Model Payload for Ice Giant Entry Probe Missions

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Descent probes afford the opportunity to make essential measurements of an atmosphere that are beyond the reach of remote sensing, including the abundances of noble gases and key isotopes, and the thermal profile and dynamical structure of the atmosphere beneath the cloud tops. Measurements are defined as Tier 1, indicating threshold science that is required to justify the probe mission, and Tier 2 indicating valuable science that would significantly complement and enhance the threshold measurements, but of themselves are not enough to justify the probe.

Tier 1 measurements comprise the abundances relative to hydrogen of the noble gases including helium, and key isotopic ratios relative to solar such as D/H, $^{3}He/^{4}He$, $^{14}N/^{15}N$, $^{12}C/^{13}C$, $^{16}O/^{18}O$, and the thermal structure of the atmosphere. Instrumentation required to achieve the Tier 1 measurements include mass spectrometers and a helium abundance detector, and an atmospheric structure instrument to measure the altitude profile of pressure and temperature.

Tier 2 science includes lower priority atmospheric structure and processes such as the altitude profile of atmospheric dynamics including zonal winds and waves, the profile of net radiative transfer of upwelling thermal infrared and downwelling visible fluxes in the atmosphere, the location, density, composition, and structure of clouds and size distribution of liquid and solid cloud aerosols, and the abundances of disequilibrium species such as PH_3, CO, AsH_3, GeH_4, and SiH_4. Potential Tier 2 instrumentation includes a nephelometer, net flux radiometer, accelerometers (likely an element of the atmospheric structure instrument) from which the upper atmospheric density profile can be retrieved, and an ultrastable oscillator as part of the telecommunications system to provide wind measurements using Doppler techniques.

Carrying Tier 1 instrumentation and possibly some or all of the Tier 2 instrumentation, a shallow probe would retrieve the abundances of noble gas, key isotopes, and many key heavy elements (other than oxygen and nitrogen), and would provide measurements of atmospheric thermal structure, dynamics, and processes at levels beneath those significantly influenced by sunlight and accessible to remote sensing. Measurement of disequilibrium species present in the upper atmosphere due to atmospheric upwelling would provide insight into atmospheric composition and chemistries at much deeper levels, possibly helping to constrain the bulk oxygen, nitrogen, and sulfur abundances.

This paper presents a summary and prioritization of key investigations and a model payload for achieving the key objectives for in situ ice giant science.

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