MARS SCIENCE LABORATORY (MSL) - FIRST RESULTS OF PRESSURE AND HUMIDITY OBSERVATIONS. A-M. Harri[1], M. Genzer[1], W. Schmidt[1], J. Gomez-Elvira[2], R.M. Haberle[3], N. Rennó[4], H. Savijarvi[5], O. Kemppinen[1], J. Manfredi[6], M. de la Torre Juarez[6], H. Kahanpää[1], M. Mischna[6], J. Martin-Torres[2], M-P Zorzano[2], S.C.R. Rafkin[7], M.I. Richardson[8], C. Newman[8], E. Atlaskin[1], J. Kauhanen[1], M. Paton[1], J. Polkko[1], H. Haukka[1], T. Siili[1] and the entire REMS Team. [1] Finnish Meteorological Institute, P.O.Box 503, Helsinki (Ari-Matti.Harri@fmi.fi), [2]Centro de Astrobiologia (INTA-CSIC), Madrid, Spain,[3]NASA/Ames Research Center, Moffett Field, CA 94035, [4]University of Michigan, Ann Arbor, MI 48109, [5]University of Helsinki, Finland, [6]Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109, [7]Southwest Research Institute, Boulder CO 80302, [8]Ashima Research, Pasadena CA 91106.

Introduction. The Mars Science laboratory (MSL) called Curiosity made a successful landing at Gale crater early August 2012. MSL has an environmental instrument package called the Rover Environmental Monitoring Station (REMS) as a part of its scientific payload. REMS comprises instrumentation for the observation of atmospheric pressure, temperature of the air, ground temparature, wind speed and direction, relative humidity, and UV measurements. The REMS instrument suite is described at length [1]. We concentrate on describing the first results from the REMS pressure and humidity observations and comparison of the measurements with modeling results.

The REMS pressure device: The REMS pressure device is provided by the Finish Meteorological Institute. It is based on silicon micro-machined capacitive pressure sensors developed by Vaisala Inc. The pressure device makes use of two transducer electronics sections placed on a single multi-layer PCB inside the MSL payload bay with

a hepa-filter-protected ventilation inlet to the ambient atmosphere (Fig. 1). The absolute accuracy of the pressure device is < 3 Pa and zero-drift < 1 Pa/year enables the investigations of long term and seasonal cycles of the Martian atmosphere. The pressure device has special sensors for very high

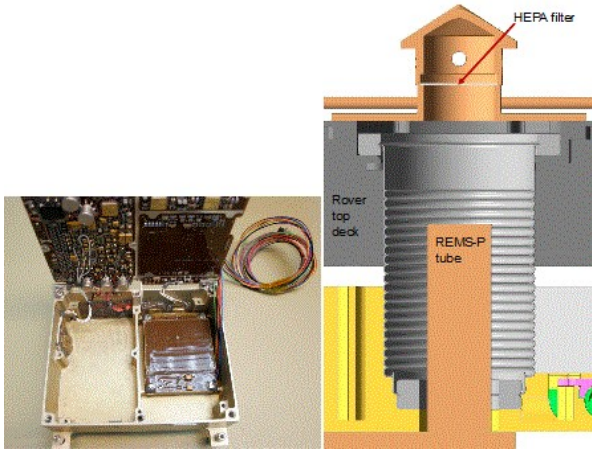

Fig 1. pressure device is accommodated inside the REMS electronics with a ventilation tube connection to the ambient atmosphere.

precision of less than 0.2 Pa that makes it a good tool to study short-term atmospheric phenomena, e.g., dust devils and other convective vortexes.

The REMS humidity device: The REMS humidity device is provided by the Finish Meteorological Institute. It is based on polymeric capacitive humidity sensors developed by Vaisala Inc. The humidity device makes use of one transducer electronics section placed in the vicinity of the three (3) humidity sensor heads. The humidity device is mounted on the (MSL) boom (Fig. 2) providing ventilation with the ambient atmosphere through a filter protecting the device from airborne dust. The absolute accuracy of the humidity device is temperature dependent, and is of the order of 2% at the temperature range of -30 to -10 C, and of the order of 10% at the temperature range of -80 to -60 C. This enables the investigations of atmospheric humidity variations of both diurnal and seasonal scale.

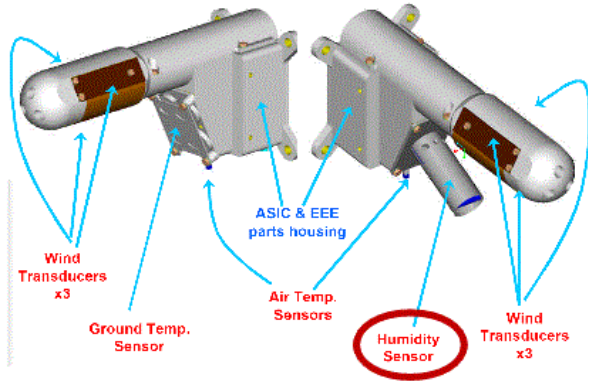

Fig 2. humidity device is mounted on the (MSL) boom at the altitude of about 1.5 meters above the ground providing ventilation with the ambient atmosphere through a filter protecting the device from airborne dust.

The humidity device measurements will have a lag, when a step-wise change in humidity is taking place. This lag effect is increasing with decreasing temperature, and it is of the order of few hours at the temperature of -75 C. We have developed a compensation algorithm to compensate for the lag effect.

Timing of Observations: The REMS instruments are making observations nominally for a period of 5

minutes each hour. During those observation windows the instruments are measuring at the rate of one sample per second for each atmospheric parameter. REMS has also an extended mode, where data will be acquired for longer time blocks, e.g., continuously for one hour. The actual observation time allocated for REMS depends on availability of power, data volume and many other issues dictated by the MSL system. Consequently, the daily observation time of REMS has been ranging between 2 to almost 10 hours per sol.

Pressure and Humidity results: The observed MSL pressure and humidity data enable us to understand both the long term and short term phenomena of the Martian atmosphere by adding to the knowledge gathered by earlier Mars missions and modeling experiments [2]. Both pressure and humidity observations are revealing new information on the local atmosphere and climate at Gale crater, and will shed light on the mesoscale and micrometeorological phenomena [3]. Pressure observations represent also planet-wide phenomena and are one key observation for enhancing our understanding of the global atmospheric flows and CO_2 cycle of the Martian atmosphere.

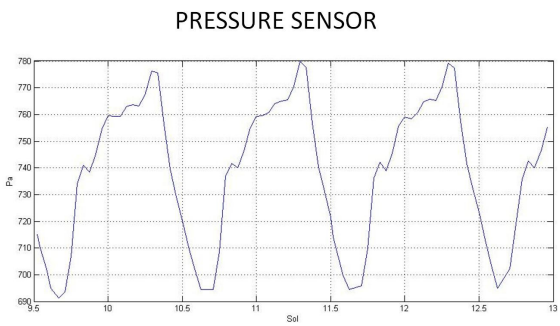

Fig 3. Pressure observations during the sols 10-13 illustrating a diurnal pressure variation of about 90 Pascals that is more than 10% of the atmospheric surface pressure.

The surface pressure is rising at this time of the Martian season, and this is clearly seen by the MSL pressure observations. The current surface pressure is slightly over 8 hPa, which represents a rise of a few % since the beginning of the mission. Figure 3 shows the observed diurnal cycle during the early phase of the MSL mission with indications of the local Gale crater effects in the data. Figure 4 depicts the results of our Mars Limited Area Model (MLAM) at Gale crater site during the time of MSL landing. These model runs produce similar results to the observations with some deviations. They are currently under investigation.

The humidity observations were validated after tedious efforts. This was needed to compensate for the artifacts of the transducer electronics. The results appear to be convincing and are aligned with earlier observations of the total atmospheric precipitable water contents as well as with the modeling results [4].

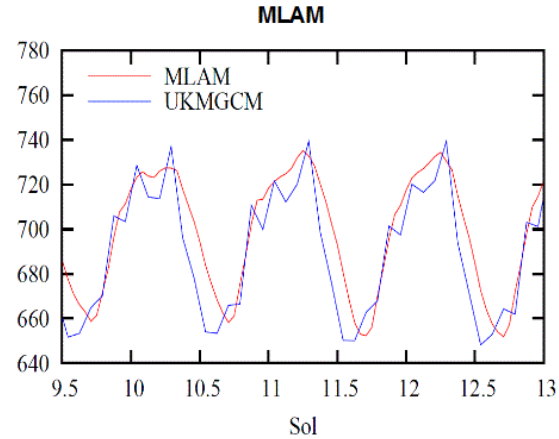

Fig 4. Atmospheric surface pressure (shown in Fig. 3) simulated by the Mars Limited Area Model (MLAM) by FMI/UH.

The preliminary relative humidity observations are presented in Figure 5 for the MSL sols 15 to 20.

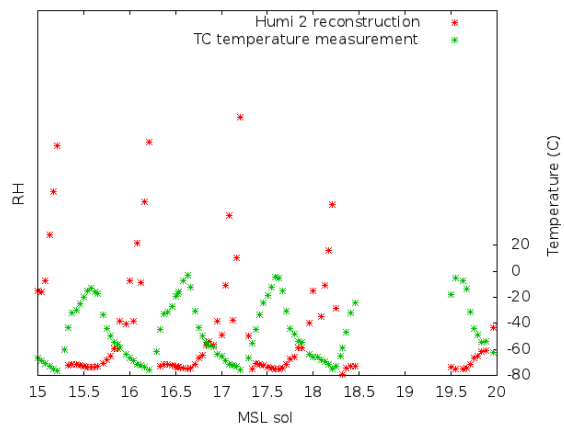

Fig 5. humidity device results for the sols 15-20 after taking into account lag compensation. The level of highest humidity here is still under saturation (TBA %RH).

Discussion: The pressure observations of the REMS instrument onboard the MSL appear to be of excellent quality. Humidity results are still under validation. The first results are supported by results of earlier Mars missions, and are also giving new insight into the atmospheric conditions at Gale crater. Observations are aligned with our modeling results that will shed light also on the atmospheric conditions beyond Gale crater area.

References:

[1] Gómez-Elvira J. et al. (2012), Space Sci. Rev. 170, 583-640. [2] Haberle, R.M. et al. (2013) Mars, submitted. [3] Smith, M. et al. (2006), J. Geophys. Res., 111, E12S13. [3] Savijarvi et al., 136, issue 651, 1497-1505.