RETRIEVAL OF AEROSOL PROPERTIES AT JEZERO CRATER USING THE SUPERCAM INSTRUMENT ON-BOARD THE NASA MARS 2020 PERSEVERANCE ROVER

T. Bertrand, *LESIA, Paris Observatory, France*, **M. Wolff**, *Space Science Institute, Boulder, USA*, **K. Connour**, *Laboratory for Atmospheric and Space Physics, Boulder, USA*, **T. McConnochie,** *Space Science Institute, Boulder, USA*, **T. Fouchet**, *LESIA, Paris Observatory, France*, **F. Montmessin**, *LATMOS, Guyancourt, France*, **E. W. Knutsen**, *LATMOS, Guyancourt, France*.

Introduction:

SuperCam on-board the Mars2020-Perseverance rover is a suite of remote sensing instruments [1,2] that includes passive visible and near-infrared (VISIR) spectroscopy covering the following channels: 385–465 nm, 536–853 nm, and 1300–2600 nm. At these wavelengths, the scattering of light by aerosols is strongly sensitive to the particle size. By observing the Martian sky light scattered by aerosols (dust and water ice clouds), at two different elevation angles with the VISIR technique, and by comparing the measurement with the results of a multiple scattering radiative transfer model, we are able to retrieve and monitor aerosols properties such as the particle sizes and phase functions. This "passive sky" technique has been demonstrated in the visible range with ChemCam on the Mars Science Laboratory (MSL) rover [3]. With SuperCam, the atmosphere is probed for the first time from the ground in both the visible and near-infrared domains [4], which provides further information on the aerosol properties.

The monitoring of these properties is important because they are considered significant factors in determining the radiative effect of aerosols and therefore in controlling the climate of Mars (e.g. [5]). In particular, the particle sizes have been observed to change depending on location and season. Typical values for dust sizes during non-storm events have been reported with an effective radius (of equivalent volume sphere) around ~1-1.5 µm (+/- 50%), and variances around 0.2–0.5 from a broad set of spacecraft and instruments at the surface and in orbit. During major dust events, an increase in dust particle size up to 3-4 µm is a general trend [6-8].

Our objectives are to retrieve aerosol properties and monitor their seasonal evolution with the VISIR passive sky technique. Here we will focus on the characterization of dust particles using the available dataset and the multiple scattering model DISORT.

The effect of dust particle sizes on the climate, which is still not well understood, will also be discussed in light of recent modeling results, exploring multimodal dust particle size distributions [9].

Method:

SuperCam passive sky observations:

Our primary observing strategy is the same approach used for MSL ChemCam "passive sky" observations [3]: ratioing instrument signals from two pointing positions with different elevation angles, which eliminates solar spectrum and instrument response uncertainties (Fig. 1).

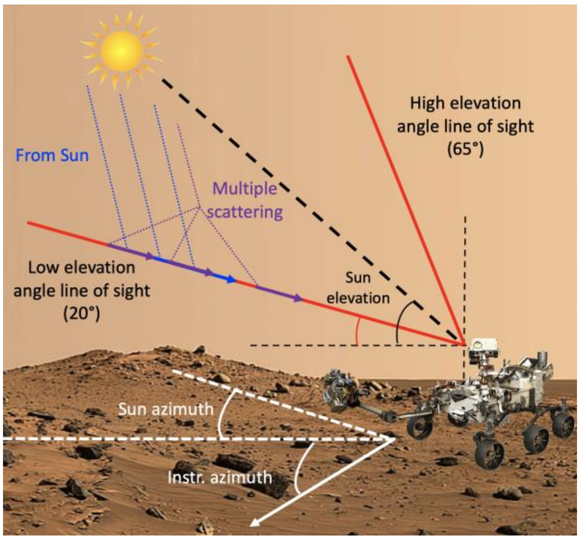

Fig. 1. Geometry of the passive sky observation.

DISORT: Multiple scattering radiative transfer model:

We use the multiple-scattering program DISORT (Discrete Ordinates Radiative Transfer Program for a Multi-Layered Plane-Parallel Medium, [10,11]) to model the Martian sky, replicate the passive sky observation by SuperCam, and fit the observed sky radiances, taking into account the diffusion of solar radiation by aerosols (dust and water ice clouds). We use cylindrical dust particles and spherical ice particles. Dust refractive indices are derived from MRO/CRISM data [12], and the library for scattering properties are calculated for a grid of effective radius r_{eff}=0.01,0.05,0.1,0.2,0.3,…3.0 µm assuming a variance of the distribution of v_{eff}=0.3. The input parameters of the model are gathered by a python preprocessing tool (https://github.com/kconnour/pyRT_DISORT) and include the column optical depth seen by the rover, the elevation and azimuth angles of the Sun and of the instrument at the time of observation, the surface albedo, the effective radius of the aerosol particles and their vertical distribution.

Preliminary results:

We analyzed the passive sky observations obtained during the first 200 sols of the mission, corresponding to the northern spring and summer on Mars (no major dust storm). Preliminary results indicate relatively small particle sizes for dust of around 1 µm (Fig. 2), which is broadly consistent with ChemCam passive sky dust particle size results for the comparable season [3].

We are currently improving the model to take into account water ice clouds, spectral surface albedo, CO_2 absorption, as well as an optimization tool to allow for better fits of the data. These improvements will allow us to extract the maximum amount of information from the SuperCam passive sky spectra.

References:

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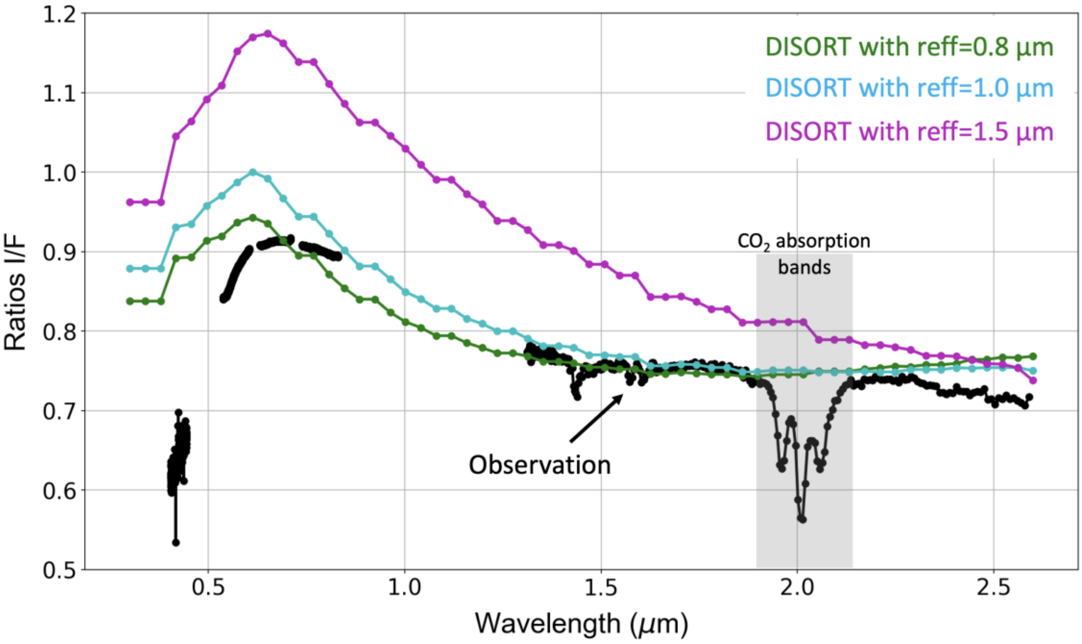

Fig. 2. Mean ratio of the low elevation spectra to the high elevation spectra. Black points are observations for sol 133 (solar longitude Ls=68°). DISORT model results are shown for different choices of dust particle sizes. The model matches the near-infrared data relatively well using 0.8-1 µm dust particles. However, the UV-VIS data are not well reproduced. We are currently investigating this issue.