ESTIMATION OF THE SALTATED PARTICLE FLUX AT THE MARS 2020 IN-SITU RESOURCE UTILIZATION EXPERIMENT (MOXIE) INLET. J. B. McClean and W. T. Pike. Imperial College London (South Kensington Campus, SW7 2AZ, London, United Kingdom, j.mcclean15@imperial.ac.uk).

Introduction: One of the objectives listed in the Mars Exploration Program Analysis Group (MEPAG) Goals Document is to "characterize the particulates that could be transported to hardware and infrastructure through the air (including natural aeolian dust and other materials that could be raised from the Martian regolith by ground operations), and that could affect engineering performance and in situ lifetime" [1].

This objective is becoming timely with the approaching Mars 2020 rover and its Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE). MOXIE will take in atmosphere through a filter, compress the gas to 1 atm using a scroll pump, before electrolyzing the carbon dioxide to produce oxygen [2].

MOXIE's intake consists of a High Efficiency Particulate Arrestance (HEPA) filter, with a face area of 240 × 80 mm. The filter is mounted at the lower left rear corner of the rover body and is oriented downwards such that the filter face is flush with the rover belly pan, at a height of 69 cm above the surface.

Analysis and wind tunnel testing of the dust loading from suspended dust has been completed and is reported in [3]. In this abstract, we provide a first estimate of the flux of particles that may be transported to the intake by the process of saltation.

Saltation: Saltation is the mobilization of particles from the surface due to wind. There are two main parameters which can be used to analyze the process: the fluid threshold and impact threshold wind stresses. The fluid threshold is the minimum wind stress required to lift particles from the surface. The impact threshold is the minimum wind stress at which an impacting particle can eject another particle. On Earth, these two parameters are similar. However, on Mars, there is a large difference between them: the fluid threshold is much higher than the impact threshold, due to the lower gravitational acceleration and atmospheric density. As a result, saltation on Mars displays a marked hysteresis effect whereby a brief gust of strong wind can mobilize particles which continue to saltate after the wind stress reduces to below the fluid threshold [4].

Modelling: The state of the art in the modelling of saltation is the COMprehensive numerical model of SALTation (COMSALT) [5]. It is written in MATLAB and has been verified against experimental measurements of saltation on Earth. Although there is some uncertainty in the model, it can be applied to obtain a first estimate of the saltated particle flux expected at the MOXIE inlet.

Here, we briefly summarize the inputs to the model before presenting the results.

Wind profile. For the wind model, we assume a logarithmic profile:

$$u_x(z) = \frac{u_*}{\kappa} \ln\left(\frac{z}{z_0}\right)$$

where u_x is the horizontal wind speed, u_* is the wind shear velocity, κ is the von Karman constant, z is the height above the surface, and z_0 is the roughness parameter [6]. As recommended by COMSALT's documentation, this is typically set to $30D$, where D is the median diameter of a regolith particle [7].

The wind shear velocity u_* can be calculated from the wind model for various roughness parameters z_0 assuming a von Karman constant κ of 0.40 and a horizontal wind speed u_x of 3.5 m s^{-1} at a height z of 1.6 m. This corresponds to the mean wind speed measured using the wind sensor on the 2008 *Phoenix* lander [8].

Regolith particle size distribution. The regolith Particle Size Distribution (PSD) used is the PSD measured at the *Phoenix* landing site for particles with diameters less than 200 μm, as shown in Figure 1:

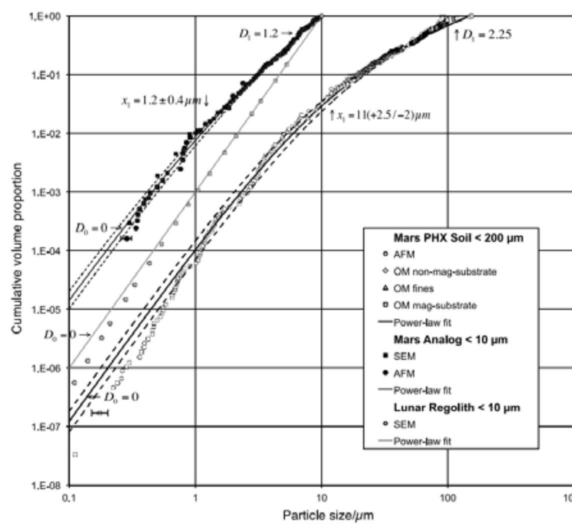

Figure 1. PSD of Martian soil as measured by *Phoenix*. The PSD used in the simulation was "Mars PHX Soil < 200 μm" (rightmost curve) [9].

COMSALT requires the PSD to be passed in a separate MATLAB function containing two vectors with n elements. The first vector contains the mean particle diameter of each of the n bins and the second contains the proportion of the total volume of particles contained within each of the n bins.

The *Phoenix* PSD is approximated using two expressions for the cumulative volume proportion as a function of particle diameter $V(x)$:

$$V(x) = \begin{cases} \left(\frac{x}{x_0}\right)^{3-D_0}, & x < 11 \\ \left(\frac{x}{x_1}\right)^{3-D_1}, & x \geq 11 \end{cases}$$

where x is the particle diameter in μm, x_0 is 22.7 μm, D_0 is 0, x_1 is 200 μm and D_1 is 2.25 (values obtained from Figure 1). With these functions, the PSD input to COMSALT is summarized in Table 1:

Particle diameter bin range (μm)	Mean particle diameter (μm)	Volume proportion in bin	Cumulative volume proportion
0 – 100	50	0.595	0.595
100 – 125	113	0.108	0.703
125 – 150	138	0.103	0.806
150 – 175	163	0.099	0.905
175 – 200	188	0.095	1.000

Table 1. PSD as used by COMSALT.

Additional parameters. COMSALT also requires a number of other parameters related to the numerical simulation. These are listed in Table 2 and are all set to the recommended values in the documentation [7].

Name	Description	Value(s)
t_max	Time that particles from each particle bin are simulated in each minor iteration	15 s
h	Time step with which particle motion is simulated	7.5 ms
delta_z	Spatial resolution of simulation	2.5 mm
u_fr_thr	Impact threshold (only required if Owen's second hypothesis is used)	0 m s^{-1}
filetext	String appended to the names of all output files	Various
switches	First switch determines whether or not Owen's second hypothesis is used. Second switch determines whether or not to include the effects of turbulence	(0,1)

Table 2. Listing of parameters required by COMSALT.

Finally, the density of Martian soil is required; a density of 3000 kg m^{-3} was used.

Results: Since MOXIE has a downward-facing filter, the vertical mass flux is of most interest and this is plotted for a range of surface roughness values in Figure 2:

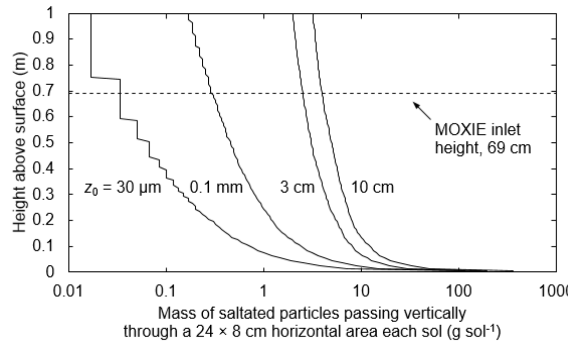

Figure 2. Vertical mass flux, expressed as the total mass of all particles that pass through a horizontal plane the same size as the MOXIE face area during one sol. The dashed line shows the height of the MOXIE inlet (69 cm).

Discussion: Figure 2 gives a first estimate of a saltated particle mass impingement rate of the order 1 g per sol at the MOXIE inlet, for typical wind conditions and surface roughnesses. Although most of these particles would be expected to bounce off the filter, when included with particle fluxes expected from landing, dust devils and storms, this contributes to the justification for a baffle in front of the filter inlet. As saltated particles will follow a ballistic path, a baffle is a straightforward way to prevent them accumulating in the folds of the filter. For larger in-situ resource utilization intakes, using baffles and mounting the intakes at a greater height will remove them from the bulk of the saltation flux.

Future work may examine the effect of variable winds, dust storms and dust devils, and include a range of PSDs as measured at various landing sites.

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