ACT Stage topic 1 - "Warming Mars with artificial greenhouse gases"

Stage topic Description

Warming Mars and increasing its atmospheric pressure are the key requirements for making the planet suitable for life. Of different proposed methods, the use of artificial greenhouse gases to increase the surface temperature is probably the most efficient and the only currently technically feasible approach [1].

Few studies have been done on the effect of artificial greenhouse gases on the climate of Mars. In one of these studies the warming potential of four strong greenhouse gases, CF4, C2F6, C3F8 and SF6, was computed by a one-dimensional radiative-convective multilayer model [2]. This study shows that for current Mars, a warming as large as 33.5 K can be obtained by introducing C3F8 in the Martian atmosphere at a partial pressures of 1 Pa (about 0.2 % of the current total surface pressure on Mars). The optimal mixture of the four fluorine-based greenhouse gases was even more effective than pure C3F8.

A next step in this study would be to use a three dimensional state-of-the-art Mars global circulation model to assess the effect of the gases more thoroughly. With these models, adapted from weather forecasting and climate models for Earth, the Martian atmospheric circulation and climate can be derived. These GCMs have successfully reproduced most of the available observations on the current Martian climate.

Within the Advanced Concepts Team (ACT) the state-of-the-art three-dimensional Mars global circulation model LMD GCM [3][4] has been modified to allow a thorough investigation of the effects of the four gases CF4, C2F6, C3F8 and SF6 [5].

In this traineeship the successful candidate will modify the Mars global circulation model together with researchers in the ACT to accommodate in the Fortran code in an efficient way different mixtures such as those proposed my Marinova et al to model the dynamics of their effect in long-term simulations. The study will for the first time reveal the required time steps for achieving new metastable points.

Candidate's tasks

- Performing model simulations with an adapted version of the Mars LMD GCM with different concentrations of artificial greenhouse gases.
- Data analysis and interpretation. Assessment of the ability of these gases, applied individually and in the most effective mixture, to increase surface temperatures.

The ideal candidate

- A student with a background in Meteorology, Atmospheric or Climate Science
- Experience with Fortran on a Unix system is a plus.

References

- [1] J. Lovelock et al., The Greening of Mars. Warner Brothers Inc., 1984
- [2] M. Marinova et al. , Radiative-convective model of warming Mars with artificial greenhouse gases, 2005
- [3] F. Forget et al., Improved general circulation models of the martian atmosphere from the surface to above 80 km, Journal of Geophysical Research, 104, 24155-24176, 1999.
- [4] F. Forget et al., User Manual for the LMD Martian Atmospheric General Circulation Model, 2007
- [5] N.N. Ridder, D.C. Maan, L. Summerer, Terraforming Mars: Generating Greenhouse Gases to Increase Martian Surface Temperatures,Journal of Cosmology,2010