DUST FORECASTING FOR HUMAN EXPLORATION OF MARS, D. G. Halleaux[1], S. F. Braswell[1], N. O. Renno[1], [1]University of Michigan Department of Atmospheric, Oceanic and Space Science, Ann Arbor, Mich. (shaneenb@gmail.com; dgossiau@umich.edu; nrenno@umich.edu)

Introduction: Forecasting the amount and type of dust suspended in the atmosphere that human explorers will encounter will be as important to future Mars missions as weather forecasting was to early seafarers. Suspended dust poses a hazard both to human health and surface operations. Previous lunar missions have shown dust to be detrimental to environmental equipment such as space suits, while terrestrial health research indicates significant biological effects of dust exposure.

Modeling: On Mars, aerosol characterization includes both number density and size distribution of the suspended dust particles. Forecasting dust requires prior knowledge of the static properties of local dust as well as accurate forecasts of their drivers. Size distribution is a function of altitude and local soil type. Smaller and light dust particles tend toward a larger height distribution than their larger, heavier counterparts. Aerosol number density is a function of both local dust size distribution and the meteorological factors that lift the dust initially.

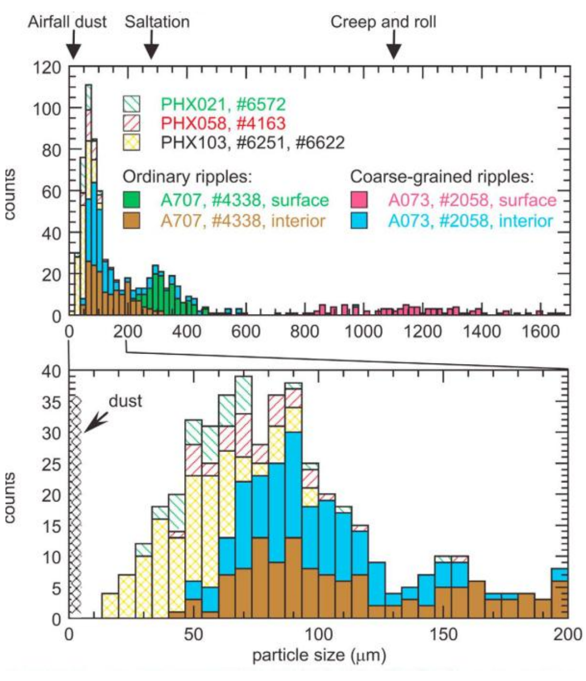

Figure 1. Soil size distributions at Phoenix and MER sites. Soil particle sizes peak here where saltation would be most effective, ~100 μm [2].

Saltation plays a primary role in dust lifting through stronger wind shear near the surface increasing aerosol quantities in the atmosphere [3]. We have modeled this process on Earth through use of COMSALT, a leading saltation model that also includes feedbacks to wind shear resulting from saltation itself [4]. Applied to Mars, COMSALT will provide accurate dust profiles given a local vertical wind shear profile- an *in-situ* meteorological measurement required. Saltation's effect is amplified for dust size distributions favoring smaller, lighter particles, and thus becomes even more critical in areas where small particles are plentiful. Discrete phenomena such as dust devils occur that can inject large amount of particles, both large and small in size, into suspension.

With limited knowledge of the specific makeup of the soil on Mars, we can rely on measurements of wind speed and electric field strength to characterize local dynamic behavior. These measurements are similar to those proposed in the DREAMS suite on ExoMars. Increases in suspended dust are accompanied by increases in local vertical electric field strength, due to charge transfer inherent in particle collisions [5]. As on Earth, increases in wind lower level wind shear drive saltation and increase suspended dust. The rate at which saltation increases with wind shear, and thus suspended dust changes with local meteorological conditions, can be quickly characterized at any location with accurate, high-resolution electric field measurements [6] and a wind shear profile

Effects: Once electrically charged dust particles become suspended in the air, it generates a hostile environment where the consequences to human health and mission operations are still unknown on Mars. Very fine dust particles (<50 μm) remain suspended for longer time periods than its larger counter parts. Such charged dust particles can adhere to the EVA suits as seen in past Apollo missions, and become extremely hard to remove before entering their outpost leading to contamination [7]. Due to the nature of their small size, very fine dust can readily gain access into the human body via inhalation and soft tissue contact. On Earth, areas of high dust suspension coincide with high incidences of respiratory health problems, cardiopulmonary symptoms and even mortality [8]. Dust events on Earth also serve as mechanism for transporting pathogens and it is a major concern for public health [9]. Although life has not been unambiguously detected on Mars yet, these concerns regarding dust-associated microorganisms should be taken in consideration.

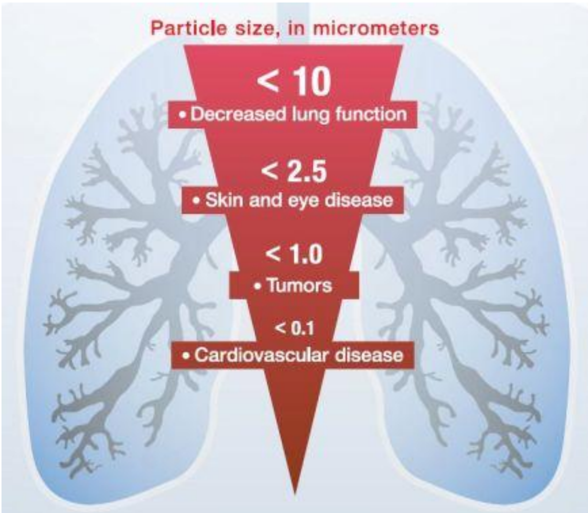

Figure 2. Particulate sizes associated with health risks. The smaller the particles the more adverse the health effects [10].

Airborne dust toxicity presents another challenge to astronauts. UV radiation impinging on the Martian surface alters the local soil properties making it extremely reactive and potentially toxic [11, 12]. This could pose a challenge for human settlement and use of local natural resources in-situ. Furthermore, the recent discovery by the Phoenix Lander mission reported traces of perchlorate in the soil. Perchlorate introduced to the blood stream can cause thyroid diseases [13]. There may be other unknown chemical constituents in the soil that can cause bodily harm. The culmination of these adverse health effects can be mitigated by development of a dust-forecasting model that will extend the window of opportunities for successful prolonged field expeditions. Apart from the detrimental effects of dust on astronaut health, it is a major concern for mission planning and instrumentation. Dust can settle on solar arrays, rovers and instruments reducing their performance. Additionally, the toxicity of dust can corrode electronics and materials that could impede mission operations or even lead to mission failure.

Conclusions: Dust forecasting will be key to enabling medical scientists and engineers to develop treatments and preventive measures to ensure astronaut safety and lengthen equipment reliability. Concerns that are more sensitive to long-term dust exposure than short-term, high concentrations of dust will benefit, also, from a comprehensive dust weather forecasting technique. Because of the environmental hazards dust creates, the measurements of electric field strength with wind shear velocity –giving us the ability to forecast dust- will be a critical precondition to manned Martian exploration.

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