Near-Infrared Observations of the Venus Surface and Lower Atmosphere

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Near-infrared (NIR) thermal emission from the night side of Venus at wavelengths near 1.0, 1.10, and 1.18-μm originates primarily from the surface and lowest scale height of the atmosphere. The Infrared Imaging Spectrometer at the Anglo-Australian Telescope was used to acquire moderate-resolution ($\lambda/\Delta\lambda=400$), NIR (0.9 to 2.5 μm) spectral image cubes of the night side during the 1991 and 1993 inferior conjunctions. Images extracted at wavelengths near 1.0, 1.1, and 1.18-μm reveal intensity variations produced by cloud opacity differences and elevated topographic features including Beta Regio, Phoebe Regio, and Aphrodite Terra. High-elevation regions are 20 to 50% darker than the surrounding plains because they are up to 40 K colder. Large reductions in the surface emissivity at high-elevations (>50%), like those seen at microwave wavelengths, could also modulate the observed emission. These low-emissivity regions have been attributed to either conductive surface weathering products, or volume scatterers embedded within the surface. The first of these could have a distinct NIR signature, while the second should not. Scattering by the H$_2$SO$_4$ clouds limits the spatial resolution to ~100 km, but atmospheric seeing further limits our spatial resolution to ~250 km. Scattering by the clouds and continuum absorption by gases also attenuate the observed emission and reduce the contrast, but these data still resolve regions with elevation differences of ~1 km. We used a radiative transfer model to simulate the observed intensities and contrasts for a variety of topographic elevations (0 to 6 km), surface emissivities (0.06 to 0.5), geoid temperatures (725 to 740 K), vertical temperature gradients (7 to 9 K/km) and H$_2$O amounts. We find that the atmospheric temperature lapse rates are marginally-stable (8 K/km) in all regions occupied by large-scale topography. The H$_2$O mixing ratios appear to decrease slightly with altitude, from about 45 ppmv at the surface to about 30 ppmv at the top of the first scale height (~16 km), but this conclusion is very dependent on the assumed CO$_2$ far-wing and continuum opacity near the surface. We find no evidence for large NIR surface emissivity variations (>10%) that are spatially correlated with known microwave low-emissivity regions.