

SLOVAKIA

OBSERVATIONAL ACTIVITIES

Column measurements of ozone

Since August 1993 Brewer ozone spectrophotometer MKIV No.097 has been operated at the Global Ozone Observing System (GOOS) station No. 331 Poprad-Ganovce (49.03N, 20.32E, 706 m a.s.l.). The station is a part of the Aerological and Radiation Centre (ARC) of the Slovak Hydrometeorological Institute (SHMI). ARC is also performing upper-air measurements and conducting SHMI solar radiation network. Poprad-Ganovce is the Global Atmosphere Watch (GAW) regional station for the total column ozone monitoring.

Profile measurements of ozone

Morning Umkehr vertical ozone profile measurements have been made with the Brewer spectrophotometer by proper weather conditions since August 1993. Every year about 150 Umkehr profiles have been taken and files are available to process.

UV measurements

Broadband measurements

At present the Slovak UV-B network consists of five stations. Four of them are equipped with SOLAR Light 501 UV Biometers. Three stations belong to SHMI (Bratislava 48.17N, 17.12E, 287 m a.s.l., in operation since 1997, Kosice 48.70N, 21.27E, 230 m a.s.l., since 1998, Poprad-Ganovce, since 1999) and one station situated in mountains belongs to the Geophysical Institute of the Slovak Academy of Sciences (GISAS) (Skalnate Pleso, 49.20N, 20.23E, 1778 m a.s.l., in operation since 2001). GISAS also measures the global ultraviolet radiation with Eppley UV-radiometer model TUVR for the wavelength range 290-385 nm located at Stara Lesna (49.15N, 20.29E, 808 m a.s.l., in operation since 2002).

Narrowband filter instruments

No UV narrowband instruments are installed at SHMI and GISAS stations.

Spectroradiometers

Spectral measurements of the solar UV-B radiation (in the region 290-325 nm at 0.5 nm increments) have been performed with the Brewer spectrophotometer at Poprad-Ganovce since August 1993. Observations are scheduled at regular time intervals. Poprad-Ganovce is GAW regional station for the spectral UV-B monitoring.

Calibration activities

The Brewer No.097 is regularly calibrated against World Travelling Standard Brewer No.017 every two years. Last international comparison and calibration was held at Hradec Kralove in May 2007.

The ARC maintains the SL 501 UV Biometer designated as the national reference instrument. The instrument is compared with the Czech reference UV Biometer during the Brewer calibration campaigns. In 2006 the Slovak reference instrument took part in the international calibration held at WRC Davos.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Figure 1 shows seasonal means of total column ozone at Poprad-Ganovce. Trends in total ozone for the period 1994-2007 are positive except for autumn. In contrast with the negative trend reported 3 years ago higher ozone in most of last ten years started to compensate very low ozone in period 1995-1997.

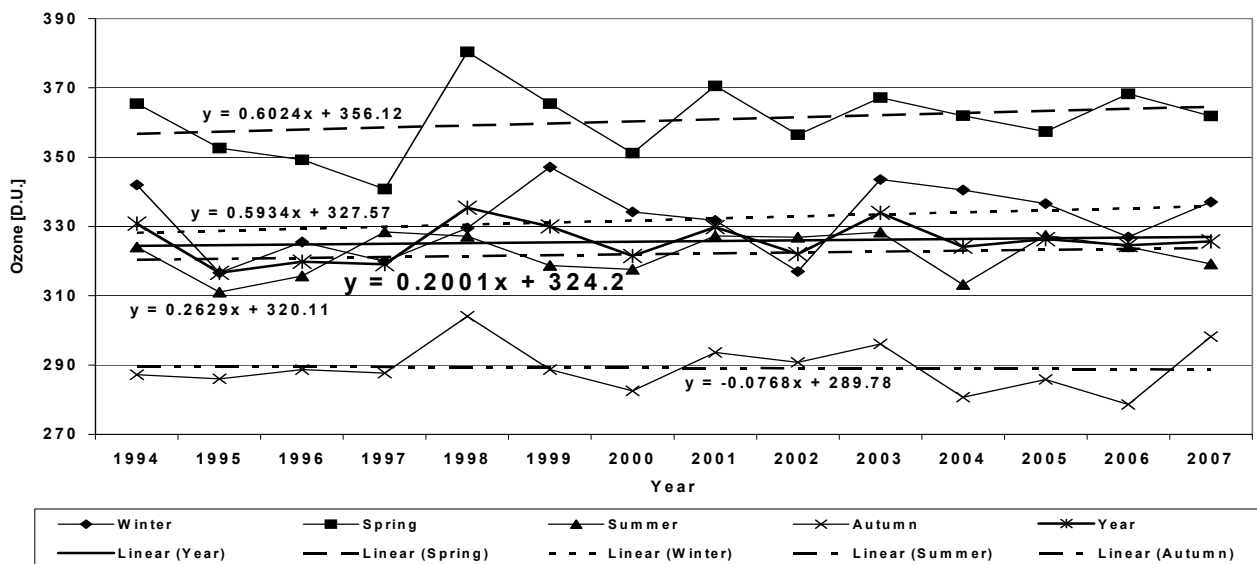


Figure 1: Seasonal trends in total column ozone at Poprad-Ganovce 1994-2007.

Months with most significant positive and negative trends in total ozone are in Figure 2. In March and June positive trends of almost 10 D.U. per decade were observed. Total column ozone was low during first half of the investigated period in June. Average ozone loss was about 10 per cent. Since 2001 ozone layer in June has improved however total column ozone amount is still about 5 per cent below long term average. Positive trend of 5 D.U. per decade was observed also in February in which big variability in total ozone is typical. In investigated period negative trends in total column ozone from -3 to -4 D.U. per decade were observed only in September, October and December.

Observations at Poprad-Ganovce indicated that the ozone decline does not continue. The onset of ozone increases should be identified in present period which is in accordance with most of models.

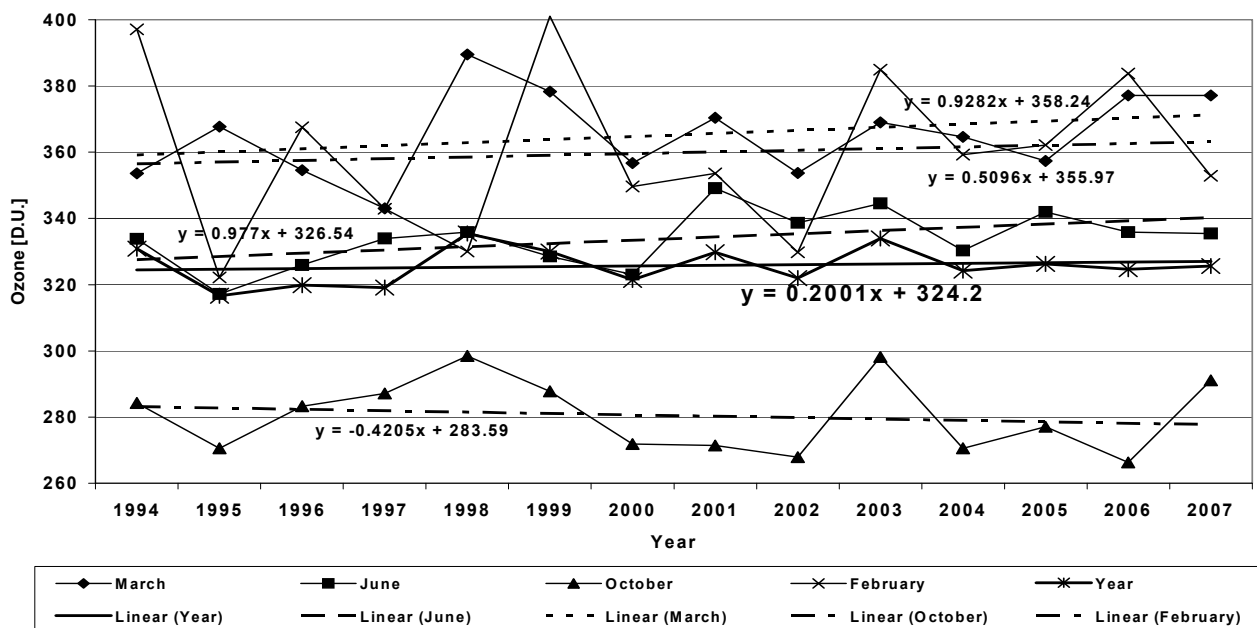


Figure 2: Months with significant trends in total column ozone at Poprad-Ganovce 1994-2007.

THEORY, MODELLING AND OTHER RESEARCH

A model of daily total ozone for Poprad-Ganovce station was created as the sum of two independent models: (1.) model of the monthly total ozone values, (2.) model of daily total ozone deviations from the monthly average. Parameters tested before inclusion into the monthly total ozone model were: ozone-depleting substance concentration in the stratosphere expressed by equivalent effective stratospheric chlorine (EESC), stratospheric aerosol, index of quasi-biennial oscillations (QBO), index of North Atlantic oscillation (NAO), solar activity expressed by sun spot number (SSN) and upper-air data (height of tropopause for January–February, temperature at 700 hPa level for December and difference between 100 hPa and 250 hPa isobaric level heights for the other months). Analysis of the Hradec Kralove monthly total ozone showed that concentration of ozone-depleting substances in the stratosphere, NAO-index and upper-air parameters belong to the best proxies of the total ozone nearly during the whole year. Aerosol plays significant role in long-term total ozone variability in December and January. Solar activity variations affect the total ozone values in April–July. QBO index does not affect the total ozone variability significantly during any month except for February. Comparison of monthly total ozone trends determined from modelled and measured 1970 - 2000 time series showed descending trend of total ozone during all months, the largest total ozone decrease was detected in April and June, but the most significant linear decrease of total ozone was determined in January and October. Difference between modelled and measured total ozone trend was below 0.3 %. Short-term total column ozone variability was modelled using upper-air proxies only. The error of final model of daily total ozone was of 6 %. Coefficient of determination between measured and modelled 1993 - 2004 total ozone was of 0.86.

Maps of the solar erythemal ultraviolet (UV) radiation daily doses were created for every month with horizontal resolution of 500 m at geographical domain 47.15N – 49.86N x 16.94E – 22.81E covering the territory of Slovakia. Cloud modification factor (cmf) for the UV radiation was modelled utilizing relation between the cmf of total and UV radiation. Measurements of total ozone performed with Brewer spectrophotometer at Poprad-Gánovce (inside the investigated domain) were considered representative for selected geographical area. Information on snow cover presence was the only meteorological parameter used in the model. Verification of the model was performed at 5 observatories equipped with broadband solar UV radiometers. The maps of the cmf factor for the UV radiation were created utilizing measurements of total solar radiation performed at 9 observatories during decade 1995–2004 and the model of monthly cmf dependence on altitude. Maps of clear-sky UV radiation daily dose and UV radiation daily dose affected by average cloudiness were constructed for average monthly total ozone values, their upper and lower monthly limits, for two probability levels of snow cover occurrence as criterion for the snow line altitude and for 1 day representing typical values of every month. The maps of the erythemal UV radiation daily doses were created for average and limit conditions of factors affecting the erythemal UV radiation.

DISSEMINATION OF RESULTS

Data reporting

The Brewer data are submitted to the World Ozone and Ultraviolet Data Centre (WOUDC) in Toronto every month. Total ozone and UV-spectral raw data are monthly submitted to Brewer Data Management System (BDMS) in Toronto to process and submit it to WOUDC. Since winter 1994 the station has participated in the WMO GAW Northern Hemisphere Ozone Mapping Experiment by daily submitting of total ozone data to Ozone Mapping Centres.

Information to the public

The report on present state of ozone layer and intensity of solar damaging UV radiation (Erythema effect) for sunny days is sent to Slovak Press Agency twice a day. It is regularly utilized by television, broadcast and newspapers.

ARC Poprad-Ganovce also has been preparing short report on the total ozone amount and recommended maximal sunburn time. This report is propagated by mobile telephone service.

SHMI provides regular total column ozone and UV Index (March-September) forecast. It is propagated by SHMI Web site.

Daily means of total ozone and deviations from long term average are part of upper-air information in monthly issued Bulletin Meteorology and Climatology, Slovak Republic.

Analyze of total ozone, surface ozone and solar UV radiation is regularly included in the annual publication: "Air Pollution in the Slovak Republic".

Relevant scientific papers

Pribullová, A., Chmelík, M., 2005: Effect of altitude and surface albedo variability on global UV-B and total radiation under clear-sky condition. Contributions to Geophysics and Geodesy, 35/3, 281-298.

Pribullová, A., Chmelík, M., 2005: Reconstruction of UV-B radiation time series at Skalnaté Pleso observatory in period 1961-2004. Proceedings of conf. Bioclimatology at present and in the future. Brno 12 – 14 September 2005, ISBN 80-86690-31-08, p. 59.

Pribullová, A., Nowaková, B., Chmelík, M., 2006: Modelling of long-term and short-term total ozone variability at Poprad-Gánovce, Slovakia. Contributions to Geophysics and Geodesy, 36/3, 283-303.

Pribullová, A., Chmelík, M., 2007: Solar erythemal UV radiation climatology over Slovakia. Contributions to Geophysics and Geodesy, 37/2, 87-108.

Nowaková, B., 2007: Evaluation of total ozone extremes at Poprad-Gánovce. Contributions to Geophysics and Geodesy, 37/3, 275-290.

PROJECTS AND COLLABORATION

SHMI participate in international ozone and UV collaboration mainly by regular submitting of the ozone, upper-air and UV-B data to the WOUDC and special project data basis.

At national level the project: "UV Biometer calibration methodology and UV-B observation series reconstruction" is solved at SHMI and the project: "Effect of atmospheric boundary layer on radiative fluxes and heat balance of Earth's surface" is solved at GISAS. Both projects are included into COST action 726: "Long term changes and climatology of UV radiation over Europe".

FUTURE PLANS

Because of limited both personal and financial capacities the main task is maintenance and regular calibration of all instruments to keep the high data quality.

Since 2007 ARC Poprad-Ganovce has served as the National Radiation Centre. Therefore the cooperative research of SHMI and GISAS will be managed to utilize the correlation of global radiation and other proxies to UV radiation for more precise modelling of UV radiation over Slovakia. The aim is also more comprehensive and detailed information about solar UV radiation and ozone layer state to the public.
