POLAND

In Poland, ozone and UV monitoring and related research activities are conducted by the Institute of Meteorology and Water Management (IMWM), and Institute of Geophysics of the Polish Academy of Sciences (IGfPAS). The ozone and UV-B monitoring and research, carried on in both Institutes, are supported by: Chief Inspectorate for Environmental Protection; National Fund for Environmental Protection and Water Management; Ministry of the Environment.

OBSERVATIONAL ACTIVITIES

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

Institute of Geophysics of the Polish Academy of Sciences
Measurements are carried out at the Belsk Observatory (51° 50' N. 20° 47'E). Since 1963 total ozone measurements and Umkehr series have been performed by means of the Dobson spectrophotometer No. 84. In 1991 Brewer spectrophotometer No. 64 was installed. Total ozone and Umkehr profile series have been re-evaluated in 1983 and 1987 respectively.
The surface ozone measurements with Monitor Labs, ML8810 meter started in 1991, and since 1992 NOx measurements have been performed with Monitor Labs, (ML8841) meter.

Institute of Meteorology and Water Management
Surface ozone measurements with Monitor Labs. ML9810 are performed at 3 stations: Leba (54.75N, 17.53E) Baltic Coast, Jarczew (51.81N, 21.98E) Centre of Poland, Sniezka (50.73N, 15.73E) Sudety Mountains.

Profile measurements of ozone

Institute of Meteorology and Water Management
The ozone soundings have been performed at Legionowo (52.40N, 20.97E) upper-air station since 1979. Up to May 1993 the OSE ozone sensor with the METEORIT/MARZ radio sounding system was used. Later on the ECC ozone sensor and DigiCora/RS80/92 radio sounding system of Vaisala is in use. The ozone soundings are launched regularly on each Wednesday. Legionowo is a complimentary station of the global NDAAC/NDSC ozone sounding network. Ozone sounding data from Legionowo are submitted to the NDSC database.

- The Legionowo ozone profiles were used in the validation procedures of ozone profiles derived from satellite projects: MIPAS, SCIAMACHY and OMI.
- Since 1993, on the base of the NOAA/TOVS satellite data, total ozone maps over Poland and surroundings have operationally been performed at a Satellite Remote Sensing Center of IMWM in Krakow.

UV measurements

Broadband measurements
Broadband UV Biometers model SL 501 vers. 3 have been used for UV measurements at three IMMW stations in Poland: Leba (54.75N, 17.53E), Baltic Coast, Legionowo (52.40N, 20.97E), Centre of Poland, Zakopane 857m, Tatra Mountains (49.30N, 19,97E). The UV measurements on the Henryk Arctowski Polish Antarctic Station (62°09'41"56/S, 58°31'49"99/W) with SL501 were performed in 2005-2007.

Systematic measurements of ground level ultraviolet solar radiation (UV-B) with the Robertson-Berger meter have been carried out at Belsk station since 1975. In 1992 UV Biometer SL501A , and in 2005 Kipp and Zonen UV-S-AE-T broadband radiometer were installed. The UV monitoring has been conducted at Polish Polar Station at Hornsund, Svalbard since 1996.

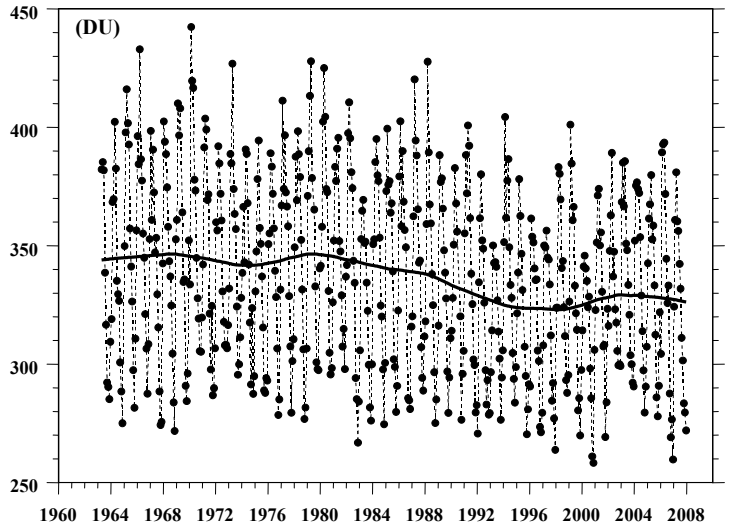
Narrowband filter instruments
Two NILU-UV spectral filter instruments, installed at IMWM station Legionowo, measure the UV-B, UV-A, total ozone and cloud transmission.

Spectroradiometers
Spectral distribution of UV radiation has also been monitored with the Brewer spectrophotometer at Belsk.

Calibration activities
The Dobson and Brewer spectrophotometers are regularly calibrated. The recent calibration of the Dobson instrument took place in 2005 at Hohenpeissenberg, and Brewer instrument was calibrated against Brewer#17 maintained by International Ozone Corporation, in 2007 at Hradec Kralove. The next calibration of Brewer and Dobson spectrophotometers is planned in 2008 and 2009 respectively.

The reference UV Biometer model SL 501 for the IMWM network took part in the calibration campaign in El Arenosillo Spain. Since 2001 the NILU-UV spectral filter instrument has been each year calibrated at NRPA, Norway.

RESULTS FROM OBSERVATIONS AND ANALYSIS



Monthly mean values of total ozone at Belsk.

RESEARCH

Institute of Meteorology and Water Management
Ozone and UV research activities are carried on in the Centre of Aerology in Legionowo in co-operation with the Satellite Remote Sensing Center in Krakow.

- The ozone research studies focus continuously on the long term changes in ozone profile. During last ten years an ozone increase in the middle stratosphere was detected. Reasons for fast significant ozone increase in the lower tropospheric ozone are also examined.
- Legionowo is often located at the border of the polar vortex and since 1995 participates in MATCH campaigns (statistical evaluation of ozone chemical destruction in Polar Vortex). Episodes of serious ozone deficiencies, observed during the displacements of the cold polar vortex in the winter/spring seasons: 1995/96, 1999/2000, 2004/2005 and 2007/2008, have been studied.
- Participation in preparation of the Scientific Assessment of the Ozone Depletion 2006.
- During the last years, UV research activities were directed mainly on UV reconstruction within COST 726 Action ‘Long term and variability UV radiation over Europe’. The IMWM

reconstruction model participated in comparison of UV reconstruction models from EU and showed very good results. Reconstructed UV series over Poland have shown a significant increase of daily UV doses since the1960s.

- Investigation on UV radiation weighted with action spectra: erythemal, previtamin D3, SCUP-H against total ozone and solar zenith angle.
- The UV Measurements on the Henryk Arctowski Polish Antarctic Station with SL501 have been analyzed for the 2005-2007 period.

Institute of Geophysics of the Polish Academy of Sciences

The ozone research activities mainly focus on statistical analyses (trends) on local and global scale, and methodology of ozone measurements. The changes in the ozone layer over middle altitudes are examined in connection with changes in the dynamic factors characterizing the atmospheric circulation in the troposphere, the lowermost stratosphere, and the stratospheric overworld. The problem of the gradual recovery of the ozone layer in the atmosphere is also investigated. The study is focused on the role played by the dynamical factors in ozone variability, because natural dynamical processes in the Earth's atmosphere can perturb the recovery of the ozone layer.

Statistical analyses have been applied to the gridded monthly means of total ozone from combined TOMS and SBUV measurements (version 8 of the data) for the period 1978-2003 [*Krzyscin 2006*]. The study is focused on the detection of a change in the trend pattern by searching for a turnaround in the previous downward trend. The ozone time series have been examined separately for each grid point and season, taking into account the various descriptions of the trend term: double-linear, proportional to the index of the overall chlorine content in the stratosphere, and a smooth curve without an a priori defined shape (the output of the regression model The multivariate adaptive regression splines methodology is used to find an optimal set of the explanatory variables and shape of the trend curve. The statistical errors of the models' estimates have been calculated using block bootstrapping of the models' residuals. The results appear to be consistent among models using different formulations of the trend pattern. The 2003 level of total ozone after the removal of the variations due to the parameterized dynamical/chemical forcing on the ozone is still below the long-term (1978-2003) mean level over the extratropical regions. The deficit is ~2-5% in the NH and much larger in the SH and exhibits clear seasonal variability, ~15% in autumn, ~10% in winter, and ~-5% in spring and summer. The present total ozone level is higher beyond the tropics than that in the mid 1990s but it is too early to announce a beginning of the ozone recovery there because of the trend uncertainties, due to errors of the regression estimates for individual grid points and longitudinal variability of the trend pattern. A rigorous statistical test has shown the statistically significant turnaround for some grid points over the extratropical region and a deepening of the ozone negative trend has not been found for any grid point.

Factors influencing the UV radiation (ozone content, aerosol, cloudiness) are studied, with particular emphasis on the response of UV radiation to forcing factors, at various time scales. In the studies of the UV-B variability advanced statistical methods such as wavelet decomposition and multivariate adaptive regression spline are used. The UV Spectrum Reconstruction Model, was elaborated and used for reconstruction UV radiation in the past.

DISSEMINATION OF RESULTS

Data reporting

The ozone data taken at Belsk are regularly submitted to the World Ozone and Ultraviolet Radiation Data Centre in Toronto. The mean daily values of total ozone are also submitted operationally to the Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki, Greece.

The ozone sounding data from Legionowo are submitted to the WMO Ozone Data Centre regularly on monthly schedule, and operationally to the Data Base at NILU (Norway).

Information to the public

- Since 2006, an operational monitoring of UV Index from the IMWM network consisting of 6 stations has been published on www.imgw.pl.
- Since 2000, the UV Index forecast for Poland has been available from May to August on the IMWM home page.

Relevant scientific papers

Krzyścin, J.W., and Rajewska-Więch, B., Preliminary comparison of the ozone vertical profiles from Umkehr and ozonesonde measurements over Poland with EOS-MLS Aura spacecraft overpasses, 2004-2005, International Journal of Remote Sensing, vol.28, 6, 2007, pp. 1089-1100.

Krzyścin, J.W., Krizan, P., and Jarosławski, J., Long-term changes in the tropospheric column ozone from the ozone soundings over Europe, Atmospheric Environment, 41, 2007, 606-616.

Krzyścin, J.W. Change in ozone depletion rates beginning in the mid 1990s: trend analyses of the TOMS/SBUV merged total ozone data, 1978-2003, Annales Geophysicae, 24, 2006, 493-502.

Białek, M. Long-term changes (1980-2003) in total ozone time series over Northern Hemisphere midlatitudes, Acta Geophysica, 54, 1, 2006, 60-70.

Krzyścin, J.W., Jarosławski, J., and Rajewska-Więch, B., Beginning of the ozone recovery over Europe? – Analysis of the total ozone data from the ground-based observations, 1964-2004: Annales Geophysicae, 23, 2005, 1685-1695.

Jarosławski, J., and Krzyścin, J.W., Importance of aerosol variations for surface UV-B level, Analysis of ground-based data taken at Belsk, Poland, 1992-2004, Journal of Geophysical Research, vol. 110, D16201, doi. 10.1029/2005JD005951, 2005.

Krzyścin J.W., Eerme, K., and Janouch, M., Long-term variations of the UV-B radiation over Central Europe as derived from the reconstructed UV time series, Annales Geophysicae, 22 2004, 1473-1485.

PROJECTS AND COLLABORATION

Institute of Geophysics of the Polish Academy of Sciences and Institute of Meteorology and Water Management participate in COST 726 Action. The main objective of the Action is to advance the understanding of UV radiation distribution under various meteorological conditions in Europe in order to determine UV radiation climatology, and assess UV changes over Europe.

FUTURE PLANS

Continuation of the current monitoring and research and:

- Installation of the sun-tracker for measurements of diffused radiation with multi-channels and broadband instruments (IMWM).
- Measurements of total ozone with multi channel with NILU UV in the meridional cross section of Poland (Leba - on the Baltic coast, Legionowo- midland, and Zakopane – the Tatra mountains) (IMWM).
- Investigations on mutual relation of tropopause and ozonopause heights over Central Europe (IMWM).
- Climatology of UV radiation over Poland and evaluation of different biological UV action spectra (IMWM).
- Umkehr measurements of the vertical profile of ozone with use of the Brewer spectrophotometer (IGfPAS).
- Investigation of the effect of UV radiation incident on inclined surface of various orientation. (IGfPAS).

NEEDS AND RECOMMENDATIONS

An additional Brewer spectrophotometer with double monochromator would make possible the extension of monitoring of ozone and UV programme.

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