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Keck OSIRIS observations of haze transport on Titan

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Abstract

We present spatially-resolved observations of Titan in the near-infrared obtained with the field integral spectrograph, OSIRIS, at the W. M. Keck Observatory. Datacubes were acquired in H- and K-bands from Apr 2006 to Mar 2011. Broadband spectra reveal atmospheric aerosol structure from the surface through the stratosphere. We present a preliminary analysis of the temporal variation in aerosol distribution, as constrained by radiative transfer models that include recent updates to methane opacity and aerosol scattering.

1. Introduction

Remote observations of Titan in the near-IR measure scattering from an ensemble of particles with a distribution of sizes, structures, and compositions — each of which depend on the altitude and geographical location. These properties change over time and result in seasonal changes in Titan's albedo, which are commonly interpreted as changes in the stratospheric aerosol density.

2. Observations

The data presented here were obtained using the OSIRIS imaging spectrometer with adaptive optics at the W. M. Keck Observatory on the Keck II telescope. The detector uses a 2048 × 2048 pixel Rockell Hawaii-2 detector, which in our observing modes corresponds to at a plate-scale of 0.020" and a spectral resolution of R ∼4000. We observed in both H- and K-bands when possible, covering 1.473–1.803 and 1.965–2.381 μm, respectively. The field of view was 0.32" × 1.28", such that four ∼5min exposures were required to cover the entire ∼1" diameter disk of Titan. We obtained datacubes on an approximately yearly basis from Apr 2006 to Mar 2011. Data are reduced using the OSIRIS data reduction pipeline, which includes flat-fielding, sky-subtraction, cosmic-ray rejection, wavelength calibration, spectral extra and datacube assembly and mosaicking. The primary limitation in the preliminary data being presented is the mosaicking of individual cubes, limited by the telescope and AO pointing information.

3. Radiative Transfer

Our models of Titan incorporate well-established numerical solutions to the radiative transfer equation [5, 3, 1, 2] and reproduce near-IR observations exceptionally well. Limitations in current analyses are due to input parameters to the model (e.g., CH_4 opacities, surface albedo spectra, and aerosol scattering) and not the numerical methodology or assumed geometry. A discrete ordinates method is used to solve the radiative transfer equation for 16 pseudo-plane-parallel layers from 0 – 200 km altitude [9, 7]. We correct for the curvature of the atmosphere with an established geometrical correction [10]. We use the atmospheric temperature and pressure profiles measured *in situ* by Huygens/HASI [4], which are in excellent agreement (below 200 km) with the Voyager profiles [6]. Starting with the *in situ* measurements of aerosol extinctions made by Hugyens/DISR [8], we vary the extinction at other locations on Titan to reproduce our observations of the global distributions of haze. The uncertainty of the CH_4 opacity translates into an uncertainty in both the retrieved surface albedo and to a lesser extent the tropospheric aerosol extinction.

4. Results

Preliminary data reductions are limited by the absolute metrology of the telescope pointing. While individual exposures are nearly diffraction-limited in spatial resolution, assembling datacubes into mosaics is often limited by systematic offsets of up to a few pixels between exposures. We present an initial algorithm for navigating and reconstructing the datacubes. Successfully mosaicked datacubes are used to retrieve the spatially-resolved atmospheric aerosol distribution on Titan.

Acknowledgements

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