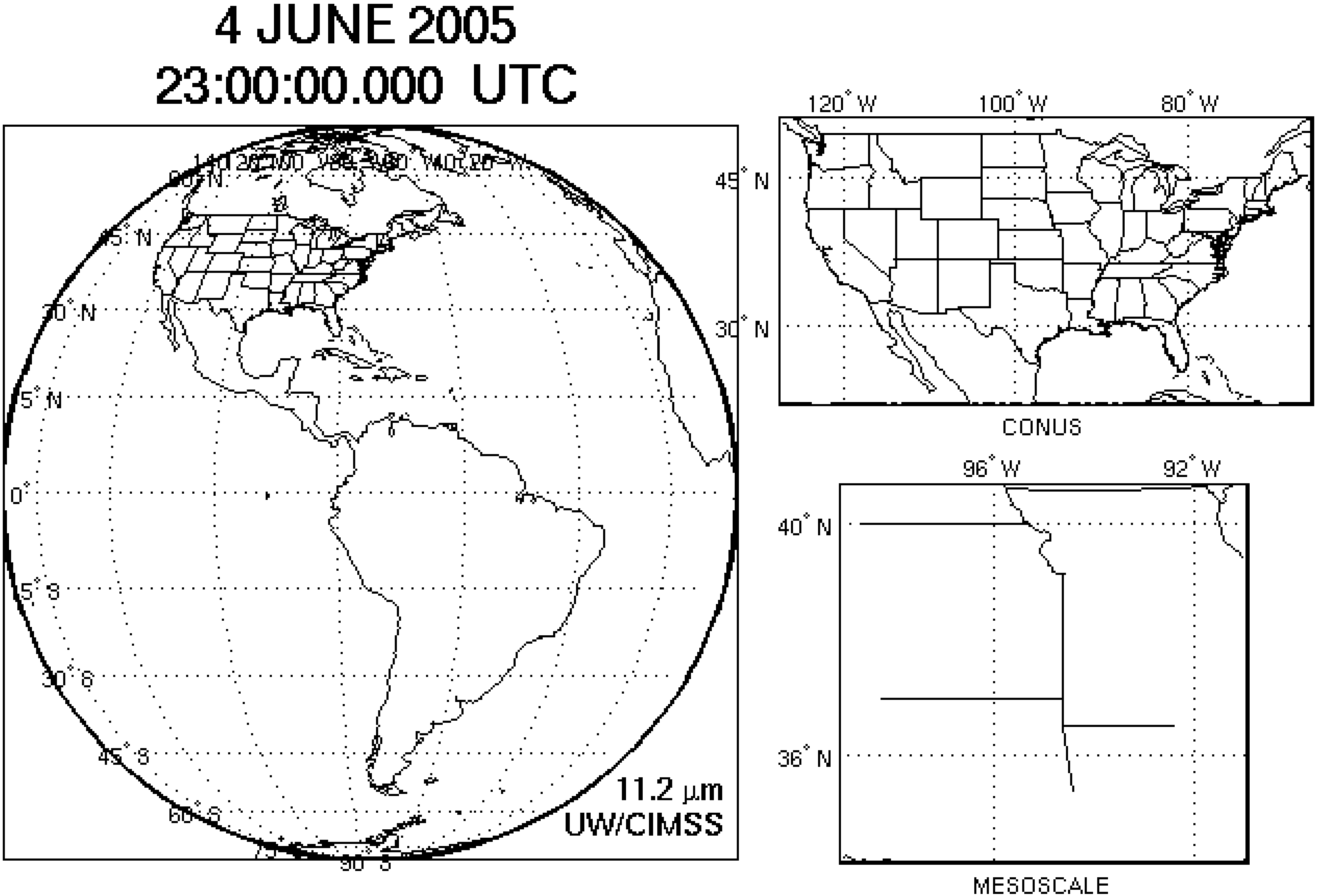
or - Full disk every 5 minutes.



ABI can offer Continental US images every 5 minutes for routine monitoring of a wide range of events (storms, dust, clouds, fires, winds, etc).
This is every 15 or 30 minutes with the current GOES in routine mode.

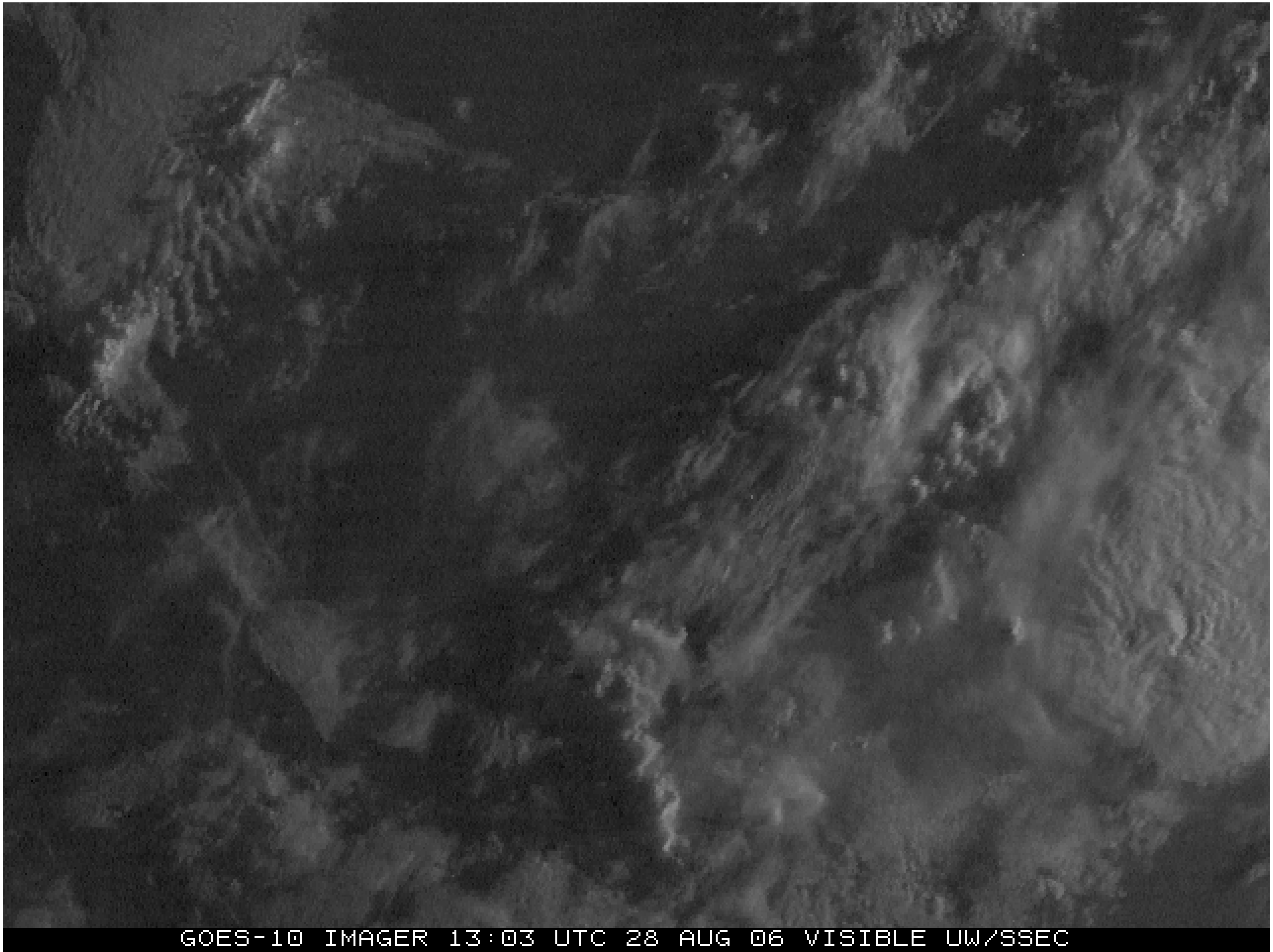



"Franklin"
SAMPLE
Mesoscale images every 30 seconds for rapidly changing phenomena (thunderstorms, hurricanes, fires, etc). Current GOES can not offer these rapid scans while still scanning other important regions

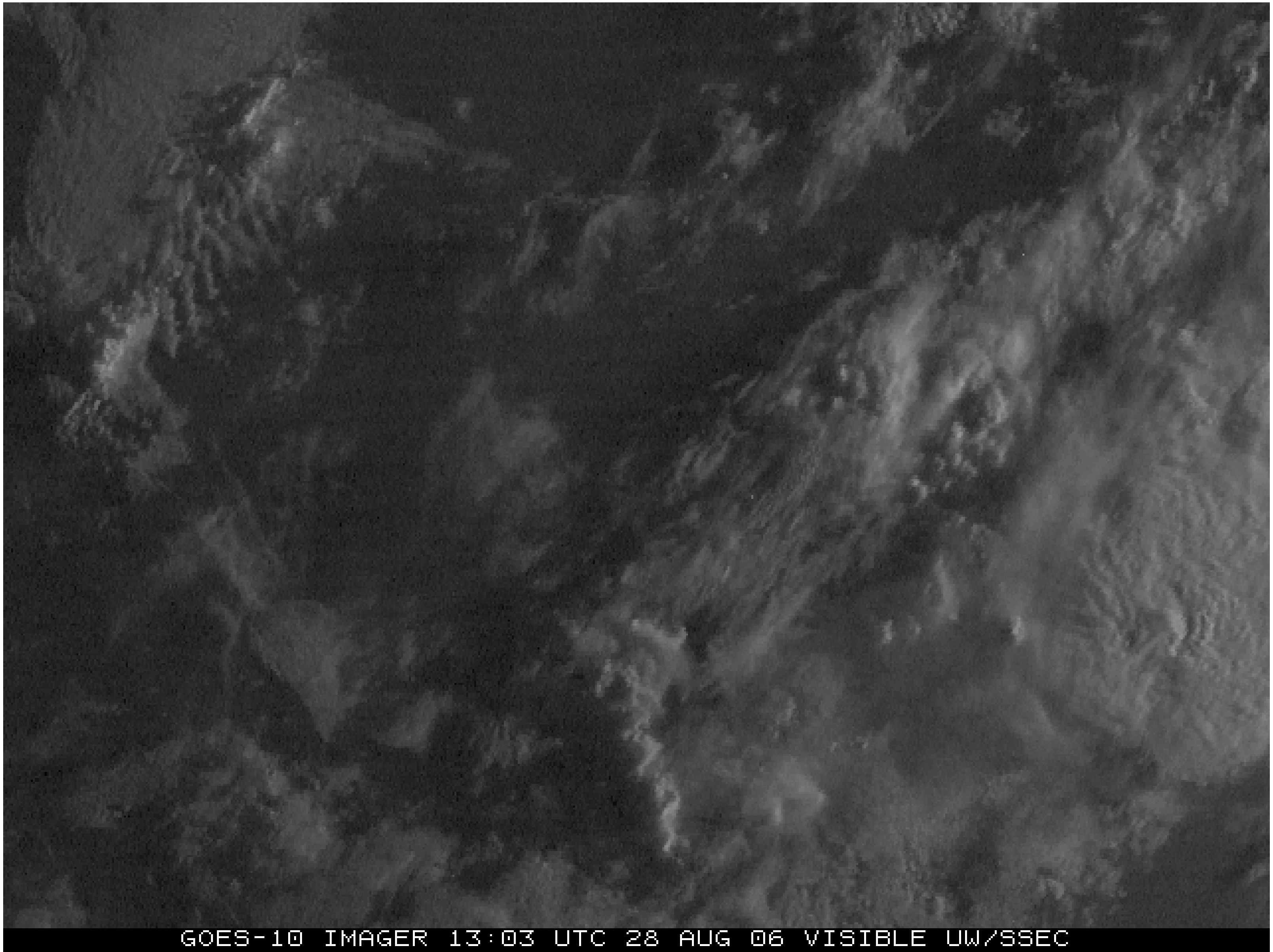

4 JUNE 2005
23:00:00.000 UTC
11.2 µm
UW/CIMSS
120° W
100° W
80° W
45° N
30° N
CONUS
96° W
92° W
40° N
36° N
MESOSCALE

animation

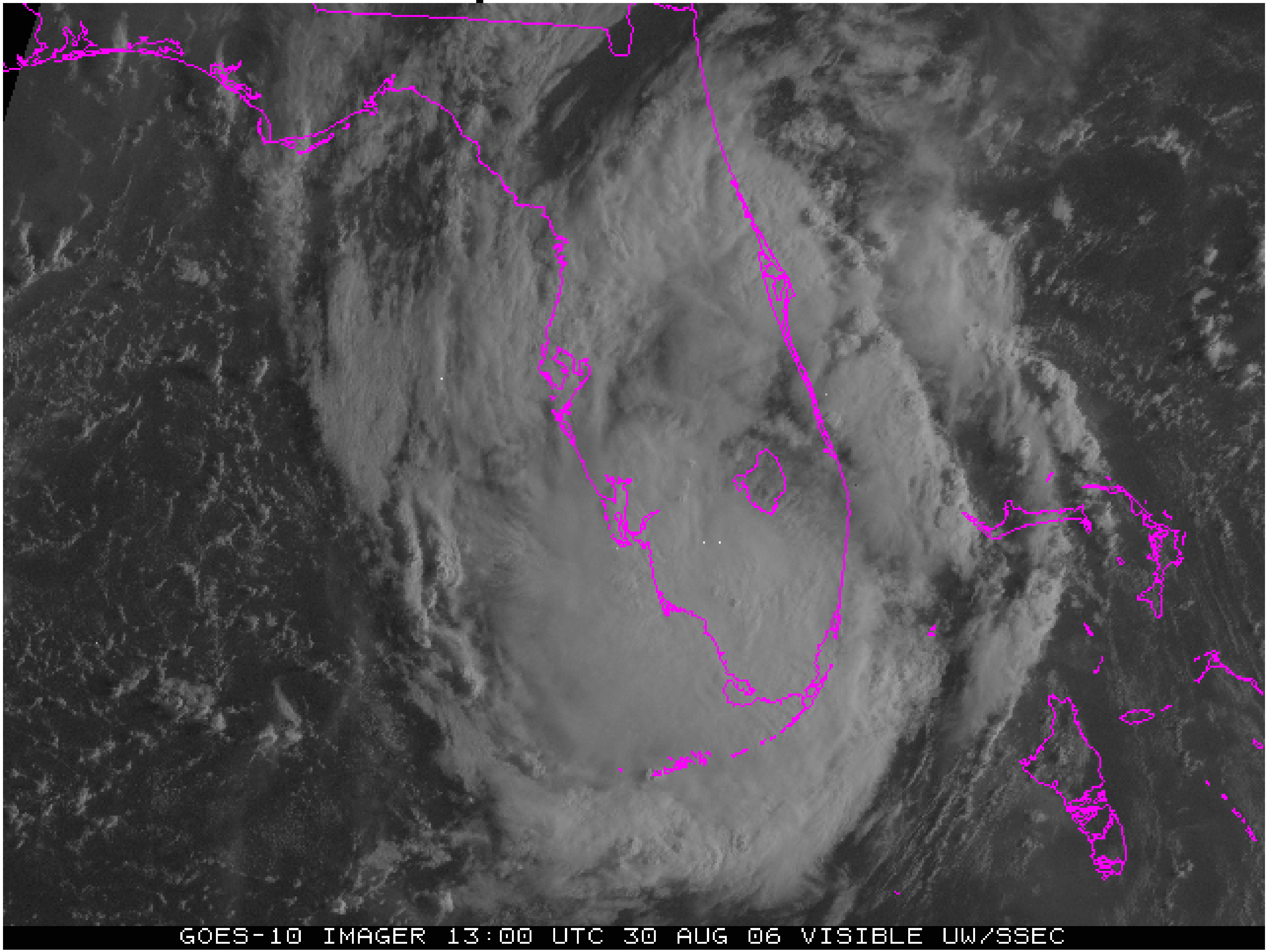
15-min time resolution "loop"



1-min time resolution loop



Ernesto – Special GOES-10 data



ABI Visible/Near-IR Bands

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

ABI IR Bands

7	3.80–4.00	3.90	2	Surface and cloud, fog at night, fire, winds
8	5.77–6.6	6.19	2	High-level atmospheric water vapor, winds, rainfall
9	6.75–7.15	6.95	2	Midlevel atmospheric water vapor, winds, rainfall
10	7.24–7.44	7.34	2	Lower-level water vapor, winds, and SO_2
11	8.3–8.7	8.5	2	Total water for stability, cloud phase, dust, SO_2 rainfall
12	9.42–9.8	9.61	2	Total ozone, turbulence, and winds
13	10.1–10.6	10.35	2	Surface and cloud
14	10.8–11.6	11.2	2	Imagery, SST, clouds, rainfall
15	11.8–12.8	12.3	2	Total water, ash, and SST
16	13.0–13.6	13.3	2	Air temperature, cloud heights and amounts

GOES-R and GOES-I/M Simulations of Southern California Fires

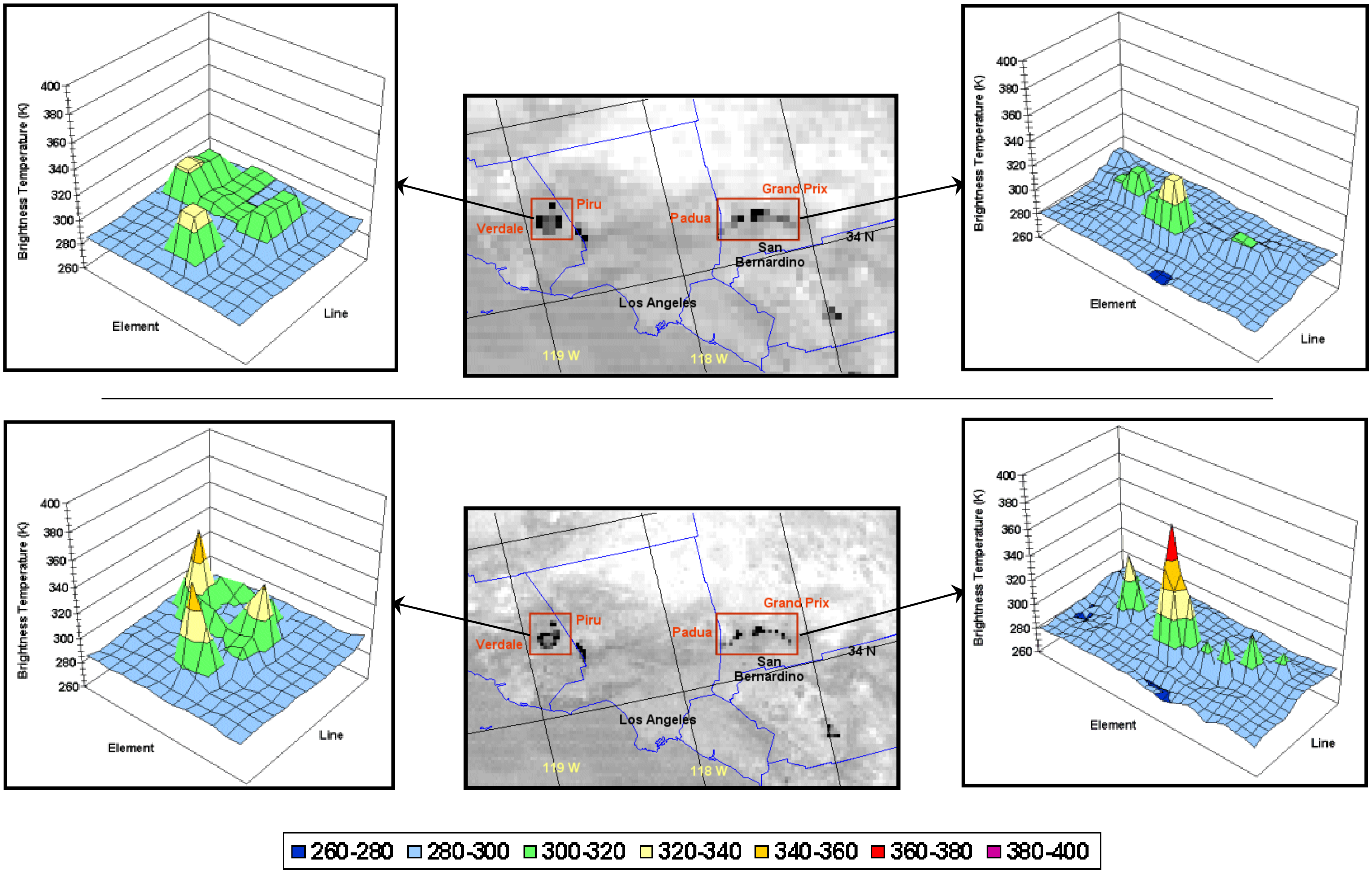
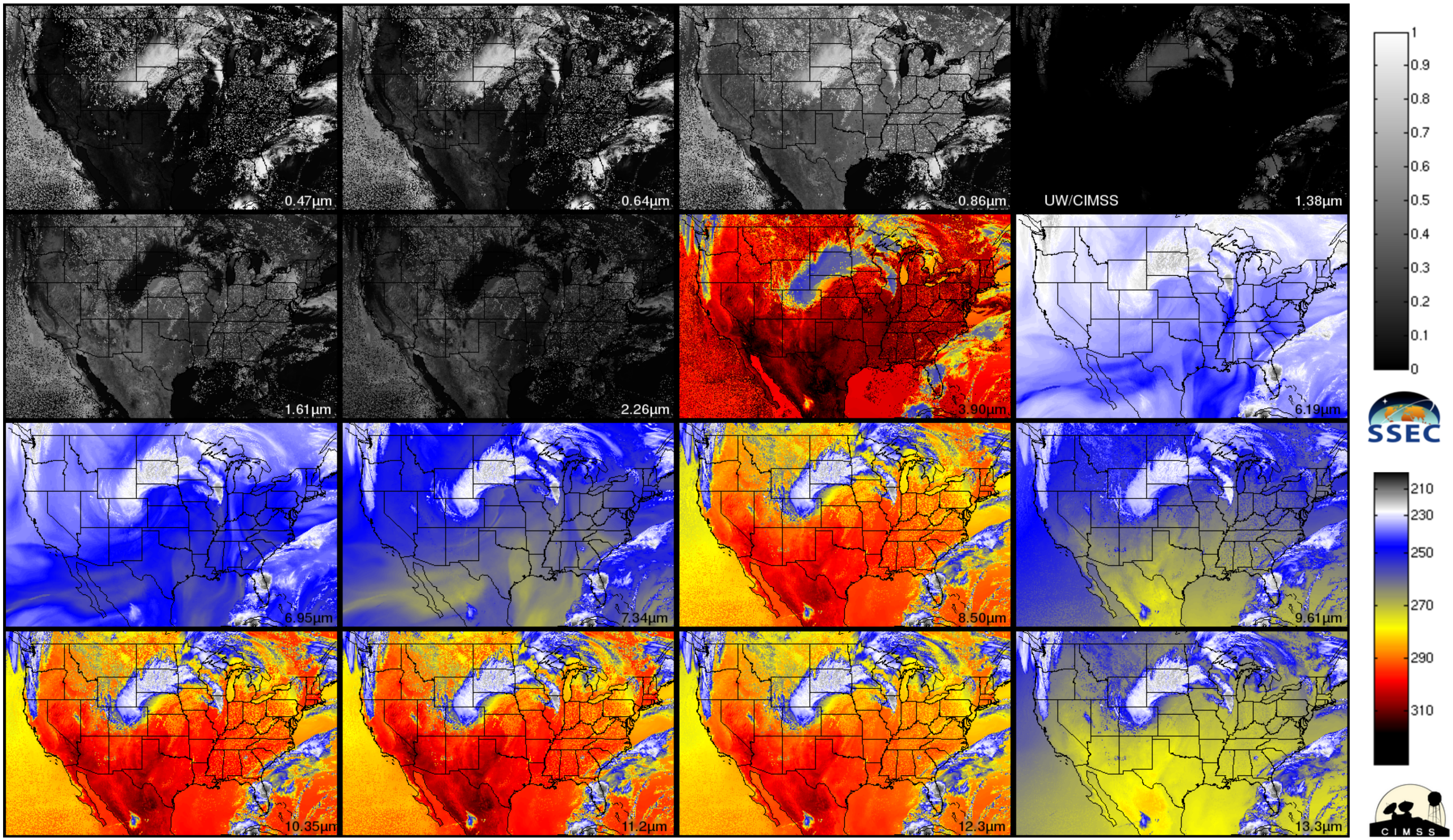


Figure courtesy of Elaine Prins

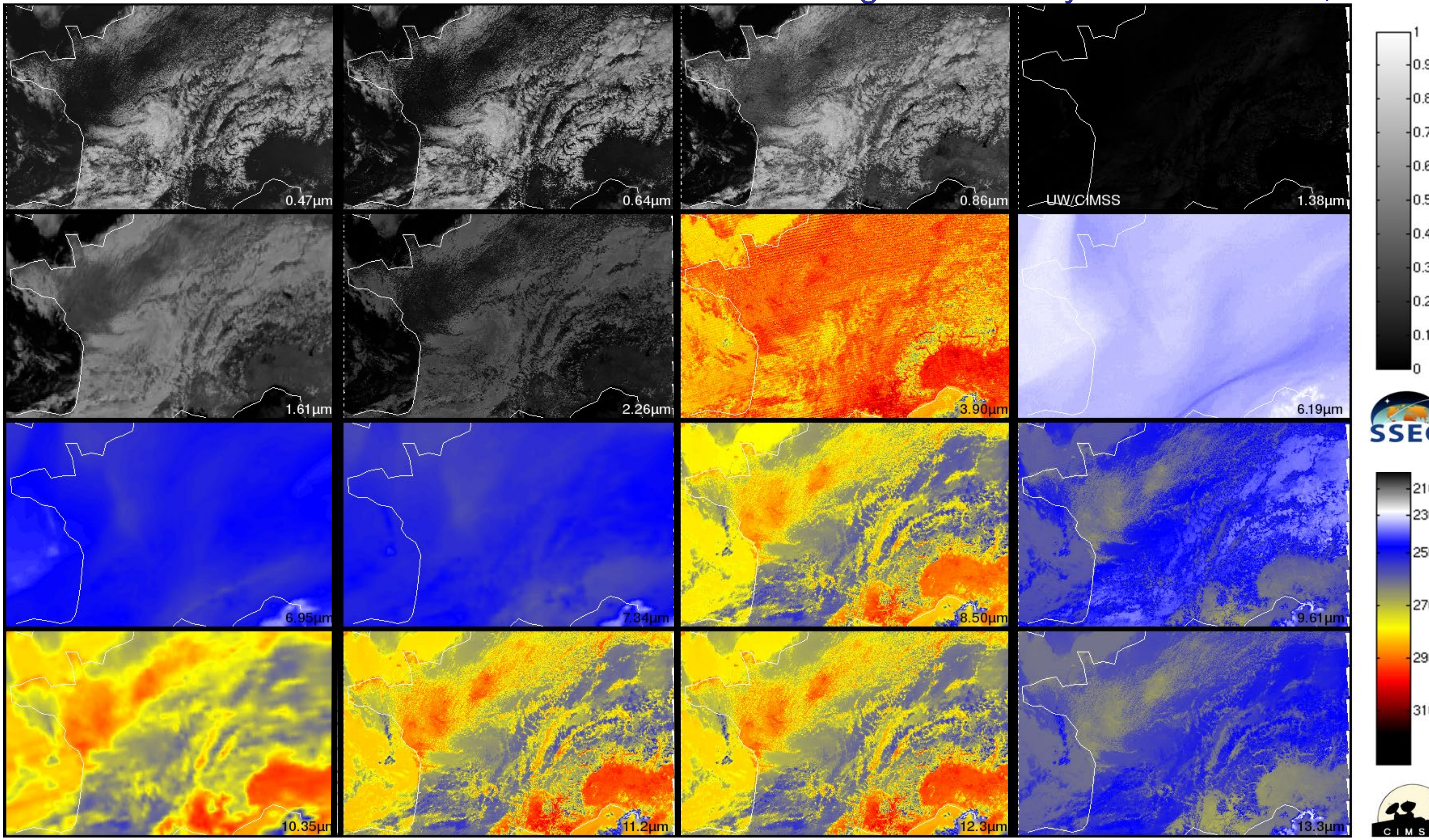
ABI bands via NWP simulation from the CIMSS AWG Proxy Team



ABI band data for 2005 June 04 18:00 UTC

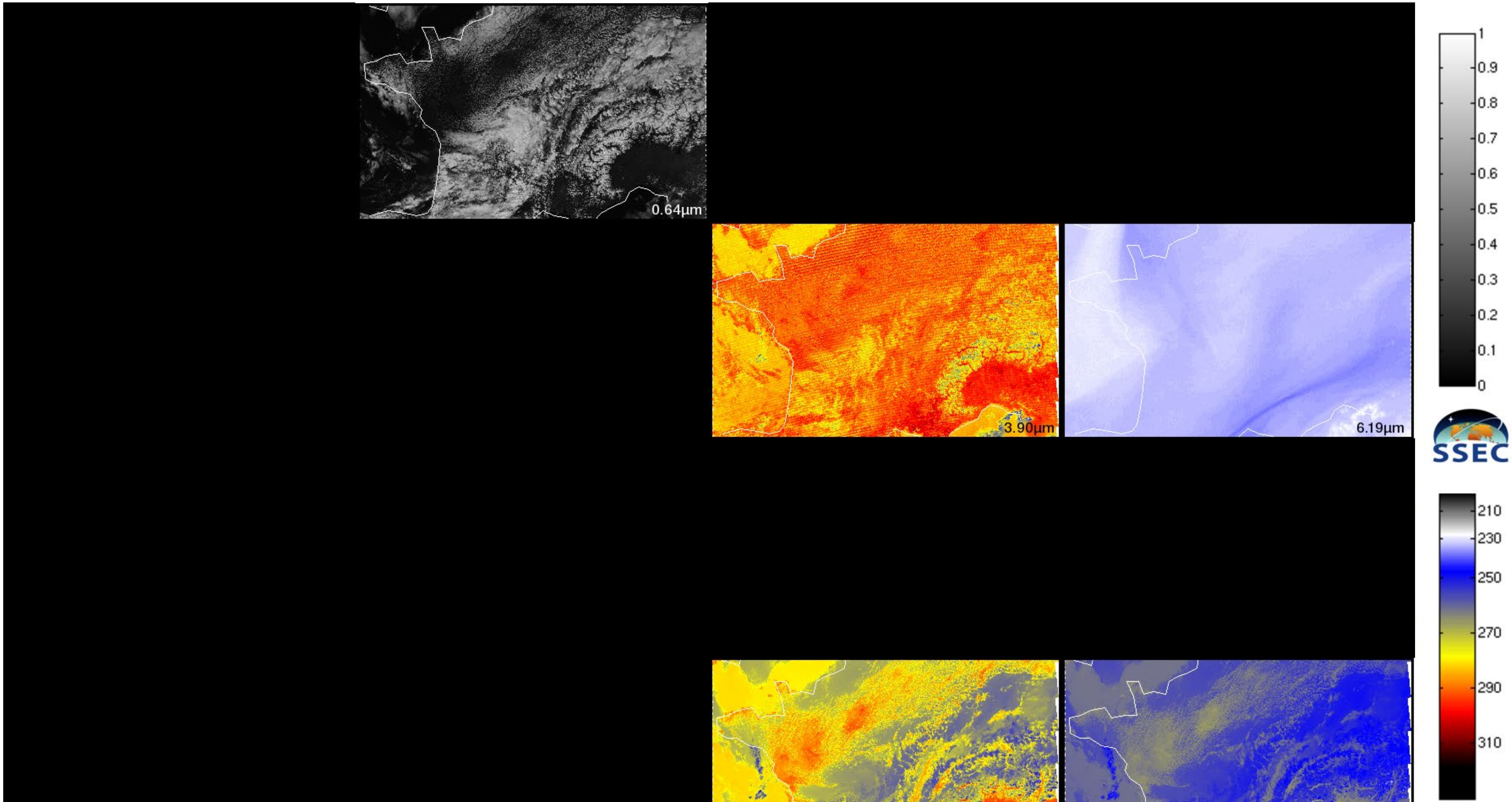
Using satellite observations (MODIS, MET-8 and AIRS) to simulate the ABI

Figure courtesy of M. Gunshor, CIMSS



ABI Simulated from MODIS, MSG, and AIRS on 2004 April 11

Similar bands on the GOES-12 Imager



ABI Simulated from MODIS, MSG, and AIRS on 2004 April 11

The additional bands on the Advanced Baseline Imager (ABI) allow new or improved products

Aerosols "0.47 μm"	Clouds, etc "0.64 μm"	Vegetation "0.86 μm"	Cirrus Clouds "1.38 μm"
Snow, Cloud phase "1.61 μm"	Particle size "2.26 μm"	Fog, Fires, clouds, etc "3.9 μm"	Water Vapor, Precip. "6.19 μm"
Water Vapor "6.95 μm"	WV, Upper-level SO2 "7.34 μm"	Vol. Ash, Cloud phase "8.5 μm"	Total Ozone "9.61 μm"
Surface features, clouds "10.35 μm"	Clouds, Precip., SST "11.2 μm"	Low-level Moisture "12.3 μm"	Cloud heights "13.3 μm"

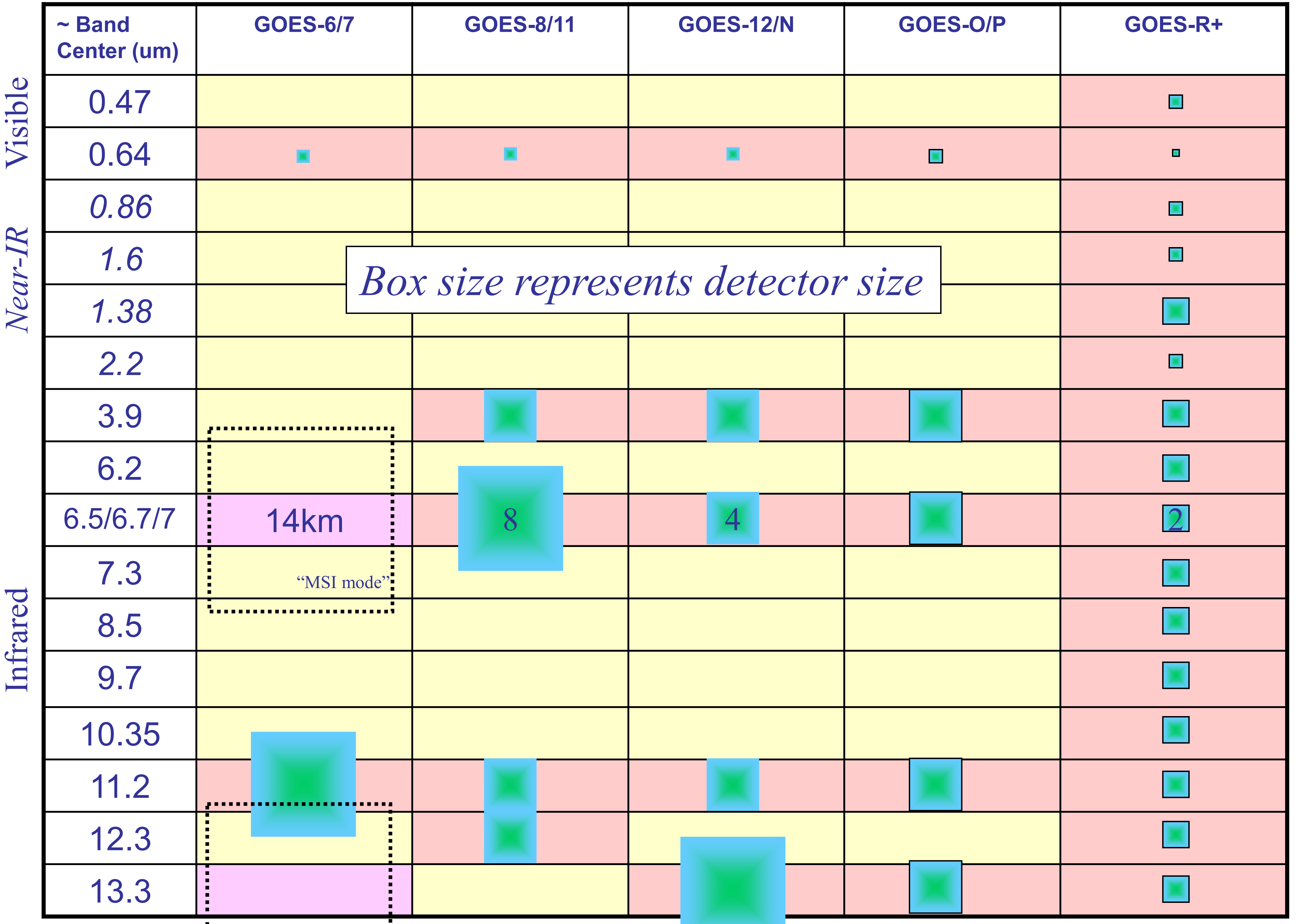
Products

Aerosol Detection (including Smoke	Geomagnetic Field	Surface Albedo
Aerosol Particle Size	Probability of Rainfall	*Surface Emissivity* *
Suspended Matter / Optical Depth	Rainfall Potential	Vegetation Fraction: Green
Volcanic Ash *	Rainfall Rate / QPE	Vegetation Index
Aircraft Icing Threat	*Legacy Afm. Vertical Moisture Profile*	Currents
*Cloud Imagery: Coastal**	*Legacy Afm. Vertical Temperature*	Sea & Lake Ice / Age
Cloud & Moisture Imagery	*Derived Stability Indices* *	Sea & Lake Ice / Concentration
Cloud Layers / Heights & Thickness	*Total Precipitable Water* *	Sea & Lake Ice / Extent & Edge
Cloud Ice Water Path *	*Total Water Content* *	Sea & Lake Ice / Motion
Cloud Liquid Water	Clear Sky Masks	Ice Cover / Landlocked
Cloud Optical Depth	*Radiances* *	Snow Cover
Cloud Particle Size Distribution	Absorbed Shortwave Radiation:	Snow Depth
Cloud Top Phase	Downward Longwave Radiation:	Sea Surface Temps
Cloud Top Height *	Downward Solar Insolation: Surface	Energetic Heavy Ions
Cloud Top Pressure *	Reflected Solar Insolation: TOA	Mag Electrons & Protons: Low
Cloud Top Temperature *	Upward Longwave Radiation *:	Mag Electrons & Protons: Med &
Cloud Type	*Ozone Total* *	Solar & Galactic Protons
Convection Initiation	*SO_2 Detection* *	Solar Flux: EUV
Enhanced "V" / Overshooting Top	*Derived Motion Winds* *	Solar Flux: X-Ray
Hurricane Intensity	Fire / Hot Spot Characterization	Solar Imagery: extreme UV / X-Ray
Low Cloud & Fog	Flood / Standing Water	
Lightning Detection	*Land Surface (Skin) Temperature* *	
Turbulence		
Visibility		

** = Products degraded from original GOES-R requirements (e.g.; no HES)*

ABI – Advanced Baseline Imager	Continuity of GOES Legacy Sounder Products from ABI	SEISS – Space Env. In-Situ Suite	EXIS – EUV and X-Ray Irradiance Sensors	GLM – Geostationary Lightning Mapper	Magnetometer	SUVI – Solar extreme UltraViolet Imager

Approximate spectral and spatial resolutions of US GOES Imagers



BAMS Article

INTRODUCING THE NEXT-GENERATION ADVANCED BASELINE IMAGER ON GOES-R

BY TIMOTHY J. SCHMIT, MATHEW M. GUNSHOR, W. PAUL MENZEL, JAMES J. GURKA, JUN LI, AND A. SCOTT BACHMEIER

The ABI will begin a new era in U.S. environmental remote sensing with more spectral bands, faster imaging, and higher spatial resolution than the current imager.

The Advanced Baseline Imager (ABI) is being developed as the future imager on the Geostationary Operational Environmental Satellite (GOES) series, slated to be launched in approximately 2012 with GOES-R (Gurka and Dittberner 2001). Similar to the current GOES imager, ABI will be used for a wide range of qualitative and quantitative weather, oceanographic, climate, and environmental applications. ABI will offer more spectral bands, higher spatial resolution, and faster imaging than the current GOES imager. ABI spatial resolution will be nominally 2 km for the infrared bands and 0.5 km for the 0.64-μm visible band. While the instrument will allow a flexible scanning scenario, two basic modes are envisioned. One mode is that every 15 min ABI will scan the full disk (FD), plus continental United States (CONUS) 3 times, plus a selectable 1000 km × 1000 km area every 30 s. The second mode is that the ABI can be programmed to scan the FD iteratively. The FD image can be acquired in approximately 5 min. Given that the current GOES imager takes approximately 25 min for a FD, this implies there will be a fivefold increase in the coverage rate.

ABI has 16 spectral bands; five are similar to the 0.6-, 4-, 11-, and 12-μm windows and the 6.5-μm water vapor band on the current *GOES-8/-9/-10/-11* imagers (Menzel and Purdom 1994; Ellrod et al. 1998), and another is similar to the 13.3 μm on the *GOES-12/*-N/-O/-P imagers and the *GOES-8/*-P sounders (Hillger et al. 2003; Schmit et al. 2001, 2002). Additional bands on ABI are 0.47 μm for aerosol detection and visibility estimation; 0.865 μm for aerosol detection and estimation of vegetation health; 1.378 μm to detect very thin cirrus clouds; 1.6 μm for snow/cloud discrimination; 2.25 μm for aerosol and cloud particle size estimation, vegetation, cloud properties/screening, hot-spot detection, moisture

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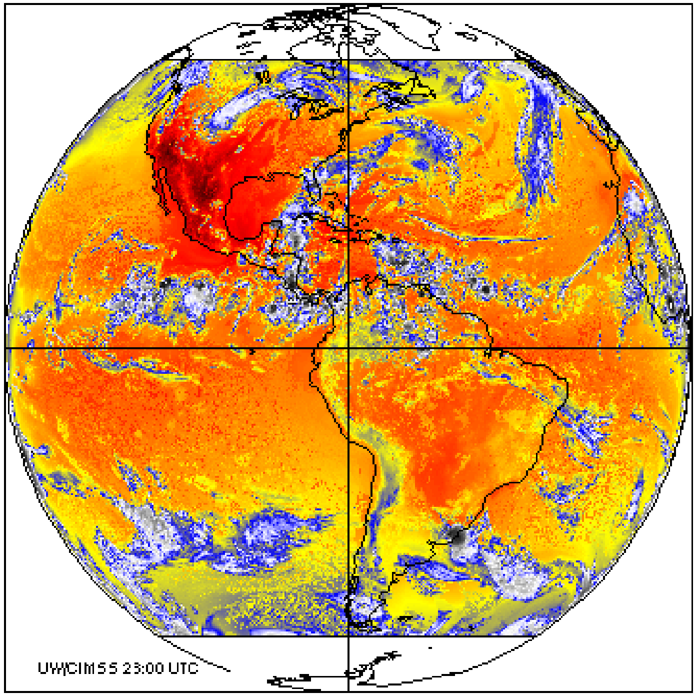
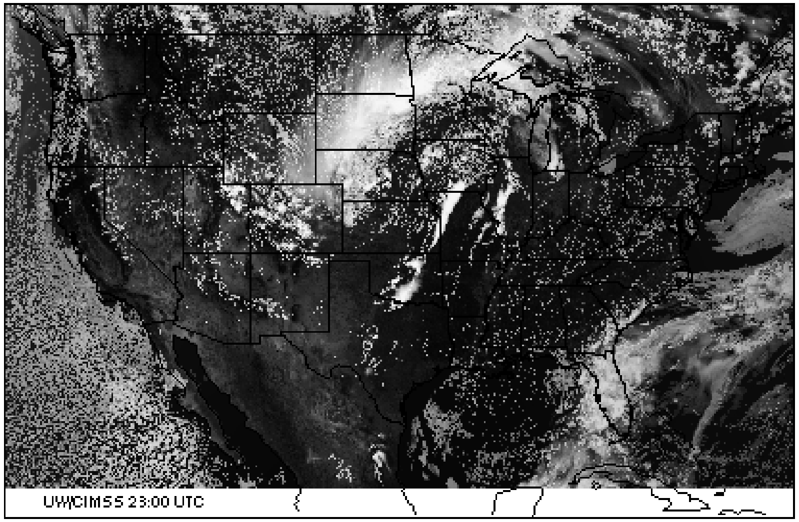
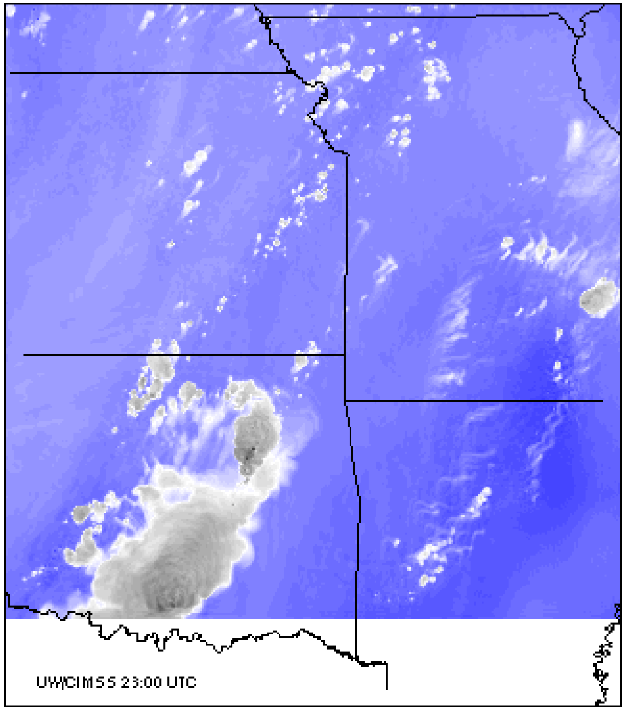
ABI band 14 (11.2 µm) BT (K) 2005-06-04

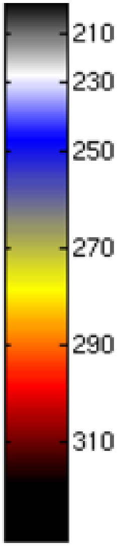


ABI band 2 (0.64 µm) reflectance 2005-06-04



ABI band 8 (6.19 µm) BT (K) 2005-06-04



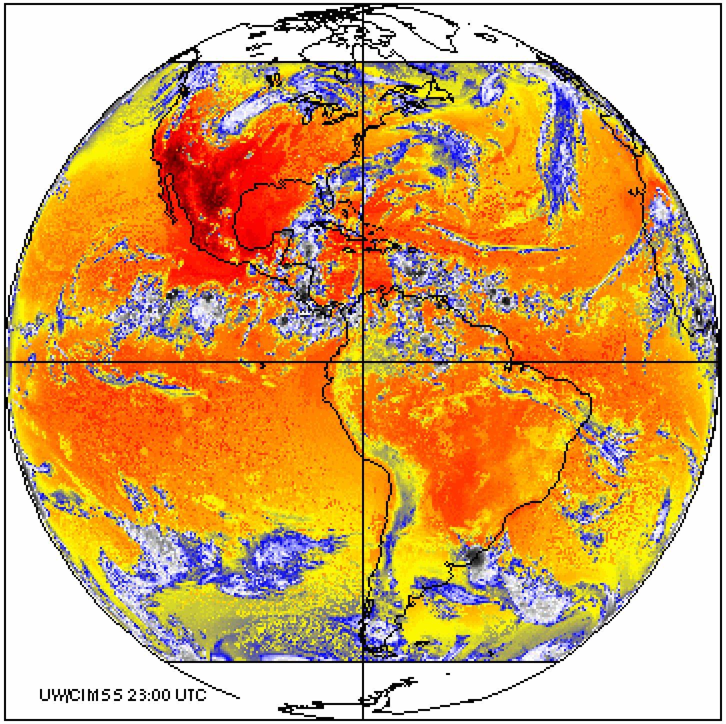


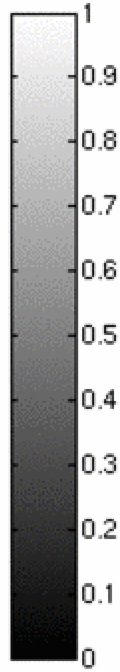
June 4, 2005 23:00 UTC

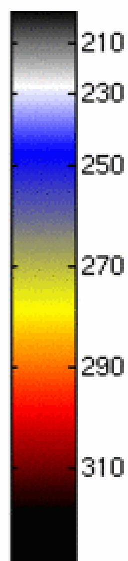
From CIMSS AWG Proxy Team

15 minutes of ABI

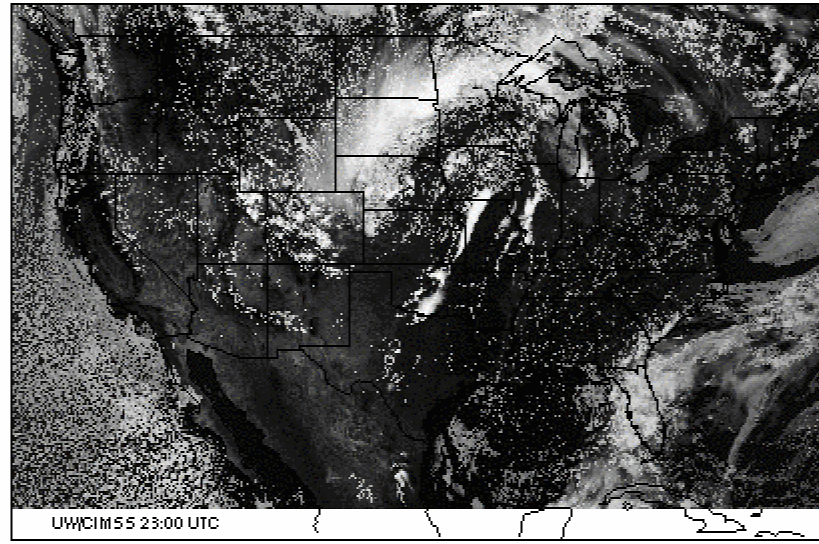
ABI band 14 (11.2 μm)   BT (K) 2005-06-04



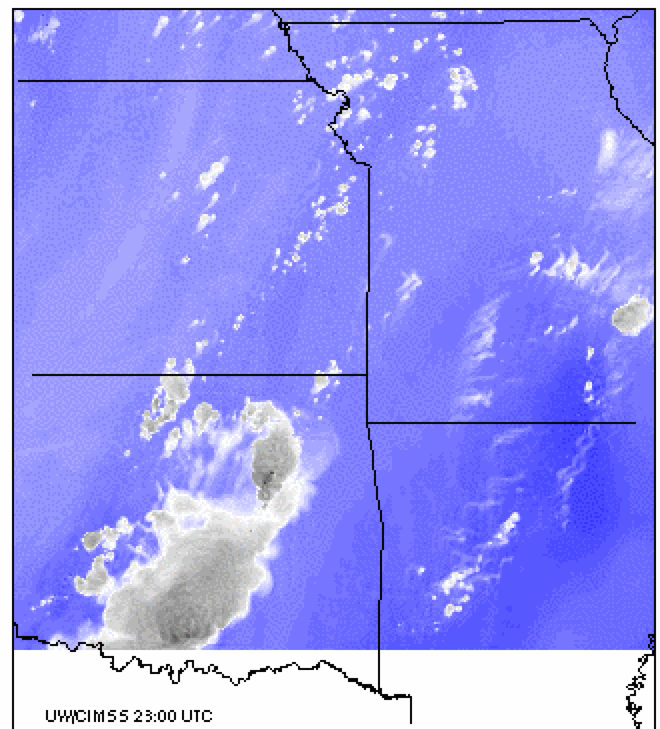




ABI band 2 (0.64 μm) reflectance 2005-06-04



ABI band 8 (6.19 μm)   BT (K) 2005-06-04

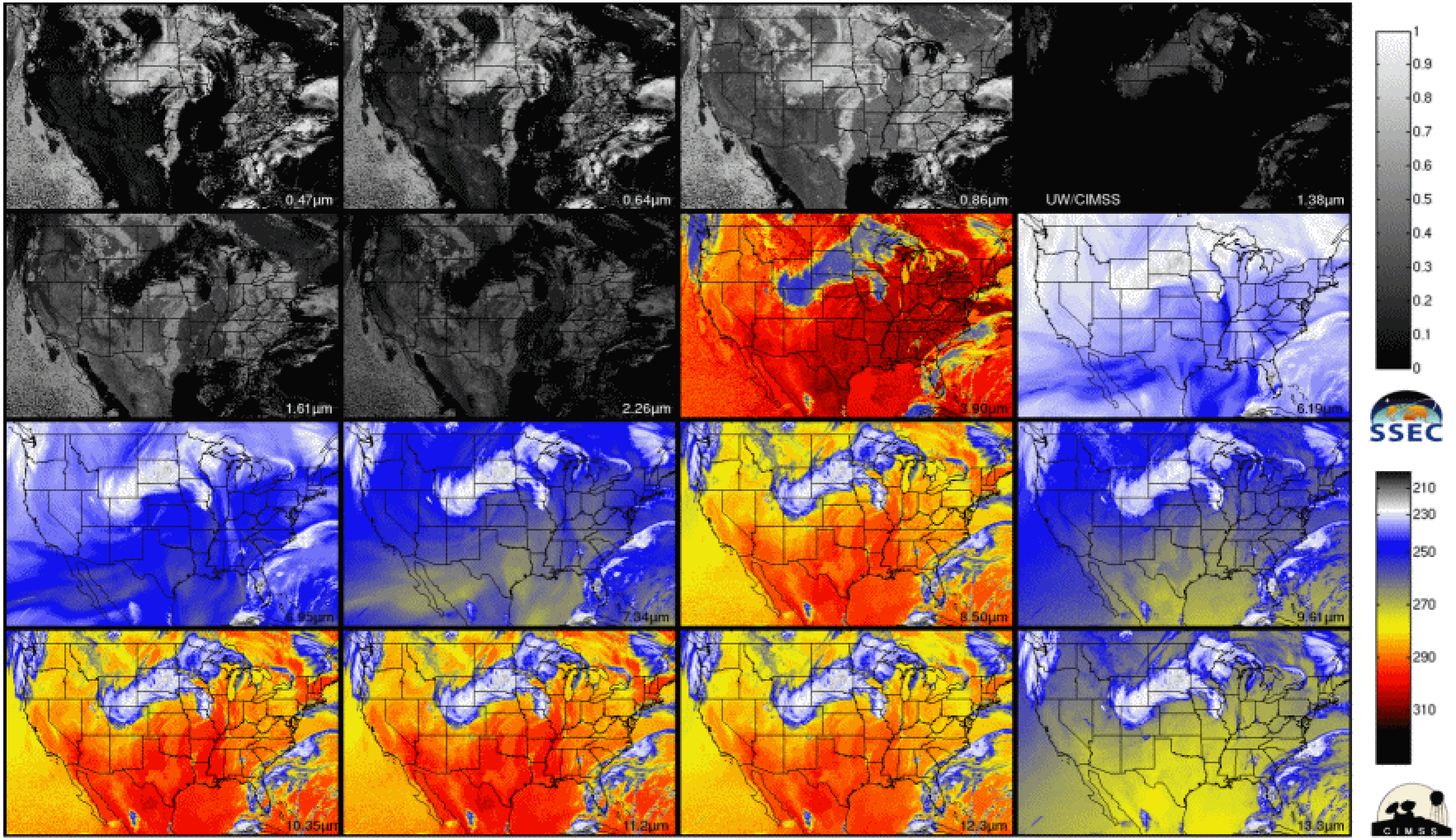


SSEC

CIMSS

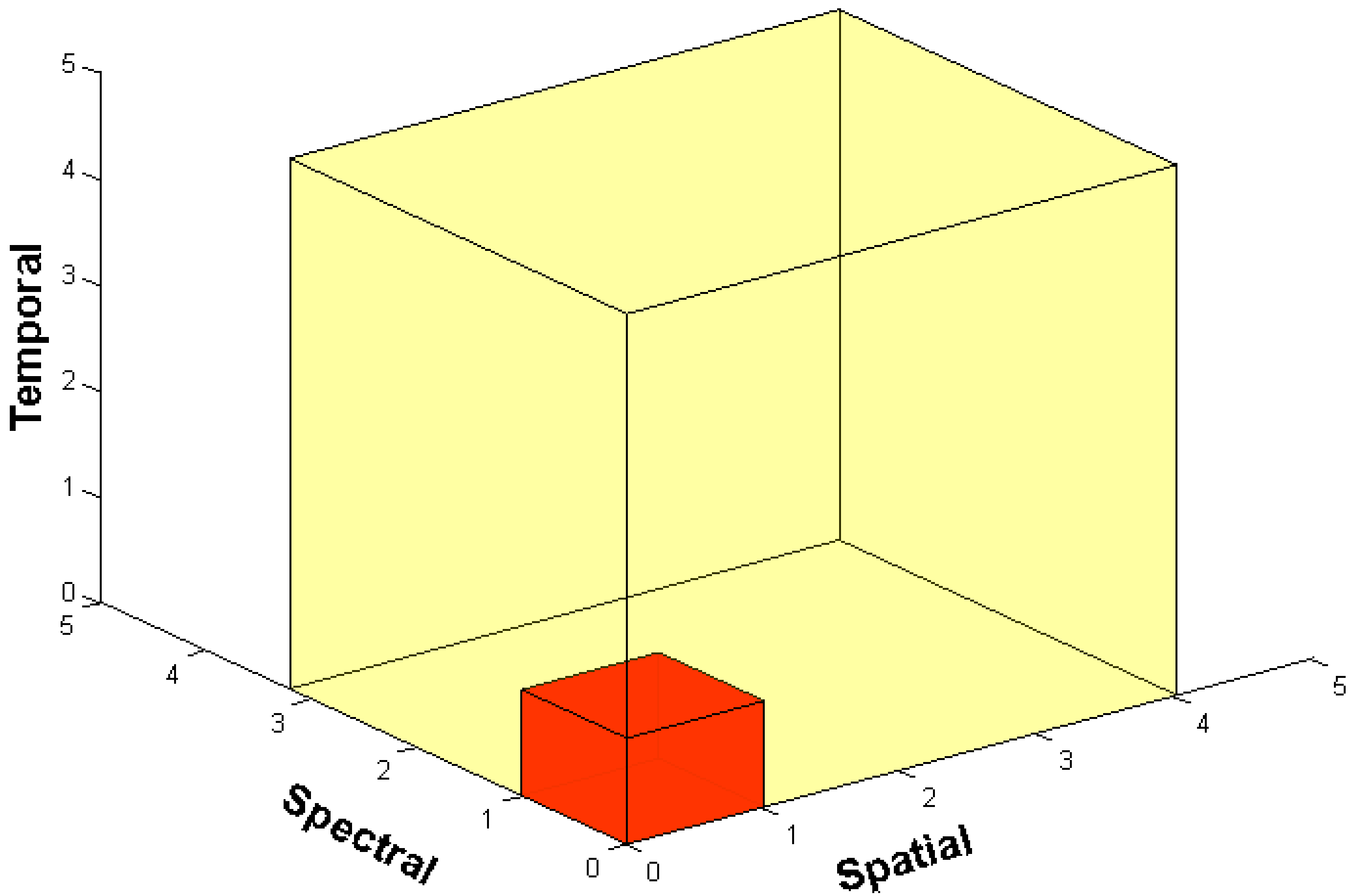
June 4, 2005 23:00 UTC

ABI (from AWG team)



ABI band data for 2005 June 04 15:00 UTC

Improvement factors for GOES and ABI



NOAA/NESDIS ASPB

Communication Services

UPS – Unique Payload Services

- LRIT--Low Rate Information transmission
- EMWIN--Emergency Managers Wx Information Network
- DCS--Data Collection System
- SARSAT--Search and Rescue
- GRB – GOES Rebroadcast
  - Follow on of L-Band GVAR
    - GRB will be a larger data rate than the GVAR
    - Approximately 31 Mbps vs 2.11 Mbps
    - Plans are to retransmit all Level 1b data within the GRB with lossless compression in L band

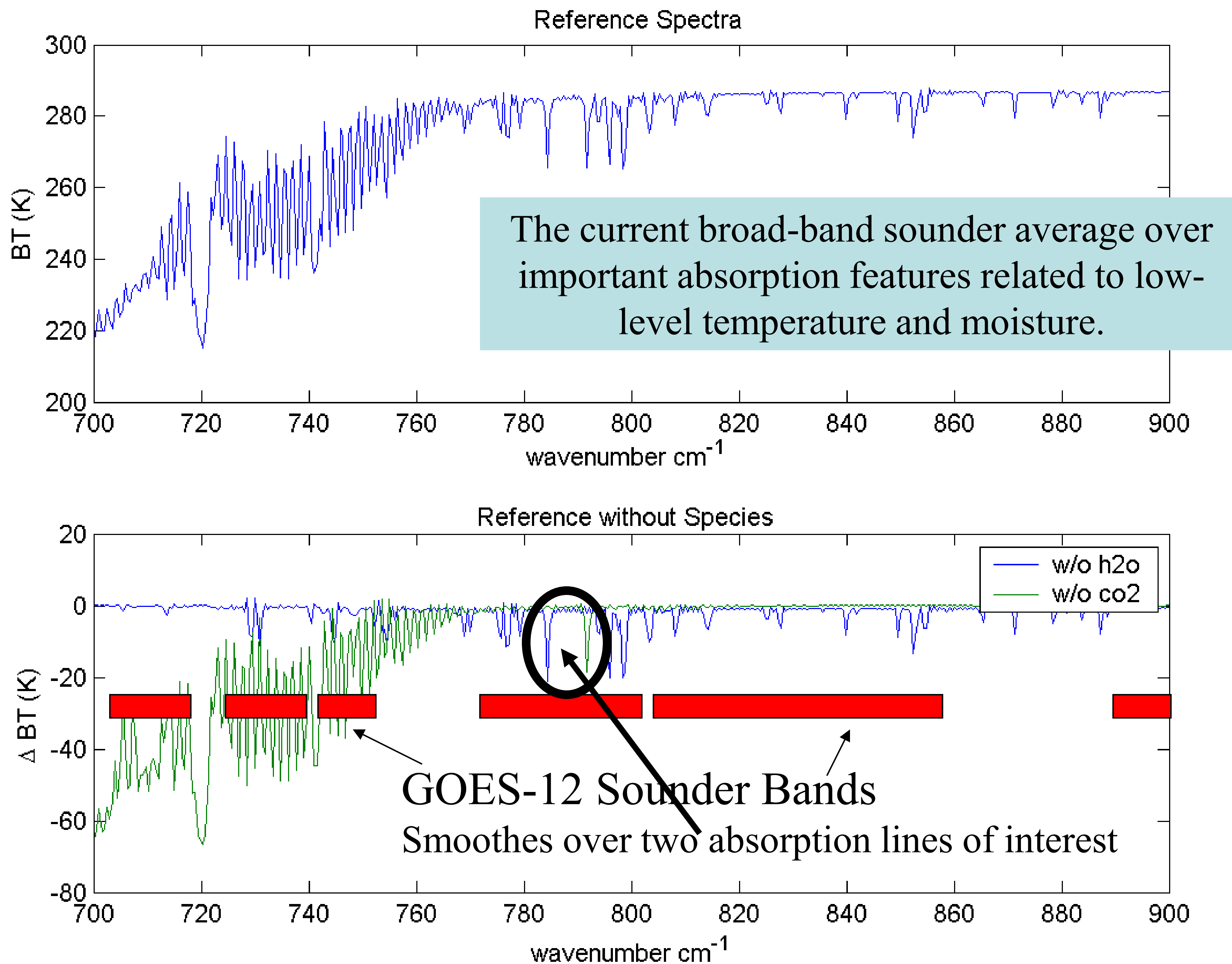
http://water.usgs.gov/nsip/

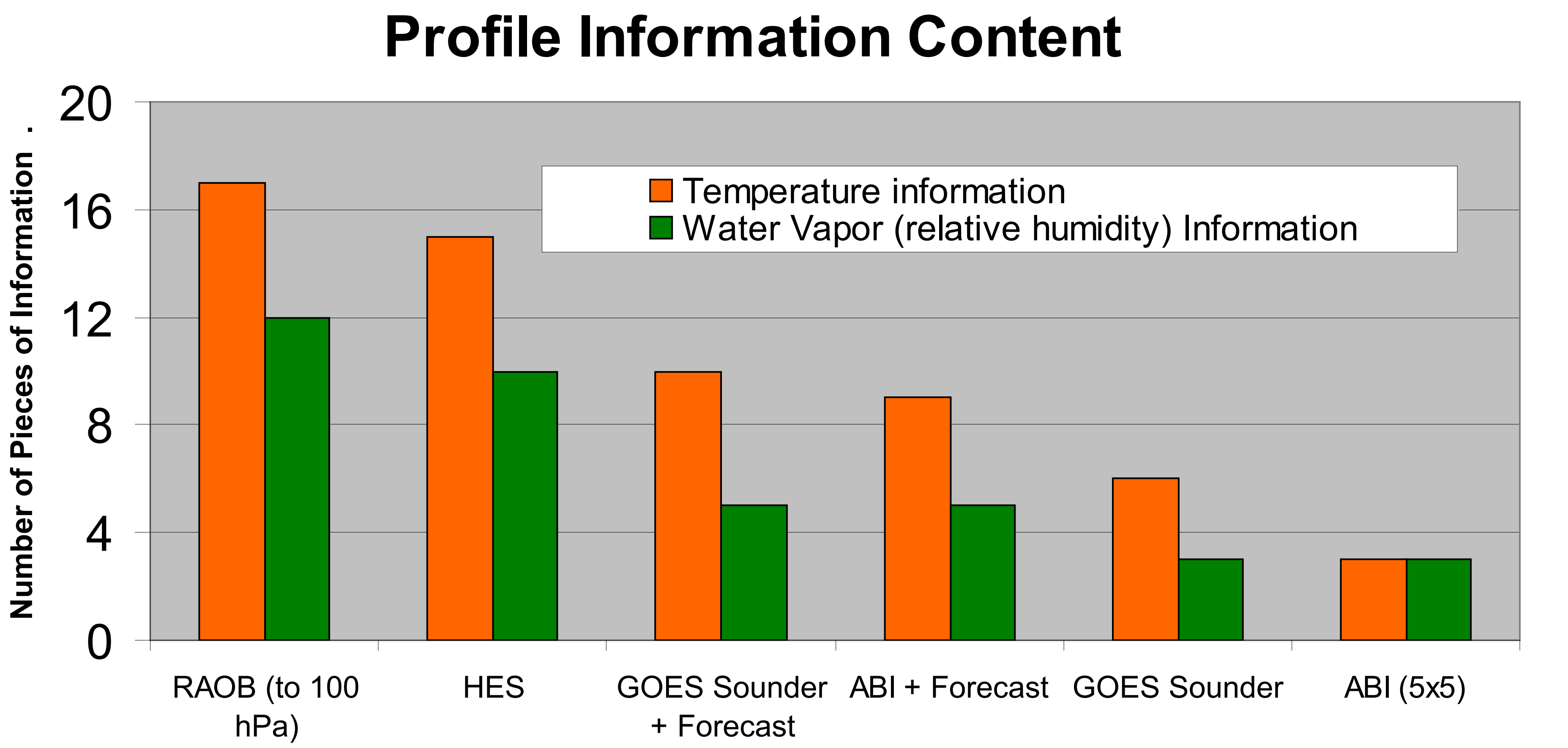
GOES-R will support improved UPS services

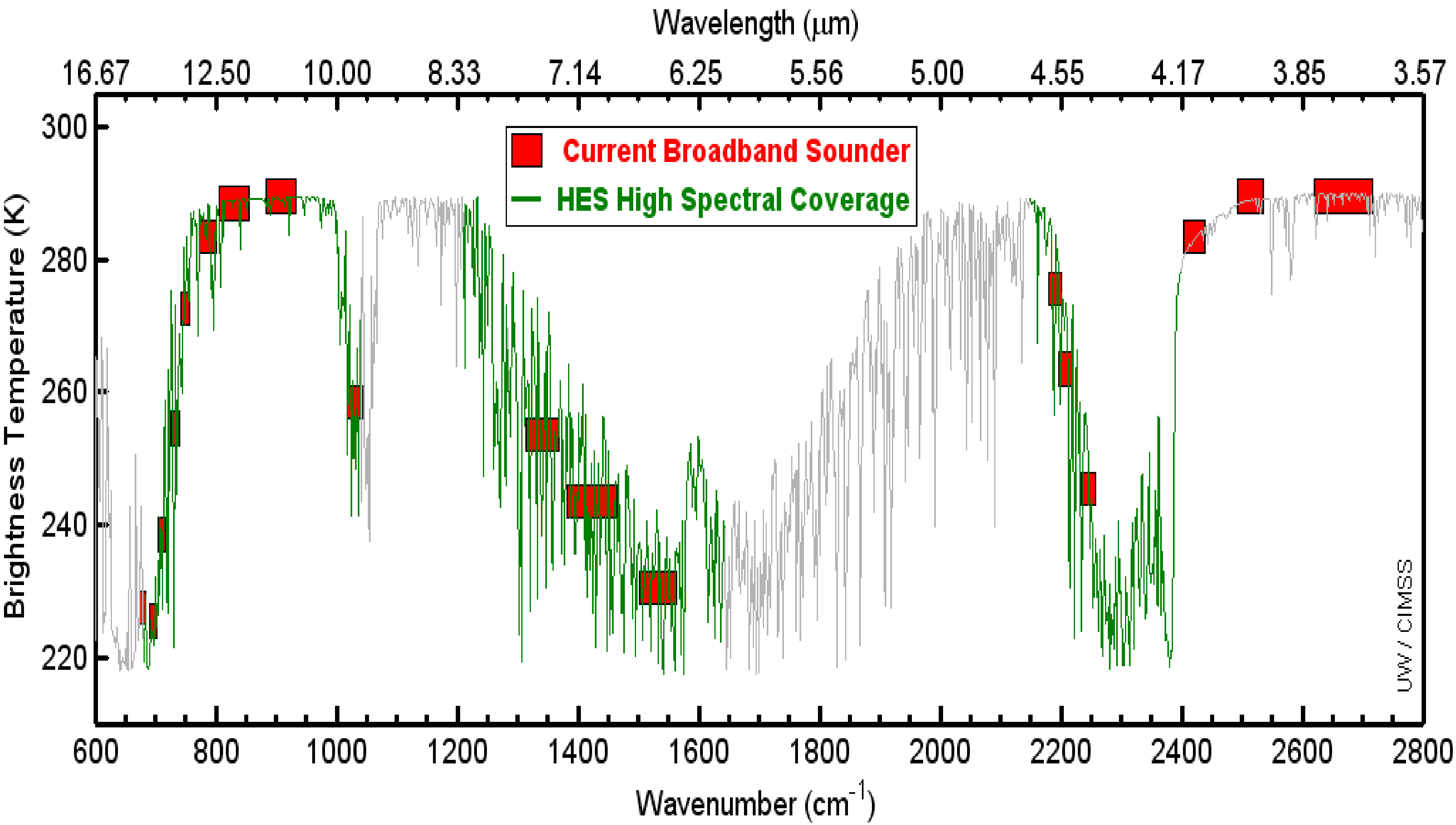
- Higher Data Rates for LRIT, EMWIN, DCS
- GRB will provided higher data rates than today's GVAR

GOES-T

- The GOES-R series is GOES-R and –S, with an option for another two satellites.
- Possibly will have an advanced high-spectral infrared sounder.


Reference Spectra
BT (K)
300
280
260
240
220
200
700
720
740
760
780
800
820
840
860
880
900
wavenumber cm-1
The current broad-band sounder average over important absorption features related to low-level temperature and moisture.
Reference without Species
w/o h2o
w/o co2
Δ BT (K)
20
0
-20
-40
-60
-80
700
720
740
760
780
800
820
840
860
880
900
wavenumber cm-1
GOES-12 Sounder Bands
Smoothes over two absorption lines of interest


Profile Information Content
Number of Pieces of Information
0
4
8
12
16
20
Temperature information
Water Vapor (relative humidity) Information
RAOB (to 100 hPa)
HES
GOES Sounder + Forecast
ABI + Forecast
GOES Sounder
ABI (5x5)



Wavelength (μm)
16.67
12.50
10.00
8.33
7.14
6.25
5.56
5.00
4.55
4.17
3.85
3.57
Current Broadband Sounder
HES High Spectral Coverage
300
280
260
240
220
Brightness Temperature (K)
UW / CIMSS
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
Wavenumber (cm-1)

5th GOES Users' Conference

Bringing Environmental Benefits to a Society of Users

88th Annual AMS Meeting
New Orleans, LA
January 23-24, 2008

http://www.osd.noaa.gov/announcement/index.htm

http://ams.confex.com/ams/88Annual/techprogram/programexpanded_447.htm