EPSC Abstracts
Vol. 12, EPSC2018-597, 2018
European Planetary Science Congress 2018

Exploring Titan's Meteorology with Dragonfly

S. C. R. Rafkin(1), R. D. Lorenz(2), E. P. Turtle(2), J. W. Barnes(3), M. G. Trainer(4), A. Le Gall(5), J. M. Lora(6), C. P. McKay(7), C. E. Newman(8), M. P. Panning(9), T. Tokano(10), C. Wilson(11) and the Dragonfly Science Team.

(1)Southwest Research Inst., Boulder, CO (rafkin.swri@gmail.com), (2)Johns Hopkins Applied Physics Lab., Laurel, MD, (3)Univ. Idaho, Moscow, ID, (4)NASA Goddard Space Flight Center, Greenbelt, MD, (5)Laboratoire Atmosphères, Milieux, Observations Spatiales, Guyancourt, France, (6)Univ. California, Los Angeles, CA, (7)NASA Ames Research Center, Moffett Field, CA, (8)Aeolis Research, Pasadena, CA, (9)Jet Propulsion Laboratory California Institute of Technology, Pasadena, CA, (10)Inst. für Geophysik und Meteorologie, Univ. Köln, Köln, Germany, (11)Oxford Univ., Oxford, UK

Abstract

Dragonfly [1] is a rotorcraft lander mission (Fig. 1) currently in a Phase A study under NASA's New Frontiers Program that would take advantage of Titan's dense atmosphere and low gravity to visit a number of surface locations, studying how far chemistry can progress in environments that provide key ingredients for life. This mission architecture also permits and demands investigation of Titan's atmosphere.

If selected for flight *Dragonfly* will launch in 2025 and arrive in 2034. It will spend over two Earth years on Titan's surface, long enough to observe many diurnal cycles, atmospheric waves, and perhaps even seasonal changes. *Dragonfly* will explore the meteorology of a number of different locations and terrains, and take vertical profiles of temperature, methane, and hydrogen to constrain diurnal mixing in the planetary boundary layer (PBL).

Dragonfly will also contribute to atmospheric science by measuring surface properties, including soil moisture, conductivity and thermal inertia, the chemical composition of surface deposits (which may contain the products of high-altitude photochemistry), the saltation threshold of Titan's dune particles (which will aid interpretation of dune morphology), and the possible confirmation of fluvial sediments (which may inform our understanding of the hydrologic cycle). *Dragonfly* results will test and improve atmospheric models, enabling a deeper understanding of both the local and global Titan climate system.

1. Instrumentation and Operations

Proposed Titan science operations feature dozens of flights over the mission, although most of the time (~99%) will be spent on the surface. In addition to cameras and chemistry/astrobiology instrumentation, *Dragonfly* includes a Geophysics and Meteorology package ("DraGMet"). This includes optical sensing of methane humidity; a solid-state hydrogen abundance sensor; pressure and temperature sensors; and wind sensors derived from those flown on Beagle 2 mounted on each rotor hub so that one is always upwind of the vehicle to avoid wake effects. Winds aloft will be determined from the vehicle navigation system during flight. DraGMet also incorporates sensing of the electric field and dielectric constant to measure surface properties and the Schumann resonance, plus instrumentation to measure seismic and surface thermal properties. A camera suite will acquire panoramic imaging that will be used to infer atmospheric opacity and some cloud properties.

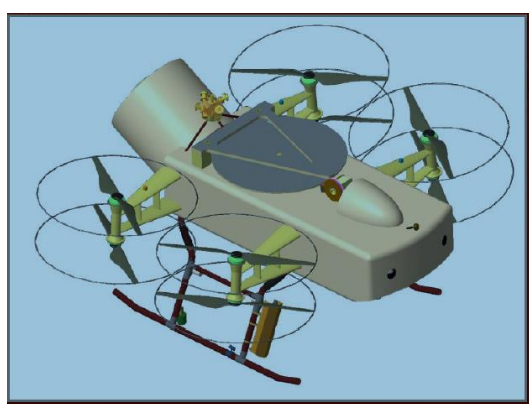

Figure 1: A conceptual CAD model of the *Dragonfly* rotorcraft.

2. Meteorological Science

Titan's meteorology, with a methane-based hydrologic cycle analogous to our own demands study not only in its own right, but as context for the distribution of surface materials, many of which are of astrobiological interest. Measurements of temperature, pressure, winds and methane abundance, both at the surface and during flight, will address key questions about the structure and dynamics of the atmosphere, as well as its exchange of mass, momentum and energy with the surface.

2.1 Surface Meteorology

Dragonfly will make measurements of the meteorological diurnal cycle on Titan, addressing such questions as: How does surface moisture influence temperature? How strongly are winds controlled by local topography (including dunes) versus the global circulation or regional slope winds? Can a gravitational tide component to Titan's winds be isolated? What is the diurnal and synoptic variability of pressure, temperature, and winds? Is there evidence of the intertropical convergence zone in pressure, winds or humidity? Is there evidence of mesoscale to large-scale wave activity at the surface? Are surface temperature variations ~1K, as suggested from Cassini measurements and atmospheric models, or are there larger variations at the small scale on low-albedo, low thermal inertia surfaces such as dunes?

2.2 Vertical Structure

Dragonfly will determine the depth of the PBL and identify structures associated with residual boundary layers, and address such questions as: How representative is the Huygens descent profile (currently the only detailed measurement of the structure of the lower atmosphere)? Are changes in stability associated with the top of the PBL from prior seasons? Is there horizontal spatial variability in the PBL structure? What is the vertical profile of wind and how does it change with location and time?

2.3 Aeolian Activity

Dragonfly will measure the saltation threshold by using its rotors at low power settings to apply increasing wind stress to the surface (e.g. of a dune) until sediment transport begins. Atmospheric models will be constrained using measurements of winds, and characterization of dunes will then be used to address: Is dune morphology and orientation consistent with present-day winds predicted in circulation models (and if so, with what saltation threshold?) or is there a paleoclimate signal in the dune configuration?

2.4 Methane Cycle and Hydrogen Profile

Dragonfly will quantify the abundance of CH_4 and H_2 and will connect surface abundance and variability to observed vertical profiles, addressing questions such as: How is methane distributed in the vertical? Is the Huygens profile typical? Is there fog or clouds? Is there a surface hydrogen sink? Are there horizontal variations in methane (e.g. associated with soil moisture, springs)? How does humidity vary with the diurnal cycle? Is moisture fluxed out of the ground during the day and returned during the night? Is there a preferred direction of atmospheric moisture transport during this season? Are methane cloud systems visible?

References

[1] Lorenz, R. et al., Dragonfly : A Rotorcraft Lander Concept for Scientific Exploration at Titan, Johns Hopkins Technical Digest, in press (2018). Downloadable at http://dragonfly.jhuapl.edu/