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Innovations at a European Planetary Simulation Facility

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Abstract

This unique and recently improved planetary simulation facility is capable of re-creating extreme terrestrial, Martian and other planetary environments. It is supported by EU activities including **Europlanet 2020 RI** and a volcanology network VERTIGO. It is also used as a test facility by ESA for the forthcoming ExoMars 2020 mission. Specifically it is capable of recreating the key physical parameters such as temperature, pressure (gas composition), wind flow and importantly the suspension/transport of dust or sand particulates. This facility is available both to the scientific and Industrial community. The latest research and networking activities will be presented.

1. Recent improvements and Activities

Improved functionalities of this facility include the implementation of an atmospheric (gas) cooling system (fig 1) allowing independent control of the air temperature, also a particle image velocimetry (PIV) system has been installed consisting of high speed imaging and laser illumination (fig 3). Also an LED based ultraviolet (UV) light source has been implemented capable of simulating the solar UV spectrum.

This environmental simulator facility is utilized for a broad range of research programs including; the study of other planets (such as Mars), for recreating extreme terrestrial environments, or in specific investigations involving aerosols and other forms of particulate transport.

This facility is part of a European network (VERTIGO) recently established to investigate the dynamics within volcanic ash clouds and pyroclastic flows including a detailed study of electrification.

The facility is also involved in the Europlanet 2020 Research Infrastructure through which a trans-national access program is allowing numerous research groups access to this facility.

Other activities include the development, testing and calibration of sensor and planetary lander systems, both for ESA and NASA. Currently testing for missions ExoMars 2020 and Mars 2020 are being carried out.

Figure 1 The main Planetary Simulation Facility under testing of the new liquid nitrogen atmospheric cooling system.

2. Design and Operation

The simulator consists of an environmental (thermal-vacuum) chamber within which a re-circulating wind tunnel is housed [1,2,6]. The wind is generated by a set of two fans which draw flow down the 2m×1m tunnel section and return it above and below. The test section can be fully removed for access. Wind speeds in the range 1-40 m/s have been demonstrated. Cooling is achieved by a novel liquid nitrogen flow system which has achieved temperatures below -160ºC. The inner chamber is thermally isolated from the vacuum chamber. A server based control system provides both control over wind flow, temperature, pressure, lighting, etc., but also acts as a data logger.

3. Atmospheric Aerosols

A unique capability of this wind tunnel facility is the production and controlled study of suspended particulates (dust, ash, sand, etc.). This type of experiment is a continuation of a large body of research performed over the past decade studying dust aerosols, specifically granular electrification, erosion and deposition processes [1 - 4]. This research has direct relevance to aerosol studies on

Earth which impact air quality, the environment and climate.
An advanced type of Laser aerosol and (2D) wind flow sensor is used for detailed study and control of these environmental parameters (fig 2).

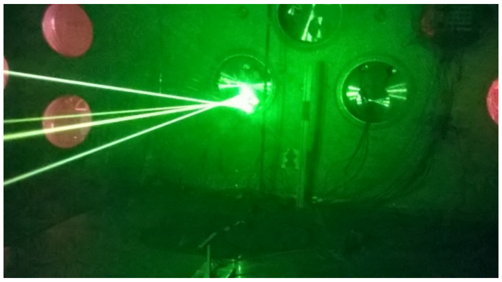

Figure 2 Laser based wind/dust sensor used for aerosol studies.

In recent studies this technology has been used to measure the size and electrification of individual (micron scale) aerosol particles as well as electrification within dispersing clouds (jets) of particles. This has direct relevance to electrification seen in volcanic eruptions and dust re-suspension where adhesion and aggregation (cohesion) are extremely important effects.

4. Planetary Surface Simulation

The combination of low pressure, low temperature, composition and aerosol injection is ideal for recreating the environment of the upper atmosphere of terrestrial planets, gas giants or even moons).
However, with control of wind flow this facility is also well suited for recreating the environment at the surfaces of terrestrial type planets such as Mars, Earth and Titan.
The interaction of wind and the planetary surface, specifically the transport of sand and dust is fundamental to understanding the evolution of the planets' surface and atmosphere. Laboratory studies of the entrainment, flow, deposition and erosion are scarce and empirical in nature. The effects of low atmospheric pressure, composition, temperature and even gravity can now be studied in detail. For example detailed measurements of sand grain trajectories are now being made under Martian pressure and composition in wind tunnel studies. This has direct relevance to the recent and still poorly understood observations of active sand transport at the Martian surface.

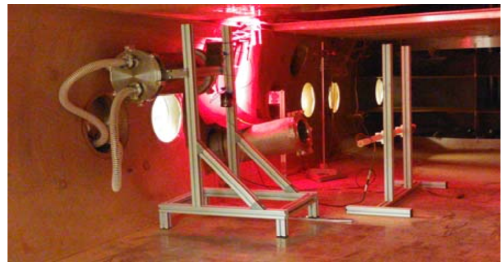

Figure 3 Inside the simulator showing a new PIV (particle image velocimetry) system using high speed imaging and laser sheets.

5. Conclusion

This planetary simulation facility has many unique and recently improved features which make it well suited for both planetary research applications and the development/testing of instrumentation. Details of this laboratory facility will be presented and some of the most recent activities will be summarized. For information on access to this facility please contact the author.

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