THREE FORKS: AN EXAMPLE OF THERMAL AND RADIATIVE CHARACTERIZATION FOR A MARS SAMPLE RETURN LANDING SITE. G. M. Martínez1, E. Sebastián2, A. Vicente-Retortillo3, H. Saviójärvi4, M. Smith5, E. Fischer6, D. Toledo6, V. Apéstigue7, I. Arruego6, A. Munguira7, R. Hueso7, A. Sánchez-Lavega1, L. K. Tamppari8, M. T. Lemmon9, C. E. Newman10, A. Stott11, M. de la Torre-Juárez7, and J. A. Rodríguez-Manfredi7, 1Lunar and Planetary Institute, Universities Space Research Association, Houston, TX, USA (gmartinez@lpi.usra.edu), 2Centro de Astrobiología, Spain, 3University of Helsinki, Finland, 4NASA Goddard Space Flight Center, USA, 5University of Michigan, USA, 6Instituto Nacional de Técnica Aeroespacial, Spain, 7Universidad del País Vasco, Spain, 8Jet Propulsion Laboratory, California Institute of Technology, USA, 9Space Science Institute, USA, 10Aeolis Research, USA, 11Institut Supérieur de l’Aéronautique et de l’Espace, Université de Toulouse, France.

Introduction: NASA’s response to the second Mars Sample Return (MSR) Independent Review Board (IRB) recommendations proposed a revised mission architecture, which would delay the return of samples to 2040 [1]. While the 10 sample tubes deposited at the Three Forks depot were deemed to be an available cache for alternatives to the revised architecture, NASA concurred with the IRB-2 that Perseverance should sample outside Jezero crater, returning to the crater floor in the 2028 timeframe.

Here, we present a methodology to characterize the thermal and radiative environment of potential landing sites across Perseverance’s traverse, showing results for Three Forks as an example of such methodology.

Figure 1. Correction for dust deposition on the downward-looking TIRS (0.3‒3 μm; blue symbols) and upward-looking RDS (0.19‒1.2 μm; red line) channels as a function of sol number [3,4]. A value equal to 1 indicates no additional attenuation of the radiation measured by the sensor, while a value of 0.8 indicates that only 80% of the incoming radiation is measured.

Data and Methods: Following the methods described in [2], we use measurements from the Mars Environmental Dynamics Analyzer (MEDA) and Mastcam-Z instruments to derive the thermal inertia (TI) and albedo (α) of the terrain traversed by Perseverance. Unlike in [2], the calculation of TI and α include recent corrections for dust deposition in MEDA’s Radiative and Dust Sensor (RDS) and Thermal Infrared Sensor (TIRS) (Fig. 1).

For a specific location and Ls, values of thermal inertia, albedo, and aerosol opacity (Fig. 2) are fed into the Finnish Meteorological Institute Single Column Model (SCM) [5], which is then run and typically provides a great match with the environmental conditions measured by MEDA (Fig. 3). Once validated at a certain location, the SCM can be used to simulate the radiative and thermal environment at any other Ls.

Figure 2. MEDA-derived values of TI (top) and α at noon (bottom) for the first 777 sols of the Mars 2020 mission when the rover was parked for an entire sol. Highlighted in blue are values corresponding to Three Forks, where the tube samples were deposited between sols 652–690 (Ls 357°–16°). Also shown are aerosol opacity values retrieved from Mastcam-Z at 0.88 μm.
Figure 3. (Top) Validation of the SCM on sols 664-666 (Ls), when the rover was parked at Three Forks on a terrain with TI = 200 SI and $\alpha = 0.14$. (Bottom) Diurnal evolution of the ground temperature as measured from MEDA (black symbols) and as simulated with the SCM (red, solid line). A similar match is obtained when comparing the simulated and measured downwelling solar and thermal flux (not shown).

Initial Results: In preparation for and to support operations of the MSR mission, we use the SCM to simulate the thermal and radiative environment at Three Forks. As an example, Fig. 4 shows SCM simulations of the ground temperature (top), downwelling solar flux (middle), and vertical profiles of temperature at noon (bottom) during the aphelion season (Ls 0°–180°), when dust opacity is low (Fig. 2) and the landing of the MSR mission would be safest. Another quantity of interest not shown here, but monitored around the clock by TIRS, is the diurnal evolution of aerosol opacity [6].

Summary: By using in-situ measurements from MEDA in combination with the SCM, we have simulated the thermal and radiative environment at Three Forks during the aphelion season. Using the same methodology, we can simulate the environmental conditions at any other location within Jezero crater in preparation for MSR.

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Figure 4. SCM-simulated diurnal evolution of ground temperature (top) and downwelling solar (0.19–5 $\mu$m) flux (middle) for different Ls values (color-coded lines). Also shown are the SCM-simulated vertical profiles of temperature at 12:00 LMST at various Ls (bottom).