AIRS
(Atmospheric Infrared Sounder)
Level 1B data

Level 0 to Level 2

Level 0: raw data

Level 1A: geolocated radiance in counts

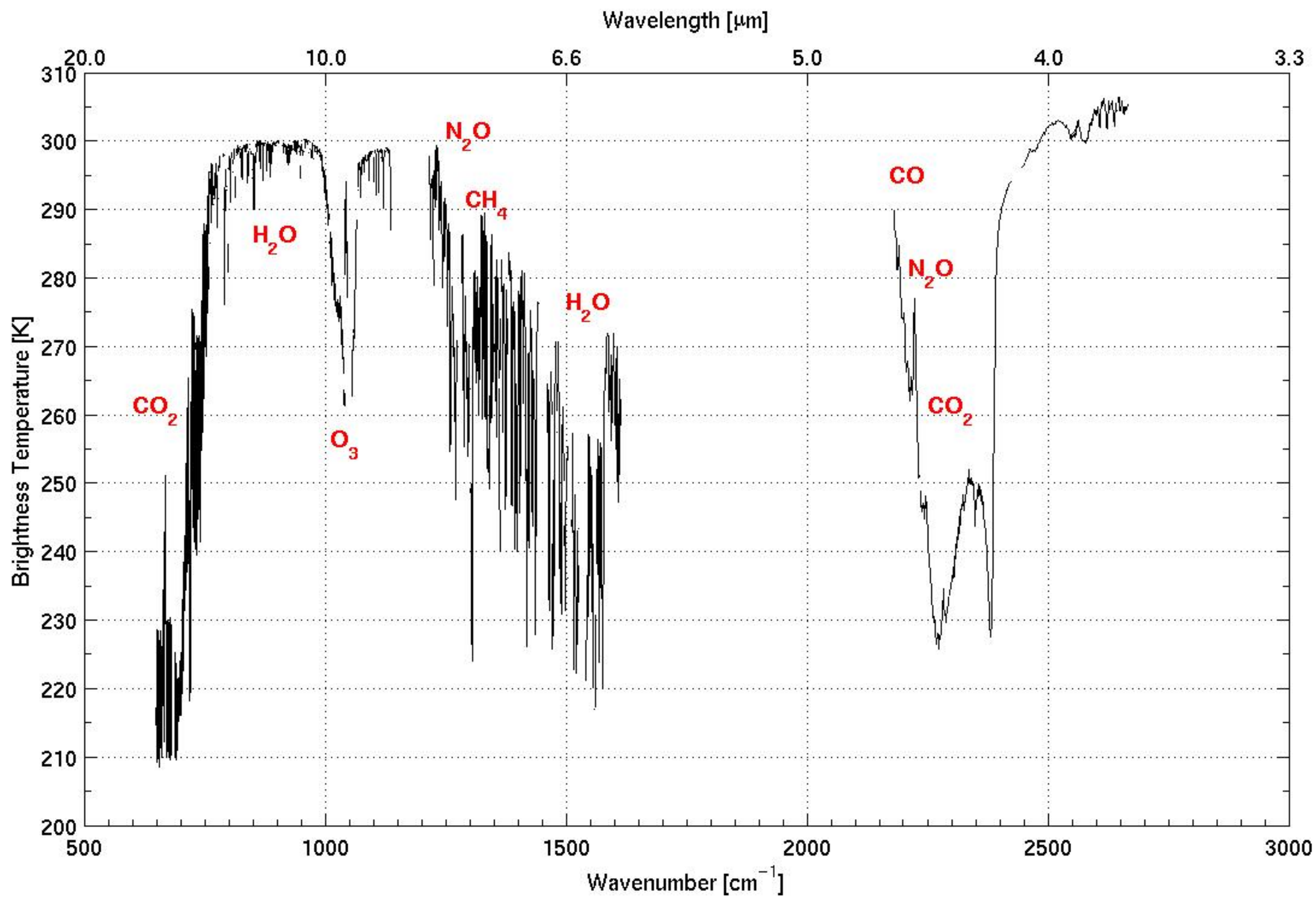
Level 1B: calibrated radiance in physical units

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

$$R_\nu = \tau_{s\nu} \cdot \varepsilon_{s\nu} \cdot B_\nu(T_S)$$ ← Upwelling IR radiation from surface

$$+ \int_{p_s}^{0} B_\nu(T(p)) d\tau_\nu(p)$$ ← Upwelling IR radiation from atm. layers

$$- \tau_{s\nu} \cdot r_{s\nu} \cdot \int_{p_s}^{0} B_\nu(T(p)) d\tau_\nu^*(p)$$ ← Reflected downwelling IR radiation

$$+ R_\nu^{sun} \cdot \cos(\theta) \cdot \tau_{s\nu}^{sun}(p_s) \cdot r_\nu^{sun}$$ ← Reflected solar radiation

R…radiance, υ…wavenumber, *s*…surface, *p*…pressure, *sun*…solar,

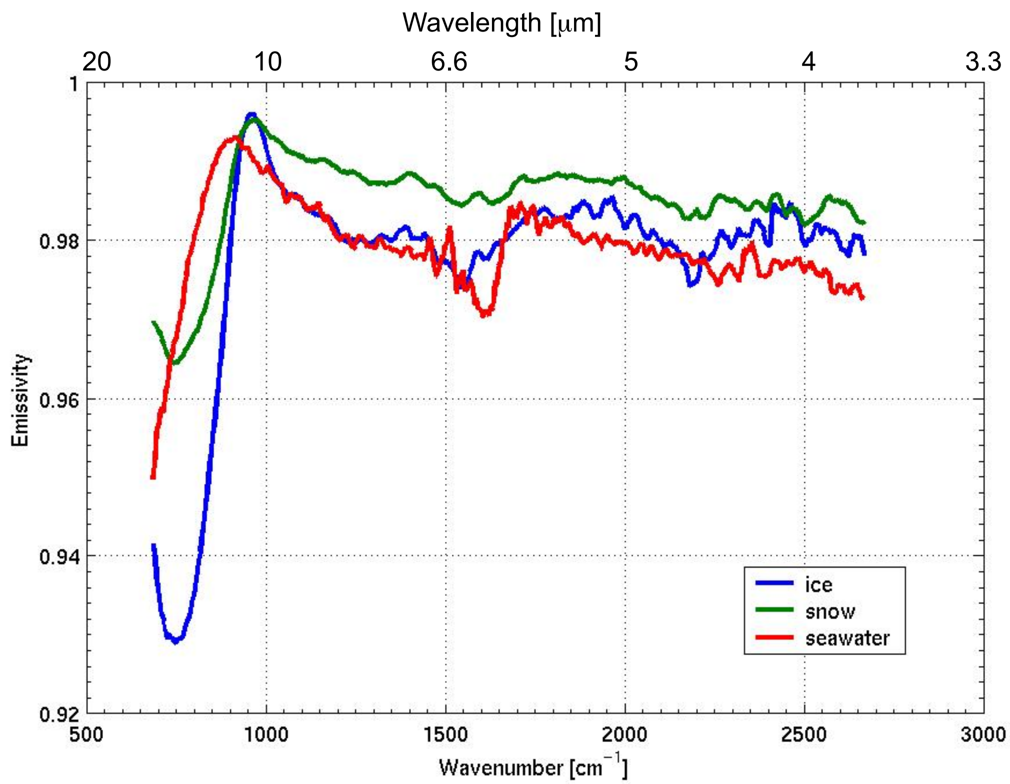
T…temperature, *B*…Planck function, ε …emissivity,

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

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

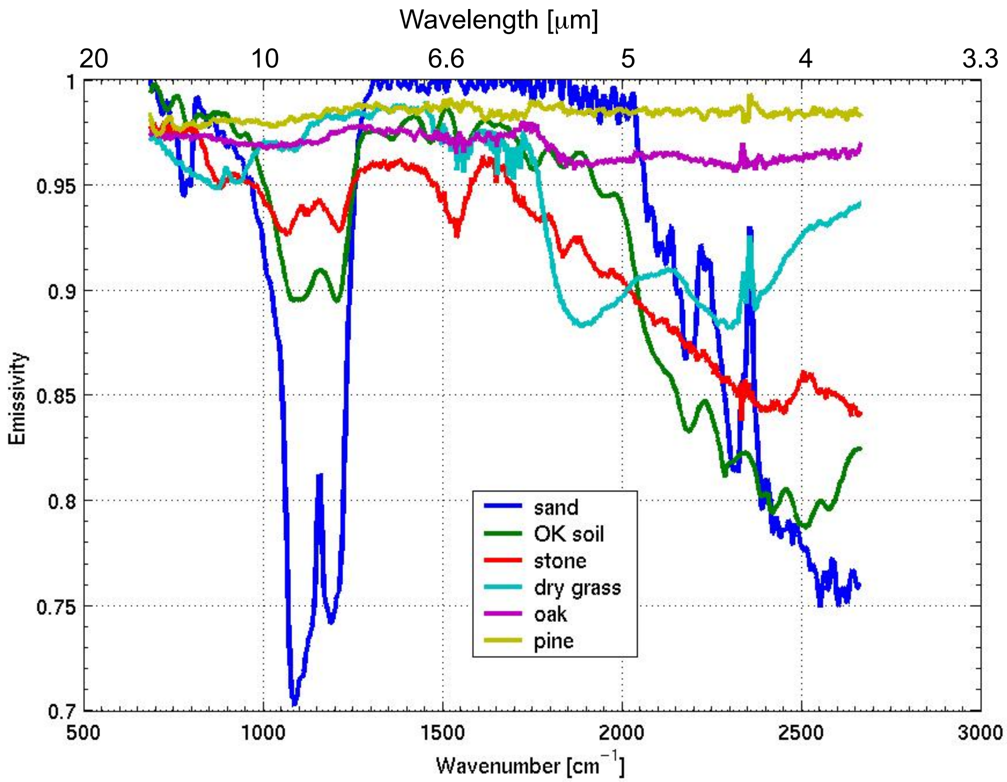
τ^*…level to surface (downwelling) transmittance [$\tau^* = \tau_\upsilon^2(p_s)/ \tau_\upsilon(p)$]

Surface Emissivity (1)



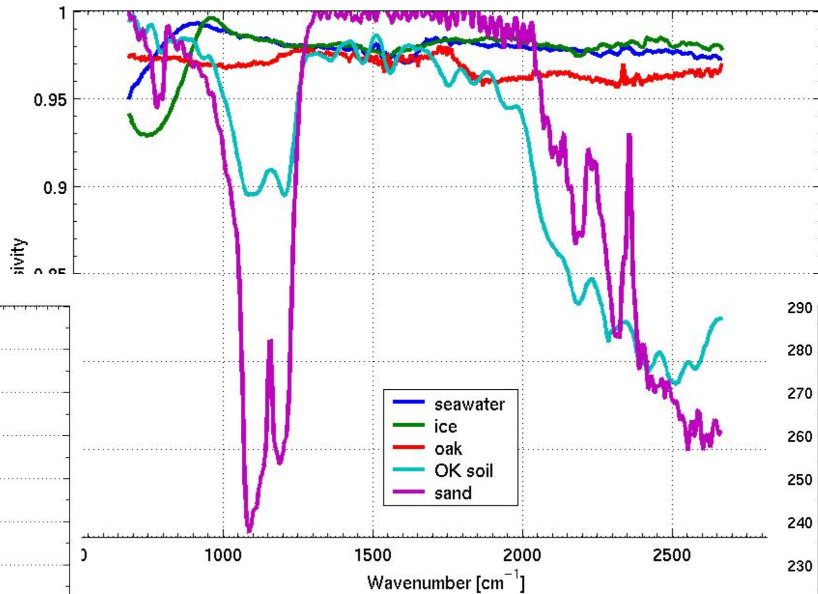
• <u>Water, ice and snow</u> have high emissivity (0.94 – 0.99) across the IR region, and high reflectance in the visible region.

Surface Emissivity (2)

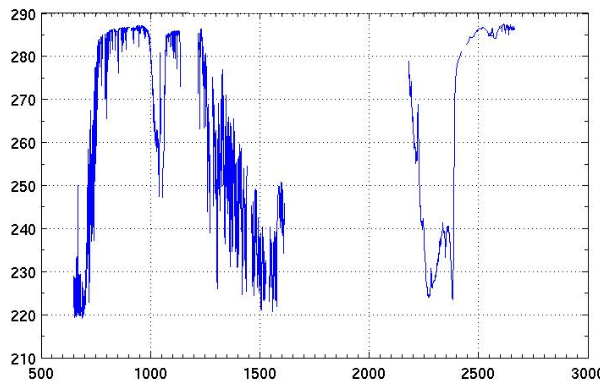


- <u>Soil and minerals</u> have strong features between 8 and 10 μm, and between 3 and 5 μm. Signature depends on water & organic content.
- <u>Vegetation</u> shows high emissivity because it contains water, dry vegetation is highly variable (e.g. 3 – 5 μm)

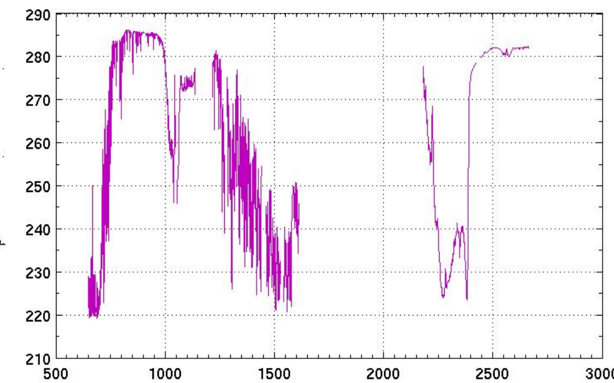
Surface Emissivity and Brightness Temperature simulations



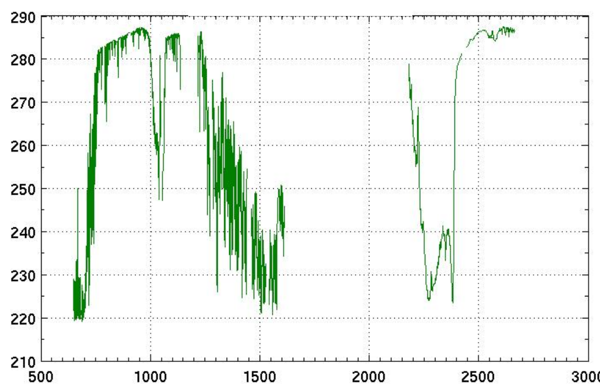
Seawater



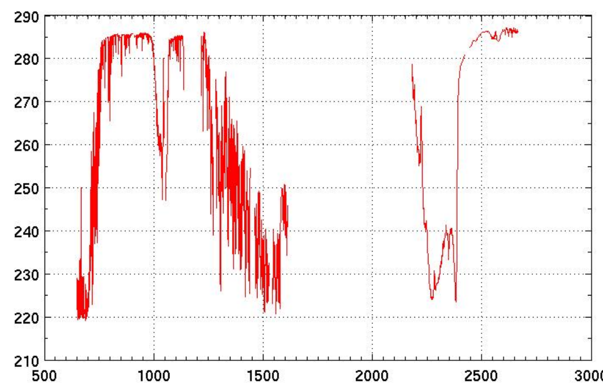
Sand



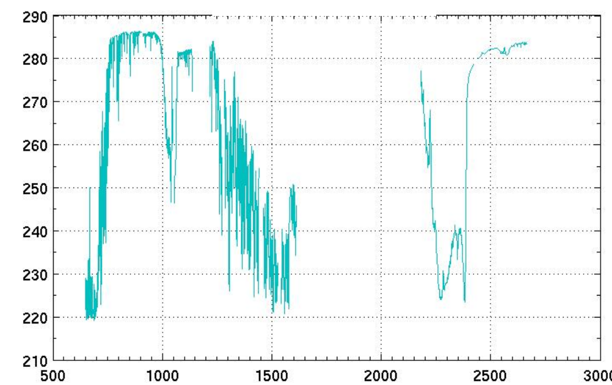
Ice



Oak



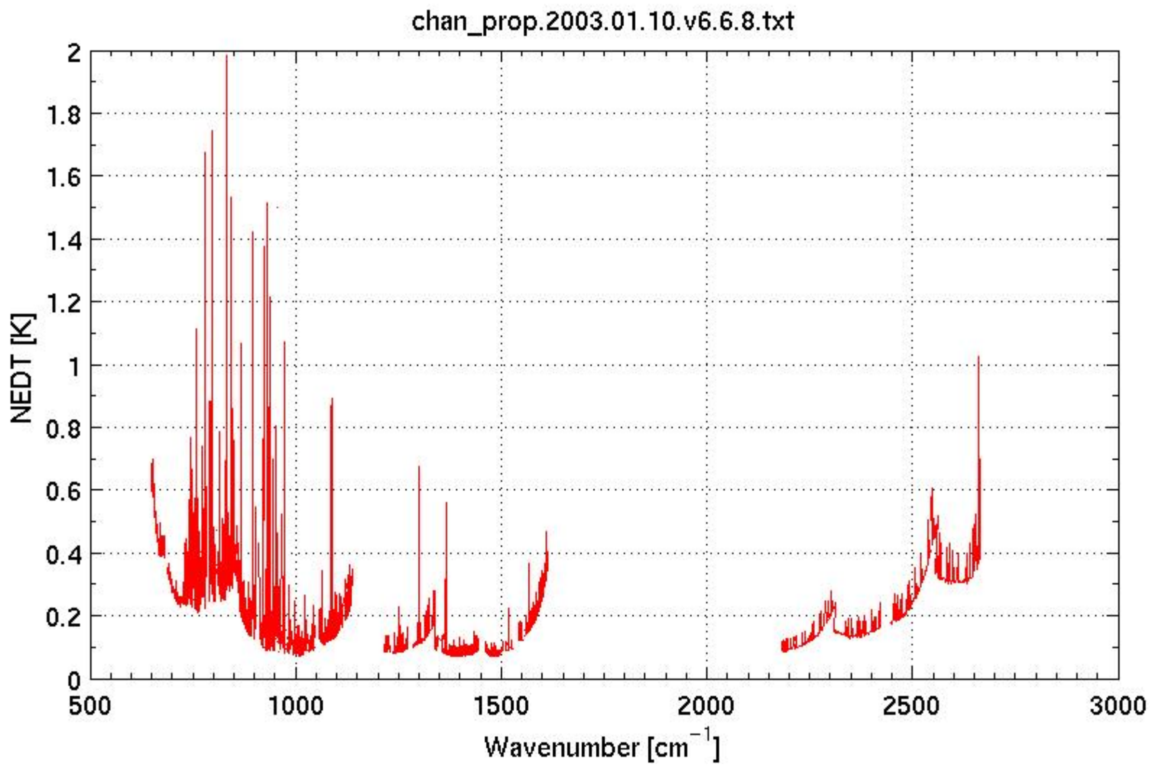
OK soil



AIRS Noise Specification

• <u>NeDT</u>: 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



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 . . . <u>Bad channels (bad_flag =1) should not be used in retrievals</u>

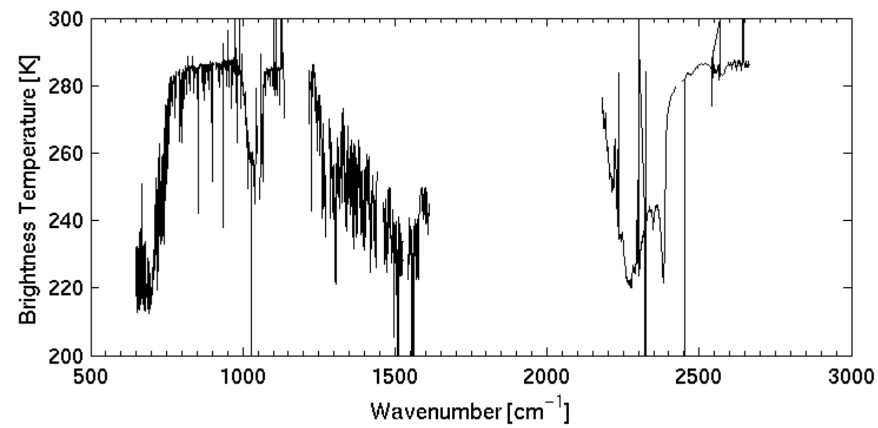
• A channel can be be bad because

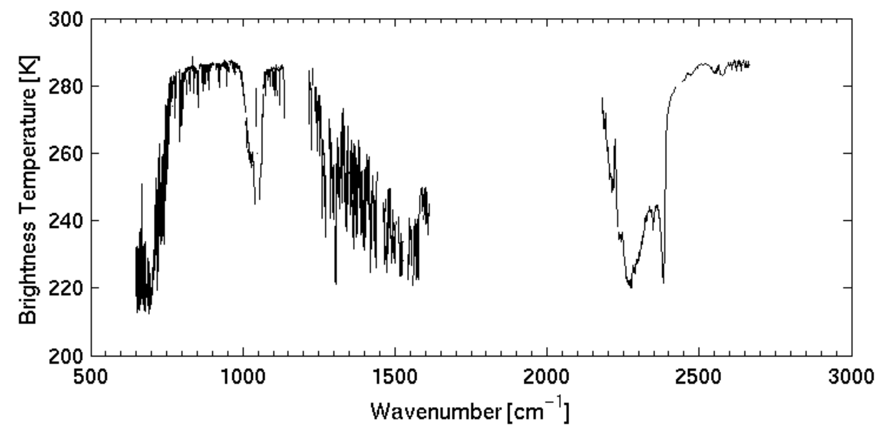
→ detector has high noise

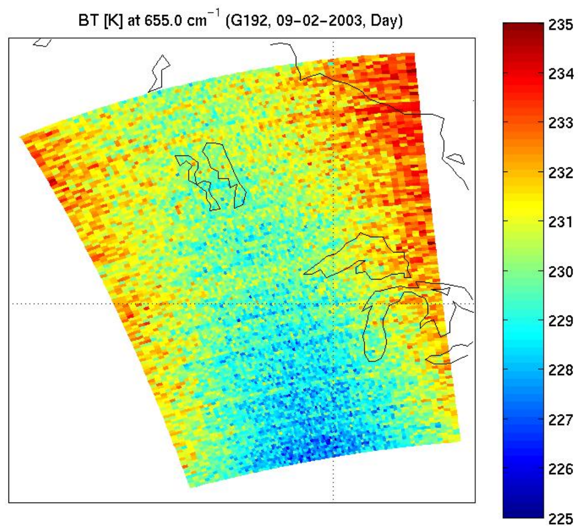
→ detector is non-responsive

→ detector response shows unexpected steps (popping)

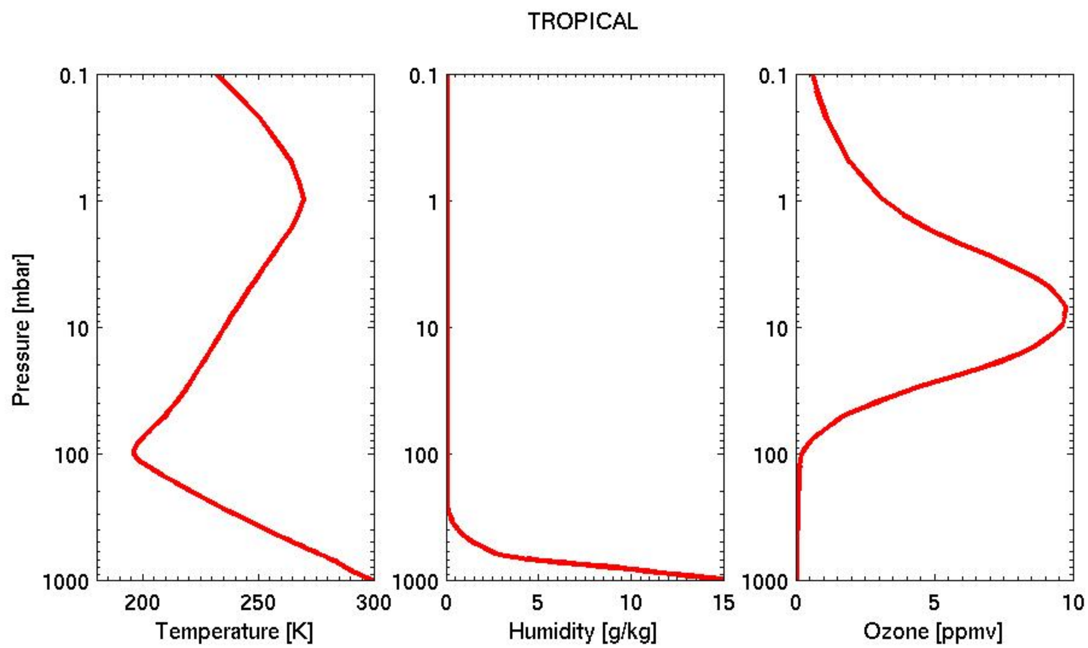
→ poor SRF (spectral response function) determination

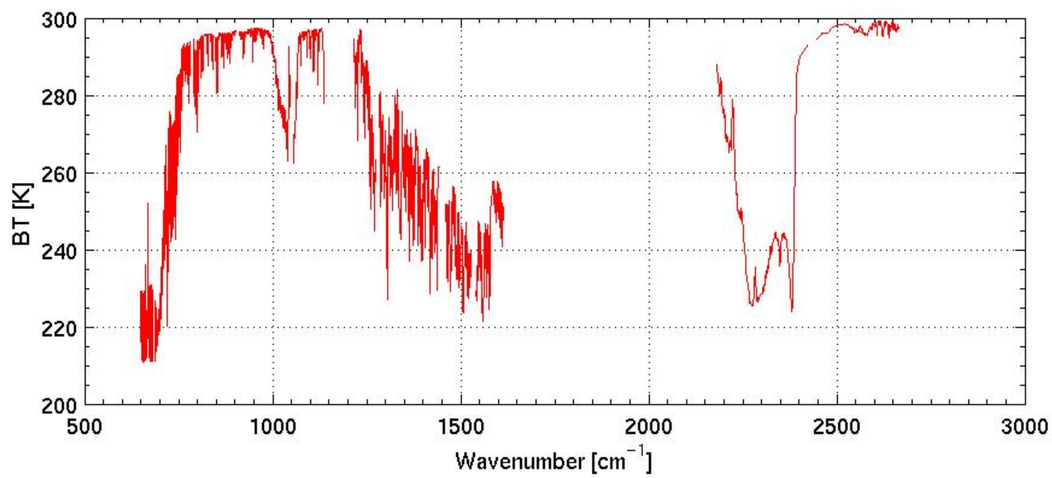






AIRS T,q, O3 profile and simulated spectrum - tropical





Tropical Profile:

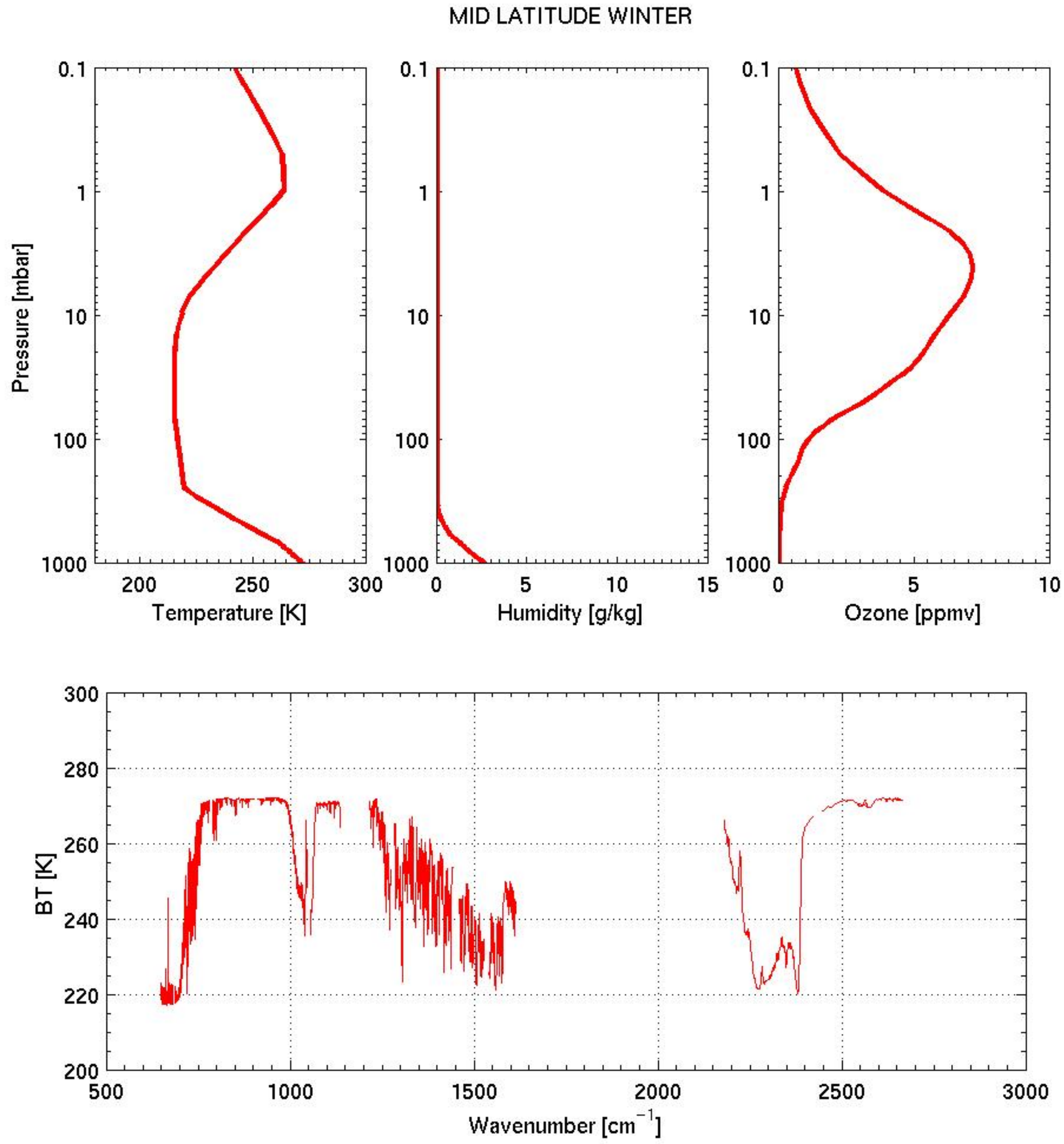
• sharp tropopause at ~100 mbar

• high water vapor amount

• high T gradient in troposphere (~100 K) and stratosphere (~80 K)

• high skin temperatures

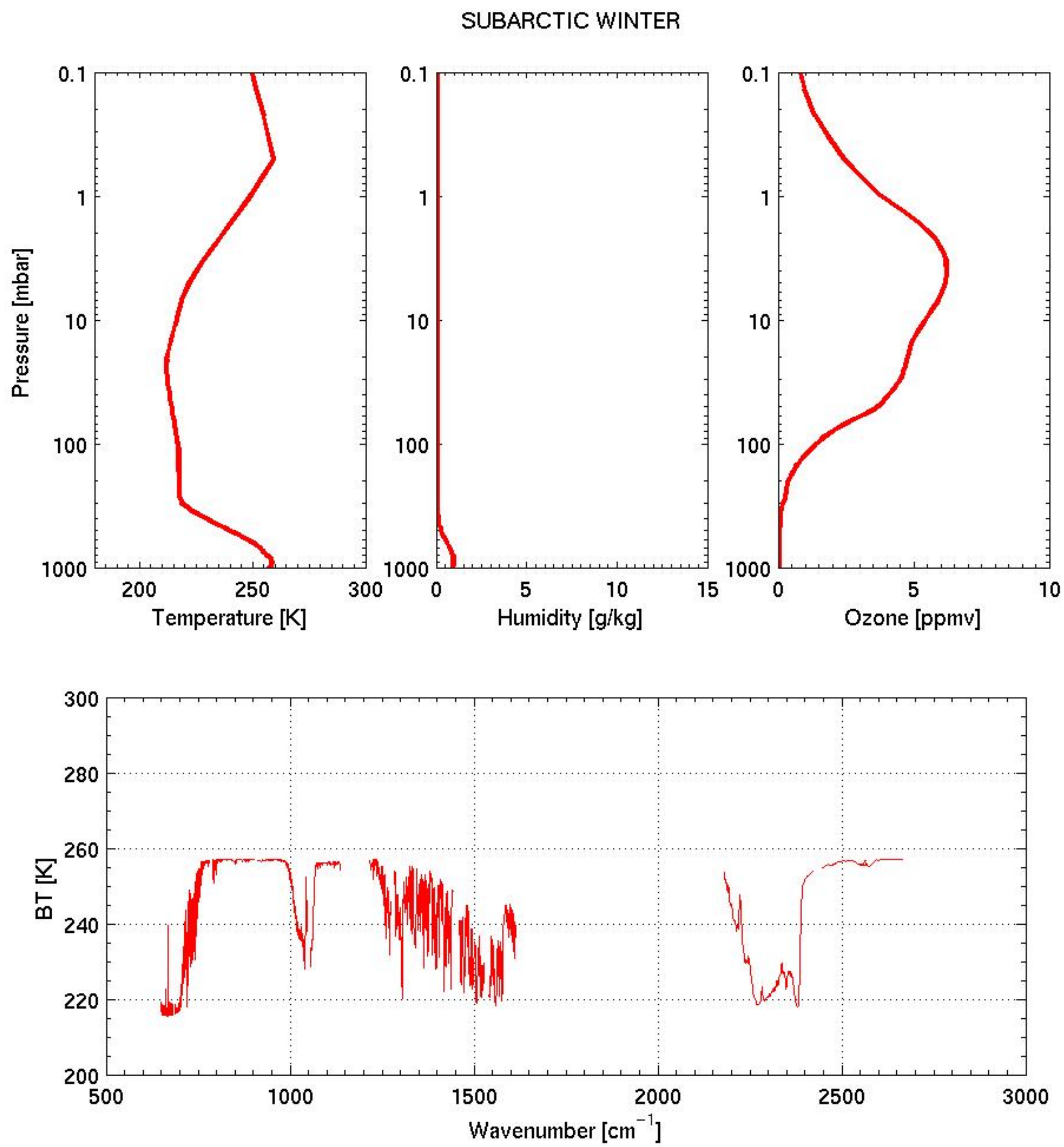
AIRS T,q, O3 profile and simulated spectrum – midlatitude winter



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



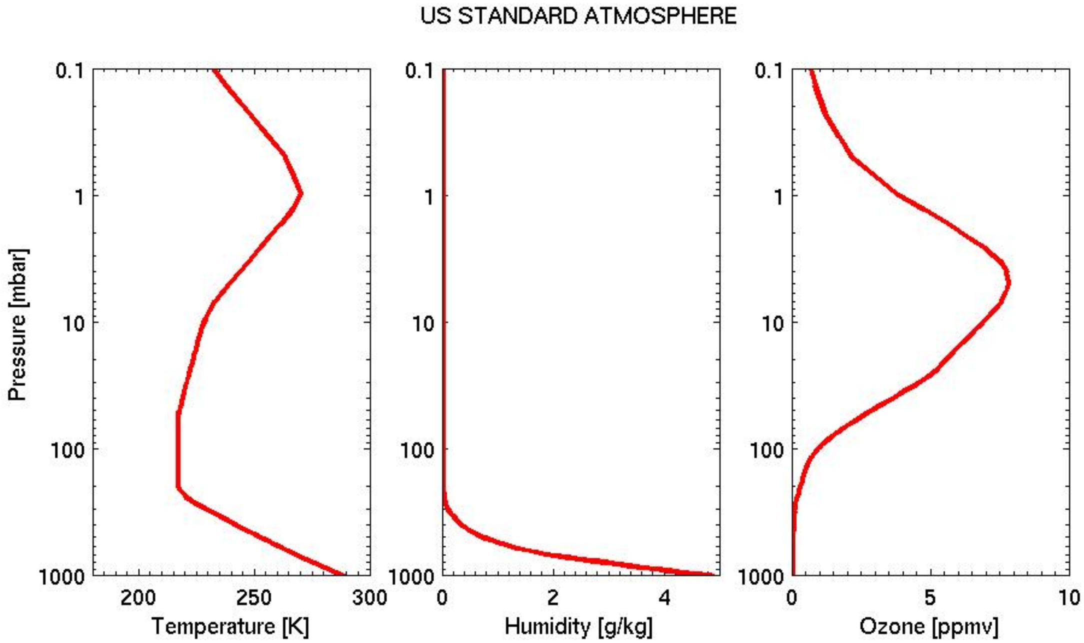
Subarctic Winter Profile:

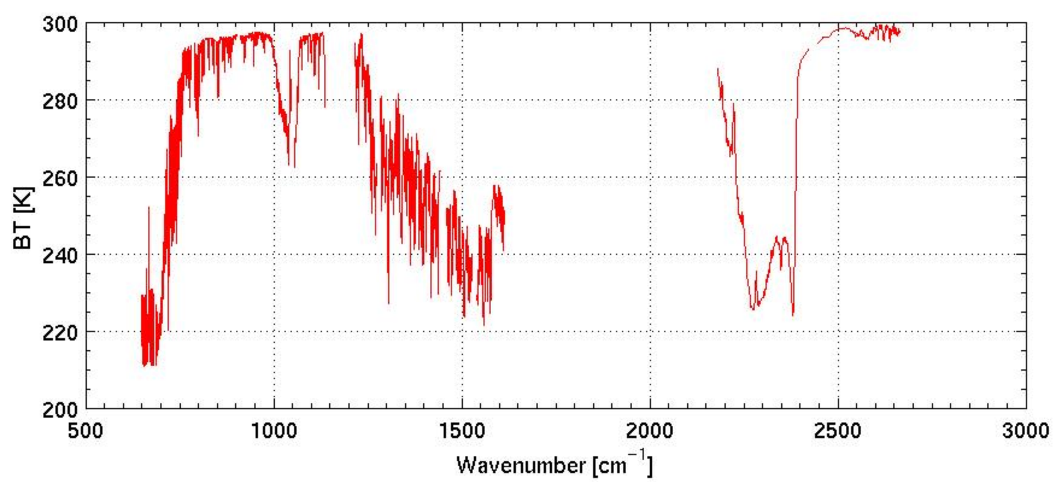
- T near surface < 260 K
- tropopause at < 100 mbar
- ~constant temperature above tropopause (20-200mbar)
- small T gradient in troposphere
- very dry
- low skin temperatures

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

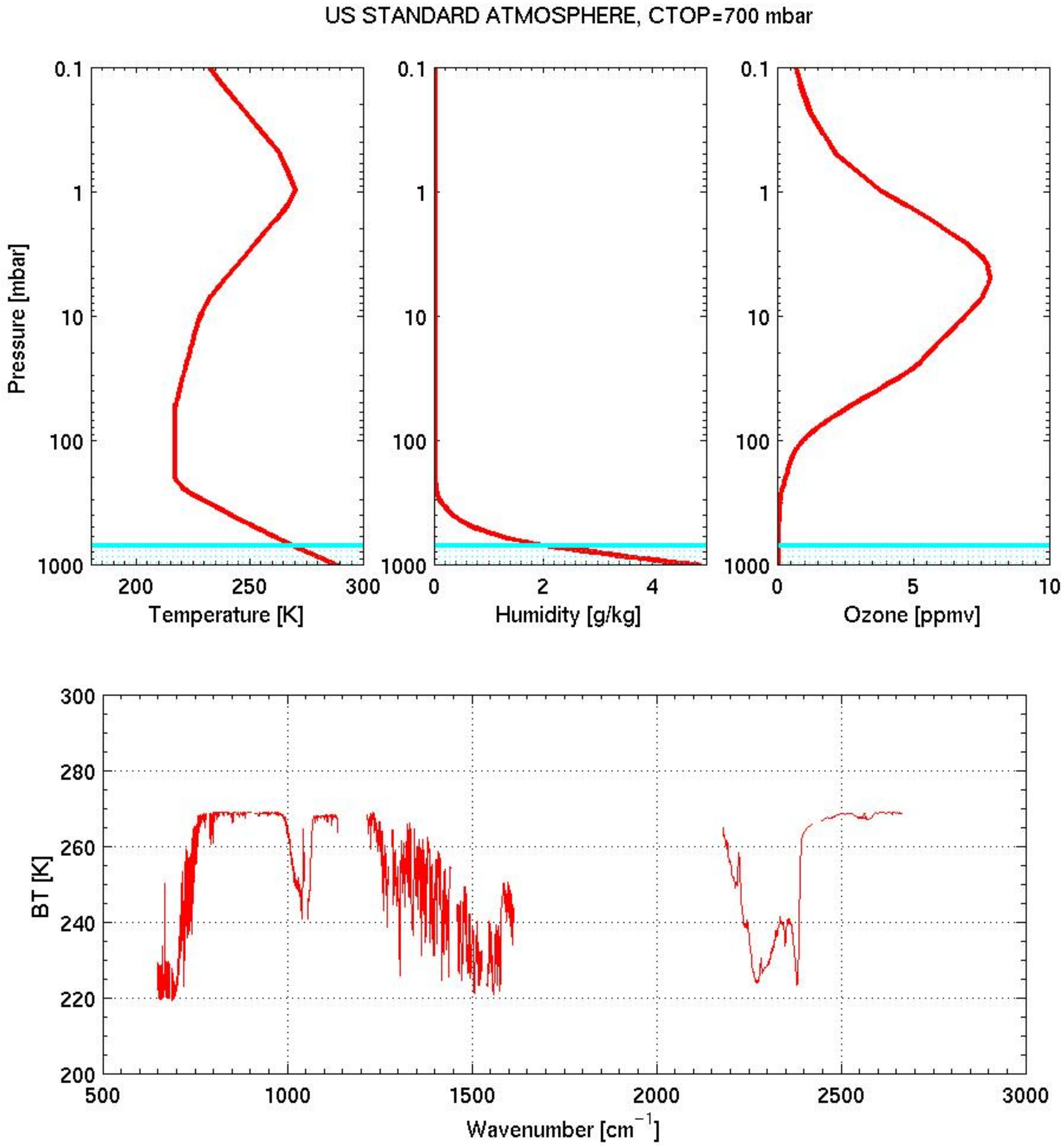




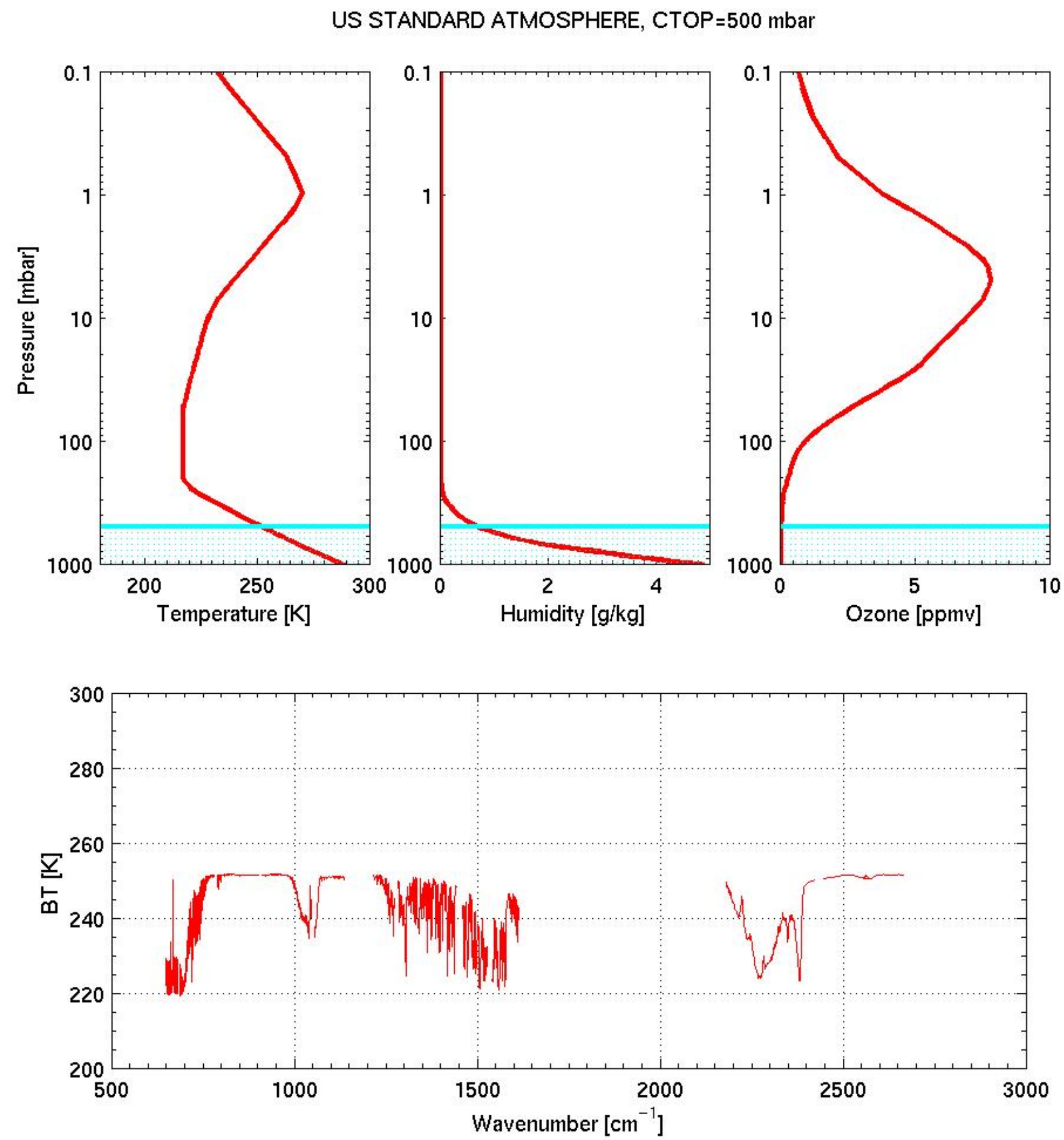
Opaque Cloud Simulation – Cloudtop at 700 mbar

<u>Opaque Cloud at 700 mbar:</u>

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



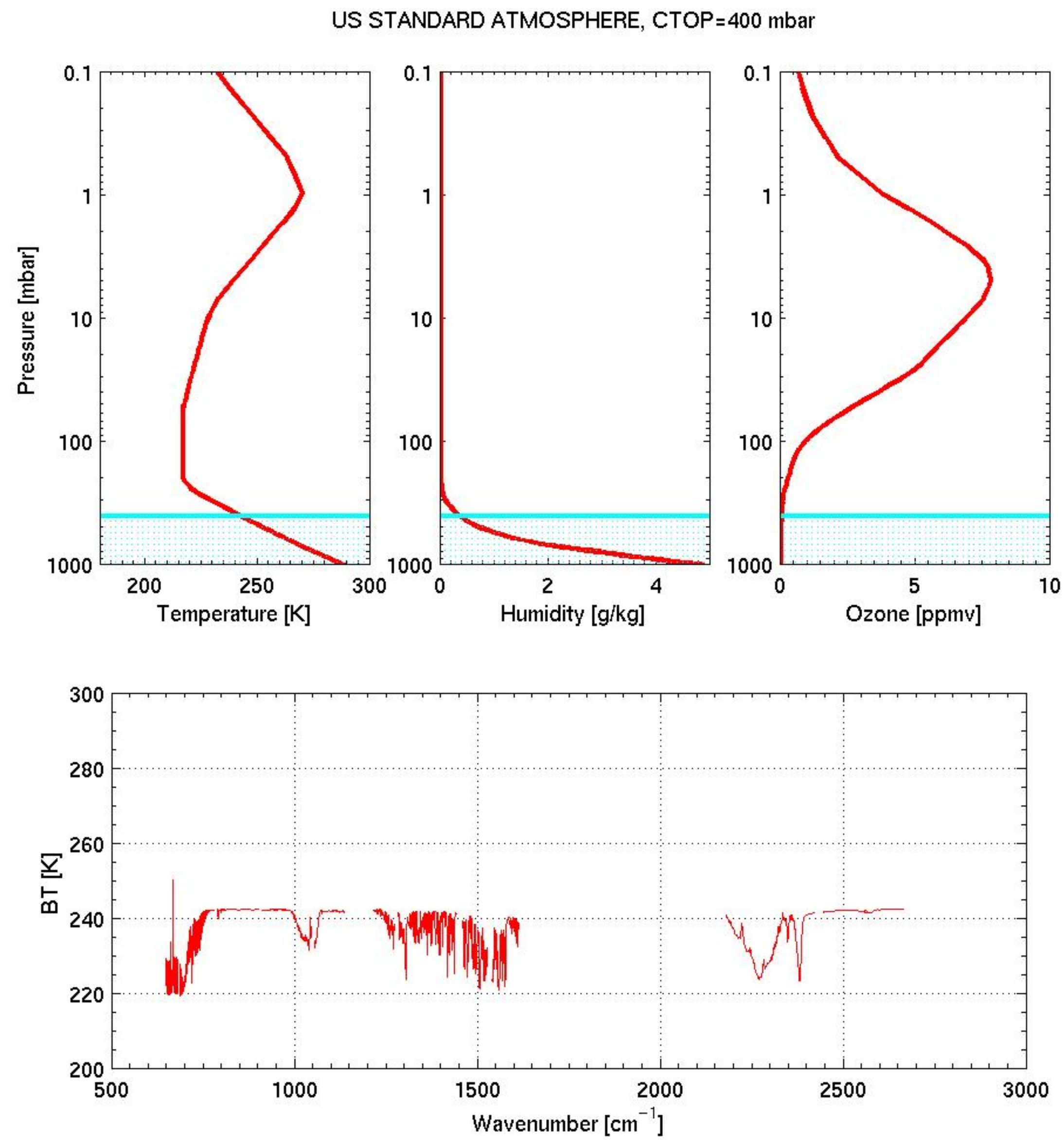
Opaque Cloud Simulation – Cloudtop at 500 mbar



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

Opaque Cloud Simulation – Cloudtop at 400 mbar



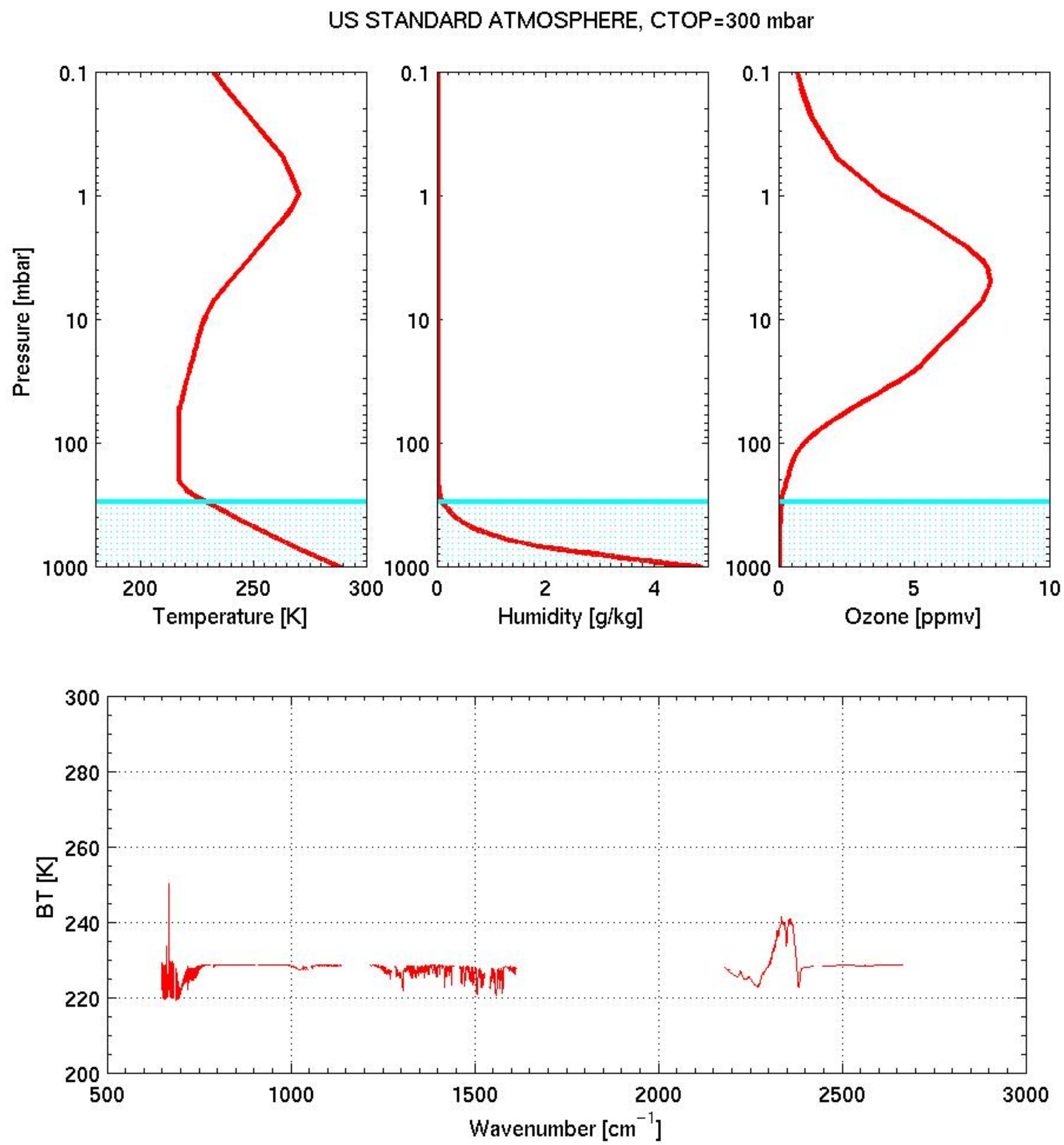
Opaque Cloud at 400 mbar:

- 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

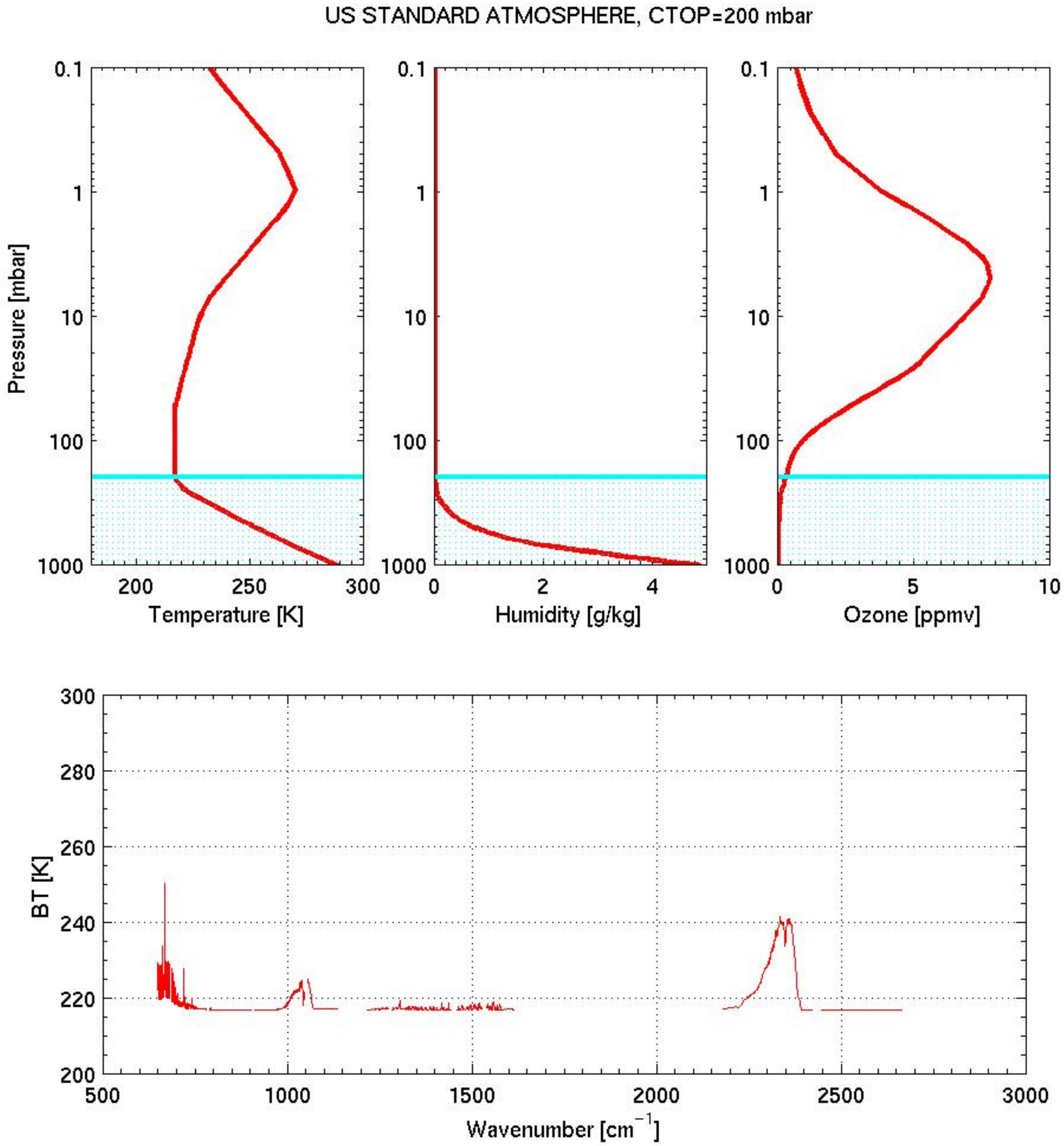
Opaque Cloud Simulation – Cloudtop at 300 mbar

<u>Opaque Cloud at 400 mbar:</u>

- 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



Opaque Cloud Simulation – Cloudtop at 200 mbar



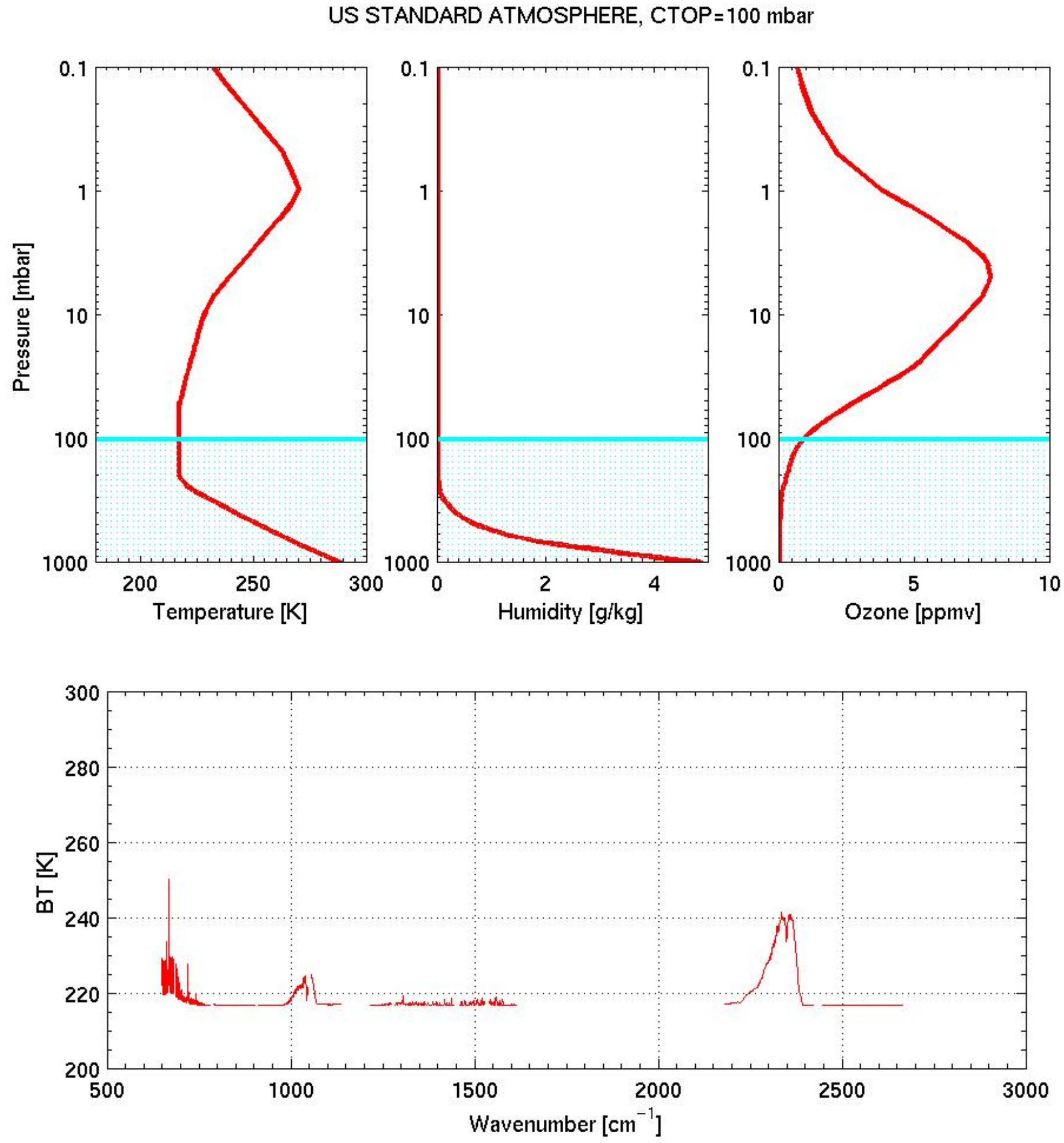
Opaque Cloud at 200 mbar:

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

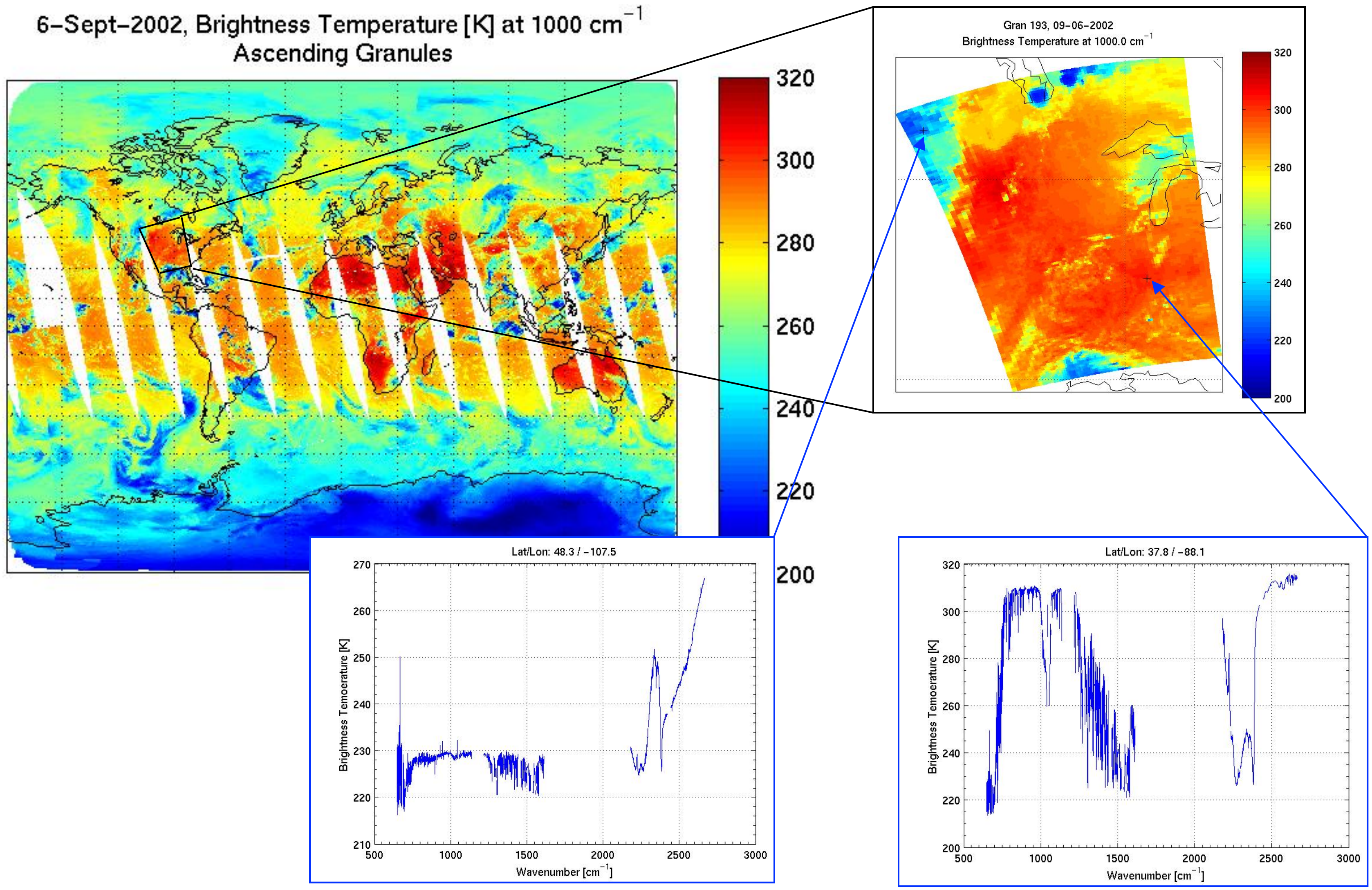
Opaque Cloud Simulation – Cloudtop at 100 mbar

Opaque Cloud at 100 mbar:

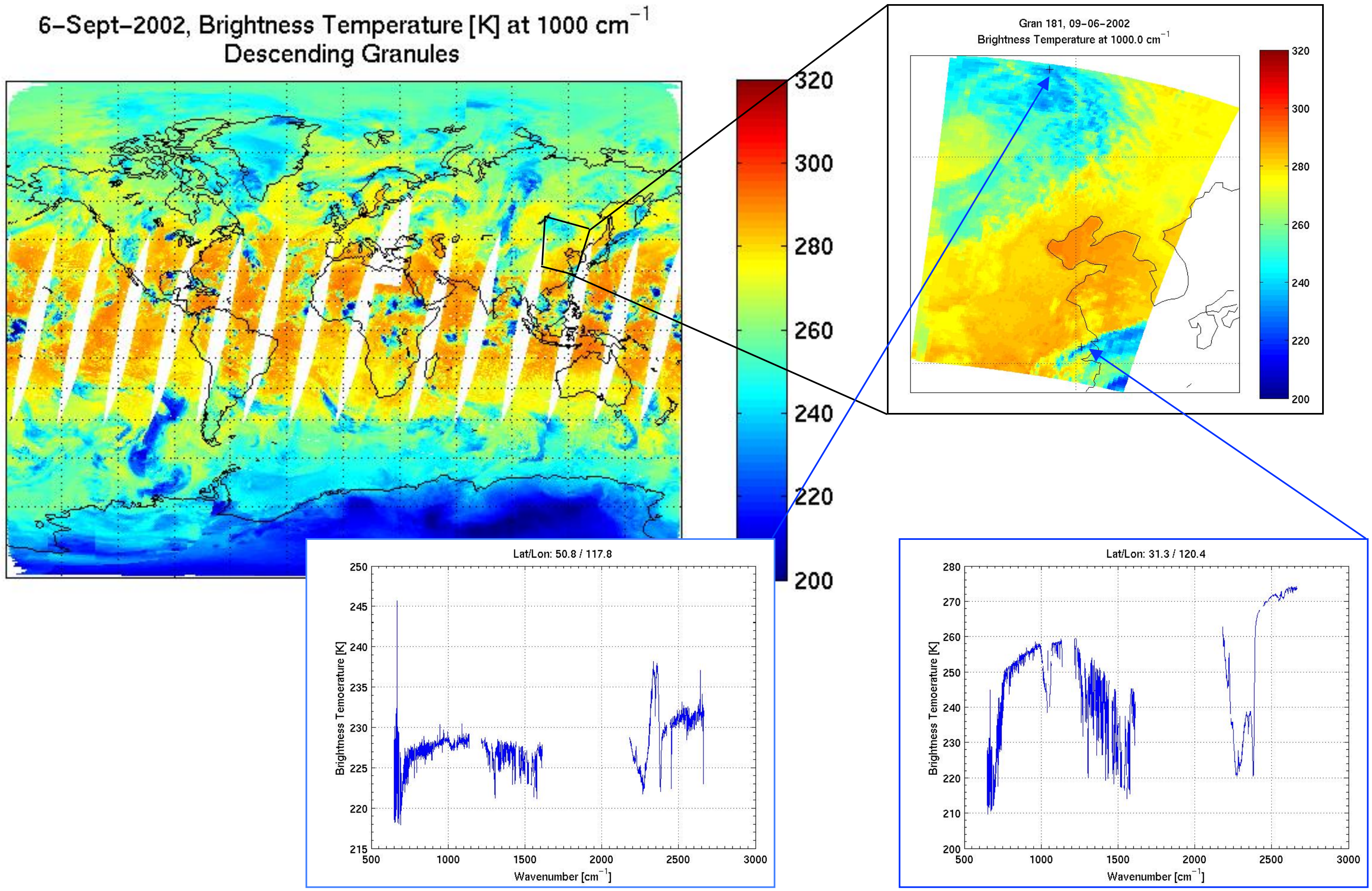
- same results as for 200 mbar since there is no change in T between 100 and 200 mbar
- T at cloudtop at ~220 K
- no moisture above cloud
- Every layer above cloud is warmer than cloudtop



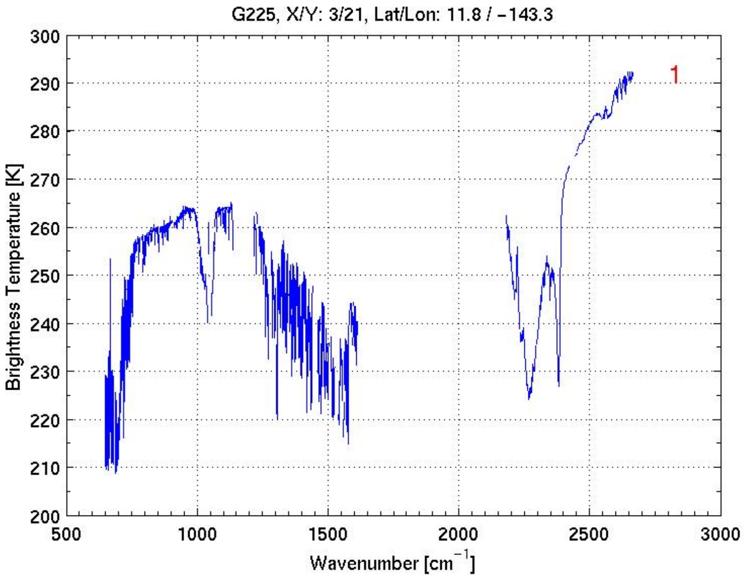
AIRS Measurements (Daytime)

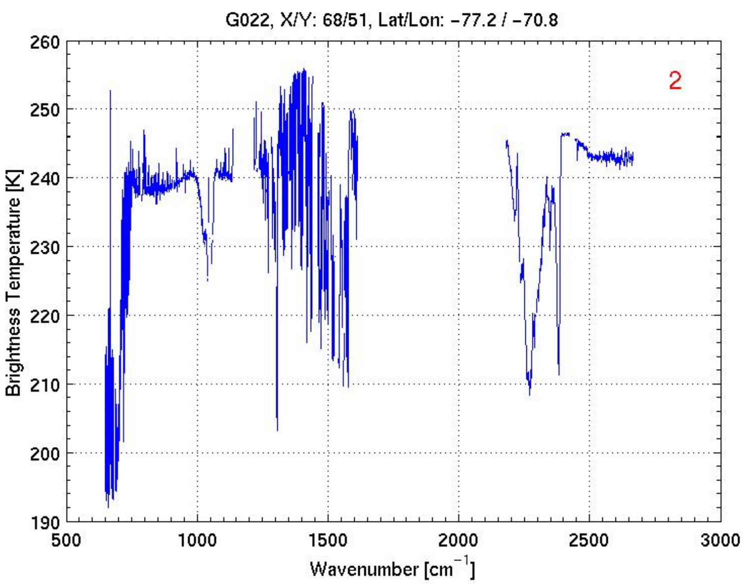


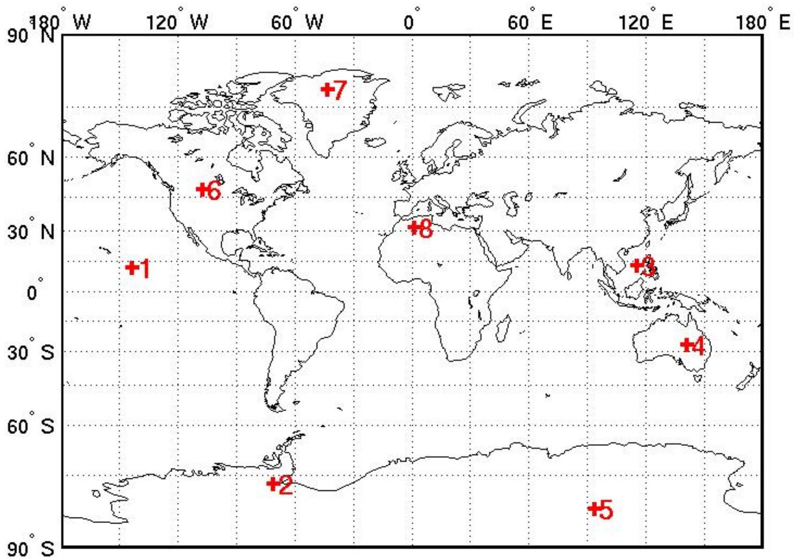
AIRS Measurements (Nighttime)



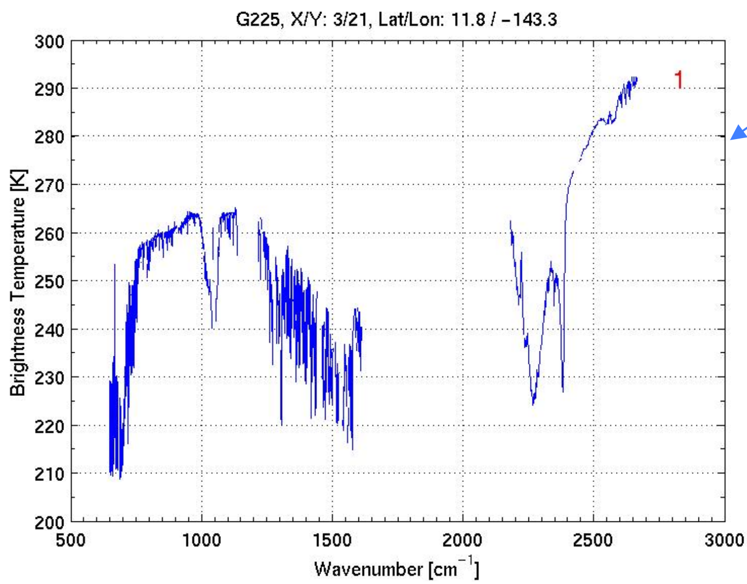
AIRS Observations (1)





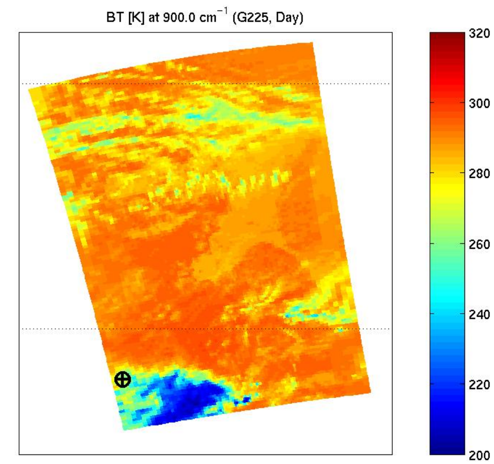


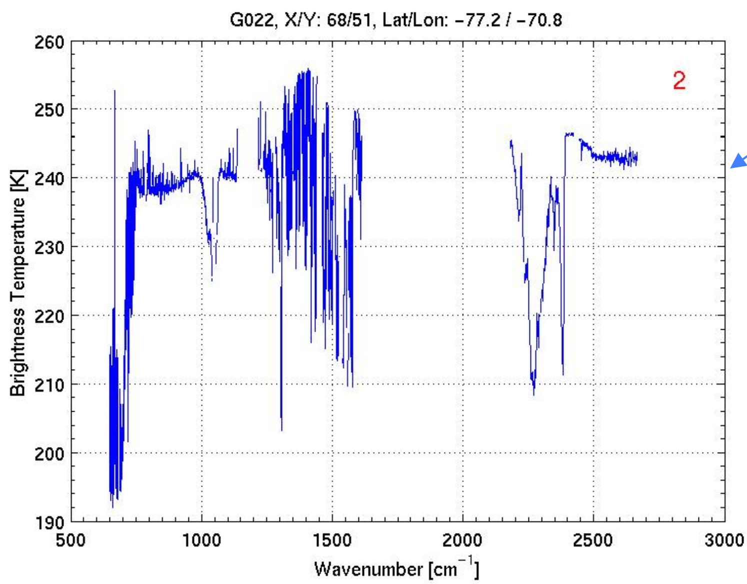
AIRS Observations (1)



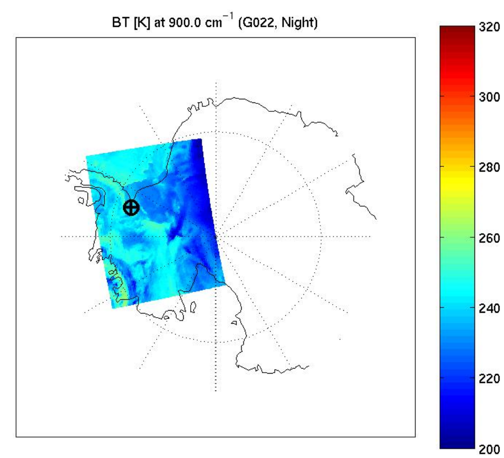
Transparent Cloud,

Solar Reflection during Daytime

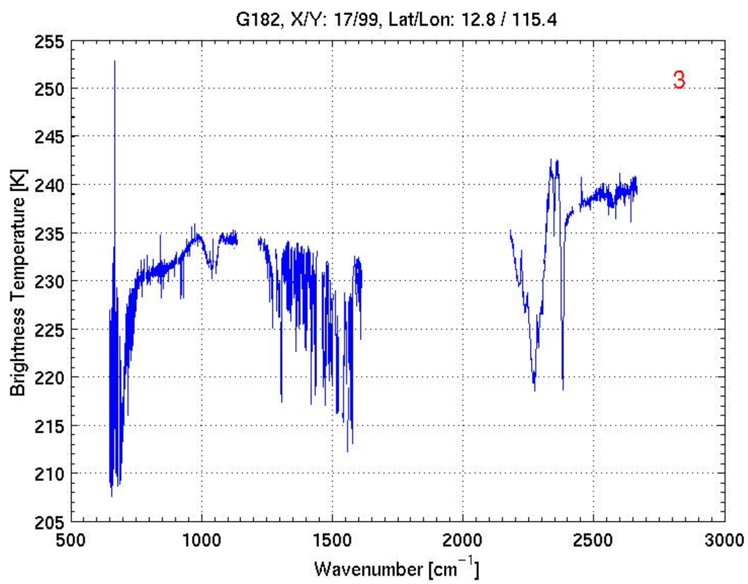


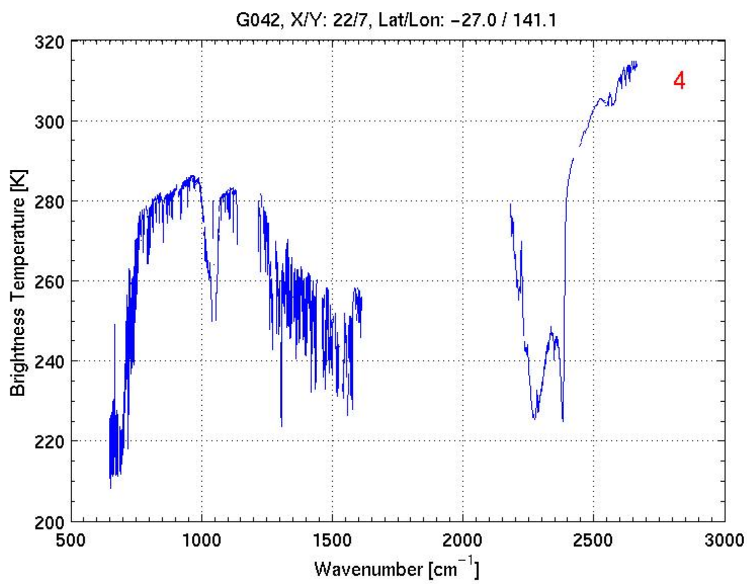


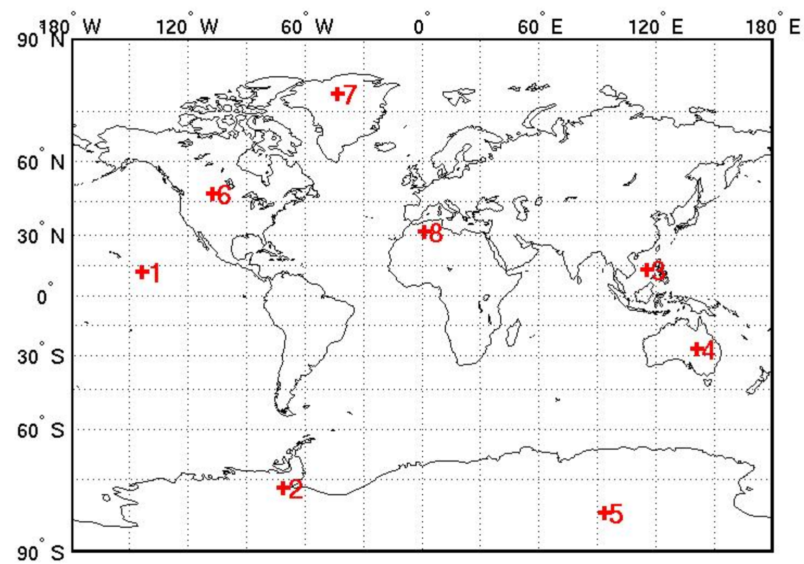
Strong Surface Inversion, Nighttime



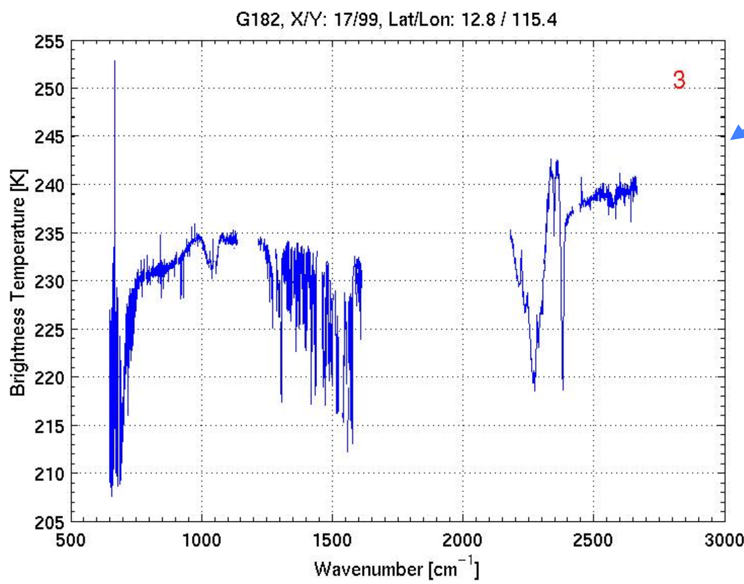
AIRS Observations (2)



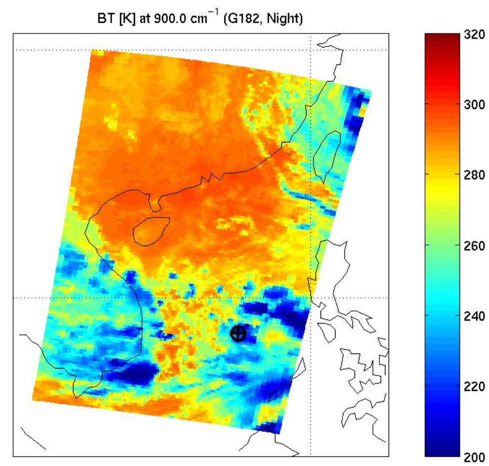


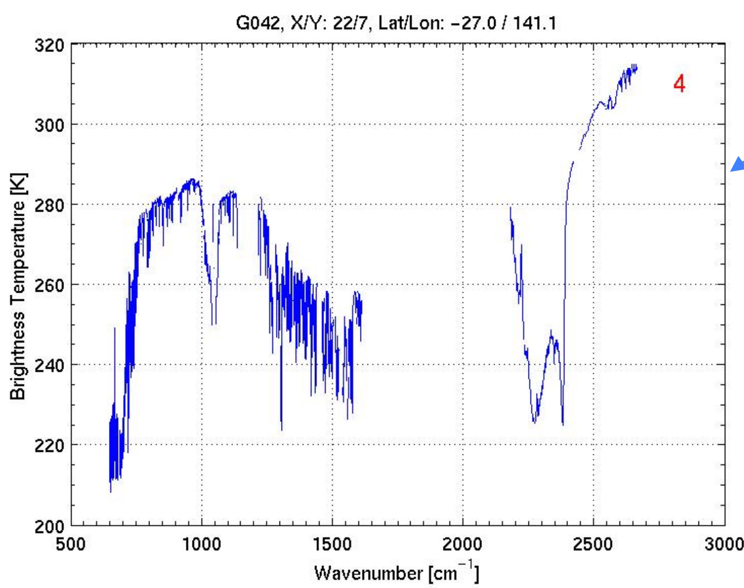


AIRS Observations (2)

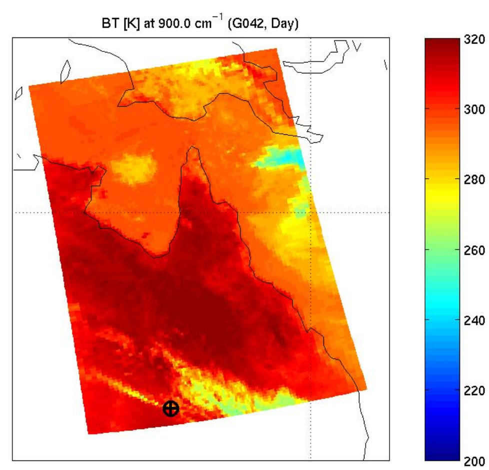


Cloudy, nighttime

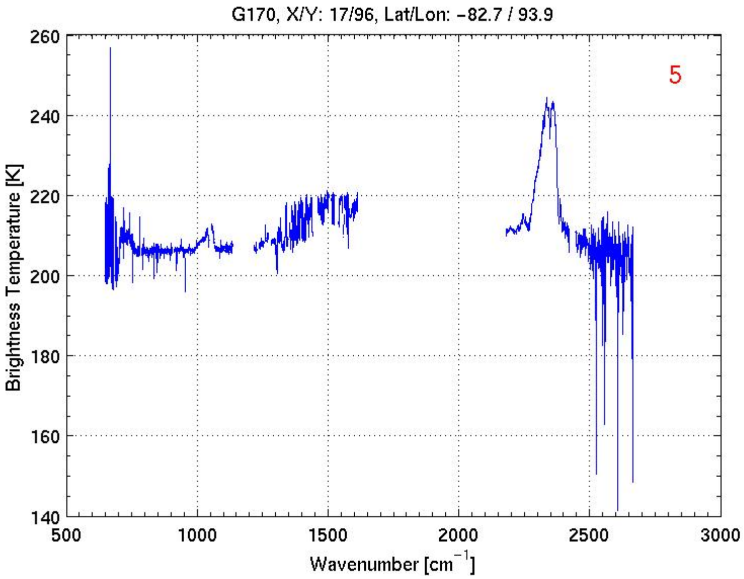


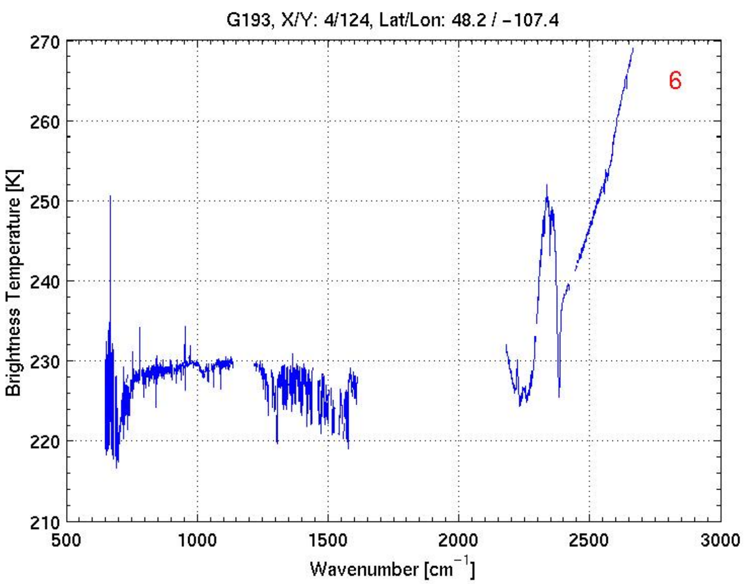


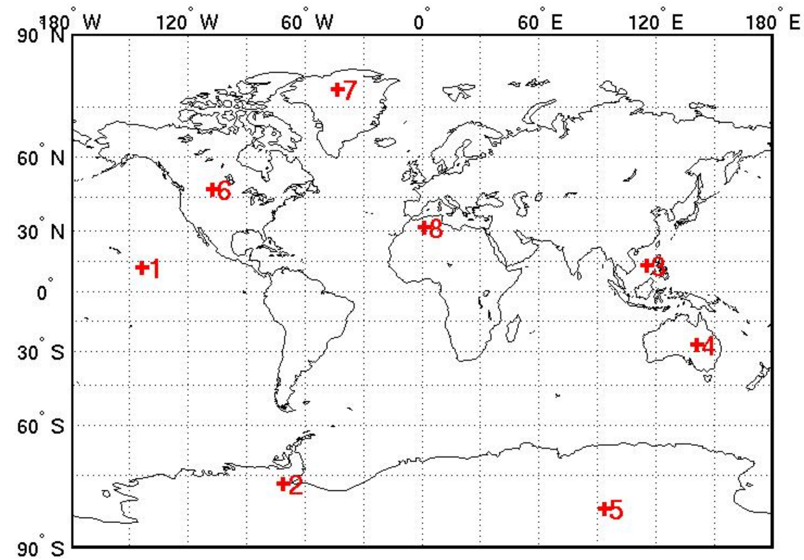
Desert, Solar reflection during daytime, transparent cloud



AIRS Observations (3)

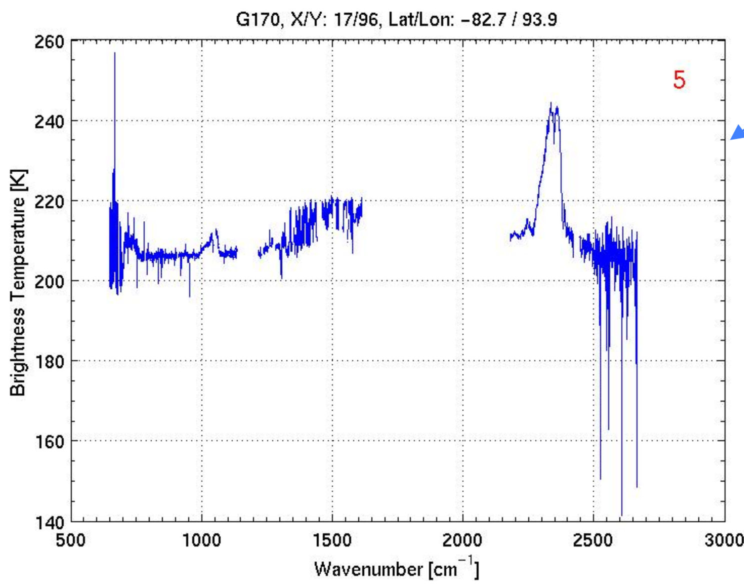


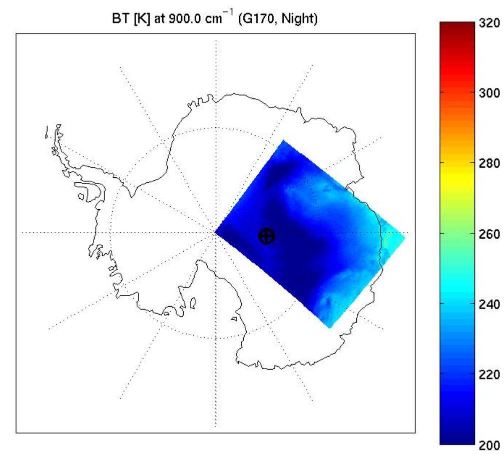




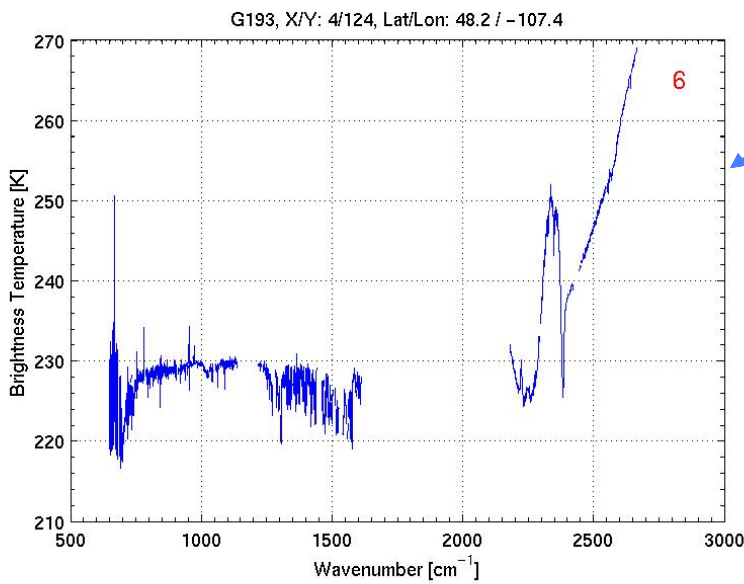
AIRS Observations (3)

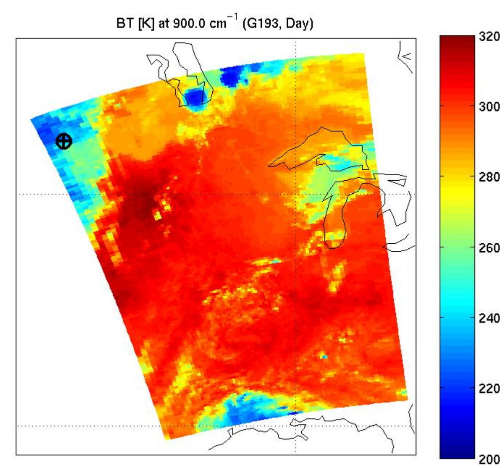
Thick cloud, nighttime



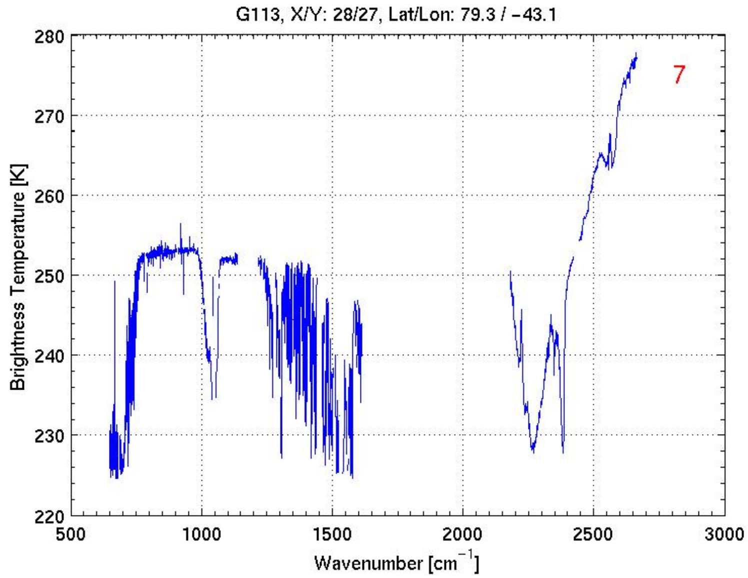


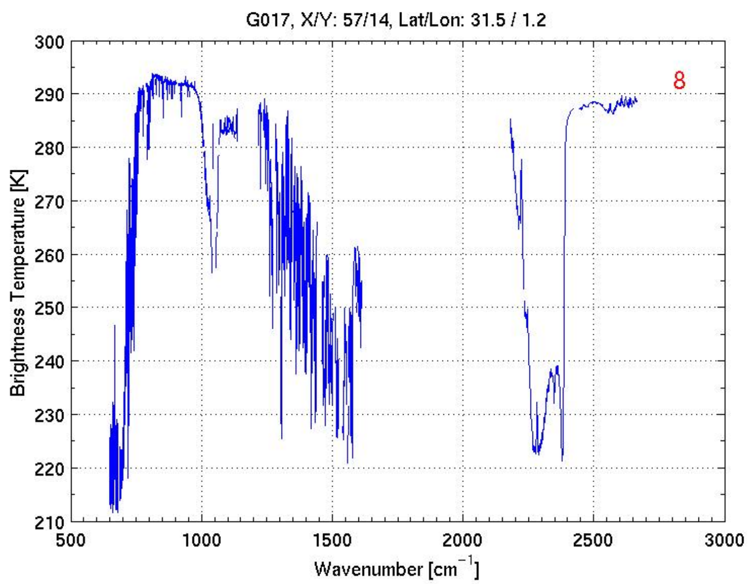
Cloud, Daytime

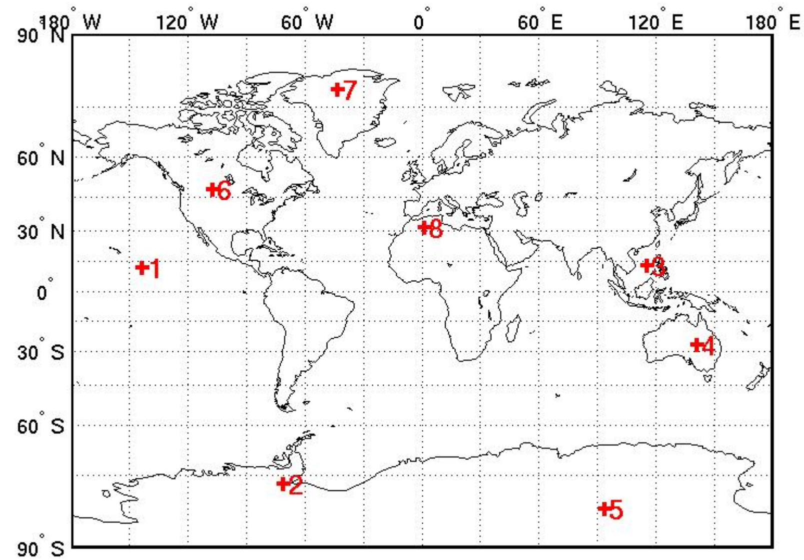




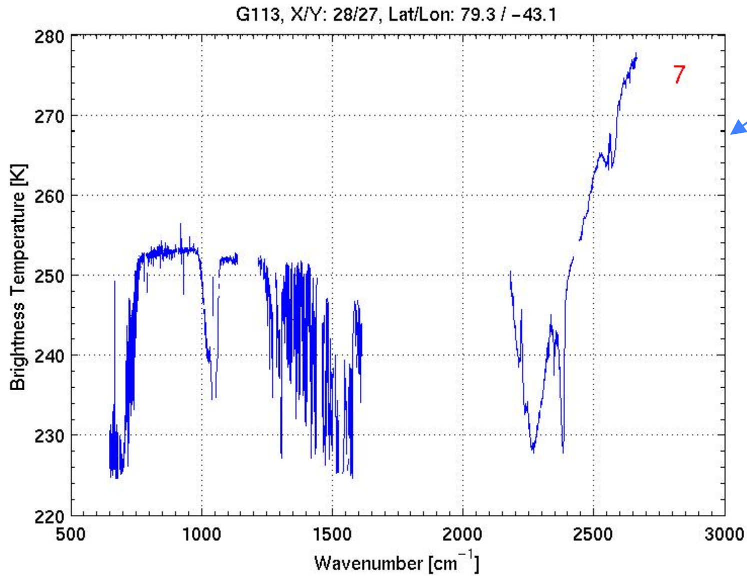
AIRS Observations (4)



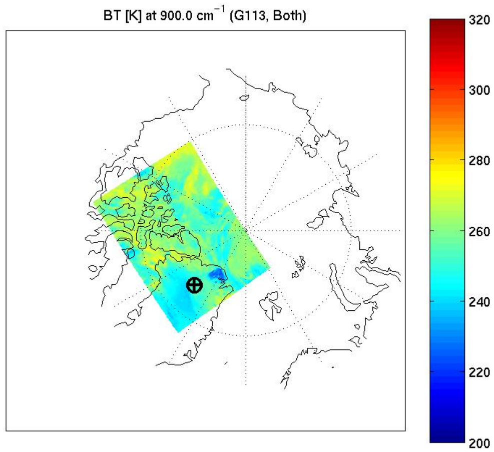


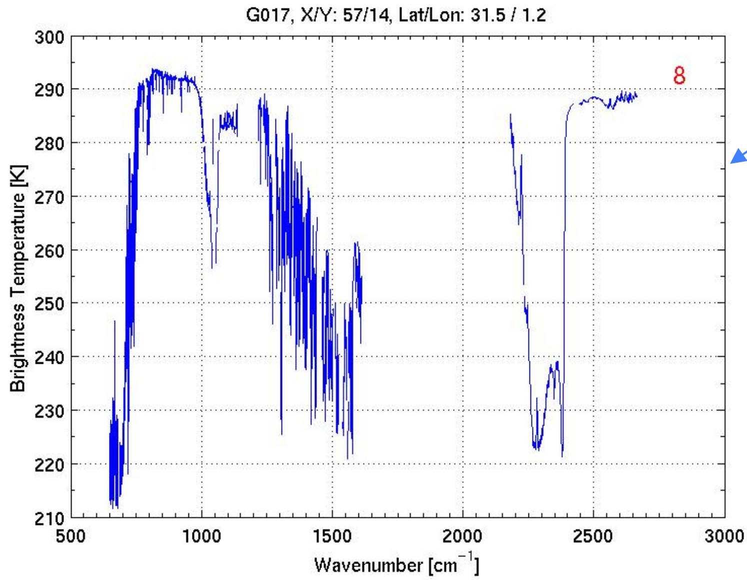


AIRS Observations (4)

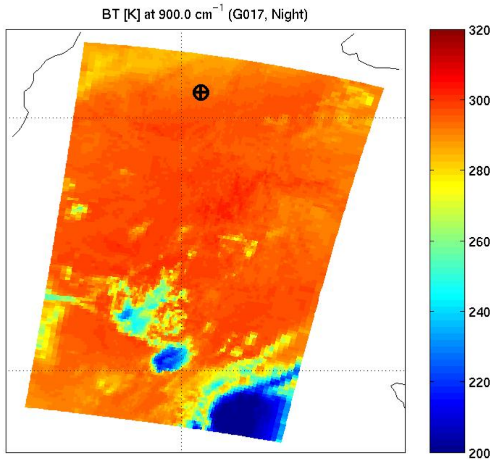


Solar Reflection during Daytime

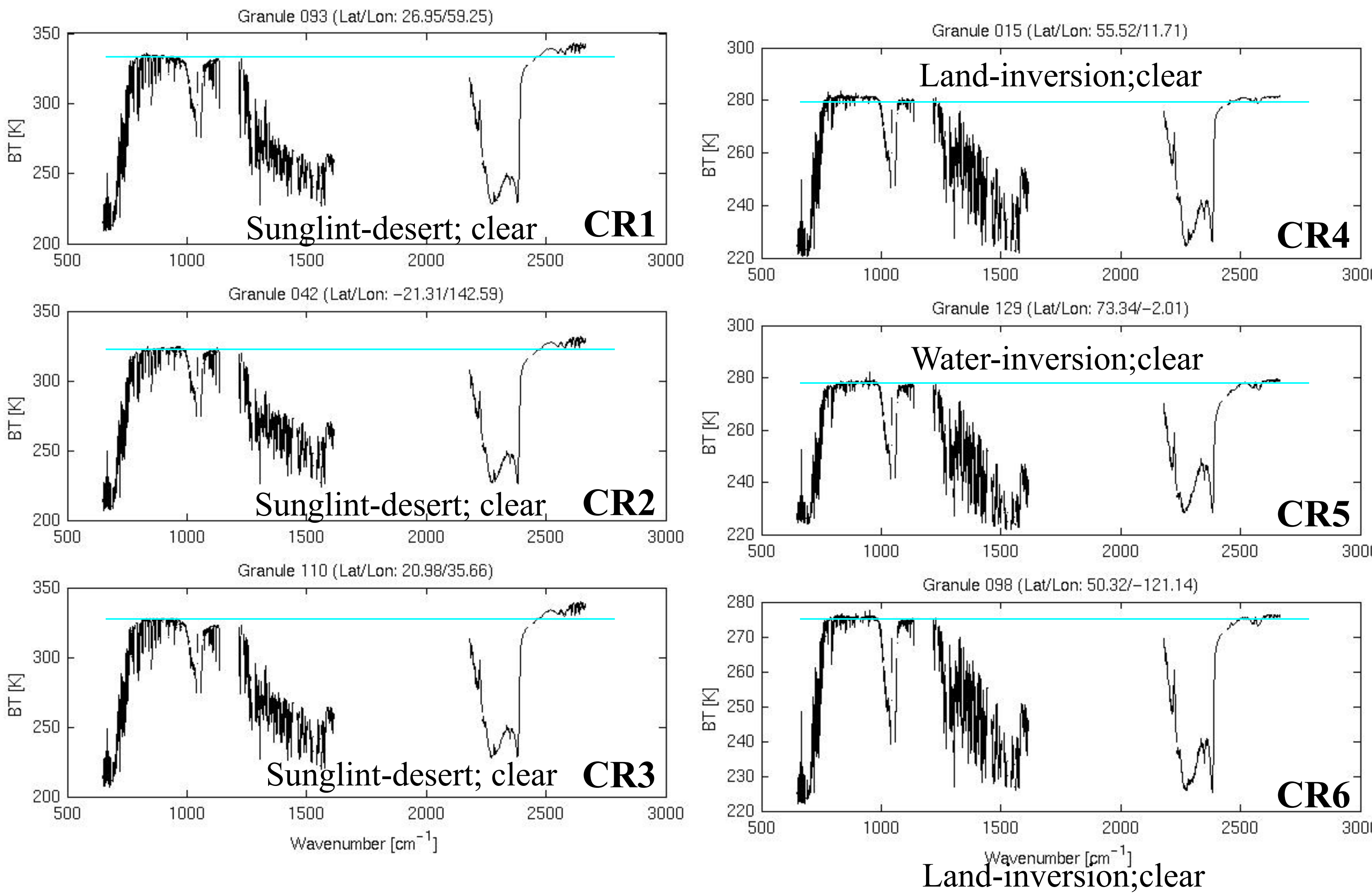




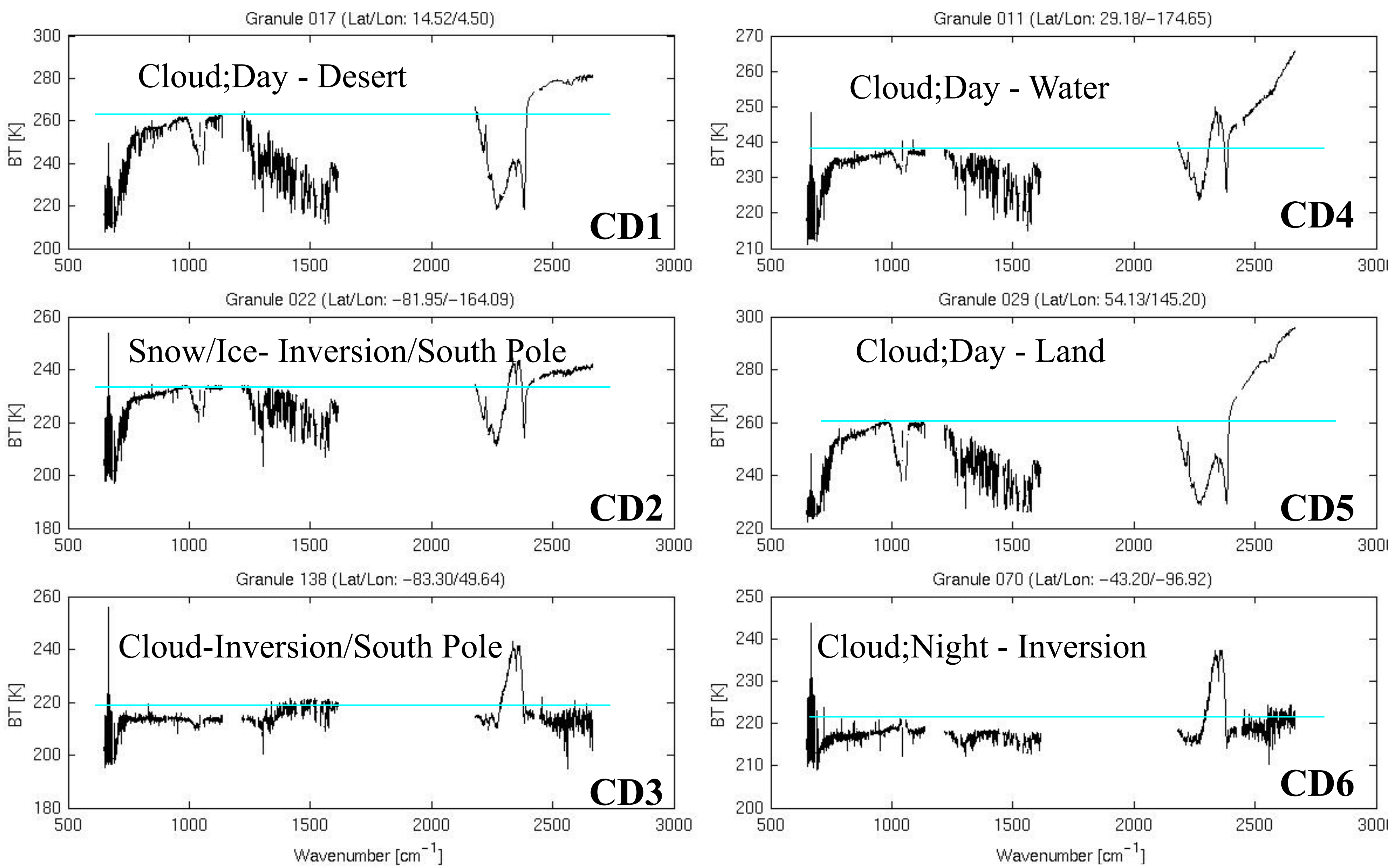
Desert, nighttime



Global AIRS Spectral Day/Night & Boundary Layer Temperature Inversion



Global AIRS Spectral Cloud, Cold Surface, & Upper Level/Boundary Layer Temperature Inversion



Global AIRS Spectral Cloud & Upper Level Temperature Inversion