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Stratospheric Ices in Titan's Atmosphere

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Abstract

Observations from Cassini, Voyager, and ground-based data point to the condensation of trace species in Titan's atmosphere, including HCN, C_2H_5CN, HC_3N, C_2H_2, C_2H_6, and C_4N_2. These and a dozen other species have now been added to the Titan CARMA microphysics model, which shows condensation occurring between about 60 and 100 km in Titan's atmosphere. Results on condensation altitudes as well as particle size will be presented, and implications for the optical properties of Titan's stratospheric aerosol particles will be discussed.

1. Introduction

Above the optically thick haze layers in Titan's atmosphere, methane and nitrogen molecules are broken apart by uv radiation, cosmic rays, and energetic electrons. A number of photochemical reactions occur, resulting in the creation of many trace hydrocarbon and nitrile species. When these trace gases reach Titan's stratosphere, many become supersaturated and condense out as ices surrounding a haze particle core. The condensation curves for 14 of these species are shown in Figure 1.

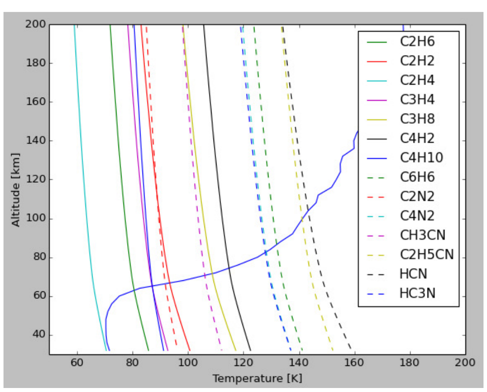

Figure 1: Condensation curves for trace species found in Titan's atmosphere. Saturation occurs where each (nearly vertical) mixing ratio line intersects Titan's temperature profile (shown in blue).

2. Modeling & Results

The ice condensation is explored using a 1-D microphysics model, which is an extension of the model described in [1] and [2]. Both haze and cloud particles are transported vertically through sedimentation and eddy diffusion. All particles are subject to coagulation. Angstrom-sized haze particles are introduced through a production function related to the photochemical destruction of methane. Cloud particles are created through nucleation following the classical theory. Cloud particles then interact with the volatiles through condensational growth and evaporation.

Both ice and droplet particles can be treated, as well as melting and freezing. Most of the species shown in Figure 1 condense below their freezing point, however propane (C_3H_8) initially forms droplet cloud particles around 70 km and then freezes at about 60 km. Both propane and ethane (C_2H_6) ice particles will melt near the surface. Condensation timescales for many of the ices are long, resulting in particles ~1-5 μm in radius. HCN, which begins to condense around 105 km, initially grows to ~20 μm, and the C_3H_8 droplets can reach ~40 μm.

Acknowledgements

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References

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[2] Barth, E. and Toon, B.: Methane, ethane, and mixed clouds in Titan's atmosphere: Properties derived from microphysical modeling, Icarus, Vol. 182, pp. 230-250.