

AIRS Instrument, Measurements, Retrieval Algorithm, Applications, and Future Sensors

Hung-Lung Allen Huang

Cooperative Institute for Meteorological Satellite Studies

Space Science & Engineering Center

University of Wisconsin-Madison, USA



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Outline

- AIRS **Instrument** Characteristics
- AIRS **Measurement** Characteristics
- AIRS Regression **Retrieval Algorithm**
- AIRS **Applications**
- Future **Operational Sensors**
- Future **Direct Broadcast Activities**

AIRS
(Atmospheric Infrared Sounder)
Instrument Characteristics

AIRS onboard of AQUA

- NASA's EOS spacecraft
- Aqua launched May 4, 2002
- 705 km orbit (polar-orbiting)
- Early afternoon (1:30 PM) equator crossing time heading north
- AIRS system on Aqua:
 - AIRS (Atmospheric Infrared Sounder)
 - AMSU-A (Advanced Microwave Sounding Unit)
 - HSB (Humidity Sounder Brazil)
- Other instruments:
 - MODIS (Moderate Resolution Imaging Spectroradiometer)
 - AMSR-E (Advanced Microwave Scanning Radiometer for EOS)
 - CERES (Clouds and the Earth's Radiant Energy System)

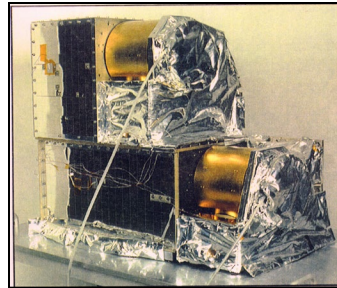


AIRS System Specification



AIRS

- Infrared: 3.74-15.4 μm , 2378 Channels
- IR Spectral Resolution: $\approx 1200 (\lambda/\Delta\lambda)$
- IR IFOV : 1.1° x 0.6° (13.5 km x 7.4 km)
- Visible: 4 Channels, 2.3 km
- Scan Range: $\pm 49.5^\circ$



AEROJET

AMSU

- Microwave: 23-89 GHz, 15 Channels
- IFOV : 3.3°, 43 km
- Scan Range: $\pm 49.5^\circ$



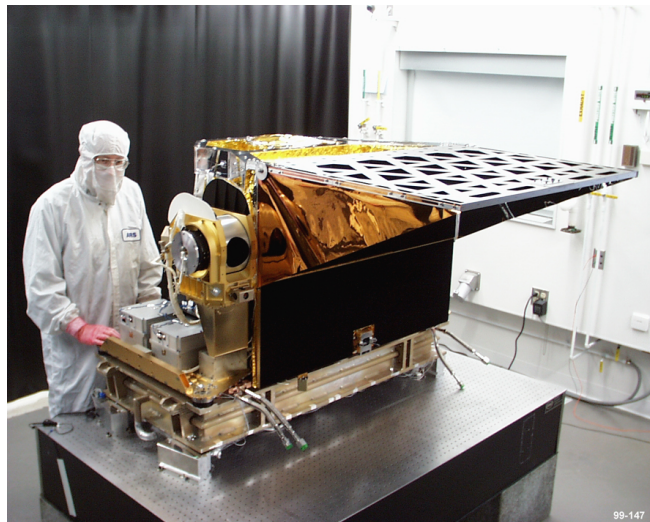
HSB

- Microwave: 150-183 GHz, 4 Channels
- IFOV : 1.1°, 13.5 km
- Scan Range: $\pm 49.5^\circ$

AIRS System Technology

BAE SYSTEMS

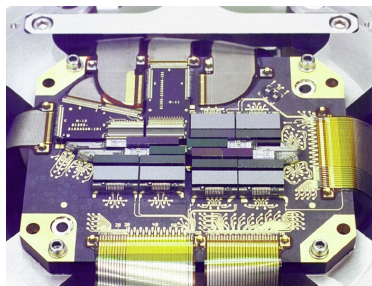
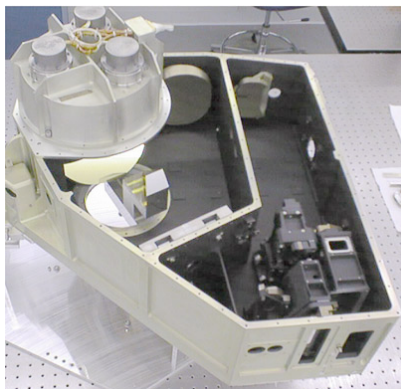
- IR Spectrometer:
Multi-Aperture Array
Grating Spectrometer
- Spectrometer
Cooling to 155K with
Two-Stage Passive
Radiator



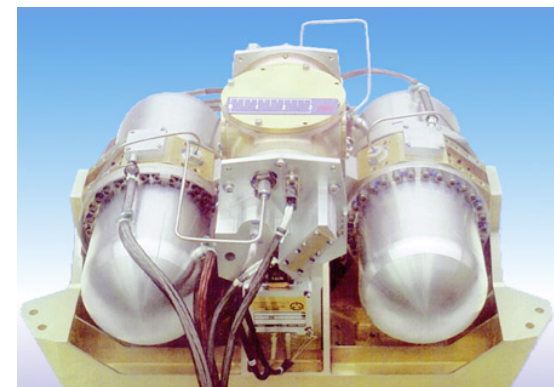
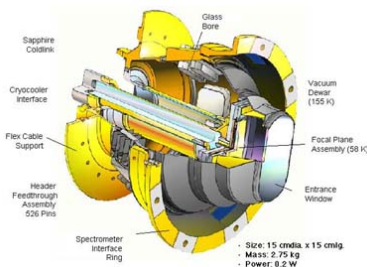
The Atmospheric Infrared Sounder (AIRS)

- Focal Plane Cooling
using Single Stage
Stirling Pulse Tube,
Redundant

- FPAs: PV HgCdTe
to 13.7 μm , PC
HgCdTe to 15.4 μm

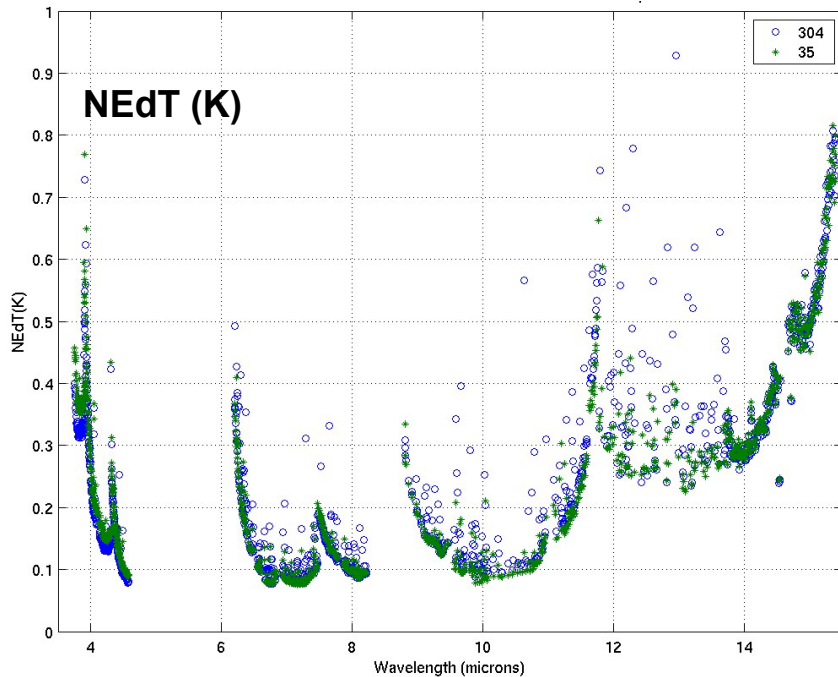


• Cryogenic



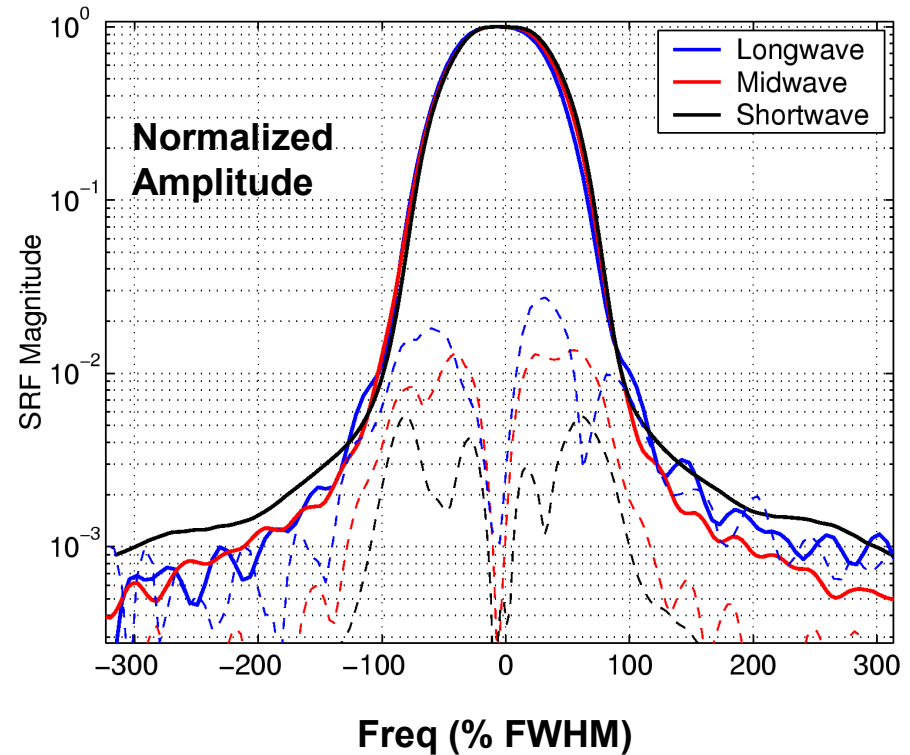
AIRS Spectral Measurement Performance

**Radiometric Sensitivity is High
Stable: Launch to Orbit**



Wavelength (μm)

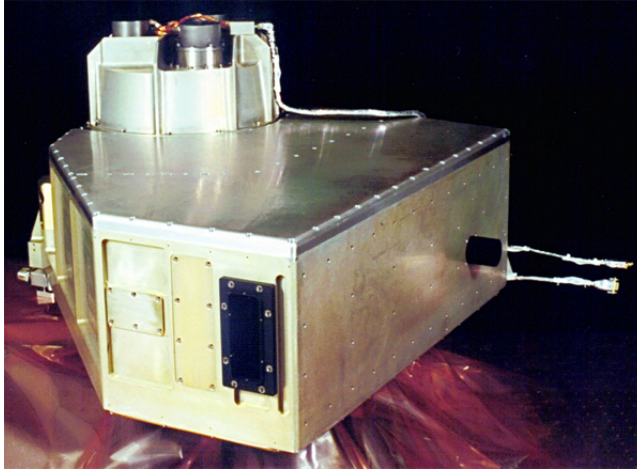
**SRF Shape Well
Characterized to $<10^{-3}$**



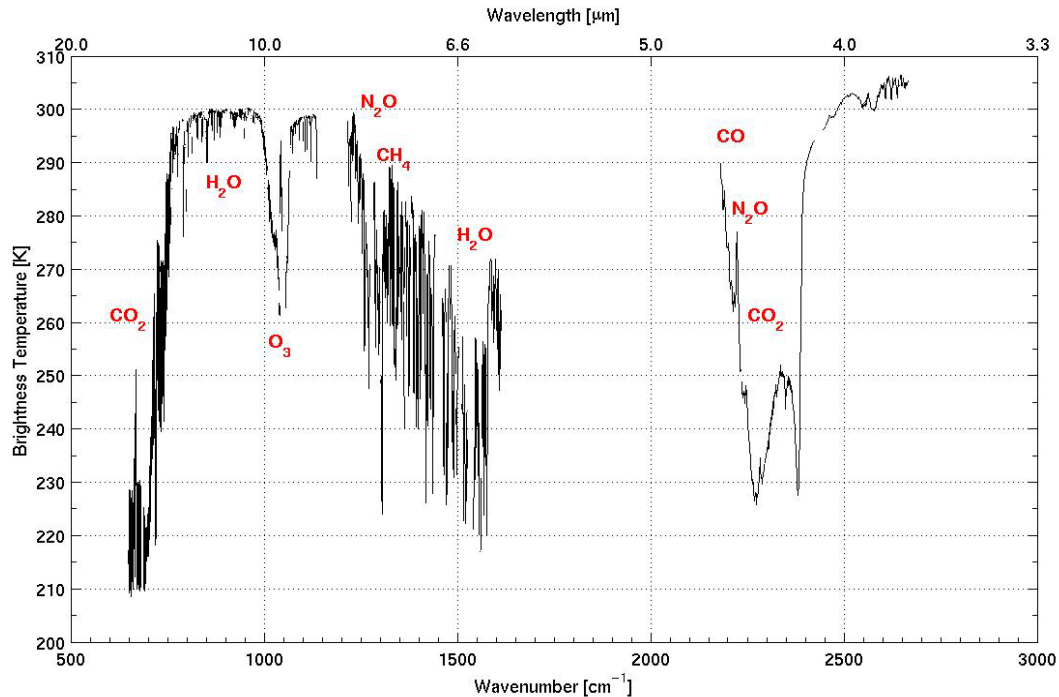
Freq (% FWHM)

Temperature Dependence Well Behaved

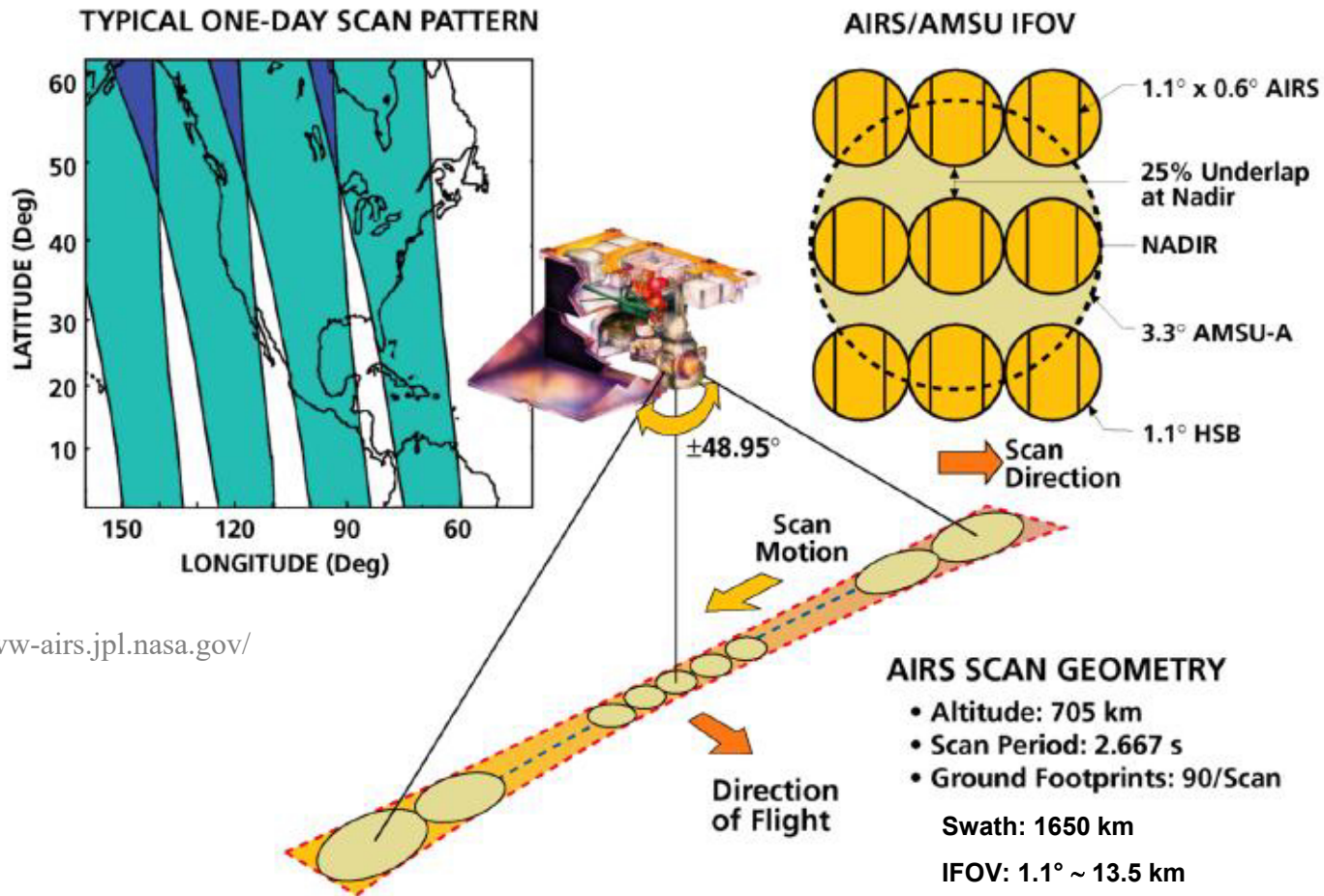
AIRS – Grating Spectrometer



- Array grating spectrometer
- Operating range: 3.7 – 15.4 μm
- Spectral resolution: $\lambda/\Delta\lambda=1200$
- Infrared energy dispersed across arrays of HgCdTe detectors (2378 detectors in 17 arrays)



AIRS Spatial Coverage (1)



<http://www-air.jpl.nasa.gov/>

AIRS Spatial Coverage (2)

AIRS data is collected in 6 minutes cunks = 1 granule

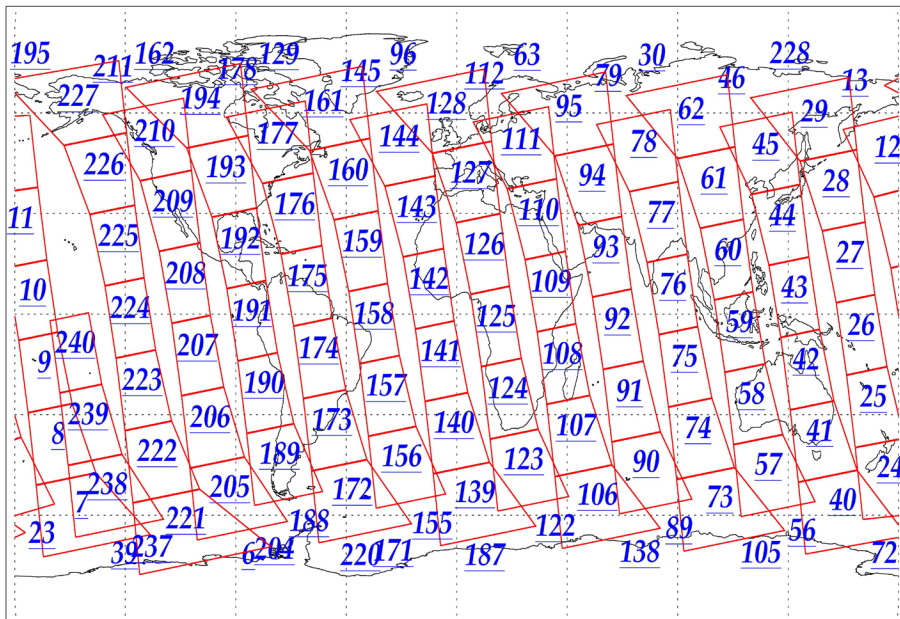
135 scanlinesx90 footprints=12150 pixels per granule (~125 MB)

240 granules per day (120 ascending daytime and 120 descending nighttime granules)

L1A Availability
 AMSU Granules: 240
 HSB Granules: 240
 AIRS Granules: 240

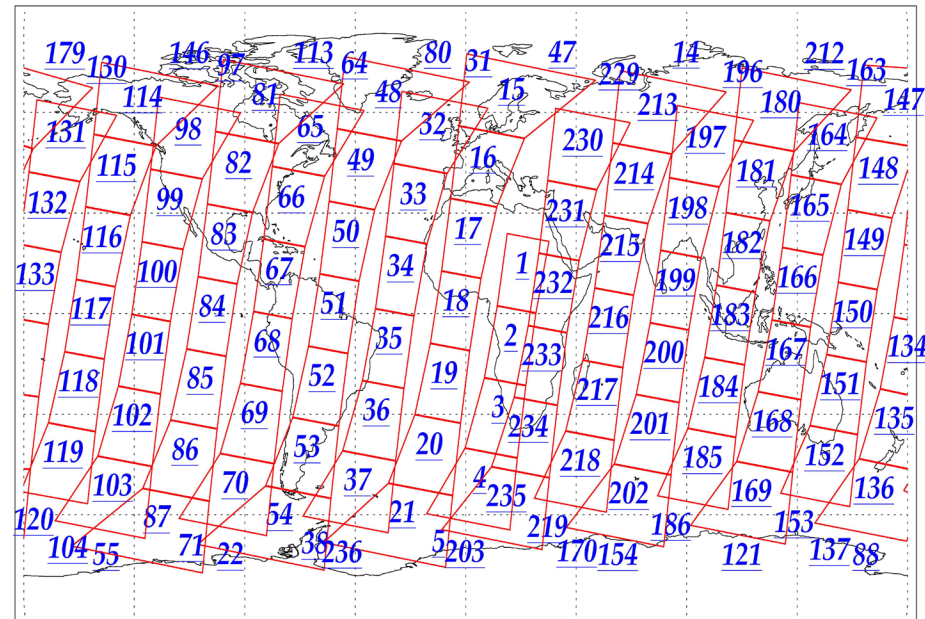
6 Sep 2002
 DoY 249
 Aqua Day 125

Ascending Granules



Descending Granules

Descending Granules

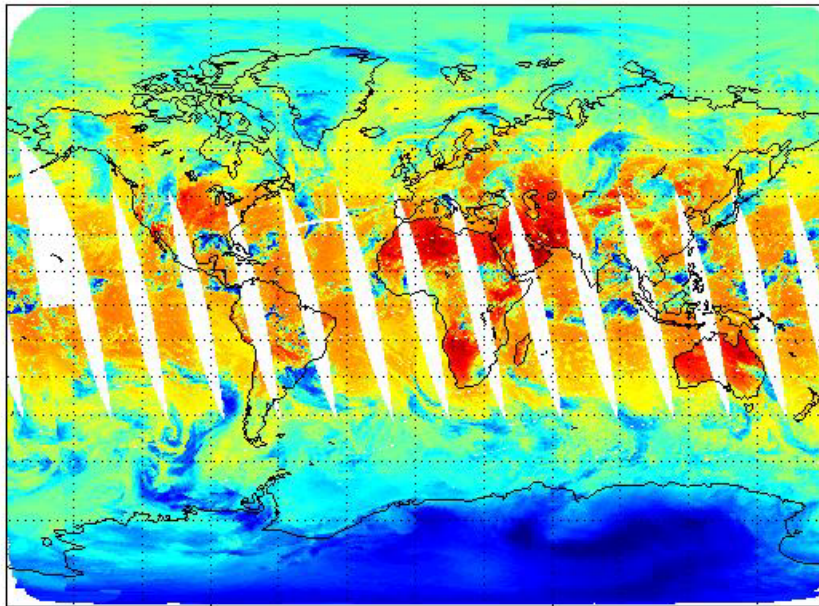


Legend: AMSU Available, HSB Available, AIRS Available

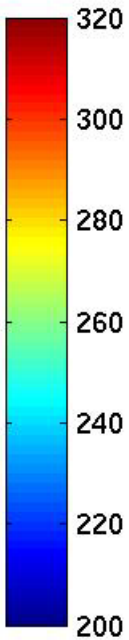
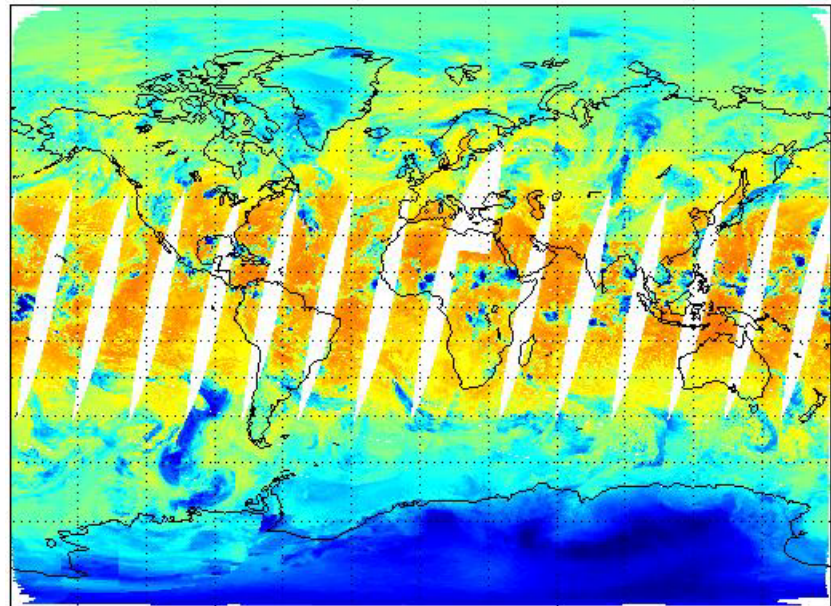
Created on 7 Oct 2002 17:39:22 PDT by eff@convection

AIRS Spatial Coverage (3)

6-Sept-2002, Brightness Temperature [K] at 1000 cm^{-1}
Ascending Granules

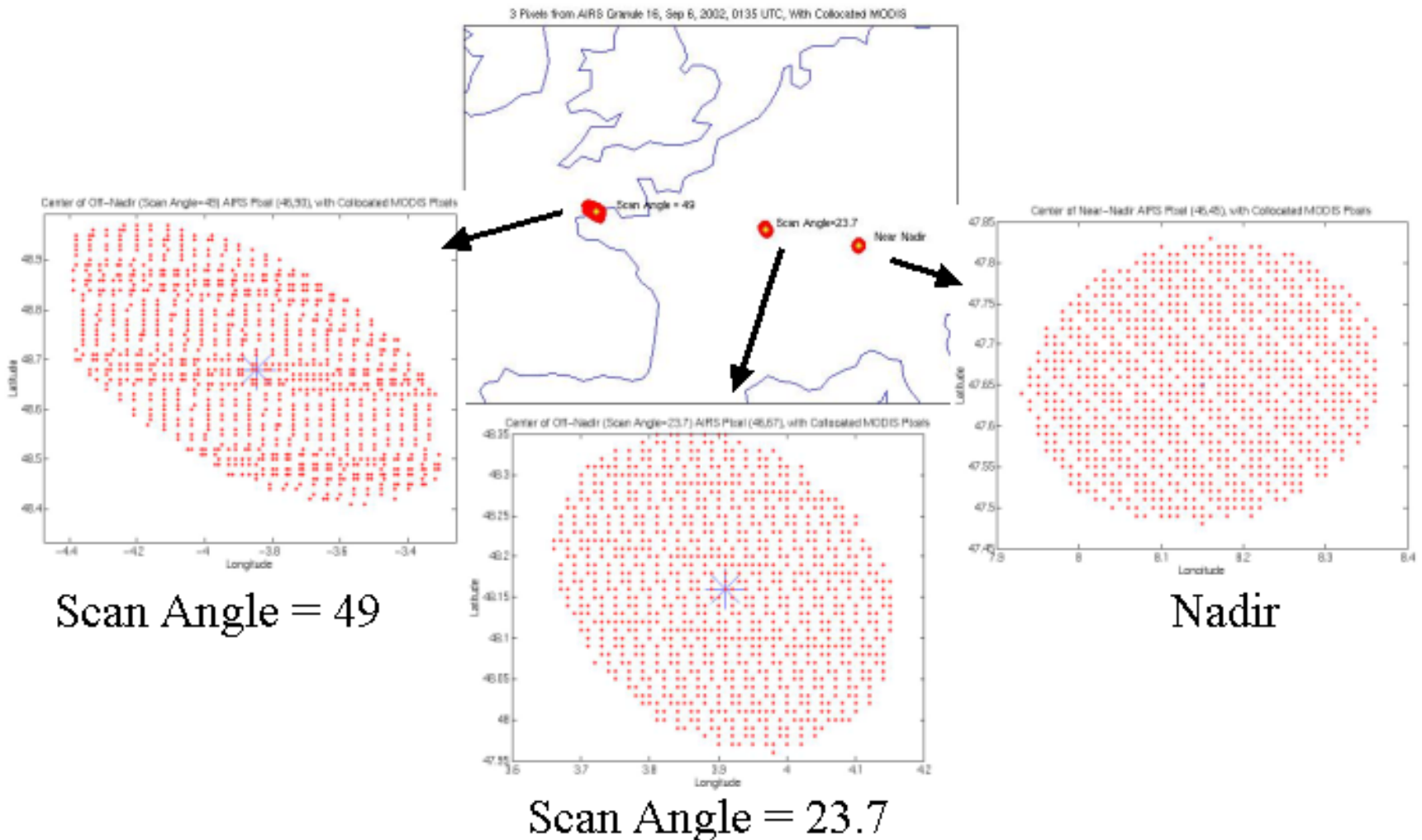


Descending Granules



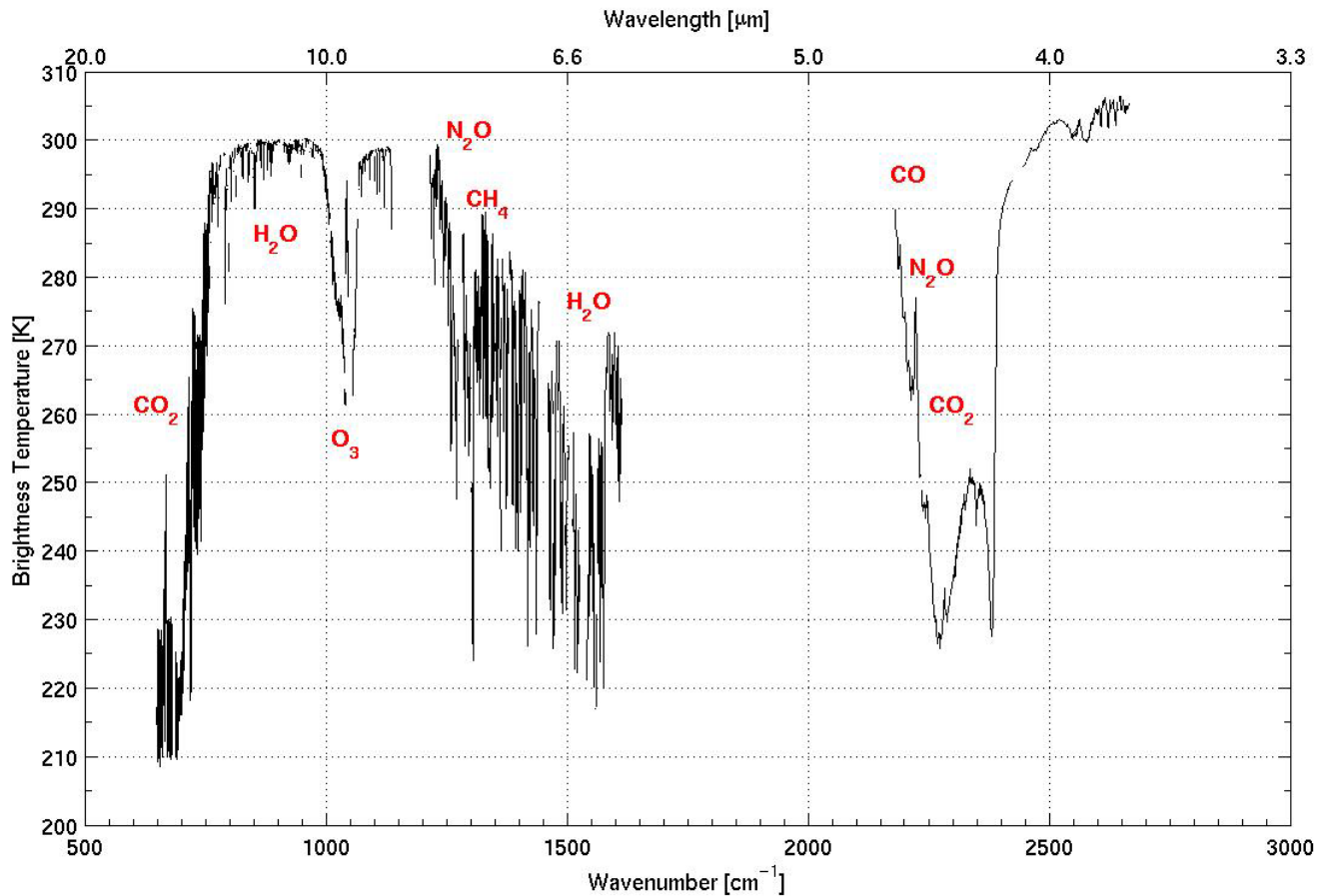
AIRS Vs. MODIS Single FOV Spatial Coverage (4)

AIRS/MODIS Co-location Example



AIRS Spectral Coverage

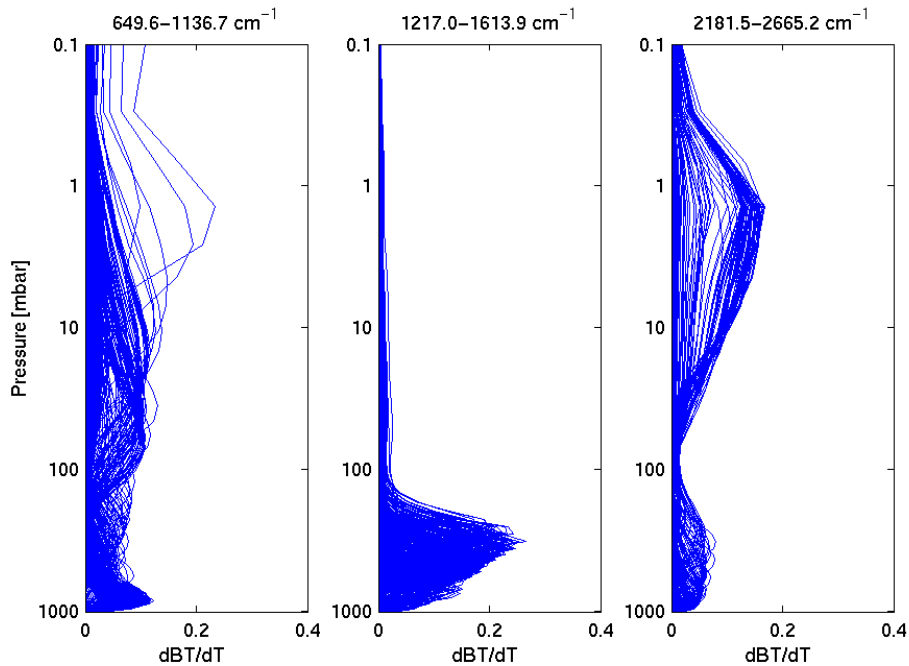
- IR sounder: 2378 channels
- spectral ranges: 3.7 - 4.61 μm , 6.2 - 8.22 μm , 8.8 - 15.4 μm ;



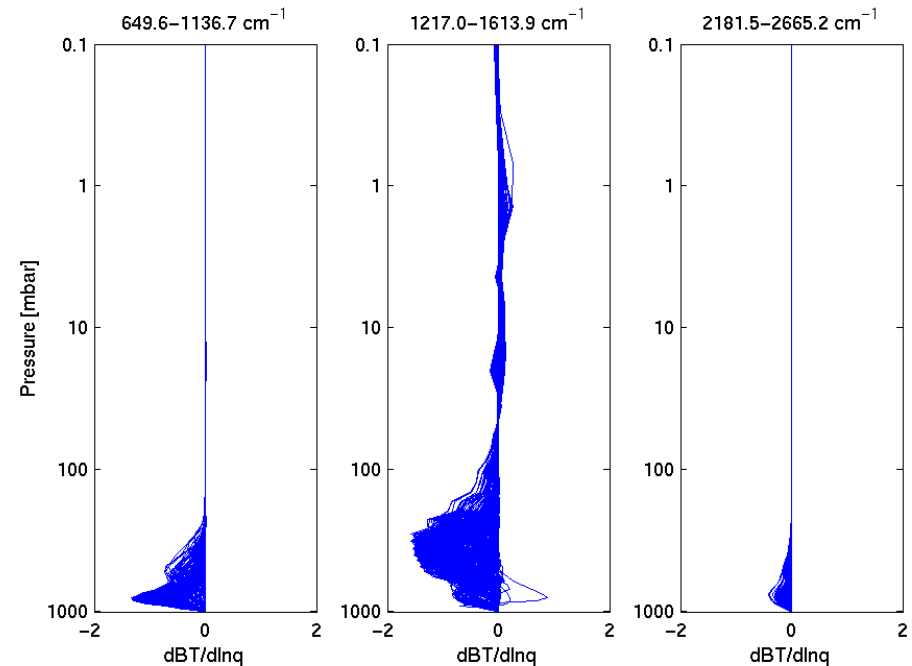
AIRS Spectral Coverage \rightarrow Vertical Resolution

Jacobian matrix $K=dBT/dX$ is the matrix of partial derivatives of the Brightness temperature with respect to the input parameter X . The weighting functions (=rows of K) reflect the relative contribution from each level to the total measured radiance.

Temperature weighting functions



Humidity weighting functions



AIRS IR Specification

Infrared Spectral Coverage:

3.74 μm - 4.61 μm [2674 – 2170 cm^{-1}]

6.20 μm – 8.22 μm [1613 – 1217 cm^{-1}]

8.80 μm – 15.4 μm [1136 – 649 cm^{-1}]

Spectral Resolution: $\lambda/\Delta\lambda=1200$

Spatial Coverage:

$\pm 49.5^\circ$ around nadir

1.1° (~13.5 km dia) IFOV (Instantaneous Field of View)

Sensitivity (NEDT):

0.14 K at 4.2 μm

0.20 K from 3.7 to 13.6 μm

0.35 K from 13.6 to 15.4 μm

Power / Mass: 256 W / 166 kg

Lifetime: 5 years

AIRS

(Atmospheric Infrared Sounder)

Measurement (Level 1B data)

Characteristics

Level 0 to Level 2

Level 0: raw data

Level 1A: geolocated radiance in counts

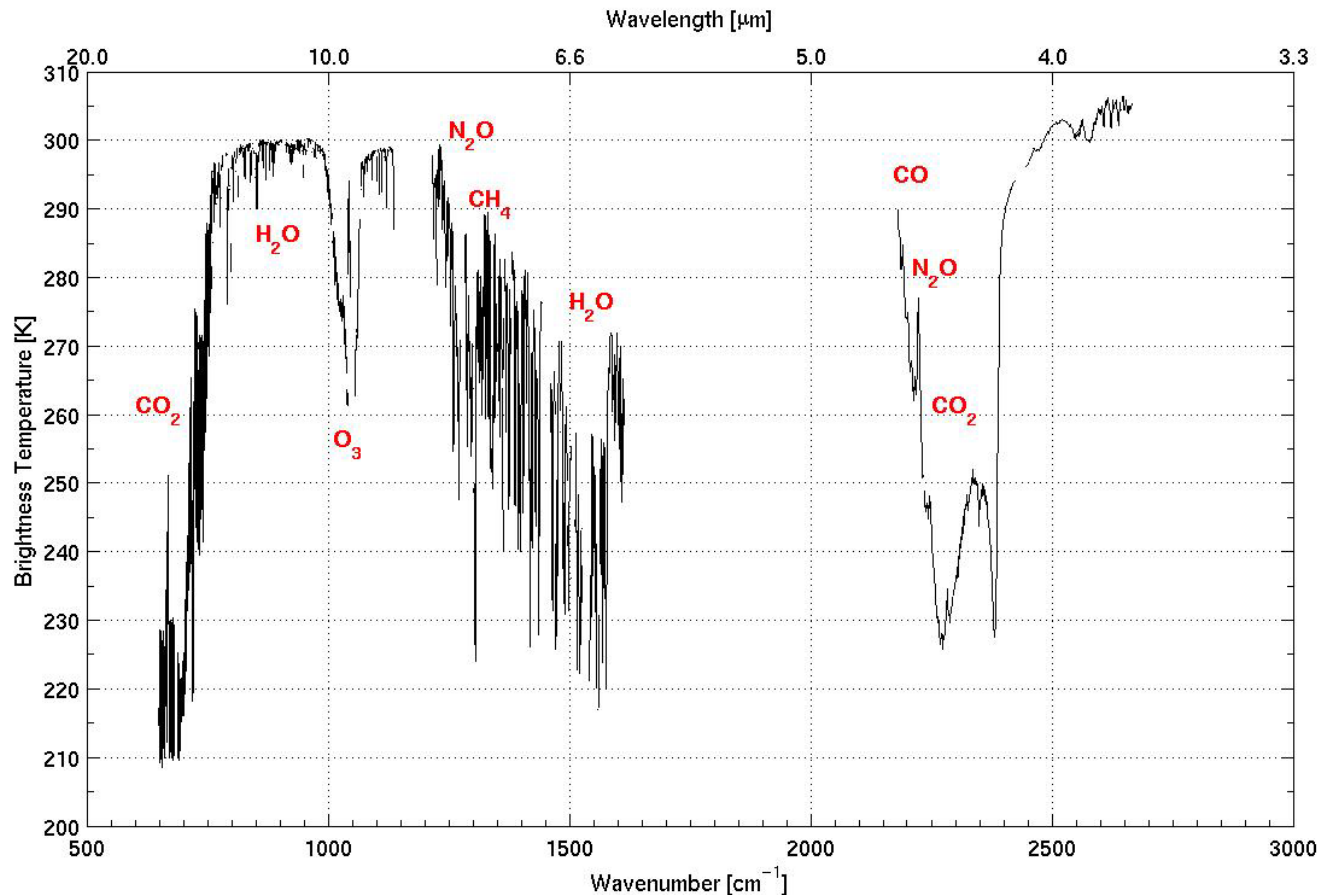
Level 1B: calibrated radiance in physical units

Level 2: retrieved physical variables

(temperature, humidity and ozone profiles, surface skin temperature, total precipitable water, total ozone content, cloud top height . . .)

AIRS Spectral Coverage

- IR sounder: 2378 channels
- spectral ranges: 3.7 - 4.61 μm , 6.2 - 8.22 μm , 8.8 - 15.4 μm ;



Radiance received by AIRS

RTE (no scattering) in LTE

$$\begin{aligned} R_\nu &= \tau_{s\nu} \cdot \varepsilon_{s\nu} \cdot B_\nu(T_S) \\ &+ \int_{p_s}^0 B_\nu(T(p)) d\tau_\nu(p) \\ &- \tau_{s\nu} \cdot r_{s\nu} \cdot \int_{p_s}^0 B_\nu(T(p)) d\tau_\nu^*(p) \\ &+ R_\nu^{sun} \cdot \cos(\theta) \cdot \tau_{s\nu}^{sun}(p_s) \cdot r_\nu^{sun} \end{aligned}$$

- ← Upwelling IR radiation from surface
- ← Upwelling IR radiation from atm. layers
- ← Reflected downwelling IR radiation
- ← Reflected solar radiation

R ...radiance, ν ...wavenumber, s ...surface, p ...pressure, sun ...solar,

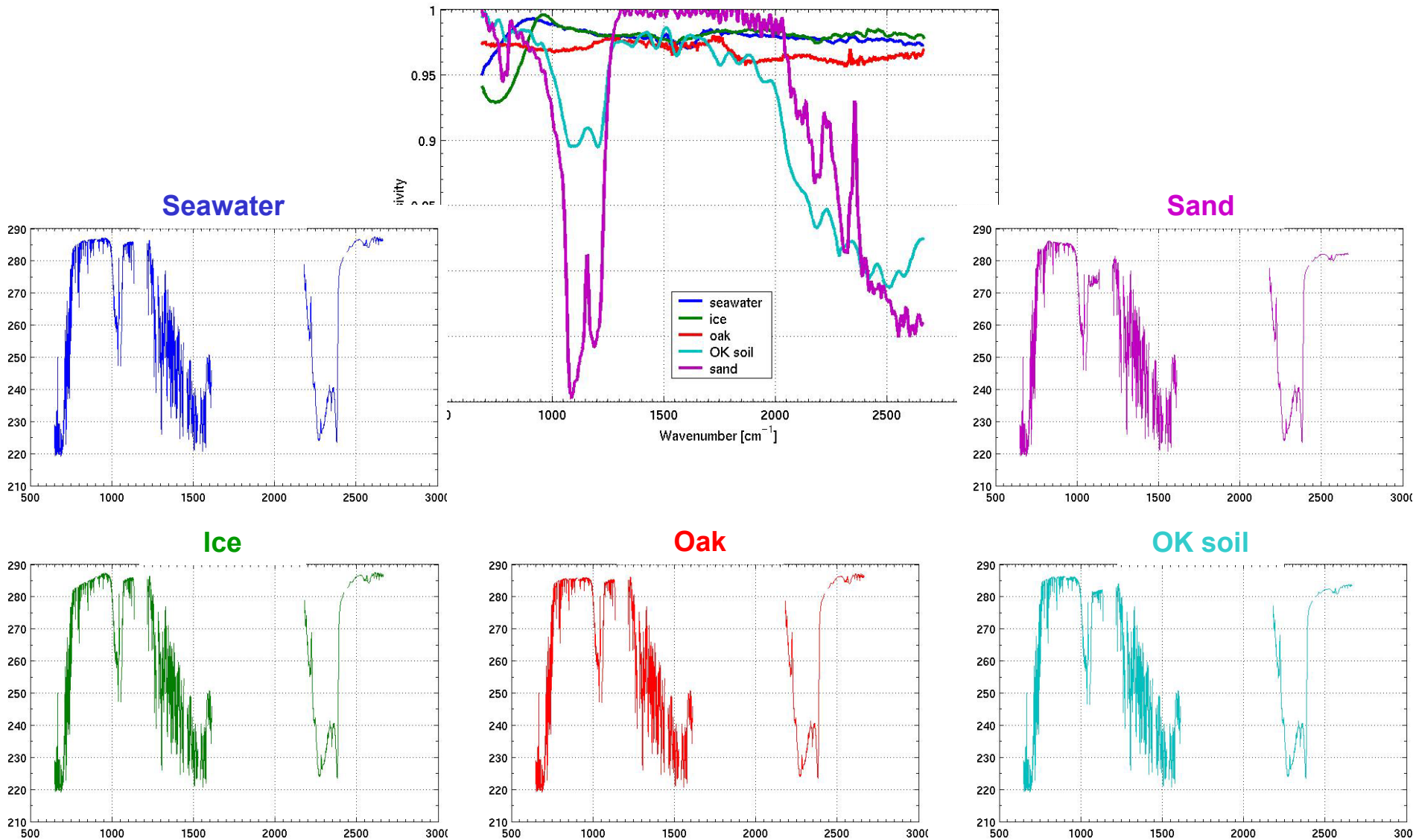
T ...temperature, B ...Planck function, ε ...emissivity,

τ ...level to space transmittance, θ ...local solar zenith angle

r ...reflectivity, with $r = (1 - \varepsilon)/\pi$,

τ^* ...level to surface (downwelling) transmittance [$\tau^* = \tau_\nu^2(p_s) / \tau_\nu(p)$]

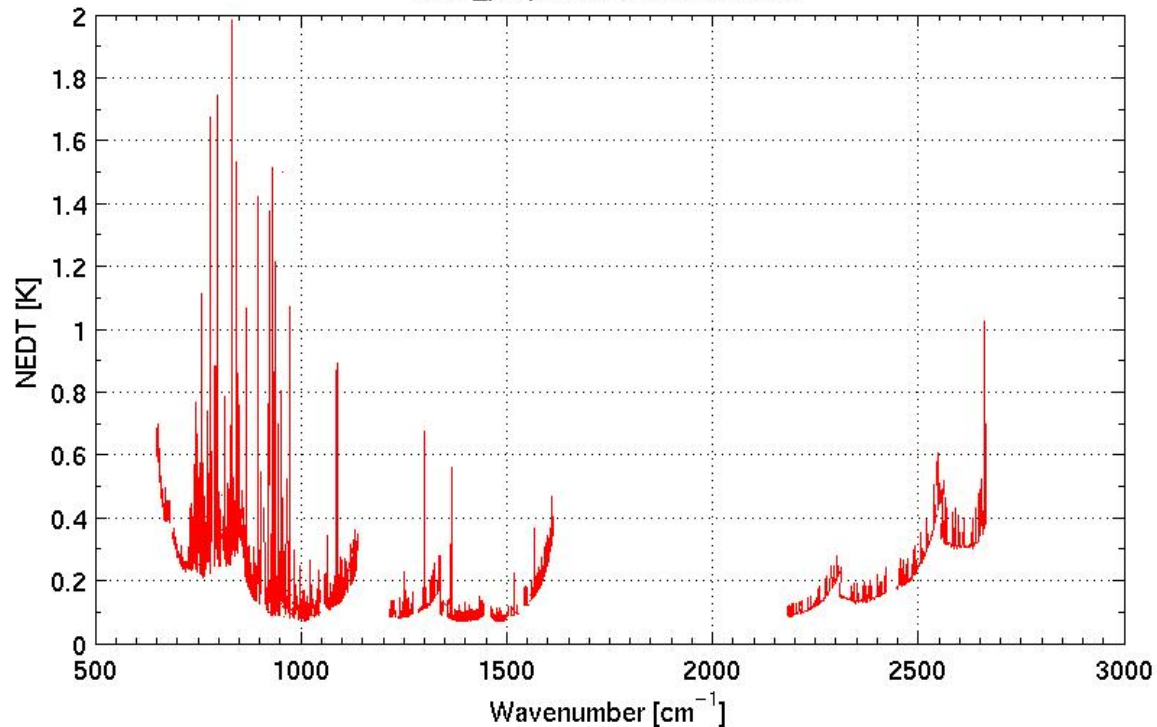
Surface Emissivity and Brightness Temperature simulations



AIRS Noise Specification

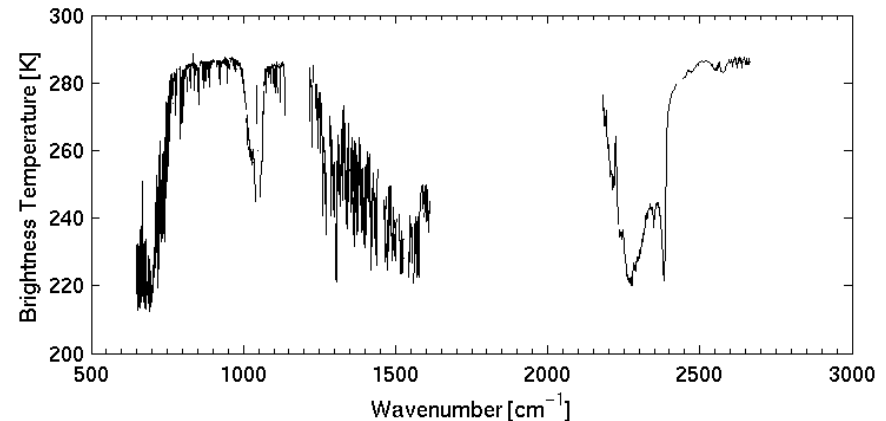
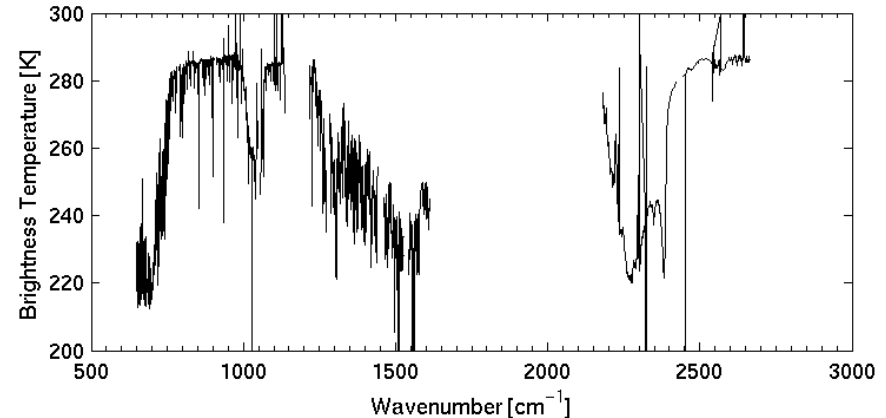
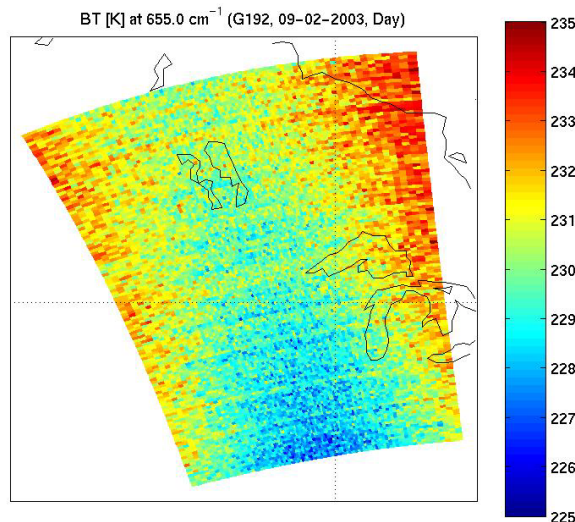
- NeDT: noise equivalent delta temperature is the uncertainty in measurements in terms of Brightness Temperature (BT) units. NeDT depends on the scene temperature.

AIRS NeDT at 250 K
chan_prop.2003.01.10.v6.6.8.txt

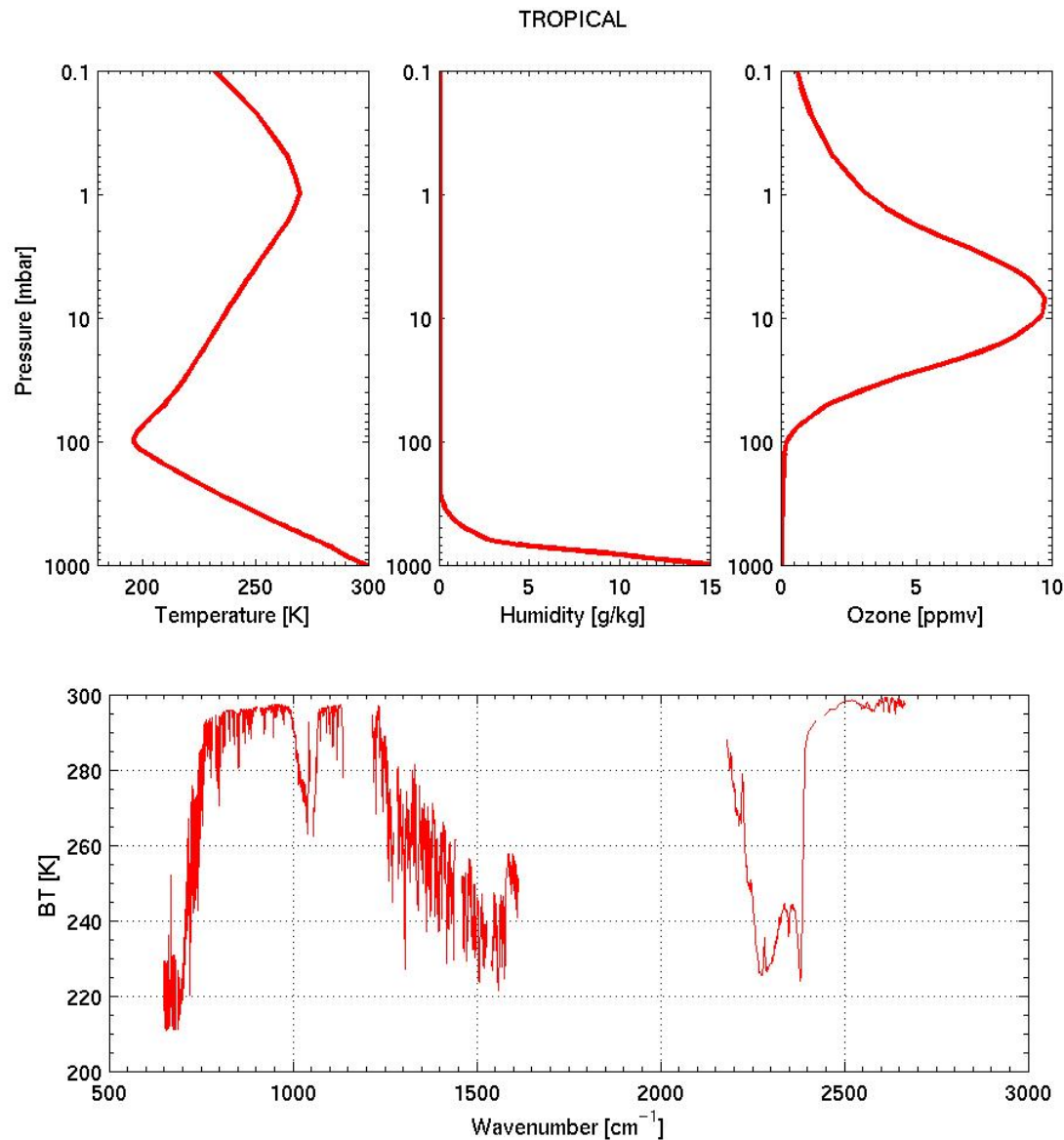


AIRS Bad Channels

- Channel Properties files
(e.g. L2_chan_prop.2003.11.19.v6.6.9.anc)
list channel frequencies, NeDT @ 250 K,
bad_flags . . . Bad channels (bad_flag =1) should not be used in retrievals
- A channel can be be bad because
 - detector has high noise
 - detector is non-responsive
 - detector response shows unexpected steps (popping)
 - poor SRF (spectral response function) determination



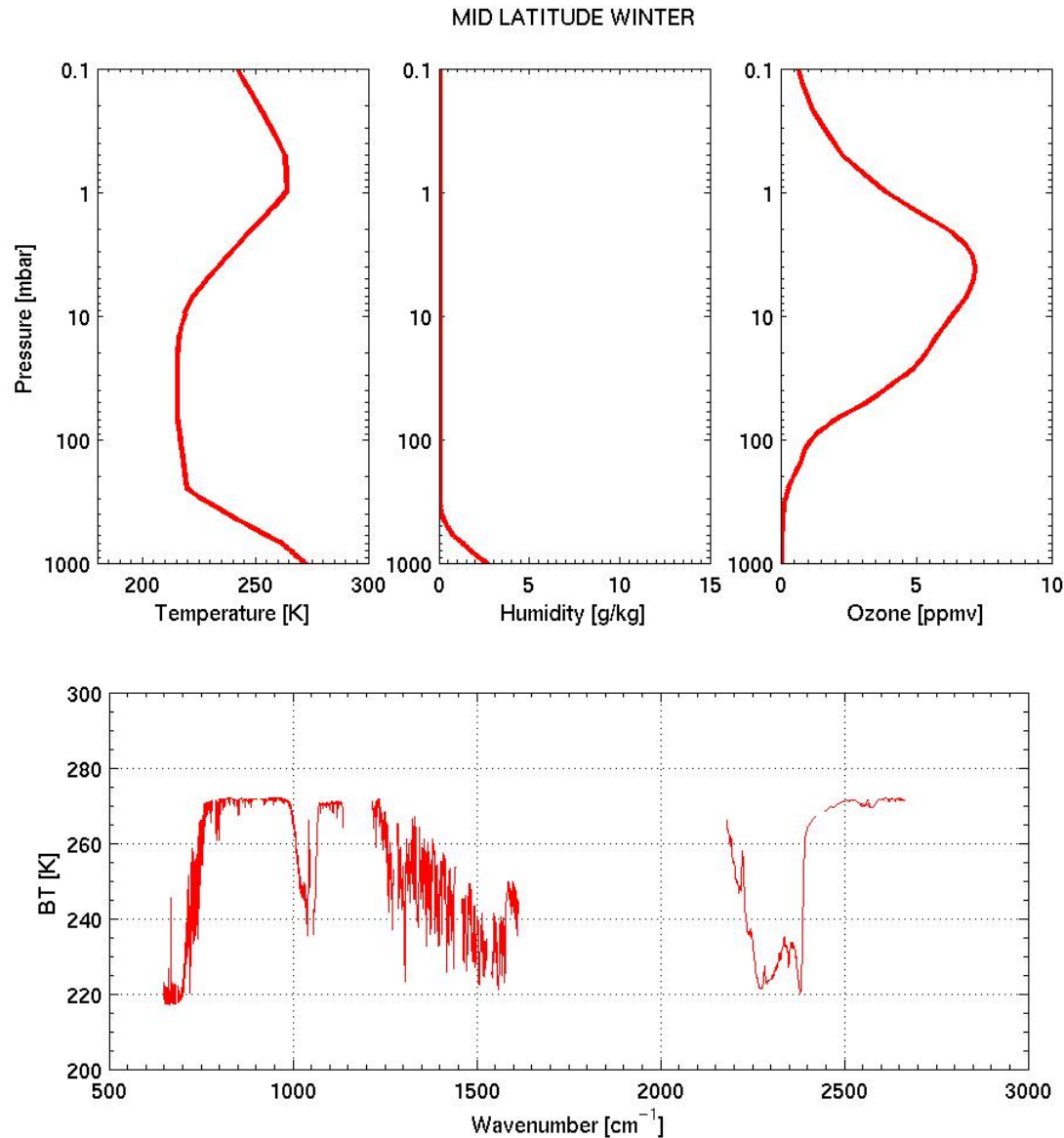
AIRS T,q, O3 profile and simulated spectrum - tropical



Tropical Profile:

- sharp tropopause at ~100 mbar
- high water vapor amount
- high T gradient in troposphere (~100 K) and stratosphere (~80 K)
- high skin temperatures

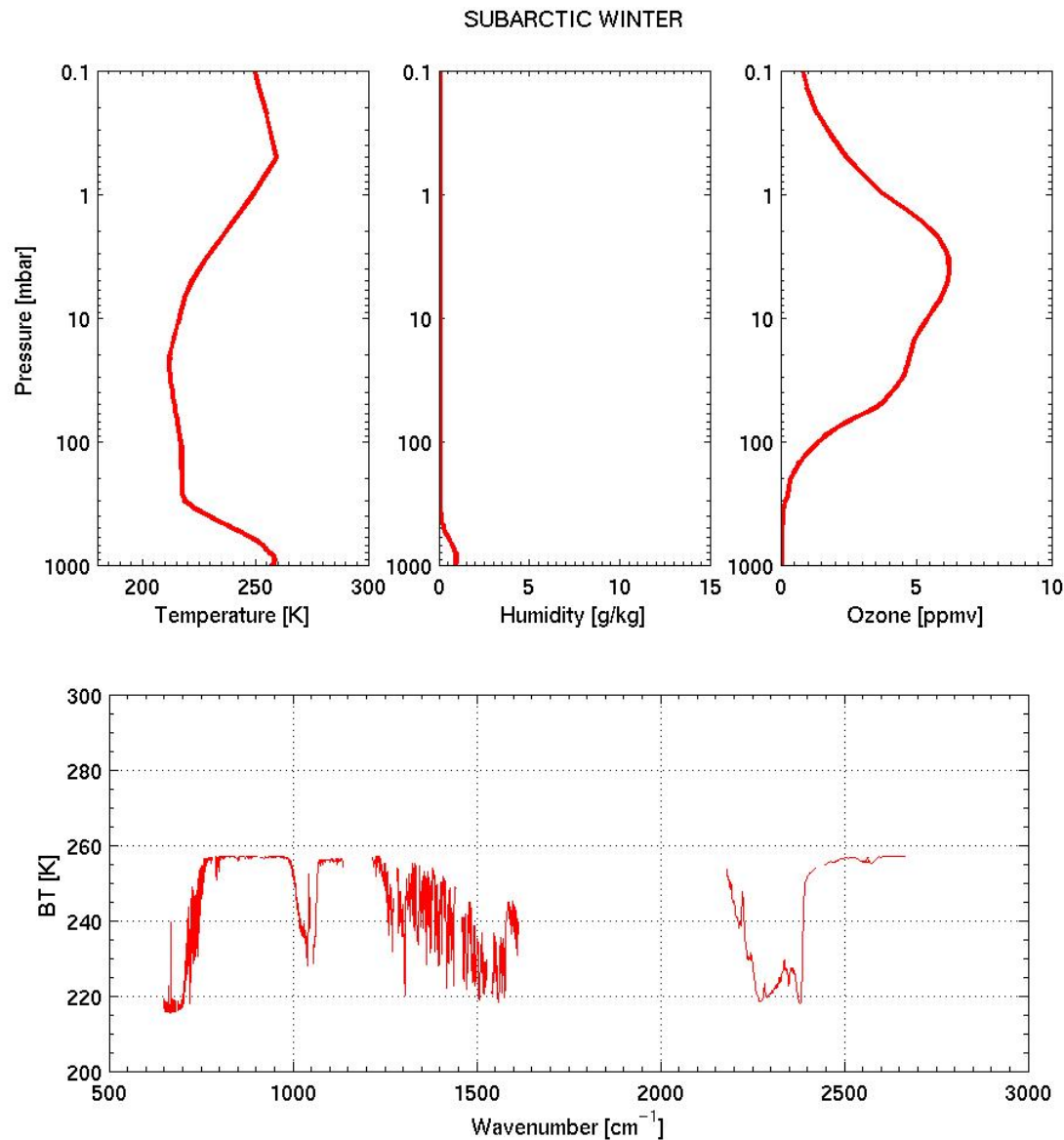
AIRS T,q, O3 profile and simulated spectrum – midlatitude winter



Midlatitude Summer Profile:

- T near surface ~ 260 K
- tropopause at < 100 mbar
- ~constant temperature above tropopause
- smaller T gradient in troposphere and stratosphere
- less moisture
- lower skin temperatures

AIRS T,q, O3 profile and simulated spectrum – subarctic winter

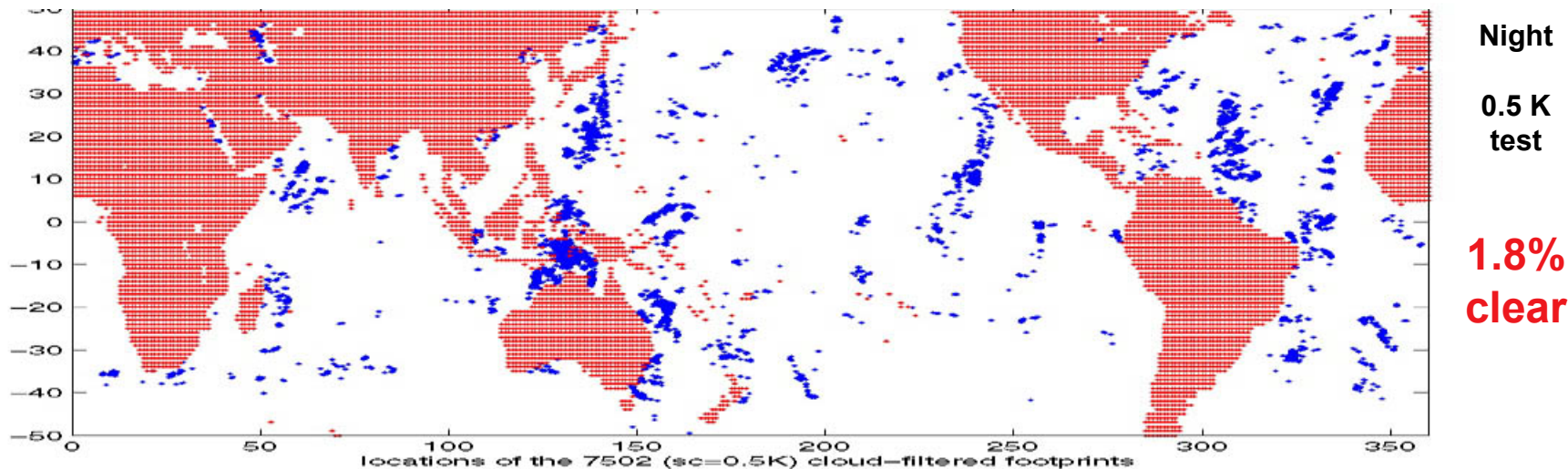
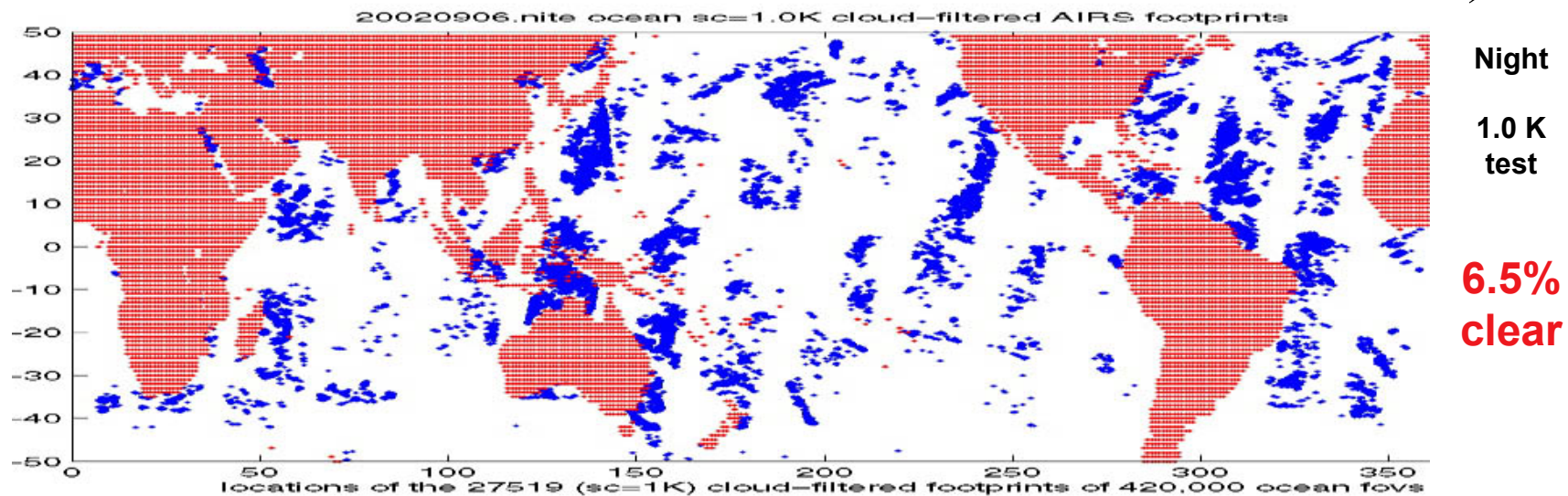


Subarctic Winter Profile:

- T near surface < 260 K
- tropopause at < 100 mbar
- ~constant temperature above tropopause (20-200mbar)
- small T gradient in troposphere
- very dry
- low skin temperatures

Global Clear/Cloudy Statistics

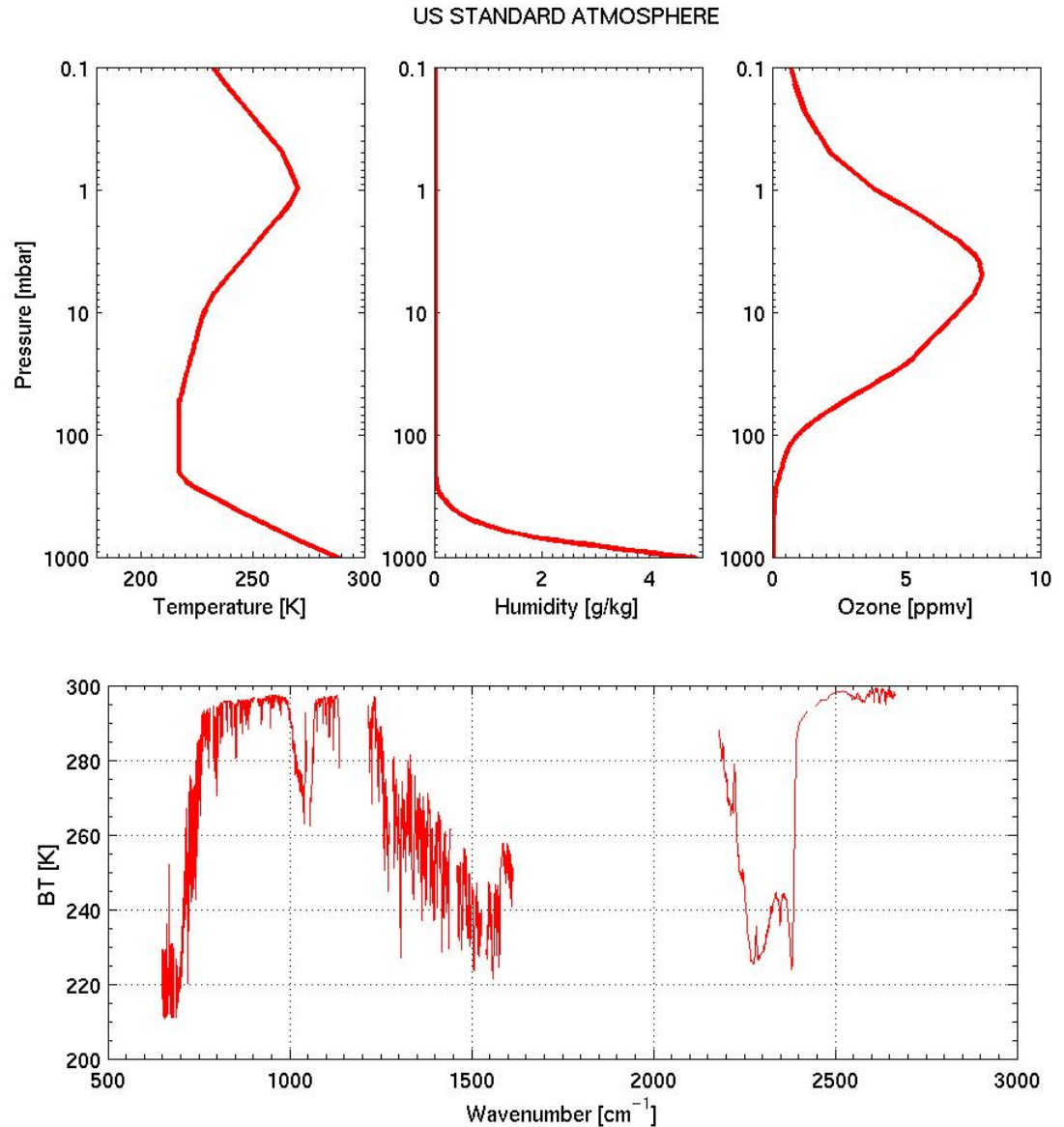
(Spatial coherence test using 2616 cm^{-1} window channel)



Opaque Cloud Simulation – Clear Conditions

Clear Profile:

- Skin Temperature ~290 K
- Moisture near surface ~5 g/kg
- Tropopause at ~ 200 mbar
- constant T from 100 to 200 mbar
- maximum ozone at ~5 mbar
- T gradient in troposphere ~80 K

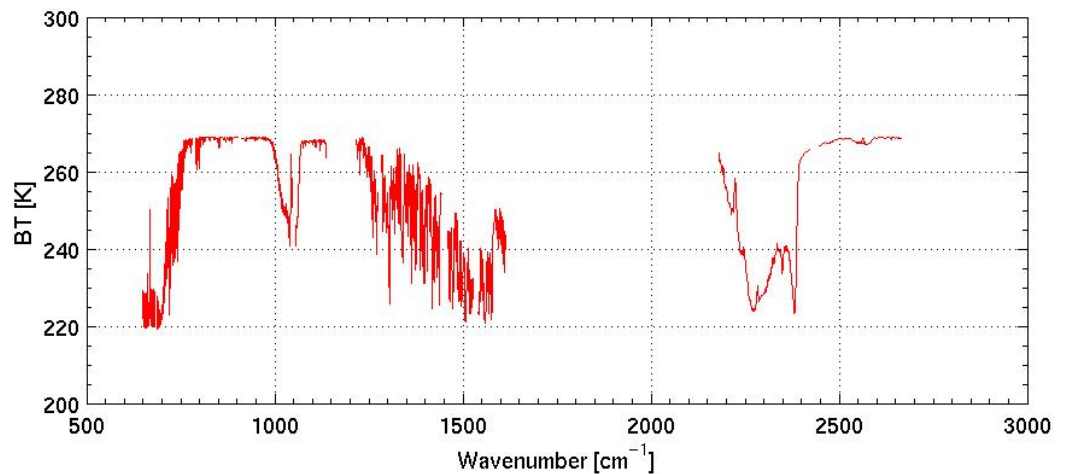
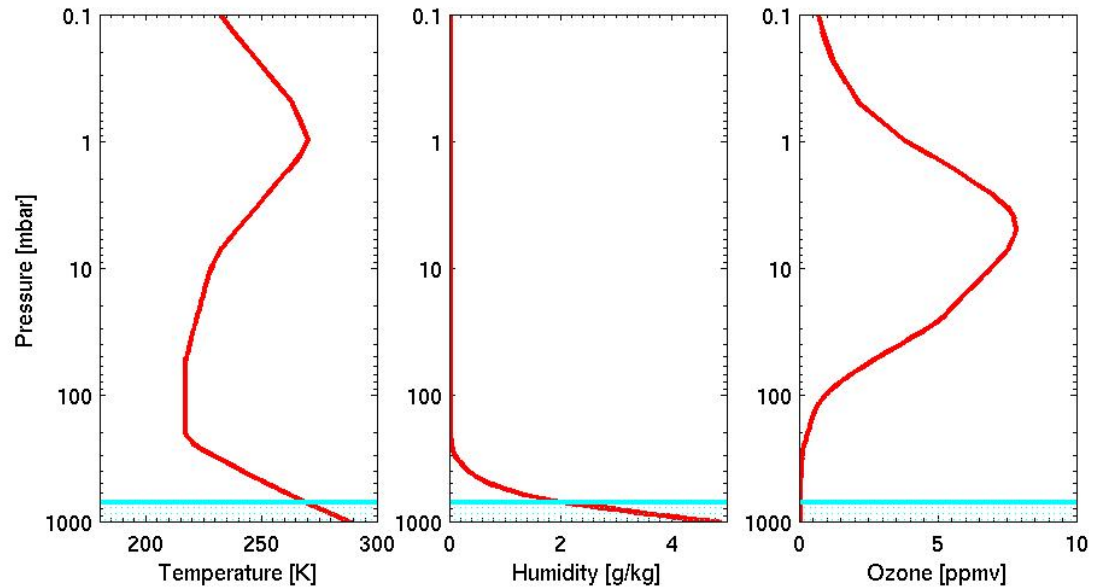


Opaque Cloud Simulation – Cloudtop at 700 mbar

Opaque Cloud at 700 mbar:

- T at cloudtop at ~270 K
- Moisture at cloudtop ~2 g/kg
- T gradient in troposphere above cloud ~60 K

US STANDARD ATMOSPHERE, CTOP=700 mbar

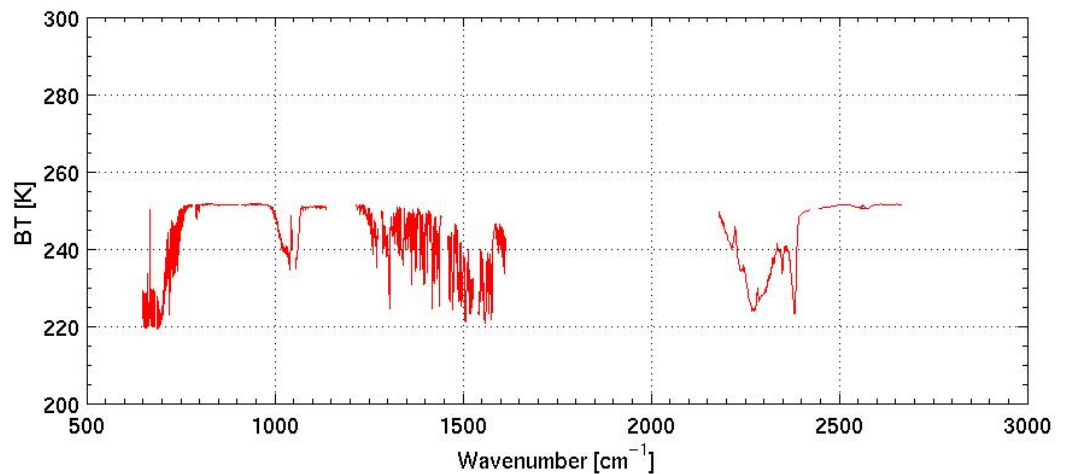
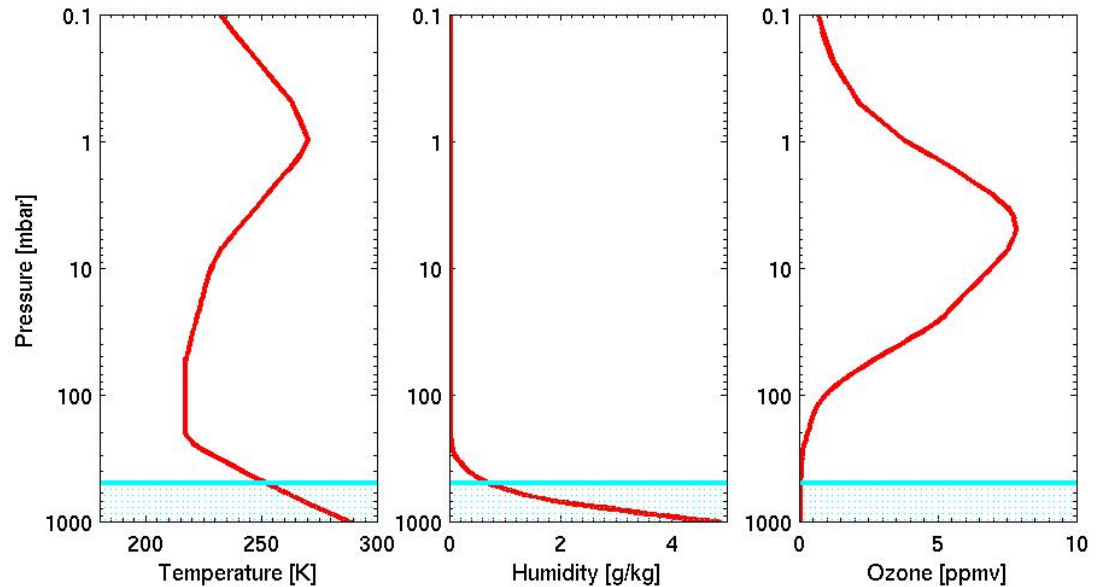


Opaque Cloud Simulation – Cloudtop at 500 mbar

Opaque Cloud at 500 mbar:

- T at cloudtop at ~250 K
- Moisture at cloudtop ~2 g/kg
- T gradient in troposphere above cloud ~30 K

US STANDARD ATMOSPHERE, CTOP=500 mbar

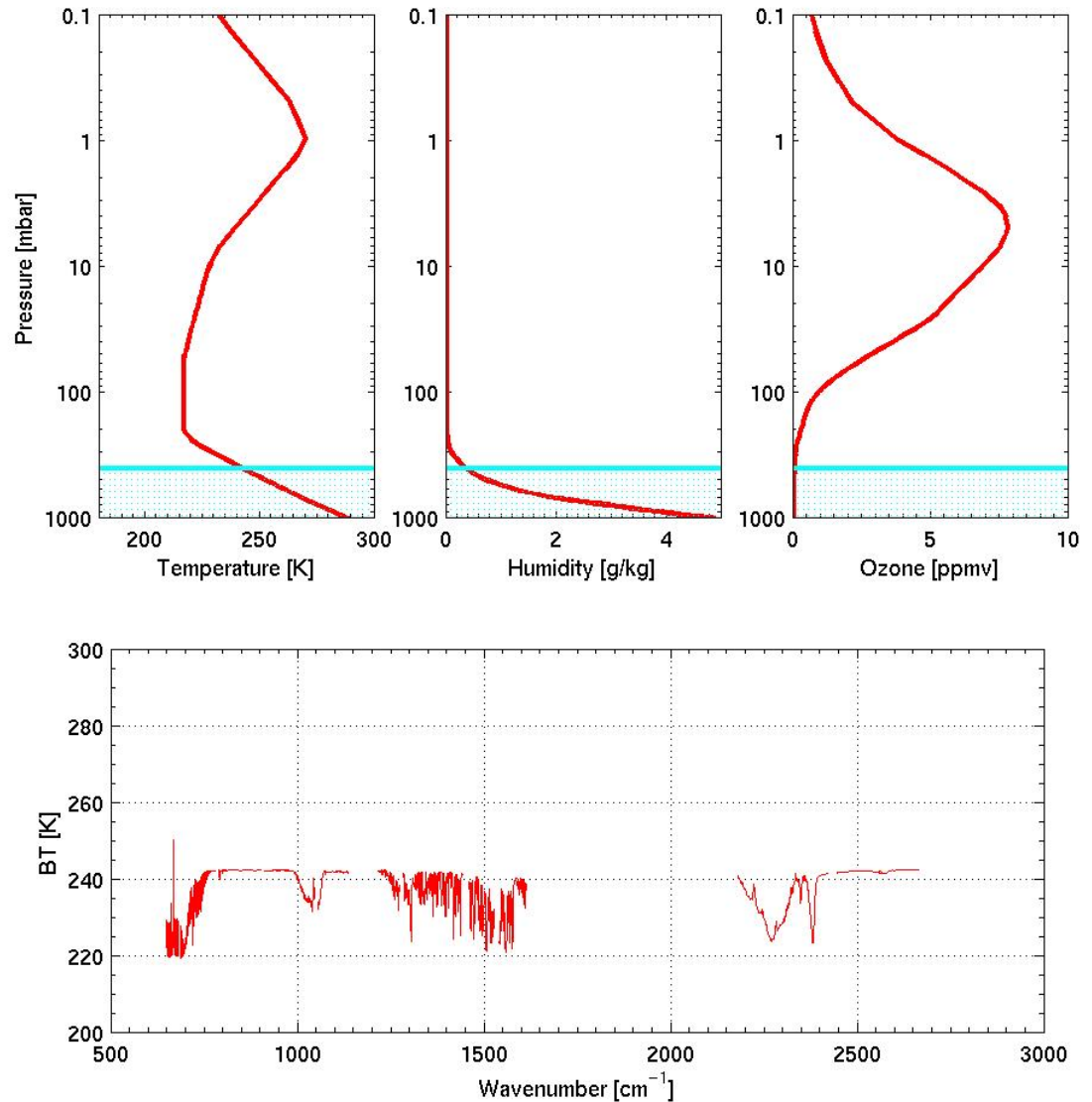


Opaque Cloud Simulation – Cloudtop at 400 mbar

Opaque Cloud at 400 mbar:

- T at cloudtop at ~240 K
- Moisture at cloudtop < 1 g/kg
- T gradient in troposphere above cloud ~20 K
- Few upper layers (~stratopause) warmer than cloudtop

US STANDARD ATMOSPHERE, CTOP=400 mbar

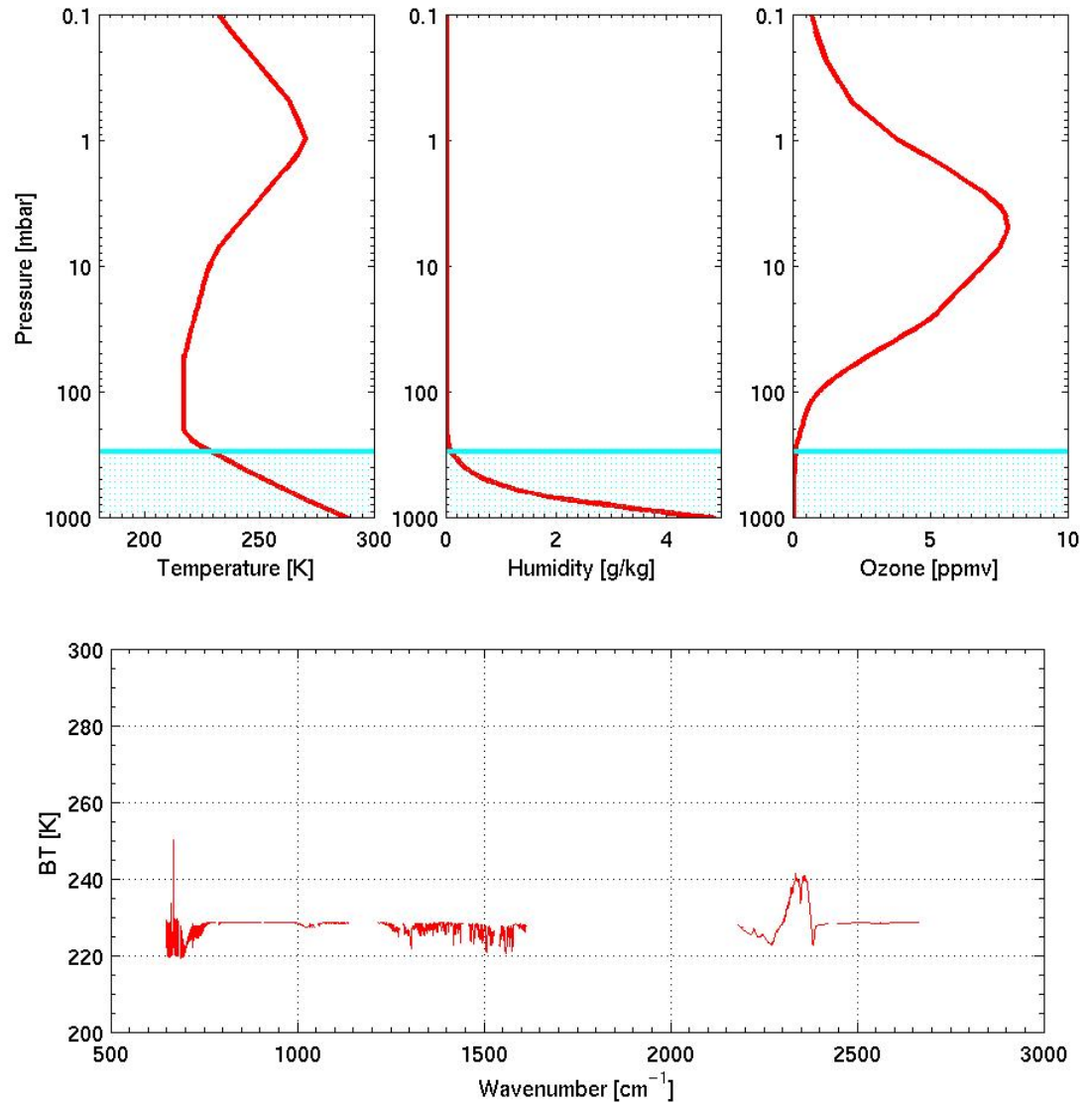


Opaque Cloud Simulation – Cloudtop at 300 mbar

Opaque Cloud at 400 mbar:

- T at cloudtop at ~230 K
- very little moisture above cloud
- T gradient in troposphere above cloud ~10 K
- Upper layers (stratosphere) warmer than cloudtop
- T at Ozone layer ~ T at cloudtop

US STANDARD ATMOSPHERE, CTOP=300 mbar

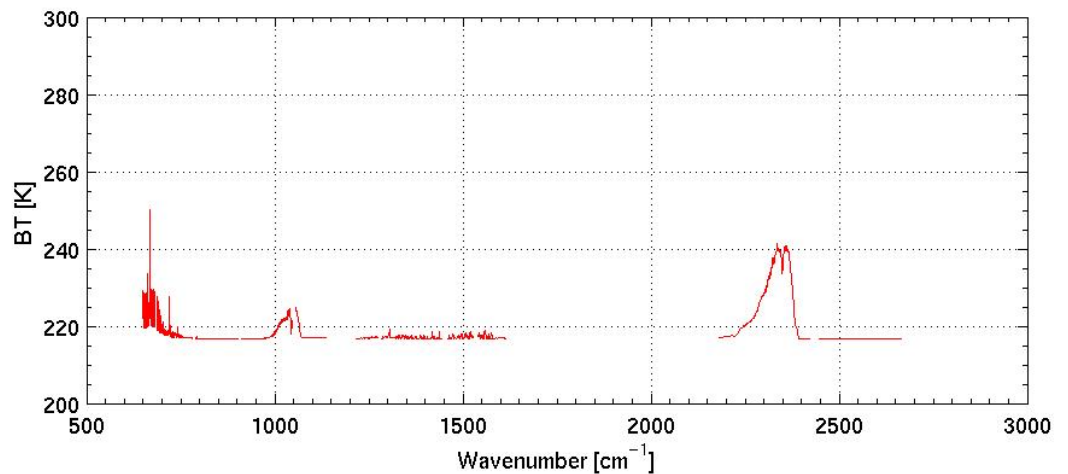
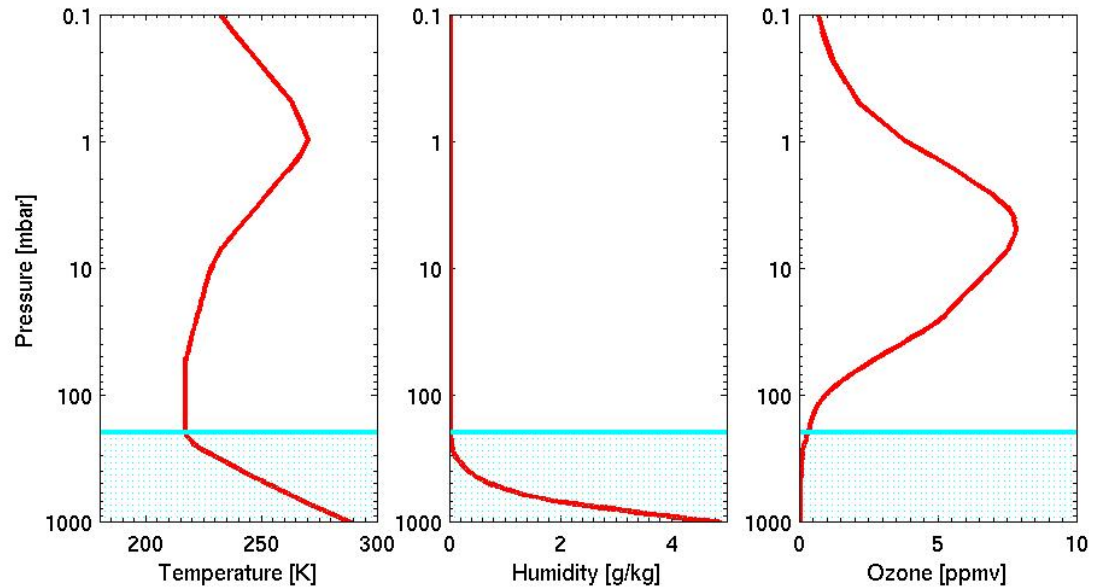


Opaque Cloud Simulation – Cloudtop at 200 mbar

Opaque Cloud at 200 mbar:

- T at cloudtop at ~220 K
- essentially no moisture above cloud
- Every layer above cloud is warmer than cloudtop

US STANDARD ATMOSPHERE, CTOP=200 mbar

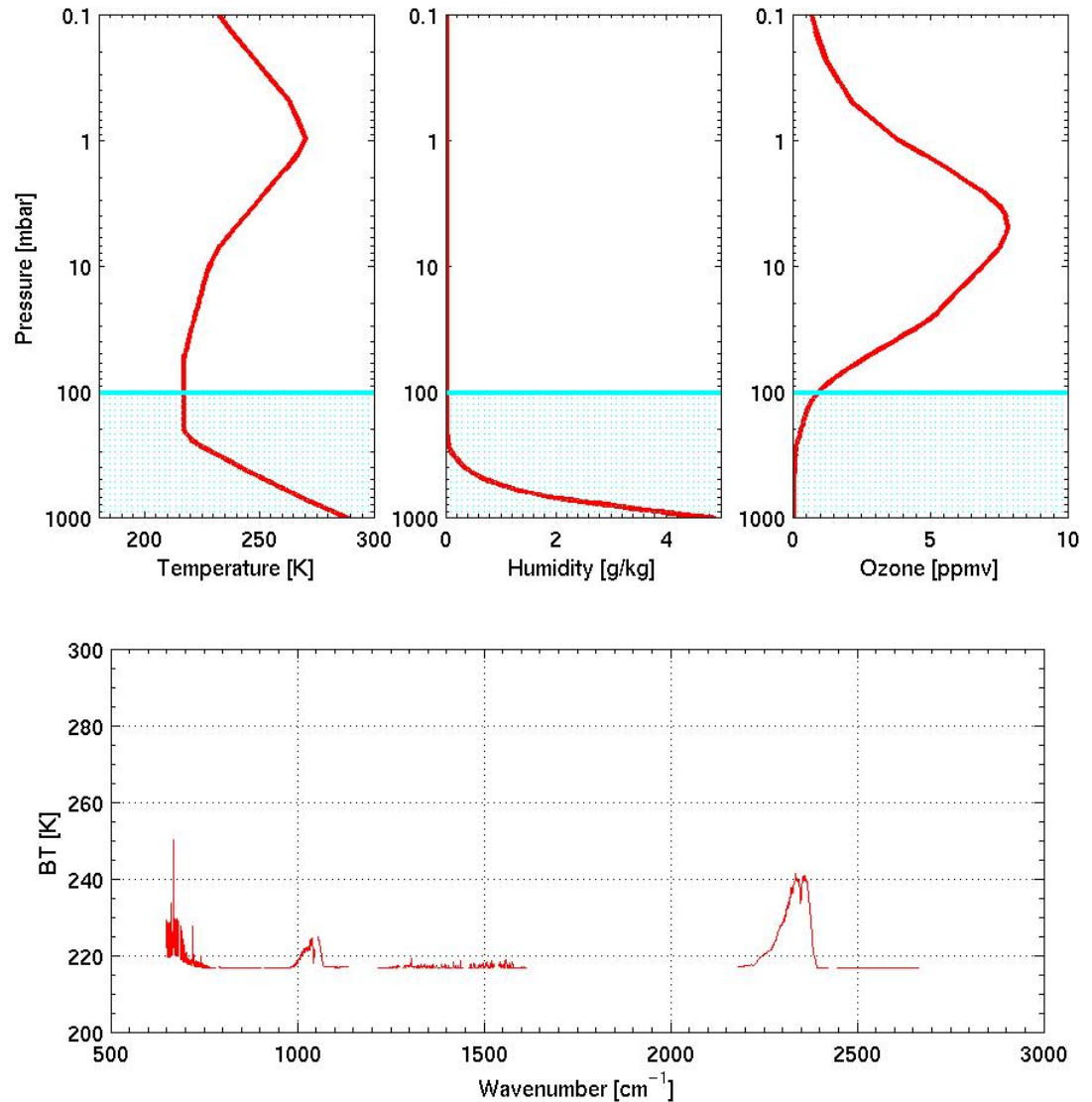


Opaque Cloud Simulation – Cloudtop at 100 mbar

Opaque Cloud at 100 mbar:

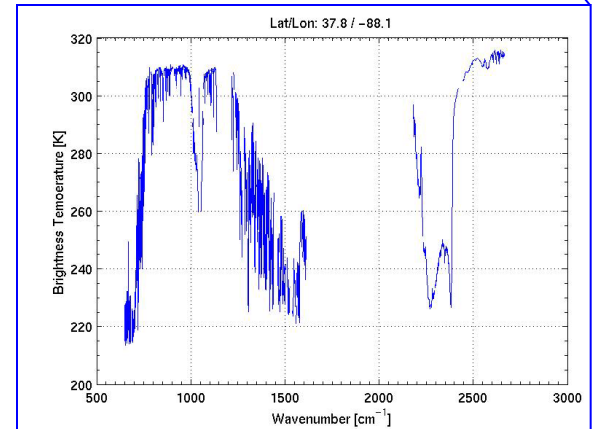
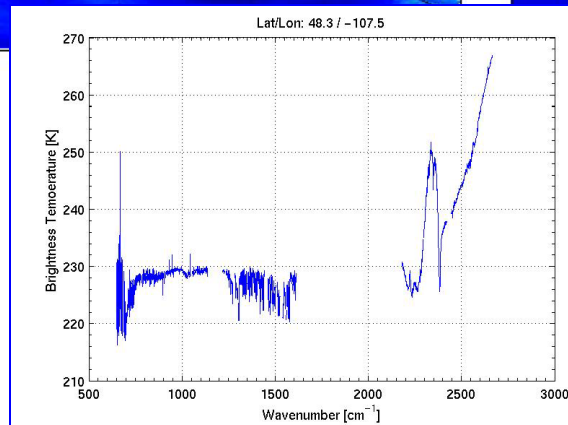
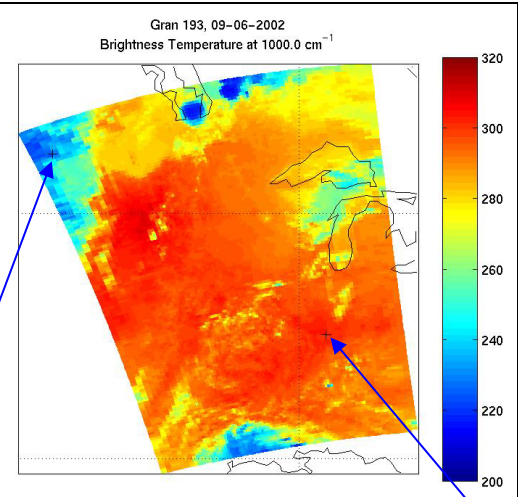
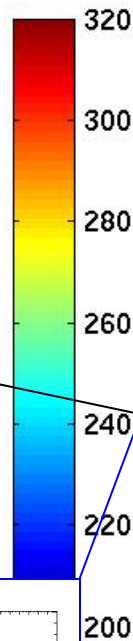
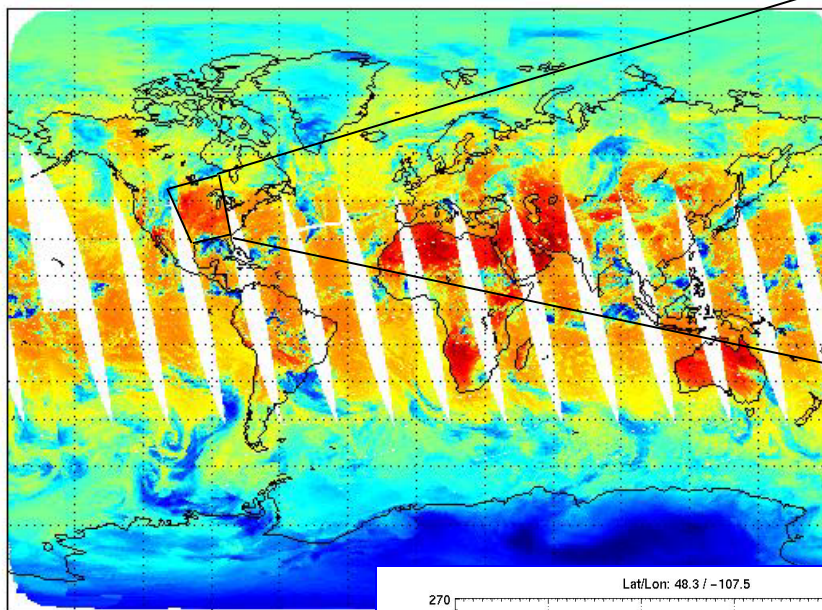
- same results as for 200 mbar since there is no change in T between 100 and 200 mbar
- T at cloudtop at ~220 K
- no moisture above cloud
- Every layer above cloud is warmer than cloudtop

US STANDARD ATMOSPHERE, CTOP=100 mbar



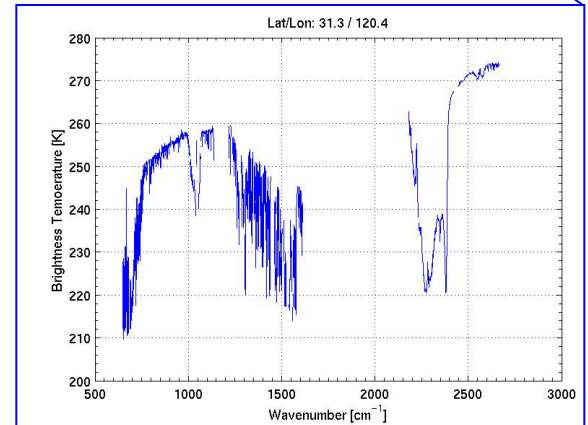
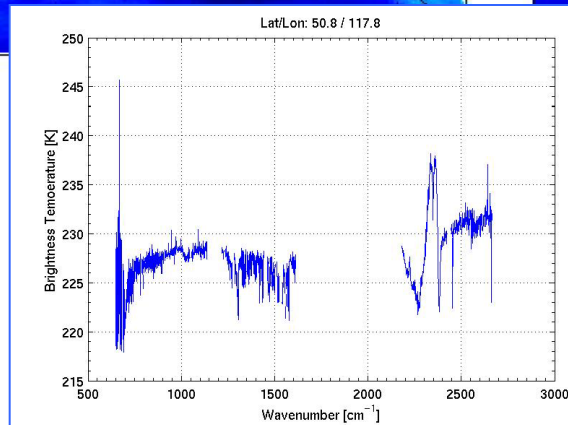
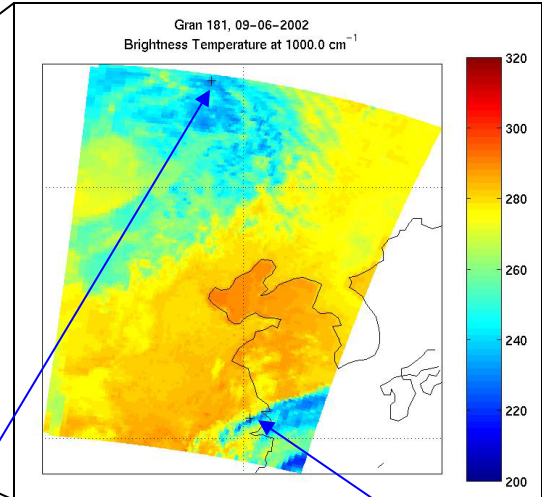
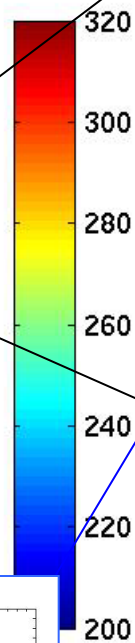
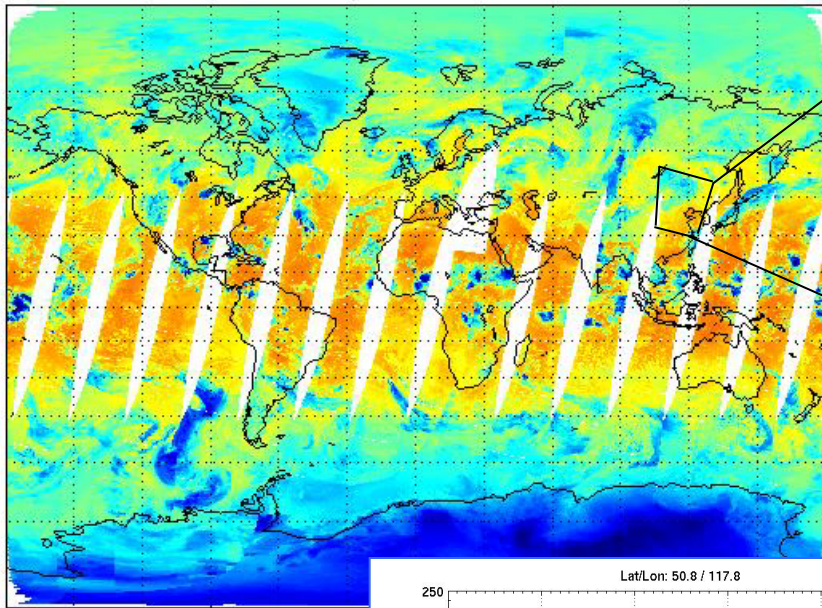
AIRS Measurements (Daytime)

6-Sept-2002, Brightness Temperature [K] at 1000 cm^{-1}
Ascending Granules

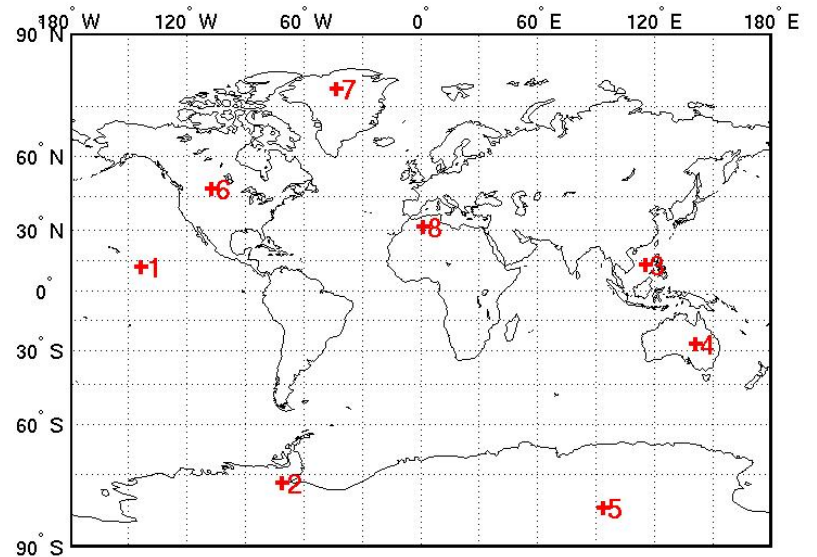
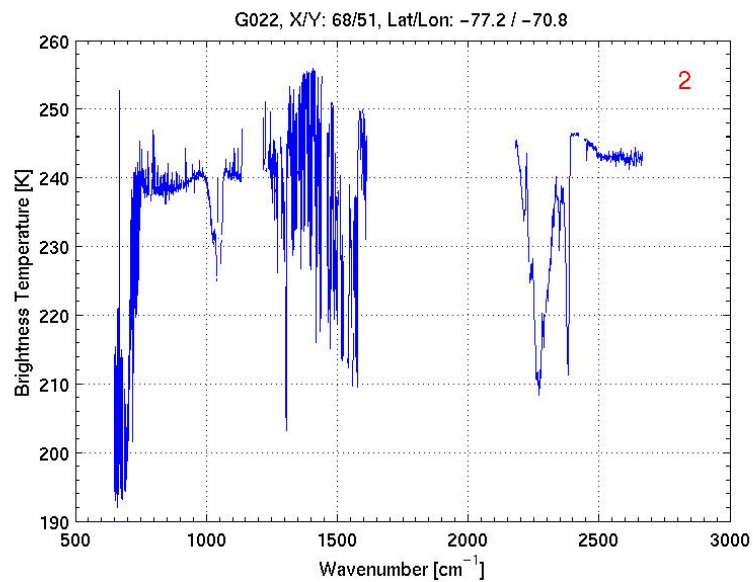
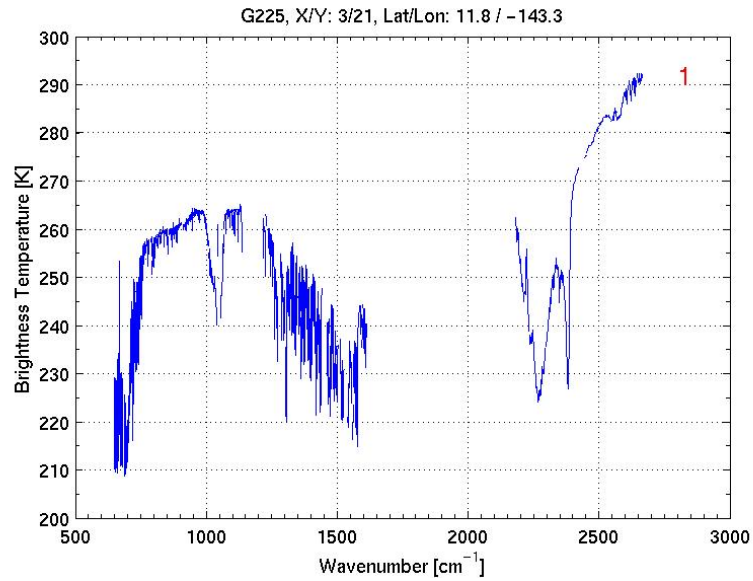


AIRS Measurements (Nighttime)

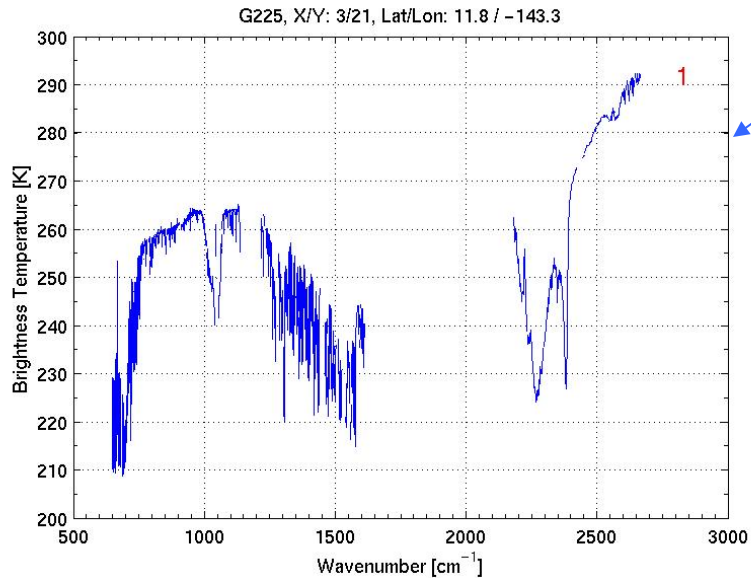
6-Sept-2002, Brightness Temperature [K] at 1000 cm^{-1}
Descending Granules



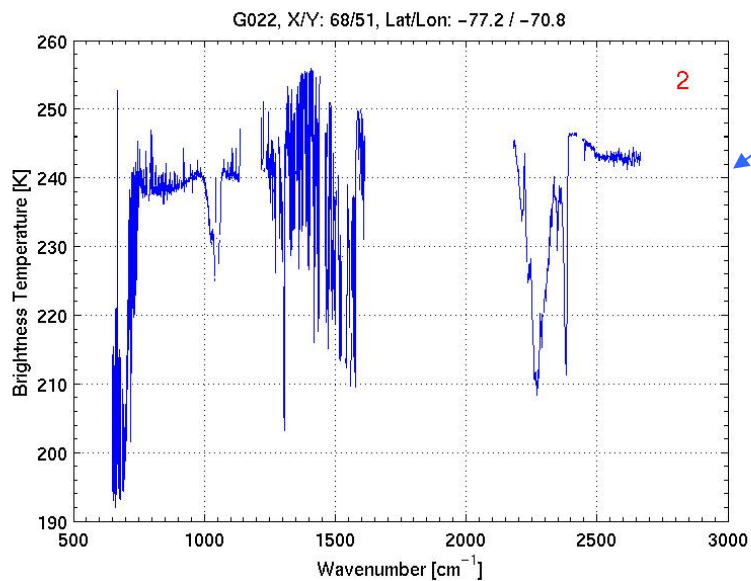
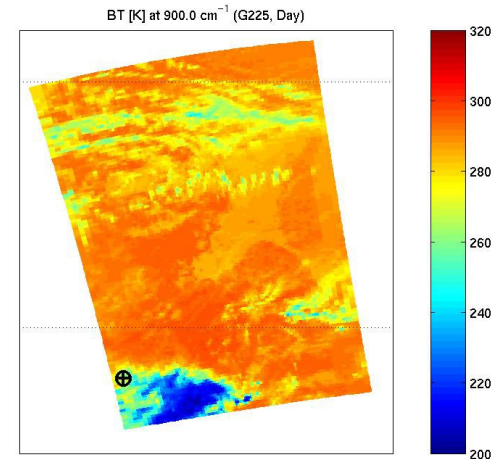
AIRS Observations (1)



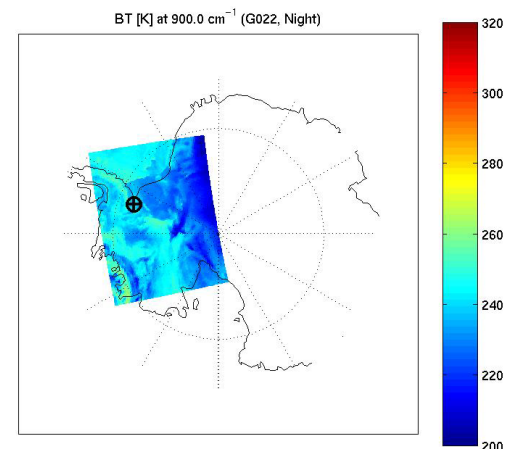
AIRS Observations (1)



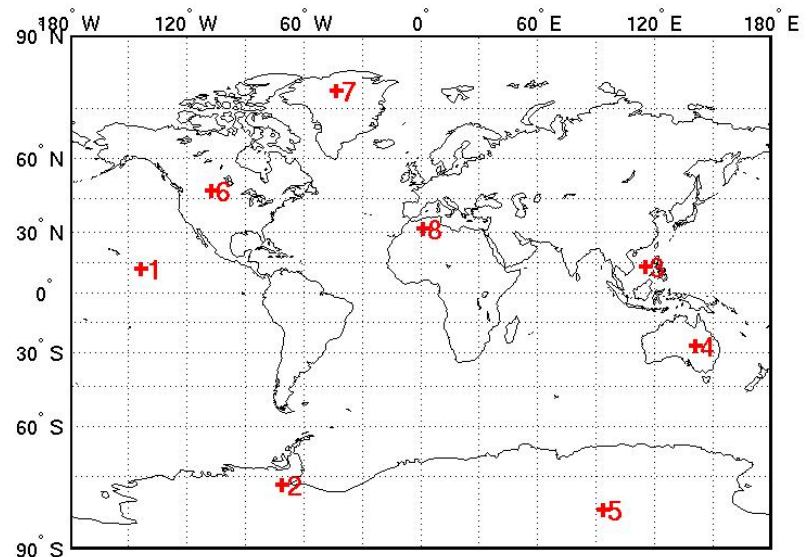
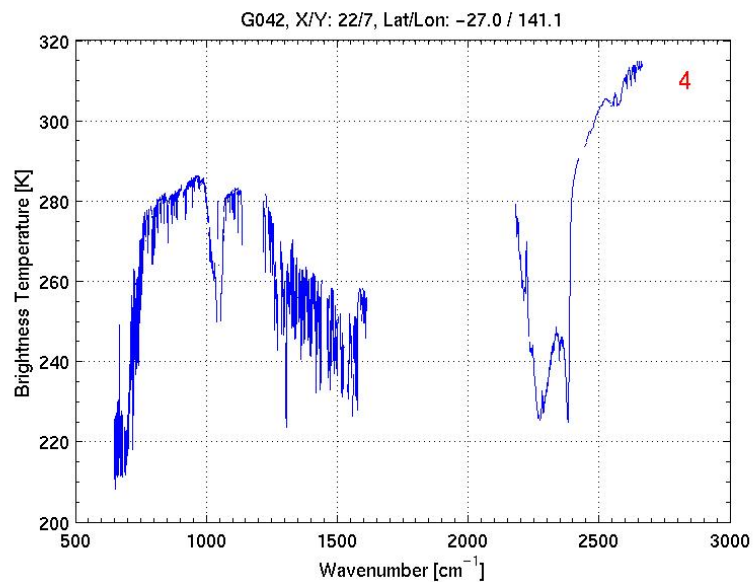
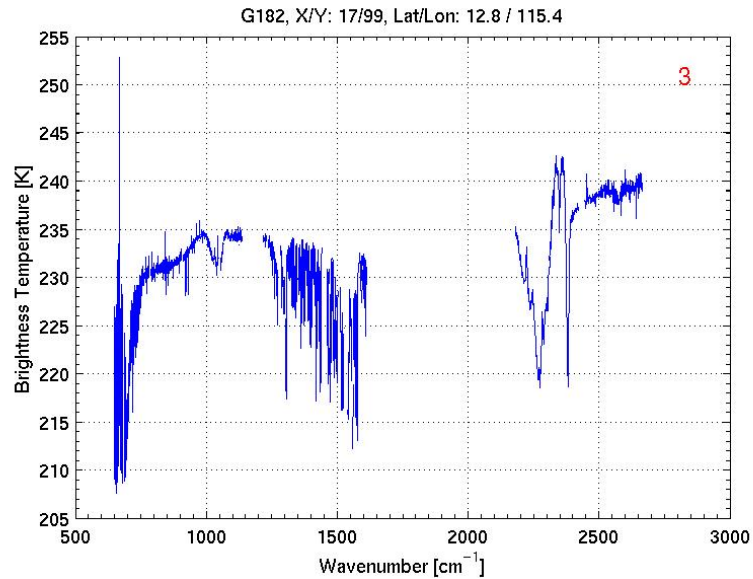
Transparent Cloud,
Solar Reflection during Daytime



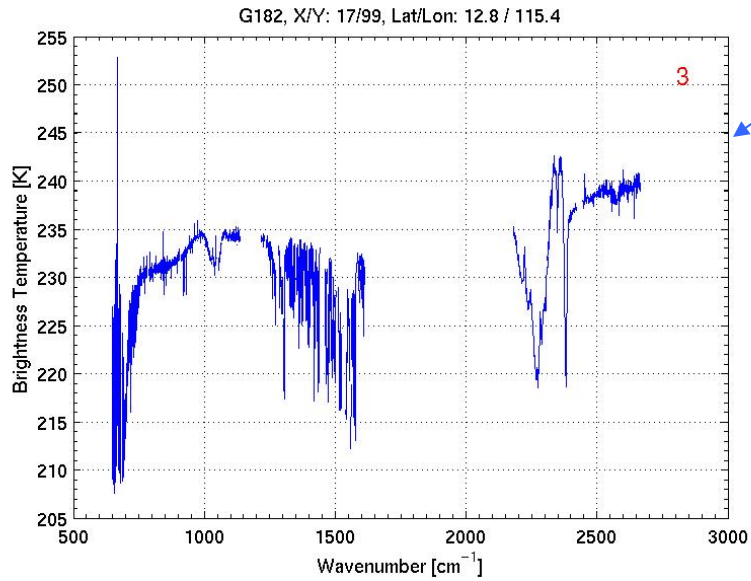
Strong Surface Inversion, Nighttime



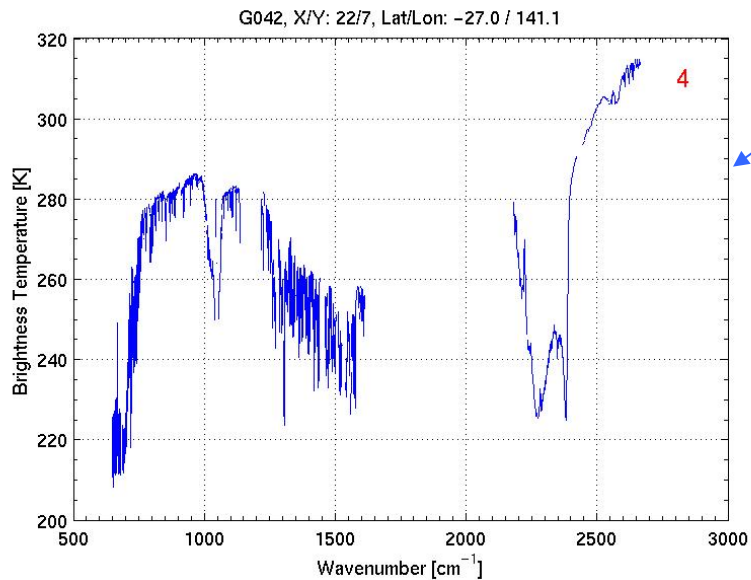
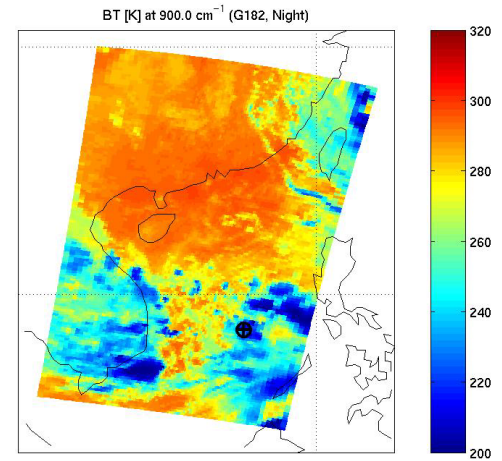
AIRS Observations (2)



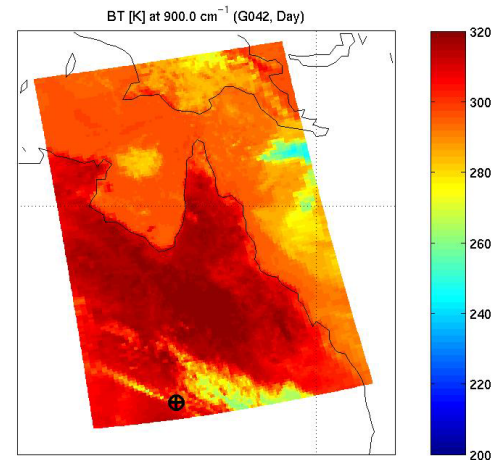
AIRS Observations (2)



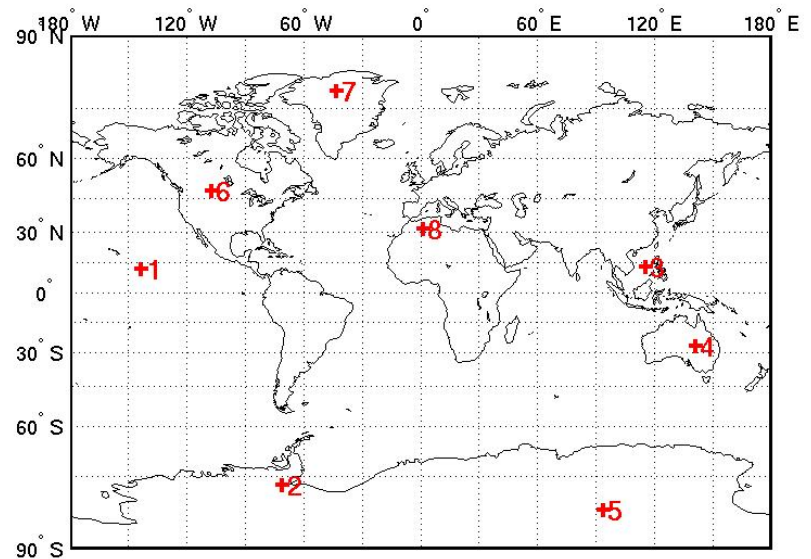
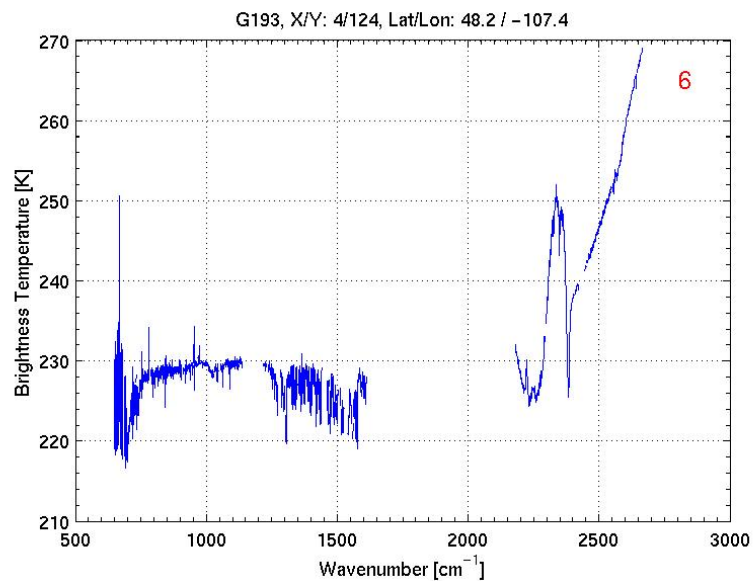
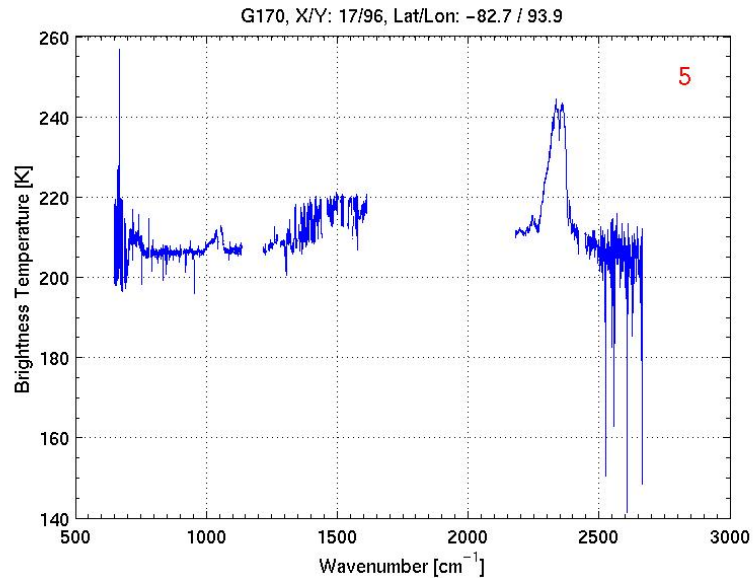
Cloudy, nighttime



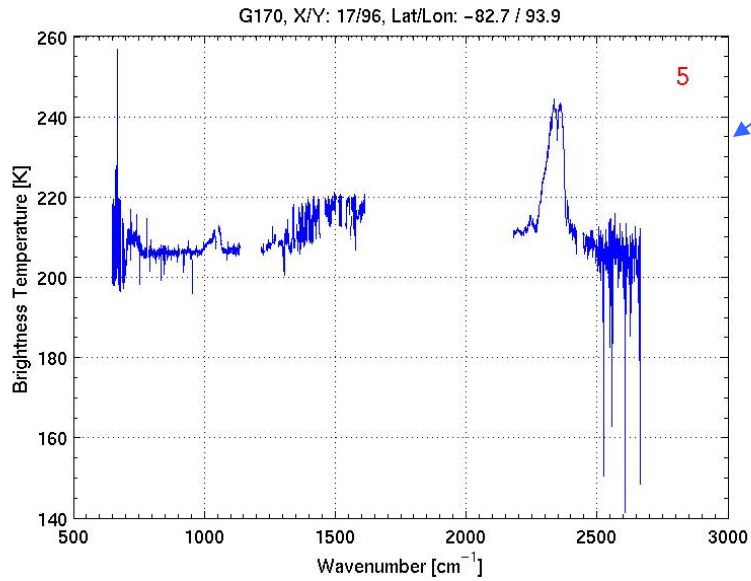
Desert, Solar reflection during daytime, transparent cloud



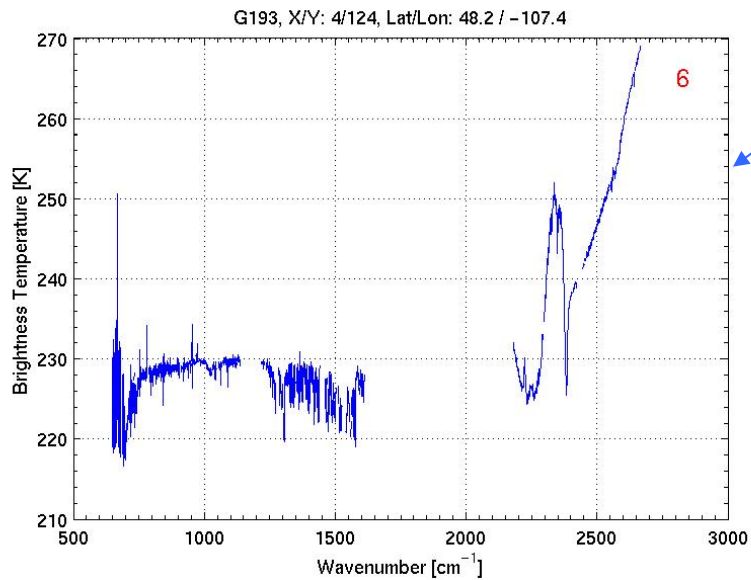
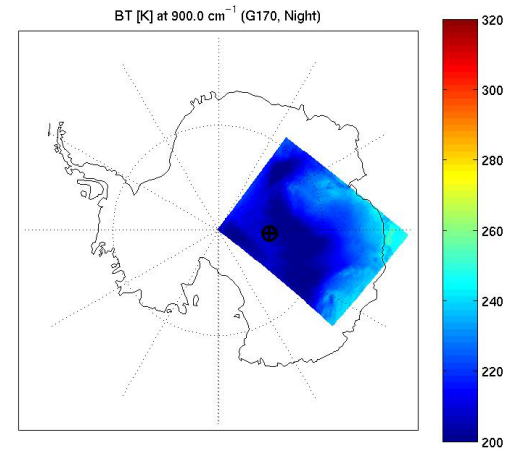
AIRS Observations (3)



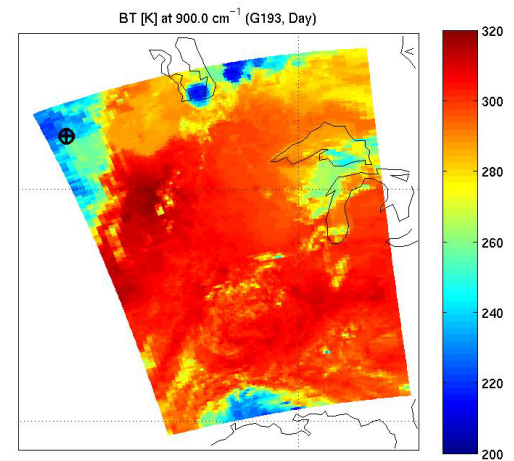
AIRS Observations (3)



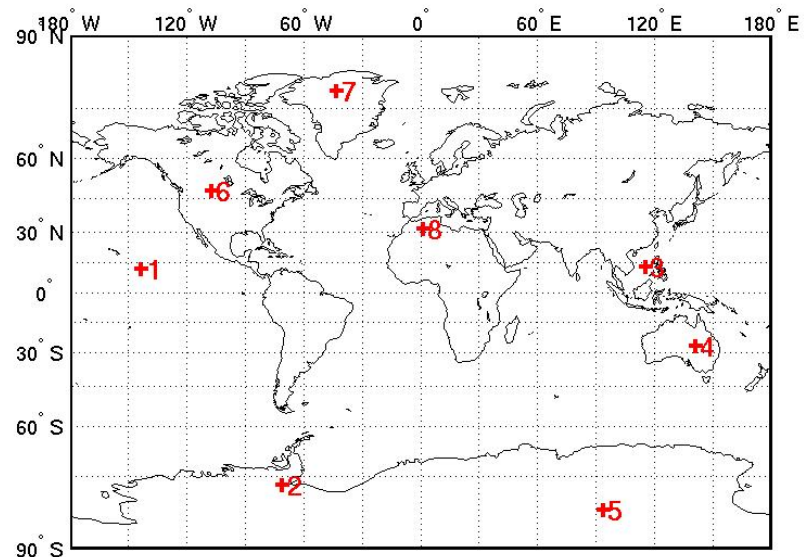
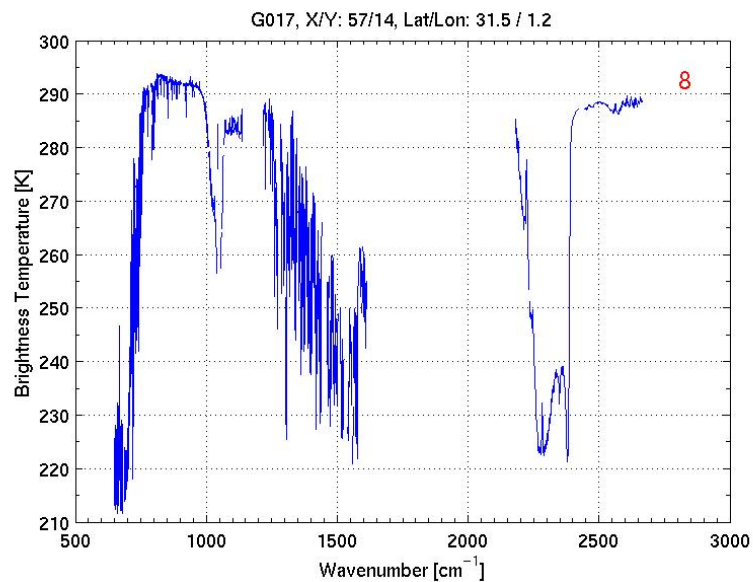
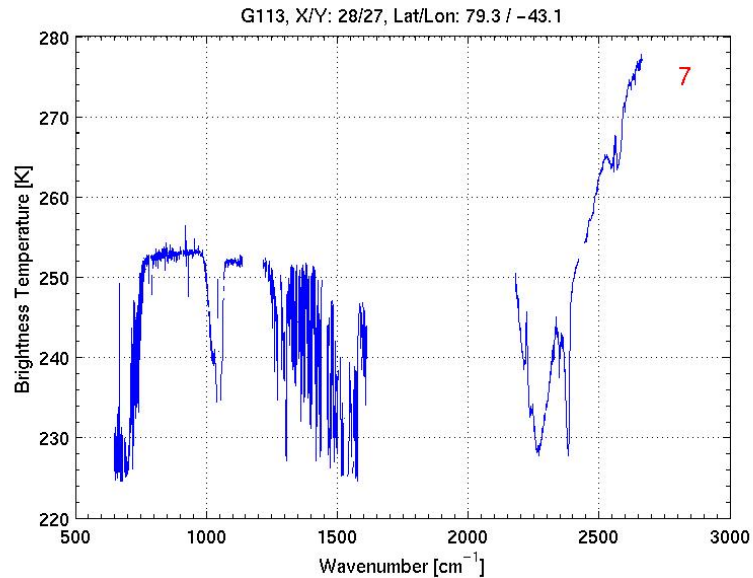
Thick cloud, nighttime



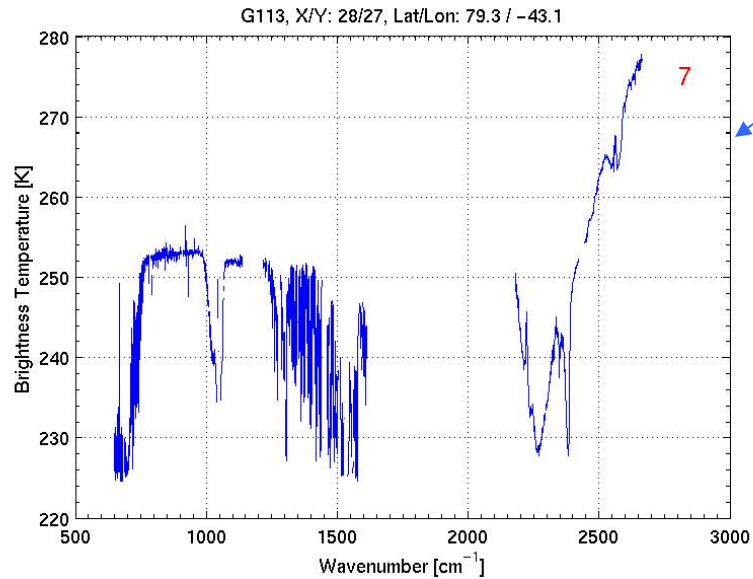
Cloud, Daytime



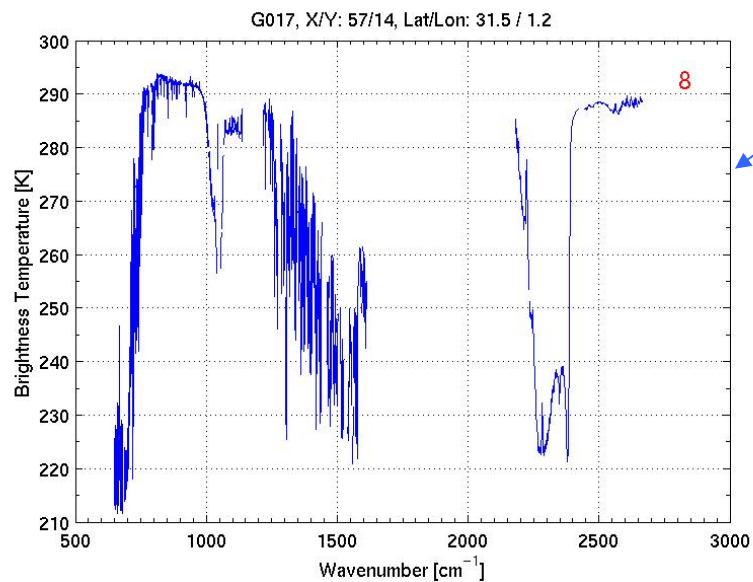
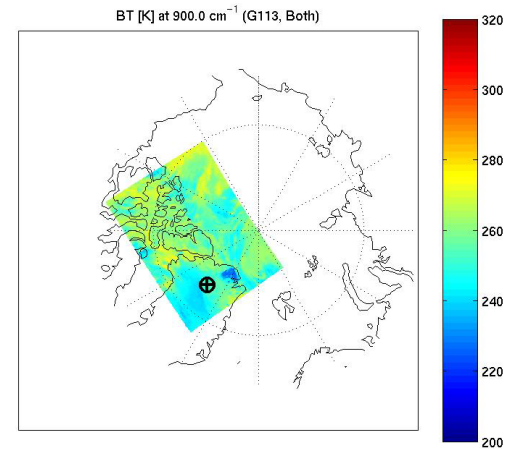
AIRS Observations (4)



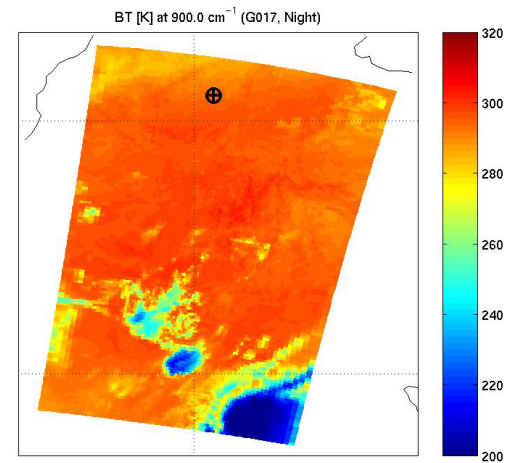
AIRS Observations (4)



Solar Reflection during Daytime



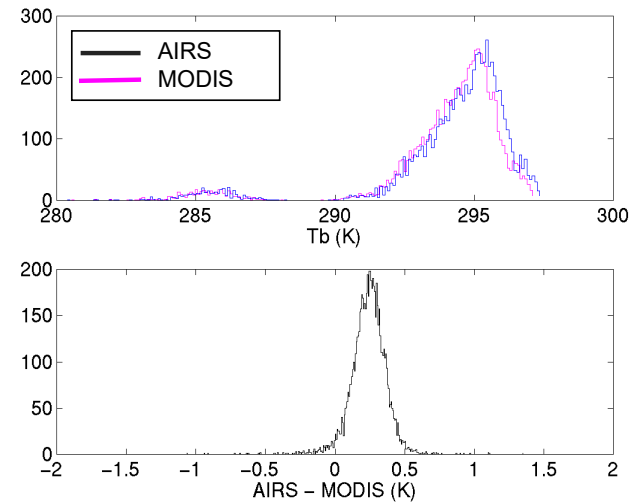
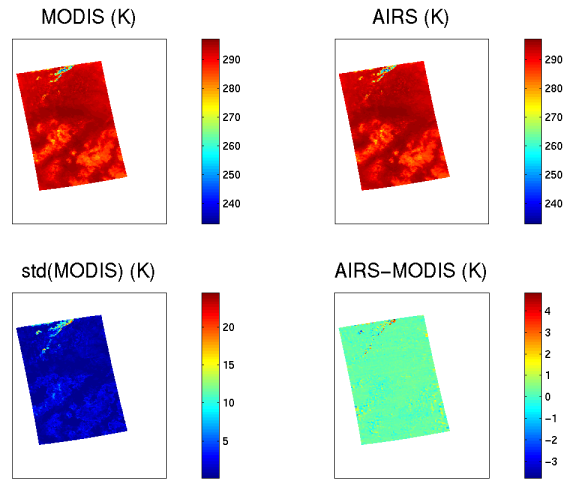
Desert, nighttime



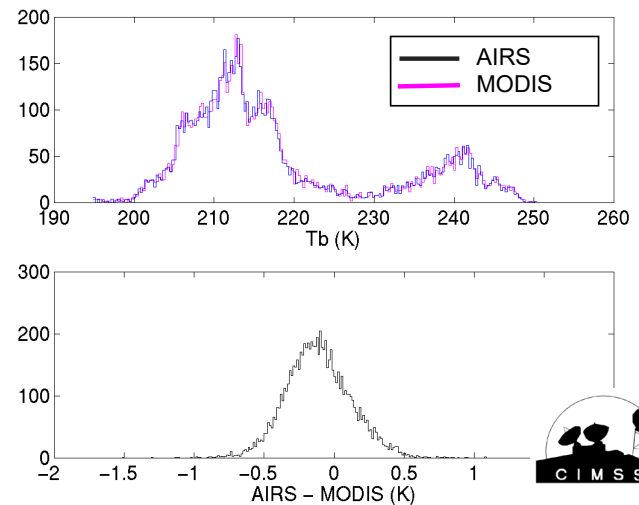
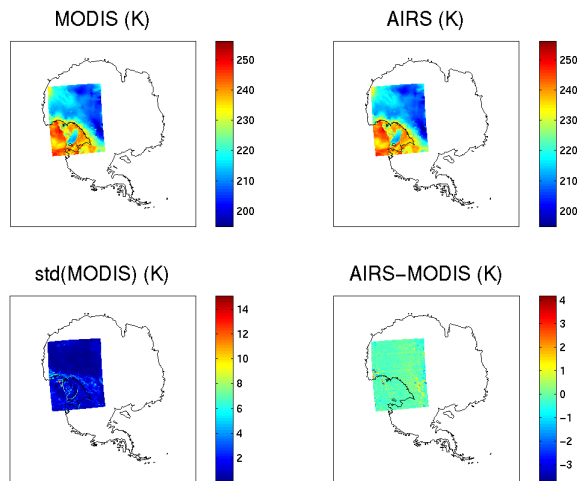
AIRS Agrees well With MODIS

AIRS/MODIS Brightness Temperature Comparisons 20-July-2002, Band 32 (~12.0 μm)

GOES-10
sub-satellite point

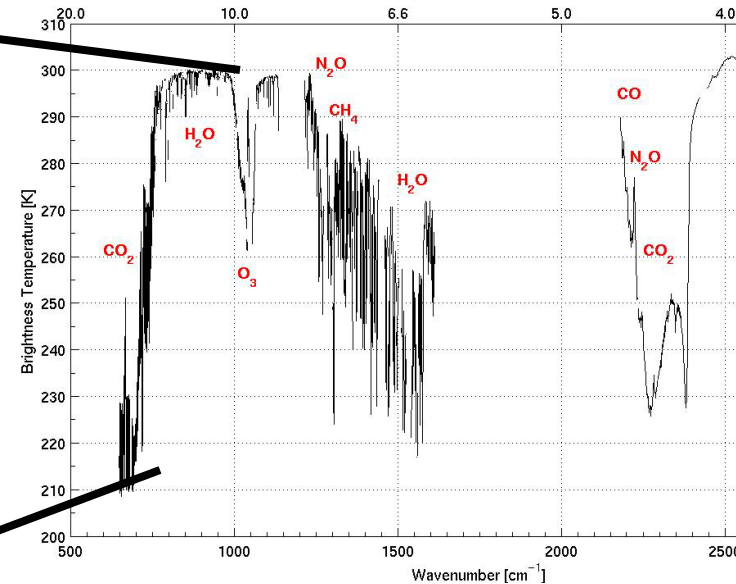
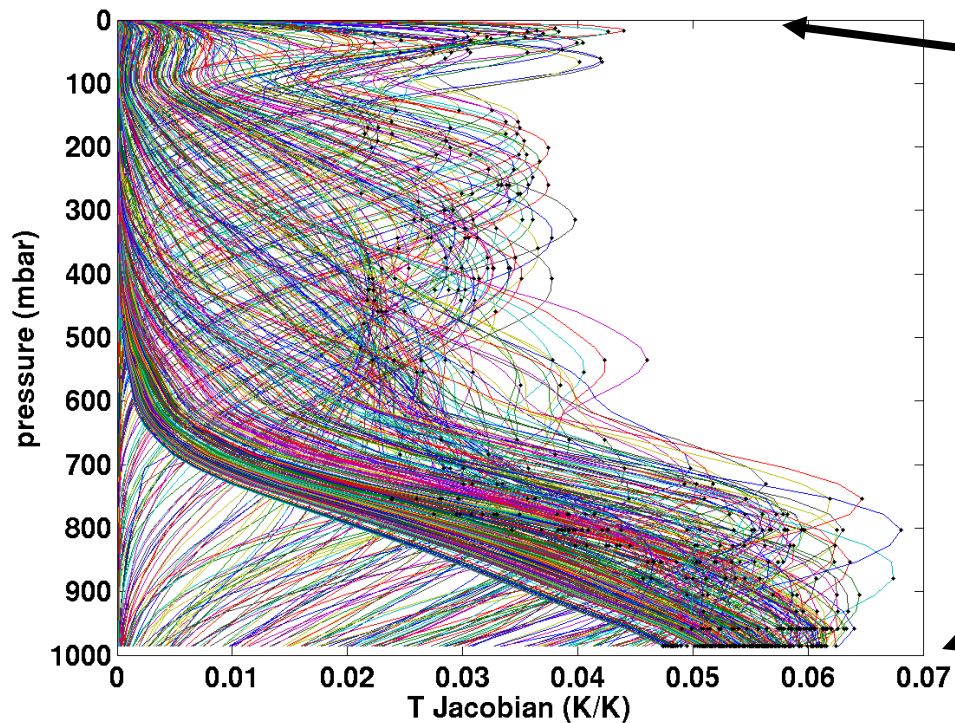


Dome Concordia,
Antarctica



AIRS movie

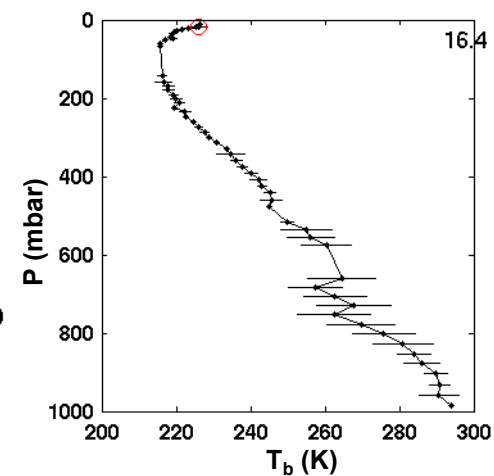
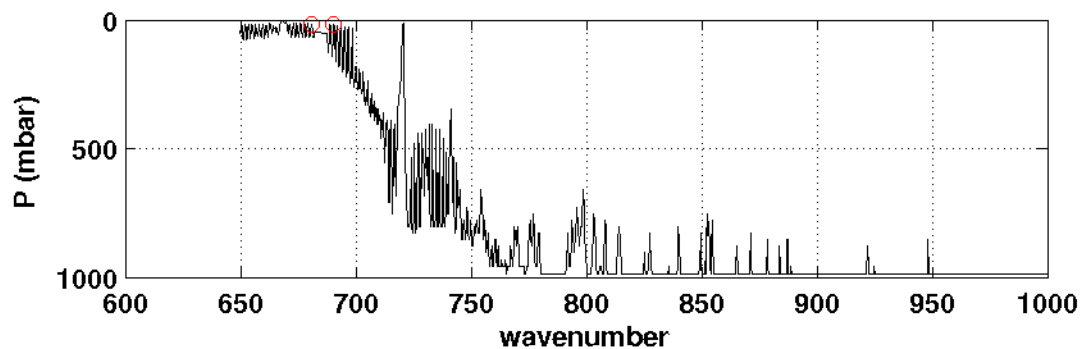
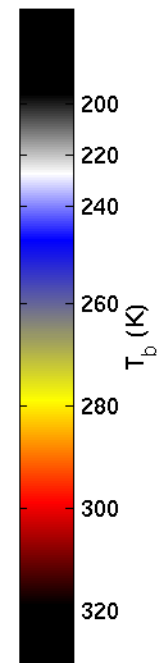
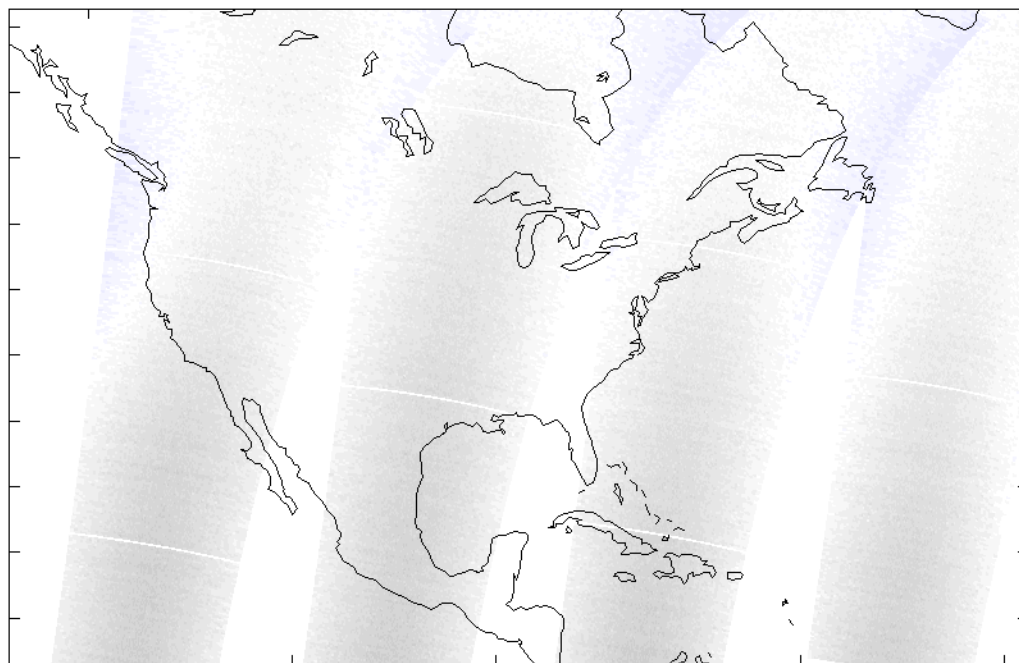
AIRS Clear Sky Temperature Jacobians for US Standard atmosphere, $680 \text{ cm}^{-1} < \nu < 900 \text{ cm}^{-1}$, Bad_Flag = 0



↙ Sort channels by pressure of Jacobian peaks

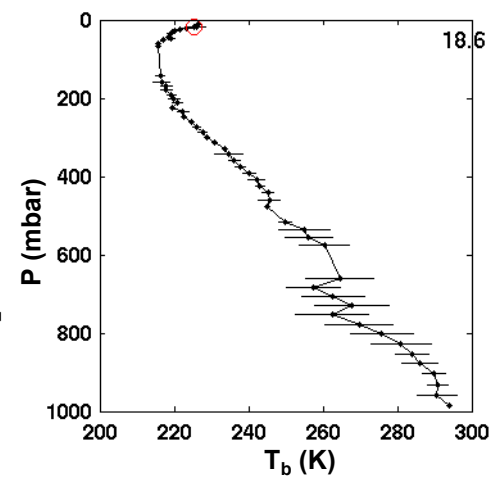
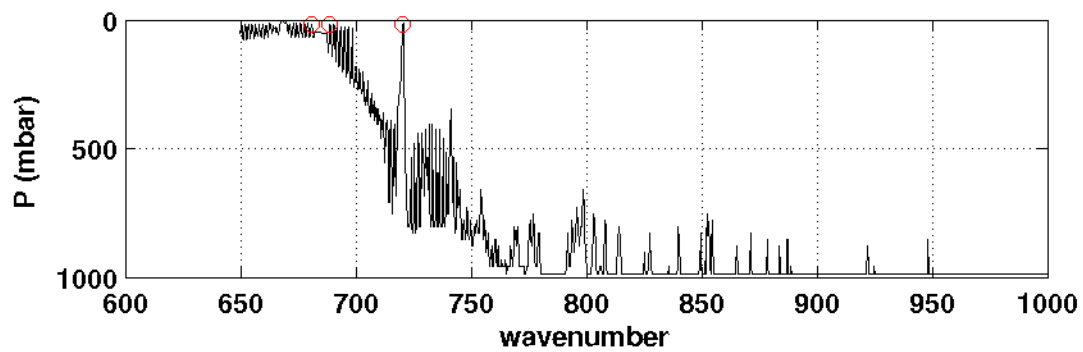
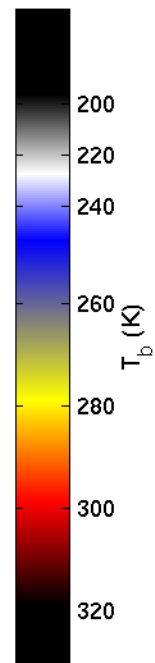
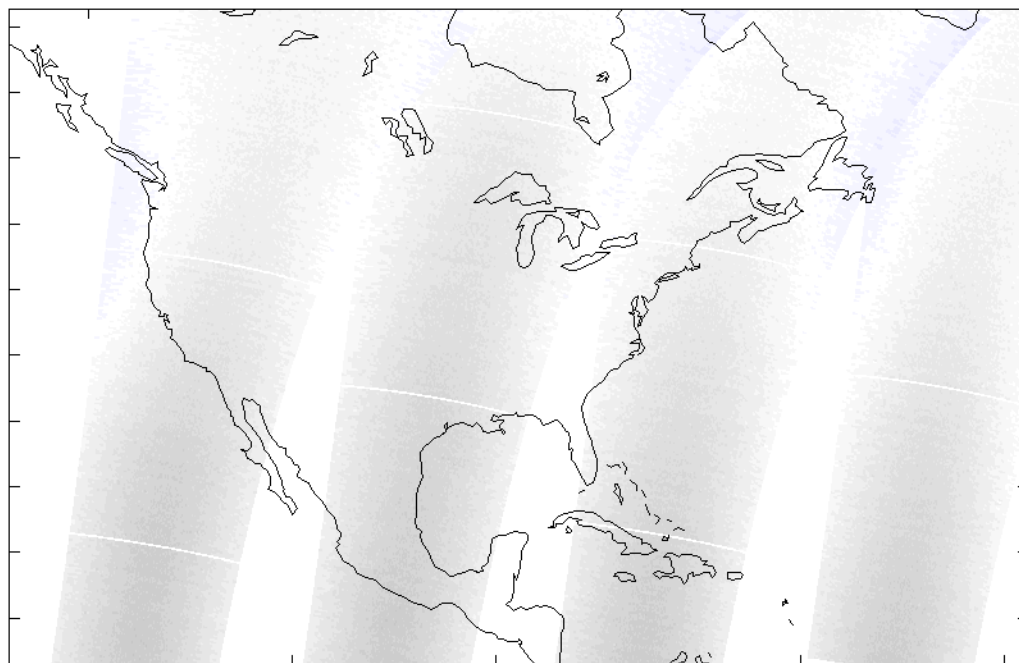
AIRS nighttime granules over CONUS, 6 Sept 2002

16.4 mbar

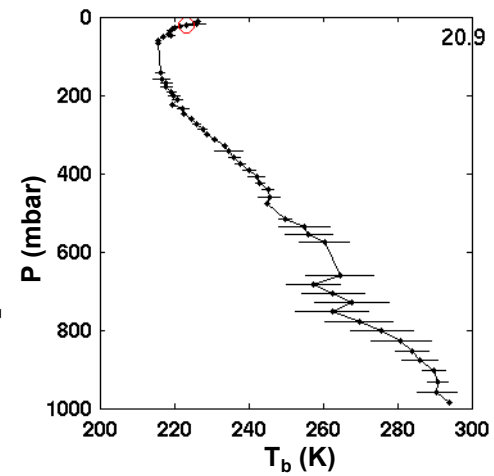
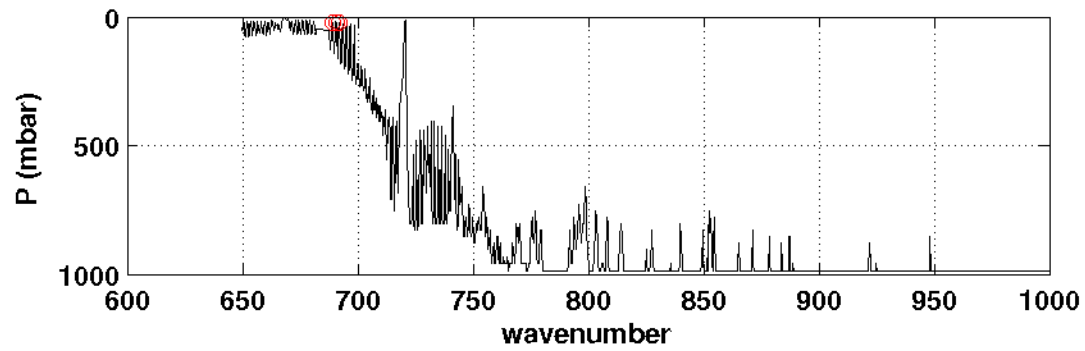
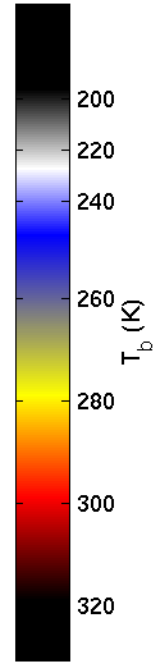
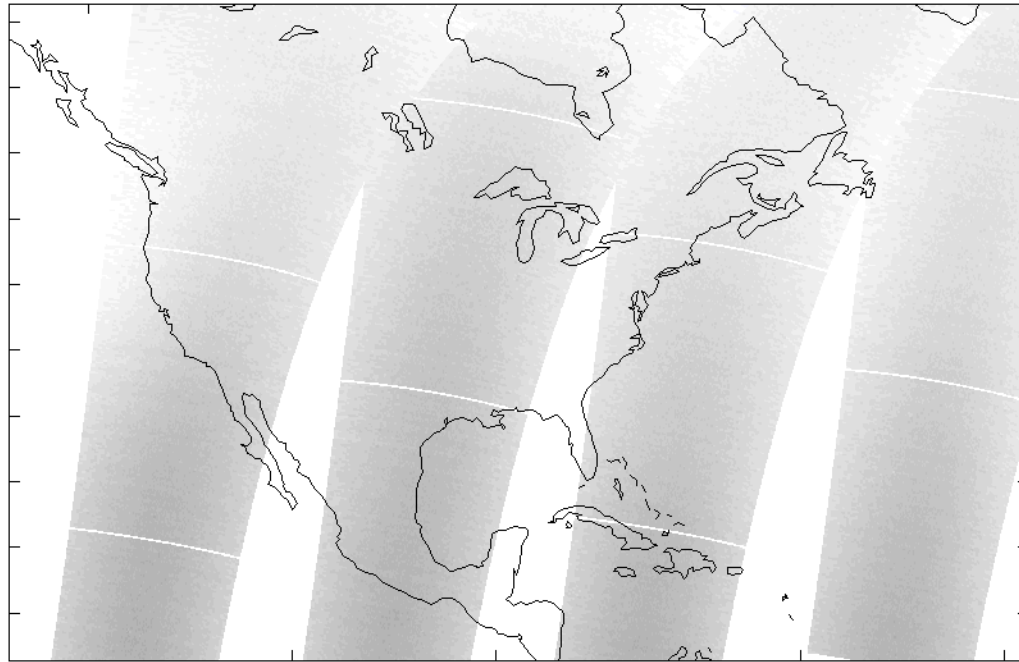


Mouse click or page down to start movie

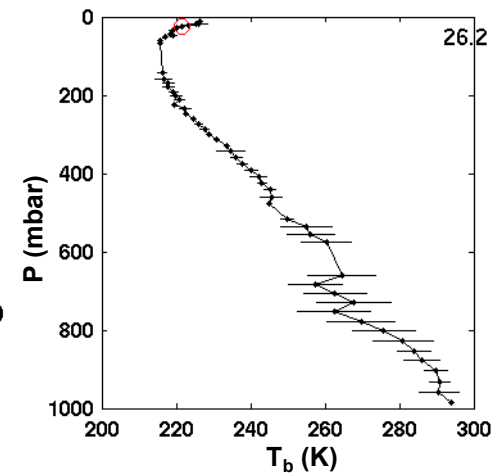
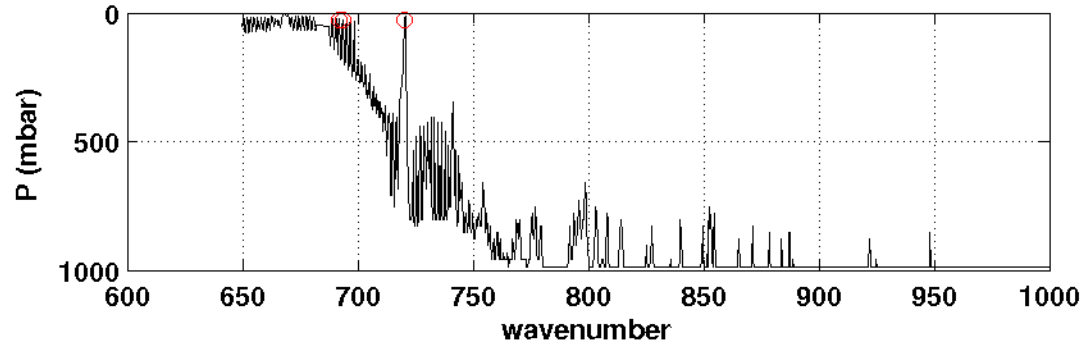
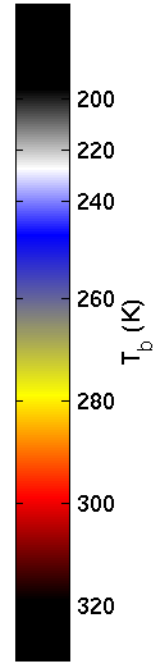
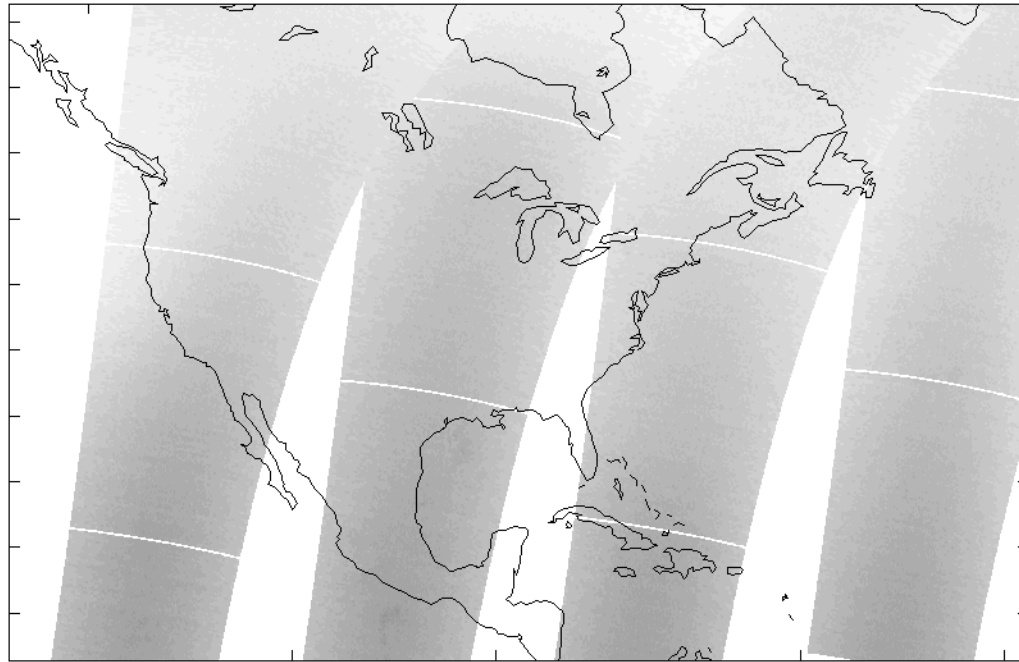
18.6 mbar



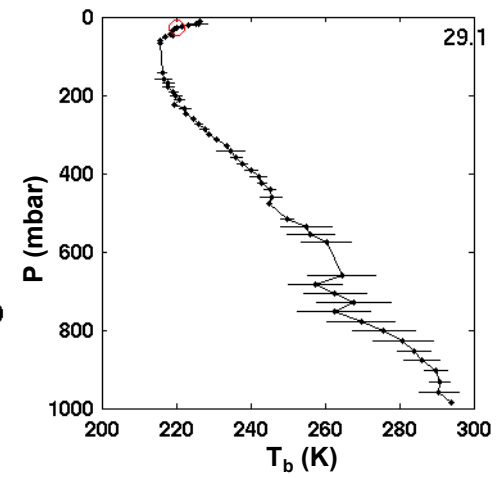
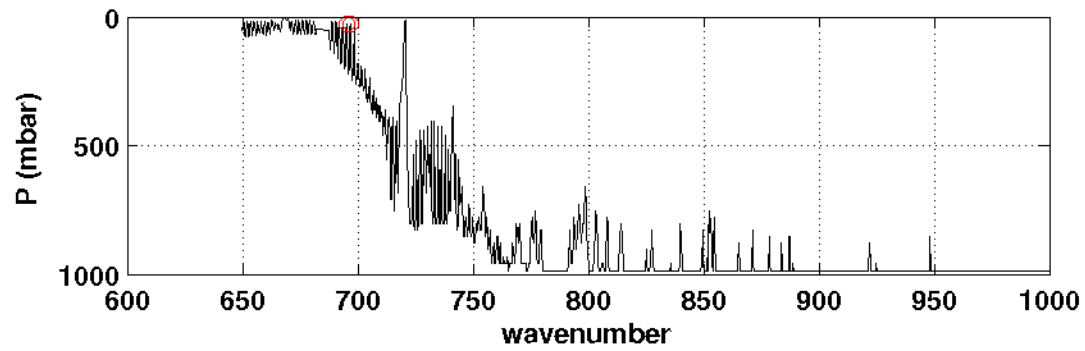
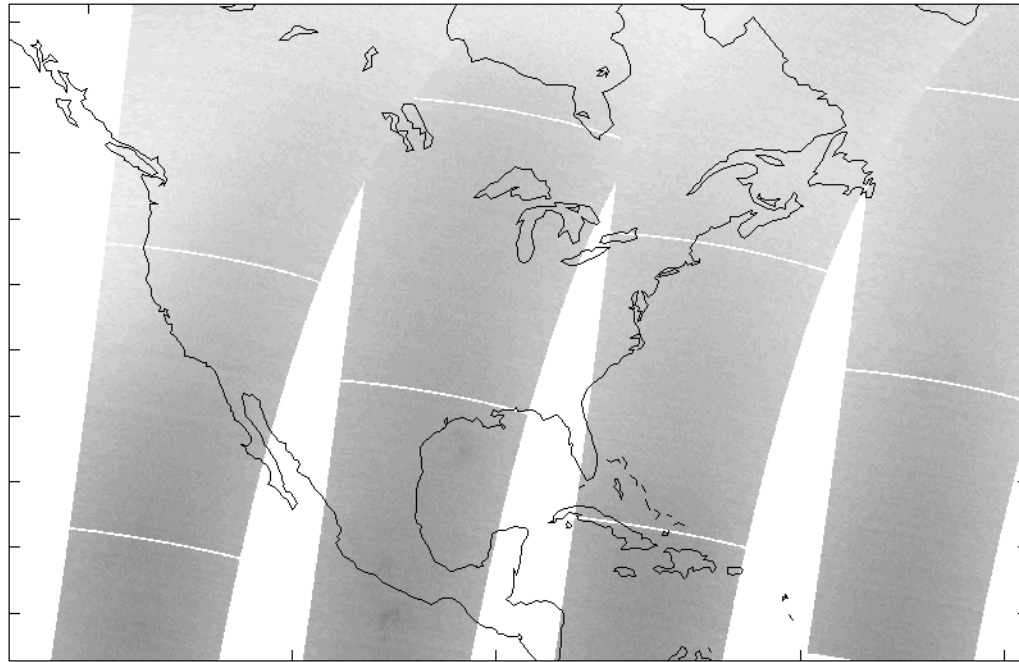
20.9 mbar



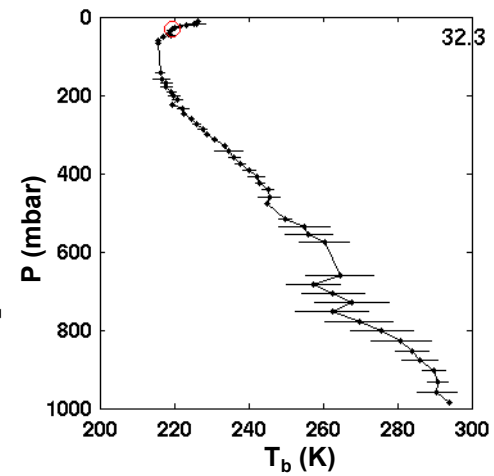
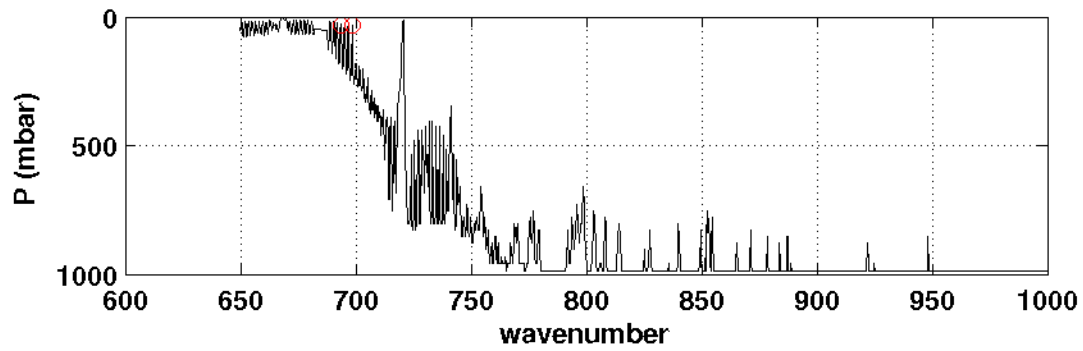
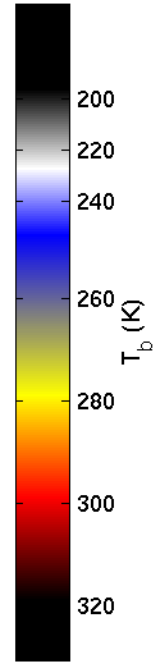
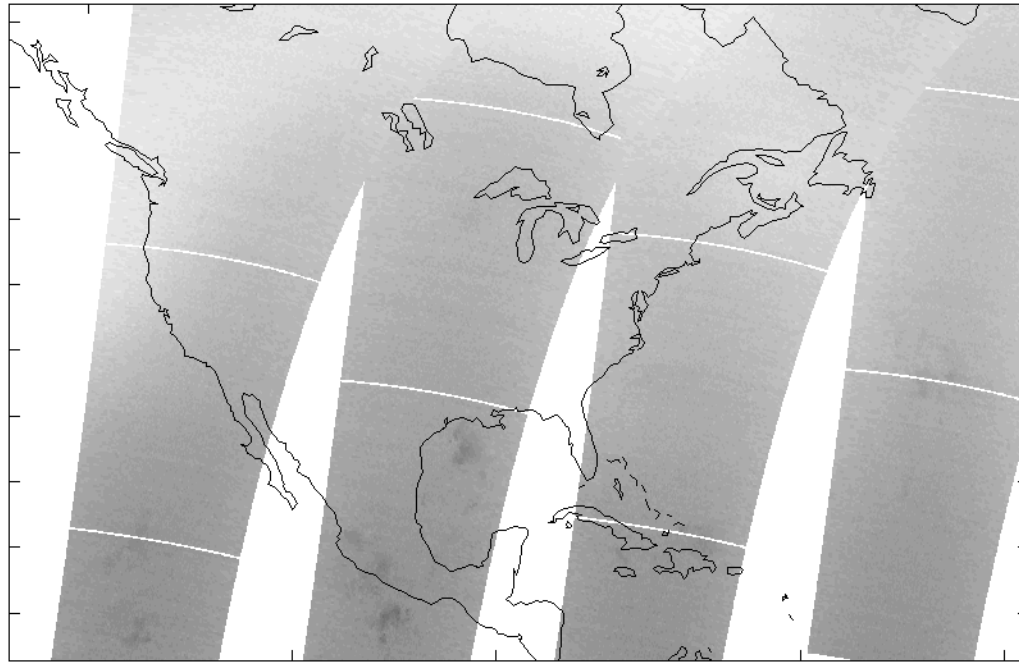
26.2 mbar



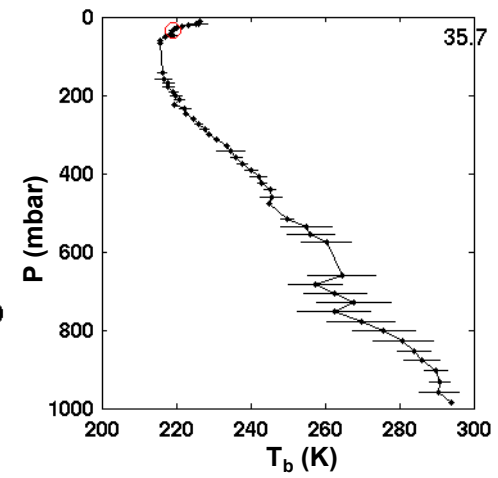
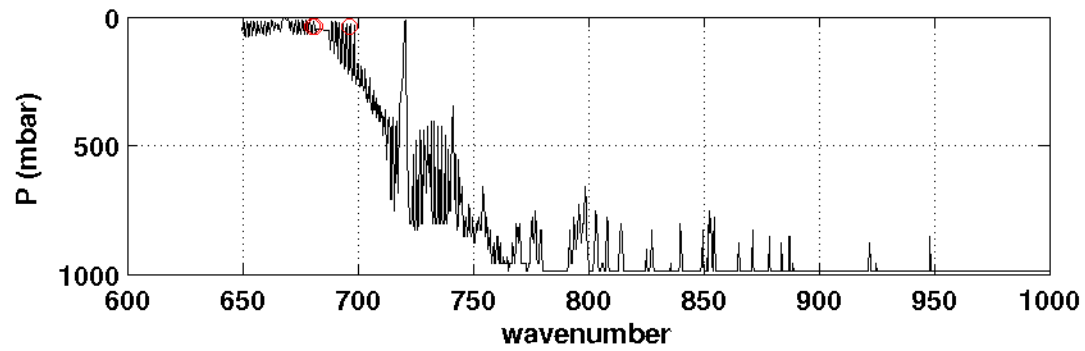
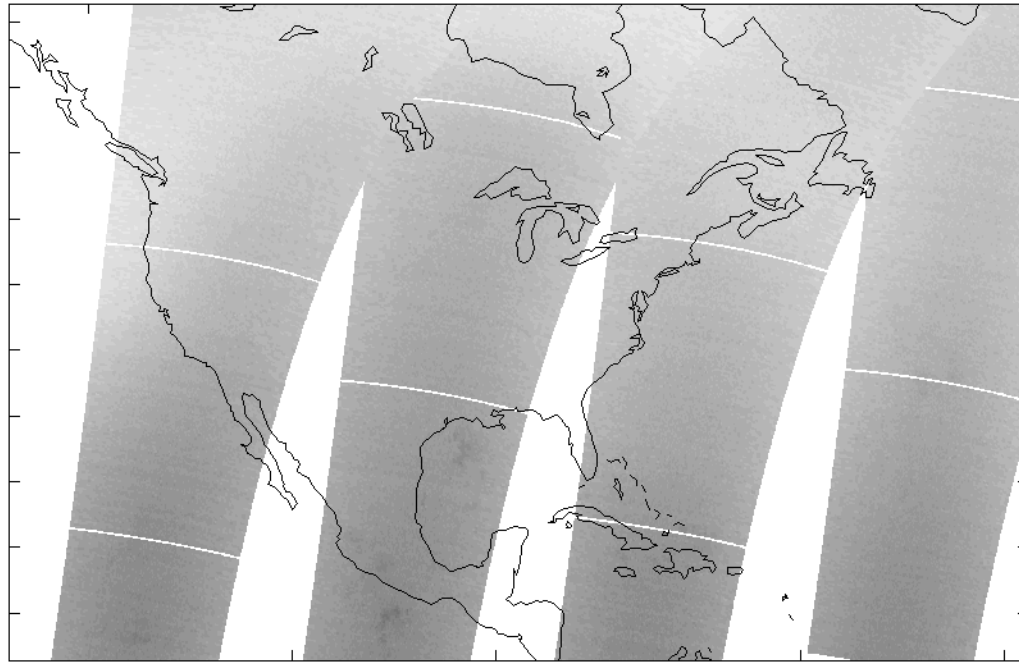
29.1 mbar



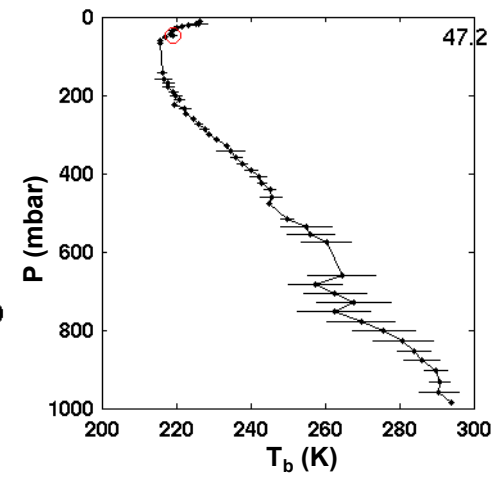
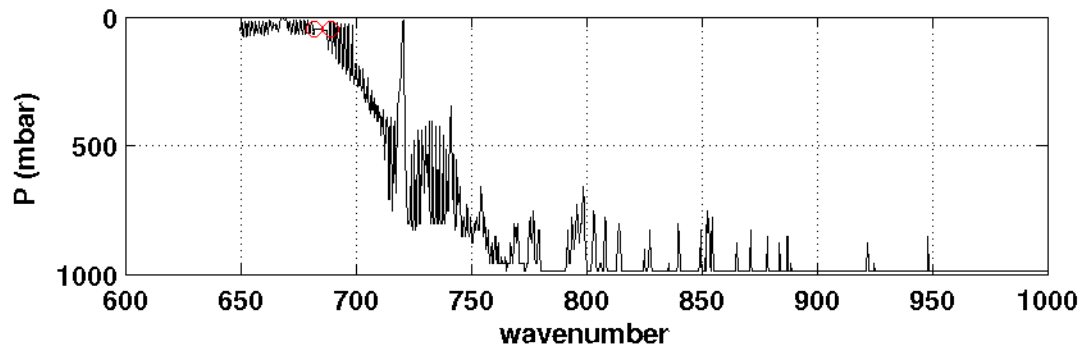
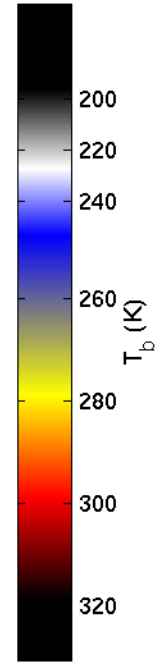
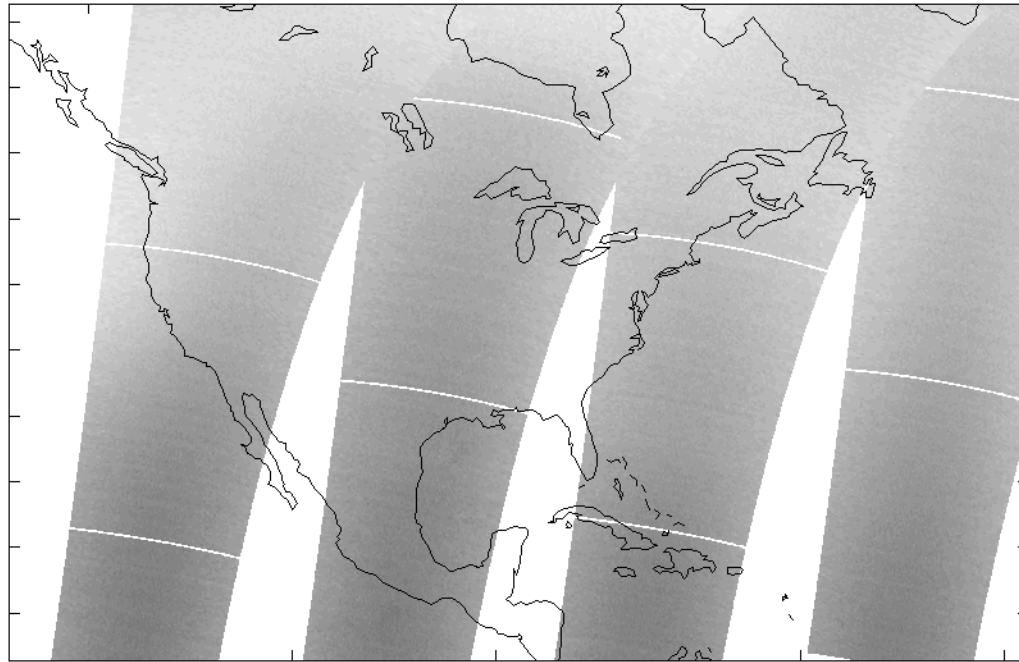
32.3 mbar



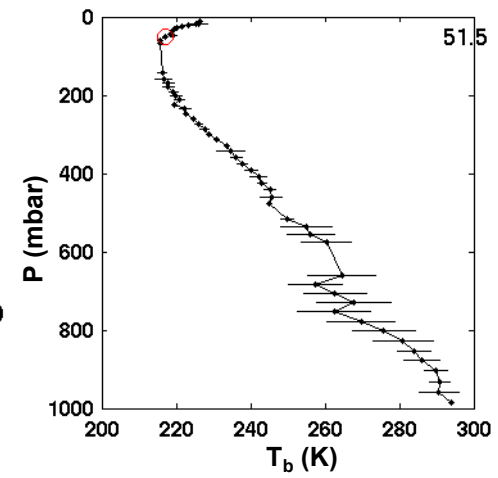
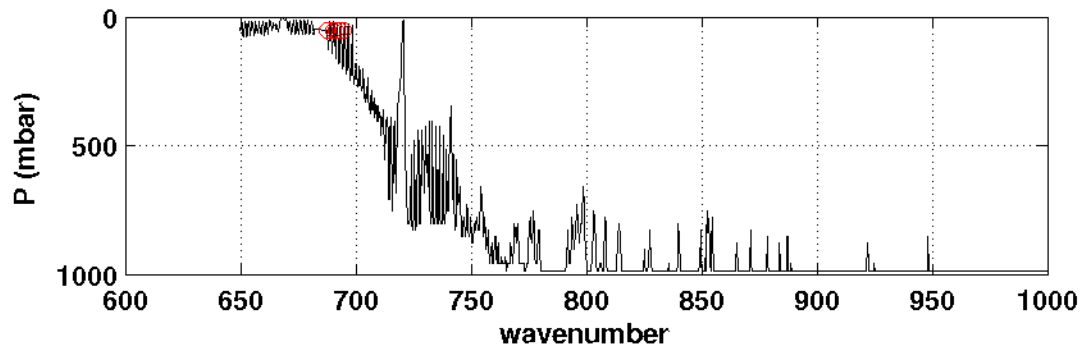
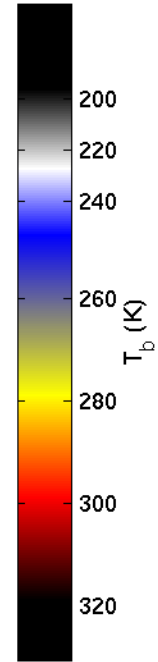
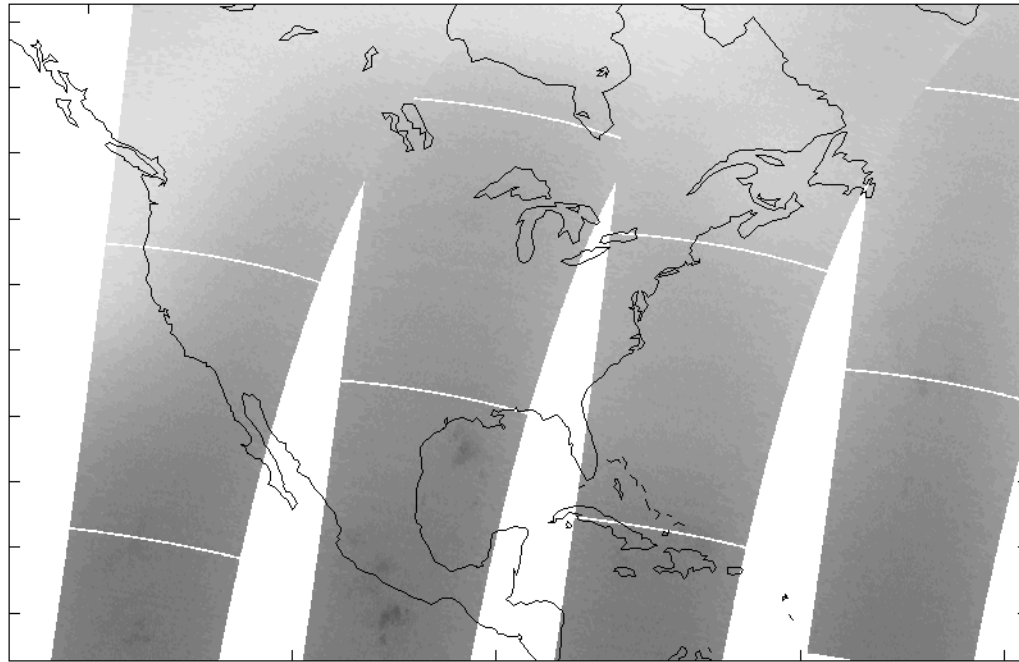
35.7 mbar



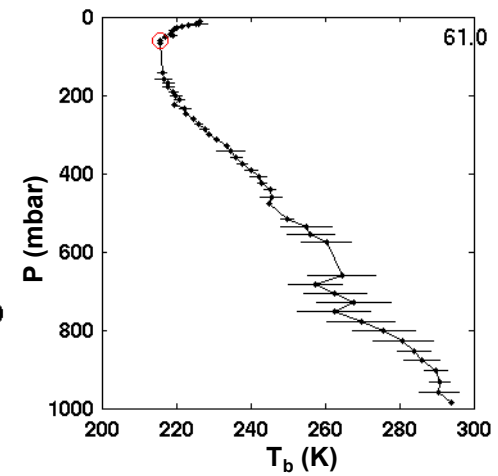
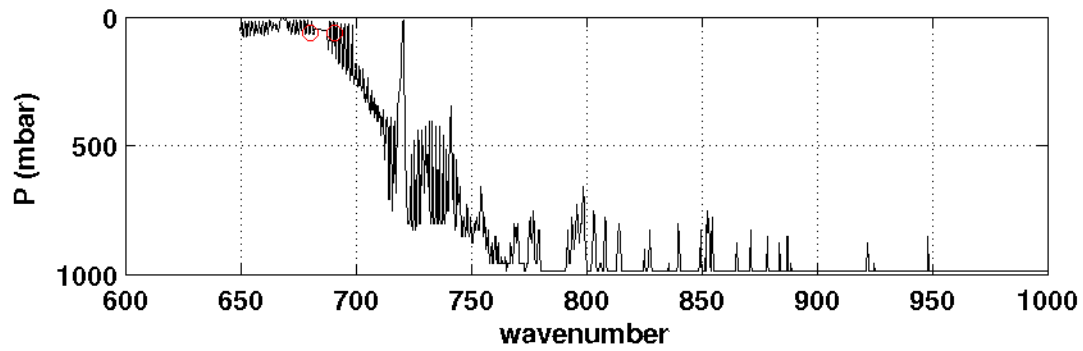
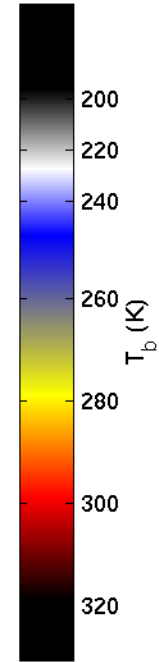
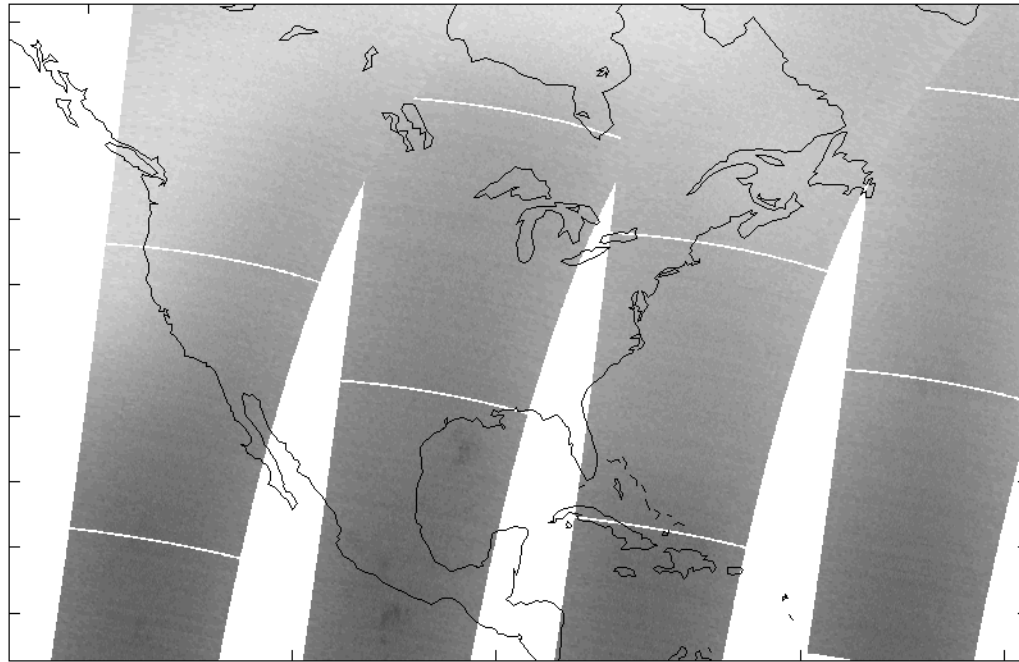
47.2 mbar



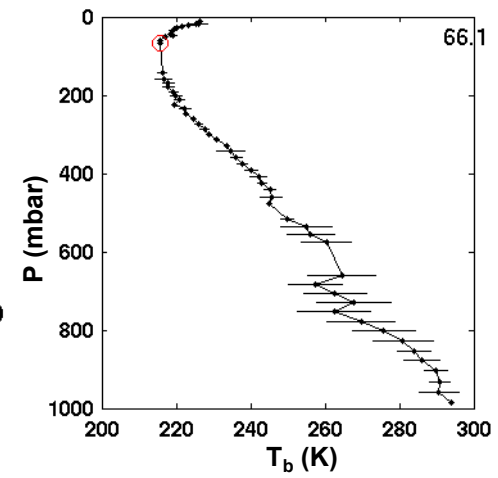
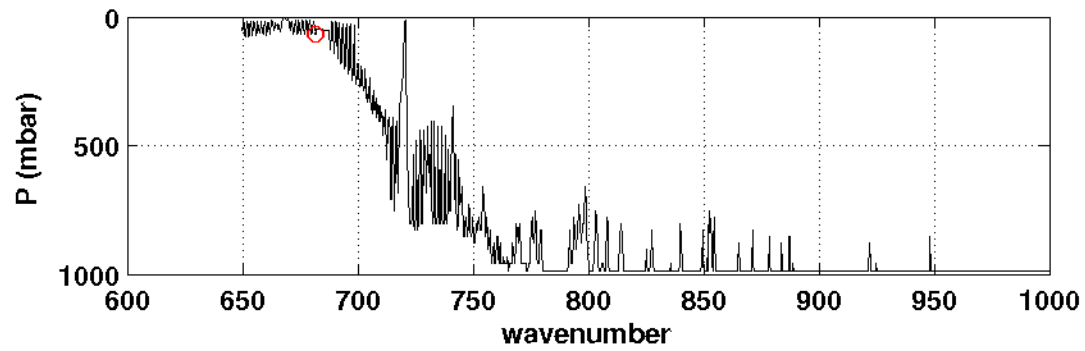
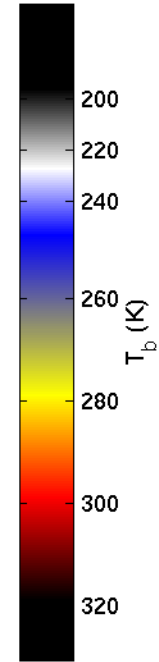
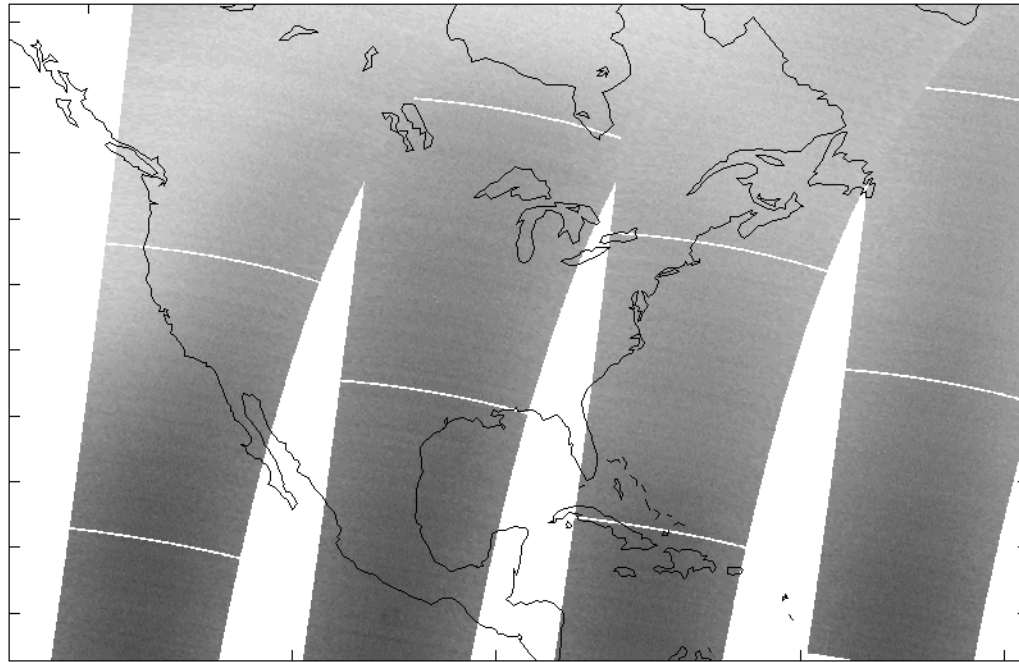
51.5 mbar



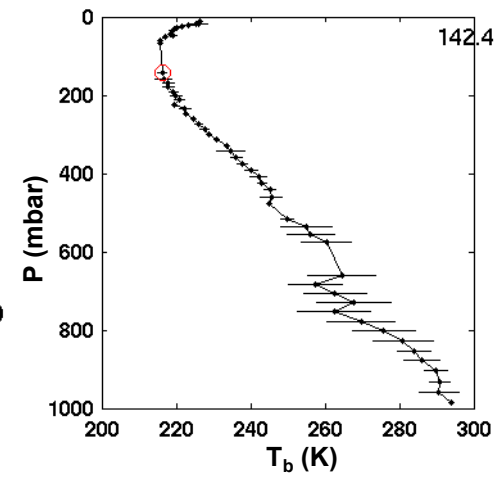
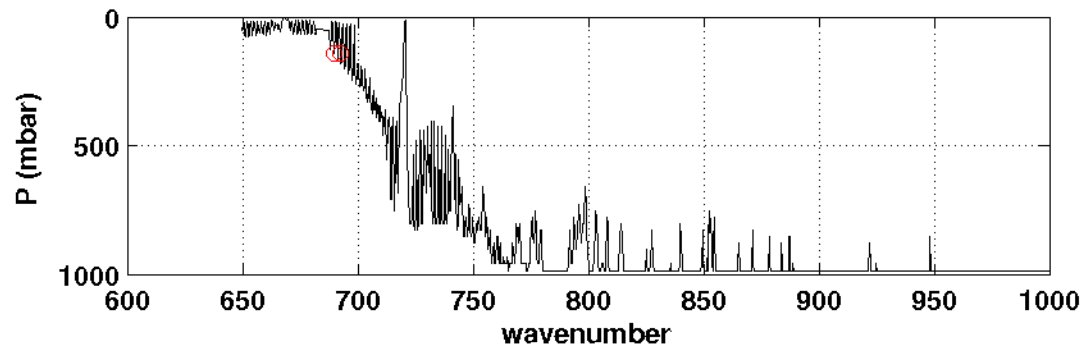
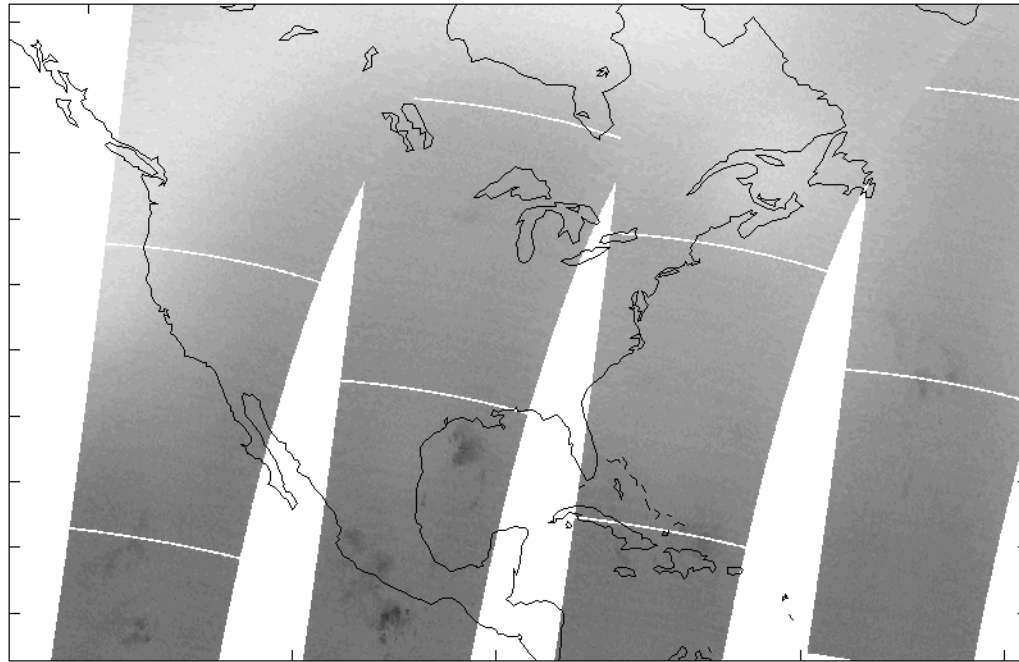
61.0 mbar



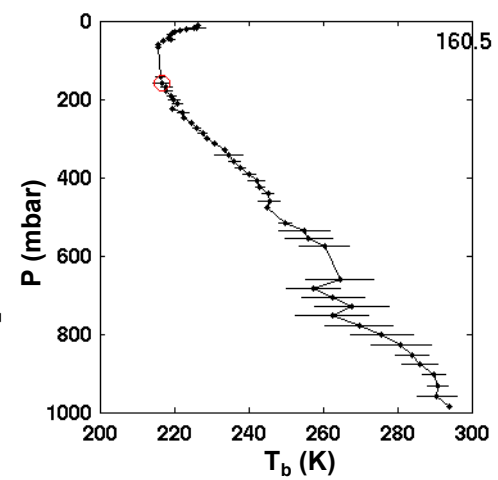
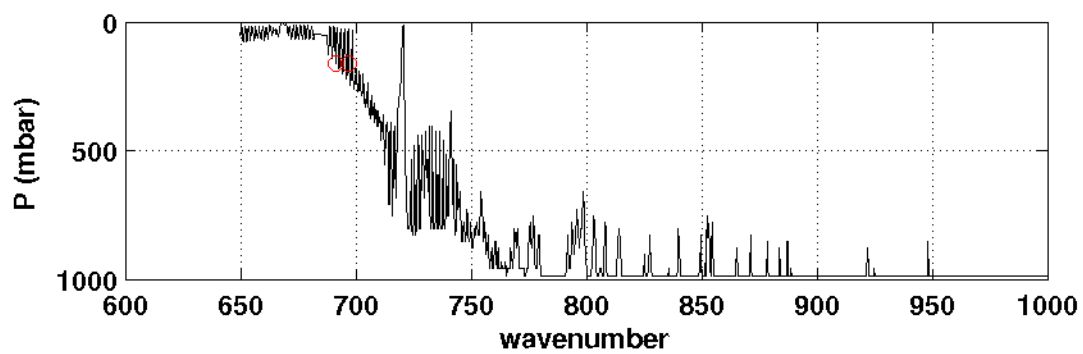
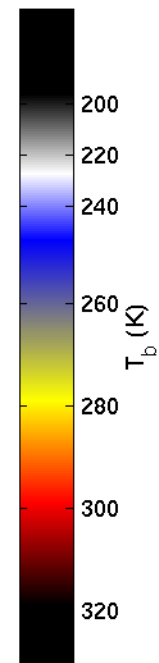
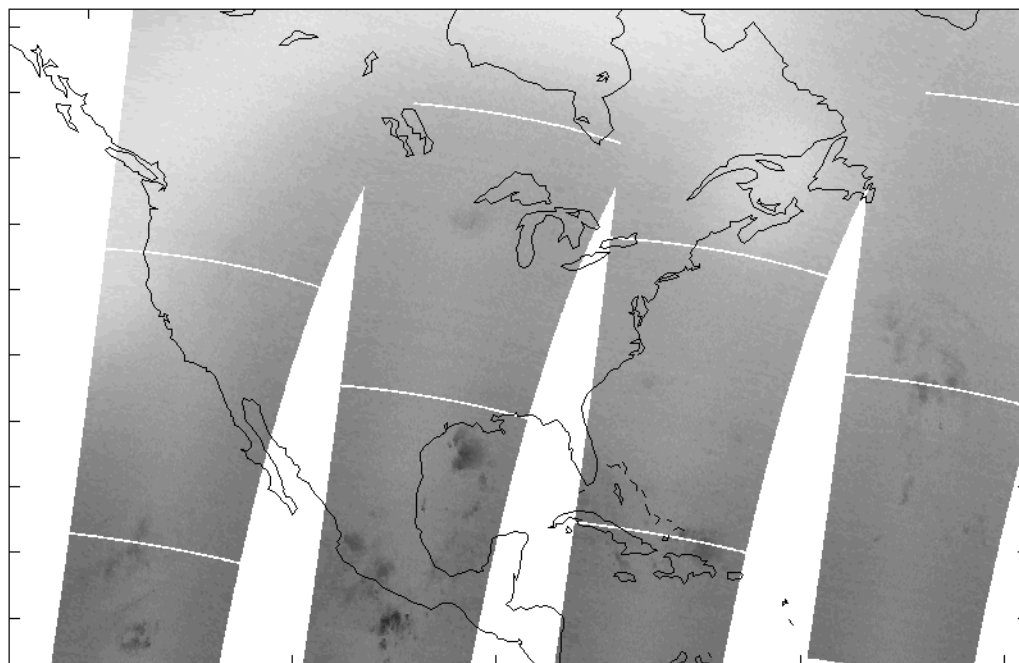
66.1 mbar



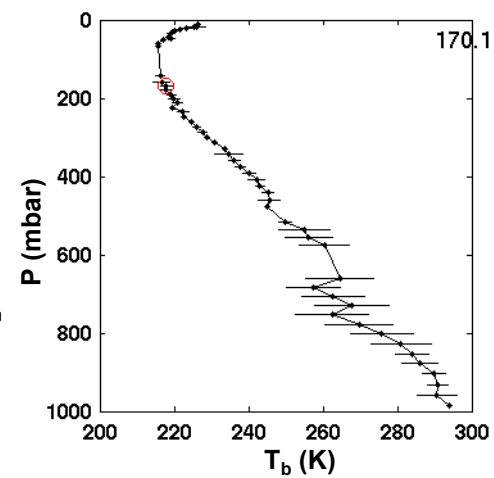
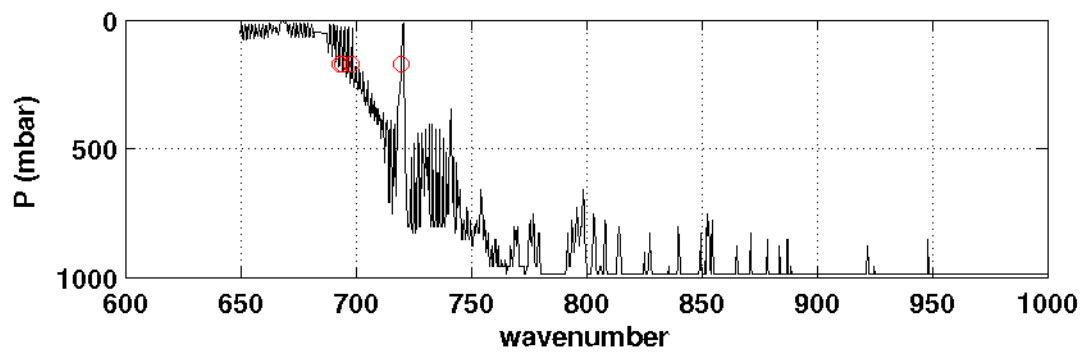
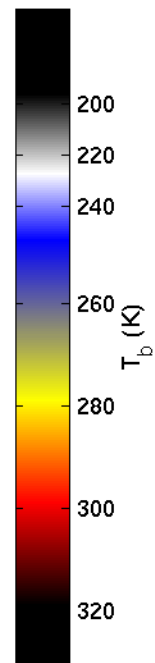
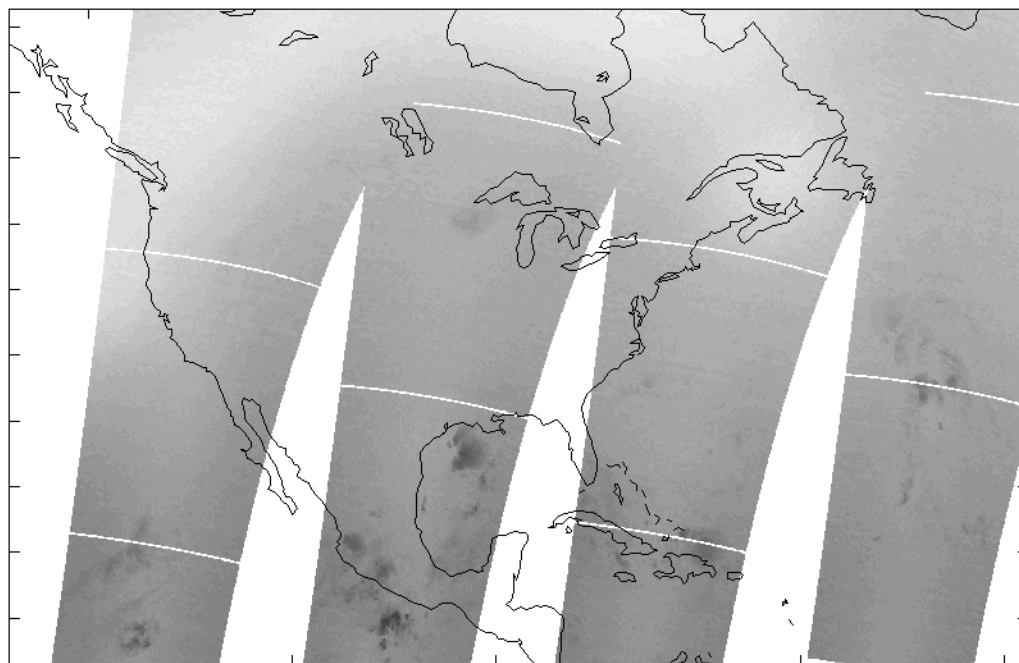
142.4 mbar



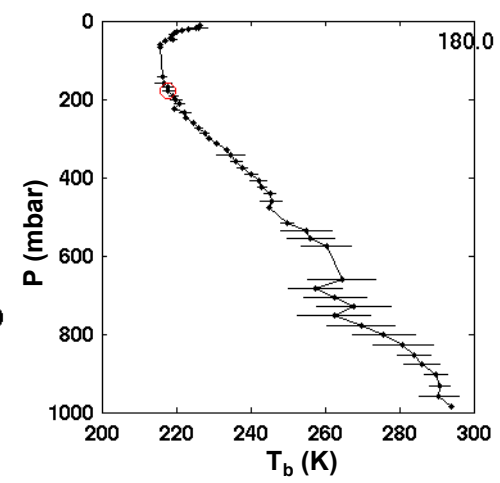
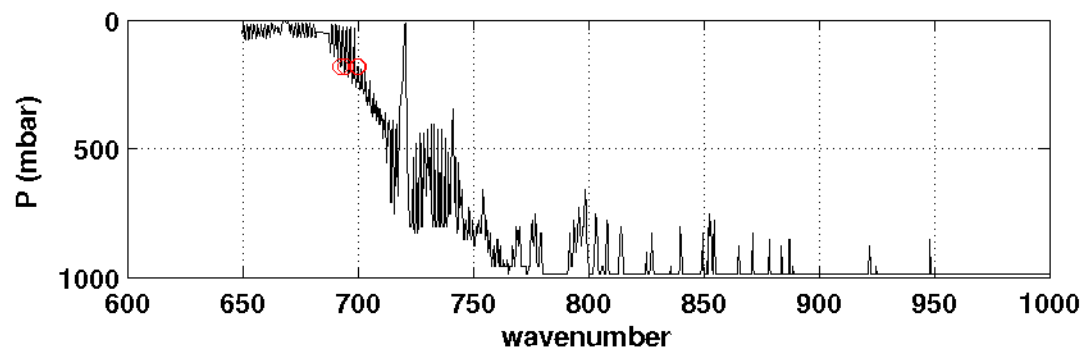
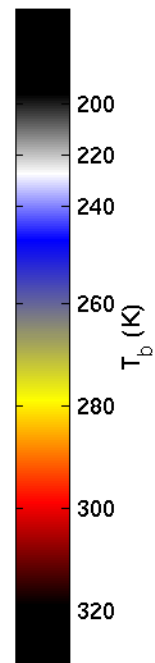
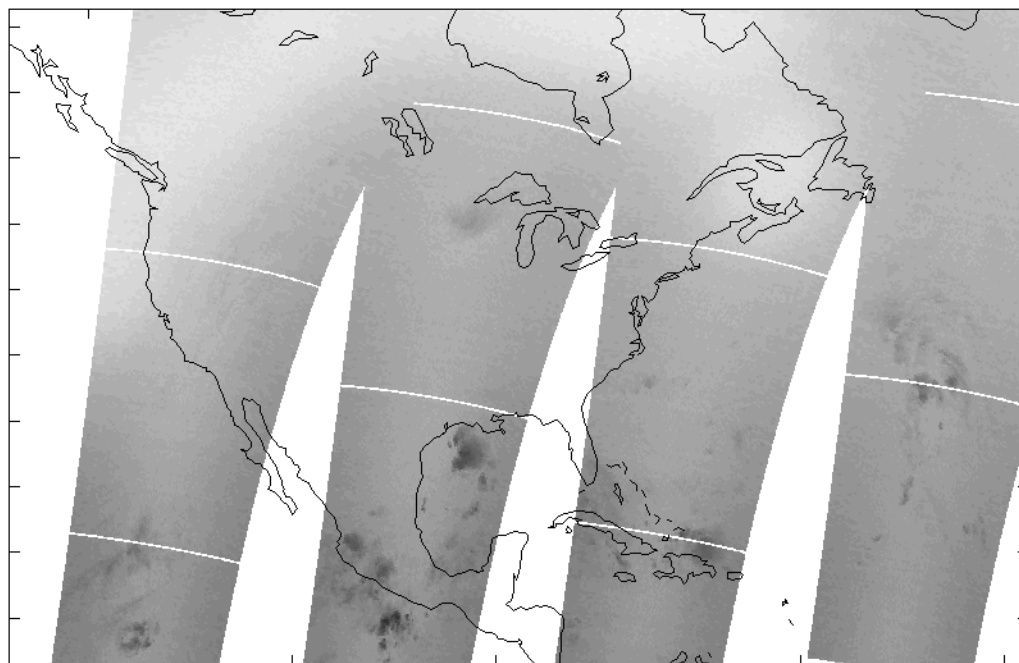
160.5 mbar



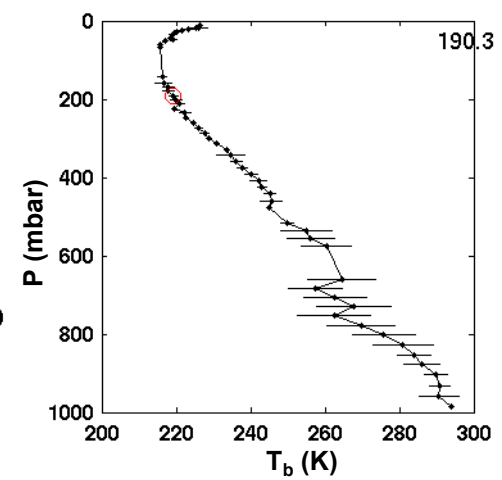
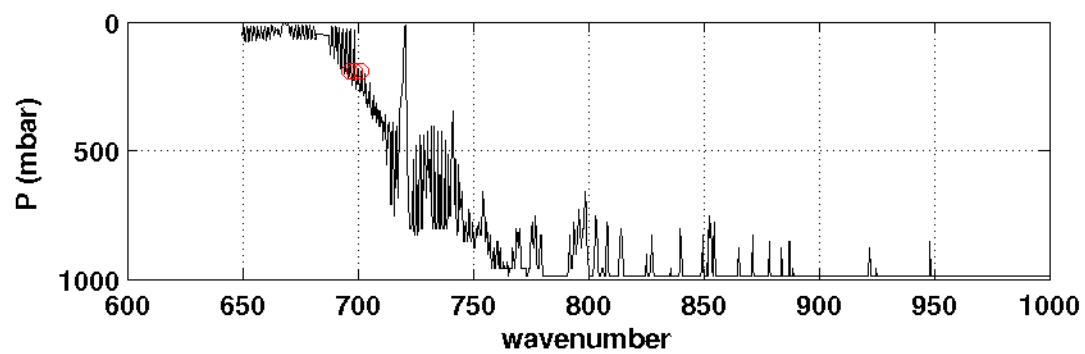
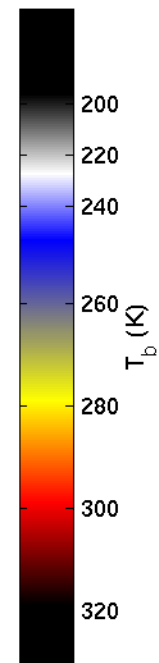
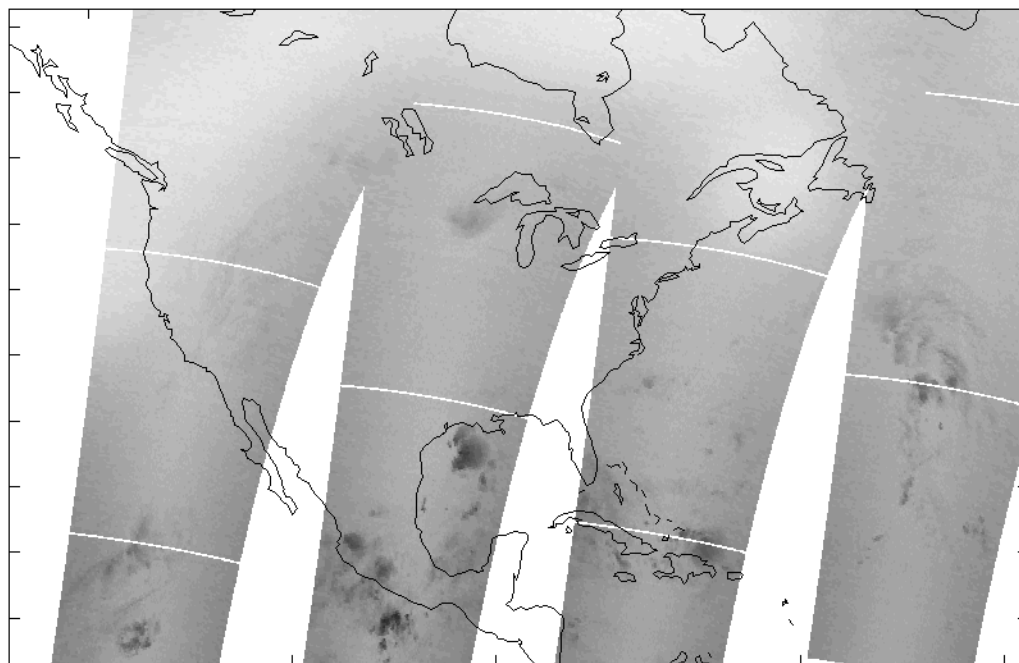
170.1 mbar



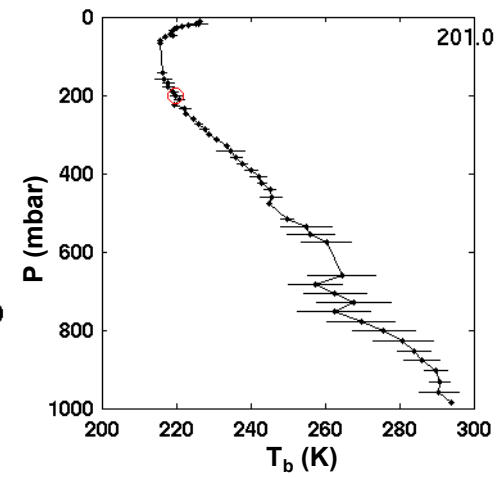
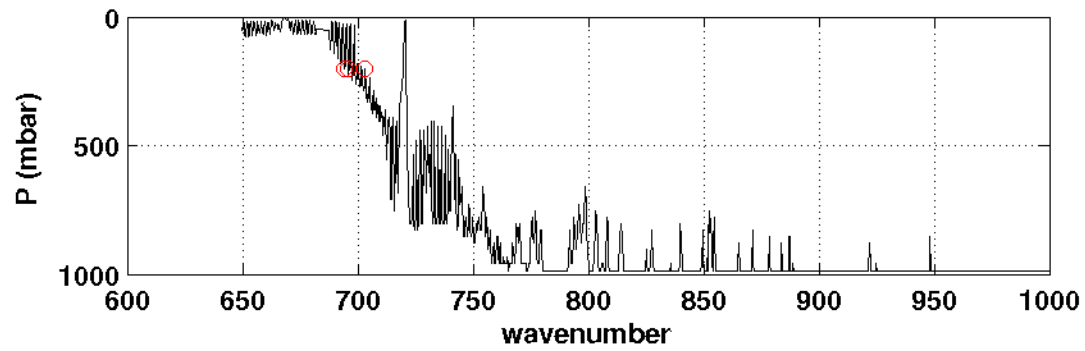
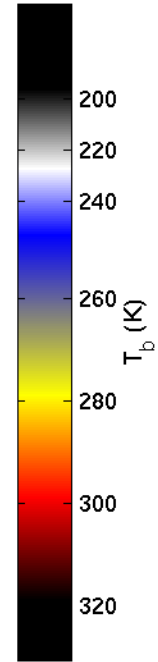
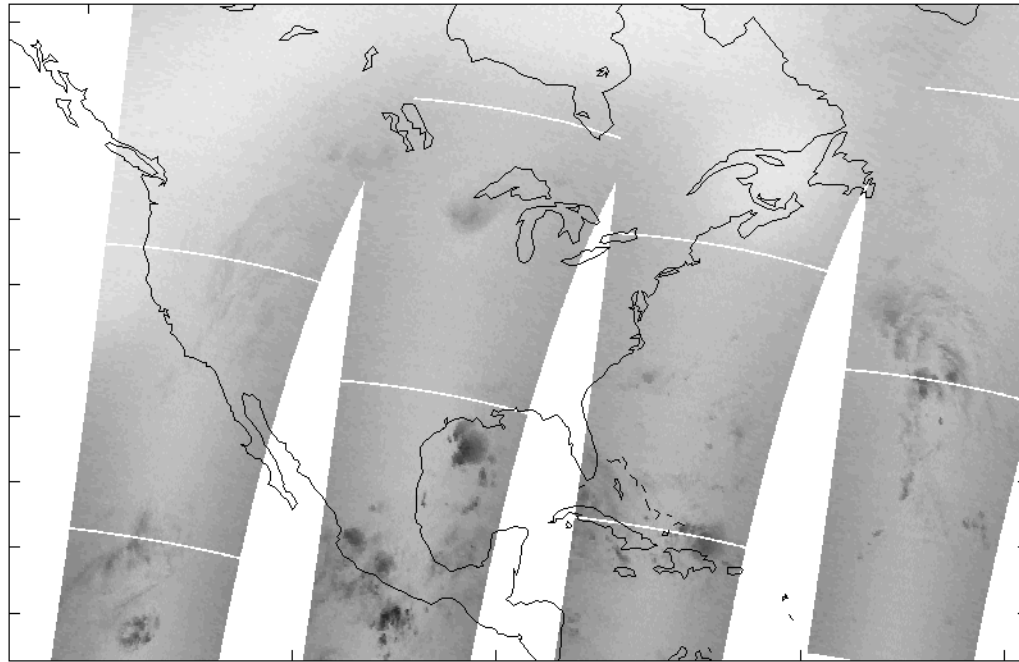
180.0 mbar



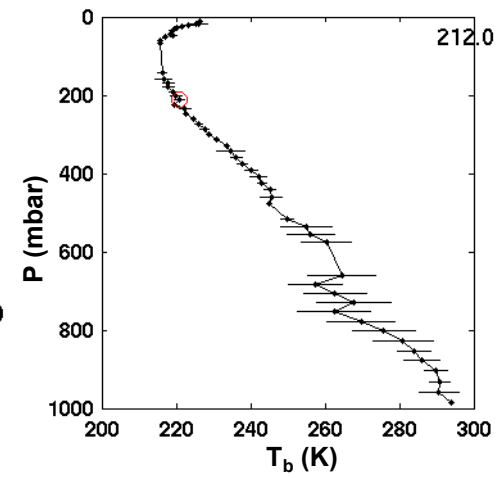
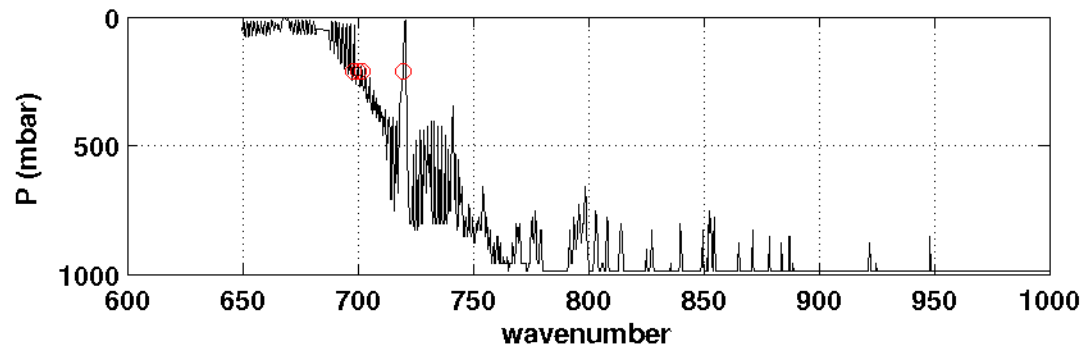
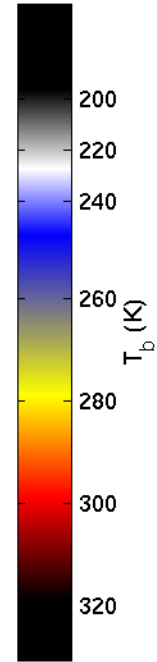
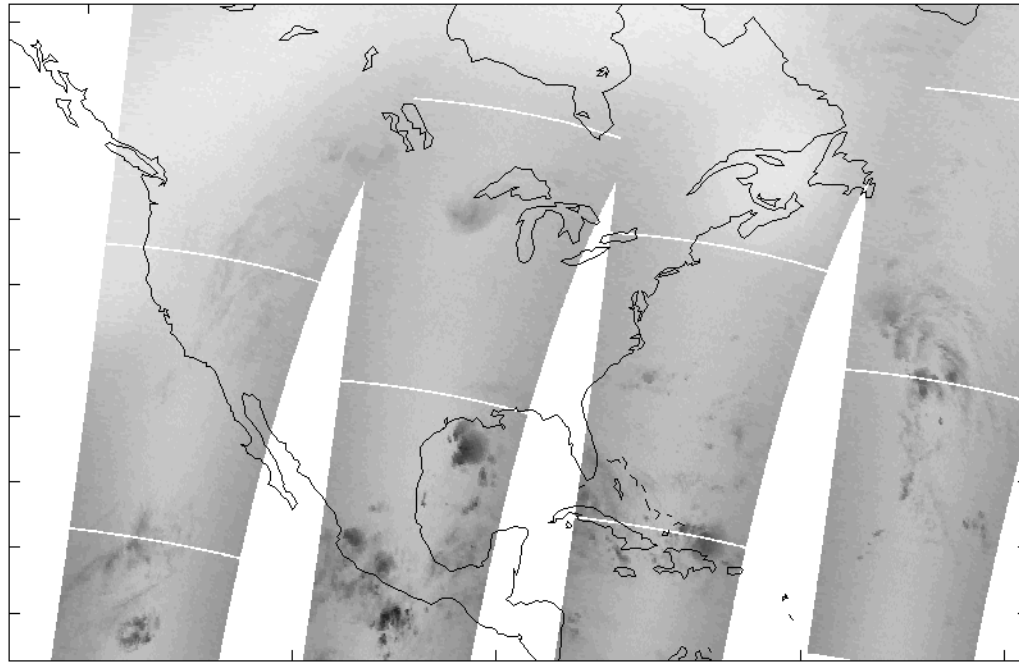
190.3 mbar



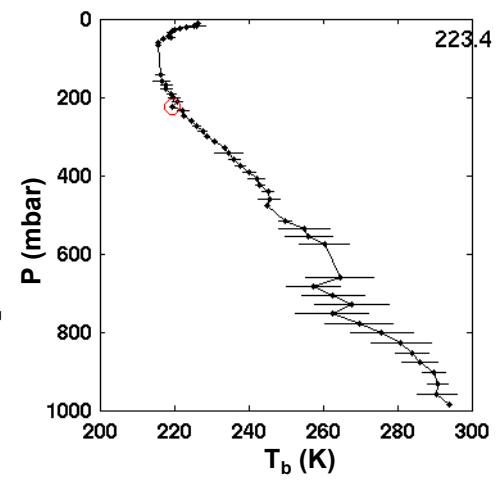
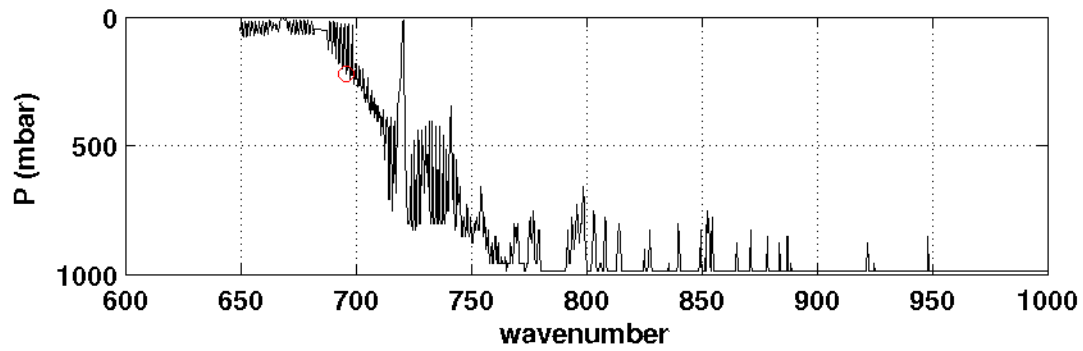
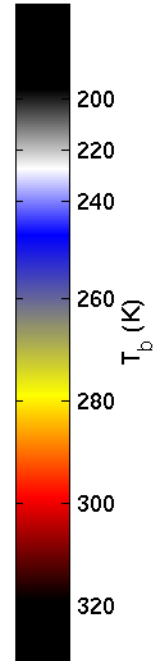
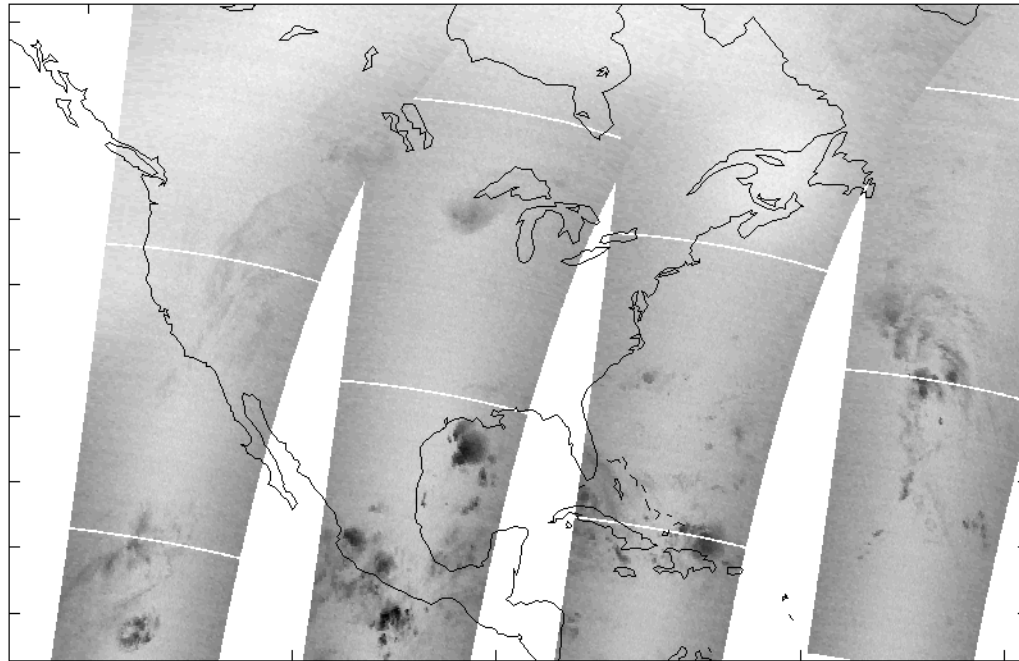
201.0 mbar



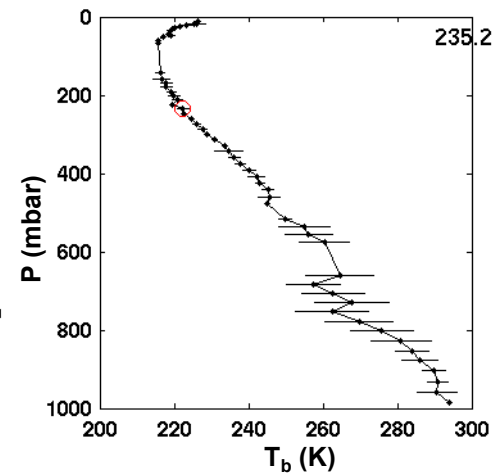
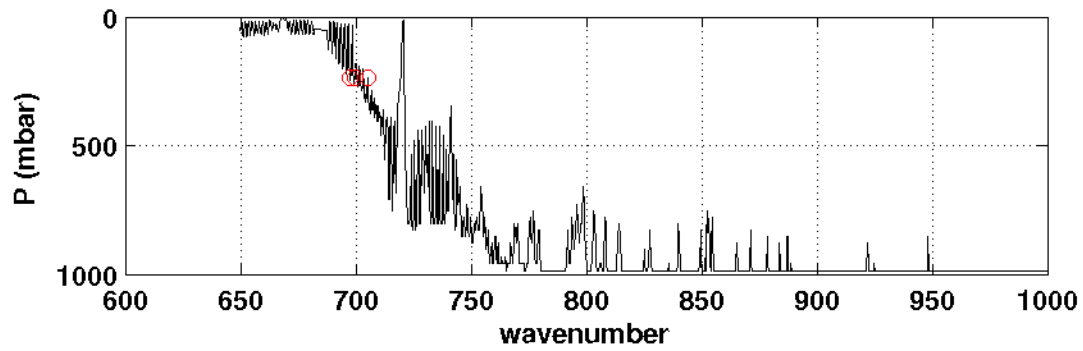
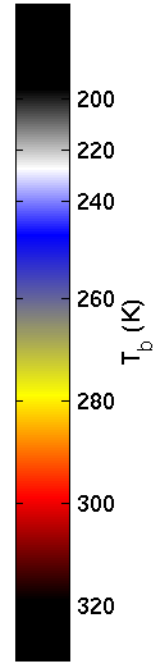
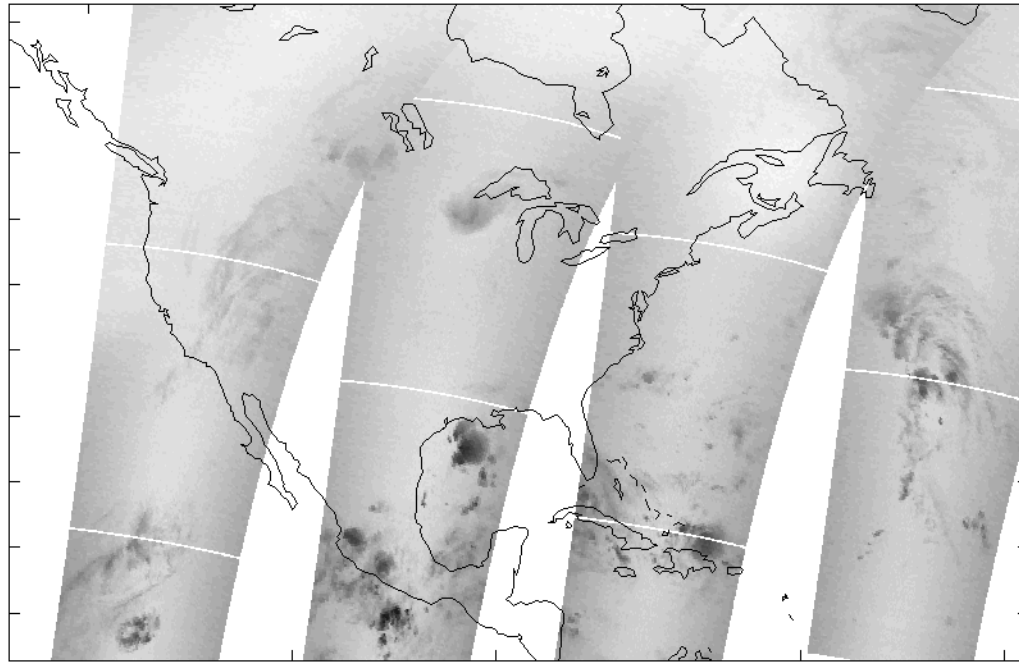
212.0 mbar



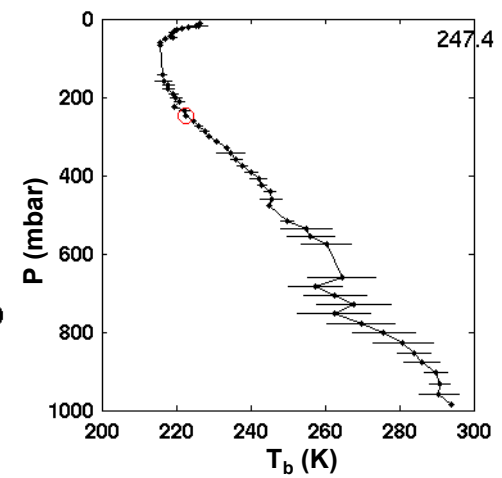
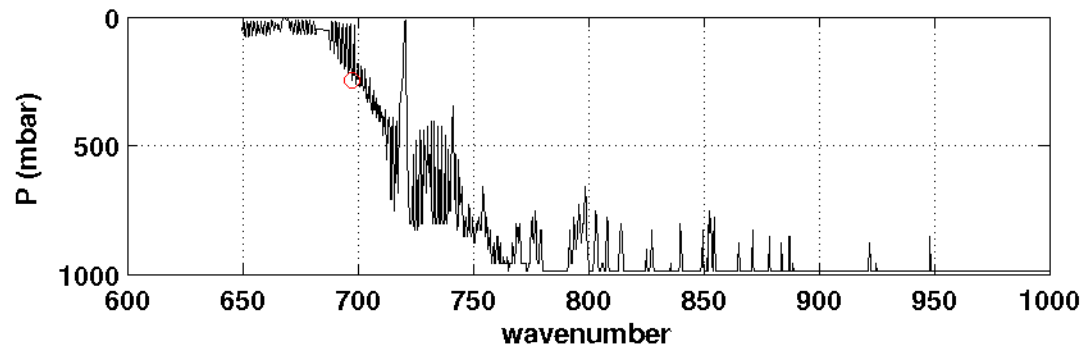
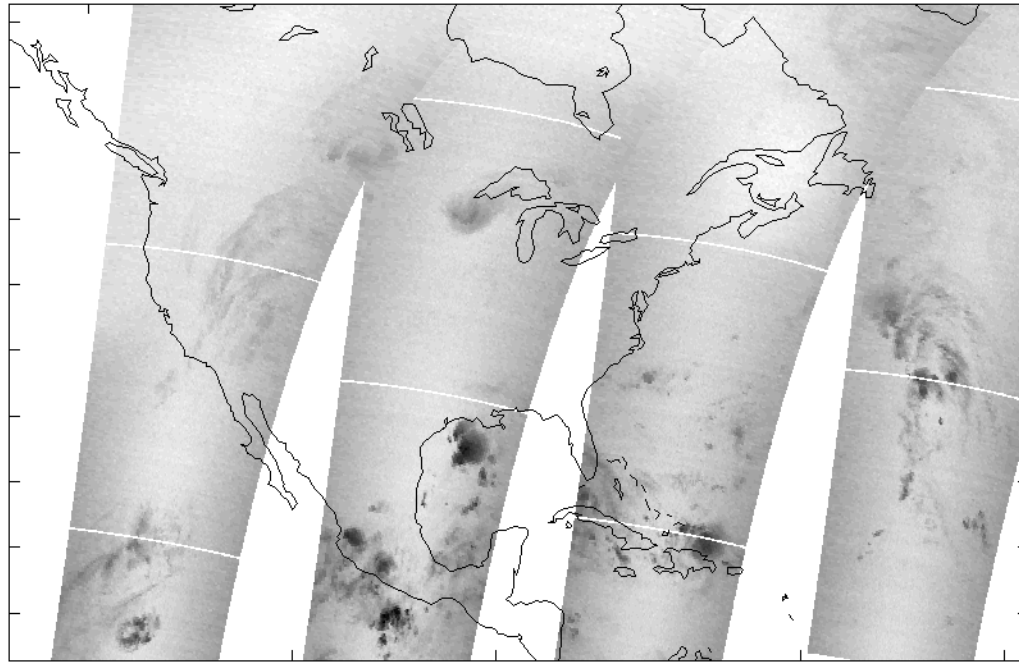
223.4 mbar



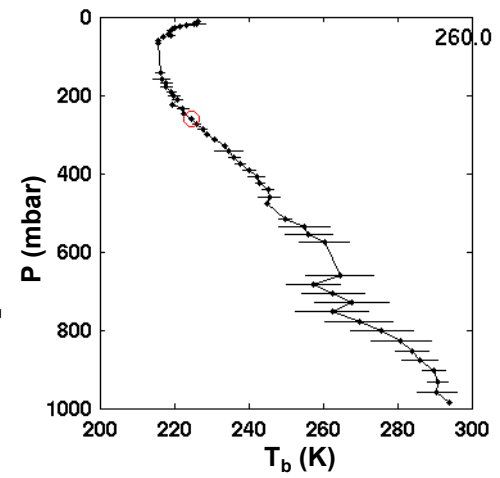
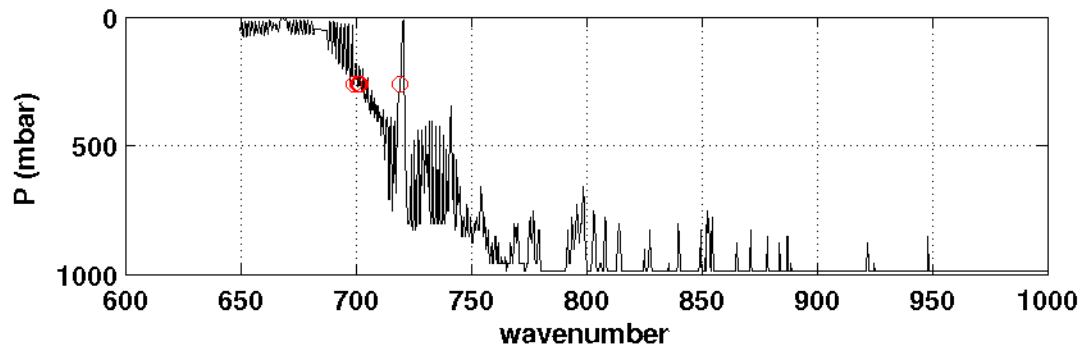
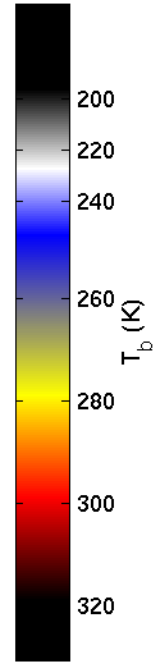
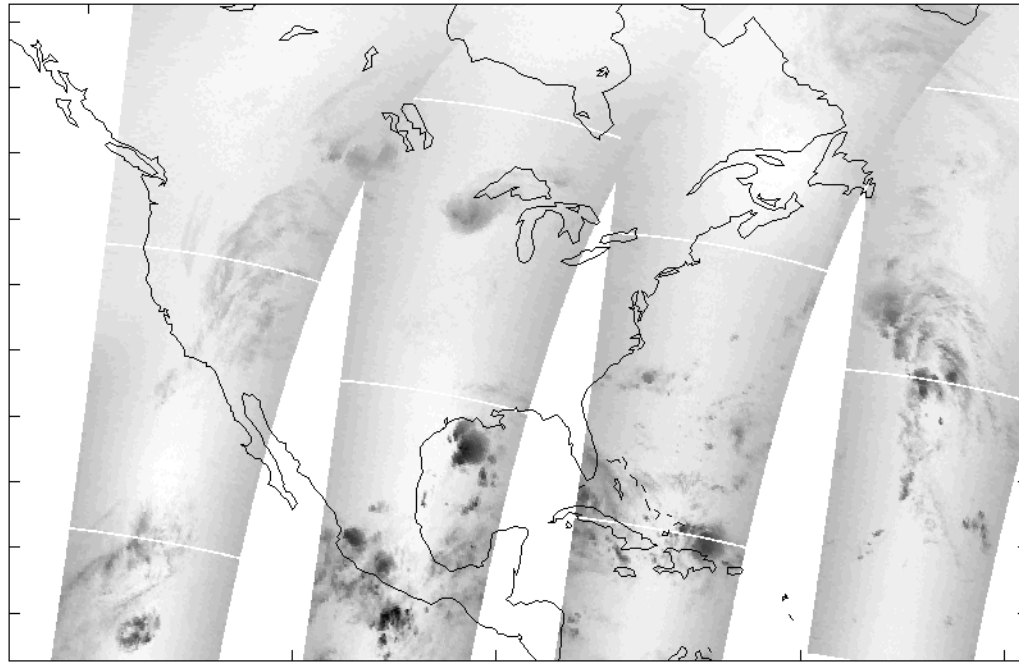
235.2 mbar



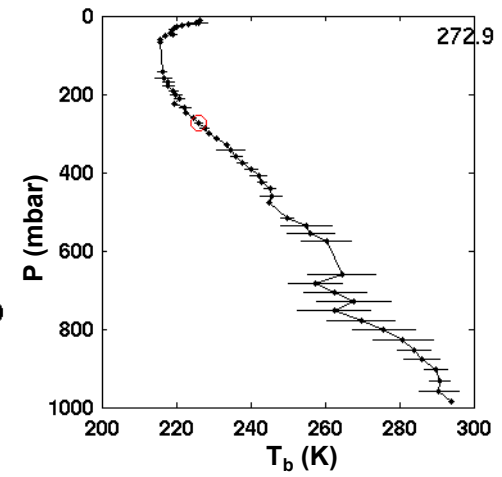
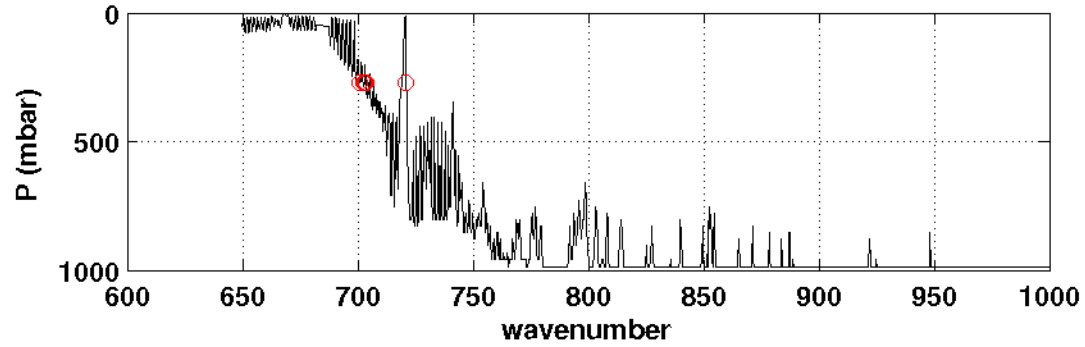
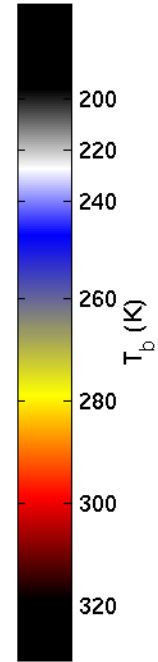
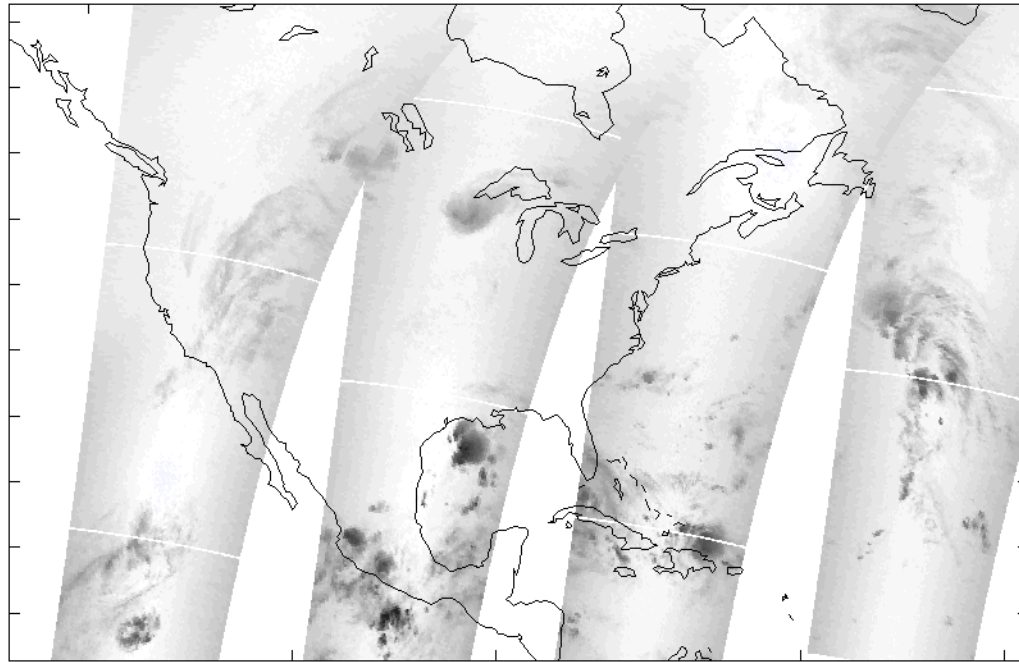
247.4 mbar



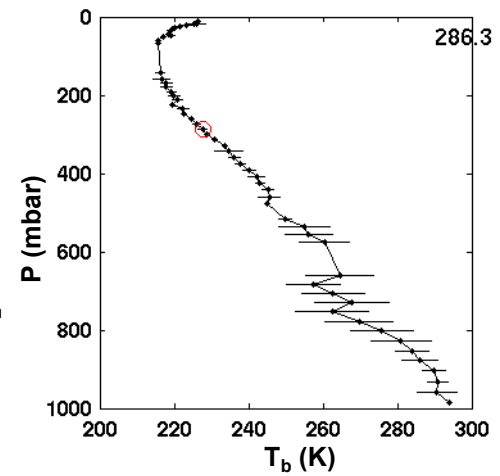
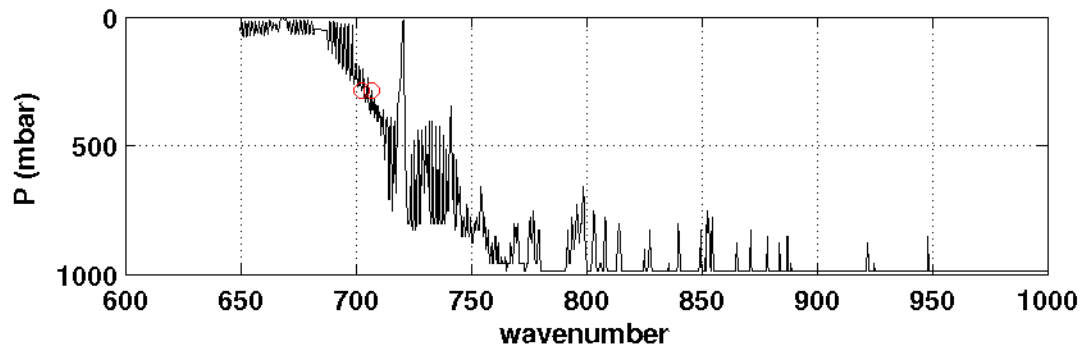
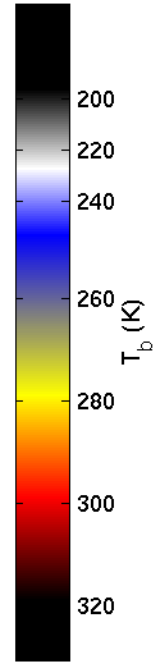
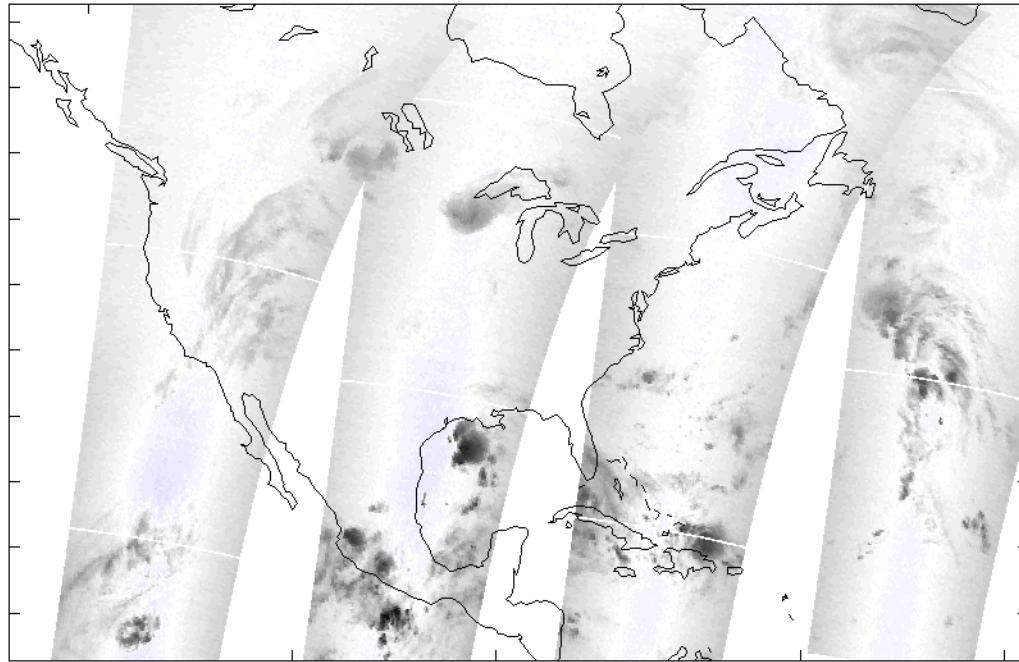
260.0 mbar



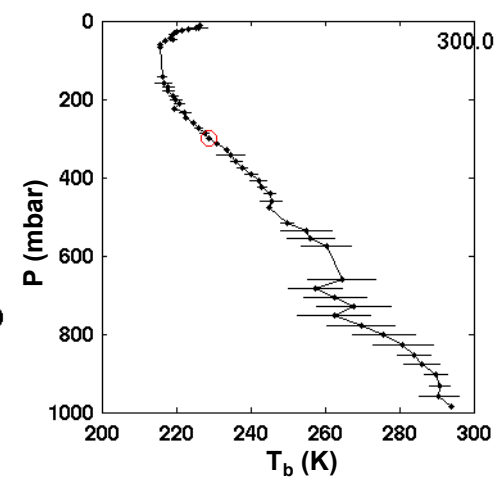
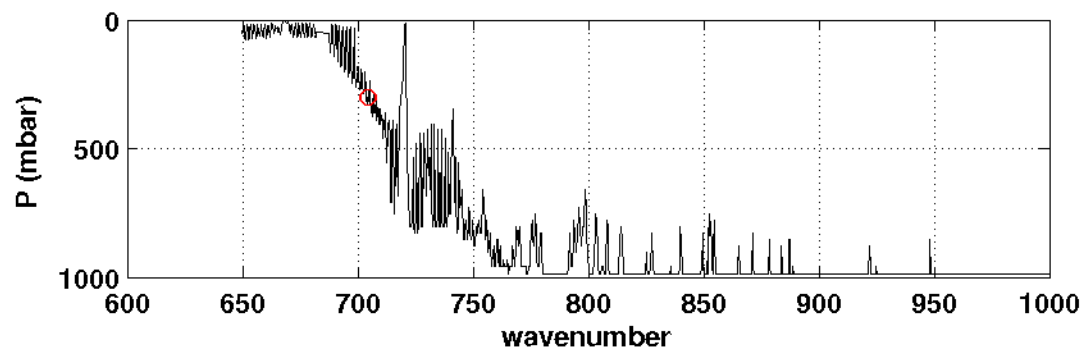
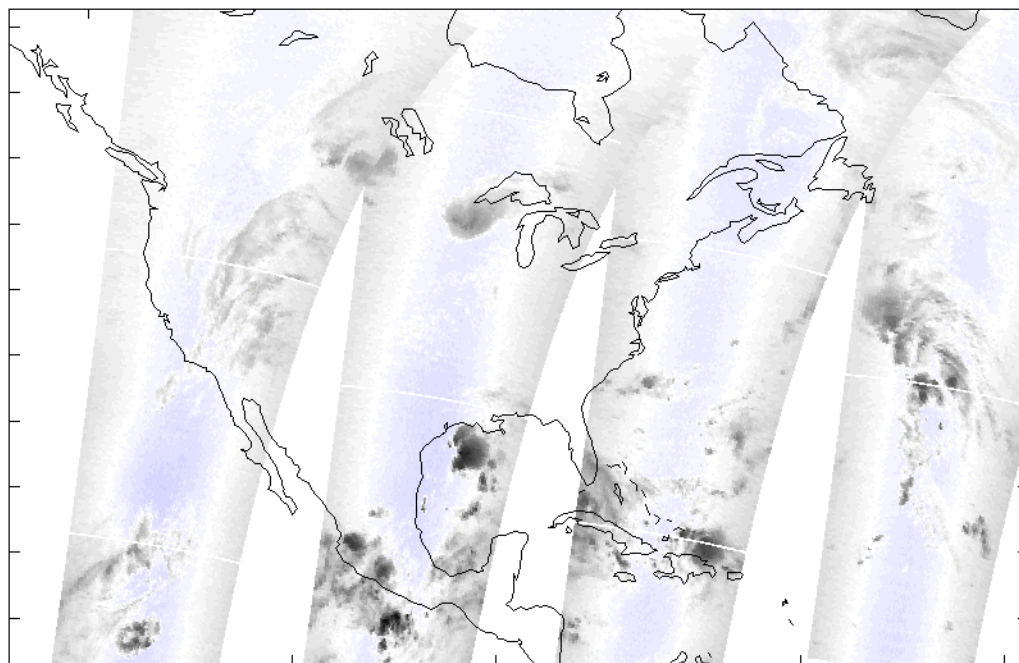
272.9 mbar



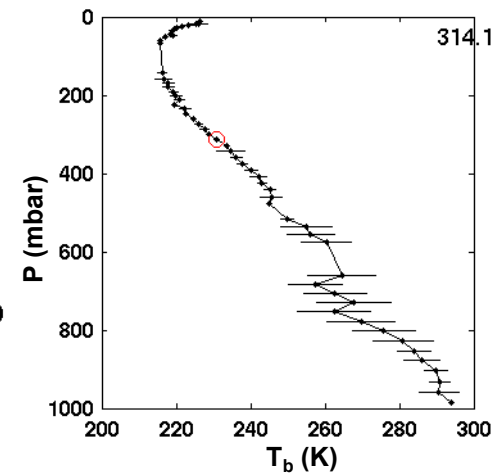
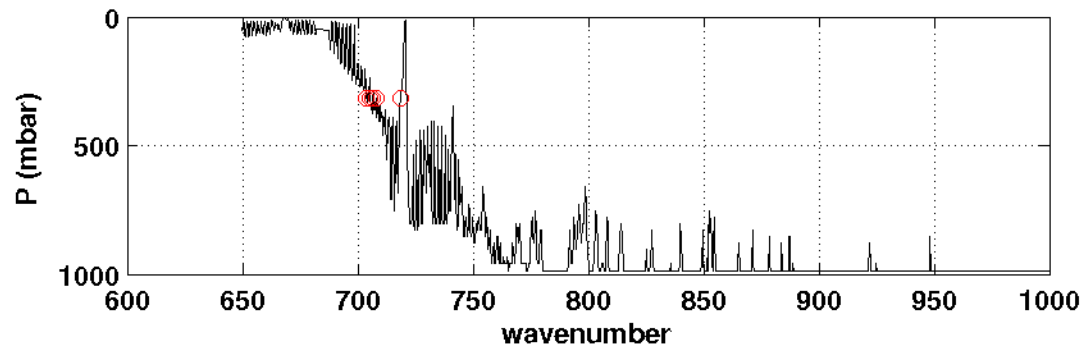
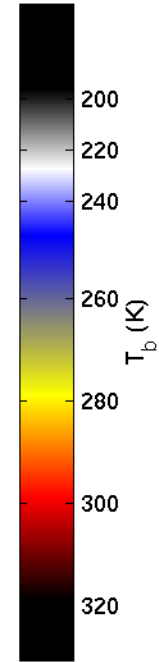
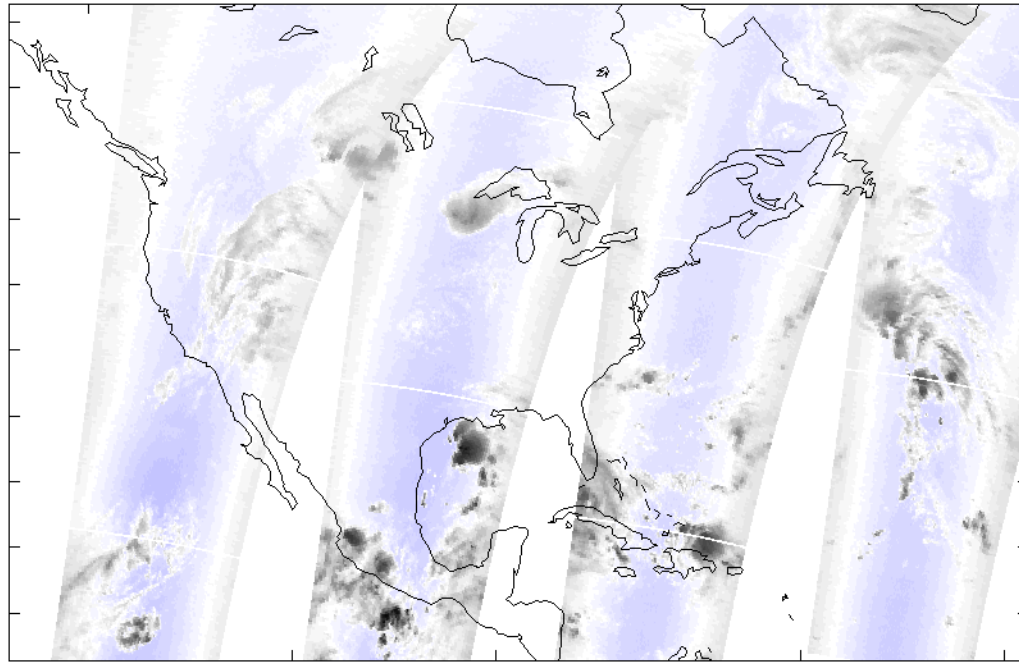
286.3 mbar



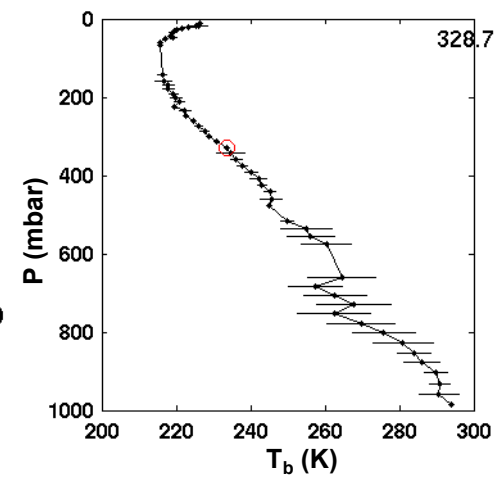
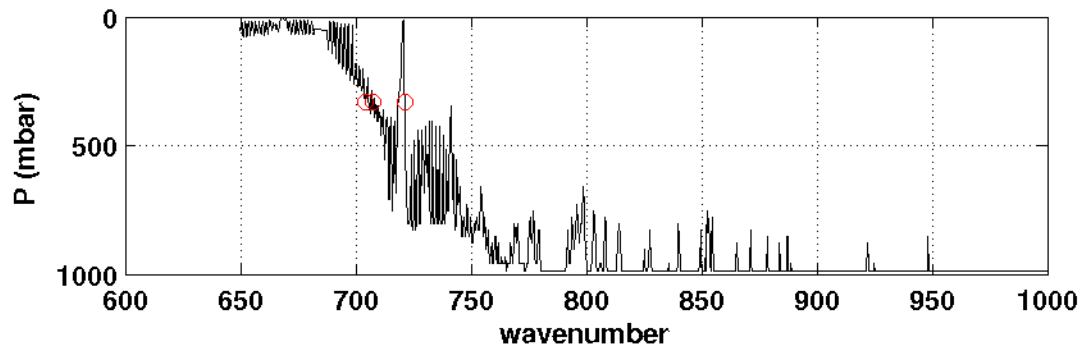
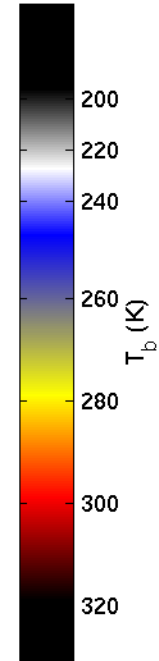
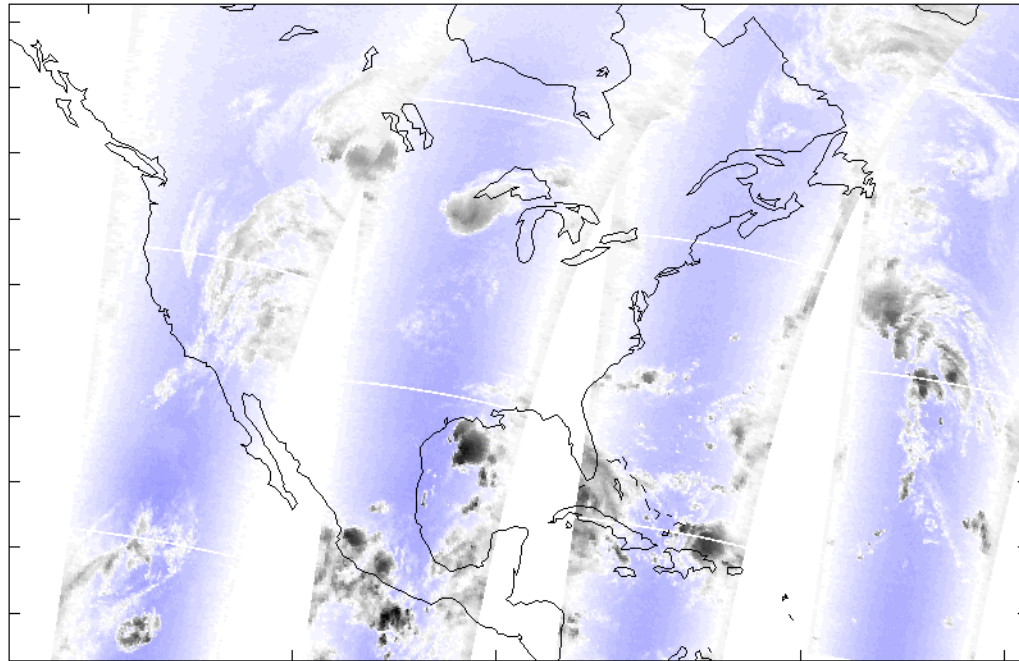
300.0 mbar



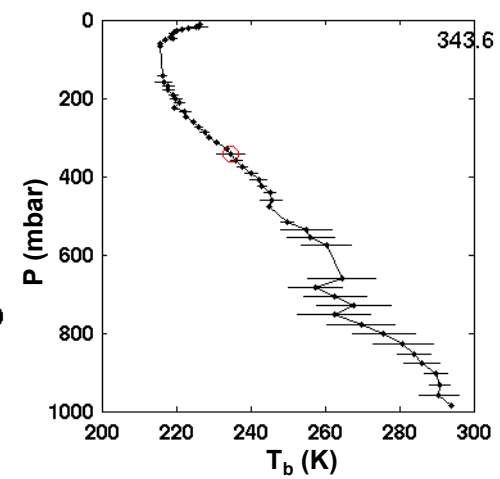
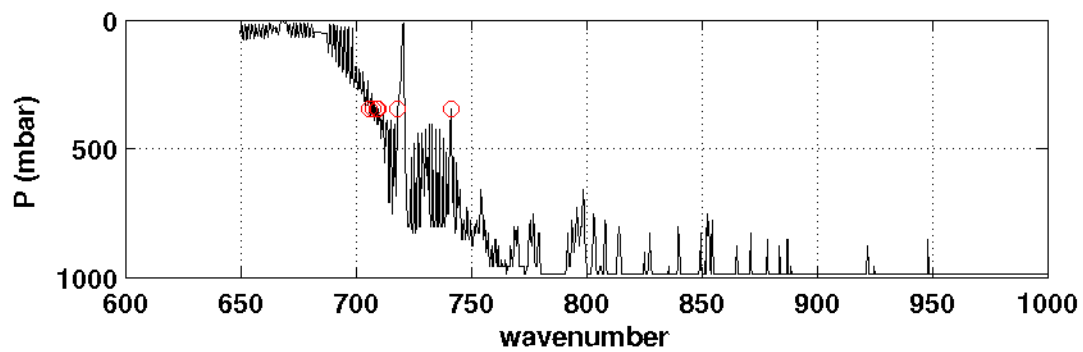
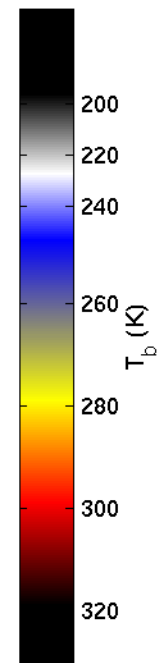
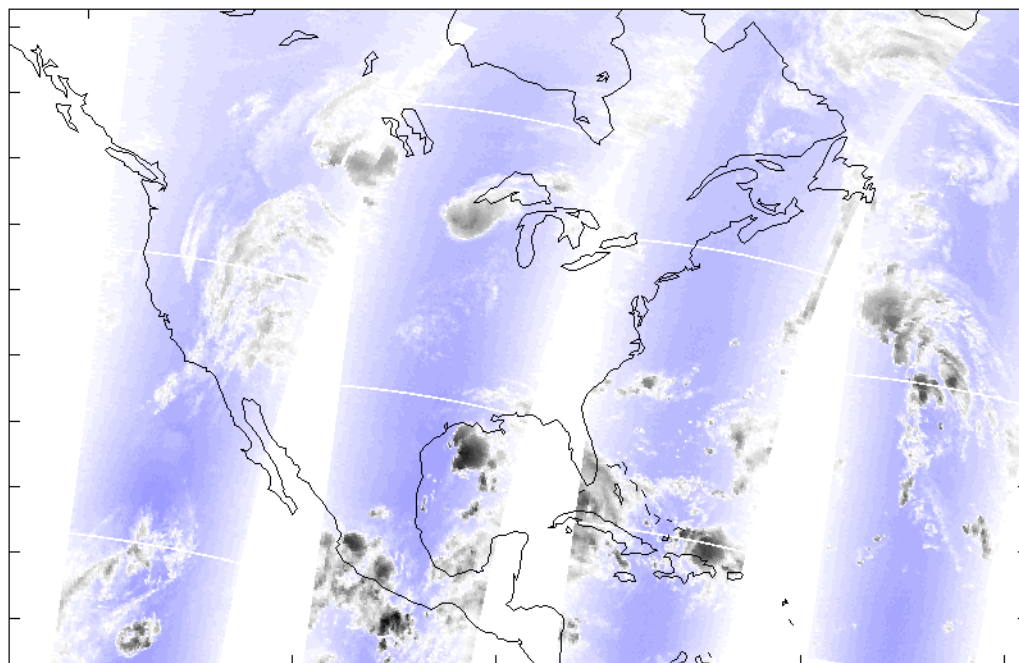
314.1 mbar



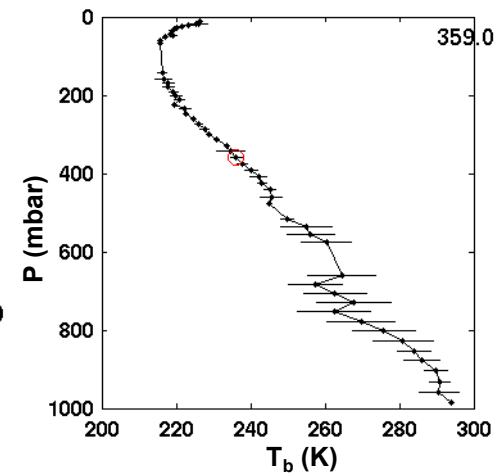
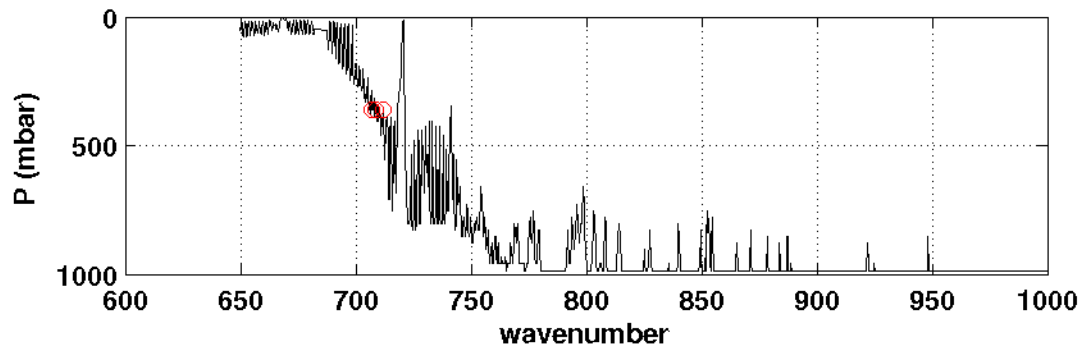
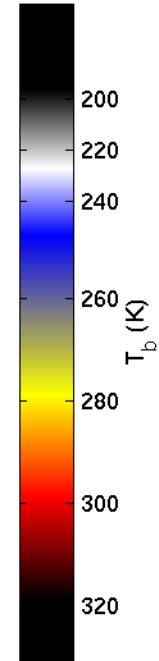
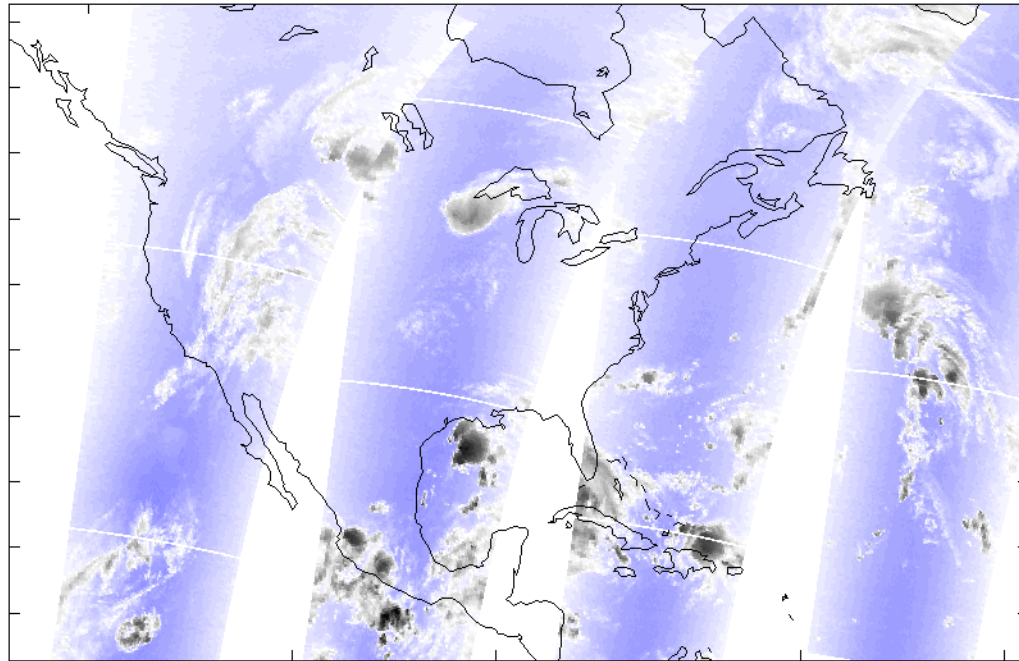
328.7 mbar



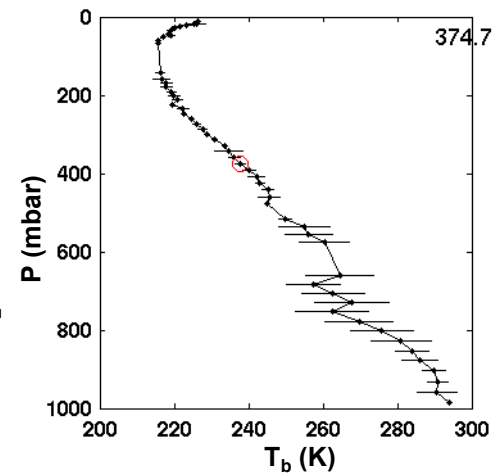
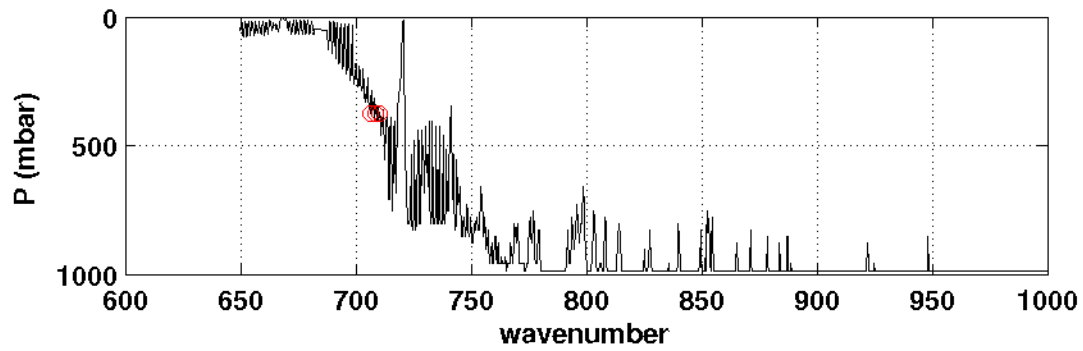
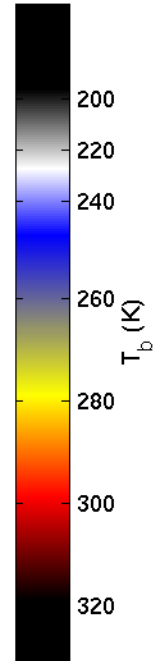
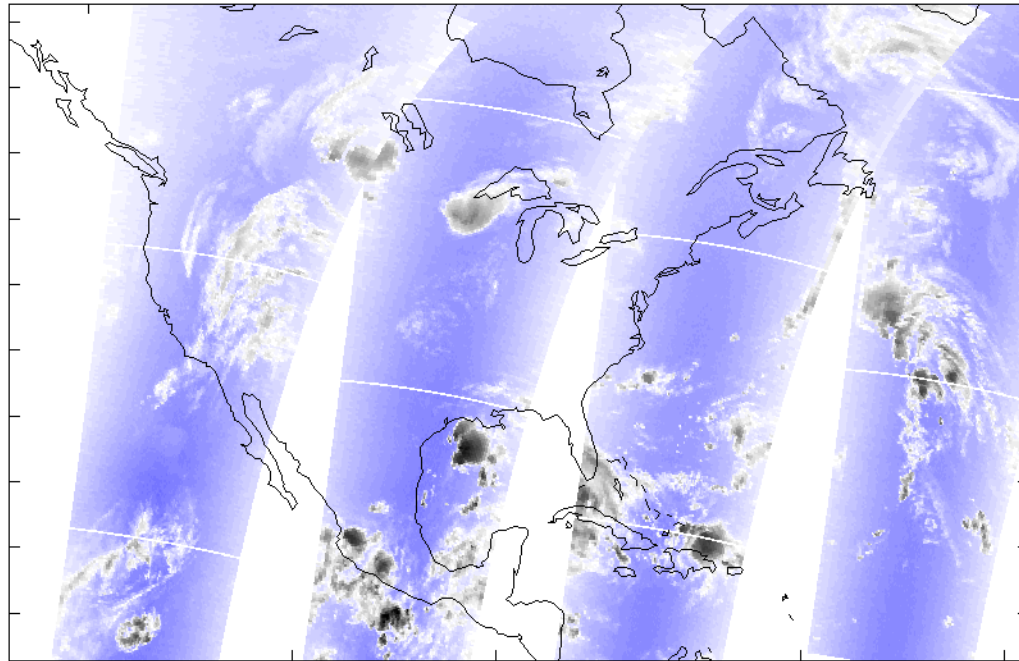
343.6 mbar



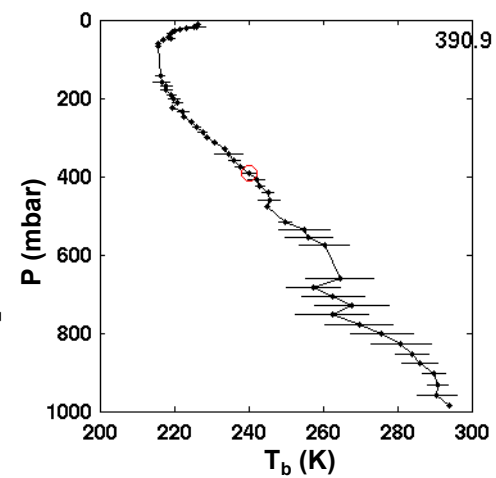
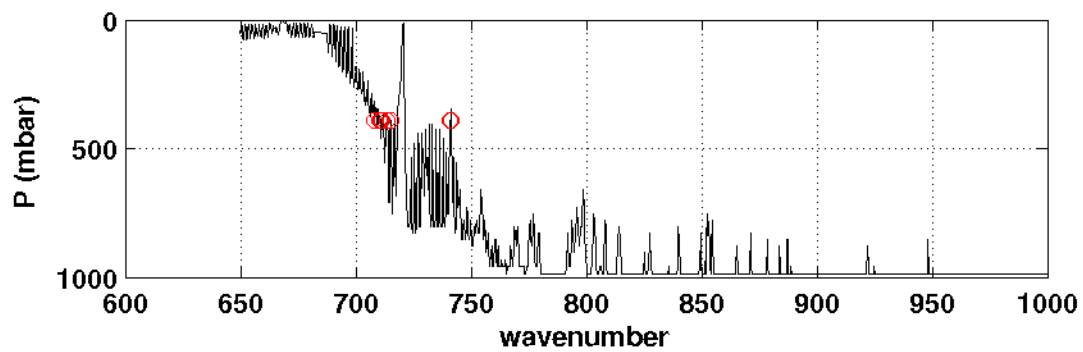
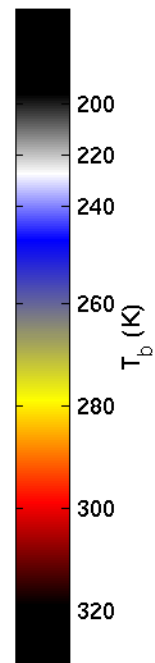
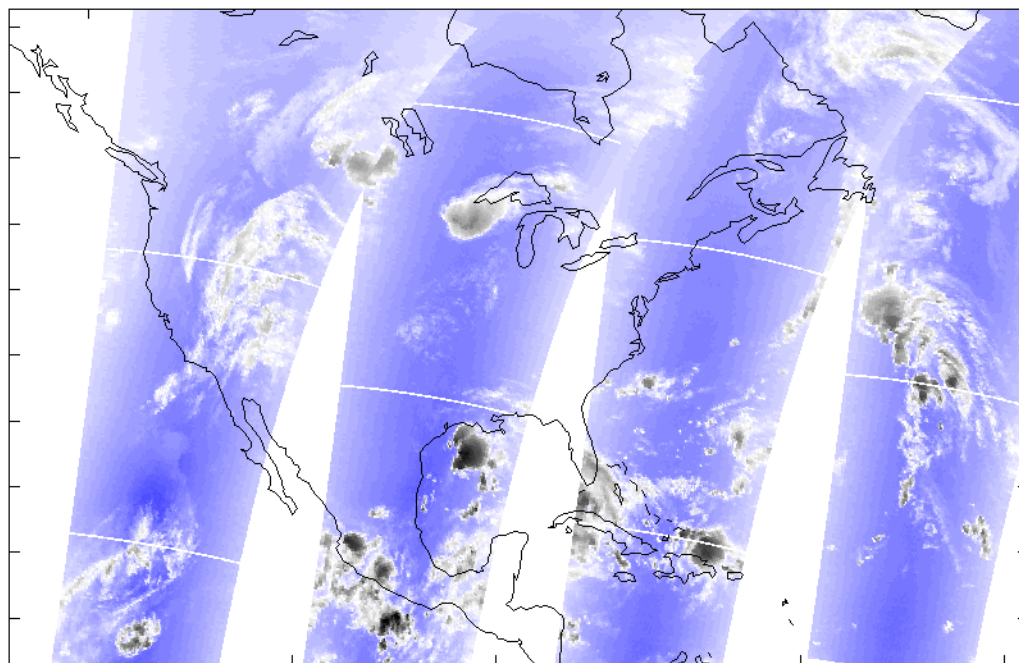
359.0 mbar



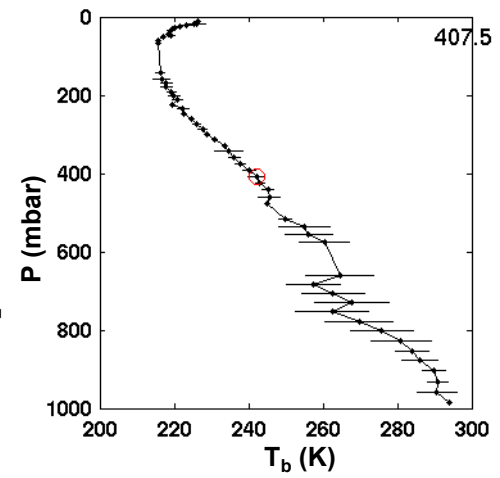
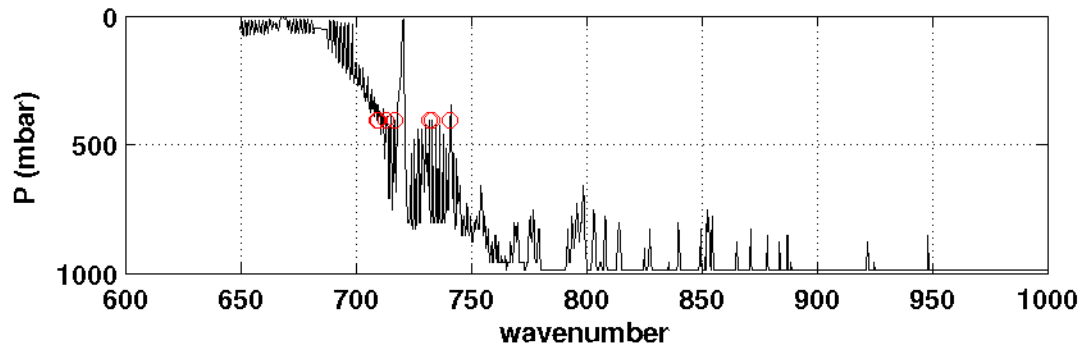
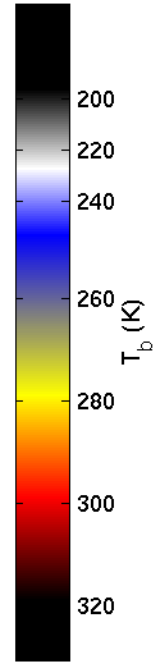
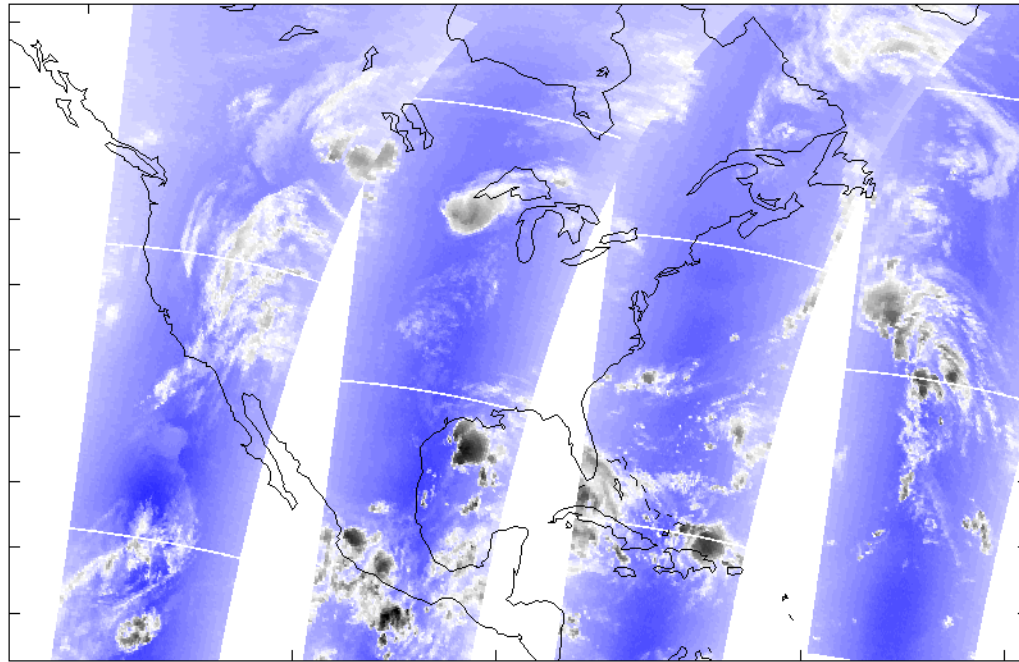
374.7 mbar



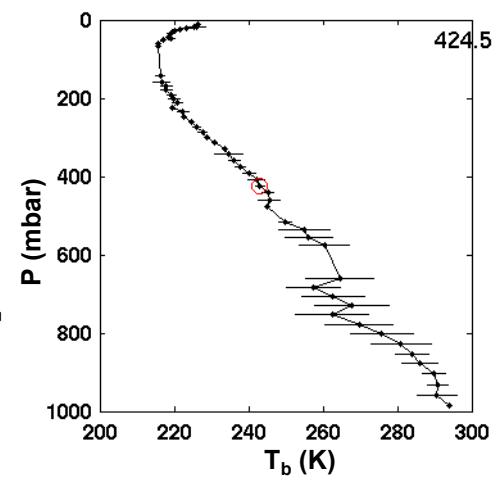
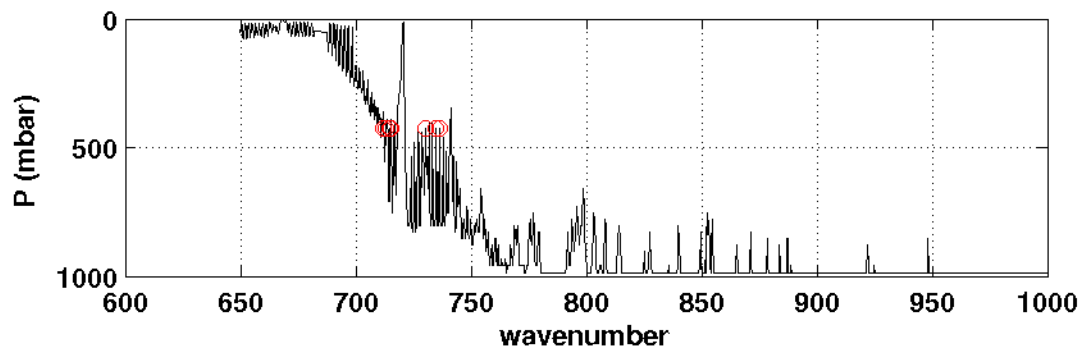
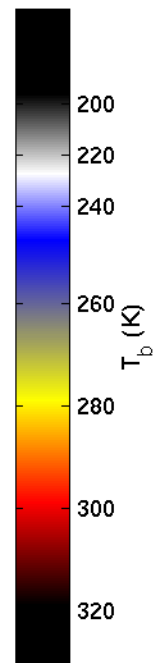
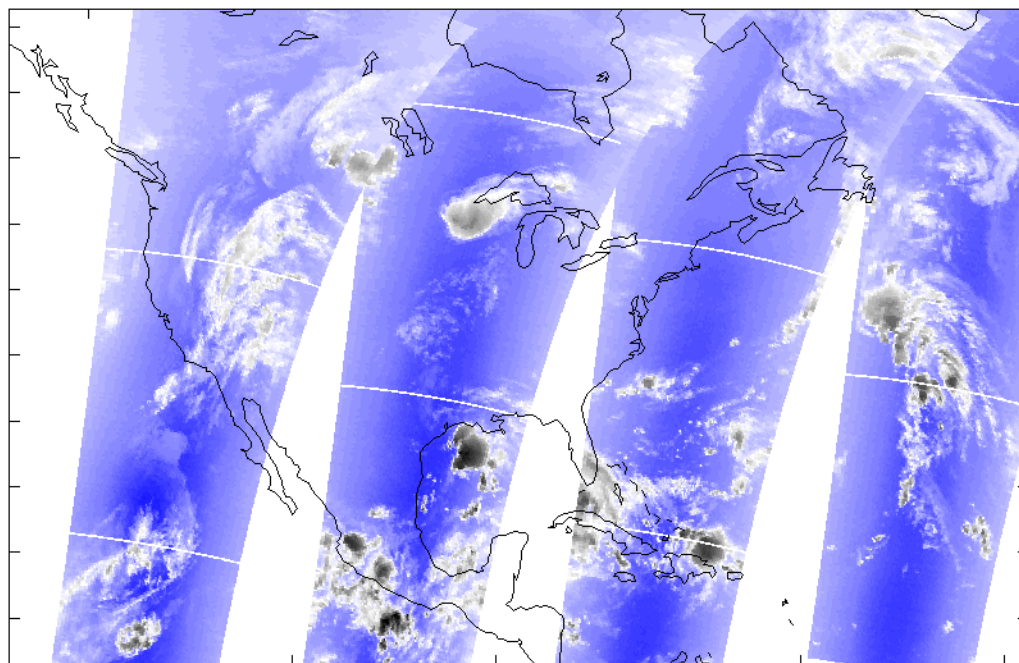
390.9 mbar



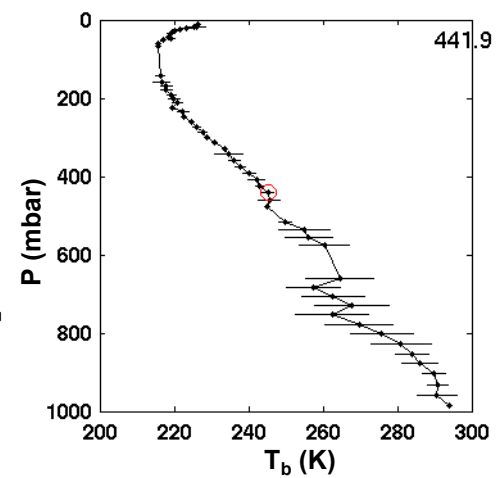
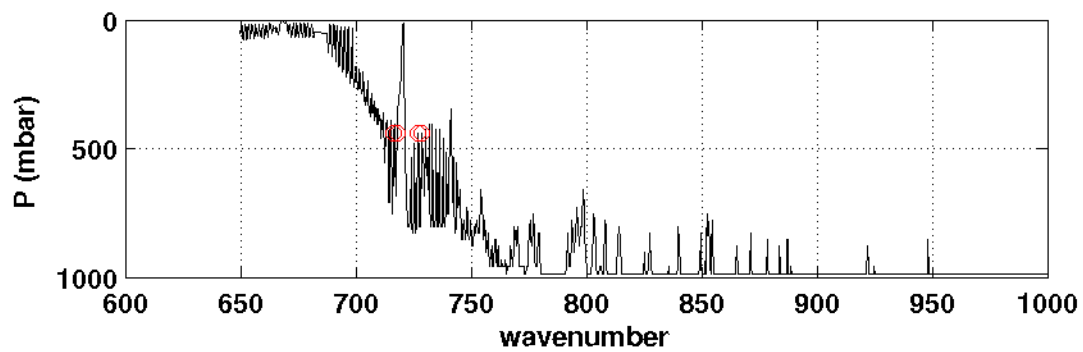
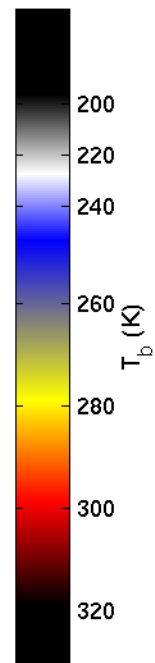
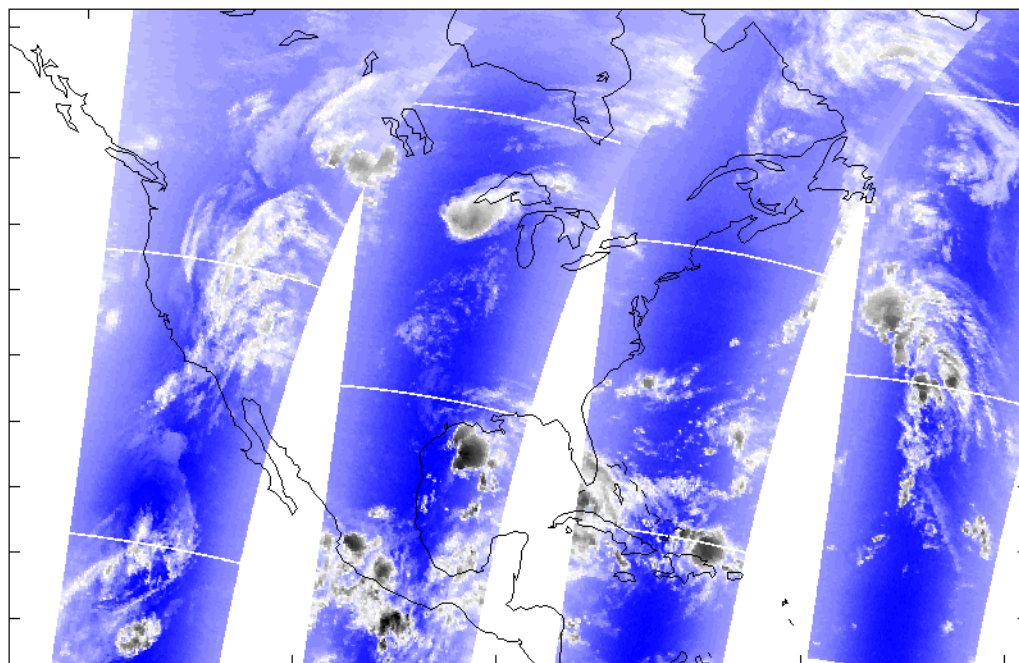
407.5 mbar



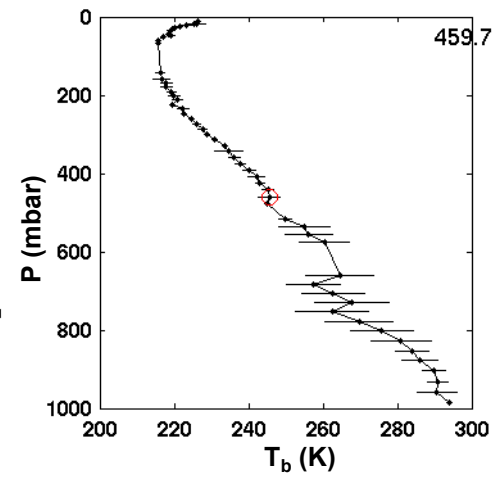
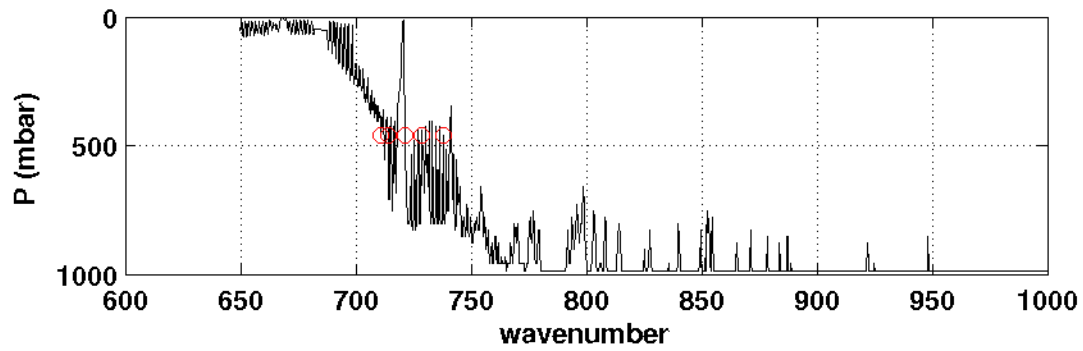
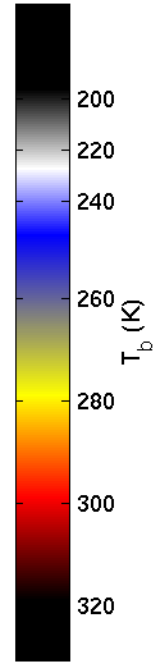
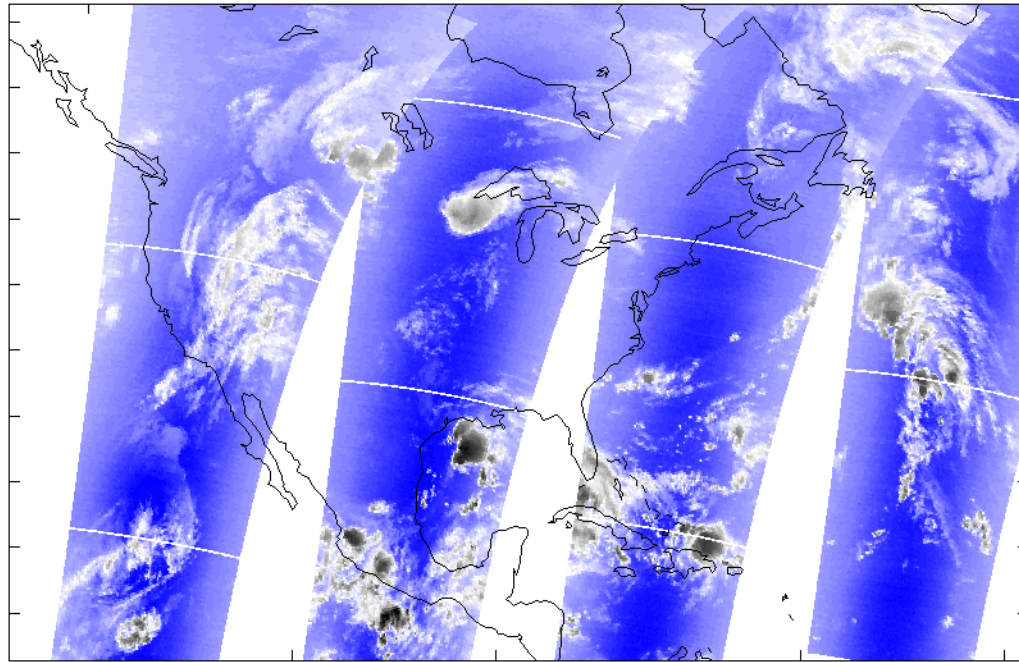
424.5 mbar



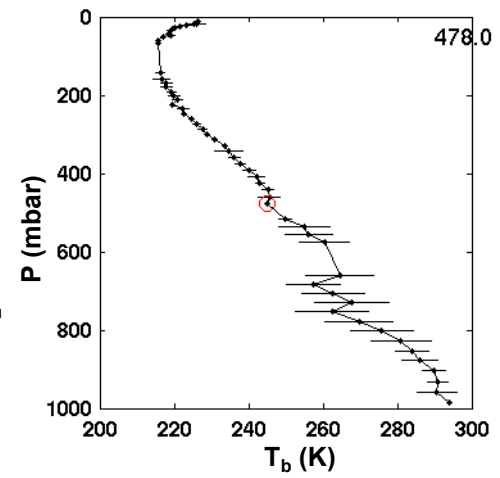
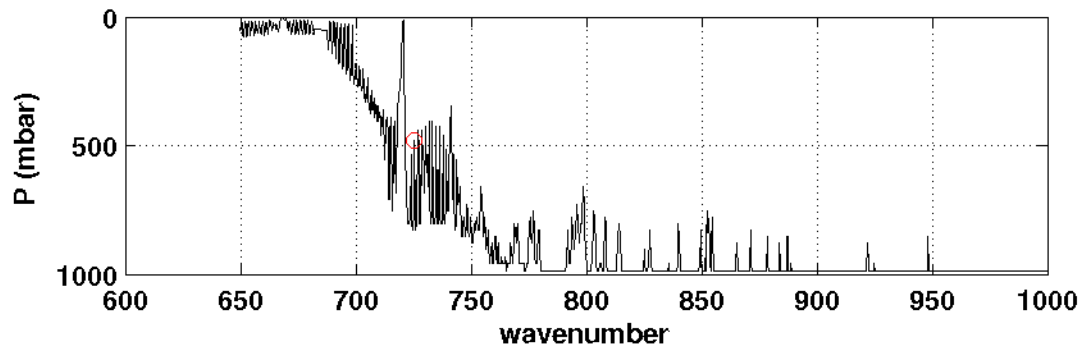
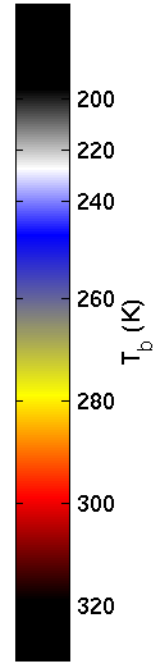
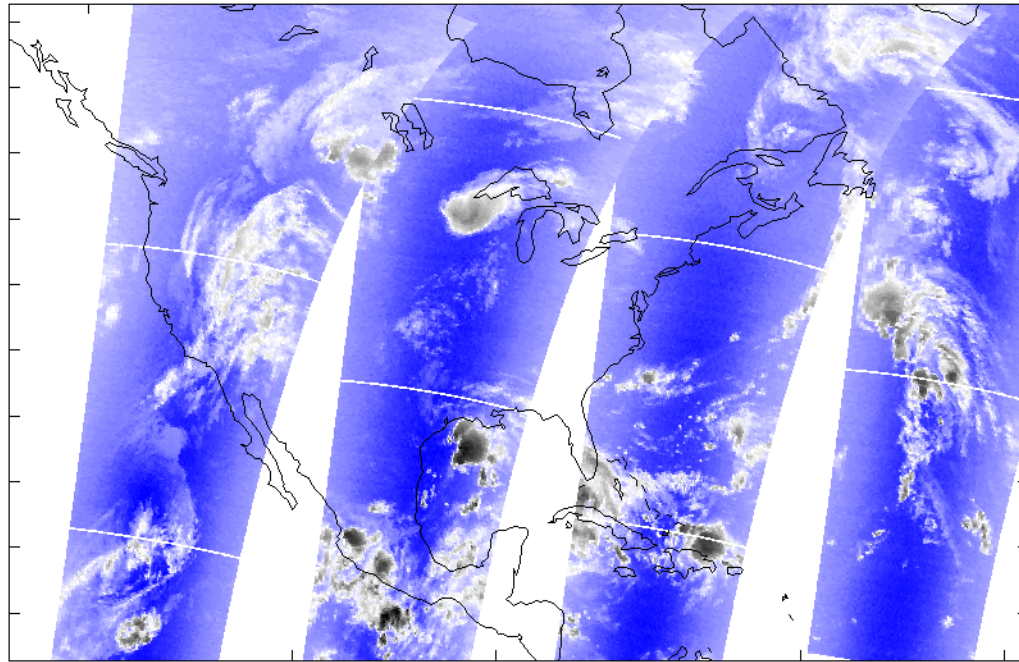
441.9 mbar



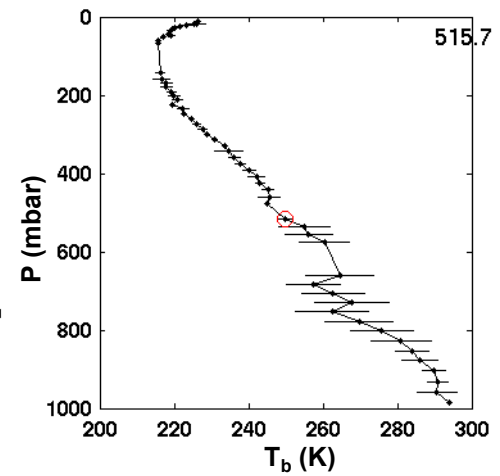
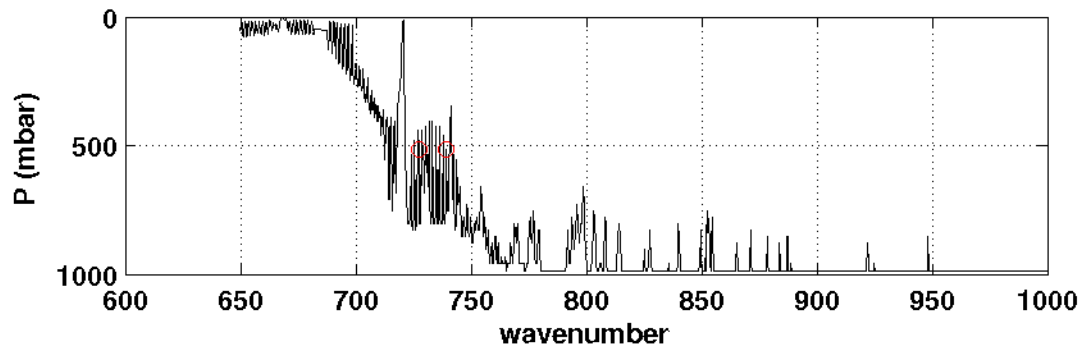
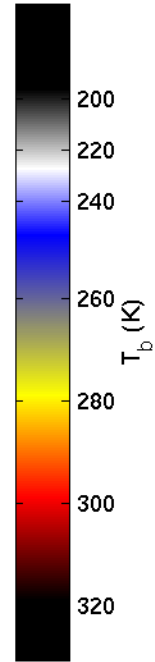
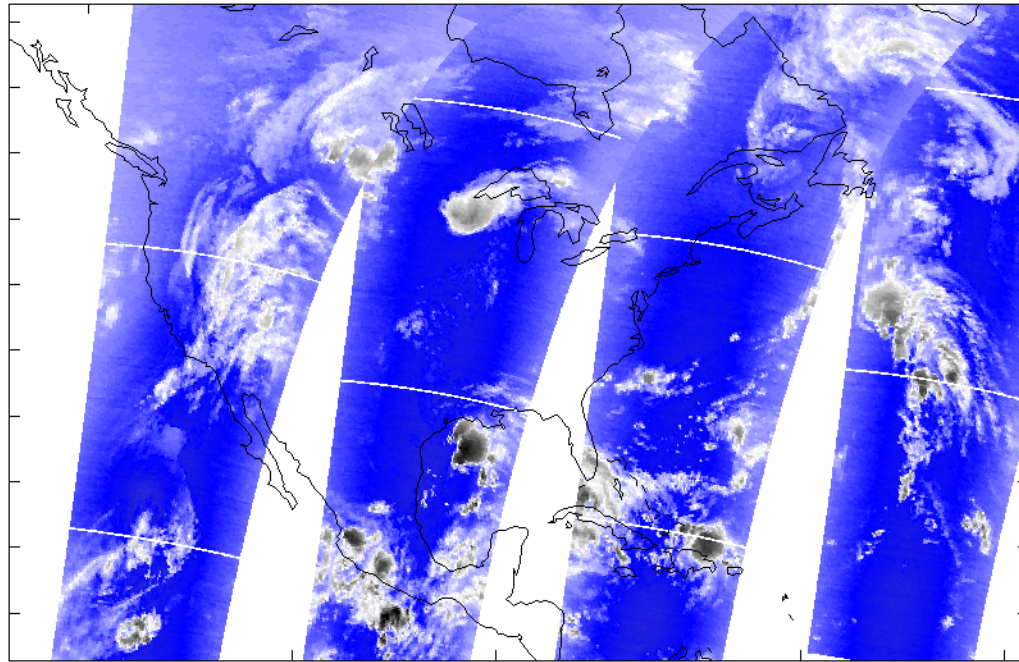
459.7 mbar



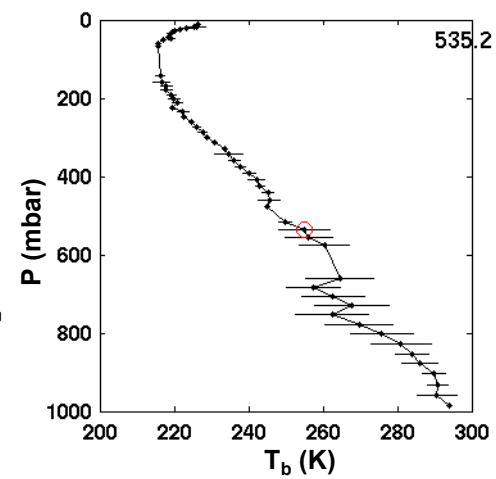
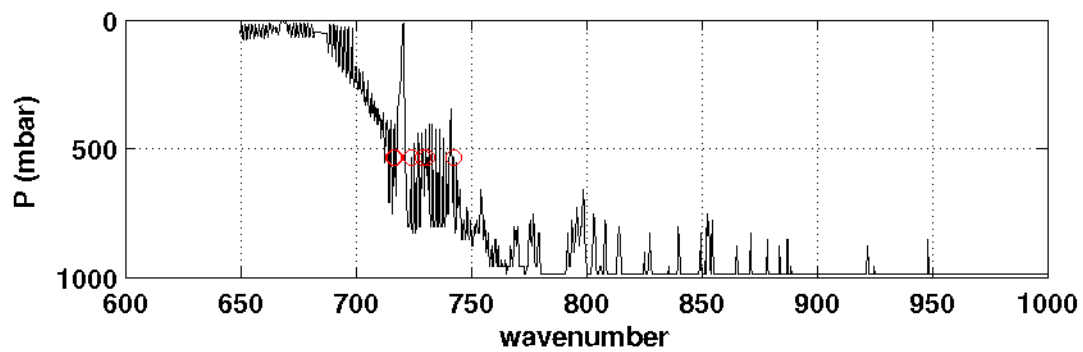
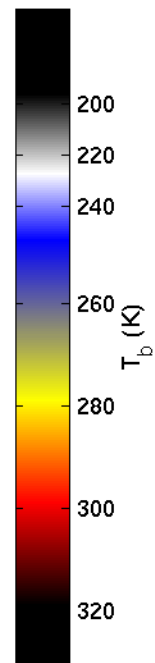
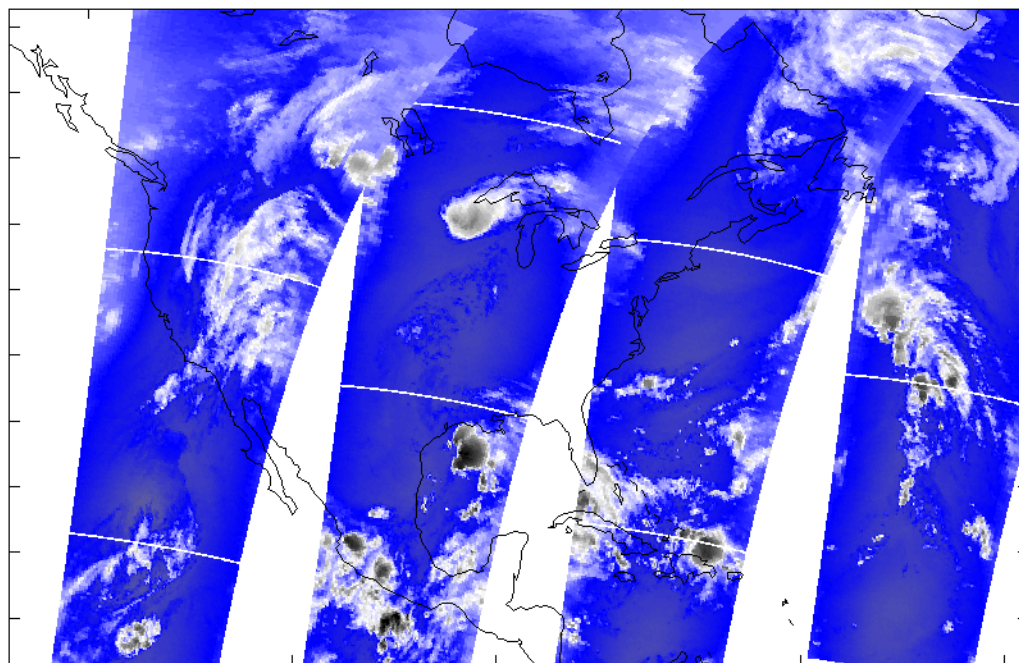
478.0 mbar



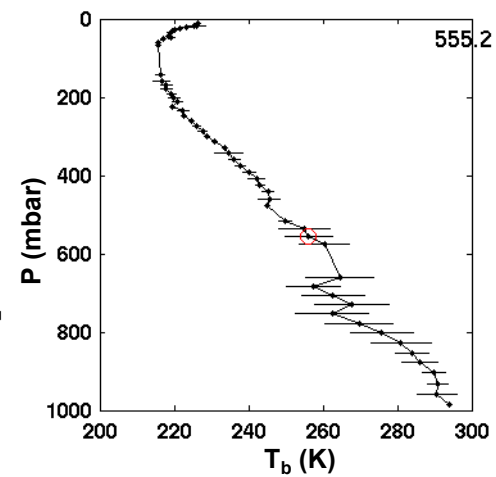
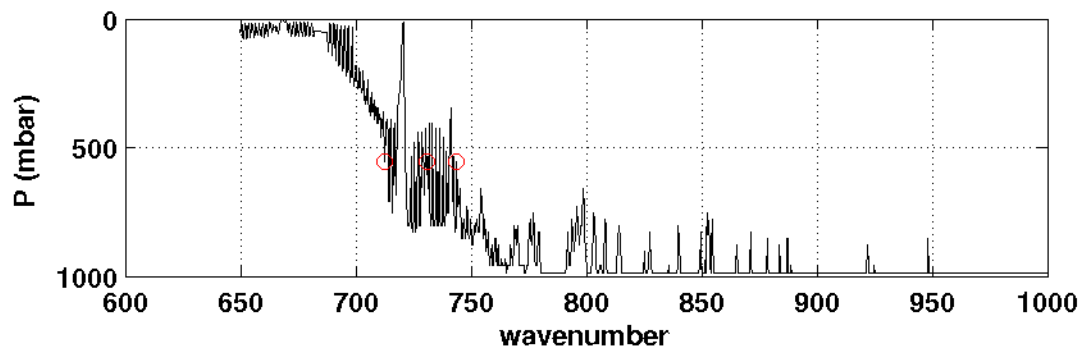
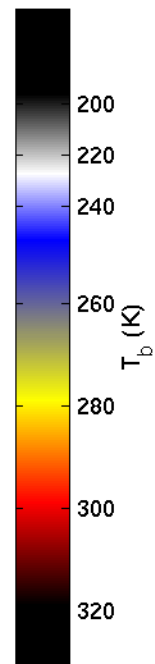
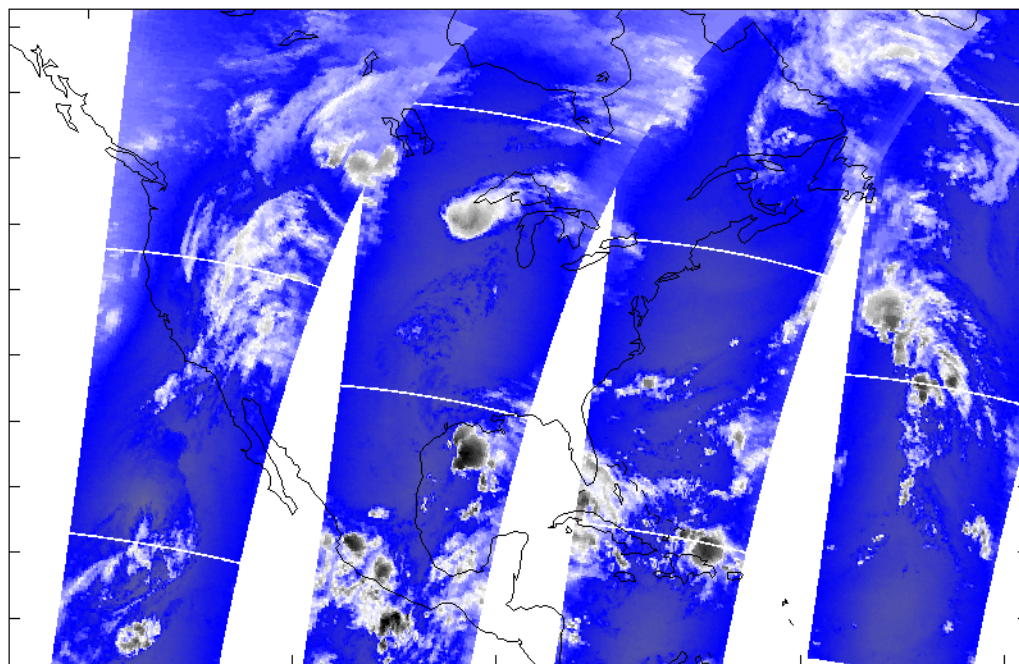
515.7 mbar



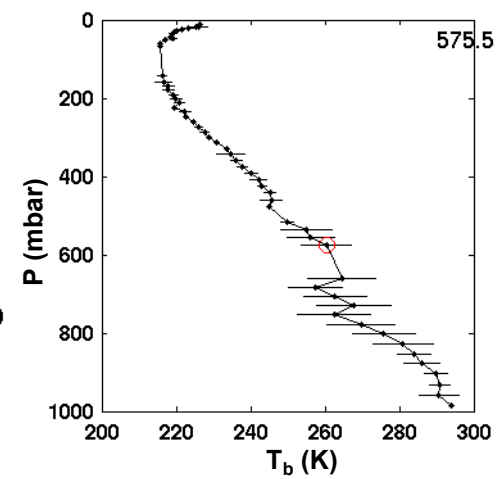
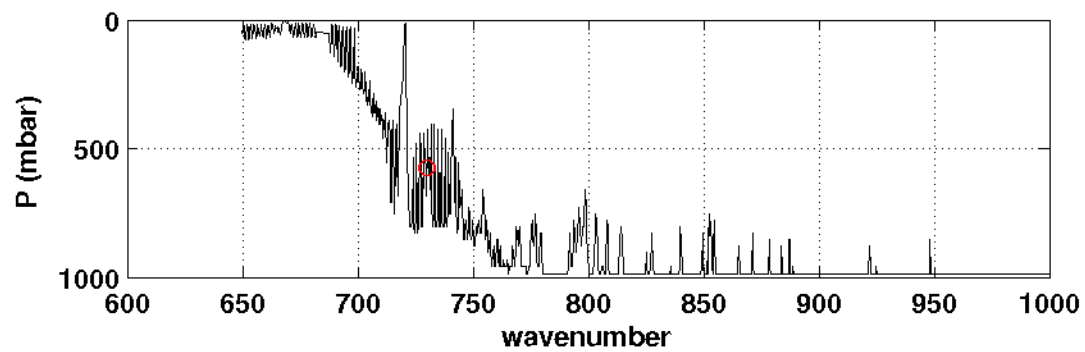
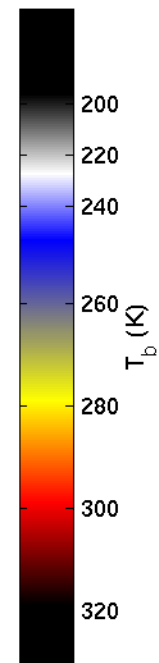
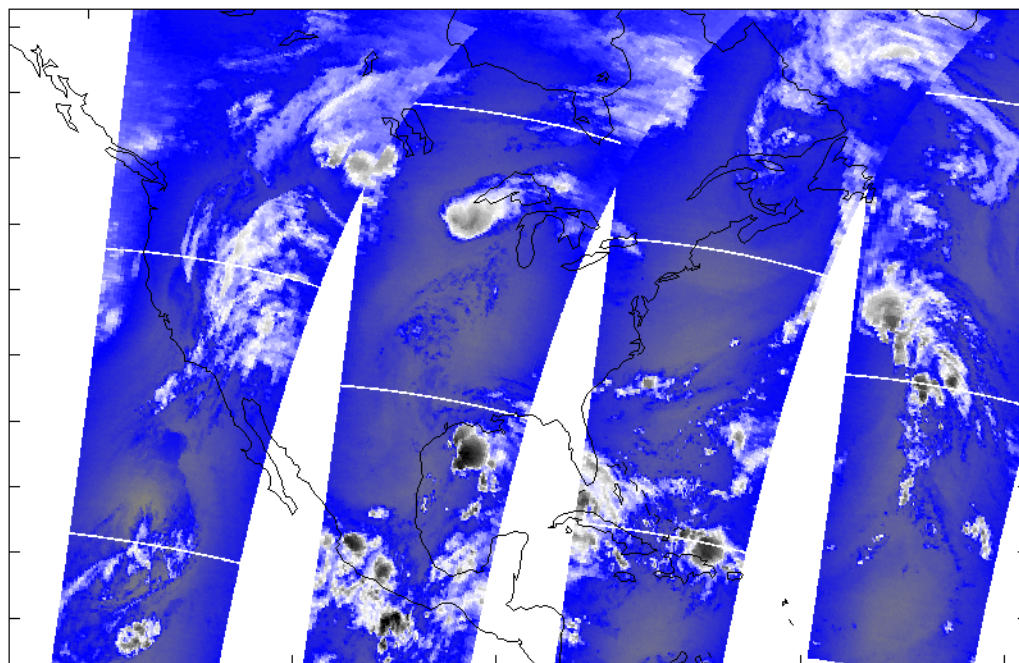
535.2 mbar



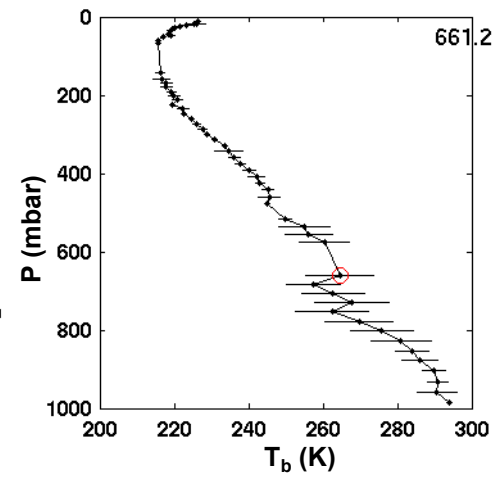
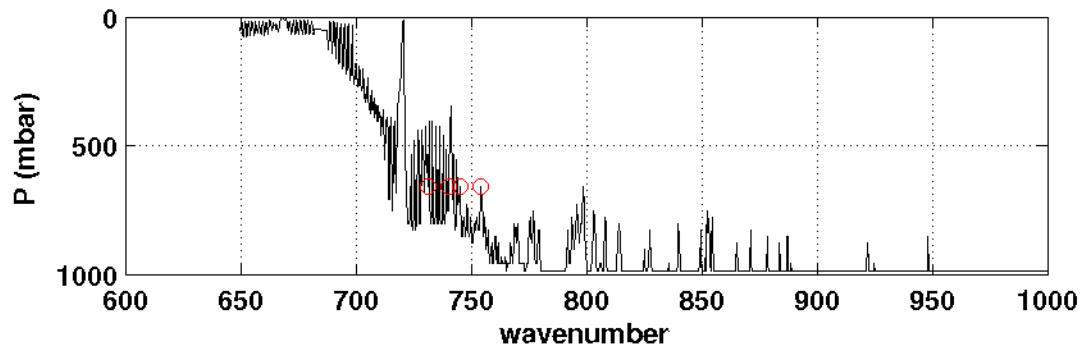
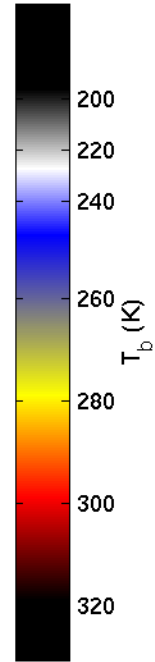
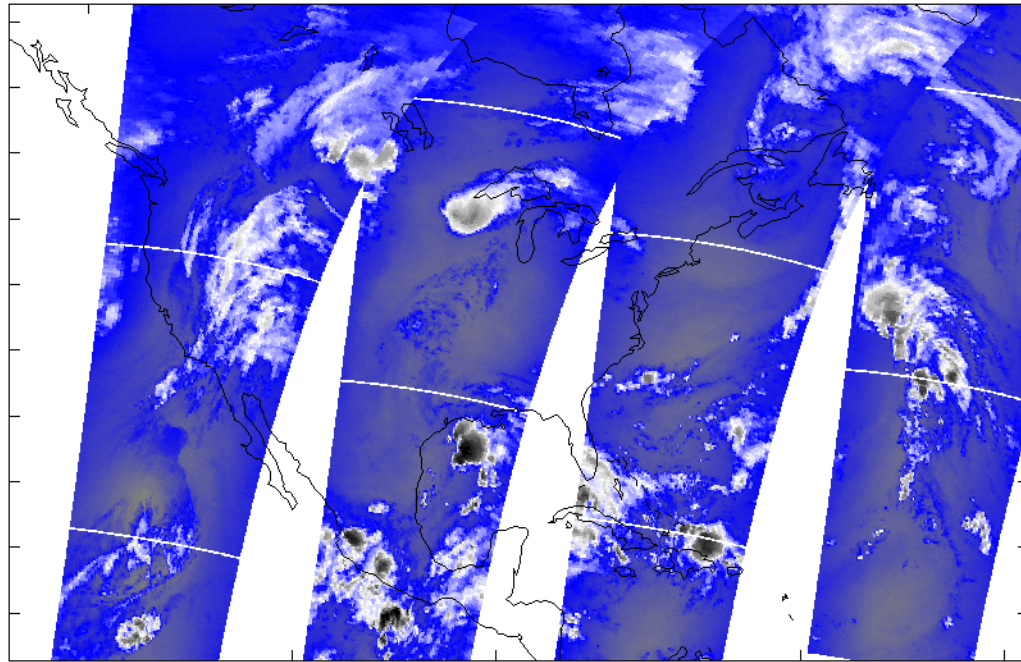
555.2 mbar



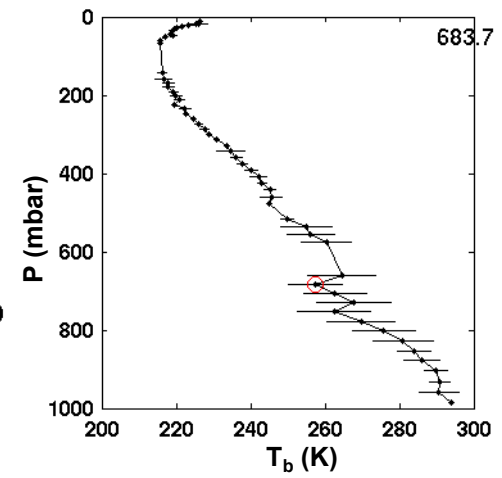
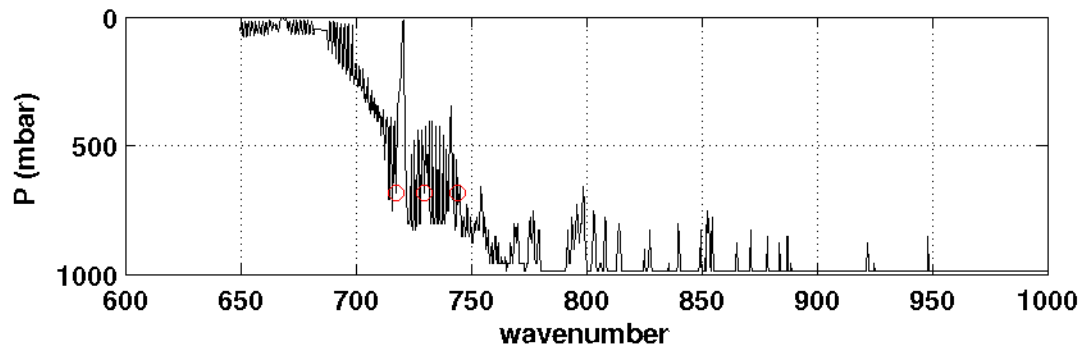
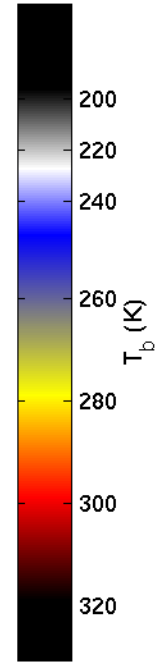
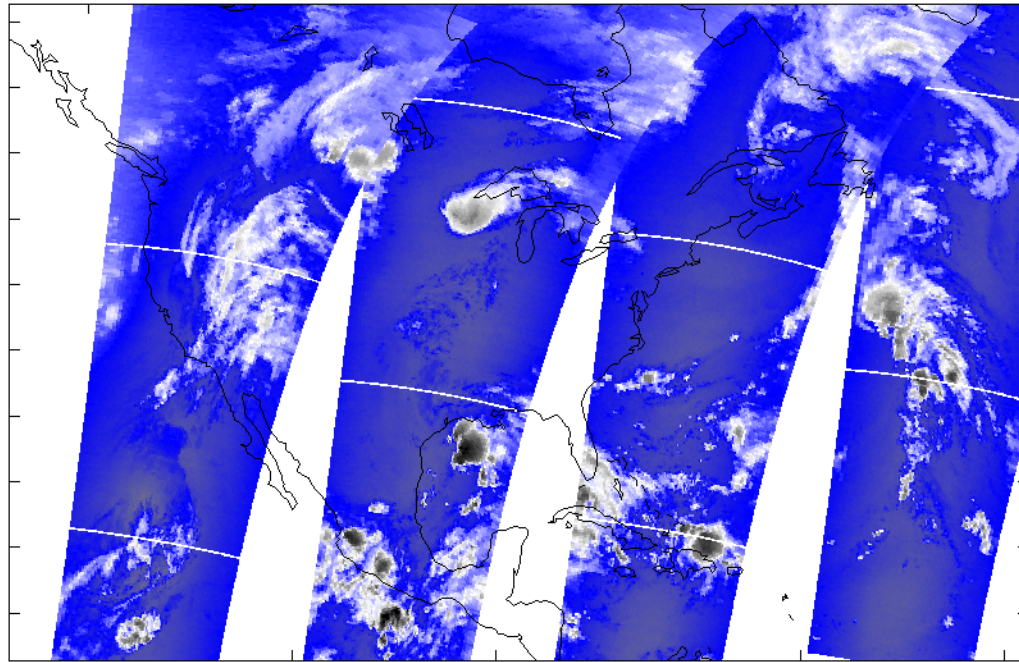
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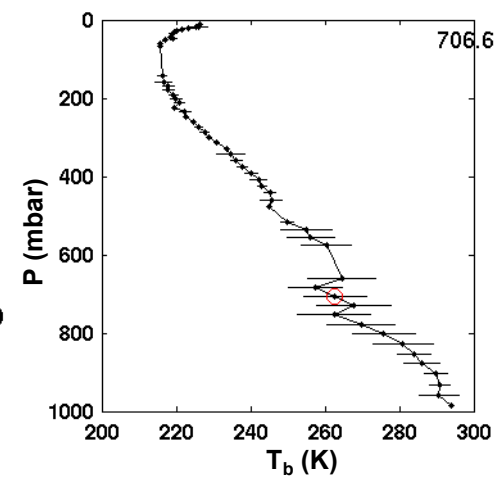
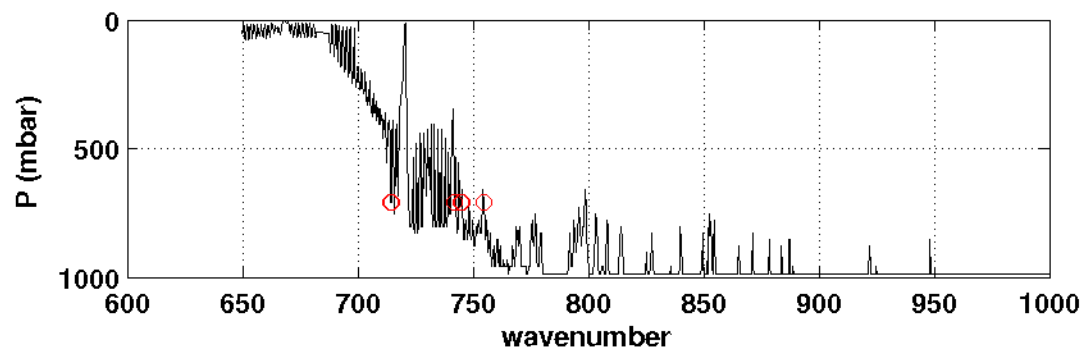
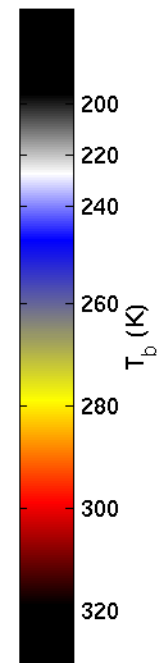
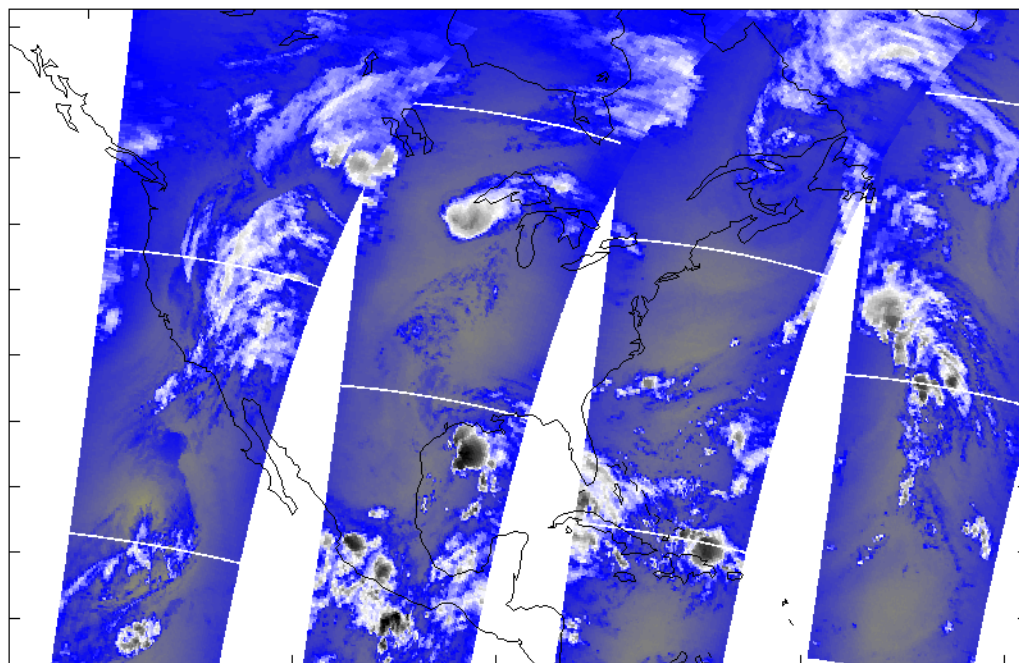
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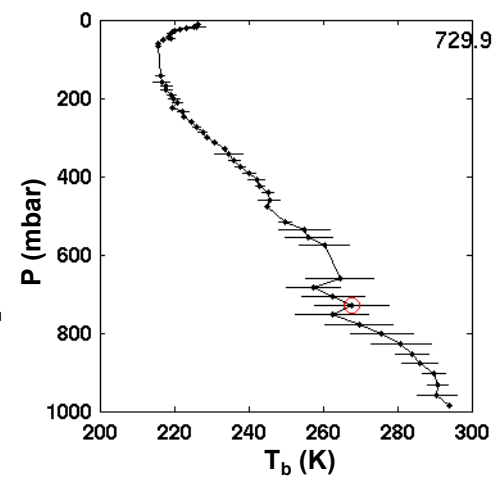
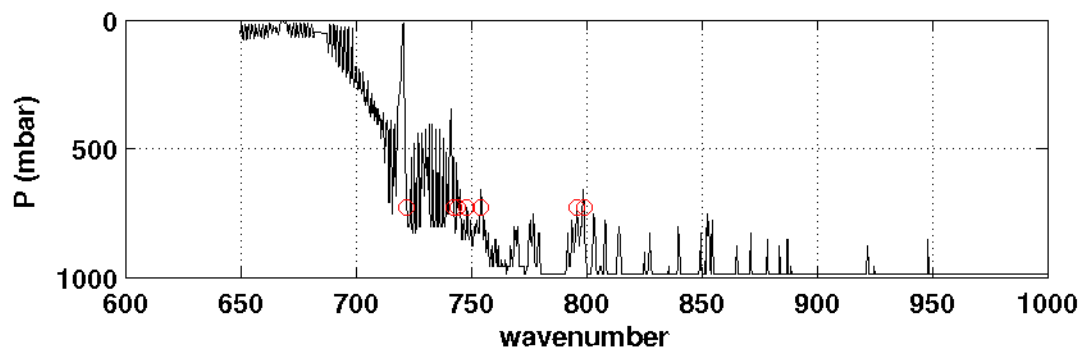
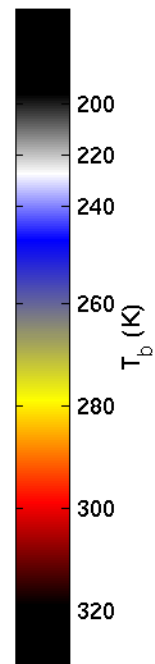
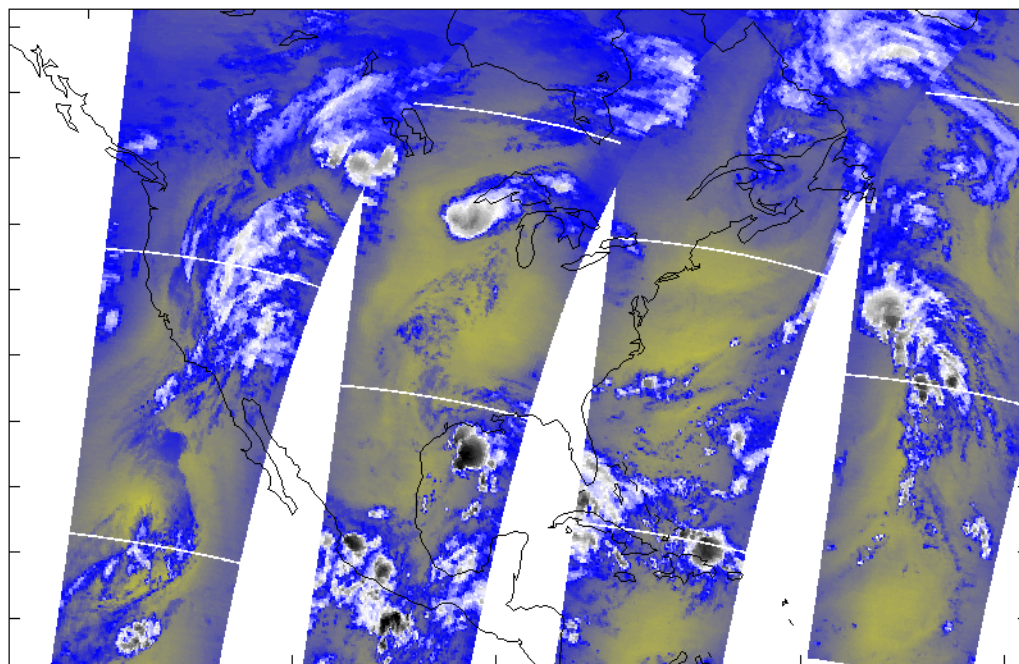
683.7 mbar



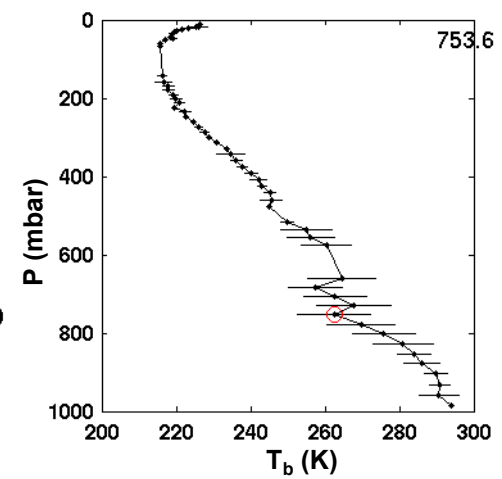
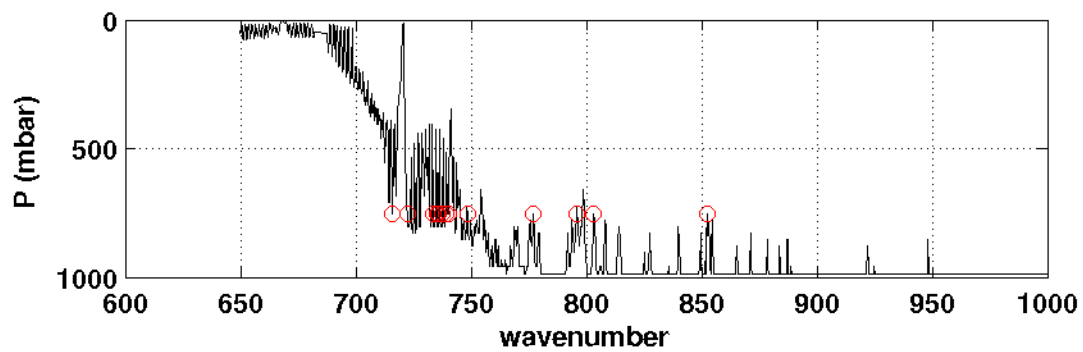
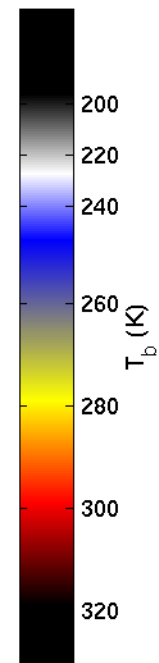
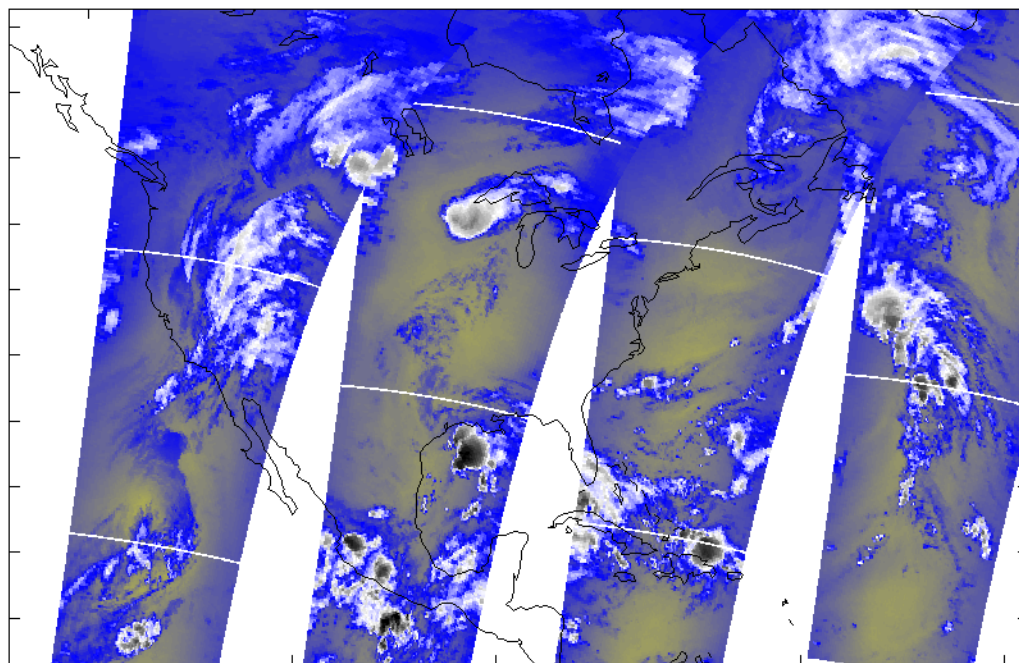
706.6 mbar



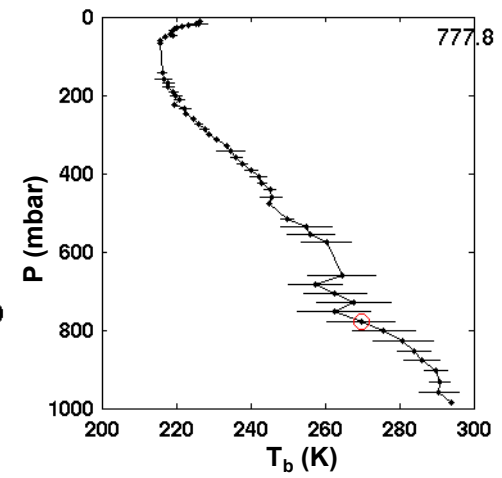
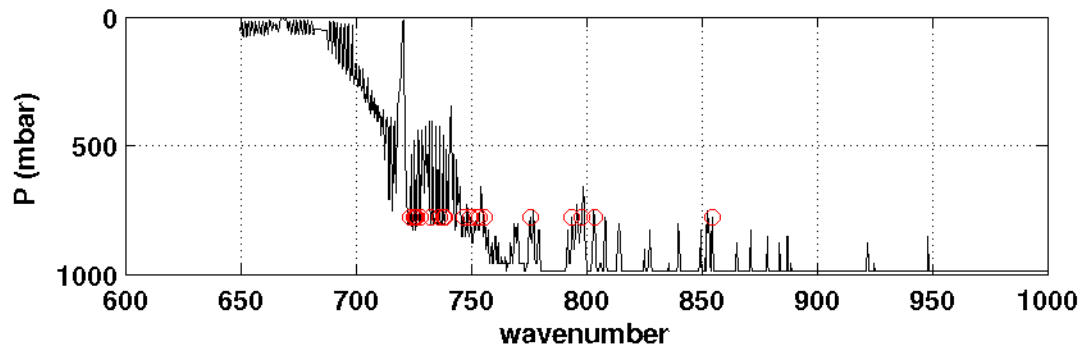
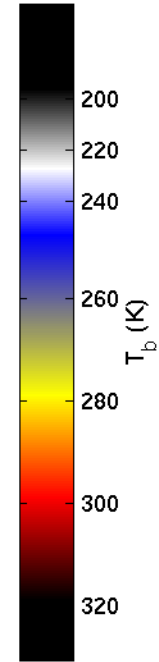
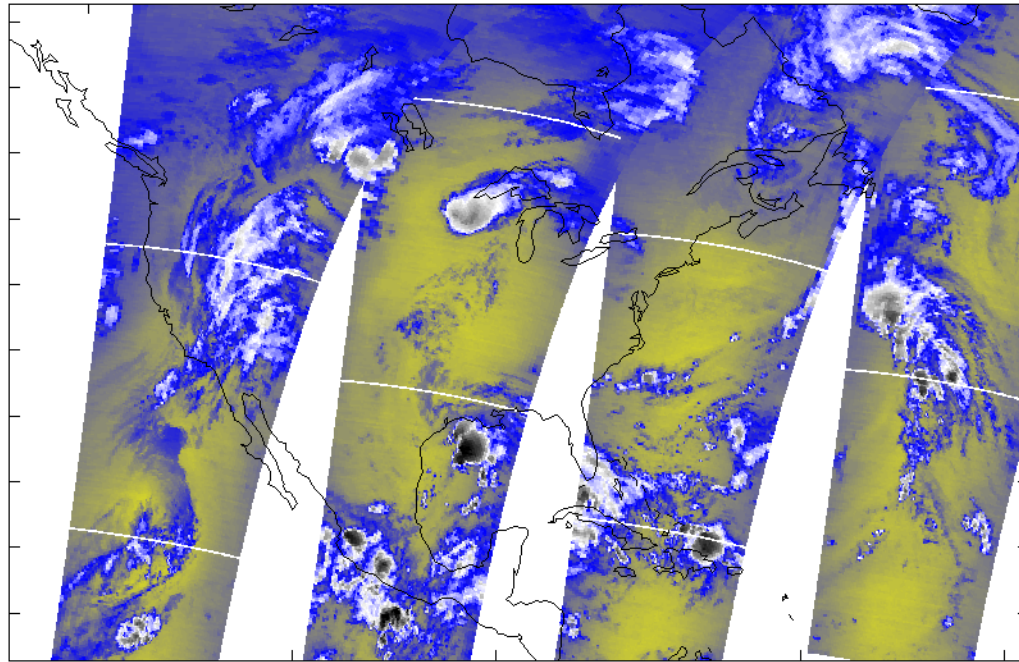
729.9 mbar



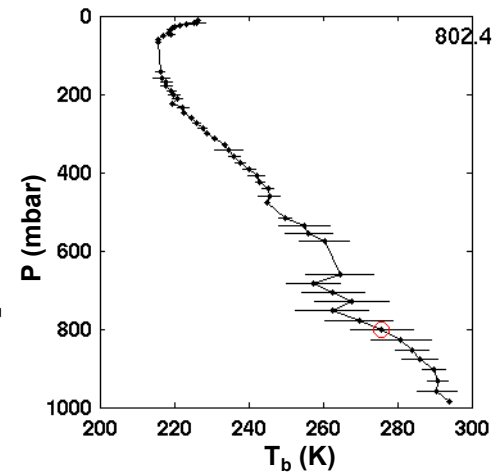
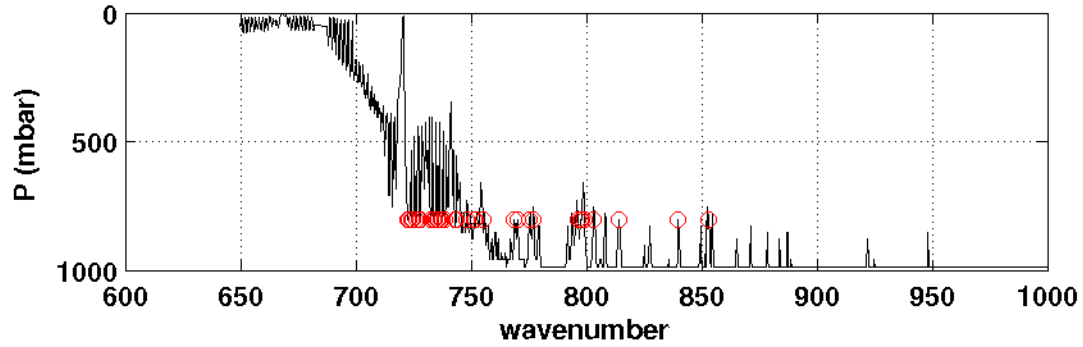
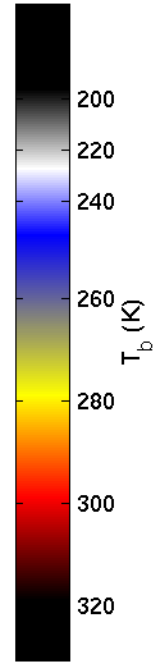
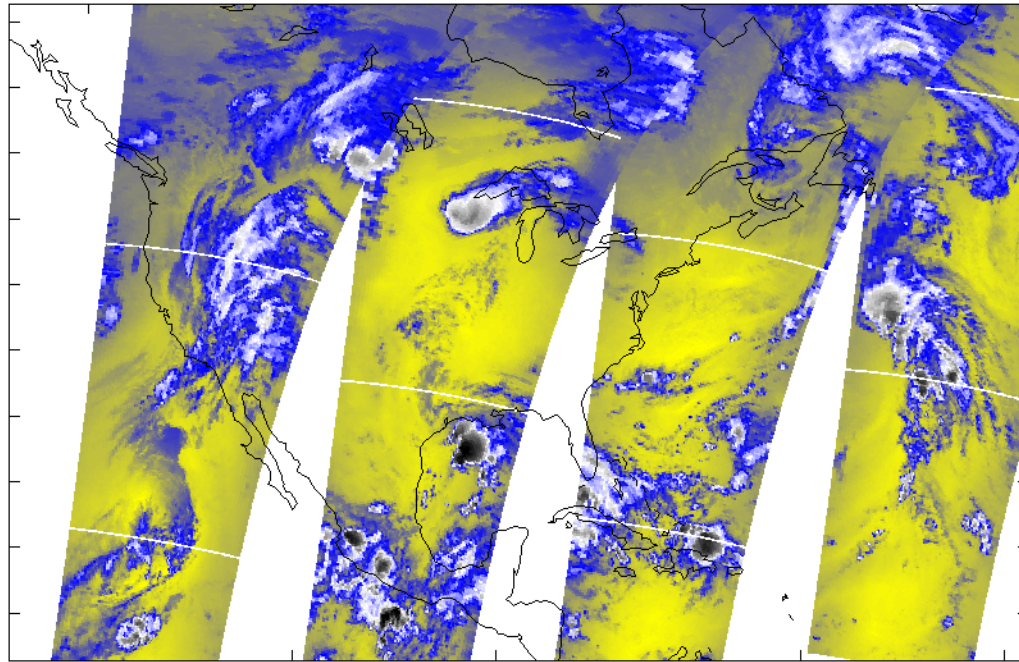
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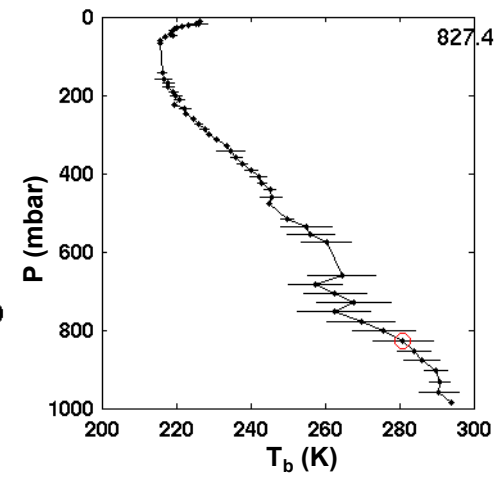
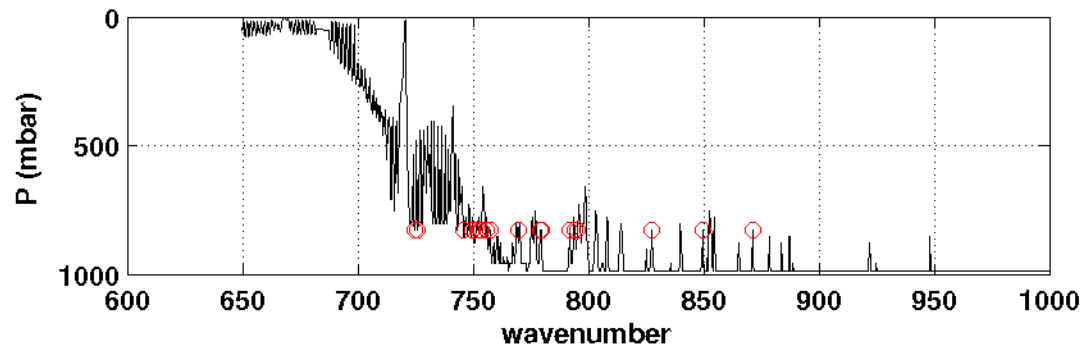
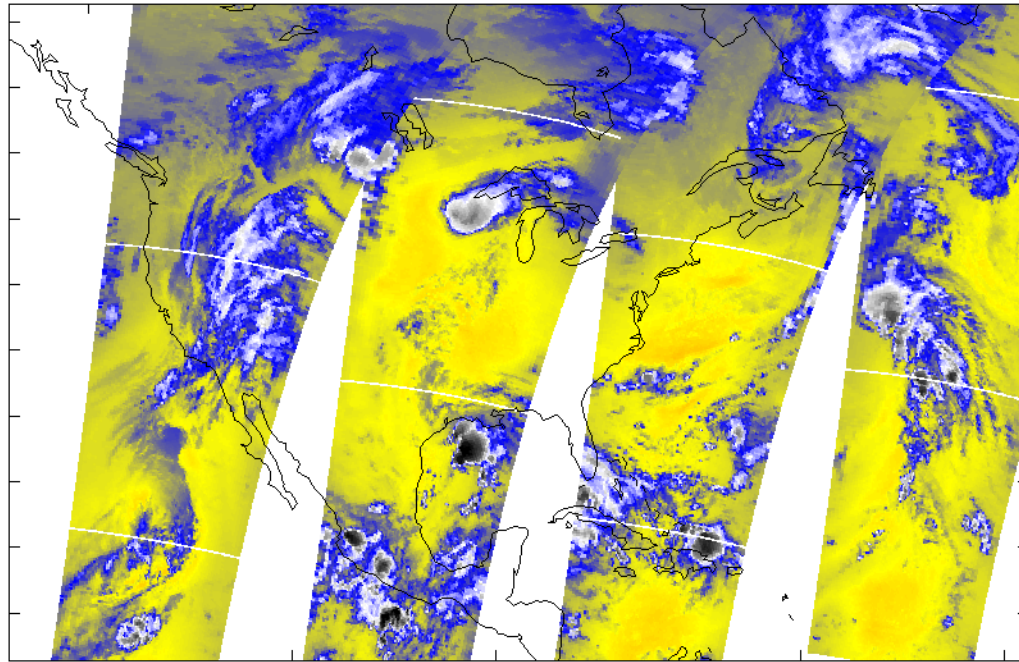
777.8 mbar



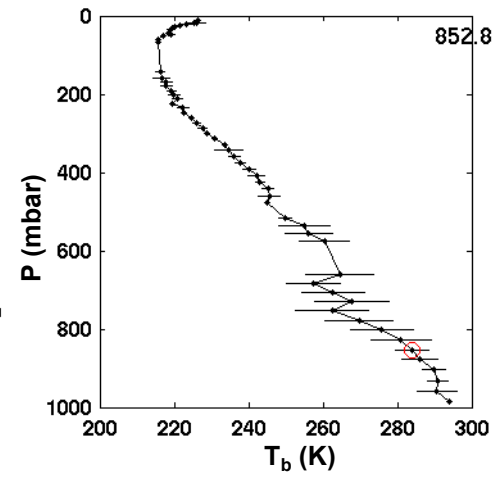
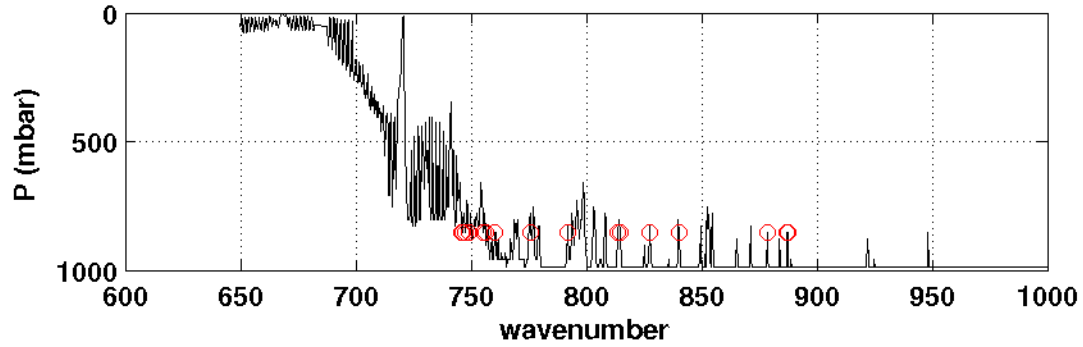
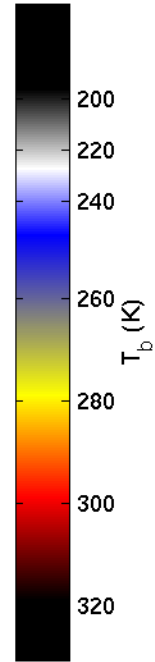
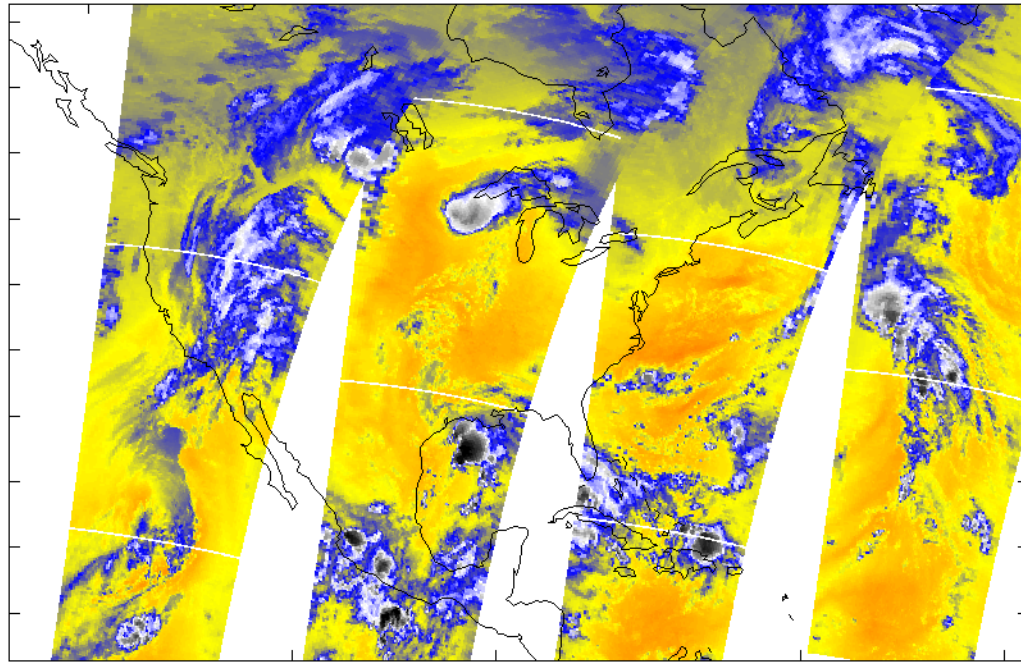
802.4 mbar



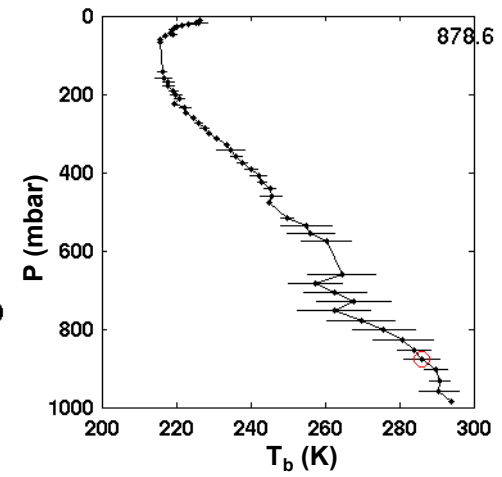
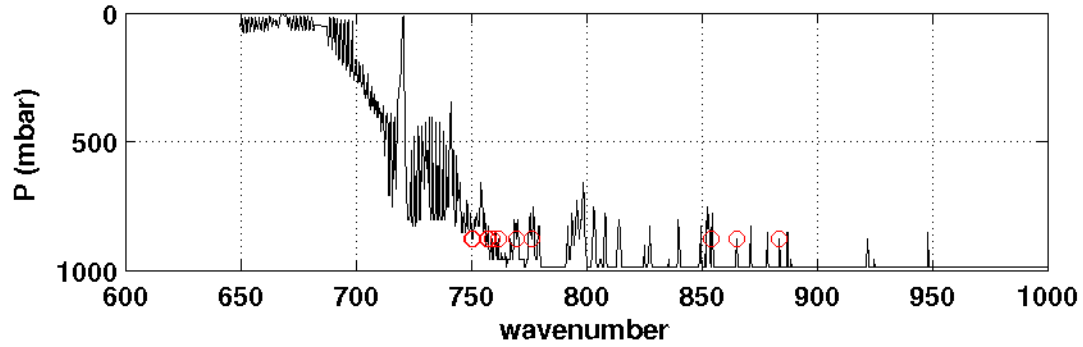
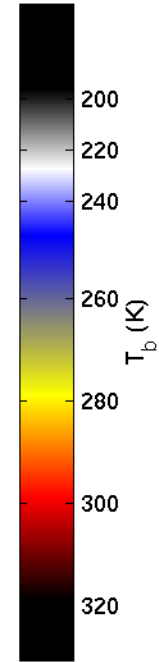
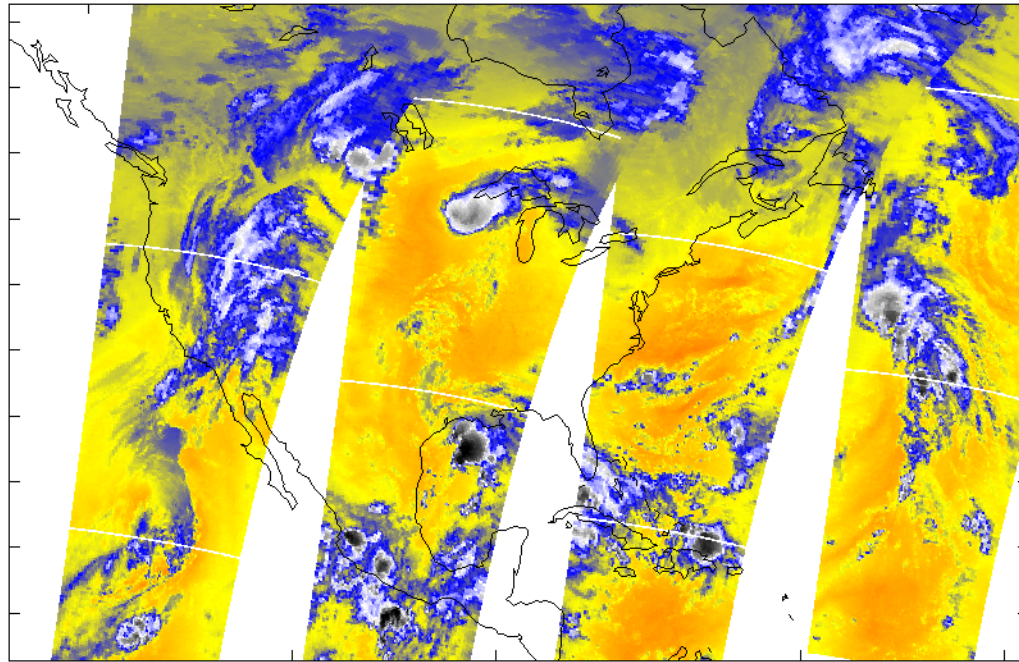
827.4 mbar



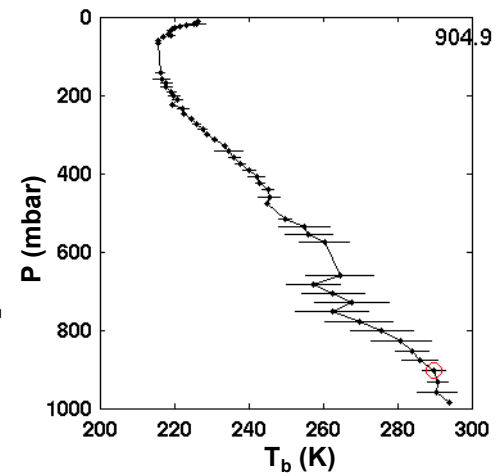
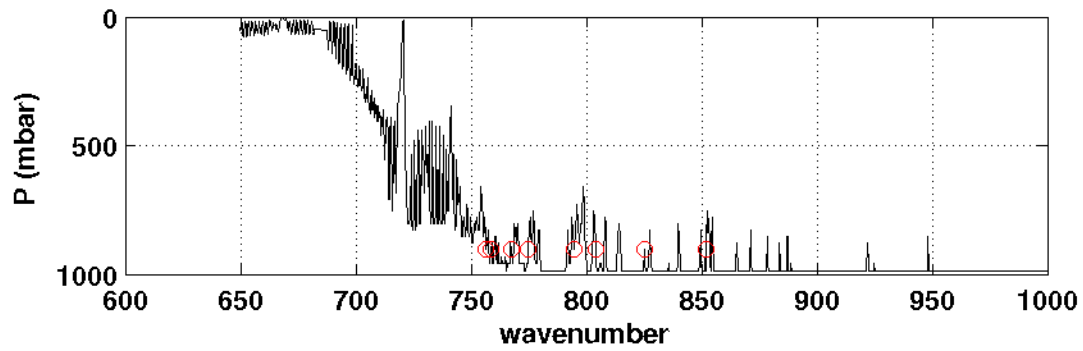
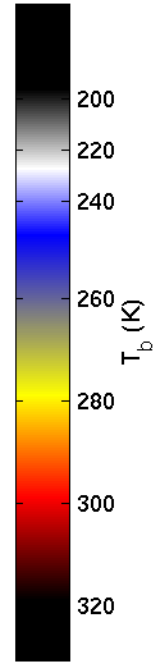
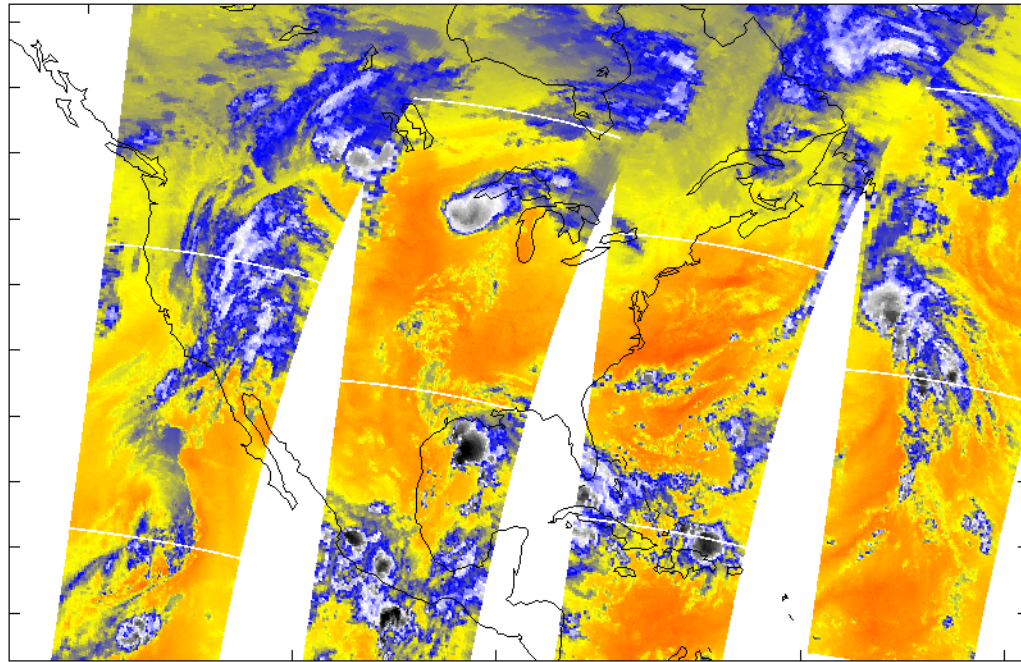
852.8 mbar



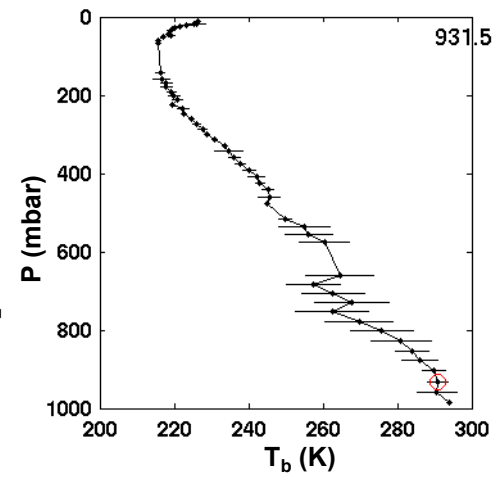
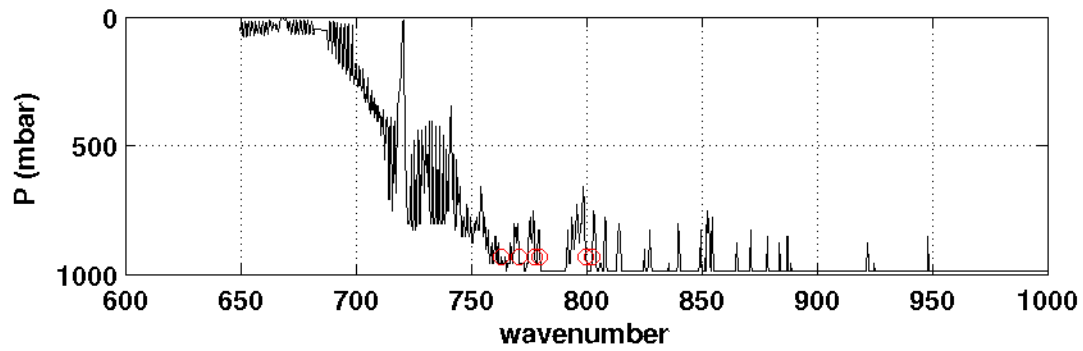
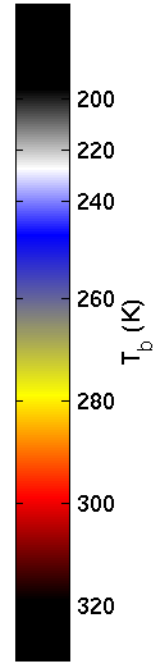
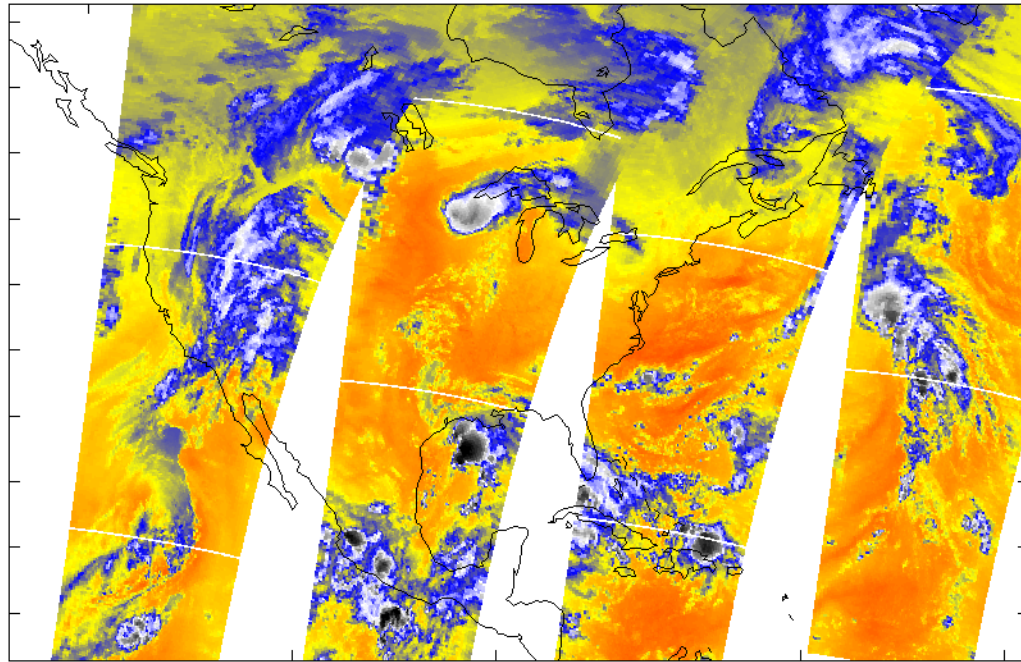
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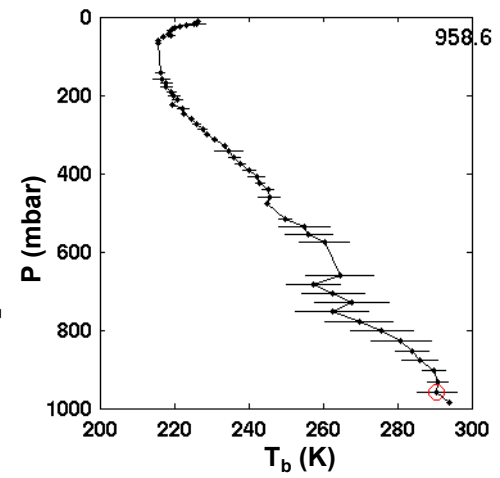
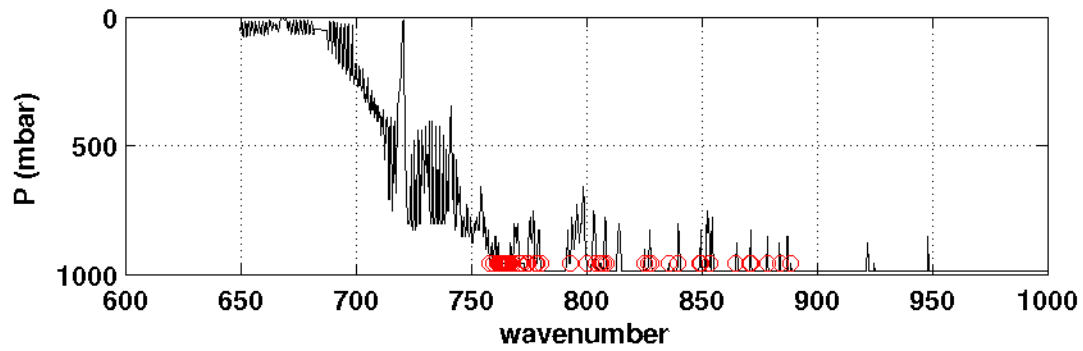
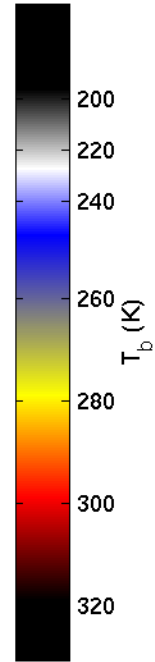
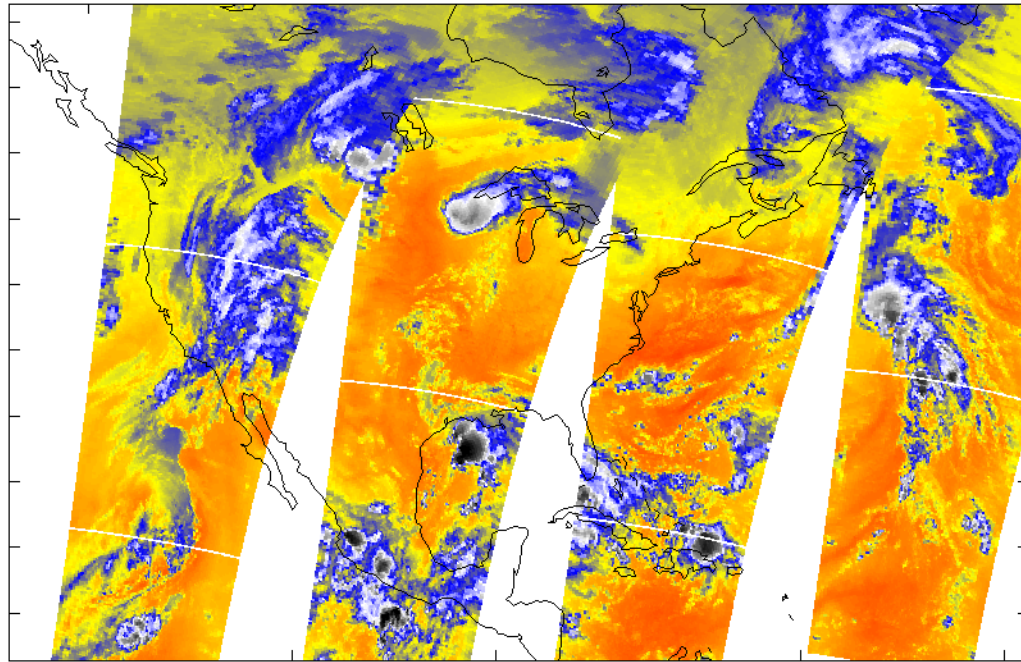
904.9 mbar



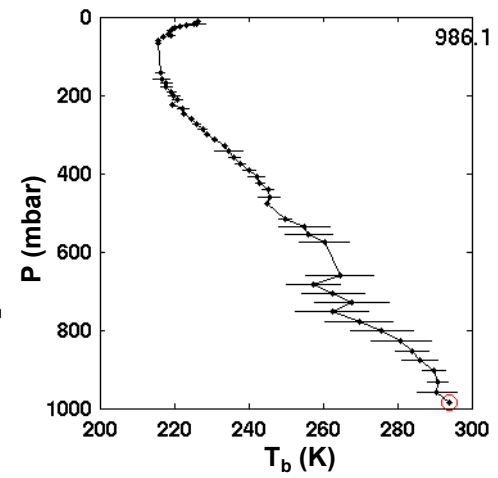
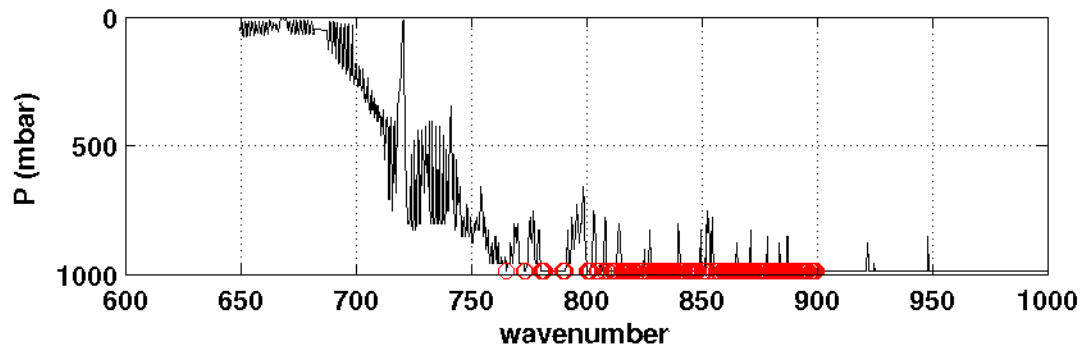
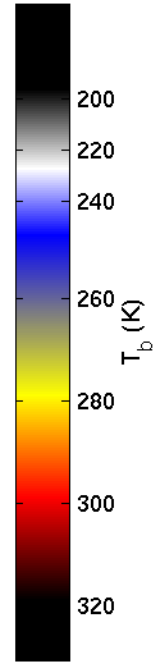
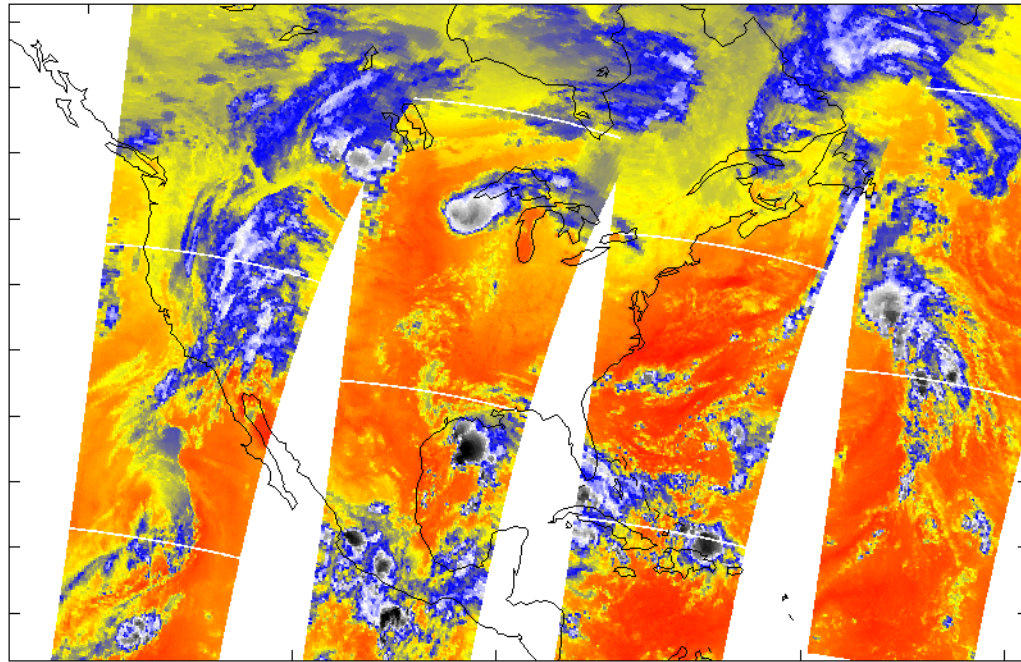
931.5 mbar



958.6 mbar

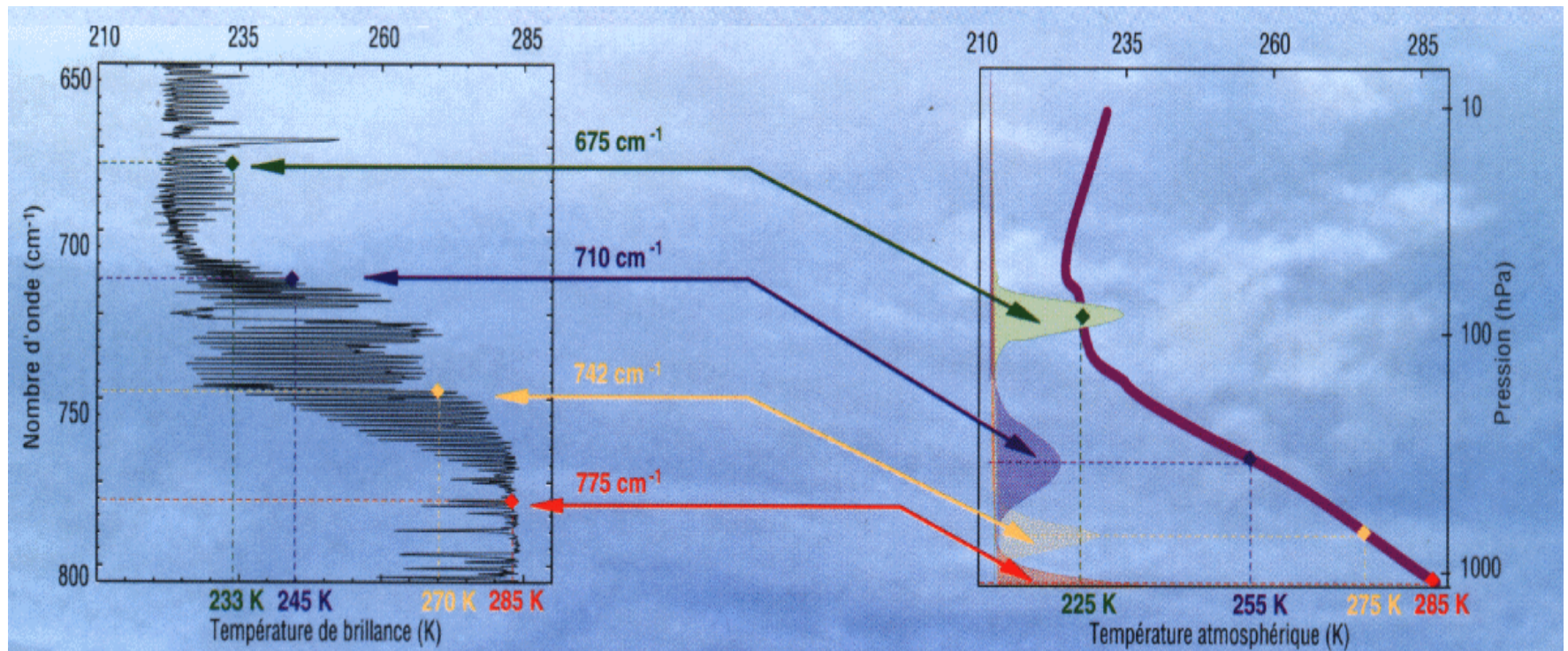


986.1 mbar



AIRS

(Atmospheric Infrared Sounder)
Regression Retrieval (Level 2)



Level 0 to Level 2

Level 0: raw data

Level 1A: geolocated radiance in counts

Level 1B: calibrated radiance in physical units

Level 2: retrieved physical variables

(temperature, humidity and ozone profiles, surface skin temperature, total precipitable water, total ozone content, cloud top height . . .)

Regression Model

1. Regression Model

$$X = C Y^T$$

2. Least squares regression solution

$$C = X Y (Y^T Y)^{-1}$$

Y...measurements [nprofs x nchannels]

C...Regression coefficients [nlevels x nchannels]

X... Atmospheric variables [nlevels x nprofs]

Regression Retrieval (1)

1. Calculate Regression Coefficients

$$C = X_{tr} Y_{tr} (Y_{tr}^T Y_{tr})^{-1}$$

2. Perform Retrieval (RTV)

$$X = C Y^T$$

Y... Measurements [nprofs x nchannels]

C ... Regression coefficients [nlevels x nchannels]

X ... Atmospheric variables [nlevels x nprofs]

Subscript tr refers to trainingset

Regression Retrieval (2)

1. Calculate Regression Coefficients

$$C = \Delta X_{tr} \Delta Y_{tr} (\Delta Y_{tr}^T \Delta Y_{tr})^{-1}$$

with

$$\Delta X_{tr} = X_{tr} - \text{mean}(X_{tr})$$

$$\Delta Y_{tr} = Y_{tr} - \text{mean}(Y_{tr})$$

2. Perform Retrieval (RTV)

$$\Delta X = C \Delta Y^T \text{ or } X = \text{mean}(X_{tr}) + C \Delta Y^T$$

with

$$\Delta X = X - \text{mean}(X_{tr})$$

$$\Delta Y = Y - \text{mean}(Y_{tr})$$

Principal Components (PC) Regression Retrieval

1. Calculate Regression Coefficients

$$M = \text{Cov}(Y_{\text{tr}})$$

$$U = \text{eig}(M)$$

$$A_{\text{tr}} = \Delta Y_{\text{tr}} U$$

$$C = \Delta X_{\text{tr}} A_{\text{tr}} (A_{\text{tr}}^T A_{\text{tr}})^{-1}$$

2. Perform Retrieval (RTV)

$$X = \text{mean}(X_{\text{tr}}) + C A^T$$

with

$$A = \Delta Y U, \quad \Delta Y = Y - \text{mean}(Y_{\text{tr}})$$

M... covariance matrix [nchannels x nchannels]

U ... First few eigenvectors of M [nchannels x npc]

A ... Projection Coefficients (or amplitudes) [nsamples x npc]

The Trainingset

X_{tr} . . . Representative set of atmospheric variables including temperature, moisture, ozone, surface pressure, surface skin temperature and surface skin emissivities

Y_{tr} . . . Corresponding set of simulated radiances, calculated by a fast RT (radiative transfer) forward model

Radiance received by AIRS

$$\begin{aligned} R_\nu &= \tau_{s\nu} \cdot \varepsilon_{s\nu} \cdot B_\nu(T_S) \\ &+ \int_{p_s}^0 B_\nu(T(p)) d\tau_\nu(p) \\ &- \tau_{s\nu} \cdot r_{s\nu} \cdot \int_{p_s}^0 B_\nu(T(p)) d\tau_\nu^*(p) \\ &+ R_\nu^{sun} \cdot \cos(\theta) \cdot \tau_{s\nu}^{sun}(p_s) \cdot r_\nu^{sun} \end{aligned}$$

- ← Upwelling IR radiation from surface
- ← Upwelling IR radiation from atm. layers
- ← Reflected downwelling IR radiation
- ← Reflected solar radiation

R ...radiance, ν ...wavenumber, s ...surface, p ...pressure, sun ...solar,

T ...temperature, B ...Planck function, ε ...emissivity,

τ ...level to space transmittance, θ ...local solar zenith angle

r ...reflectivity, with $r = (1 - \varepsilon)/\pi$,

τ^* ...level to surface (downwelling) transmittance [$\tau^* = \tau_\nu^2(p_s) / \tau_\nu(p)$]

Fast Radiative Transfer Forward Model

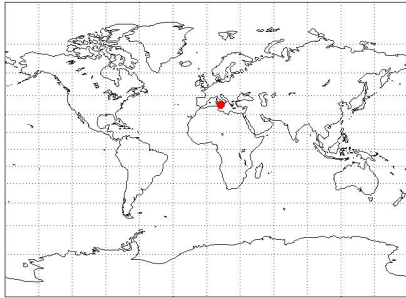
- Fast Model Regression :
 - Computation of line-by-line Transmittance τ for FM training data set
 - Convolve with AIRS SRF (spectral response function)
 - Solve regression scheme $\tau = AC$ for coefficients C using predictors A
(predictors are functions of T, p, absorber amount, scanang ...)
- Calculate transmittance τ for any other profile
- Solve RTE to get radiance R_ν

IMAPP AIRS Regression Retrieval Results:

Comparison with co-located
radiosonde observations (RAOBs)

Co-located RAOB / AIRS single profile retrieval (RTV)

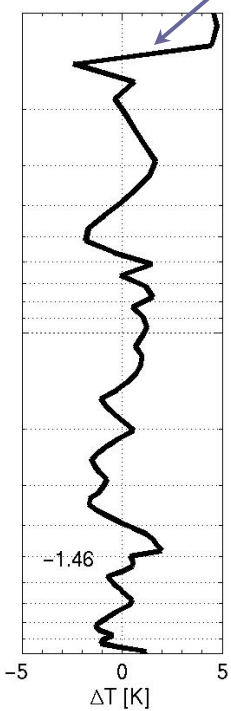
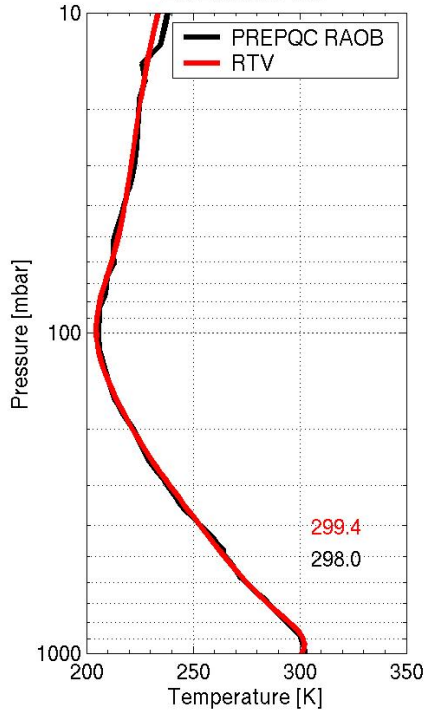
pixel 1259



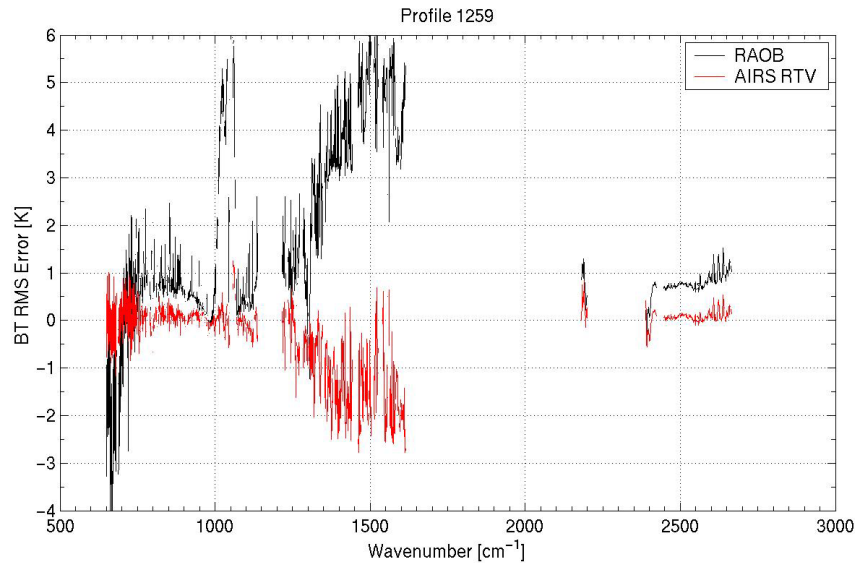
residual = observed minus calculated spectrum

— RAOB - RTV

Profile 1259
Lat/Lon: 37.9/12.5



— RAOB Residual (Obs - Calc BT)
— Retrieval Residual (Obs - Calc BT)

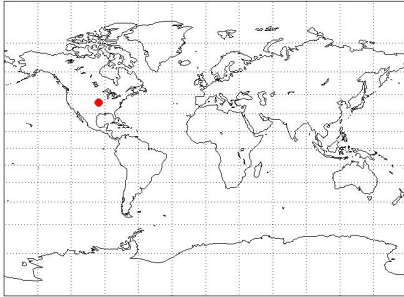


Temperature (pixel 1259)

Brightness Temperature (BT) residual

Co-located RAOB / AIRS single profile retrieval (RTV)

pixel 1516

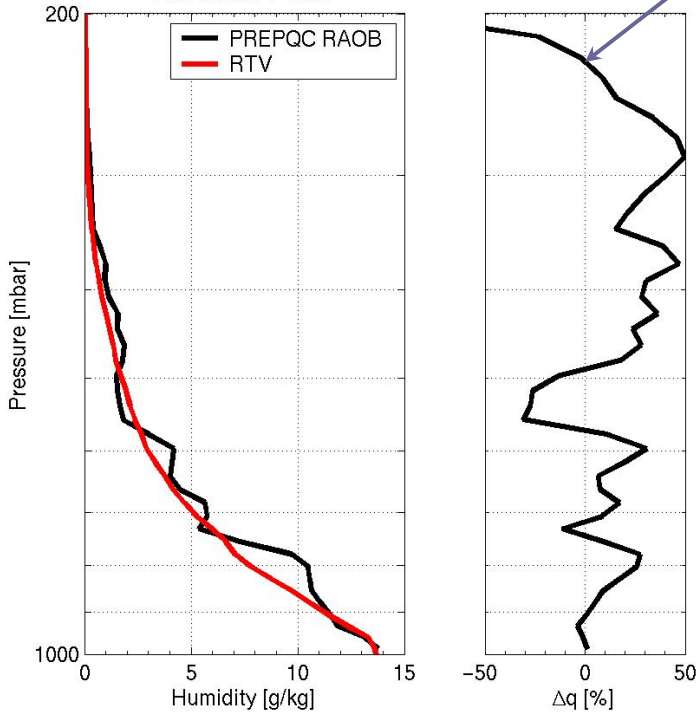


residual = observed minus calculated spectrum

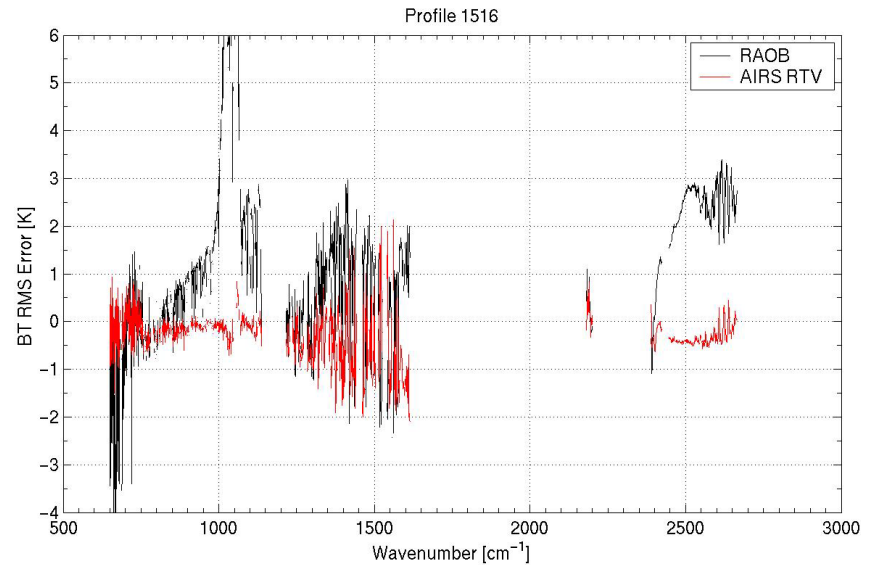
— RAOB - RTV

— RAOB Residual (Obs - Calc BT)
— Retrieval Residual (Obs - Calc BT)

Profile 1516
Lat/Lon: 39.1/-95.6

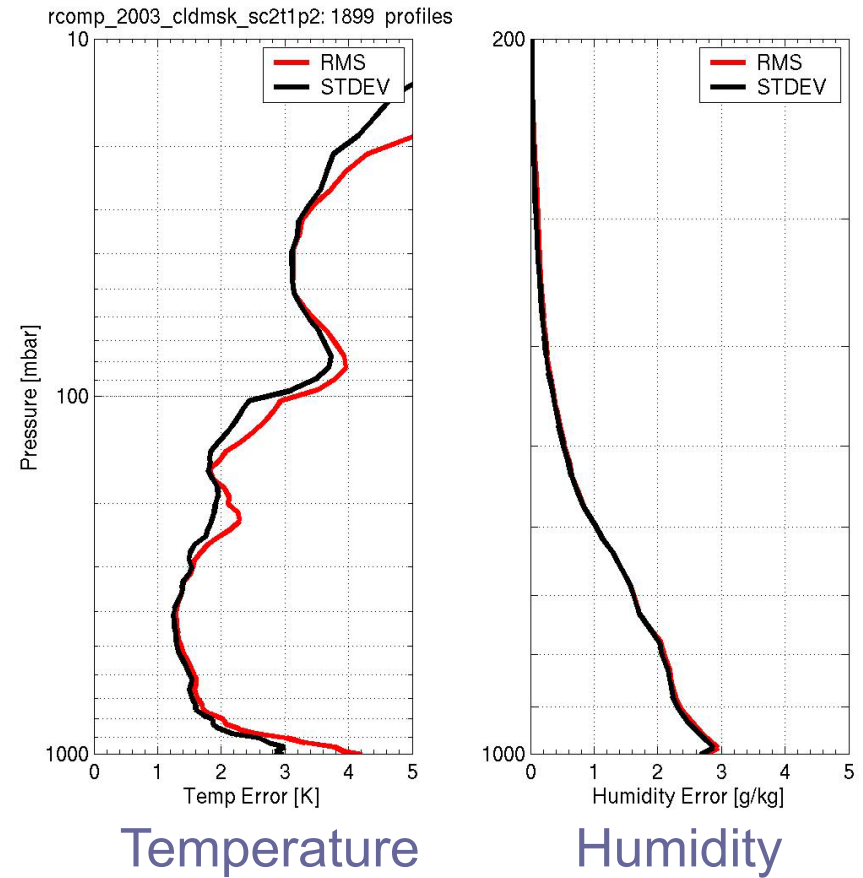
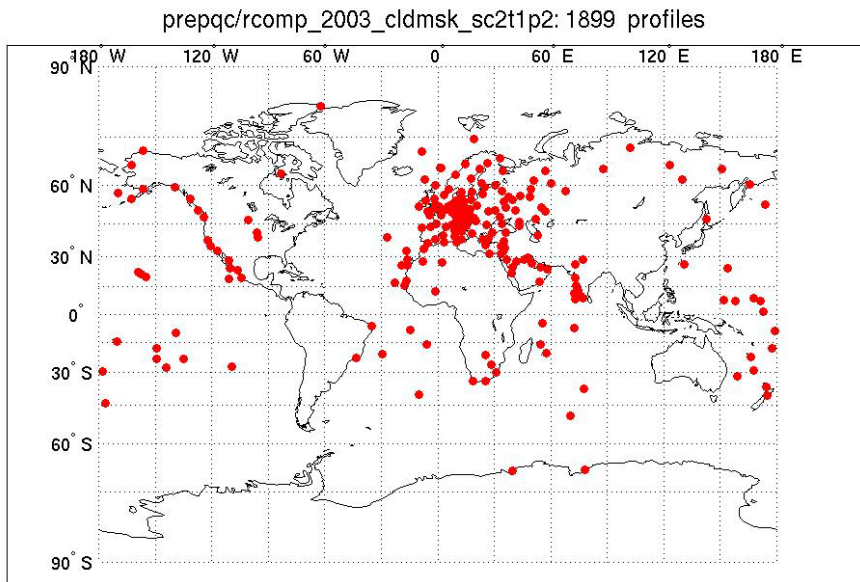


Humidity (pixel 1516)



Brightness Temperature (BT) residual

Co-located RAOB / AIRS retrieval statistics (1899 profiles)



Land Surface Characterization Using High Spectral Resolution AIRS and Moderate Spatial Resolution MODIS Observations from the EOS Aqua Platform

PI: Robert O. Knuteson

co-Is:

Steve Ackerman
Hank Revercomb

Dave Tobin

Brian Osborne

University of Wisconsin-Madison,
Space Science and Engineering Center

Objectives:

- Create a gridded product of land surface temperature and IR emissivity at AIRS spatial resolution.
- Intercomparison of AIRS, MODIS, and ASTER land surface infrared emissivity and temperature products.
- Create spectral land surface infrared emissivity maps for geographic regions of climatic importance.

This proposal addresses the following two important goals: (1) better utilization of satellite sounding data over land and (2) study of the evolution of land surface characteristics.

Abstract

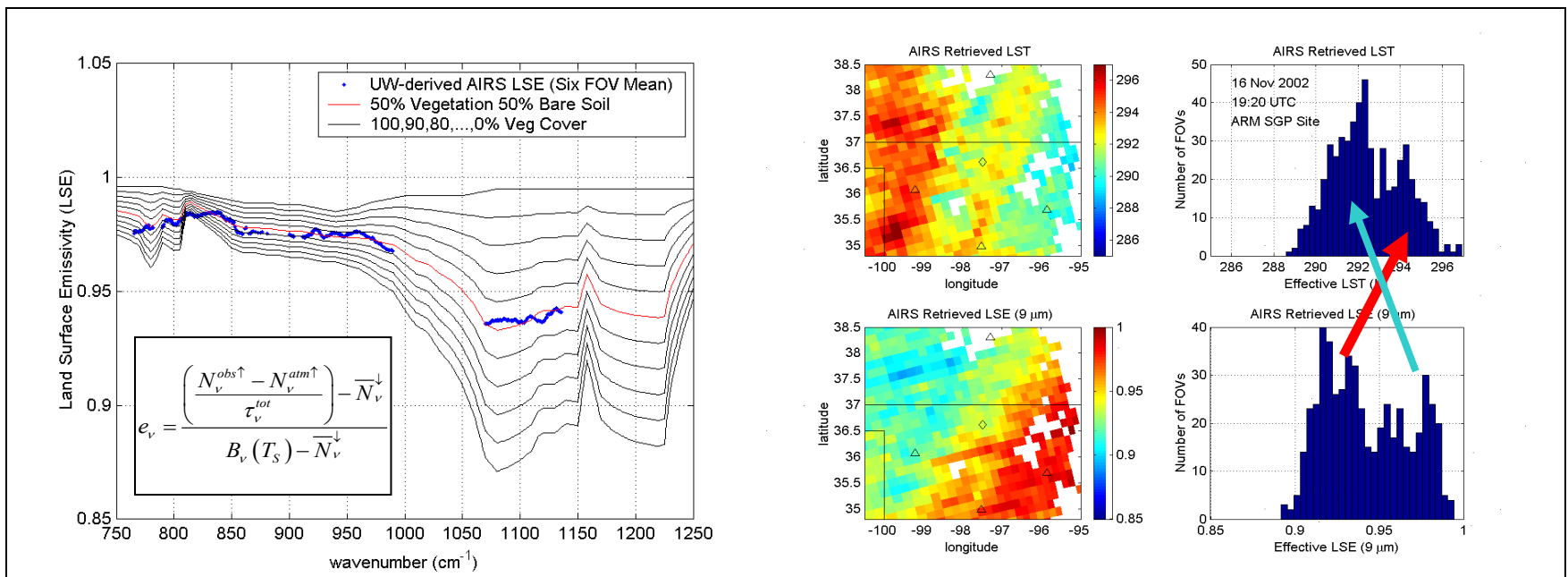
The **accuracy of the land surface temperature** derived from satellite infrared observations **is dependent on accurate knowledge of the land surface emissivity**. **Surface emissivity errors of 1.5 % lead to surface temperature errors of about 1 °C**. Global numerical weather prediction (NWP) models assimilate global radiosonde measurements of atmospheric temperature, water vapor, and winds but use only infrared satellite data not affected by emission from the land surface. This is due to the uncertainty in surface emissivity at the spatial scales needed for atmospheric remote sensing. This proposal addresses the following two important goals: **(1) better utilization of satellite sounding data over land and (2) study of the evolution of land surface characteristics**. Observations from the Atmospheric InfraRed Sounder (AIRS) sensor on the EOS Aqua platform provide the key information needed to significantly improve the characterization of the land surface at the spatial scales needed for NWP models.

Abstract - continue

The investigators have recently demonstrated a new technique for the **simultaneous separation of land surface temperature and emissivity** that takes advantage of the high spectral resolution information contained in the AIRS observations. This proposal will apply the technique for **land surface temperature and emissivity retrieval to AIRS data** in a quality assessment of the operational AIRS product. In parallel, a quality assessment of the Moderate Resolution Imaging Spectroradiometer (MODIS) operational products will be made by weighting the MODIS one kilometer temperature and emissivity products with the spatial response function of the AIRS sensor and comparing the spectral content of the derived emissivities. **A new gridded product of land surface temperature and emissivity** at AIRS spatial resolution **will be developed** under this proposal for three limited spatial domains chosen **to highlight the correlation of surface emission to land cover change**.

- Land surface temperature (**LST**) and emissivity (**LSE**) have been derived from AIRS data over the DOE ARM Southern Great Plains site in North Central Oklahoma.
- The technique takes advantage of the **surface reflection** on and off of atmospheric absorption lines to simultaneously retrieve LST and LSE.
- The effective land surface emissivity derived from AIRS data can be fit by a linear combination of **two pure scene types** (bare soil and grass vegetation).
- The resulting spatial distributions are consistent with the **known land use**; cattle grazing in eastern Oklahoma and wheat farming in western Oklahoma and Kansas.
- Wheat farming leads to more **exposed bare soil** with lower emissivities but higher daytime land surface temperatures than the grassland regions.

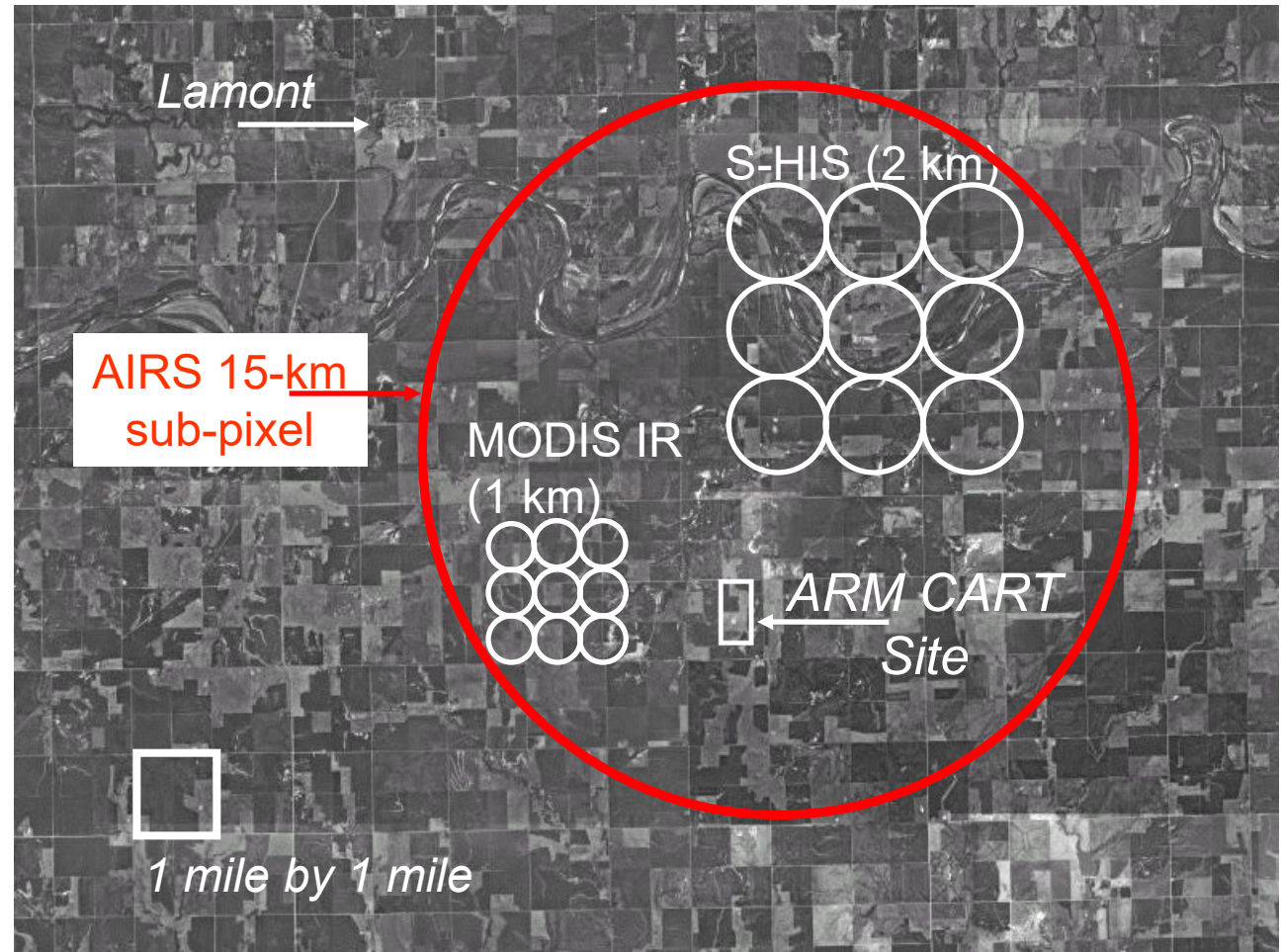
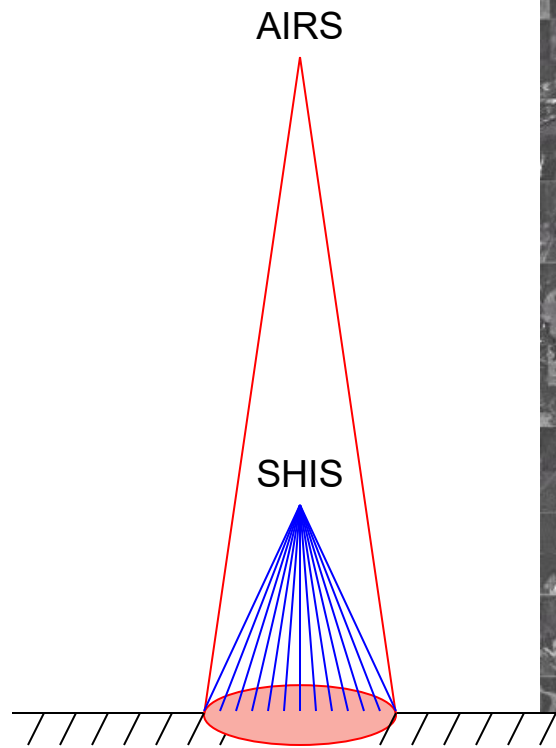
AIRS Case Study
 DOE ARM Site
 16 Nov 2002 19 UTC



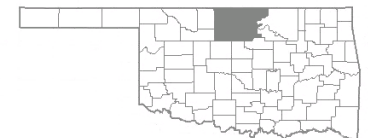
Validation: The scale problem

Farm Fields < 0.5 km; Aircraft \approx 2 km; AIRS \approx 15 km

View Angles



Aerial photo from <http://terraserver.homeadvisor.msn.com/>

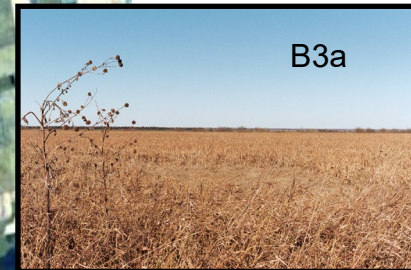
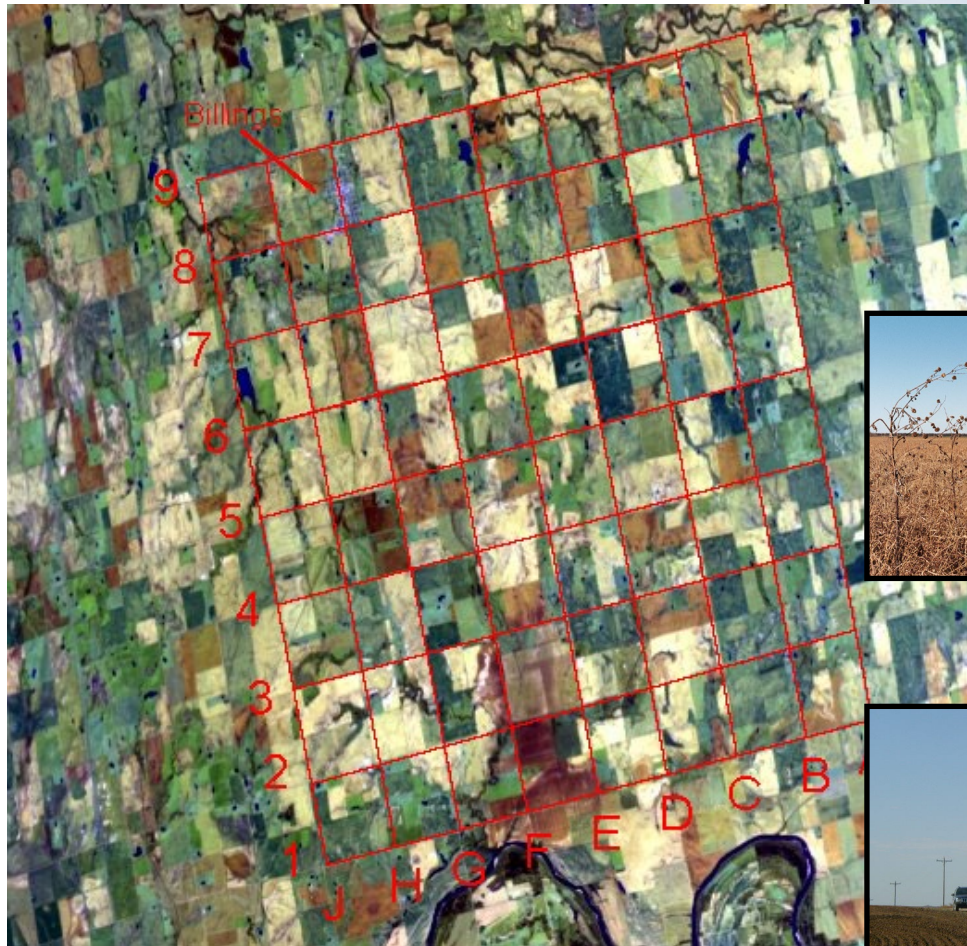


U.S. Department of Energy ARM Site

Survey Grid

NASA ER-2: 22 Nov 2002

9 mile
(15 km)
square
survey
grid



The Problem of Mixed Scenes

The observed radiance is a linear combination of uniform scenes.

$$R_{\nu}^{OBS} = \sum_{i,j} w_{i,j} \cdot I_{i,j,\nu} + S_{\nu}$$

Define an Effective Emissivity and Effective Surface Temperature such that

$$\hat{\epsilon}_{\nu} = \sum_{i,j} w_{i,j} \cdot \epsilon_{i,j,\nu}$$

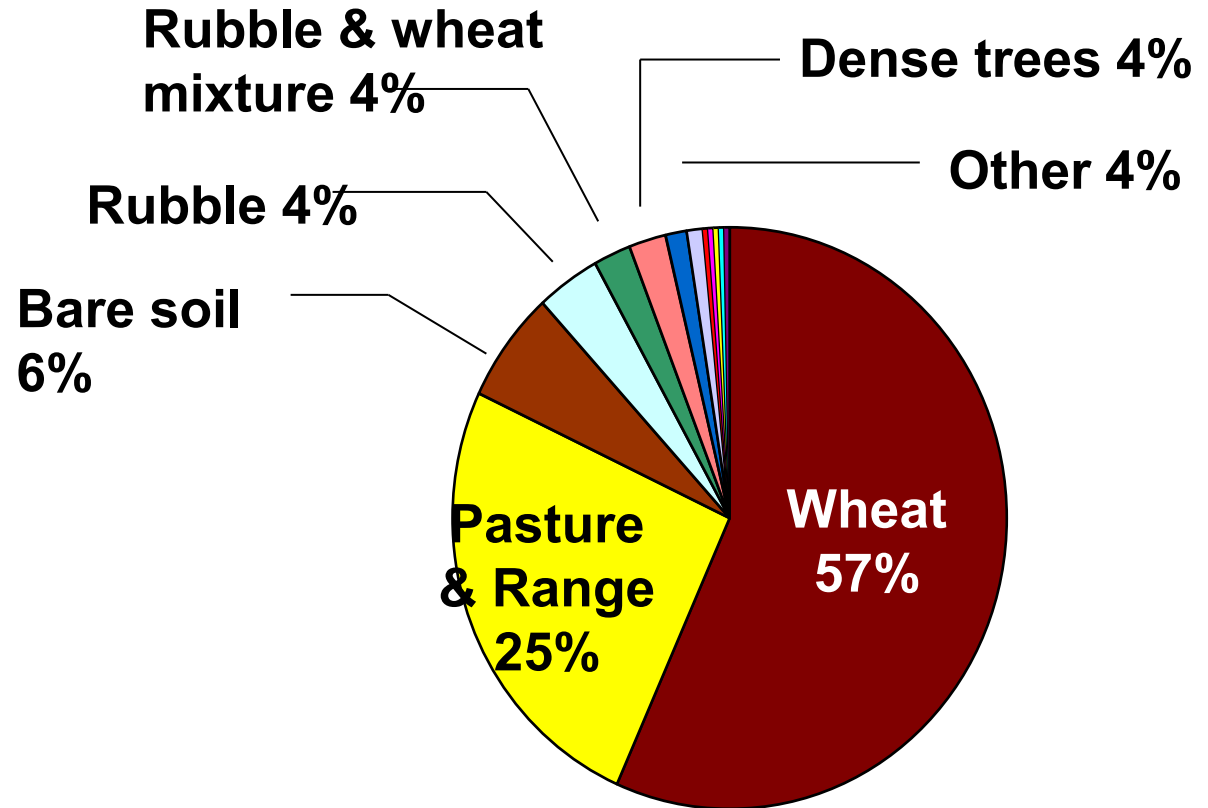
$$\hat{\epsilon}_{\nu} \cdot B_{\nu}(\hat{T}_S) = \sum_{i,j} w_{i,j} \cdot \epsilon_{i,j,\nu} \cdot B_{\nu}(T_{i,j,S})$$



9 miles (15 km)

ARM Site Land Use Survey

(Osborne, 2003)



November 2002; 63 square mile area.

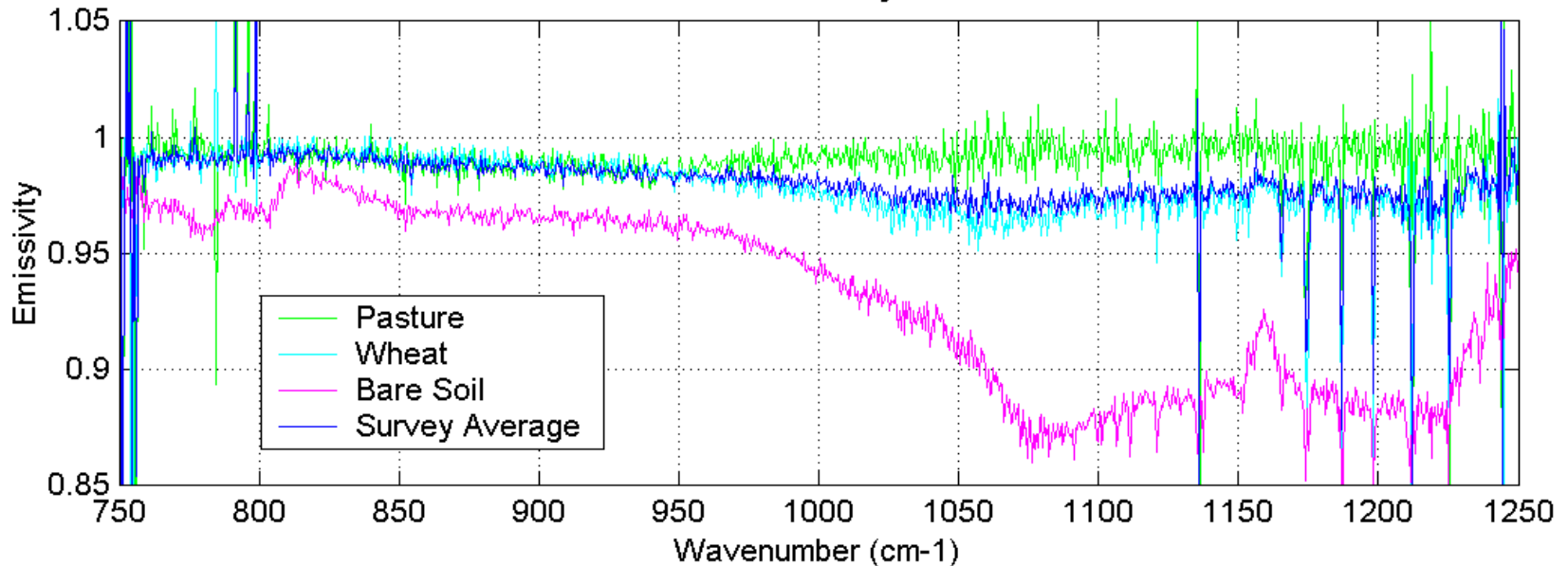
- Two land cover types dominate: wheat fields and pasture (grassland).

Emissivity Survey

- ARM SGP site is dominated by two land cover types “pasture” and “wheat”.
- We noticed that the measured wheat field emissivity can be approximated by a linear combination of pure scene types; bare soil and grass.

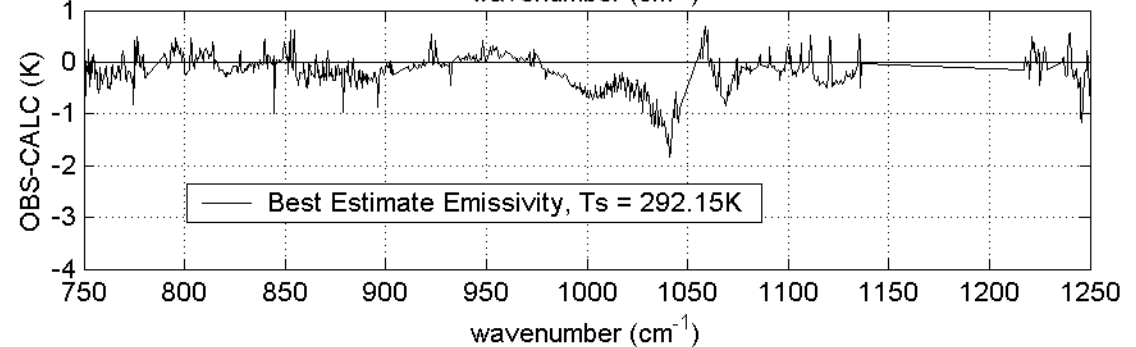
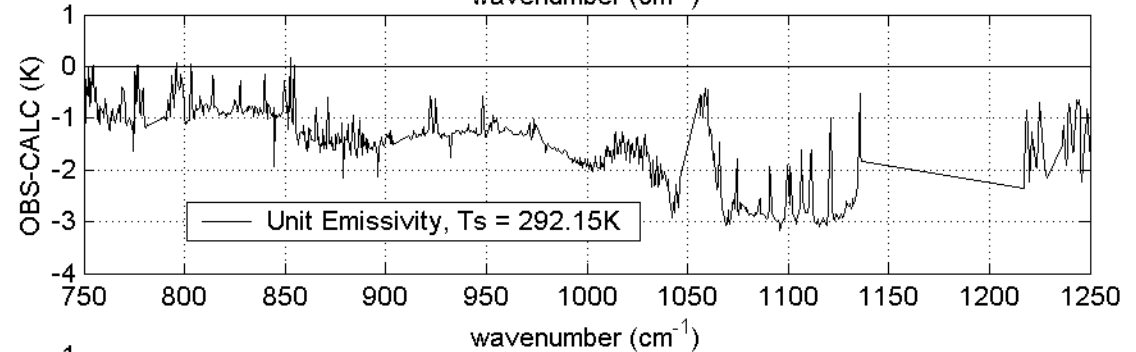
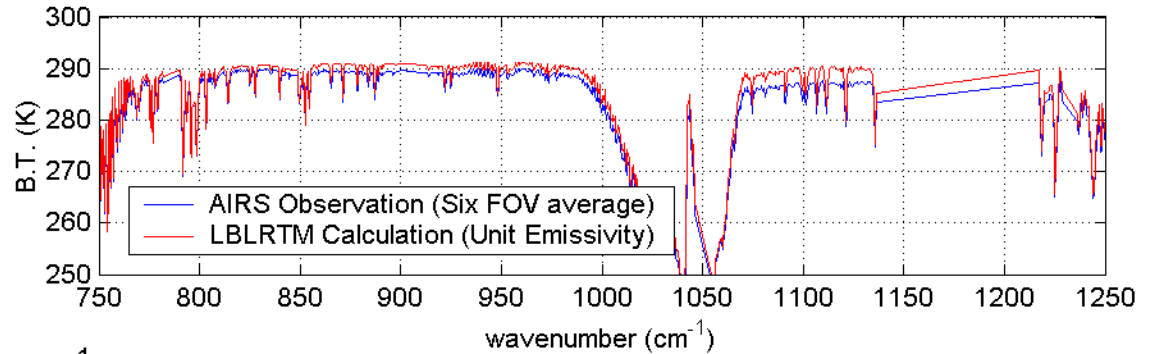
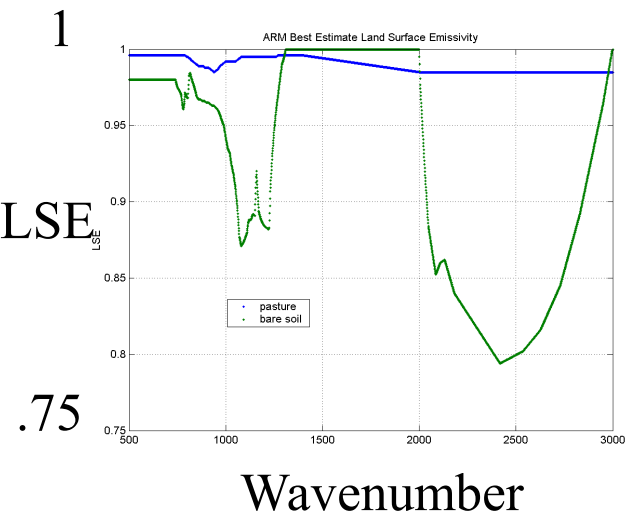
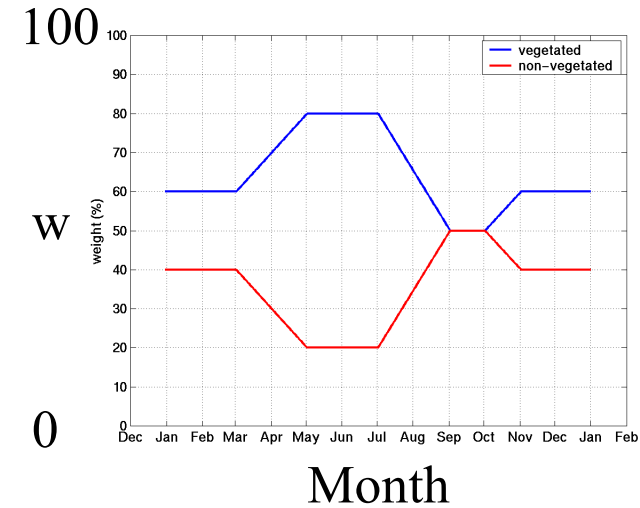


S-AERI Surface Emissivity Measurements



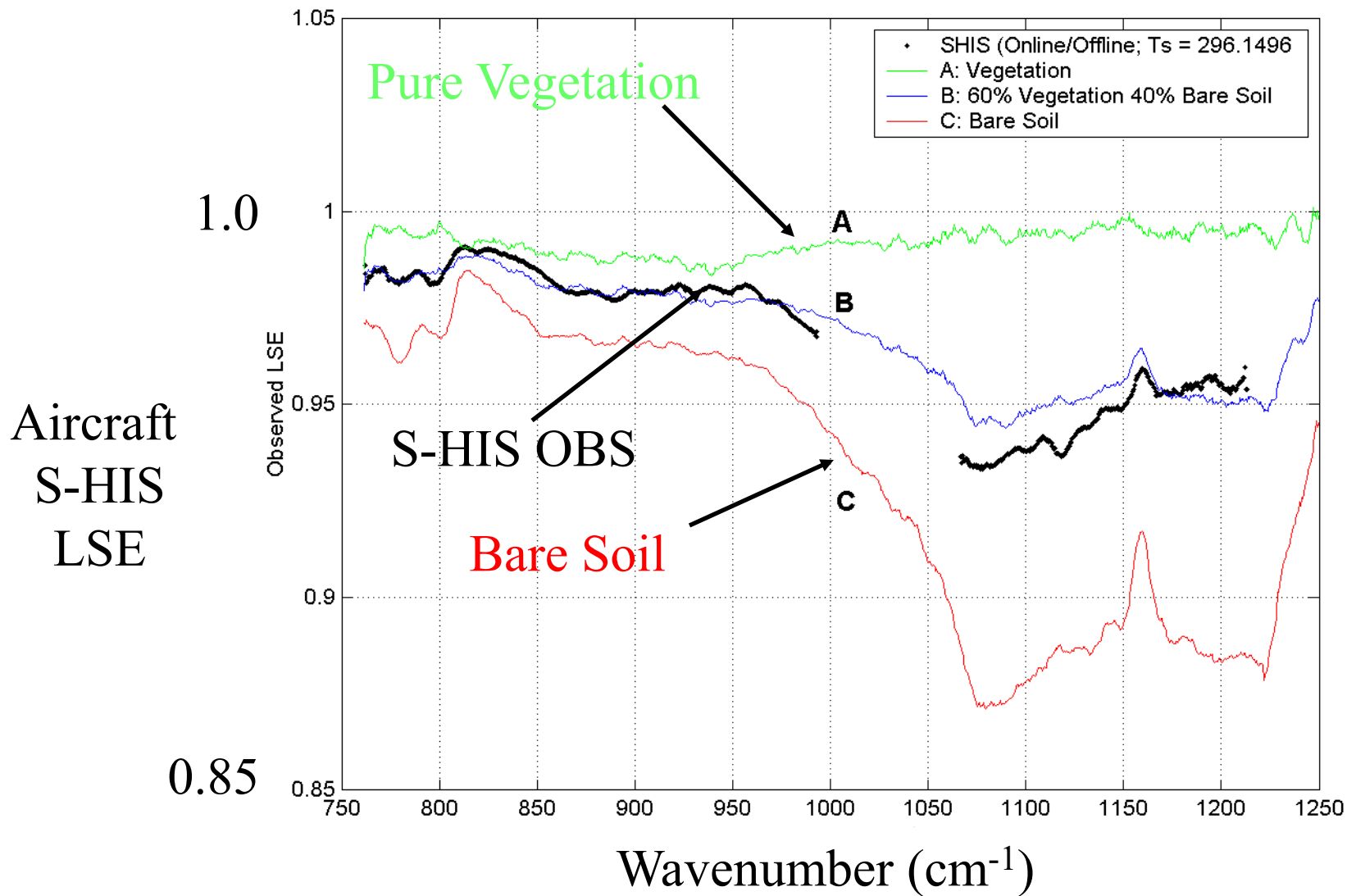
ARM SGP LST/LSE “Best Estimate”

- Formulated in April 2001 to supply the surface contribution to the ARM/AIRS validation product developed by D. Tobin the vegetation model will be validated using AIRS and MODIS data.





Aircraft validation measurements are also consistent with a linear combination of vegetation and bare soil.



Benefits to the AIRS Team

- **Validation of AIRS standard land surface products using UW ground-based and aircraft-based sensors during selected field campaigns.**
- **Cross-validation of AIRS standard products against MODIS land surface products from the Aqua platform.**
- **Creation of a global infrared surface emissivity database valuable for both data assimilation of AIRS radiance over land and AIRS retrieval of vertical T/Q profiles over land.**

Potential Benefits to the Broader Community

- **Use of AIRS observations to separate effective skin temperature from absolute IR emissivity is a unique contribution to land surface remote sensing.**
- **Use of a combination of AIRS (high spectral) and MODIS (higher spatial) can improve the surface temperature estimate at MODIS 1-km resolution.**
- **Use absolute IR emissivity to estimate “true” vegetation fraction, i.e. fraction of bare soil exposed.**
- **Use AIRS satellite observations to monitor the seasonal and annual change in climate sensitive “semi-arid” regions adjacent to deserts.**

For more information:

<http://airs3.ssec.wisc.edu/~airs/lste>

AIRS/AMSU/HSB DATA PRODUCTS

<u>Radiance Products (Level 1B)</u>	RMS Uncertainty*	Horizontal Resolution	
AIRS IR Radiance	3%	15 x 15 km	
AIRS VIS/NIR Radiance	20%	2.3 x 2.3 km	
AMSU Radiance	0.25-1.2 K	45 x 45 km	
HSB Radiance	1.0-1.2 K	15 x 15 km	
<u>Standard Core Products (Level 2)</u>			Vertical Resolution
Cloud Cleared IR Radiance	1.0K	45 x 45 km	
Sea Surface Temperature	0.5K	45 x 45 km	
Land Surface Temperature	1.0K	45 x 45 km	
Temperature Profile	1K	45 x 45 km	1 km below 700 mb 2 km 700-30 mb
Humidity Profile	15%	45 x 45 km	2 km in troposphere
Total Precipitable Water	5%	45 x 45 km	
Fractional Cloud Cover	5%	45 x 45 km	
Cloud Top Height	0.5 km	45 x 45 km	
Cloud Top Temperature	1.0 K	45 x 45 km	

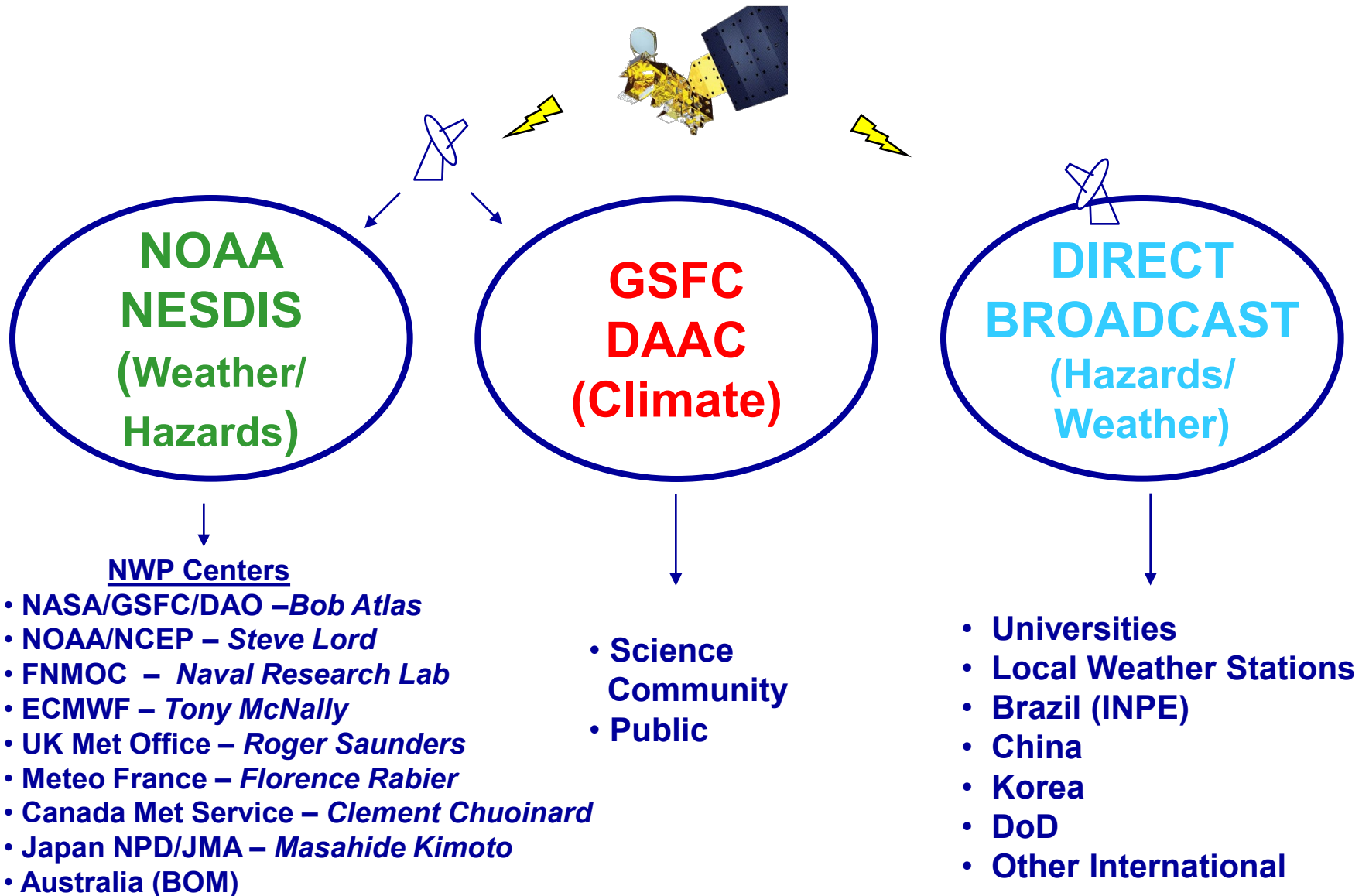
AIRS Level 1 PRODUCTS

Product Name	Accuracy Absolute::Relative	Temporal Resolution	Horizontal Resolution :: Coverage
Radiance (AIRS) IR	3% (190K-330K) :: 0.2K at 250K	2/day (d/n)	15 km:: Global
Radiance (AIRS) VIS_NIR	10%::1%	2/day (d/n)	2.7 km: Global
Radiance (AMSU- A)	1.5K:: 0.5K	2/day (d/n)	50 km :: Global
Radiance (HSB)	1 K:: 0.6K	2/day (d/n)	15 km:: Global
Radiance (AIRS) IR cloud_cleared	3% (190K-330K) :: 0.3K at 250K	2/day (d/n)	50 km :: Global

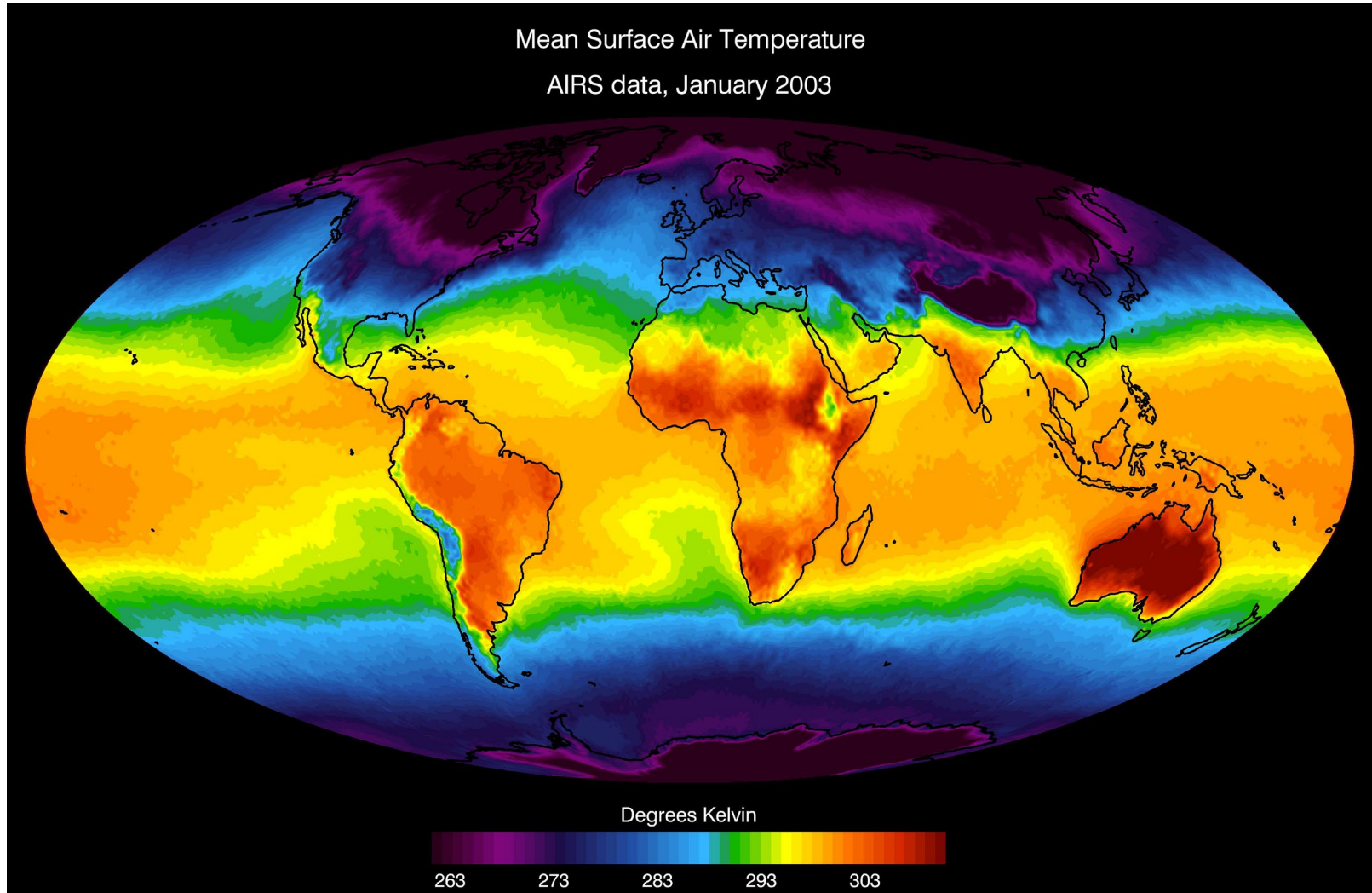
AIRS Level 2 PRODUCTS

Product Name	Accuracy Absolute ::Relative	Temporal Resolution	Horizontal Resolution:: Coverage	Vertical Resolution:: Coverage
Temperature Profile T(p)	1K rms	2/day (d/n)	50 km :: Global	1 km :: surface to 100mb
Humidity Profile q(p)	20% required, 10% goal ::10%	2/day (d/n)	50 km :: Global	2 km:: surface to 100mb
Precipitable water [mm]	5%::3%	2/day (d/n)	50 km :: Global	Column:: Troposphere
Surface Skin Temp.	1K:0.5K	2/day (d/n)	50 km :: Global	NA
Cloud Top Height	0.5km ::0.25K	2/day (d/n)	50 km :: Global	Surface::100mb
Cloud Fraction	10%:5%	2/day (d/n)	50 km :: Global	Surface::100mb
Cloud Liquid water content	20%	2/day (d/n)	50 km :: Global	NA
Ozone total column	20%	2/day (d/n)	50 km :: Global	NA

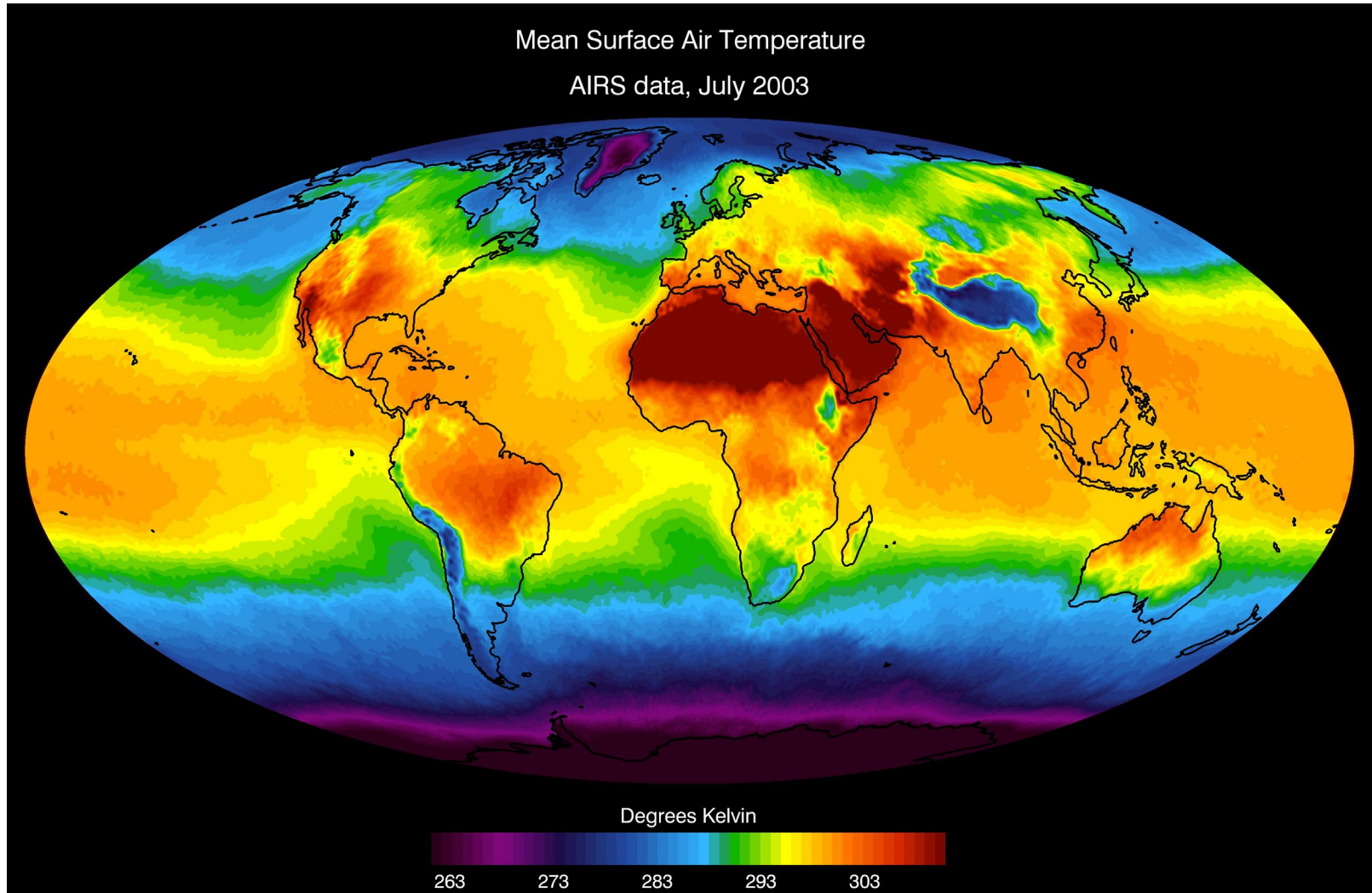
AIRS/AMSU DISTRIBUTION CENTERS



AIRS SURFACE TEMPERATURE

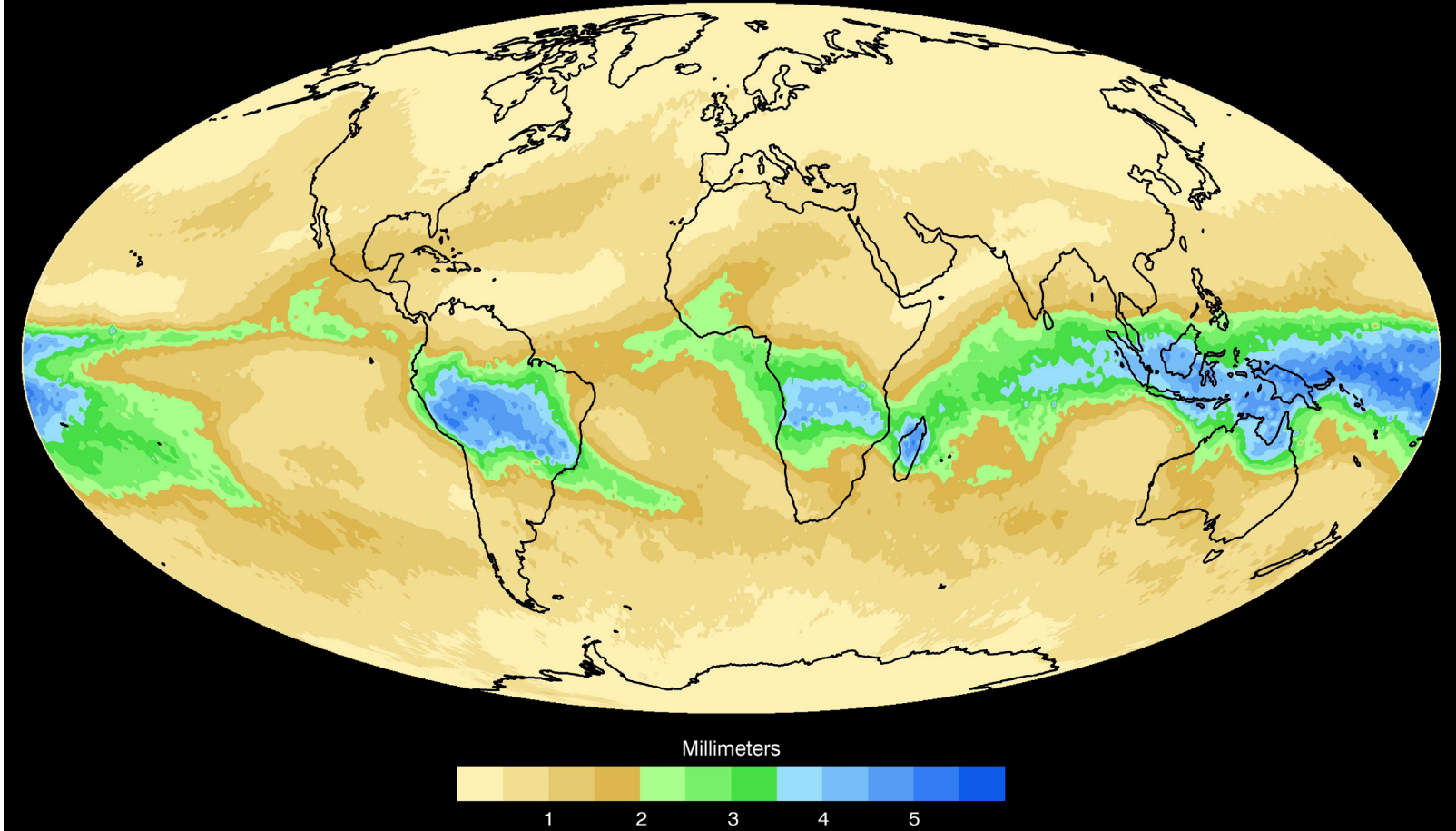


AIRS SURFACE TEMPERATURE



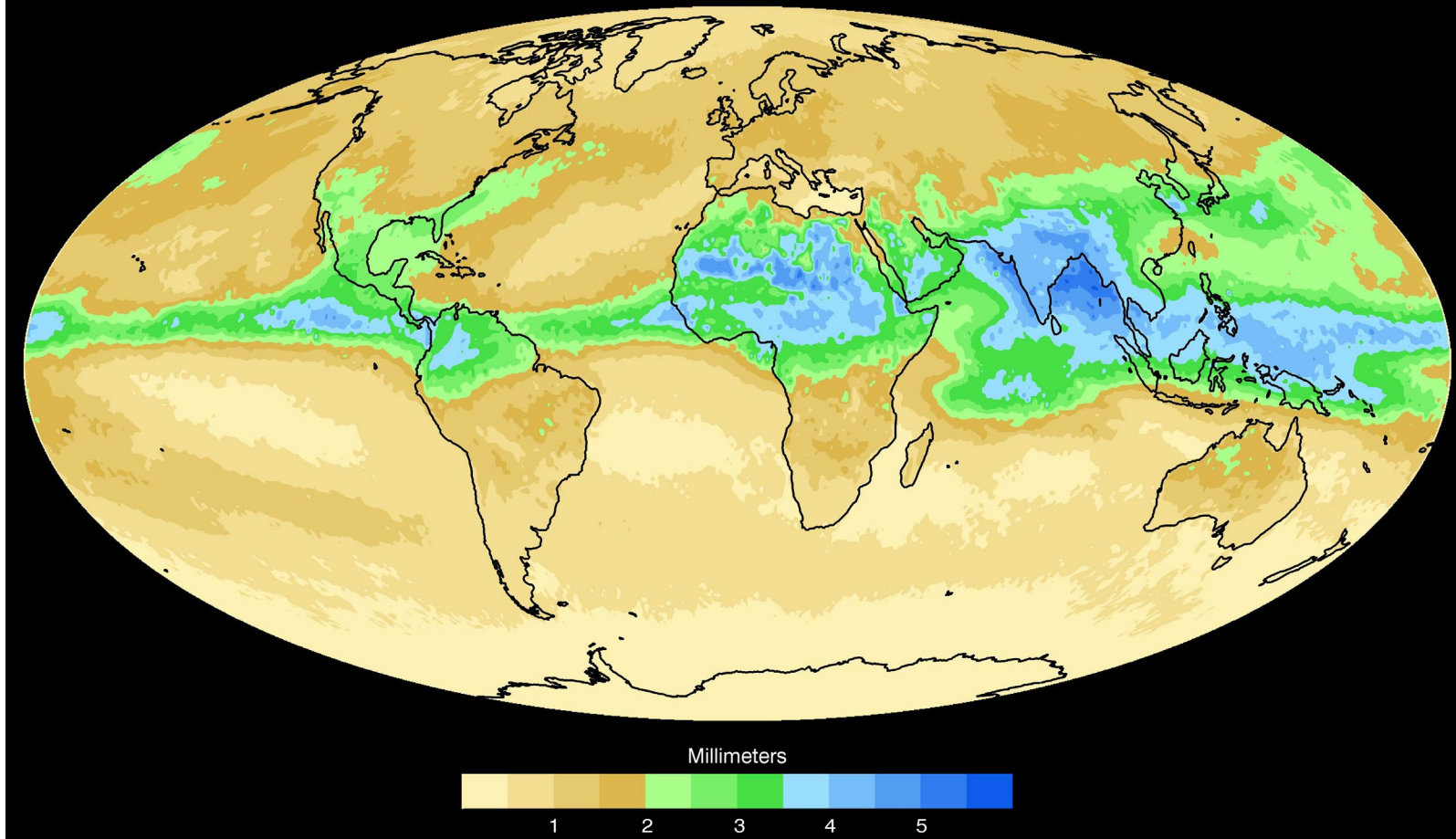
AIRS UPPER ATMOSPHERIC MOISTURE

Mean Clear Air Precipitable Water
500mb to TOA
AIRS data, January 2003

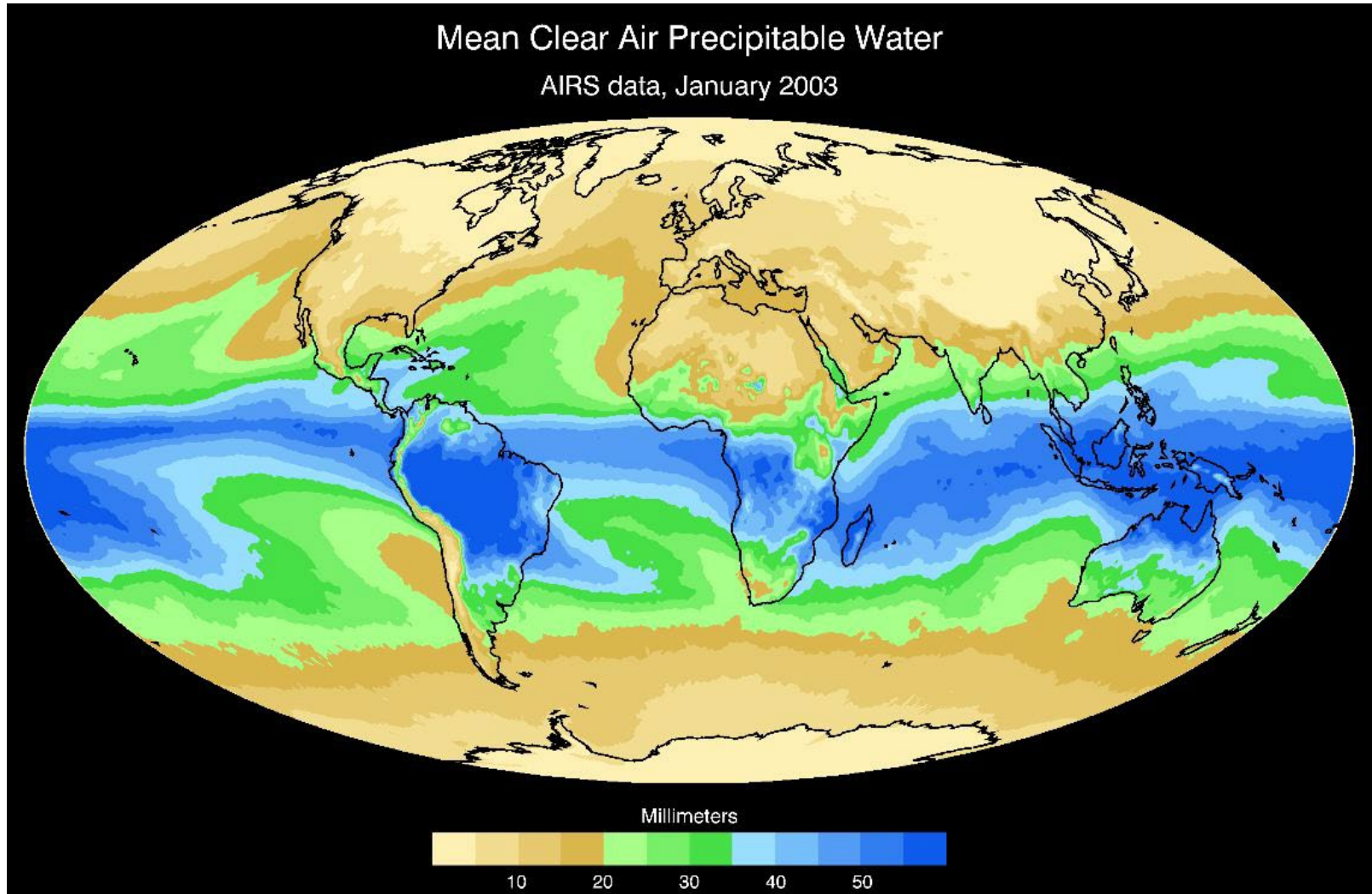


AIRS UPPER ATMOSPHERIC MOISTURE

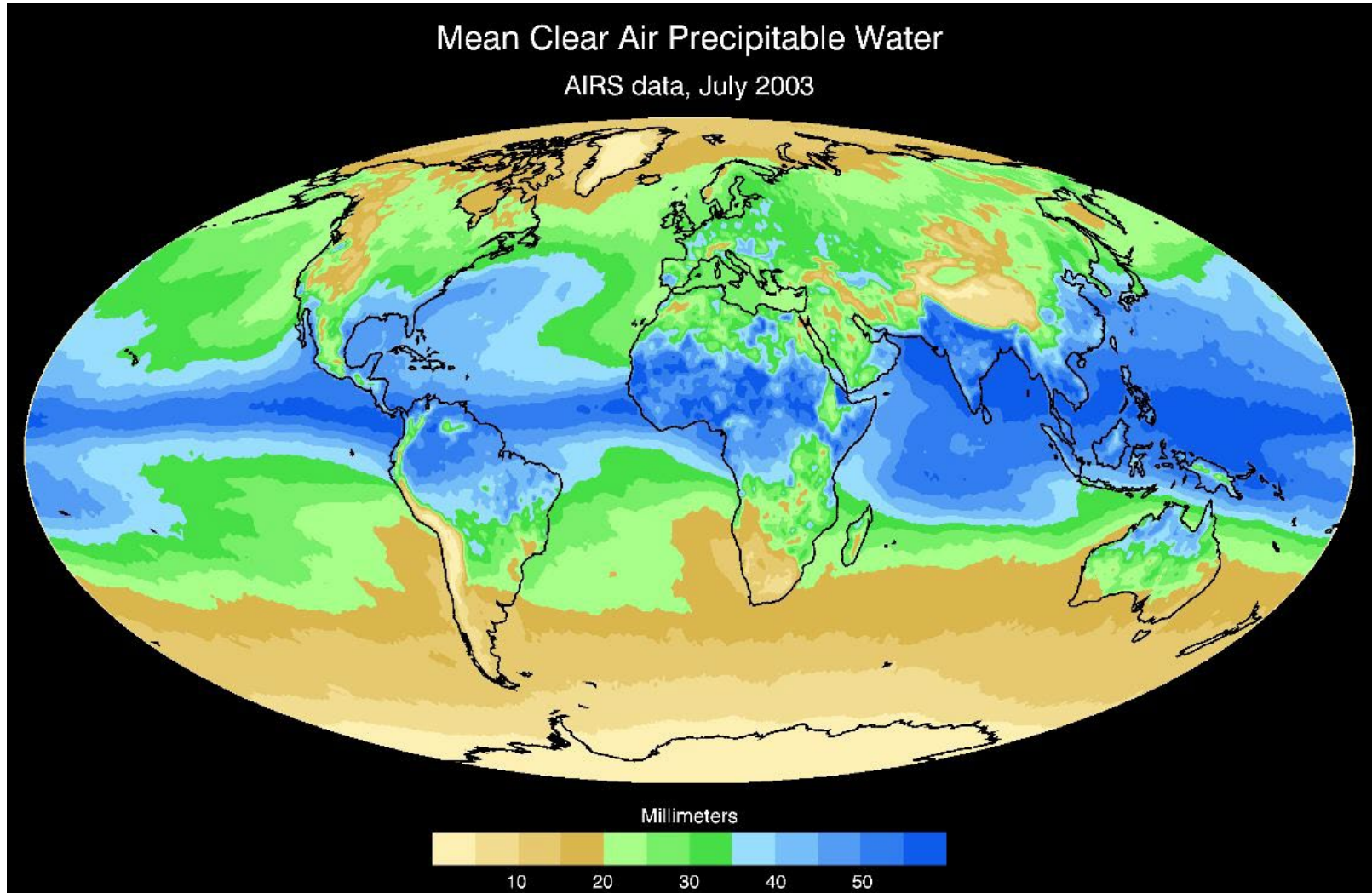
Mean Clear Air Precipitable Water
500mb to TOA
AIRS data, July 2003



AIRS TOTAL WATER VAPOR

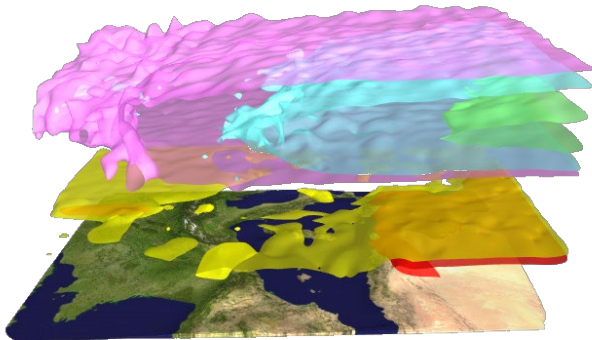


AIRS TOTAL WATER VAPOR

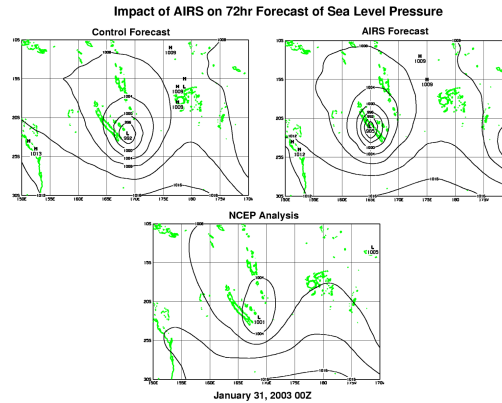


AIRS SUPPORTS WEATHER

Improved Temperature and H2O Profiles



Data Assimilation



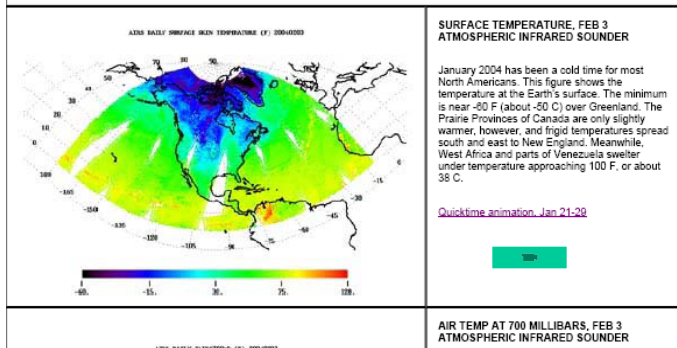
Hurricane Tracking



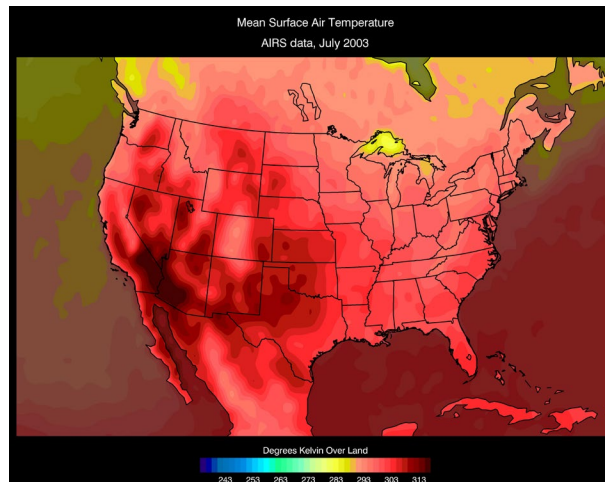
Near-Real-Time Products on Web



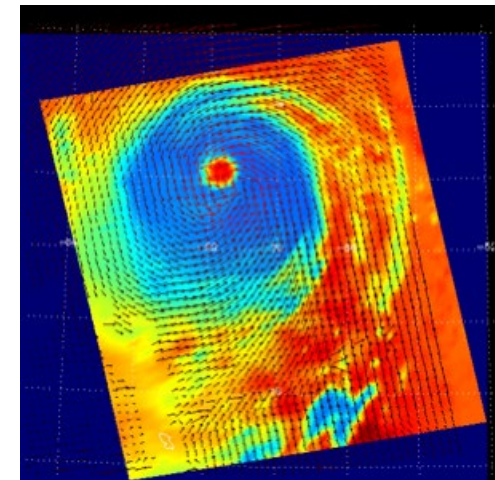
Maps for February 3 from the Atmospheric Infrared Sounder



Heat Wave

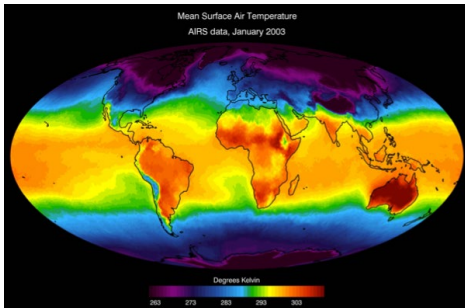


Data Synthesis

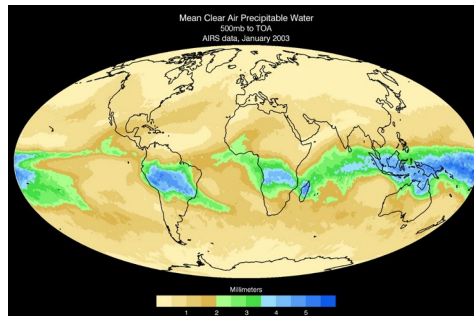


AIRS SUPPORTS CLIMATE STUDIES

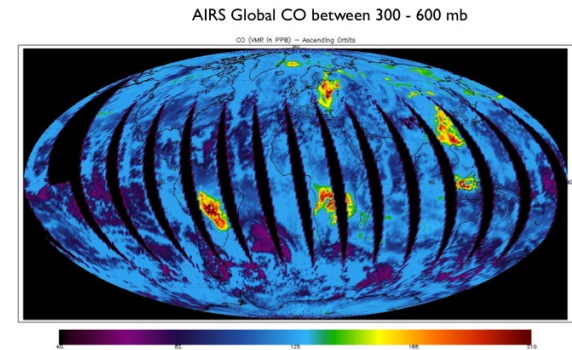
Monthly Temperature



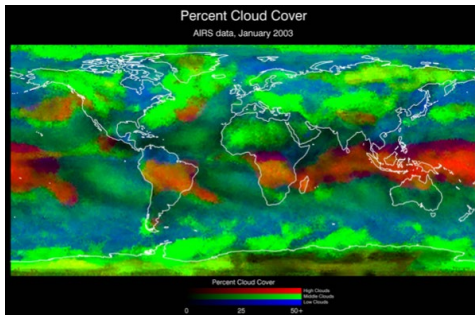
Monthly H2O



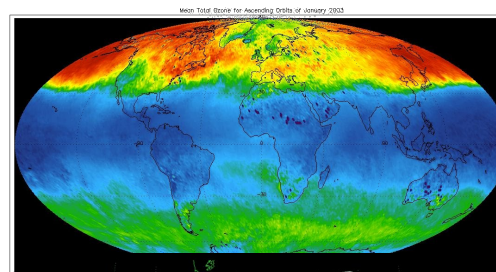
CO



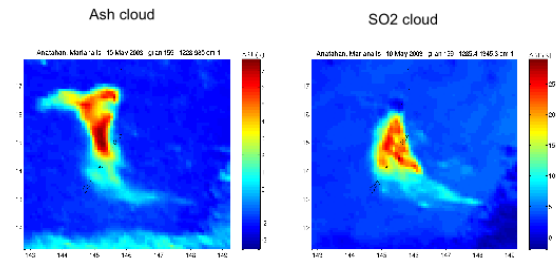
Clouds



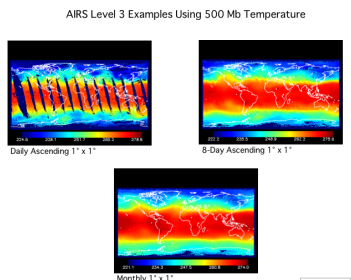
Ozone



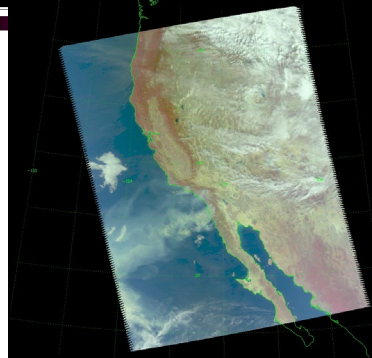
SO2



Level 3 Products

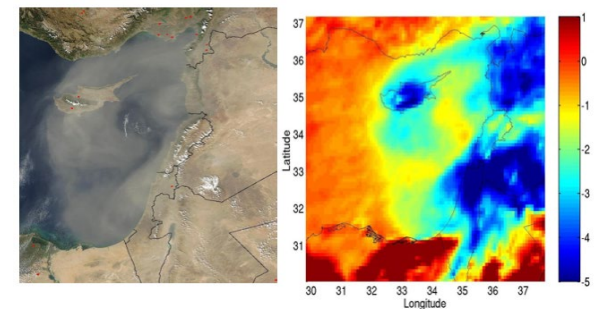


©S. Granger



Aerosols

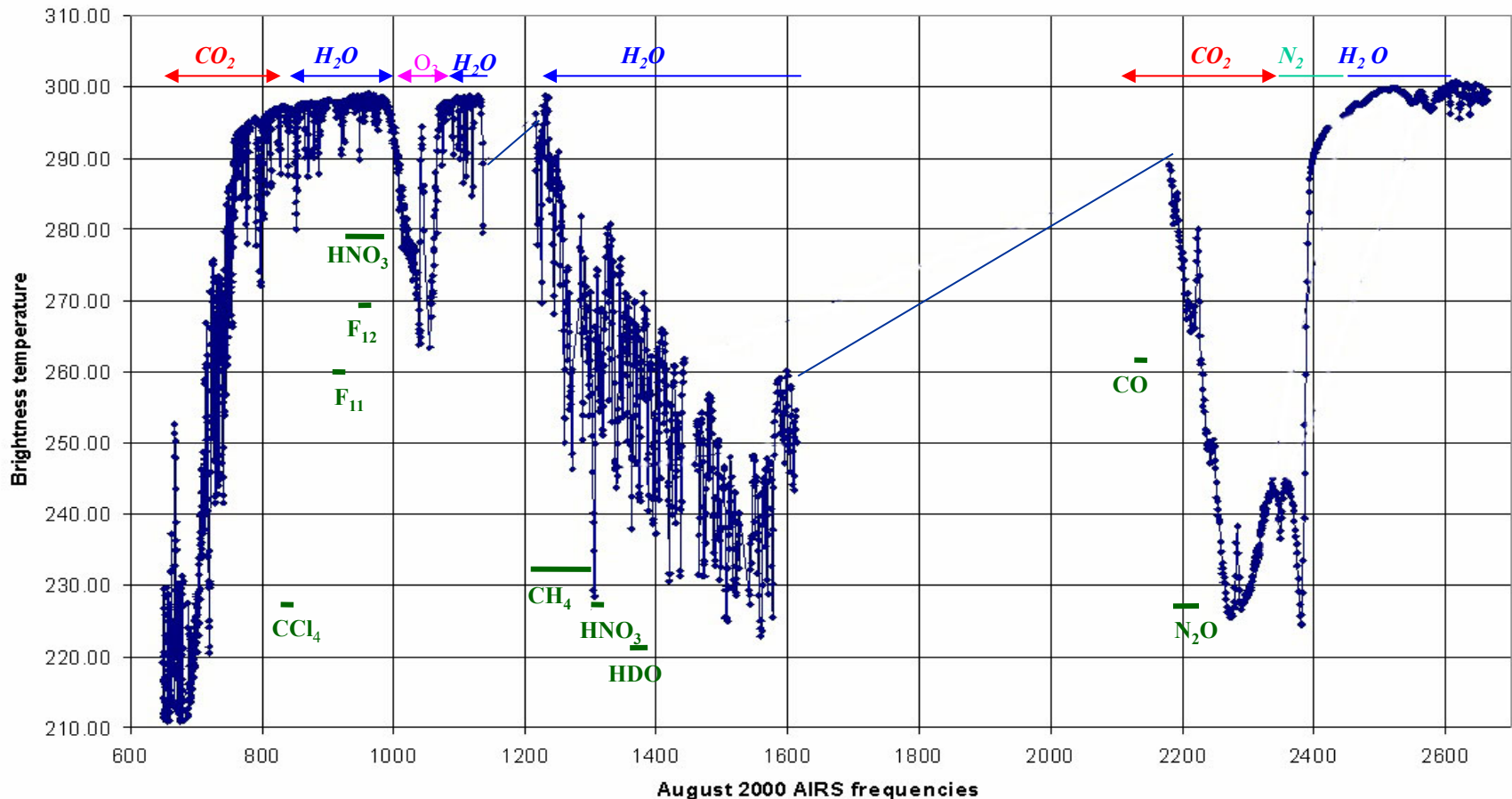
AIRS vs MODIS AEROSOLS
Eastern Mediterranean Dust Storm



AIRS RESEARCH PRODUCTS INCLUDE TRACE GASES

AIRS Channels for Tropical Atmosphere with $T_{\text{surf}} T=301\text{K}$

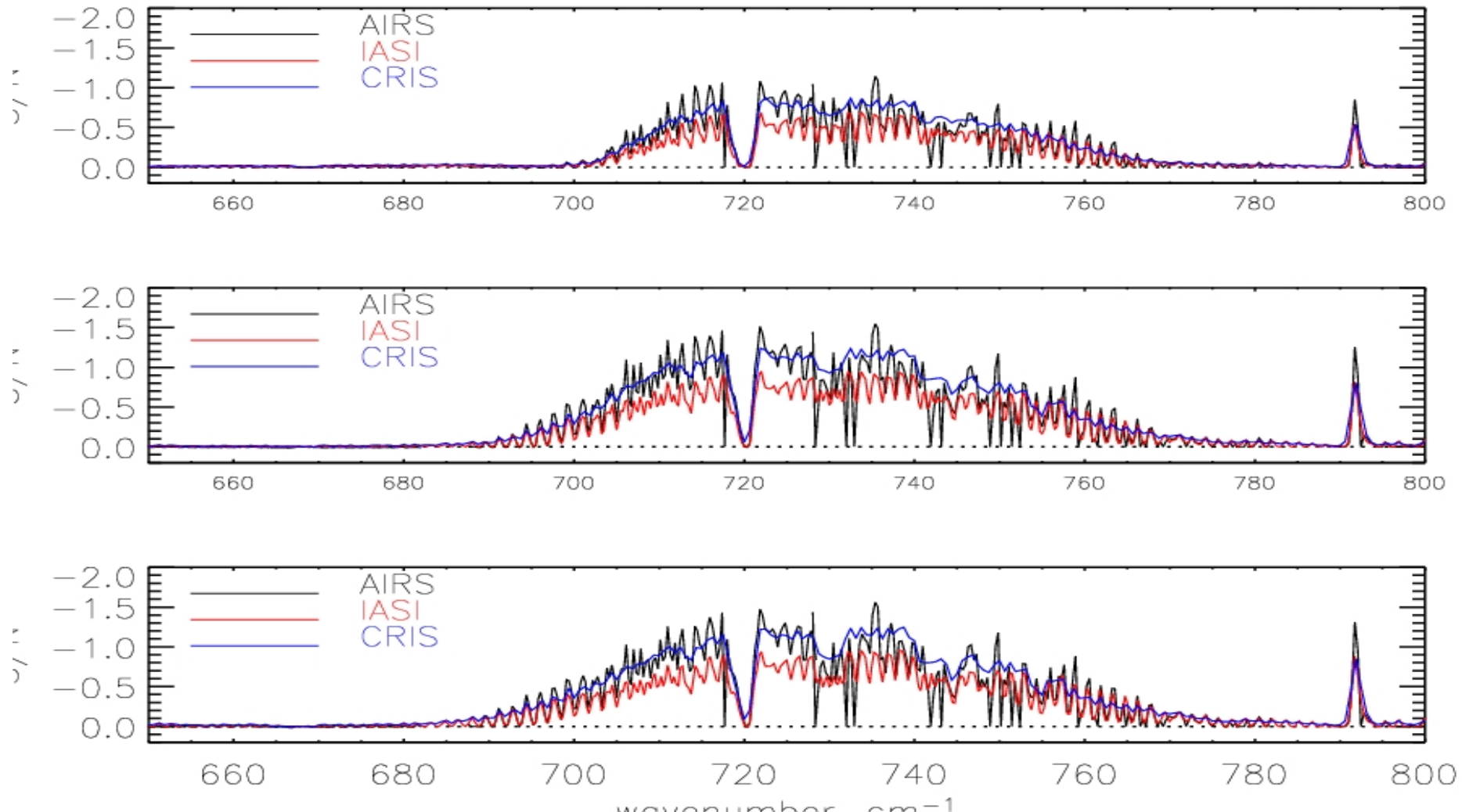
Full Spectrum
2378 channels



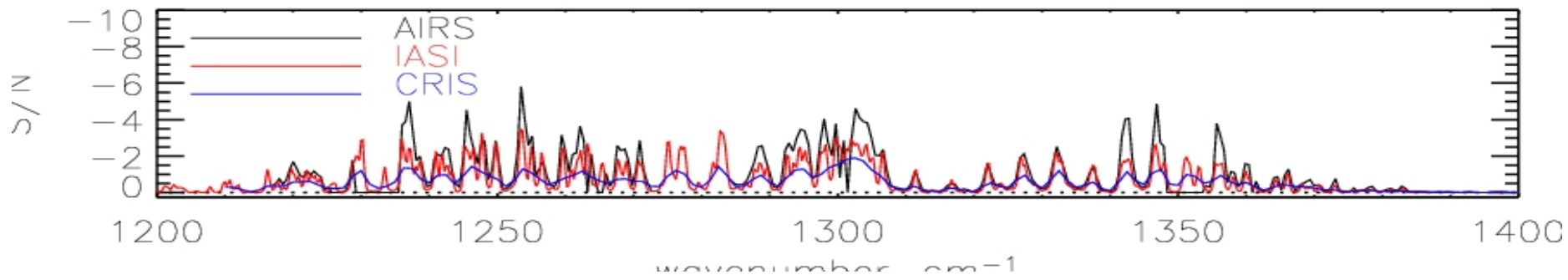
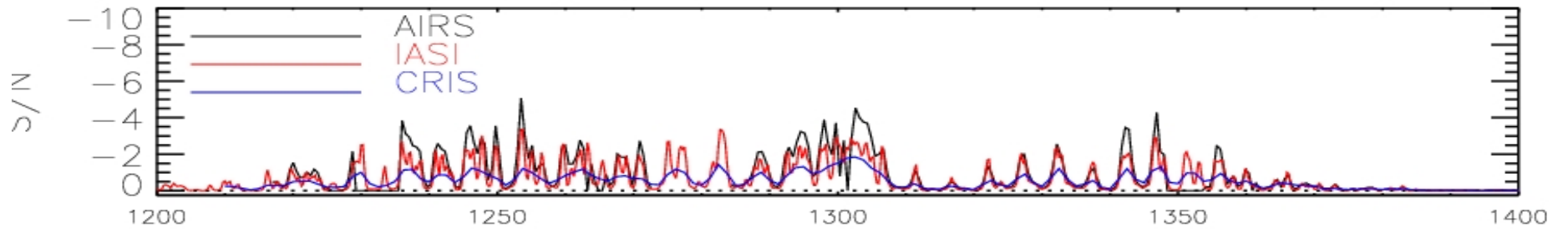
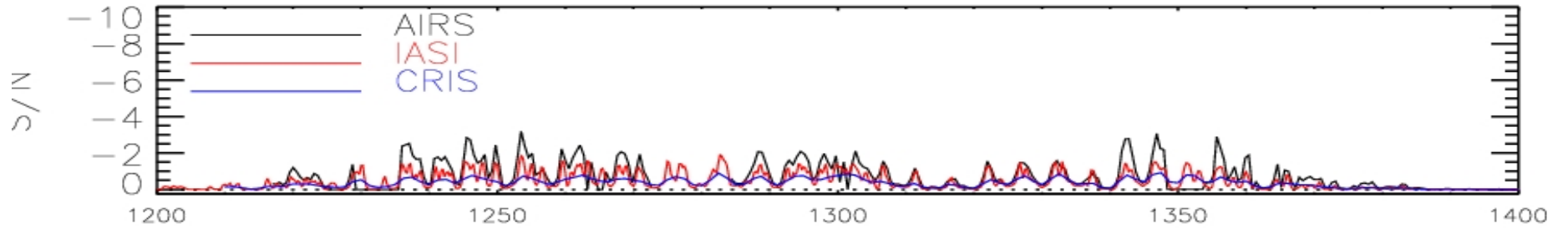
Spectral Resolution in Trace Gas Bands for AIRS, IASI, CrIS

Gas	Wave Number	AIRS v/1200	IASI L=2 cm (apodized)	CrIS L=.8,.4,.2 (apodized)
CO₂	735 cm ⁻¹	0.61	0.5	1.13
CO₂	791 cm ⁻¹	0.66	0.5	1.13
O₃	1045 cm ⁻¹	0.88	0.5	1.13
CH₄	1306 cm ⁻¹	1.09	0.5	2.25
CO	2142 cm ⁻¹	1.79	0.5	4.50
CO₂	2385 cm ⁻¹	1.99	0.5	4.50

CO₂ S/N for a 1% (3.7 ppm) Perturbation

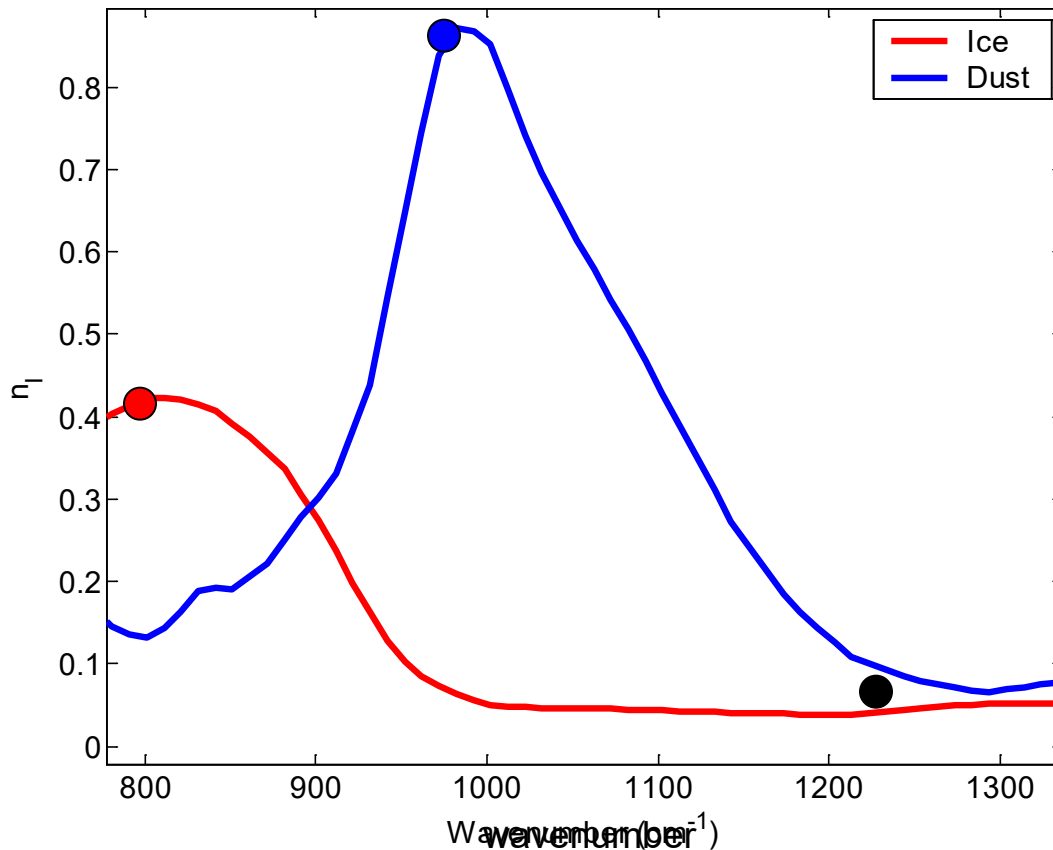


Methane S/N for a 2% (36 ppb) Perturbation



Dust and Cirrus Signals

Imaginary Index of Refraction of Ice and Dust



- Both ice and silicate absorption small in 1200 cm⁻¹ window

- In the 800-1000 cm⁻¹ atmospheric window:

Silicate index increases

Ice index decreases

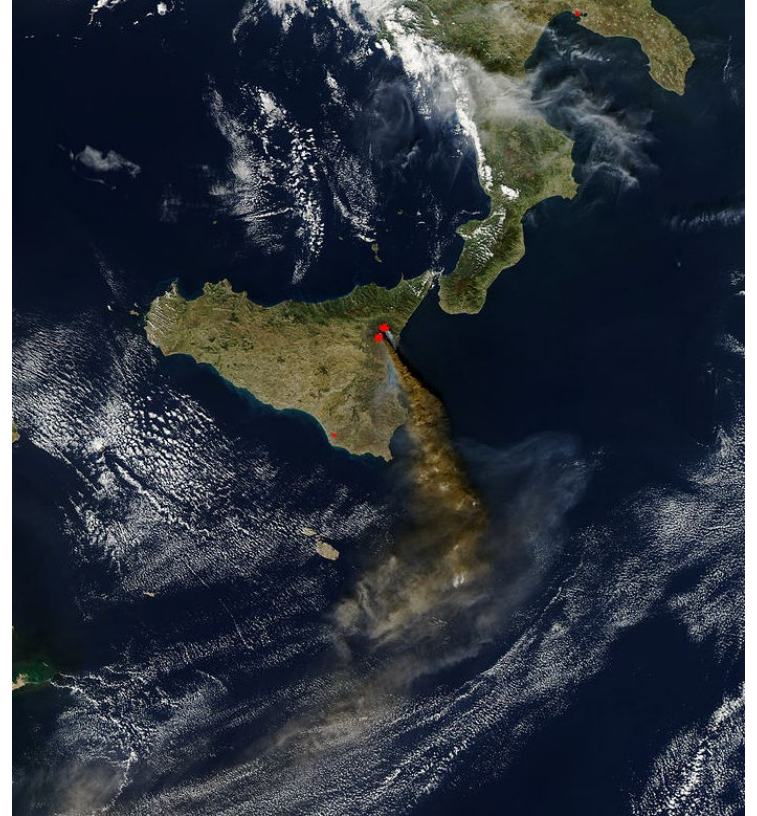
with wavenumber

Volz, F.E. : Infrared optical constant of ammonium sulphate, Sahara Dust, volcanic pumice and flash, Appl Opt 12 564-658 (1973)

Mt Etna eruption

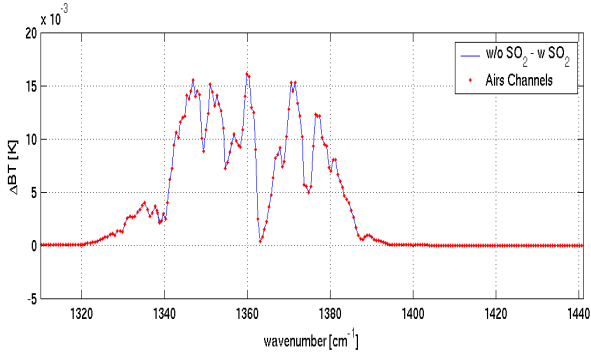


28 October 2002
ISS photo



28 October 2002
MODIS Aqua

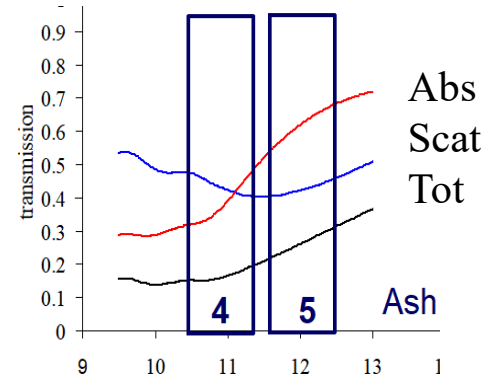
Anatahan Volcano viewed with AIRS



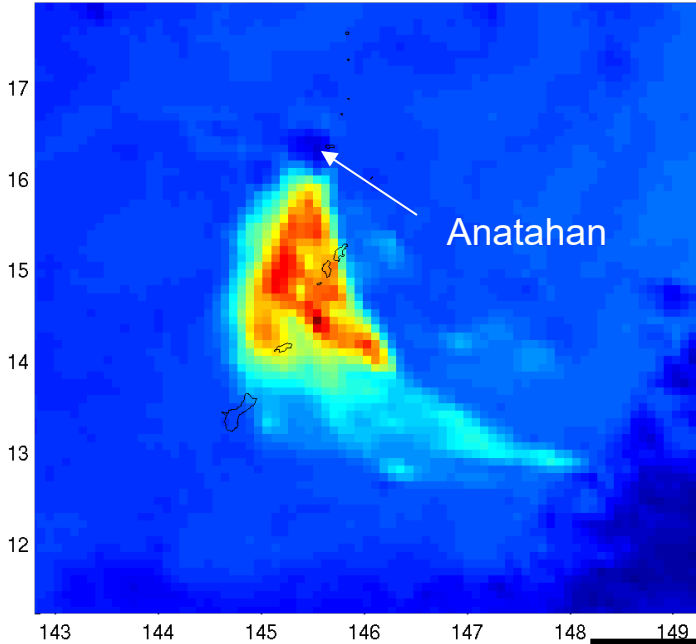
SO₂ signal
1284-1345 cm⁻¹



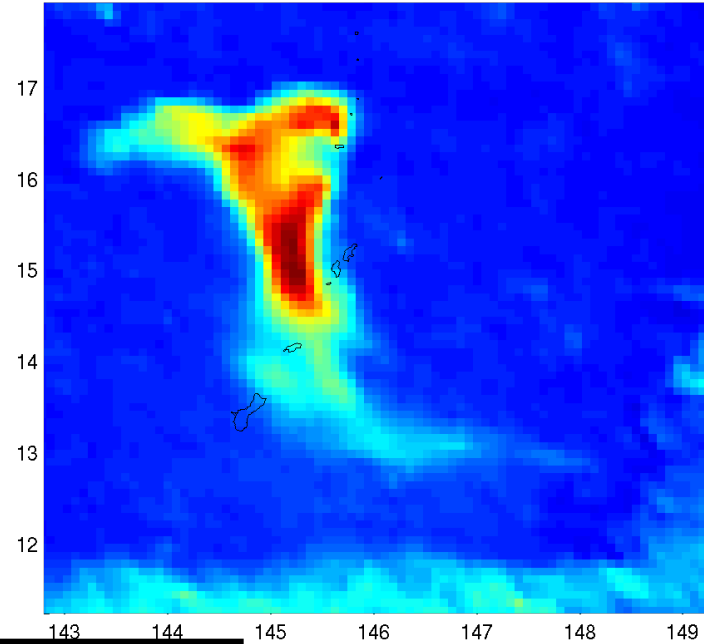
Ash signal
1228-995 cm⁻¹



Anatahan, Mariana Is - 10 May 2003 - gran 159 - 1285.4-1345.3 cm-1

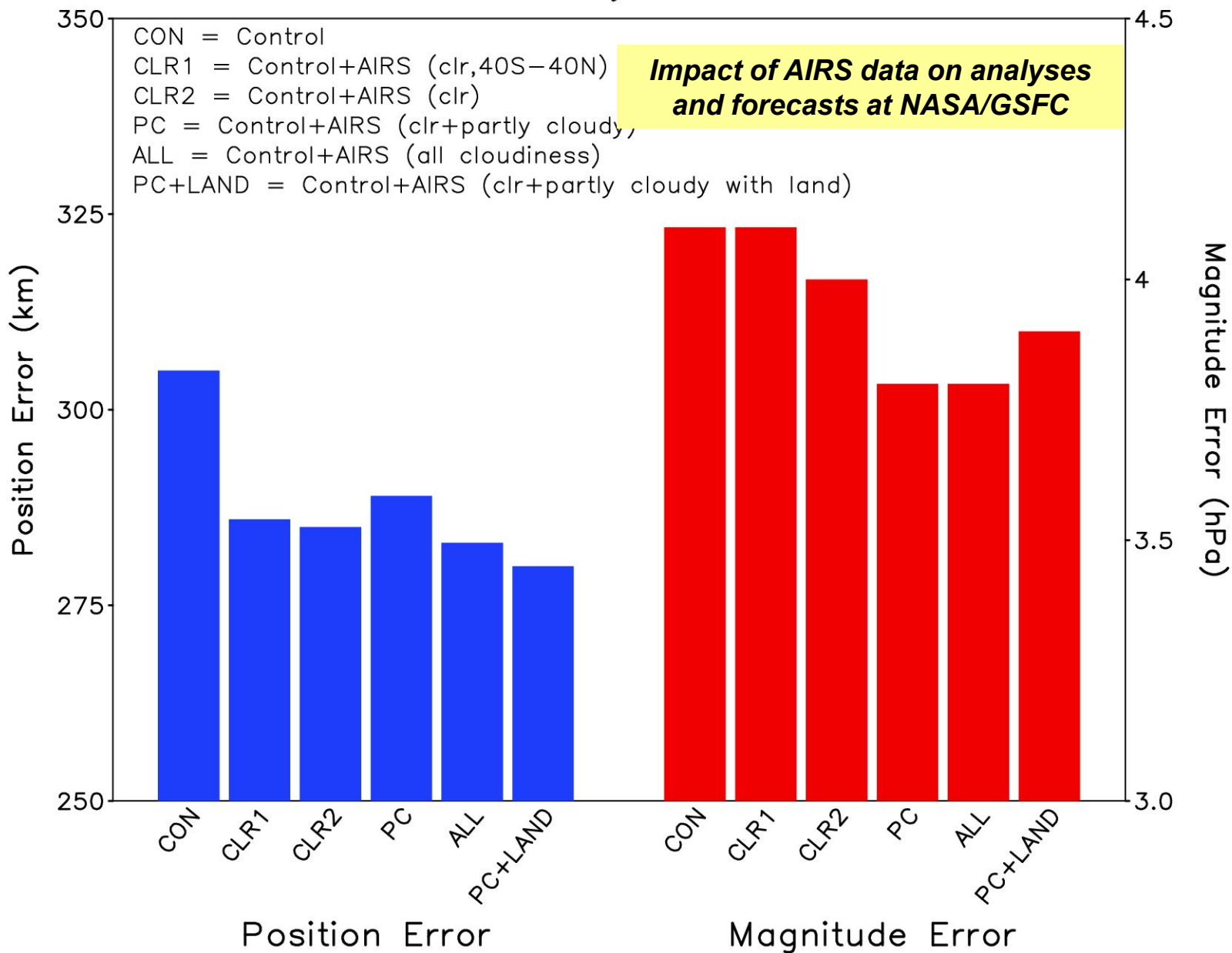


Anatahan, Mariana Is - 10 May 2003 - gran 159 - 1228-980 cm-1

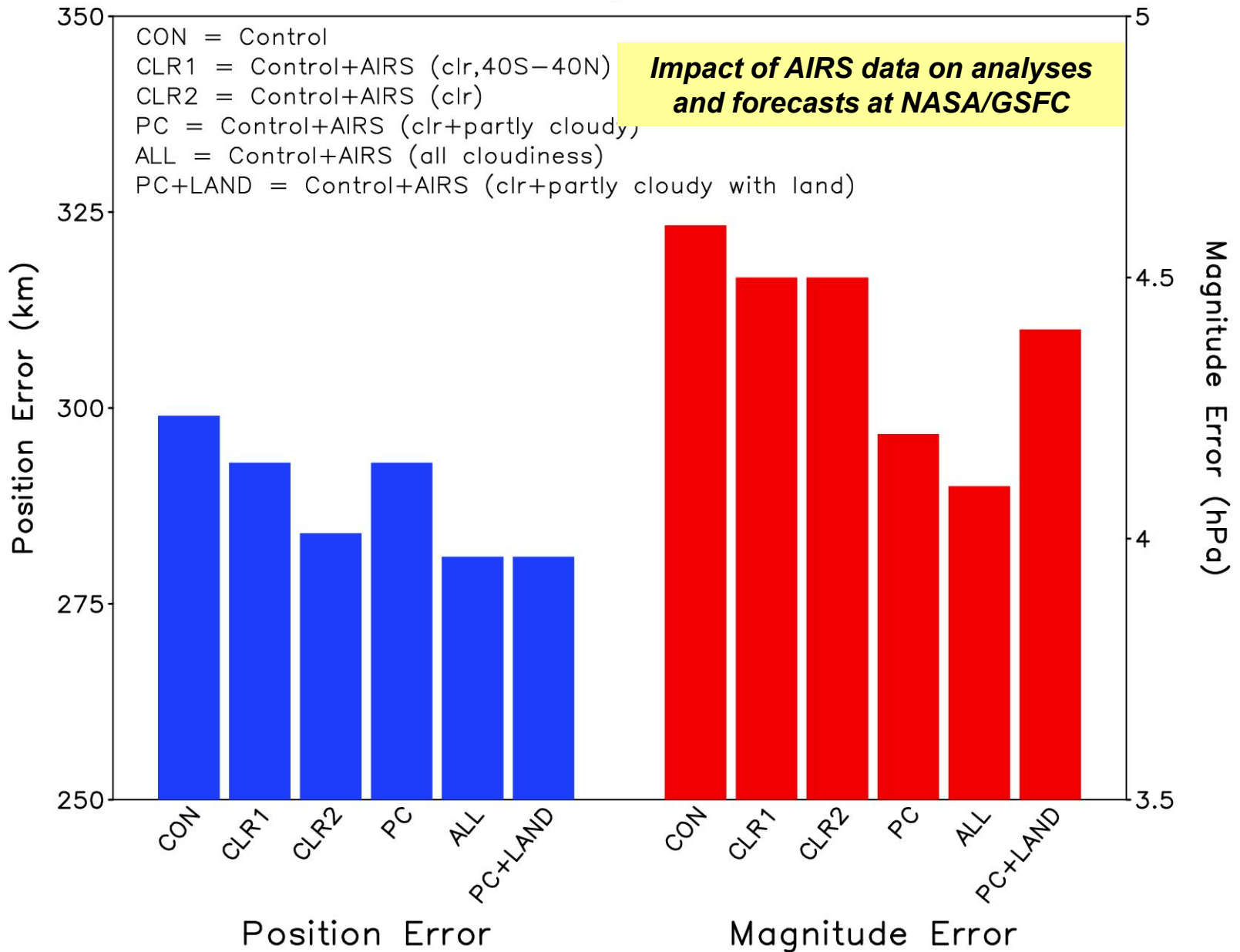


10 May 2003 (1554 UT)

Global Extratropical Cyclone Forecast Error from 11 Five-day FVSSI Forecasts



N. Hem. Extratropical Cyclone Forecast Error from 11 Five-day FVSSI Forecasts



System	Description
<p><u>Data Pool</u> (Download Online data)</p>	<p>Using WHOM (Web Hierarchical Ordering Mechanism), search on-line data collections. Level 3 grid products are stored permanently, whereas Level 1 and 2 are limited to the most recent monthly-to-yearly time series. Level 1 and 2 channel and variable subsets are available. FTP scripts for batch download are provided.</p>
<p><u>Tape Archive</u> (place orders)</p>	<p>Using WHOM, search for full collections of AIRS products. Orders are placed in the system and email notifications sent when data are shipped. Level 1 and 2 subsets are available.</p>
<p><u>Earth Observing System Data Gateway</u></p>	<p>A WWW interface to access all data available in NASA's Earth Observation System Data Information System and related data centers. With EDG, a user can search for and acquire a large variety of earth, ocean, and atmospheric science data obtained from EOS instruments.</p>
<p><u>ESDT Search</u></p>	<p>The Earth Science Data Type (ESDT) shortname is a unique designator for EOS data products. Using either Quick Search or Browse method, you will get information about data sets, organized by ESDT view. It then leads directly to data ordering page.</p>
<p><u>OPeNDAP/DODS server</u></p>	<p>Provide access to the data stored by the Open Source Project for a Network Data Access Protocol OPeNDAP/DODS, formerly Distributed Oceanographic Data System.</p>
<p><u>Mirador</u></p>	<p>A beta (β), experimental release of our simplified interface for searching, browsing, and ordering Earth science data at NASA GES DISC.</p>
<p>FTP</p>	<p>Anonymous FTP Server</p>

Useful Links for getting AIRS Data, Product, and Associated Information

- Data Pool (Download online data)
 - <http://disc.gsfc.nasa.gov/data/datapool/AIRS/>
- Tape Archive (place orders)
 - <http://disc.gsfc.nasa.gov/data/dataset/AIRS/>
- EOS Data Gateway
 - <http://deleenn.gsfc.nasa.gov/~imswww/pub/imswelcome/>
- ESDT Search
 - <http://disc.gsfc.nasa.gov/data/esdt/>
- OPeNDAP/DODS server
 - http://disc.gsfc.nasa.gov/services/dods/airs_dp.shtml
- Mirador
 - <http://g0dup05u.ecs.nasa.gov/OPS/mirador/>
- FTP
 - <ftp://g0dps01u.ecs.nasa.gov/AIRS/>

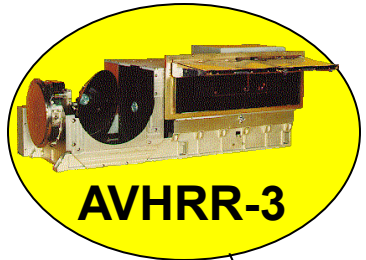
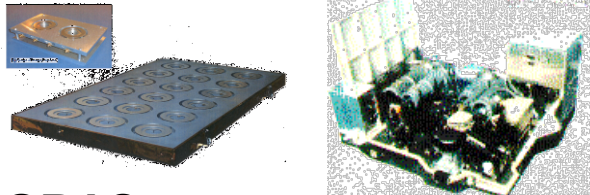
EUMETSAT POLAR SYSTEM

- Metop-2 Scheduled launch 30 June 2006
- Metop-2 renamed Metop-A after launch
- Sun synchronous orbit 820 km, 9h30 LST
- 14 years of operation
- Central and distributed Ground Segment components



- Metop-B and Metop-C recurrent models

Metop: Satellite and Instruments



GRAS

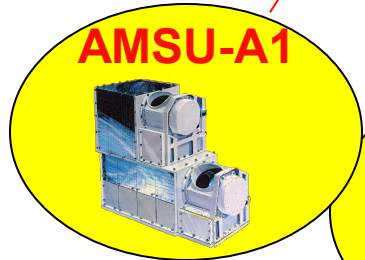
GOME-2



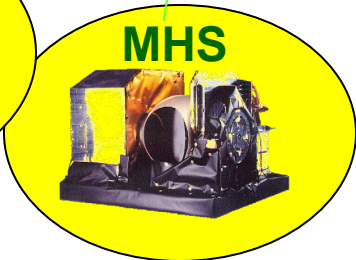
HIRS-4
Metop 1/2 only



IASI



AMSU-A1

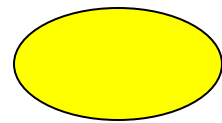
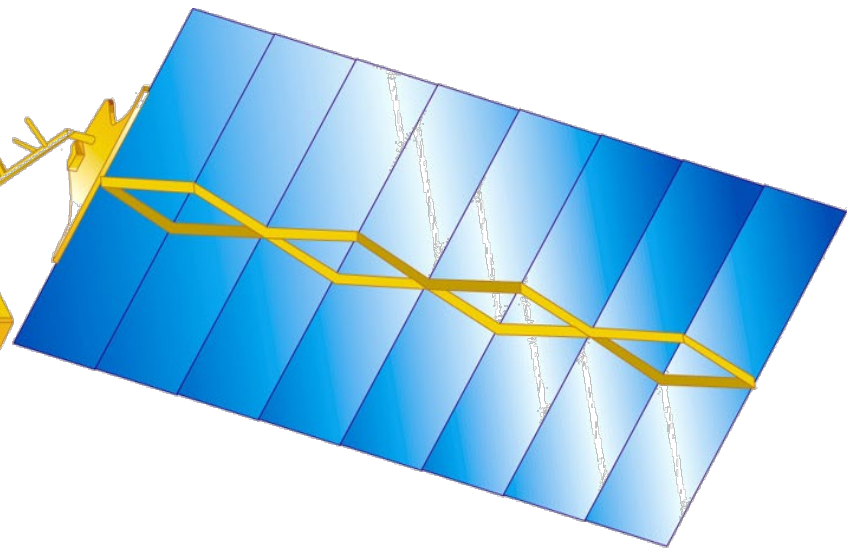


MHS



AMSU-A2

ASCAT

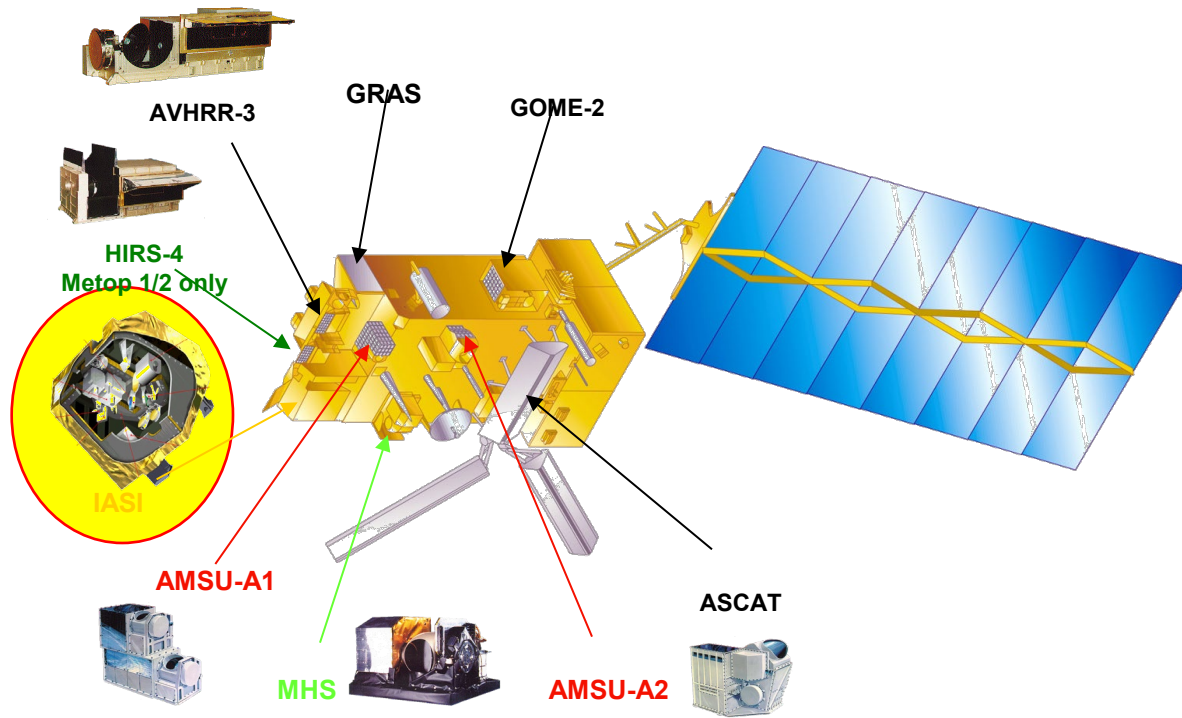


Direct Broadcast



IASI

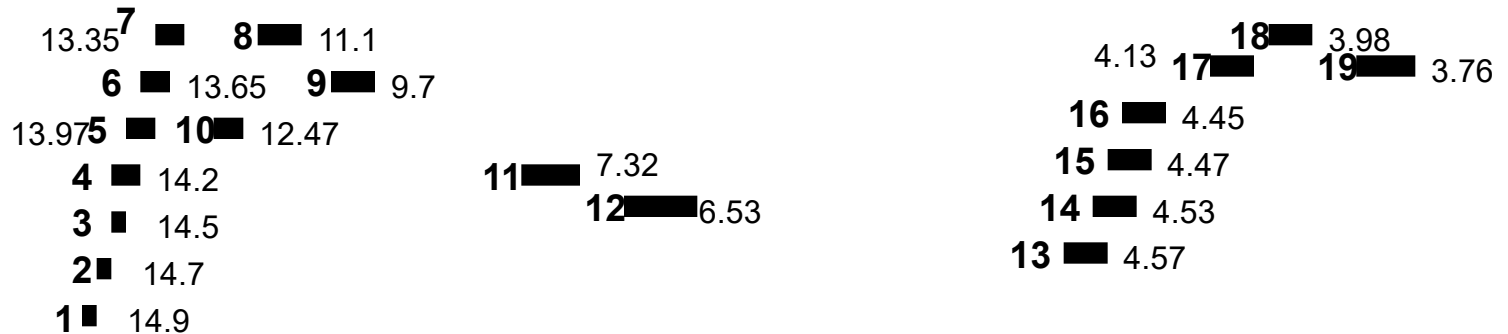
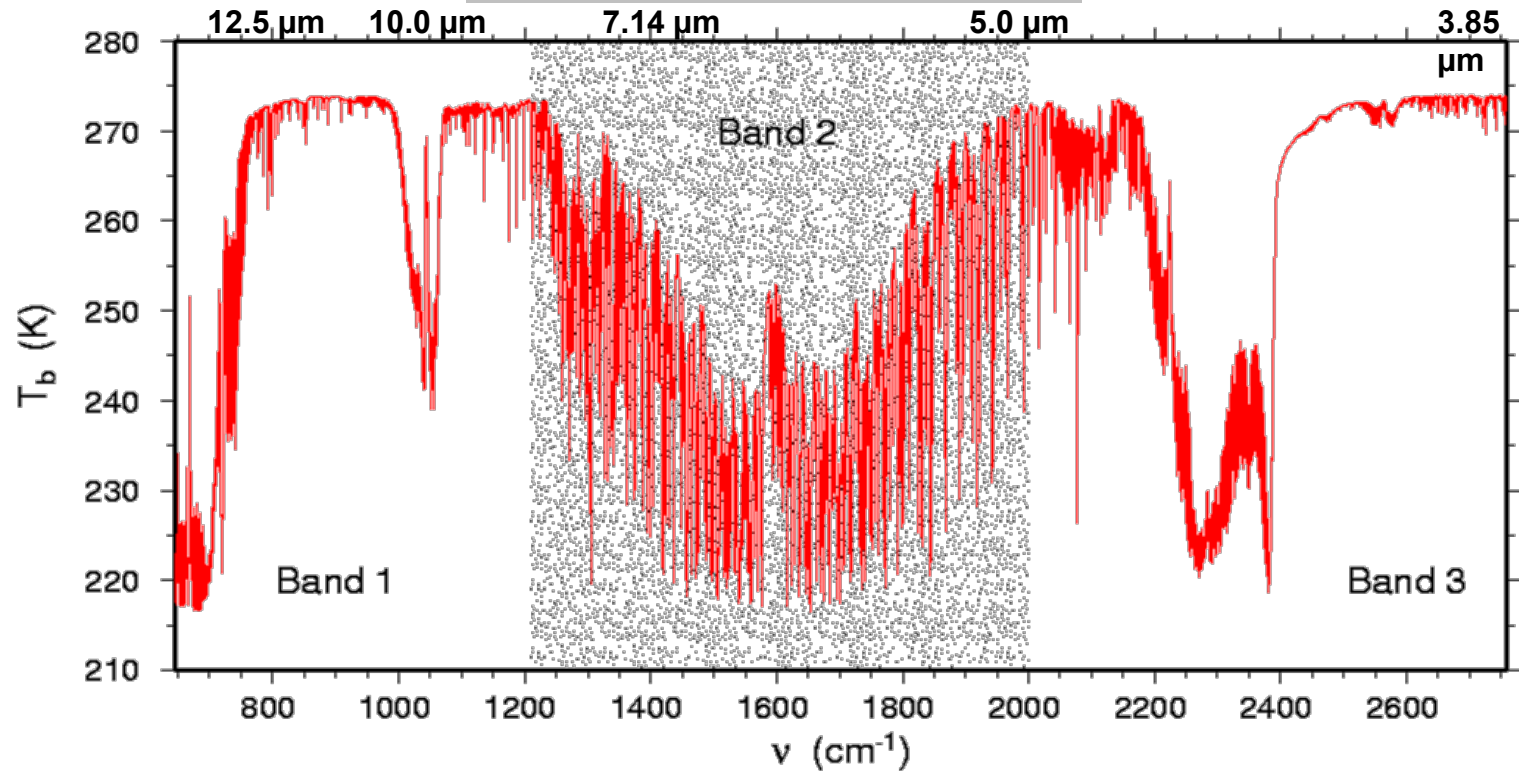
Infrared
Atmospheric
Sounding
Interferometer



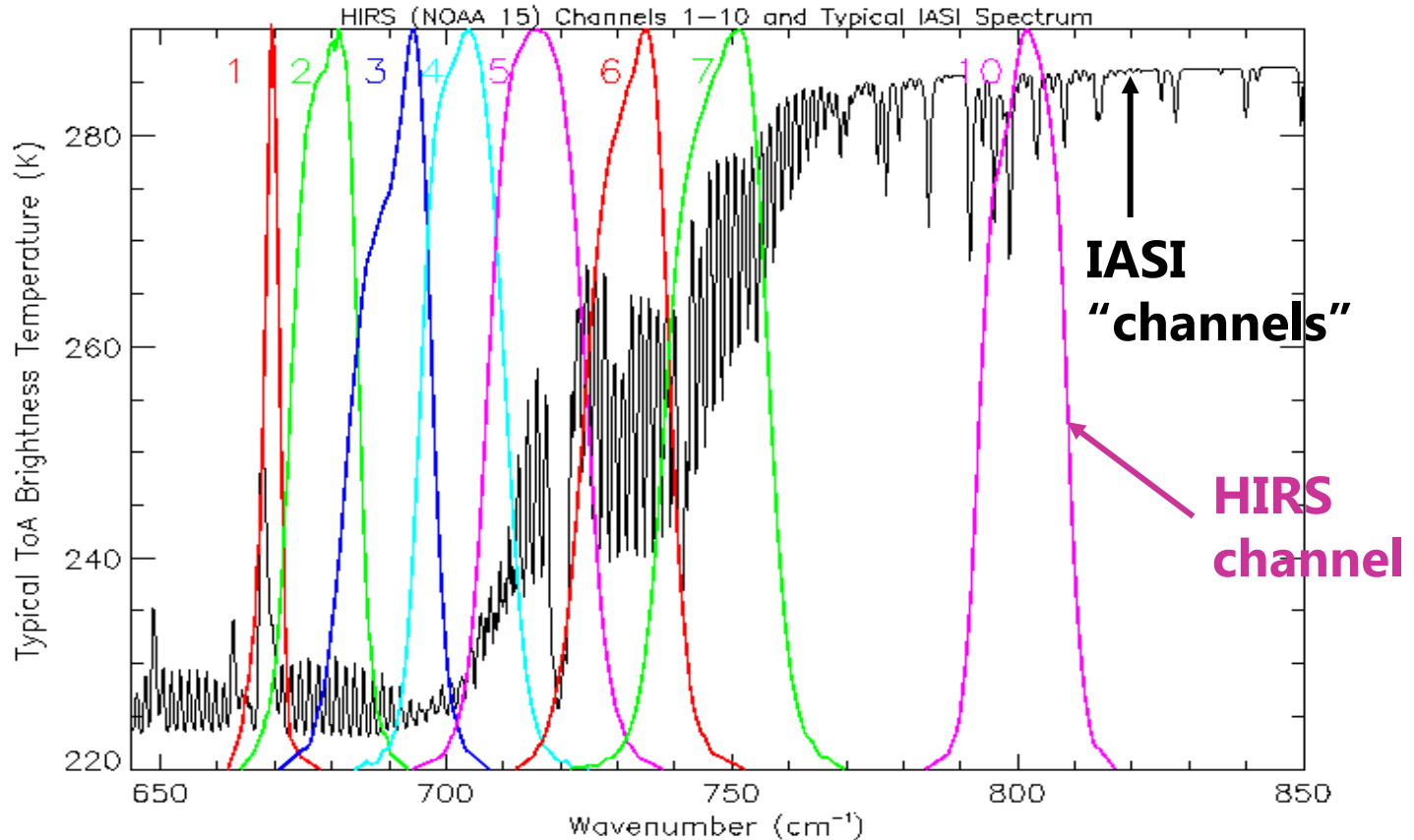
**New Technology provides
enhanced capabilities for
Infrared Sounding**

HIRS/4 IR Channels

IASI Bands



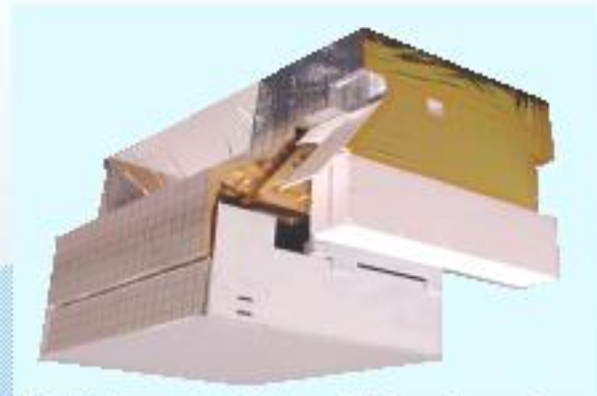
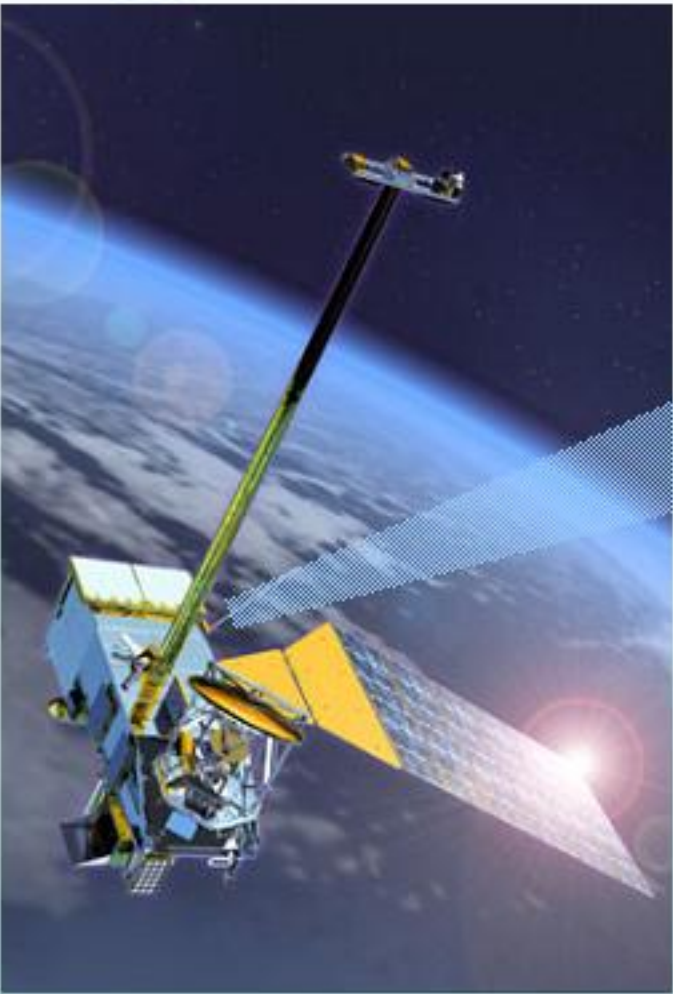
Comparison of IASI and HIRS Spectra



HIRS 19 channels versus IASI 8461 spectral samples



CrIS Mission: Provide Vertical Soundings of Temperature, Moisture, and Pressure for NPOESS



CrIS - A Mission-Critical Payload on NPOESS

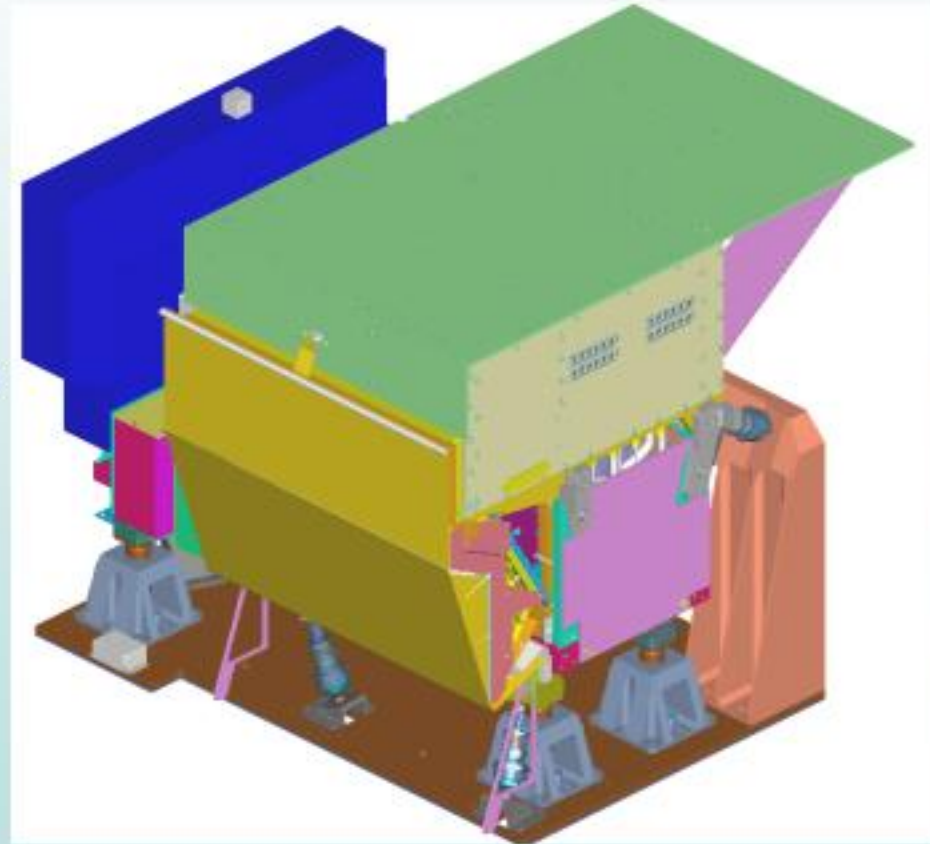
- Part of the Crosstrack Infrared and Microwave Sensor Suite (CrIMSS) with Advanced Technology Microwave Sounder (ATMS) on NPP in 2 of 3 NPOESS orbits
- Interferometric Collection of Upwelling Infrared Radiance Spectra at Very High Spectral Resolution
- Data Is Combined With ATMS to Produce All Weather High Vertical Resolution Vertical Profiles of Temperature, Moisture, and Pressure



NPOESS CrIS



- Michelson Interferometer (FTS)
- Large 8 cm Clear Aperture
- Three Spectral Bands
 - LWIR: 650-1095 cm^{-1} (713 Chan)
 - MWIR: 1210-1750 cm^{-1} (433 Chan)
 - SWIR: 2155-2550 cm^{-1} (159 Chan)
- 1305 Total Spectral Channels
- 3x3 FOVs at 14 km Diameter for each Band
- Photovoltaic Detectors in All 3 Bands
- 4-Stage Passive Detector Cooler (81K)
- Plane-Mirror Interferometer With DAPS
- Internal Laser Wavelength Calibration
- Deep-Cavity Internal Calibration Target
- Extended Radiator
- Passive Vibration Isolation System Allows Robust Operation
- Modular Construction





CrIS Contributes to Sixteen (16) NPP/NPOESS Data Products



★ Atmospheric Vertical Moisture Profile	Cloud Top Pressure	Precipitable Water
★ Atmospheric Vertical Temp Profile	Cloud Top Temperature	Precipitation Type/Rate
★ Imagery	Downward Longwave Radiance (Sfc)	Pressure (Surface/Profile)
★ Sea Surface Temperature	Downward Shortwave Radiance(Sfc)	Sea Ice Characterization
★ Sea Surface Winds	Electric Field	Sea Surface Height/Topography
★ Soil Moisture	Electron Density Profile	Snow Cover/Depth
Aerosol Optical Thickness	Energetic Ions	Solar Irradiance
Aerosol Particle Size	Geomagnetic Field	Supra-Thermal-Auroral Particles
Aerosol Refractive Index	Ice Surface Temperature	Surface Type
Albedo (Surface)	In-situ Plasma Fluctuations	Wind Stress
Auroral Boundary	In-situ Plasma Temperature	Suspended Matter
Auroral Energy Deposition	Ionospheric Scintillation	Total Water Content
Auroral Imagery	Medium Energy Charged Particles	Vegetation Index
Cloud Base Height (Cirrus)	Land Surface Temperature	
Cloud Cover/Layers	Net Heat Flux	
Cloud Effective Particle Size	Net Solar Radiation (TOA)	
Cloud Ice Water Path	Neutral Density Profile	
Cloud Liquid Water	Color/Chlorophyll	
Cloud Optical Thickness	Ocean Wave Characteristics	
Cloud Particle Size/Distribution	Outgoing Longwave Radiation (TOA)	
Cloud Top Height	Ozone - Total Column/Profile	

- VIIRS (23)
- CMIS (19)
- CrIS/ATMS (3)
- OMPS (1)
- SES (13)
- GPSOS (2)
- ERBS (5)
- TSIS (1)
- ALTIMETER (3)
- APS (4)

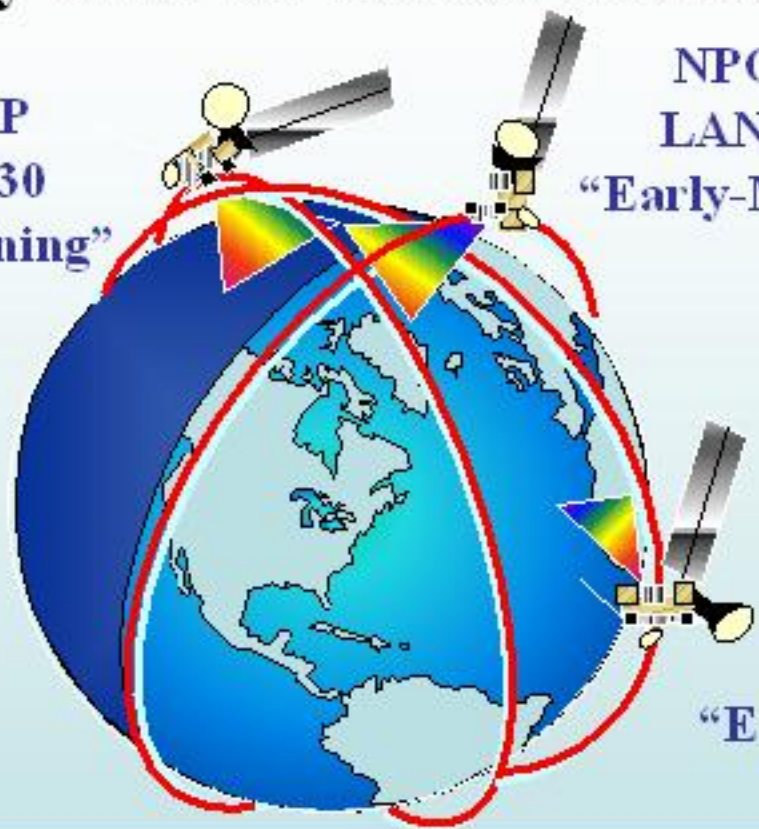
CrIS (16)

★ Environmental Data Records (EDRs) with Key Performance Parameters



NPOESS/METOP Will Provide 4-hourly Interval Global Soundings

METOP
LAN 2130
“Mid-Morning”



NPOESS
LAN 1730
“Early-Morning”

NPOESS
LAN 1330
“Early-Afternoon”

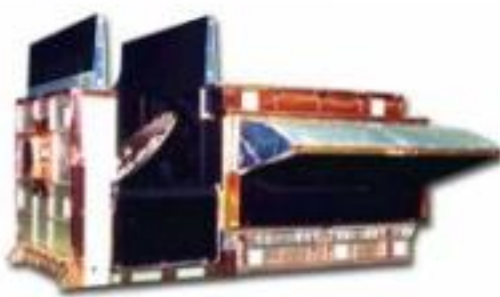
	Launches	Lifetime	Atmos Sounders
METOP [2130]	~2005, 2010, 2015	5 yr	IASI/AMSU/MHS
NPOESS [1330]	~ 2009, 2015	7 yr	CrIS/ATMS
NPOESS [1730]	~2013, 2018	7 yr	CrIS/ATMS



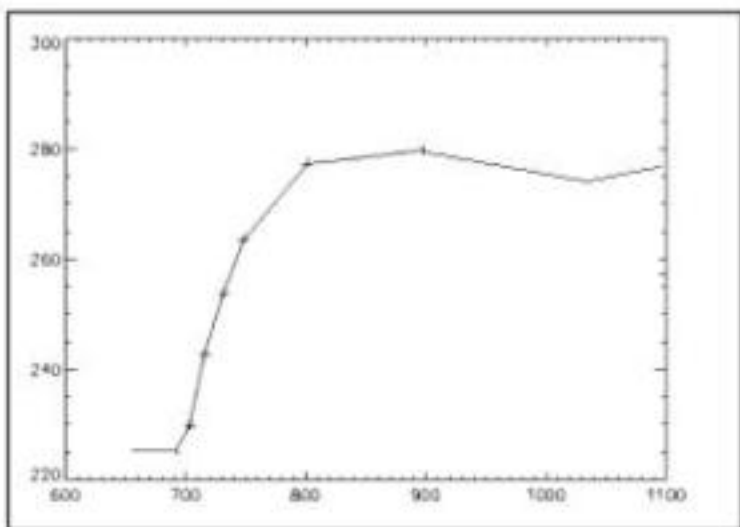
CrIS Objective: Much Higher Spectral Resolution for Improved Soundings



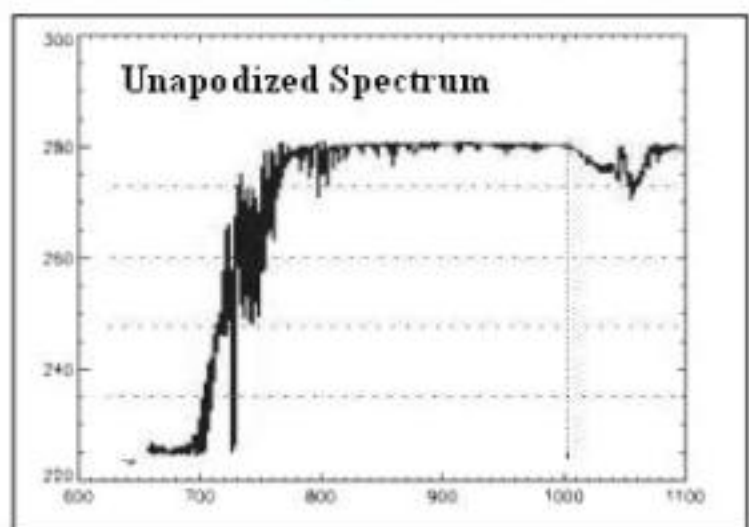
**Current Generation
HIRS**



**Next Generation
CrIS**



LWIR Spectra Measured By HIRS (12 Channels)

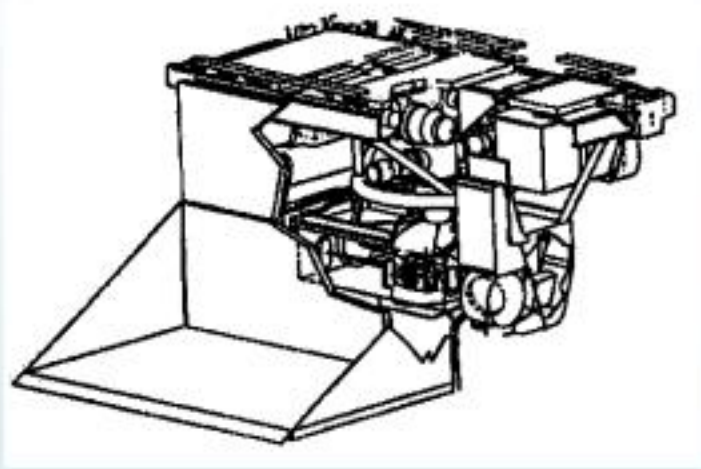


LWIR Spectra Measured By CrIS (712 Channels)

More Spectral Channels Improves Sounding Accuracy and Vertical Resolution

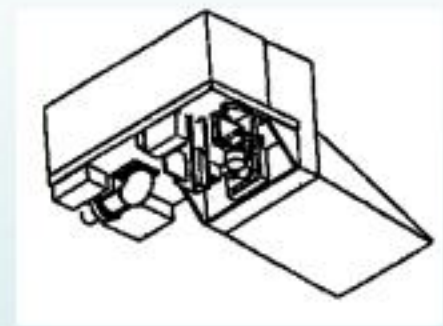


CrIS is An Evolutionary Improvement of the Current Sounding Capability



Aqua AIRS

Volume: 140 x 151 x 76 cm
1.6 m³
Mass: 166 kg
Power: 256 W
Data Rate: 1.3 Mbps



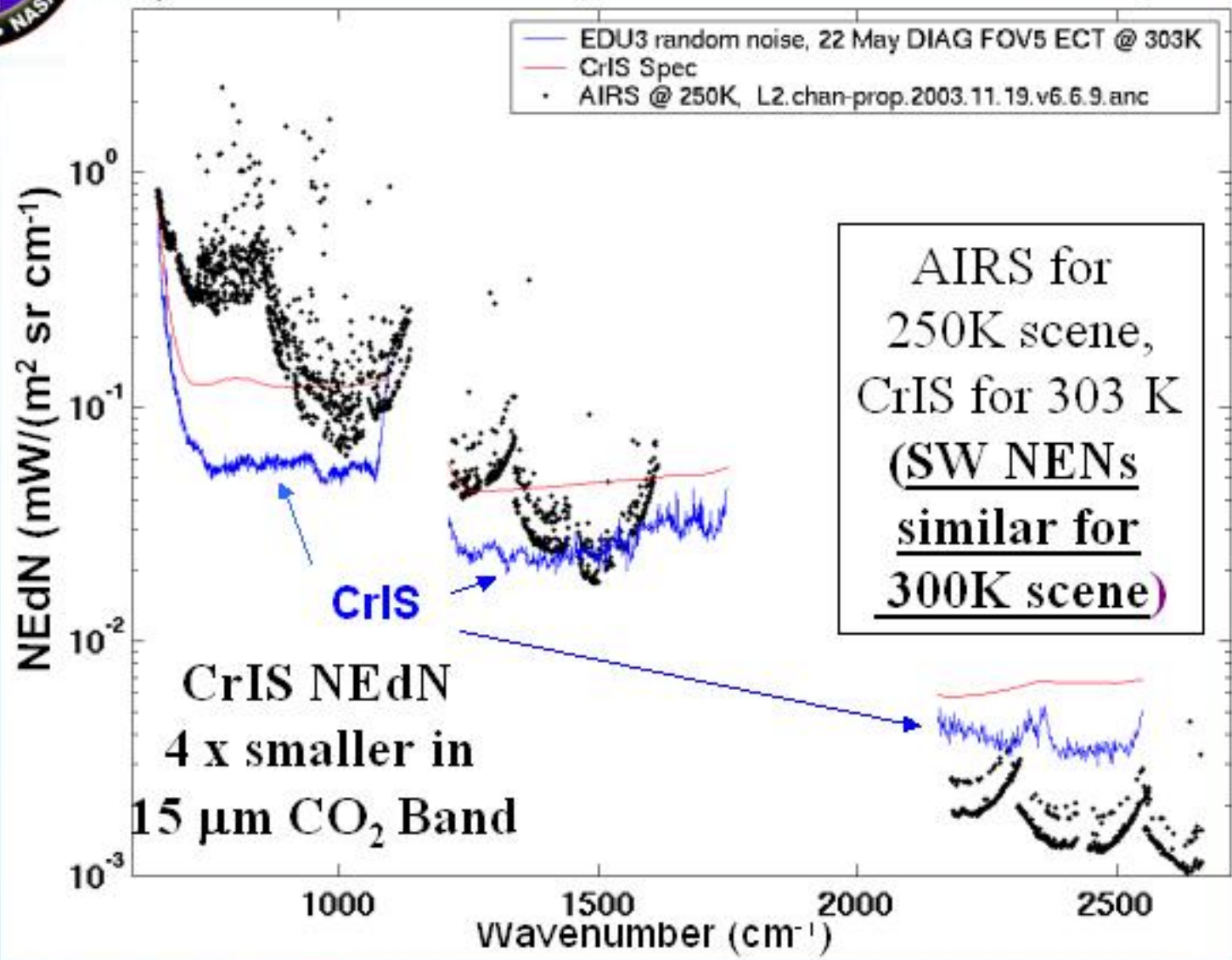
NPOESS CrIS

71 x 80 x 95 cm
0.6 m³
152 kg
124 W
1.5 Mbps



CrIS Vs AIRS Noise Comparison

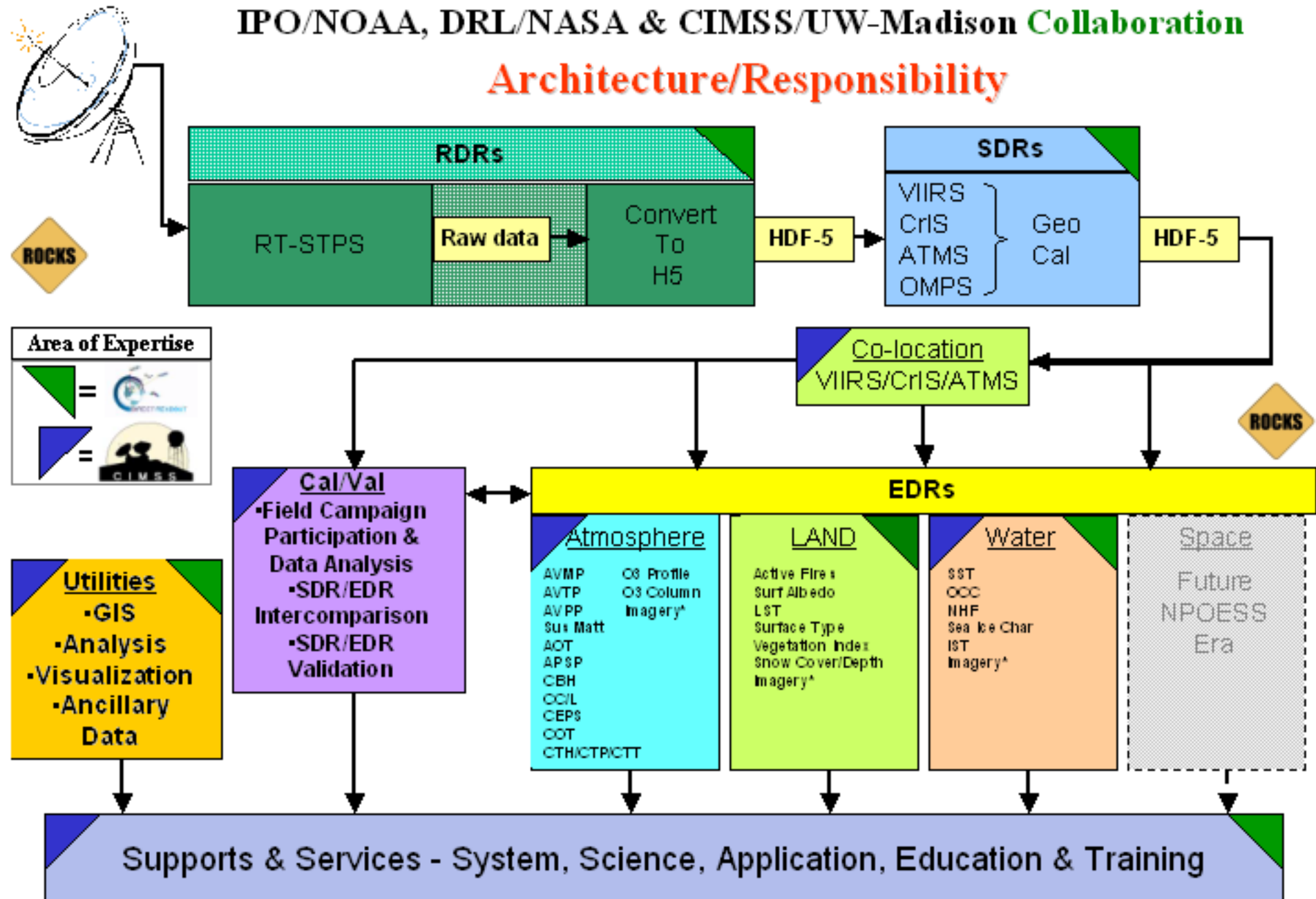
(Lower Noise = Higher Vertical Resolution)



International Polar Orbiter Processing Package (IPOPP)

IPO/NOAA, DRL/NASA & CIMSS/UW-Madison **Collaboration**

Architecture/Responsibility



IPOPP Partial Product List

- True color atmospherically corrected images
- Single VIIRS FOV cloud mask and phase
- **Cloud Infrared Properties**
- Land Surface Reflectance
- Snow/Sea Ice Detection
- **Scene Classification (Clouds and Land Surface)**
- **CrIS single FOV retrieval of temperature and moisture profiles**
- CrIS/ATMS sounding EDR evaluation/validation.
- CrIS/VIIRS synergistic high spatial resolution cloud cleared radiances and retrievals
- **Efficient and accurate CrIS/VIIRS/Others collocation**
- Other high propriety non-core EDRs as identified by direct broadcast users.

EOS IMAPP & NPP/NPOESS/METOP IPOPP **- Continuing & Evolving Role**

- **Provide tools and services to support DB users**
- **Provide validated measurements & products that DB users want**
- **And to conduct synergistic process to**
 - ❖ **Provide value-added and performance enhanced products for the demands of achieving high quality information and knowledge**
 - ❖ **Provide data/products inter-comparison as part of validation and calibration efforts**