Preparation for GOES-R OSSE: ABI Synthetic Radiances

Dr. Fuzhong Weng, Chief
Sensor Physics Branch
Satellite Meteorology and Climatology Division
NOAA/NESDIS/STAR

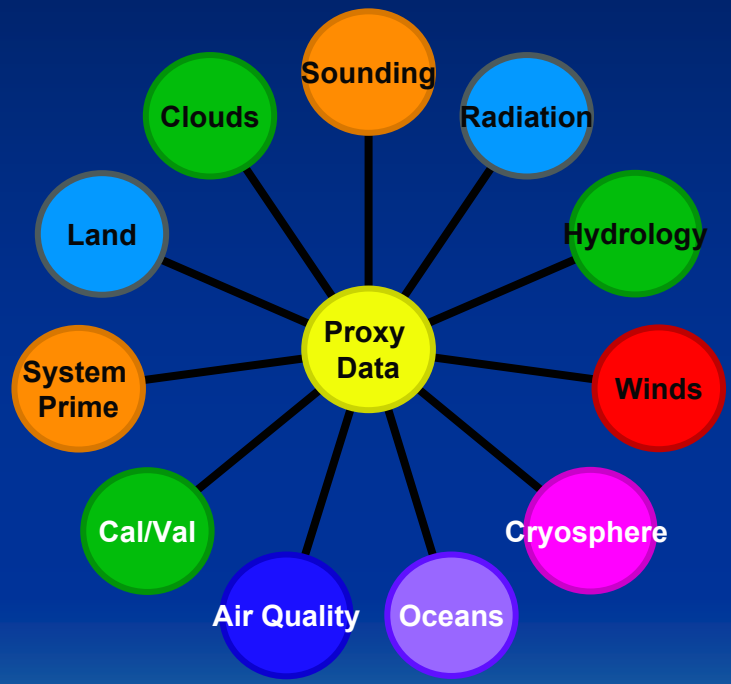
Presented at OSSE Subgroup Meeting
NOAA Science Center, Camp Springs, MD
June 22, 2007

Team Members and Responsibility

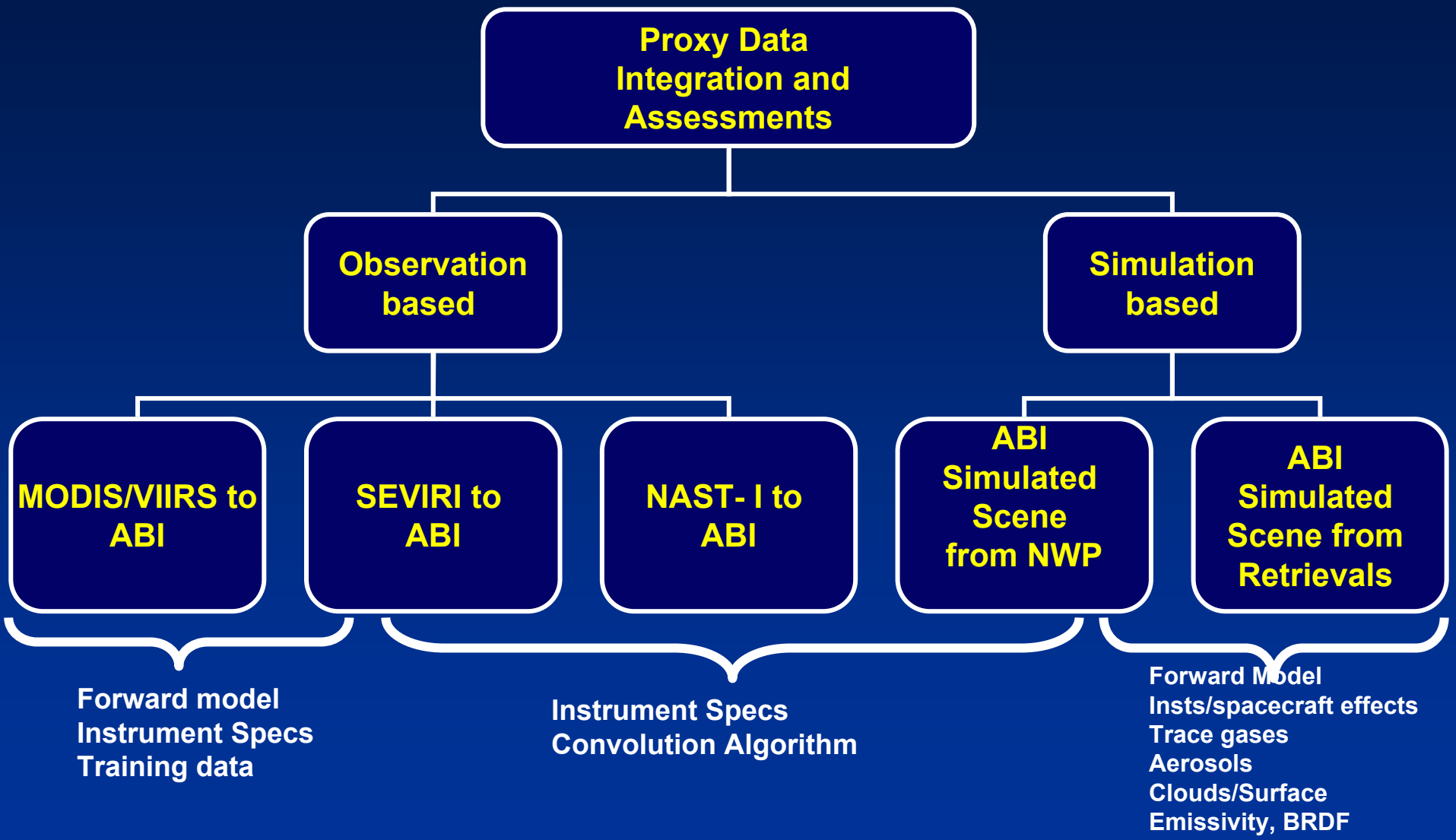
Name	ORG	Role	Contact
Mark Liu	JCSDA	GOES-R Forward Model	
Ping Yang	Texas A&M	GOES-R Forward Model	
Yong Han and Paul van DesIt	STAR/EMC	Integration of GOES-R components into CRTM	
Allen Huang Team	CIMSS	WRF nature runs and synthetic radiance	
Fred Wu and Changyong Cao	STAR	GOES-R calibration	
Mark DeMaria Team	CIRA	RAMS nature run and RAMDIS assimilation	
Ben Ruston	NRL&JCSDA	GOES-R surface emissivity	
Tong Zhu	JCSDA&STAR	T511 and T799 synthetic radiance	
Min-Jeong Kim	JCSDA&STAR	Cloudy radiance assimilation	

GOES-R Synthetic Radiance Users

- **User Community:**
  - For the development of operational-certified GOES-R product algorithms and processing systems
  - the GOES-R Algorithm Working Group (AWG) program requests a high quality of proxy data for algorithm developments, assessment, validation
  - GOES-R PDRR contractors
- **NOAA Mission Goal supported**
  - Weather and Water
  - Climate



GOES-R Proxy Data Management System



STAR Proxy Data Generation Tool

- **GOES-R Community Radiative Transfer Models**
  - Fast gas absorption (SARTA)
  - Aerosols (GOCART)
  - Cloud scattering
  - BRDF/emissivity models (Prospect optical model)
  - JCSDA Community Radiative Transfer Model (CRTM)
  - CIMSS radiative transfer mode
  - Spectral response function (SRF) data base
- **Mesoscale Simulation Systems (WRF/MM5/RAMS)**
  - severe weather
  - lake effect snow
  - hurricanes
  - fire hotspots embedded in severe weather
  - Fire case in the tropics that contains both cloudy and clear regions
- IDL Widget-Based Visualization System
  - display proxy data, including SEVIRI, GOES-E/W, MODIS, ABI, MM5, WRF datasets

Proxy Datasets - Observation

Observation Data							
Dataset	Time coverage	Space coverage	Temporal resolution	Spatial resolution	# of channels	Format	Data Volume
MSG-SEVERI	36 days in 2005	Full disk	15 minutes	1 km/3 km	12	McIDAS	2 TB
GOES-08	365 days in 2001	Full disk	15 minutes	1 km/4 km	5	McIDAS	6.8 TB
GOES-10	365 days in 2001	Full disk	15 minutes	1 km/4 km	5	McIDAS	6.8 TB
GOES08/SURFRAD	365 days in 2001	8 SURFRAD sites	Hourly	1 km/4 km	5	ASCII	113 GB
GOES10/SURFRAD	365 days in 2001	7 SURFRAD sites	Hourly	1 km/4 km	5	ASCII	226 GB
MODIS L1B	3 days in 2005	Globe	Day/Night	1 km	36	HDF	100 GB
ABI_(MODIS)	5 Cases	1000 x 1000 km^2	one time	0.5 / 1 / 2 km	14	NetCDF	647 MB
AERONET/MODIS	2000	ARM site	599 points	n/a	n/a	Excel	620 KB
ABI_EMIS_GOES	Mar-Apr 2003	55S-55N, 135W-15W	2-month averaged	~5 km	10	NetCDF	138 MB
ABI_(SEVIRI)	1-Oct-05	Full disk	15 minutes	1 km/3 km	10	BINARY	31 GB
NAST-I (on demand)	Flight to flight	Regional	One time	2.5 km/FOV	10 ABI	Binary	10 GB

GOES-R ABI Simulations

Simulation Data							
Dataset	Time coverage	Space coverage	Temporal resolution	Spatial resolution	# of channels	Format	Data Volume
MM5 Simulation	25-Aug-05	2079 x 1971 km^2	hourly/10-min	3 km	n/a	BINARY	2.7 GB
WRF Simulation	25-Jun-03	12640 x 14640 km^2	40 minutes	8 km	n/a	NetCDF	43 GB
WRF Hyperspectral radia	25-Jun-03	12640 x 14640 km^2	40 minutes	8 km	n/a	NetCDF	100 GB
ABI simulation (WRF)	25-Jun-03	12640 x 14640 km^2	40 minutes	8 km	9 IR	NetCDF	452 MB
RAMS Simulation -Lili	6 hr 10/02/2002	1862 x 1562 km2	5 minutes	2 km	n/a	BINARY	196 GB
ABI simualtion (RAMS)	6 hr 10/02/2002	1862 x 1562 km2	5 minutes	2 km	10 IR	BINARY	41 GB

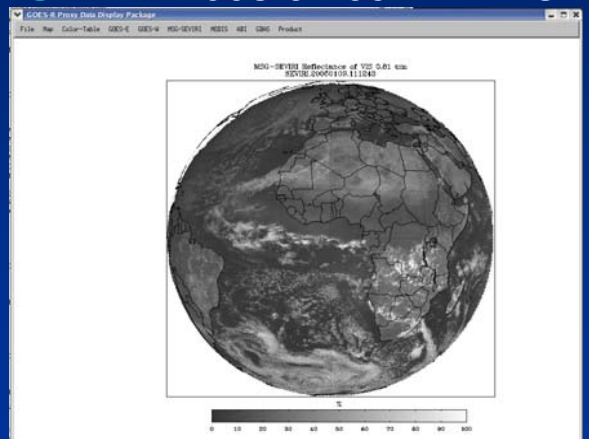
Visualization

IDL based interactive system can now display proxy data, including SEVIRI, ABI datasets.

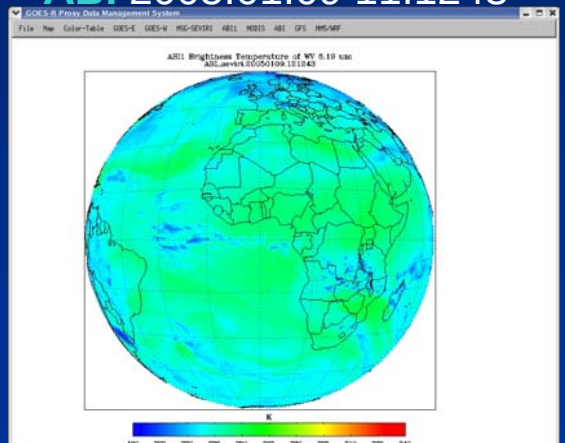
SEVIRI 2005.01.09 11:1243

ABI 2005.01.09 11:1243

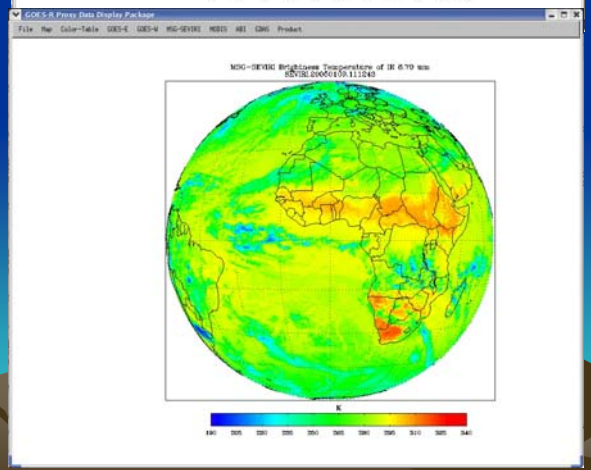
VIS 0.81µm



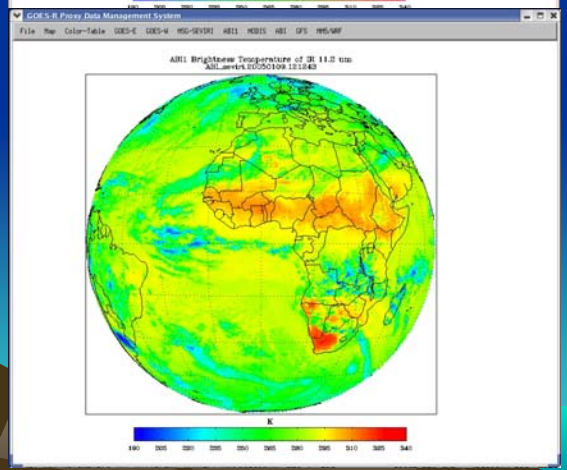
IR 6.19 µm



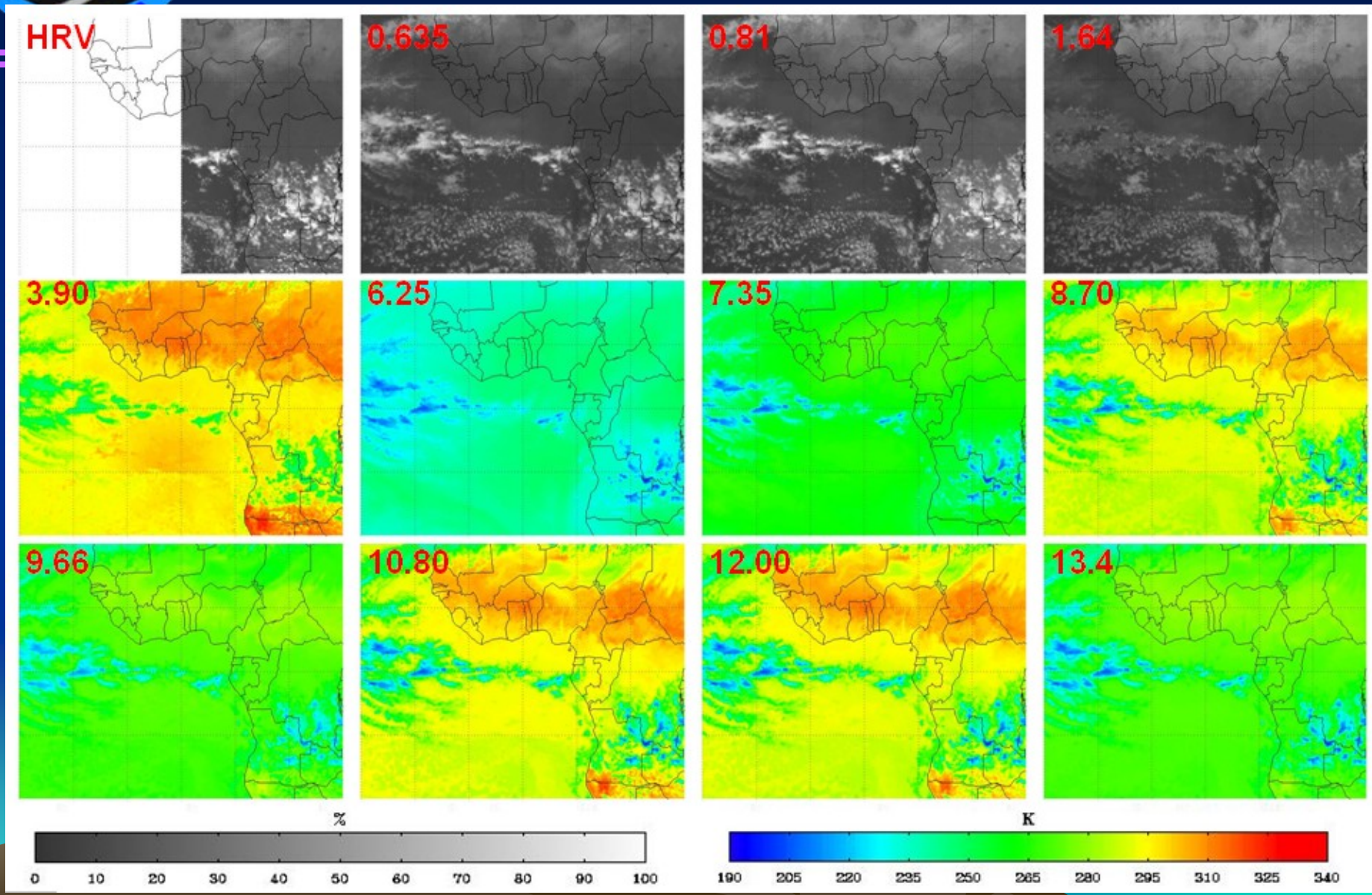
IR 8.70 µm



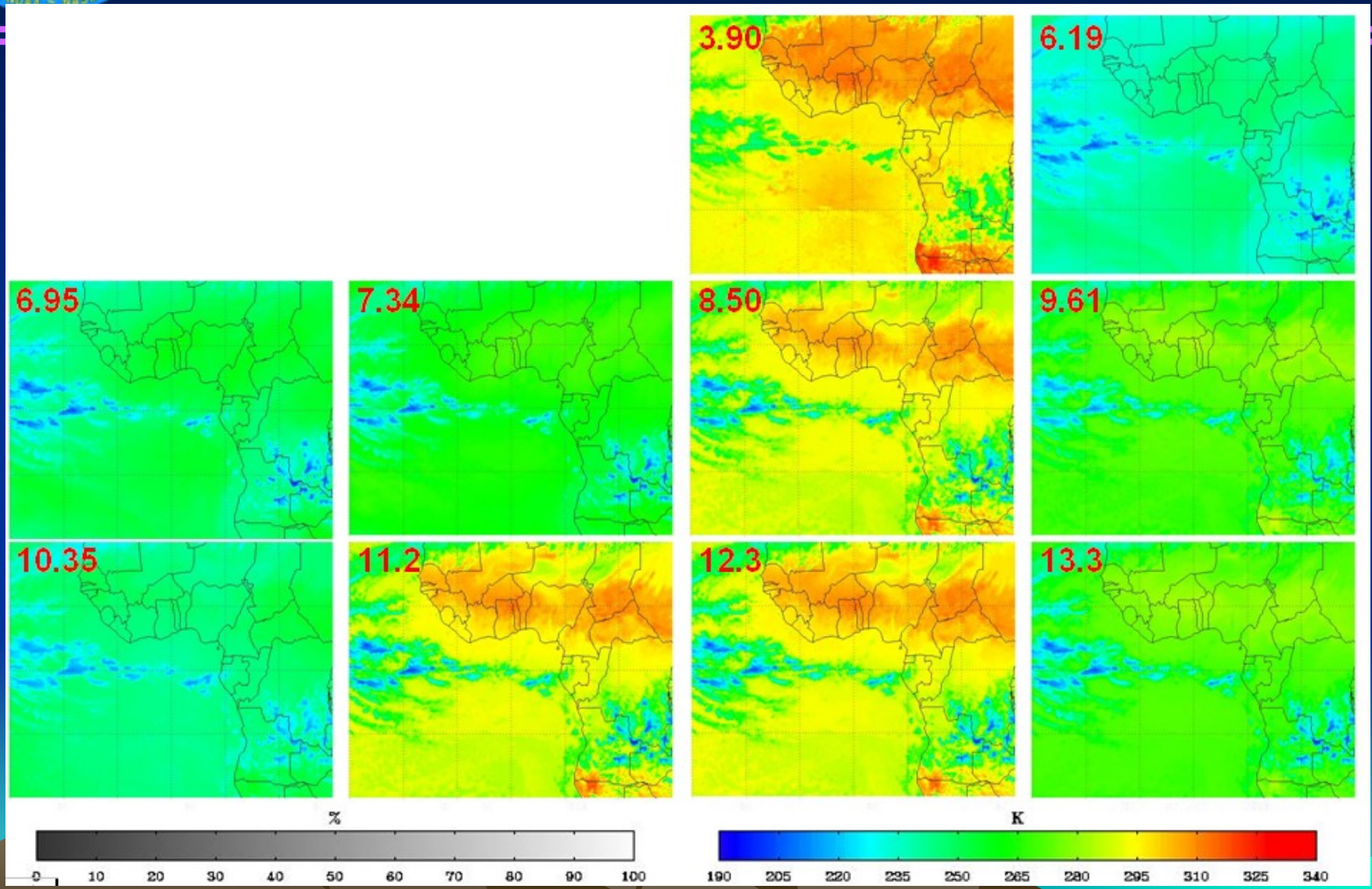
IR 11.2 µm



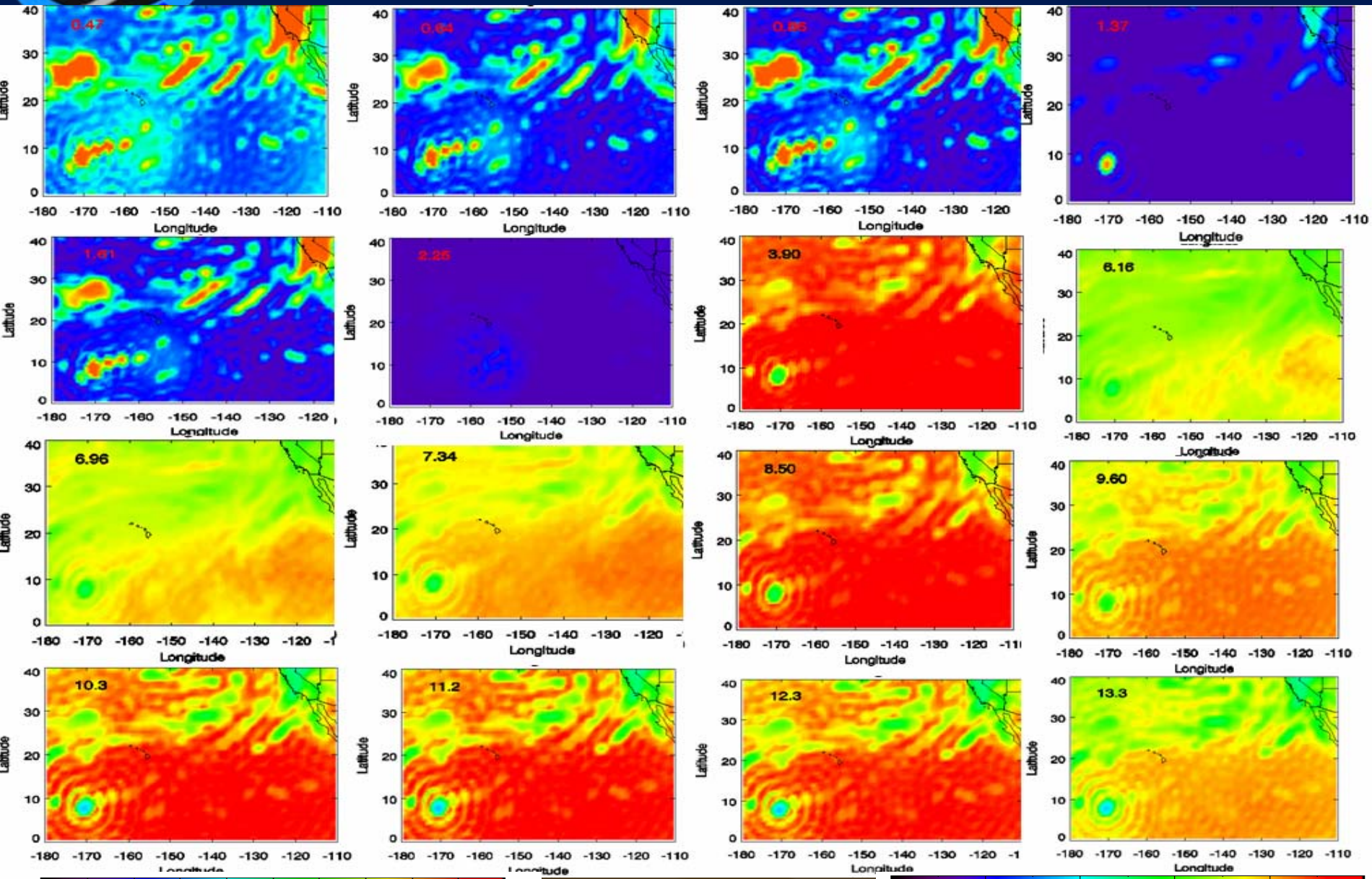
SEVIRI 12 Bands



ABI 10 IR Bands Simulated from SEVIRI



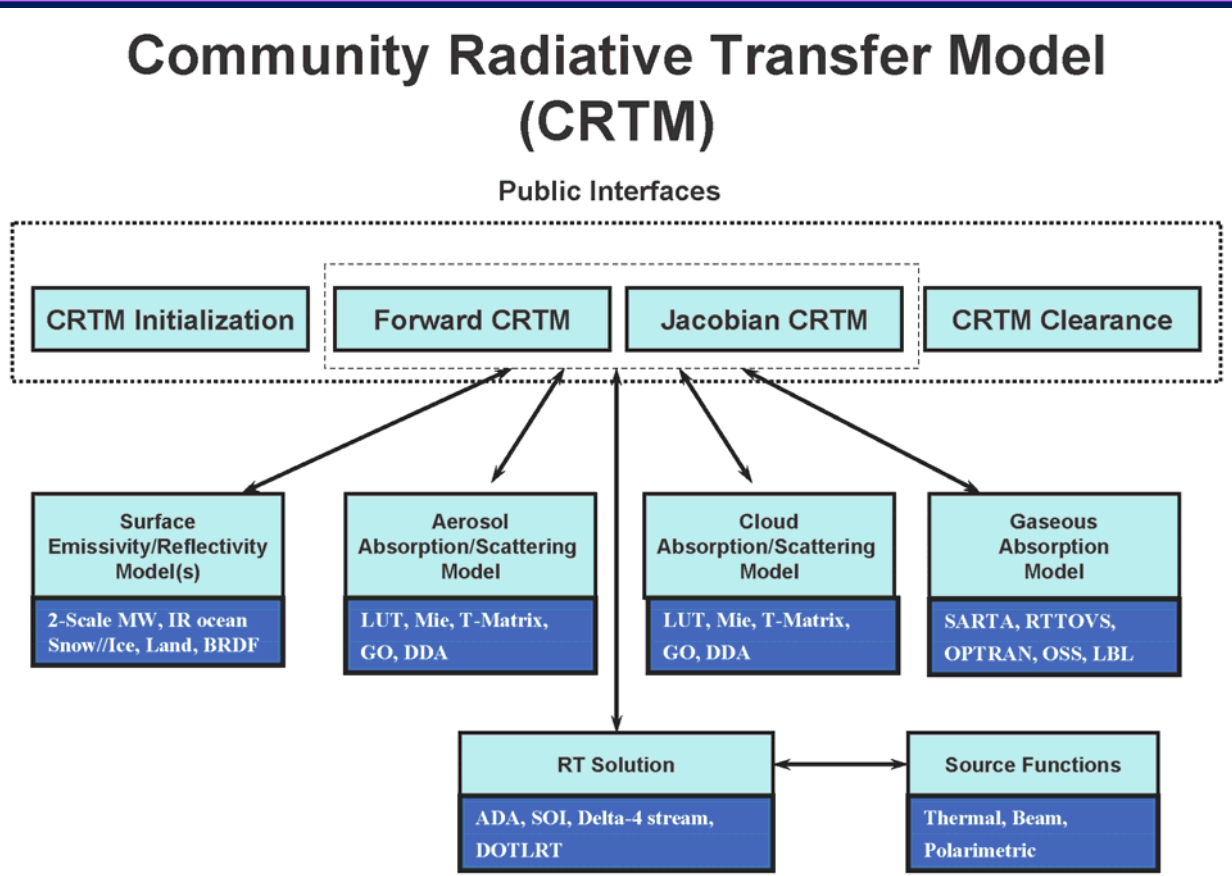
GOES-R ABI Simulations using CRTM



CRTM Capability

Supported Instruments

- GOES-R ABI
- Metop IASI
- TIROS-N to NOAA-18 AVHRR
- TIROS-N to NOAA-18 HIRS
- GOES-8 to 13 Imager channels
- GOES-8 to 13 sounder channel 08-13
- Terra/Aqua MODIS Channel 1-10
- METEOSAT-SG1 SEVIRI
- Aqua AIRS
- Aqua AMSR-E
- Aqua AMSU-A
- Aqua HSB
- NOAA-15 to 18 AMSU-A
- NOAA-15 to 17 AMSU-B
- NOAA-18 MHS
- TIROS-N to NOAA-14 MSU
- DMSP F13 to15 SSM/I
- DMSP F13,15 SSM/T1
- DMSP F14,15 SSM/T2
- DMSP F16 SSMIS
- NPP ATMS
- Coriolis Windsat



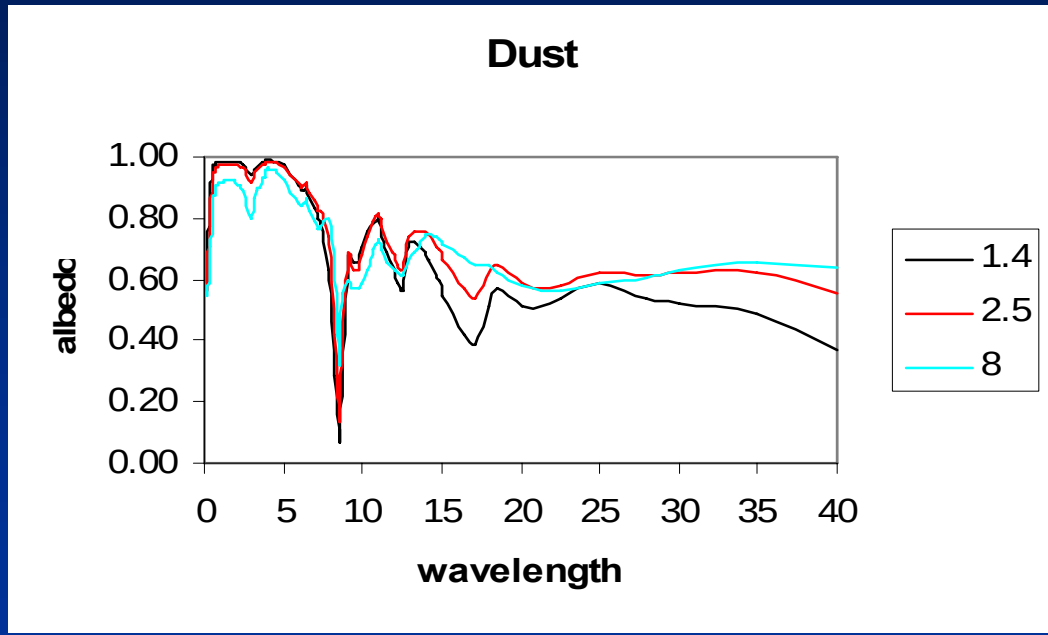
***Significance:** CRTM framework is designed to accelerate transition of new radiative transfer science for assimilation of operational and research satellite data in NWP models and to improve the retrieval technology in satellite remote sensing system*

Aerosol Models

- **Global Model,** Goddard Chemistry Aerosol Radiation and Transport (GOCART)
  - Dust
  - Sea Salt
  - Organic carbon
  - Black carbon
  - Sulfate
- **Regional Model WRF-NMM,** Community Multi-scale Air Quality (CMAQ)
  - Sulfate mass
  - Ammonium mass
  - Nitrate mass
  - Organic mass
  - Unspecified anthropogenic mass
  - Elemental carbon mass
  - Marine mass
  - Soil derived mass

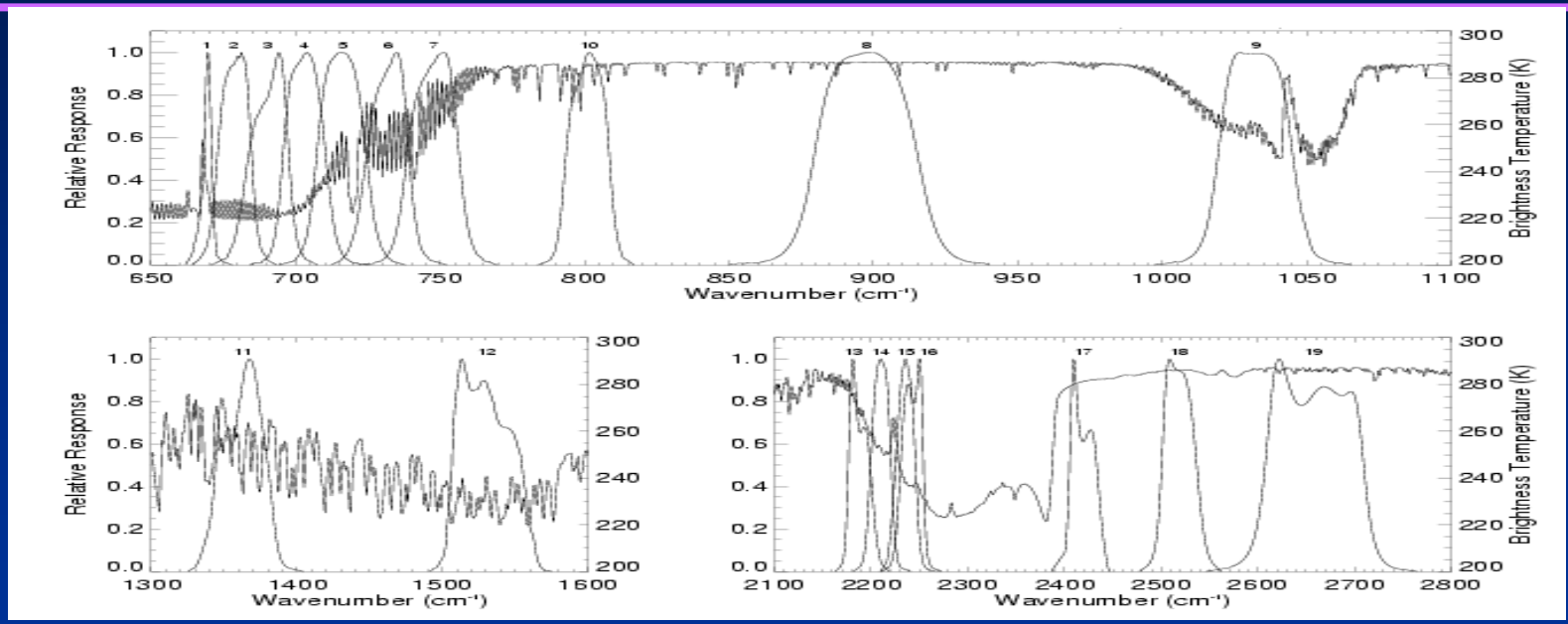
Aerosols Scattering Model

1. Sulfur: DMS (Dimethyl sulfide), SO2, SO4, MSA (methanesulfonate)
2. Carbon: Hydrophobic BC/OC, hydrophilic BC/OC (water-like)
3. Dust: 8 bins: 0.1-0.18, 0.18-0.3, 0.3-0.6, 0.6-1, 1.0-1.8, 1.8-3.0, 3.0-6.0, 6.0-10.0 μm
4. Sea-salt: 4 bins: 0.1-0.5, 0.5-1.5, 1.5-5.0, 5.-10. μm



Significance: The Goddard Chemistry Aerosol Radiation and Transport (GOCART) model simulates major tropospheric aerosol components, including sulfate, dust, black carbon (BC), organic carbon (OC), and sea-salt aerosols. It is also used by NOAA in its air quality forecast system. The same GOCART aerosol physics implemented into CRTM will attract more users for air quality data assimilation

Aerosols' effect on hirs3_n17

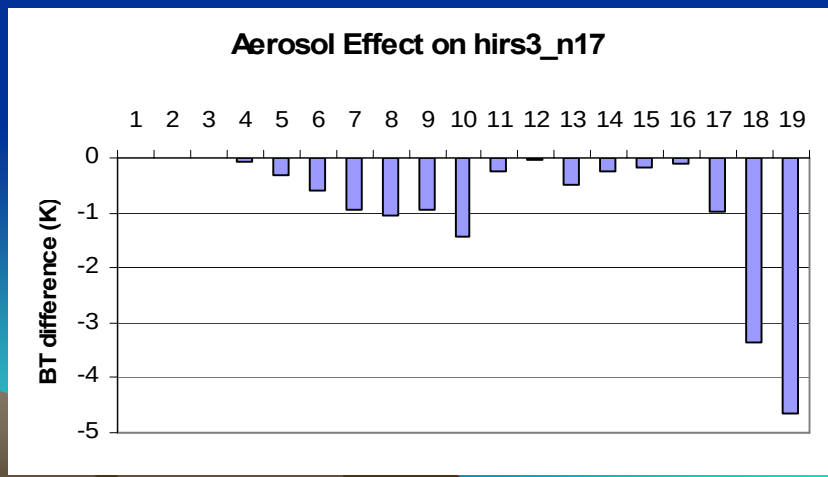


No clouds

0.1 g/m2 OC aerosol at 300 hPa

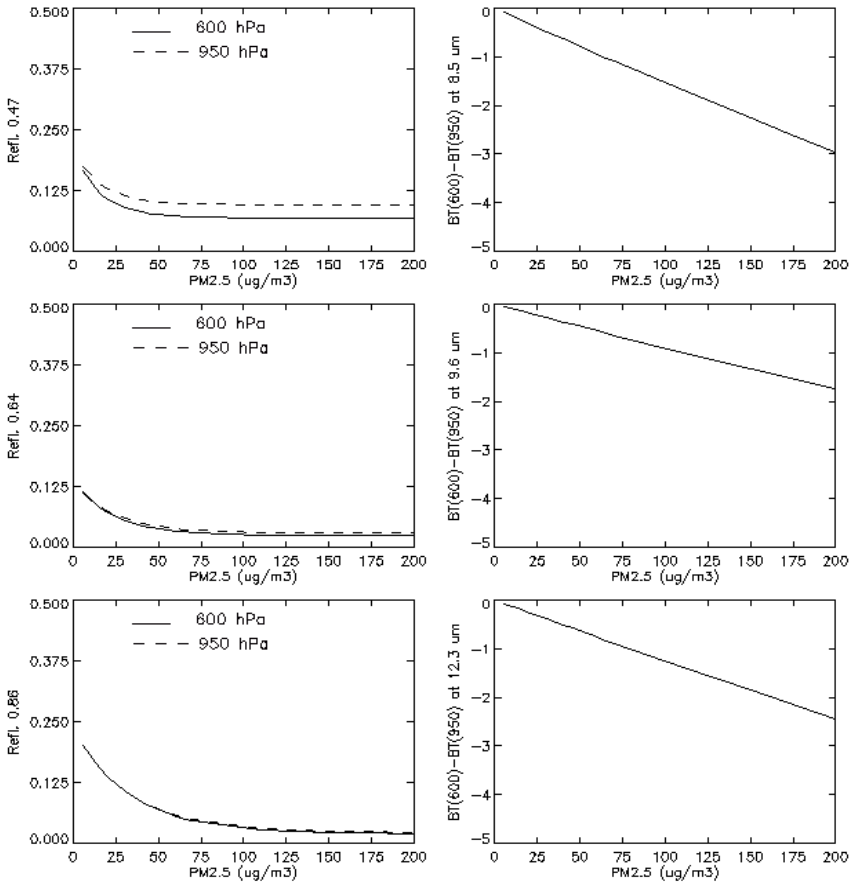
0.1 g/m2 Dust aerosol at 600 hPa

0.1 g/m2 Dust aerosol at 650 hPa

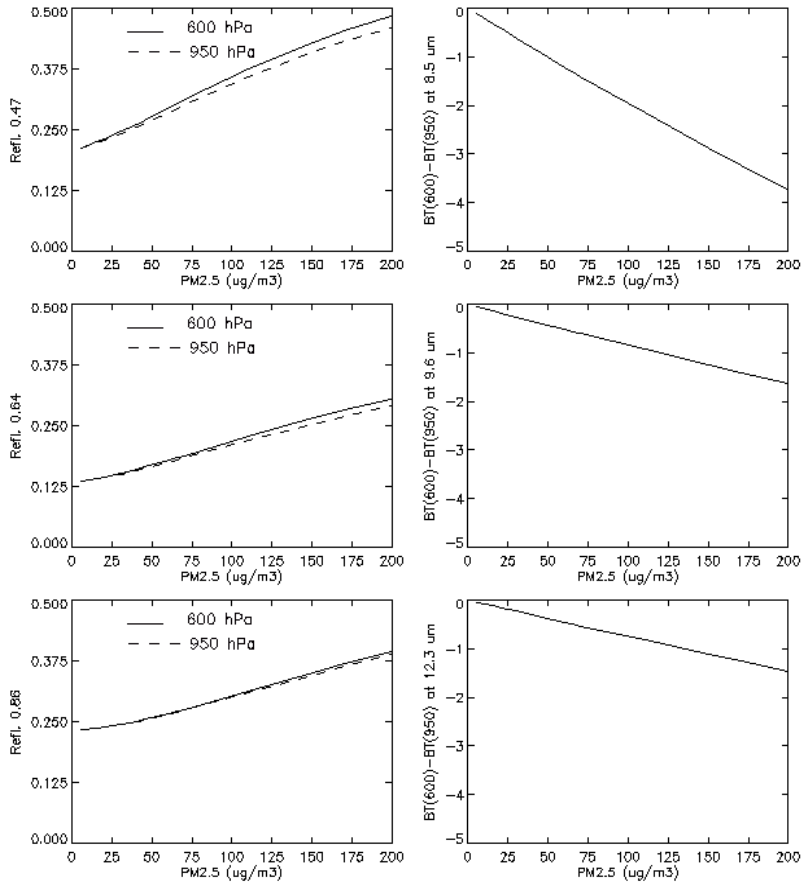


ABI Sensitivity to Aerosol Altitude

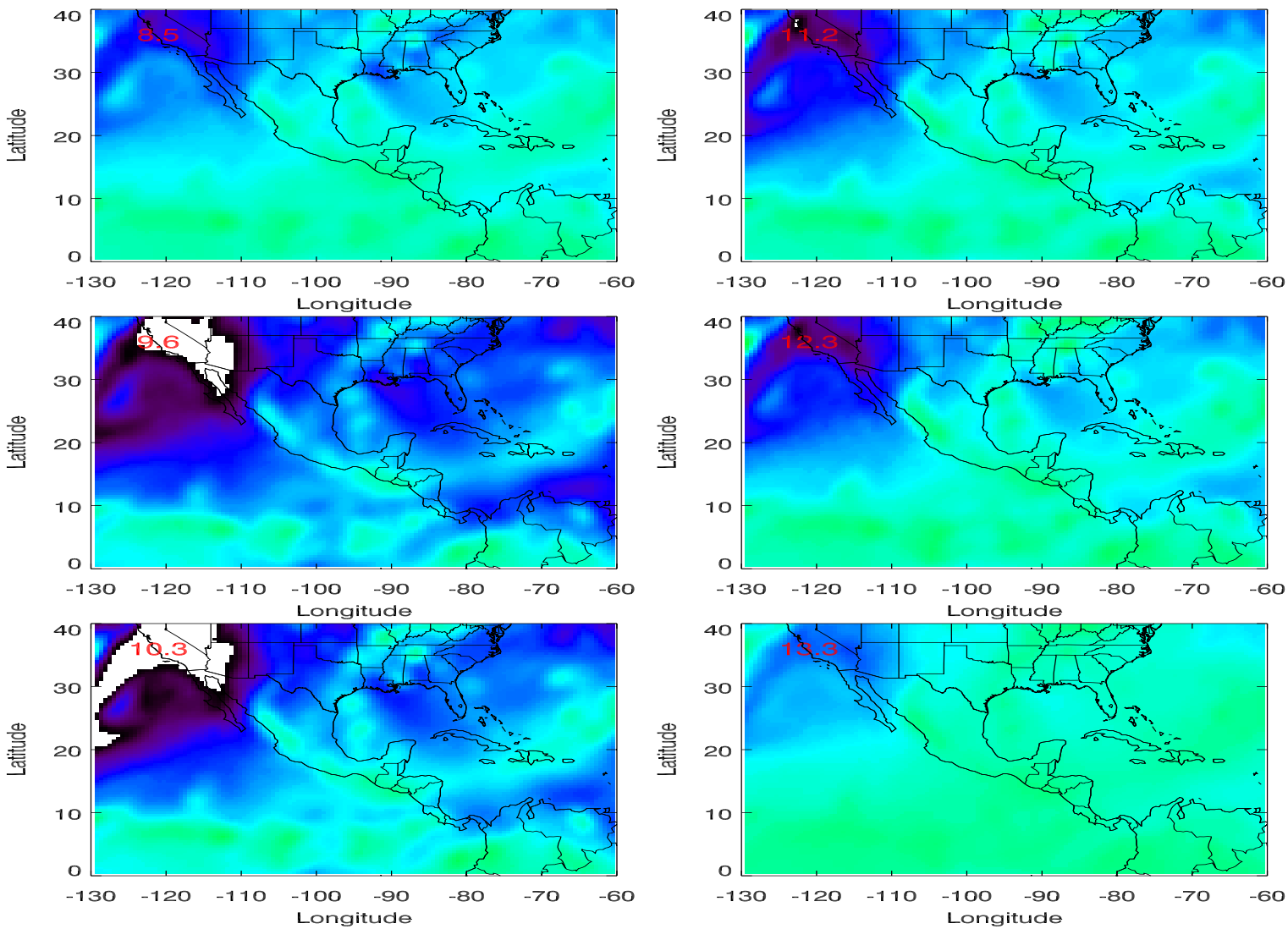
Black carbon



Sulfate



BT difference (with – without aerosols)



GOES-R ABI SRF Studies

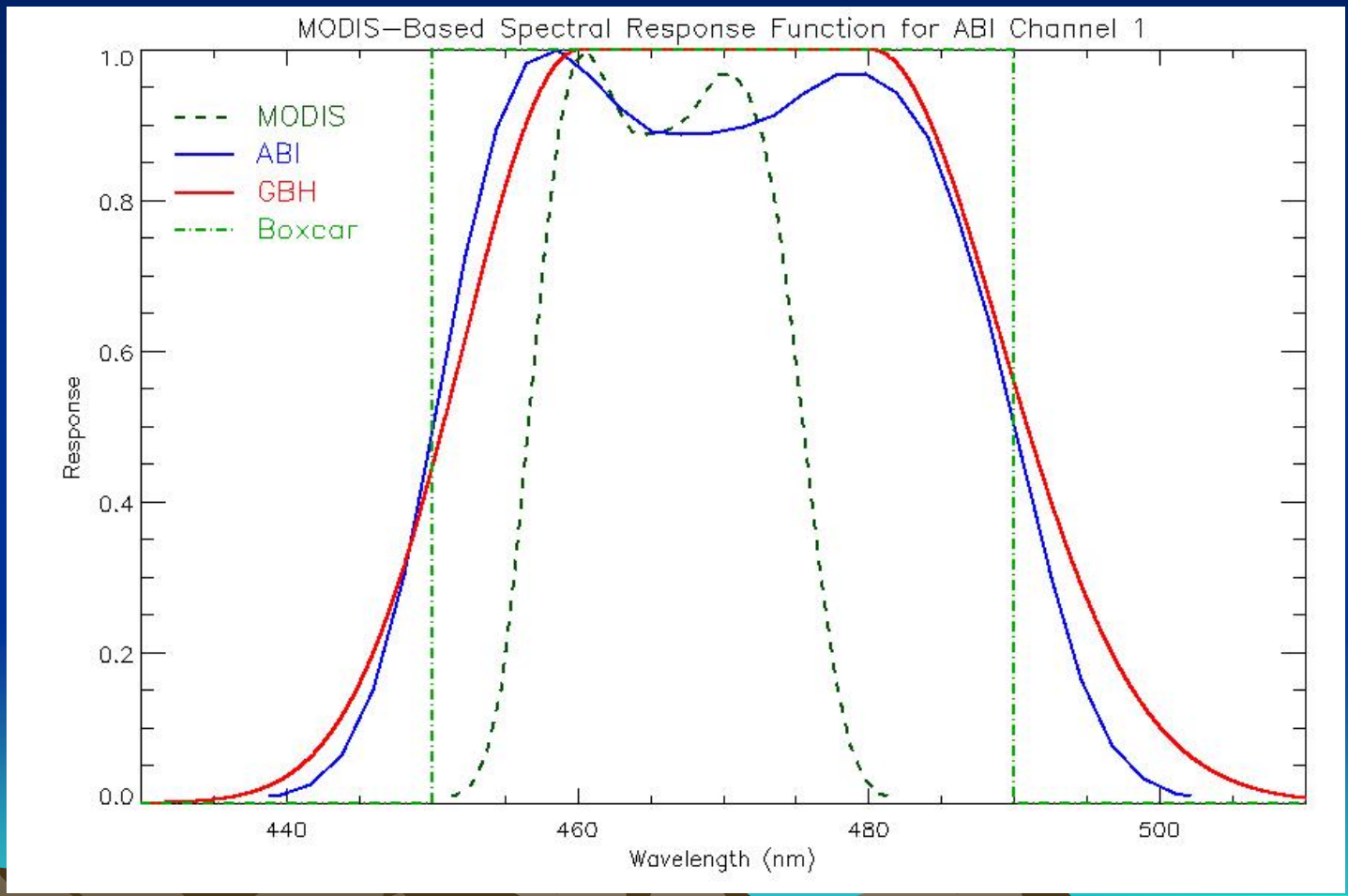
- ABI SRF will not be known until it's built
- Proxy is imperative in preparation for ABI applications
- Have to build from the "specs" as in PORD shown on the right

Spectral Response Table

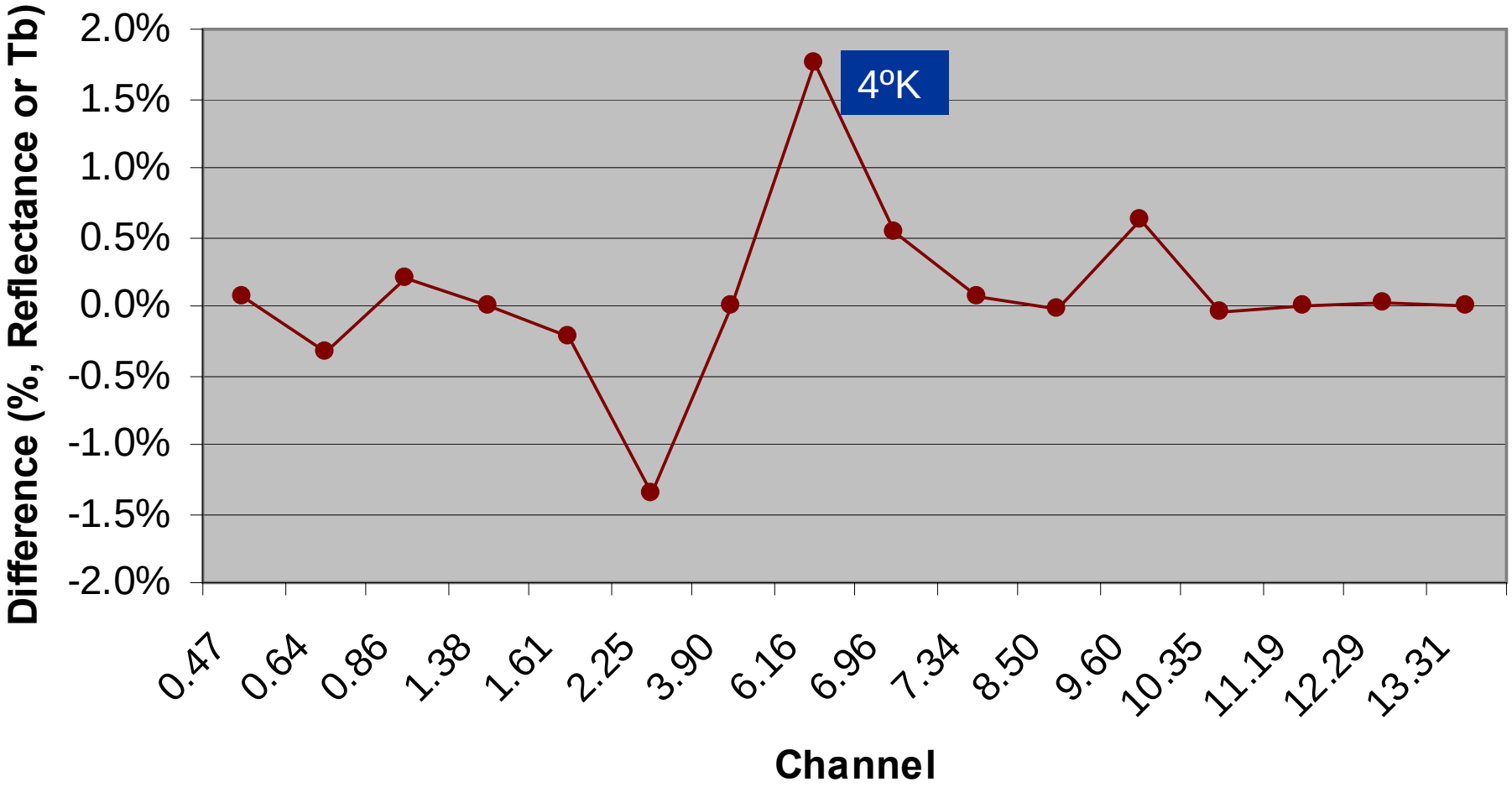
Nominal Center Wavelength (μm)	T1 (μm)	T2 (μm)	T3 (μm)	T4 (μm)	Nominal 50% Bandwidth
Baseline Channels					
0.47	0.02	0.054	0.054	0.07	0.04
0.64	0.08	0.12	0.135	0.175	0.10
0.865	0.02	0.053	0.053	0.0683	0.039
1.378	0.01	0.02	0.0203	0.0263	0.015
1.61	0.04	0.08	0.081	0.105	0.06
2.25	0.03	0.0675	0.0675	0.0875	0.05
3.9	0.1	0.27	0.27	0.35	0.20
6.185	0.77	0.89	1.1205	1.4525	0.83
6.95	0.34	0.46	0.54	0.7	0.40
7.34	0.16	0.24	0.27	0.35	0.20
8.5	0.34	0.46	0.54	0.7	0.40
9.61	0.32	0.44	0.513	0.665	0.38
10.35	0.3	0.675	0.675	0.875	0.50
11.2	0.6	1.00	1.08	1.4	0.80
12.3	0.8	1.2	1.35	1.75	1.0
13.3	0.48	0.72	0.81	1.05	0.6

(CCR 00092), (CCR 00214)

Spectral Response Function



Relative Difference Using MODIS-Like and Hybrid SRF for ABI



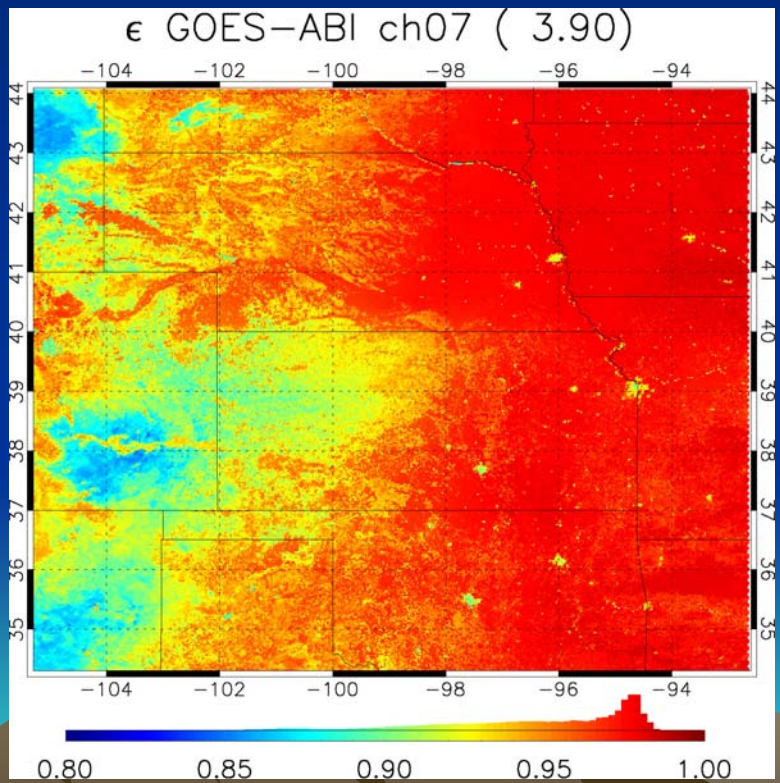
Mark Liu

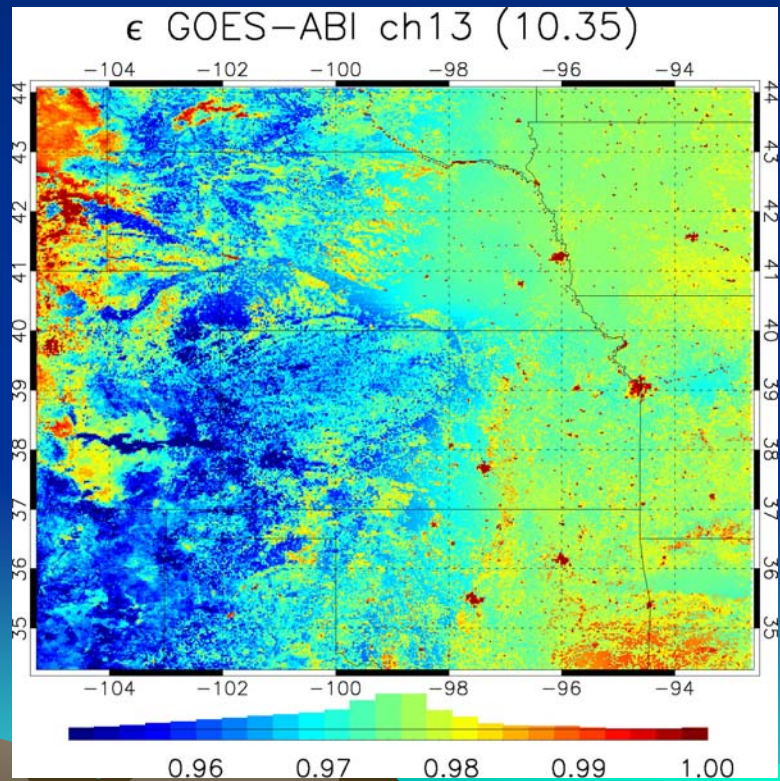
GOES-R Surface Emissivity Approximation

- Instantaneous under all weather conditions
- Static data base from retrievals
- Emissivity/BRDF models

NRL High Resolution Emissivity

CIRA model domain – at 1km resolution
estimate for Aug 2006
available though GOES-Proxy Data AWG



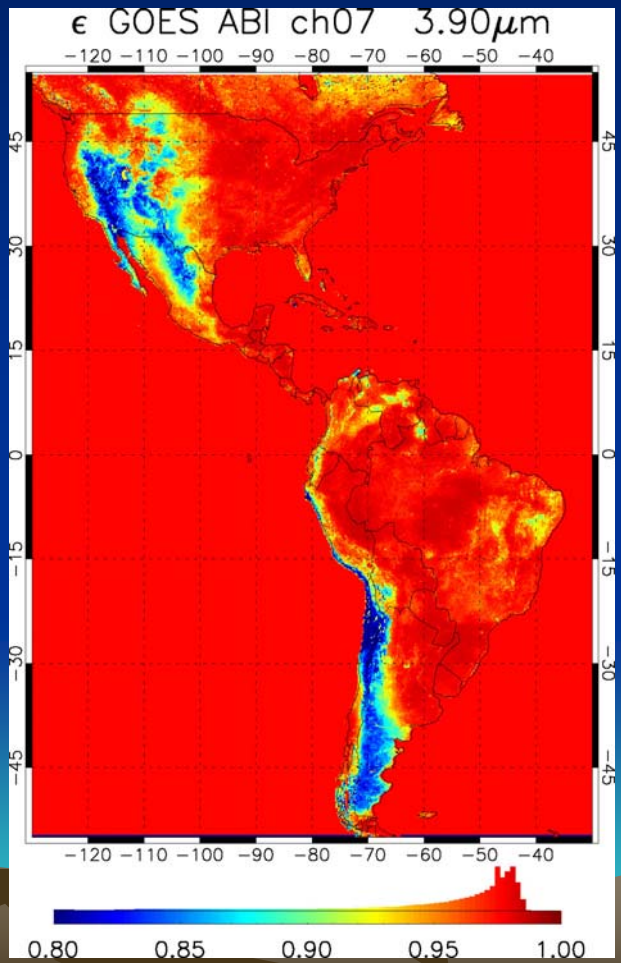


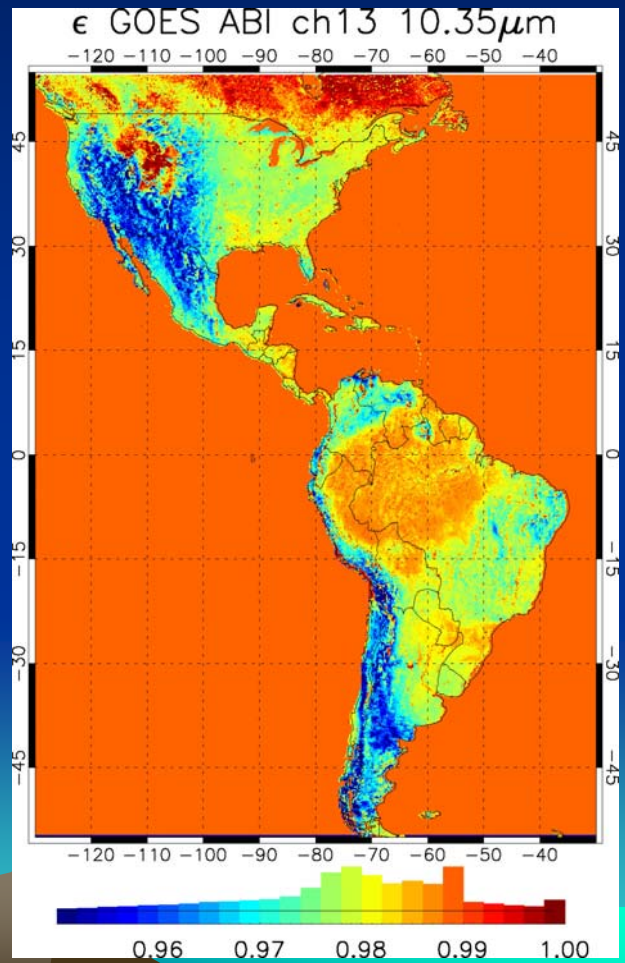
NRL Emissivity Data Base

CIMMS model domain
5km resolution

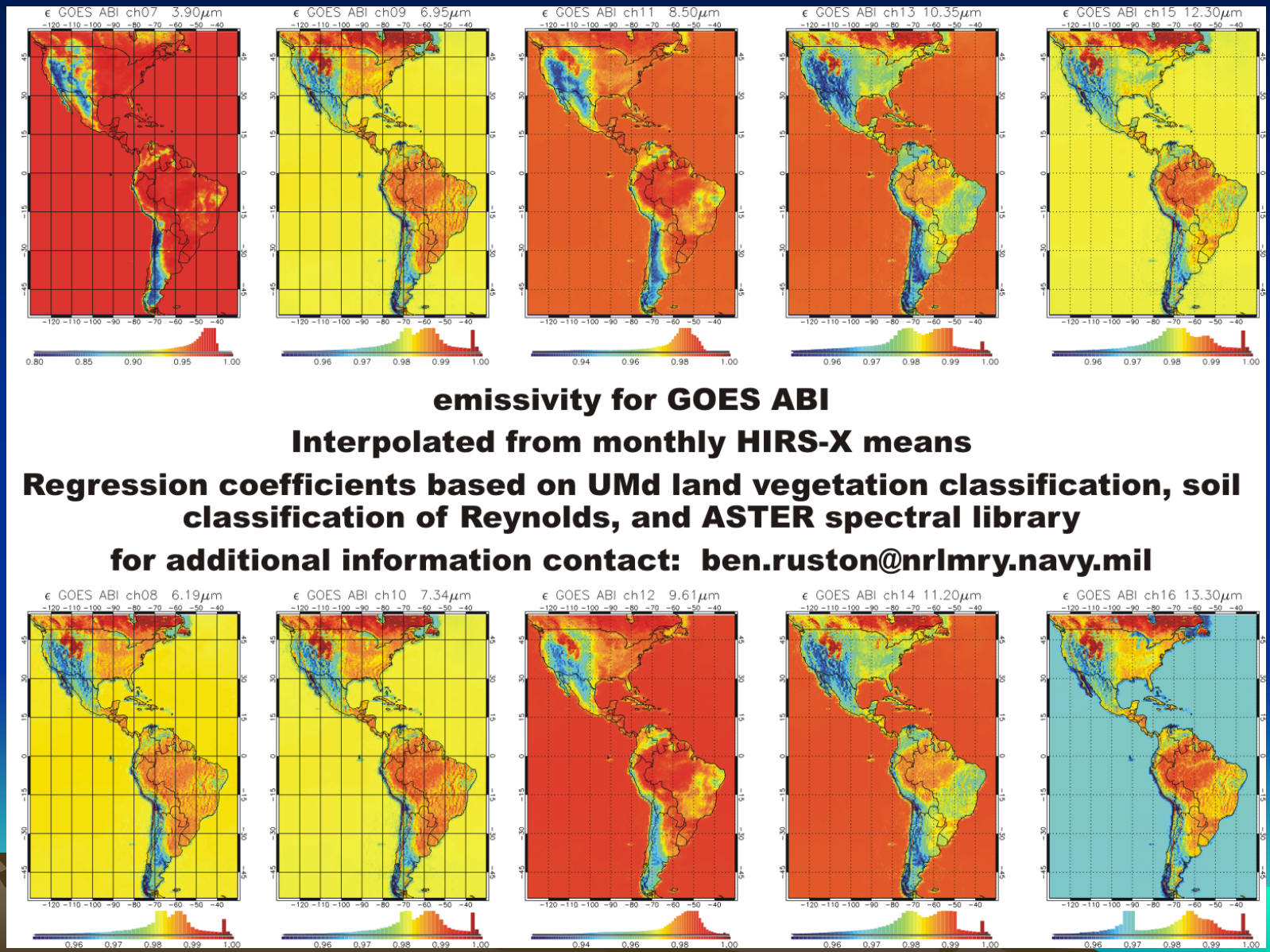
estimate May 2003

available though
GOES-Proxy Data
AWG





Delivered emissivities to GOES Proxy Data Team



emissivity for GOES ABI

Interpolated from monthly HIRS-X means

Regression coefficients based on UMd land vegetation classification, soil classification of Reynolds, and ASTER spectral library

for additional information contact: ben.ruston@nrlmry.navy.mil

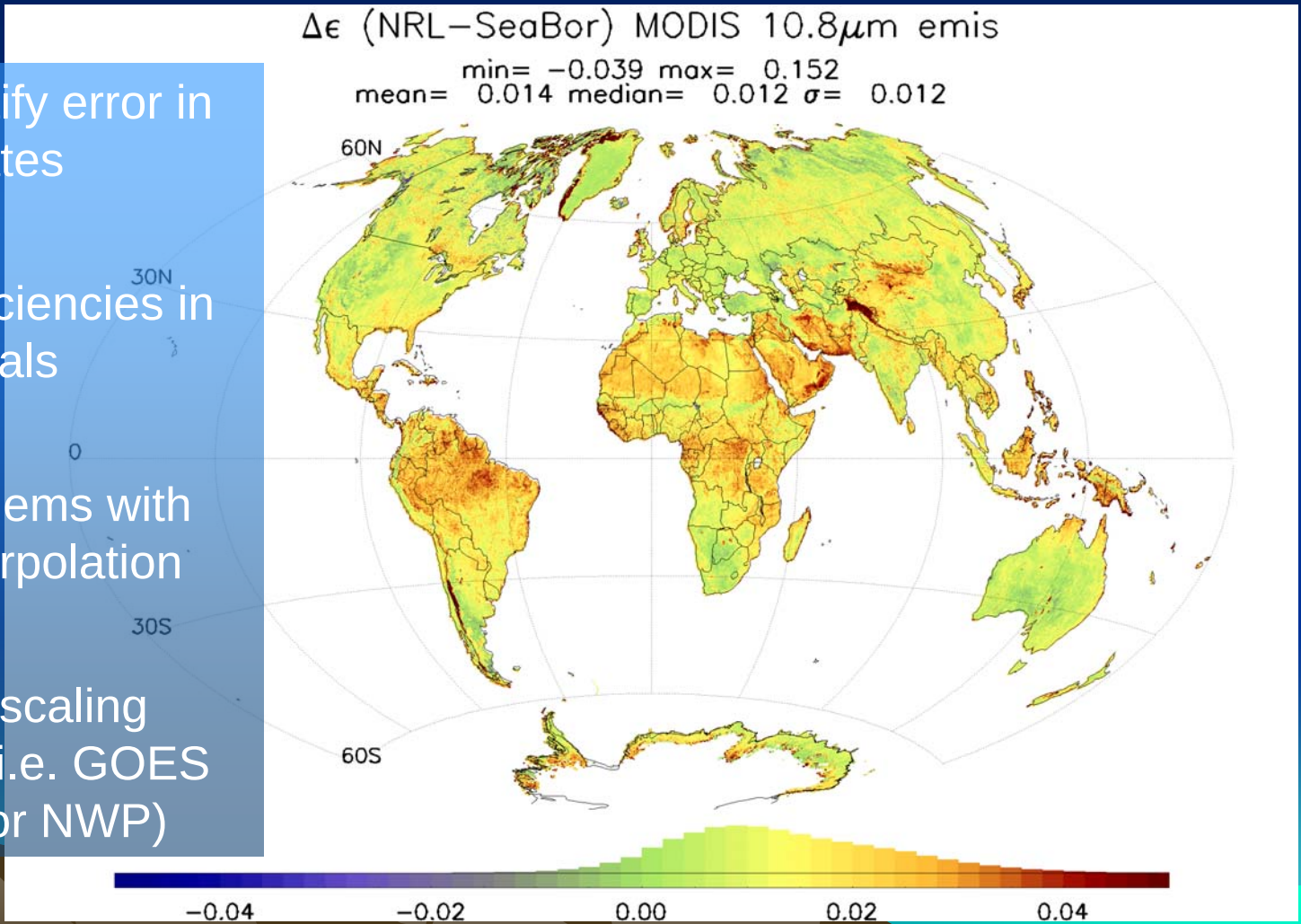
Vicarious calibration/validation using other high quality databases

used to quantify error in estimates

diagnose difficiencies in retrievals

identify problems with spectral interpolation

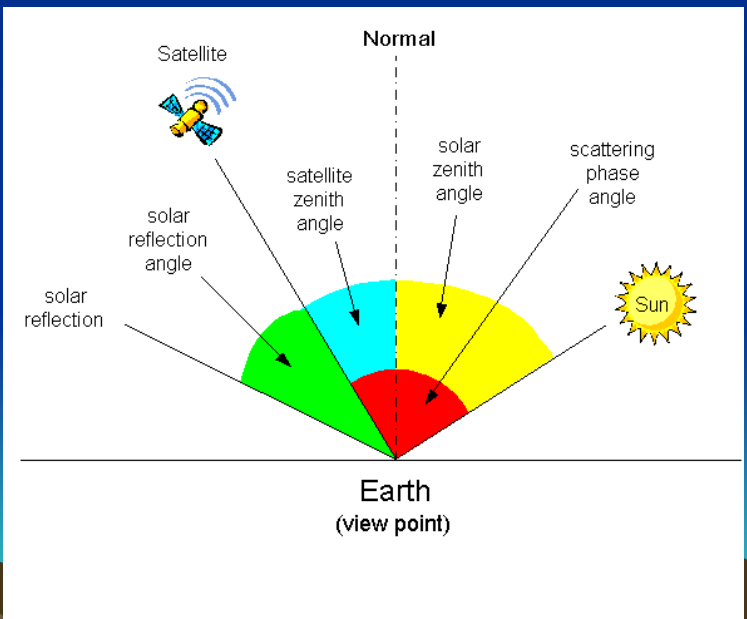
explore upscaling applications (i.e. GOES upscaling for NWP)

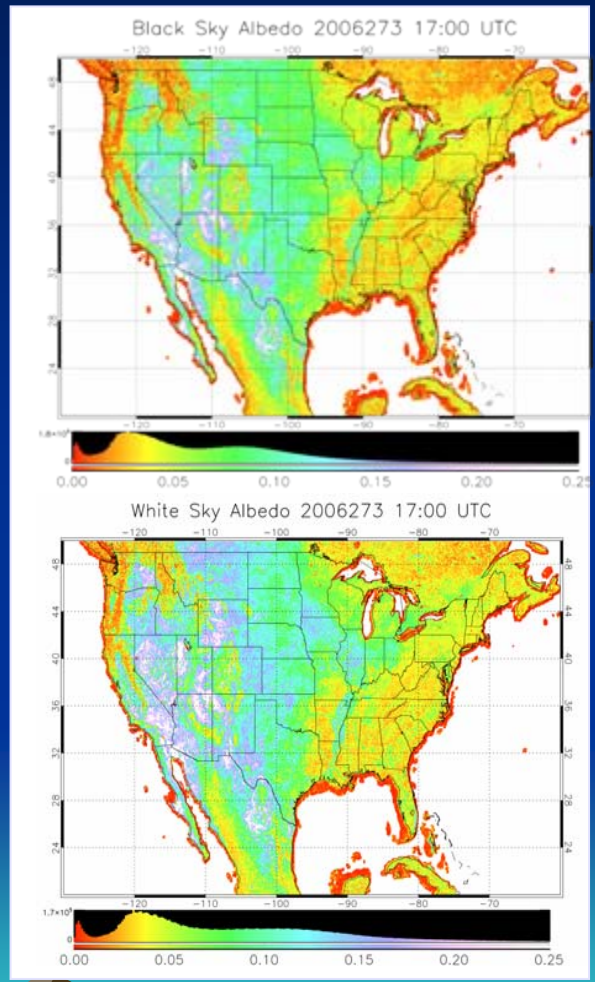


NRL BRDF Functions

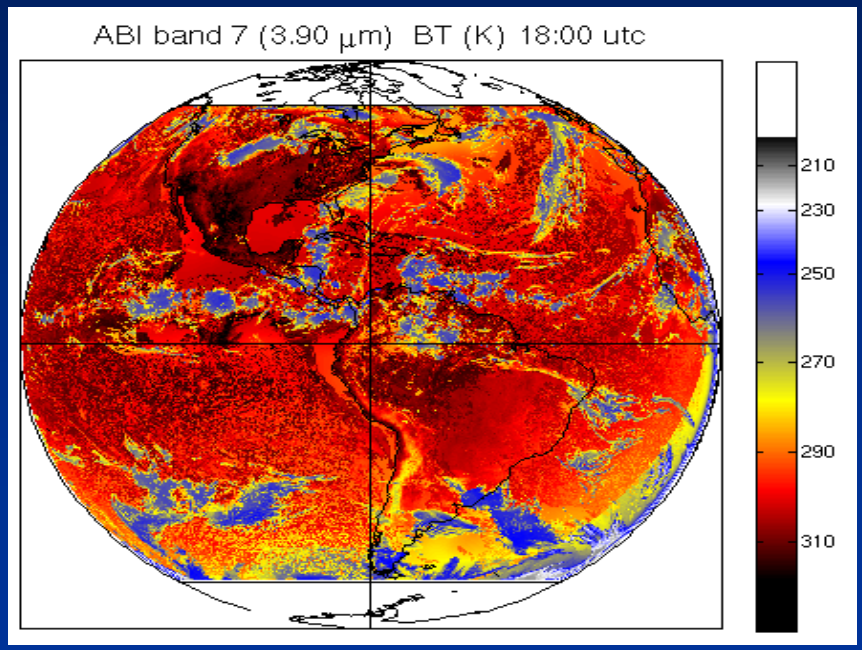
Gathered MODIS BRDF function parameters 2006 jjj's: 1, 65, 145, 193, 273, 289, 305

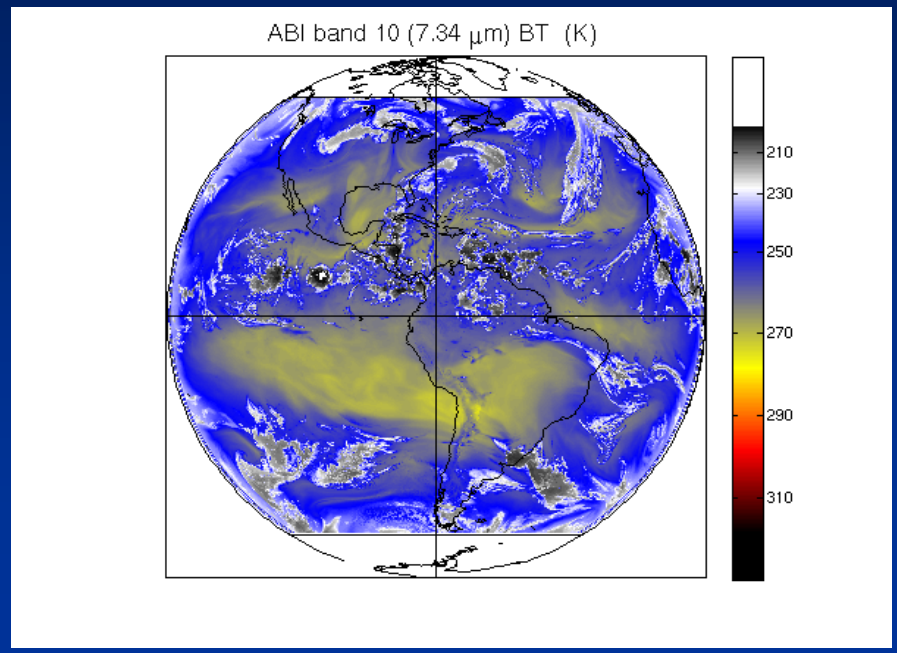
compute solar geometry, viewing geometry and relative azimuth





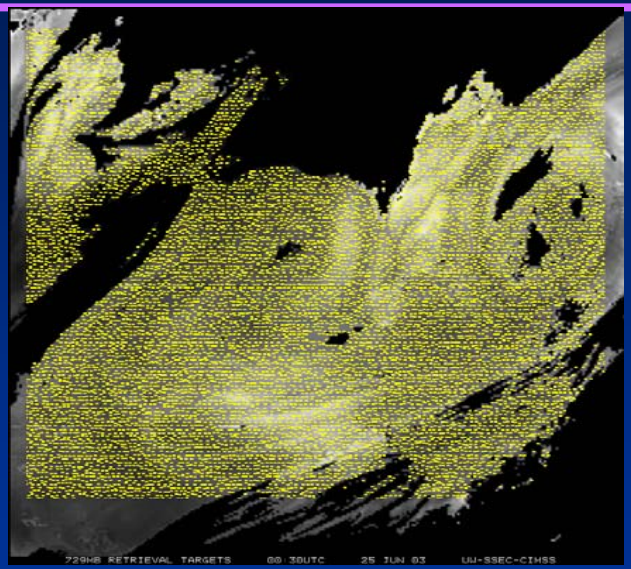
WRF Model Simulation - CIMSS

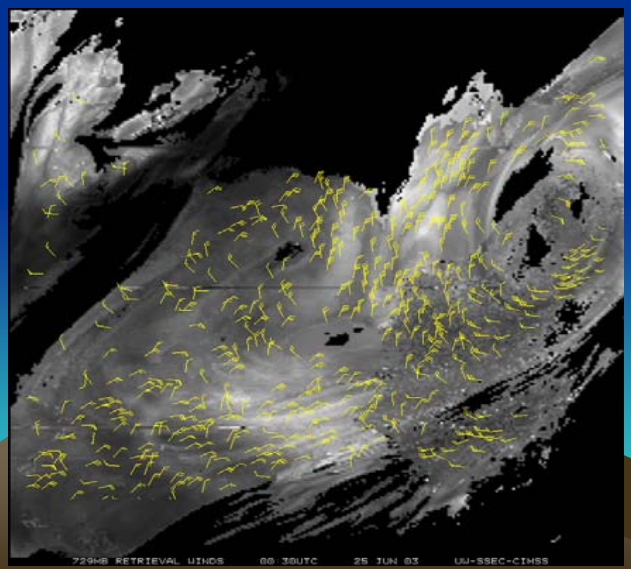




- WRF model
- GDAS and NOAH outputs
- 24 hour dataset
- 6 Km spatial resolution
- 3100 by 2600 grid points (16 MB/Band)

CIMSS GOES-R Proxy Datasets
Utilized by WIND Team





- Winds group used simulated hyperspectral TOA radiances and water vapor retrievals to generate simulated AMVs on constant pressure surfaces using a water vapor tracking algorithm
- Datasets have been used primarily for demonstration purposes and for risk reduction (proof of concept)
- Potential targets that have passed preliminary quality control for a single time period are shown in the top panel
- Simulated AMVs are shown in the bottom panel

CIRA Data Sets

Proxy Dataset Archived

Hard disk:
- binary RAMS forecast fields (6 hour forecast / 5 minute data)
- Fortran reader
- ReadMe text file

ftp directory: synthetic images of brightness temperature and radiances
- NetCDF
- ASCII
- Gif (of McIDAS)
- McIDAS area files

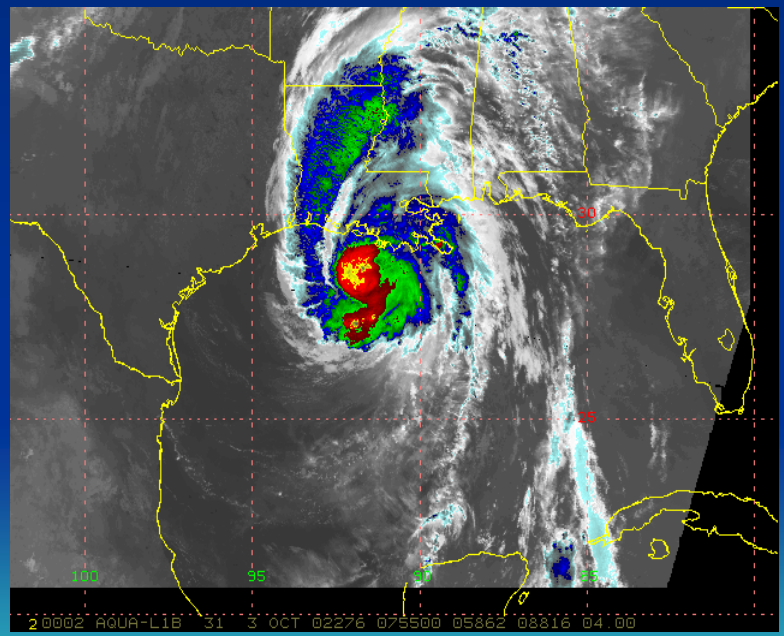
Web site:
- 3 mesoscale study cases (6 hour loops / one image every 5 minutes)

  Status: All 3 mesoscale simulations can be viewed at

  http://rammb.cira.colostate.edu/intranet/GOES-R_IPO/GOESR_IPO_case_study_database.html

Hurricane Lili - 2 Oct 2002

RAMS Simulated GOES-R imagery for wavelength 10.35 µm every 5 minutes over a 6 hour period



Tropical Cyclone Data Set Archive

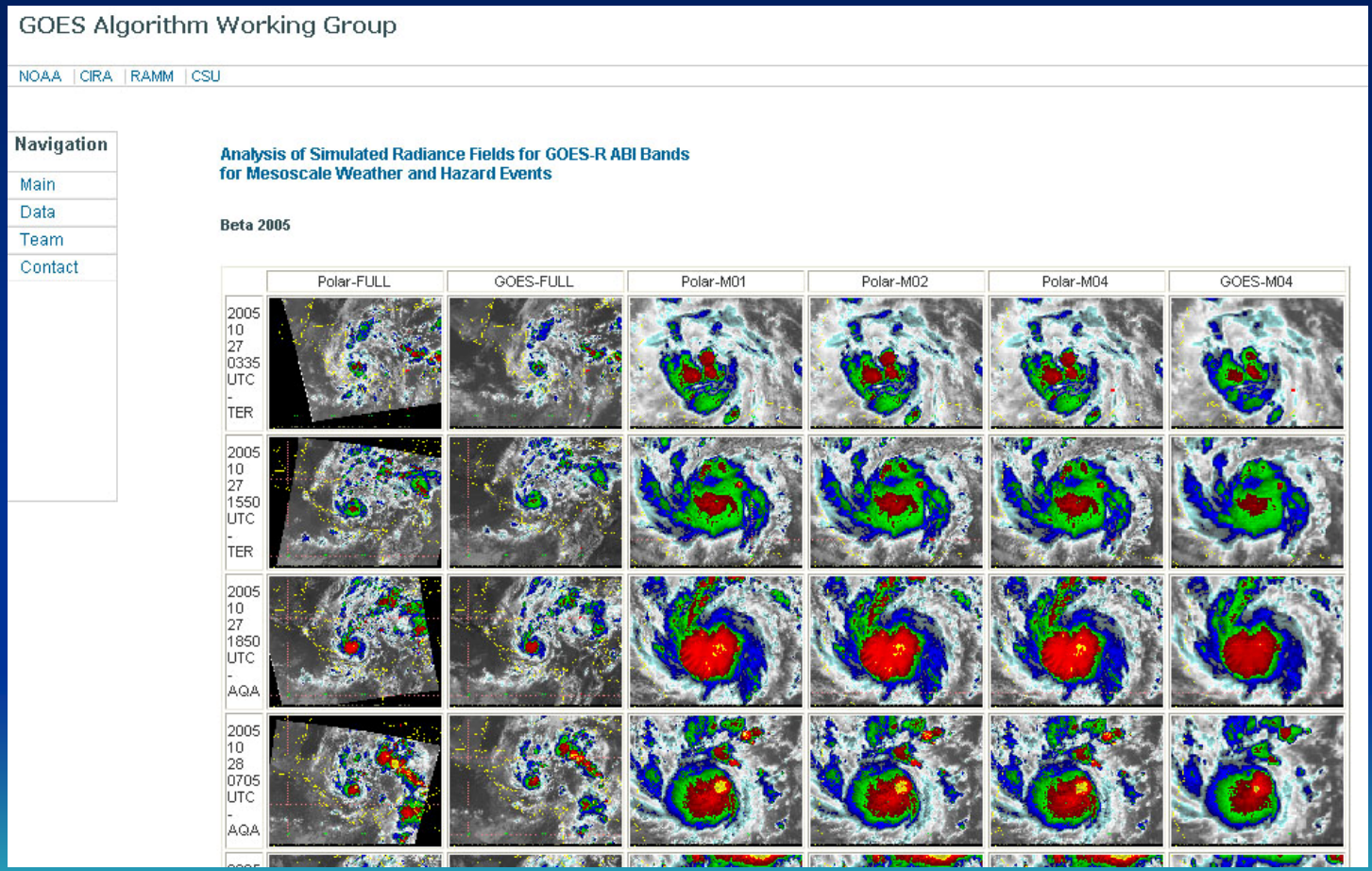
2002:
Lili (25)

2003:
Isabel (86)

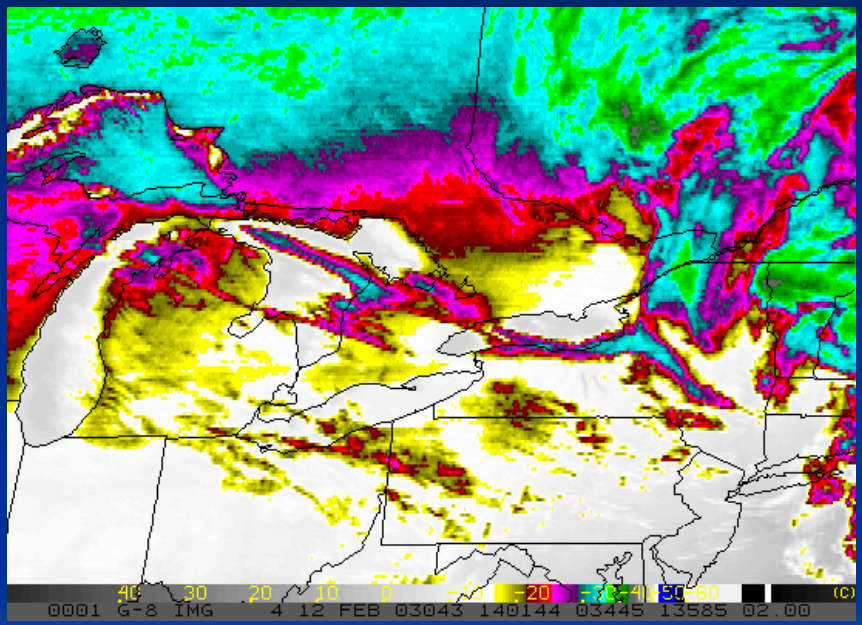
2005:
Emily (51)
Katrina (67)
Rita (67)
Stan (13)
Wilma (75)
Alpha (10)
Beta (9)

2006:
Ernesto (29)

2005-EP:
Hilary (13)

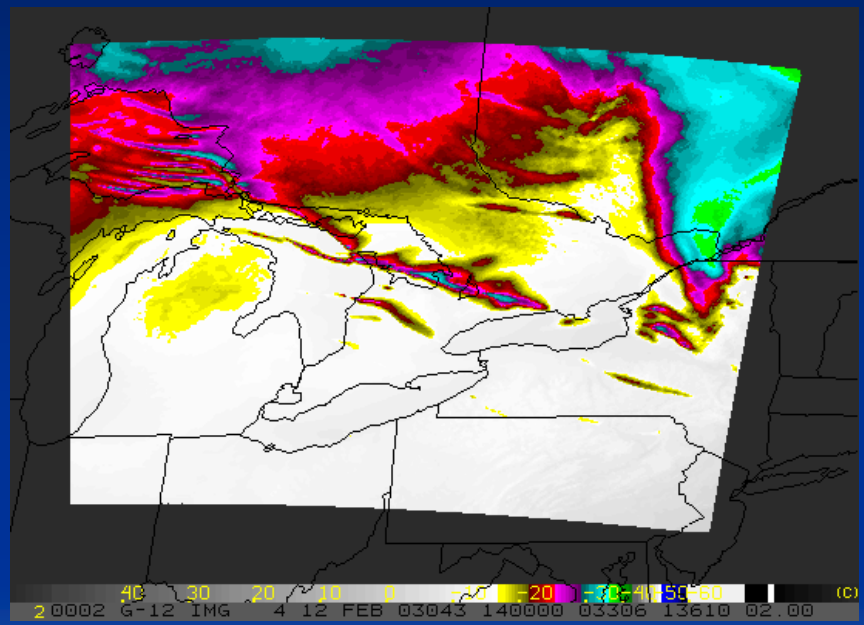


Lake Effect Snow Event on 12 February 2003



GOES-8 IR Image:

4 km 10.7 μm at 12 Feb 2003 1400 UTC



Synthetic GOES-R Imagery:

2 km at 10.35 μm at 12 Feb 2003 1400 UTC

Summary

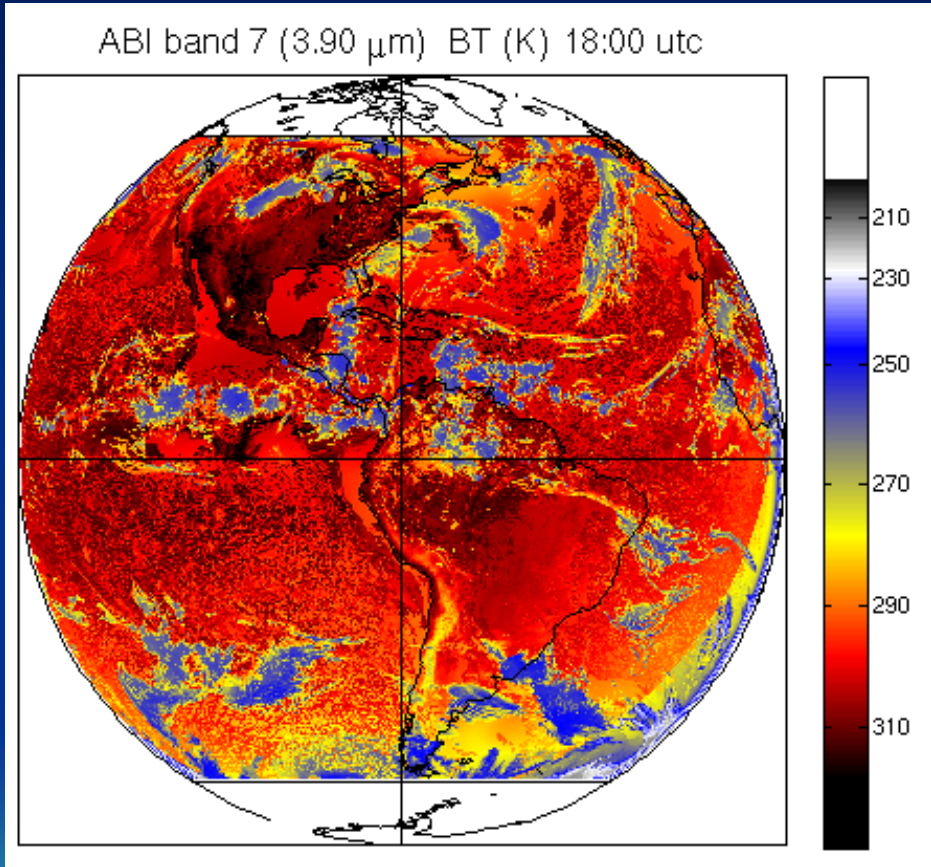
- GOES-R Algorithm Working Group (AWG) has invested a considerable resource in building GOES-R OSSE infrastrure
- Synthetic radiances have been generated from several mesoscale systems (WRF, RAMS, MM5).
- GOES-R data assimilation components including CRTM, surface emissivity data base have been started
- AWG teams and GOES-R PDRR and PDR contractors have been benefited from uses of simulated radiances and Tools.

GOES-R OSSE Issues

- Special Events: Fire hot spot simulations for example
- Surface Properties: emissivity and BRDF models related to surface physical models (NOAH for example)
- Advanced Simulations of Clouds: better information on aerosol and cloud particles
- Instrument Characterization: Spatial (e.g. PSF) and Spectral (e.g. SRF)

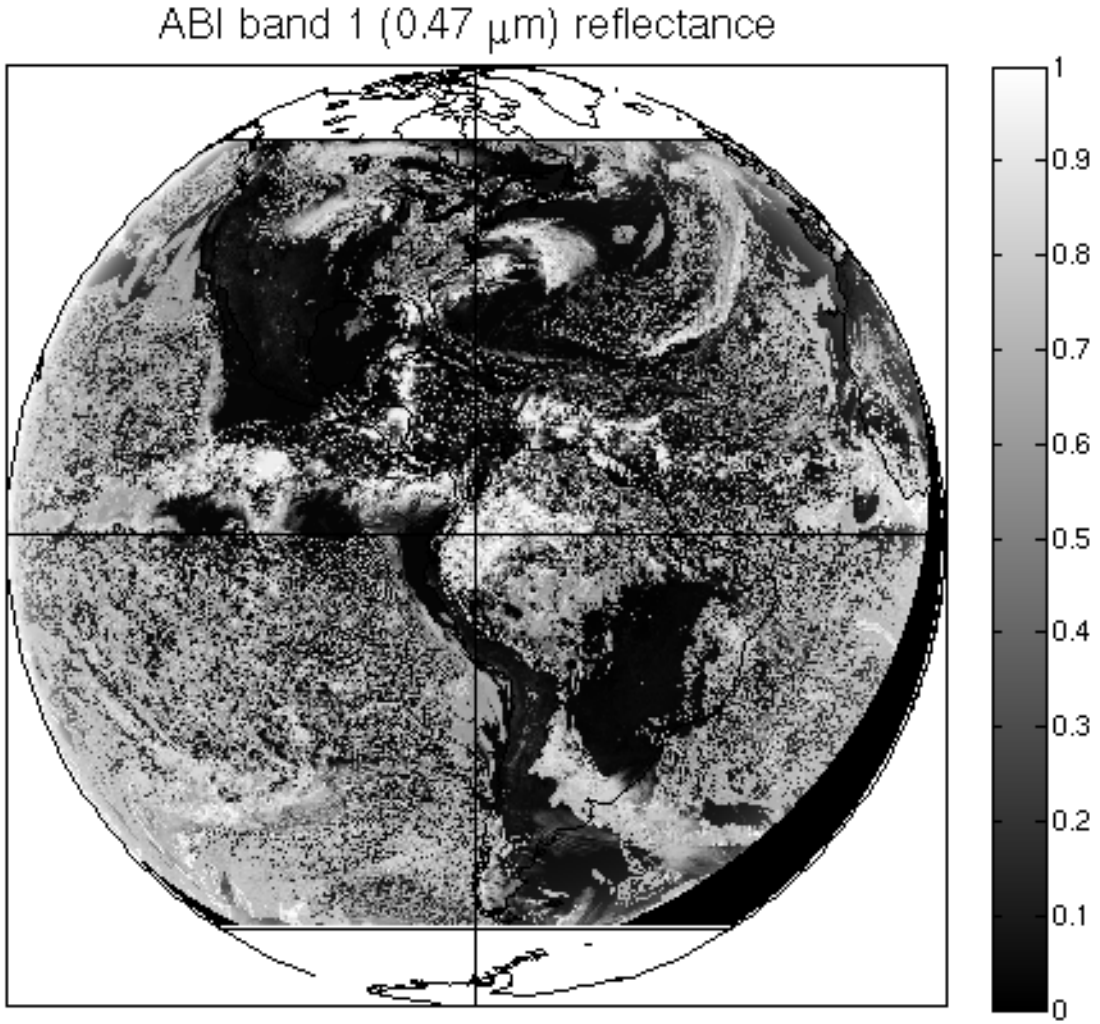
Backup Slides: GOES-R ABI Full Disks

ABI Fulldisk Dataset

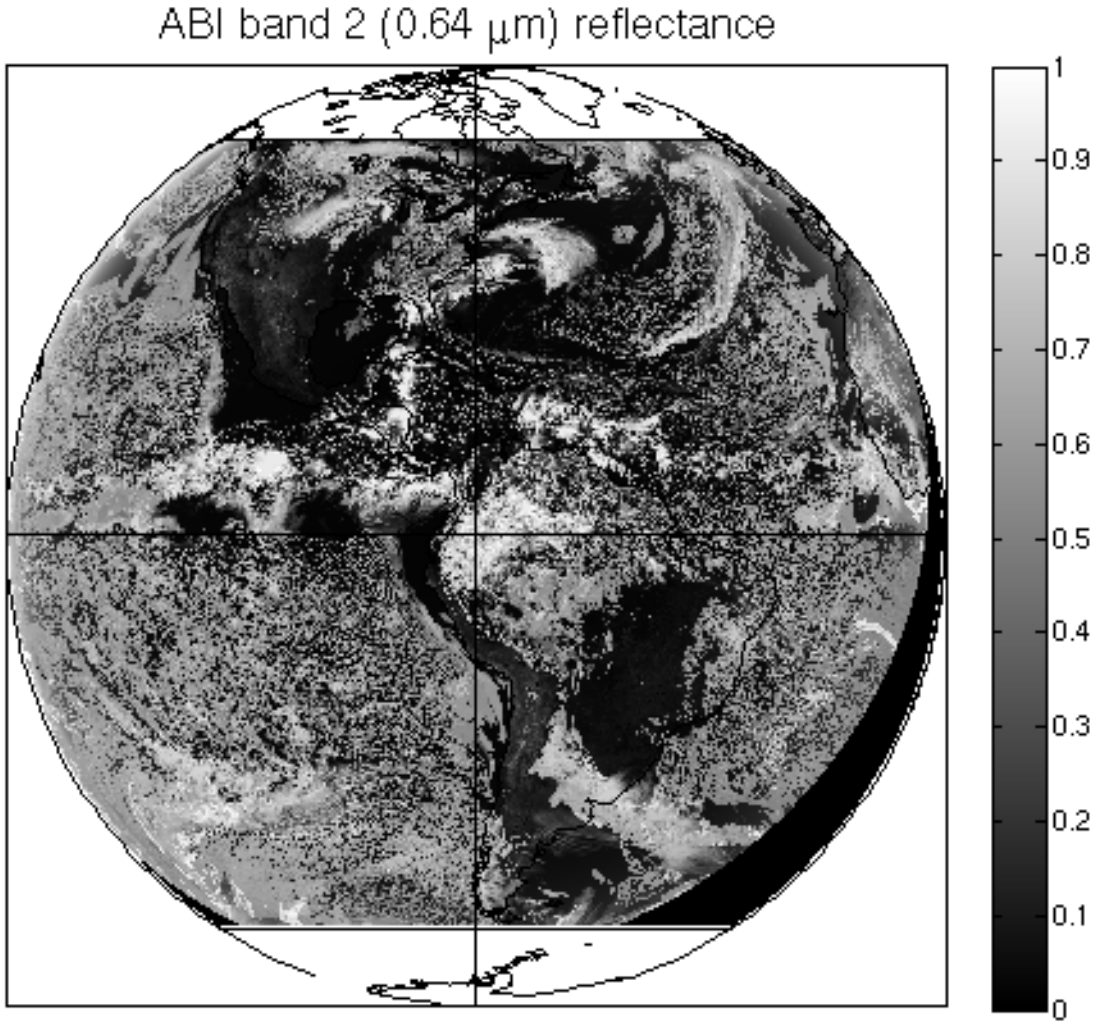


- **24 hour dataset**
- **6 Km spatial resolution**
- **3100 by 2600 grid points (16 MB/Band)**

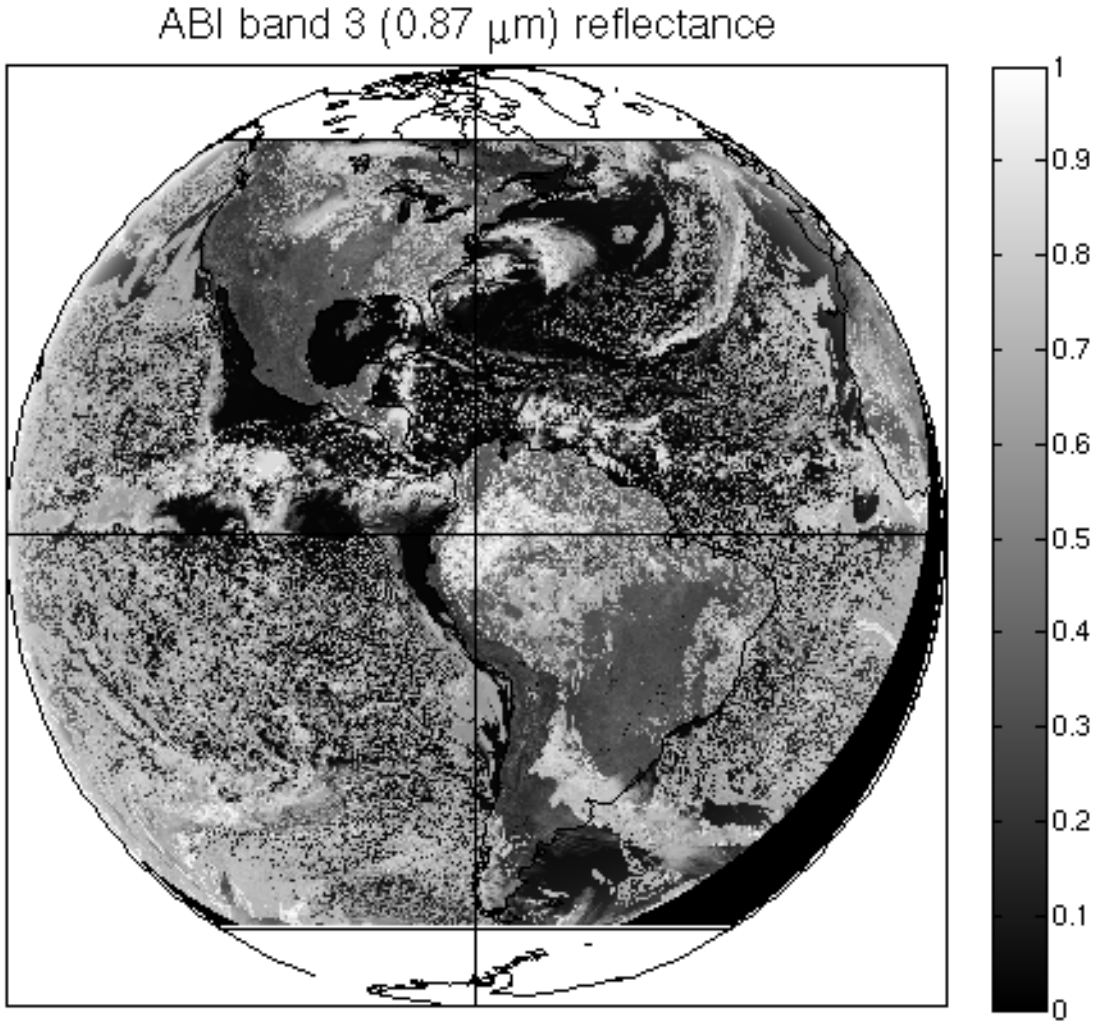
ABI Fulldisk Dataset



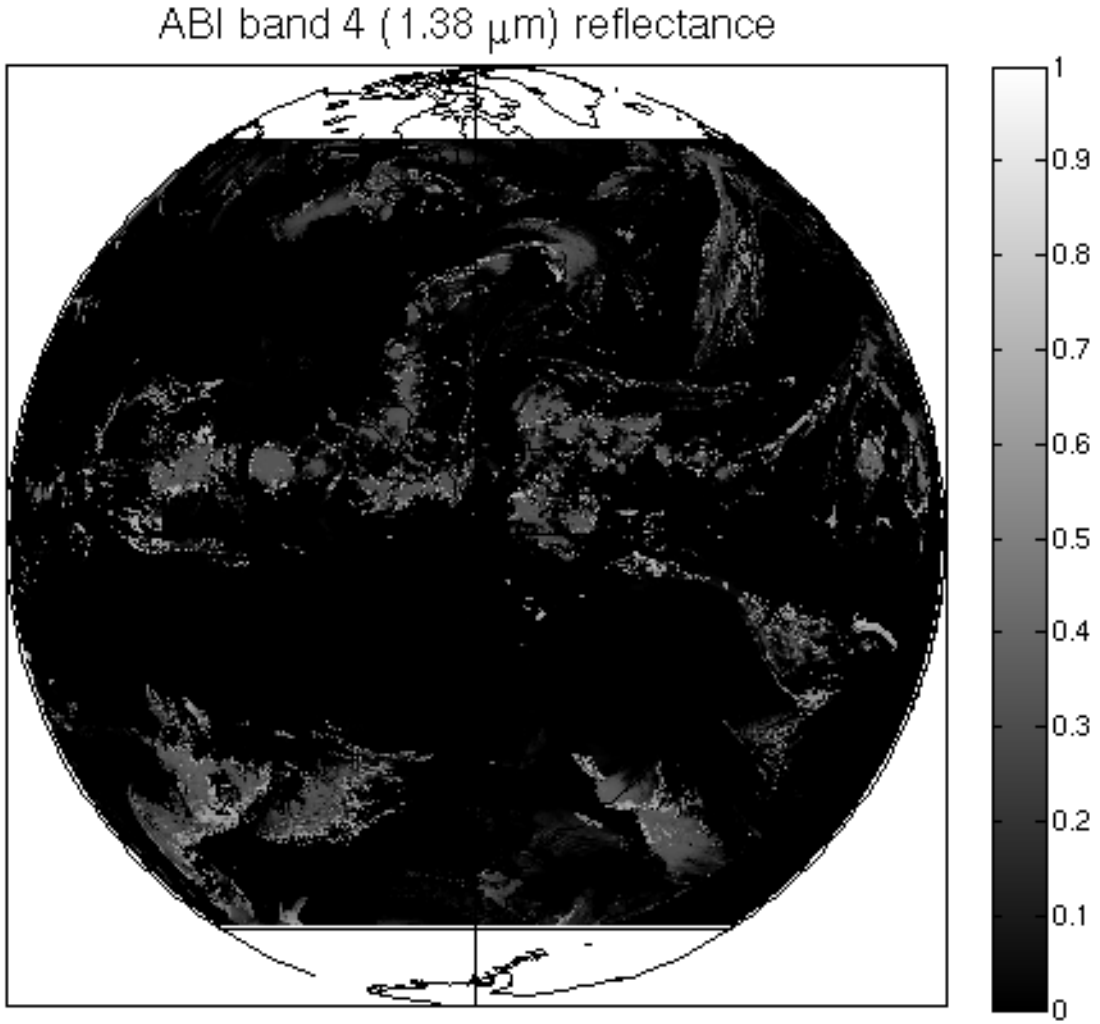
ABI Fulldisk Dataset



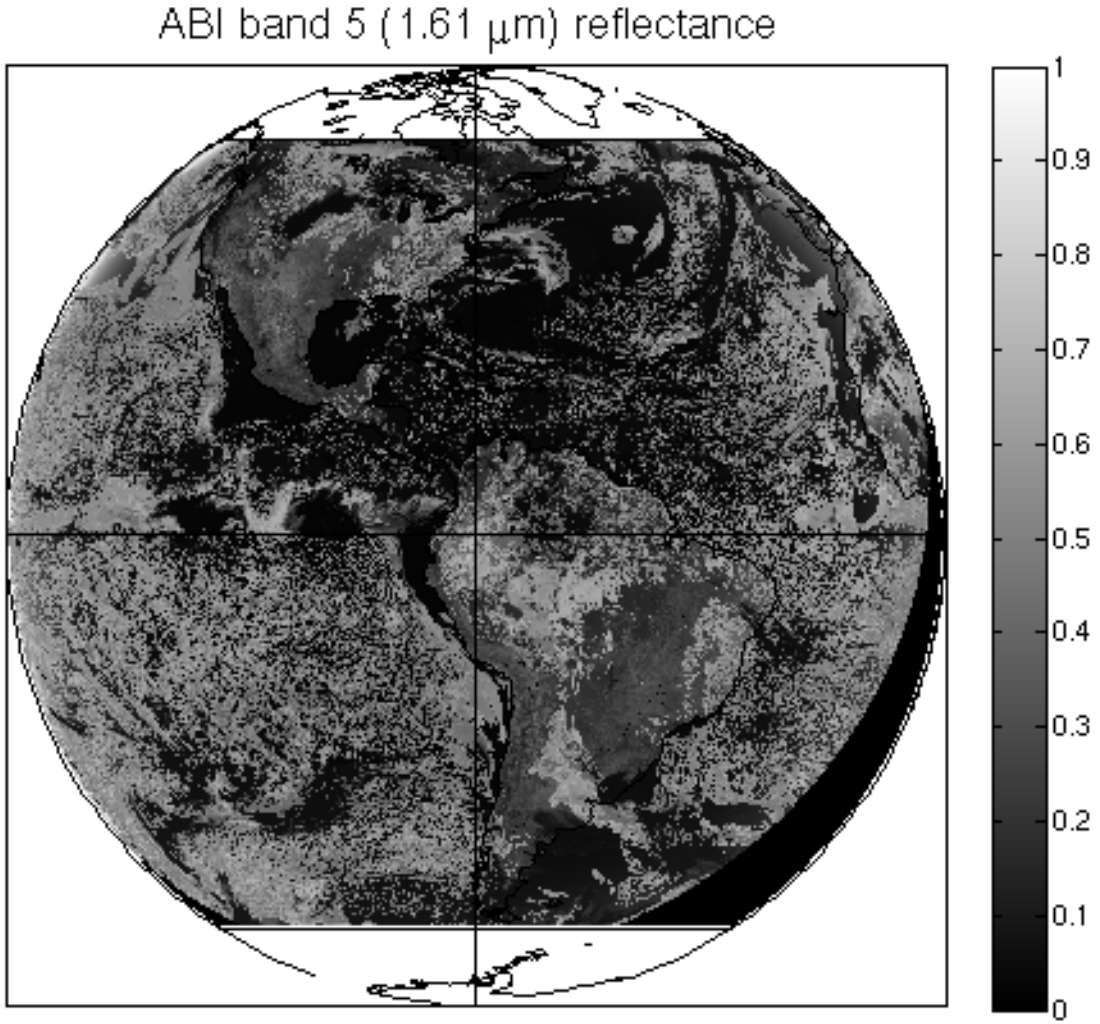
ABI Fulldisk Dataset



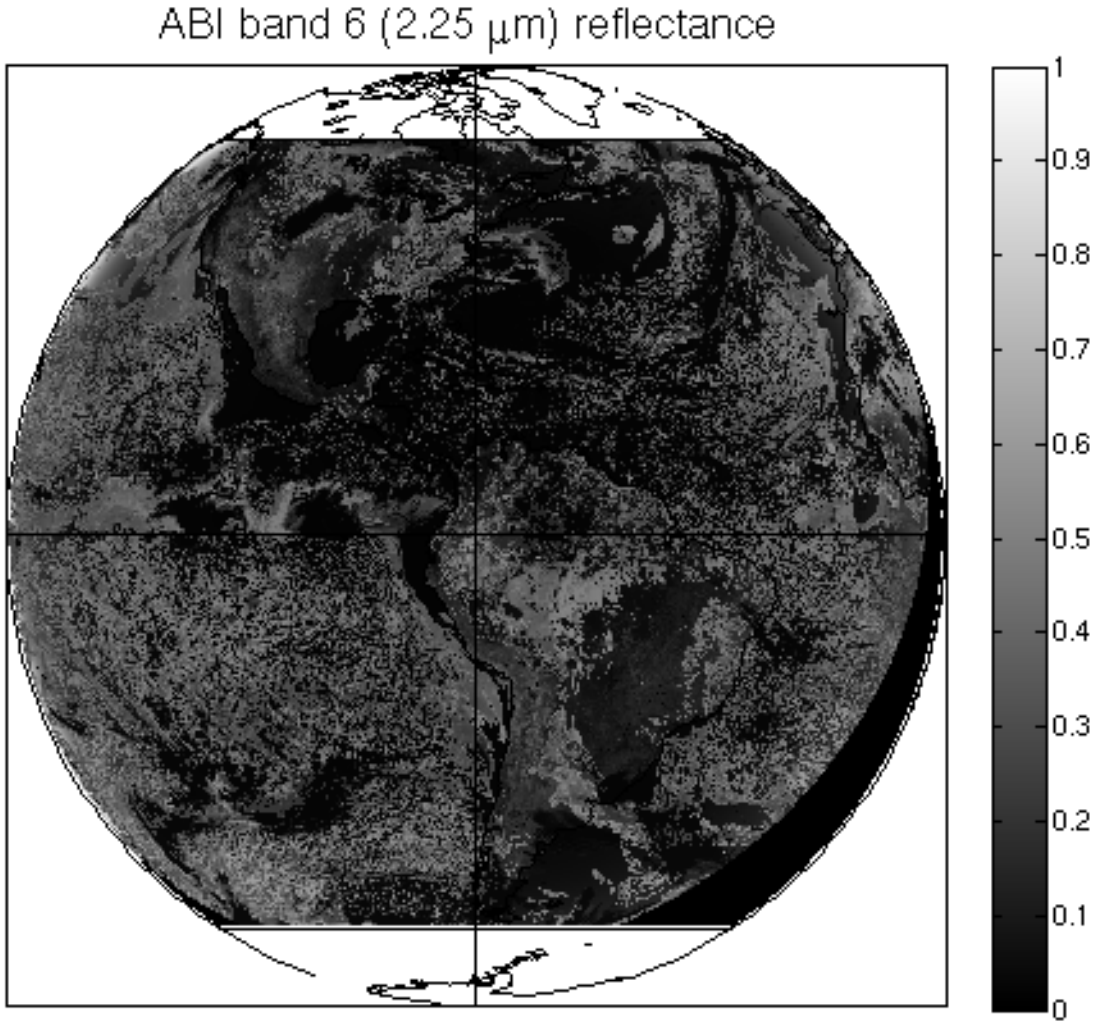
ABI Fulldisk Dataset



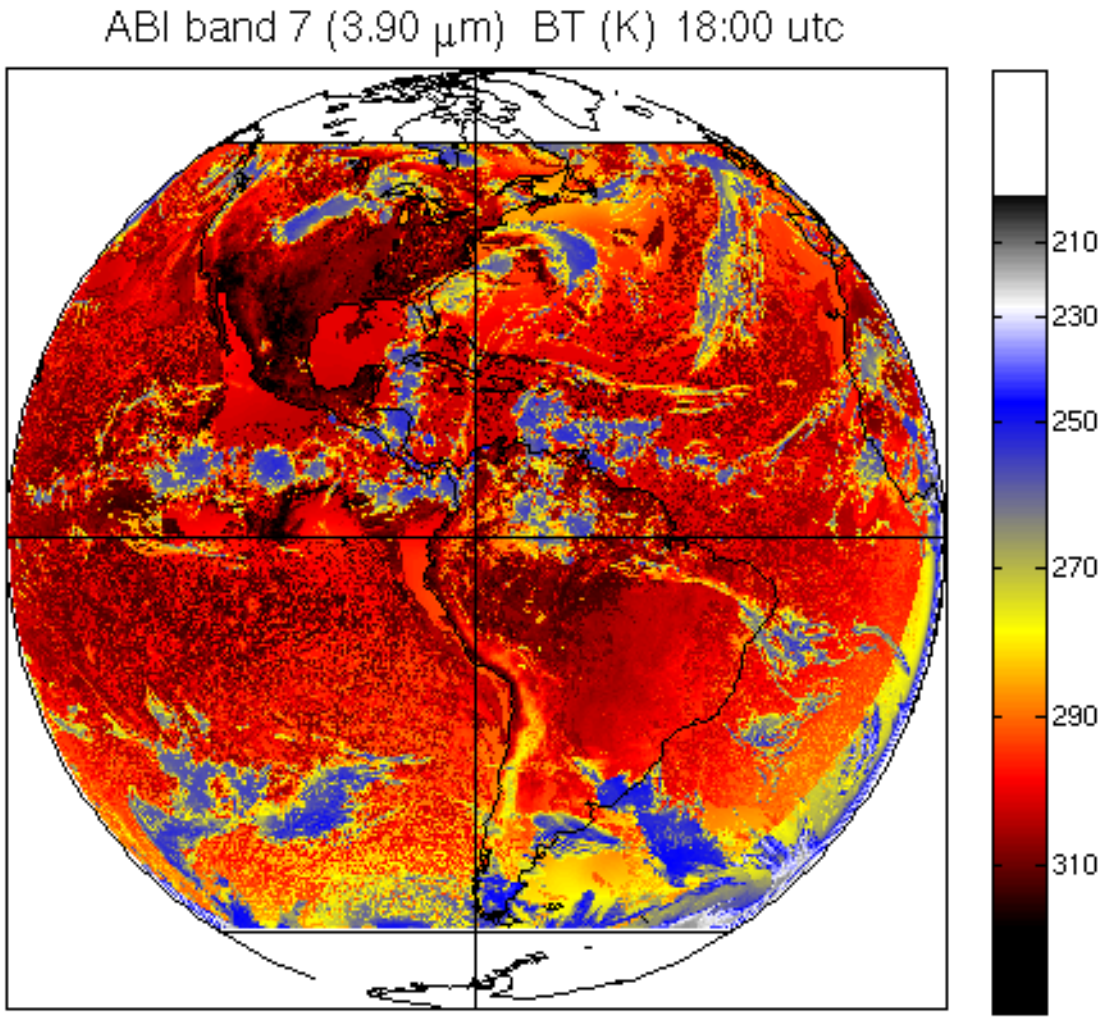
ABI Fulldisk Dataset



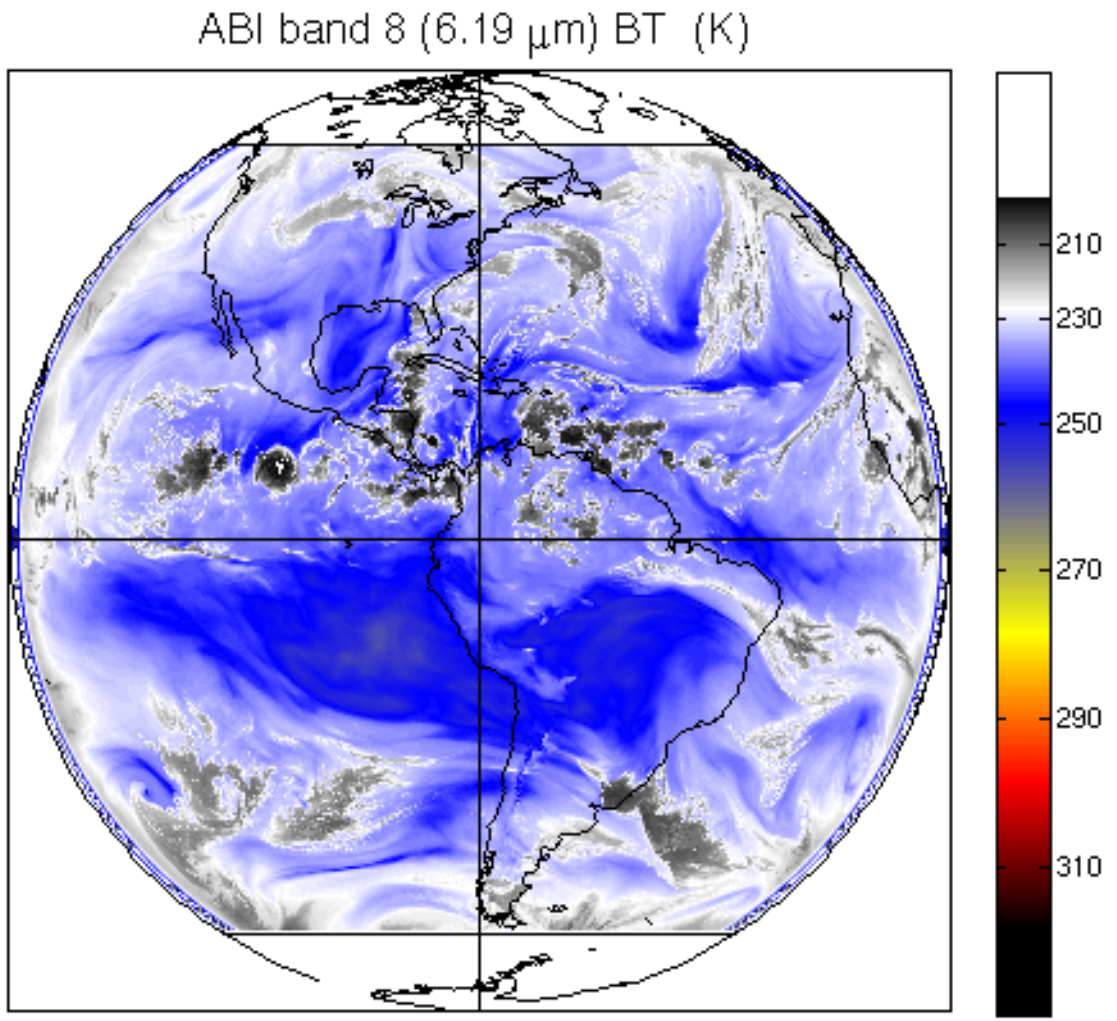
ABI Fulldisk Dataset



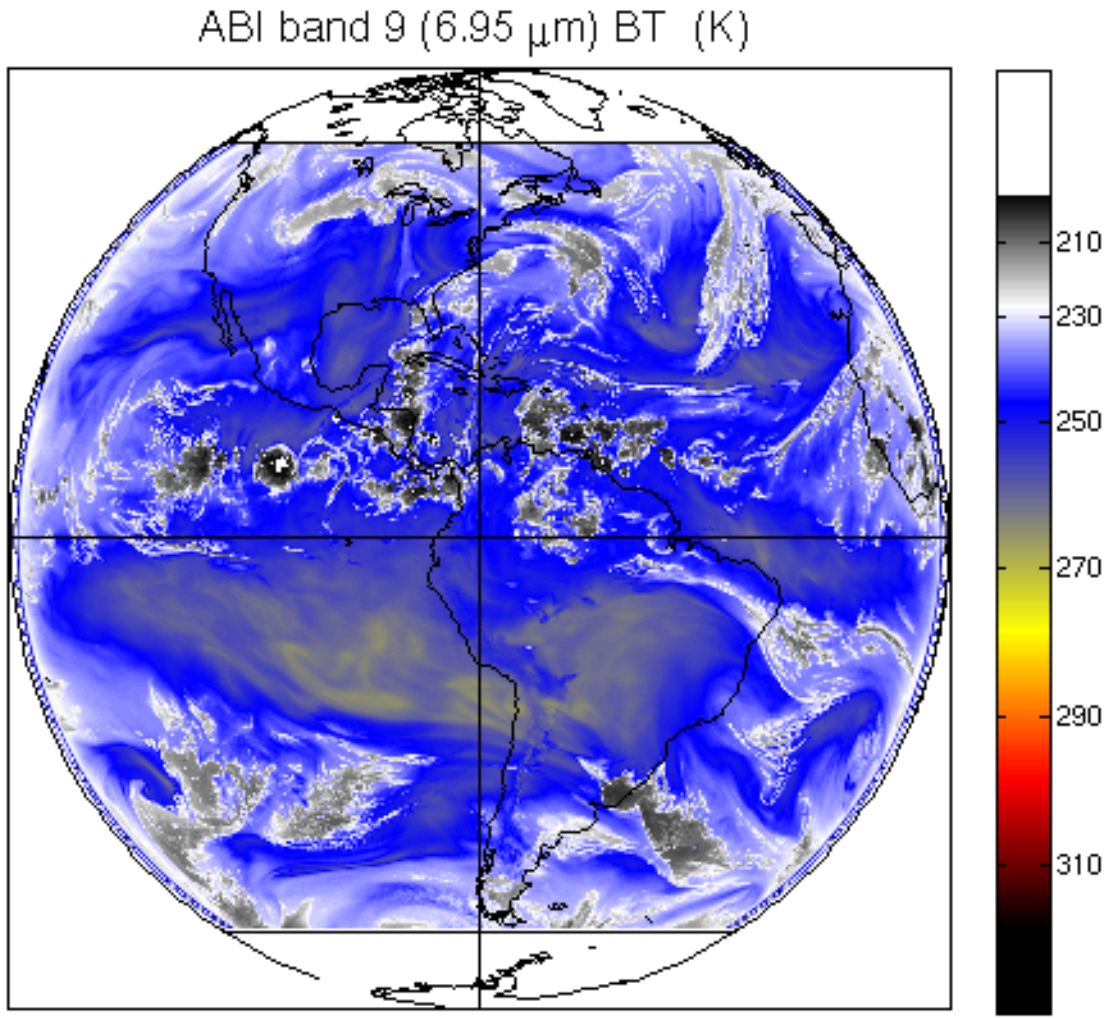
ABI Fulldisk Dataset



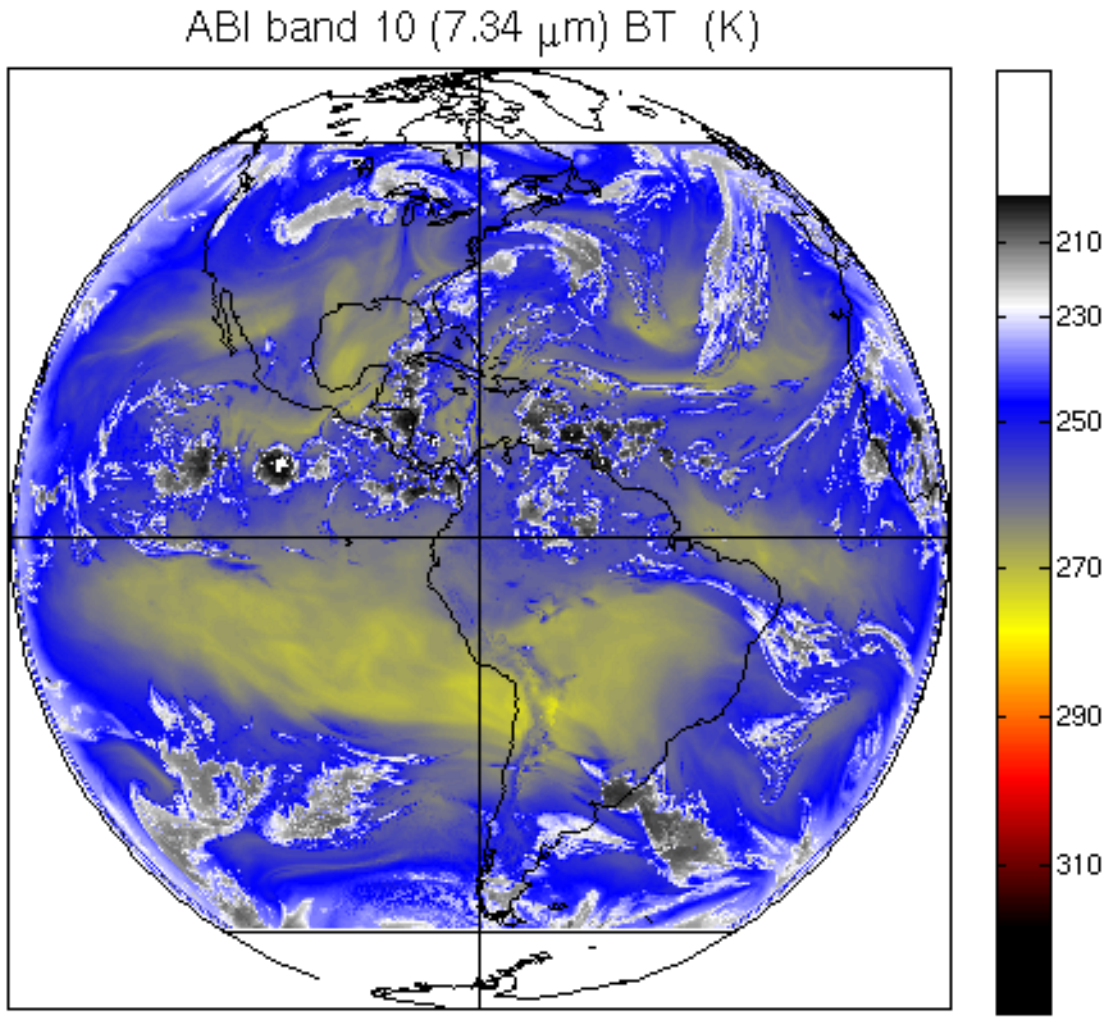
ABI Fulldisk Dataset



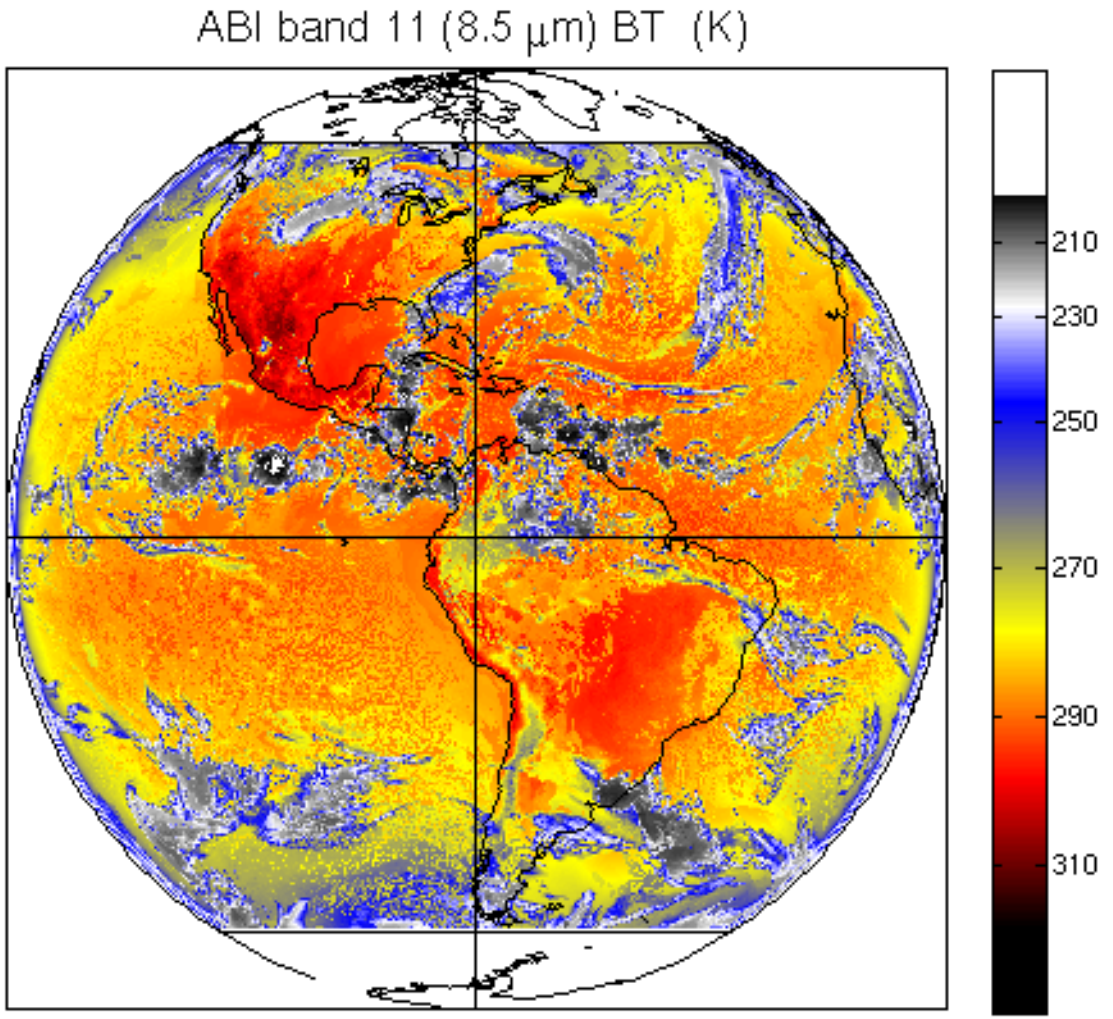
ABI Fulldisk Dataset



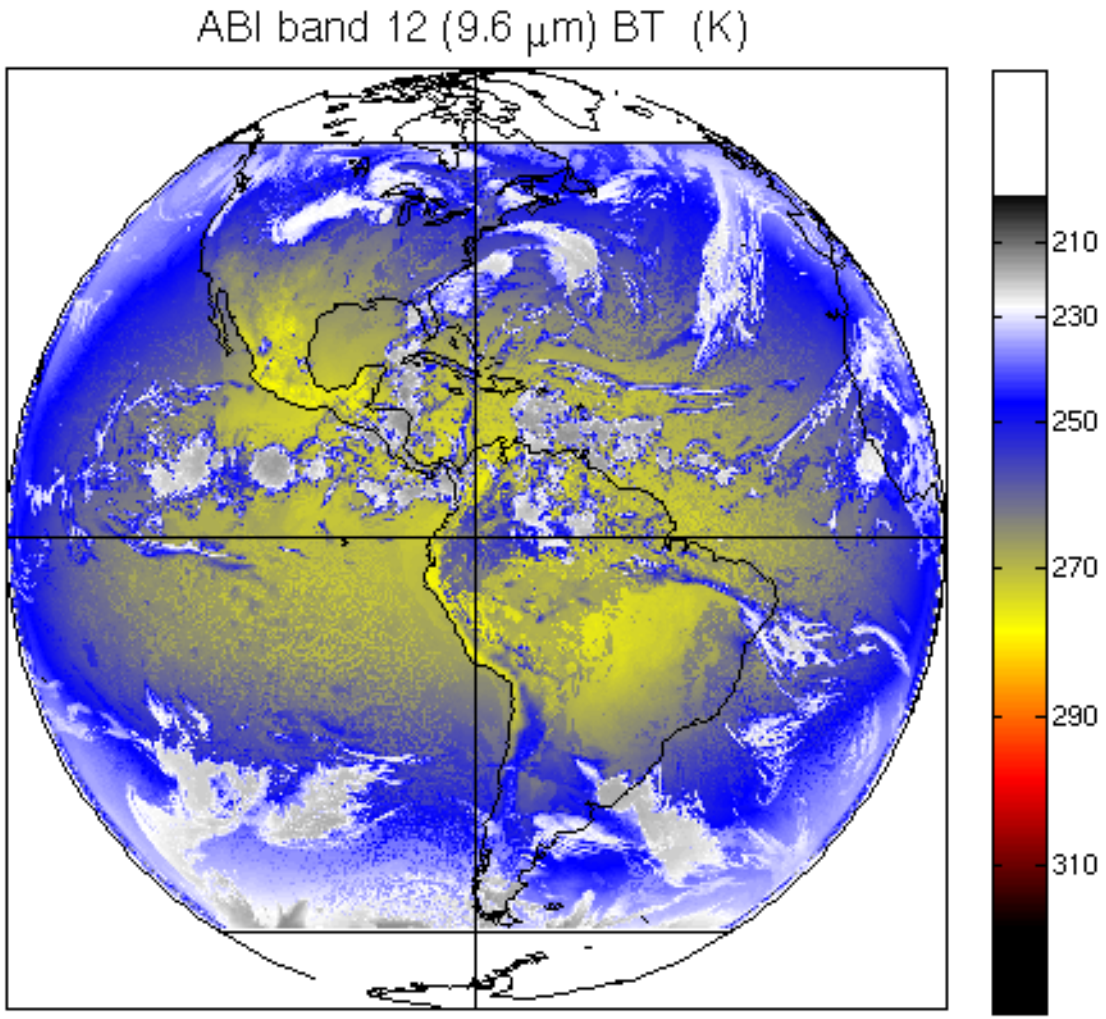
ABI Fulldisk Dataset



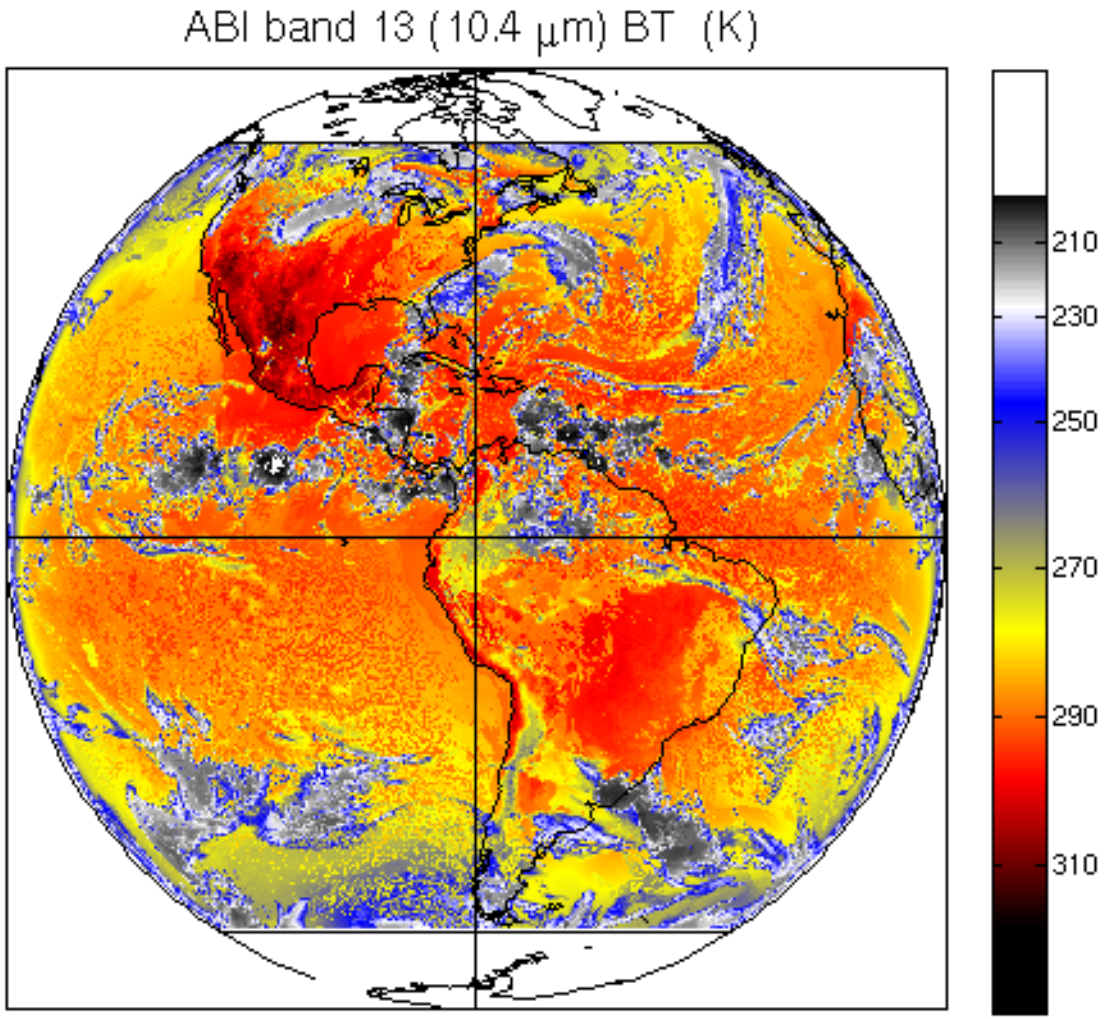
ABI Fulldisk Dataset



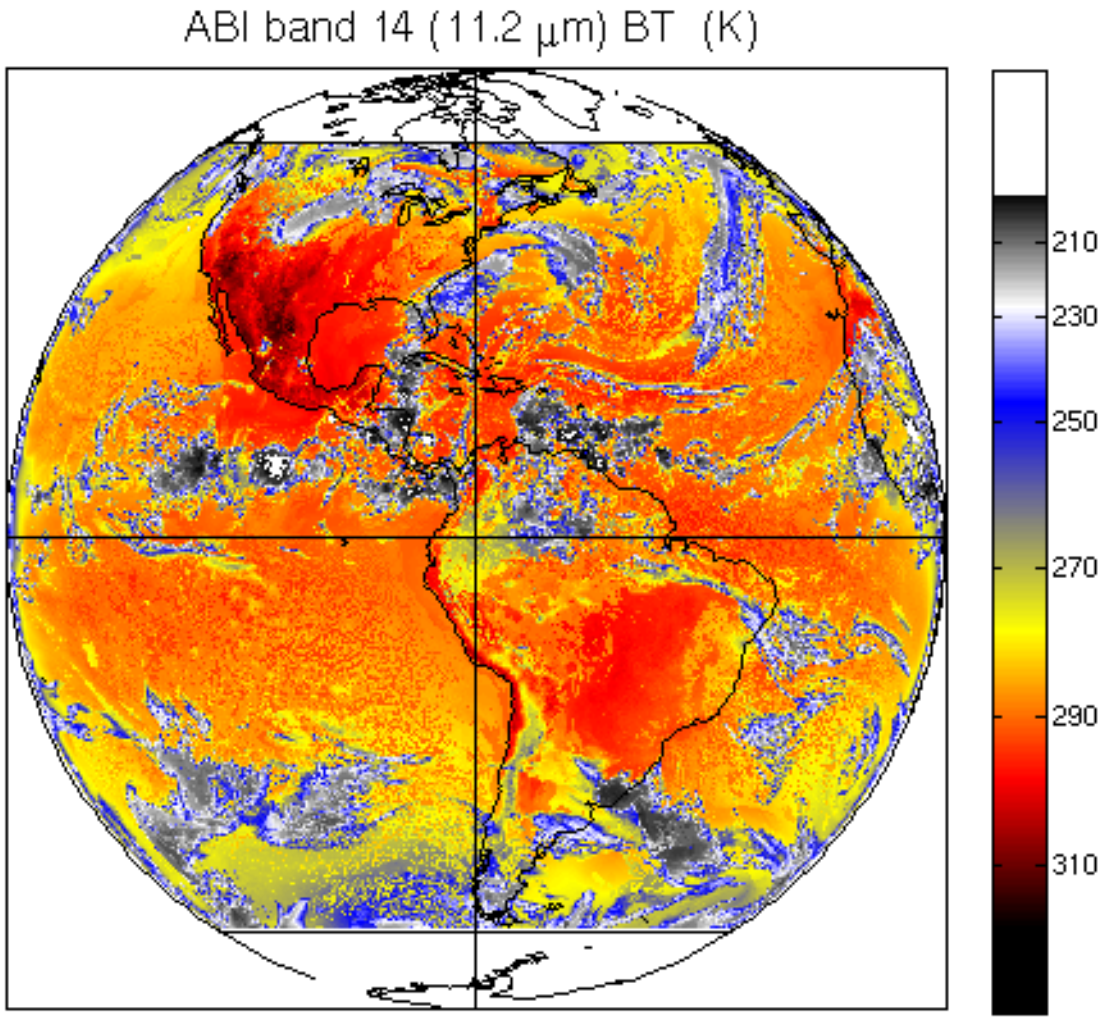
ABI Fulldisk Dataset



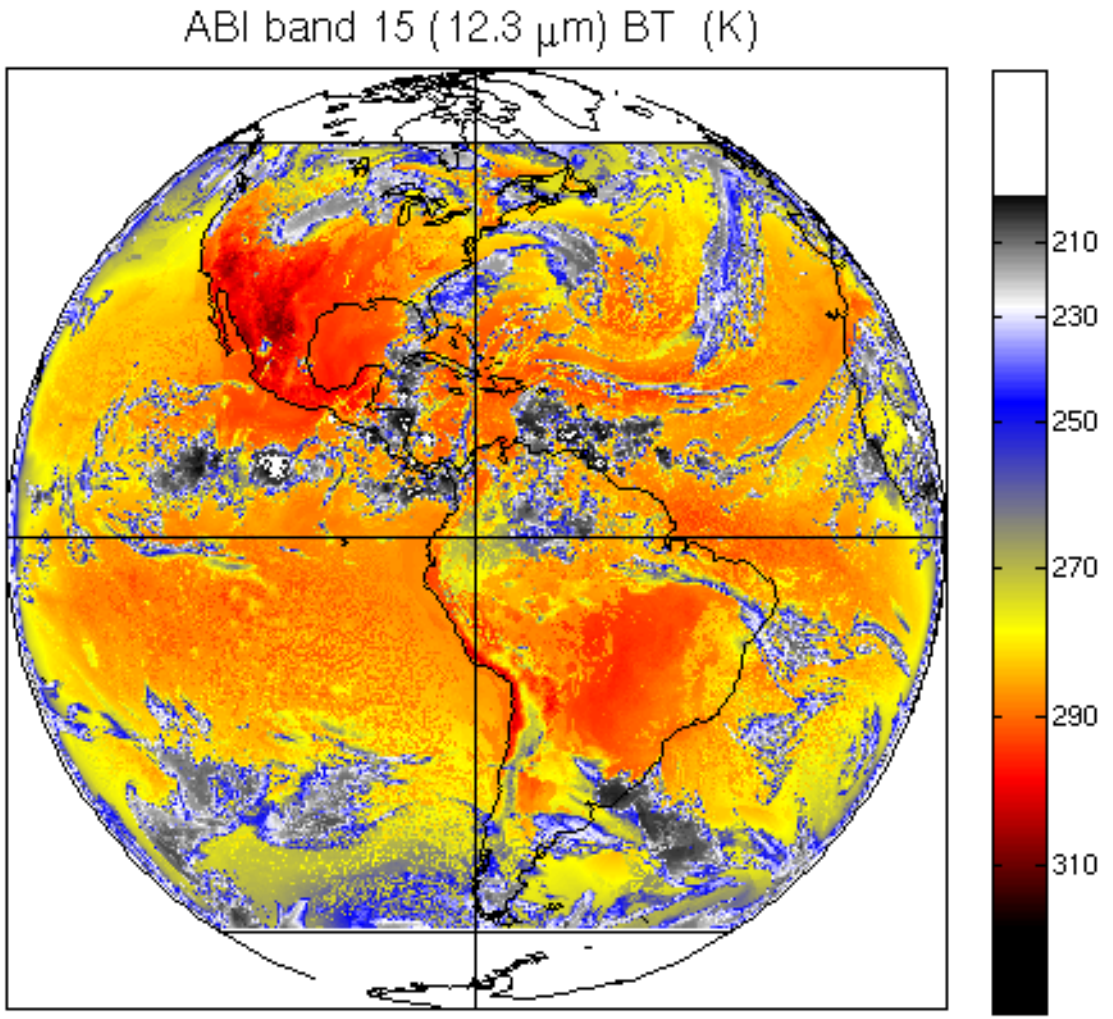
ABI Fulldisk Dataset



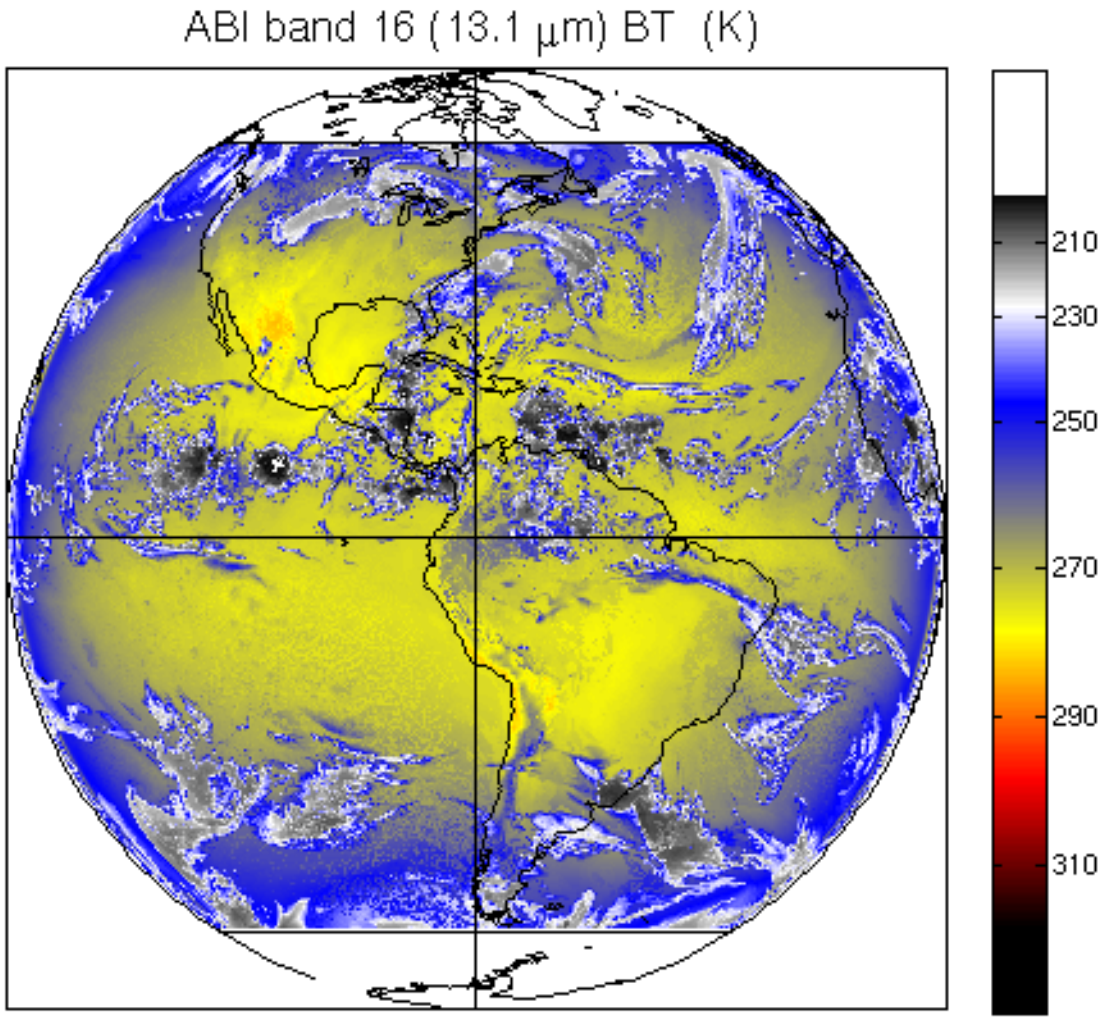
ABI Fulldisk Dataset



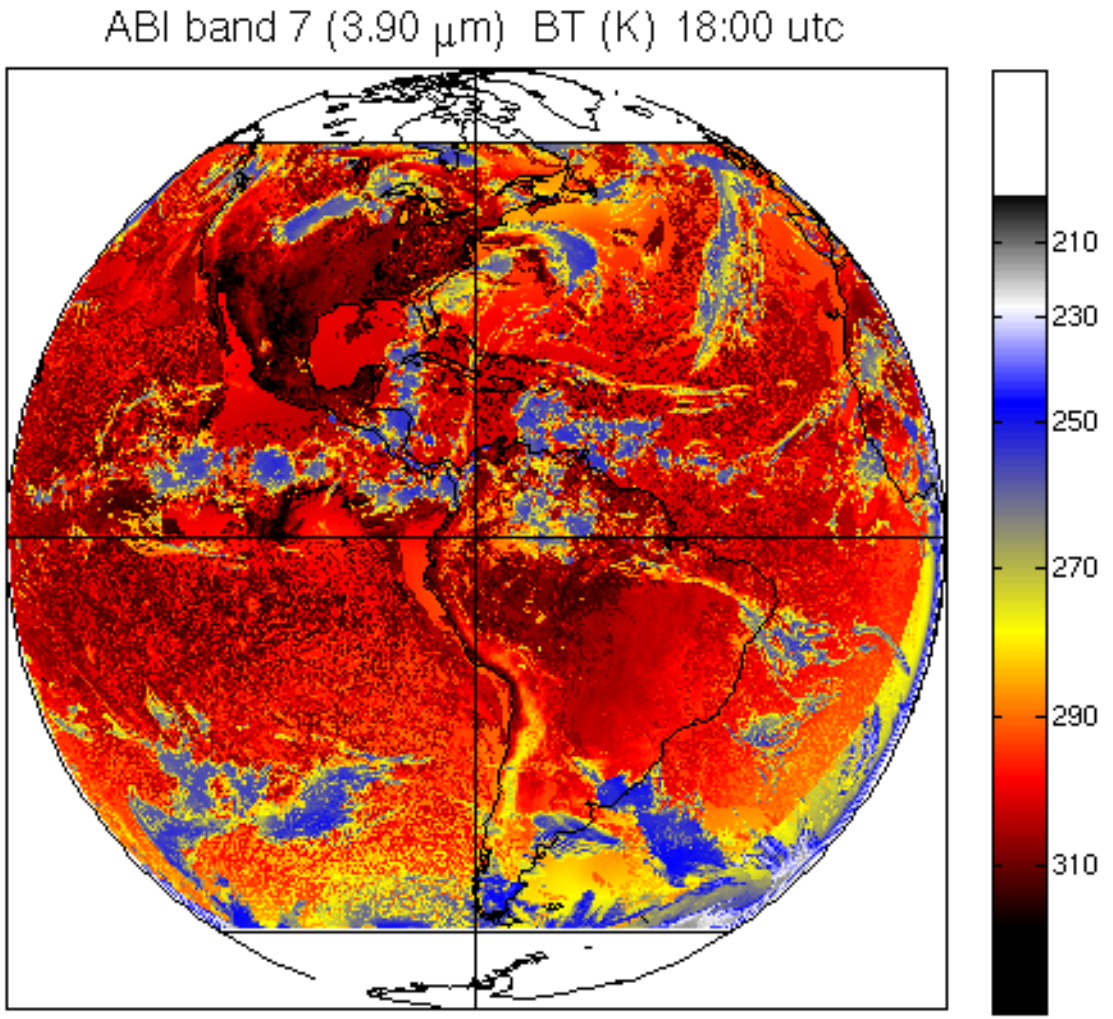
ABI Fulldisk Dataset



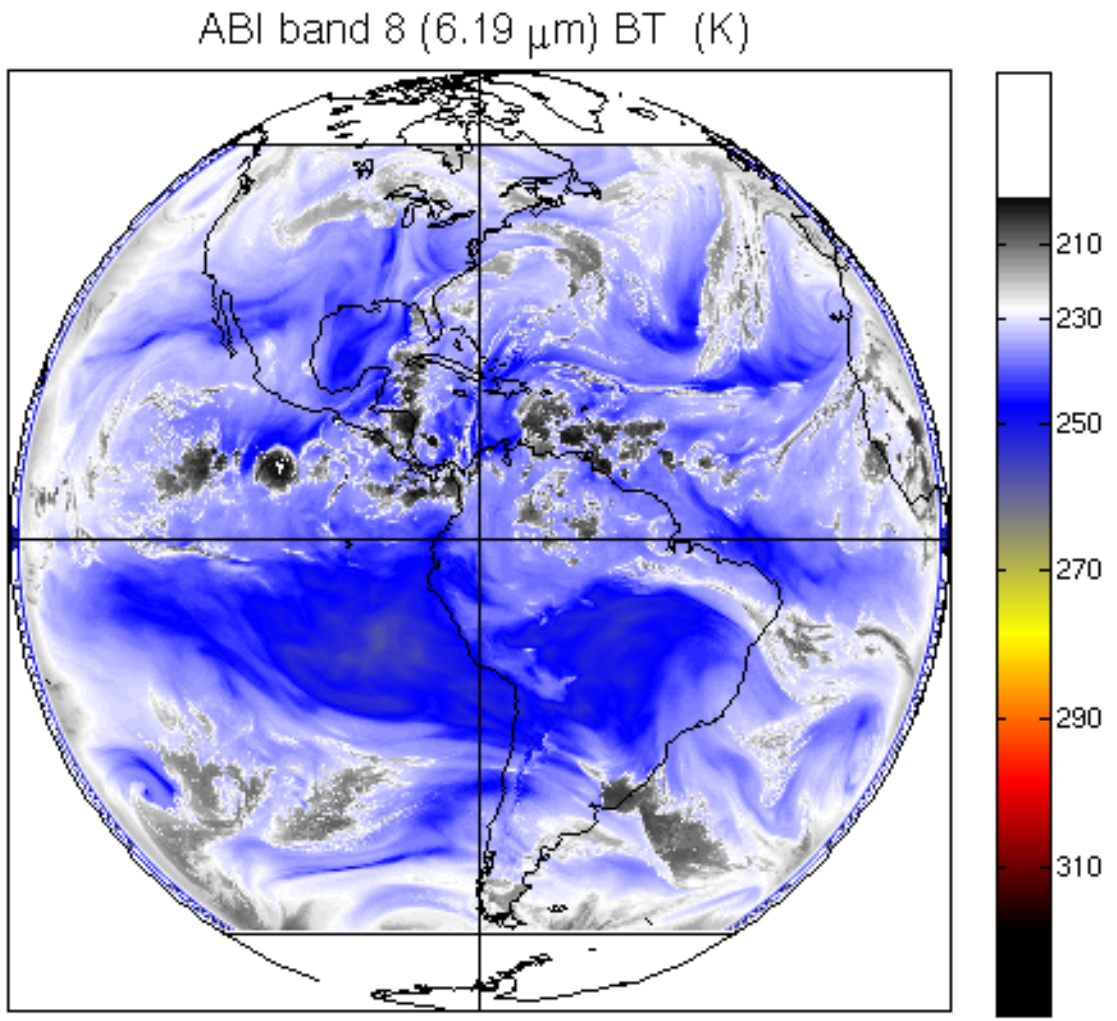
ABI Fulldisk Dataset



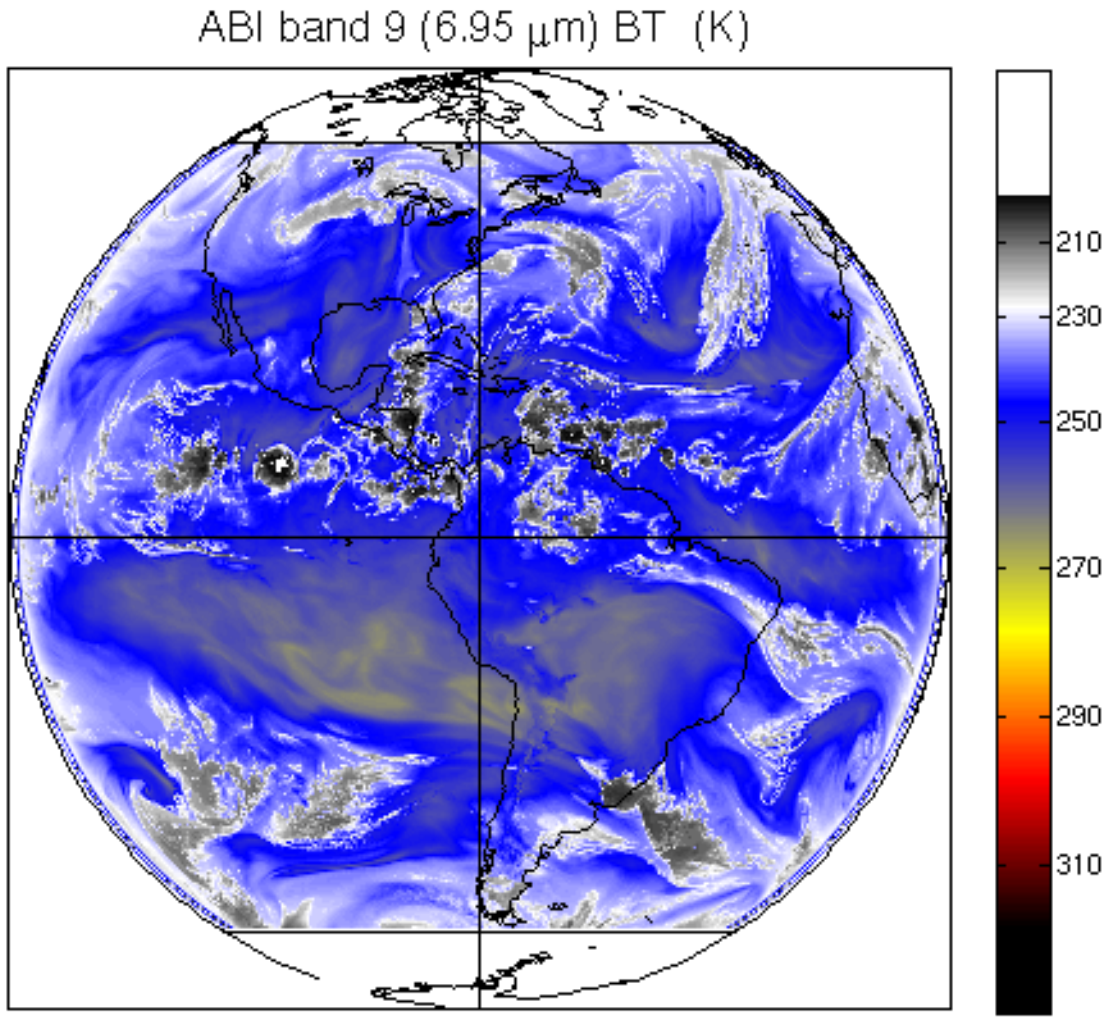
ABI Fulldisk Dataset



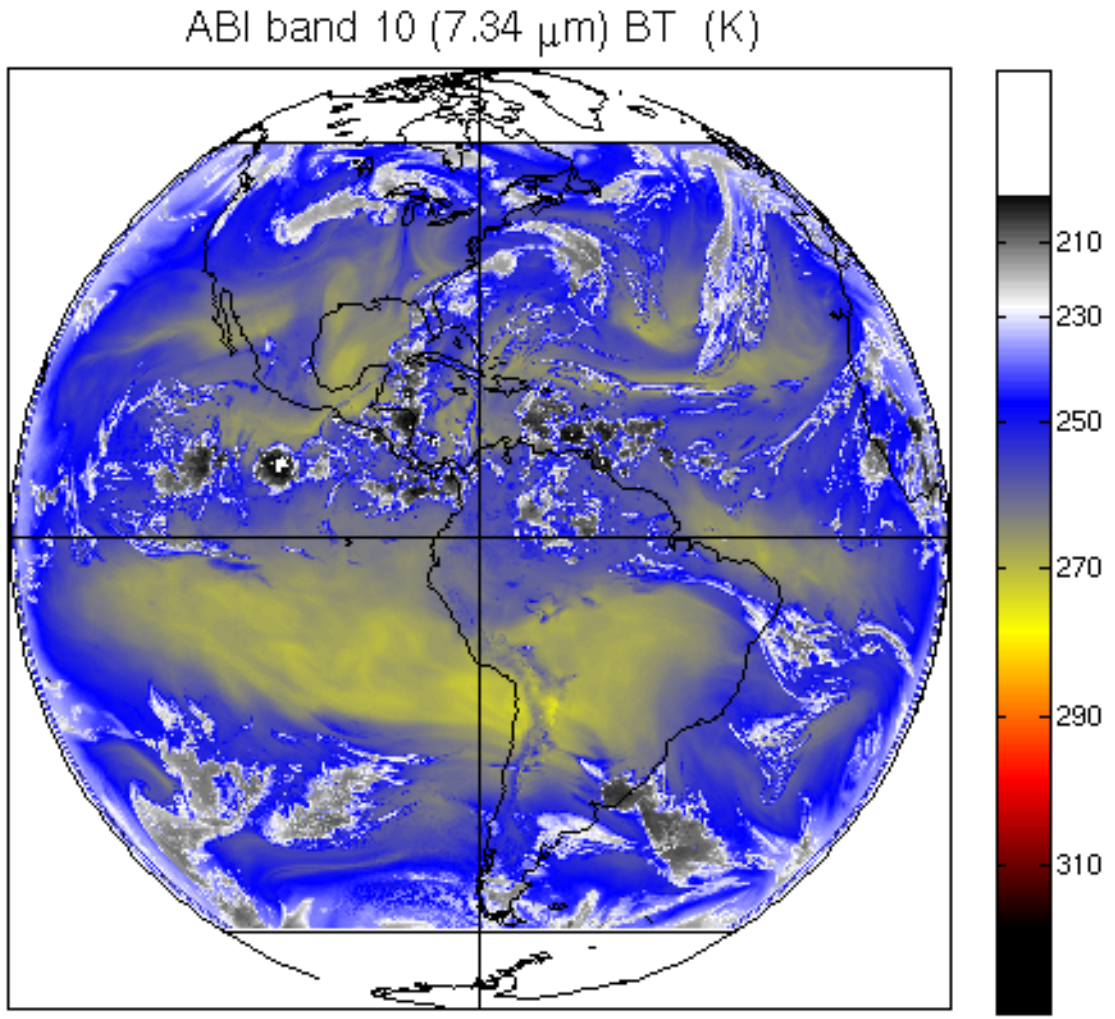
ABI Fulldisk Dataset



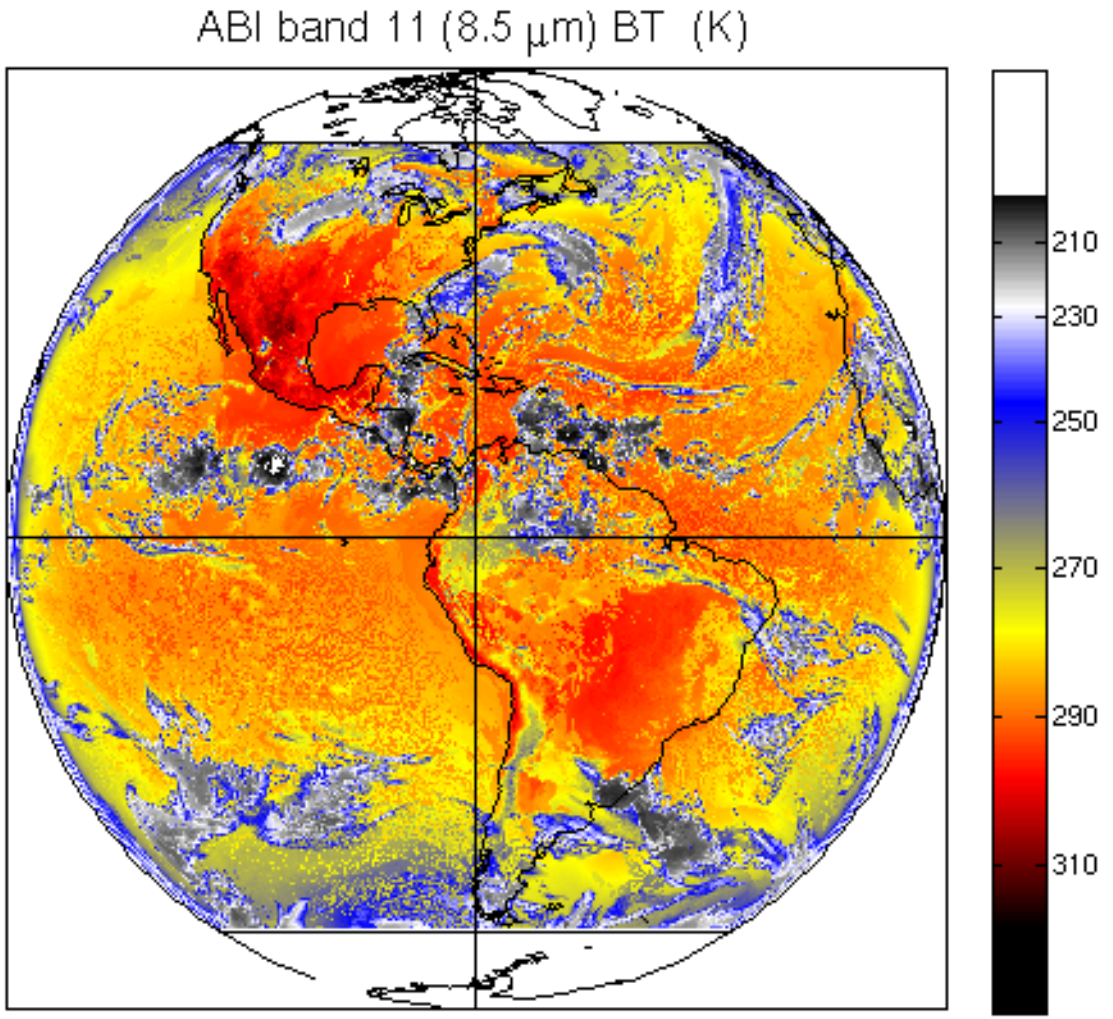
ABI Fulldisk Dataset



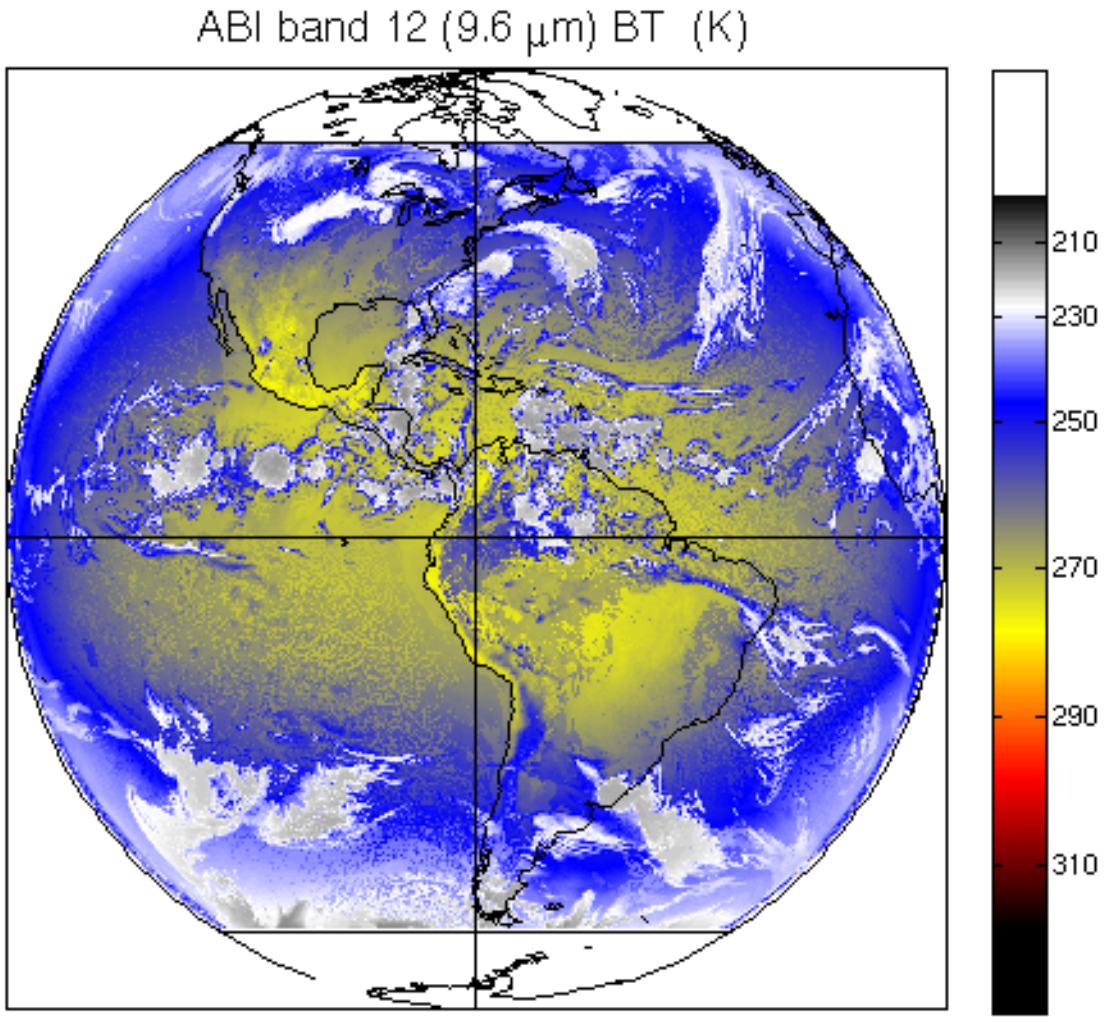
ABI Fulldisk Dataset



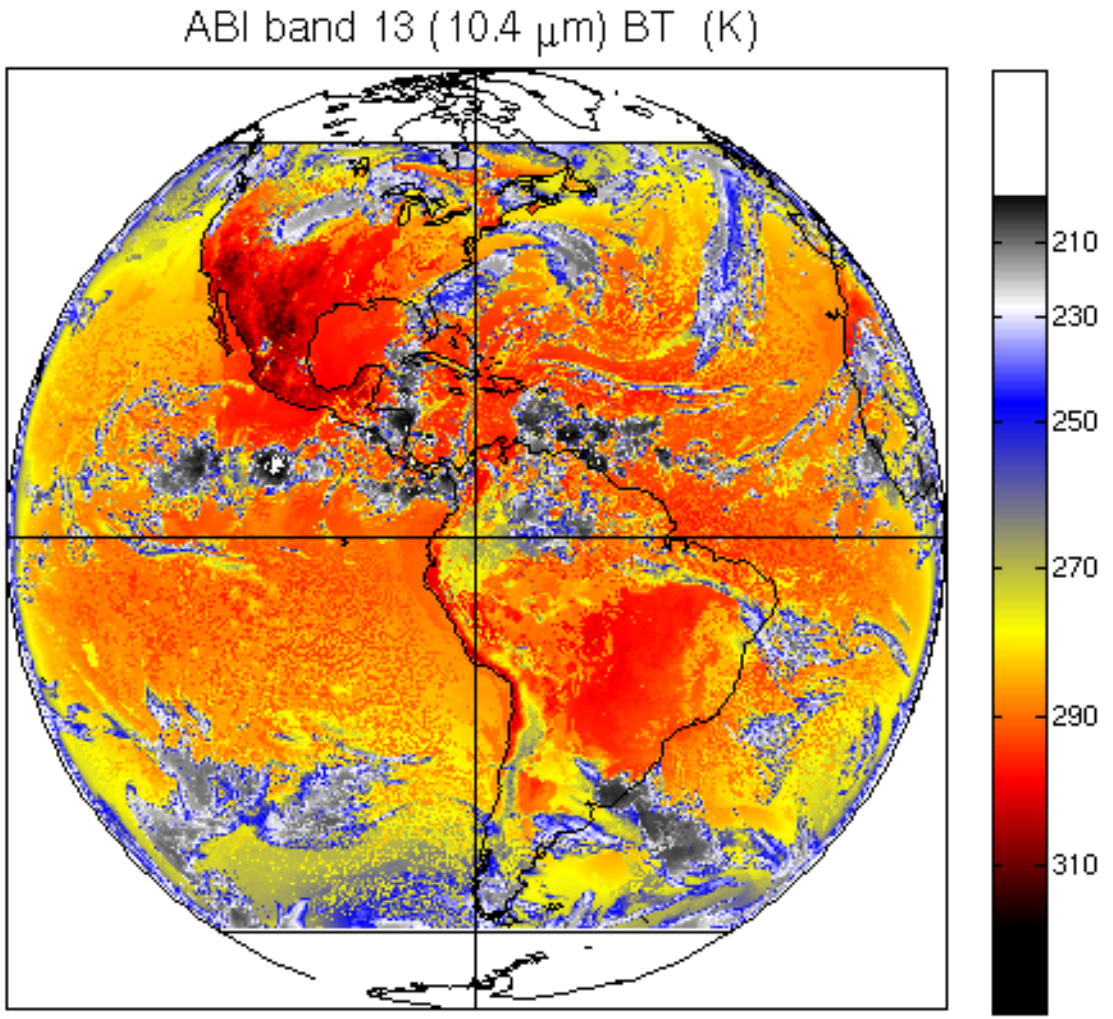
ABI Fulldisk Dataset



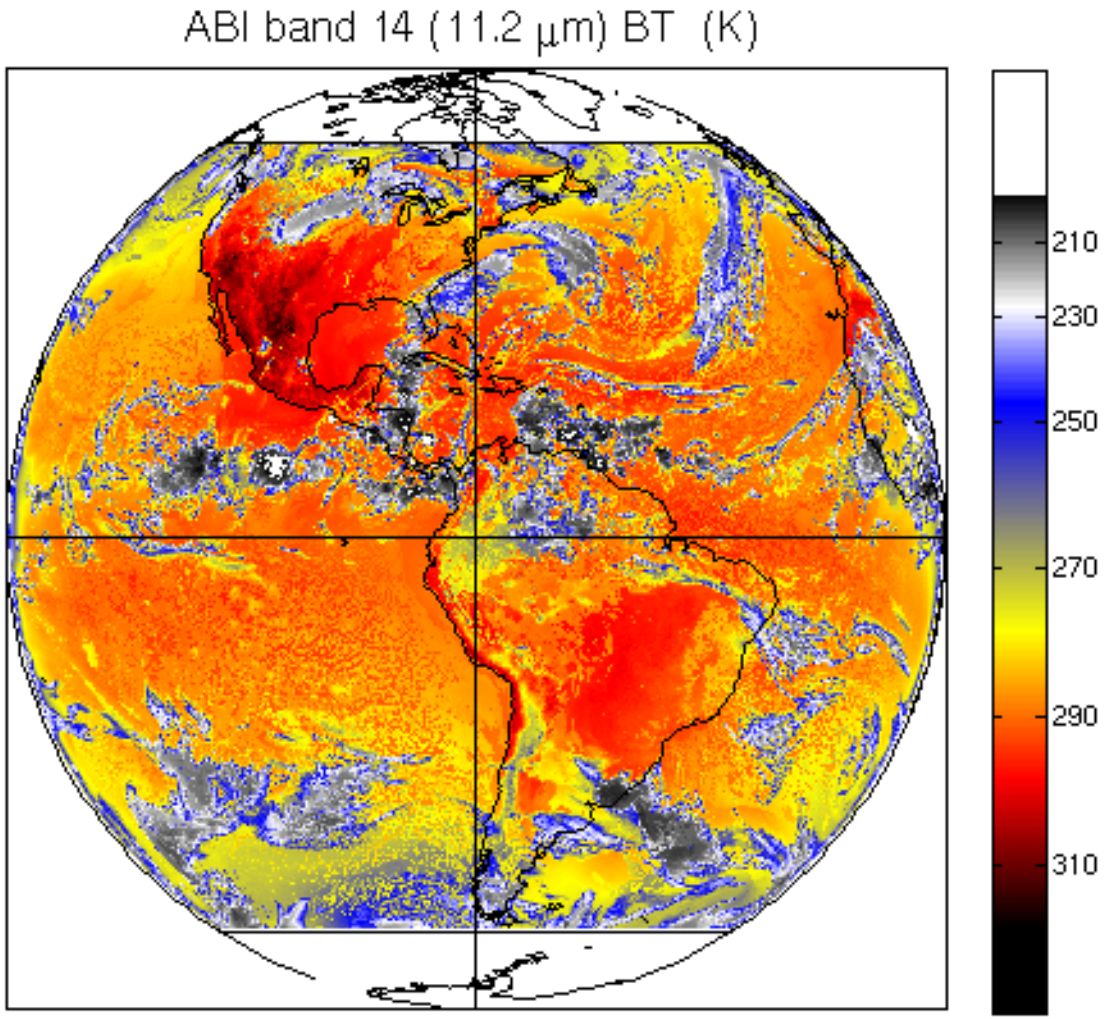
ABI Fulldisk Dataset



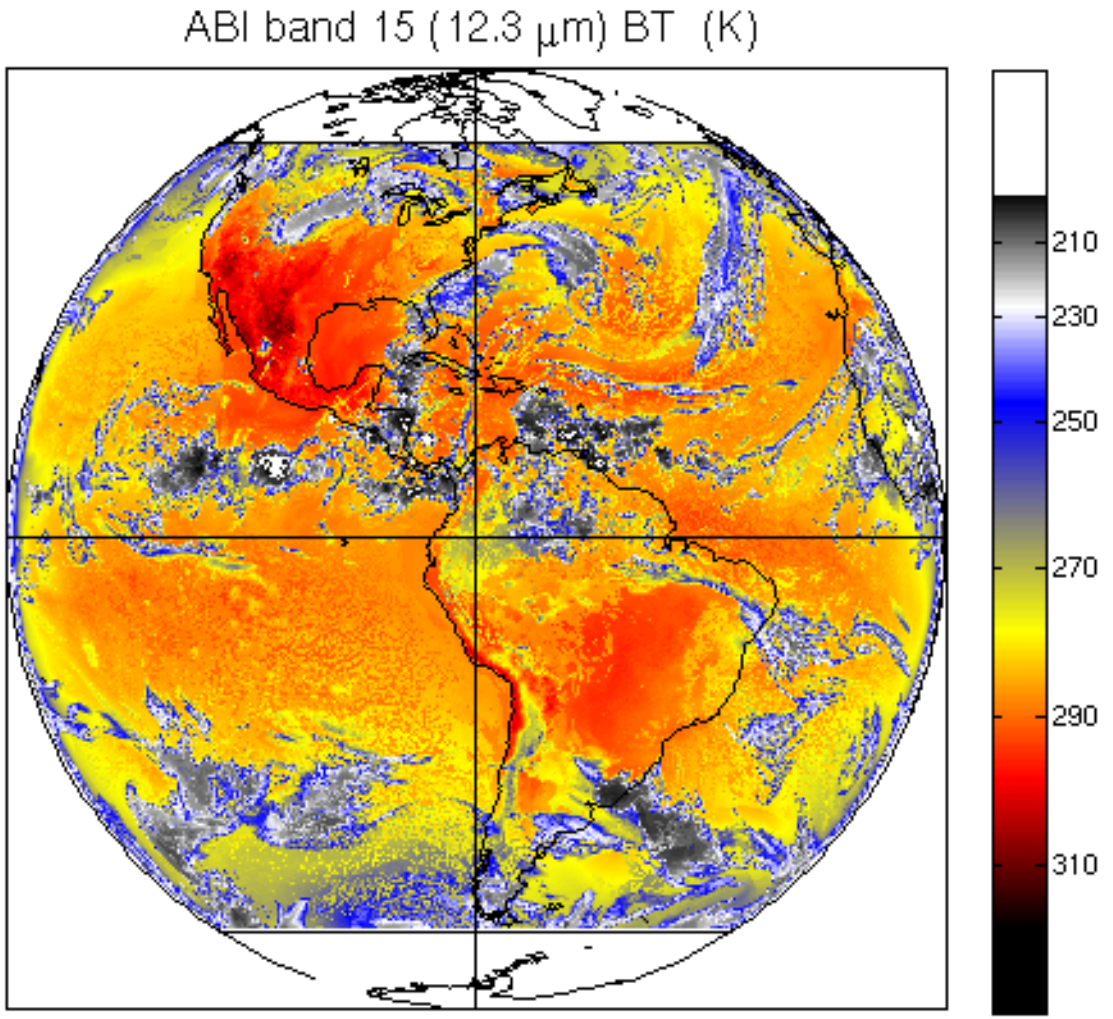
ABI Fulldisk Dataset



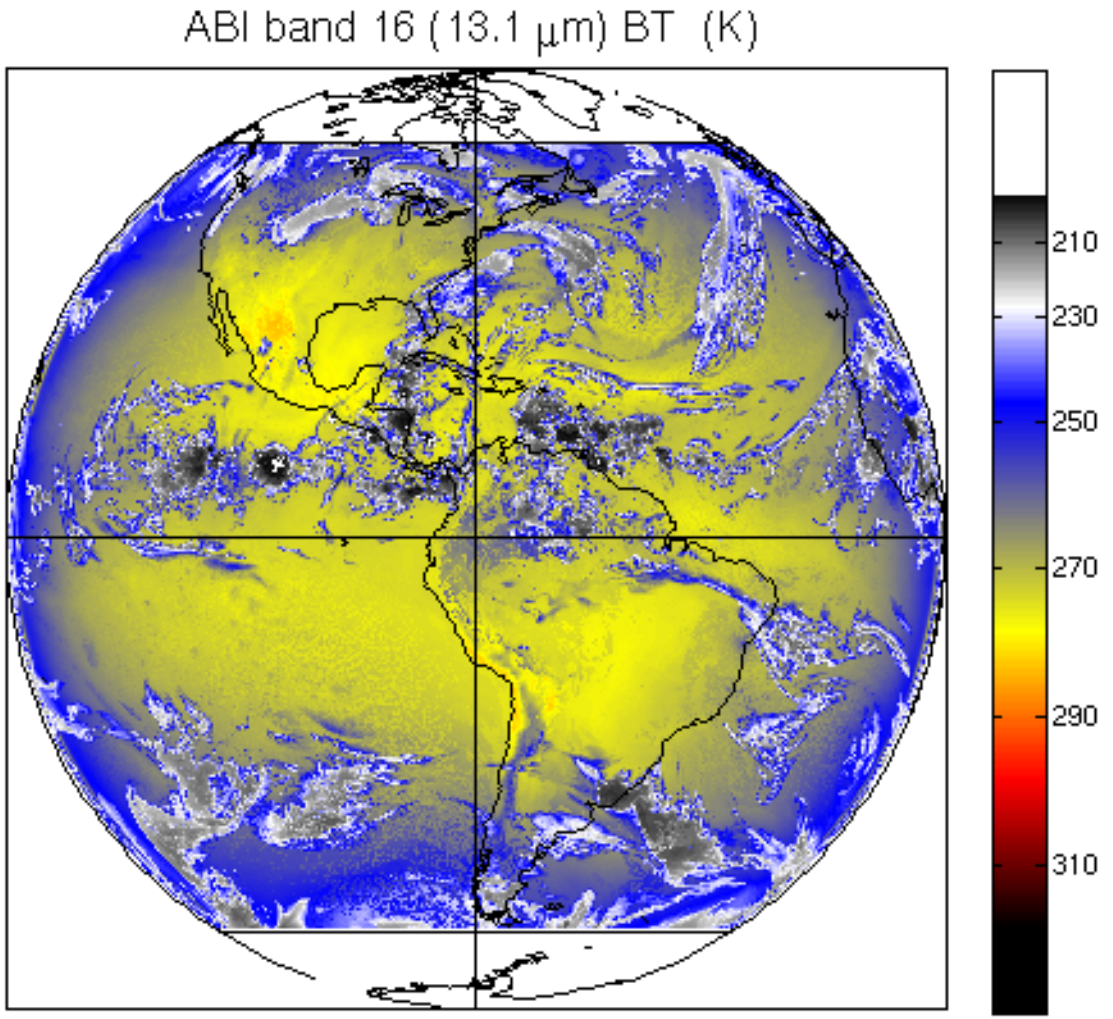
ABI Fulldisk Dataset



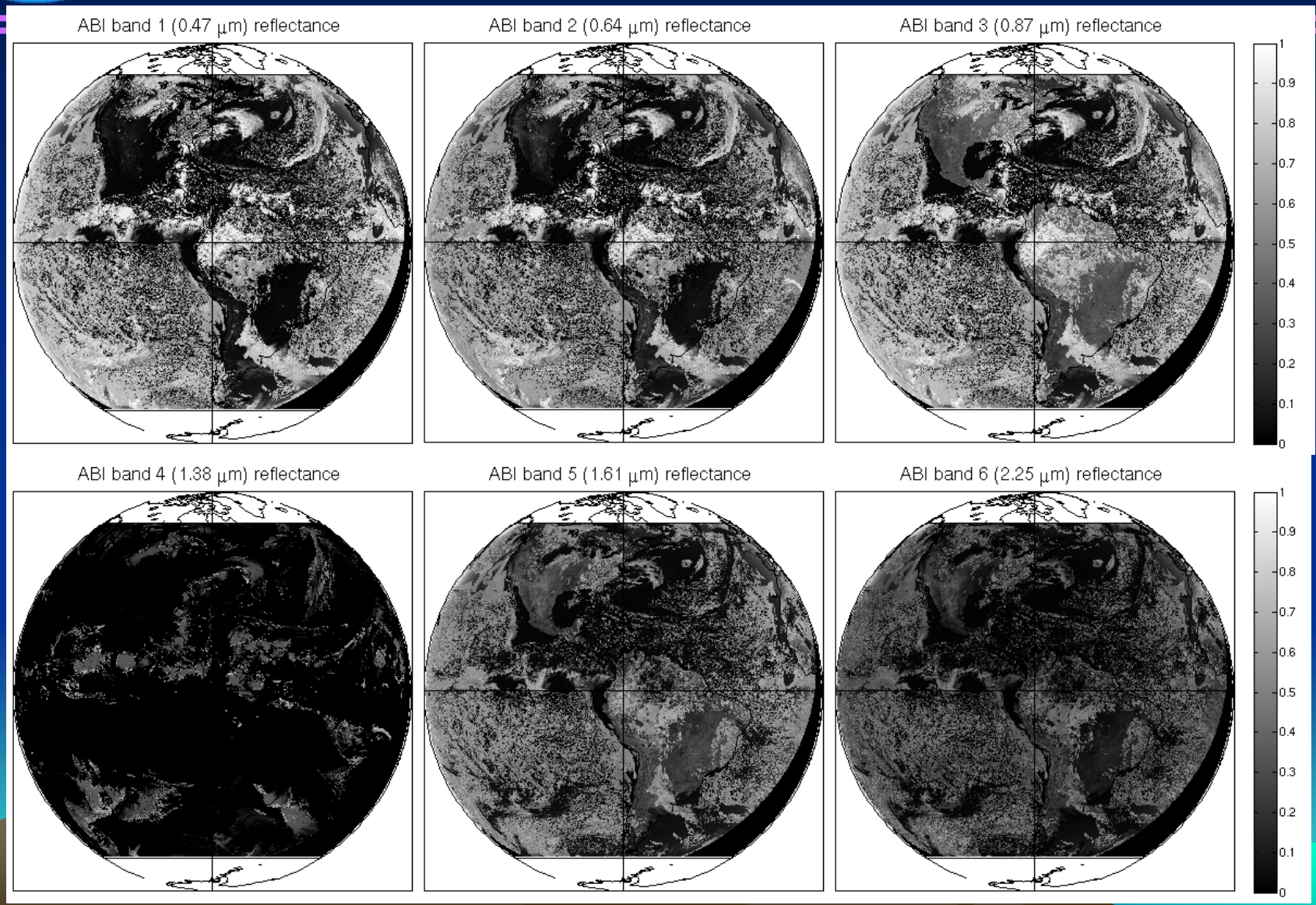
ABI Fulldisk Dataset



ABI Fulldisk Dataset



Full disk 6km Sampling ABI Visible Band Reflectances



ABI IR 6km Sampling Band Brightness Temperatures