ESTIMATING THE ALTITUDE OF MARTIAN CLOUDS AT THE MARS SCIENCE LABORATORY ROVER LANDING SITE. Charissa L. Campbell[1], Alexandre Kling[2], Robert M. Haberle[2] and John E. Moores[1], [1]Center for Research and Space Science, York University, 4700 Keele Street, Toronto, ON, M3J 1P3, ccamp93@yorku.ca, [2]NASA-AMES Research Center, alexandre.m.kling@nasa.gov

Introduction: At Gale Crater, clouds on Mars have been observed from the surface through Zenith movies (ZMs) taken from the NavCam from the Mars Science Laboratory (MSL) Rover, also known as Curiosity [1,2]. However, the altitude of these clouds as yet to be determined, as Curiosity lacks a lidar [3,4] with which cloud height could be directly measured. Previous studies [2,5] have suggested that the Planetary Boundary Layer (PBL) at Gale Crater may be too dry to support clouds near this surface which suggests that features may be located at altitudes higher than the crater rim. This theory is supported by recent analysis which shows a correlation in season between cloud and the prescence of the aphelion cloud belt (ACB) [5]. Furthermore, looking at the granularity of the ZMs indicates a characteristic wavelength of approximately 7° which suggests a cloud spacing of 5 km if the altitude of the cloud is 40 km [2].

However, such estimates give only a rough approximations of the height of these clouds. To better find the altitude, an atmospheric model, the Mars Regional Atmospheric Modeling System (MRAMS) [6] will be used to correlate wind direction, wind speed and supersaturation with the available data derived from imaging sequences.

Method: Cloud motion directions may be determined based on the ZMs [1]. These movies consist of eight images that are taken at a camera elevation of 85° so that the zenith point is within each image [1]. These observations are usually obtained every 3-4 sols from the beginning of the mission and are still a part of current operations. The current record of ZMs span two Martian years with observations taken throughout the day [5].

Before wind direction and angular speed can be found, images must be processed using the mean-frame subtraction technique [1,2,3] as the raw images do not directly show the clouds due to their low optical depth. The mean-frame subtraction technique consists of calculating the average frame of all eight images and then subtracting this to each individual image to isolate a time-variable component [1]. From this, a movie is made showing the differences between each frame, which show the thin clouds. An example of this is shown in Figure 1.

Since the motion of the clouds are visible in the ZMs, the angular wind speed can be calculated by finding the average distance the clouds move across the frame. This will be used to compare wind speed and direction to the MRAMS model data at each altitude from 0 to 50 km above Curiosity

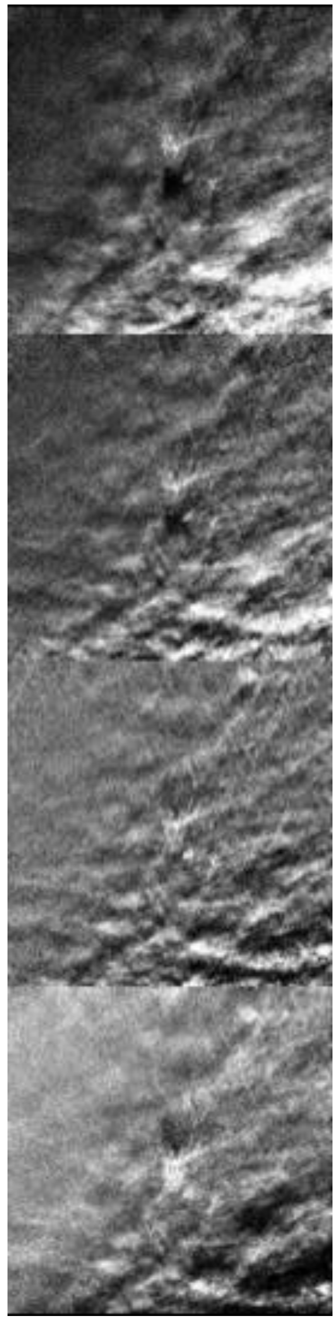

Figure 1: *An example of clouds found from the sol 429 ZM. This was after the processing of the images using the mean subtraction method. With this orientation, cloud movement can be observed from top to bottom [1].*

Ongoing Work: The first solar longitude (L_S) to be modelled was 90° and results from the analysis will be presented. Eventually, an entire Martian year will be simulated which will allow the examination of the evolution of the height of the clouds above Gale Crater over the entire Martian year.

References:
[1] Kloos et al (2016) Adv. Space Res. 57 (5) 1223-1240. [2] Moores J. E. et al. (2015) Adv. Space Res. 55 (9) 2217-2238. [3] Moores et al. (2010) J. Geophys. Res. [4] Whiteway et al. (2009) Science [5] Moores et al. (2015) Icarus. [5] Kloos et al (2017) This Conference. [6] Rafkin et. Al (2001) Icarus 151, 228–256.

Figure 2: *The MRAMS profile of data modelled on Ls 90°. Samples of modeling results from MRAMS on Ls 90° used for comparison of observations with numerical predictions [6]. The graphs correspond to temperature, wind speed and wind direction respectively. These were plotted against time and altitude.*