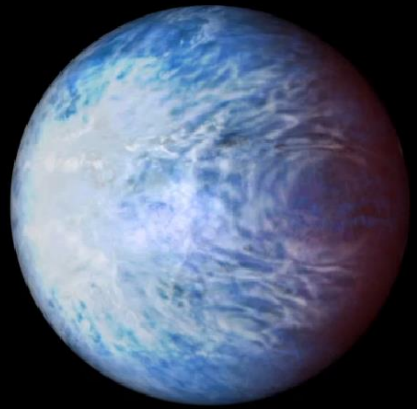
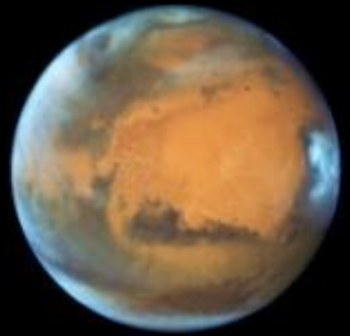
Socrates: correlated-*k* methods

James Manners, Met Office

CKDMIP Workshop, 8/9/20





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Socrates: Suite Of Community RAdiative Transfer codes based on Edwards & Slingo

- Two-stream code used in Met Office GCMs
- Spherical harmonics radiance code
- Correlated-k code: calculate optimal k-terms
- Mie scattering code: calculate droplet optical properties

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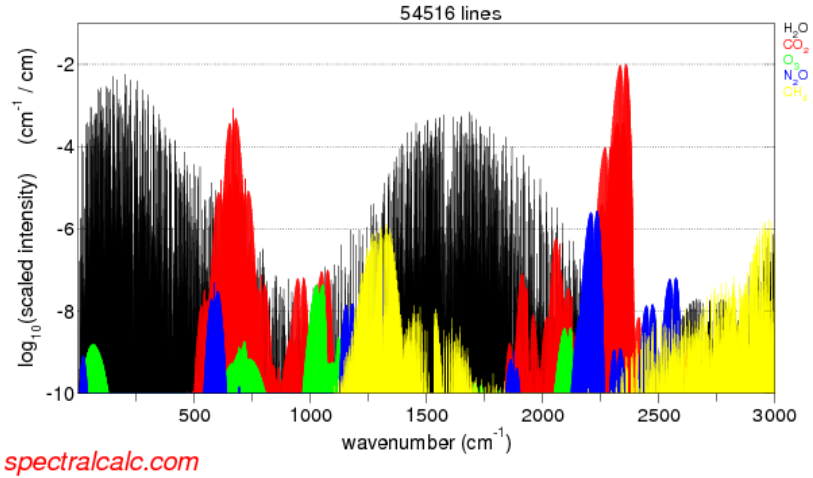
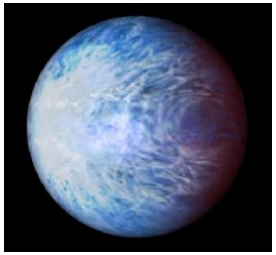
Flexible configuration: spectral files



- Spectral bands: high / low resolution
- Gas *k*-terms
- Aerosol / cloud optical properties
- Solar spectrum (including time variation) etc.



Hot Jupiters

Mars

Many configurations can be run

HadCM3

HadGEM1

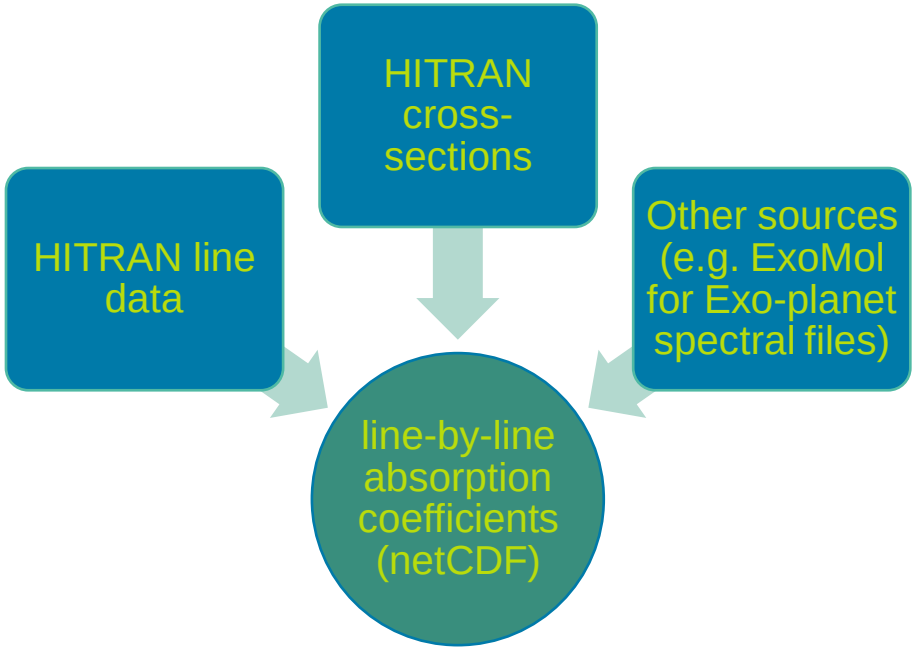
HadGEM2

GA3

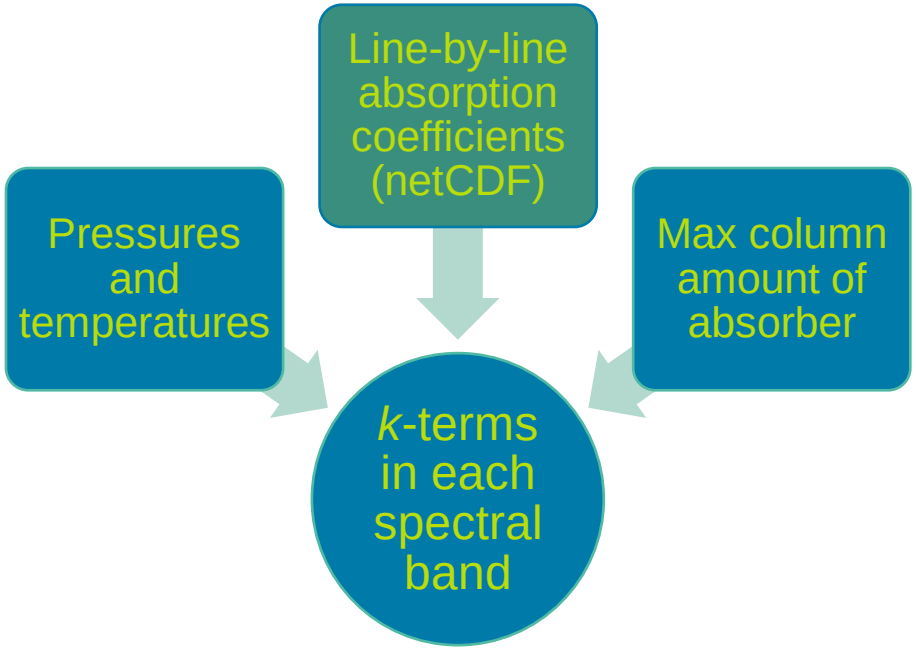
GA7

300 band LW / 260 band SW

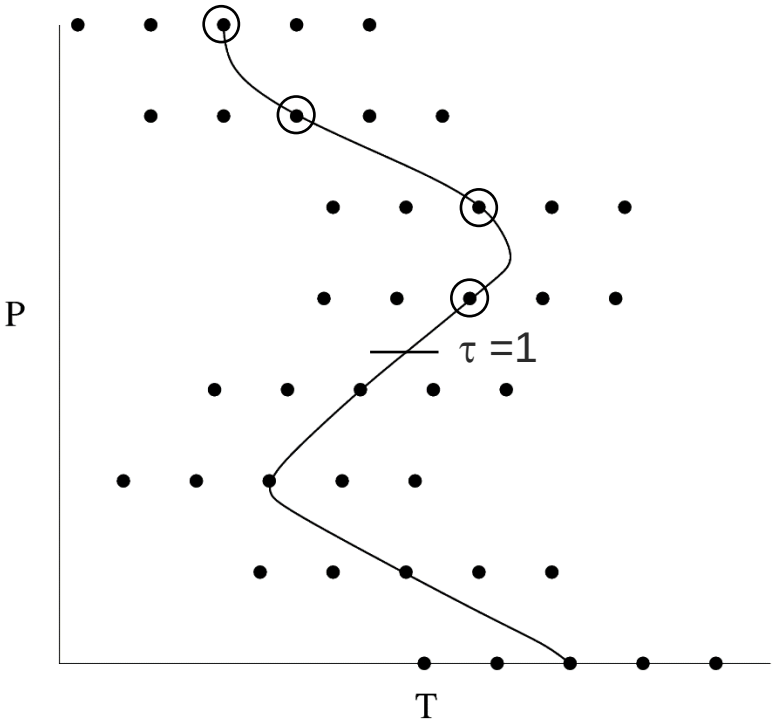
Stage 1:
generate line-by-line absorption coefficients

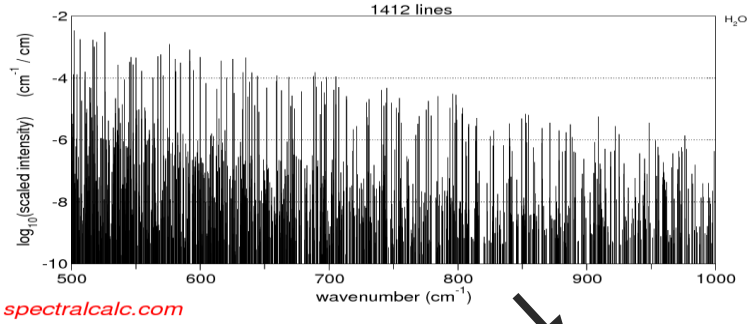


Stage 2:
generate k-terms separately for each gas

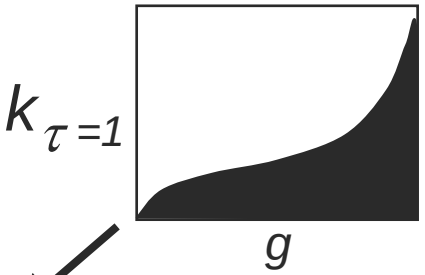


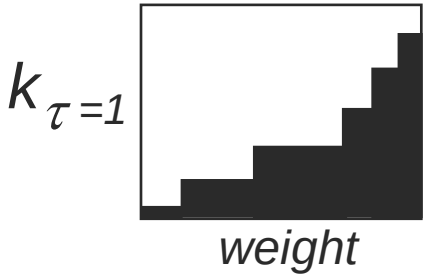
Optimal selection of k-term weights





Effective absorption coefficient for column down to τ=1

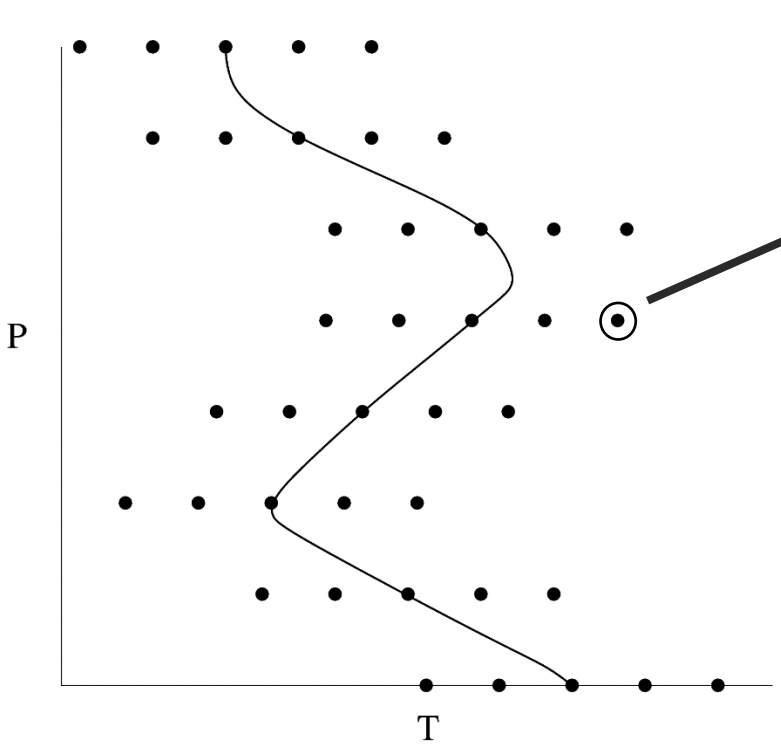




Use weights that give equal increments in log $k_{\tau=1}$

(Based on similar ideas from Hogan 2010)

Calculate k-terms for P/T look-up table

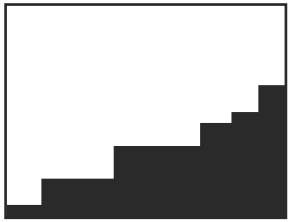


$k_{P/T}$

g

Re-order absorption coefficients for each P/T

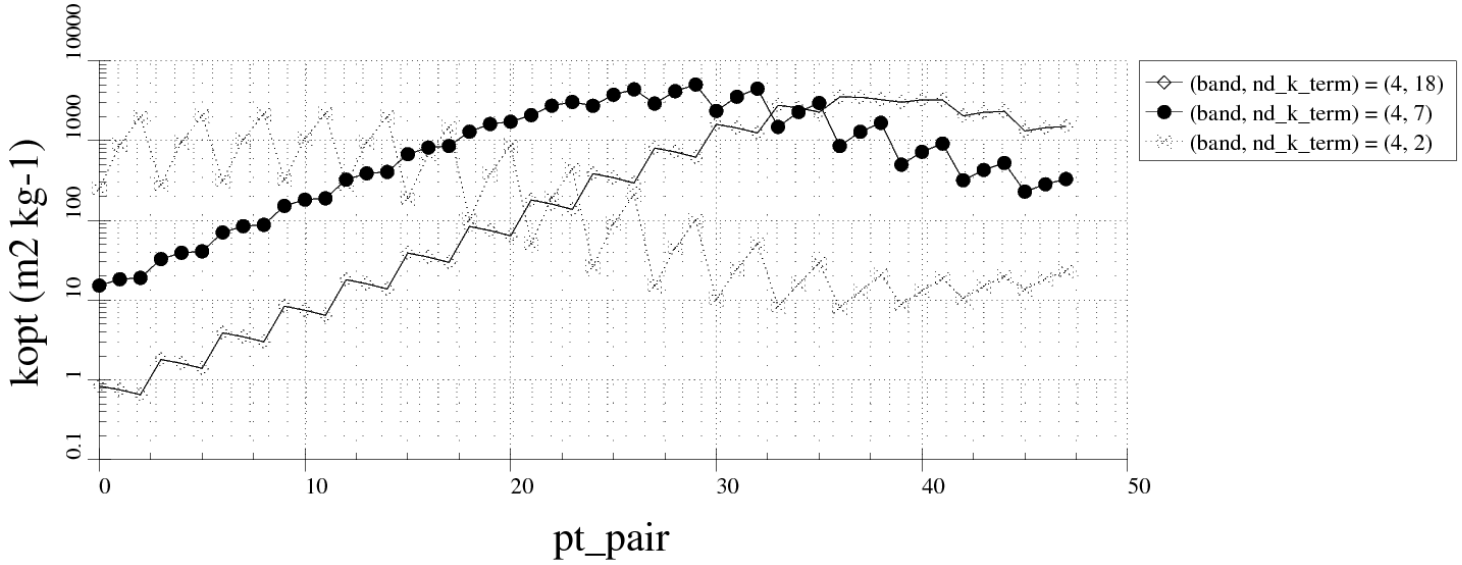
$k_{P/T}$



weight

Within each g-interval fit the k-terms to match transmission over a range of paths

Option to bin according to scaling behaviour of absorption as well as just absorption strength

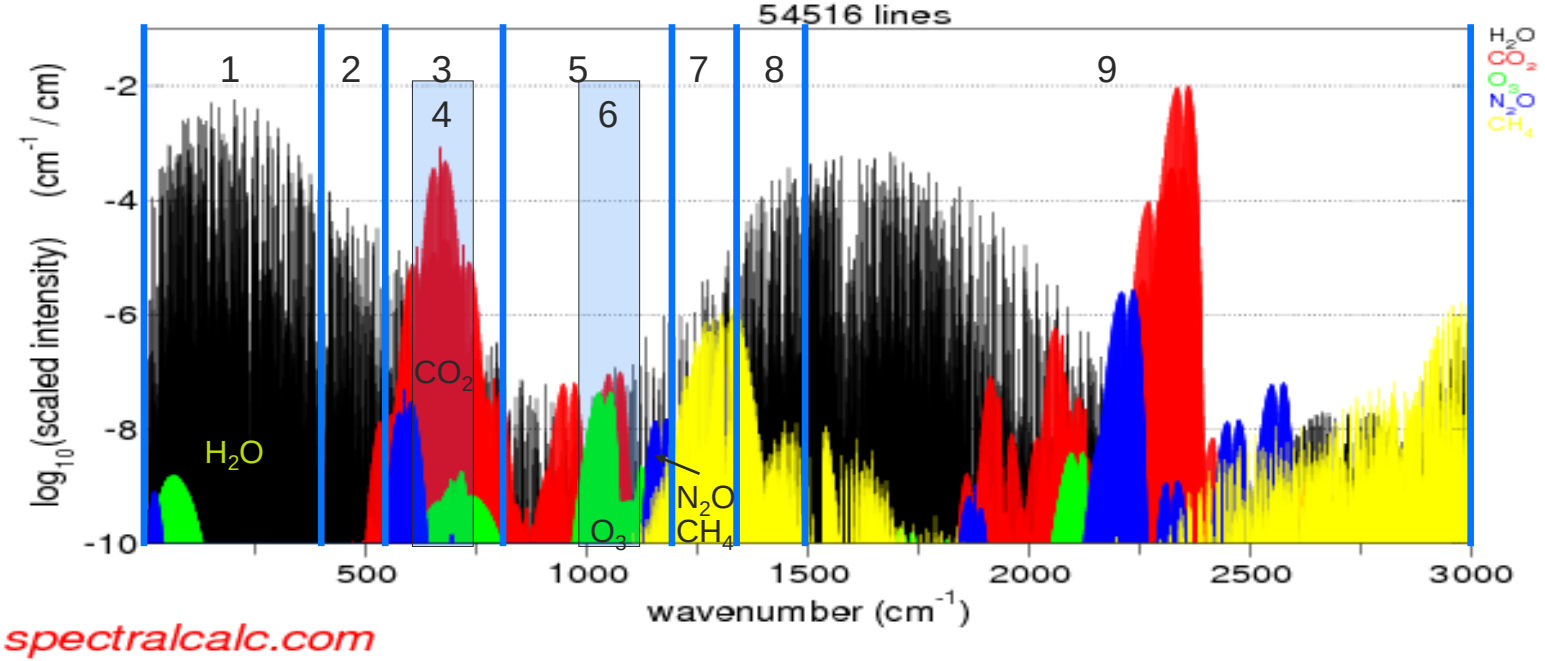


k-term

Figure 5: Scaling behviour of three k-terms for CO2 in band 4 of the HadGEM spectral file. The x axis is the pressure/temperature combination which is logaritmically spaced in pressure starting from 1Pa on the left to 1000 hPa on the right. Three temperatures are used for each pressure: 190, 240, 290K.

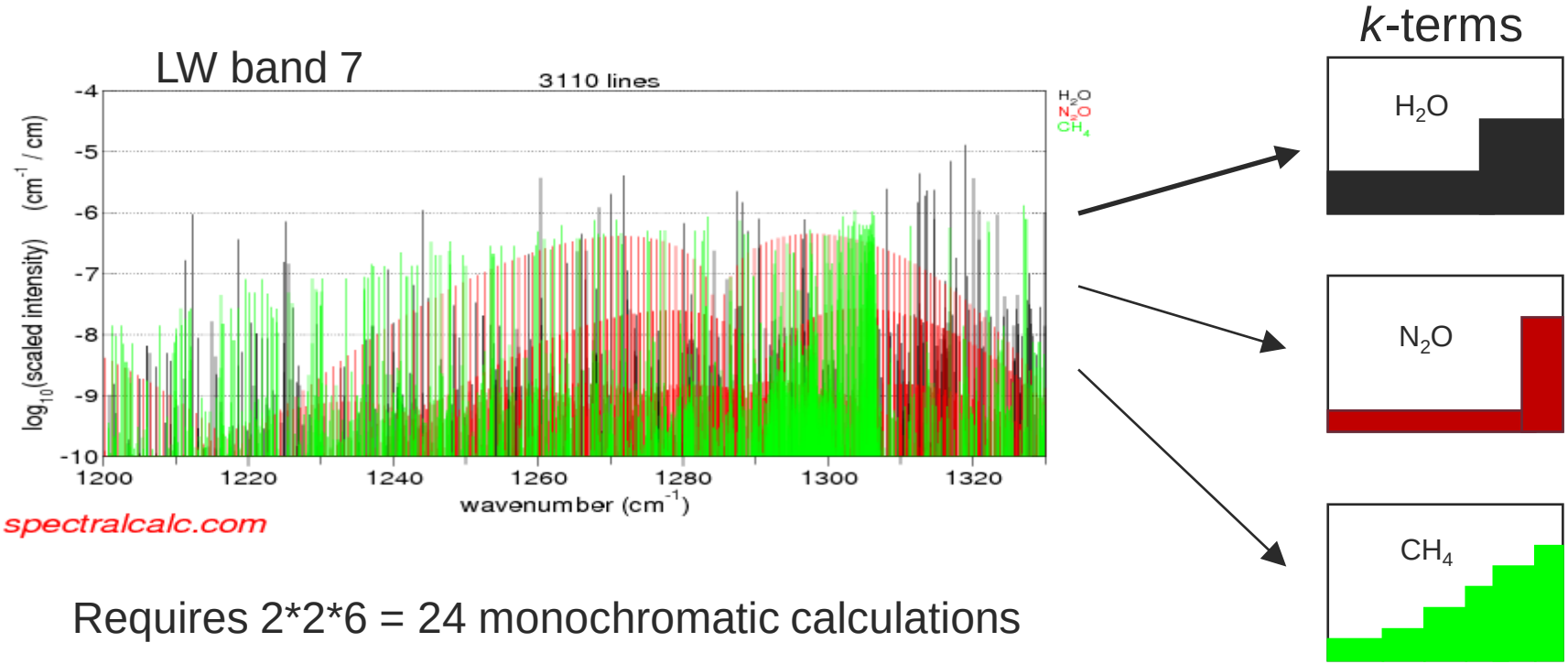
Overlapping gaseous absorption

LW bands used in broadband configuration



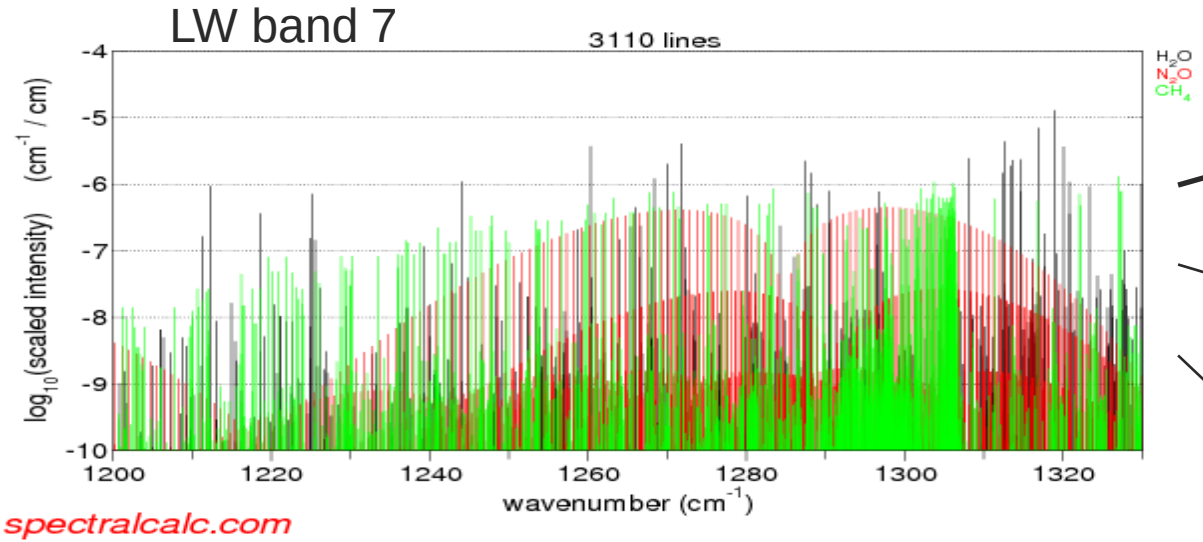
Relative abundances at 10km
(mid-latitude summer, ~ tropopause)

Random overlap of absorption lines

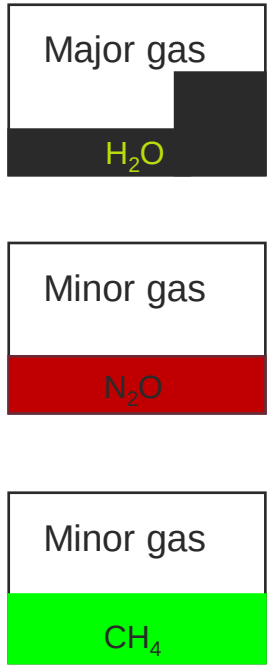


Requires 2*2*6 = 24 monochromatic calculations

Equivalent extinction



k-terms



Calculate single “equivalent extinction” coefficient using clear-sky atmosphere with minor gas.

Requires 2*1*1 = 2 monochromatic calculations

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Complications for intercomparison:

LW equivalent extinction:

- Full (scattering) calculations for each “major” gas k-term
- Plus non-scattering calculations for each “minor” gas k-term

SW equivalent extinction

- Diffuse fluxes as LW
- Direct fluxes use accurate “random overlap” without additional cost

(equivalent extinction is adjusted to give the product of transmissions for each gas)

Optical properties of scatterers, surface, etc. also require appropriate band structure / wavelength resolution.

Questions