LITHUANIA
National report to the Ozone Secretariat, UNEP, for the 12th WMO/UNEP Ozone Research Managers Meeting April 2024, Geneva, Switzerland

This report has been prepared on activities performed in 2022–2023 and contains information on:
- Observational and research activities related to stratospheric ozone and ultraviolet solar radiation (UV) monitoring;
- Promoting public awareness.

1. OBSERVATIONAL ACTIVITIES

Lithuania ratified the Vienna Convention on the Protection of Ozone Layer and Montreal's Protocol on Substances that Deplete the Ozone Layer on December 19, 1994. The London, Copenhagen, and Montreal Amendments were ratified on December 9, 1997. The Montreal and Beijing Amendments to the Montreal Protocol were ratified on January 15, 2004. The Göteborg Protocol to Abate Acidification, Eutrophication, and Ground-level Ozone was ratified on February 5, 2004.
In Lithuania, total column ozone and UV monitoring are conducted mainly by the Lithuanian Hydrometeorological Service under the Ministry of Environment of the Republic of Lithuania (LHMS). Following the State Monitoring Programme for 2024-2029, the implemented objectives of the program regarding monitoring of total column ozone content and UV-A, UV-B and UV-E allow for assessment of the condition of the natural environment (air, climate, ozone layer, radiological condition, water, soil, wildlife, conditionally natural forest ecosystems, landscape) in Lithuania, manage and forecast both nationally and internationally, provide all levels of environmental protection properly. Total column ozone and UV monitoring are being conducted using the standard observation program recommended by the World Meteorological Organization for National Meteorological Service.

Table 1. Total column ozone and UV measurement sites in Lithuania during 2022-2023

Meteorological station	*Location*	*UV-A*	*UV-B*	*UV-E*	*Total column ozone*
Kaunas	54º53'N, 23º50'E	x	x	x	x
Vėžaičiai	55º43'N, 21º28'E		x	x	

The beginning of UV radiation measurements in Lithuania was in 2000 at Kaunas meteorological station (WIGOS ID 0-20000-0-26629). In 2020 February UV measuring started at Vėžaičiai automatic meteorological station (WIGOS ID 0-20000-0-26517) replacing measurements canceled at Palanga aeronautical meteorological station (WIGOS ID 0-20000-0-26502) due to changed station representativeness (the airport terminal was expanded, and site effected by new surroundings). UV radiation is being measured by the Kipp & Zonen equipment at both stations. The sensors were upgraded and fully installed in Vėžaičiai at the end of 2019. The UV-E element has been started to measure additionally at both stations (from January 2020 in Kaunas and from February 2020 in Vėžaičiai).

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

The state of the ozone layer is monitored at Kaunas meteorological station (WIGOS ID 0-20000-0-26629), which is located close to the geographical center of Lithuania. Total column ozone measurements have been carried out since January 1, 1993, with the M-124 filter ozonometer installed according to its viewing requirements. Routine measurements of total column ozone were made manually (in the daytime) up to a maximum of nine times per day. Since 2014, Kaunas meteorological station has been equipped with Brewer MK-III spectrophotometer for continuous outdoor operation and contains two modified Ebert f/6 spectrometers. For several years, measurements have been compared

and since April 2018, measurements have been fully automated. For the period 2022-2023 measurements were continued and the analysis of data accuracy and suitability was carried out by specialists in LHMS.

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

LHMS sites are not equipped with ozone sondes and ozone lidar to make measurements of ozone profile.

1.3 UV measurements

UV measurements have been carried out since 2000 at Kaunas and since 2020 at Vėžaičiai. Mean and maximum daily radiation is being monitored using the Smart UV radiometers made by Kipp & Zonen SUV Series (SUV-A, SUV-B, and SUV-E in Kaunas, also SUV-B and SUV-E in Vėžaičiai).
Kaunas UV-A and UV-B data for the period from January 1, 2020, to May 31, 2020, is used and measured by the Solar Light biometer 501-A, due to the results of the comparative analysis of the instruments. From July 1, 2020, UV-A and UV-B data measured with the Kipp & Zonen Smart UV device is used. Kaunas UV-E radiation data measured by the Kipp & Zonen Smart UV instrument is used from January 17, 2020.
Vėžaičiai UV-B and UV-E data started to be measured with the Kipp & Zonen Smart UV instrument on February 4, 2020. Due to the analysis carried out after the installation of the instruments, the daily average and maximum values of these parameters are in operational use from February 5, 2020.

1.5 Calibration activities

The network UV instruments are calibrated against the working references (standards) of LHMS Metrological Laboratory at regular intervals, at least once every two years. The last calibration was performed in 2023. The working references were calibrated at their manufacturer's Kipp & Zonen laboratory, using traceable references.
The Brewer MK III spectrophotometer #219 in Kaunas was last calibrated by Kipp & Zonen in 2023. A dispersion test with external cadmium and an internal mercury lamp was done to generate new dispersion constants after which a new cubic dispersion file was applied. Then Brewer was calibrated for ozone against the traveling reference Brewer #158.
On April 6, 2022, a failure of the Brewer MK-III spectrophotometer was registered. LHMS specialists performed a technical inspection, during which a malfunction of the mechanical part of the device was detected. The malfunction was fixed on May 17, 2022.
In the period from March 23, 2023, to November 26, 2023, the Brewer MK-III spectrophotometer was not working. LHMS specialists could not determine the cause of the failure due to the complex technical structure of the device. The public procurement procedures for repair and calibration service and the coordination of arrival schedules of repair specialists took some time. The Brewer MK-III was repaired by a representative of Kipp & Zonen, the manufacturer of the device. The malfunction of the instrument was caused by very low lamp counts due to a faulty lampboard. After the repairs, the manufacturer's representative performed testing, adjustment, and calibration of the device.

2. RESULTS FROM OBSERVATIONS AND DATA ANALYSIS

2.1 Total column ozone measurements

In 2022 the distribution of stratospheric ozone data over Lithuania reached an average of 338 DU, which was in line with the long-term mean (1993-2020) of 345 DU. The 2022 mean ozone value was significantly affected by a mechanical part malfunction of the spectrophotometer on 6 April which prevented automatic measurements from 6 April to 16 May. Accordingly, due to the prolonged period of data gap, the mean values for April and May are not usable and have not been included in the

calculations. The observed ozone results for 2022 follow a similar trend to the recent years 2018, 2019, and 2021, which were characterized by exceptionally high daily maximum values, and in contrast to 2020, which had exceptionally decreased ozone values (Fig. 1).

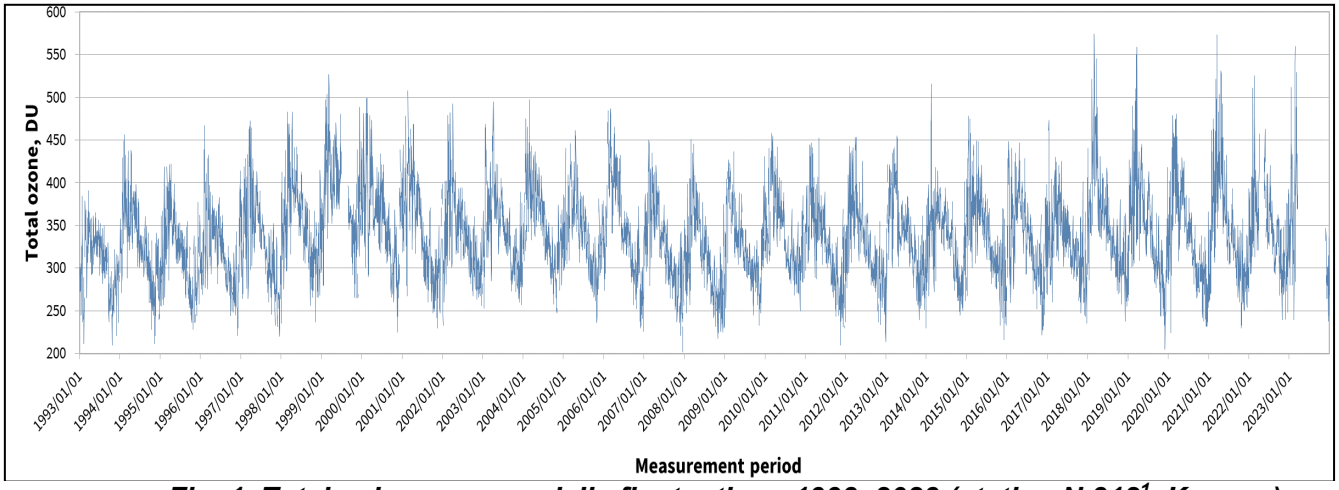

Fig. 1. Total column ozone daily fluctuations 1993–2023 (station N 312[1], Kaunas)

The 2023 annual mean ozone over Lithuania has not been calculated and is not usable due to a spectrophotometer malfunction on 23 March. Between 23 March and 27 November, no automatic measurements were made and 69 % of the data were lost.
Due to the gaps in the ozone data for 2022 and 2023, and the comparative analysis made by comparing different long-term means (2022 compared to (1993-2020) and 2023 compared to (1993-2022)), the results for these years will be presented in separate chapters.

2.1.1 Analysis of 2022 total column ozone data

In 2022, all months (except March) recorded positive monthly mean deviations from the long-term values. The highest positive mean monthly deviation was recorded in September (338 DU), which was 11 % higher than September's long-term mean (304 DU) (Fig. 2).

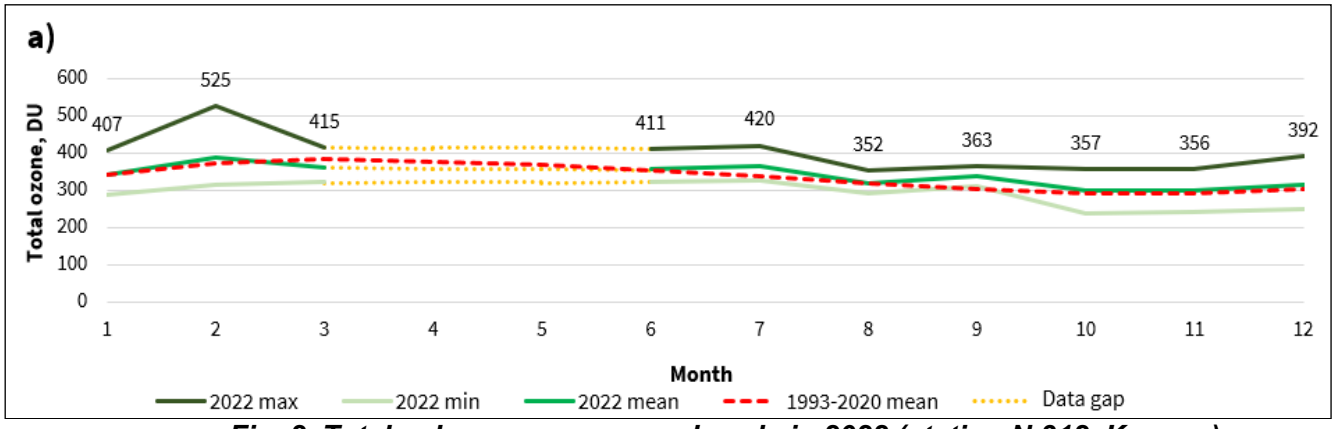

Fig. 2. Total column ozone annual cycle in 2022 (station N 312, Kaunas)

The absolute minimum for the year 239 DU – was measured on 31 October, which is 15 % lower than the long-term minimum mean (283 DU) and 18 % higher than the Lithuanian all-time absolute minimum 202 DU (December 21, 2007). Cases when measured ozone values were dangerously low and below

[1] 312 - WOUDC Station ID

20 % of the long-term mean were not recorded in 2022. Longer periods with negative deviations have been observed in January, March, June, and December (Fig. 3).

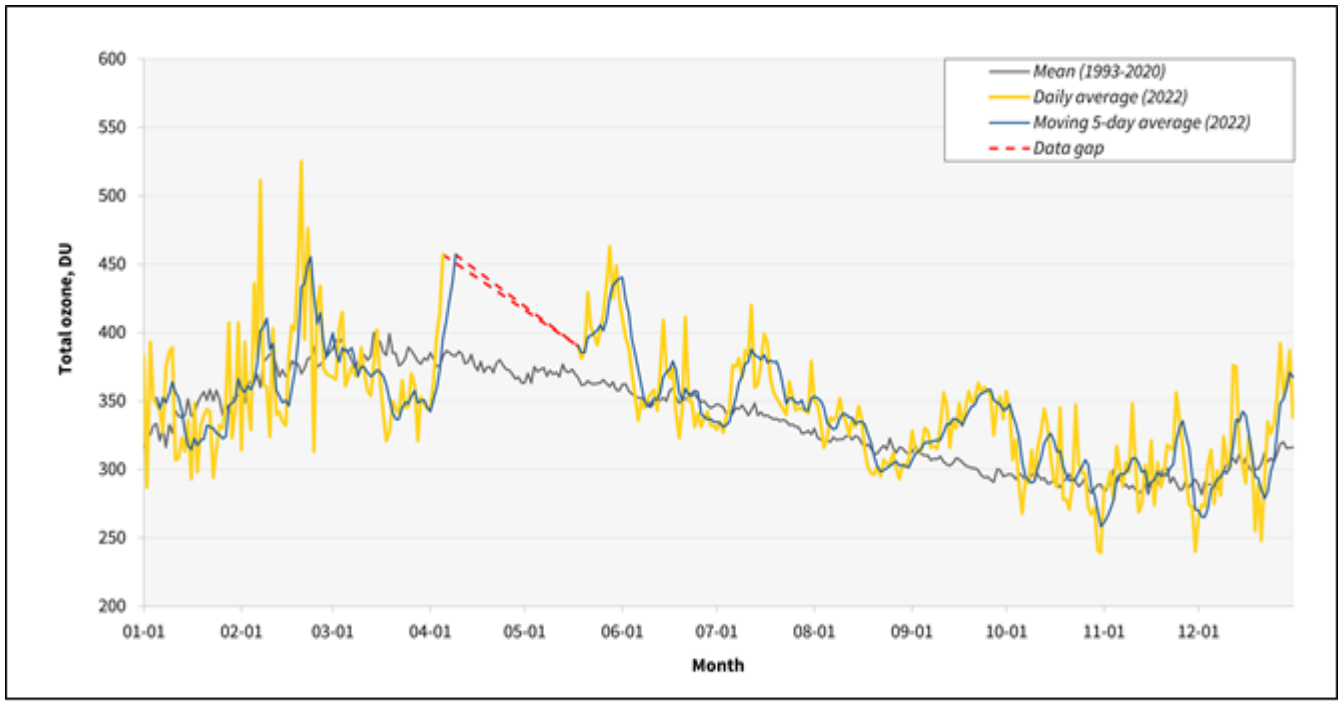

Fig. 3. Total column ozone fluctuations in 2022 (station N 312, Kaunas)

In 2022, the absolute maximum of 525 DU was reached on 20 February. It was 31 % higher than the long-term maximum mean (400 DU) and 9 % lower than Lithuania's measured all-time absolute maximum of 574 DU (March 3, 2018) (Fig. 3).

2.1.2 Analysis of 2023 total column ozone data

In 2023, due to the delays in the repair of the device and the resulting long period of data gaps (March-November), this part of the report will only provide an analysis of data for individual months (January, February, and December) in 2023 (Fig. 4).

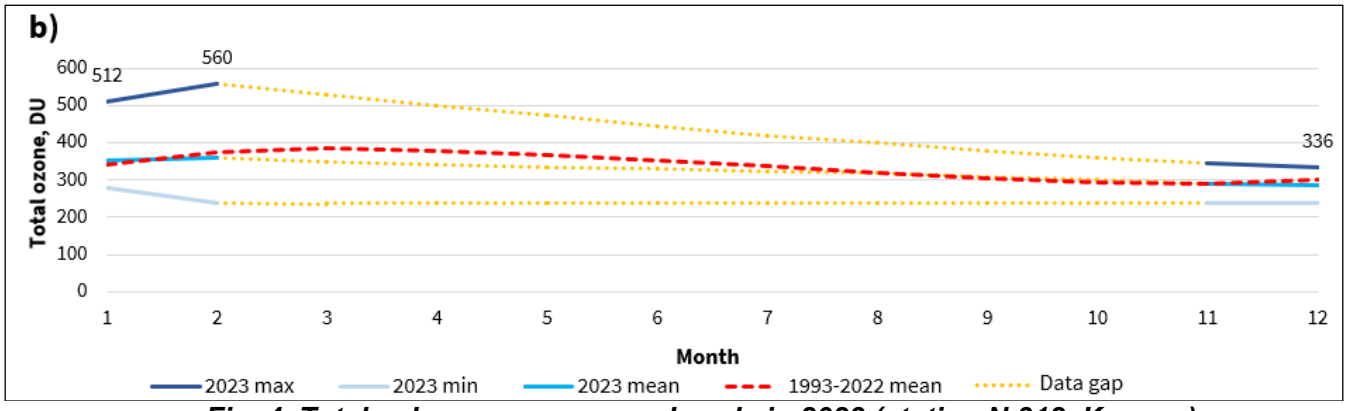

Fig. 4. Total column ozone annual cycle in 2023 (station N 312, Kaunas)

In January, the total column ozone measured in Kaunas (352 DU) was on average 4 % higher than the long-term mean result (340 DU). This month, historically high and dangerously low values of ozone measurements were recorded. The highest values and the improved daily records for January were

recorded on 17 (458 DU), 19 (512 DU), and 21 (447 DU). Accordingly, these days records have pushed into second place 2016 (448 DU), 2000 (441 DU), and 2000 (446 DU). The January maximum record for total column ozone (512 DU) was also improved on 19 January, leaving in second place (481 DU measured on January 18, 2000) and in third place (479 DU on January 18, 2015). The lowest ozone concentrations at the end of the first and third decades were recorded. The most dangerous decrease was on 29 (280 DU), which is 20 % less than the long-term mean for this day (352 DU). This ozone depletion in 2023 is recorded for the first time since October 26, 2021, but it still was 25 % higher than the absolute January minimum (224 DU measured on January 26, 2020) and 39 % higher than the Lithuanian all-time minimum (202 DU measured on December 21, 2007) (Fig. 5 (a)).

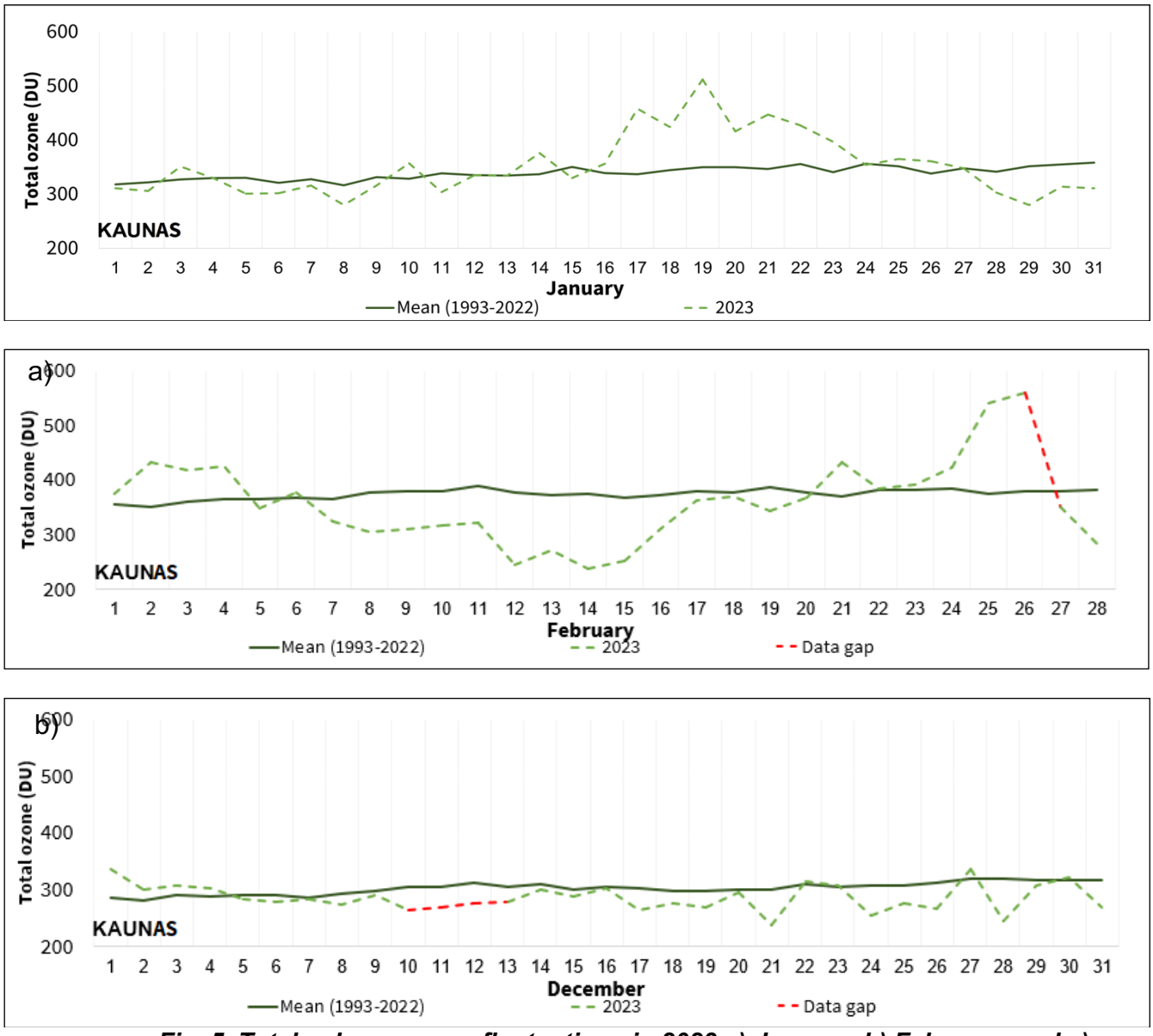

Fig. 5. Total column ozone fluctuations in 2023 a) January, b) February, and c) December

In February (due to a malfunction of the spectrophotometer software 27th-day data were not included), the total column ozone measured (360 DU) was on average 4 % lower than the long-term mean result (374 DU). This month, same as in January, recorded historically high and dangerously low values. The highest ozone values and improved daily records for February were recorded on 25 (540 DU) and 26 (560 DU). Accordingly, these days records have pushed into second place 2018 (470 DU) and 2000

(481 DU). Also on 26 February, the record for the February maximum (560 DU) was improved, leaving the second place (540 DU measured on February 25, 2023) and the third place (525 DU measured on February 20, 2022). The lowest values are recorded in the second and third decade of the month. Dangerous ozone depletion was recorded on 5 days this month – 12 (245 DU), 13 (272 DU), 14 (239 DU), 15 (253 DU) and 28 (284 DU), which was lower than the long-term mean of these days on 12 (-35 %), 13 (-27 %), 14 (-36 %), 15 (-31 %) and 28 (-26 %). The ozone values measured on 14 and 28 also improved previous daily minimum records and left them in second place (260 DU, February 14, 2017) and (290 DU, February 28, 2000) (Fig. 5 (b)).

In December (due to a malfunction of the spectrophotometer software 11-12th-days data were not included), the total column ozone measured in Kaunas (287 DU) was on average 5 % lower than the long-term mean result (303 DU). This month, dangerously low ozone values have been recorded. The lowest values were recorded in the second and third decades. Dangerously low ozone values were recorded on 2 days this month, on 21 (238 DU) and 28 (244 DU), which were -21 % and -24 % lower than the long-term mean values on these days, and accordingly, the deviation from the long-term minimum mean value for December (282 DU) was -15 % and -13 %. The highest values were recorded on the days of the first and third decades – 1 and 27 (336 DU) and 30 (322 DU). Accordingly, the deviation of these days from the long-term maximum mean value for December (320 DU) was 5 % and 1 % (Fig. 5 (c)).

Cases when measured ozone values were dangerously low and below 20 % of the long-term mean in 2023 was recorded 8 times.

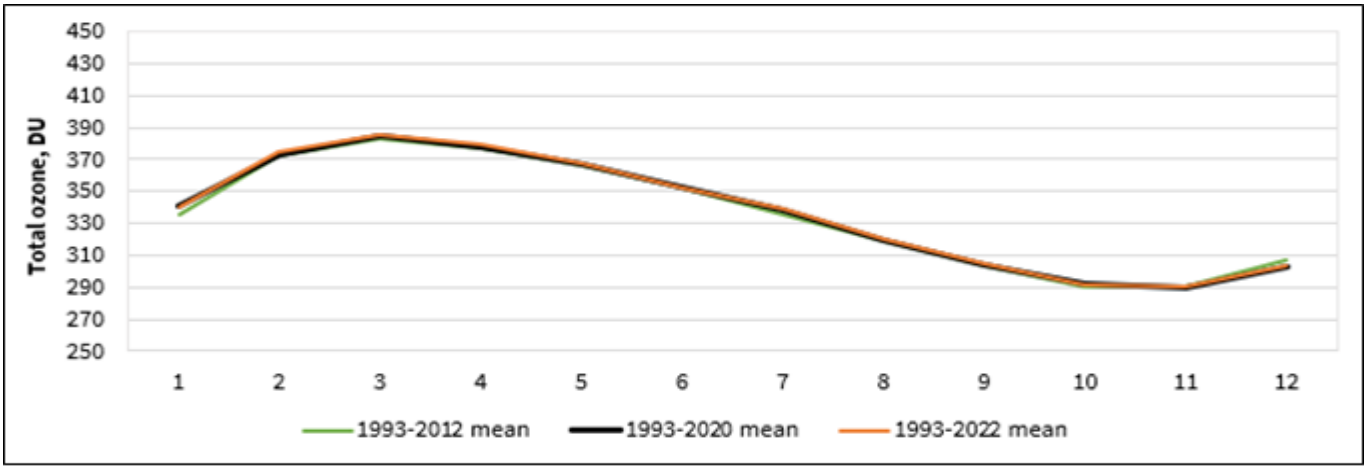

Fig. 6. Total column ozone long-term means (station N 312, Kaunas)

All observational data is stored and processed regularly. In 2023, the LHMS carried out the ozone data analysis resulting in the establishment of the mean total column ozone values for the period of 1993–2022, which have since been used to assess the ozone layer depletion over Lithuania (Fig. 6). It is also used in monitoring the total column ozone and assessment of its quantitative changes until now.

2.2 UV measurements

UV in Lithuania is measured at 2 stations – in Kaunas and Vėžaičiai. This part of the report presents the seasonal change of the UV index (UVI) in Lithuania in 2022 and 2023.

In 2022, Kaunas and Vėžaičiai had a high UVI (calculated by multiplying the maximum daily UV-E value by 40) in June and July (6 UVI), a moderate UVI (3-5 UVI) in April-May and August-September, and a low UVI (0-2 UVI) in other months. In Kaunas, there were 142 cases, and in Vėžaičiai – 138 cases, where UVI values were recorded as equal to or higher than 3 UVI. A high (6 UVI) index prevailed for 5 days in Kaunas and 8 days in Vėžaičiai. In both stations, most of these days occurred in June and July. The highest UVI value in 2022 for Kaunas was recorded on July 3, reaching 6.1 UVI (recorded at 10:03

UTC), and for Vėžaičiai, it was recorded on July 2, also reaching 6.1 UVI (recorded at 11:04 UTC) (Fig. 7 (a)).

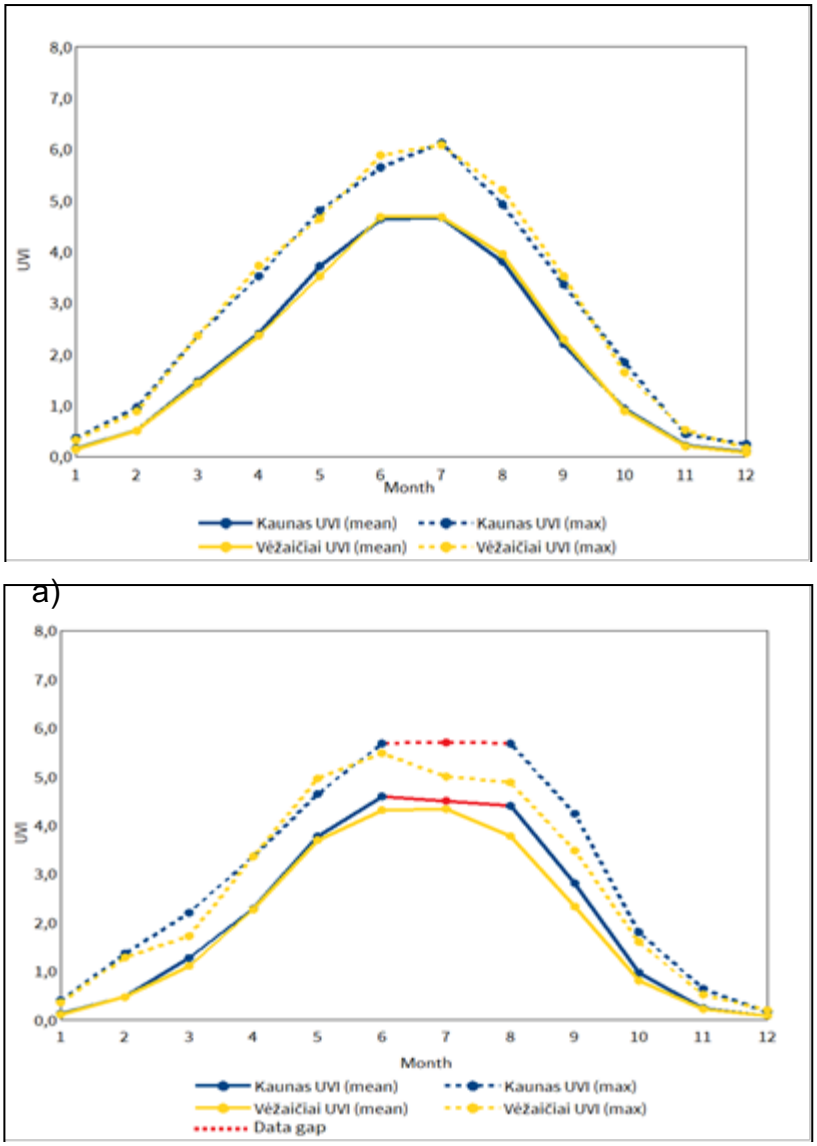

Fig. 7. UVI annual cycle in Kaunas and Vėžaičiai in a) 2022 and b) 2023

In 2023, in Kaunas, high UVI (6 UVI) were observed in June and August (the value for Kaunas in July cannot be used due to a UV-E data gap on 24-31 July), while in Vėžaičiai no such cases were recorded. In Vėžaičiai, moderate UVI (3-5 UVI) was recorded from April to September, while in Kaunas, moderate UVI was recorded only in April, May and September. In the remaining months, both stations recorded a low UVI (0-2 UVI). There were 144 cases in Kaunas and Vėžaičiai where UVI values were recorded equal to or higher than 3 UVI. The high index (6 UVI) was measured for 4 days in Kaunas. The mentioned days were June 19 and 23, July 3 and August 13. The highest 2023 UVI value in Kaunas was recorded on 23 June (10:42 UTC) and 13 August (10:22 UTC) – reached 5.7 UVI. In Vėžaičiai the highest value was on 22 June with a UVI of 5.4 (recorded at 10:26 UTC) (Fig. 7 (b)).

According to the available data, the maximum daily UV values are usually observed between 10 and 11 UTC at both stations in central and western Lithuania.

3. THEORY, MODELLING, AND OTHER ZONE RELATED RESEARCH

No research, analysis, or studies have been carried out on this initiative.

4. DISSEMINATION OF RESULTS

4.1 Data reporting

The ozone measurement data is sent regularly to the World Ozone and Ultraviolet Data Centre (WOUDC) in Toronto, Canada. Since 2004, also the UV-B measurement data from the Kaunas station has been sent to WOUDC each month.
To forecast the UV Index, data from the Human Biometeorology Unit (GF MM) of the German Meteorology Service (DWD) are used with modifications depending on local cloudiness.

4.2 Information to the public

Considering that public awareness and exchange of information is important for the successful implementation of the Montreal Protocol, and relevant European and national legislation, the Government of Lithuania considers awareness rising as one of the priorities.
The Ministry of Environment of Lithuania provides interested parties with consultations and explanations on particular ozone-depleting substances (ODS) related issues, especially concerning the legal interpretation of the particular provisions of Regulation (EC) No 1005/2009 of the European Parliament and of the Council of 16 September 2009 on substances that deplete the ozone layer and national legal acts.
The population of Lithuania is informed about the level of UV radiation in Lithuania and the risks related to it. In the event of significant ozone layer depletion or a dangerous UVI, LHMS issues warnings, which are disseminated via mass media and on the LHMS website (www.meteo.lt). Such announcements have been made 11 times: on June 6 and 29, 2022, January 30, 2023, February 13, 2023, March 1, 2023, May 25 and 31, 2023, June 7, 21, and 23, 2023 and July 12, 2023.
Since 2001, LHMS has been providing the UVI forecasts for the period May-August. Since 2008, the forecasting period has been extended to the period April – September. These forecasts continuously are disseminated via mass media and on the LHMS website.
UV data and their analysis as an environmental and health indicator each year (as well as in 2022 and 2023) are presented to the Institute of Hygiene Health Promotion Centre under the Ministry of Health of the Republic of Lithuania.
In 2023, publicly and accessible ozone data were made available on the LHMS website:

- Total column ozone (long-term means of 1993-2022 period);
- Total column ozone (daily and monthly means of 1993-2022 period).

4.3 Relevant scientific papers

Articles on ozone depletion over Lithuania were published on the LHMS website in January, February, and March 2023, stating the reasons and providing recommendations.
The following scientific papers were published during the reporting period:

- Vasiliauskienė V., Pačiulienė M., Jasaitis D. (2022). Influence of Meteorological Parameters on the Dynamics of Ozone and Aerosol Particles Near a Road Transport Street. *Human & Nature Safety,* 82, DOI: 10.7220/2538-9122.2022.
- Bukantis A. (2022). Ozone depletion, recovery, and climate impacts. Vilnius University.
- Kerpytė U., Nedzinskeinė L. (2023). Prevalence, risk factors and recommendations for skin cancer: literature review. *Public Health*, 102, 13-18.

5. PROJECTS, COLLABORATION, TWINNIG AND CAPACITY BUILDING

At present no international or national projects on the study of ozone are conducted.

6. IMPLEMENTATION OF THE RECOMMENDATIONS OF THE 11th OZONE RESEARCH MANAGERS MEETING

The main task following the recommendations from the 11th Ozone Managers Meeting has been to keep up with important long-term monitoring activities, share the results internationally, and contribute to research on measurement methods.

7. FUTURE PLANS

Continue all running ozone and UV measurements and data sharing.

8. NEEDS AND RECOMMENDATIONS

Improve knowledge, usage, and implementation of distance methods for measuring total ozone data over Lithuania.