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Titan's dynamic meteorology: new perspectives after early Cassini CIRS observations

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The Composite Infrared Spectrometer (CIRS) on the Cassini orbiter provides a combination of global coverage and spatial resolution that presents a unique opportunity for temperature and composition mapping of Titan's atmosphere. Early CIRS results are summarized and their meteorological implications discussed. Like Venus, Titan has cyclostrophic winds, but unlike Venus, Titan's stratosphere has strong seasonal variations in its winds and temperatures. Comparison of the CIRS observations with earlier Voyager IRIS infrared observations, and with winds inferred from ground-based observations of stellar-occultation central-flash events, should provide a handle for probing the dynamical processes driving these rapid winds, which currently are poorly understood. The early Cassini CIRS observations pertain to northern winter. A strong circumpolar vortex is observed, but it extends down to low latitudes, $\sim 20^{\circ}$ N. Titan's south pole is colder than its equator in the stratosphere. Given the season, this is a bit of a surprise, and it may suggest upwelling (~ 0.04 cm s^{-1}) at the south pole. Mechanically forced meridional circulations, necessary to transport angular momentum between hemispheres, had been proposed to explain Voyager observations of a hemispheric asymmetry in stratospheric temperatures near the northern spring equinox. Help in unraveling these meridional circulations may come from CIRS's ability to take spectra in the limb-viewing mode. The higher air mass afforded by limb viewing enables CIRS to sound at higher altitude, into the mesosphere. Terrestrial studies indicate that meridional circulations often remain coherent across the stratopause. The CIRS spectra indicate that there is an enhancement of several nitriles and hydrocar-

bons at mid and high northern latitudes. Voyager IRIS observed a similar phenomenon. The combination of enhanced constituent abundance at high northern latitudes, cold polar air, and strong circumpolar jets argues for an isolation of the atmosphere within the winter vortex from that outside of it, similar to the Antarctic ozone hole on Earth. Cassini will provide the opportunity to observe this vortex evolve into spring, and, if an extended mission materializes, observe the vortex dissipate as the season approaches northern summer. On Earth, planetary waves play a major role in this. Planetary waves may also be important on Titan, but their amplitudes are smaller: zonal temperature variations in Titan's stratosphere are $\sim$1-2 K or less.