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SNAP – the Small Next-generation Atmospheric Probe Concept for Future Ice Giant Missions

D.H. Atkinson (1), K.M. Sayanagi (2), R.A. Dillman (3), A.A. Simon (4), M.H. Wong (5), T.R. Spilker (6), S. Saikia (7), J. Li (8), D. Hope (2)

(1) Jet Propulsion Laboratory, California Institute of Technology (David.H.Atkinson@jpl.nasa.gov), (2) Hampton University, (3) NASA Langley Research Center, (4) NASA Goddard Space Flight Center, (5) University of California, Berkeley, (6) Independent Consultant, (7) Purdue University, (8) NASA Ames Research Center.

Abstract

A concept is presented for a small atmospheric *in situ* probe designed as a secondary payload to future giant planet missions. SNAP, the Small Next-Generation Atmospheric Probe, is a 30-kg entry probe designed to enable future outer planet multi-probe missions. Specifically, the advantages and impact of adding SNAP to a future flagship Orbiter and Probe mission to Uranus are considered. SNAP would perform atmospheric *in situ* measurements in combination with a primary entry probe, at a location spatially (and possibly temporally) separated from the primary probe to enable measurement of the spatial variability of atmospheric structure and dynamics as recommended by the 2013-2012 Planetary Science Decadal Survey and the 2014 NASA Science Plan.

The primary atmospheric scientific objective of a second *in situ* entry probe is to measure the spatial variability of thermal structure and atmospheric dynamics that cannot be retrieved by a single probe. The SNAP measurement objectives are to determine (1) the vertical distribution of cloud-forming molecules including CH_4, H_2S, and NH_3; (2) the thermal stratification of the atmosphere; and (3) zonal wind speed as a function of depth at a location separated from the primary probe entry location. To the extent reasonable and possible from a mission design point of view, the SNAP entry location would be selected to examine different climatic zones (different latitudes), hemispheric seasonal differences, diurnal variations, or specific localized meteorological features or temporally transient phenomena. As a second *in situ* probe, SNAP would provide additional ground-truth for a separate region to further validate and calibrate remote sensing observations. The scientific objectives of SNAP do not include measurements of noble gas abundance and elemental isotopic ratios because these quantities are expected to show little or no spatial variation 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 science objectives at pressures of 5-10 bars with a 30-kg entry probe that is less than half the radius of the Galileo probe. Science data would be returned by way of a telecommunications link to a carrier relay spacecraft prior to Earth downlink. The baseline instrument payload would comprise an Atmospheric Structure Instrument (ASI) to measure the altitude profile of temperature and pressure as well as entry and descent accelerations and an atmospheric composition sensor based on carbon nanotube technologies (NanoChem), and ultrastable oscillators (USO) on both the probe and the carrier relay spacecraft to enable retrieval of atmospheric dynamics using Doppler Wind techniques. The miniaturization of SNAP is enabled primarily through the development of the low-mass NanoChem atmospheric composition sensor.

Numerous Uranus arrival trajectory options were examined 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 relay spacecraft. Challenges inherent to multi-probe missions were identified and considered.

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 adopted as a secondary *in situ* probe for future giant planet mission.

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Predecisional information for planning and discussion only.