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Spatial Variability in the Stratosphere of Uranus

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Observations of spatial variability in the atmosphere of Uranus have been limited to cloud properties and temperatures in the troposphere from a combination of spacecraft and ground-based observations. We report observations of the spatial distribution of (1) the stratospheric temperature field and (2) the distribution of stratospheric acetylene from ground-based mid-infrared observations using giant telescopes that resolve the planet spatially. (1) Temperatures in the stratosphere were derived from spectral scanning of the molecular hydrogen rotational S(1) quadrupole using the TEXES spectrometer at the Gemini North observatory in 2007, near Uranus' equinox at high resolution (R=55,000). The hydrogen S(1) line was mapped by scanning the slit longitudinally across the entire disk of the planet. The observed radiances from the line center emerge primarily from the 0.1-0.3mbar pressure level. As expected for the "thermally-inverted" stratosphere, the planet is limb brightened at all latitudes, generally consistent with the predictions for the temperature structure derived from Spitzer IRS disk-averaged spectra (Orton et al. 2014 Icarus 243, 494). A pole-to-pole cut through the central meridian shows a generally smooth variability, with the (IAU-defined) northern hemisphere emerging from winter darkness marginally brighter than the southern hemisphere, consistent with a smooth meridional gradient of temperatures. A latitudinal cut across the equator reveals an ostensible central brightening, as well as equal brightening toward the limbs. (2) The distribution of acetylene in the stratosphere was derived from images of thermal emission made in 2008 and 2009 using the mid-infrared imager/spectrometer VISIR at the Very Large Telescope and in 2009 using the mid-infrared imager/spectrometer T-ReCS at the Gemini South Observatory using a 13.04-μm moderate-band (NeII_2) filter and from spatially resolved 12.0-13.4 μm spectra of the central meridian. Emission from acetylene dominates the spectrum at 13.1 μm, as well as radiance imaged by the 13.04-μm filter; this emission emerges from roughly the same pressure level at the radiation from the hydrogen S(2) quadrupole line. Weaker emission from stratospheric ethane is also detected at 12.3 +- 0.2 μm, where center-to-limb structure suggests that it is combined with emission from the deeper troposphere. Although the general center-to-limb structure of the acetylene emission is consistent with predictions from its distribution derived from the low-eddy-diffusion rate models fitting the Spitzer IRS data (Orton et al. 2014 Icarus 243, 471), there is a strong latitudinal gradient with elevated acetylene emission pole ward of $\sim$25 degrees latitude in both hemispheres. Given the apparent smooth meridional variability of temperature, this implies a distinct boundary of higher vs. lower acetylene abundance regions. This boundary is most likely to be maintained dynamically, being quite different from the expectations of photochemical models with temporal and spatial dependence.