EPSC Abstracts
Vol. 8, EPSC2013-641, 2013
European Planetary Science Congress 2013

Investigation of the solar influence on the Martian polar caps

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Abstract

The planetary greenhouse effect, and the temperature increase connected to it, is one of the prime parameters driving atmospheric and surface conditions on terrestrial planets. A similar effect takes place on moons and planets totally or partially covered with ice – the so-called Solid State Greenhouse Effect (SSGE). The SSGE at the Martian polar caps may be of great importance for the sublimation and re-condensation of CO_2 and its circulation in the Martian atmosphere. Our work will concentrate on the influence of the SSGE on the Martian polar caps and the cryptic region. Therefore experiments under controlled conditions and numerical simulations were done in order to evaluate the efficiency of the SSGE.

1. Introduction

The influence of the atmospheric greenhouse effect on the Earth's climate was studied in detail and its importance has also been investigated for Venus. Icy surfaces like the polar caps of Mars behave different than rock and soil surfaces when they are irradiated by solar light. The latter ones absorb and reflect incoming solar radiation immediately at the surface. In contrast ices are partially transparent in the visible spectral range and opaque in the infrared. Due to this property it is possible for the solar radiation to reach a certain depth and raise the temperature of the ice layer below the surface. One possible consequence of the SSGE are the 'Martian spiders' observed at the cryptic region on Mars (see e.g. [2]), which may be partially driven by CO_2 phase changes within massive CO_2 ice.

In the frame of a project performed at the Space Research Institute in Graz, the SSGE was investigated experimentally and theoretically. Several experiments were performed, including diverse samples with the main focus on layered samples with a covering coat consisting of pure H_2O-ice (see [1]). In addition, models describing the influence of the SSGE on Mars, where the surface is partially covered by CO_2-ice, were developed. The experimental work on the SSGE in CO_2-ice is now continued at the OU. The first results of measurements and models with sample material CO_2-ice will be shown and possible implications for the understanding of various phenomena observed at the Mars polar areas will be discussed.

2. Laboratory Equipment

Our SSGE experiments make use of the CEPSAR environmental chambers at the Open University. These can be cooled down to 80 K and evacuated to a pressure of $<10^{-5}$ mbar. A solar simulator with a xenon short arc lamp that has a daylight colour temperature of approximately 5700 K, radiating into the chamber through a fused silica viewport that is used to provide insolation. Depending on the electrical power supplied, the solar simulator produces a radiation intensity corresponding to solar distances from 1 to 2 AU. Due to the horizontal orientation of the beam it has to be redirected using a mirror.

With this set up the following tests are planned:

- building of compact, smooth transparent CO_2-ice layers under Martian conditions

- ice samples (H_2O, CO_2) including different amounts of dust under Martian conditions

- measurement of the temperature distribution inside these samples when irradiated with solar light

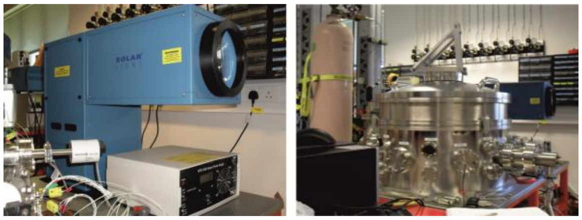

Figure 1: Left: the solar simulator. Right: the vacuum chamber.

3. First results

First tests were done using a sample container with 9.5 cm diameter and a height of 21 cm, built from a thin plastic foil. The ice was created by inflow of CO_2 gas at constant pressure into the sample container that was placed in the center of the chamber. During the test the chamber was cooled using liquid nitrogen.

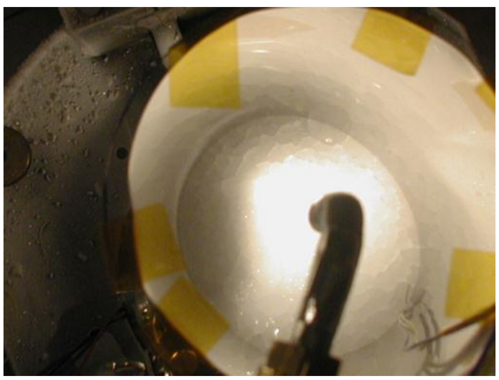

Figure 2: Picture of a CO_2 ice sample.

The ice obtained was slightly transparent and showed a honeycombed structure. The ice layer was flat and had reached a height of 2 cm by the end of the test (duration of sample growth: 5 h 20 min).

4. Summary

The first test showed that it is possible to build layers of transparent compact CO_2-ice under low pressure conditions. Models in which the influence of the SSGE on sub-surface layers in H_2O and CO_2-ice are compared showed that, for CO_2-ice, one may obtain a more clearly detectable internal temperature maximum as the one shown in [1], even if the mean irradiation intensity is much smaller.

Acknowledgements

This project is funded by the UK Space Agency.

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