Europlanet TA Scientific Report

PROJECT LEADER

Project number: 22-EPN3-041
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Project Title:

Study of the dust lifting phenomena and electrification processes in a martian analogue site

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database and published)

We performed a field campaign in the Makgadikgadi Salt Pans, during the dry season, to study the local dust lifting events and test a space designed dust sensor. With these purposes, we deployed a fully equipped meteorological station with the addition of a camera system and of the MicroMED sensor, the Optical Particle Counter selected on board of the ExoMars programme to characterize in situ the martian airborne dust. Here we used the terrestrial version of MicroMED, fully representative of its Martian counterpart.
We spent one week between two sites, facing different soil and wind conditions and successfully achieving both aspects of the campaign.
MicroMED was indeed able to automatically operate using a preloaded acquisition schedule during day and night, in a range going from clear to highly loaded dust conditions. The campaign has hence been truly representative of the martian expected scenario and the data will be useful for further tuning the sensor and its functioning pipeline.
Moreover, MicroMED acquisitions are precious also for studying the dust lifting events, in combination with all the other installed sensors. We were indeed able to monitor two days of intense dust devil activity, performing also an image survey of the events. The acquired data are promising, being under various aspects totally new to the literature. They can hence lead to highly improve our knowledge of the dust lifting phenomenon, regarding in particular the induced electric field.

Full Scientific Report on the outcome of your TNA visit

We encourage you to add figures to your report, which should be approx. 1 page of text plus figures.

Atmospheric dust is one of the driving forces able to lead the planetary climate. The grains can remain in suspensions for months in circulation across the globe, regulating the cloud lifecycle and the planet radiative budget, affecting so the thermal structure of the atmosphere and its chemical composition. In addition, mobilized sand and dust grains tend to acquire and hold a net charge that can lead to the generation of large electric fields inside the dust clouds. These effects can be even more impactful on other planets of the solar system, as f.e. Mars, due to the lack of vegetation and oceans and the abundance of dust sources. The two main lifting phenomena acting on Mars are the dust devils and storms, both approximatively responsible for about 50% of the planetary budget.

Currently, we are conscious of the different mechanisms related to the embedment of dust into the atmosphere, but are still far from a quantification of their total effect. The first crucial step for this evaluation is the comprehension of the lifting physics and the quantification of the amount of primary lifted dust. New surveys are required to solve the questions still open in literature, justifying the development of new sensors specifically devoted to the dust monitoring and the execution of new field campaign for the data acquisition.

In this optic, our team performed various field campaigns in martian analogue sites and developed different sensors for space applications. Last sensor we designed is MicroMED, an Optical Particle Counter (OPC) that aims to achieve the first direct measurement of martian dust size distribution and concentration. The sensor has been selected for the previous configuration of the ExoMars programme, preceding the Ukranian crisis. MicroMED is characterized by low dimension and power consumption, making it suitable for space application but also for its deployment in harsh environment as the terrestrial deserts. We indeed developed an Earth version of the sensor, in all similar to its martian counterpart except being tuned to operate at terrestrial pressure and temperature.

To study the lifting phenomena in a martian analogue site, we organized this field campaign in the Kalahari Desert at the Makgadikgadi Salt Pans with the two main purposes of:

- studying the local dust devil population and induced grain electrification,
- testing for the first time on field the MicroMED sensor.

The campaign lasted from the July 24 to the first of August 2023, and we installed the base camp in Kubu Island, deploying our sensors in the Sua Pan.

The first couple of campaign days has been spent to optimize the staging and functioning of the meteorological station. The final set up (visible in Fig. 1) comprises two different masts. The main mast was equipped with the meteorological station:

- three 2D anemometer placed at 0.76 m, 2.045 m and 2.8 m;
- one pressure sensor placed close to the ground;
- two thermometers, one control sensor placed close to the surface and one comprehensive of the relative humidity probe placed at 1.84 m;
- three electric field sensors at 0.94 m, 1.58 m and 2.41 m;
- one solar radiation sensor;
- one impact sensor placed 5.5 m away from the mast and few centimetres above the surface level to measure the amount of saltating grains.

The secondary mast was instead equipped with:

- two photo-cameras to acquire the visual survey of the passing dust events;
- the solar panels and batteries system to power the whole sensor suite.

The station was finally completed by MicroMED to monitor the atmospheric dust concentration and size distribution, placed 5 meters away from the main mast.

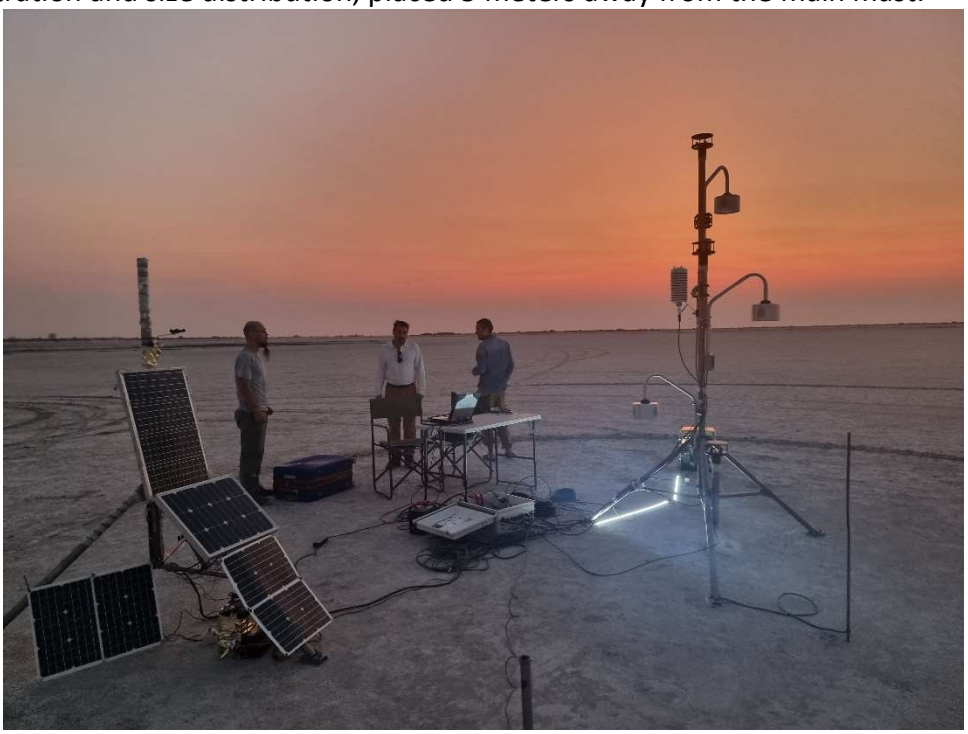

Fig. 1 On the left the mast with the solar panel and camera systems, on the right the main mast with the meteorological sensors.

Compatibly with the battery energy budget the meteorological sensors and MicroMED acquired day and night. Only the cameras and the electric field probes acquired just during the day, the firsts for illumination reasons, the latter for their high energy drain. The data has been acquired in continuous with a rate of 1 Hz for the meteorological sensors, 20 Hz for the electric field probes and 0.5 Hz for the images. MicroMED has instead an acquisition rate of 5 Mhz, but it does not operate continuously. We tested different activation pipelines, measuring on average for one minute every five minutes. We remained in the Sua Pan until July 29 night, measuring fair weather conditions with a relative low dust concentration. Due to the scarce lifting activity observed in this site, on 30 early morning we decided to move the station about 15 kilometres away, in a site characterized by a drier soil and a stronger convective activity. We were so able to monitor two high dense days of dust devil activity.

The data analysis is currently ongoing, but the preliminary results are quite encouraging, and the general outcome of the campaign has been successful.

As an example, Fig. 2 shows the images of one dust devil encounter directly crossing our meteorological station.

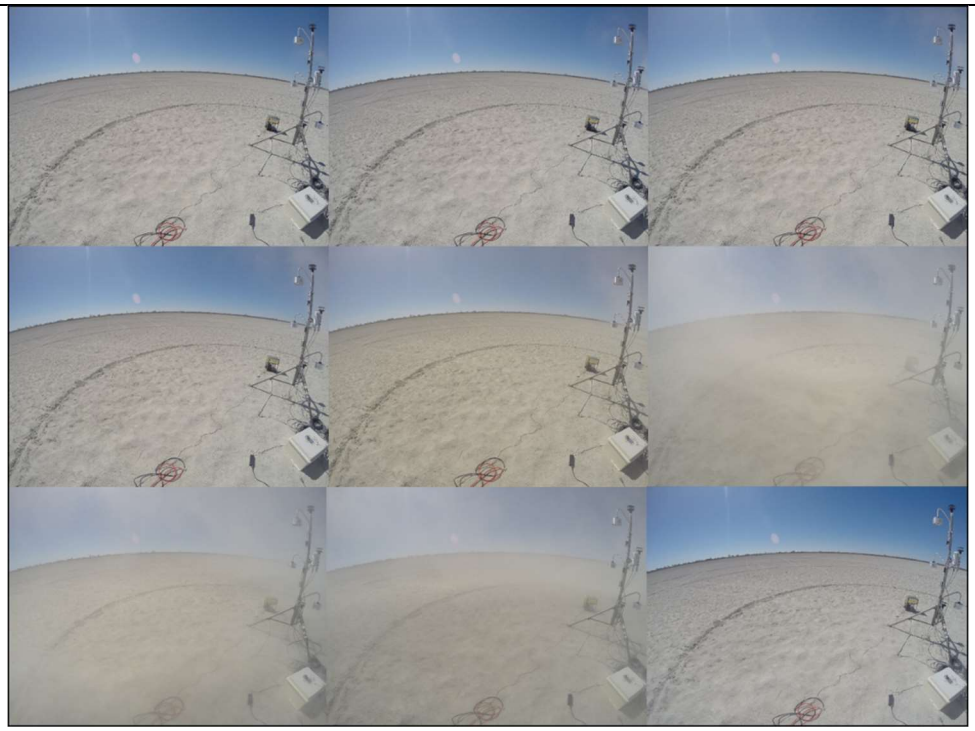

Fig. 2 The image sequence (from left to right, top to bottom) of a dust devil directly crossing our sensors. The vortex arrives from top left of the frame

Fig. 3 shows the data relative to this encounter, specifically the peak in the saltation activity and the correlated raise of the atmospheric electric field during the passage of the dust devil. The E-field is monitored at three different heights and all the signals closely mirror the saltation trend. As far as the authors know, our survey is the first available in literature to provide the vertical E-field profile of a dust devil. We are continuing the analysis to compare these data to the dust amount measured by MicroMED.

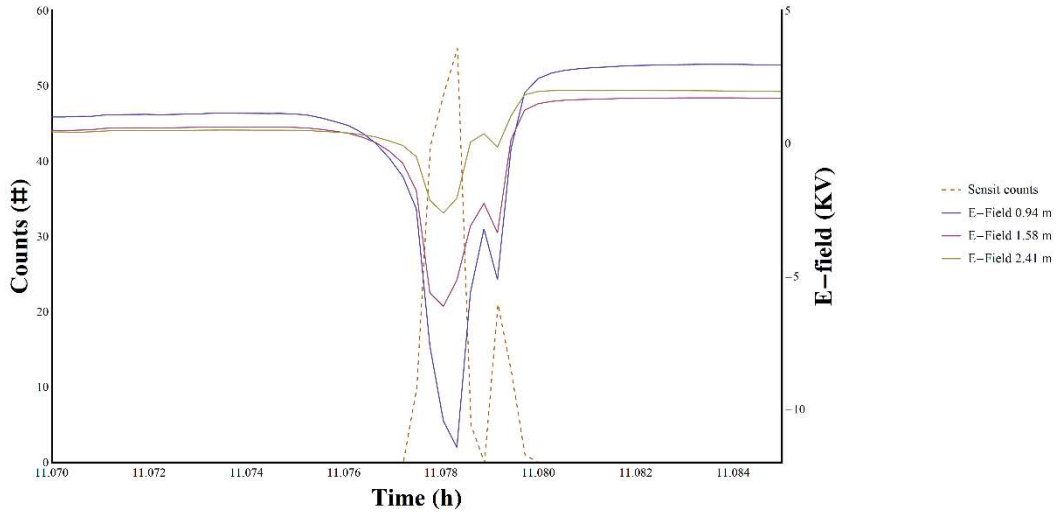

Fig. 3 The time series of the saltation and atmospheric electric field signals during a direct encounter with a dust devil over the station.

Regarding MicroMED, the realized set up and the automatically controller and activation pipeline proved to be fully functional in all the conditions faced during the mission. The acquired data will be useful to further improve the sensor and its operation routine, and in combination with the meteorological measurement represent a great opportunity to enhance our knowledge of the grain lifting and electrification.

In conclusion, both mission objectives have been achieved, thanks also to the crucial support provided by the facility team.

- Give details of any publications arising/planned (include conference abstracts etc)

Thanks to the dual purpose of the mission, we plan to publish a paper regarding the successful first in situ testing of the MicroMED sensor and others on the study of the observed dust devil population. The exact journals will be selected depending on the outcome of the currently ongoing analysis, between various candidates, as Aeolian Research, Icarus, Planetary and Space Science, Earth and Planetary Science Letters etc.

- Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: dd-mm-yy Arrived: dd-mm-yy	24/07/23	1	7	1	02/08/23	Departed: 23/07/23 Arrived: 03/08/23

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	Fulvio Franchi
Host Signature	
Date	26/09/2023

- Project Leader confirmation

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Project Leader Name	Gabriele Franzese

Project Leader Signature	Francesca LaBriola
Date	03/10/2023