CHARACTERIZATIONS OF MARTIAN WATER-ICE CLOUD CRYSTAL GEOMETRIES FROM PHASE FUNCTIONS DERIVED USING MARCI IMAGE DATA. B. A. Cooper[1], R. Modestino[1] , C. L. Smith[1], J. E. Moores[1], [1]Centre for Research in Earth and Space Science, York University, 4700 Keele St. Toronto, ON, Canada, M3J 1P3

Introduction: The Mars Color Imager (MARCI) was launched aboard the Mars Reconnaissance Orbiter (MRO) in early August of 2005. During the orbiter's primary science phase (PSP), MRO was locked in a 3am-3pm sun-synchronous orbit, allowing MARCI to capture 12 to 13 images per Martian day in 5 visible and 2 ultraviolet wavelengths. These filters were permanently mounted on top of MARCI's 180° field of view (FOV) charge coupled device (CCD), operating as a 'pushbroom' imager capturing frames every few seconds, [1]. Our work seeks to derive the phase function of Martian water-ice clouds through the analysis of MARCI images taken during the PSP. We will then use the phase function data to deduce the dominant geometries of water-ice crystals in Martian clouds by comparing the phase functions to their corresponding scattering angles over the course of the entire PSP. We take into account the angles at which the clouds were observed by MARCI and the angles at which they received incident solar radiation, to have a thorough understanding of how the ice crystals in any image pixel scatter light.

Radiometric Image Calibration: The MARCI dataset was acquired from the planetary data system (PDS), and radiometrically calibrated in accordance with [1]. The pixel values were converted into spectral radiance, and from there reflectances were found by simply dividing the spectral radiance by the appropriate solar flux pertaining to the time of image capture. For greater accuracy, the radiative flux for each image was calculated based upon Mars' distance from the sun, dictated by the planet's position in its orbit otherwise known as the solar longitude. This parameter was derived from the spacecraft clock time found in each image header, using an adapted version of the NASA Mars24 algorithm.

Phase Function Calculation: The phase function can be formally defined as the angular distribution of light intensity scattered by a particle at a given wavelength, and is directly dependent upon the angle between the incident radiation and the scattered radiation detected, known as the 'scattering angle'. A matrix of viewing geometries from the orbiter was created corresponding to every photoactive pixel on the MARCI CCD, along with a matrix of incident radiation angles based upon MRO's orbit in the PSP. These angle matrices were used in conjunction with the calibrated reflectance data for each filter, along with Martian atmospheric parameters, as inputs for an adapted equation from [2] to compute phase functions.

MARCI's orbital vantage point poses a drawback in that a majority of the reflectance data in each image comes from the Martian surface, when our data target is optically thin clouds. To combat this, we cropped our calculation range to exclude the polar caps and the atmospheric limbs, which then allowed us to make the assumption that the pixels with the highest reflectance values in all visible filters would be those belonging to clouds. This is a safe assumption as water-ice clouds scatter uniformly through all visible wavelengths and have much higher albedos than Martian equatorial regions.

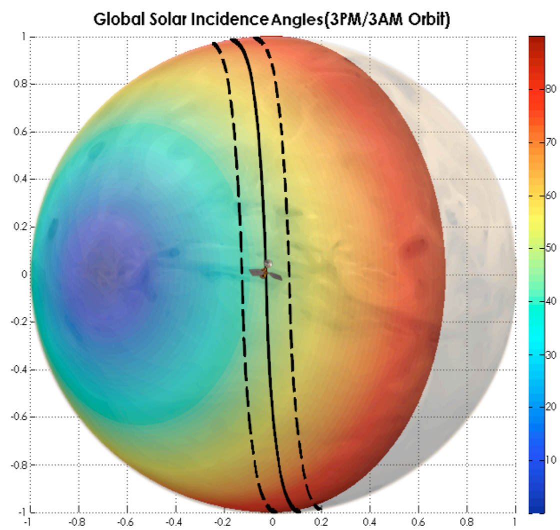

Figure 1: *Solar incidence angle map of Mars, with respect to MARCI's 3PM/3AM orbit.*

Method: We created a pipeline which calibrated, cropped, and reduced images, as well as calculated and output reflectance, spectral radiance and phase function values. We ran through the thousands of images captured during the PSP with our program for both visual and ultraviolet filters, logging the output data on each run. A scatter plot was produced of the phase functions with respect to scattering angles, for each filter from the resultant dataset. As previously stated, the upper bound of this plot should accurately represent the contribution of Martian water ice clouds to the phase functions calculated.

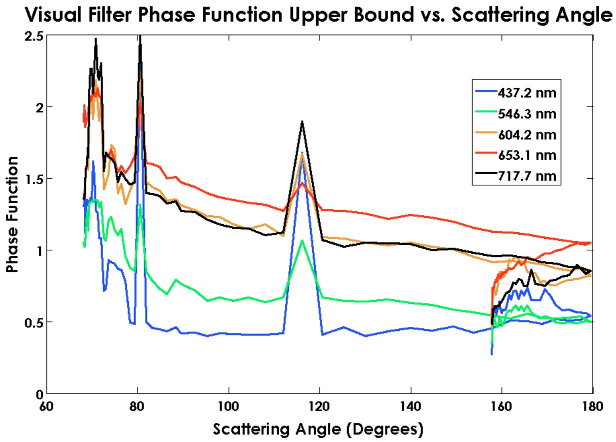

Figure 2: *Upper bound of phase functions for each visual filter, plotted with respect to scattering angle.*

Ongoing Work: The upper boundary curves for each filter (preliminary plots shown in Figure 2) can be compared to Figure 1 from [3] which displays the unique phase function curves of 14 different ice crystal types, to determine which type appears to dominate the clouds observed over the course of the PSP. Additional work is to be done in verifying the accuracy of the preliminary scattering phase functions calculated so far. Furthermore, we hope to observe how the dominant ice crystal types change over the course of a Martian year, and over Martian longitude.

With a more concrete understanding of the types of ice crystals that exist in Martian water-ice clouds, we can better understand the global climate impact of these clouds, as their particulate geometries affect how solar radiation is distributed in the atmosphere. It can also dictate whether optical phenomena such as haloes could be observed on Mars.

References: [1] Bell J. F. et al. (2009) *JGR, 114,* 2156–2202. [2] Wang C. et al. (2014) *JQSRT, 138,* 36-49. [3] Chepfer H. et al. (2002) *JGR, 107, AAC 21-1–AAC 21-16*.