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Expanded line-of-sight extinction measurements from the Mars Science Laboratory at Gale Crater, Mars

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Abstract

In this abstract we present updates and expansions to the line-of-sight extinction measurements taken by the Mars Science Laboratory Rover at Gale Crater. We update the single frame line-of-sight dust extinction record through to beyond sol 2000, and extend this work using a combination of two radiative transfer algorithms to expand the dataset beyond north pointing images taken at noon LTST.

1. Introduction

Gale Crater, the landing site of the Mars Science Laboratory Rover, Curiosity, is a 154 km impact crater situated at $4.5°$ S and $137.4°$ E on the Martian surface, in the centre of which is Aeolis Mons (colloquially known as Mount Sharp), a 5 km high mountain. The topography of Gale Crater has important implications for atmospheric mixing and aerosol abundance distributions. Before Curiosity arrived on Mars, investigations into the atmospheric circulation in the vicinity of Gale Crater were carried out (e.g. [9, 10]) predicting a suppressed thickness of the planetary boundary layer (the lowest layer of the atmosphere, affected dynamically by the presence of the planet's surface) from 8-10 km outside the crater, to 1-2 km within it. This, in essence, isolates the crater with only minimal atmospheric mixing with the air outside of the crater occurring, making Gale Crater of particular interest for atmospheric dust abundance studies. One of the observable effects of a suppression of the planetary boundary layer is a decrease in the abundance of dust in the lower atmosphere.

In this abstract, we update the noon-time line-of-sight (LOS) dust extinction measurements of [3, 4] through to the present day (sol 2034 at the time of writing). We will then discuss the preminimary work and results obtained by expanding the measurements of the line-of-sight extinction within Gale Crater beyond the time and pointing restrictions using a combination of radiative transfer models.

2. North-pointing noon LOS

Observations have been consistently obtained with MSL's Navigational Cameras (Navcam) since sol 100, initially using Dust Devil Search Movies (DDSM), created to look for Dust Devils in the northern reaches of Gale Crater. Single frames from these observations were used [3, 4] to determine the line-of-sight extinction between MSL and the crater rim. After sol 1582, when this particular version of the Dust Devil search movies was retired in favour of others, these observations were reduced to a single frame to continue this line-of-sight extinction record. In both cases, DDSM and single-frame, the observation points due north and includes regions of the sky, crater rim, and ground in the vicinity of the rover. As derived in [5], the opacity, τ and thus the LOS extinction ($= \tau/d$ where d is the distance between the rover and the crater rim) can be calculated via:

$$\tau = -\ln\left(\frac{1 - I_S/I_C}{I_G/I_C - I_S/I_G}\right) \quad (1)$$

where I_S, I_C, and I_G are the spectral radiances of the sky, crater rim, and ground respectively, as measured from the Navcam images. This relation is accurate to within 4% during the 12:00 $\pm$ 02:00 LTST, as shown by radiative transfer models carried out at Texas A&M University (see [5] for further details).

3. Temporally expanded LOS

These single frame LOS and DDSM observations have been obtained outside of the 10:00-14:00 LTST time period, but retaining the northern pointing. Since sol 1582, they have been obtained in every other morning suite - a weekly set of early morning observations designed to examine the atmospheric conditions before daytime atmospheric heating, and thus dust lifting and cloud dissipation, has occurred. They also, more

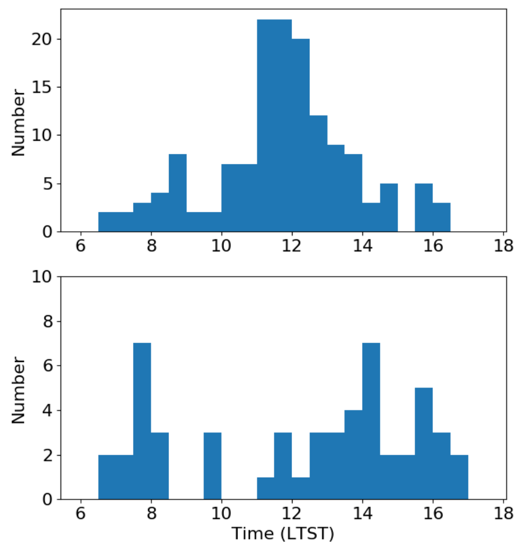

Figure 1: Diurnal distribution of single frame (lower) and DDSMs (upper) for sol 100 to 2034. Note the different y axis scales between the upper and lower panels.

rarely, have been obtained later in the day to constrain the diurnal variation in extinction. Figure 1 shows the LTST distribution of all DDSMs (circles) and single-frame Navcam LOS observations (crosses).

To analyse these observations, we use a combination of radiative transfer algorithms: the plain parallel doubling and adding (D&A, [1]) code used in [6, 8] and Hyperion [7], a 3D radiative transfer code, able to accurately model the topography of Gale Crater. The topography of Gale Crater is taken from the 3D digital elevation model (DEM) constructed from High/Super Resolution Stereo Camera images (HRSC) on-board the Mars Express orbiter [2]. The D&A code is used to determine the sky radiance as a function of time of day and season - for further details see [8].

Ultimately this work will expand to encompass all possible Navcam images that include regions of the sky, crater rim, and ground near the rover to give as complete a view as possible of the dust extinction record in Gale Crater possible. These will subsequently be used to produce a quantitative analysis of the dust deposition rate within Gale Crater as a function of time.

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