EPSC Abstracts
Vol. 9, EPSC2014-650, 2014
European Planetary Science Congress 2014

Ice particles in Saturn's hazes

E. L. Barth (1), K. A. Rages (2) and J. I. Moses (3)
(1) Southwest Research Institute, Boulder, CO, USA (ebarth@boulder.swri.edu), (2) SETI, (3) Space Science Institute

Abstract

Haze particles in Saturn's stratosphere can be seen in the visible limb images of Cassini's Imaging Science Subsystem (ISS). These hazes are likely a mix of particles, including solid organics formed as a result of methane photolysis and electron deposition, as well as the condensation of water and hydrocarbon ices. Quantifying the composition, size, and vertical structure of these stratospheric particulates is important to the understanding of gas giant atmospheric dynamics, energy deposition, and the composition of particles in the troposphere.

1. Introduction

To properly explore the dynamics of a gas giant atmosphere such as that of Saturn, the atmosphere's vertical structure must first be known as a function of latitude, including the altitudes and scattering properties of particulates. This vertical scattering profile determines where solar energy is initially deposited, as a function of both latitude and altitude. Absorption of solar energy by stratospheric aerosols affects the stratospheric temperature and the location of the tropopause. Compounds formed in the stratosphere, either photochemically or through other processes such as electron deposition, may form significant components or coloring agents for tropospheric clouds. The overall solar heating profile of the atmosphere is regulated by the altitude and optical density of absorbing/scattering clouds and hazes in the troposphere, with consequent influence on the altitude and temperature of the tropopause, the relative humidity profile of any volatiles present (ammonia or methane), and the meridional wind profile. Horizontal variations in vertical structure (belt vs. zone, pole vs. temperate latitudes, or albedo feature vs. surroundings) can also provide information on the vertical motions of the atmosphere.

We have examined data from both Cassini and Voyager to study the detailed vertical structure of absorbing/scattering particulates in Saturn's stratosphere. Our goal is to use this information to determine the fractal scattering properties of the stratospheric hazes, and in combination with microphysical modeling, to determine how and where these hazes are being produced, transported, and destroyed at locations across Saturn. This will lead to an understanding of the different environments in Saturn's northern and southern stratospheres around the time of northern spring equinox (the last such equinox was in February 1980, nine months before the arrival of Voyager 1; the next is in August 2009).

2. Modeling

The CARMA (Community Aerosol and Radiation Model for Atmospheres) code solves the continuity equation for aerosol particles (vertical transport, coagulation, cloud formation and growth, i.e. microphysics) and calculates their radiative effects in a column of atmosphere. We have developed a Saturn version of the model and added a large database of hydrocarbons that are observed or expected to be present in Saturn's atmosphere.

An example of running the full microphysics model to explore condensation of ices in Saturn's atmosphere is shown in Figure 1. The solid (colored) lines show the resulting number density of particles when water vapor, diacetylene (C_4H_2), and butane (C_4H_{10}) condense. A population of aerosol particles similar to Titan haze particles (radius~10 Å to 1 μm) was included to serve as condensation nuclei for the ices; a Gaussian distribution with enough particles so as not to limit the number of CCN was included (black line). The dashed lines show the relative humidity, RH, of the gases after cloud formation has begun. The water vapor peak is RH~80%, which will inhibit additional ice formation until eddy diffusion brings more into the 1 mbar level. Butane is at saturation and diacetylene is slightly supersaturated at RH~120%.

A number of factors including temperature profile, vapor pressure equation, volatile abundance, nucleation critical saturation, and coagulation efficiency will affect the altitudes of the individual ice layers. Additionally, some ices are likely to serve as condensation nuclei for others. We will present a number of results following the nucleation and growth of compounds in addition to those shown above in order to quantify the likely size and altitude of these particles in Saturn's stratosphere.

Acknowledgements

This work was funded by NASA's Cassini Data Analysis and Participating Scientist program and the Outer Planet Research program.

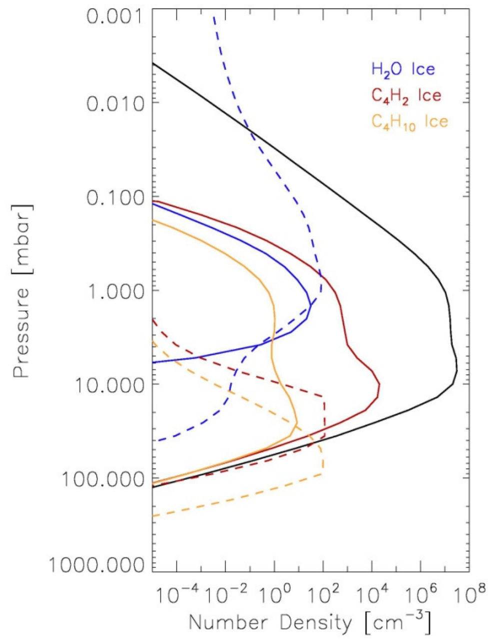

Figure 1: Condensation of ices in Saturn's stratosphere from microphysical modeling