UNDERSTANDING THE FORMATION AND EVOLUTION OF WATER ICE CLOUDS IN THE HELLAS BASIN DURING NH SUMMER ON MARS. M. A. Kahre[1], J. L. Hollingsworth[1], R. M. Haberle[1], and M. J. Wolff[2], [1]NASA Ames Research Center, Moffett Field, CA, 94035 (melinda.a.kahre@nasa.gov), [2]Space Science Institute, Boulder, CO, 80301.

Introduction: Water in the atmosphere of Mars moves between the northern and southern hemispheres seasonally, with north-to-south transport during northern hemisphere (NH) summer and south-to-north transport during southern hemisphere (SH) summer. Understanding the processes that control this seasonal transport of water is critical for understanding the current climate of Mars. Because water ice clouds both track and influence atmospheric circulations on a range of spatial scales, investigations about when and why clouds form enhance our knowledge of the water cycle as a whole.

We focus here on a population of clouds that has recently been observed by the MARs Color Imager (MARCI) instrument on the Mars Reconnaissance Orbiter (MRO) to persist in the Hellas Basin throughout the majority of NH summer (Fig. 1). Centered at 321 nm, Band 7 of the MARCI instrument is ideally suited for mapping water ice clouds on Mars because water ice is bright in the UV [1, 2]. It is notable that the clouds observed by MARCI in Hellas during NH summer are not as easily observed by the Thermal Emission Spectrometer (TES) on Mars Global Surveyor (MGS), which observes in the IR. We use a Global Climate Model (GCM) to investigate the dynamical mechanisms that control the formation and evolution of Hellas water ice clouds.

NASA Ames GCM: The NASA Ames GCM is a 3D finite-difference model of the Martian atmosphere that has been utilized extensively for investigations of Mars' current and past climate [3, 4, 5]. The simulated water cycle includes sublimation from the north residual cap and the microphysical processes of nucleation, growth, and settling of water ice clouds [6, 7]. The particle size distribution of cloud particles is represented in the model using a "moment" method, whereby it is assumed that the distribution is lognormal and therefore fully described by a spatially and temporally varying mass and number, and a fixed (constant in time and space) effective variance. This allows for the evolution of cloud and dust particle sizes as the result of microphysical processes in a computationally efficient manner. Water ice clouds are radiatively active for this study.

Results: The GCM predicts clouds in the Hellas Basin during NH spring and summer that agree well in spatial structure with those observed by MARCI (Fig. 1), although the model-predicted optical depths are about a factor of two higher than the observations indicate. Two prominent peaks in cloud optical depth are visible at L_s~90° in the observations: one occurs on the western flank of Hellas at ~40° S, 50° E, while the second occurs on the northwestern flank of Hellas at ~40° S, 75° E. These peaks, as well as the more diffuse band of clouds that outline the entire edge of the northern side of Hellas are very near the surface in the model (Fig. 2). Below we present our working hypothesis for how the general circulation delivers water to this region and how it controls the formation and evolution of clouds in the Hellas Basin.

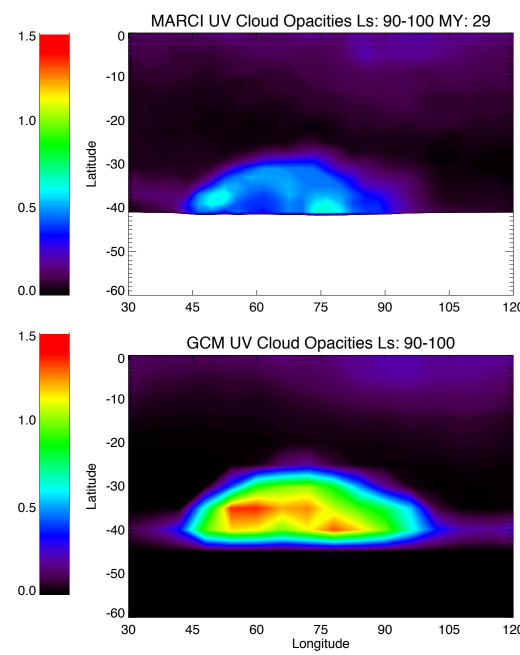

Figure 1: MARCI-observed (top) and GCM-predicted (bottom) water ice cloud opacities at 3 pm at L_s=90°-100°. The GCM results have been spatially masked for consistency with the observations.

Source of Water. During this season, water sublimated from the North Residual Cap (NRC) travels southward aloft in the upper branch of the Hadley cell and returns to lower altitudes in the southern hemisphere in the descending branch. Further southward transport of water vapor occurs in preferential longitudinal corridors; one such corridor is located to the east of Tharsis near the prime meridian, which results in a relatively large influx of water just to the west of Hellas (~15° E; Fig. 2). Low-level westerlies in the southern middle latitudes subsequently transport water eastward into Hellas.

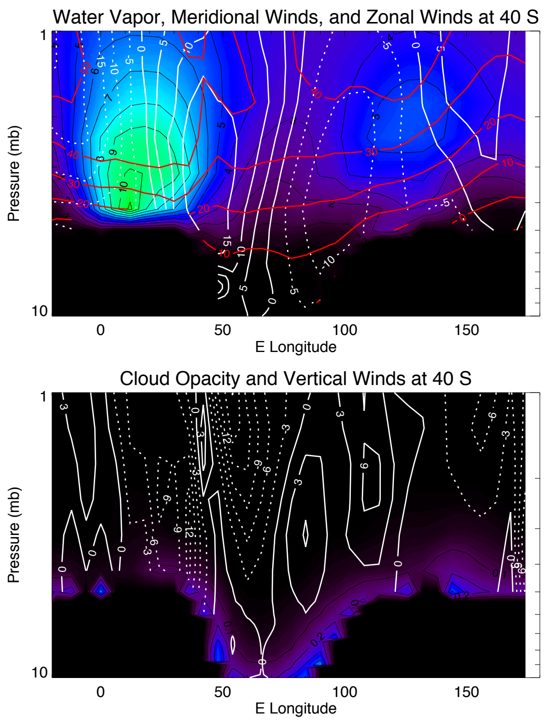

Figure 2: Top: Eastern hemisphere water vapor (color shading), meridional winds (white contours), and zonal winds (red contours) at 40° S. Bottom: cloud opacity (color shading), and vertical winds (white contours) at 40° S.

Cloud Formation and Evolution. As water travels eastward near the surface at southern middle latitudes, clouds begin forming to the east of Hellas in regions of predominantly upward vertical motion as the topography slopes up towards the basin rim (~0° E; Fig. 2). These clouds then move into the basin, hug the surface and begin dissipating in the sinking air (~25° E). As they approach the basin floor, they encounter upslope flow that is set up by the low-level cyclonic low pressure system that resides at the bottom of Hellas. Cloud growth begins again (creating the opacity maximum at ~40° S, 50° E), and clouds are subsequently transported along with any remaining water vapor clockwise in a circular pattern around the northern flanks of Hellas. As the clouds and water vapor approach the eastern side of the basin, they are transported upward and out of the basin toward the east. Increased cloud growth occurs as the clouds and water vapor travel upward towards the rim of Hellas, producing a second opacity maximum at ~40° S, 75° E.

Cloud Particle Sizes. It is notable that clouds in the Hellas Basin form in a region that is quite dry (Fig. 2). In fact, there is so little water available that the model-predicted cloud particles are only slightly larger than the dust particles that they form onto. Dust cores contribute between 80% and 95% of the total diameter of the cloud particles inside Hellas. The fact that these cloud particles contain so little ice mass may contribute to the reason why MARCI—an instrument that observes in the UV and is therefore sensitive to small amounts of ice—detects them while TES—an IR instrument—does not.

Summary: We use a GCM to investigate how and why clouds form in the Hellas Basin. In the model, water is delivered to the south by the overturning circulation and is transported by westerlies into the basin. The circulations set up by Hellas itself induces cloud growth and transport along the northern side of the basin. Because there is so little water available, the clouds particles that form are small.

References: [1] Bell et al., (2009) *JGR, 114*, E08. [2] Wolff et al., (2010) *Icarus, 208,* 143. [3] Haberle et al., (1999) *JGR, 104,* 8957. [4] Kahre et al., (2006) *JGR, 111,* E6. [5] Hollingsworth and Kahre (2010), *GRL*, *37*, L22202. [6] Montmessin et al., (2002), *JGR, 107,* 5037. [7] Montmessin et al., (2004), *JGR, 109*, 10004.