MODELLING THE RECEIVED SOLAR ENERGY AT THE MARTIAN SURFACE OVER THE TRIPLE-JUNCTION SOLAR PANEL SENSITIVITY RANGE

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Introduction: Solar radiation is an important source of energy for space missions. Mars spacecraft of the past have used solar panels to take advantage of solar energy such as the Phoenix Lander, Sojourner and Mars Exploration Rovers. Available solar energy is not typically a driving factor of landing site selection, instead the science goals of the mission are used to narrow down the list of potential locations. As such, it is only at these isolated sites at which formal analyses of solar energy availability are conducted.

Recently, a global analysis of available solar energy was completed [1] and we will build on this work to investigate how much energy a solar panel receives at any latitude and solar longitude on Mars as a function of solar panel altitude and azimuth angle. A radiative transfer model [2,3,4] will be used to produce an energy map over the entire triple-junction solar panel sensitivity range of 200 -1800nm.

Radiative transfer model: The radiative transfer model uses the Doubling and Adding code of [2], as modified by [3] and the UV region described in [4]. The model uses a two-layer, three-level configuration and includes Rayleigh scattering, gaseous absorption and Mie scattering to model atmospheric interactions. The ground is assumed to be a Hapke surface with parameters taken from [5]. The model takes in the solar flux at a specific solar longitude and given solar azimuth and elevation, and outputs the direct and diffuse components of upward and downward fluxes.

Optical depth contribution due to aerosols: The aerosols (dust particles) are described by a Mie scattering model, specifically cylindrical particles with parameters taken from [5] and [6]. Aerosol optical depths themselves were taken from the Mars Climate Database complete-coverage reconstructed maps based off of Thermal Emission Spectrometer observations [7]. The optical depth data used was from Mars Year 31. The optical depths are only for absorption at 9.3µm which were then multiplied by 2.6 to get the total extinction optical depths at 880nm, following the procedure of [7]. From the knowledge of the optical depths, the Mie scattering abundance required to the produce the 880nm optical depths were computed for each point in latitude and solar longitude. These abundances were used as inputs in the radiative transfer model.

Energy maps: The model allows us to look at how much flux is received at the surface over a year.

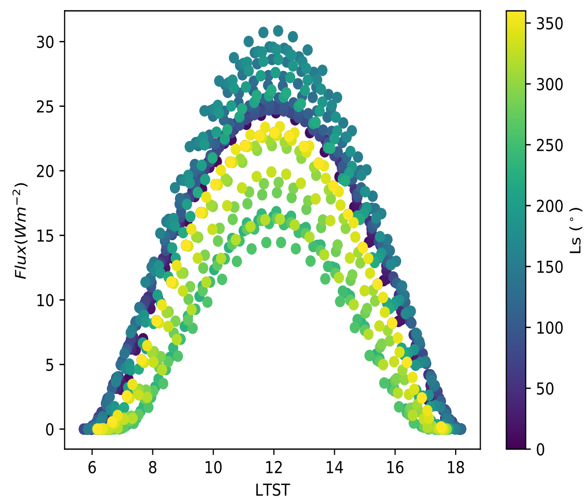

Figure 1: Solar flux at North 10.5° in UVA (215- 300nm). Each curve is a single day at a different Ls for an entire year.

The model was run for every point on the sun path for a given latitude and every 10° of solar longitude. The model has been run for latitudes ±88.5°, ±79.5°, ±70.5°, ±61.5°, ±49.5°, ±40.5°, ±31.5°, ±19.5°, ±10.5°and -1.5°, though by the time of the conference the model will be run for a regular grid at 5° increments from -90° to +90°. Examples of flux received as a function of local time and sol are shown in Fig. 1. The data were interpolated to provide a complete picture of all latitudes. The total energy received by a flat 1m^2 surface was calculated by integrating the instantaneous downwards fluxes from the model when the solar zenith angle was less than 89.9° and the results shown in Fig. 2.

The model was run for a total of nine wavelength bands UVA (315-400nm), UVB (280-315nm), UVC (200-280nm), Visible (400-700nm) and Near-infrared bands: 700-1000nm, 1000- 1200nm, 1200- 1400nm, 1400- 1600nm and 1600- 1800nm. UV and Near-infrared were split into further bands as the optical depth contributions due to Rayleigh scattering, gaseous absorption and Mie scattering vary with wavelength. All nine bands were combined to produce a single map that encompasses all ranges.

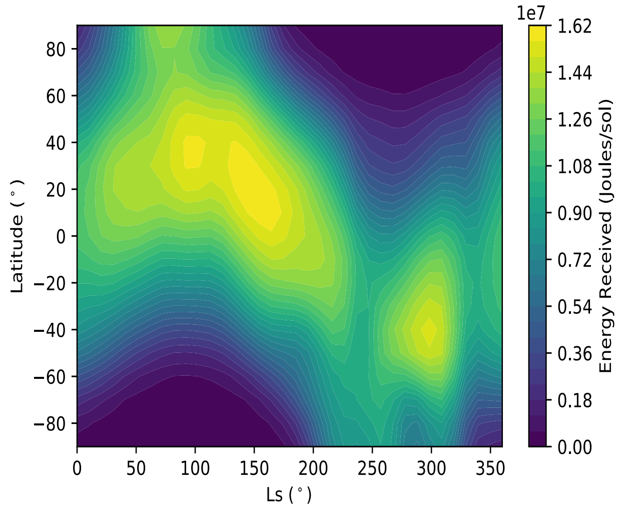

Figure 2: Energy received at the Martian Surface for 200 - 1800nm.

Ongoing Work: Currently the model only accounts for the energy received on a flat $1m^2$ surface. The next step will be to calculate the received energy for different angles of the solar panel in order to demonstrate the best direction to point them to maximize the energy received as well as weighting the energy maps with the quantum efficiency curves of the solar panels. These will be accomplished by March for the Lunar and Planetary Science Conference.

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References: [1] Delgado-Bonal et al Energy (2016) 102 550-558 ; [2] Griffith et al. Icarus (2012) 218, 975-988 ; [3] Smith et al. Icarus (2019) 338 ; [4] Moores et al. Planetary and Space Science (2017) 232 ; [5] Smith et al. Icarus (2016) 280 234-248; [6] Wolff et al. Icarus (2010) 208, 143-155 ; [7] Montabone et. al Icarus (2015) 251 65-95;