Quick Review of Remote Sensing Basic Theory

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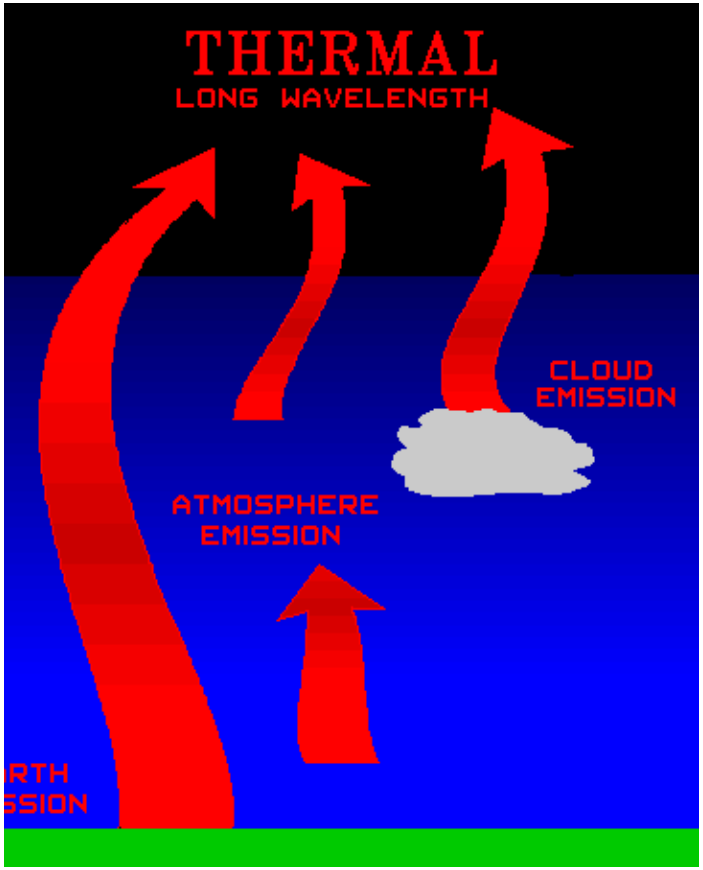
Outline

IR at High Spectral Resolution

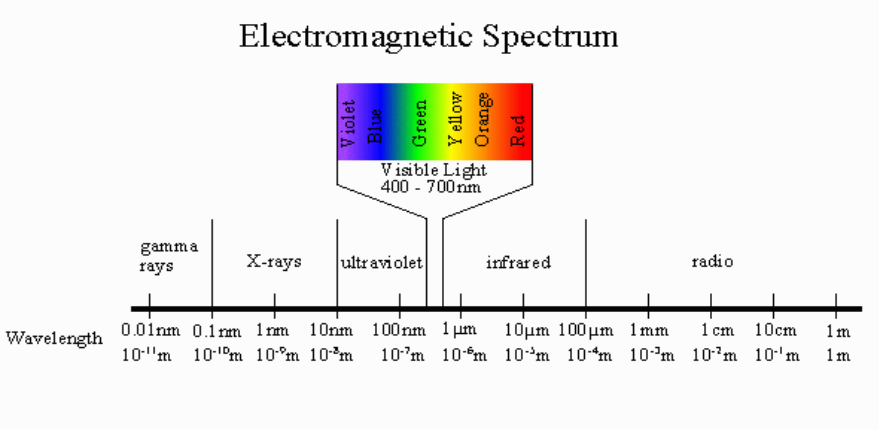
- Basic Principles
- Limits in IR remote sensing

Infrared
(Emissive Bands)

High Spectral Resolution



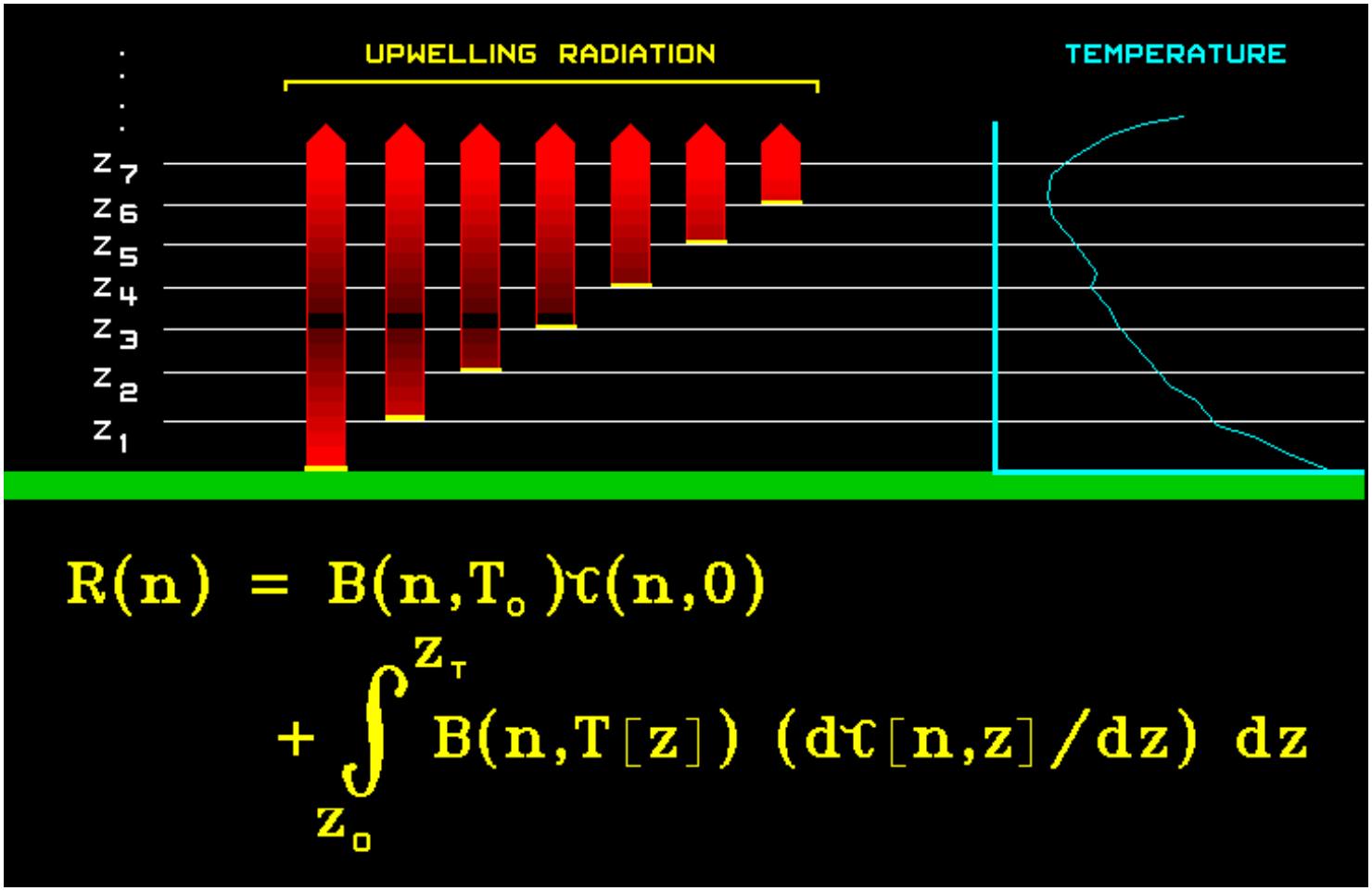
High Spectral Resolution



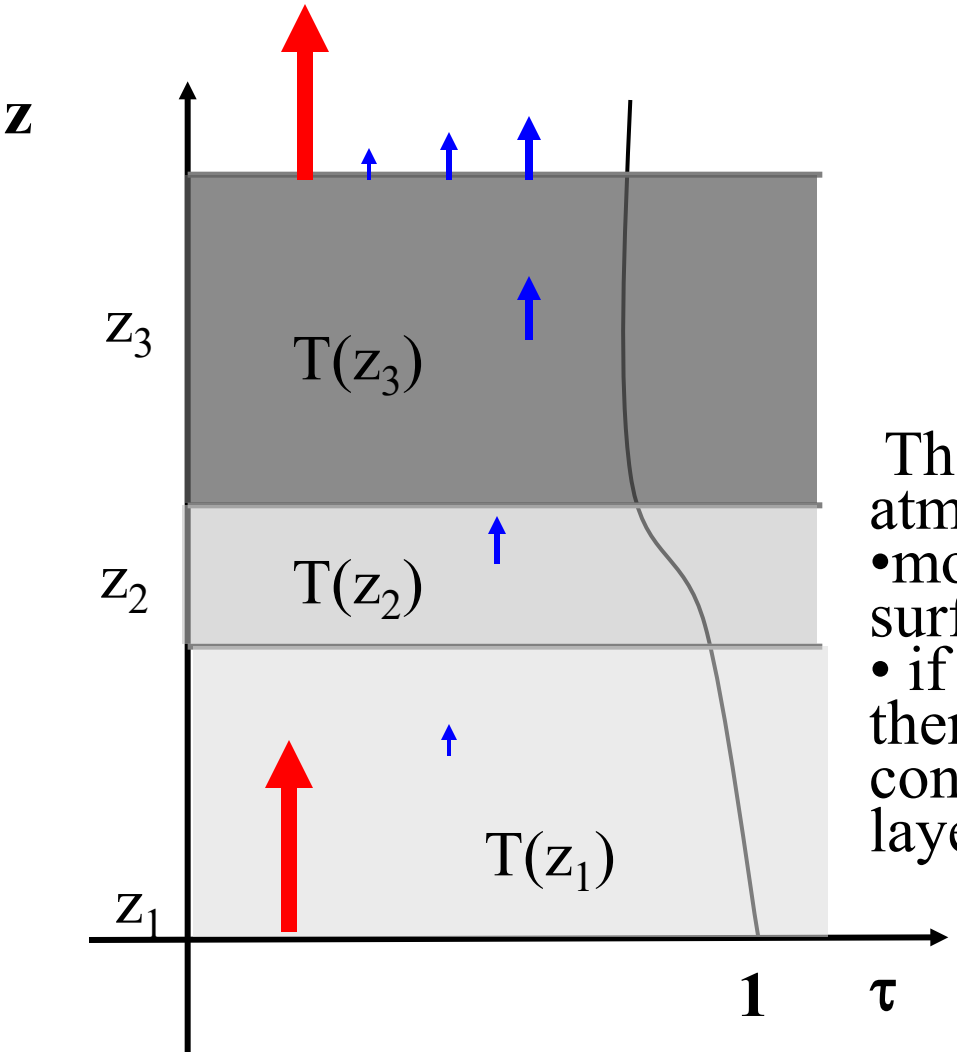
QuickTime™ and a
decompressor
are needed to see this picture.

High Spectral Resolution ⟷ High Vertical Resolution

Radiative Transfer Equation



Transmittance for an off-line Channels



$\tau + a + \cancel{r} = 1$

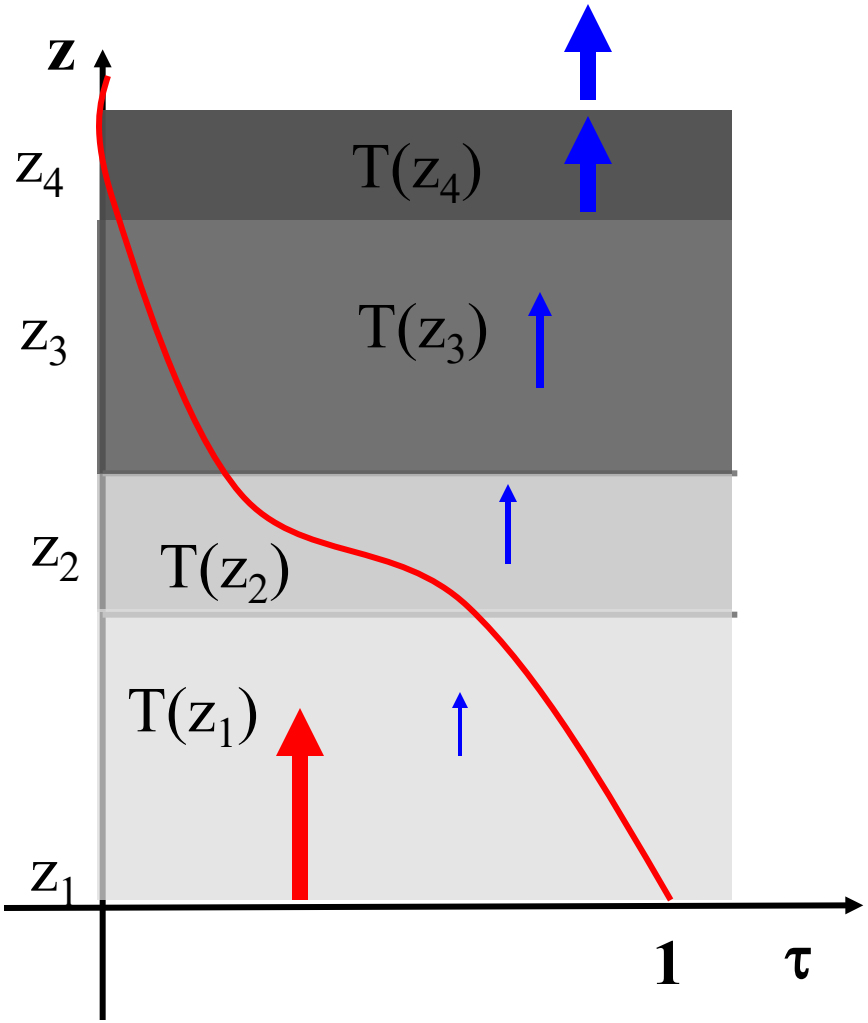
τ close to 1
a close to 0

The molecular species in the atmosphere are not very active:
•most of the photons emitted by the surface make it to the Satellite
• if a is close to 0 in the atmosphere then ε is close to 0, not much contribution from the atmospheric layers

Surface emission

Atmospheric emission

Trasmittance on an Absorption Line

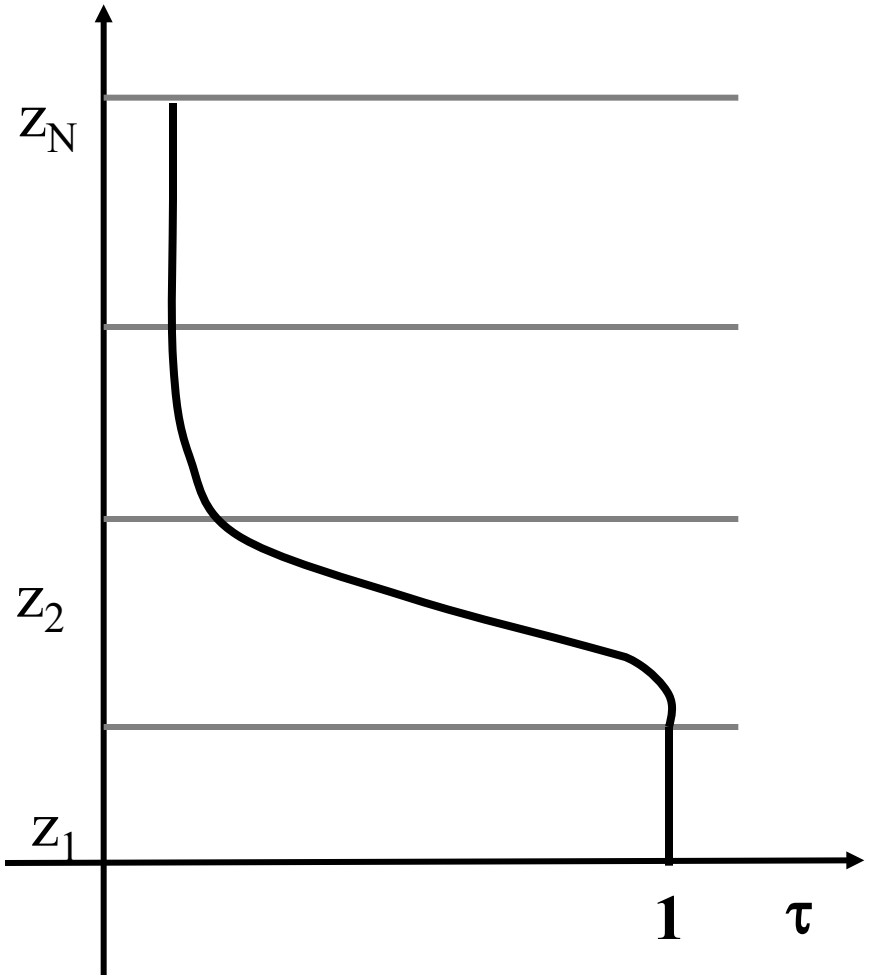


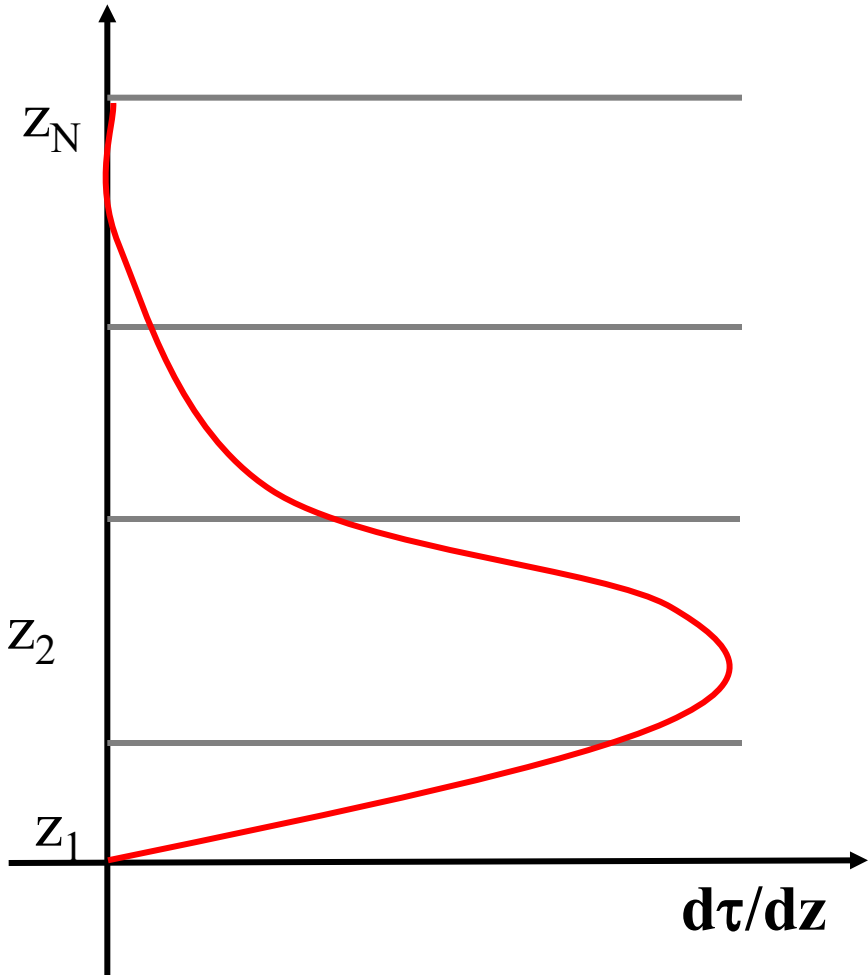
Absorption Channel:
τ close to 0
a close to 1

One or more molecular species in the atmosphere is/are very active:

- most of the photons emitted by the surface will not make it to the Satellite (they will be absorbed)
- if a is close to 1 in the atmosphere then ε is close to 1, most of the observed energy comes from one or more of the uppermost atmospheric layers

Weighting Functions





What Causes Absorption?

Molecules in the Atmosphere.

For any layer of the atmosphere,
molecular absorption
determines the layer emissivity
and trasmittivity

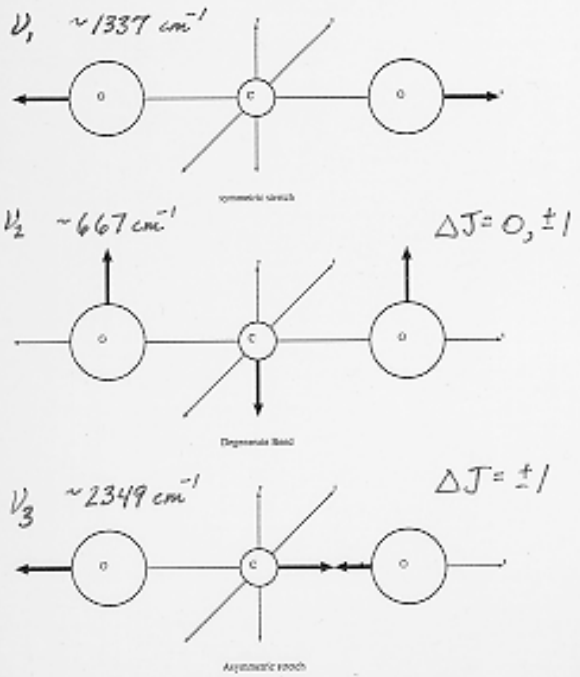
CO_2 Lines

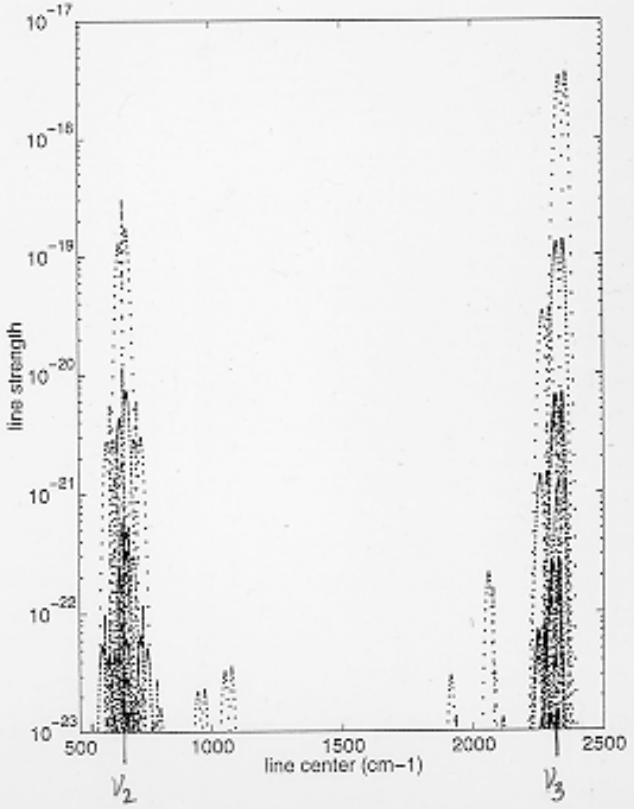
D. Tobin, UMBC

LANL 04/16/96

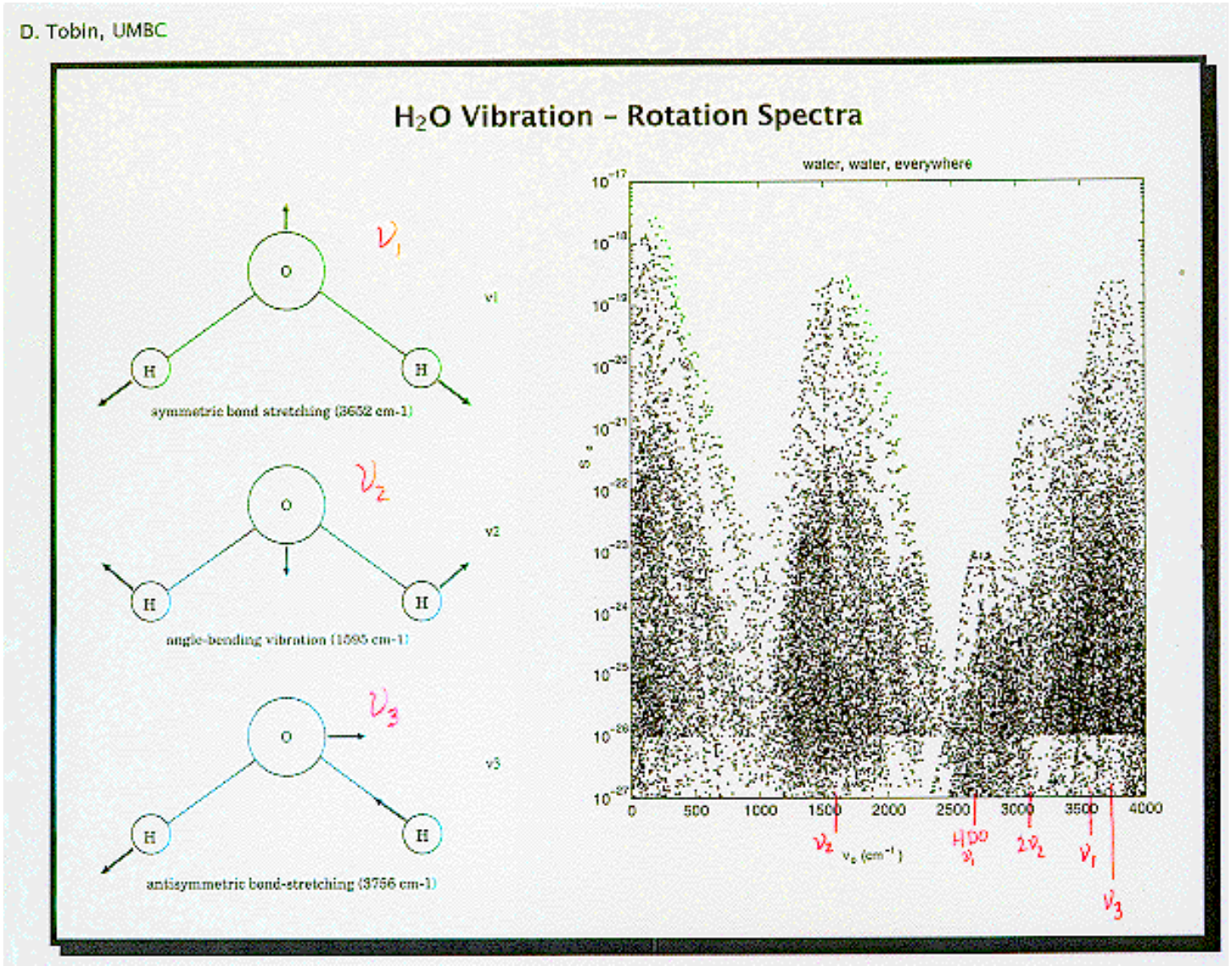
CO_2 Vibration – Rotation Spectra

$$E(\upsilon, J) = \underbrace{h\nu(\upsilon + \frac{1}{2}) - xh\nu(\upsilon + \frac{1}{2})^2 + \ldots}_{\text{vibration}} + \underbrace{B_\nu[J(J+1) - \ell^2] - D_\nu[J(J+1) - \ell^2]^2 + \ldots}_{\text{rotation}}$$

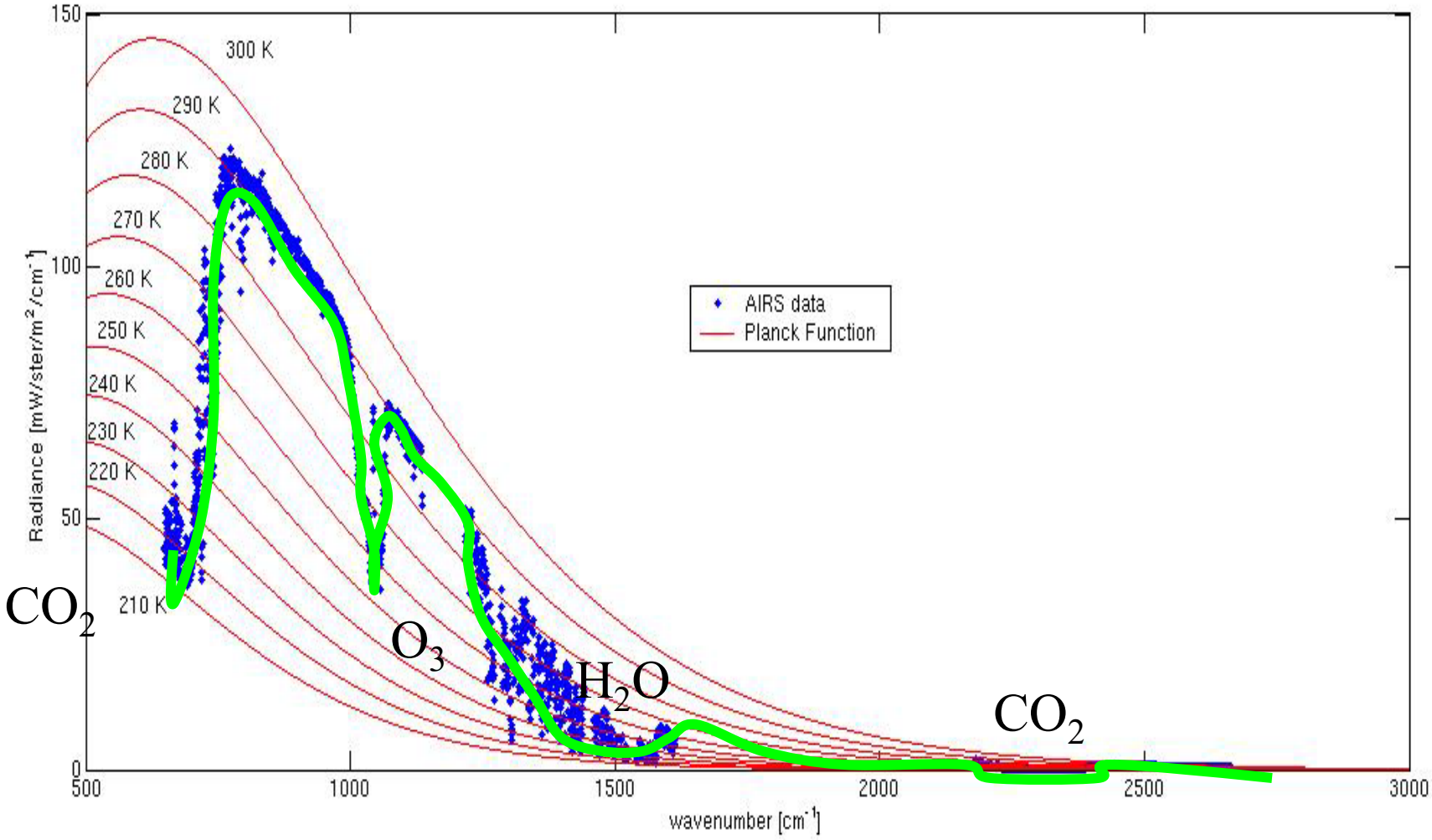




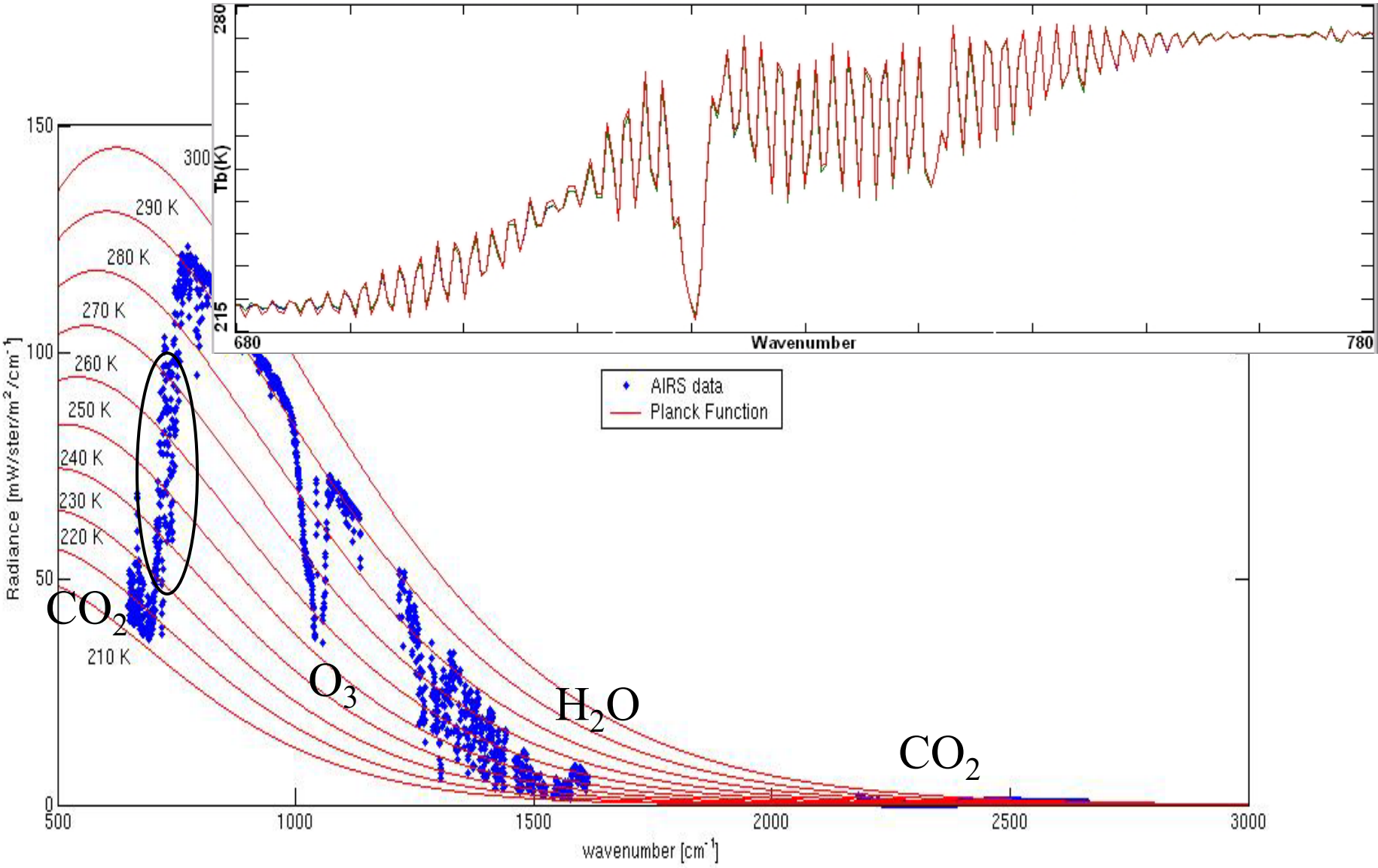
H_2O Lines


D. Tobin, UMBC
H2O Vibration – Rotation Spectra
water, water, everywhere
symmetric bond stretching (3652 cm-1)
angle-bending vibration (1595 cm-1)
antisymmetric bond-stretching (3756 cm-1)
ν1
ν2
ν3
2ν2
HDO

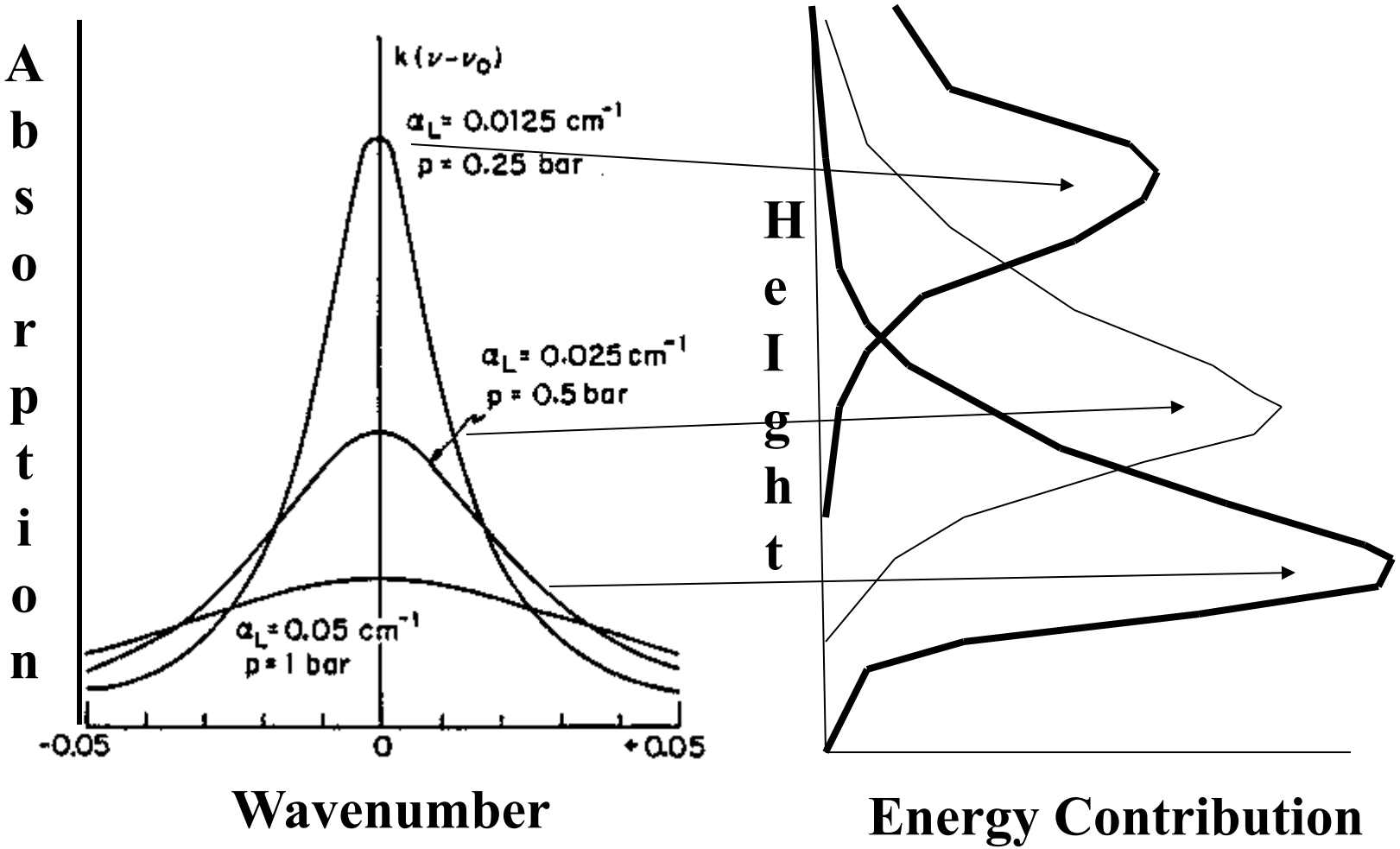
Vibrational Lines



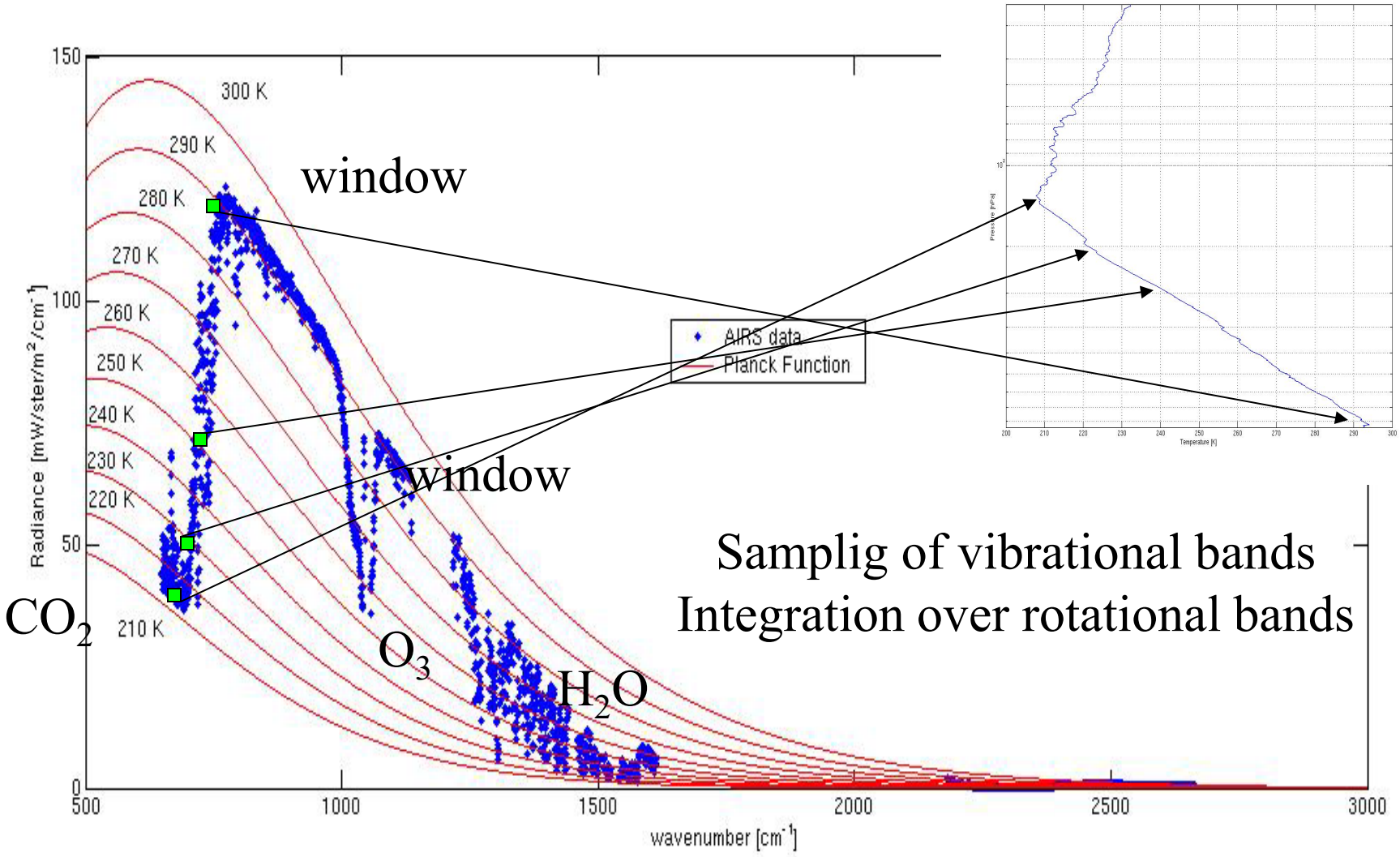
Rotational Lines



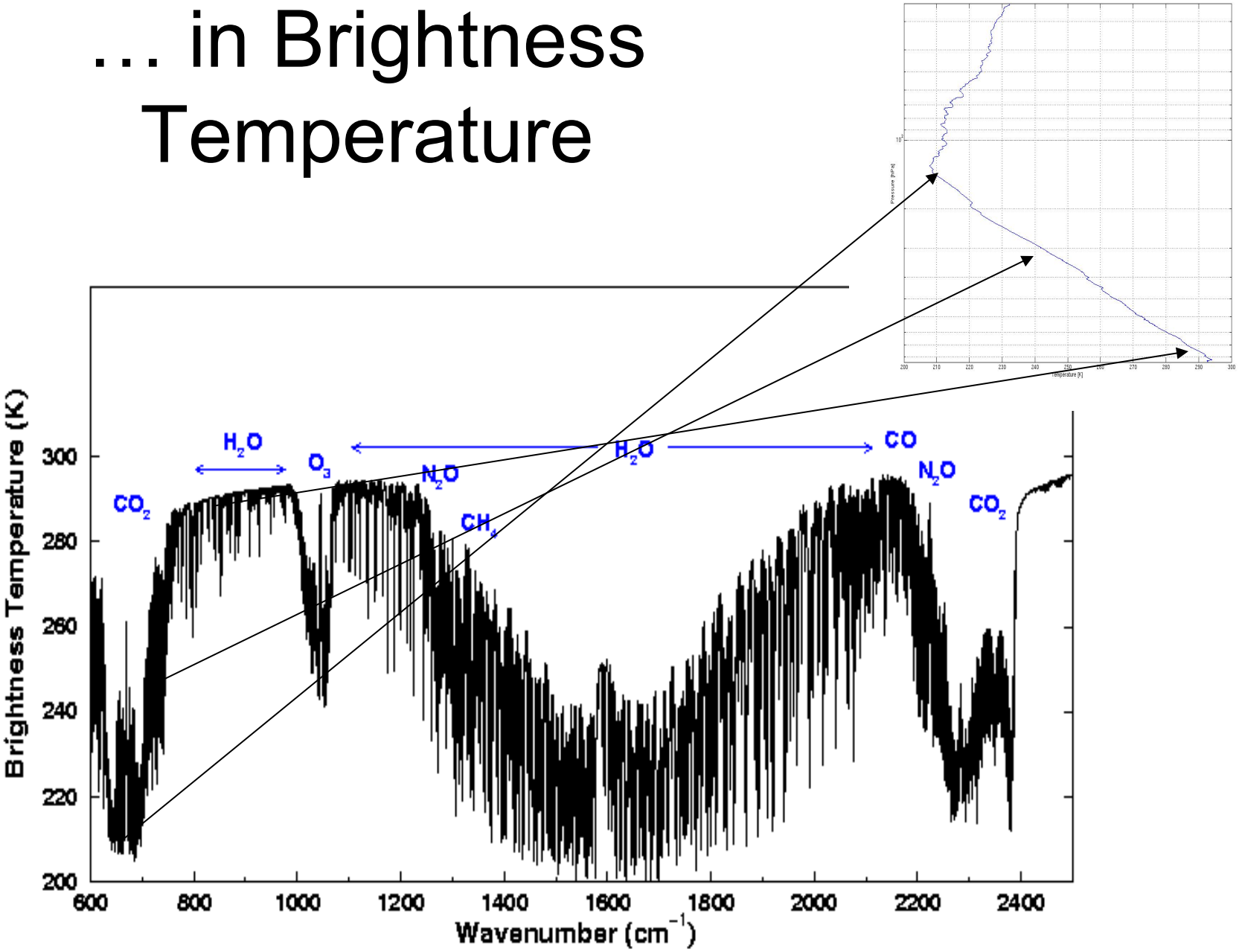
Weighting Functions



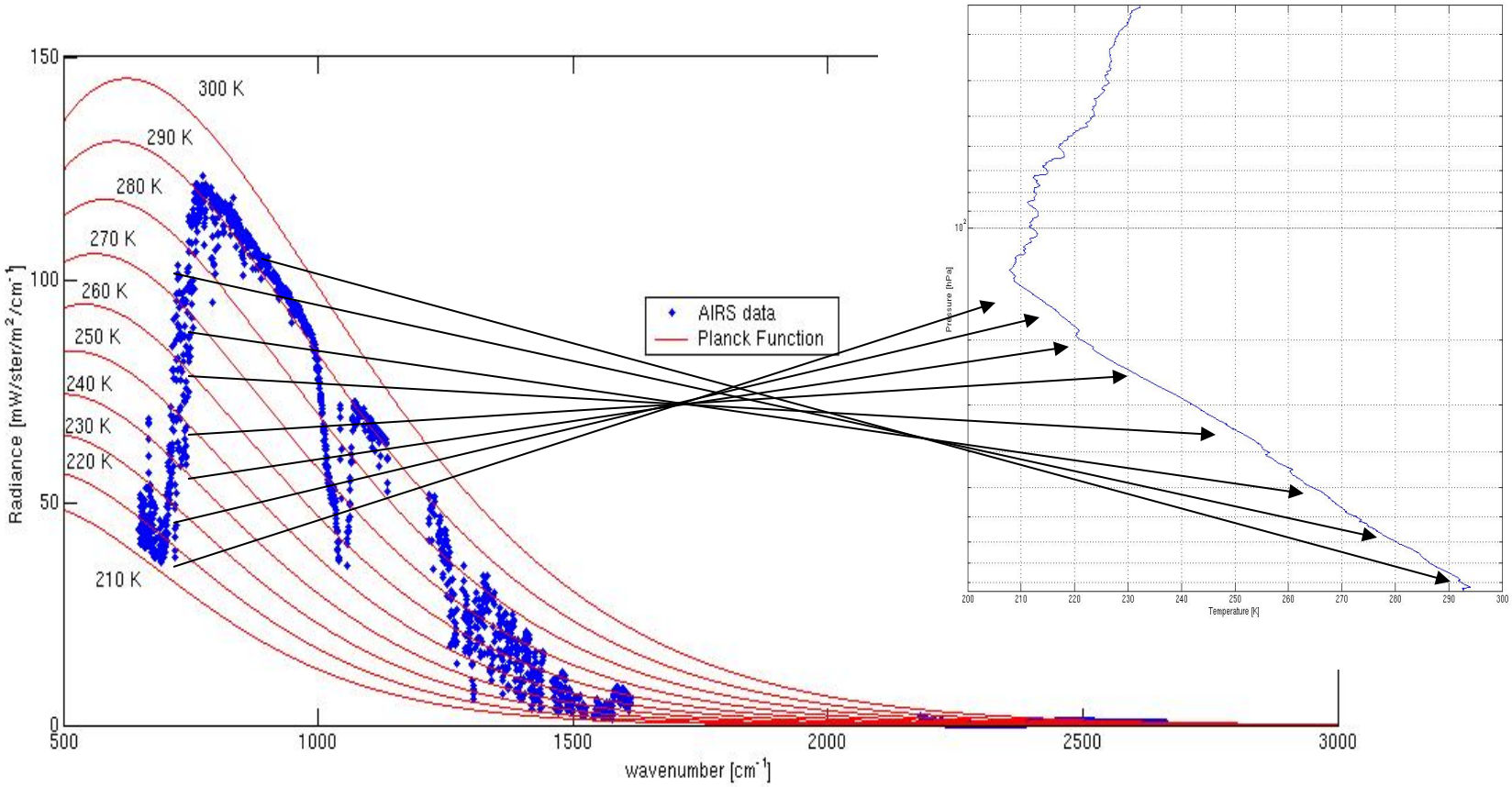
Broad Band


300 K
290 K
280 K
270 K
260 K
250 K
240 K
230 K
220 K
210 K
window
window
AIRS data
Planck Function
CO_2
O_3
H_2O
Samplig of vibrational bands
Integration over rotational bands
Radiance [mW/ster/m^2/cm^{-1}]
wavenumber [cm^{-1}]
0
50
100
150
500
1000
1500
2000
2500
3000

… in Brightness Temperature

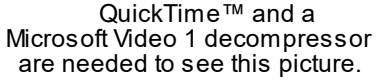


High Spectral Resolution

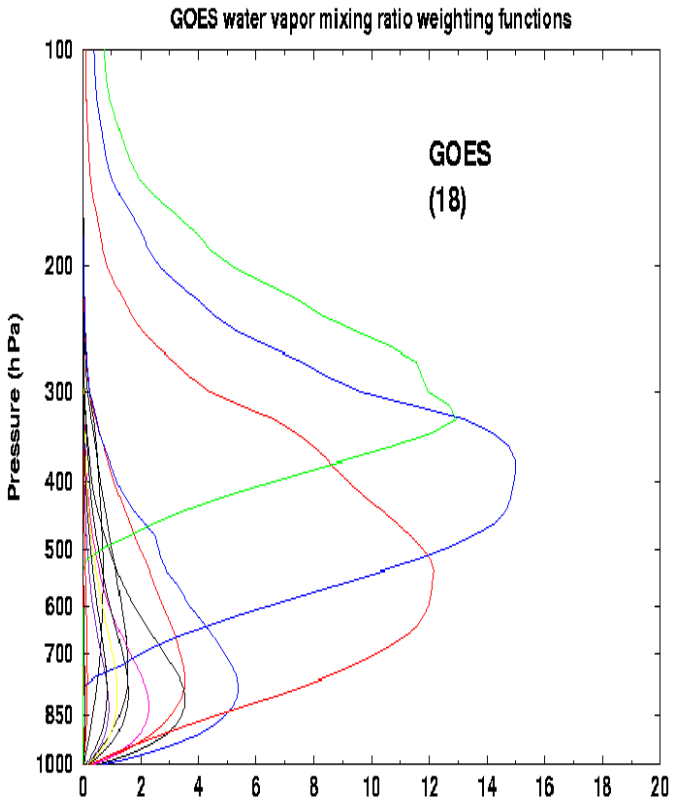


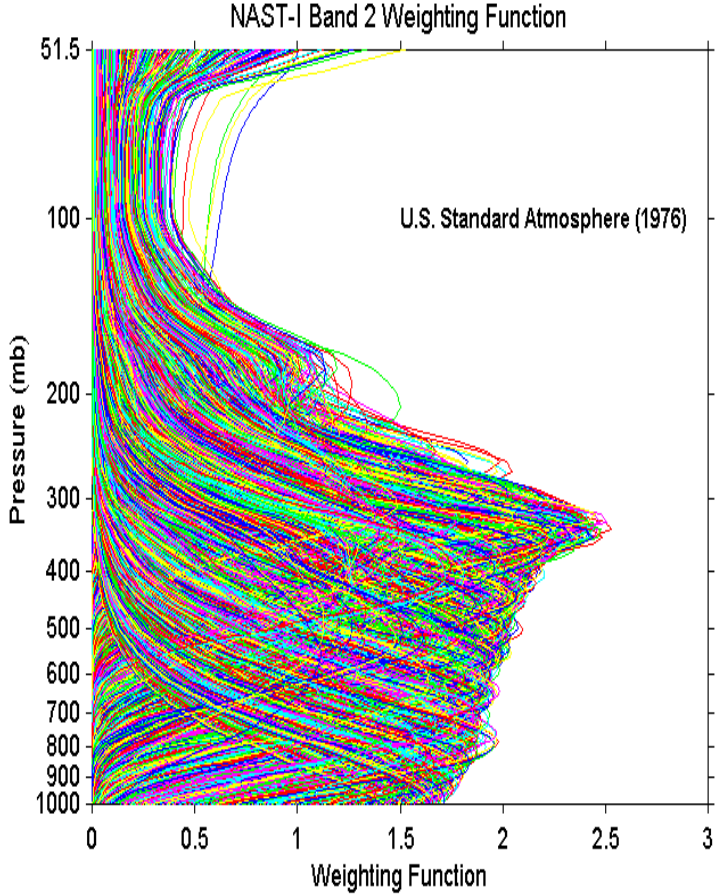
Samplig over rotational bands

AIRS and MODIS (mt Etna, Sicily, 28 Oct 2002)



Broad Band vs High Spectral



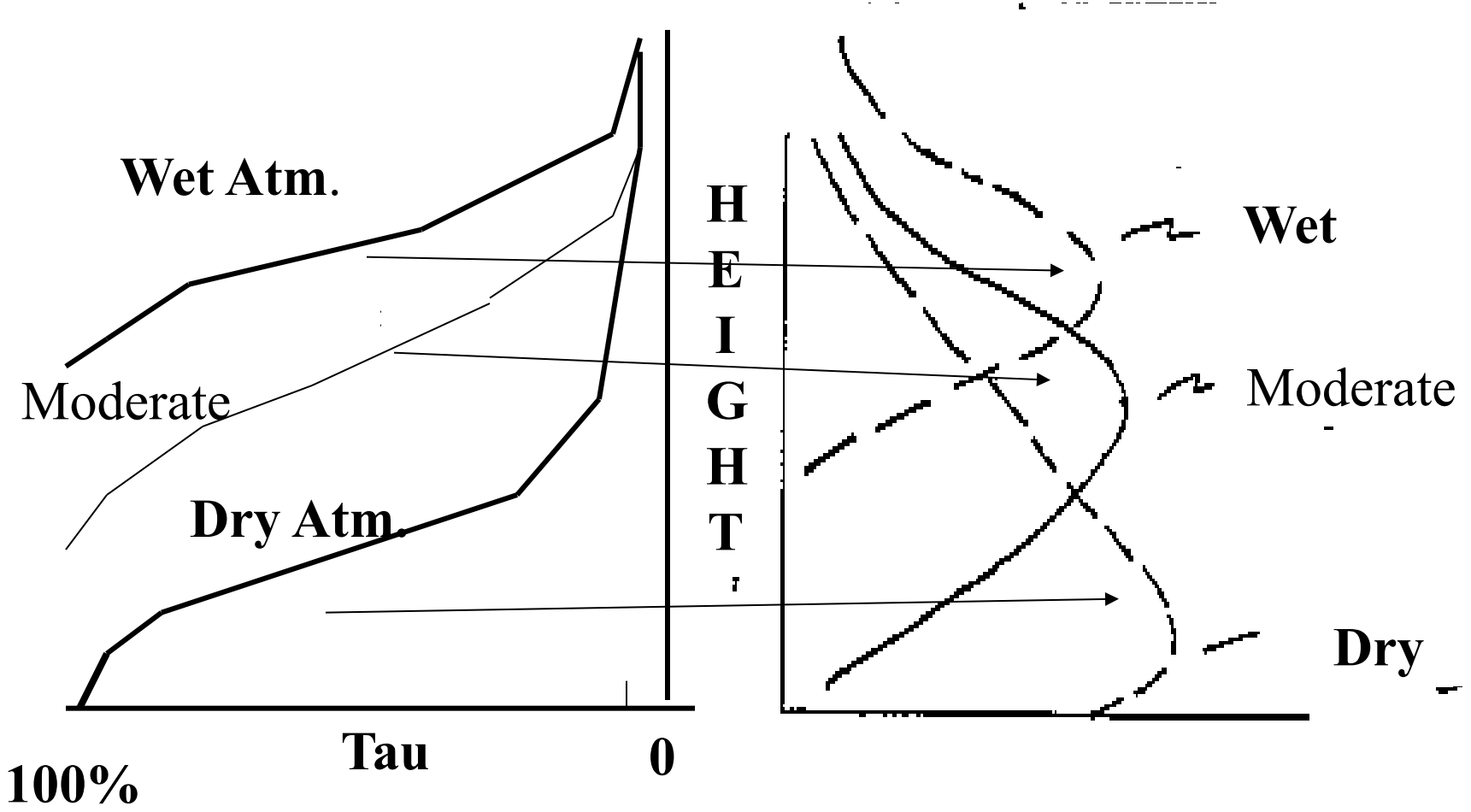


Questions

For a given water vapor line what happens to its weighting function When the amount of upper tropospheric water vapor increases?

Weighting Function

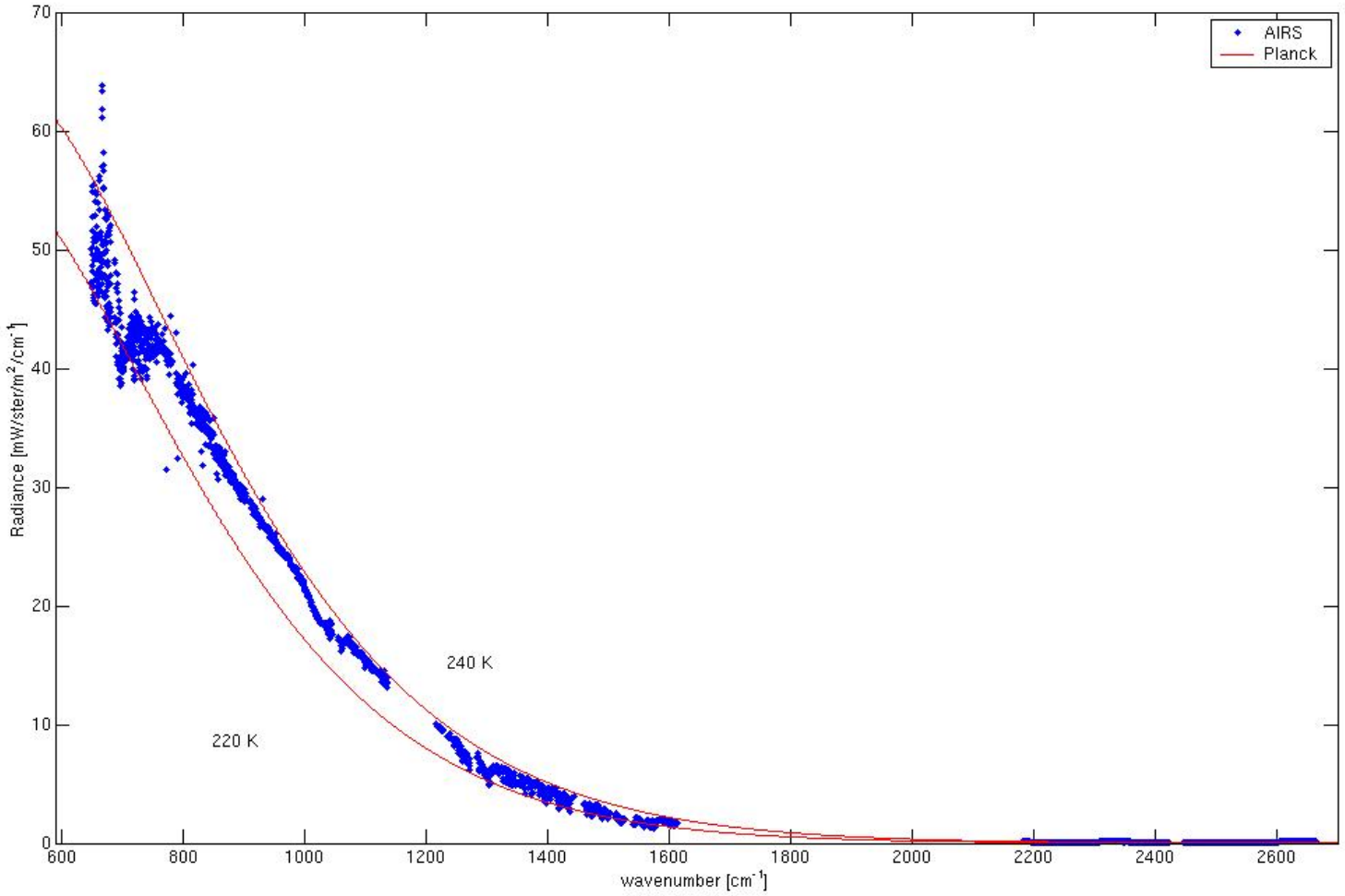
For a given water vapor spectral channel



Questions

How does it look the observed spectrum for high thick water vapor cloud ?

Thick Cloud Opacity

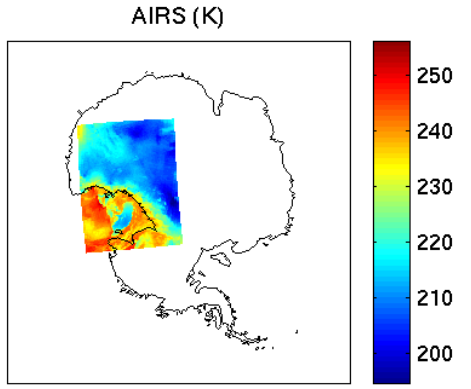


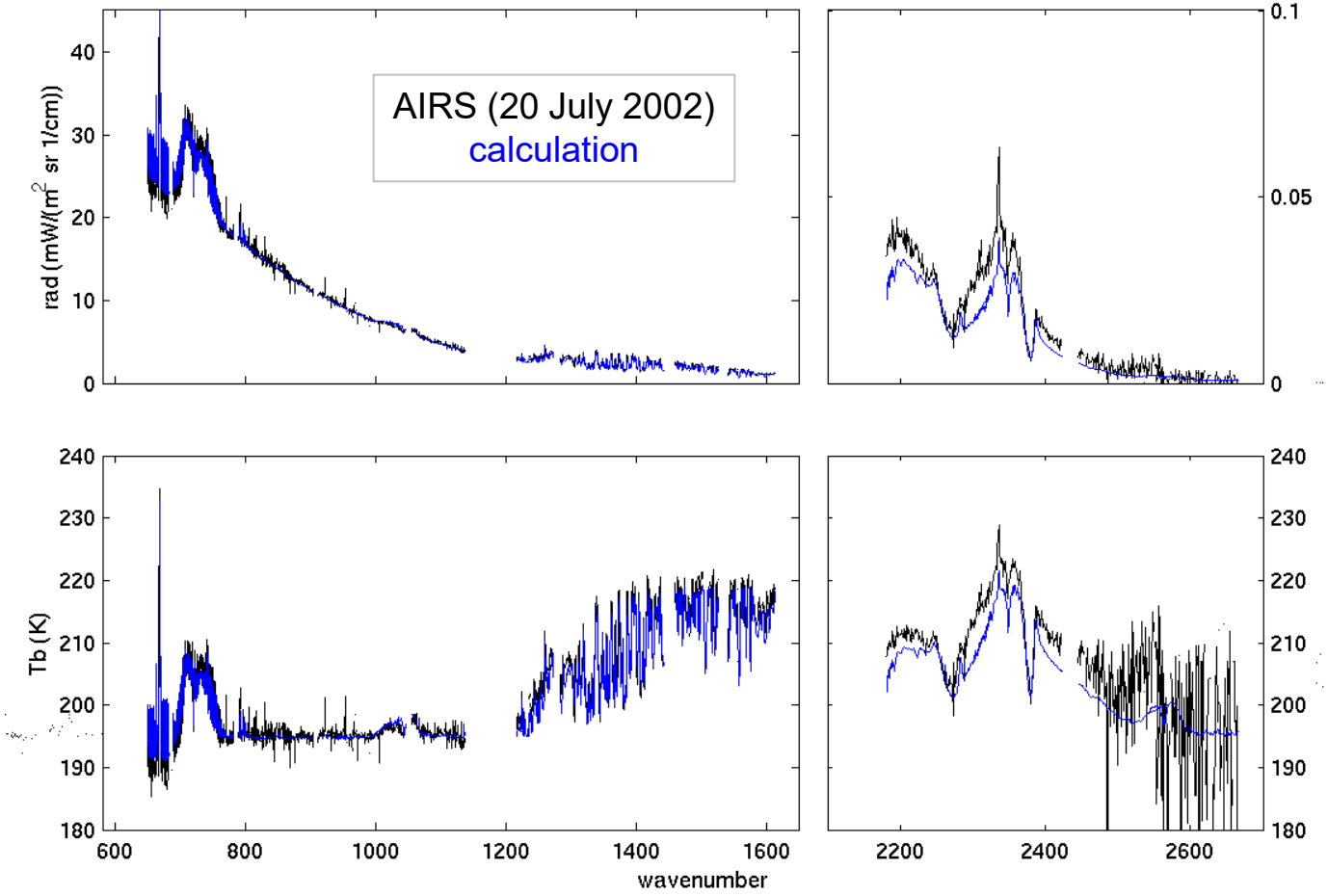
Questions

Moving deeper and deeper into an absorption line the observed BT tends do decrease, why?

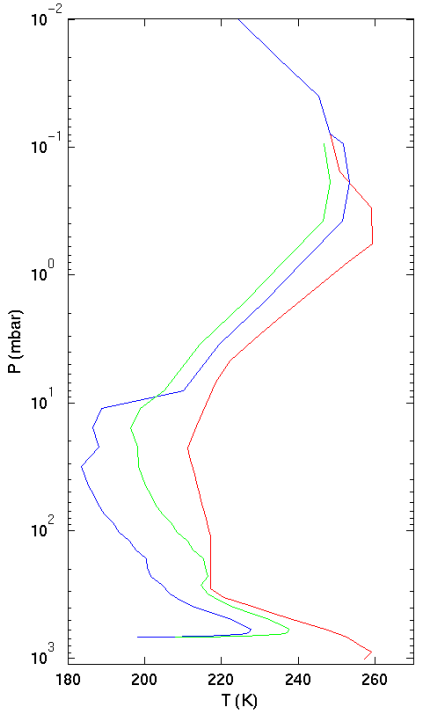
Is it always true that the BT decreases going deeper into the absorption band?

Temperature Inversions





Sub-Arctic Winter
May 2001 S. Pole radiosonde
profile used in calculation
(0.365 mm H_2O)



Conclusions