MICROMETEOROLOGICAL STATION AT THE MARS ANALOG FIELD WORK, UTAH, APRIL, 2008. *Weidinger T.*[1], *Istenes Z.*[2], *Hargitai H.*[3], *Tepliczky I.*[4], *Bérczi Sz.*[3], [1]Eötvös University, Dept. of Meteorology, Budapest, Pázmány P. s. 1/A, Hungary, [2]Eötvös University, Dept. of Programming Theory and Software Technology, H-1117 Budapest, Pázmány P. s. 1/C, Hungary, [3]Eötvös University, Institute of Physics, Cosmic Materials Space Research Group, H-1117 Budapest, Pázmány P. s. 1/A, Hungary, [4]Hungarian Astronomical Association, Polaris Observatory, H-1037, Budapest, Laborc u. 2/C. (weidi@ludens.elte.hu, istenes@inf.elte.hu, hhargitai@gmail.com, tepi@mcse.hu, bercziszani@ludens.elte.hu)

Introduction: The planetary boundary layer is the bottom layer of the atmosphere, which suffers from mechanical and thermal effects from the planetary surface. Planetary means that on all other planets which is surrounded by atmosphere as physical laws generate the structure of this type of layer as are well known from Earth. We find on all these planets near logarithmic profiles of wind, temperature and trace gases in the bottom 10–100 m deep layer. Above this layer one can find the called wind-veering layer (or Ekman-layer), where the friction force gradually decreases with height – the wind gradually turns right with height. This layer is deeper during daytime (due to the presence of both thermal and mechanical turbulences) and shallower at night (due to the presence of only mechanical turbulence in the lack of thermal mixing). Aloft the Ekman-layer the free atmosphere is located.

Upon the establishment of a meteorological station one has to work in a uniform way, either in case of a synoptic station in the country (which reports operational meteorological data every hour) or in case of a background climatic station (which studies the long range effects of climate variability) [1], or even in Martian measurements [2].

There are similar challenges for micrometeorological station on any terrestrial planets surrounded by atmosphere:

(i) Generation long time-series of the main physical parameters (temperature, humidity, wind speed, wind direction, atmospheric pressure, precipitation, cloud cover, solar radiation) and also determination of their daily and yearly variations;

(ii) Measurement of radiation balance components, i.e., shortwave or global radiation (G), photosynthetic active radiation (PAR) and net radiation (the balance of short wave and long wave radiation, Rn);

(iii) Determination energy budget of the soil including heat flux into the soil (G_s), underground temperature and humidity profile, and the heat flux into deeper layers under the surface (e.g., using heat flux plates);

(iv) Determination of surface energy budget components, that is, the quantification of the surface energy balance equation:

$$Rn = H + LE + G_s \, .$$

were H is sensible heat flux, LE is latent heat transport, (in terrestrial environments this is water vapor flux, on Mars it can be the sublimation (positive), or deposition (negative) of CO_2. The net radiation and the heat flux into the soil is positive, if the heat transport is performed downward. (For example daytime, when irradiation energy is larger than the emission, the heat is transported into the soil. The sensible and latent heat fluxes are positive, when turbulent eddies transport the energy upward.) The transport is performed by the eddies with size scales proportional to their height above the surface.

In order to determine the turbulent heat fluxes (H, LE), and the momentum (τ), or any trace gas fluxes (F_c) various micrometeorological measurement methods are known [1], as eddy covariance method, gradient and profile techniques or Bowen-ratio method. For the determination of energy balance parameterization methods standard meteorological measurements are commonly used [3].

The measurement system: In April, 2008, the 71-th crew of the Mars Desert Research Station, (MDRS) had Hungarian members. Building of and working with a meteorological station was essential in the scientific program. Above listed (i–iv) requirements were satisfied by the instrumentation, computer data acquisition and control system in order to carry out the measurement program. (Heat flux into the soil was to be estimated from soil temperature profile and soil physical parameters.)

Measurement system setup was designed by program leader *Henrik Hargitai*. Computer data acquisition and control system was designed and realized by *Zoltán Istenes* [4].

Below we show the structure of the setup and the instrumentation of the micrometeorological station first, we illustrate the desert environment by presenting daily run of several meteorological parameters.

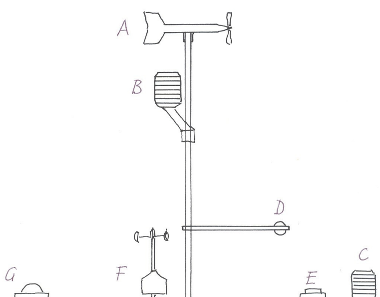

Fig. 1. The micrometeorological station at Utah

The micrometeorological station (HUNMET): The main task of the station was to carry out standard meteorological measurements, together with measurements of radiation balance components and surface energy balance parameters (using both gradient and Bowen-ratio methods). Wind speed, temperature and humidity were also measured at two levels. Mean, minimum, maximum and standard deviation of data were registered every five minute. Sampling rate was 10 sec

[4]. The measurement system is shown on Fig. 1. Each unit is labeled as follows:

A: wind-speed and wind direction, (Young),
B: temperature and relative humidity (Vaisala) – upper,
C: temperature and relative humidity (Vaisala) –lower,
D: net radiation, Rn (Q7 Rebs),
E: photosynthetic active radiation (Kipp & Zonen),
F: wind-speed (Vaisala),
G: global radiation (Schenk),
H: infrared-temperature measurement unit (Campbell),
I: leaf-wetness grid (Campbell),
J: solar panel,
K: computer data acquisition and control system,
L: soil temperature (2, 5, 10, 30 cm) (termistor, Campbell).

Fig. 2. Build-up the HUNMET station at Utah.

Measurements at the MDRS: The station (*Fig. 2.*) worked well, collecting continuous data for 10 days of operation. Data was online available at the Mars Base and at the Eötvös University Budapest, in order to carry out preliminary data control and for making proposals to the relocation of instruments (i.e. shielding, sensor distance at gradient measurements, etc.) during the campaign. Cloud cover information was collected every half hour with a sky observing web cam.

Processing of the Utah MDRS measurement data: First step was the systematization of the database, the quality control of the measurements compared to physical principles. Next was the determination of turbulent fluxes based on the Monin-Obukhov similarity theory. Then came the calculation of both ground heat flux and components of the energy budget. The next step was comparison of the data of different days, then analysis of the components of the surface energy budget. The existence of the dataset gave opportunity for the comparison of near surface layers of temperate belt and desert environments, comparison of terrestrial and Martian conditions [5] and to show the differences between the two planetary environments. Martian space probe measurements are looking for answers to similar questions we studied.

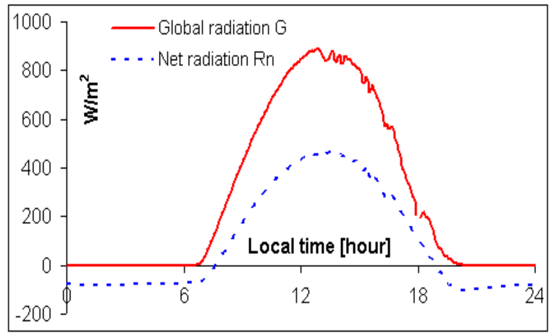

Fig. 3. The average solar irradiation (G) and the radiation balance (Rn) during the first 5 days in Utah.

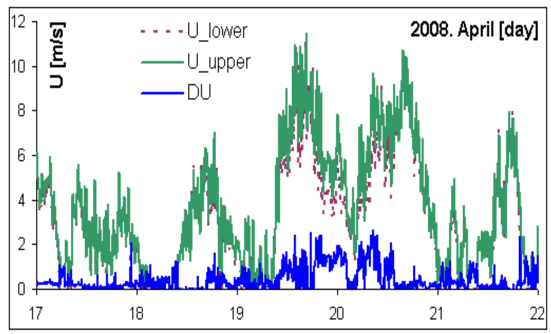

Fig. 4. Wind-speed measurements at two levels.

Global radiation at noon was well above 900 W/m^2. Because of the large albedo and high temperature of the sandy surface, net radiation values were relatively low. In the morning the global radiation „run" is clear, the fluctuation (appearing even in the average data) during the afternoon is caused by clouds. In Fig. 4. wind speed data are shown. On 19 and 20 April there was a windstorm. The wind speed gradient is of course positive.

Summary: The HUNMET (Hunveyor-10) measurement system developed at Eötvös University fulfilled the requirements on the Utah desert MDRS Base.

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