

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

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Steve Goodman, James J. Gurka, etc.

GOES-R Program Office

National Weather Association  
Birmingham, AL  
20 October 2011



UW-Madison

# Also Thanks to...

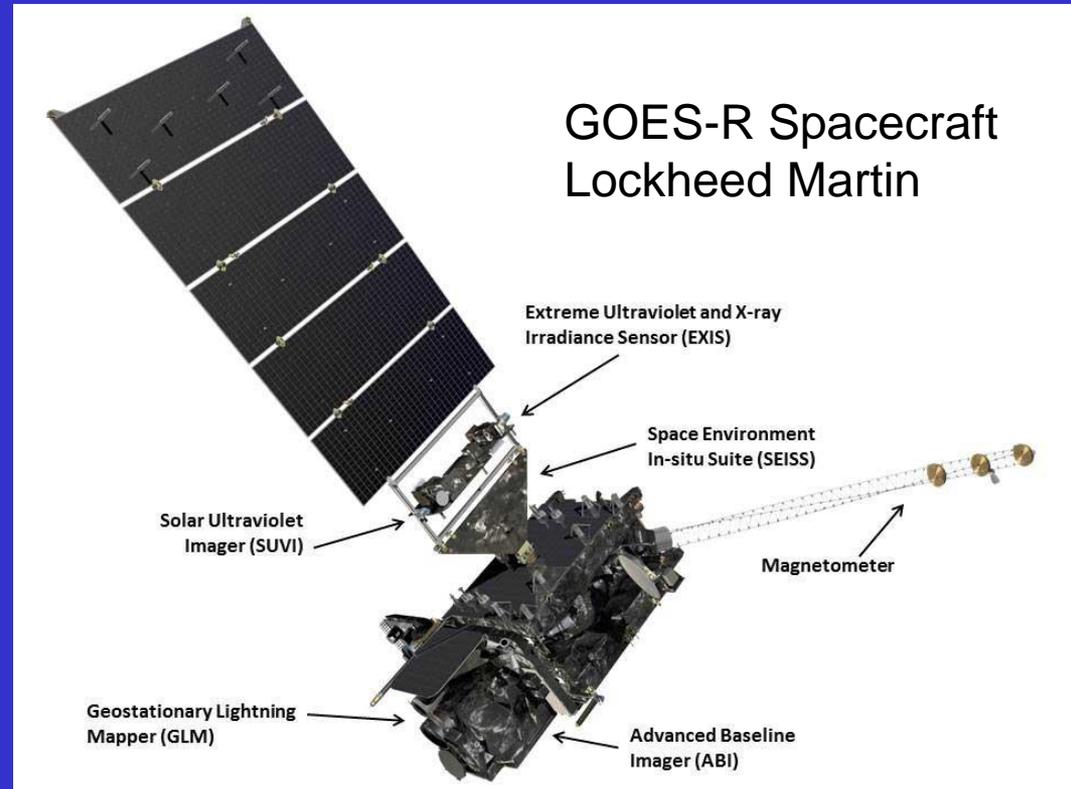
- Renkevans, Tom; Achteor, Tom; Ackerman, Steve; Antonelli, Paolo; Aune, Bob; Baggett, Kevin; Baum, Bryan; Ellrod, Gary; Feltz, Joleen; Feltz, Wayne; Frey, Rich; Griffin, Michael K.; Gumley, Liam; Heymann, Roger; Hillger, Don; Huang, Allen; Key, Jeff; Knuteson, Bob; Mecikalski, John; Menzel, Paul; Moeller, Chris; Mosher, Fred; Nelson, James; Nasiri, Shaima; Olander, Tim; Plokhenko, Yuri; Prins, Elaine; Rabin, Bob; Revercomb, Hank; Schmidt, Chris; Schreiner, Tony; Seemann-Wetzel, Suzanne; Sieglaff, Justin; Strabala, Kathy; Sun, Fengying; Will Straka, Tobin, Dave; Velden, Chris; Wade, Gary; Whittaker, Tom; Woolf, Hal, Jason Otkin, etc.
- Jaime Daniels, Mitch Goldberg, AWG co-chairs, AWG Leads, Walter Wolf, GPO, Jordan Gerth, Chian-Yi Liu, Thomas Greenwald, Monica Coakley, GOES-R flight/ground, Bill Smith, ASPB, PG, SSEC data center, CWG, etc.
- NASA, ITT Industries, Lockheed-Martin, other industry partners, etc.

# GOES-R Overview

- Advanced Baseline Imager (ABI)
- No dedicated Sounder
- Geostationary Lightning Mapper (GLM)
- Space Weather
  - Space Environmental In-Situ Suite (SEISS)
  - Solar Ultra Violet Imager (SUVI)
  - Extreme Ultra Violet/X-Ray Irradiance Sensor (EXIS)
  - Magnetometer
- Communications
  - GOES Rebroadcast (GRB)
  - High Rate Information Transmissions (HRIT)
  - Emergency Managers Weather Information Network (EMWIN)
  - Search and Rescue (SAR)
  - Data Collection System (DCS)

# Overview

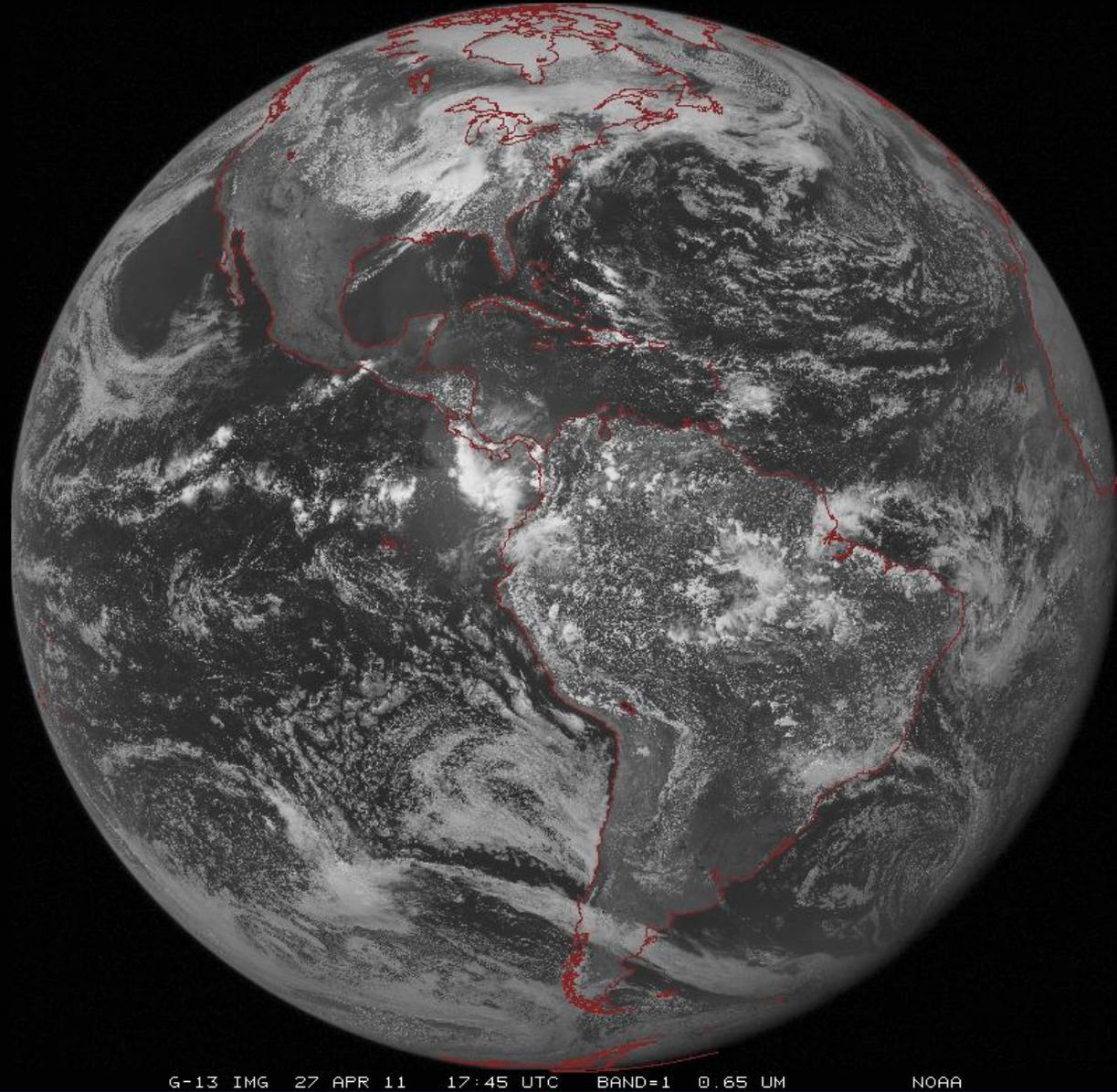
- ABI (Advanced Baseline Imager)
  - Temporal
  - Spatial
  - Spectral
  - Imagery
- Select Products
- Summary
  - More information



See Poster 4.18: **GOES-R Sectorized Cloud and Moisture Imagery Products**

# The Advanced Baseline Imager:

	ABI	Current
<b>Spectral Coverage</b>		
	16 bands	5 bands
<b>Spatial resolution</b>		
0.64 $\mu\text{m}$ Visible	0.5 km	Approx. 1 km
Other Visible/near-IR	1.0 km	n/a
Bands ( $>2 \mu\text{m}$ )	2 km	Approx. 4 km
<b>Spatial coverage</b>		
Full disk	4 per hour	Scheduled (3 hrly)
CONUS	12 per hour	~4 per hour
Mesoscale	Every 30 sec	n/a
<b>Visible (reflective bands)</b>		
On-orbit calibration	Yes	No



G-13 IMG 27 APR 11 17:45 UTC BAND=1 0.65 UM NOAA

ABI  
scans  
about 5  
times  
faster  
than the  
current  
GOES  
imager

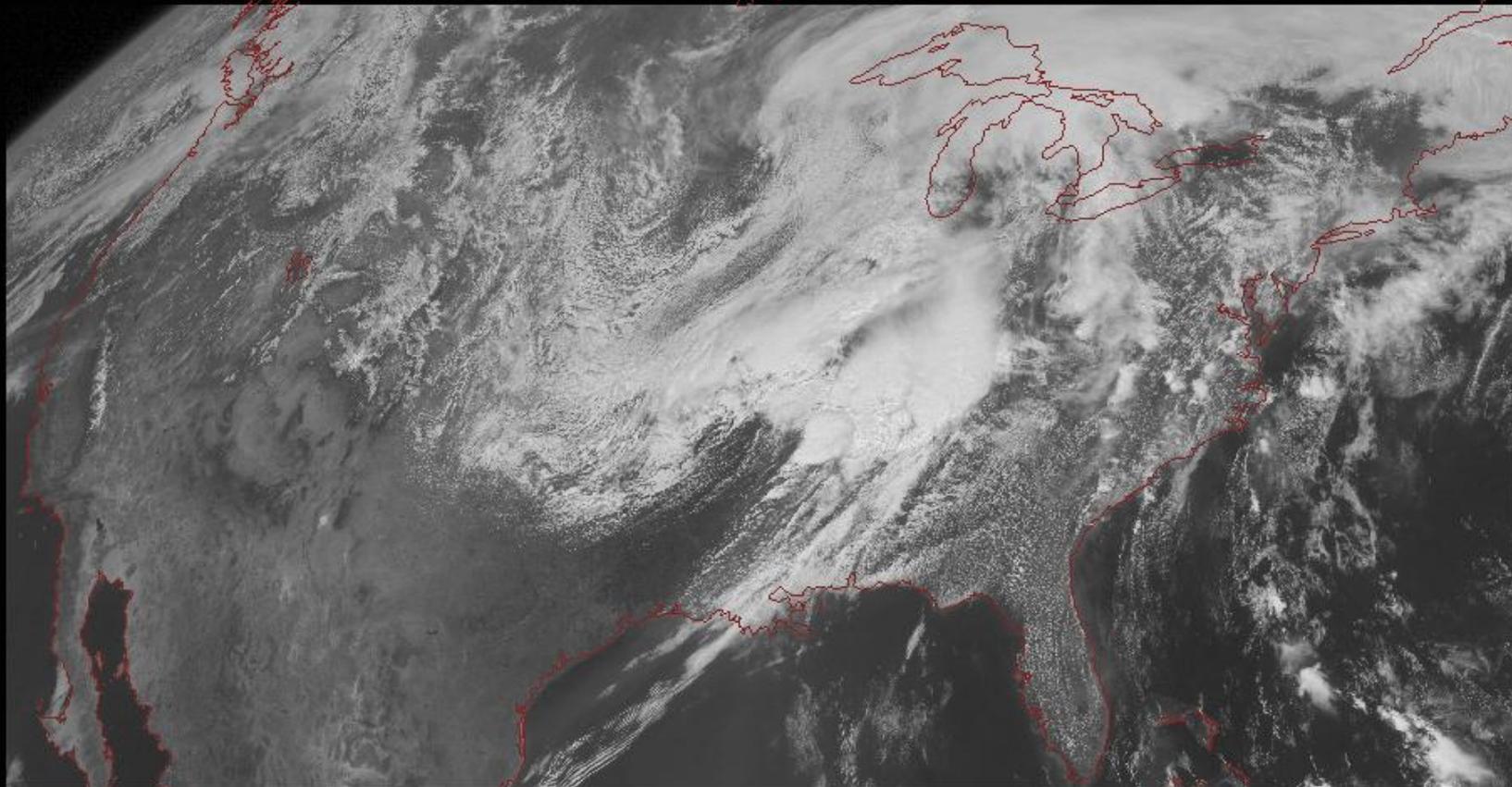
There are two anticipated scan modes for the ABI:

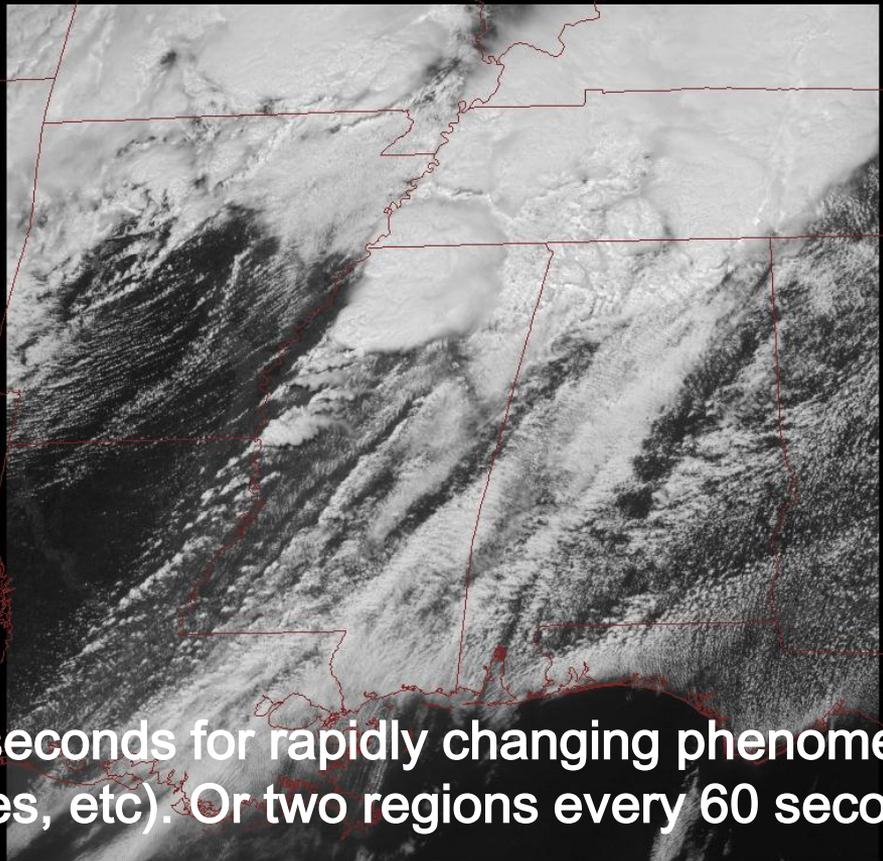
- Full disk images every 15 minutes + 5 min CONUS images + mesoscale.
- or - Full disk every 5 minutes.



G-13 IMG 27 APR 11 17:45 UTC BAND=1 0.65 UM NOAA

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.



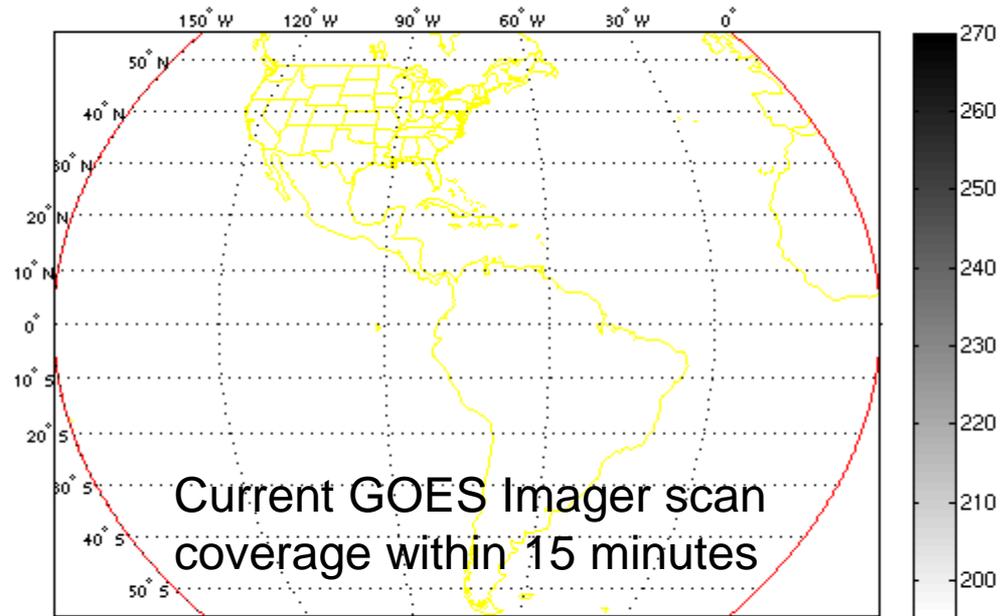


G-13 IMG 27 APR 11 1

Mesoscale images every 30 seconds for rapidly changing phenomena (thunderstorms, hurricanes, fires, etc). Or two regions every 60 seconds.

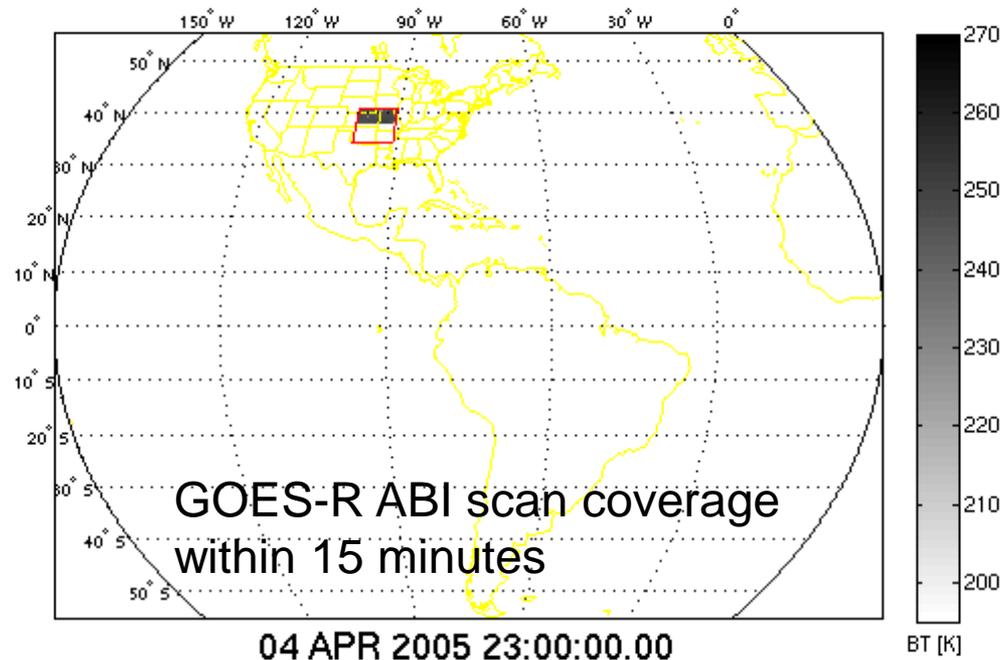
In 15 Minutes  
Current GOES Imager  
can scan:

- 3/5<sup>th</sup> of a Full Disk Image

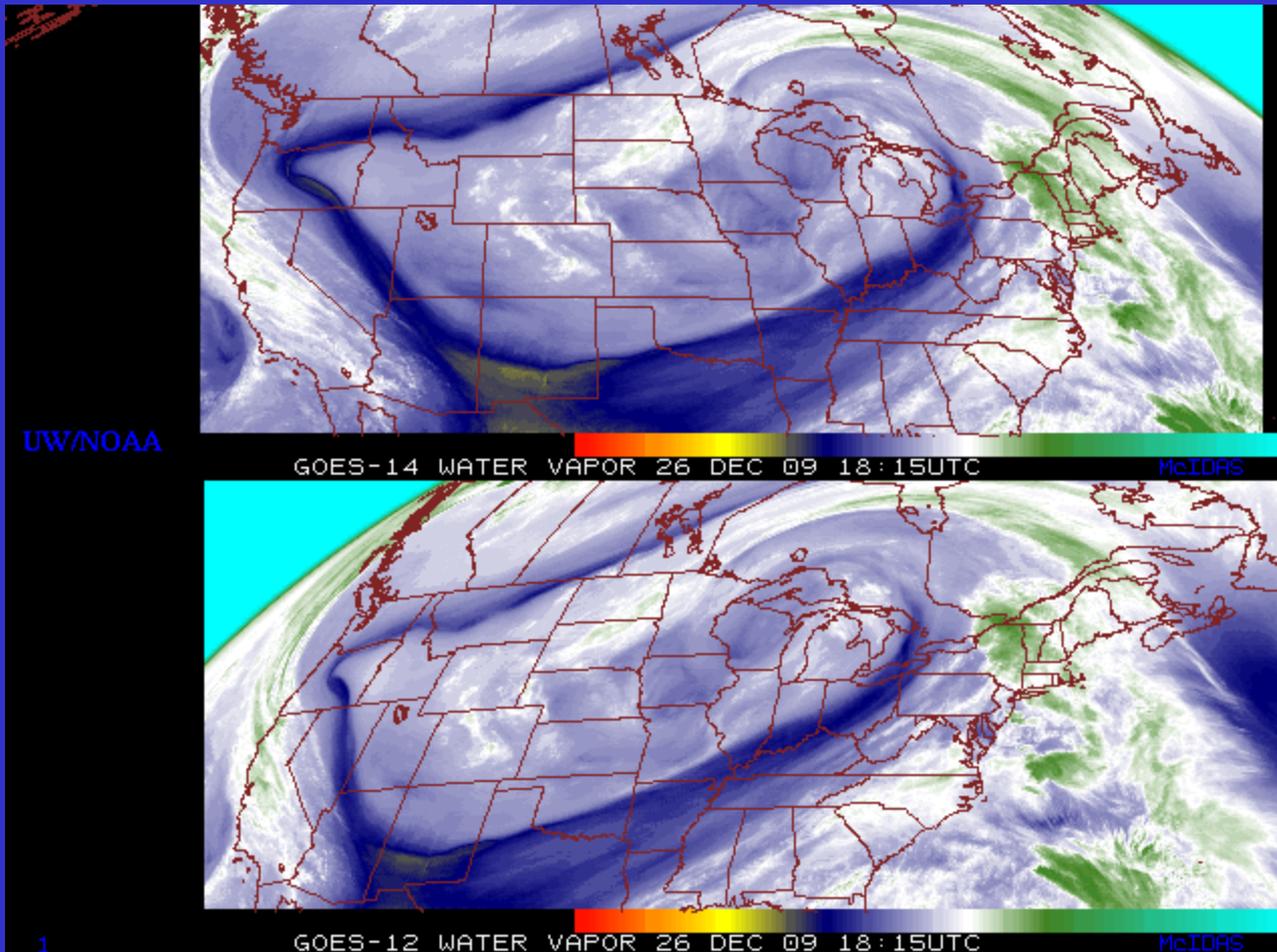


In 15 Minutes  
ABI (“Flex Mode”) will  
scan:

- 1 Full Disk Image
- 3 CONUS Images
- 30 Mesoscale Images



# GOES-14: Sample “5-min” imagery

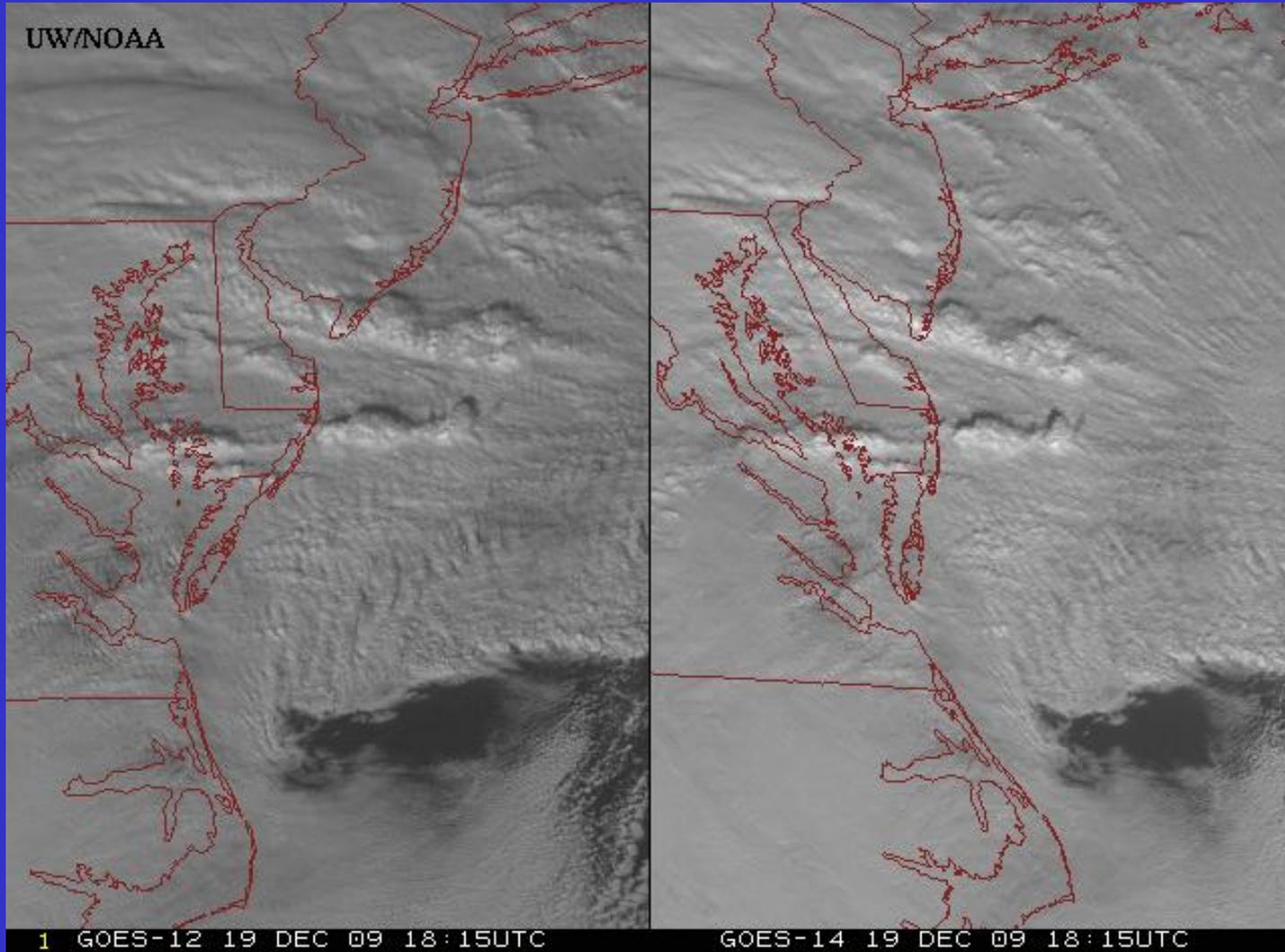


GOES-14

GOES-12

“Water vapor” data from the GOES-14 NOAA Science Test, lead by Hillger and Schmit

# GOES-14: Sample "1-min" imagery

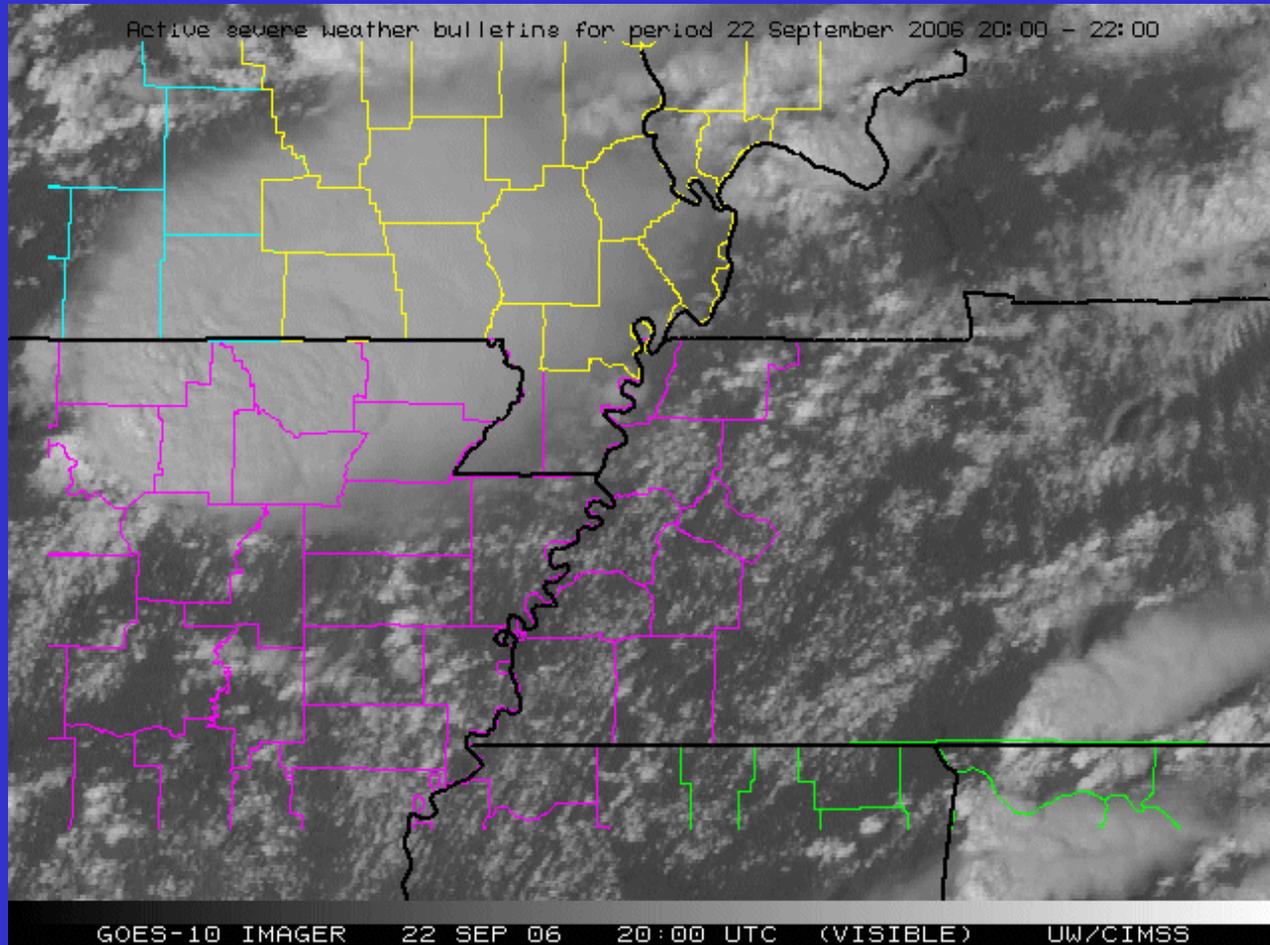


GOES-12

GOES-14

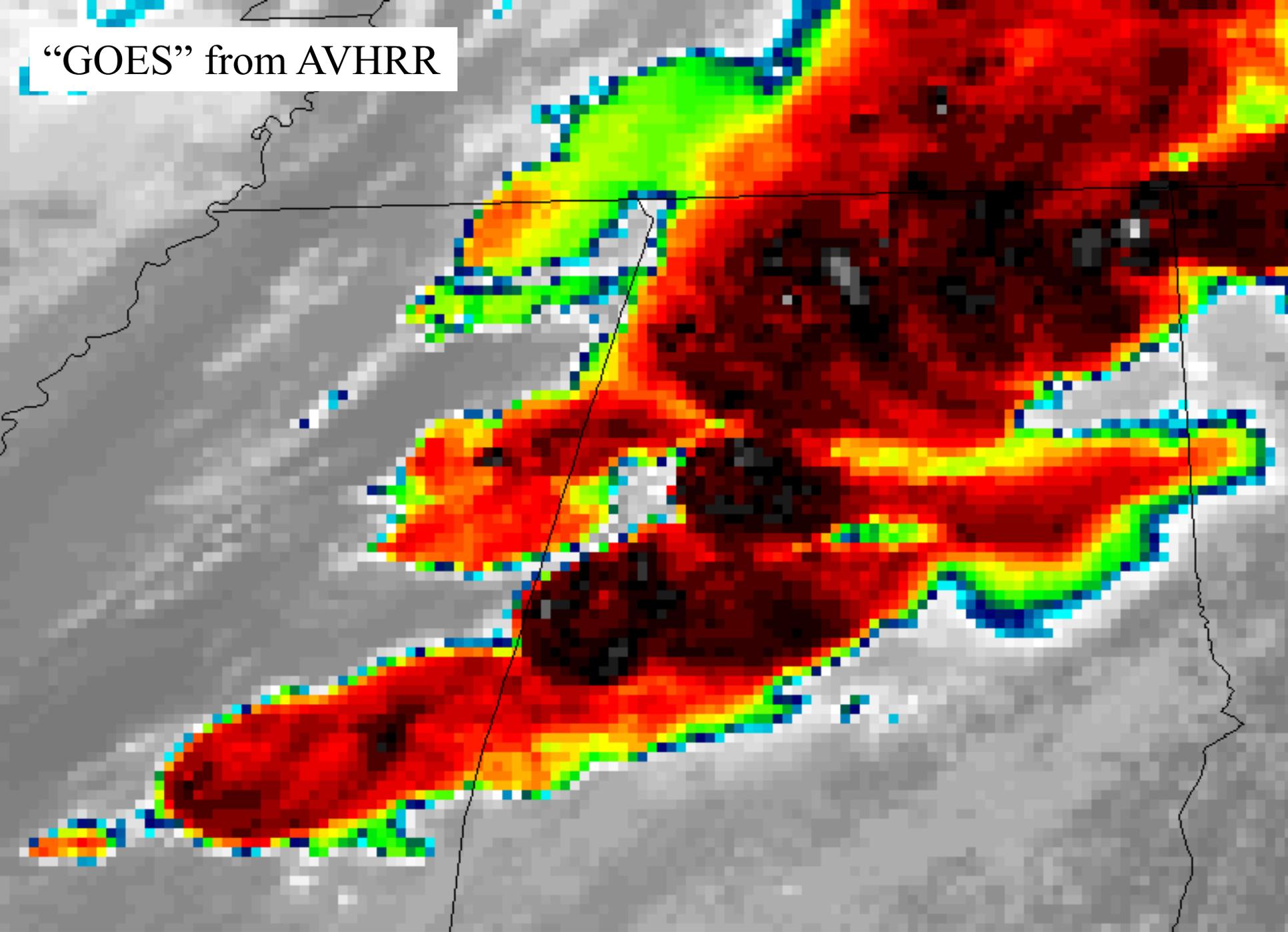
Visible data from the GOES-14 NOAA Science Test, lead by Hillger and Schmit

# GOES-10: Experimental 1-min data



Experimental 1-minute GOES-10 visible data provided a rapid assessment of the current state of the atmosphere over western Tennessee, and indicated that although there was some development of the cumulus clouds, the apparent TCUs did not appear to favor continued development. Hence, the odds of strong convection developing over that area would be lower during the next several hours.

“GOES” from AVHRR



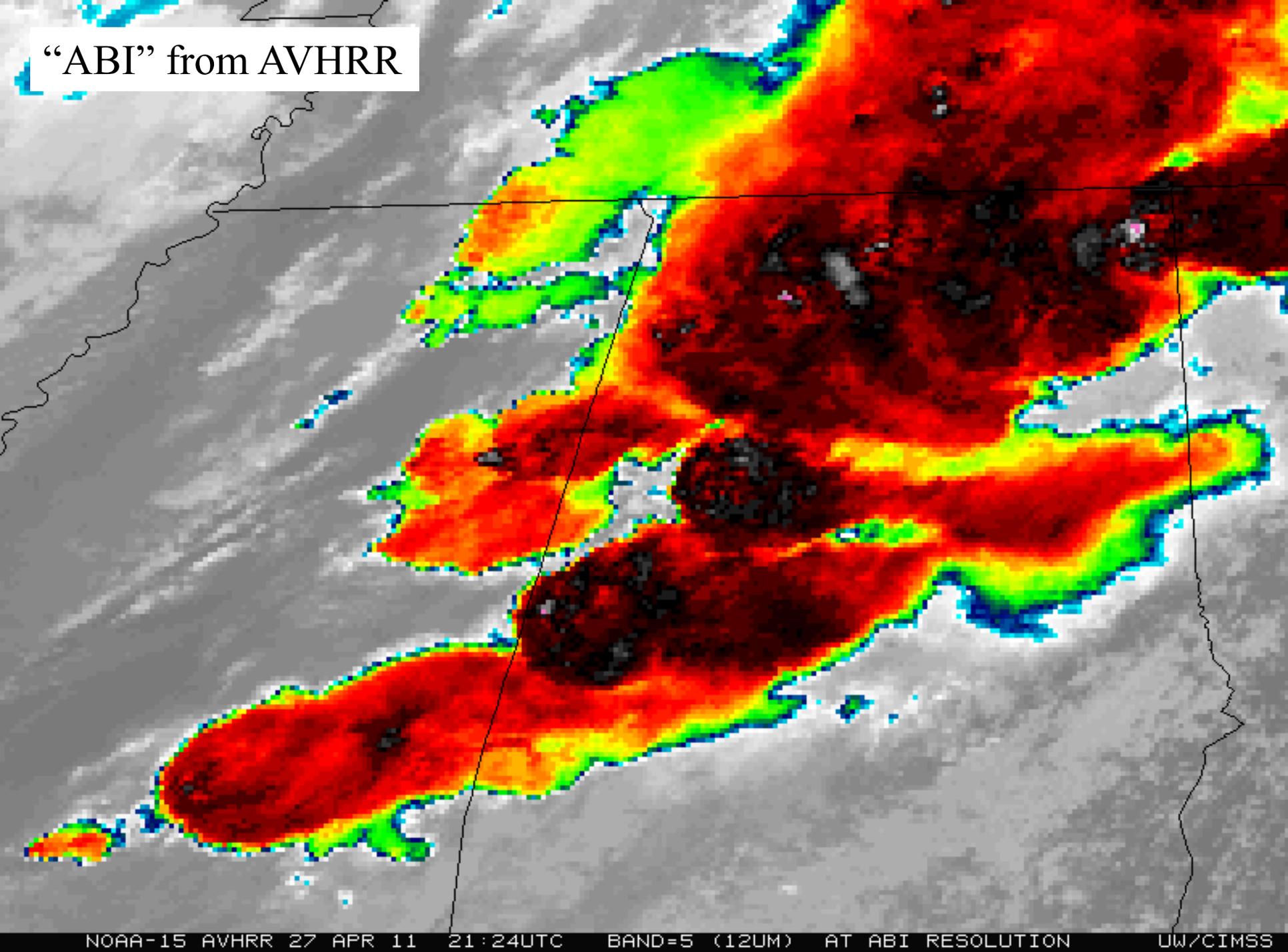
NOAA-15 AVHRR 27 APR 11 21:24UTC

BAND=5 (12UM)

AT GOES RESOLUTION

UW/CIMSS

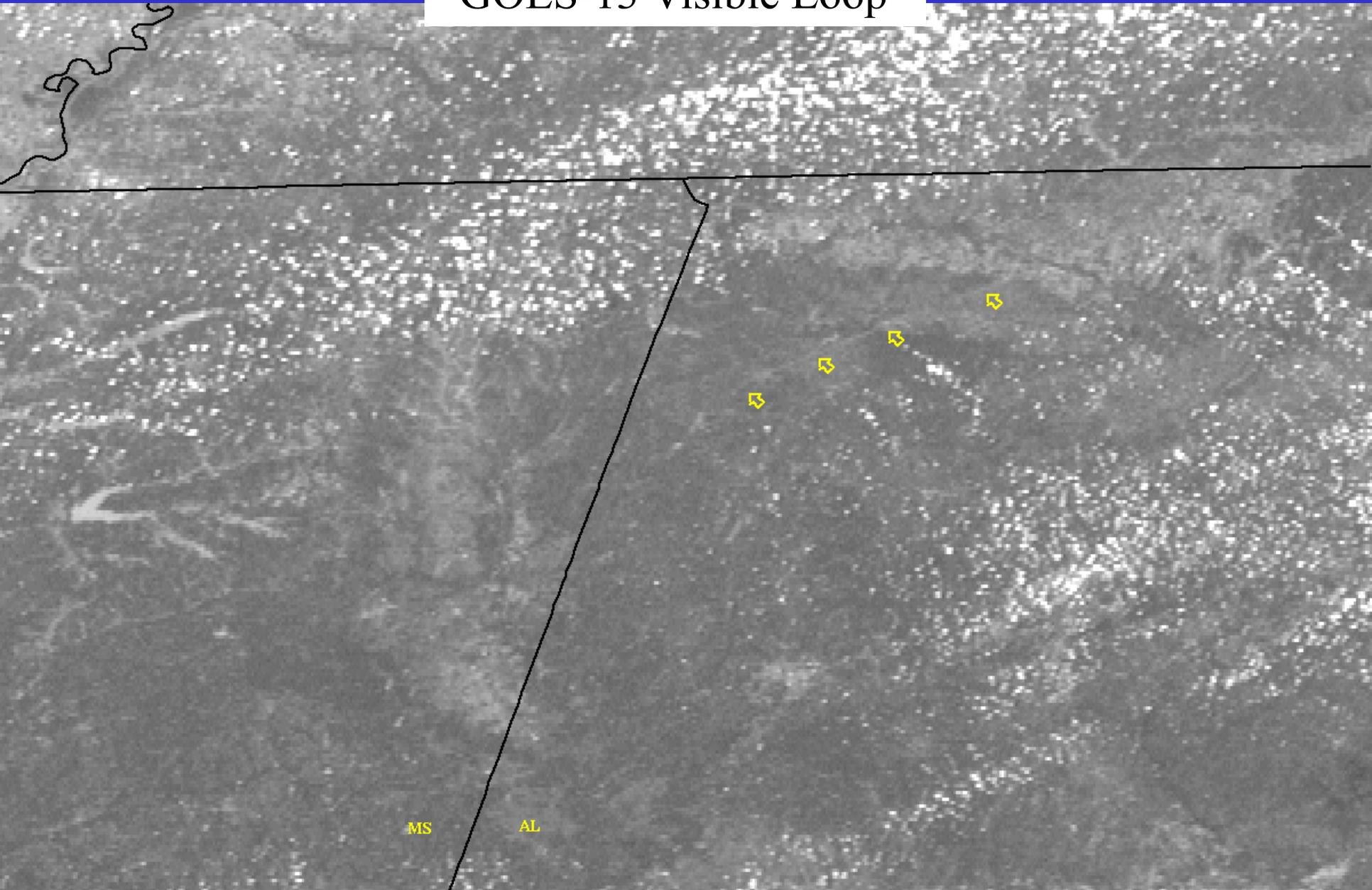
“ABI” from AVHRR



NOAA-15 AVHRR 27 APR 11 21:24UTC BAND=5 (12UM) AT ABI RESOLUTION

UW/CIMSS

# “GOES-13 Visible Loop”



MS

AL

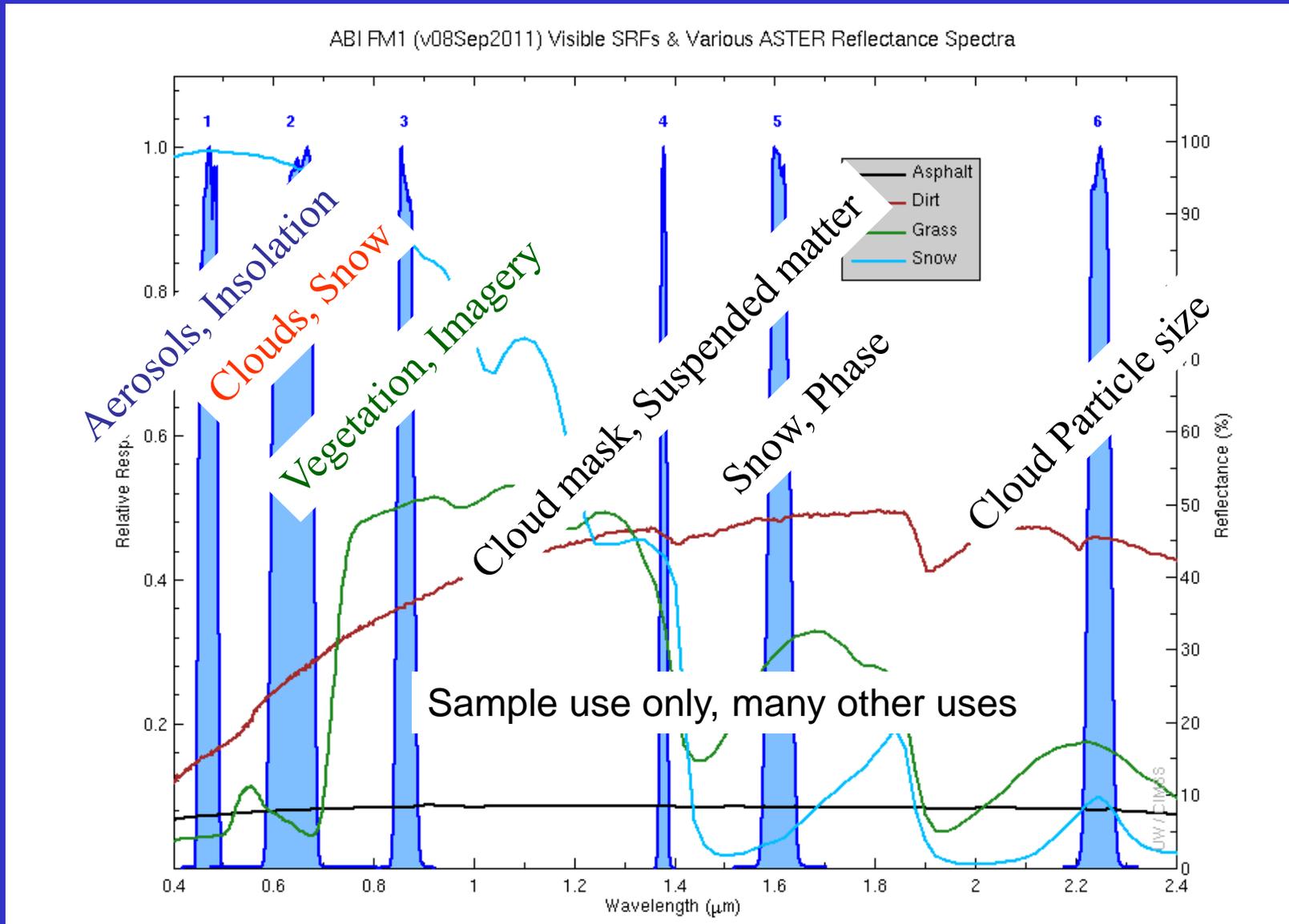
# ABI Visible/Near-IR Bands

Future GOES imager (ABI) band	Wavelength range ( $\mu\text{m}$ )	Central wavelength ( $\mu\text{m}$ )	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 <sub>2</sub>
11	8.3–8.7	8.5	2	Total water for stability, cloud phase, dust, SO <sub>2</sub> 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

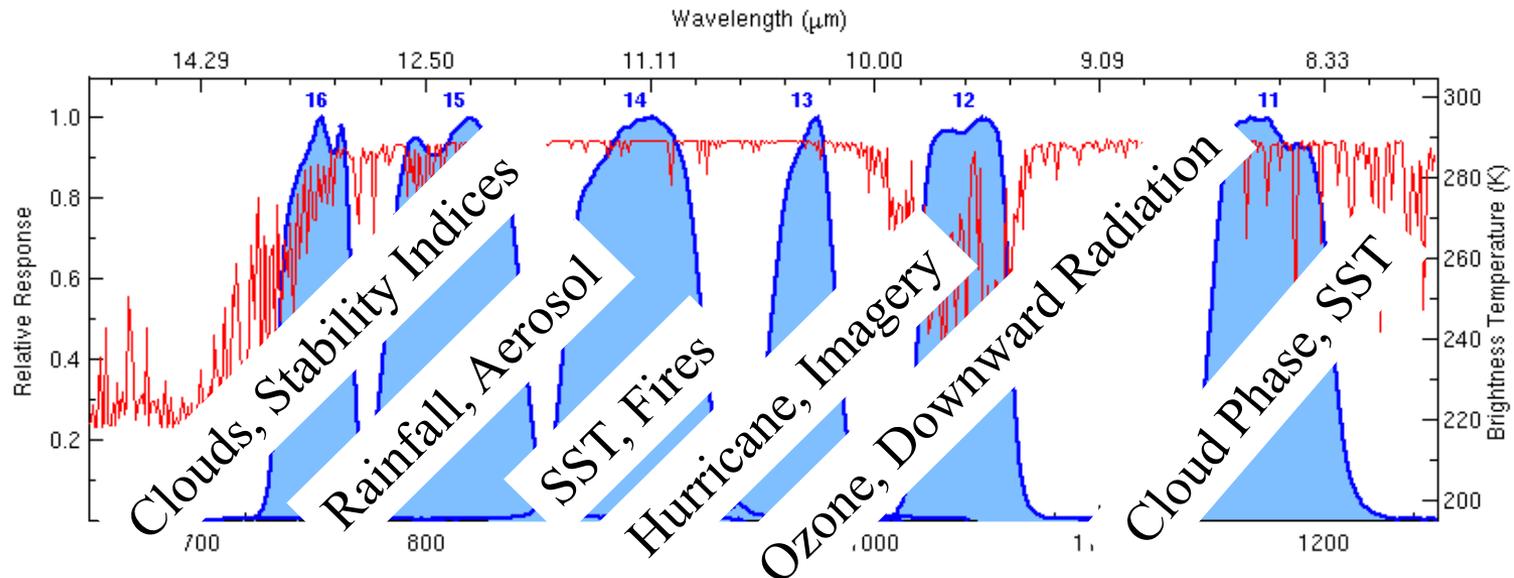
# Visible and near-IR channels on the ABI



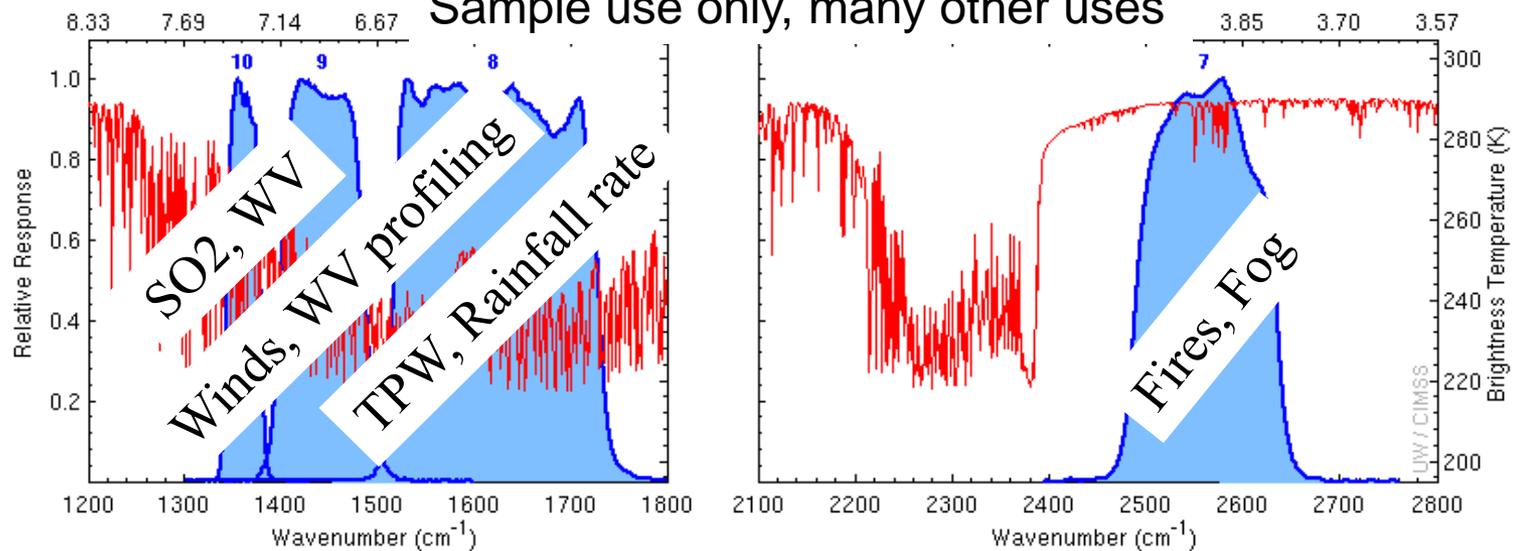
The ABI visible and near-IR bands have many uses.

# The IR channels on the ABI

ABI FM1 (v08Sep2011) SRFs & US Std Atms Brightness Temperature Spectrum

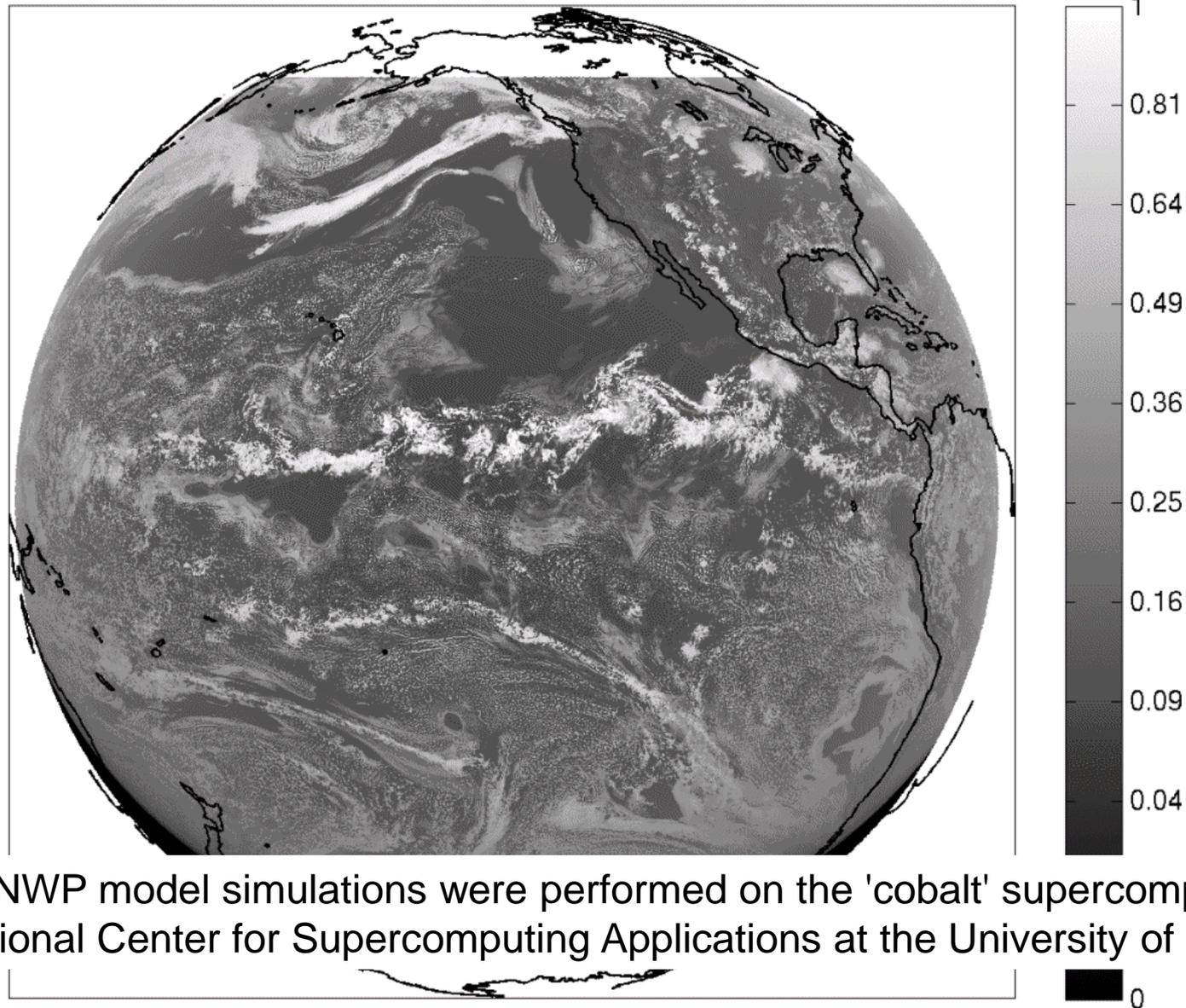


Sample use only, many other uses



ABI has many more bands than the current operational GOES imagers.

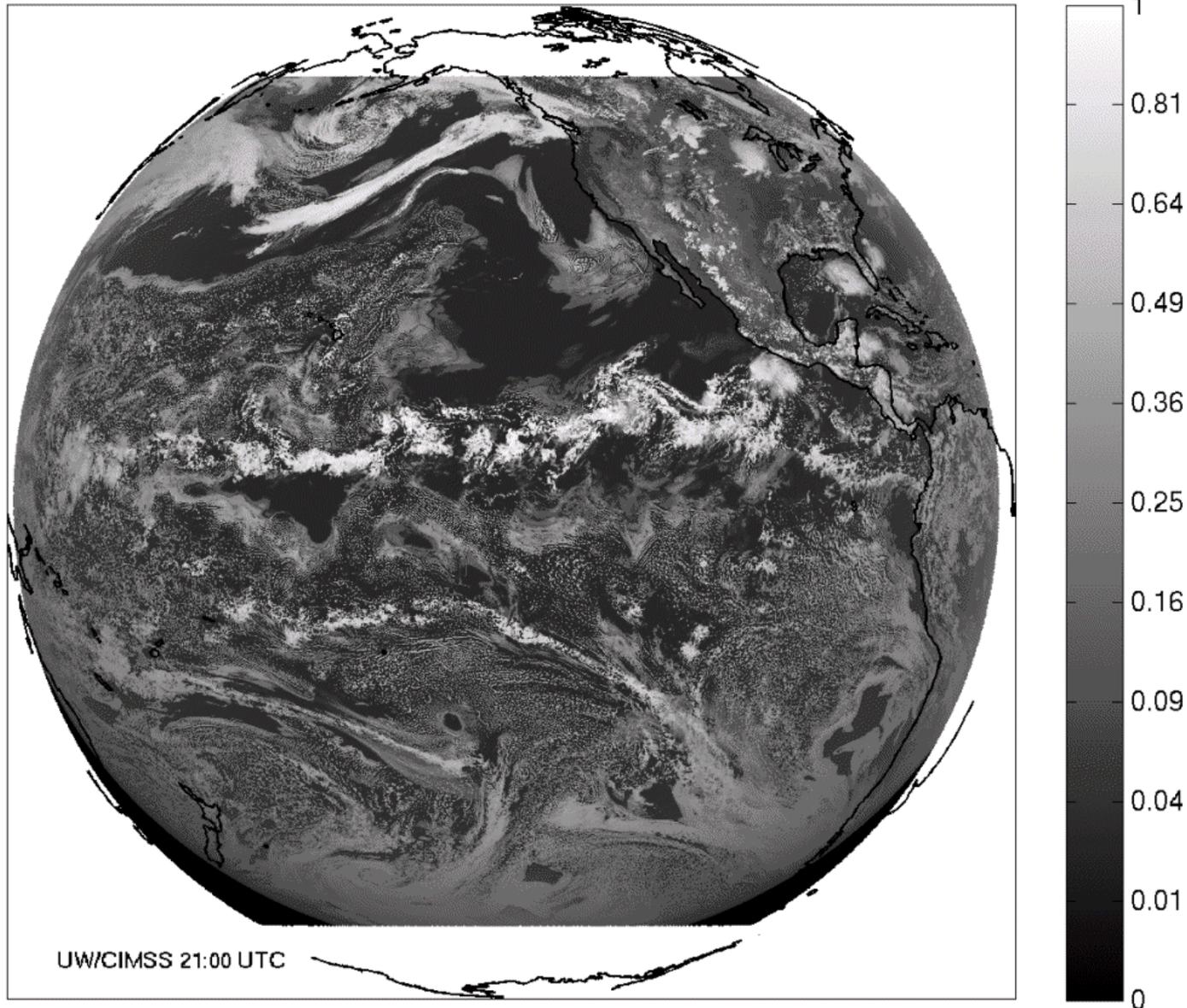
# ABI band 1 (0.47 $\mu\text{m}$ ) reflectance 2008-06-26



These NWP model simulations were performed on the 'cobalt' supercomputer at the National Center for Supercomputing Applications at the University of Illinois.

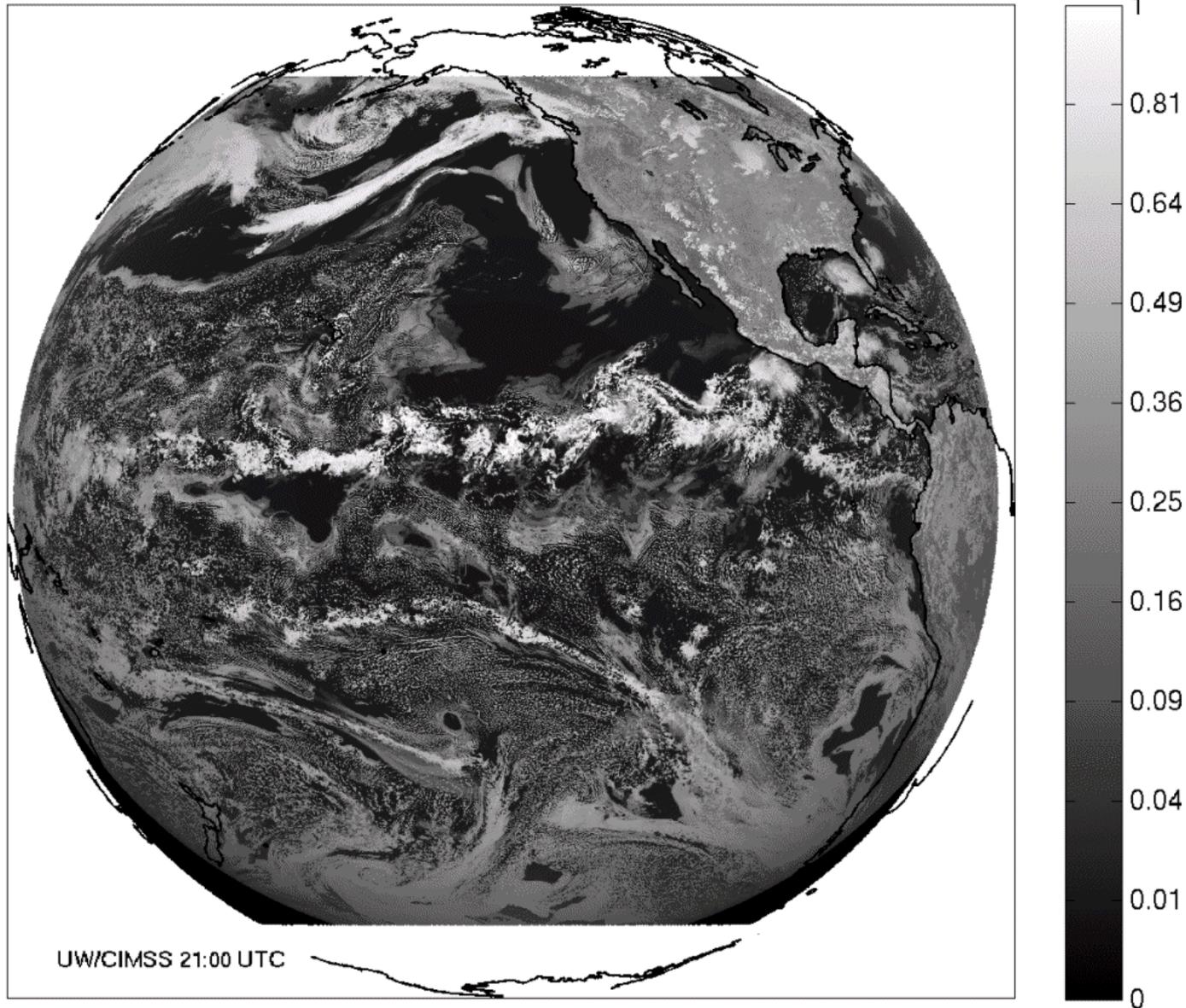
Band 1: Daytime "Blue" band -- aerosols

ABI band 2 (0.64  $\mu\text{m}$ ) reflectance 2008-06-26



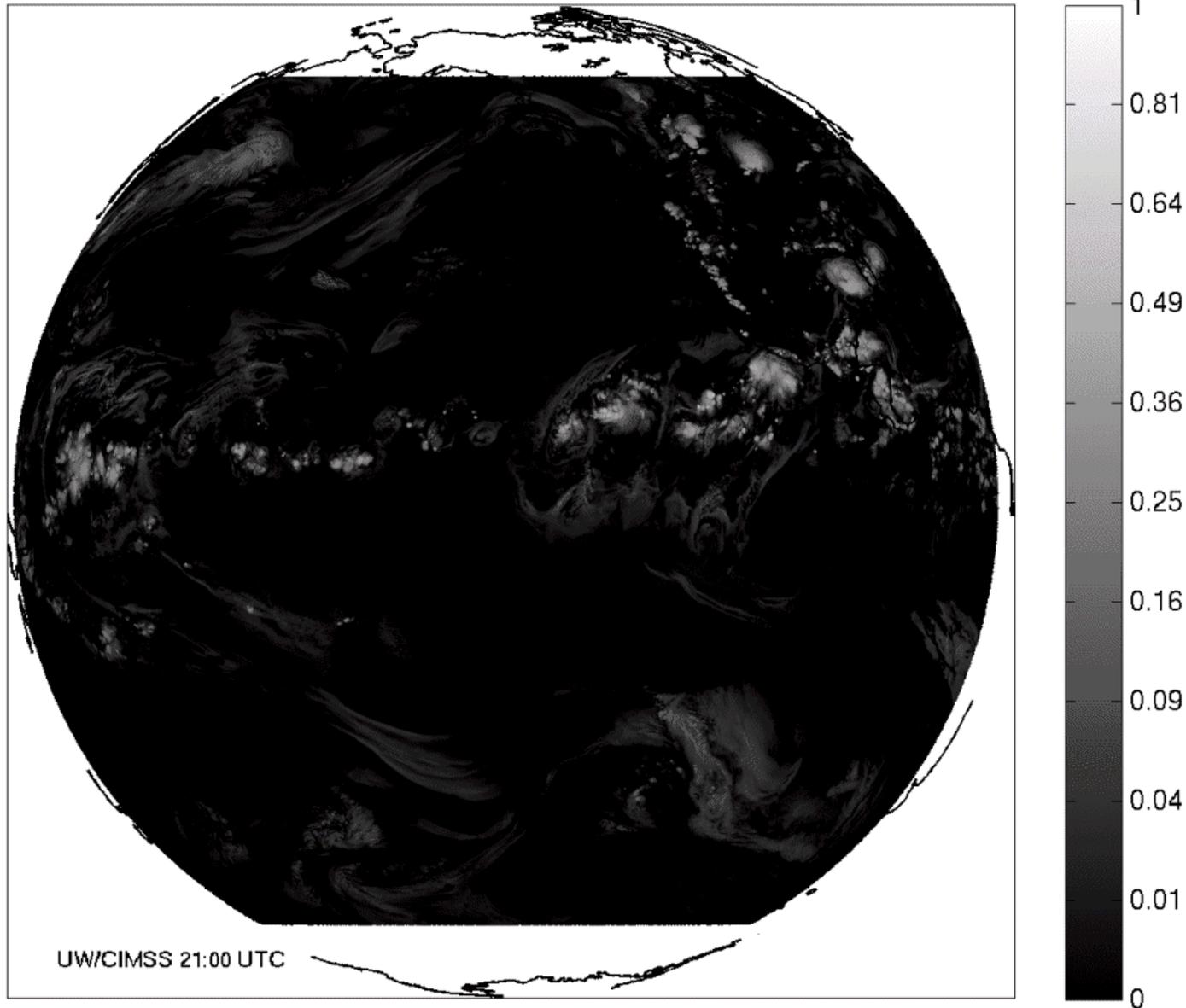
Band 2: Daytime “Red” band – clouds, etc.

ABI band 3 (0.87  $\mu\text{m}$ ) reflectance 2008-06-26



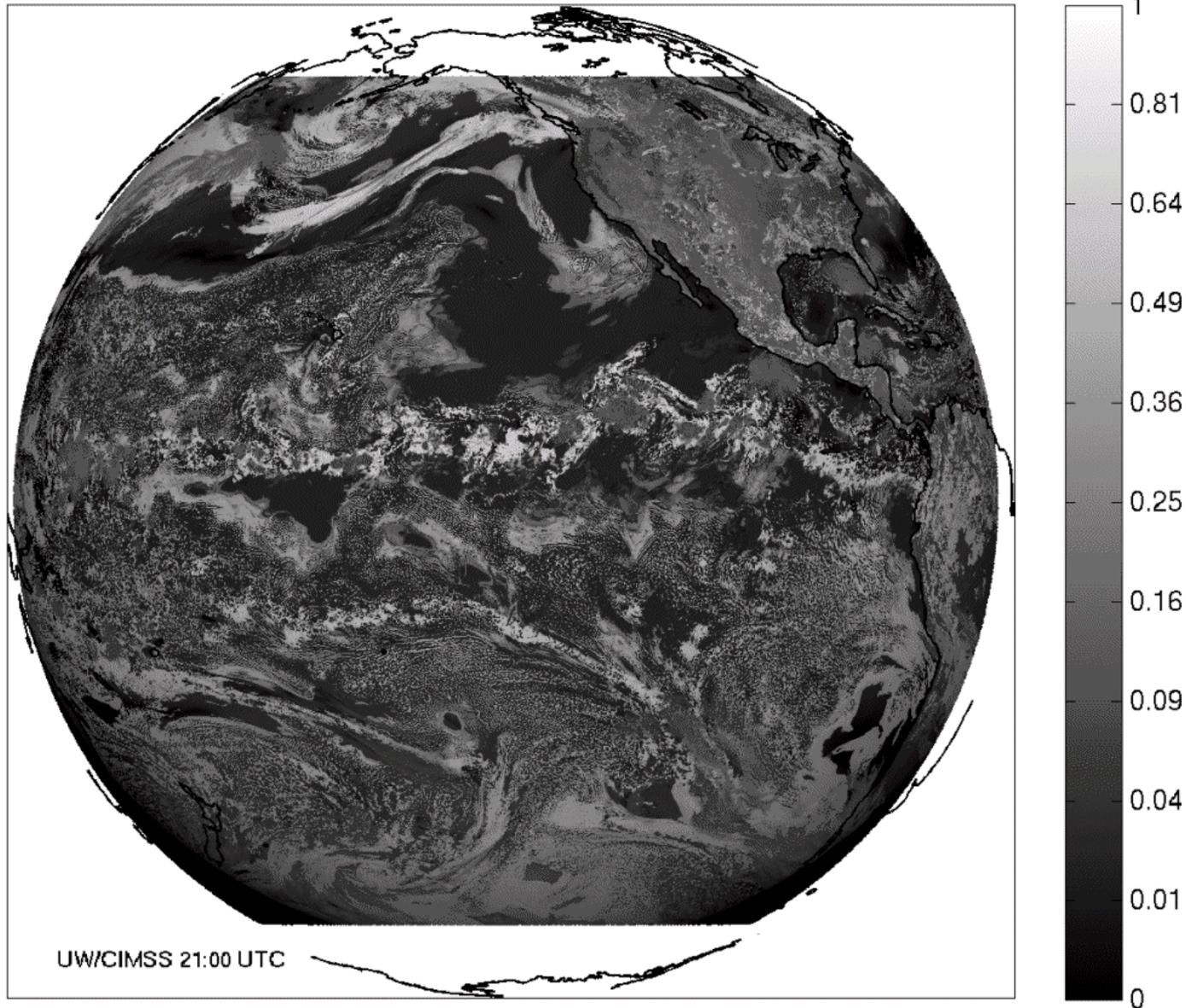
Band 3: Daytime “Veggie” band

ABI band 4 (1.38  $\mu\text{m}$ ) reflectance 2008-06-26



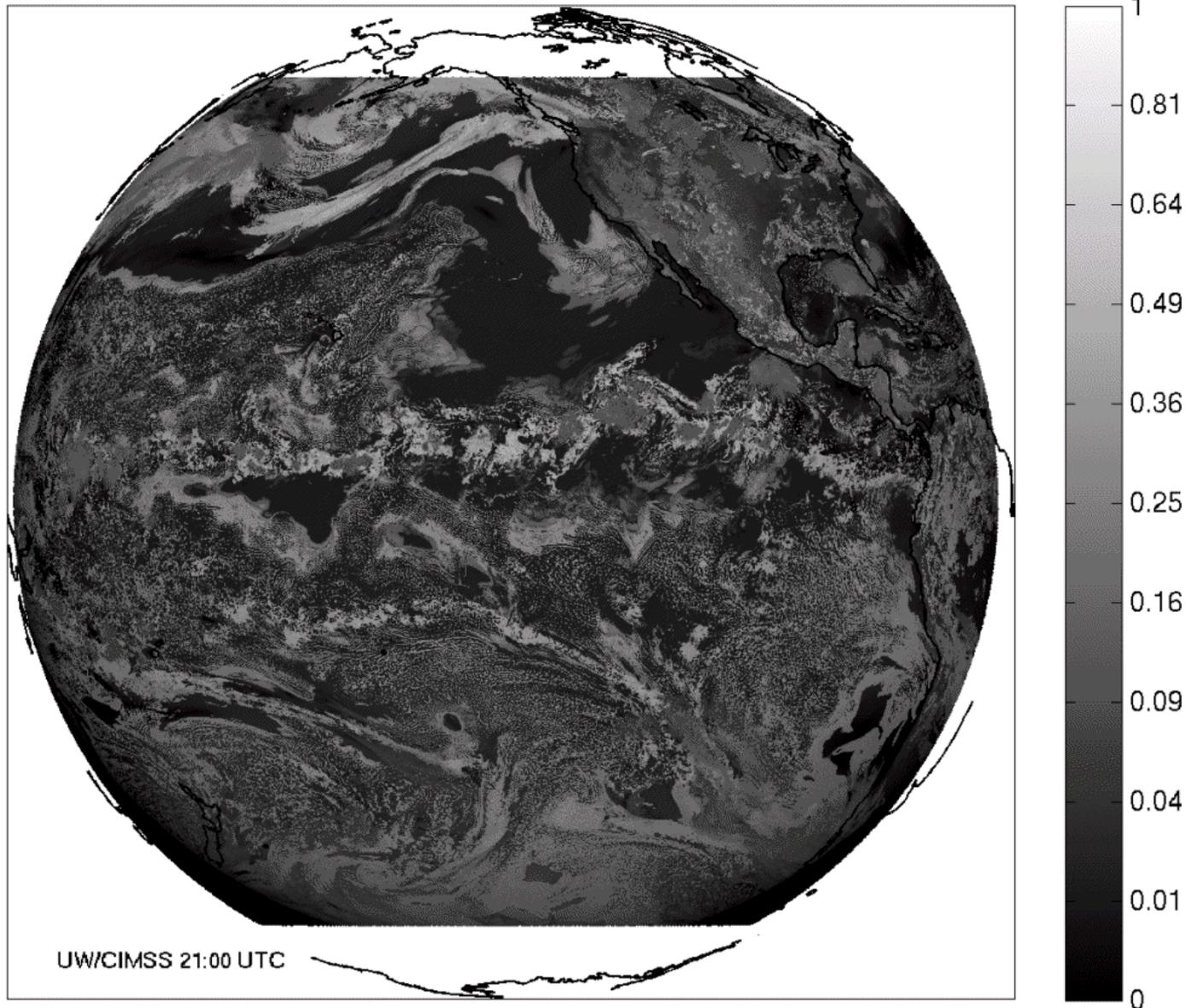
Band 4: Daytime "Cirrus" band

ABI band 5 (1.61  $\mu\text{m}$ ) reflectance 2008-06-26



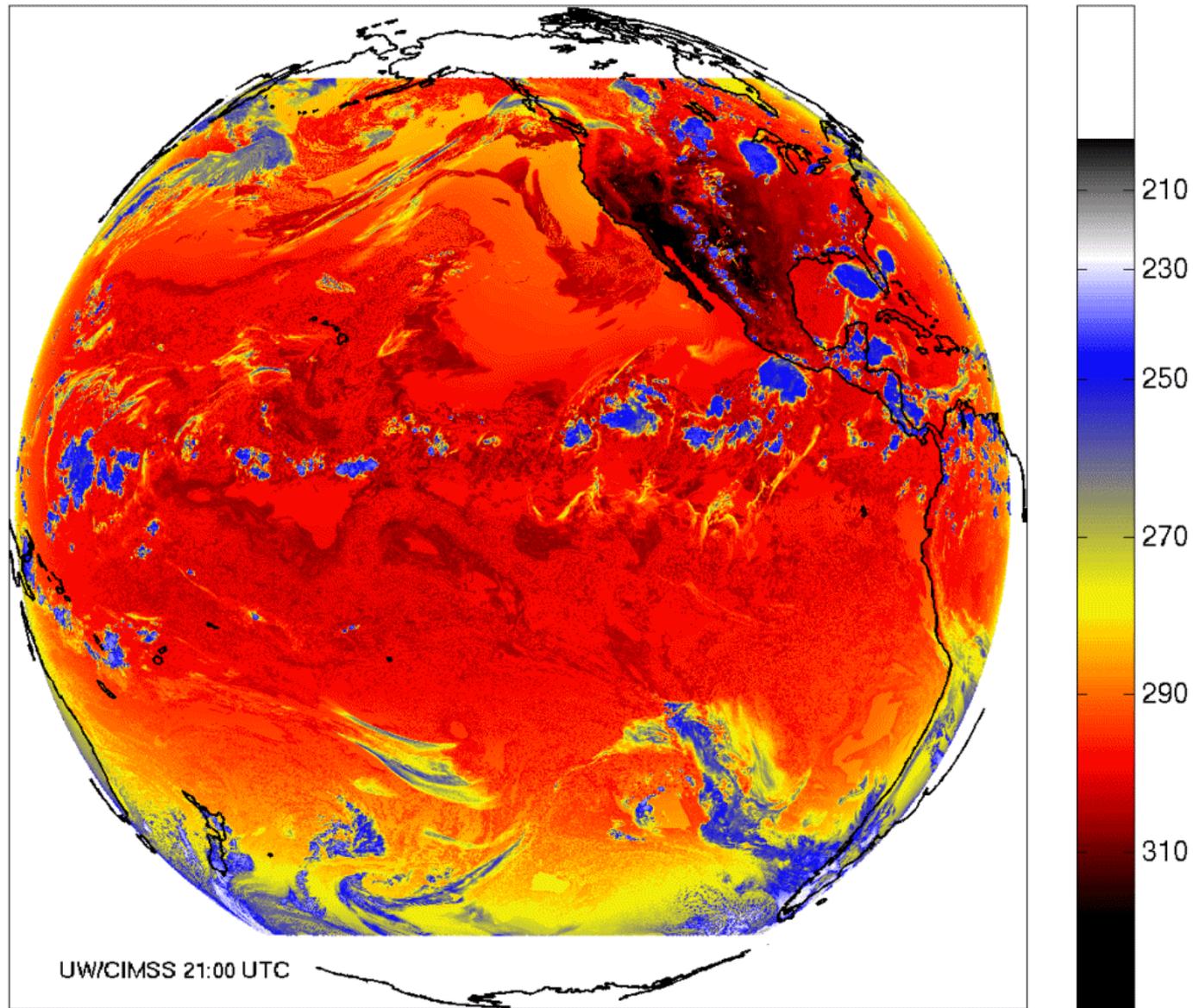
Band 5: Daytime "Snow" band

# ABI band 6 (2.25 $\mu\text{m}$ ) reflectance 2008-06-26



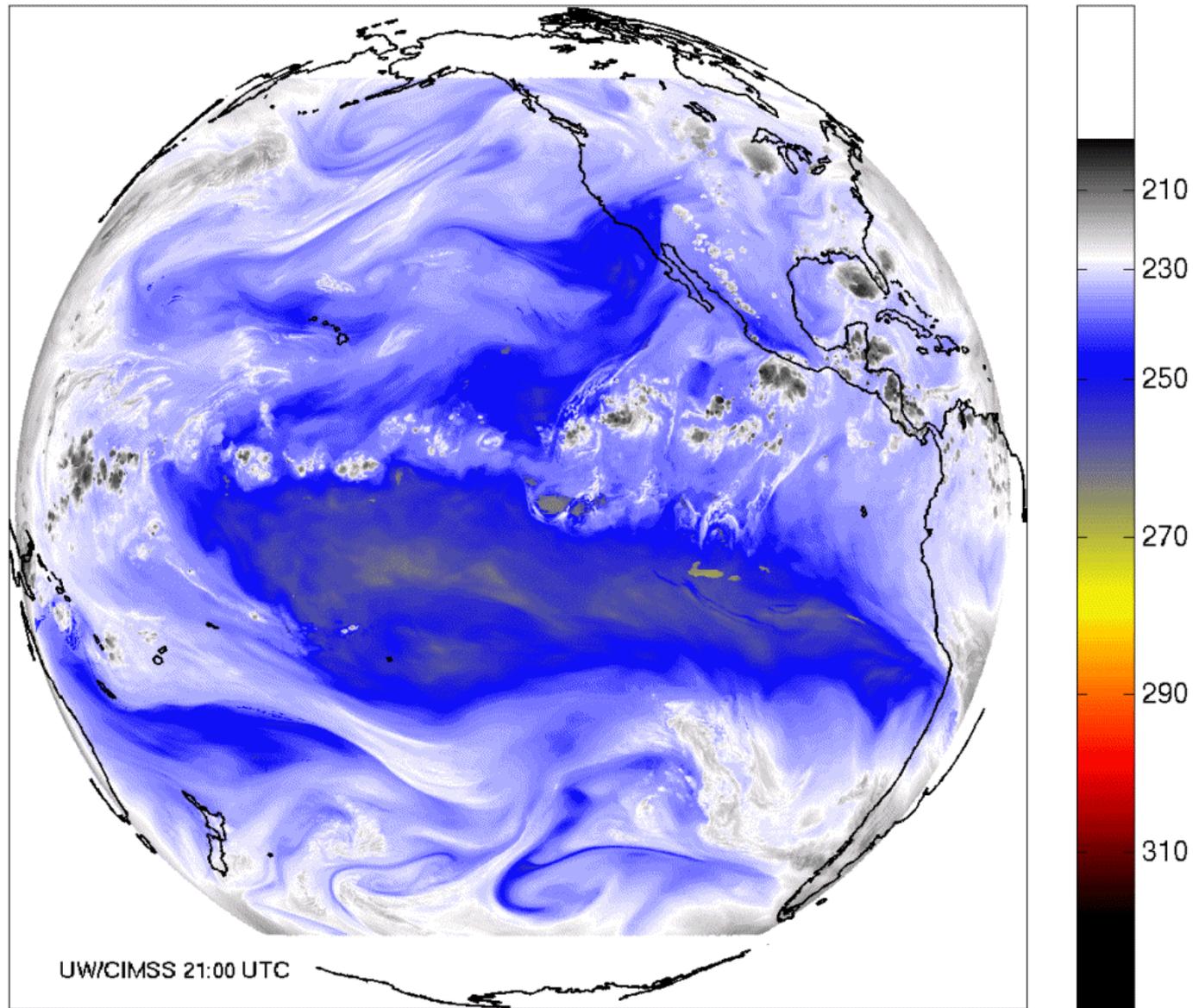
Band 6: Daytime “Cloud-top phase” band

ABI band 7 (3.90  $\mu\text{m}$ ) BT (K) 2008-06-26



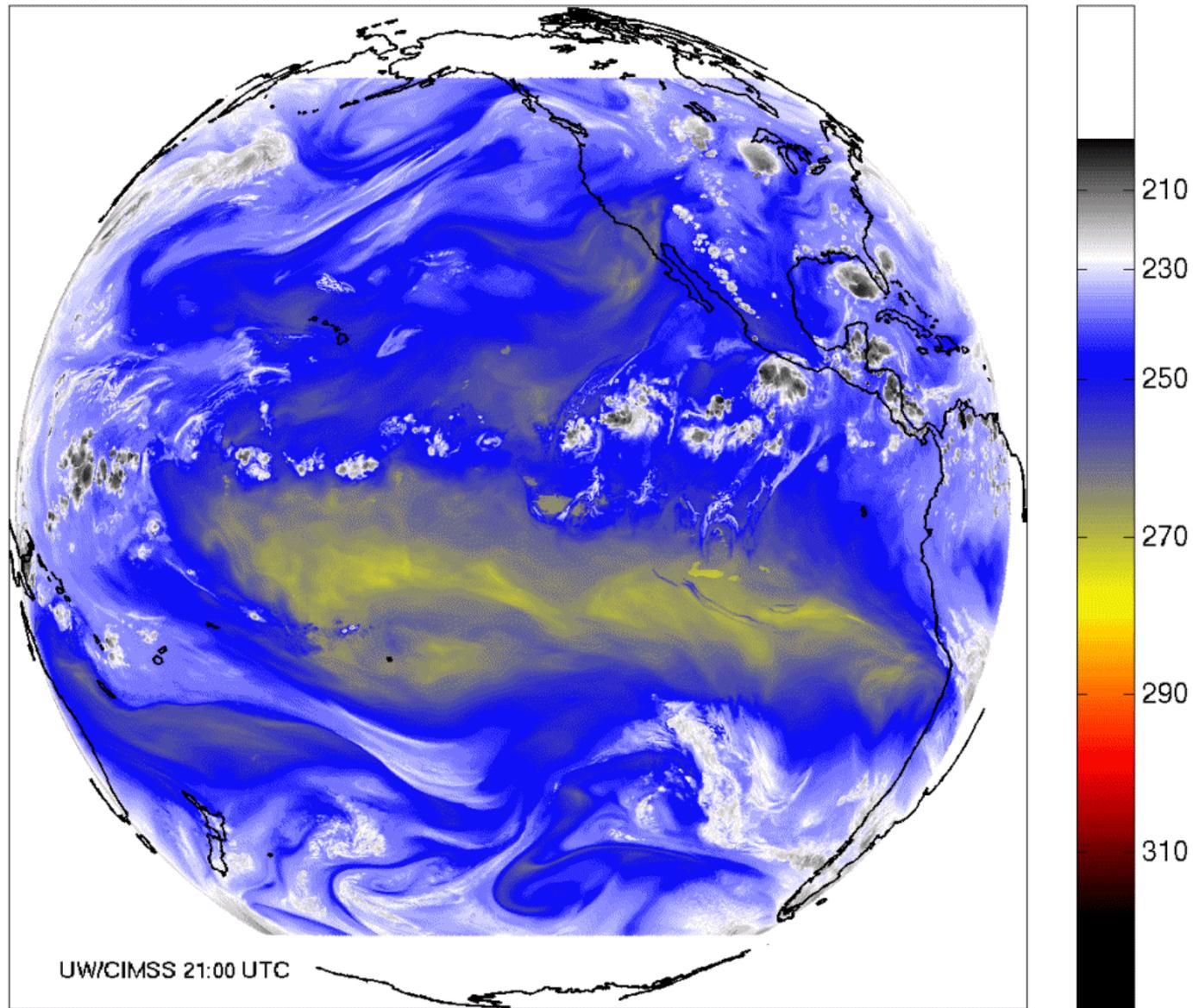
Band 7: Shortwave IR window band - fog, fires, etc.

ABI band 8 (6.19  $\mu\text{m}$ ) BT (K) 2008-06-26



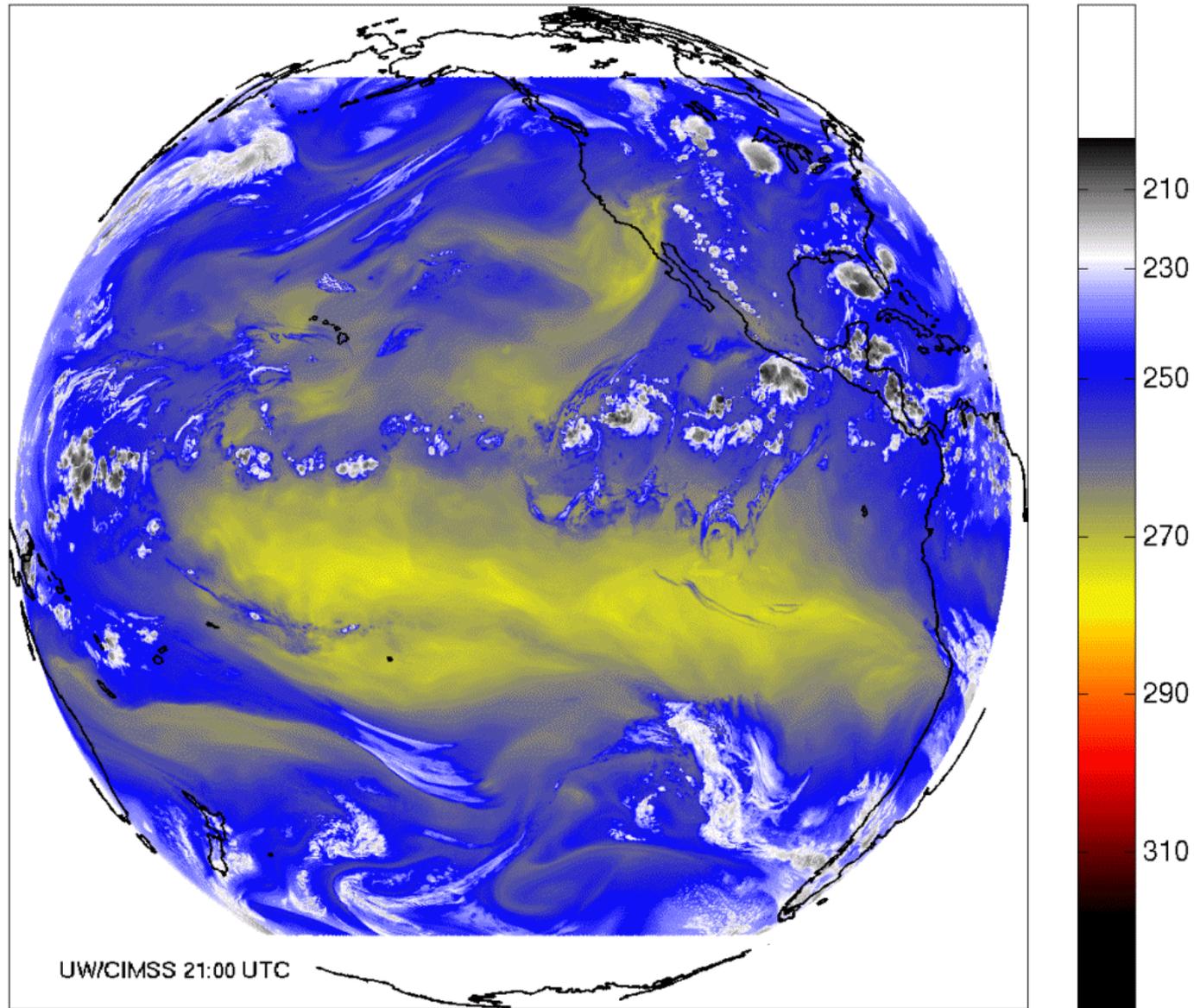
Band 8: Upper-level tropospheric water vapor band

ABI band 9 (6.95  $\mu\text{m}$ ) BT (K) 2008-06-26



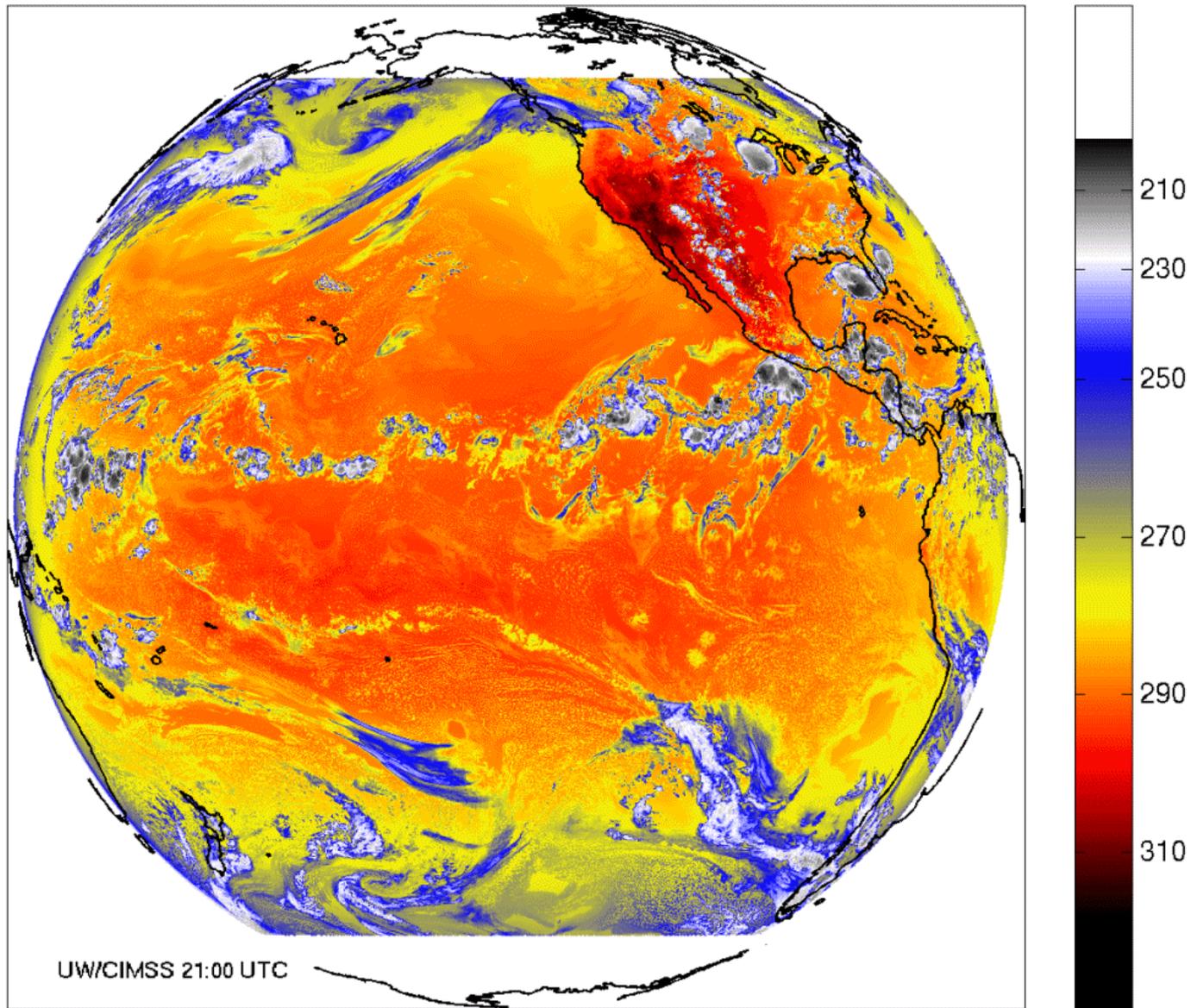
Band 9: Upper/mid-level tropospheric water vapor band

ABI band 10 (7.34  $\mu\text{m}$ ) BT (K) 2008-06-26



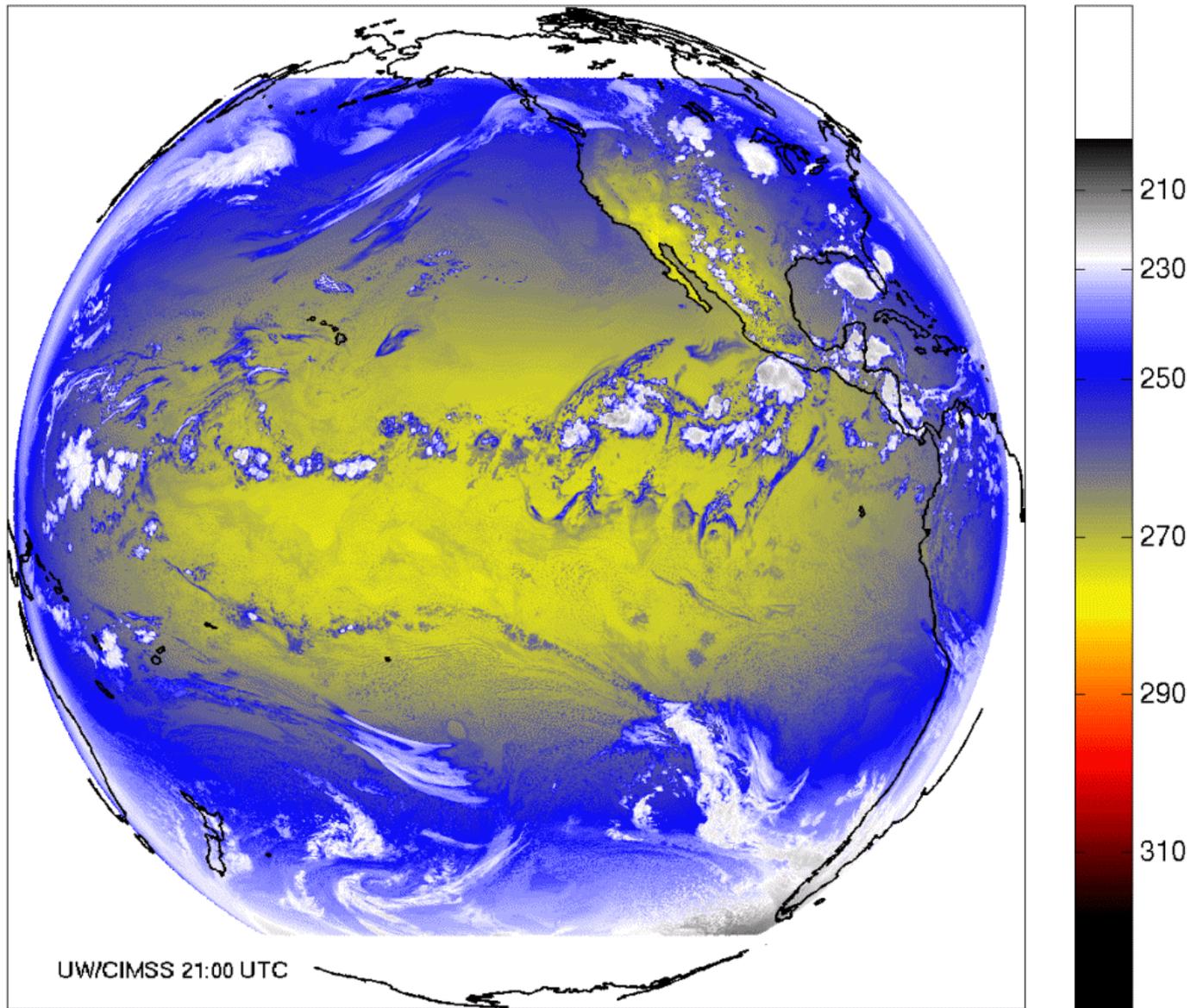
Band 10: Lower mid-level tropospheric water vapor band

ABI band 11 (8.5  $\mu\text{m}$ ) BT (K) 2008-06-26



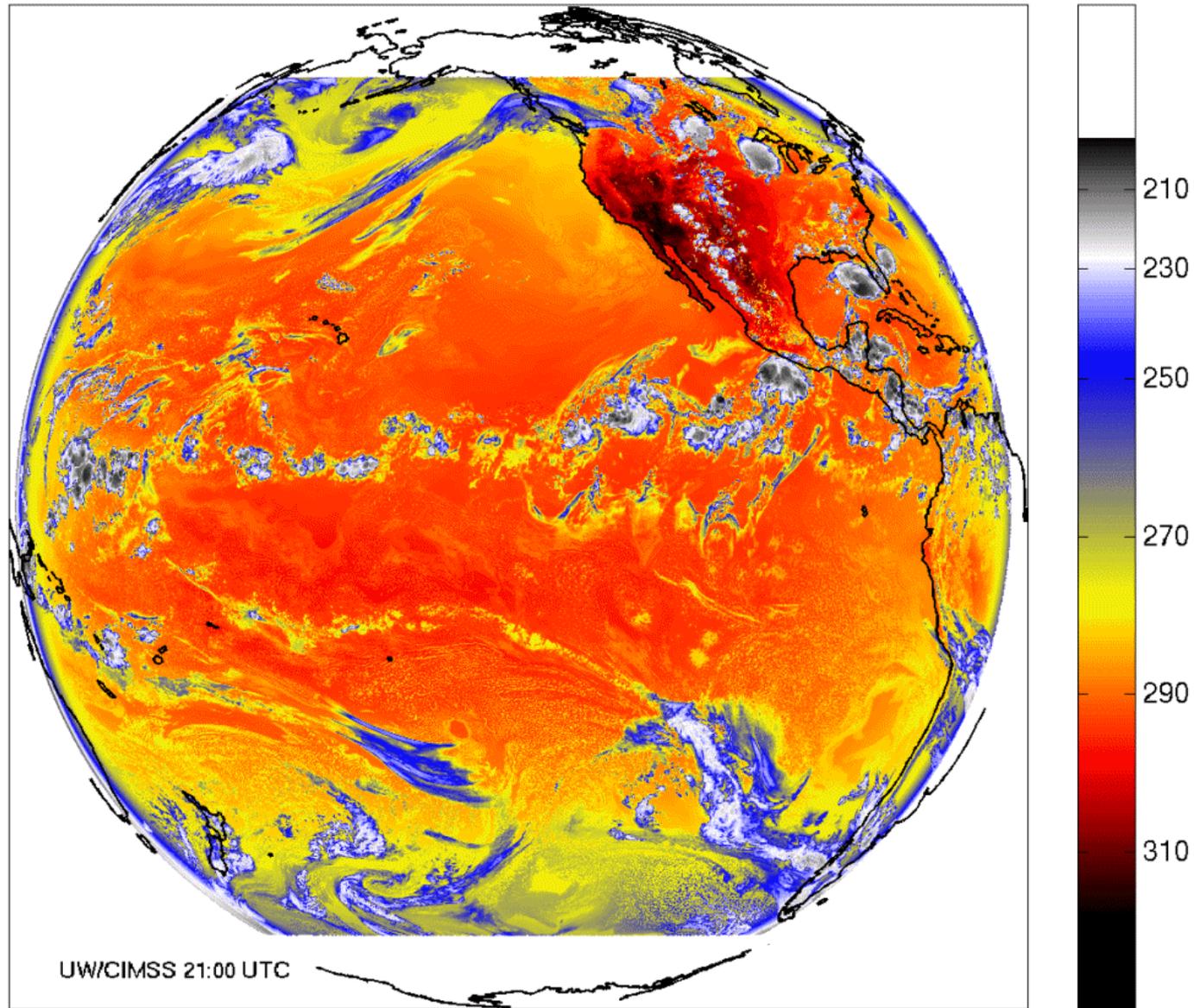
Band 11: "Cloud-top phase" band

ABI band 12 (9.6  $\mu\text{m}$ ) BT (K) 2008-06-26



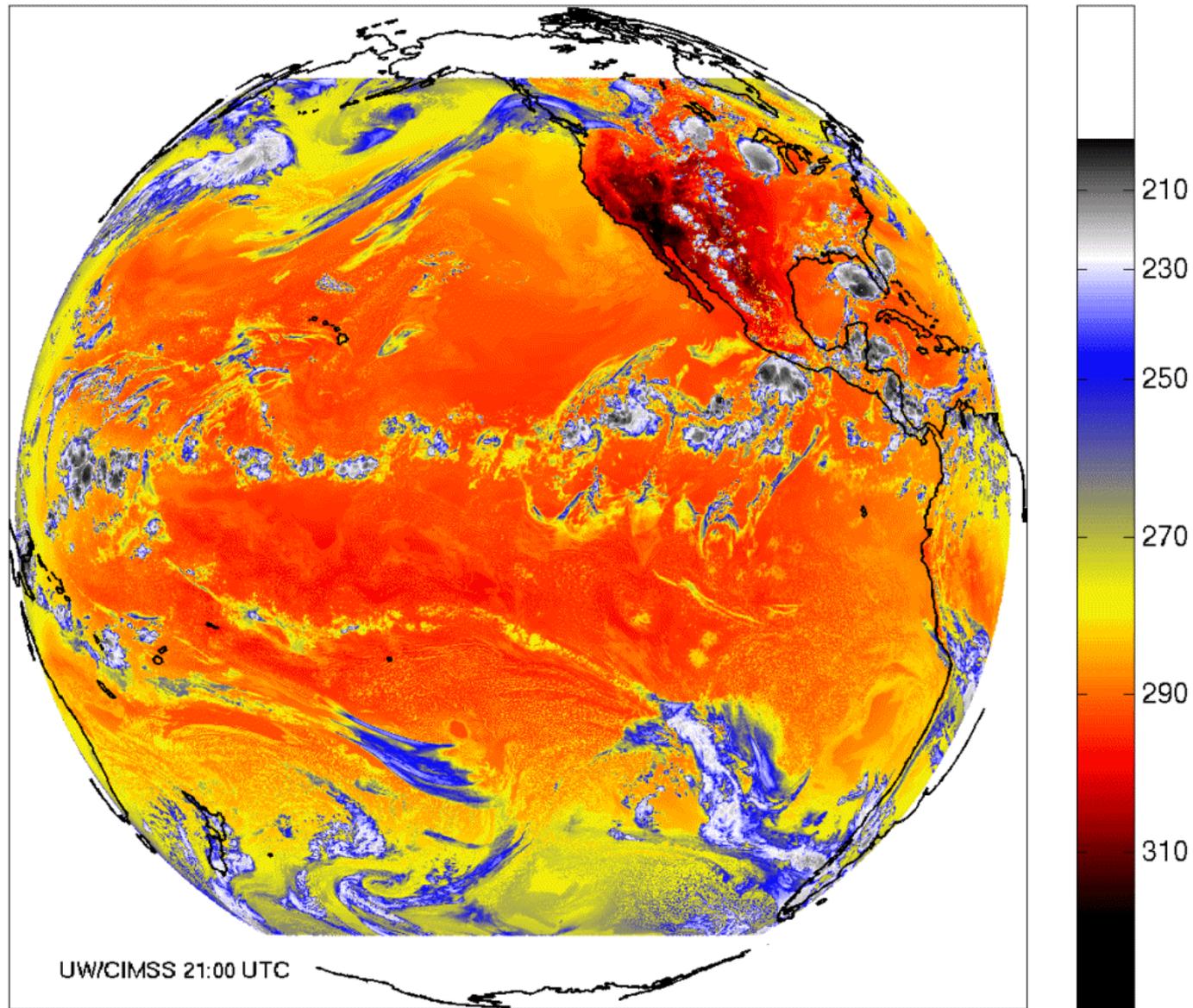
Band 12: "Ozone" band

ABI band 13 (10.4  $\mu\text{m}$ ) BT (K) 2008-06-26



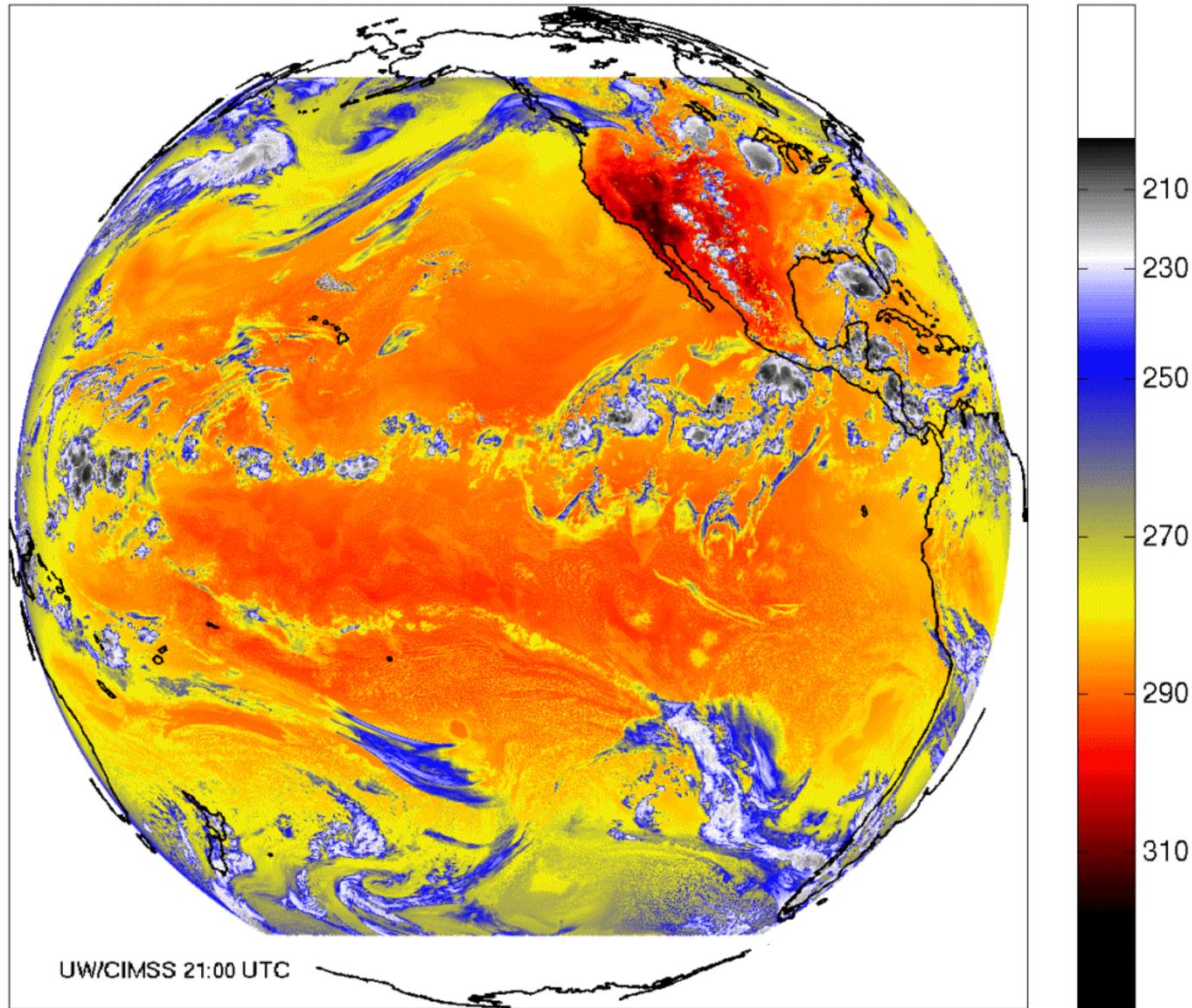
Band 13: "Clean" IR longwave window band

ABI band 14 (11.2  $\mu\text{m}$ ) BT (K) 2008-06-26



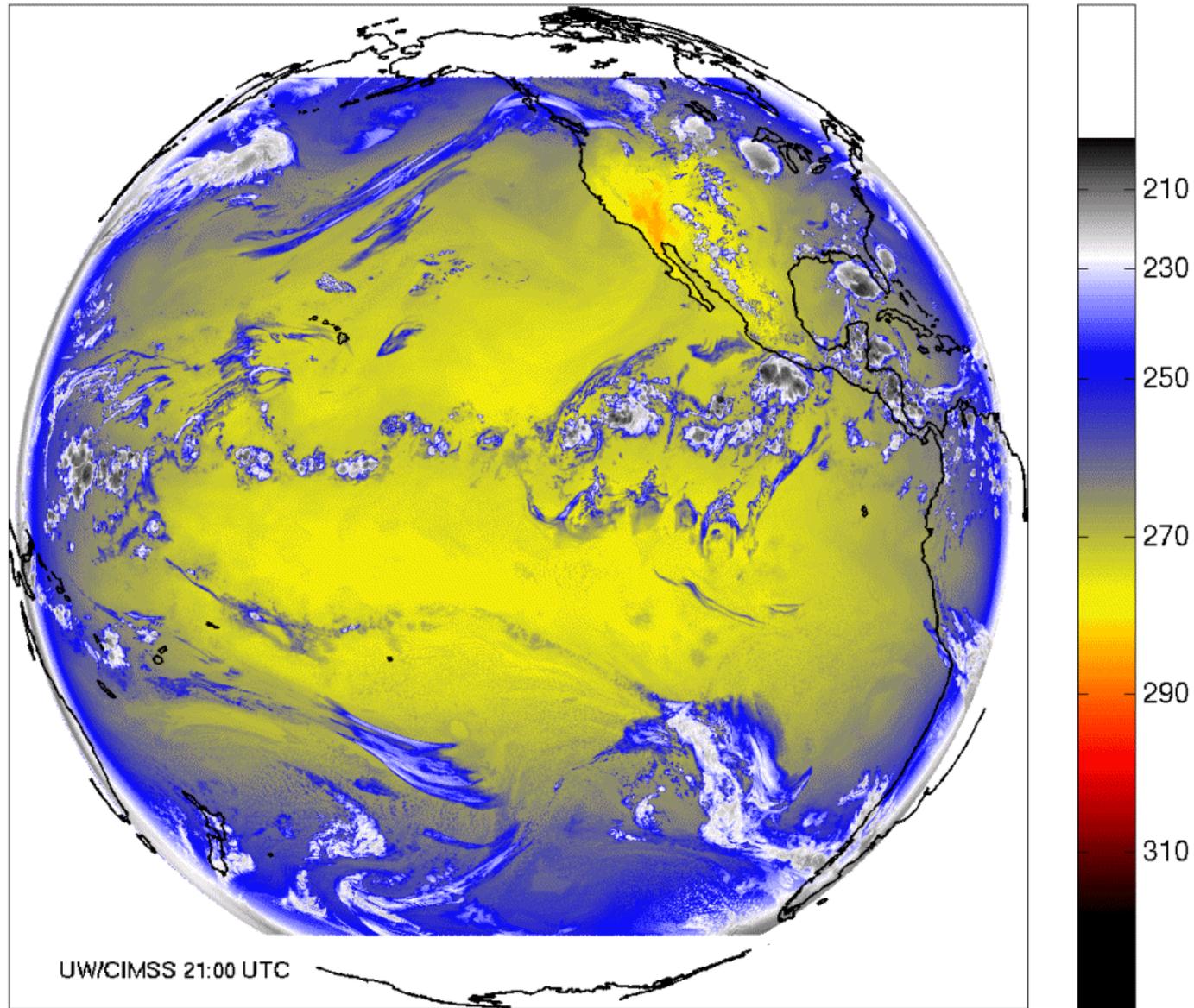
Band 14: IR longwave window band

ABI band 15 (12.3  $\mu\text{m}$ ) BT (K) 2008-06-26

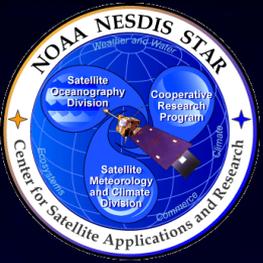


Band 15: "Dirty" IR longwave window band

ABI band 16 (13.3  $\mu\text{m}$ ) BT (K) 2008-06-26

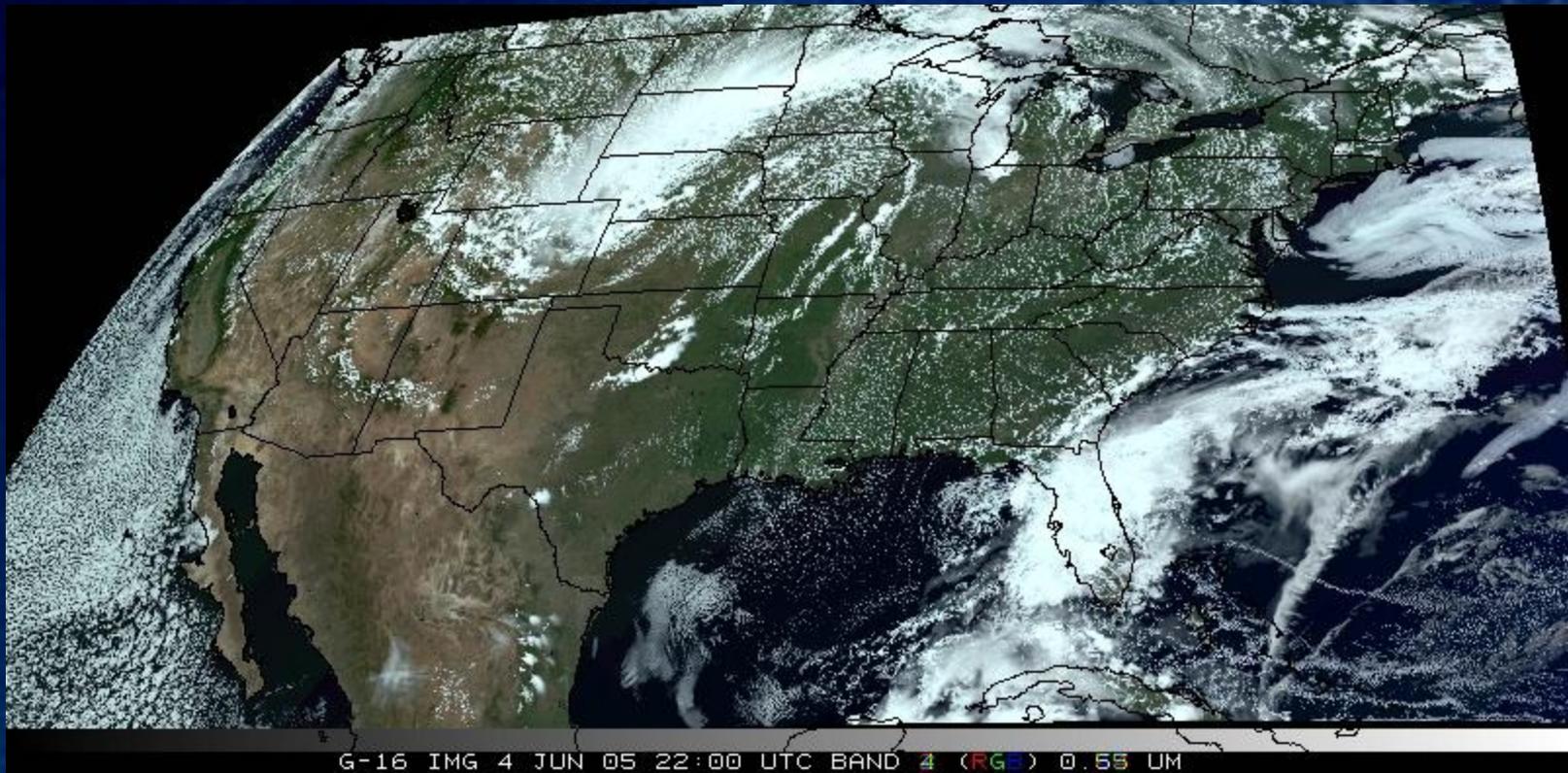


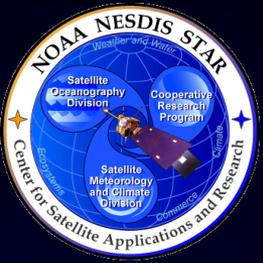
Band 16: "CO<sub>2</sub>" longwave IR band



# Visualization ("true color" as a decision aid")

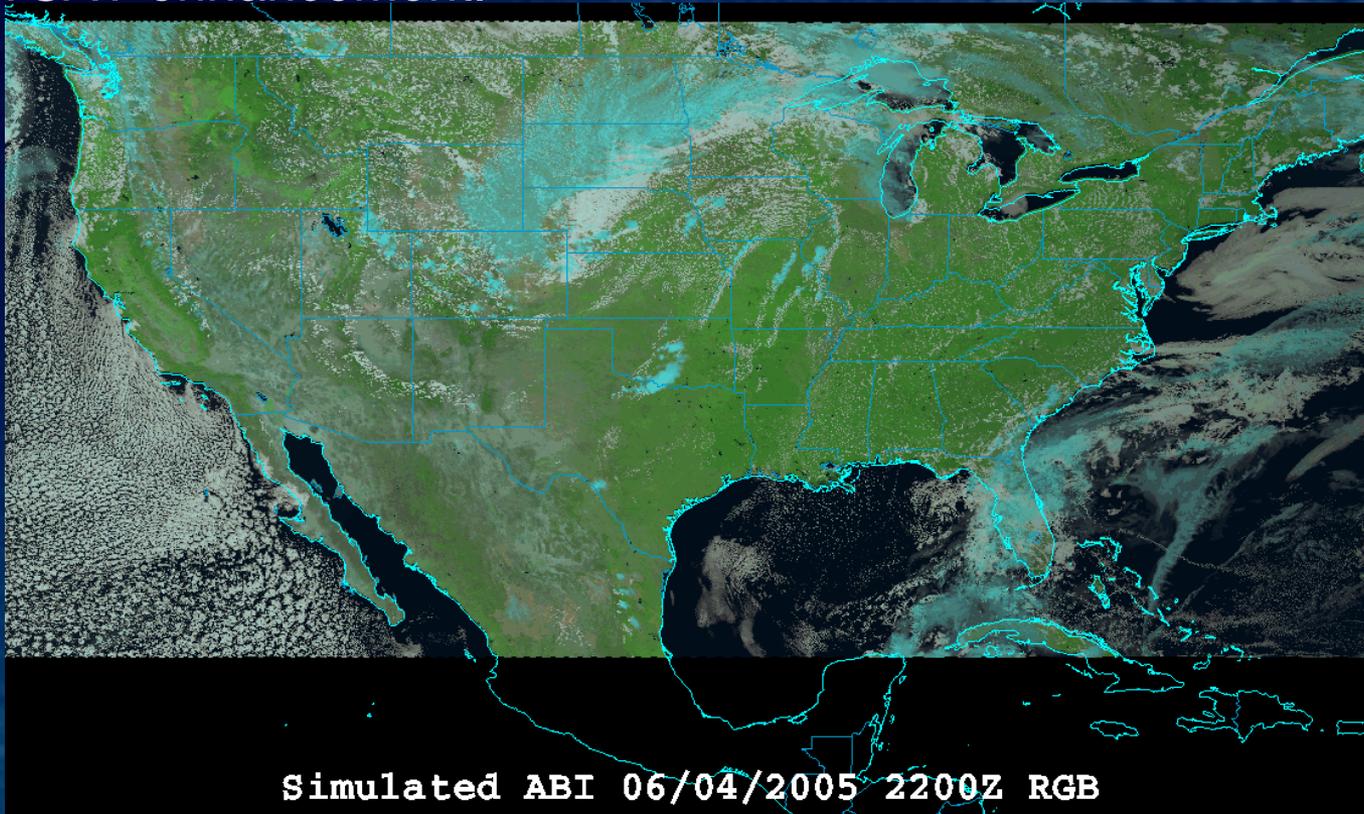
- "True Color" with "synthetic" green from ABI simulated data (from CIMSS); image from Don Hillger, RAMMB.





# Visualization ("RGB highlights cloud phase")

- "RGB Color" (VIS 0.6, VIS 0.8, and NearIR 1.6 um) with ABI simulated data (from CIMSS); image from William Straka, CIMSS and using the EUMETSAT enhancement.



# Overview

- ABI (Advanced Baseline Imager)
  - Temporal
  - Spatial
  - Spectral
  - Imagery
- **Select Products**
- **Summary**
  - More information



Photo courtesy of ITT Geospatial Systems

See Poster 4.1: **ABI Flight Performance Predictions Based on PTM Test Results**



# Algorithm Working Group (AWG)

Develop algorithms for the Level 2 products  
(Both 'Baseline' and 'Future Capability' products)

Advanced Baseline Imager (ABI)

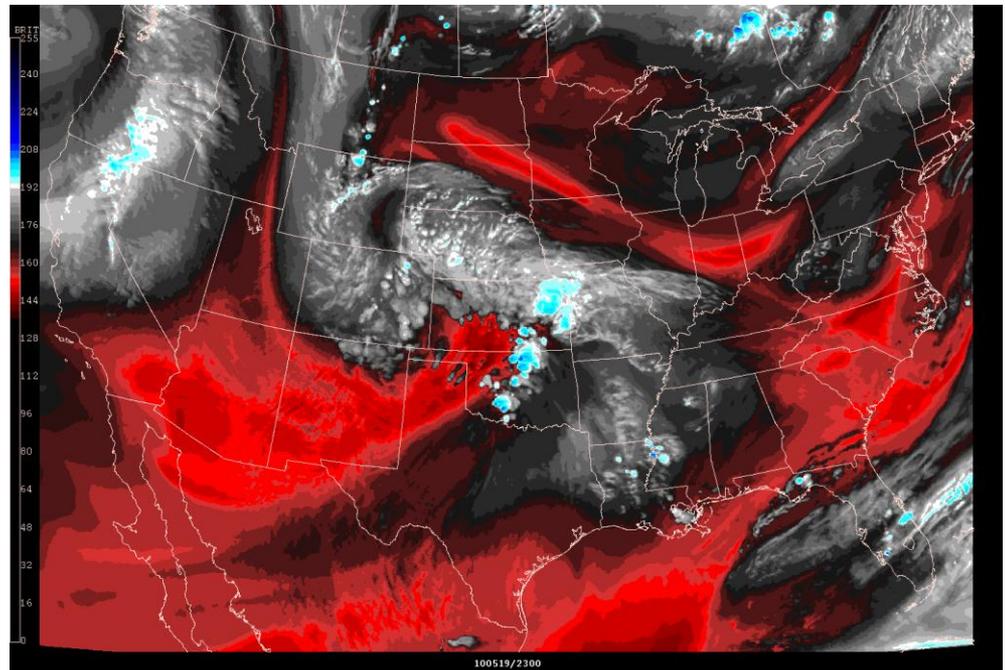
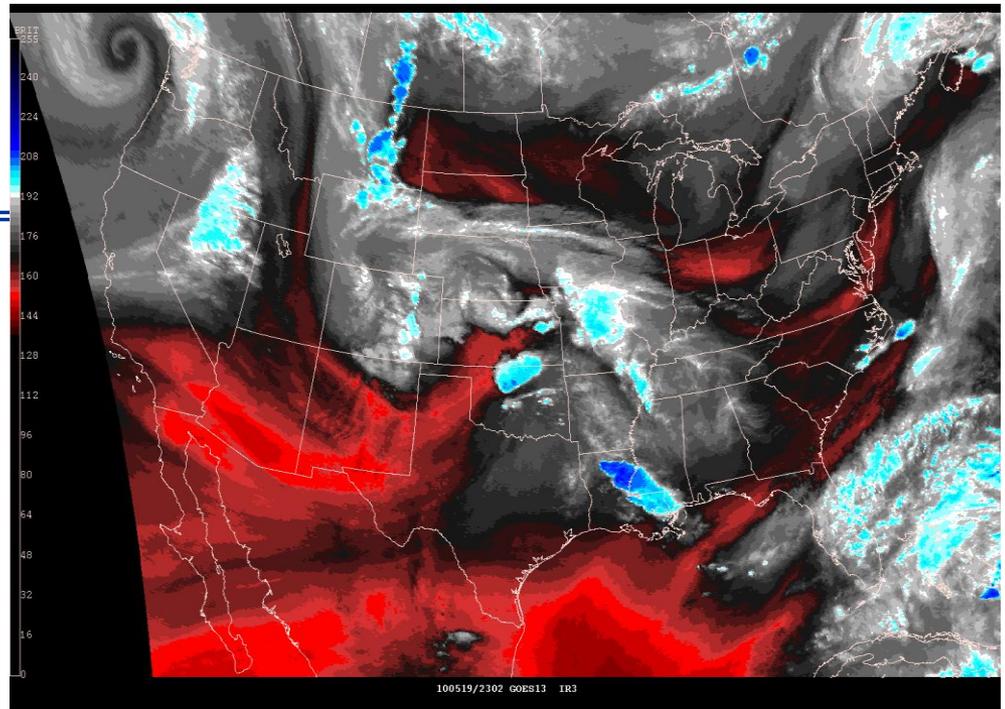
GLM

- **Clouds and Moisture Imagery (KPP)**
- Clear Sky Mask
- Cloud Top Pressure and Height
- Cloud Top Phase
- Cloud Top Temperature
- Cloud Particle Size Distribution
- Cloud Optical Path
- Temperature and Moisture Profiles
- Total Precipitable Water
- Stability Parameters (Lifted Index, etc.)
- Aerosol Detection
- Aerosols Optical Depth
- Derived Motion Winds
- Hurricane Intensity
- Fire/Hot Spot Characterization
- Land and Sea Surface Temperature
- Volcanic Ash
- Rainfall Rate
- Snow Cover
- Downward Solar Insolation: Surface
- Reflected Solar Insolation: TOA
  
- Lightning Detection

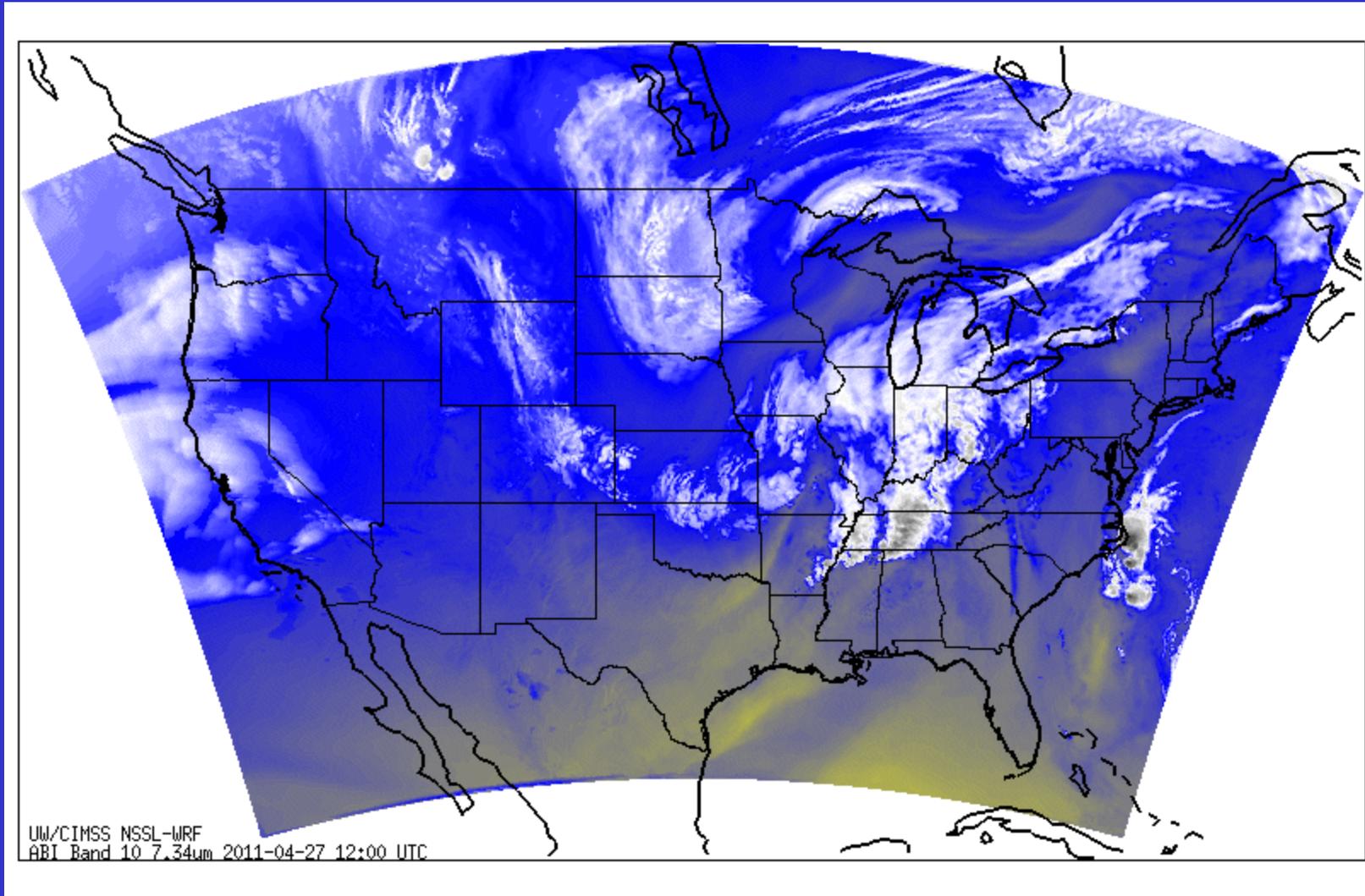
- Cloud Layer/Heights
- Cloud Ice Water Path
- Cloud Liquid Water
- Cloud Type
- Convective Initiation
- Turbulence
- Low Cloud and Fog
- Enhanced "V"/Overshooting Top
- Aircraft Icing Threat
- SO<sub>2</sub> Detections (Volcanoes)
- Visibility
- Upward Longwave Radiation (TOA)
- Downward Longwave Radiation (SFC)
- Upward Longwave Radiation (SFC)
- Total Ozone
- Aerosol Particle Size
- Surface Emissivity
- Surface Albedo
- Vegetation Index
- Vegetation Fraction
- Flood Standing Water
- Rainfall probability and potential
- Snow Depth
- Ice Cover
- Sea & Lake Ice Concentration, Age, Extent, Motion
- Ocean Currents, Currents: Offshore

# Imagery

- Imagery for nowcasting
  - Clouds
  - Input for products
  - Channel differences
  - RGB
  - Broadcasters
  - General Users
  - Etc.
- Radiances for NWP
  - Clear-sky
  - Cloudy-sky
  - Validations
  - Monitoring
  - Etc.

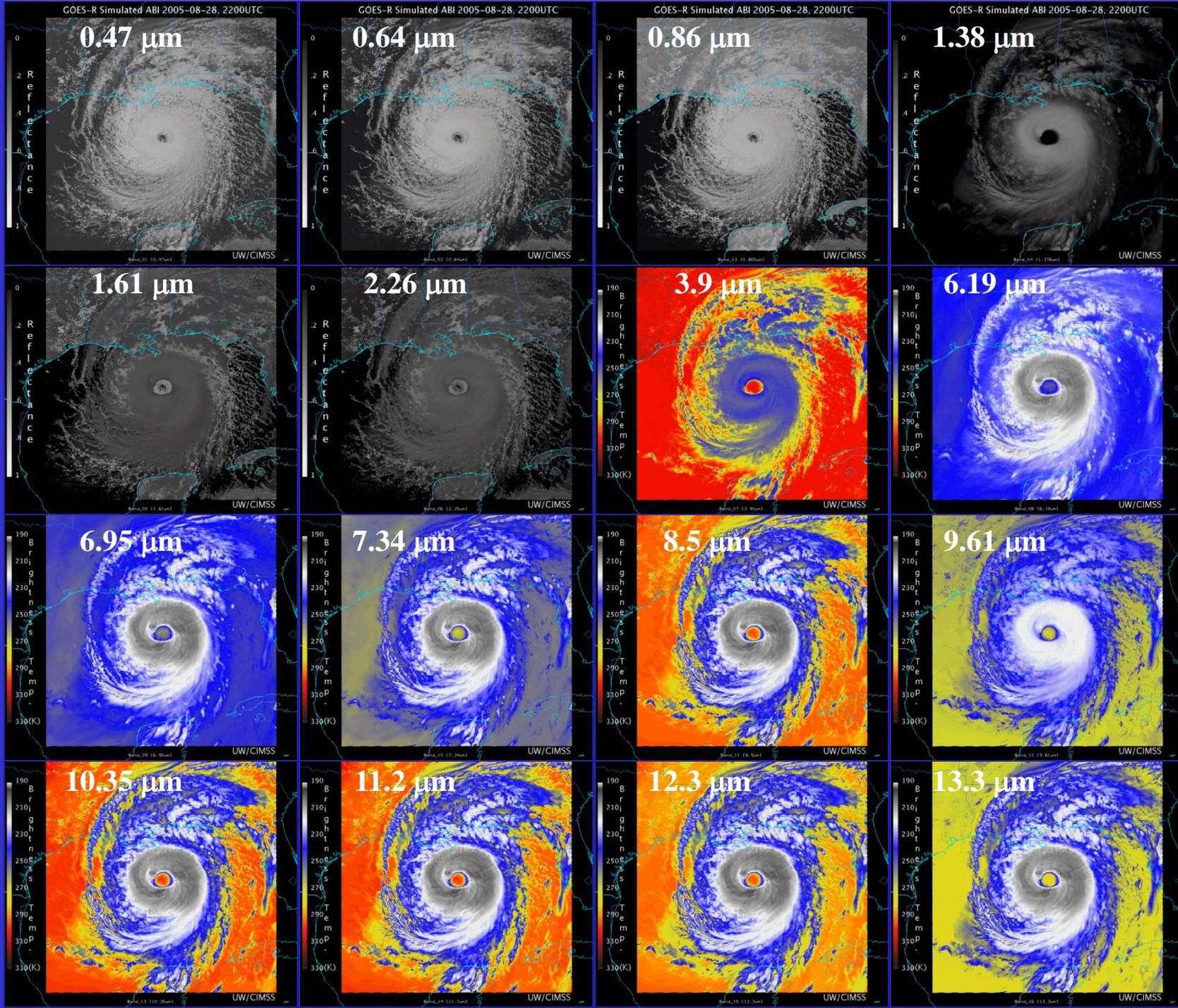


# Simulated ABI band – NSSL WRF

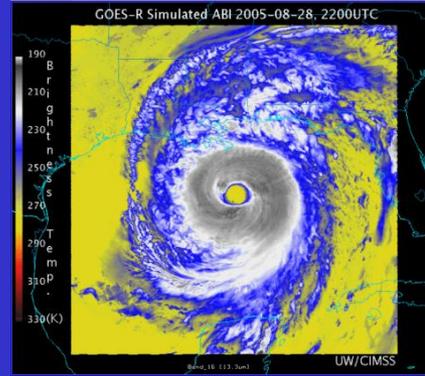
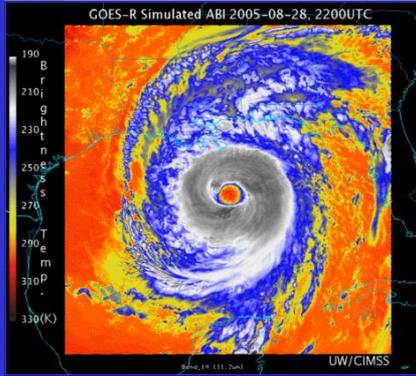
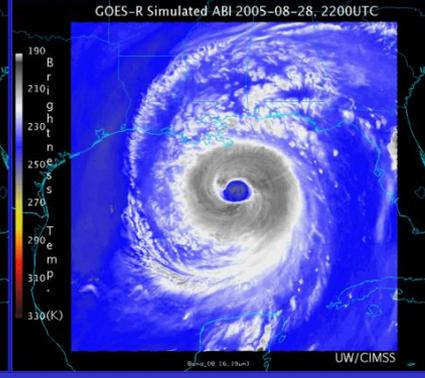
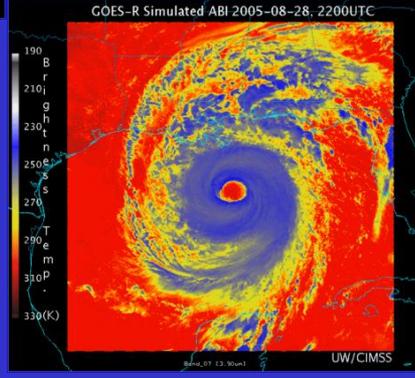
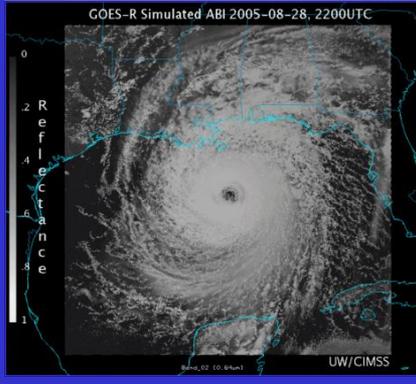


[http://cimss.ssec.wisc.edu/goes\\_r/proving-ground/nssl\\_abi/nssl\\_wrf\\_goes.html](http://cimss.ssec.wisc.edu/goes_r/proving-ground/nssl_abi/nssl_wrf_goes.html)

# AWG Proxy ABI Simulations of Hurricane Katrina



# Corresponding current Imager bands of Hurricane Katrina





# Cloud Phase

- **Algorithm Highlights**

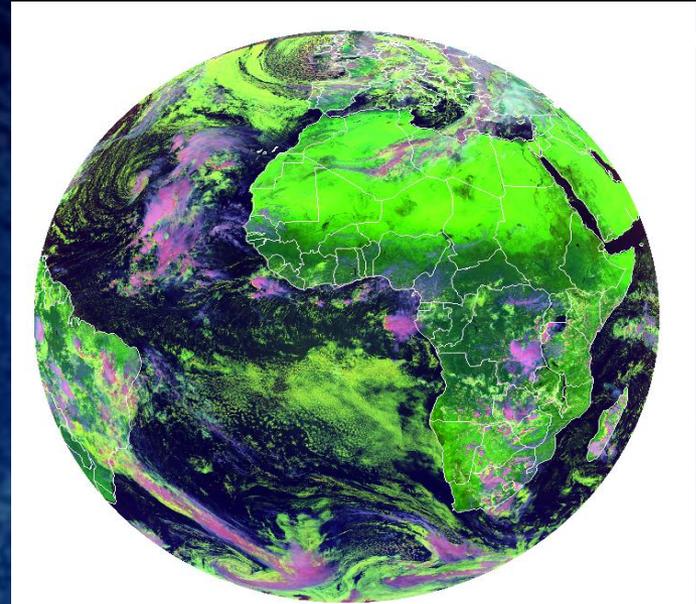
- An Infrared only algorithm that exploits the rich infrared information (7.4, 8.5, 11.2, and 12.3  $\mu\text{m}$ ) provided by the ABI
- Algorithm determines the cloud top (layer that the radiometer senses) thermodynamic phase of the highest cloud layer
- Exploits recent improvements in fast clear-sky radiative transfer models and ancillary data (land cover, surface emissivity)
- Makes advanced use of spatial information

- **Operational Applications**

- Prerequisite for other cloud property retrievals (height, temperature)
- Climate prediction
- Aviation forecasting (Aircraft icing)

GEOCAT\_v0.50

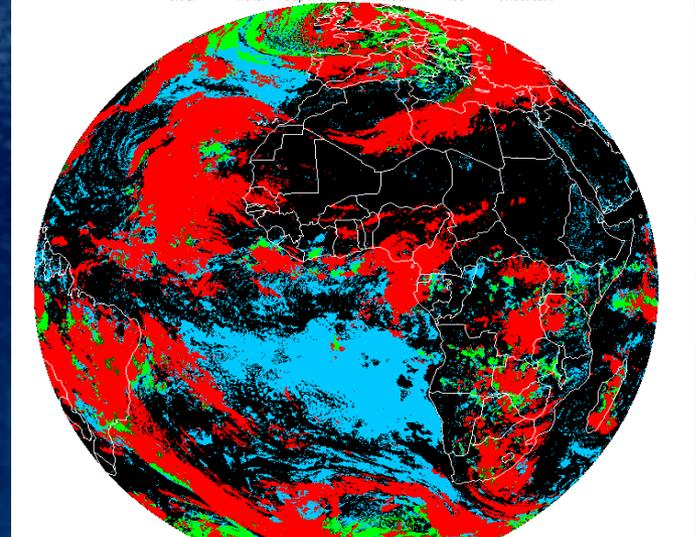
Meteosat-8 2005-11-25 12:00:00  
RGB(0.65/1.6/11  $\mu\text{m}$  or 3.75/11/11  $\mu\text{m}$ )



GEOCAT\_v0.50

Meteosat-8 2005-11-25 12:00:00  
Cloud Type

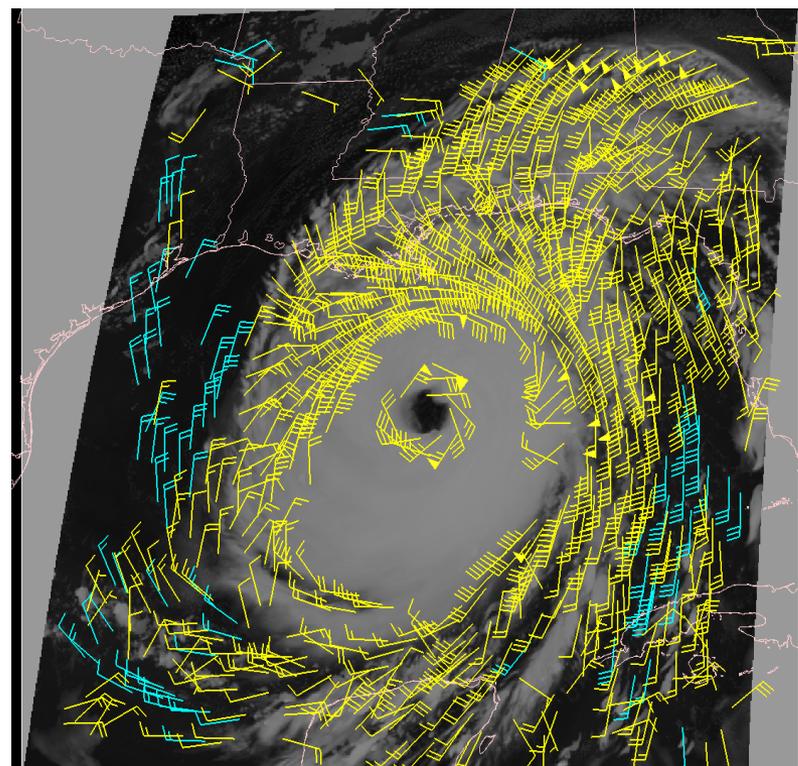
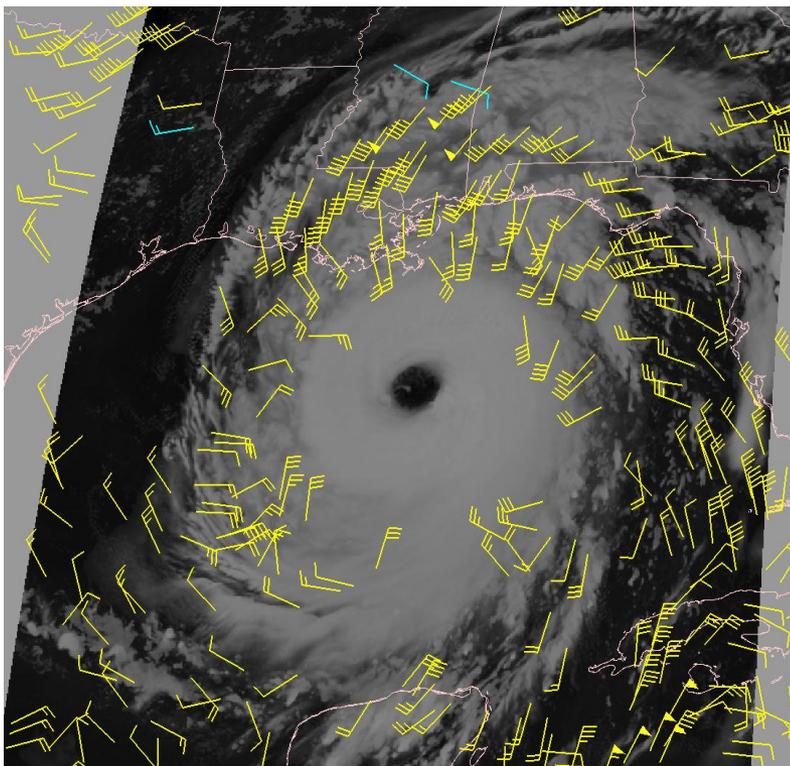
Clear Water Supercooled Mixed Ice Uncertain



Water, Supercooled Water, Mixed Phase, Ice

# GOES-R Atmospheric Motion Vectors

Product Example: Hurricane Katrina



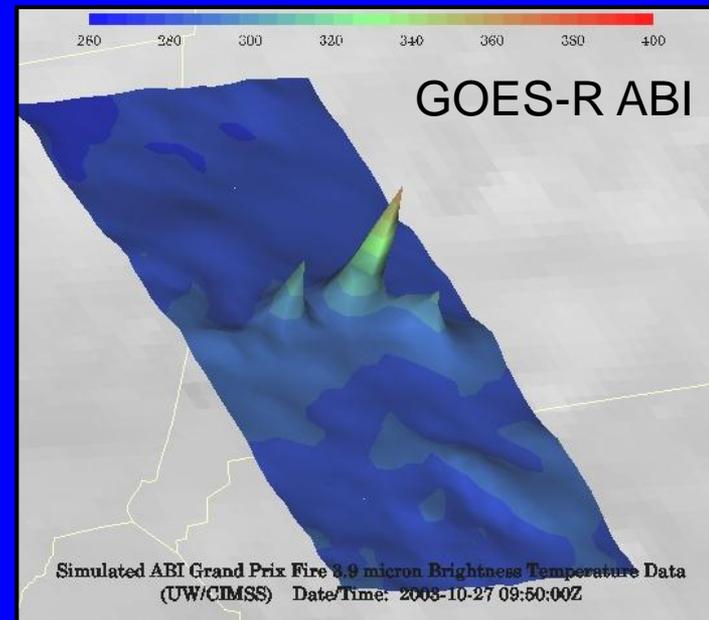
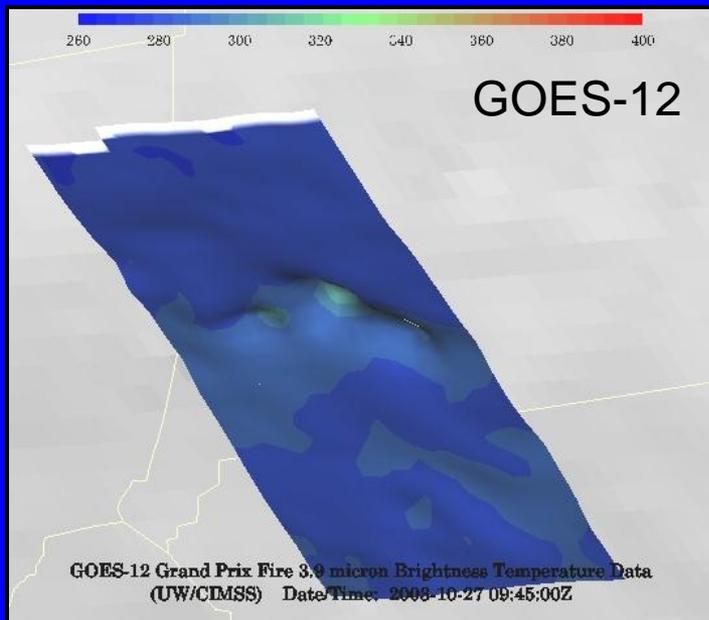
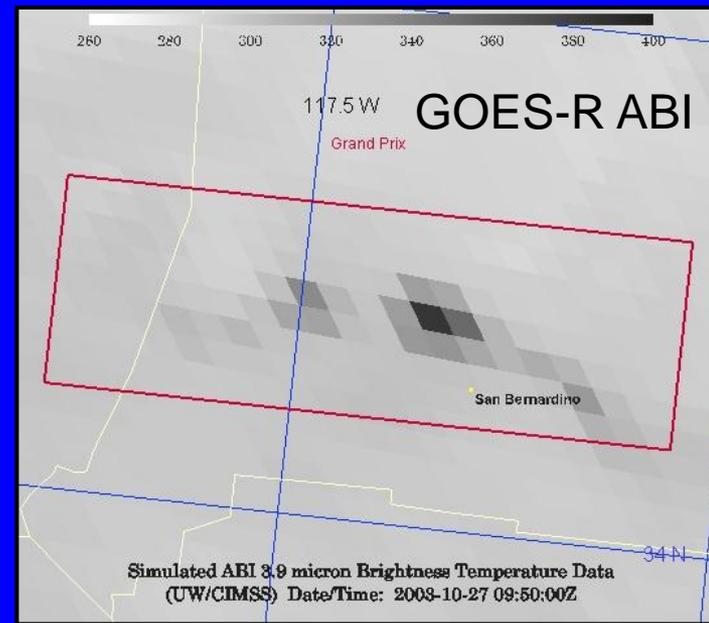
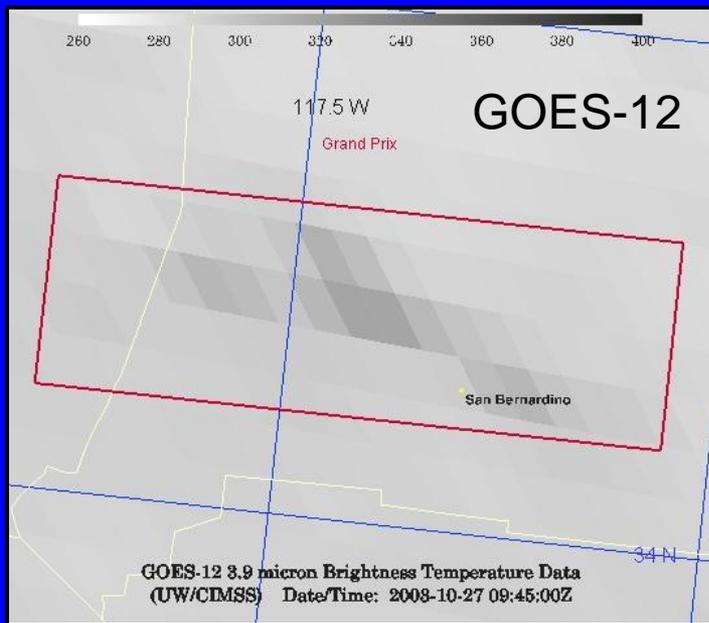
Low-mid level vectors - cyan Upper-level vectors - yellow

IR AMVs derived from current GOES-12  
4km resolution; 15-minute time step

IR AMVs derived from WRF model images  
using simulated future GOES-R radiances  
2 km resolution; 5-minute time step

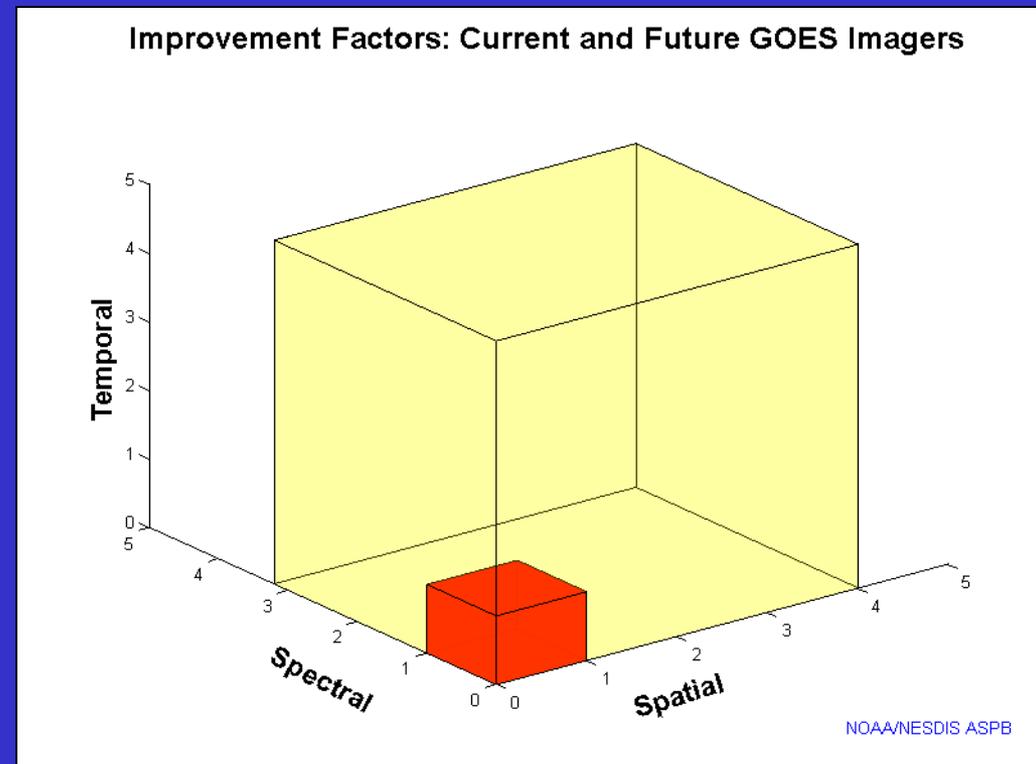
# GOES-12 and GOES-R ABI

## Simulation of Grand Prix Fire/Southern California

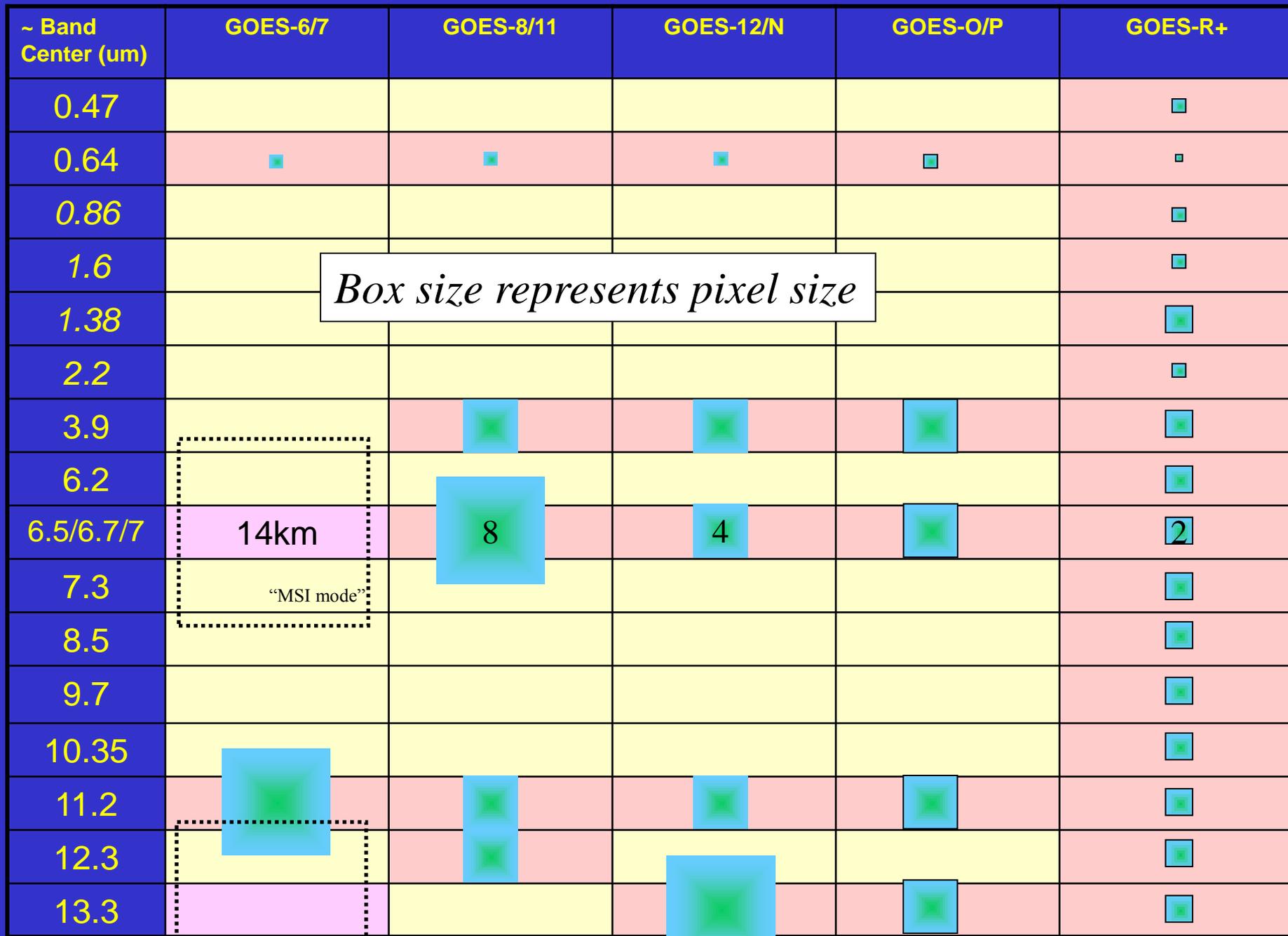


# Overview

- ABI (Advanced Baseline Imager)
  - Temporal
  - Spatial
  - Spectral
  - Imagery
- Select Products
- **Summary**
  - More information

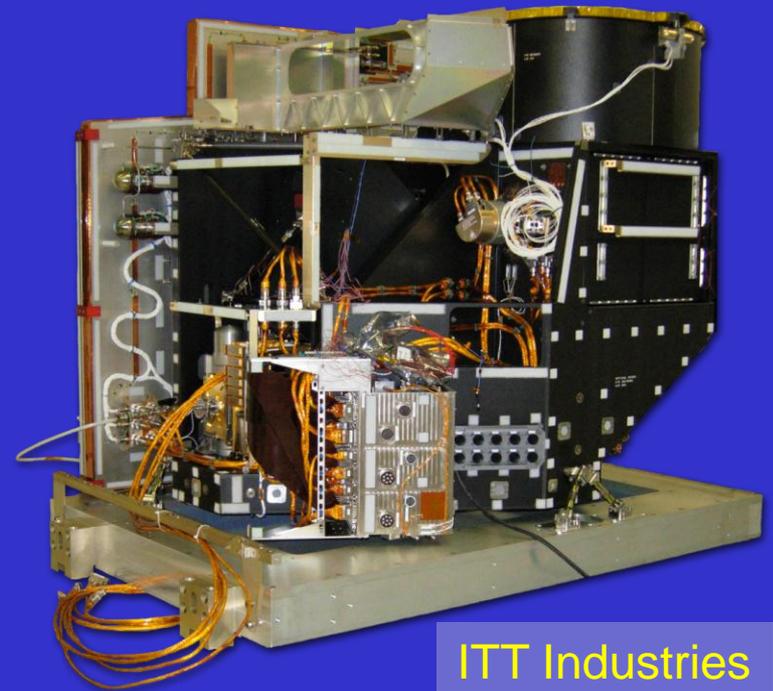


# Approximate spectral and spatial resolutions of US GOES Imagers



# Summary

- The ABI on GOES-R will improve over the current instrument in many aspects (spectral, spatial, and temporal on orders of 3, 4, and 5, respectively), plus improved image navigation and registration and radiometer performance.
- These improvements will greatly assist a host of applications, especially on the regional and meso-scales.

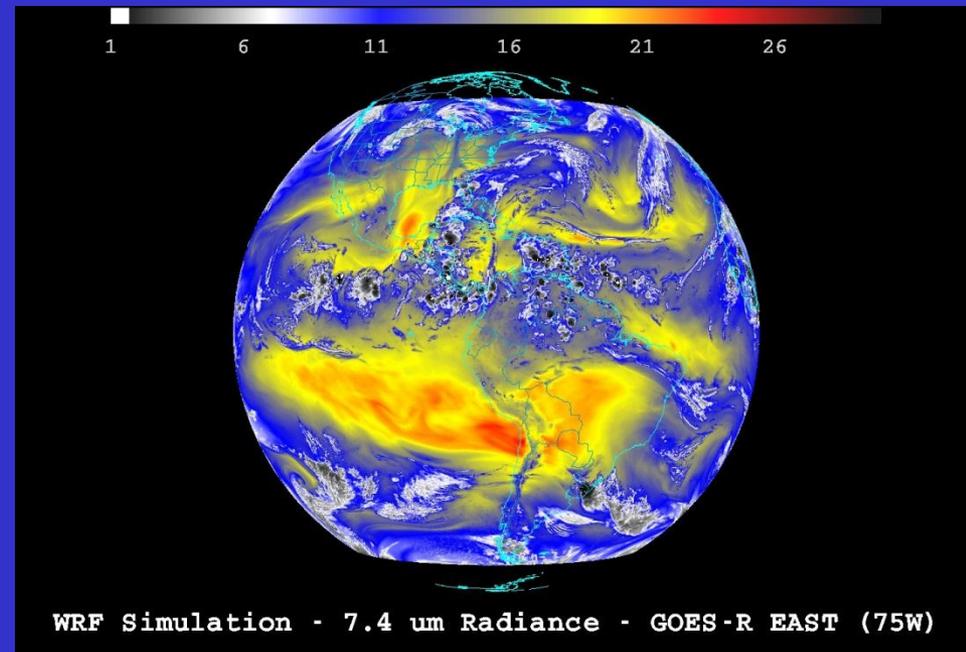


# Back-up Slides

- Google Earth
- Select links
- Acknowledgements
- Products vs bands
- GOES-R at 137W scan strategy

# Google Earth

- Sample ABI simulated data are available in google earth format:
  - <http://cimss.ssec.wisc.edu/goes/abi/loops/links.html>

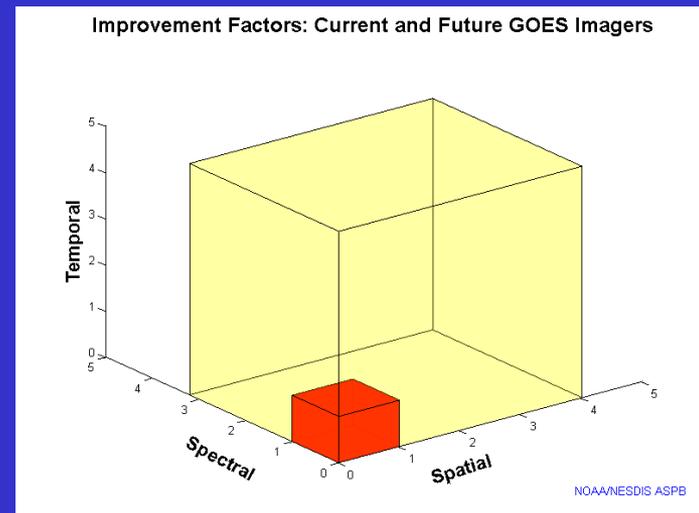
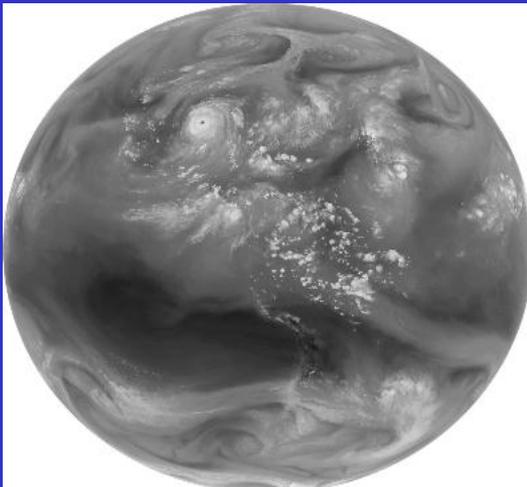






# Acknowledgements

- The authors would like to thank the entire GOES-R team; 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.

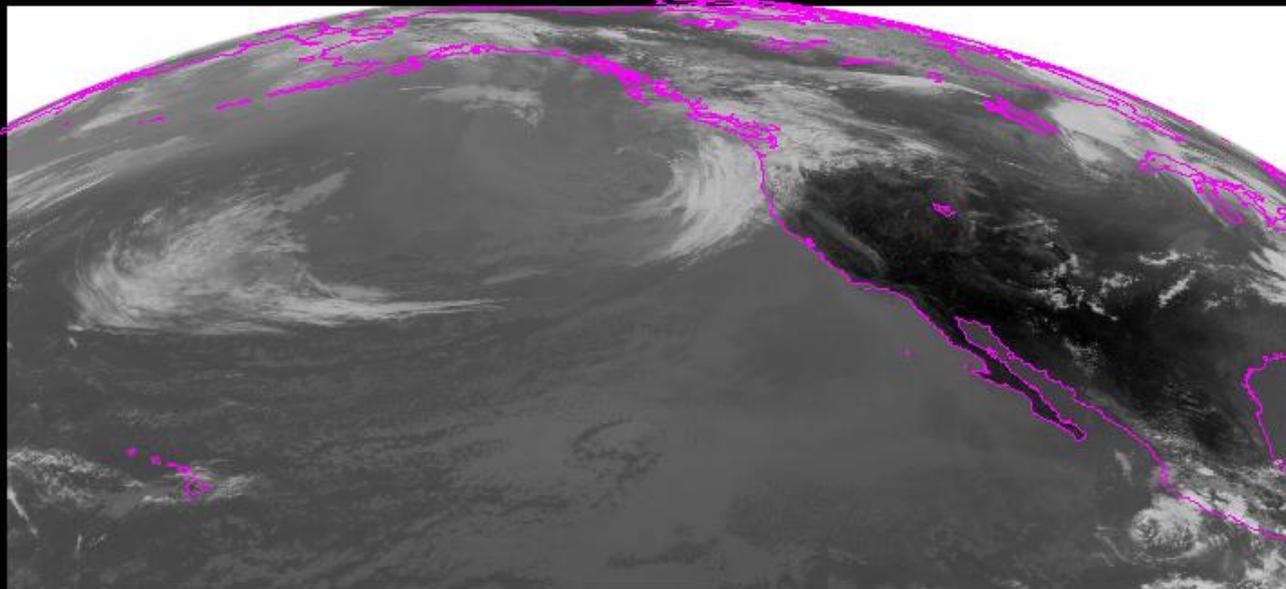


# ABI “Baseline” Products

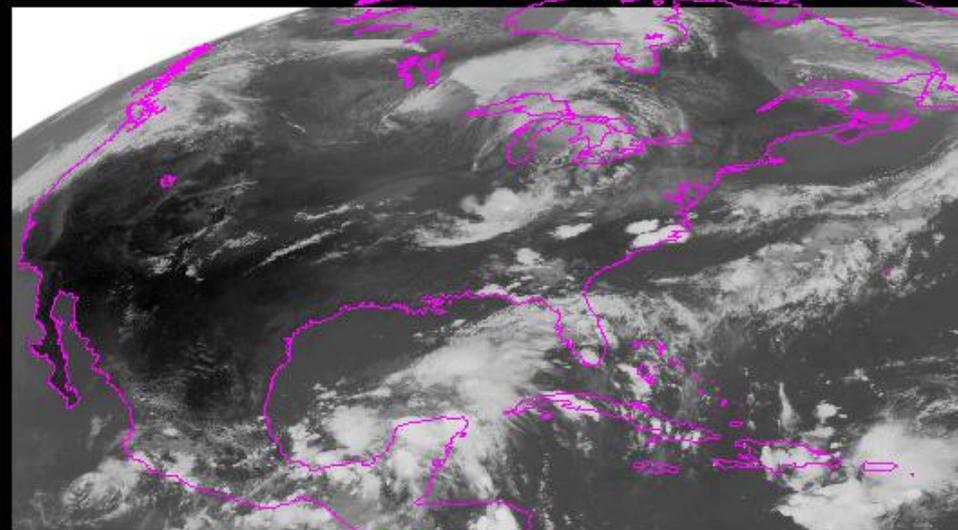
Wavelength Micrometers	0.47	0.64	0.865	1.378	1.61	2.25	3.90	6.185	6.95	7.34	8.5	9.61	10.35	11.2	12.3	13.3
Channel ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<b>Baseline Products</b>																
Aerosol Detection	X	X	X	X	X	X	X							X	X	
Suspended Matter/OD	X	X	X		X	X										
Clear Sky Masks		X		X	X		X		X	X	X			X	X	
Cloud & Moisture Imagery	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cloud Optical Depth		X				X	X							X	X	
Cloud Particle Size		X				X	X							X	X	
Cloud Top Phase										X	X			X	X	
Cloud Top Height														X	X	X
Cloud Top Pressure														X	X	X
Cloud Top Temperature														X	X	X
Hurricane Intensity													X			
Rainfall Rate/QPE								X		X	X			X	X	
Legacy Vertical Moisture Profile								X	X	X	X	X	X	X	X	X
Legacy Vertical Temp Profile								X	X	X	X	X	X	X	X	X
Derived Stability Indices								X	X	X	X	X	X	X	X	X
Total Precipitable Water								X	X	X	X	X	X	X	X	X
Downward Solar Insolation Surf	X	X	X		X	X										
Reflected Solar Insolation TOA	X	X	X		X	X										
Derived Motion Winds		X					X	X	X	X				X		
Fire Hot Spot Characterization		X					X							X	X	
Land Surface Temperature														X	X	
Snow Cover	X	X	X		X	X	X						X			
Sea Surface Temps							X				X		X	X	X	

# ABI “Future Capabilities” Products

Wavelength Micrometers	0.47	0.64	0.865	1.378	1.61	2.25	3.90	6.185	6.95	7.34	8.5	9.61	10.35	11.2	12.3	13.3
Channel ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<b>Option 2 Products</b>																
<b>Cloud Layer/Heights</b>														X	X	X
<b>Cloud Ice Water Path</b>							X							X	X	
<b>Cloud Liquid Water</b>		X				X					X					
<b>Cloud Type</b>										X	X			X	X	
<b>Convective Initiation</b>								X	X	X	X	X		X	X	X
<b>Turbulence</b>								X								
<b>Low Cloud and Fog</b>		X					X									
<b>Enhanced-V/Overshooting Top</b>														X		
<b>Aircraft Icing Threat</b>		X				X	X			X	X			X	X	X
<b>SO<sub>2</sub> Detection</b>								X		X	X			X	X	
<b>Visibility (no direct use of ABI bands)</b>																
<b>Upward Longwave Radiation (TOA)</b>								X		X	X		X			X
<b>Downward Longwave Radiation (SFC)</b>									X	X	X	X	X	X	X	X
<b>Upward Longwave Radiation (SFC)</b>											X		X	X	X	
<b>Total Ozone</b>								X	X	X		X	X	X	X	X
<b>Aerosol Particle Size</b>	X	X	X		X	X										
<b>Surface Emissivity</b>								X	X	X	X	X	X	X	X	X
<b>Surface Albedo</b>	X	X	X		X	X										
<b>Vegetation Index</b>		X	X													
<b>Vegetation Green Fraction</b>		X	X													
<b>Flood/Standing Water</b>		X	X		X									X	X	
<b>Rainfall Potential (no direct use of ABI bands)</b>								X		X	X			X	X	
<b>Rainfall Probability (no direct use of ABI bands)</b>								X		X	X			X	X	
<b>Snow Depth (no direct use of ABI bands)</b>	X	X	X		X	X	X						X			
<b>Sea &amp; Lake Ice: Age (no direct use of ABI bands)</b>		X	X		X									X	X	
<b>Sea &amp; Lake Ice: Concentration</b>		X	X		X									X	X	
<b>Sea &amp; Lake Ice: Motion</b>														X		
<b>Ocean Currents</b>														X		
<b>Ocean Currents: Offshore</b>														X		



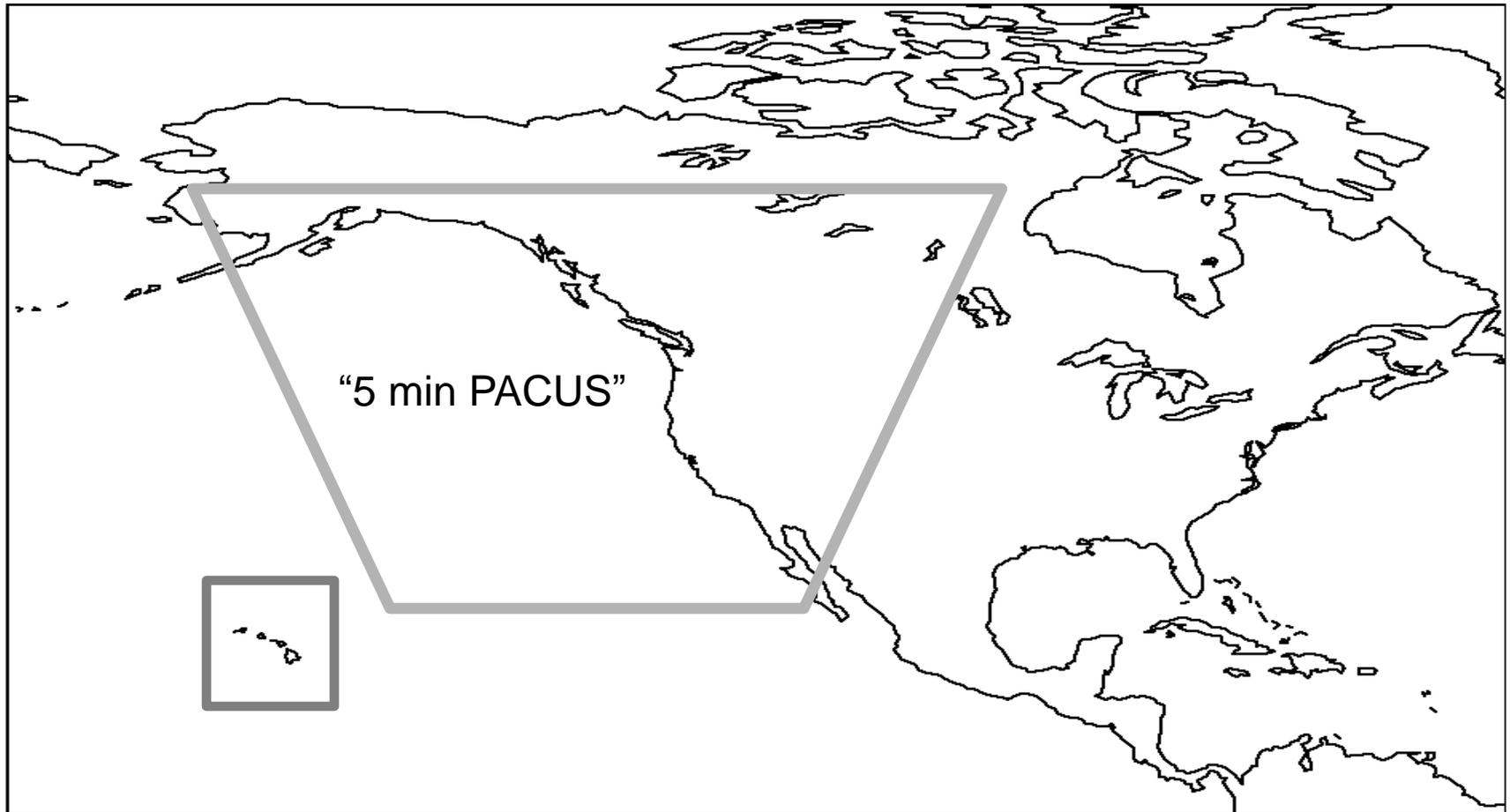
G-11 IMG 27 JUN 11 19:45UTC BAND=4 IR RES: 983 X 2854



G-13 IMG 27 JUN 11 19:32UTC BAND=4 IR RES: 883 X 2126

Current GOES Imager scans: PACUS and CONUS (note that PACUS is one-third larger). These regions are sub-selected for AWIPS.

## ***Proposed -Shifted "5 min PACUS"***



Proposed "shifted" "PACUS" would give a 5 min scan of southern AK and western CONUS. This would mean that Hawaii could be covered with one of the meso-scales (and 15 min FD); if in 'flex mode (3)'. Note that the positions are approximate.