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The dynamics and composition of Saturn's atmosphere

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We summarize recent results on the thermal structure, composition, and dynamics of Saturn's atmosphere, particularly from the Cassini CIRS and Radio-Science experiments. Temperatures retrieved from spacecraft radio-occultation soundings have provided the most detailed vertical profiles. These generally exhibit wavelike behavior in the stratosphere, and this is particularly pronounced at equatorial latitudes, where there is evidence that waves may modulate the mean zonal winds and thermal structure. Cloud-tracking velocity determinations since 1996 have suggested that Saturn's equatorial winds have slowed dramatically ($\sim$200 m/s), compared to earlier measurements from Voyager in 1980-81, but whether this represents a real change in the zonal winds or a change in cloud heights is controversial. Cassini thermal-infrared measurements indicate a strong decay in low-latitude zonal winds with altitude in the upper troposphere and stratosphere. The retrieved Cassini radio-occultation profiles (all near the equator) are affected by the winds, because the propagation of the radio rays through Saturn's atmosphere depends on the shape of the surfaces of constant density. We report the helium abundance derived from the comparison of CIRS spectra with synthetic spectra based on temperatures derived from radio-occultations, and discuss its sensitivity to the wind uncertainties. Outside the equatorial region, the zonally averaged temperatures obtained from CIRS spectra also show some correlation with the meridional structure of the zonal winds. The stratosphere, where radiative relaxation times are smaller, also exhibits a hemispheric-scale associated with the seasonal modulation of solar heating. Still, there are apparent departures from a purely radiative response in the stratosphere, for instance the very warm south pole, which may partly result from subsidence and adiabatic heating. Besides temperatures, the spatial distribution of gaseous constituents, like hydrocarbons in the stratosphere and phosphine in

the troposphere, can effectively probe meridional and vertical motions.