

SWITZERLAND

OBSERVATIONAL ACTIVITIES

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

Total ozone is measured regularly at Arosa since 1926. Presently, the measurements are performed with two semi-automated Dobson spectrophotometers (D101 & D062) and three automatic Brewer instruments B040, B072 (Mark II) and B156 (Mark III).

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

Balloon ozone soundings are measured from the Payerne Aerological Station three times per week since 1968. Until August 2002, Brewer-Mast ozone sondes were used while since September 2002 ECC (ENSCI – 0.5%) sensors are the operational instruments.

The Umkehr ozone profiles are recorded at sunrise and sunset since 1956. Originally, the measurements were manual and since 1989 an automated Dobson (D051) is dedicated to this task. In 1988, the Brewer (B040) Umkehr series have also been started,

Since 2001, ozone profiles (20 – 70 km) are retrieved from the millimetre wave radiometer SOMORA. Located at Payerne, this instrument delivers thirty minutes averaged profiles continuously.

UV measurements

The **Swiss Atmospheric Radiation Monitoring** programme (CHARM) consisting of 4 stations covering the altitude range of 366 to 3587 m.a.s.l was build up between 1995 and 2000.

The measurements programme consists of :

- *Broadband measurements:* the direct, diffuse and global components of the broad-band erythemal UV-ERY radiation (Solar Light UV-Biometers) are measured,
- *Narrowband filter instruments:* spectral direct irradiances are measured with Precision Filter Radiometers (PFR) at 16 wavelengths in the range 305 nm to 1024 nm.

Besides the direct measurements, the UV index, the AOD at various wavelengths as well as the Integrated Water Vapor (IW) are calculated from those data.

Spectral Brewer UV measurements

At Arosa, since 1994 spectral global UVB measurements are recorded with the Brewer instruments 072 on the range 290 nm – 325 nm. Since 1998, the Brewer Mark III 156 is in operation and it measures the range 286.5 - 363 nm.

Halocarbon measurements at the global GAW station Jungfrauoch

The high Alpine site of Jungfrauoch (3580 m asl) is one of a few stations covering the entire measurement programme of the GAW concerning greenhouse gases and reactive gases.

The measurements of halocarbons are a part of the SOGE – project (System for Observation of Halogenated Greenhouse Gases in Europe) which is related in terms of standard and quality assurance to the world-wide AGAGE programme (Advanced Global Atmospheric Gases Experiment).

Calibration activities

Regular calibration and maintenance are organised for the Arosa Brewers (every year) and Dobsons (every 4 years) traceable to the world standards for each instrument types.

Each ozone sonde is calibrated in the laboratory prior to the sounding.

The CHARM instruments are compared to reference instruments traceable to the world standards.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Payerne ozone soundings: after a homogenization of the sounding series, the trends at different levels have been updated and the hypothesis of a change of trend at the end of the nineties has been tested. In Fig. 1, the long term trend profiles are given for different cases explained in the caption.

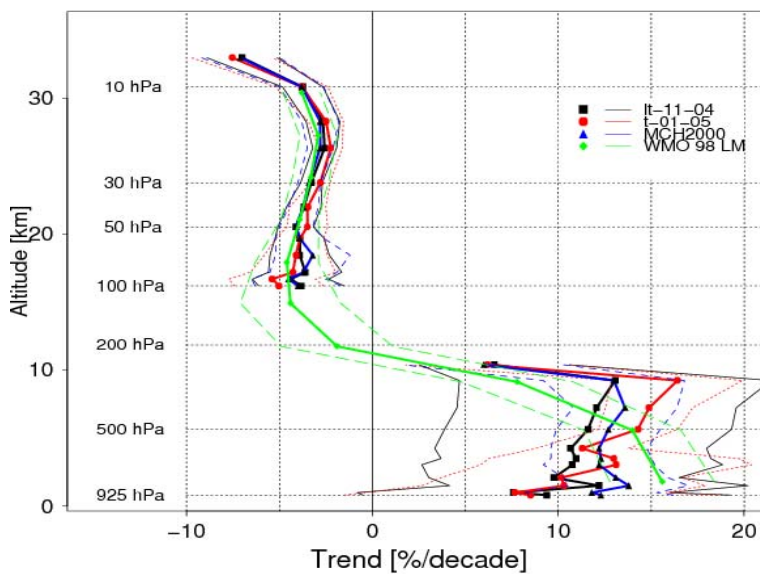


Figure 1: Trend profiles of the homogenized Payerne ozone sounding series. The green diamonds is the results given in the 98-WM trend assessment while the three others correspond to different selection data subsets used in the analysis (see Favaro et al. 2002 below).

Dobson Umkehr profiles: similarly, the Umkehr Arosa dataset have been homogenized and the trend evaluated. In Fig.2, the trend analysis results are reported and compared to other instruments like satellites (SAGE, SBUV) taken from the last WMO trend assessment.

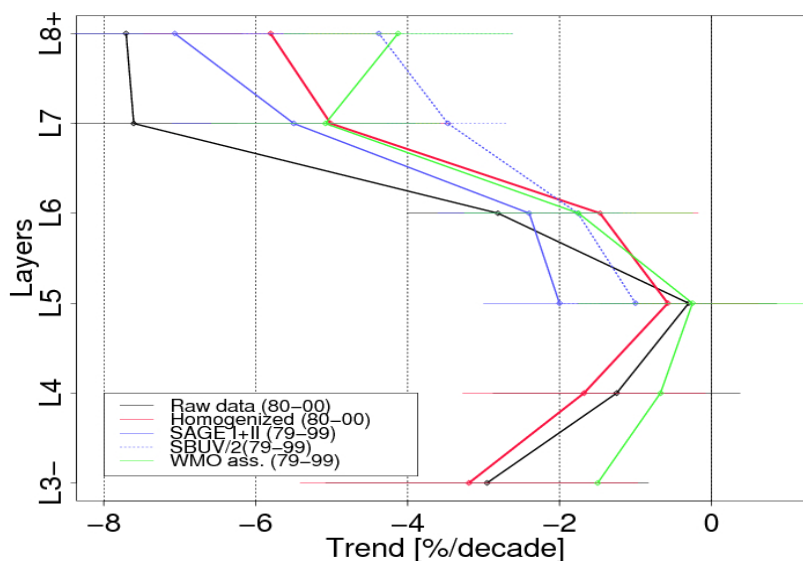


Figure 2: Trend analysis of the Arosa Umkehr dataset before and after homogenization. No proxy beside time has been incorporated in the model and the time period considered is 1980-2000. Trend profiles from satellites (SAGE I+II, SBUV) as well as the mean Umkehr trend from the WMO-trend assessment are also reproduced.

The UV dataset measured at the CHARM station Davos has been extended back in time using a reconstruction method based on sunshine duration, snow cover and ozone amount [Lindford, 2005]. As seen in fig. 3, the last decades present an upward tendency compared to the reference period.

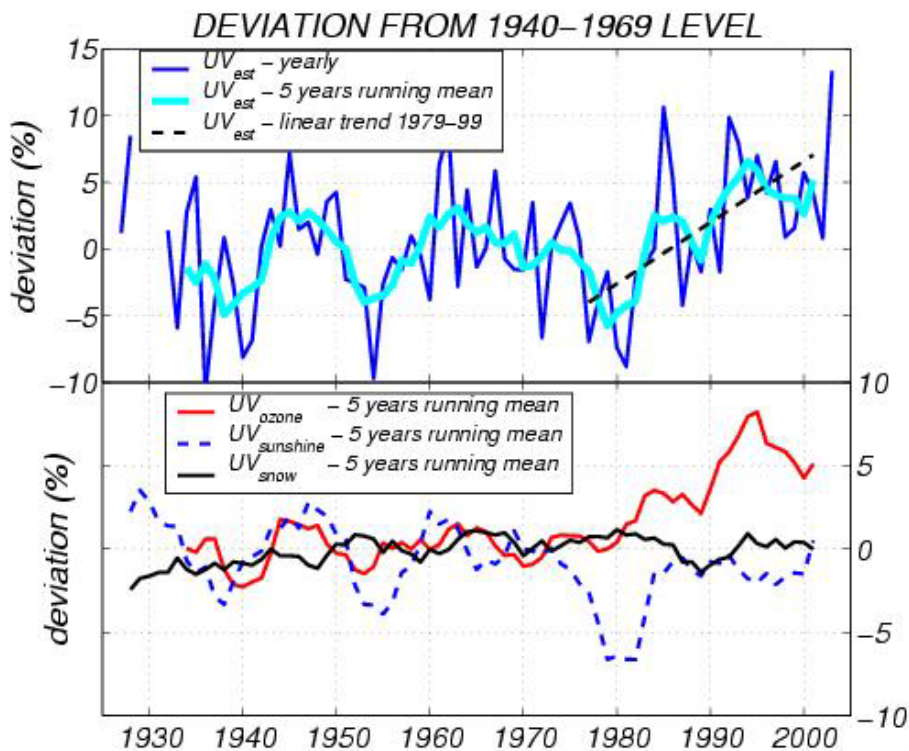


Figure 3:
UV reconstructed series for the Davos site. The upper panel shows the deviation of the reconstructed UV dose and the lower panel, the main parameters used in the model.

For the localisation of potential European halocarbon source regions a trajectory model was used based on the Swiss Alpine Model, aLMo. Results of the temporal development of the emissions for HCFC 141b and HFC 152a, seen with the trajectory statistics, are shown in fig. 4. The estimated European emissions of the now forbidden HCFC 141b have declined. Those of HFC 152a (not restricted by the Montreal-Protocol) have increased (Reimann and al., 2004).

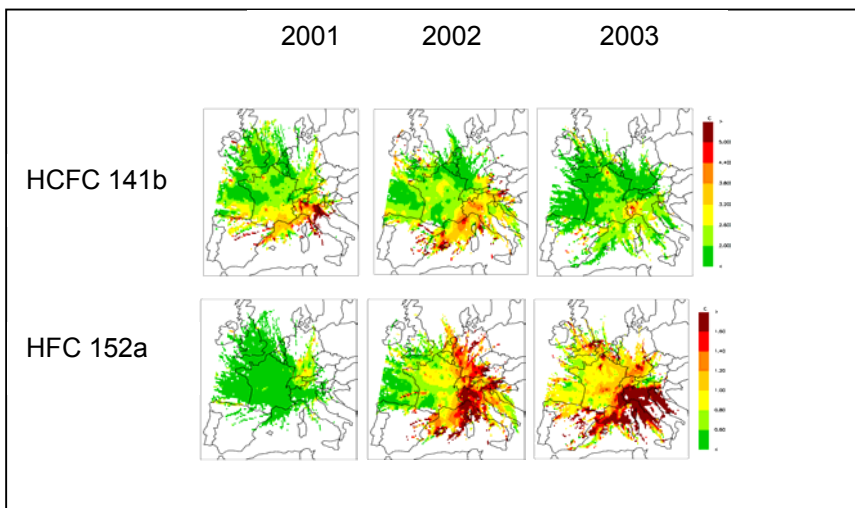


Figure 4:
Source regions resulting from trajectory statistics of the HCFC 141b and the HFC 152a between 2001-2003 seen at Jungfraujoch. Units indicate averaged concentrations above the baseline [ppt], linked to trajectories that passed over the respective grid cell.

DISSEMINATION OF RESULTS

Data reporting

The ozone data from Arosa, respectively Payerne are regularly deposited at the WODC and at the NDSC data centers. They are also deposited at NILU data center for validation projects and measurements campaigns (Satellites, ECMWF, MATCH).

The radiation data from the CHARM Payerne station are deposited at the WRM-BSRN data center.

The SOMORA radiometer data are deposited at NDSC and NILU data centres.

Information to the public

The UV forecasts are issued daily during the summer months in many newspapers, on different web sites (public media, national institutions) and at the TV weather presentations. The alerts for high ozone concentration at surface level are also announced when necessary in the same information channels.

Relevant scientific papers

Brönnimann, S., J. Luterbacher, J. Staehelin and T. Svendby, 2004: An extreme anomaly in stratospheric ozone over Europe in 1940-1942, *Geophys. Res. Lett.*, **31**, Art. No. L08101.

Calisesi, Y., R. Stübi, N. Kaempfer and P. Viatte, 2003: Investigation of systematic uncertainties in Brewer-Mast ozone soundings using observations from a ground-based microwave radiometer, *J. Atmos. Ocean. Tech.*, **20** (11), 1543-1551

Calisesi, Y., H. Wernli and N. Kämpfer, 2001: Midstratospheric ozone variability over Bern related to planetary wave activity during the winters 1994-1995 to 1998-1999, *J. Geophys. Res.*, **106**, 7903-7916.

Favaro, G., P. Jeannet and R. Stübi, 2002: Re-evaluation and trend analysis of the Payerne ozone soundings, *Veröffentlichung Nr. 63, MeteoSchweiz, Zürich, Switzerland*, **63**, 99pp

Klausen, J., C. Zellweger, B. Buchmann and P. Hofer: 2003: Uncertainty and bias of surface ozone measurements at selected Global Atmosphere Watch sites, *J. Geophys. Res.*, **108** (D19), Art. No. 4622, doi:10.1029/2003JD003710.

Koch, G., H. Wernli, C. Schwierz, J. Staehelin, and T. Peter (2005), A composite study on the structure and formation of ozone miniholes and minihighs over central Europe, *Geophys. Res. Lett.*, **32**, L12810, doi:10.1029/2004GL022062.

Koch, G., H. Wernli, J. Staehelin and T. Peter, 2002: A Lagrangian analysis of stratospheric ozone variability and long-term trends above Payerne (Switzerland) during 1970-2001, *J. Geophys. Res.*, **107** (D19), Art. No. 4373.

Lehmann, A. A., 2001: Direct and diffuse components of erythemal irradiance: measurements and modeling for clear-sky conditions, *PhD. thesis, Institute for Atmospheric and Climate Science, Swiss Federal Institute of Technology Zurich, Zurich, Switzerland*.

Lindfors, A. and L. Vuilleumier (2005), Erythemal UV at Davos (Switzerland), 1926–2003, estimated using total ozone, sunshine duration, and snow depth, *J. Geophys. Res.*, **110**, D02104, doi:10.1029/2004JD005231

Meijer, Y. J., et al. (2004), Pole-to-pole validation of Envisat GOMOS ozone profiles using data from ground-based and balloon sonde measurements, *J. Geophys. Res.*, **109**, D23305, doi:10.1029/2004JD004834.

Müller, G., and Viatte, P., 2005: The Swiss contribution to the WMO Global Atmospheric Watch Programme – Achievements of the First Decade and Future Prospects, *Veröffentlichung Nr. 70, MeteoSchweiz, Zürich, Switzerland*, **70**, 112pp.

Reimann, S., D. Schaub, K. Stemmler, D. Folini, M. Hill, P. Hofer, B. Buchmann, P.G. Simmonds, B.R. Grealley and S. O'Doherty, 2004: Halogenated greenhouse gases at the Swiss High Alpine Site of Jungfrauoch (3580 m asl): Continuous measurements and their use for regional European source allocation, *J. Geophys. Res.*, **109**, Art. No. D05307.

- Staehelin, J., J. Kerr, B. Evans and K. Vanicek, 2003: *Comparison of total ozone measurements of Dobson and Brewer spectrophotometers and recommended transfer functions*, GAW Report, **149**.
- Staehelin, J., A.J. Mäder, K. Weiss and C. Appenzeller, 2002: *Causes of northern mid-latitude stratospheric ozone trends*, *Physics and Chemistry of the Earth*, **27**, 461-469.
- Staehelin, J., and A.K. Weiss, 2001: *Swiss history of atmospheric ozone research and results of long-term Swiss ozone measurements*, *Ozon - Sci. Eng.*, **23**, 461-466.
- Stübi, R., 2002: *SONDEX/OZEX Campaigns of dual ozonesondes flights: report on the data analysis*, Veröffentlichung Nr. 65, MeteoSchweiz, Zürich, Switzerland, **65**, 76pp.

PROJECTS AND COLLABORATION

Besides of the activities in the framework of the national and international monitoring and research programmes, Switzerland contributes to the international WMO/GAW programme through the following services and cooperations:

- support to the ozone sounding station Nairobi of the Kenyan Meteorological Institute,
- **World Optical Depth Research Centre (WORCC)** at Physikalisch-Meteorologisches Observatorium / World Radiation Centre (PMOD /WRC) in Davos
- **World Calibration Centre (WCC) and Quality Assurance /Science Activity Centre (QA/SAC)** for Surface Ozone, carbon monoxide and methane at the Swiss Federal Laboratories for Materials Testing and Research (EMPA) in Dübendorf.
- Support to the **Jungfrauoch site** which recently reached to the status of global GAW station

At the national level, there is an important cooperation between the national Weather and Climate office (MeteoSwiss) and the academic and research institutions. This collaboration organised within a national GAW-CH programme allows to support research projects for the development and improvement of the monitoring programme as well as for the data analysis.

Other participations are related to:

- satellites validations campaigns (ENVISAT, ODIN, AURA ...) with the different instruments mentioned above,
- The development of Standard Operating Procedures for ECC ozone sondes,
- Participation to COST EU actions, ...

FUTURE PLANS

- Dobson and Brewer total ozone series difference will be further analyzed and the developed transfer functions will be made available for use in the operational measurements at Arosa,
- Update of the Dobson and Brewer Umkehr retrieval algorithm,
- Study of the long term tropospheric ozone series of Payerne and other sites using trajectory analysis,
- Use of the merged soundings and SOMORA ozone profiles to take profit of the high time resolution and high vertical coverage to investigate phenomena such as solar cycle, QBO (Quasi Biannual Oscillation), planetary waves, etc,
- Development of the Brewer data processing to get other parameters like aerosol optical depth (AOD) or the ozone layer effective temperature,
- Developing the capability of measuring the solar irradiance in other spectral bands within the CHARM network,
- Improve the link between the CHARM radiation measurements and future cloud detection systems,
- Integration of the Alpine Surface Radiation Budget (ASRB) network of 11 stations within the Alpine Arc to the radiation monitoring programme,
- WCC, QA/SAC (EMPA): development and maintenance of the meta-data information system GAWSIS at WMO will be carried on.
