CZECH REPUBLIC

OBSERVATIONAL ACTIVITIES

Column measurements of ozone and other gases/variables relevant to ozone loss
Routine daily observations of total ozone (DS and ZS) are performed with the Dobson and Brewer (single and double) spectrophotometers operated at the Solar and Ozone Observatory (SOOHK) of the Czech Hydrometeorological Institute (CHMI) in Hradec Kralove that is a long-term platform of the GAW Programme. The observations are saved in the ozone database of CHMI and submitted to partner institutions including the WOUDC, Toronto.

Profile measurements of ozone and other gases/variables relevant to ozone loss
Balloon-borne ECC ozone sondes are launched three times a week from January to April at the Upper Air Department (UAD) of CHMI in Prague. The vertical profiles of ozone from the ground to about 30 km, with a vertical resolution of approx.150 m are stored in the ozone database of CHMI, WOUDC and NDACC, as well. Vertical distribution of ozone is also measured by the Umkehr inverse technique with the Brewer spectrophotometers and processed by the NOAA/NASA UMK-2004 algorithm at SOOHK.

UV measurements

Broadband measurements
UV-Biometers are operated at three CHMI stations (Hradec Kralove, Kosetice and Labska Bouda) that are located in typical climate and geographical regions (lowlands, rural land and mountains). On-line erythemal irradiances (EUV) are collected in the NRT regime and displayed together with UV-Index values at the web site of SOOHK and used for research applications.

Narrowband filter instruments
Narrowband filter instruments are not operated in the Czech Republic.

Spectroradiometers
Spectral measurements of UV solar radiation (298-325 nm) are performed with single (MKIV) and double (MKIII) Brewer spectrophotometers at SOOHK. After passing through strict QA/QC procedures more than 7.000 UV scans are submitted to the European UV Data Base (EUVDB) maintained at FMI, Helsinki. The scans are also used for calculation of reference EUV values for calibration of the UV-Biometers. The observations are accompanied by measurements of other auxiliary solar radiation fluxes (global, direct, diffuse, reflected).

Calibration activities
All ozone and UV instruments in CHMI are regularly calibrated towards GAW etalons and operated according to proper SOPs. In this way ISO standards on observations and data quality assurance are met and long-term drift of calibration stability of instruments are kept in the best accessible limits. The experience gathered in recent decades allows experts from SOOHK to assist in calibration of ozone spectrophotometers in other countries, e.g. under the umbrella of the GAW Regional Dobson Calibration Centre - Europe (RDCC-E) – see Projects and Collaborations.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Ozone an UV observations performed in CHMI are analyzed both by Czech experts and by the international scientific community. The data sets from Czech stations have been used for analyses presented in the WMO/UNEP “Scientific Assessment of Ozone Depletion: 2006” or in the national expert publication devoted to the 20-th anniversary of the Montreal Protocol [1] among others. Results of the analyses show, that the ozone layer over Central Europe remains depleted by about 6 % towards the pre-ozone hole period. Though the ozone reduction was almost stabile in recent years the recovery has not appeared yet. Surprising persistent depletions are seen in the summer

season - Fig.1. This indicates a change in the UT/LS dynamics over European mid latitudes during last two decades. Ground ozone observations taken at SOOHK have been compared with overpass total ozone observed by the GOME and OMI satellite instruments [2]. As for the current OMI mission it has been found that the OMI-TOMS data agree with ground (mainly Brewer) observations within 1% but the difference of OMI-DOAS data have a seasonal variation up to 4 %, Fig.2.

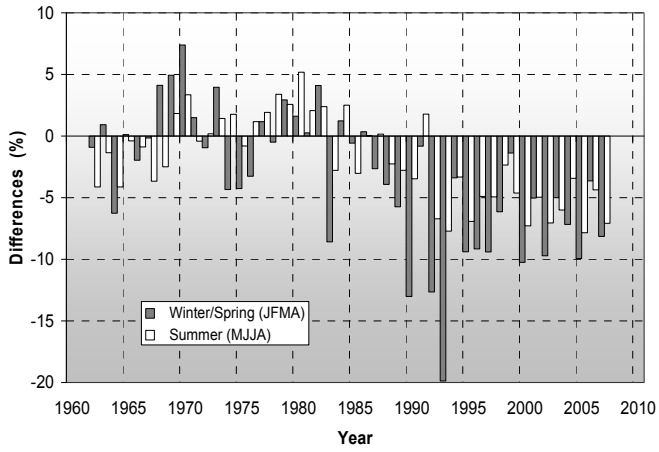

Figure 1: Differences between seasonal averages of total ozone towards the pre-ozone hole period (1962-1980), Hradec Kralove, Czech, 1962-2007.

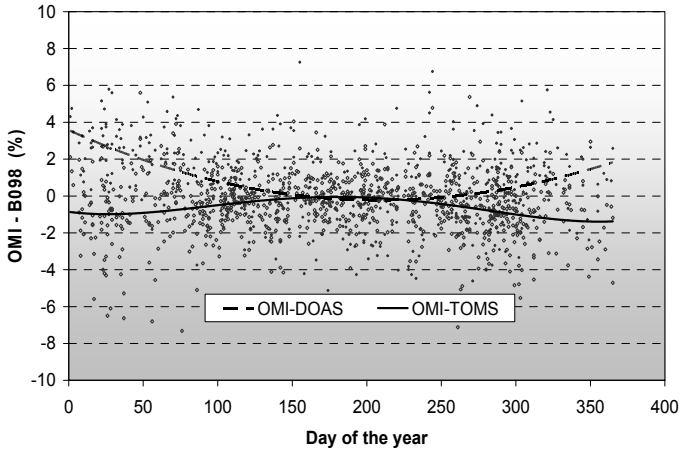

Figure 2: Annual courses of differences between ground Brewer and overpass satellite OMI_TOMS and OMI_DOAS total ozone observations, Hradec Kralove, Czech, 2004-2007.

Data from ozonesonde measurements taken at UAD Prague are periodically analyzed and compared towards the long term mean values. The results show that there is an evident increase in tropospheric ozone during last twenty years and that the difference is nearly constant in last five years. Stratospheric ozone values remain under the long term average. This is in good agreement with analysis of connection between pressure in tropopause level and amount of ozone above the Czech Republic [3]. Changes in ozone values integrated through 20 hPa layers were studied for the period 1979-2005. It has been found that amount of ozone increased rapidly in lowest troposphere (layer between 900 and 880hPa) during last two decades. There is a turning point in ozone amount in the 80-60 hPa layer approximately in 1996, Fig.3. But the strong reduction of ozone in higher levels that has occurred up to the middle nineties has not been ensued by significant increase in the 40-20 hPa layer. The ozone values remain nearly constant in this part of stratosphere during last ten years.

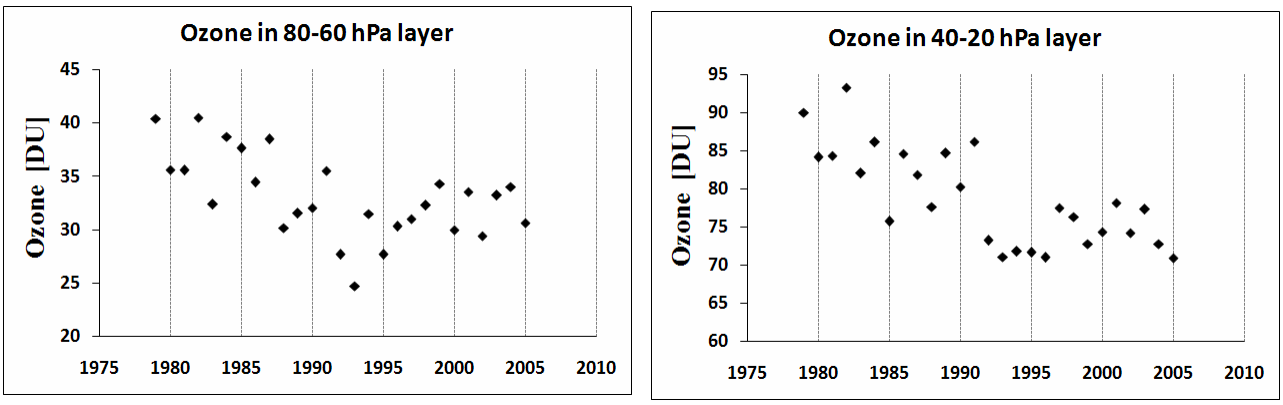

Figure 3: Changes of ozone amount in the layers 80-60 and 40-20 hPa in Prague, Czech, 1975-2005.

THEORY, MODELLING, AND OTHER RESEARCH

Cooperation of SOOHK with specialists from NASA and NOAA on development and tests of a new software package for processing of Brewer Umkehr observations with the new UM-2004 algorithm was performed in recent years. The product is now available for operational application in the network or at data centres.

Long-term trends in strong laminae in ozone profiles and Impact of geomagnetic storms and Forbush decreases of cosmic rays on total ozone at higher middle latitudes (40-60^o) were investigated by specialists of the Institute of Atmospheric Physics (IAP) of the Czech Academy of Science. Substantially higher ozone content, numbers of laminae and well pronounced trend reversal due to stratospheric dynamics and NAO have been found in the mid-1990s in the Northern Hemisphere, [6], Fig 4. Also, the total ozone response to strong geomagnetic storms seems to be caused by storm-related changes in atmospheric dynamics. The Forbush decreases of cosmic rays seem to play important, likely rather decisive role in the effects of geomagnetic storms on total ozone [7].

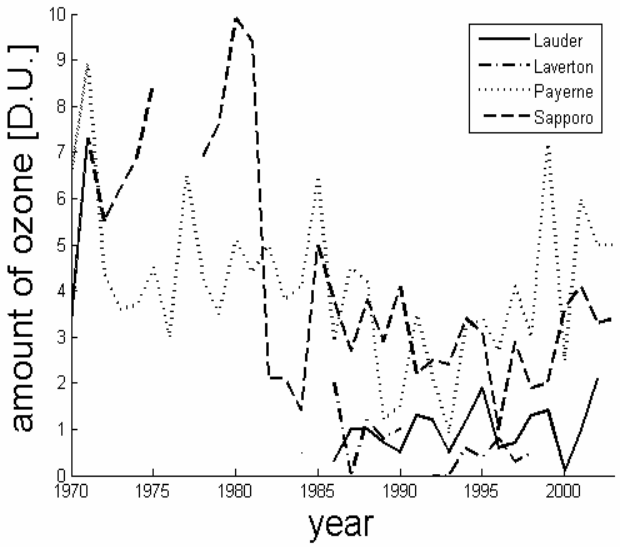

Figure 4: Trends in the ozone content in positive laminae per profile at middle latitudes of the SH (Lauder, Laverton) and NH (Payerne, Sapporo).

UV models based on neural-network technologies developed at CHMI were used for reconstruction of the EUV irradiances in the territory of Czech Republic during last decades. The results show, that since the early nineties the yearly totals of erythemal UV radiation have increased by more than 10 %, Fig.5. But this trend is mostly originated by higher numbers of sunny days and by lower total ozone in the summer months (see Fig.1) related to UT/LS dynamics during last 15 years than by chemical ozone reduction in the Winter/Spring season.

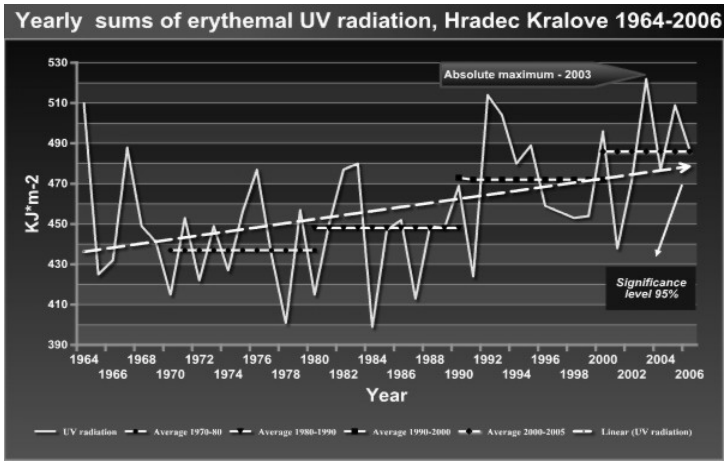

Figure 5: Reconstructed (1962-1995) and measured (1996-2005) yearly sums of EUV, Hradec Kralove, Czech.

DISSEMINATION OF RESULTS

Data reporting

Ozone observation are regularly submitted to the WOUDC, Toronto and also to other partner institutions and projects - e.g. the Ozone Mapping Centre of Environment Canada, NDSC data base, GAW cooperating stations in Central Europe, MATCH campaigns and satellite validating teams. The UV observations are reported to partners in current research projects (COST-726, SCOUT). The high quality UV spectral irradiances are deposited into the European UV Data Base (EUVDB) at FMI.

Information to the public

The public ozone and UV information system has been operated by CHMI since 1999. Actual and forecasted UV Indices and variation of ozone are presented in NRT at the web site of CHMI-SOOHK: http://www.chmi.cz/meteo/ozon/hk-e.html and disseminated to mass media daily. The system is supported by information campaigns joined by medical experts and linked with international centres (e.g. TEMIS/KNMI the Netherlands and ECUVF/DWD, Germany). Actual ozone profiles are presented at the web site of CHMI-UAD: http://www.chmi.cz/meteo/oap/eoap_o3data.html.

Relevant scientific papers

[1] *Achrer J. et al, (2007): Protection of the Ozone Layer in the Czech Republic – 20 Years of the Montreal Protocol. Publ. of the Ministry for Environment, Prague, ISBN: 978-80-7212-471-8, 2007 (in Czech)*

[2] *Vanicek K. (2006): Differences between Dobson, Brewer and satellite TOMS-8 and GOME-WFDOAS total ozone observations at Hradec Kralove, Czech. Atmos. Chem. Phys. Discuss., 6,5839–5865, 2006*

[3] *Motl M., Kalvova J., Skrivankova P. (2008): Connection between pressure in tropopause level and amount of ozone above the Czech Republic, Meteorological Bulletin, In Press (in Czech)*

[4] *Schmalwieser A.W. et al.(2005): Global Forecast Model to Predict the Daily Dose of the Solar Erythemally Effective UV Radiation, Photochemistry and Photobiology, Vol.81, Number 1,154-162.*

[5] *Seckmeyer G et al. (2007): Variability of UV irradiance in Europe. Photochem. and Photobiol., 83: 1-8.*

[6] *P. Križan, J. Laštovička: Ozone laminae: comparison of the Southern and Northern Hemisphere, and tentative explanation of trends, J. Atmos. Solar Terr. Phys., 68, 1962-1972, 2006.*

[7] *J. Laštovička, P. Križan: Geomagnetic storms, Forbush decreases of cosmic rays and total ozone at northern higher middle latitudes, J. Atmos. Solar Terr. Phys., 67, 83-92, 2005.*

[8] *Harris N.R.P et al. (2007): Ozone trends at northern mid- and high latitudes – a European perspective. Analys Geophysicae, In Press.*

PROJECTS AND COLLABORATION

In recent years experts from Czech institutions participated in the following research and development projects that were focused both on scientific topics, analyses of observations and cooperation on maintenance of the international ozone monitoring systems.

- CANDIDOZ: “Chemical and Dynamical Influences on Decadal Ozone Change”. EC FP-5, 2002-2005. CHMI-SOOHK, IAP-CAS, [7].
- COST-726: “Long term changes and climatology of UV radiation over Europe”. EC coordinated, 2004-2008. CHMI-SOOHK, MFUK-HK
- Czech-German project (2007-2010) “Structural changes in long-term trends of the dynamics of the upper atmosphere”, where changes in long-term trends in lower thermospheric, mesospheric (MLT) and stratospheric dynamics are investigated, IAF-CAS
- ENV-CR: “Maintenance of the Network for Monitoring of the Ozone Layer in Developing Countries” Project No.: RV/32/2004 funded by the Ministry for Environment of the Czech Republic, 2004-2006
- GMES: “Global Monitoring for Environment and Security - GAS”. An initiative of the European Commission, since 2007. Contribution of Czech experts in definition of the Implementation Plan of the GAS in the area of In-situ infrastructure for monitoring of Ozone and UV. CHMI-SOOHK.
- MATCH: International ozone sonde campaigns for the quantification of polar chemical ozone loss since 1998. Participation in particular campaigns by alert ozone sonde flights. Multinational funding. CHMI-UAD
- NDACC: “The Network for the Detection of Atmospheric Composition Change”. Contribution to ozone monitoring infrastructure. CHMI-UAD.
- SCOUT-O3: “Stratospheric-Climate Links with Emphasis on the UTLS”. EC FP-6, 2004-2009. CHMI-SOOHK

- WMO-GAW-RDCCE: The Regional Dobson Calibration Centre – Europe. Bilateral cooperation between MOHp Hohenpeissenberg, Germany and the CHMI-SOOHK on activities, since 1999.
- WMO-GAW-SAG Ozone: “The Scientific Advisory Group for Ozone”, Participation of Czech experts since 2002. CHMI-SOOHK.

FUTURE PLANS

- Long-term monitoring of ozone and UV will be pursued in CR as specified above. Attention will be paid mainly to implementation and application of ISO quality standards on the data products.
- Participation of Czech experts in the ongoing projects will continue. Future activities will be focused on the Czech contribution to building up the GAW/IGACO infrastructure in the regional scale. This includes the assistance to the Regional Dobson and Brewer Calibration Centres and to implementation of the GMES-ACS infrastructure in the area of in-situ monitoring ozone and UV.
- Studies of long-term trends in laminae in relation to in dynamics of the stratosphere and investigation of impacts of ozone trends in the upper atmosphere and ionosphere will continue.
- Implementation of ozone and UV observations into the Czech Antarctic programme is proposed.
- The UV models developed in CHMI will be applied in the reconstruction of UV climatology in the territory of CR and in the Czech and international integrated environmental projects.

NEEDS AND RECOMMENDATIONS

- Implementation of ISO standards for data quality assurance is needed for all instruments and observation technologies used for monitoring of ozone and UV in the global networks. This includes manly definition and implementation of traceable calibration systems/chains, SOPs and maintenance of relevant metadata files.
- The GTS/WIS telecommunication system should be more extensively used for the NRT ozone and UV data transfer.
- The BUFR/CREX descriptors need to be defined for reporting of the UV data.
- Problems on operation of instruments and stability of data quality persist at some strategic ozone stations located mainly in developing countries in the tropics and in the Southern Hemisphere. To solve the situation the WMO/GAW and the UNEP Programmes should reinforce their key role in the capacity building and in maintenance of the global ozone and UV monitoring infrastructure.

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