EPSC Abstracts
Vol. 10, EPSC2015-436, 2015
European Planetary Science Congress 2015

3D Modelling of the impact of outflow channel events on Late Hesperian Mars climate.

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1. Introduction

During late Hesperian, large outflow channels observed in the Chryse Planitia area [1] are thought to have been carved by catastrophic and sudden water floods [2,3]. It has been speculated that such events may have modified the climate, at least locally and episodically, and could have induced precipitations and even rain [4] that could explain the formation of Late Hesperian valley networks under a cold contemporaneous climate.

We present below 3D modeling of a sudden and extreme release of warm liquid water in the Chryse Planitia area on ancient Mars, assuming a faint young Sun and CO_2-dominated atmospheres thicker than today. 3D climate modeling under these conditions [5,6], and performed with a water cycle taking into account water vapor and clouds, have not been able yet to produce liquid water or at least significant precipitations by climatic processes anywhere on the planet, even when maximizing the greenhouse effect of CO_2 ice clouds.

2. Method

The study was lead thanks to the complete 3 Dimensions LMD Global Circulation Model, performed in a 64x64x15 resolution grid, that takes into account generalized radiative transfer and cloud physics. The model works with a water cycle that includes the formation of water clouds, ice clouds and CO_2 ice clouds. The version we use here is designed to work under CO_2 atmospheres presented in Forget et al. 2013 and Wordsworth et al. 2013 [5,6].

We started from a converging initial state with stabilized surface water ice reservoir [6] and assumed that a warm source of liquid water, modeled by a layer of fully mixed water above a multilayers cold martian regolith, suddenly fills the Chryse Planitia area. The largest estimations of outflow channel events [7] give an amount on the order of an equivalent of a several meters thick layer of water at few tens of degrees above the freezing point, over the whole planet. Thus, we explored the influence of warm (~300K) large amounts of water (~100 meters deep) discharged in area ranging from the Chryse Planitia area to the whole Northern plains, and under various atmospheric pressures.

3. Results and Discussion

The figure 1 presents the results of the total cumulative precipitations induced by the climatic impact of a 100m thick layer of 320K liquid water emplaced at the Chryse Planitia location (~2.10²²J event), under atmospheres of 40mbar and 1bar.

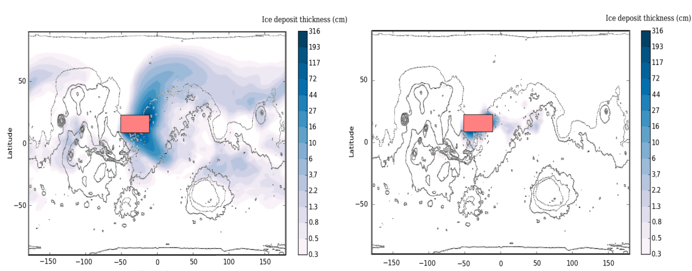

Figure 1: Total accumulation of surface ice (cm per m²) induced by precipitations, 100 days after the outflow channel event, under a 40mbar atmosphere (left) and a 1bar atmosphere (right). The warm liquid water discharge area is displayed in pink.

We found that the climatic impact of the outflow channel, in spite of the fact that the intensity of the event was very high, is low. The precipitations – only snowfalls – stop after few tens of days whatever the atmospheric pressure is.

For the first few days, an intense local water cycle takes place. The atmosphere is warmed very quickly by the water vapor latent heat and by radiative transfer processes. But then, it takes only ~100 days (figure 2) for the initial energy reservoir to run out / for the liquid water to start to freeze and ~50 martian years to be completely frozen.

The thiner the atmosphere is, the shorter the relaxing timestep of the atmosphere will be. First, for the spread of a given initial reservoir amount of energy, a thin atmosphere will be warmer and will radiate more efficiently to space (figure 2). Second, because a thin atmosphere will inject (figure 3) more water but also create more water ice clouds which are responsible for a large solar absorption loss (figure 2).

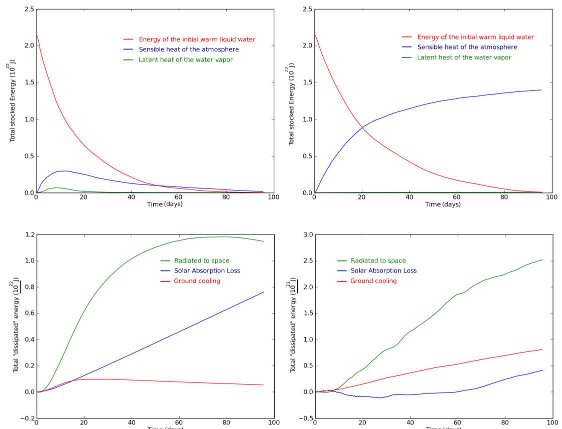

Figure 2: Evolution of energy reservoirs (top pannels) and energy cumulative loss (low pannels) with time, under a 40mbar atmosphere (left pannels) and a 1bar atmosphere (right pannels). These figures were drawn with respect to a control simulation.

We in fact found that the direct climatic impact is much higher for thiner atmospheres (figure 1). A thin atmosphere, because of its low volumetric heat capacity, will warm quickly and thus be able to transport much more water vapor. This will trigger the formation of a convective plume (figure 3) that is very efficient to transport water vapor and ice responsible for further global scale precipitations.

More results will be discussed at the EPSC about **1.** the conditions required for the outflow channel events to trigger a deep convection through the formation of a convective plume (figure 3) and **2.** the possible dumping of the warm liquid water from Chryse Planitia to Acidalia Planitia and even to the Northern Plains.

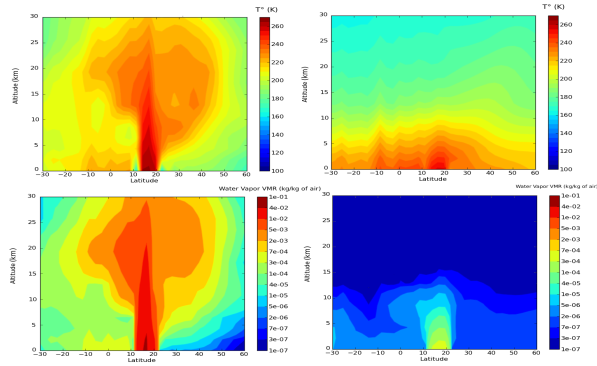

Figure 3: Temperature (top pannels) and Water Vapor Mixing Ratio (low pannels) distributions at the longitude of the liquid water discharge (40°W), 2 days after the outflow channel event, under a 40mbar atmosphere (left) and a 1bar atmosphere (right).

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