Diurnal and Seasonal variations of clouds in the Tharsis Montes region of Mars using the Emirates eXploration Imager (EXI) observations. M. Yousuf[1], M. Osterloo[2], and C. S. Edwards[3], [1]Mohammed Bin Rashid Space Centre, Dubai, UAE (Maryam.yousuf@mbrsc.ae), [2]Space Science Institute, Boulder, CO, USA, [3]Northern Arizona University, Department of Physics and Astronomy, Flagstaff, AZ, USA.

Introduction: Observations of clouds on Mars have long been studied to understand activity and the Martian water cycle. Previous work has shown an increase in cloud formation when Mars is farthest from the sun at aphelion due to the atmosphere cooling; in contrast, a decline in the formation occurs when the atmosphere begins to warm at perihelion when Mars is closest to the sun [1]. The Martian volcanoes (specifically those in the Tharsis region) have associated cloud formations, such as the Aphelion Cloud Belt (ACB) [2], Orographic Clouds [3], and Perihelion Cloud Trails [4]. Previous studies provide insights into how these clouds appear and contribute to the atmosphere [1],[2],[3], and [4]. In recent years, advancement has been made in spatial coverage and seasonal variation through missions such as Mars Reconnaissance Orbiter (MRO), Mars Odyssey, Trace Gas Orbiter (TGO), etc [2]. Observations of the daily cycle, however, are restricted to specific regions or time of day through observations from Curiosity, Insight, Perseverance, etc [2].

Objective: The objective of this study is to provide a catalog of the life cycle of clouds observed by the Emirates eXploration Imager (EXI) spatially (longitude, latitude) and temporally (Solar Longitude (Ls), local time) using the following wavelength channels 635nm (red), 546nm (green), 437nm (blue) and 320nm (ultraviolet which can be used to retrieve the water ice optical depth). To undertake this study, we identified the volcanic region (Olympus Mons and Arsia Mons) as the study region due to cloud presence in the area throughout the Martian year. We will present the results of our database for clouds for Mars year 36. Figures 1 and 2 show an observation of the Tharsis Montes region where clouds form in Ls 83 a UTC 22:57.

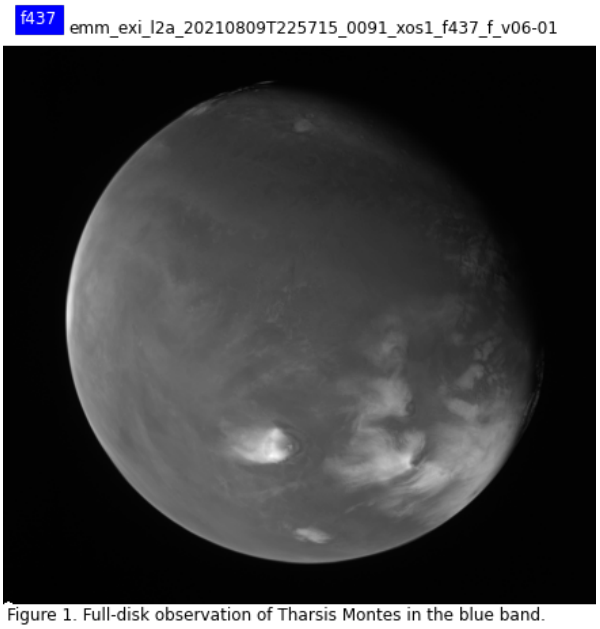

Figure 1. Full-disk observation of Tharsis Montes in the blue band.

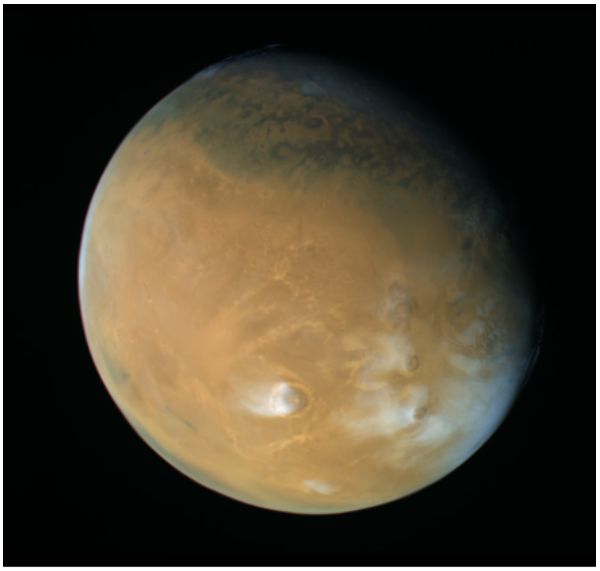
Figure 2. Full-disk observation of Tharsis Montes in color (RGB bands).

Dataset: EXI is a camera on board the Emirates Mars Mission (EMM) – Hope Probe that provides diurnal observations covering most of the planet within approximately 10 days [5]. EXI provides full-disk observations of Mars with six ultraviolet and visible spectral bands (220, 260, 320, 437, 546, 635 nm) with a resolution of 2-4 Km per pixel [5]. In these wavelengths, EXI acquires 12-megapixel images with a full

radiometric calibration for detailed scientific analysis [5]. EXI's primary goals are to better understand the geographic distribution and diurnal variation of several critical constituents (e.g., dust, water ice clouds, etc.) on sub-seasonal timescales in the lower atmosphere [5]. EXI has numerous observation modes that bracket Emirates Mars Infrared Spectrometer data and provide alternate views (e.g. high-cadence imaging) of the martian surface. In this study, we use XOS1, which provides the primary science data with medium resolution [6]. Moreover, the level of data used is Level-2A which consists of the calibrated observations [6].

Mission Background: The Emirates Mars Mission (EMM) is the United Arab Emirates' (UAE) first mission to Mars and the Arab World's first mission to another planet [7]. EMM is designed to study the dynamics of the Martian atmosphere on a global, diurnal, and seasonal timescales using three instruments onboard a spacecraft named the Hope Probe [7]. EXI and the Emirates Mars InfraRed Spectrometer (EMIRS), focus on the lower atmosphere. And the Emirates Mars Ultraviolet Spectrometer (EMUS), focuses on studying the Martian thermosphere and exosphere. The primary science phase commenced on May 23rd, 2021, and is set for one Martian year [7]. The data of the three instruments became publicly available on October 1st, 2021 [7].

Methodology: We have identified two regions of interest to determine the cloud life cycle over (1) Olympus Mons and (2) Arsia Mons. In order to assist with the assessment of the diurnal evolution on seasonal timescales, we have divided the seasonal and diurnal coverage as follows: (1) Ls 48.7-89.9 for Sol 102-193 (the start of the primary science phase), (2) Ls 90.3-179.6 for Sol 194-372, (3) Ls 180.1-269.7 for Sol 373-515, and (4) Ls 270.4-359.7 for Sol 516-668. Next, we visually identify clouds in the following channels 635nm (red), 546nm (green), and 437nm (blue) separately and construct a database. Moreover, the results will be compared to the measurements reported previously by other missions.

Preliminary Results: Figures 3-5 show the observed occurrence of clouds in Ls 48.7-89.9 for Sol 102-193 in the RGB channels over Olympus Mons. It is noticeable that the highest number of clouds are found in the blue wavelength as seen in figure 5. The presence of ice needs to be further investigated by retrieving water ice optical depth from the ultraviolet band 320nm once the maps are publicly available. Work involving cloud detection is ongoing, but it is also expected that results might vary depending on events such as dust storm activity. The results will be provided as a database, with information on the location (latitude and longitude), date, time (hour), season, and the wavelength used.

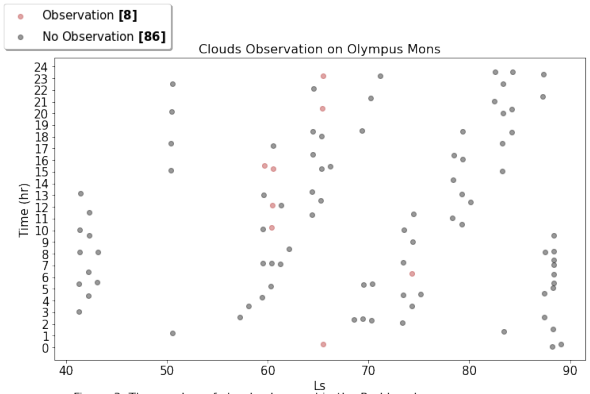

Figure 3. The number of clouds observed in the Red band.

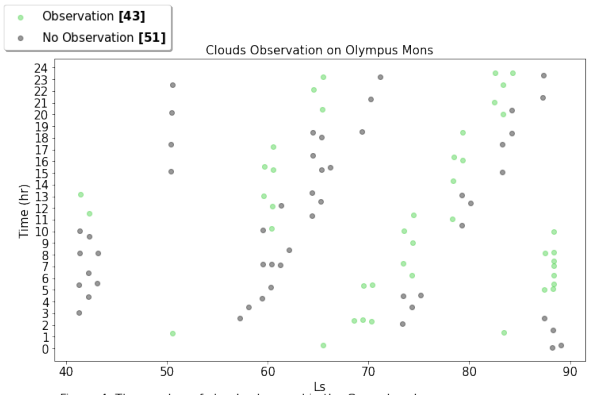

Figure 4. The number of clouds observed in the Green band.

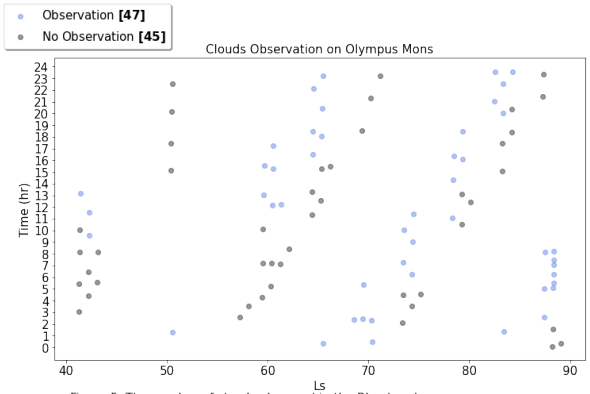

Figure 5. The number of clouds observed in the Blue band.

References: [1] Cooper, B. A., et al. (2020) Planetary and Space Science, 184, 104840., [2] Wolff, M. J., et al. (2022) GRL, 49, 18., [3] Benson, J., et al. (2006) Icarus, 184, 2, 365-371., [4] Clancy, R. T., et al. (2021) Icarus, 362, 114411., [5] Jones, A. R., et al. (2021) Space Science Reviews, 217, 8., [6] Jeppesen, C., et al. (2022) EMM Science Data Center, 169996., [7] Amiri, H.E. S., et al. (2022) Space Science Reviews, 218, 4.