SYMPOSIUM ON STEPPING STONES TO THE FUTURE: STRATEGIES, ARCHITECTURES, CONCEPTS AND TECHNOLOGIES (D3)
Novel Concepts and Technologies for the Exploration and Utilization of Space (2)

Author: Dr. Leopold Summerer
European Space Agency (ESA), The Netherlands, leopold.summerer@esa.int

Mrs. Cynthia Maan
European Space Agency (ESA), The Netherlands, cynthia.maan@esa.int
Mrs. Nina Nadine Ridder
European Space Agency (ESA), The Netherlands, nina.nadine.ridder@esa.int

THREE-DIMENSIONAL MODELLING THE POTENTIAL OF GREENHOUSE GASES TO INCREASE MARTIAN SURFACE TEMPERATURES

Abstract

This study used the LMD Global Circulation Model (GCM) of the Martian atmosphere to investigate the warming potential of four fluorine based greenhouse gases (GHG) and their mixtures in regards to their ability to increase the Martian surface temperature to above the freezing point of water (sometimes considered as key part of visionary concepts for "terraforming")

Starting from an approach taken by Marinova et al. (2005), who were amongst the first to perform such an investigation using a simple one-dimensional radiative-convective model, the present study has taken recent advances in modelling and understanding of Martian climate into account to make a full three dimensional assessment (based on the LMD GCM). Thus the suit of scenarios could be extended and the exploration was not restricted to a global average of emission sources but allowed modelling the variation of source locations in addition to the varying atmospheric concentrations of GHG.

Along with the increase in dimension compared to the model applied by Marinova et al., the LMD GCM also considers chemical interactions between the constituents of the Martian atmosphere, which has been neglected in previous studies. This allowed a consistent determination of the atmospheric lifetime of the injected GHG and the prediction about the evolution of the atmospheric composition in addition to the determination of the attainable temperature increase.

With the extension to three dimensions and the increased variability of scenarios, as well as the inclusion of the Martian photochemistry, the results provide a more realistic analysis of the required volumes, emission rates and durations to achieve measurable long-term effects within the complex system of the Martian atmosphere and its reaction to alterations in its climatic conditions. Furthermore, the study gave a brief assessment of the abilities of and the possible applications of modern Martian GCMs. The results are understood as contributions to the scientific assessment of Martian climate modelling as well as to putting terraforming concepts onto a more solid scientific basis, a field in which serious research is still scarce.

References

M. M. Marinova, C. P. McKay, and H. Hashimoto. Radiative-convective model of warming Mars with artificial greenhouse gases. *Journal of Geophysical Research (Planets)*, 110(E9):3002 ff., March 2005.

(1. author: N. Ridder; 2. author: F. Sontag; 3. author: L. Summerer)