Geophysical Research Abstracts, Vol. 9, 09467, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-09467

Simulations of the early Mars climate with a General Circulation Model

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The environmental conditions that existed on early Mars during the Noachian period are subject to debate in the community. While some authors suggest that the difference resulted from a stronger geothermalism during that period, and that a warm climate was not necessary to explain the valley network, others claim that a warm, wet early climate capable of supporting rainfall and surface runoff is the most plausible scenario for explaining the entire suite of geologic and mineralogical features in the Martian cratered highlands. The observations from Mars Express, the Mars Exploration Rovers, and Mars Odyssey are more than ever raising the issue.

To help understand this key issue in Mars science, we have developped a 3D general circulation model similar to the one used on current Earth or Mars to study the details of the climate today. Our first objective is to answer the following questions : how is the Martian climate modified if 1) the surface pressure is increased up to several bars and 2) if the sun luminosity is decreased by 25% like 3.8 Billion years ago. We did not take into account the heat possibly released by impacts during short periods, although it may have played a role. We show that, assuming a 2 bars atmosphere even without taking into account the radiative effect of CO_2 clouds, temperature near or above the freezing point of water may be obtained. Moreover CO_2 ice clouds are found to form almost everywhere on the planet in the upper atmosphere above 40 km. Their radiative effect on the climate is very model dependent but, in our baseline simulation, correspond to a 15 K warming of the surface. We found that above freezing temperatures are especially likely in the lower plains, due to the atmospheric adiabating warming. This would support a scenario were the lower northern plains would be filled by liquid water and the higher regions more or less covered by snow and glaciers. To better investigate the kind of water cycle one can expect in such conditions, we plan to apply parameterisations currently used in Earth models to simulate the water cycle on our

planet.

However, these results remains uncertain because the CO2 gas greenhouse effect may be overestimated because pressure induced absoprtion may have been overestimated in studies