INVESTIGATION OF ASYMMETRIC H_2O ICE DISTRIBUTION DURING NORTHERN SPRING ON MARS USING A MODIFIED NASA AMES GLOBAL CLIMATE MODEL. B. A. Mellem[1,2], A. J. Brown[2], M. A. Kahre[3], J. L. Hollingsworth[3] and J. R. Schaefer[3], [1]St. Olaf College (mellem@stolaf.edu), [2]SETI Institute (abrown@seti.org), [3]NASA Ames Research Center, Moffett Field, CA 94035.

Introduction: During spring on the north pole of Mars, TES data indicate that CO_2 ice should extend approximately symmetrically around the pole [1]. Appéré et al. [2] used OMEGA data to find that water ice covered the edges of the retreating CO_2 ice cap. Appéré et al. and Schmidt et al. [3] suggested that a fine grained thin cover of water ice could come from a 2° wide annulus of H_2O ice around the CO_2 cap [3].

Brown et al. [4] used CRISM data to show that in fact the distribution of water ice is not symmetric around the pole from L_s=25-31 until at least L_s=50-55 [4].

Brown et al. [4] proposed a model for the process whereby the asymmetrical water ice distribution is sourced from the polar outlier deposits as they were uncovered by CO_2 ice at around L_s=25.

In this project, we attempt to test the Brown et al. [4] model using the NASA Ames Mars Global Circulation Model. We set out to test **whether a source of water ice in the location of the residual ice deposits could deposit water ice asymmetrically on top of the residual ice cap**.

Methods: We used the NASA Ames GCM version 2.1.23. We ran the GCM in standard and modified configurations. In each case, we ran the GCM for three Mars Years with outputs ever 1.5 hours, and examined the output for the third Mars Year.

Standard GCM Setup: Prior to this project, the standard NASA Ames GCM used a symmetric circular north pole cap and did not include outlying ice deposits. The standard GCM setup flags the two rows of grid points nearest to the pole as permanent ice cap locations. This standard GCM cap extends symmetrically about the pole down to a longitude of 77.5°.

Using this standard GCM setup, we observed no asymmetries in the amount of water

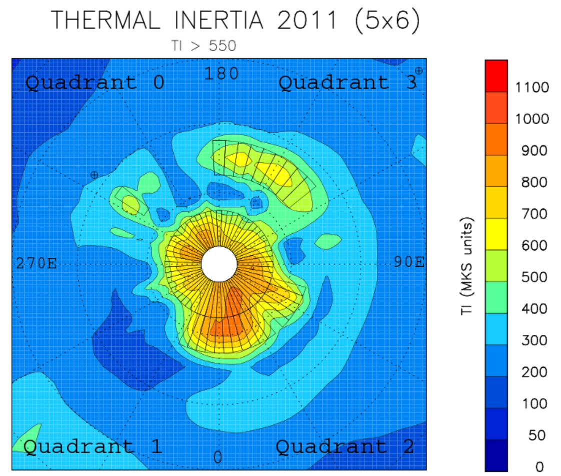

Figure 1 The north pole of Mars. Boxes show the location of the new north polar cap, representing a change to the Ames GCM's standard circular ice cap extending to 77.5N.

ice deposited over the polar cap. We split the pole into four quadrants: quadrant 0 extends from 180° to 270° E, quadrant 1 from 270°E to 0°, quadrant 2 from 0° to 90°E, and quadrant 3 from 90°E to 180° (Figure 1).

Our GCM Setup with Outlying Deposits: In order to add outlying deposits to the GCM, we reduced the size of the standard cap and added deposits further from the pole. We used the new OSU thermal inertia (TI) map to define the residual ice cap. Locations where the TI was greater than 550 were designated as part of the polar ice cap. As shown in Figure 1, this introduced the ice cap outliers.

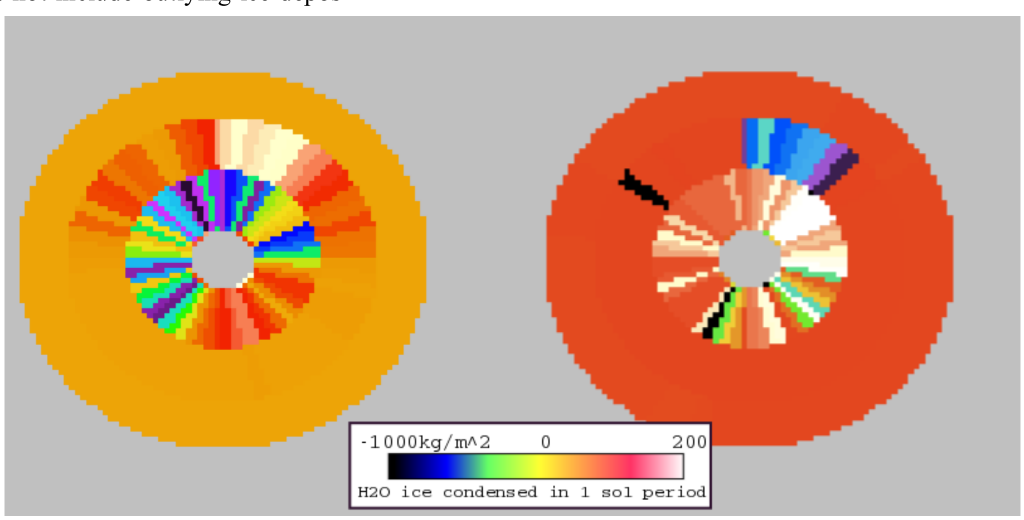

Figure 2 Modeled Diurnal average of water ice deposition at L_s=25. On the left is the symmetric cap for the previous circular GCM ice cap. On the right is the effect of the new polar ice cap with residuals. Blue regions are where water ice has sublimed; white and red show where water ice has condensed. In quadrant 3 (top right quadrant), condensation and sublimation regions are reversed under these two configurations. Polar sterographic projection, outer rim is 72.75N

The largest outlier deposits are directly opposite quadrant 3, where CRISM data showed the bulk of CO_2 ice (Figure 1). They are uncovered in the GCM between L_s ~25 and L_s ~30, concurrent with the appearance of asymmetries in CRISM [2].

Results: As seen in Figure 2, the condensation patterns differ markedly for the symmetric cap and asymmetric cap with outliers. In quadrant 3, the outliers have become an H_2O ice source rather than a sink, and H_2O ice is accumulating on the residual ice cap next to the outlier.

In Figure 3, we plot the cumulative H_2O ice deposited over two innermost pixels (i.e. the residual ice cap) over the early-mid spring period L_s=0-60, only the Ls=25-60 interval is shown. We show the situation for the standard circular ice cap (left) and the asymmetrical cap with outliers (right).

Over the course of early-mid spring (L_s=0-60), the GCM suggests roughly 200±25x10^9kg of water ice are accumulated per quadrant (Figure 3). By comparison, the Greenland ice sheet is 2.6x10^{18} kg and loses 44±53x10^{12} kg per year [5].

Asymmetrical water ice accumulation during spring: The brown line shows condensation in quadrant 3. In the asymmetric cap with outliers configuration (right), quadrant 3, nearest to the outlying water ice deposits, received about 10% more water ice condensation than the other quadrants.

The standard run on the left in Figure 3 shows a decrease in deposition on quadrant 3, beginning around L_s=52.5. This does not occur when outlying deposits are present, as shown on the right of Figure 3. Instead, quadrant 3 has the most condensation beginning at L_s=~37. Every quadrant except for quadrant 2 shows significantly increased H_2O deposition when outlying deposits are present.

Reconstruction of Condensation Types: In order to track the physical cause of these asymmetries, we modified the GCM to produce a log of all condensation events. We flagged events by type and located them in time and space. The "NEWPBL" flag corresponds to water condensed through direct temperature and vapor pressure deposition. The "MICROPHYS" flag labels condensation due to cloud microphysics—ordinary precipitation events. The "SCAVENGING" flag marks condensation due to CO_2 scavenging as the atmosphere condenses. We found it necessary to disable the CO_2 scavenging scheme in order to concentrate on deposition from the atmosphere and condensation from clouds.

Conclusions: We conclude that more realistic water ice sources may lead to asymmetric condensation in the GCM, favoring quadrant 3. We conclude that this GCM model supports the hypothesis that asymmetrical H_2O ice distribution during mid-spring is due to an outlying water ice source that is exposed around L_s=25.

Future work: We intend to further develop this model in the coming year, and attempt to develop a better understanding of the water ice transport during this fascinating Martian north polar spring.

Acknowledgements. We would like to than the OSU mesoscale modeling team (especially Dan Tyler) for making their TI map available for this project.

References: [1] Kieffer H. H. and Titus T. N. (2001) *Icarus*, *154, 1,* 162-180. [2] Appéré T. et al. (2011) *JGR, 126,* doi:10.1029/2010/JE003762. [3] Schmitt, B. (2006) *4th Mars Polar Conf.* abs. #8050 [4] Brown A. J. et al. (2011) *5th Mars Polar Conf.* abs. #6060. [5] Bales et al. (2001), *JGR,* 106(D24), doi:10.1029/2001/JD900153.

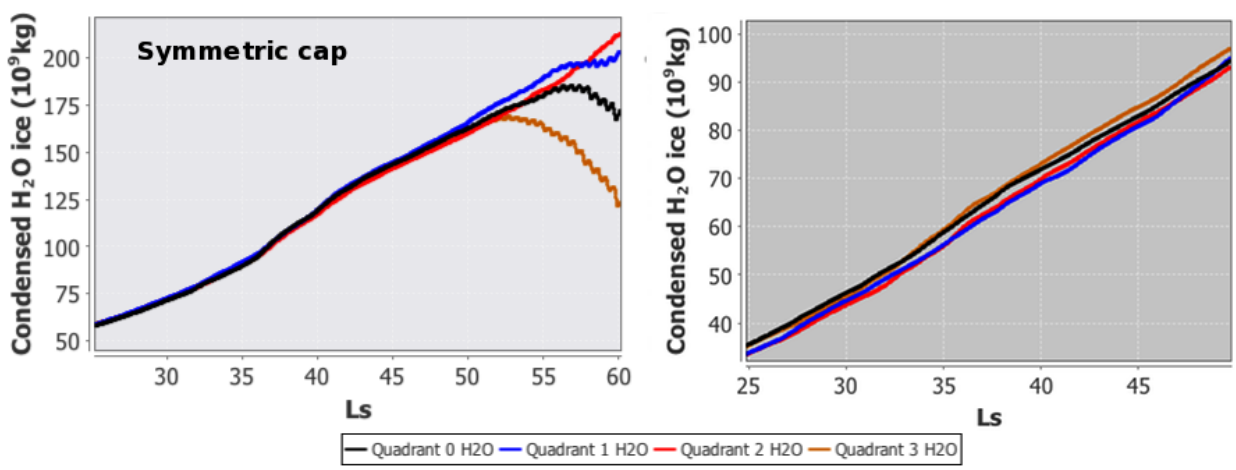

Figure 3 Cumulative water ice condensation by quadrant in the two GCM pixels nearest to the North Pole from L_s=25-60. On left is the standard circular cap run, on the right is the asymmetrical cap with outliers. No asymmetries in H_2O ice deposition are visible until the CO2 cap has disappeared. For the asymmetrical cap, much higher water ice condensation is visible in quadrant 3, near the outlying H_2O ice deposits.