



The methane stratospheric abundance, global-mean temperature structure and time variability of the atmosphere of Uranus from Spitzer IRS spectra

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The IRS spectra of Uranus taken on November 15, 2004, provide information on the temperature structure of the upper troposphere and lower stratosphere and the abundance of CH₄. The temperature structure was derived using the collision-induced absorption of H₂ at wavelengths between 15 and 38 μm. The overlap of the vertical regions from which the upwelling radiance emerges in the lower stratosphere from both the H₂ collision-induced continuum and the 7.8-μm band of CH₄, allows us to derive a CH₄ molar fraction of $\sim 2 \times 10^{-7}$, assuming a H₂ molar fraction of 0.83 and a constant CH₄ mixing ratio in the stratosphere. This abundance is some two orders of magnitude lower than one predicted by saturation equilibrium, and it is below the upper limits derived previously from ISO SWS. The prominent C₂H₂ feature near 13.7 μm appears to be consistent with ISO SWS observations taken in the mid 1990s and earth-based observations taken in the mid 1980s, and there is a good match between the IRS and ISO SWS spectra of the H₂ continuum in regions of high flux longward of 30 μm. On the other hand, the H₂ continuum between 15 and 24 μm is lower than the earth-based observations in this region. If the calibration of each data set is trustworthy, this indicates a change of the global mean temperature near the tropopause of Uranus between its nearly pole-on and near-equinox appearances. Furthermore, the 8-11 μm region observed by IRS in November is also lower than the earth-based spectra, but not as low as an H₂ continuum modeled on its longer-wavelength characteristics. One model matching the ground-based measurements corrected for the low H₂ continuum by increasing the He mixing ratio substantially, but that solution is precluded by Voyager and far-infrared earth-based results. Alternatively a spectrally neutral stratospheric haze was invoked to match the earth-based 8-11 μm spectrum, but our IRS spectrum is inconsistent with a spectrally neutral emitter in this region.

In fact, the spectra qualitatively emulate some of the spectral characteristics of the expected H_2 continuum. Care must be taken to separate systematic effects of calibration uncertainties from true time dependence, and models for the collision-induced H_2 - H_2 absorption at low temperatures should be re-examined.