Building a Cryogenic Aerosol Chamber for the Study of Pluto's Atmosphere

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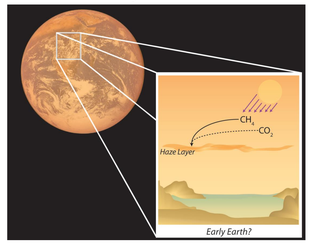
Introduction

In the solar system, there are three terrestrial bodies that have photochemical hazes present in their atmospheres: Earth, Titan, and Pluto. While the photochemical hazes of the current Earth are viewed as a health hazard, similar hazes also existed in the distant past and are believed to have played an important role in the beginning of life.

Modern Earth

Early Earth?

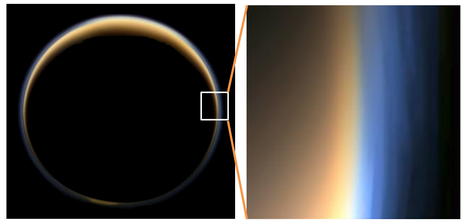


While Pluto and Titan receive considerably less light than Earth, their atmospheres both contain photochemical hazes believed to be similar to those of the early Earth.

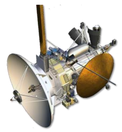
Comparisons of Terrestrial Atmospheres

	Early Earth	Titan	Pluto
Atmospheric Composition	N_2, CH_4 CO, CO_2 SO_2, H_2S	98.4% N2 1.4% CH4 0.1% H2 <0.1% CO	~95% N2 ~2-5% CH4 ~0.5% CO
Surface Pressure	1 bar	1.5 bar	10 µbar
Surface Temperature	300 K	96 K	40 K

Titan

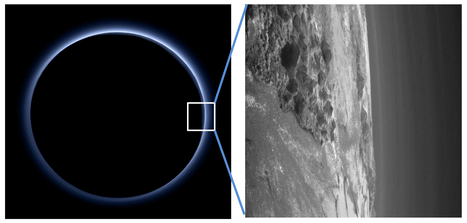


Cassini

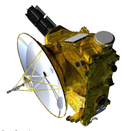


Arrived: 2004
Flybys: 118+
Status: On going till 2017

Pluto



New Horizons



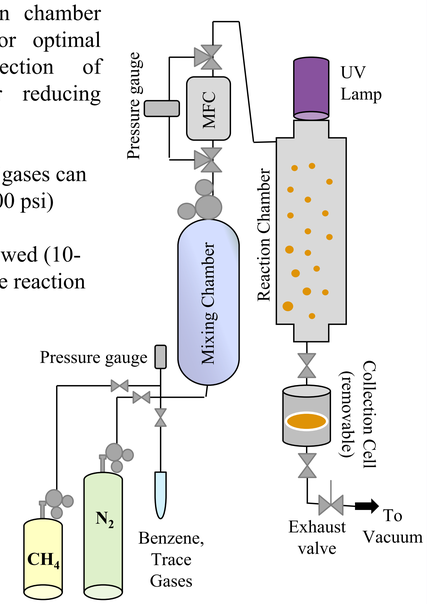
Arrived: June 2015
Flybys: 1
Status: Downloading

In order to better understand Earth's past, missions have been sent to both Pluto and the Saturnian system. With the vast amounts of data being returned from the New Horizons and Cassini spacecrafts, there is a need for laboratory simulations to provide experimental results. These experimental results provide much of the basis for interpreting the spacecraft observations.

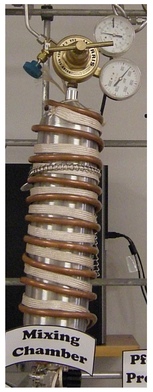
Atmospheric Photolysis Chamber

The aerosol generation chamber has been designed for optimal formation and collection of aerosols made under reducing conditions.

1. Custom mixtures of gases can be mixed at high (800 psi) pressure.
2. The mixtures are flowed (10-25 sccm) through the reaction chamber.
3. Irradiation is carried out with a VUV lamp (115-400 nm)
4. Aerosols can then be directed into other collection chambers for analysis



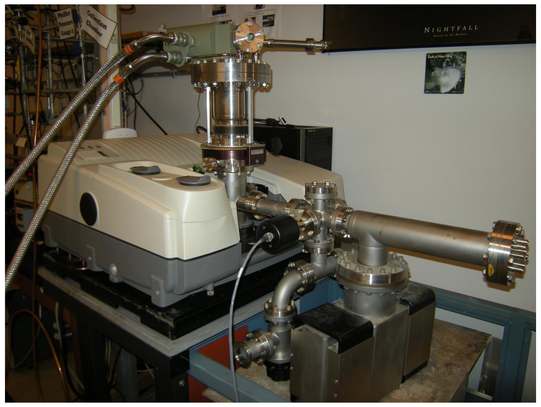
Cryogenic Modifications



In order to match the conditions of Pluto and Titan more closely, a cooling shroud has been installed on the mixing and reaction chambers. (Shown without covers).

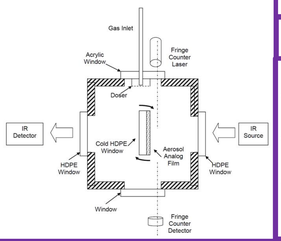
- Premixed gases are held at ~273 K in Mixing Chamber
- Gases can be cooled as low as 185 K upon entering the reaction chamber.
- To prevent thermal heating of the gases, the lamp is separated from the reaction chamber by a vacuum purged CaF_2 window.
- Aerosol generation can be maintained at pressures from 1 bar down to 20 mbar.

In Situ Analysis (under construction)



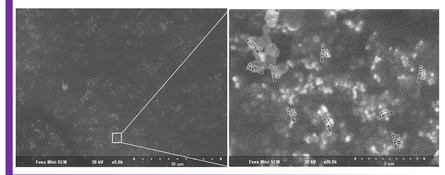
In order to prevent contamination of samples and more closely match the conditions of Pluto's and Titan's surfaces, we are in the process of installing a cold-head mounted infrared setup.

This will let us collect and analysis aerosols without the need to transfer between setups.



Preliminary Results

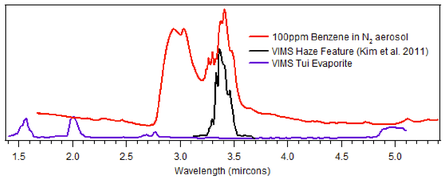
Aerosol Size

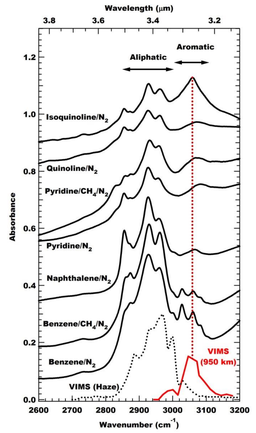


SEM analysis has shown that the average size of the collected aerosols is ~200nm

Infrared Analysis

Mid-IR analysis of aerosols generated from several different starting mixtures has shown a close match to the observations of Cassini's Visual and Infrared Mapping Spectrometer (VIMS) in both the atmosphere (Right) and of the surface (Below)





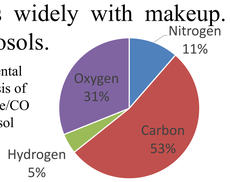
Other Properties

The bulk color and composition of aerosols varies widely with makeup. Future studies will include UV/Vis analysis of the aerosols.

Methane + Carbon Monoxide aerosol

Aromatic (pyridine) seeded aerosol

Elemental Analysis of Pyridine/CO aerosol



Conclusions

In conclusion, the construction of the cryogenic aerosol chamber is nearly complete with only the cold-head setup left to complete. Preliminary results at room temperature have shown the aerosols have spectral features similar to those observed by Cassini at Titan.

As more data is made available from the New Horizons spacecraft, we anticipate further matches as the cold-head will allow for observations of aerosols that still contain their volatile portions that currently are lost at room temperature.

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References

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