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Jupiter's Temperature Structure: A Reassessment of the Voyager Radio Occultation Results

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Atmospheric temperature is an important parameter controlled by the outward transport of internal energy and the absorption of solar radiation and auroral heating. It is used widely in models of cloud formation, photochemistry, retrieval of elemental abundances from observations, vertical extrapolation of cloud level winds, and as a boundary condition for interior models. The Galileo probe made very precise in situ measurements of Jupiter's temperature from the upper atmosphere down to a pressure level of ~22 bars. However, those data correspond to a single location of the probe entry site, which also turned out to be a 5-micron hotspot. Other data covering a wider range of latitude and longitude locations are available from the Voyager radio occultation measurements (Lindal et al. JGR 86, A10, 8721, 1981). The use of S and X bands (2.3 GHz and 8.4 GHz) on Voyager allowed measurements of atmospheric refractivity from approximately 1 millibar to the 1 bar level. However, the temperatures derived from these observations were based on the then-available information on refractivities and composition, which have since been refined. Tabulated data are largely not available and so we have first digitized the data from the published figures of all available Voyager radio occultations and verified their fidelity. We then applied correction factors to the pressures and temperatures based on current laboratory data on radio refractivities of gases relevant to the radio occultation regime (H_2, He, CH_4, PH_3, Ne and Ar) and used the gas abundances measured by the Galileo probe, also accounting for their implied revision of the assumed molecular weight. Depending on the set of

radio occultation observations, the corrected temperature is greater by as much as 3 K at the 1-bar level and 6 K at the 1-millibar level compared to the originally published profile (Lindal et al. 1981). Considering all available radio occultation data sets the corrected temperature at the 1-bar level is 168.69±6.13 K, including some allowance for small latitudinal, longitudinal, and temporal variations. That allows for the possibility of a wider temperature range of 163-175 K at the 1-bar level than the commonly assumed value of 166 K from the Galileo probe. The profile itself provides an alternative a priori profile for retrieval of temperatures from remote sensing of thermal emission. Temperature at the 1-bar level is a particularly important reference since it serves as an "anchor" in models for retrieving the atmospheric composition and thus has a potential effect on the derived water abundance. It also broadens the range of acceptable upper boundary temperatures for interior models. The corrected data will also serve as a baseline for the radio occultation of Jupiter observations planned in Juno's extended mission.