Geophysical Research Abstracts
Vol. 20, EGU2018-10532-1, 2018
EGU General Assembly 2018

Small Next-generation Atmospheric Probe (SNAP) Concept for Ice Giant Missions

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A concept proposal for a small atmospheric entry probe designed as a secondary payload to future giant planet missions is presented. Our 30-kg atmospheric probe would be designed to enable future multi-probe missions. Specifically, we examine the advantages of adding SNAP to a future Uranus Orbiter and Probe flagship mission. In combination with a primary entry probe, SNAP would perform atmospheric in situ measurements at a second location to enable determination of atmospheric spatial variabilities as recommended by the 2013-2012 Planetary Science Decadal Survey and the 2014 NASA Science Plan.

The main scientific objective to be advanced by a second atmospheric entry probe is to measure spatial variabilities within a planetary atmosphere that cannot be revealed by a single probe. SNAP's measurement objectives are therefore to determine; (1) Vertical distribution of cloud-forming molecules (CH_4, H_2S, and NH_3); (2) Thermal stratification; and (3) Wind speed as a function of depth at a location separated from the primary probe entry location. The SNAP entry location would be selected to examine spatial variabilities of different climatic zones, hemispheric seasonal differences, localized meteorological features, or temporally transient phenomena. A second in situ probe would provide a representative ground-truth for a separate region that would be used to further validate and calibrate remote sensing observations; multiple probes targeting a variety of conditions would enhance the value of the overall mission. Our scientific objectives do not include measurements of noble gas abundance and elemental isotopic ratios because these quantities are not expected to vary spatially and would be measured by the primary probe equipped with a mass spectrometer.

The primary goal of the SNAP concept development is to achieve the stated science objectives with a 30-kg entry probe that is less than half the radius of the Galileo probe and would reach a pressure of 5-bars. Data would be returned by way of a telecomm link to the Carrier spacecraft prior to Earth downlink. The baseline instrument payload would comprise an Atmospheric Structure Instrument (ASI) to measure entry and descent accelerations and the altitude profile of temperature and pressure, a carbon nanotube-based NanoChem atmospheric composition sensor, and UltraStable Oscillators (USO) on both the probe and the Carrier spacecraft to enable retrieval of atmospheric dynamics using Doppler Wind techniques. The miniaturization of SNAP is enabled primarily through the adaptation of low-mass atmospheric composition sensor, NanoChem, that can operate under atmospheric pressure unlike a mass spectrometer which requires a heavy vacuum pump.

We also examined numerous Uranus arrival trajectory options to evaluate the feasibility of delivering two probes at two significantly different locations (e.g., autumn and spring hemispheres), and send data to the Carrier spacecraft. We identified unique challenges inherent to multi-probe missions, and present viable solutions.

Although the current SNAP concept is developed as a possible element for a future Uranus Orbiter and Probe flagship mission, the probe conceptual design and mission architecture would maintain flexibility so as to be easily adapted to other giant planets