

The ABI on the GOES-R Series

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“The birthplace of Satellite Meteorology”

Air Quality Workshop
Virtual
September 25, 2017



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



UW-Madison

- GOES-R Advanced Baseline Imager (ABI)

- Spectral

- Improved!

- Spatial

- Improved!

- Temporal

- Improved!

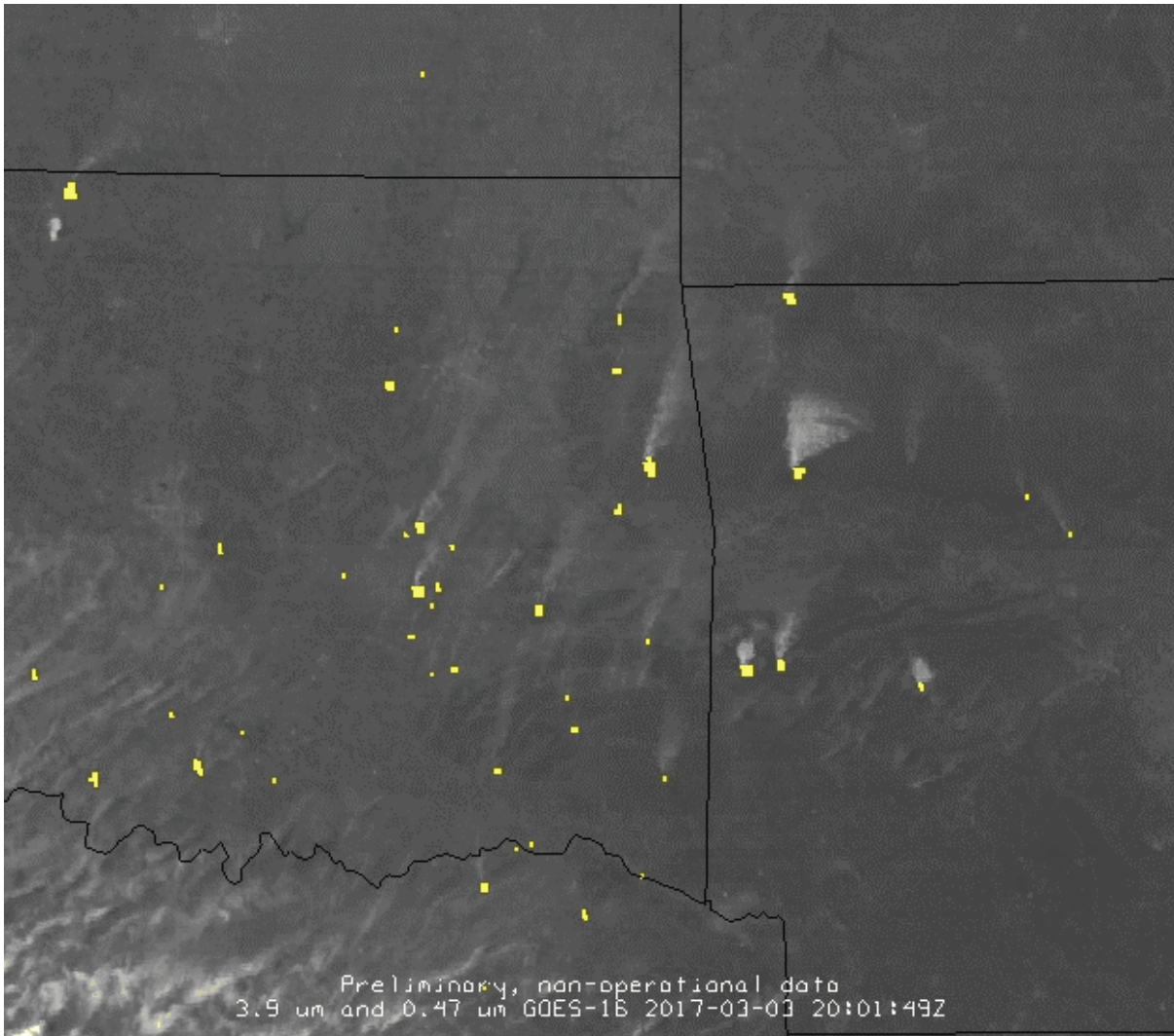
- Calibration

- Improved!



Lockheed Martin

GOES-16 ABI

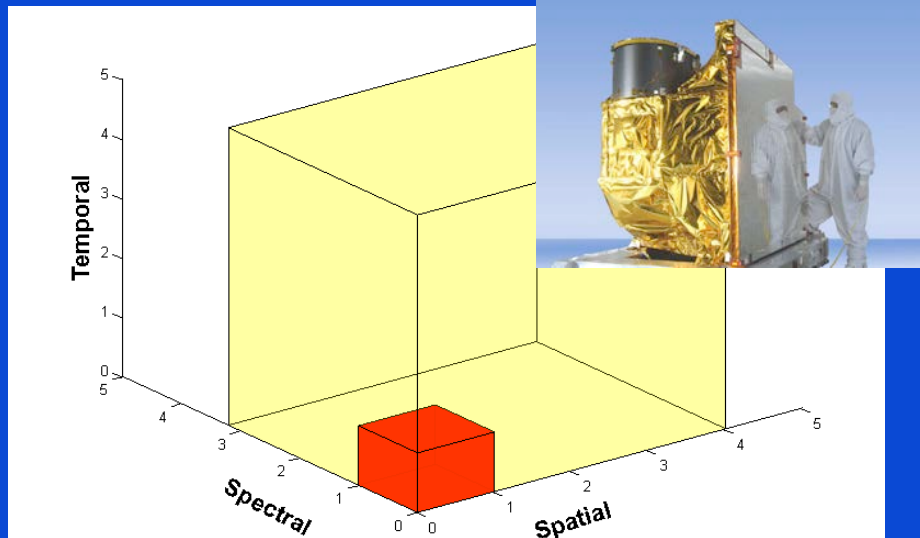


Credit: Bill Line

The Advanced Baseline Imager:

	ABI	Current Imager
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 ($>2 \mu\text{m}$)	2 km	Approx. 4 km
Spatial coverage		
Full disk	4 per hour	Scheduled (3 hrly)
CONUS	12 per hour	~4 per hour
Mesoscale	2 every 1-min	n/a
On-board Vis/nearIR Cal	Yes	No

Advanced Baseline Imager (ABI)

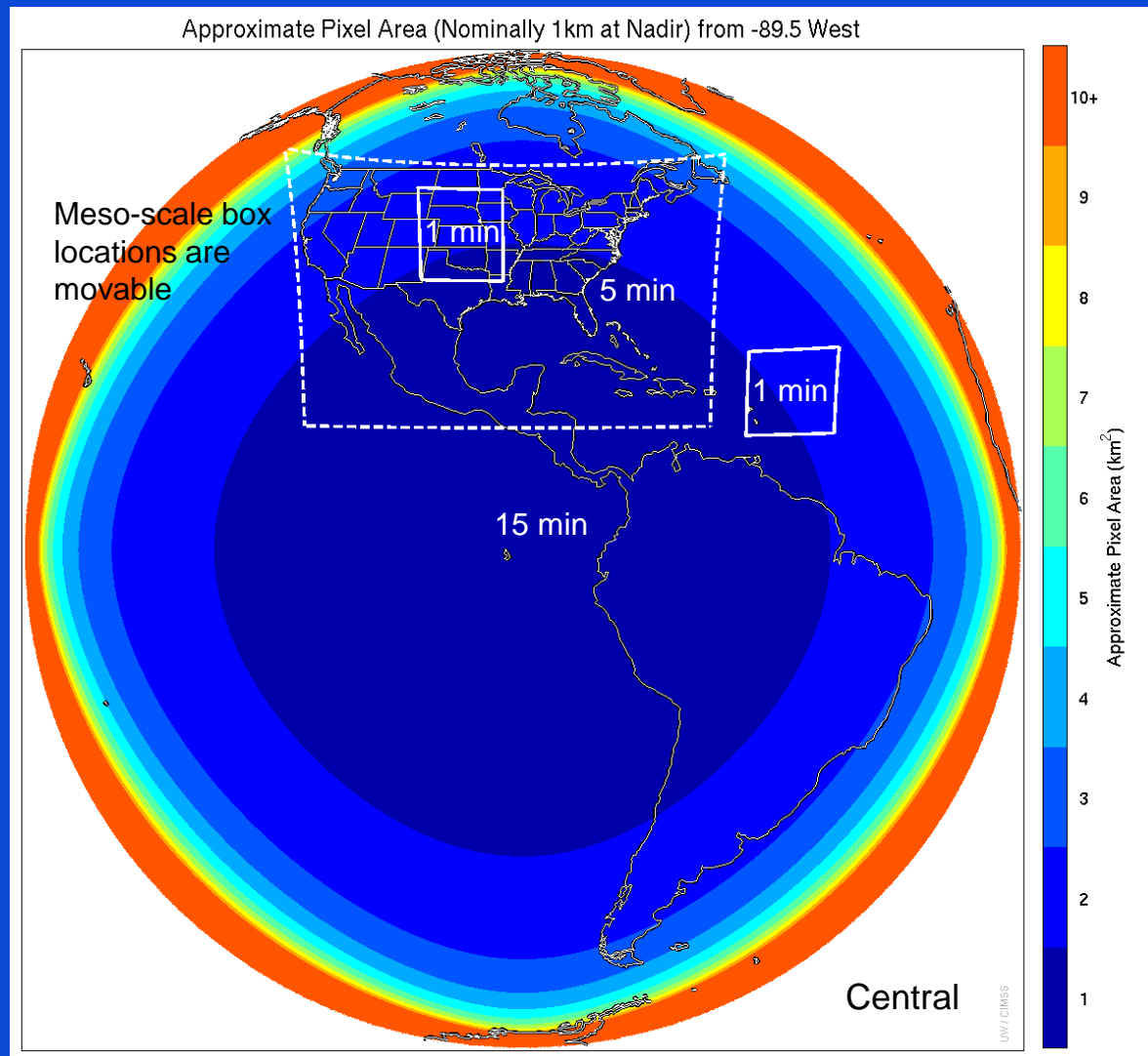


5^x Faster coverage
(5-minute full disk
vs. 25-minute)

4^x Improved spatial
resolution
(2 km IR vs. 4 km)

3^x More spectral
bands (16 on ABI
vs. 5 on the
current imager)

Plus improved radiometrics and higher bit depths, etc.



Mat Gunshor, CIMSS

Scan mode (3) or 'flex mode' for the ABI:

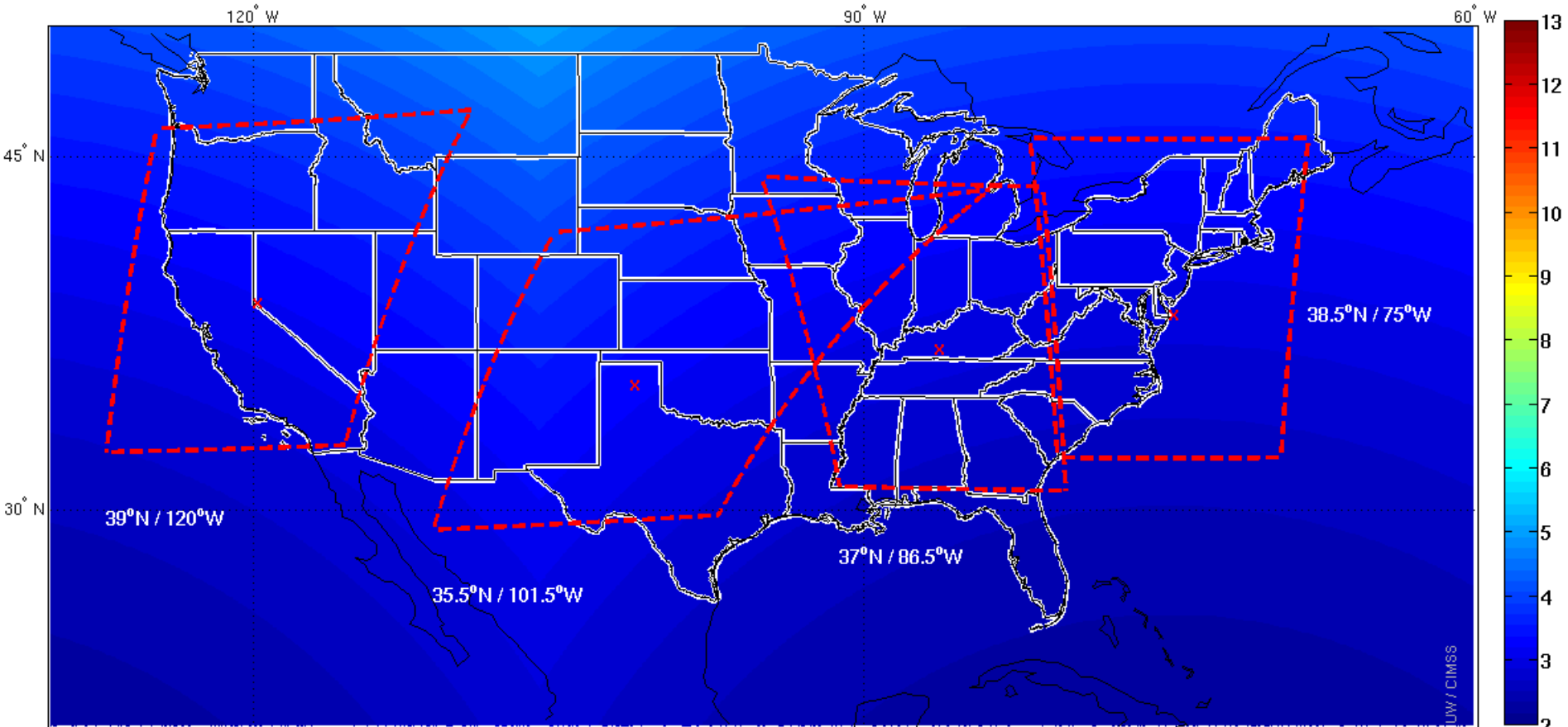
– Full disk every 15 min + 5 min CONUS + 1-min mesoscale (2 locations).

[Scan mode (4) or 'Continuous Full Disk' (CFD) is a full disk every 5 min]

ABI Sectors



Default Meso Locations



GOES-R Era West (137W) & East (75W) Pixel Size with potential default Mesoscale scan location examples

Two meso from GOES-West and two from GOES-East



GOES-R ADVANCED BASELINE IMAGER (ABI): THE NEXT GENERATION OF GEOSTATIONARY IMAGER WEATHER AND ENVIRONMENTAL PRODUCTS

PAUL GRIFFITH¹, W. J. LEBAIR², T. J. SCHMIT³, X. WU³, AND J. VAN NAARDEN¹

¹Harris Corporation, ²NASA/GSFC, ³NOAA/NESDIS/STAR

The Advanced Baseline Imager (ABI) is a NOAA funded, NASA administered meteorological instrument program. This document does not reflect the views or policy of the GOES-R Program Office.

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13NGOESS-2.2 ABI Overview

ABI's 2-Mirror Scanner Key to Operational Flexibility and Improved Calibration Capability



Scans parallel to equator without rotating image

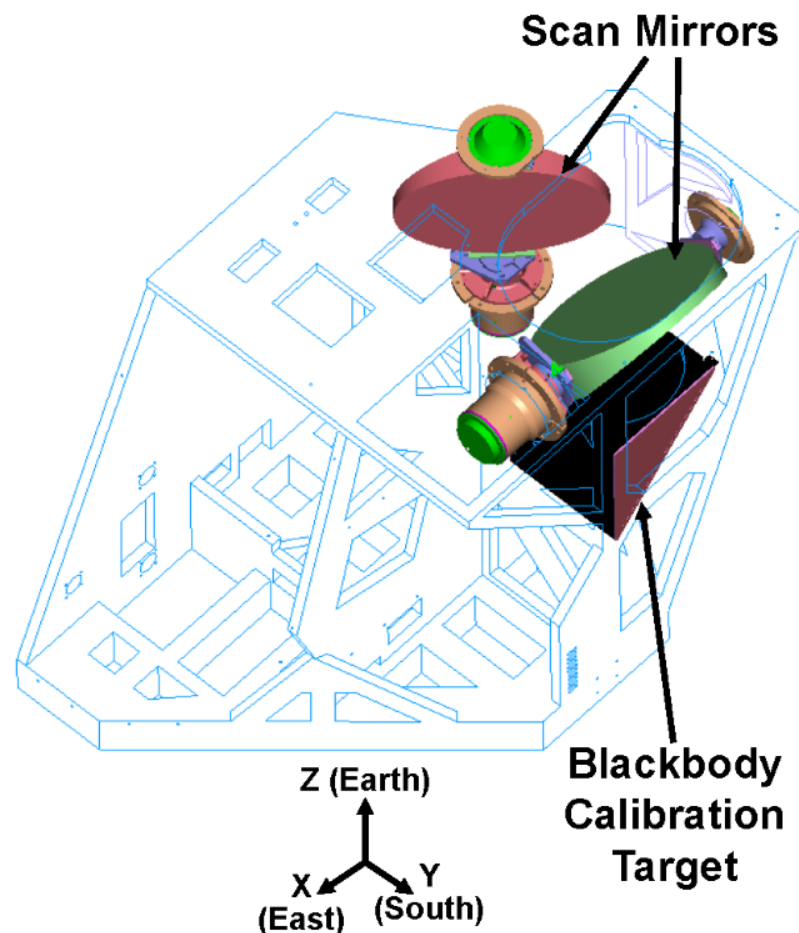
- 100% scan coverage efficiency

Lowest inertia and power

2x EW and NS mechanical-to-optical motion

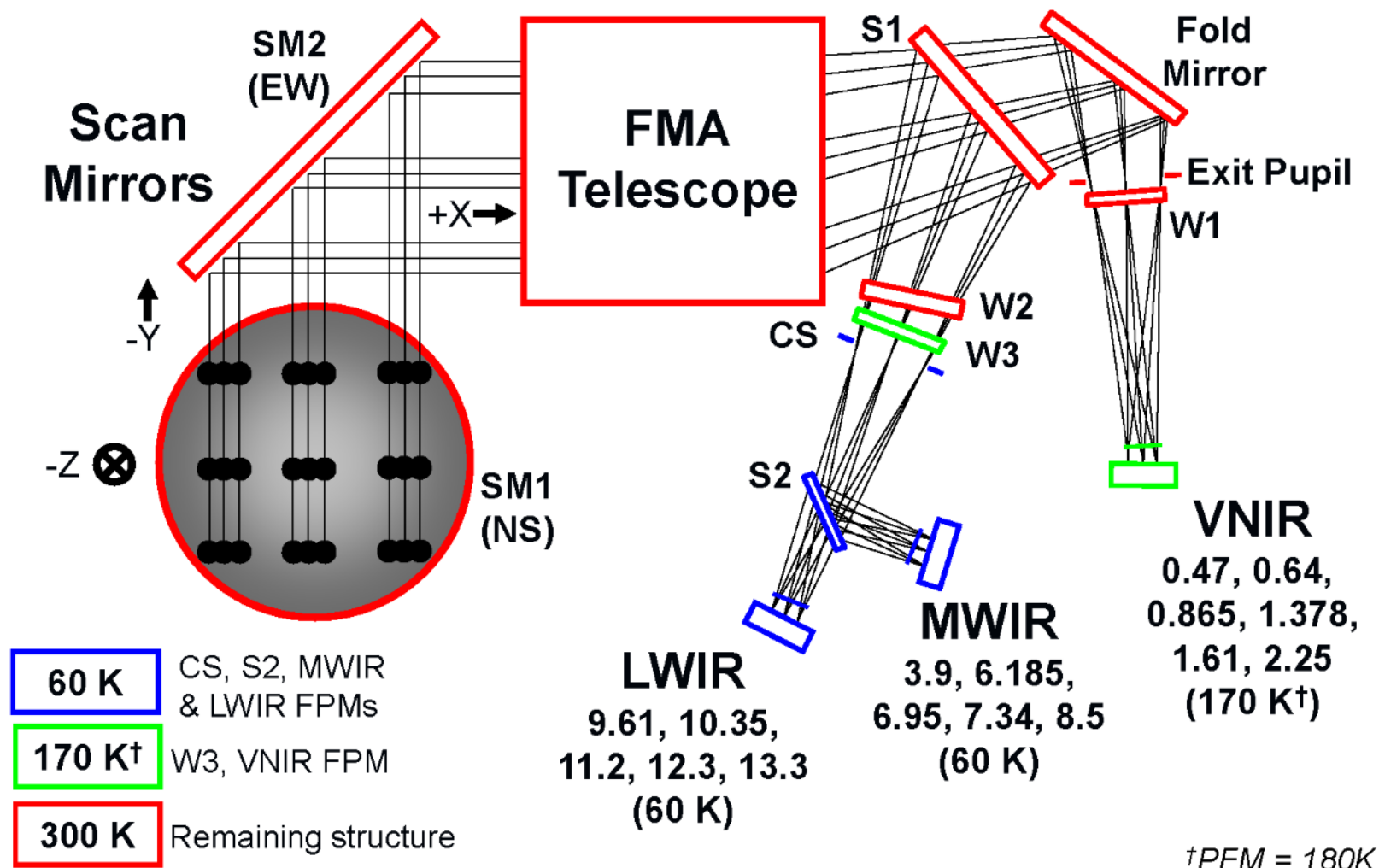
Inherently polarization compensating

- At nadir, polarization introduced by reflection off NS scanner is canceled by reflection off of EW scanner
- Blackbody located anti-nadir, so same observing geometry applies

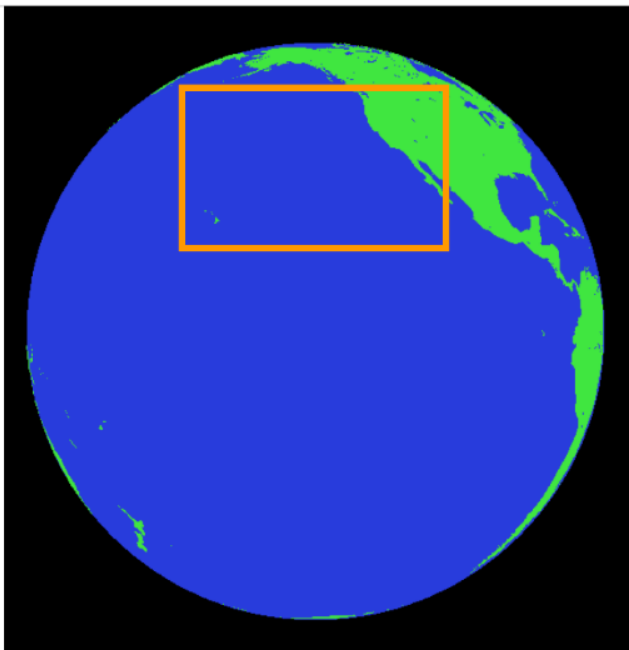


Delivers fast slews and accurate slow scans with minimal disturbance

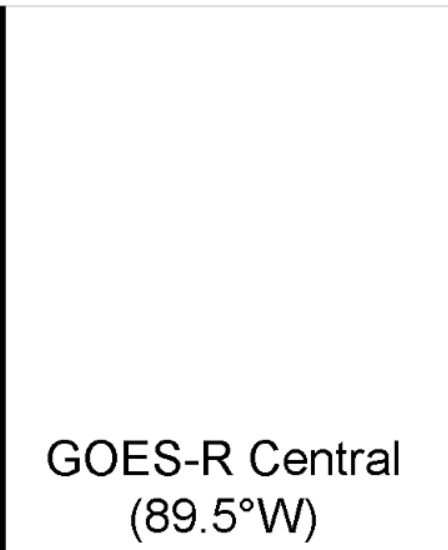
ABI Optical Architecture: Simple Solution to Mission Needs



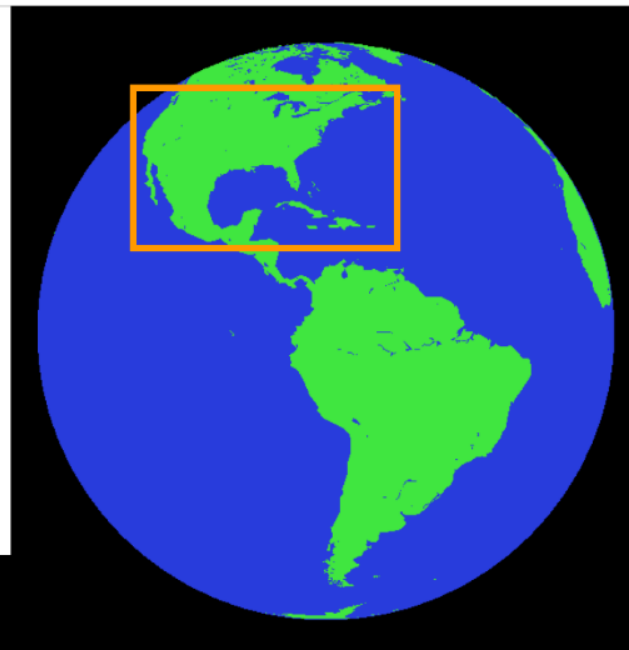
ABI CONUS: Same Size But Different Location For Each Satellite



GOES-R West
(137°W)



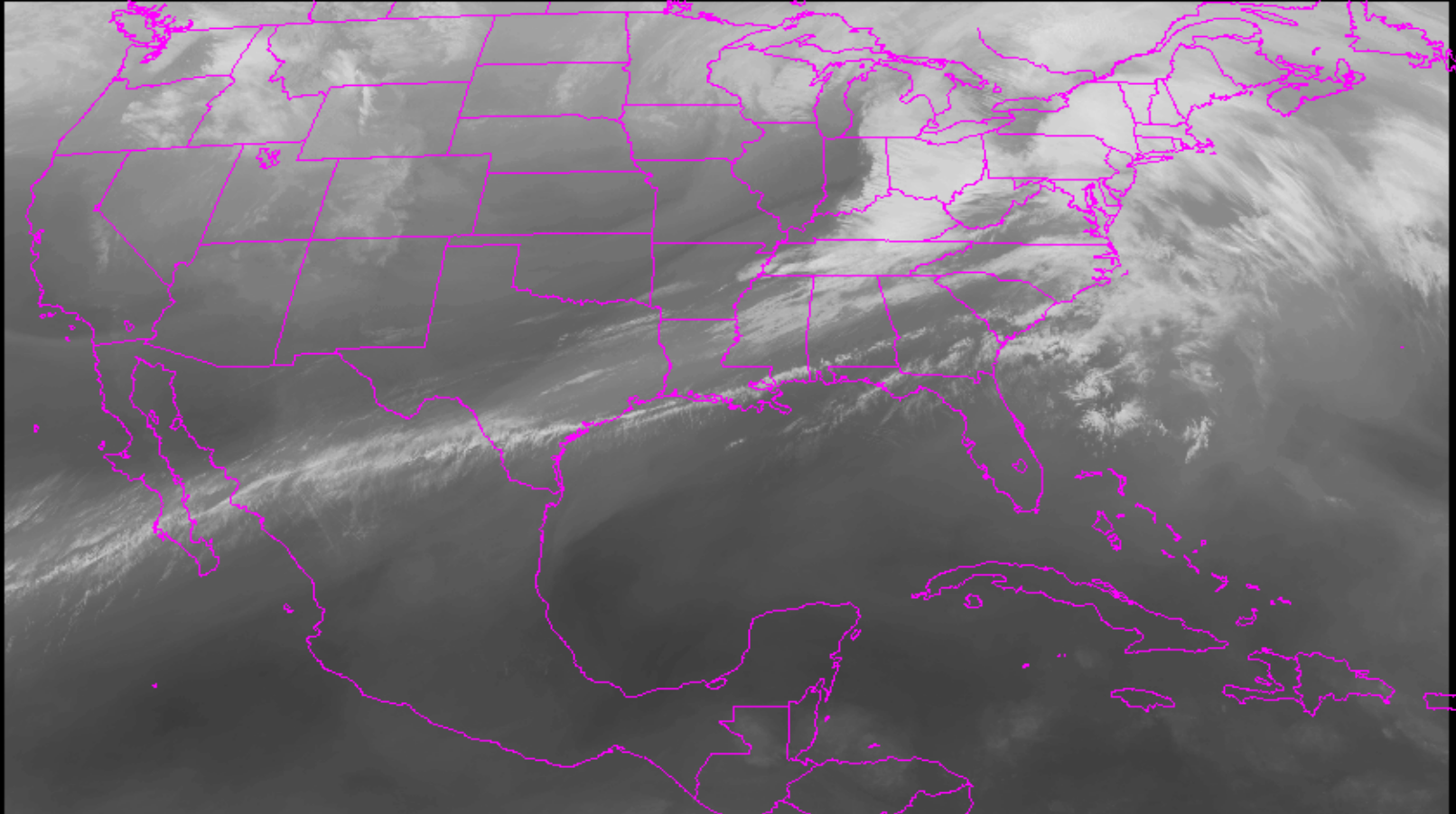
GOES-R Central
(89.5°W)



GOES-R East
(75°W)



ABI CONUS Sector (Central)

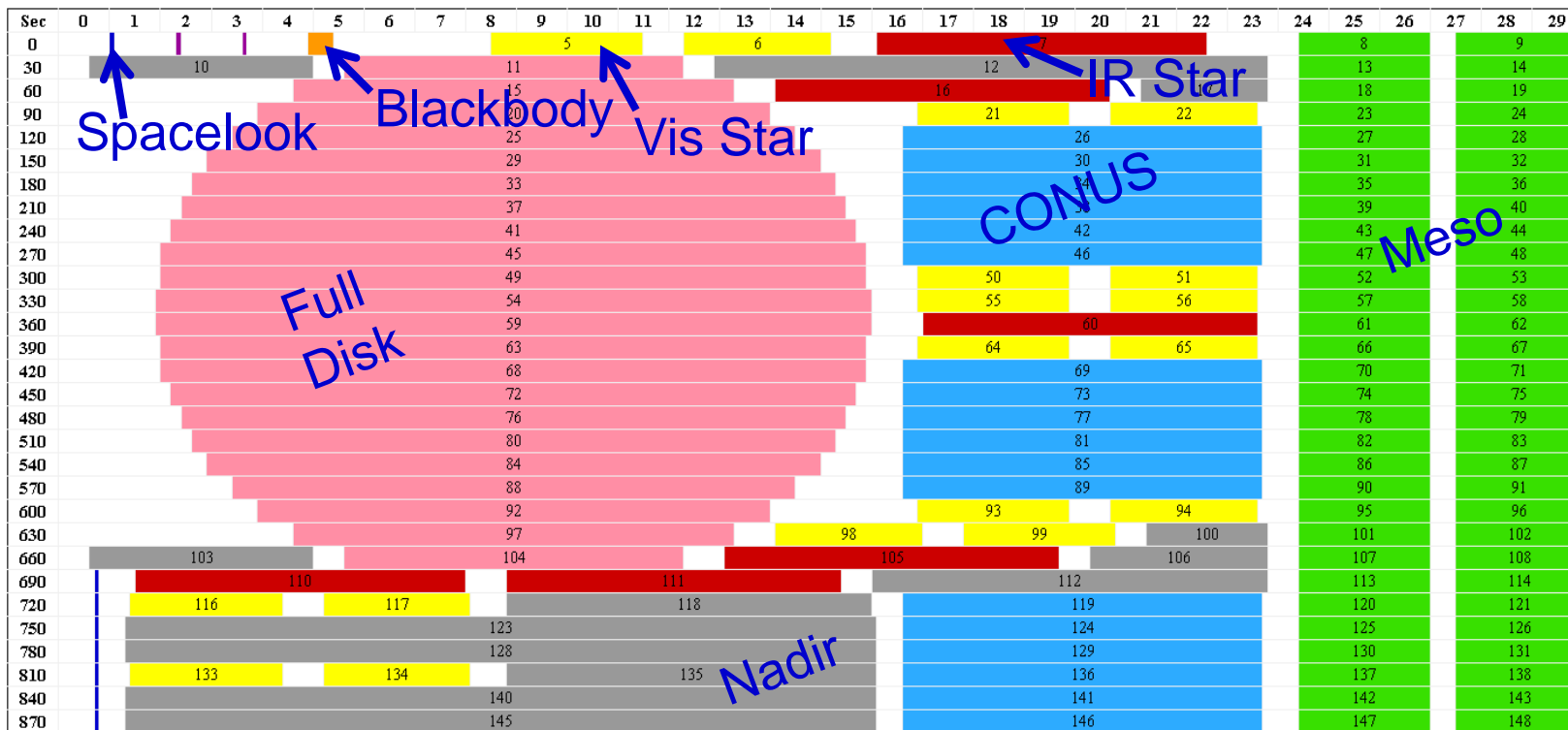


CONUS FROM CENTRAL BAND=10 7.34 UM

Scan Mode 3 Timeline (Flex Mode) Delivers Storm Watch Every 30 Seconds



NOTE: This depiction of the timeline is only to 1/10 sec. resolution.

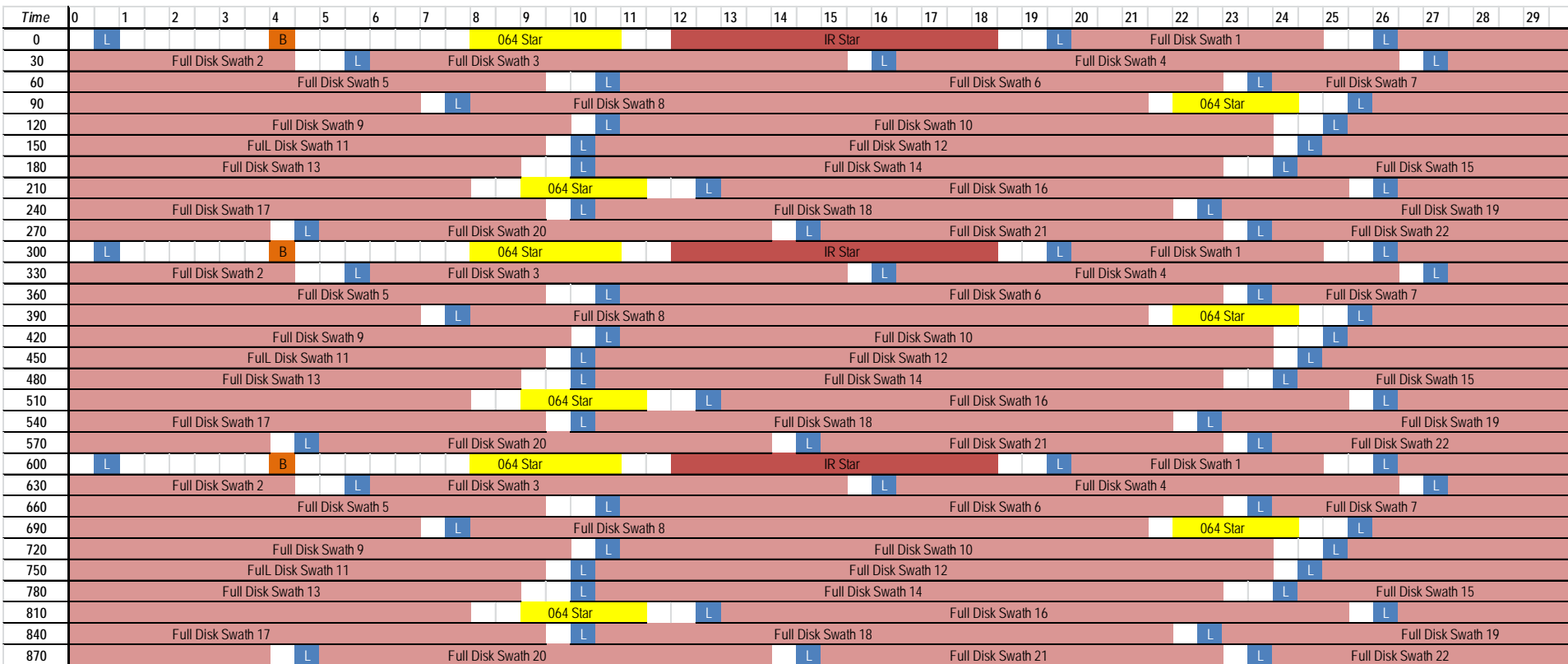


Note: Autonomous spacelook collected with each Full Disk swath MISTiC

Meso: one every 30 seconds or two at 1 minute intervals each
Scene locations can be changed on the fly (no interruption of timeline)

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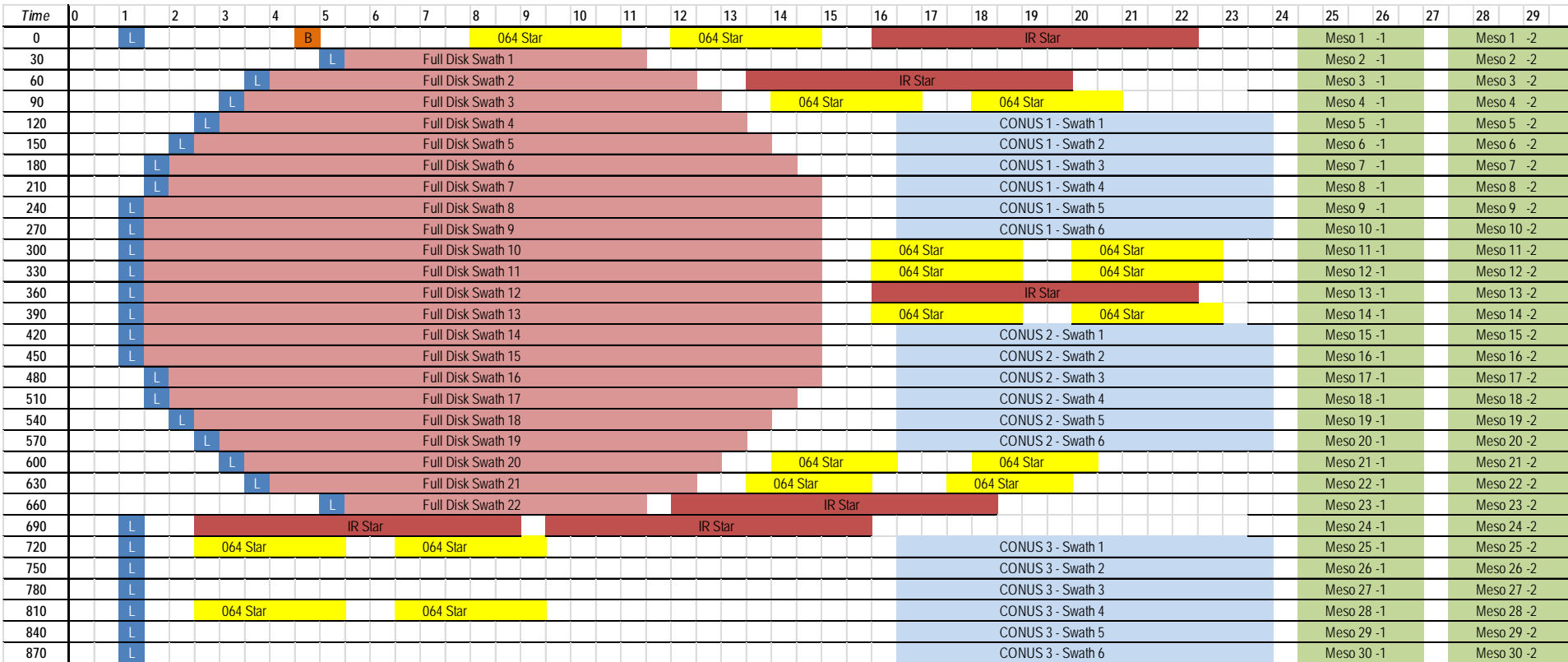
Baseline Time-Time Mode 4 (Continuous Full Disk)



- This is the Continuous Full Disk (every 5 min) mode
- This is the highest data rate.
- When might this mode be run?

Recent Mode 3 (Flex mode)

“Time-Time” chart



Note the ‘white’ space is instrument idle time.

Approximate number of ABI pixels

Sector	0.5 km	1 km	2 km	
Full disk diameter	21696	10848	5524	pixels
CONUS height	6000	3000	1500	pixels
CONUS width	10000	5000	2500	pixels
Meso height/width	2000	1000	500	pixels

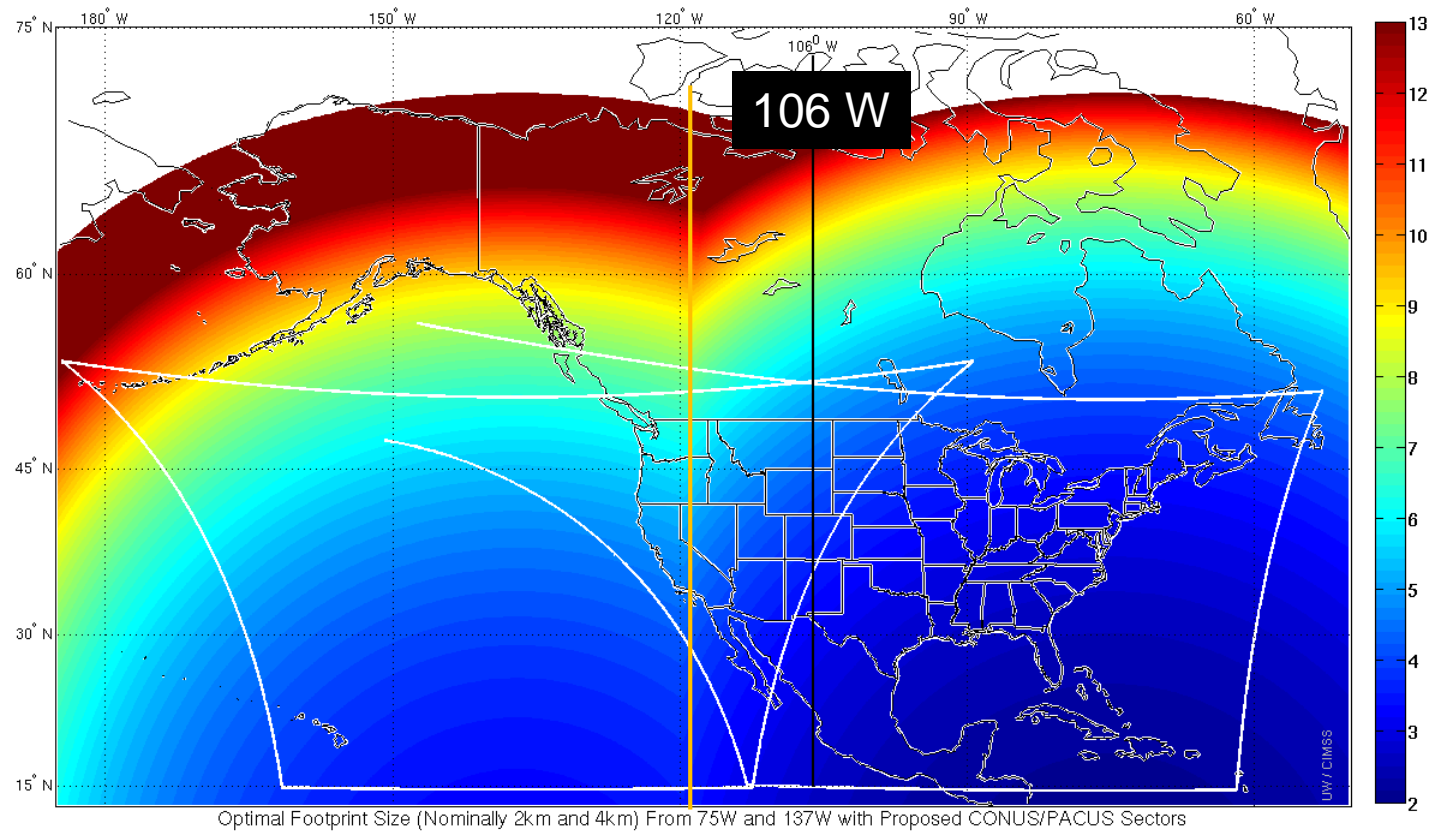
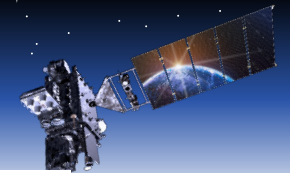
Details: PUG Volume L1b. Table 5.1.2.6

Jan17_16072_tc_fulldisk_full_resolution_ppm.paged





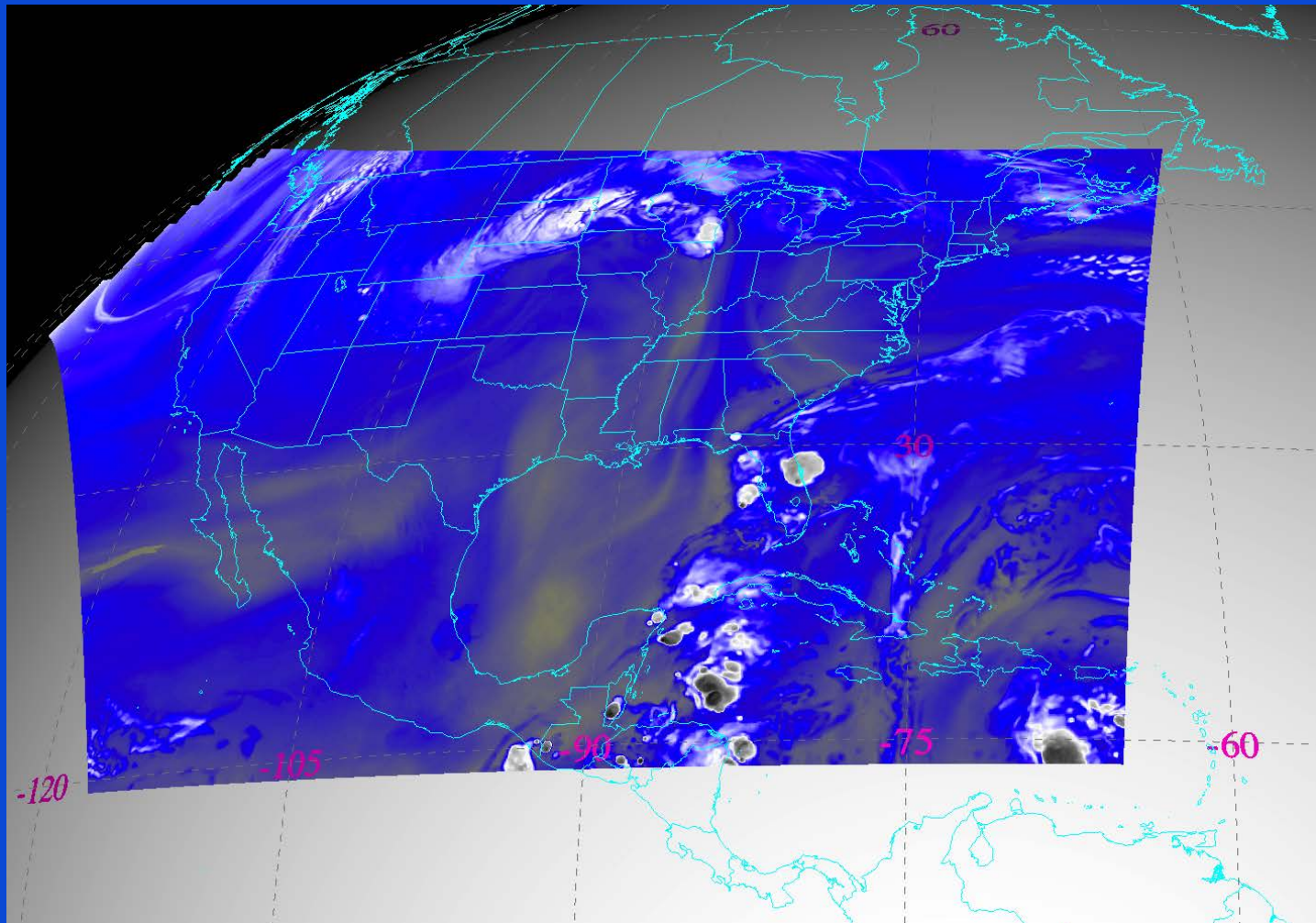
GOES-R (16) as GOES-East GOES-15 as GOES-West



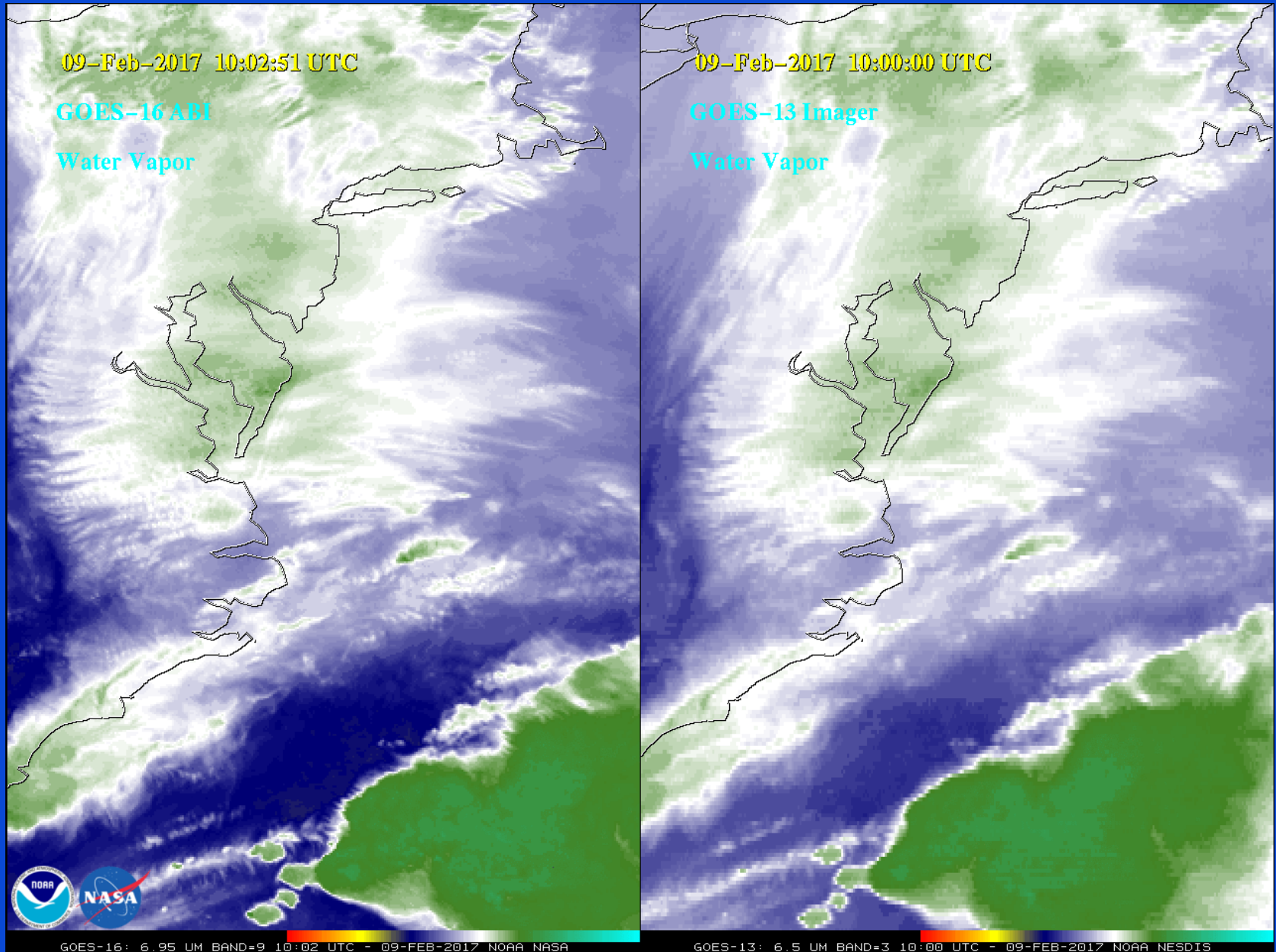
The spatial resolution from the GOES-R ABI is better than current GOES For the eastern contiguous United States to 120 degrees West. Note that even west of there, the ABI offers improved temporal resolution.

GOES-16 East CONUS

- Approximate location



ABI vs GOES-13



ABI vs GOES-13



GOES-16 vs GOES-13

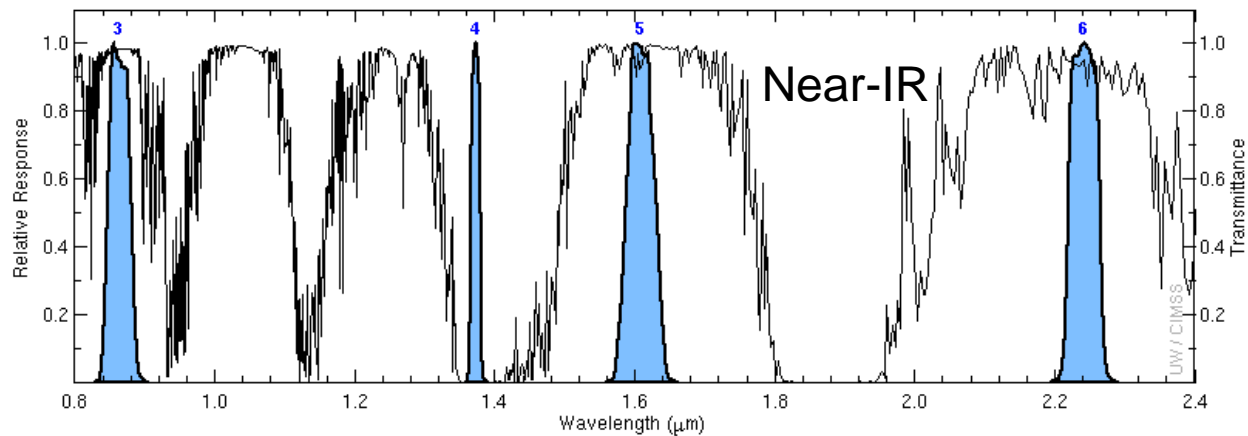
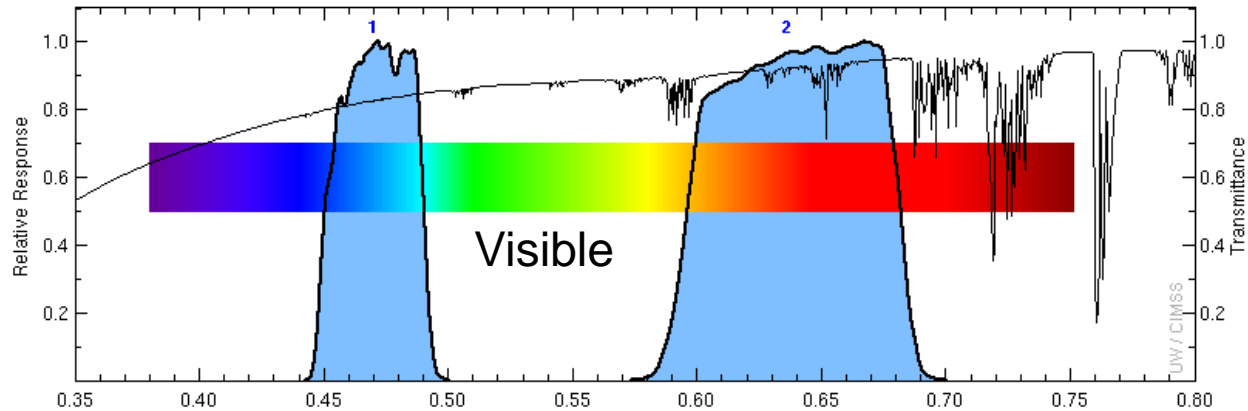


ABI: Bands 1-6 (Visible / NearIR)

ABI Band	Wavelength (μm)	Wavelength range (μm)	Sub-point pixel spacing (km)	Descriptive Name
1	0.47	0.45 - 0.49	1	"Blue"
★ 2	0.64	0.60 - 0.68	0.5	"Red"
3	0.864	0.847 - 0.882	1	"Veggie"
4	1.373	1.366 - 1.380	2	"Cirrus"
5	1.61	1.59 - 1.63	1	"Snow/Ice"
6	2.24	2.22 - 2.27	2	"Cloud Particle Size"

Six visible or near visible bands on ABI, one on heritage imager

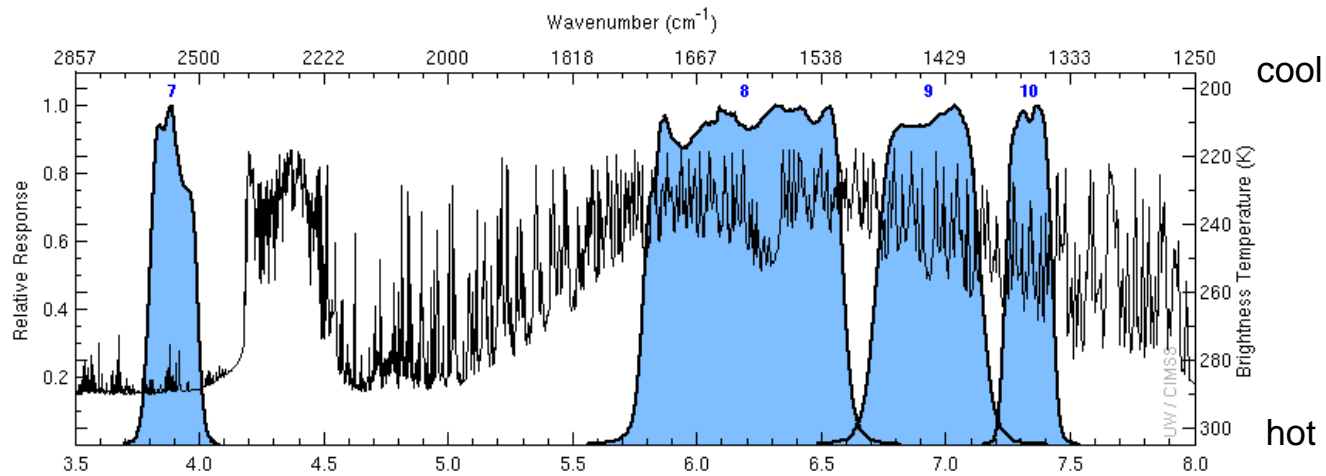
ABI Spectral Bands (1-6)



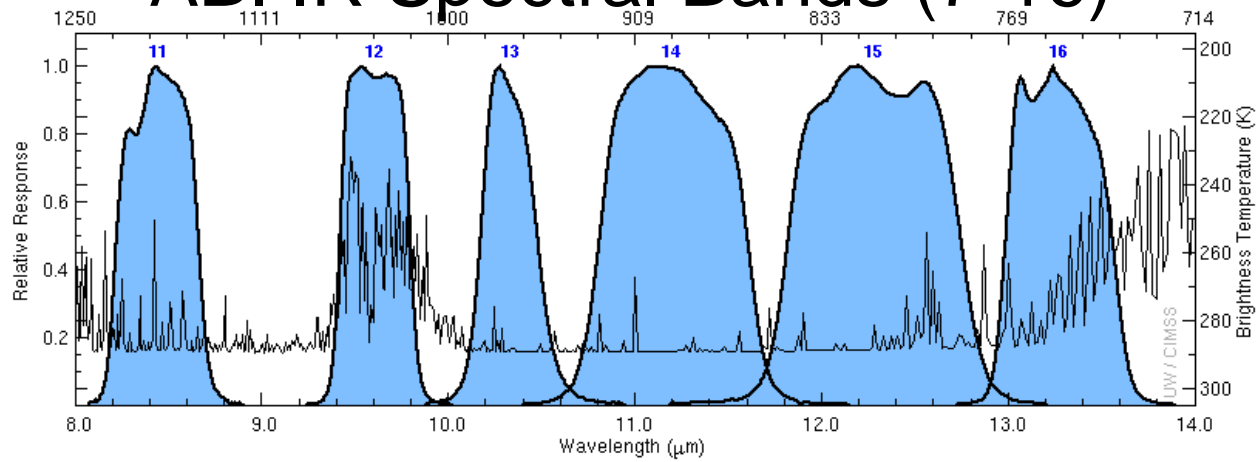
ABI: Bands 7-16 (Infrared)

ABI Band	Wavelength h (μm)	Wavelength range (μm)	Sub-point pixel spacing (km)	Descriptive Name
★ 7	3.90	3.80 - 3.99	2	“Shortwave window”
★ 8	6.19	5.79 - 6.59	2	“Upper-level Water Vapor”
★ 9	6.93	6.72 - 7.14	2	“Mid-Level Water Vapor”
10	7.34	7.24 - 7.43	2	“Lower/Mid-level Water Vapor”
11	8.44	8.23 - 8.66	2	“Cloud-top Phase”
12	9.61	9.42 - 9.80	2	“Ozone”
13	10.33	10.18 - 10.48	2	“Clean longwave window”
★ 14	11.21	10.82 - 11.60	2	“Longwave window”
15	12.29	11.83 - 12.75	2	“Dirty longwave window”
★ 16	13.28	12.99 - 13.56	2	“CO ₂ ”

10 infrared bands on the ABI, four on heritage imager



ABI IR Spectral Bands (7-16)



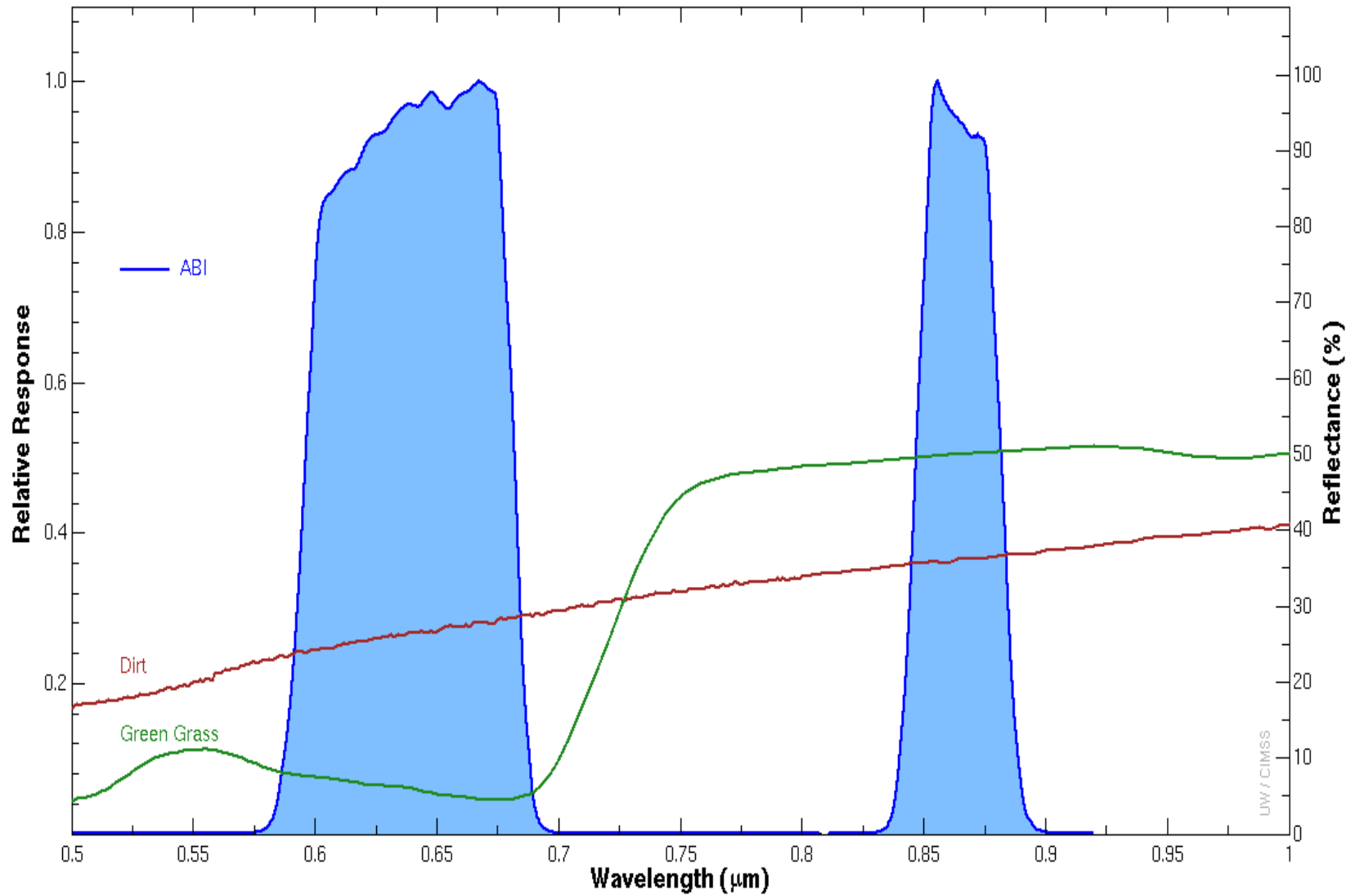
ABI Visible Bands

- Current GOES imagers: One visible band
- GOES-R ABI:
 - Two visible bands (1 km and 0.5 km)
 - Near IR bands 1 or 2 km resolution
- Benefits to the operational meteorologist:
 - Depiction of clouds
 - Depiction of smoke
 - Depiction of fog
 - Used for AMV (Atmospheric Motion Vector) generation
 - Used in snow cover estimates

ABI Near-Infrared Bands

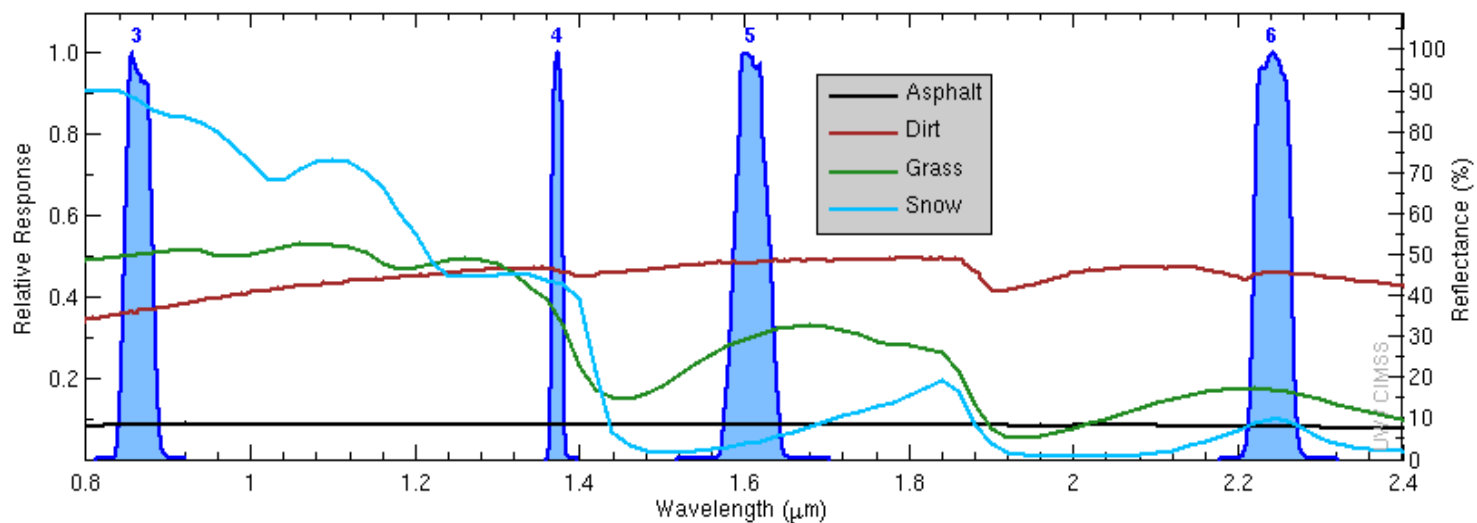
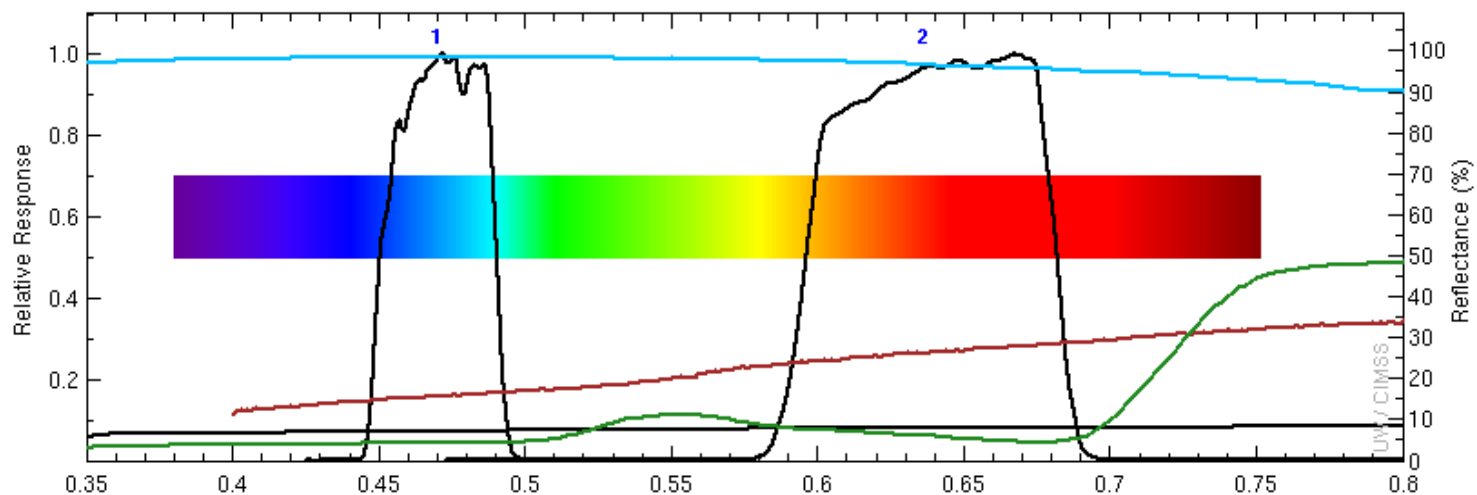
- Current GOES imagers: No near-infrared bands
- GOES-R ABI: Four near-infrared bands, two at 1 km resolution, two at 2 km resolution
- Benefits to the operational meteorologist:
 - Depiction of vegetation health/coverage
 - Sharper coastlines and easier detection of inland river flooding
 - Easier cirrus cloud
 - Cloud-phase discrimination
 - Nocturnal fire detection

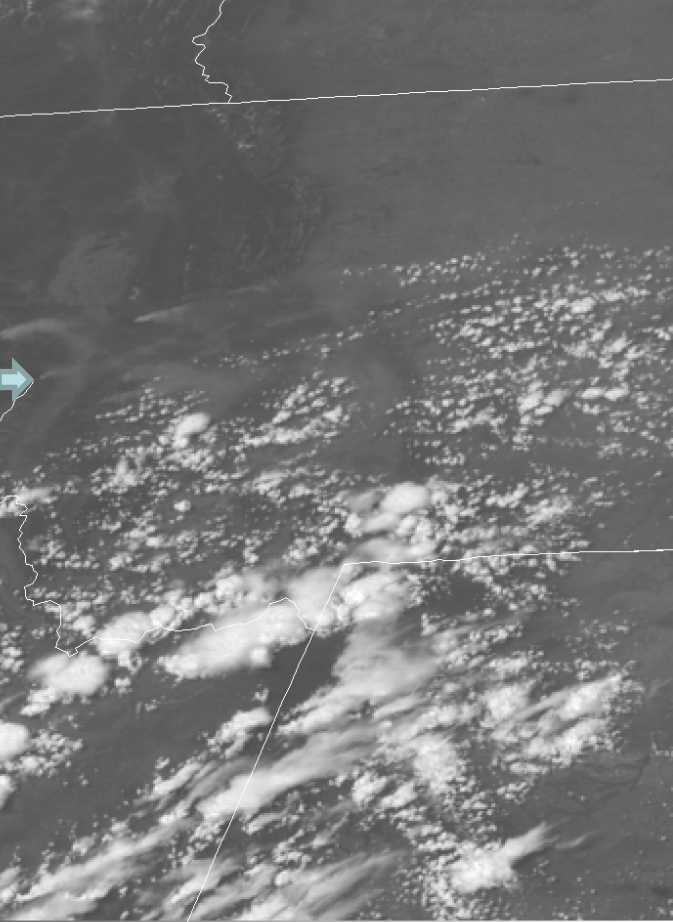
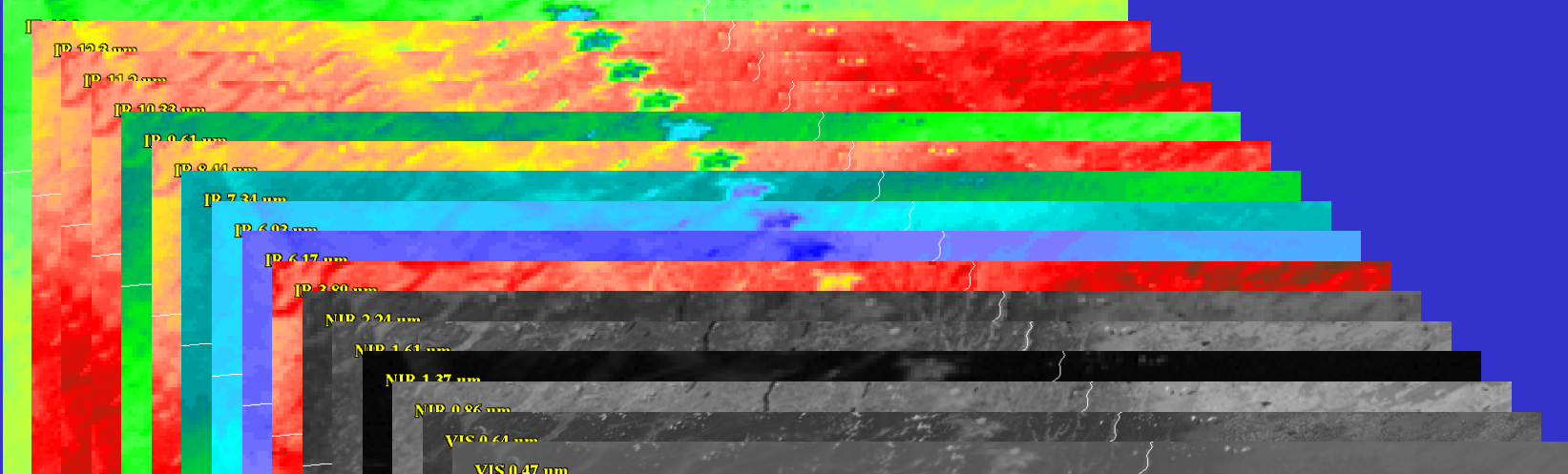
ABI Flight Model 1 v2 SRFs



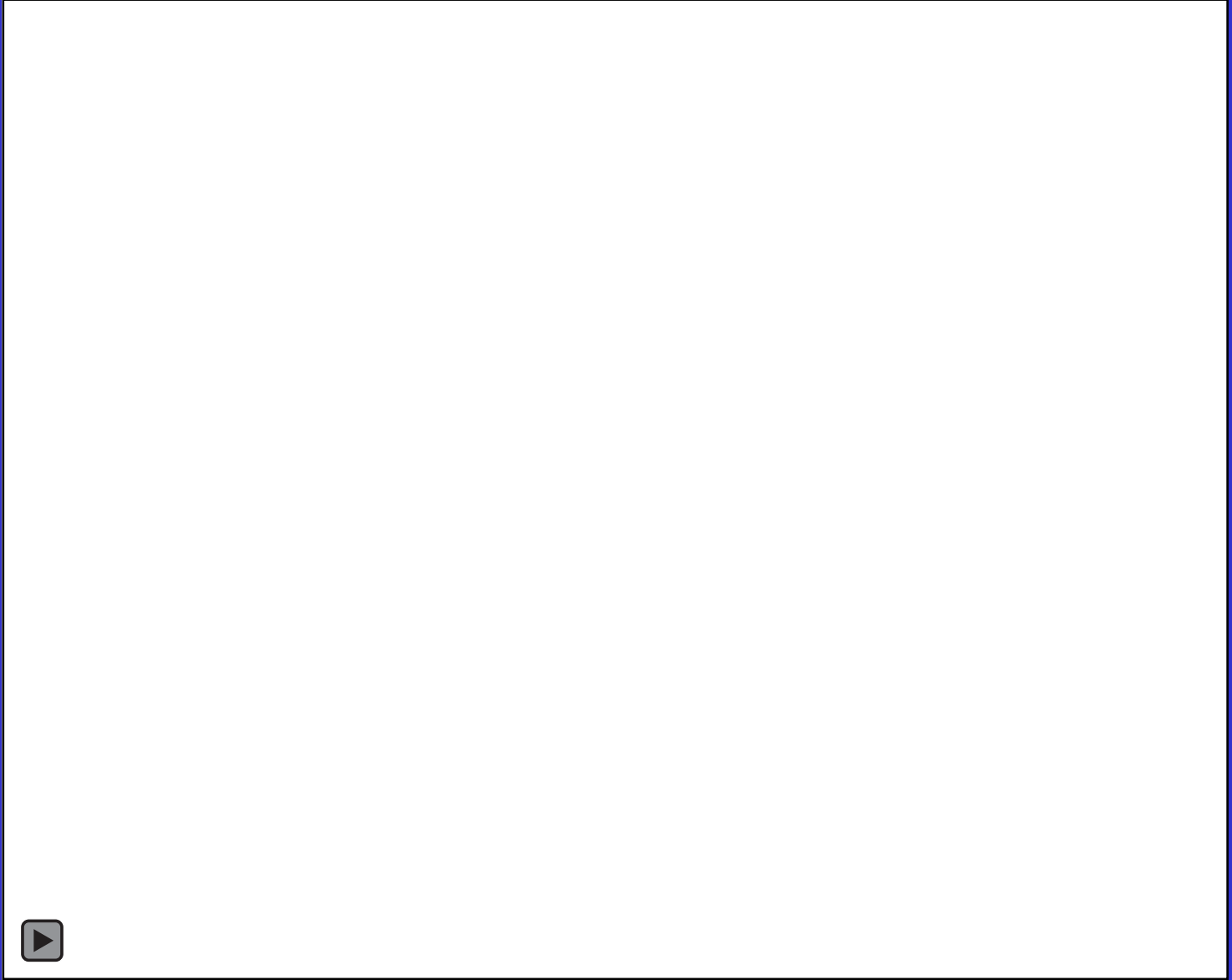
UW / CIMSS

ABI FM1 v2 (Jan2014) Visible SRFs & Various ASTER Reflectance Spectra





ABI 0.62 μm



GOES-16 ABI



GOES-16 0.47 um and 3.9 um 2017-03-06 17:05:29Z
Preliminary, non-operational data.

Credit: Bill Line



Fire Burn Scars

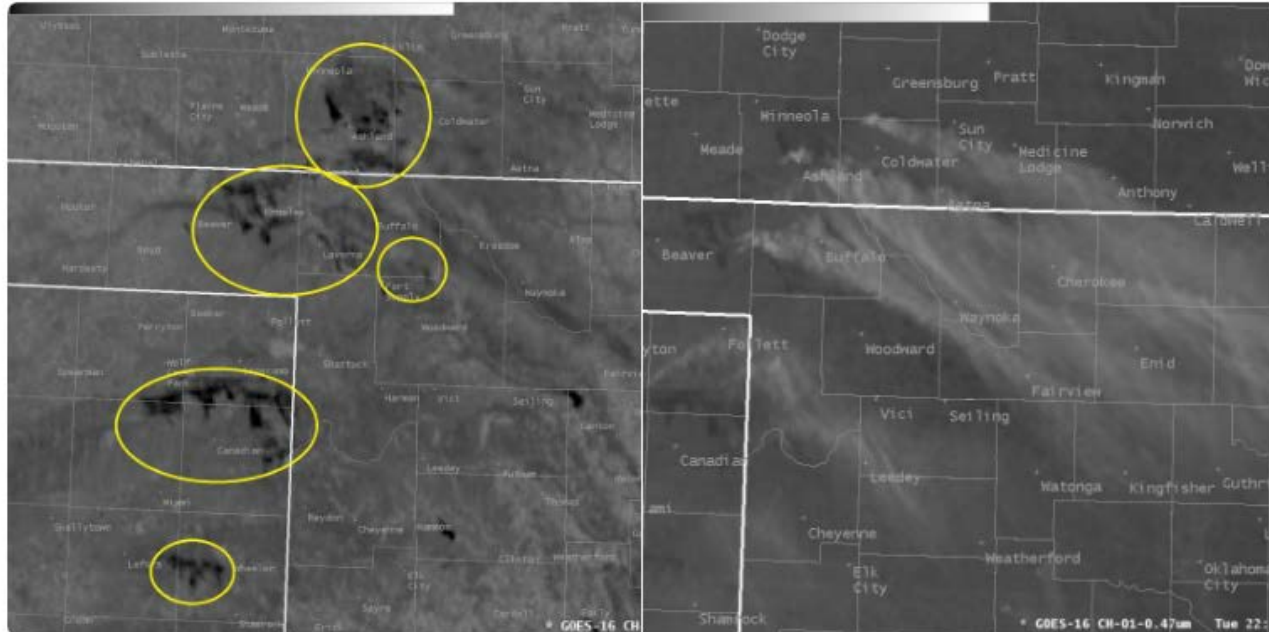


NWS Norman 
@NWSNorman

Following



The new GOES-16 satellite shows both the burn scars from yesterday's wildfires, but also today's smoke. [Preliminary, non-operational data.]





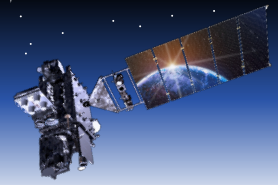
GOES-16 Products



ABI L1b Product	ABI L2+ Products (con't)	GLM L2 Product
Radiances	Downward S/W Radiation: Surface	Lightning: Events, Groups, Flashes
ABI L2+ Products	Fire/Hot Spot Characterization	SEISS L1b Products
Cloud and Moisture Imagery (KPP)	Hurricane Intensity Estimation	Energetic Heavy Ions
Aerosol Detection (Smoke & Dust)	Land Surface Temperature	Magnetospheric e ⁻ /p ⁺ : Low Energy
Aerosol Optical Depth (AOD)	Legacy Vertical Moisture Profile	Magnetospheric e ⁻ /p ⁺ : High Energy
Clear Sky Mask	Legacy Vertical Temperature Profile	Solar & Galactic Protons
Cloud Particle Size Distribution	Rainfall Rate/QPE	EXIS L1b Product
Cloud Top Height	Reflected S/W Radiation: TOA	Solar Flux: EUV
Cloud Top Phase	Sea Surface Temperature	Solar Flux: X-ray Irradiance
Cloud Top Pressure	Snow Cover	
Cloud Top Temperature	Total Perceptible Water	Plus from the ABI (Pathfinders)
Derived Motion Winds	Volcanic Ash: Detection and Height	Aerosol Particle Size
Derived Stability Indices		Cloud Layers/Heights
		Ice Thickness
		Low Cloud and Fog
		Ice: Concentration
		Ice: Motion



A Closer Look at the ABI



- <http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-15-00230.1>
- April BAMS issue
- Schmit, T.J., P. Griffith, M. M. Gunshor, J. M. Daniels, S. J. Goodman, and W. J. Lebair, 2017: A closer look at the ABI on the GOES-R series. Bull. Amer. Meteor. Soc., 98, 681–698, doi:10.1175/BAMS-D-15-00230.1.



GOES-R Baseline Products



Many critical derived quantities

<http://www.goes-r.gov>



INITIAL ON-ORBIT ADVANCED BASELINE IMAGER (ABI) PERFORMANCE OBSERVATIONS

PAUL GRIFFITH¹, W. J. LEBAIR², T. J. SCHMIT³, X. WU³, AND J. VAN NAARDEN¹

¹Harris Corporation, ²NASA/GSFC, ³NOAA/NESDIS/STAR

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13NGOESS-10.2 ABI Performance

Visible and Near-IR Signal-to-Noise All Greater than 500 and Matching Ground Expectations



PRELIMINARY

Channel (μm)	Expected BOL SNR [†]	On-Orbit SNR [†]	Ratio (On-Orbit/Ground)
0.47	1176	1196	102%
0.64	531	508	96%
0.86	833	784	94%
1.38	1065	1124	106%
1.61	672	640	95%
2.25	1149	1137	99%

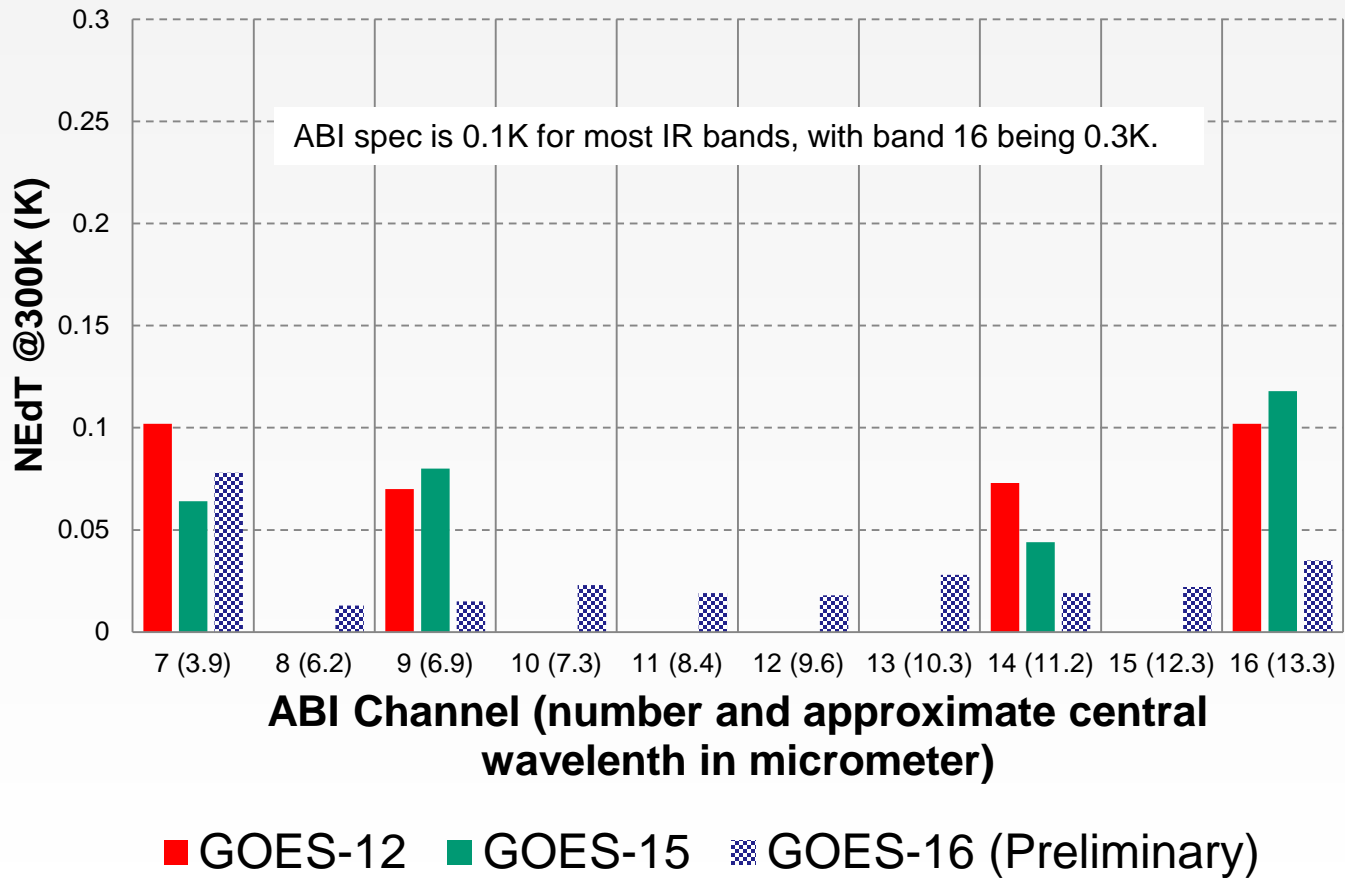
[†]Mean of all pixels (Note: Higher SNR is better)

BOL expectations calculated from ABI response to integrating sphere near 100% albedo

On-orbit values calculated via on-board solar calibration capability

- Partial-aperture observation of onboard Spectralon™ diffuser illuminated by the Sun

GOES Imager and GOES-16 ABI ICT Noise Estimates

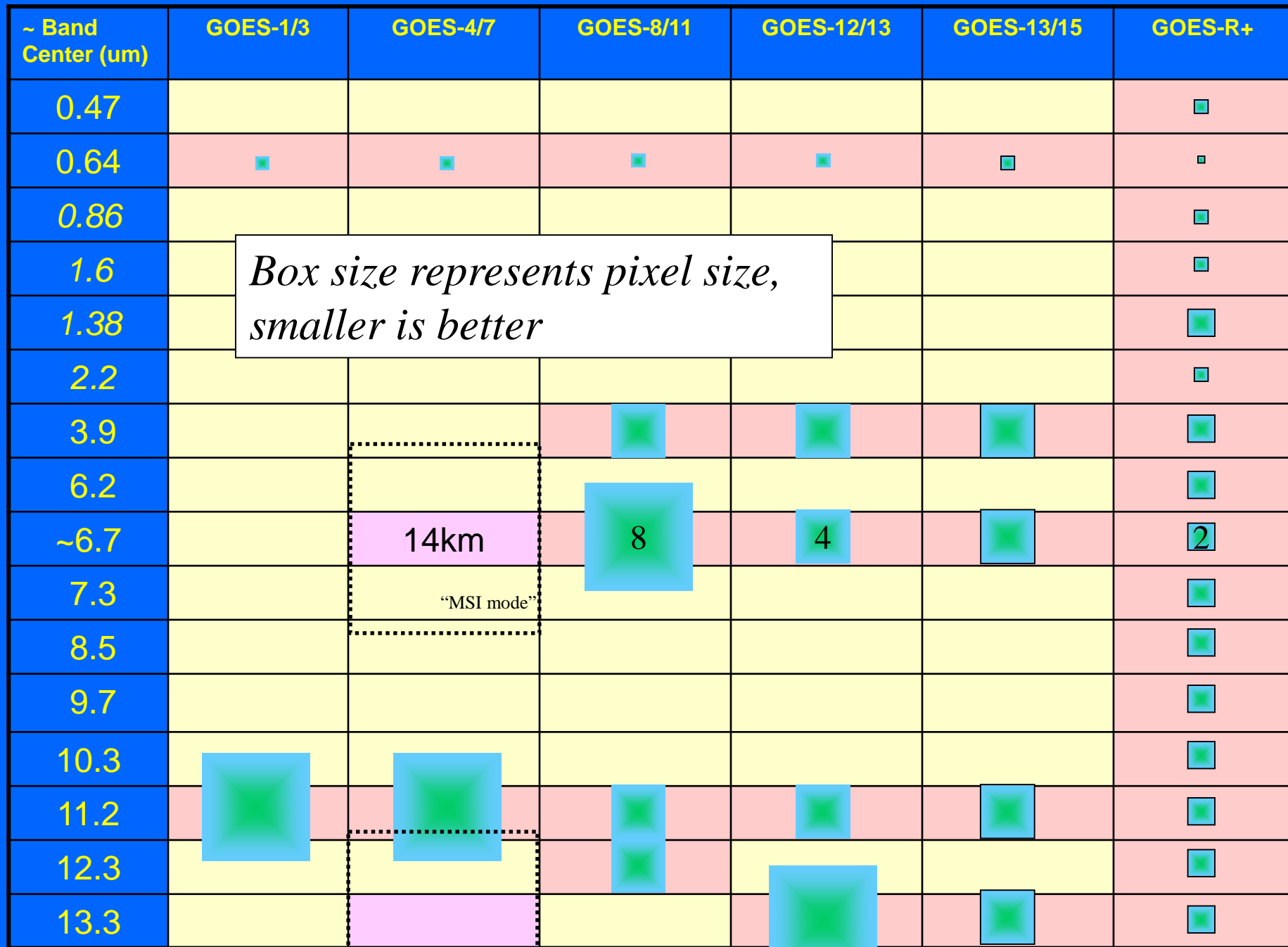


Approximate spectral and spatial resolutions of US GOES Imagers

Visible

Near-IR

Infrared



GOES Continuity

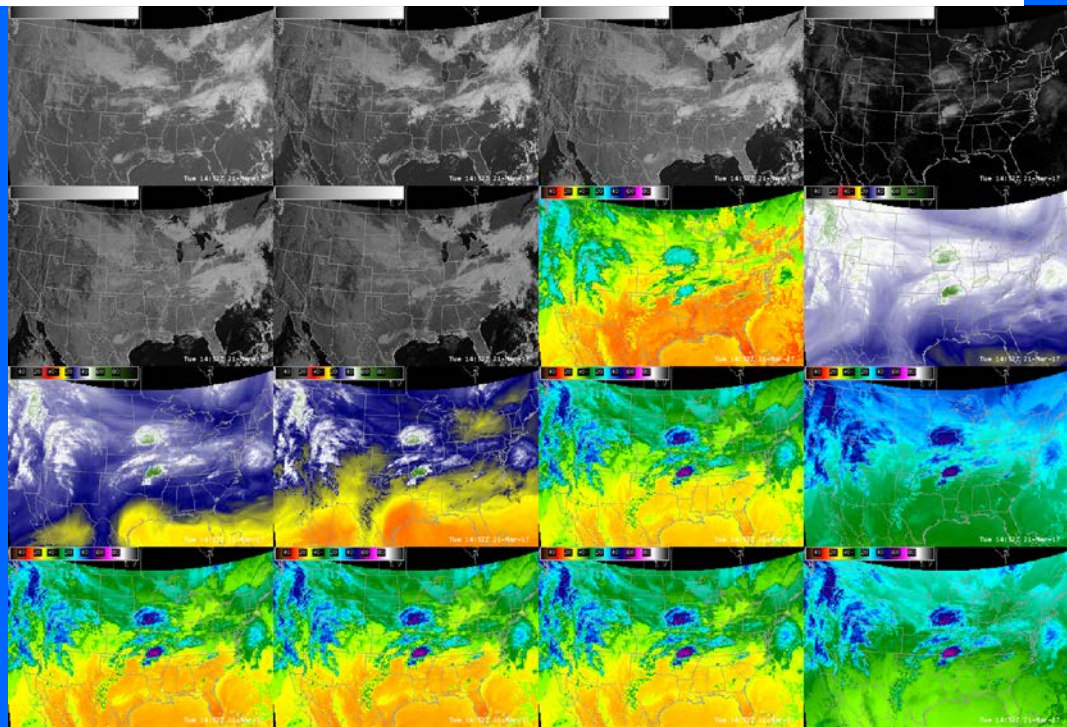
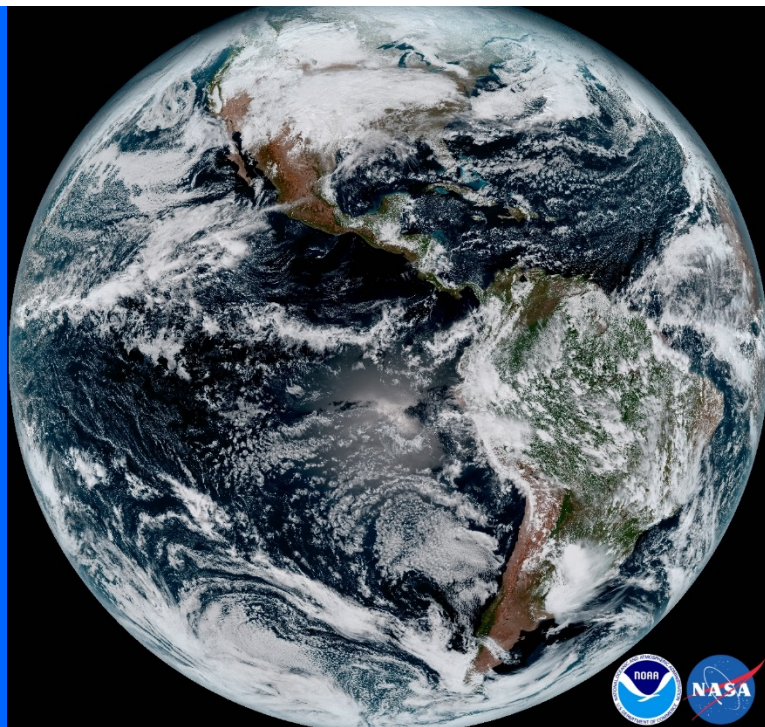




Acknowledgements

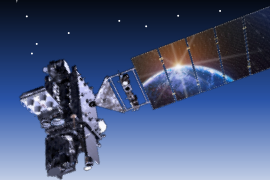
- The authors would like to thank the entire GOES and GOES-R teams; both within the government, industry and academia.
- The views, opinions, and findings contained in this presentation are those of the authors and should not be construed as an official National Oceanic and Atmospheric Administration or U.S. Government position, policy, or decision. All GOES-16 data shown are experimental, during on-orbit testing.

<http://cimss.ssec.wisc.edu/goes/goesr.html>





GOES-R Series web sites



- <http://www.goes-r.gov>
- <http://cimss.ssec.wisc.edu/goes-r/>
- <http://cimss.ssec.wisc.edu/goes/goesdata.html>

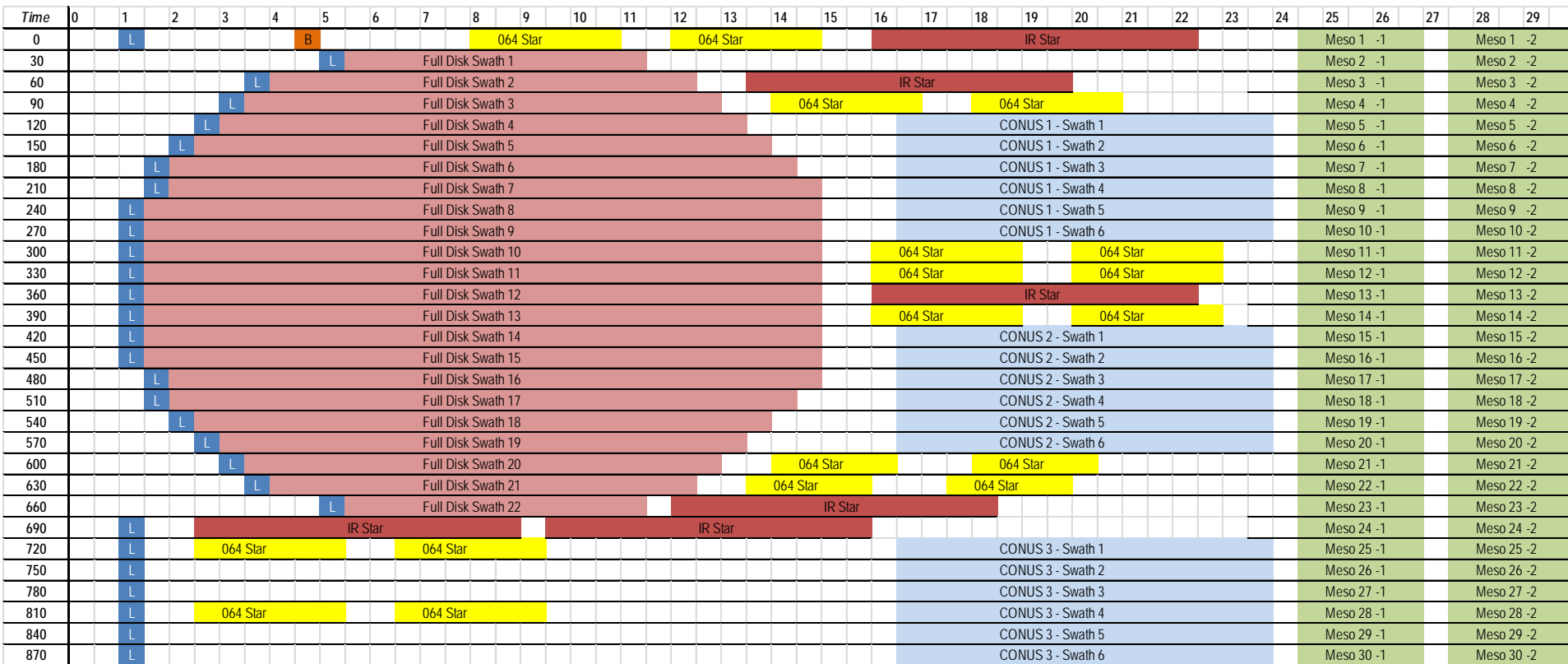


*Lockheed Martin

GOES-16 data shown are preliminary, experimental, during on-orbit testing.

Recent Mode 3 (Flex mode)

“Time-Time” chart



Note the ‘white’ space is instrument idle time.

ABI Scan Mode "6" with 10-min FD

- In 10-min:
 - 1 Full Disk +
 - 2 CONUS +
 - 20 Meso-scale
- The 10-min Full Disk would offer synergy with other geos and improved AMVs outside of CONUS, plus still allow for meso-scale observations.
- Data from the mode has been collected during the PLPT (Post Launch Products Test).
- This mode maintains the scan sectors (same size/locations) as in mode 3 and is currently under contract for the needed ground system modifications.

ABI Scan Mode "6" with 10-min FD

NOTE : This depiction of the timeline is only to 1/10 sec. resolution.



Figure 1 Scan Mode 6 Time-Time Diagram

Note less 'white space' than scan mode 3 (flex mode)