Geophysical Research Abstracts, Vol. 8, 03164, 2006
SRef-ID: 1607-7962/gra/EGU06-A-03164

Modeling the Far-infrared Spectra of the Terrestrial Atmosphere

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A considerable fraction of the thermal energy that escapes to space from the atmosphere-surface system of a terrestrial planet emanates from a portion of the spectrum known as the far-infrared. Defined to cover the wave-number range from 100 to 650 inverse centimeters (15.4 to 100 micrometers), the far-infrared is dominated by molecular transitions characterized by the pure rotational bands. For cloud-free conditions in the Earth's atmosphere, the primary absorber and emitter of far-infrared radiation is water vapor, which is spatially and temporally the most variable of the principal atmospheric trace species. Recent studies have emphasized the crucial contribution afforded by the pure rotational band of water vapor in determining the transfer of far-infrared radiation through the Earth's atmosphere. These investigations have uncovered how the far-infrared water vapor absorption and emission play a prominent role in determining the rate of cooling throughout the free troposphere, and provide the greatest sensitivity of the outgoing thermal radiation, for any spectral range, to perturbations in upper tropospheric humidity. For cloudy conditions, the far-infrared spectrum between 250 and 590 inverse centimeters (17 to 40 micrometers) has also been determined to be sensitive to water and ice cloud optical depth, as well as effective ice-particle size. Mars, having considerably less atmospheric water vapor than the Earth (of order 210 ppmv), provides an opportunity to investigate the far-infrared spectrum under low water vapor conditions where even fairly strong water vapor transitions may not be saturated. Such conditions may help to refine the spectral traits of the pure-rotation band of water vapor, although separating the far-infrared spectral features of water vapor from the surface materials remains a concern.