Investigations with High Spectral Resolution Data from AIRS

Lectures in Bertinoro

Lecture 3

Paul Menzel
NOAA/NESDIS/ORA

Investigations with High Spectral Resolution Data from AIRS

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NOAA/NESDIS/STAR
in collaboration with
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Dave Tobin, Hank Revercomb
and colleagues at CIMSS

The road to improved IR sounding

(~1600) ***HES*** (geo operational)

(~1600) ***GIFTS*** (geo experimental)

CrIS (leo operational)

(~3600) **IASI** (leo operational)

(~2400) **AIRS** (leo pseudo-operational)

NAST-I (airborne experimental)

IMG (leo experimental)

(18) ***GOES Sounder*** (geo operational)

HIS (airborne experimental)

(12) ***VAS*** (geo experimental)

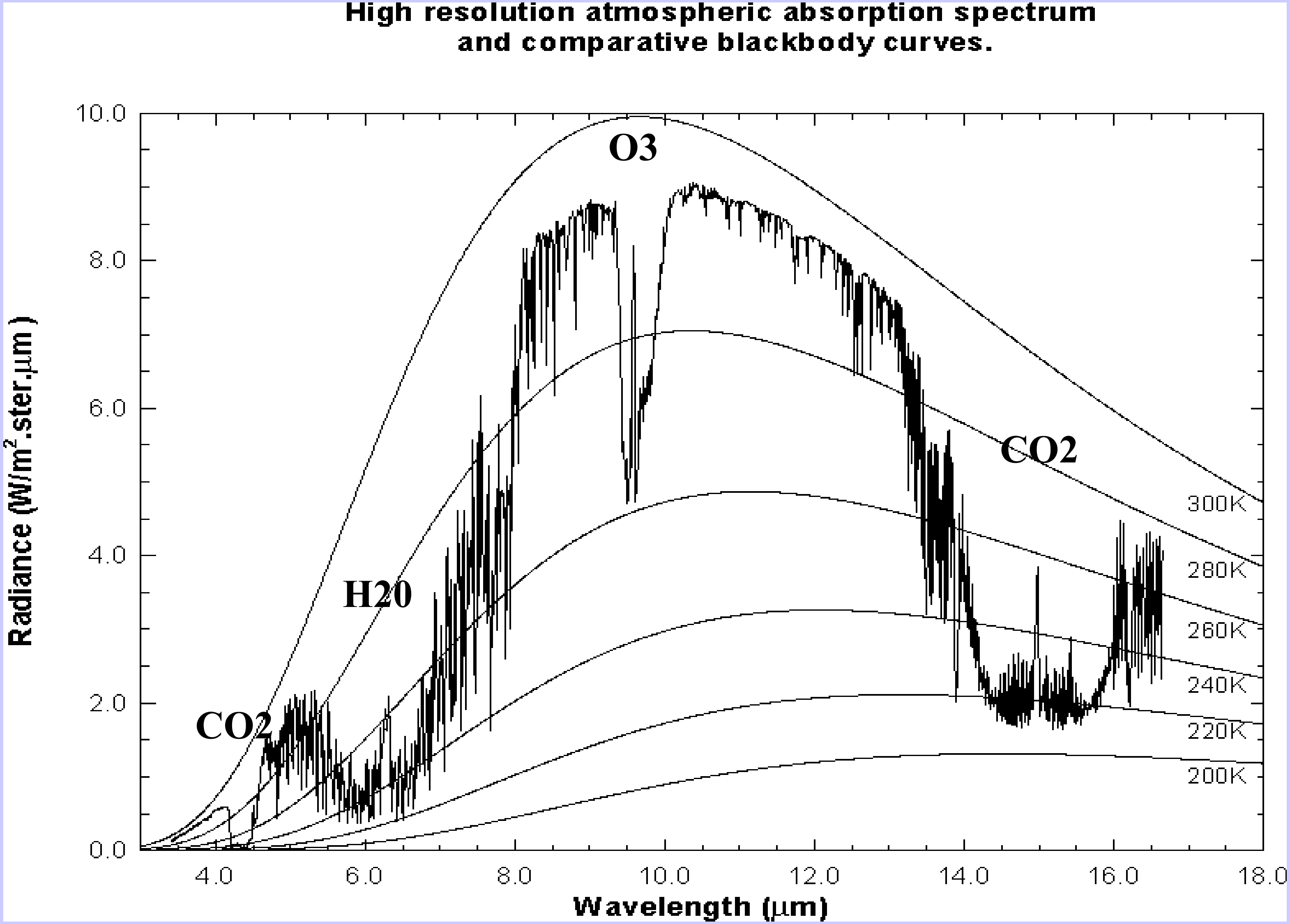
(# of spectral bands)

VTPR, HIRS (leo operational)

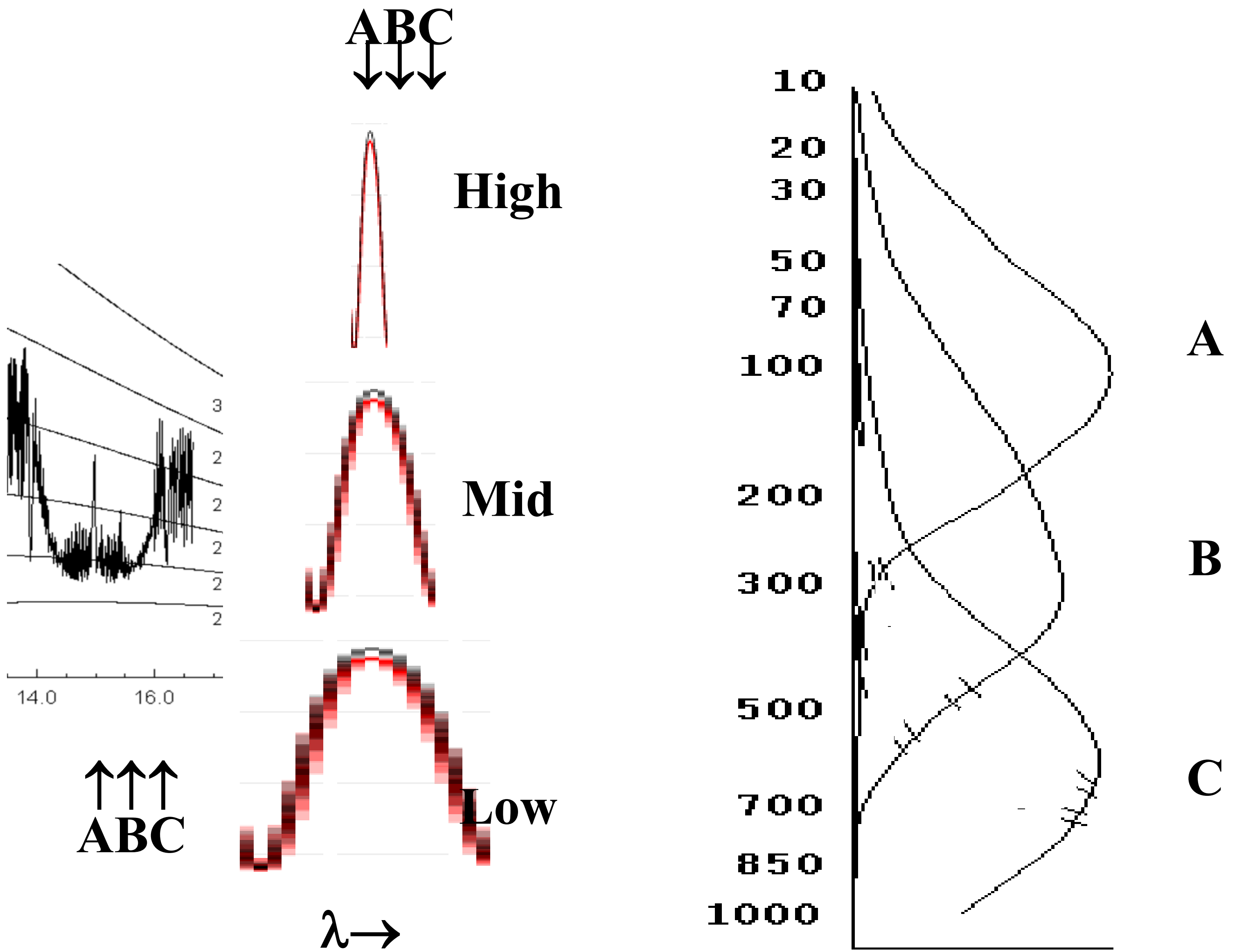
IRIS (leo experimental)

→ time

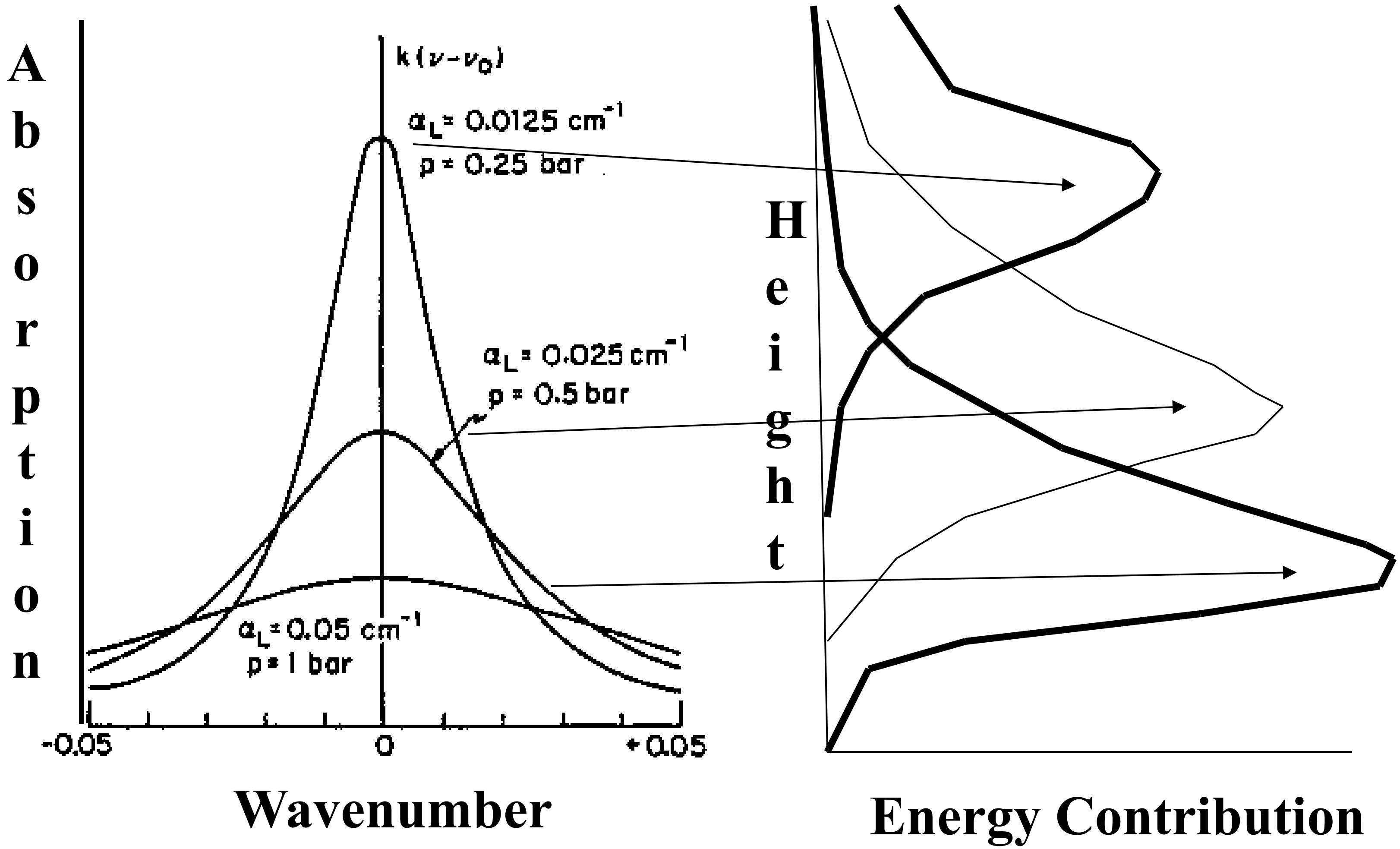
Earth emitted spectra overlaid on Planck function envelopes



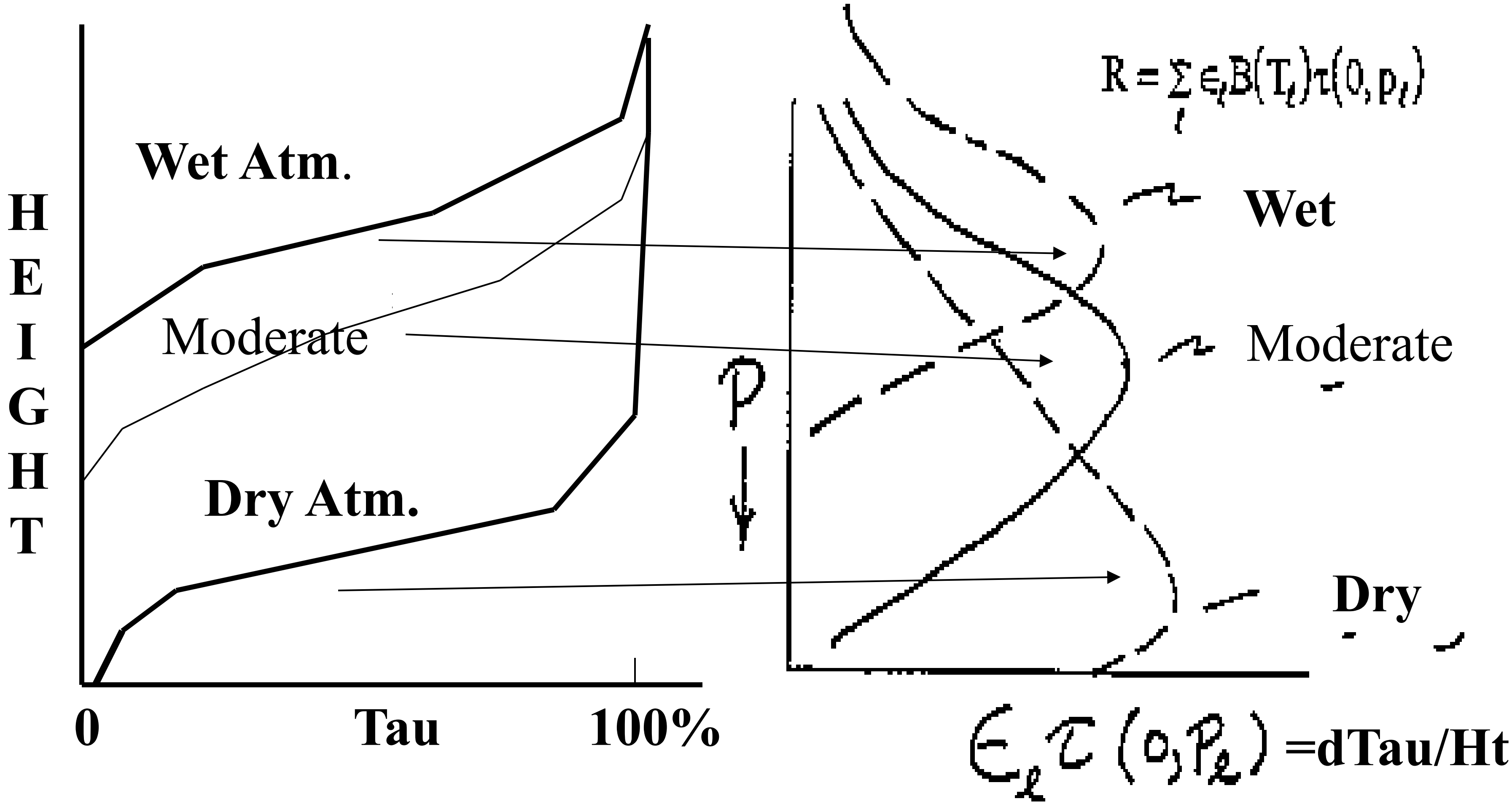
line broadening with pressure helps to explain weighting functions



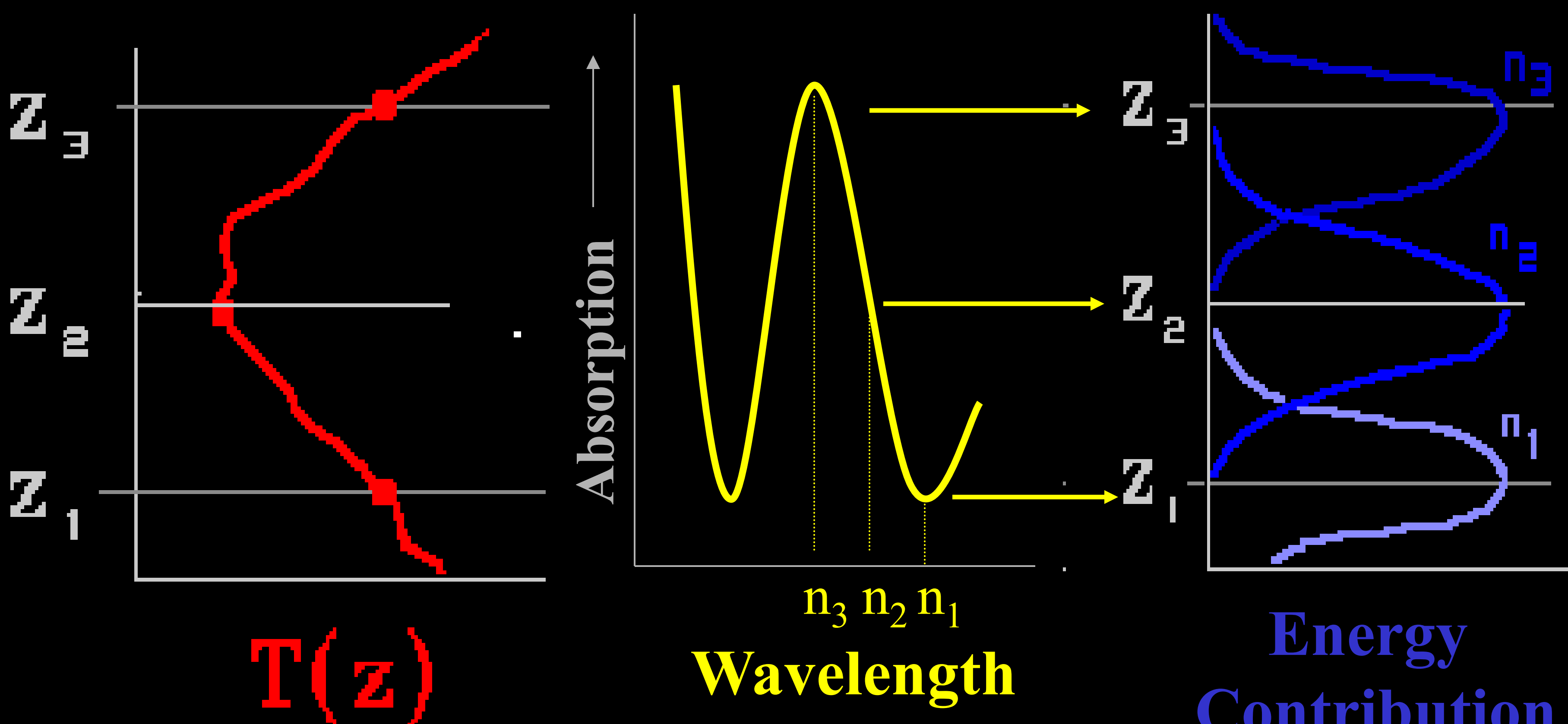
Fourier Transform Spectrocopy
Infrared Atmospheric Sounding



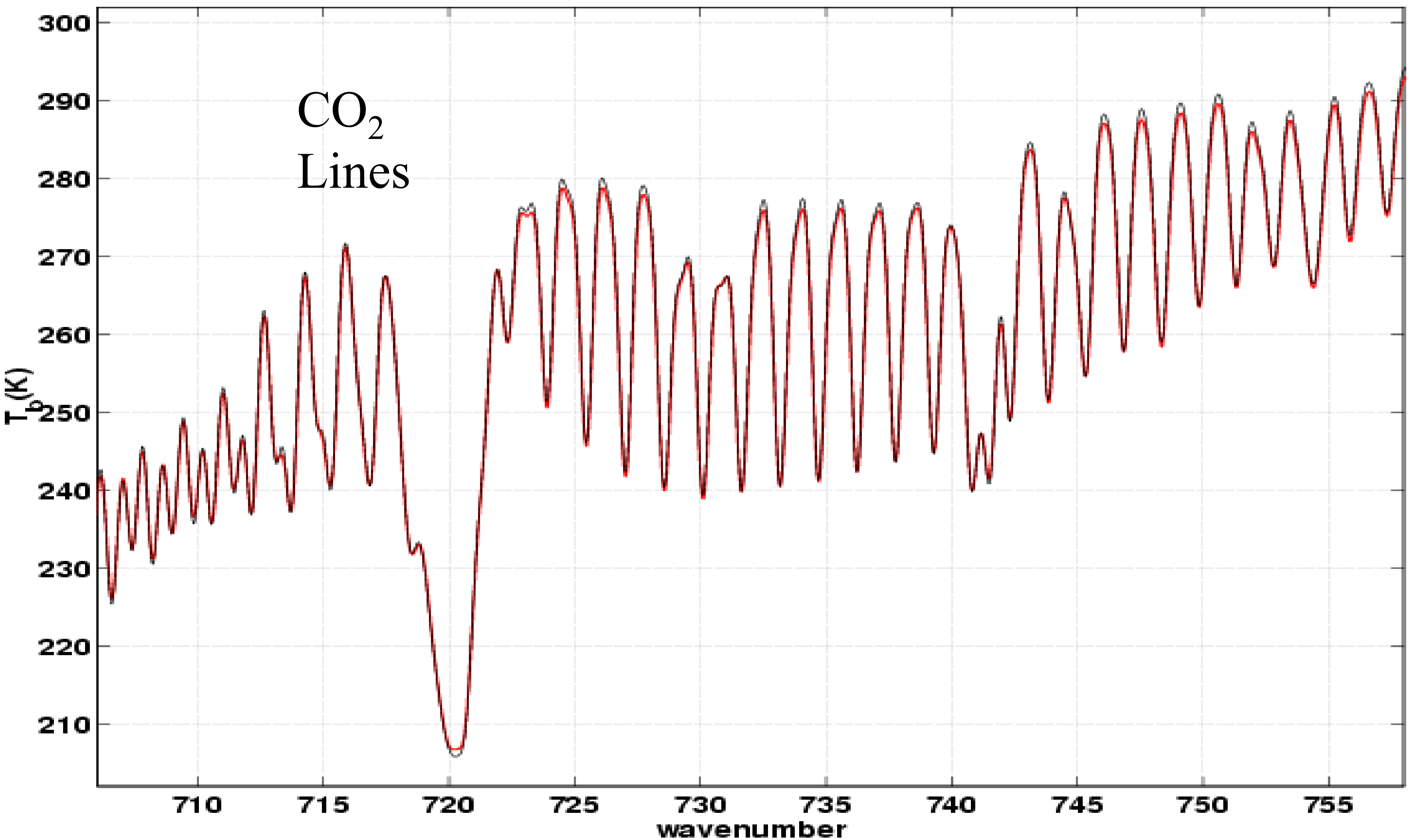
For a given water vapor spectral channel

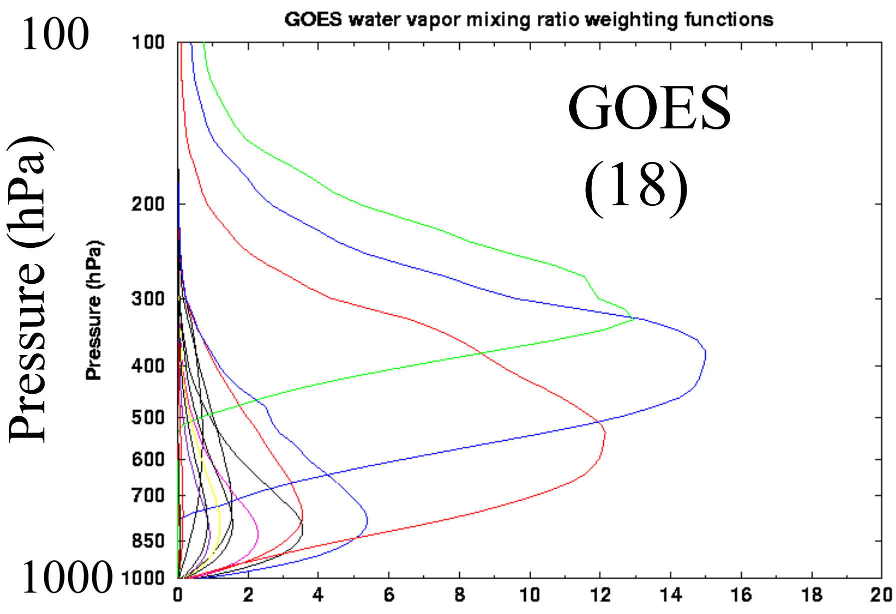


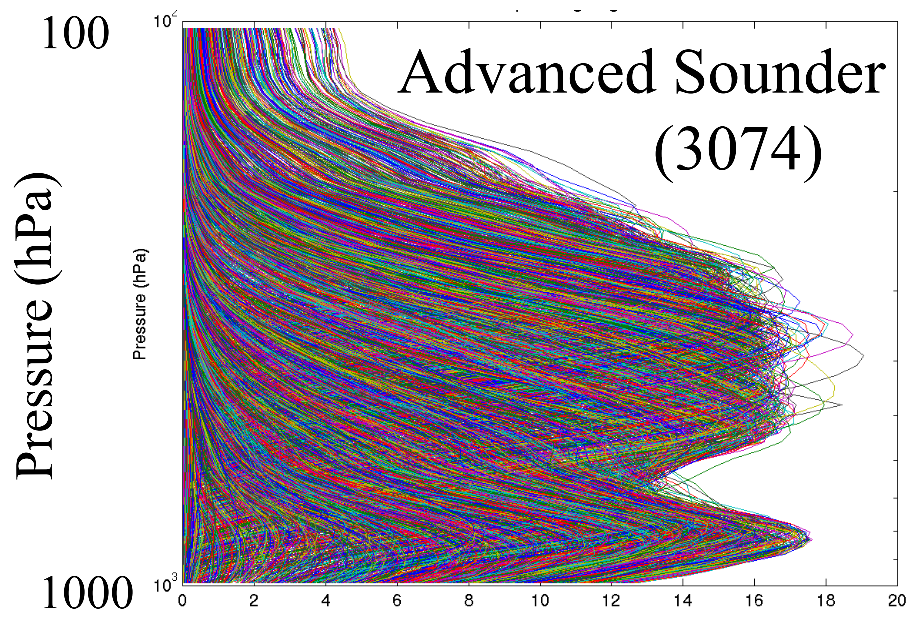
Wavelength Converts to Altitude



Earth emitted spectrum in CO2 sensitive 705 to 760 cm-1





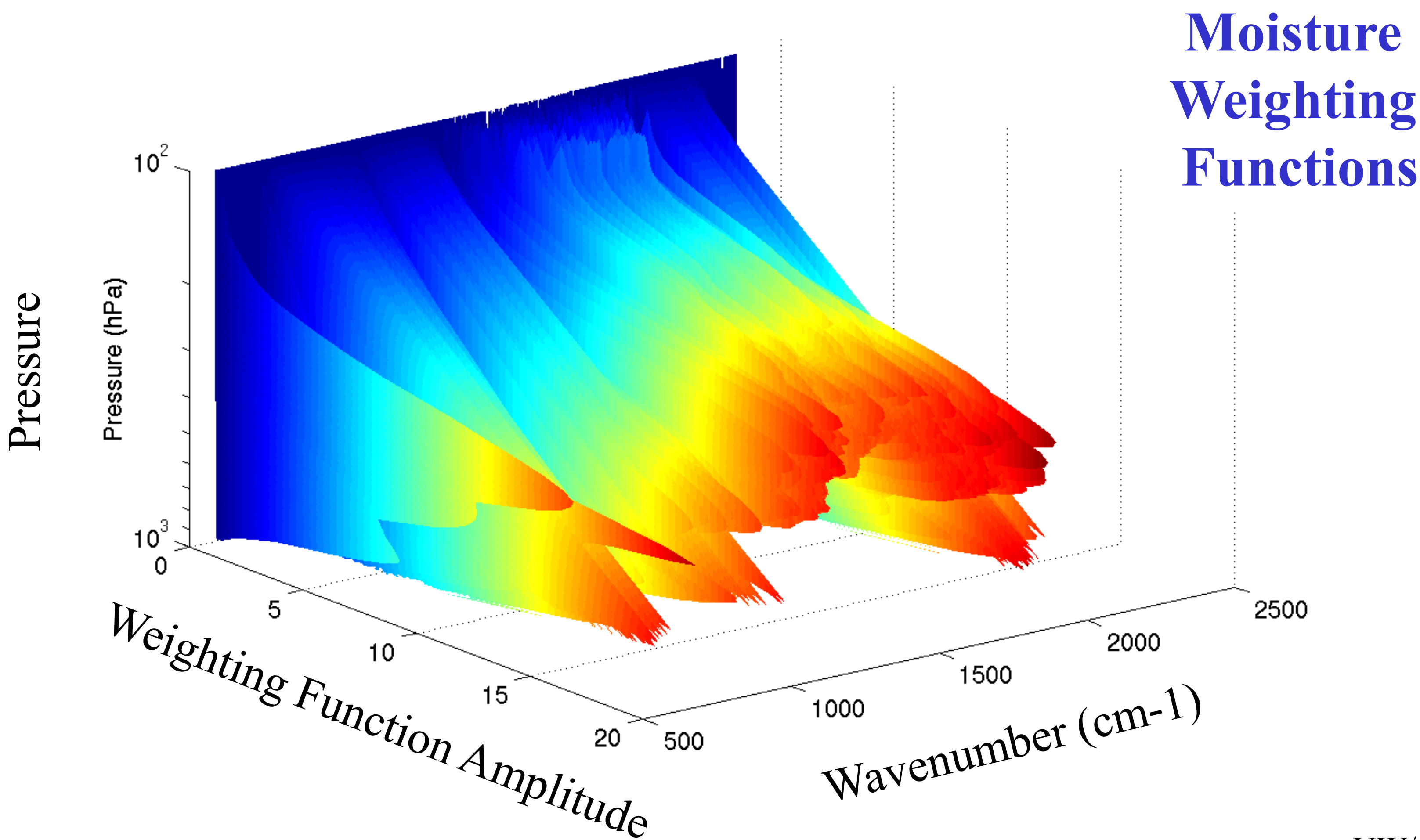


Moisture Weighting Functions

High spectral resolution advanced sounder will have more and sharper weighting functions compared to current GOES sounder. Retrievals will have better vertical resolution.

UW/CIMSS

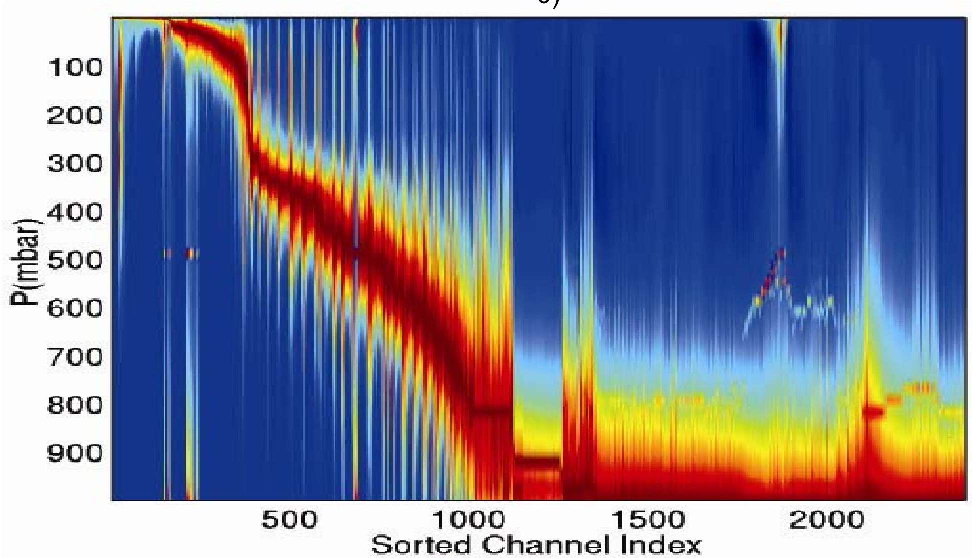
These water vapor weighting functions reflect the radiance sensitivity of the specific channels to a water vapor % change at a specific level (equivalent to dR/dlnq scaled by dlnp).



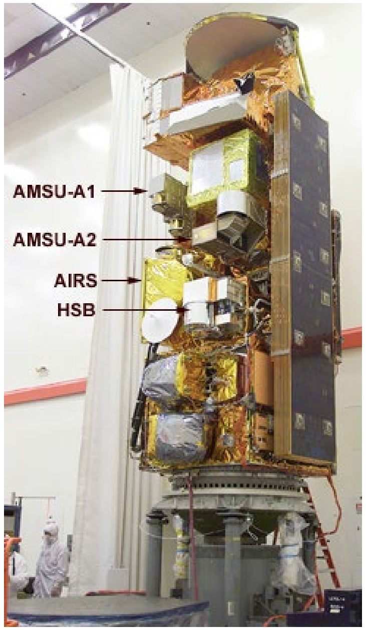
UW/CIMSS

The advanced sounder has more and sharper weighting functions

temperature weighting functions sorted by pressure of their peak (blue = 0)



AIRS On Aqua

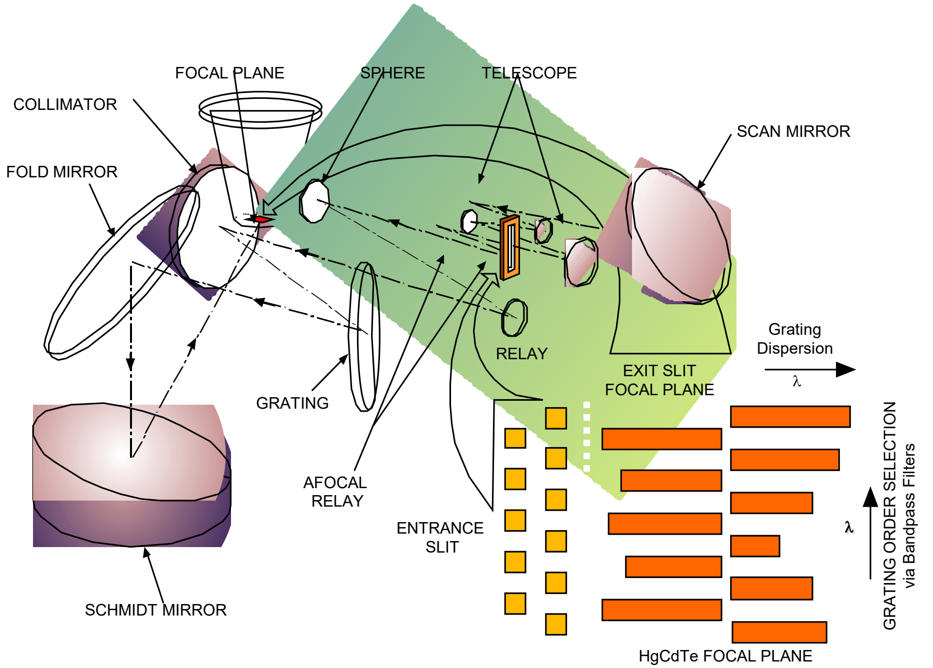


Instrument

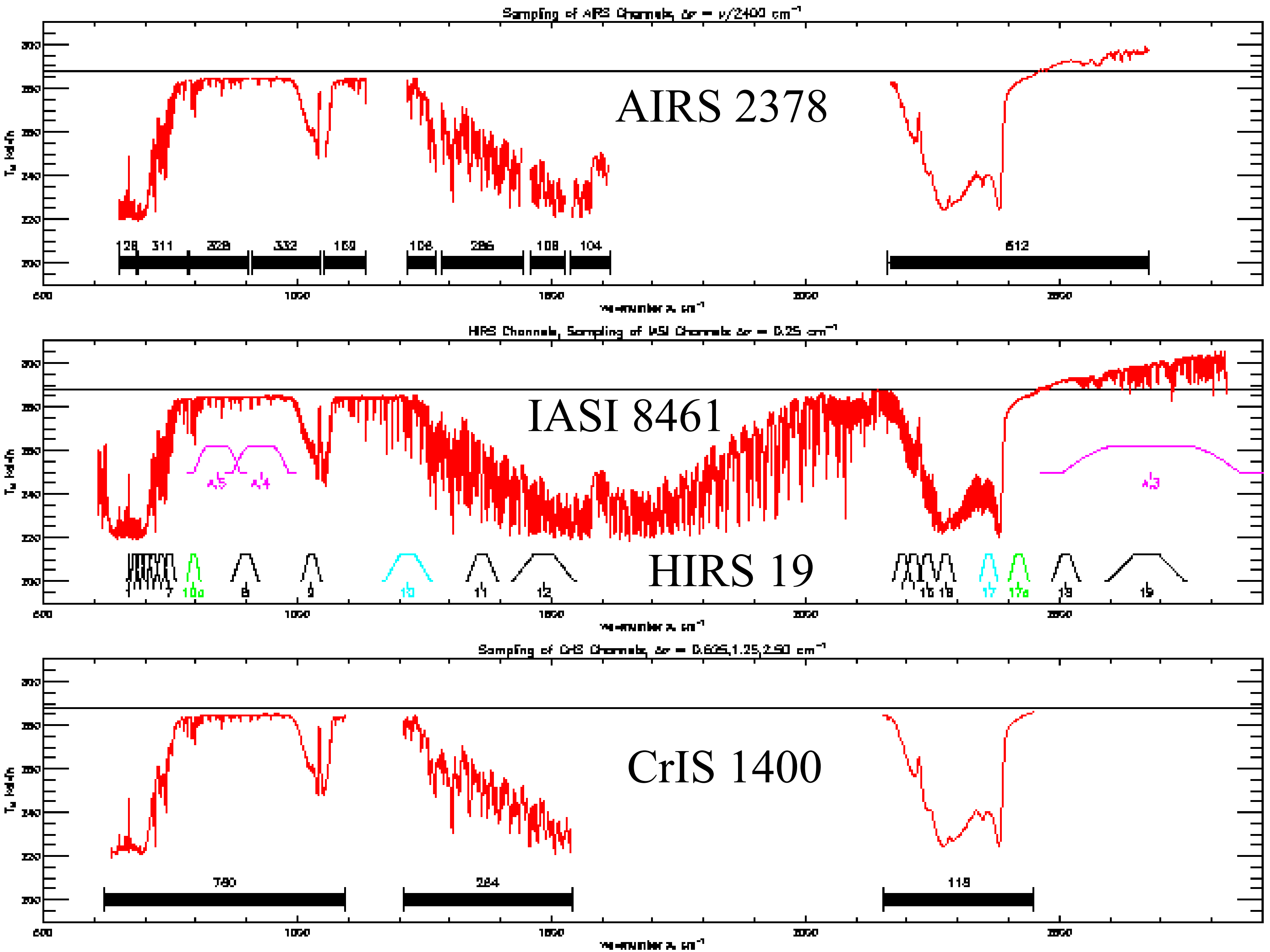
- Hyperspectral radiometer with **resolution of 0.5 – 2 cm^{-1}**
- Extremely well calibrated pre-launch
- **Spectral range: 650 – 2700 cm^{-1}**
- Associated microwave instruments (AMSU, HSB)

Design

- Grating Spectrometer passively cooled to 160K, stabilized to 30 mK
- **PV and PC HdCdTe focal plane cooled to 60K** with redundant active pulse tube cryogenic coolers
- **Focal plane has ~5000 detectors,** 2378 channels. PV detectors (all below 13 microns) are doubly redundant. Two channels per resolution element (n/Dn = 1200)
- 310 K Blackbody and space view provides radiometric calibration
- Paralyene coating on calibration mirror and upwelling radiation provides spectral calibration
- **NEDT (per resolution element) ranges from 0.05K to 0.5K**

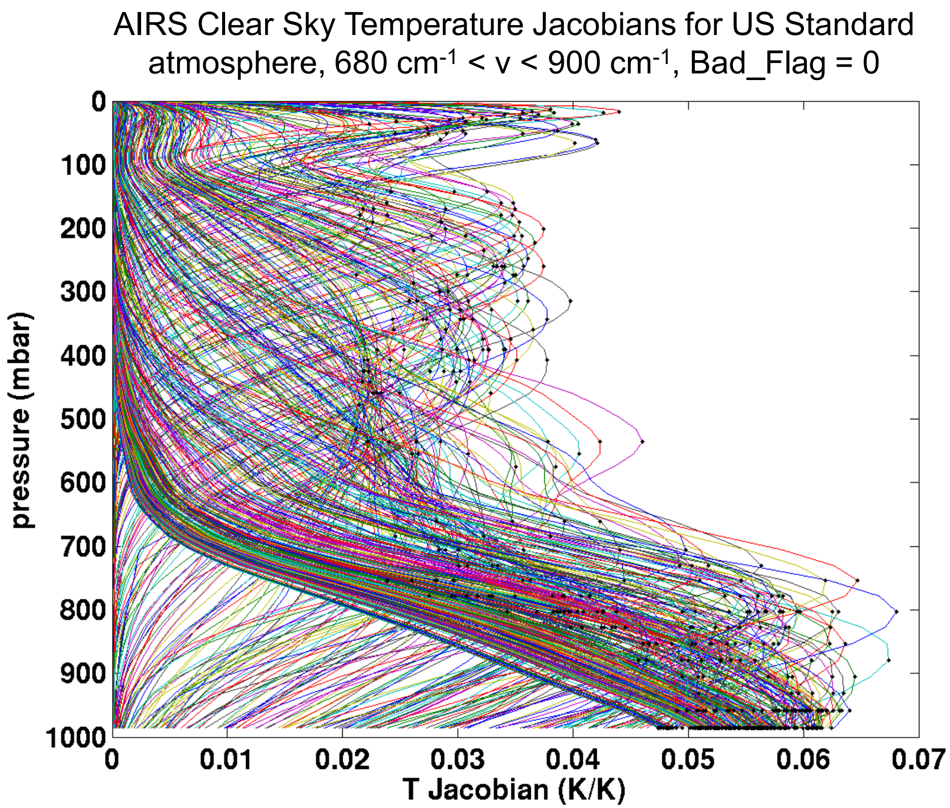


Spectral filters at each entrance slit and over each FPA array isolate color band (grating order) of interest



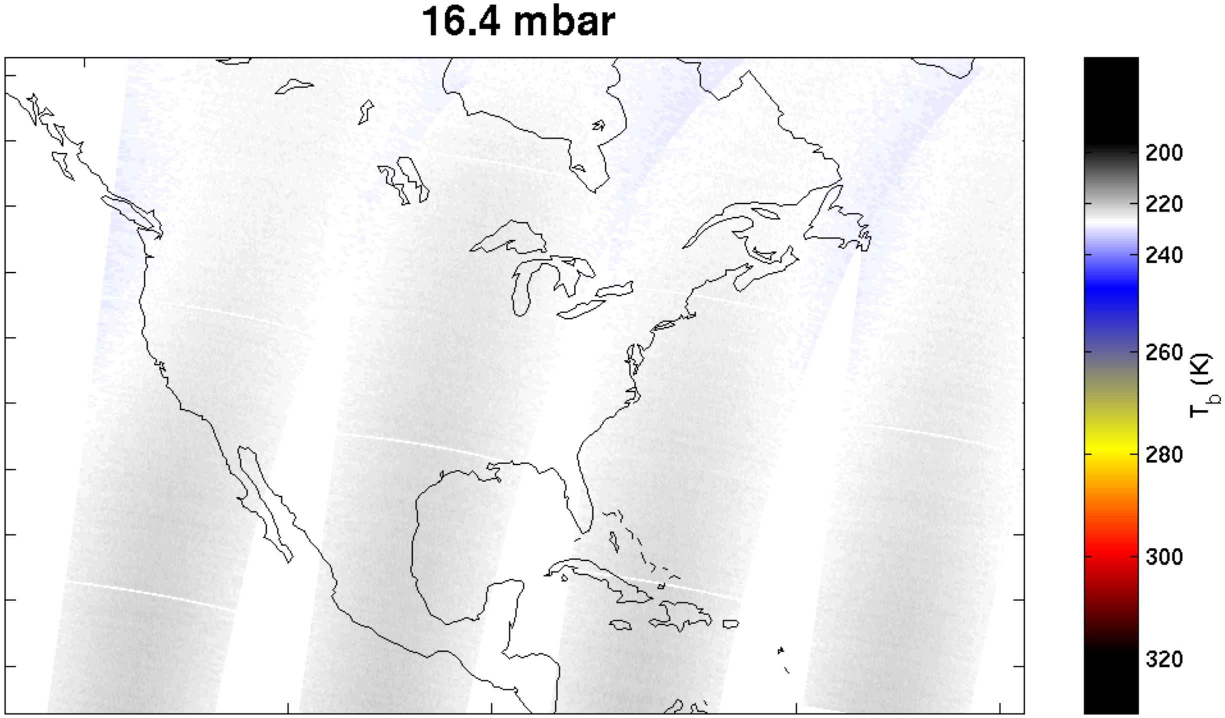
Sampling of AIRS Channels, Δσ = ν/2400 cm⁻¹
AIRS 2378
128 311 328 332 160 106 286 108 104 512
HIRS Channels, Sampling of IASI Channels Δσ = 0.25 cm⁻¹
IASI 8461
HIRS 19
Sampling of CrIS Channels, Δσ = 0.625,1.25,2.50 cm⁻¹
CrIS 1400
780 264 118

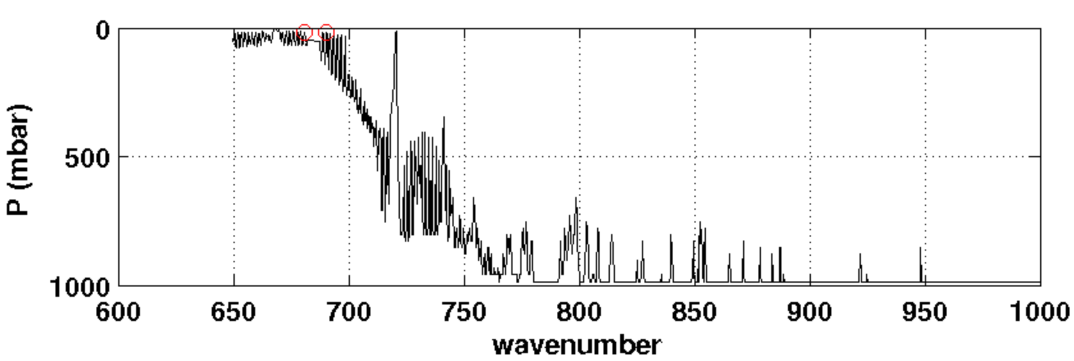
AIRS movie

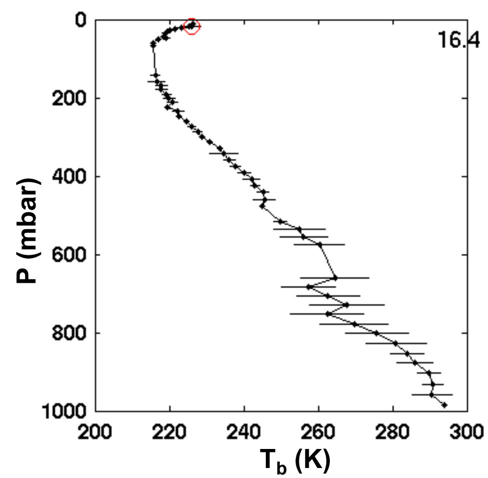


↙ Sort channels by pressure of Jacobian peaks

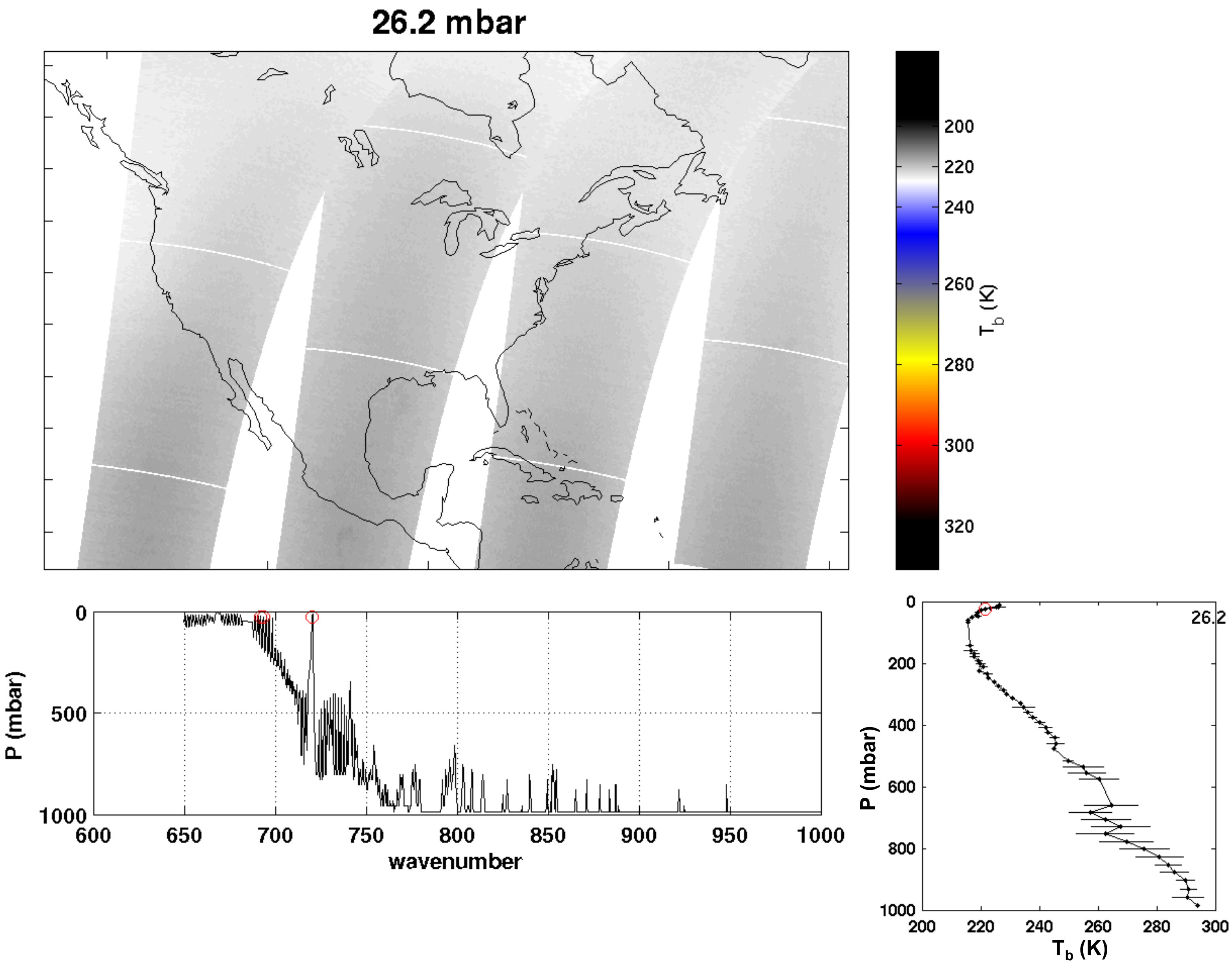
AIRS nighttime granules over CONUS, 6 Sept 2002



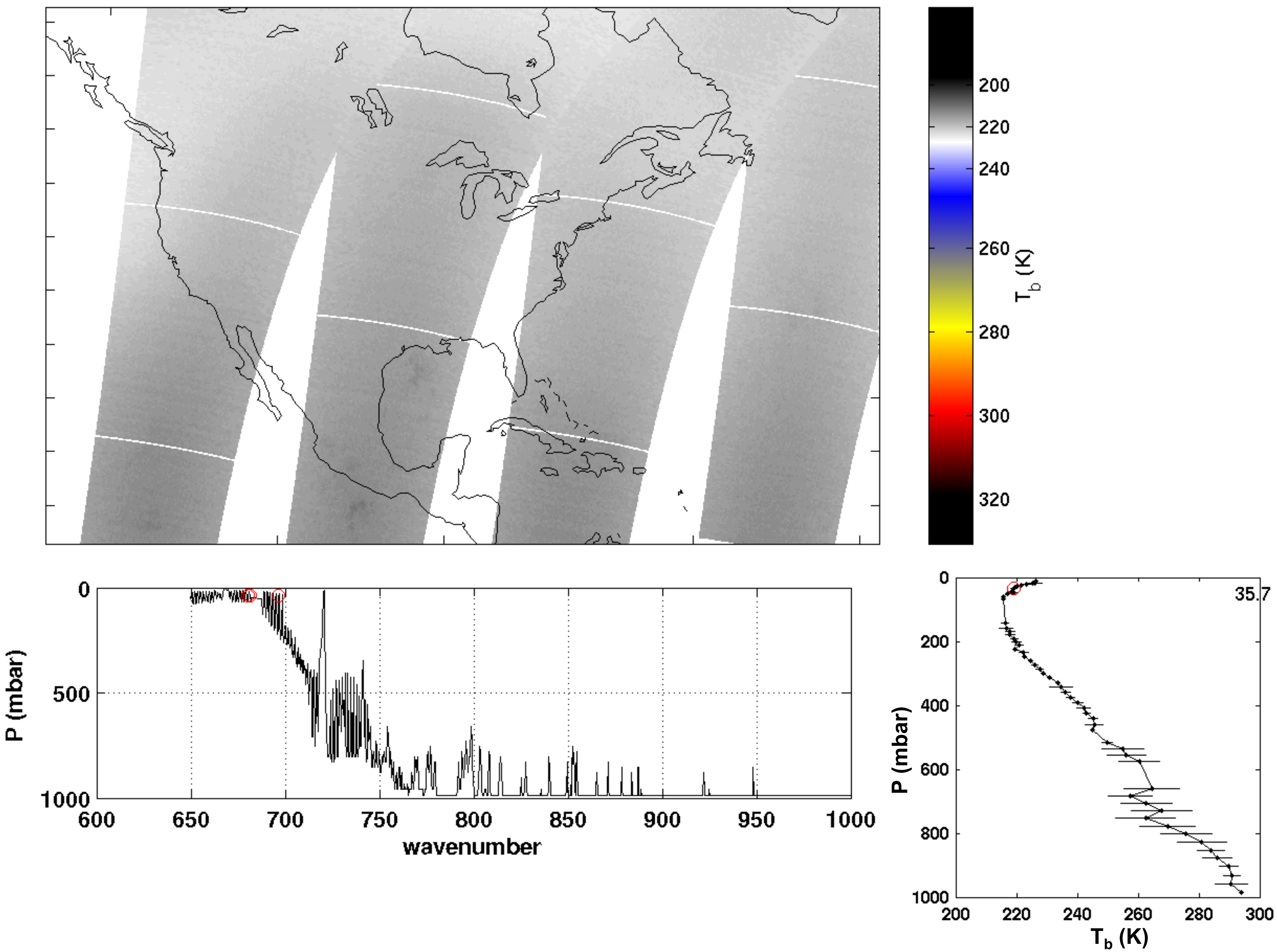




Mouse click or page down to start movie

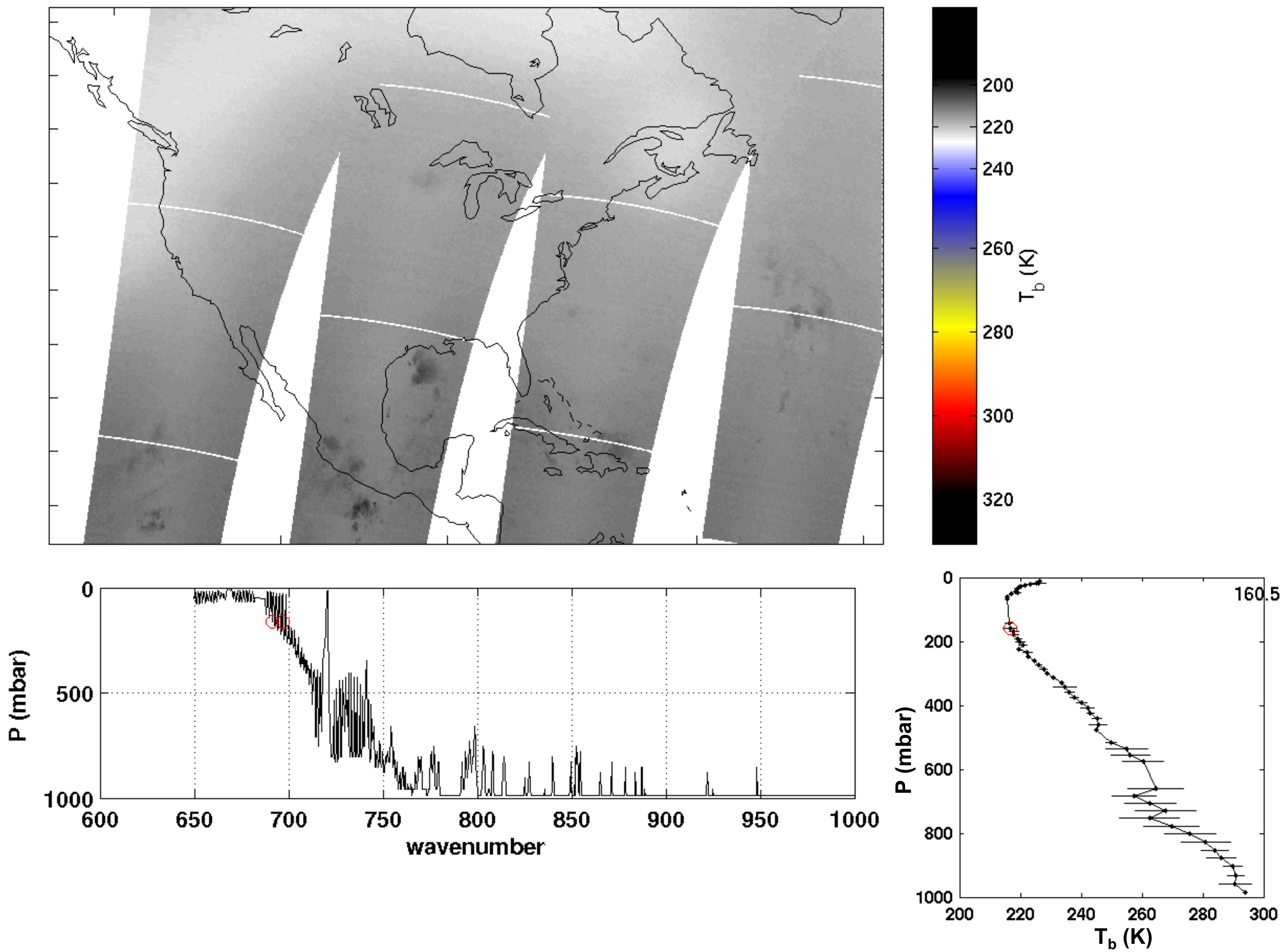

26.2 mbar
200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
26.2
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

35.7 mbar



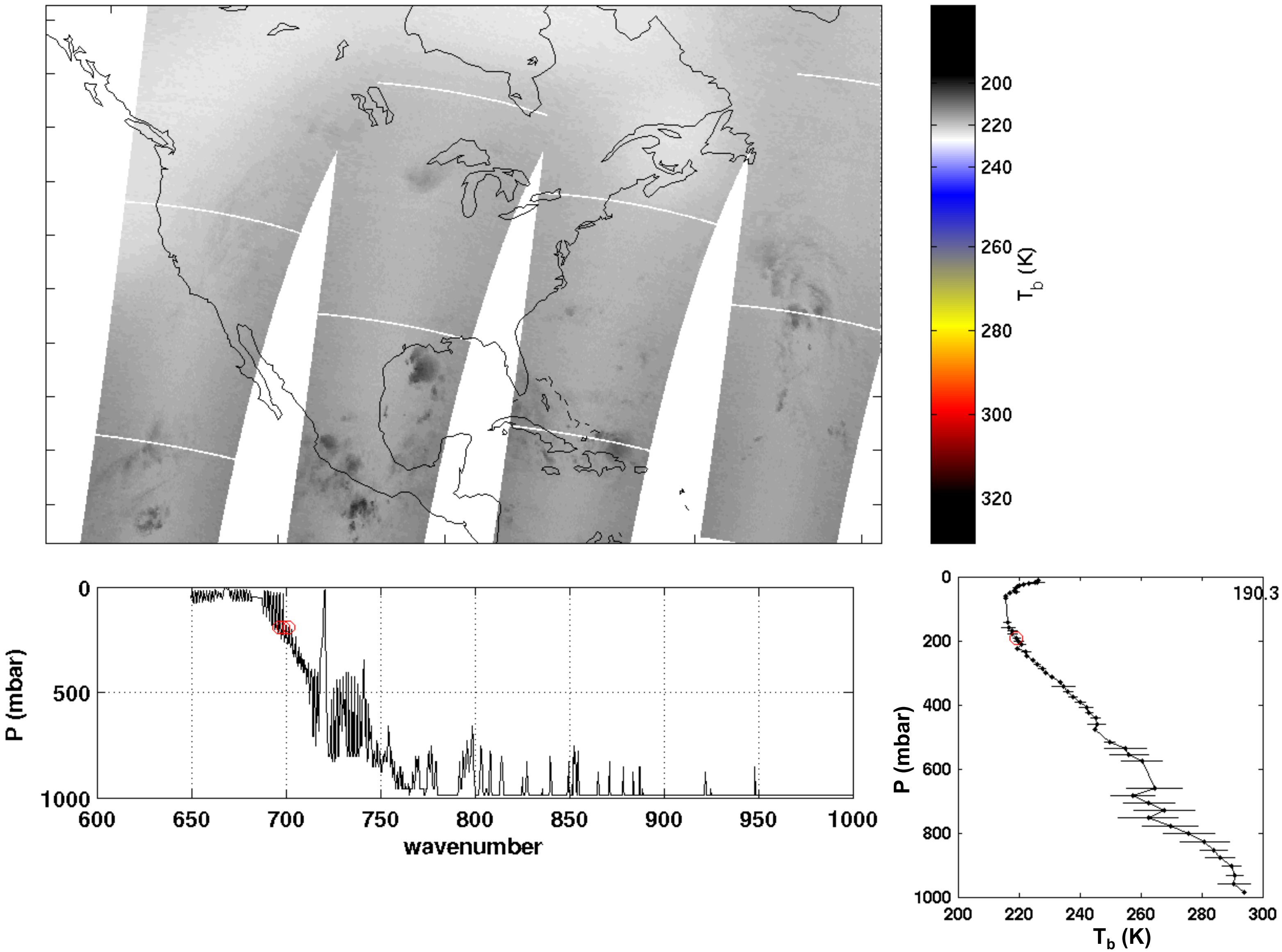
200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
35.7
200
400
600
800
1000
220
240
260
280
T_b (K)

160.5 mbar



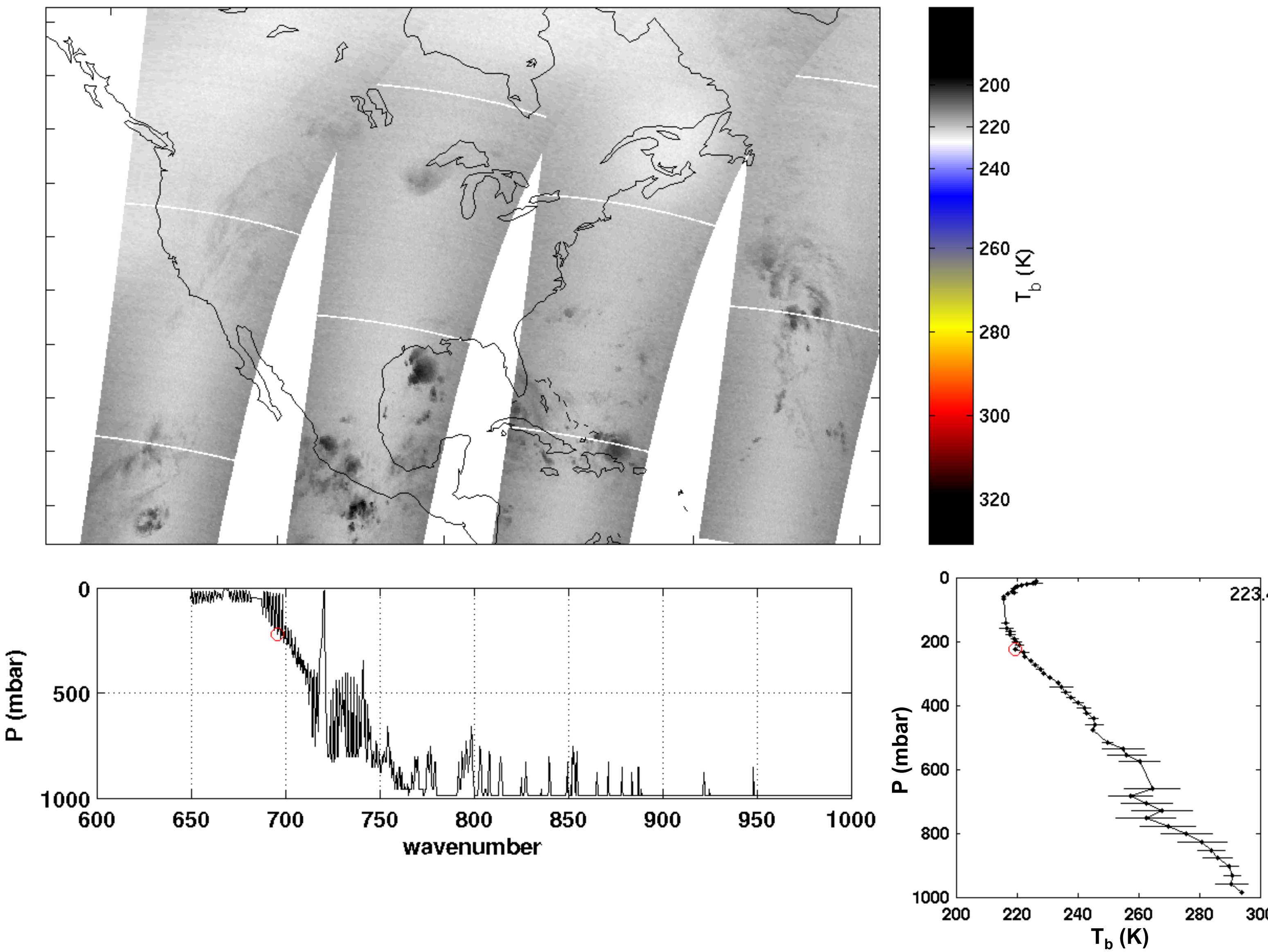
200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
160.5
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

190.3 mbar



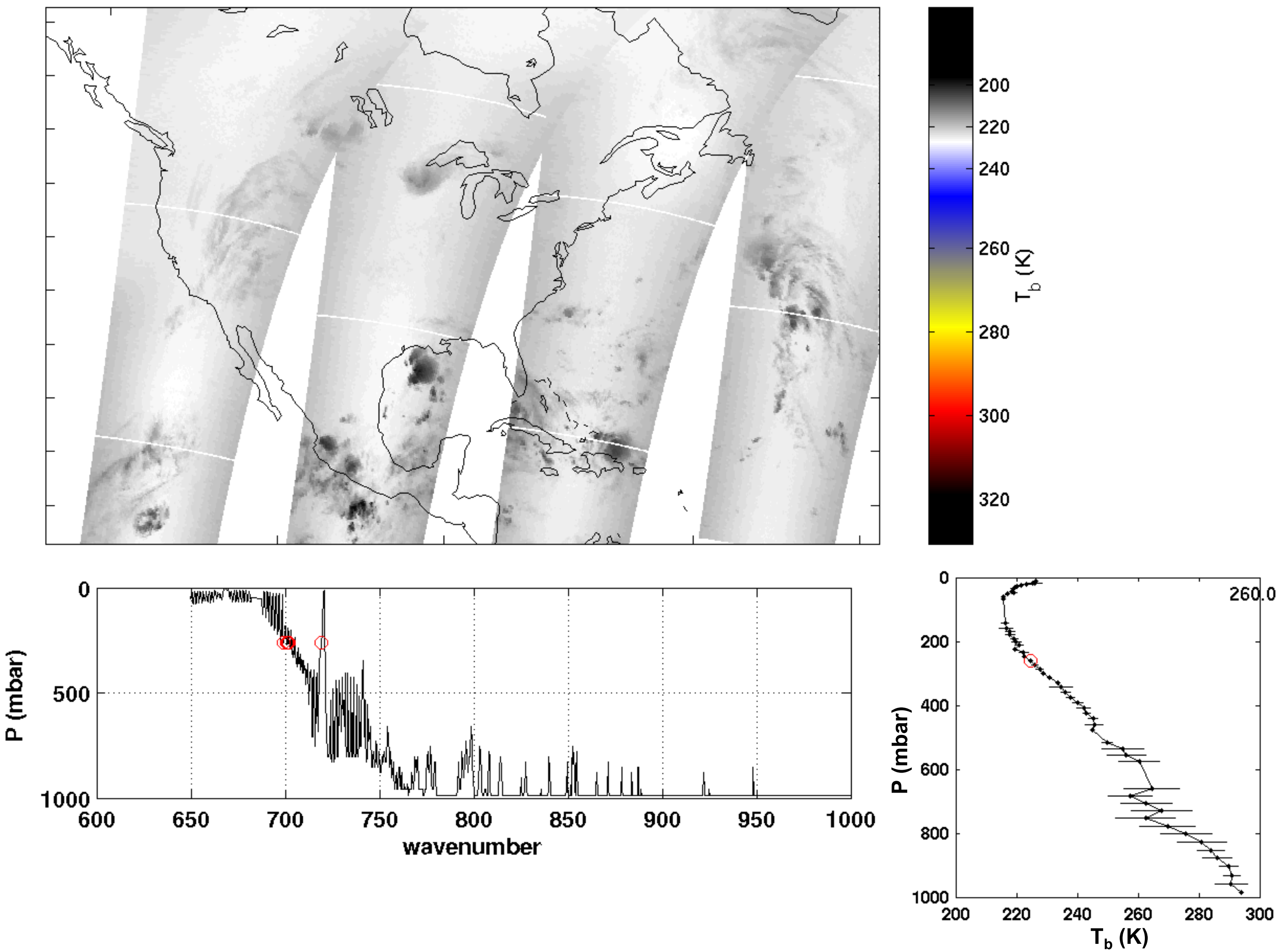
200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
190.3
0
200
400
600
800
1000
200
220
240
260
280
300
P (mbar)
T_b (K)

223.4 mbar



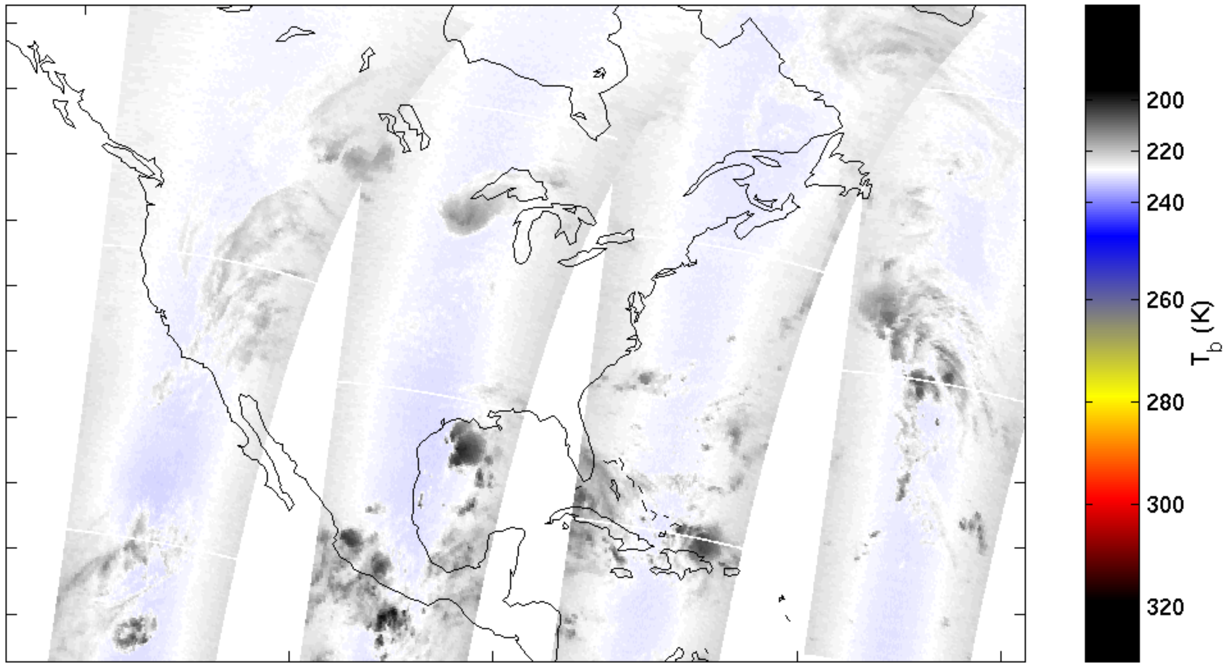
200
220
240
260
280
300
320
T_b (K)
0
500
1000
P (mbar)
600
650
700
750
800
850
900
950
1000
wavenumber
223.4
0
200
400
600
800
1000
P (mbar)
200
220
240
260
280
300
T_b (K)

260.0 mbar

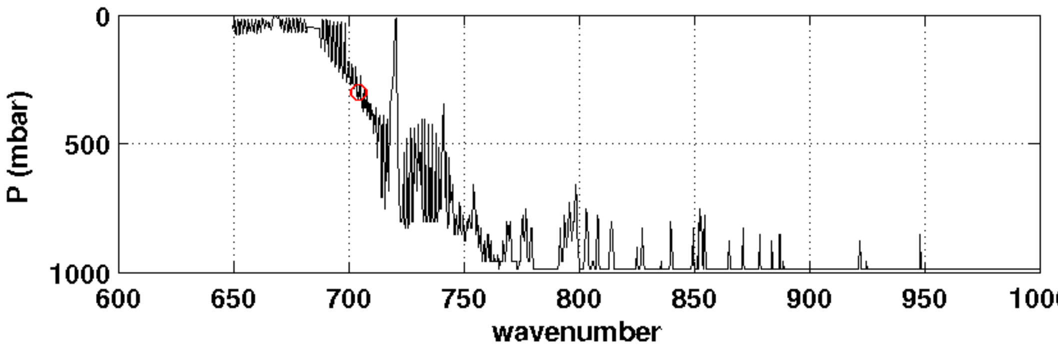


200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
260.0
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

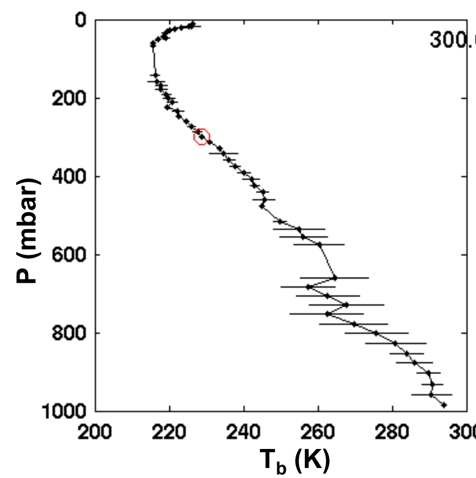
300.0 mbar



200
220
240
260
280
300
320
T_b (K)

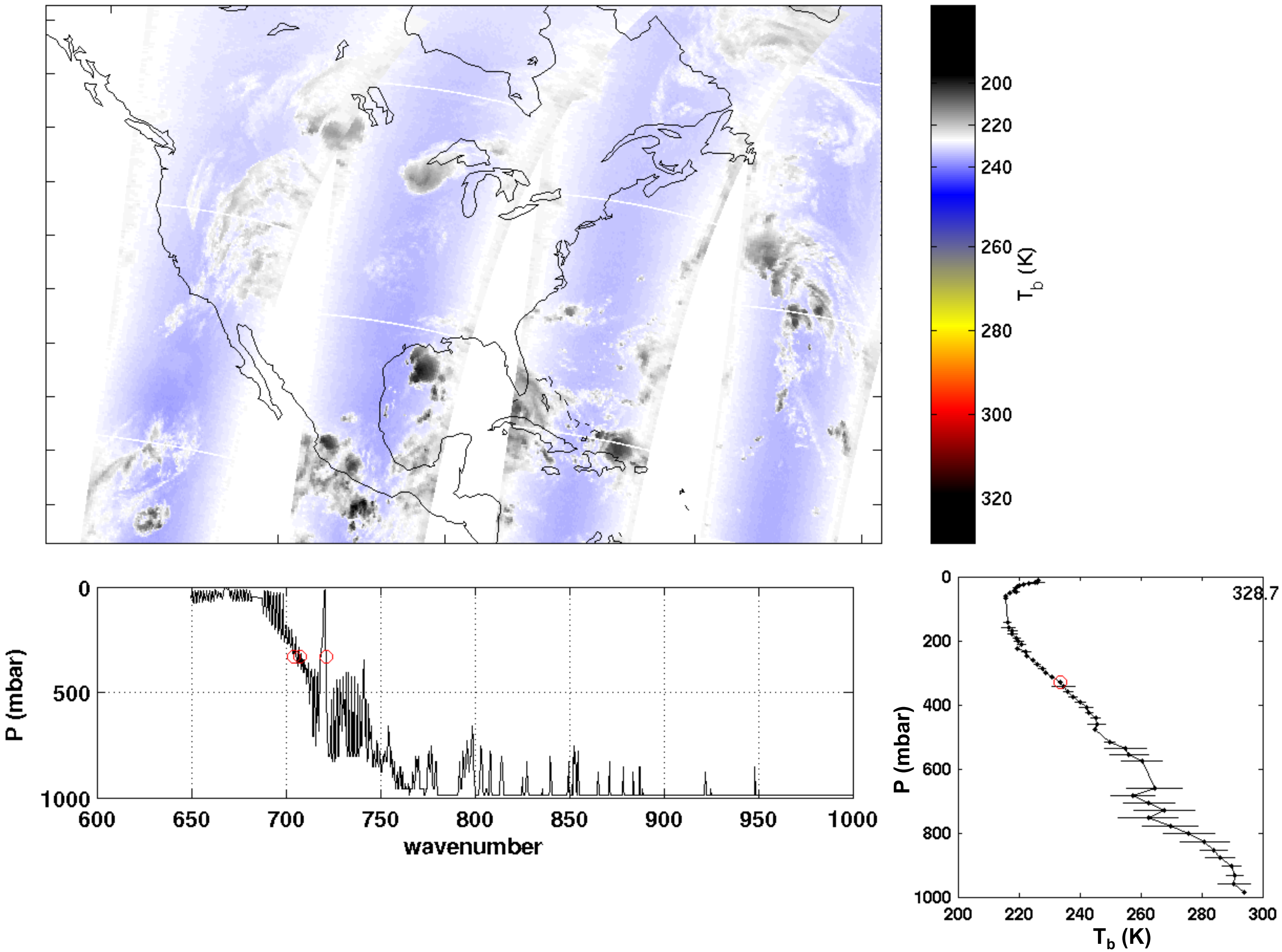


P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber



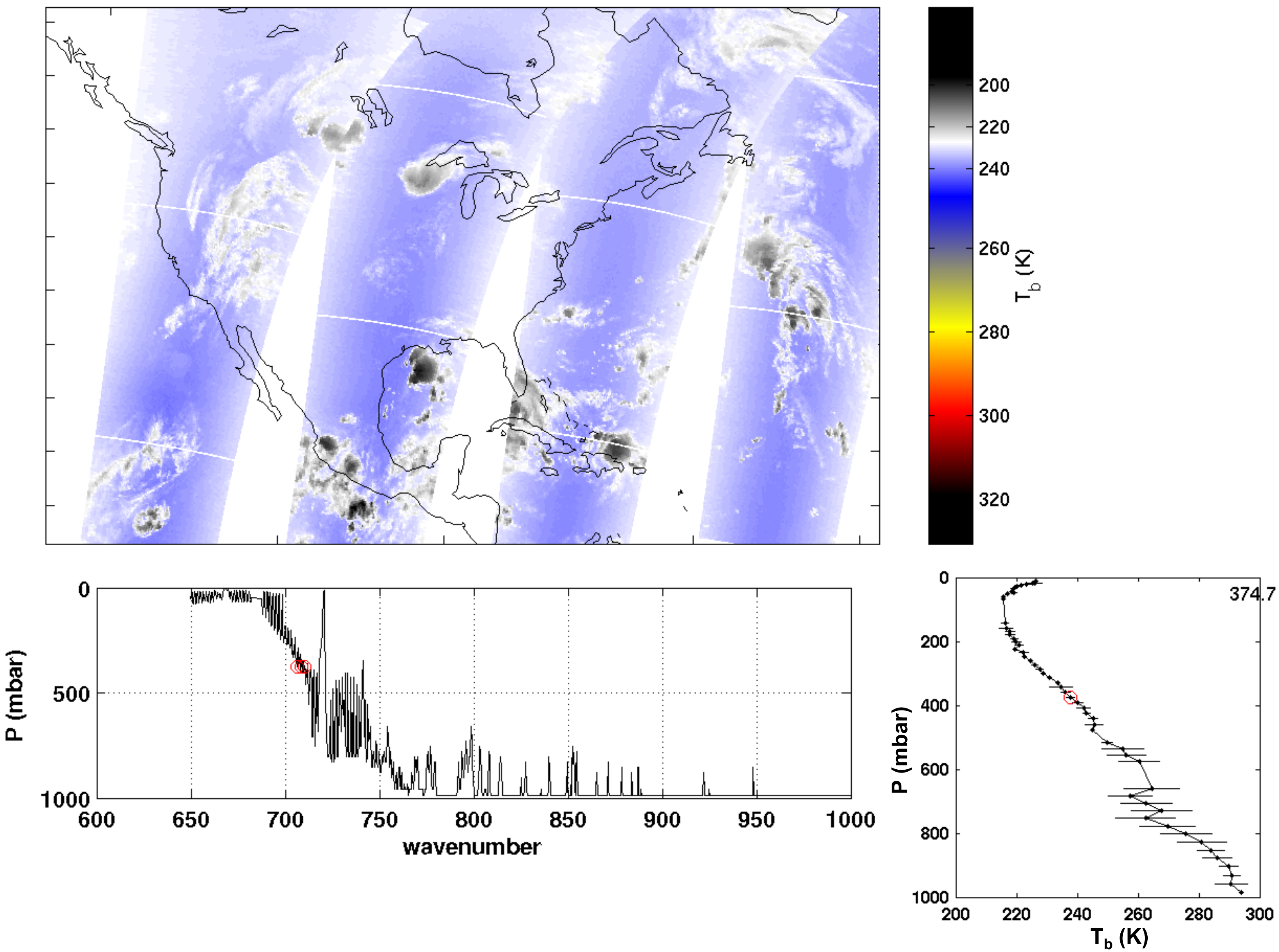
300.0
P (mbar)
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

328.7 mbar



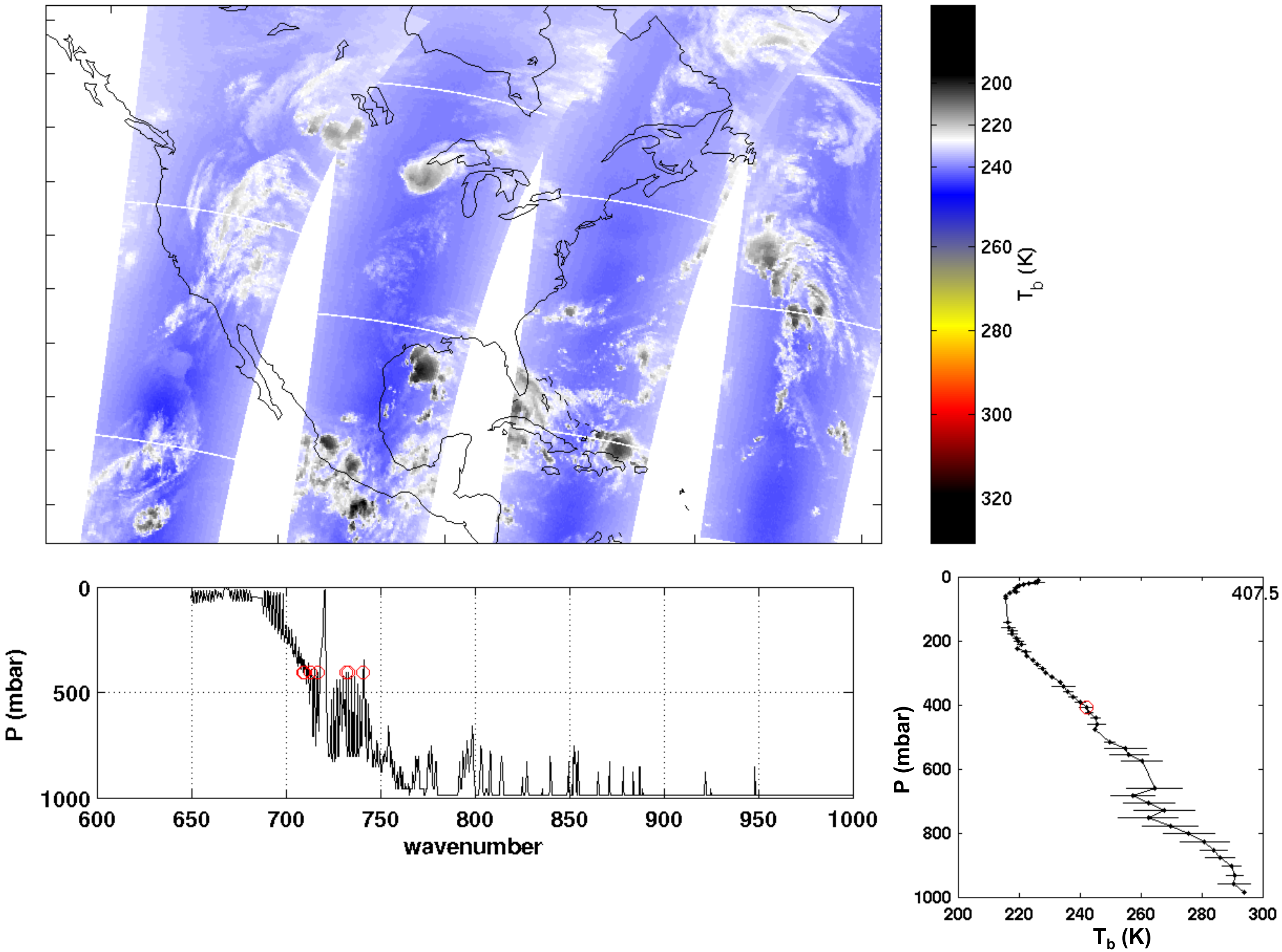
200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
328.7
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

374.7 mbar



200
220
240
260
280
300
320
Tb (K)
0
500
1000
P (mbar)
600
650
700
750
800
850
900
950
1000
wavenumber
374.7
200
400
600
800
1000
P (mbar)
200
220
240
260
280
300
Tb (K)

407.5 mbar



200
220
240
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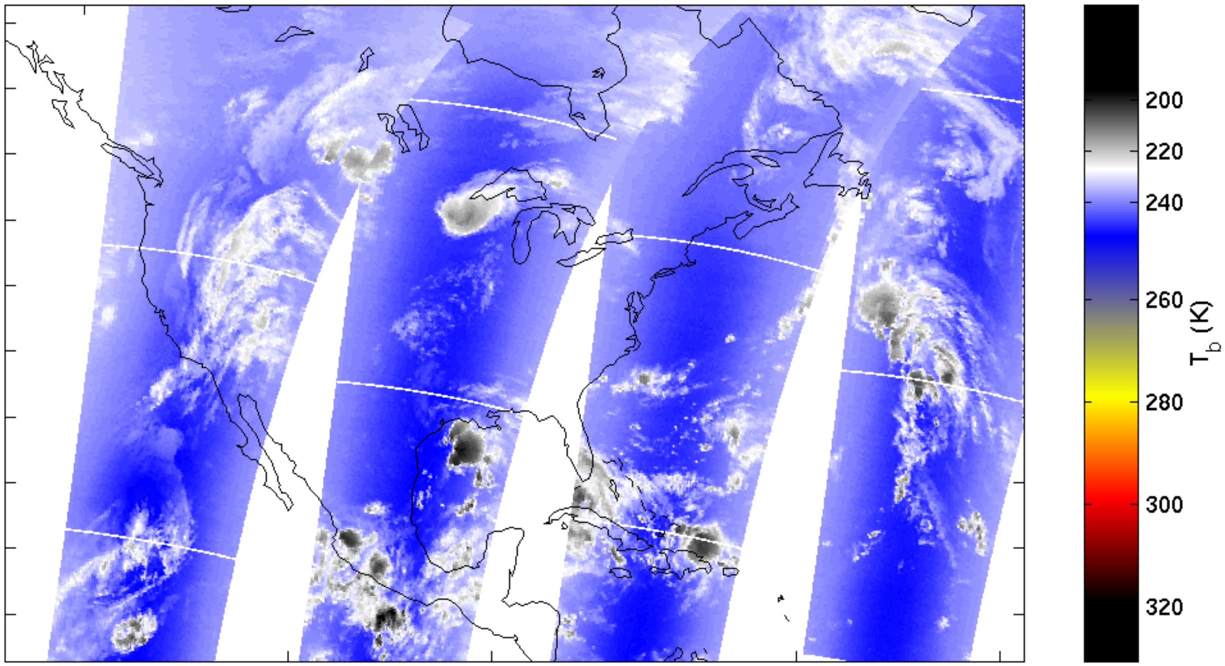
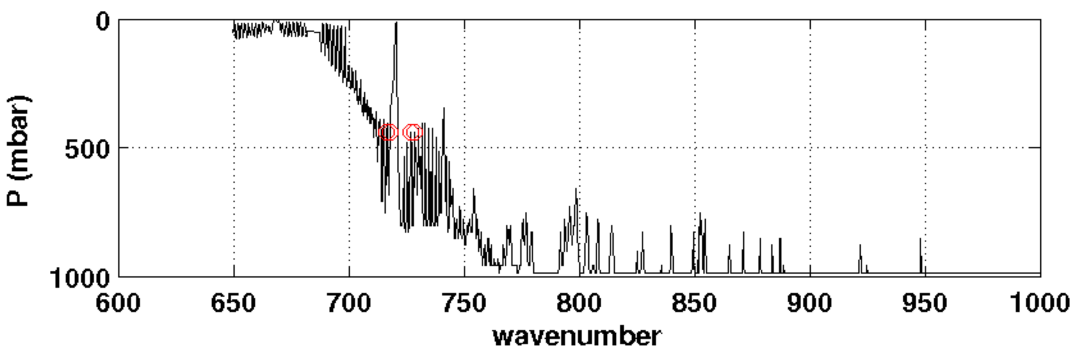
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
407.5
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

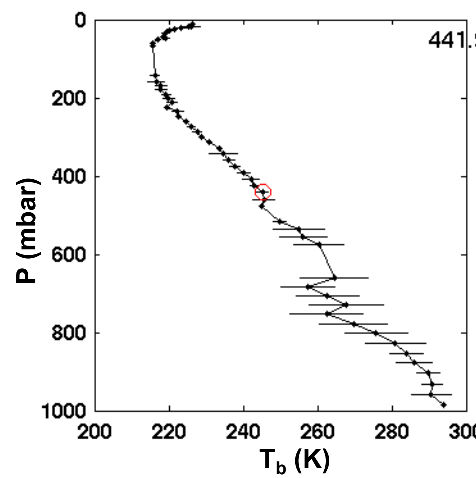
441.9 mbar



200
220
240
260
280
300
320
T_b (K)

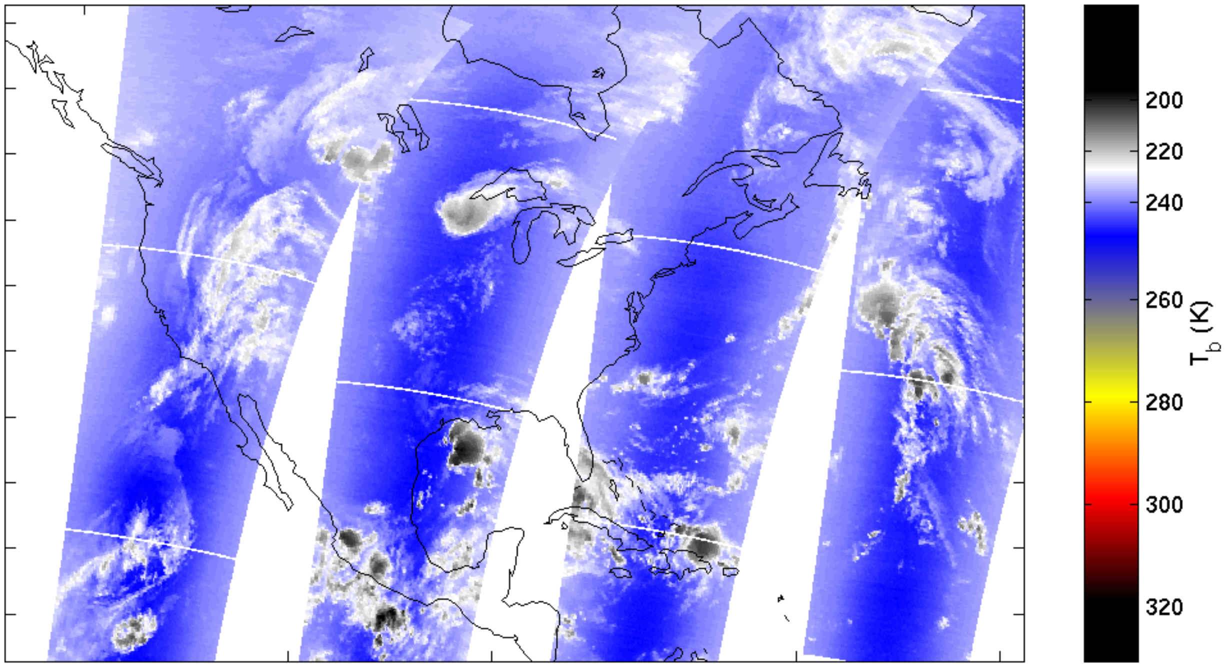


P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber

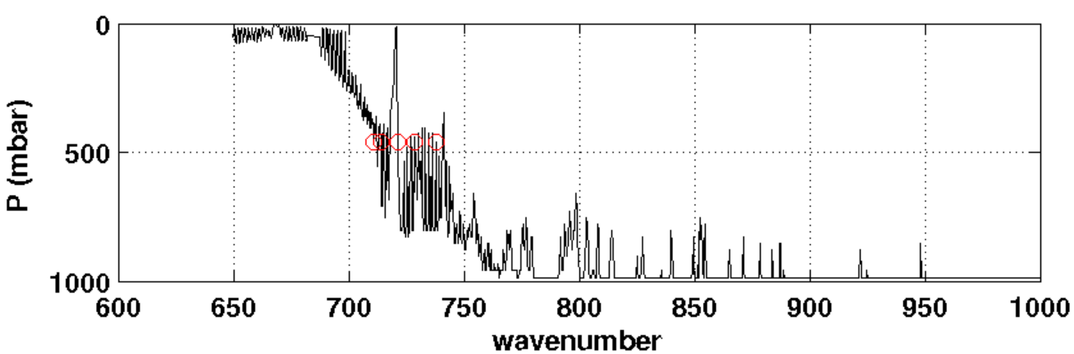


441.9
P (mbar)
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

459.7 mbar



200
220
240
260
280
300
320
T_b (K)



0
500
1000
P (mbar)
600
650
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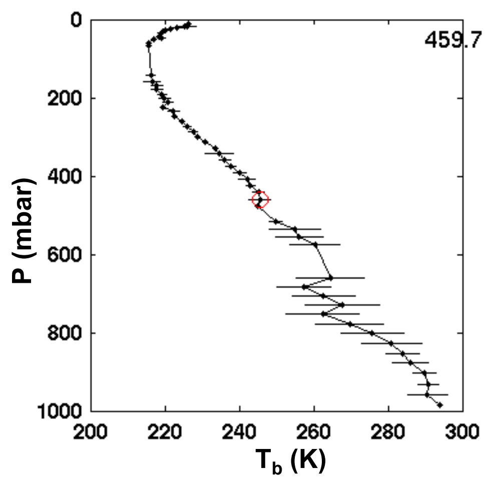
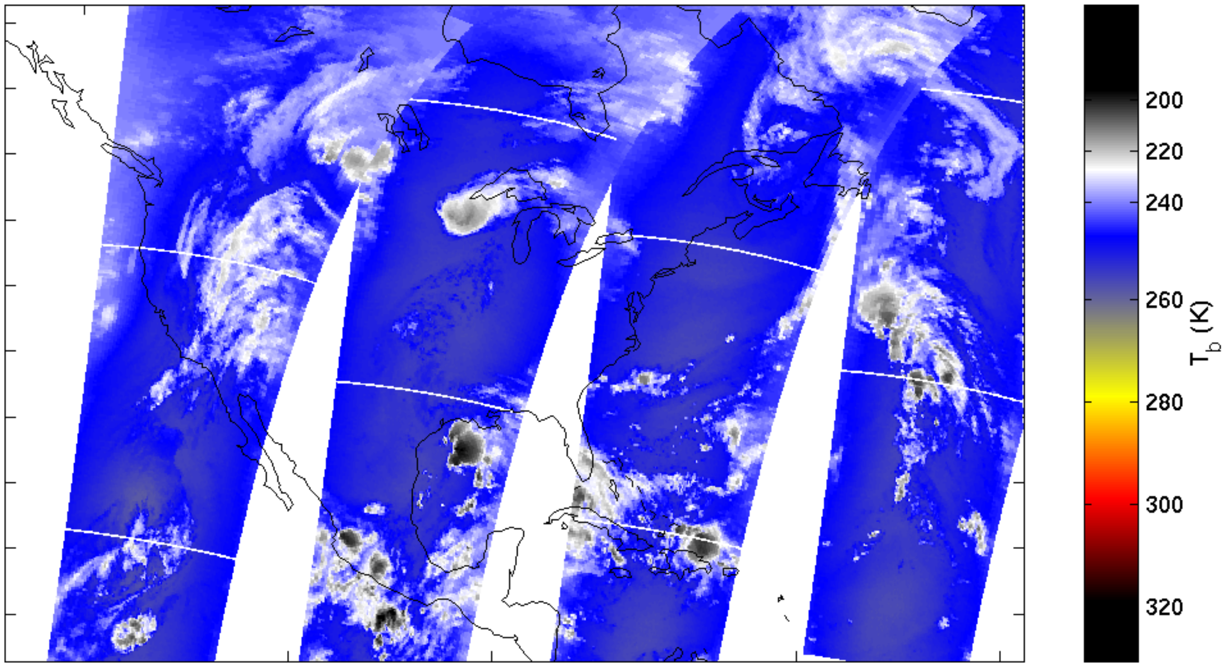
750
800
850
900
950
1000
wavenumber

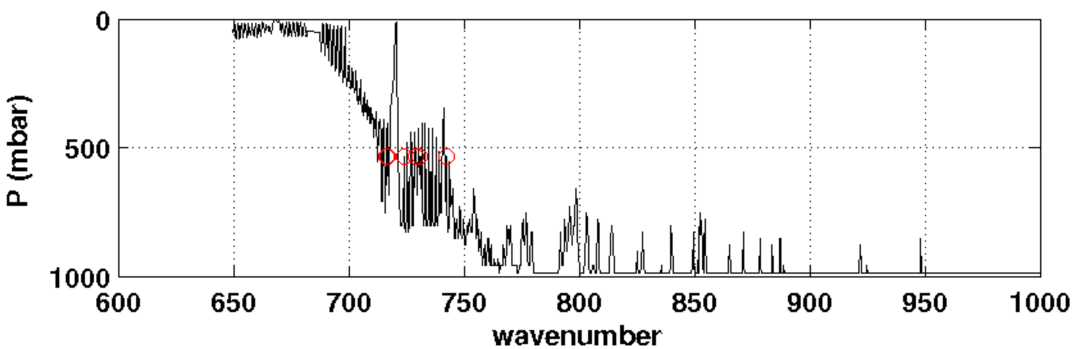


459.7
0
200
400
600
800
1000
P (mbar)
200
220
240
260
280
300
T_b (K)

535.2 mbar



200
220
240
260
280
300
320
T_b (K)



P (mbar)
0
500
1000
600
650
700
750
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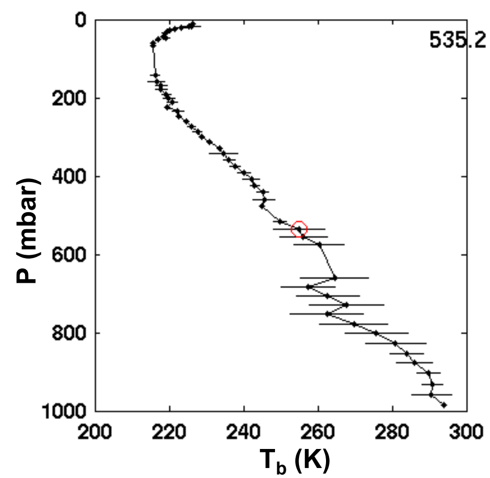
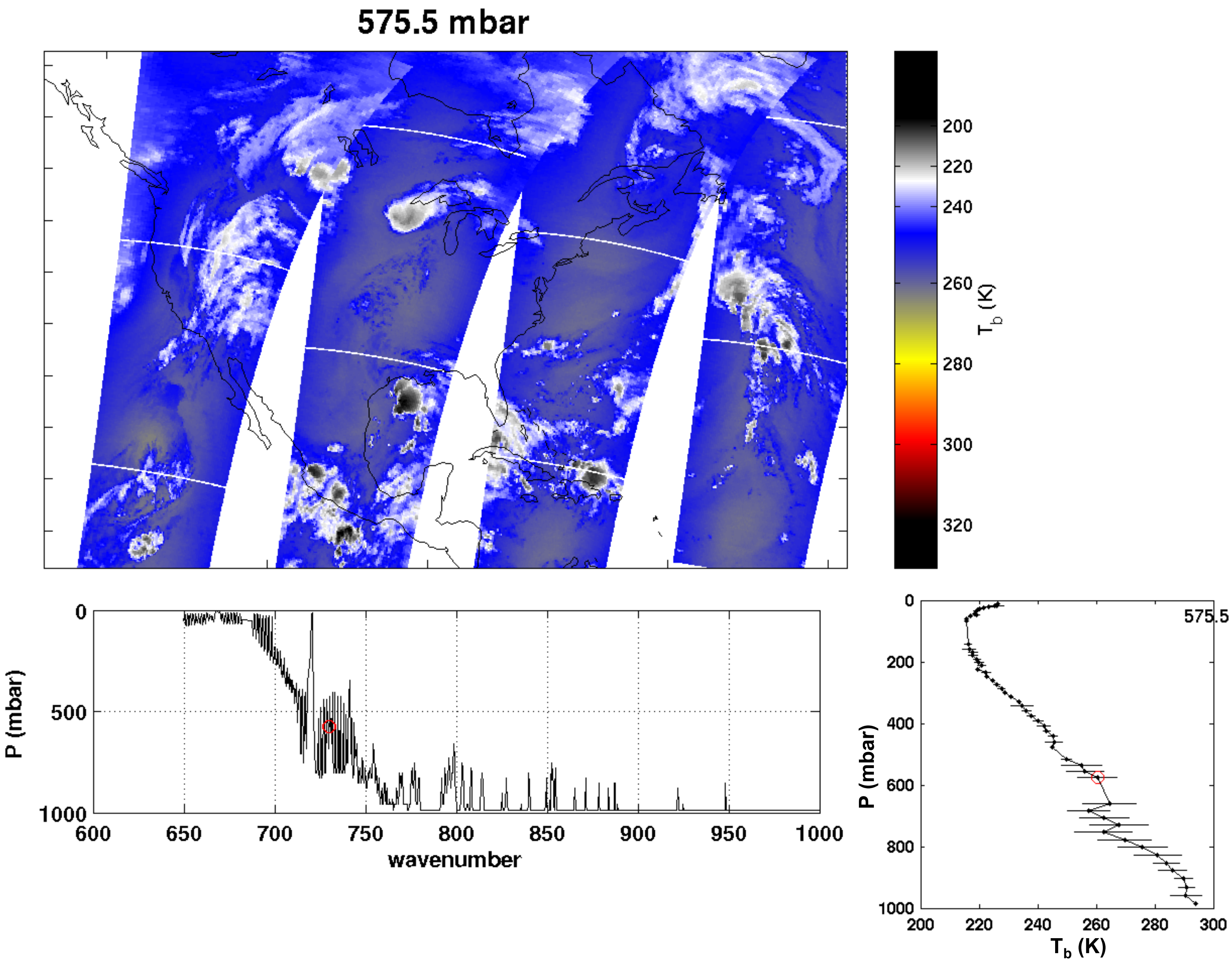
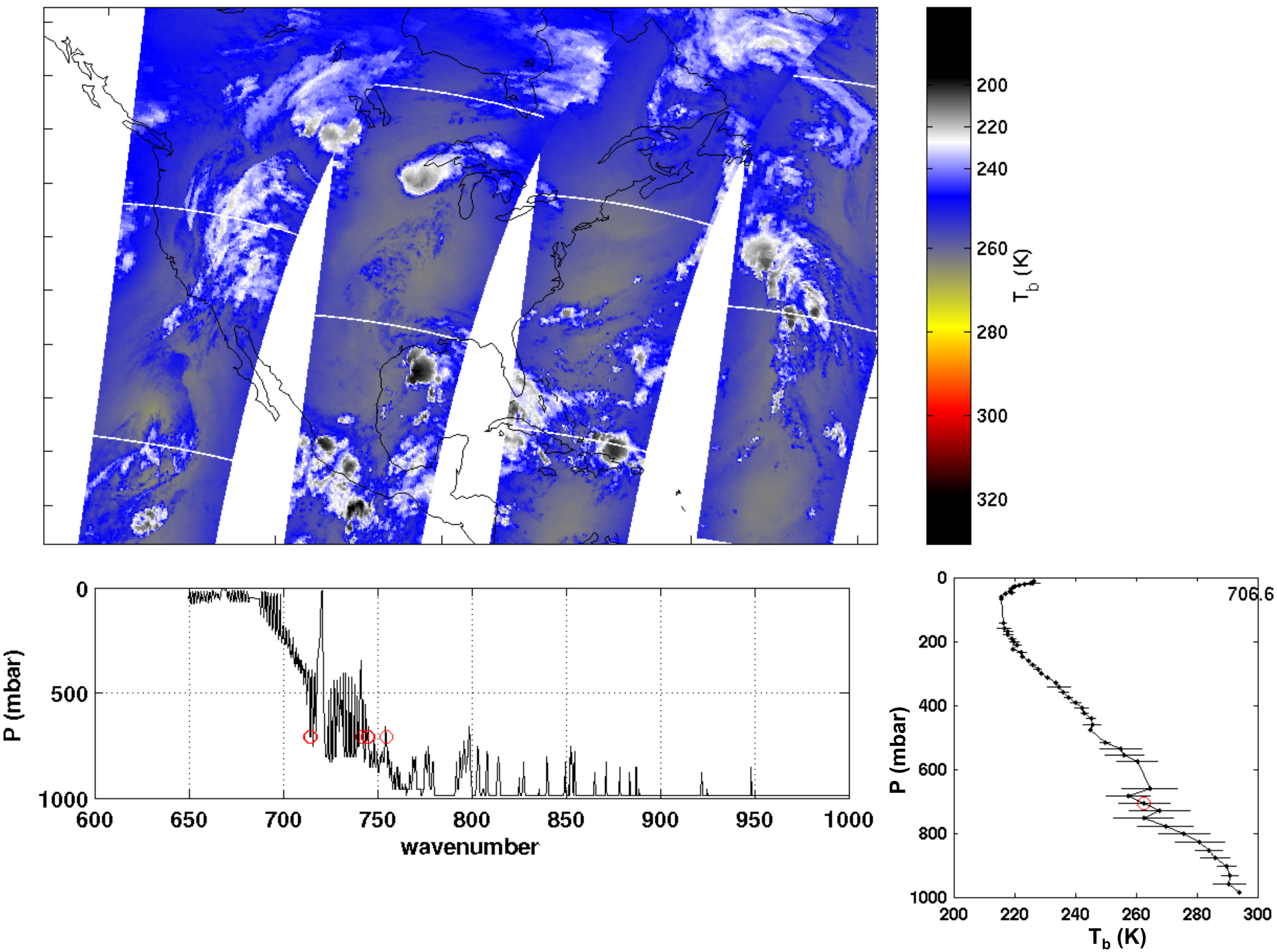
850
900
950
1000
wavenumber



535.2
P (mbar)
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)


575.5 mbar
200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
575.5
P (mbar)
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

706.6 mbar



200
220
240
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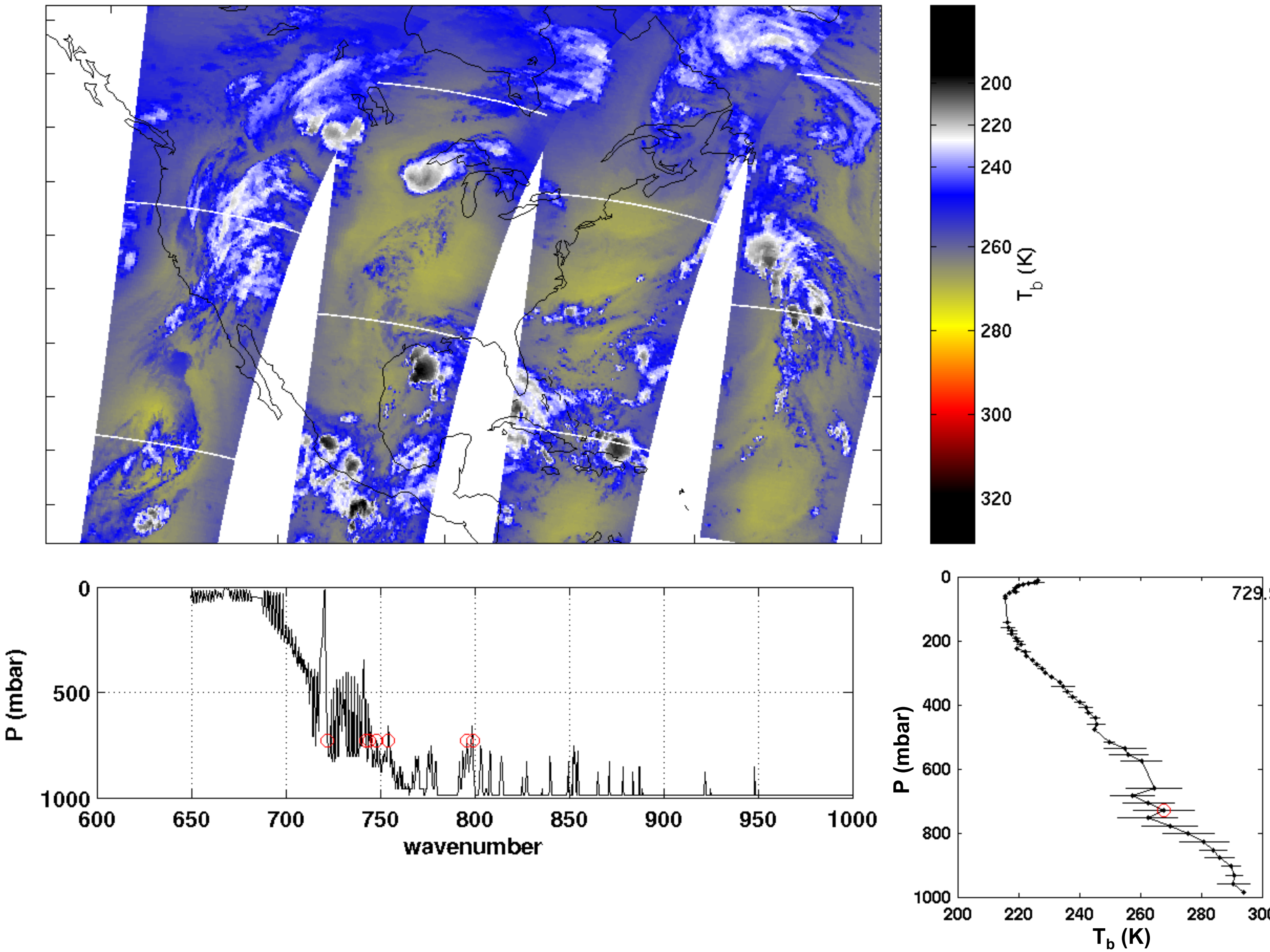
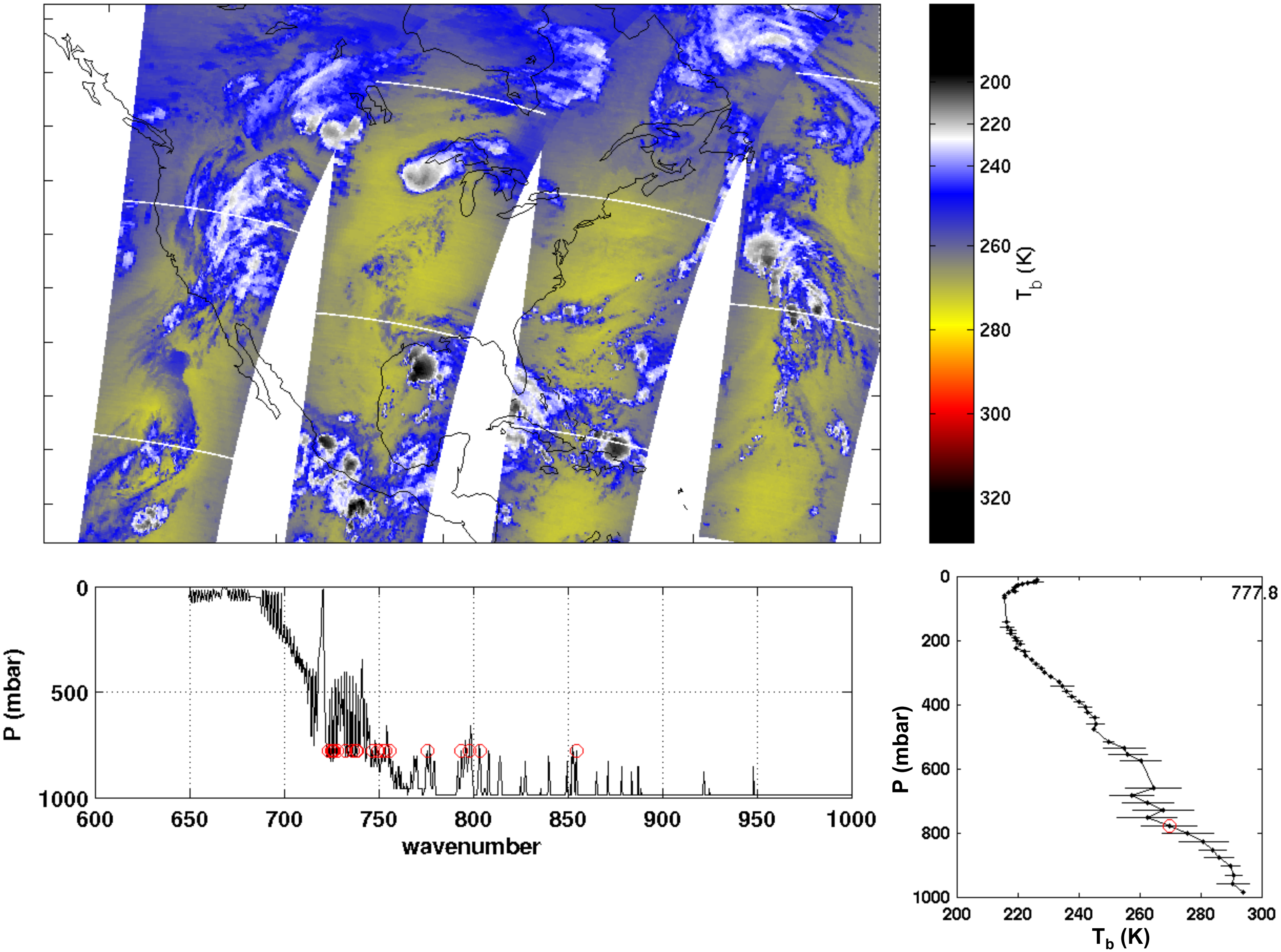
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
706.6
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

729.9 mbar



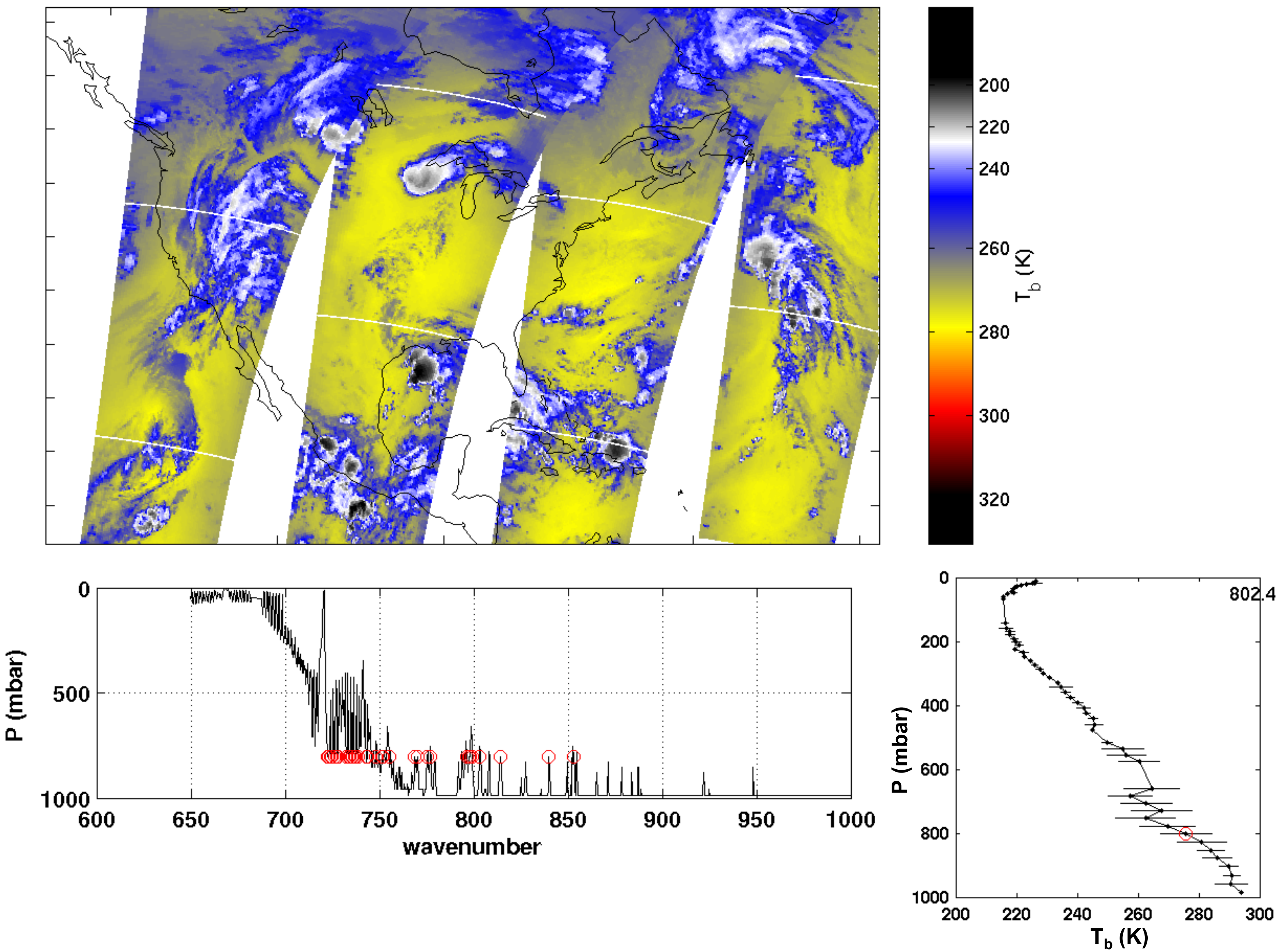
200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
729.9
0
200
400
600
800
1000
200
220
240
260
280
300
P (mbar)
T_b (K)

777.8 mbar

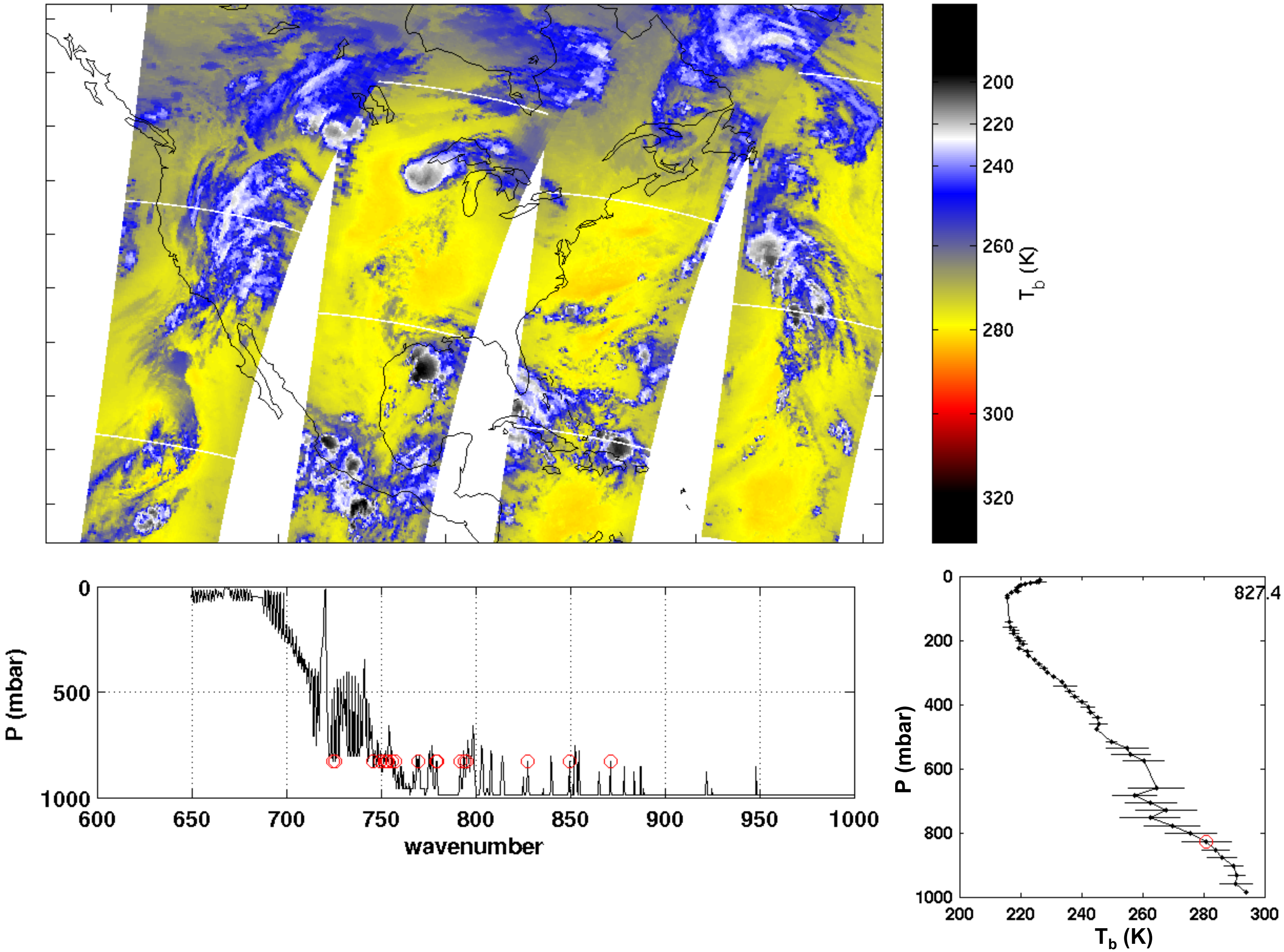


200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
777.8
200
400
600
800
1000
220
240
260
280
300
T_b (K)

802.4 mbar

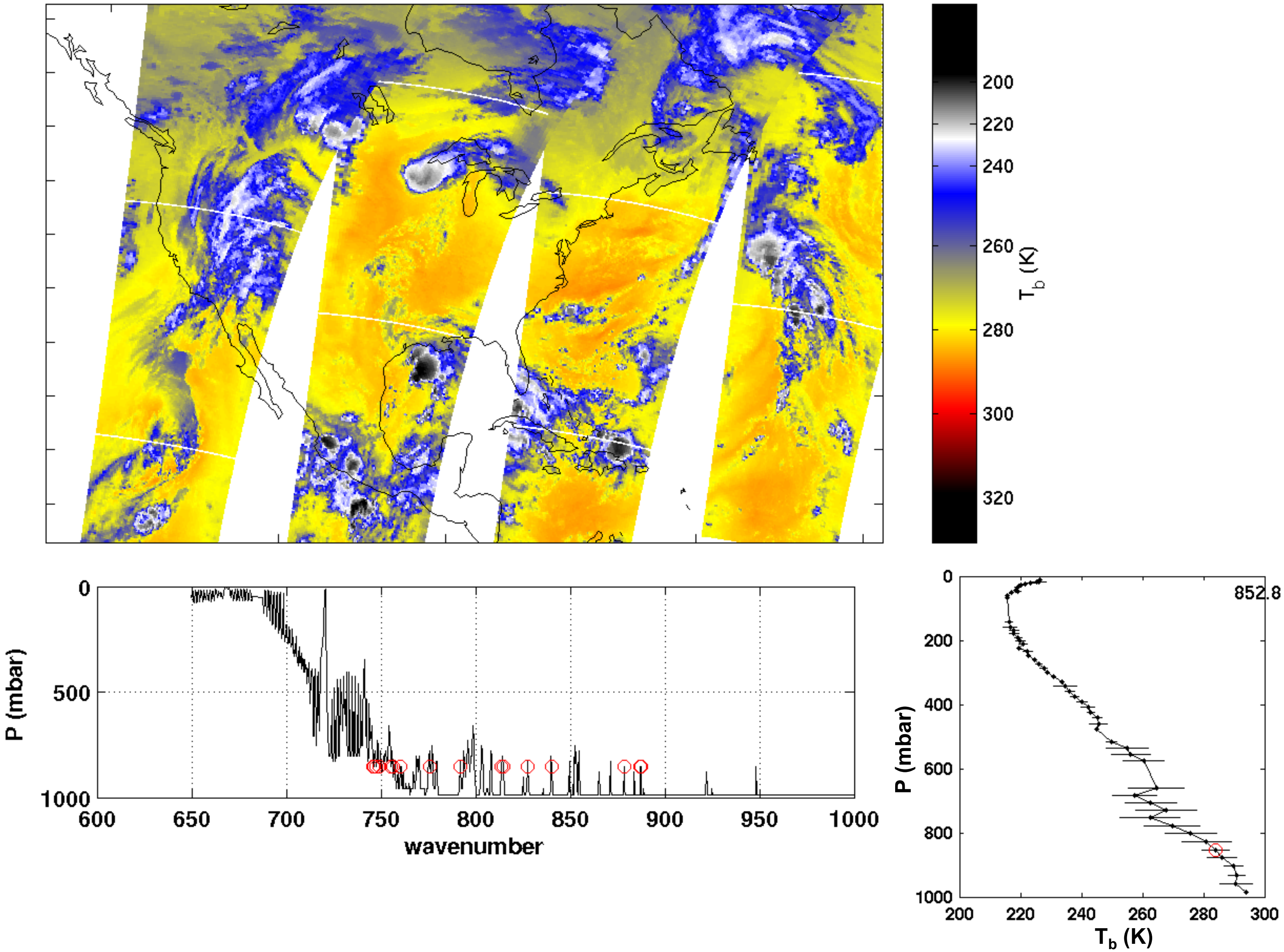

200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
802.4
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

827.4 mbar



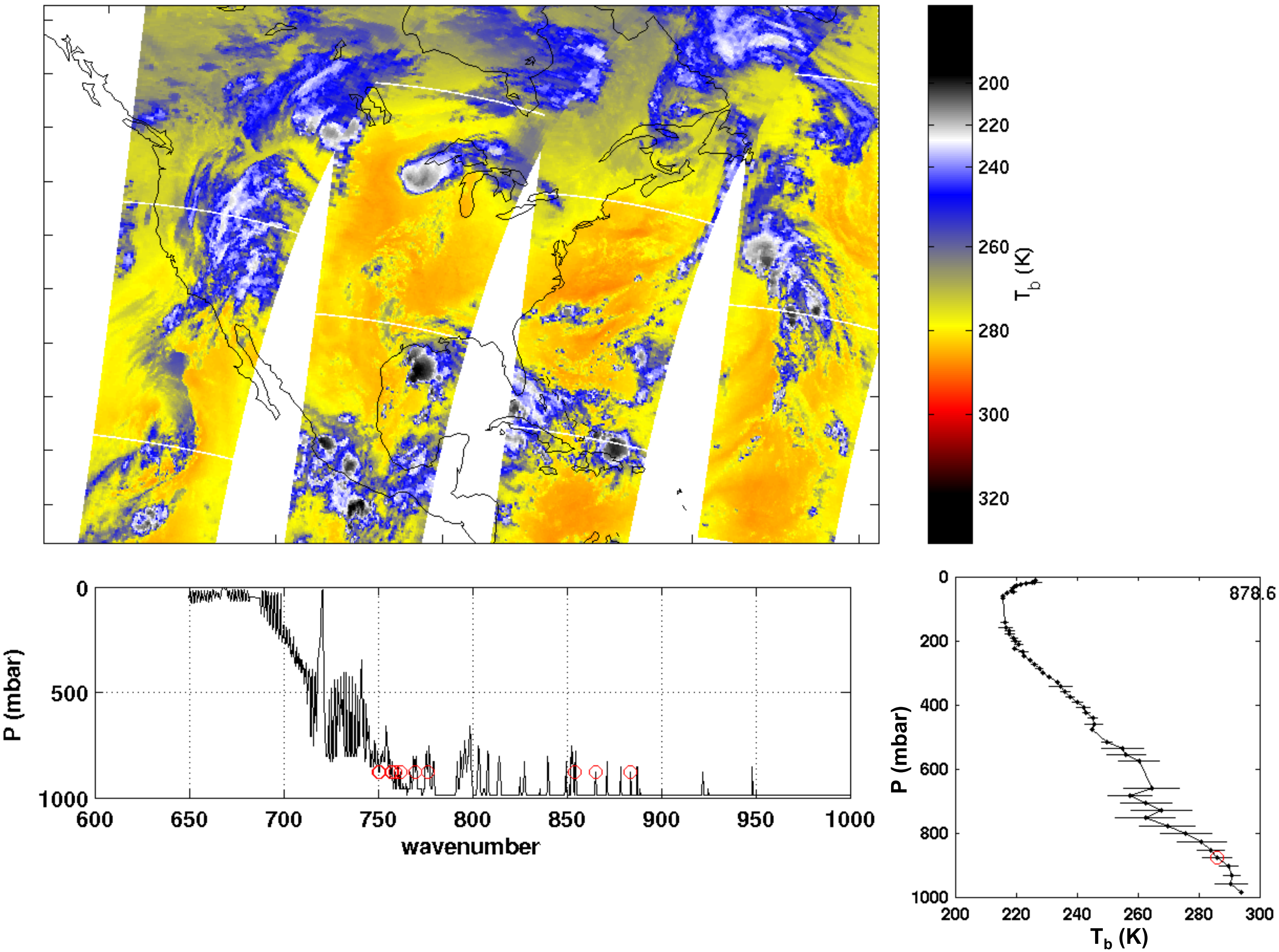
200
220
240
260
280
300
320
T_b (K)
P (mbar)
wavenumber
0
500
1000
600
650
700
750
800
850
900
950
1000
827.4
P (mbar)
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

852.8 mbar



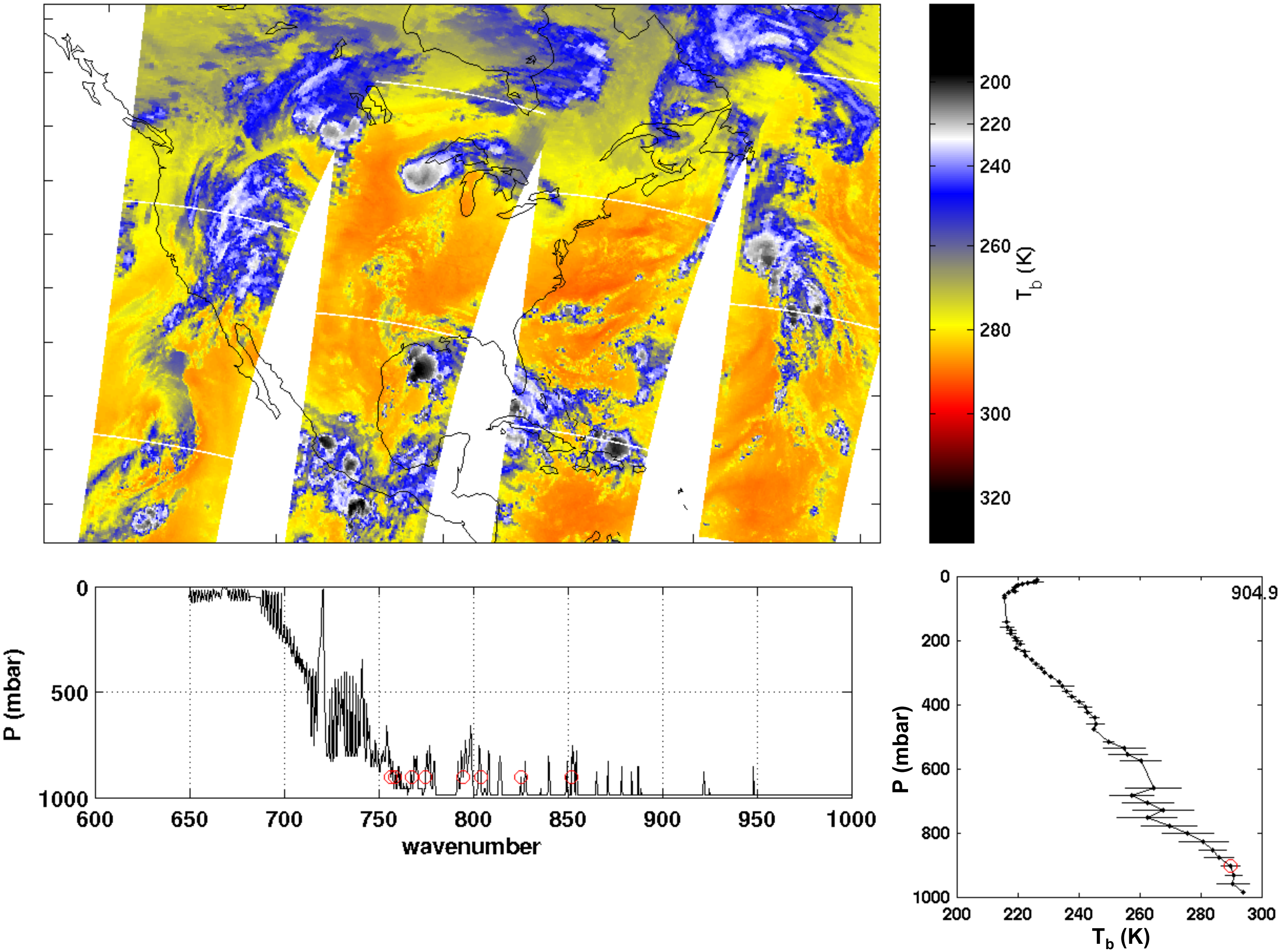
200
220
240
260
280
300
320
T_b (K)
0
500
1000
P (mbar)
600
650
700
750
800
850
900
950
1000
wavenumber
852.8
0
200
400
600
800
1000
P (mbar)
200
220
240
260
280
300
T_b (K)

878.6 mbar



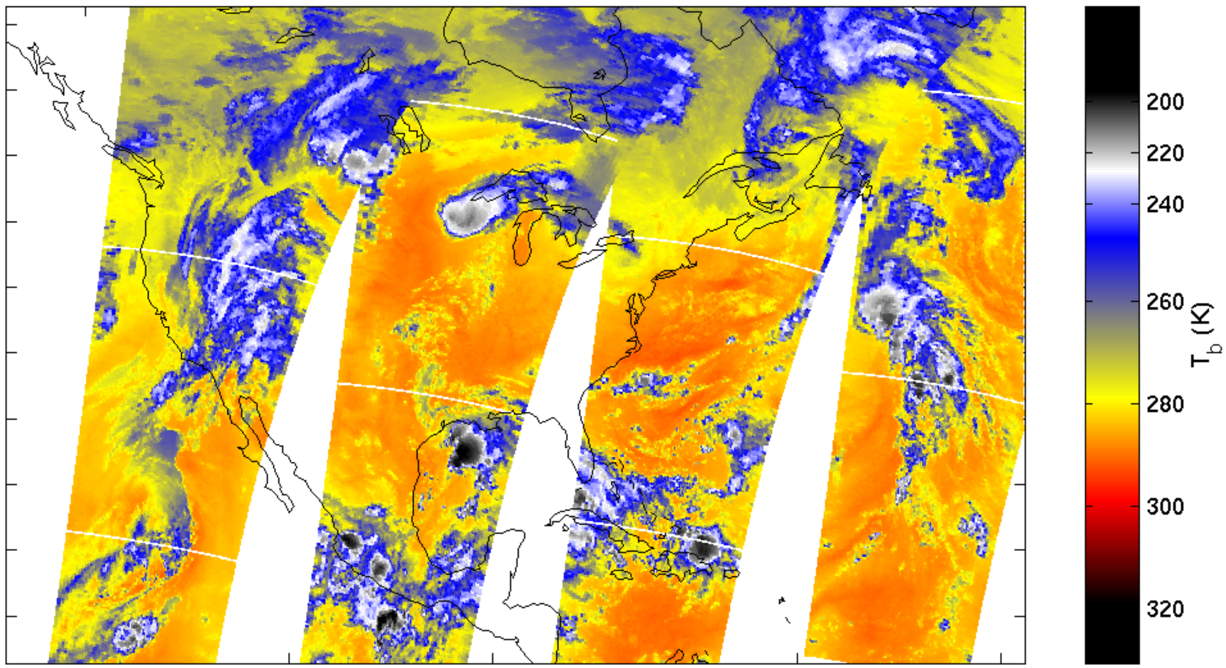
200
220
240
260
280
300
320
T_b (K)
0
500
1000
P (mbar)
600
650
700
750
800
850
900
950
1000
wavenumber
878.6
0
200
400
600
800
1000
P (mbar)
200
220
240
260
280
300
T_b (K)

904.9 mbar

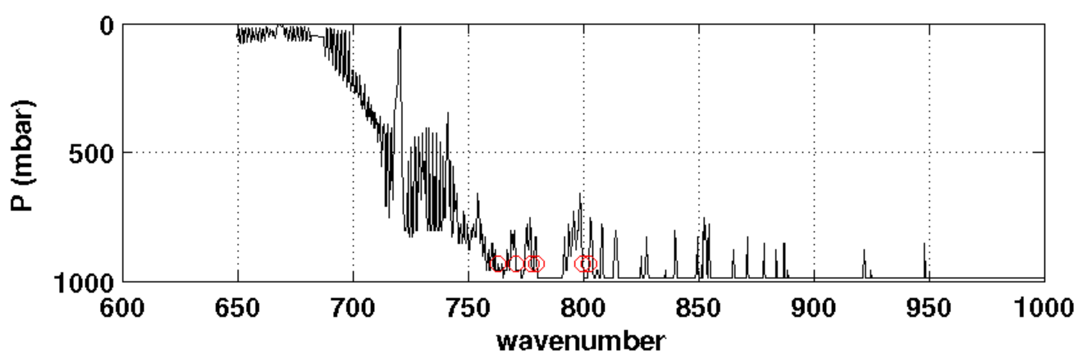


200
220
240
260
280
300
320
T_b (K)
0
500
1000
P (mbar)
600
650
700
750
800
850
900
950
1000
wavenumber
904.9
0
200
400
600
800
1000
P (mbar)
200
220
240
260
280
300
T_b (K)

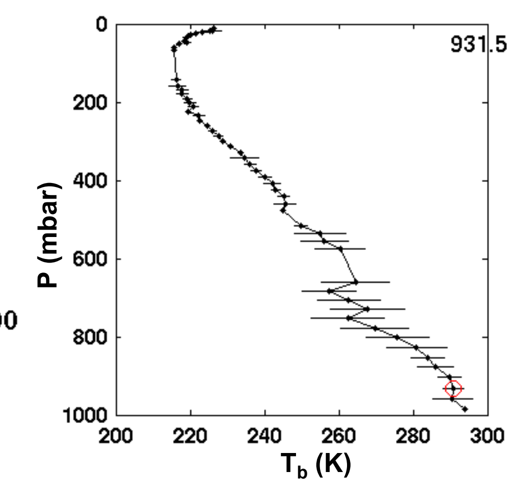
931.5 mbar



200
220
240
260
280
300
320
T_b (K)

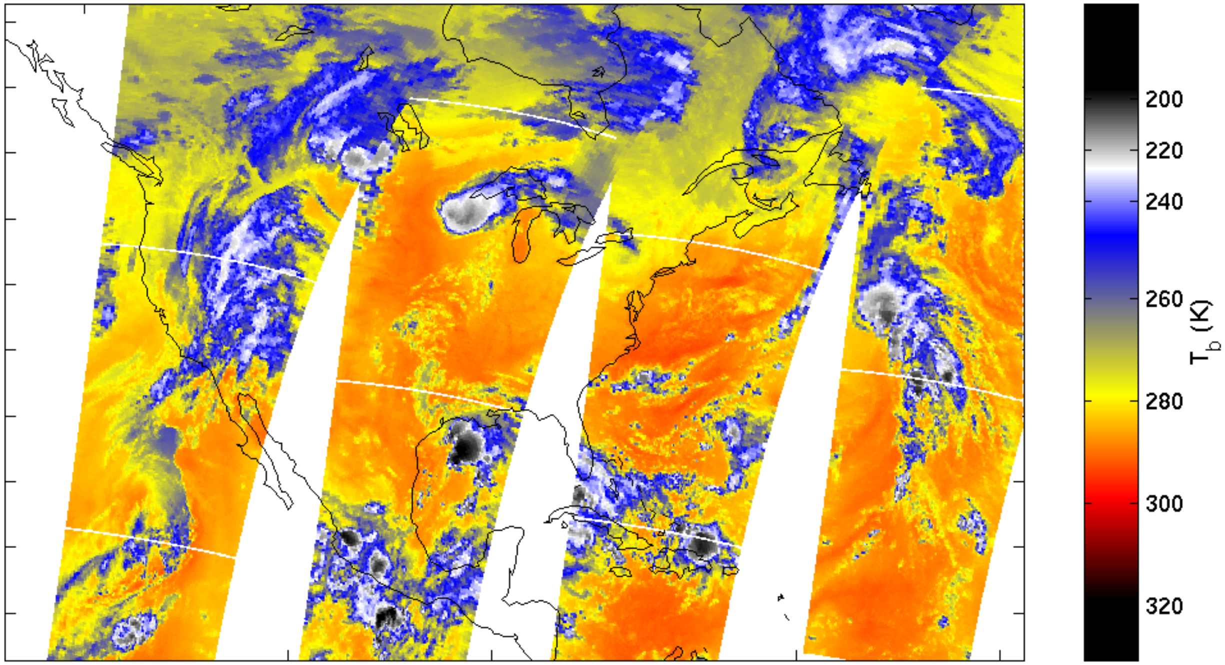


P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber

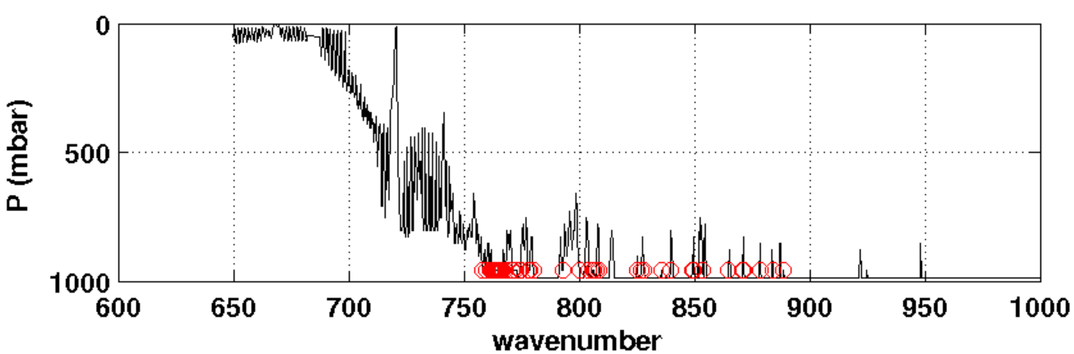


931.5
P (mbar)
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

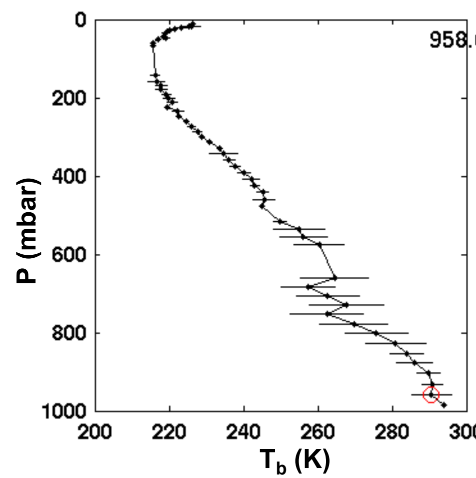
958.6 mbar



200
220
240
260
280
300
320
T_b (K)

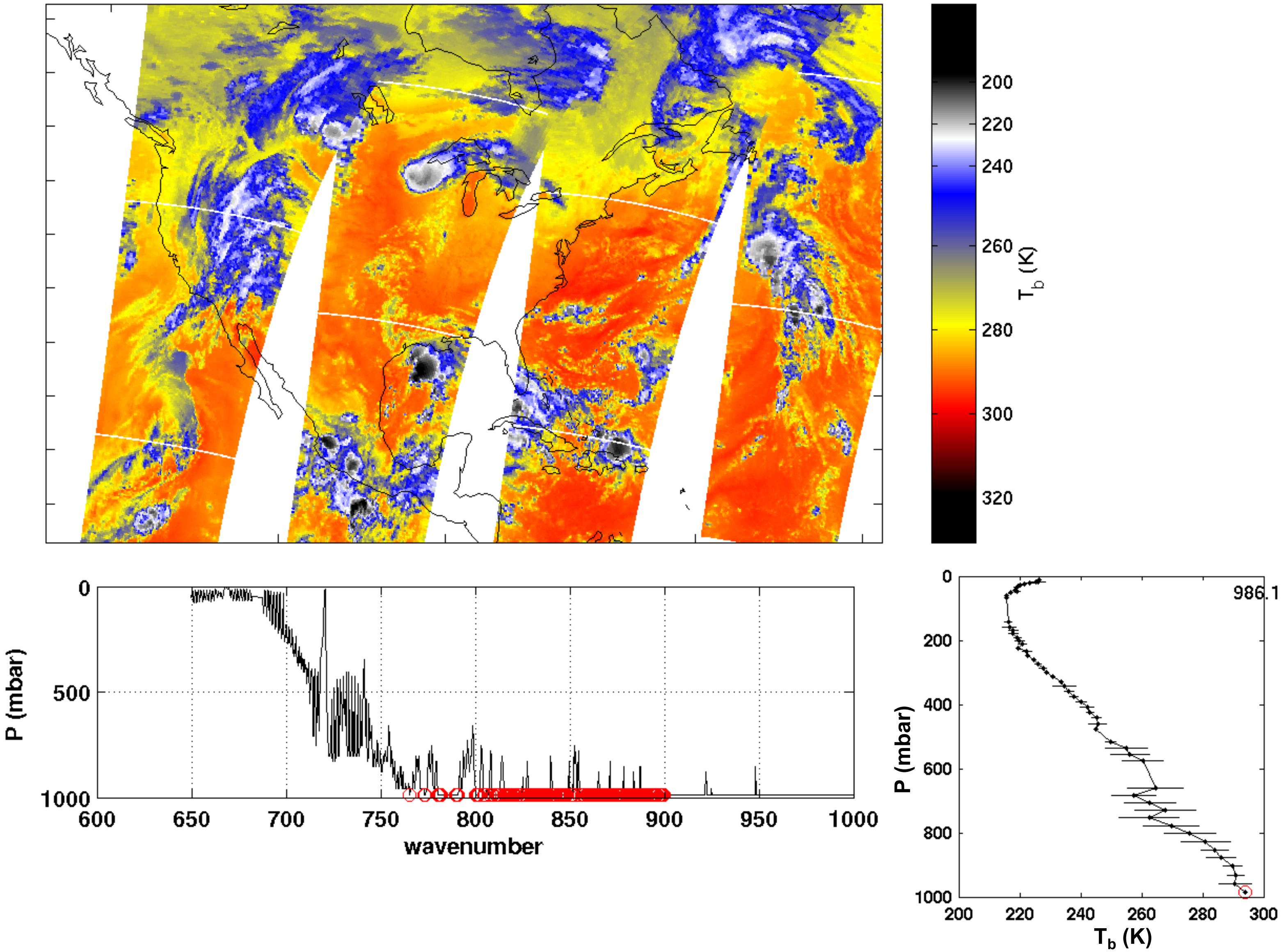


0
500
1000
P (mbar)
600
650
700
750
800
850
900
950
1000
wavenumber



958.6
0
200
400
600
800
1000
P (mbar)
200
220
240
260
280
300
T_b (K)

986.1 mbar



200
220
240
260
280
300
320
T_b (K)
P (mbar)
0
500
1000
600
650
700
750
800
850
900
950
1000
wavenumber
986.1
0
200
400
600
800
1000
200
220
240
260
280
300
T_b (K)

AIRS Level 2 Products are being processed at the GSFC DAAC and now available to the public! There are three data access sites available:

1. EOS Data Gateway http://redhook.gsfc.nasa.gov/~imswww/pub/imswelcome/

2. NASA GSFC Data Pool (cache archive)

http://daac.gsfc.nasa.gov/data/datapool/AIRS_DP/01_Data_Products/index.html

3. NASA GSFC Web-based Data Order Mechanism (WHOM)

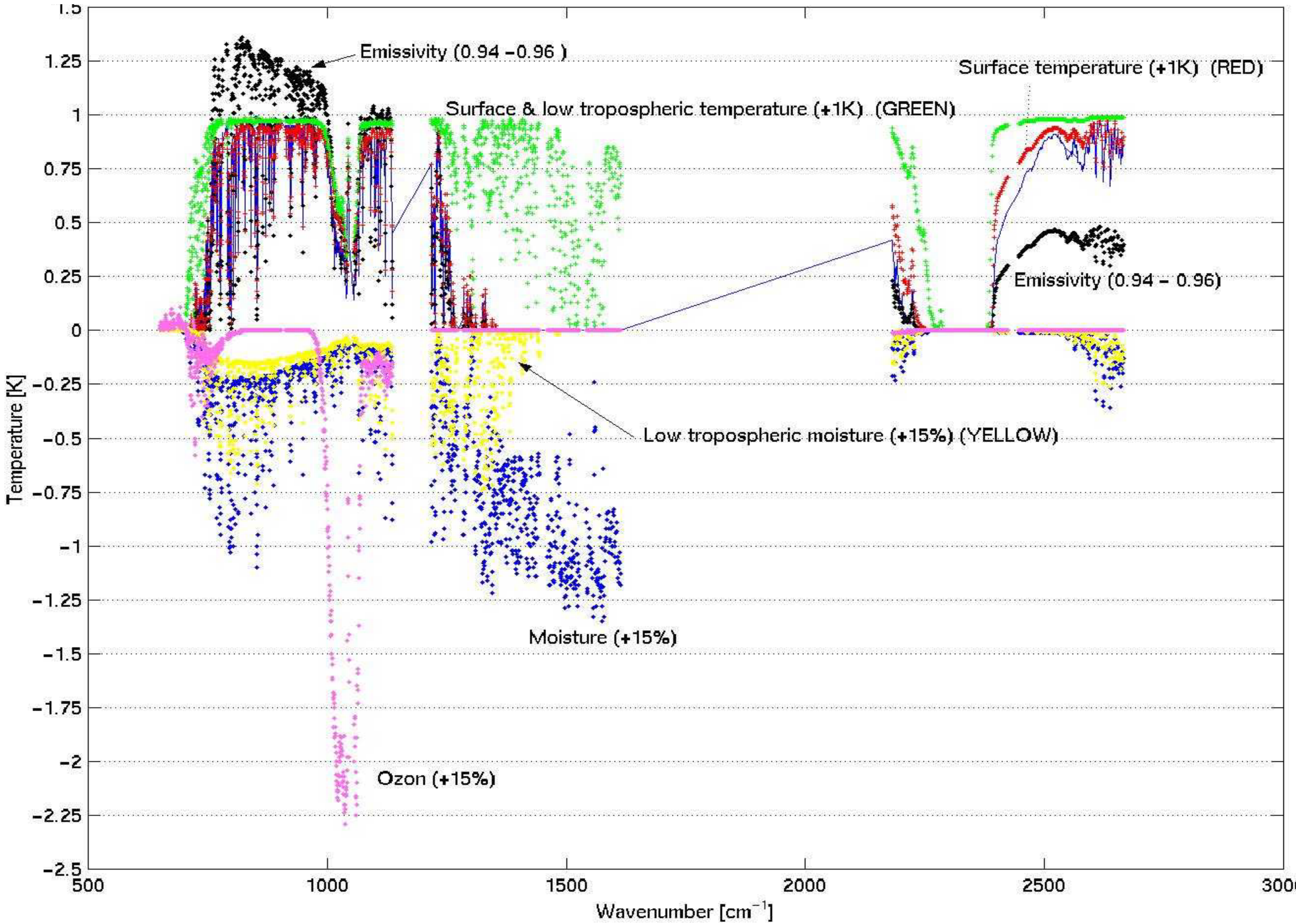
http://daac.gsfc.nasa.gov/data/dataset/AIRS/01_Data_Products/

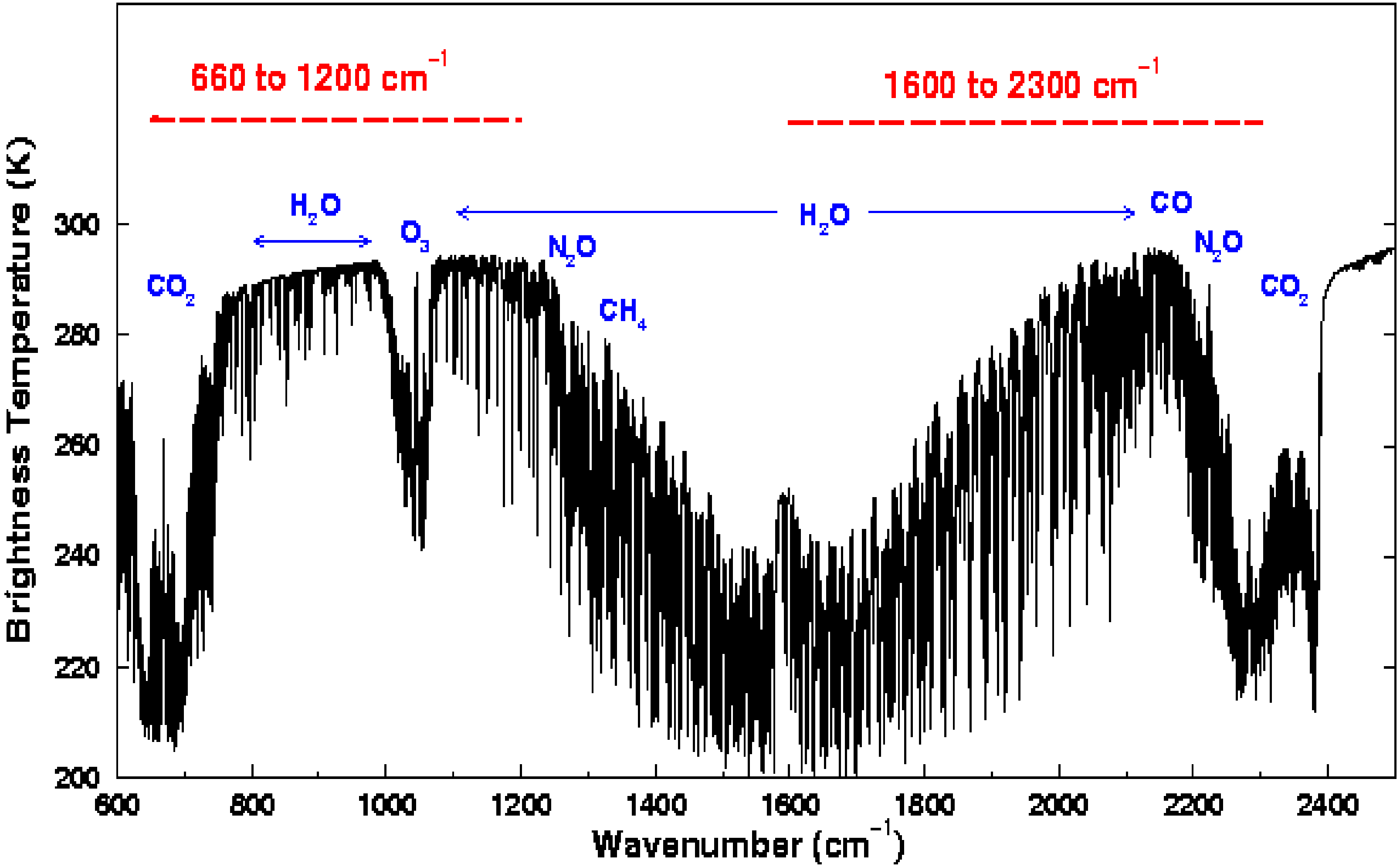
At this time, there is nearly complete Level 2 data coverage from August 24th, forward. Additional days in August 2003 as well as January 2003 are also available. The DAAC plans to start reprocessing all AIRS data beginning with August 31, 2002. As the DAAC produces these products, they will be made available at all three sites.

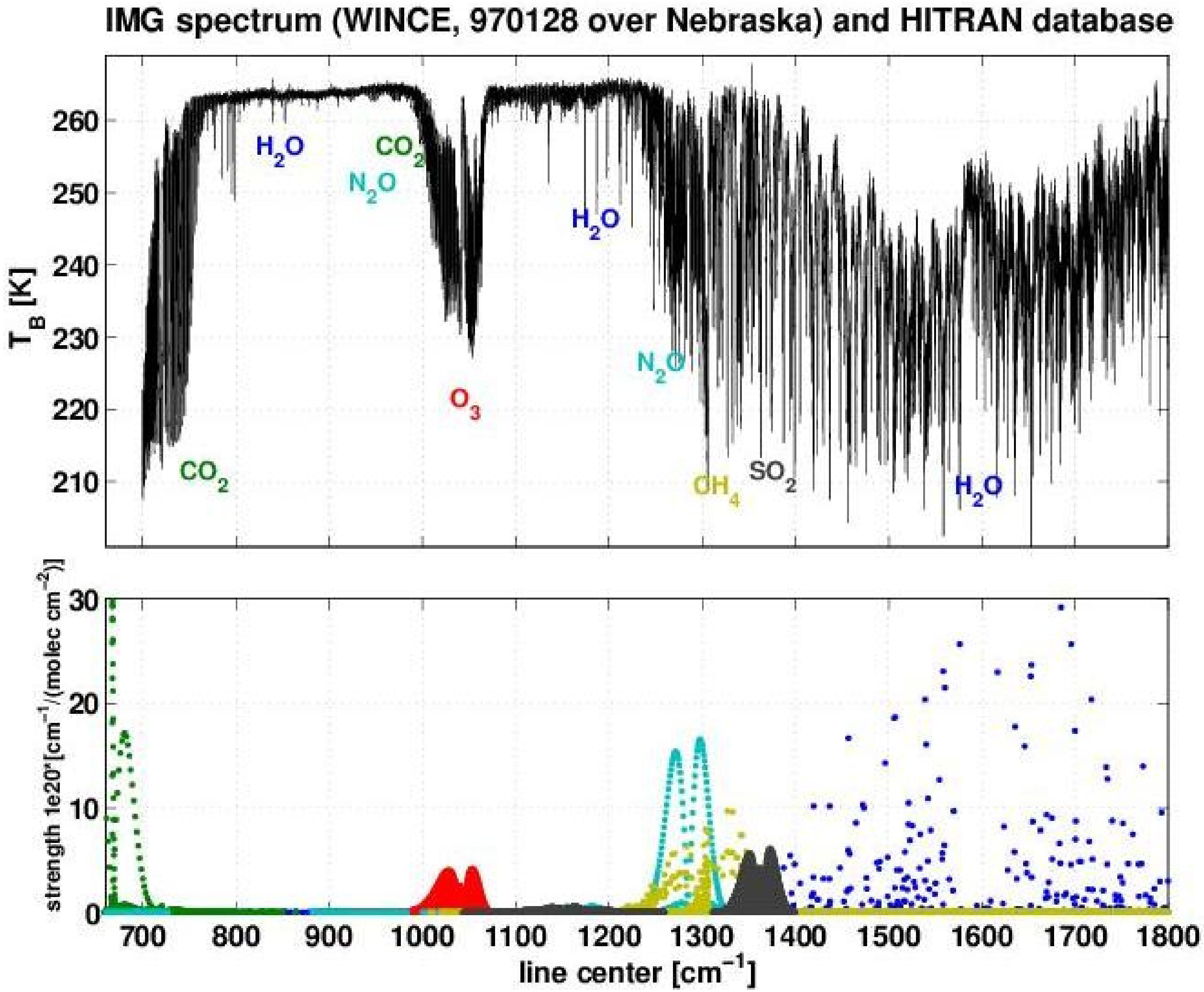
For more information and access to supporting documentation, please see AIRS Data Support web page at the GSFC DAAC:http://daac.gsfc.nasa.gov/atmodyn/airs/

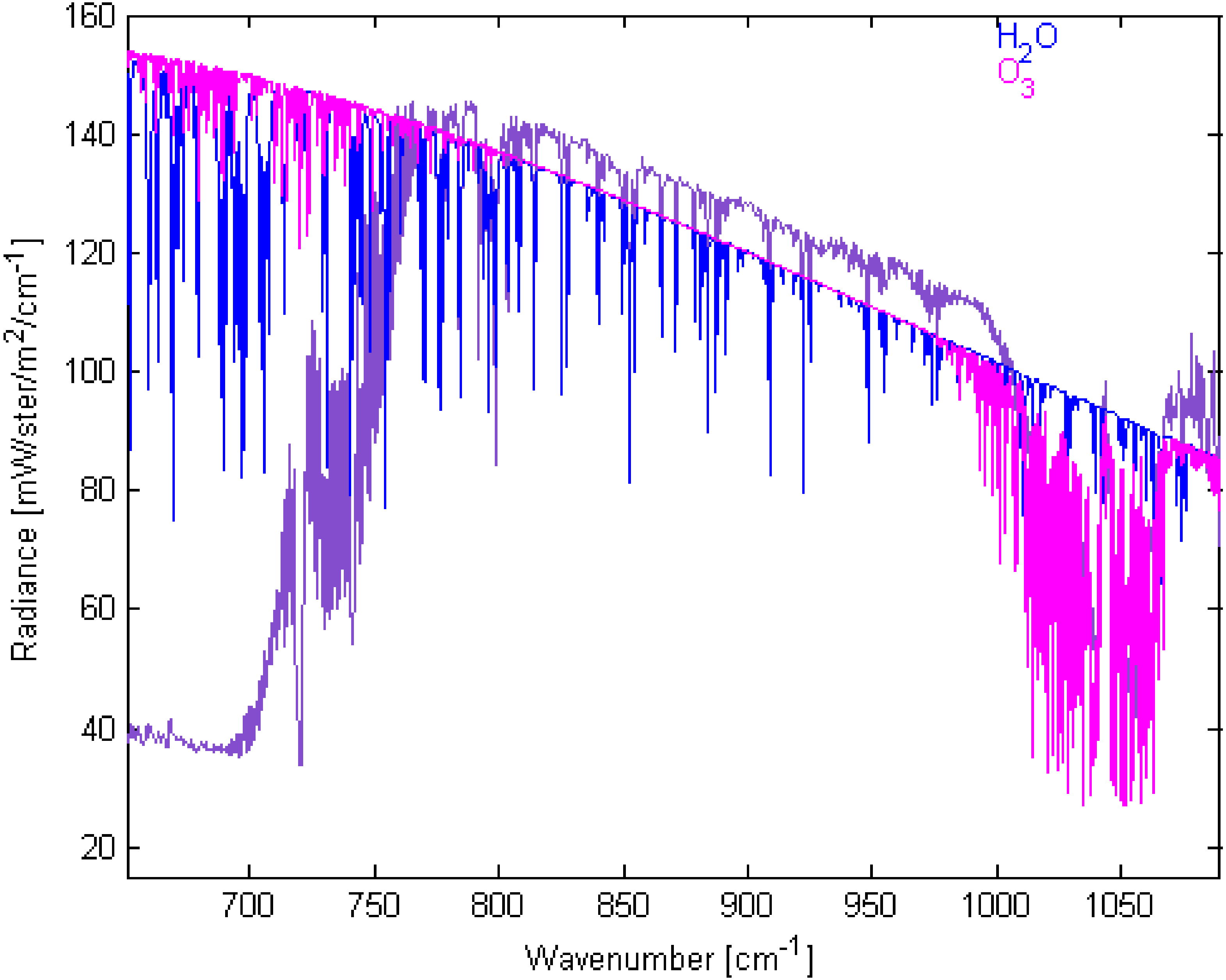
The AIRS Project appreciates the efforts of the entire AIRS software development and science teams. Without your efforts, this important milestone could not have been achieved.

AIRS radiance changes (in deg K) to atm & sfc changes

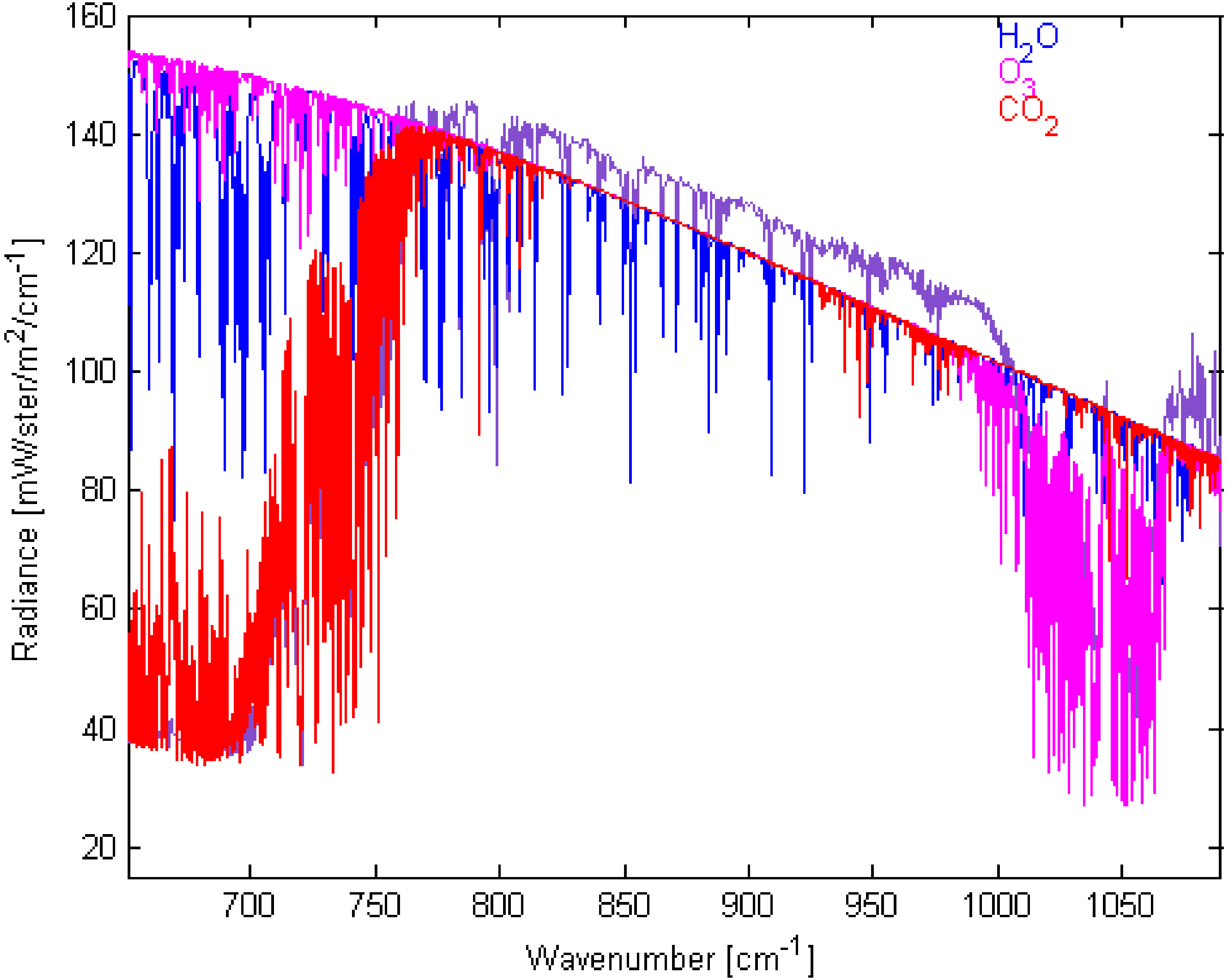



660 to 1200 cm^{-1}
1600 to 2300 cm^{-1}
H_2O
O_3
H_2O
CO
N_2O
N_2O
CO_2
CH_4
CO_2
Brightness Temperature (K)
300
280
260
240
220
200
600
800
1000
1200
1400
1600
1800
2000
2200
2400
Wavenumber (cm^{-1})

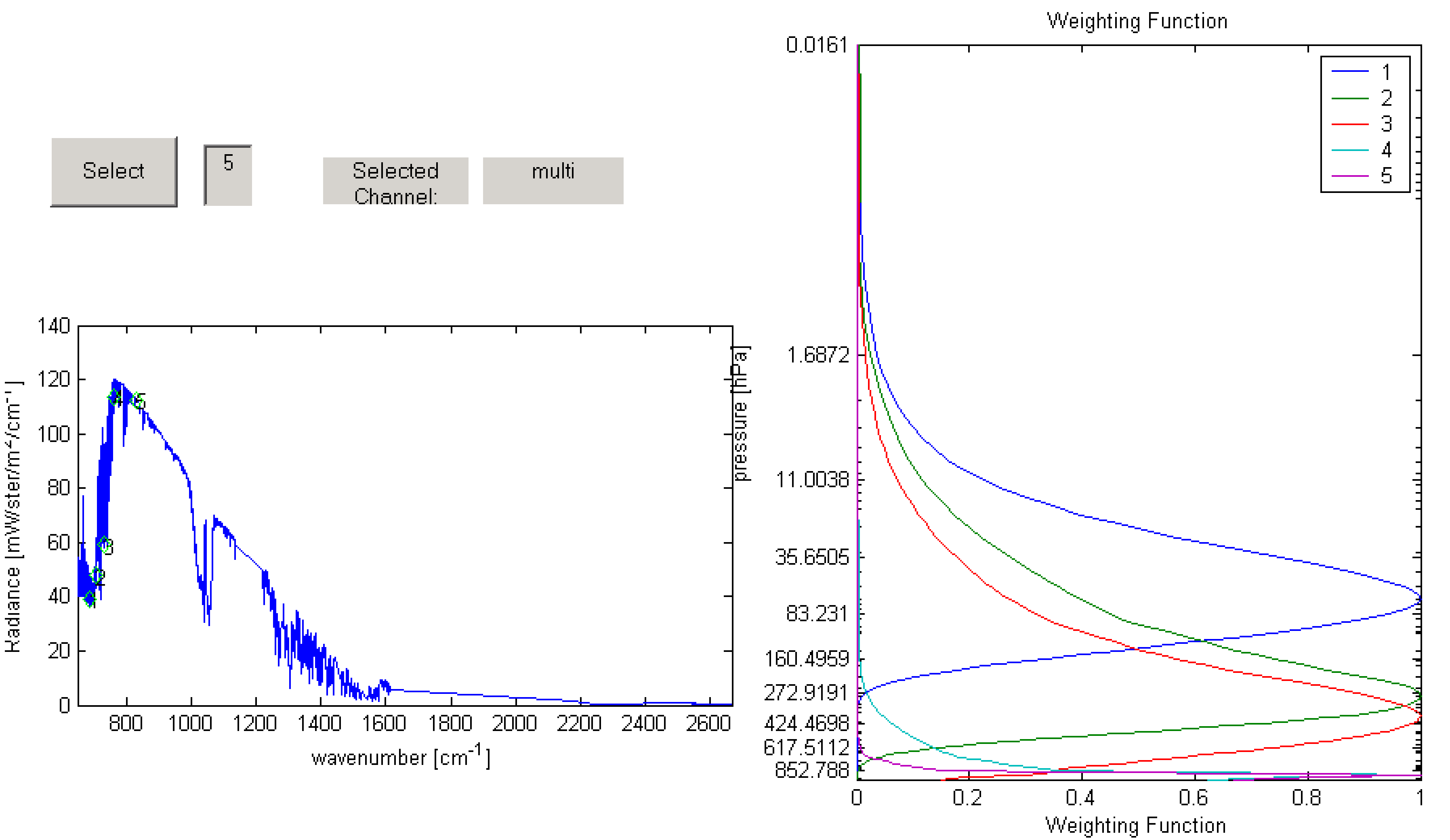

IMG spectrum (WINCE, 970128 over Nebraska) and HITRAN database
T_B [K]
260
250
240
230
220
210
H_2O
CO_2
N_2O
H_2O
N_2O
O_3
CO_2
CH_4
SO_2
H_2O
strength 1e20*[cm^-1/(molec cm^-2)]
30
20
10
0
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
line center [cm^-1]



H2O
O3
160
140
120
100
80
60
40
20
Radiance [mW/ster/m2/cm-1]
700
750
800
850
900
950
1000
1050
Wavenumber [cm-1]

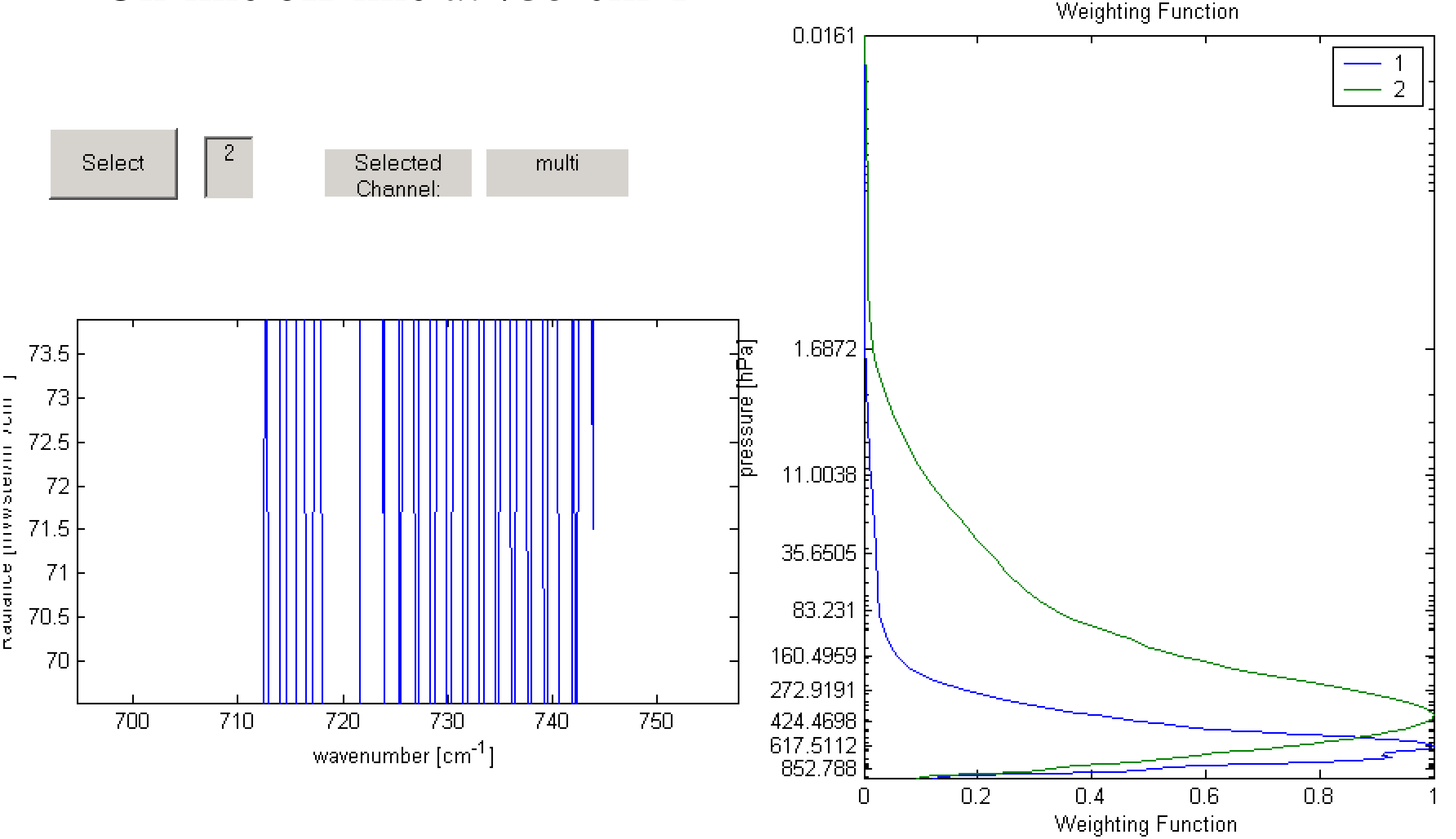


H2O
O3
CO2
160
140
120
100
80
60
40
20
700
750
800
850
900
950
1000
1050
Radiance [mW/ster/m2/cm-1]
Wavenumber [cm-1]

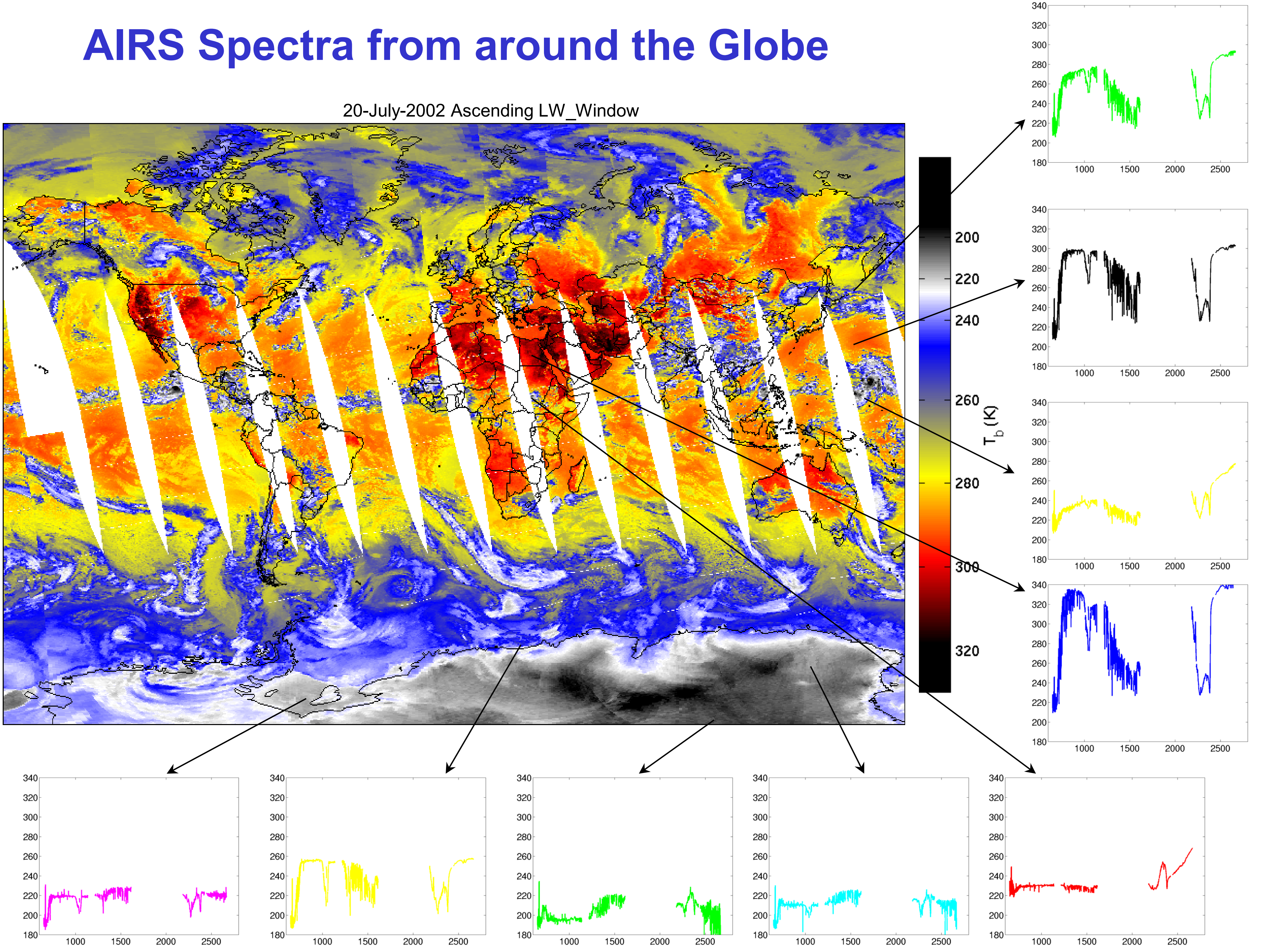


Select
5
Selected Channel:
multi
Radiance [mW/ster/m^2/cm^-1]
140
120
100
80
60
40
20
0
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
wavenumber [cm^-1]
Weighting Function
pressure [hPa]
0.0161
1.6872
11.0038
35.6505
83.231
160.4959
272.9191
424.4698
617.5112
852.788
0
0.2
0.4
0.6
0.8
1
Weighting Function
1
2
3
4
5

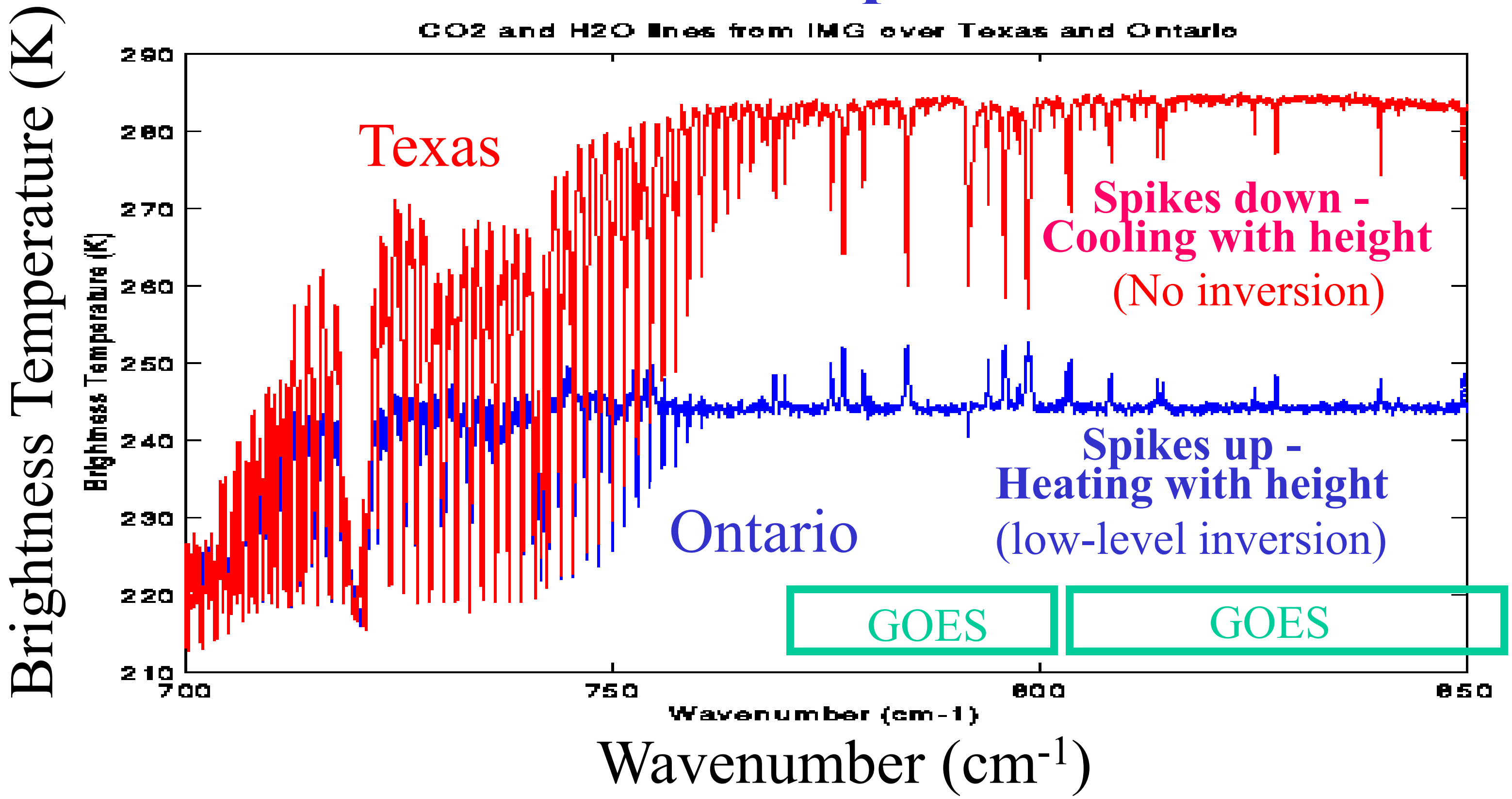
On-line off-line at 735 cm-1



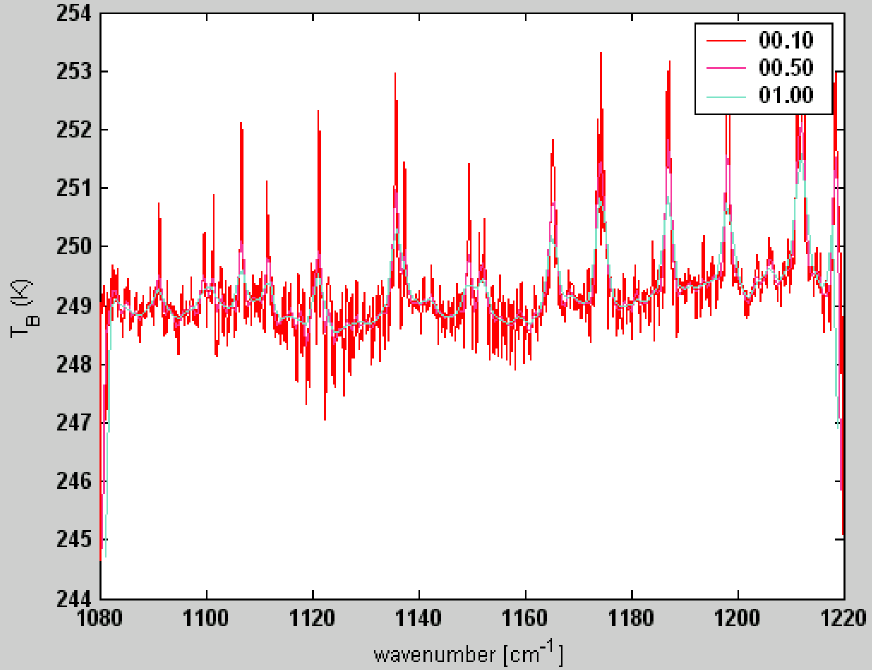
AIRS Spectra from around the Globe

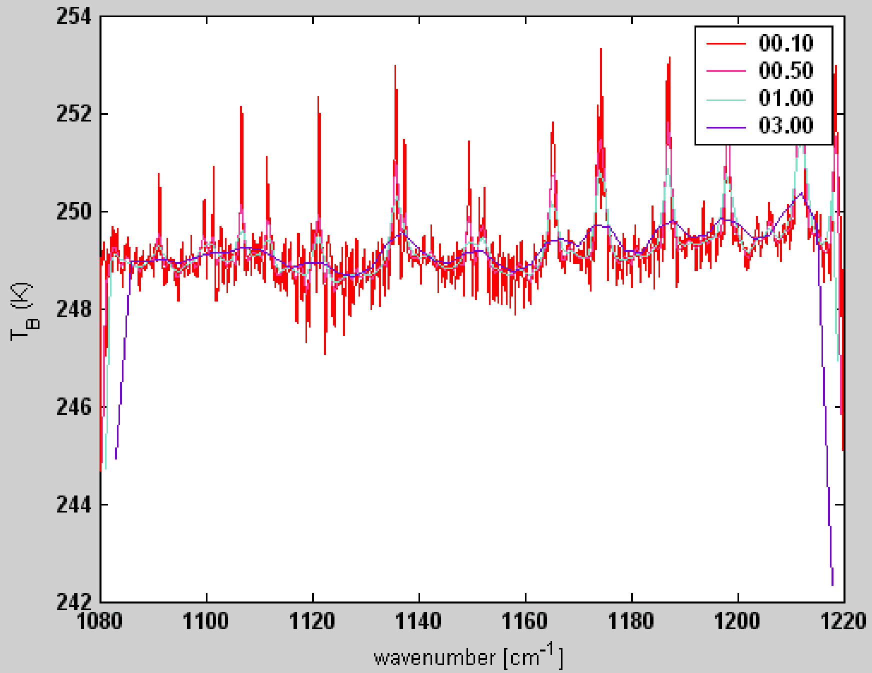


Resolving absorption features in atmospheric windows enables detection of temperature inversions



Detection of inversions is critical for severe weather forecasting. Combined with improved low-level moisture depiction, key ingredients for night-time severe storm development can be monitored.

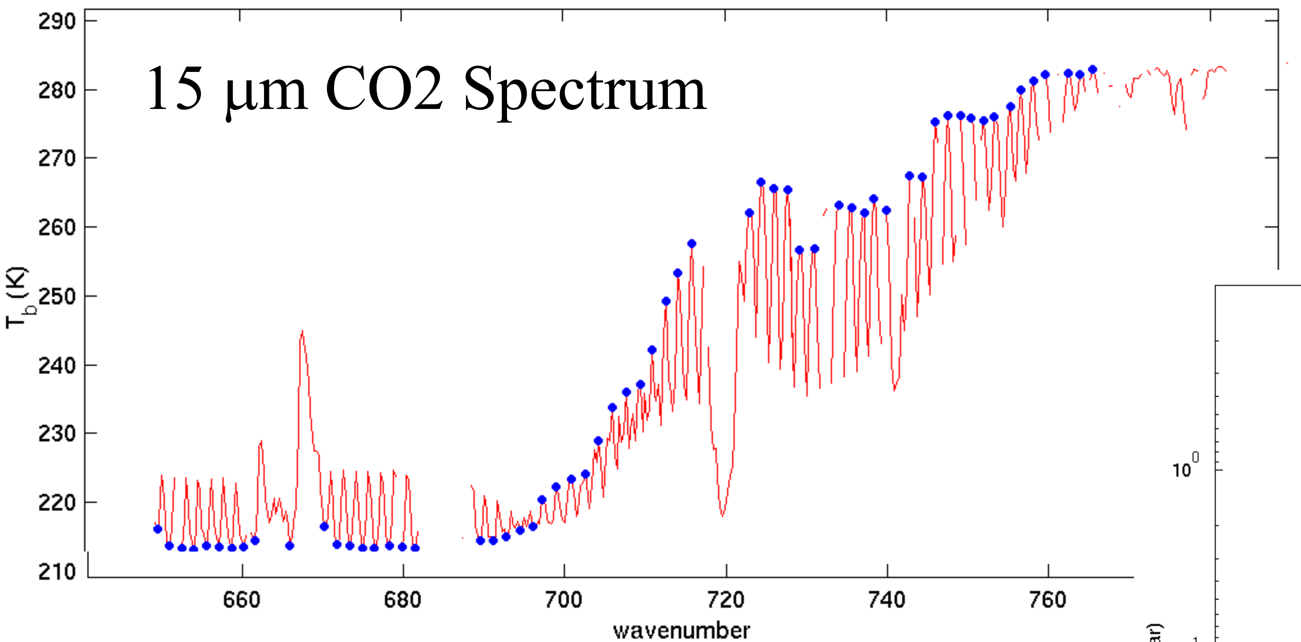


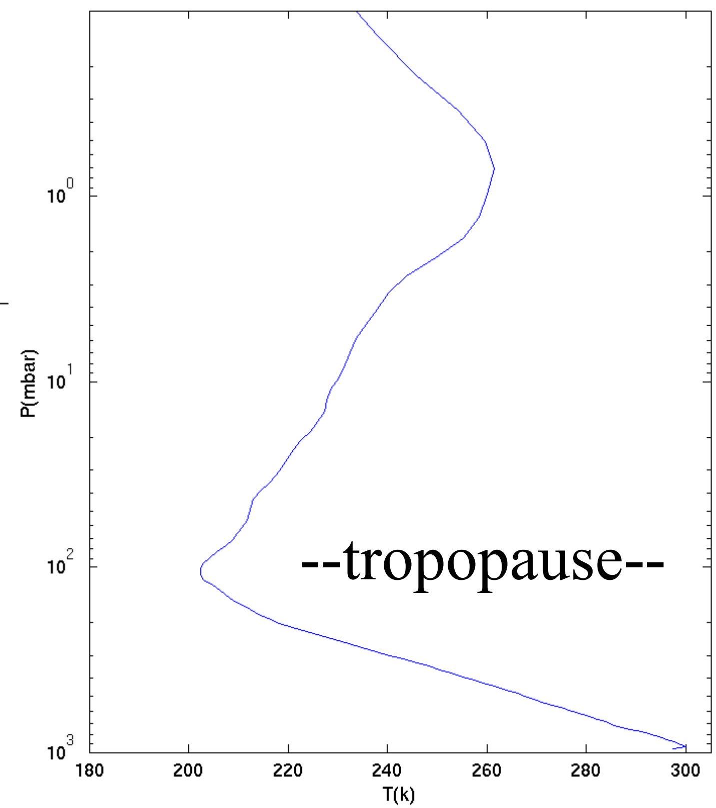


Ability to detect inversions disappears with broadband observations (> 3 cm-1)

Twisted Ribbon formed by CO_2 spectrum:

Tropopause inversion causes On-line & off-line patterns to cross





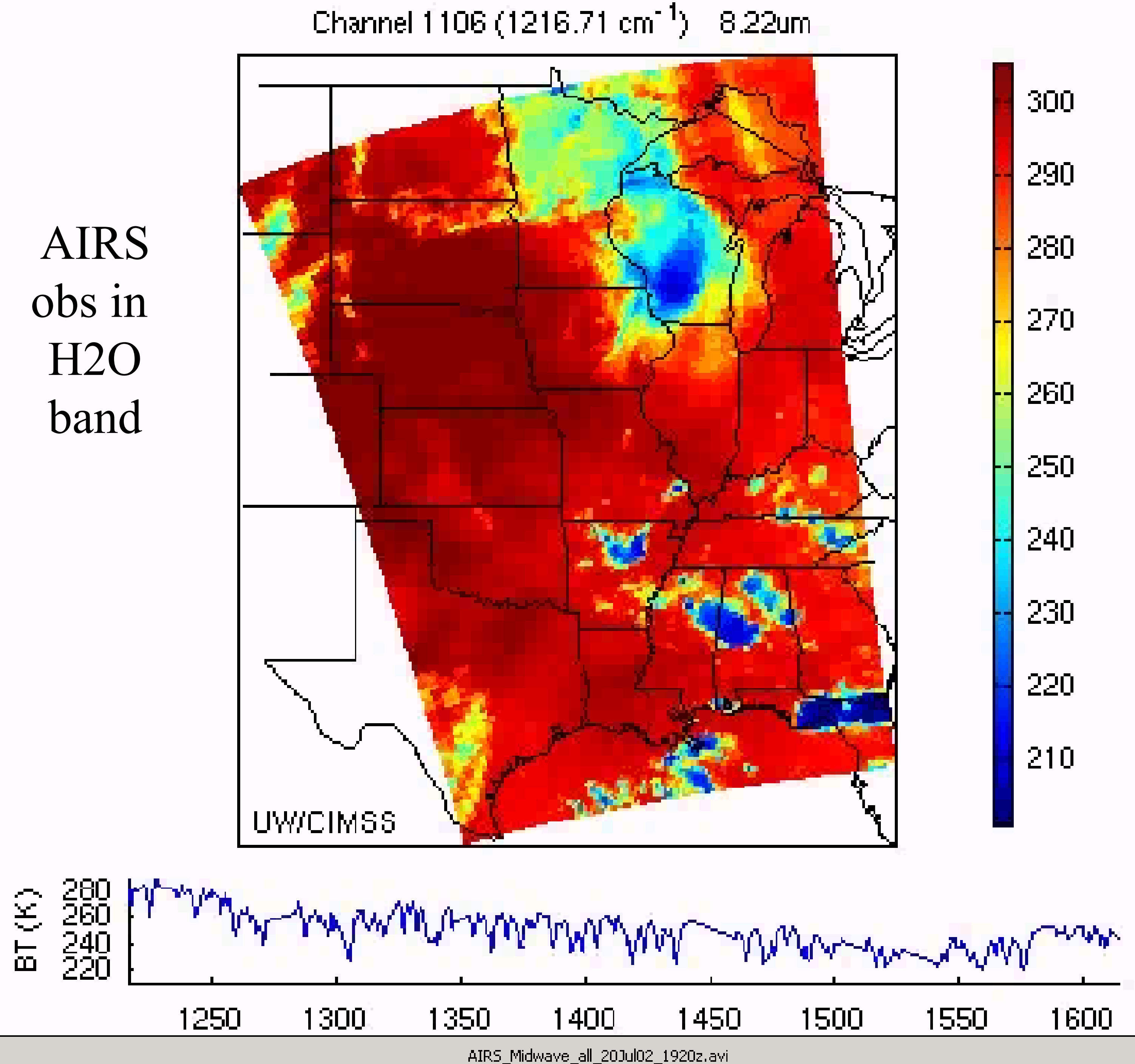
Blue between-line T_b

warmer for tropospheric channels,

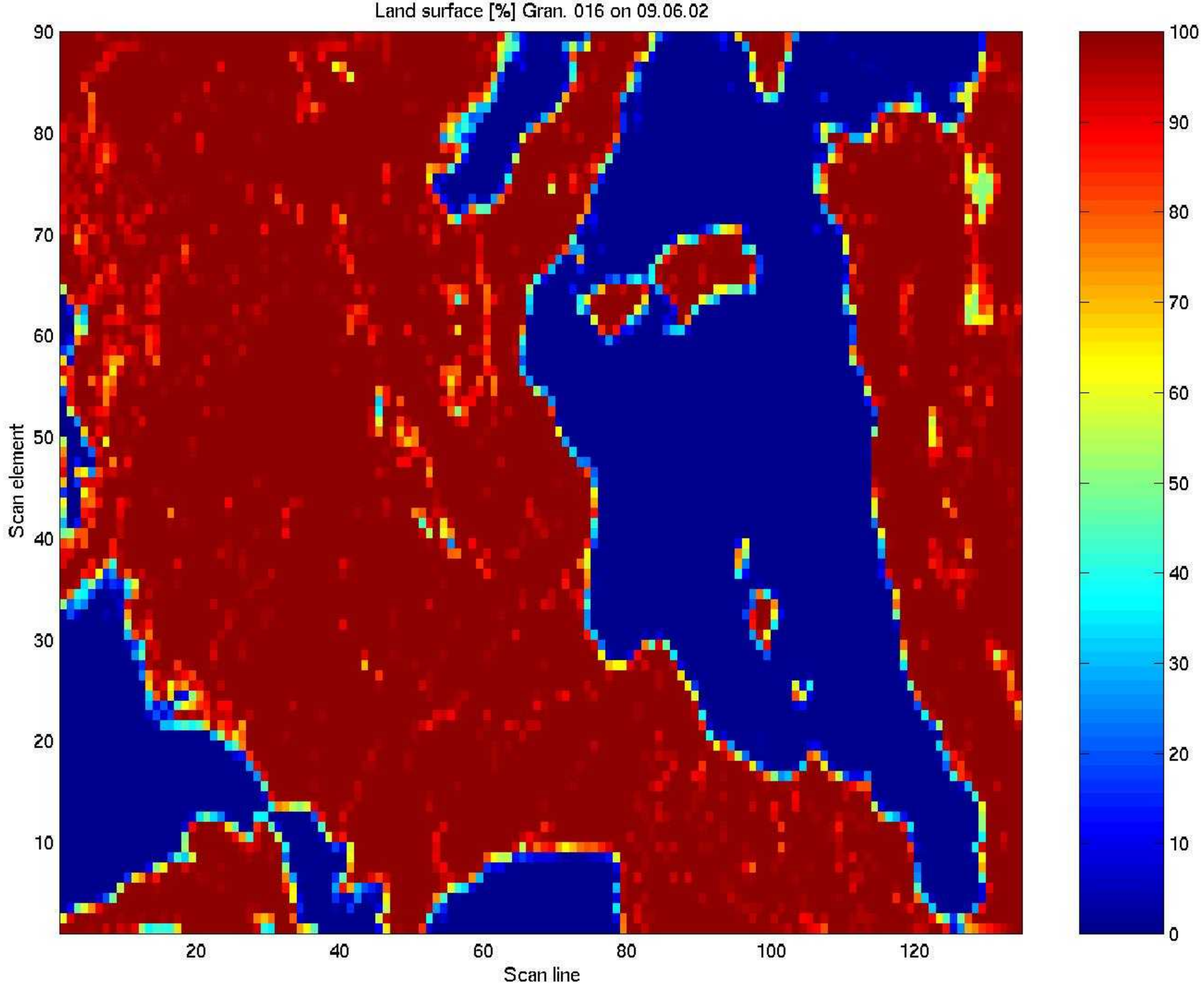
colder for stratospheric channels

Signature not available at low resolution

AIRS obs in H2O band

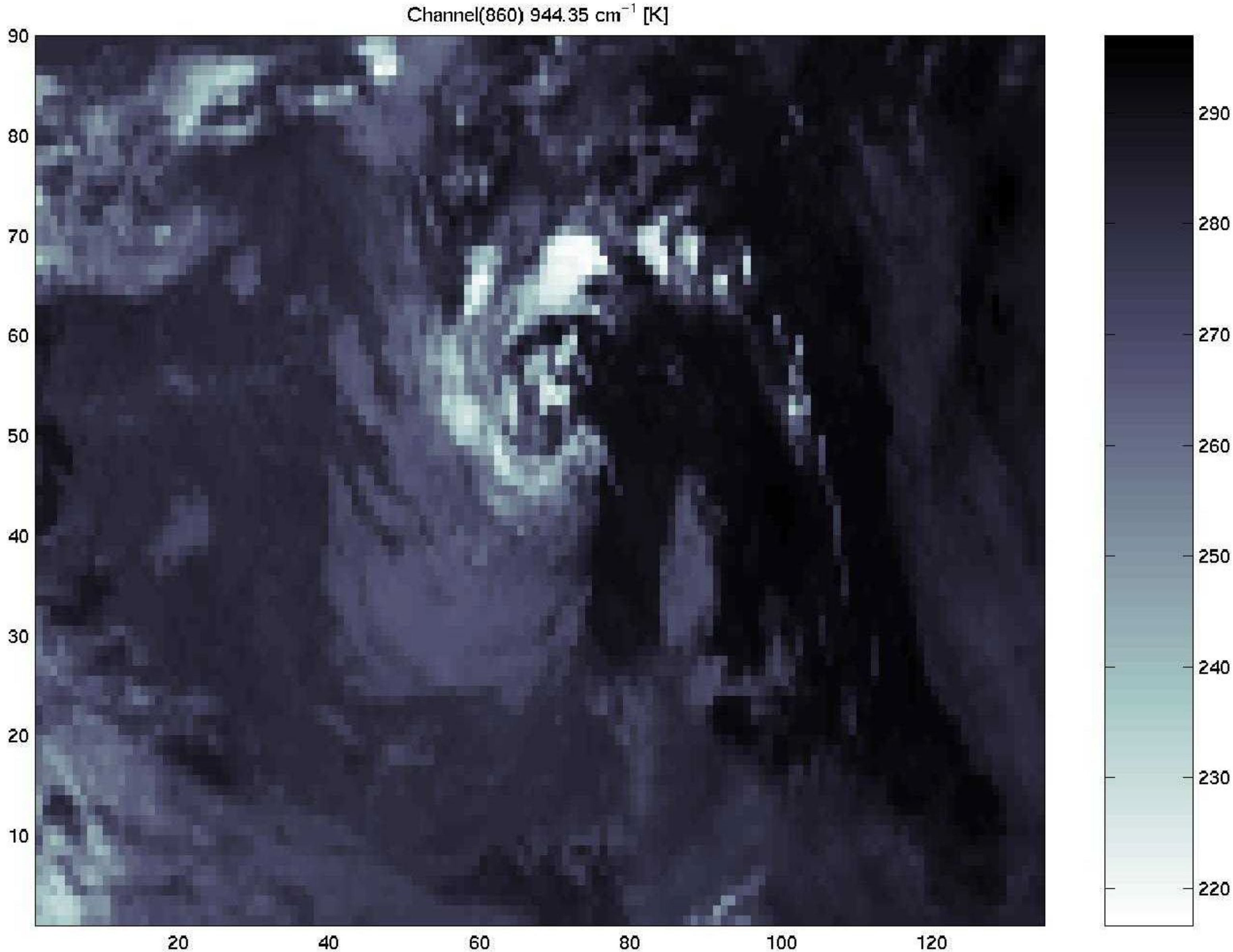


AIRS over Europe on 6 Sep 02

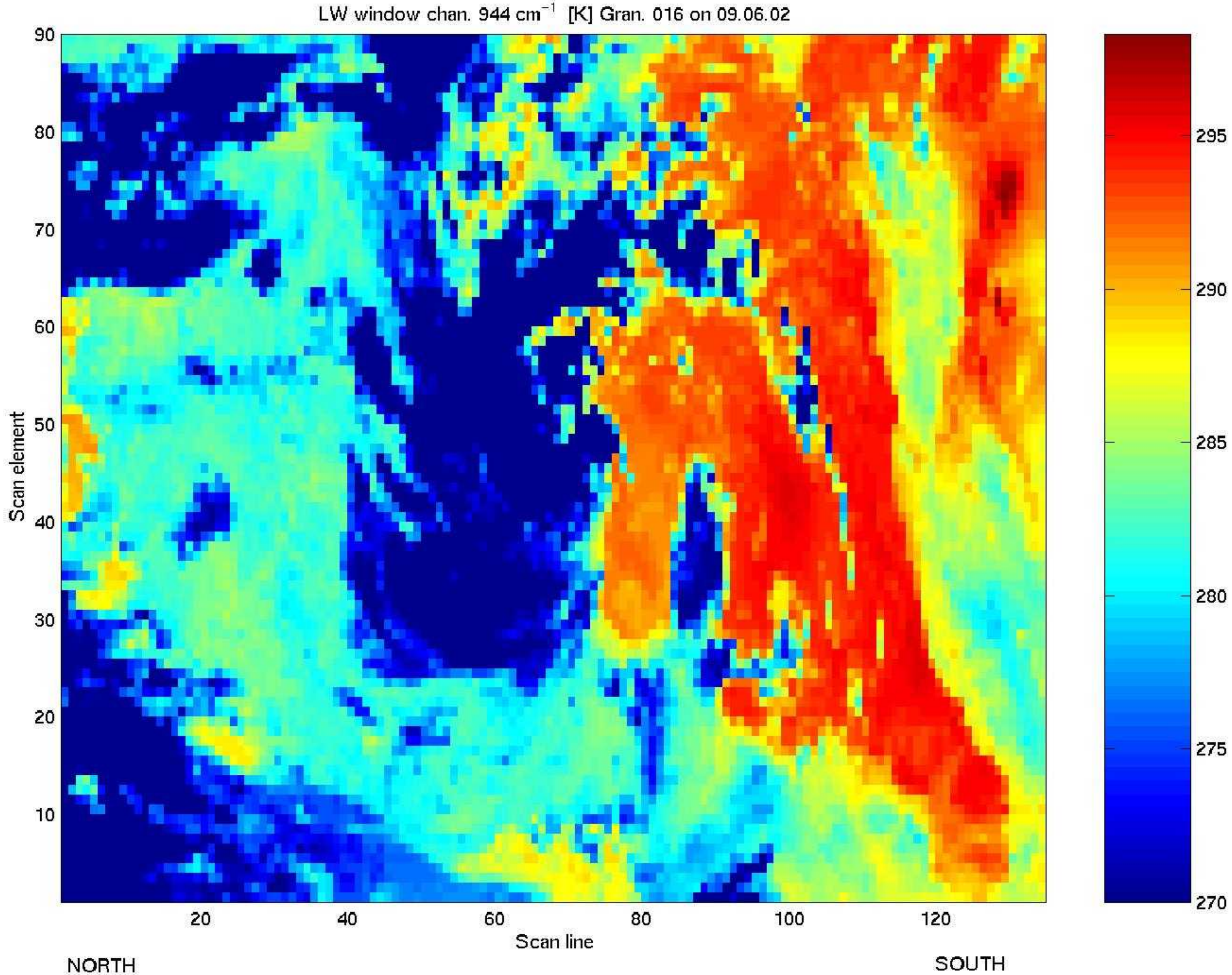


NORTH

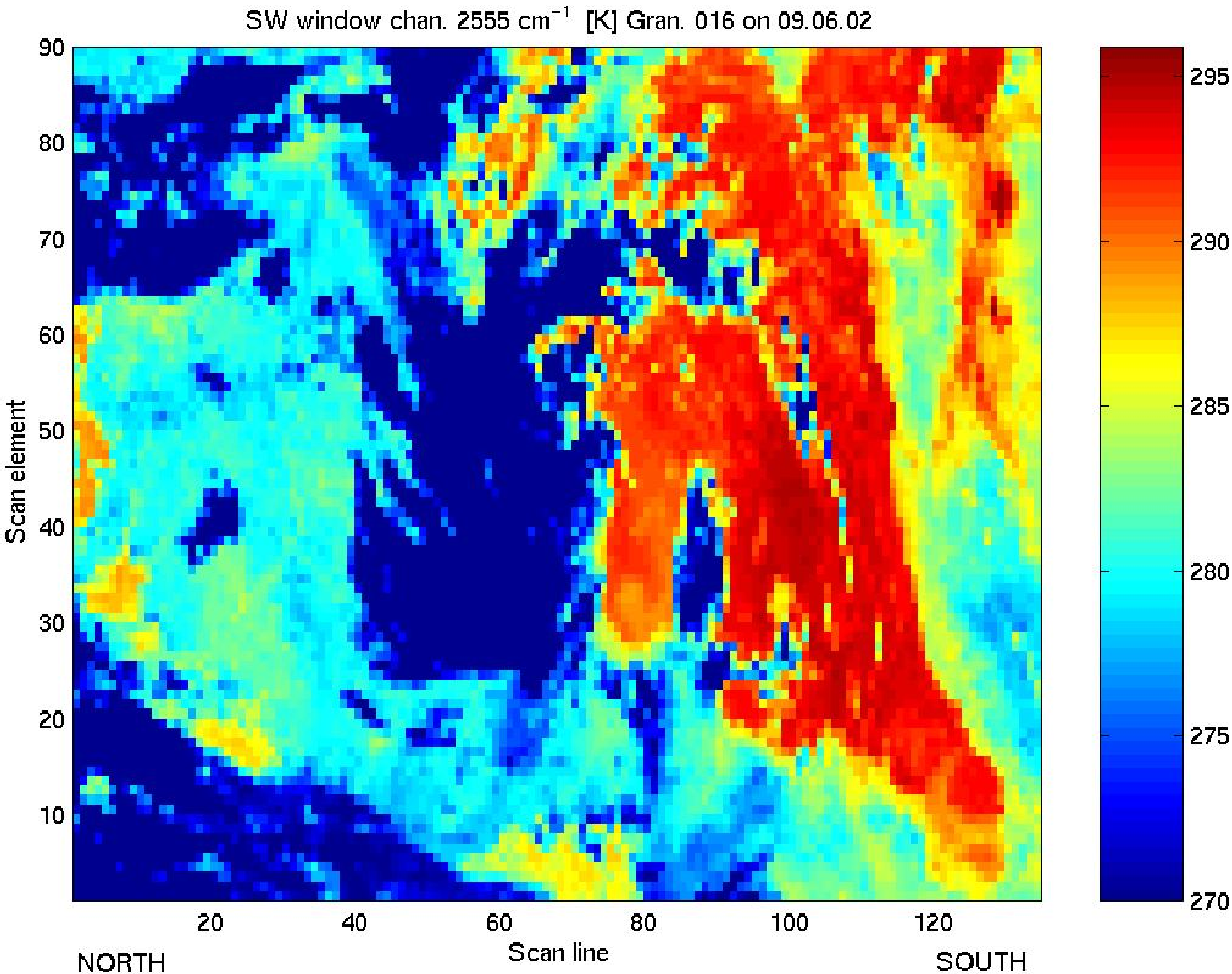
Spatial distribution of 944.1 [1/cm] measurements [K]



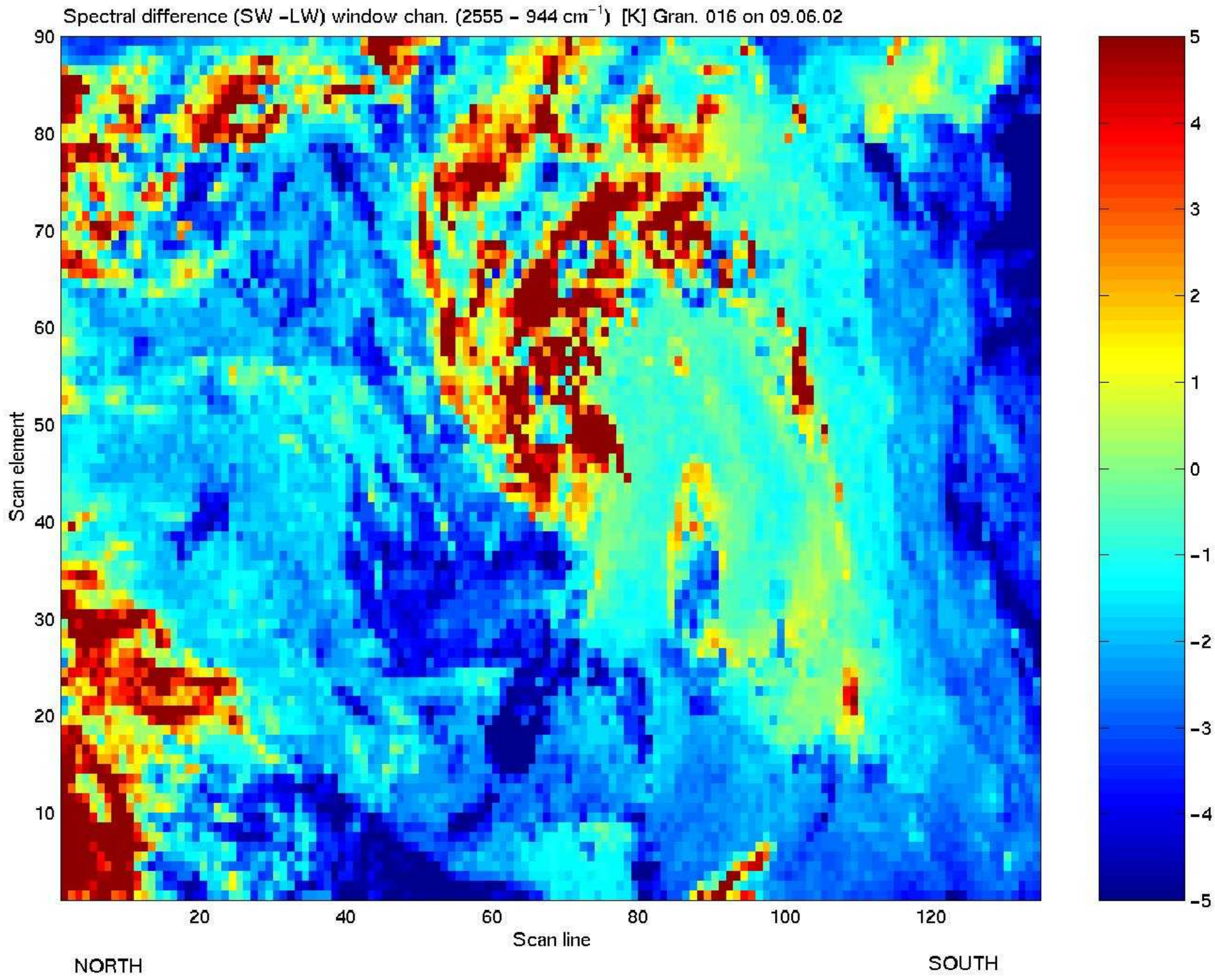
Spatial distribution of 944.1 [1/cm] measurements [K]



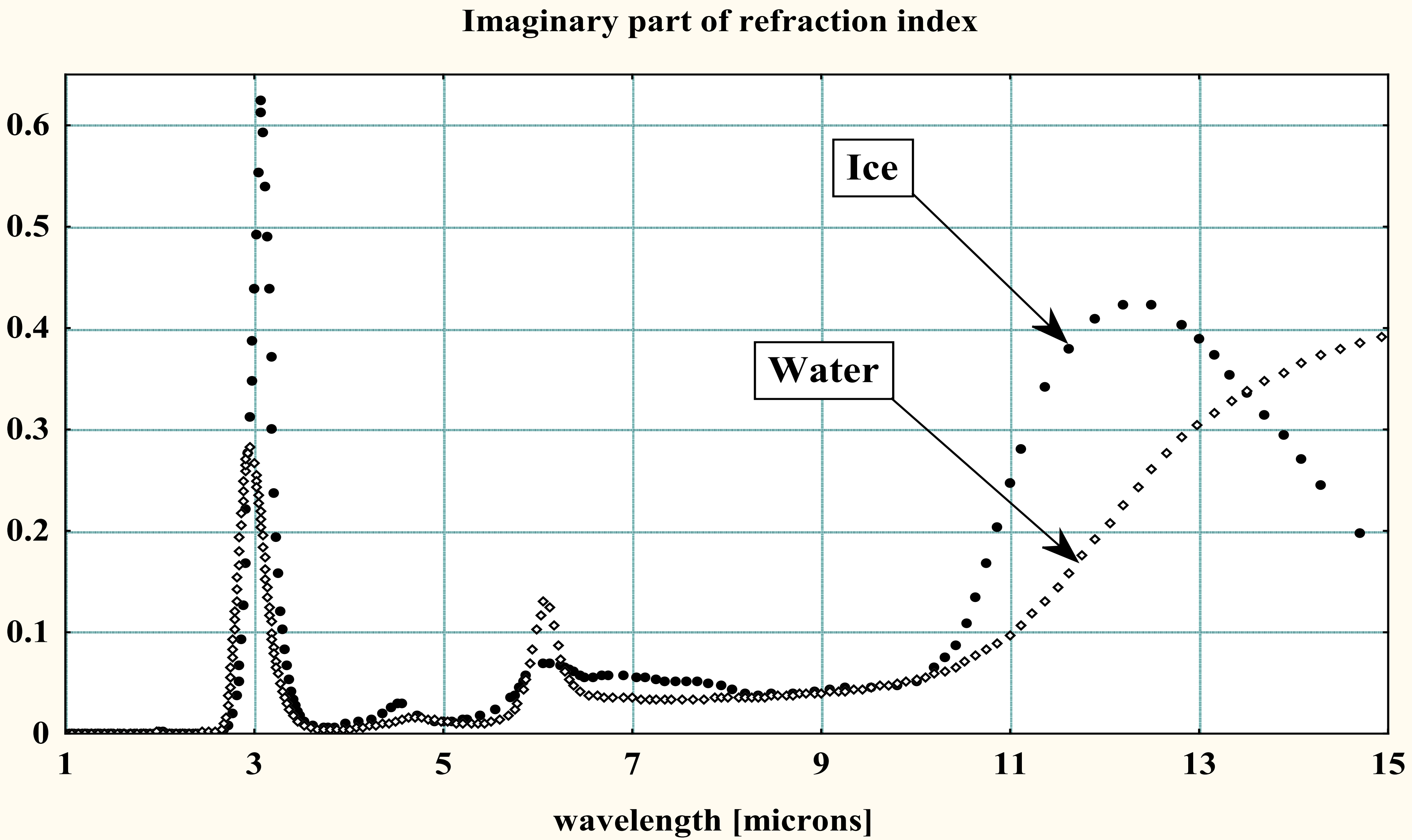
Spatial distribution of 2555 [1/cm] measurements [K]



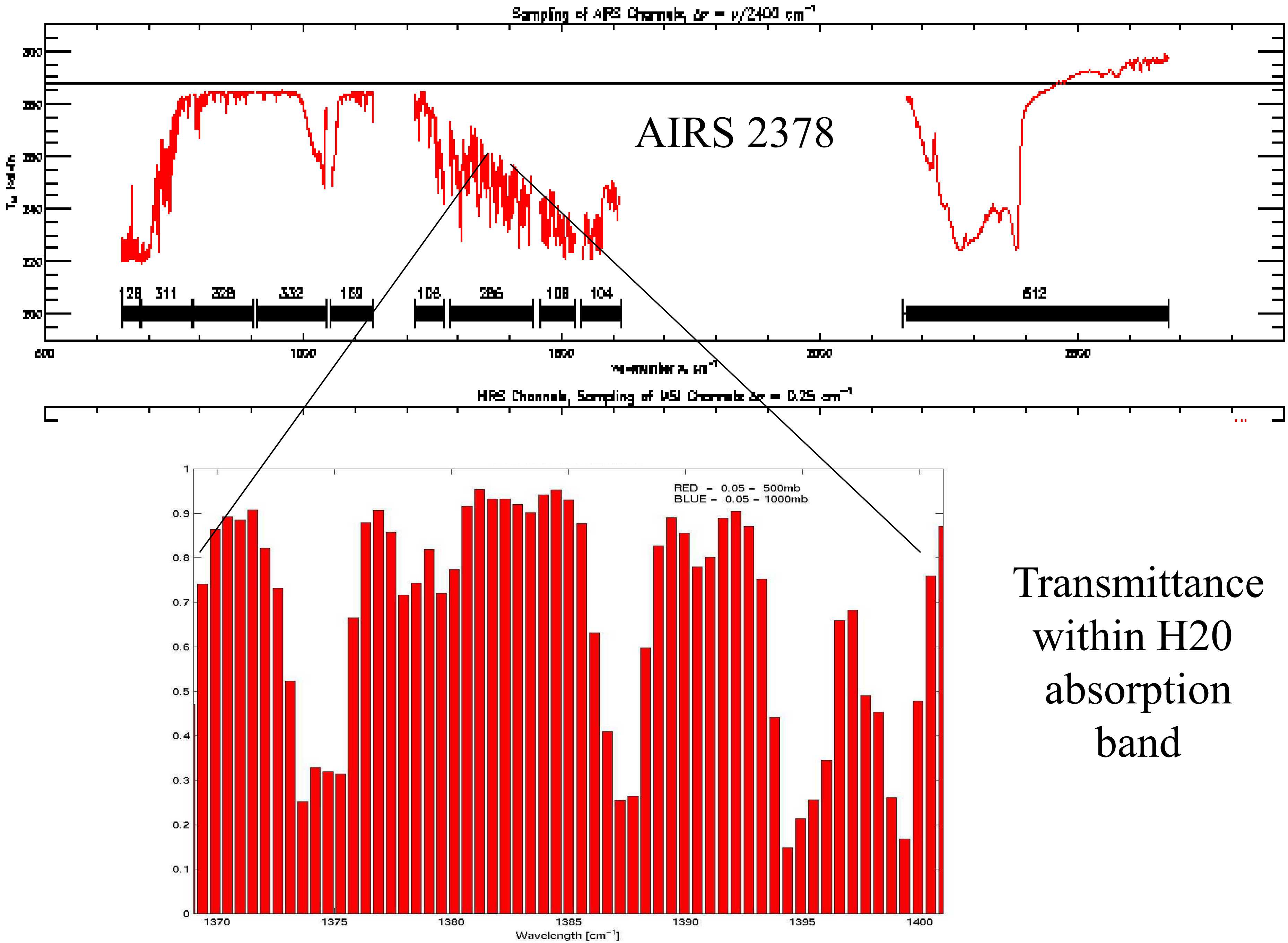
Spatial distribution of 2555 – 944.1 [1/cm] measurements [K]



Optical properties of cloud particles: imaginary part of refraction index

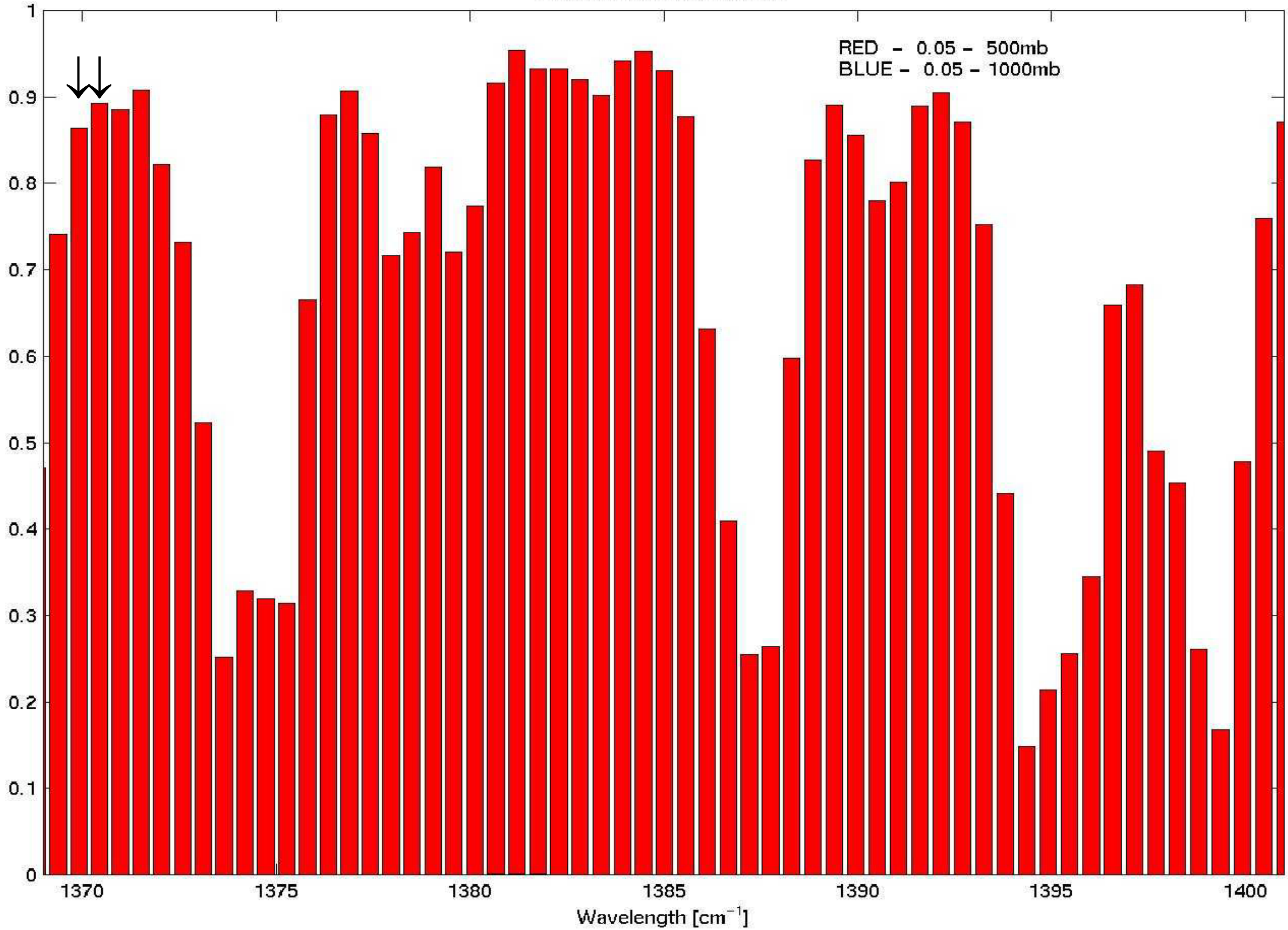


SW & LW channel differences are used for cloud identification
{4 µm - 11µm}, {4.13 µm - 12.6µm}, and {4.53 µm - 13.4µm}

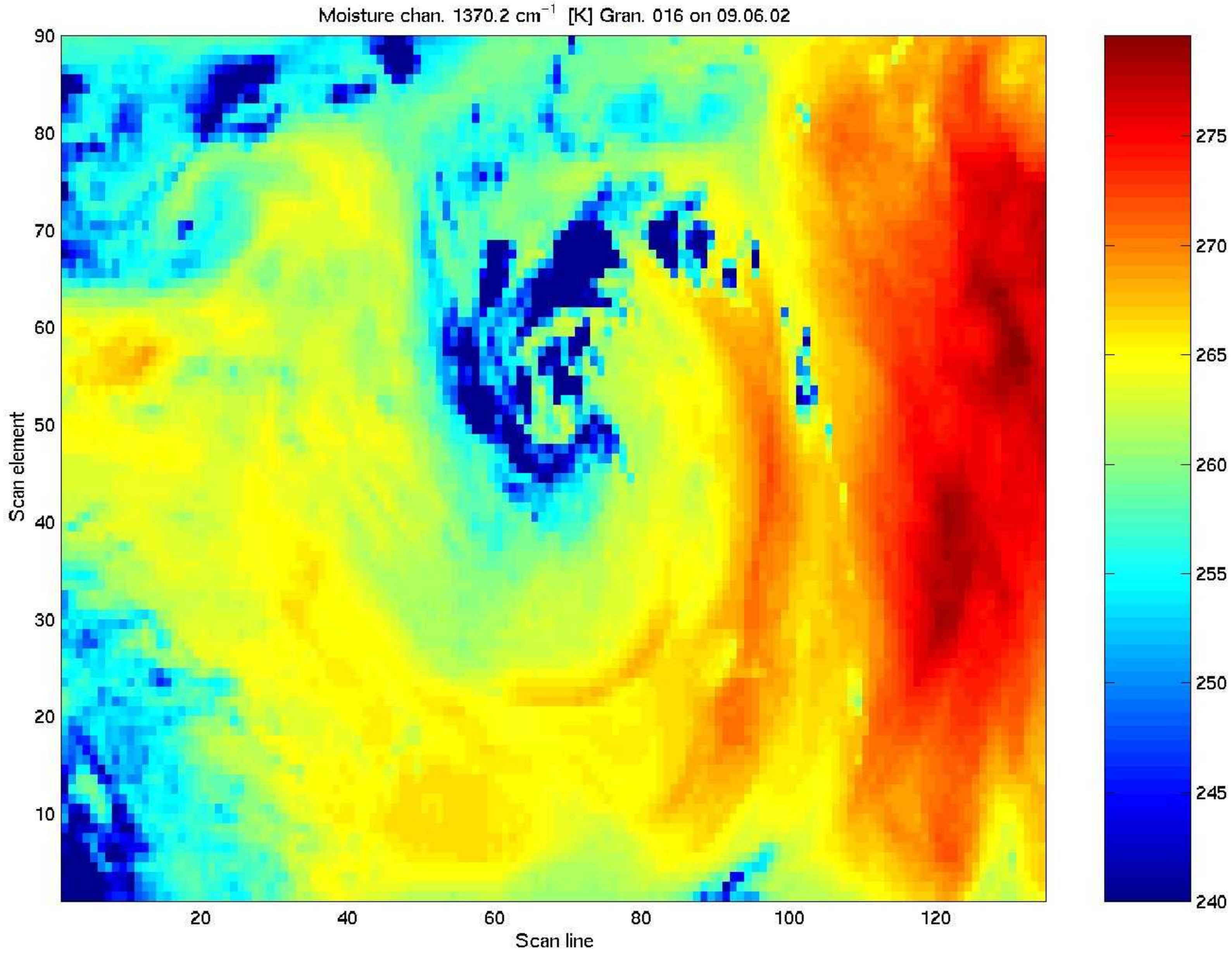


Transmittance within H20 absorption band

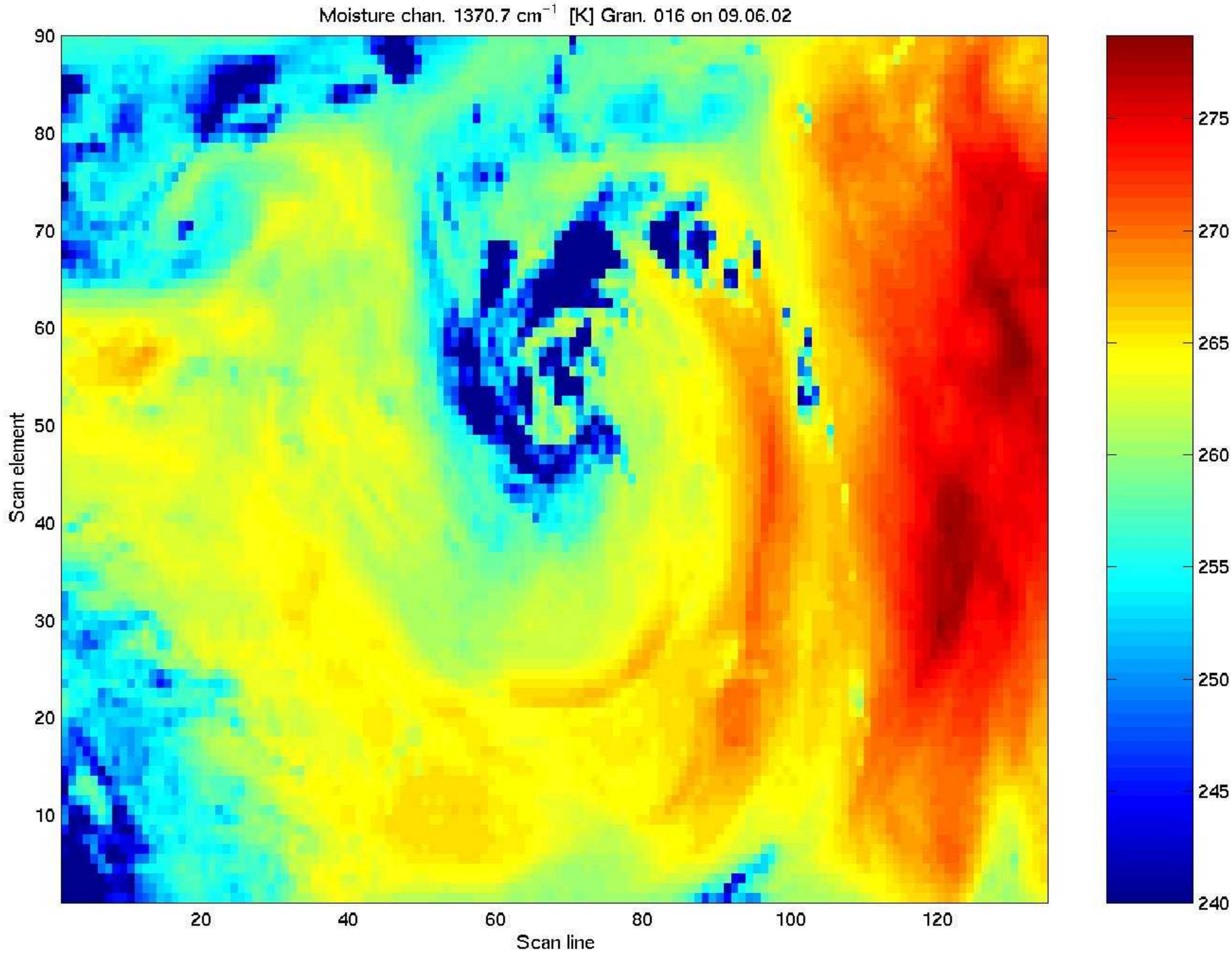
Atmospheric transmittance in H2O sensitive region of spectrum



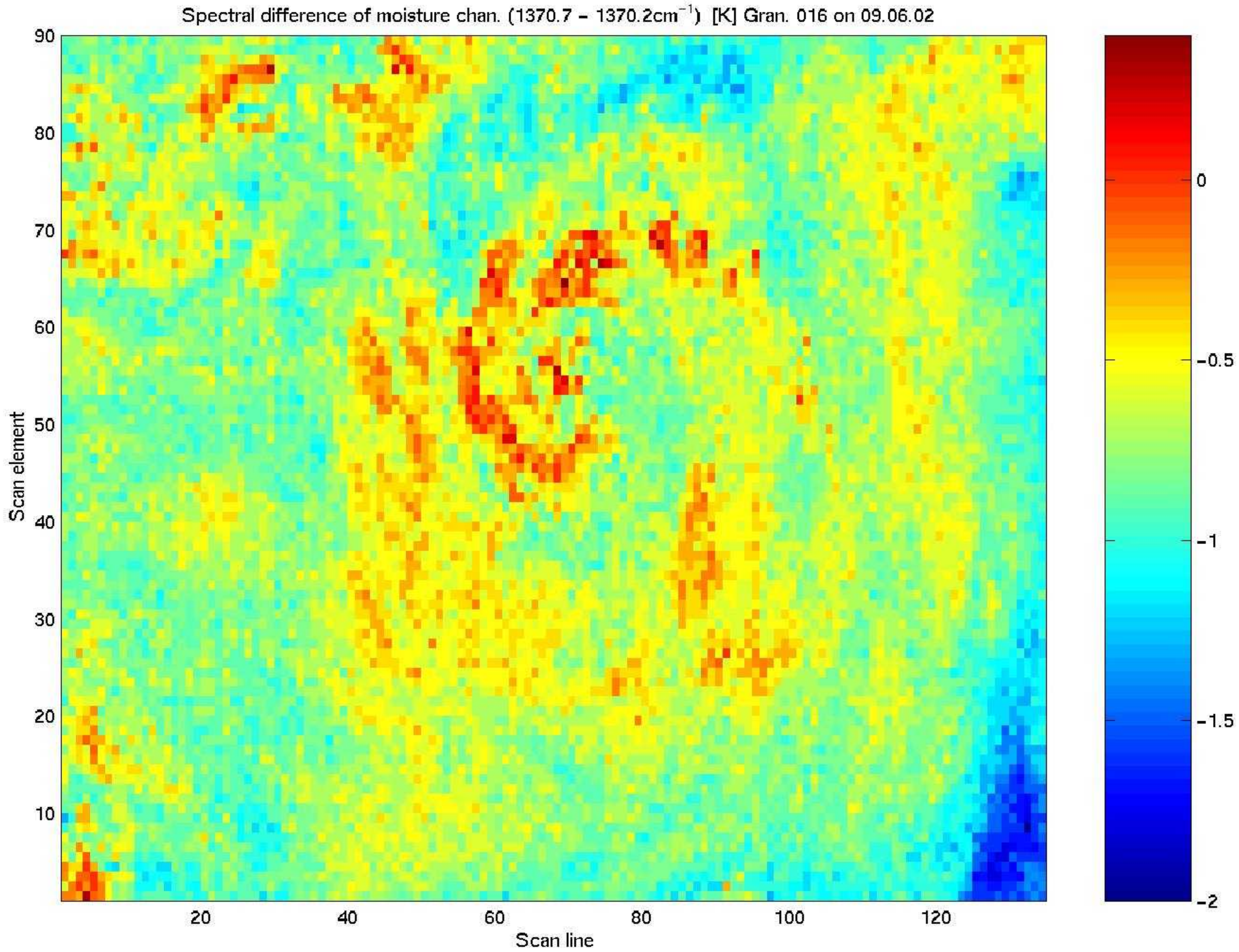
Spatial distribution of 1370.2 [1/cm] measurements [K]



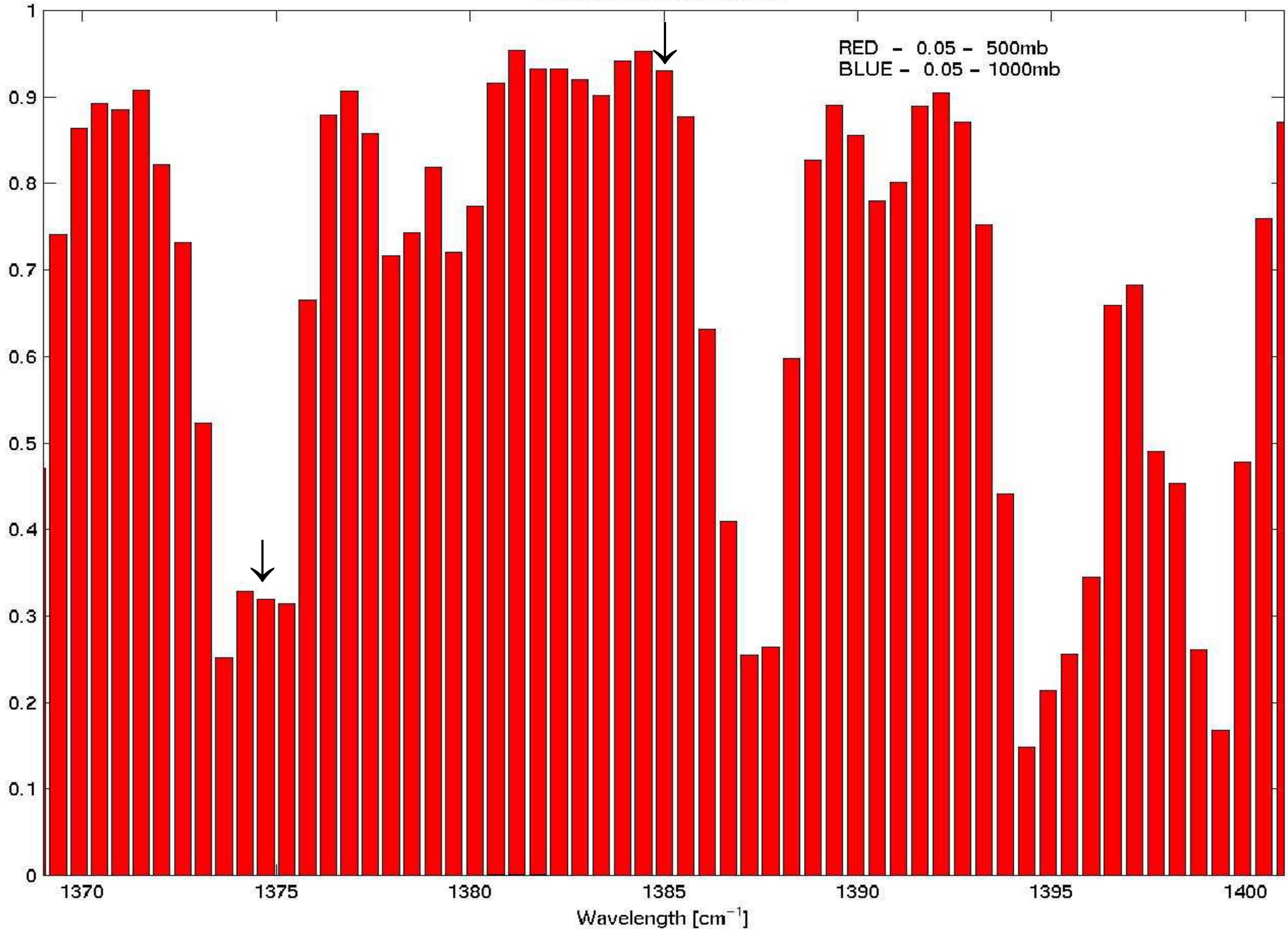
Spatial distribution of 1370.7 [1/cm] measurements [K]



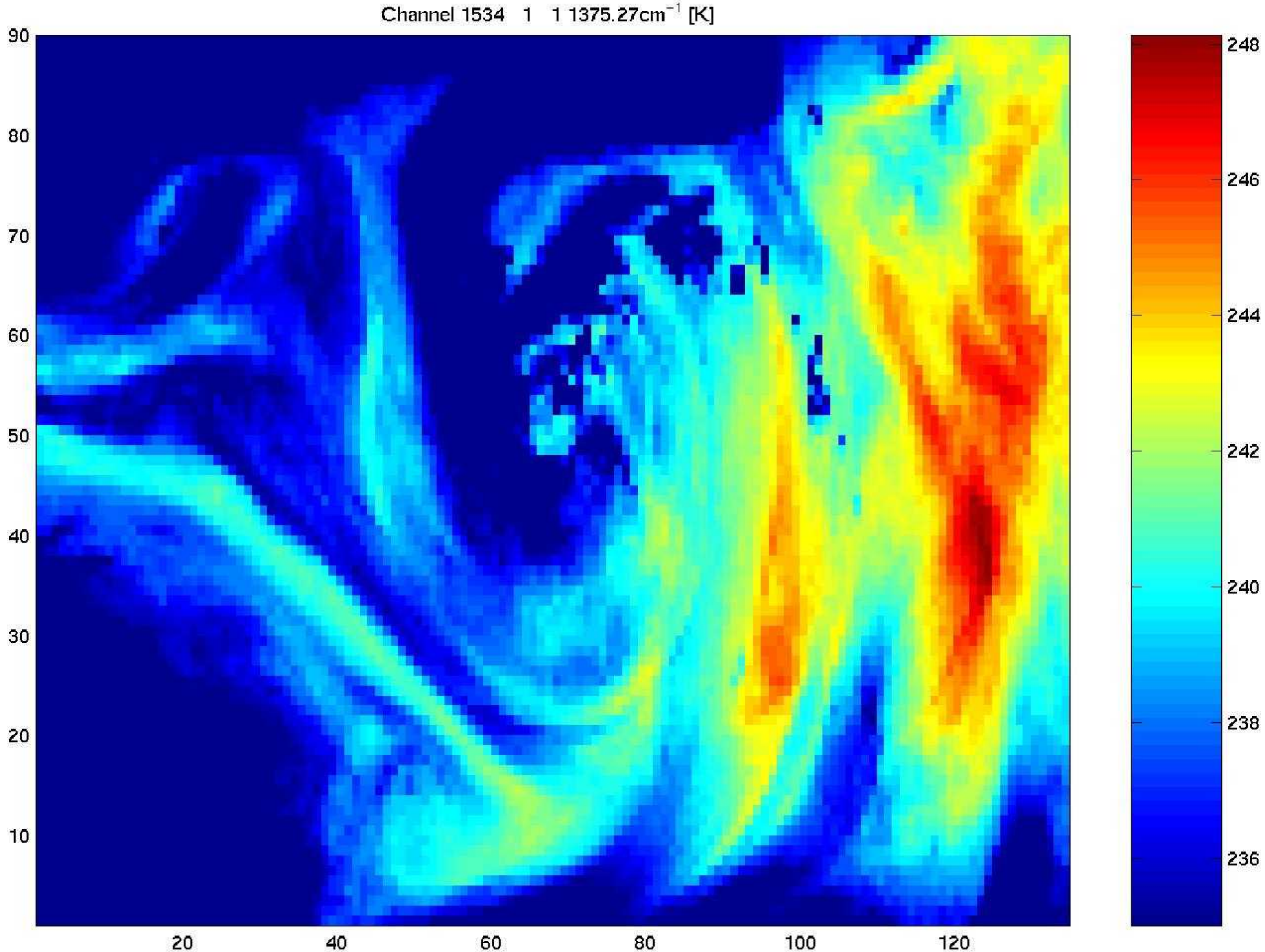
Spatial distribution of 1370.2 – 1370.7 [1/cm] measurements [K]



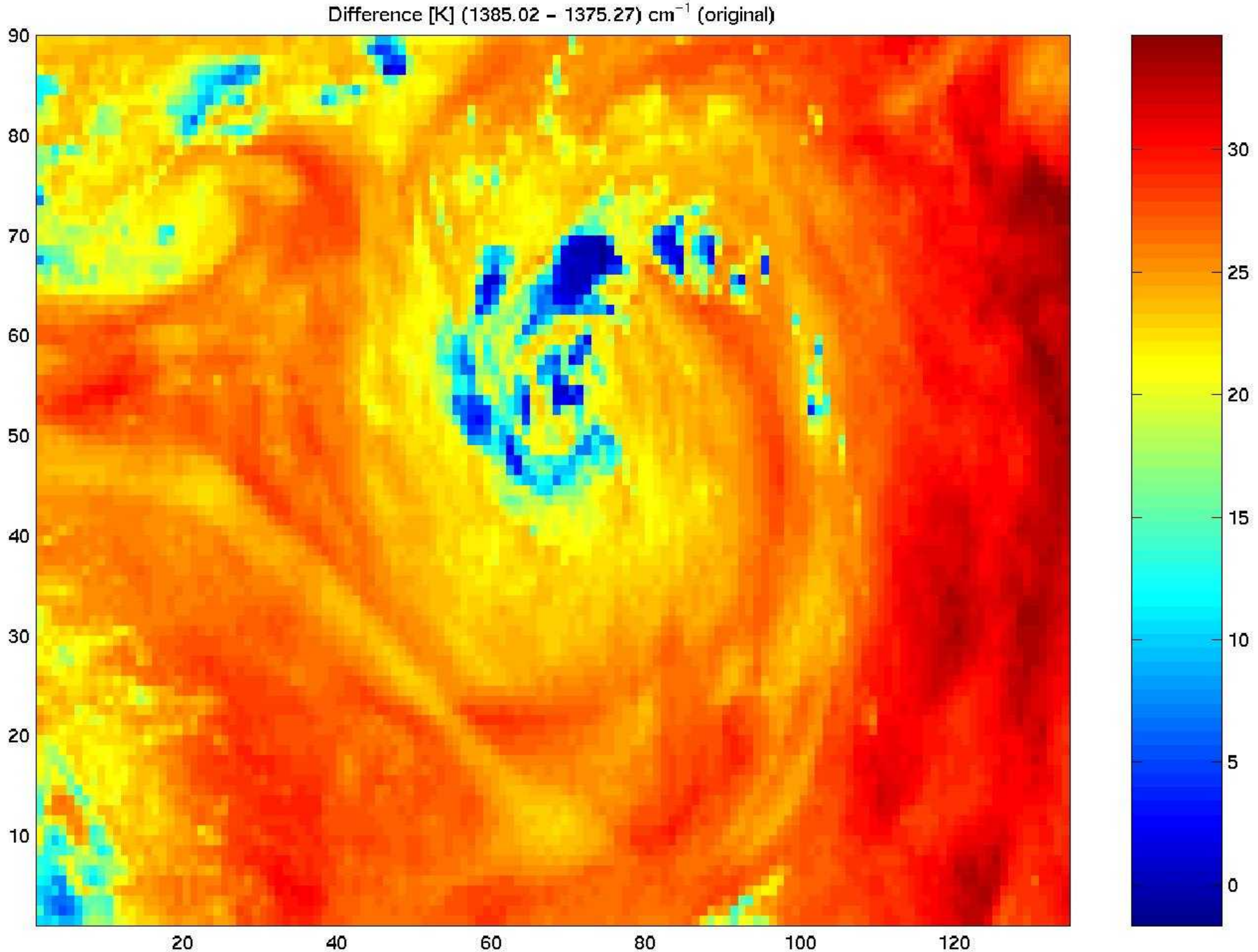
Atmospheric transmittance in H2O sensitive region of spectrum



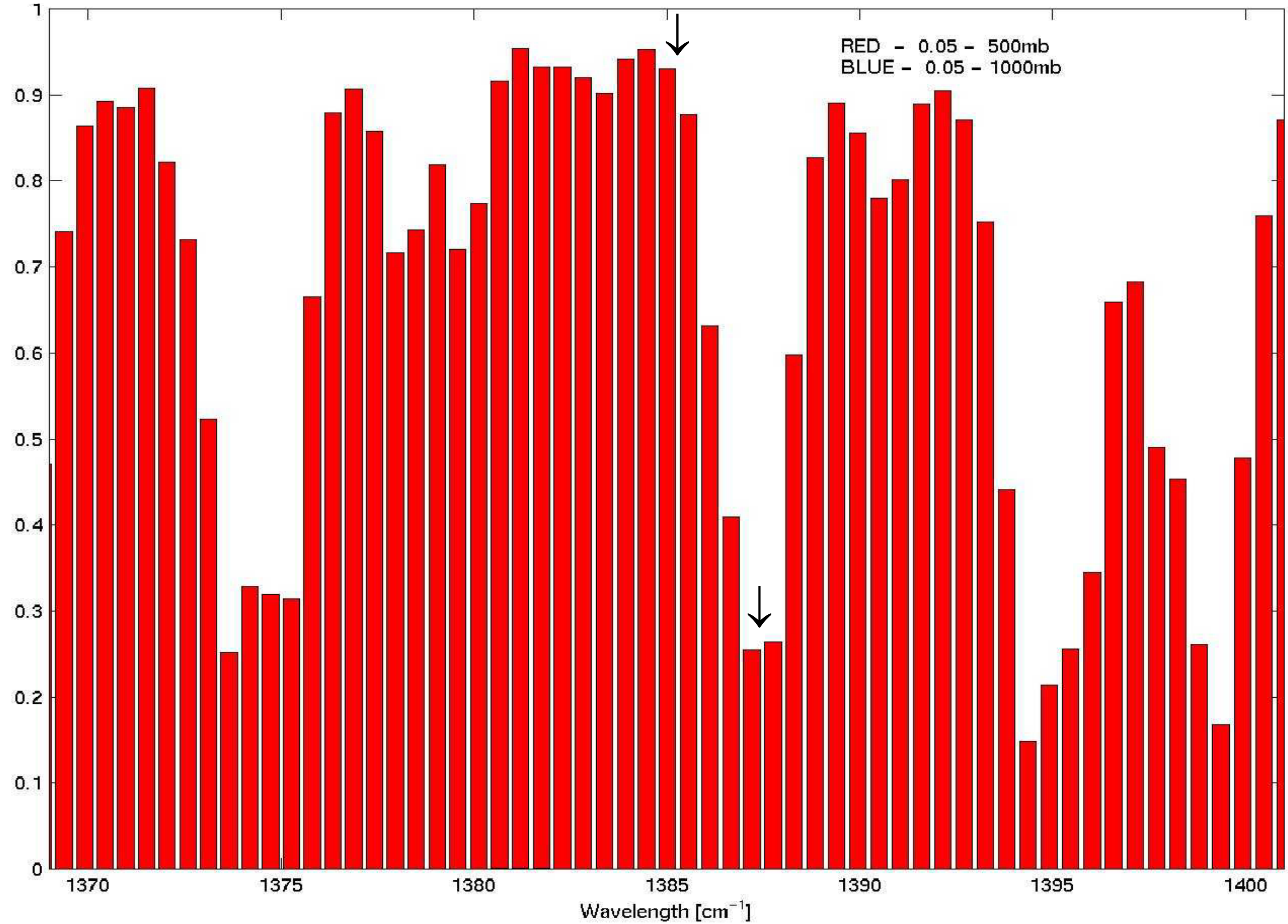
Spatial distribution of Ch 1534 at 1375.27 [1/cm] measurements [K]



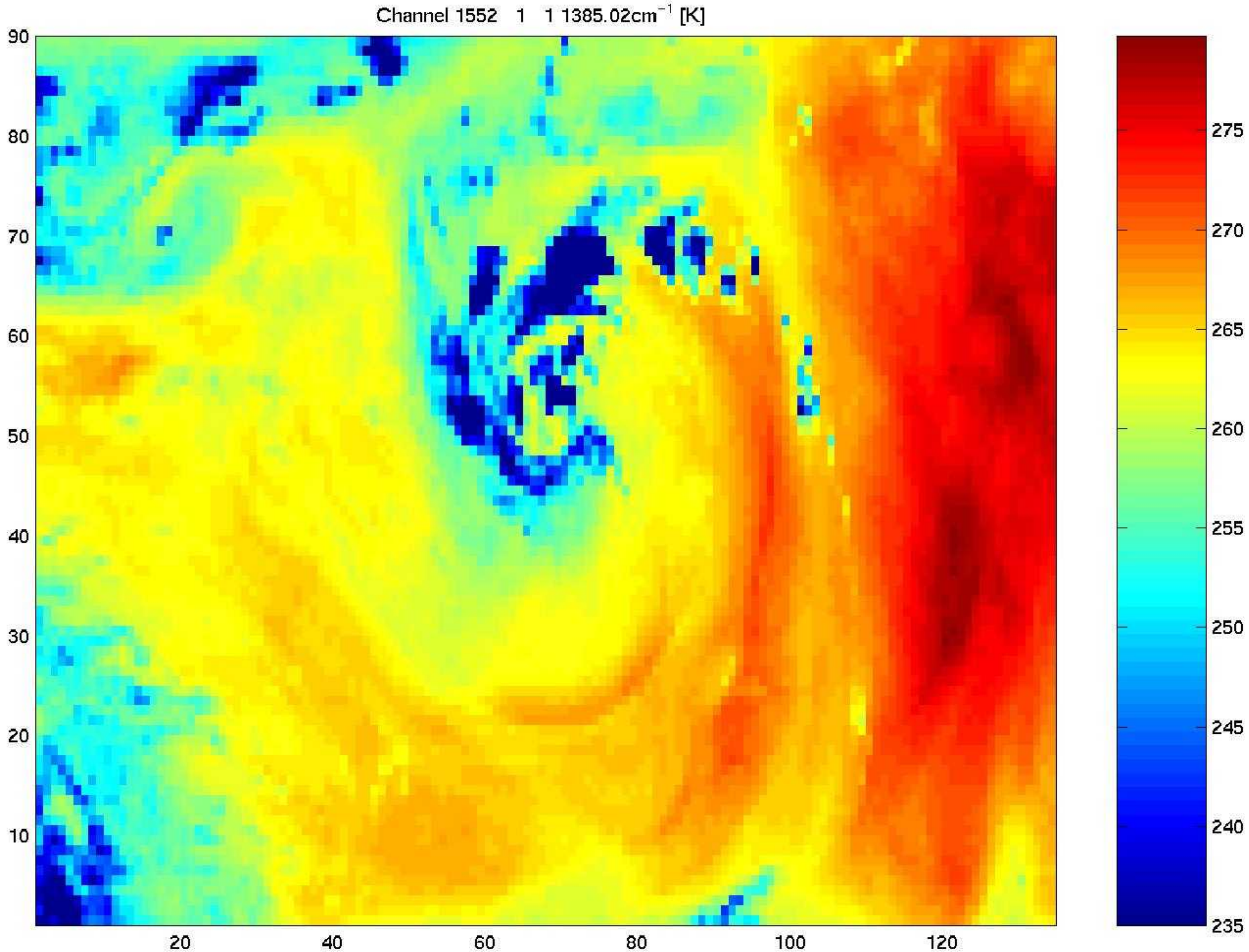
Spatial distribution of 1385.02 – 1375.27 [1/cm] measurements [K]



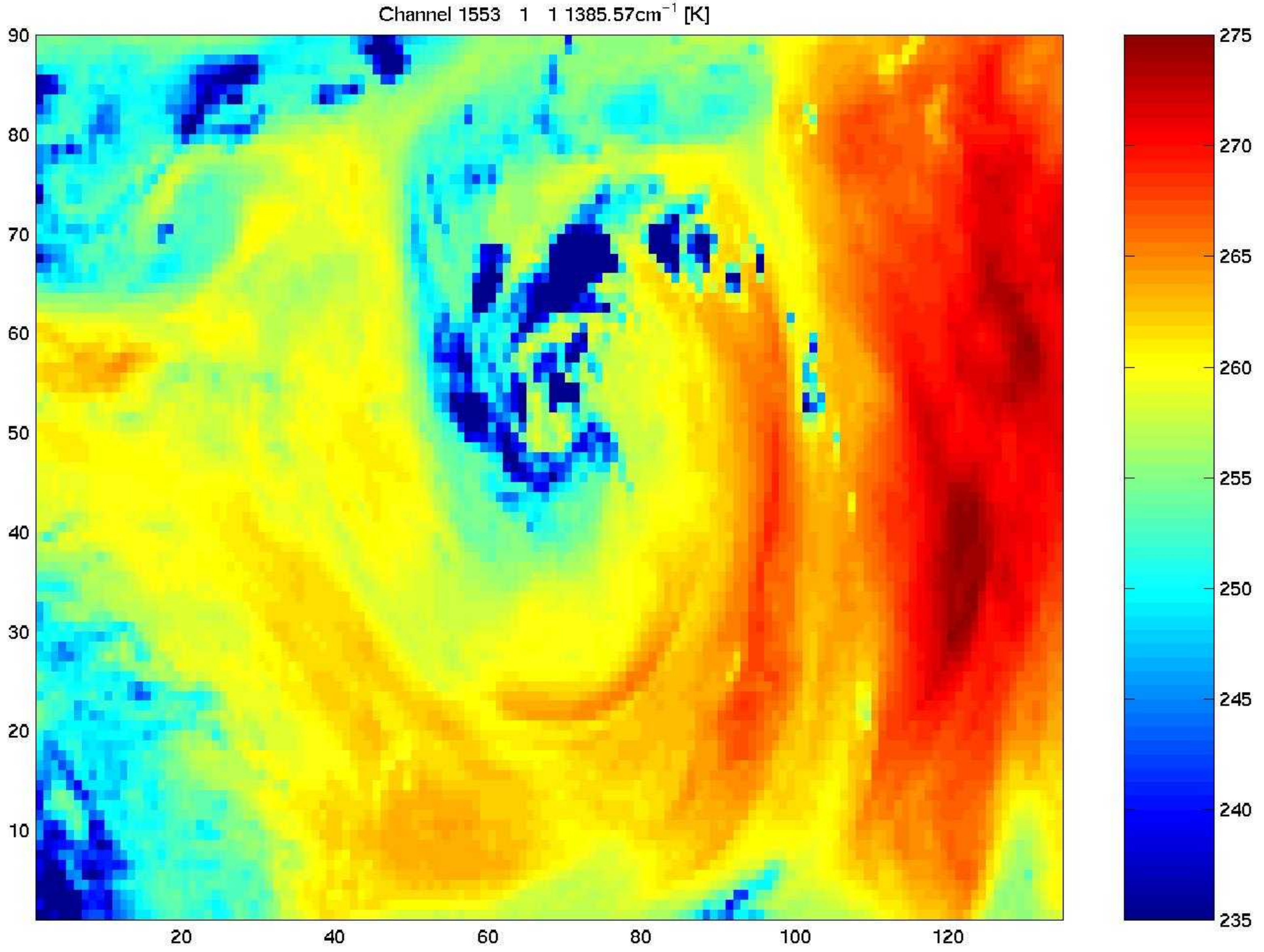
Atmospheric transmittance in H2O sensitive region of spectrum



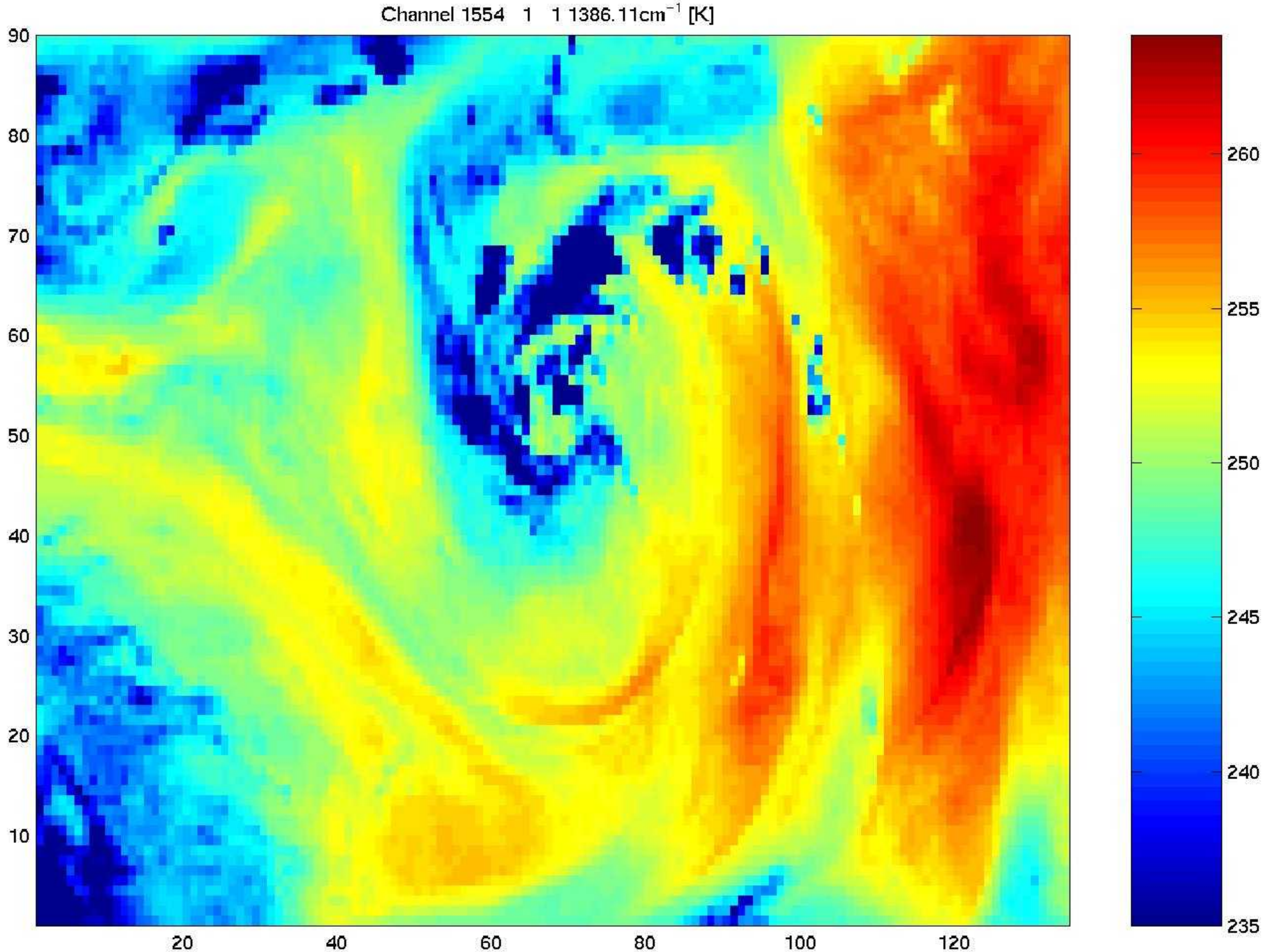
Spatial distribution of Ch 1552 at 1385.02 [1/cm] measurements [K]



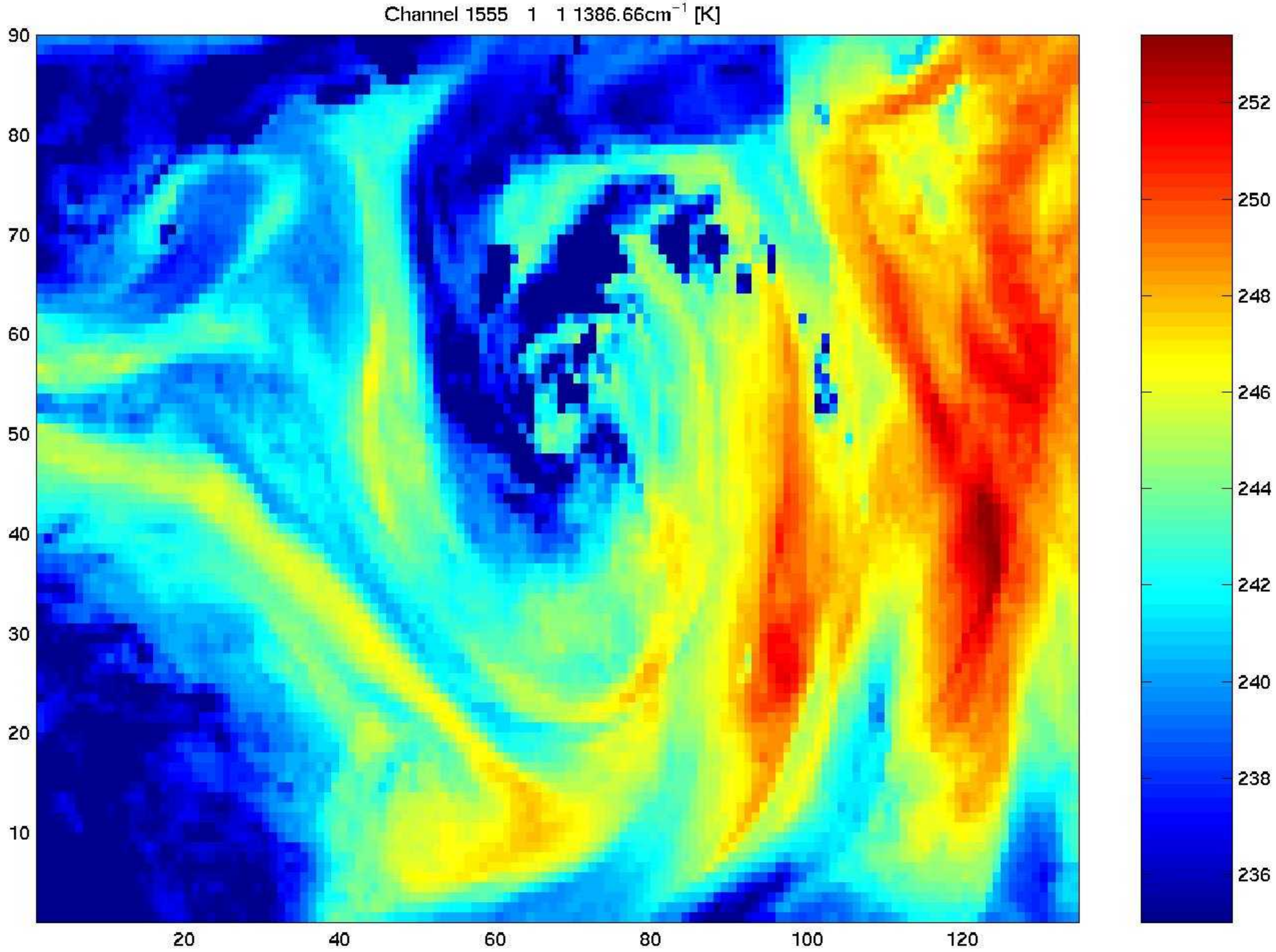
Spatial distribution of Ch 1553 at 1385.57 [1/cm] measurements [K]



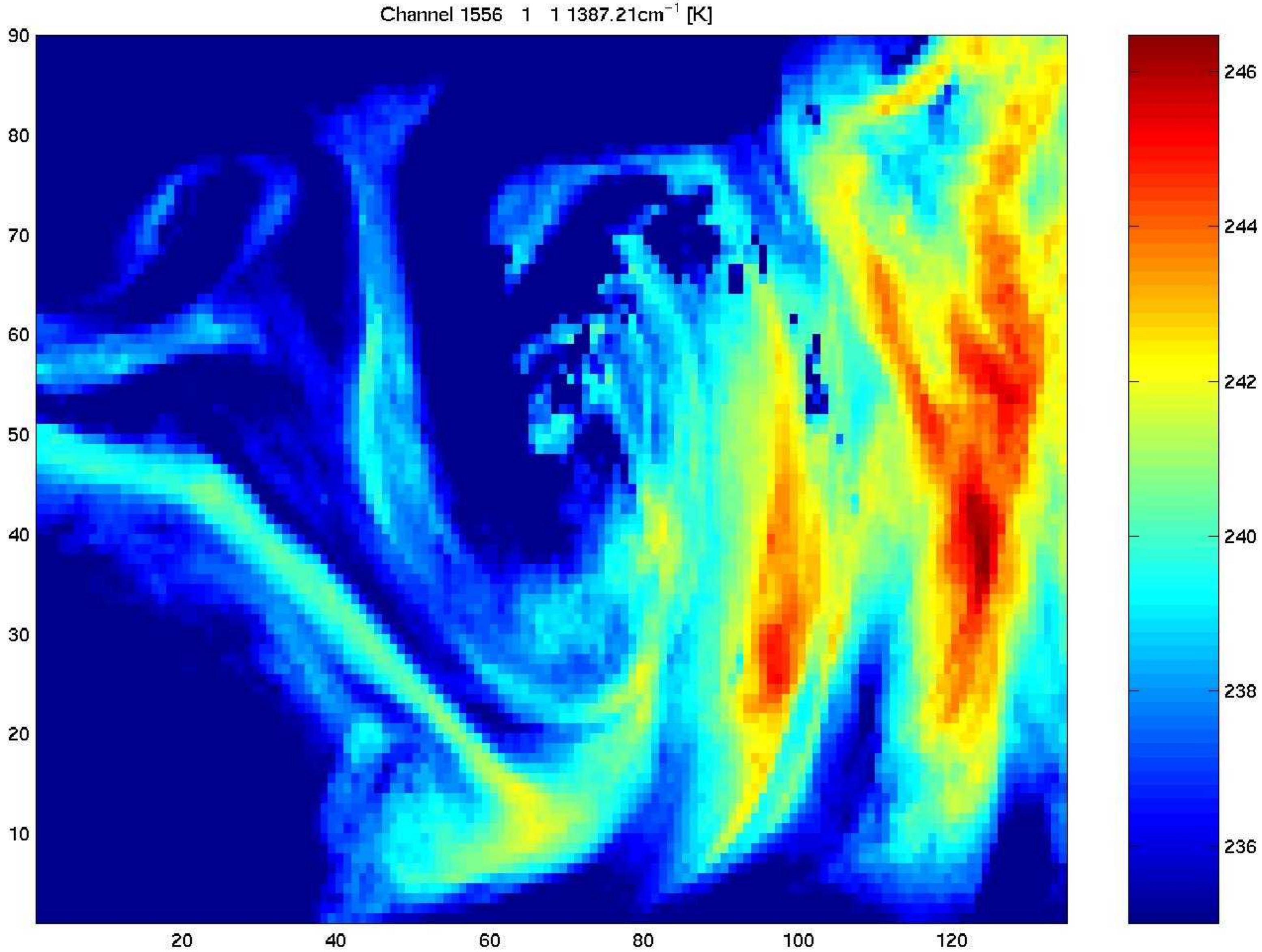
Spatial distribution of Ch 1554 at 1386.11 [1/cm] measurements [K]



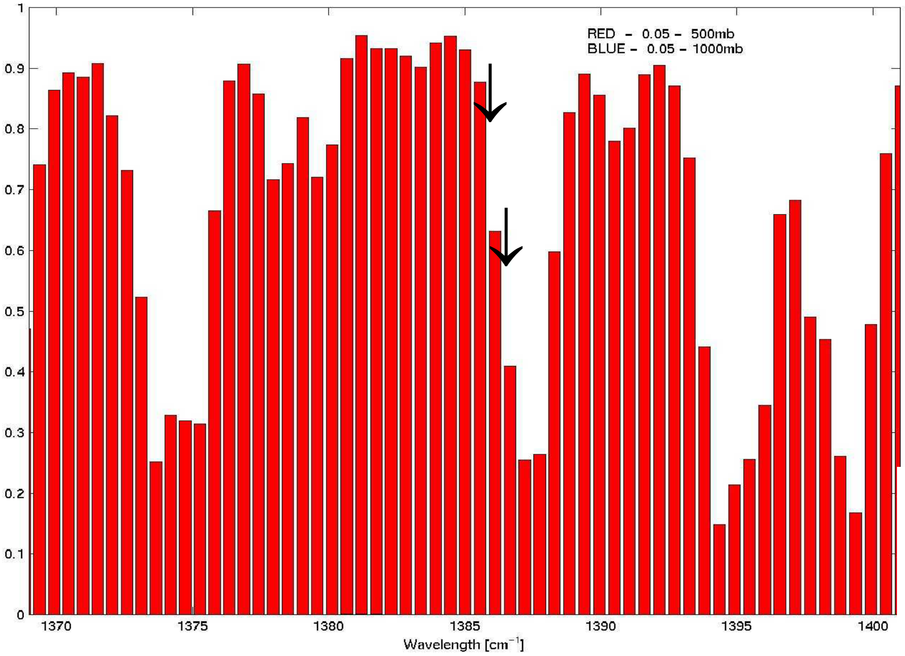
Spatial distribution of Ch 1555 at 1386.66 [1/cm] measurements [K]



Spatial distribution of Ch 1556 at 1387.21 [1/cm] measurements [K]

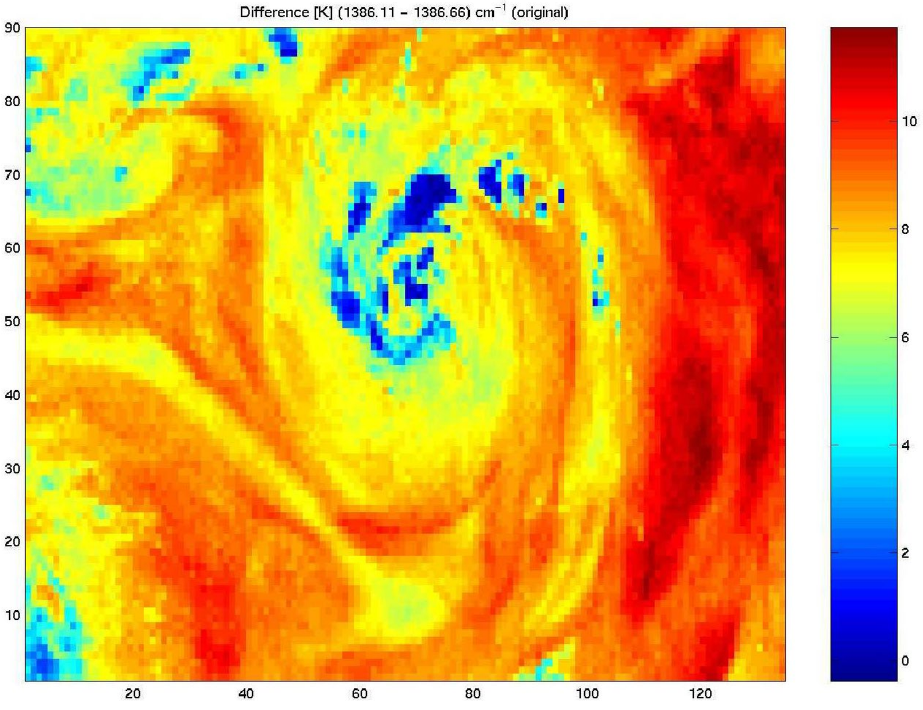


Atmospheric transmittance in H2O sensitive region of spectrum



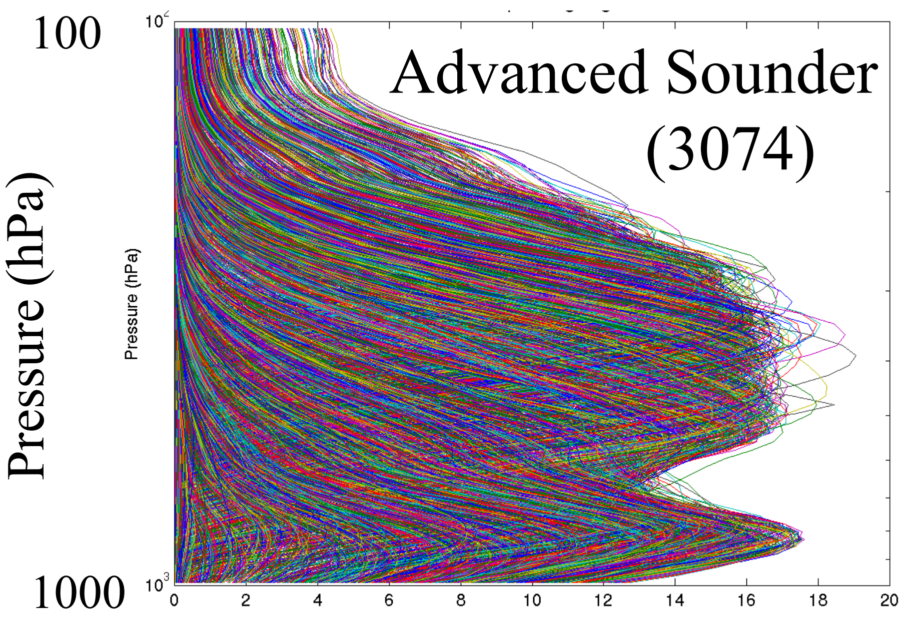
Studying spectral sensitivity with AIRS Data

AIRS BT[1386.11] – BT[1386.66]



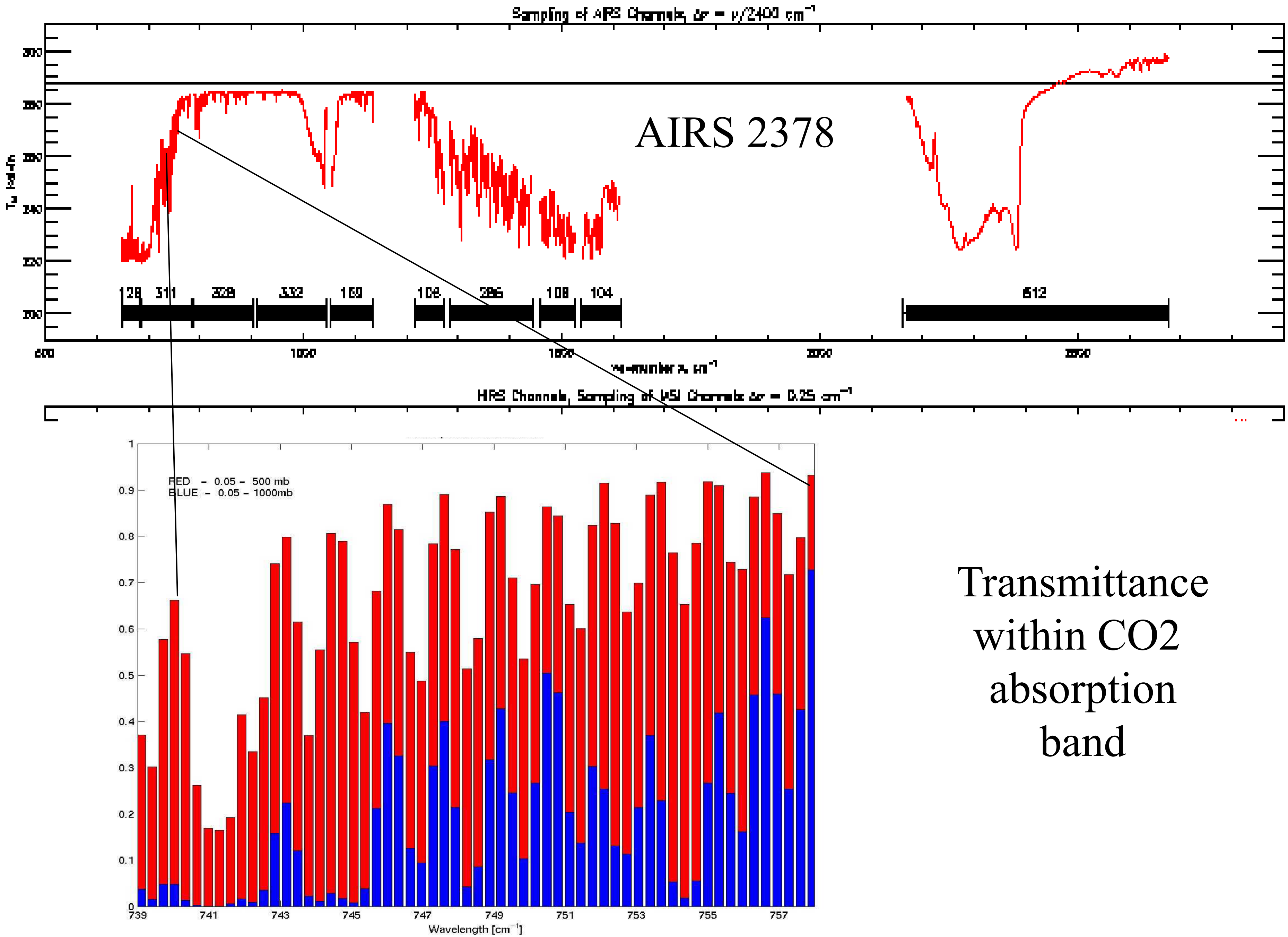
Spectral change of 0.5 cm-1 causes BT changes > 10 C

H2O spectral bands receive radiation from overlapping layers of the atmosphere



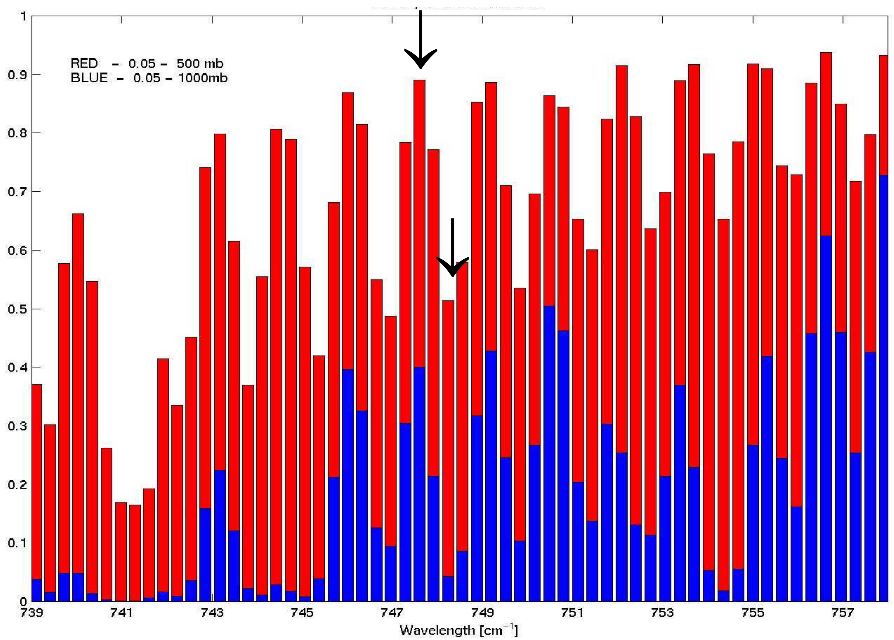
Moisture Weighting Functions

High spectral resolution advanced sounder will have more and sharper weighting functions compared to current GOES sounder. Retrievals will have 2 to 3 x better vertical resolution.



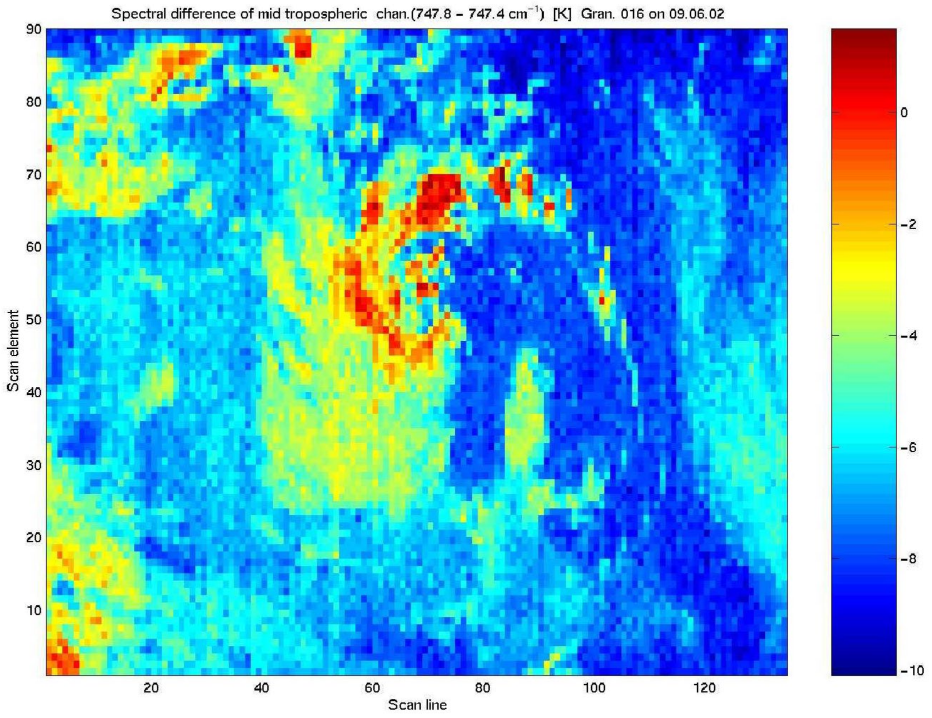
Transmittance within CO2 absorption band

Atmospheric transmittance in CO2 sensitive region of spectrum



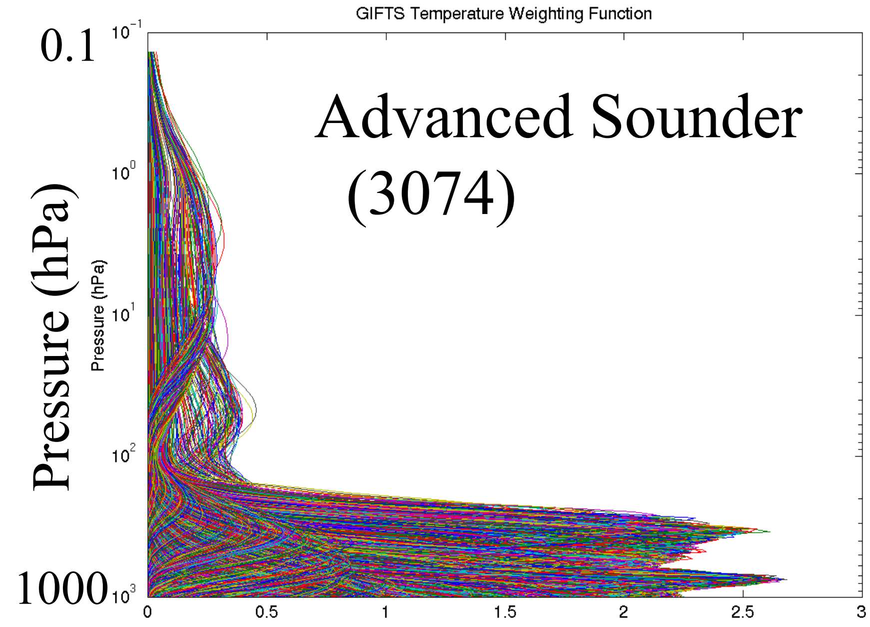
Studying spectral sensitivity with AIRS Data

AIRS BT[747.8] – BT[747.4]



Spectral change of 0.4 cm-1 causes BT changes > 8 C

CO2 spectral bands receive radiation from overlapping layers of the atmosphere

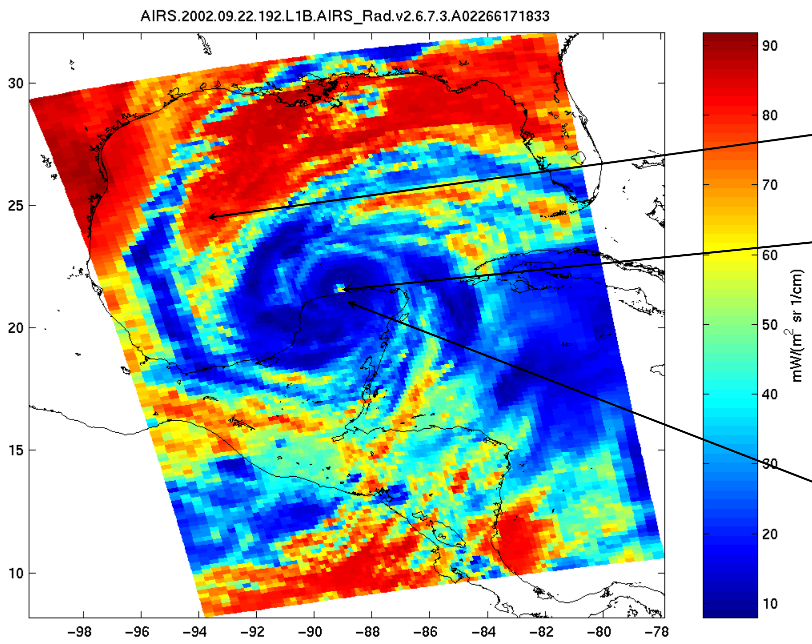


Temperature Weighting Functions

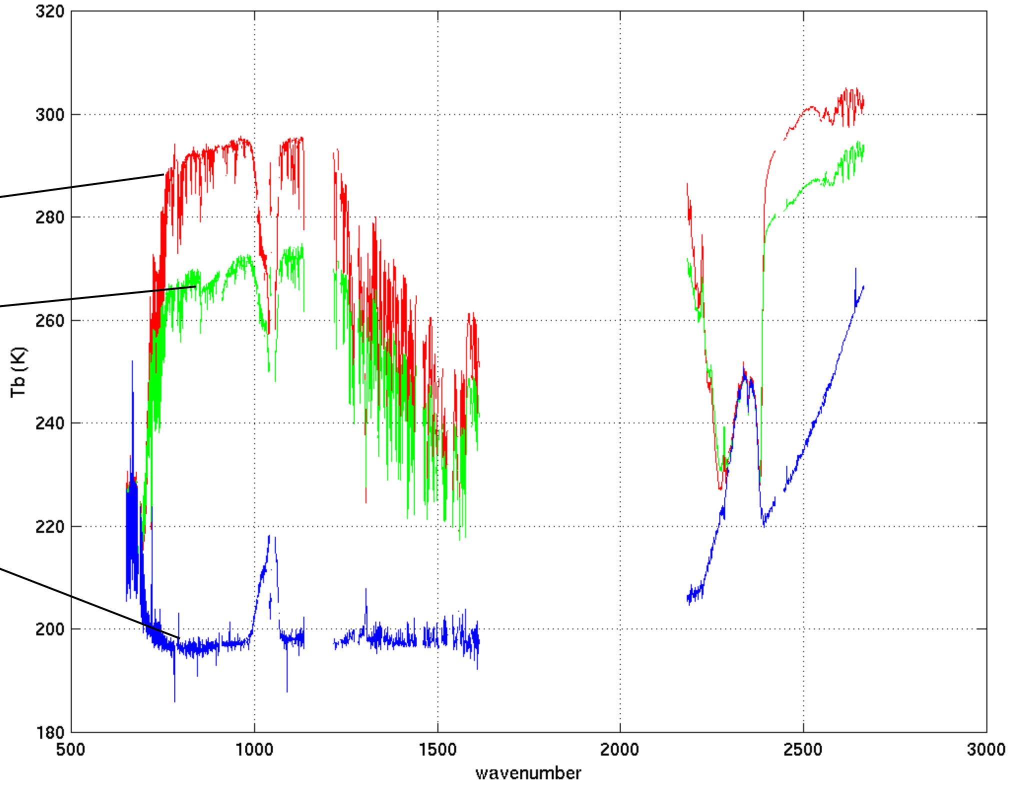
High spectral resolution advanced sounder will have more and sharper weighting functions compared to current GOES sounder. Retrievals will have 3 to 4 x better vertical resolution.

Brightness Temperature Spectra reveal changes in atmosphere from eye to boundary of Tropical Cyclone

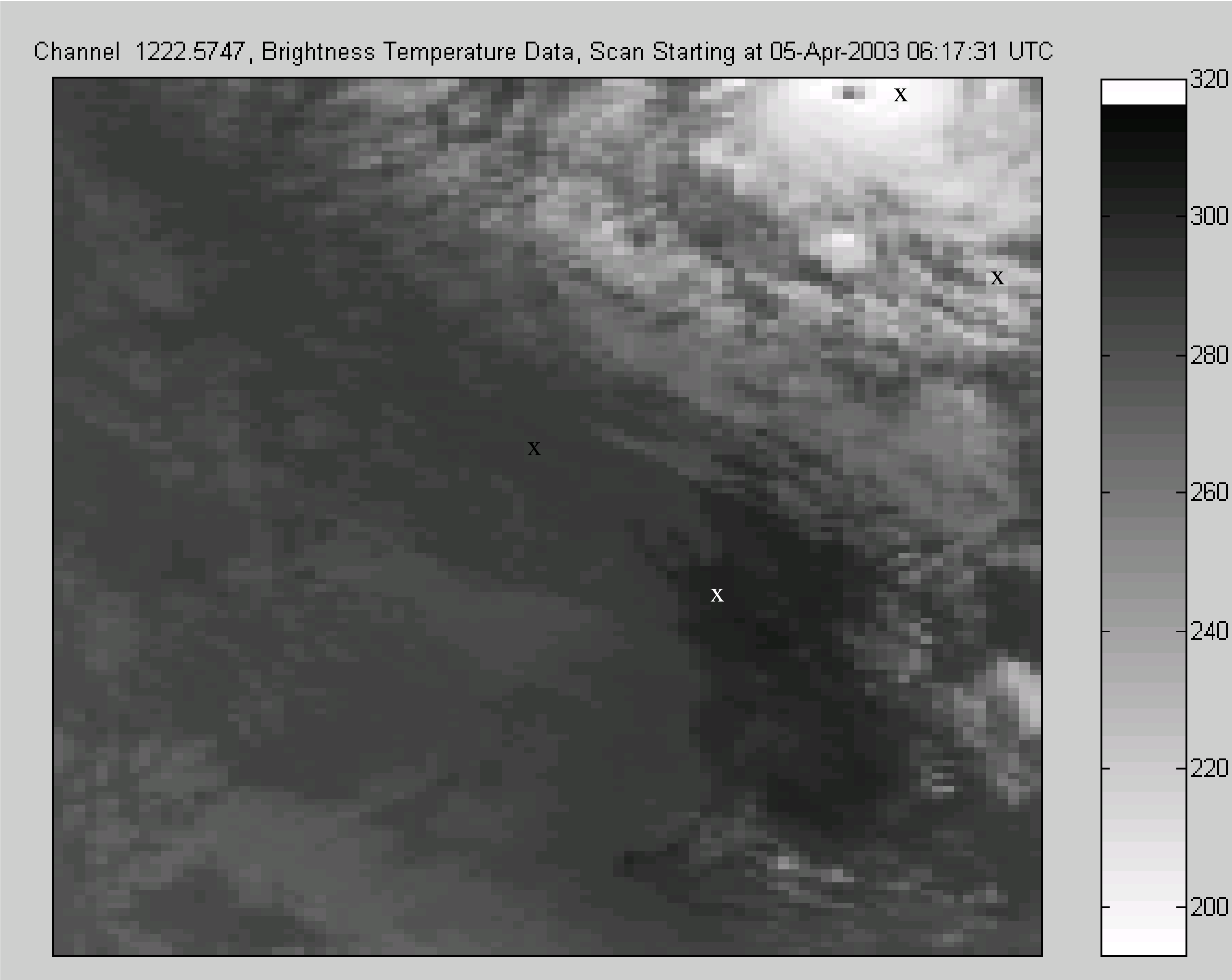
~999 1/cm radiances



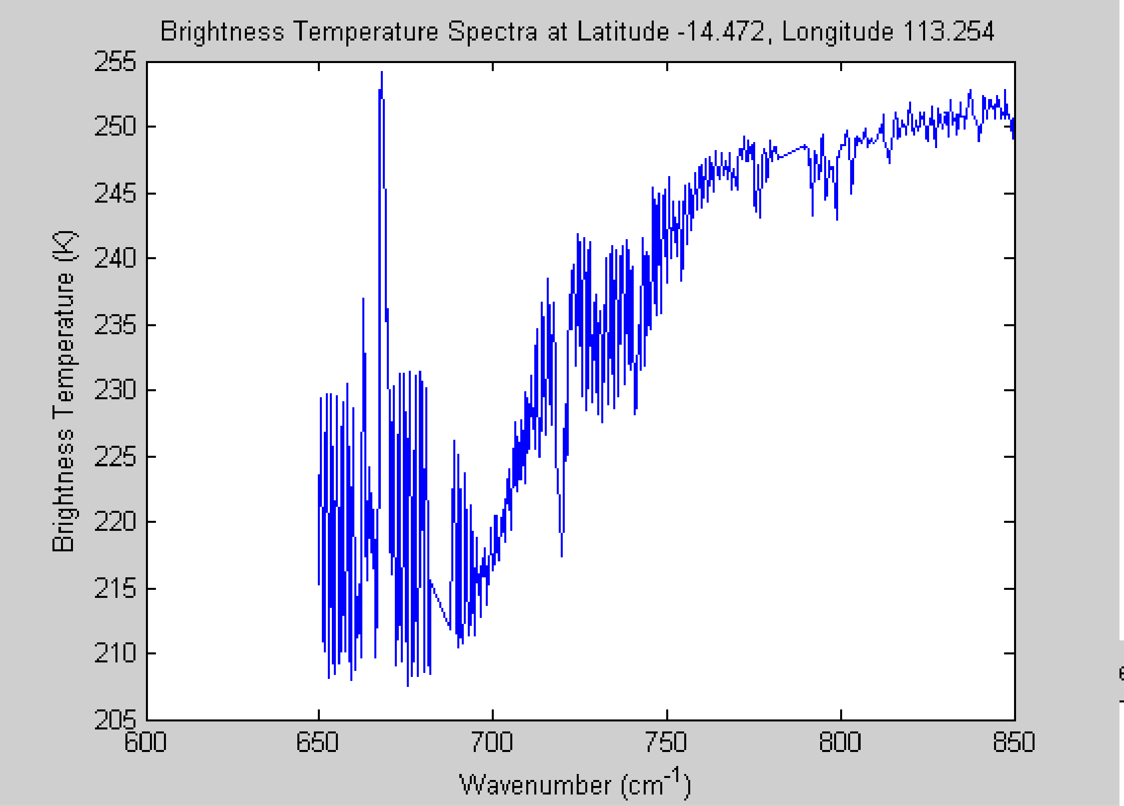
Brightness temperature spectra

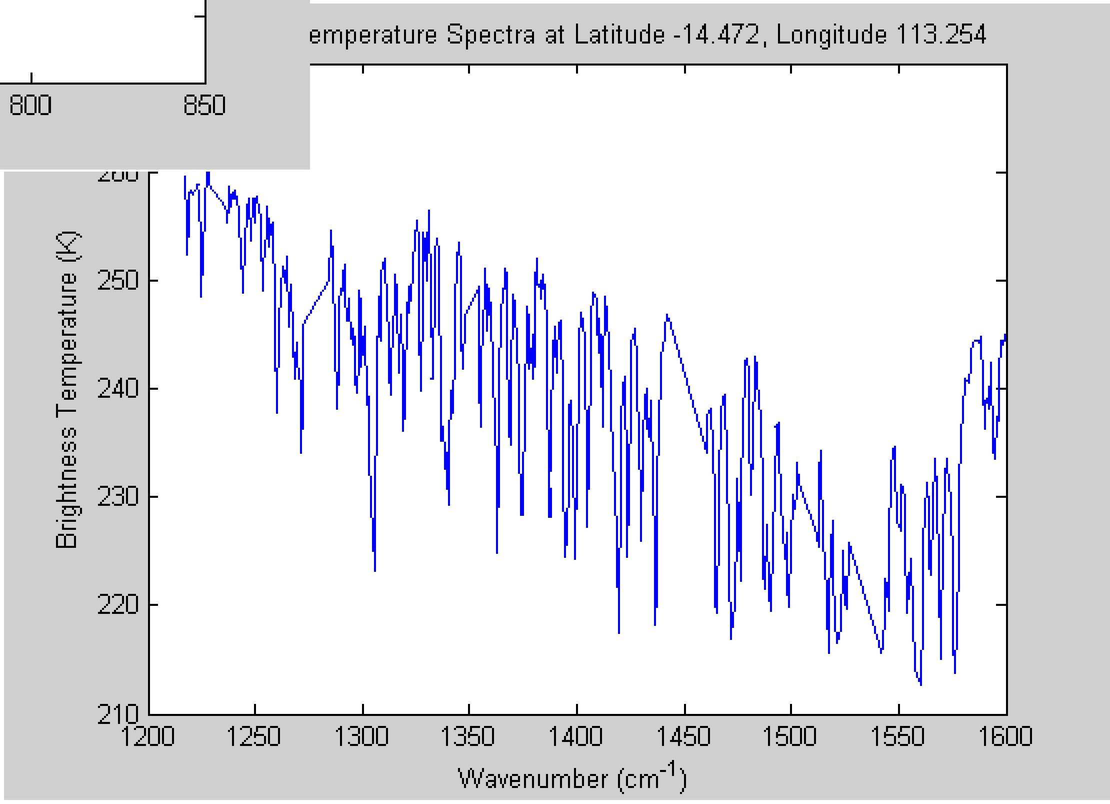


AIRS observations of tropical storm Isadore
on 22 Sept 2002 @ ~19:12-19:18 UTC

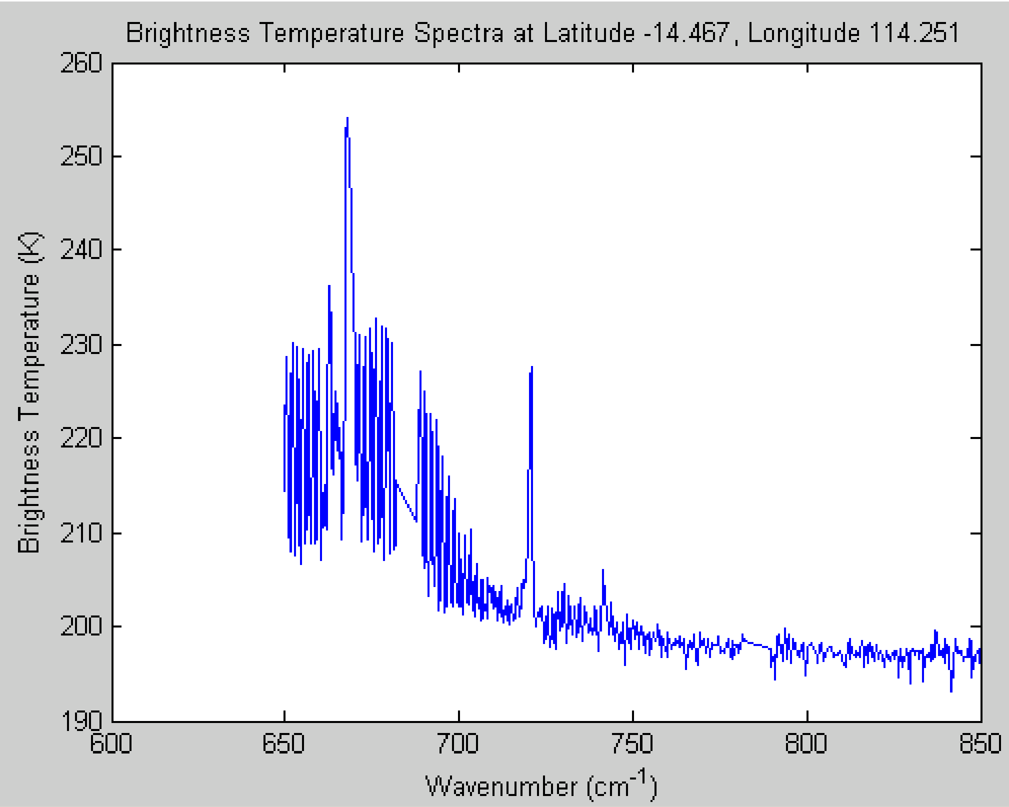


Channel 1222.5747, Brightness Temperature Data, Scan Starting at 05-Apr-2003 06:17:31 UTC
X
X
X
X
320
300
280
260
240
220
200

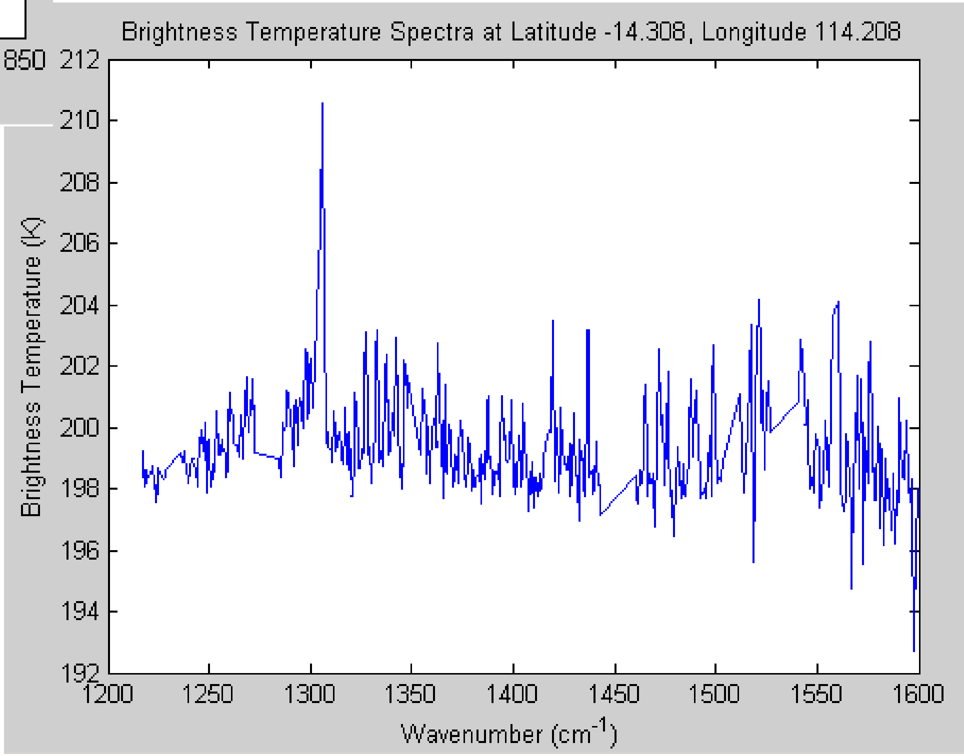


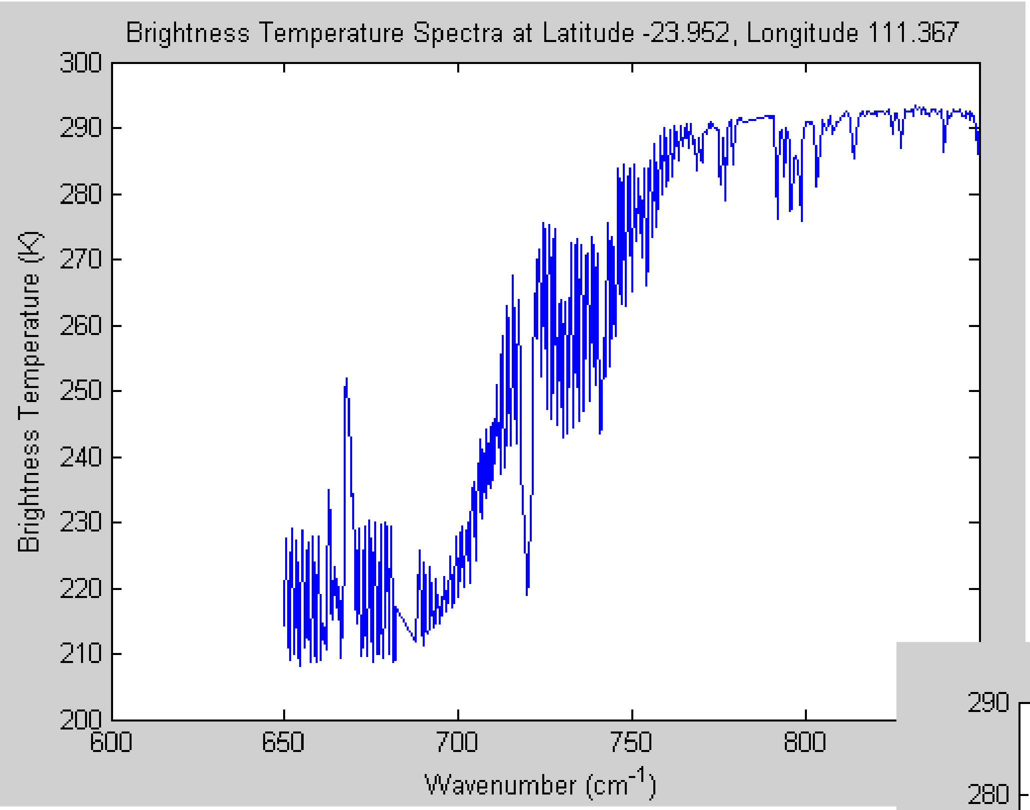


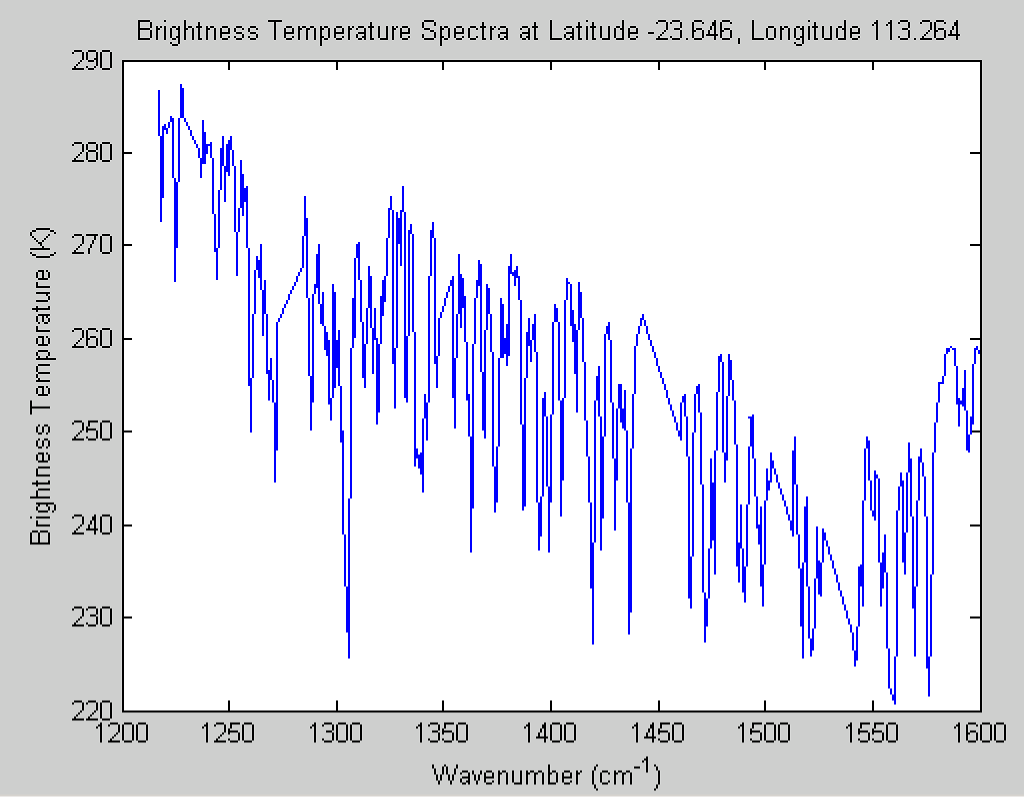
BT spectra in eye of TC Inigo



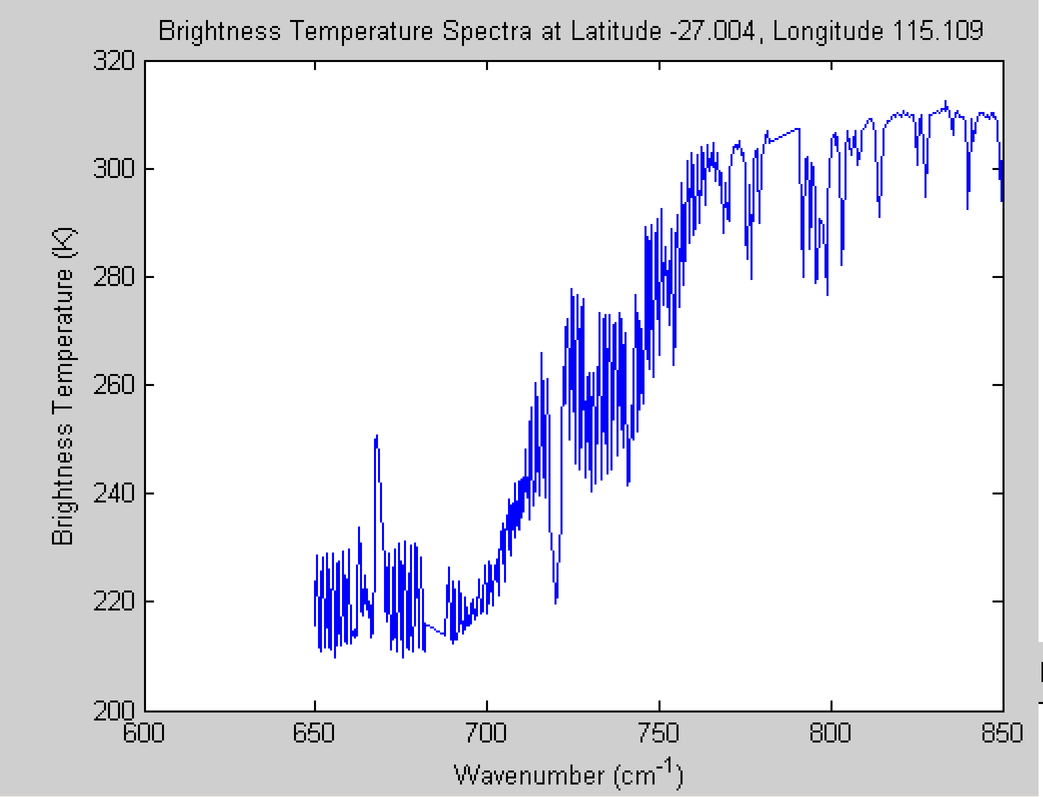
BT spectra in cloud next to eye of TC Inigo

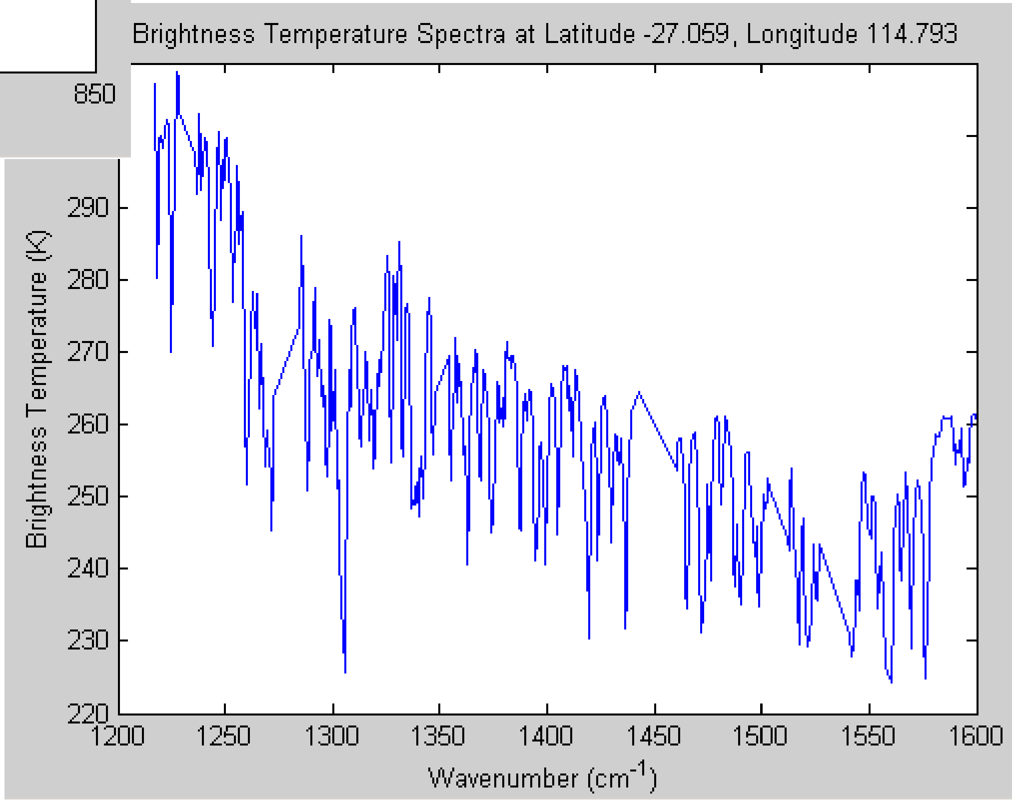




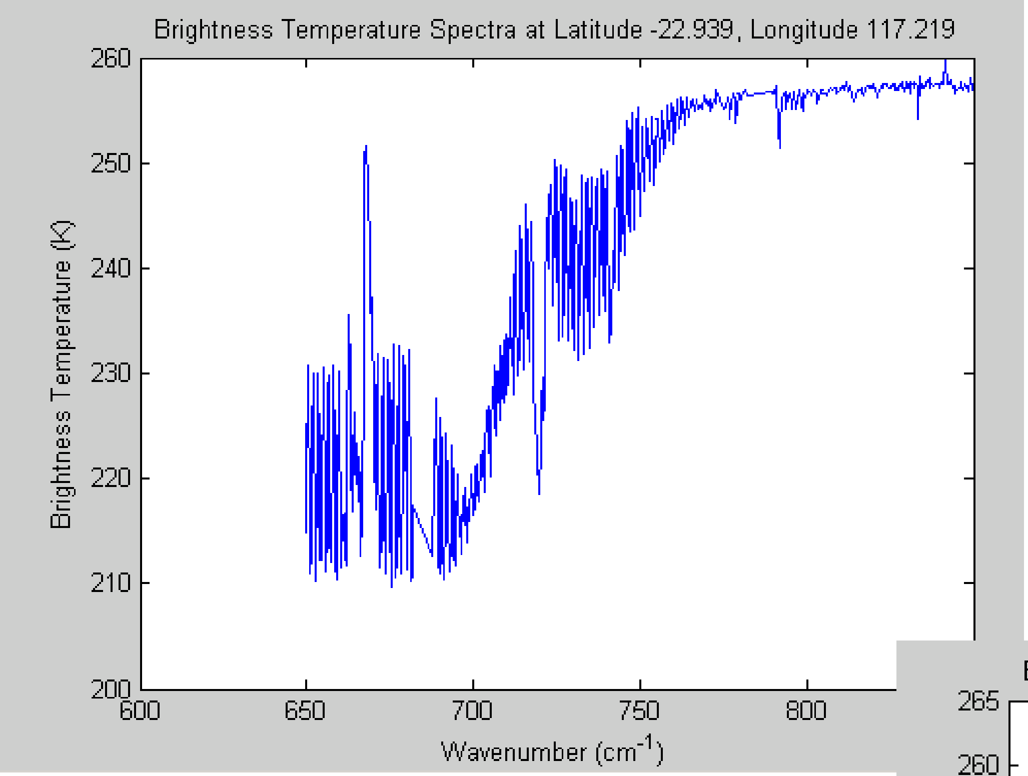


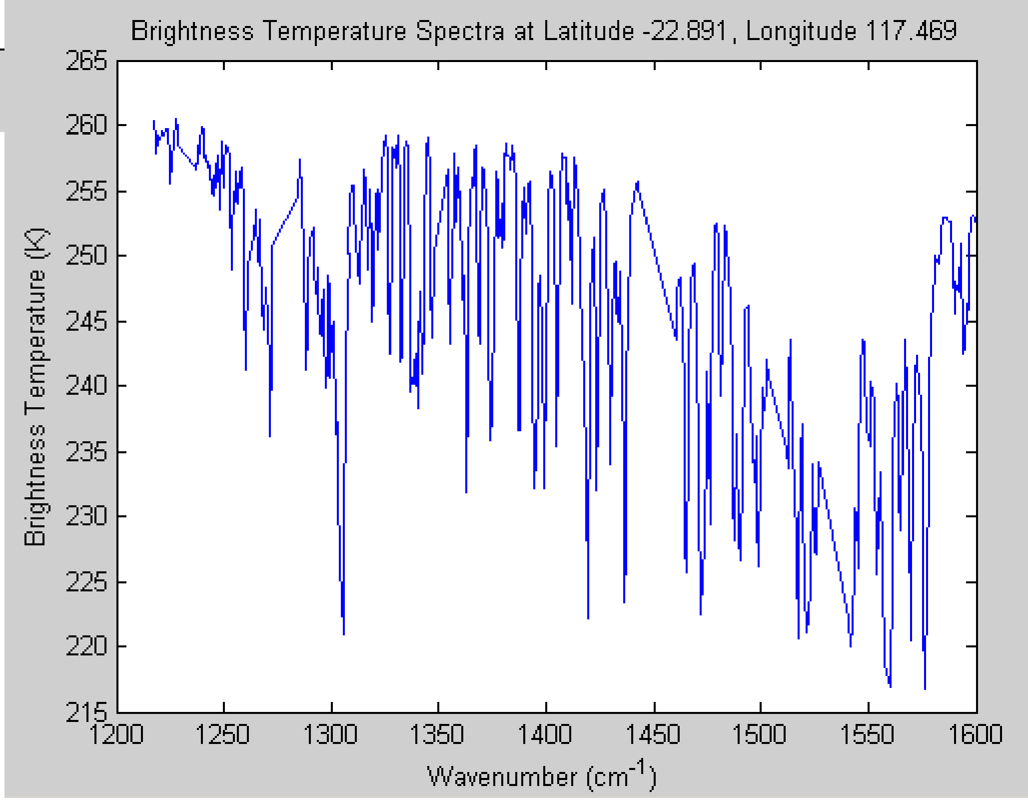
BT spectra in clear ocean outside of TC Inigo





BT spectra in clear land outside of TC Inigo





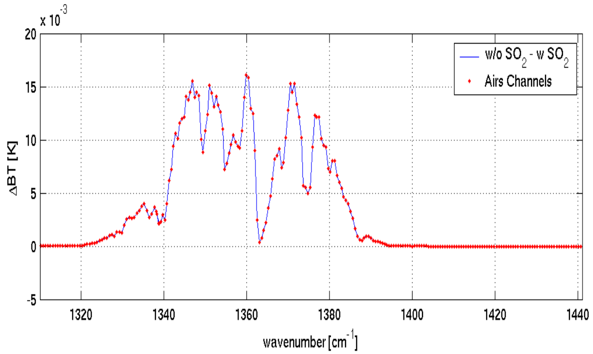
BT spectra in low cloud on periphery of TC Inigo

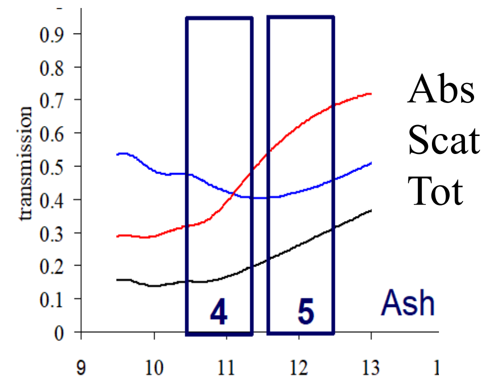
Mt Etna eruption

28 October 2002
ISS photo

28 October 2002
MODIS Aqua

Anatahan Volcano viewed with AIRS



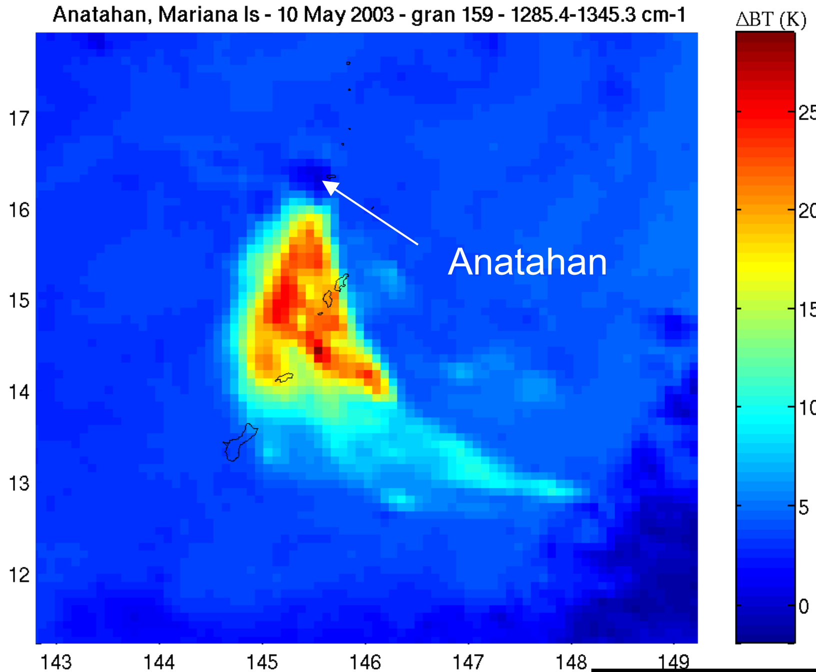


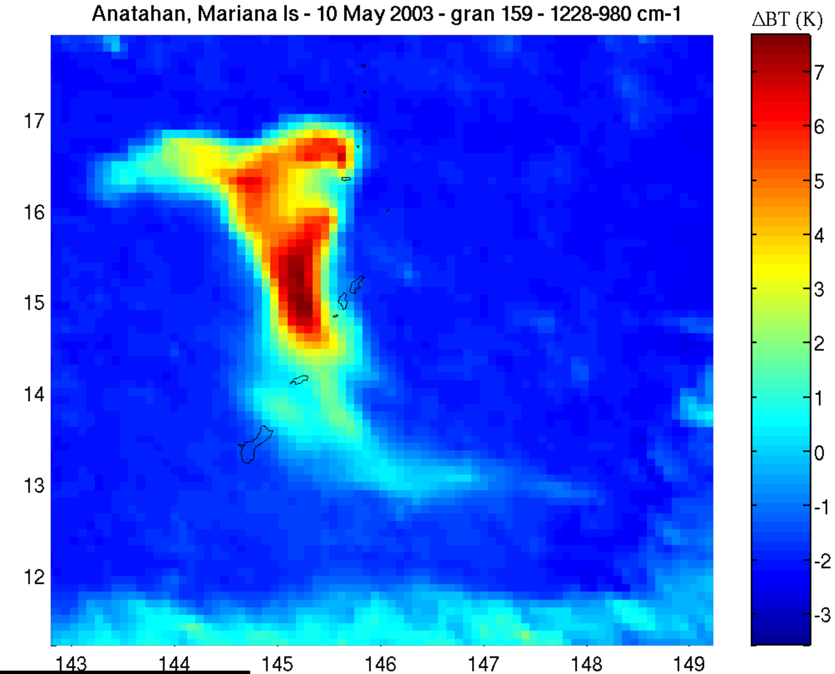
SO_2 signal

1284-1345 cm^{-1}

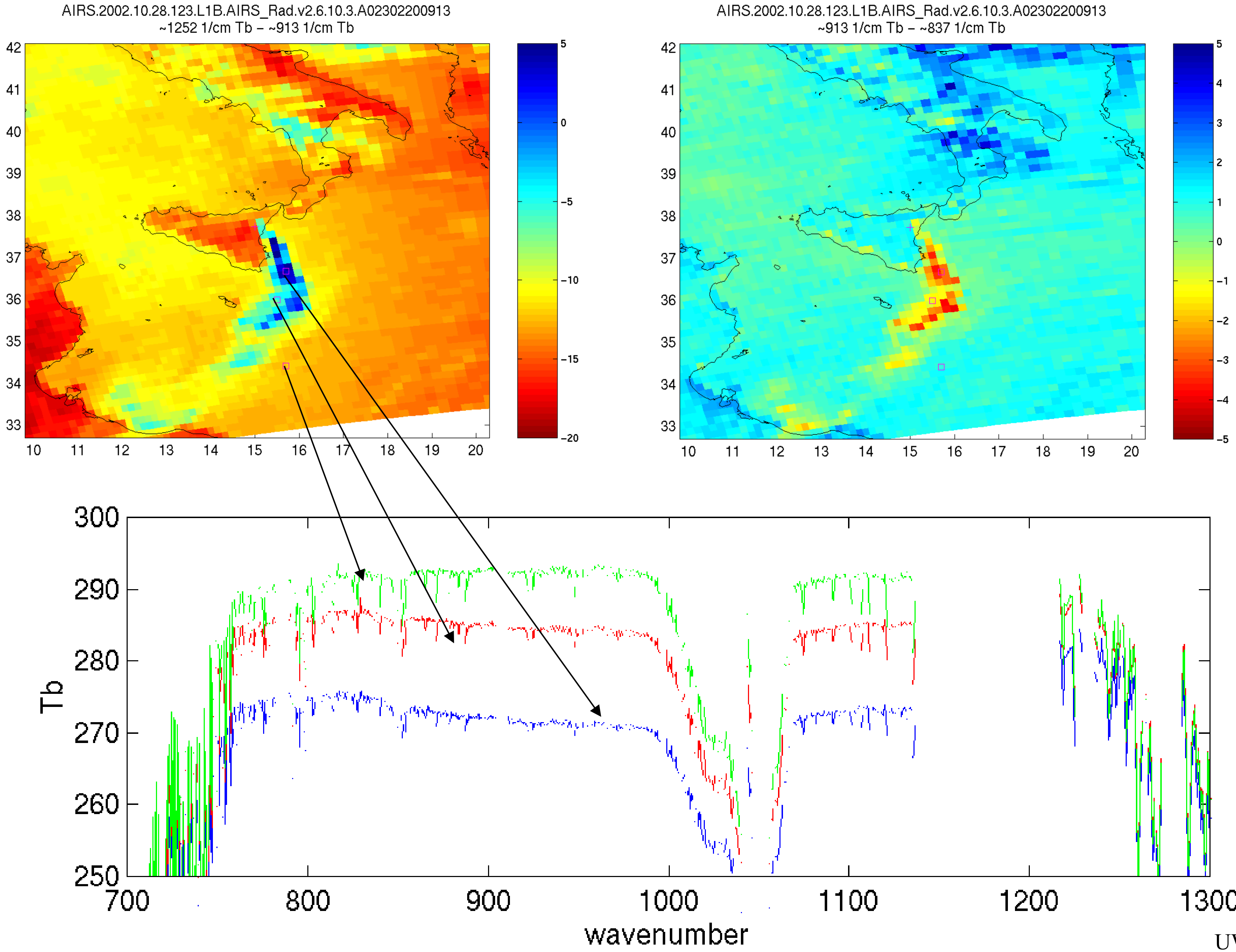
Ash signal

1228-995 cm^{-1}



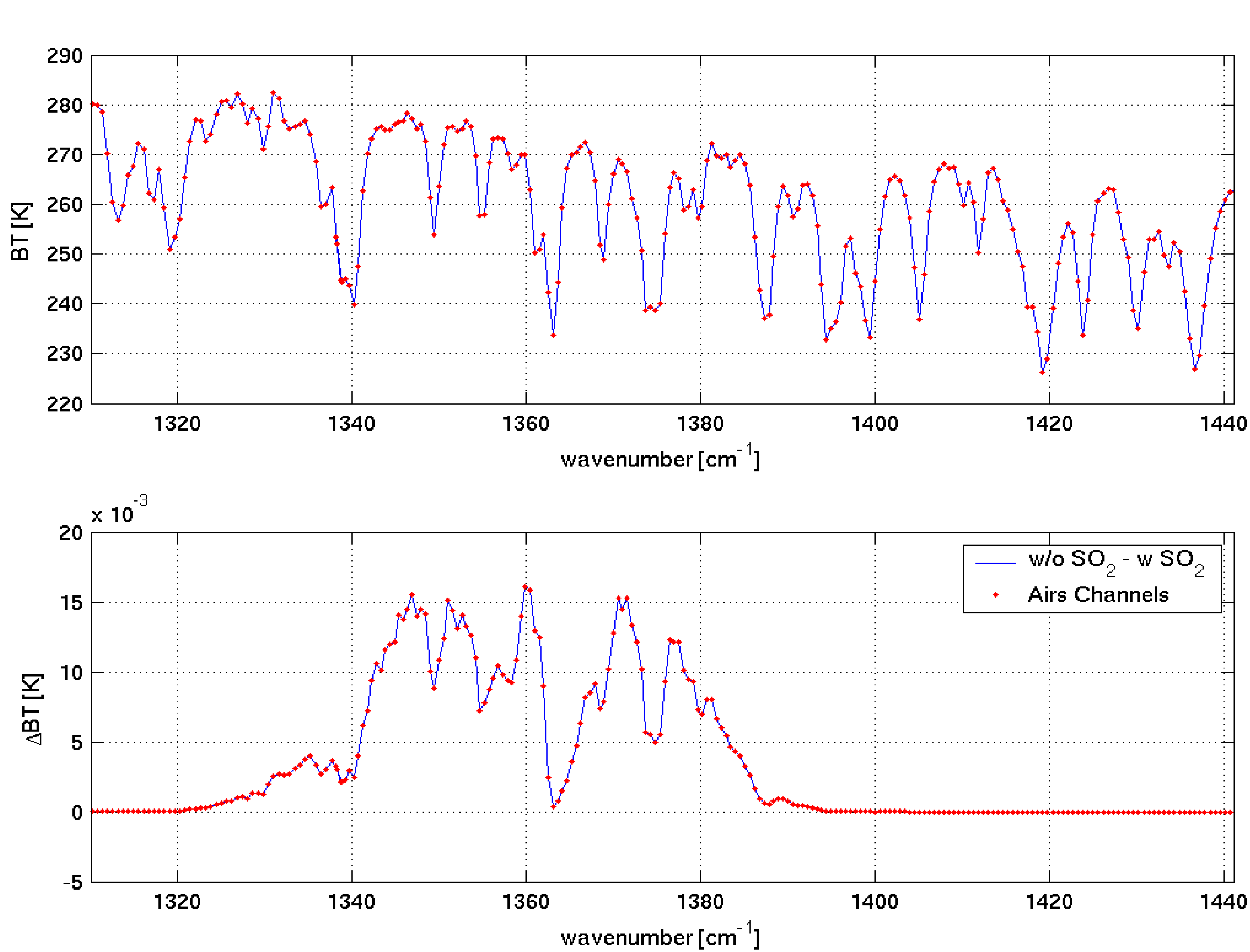


10 May 2003 (1554 UT)

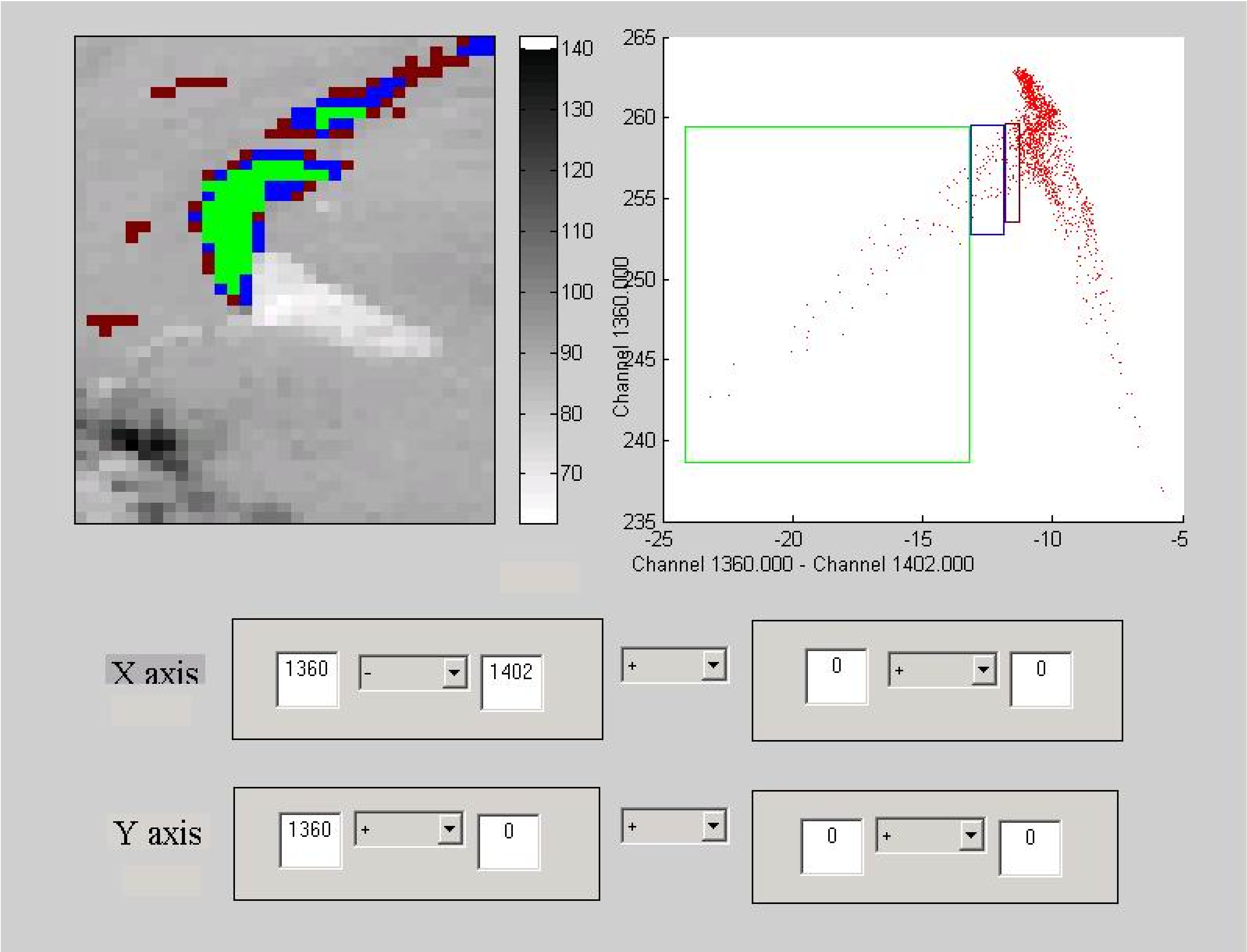


AIRS.2002.10.28.123.L1B.AIRS_Rad.v2.6.10.3.A02302200913
~1252 1/cm Tb – ~913 1/cm Tb
AIRS.2002.10.28.123.L1B.AIRS_Rad.v2.6.10.3.A02302200913
~913 1/cm Tb – ~837 1/cm Tb
Tb
wavenumber

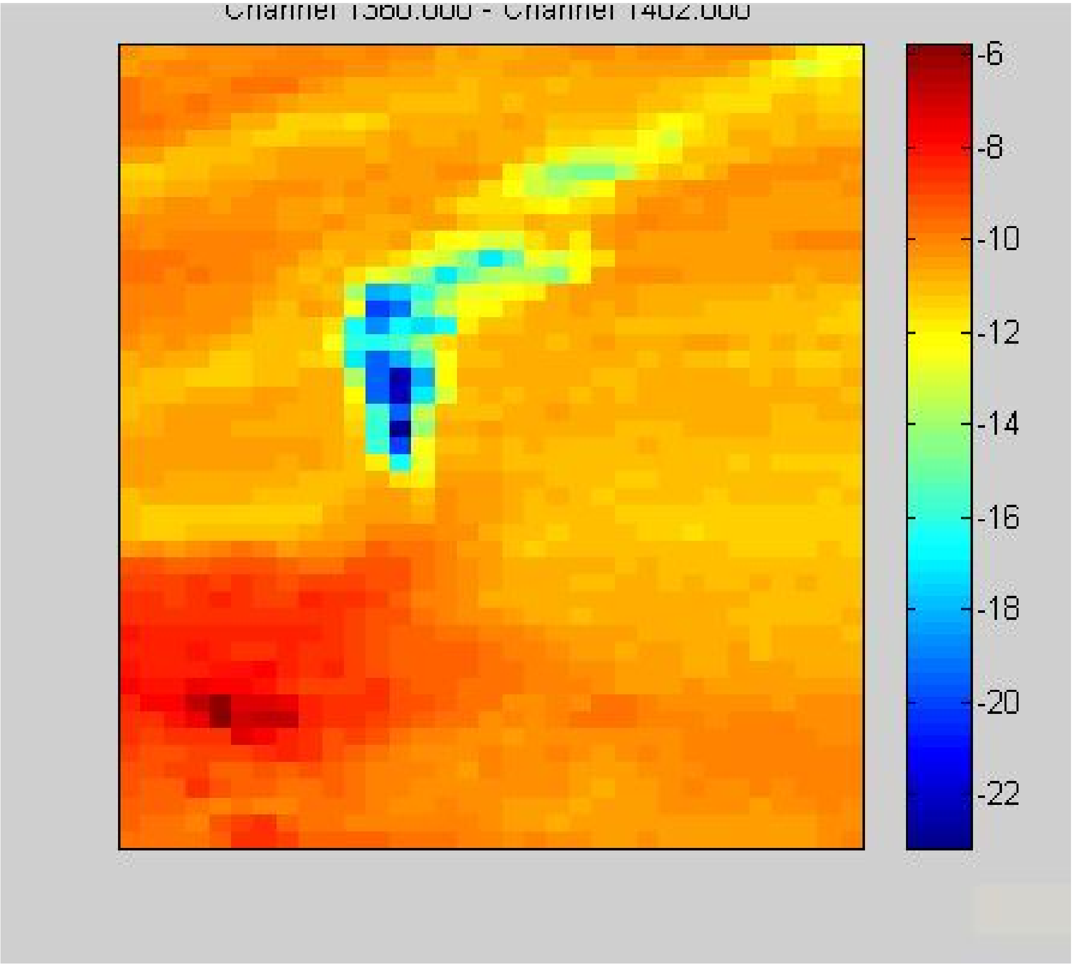
UW
CIMSS

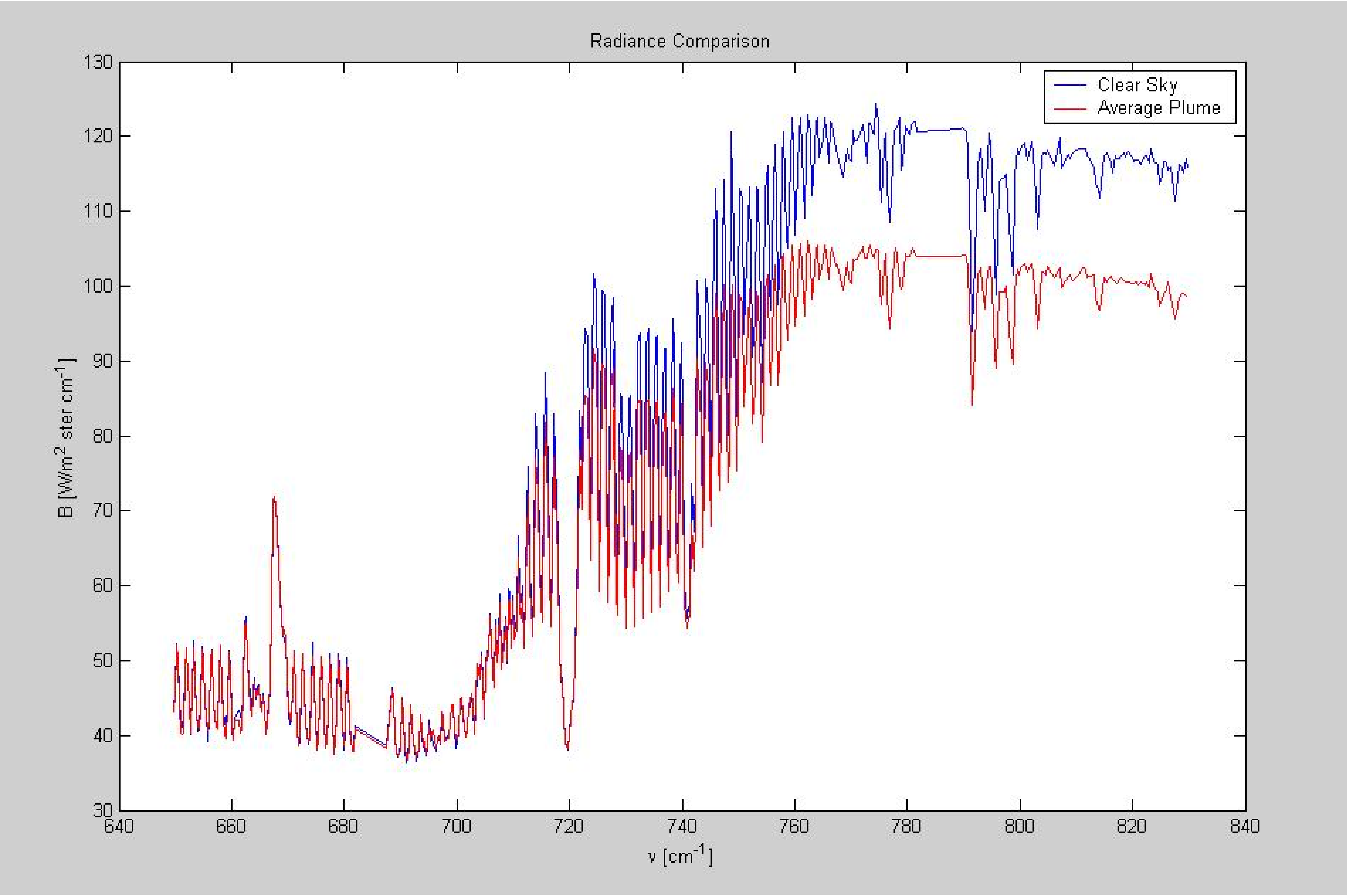


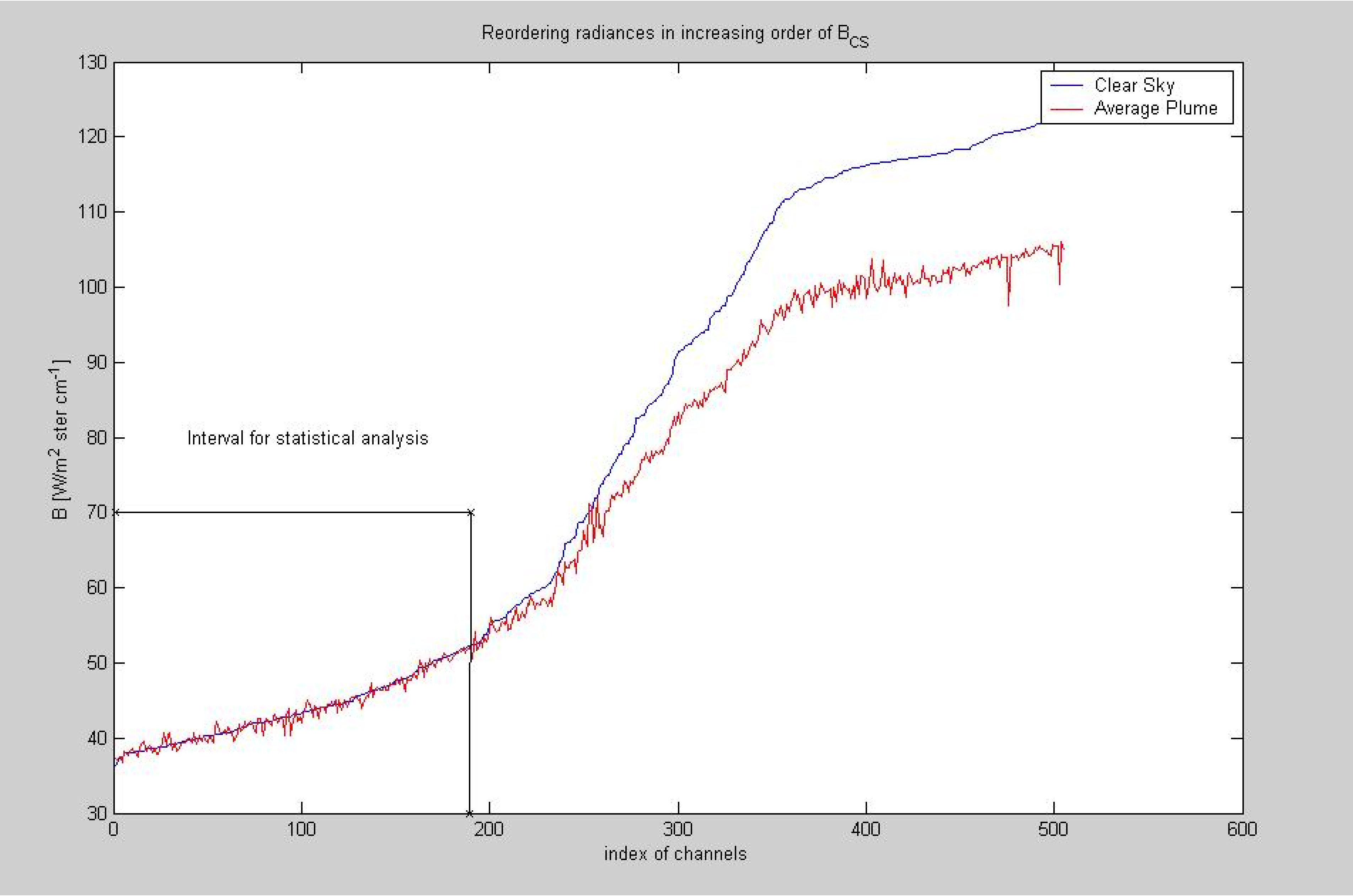
290
280
270
260
250
240
230
220
BT [K]
1320
1340
1360
1380
1400
1420
1440
wavenumber [cm^-1]
x 10^-3
20
15
10
5
0
-5
ΔBT [K]
w/o SO2 - w SO2
Airs Channels
1320
1340
1360
1380
1400
1420
1440
wavenumber [cm^-1]

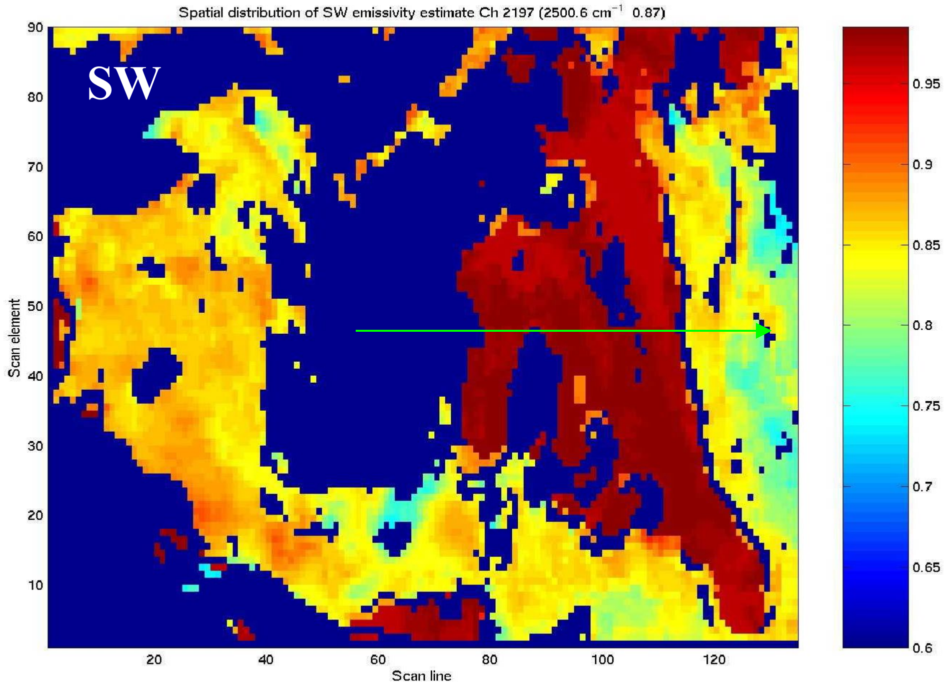


140
130
120
110
100
90
80
70
265
260
255
250
245
240
235
-25
-20
-15
-10
-5
Channel 1360.000
Channel 1360.000 - Channel 1402.000
X axis
1360
-
1402
+
0
+
0
Y axis
1360
+
0
+
0
+
0


Channel 1360.000 - Channel 1402.000
-6
-8
-10
-12
-14
-16
-18
-20
-22

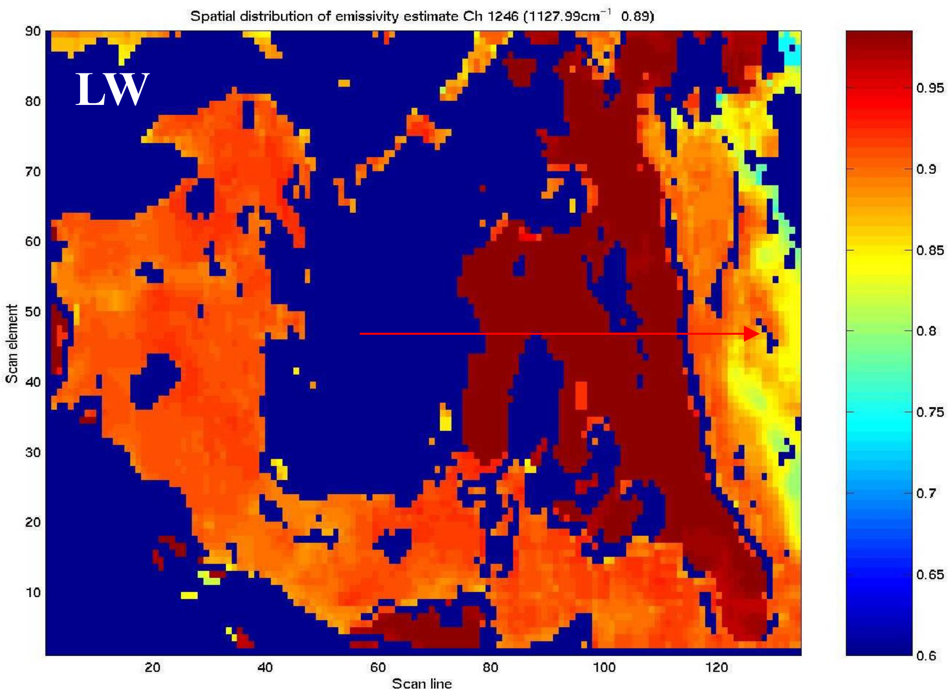

Radiance Comparison
Clear Sky
Average Plume
B [W/m2 ster cm-1]
ν [cm-1]
130
120
110
100
90
80
70
60
50
40
30
640
660
680
700
720
740
760
780
800
820
840

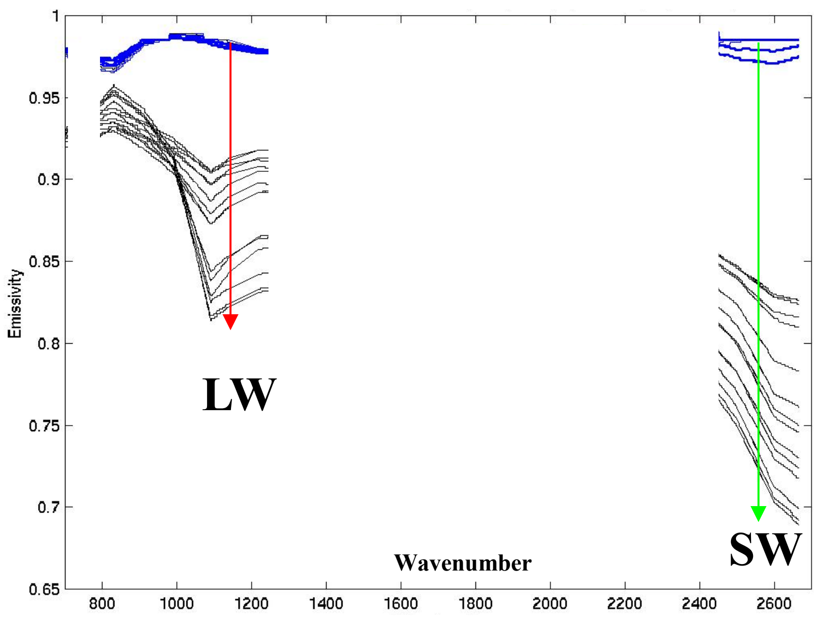

Reordering radiances in increasing order of B_CS
Clear Sky
Average Plume
Interval for statistical analysis
B [W/m2 ster cm-1]
index of channels
130
120
110
100
90
80
70
60
50
40
30
0
100
200
300
400
500
600



Characterizing Land and Sea Surfaces

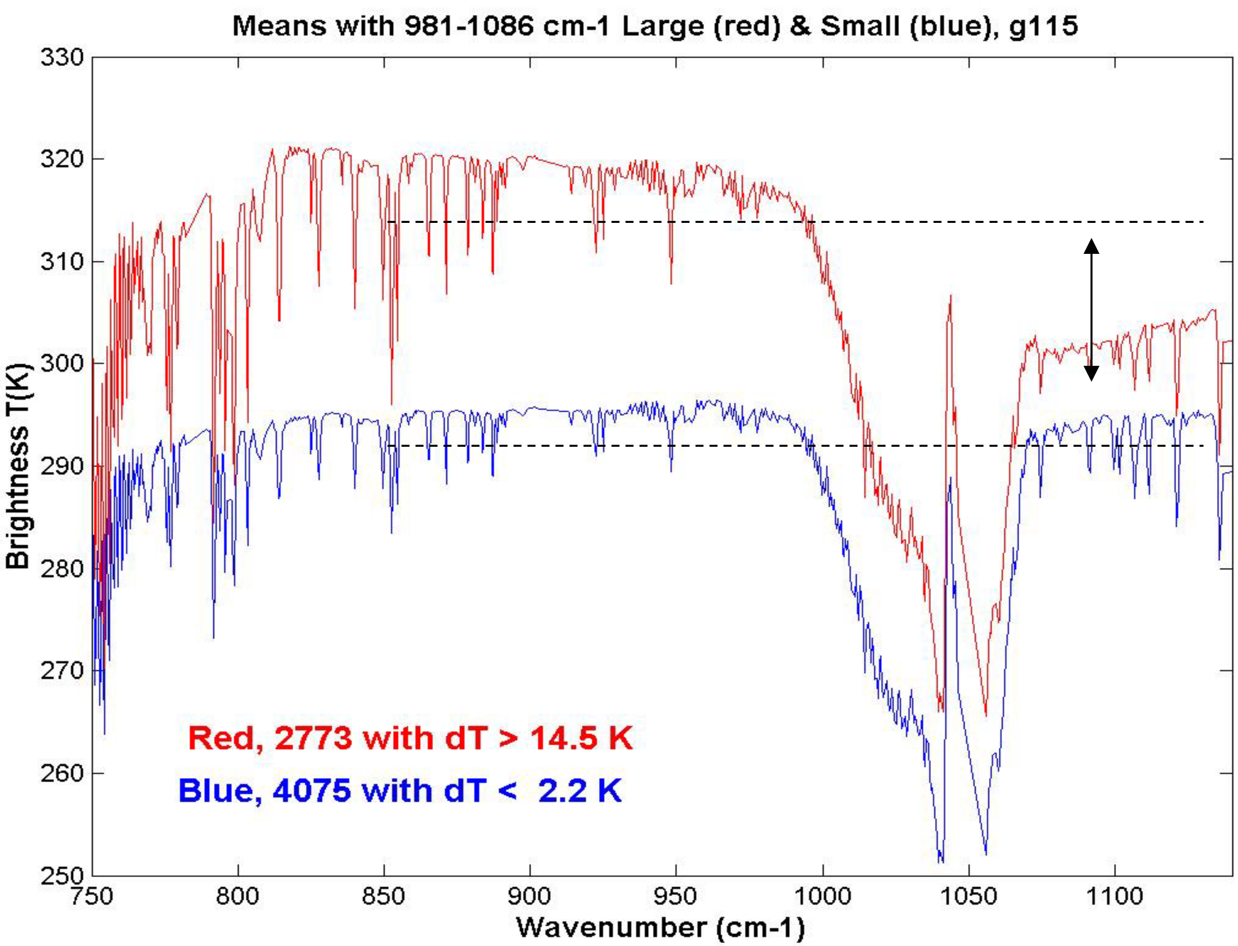
AIRS is enabling surface emissivity estimates from atmospheric window channel measurements. Example shows $\varepsilon_{sfc}(\lambda)$ over the Mediterranean Sea to Algeria to the Sahara Desert.





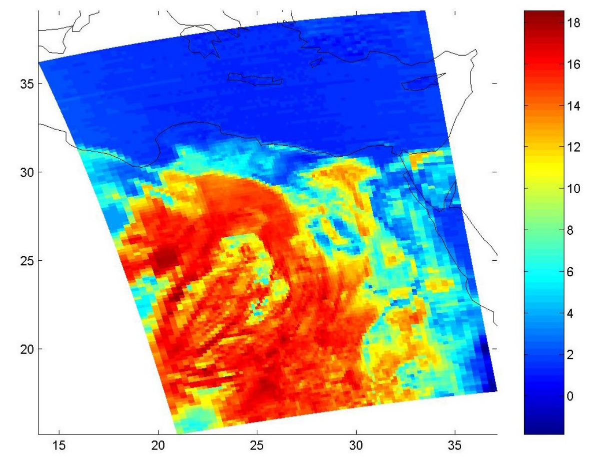
Inferring surface properties with AIRS high spectral resolution data
Barren region detection if T1086 < T981

Barren vs Water/Vegetated

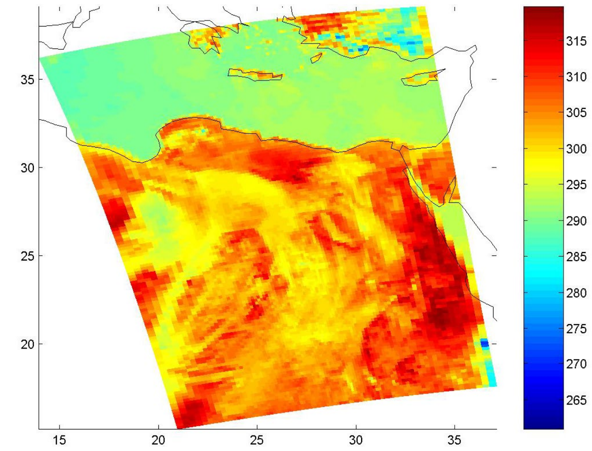


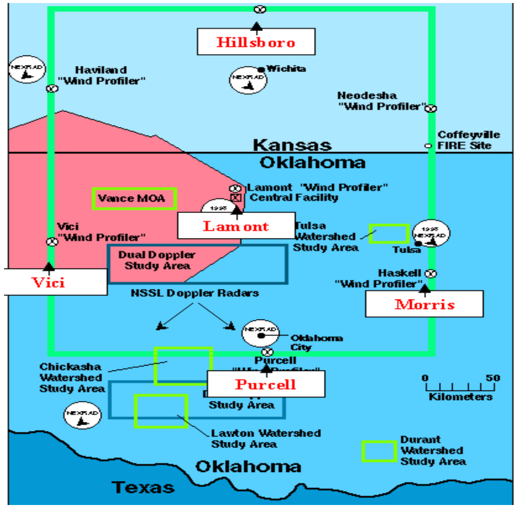
AIRS data from 14 June 2002

T(981 cm-1)-T(1086 cm-1)



T(1086 cm-1)





AERI & Profiler Network Depiction of Moisture Advection

Moisture Advection shows:

1 – A weakening low-level moisture source early in the period,

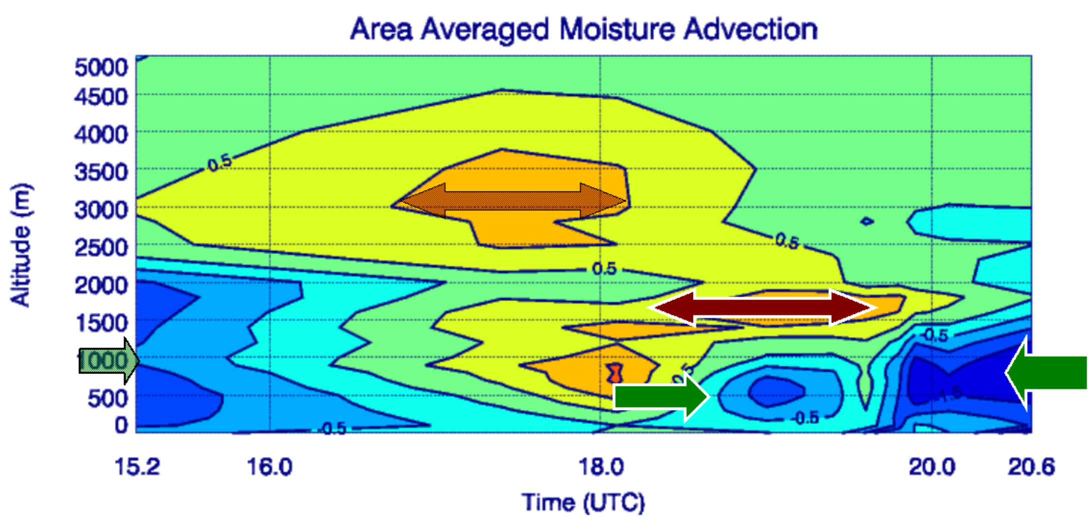
2 – Persistent drying aloft, including dominant source at the top of the "lid" during the later time periods *(helps maintain convective instability)*

3 – Rapid increase of low-level moisture convergence around 19Z, which

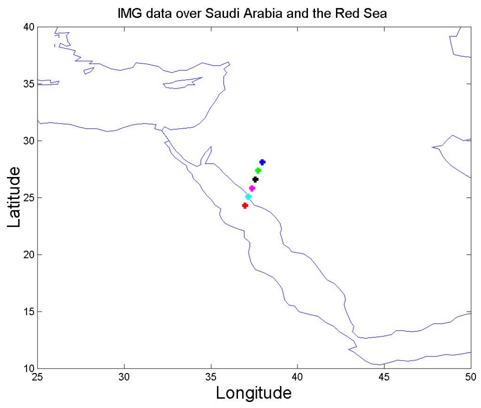
4 – Strengthens and play the dominating role at the end of the period *(supports growth of subsequent convection)*

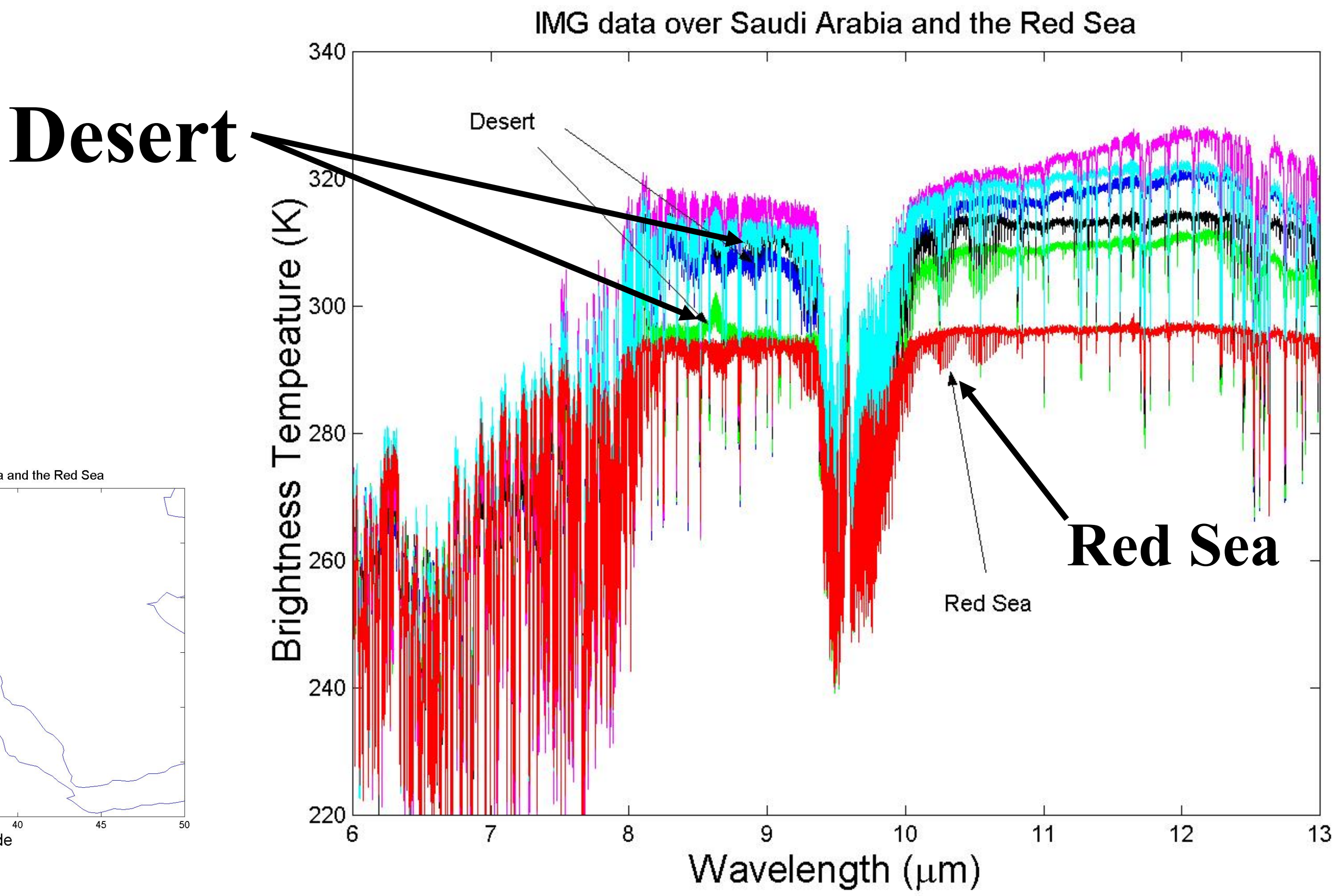
evolution of ***temperature*** and ***moisture*** fields using AERI data

evolution of ***wind*** fields using Profiler data



Hyperspectral Dust Observations

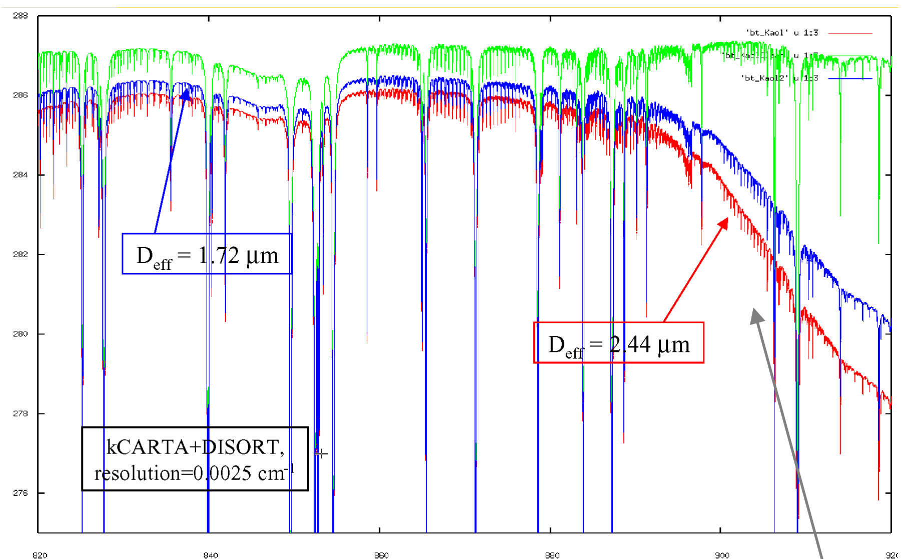




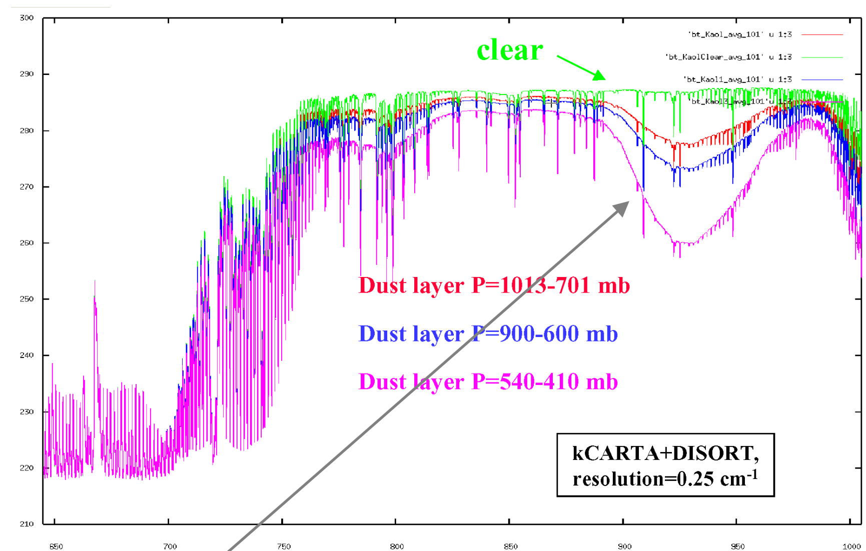
Hyperspectral Dust/Aerosol Modeling

Negative Slope – The Dust Signature

Green – Clear Spectrum



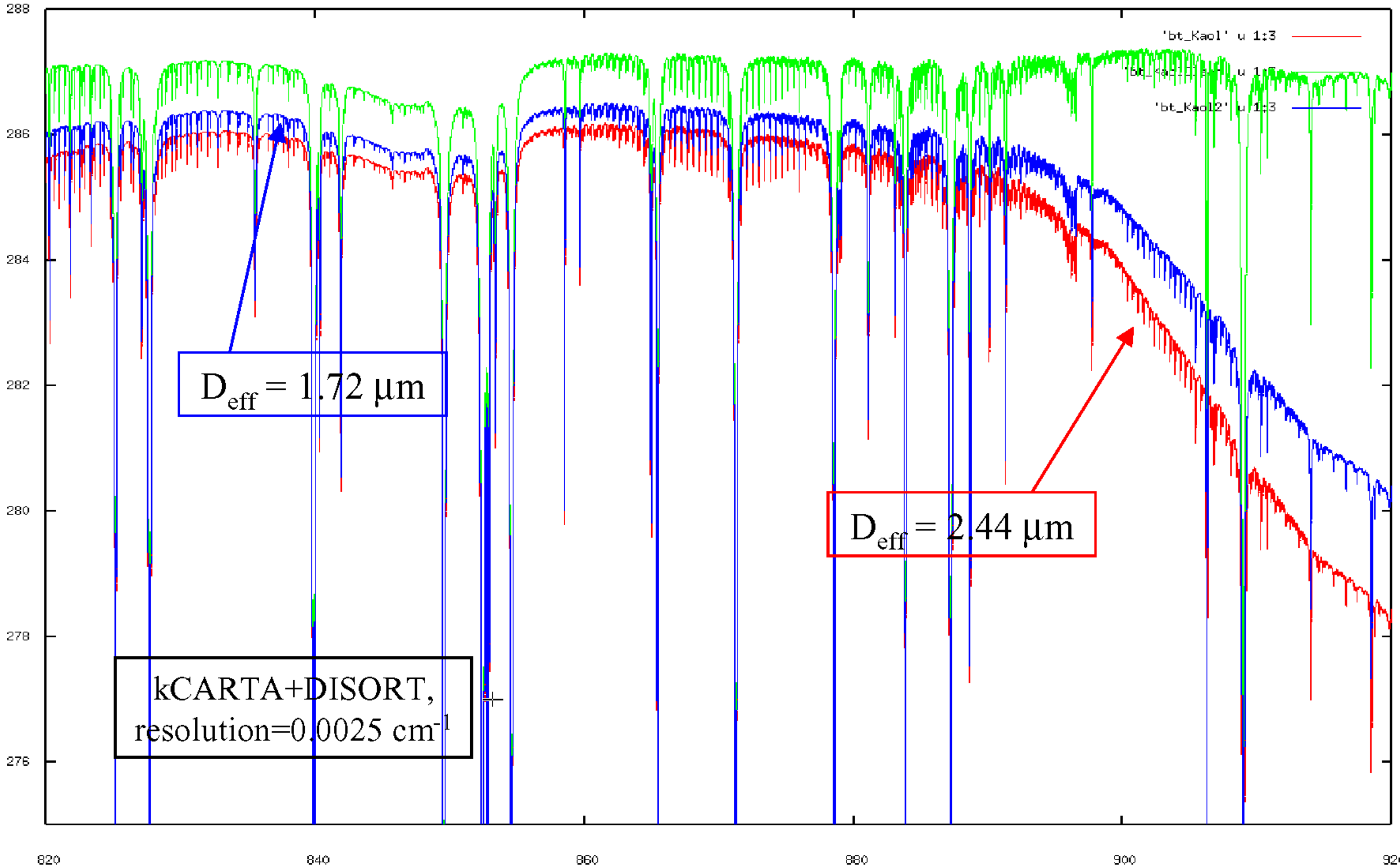
Effect of Dust Particle Sizes

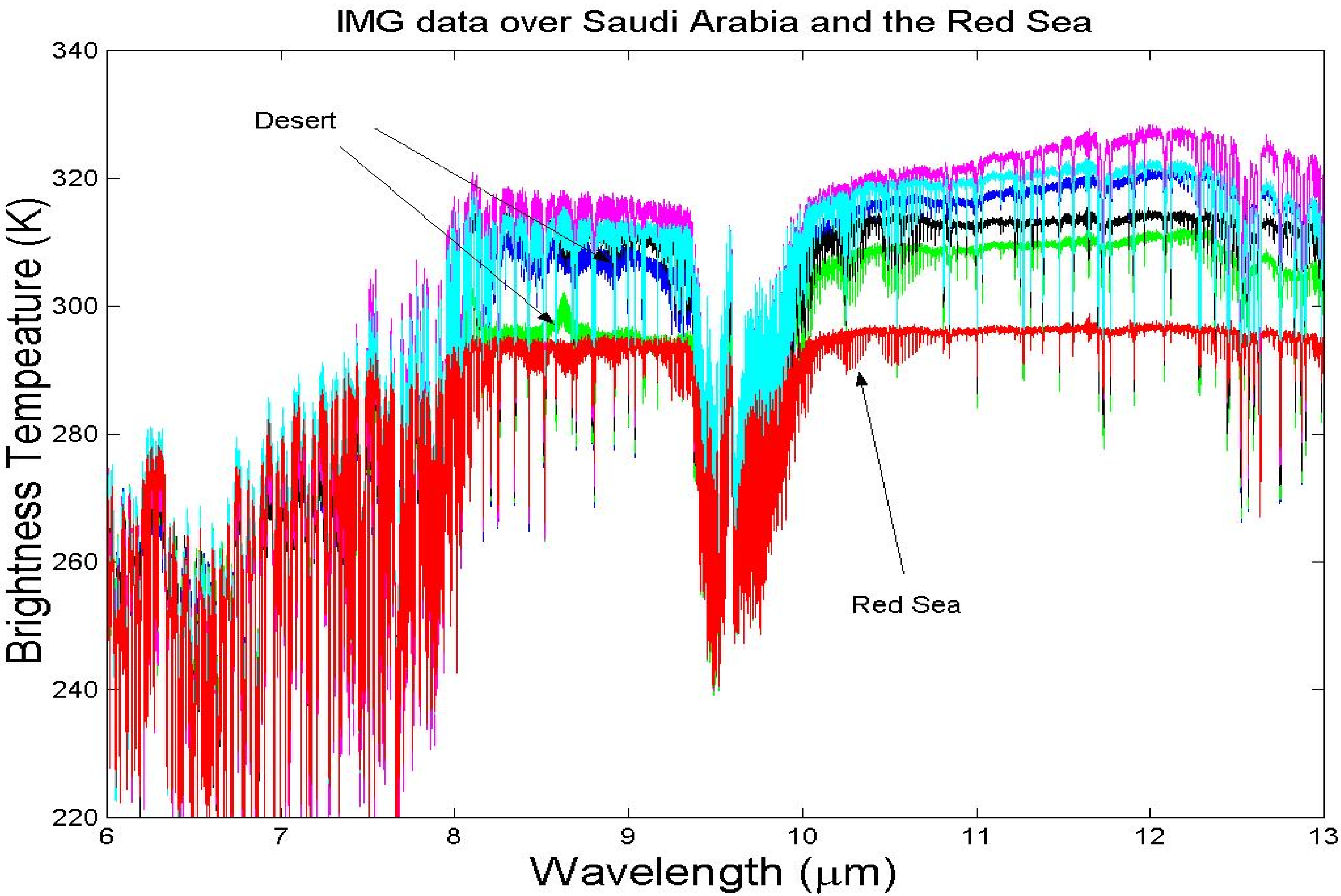


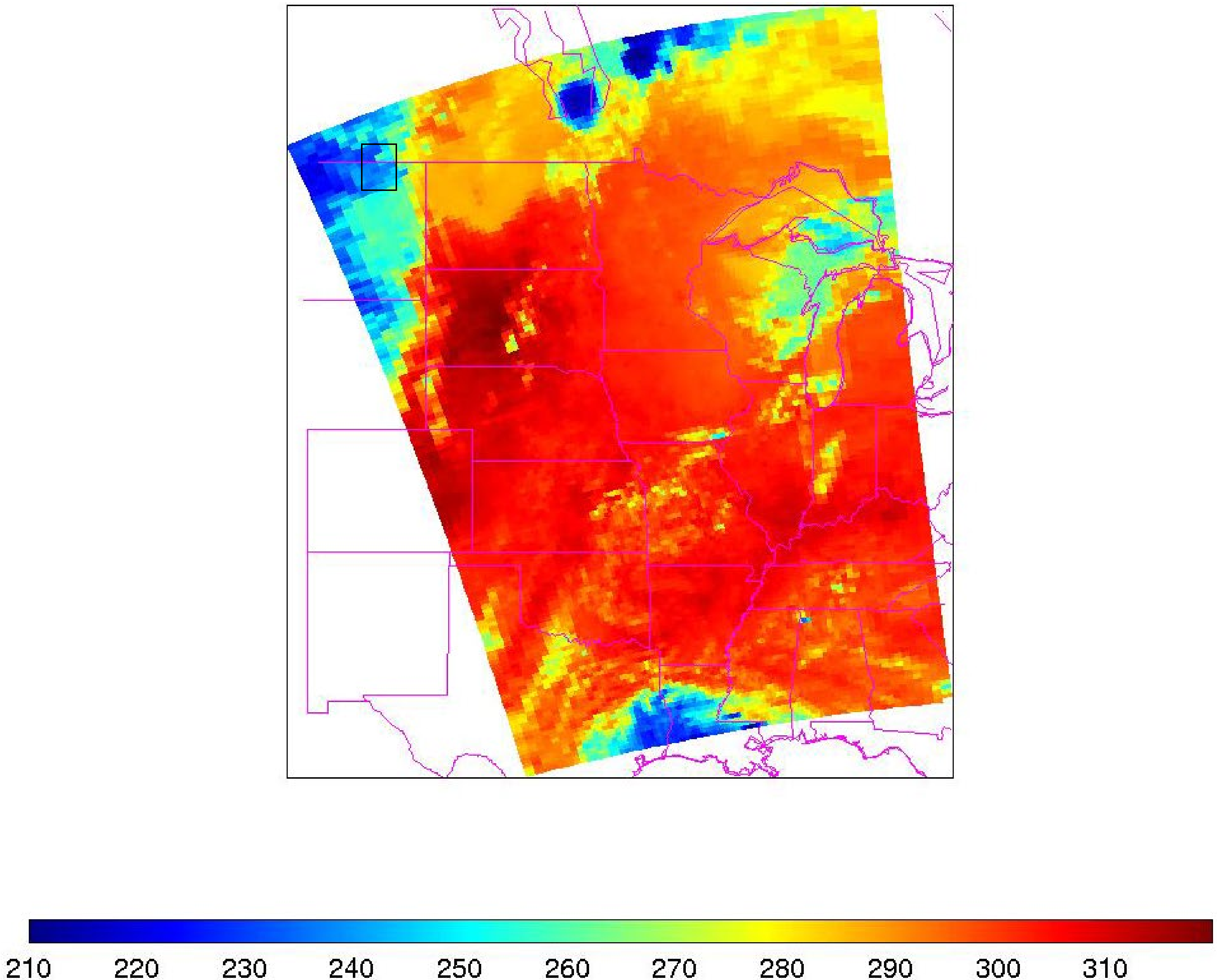
Effect of Dust Layer Location

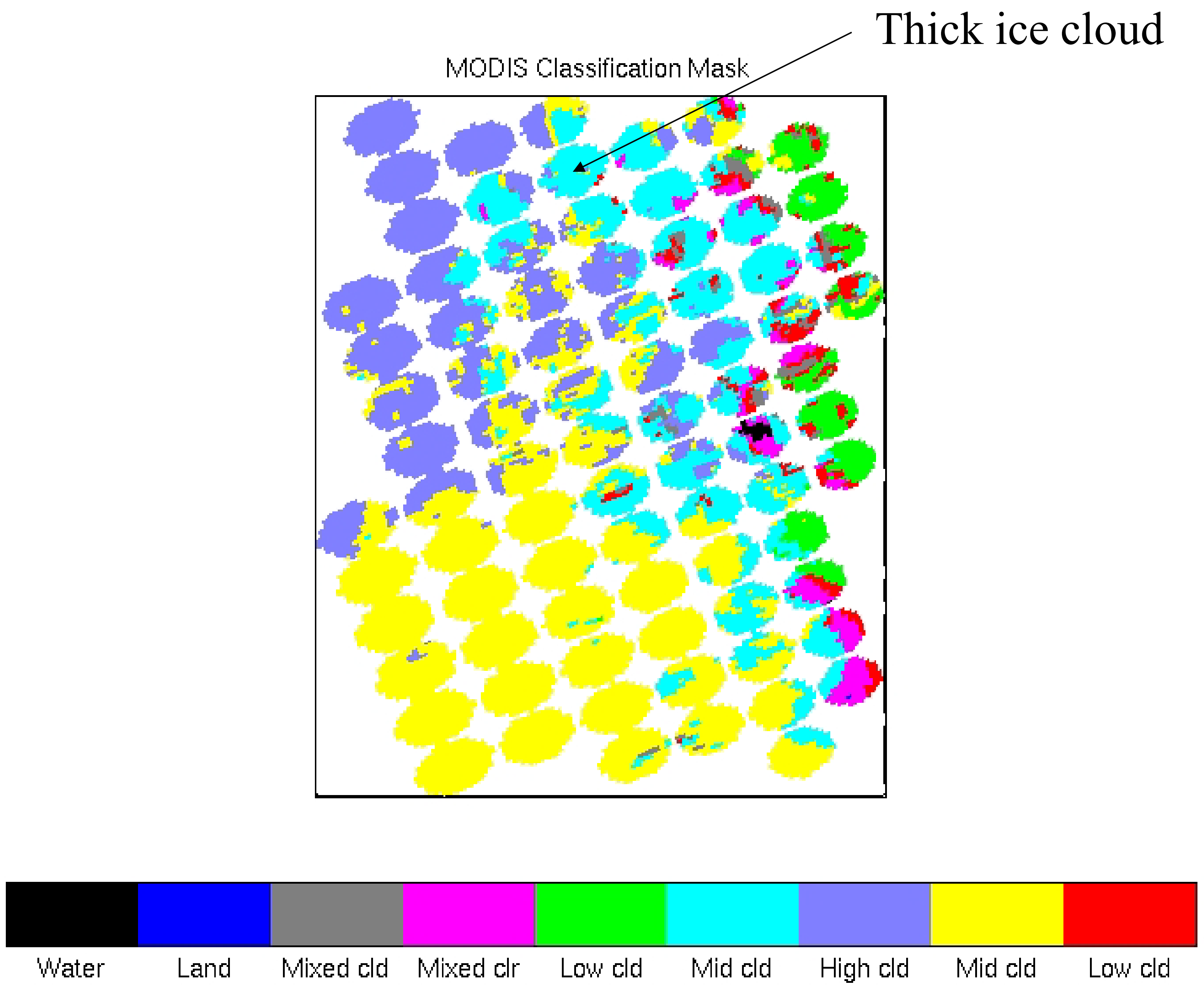
Negative slope

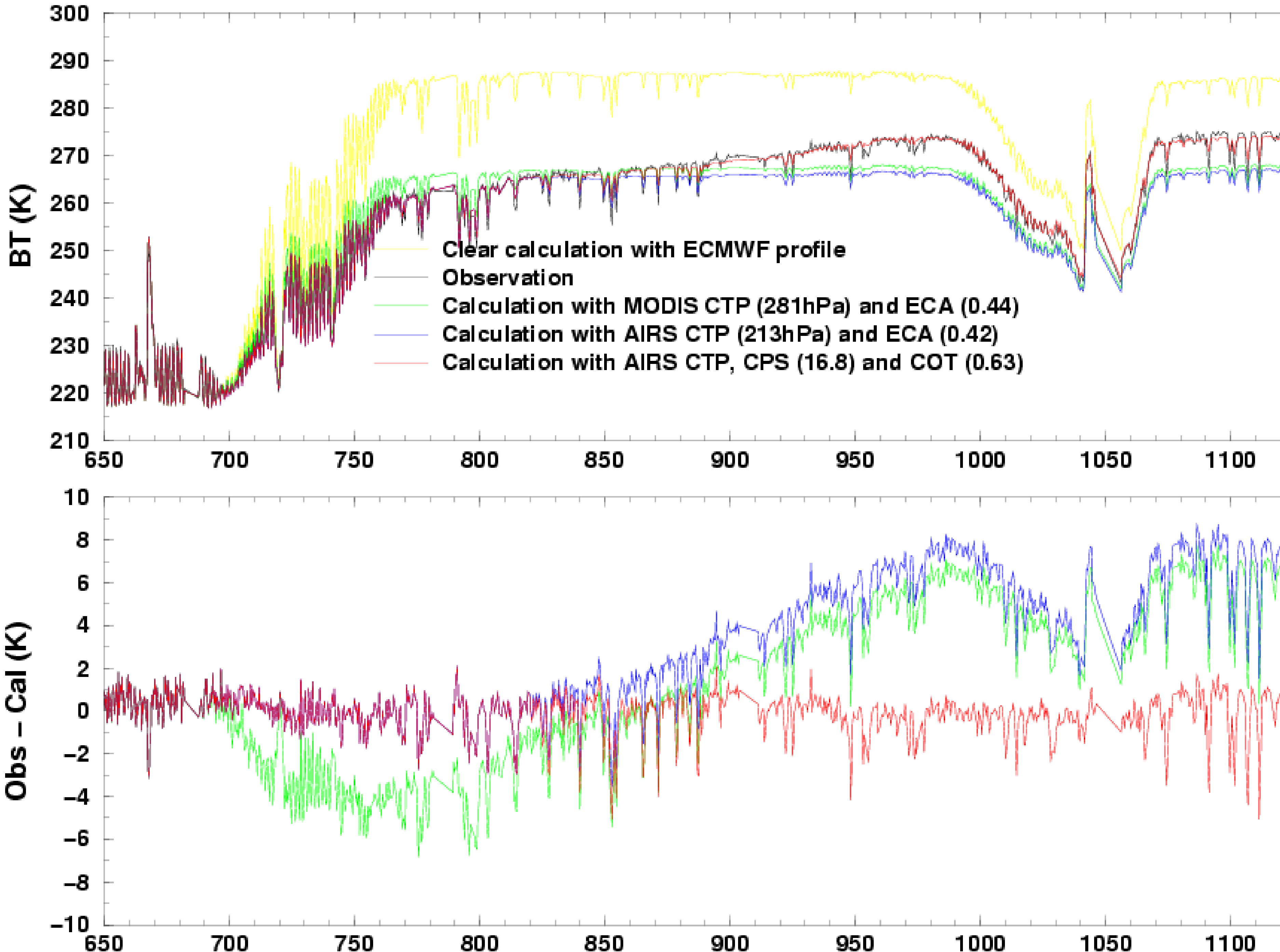
kCARTA+DISORT, spectral resolution = 0.0025 cm^{-1}


288
286
284
282
280
278
276
820
840
860
880
900
'bt_Kaol' u 1:3
'bt_Kaol2' u 1:3
D_eff = 1.72 μm
D_eff = 2.44 μm
kCARTA+DISORT,
resolution=0.0025 cm-1


IMG data over Saudi Arabia and the Red Sea
Brightness Tempeature (K)
Wavelength (μm)
Desert
Red Sea
340
320
300
280
260
240
220
6
7
8
9
10
11
12
13

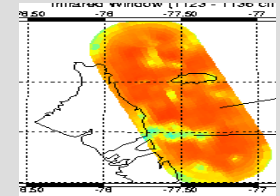

210
220
230
240
250
260
270
280
290
300
310


Thick ice cloud
MODIS Classification Mask
Water
Land
Mixed cld
Mixed clr
Low cld
Mid cld
High cld
Mid cld
Low cld

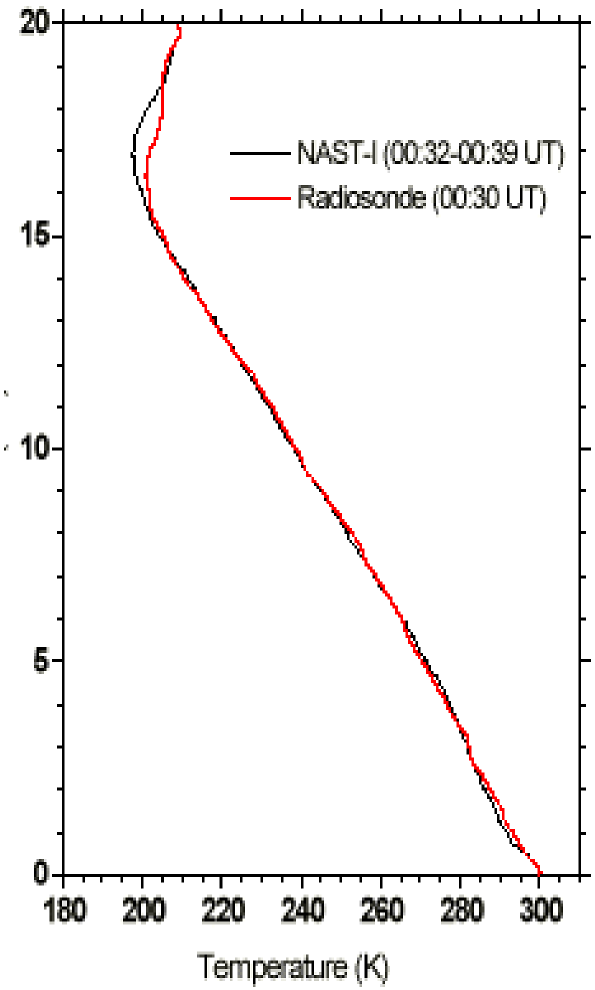


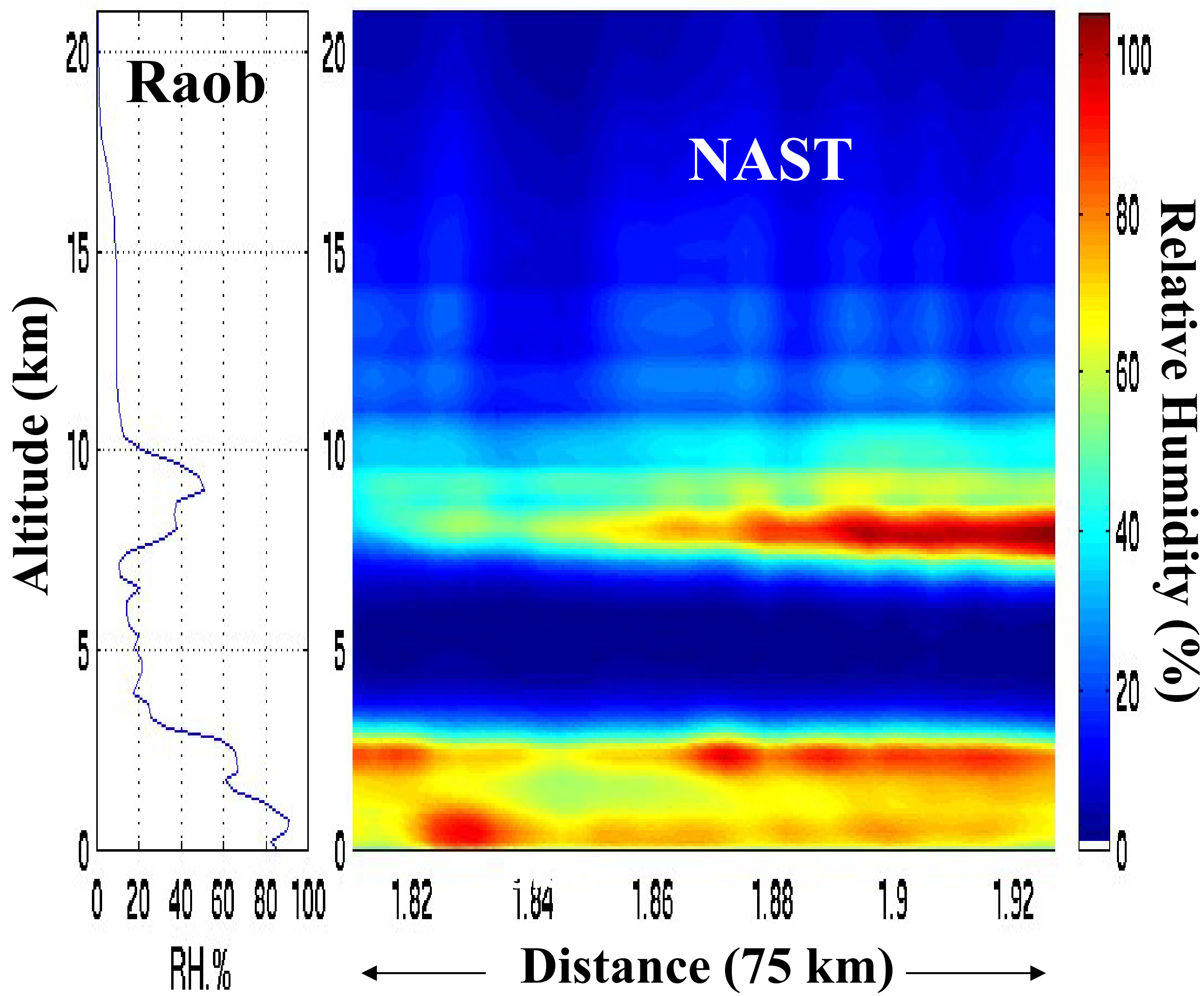
BT (K)
Clear calculation with ECMWF profile
Observation
Calculation with MODIS CTP (281hPa) and ECA (0.44)
Calculation with AIRS CTP (213hPa) and ECA (0.42)
Calculation with AIRS CTP, CPS (16.8) and COT (0.63)
Obs – Cal (K)

Radiosonde Validation

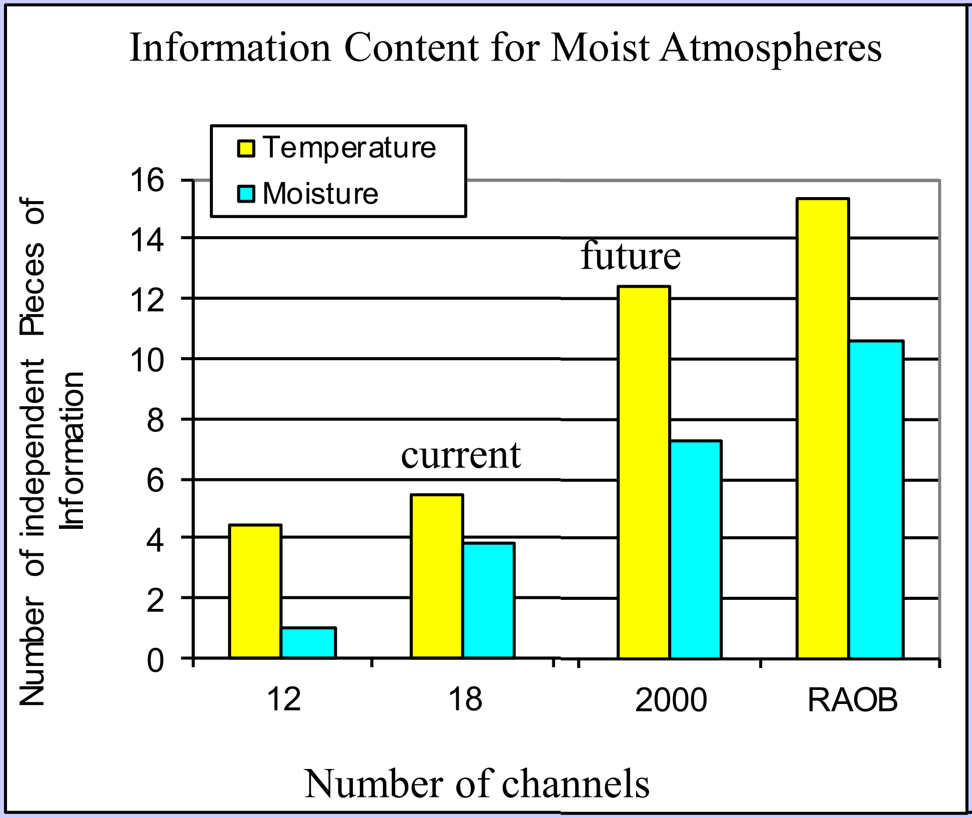


Andros Is. Bahamas, Sept 12, 1998





Hyperspectral IR Sounder nears Raob-like Depiction of Atmosphere
with an Order of Magnitude Increase in Spatial and Temporal Resolution



Hyperspectral IR Sounder
- land and coastal waters
  - nearly instantaneous obs
  - 10 km separation
  - every hour

RAOB
- over land only
- 1 hour ascent
- 300 km separation
- 12 Z and 00Z only

Doubles critical low-level moisture information (wrt current sounder)

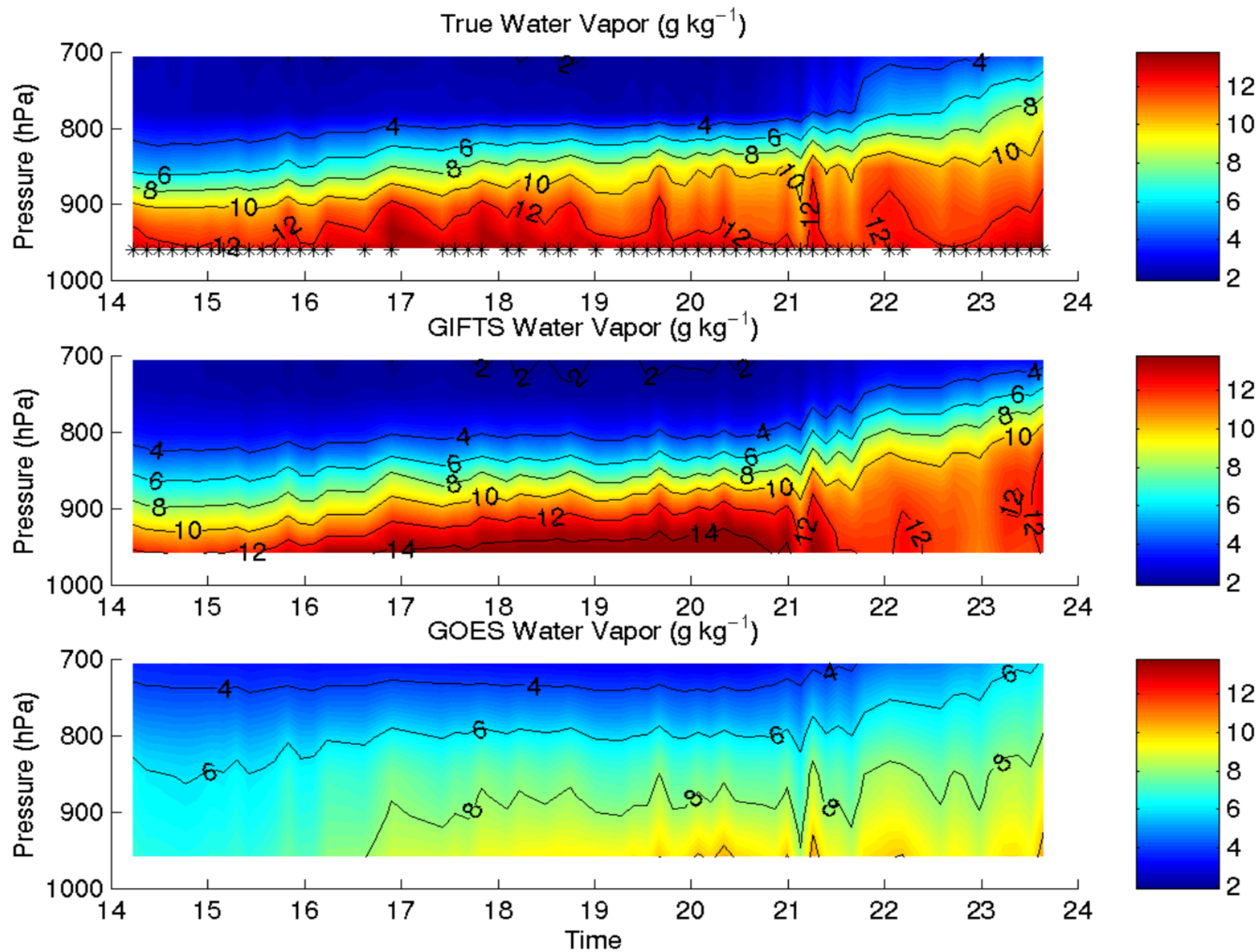
Time series of low-level vertical moisture structure during 9 hours prior to Oklahoma/Kansas tornadoes on 3 May 1999

Truth>

GIFTS>

Note GIFTS retains strong vertical gradients needed to detect changes in convective instability

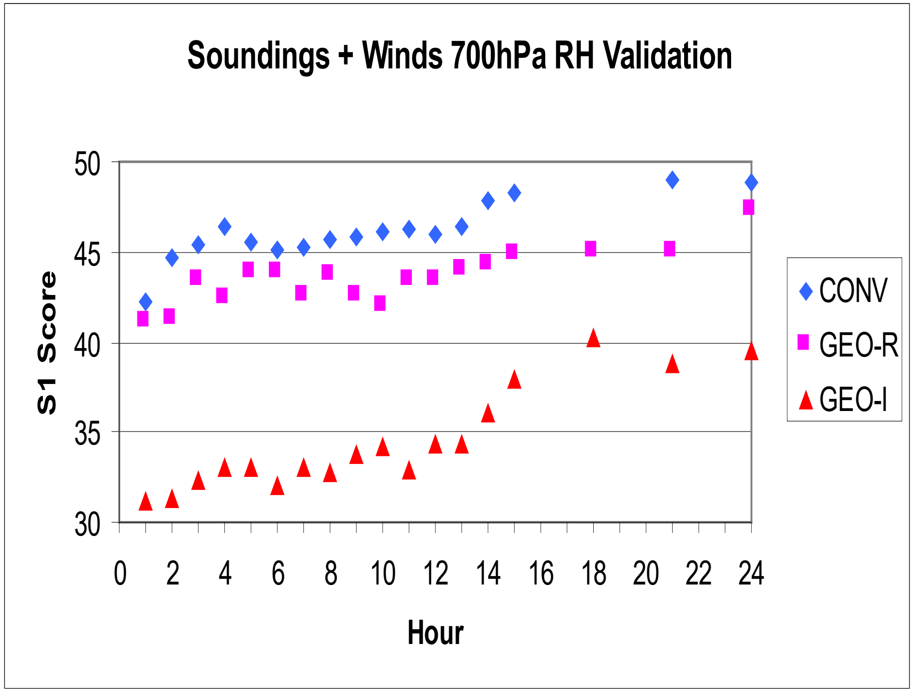
Current GOES>

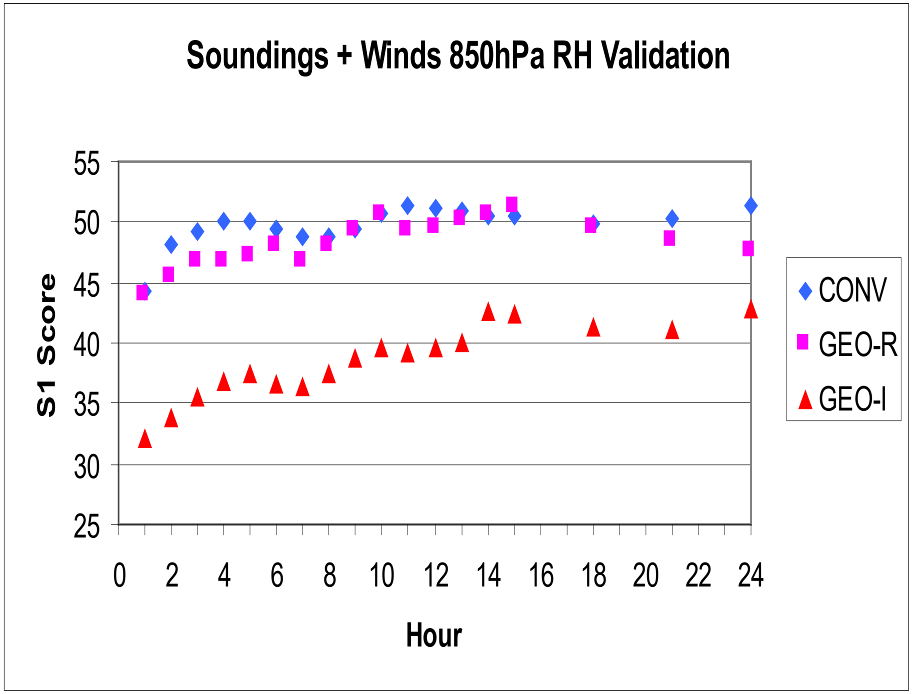


GIFTS traces moisture peaks and gradients with greatly reduced errors

Significant Findings from Geo-Interferometer OSSE

Geo-Interferometer (Geo-I) sees into Boundary Layer (BL) providing low level (850 RH) moisture information; Geo-Radiometer (Geo-R) only offers information above BL (700 RH)

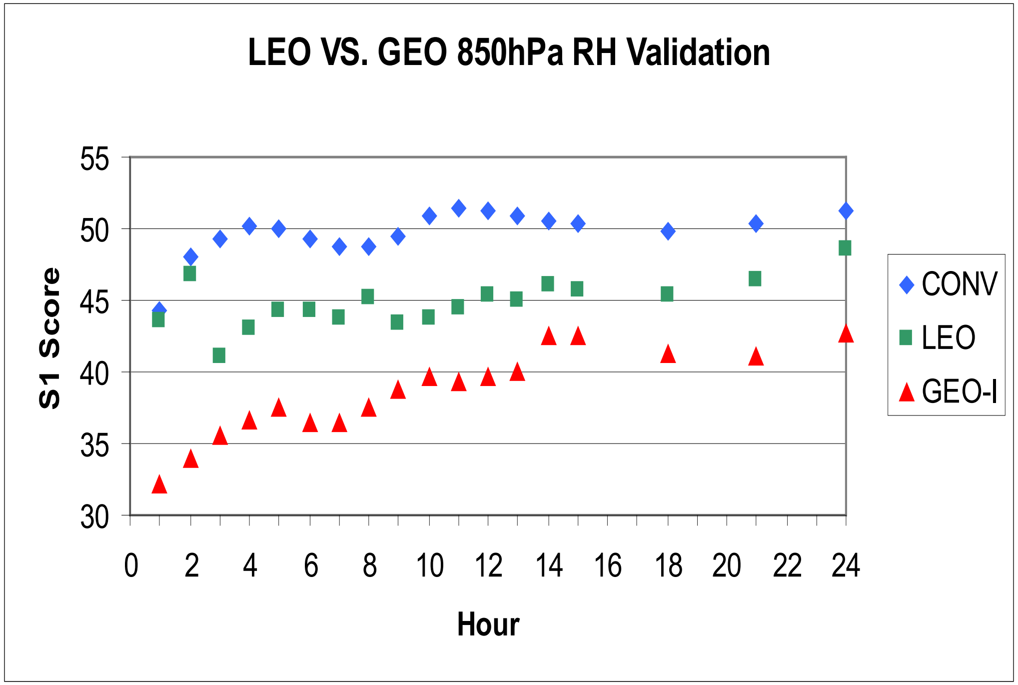




OSSE 12 hr assimilation followed by 12 hr forecast

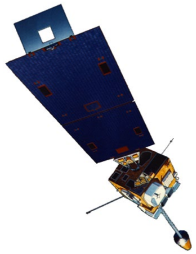
Significant Findings from Geo-Interferometer OSSE

Two polar orbiting interferometers (Leo) do not provide the temporal coverage to sustain forecast improvement out to 12 hours. Only the hourly Geo-Interferometer (Geo-I) observations depict moisture changes well enough for forecast benefit.



OSSE 12 hr assimilation followed by 12 hr forecast

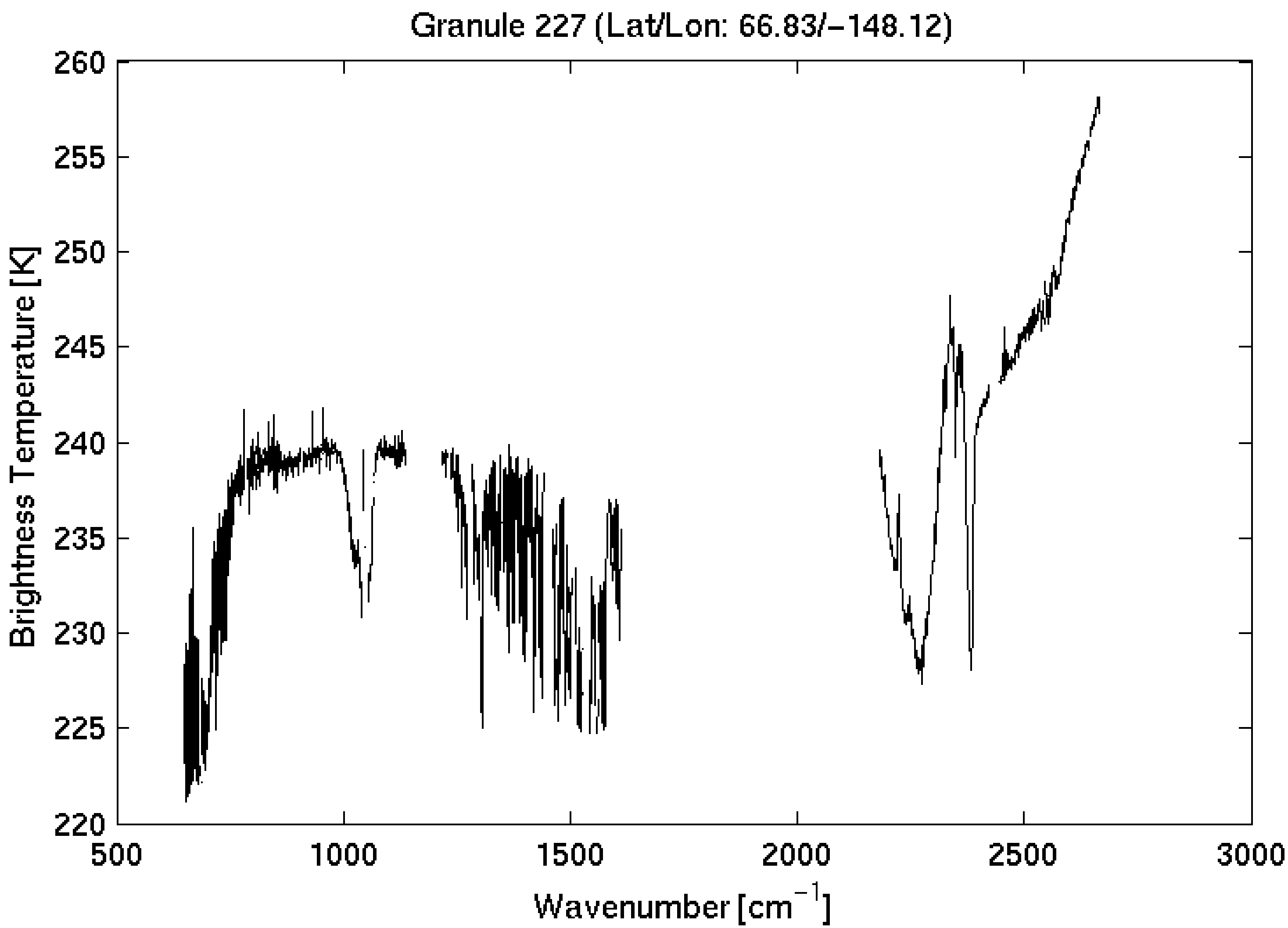
Evolving to Future Satellites



Future remote sensing will address all four key remote sensing areas

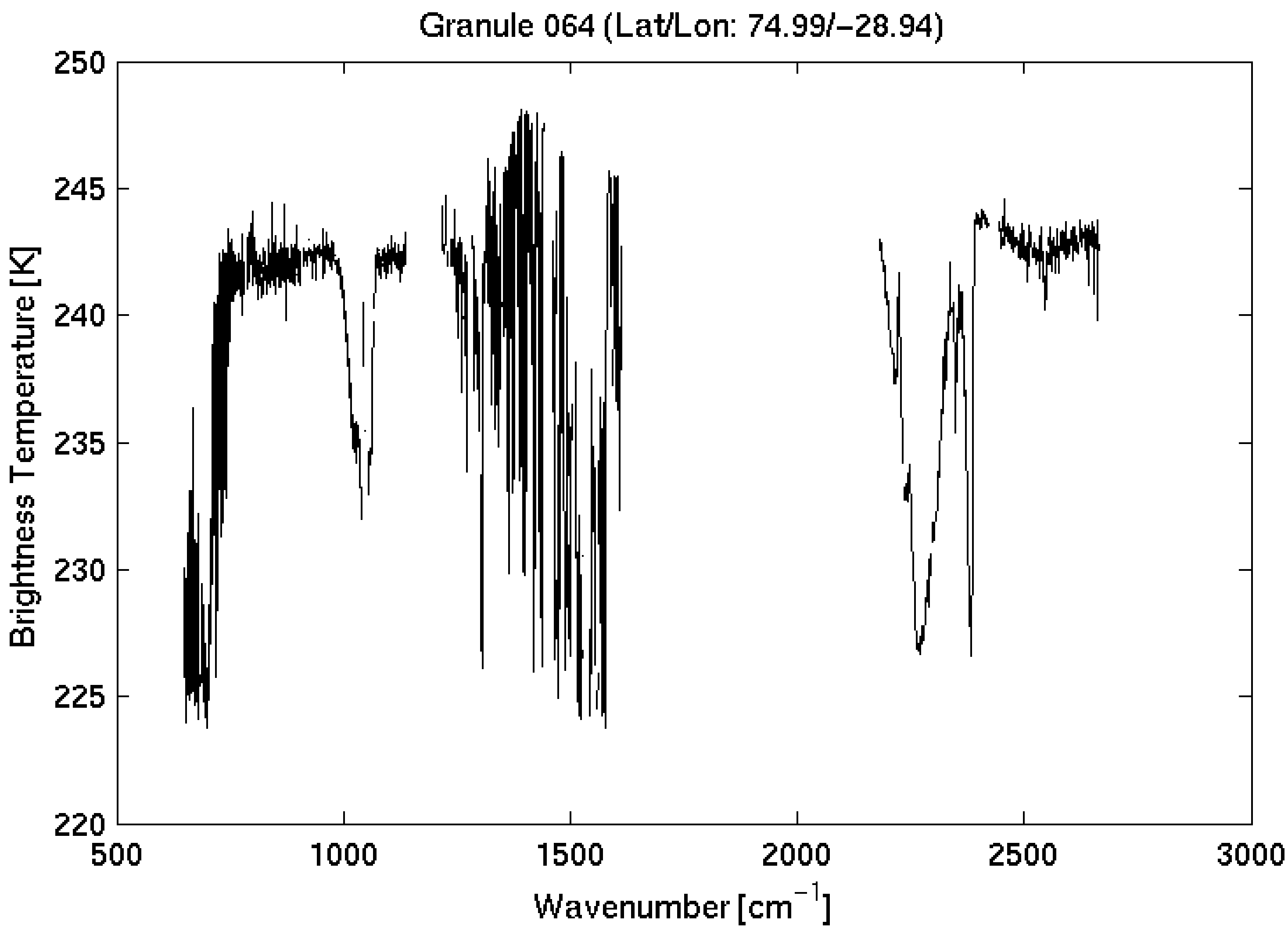
* **spatial resolution** – what picture element size is required to identify feature of interest and to capture its spatial variability;
* **spectral coverage and resolution** – what part of EM spectrum at each spatial element should be measured, and with what spectral resolution, to analyze an atmospheric or surface parameter;
* **temporal resolution** – how often does feature of interest need to be observed; and
* **radiometric resolution** – what signal to noise is required and how accurate does an observation need to be.

Example Spectra

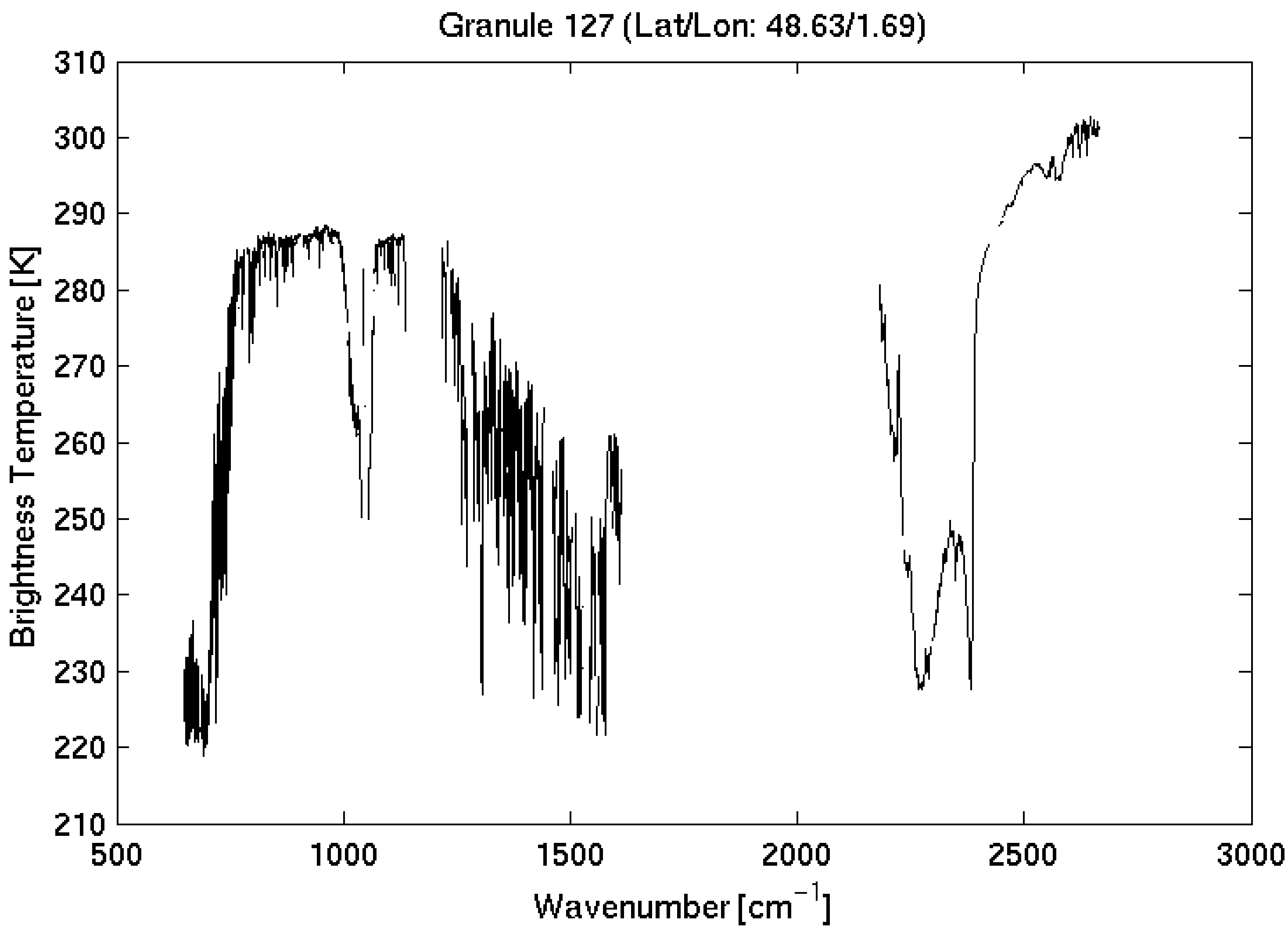


Granule 227 (Lat/Lon: 66.83/−148.12)
Brightness Temperature [K]
260
255
250
245
240
235
230
225
220
500
1000
1500
2000
2500
3000
Wavenumber [cm−1]

Day or night?

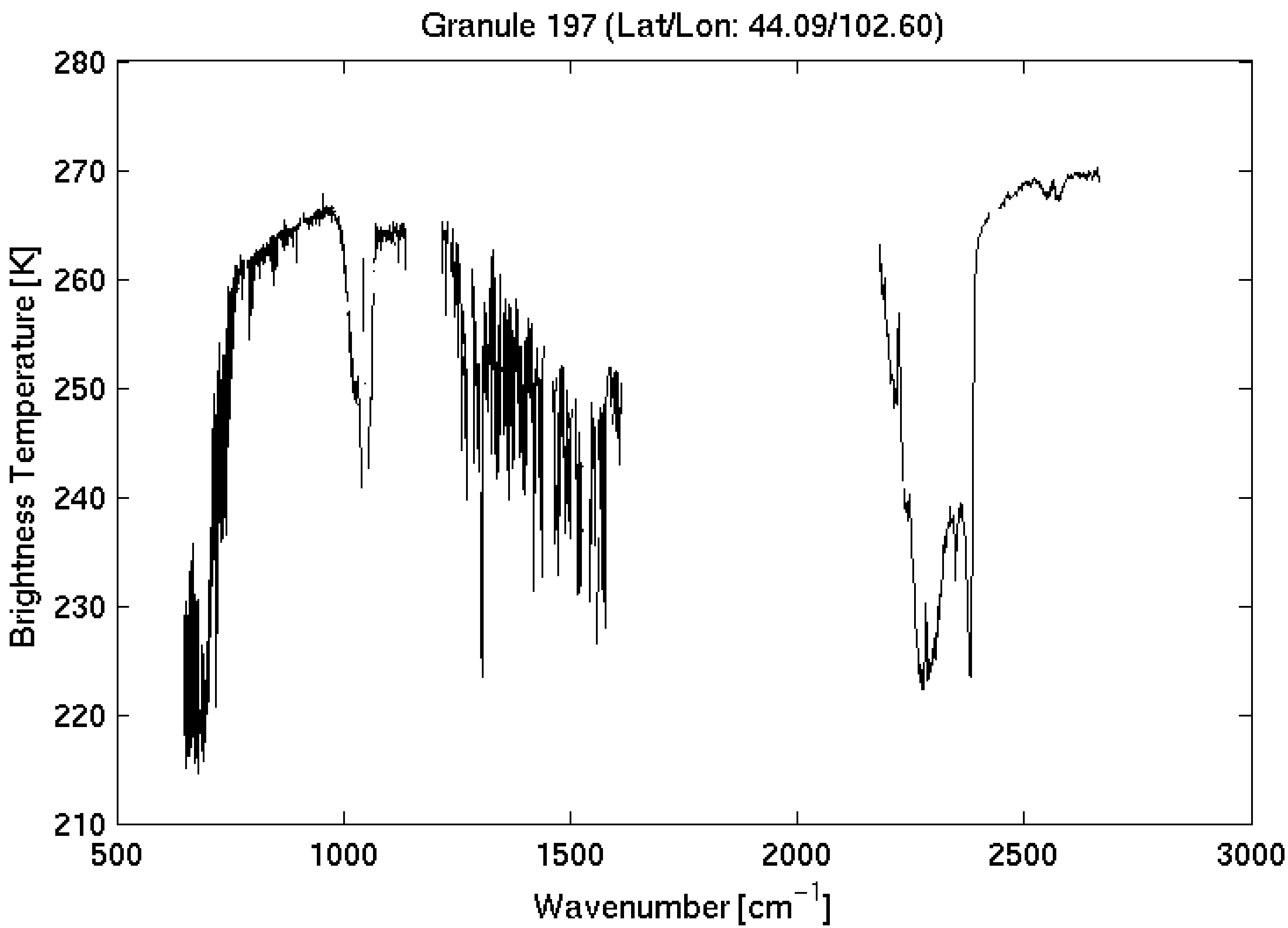


Day, night, desert, or ice/snow?

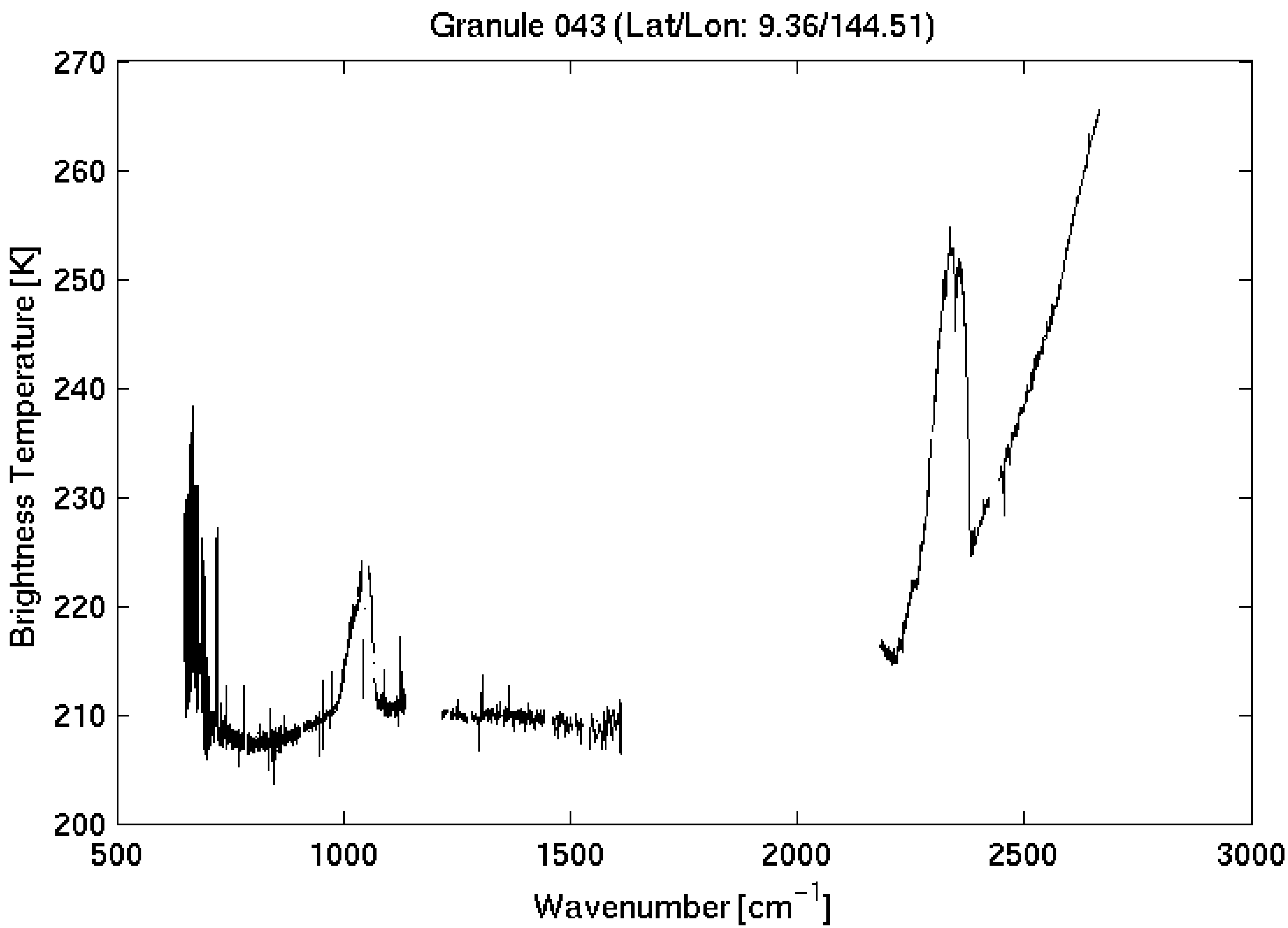


Granule 127 (Lat/Lon: 48.63/1.69)
310
300
290
280
270
260
250
240
230
220
210
Brightness Temperature [K]
500
1000
1500
2000
2500
3000
Wavenumber [cm^{-1}]

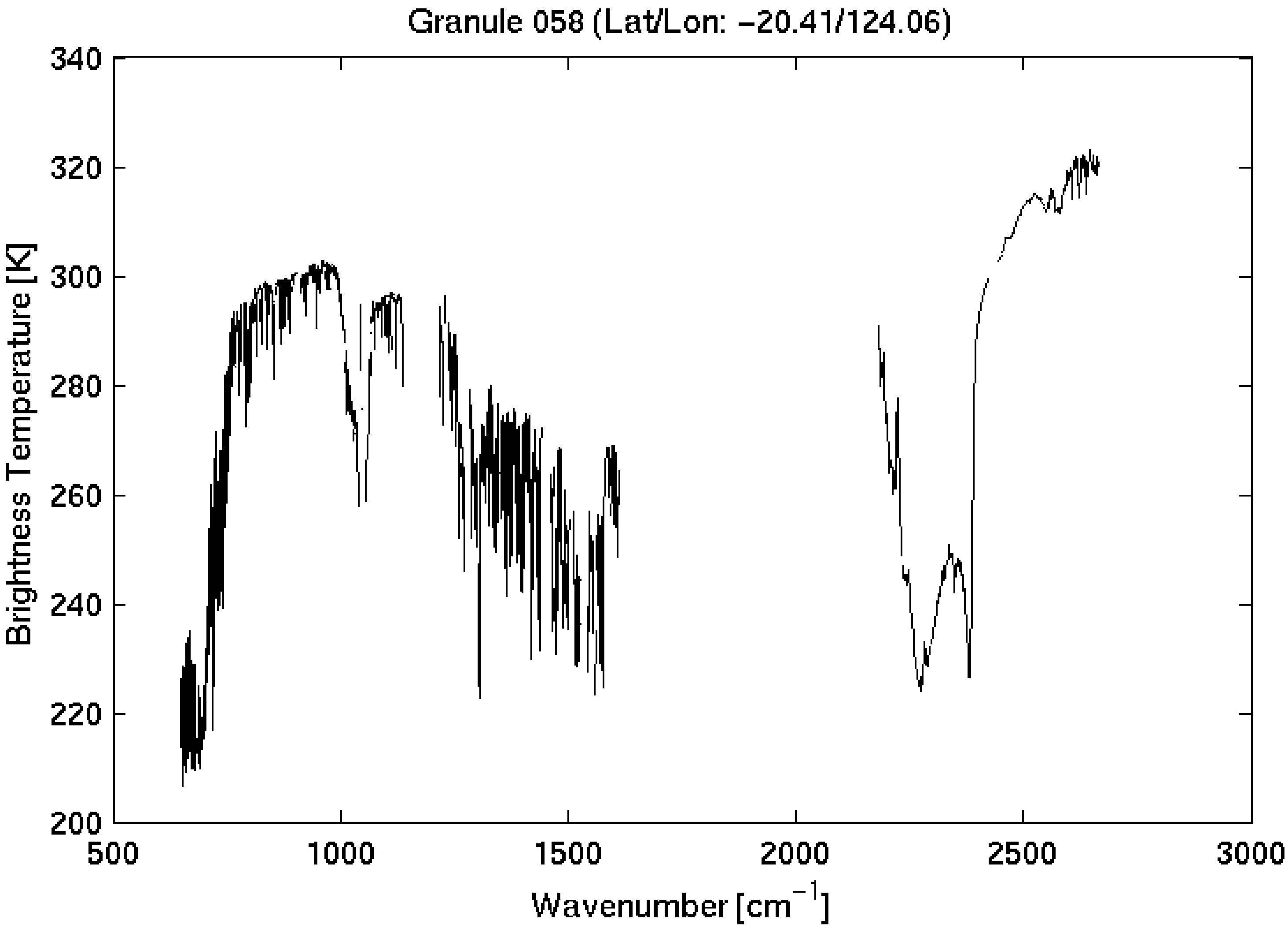
Day or night?



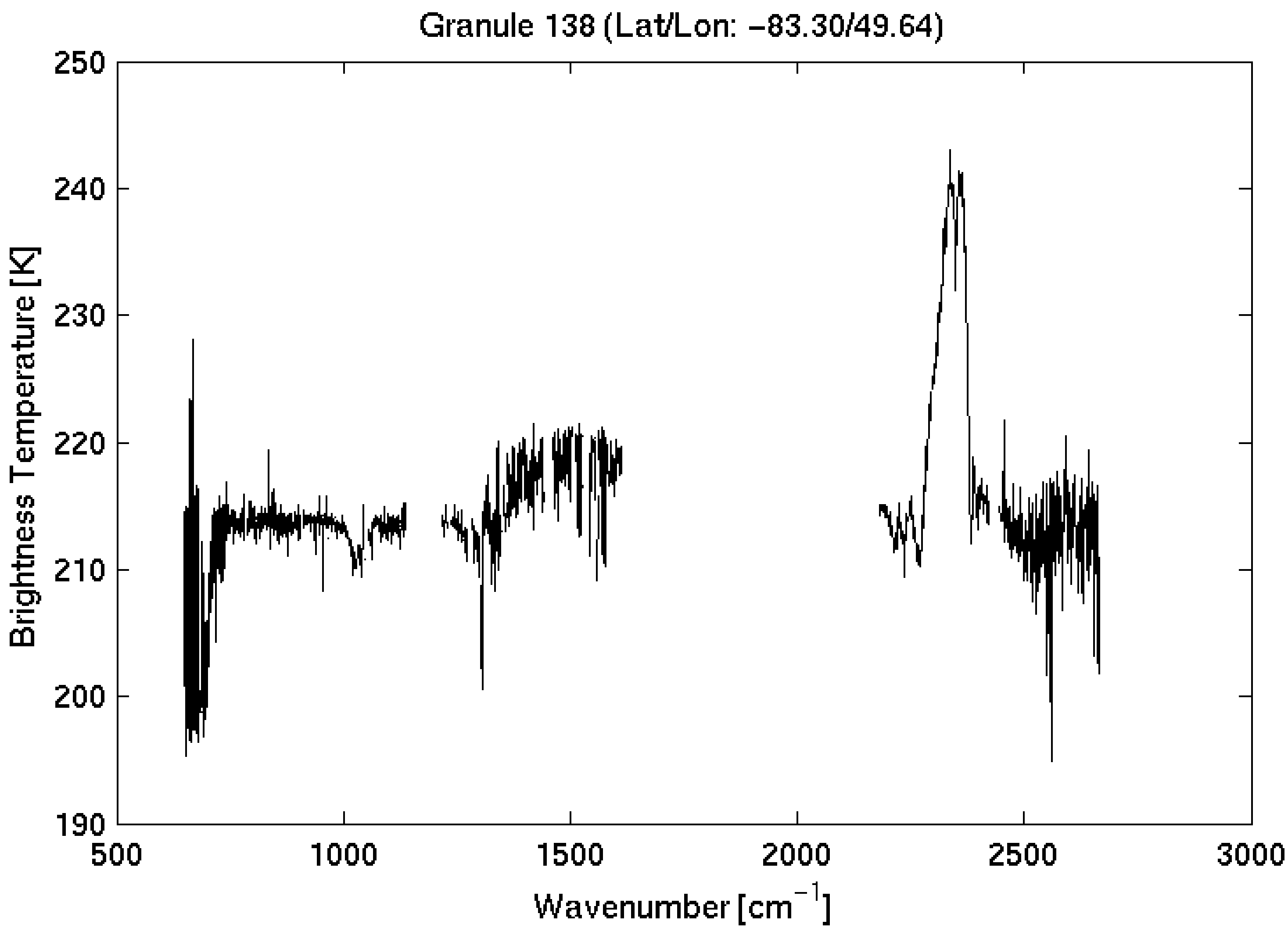
Land or ocean?



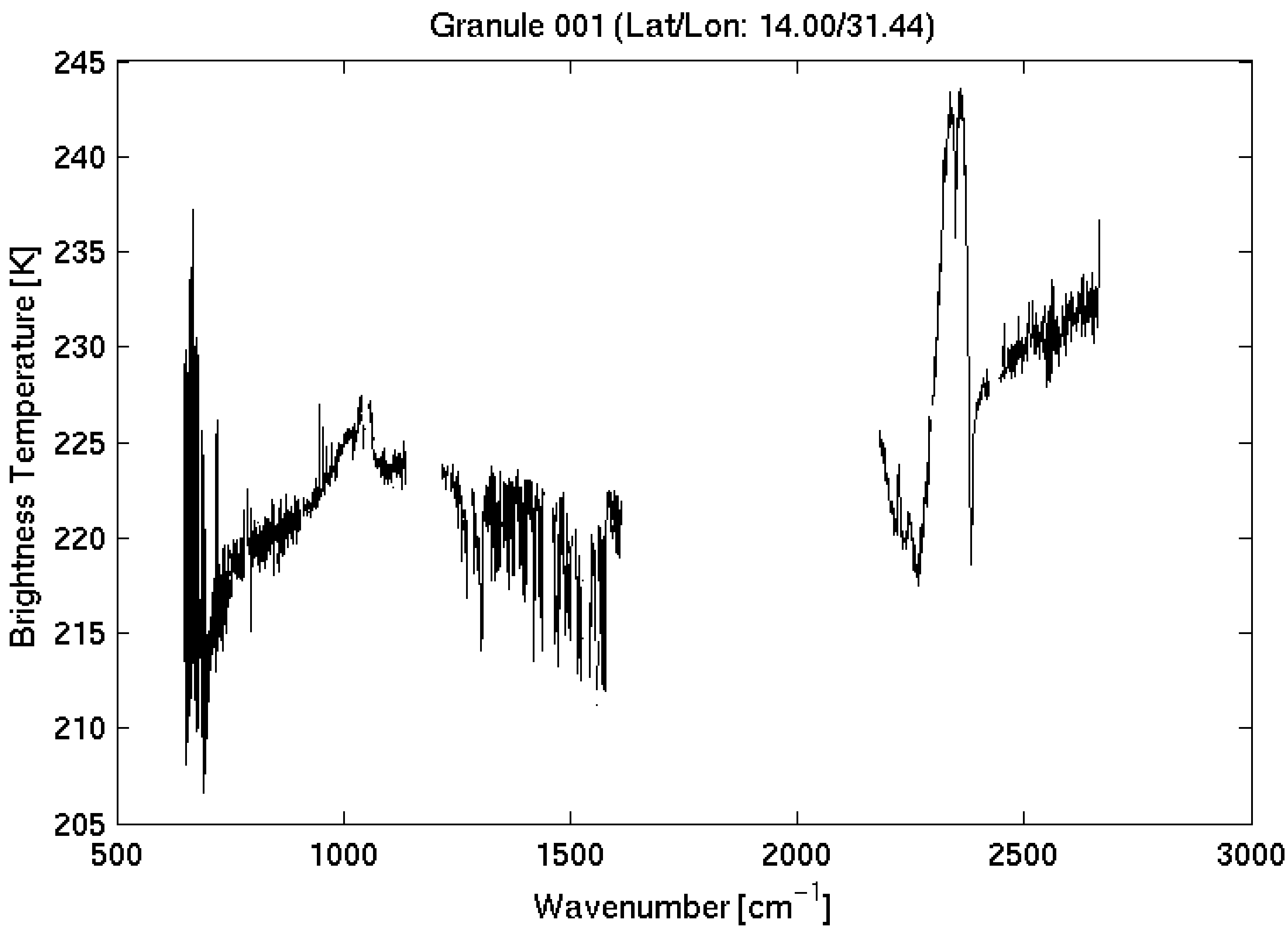
Desert, ocean, or cloudy?



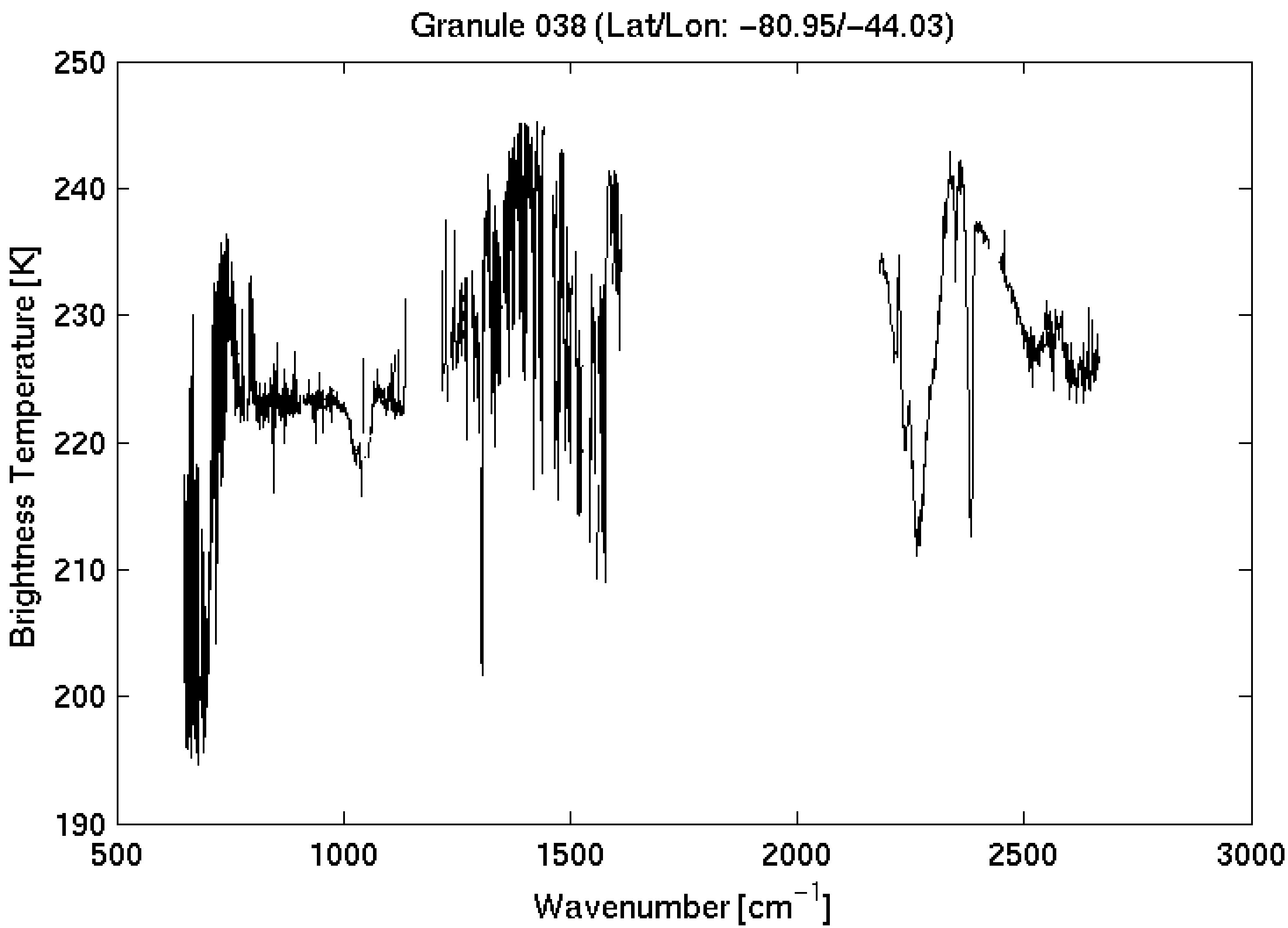
Day, night, desert, or ocean?



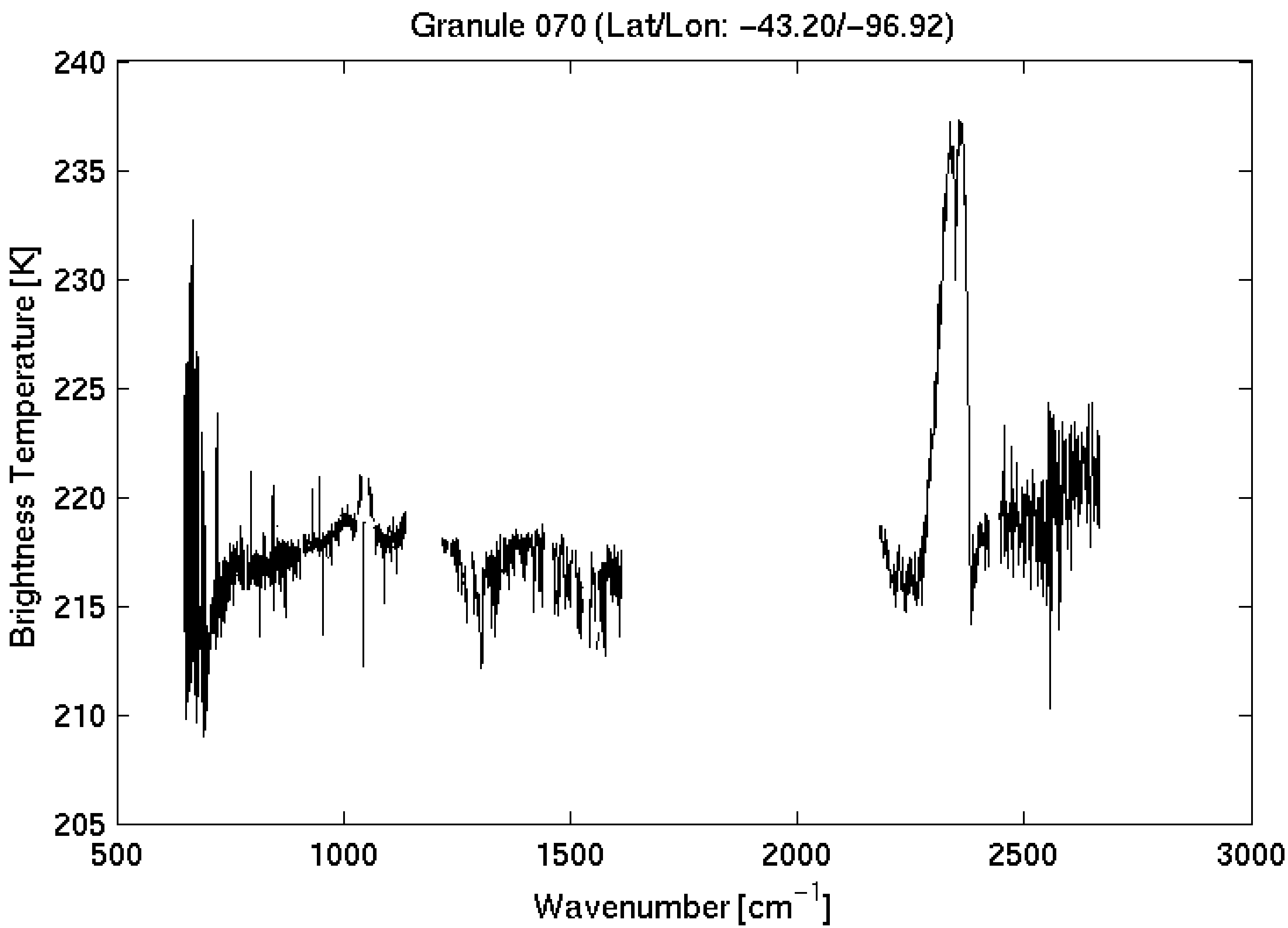
Ocean, cloudy, snow/ice, or desert?



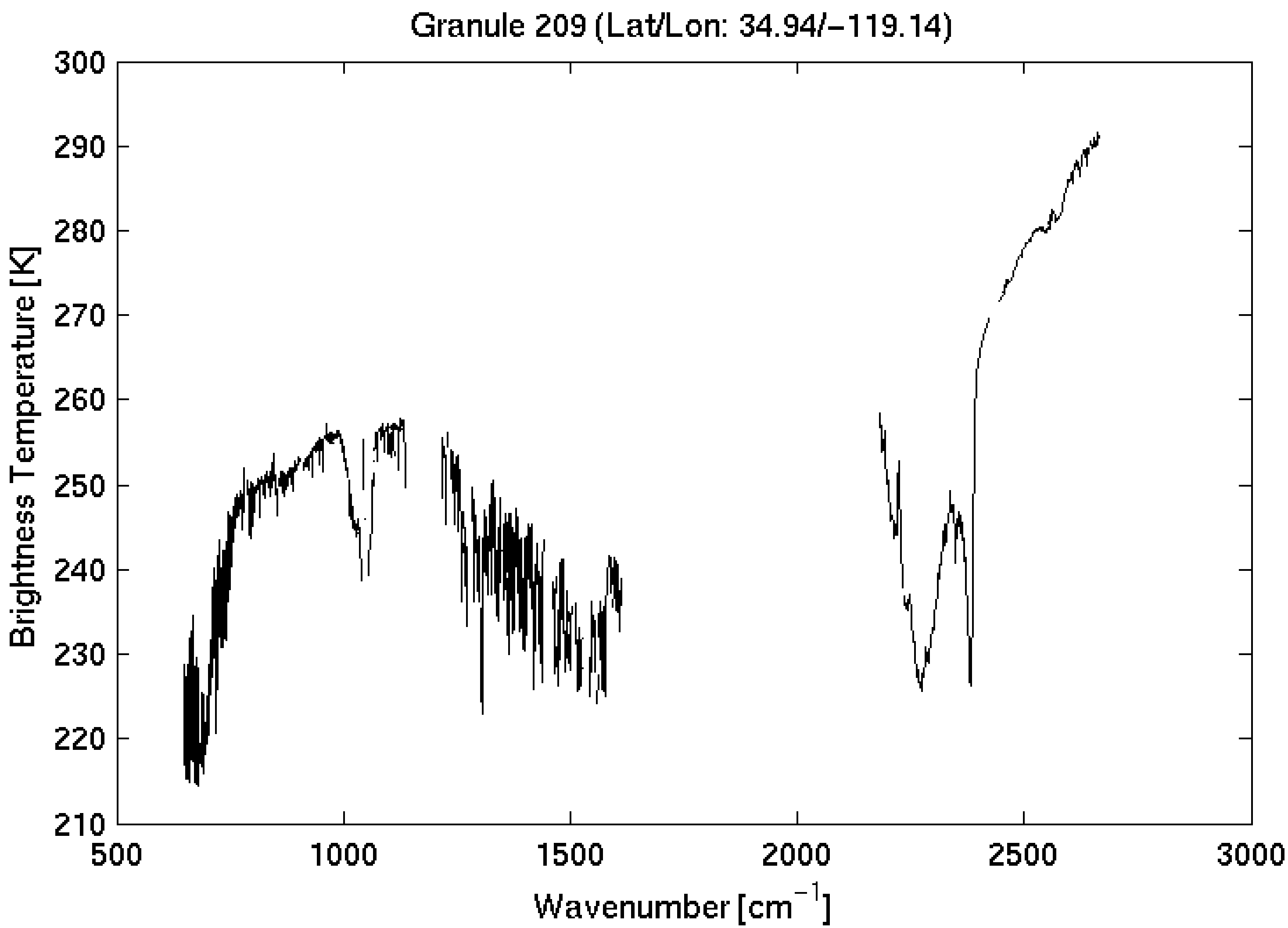
Day, night, desert, or cloudy?



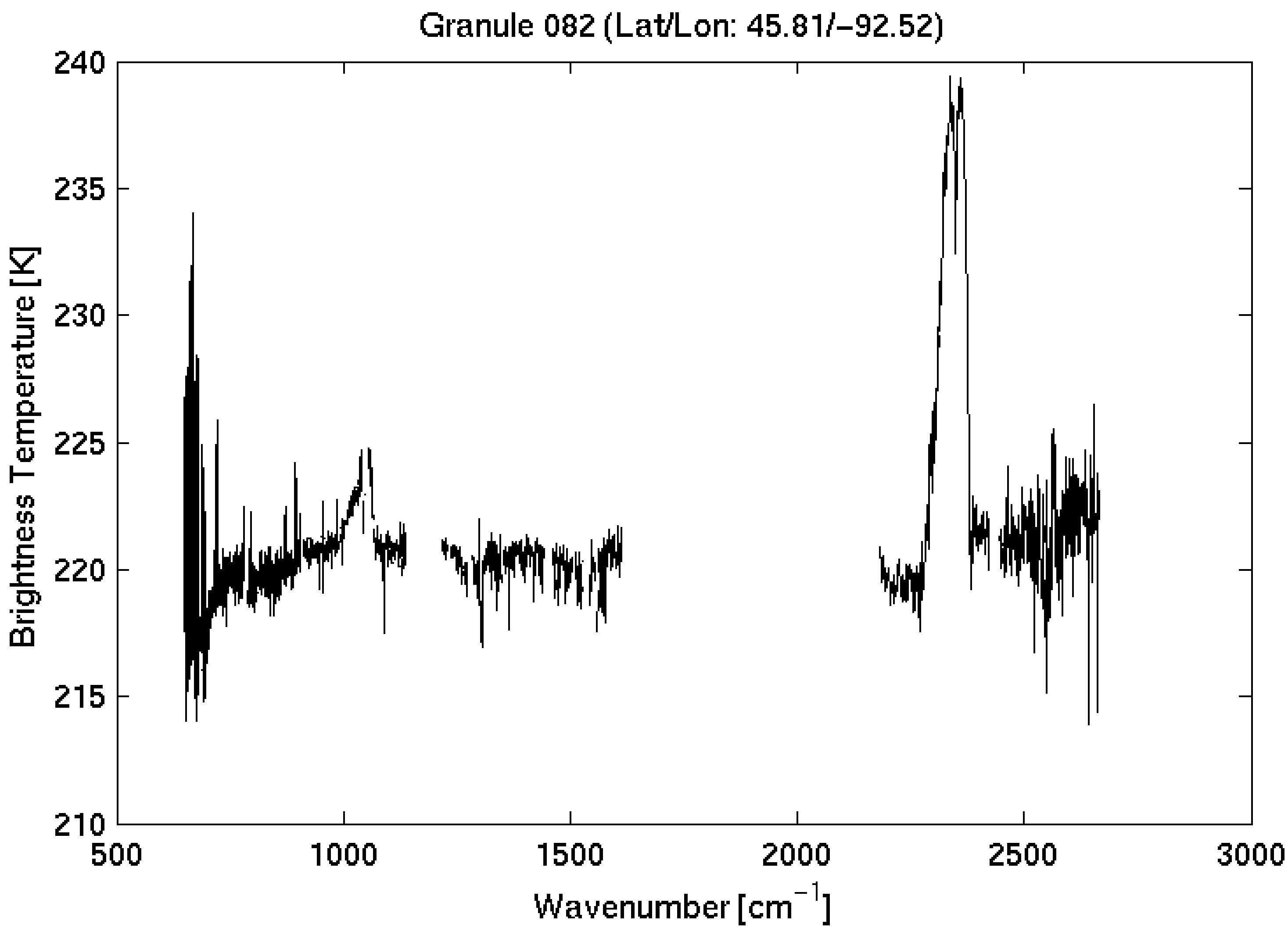
Cloudy, desert, or ocean?



Land, desert, ice/snow, or ocean?



Day, night, desert, or cloudy?



Day, night, ocean, or cloudy?