MONITORING THE WEATHER ON MARS WITH AN AREOSTATIONARY SMALLSAT.

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Introduction: The spatial distribution and temporal evolution of dust and water ice aerosols are essential observables for any fundamental or applied study related to the atmosphere of Mars, including weather monitoring for robotic and future human exploration missions.

The dust cycle –which dust storms are the most remarkable manifestation of- is considered to be the key process controlling the variability of the Martian atmospheric circulation at inter-annual and seasonal time scales, as well as the weather variability at much shorter time scales. It has also been demonstrated that the radiative effects of the presence of water ice clouds are very important in understanding the details of the atmospheric thermal and dynamical structures.

Science objectives: We propose to focus the attention on tracking[1] Martian dust storms and water ice clouds, helping to address the scientific questions: *What are the processes controlling the dynamics of dust and water ice aerosols, and promoting the evolution of regional dust storms into planetary-encircling storms?* These questions are aligned with MEPAG's and the "Vision and Voyages" Decadal Survey's goals.

Measurements needed: Monitoring in detail the dynamics of dust storms (i.e. their onset, transport, and decay) and water ice clouds (i.e. their formation, evolution, and dissipation) requires both continuous and synoptic observations[2] of Martian aerosols from space.

The key factor to achieve this objective is the choice of the satellite orbit. None of the satellites already in orbit around Mars or currently planned has the required orbital characteristics. Polar Sun-synchronous orbits ensure (asynoptic) global coverage –mostly for mapping surface features and properties- but prevent frequent atmospheric observations at the same locations. Quasi-polar eccentric orbits (e.g. NASA's MAVEN or ESA's Mars Express) provide some coverage at different local times, and synoptic views of the Martian disk near apoapsis, but they still cannot achieve continuous monitoring of rapidly evolving meteorological phenomena at fixed locations.

[1] We refer to *aerosol tracking* as the process of following the evolution of the aerosol spatial distribution.

[2] By *continuous monitoring* we mean obtaining data at a high rate for a long time. By *synoptic monitoring* we mean obtaining data simultaneously over a large area.

Mission concept: A truly innovative method to obtain continuous and synoptic observations of the aerosol distribution (at least the horizontal one) would be to use a spacecraft in Mars-synchronous (areosynchronous) orbit, which can additionally be circular and equatorial (i.e. Mars-stationary, or areostationary). The planned Emirates Mars Mission is the only spacecraft whose orbit approaches the unique coverage offered by a truly areosynchronous or areostationary satellite.

For Mars, the areostationary altitude is 17,031.5 km above the equator (semi-major axis = 20,428.5 km). The sub-spacecraft point is at 0° latitude at the chosen longitude, and the satellite can observe the surface up to 80° away from nadir, although the portion of the disk useful for scientific purposes might be limited to about 60°. In Fig.1 we show how a regional dust storm that developed in Martian year 24 is seen during several daylight orbits of the Mars Global Surveyor polar orbiter (left panel), compared to a reconstruction of the storm as it would be seen from the vantage point of an areostationary satellite (right panel).

We have elaborated a mission concept to put a stand-alone SmallSat in an areostationary orbit around Mars. This would offer the unequaled possibility to monitor the weather and obtain a novel set of frequent measurements of aerosol optical depth throughout multiple local times over a large portion of the planet. The use of a low-cost SmallSat with a focused meteorological science objective, included as a secondary payload of a primary mission, is a key innovation with respect to previous orbiter missions to Mars.

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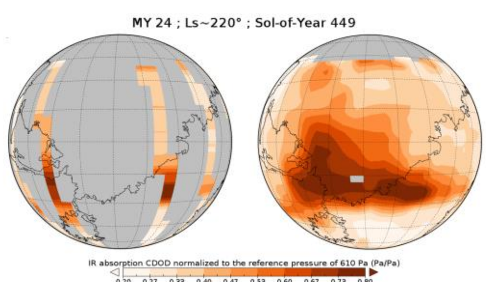

Figure 1: A regional dust storm from Mars Global Surveyor/Thermal Emission Spectrometer gridded IR column dust opacities accumulated in 1 sol (left), and reconstructed with data gridded over 7 sols (right). Vertical perspective views.