"Humboldt Kolleg"
Technologies and Threats of the 21-st Century –
physical, biological, informational and social aspects
Kishinev, Moldova, September 15-18, 2006

Atmosphere and Solar Radiation Observations at the Ground-Based Radiation Monitoring Complex in Moldova

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ABSTRACT
Description of the ground-based solar radiation monitoring complex is presented. Complex is equipped with the state-of-the-art solar radiation sensors, sun-tracking unit and electronics, sunphotometer, ozonometer, and automatic weather station. Total ozone content in column of atmosphere, solar broadband irradiances from UV-B to the far IR, spectral aerosol optical thickness, retrieved column integrated aerosol optical and microphysical characteristics, and main surface meteorological elements are measured at this ground station. Some preliminary results of atmosphere and solar radiation observations carried out at the ground based solar radiation station are presented.

EQUIPMENT AND MEASUREMENTS

In September 2003, for the first time in Moldova it was developed and established a ground-based multifunctional solar radiation monitoring complex [1]. The complex is placed in an urban environment at the Kishinev site (see Fig. 1) with coordinates: φ=47.0013^{0}N, λ_o= 28.8156^{0}E, h=205 m a.s.l. All instrumentation was mounted on the roof of the building of the Institute of Applied Physics, Academy of Sciences of Moldova. Complex is composed from the state-of-the-art solar radiation sensors, data logger CR10X-4M and automatic solar tracker unit 2AP BD (Kipp&Zonen) and it was separately assembled in two main sub-units (see Fig.1): moving platform (to measure diffuse and direct components of solar radiation) and stationary platform (to measure global component of solar radiation). This complex is used for long-term continuous monitoring of solar broadband irradiance at the Earth's surface in a wide wavelength bands from UV to IR. Sample rate and interval of averaging were selected as 1 sec and 1 minute, respectively, for each of the sensor. Data sets stored in memory module SM4M are regularly transferred to the remote PC located in Laboratory. Flow of raw data averaged for 1-minute interval and hourly totals from each of solar sensors amounts to 6 Mb/month.

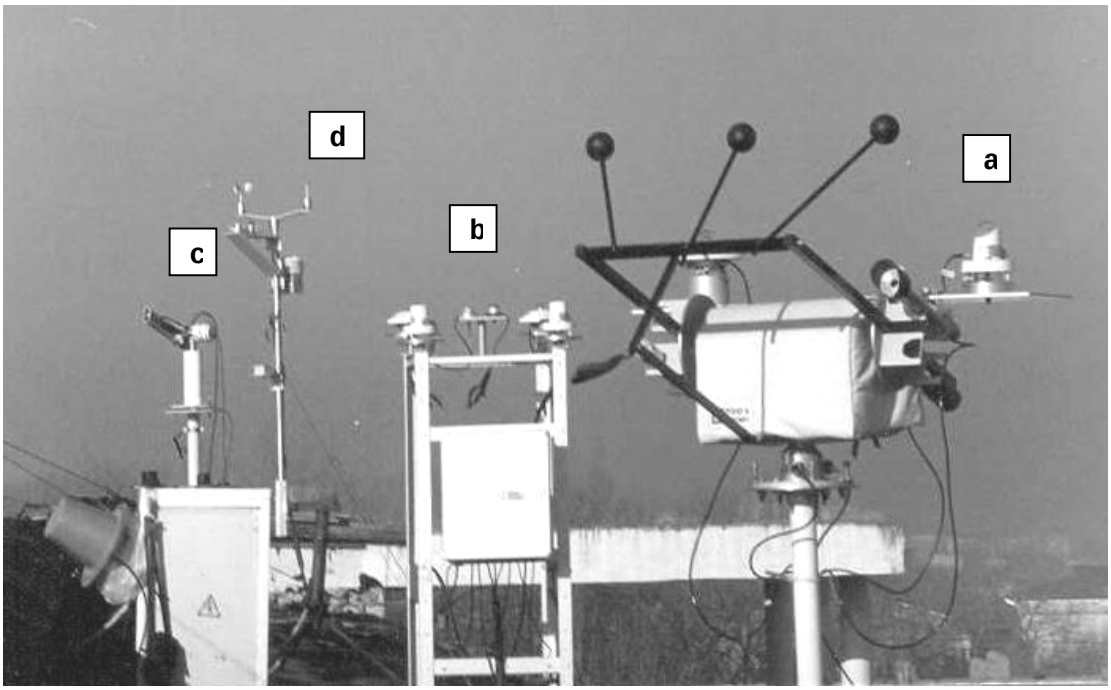

Figure 1. Ground-based solar radiation monitoring station in operation at the Kishinev site. Solar monitoring station consists of radiometric complex with moving (a) and stationary (b) platforms, sunphotometer Cimel-318 (c) and automatic weather station MiniMet (d).

The set of solar radiation sensors in use at the solar radiometric complex, description of measured values and broadband wavelength ranges are presented in Table 1. The solar radiation sensors are of the Secondary Standard and First Class. Radiometric complex is currently used to carry out continuous and simultaneous measurements of diffuse, direct and global components of shortwave solar radiation and global longwave atmospheric radiation. A set of sensors UV-S-B-C, CM-11 and CH-1 is utilized to make measurements of diffuse and direct components of solar radiation. These sensors are placed on the moving platform from the automatic solar tracking unit 2AP BD. Another set of sensors is mounted on the stationary platform placed at a distance of 6 meters apart from the moving platform. These sensors are used to carry out measurements of global downwelling components of solar and atmospheric radiation. Time series of monthly totals and duirnal variation of global and diffuse components of solar radiation on horizontal plane are shown in Figure 2 and 3, respectively.

Table 1. Solar radiation sensors used in ground solar radiometric complex

Type of sensor	Measured components	Radiation	wavelength range
UV-S-B-C	diffuse, global	UV-B radiation	280 - 315 nm
UV-S-A-C	global	UV-A radiation	315 - 400 nm
PAR Lite	global	Photosynthetically active radiation	400 - 700 nm
SP Lite	global	Visible and near infrared radiation	400 - 1100 nm
CM-11	diffuse, global	Solar radiation	305 - 2800 nm
CH-1	direct	Solar radiation	200 - 4000 nm
CG-1	global	Atmospheric (longwave) radiation	4,5 - 42 μm

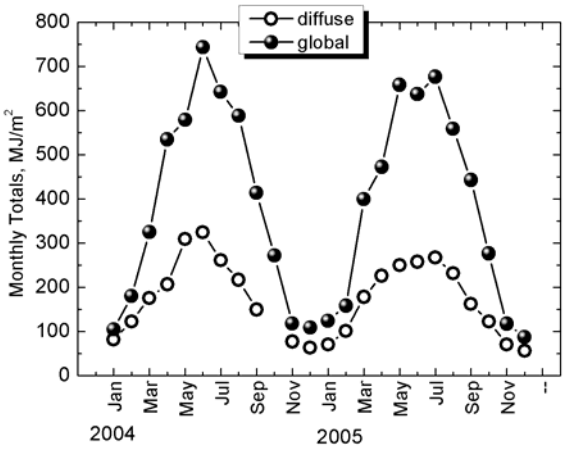

Fig. 2. Time series of the monthly totals of the global and diffuse solar radiation (305-2800 nm) measured at the Kishinev site from 2004 to 2005.

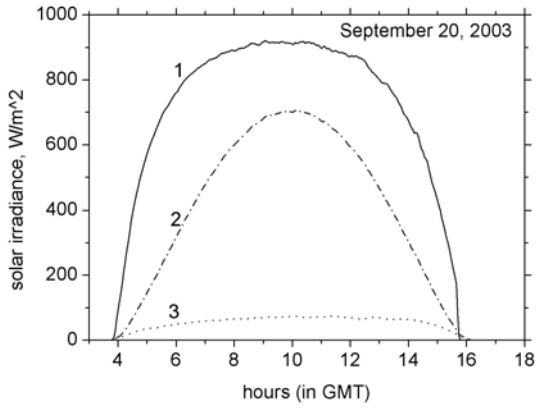

Fig. 3. Diurnal variation of the direct (1), global (2) and diffuse (3) components of the solar radiation on horizontal plane.

Since 1999, Moldovan research group has been using sunphotometer Cimel CE-318 (see Fig. 4) in their research activity and carrying out regular measurements of the direct sun radiance at 7 wavelengths in visible spectrum from 340 to 1020 nm, sky radiance in almucantar and in solar principal plane at 4 wavelengths from 440 to 1020 nm. These data are used to retrieve the columnar integrated optical and microphysical properties of atmospheric aerosols such as spectral aerosol optical thickness (see Fig. 5), Angstrom exponent (as a parameter of spectral dependence of the aerosol optical depth), volume size distributions, complex refractive index of particulate matter, and single scattering albedo. This sunphotometer is in operation within the framework of the global international Aerosol Robotic Network (AERONET) program under supervision of the NASA/GSFC (http://aeronet.gsfc.nasa.gov) [2,3].

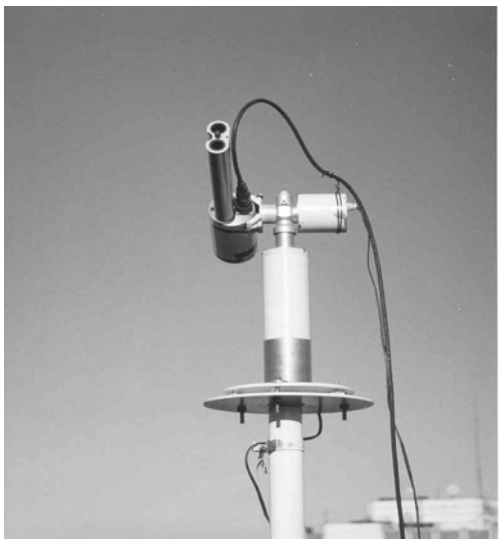

Fig. 4 Sunphotometer CIMEL 318 in operartion at the Kishinev site (within the framework of the AERONET programe).

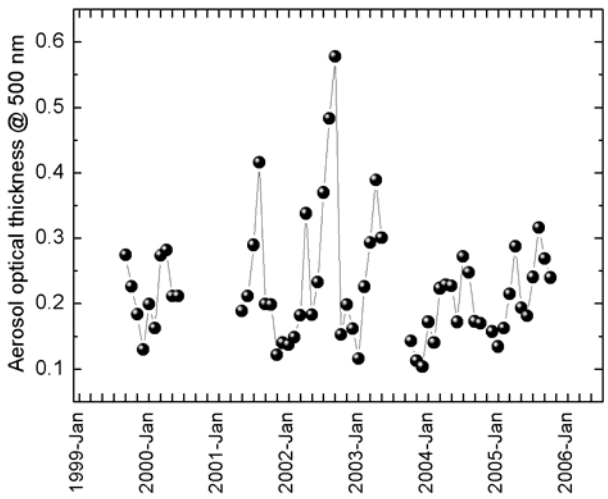

Fig. 5 Time series of monthly mean values of the aerosol optical thickness at 500 nm observed at the Kishinev site during September 1999-December 2005.

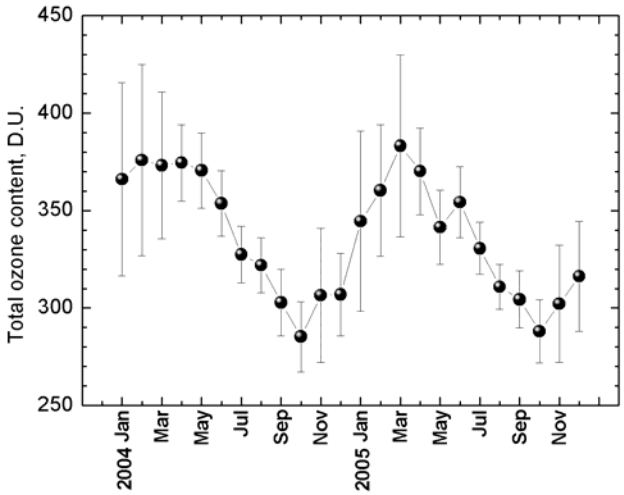

Fig. 6 Time series of the monthly mean values of total ozone content measured with MICROTOPS II ozonometer at the Kishinev site during of the 2004-2005.

Measurements of the total ozone content (TOC) in the column of atmosphere are made on a regular basis at the Kishinev site. The measurements are carried out with the hand-held ozonemeter MICROTOPS II Ozonemeter, Solar Light Co. This instrument, equipped with the highest grade and long stability filters (with ion-beam assisted deposition) at λ= 305, 312, 320, 936 & 1020 nm, which embedded into a solid cast aluminum housing to assure accurate and stable optical alignment. MICROTOPS II Ozonemeter has a low noise electronics and 20 bit A/D converter to give an accuracy (< 2% for ozone) comparable to much larger and more expensive instruments such as Brewer and Dobson spectrophotometers. MICROTOPS II is a hand-held device for simultaneous measurements of direct solar ultraviolet radiation at 3 discrete wavelengths within UV-B range and TOC, accurately and dependably, and also for measuring total water vapor at fixed channel with 936 nm and aerosol optical thickness at 1020 nm. Variability of the monthly mean values of total ozone content measured with MICROTOPS II ozonometer at the Kishinev site during of the 2004-2005 are shown in Figure 6.

Fig. 7. Automatic meteorological station MiniMet in operation at the Kishinev site

Radiometric data are supplied with the main meteorological elements such as air temperature, relative humidity of air, atmospheric pressure, wind mean velocity and direction, and solar irradiance in spectral wavelength ranges 280-315 nm and 400-1100 nm. Main meteorological elements are obtained from the automatic weather station MiniMet, Skye Instruments, Ltd., U.K. The system has seven active channels connected with the meteorological sensors. Each channel can be individually configured from the remote PC. Sample rate and interval of averaging were selected as 10 sec and 5 minute, respectively. Data acquiring, preliminary processing and store is fulfilled by data logger DataHog2. The overall raw data flow consists of 1.5 Mb/month. Automatic weather station MiniMet is arranged at a distance of 30 meters apart from the solar radiation measuring

complex. Meteorological observations carried out at the ground station during 2004-2005 are presented below (see Fig. 8 and 9)

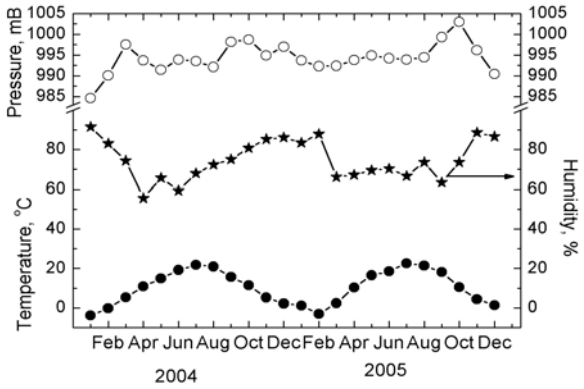

Fig. 8. Time series of monthly mean values of the air temperature and pressure, and relative humidity observed at the ground station during 2004-2005.

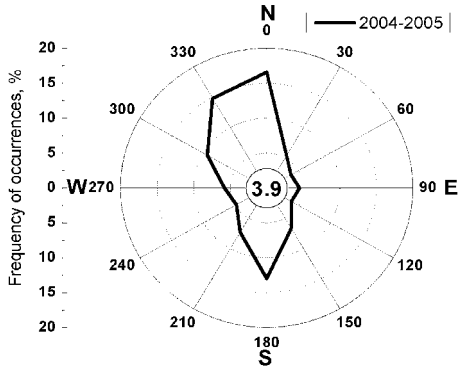

Fig. 9. Combined wind rose observed at the ground station during 2004-2005. Frequency of occurrence of calm episodes is shown in the center of figure.

Output products from the long-term continuous observations made at the ground based solar radiation monitoring station are submitted to the AERONET and SolRad-Net databases, managed by NASA/GSFC, to the WMO World Data Centers such as World Ozone and Ultraviolet Radiation Data Centre (WOUDC), Toronto, Canada and World Radiation Data Centre (WRDC), St. Petersburg, Russia. Solar radiation monitoring station in Kishinev was registered in Global Atmosphere Watch Station Information System (GAW SIS) as a Regional fixed station in WMO RA VI – Europe managed by Swiss Federal Laboratories for Materials Testing and Research (EMPA), Dübendorf, Switzerland.

ACKNOWLEDGEMENTS

The work was funded in part by the U.S. Civilian Research &Development Foundation (CRDF) and the Moldovan Research and Development Association (MRDA) through grant #ME2-3033.

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