Lower Stratospheric Densities from Continuum Absorption near 2400 cm^{-1}

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Background

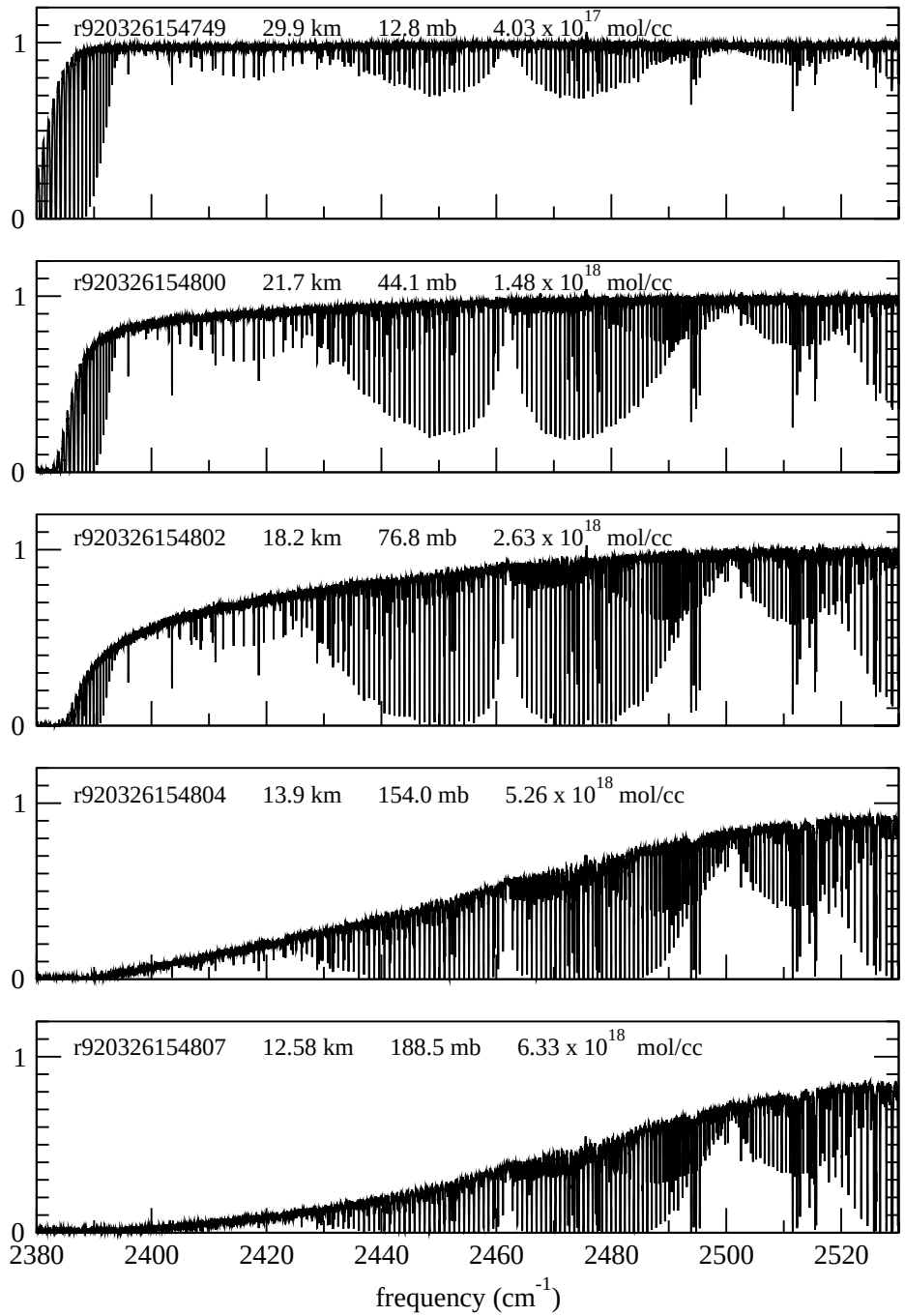
- The 2380-2500 cm^{-1} spectral range in lower stratospheric high resolution solar occultation spectra is dominated by weak atmospheric lines superimposed on the continuous absorption by the pressure-induced N_2 continuum and far wings of the intense CO_2 ν_3 band
- Both processes produce extinction that varies with the square of the atmospheric density at constant temperature
- Can continuum measurements be used to derive density and precise pointing for ACE retrievals?
- Are there other spectral regions where a similar technique can be applied?

Previous high spectral resolution solar occultation measurements of the 4.3 μm continuum

- "Stratospheric measurements of continuous absorption absorption near 2400 cm^{-1}" Rinsland et al., Appl. Opt. 20, 4167-4171, 1981.
- "Stratospheric Infrared Continuum Absorptions Observed by the ATMOS Instrument", Rinsland et al., J. Geophys. Res., 94, 16,303-16,322, 1989.

ATMOS ATLAS 1 Spectra

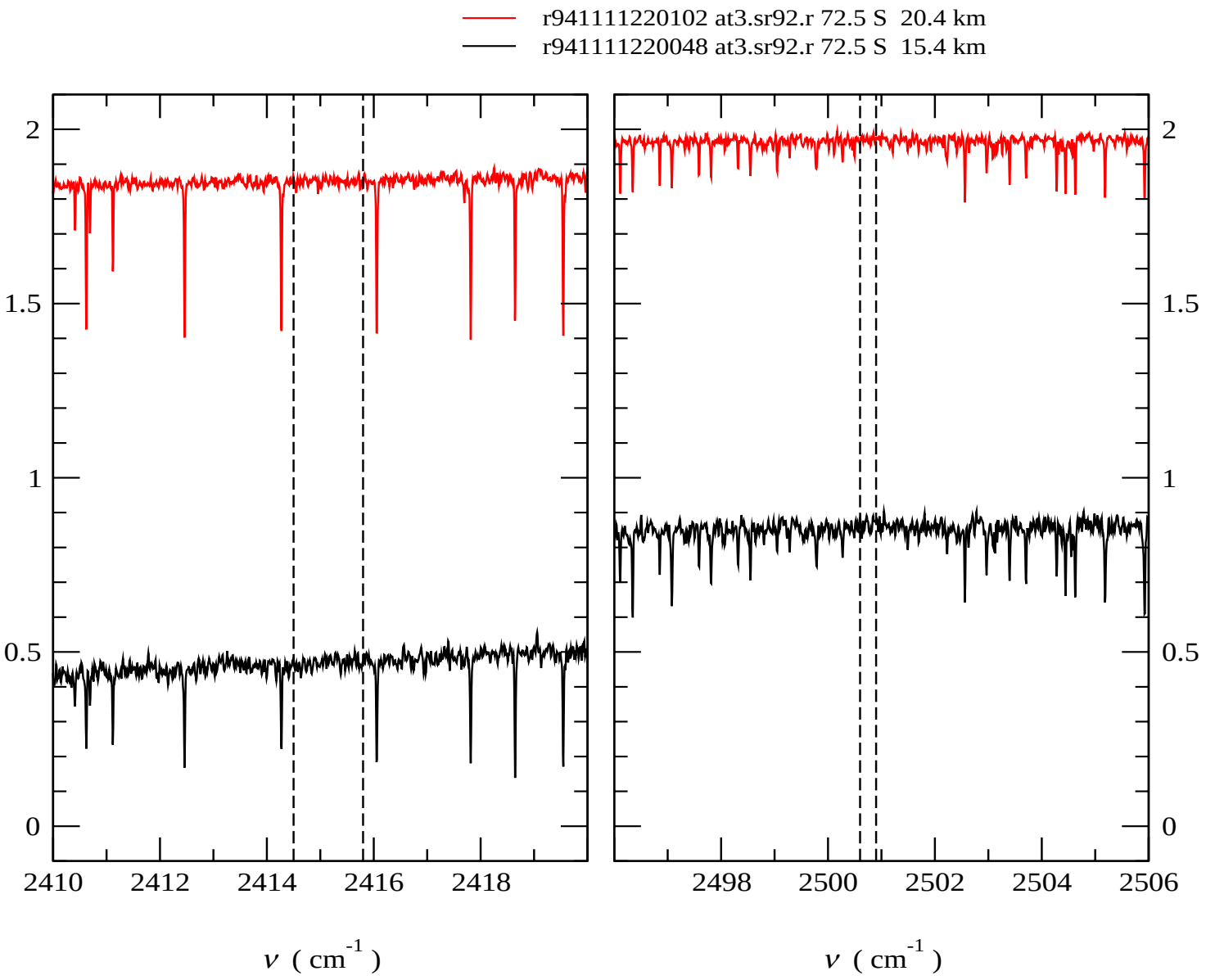
March 1992 (9 ½ months after Mt. Pinatubo)



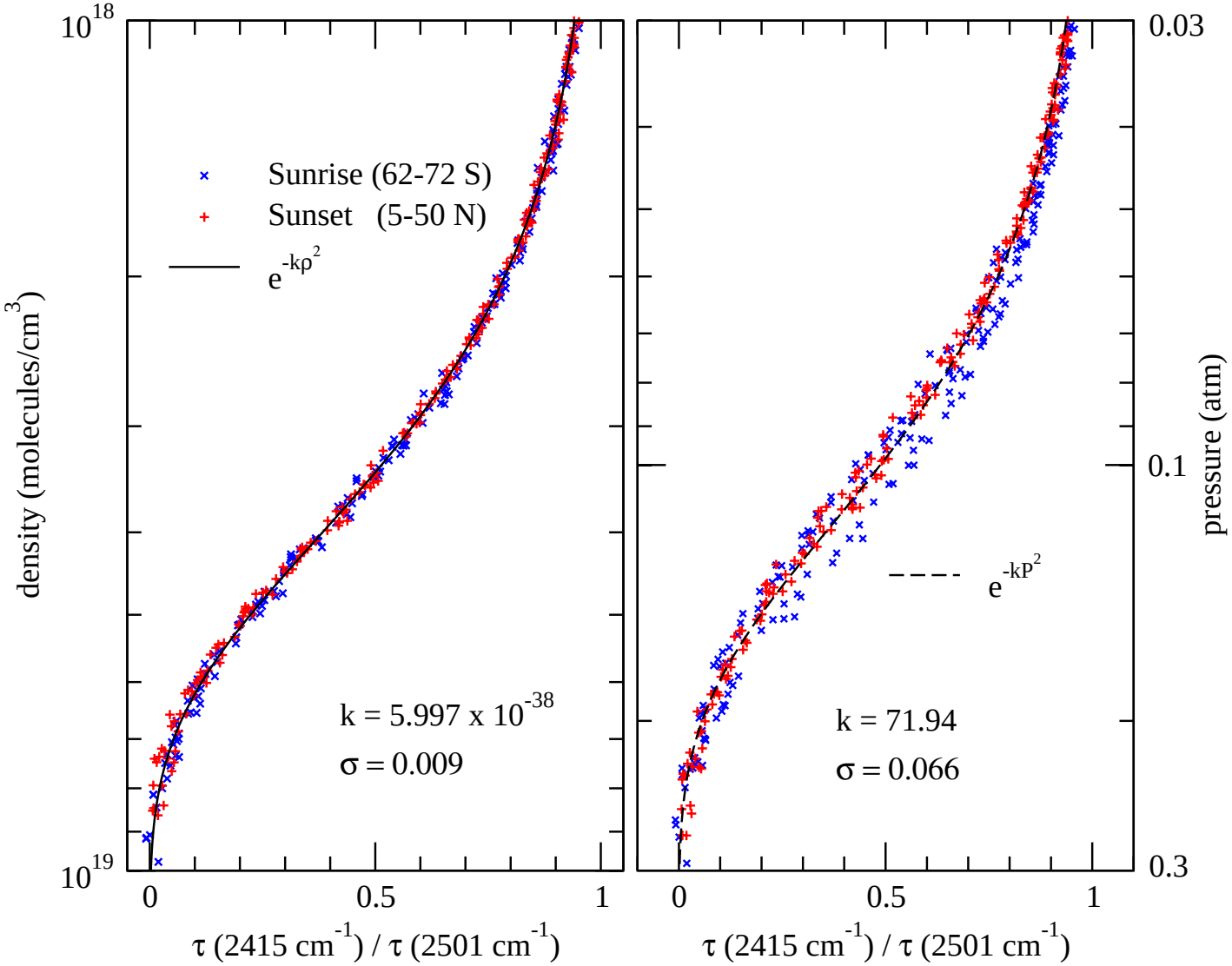
Microwindow Measurements

- Measurements have been obtained from all filter 3 occultations in microwindows extending from 2414.50-2414.80 $cm^{-1}$and 2500.60-2500.90 cm^{-1}
- Both intervals are nearly free of line absorption
- Averaging increases precision in determining the mean by one order of magnitude
- Transmission Ratios compared with corresponding ATMOS version 3 tangent point pressures and densities [Irion et al., Appl Opt., 41, 6968-6979, 2002]

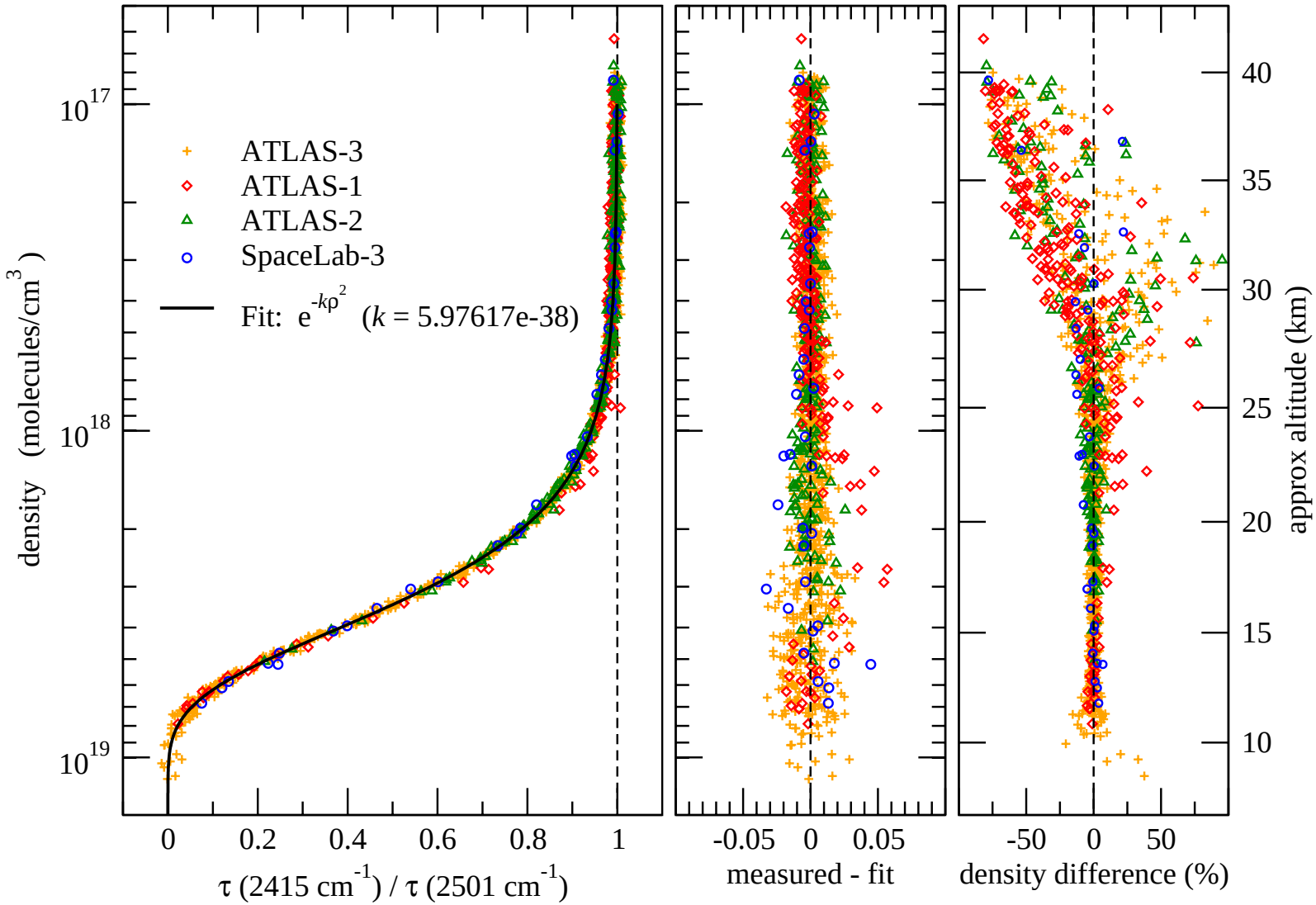
Microwindows



Transmission Ratios vs Density and Pressure



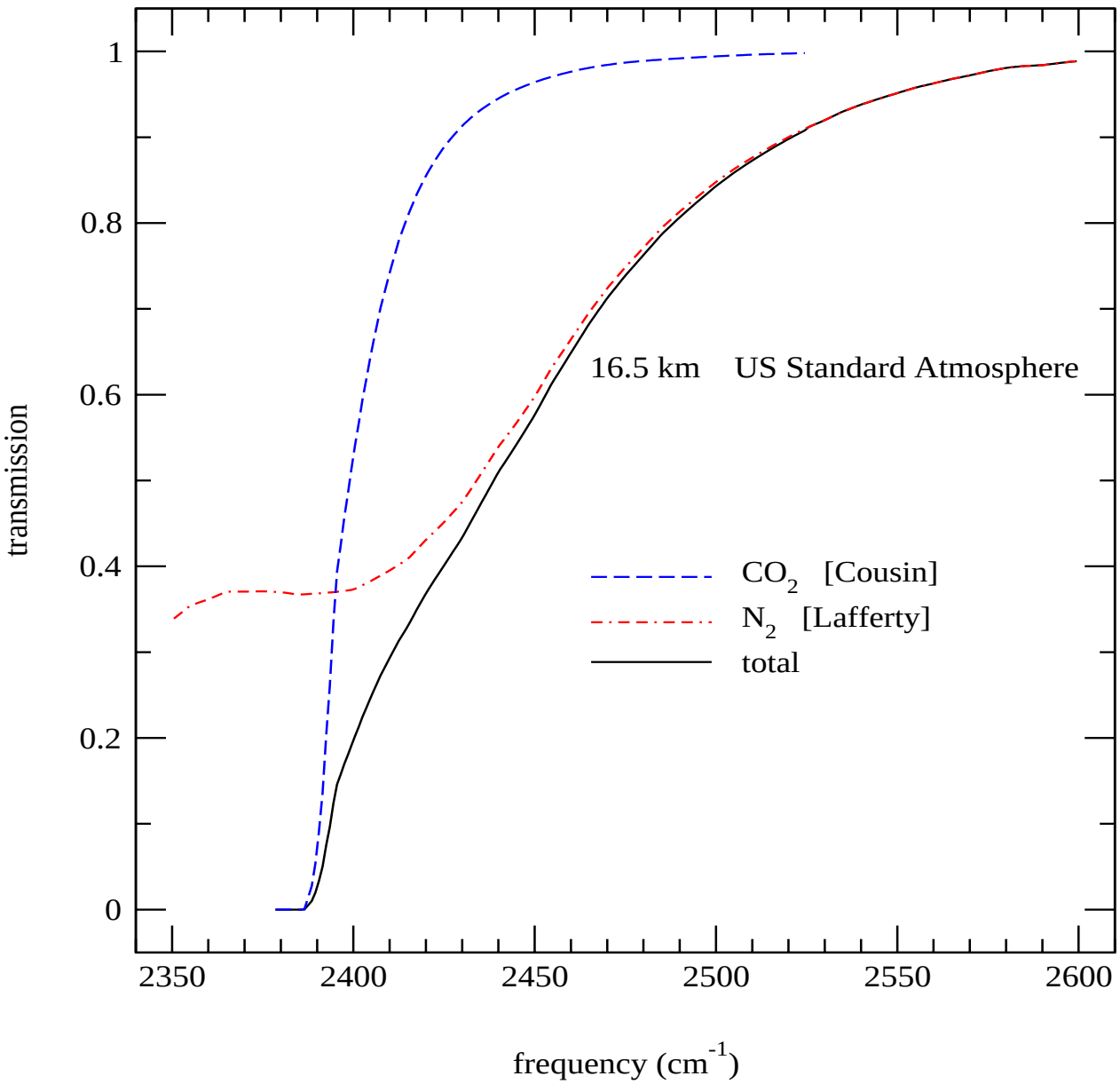
Empirical Fit of Ratios vs Density



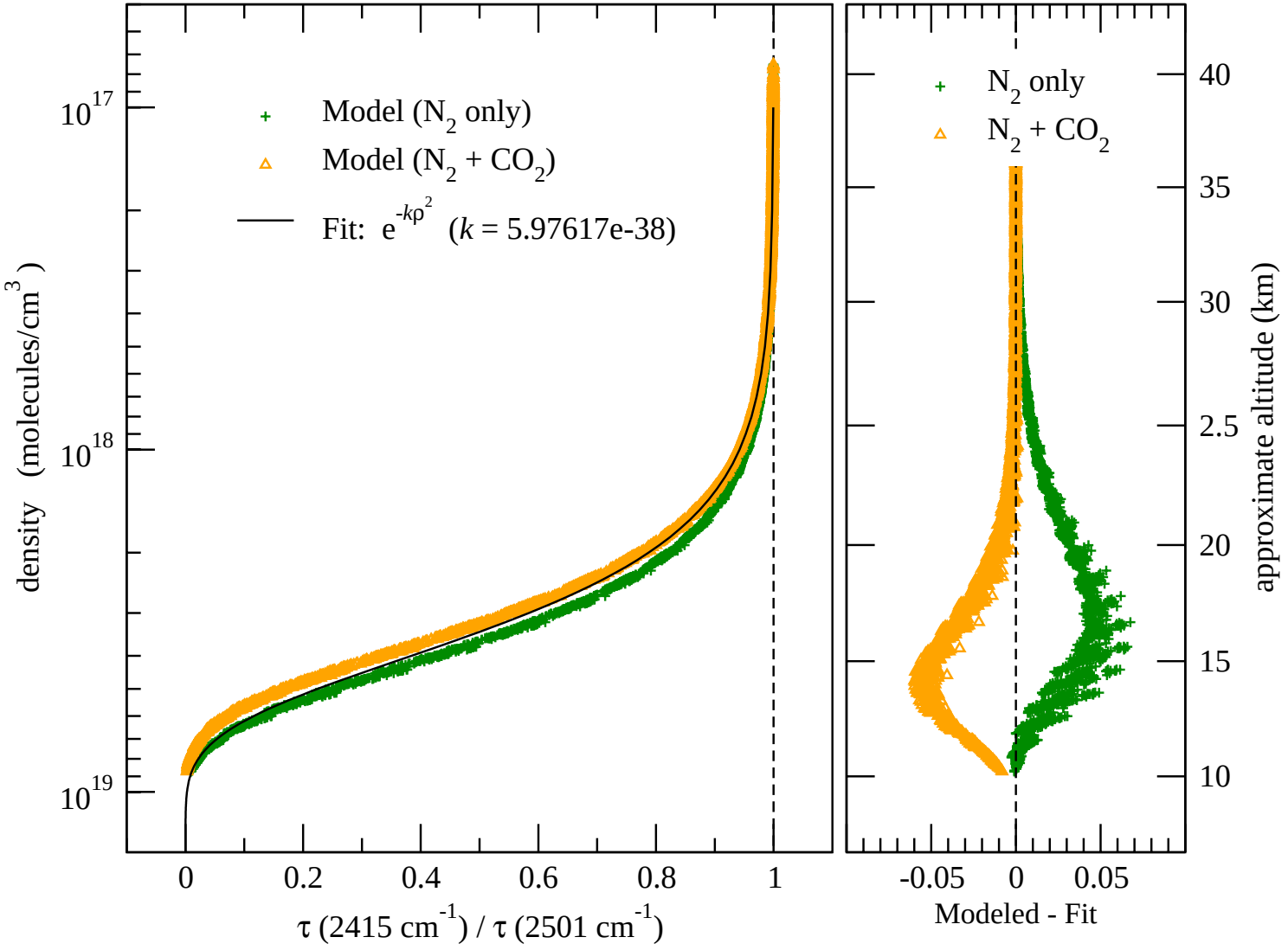
Key Laboratory Studies

- Menoux et al., "Collision-induced absorption in the fundamental band of N_2: temperature-dependence of the absorption by N_2-N_2 and N_2-O_2 pairs, Appl. Opt., 32, 263-268, 1993.
- Lafferty et al., "Infrared collision-induced absorption by N_2 near 4.3 μm for atmospheric applications: measurements and empirical modeling" Appl. Opt., 35, 5911-5917, 1996.
- Cousin et al., "Temperature dependence of the absorption in the region beyond the4.3 μm band head of CO_2: N_2 and O_2 broadening, Appl. Opt. 24, 3899-3907, 1985.

Simulated Continuum



Simulation Using Laboratory Models



Conclusions

- A compact relationship exists for all 3 ATLAS measurements between the 2414 to 2500 cm^{-1} transmission and atmospheric density
- The ratio decreases from 1 to 0 as the density increases from $10x10^{17}$ molecules cm^{-3} to $100x10^{17}$ molecules cm^{-3}
  - Good sensitivity from 12 to 30 km altitude
  - Some sensitivity from 10 to 35 km altitude
- Simulated relation based on laboratory measurements is also compact globally but relation differs by up to 7% in the lower stratosphere