Report of Ozone and Ultraviolet Radiation Activities in Estonia

for the 12th WMO/UNEP Ozone Research Managers Meeting, 24-26 April 2024, Geneva, Switzerland

1. OBSERVATIONAL ACTIVITIES

In Estonia, solar UV radiation has mainly been measured by the Estonian Environment Agency. In addition, from 2004 to 2019, spectral UV measurements were carried out by a research institute - Tartu Observatory (part of the University of Tartu since Jan. 1, 2018). The primary instrumentation for ozone and UV-related measurements is located in Tõravere (58° 15' N, 26° 28' E, 70 m a. s. l.), at the location of Tartu Observatory and the Tartu-Traverse Meteorological Station. The landscape pattern around the Tõravere measurement site consists of arable fields, grassland areas and patches of coniferous forest. It may be considered typical of Estonia. Since 1999, the meteorological station has belonged to the Baseline Surface Radiation Network (BSRN) and specializes in solar radiation measurements. Scientific work on ozone and UV radiation has been mainly performed in Tartu Observatory by the Department of Remote Sensing. Different auxiliary regular measurements like aerosol and cloud data collection are made at the same site. A NASA AERONET sun photometer measuring column aerosol optical depth (AOD) has operated there since 2002.

1.1. Column measurements of ozone and other gases/variables relevant to ozone loss

Column ozone data is received from satellite measurements. No column measurements from the ground of ozone and other gases/variables relevant to ozone loss are carried out.

1.2. Profile measurements of ozone and other gases/variables relevant to ozone loss

No profile measurements of ozone and other gases/variables relevant to ozone loss have been performed in Estonia.

1.3. UV measurements

1.3.1. Broadband instruments

Broadband measurements of UV radiation are performed by the Estonian Environment Agency.

There are five meteorological stations in Estonia measuring UV index (UVI) with erythemally weighted sensors UV-S-E-T (Kipp & Zonen): Tartu-Tõravere, Haapsalu, Pärnu (located in Pärnu-Sauga until 31.03.2019), Roomassare and Tallinn-Harku, Fig. 1. In the Pärnu station, SUV-E (Kipp & Zonen) is used. In the Tartu-Tõravere station, one sensor is used for continuous measurements and another for calibration.

In addition, at theTartu-Tõravere meteorological station, in July 2019, two Kipp & Zonen instruments were installed: CUV5 (280 – 400 nm) and UVS-B-T (280-315 nm). Until August 2018, a CUV3 (290-400 nm), also from Kipp & Zonen, was used.

1.3.2. Narrowband filter instruments

From 2002 until May 2020, a Kipp & Zonen narrowband filter instrument CUVB1 with an effective wavelength of 306±0.2 nm and bandwidth 2±0.5 nm operated at the Tartu-Tõravere Meteorological Station from 2002 until May 2020.

1.3.3. Spectroradiometers

Spectral measurements of solar UV radiation have been performed by Tartu Observatory since 2004.

In 2009, a spectrometric system based on a DMc150F-U double monochromator by Bentham Instruments Ltd. was installed, which measured regularly from sunrise to sunset with a period of 15 min in the wavelength range of 280-400 nm.

Scanning of each spectrum took approximately 40 seconds. All the spectra were recorded in a database. In the summer of 2016, diffuse UV measurements were started at Tartu Observatory in addition to global UV radiation. Spectral measurements ended at the beginning of 2019 due to an instrument failure.

1.4. Calibration activities

Broadband instruments operated by the Tartu-Tõravere Meteorological Station of the Estonian Environment Agency need regular recalibration and intercomparison. Local intercomparison of the operational UV-S-E-T is carried out once a year in Tõravere and every two years in the rest of the locations, with a comparison instrument being sent to the World Radiation Center (Davos, Switzerland) for intercomparison every five years. This is completed with the support of WMO. The last calibration in Davos took place in August 2022.

A narrowband instrument CUVB1 is calibrated at Tartu Observatory's optical laboratory every two years. The CUV5 and UVS-B-T are sent to Kipp & Zonen for calibration, which is done every two years.

The spectroradiometric Solar UV system was calibrated in the measurement configuration, i.e., the fiber and measurement head was attached, using the field calibrator CL6-V (S/N 9759/1) every three months. The CL6-V is calibrated in the Tartu Observatory's optical laboratory against a NIST traceable 1000 W quartz tungsten halogen lamp (FEL) once a year.

In 2018, Bentham DMc150F-U was taken to Sodankylä, Finland, to participate in on-site quality assurance of spectral solar UV measurements performed by the travelling reference spectroradiometer QASUME (Quality Assurance of Spectral UV Measurements in Europe). The report can be found at https://www.pmodwrc.ch/en/world-radiation-center-2/wcc-uv/qasume-site-audits/ (last visited 20.02.2024).

2. RESULTS FROM OBSERVATIONS AND ANALYSIS

In the past five years, the research related to ozone conducted in Estonia has focused on the temporal changes in ground-level UV irradiance and ozone to monitor the long-term changes resulting from the direct and indirect influences of the Montreal Protocol and climate change.

Measurement and modelled data were used to study the annual and seasonal changes in UVB and UVA doses from 2004-2016 (Aun et al., 2019). No significant trends were found. However, there is a high inter-annual variation, especially in the spring and summer periods, where most annual UV doses reach the ground in Estonia and when a significant amount of time is spent outdoors. For extreme UV values in Estonia, several favourable conditions must coincide, like in 2011, with low cloudiness and low ozone.

A study of ozone over Estonia from OMI (Ozone Monitoring Instrument) measurements from 2009-2018 showed no significant trend but revealed a high inter-annual variability in the annual mean (Puusepp 2019). The lowest values during that period were measured in 2011 when a substantial ozone depletion occurred over the Arctic.

3. THEORY, MODELLING, AND OTHER RESEARCH

Models for calculating UVB and UVA daily doses have been developed using ARESLab and libRadtran software. The models use measured daily global solar radiation, column ozone, noon SZA and calculated clear sky UV daily dose.

The models have been used to reconstruct past UV levels and to fill the data caps in the measurements to study annual and seasonal changes (Aun, 2017; Aun et al., 2019).

4. DISSEMINATION OF RESULTS

4.1. Data reporting

Data on UV measurements by the Estonian Environment Agency is collected in the database and is available on request through the Estonian Environment Agency online form (https://www.ilmateenistus.ee/teenused/teenuste-tellimine/tellimisvorm/?lang=en).

4.2. Information to the public

UVI is reported online to the public at the Estonian Environment Agency web page (https://www.ilmateenistus.ee/ilm/ilmavaatlused/uv-indeks/?lang=en). The last measurements of UVI values in each station are shown on a map (Fig. 1). There is a guide for UVI risk assessment next to the map. Daily maximum UVI are displayed on a graph for each station for the past two weeks (Fig. 2).

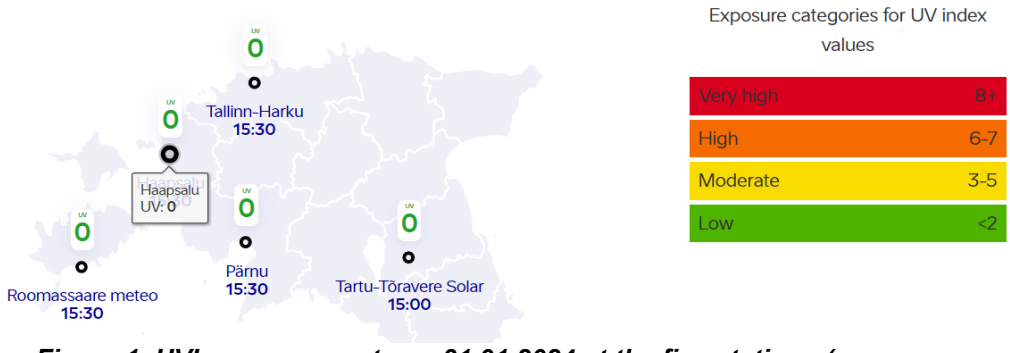

Figure 1. UVI measurements on 31.01.2024 at the five stations (source: https://www.ilmateenistus.ee/ilm/ilmavaatlused/uv-indeks/?lang=en).

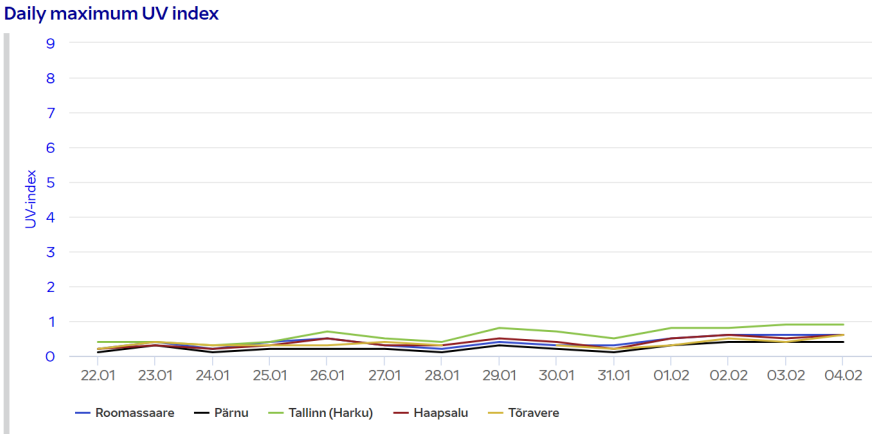

Figure 2. Daily maximum UVI at all the stations, 22.01.2024 – 04.02.2024 (source: https://www.ilmateenistus.ee/ilm/ilmavaatlused/uv-indeks/?lang=en).

Also, general information on UV radiation is available on the Environment Agency web page.

The press often displays materials on UV index, sun protection measures, and other sunbath-related questions from May to August. UV radiation receives more attention during extremely sunny periods.

General information on the availability of solar radiation, including UV, is presented in the annual Survey of the Estonian Environment and the Yearbook of Meteorology by the Estonian Environment Agency, available online.

4.3. Relevant scientific and popular papers in 2017-2023

Aun, M., Eerme, K., Ansko, I., Aun, M., 2019. Daily, seasonal, and annual characteristics of UV radiation and its influencing factors in Tõravere, Estonia, 2004–2016. Theoretical and Applied Climatology 138, 887–897. https://doi.org/10.1007/s00704-019-02865-1

Aun, M., 2017. Dependence of UV radiation on climate factors. Reconstruction of UV doses in Estonia for past years. University of Tartu. PhD thesis.

Aun, M., Lakkala, K., Sanchez, R., Asmi, E., Nollas, F., Meinander, O., Sogacheva, L., De Bock, V., Arola, A., de Leeuw, G., Aaltonen, V., Bolsée, D., Cizkova, K., Mangold, A., Metelka, L., Jakobson, E., Svendby, T., Gillotay, D., Van Opstal, B., 2020. Solar UV radiation measurements in Marambio, Antarctica, during years 2017–2019. Atmos. Chem. Phys. 20, 6037–6054. https://doi.org/10.5194/acp-20-6037-2020

Lakkala, K., Aun, M., Sanchez, R., Bernhard, G., Asmi, E., Meinander, O., Nollas, F., Hülsen, G., Karppinen, T., Aaltonen, V., Arola, A., de Leeuw, G., 2020. New continuous total ozone, UV, VIS and PAR measurements at Marambio, 64 ,S, Antarctica. Earth System Science Data 12, 947–960. https://doi.org/10.5194/essd-12-947-2020

Lakkala, K., Kujanpää, J., Brogniez, C., Henriot, N., Arola, A., Aun, M., Auriol, F., Bais, A.F., Bernhard, G., De Bock, V., Catalfamo, M., Deroo, C., Diémoz, H., Egli, L., Forestier, J.-B., Fountoulakis, I., Garane, K., Garcia, R.D., Gröbner, J., Hassinen, S., Heikkilä, A., Henderson, S., Hülsen, G., Johnsen, B., Kalakoski, N., Karanikolas, A., Karppinen, T., Lamy, K., León-Luis, S.F., Lindfors, A.V., Metzger, J.-M., Minvielle, F., Muskatel, H.B., Portafaix, T., Redondas, A., Sanchez, R., Siani, A.M., Svendby, T., Tamminen, J., 2020. Validation of the TROPOspheric Monitoring Instrument (TROPOMI) surface UV radiation product. Atmospheric Measurement Techniques 13, 6999–7024. https://doi.org/10.5194/amt-13-6999-2020

Puusepp, R. 2019. Changeability of ozone above Estonia. Bachelor's thesis.

5. PROJECTS AND COLLABORATION

Tartu Observatory has been a member of the Nordic Ozone and UV Group (NOG). In addition, there has been a strong collaboration with the Finnish Meteorological Institute for UV and ozone studies in Antarctica and validation of UV products from Sentinel-5P. Even though no validation with the Estonian data was published, the collaboration with FMI helps to keep and improve the expertise in these fields in Estonia.

6. FUTURE PLANS

The Estonian Environmental Agency has and will continue to update the instrumentation and its calibration used for operational UV measurements to ensure the continuation of high-quality measurements in Estonia.

Tartu Observatory aims to continue the UV spectral measurements and related research in the future. Possible funding sources are being looked for.

Tartu Observatory will also try to keep the collaboration with FMI ongoing to make sure that ozone and UV-related research and expertise are held in the country.

7. NEEDS AND RECOMMENDATIONS

There is a need to have continuous, high-quality broadband and spectral measurements of UV radiation and related products to continue the research on the effect of UV on humans, ecosystems and materials and the impact of climate change on ozone and UV.

A long-term funding scheme is needed to ensure the continuation of the Estonian Environmental Agency's current measurements and add spectral measurements that the research group at Tartu Observatory could carry out. In addition, funding is needed to analyze the data and research – neither is currently done in Estonia.