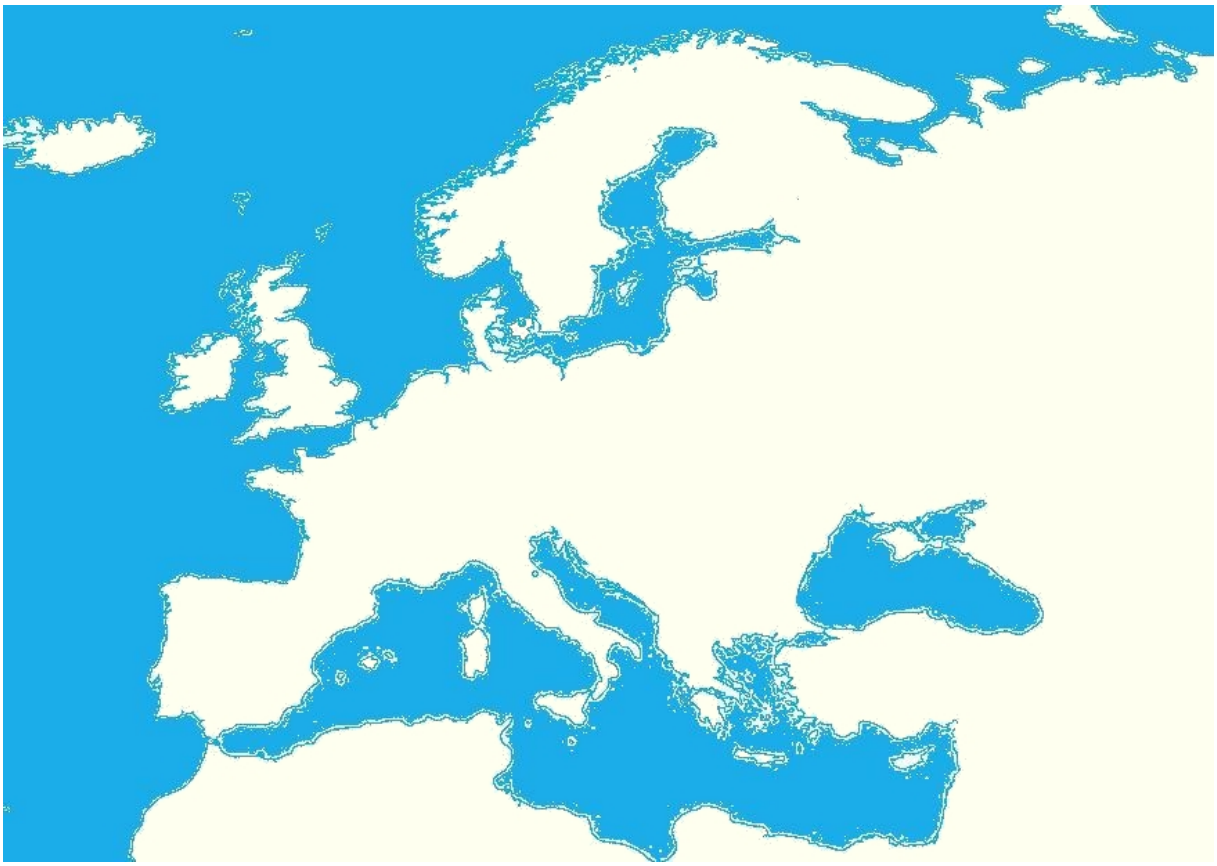

European Conference on Solar UV Monitoring

“UV Monitoring in the European Countries - Past, Present and Future”

12. - 14. September 2018

University of Veterinary Medicine, Vienna, Austria

ABSTRACTS

Federal Ministry
Sustainability and Tourism

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Aim and Scope:

The conference will provide a forum for presentations on solar UV Monitoring activities of the past, the present and for the future. This conference will also provide a forum for exchange, interrelated support and joint activities to link resources and retrieve additional value. As a significant topic of discussion, a joint visualisation of measured UV-Index values in Europe is aspired. This discussion is an item of the conference agenda.

Scientific committee:

Alois W. Schmalwieser (University of Veterinary Medicine, Vienna, Austria)

Mario Blumthaler (Medical University, Innsbruck, Austria

Julian Gröbner (PMOD, Davos, Switzerland)

Location:

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www.uv-index.org

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Wednesday 12. Sept. 2018

Needs and requirements for monitoring of UV: past, present and future perspectives for climatology and health

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Ozone depletion and climate change can influence the solar UV radiation levels relevant for health. Many health effects are associated with exposure to solar ultraviolet radiation. Sunburn, or snow blindness can occur shortly after exposure and on the long term UV-exposure can lead to skin ageing, skin cancer and cataracts. In addition to these adverse health effects some UV-exposure is necessary for vitamin D production in the skin. UV-measurements in the Netherlands started in 1993. Continuous monitoring data are available since early 1994, and a full spectral dataset since 1996. The data were used to develop and validate UV-transfer models that can be used to analyze long term trends in relation to ozone and climate changes. All measured spectra are analyzed using the SHICrivm QA/QC software package, which checks and corrects wavelength scale errors and identifies spectral abnormalities. We now compare the full 25 year measured UV-dataset with modelling approaches using ozone and pyranometer measurements, and compare these trends and changes to long term prognostic scenario calculations made previously to assess the effects of countermeasures taken under the Montreal Protocol on UV-radiation levels and skin cancer risks. UV-radiation levels in the Netherlands were shown to increase during the nineteen-eighties, peaking around the mid-nineties and were shown to slightly decline or remain stable afterwards. Separating clouds and ozone-related changes, we estimate that a slight decline in yearly available UV-doses occurred in relation to small ozone increases, but this is almost compensated by cloud changes. Comparing the overall trend in available UV, we see that the prognostic calculations from a 1996 Nature-paper are closely followed in the past decades. However, skin cancer risks in the Netherlands have increased much more than previously estimated, and much more than one would expect due to ozone depletion and ageing. Similar upward trends are reported elsewhere. A different factor must be involved and behavior is a likely candidate. A new era for the use of UV-measurements is dawning: the support of a fight against skin cancer focusing on influencing exposure behavior. So, in addition to analyzing long term trends in relation to ozone and climate changes, measurements should play a role in the public domain to increase awareness of the risks and benefits of solar UV, and thus how and when to enjoy the sun safely. The UV-index might not be the only end point that needs to be used and considered in stimulating awareness. Some examples will be proposed and discussed.

The Austrian UVB monitoring network: Data processing and Quality assurance

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Abstract: The Austrian UVB monitoring network is operational since 1998 and consists nowadays of 13 measurement sites distributed all over Austria. The sites are equipped with broadband UV biometers to measure erythemally weighted UV irradiance that is recorded continuously and transferred every 10 minutes to Innsbruck for data processing and evaluation. Routinely the dark current of the raw data is considered and then the calibration matrix, which depends on solar zenith angle and ozone amount, is applied. Next the data is compared to a clear sky model to detect and eliminate outliers that are 20% larger than the modeled values. As input for the model calculations, obtained with the radiative transfer model libRadtran, climatological aerosol optical depth is used together with local distributions of ozone levels forecasted by NOAA Global Forecast System as well as albedo maps estimated from snow height information. This routine processing is done every 5 minutes and the obtained UV Index from each station is published in near real time on the website uv-index.at. Furthermore the regional distribution of the UV Index for the whole country, based on the measurements at the sites and on cloud attenuation information calculated from Meteosat data every 15 minutes, is displayed on the website. Since solar UVB radiation is very sensitive to the actual ozone column, the raw data usually is re-evaluated after 2 days when ozone levels derived from satellite data (Aura OMI) are available. The stability of the broadband UV biometers is checked every year by means of a full calibration. Afterwards the whole data set starting from last year's calibration is reprocessed to consider the changes of the calibration of the broadband meters during the covered 12 months.

Making UV visible – Visualizing the data of the Austrian UV network

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Abstract: The Austrian UV network consists of 13 measurement stations providing real time measurements of the UV Index. These stations have been collecting data for up to 20 years. 6 additional stations of neighbouring countries deliver data to our data centre.
The website www.uv-index.at provides diagrams of the latest measurements from all 19 stations updated every 5 minutes. Also summary plots of the last day, the last week, the last month, and the last year are shown accompanied by a climatological diagram indicating the median value and maximum value of the measured UV Index for each month.
With additional data from Meteosat Second Generation a map of the spatial distribution of the UV-Index over Austria is calculated every 15 minutes. The website shows the latest map and an animated map of the temporal evolution of the UV Index of the current day. For every day starting January 1, 2005, a map of the daily maxima can be retrieved.
The evolution from a simple web page in the early years of our measurement network to the current state will we presented with an outlook to a possible future interactive platform for all data of the Austrian UV network.

German Solar UV-Monitoring Network – UV-Index Visualization for improved understanding and better everyday use

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Abstract: Since the 1990s, the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) operates a nationwide network in Germany for solar ultraviolet radiation monitoring in cooperation with Federal Environment Agency (Umweltbundesamt), Germany's National

Meteorological Service (Deutscher Wetterdienst) and other associated institutions. Currently, the network includes twelve stations at defined locations in Germany, at which the solar UV irradiance is measured spectrally resolved continuously from sunrise to sunset.
Since many years the BfS publishes the daily maximum value of the UV Index (30 minute average) of each station on the BfS web page. To communicate the UV index more understandable and applicable to the population, this well-established practice is now complemented by the transfer of the daily maximum values to the Geoportal of the BfS (https://www.imis.bfs.de). Additionally, daily courses of the measurements are published at Geoportal. With these continuously updated graphics, the public can now get information about the current determined erythemally weighted UV irradiance displayed as UV Index. The measured diurnal UVI variation curve of each UV monitoring station is supplemented with a modelled daily course of UVI at clear sky conditions which is provided by the Germany's National Meteorological Service. With the next Geoportal update, further information (legend, WHO recommendations and station information) are added and the mobile/smartphone access to the Geoportal will be improved.
Finally, the BfS publishes 3-day-forecasts of the expected maximum UV Index value for 10 regions at its website and as a newsletter. The BfS notes a constant rise of newsletter subscribers.

The Spanish network for Ultraviolet radiation measurement operated by AEMET

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Abstract: AEMET operates the nationwide UV Erythematically broadband network since the middle of the 90s providing valuable information for watching UV radiation in southern Europe as well as in the Canary Islands (Subtropical Region). At first UV was measured just at a few locations, today the network is comprised by 28 broadband filter radiometers located all around Spain. The choice of the stations responds to the interest of monitoring the UV radiation in areas with different geographical characteristics: mountainous areas with high-altitude (Pyrenees, Navacerrada or Izaña), along the coast and also in urban areas. The UV Index measured is daily published in the AEMET web to give information to the public.
In order to ensure the quality and homogeneity of the data, AEMET has a Radiometric Laboratory to carry out the UV calibration. Periodically all radiometers are calibrated following the methodology that WMO recommends for this kind of instruments. The spectral and angular responses are determined in the laboratory and the outdoor calibration is carried out by comparing the radiometer with the spectral reference instrument using the sun as source. The factors of the Calibration Equation are calculated to convert the output signal in irradiance units. In this process, a radiative transference model is used to simulate the spectral radiation received in the earth surface for different solar angles and ozone column values.
In this presentation, the AEMET UV network is described: characteristics of the instruments, spatial distribution of the network, data series, maintenances and calibrations realized to the instruments, achieved targets and future plans to improve the net management.

Modelling and Measurements of Ground-Based UV Radiation at the Institute Geophysics, Polish Academy of Sciences

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Abstract: UV observing network under control of the Institute of Geophysics PAS consists of 6 stations: Belsk (20.8E, 51.8N, 177m) equipped with broad-band instruments (Kipp&Zonen, UVS-EA-T, and Solar Light 501) and the Brewer spectrophotometer (BS) Mark II (290-325 nm spectra), Warsaw

(20.1E, 52.3N, 111m) with the BS Mark III (290-363 nm spectra) and Davis Vantage Pro2 (DVP2) broad-band meter, Racibórz (18.2E, 50.1N, 205m) with the broad-band instrument (Kipp&Zonen, UVS-EA-T), Łódź (19.6E, 51.7N, 214m) and Kowala (22.1E, 51.2N, 194m) with the DVP2 broad-band instrument, and Hornsund (15.5E, 77.0N, 5m, Svalbard) with 2 broad-band instruments (UVS-E-T, UVS-AE-T). Every year one of the BSs is calibrated against the travelling world standard and it serves as the secondary standard for all other our UV instruments. At Hornsund, Kipp&Zonen UVS-AE-T is calibrated by comparisons with the modelled clear sky erythemal UV irradiance based on observed total ozone and aerosols optical depth at 360nm (by the CIMEL sunphotometer). The time series of the yearly sums of the homogenized daily erythemal dose measured at Belsk and at Hornsund since 1976 and 1995, respectively, are analysed for the trend detection. The maximum of the yearly sum at Belsk is found in 2002, i.e. about 14% larger that the yearly doses at the beginning of the observations. Both total ozone and clouds variability contributed to the trends. The present level at Belsk is ~2% lower than the maximum due to more opaque clouds in recent years. Trend analyses of the yearly erythemal doses at Hornsund comprising the reconstructed (based on total ozone and clearness index) and observed UV data do not reveal a statistically significant trend in the period 1983–2016. The trends based on the observed data only (1996–2001 and 2005–2016) show declining tendency (about −1% per year) in the monthly mean of daily erythemal doses in May and June, and in the yearly sum of daily erythemal doses. An analysis of sources of the yearly dose variability since 1983 shows that cloud cover changes are a basic driver of the long-term UV changes at Hornsund. Comparison of the erythemal and UVA doses measured by BS at Belsk (rural background station) and in Warsaw in the period 2013-2015 allows determining the urban effects on surface UV. Radiative model simulations were carried out to find sources of the observed differences between the sites. The erythemal and UVA doses were 8% and 6% lower in Warsaw, respectively. This is mostly due to the lower sun elevation in Warsaw during the near-noon measurements and the larger optical depth of the city aerosols and increased cloudiness. It could be hypothesized that the expected stronger absorption of the solar UV radiation by urban aerosols is compensated by a higher surface reflectivity over the city. In recent years we put a lot of efforts to 24h forecast of UV index and the optimal doses for the psoriasis healing and vitamin D3 synthesis. The forecasts are available on the web pages (e.g. http://cirrus.cba.pl/uvi_hour/cloud.htm#loaded) and as the smartphone applications.

Measurement and evaluation of erythemal UV radiation in the city of Brno, Czech Republic

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Abstract: The features of erythemal ultraviolet (EUV) radiation and atmospheric ozone column observed in Brno, Czech Republic, over the period 2012–2017 were analyzed. EUV monitoring has been made with two broadband instruments: UV Biometer 501D version 3 manufactured by Solar Light (USA) and UV-S-E-T radiometer from Kipp&Zonen, the Netherlands. The second one is in a parallel operation since December 2017. EUV data were measured with a resolution of 5 s and recorded as 5-min averaged values. The ozone amounts were obtained from the Ozone Monitoring Instrument (OMI) satellite data for geographical coordinates of the Brno station. We analyzed daily and seasonal variation of EUV radiation, and differences in the transmittance characteristics of the atmosphere and clouds in the individual years. Thus, the contribution of ozone and clouds on EUV radiation was quantified using a nonlinear regression model (Láska et al., 2010) and cloud modification factor. The nonlinear model results agreed fairly well with the observed EUV radiation, with the mean average prediction error of 6.0 % over the whole period. EUV radiation doses were largest in June and July when small solar zenith angles coincide with relatively low total ozone column. During these months, the noon-time UV Index typically varied between 3 and 7. In winter, the UV index did not reach more than 0.7 in clear-sky days. The largest erythemal daily dose of 4.8 kJ m^2 was measured in June 2012.

References: *Láska K., Prošek, P., Budík, L., Budíková, M. & Milinevsky, G. 2010. Estimation of solar UV radiation in maritime Antarctica using nonlinear model including cloud effects. Int. J. Remote Sens. 31, 831–849.*
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UV Index monitoring in Novi Sad, Serbia: Fifteen years of experience

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Abstract: UV Index monitoring in Novi Sad, the administrative center of the Autonomous Province of Vojvodina, has been started in 2003. The Yankee UVB-1 Biometer is placed at the roof of the Faculty of Agriculture inside the campus of the Novi Sad University (45°14'49.8"N 19°51'06.4"E and 90 m.a.s.l). The instrument is connected to PC via precision A/D converter. Data of UV index are taken every 30 s and averaged over 10 min intervals. The averaged values are automatically saved in the data base. The software developed at the Department of Physics, enables us to retrieve data of the interest (daily, month or year doses; values of UV index for particular day(s), month(s) or maximal values for year(s) and other quantities) from this data base. In this work, the maximum daily values for the period of fifteen years are presented. Analyzing the measurements we concluded that maximum daily values are almost the same in the period of fifteen years, in the summer months maximum values are about 9. In addition to the presentation of measured UV index, the measuring site and the procedure for checking the long time stability of the instrument are described. This procedure is based on the use of three UV sources. The results of the measurements of stratospheric ozone layer thickness in Novi Sad are also presented. The measurements of ozone layer thickness, using Microtops II instrument has been started in 2008.

12 years of solar UV monitoring in the Aosta Valley

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Abstract: Since 2006, ARPA has been monitoring the irradiance of the solar ultraviolet (UV) radiation reaching the surface in the Aosta Valley region, located in the north-western Alps, Italy. During this period, UV irradiance spectra have been continuously recorded at 15-min intervals with a Bentham DTMc300 double monochromator spectroradiometer in Aosta - Saint Christophe (45.7422°N, 7.3570°E, 570 m a.s.l.). The measurements are traceable to the world standard QASUME through both regular monthly calibrations based on portable reference lamps and in-situ intercomparisons performed every 2 years. Furthermore, UV-A and erythemal irradiances are available every 5 minutes from broadband radiometers operating at three sites: a valley site (Aosta—Saint Christophe), a mountain site (La Thuile, 1640 m a.s.l.) and a glacier (Plateau Rosa, 3500 m a.s.l.). Although the three stations are geographically close to each other (the maximum distance from the headquarter in Aosta - Saint Christophe being 35 km), they are representative of different Alpine environments because of their importantly different altitudes. Notably, Plateau Rosa is one of the highest UV monitoring stations in Europe and the UV index at that site can easily exceed the value of 14 during the summer owing to the combined effect of altitude and snow/ice albedo. Moreover, the Aosta—Saint Christophe station is equipped with ancillary instrumentation suitable to thoroughly characterise the state of the atmosphere and, in particular, to monitor the main atmospheric components influencing the UV radiation at the ground. Systematic measurements of the following atmospheric components are available: total

column of ozone and nitrogen dioxide (MkIV Brewer spectrophotometer), aerosol amount and optical properties (sun/sky POM-02 photometer, diode-array spectrophotometer, CHM-15k automated ceilometer, Fidas-Palas optical particle counter, aethalometer, aerosol chemical analyses on daily samples), cloud amount and height (CHM-15k automated ceilometer), short-wave and long-wave global downwelling irradiances (CMP-21 pyranometer and CGR-4 pyrgeometer). Measurements are furthermore complemented by sensitive studies and forecasts based on radiative transfer models. The present contribution will illustrate the most important outcomes from the past and present monitoring activities, such as the analysis of the altitude and temporal (short- and long-term) variability of the solar UV irradiance in this part of the Alps.

Confessions and Lessons from a Quarter Century of UV Monitoring

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Abstract: Spectral solar UV measurements have been collected routinely in Reading, UK (51.5N) since 1993, and on an ad hoc basis for a further two years before that. The site is a long-running climatological station and column ozone measurements were collocated in 2002. In 1997 multi-filter UV measurements also began in Manchester, UK (53.5N), supplemented in 2000 by Brewer column ozone and spectral UV measurements, plus broadband erythemal UV and solarimeter data. In the 25 years of monitoring the core technology, the central instruments, have changed very little. However, the systems surrounding them have undergone significant change and modification, from instrument monitoring and feedback to QC/QA, data handling and availability, set against a background of changing politics in scientific favor and funding. Twenty five years of data will be considered against this changing landscape of practical challenges and climate variations.

Thursday, 13. Sept. 2018

Health effects of UV radiation on animals

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Abstract: UV radiation is an important health factor not only for humans but also for animals. Vitamin D deficiency is found frequently in indoor kept animals as there are many species which do not gain Vitamin D from food. Animals may also suffer damage like from sun burns, tumors, cataracts and others. This talk provides a short review on the research health effects of UV radiation on animals, including activities at the University of Veterinary Medicine in Vienna. This talk may also explain why this conference is organized at the University of Veterinary Medicine.

The Austrian UVB monitoring network: Scientific results

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Abstract: Since 1998 the Austrian UVB monitoring network is operational, starting with 10 measurement sites. Nowadays 13 sites submit their data to the server in Innsbruck, where the UV Index is calculated from the raw data in near real time and presented on the web site www.uv-index.at. The measurement sites are distributed all over Austria in urban and rural areas and at altitudes between 153 m and 3105 m above sea level. Broadband detectors are used to measure erythemally weighted irradiance. Due to the high demand for quality assurance and quality control with annual calibration of all detectors it is possible to analyze the measurements for scientific interpretations. The long-term variation of the UV Index at 19 degree solar elevation does not show any significant trend for any of the stations of the network. For this analysis clear sky conditions were selected by comparing the simultaneous measurements of total global radiation with a radiative transfer model. The result is in agreement with expectations, as for the same time period and for the locations of the measurement site there is no significant trend of total atmospheric ozone, according to ozone data from satellite retrievals. Also for measurements under all conditions of cloudiness no significant trend in the UV Index could be found, indicating that also the average amount of cloudiness did not change significantly. Further analyses show the effect of ozone variations (the so-called radiation amplification factor) and of snow-covered terrain on erythemally weighted irradiance. The increase of the UV Index with altitude is analyzed for stations at different altitudes. For measurements under clear sky conditions the altitude effect could be derived quantitatively. For monthly averages, which are strongly influenced by the local amount of cloudiness, a significant smaller altitude effect was found.

Influence of low ozone episodes on erythemal UV-B radiation in Austria

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Abstract: We investigate the influence of low ozone episodes on UV-B radiation in Austria during the period 1999 to 2015. To this aim observations of total column ozone (TCO) in the Greater Alpine Region (Arosa, Switzerland; Hohenpeissenberg, Germany; Hradec Kralove, Czech Republic; Sonnblick, Austria), and erythemal UV-B radiation, available from 12 sites of the Austrian UV-B monitoring network, are analyzed. As previous definitions for low ozone episodes are not particularly suited to investigate effects on UV radiation, a novel threshold approach - considering anomalies - is developed to provide a joint framework for the analysis of extremes. TCO and UV extremes are negatively correlated, although modulating effects of sunshine duration impact the robustness of the statistical relationship. Therefore, information on relative sunshine duration (SD_{rel}), available at (or nearby) UV-B monitoring sites, is included as explanatory variable in the analysis. The joint analysis of anomalies of both UV index (UVI) and total ozone (ΔUVI, ΔTCO) and SD_{rel} across sites shows that more than 65% of observations with strongly negative ozone anomalies ($\Delta TCO < -1$) led to positive UVI anomalies. Considering only days with strongly positive UVI anomaly ($\Delta UVI > 1$), we find (across all sites) that about 90% correspond to negative ΔTCO. The remaining 10% of days occurred during fair weather conditions ($SD_{rel} \geq 80\%$) explaining the appearance of $\Delta UVI > 1$ despite positive TCO anomalies. Further, we introduce an anomaly amplification factor (AAF), which quantifies the expected change of the ΔUVI for a given change in ΔTCO.

Variability of high erythemal UV radiation doses in Hradec Králové, Czech Republic, over the last 50 years

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Abstract: The changes in ozone layer and atmospheric dynamics have had a significant impact on the intensity of solar UV radiation not only in the Polar Regions, but also in the mid-latitudes. In this study, we focused on the high UV radiation doses, which are the most dangerous to human health. Using the reconstructed erythemal UV radiation time series from Hradec Králové, Czech Republic, over the period 1964–2013 (Čížková et al., 2018), we analyzed the variability of high erythemal UV radiation daily doses, and their possible meteorological and dynamical causes. A high erythemal UV radiation dose was defined as the 10 % of highest daily doses per each month; we therefore assessed a set of 1827 days with high erythemal UV doses. We observed a statistically significant ($\alpha = 0.05$) increase in days with high erythemal UV radiation doses (8.1 ± 1.1 days per decade), the increase was significant in all months except October, November, and December. The main cause of the days with high erythemal UV radiation doses was the combination of low ozone amounts (below the mean of each month) and clear or partly cloudy skies (cloud cover below 4 octas). In winter months, the increased UV albedo (over 0.3) was also an important factor. The relationship between high erythemal UV radiation doses and large-scale atmospheric circulation was studied using the principal component analysis at the geopotential heights 1000 and 70 hPa. We found that the days with high erythemal UV radiation doses are most likely to occur during the positive phase of North Atlantic Oscillation, when a high pressure promontory reaches over central Europe, or during the influx of ozone-poor air from south-west.

References: *Čížková, K., Láska, K., Metelka, L., and Staněk, M.: Reconstruction and analysis of erythemal UV radiation time series from Hradec Králové (Czech Republic) over the past 50 years. Atmospheric Chemistry and Physics, 18, pp. 1805–1818, 2018.*

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The Solar UV-VIS Spectral Irradiance Measurements - Overview of Recent Space and Ground-based Activities from Belgium

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Abstract: IASB contributed in the 90's to initiate the climatology of UV-VIS global Solar Spectral Irradiance (SSI) through the development of instrumentation and the participation to the first European intercomparison campaigns. A ground-based network for UV index measurements was developed in Belgium and contributed to European UV Database (EUVDB). In parallel, IASB was fully involved in SSI measurements from space (166 nm to 3088 nm) using the SOLAR/SOLSPEC instrument. It was part of the SOLAR payload operating during 9 years (2008-17) on board the International Space Station. SOLAR/SOLSPEC UV absolute level and variability are key inputs for the atmospheric photochemistry. Currently, the ground-based network activities as well as the laboratory calibration facilities are redeveloped to increase the radiometric and optical performances of the ground UV-VIS SSI and UV index measurements network. We will present shortly the SOLAR/SOLSPEC results, the radiometric and optical performances of the facilities and the field instrumentation deployment following the redevelopment. The objective is to provide a level of excellence for UV index measurements and to be ready for collaboration and joined efforts for the visualization of UV index values in Europe.

UV irradiance changes according to INM-RHMU chemical-climate model, satellite measurements, and re-analysis data over Northern Eurasia for the 1979-2015 period

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Abstract: We obtained a temporal variability of UV erythemal radiation (UVery) and UV resources over Northern Eurasia for the 1979-2015 period on the basis of the ERA-INTERIM reanalysis, TOMS and OMI satellite data with new aerosol correction, and the results of numerical experiments using a chemistry climate INM-RSHU model. Implementing the aerosol correction for satellite measurements was carried out according to the updated Macv2 aerosol dataset (Kinne et al., 2013). A statistically significant positive UVery trend up to 2.5% per decade due to the reduction of ozone in the spring and summer periods was obtained for European territory and 3% per decade - for the regions of Central Siberia (the Baikal region) according to both satellite data and ERA-INTERIM datasets. In addition, for several regions a statistically significant positive UVery trend in cloud transmittance of up to 6-8% per decade was revealed. The account for both ozone and cloud factors provides positive UVery trend of about 6-9% per decade over Eastern Europe, some regions of Siberia and the Far East in the spring and summer and negative trend in July over some Arctic area. These temporal changes agree well with the estimated UVery trend over Moscow. Model experiments with INM-RSHU chemical-climate model has revealed that the anthropogenic emissions of ozone-depleting substances have the greatest impact on the variability of ozone and, hence, UVery. Among the natural factors, volcanic aerosol as well as sea surface temperature and sea ice coverage play also an important role. We observe a noticeable UV growth which is mainly translated in increase of occurrence of the extreme category of UV resources except Arctic regions where during summer time there is a slight increase of the zone with UV-optimum conditions for the 2 and 3 skin types.

The Austrian UV-Monitoring Network - Quality assurance by yearly absolute calibration of the UV detectors

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Abstract: Broad band filter radiometers with a similar response function as the standardised CIE erythemal response function are in use in national and regional monitoring networks.
Experience within the Austrian UV Monitoring network, which is operational since 1998 shows the sensitivity of the broadband detectors to environmental conditions. Significant short time variations up to 10% in the absolute response may be affected by environmental temperature variations especially in case of high internal humidity, although the instruments have an internal temperature regulation. Changes in the internal relative humidity affect the spectral response up to more than 10%. Long-time variations of the absolute response of up to ±20% affect the data quality in the routine operation. These variations are quite individual for each detector.
The high frequency of recalibrations each year turned out to be necessary because the sensitivity of some detectors changed irregularly during operation. The applied method of absolute calibration is a combination of a laboratory characterisation of the relative spectral response function and a field characterisation of the solar erythemal irradiance. To characterise the relative spectral response a tuneable light source, developed by CMS at the Medical University of Innsbruck is in use. The actual system consists of a 150W Xenon high pressure lamp and a DM150 Bentham double monochromator. To characterise the angular response regarding DIN5032, a specially developed cosine-measurement

facility is in use. The absolute sensitivity is calibrated in relation to a DTM300 Bentham double monochromator traceable to the Physikalisch-Technische Bundesanstalt in Germany.
By applying these carefully and regular method of calibration, high quality measurement data are guaranteed. With this data investigation of short time fluctuations as well as long-time trends of the UV irradiance is accomplished.

Improving models for quality assurance of the Austrian UV measurement network and implications for atmospheric research

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Abstract: UV radiation in cloud free conditions can be accurately predicted by radiative transfer models, given the knowledge of the key environmental variables: total ozone column, ground albedo and aerosol optical depth (AOD). The convenient sources of these variables for routine network analysis of distributed instruments are satellite retrievals or even climatological data. We show that for the Innsbruck station, local measurement of total ozone column and AOD using direct sun measurements from a Pandora spectroradiometer can considerably improve UV modelling compared to using a satellite measurement with its uncertainty and from one daily overpass only. Furthermore, given a better constraint on ozone and AOD, we can determine the effective albedo by fitting a model to the measured UV time series. This may allow the improvement of the albedo prediction from a combination of satellite albedo products and snow height information which in turn improves the UV prediction. Finally, we show that Pandora trace gas data products from two stations in Innsbruck, one located in the valley and one on a nearby mountain top, are also highly valuable for improving our scientific understanding of the atmospheric conditions and the radiation field in an Alpine valley environment.

Report of the 2nd International UV Filter Radiometer calibration campaign UVC-II

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Abstract: The main task of the WCCUV is to assist WMO members operating WMO/GAW stations to link their UV radiation observations to the WMO/GAW reference scale through comparisons of the station instruments with the standard instruments operated by PMOD/WRC. Therefore an “International UV Filter Radiometer Comparison” was organized at the WCCUV of PMOD/WRC. The campaign lasted from 25th May to 5th October 2017; it is located at 1610 m a.s.l. in the Swiss Alps.
A total of 75 UV filter radiometers from 37 Countries participated at the campaign, of which 22 from Europe. The nine different radiometer types represented at the campaign were Kipp&Zonen / Sintec (28), Yankee UVB-1 (11), analog and digital Solar Light V. 501 (19/9), Delta Ohm LP UVI 02 (2), EKO MS 212W (2) and each one of Indium Sensor 1E.1-081, Genicom GUVB, Eppley TUVR and Middleton Solar UVR1-B2. The filter weighting function were mostly approximating the erythemal action spectrum and some UVB, UVA and UVG. 16 radiometers were not well maintained according to the recommendations of Webb et al. 2007.
The two reference spectroradiometers QASUME and QASUMEII of the WCCUV operated during the campaign agreed within ±2%. The atmospheric conditions during the campaign varied between fully overcast to clear skies and allowed a reliable calibration for all instruments.
The standard calibration methodology, using the instrumental spectral as well as the angular response functions measured in the laboratory, provided remarkable agreement with the reference spectroradiometer, with expanded uncertainties (k=2) of around 6% for most instruments.

The measurements of the broadband radiometers were analyzed both with the PMOD/WRC calibration as well as the calibration used by the home institutes. The average date of the user calibration was five years prior to this campaign (e.g. 2012) and 40 out of the 75 instruments used a single calibration factor, instead of the suggested calibration matrix [5, 7, 8]. The relative differences between the measurements using the user calibration and the one from PMOD/WRC varied between 0.04% to differences larger than 50% for specific instruments.

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Spectral UV measurements within EUBREWNET

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The aim of COST Action ES1207 “EUBREWNET” was to establish a coherent network of European stations equipped with Brewer spectrophotometers for the monitoring of total ozone, spectral UV radiation, and aerosol optical depth in the UV spectral range, ensuring sustainable operation in the long term. Among the primary objectives of EUBREWNET were harmonisation of operations and development of approaches, practices and protocols to achieve consistency in quality control, quality assurance and coordinated operations. The WMO/GAW Regional Brewer Calibration Center for Europe (RBCC-E) campaigns have been held since 2005 at the El Arenosillo sounding station of the Instituto Nacional de Técnica Aeroespacial (INTA) at Huelva in the south of Spain, with those of 2015 and 2017 specifically included in the EUBREWNET project. The spectral UV calibration has been consistently performed by the World Calibration Center for UV (WCC-UV) of the PMOD/WRC, through the operation of the travelling reference spectroradiometer QASUME. An overview of the results of these campaigns during the last 12 years will be presented.

BTS Array Radiometer Validation for Solar UV Radiation Monitoring and Integration of the Alpine Climate Region into the Nationwide UV Monitoring Network

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Abstract: The Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) operates a nationwide network in Germany for solar ultraviolet radiation monitoring in cooperation with Federal Environment Agency, Germany's National Meteorological Service and other associated institutions. To include the Alpine climate zone, an additional measuring station was installed at the Environmental Research Station Schneefernerhaus (UFS) near the summit of Germany's highest mountain, the Zugspitze, in summer 2017. Here, at an altitude of 2,666 m, the BfS is now continuously measuring the spectral solar UV irradiance.
The applied diode array radiometer with a so-called BiTec Sensor (BTS) requires shorter measuring time than conventional scanning spectroradiometers. Thus, the spectral solar UV irradiance can be more precisely determined even when cloud conditions change fast.

After a brief introduction of the used BTS technology and its application, results are presented of comparative measurements with the diode array radiometer and a double monochromator measuring system. In this context, the selected operating mode of the diode array radiometer as well as the differences between the two measuring systems is addressed. Finally, the measuring location at the UFS and measurement results of the first operating year are presented. A comparison with the data from the station Neuherberg illustrates, among others, the higher UV irradiance at higher altitudes as described in the international literature.

Personal UV exposure from ambient UV radiation

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Abstract: People are exposed to solar radiation during their whole life. Exposure to UV radiation is vital but holds serious risks, too. The quantification of human UV exposure is a complex issue. UV exposure is directly related to incoming UV radiation as well as to a variety of factors such as the orientation of the exposed anatomical site in respect to the sun and the duration of exposure.
The use of badge sensors allows assessing the UV exposure of differently oriented body sites. Such UV devices have been available for over 40 years and a variety of measuring campaigns have been undertaken since then.
Another possibility to asses UV exposure of different body sites is the application 3d-body models. These allow calculating the UV exposure over the whole body. Precise model calculations need ambient UV measurements as input parameter or calibration factor, because atmospheric input parameters are not always available with satisfactory accuracy.
Measured or modeled UV Exposure can be expressed as “Exposure Ratio To Ambient” (ERTA). The ERTA expresses the percentage of irradiance received by a certain body site compared to the irradiance received by a horizontally oriented receiver (free horizon). The ERTA depends on the orientation of body side in respect to the sun and on the local environ. The orientation changes with soar elevation and with the posture.
With that, the ERTA (when given as a function of solar elevation, body site and activity) can be used in conjunction with ambient UV radiation to calculate the personal UV exposure of people.

UV-monitoring in urban shaded areas

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Abstract. Shading in the natural and artificial environment of humans can limit the availability of solar radiation quite drastically. For vitamin D-weighted exposure the direct sun plays a minor role only. Instead, sky radiance has been found to be the dominant factor for human solar UV exposure. To determine the vitamin D_3–weighted exposure the solar spectral radiance must be known from all directions. Shading of buildings or trees reduces the incident radiance significantly. Within a city we found reductions of typically more than 50% compared to unshaded areas. We also found the reduction of exposure to be not simply proportional to the shaded fraction of the sky. As expected, the actual reduction strongly depends on the location. This will be demonstrated in a movie taken by an all-sky camera. The incident radiance is also highly variable in time due to the presence of clouds. While in summer vitamin D-weighted radiation is plentiful, the situation in winter is completely different.

Quantifying the potential of shades in diminishing human exposure to solar UVB radiation

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Abstract: The harmful effects of solar UV radiation on human health are well established. People are extensively educated for sun awareness and encouraged to embrace appropriate measures to protect themselves against erythema and to restrict their life-long cumulative solar UV exposure. National programs aiming at increasing the sun awareness of population are being implemented in various parts of the world. The instructions for smart sun behavior follow the general guidelines formulated by the World Health Organization WHO. In Finland, the Cancer Society of Finland has estimated that over 90 % of the incidence of skin melanoma amongst the Finns could be prevented through “sun smart” behavior. The recommendations therein include taking protective measures whenever the UV levels in terms of UV index reach or exceed 3: wearing protective clothing, applying sunscreen and seeking shade. To estimate the potential efficiency of shades in human exposure to solar UVB radiation, measurements of diffuse erythemally weighted UVB radiation were started in Helsinki, Finland, in March 2017. The data produced by this setup and the already existing on-site measurements of global erythemally weighted UVB radiation are analyzed. In addition, these data are compared to the data obtained from the co-existing diffuse and global solar radiation measurements, and the differences between the two data sets are discussed. Finally, the data are used to produce estimates on the potential of shades in the natural and built environment to diminish harmful solar UV exposure of the people in Finland. The outcome of the study is expected to yield new experimental knowledge to be used in the planning of the outdoor areas where people stay for their work or spend their leisure time.

Investigating the future evolution of the ozone layer above Switzerland (INFO$_3$RS)

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Abstract: The Arosa total ozone column measurement series represent the World’s longest continuous dataset, starting in 1926. It is composed of direct UV measurements from three Dobsons and at a later stage from three Brewer spectrophotometers.
The observation of an eventual recovery of the ozone layer requires uninterrupted measurements of the highest quality, spanning several decades, and extending the current dataset to at least the middle of the 21st century. This long-term vision currently relies on instruments developed in the 1920’s and 1980’s respectively, with consequent substantial risks of the remaining lifetime of these instruments. Therefore, the recently started project (INFO$_3$RS) assess the capabilities of state-of-the-art UV spectroradiometer systems to complement and eventually replace this ageing instrumentation. The new system includes research findings from the two previous EMRP projects “Solar UV” and “Traceability of total column ozone” (ATMOZ) and should provide reliable, stable, traceable and cost-efficient direct UV radiation measurements from novel array-spectroradiometers. As a priority, the new system will be tested to derive total column ozone and secondarily to obtain different UV products from global UV measurements such as action spectra weighted UV dose rates.
Furthermore, project addresses the question: “How and when can we detect the long-term trend of total column ozone in Switzerland”? For this objective a revision of the time series with state-of-the art methods and indication of the overall uncertainty budget of the entire time series is needed. The

statistical significance of the future evolution of ozone above Switzerland requires also the development of sophisticated trend-analysis methods including an overall uncertainty budget.
The improvement of the revised time series and the significance of the trend analysis will be supported by the evaluation of the future total ozone content evolution over Switzerland simulated with a state-of-the-art chemistry climate model (SOCOL) for various scenarios.
The time when an unequivocal observation of ozone recovery can be expected will be obtained in INFO$_3$RS by combining the data-set analysis, the corresponding observational uncertainties and the model calculations.
The presentation will outline the project with focus on methods of data analysis, trend detection and instrumentation.

POSTER SESSION

AUSTRIA

P01 - UV radiation south of the Austrian main Alpine ridge

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Abstract: Joint measurements of UV radiation at the sites Klagenfurt, Gerlitzen, and Sonnblick are available since 2004. The radiation profile from these three sites spans from 448 to 3.106 m a.s.l. and approximately 110 km in horizontal distance. This radiation profile is of particular interest given that the station locations differ substantially in surrounding environment, surface albedo, and altitude (atmospheric column). At the same time these sites are, due to their geographic location, frequently affected by the same large-scale weather regime and thus air mass. Here we present selected results regarding the UV climatology at these three UV monitoring sites, which highlight the importance of environment and altitude for the UV radiation field. Further we investigate day by day correlation and joint extremes and their underlying drivers. Particular emphasis is given on the role of reduced column ozone content for UV extremes and sky conditions. As direct cloud observations are not available we derive information on cloud cover via relative sunshine duration. Our result show a significant negative correlation of ozone and UV anomalies, which is particularly pronounced on days with clear-sky or partly cloudy conditions. Nevertheless a large fraction of positive UV anomalies can be solely attributed to low ozone conditions; independent of sunshine duration and site.

P02 - Monitoring of Stratospheric Ozone at Hoher Sonnblick, Austria since 1994

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Abstract: Since the mid-1990s spectral UV irradiance and stratospheric ozone are continuously monitored at two sites in Austria. One measurement site, Sonnblick Observatory, located at 3106 m on the summit of a high alpine mountain is the only one of its kind in Austria. There, a Brewer spectrophotometer is used to measure total ozone column, vertical ozone profiles (so called *Umkehr layers*) and spectral UV radiation, while a Bentham spectroradiometer monitors spectral UV irradiance in a more precise fashion. Monitoring ozone at such a high altitude gives the advantage of evading most tropospheric disturbances, while the UV irradiance measurements represent the impact of UV radiation on mountainous high-altitude terrain. The other site, Groß-Enzersdorf, located at 156 m near Vienna, a major urban area is equipped with a second Bentham spectroradiometer to monitor spectral UV radiation. The measurements aim to determine the impact of UV irradiance on densely populated low-altitude areas. The total ozone and the vertically resolved ozone data records are used to investigate trends and extreme events in the period from 1994 to 2017. Trends in ozone time-series, however, are often difficult to determine because of high variability. Since extreme events can also be hard to classify, a method to estimate daily thresholds for extreme events in total ozone, using extreme value theory, is presented. Case studies of selected extreme events, the corresponding

synoptic situations and vertical ozone profiles are closely examined for existing correlations between lower stratospheric dynamics and stratospheric ozone concentration.

BELGIUM

P03 - UV measurements at Uccle, Belgium (1990-2017) and Utsteinen, Antarctica (2010-2018)

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Abstract: The Royal Meteorological Institute of Belgium performs spectral UV measurements with Brewer spectrophotometers at two stations: Uccle, Belgium (50.8°N, 4.35°E, 100m a.s.l.) and Utsteinen, Antarctica (at the Belgian research station Princess Elisabeth; 71.95°S, 23.35°E, 1372m a.s.l.). The UV time series at Uccle started with measurements of the single monochromator Brewer#016 in 1990 and are complemented by measurements of the double monochromator Brewer#178 since 2002. At Utsteinen, Brewer#100 (double monochromator) started measuring in 2011. Its measurements are not continuous throughout the year since the instrument only operates during austral summer when the Princess Elisabeth station is inhabited. The UV index (UVI) measurements at both stations are analysed. The maximum daily UVI is determined and histograms showing the distribution over different UVI categories are studied. At Utsteinen, almost 90% of the observed maximum UVI values are between 3 and 8. There is a difference between the different measurement campaigns: especially during the 2014-2015 and 2015-2016 seasons, higher UVI values (>8) are observed in 17% of the cases. However, during the 2012-2013 and 2017-2018 season, maximum UVI values were clearly lower (respectively 7.3 and 6.1). This can be explained by the temporal behaviour of the total ozone column over the Antarctic. Seasons with higher UVI are characterized by a more pronounced ozone hole. Over the other seasons, the total ozone amount was higher and more stable. At Uccle, observed UVI (which cover the whole-year period) are clearly much lower than at Utsteinen and more than 30% of the observed daily max UVI are lower than 1 for the 1990-2017 period. Values higher than 6 are rather sparse (~10%) but their occurrence becomes more frequent over time. UVI values from both Brewers have been compared and show a good agreement with a correlation coefficient of 0.99. On average, the values of Brewer#178 tend to be slightly higher than those of Brewer#016.
The stability of the instruments (based on the change in instrument response) over time is also studied. For all three instruments it remains within 5%.

FINLAND

P04 - Linking UV monitoring at an European Arctic site and a site in Antarctica: Sodankylä 67ºN and Marambio 64ºS

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Abstract: New UV measurements have been started in collaboration between Servicio Meteorológico National (SMN), Argentina, and the Finnish Meteorological Institute (FMI) in Marambio, Antarctica, in 2017. A GUV multifilter radiometer has been installed to monitor continuously UV irradiances at five channels, visible radiation and photosynthetically active radiation. The cloud optical thickness and total column ozone can be retrieved from the measurements. The measurements continue the NILU-UV time series of the Spanish-Finnish-Argentinean Antarctic NILU-UV network. Two GUVs have been purchased in order to ensure the quality of the measurements: the GUVs rotate so that while one is measuring at Marambio, the other one is compared to spectral UV measurements in Sodankylä. These yearly comparisons make possible the quantitative comparison of Arctic and Antarctic UV measurements, as the GUV measurements can be scaled to the Brewer measurements in Sodankylä. Spectral Brewer UV measurements at Sodankylä, started in 1990, and a homogeneous time series of 28 years has been processed. In addition, FMI is responsible for three satellite-derived UV products: EUMETSAT's Offline UV (OUV), and the OMI and TROPOMI UV products. These remote sensing activities complete the possibility to study UV time series in both hemispheres. In this study, first results of Marambio's GUV measurements will be shown together with the analysis of Sodankylä's spectral UV time series. At both stations, the influence of spring time stratospheric ozone loss can be quantified and the time series can be used to follow the impact of the Montreal Protocol, and detect the effects of the ozone recovery.

P05 - UV monitoring products derived from satellite measurements

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Abstract: UV products derived from satellite data are complementary to traditional ground-based measurements. On the one hand satellites have global coverage and provide data for regions uncovered by the ground-based UV measurement network, but on the other hand ground-based measurements are needed in validating the satellite products. As opposed to the direct ground-based measurements, satellite products are indirectly obtained by radiative transfer modelling using as main inputs: total ozone column, cloud and aerosol optical properties, surface albedo and pressure. The output quantities include UV dose rates and integrated daily UV doses obtained by weighting the spectral irradiance by different action spectra, e.g. the erythema action spectrum giving the UV Index. The Finnish Meteorological Institute (FMI) is currently responsible for the following three satellite products using different satellite data: the OMI UV product uses the measurements of the Ozone Monitoring Instrument (OMI) aboard the NASA EOS-Aura satellite launched on 15 July 2004, the TROPOMI UV product uses the measurements of the Tropospheric Ozone Monitoring Instrument (TROPOMI) aboard the Copernicus Sentinel-5 precursor satellite launched on 13 October 2017, and the EUMETSAT offline UV product, generated in the framework of the AC SAF (Satellite Application Facility for Atmospheric Composition), uses the measurements of the Global Ozone Monitoring Experiment-2 (GOME-2) instrument aboard the Metop satellites, the first one, Metop-A, launched on 19 October 2006. In this presentation, the satellite UV products are described and compared to ground-based Brewer spectrophotometer measurements in Finland.

FRANCE

P06 - Inter-Comparison campaign of solar UVR instruments at Reunion Island (21.0°S, 55.5°E): Findings and Recommendations

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Abstract: Reunion Island (21.0°S, 55.5°E) is a French and European territory situated in the Indian Ocean in the tropics where solar ultraviolet radiation (UVR) levels are high almost all-year round. This is mainly due to intense incident solar radiation combined with weak stratospheric ozone columns. Yet, very few UVR and ozone measurements are available or operational in these regions, especially in the south-west Indian Ocean countries. Since 2009, the Reunion University, a French and European university, started a research program based on ground-based solar UVR and ozone observations.

Continuous UVR measurements require instrument monitoring and calibration processes in terms of wavelength and intensity on regular intervals and made with regular comparison against a reference instrument. Ground-based solar UVR data is used for various purposes, such as exposure assessment in epidemiological studies and as input for atmospheric studies. In the framework of the NDACC (Network for the Detection of Atmospheric Composition Change) and in collaboration with the LOA (Laboratoire d'Optique Atmosphérique, University of Lille, France) a Bentham DM300 spectrometer is operated at Reunion Island. We recently implemented an inter-comparison campaign between the Bentham spectrophotometer and three UV radiometers: a Kipp&Zonen UVS-E-T, and two Solar Light 501 and 6.5 instruments, with the Bentham spectrometer as a reference. It should be noted that the Kipp&Zonen and Solar Light 501 radiometers were calibrated during the last Davos campaign in July 2017.
Knowing that the UV index, a measure of the level of solar UVR at the Earth's surface that is used to alert people about the need to use sun protection, is deeply cloud cover dependant, only clear sky data were used in the present study. In order to identify clear sky conditions, an all-sky camera has been operating at the observation site. For the clear sky filtering, we used a maximum threshold of 25 %. Our inter-comparison campaign results showed a similar positive bias of 5 % for both Kipp&Zonen and Solar Light 501 radiometers, while we observed 10 % positive bias for Solar Light 6.5, in comparison with the Bentham spectrometer. Such observation data from instruments used to measure ground-based solar UVR should be carefully scrutinised and corrected to reduce measurement error.

GREECE

P07 - Global projections of the solar erythemal UV radiation in the 21st century

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Abstract: Erythemal solar irradiance is simulated on a global scale, for the present (2010-2020) and the future (2085-2095) using a radiative transfer model. The input parameters to the radiative transfer model are total ozone, ozone and temperature profiles, aerosol optical depth, surface reflectivity and cloudiness, which have been obtained from global climate-chemistry models, participating in IGAC/SPARC Chemistry-Climate Model Initiative. For the present, a comparison between the monthly mean simulated and measured UV Index at local noon is conducted for three ground based stations: [Thessaloniki (40^{o}38'N, 22^{o}55'E), Uccle (50^{o}48'N, 04^{o}20'E), Sodankyla (67^{o}25'N, 26^{o}35'E)], resulting in a sufficient agreement. Differences between the future and the present levels of the noon UV Index are calculated in order to construct seasonal global maps. Important changes in the UV radiation are projected for the end of 21st century relative to present, driven by different factors depending on region: (1) ozone recovery (due to decreasing ozone-depleting substances and increasing greenhouse gases) would lead to decreases in erythemal irradiance, which are more significant over the high and

polar latitudes of both hemispheres; (2) reductions in surface reflectivity, mainly due to the melting of sea-ice, would lead to significant decreases in the UV Index over the Arctic; (3) the expected improvement of air-quality and reductions of aerosols over the most populated areas of the northern hemisphere would result in increases of the UV Index over these areas; (4) changes in cloudiness are highly uncertain and would have effects which vary spatially and temporally. This study, points to the complex interaction between UV radiation and its main regulatory factors and highlights the importance of accurate monitoring of surface UV radiation in order to validate the UV simulations and, eventually, the projections.

P08 - Optimization of the AOD retrieval from direct sun spectral UV measurements by a Brewer spectrophotometer, in Thessaloniki, Greece

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Abstract: Changes in aerosol load have an important impact on the levels of the solar UV radiation that reaches Earth's surface. The interactions of aerosols with UV radiation are usually stronger than those with solar radiation at longer wavelengths, making the direct sun UV measurements a very useful tool for studying the short- and long-term variability of aerosols. The aerosol optical depth (AOD) is used to quantify the amount and variability of aerosol loading in the atmospheric column over a certain area and it can be determined by estimating the attenuation of the direct solar beam throughout the atmosphere. Since measurements of the AOD, based on the (commonly used) Langley extrapolation method over polluted environments, are highly uncertain, an alternative methodology, more appropriate for urban environments, has been used at the Laboratory of Atmospheric Physics (LAP), Thessaloniki, Greece, to measure the AOD in the UV region. More specifically, instead of deriving the extra-terrestrial spectrum using the Langley extrapolation method, the extra-terrestrial spectrum by Kurucz et al., (1992) is used and the AOD is calculated using calibrated direct sun spectra recorded by a double monochromator Brewer spectrophotometer, operating at LAP (latitude 40.634o N, longitude 22.956o E, altitude 60 m above sea level). The main purpose of this study is to evaluate the results of this methodology and investigate the effect of different parameters on the AOD retrieval at 340 nm.
In order to assess the quality of our results, the Brewer-derived AOD values are compared with quasi-simultaneous measurements (within 3 min), obtained by a co-located Cimel sunphotometer. The effects of the polarization and the circumsolar light on the Brewer's calibration are relatively small (< 1%) for SZAs smaller than 55o and become more significant at larger SZAs. Applying a correction for the Brewer's internal temperature, further reduce the differences between the AOD values derived by the Brewer and the Cimel sun-photometer. Moreover, the agreement between Brewer-derived and Cimel-derived AOD becomes slightly better when the effect of NO2 is taken into account using climatological values. In the frame of this study, we have also estimated the effect of the extra-terrestrial spectrum that is used in the retrieval algorithm, testing the low- and high-resolution Kurudz spectra (Kurucz et al., 1992), as well as the ATLAS 3 (Thuillier et al., 2003) extra-terrestrial spectrum. The differences between Brewer and Cimel measurements increase when the low resolution solar extra-terrestrial spectrum is used and are intensified during the winter period.

P09 - UV-index estimations from space and validation against groundbased measurements

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Abstract: The solar ultraviolet (UV) radiation at surface is responsible for various valuable and unfavorable impacts on human health, and therefore, the continuous monitoring of UV-index, which is very popular and used in prevention activities, is crucial for human wellbeing. Earth observation from space in conjunction with radiative transfer modeling (RTM) techniques and speed-up technologies based on multilinear regression related processes and machine learning, is a promising tool for operationallyready relevant monitoring and forecasting applications and services. In this study we report on the development of a satellite-driven model that estimates the UV-index under clear and all sky conditions by using a synergy of RTM simulations and real-time atmospheric inputs from the EUMETSAT's Satellite Application Facility on Climate Monitoring (CM SAF) for cloud optical properties, the Copernicus Atmosphere Monitoring Service (CAMS) for aerosol optical properties and the Tropospheric Emission Monitoring Internet Service (TEMIS) for total ozone column. The model's reliability and accuracy was tested against ground-based measurements in Thessaloniki (Greece) for a period of three years (2015-2017) for different time horizons (from 15 minutes to monthly averages). A sensitivity analysis of model inputs and outputs was performed as well in order to quantify the uncertainty factors and to identify the dependencies on inputs spatial and temporal resolution and quality..
Acknowledgments: *This study has been implemented in the framework of the GEO-CRADLE project (http://geocradle.eu/) which has received funding from the EU's Horizon 2020 research and innovation program under grant agreement No 690133.*

HUNGARY

P10 - Variation of erythemally weighted UV irradiance in Hungary during the period 1995-2017

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Abstract: First of all, the national UV monitoring network operated by the Hungarian Meteorological Service is introduced briefly. The network was established in 1994 and includes 6 stations using broad band UV-Biometers. In the Marczell György Main Observatory, Budapest, Brewer MKIII spectrophotometer No. 152 was installed in 1998 that became the primary standard for the network. As basic conditions to provide the possible best data quality, calibration procedures and checking methods are also shown.
Both variation of broad band UV irradiance and some narrow spectral bands are shown and analysed. For all stations, increasing trend of UV radiation was found despite the increasing air columnar total ozone amount during the period studied. The trends are similar, except the highest peak of Hungary, Kékestető (1015 m a. s. l.),where the increasing gradient is considerably lower. Both the general increase in the area of Hungary and the lower increasing trend for Kékestető is probably resulted in by the decrease in the measured broad band optical depth during the period in question that was caused mainly by the decreasing trend in the concentration of the main pollutants. Namely, it is to be concluded that the UV enhancing effect of the increasing atmospheric transparency exceeds the UV reducing effect of the increasing total ozone content. The results concerning these phenomena are analysed in details.

ITALY

P11 - A Website for the UV-Index values in South-Tyrol (Italy)

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Abstract: The Environment Agency of Bolzano/Bozen presents its online website of UV-Index measured values, which is online since May 2018 on the homepage of the Environment Agency and since October 2017 on the homepage of the Austrian UV-network.
The Laboratory of physical chemistry of the Environment Agency measures the air quality parameters, both chemical and physical, in autonomous Province of Bolzano/Bozen. The measurement of UVB and UVA radiation has been carried out since mid '90es, based on broadband radiometers located on several air-quality stations.
2015 the UV-measurement strategy has been redefined, focusing on two sites and improving the data quality in order to provide UV-Index online-values. We have chosen two sites, on the air-quality station of Leifers/Laives, near Bozen/Bolzano (230 m a.s.l.) and on Ritten/Renon (1770 m a.s.l.). They represent on the one hand a typical valley situation, on the other a mid-mountain alpine exposition.
2017 the Environment Agency started a collaboration with the Division of Biomedical Physics with the goal to implement its UVB and UVA data into the UV network of the Innsbruck Medical University, which already reports data coming from Austria, Germany and Switzerland. The raw data acquired from the radiometer is elaborated by the University of Innsbruck, corrected through the calibration matrices and presented graphically on its online page, according to its standard layout.
Since May 2018 the UV-Index values of Leifers/Laives and Ritten/Renon containing the real time UV-Index values of today, yesterday's UV graphic, and last month daily maxima are published on the Environment Agency's website.
The poster presents the most important data and information about the UVI-network of South-Tyrol, as well as the characteristics of the measurement sites, of the instruments, in conjunction with the implemented QA/QC policy.
UV-Index values on the Environment Agency of Bolzano/Bozen: http://umwelt.provinz.bz.it/strahlung/uv-strahlung.asp

P12 - UV radiation in Florence, Italy, (2004-2017) and its relationship with weather circulation types

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Abstract: Italy is one of the European nations characterized by the highest levels of ultraviolet radiation (UV) therefore it was important for both the resident population and the numerous tourists to know the risk level deriving from UV exposure. Based on these considerations starting from 2004 at the Institute of Biometorology of National Reasearch Council (IBIMET-CNR), in cooperation with the LaMMA Consortium, a continuous UV monitoring activity was started. The UV monitoring station was located in Sesto Fiorentino (43° 82' N, 11° 20' E, 40 m a.s.l.), a suburb of Florence, Tuscany (Central Italy). The radiometer used was the UVB-501 (Solar Light CO., Philadelphia, USA) with spectral response close to the erythemal action spectrum, periodically compared with a reference instruments (of the same type as the operational one) calibrated during international inter-comparison campaigns.

Continuous measurements of erythemally effective UV radiation (also converted in UV Index) and averaged over 15-min intervals were performed starting from 2004 and stored in a database. On the basis of these 14 years of data an UV Index climatology was obtained.
During the last few decades, weather circulation type classifications (CTCs) have been widely used to gain insight into processes at the synoptic scale, but also for studying the relationship between atmospheric circulation and surface climate variability. As at LaMMA, were evaluate the best performing CTCs based on COST733 software for the stratification of daily ground-level precipitation and surface air temperature across Italy, in this study we have done a very preliminary investigation on possible relationships between UV and such CTCs; especially in certain periods of the year a relationship between specific weather circulation and UV was present.

P13 - Analysis of the Reconstructed Daily UVI Time-Series from the COST-726 data at Two Different Italian Sites

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Abstract: This study deals with the analysis of total ozone column (TOC) and Ultra Violet Index (UVI) behaviours at two Italian sites, namely Rome and Aosta, representative of quite different environmental and geographical conditions. To this purpose, we used the long time series of UV dose and TOC retrieved from the COST Action 726 database. Noon UVI values are reconstructed by applying in a reverse way the algorithm proposed by Diffey to the COST UV doses.
UVI and ozone data are then compared with measurements from Brewer spectrophotometers in operation at Rome and at Aosta and with OMI products to assess the consistency between the COST series and independent datasets at the two selected stations. The results of the analysis show that significant differences in the Pearson correlation between the two sites only emerge at the higher (daily) resolution whereas an overall similarity between the two sites appears at seasonal and yearly scales.
In addition the noon UVI series retrieved at Rome and Aosta are used to test three approaches for the short term prediction of UVI, namely: the Persistence, Empirical-Statistical relationship and the method of Analogues.

LUXEMBOURG

MeteoLCD – The meteorological station at the Lycée Classique de Diekirch, Luxembourg

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This **video presentation** (made by 4 students of the Lycee) gives an short overview on the meteorological station at the Lycée Classique de Diekirch: http://meteo.lcd.lu which was launched by Francis Massen, a (reitred) teacher for physics, mathematics and computation. This stations is online since more than 20 years and provides, beside other meteorological paramteres, UV-Index, UVA and total ozone measurements. Purpose of this station is not only to make continous meassurements but also to introduce pupils into practical meteorology.

POLAND

P14 - UV monitoring in Poland for public of IMGW-PIB

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Abstract: Measurements of erythemal UV-B radiation with Solar Light UV sensors Biometer ver. 501 (SL501) have been carried out in the monitoring network of the Institute of Meteorology and Water Management (IMGW-PIB) since mid-1993. Currently, these detectors operate on three stations. The stations are arranged along the meridian to represent different climatic regions of Poland. Leba station is located in the north, by the sea, Legionowo in the central part of Poland and Zakopane in the mountains, in the south. The amount of UV radiation reaching the earth's surface can vary significantly at a given moment in different parts of Poland, whereas the number of stations measuring UV-B radiation with good quality sensors is small. Therefore, it is not possible to provide current UV radiation for each region. The basic method of informing the population is the UV Index forecast presented as maps. The UV Index forecast has been operating in Poland since 2000. The presentation of UV-B measurements in real time was launched in Poland in 2006. The measurements were made using UVEM-6C OPTIX sensors. Measurements from six IMGW-PIB stations (Leba, Mikolajki, Legionowo, Katowice, Zakopane and Kasprowy Wierch) were published. The launch of such a presentation had two basic goals. First of all, it was an extension of the UV Index forecast. So, the presentation of information about the UV Index should be more attractive. The second goal was educational, showing how various factors, including clouds, height above sea level and solar elevation angle change the amount of radiation reaching the ground. After a few years, OPTIX detectors stopped working properly. Therefore, mainly due to financial reasons, it turned out that it is impossible to keep this type of presentation in the initially assumed form. Nowadays, the real-time presentation uses measurements with SL501 sensors for Leba, Legionowo and Zakopane stations. In addition, the real-time presentation has been extended by measurements from a multi-channel NILU-UV sensor in Warsaw. On the website, the measured UV index is shown together with the forecasted UV Index curve for clear sky. The information aimed at common people who do not know the problems of measurements and UV modelling. The risks associated with publishing forecasted and real-time measured data will be discussed. Also, UV-B measurements from the IMGW-PIB network showing what radiation values we can expect in different parts of Poland will be presented.

RUSSIA

P15 - Long-term UV irradiance variability in Moscow since 1968 according to ground-based measurements, reconstruction model and INM-RHMU chemical-climate model

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Abstract: Long-term UV measurements and reconstruction modelling in Moscow revealed distinct long-period changes over the period from 1968 to 2015 in both, UV 300-380nm and erythemal irradiance. They are characterized by a pronounced decrease at the end of the 1970s and since 1979 - a statistically significant positive trend of more than 5% per decade growth for erythemal irradiance and of about 3% per decade increase - for UV 300-380nm irradiance. The positive trend in erythemal

irradiance is shown to be associated mainly with a decrease in the effective cloud amount, total ozone content, and aerosol optical thickness. We show that due to these changes, there are distinct changes in UV resources especially in spring from the UV optimum to UV moderate excess category for the population with the most vulnerable skin type 1. The model experiments using the INM-RSHU chemistry climate model were fulfilled for several scenarios with different natural and anthropogenic scenarios. We have revealed that anthropogenic emissions of halogens have the most significant impact on negative changes in ozone, and, hence, increase erythemal irradiance. We also show that among natural factors, noticeable effects are observed due to volcanic aerosol and sea surface temperature. The simulations in UV cloud transmittance in INM-RSHU model are generally consistent with the measurements in absolute value except cold period. However, actual values of positive UV irradiance trends regulated by decrease in effective cloud amount are not reproduced well in INM-RSHU model.

P16 - The erythemal UV irradiance forecast over the territory of Northern Eurasia in the 21 century according to the INM-RSHU chemical-climate model

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Abstract: We examined the impact of different natural (solar activity, stratospheric aerosol, sea surface temperature) and anthropogenic (ozone depleting substances) factors influencing erythemal UV irradiance (Qery) via total ozone column and cloudiness changes over Northern Eurasia. The ozone and cloudiness variations based on the results of numerical experiments were estimated from 1979 to 2099 using a chemistry climate INM-RSHU model. We showed that the most significant natural factor influencing Qery variations is sea surface temperature (SST), which noticeably affects the atmospheric dynamics. Several numerical experiments with various SST datasets (MetOffice, ERA-Interim, SOCOL CCM) were fulfilled according to which we showed that the most significant changes in ozone due to the application of different SST datasets were observed in winter and spring. Annual total ozone column variations are about 15-20% due to different SST. The numerical experiment with the only change in ozone depleting substances according to Montreal protocol showed the ozone recovery and, as a result, Qery reduction, but this recovery is not linear. During the 2016-2020 period we estimated the 2-5% increase in Qery values relative to the baseline period (1979-1983) with about 6% maximum over Russian polar region. During the 2035-2039 period the Qery change against 1979-1983 period is about zero, during the 2055-2059 period we obtained the decrease of about 4-6% over Northern Asia and 6-8% over Northern Europe, which reached 15-20% during the 2095-2099 period. These changes corresponded to the noticeable boundary location shift of UV resources, which are determined according to (Chubarova, Zhdanova, 2013), almost for all skin types. For example, by the end of the 21st century in spring and summer the UV excess zone over northern seas will be partly replaced by the area which is characterized with the UV optimum conditions. In winter and autumn the areas with the UV deficiency conditions will be significantly increased for 1,2 and 4 skin types.
References: *Chubarova, N., Zhdanova, Ye. Ultraviolet resources over Northern Eurasia, Journal of Photochemistry and Photobiology B: Biology, 2013, 127, 38-51.*

P17 - Long-term variability of UV index and erythemal UV radiation in Moscow

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Abstract: Continuous measurements of biological active erythemal UV radiation have been started at Meteorological Observatory of Moscow State University by broadband radiometers since 1999. To maintain high quality of measurements, checking of calibration coefficients is regularly carried out. Twice a year, a comparison with control devices, which, in turn, are calibrated against European standards, takes place. It was revealed that one of the used UVB-1 YES devices had noticeable temperature dependence in conditions of cold period of year (20-30% underestimation of measurements). Therefore, special correction of its measurements, based on air temperature and model calculations, was developed. In addition, rigorous research of calibration coefficient for another device that had been used in the beginning of measurements was carried out and additional correction of its measurements (+/-2%) for 2000 and 2003 years was accomplished by the use of model calculations. Variability of erythemal UV radiation and factors influencing it were analyzed based on the corrected measurements. Maximum values of UV index reach 6-7 in Moscow. We showed that the average annual erythemal UV radiation attenuation due to cloudiness and total ozone content are approximately equal in Moscow conditions. The maximal loss of erythemal UV radiation due to cloudiness is observed in November, while ozone-dependent attenuation is maximal in February–March. We also analyzed statistical parameters of UV radiation variability. The kurtosis of daily erythemal UV doses is statistically significant positive from November to February and negative from March to September. The skewness of daily erythemal UV doses is characterized by significantly positive values from September to April and negative values from May to August due to changes in cloud conditions throughout the year. Relative variability of yearly UV radiation doses in comparison with average value is low in recent years.
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P18 - Spatial variability of erythemal UV radiation and geophysical factors influencing it over the territory of Moscow region

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Abstract: Main goal of this research is determination of spatial and temporal variability of erythemal UV radiation over the territory of Moscow region due to variability of different geophysical factors. Because of rare UV radiation measurement network, a suitable approach for UV radiation retrievals consists of two steps. First of all, spatial variability of factors influencing UV radiation needs to be determined. Secondly, UV radiation is calculated based on spatial distribution of obtained parameters. For this purpose spatial and temporal variability of such parameters as total ozone content, cloud UV transmittance, and aerosol optical thickness were investigated over the territory of Moscow region. Spatial and temporal variability of main geophysical parameters that determine doses of UV radiation on the Earth's surface was defined using satellite data. We used OMI satellite data for retrieval total ozone content. Retrievals of aerosol optical thickness were carried out according to the data of modern sensor VIIRS onboard polar-orbiting satellite Suomi National Polar-orbiting Partnership (Suomi NPP) and also using data from AERONET stations. An algorithm of computing cloud UV transmission based on operational data of SEVIRI sensor onboard geostationary satellite METEOSAT was developed. The proposed algorithm is implemented in the prototype of operative monitoring web-service (http://uv-moscow.com) and will be subsequently used to retrieve spatial distribution of UV radiation over the territory of Moscow region.
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SLOVAKIA

P19 - Solar UV radiation measurements by broadband UV radiometers in the Slovak Hydrometeorological Institute

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Abstract: Network of broadband UV radiometers belongs to direction of the National radiation centre SHMI at Poprad-Gánovce. The first broadband UV radiometers SL501A were installed at three stations of the Slovak Hydrometeorological Institute at the end of 90-ties. The aim of this network was monitoring of that part of the solar UV radiation spectra which were most significantly influenced by stratospheric ozone depletion. Instruments with relative spectral response function similar to the biological action spectrum for the erythema of human skin were selected for this aim. They were installed at observatories with different climate to monitor UV irradiances influenced by the local condition. It was known that the measured irradiances did not exactly represent the erythemal UV radiation, especially by low solar elevations and extreme values of total ozone. Stability of the instruments was controlled by comparative measurements with traveling etalon instrument of the same type. Comparative measurements were done during the same season by similar total ozone every year. Irradiances measured by operational instruments started to be compared with the erythemal irradiances measured by the etalon after the etalon calibration at the WRC PMO Davos. New broadband UV radiometers with calibration characteristics provided by manufacturer were installed in the network in 2014. Irradiances measured by operational instruments can be corrected to get values close to the erythemal UV irradiance. Influence of instrument stability control procedure on measured or recalculated erythemal irradiances will be discussed in the paper. Long-time measurements enabled to calculate typical local values of UV irradiance and to consider how the actual measurements differ from the typical values. It enables more relevant presentation of UV irradiance extremeness for the public. Results of nearly 20-years long measurements of UV irradiances by broadband radiometers in Slovakia will be presented.

SPAIN

P20 - CCD spectrometers and RPAs in the framework of the ICARO project: innovative technologies for a better understanding of the radiation field in the atmosphere

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Abstract: The project ICARO is a new initiative consisting in using vanguard technologies in order to monitor the spectral radiation field at ground and in low and middle troposphere, up to around 4000 m. This initiative is being developed by the National Institute for Aerospace Technology (INTA) and the University of Extremadura (UEX). It is funded by the “Ministerio de Economía, Industria y Competitividad” of the Spanish Government under contract CGL2014-56255-C2-1-R. The research project combines vanguard technologies on broad remotely piloted aircrafts (RPAs) with ground-based instrumentation with the aim to improve the monitoring of the radiation field, mainly in regards to its spectral structure.

The project definitely benefits from the use of small CCD spectroradiometers. These instruments have been installed at two ground stations located in El Arenosillo and Badajoz, and on board RPAs for measuring the radiation at several altitude levels. These CCD-based spectroradiometers offer an innovative, promising and versatile technology for reliably measuring the spectral structure of the solar radiation. Thus, while broadband radiometers only provide wavelength-integrated radiation, the new CCD spectroradiometers allow obtaining spectrally resolved measurements. Additionally, in contrast to standard scanning spectrometers, CCD spectroradiometers can measure the whole spectrum simultaneously and almost instantaneously (typical times shorter than 1 second). This fast response makes this technology suitable to discriminate the fast variability of the radiation field under certain sky conditions such as with broken clouds.
At ground stations, the CCD spectroradiometers are complemented by more standard instrumentation, such as Brewer spectroradiometer, Dobson spectrophotometer, broadband radiometers for measuring total and ultraviolet solar radiation and its global, direct and diffuse components, multichannel radiometers, pyrgeometers, ceilometers, all-sky cameras, etc. As mentioned above, CCD spectroradiometers were also installed on board RPAs, which is considered an innovative and very promising technology in the exploration of the atmosphere.
The flights of the RPAs were performed at the "El Arenosillo" station belonging to INTA. In fact, INTA is the national center responsible for aerospace certification, and "El Arenosillo" site in Huelva is the common location for essaying flights with RPAs in Spain. Up to date, seven flights have been conducted. A new gyro-stabilization system was developed in order to assure the horizontal leveling of the sensors during the flight.
The flights usually cover the first 4500 m, measuring the vertical profile of the downward and upward radiation in the lower atmosphere. This information is highly interesting for the study of the effect of aerosols and clouds on the radiation field. These atmospheric constituents remain to be the largest source of uncertainty in respect to climate change assessment and, therefore, to achieve a better monitoring of their effects on the radiation is needed for an accurate understanding of the climate and its present and future changes.