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EXOMARS ATMOSPHERIC SCIENCE AND MISSIONS WORKSHOP ABSTRACTS


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Title
ExoMars Atmospheric Science and Missions Workshop Abstracts

Abstract

The "ExoMars Atmospheric Science and Missions" Workshop served as a forum for general discussions on Martian atmospheric science with a focus on the assessment of the results and instrumentation development cycle of the ExoMars 2016 mission. These led to presentations and discussions of the atmospheric investigation plans and strategies for the ESA ExoMars-2020 mission in particular and for forthcoming Mars missions in general. The workshop gave overviews of the ExoMars atmospheric investigations through invited talks by Exomars scientists. The ExoMars atmospheric results and planned investigations were covered by individual scientific presentations. The workshop engaged early career scientists, inclusiveness states and scientific and technological cooperation in the European planetary science community.

The Workshop provided a forum for discussion and debate on the outstanding scientific topics of the Martian atmosphere, and on how to integrate and network the scientific teams with providers of instruments and technical systems. Thus the workshop also contributed to international cooperation in the field of Martian atmospheric science and technology.

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Nimeke

ExoMars Atmospheric Science and Missions Workshop Abstracts

Tiivistelmä

”ExoMars Atmospheric Science and Missions” –työpajassa käytiin laaja-alaisia keskusteluja Marsin kaasukehän tutkimuskohteista ja viimeaikaisista tieteellisistä edistysaskelista. Keskustelujen painopiste oli ExoMars 2016 –hankkeen tulokset ja mittalaitteiden kehitys. Näiden pohjalta keskusteltiin ESAn ExoMars-2020 –hankkeen sekä yleisellä tasolla myös tulevien Mars-hankkeiden strategiasta ja kaasukehän tutkimussuunnitelmista. Työpajassa muodostettiin yleiskuva ExoMarsin kaasukehätutkimuksesta, sekä tutustuttiin tarkemmin erillisten mittalaitteiden kehitykseen ja niiden antamiin tuloksiin. Työpajaan osallistui myös nuoria tutkijoita ja tutkijoita EU:n uusimmista jäsenmaista (”inclusiveness states”) ja siinä korostettiin yhteistyötä eurooppalaisten tutkijoiden ja mittalaitteiden kehittäjien välillä.

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The Relevance of Current and Future Mars Missions to Mars Atmospheric Science

S. Rafkin

Southwest Research Institute, Department of Space Studies, Boulder, USA, rafkin.swri@gmail.com.

Abstract

Beginning with the first successful mission to Mars, spacecraft have carried instrumentation to measure the atmosphere from orbit and from the surface. Currently in orbit around Mars are the NASA Mars Odyssey (MO), NASA Mars Reconnaissance Orbiter (MRO), NASA MAVEN, Mangalyaan from the Indian Space Research Organization, and the newly arrive ESA Trace Gas Orbiter (TGO). Operating on the surface is the NASA Mars Exploration Rover Opportunity without dedicated meteorological instrumentation, and the Mars Science Laboratory with the Rover Environmental Monitoring System.

On the horizon is the NASA 2020 rover, carrying an updated meteorological investigation Mars Environmental Dynamics Analyzer, the science phase of TGO, and the NASA geophysics mission InSight with minimal meteorological instrumentation. The ESA 2018 ExoMars surface and rover platform will measure the atmospheric environment, and the United Arab Emirates is funding U.S. institutions to provide a spacecraft in areostationary orbit around Mars for launch in 2020.

The history of the Mars exploration program may be divided into four distinct epochs (Figure 1): 1) Mapping; 2) In Situ Geology; 3) Forgotten Science; and 4) Next Steps. We are currently transiting through the Forgotten Science epoch which features aeronomy measurements from MAVEN, the continuing surface meteorological investigation of MSL, and the upcoming measurements from future missions.

The future of Mars exploration and atmospheric science in particular remains unclear. At the NASA, the Mars Program is experiencing major programmatic and political headwinds. A replacement telecommunication orbiter in 2022 has not been approved, and the Mars Sample Return Program has failed to secure Congressional support. At the same time, the Mars Human Exploration Program has taken the driver's seat and is strongly influencing the path of the Mars science program. ESA is committed to Mars through the ExoMars program, but the future is unclear after that.

The Mars Exploration Analysis Group (MEPAG) provides prioritized Mars Climate goals and investigations. The opportunities to achieve these goals is discussed in the context of current and future missions, and what investigations are needed to continue to advance Mars atmospheric and climate science.

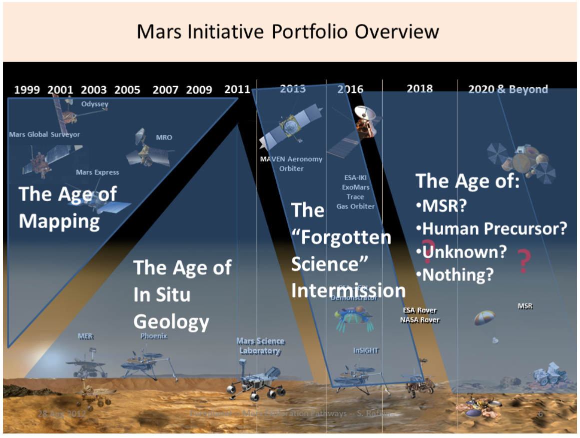

Figure 1. The Four Epochs/Ages of Mars Exploration

ExoMars Atmospheric Science and Missions Workshop
Saariselkä, Finland, 26.-30.3.2017

Micro-ARES on the ExoMars EDM:
A promise and a demise…

G. Déprez (1), F. Montmessin (1), F. Vivat (1), R. Hassen-Khodja (1), P. Granier (1), D. Moirin (1), L. Lapauw (1), J.-J. Berthelier (1), O. Witasse (2), R. Trautner (2), F. Esposito (3), C. Molfese (3), S. Debei (4), A. Aboudan (4), C. Bettanini (4), E. Barth (5), S. Rafkin (5).

(1) CNRS LATMOS, UVSQ, Guyancourt, France (gregoire.deprez@latmos.ipsl.fr), (2) ESA ESTEC, Noordwijk, Netherlands, (3) INAF, Napoli, Italy, (4) CISAS, Padova, Italy, (5) SwRI, Boulder (CO), USA.

Abstract

Atmosphere ionization and electrification mechanisms of various sorts are known to exist in most of the planetary environments but the lower atmosphere and surface of Mars combine a number of favorable conditions for the development of intense atmospheric electric fields (henceforth E-fields). This was the original goal of the Micro-ARES sensor, an element of the DREAMS (Dust Characterization, Risk Assessment, and Environment Analyzer on the Martian Surface, see Figure 1) meteorological suite (Esposito et al., 2017), the only scientific payload that equipped the Schiaparelli module onboard the ExoMars 2016 mission. Unfortunately, the Schiaparelli module failed at completing the last phases of its descent after parachute deployment and eventually hit the ground at more than 300 km/h.

Onboard, Micro-ARES was supposed to unveil the yet to be discovered Martian E-fields. Future missions may carry again these kind of sensors and the following text is intended to give a flavor of the science that this kind of instrument may promise for the future.

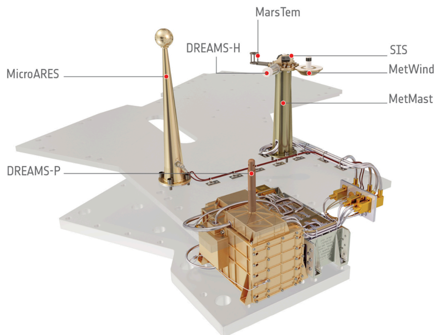

Figure 1: The DREAMS meteorological suite mounted onboard the Schiaparelli [1].

Micro-ARES is a single probe E-field instrument consisting of a spherical electrode installed on a stiff metallic mast (*Figure 1*) and a single electronics board housed in the common electronics box of DREAMS inside the warm compartment. The parent version of Micro-ARES called ARES (proposed in a double probe version, see [2]) was validated on two balloon flights and was developed until a Preliminary Design Review as part of the HUMBOLDT platform payload in a previous configuration of ExoMars.

The Micro-ARES experiment was designed to obtain first hand observations in these domains:

- The electric conductivity, its diurnal and seasonal variations and its perturbations following solar events;
- The quasi DC E-field, which reflects the nature and role of the various charging mechanisms at work on the surface of Mars;
- The ELF/VLF radio-electric emissions that may originate from atmospheric as well as from ionospheric processes and the AC signals from dust particle impacts on the sensors or on the lander structure.

The existence of a planetary E-field with very intense local enhancements and possibly significant breakdown currents may have a significant influence on the physics and chemistry of the surface materials, in particular through their control of the photo-electron emission and transport. Even more importantly, the motion of the dust particles themselves depend on the electrical state of the atmosphere. The electrical force exerted on micron size dust particles by the large E-fields generated by dust devils or dust storms may become larger than the drag force due to the wind and therefore control the global transport of dust [2].

References

[1] Esposito et al., 2017; *The DREAMS experiment onboard the Schiaparelli Module of the ExoMars 2016 mission: design, performances and expected results.*

[2] Berthelier et al., 2006; *ARES, atmospheric relaxation and electric field sensor, the electric field experiment on NETLANDER.*.

AMELIA: the ExoMars Entry, Descent and Landing Science.

F. Ferri (1), O. Karatekin (2), A. Aboudan (1), B. Van Hove (2), G. Colombatti (1), C. Bettanini (1), S. Debei (1), S. Lewis (3), F. Forget (4), S. Asmar (5)

(1) Università degli Studi di Padova, Centro di Ateneo di Studi e Attività Spaziali "Giuseppe Colombo" (CISAS) (francesca.ferri@unipd.it), (2) Royal Observatory of Belgium (ROB), Brussels, Belgium, (3) School of Physical Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK, (4) Laboratoire de Météorologie Dynamique, UPMC BP 99, 4 place Jussieu, 75005, Paris, France, (5) Jet Propulsion Laboratory, California Institute of Technology - NASA, Pasadena, CA, USA

Abstract

The *ExoMars* program, with the Schiaparelli Entry Demonstrator Module (EDM) in 2016 and the entry module containing the Surface Platform and Rover in 2020 provides the rare (one-per-mission) opportunity for new direct *in situ* measurements over a wide altitude range and with resolution not achievable over the full altitude range by remote sensing observations.
The Atmospheric Mars Entry and Landing Investigations and Analysis (AMELIA) experiment aims at exploiting the Entry Descent and Landing System (EDLS) engineering measurements of the for scientific investigations of Mars' atmosphere and surface. The data recorded during the different phases can be used for an accurate trajectory and attitude reconstruction and for the retrieval of atmospheric vertical profile to study the atmospheric structure, dynamics and static stability and to characterize the landing site context.

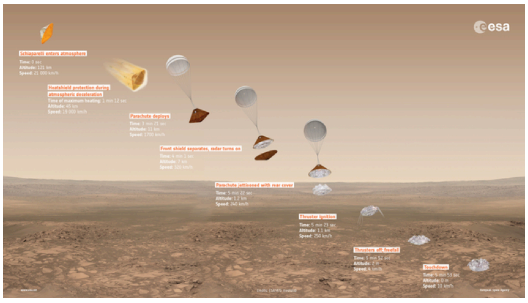

Figure 1: ExoMas2016 Schiaparelli EDL scenario

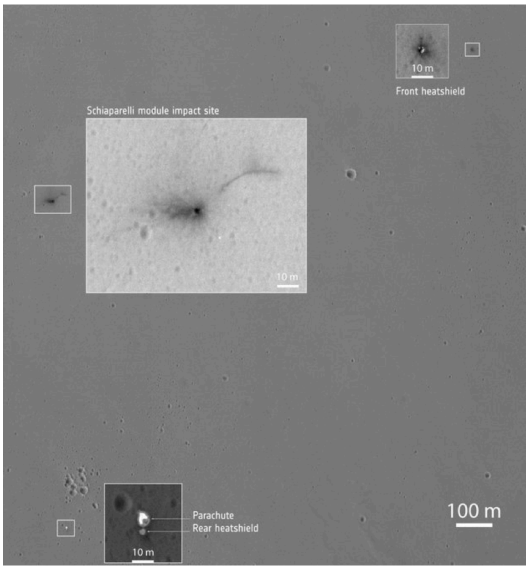

Figure 2: MRO-HIRISE image of Schiaparelli crash landing

Despite the ultimate failure of Schiaparelli to land safely, sufficient EDL data were returned in order to retrieve atmospheric profiles over the altitude range from 121 to 4 km above the surface. The analysis of the Schiaparelli data and the results on the assessment of the atmospheric science will be reported and put into perspectives for the ExoMars 2020 mission.

Exo-Mars Meteo

A. Lipatov (1), V. Linkin (1), O. Korablev (1), D. Rodionov (1), A. Borisov (2) and A. Economov (1)

(1) Space Researh Institute, Physics of planets and small bodies of the Solar system., Moscow, Russia (slip@iki.rssi.ru)
(2) Central research Institute of mechanical engineering, The Division Microgravity, Korolev, Russia (bab12bab@yandex.ru)

Abstract

The presentation will be provided by the meteorological instruments developed in Russia, their description and the solved scientific tasks of these tools. The same will be briefly told about all the instruments included in the meteorological instruments for the solution of scientific problems. We consider problems of simultaneous measurements of these devices. Discusses the General sequence diagram of the meteorological instrument. The questions of synchronization of the operation of the sensors, taking into account the information content and energy consumption.

Curiosity rover humidity measurements – First two Mars years of the mission

Ari-Matti Harri (1), Maria Genzer (1), Javier Goméz-Elvira (2), Hannu Savijärvi (1), Tim McConnochie (3), Manuel De la Torre (4), German Martínez (5), Robert Haberle (6), Jouni Polkko (1), Mark Paton (1), Claire Newman (7), Terhi Mäkinen (1), and Luis Vazquez (8)

(1) Finnish Meteorological Institute, Space Research Division, Helsinki, Finland (ari-matti.harri@fmi.fi), (2) Centro de Astrobiologia, Madrid, Spain, (3) Department of Astronomy, University of Maryland, United States, (4) NASA Jet Propulsion Laboratory, Pasadena, US, (5) Depi of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, USA, (6) NASA AMES Research Center, San Francisco, US, (7) Aeolis Research Inc., Pasadena, US, (8) University of Complutense, Madrid, Spain

Abstract

Since early August 2012 the Mars Science laboratory (MSL) has been operating successfully with the REMS instrument providing extremely valuable atmospheric observations of atmospheric pressure, temperature of the air, ground temperature, wind speed and direction, relative humidity (REMS-H), and UV measurements.

The REMS-H relative humidity device is based on polymeric capacitive humidity sensors developed by Vaisala Inc. and it makes use of three (3) humidity sensor heads. The humidity device is mounted on the REMS boom providing ventilation with the ambient atmosphere through a filter protecting the device from airborne dust. The REMS-H humidity instrument has created an unprecedented data record of more than two full Martian years. It has measured the relative humidity and temperature at 1.6 m height for a period of 5 minutes every hour as part of the MSL/REMS instrument package.

We focus on describing the annual in situ water cycle with the new REMS-H instrument calibration for the period of two Martian years. The results will be constrained through comparison with independent indirect observations and through modeling efforts. We inferred the hourly atmospheric VMR from the REMS-H observations and compared these VMR measurements with predictions of VMR from our 1D column Martian atmospheric model and regolith to investigate the local water cycle, exchange processes and the local climate in Gale Crater.

The strong diurnal variation suggests there are surface-atmosphere exchange processes at Gale Crater during all seasons, which depletes moisture to the ground in the evening and night-time and release the moisture back to the atmosphere during the daytime. On the other hand, these processes do not result in significant water deposition on the ground, because frost has not been detected in Gale Crater by any of the MSL observations. Hence, our modelling results presumably indicate that adsorption processes take place during the night-time and desorption during the daytime. Other processes, e.g. convective turbulence play a significant role in the daytime in conveying the moisture into the atmosphere.

Calibration of Relative Humidity Instruments in Low Pressure, Low Temperature, CO_2 Environment

M. Genzer, J. Polkko, T. Nikkanen, M. Hieta and A.-M. Harri

Finnish Meteorological Institute, Helsinki, Finland (maria.genzer@fmi.fi)

Abstract

Calibration of relative humidity devices requires in minimum two humidity points: dry (0%RH) and (near)saturation (95-100%RH) over the expected operational range of the device. For applications intended for Mars measurements those points need to be achieved also in very low temperatures and low pressure CO_2 environment.

We have developed a custom-made, small, relatively low-cost calibration chamber able to produce both dry and near-saturation points in Martian pressure range, CO_2 environment and temperatures down to -70°C. The system utilizes a commercially available temperature chamber for temperature control, vacuum vessels and pumps. The main pressure vessel with the devices under test inside is placed inside the temperature chamber, and the pressure inside is controlled by pumps and manual valves and needed another gas like N2, is used for filling the vessel until the desired pressure is achieved. Another pressure vessel with a dedicated pressure pump is used as the saturation chamber. This vessel is placed in the room outside the temperature chamber, partly filled with water and used for achieving saturated water vapour in room-temperature low-pressure environment. The saturation chamber is connected to the main pressure vessel via valves.

In this system dry point, low pressure CO_2 environment is achieved by filling the main pressure vessel with dry CO_2 gas until the desired pressure is achieved. A constant flow of gas is maintained with the pump and valves and monitored with the pressure reference. The saturation point is then achieved by adding some water vapour from the saturation chamber to the main pressure vessel. The amount of water vapour added is also monitored with the pressure reference. For example in -70°C, very small absolute amount of water vapour corresponding to ~1 Pa [1][2] pressure rise in the main chamber results in humidity saturation. As the flow of both CO_2 and water vapour is kept constant, the main chamber is served with water vapour all the time, keeping the uniform saturation conditions inside the vessel even if some of the water freezes on the vessel and pipe walls.

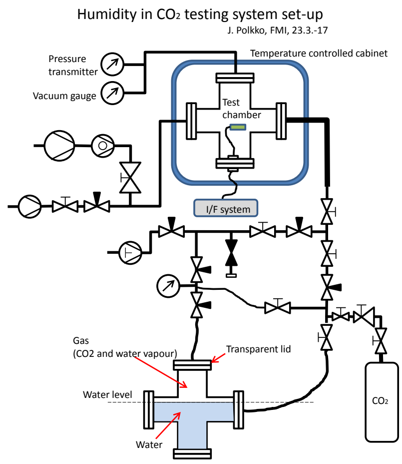

Figure 1: Calibration system set-up

References

[1] Goff, J.A, and Gratch, S. (1946) Low-pressure properties of water from -160 to 212°F, Transactions of the American Society of Heating and Ventilating Engineers

[2] Goff, J.A. (1957) Saturation pressure of water on the new Kelvin temperature scale, Transactions of the American Society of Heating and Ventilating Engineers

How windy is Mars?

R. Lorenz

Johns Hopkins Applied Physics Laboratory, Maryland, USA (Ralph.Lorenz@jhuapl.edu)

Abstract

I review meteorological data from Mars landers, considering the questions of how well we know the wind environment, and how 'windy' is the planet. The public perception, guided by movies such as 'The Martian' is of a windswept world, but by metrics of exceedance probabilities (often usefully described with a Weibull or similar distribution) of given dynamic pressure, is this really accurate? Similarly, careful examination of observational bias is needed to gauge whether Martian dust devils are really 'bigger' than Earth's (they seem to be, but only by a modest factor). I also explore the empirical predictability of Martian wind using simple models.

Properties of Martian winds as determined from trajectory modelling of jettisoned spacecraft hardware

M. Paton (1), A. -M. Harri (1), and H. Savijärvi (2)

(1) Finnish Meteorological Institute, Helsinki, Finland, mark.paton@fmi.fi, (2) Department of Physics, University of Helsinki, Finland

Abstract

Surface winds have previously been characterised by a number of landers providing time sequences ranging from a handful of Martian months obtained by Pathfinder and Phoenix to multiple Martian years obtained by the Viking landers. Winds aloft have been observed directly by observing the motion of clouds but these have been rather scattered. More measurements of the winds aloft in the Martian boundary layer are therefore required to help understand better the weather on Mars, verify atmospheric models, model transport processes and for the planning of spacecraft landings.

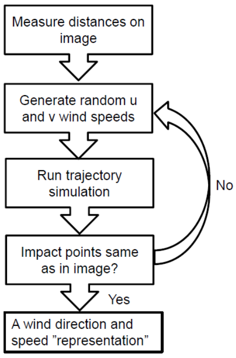

Figure 1: Approach used to analyse the distribution of jettisoned hardware.

A technique based on [1] is described to obtain wind speed and direction from trajectory modelling of jettisoned spacecraft hardware. This is essentially acheived (fig. 1) by comparing the trajectory calculations to the distribution of hardware on the surface as imaged from orbit. Some preliminary wind speed and directions are presented for a number of lander sites (fig. 2). These results are compared to wind data obtained from the Mars Climate Database (MCD).

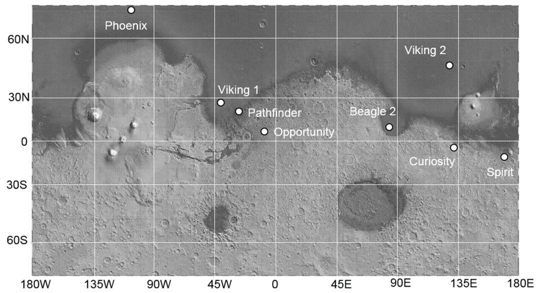

Figure 2. Locations of spacecraft superimposed on a topographical map of Mars (MOLA Science Team)

For wind direction there is a good correlation between our results and those obtained from the MCD. For wind speed the agreement is not so good with a number of clear disagreements. Possible reasons for the differences are discussed.

References

[1] M.D. Paton, A.-M. Harri, H. Savijärvi, Martian Wind Speed and Direction as Determined from Trajectory Modelling of Jettisoned Spacecraft Parts, Division for Planetary Sciences and European Planetary Science Congress, Pasadena, USA, October 16–21, 2016.

ExoMars Atmospheric Science and Missions Workshop
Saariselkä, Finland, 26.-30.3.2017

The MARs Boundary Layer Lidar experiment (MARBLL): Winds at last!

F. Montmessin (1), M. Patel (2), F. Forget (3), D. Bruneau (1), D. Coscia (1), T. Fouchet (4), J.-M. Reess (4), P. Bernardi (4), S. Lewis (11), C. Flamant (1), A. Spiga (3), A. Määttanen (1), Chris Howe (2), **G. Déprez (1)**, T. Bertrand (3), S. Maurice (5), M. Kahre (6), J. Abshire (7), A. Vasavada (8), R. Lorenz (9), B. Faure (10), M.-S. Clerc (1), P. Sengenes (10), P. Gilbert (1), J- B. Madeleine (3)

(1) CNRS LATMOS, UVSQ, Guyancourt, France (gregoire.deprez@latmos.ipsl.fr), (2) Rutherford Appleton Laboratory, Didcot, UK, (3) Laboratoire de Météorologie Dynamique, Paris, France, (4) LESIA, Meudon, France, (5) IRAP, Toulouse, France, (6) NASA ARC, Moffett Field (CA), US, (7) NASA GSFC, Greenbelt (MD), US, (8) NASA JPL, Passadena (CA) US, (9) Applied Physics Laboratory, Laurel (MD), USA, (10) CNES, Toulouse, France, (11) Open University, UK

Abstract

MARBLL is an optical remote sensing instrument using a mature state-of-the-art Doppler wind lidar technology specifically designed to operate at the surface of Mars. The instrument includes an emitting device (laser) and a spectral analyzer (Mach-Zehnder interferometer). Wind profiling is inferred from the 1064 nm beam emitted by the laser and subsequently backscattered to the telescope by the suspended aerosols. The received signal has a Doppler shift induced by the radial velocity component of the particles, which is quantified by the interferometer (*Figure 1*).

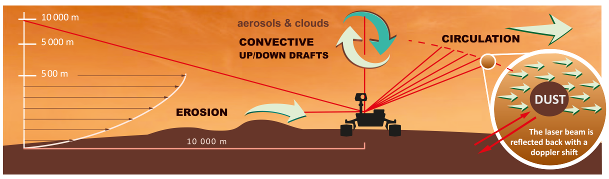

Figure 1: MARBLL instrument capabilities overview

Doppler wind lidars (DWL) offer a unique combination of accuracy and spatial resolution making them the most efficient technique to profile winds in the terrestrial boundary layer [1][2]. Existing DWL methods usually require a quasi-monochromatic laser emission and a precise frequency locking between the emitter and the spectral analyzer to infer the wind Doppler shift. These requirements lead to specific laser designs (single mode emission) associated with delicate servo-loops. The technical readiness level (TRL) of such systems remains too low to plan their use in the upcoming Mars missions. The conceptual approach of MARBLL started from this consideration: instead of developing space-qualified lasers to meet specific system detection requirements, MARBLL concept was led by the idea to design a detection system matching the specifications of an existing space-qualified laser (ChemCam) and by the need to guarantee high performances in the harsh Martian environment. The mature MARBLL design, which has undergone five years of Research and Development (R&D), ensures high performances for a large range of temperature and for any atmospheric condition (e.g. dust opacity) known to prevail on Mars. The relative detection method of MARBLL does not require the use of frequency control for both the emitter and the spectral analyzer. The uniqueness of the MARBLL patented concept stands in its capability to infer a Doppler shift, free from the common wind lidar constraints (see [3], for the detailed optical design).

MARBLL is able to derive wind velocity and orientation with a typical accuracy of respectively 0.1 to 10 m/s and 1 to 10°, a dynamic range of ±272 m/s and with a vertical resolution of 50 m up to 1 km within the first 5 km above the surface [4][5]. Aerosol abundance can be retrieved up to 10 km with a vertical resolution ranging from 50 meters to 1500 m. At the laser wavelength, dust is non-absorbing and all photons are scattered, maintaining high levels of backscattered flux even at high dust opacity. MARBLL thus guarantees those performances for all dust opacities (from 0.2 to 5), with an optimum estimated around 0.7, lying close to the average dust conditions prevailing on Mars.

References

[1] Gentry, 2000

[2] Frehlich, 2008

[3] Bruneau et al., 2013

[4] Déprez et al., 2017

[5] Montmessin et al., 2017

INTA's family of compact Sun Irradiance Sensors for the Martian surface

I. Arruego

Instituto Nacional de Técnica Aeroespacial, Madrid, Spain

Abstract

During the last 8 years, the Payloads and Space Sciences Department of INTA has developed a complete family of Sun Irradiance Sensors suited for operation on the Martian Surface. Their scientific capabilities range from the estimation of the Optical Depth to the detection of clouds in the Martian atmosphere, going through the identification of dust particle sizes and shapes by means of the scattering phase function estimation, or the in-situ measurement of mid-resolution spectral components from UV to NIR. This family of sensors includes:

- MetSIS: the precursor one, developed for the Mars MetNet Lander Precursor mission. Includes a complete set of 34 discrete detectors in 11 different spectral bands.
- DREAMS-SIS: was part of the DREAMS payload on board the ill-fated Schiaparelli lander (ExoMars 2016 mission, ESA/ROSCOSMOS). An ultra-compact sensor that has proven the capability of estimating AOD variations within a single Sol.
- RDS: part of the MEDA meteorological station on board JPL/NASA Mars 2020 Rover. It includes a number of discrete detectors pointed to different areas of the sky, plus a zenith-pointed CCD intended to get sky-brightness maps.
- SIS'20: part of the METEO meteorological package (led by IKI/RAN) on board ExoMars 2018 Lander (ESA/ROSCOSMOS). It incorporates, apart from a number of discrete detectors in a sectored and multi-spectral configuration, a compact micro-spectrometer to obtain first-ever direct spectral measurements with 10 nm resolution.

All these sensors, their concept and development status, together with the main science retrieval aspects, will be presented.

Monitoring the atmospheric dust on Mars: the MicroMED sensor

F. Esposito (1), C. Molfese (1), F. Cozzolino (1), F. Cortecchia (2), B. Saggin (3), D. Scaccabarozzi (3), I. Arruego Rodríguez (4), A. Martín Ortega Rico (4), V. Apestigue (4), P. Schipani (1), S. Silvestro (1), C.I. Popa (1), A. Zakharov (5), G. Dolnikov (5), A. Lyash (5), I. Kuznetsov (5)

(1) INAF - Osservatorio Astronomico di Capodimonte, Napoli, Italy (francesca.esposito@na.astro.it), (2) INAF – Osservatorio Astronomico di Bologna, Bologna, Italy, (3) Politecnico di Milano, Milano, Italy, (4) INTA, Madrid, Spain, (5) IKI, Moscow, Russia

Abstract

MicroMED is an Optical Particle Counter, proposed as a European contribution to the Russian-led Instrument "Dust Suite". It is a novel experiment, never developed for space applications. It has been designed to measure, for the first time directly and in situ, the size distribution and number density vs size of dust particles suspended into the atmosphere of Mars, close to the surface. This information represents a key input in different areas of interest: 1) to improve knowledge on airborne mineral dust in terms of physical properties and lifting mechanism, 2) to improve climate models and 3) to address potential hazards for future landed Martian exploration missions. MicroMED is a miniaturized/optimized version of the MEDUSA instrument, which was selected by ESA for the Humboldt Payload, on board the lander of the previous configuration of the ESA ExoMars, before the mission changes approved in 2009. An Elegant breadboard has been realized by the proposing team. Tests have been performed to demonstrate the functionality and performances of the experiment. The present breadboard has a TRL between 4 and 5.

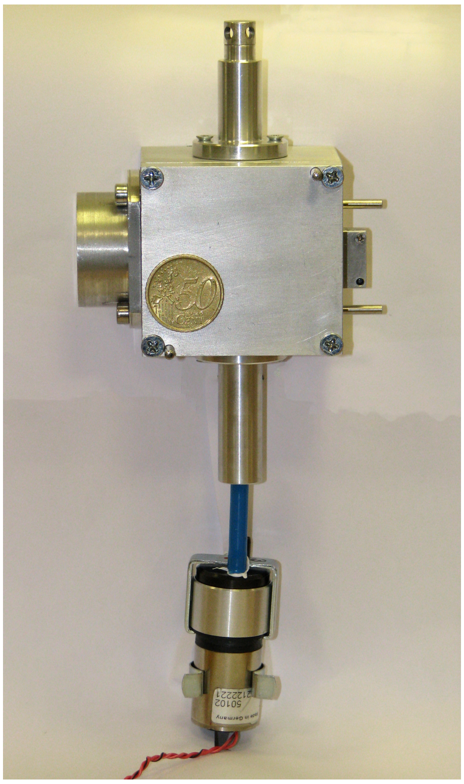

Figure 1: MicroMED Elegant BreadBoard

MicroMED: the Dust Particle Analyser of the ExoMars 2020 Dust Suite

C. Molfese (1), F. Esposito (1), F. Cozzolino (1), F. Cortecchia (2), B. Saggin3, D. Scaccabarozzi3, I. Arruego Rodríguez4, A. Martín Ortega Rico4, V. Apestigue4, P. Schipani1, S. Silvestro1, C.I. Popa1, A. Zakharov5, G. Dolnikov5, A. Lyash5, I. Kuznetsov5

(1) INAF - Osservatorio Astronomico di Capodimonte, Napoli, Italy (molfese@na.astro.it), (2) INAF – Osservatorio Astronomico di Bologna, Bologna, Italy, (3) Politecnico di Milano, Milano, Italy, (4) INTA, Madrid, Spain, (5) IKI, Moscow, Russia

Abstract

MicroMED is a Dust Particle Analyser aimed at measuring for the first time the dust suspended in Martian atmosphere, near the surface where the dust lifting phenomena are present. This instrument, with autonomous capability to perform systematic measurement of the dust particles and the computation of their distribution and density, was selected as part of the Russian "Dust Suite", on-board the landing platform of the ExoMars 2020 mission. The instrument is based on a light scattering measurement and derives from the MEDUSA experiment, previously selected for the Humboldt Payload. It was already implemented as laboratory breadboard, achieving a 4<TRL<5. The activities of design and development of the flight version are now in progress, concerning: the accommodation of the instrument and the definition of the interfaces with the other components of the Dust Suite; the optical, mechanical and electronic design; the development of a space qualified pump.

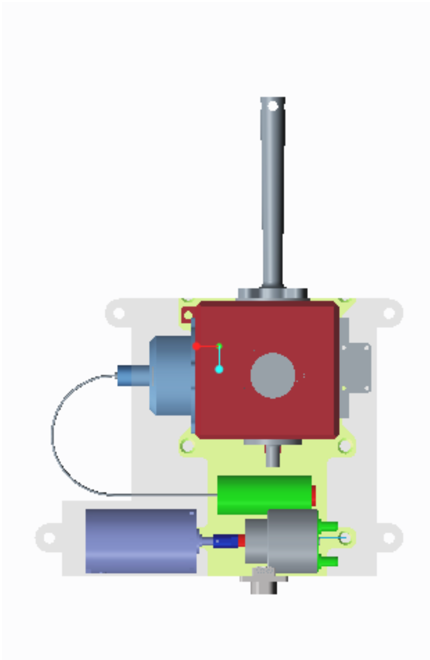

Figure 1: MicroMED Flight Version for Exomars 2020

MicroMED Processing Unit: Enhanced Computing for Planetary Exploration Payloads

A. Martin-Ortega (1), I. Arruego (1), I. Traseira (1), N. Andres (1), J. Rivas (1), J. Jimenez (1), A. Gonzalo (1), S. Rodriguez (1), J.R. de Mingo (1), F. Esposito (2), C. Molfese (2), F. Cozzolino (2), B. Saggin (3), D. Scaccabarozzi (3), A. Zakharov (4), G. Dolnikov (4), A. Lyash (4), I. Kuznetsov (4)

(1) INTA – National Institute of Aerospace Technique, Madrid, Spain, (martinora.pers_externo@inta.es), (2) INAF - OAC, Napoli, Italy, (3) Politecnico di Milano, Milano, Italy, (4) IKI, Moscow, Russia

Abstract

Planetary exploration strives for more capable processing technologies. In-situ processing capabilities enable the possibility of executing payloads for longer periods, reducing the size of data needed to be down-linked to Earth. Moreover, further processing capabilities facilitates the decision making, reducing the iteration of payloads operating far away from ground stations. This definitely increases the productivity of the science data retrieved from those instruments. In addition, mass and power consumption requirements are even more restrictive than for orbital space missions. This is true for the overall planetary mission, but even more for payloads, which are not considered critical for the survival of the whole mission. Taking all these requirements into account, it is clearly required to obtain better controllers, capable of operating in such environments, without being careless of the intrinsically reliability requirements of space missions.

MicroMED's Central Electronics Board aims for covering the required processing capabilities, with an open design capable to adjust to many different sensors, while keeping low power and mass budget.

ExoMars Atmospheric Science and Missions Workshop
Saariselkä, Finland, 26.-30.3.2017

A reliable and lightweight dust sensor for Mars missions based on spectral and angular resolution of local infrared scattering

A.J. de Castro (1), F. Cortés (1), C. López-Ongil (2), M. Portela-García (2) and F. López (1)

(1) LIR Infrared Laboratory Physics Dept, Universidad Carlos III de Madridm, Spain (decastro@fis.uc3m.es), (2) Electronic Technology Dept, Universidad Carlos III de Madrid

Abstract

The Dust Sensor (DS) is an instrument devoted to the retrieval of parameters of the size distribution of suspended dust at the surface of Mars. The DS took part in MetNet capsule and currently in METEO package of Exomars. Different groups and departments of the Universidad Carlos III de Madrid (Spain) are involved in the development of this instrument. The design and development of this sensor are focused on these key ideas: lightweight (100 g) and low power consumption sensor, no moving parts, working in open air at the surface and measuring in a local volume.

The scientific principle of measurement is based on the scattering produced by dust particles on the infrared light emitted by a pulsed IR thermal source and measured by two bi-spectral sensors located in backward-like and forward-like directions. The bi-spectral character is defined by two filters in the 1-5 μm spectral region, where the scattering of IR light is expected to be more effective due to the micron-size dust particles predominant in the Martian lower atmosphere.

A computational model that incorporates a) the physical properties of the dust scenario (particle distribution, optical properties of the particles) b) the detectors geometry c) the optics and electronics of the detectors has been developed. Such a model is a key element to develop retrieval algorithms to obtain the physical properties of interest from the scattering measurements.

The electronics architecture and placement are also presented in this work, as well as accommodation and operation features. Finally the fabricated Elegant Breadboard of the DS is presented.

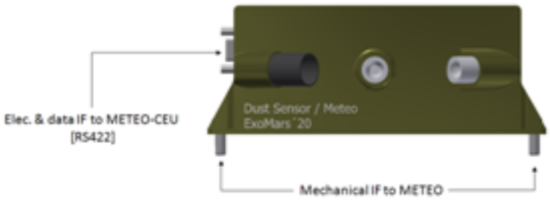

Figure 1: Final envelope of DS in METEO-ExoMars

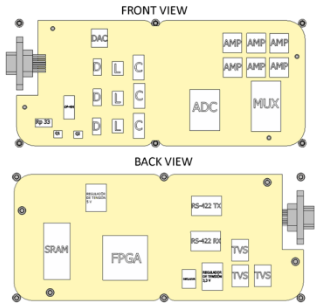

Figure 2: Electronics architecture of DS

New column boundary layer model integrations for the Viking landers

H. Savijärvi

University of Helsinki (UH) and Finnish Meteorological Institute (FMI), Helsinki, Finland

Abstract

Boundary layer simulations are made for the first sols of the two Viking landers on Mars and are compared with observations. The UH/FMI 1-D model is the same as for Phoenix (with Prandtl slope wind terms and cloud/radiation interaction, [1]), but includes our latest MSL REMS-H validated adsorption-diffusion scheme for water vapor transport in porous regolith [2]. The resulting 1.6 m temperatures and winds are quite close to those observed. In particular the weak summer slope winds of the VL-2 site are excellently reproduced.

The model predicts for both sites adsorption in the evening, frost at around midnight, and due to formation of fog, an early morning inflection in T1.6m at the observed time and temperature, with simultaneous increase in optical depth as observed from Phobos sightings. After sunrise the fog and frost sublimate away in the model, allowing desorption of water from the regolith and conserving PWC from sol to sol with only little diurnal variation.

In simulations without adsorption frost forms earlier but fog at VL-1 nearly as above. However, in the moister VL-2 simulation (MAWD PWC 25 μm vs. 12.5 μm at VL-1) fog now occurs too early compared to the observed inflection and change in optical depth. Hence we suggest that adsorption occurs at the VL sites in summer. VL-1 is known to be buried to porous regolith [3].

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Space weather at Mars

M. Dosa

Wigner Research Centre for Physics, Budapest, Hungary (dosa.melinda@wigner.mta.hu)

Abstract

Thanks to the large number of planetary space missions, planetary space weather has an increasing role in space sciences. In order to analyze and interpret spacecraft observations near Mars, it is essential to know the space weather circumstances near the space probe.

There are several models propagating solar wind to Mars orbit and giving estimates of the main solar wind parameters. A new ballistic-based method and its validation with plasma measurements by IMA ion and ELS electron experiments onboard MEX is presented here. A comparison with the simple ballistic model and two MHD models is also given. Our strength is that we clean the input data from transient signatures when propagating the background solar wind.

Atmospheric Martian Data Analysis and Simulations

L. Vázquez and UCM Martian Studies Group

Departamento de Matemática Aplicada - Facultad de Informática-Universidad Complutense de Madrid - 28040-Madrid, Spain.
lvazquez@fdi.ucm.es.

Abstract

We present a summary of the present and future Martian research lines at Complutense University of Madrid:

- The Cloud Computing Environment.
- The Solar Radiation and Atmospheric Dust.
- Fractional Calculus Modelling.
- Data Analysis: Tomographic Approach.
- Sensor Multivariate Analysis.

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Recent Results from Mars Mesoscale Modeling: From Gale Crater to Regional Dust Storms

S. Rafkin (1), J. Pla-Garcia (2), and C. Leung (2)

(1) Southwest Research Institute, Department of Space Studies, Boulder, USA, rafkin.swri@gmail.com, (2) Centro de Astrobiologia, Torrejon de Ardoz, Spain, University of Arizona, Department of Planetary Sciences, Tucson, USA.

Abstract

Mesoscale models can simulate Martian weather over regional areas down to scales of <1 km. The Rover Environmental Monitoring Station (REMS) on board the Mars Science Laboratory Rover Curiosity has afforded the first opportunity since the Viking Landers to validate these models in any meaningful way [1]. Based on the reasonable agreement between mesoscale model simulations and observations at Gale Crater, greater confidence is given to model results at other locations within Gale Crater where observations are not available.

The complex topography of the Gale Crater landing area drives a meteorological environment far more dynamic than any location previously measured. From combined observations and modeling, Gale Crater is shown to exhibit a broad array of upslope and downslope circulations, large amplitude mountain waves, a strong diurnal pressure signal, and large seasonal cycle variations [2] (Figure 1).

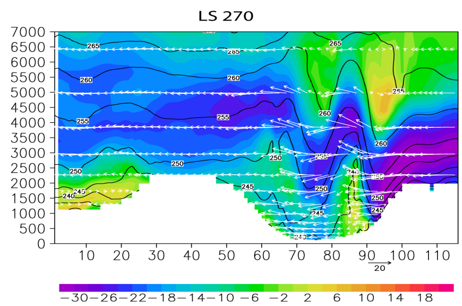

Figure 1: South to North vertical cross-section through Gale Crater showing a breaking, large amplitude mountain wave.

Greater confidence in model solutions can now also be given to simulations of phenomena at other locations and times. The unmeasured active lifting centers of a regional dust storm is one such example [3]. Simulations of a realistic dust storm in Isidis Basin reveal highly convective dusty plumes with mesoscale organization, deep vertical transport of dust, strong pressure perturbations, and strong modulation of the wind field (Figure 2).

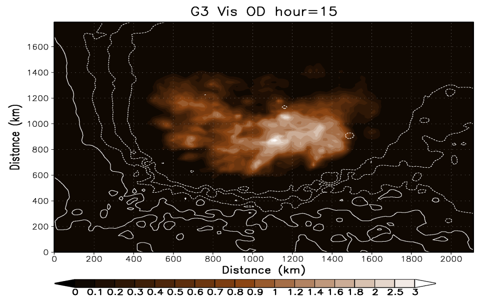

Figure 2. Total column visible dust opacity in a simulated dust storm in Isidis Basin.

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Mars MetNet Mission - Martian Atmospheric Observational Post Network

Ari-Matti Harri (1), Harri Haukka (1), Sergey Aleksashkin (2), Ignacio Arruego (3), Walter Schmidt (1), Maria Genzer (1), Luis Vazquez (4), Timo Siikonen (5), and Matti Palin (5)

(1) Finnish Meteorological Institute, Earth Observation Research, Helsinki, Finland (harri.haukka@fmi.fi), (2) Lavochkin Association, Moscow, Russia, (3) Instituto Nacional de Técnica Aeroespacial, Madrid, Spain, (4) Universidad Complutense de Madrid, Madrid, Spain, (5) Finflo Ltd., Helsinki, Finland

Abstract

A new kind of planetary exploration mission for Mars is under development in collaboration between the Finnish Meteorological Institute (FMI), Lavochkin Association (LA), Space Research Institute (IKI) and Instituto Nacional de Técnica Aeroespacial (INTA). The Mars MetNet mission is based on a new semi-hard landing vehicle called MetNet Lander (MNL).

The scientific payload of the Mars MetNet Precursor [1] mission is divided into three categories: Atmospheric instruments, Optical devices and Composition and structure devices. Each of the payload instruments will provide significant insights in to the Martian atmospheric behavior. The key technologies of the MetNet Lander have been qualified and the electrical qualification model (EQM) of the payload bay has been built and successfully tested.

1. MetNet Lander

The MetNet landing vehicles are using an inflatable entry and descent system instead of rigid heat shields and parachutes as earlier semi-hard landing devices have used. This way the ratio of the payload mass to the overall mass is optimized. The landing impact will burrow the payload container into the Martian soil providing a more favorable thermal environment for the electronics and a suitable orientation of the telescopic boom with external sensors and the radio link antenna. It is planned to deploy several tens of MNLs on the Martian surface operating at least partly at the same time to allow meteorological network science.

2. Strawman Scientific Payload

The strawman payload of the two MNL precursor models includes the following instruments:

Atmospheric instruments:
- MetBaro Pressure device
- MetHumi Humidity device
- MetTemp Temperature sensors

Optical devices:
- PanCam Panoramic
- MetSIS Solar irradiance sensor with OWLS optical wireless system for data transfer
- DS Dust sensor

Composition and Structure Devices:
- Tri-axial magnetometer MOURA
- Tri-axial System Accelerometer

The descent processes dynamic properties are monitored by a special 3-axis accelerometer combined with a 3-axis gyrometer. The data will be sent via auxiliary beacon antenna throughout the descent phase starting shortly after separation from the spacecraft. MetNet Mission payload instruments are specially designed to operate under very low power conditions. MNL flexible solar panels provides a total of approximately 0.7-0.8 W of electric power during the daylight time. As the provided power output is insufficient to operate all instruments simultaneously they are activated sequentially according to a specially designed cyclogram table which adapts itself to the different environmental constraints.

3. Mission Status

The eventual goal is to create a network of atmospheric observational posts around the Martian surface. Even if the MetNet mission is focused on the atmospheric science, the mission payload will also include additional kinds of geophysical instrumentation.

The next step is the MetNet Precursor Mission that will demonstrate the technical robustness and scientific capabilities of the MetNet type of landing vehicle. Definition of the Precursor Mission and discussions on launch opportunities are currently under way. The first MetNet Science Payload Precursors have already been successfully completed, e,g, the REMS/MSL and DREAMS/Exomars-2016. The next MetNet Payload Precursors will be METEO/Exomars-2018 and MEDA/Mars-2020. The baseline program development funding exists for the next seven years. Flight unit manufacture of the payload bay takes about 18 months, and it will be commenced after the Precursor Mission has been defined.

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3D fractional models and numerical methods for atmospheric dust dynamics

S. Jiménez (1), M.P. Velasco (1) and L. Vázquez (2**)**

(1) Department of Applied Mathematics, Universidad Politécnica de Madrid. E-mail: s.jimenez@upm.es, mp.velasco@upm.es,
(2) Department of Applied Mathematics, Universidad Complutense de Madrid. E-mail: lvazquez@fdi.ucm.es

Abstract

We extend our previous 1 dimension model for the diffusion of solar radiation by dust in Mars atmosphere to full 3 dimensions in either the general or the radial symmetry cases. We also present numerical methods to simulate our models.

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Martian clouds and dust storm monitoring by an Optical Depth Sensor on board the EXOMARS 2020 Russian lander

J.P. Pommereau (1), P. Rannou (2,1), A. Sarkissian (1), D. Toledo-Carrasco (3), A. Lipatov (4), Y. Dobrolensky (4), A. Federova (4), and O. Korablev (4)

(1) Latmos-CNRS, Paris, (2) GSMA, Univ. Reims, (3) Physics Dept, Oxford, Univ, UK. (4) IKI, Moscow, Russia.

Abstract

The Optical Depth Sensor (ODS) is a lightweight instrument designed for cloud altitude and thickness daily monitoring of as well as aerosol or dust Atmospheric Optical Thickness (AOT) daily measurements from the ground. Since its design, ODS has been selected for all Martian missions but with unfortunately little scientific return for a variety of reasons, including launch failure, lander development delay, RTG security, space agencies funding priorities. Its performances are well established and demonstrated by a number of cloud and AOT comparisons on Earth including Martian-like high altitude cirrus and Saharan dust storms in Africa. Its most recent selection is for its mounting on the Meteorological Package of the EXOMARS 2020 Russian lander for which flight models will be manufactured by IKI under CNES/CNRS licence.

The presentation will include explanations on how ODS is working; its recognised performances and the status of hardware development and exchange of scientific information for preparing the modelling of the data processing.

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

FINNISH METEOROLOGICAL INSTITUTE
Erik Palménin aukio 1
FI-00101 Helsinki
tel. +358 29 539 1000
WWW.FMI.FI

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