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

The ABI (Advanced Baseline Imager) on the GOES-R series

Timothy J. Schmit

NOAA/NESDIS/Satellite Applications and Research

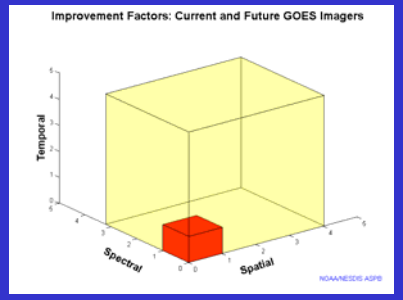
Advanced Satellite Products Branch (ASPB)

Kaba Bah, Mathew M. Gunshor, Jun Li, Scott Bachmeier, etc.

CIMSS, Madison, WI

James J. Gurka, Steve Goodman, etc.

GOES-R Program Office



MUG meeting
03-June-2009

UW-Madison

Also Thanks to…

- Achtor, Tom; Ackerman, Steve; Antonelli, Paolo; Aune, Bob; Baggett, Kevin; Baum, Bryan; Ellrod, Gary; Feltz, Joleen; Feltz, Wayne; Frey, Rich; Griffin, Michael K.; Gumley, Liam; Heymann, Roger; Hillger, Don; Huang, Allen; Key, Jeff; Knuteson, Bob; Mecikalski, John; Menzel, Paul; Moeller, Chris; Mosher, Fred; Nelson, James; Nasiri, Shaima; Olander, Tim; Plokhenko, Youri; Prins, Elaine; Rabin, Bob; Revercomb, Hank; Schmidt, Chris; Schreiner, Tony; Seemann-Wetzel, Suzanne; Sieglaff, Justin; Strabala, Kathy; Sun, Fengying; Tobin, Dave; Velden, Chris; Wade, Gary; Whittaker, Tom; and Woolf, Hal
- Mitch Goldberg, AWG co-chairs, AWG Leads, GPO, GUC committee team(s), Jordan Gerth, Chian-Yi Liu, Jason Otkin, Thomas Greenwald, Monica Coakley, Bill Smith, ASPB, PG, Sharon Bard, Todd Doehring, SSEC data center, etc.

Overview

- GOES-R Overview
- GOES-13/O
- ABI (Advanced Baseline Imager)
  - Temporal, Spectral, Spatial
  - Product List
  - ABI “Soundings”
- GOES Users’ Conference
  - Madison, WI
- Summary
  - Select references
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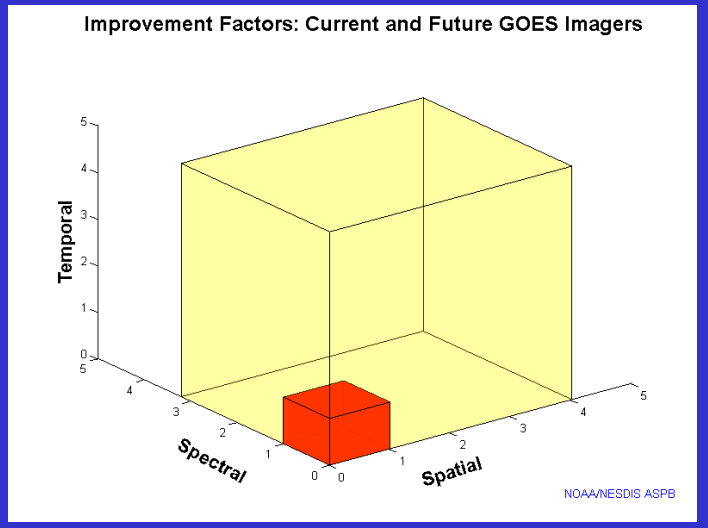
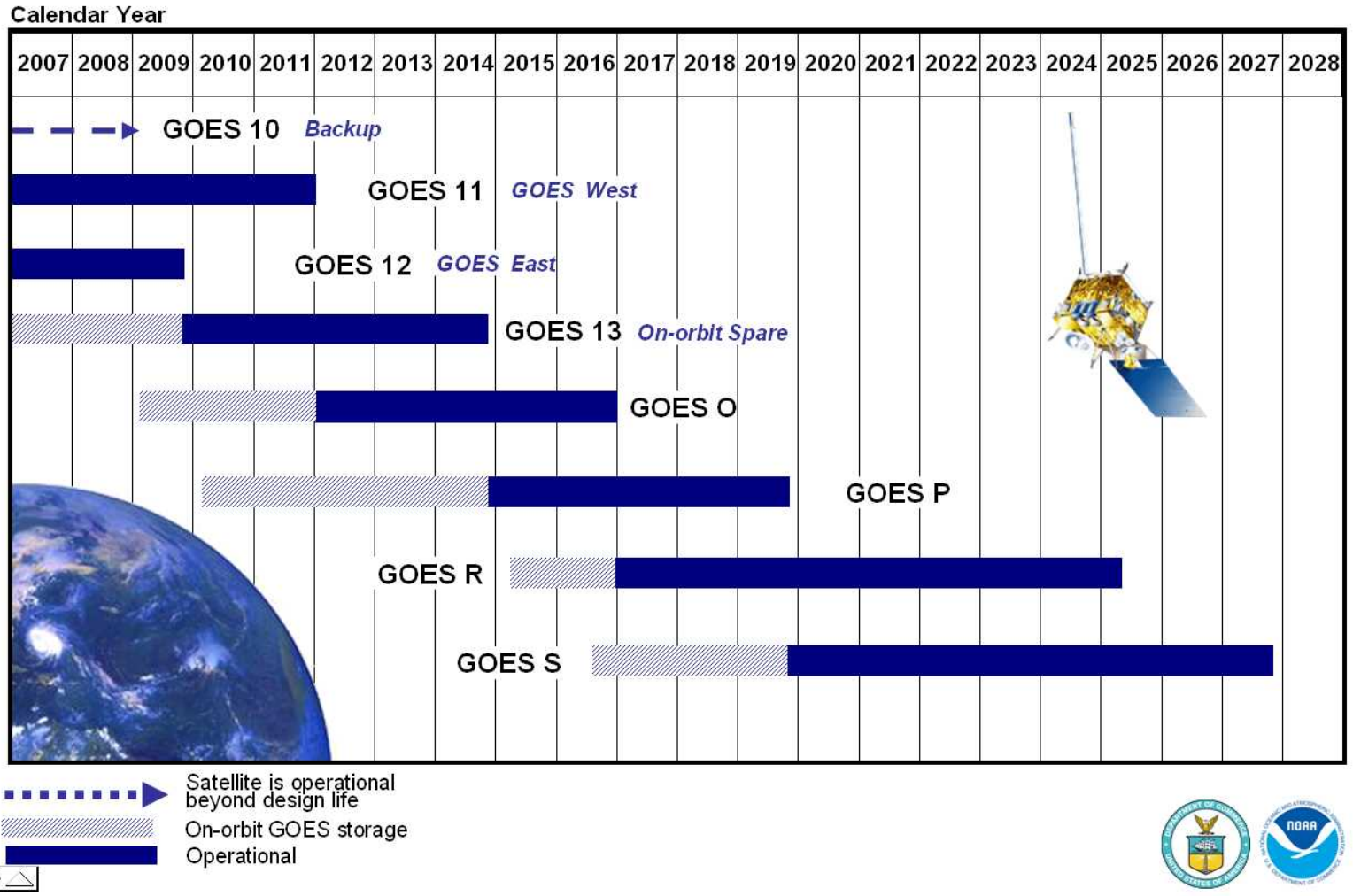


Launch Schedule

Current Satellite Systems - GOES



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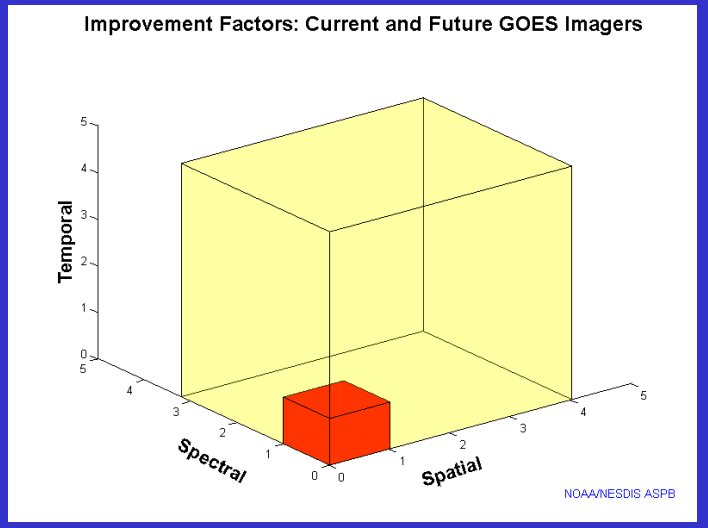


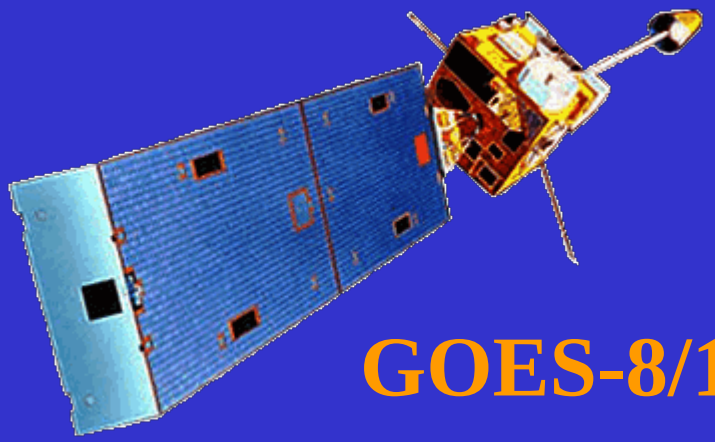
GOES-13

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

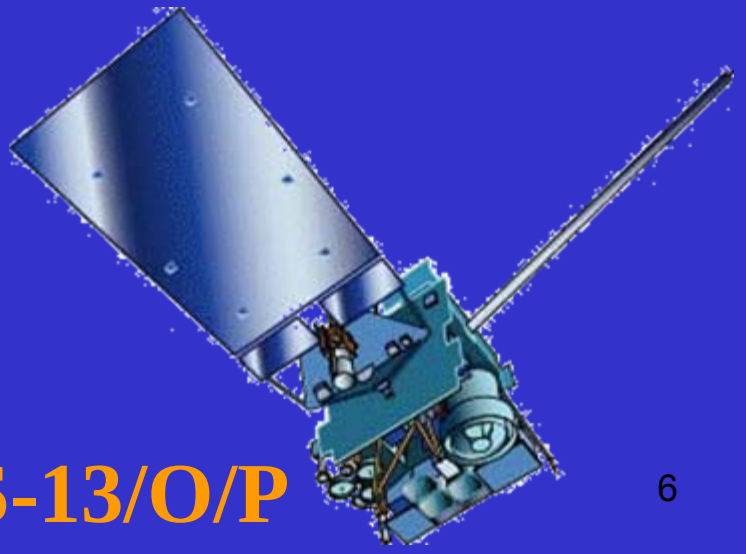
Spring and fall eclipse outages will be avoided by larger onboard batteries.

Improved navigation

Improved radiometrics

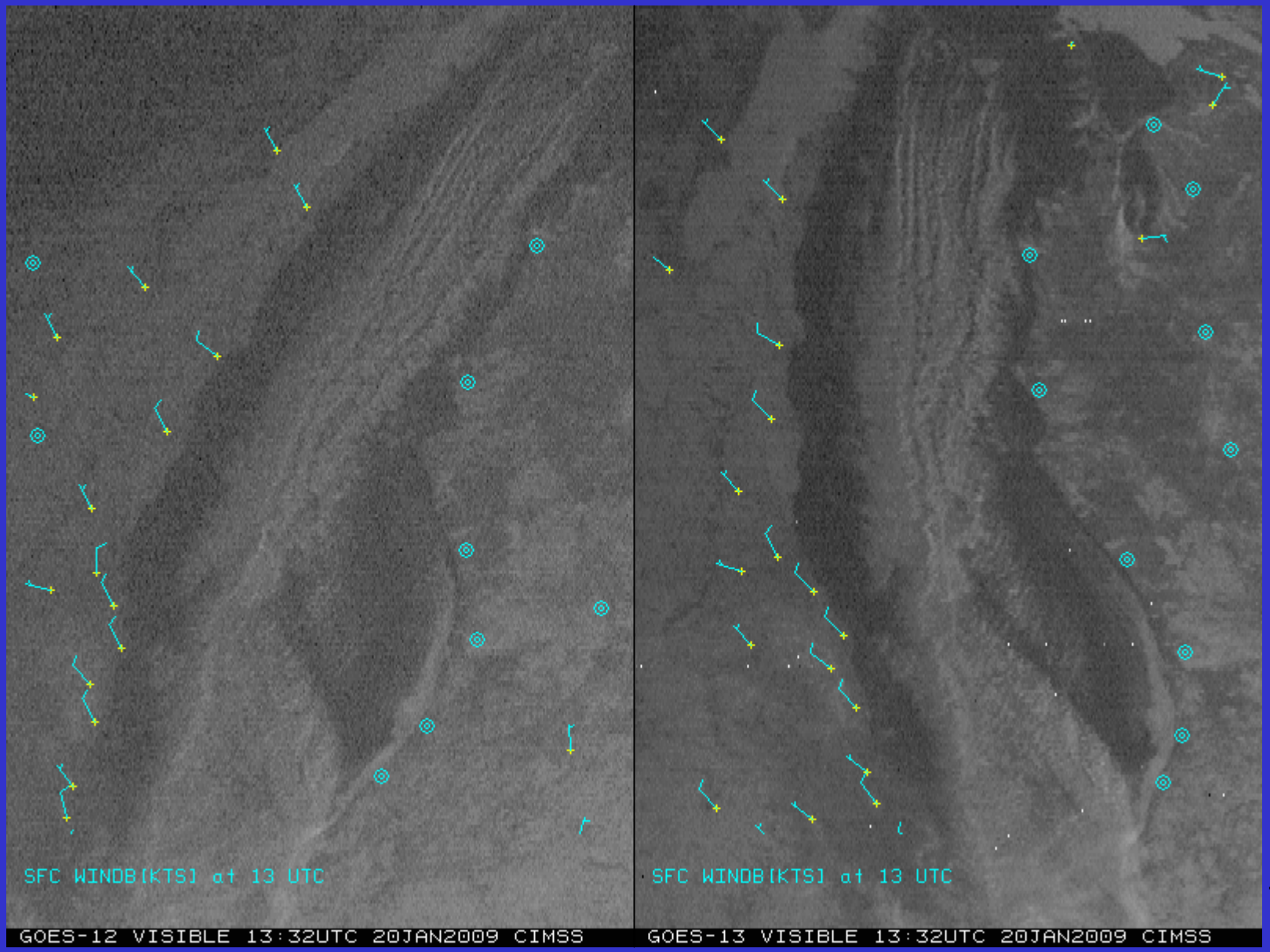


GOES-8/12



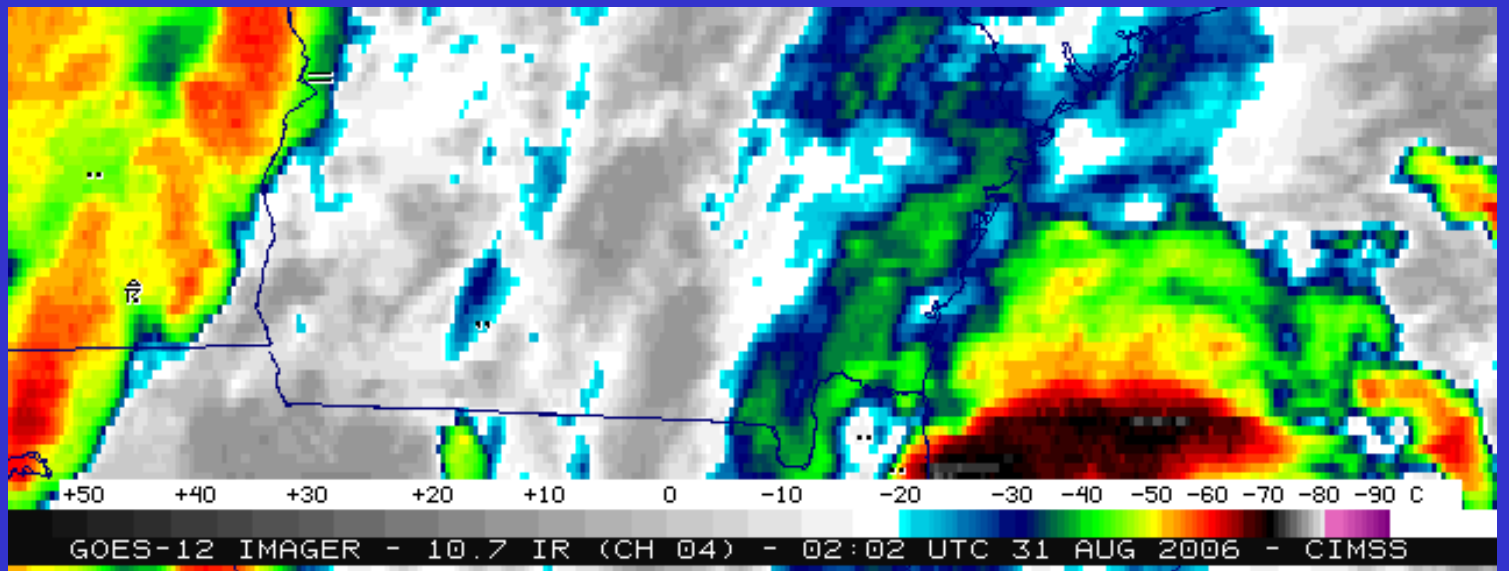
GOES-13/O/P

GOES-13 shows improved navigation

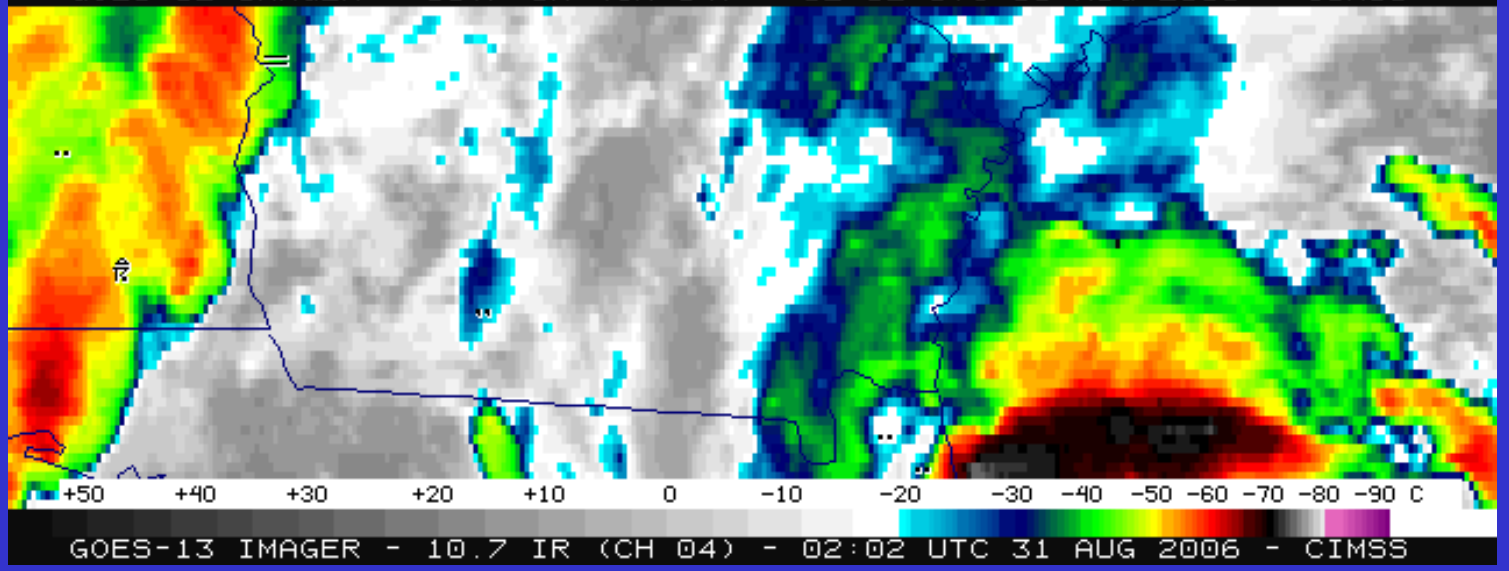


GOES-12/13 (Around eclipse period)

GOES-12



GOES-13



Courtesy of S. Bachmeier, CIMSS

GOES-12/13 (During eclipse)

GOES-12

GOES-13

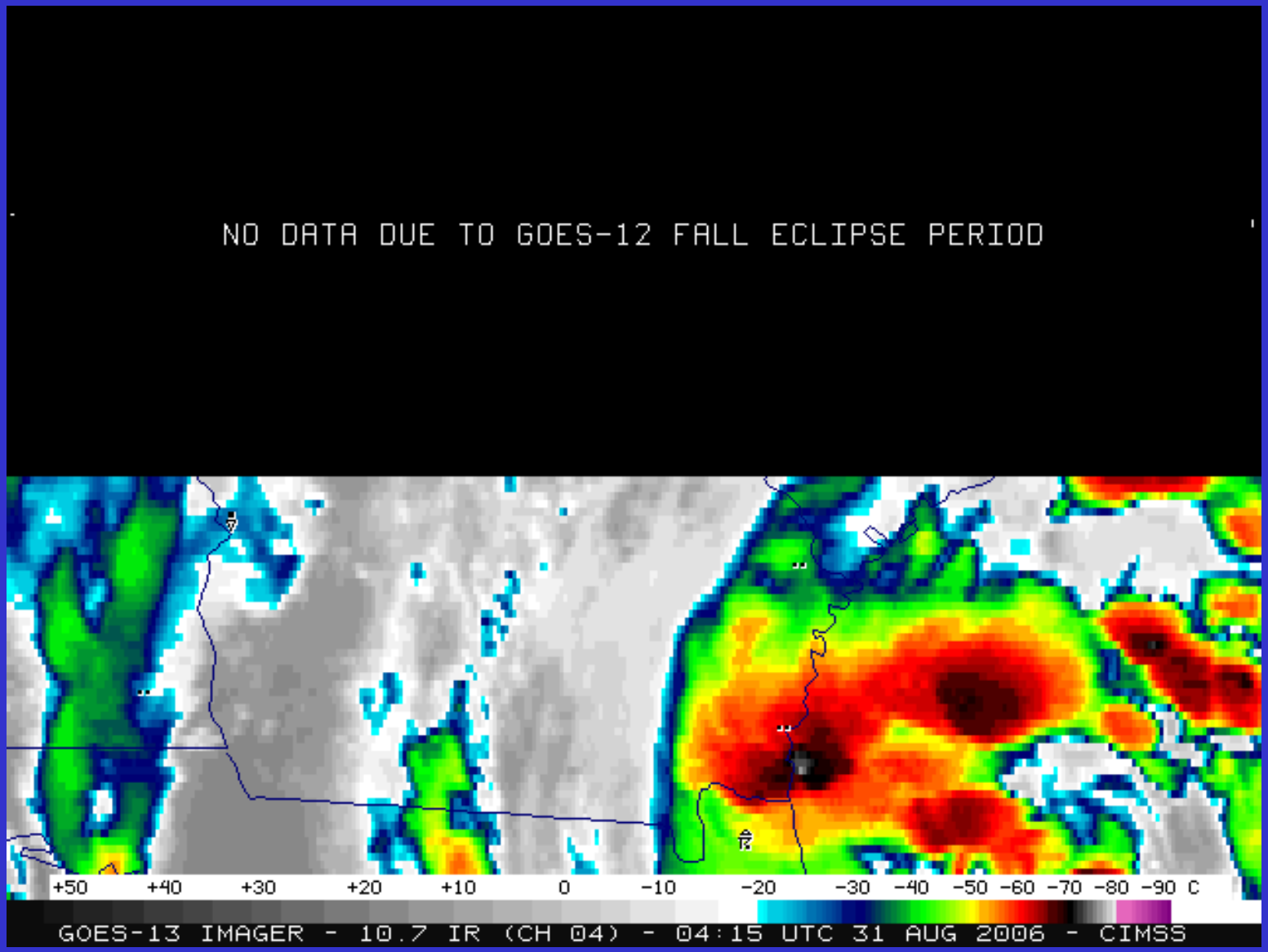
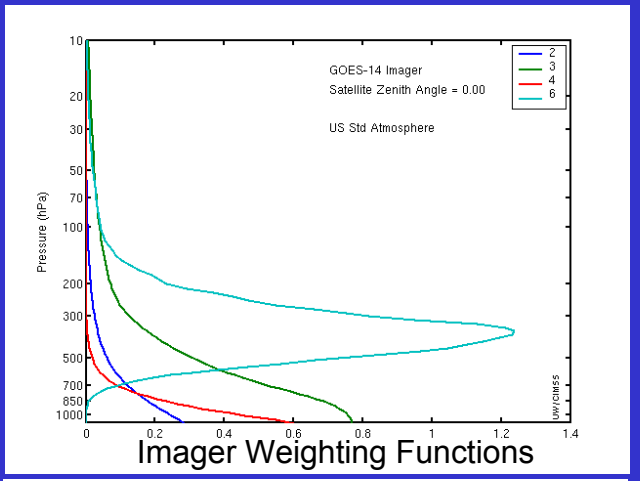


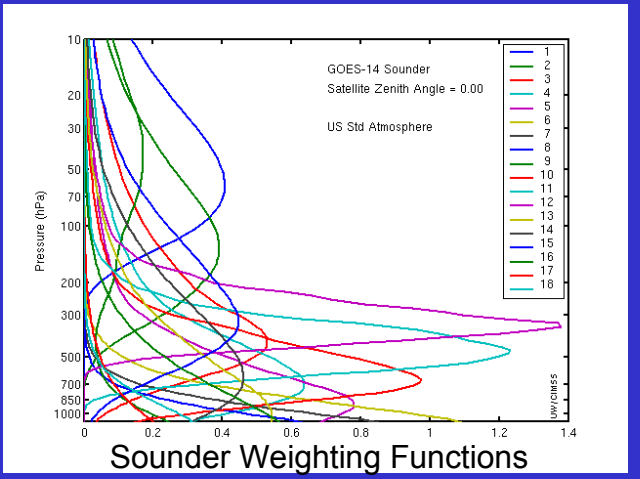
Figure courtesy of S. Bachmeier, CIMSS

GOES-O Science checkout

- Expected launch (no earlier than):
  - 28 April 2009.
- GOES-O Science Test web page:
  http://rammb.cira.colostate.edu/projects/goes-o/
- Changes to GOES-O Imager:
  - Improved spatial resolution of 13.3 μm band (8 km to 4 km)
  - Change in GVAR data format may be necessary!



Imager Weighting Functions



Sounder Weighting Functions

Significance: The GOES-O Science Test goals include: assess the GOES-O data, generate products, investigate instrument changes, and collect unique rapid-scan imagery.

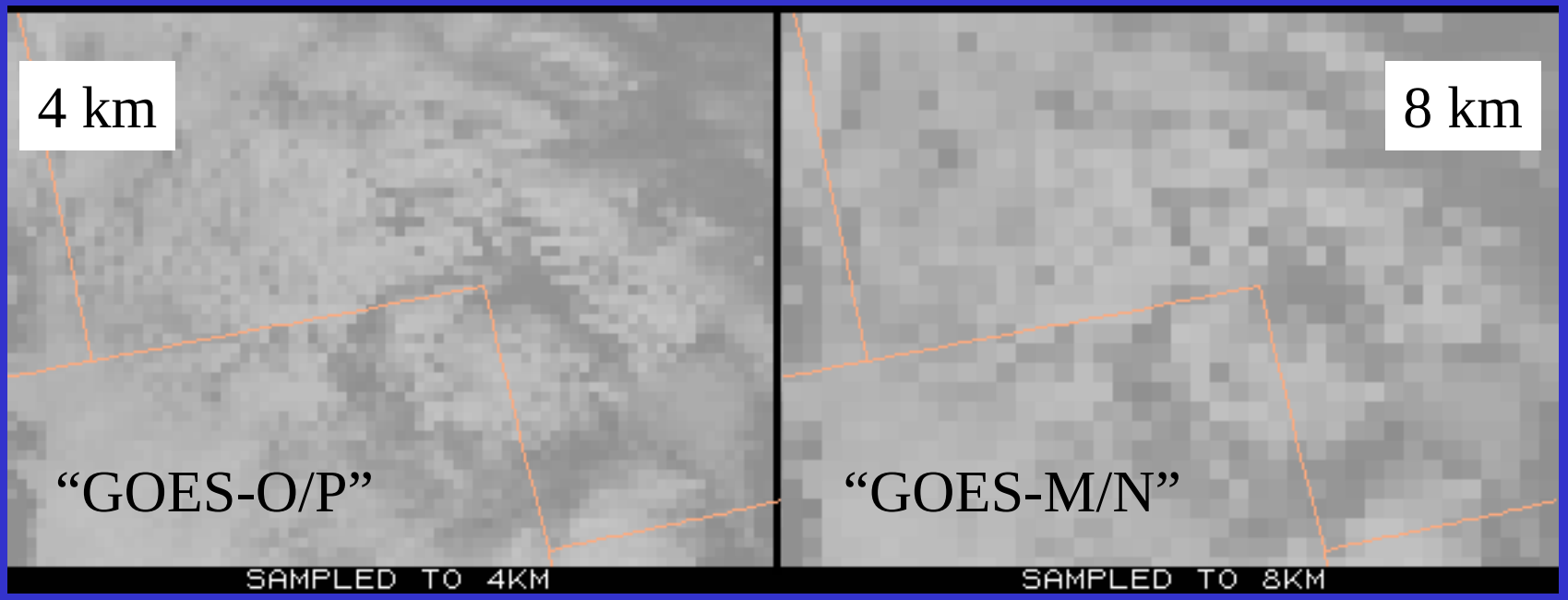
(Courtesy of D. Hillger and T. Schmit)

GOES-O/P – improved spatial resolution of the 13.3 µm band

The GOES-O/P Imagers have improved resolution in the 13.3 µm band. The nominal detector size improves from 8 km to 4 km meaning that these are the first GOES imagers with all the same spatial resolution of the infrared bands.

The improved spatial resolution allows an improved:

- **cloud-top product,**
- **height of the 'satellite-derived' atmospheric motion vectors,**
- **volcanic ash detection.**



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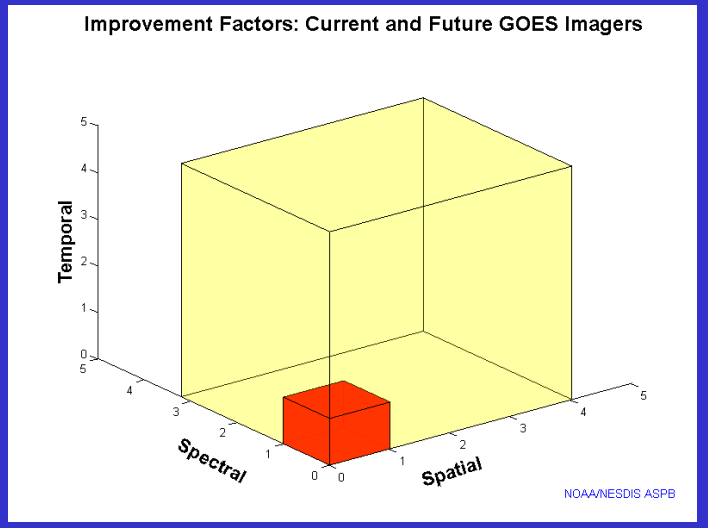
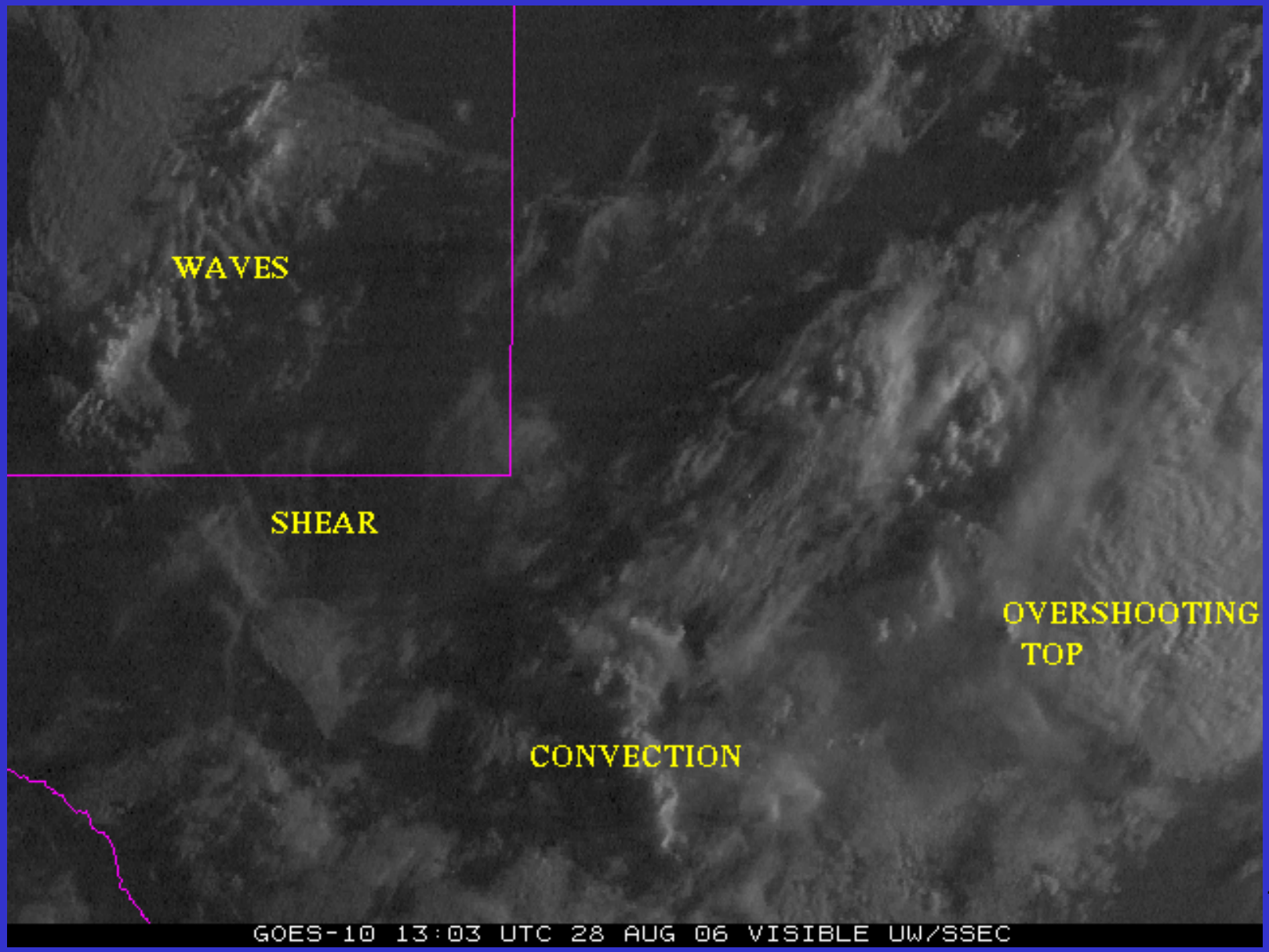


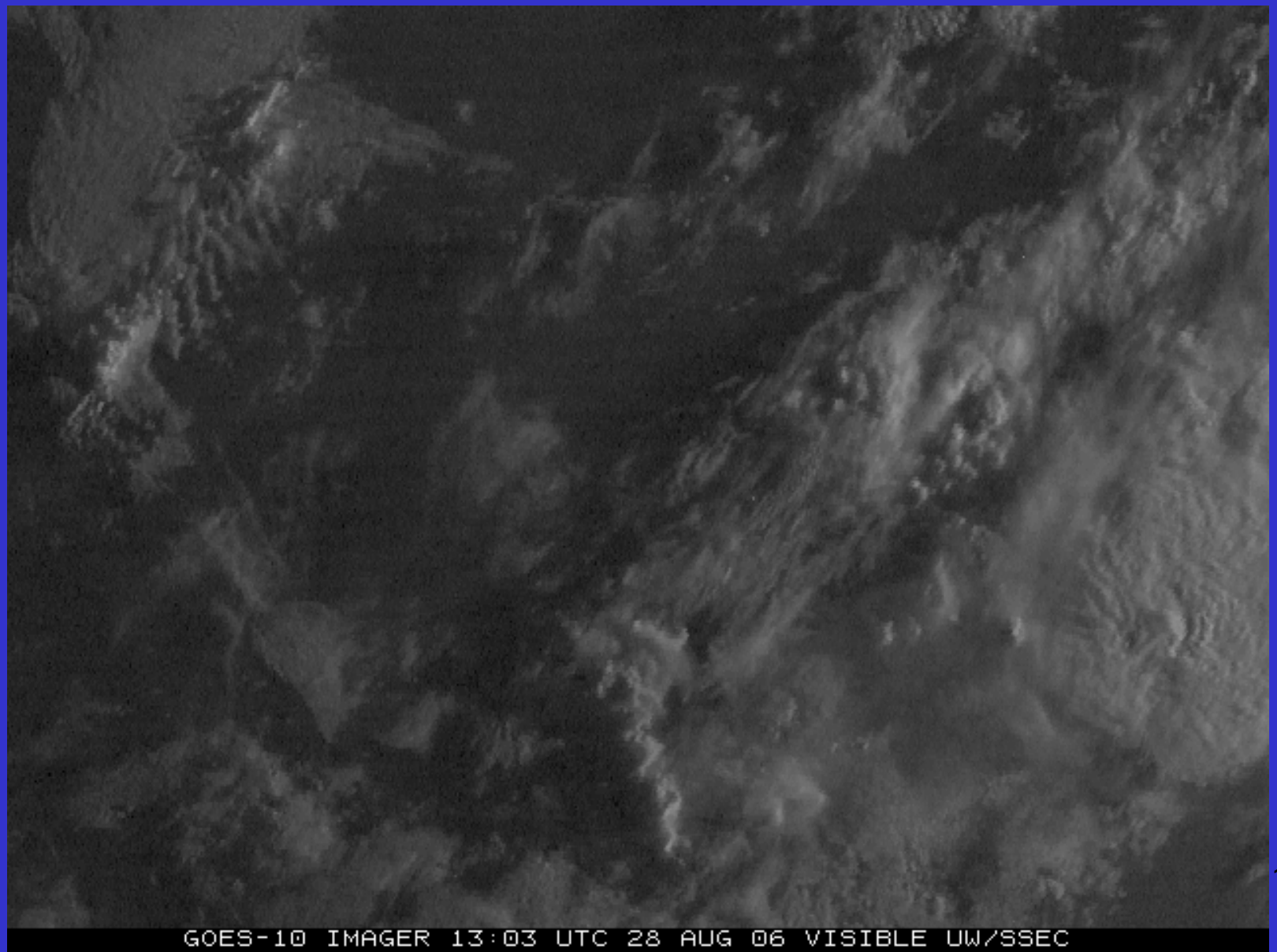
The Advanced Baseline Imager:

	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

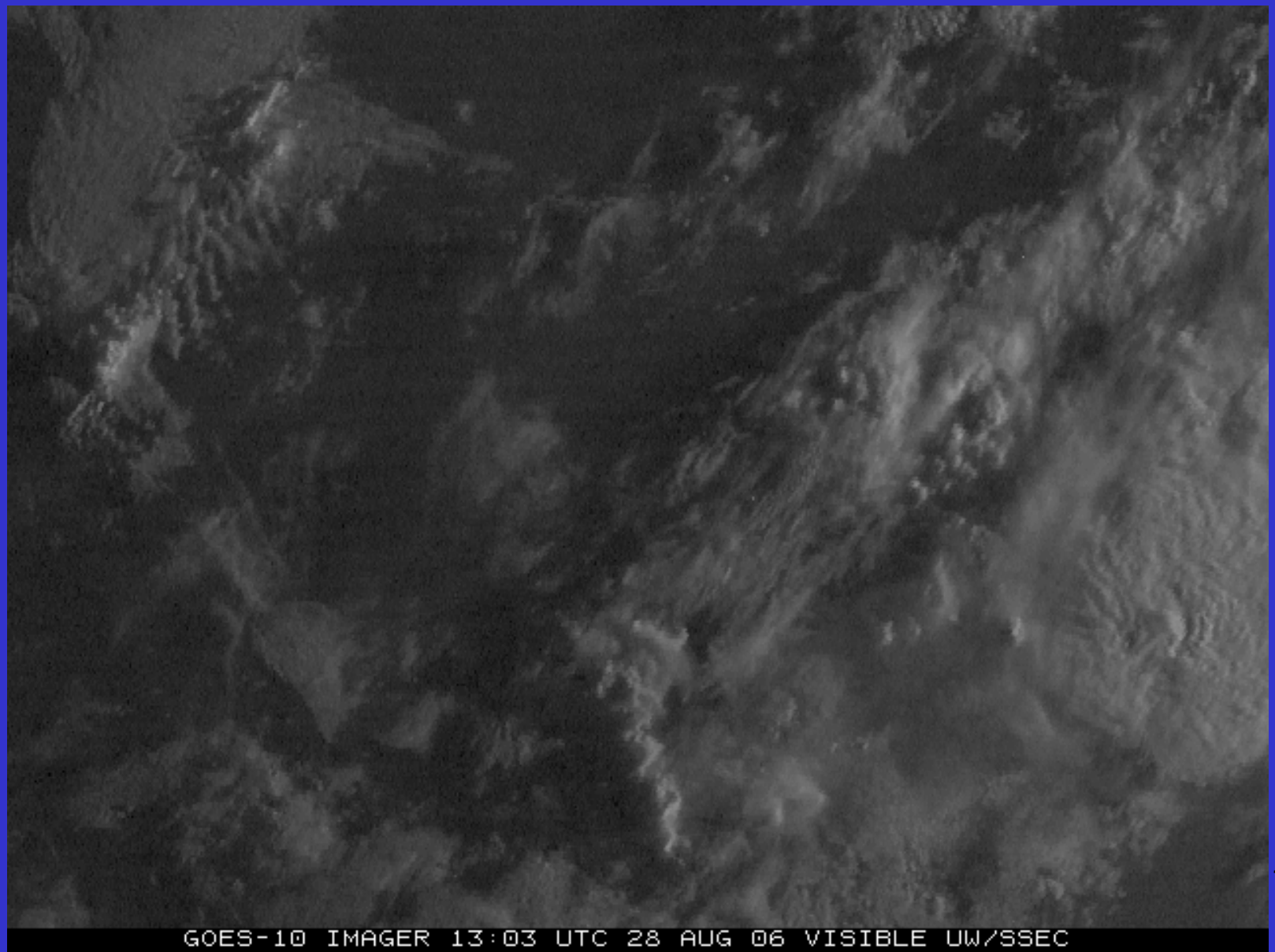
GOES-10


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

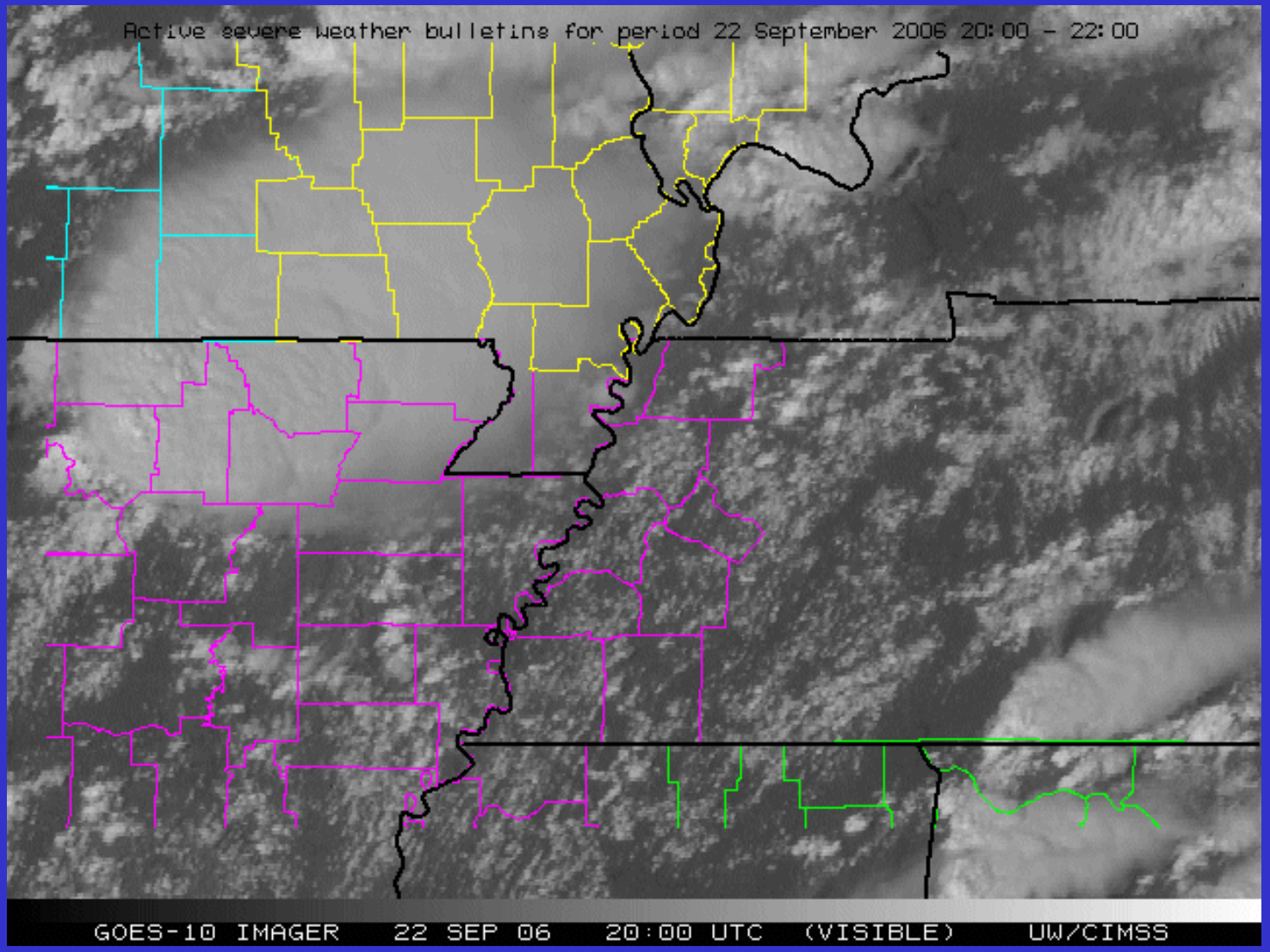
15-min time resolution “loop”



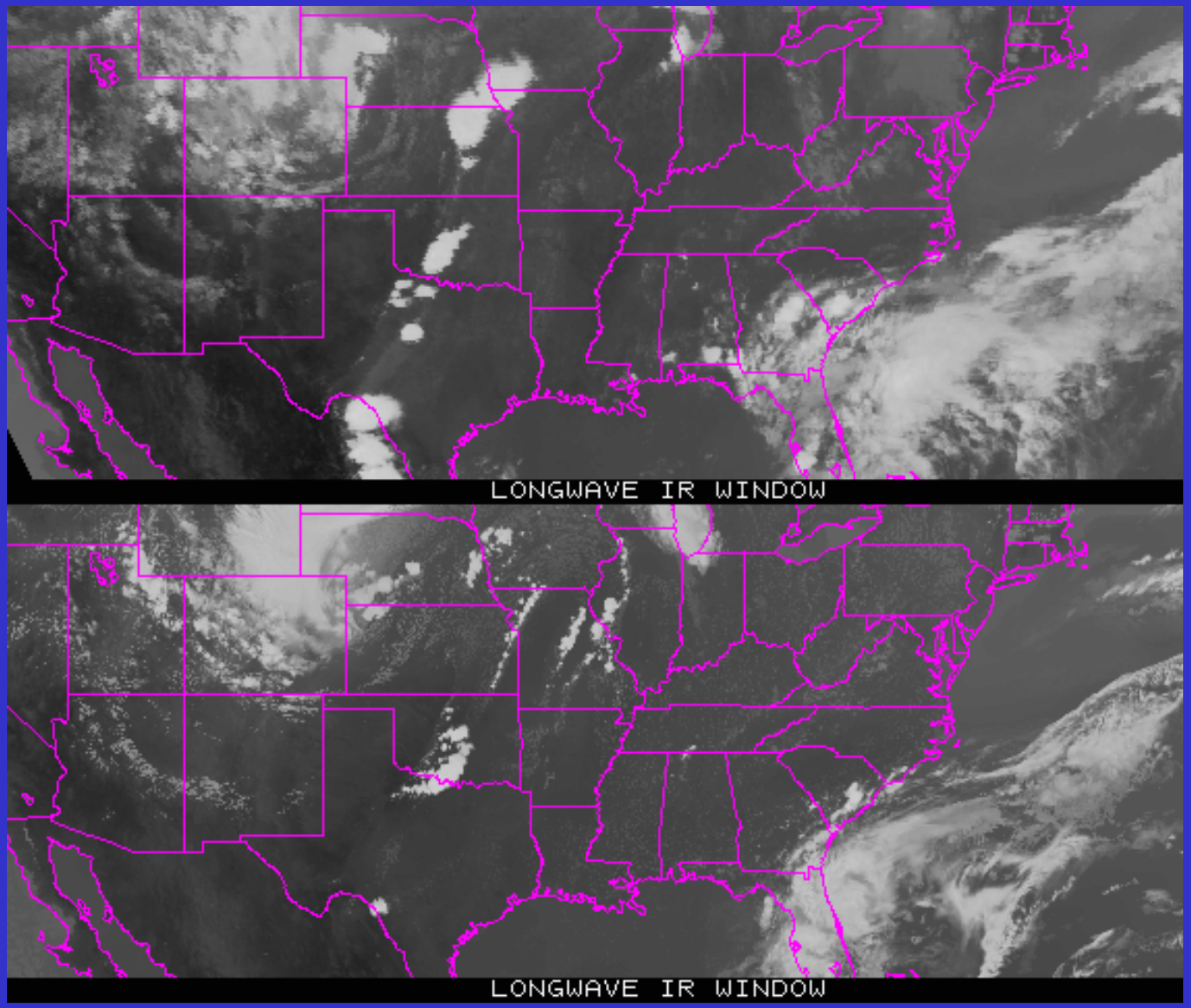
1-min time resolution loop



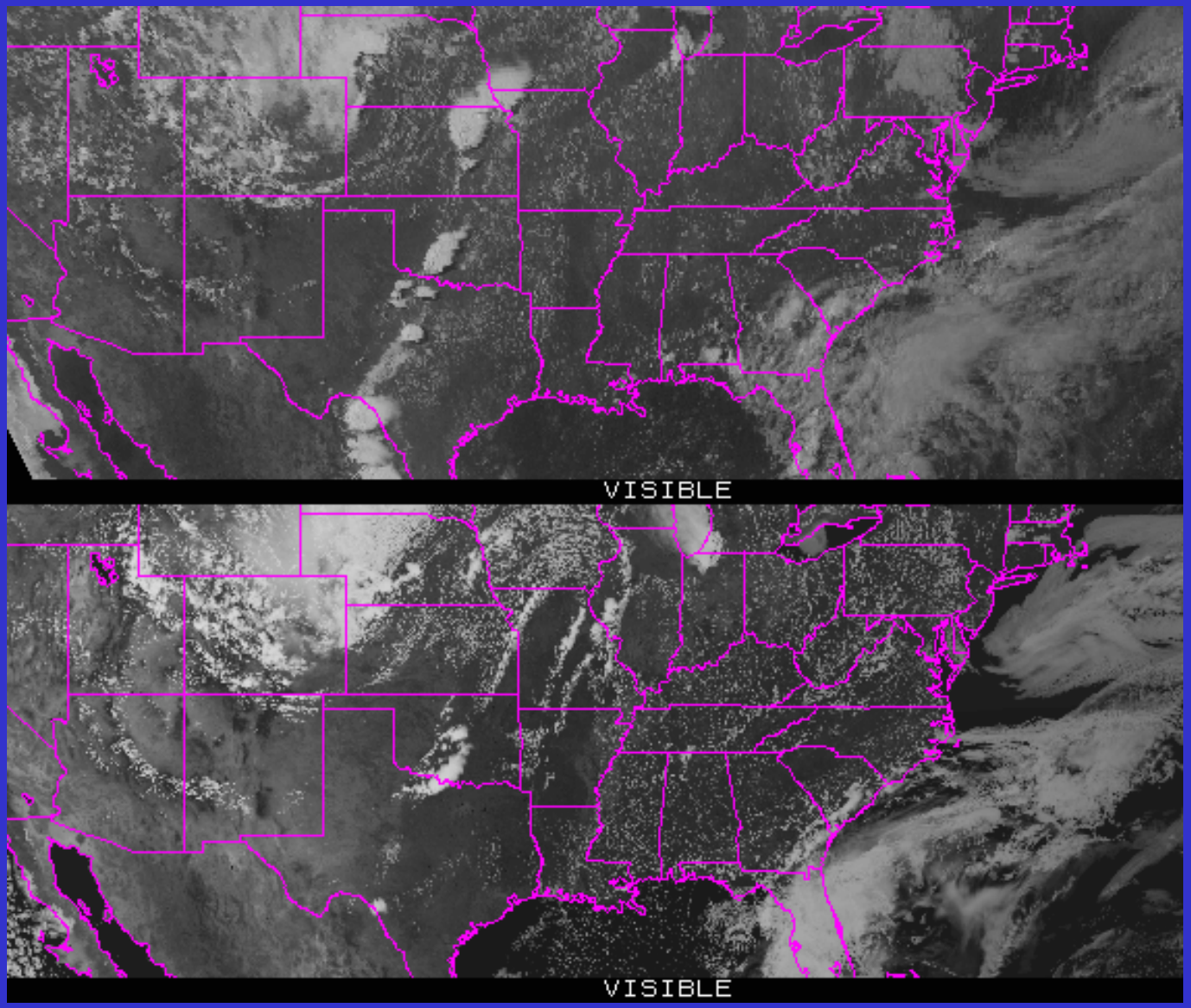
1-min time resolution loop



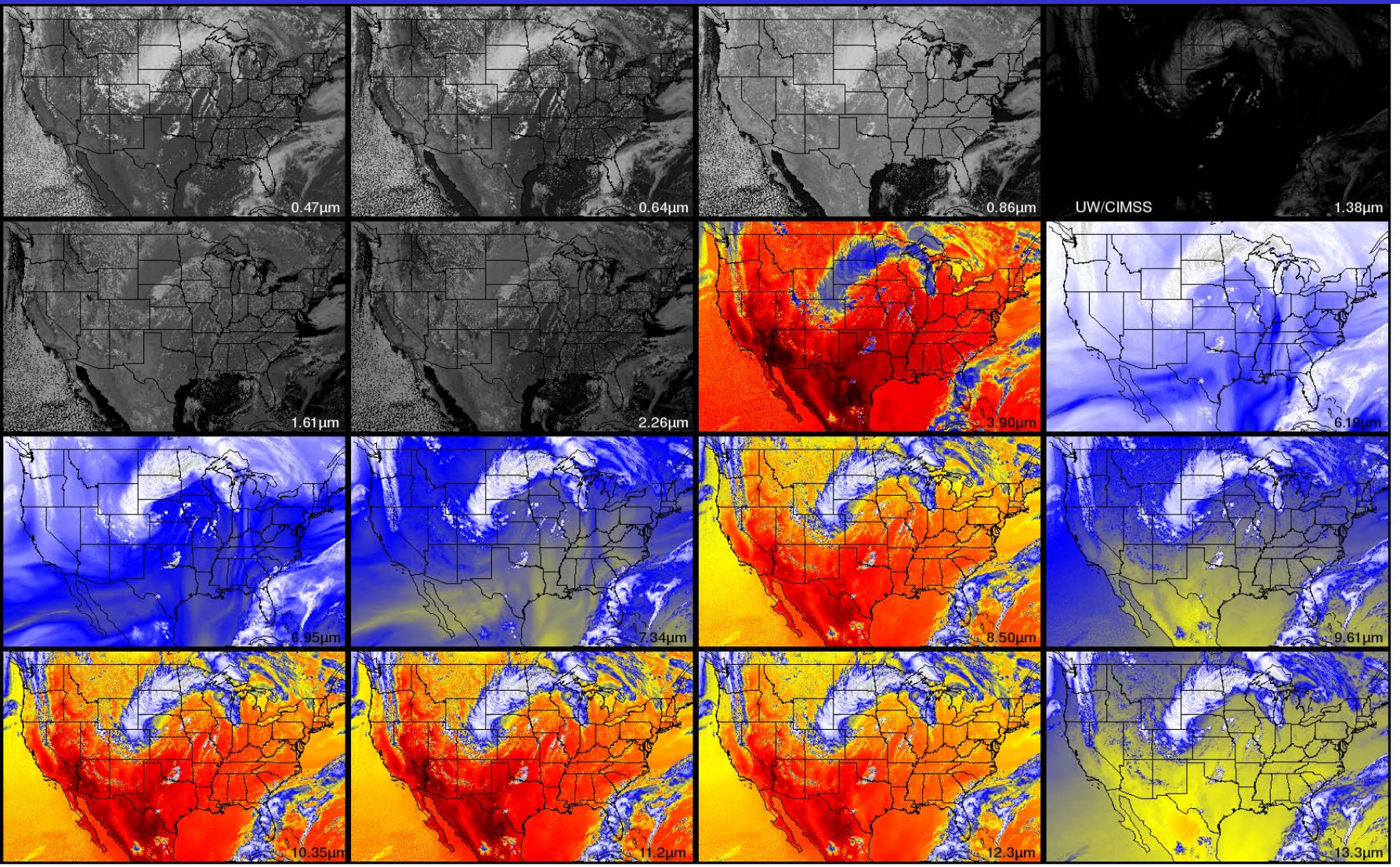
Real or Simulated?



Real or Simulated?



ABI bands via NWP simulation (CIMSS AWG Proxy Team)

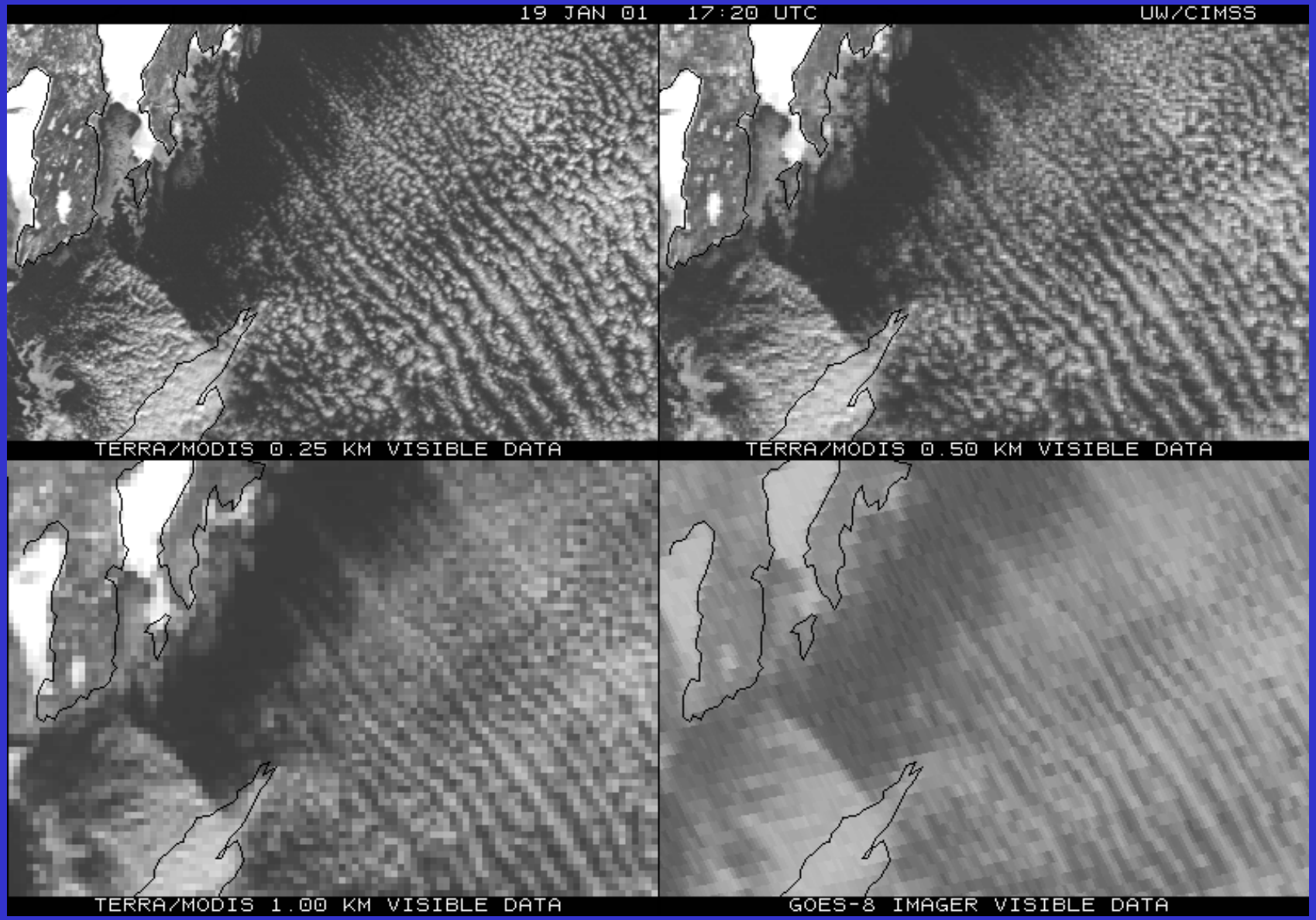


ABI band data for 2005 June 04 22:00 UTC

MODIS 0.25 km

Lake Effect Snow Bands: Visible

MODIS 0.5 km



MODIS 1 km

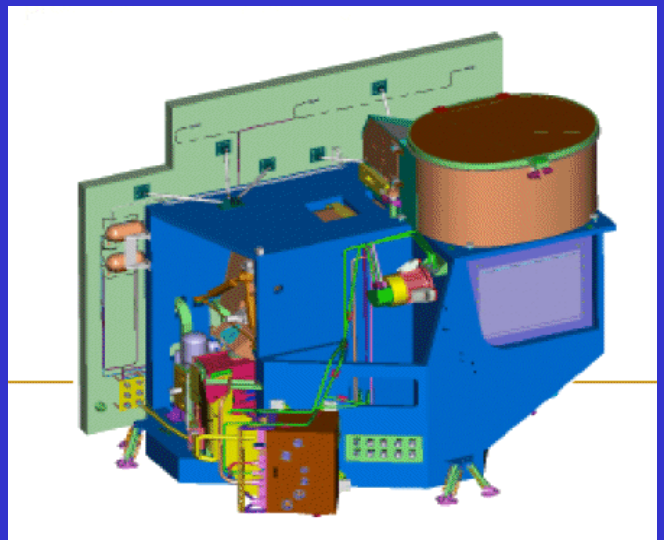
19 January 2001, 1720 UTC

GOES-8 1 km

Approximate number of ABI pixels

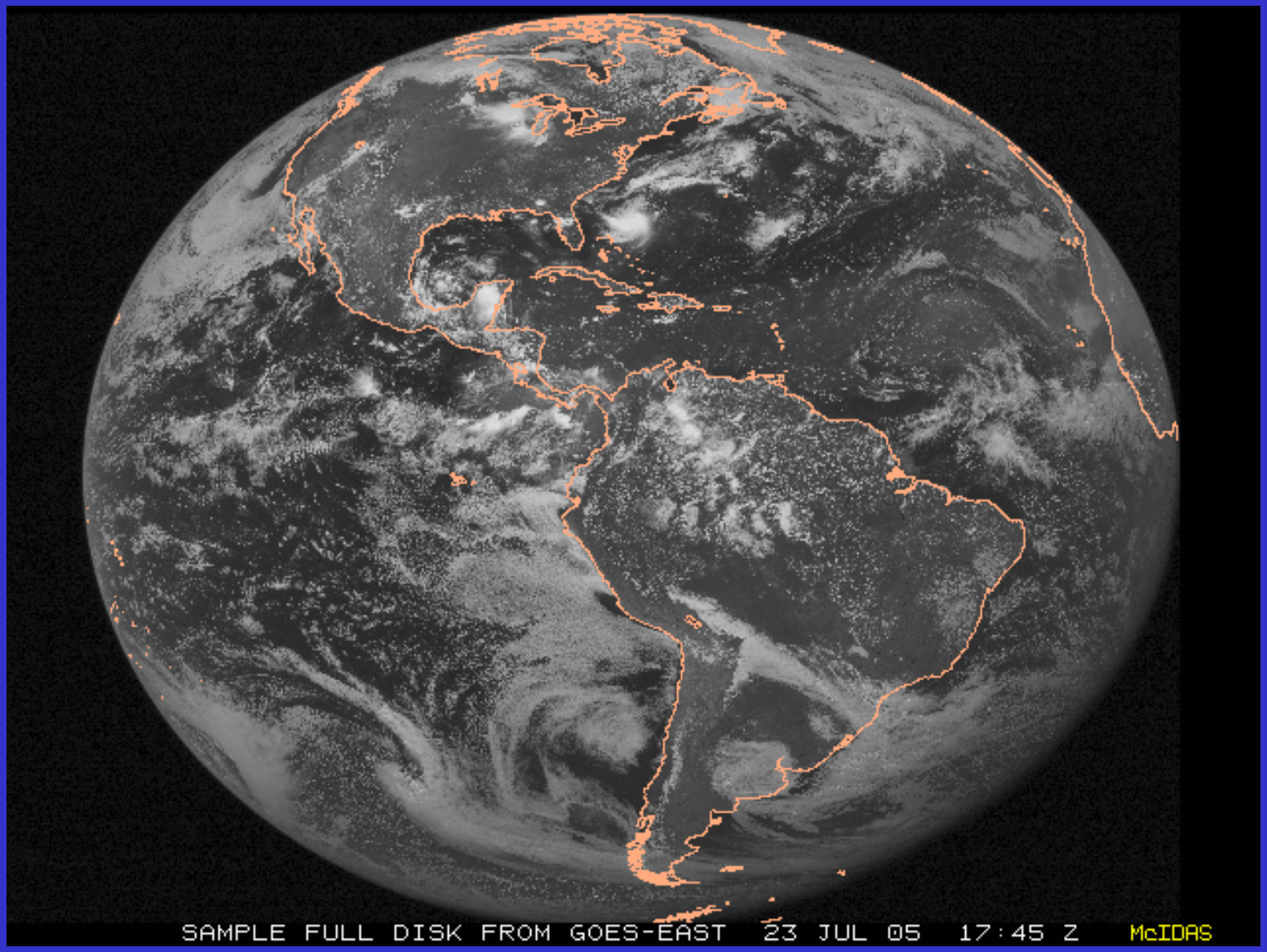
Current GOES is approximately 2705 x 5209 for the FD IR

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



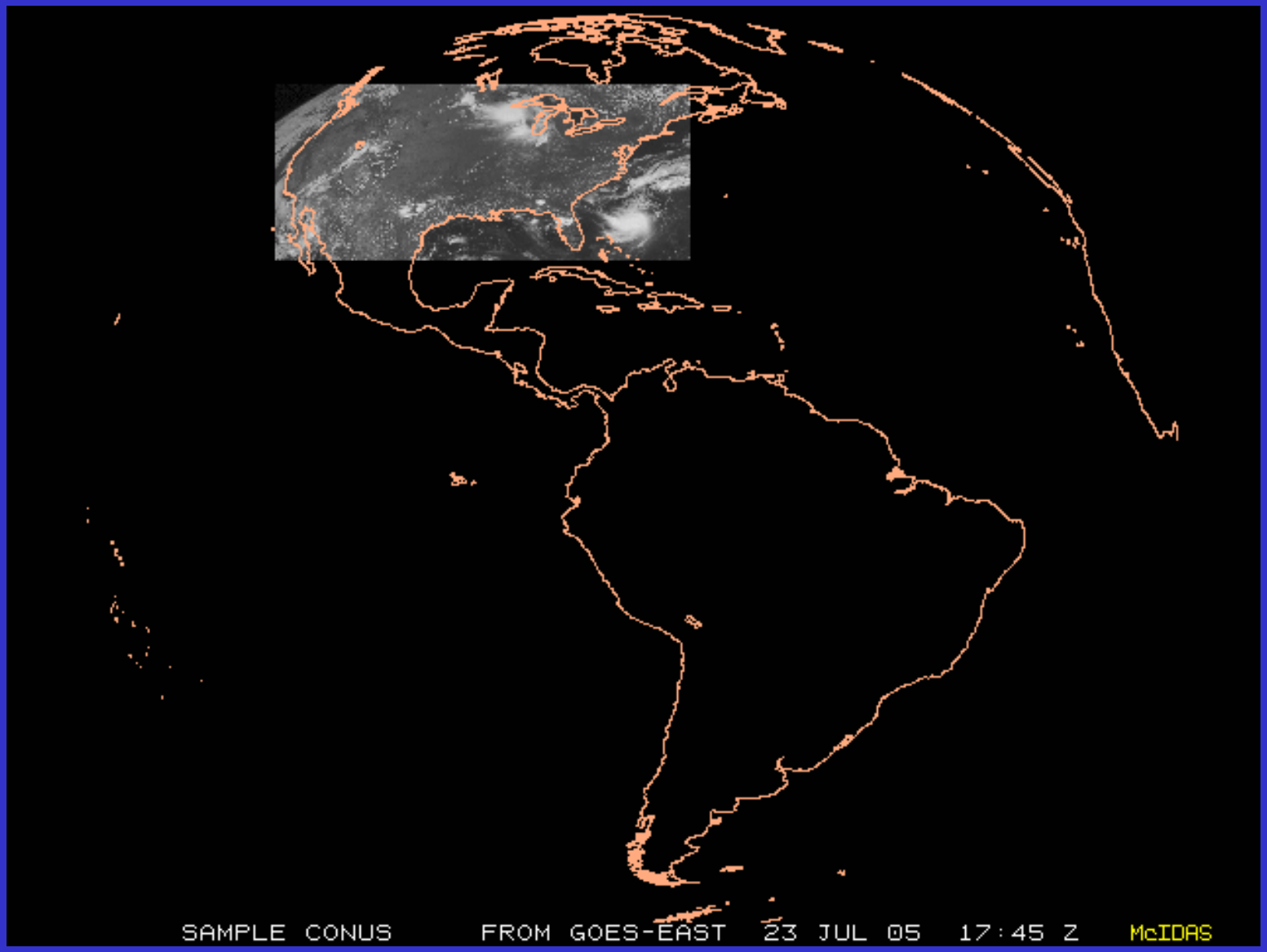
	0.5 km	1 km	2 km
Full disk	490,223,881	122,544,900	30,636,225
CONUS	60,000,000	15,000,000	3,750,000
Meso	4,000,000	1,000,000	250,000

Figure courtesy of ITT Industries

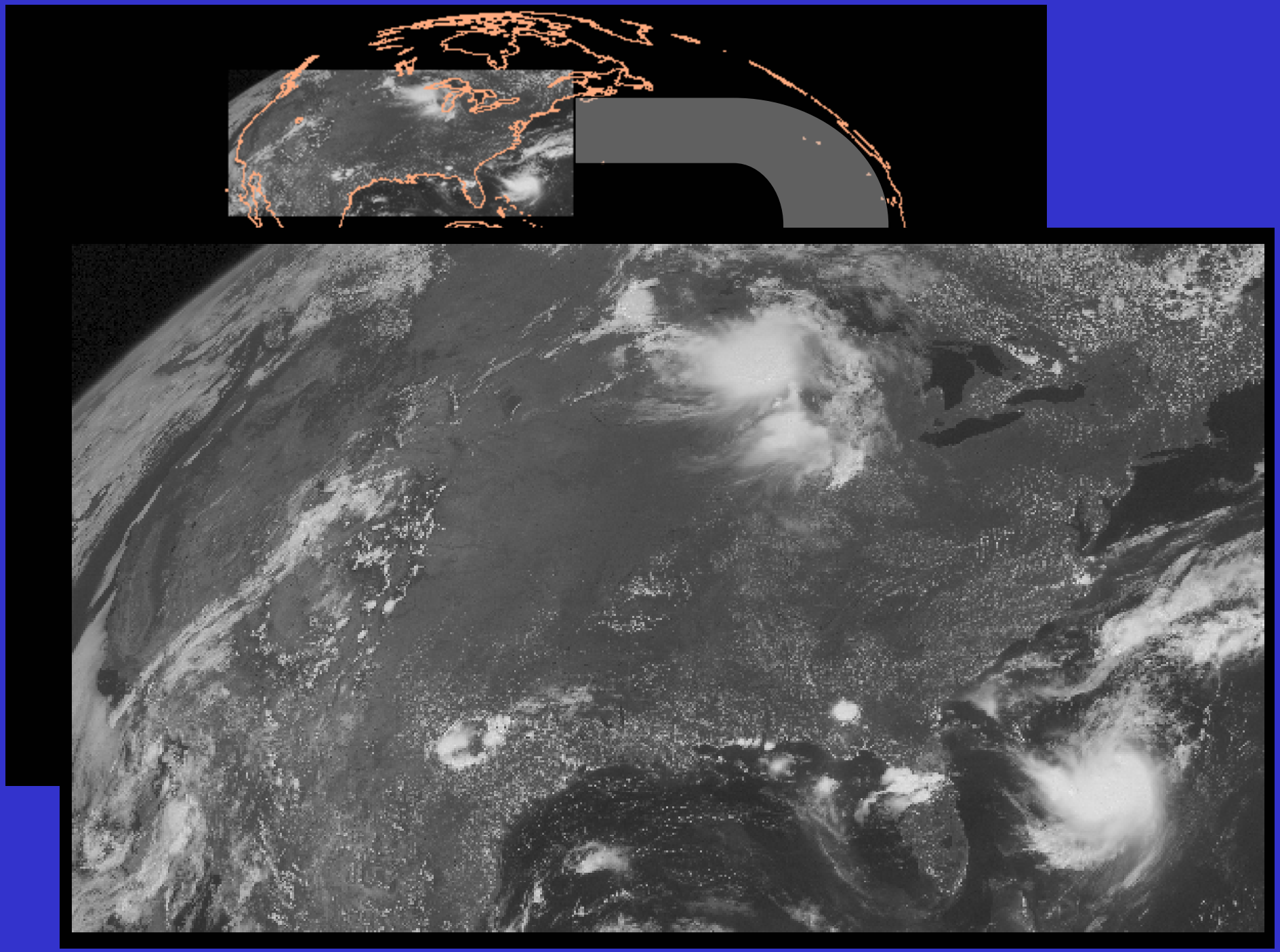


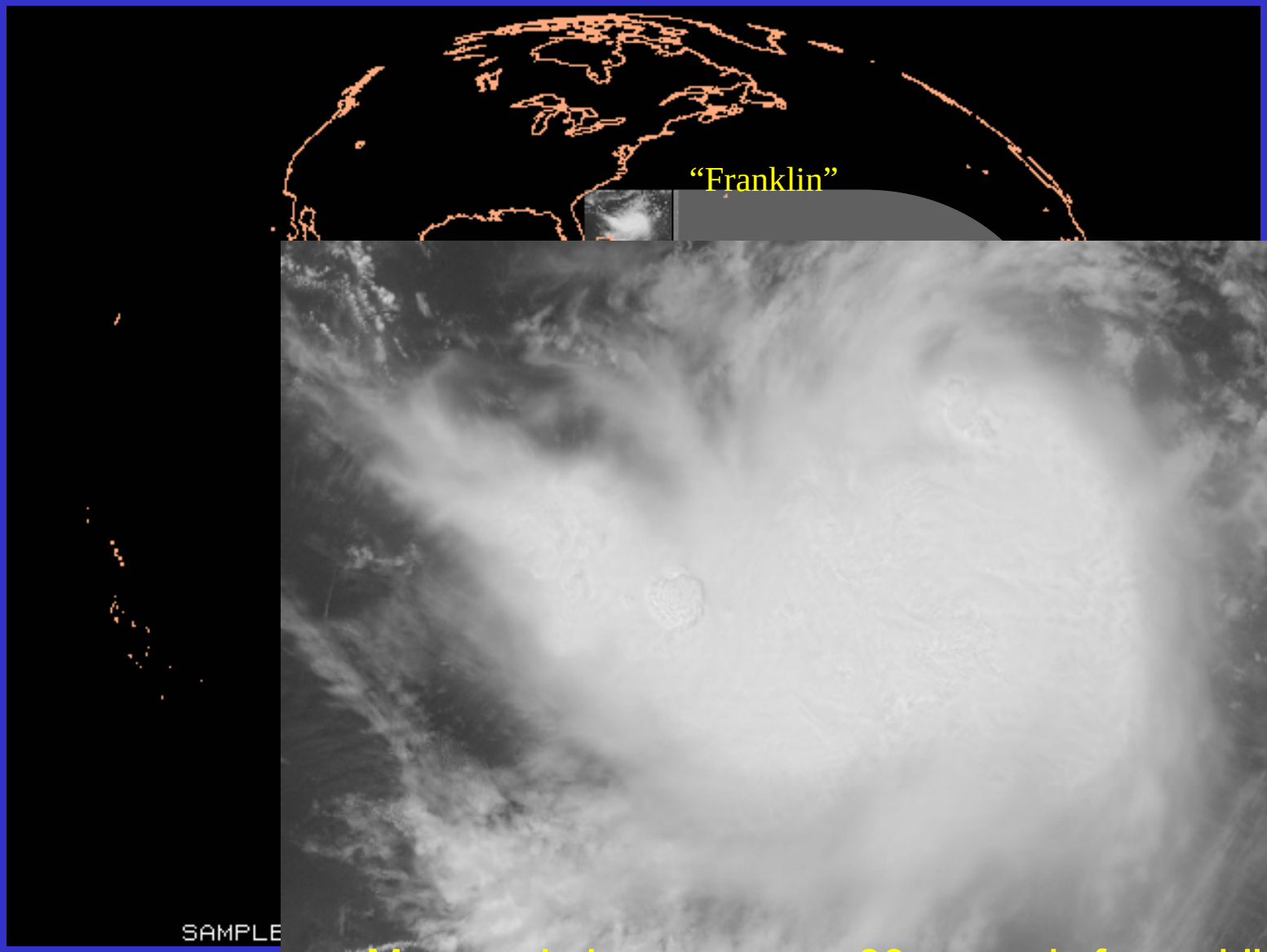
ABI scans about 5 times faster than the current GOES imager

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.

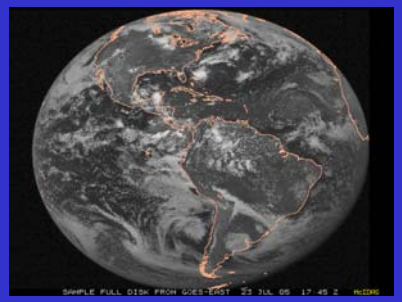




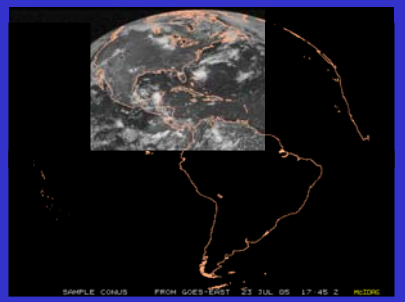
Mesoscale images every 30 seconds for rapidly changing phenomena (thunderstorms, hurricanes, fires, etc). Current GOES can not offer these rapid scans while still scanning other important regions

Imager Coverage in ~30 minutes

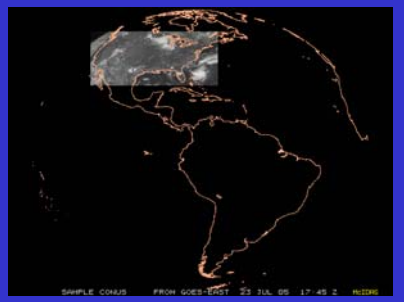
	Current Imager (Rapid Scan mode)	**Future Imager** ("Flex" mode)
Full Disk	0	2
Northern Hemi	1	-
CONUS	3	6
Mesoscale	0	60



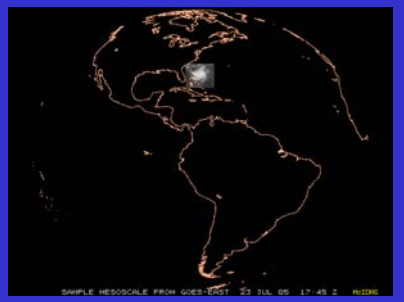
Full Disk



N. Hemisphere



CONUS



Mesoscale

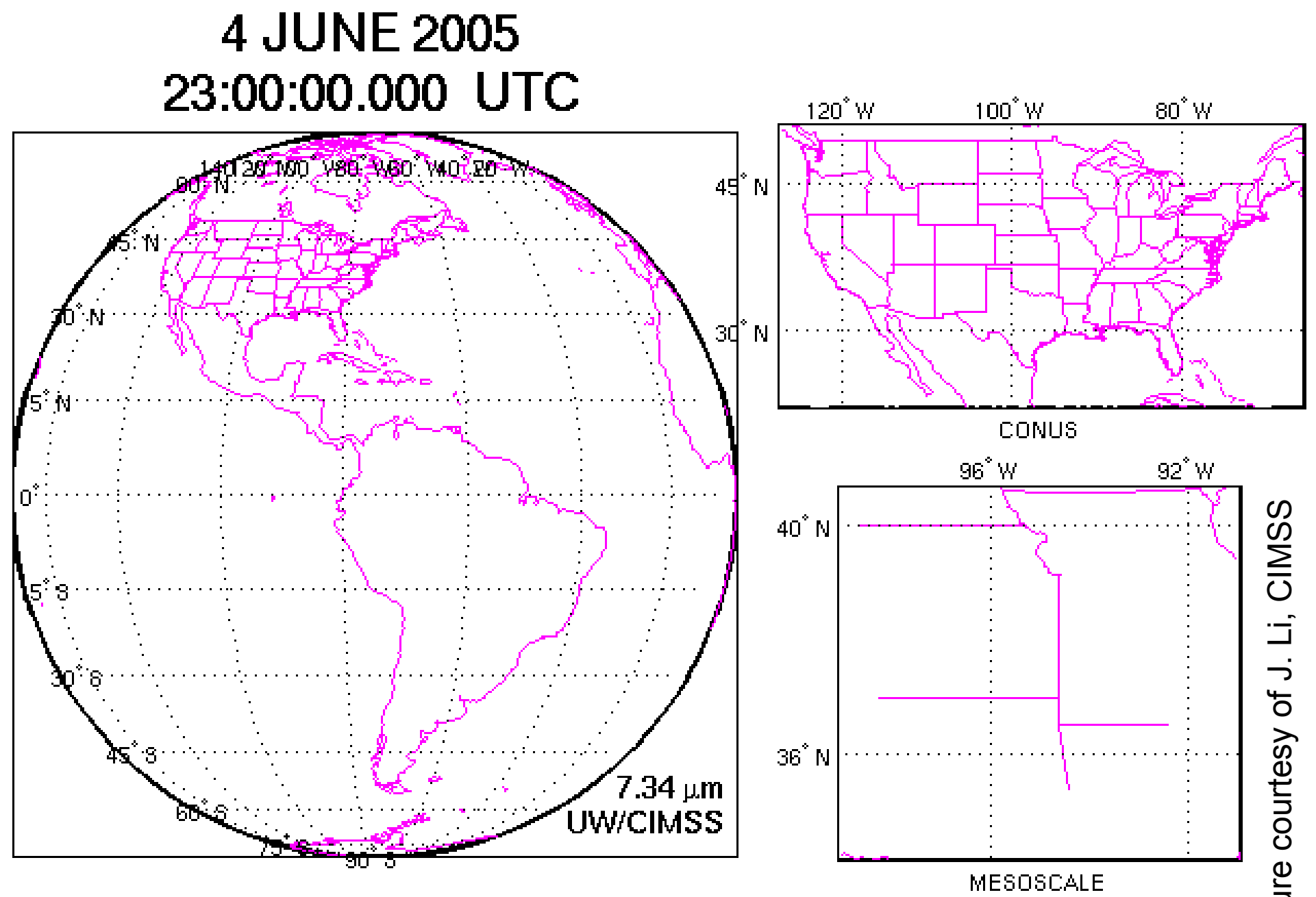
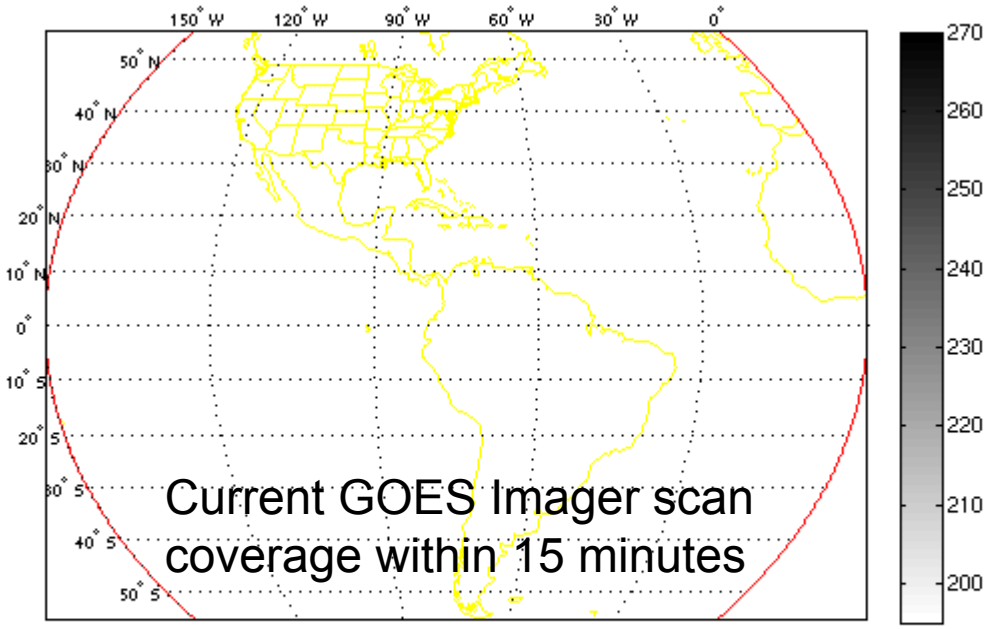
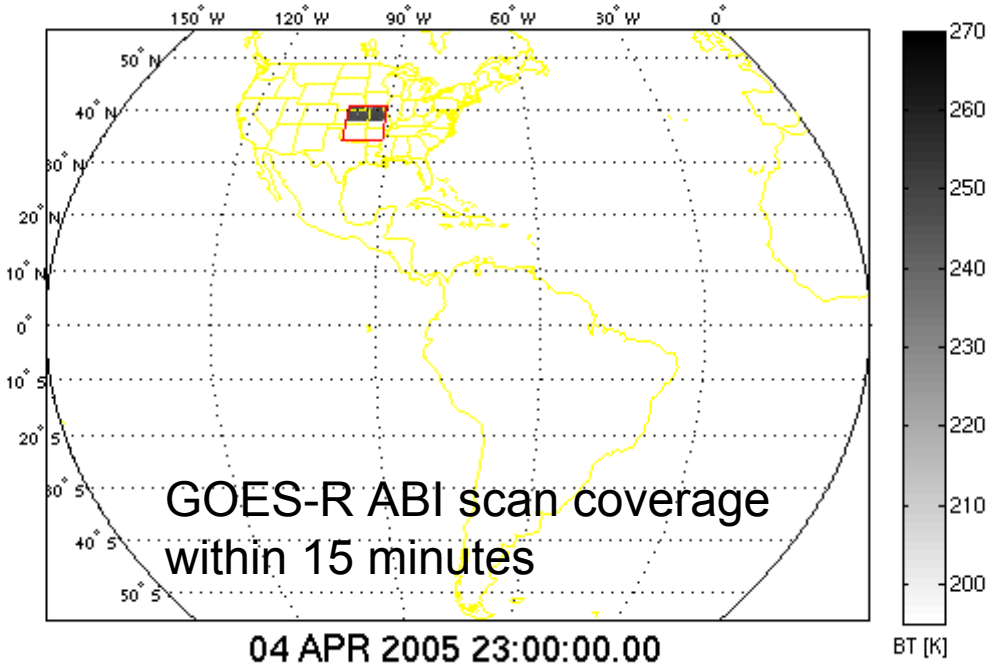


Figure courtesy of J. Li, CIMSS

Concept of flex mode scanning animation


150° W
120° W
90° W
60° W
30° W
0°
50° N
40° N
30° N
20° N
10° N
0°
10° S
20° S
30° S
40° S
50° S
270
260
250
240
230
220
210
200
Current GOES Imager scan coverage within 15 minutes


150° W
120° W
90° W
60° W
30° W
0°
50° N
40° N
30° N
20° N
10° N
0°
10° S
20° S
30° S
40° S
50° S
270
260
250
240
230
220
210
200
GOES-R ABI scan coverage within 15 minutes
04 APR 2005 23:00:00.00
BT [K]

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

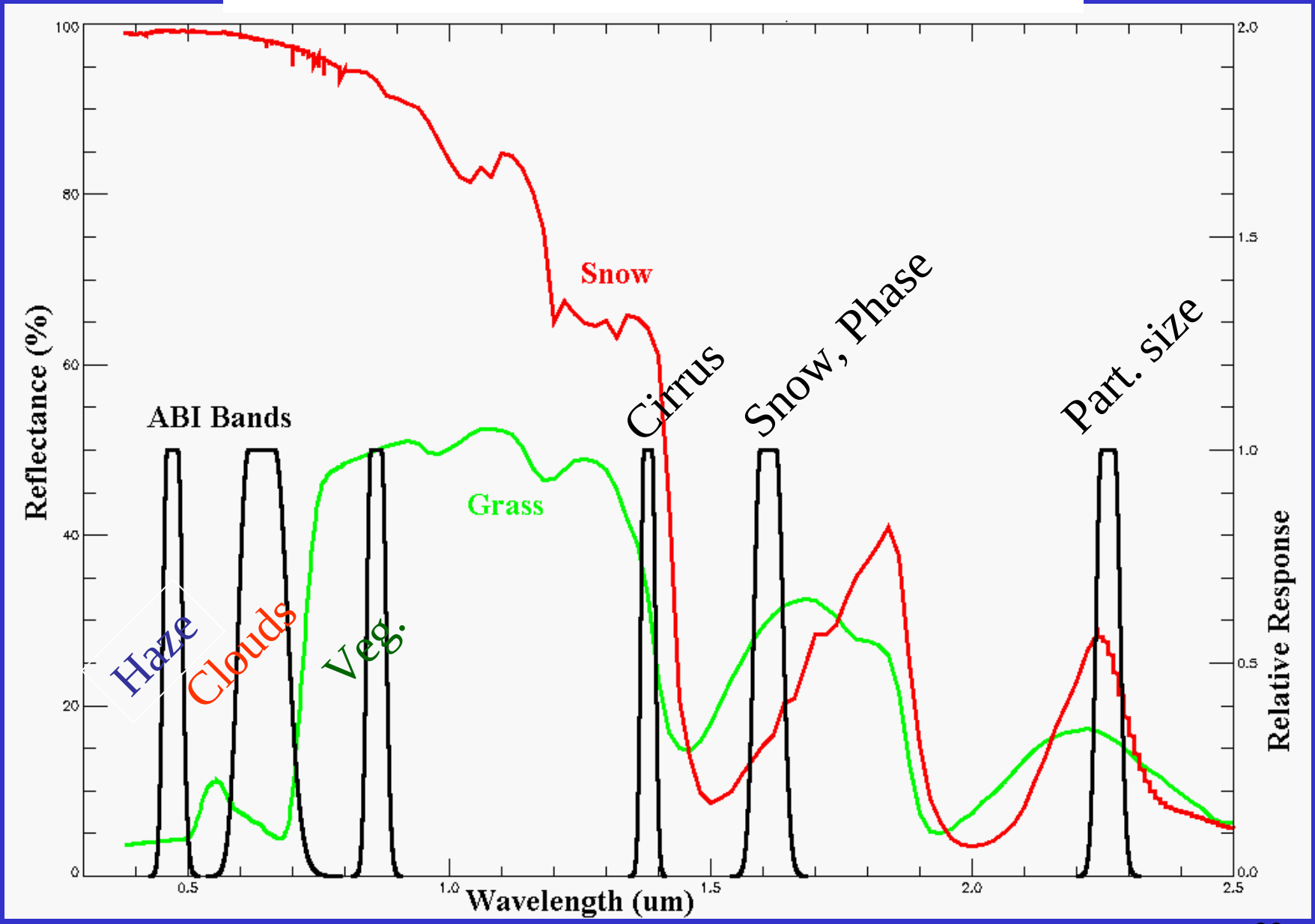
Schmit et al, 2005

ABI IR Bands

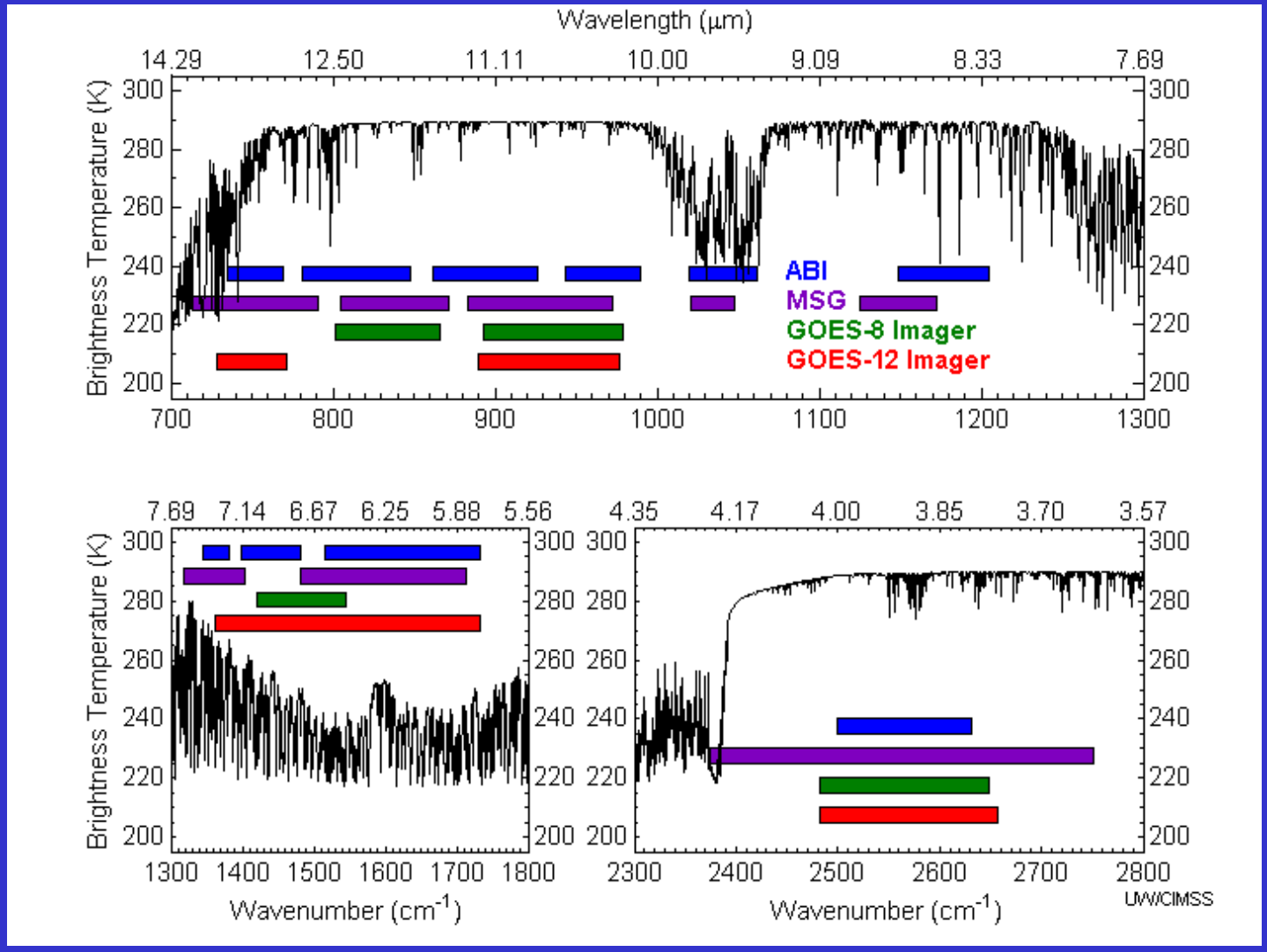
7	3.80–4.00	3.90	2	Surface and cloud, fog at night, fire, winds
8	5.77–6.6	6.19	2	High-level atmospheric water vapor, winds, rainfall
9	6.75–7.15	6.95	2	Midlevel atmospheric water vapor, winds, rainfall
10	7.24–7.44	7.34	2	Lower-level water vapor, winds, and SO_2
11	8.3–8.7	8.5	2	Total water for stability,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

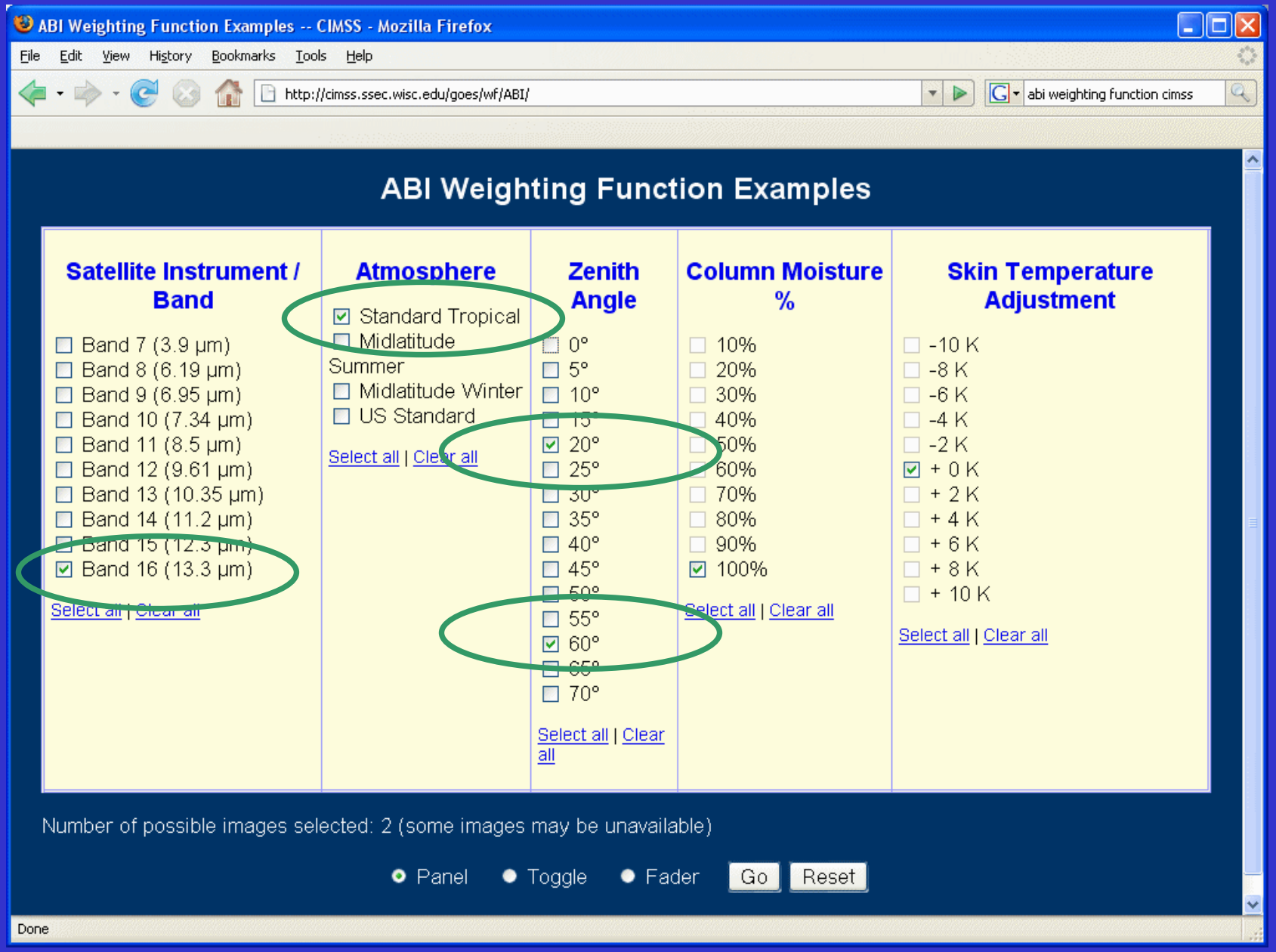


The ABI visible and near-IR bands have many uses.

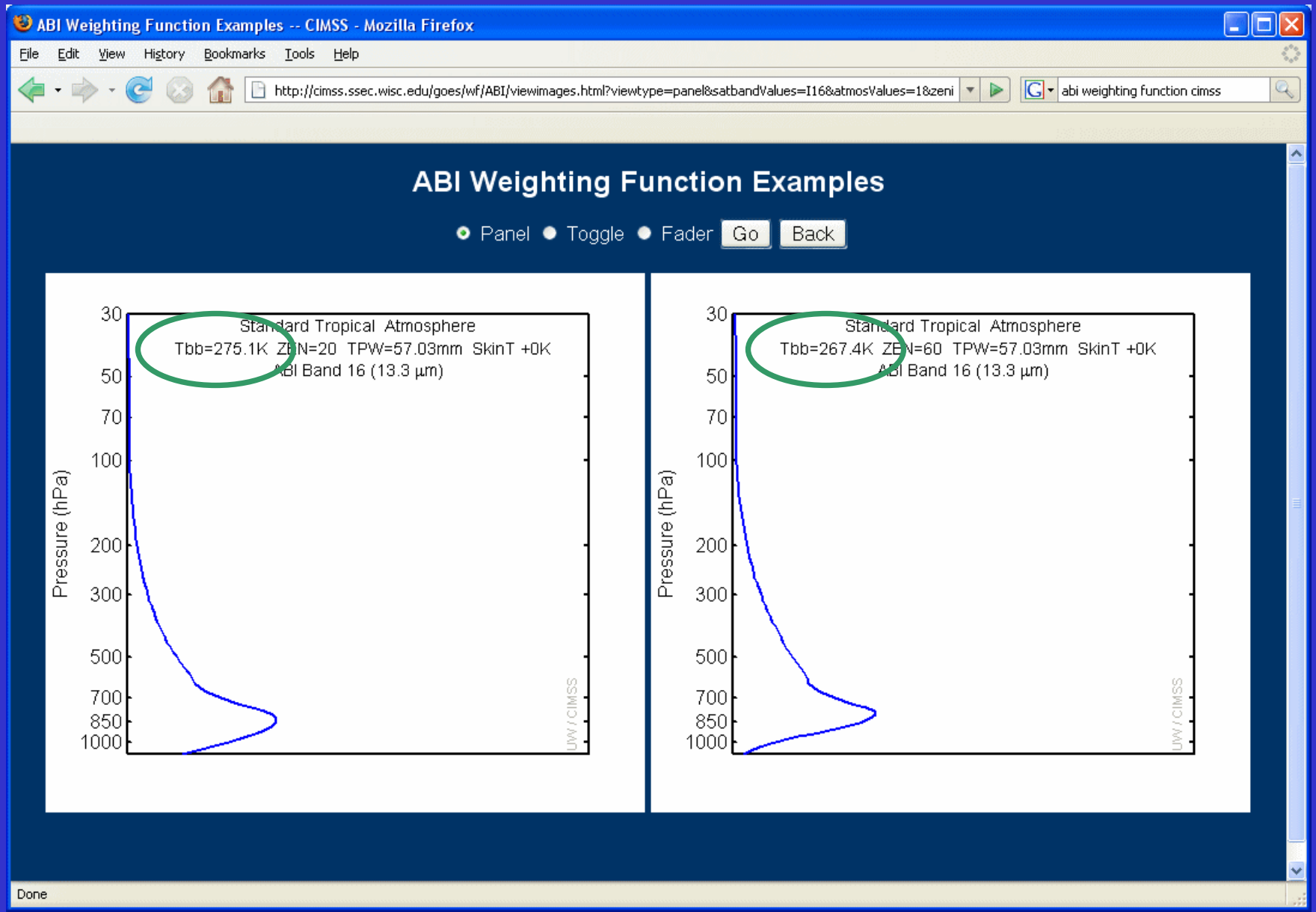


While there are differences, there are also many similarities for the spectral bands on MET-8 and the Advanced Baseline Imager (ABI). Both the MET-8 and ABI have many more bands than the current operational GOES imagers.

ABI Clear-sky Weighting Functions



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



GOES-R Product Set- 68

GOES-R 34 Baseline Products
Aerosol Detection (incl Smoke & Dust)
Suspended Matter / Optical Depth
Volcanic Ash: Detection & Height
Cloud & Moisture Imagery
Cloud Optical Depth
Cloud Particle Size Distribution
Cloud Top Phase
Cloud Top Height
Cloud Top Pressure
Cloud Top Temperature
Hurricane Intensity
Lightning Detection: Events & Flashes
Rainfall Rate / QPE
Legacy Vertical Moisture Profile
Legacy Vertical Temperature Profile
Derived Stability Indices
Total Precipitable Water
Clear Sky Masks
Radiances
Downward Solar Insolation: Surface
Reflected Solar Insolation: TOA
Derived Motion Winds
Fire / Hot Spot Characterization
Land Surface (Skin) Temperature
Snow Cover
Sea Surface Temperature
Energetic Heavy Ions
Magnetospheric Electrons and Protons: Low Energy
Magnetospheric Electrons and Protons: Medium & High Energy
Solar and Galactic Protons
Geomagnetic Field
Solar Flux: EUV
Solar Flux: X-Ray
Solar Imagery: X-Ray

GOES-R 34 Additional Products (Option 2)
Aerosol Particle Size
Aircraft Icing Threat
Cloud Ice Water Path
Cloud Imagery: Coastal
Cloud Layers / Heights and Thickness
Cloud Liquid Water
Cloud Type
Convective Initiation
Enhanced “V” / Overshooting Top Detection
Low Cloud and Fog
Turbulence
Visibility
Probability of Rainfall
Rainfall Potential
Total Water Content
Absorbed Shortwave Radiation: Surface
Downward Longwave Radiation: Surface
Upward Longwave Radiation: Surface
Upward Longwave Radiation: TOA
Ozone Total
SO2 Detection
Flood/Standing Water
Ice Cover/Landlocked
Snow Depth
Surface Albedo
Surface Emissivity
Vegetation Fraction: Green
Vegetation Index
Currents
Currents: Offshore
Sea & Lake Ice: Age
Sea & Lake Ice: Concentration
Sea & Lake Ice: Extent
Sea & Lake Ice: Motion

ABI	SUVI	EXIS
GLM	SEISS	Magnetometer

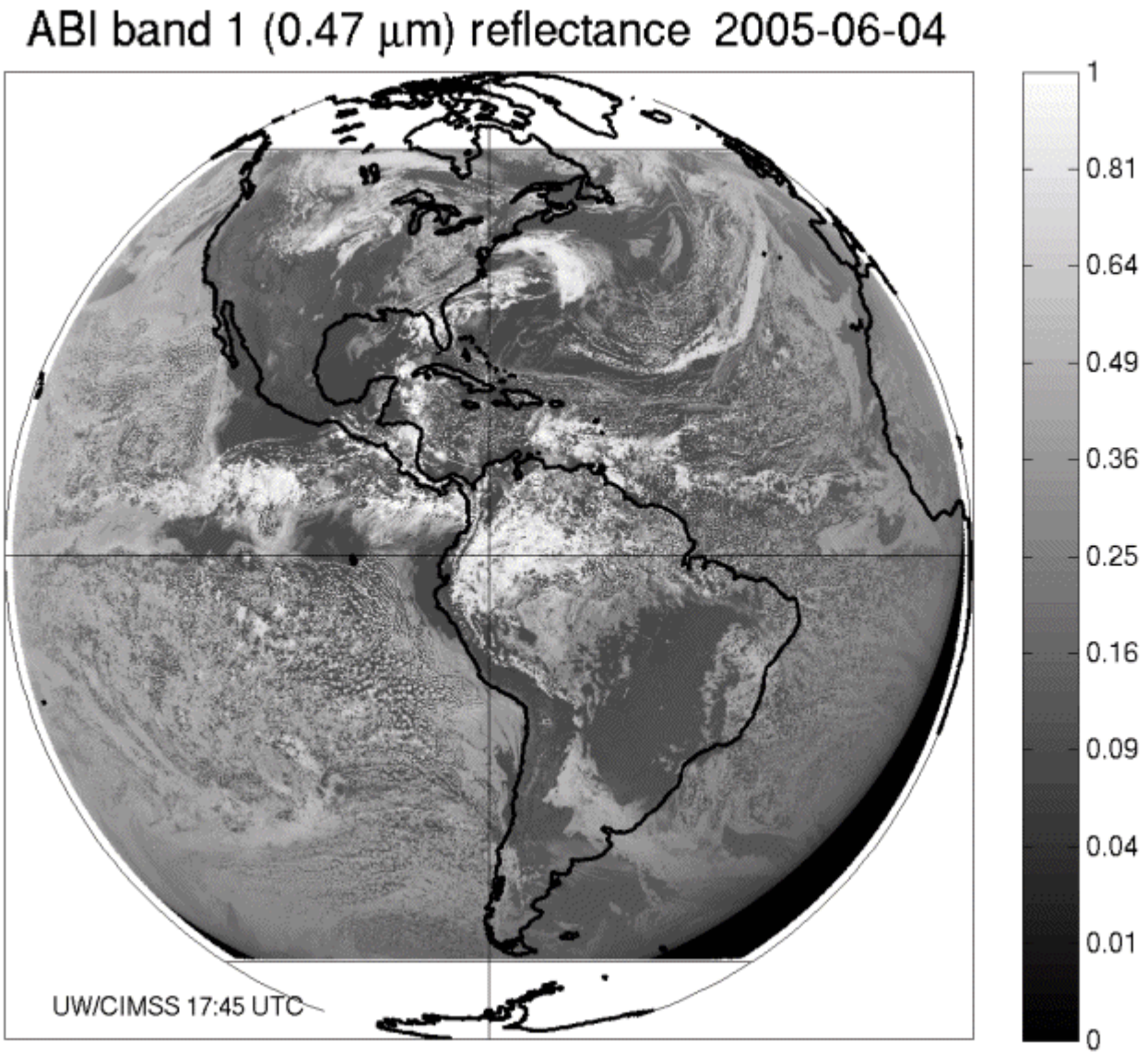
GOES-R Products List

Observables- Product Sets 1 & 2 Baseline Products	# GOES-R GS End-Products	Observables- Product Sets 3 & 4 Option 2 Products	# GOES-R GS End-Products
Aerosol Detection (incl Smoke & Dust)	6	Aerosol Particle Size	2
Suspended Matter / Optical Depth	4	Aircraft Icing Threat	2
Volcanic Ash: Detection & Height	2	Cloud Ice Water Path	6
Cloud & Moisture Imagery	54	Cloud Imagery: Coastal	2
Cloud Optical Depth	4	Cloud Layers / Heights and Thickness	6
Cloud Particle Size Distribution	6	Cloud Liquid Water	6
Cloud Top Phase	6	Cloud Type	6
Cloud Top Height	6	Convective Initiation	4
Cloud Top Pressure	4	Enhanced "V" / Overshooting Top Detection	4
Cloud Top Temperature	4	Low Cloud and Fog	2
Hurricane Intensity	2	Turbulence	4
Lightning Detection: Events & Flashes*	12	Visibility	2
Rainfall Rate / QPE	2	Probability of Rainfall	2
Legacy Vertical Moisture Profile	6	Rainfall Potential	2
Legacy Vertical Temperature Profile	6	Total Water Content	6
Derived Stability Indices	30	Absorbed Shortwave Radiation: Surface	2
Total Precipitable Water	2	Downward Longwave Radiation: Surface	4
Clear Sky Masks	6	Upward Longwave Radiation: Surface	4
Radiances*	6	Upward Longwave Radiation: TOA	4
Downward Solar Insolation: Surface	6	Ozone Total	4
Reflected Solar Insolation: TOA	4	SO2 Detection	2
Derived Motion Winds	36	Flood/Standing Water	4
Fire / Hot Spot Characterization	8	Ice Cover/Landlocked	2
Land Surface (Skin) Temperature	6	Snow Depth	6
Snow Cover	6	Surface Albedo	2
Sea Surface Temperature	6	Surface Emissivity	2
Energetic Heavy Ions*	1	Vegetation Fraction: Green	2
Magnetospheric Electrons and Protons: Low Energy*	1	Vegetation Index	2
Magnetospheric Electrons and Protons: Medium & High Energy*	1	Currents	4
Solar and Galactic Protons*	1	Currents: Offshore	4
Geomagnetic Field*	1	Sea & Lake Ice: Age	2
Solar Flux: EUV*	1	Sea & Lake Ice: Concentration	4
Solar Flux: X-Ray*	1	Sea & Lake Ice: Extent	2
Solar Imagery: X-Ray*	2	Sea & Lake Ice: Motion	4

*** GRB Product**

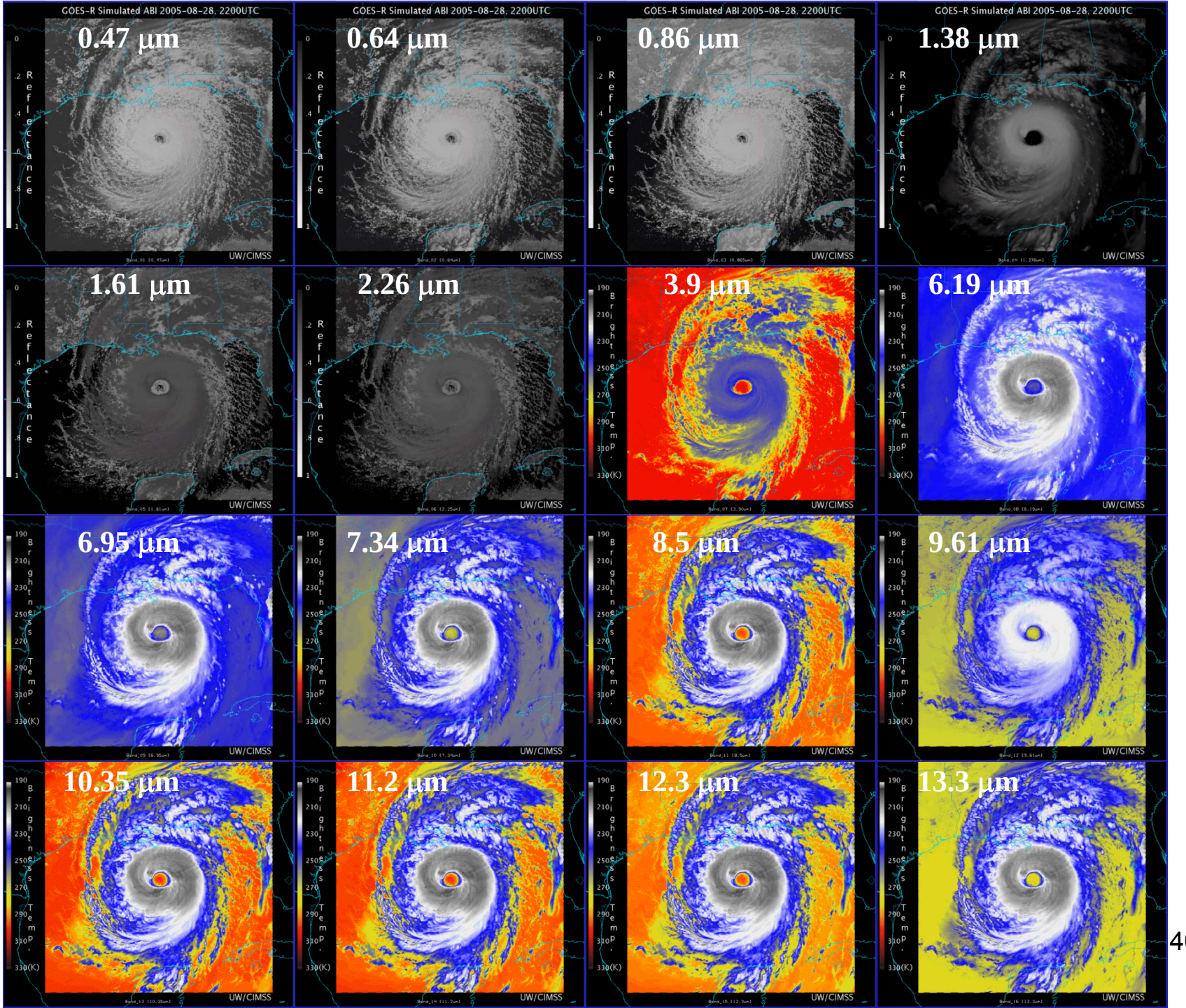
ABI	GLM	SUVI/EXIS	SEISS	MAG

Sample 16-bands of the ABI



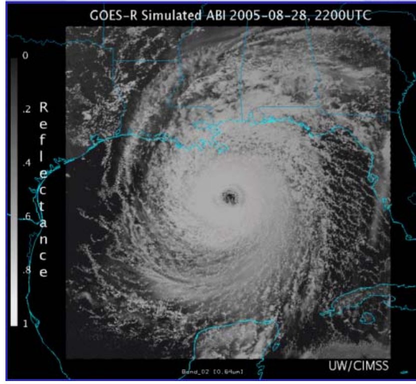
animation

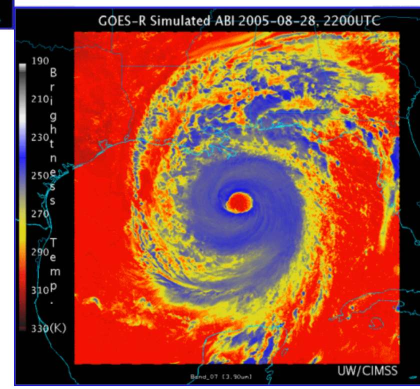
AWG Proxy ABI Simulations of Hurricane Katrina

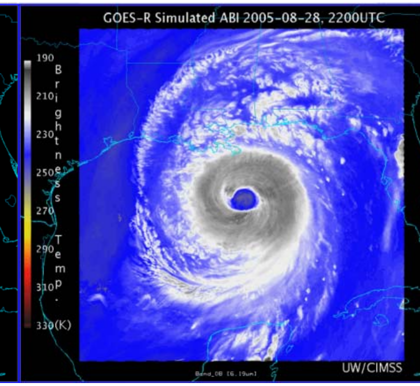


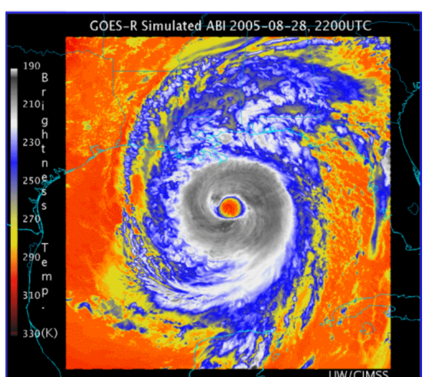
NOAA/NESDIS STAR and GOES-R Imagery Team

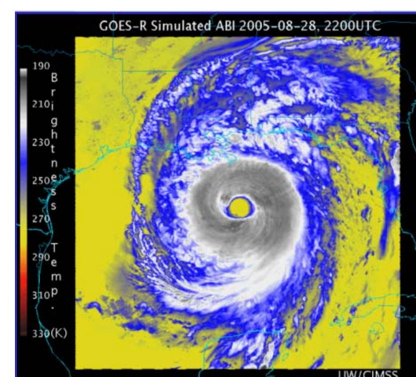
Corresponding current Imager bands of Hurricane Katrina









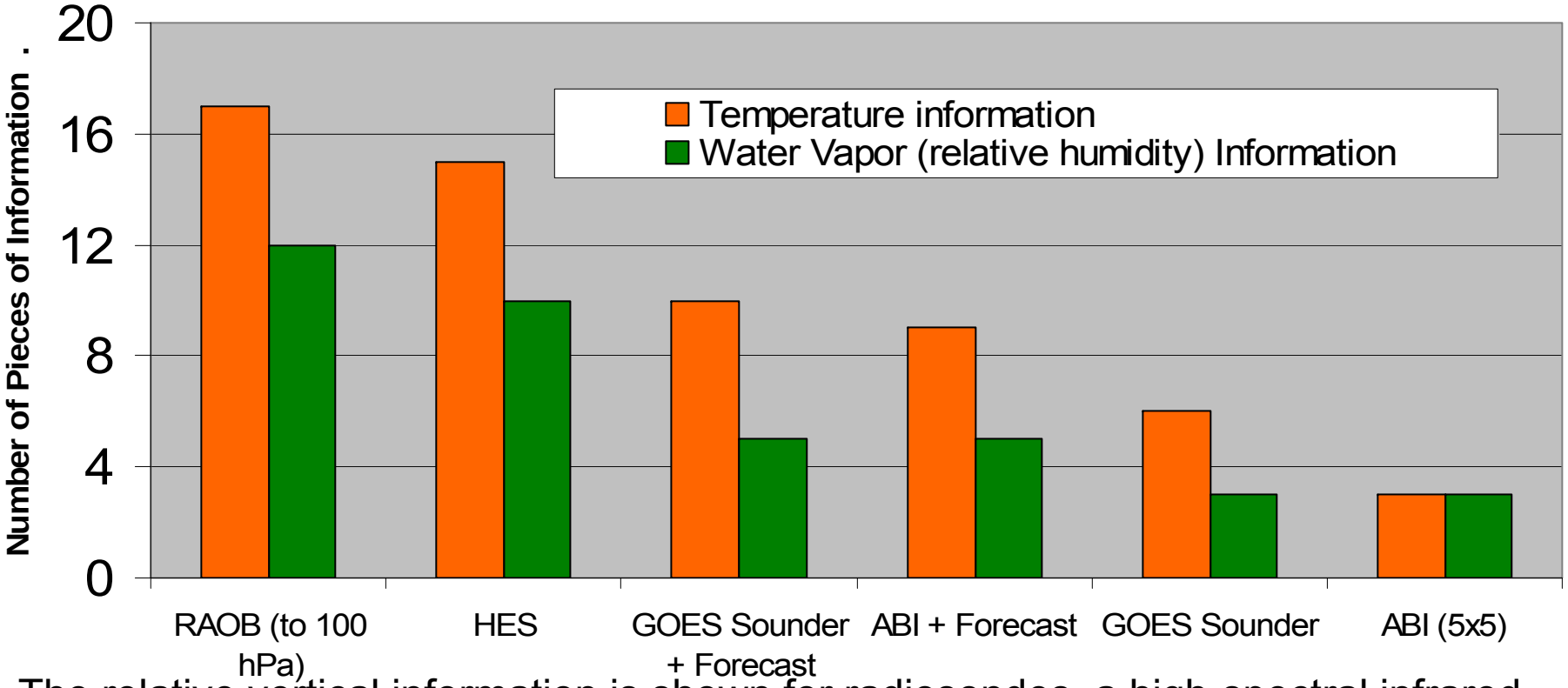


Forecasters Need an advanced sounder

- Forecasters value the current GOES sounder products; however, the same forecasters also noted several limitations of the current sounder, including:
  - the scanning rate is relatively slow, which limits coverage; and
  - the vertical resolution, especially in moisture, from the current generation GOES radiometers is limited.

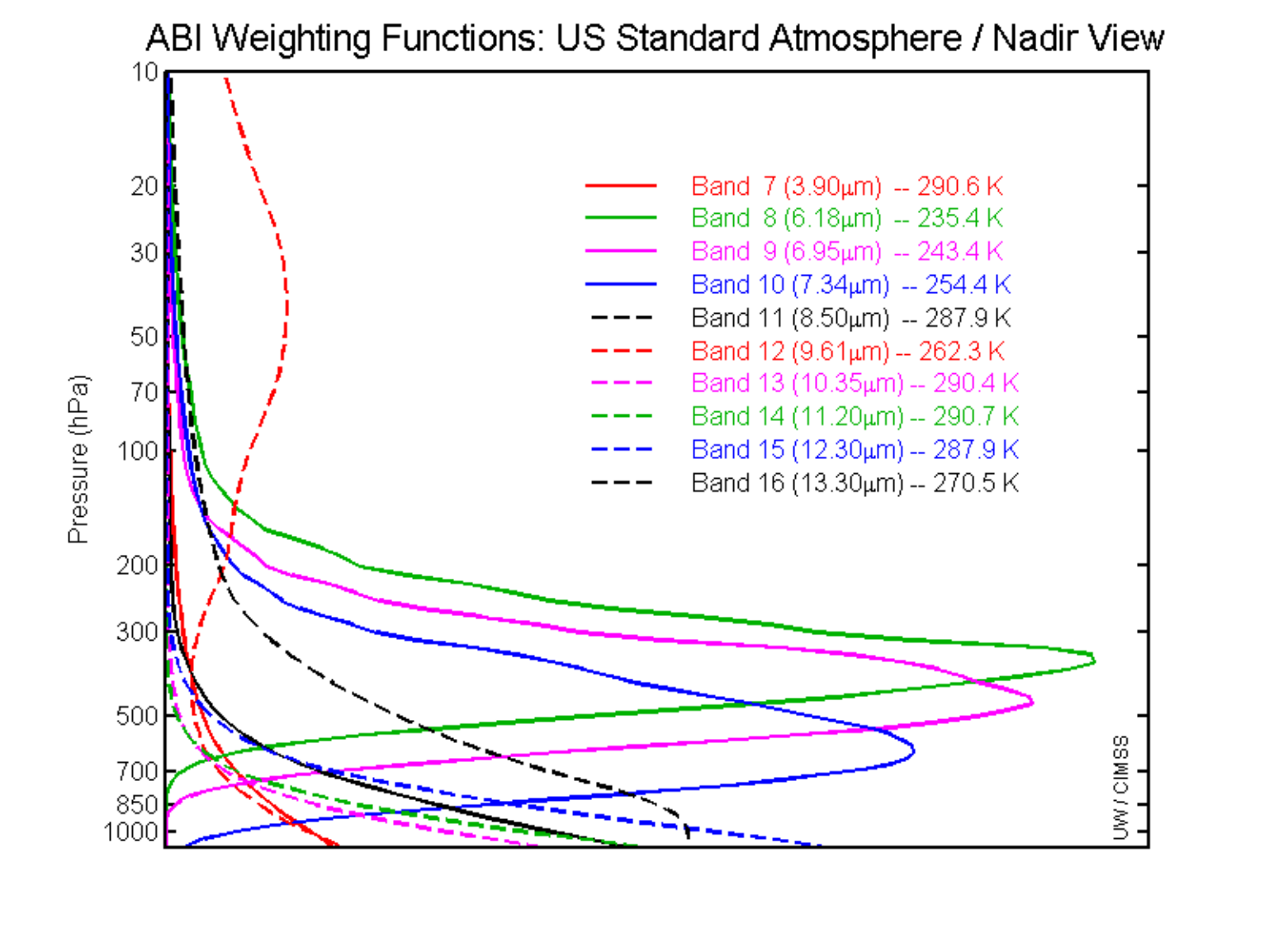
A hyperspectral sounder in a geostationary orbit will meet these forecaster needs, but will not be on GOES-R or -S.

Profile Information Content



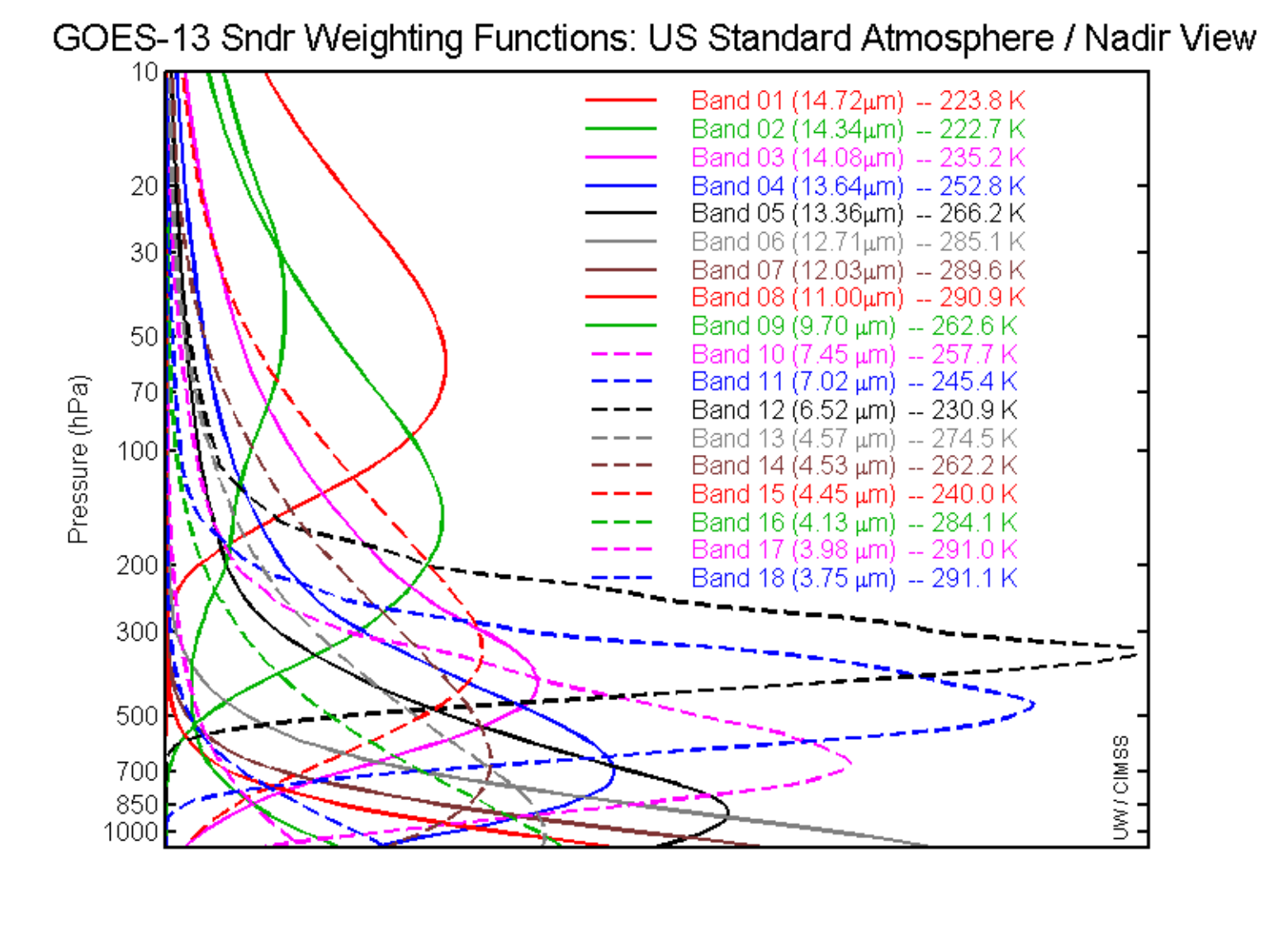
The relative vertical information is shown for radiosondes, a high-spectral infrared sounder, the current broad-band GOES Sounder and the ABI. The high-spectral sounder is much improved over the current sounder. This information content analysis does not account for any spatial or temporal differences.

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



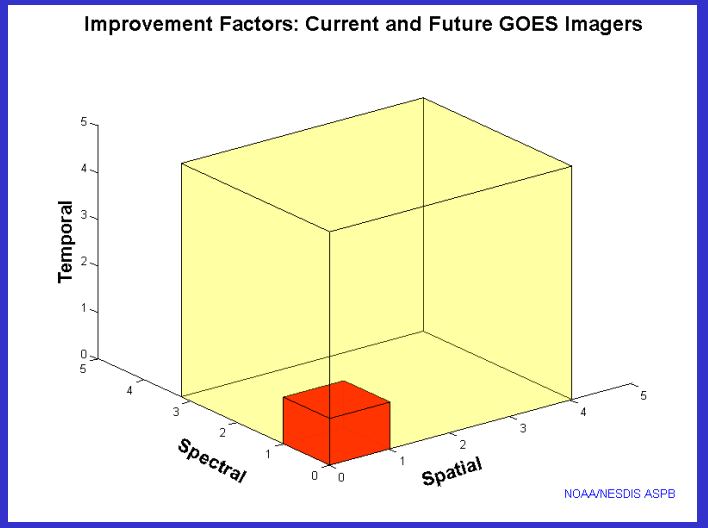
The GOES-N sounder has 5 CO_2 bands, more Shortwave bands than ABI

Potential Benefits of an advanced geo sounder

- High spectral and temporal resolution observations will benefit nowcasting and NWP applications.
  - Retrievals from high spectral resolution data exhibit much less dependence on the first guess information.
- Would be able to monitor important low-level information about the atmosphere and thus substantially improve the capability to forecast severe weather.
- The potential uses (atmospheric profiling, surface characterization, cloud information, total ozone, atmospheric motion vector winds) of high spectral resolution IR data have been amply documented.
  - Other application areas include trace gases/air quality, dust detection and characterization, climate, and calibration.

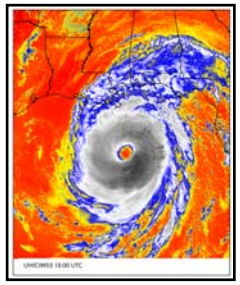
Overview

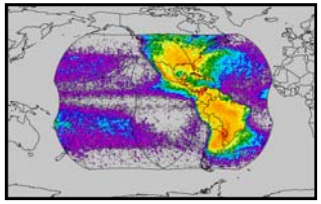
- GOES-R Overview
- GOES-13/O
- ABI (Advanced Baseline Imager)
  - Temporal, Spectral, Spatial
  - Product List
  - ABI “Soundings”
- GOES Users’ Conference
  - Madison, WI
- Summary
  - Select references
  - More information

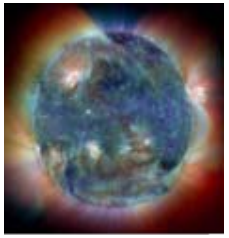


6TH GOES USERS' CONFERENCE

http://cimss.ssec.wisc.edu/goes_r/meetings/guc2009/







Geostationary Operational Environmental Satellites: http://www.goes-r.gov

Special Event on 2 November: 50th Anniversary of the 1st Meteorological Satellite Experiment

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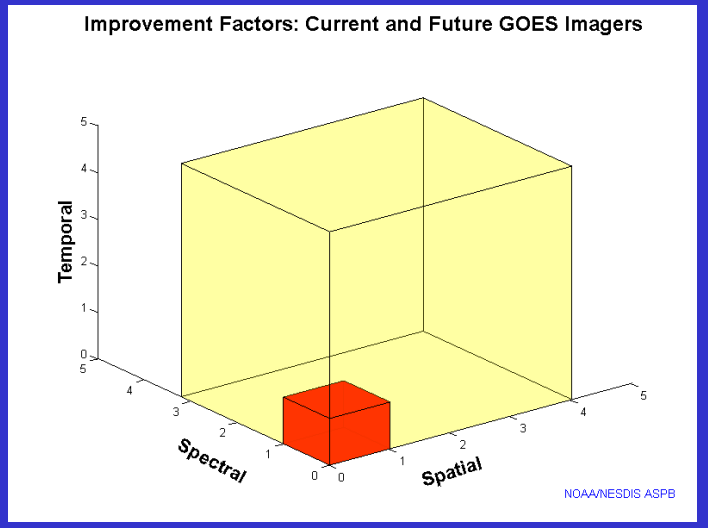
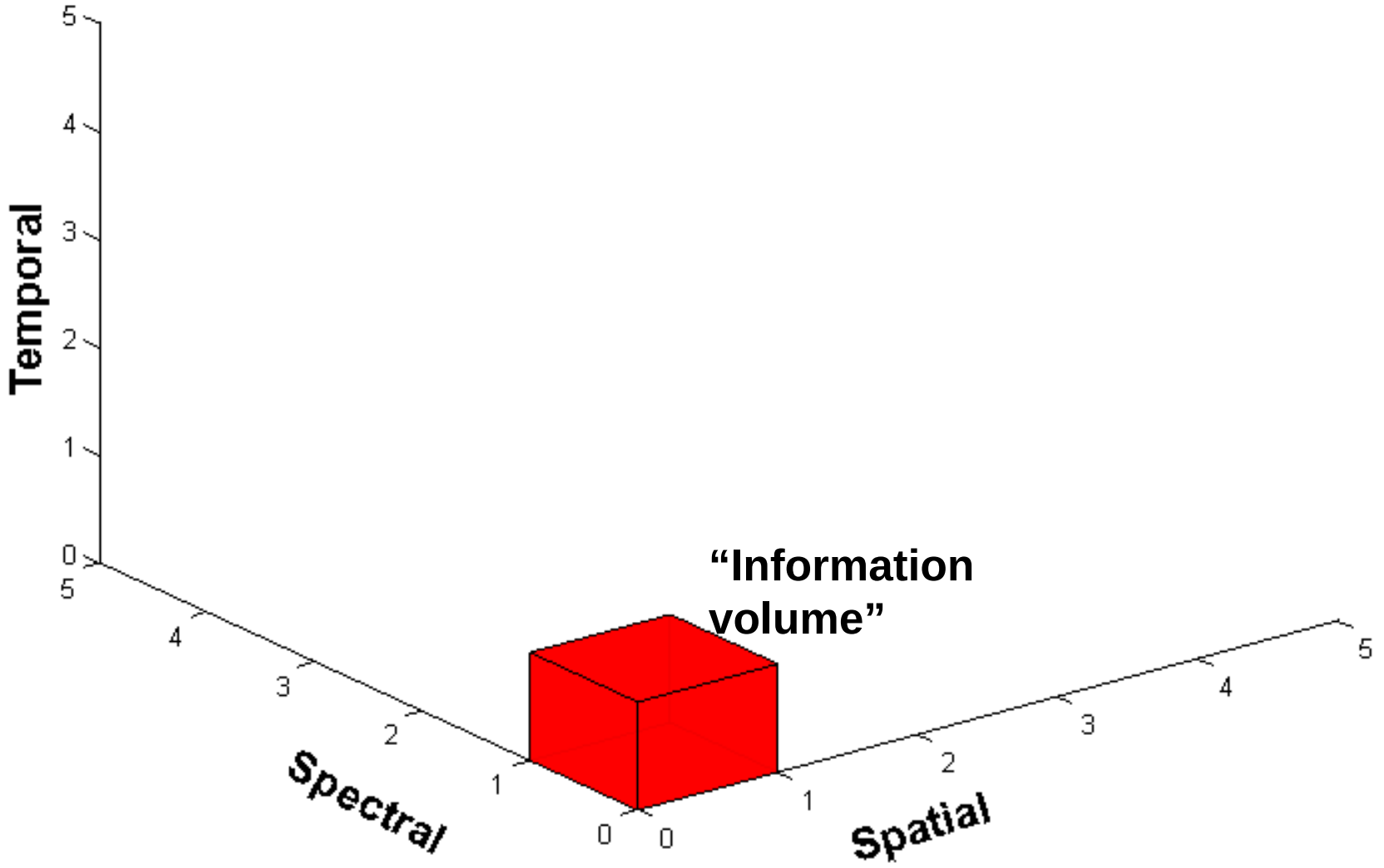
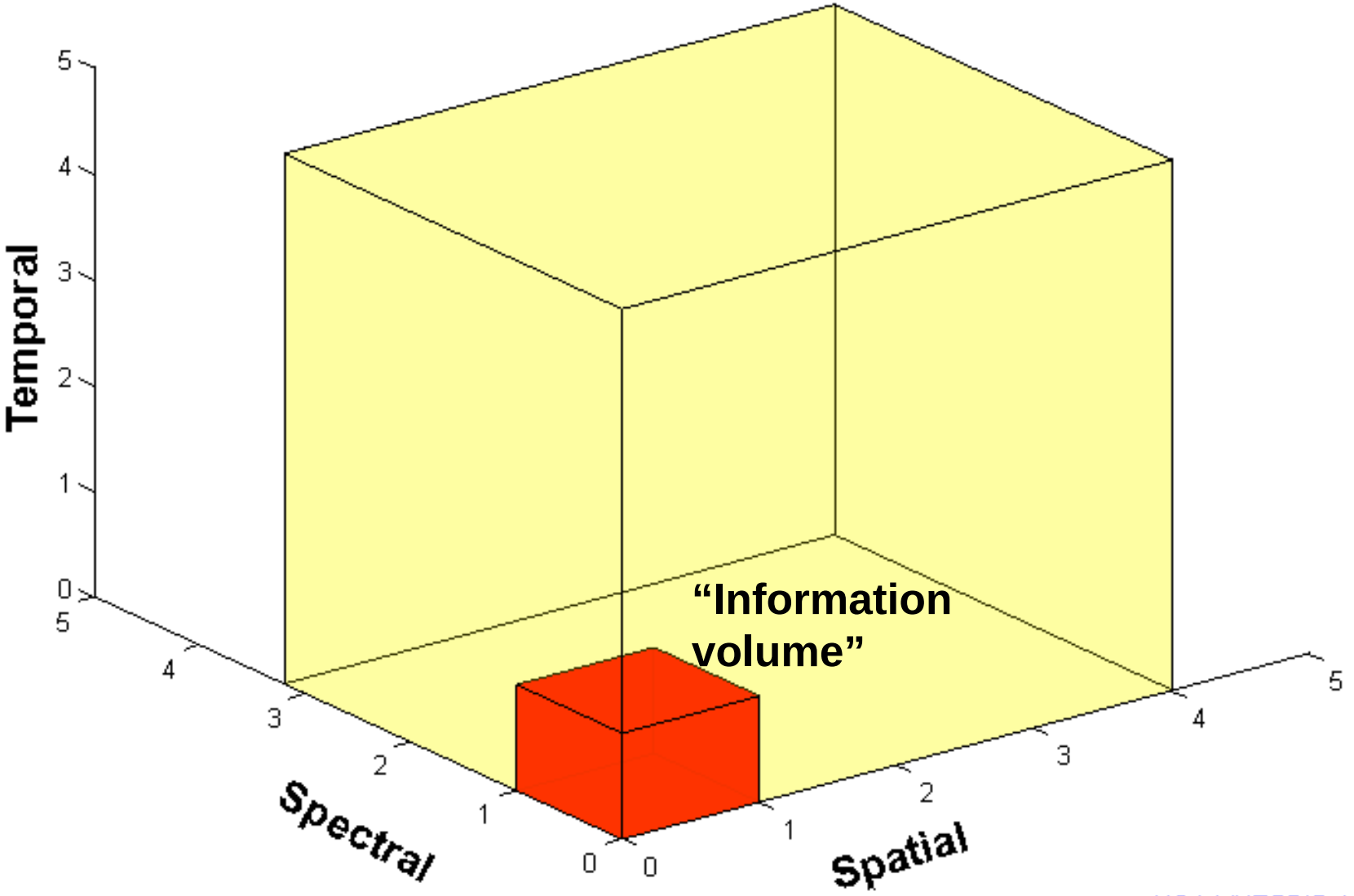


Current attributes: defined to be 1

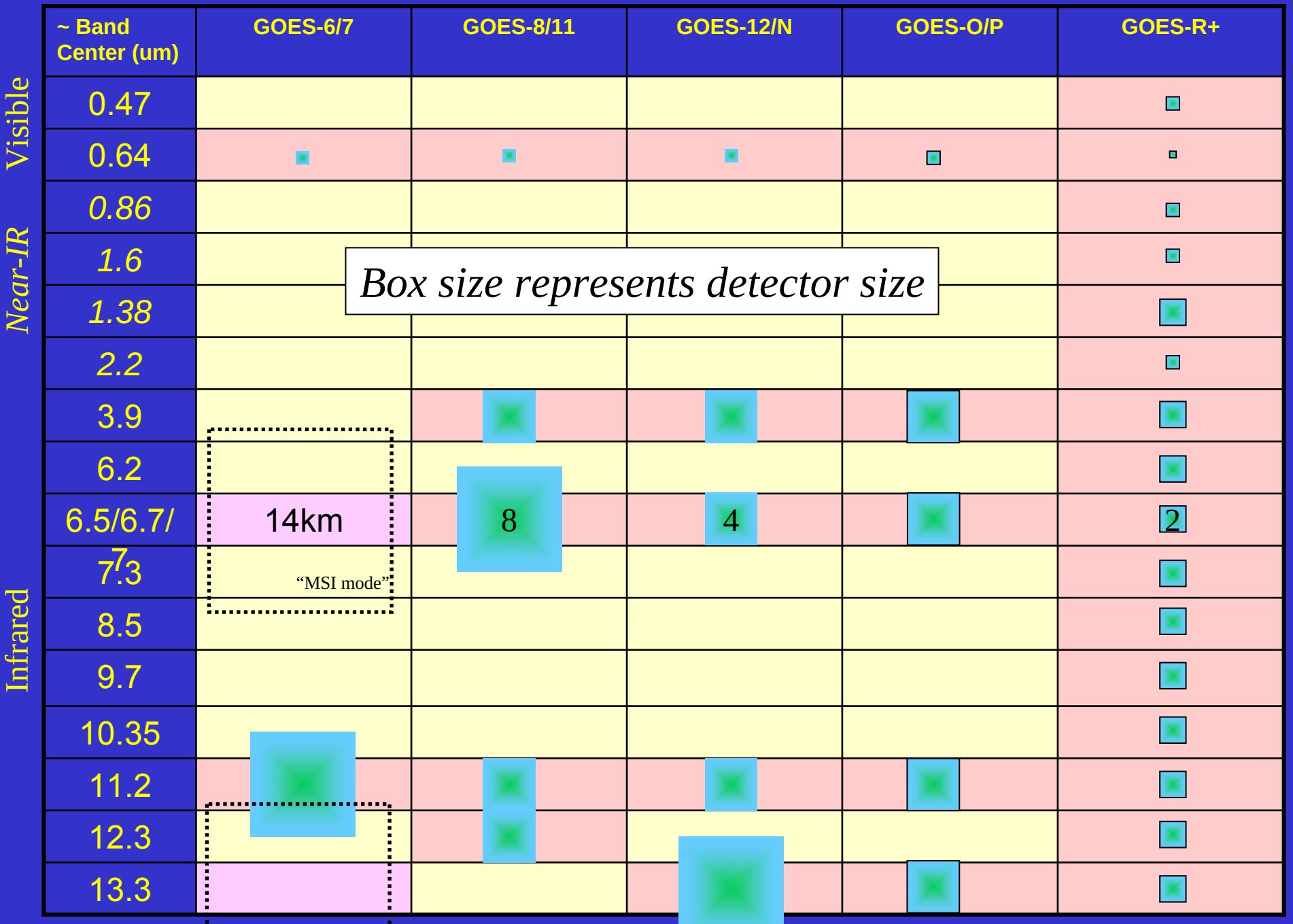


Improved attributes with the Future GOES Imagers



NOAA/NESDIS ASPB

Approximate spectral and spatial resolutions of US GOES Imagers



Select (Schmit) Publications

Potential benefits of an advanced geo sounder:

- Schmit, T.J., J. Li, S.A. Ackerman, J.J. Gurka, 2009: Geostationary High Spectral and Temporal Resolution Infrared Measurements. J. Tech., accepted

Potential benefits of 1-minute data:

- Schmit, T. J., R. M. Rabin, A. S. Bachmeier, J. Li, M. M. Gunshor, H. Steigerwaldt, A. J. Schreiner, R. M. Aune, and G. S. Wade, 2009: Many uses of the geostationary operational environmental satellite-10 sounder and imager during a high inclination state, JARS, Vol. 3, 033514.

ABI on GOES-R can produce sounder-like products:

- Schmit, Timothy J.; Li, Jun; Gurka, James J.; Goldberg, Mitchell D.; Schrab, Kevin J.; Li, Jinlong and Feltz, Wayne F. The GOES-R Advanced Baseline Imager and the continuation of current sounder products. JAMC, 47, 2008, pp.2696-2711.

ABI Overview:

- Schmit, Timothy J.; Gunshor, Mathew M.; Menzel, W. Paul; Gurka, James J.; Li, Jun and Bachmeier, A. Scott Introducing the next-generation Advanced Baseline Imager on GOES-R. BAMS, Volume 86, Issue 8, 2005, pp.1079-1096.

GOES-R Bibliography

Schwerdtfeger Library at SSEC:

- GOES-R Bibliography (WI)
- http://library.ssec.wisc.edu/resources/goesr/goesr.php.

Select journal articles:

Jin, Xin; Li, Jun; Schmit, Timothy J.; Li, Jinlong; Goldberg, Mitchell D. and Gurka, James J. Retrieving clear-sky atmospheric parameters from SEVIRI and ABI infrared radiances. Journal of Geophysical Research, Volume 113, 2008, doi:10.1029/2008JD010040, 2008. Call Number: Reprint # 5816.

Li, Zhenglong; Li, Jun; Menzel, W. Paul; Schmit, Timothy J.; Nelson, James P. III; Daniels, Jaime and Ackerman, Steven A. GOES sounding improvement and applications to severe storm nowcasting. Geophysical Research Letters, Volume 35, Issue 3, 2008, doi:10.1029/2007GL032797, 2008. Call Number: Reprint # 5677.

Schmit, Timothy J.; Li, Jun; Gurka, James J.; Goldberg, Mitchell D.; Schrab, Kevin J.; Li, Jinlong and Feltz, Wayne F. The GOES-R Advanced Baseline Imager and the continuation of current sounder products. Journal of Applied Meteorology and Climatology, Volume 47, Issue 10, 2008, pp.2696-2711. Call Number: Reprint # 5861.

Brunner, Jason C.; Ackerman, Steven A.; Bachmeier, A. Scott and Rabin, Robert M. A quantitative analysis of the enhanced-V feature in relation to severe weather. Weather and Forecasting, Volume 22, Issue 4, 2007, pp.839-852. Call Number: Reprint # 5425.

Zhang, Peng; Li, Jun; Olson, Erik; Schmit, Timothy J.; Li, Jinlong and Menzel, W. Paul Impact of point spread function on infrared radiances from geostationary satellites. IEEE Transactions on Geoscience and Remote Sensing, Volume 44, Issue 8, 2006, pp.2176-2183. Call Number: Reprint # 5216.

Li, Jun; Liu, Chian-Yi; Huang, Hung-Lung; Schmit, Timothy J.; Wu, Xuebao; Menzel, W. Paul and Gurka, James J. Optimal cloud-clearing for AIRS radiances using MODIS. IEEE Transactions on Geoscience and Remote Sensing, Volume 43, Issue 6, 2005, pp.1266-1278. Call Number: Reprint # 4448.

Schmit, Timothy J.; Gunshor, Mathew M.; Menzel, W. Paul; Gurka, James J.; Li, Jun and Bachmeier, A. Scott Introducing the next-generation Advanced Baseline Imager on GOES-R. Bulletin of the American Meteorological Society, Volume 86, Issue 8, 2005, pp.1079-1096. Call Number: Reprint # 4474.

Li, Jun; Menzel, W. Paul; Sun, Fengying; Schmit, Timothy J. and Gurka, James AIRS subpixel cloud characterization using MODIS cloud products. Journal of Applied Meteorology, Volume 43, Issue 8, 2004, pp.1083-1094. Call Number: Reprint # 3759.

AMS BAMS Article on the ABI (Aug. 2005)

More information

GOES-R:

- http://www.goes-r.gov
- http://www.meted.ucar.edu/index.htm
- http://cimss.ssec.wisc.edu/goes_r/proving-ground.html

GOES and NASA:

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

UW/SSEC/CIMSS/ASPB:

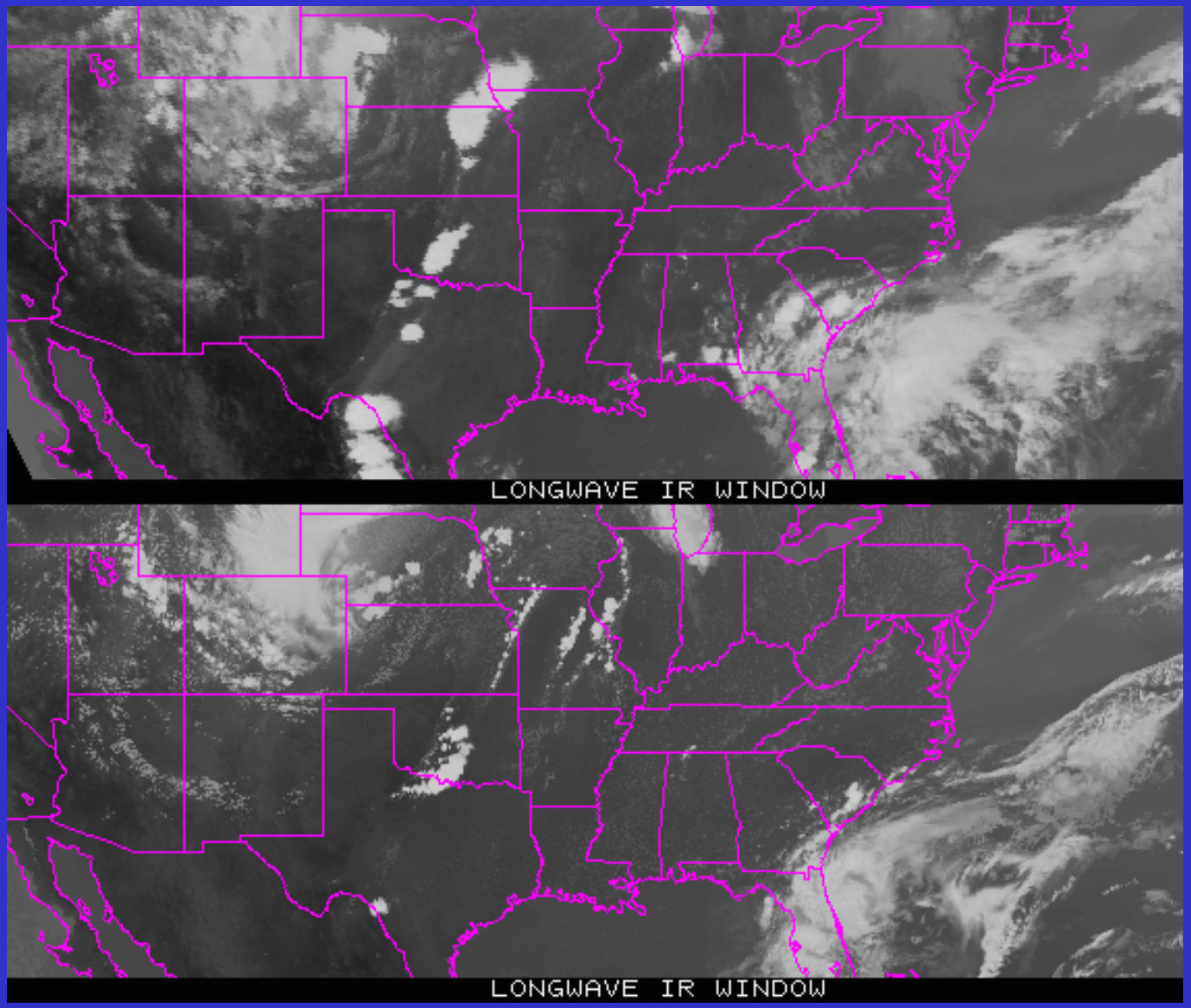
- http://cimss.ssec.wisc.edu/goes_r/awg/proxy/nwp/
- http://cimss.ssec.wisc.edu/goes/abi/
- http://cimss.ssec.wisc.edu/goes/abi/wf
- http://cimss.ssec.wisc.edu/goes/blog/
- http://www.ssec.wisc.edu/data/geo/


ARTICLES

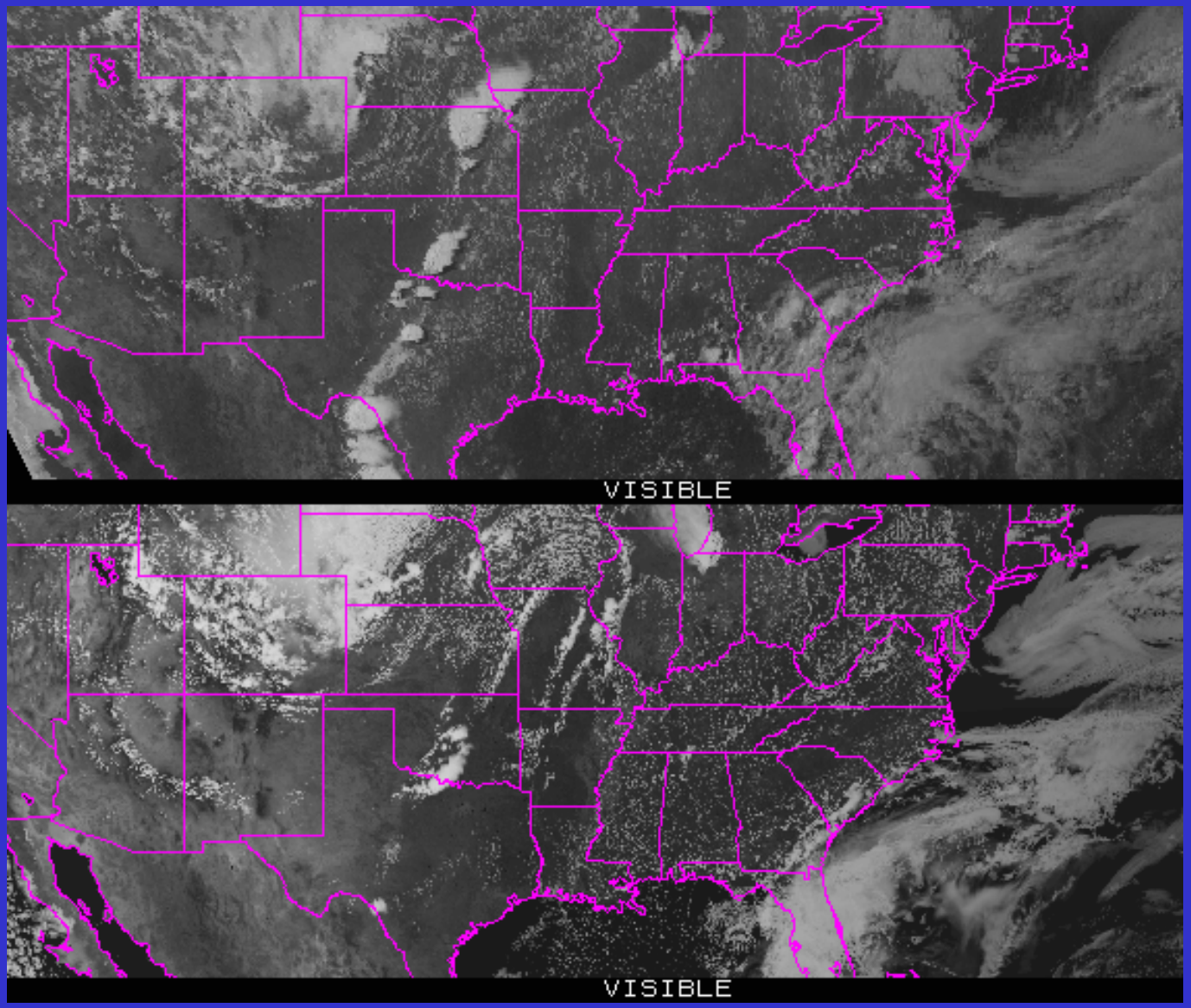
INTRODUCING THE NEXT-GENERATION ADVANCED BASELINE IMAGER ON GOES-R

AMS BAMS Article on the ABI (Aug. 2005)

Real, Simulated



Real, Simulated



Summary

- The ABI on GOES-R will improve over the current instrument in many aspects (spatial, temporal, spectral), plus improved image navigation and registration and radiometer performance.

- Thank you for your time.

- Contact information:
  - tims@ssec.wisc.edu or tim.j.schmit@noaa.gov

Acknowledgements

- The authors would like to thank the entire GOES-R team; both within the government, industry and academia.

- 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.