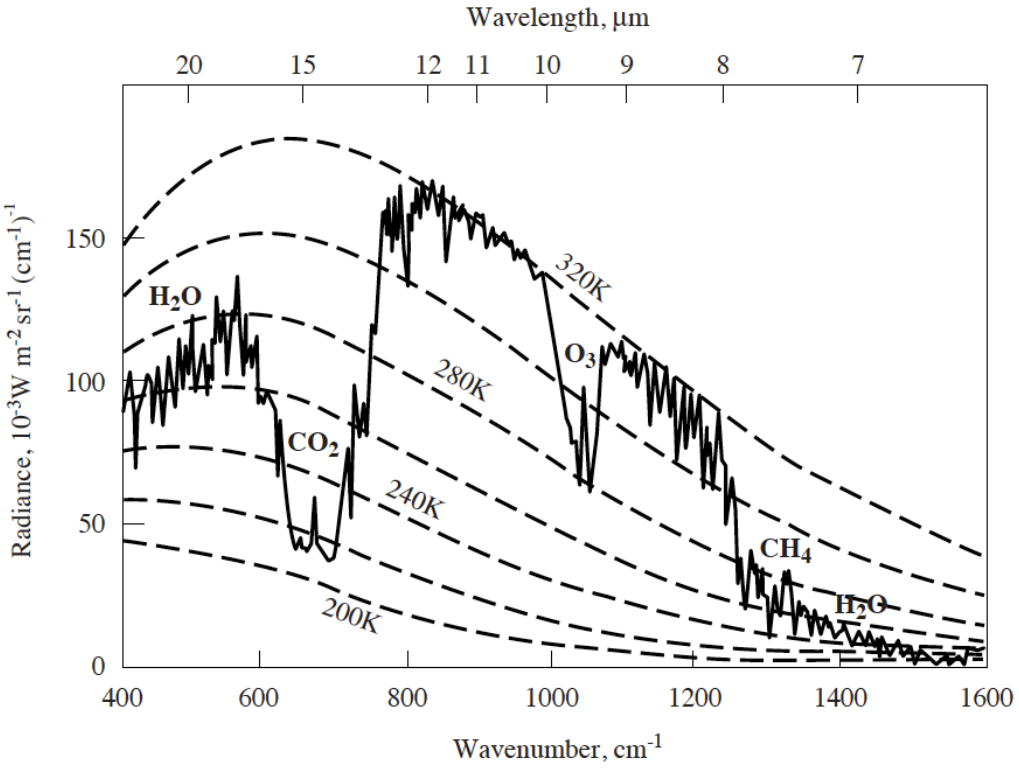
PHY392S
Physics of Climate

Lectures 17 and 18

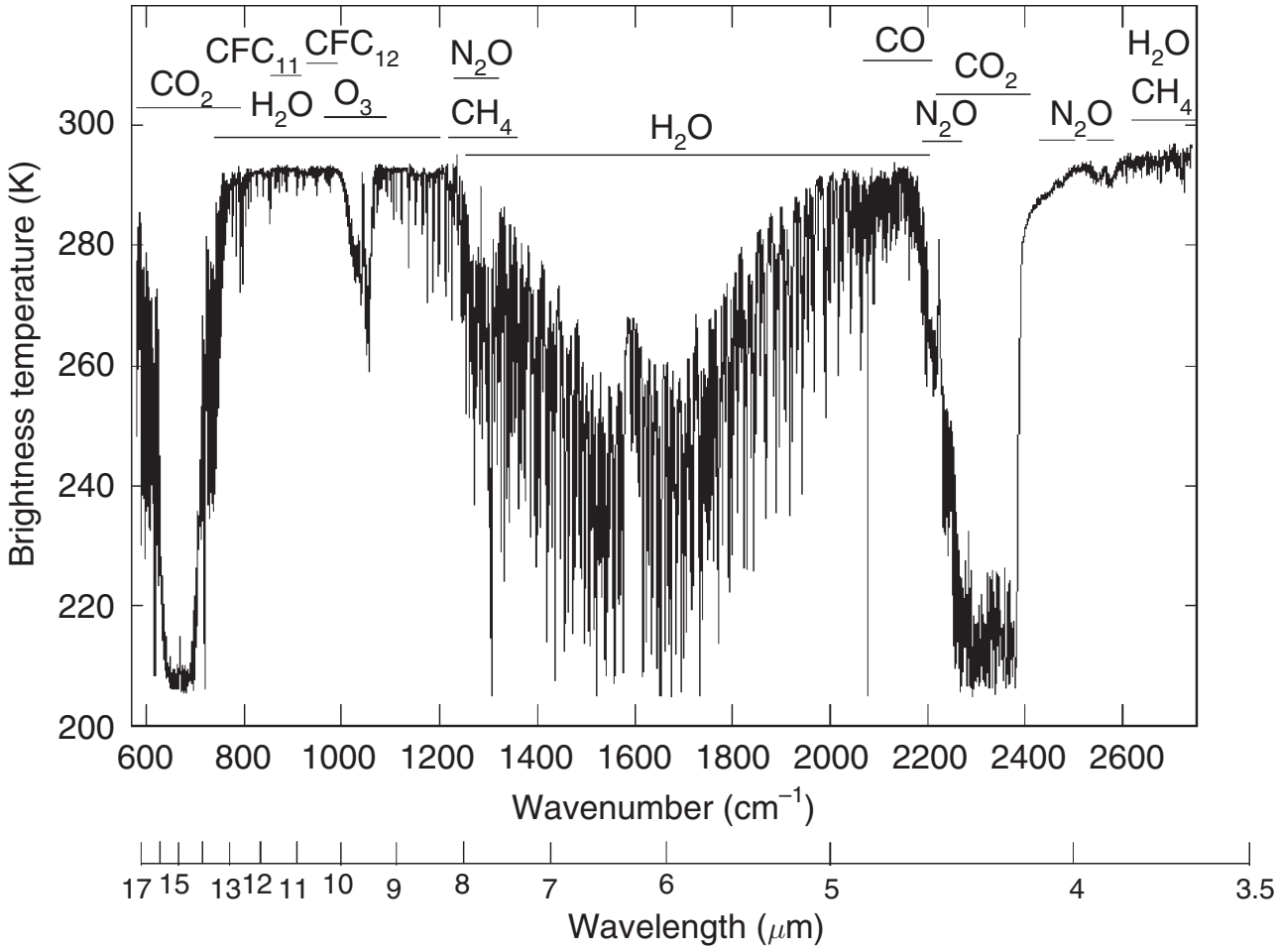
Supplementary slides

Terrestrial Radiation Spectrum



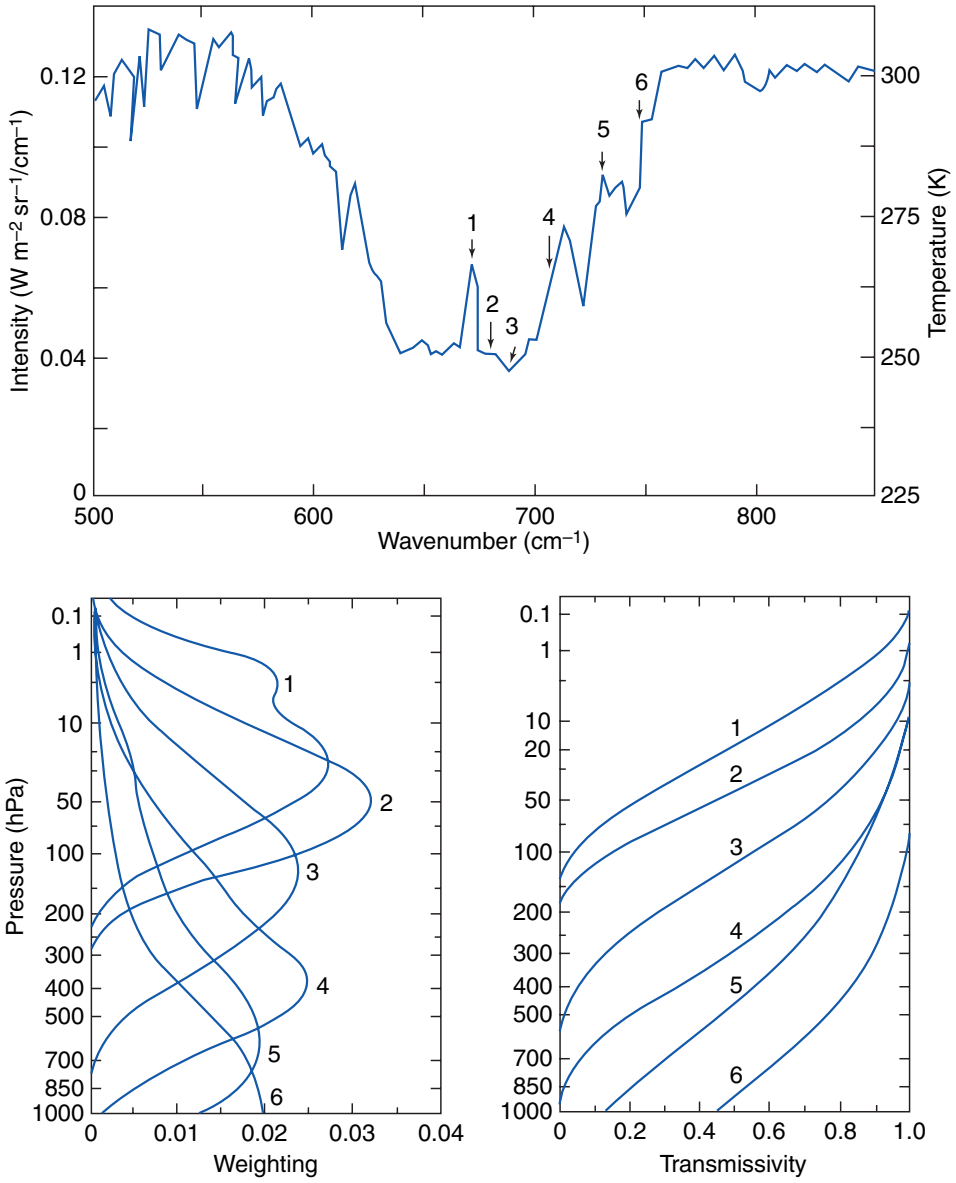
[Jacob, 1999]

Terrestrial Radiation Spectrum



[Wallace and Hobbs, 2006]

15 μm CO_2 Absorption Band



[Wallace and Hobbs, 2006]

Tropospheric Emission Spectrometer (TES)

- On the NASA Aura spacecraft (launched July 2004)
- Infrared Fourier transform spectrometer (3.3 - 15.4 μm)
- Nadir footprint = 8 km x 5 km
- Orbit repeats every 16 days
- Observations spaced about 2° along orbit track
- Data products include O_3, CO, H_2O, HDO, CO_2, and CH_4

TES CO_2 Retrievals

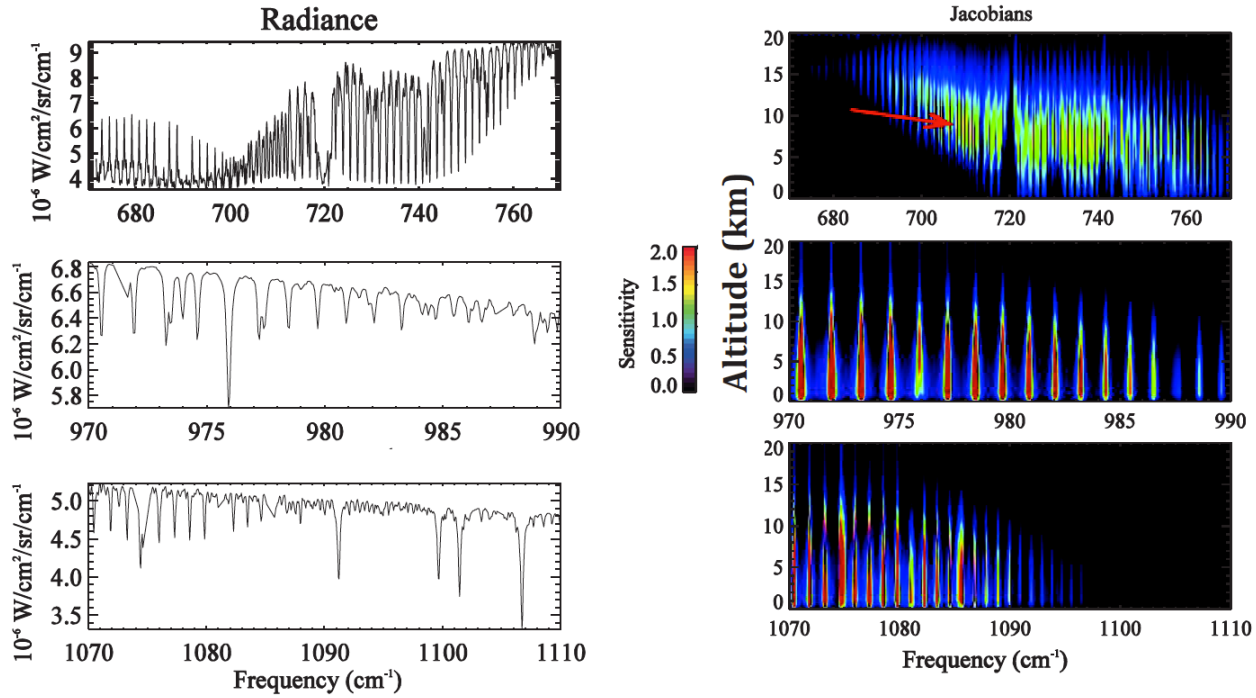
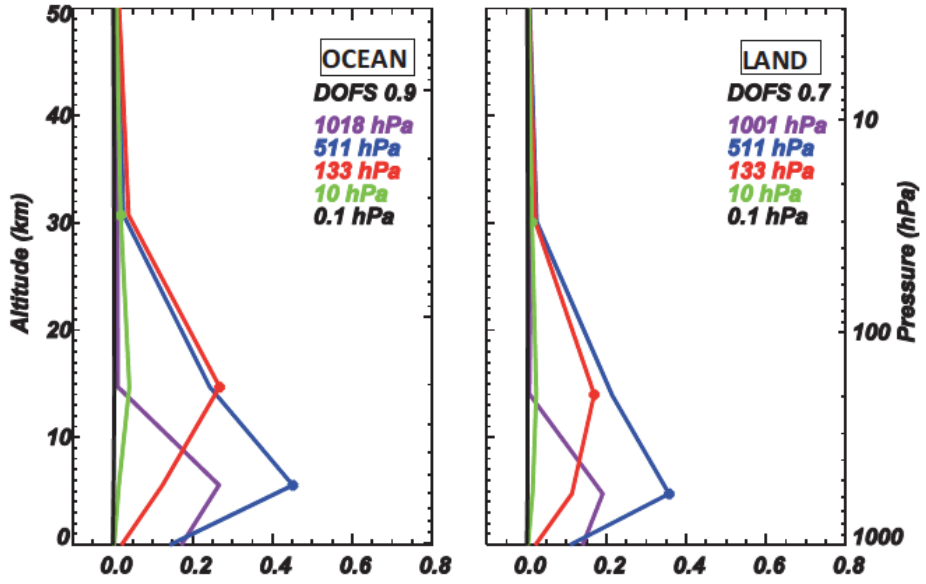


Fig. 2. Radiances and Jacobians for the three CO_2 bands used in the retrievals. The Jacobians show the sensitivity of radiances to changes in CO_2 at different altitudes. The red arrow shows the sensitivity of the radiance at 710 cm^{-1} when CO_2 at 10 km is changed. The Jacobians have been divided by the radiance noise, so a value of 1 means that the radiance will change by the same amount as the expected radiance noise.

[Kulawik et al., 2010]

TES CO_2 Retrievals



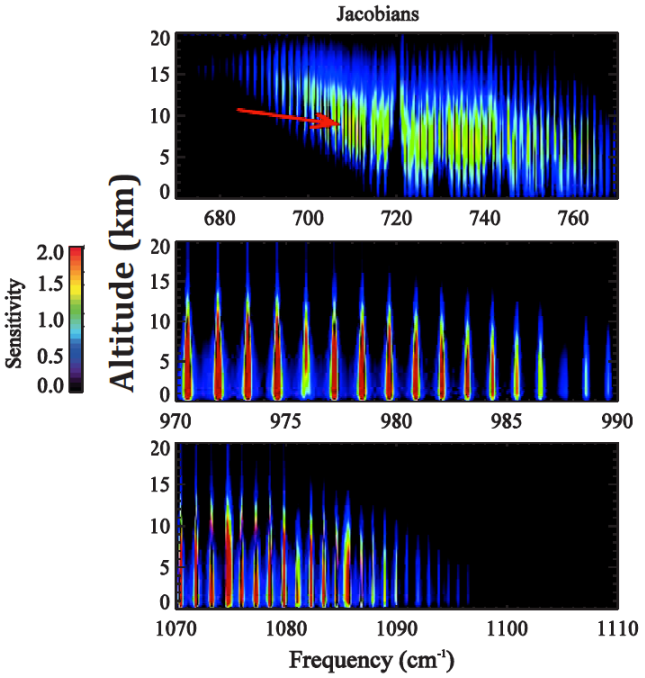
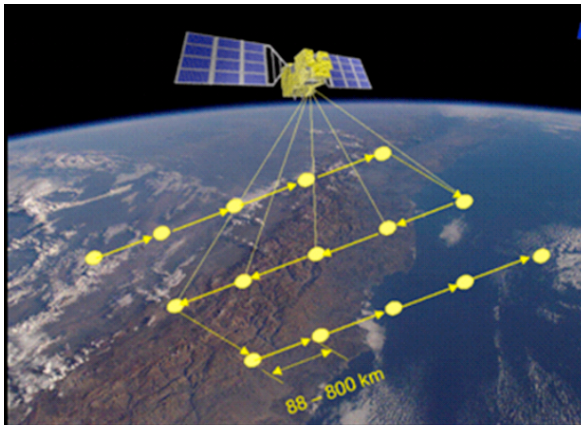


Fig. 4. Averaging kernel rows for an average of ocean (near Mauna Loa, left) and land (near the SGP site, right) targets over a 4-year period. The ocean targets show more sensitivity on average because the mean tropical ocean temperature is 300 K versus 290 K for the land cases, leading to a higher thermal contrast. Therefore, although daytime, summer, land targets will have the greatest sensitivity, averaging over winter and night reduces land average sensitivity.

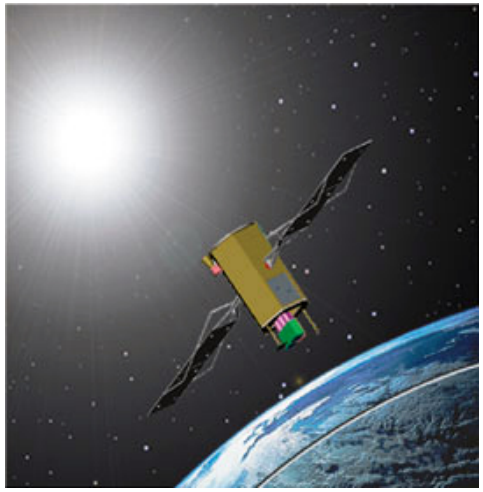
[Kulawik et al., 2010]

GOSAT and OCO-2



Greenhouse gas Observing SATellite (GOSAT)

- **launched January 2009**



Orbiting Carbon Observatory (OCO-2)

- **to be launched July 2014**

CO_2 absorption in reflected sunlight

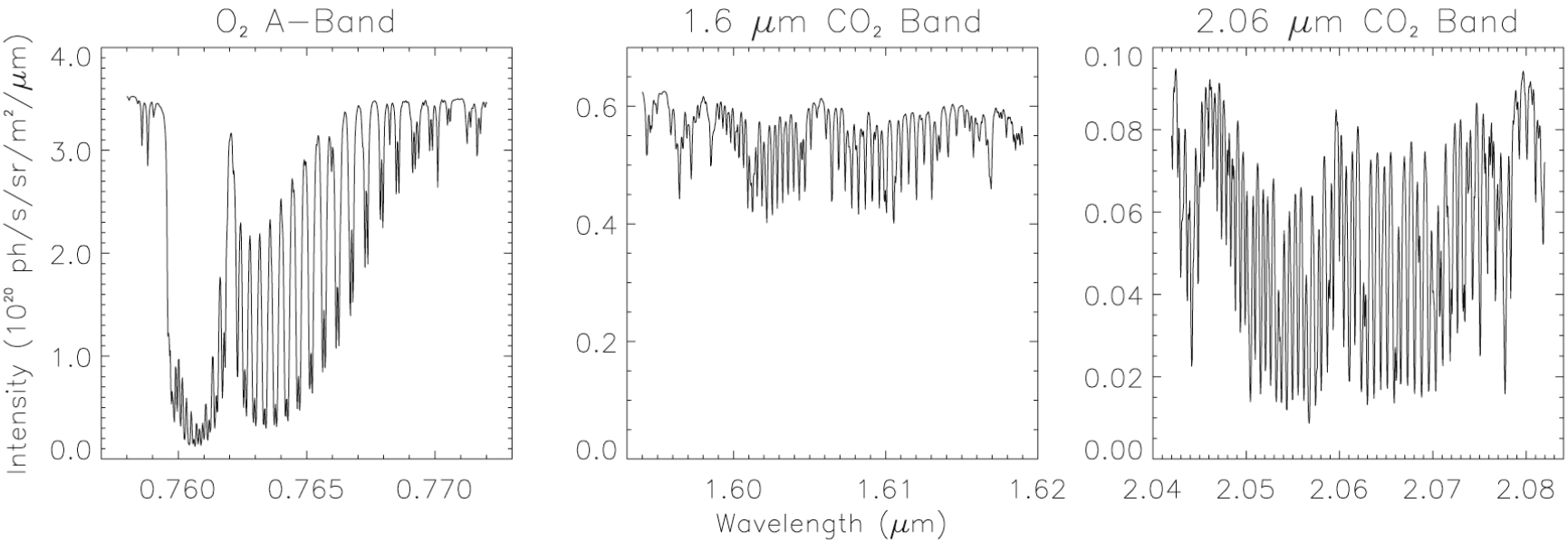


Figure 1. Three spectra observed by OCO on each sounding, calculated for Park Falls in July.

[Connor et al., 2008]

OCO-2 vertical sensitivity

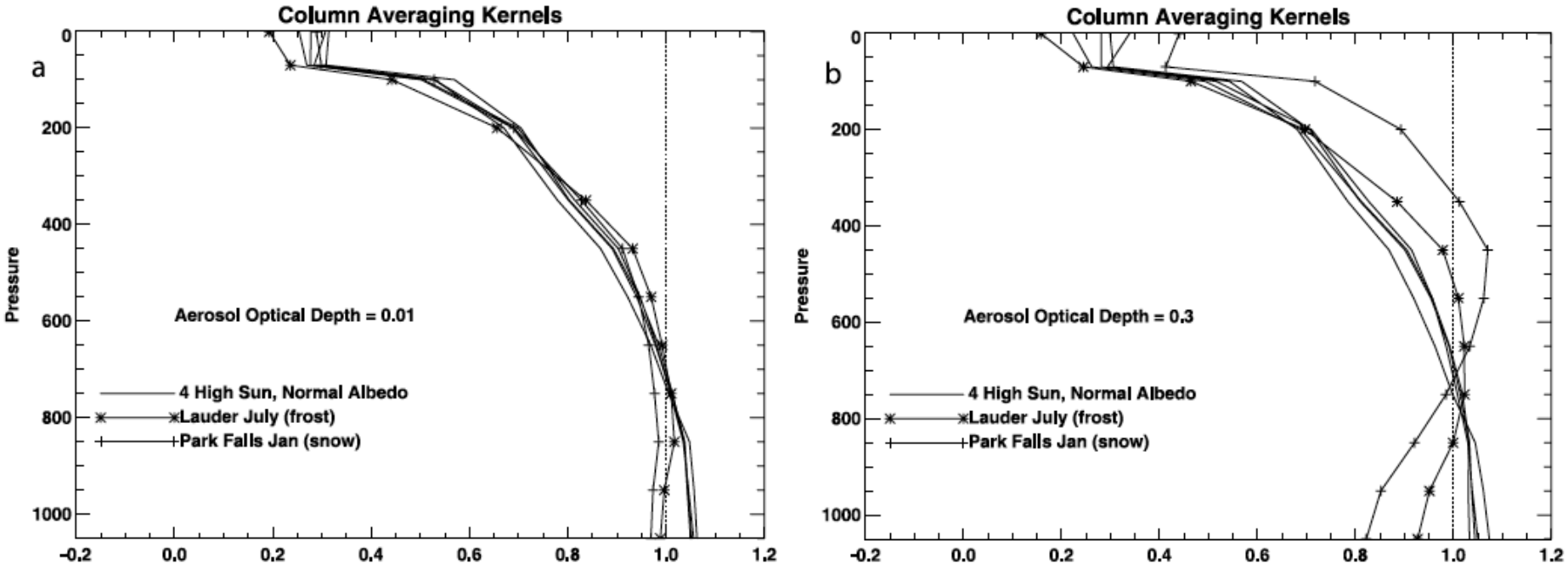


Figure 3. (a) Column averaging kernels for aerosol optical depth $\tau = 0.01$. The four high sun cases are Lauder in January, Park Falls in July, and both months at Darwin. (b) Same as Figure 3a but for $\tau = 0.3$.

[Connor et al., 2008]