First Results from Atmospheric Observations of CO2, H2O, and CO from SuperCam on Mars2020-Pereverance Rover

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Introduction:

The SuperCam instrument onboard the Mars2020-Perceverance rover [1, 2] has the capability of performing several active and passive techniques. Passive spectroscopic measurements of the atmosphere are possible in the 0.4-0.85 (VIS) and the 1.3-2.6 (IR) micron ranges [3, 4]. Since landing in Jezero crater in February 2021, SuperCam has performed numerous atmospheric observations.

The technique used is called "passive sky", and has already been successfully conducted by ChemCam on the Mars Science Laboratory rover [5]. SuperCam extends on the Capabilities of ChemCam, by also being able to probe the atmosphere in the critical IR window which includes absorption and scattering characteristics of gases and aerosols of particular interest.

Passive sky measurements have typically been carried out every two weeks, providing a consistent monitoring of key quantities such as CO_2, O_2, H_2O and CO abundances along with cloud and aerosol properties. Particular attention was given to joint measurements of O_2 and CO, as they provide unique insights into the Martian chemical cycle and have never before been measured at the same time from the surface. The results presented here will focus on the retrieval of CO_2, H_2O and CO volume mixing ratios.

Primary science objectives. CO has been observed [6] to follow the expected seasonal cycle of a chemically-inert non-condensable trace gas. To resolve the expected seasonal cycle of CO, our target measurement precision is +/- 100 ppm. Near-surface abundances of water vapor are notoriously difficult to obtain, but are particularly valuable for assessing possible surface-atmosphere exchange processes. Our primary objective for water vapor is therefore to routinely sample the daytime H_2O column, for direct comparison with nighttime mixing ratio measurements made by the Mars 2020 Mars Environmental Dynamics Analyzer (MEDA) humidity sensor [7], but also to help connect in-situ measurement by MEDA with measurements from orbit. We target a precision for precipitable water column of +/- 1 precipitable microns, comparable to ChemCam [8].

Method:

The SuperCam instrument suite consists of a ChemCam-heritage reflection spectrometer, 385–465 nm ("violet"), < 0.2 nm res. [3], an intensified transmission spectrometer, 536–853 nm, 0.3 – 0.7 nm res. [3], and an acousto-optic-tunable-filter (AOTF) - based IR spectrometer, 1300 – 2600 nm, 20 – 30 cm^{-1} res. [2, 4].

The passive sky observing strategy is the same as the ChemCam MSL approach, where SuperCam is pointed to the sky at two different elevation angles thus yielding two different path lengths through the absorbing gas of interest. By ratioing the two obtained spectra, one removes most instrument response and solar spectrum uncertainties that are ~10x and ~100x larger than the signals of interest for the IR AOTF and transmission spectrometers, respectively. Due to sun-safety constraints, all sky spectra are effectively out of focus yielding an effective field of view of ~3° diameter. To obtain the desired sensitivities for O_2 and H_2O vapor, we use ~20 minutes of total integration time to provide multiple visits to each pointing position.

First results:

Initial results include several retrievals of water vapor mixing ratios along with a tentative determination of CO abundances in a limited number of measurements. H_2O was found to vary between 24 and 147 ppmv with a 5 ppmv uncertainty from H_2O and CO_2 infrared signatures, in rough agreement with previous

MEDA RH measurements [9].

CO mixing ratios range between 900 and 1700 ppmv, values which correspond well with concentrations observed from orbit, such as with the ACS instrument onboard the ExoMars Trace Gas Orbiter [10].

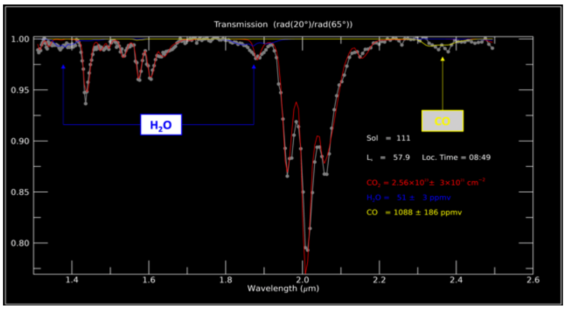

Figure 1: Fitting attempt of CO, CO_2 and H_2O in the IR. Data collected on Sol 111.

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