GCM SIMULATIONS OF TROPICAL ICE ACCUMULATIONS: IMPLICATIONS FOR COLD-BASED GLACIERS. R. M. Haberle[1], F. Montmessin[1], F. Forget[2], B. Levrard[3], J. W. Head III[4], and J. Laskar[3], [1]Space Science Division, NASA/Ames Research Center, Moffett Field, CA 94035 (Robert.M.Haberle@nasa.gov, fmontmessin@mail.arc.nasa.gov), [2]Laboratoire de Météorologie Dynamique, Tour 25 5e et., Universite Paris 6 BP99, 4 Pl. Jussieu, 75272 Paris, France (forget@lmd.jussieu.fr), [3]Astronomie et Systèmes Dynamiques, IMCCE-CNRS UMR8028, 77 Av. Denfert-Rochereau, 75014 Paris, France(Benjamin.Levrard@imcce.fr, Jacques.Laskar@imcce.fr,) , [4]Dept. Geological Sciences, Brown University, Box 1846, Providence, RI 02912 (James_HeadIII@Brown.Edu).

Each of the three Tharsis Montes shield volcanoes on Mars has fan-shaped deposits on their flanks[1]. A detailed analysis of the multiple facies of the Arsia Mons deposits, coupled with field observations of polar glaciers in Antarctica, shows that they are consistent with deposition from cold-based mountain glaciers [2,3,4]. Key features of these glaciers are: (1) they formed only on the western flank of each volcano, (2) enough ice accumulated to cause them to flow but without basal melting, (3) there were multiple advances and retreats, (4) the last major glaciation was more than several million years ago, (5) the areal extent of the deposits they left behind decreases northward, (6) together the deposits range in elevation from a low of 1.5 to a high of 8.5 km, and (7) there are no signs that significant accumulation is occurring today.

Our working hypothesis is that these glaciers formed at a time of high obliquity when water ice was mobilized off the pole and re-deposited in lower latitudes. Jakosky and Carr [5] were the first to suggest this possibility and recent General Circulation Model (GCM) simulations have confirmed it [6,7,8,9]. However, the models don't predict deposition in the same places.

To test the cold-based glacier interpretation of the deposits, we have initiated simulations with the Laboratoire de Météorologie Dynamique (LMD) and NASA/Ames GCMs to explore the possibility that the atmosphere can precipitate large amounts of ice on the western flanks of the Tharsis volcano's at high obliquity. Our simulations differ from previous simulations in that we select the orbit conditions that existed the last time the obliquity peaked above 45°. According to the recent orbit calculations of Laskar et al. [10], this occurred ~5.5 Myr ago when the obliquity was 46.3°, the eccentricity was 0.0517, and the longitude of perihelion was 248.8°. Thus, we have run both models with these orbital conditions.

Results from the LMD model support the cold-based glacier interpretation and show that ice is transferred from the North Pole to the western flanks of the Tharsis volcanoes. The accumulations are significant and could lead to flow. The Ames model run has not yet finished, but 3 years into its 10-year run, it too shows significant precipitation on the western flanks of the volcanoes (Fig. 1) though the accumulations there do not yet appear to be permanent (the model has not yet equilibrated). The preference for precipitation in the Tharsis region is probably related to the effects of topography on the general circulation. Moisture converges in this region thereby increasing the saturation state of the atmosphere. Why the ice accumulates on the western flanks of the volcanoes must also be related to the general circulation, which generally has winds blowing from east to west at these latitudes. However, much more analysis is needed to better understand these results.

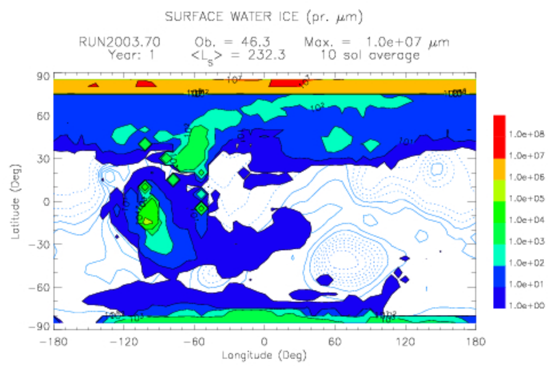

Fig. 1. Surface water ice distribution during year 3 at Ls=232° (mid northern fall) from the Ames GCM. One to ten cm of ice have accumulated west of the Tharsis volcanoes.

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