Report of Ongoing and Planned Ozone and Ultraviolet Radiation Activities in Estonia

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By Kalju Eerme,
Tartu Observatory

1. OBSERVATIONAL ACTIVITIES

Most of systematic monitoring of atmospheric ozone and UV solar radiation in Estonia is performed at Tõravere (58° 15' N, 26° 28' E, 70 m a. s. l.), where the research institute Tartu Observatory and the Tartu-Tõravere Meteorological Station of the Estonian Meteorological and Hydrological Institute (EMHI) are located. Research areas of the Tartu Observatory are astrophysics and atmospheric physics. The meteorological station belongs to the Baseline Surface Radiation Network (BSRN) and is specialized on solar radiation measurements. Scientific work on ozone and UV radiation is performed since early 1990s at the department of atmospheric physics of Tartu Observatory. Different auxiliary regular measuremants like aerosol and cloud data collection are also performed at the same location. Since 2002 sun photometer of NASA AERONET measuring column aerosol optical depth (AOD) operates there and the group of aerosol studies of University of Tartu performs atmospheric aerosol size distribution measurements. The landscape pattern around consits of arable fields, grassland areas and patches of coniferous forest. It may be considered typical to Estonia.

1.1 Measurements of column ozone

Most of research work using column ozone is based on satellite data. Local column ozone measurements at Tõravere have been rather episodic. Regular direct sun column ozone measurements have been carried out in 1994-1999 using specially suited laboratory spectrometer SDL-1 supplied with a mirror system and Dobson retrieval algorithm. Since 2003 direct sun column ozone measurements are performed using MICROTOPS-II instrument. The average ratio of MICROTOPS-II to OMI values has been 1.002 with SD ± 2.3 %. In summer season SD is approximately ± 8 DU.

1.2 Profile measurements of ozone

No profile measurements of ozone have been performed in Estonia.

1.3 UV measurements

1.3.1 Broadband instruments

All the solar radiation measurements with filter instruments are performed at the Tartu-Tõravere Meteorological Station under scientific supervising by research scientists of Tartu Observatory. The first broadband instrument erythemally weighted sensor UV-SET operates since January 1998. The locally developed, manufactured and tested broadband UV-A and erythemal sensors on the basis of the solar blind phototube with caesium telluride photocatode were installed in 2002. Kipp & Zonen broadband UV-A sensor as well as YES broaband UV-B sensor were operate since 2005. An handheld erytheme UV meter Solar Light PMA 2200 is used as a transfer instrument.

1.3.2 Narrowband filter instruments

Kipp & Zonen narrowband filter instrument CUVB 1 with effective wavelength 306±0.2 nm and bandwith 2±0.5 nm operates at Tartu-Tõravere meteorological Station since 2002. Similar UV-B instruments are installed at two other meteorological stations Tallinn-Harku (59°26' N, 24°45' E) and Pärnu (58°23' N, 24° 38' E).

1.3.3 Spectroradiometers

Spectral measurements of solar UV radiation are performed by Tartu Observatory at the same location with filter instruments. Since 2004 UV spectra are collected by Avantes Inc. simple array minispectrometer AvaSpec-256. A quartz fiber of 4 m length and 100 μm diameter connects the optical input diffuser to the spectrometer inserted to special refrigerator weather box and kept at the temperature +7° C. An UFS-5 glass optical filter was installed between the diffuser and fiber to reduce the stray light inside the spectrometer and to guarantee a reliable recording of signal in the whole UV range. For the reliable recording of noise level the optical interface is periodically covered by a shutter before and after each measurement cycle. Control of the sensitivity for the uniform recording of spectra is realized through the change of integrating time within the interval 1 to 60 s.

In 2008 purchising of spectrometric system based on Bentham Instruments Ltd. DMc150F-U double monochromator was realized by funding of the EC REGPOT project EstSpacE. The system was installed by early 2009 and is used for recording of the solar UV spectra range 280-400 nm. By both systems the spectra are recorded regularly with a period of 15 minutes.

1.4 Calibration activities

The broadband instruments operated by EMHI need regular recalibration and intercomparison. Problems with funding restrict these activities. For the classical broadband solar radiation sensors the problem is solved. During the period of UV measurements the Eppley Labor Inc. pyrheliometers and Kipp & Zonen pyranometers were used as the broadband solar radiation sensors. The intercalibration of sensors is regularly performed in the World Radiation Center (Davos, Switzerland). Between the campaigns, the absolute radiometer PMO-6 nr. R850405 is used as a secondary standard for regular assurance of the calibration.

Calibration of optical instruments has been performed at Tartu Observatory during several decades. The calibration is based on the tungsten-halogen standard lamp FEL calibrated by Oriel traceable to NIST. An absolute radiometer PMO-6, previously established as the reference instrument for solar radiometry, was used for comparison of FEL lamps in the laboratory.

A program for compensatory calculation of the stray light influence of the array spectrometer AvaSpec-256 was applied. The slit-scattering function of the spectrometer was measured directly using a 450 W xenon arc source and monochromator at the Metrology Research Institute, University of Helsinki (Finland). The stray-light level of the AvaSpec-256 spectrometer is rather high (0.1-1 %), but the slit-scattering function is symmetrical and without noticeable artefacts. The uncertainty estimation of the stray-light correction is based on empirical comparison of the simplified algorithm and deconvolution over the set of measured spectra. For the Bentham spectrometer the calibrator CL 6 is regularly used for checking the sensitivity. The source is checked in laboratory of Tartu Observatory.

2. RESULTS FROM OBSERVATIONS AND ANALYSIS

Most of recent work in Estonia has been pointed to the studies of spectral composition of the UV doses. Different environmental, biospheric, and health effects as well as influences on atmospheric photochemistry depend on UV spectral composition. The net effect of UV radiation on biological systems is a result of balance between damage and repair which depends on the intensity and duration of irradiance and is modulated by its variability. UV radiation in the lower atmosphere is closely associated with stratospheric ozone, while air pollution and atmospheric composition are strongly influenced by UV radiation. Environmental effects of the UV-B irradiance at any site depend strongly on the availability of direct sunshine and on solar elevation. In quantifying the effects of UV radiation and possible biospheric responses, adequate estimation of doses weighted by action spectra is a necessary precondition. At the site of Tartu Observatory the necessary auxiliary data extend back to 1955 and allows to reconstruct action specta weighted UV doses.

Despite the fact that the most widely met low and medium level overcast cloudiness is seemingly the most stable attenuating medium for the UV radiation, its cloud modification factor (CMF) for most frequently met cloud types varies in wide ranges. In the most UV radiation rich season when local noon SZA remains in range between 35^o and 45^o, the average CMF for overcast days appeared to be around 0.33 in the UVB range and 0.35 in the UVA range, manifesting a relatively large contribution of optically thick frontal clouds. No clear difference in the influence of SZA on CMF between low level (*St, Ns)* and medium level (*As, Ac*) overcast cloudiness has been found. The aerosol attenuation during large AOD episodes was found comparable to that of medium level clouds. The major difference is that the aerosol attenuation decreases with wavelength in the whole UV range and in the UVA range has wavelength dependency opposite to that of attenuation by clouds.

The the work was addressed to potential collaboration with the researchers of UV effects. The health effects depend more on the human behaviour than on the availability of UV radiation. According to the medical study of random selection of 367 individuals performed in the Department of Internal Medicine University of Tartu in winter 73 % in summer 29 % of them had serum 25(OH)D insufficiency. The study of influence of UV-B radiation on the antioxidant anthocyanines content in blueberries and strawberries performed in the Department of Horticulture of the Estonian University of Life Sciences is in initial stage but the effect of UV-B radiation on the antioxidant content is evident. In the Estonian Environmental Research Institute the monitoring of air pollution and stone material corrosion manifested obvious effect on UV-B radiation.

3. THEORY, MODELLING, AND OTHER RESEARCH

Most of the analysis of UV data has been based on statistical methods. In particular cases the radiative transfer calculations using LibRadtran codes have been performed. In statistical trend analyses the conventional mean is widely used as a central tendency measure. The analysis performed at the Tartu Observatory has shown that in the case of monthly distributions of the ratio daily relative global irradiance to its normal clear value the distributions are asymmetric and the central tendency will be underestimated in summer months and overestimated in winter months. Trimean or median are more robust measures of central tendency. Also the AOD measured by the NASA AERONET sun photometer is distributed asymmetrically and the conventional mean overestimates its typical value by about 25 %.

4. DISSEMINATION OF RESULTS

4.1 Data reporting

The local database of AvaSpec-256 UV spectra has been built in compliance with the EDUCE standard. Raw spectrometer output data as well as the calibration coefficients are recorded in the MySQL database. Calibration coefficients are regularly updated. For inspecting and analyzing the spectra, a web-based interface was created using the PHP programming language. During database query, all the necessary calculations are performed, e.g. correcting for the dark signal and stray-light and applying of the radiometric calibration. Calibration coefficients are interpolated linearly for any given time. The recording of spectra measured by Bentham spectrometer is performed using the software Benwin+. During the first year of measurements there have been some problems with jumping of scale. For that reason the recorded spectra still have been not transformed from the local databases to the European UV Data Base.

4.2 Information to the public

Short texts (about one page each) containing necessary information about atmospheric ozone, UV radiation and recommendations on the optimal behaviour for safe sunshine are available on homepage of Tartu Observatory (http://sputnik.aai.ee/koduleht/). A graph showing the advance of UV-index during current day is also available. The value of UV index is automatically integrated from the recorded spectra. The EMHI homepage presented a daily maximum value of UV-index from UV-CET and now is going to display current value in real time. During the period May to August the press often displays materials on the UV index, on the quality of sun-glasses, on the sun protection factor and on other sunbath related problems.

4.3 Relevant scientific papers

Ansko I., Eerme K., Lätt S., Noorma M., and Veismann U. (2008): Study of suitability of AvaSpec array spectrometer for solar UV field measurements. Atmos. Chem. Phys., 8 (12), 3247-3253.

Eerme K., Veismann U., Ansko I. (2008): Solar UV radiation and nature. 31 Estonian Naturalists Congress. Planet Earth: Global and Local Problems. Eesti Loodusuurijate Selts, 24-41, Tartu (in estonian)

Koepke P., De Backer H., Bais A., Curylo A., Eerme K., Feister U., Johnsen B., Junk J., Kazantzidis A., Krzyscin J., Lindfors A., Olseth J. A., den Outer P., Pribullova A., Schmalwieser A., Slaper H., Staiger H., Verdebout J., Vuilleumier L., Weihs P.

(2008): Modelling Solar UV radiation in the past: Comparison of the algorithms and input data. Cost Action 726. Earth System Science and Environmental Management. Final Report. COST Office, Luxembourg, 94 pp. ISBN 978-92-898-0043-3,
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Roots O., Roose A., Eerme K., Teinemaa E. (2009): Developing long-term monitoring of ozone in Estonia: The mandate of the Montreal Protocol. Int. J. of Remote Sensing 30, (15&16), 4181-4194.
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Aun M., Eerme K., Ansko I., VeismannU., Lätt S. (2011): Modification of Spectral Ultraviolet Doses by Different Types of Overcast Cloudiness and Atmospheric Aerosol, Photochemistry and Photobiology 87, 461-469.

Roots O, Roose A., Eerme K. (2011): Remote sensing of climate change and long-term monitoring of air pollution and stone material corrosion in Lahemaa test site in Estonia, Int. J. of Remote Sensing (in press).

5. PROJECTS AND COLLABORATION

In 2004-2009 Estonia has participated in COST 726 action. At presesnt interest has been expressed to participate in one submitted COST proposal.

6. FUTURE PLANS

Development of methods for backward estimation of UV doses corresponding different action spectra in all weather conditions.
Searching and developing Estonian internal cooperation in quantitative studies of environmental and biospheric effects of UV radiation.

7. RECOMMENDATIONS addressed to the 8-th ORMM

It should be useful if WMO/UNEP distributes some official recommendations to the governments on the necessity to participate in intercomparisons of UV instruments like it is done in the case of pyranometers. Otherwise the UV part of solar radiation can be considered as something exotic and less important.

To emphasize the necessity of closer collaboration between the UV radiation measuring community and process biologists community to produce synergy on the influence of environmental factors on biospheric species and ecosystems.

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