

Dynamic Simulations of the North and South Polar Cap of Mars over Climate Cycles

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The polar ice caps of Mars are one of the most prominent surface features. While the seasonal caps consist of some ten centimeters of CO₂ snow only, the complexes composed of the residual caps and the underlying layered deposits are massive topographic structures. These complexes will be referred to as the north- and south polar cap₃ (NPC/SPC), respectively. Their volumes have been estimated at more than 10⁶ km³ each, and they raise by about three kilometers above the surrounding terrain. The most likely composition is H₂O ice with an unknown amount of mixed-in dust, CO₂ ice and, perhaps, clathrate hydrates. Similar to the terrestrial ice sheets and ice caps, the long-term evolution and dynamics of the Martian polar caps is expected to be governed essentially by the surface mass balance (net accumulation-ablation rate) and glacial flow.

In this study, the thermomechanical ice-sheet model SICOPOLIS is applied to the NPC and SPC, and their evolution and dynamics over the last 10 million years are investigated. During this period, the Martian climate has undergone significant changes, driven by quasi-periodic variations of the orbital parameters obliquity and eccentricity. By applying suitable parameterizations combined in the Mars Atmosphere-Ice Coupler MAIC, the obliquity and eccentricity histories by Laskar et al. [1] are directly converted into the climatic forcing required to drive the model SICOPOLIS. It will be demonstrated that likely scenarios for the NPC and SPC are very different, in that the NPC has evolved over the last ≈ 5 Ma from an ice-free initial state, whereas the SPC has remained essentially stagnant. These findings are in agreement with the large difference in surface ages, which have been estimated by Herkenhoff and Plaut [2] at 100 ka for the NPC and 10 Ma for the SPC.

Keywords: Mars; ice; ice cap; polar cap; seasonal cap; residual cap; layered deposits; climate; climate cycles.

References

- [1] J. Laskar and five others, *Icarus* 170, 343–364 (2004).
- [2] K. E. Herkenhoff and J. J. Plaut, *Icarus* 144, 243–253 (2000).