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Supercam Laser Induced Breakdown Spectroscopy Calibration, Data Processing, and First Results

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The Mars 2020 Mission was designed to address four overarching goals [1]: i) investigate the mineralogy and geology of the Jezero crater as representative of the ancient Martian environment, ii) assess the habitability of this ancient environment, iii) identify and cache samples with a high potential of preserving biosignatures, iv) study the current environmental Martian conditions in preparation for human exploration.The SuperCam Instrumental Suite was designed as the primary tool to remotely investigate elemental composition and mineralogy of rock and soil targets. It will also provide sub-mm context color imaging of outcrop textures, search for organics and volatiles, perform atmospheric characterization, and record sounds [2], [3]. To achieve these objectives, SuperCam implements four nested and co-aligned spectroscopic techniques: laser induced breakdown spectroscopy (LIBS), Raman spectroscopy, time-resolved fluorescence spectroscopy, and passive VISIR spectroscopy. Laser-induced breakdown spectroscopy (LIBS) obtains emission spectra of materials ablated from the samples in electronically excited states. The Supercam LIBS instrument comprises three spectrometers covering the UV (245 – 340 nm), the violet (385 – 465 nm), and the visible and near-infrared (VNIR, 536 – 853 nm) ranges encompassing spectral lines of the majority of the elements of interest. Using a dedicated LIBS database, it is possible to retrieve the composition of the ablated targets. For ChemCam, the first planetary LIBS device on board the Curiosity rover on Mars, this was achieved using multivariate techniques [4] for the major elements and univariate techniques for some minors and traces [5]. A similar procedure has been applied on SuperCam: LIBS measurements of a suite of more than 300 samples covering a wide range of compositions for the major elements has been acquired at a distance of 3m with a representative model of the instrument. The database includes a set of the calibration targets (SCCT) similar to those that are mounted on the Perseverance rover. Measurements of the SCCT were also acquired a 1.5m and 4.2m. Some SCCTs were also analysed using the Flight Model during System Thermal Test (STT). Several steps in the quantification procedure are achieved. i) Identification and removal of outliers ii) Definition of representative five-fold cross-validation for model evaluation. iii) definition of the train set and test set. iv) training of various multivariate regression methods among them Partial Least Squares (PLS), linear methods (Lasso, Elastic Net, Blended Lasso [6]) or ensemble methods (Random Forest, Gradient Boosting) v) prediction of the

test set and SCCT at various distances and on the STT targets. The performances of the methods are evaluated using statistical for both the Cross Validation and Prediction) vi) Selection of the best model for a given element. A specialized pipeline is designed to produce the quantified results at tactical timescales.

[1] Farley et al. (2020), Space Sci. Rev. 216, 142. [2] Wiens et al. (2020) Space Sci. Rev. 216, in press [3] Maurice et al. (2020) Space Sci. Rev. 216, in press [4] Clegg et al. (2017), SCAB, 129, 64. [5] Payré et al. (2017) JGR, 122, 650. [6] Anderson et al. (2017), SCAB, 129, 49.