FIRST OBSERVATIONS WITH MEDA: THE ENVIRONMENTAL AND METEOROLOGICAL PACKAGE FOR MARS 2020.

J.A. Rodriguez-Manfredi[1,3], M. de la Torre Juárez[2], V. Apestigue[3], I. Arruego[3], D. Banfield[4], J. Boland[2], J. Ceballos[5], P.G. Conrad[6], T. Del Río[7], M. Dominguez-Pumar[8], S. Espejo[7], A. G. Fairen[1], F. Ferri[9], R. Ferrandiz[1,3], E. Fischer[12], M. Genzer[15], S. Giménez[1,3], J. Gomez-Elvira[3], F. Gomez[1,3], S.D. Guzewich[10], A.-M. Harri[15], M. Hieta[15], R. Hueso[7], M.T. Lemmon[11], A. Lepinette[1,3], M. Marin[1,3], J. Martin-Soler[1,3], G. Martinez[13], A. Molina[1,3], L. Mora[1,3], S. Navarro[1,3], C. Newman[14], V. Peinado[1,3], S. Pérez-Hoyos[7], J. Pla-García[1,3], O. Prieto-Ballesteros[1,3], S.C.R. Rafkin[19], M. Ramos[16], J. Romeral[1,3], K. Runyon[18], A. Saiz-Lopez[17], A. Sanchez-Lavega[7], E. Sebastian[1,3], M.D. Smith[10], R.J. Sullivan[4], L.K. Tamppari[2], D. Toledo[3], J. Torres[1,3], R. Urqui[1,3], Á. Vicente-Retortillo[1,3], D. Viudez-Moreiras[1,3], S. Zurita[1,3] and MEDA team. [1]Centro de Astrobiologia (INTA-CSIC), Madrid, Spain; [2]Jet Propulsion Laboratory, Pasadena, CA, USA; [3]Instituto Nacional de Tecnica Aeroespacial, Madrid, Spain; [4]Cornell Center for Astrophysics and Planetary Science, Cornell University, NY, USA; [5]Instituto de Microelectronica de Sevilla (US-CSIC), Seville, Spain; [6]Carnegie Institution for Science, USA; [7]University of Basque Country, Bilbao, Spain; [8]Universidad Politecnica de Cataluña, Barcelona, Spain; [9]Universita degli Studi di Padova, Padova, Italy; [10]NASA Goddard Space Flight Center, Greenbelt, MD, USA; [11]Space Science Institute, Boulder, CO, USA; [12]University of Michigan, Ann Arbor, MI, USA; [13]Lunar and Planetary Institute, Houston, TX, USA; [14]Ashima Research, Pasadena, CA, USA; [15]Finnish Meteorological Institute, Helsinki, Finland; [16]University of Alcala, Alcala de Henares, Spain; [17]Institute Physical-Chemistry Rocasolano (CSIC), Madrid, Spain; [18]John Hopkins Applied Physics Laboratory, MD, USA; [19]Southwest Research Institute Boulder, CO, USA.

Introduction: NASA's Mars 2020 (M2020) rover mission [1] includes a suite of sensors to monitor and document the modern environmental conditions near the surface of Mars, and to constrain bulk aerosol properties from changes in atmospheric radiation at the surface. The Mars Environmental Dynamics Analyzer (MEDA) [2] consists of a set of meteorological sensors including a wind sensor, a barometer, a relative humidity sensor, a set of 5 thermocouples to measure atmospheric temperature at ~1.5 m and ~0.5 m above the surface, a set of thermopiles to characterize the thermal IR brightness temperatures of the surface and the lower atmosphere. MEDA adds a radiation and dust sensor to monitor the optical atmospheric properties that can be used to infer bulk aerosol physical properties such as particle size distribution, non-sphericity, and concentration.

MEDA's investigation: The Mars Environmental Dynamics Analyzer (MEDA) is a contributed suite of sensors designed to address the characterization of dust size and morphology, as well as monitoring the surface weather measurements. MEDA's design makes it more than a dust characterization and MET station package, as it offers synergies with the goals of other Mars2020 investigations, Mars Program objectives, and with Mars Strategic Knowledge Gap investigations.

MEDA will monitor dust properties and in-situ near-surface pressure, relative humidity, the air and surface thermal environment, wind, and the solar radiation cycle autonomously on Mars around the clock. The solar radiation sensors can track direct and diffuse radiation in a geometry that characterizes the prevailing environmental dust properties, the behavior of solar radiation on sub-diurnal time scales, and the impact of solar radiation on local photochemistry, thus supporting assessments of the preservation potential for organics on a cache sample.

Resolving dust and environmental variables over many time scales is required to (a) improve the predictive capabilities of models of the near surface environment on Mars, and (b) assess how the environment affects operational and rover engineering cycles. Therefore, MEDA's operation concept is to work autonomously and continuously with a programmable continued temporal coverage and a variable sampling rate, including during rover sleep periods.

Fig. 1 shows MEDA's elements on the rover Perseverance.

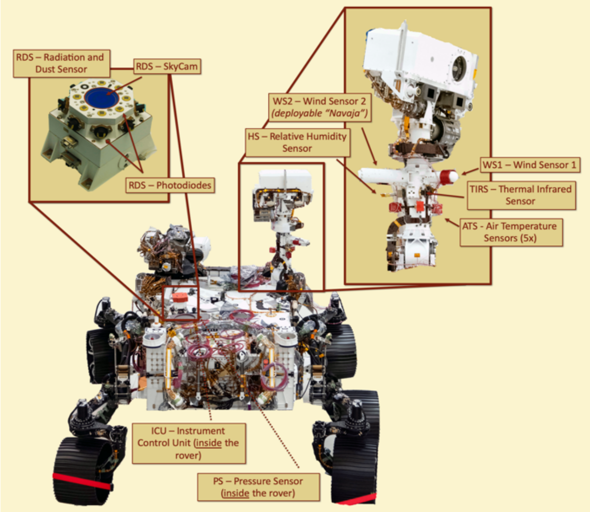
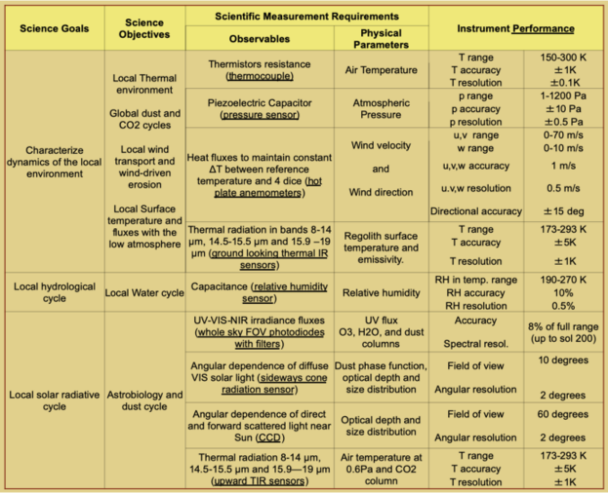


Fig 1. MEDA on Perseverance

Science Performance: The MEDA instrument shows the following performance, after being integrated on the Mars 2020 rover:



Science Goals	Science Objectives	Scientific Measurement Requirements		Instrument Performance	
		Observables	Physical Parameters		
Characterize dynamics of the local environment	Local Thermal environment Global dust and CO2 cycles Local wind transport and wind-driven erosion Local Surface temperature and fluxes with the low atmosphere	Thermistors resistance (thermocouple)	Air Temperature	T range T accuracy T resolution	150-300 K ±1K ±0.1K
		Piezoelectric Capacitor (pressure sensor)	Atmospheric Pressure	p range p accuracy p resolution	1-1200 Pa ±10 Pa ±0.5 Pa
		Heat fluxes to maintain constant ΔT between reference temperature and 4 dice (hot plate anemometers)	Wind velocity and Wind direction	u,v range w range u,v,w accuracy u.v,w resolution Directional accuracy	0-70 m/s 0-10 m/s 1 m/s 0.5 m/s ±15 deg
		Thermal radiation in bands 8-14 µm, 14.5-15.5 µm and 15.9 –19 µm (ground looking thermal IR sensors)	Regolith surface temperature and emissivity.	T range T accuracy T resolution	173-293 K ±5K ±1K
Local hydrological cycle	Local Water cycle	Capacitance (relative humidity sensor)	Relative humidity	RH in temp. range RH accuracy RH resolution	190-270 K 10% 0.5%
Local solar radiative cycle	Astrobiology and dust cycle	UV-VIS-NIR irradiance fluxes (whole sky FOV photodiodes with filters)	UV flux O3, H2O, and dust columns	Accuracy Spectral resol.	8% of full range (up to sol 200)
		Angular dependence of diffuse VIS solar light (sideways cone radiation sensor)	Dust phase function, optical depth and size distribution	Field of view Angular resolution	10 degrees 2 degrees
		Angular dependence of direct and forward scattered light near Sun (CCD)	Optical depth and size distribution	Field of view Angular resolution	60 degrees 2 degrees
		Thermal radiation 8-14 µm, 14.5-15.5 µm and 15.9—19 µm (upward TIR sensors)	Air temperature at 0.6Pa and CO2 column	T range T accuracy T resolution	173-293 K ±5K ±1K

Operations: MEDA has been designed to work continuously around the clock, logging the environmental magnitudes with the cadence and frequency that are indicated to the instrument through a certain programming, even when the rover is sleeping.

This way, the Atmospheric working group and the MEDA team will be able to adjust the instrument's activity to the power, timing and data volume restrictions set by the mission, depending on each day scenario.

MEDA's first investigation - Atmospheric context around Perseverance Entry-Descent-and-Landing: MEDA's first investigation was dedicated to collect data that would support EDL post analysis and future missions to Mars. The first sols of MEDA on the Martian surface were used to schedule health checks; the instrument used those to include atmospheric observations that could constraint the large scale atmospheric context in which M2020 performed EDL. These data will be used for post-analysis of the atmospheric models used for EDL. Like atmospheric data from previous missions, this analysis and MEDA's first results help understand the safety margin of future landing and launch maneuvers of future missions such as the Mars Sample Return mission, as well as for future Human Exploration.

MEDA entered the Mars atmosphere at Ls~ 5. The presentation will show the large scale atmospheric variability in pressure characteristic of a (calm/unstable) atmosphere with (high/low) variability sol-to-sol. There will be also an analysis of the level of sub-hourly variability encountered on Jezero at the time of landing on the first 10 sols after landing.

Measurements: Through the daily operation of the instrument throughout the mission, the team plans to record a vast amount of data to support the operation of other instruments and systems on the rover, specially the MOXIE technology; characterize the atmospheric dust size and morphology to understand its effects on the operation of surface systems and human health; and to validate the global atmospheric models.

Acknowledgments: This work has been mainly sup-ported by the Spanish Ministry of Economy and Competitiveness (under the projects ESP2014-54256-C4-1-R, ESP2015-68281-C4-1-R, ESP2016-79612-C3-1-R, and RTI2018-098728-B-C31), the Jet Pro-pulsion Laboratory (under a contract from NASA), and the Finnish Meteorological Institute.

References: [1] Farley, K.A. SSR 216 (2020) and companion papers in the same issue; [2] Rodriguez-Manfredi, et al. JA. SSR 216 (2020)