SWEDEN

OBSERVATIONAL ACTIVITIES

Column measurements of ozone

Total ozone is monitored at two sites in Sweden by SMHI (Swedish Meteorological and Hydrological Institute) on behalf of the Swedish Environmental protection Agency. Daily measurements started in Norrköping in 1988 using the Brewer #6, which was replaced by Brewer #128 in 1996. In Vindeln manual measurements started in 1991 using the refurbished old Dobson #30 and since 1996 the automatic Brewer #6 is used. Much efforts has been spent on improving the methods to retrievs good observations at low solar elevations, Josefsson (2003). Recently, all zenith sky observations recorded by the Dobson (1991-2007) have been recalculated using a new algorithm Josefsson and Ottosson Löfvenius (2008).

Profile measurements of ozone and other gases

At the Swedish Institute of Space Physics in Kiruna there are a number of sophisticated instruments in operation. Special radars can track the circulation in the stratosphere. LIDAR gives a profile of the ozone and aerosols in the stratosphere, when there are no interfering clouds. There is also an instrument KIMRA (Kiruna Millimeter wave radiometer) that is used to monitor O_3, ClO, N_2O and HNO_3. The vertical resolution may not be the best, but it is independent of the weather so it can operate continuously. Forschungszentrum Karlsruhe has located a Fourier-Transform Infrared Spectroradiometer at the same site to record long-term trends. There is also a DOAS-instrument from NIWA and University of Heidelberg recording primarily total ozone and the column amounts of a number of other species.

UV measurements

Broadband measurements

Monitoring of broadband UV (CIE-erythema weighted) started relatively early in Sweden. Supported by SSI (the Swedish Radiation Protection Agency) SMHI has been measuring since 1983. Josefsson (2006). There has also been a small network of five stations for a limited period. Presently, SMHI operates one station in Norrköping using a Solar Light Model 501. In the northernmost part of Sweden the Abisko Scientific Research Station is also running a similar instrument.

Narrowband filter instruments

The SSI runs three stations, Stockholm, Tylösand and Visby, using GUV-instruments.

Spectroradiometers

In between the monitoring of total ozone both Brewer instruments operated by SMHI are used for recording about one UV-spectrum per hour. These data have been included in EC-funded projects SUVDAMA, EUDUCE and SCOUT-O3, e.g. Bais et al. (2007), Outer den (2006).

Calibration activities

The Brewer instruments for total ozone are calibrated and serviced regularly by three year interval by IOS (International Ozone Services Inc.). Thus the output will be traceable to the Brewer Triad, which forms the WMO/GAW calibration centre. The Dobson instrument is recalibrated at longer time intervals by visits to the WMO regional calibration centre at Hohenpeissenberg, Germany. The last calibration was in June 2007 and the next is planned to be within three years to be able to replace some of the electronics before the expert on this retires.

The broadband UV-meter used at Norrköping has participated in a number of international comparisons, see e.g. Gröbner et al (2002), Johnsen et al. (2006) and Josefsson (2006). Also the radiometers used by SSI have participated in comparisons or have been compared to the one of SMHI.

Due to lack of funding the absolute calibration (lamp or intercomparisons) of the spectroradiometers have not been done for recent years.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Controlled and processed total ozone and broadband UV-data are available from SMHI-web site and/or WOUDC. Below is shown a summary of various observations made at Norrköping, Sweden. Interestingly, the Brewer spectrophotometer data can also be used to compute the aerosol optical depth (AOD), Cheymol et al (2006).

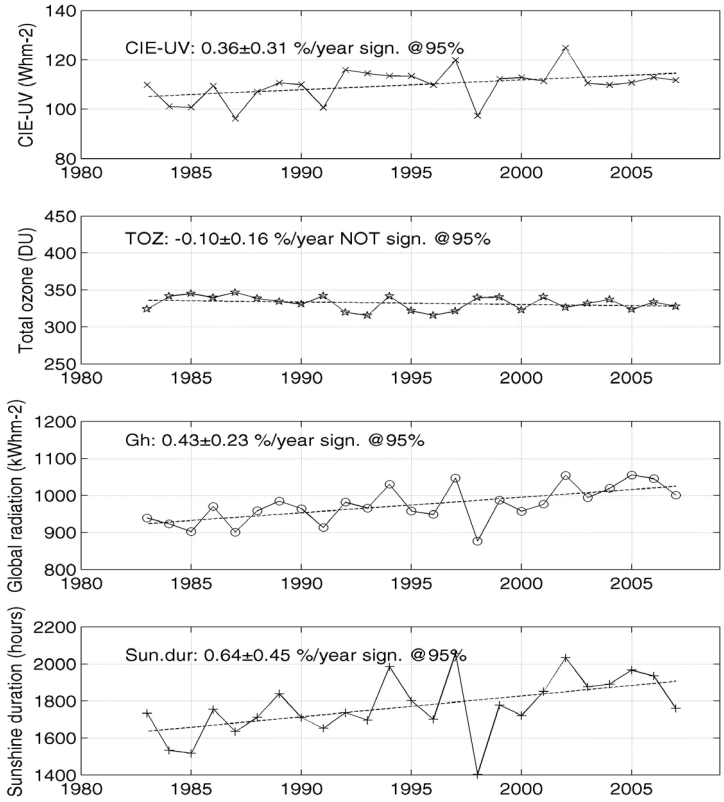

Figure 1: Long-term, 1983-2007, CIE-weighted UV, total ozone, global radiation and sunshine duration from Norrköping, Sweden. A linear trend is tested on the level of 95% significance for each variable.

THEORY, MODELLING, AND OTHER RESEARCH

Modelling

In early 2000 the STRÅNG-model system Landelius, Josefsson and Persson (2001) was launched, see http://produkter.smhi.se/strang/ as a co-operation between SMHI, the Swedish Environment Protection Agency and the Swedish Radiation Protection Authority. Now, there is over 10 years of hourly data available for anyone to download, period 1999- up to yesterday. The modelled variables are CIE-weighted UV, global radiation, direct solar radiation, sunshine duration and photosynthetic photon density (PAR). The geographical area covers a large part of northern Europe with a present spatial resolution of 11 km. Swedish data has also been used for re-construction of past UV-variation and for validation of these methods, see e.g. Kaurola et al (2007), Lindfors et al (2007).

Satellite

The Swedish satellite Odin has now been in orbit for more than seven years. On board there are two instruments with connection to stratospheric studies a microwave radiometer, SMR, and an optical spectrograph, OSIRIS. At Chalmers University of Technology data have been assimilated from the SMR instrument into an atmospheric model. From this it is possible to estimate the ozone loss over the period 2002-2007 caused by anthropogenic influence Rösevall et al.(2007a, 2007b, 2008). Using the OSIRIS instrument and limb scatter observations both ozone and nitrogen dioxide can be retrieved with global coverage and also vertical resolution. These data can be used for validating atmospheric models, Haley et al. (2004), Brohede et al. (2007a, b, c) Haley and Brohede (2007), Brohede, Jones and J´egou (2007). Some work has also been done at Stockholm University to validate photochemical models using satellite ozone and nitrous oxide data, Khosrawi et al. (2006).

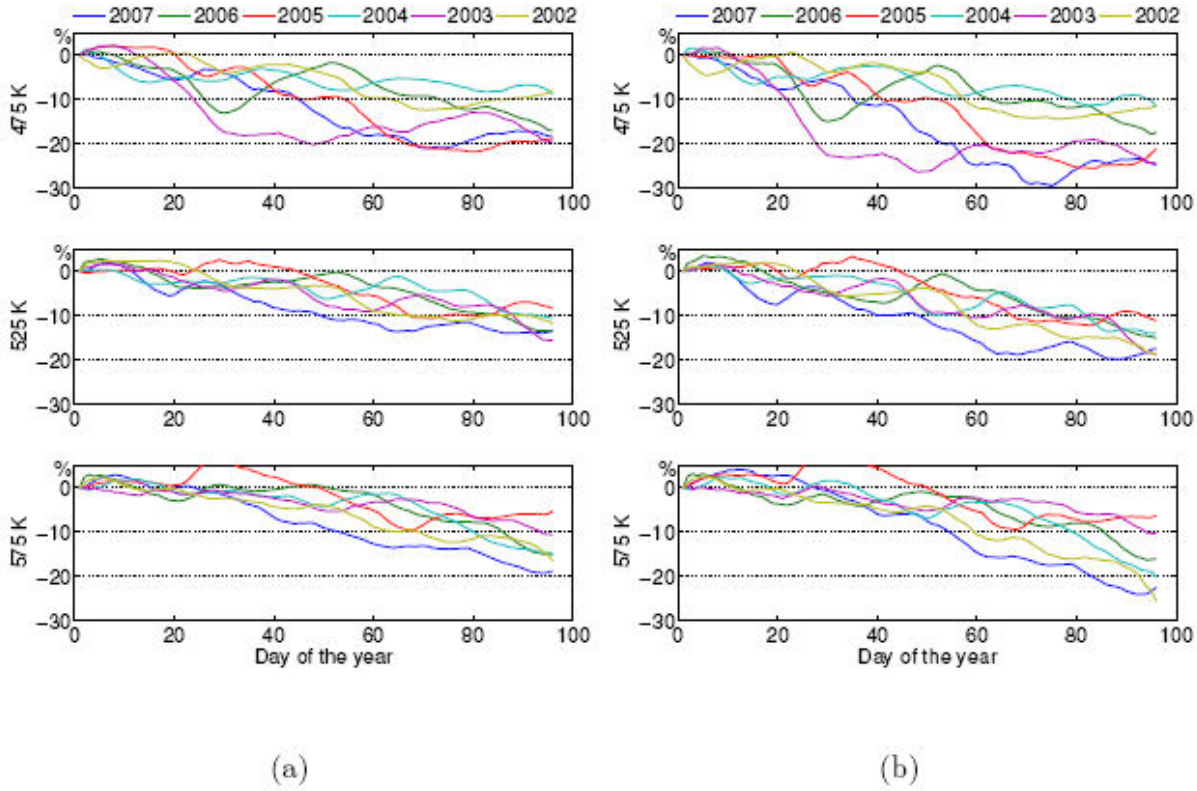

Figure 2: **Ozone depletion in all Arctic winters yet observed by the Odin/SMR instrument. Vortex average losses in percent, The percentual losses of ozone in all Arctic winters yet observed by the Odin/SMR instrument. Assimilated fields compared to passively transported fields. (a)-Average ozone loss north of 67°. (b)- Average ozone loss north of 75°. From Thesis of Rösevall (2007).**

DISSEMINATION OF RESULTS

Data reporting

Daily total ozone data are submitted once a month to the WOUDC. These data are also available at the www.smhi.se where also daily UV can be downloaded.

Information to the public

General information on the stratospheric ozone and UV-radiation can be found at www.smhi.se and at www.naturvardsverket.se/

The SSI (the Swedish Radiation Protection Authority) has more public information on their web-site www.ssi.se and in addition near real-time data from their three sites with UV-measurements. This governmental authority also produce brochures and some of them are possible to download from their web site. They have also had activities with the goal to change the behaviour of people mainly directed towards children. One activity was to publish and distribute “A book about the sun” to all kindergartens (8000) in Sweden, http://www.ssi.se/UVindex/PDFer/EnBokOmSolen.pdf another one

was to educate the teachers of preschools and primary schools on the basics of and risks of UV. Collaboration with the Swedish Life Saving Society offers sun protection information to many thousands of children every year.

The distribution of the daily UV-index forecasts from SMHI started in 1993 at the end of June and lasted to the end of the summer. In 1994 the distribution started in spring as a weekend forecast at the end of each week. This forecast was valid for clear skies and for the optimal slope (the sloping surface receiving the maximum radiation). During the summer season the daily forecast produced included the effect of clouds.

At a WMO-meeting in July 1994 it was agreed that the UV-information to the public should be harmonised. The meeting agreed on a minimum set of criteria that the UV-information should be based on. Starting in spring 1995 the Swedish UV-index was changed according to these recommendations. One large change was the introduction of the new action spectrum (from ACGIH-NOISH to the CIE-erythemal action spectrum recommended by WMO, WHO and ICNIRP. For the public the most apparent change was seen in the new scale range. This was a shift from 0-100 to roughly 0-16.

In 1996 the UV-index forecast of SMHI was introduced on the World Wide Web (http://www.smhi.se) as a Table for 15 regions in Sweden and three resorts. Next year, 1997, the graphical layout was improved and since then the daily course of the UV-index is presented for a number of climatological similar regions in Sweden. During the first winters there was no forecasting of UV-index done. The season started in late March and stopped at the end of August. After the year 2000, it is in operation all the year around. There is also some additional text presenting the some specific features of interest regarding UV-radiation in general.

Relevant scientific papers

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