Spectral Band Selection for the Advanced Baseline Imager (ABI)

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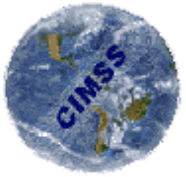
NESDIS/ORA
Advanced Satellite Products Team

Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin - Madison



Why ABI?:
A Continuing Evolution

To keep pace with the growing needs for GOES data and products, NOAA must continue to evolve its geostationary remote sensing capabilities.

The Advanced Baseline Imager (ABI) follows this evolutionary path. ABI enhances the current capabilities and addresses unmet NWS requirements.

What's the Advance Baseline Imager:

Spatial resolution	Visible (0.64 μm)	0.5 km (14 μrad)	
	All other bands	2 km (56 μrad)	
Spatial coverage	Full disk	4 per hour	(every 15 min)
	CONUS (3000 x 5000 km)	12 per hour	(every 5 min)
Operation during eclipse		Yes	
Lifetime	Mean Mission life	8.4 years	
Noise	NEdT (except 13.3 μm)	0.1K @ 300K	
Data rate	< 15 Megabits-per second (Mbps)		

When's the ABI:

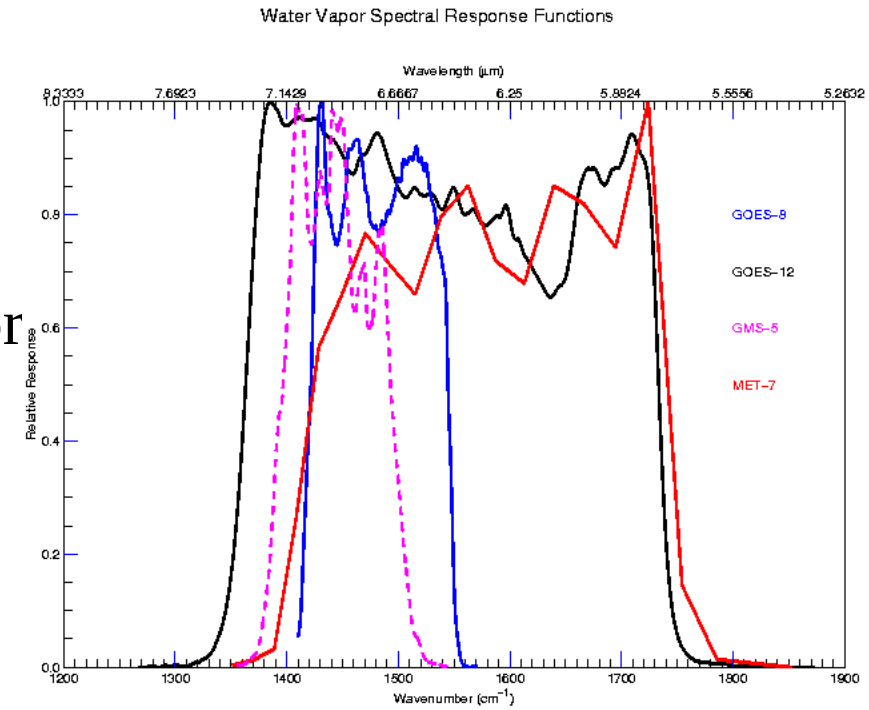
GOES-__ (L) - 3 May 2000 launch

GOES-__ (M) - early 2002 (estimate)
- spectrally wider water vapor
- higher spatial resolution water vapor
- additional 13.3 μm band
- no 12 μm band

GOES-__ (N, O, P)

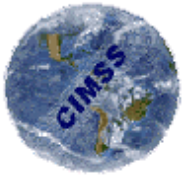
GOES-__ (Q) - 2008 (estimate) w/ **ABI**

GOES-__ (R) - 2010



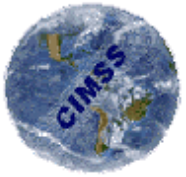
ABI - 8

#	Wavelengths Range (μm)	Center	Description	Primary Use
1	0.52 – 0.72	**0.62**	Visible	Daytime clouds, fog
8	1.3 – 1.9	**1.6**	Near IR	Daytime clouds/snow, water/ice clouds
2	3.8 – 4.0	**3.9**	Shortwave IR	Nighttime low clouds, fog, fire detection
3	6.5 – 7.0	**6.75**	Water Vapor 1	Upper tropospheric flow, winds
6	7.0 – 7.5	**7.25**	Water Vapor 2	Mid tropospheric flow, winds
4	10.2 – 11.2	**10.7**	IR Window 3	Clouds, low-level water vapor, fog, winds
5	11.5 – 12.5	**12.0**	IR Window 4	Low-level water vapor, volcanic ash
7	13.2 – 13.8	**13.5**	Carbon Dioxide	Cloud-top parameters, heights for winds

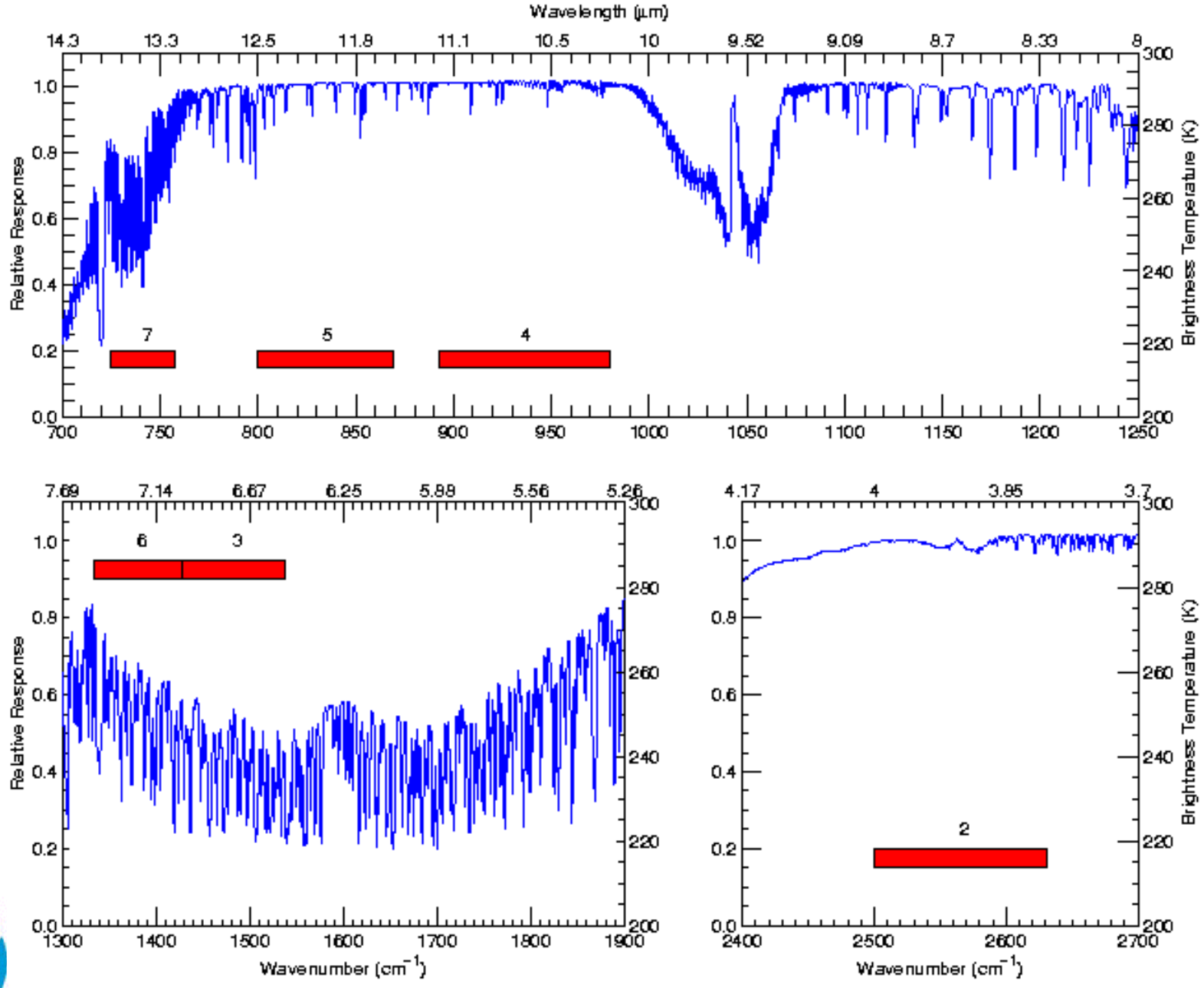


ABI - 12

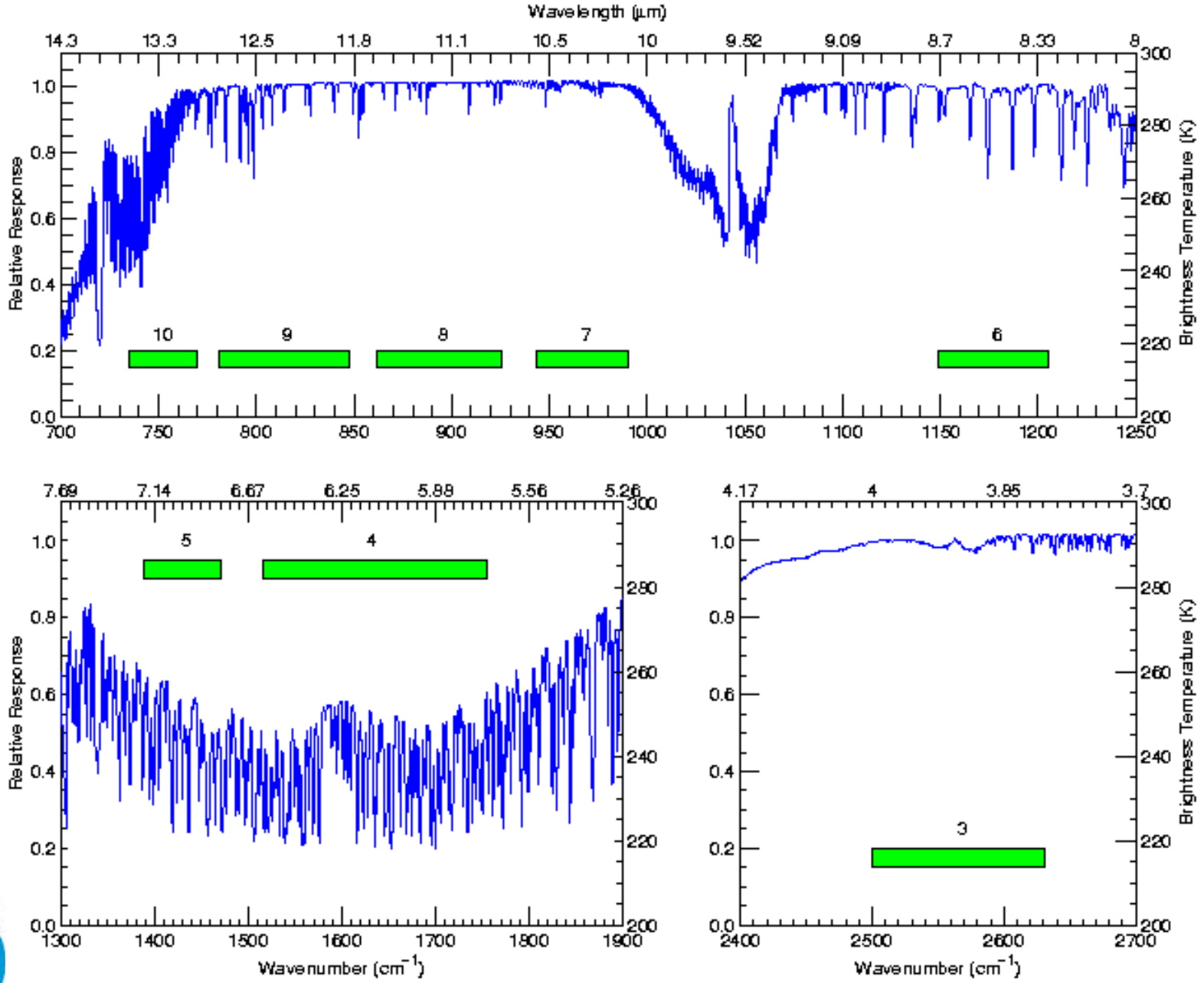
#	Wavelengths Range (μm)	Center	Description	Primary Use
1	0.59 – 0.69	**0.64**	Visible	Daytime clouds, fog
-	0.81 - 0.91	**0.86**	Solar window	Day clouds, NDVI, fog, aerosol, ocean studies
-	1.36 - 1.39	**1.375**	Near IR	Daytime thin cirrus detection
2	1.58 – 1.64	**1.61**	Near IR	Daytime clouds/snow, water/ice clouds
3	3.8 – 4.0	**3.9**	Shortwave IR	Nighttime low clouds, fog, fire detection
4	5.7 – 6.6	**6.15**	Water Vapor 1	Upper tropospheric flow, winds
5	6.8 – 7.2	**7.0**	Water Vapor 2	Mid tropospheric flow, winds
6	8.3 – 8.7	**8.5**	IR Window 1	Sulfuric acid aerosols, cloud phase, sfc
7	10.1 – 10.6	**10.35**	IR Window 2	Cloud particle size, sfc properties
8	10.8 – 11.6	**11.2**	IR Window 3	Clouds, low-level water vapor, fog, winds
9	11.8 – 12.8	**12.3**	IR Window 4	Low-level water vapor, volcanic ash
10	13.0 – 13.6	**13.3**	Carbon Dioxide	Cloud-top parameters, heights for winds



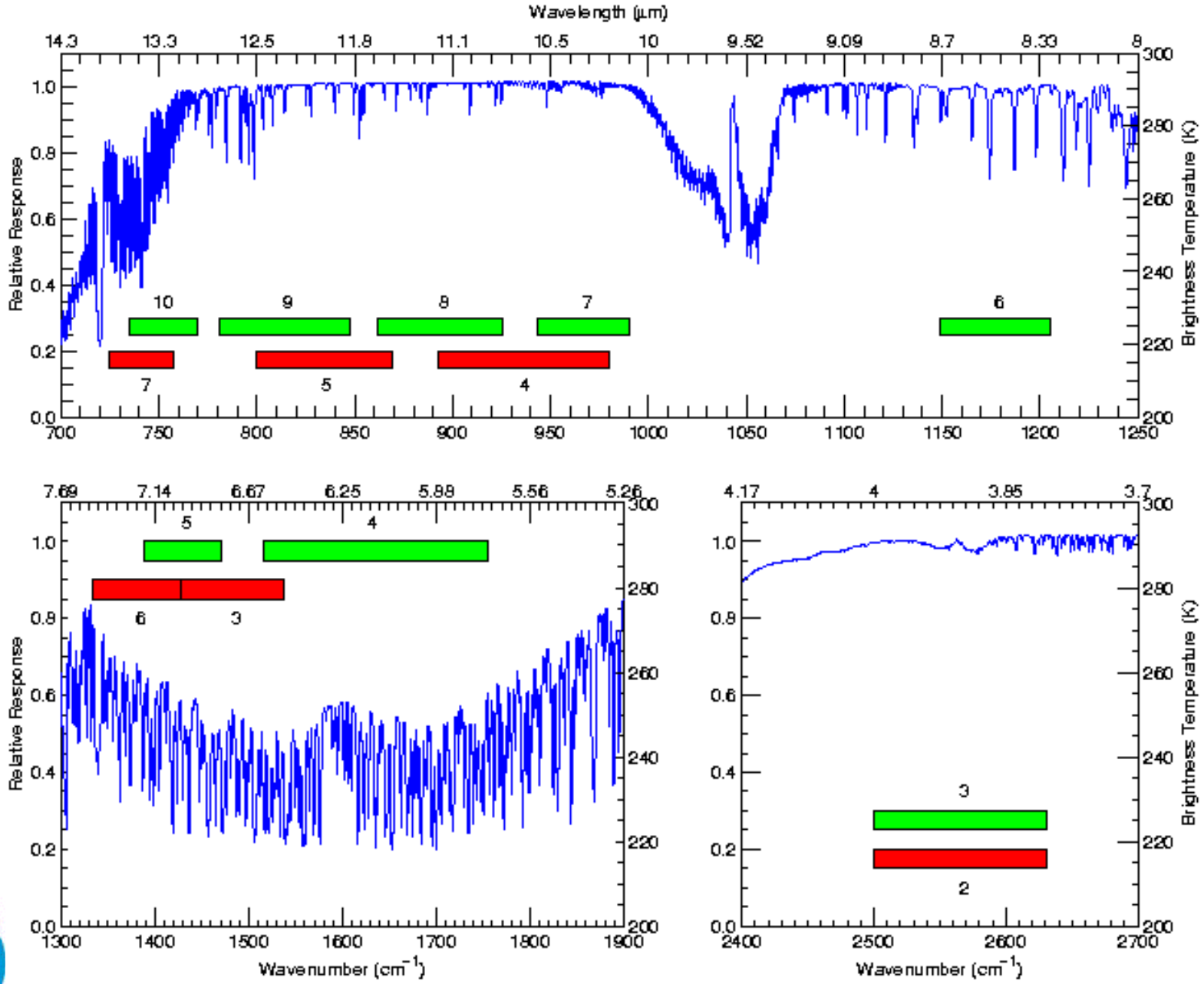
ABI-8 (IR only) Channels

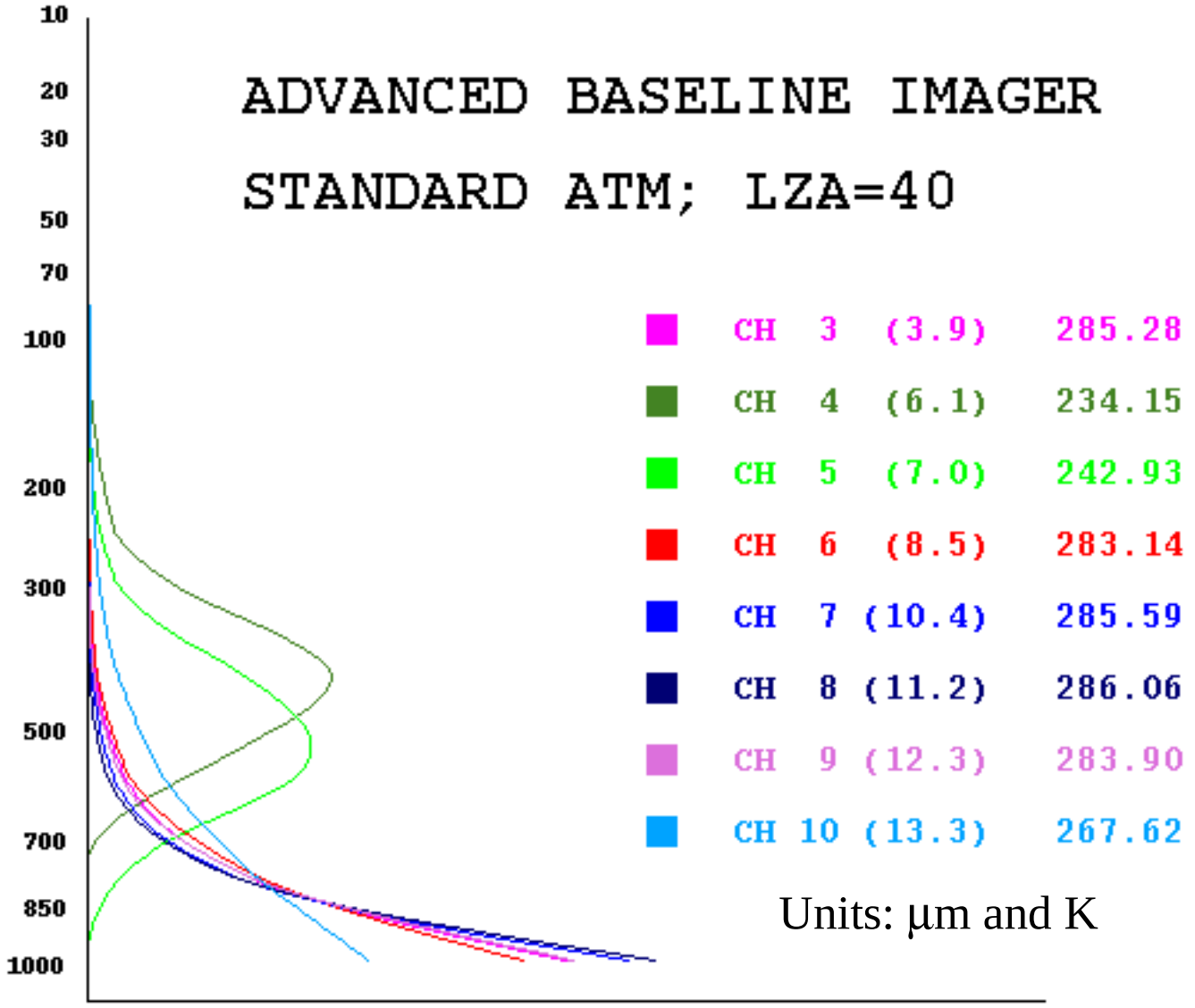


ABI-12 (IR only) Channels



ABI-12 (top bars) and ABI-8 (bottom bars) IR Channels

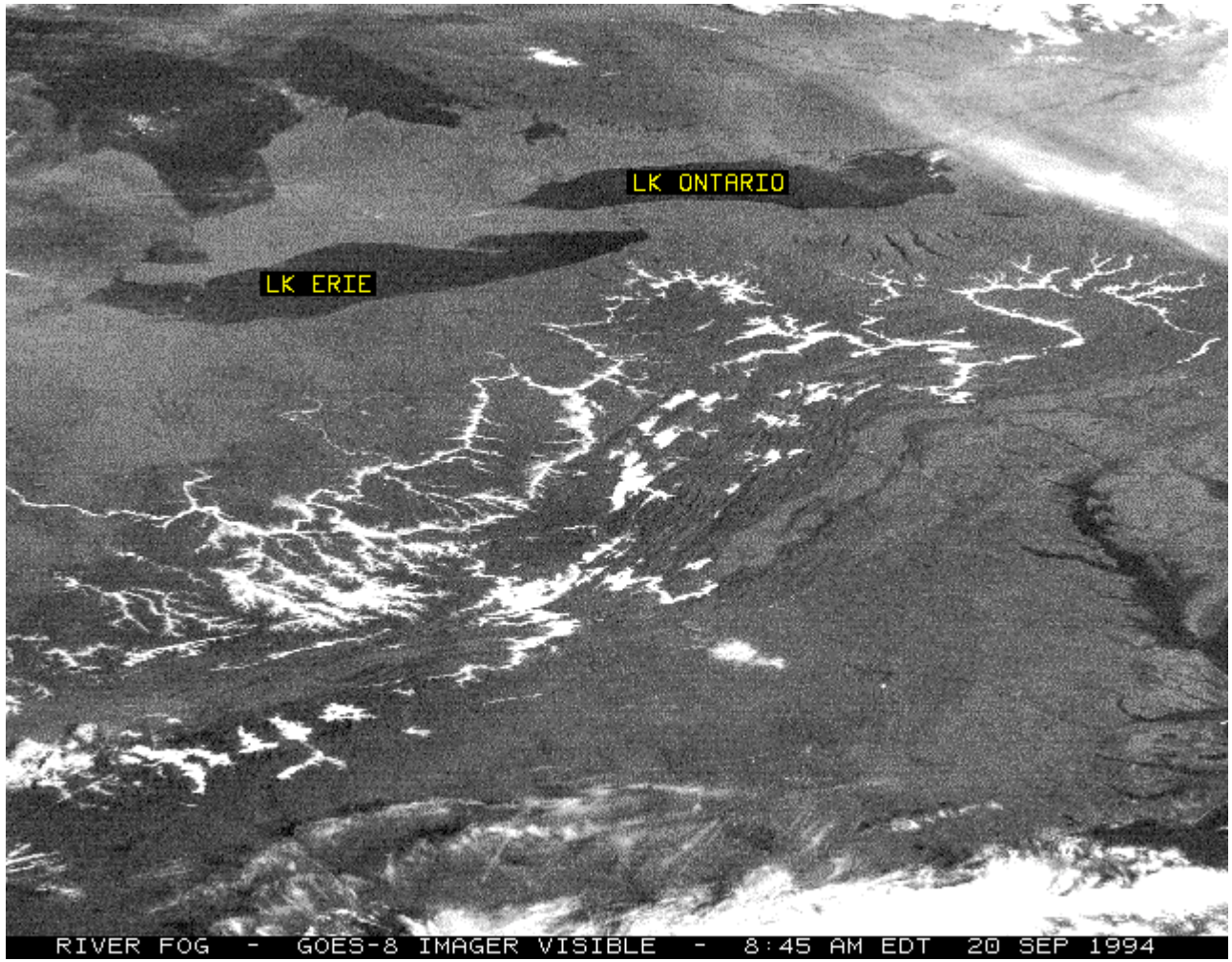




Weighting Functions for the IR Channels

ABI High Spatial Resolution Visible (0.64 μm)

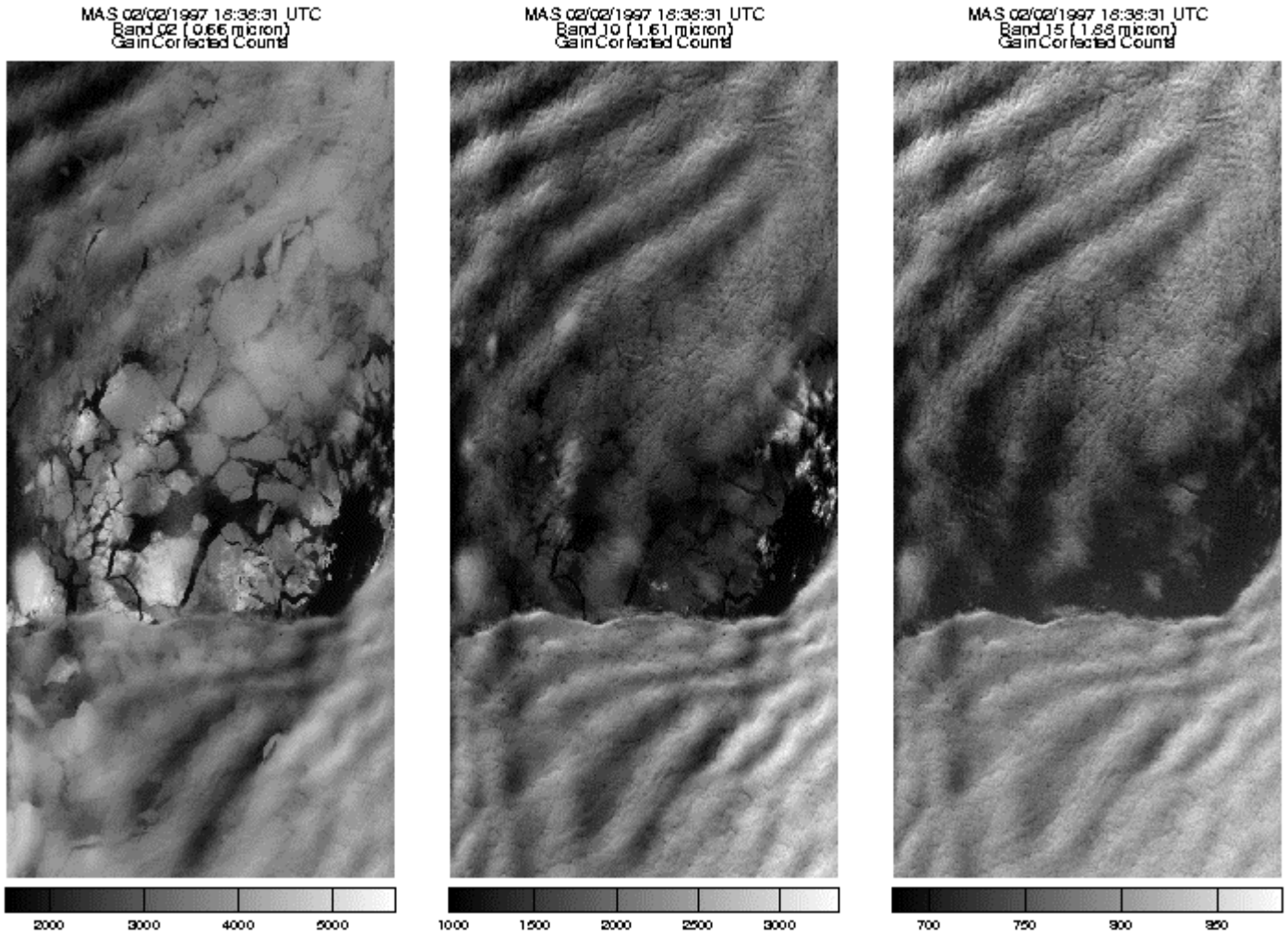
Based on GOES Imager Ch 1



ABI Channel 2 (1.61 um)

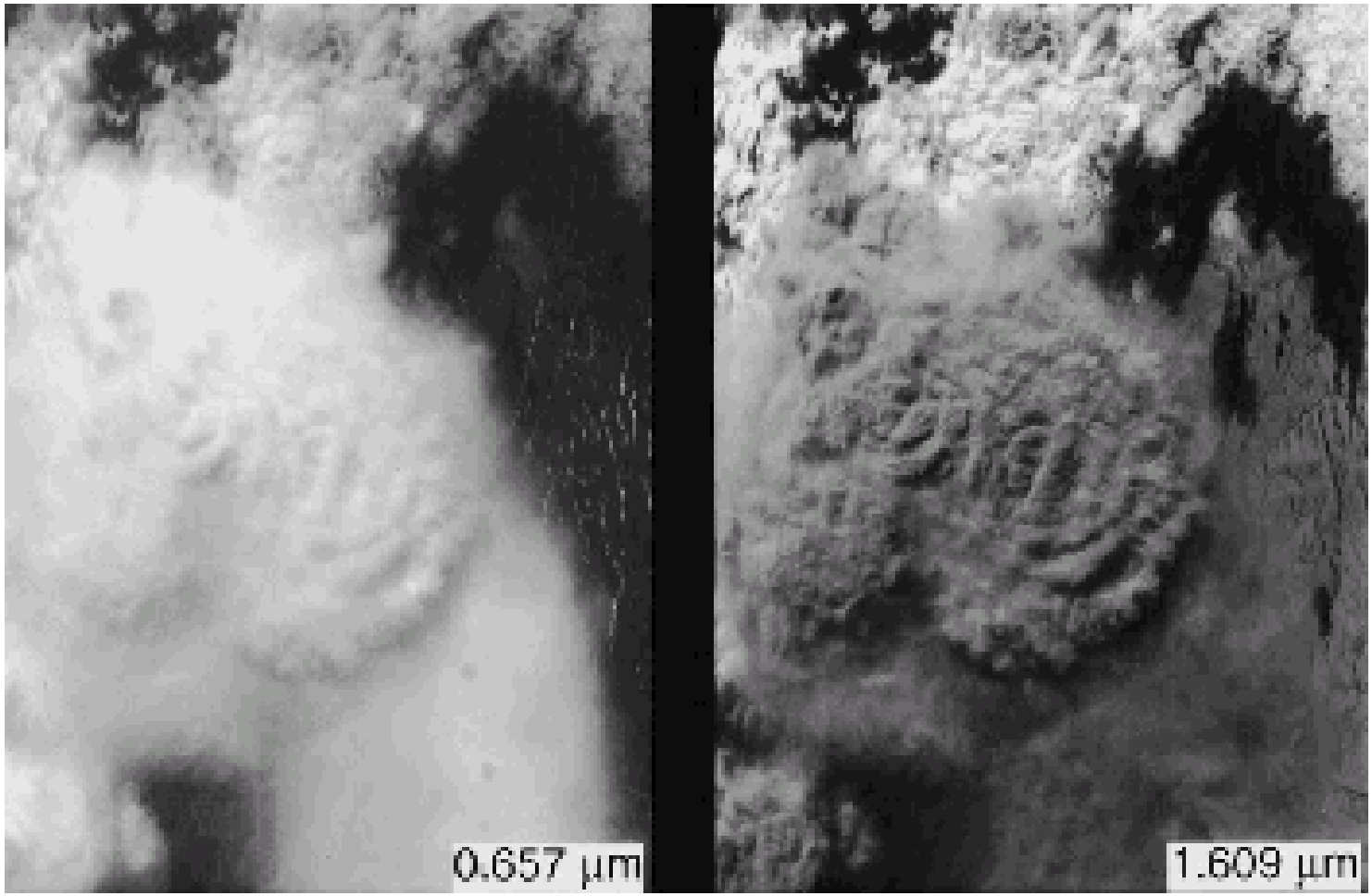
Based on AVHRR/3 and MODIS

Example of MAS 0.66, 1.61, and 1.88 um

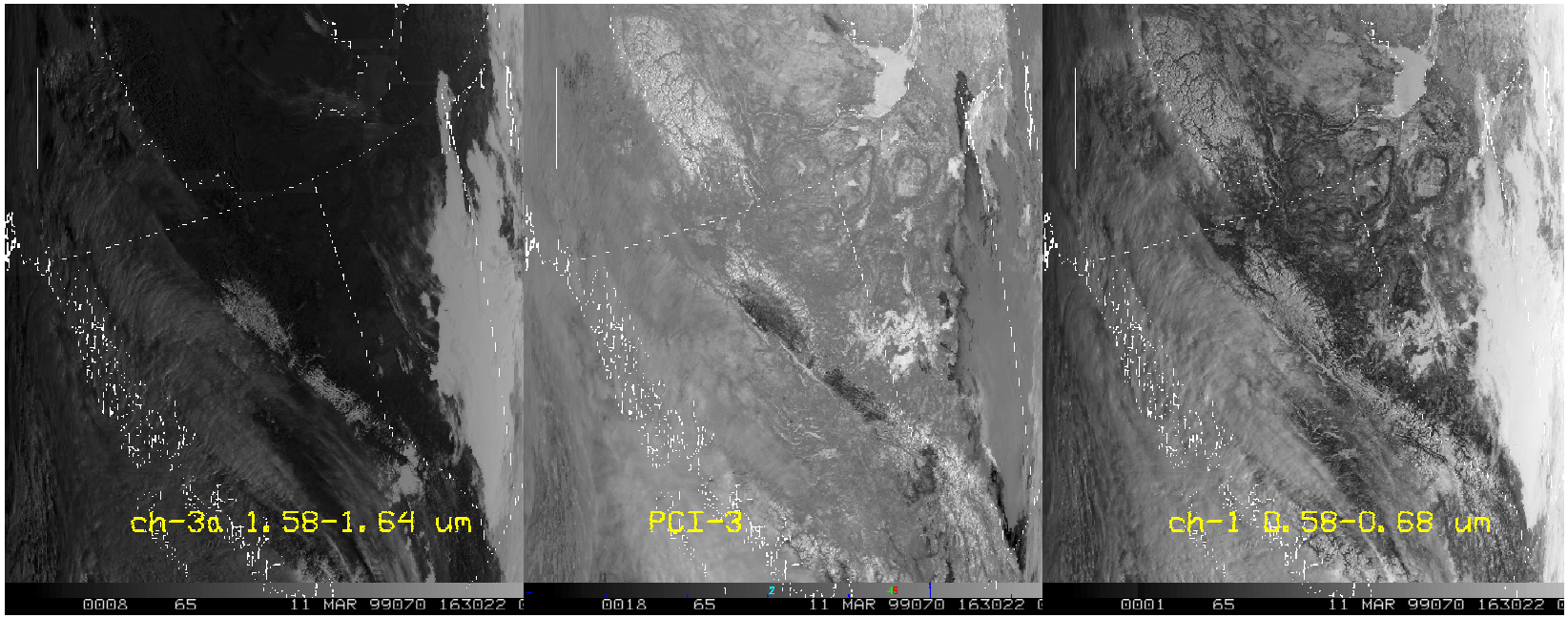


ABI Channel 2 (1.61 um)

Example of MAS 0.66 and 1.61 um
convective cumulonimbus surrounded by lower-level water clouds
(King et al., JAOT, August 1996)



ABI Channel 2 (1.61 um) AVHRR/3a



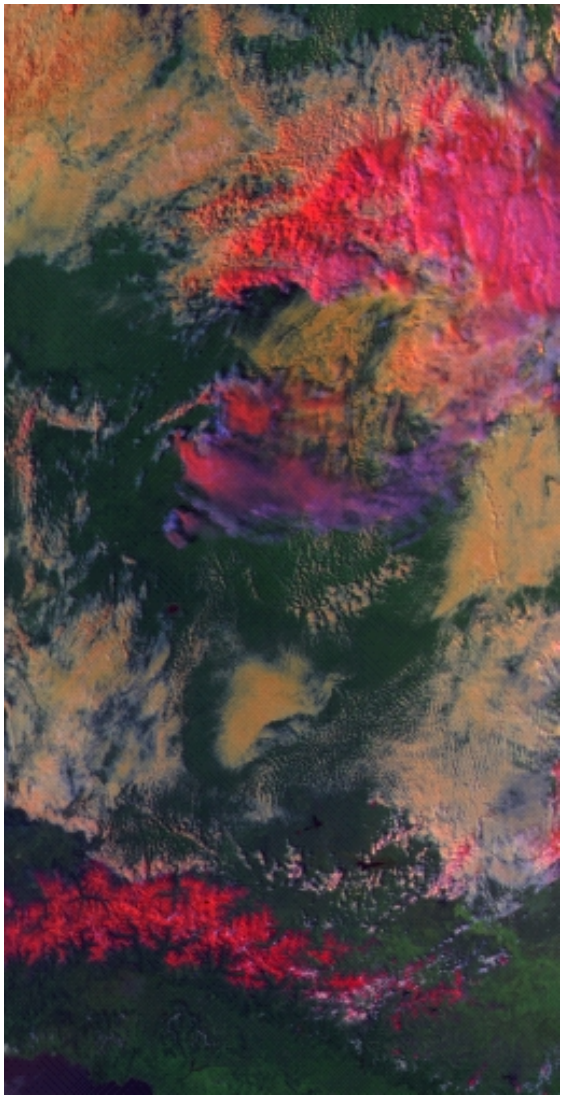
Snow cover over western Canada for 1999 March 11.

- *Left:* **AVHRR channel-3a (1.6 µm)** showing mostly solar energy reflected from low clouds.
- *Center:* **Principle Component Image 3 (containing primarily input from AVHRR channel-3a)** discriminating between snow (white) and cloud (dark).
- *Right:* **AVHRR channel-1 (0.6 µm)** verifying snow cover by texture, but not discriminating between snow and cloud.

RAMM-CIRA

ABI Channel 2 (1.61 um)

Snow detection example from VIRS



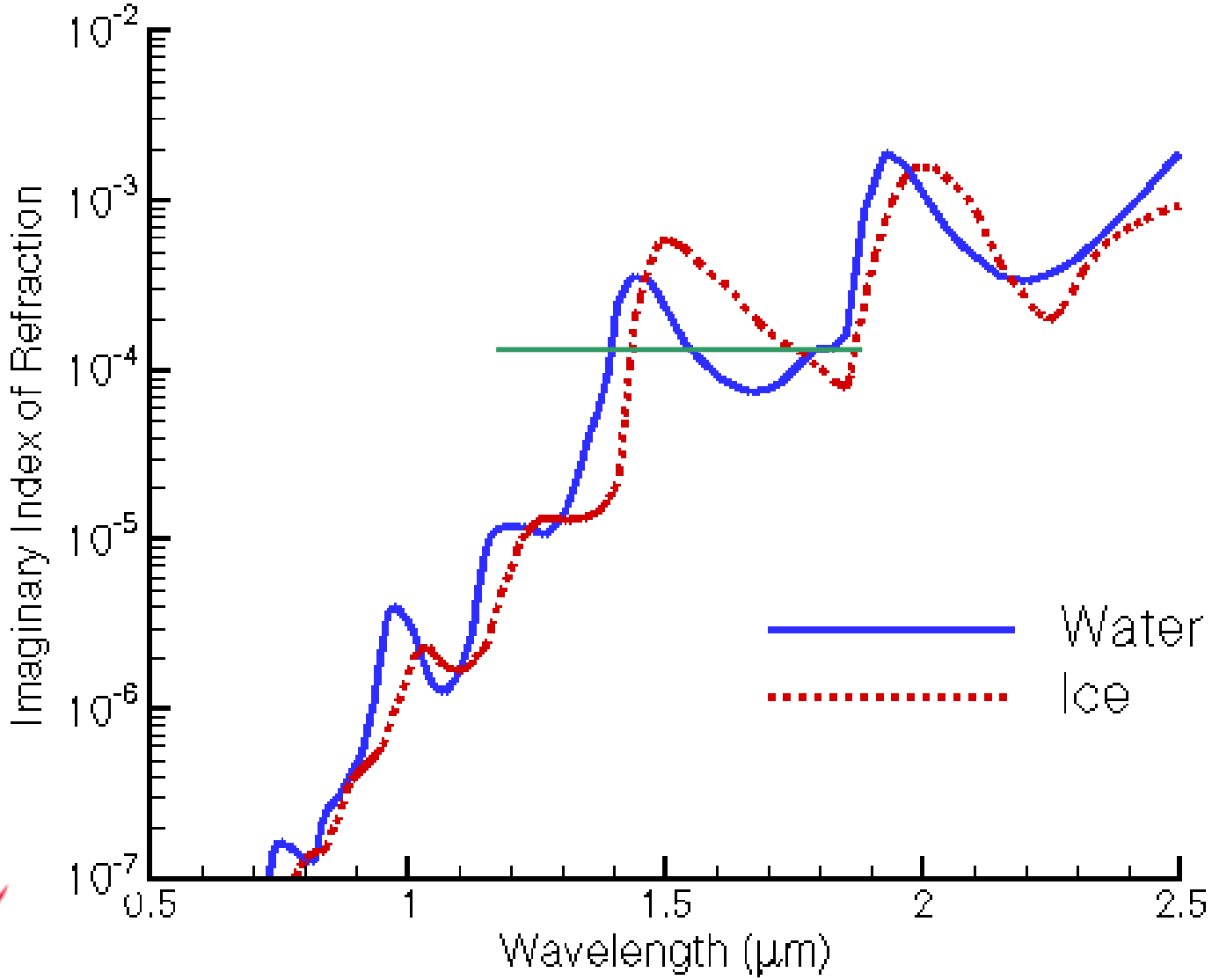
Clouds

Thin Cirrus

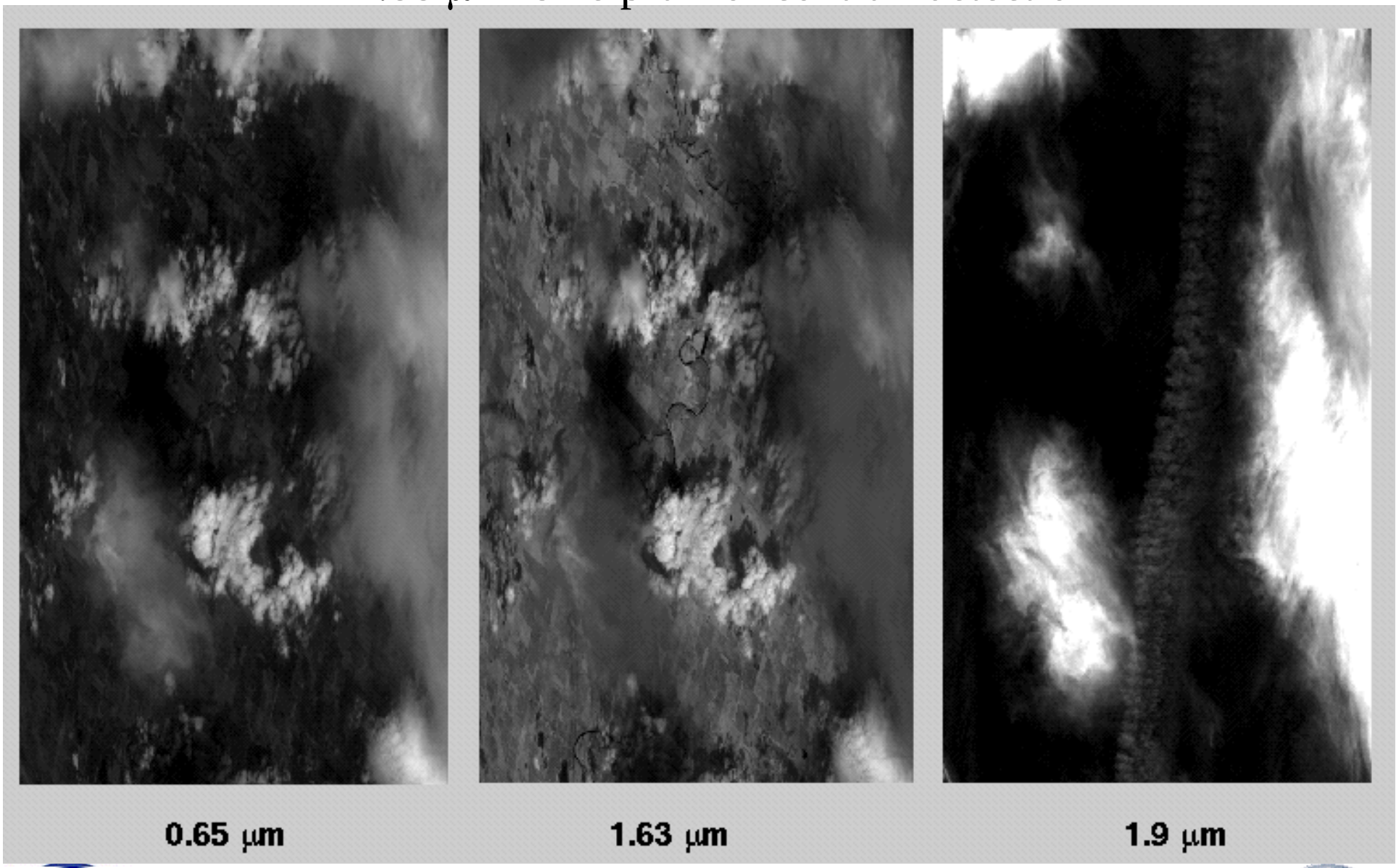
Snow

ABI Channel 2 (1.61 um)

spectral width was narrowed (was 1.3 to 1.9 um)



1.88 μm is helpful for contrail detection

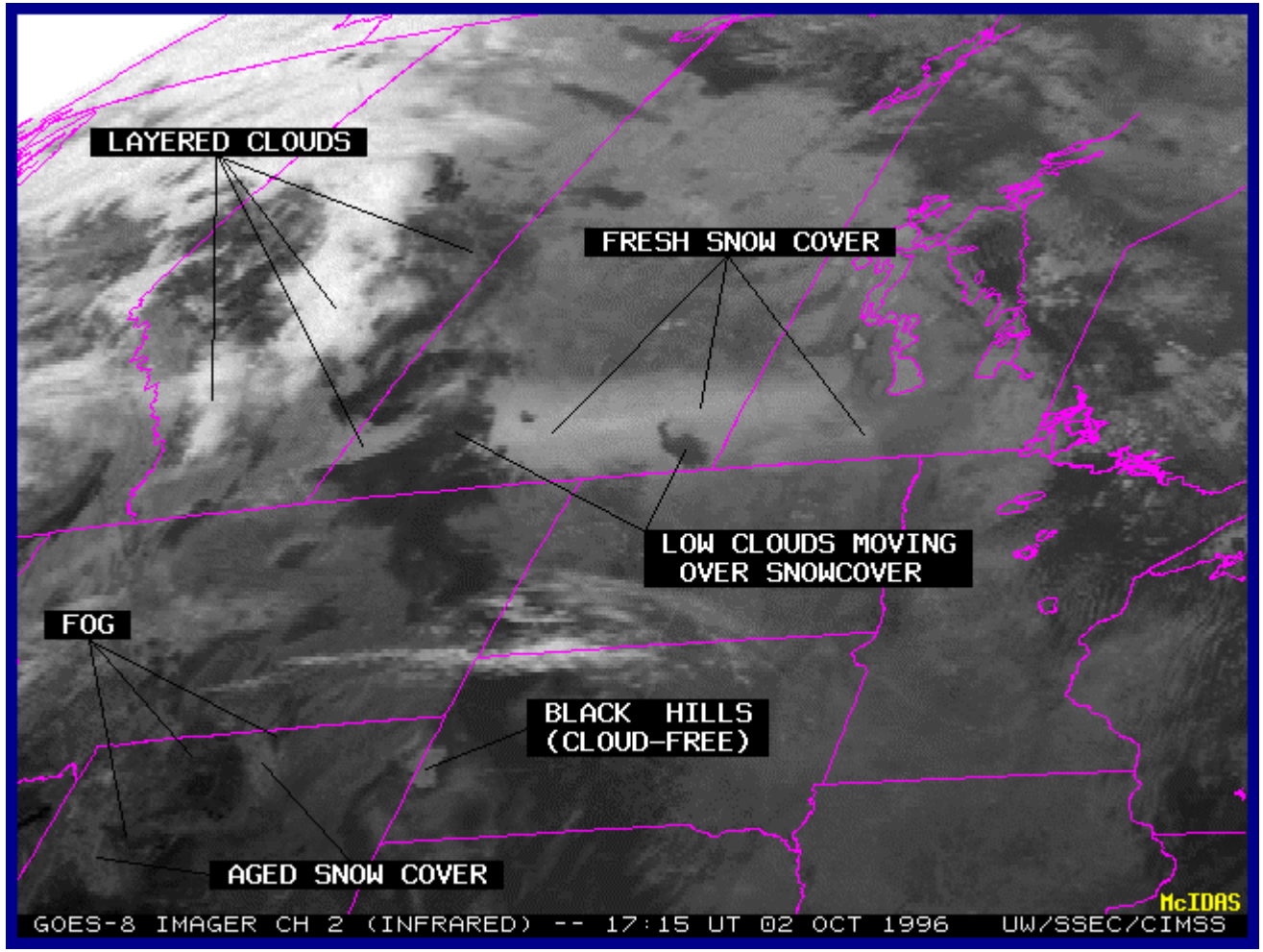


Examples from MAS (Chs 2, 10, 16)

ABI Channel 3 (3.9 μm)

Based on GOES Imager Ch 2

useful for fog, snow, and cloud detection

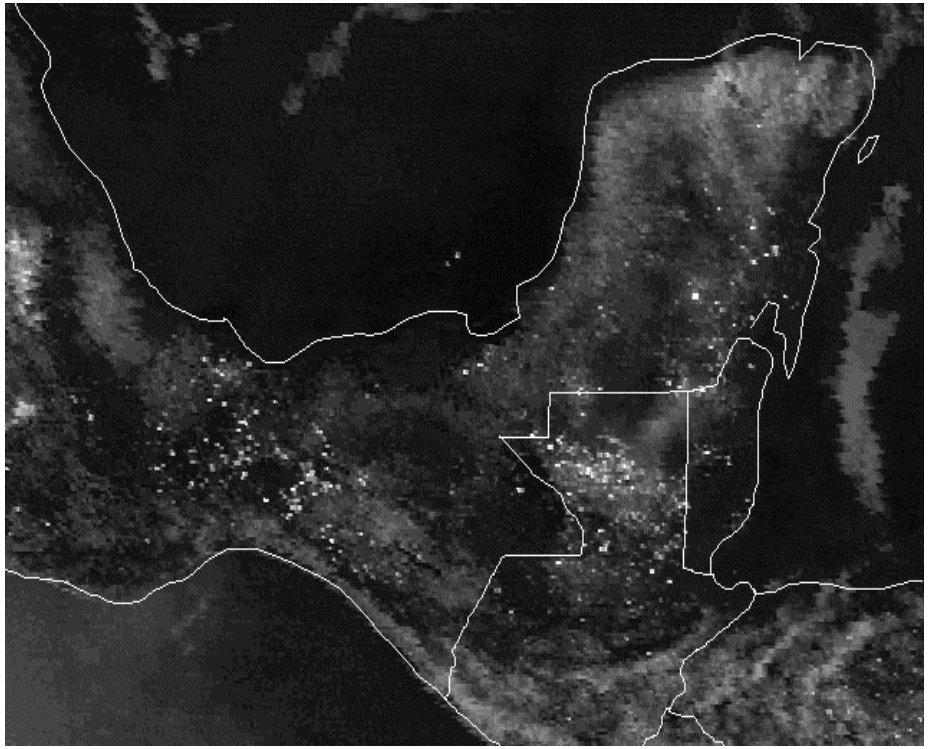


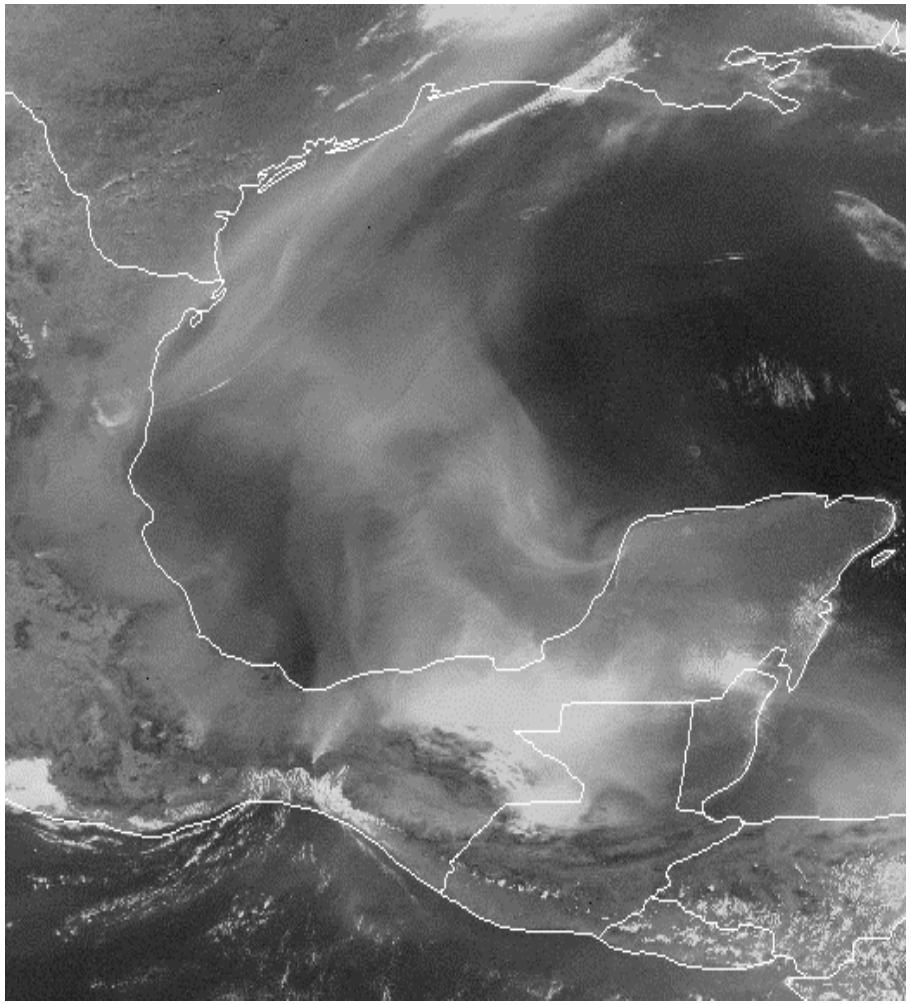
ABI Channel 3 (3.9 µm)

useful for fire and smoke detection

GOES-8 imagery on 9 May 1998 at 15:45 UTC

fire detection using the 3.9 and 11 µm



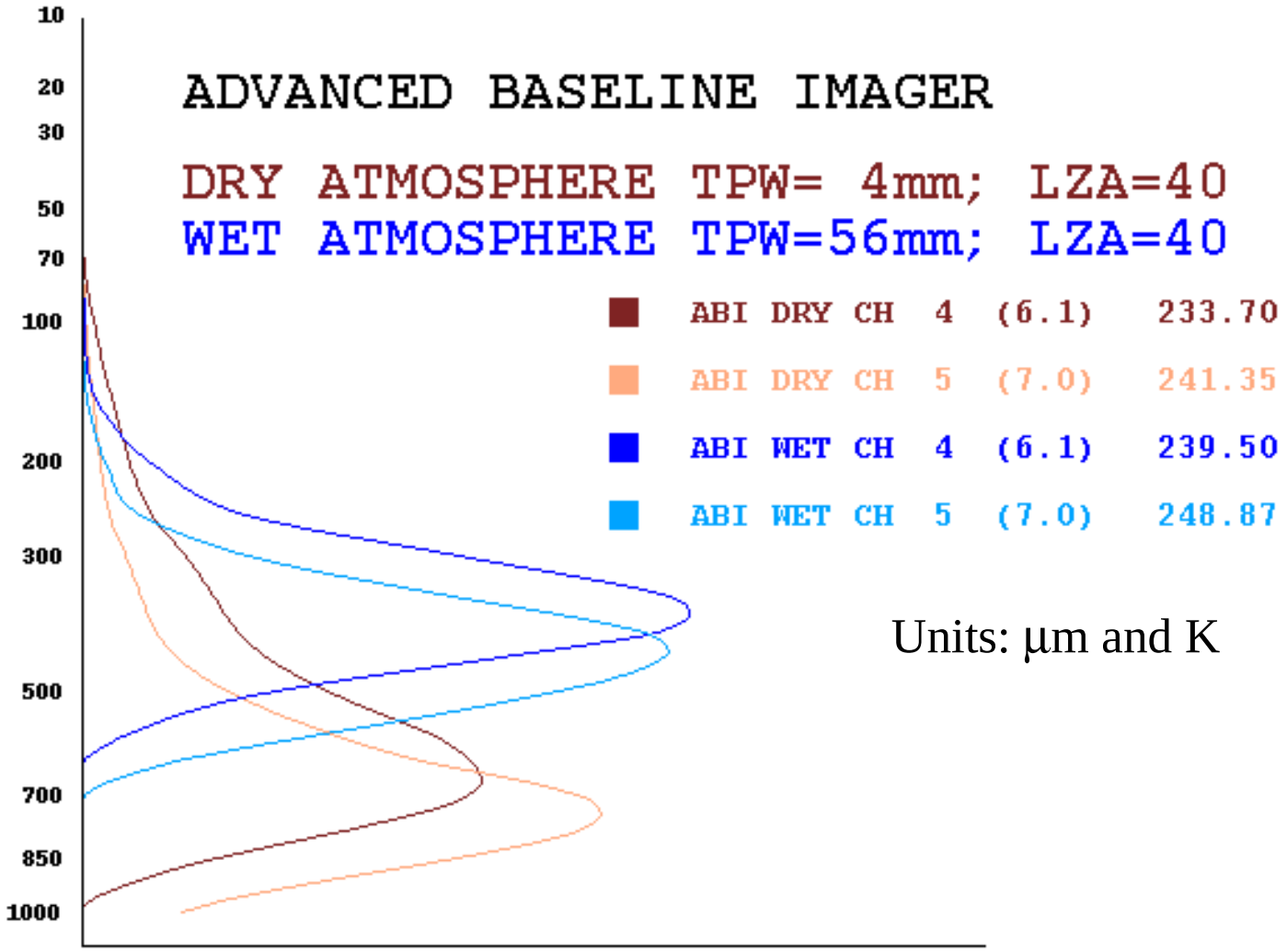


visible imagery showing smoke

RAMM-CIRA

ABI Channel 4 (6.15 µm)

Based on MSG/ SEVIRI

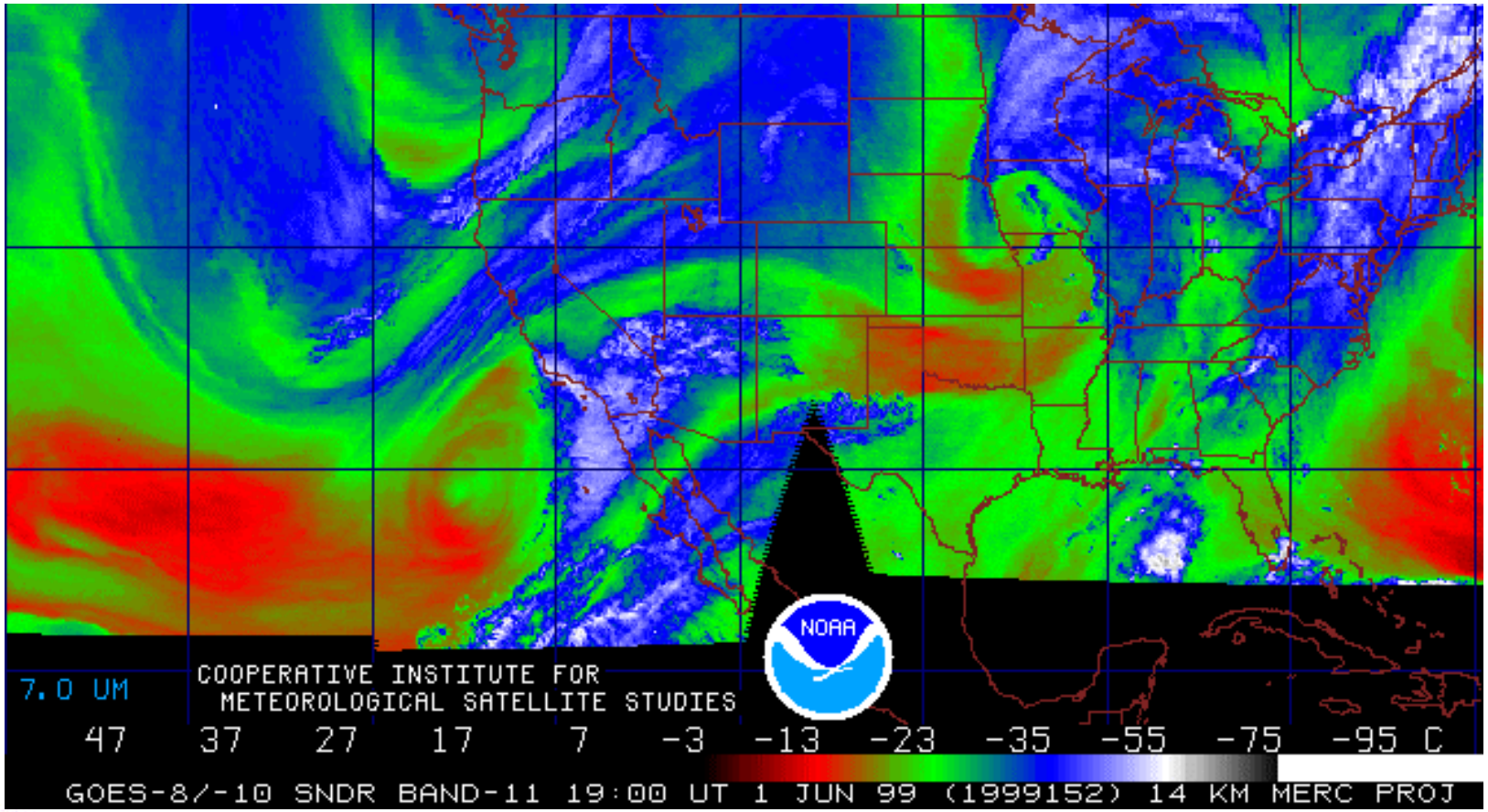


Units: µm and K

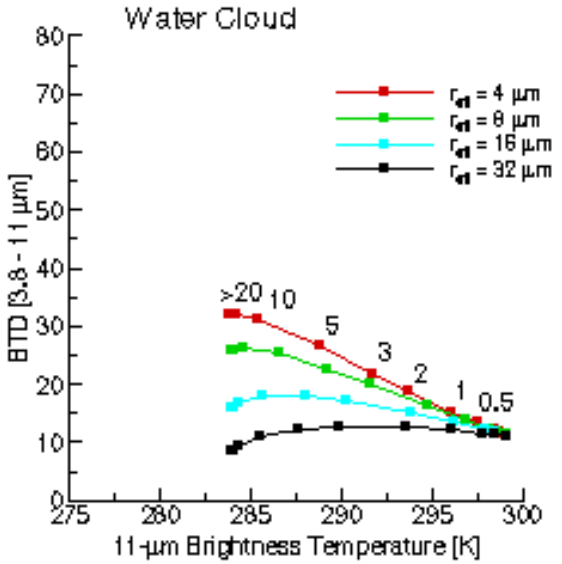
ABI Channel 5 (7.0 μm)

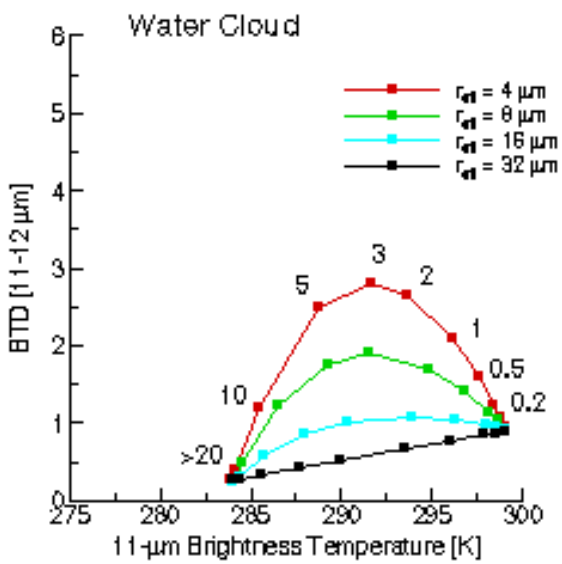
Based on GOES Sounder Ch 11

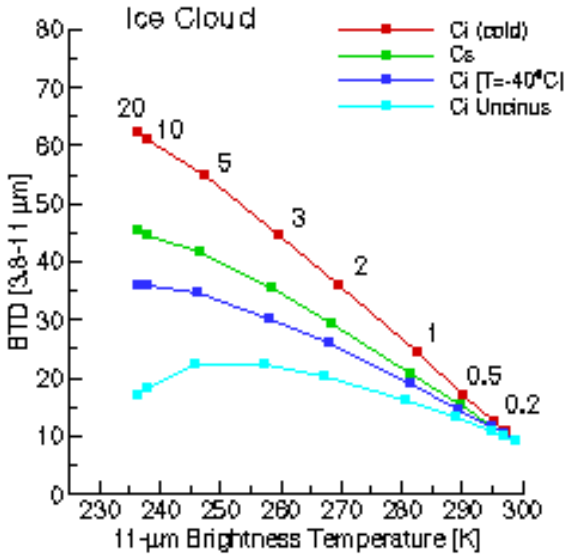
Used together with ABI Ch 4

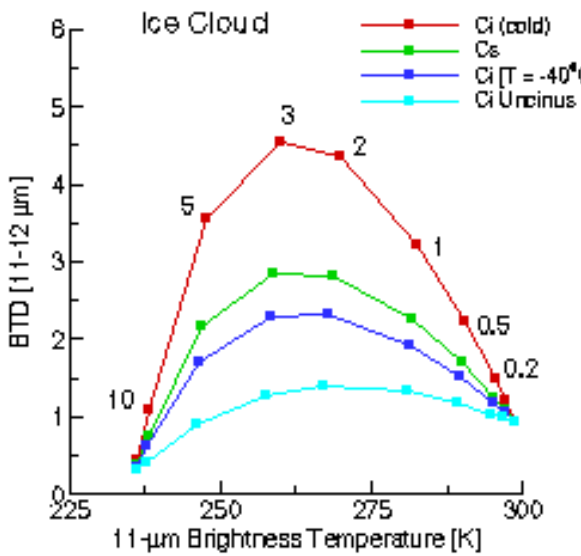


Current Phase Discrimination



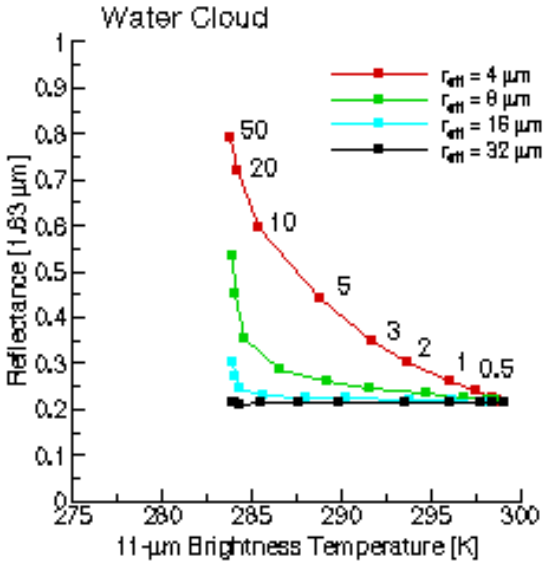


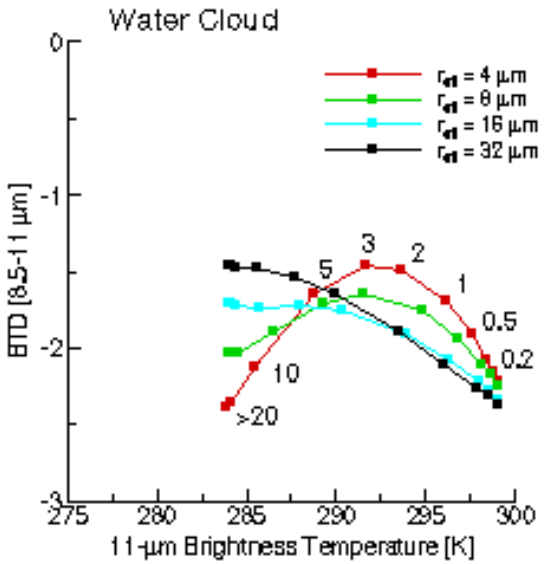


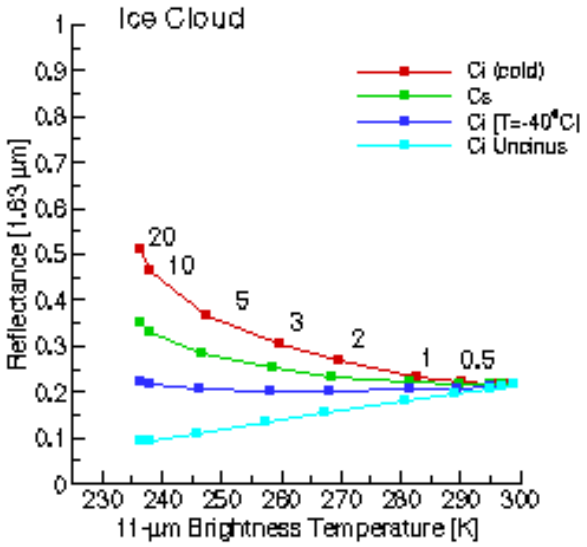


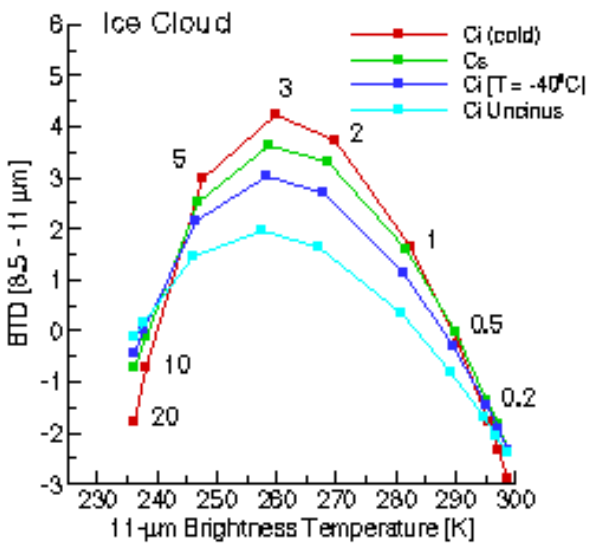
Daytime phase discrimination is most effective for fairly thick clouds

Future Phase Discrimination







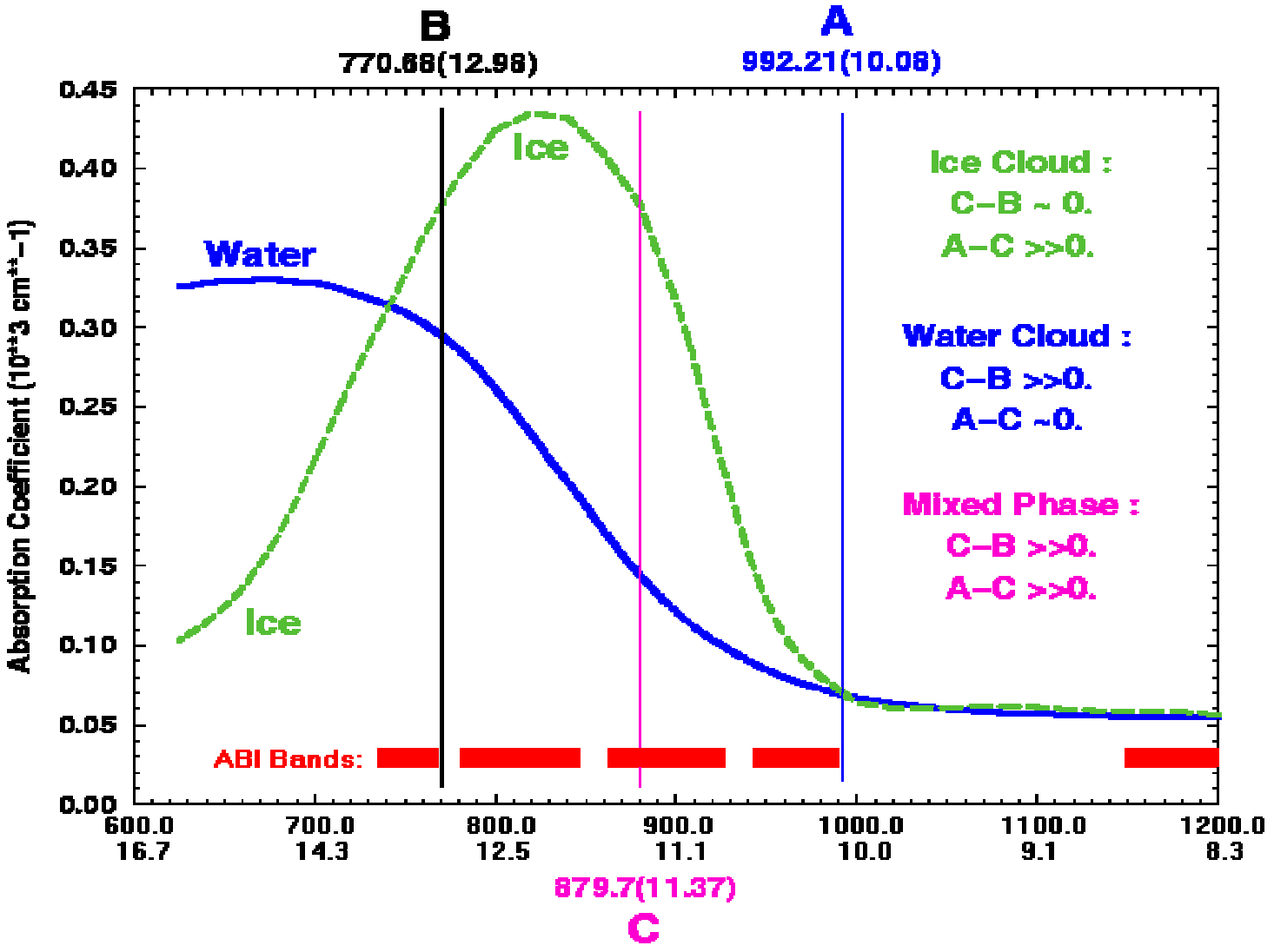


With the addition of the 8.5 µm, phase discrimination is improved for both day/night time clouds for non-opaque clouds

ABI Channel 6 (8.5 μm)

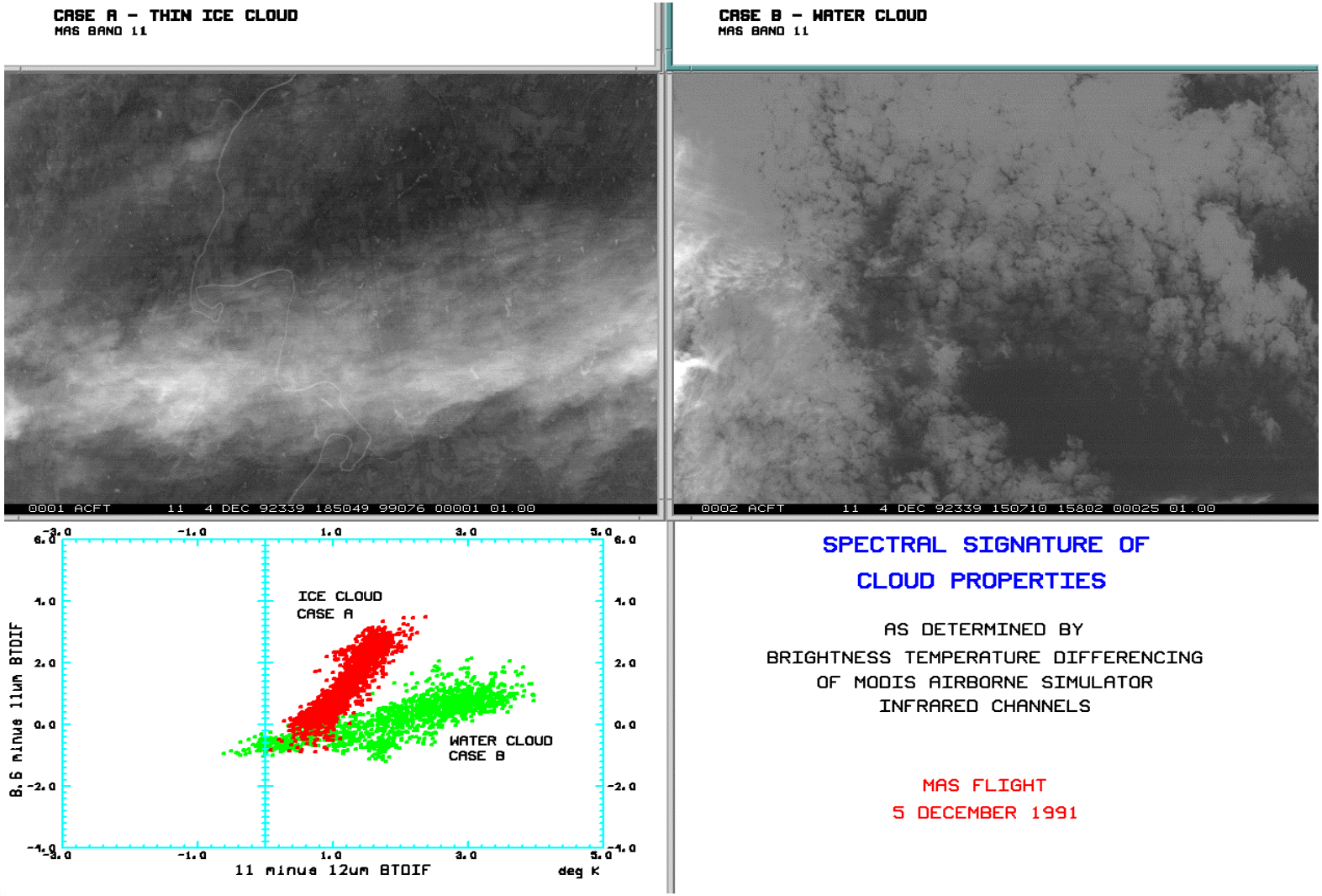
Based on MODIS

used with ABI Chs 7, 8, 9, 10 to separate water from ice clouds



SSEC/CIMSS

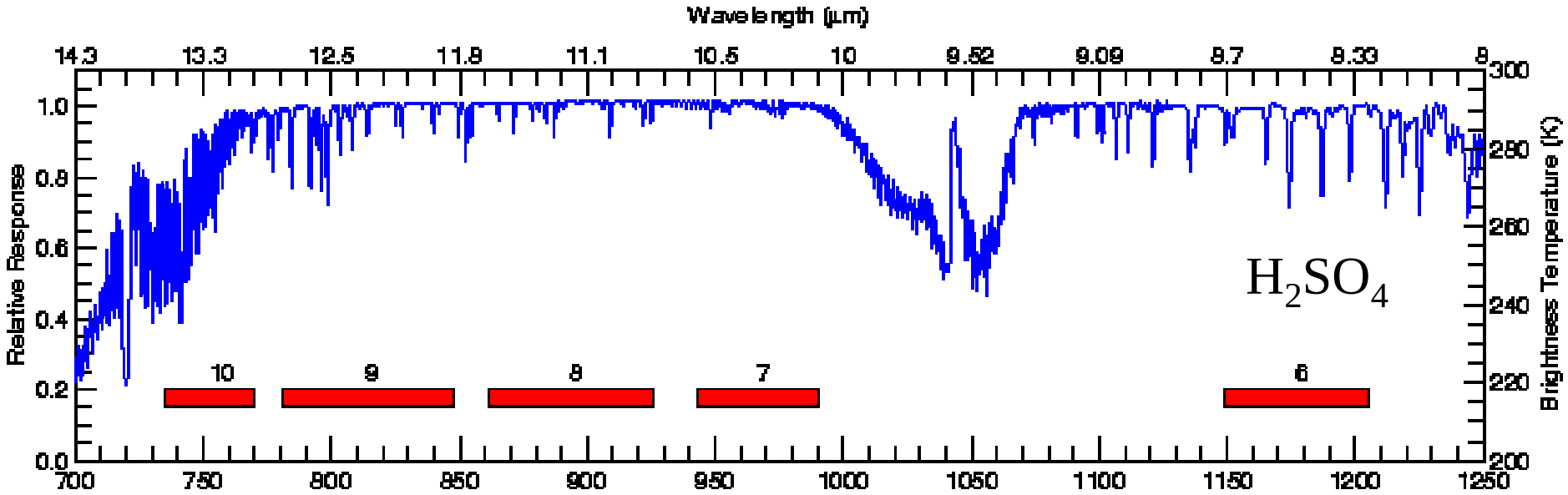
Ice / Water Clouds Separate in 8.6 - 11um vs 11 - 12 um BT plots



ABI Channel 6 (8.5 μm)

Based on MODIS

used with ABI Chs 8 & 9 to improve volcanic cloud detection



similar to MSG (8.7) and proposed VOLCAM (8.6)

ABI Channel 6 (8.5 μm)

- volcanic cloud detection can be improved by detecting sulfuric acid aerosols (Realmuto et al., JGR, July 1997)

- microphysical properties of clouds can be determined. This includes a more accurate and consistent delineation of ice from water clouds during the day or night

- international commonality is furthered as MSG carries a similar channel (8.5 to 8.9 μm) as well as MODIS and GLI

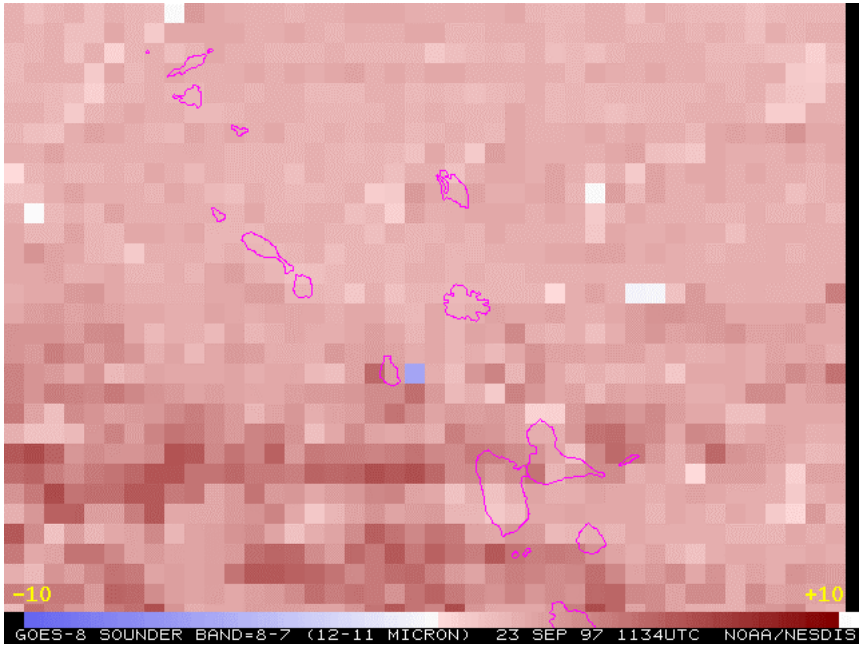
- thin cirrus can be detected in conjunction with the 11 μm. This will improve other products derived from the split window (SST or low-level moisture) by avoiding cloud contamination

- SST estimates can be improved by a better atmospheric correction in relatively dry atmospheres

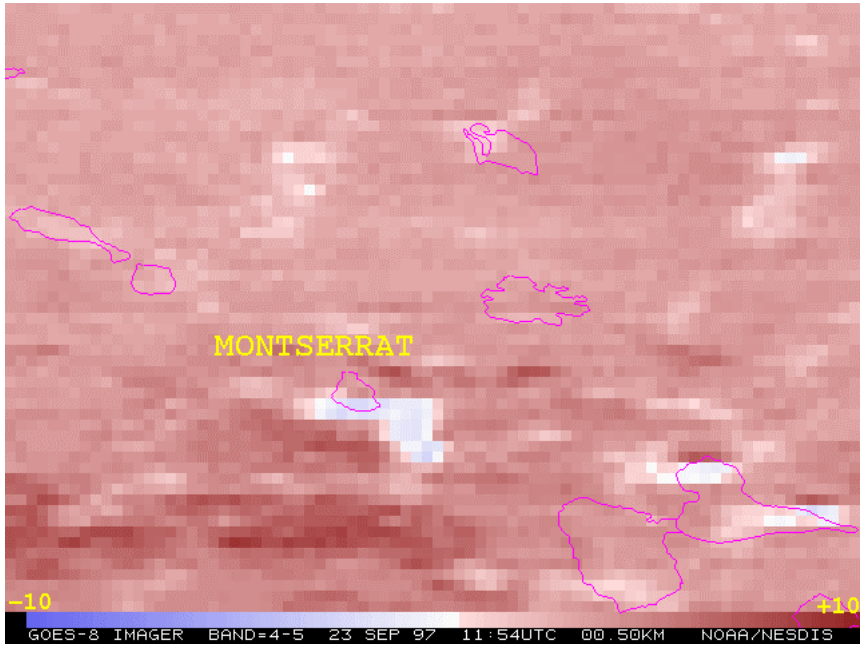
- surface properties can be observed in conjunction with the 10.35 μm channel.

ABI Channel 6 (8.5 μm)

10 km too coarse for volcanic ash detection



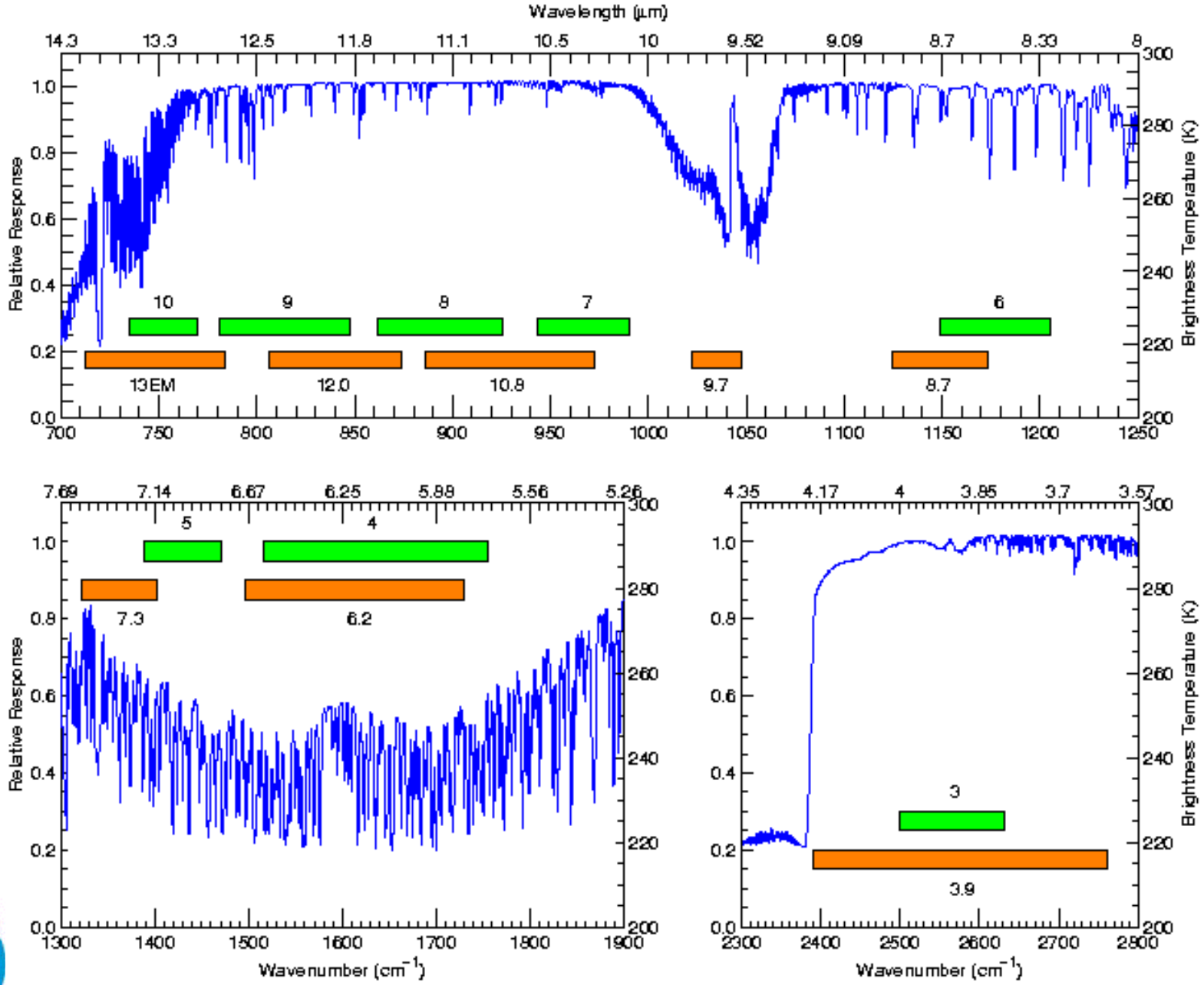
~10 km resolution (sounder)



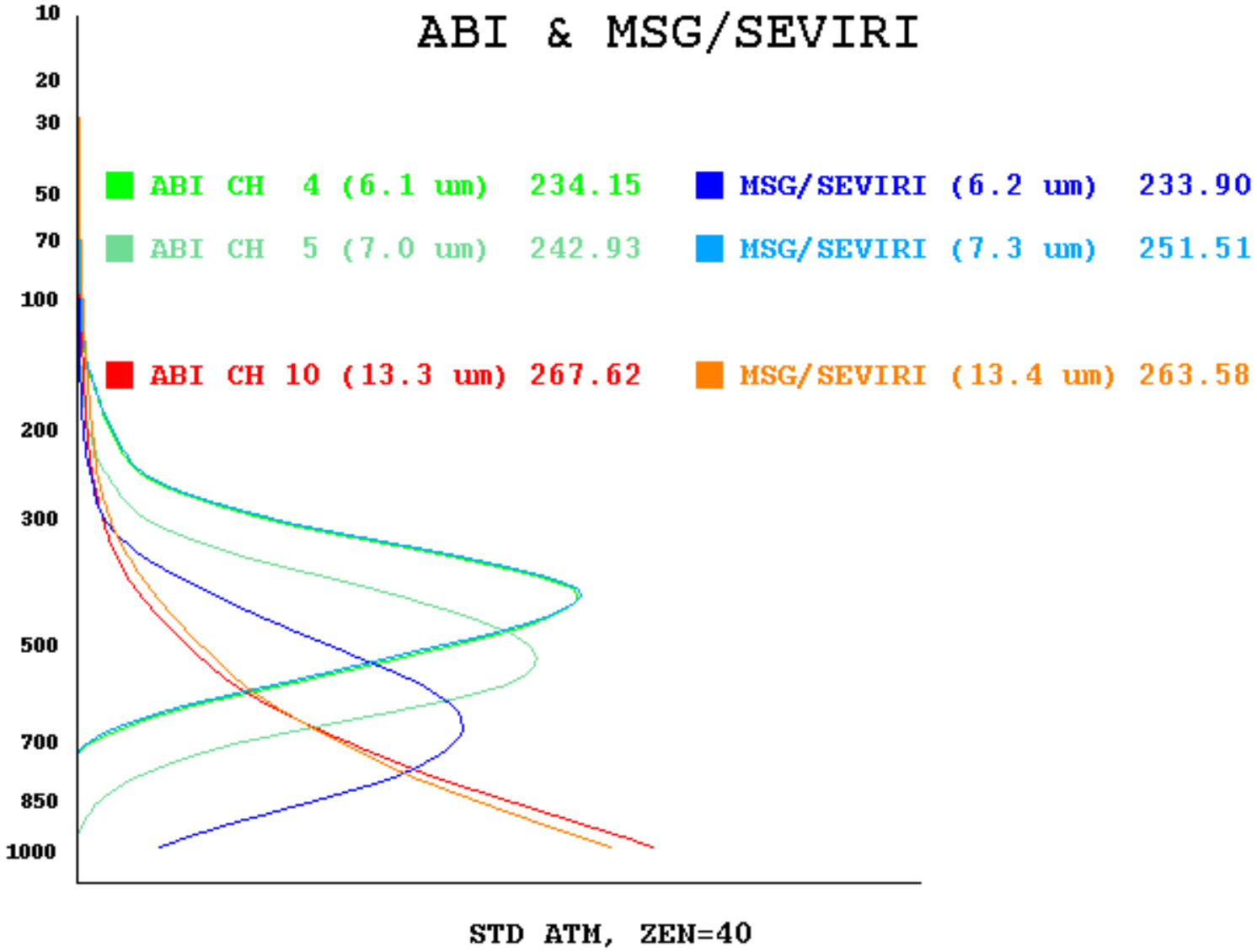
~4 km resolution (imager)

Split Window Differences

ABI-12 (top bars) and MSG/SEVIRI (bottom bars) Channels

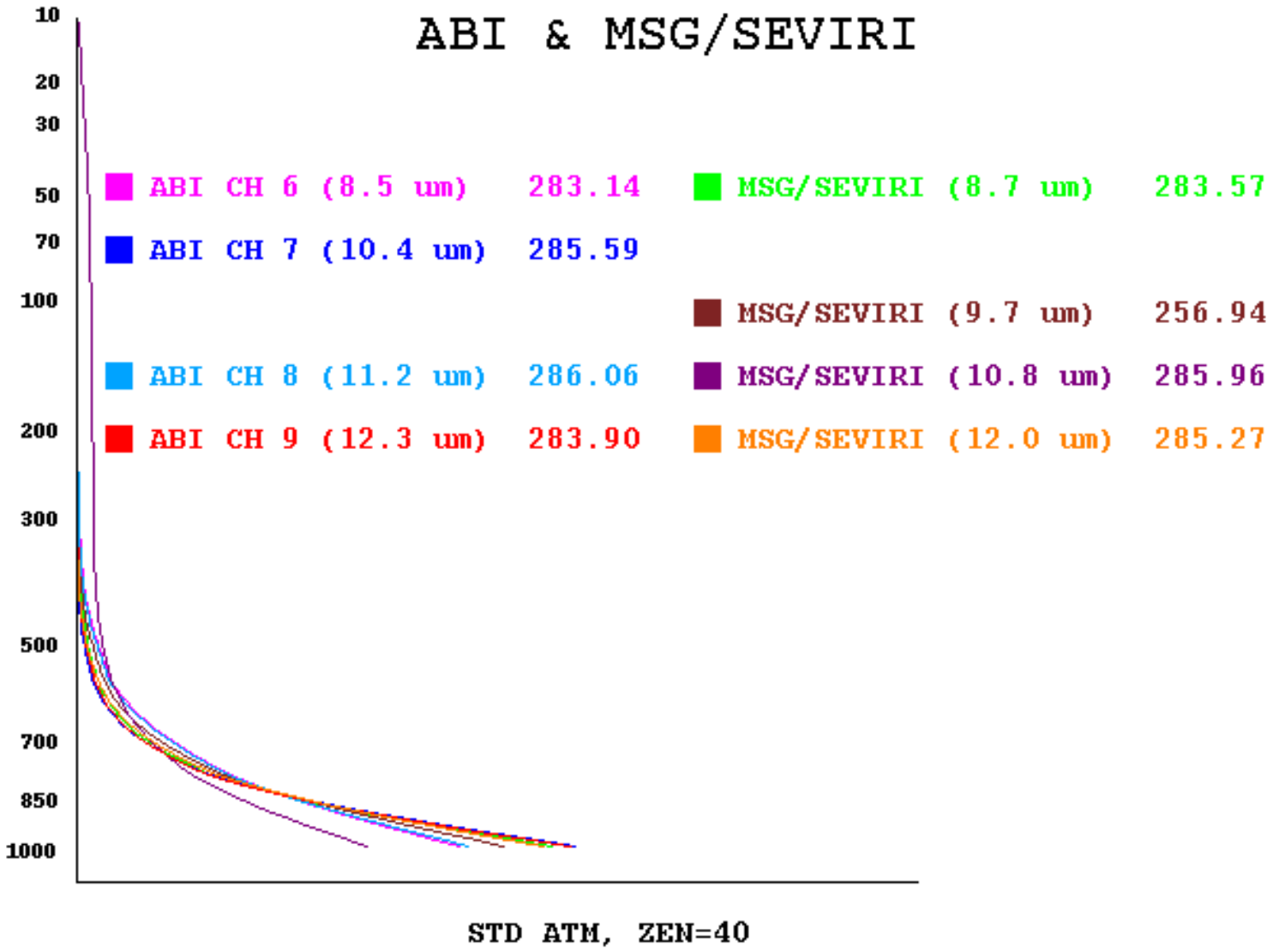


ABI and MSG/SEVIRI Weighting Functions



UW/CIMSS

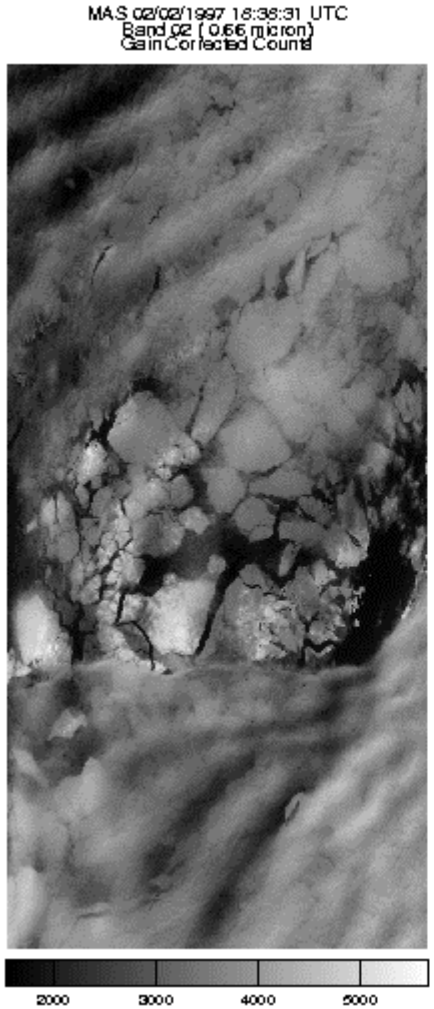
ABI and MSG Weighting Functions



UW/CIMSS

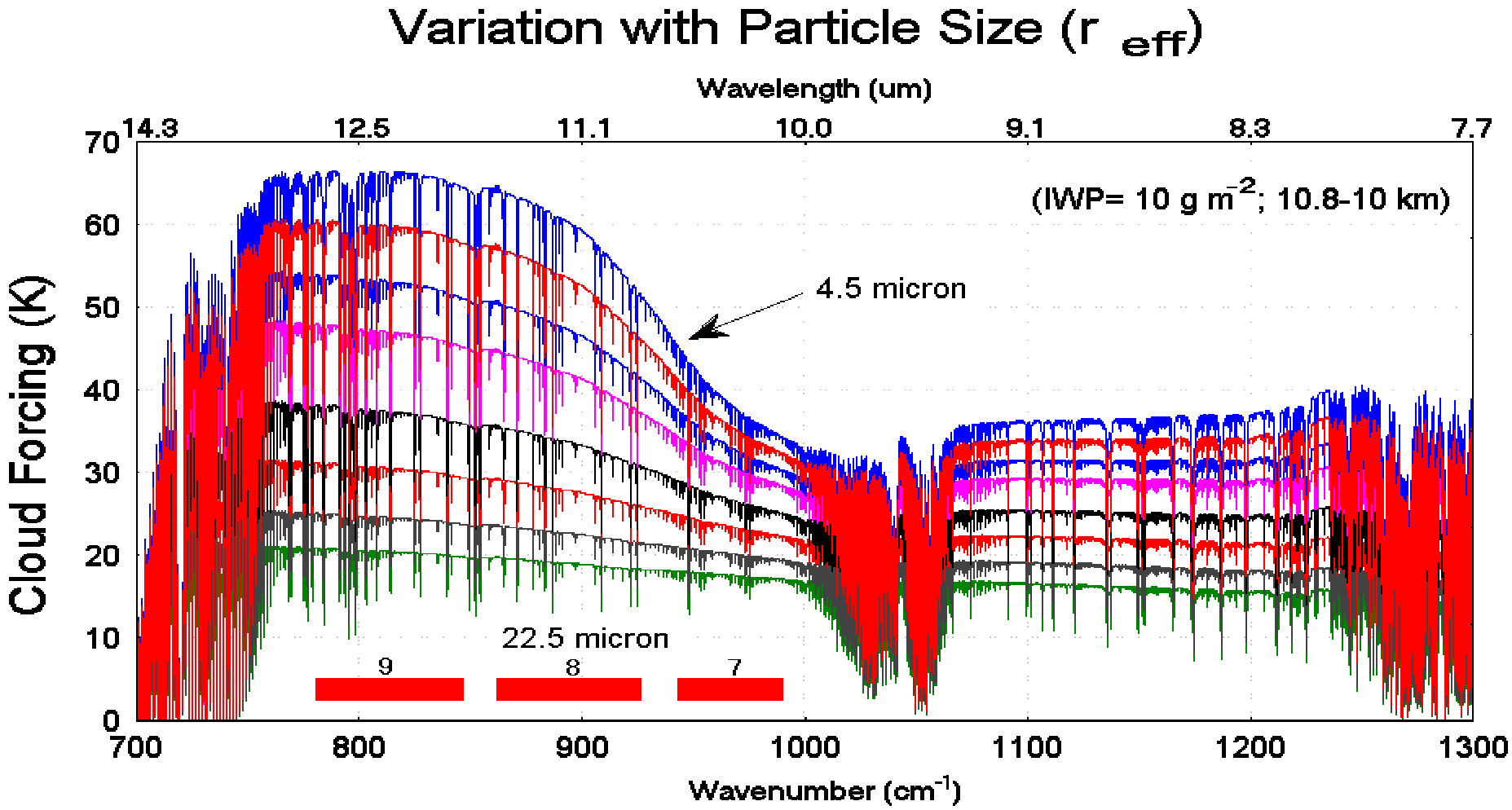
ABI Channel 7 (10.35 μm)

Examples of MAS 0.66, 10.5-11.0, and 8.6-10.5 um reveal utility of new IR window for seeing through clouds to ice floes



Cloud particle size emerges in high resolution IR window spectra

Based on HIS data, ABI Chs 7, 8, & 9 useful for effective radius



UW/CIMSS

ABI Channel 7 (10.35 μm)

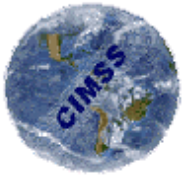
- microphysical properties of clouds can be determined. This includes a more accurate determination of cloud particle size during the day or night

- cloud particle size is revealed along with cloud liquid water content.

- particle size may be related to the “enhanced V” signature

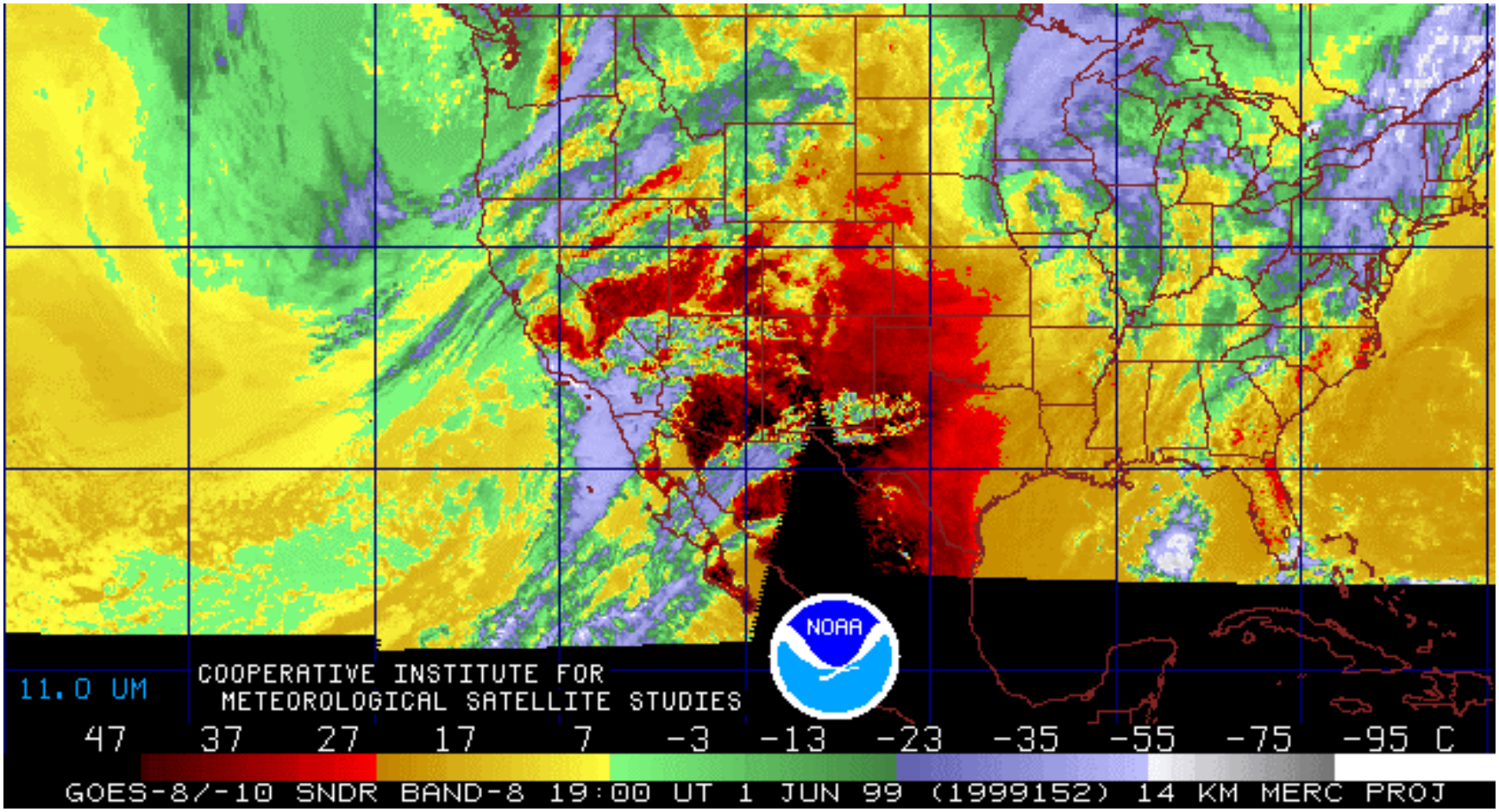
- surface properties can be observed in conjunction with the 8.6, 11.2, and 12.3 μm bands

- low level moisture determinations are enhanced with more split windows



ABI Channel 8 (11.2 μm)

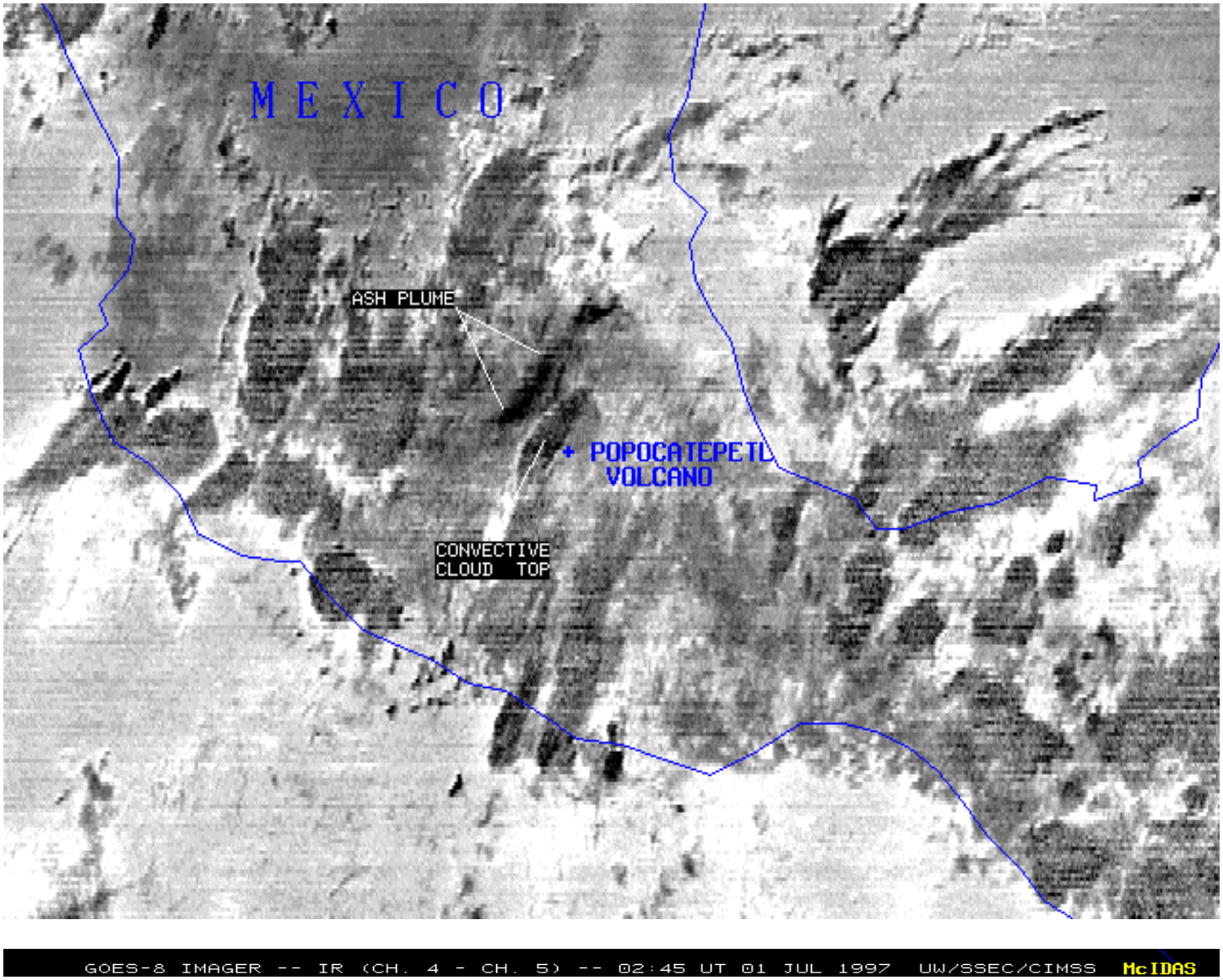
Based on GOES Sounder Ch 8



Channel 9 (12.3 μm)

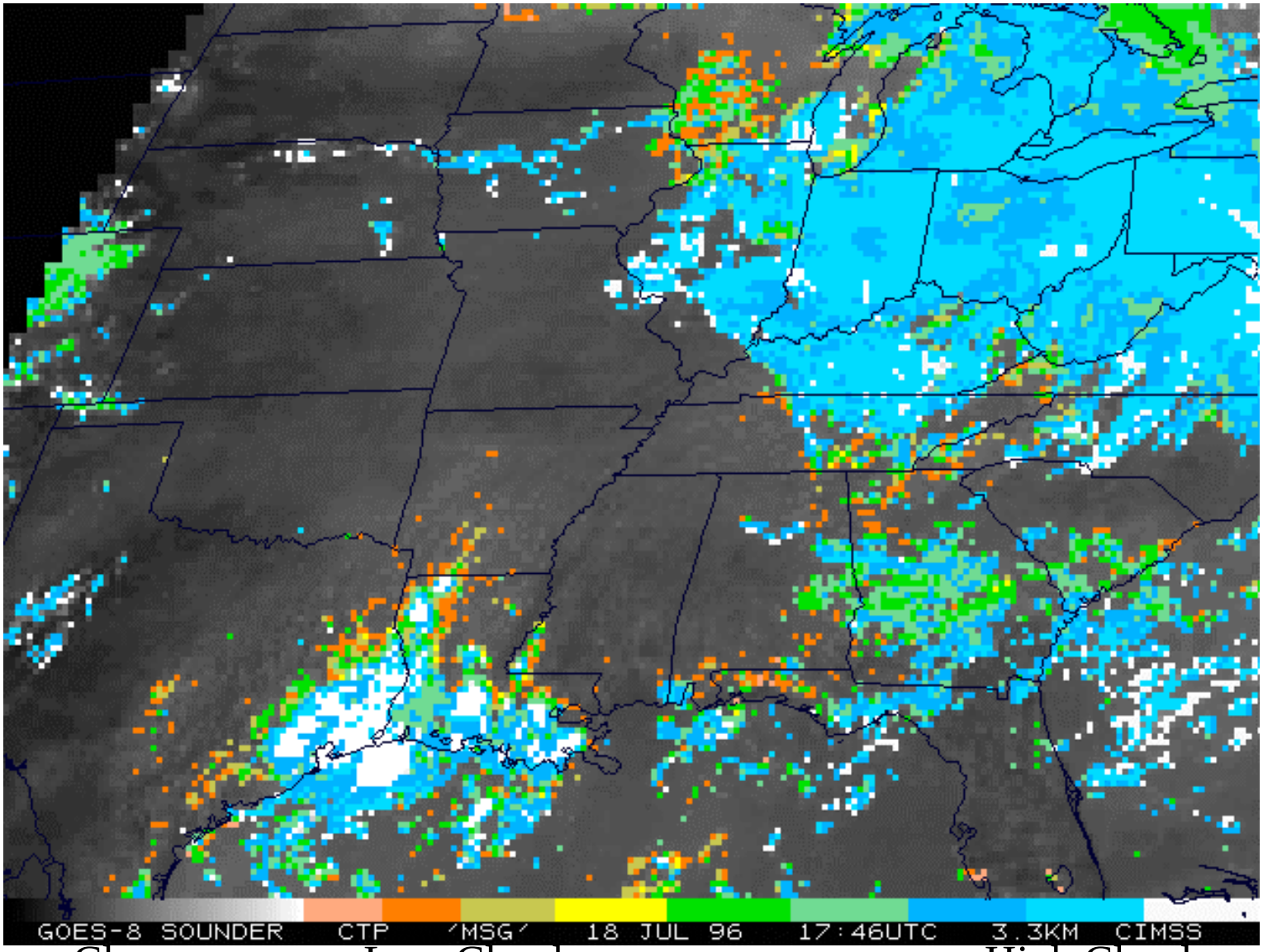
Based on GOES Imager Ch 5

used with ABI Ch 8 for low atm moisture, volcanic ash, and SST



ABI Channel 10 (13.3 μm)

Based on GOES Sounder Ch 5
used with ABI Ch 8 for cloud heights



Clear Low Cloud High Cloud

ABI-8 (Threshold) ; ABI-12 (Goal)

In order of priority: **8.5, 10.35, 0.86 and 1.375** μm.

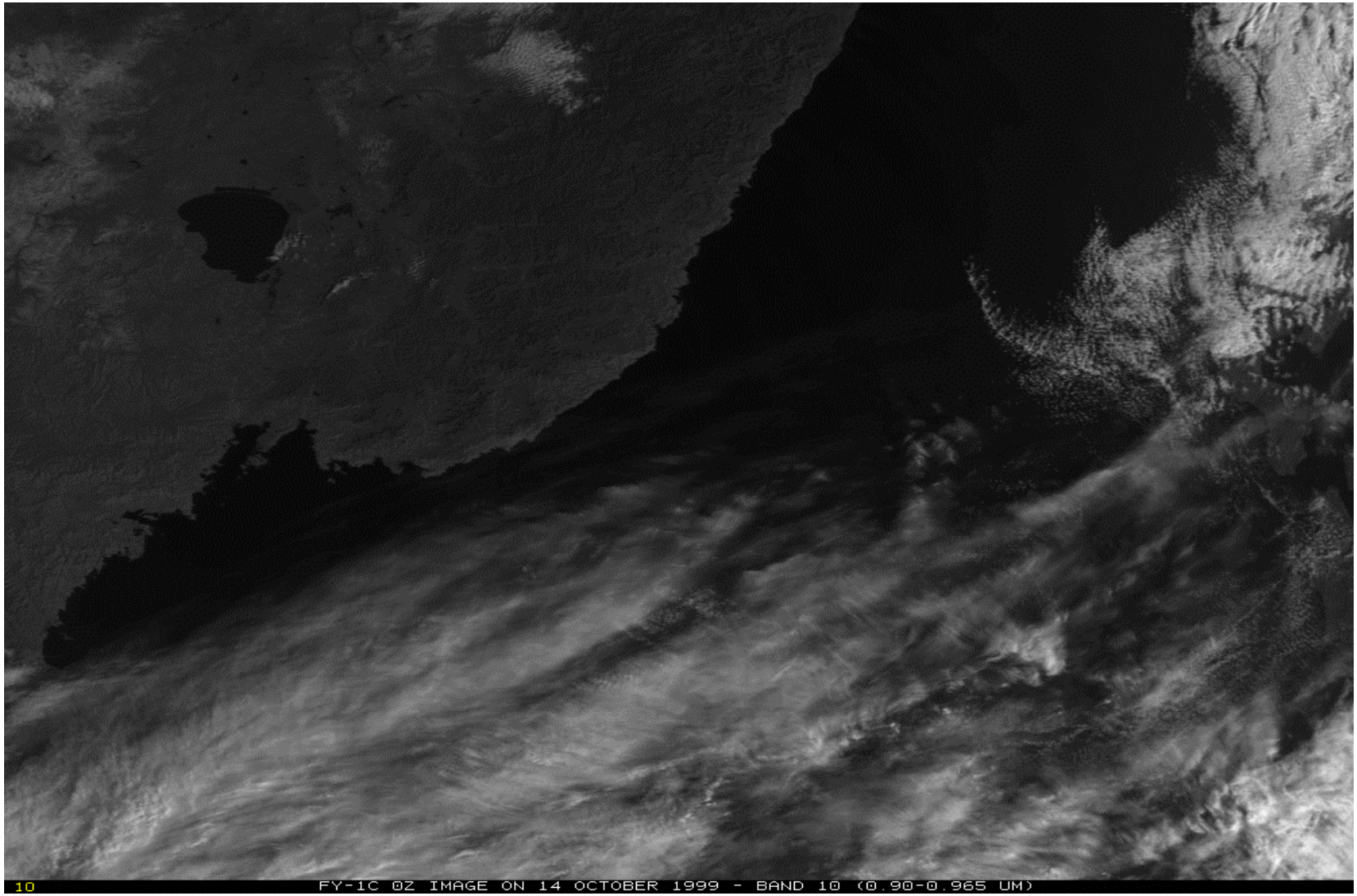
The 0.86 μm channel:

- provides synergy with the AVHRR/3;
- determining vegetation amount, aerosols and ocean/land studies;
- also enables localized vegetation stress monitoring, fire danger monitoring, and albedo retrieval.

The 1.38 μm channel:

- is modeled on the band on MODIS;
- does not see into the lower troposphere due to water vapor sensitivity and thus it provides excellent daytime sensitivity to very thin cirrus.

Example of 0.93 um (Band 10 on FY-1C)



ABI and NWS REQUIREMENTS:

(ABI channels in order of increasing wavelength)

Visible (1): Daytime cloud imaging, snow and ice cover, severe thunderstorm detection, cloud drift winds, precipitation estimates, fog, flash floods, winter storms

Near IR (2): Daytime automated discrimination of clouds from snow for estimating total cloud cover, discrimination of water clouds from ice clouds (in aviation), detection of smoldering fires

Shortwave IR window (3): Nighttime detection of low clouds and fog detection when used with the IR and "dirty" IR windows; identification of fires; daytime detection of cloud over snow, fog

***IR water vapor 1 (4)*:** Delineates broad scale mid-tropospheric patterns, mid-tropospheric water vapor drift winds (used for numerical model initialization and hurricane track prediction)

***IR water vapor 2 (5)*:** Delineates upper-tropospheric water vapor-drift winds (used for numerical model initialization), broad scale patterns corresponding with jet stream cores

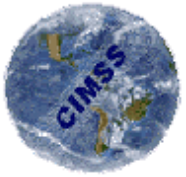
IR window 1 (6): Determination of cloud phase (ice or water)

IR window 2 (7): Determination of cloud particle size, discrimination of surface water and ice in cloudy scenes

IR window 3 (8): Continuous day and night detection of cloud cover and cloud top heights, low-level water vapor, fog, when used with the "dirty" IR window 4, precipitation estimates, surface temperatures, hurricane winds, winter storms

IR window 4 (9): Determination of low-level water vapor when used with IR window, detection of volcanic ash, and estimation of SST

IR carbon dioxide (10): Used with the IR window to determine cloud top heights and cloud parameters above 12,000 feet complementing ASOS and providing cloud information to forecasters and numerical models; parameters include sky cover, heights of cloud tops, and cloud opacity



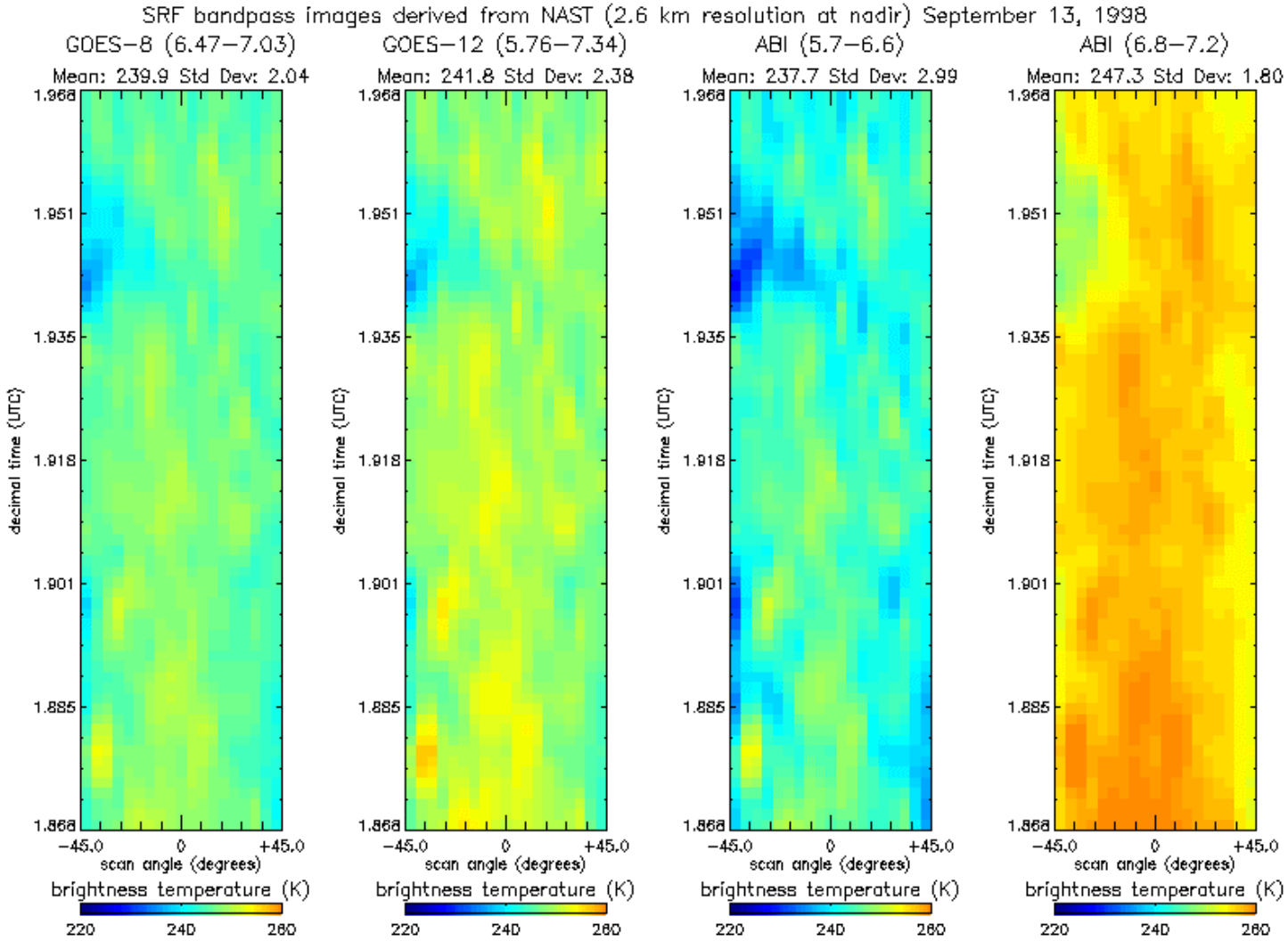
Simulated Water Vapor Images

The following figure demonstrates the simulation comparisons of water vapor images of current GOES-8, GOES-12, and two proposed ABI water vapor bands. High spectral resolution data from the NAST (NPOES Atmospheric Sounder Testbed) were convoluted with the various GOES spectral response functions (SRF) to derive the field of brightness temperatures.

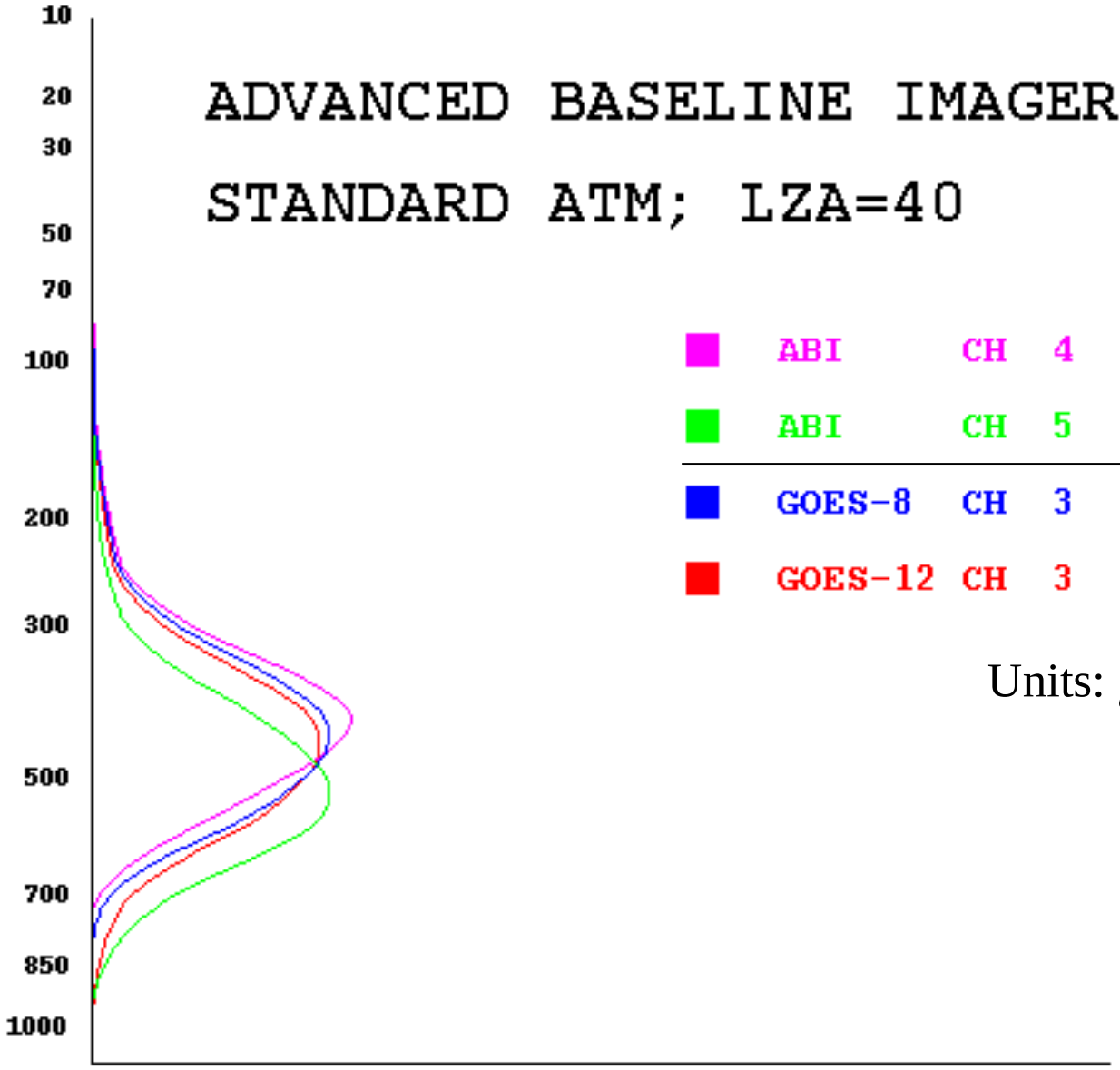
The ABI water vapor band (5.7-6.6 μm) is very similar to the current GOES. Additional low-level water vapor information is provided by the new band of 6.8-7.2 μm. The mean brightness temperature difference between the GOES-8 and ABI 6.15 μm is approximately the same size (2 K) as between GOES-8 and the spectrally wider GOES-12 water vapor band.

SRF bandpass images derived from NAST-I.

GOES-8 GOES-12 ABI ABI



These water vapor images were simulated from NAST-I 2.6 km resolution data collected during WALLOPS 99 field experiment (September 13, 1998).

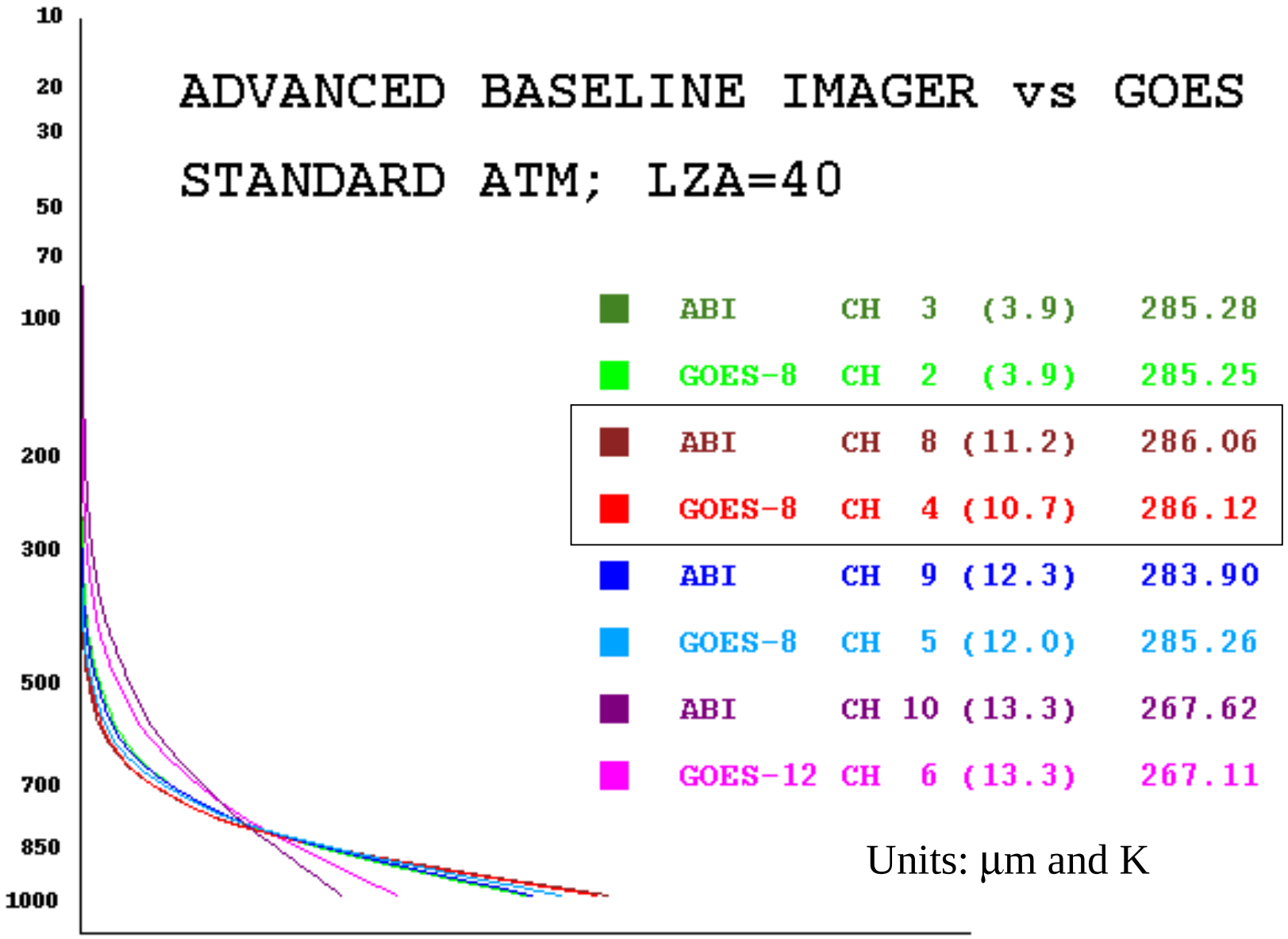


ADVANCED BASELINE IMAGER vs GOES

STANDARD ATM; LZA=40

ABI	CH	4	(6.1)	234.15
ABI	CH	5	(7.0)	242.93
GOES-8	CH	3	(6.7)	235.80
GOES-12	CH	3	(6.5)	237.40

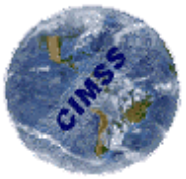
Units: μm and K



11 μm brightness temperatures similar to existing instrument

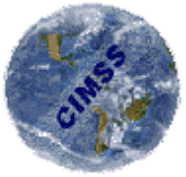
Summary

- ABI 12 channels address NWS requirements for cloud, moisture, and surface products.
- Original ABI (8) channels have been adjusted:
  - experience with new channels/applications on the MAS (MODIS Airborne Simulator) suggested new channels,
  - additional window channels will be on future NPOESS instruments,
  - some channels were modified to conform to other sensors that will be in-orbit in the same time frame,
  - channel selection continues on an evolutionary path.
- A second visible channel was added (as a goal) for NDVI and aerosol detection.
- A second near IR channel was added (as a goal) for daytime thin cirrus detection.
- IR Window brightness temperatures will be similar to those on existing instruments.



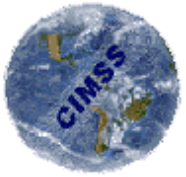
What if we could have more bands?

- **9.6** μm -- total ozone
- **14.2** μm -- better cloud heights
- **4.57** μm -- better TPW
- **0.47** μm -- aerosols particle size (over land)



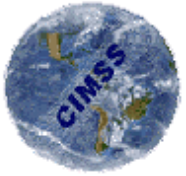
More information can be found at

- http://cimss.ssec.wisc.edu/goes/abi/
- http://cimss.ssec.wisc.edu/modis1/modis1.html
  - MODIS
  - MAS
- http://cimss.ssec.wisc.edu/nast/index.html
- http://cimss.ssec.wisc.edu/goes/goes.html
  - Real-time Sounder page
  - GOES Gallery
  - Biomass Burning
- http://www2.ncdc.noaa.gov/docs/klm/html/c3/sec3-0.htm
  - NOAA KLM User's Guide
- http://www.eumetsat.de/en/
  - MSG..System..MSG..Payload..Spectral bands..Spectral bands

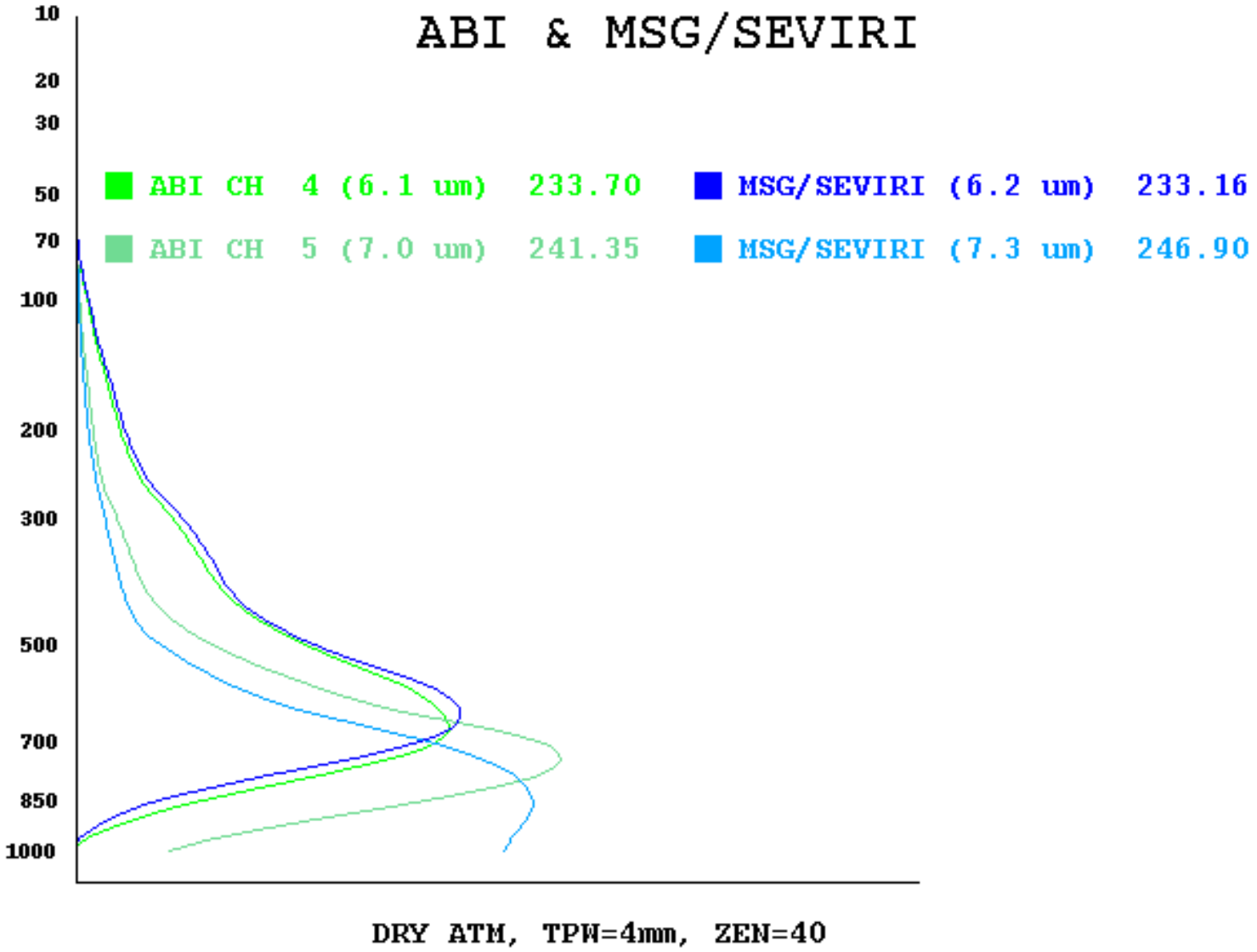


Acronyms

- ABI -- Advanced Baseline Imager
- AGS -- Advanced Geostationary Studies
- AVHRR -- Advanced Very High Resolution Radiometer
- CIMSS -- Cooperative Institute for Meteorological Satellite Studies
- GLI -- Global Imager
- HIS -- High-resolution Interferometer Sounder
- MAS -- MODIS Airborne Simulator
- MODIS -- MODerate-resolution Imaging Spectrometer
- MSG -- Meteosat Second Generation
- NWS -- National Weather Service
- GOES -- Geostationary Operational Environmental Satellite
- SEVIRI -- Spinning Enhanced Visible and Infra Red Imager
- VIRS -- Visible Infrared Scanner



ABI and MSG Weighting Functions



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