STAR Center for Satellite Applications and Research
formerly ORA — Office of Research and Applications

The ABI on the GOES-R series

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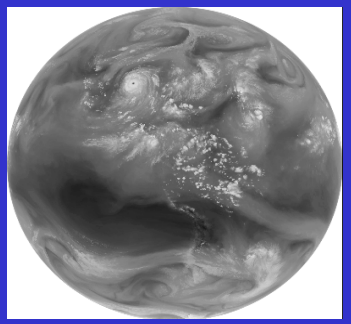


5th GOES Users' Conference
New Orleans, LA
January 23, 2008

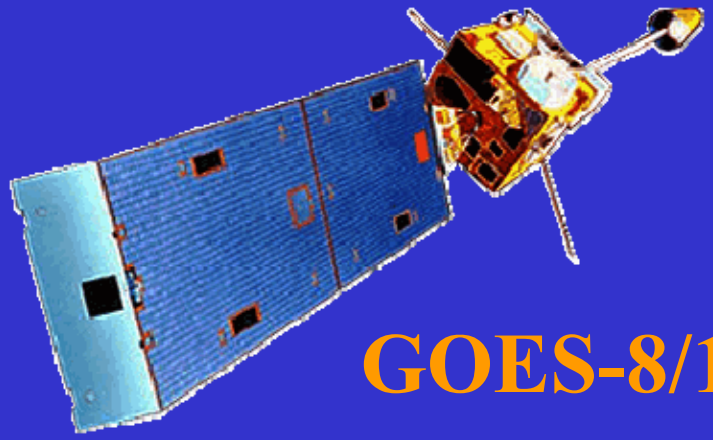
CIMSS
UW-Madison

Overview

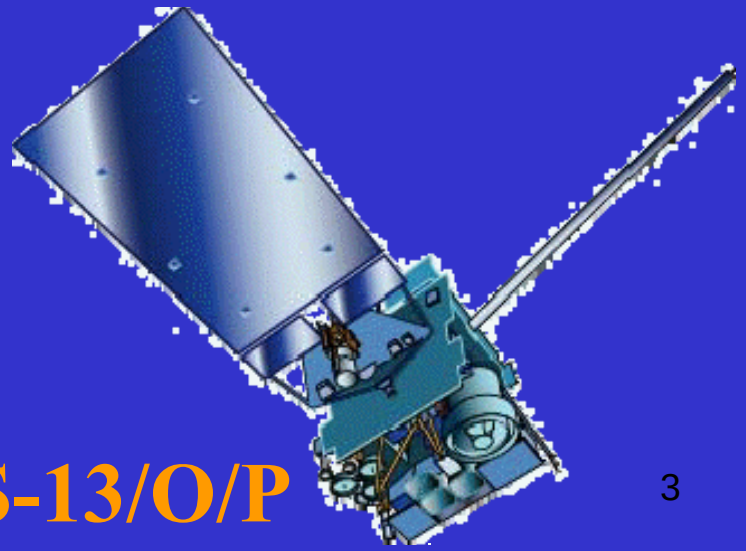
- GOES-13
- ABI (Advanced Baseline Imager)
  - Temporal
  - Spectral
  - Spatial
  - Radiometric
- Select Products
- ABI for continuity of current Sounder products
- Summary
- More information

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

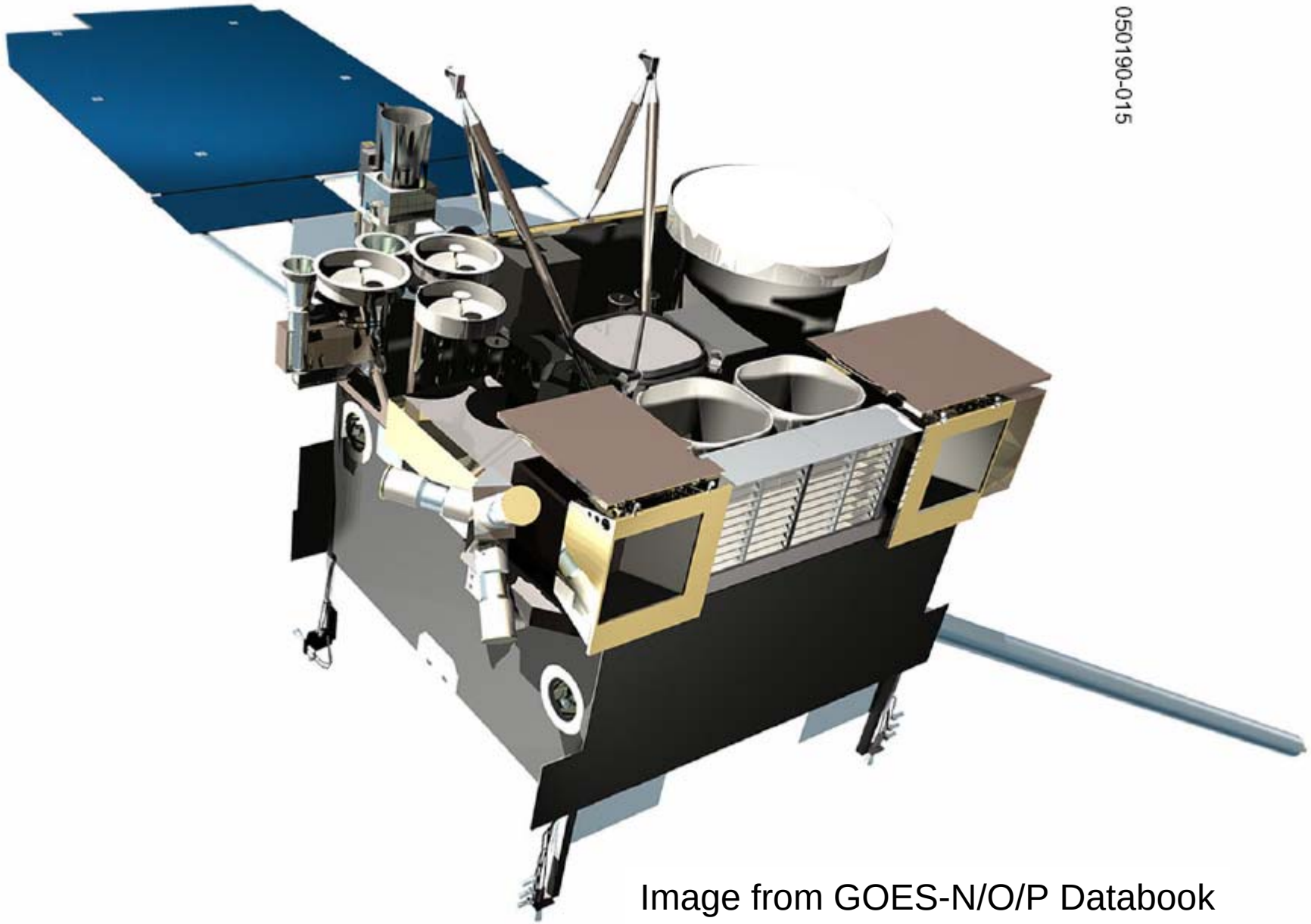
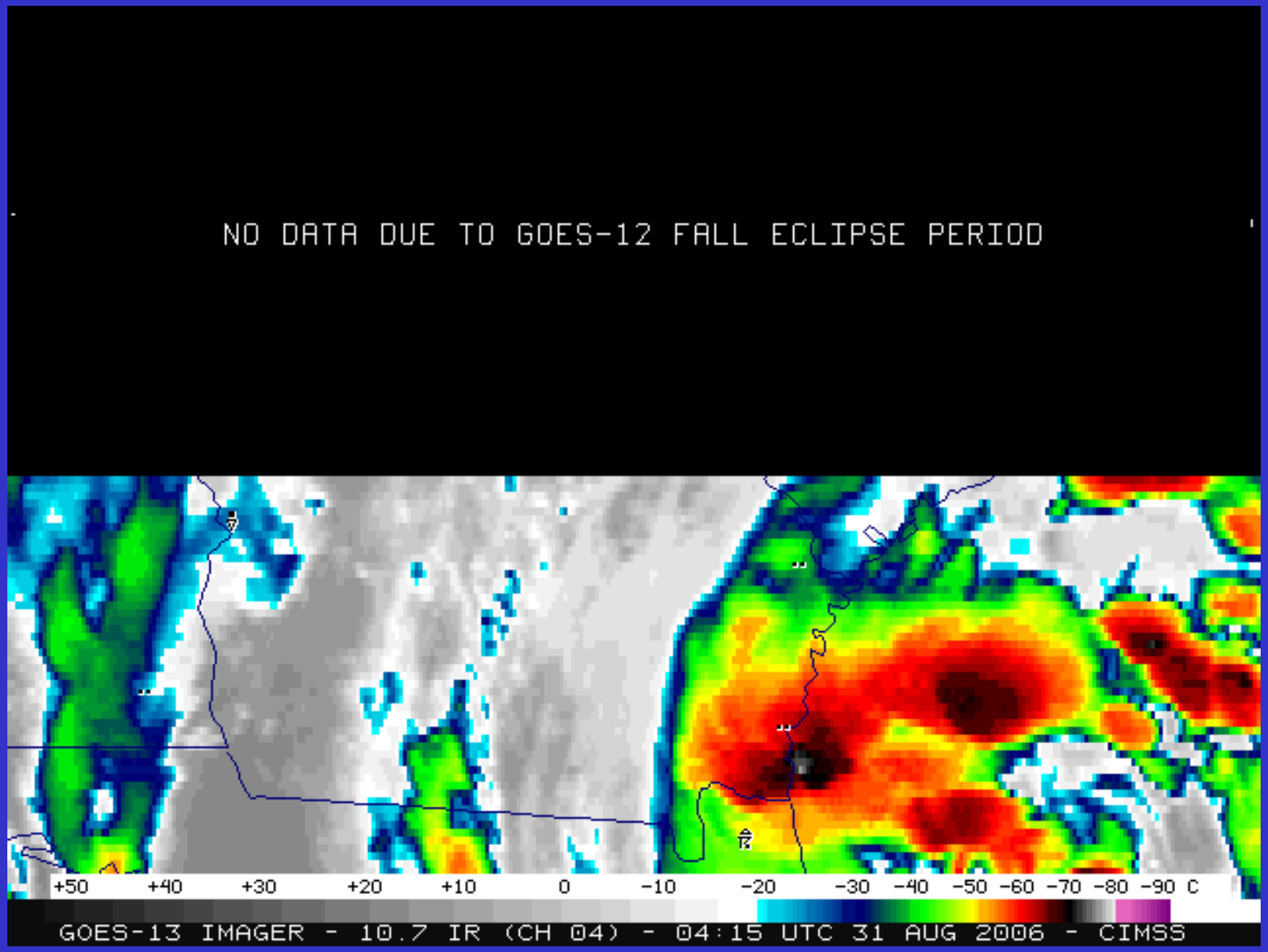


Image from GOES-N/O/P Databook

GOES-12/13 (During eclipse)

GOES-12



GOES-13

Figure courtesy of S. Bachmeier, CIMSS

Upper Peninsula MI Fires

Visible | Shortwave Window

GOES-12:

GOES-13:

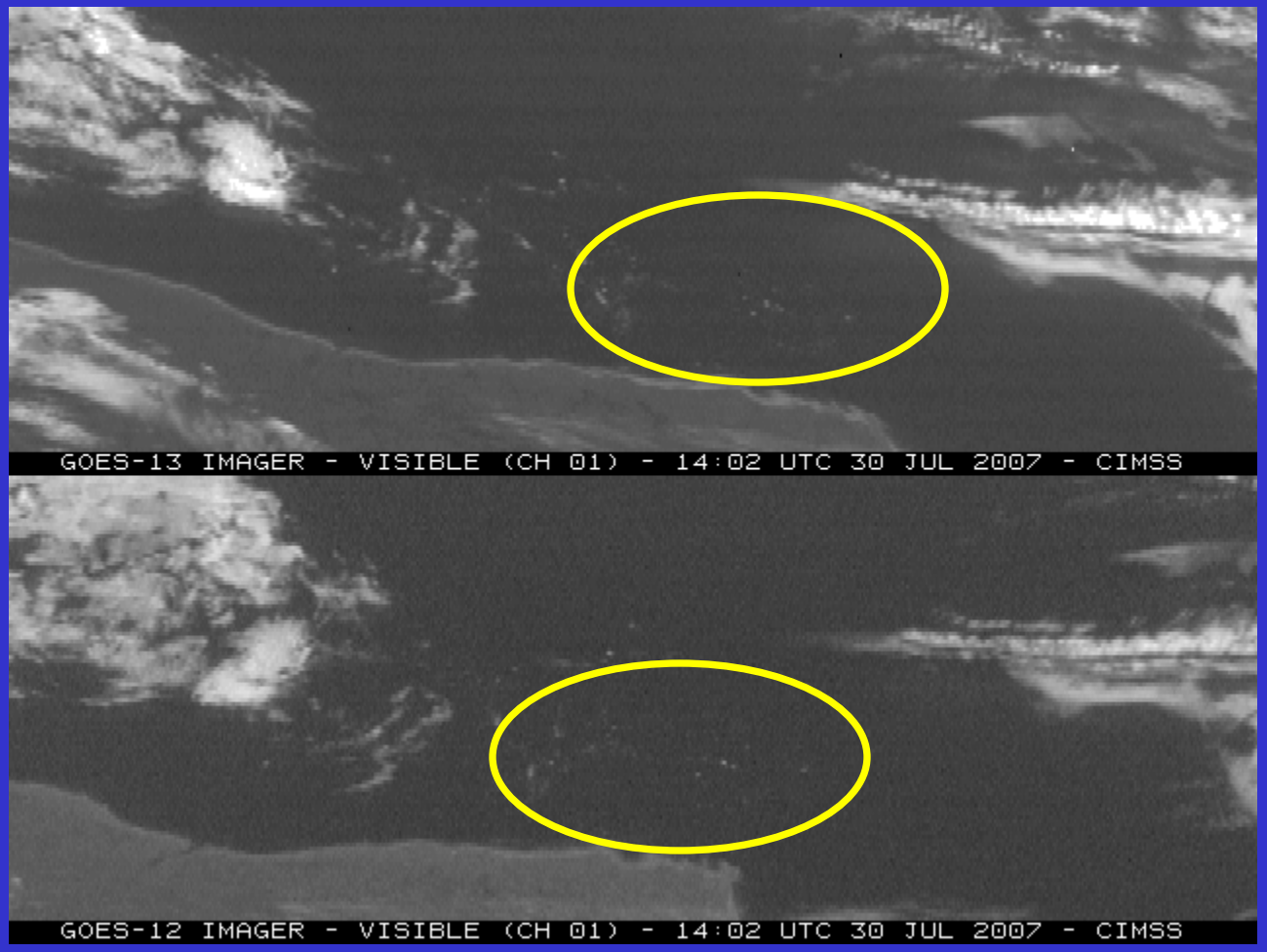
animation

Figure courtesy of S. Bachmeier, CIMSS

Ice Floes

GOES-**13**:

GOES-**12**:



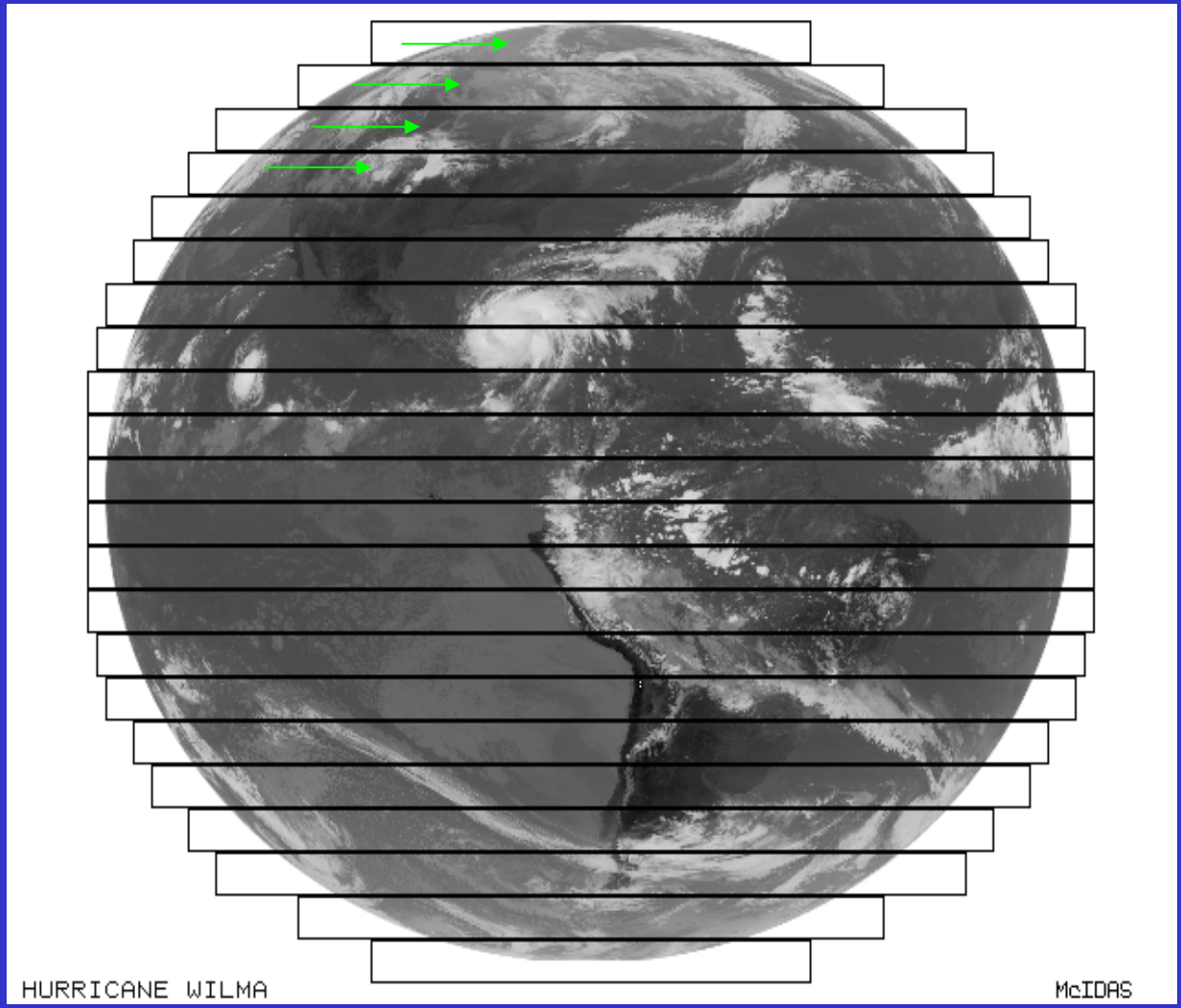
animation

Figure courtesy of S. Bachmeier, CIMSS

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	Scheduled (3 hrly)
CONUS	12 per hour	~4 per hour
Mesoscale	Every 30 sec	n/a
Visible (reflective bands)		
On-orbit calibration	Yes	No

Full Disk with stepped-edge



The ABI instrument can scan west-to-east OR east-to-west, the alternating pattern ‘swath-to-swath’ of the GOES-I/N series will not be continued.

Approximate number of ABI pixels

Current GOES is approximately 2705 x 5209 for the FD IR

Input Information			0.5 km	1 km	2 km	
Full disk diameter	17.76	deg	22141	11070	5535	pixels
CONUS height	4.8129	deg	6000	3000	1500	pixels
CONUS width	8.0215	deg	10000	5000	2500	pixels
Meso height/width	1.6043	deg	2000	1000	500	pixels

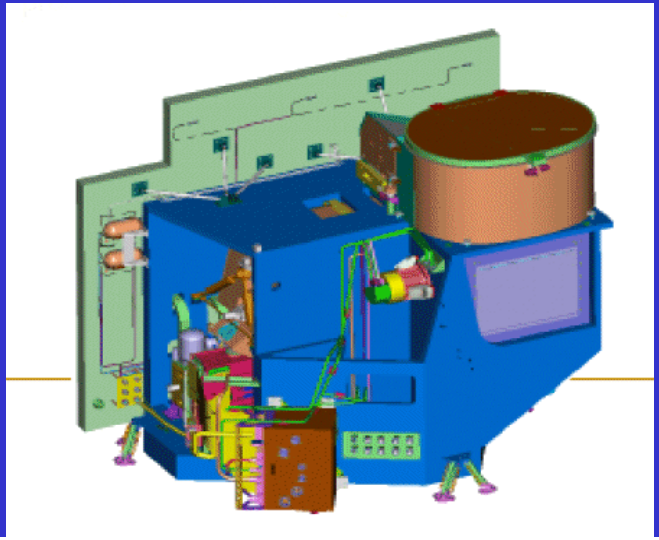
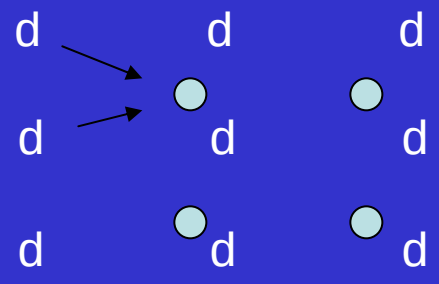


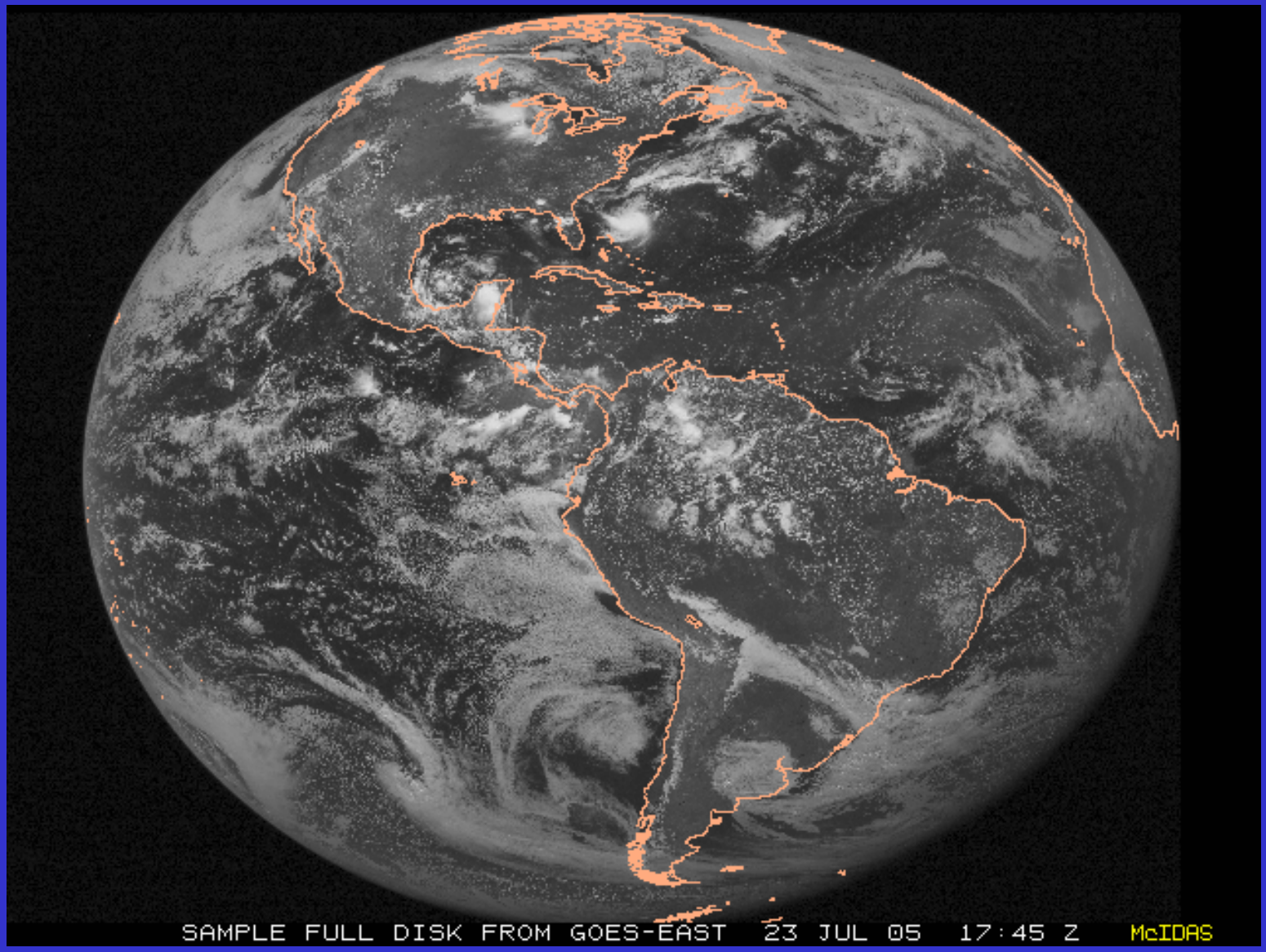
Figure courtesy of ITT Industries

Imagery Requirement

- The distributed, calibrated and navigationally corrected **image data will be rectified to a fixed grid**. The grid is defined relative to an ideal geostationary satellite viewpoint.

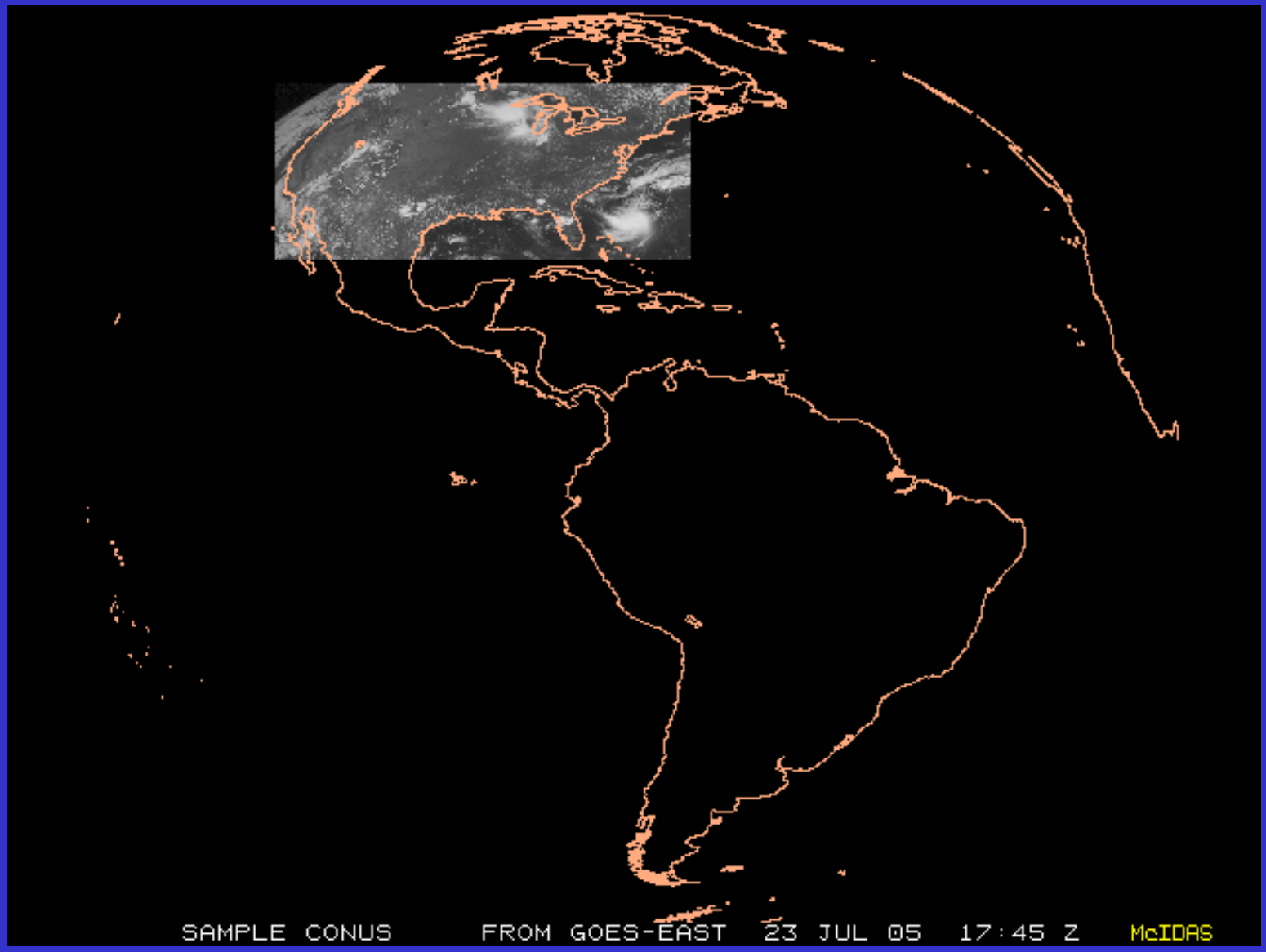
- The image pixels will have an angular separation of:
  - 14 microradians (0.5 km) in the 0.64 um channel;
  - 28 microradians (1 km) in the 0.47, 0.86 and 1.61 um channel;
  - 56 microradians (2 km) in all other channels.



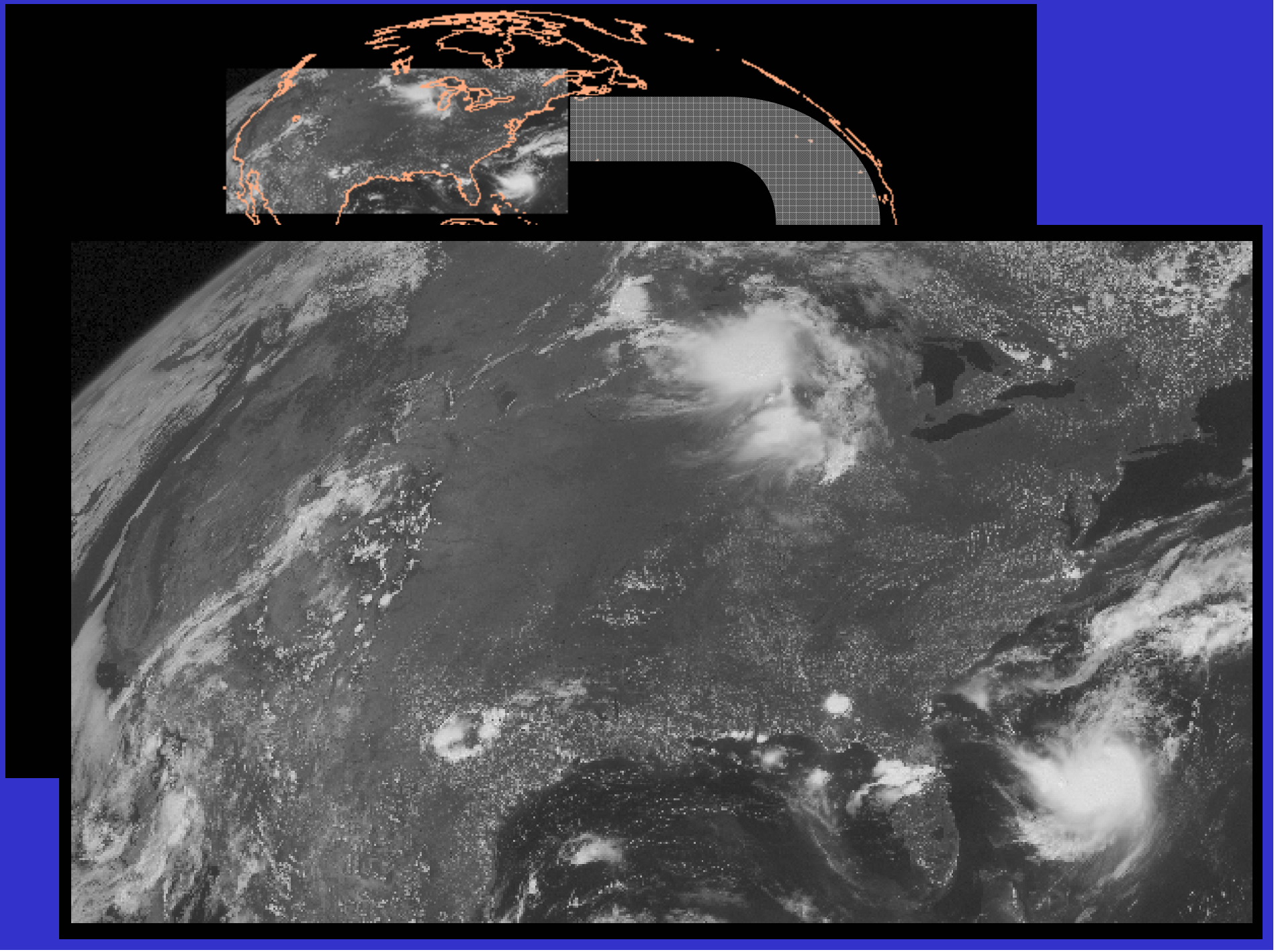


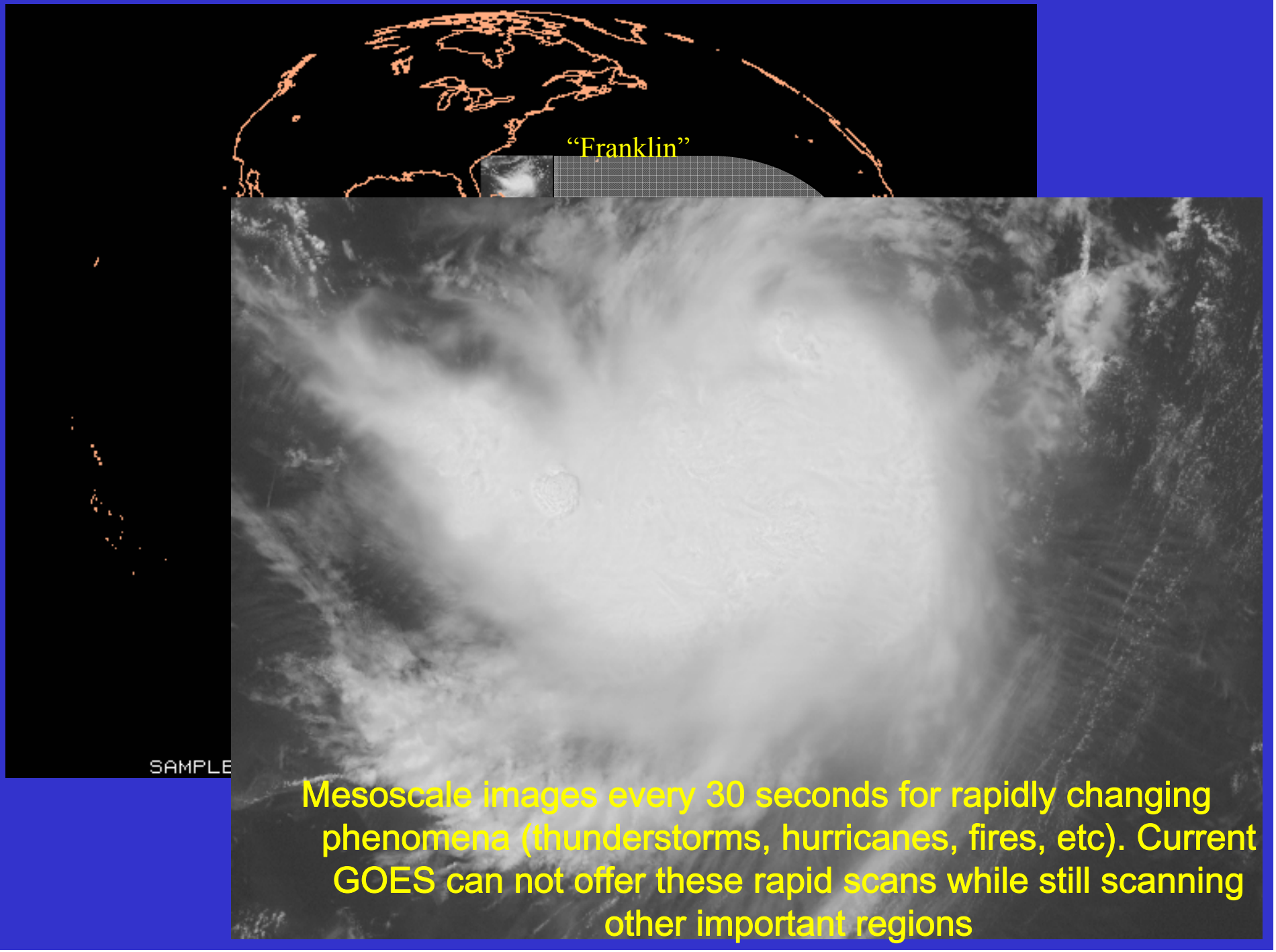
ABI scans about 5 times faster than the current GOES imager

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.

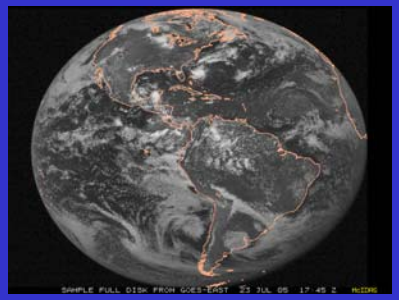




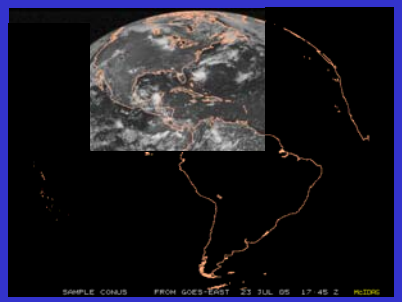
Mesoscale images every 30 seconds for rapidly changing phenomena (thunderstorms, hurricanes, fires, etc). Current GOES can not offer these rapid scans while still scanning other important regions

Imager Coverage in ~30 minutes

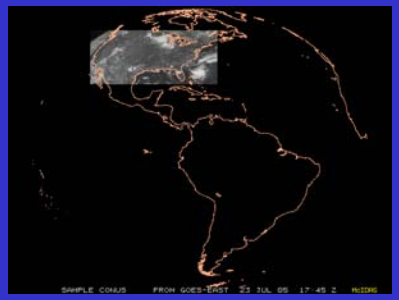
	Current Imager (Rapid Scan mode)	**Future Imager** ("Flex" mode)
Full Disk	0	2
Northern Hemi	1	-
CONUS	3	6
Mesoscale	0	60



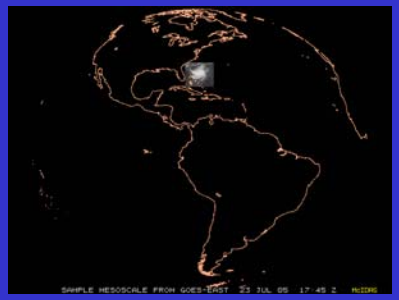
Full Disk



N. Hemisphere

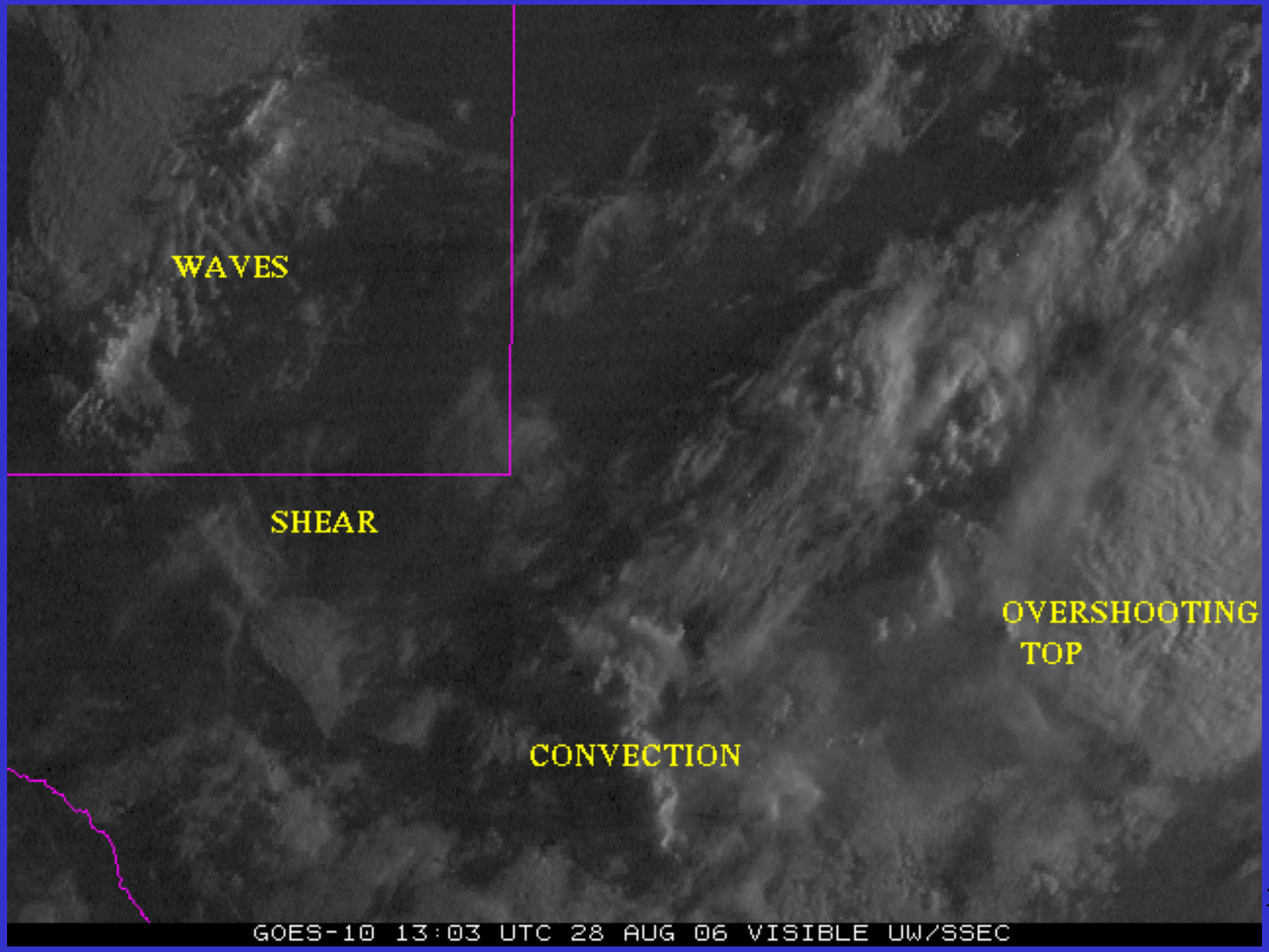


CONUS

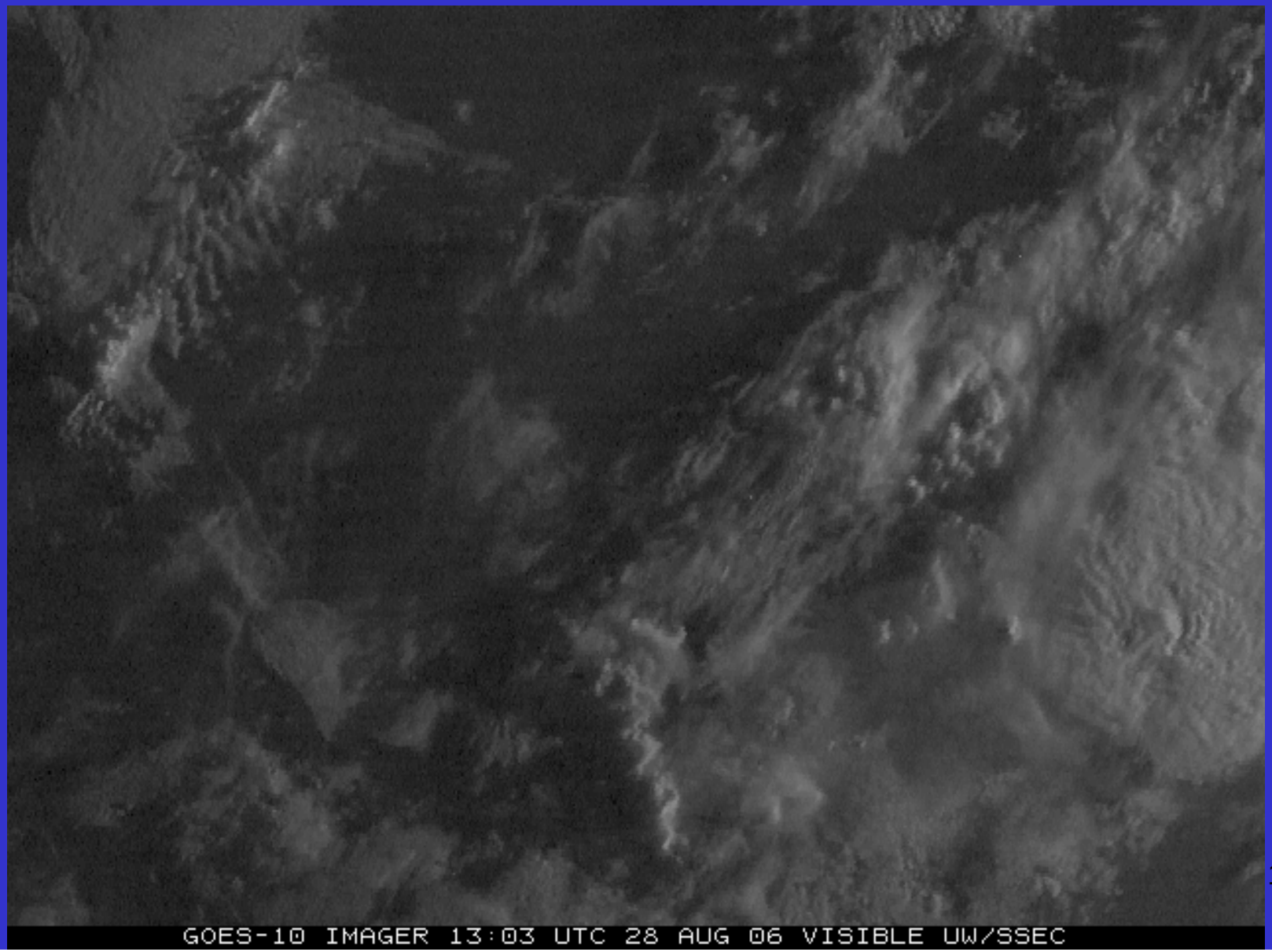


Mesoscale

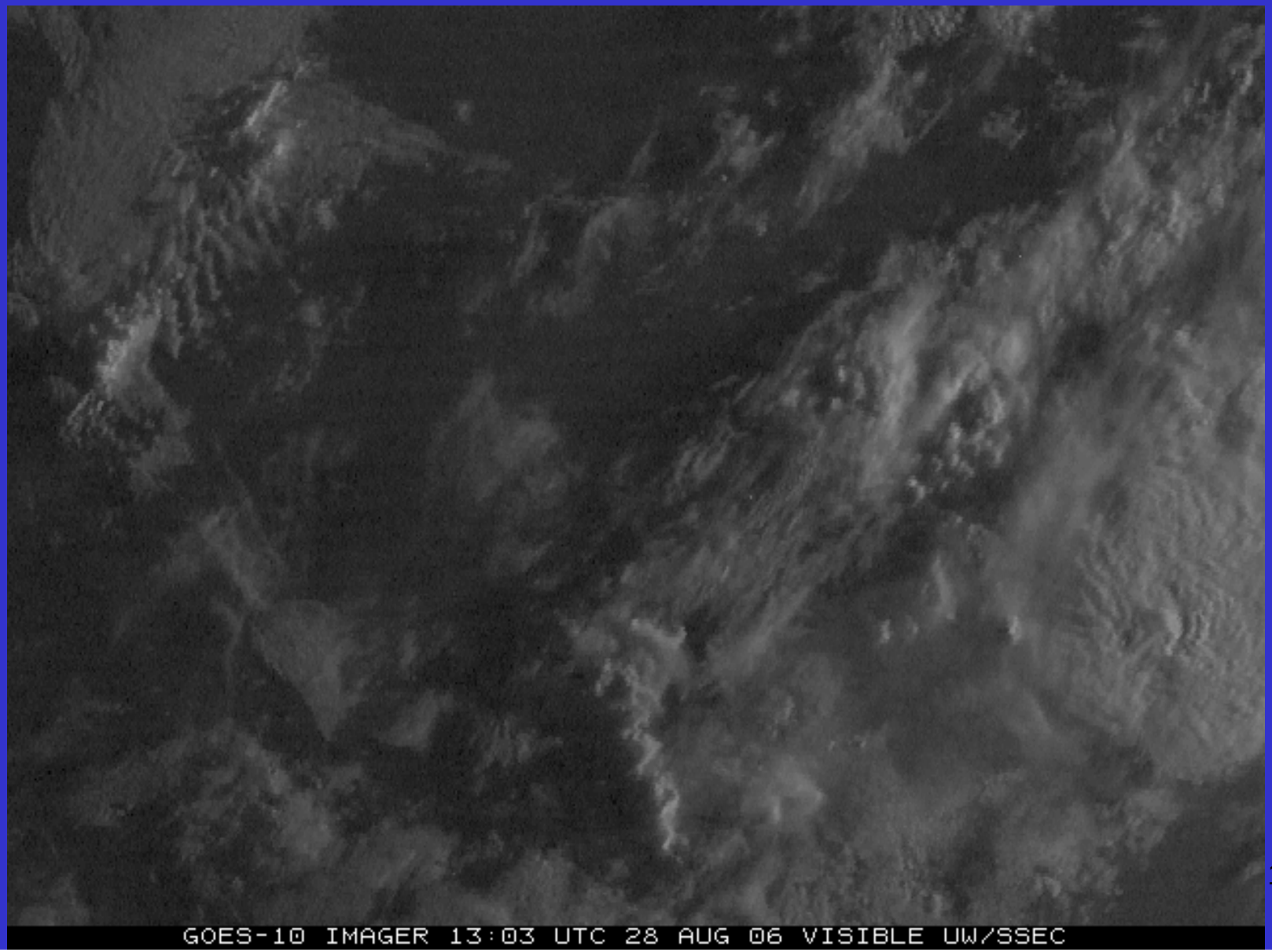
GOES-10


WAVES
SHEAR
OVERSHOOTING
TOP
CONVECTION
GOES-10 13:03 UTC 28 AUG 06 VISIBLE UW/SSEC

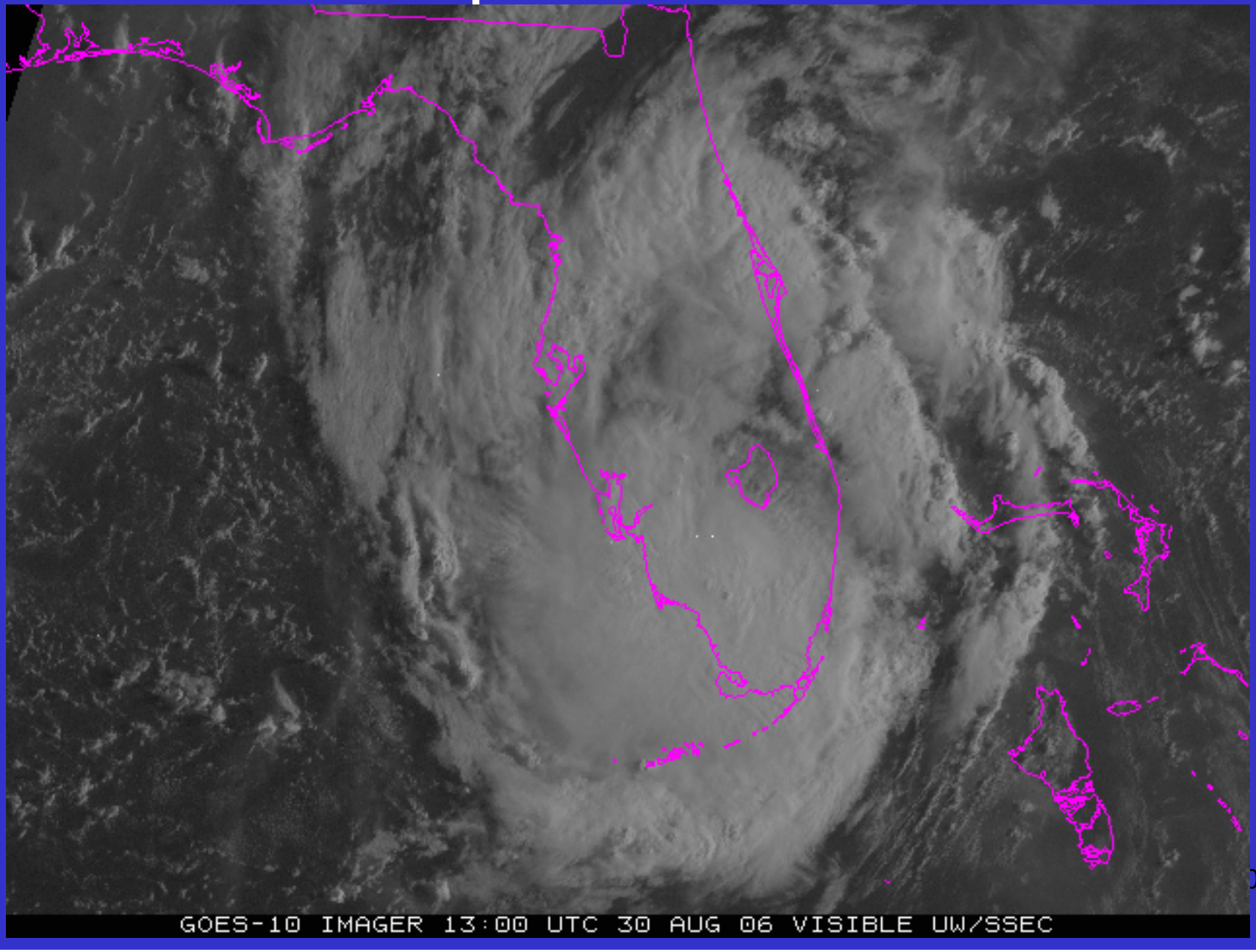
15-min time resolution “loop”



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, inso-lation, 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

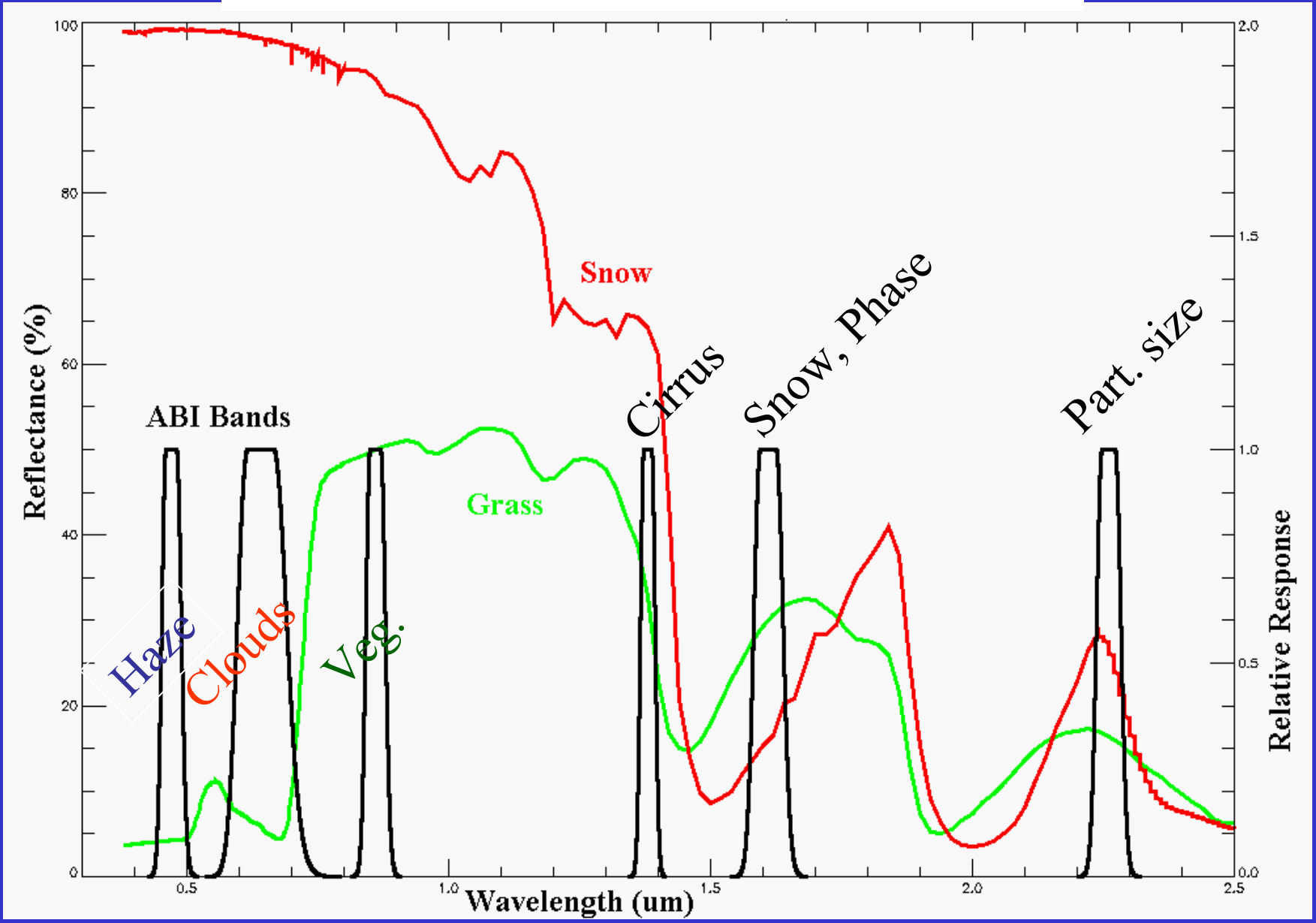
Schmit et al, 2005

ABI IR Bands

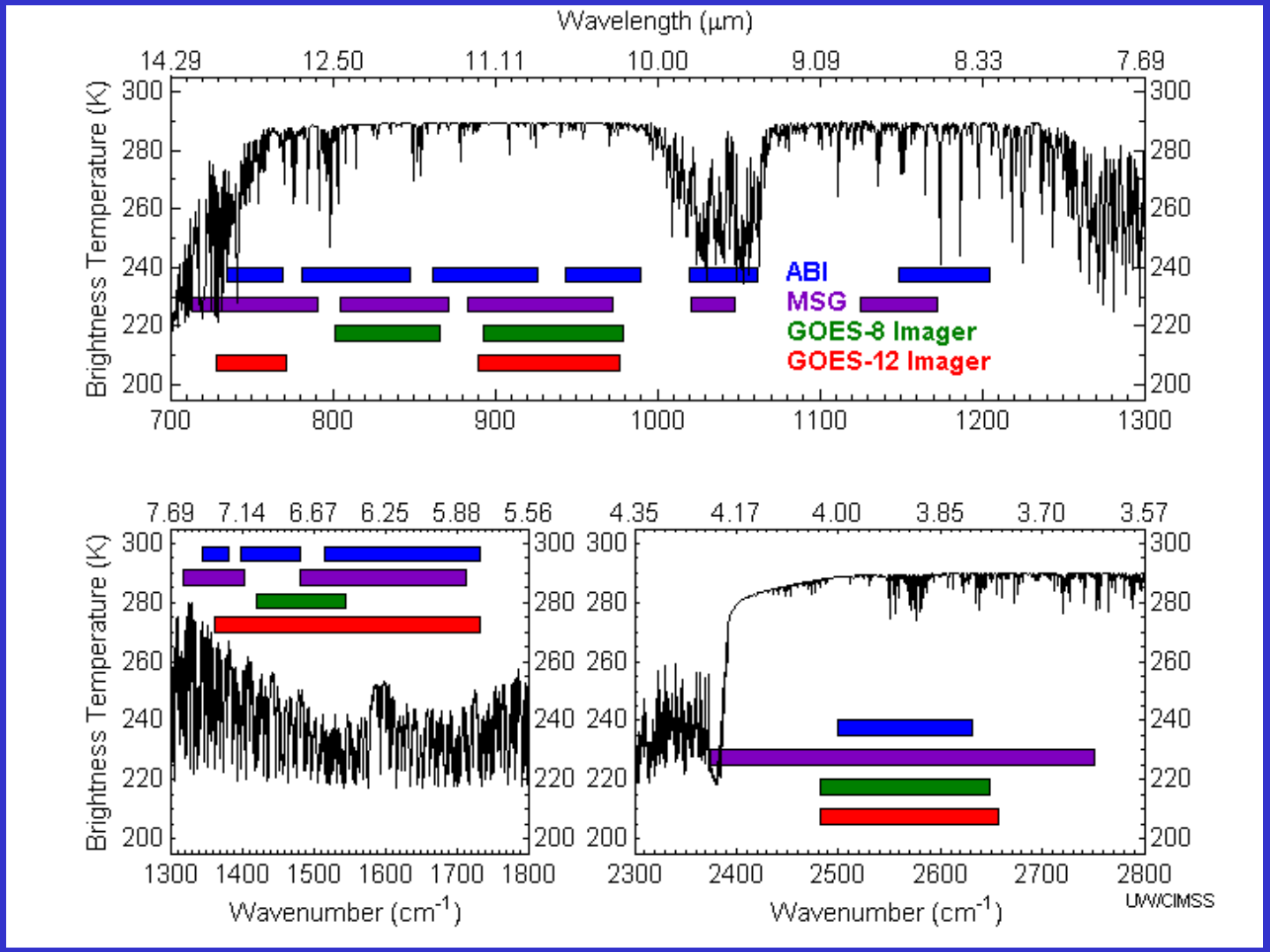
7	3.80–4.00	3.90	2	Surface and cloud, fog at night, fire, winds
8	5.77–6.6	6.19	2	High-level atmospheric water vapor, winds, rainfall
9	6.75–7.15	6.95	2	Midlevel atmospheric water vapor, winds, rainfall
10	7.24–7.44	7.34	2	Lower-level water vapor, winds, and SO_2
11	8.3–8.7	8.5	2	Total water for stability, 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

Schmit et al, 2005

Visible and near-IR channels on the ABI



The ABI visible and near-IR bands have many uses.



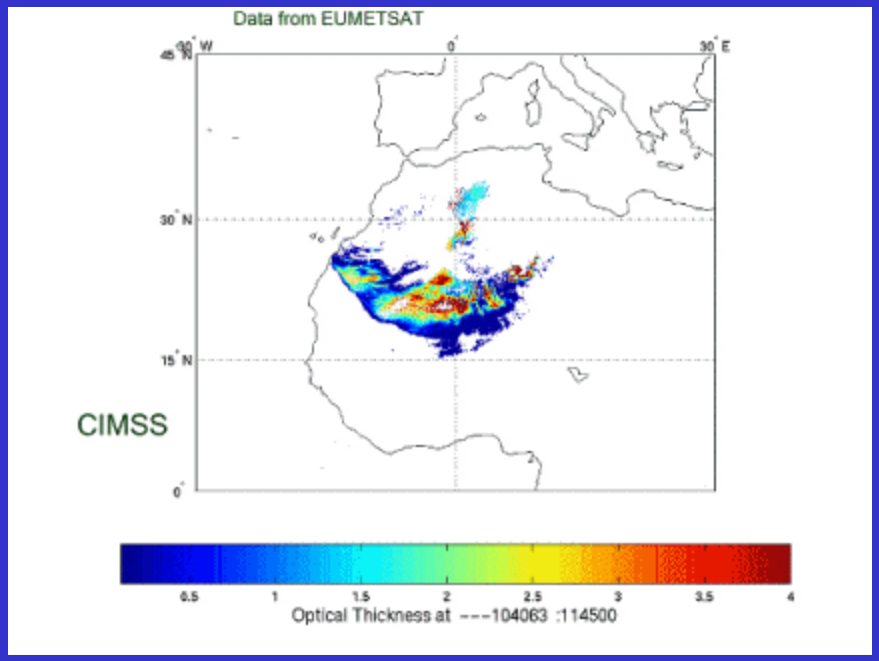
While there are differences, there are also many similarities for the spectral bands on MET-8 and the Advanced Baseline Imager (ABI). Both the MET-8 and ABI have many more bands than the current operational GOES imagers.

ABI to Imager Noise Comparison

	Spec	Spec/"2"				Measured	
ABI	**NEdT**	**NEdT**		**Band**	**Imager**	**G-12**	**Spec**
3.9	0.1	0.05		2	3.9	0.13	1.4
6.185	0.1	0.05					
6.95	0.1	0.05		3	6.5 / 6.7	0.15	1
7.34	0.1	0.05					
8.5	0.1	0.05					
9.61	0.1	0.05					
10.35	0.1	0.05					
11.2	0.1	0.05		4	10.7	0.11	0.35
12.3	0.1	0.05		5	12	No band	0.35
13.3	0.3	0.075		6	13.3	0.19	0.32
from MRD				from GOES-12 Tech Report			

When taking into account the ABI improved FOV size, **the expected noise is less (by 2-3 times) than the current GOES Imagers**. A factor of 2 was used (square root 4) for most Imager bands.

Aerosol/Dust Optical Thickness Retrieval
Results from SEVIRI@EUMETSAT



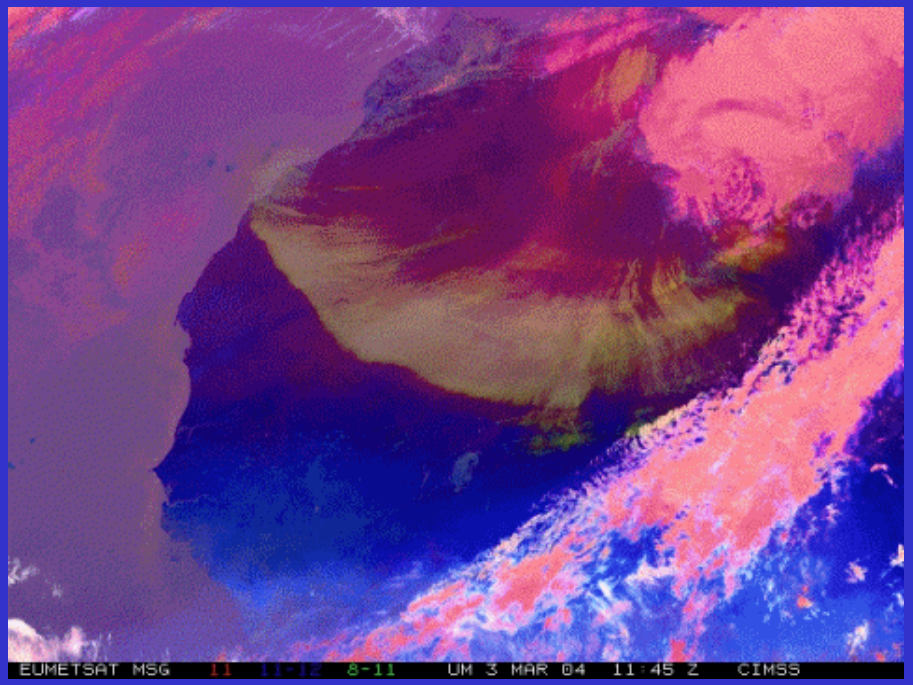


Figure courtesy of J. Li and P. Zhang

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

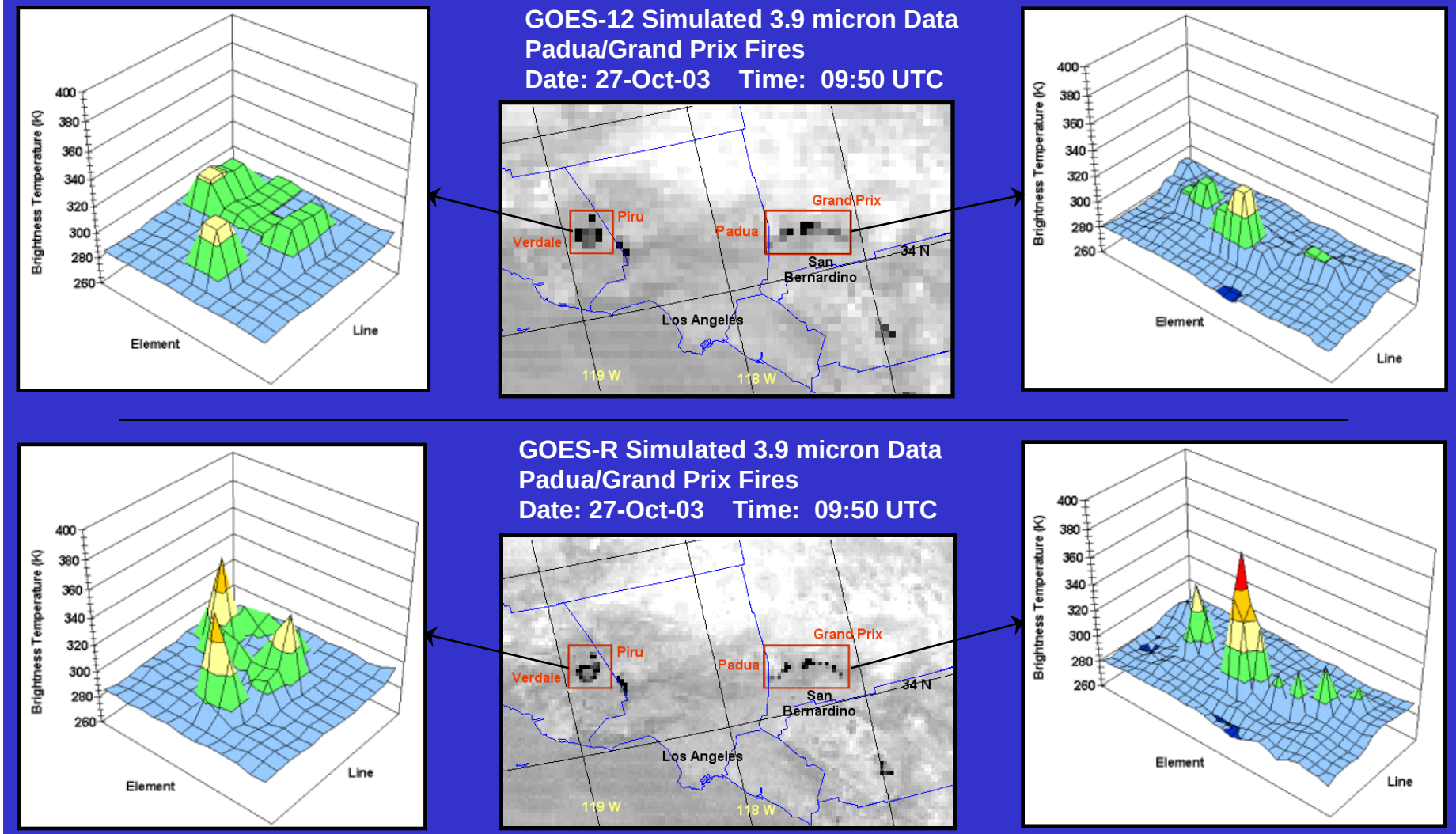


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Figure courtesy of Elaine Prins

Three-color composite (0.64, 1.6 and 11 μm) shows the low cloud over the snow and the water versus ice clouds.

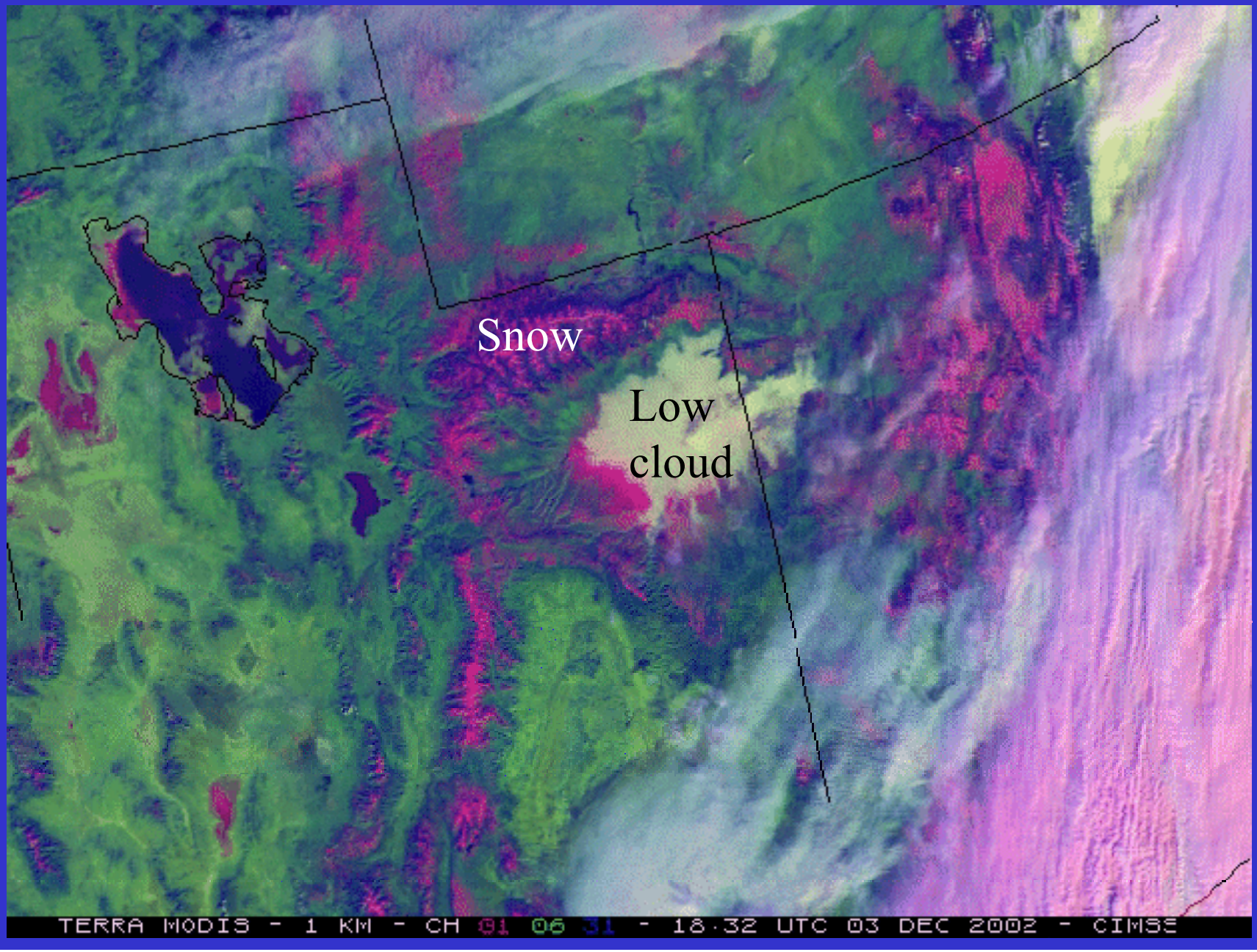
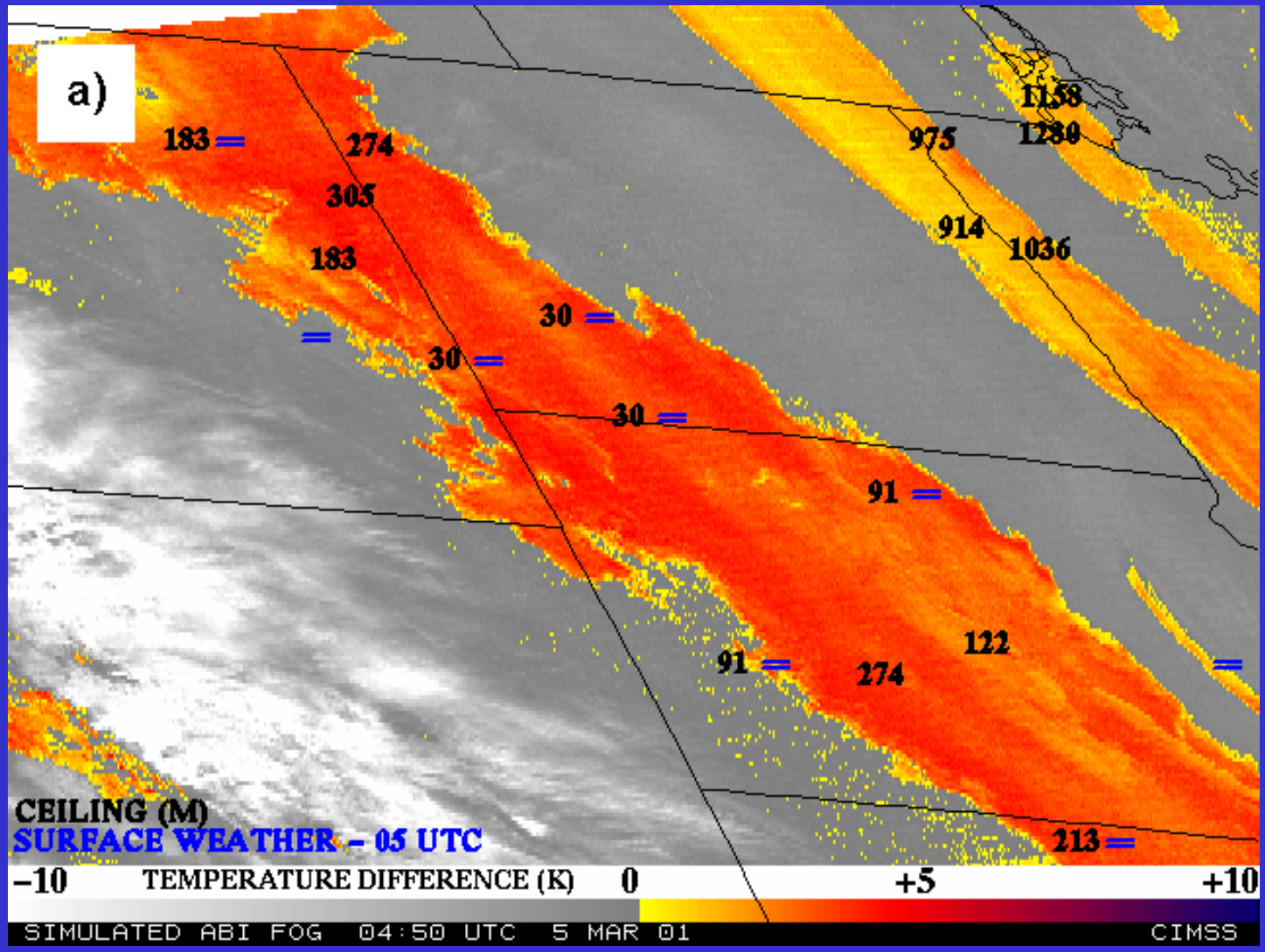


Figure courtesy of S. Bachmeier

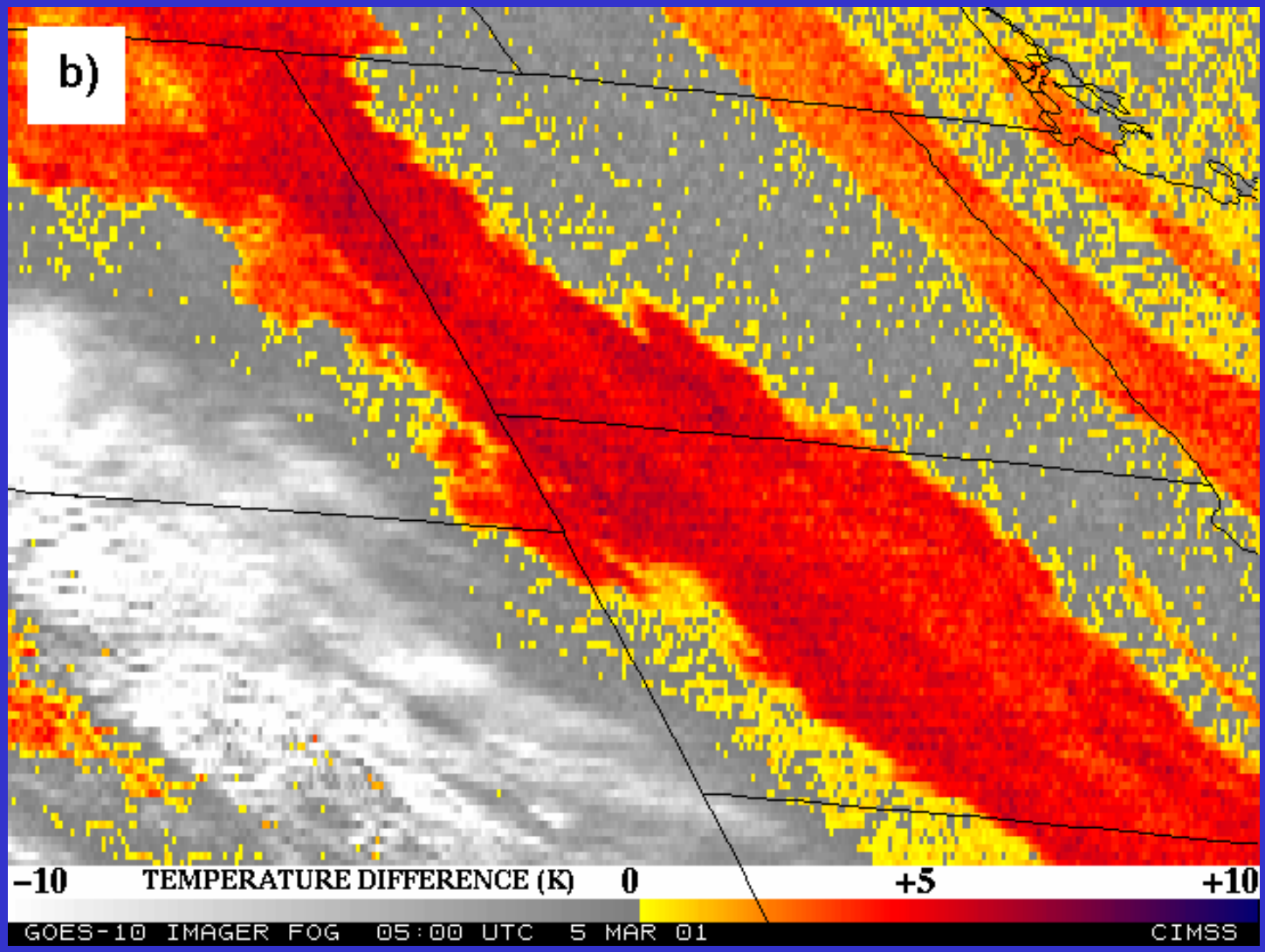
Nocturnal Fog/Stratus Over the Northern Plains



"ABI" 4 minus 11 μm Difference

ABI image (from MODIS) shows greater detail in structure of fog.

Nocturnal Fog/Stratus Over the Northern Plains

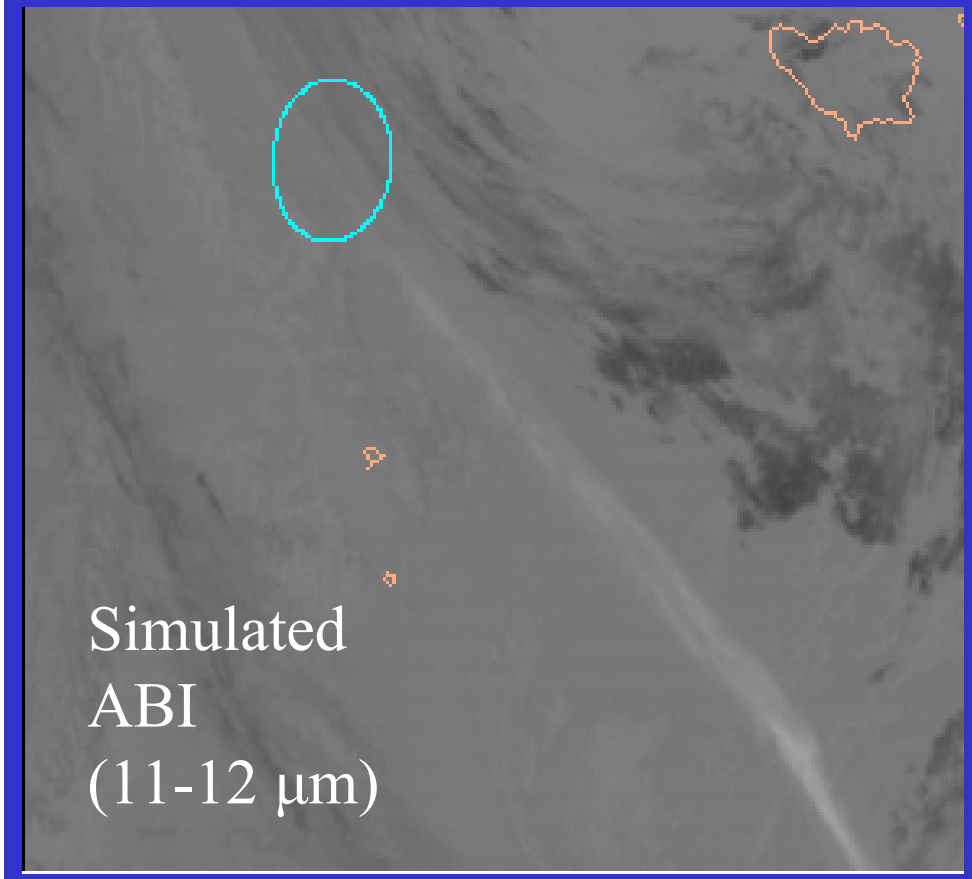


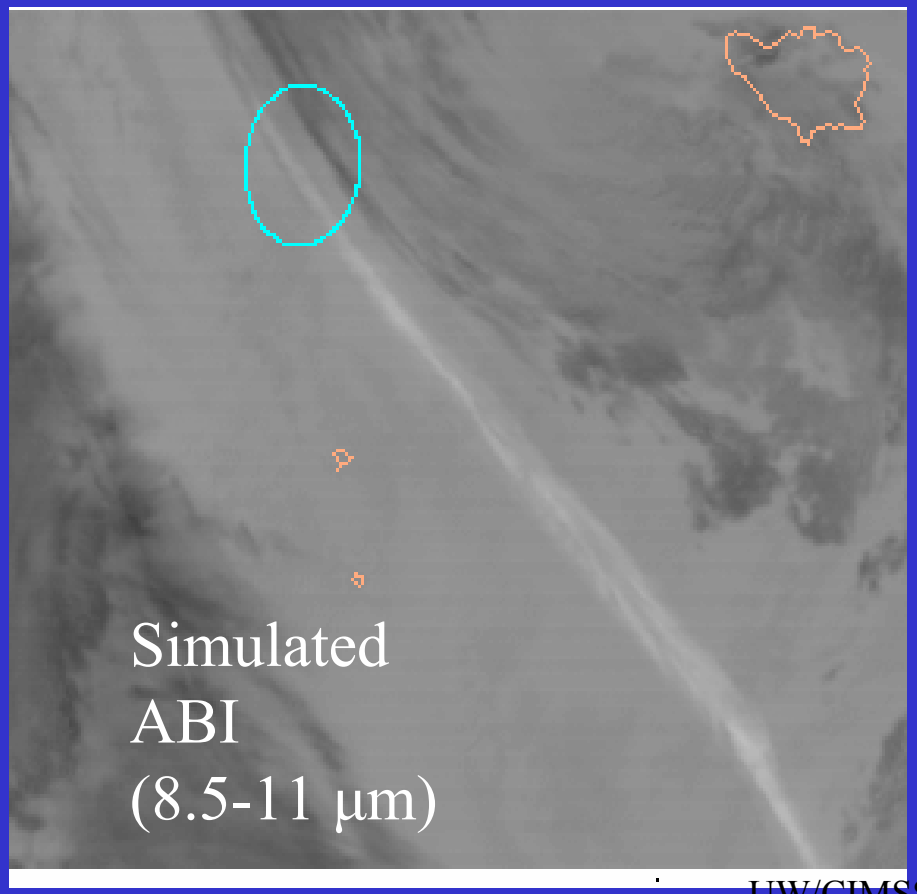
GOES-10 4 minus 11 μm Difference

ABI image (from MODIS) shows greater detail in structure of fog.

Volcanic Ash Plume: 11-12 and 8.5-11 µm images

One day after the Mt. Cleveland eruption
20 February 2001, 8:45 UTC





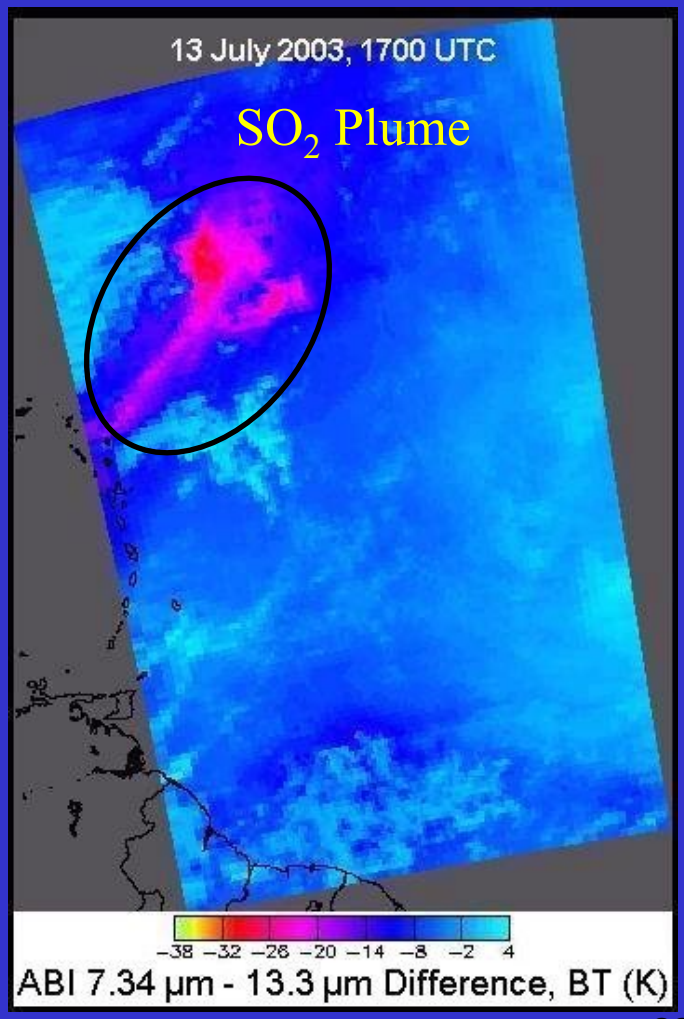
UW/CIMSS

GOES-R ABI will detect SO2 plumes

Water Vapor Band Difference convolved from AIRS data sees SO_2 plume from Montserrat Island, West Indies

Current GOES Imager
No skill in monitoring

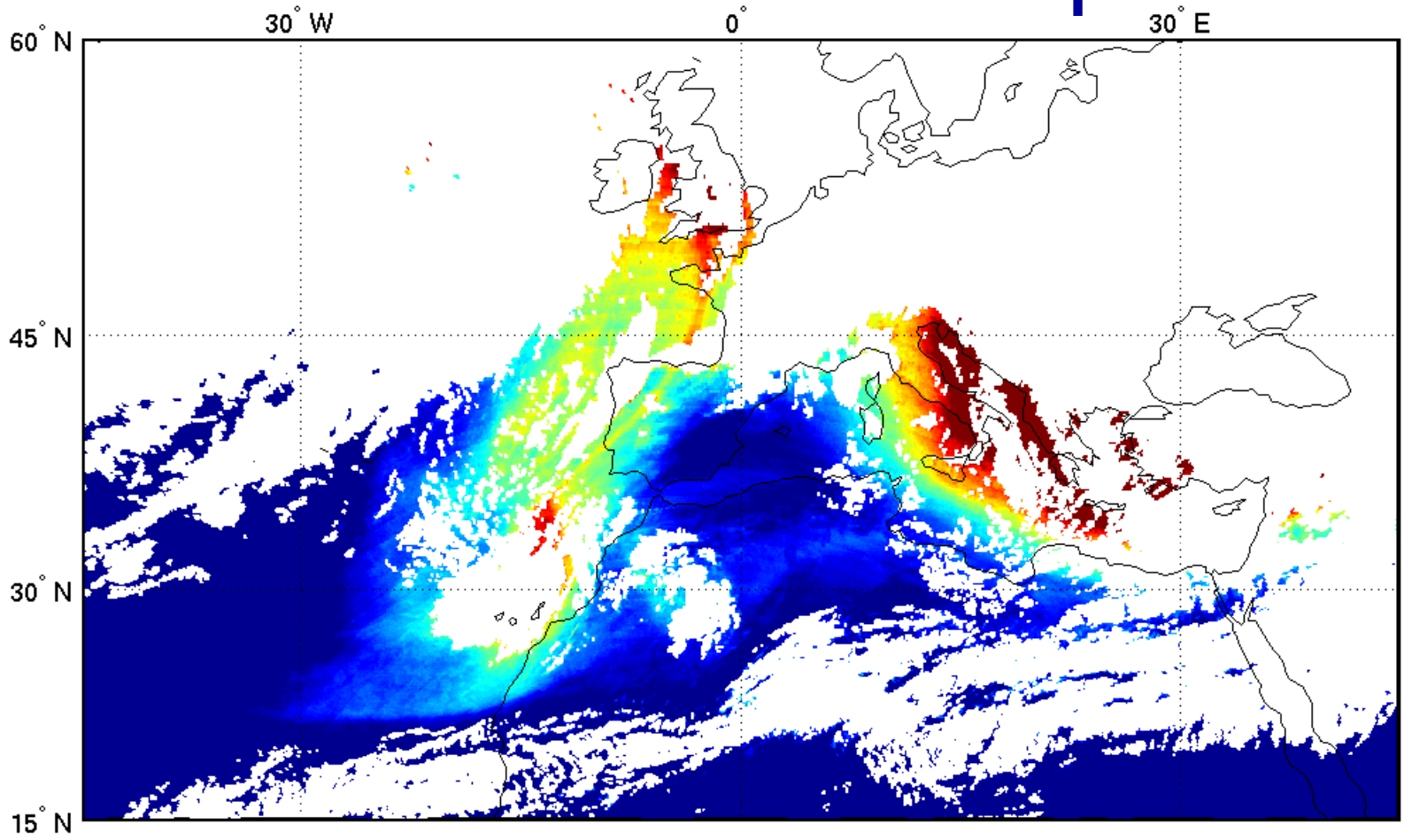
Current GOES Imager can not detect SO_2



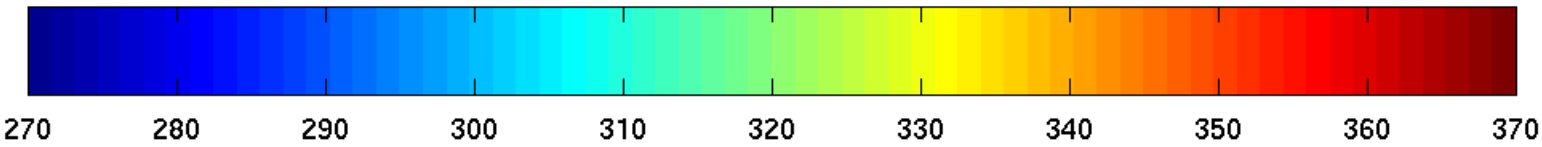
ABI 7.34 µm – 13.3 µm

Figure courtesy of Kris Karnauskas

Total Ozone Loop



SEVIRI data from EUMETSAT



Total Column Ozone (DU) 2006045 12UTC – 2006046 12UTC

UW/CIMSS

Figure courtesy of J. Li and X. Jin, CIMSS

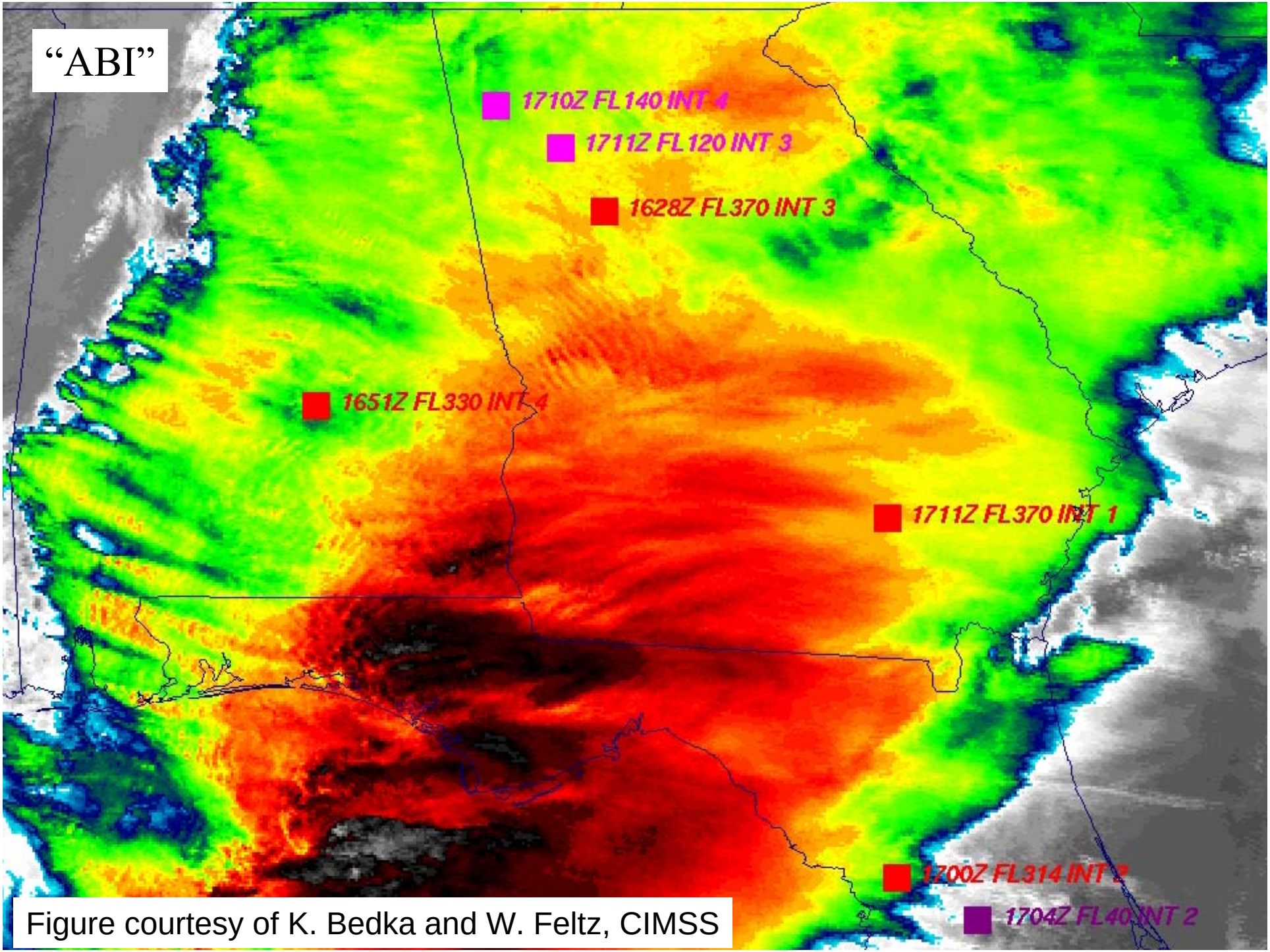


Figure courtesy of K. Bedka and W. Feltz, CIMSS

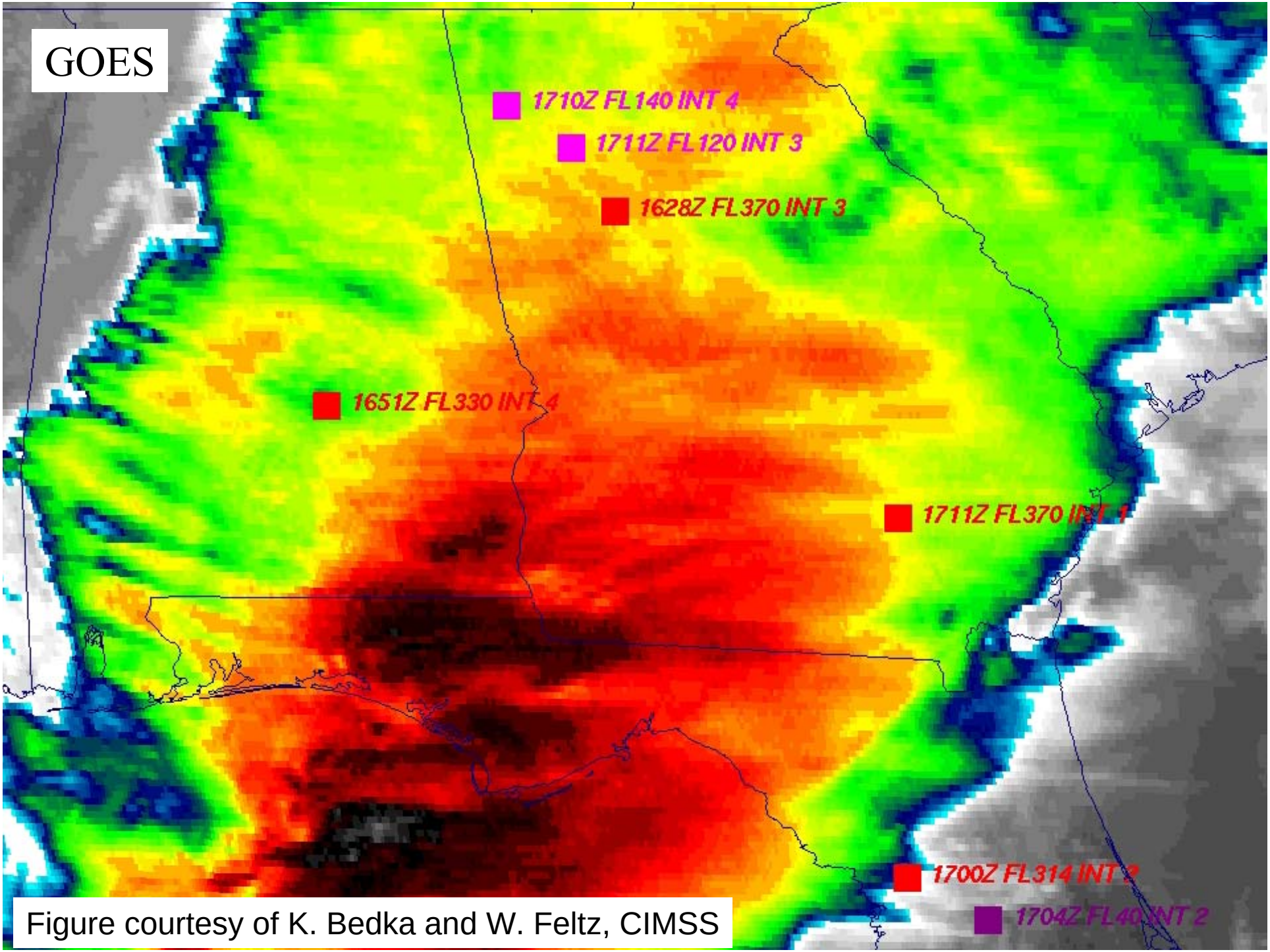
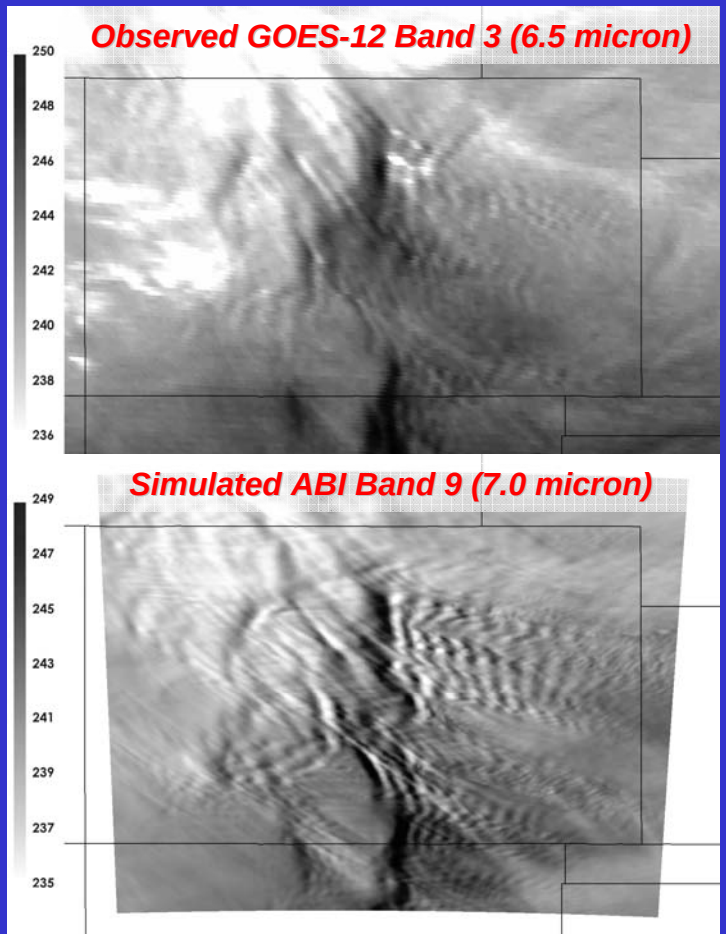


Figure courtesy of K. Bedka and W. Feltz, CIMSS

Synthetic 2 km GOES-R ABI WV Imagery

- **Waves are evident in all three ~2 km ABI WV channels, with wave spatial patterns being far clearer than current GOES-12**
- **3 ABI WV channels could provide information on mountain wave amplitude, as they detect peak signal from differing heights**



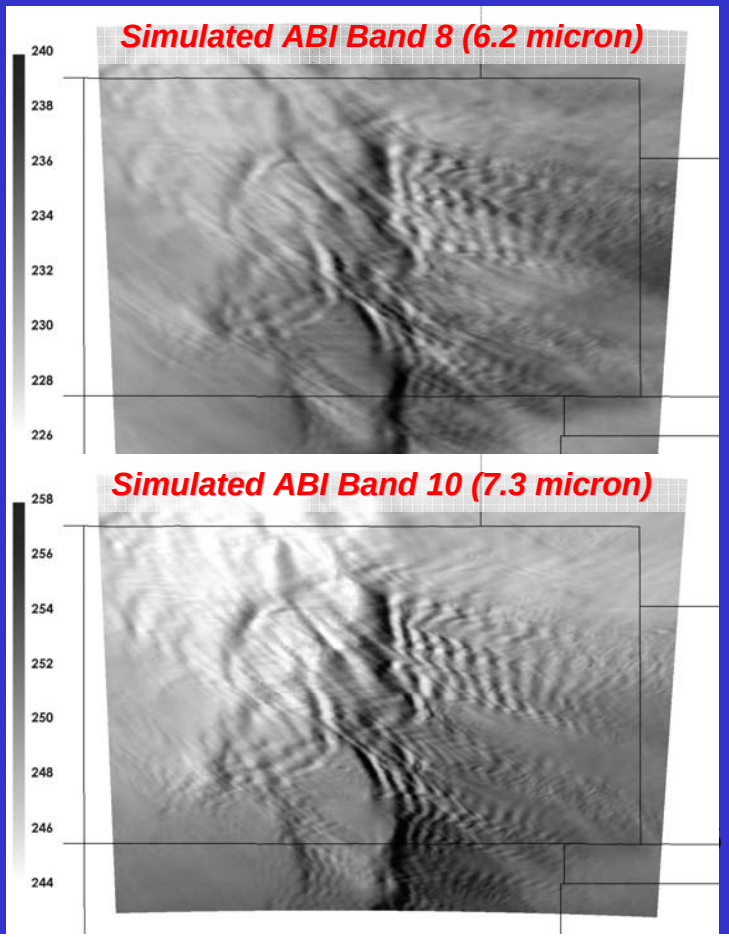
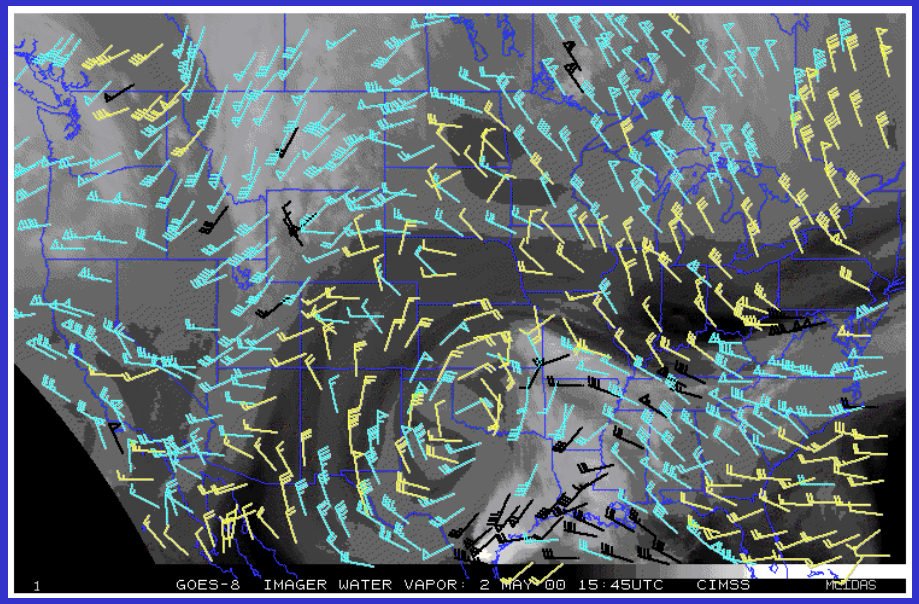


Figure courtesy of K. Bedka and W. Feltz, CIMSS

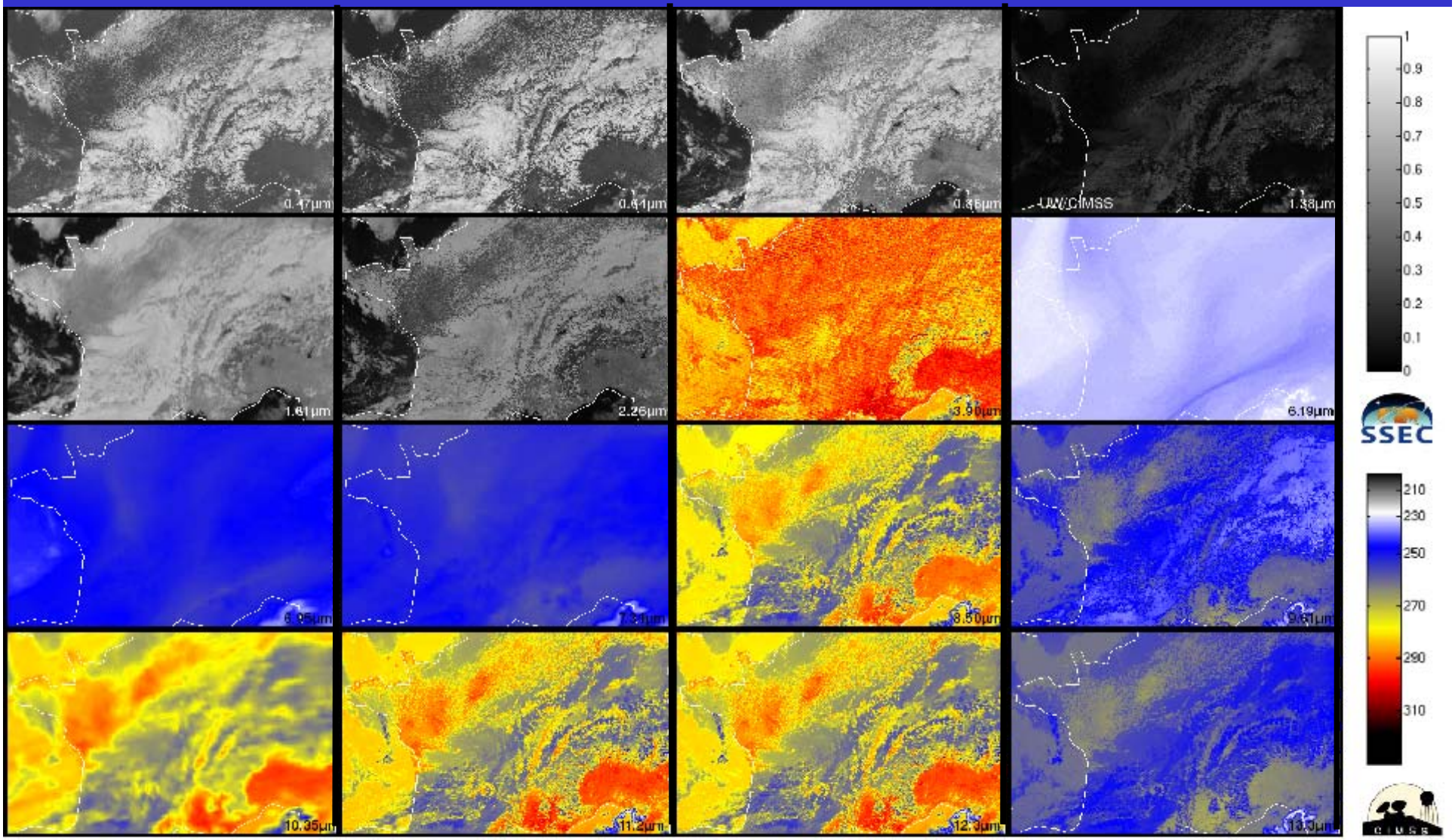
Satellite-derived winds



Satellite-derived winds will be improved with the ABI due to:

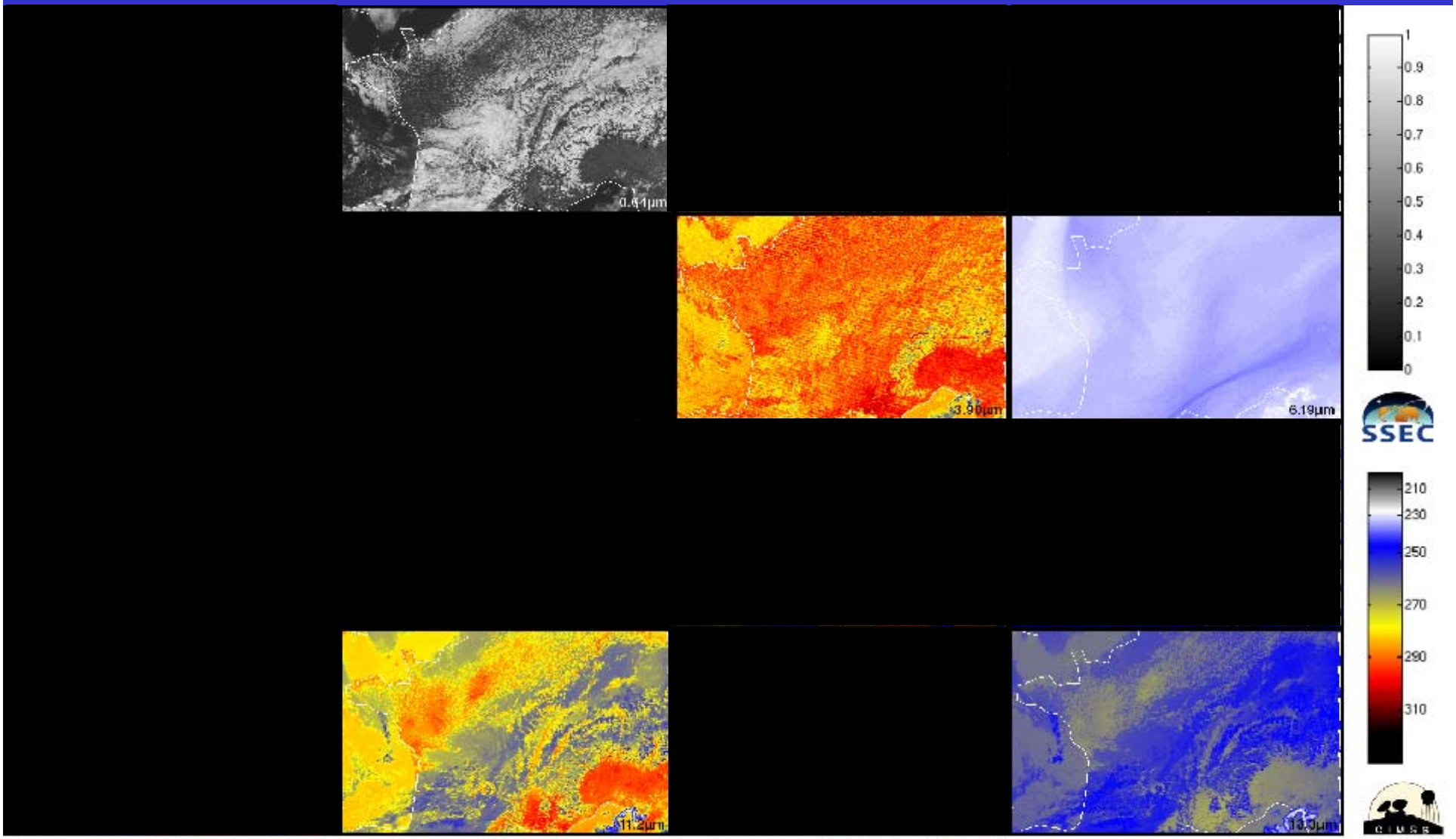
- **higher spatial resolution (better edge detection)**
- **more frequent images (offers different time intervals)**
- **better cloud height detection (with multiple bands)**
- **new bands may allow new wind products**
- **better NEdT's**
- **better navigation/registration**

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



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

Similar bands on the GOES-12 Imager



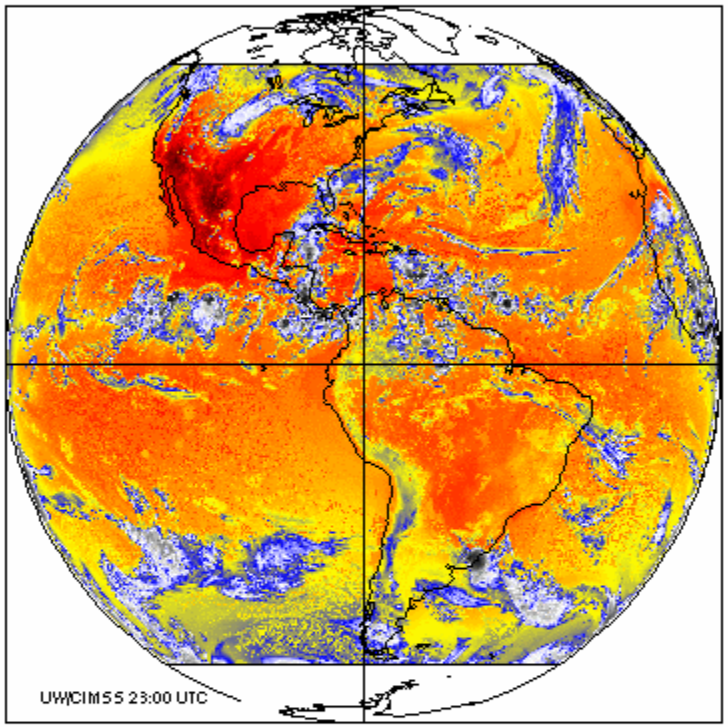
ABI Proxy from MODIS, MSG, and AIRS on 2004 April 11

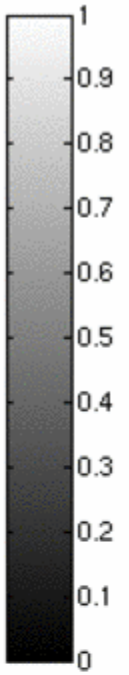
The additional bands on the Advanced Baseline Imager (ABI) allow new or improved products

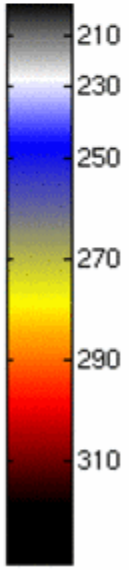
Aerosols "0.47 μm"	Clouds, etc "0.64 μm"	Vegetation "0.86 μm"	Cirrus Clouds "1.38 μm"
Snow, Cloud phase "1.61 μm"	Particle size "2.26 μm"	Fog, Fires, clouds, etc "3.9 μm"	Water Vapor, Precip. "6.19 μm"
Water Vapor "6.95 μm"	WV, Upper-level SO2 "7.34 μm"	Vol. Ash, Cloud phase "8.5 μm"	Total Ozone "9.61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

15 minutes of ABI

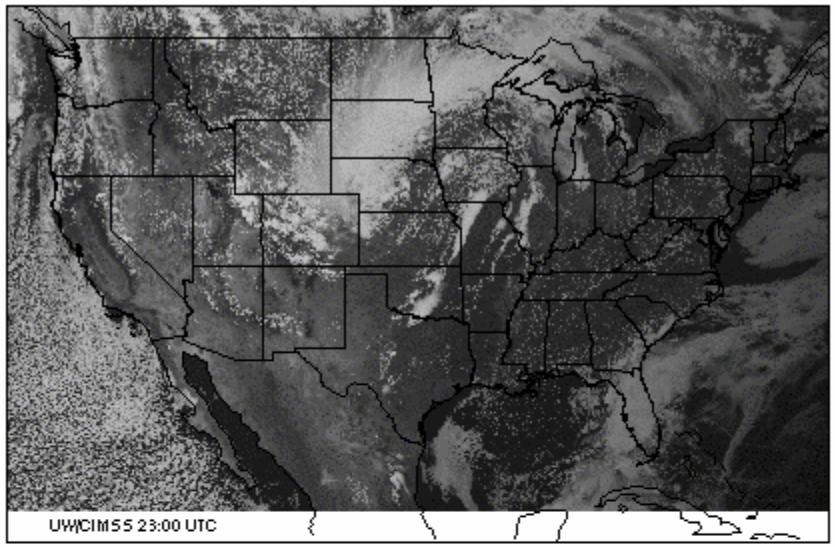
ABI band 14 (11.2 μm) BT (K) 2005-06-04



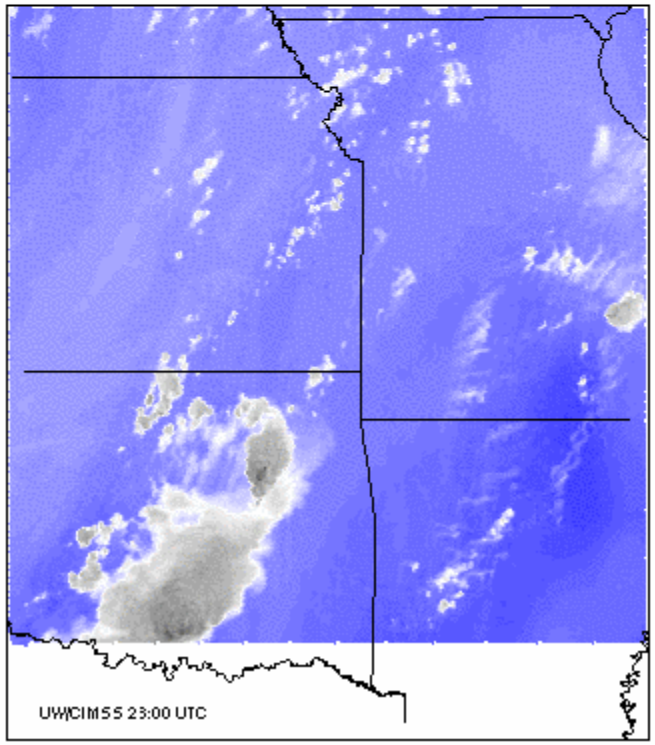




ABI band 2 (0.64 μm) reflectance 2005-06-04



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

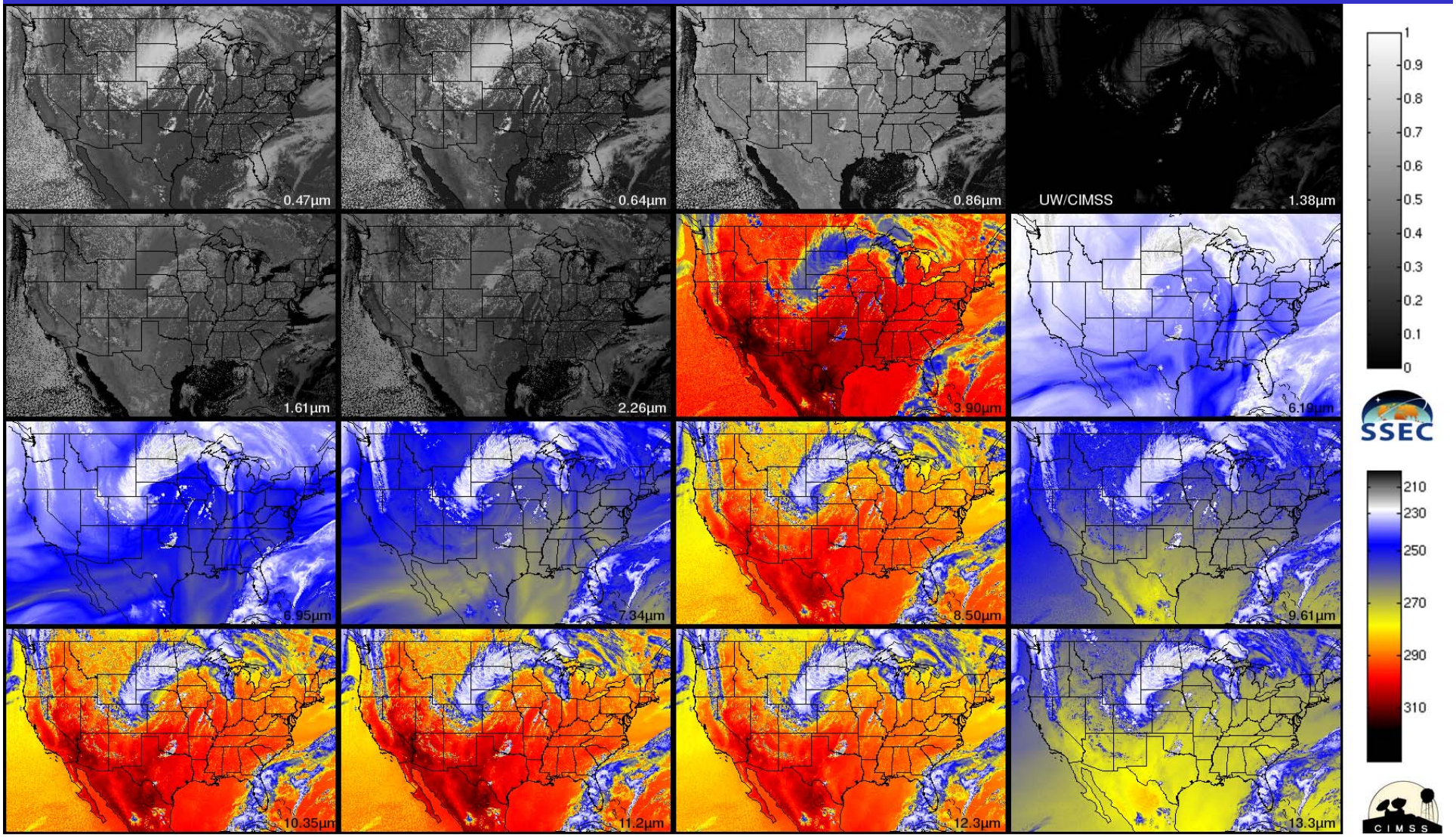


SSEC

CIMSS

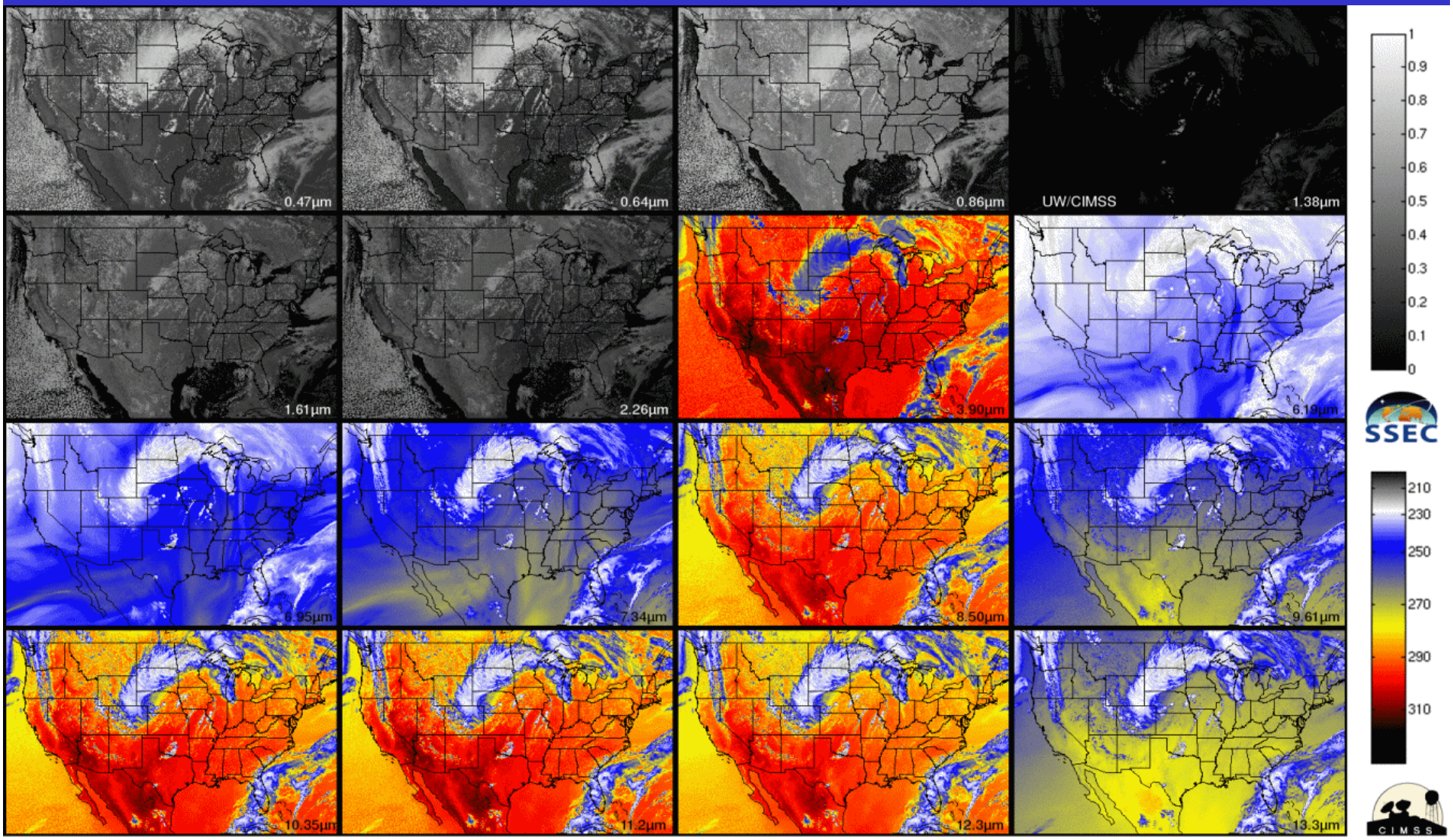
June 4, 2005 23:00 UTC

ABI bands via NWP simulation (CIMSS AWG Proxy Team)



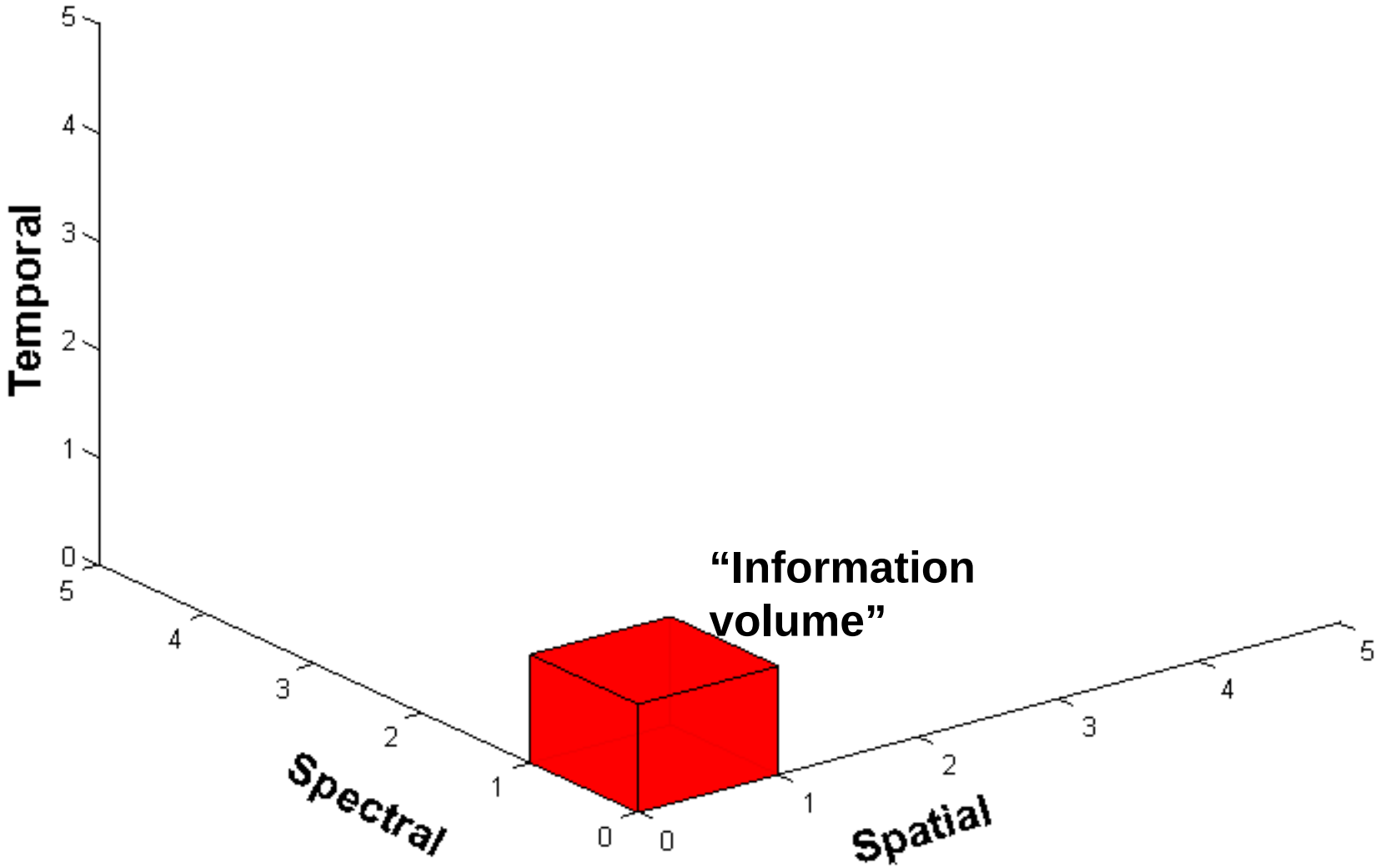
ABI band data for 2005 June 04 22:00 UTC

ABI bands via NWP simulation (CIMSS AWG Proxy Team)

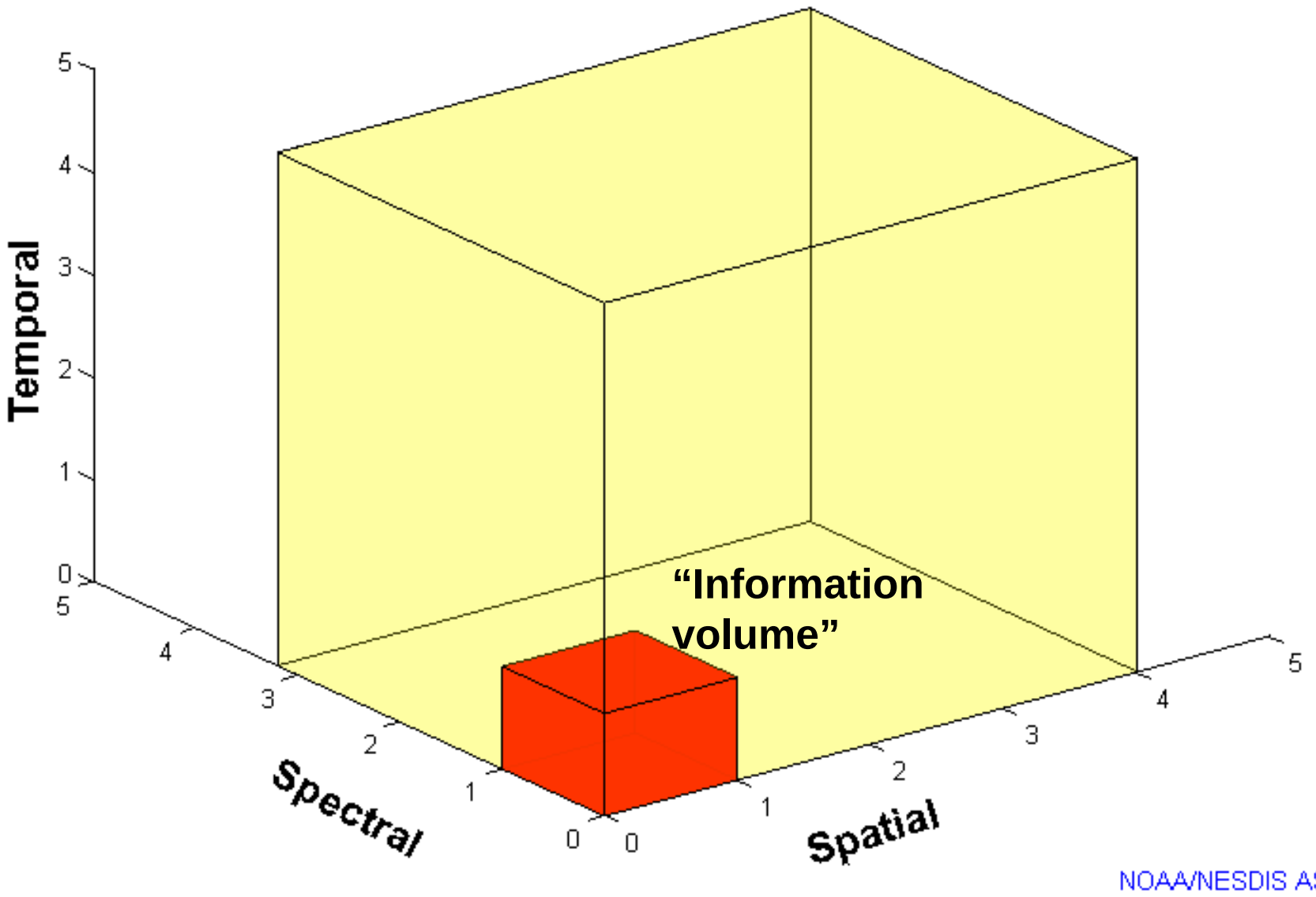


ABI band data for 2005 June 04 22:00 UTC

Current attributes: defined to be 1

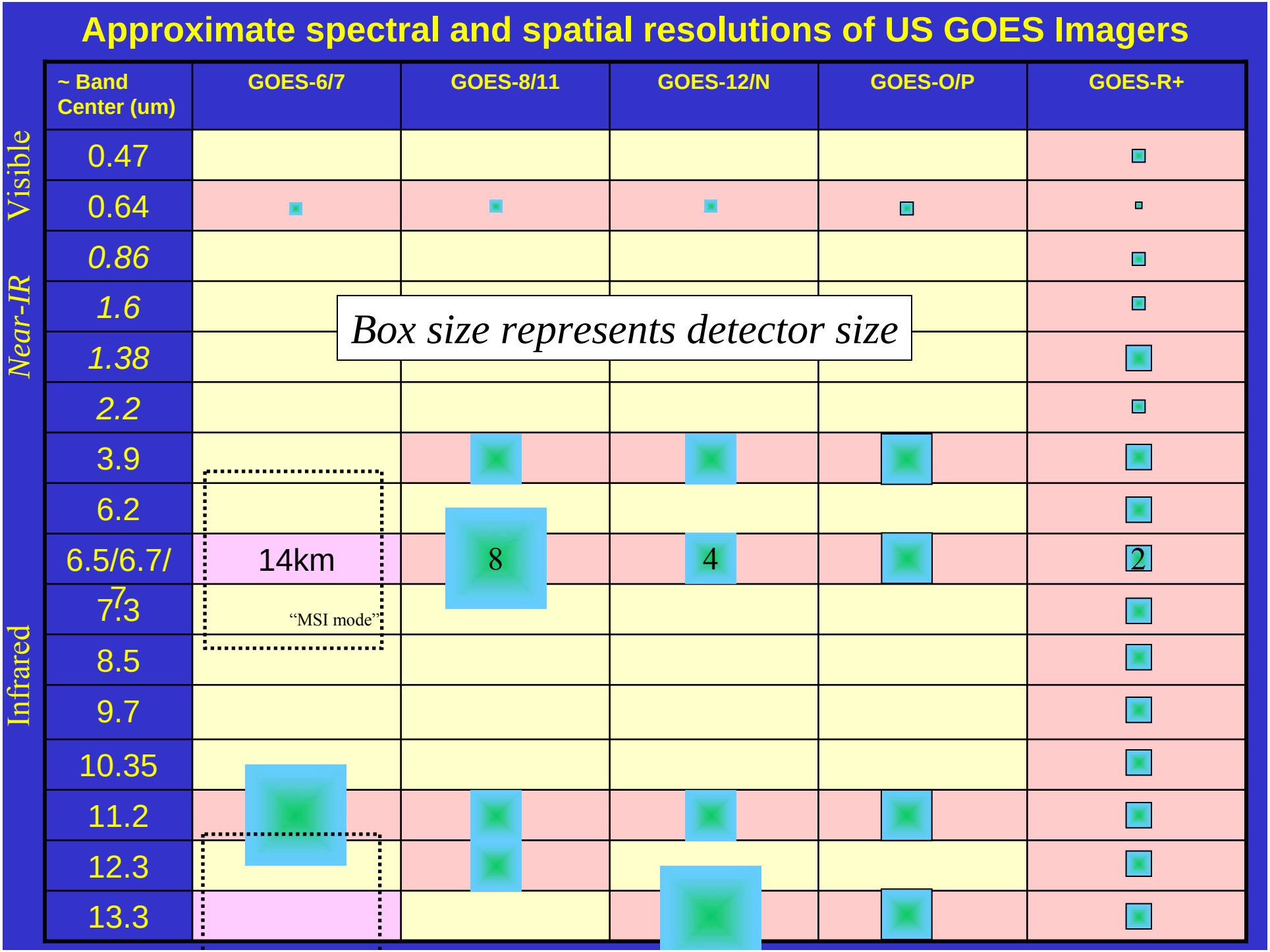


Improved attributes with the Future GOES Imagers



NOAA/NESDIS ASPB

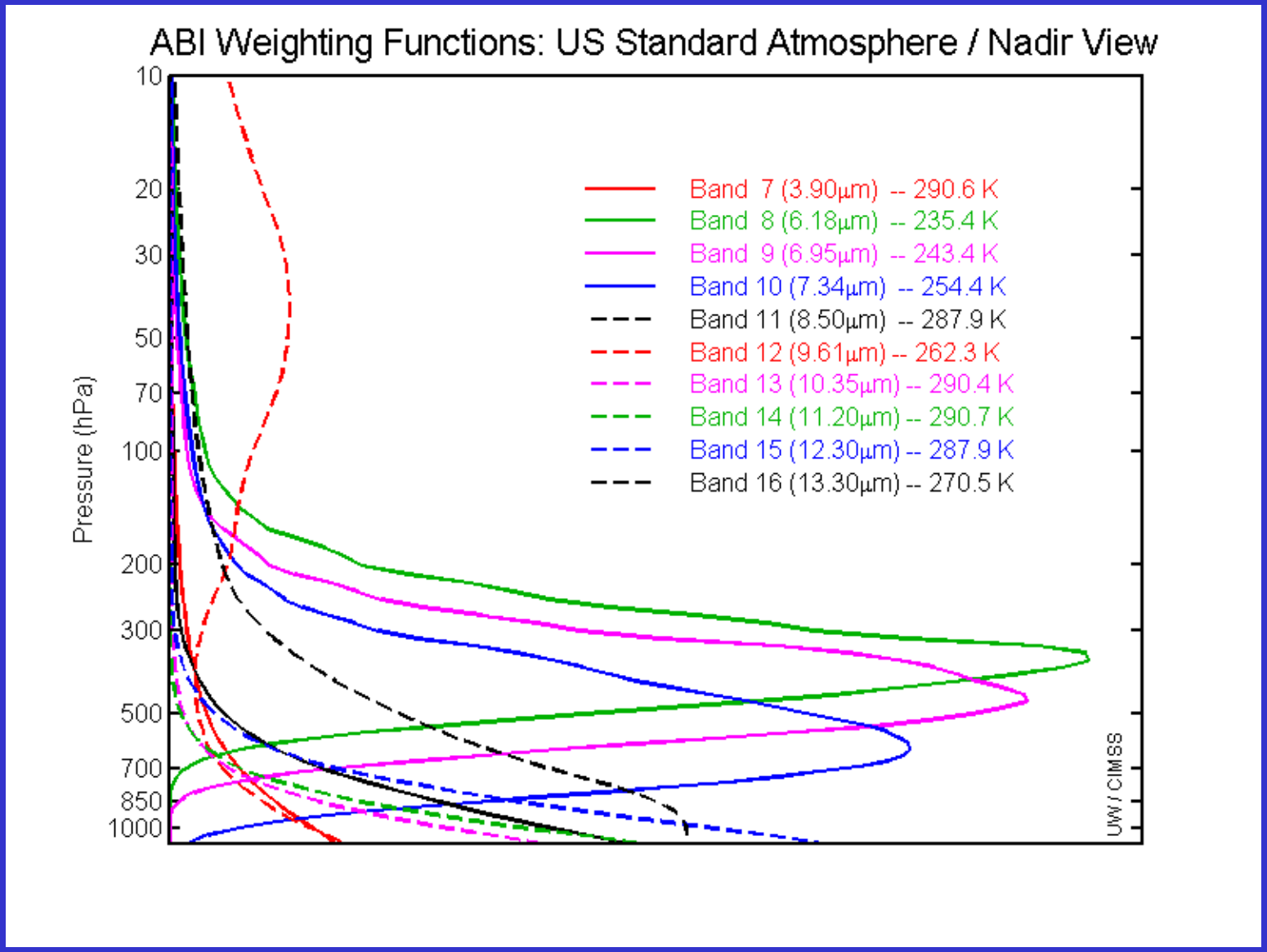
Approximate spectral and spatial resolutions of US GOES Imagers



Operational Products from the current GOES Sounder and how the ABI measurements, along with ancillary data, can produce legacy products.

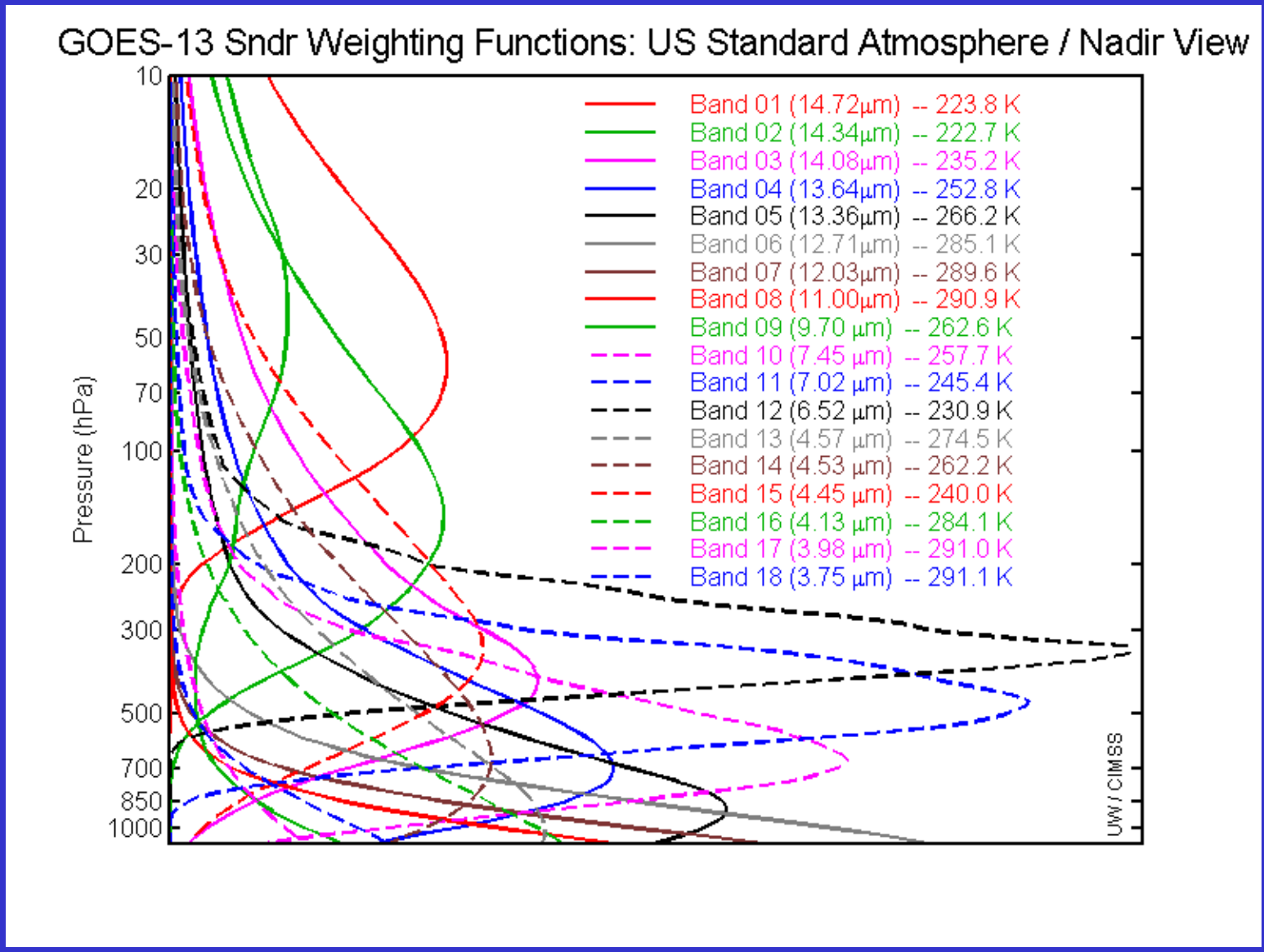
Product	Temporal/Latency	Spatial	Accuracy	Comments
Radiances	ABI ~ 20X faster	Comparable (when averaged)	Comparable for moisture information	Only 1 CO_2 band on ABI (5 bands on Sounder)
TPW	ABI ~ 20X faster	Comparable (when averaged)	Sounder more precise	ABI product quality helped with model info
Lifted Index	ABI ~ 20X faster	Comparable (when averaged)	Sounder more precise	ABI product quality helped with model info
Skin Temperature	ABI ~ 20X faster	Comparable (when averaged)	Comparable	ABI has extra window band
Profiles	ABI ~ 20X faster	Comparable (when averaged)	Sounder more precise	Worse upper-level T and lower-level moisture
Clouds	ABI ~ 20X faster	ABI Finer	Sounder more precise for cloud height	Current Sounder with more CO_2 bands gives a better height
Moisture winds	ABI ~ 20X faster	ABI Finer	Comparable	-

GOES-R ABI Weighting Functions



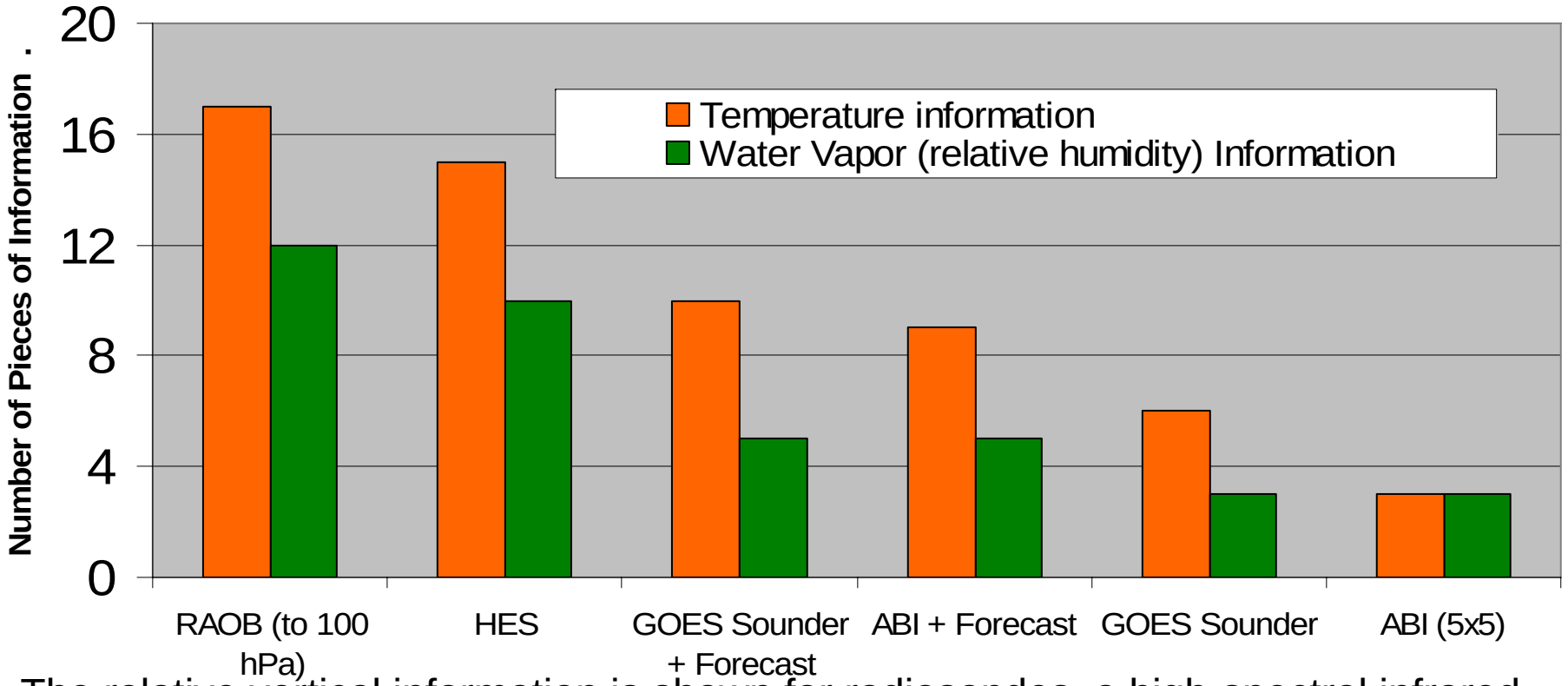
ABI has 1 CO_2 band, so upper-level temperature will be degraded compared to the current sounder

GOES-13 Sounder WFs



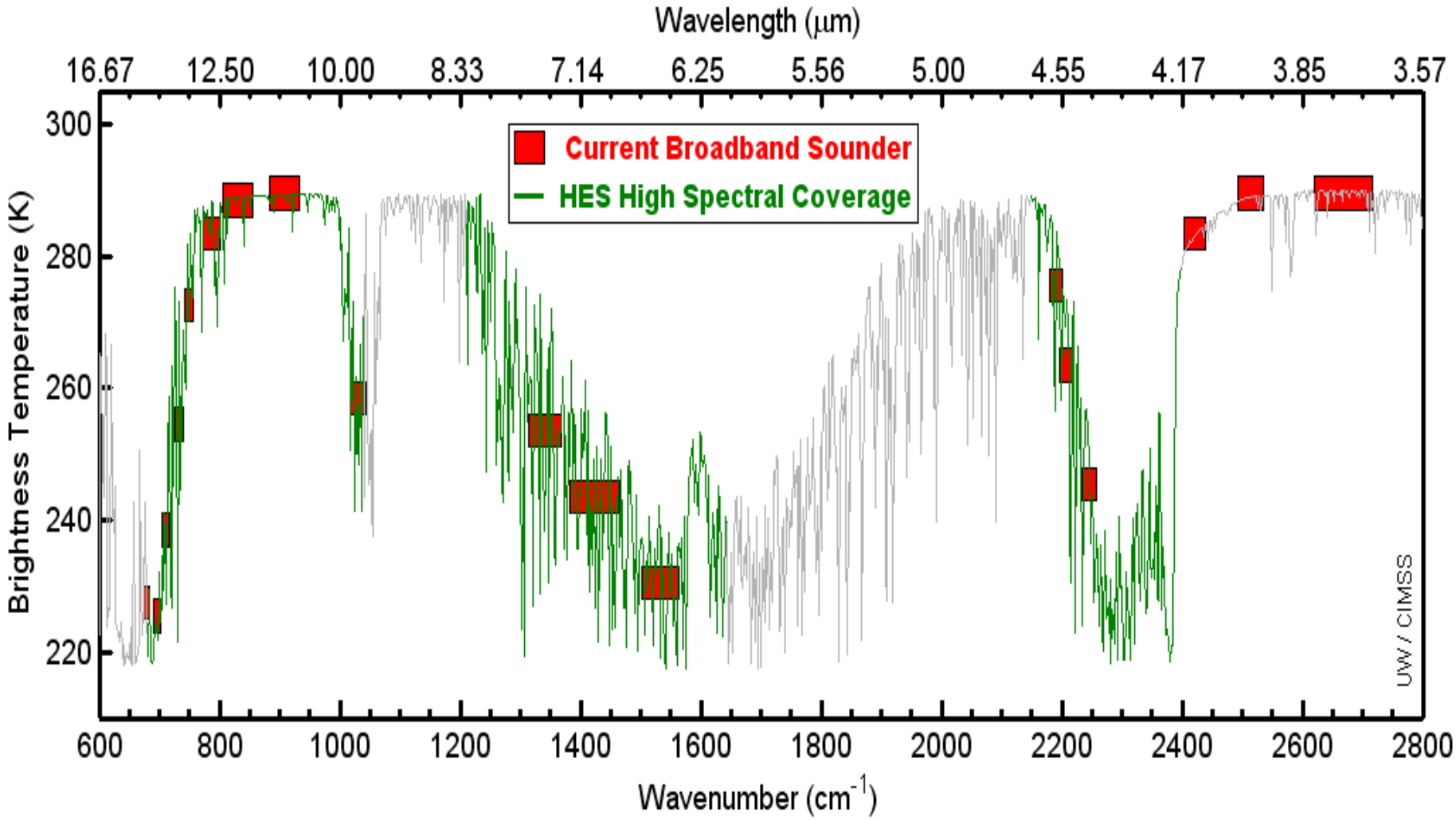
The GOES-N sounder has 5 CO_2 bands, more Shortwave bands than ABI

Profile Information Content



The relative vertical information is shown for radiosondes, a high-spectral infrared sounder, the current broad-band GOES Sounder and the ABI. The high-spectral sounder is much improved over the current sounder. This information content analysis does not account for any spatial or temporal differences.

Example spectral coverage



Current GOES Sounder spectral coverage and that possible from an advanced high-spectral sounder. The broad-band nature of the current GOES limits the vertical resolution.

ABI to Sounder Noise Comparison

	Spec	Spec/4			Measured	
ABI	**NEdR**	**NEdR**		**Sounder**	**G-12**	**Spec**
				3.74	0.00094	0.004
3.9	0.004	0.001		3.98	0.0022	0.008
				4.13	0.0024	0.008
				4.46	0.0066	0.013
				4.52	0.0062	0.013
6.185	0.1	0.025		4.57	0.0062	0.013
6.95	0.09	0.0225		6.51	0.11	0.15
7.34	0.055	0.01375		7.02	0.059	0.12
8.5	0.13	0.0325		7.43	0.099	0.16
9.61	0.154	0.0385		9.71	0.14	0.33
10.35	0.17	0.0425		11.03	0.11	0.16
11.2	0.17	0.0425		12.02	0.11	0.16
12.3	0.18	0.045		12.66	0.14	0.25
13.3	0.53	0.1325		13.37	0.34	0.44
				13.64	0.39	0.45
				14.06	0.45	0.54
				14.37	0.61	0.58
				14.71	0.77	0.66
from MRD				from GOES-12 Tech Report		

When taking into account the ABI improved FOV size, **the expected noise is less (by 2-5 times)** than the current GOES sounders. A factor of 4 was used, the sqrt of 16.

Summary

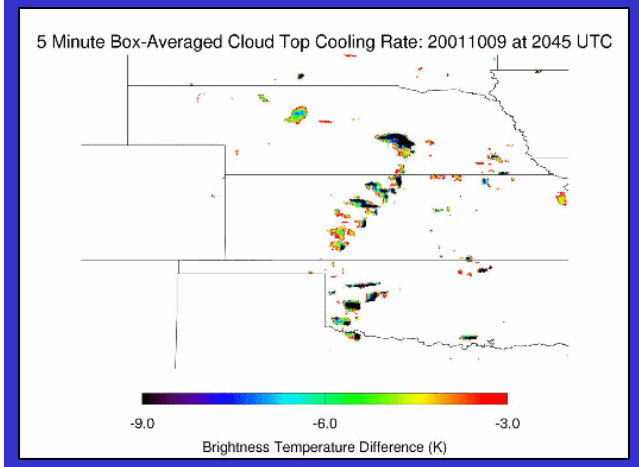
The ABI improves over the current GOES Imager the **spectral, temporal, spatial** and **radiometric** performance.

The **great amount of information** from the GOES-R will offer a **continuation of current products** (precipitation, atmospheric motion vectors, SST, radiances, hurricane intensity, dust, fog, smoke, fires, clouds, etc) and new products (upper-level SO_2, vegetation, cloud micro-physics, atmospheric waves, etc).

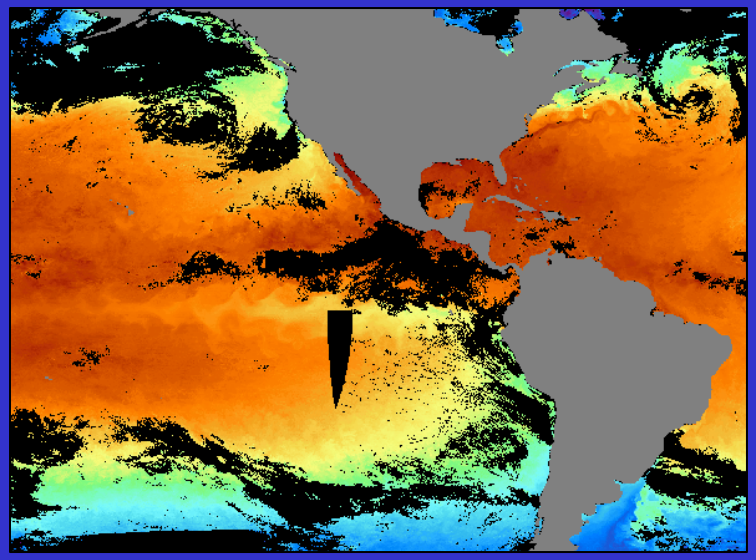
The **potential benefits of ABI** on the GOES-R series beyond the benefits of the current system are **more than $4B**.
(Thursday talk: Potential Socio-Economic Benefits of GOES-R)

The ABI applications relate to:

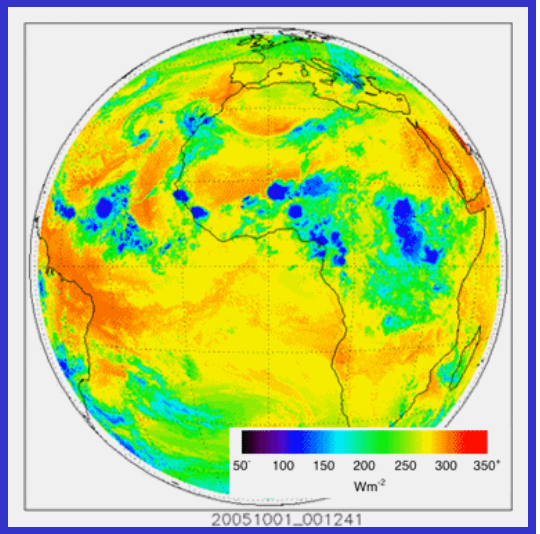
weather, ocean, climate, cryosphere, land, and hazards, etc.



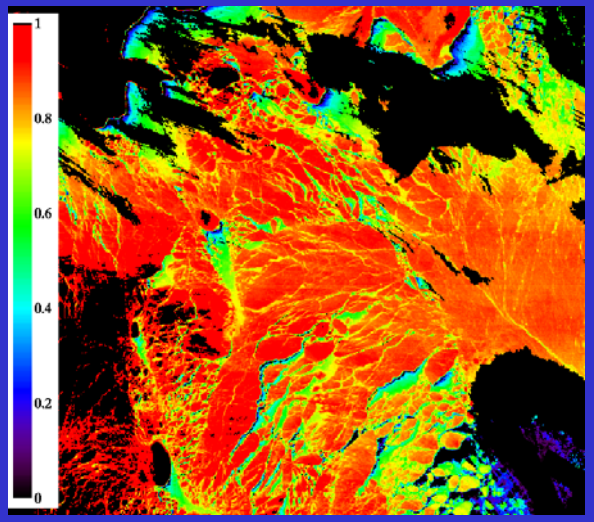
CI (K. Bedka)



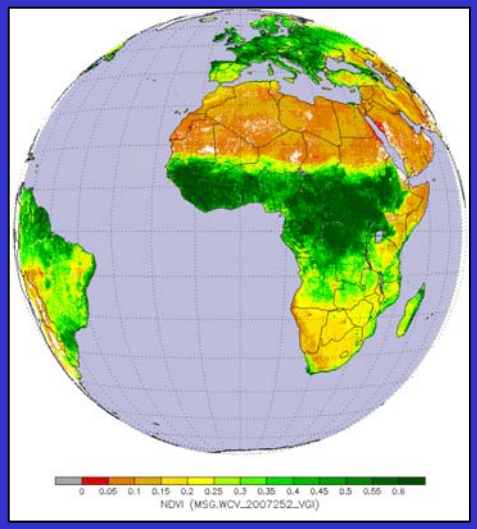
SST (E. Maturi)



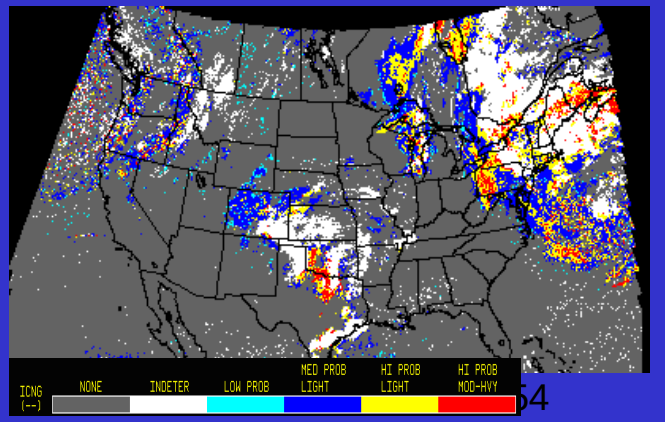
OLR (H. Lee)



Ice concentration [%] (X. Wang)

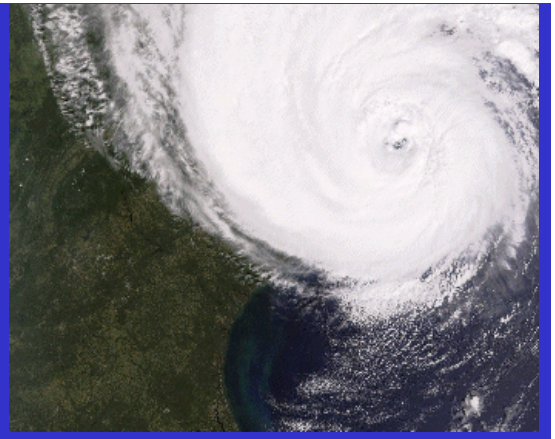


NDVI (P. Romanov)



Icing Threat (W. Smith, Jr.)

More information



Poster session (this conference)

GOES-13 NOAA Tech Report #125:

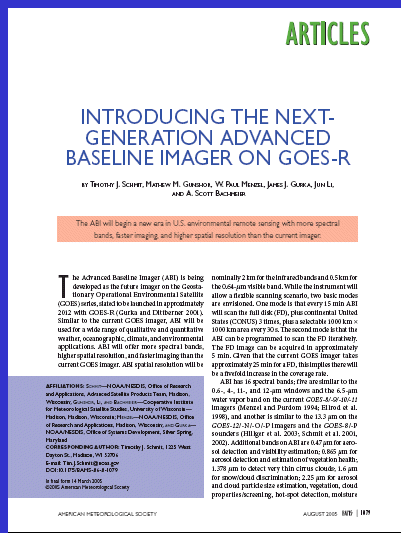
- http://rammb.cira.colostate.edu/projects/goes_n/

GOES and NASA:

- http://goespoes.gsfc.nasa.gov/goes/index.html
- http://goes.gsfc.nasa.gov/text/goes.databookn.html

ABI Research Home page:

- http://cimss.ssec.wisc.edu/goes/abi/
- ftp://ftp.ssec.wisc.edu/ABI/SRF
- AMS BAMS Article on the ABI (Aug. 2005)



ARTICLES

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 2004). 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 four times. 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/-10/-11* Imagers (Menzel and Purdom 1994; Elrod et al. 1998), and another is similar to the 13.3 μm on the *GOES-12/-NOAA-D* Imagers and the *GOES-8/-9* 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

AFFILIATIONS: SCHMIT—NOAA/NESDIS, Office of Research and Applications, Advanced Satellite Products Team, Madison, Wisconsin; GUNSHOR, LI, AND BACHMEIER—Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin—Madison, Madison, Wisconsin; MENZEL—NOAA/NESDIS, Office of Research and Applications, Madison, Wisconsin; and GURKA—NOAA/NESDIS, Office of System Development, Silver Spring, Maryland

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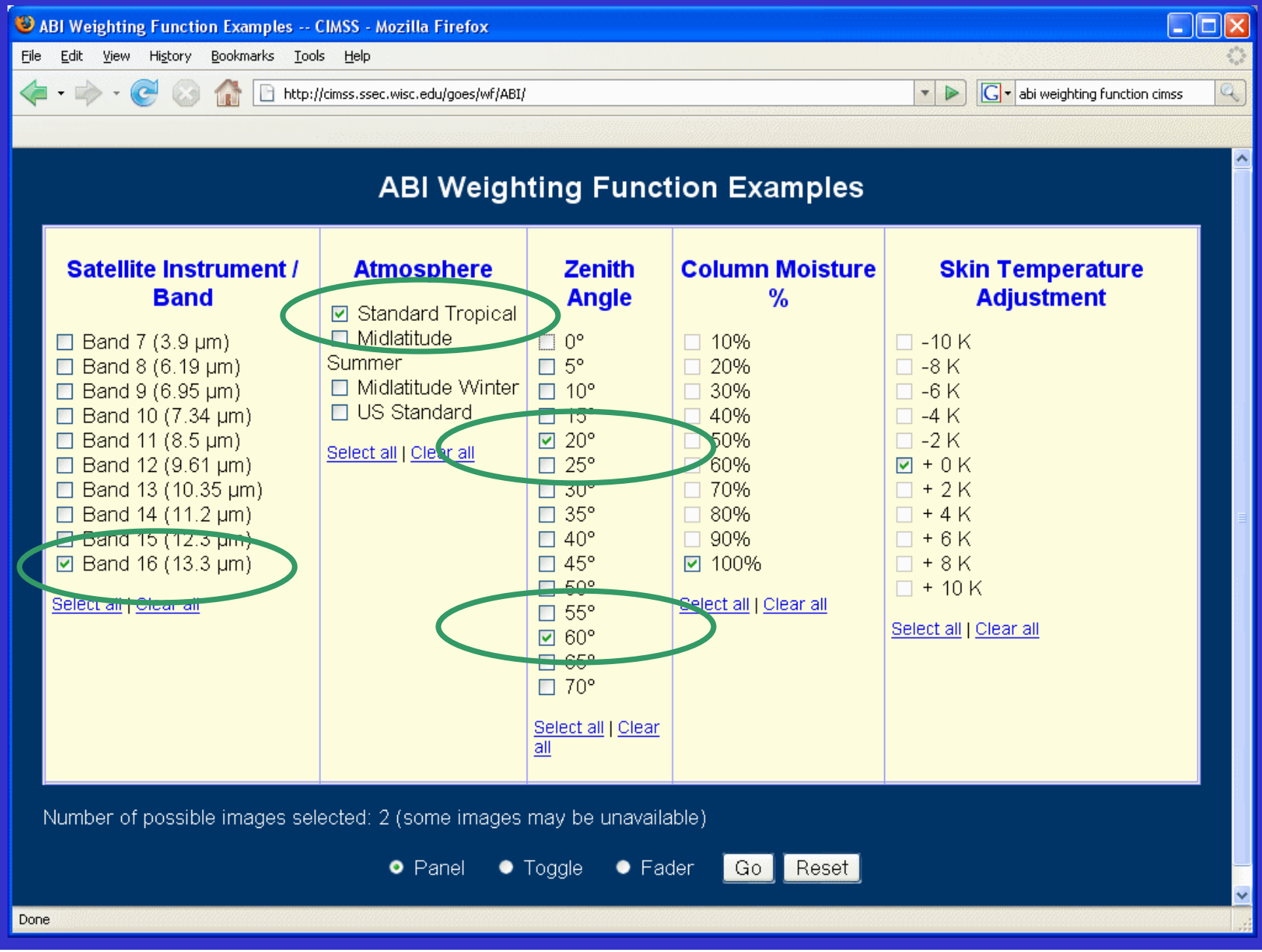
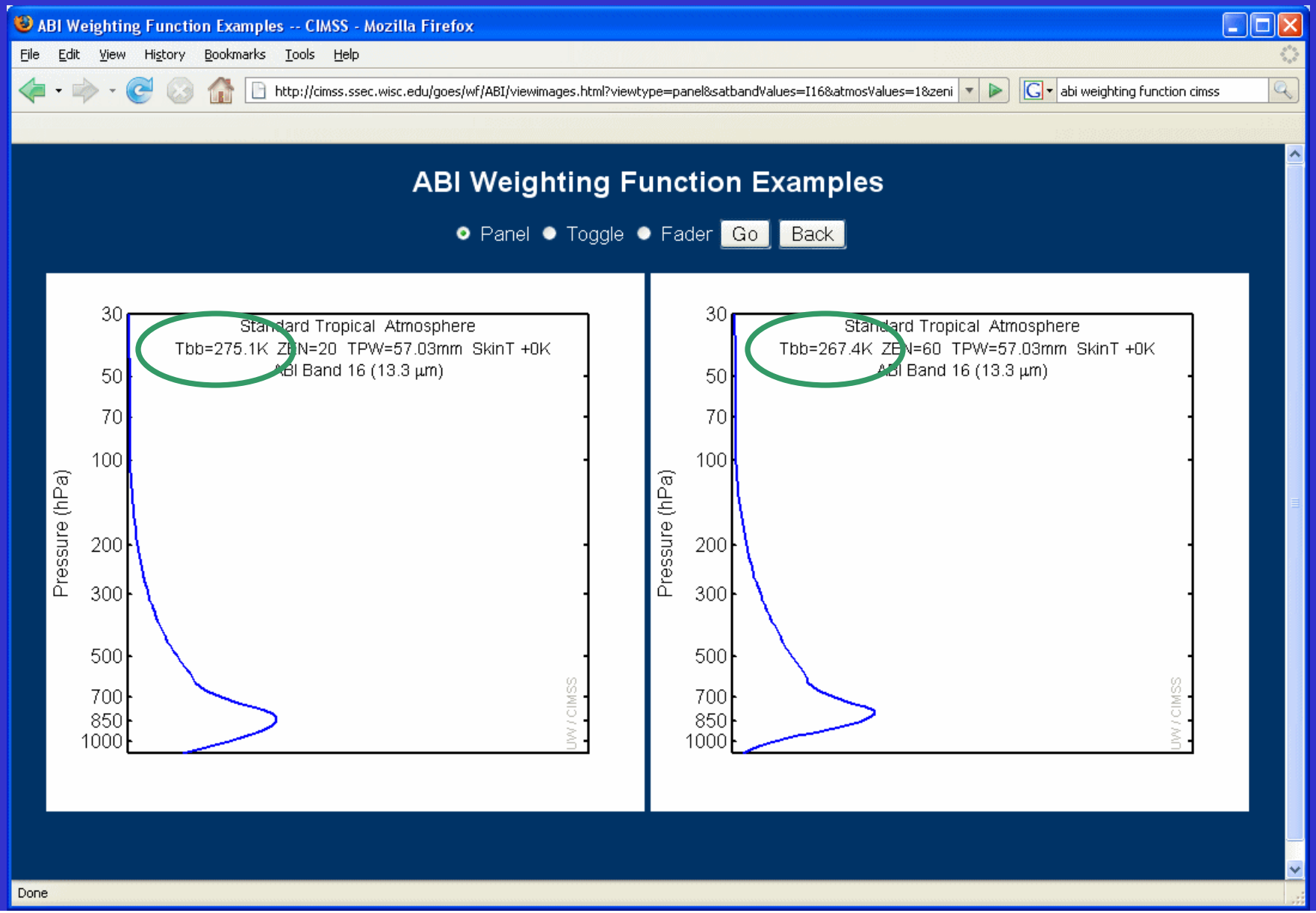
ABI Clear-sky Weighting Functions



http://cimss.ssec.wisc.edu/goes/wf/ABI/



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- The authors would like to thank the entire GOES-R team; both within the government, industry and academia. W. P. Menzel and Scott Bachmeier of CIMSS are especially thanked.

- The views, opinions, and findings contained in this presentation are those of the authors and should not be construed as an official National Oceanic and Atmospheric Administration or U.S. Government position, policy, or decision.