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Titan's Atmosphere: Cassini Radio Science Extinction Observations

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Cassini conducted the first two radio occultations of Titan's atmosphere on March 18 (T12) and May 20 (T14), 2006. In both cases, the atmosphere was probed on the ingress and egress sides, yielding observations at four mid-southern latitudes. Quasi-monochromatic S-, X-, and Ka-band signals (13, 3.6, and 0.94 cm-wavelength, respectively) were transmitted from Cassini, and the perturbed signals were observed at the ground receiving stations of the NASA Deep Space Network. Demanding spacecraft maneuvers to point the Cassini high-gain antenna boresight to virtual Earth during the occultations were successfully implemented. The refracted S- and X-band signals were tracked down to Titan's surface. In contrast, the Ka-band signal was extinguished by atmospheric absorption at about 10 km above Titan's surface. Changes of signal strength, corrected to remove refractive defocusing, reveal both small-scale and large-scale effects. The former are likely due to gravity waves and turbulence. The latter exhibit remarkable differential extinction of the three radio signals, an attribute of Titan's atmosphere observed for the first time. Abel inversion of signal extinction integrated over the radio path yields altitude profiles of the local extinction coefficient (dB/km), revealing distinct behavior in the stratosphere and in the troposphere. The profiles appear remarkably consistent among the ingress and egress sides and also among the T12 and T14 observations and clearly illustrate the strongly dispersive nature of the responsible physical mechanism. We investigate and discount extinction by methane rain droplets as the main mechanism for the observed tropospheric differential extinction. We show that N2-N2 collision-induced gaseous absorption is most likely the dominant responsible mechanism, although additional extinction due to rain

droplets or other localized sources is a possibility. Investigation of physical mechanisms responsible for the observed stratospheric extinction remains in progress.