NORWAY

Ozone monitoring and related research in Norway involves several institutions and there is no distinct separation between research and development, monitoring and quality control. The following significant research and monitoring activities have been carried out in Norway since 2002.

OBSERVATIONAL ACTIVITIES

The Norwegian Pollution Control Authority established the programme *"Monitoring of the atmospheric ozone layer"* in 1990, which at that time only included measurements of total ozone. The Norwegian UV network was established in 1994/95 and consists of eight 5-channel GUV instruments located at sites between 58°N and 79°N. In addition the observational activities include ozone lidar and ozonesonde measurements. Table 1 gives an overview of the location of the various stations, the type of measurements, and the institutions responsible for the daily operation of the instruments at the different sites.

Table 1: Overview of the locations and institutes involved in ozone and UV monitoring activities in Norway

Station	UV	Total ozone	Ozone profiles		Institute
			Lidar	Sondes	
Landvik, Grimstad, 58°N	x				Norwegian Radiation Protection Authority
Blindern, Oslo , 60°N	x	x			University of Oslo/ Norwegian Institute for Air Research
Østerås, Bærum, 60°N	x				Norwegian Radiation Protection Authority
Bergen, 60°N	x				Norwegian Radiation Protection Authority
Kise, Mjøsa, 60°N	x				Norwegian Radiation Protection Authority
Trondheim, 63°N	x				Norwegian Radiation Protection Authority
Ørlandet, 63°N				x	Norwegian Institute for Air Research
Andøya, 69°N	x	x	x		Norwegian Institute for Air Research /Andøya Rocket Range/ FFI*
Ny-Ålesund, 79°N	x	x			Norwegian Institute for Air Research

* Norwegian Defence Research Establishment

Column measurements of ozone and other gases relevant to ozone loss

Total ozone measurements using the Dobson spectrophotometer were performed on a regular basis in Oslo from 1978 to 1998 and in Tromsø from 1985 to 1999. Brewer measurements were started up in Tromsø in 1994, but after the termination of ozone-related observations at the Auroral Observatory in Tromsø in 1999 the instrument was moved to Andøya, 130 km southwest of Tromsø. Daily total ozone values for Oslo and Andøya are now based on measurements with Brewer spectrometers. The ozone values are based on direct-sun measurements, when available. However, on overcast days and days where the solar zenith angle is large the ozone values are based on the global irradiance method. As the Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR), which has replaced Tromsø as the North Norwegian ozone and UV monitoring site, is located north of the polar circle (69.3°N, 16.0°E, http://alomar.rocketrange.no/), there are no measurements of total ozone for about 100 days due to the polar night.

The Norwegian Institute for Air Research (NILU) is also operating instruments capable of monitoring ozone relevant traces gases at two sites. At ALOMAR two UV/VIS DOAS instruments (SYMOCS) are measuring total columns of ozone, NO_2, BrO and OClO since the late 1990s. Additionally, there is a DOAS instrument (type SAOZ) at Ny-Ålesund, measuring total columns of ozone and NO_2 since 1991. The NO_2 and ozone measurements at ALOMAR fulfil the requirements of the Network for the Detection of Stratospheric Change (NDSC) and formal approval is expected in autumn 2005. The SAOZ measurements contribute to the NDSC.

Profile measurements of ozone and other parameters relevant to ozone loss

Norway operates one ozone lidar, which is located at the ALOMAR facility at Andøya. Together with the Norwegian Defence Research Establishment and the Andøya Rocket Range, NILU has operated the ozone lidar continuously since January 1995. Since 1997 the instrument has been approved as a complementary site of the NDSC, and data are submitted to the NDSC database. The ozone lidar has also been used to measure polar stratospheric clouds and stratospheric temperature profiles. The lidar is run on a routine basis during clear sky situations providing ozone profiles in the height range 8 to 50 km. The latest measured raw data profiles and the latest analysed ozone data are available at http://alomar.rocketrange.no/alomar-lidar.html.

NILU has operated an ozonesonde station at Ørlandet (63.4°N, 9.2°E) since 1994 and is nominally launching between 1 and 4 sondes per month, depending on the time of the year. These measurements have traditionally been used for national monitoring purposes. In addition, NILU has participated in a number of experimental (match) campaigns where several stations launch sondes in a coordinated pattern to probe the same air masses several times. This is used to estimate ozone loss as a function of time and sun-lit hours. Finally, the ozone vertical profile soundings have extensively been used for validation of satellite instruments, especially on the ERS-2 and Envisat platforms.

UV measurements

Narrowband filter instruments

The instruments in the Norwegian UV network are designed to measure UV irradiances in 4 channels. Using a technique developed by *Dahlback (1996)*[1], we are able to derive from the raw data total ozone abundance, cloud cover information, complete spectra from 290 to 400 nm, and biologically weighted UV doses for any action spectrum in the UV.

In November 2004, NILU installed a NILU-UV radiometer at the new Norwegian research station, Troll, in Antarctica. The instrument was brought back to Norway in March 2005 to participate in the intercomparison of multiband filter radiometers (MBFR) at NILU (the FARIN campaign described in section 5). The NILU-UV instrument will be reinstalled at the Troll station in November 2005 and will be calibrated every year against a travelling standard. The NILU-UV measurements at the Troll station will be traceable to the Norwegian UV network through yearly calibration of the reference instrument at the Norwegian Radiation Protection Authority.

Spectroradiometers

Spectral UV irradiances (both direct and global scans) are measured daily with Brewer instruments at Department of Physics, University of Oslo and at ALOMAR.

There have also been campaigns with global spectral measurements in the wavelength range from 290-450 and collection of data from periods in 2001, 2002, and 2003. In 2005 there were campaigns with direct and diffuse spectral measurements

Calibration activities

The Brewer instruments

The Brewer instrument at the University of Oslo has been in operation since summer 1990, while Brewer operations in North Norway started in 1994. The International Ozone Services, Canada, calibrates the Brewer instruments in Oslo and Andøya on a yearly basis, and the instrument are regularly calibrated against standard lamps in order to check their stability. The calibrations show that the Brewer instruments have been stable during the 11 years of observations. The total ozone measurements from the Oslo Brewer instrument agree well with the Dobson measurements.

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[1] *Dahlback, A. (1996) Appl. Opt., Vol. 35., No.33, 6514-6521.*

The GUV instruments

The Norwegian FARIN project, described in section 5, included a major international UV instrument intercomparison. All in all 51 UV radiometers from various nations participated, among them 39 multiband filter radiometers (MBFR's). The instruments were also characterized on site. Beside measurements of spectral responses, measurements against QTH lamps and of the cosine responses were done for a selection of instruments. The data are available on the ftp server zardoz.nilu.no at NILU. The directories are /nadir/projects/other/farin/rawdata and /nadir/projects/other/farin/processed.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Ozone observations in Oslo

Table 1: Percentage changes in total ozone per year for Oslo for the period 1.1.1979 to 31.12.2004. The numbers in parenthesis gives the uncertainty (1 σ).

Time period		Trend (% per year)
Winter:	December – February	-0.11 (0.11)
Spring:	March – May	-0.35 (0.11)
Summer:	June - August	-0.02 (0.06)
Fall:	September - November	-0.10 (0.06)
Annual		-0.17 (0.05)

In order to look at possible ozone reductions and trends for the period 1979 to 2004 in Oslo we have employed the total ozone values from 1979 to 1998 from the Dobson instrument, whereas for the period 1999 to 2004 the Brewer measurements have been used. The results of the trend analysis are summarized in Table 1. For spring months a significant negative trend of –0.35% per year is observed. For the winter, summer and fall months no significant trends are detected. When all months are included a significant negative trend of – 0.17% per year is observed. The analysis of the data shows that the low ozone values in the 1990's contribute strongly to the observed negative trends in total ozone. For 2004 the yearly mean ozone value was 0.4% higher than the long-term yearly mean.

Ozone observations at Andøya

Table 2: Percentage changes in total ozone per year for Andøya/Tromsø for the period 1979 to 2004. The numbers in parenthesis gives the uncertainty (1σ).

Time period	Trend (% per year)
Spring: March – May	-0.13 (0.12)
Summer: June - August	-0.00 (0.05)
Annual (March-September)	-0.08 (0.06)

As mentioned, ozone measurements in North-Norway were performed in Tromsø until 1999 and at ALOMAR/Andøya from 2000. Correlation studies have shown that the ozone climatology is very similar at the two locations so that the two datasets are considered as equivalent representing one site. For the time period 1979 – 1994 total ozone values from the satellite instrument TOMS (Total ozone Mapping Spectrometer) were used because of insufficient calibration of the Tromsø Dobson instrument before 1991 and low data coverage (after 1990, there is a good agreement between TOMS and Tromsø Dobson and Brewer measurements). The result of the trend analysis is summarized in Table 2. No significant trends were observed for Andøya for this time period. The missing trend in spring is mainly caused by several warm winters since 1998 with very high total ozone, compensating the significant negative trend before 1998.

In recent years, the historical total ozone series from Tromsø (Fery spectrograph: 1935-1939, Dobson #14: 1939-1972, 1985-1999) and Svalbard (1950-1962) have been re-analyzed, homogenized, and evaluated by multi-linear regression methods *(Hansen and Svenøe, 2005[2])*. The analysis, based on a combination with TOMS data, revealed a strong influence of the local stratospheric temperature at the 30 mbar level and a composite influence of climate tele-

[2] *Hansen, G., and T. Svenøe, (2005) J. Geophys. Res., 110, no. D10, D10103,doi: 10.1029/2004JD005387*

connection patterns. Variations in the recent decades are best explained if the linear trend since 1978 is modified, such that in years with a weak polar stratospheric vortex the trend is set to zero.

A preliminary analysis of the Svalbard data reveals similarities with the Tromsø results but also some surprising differences, like the importance of the QBO and the solar cycle in summer.

Measurements with the ALOMAR ozone lidar were used, in combination with leading chemical transport models, to quantify Arctic ozone loss during several winters in the late 1990s *(Hansen et al., 1997* [3]*; Hansen and Chipperfield, 1999*[4]*).* They were also used to study other properties of the Arctic ozone layer, like laminae and summer variability *(e.g., Orsolini et al., 1997*[5]*; Orsolini et al., 2003*[6]*)* and properties of polar stratospheric clouds (PSCs) were investigated for the winters 1995/96 and 1996/97 *(Hansen and Hoppe, 1997*[7]*; Deshler et al., 2000*[8]*).*

UV observations

Table 3: Annual integrated UV doses (kJ/m²) at the three stations during the period 1995 - 2004.

Year	Oslo	Andøya	Tromsø*	Ny-Ålesund
1995	387.6			
1996	387.4		253.6	218.5
1997	415.0		267.0	206.5
1998	321.5		248.4	217.7
1999	370.5		228.0	186.1
2000	363.0	239.7		231.0
2001	371.0	237.0		208.6
2002	382.5	260.0		201.8
2003	373.2	243.4		No measurements
2004	373.2	243.7		190.5

*The GUV instrument at Andøya was operating at Tromsø in the period 1996 – 1999

Annual UV doses for the period 1995 - 2004 are shown in Table 3 for the three GUV instruments located at Oslo, Andøya and Ny-Ålesund. For periods with missing data we have estimated the daily UV doses by using a radiative transfer model, FastRt, *http://nadir.nilu.no/~olaeng/fastrt/fastrt.html*. The time series are still considered to be too short for trend analysis.

THEORY, MODELLING, AND OTHER RESEARCH

University of Oslo

Department of Geosciences The model primarily used for studying the stratospheric ozone layer is called Oslo CTM2 and it is a global three-dimensional chemical transport model covering the troposphere and stratosphere. The model can be run in different horizontal and vertical resolution and can be forced by either IFS or ERA-40 data. Two comprehensive and well-tested chemistry schemes are included in the model, one for the troposphere (up to the level of 150 ppbv ozone) and one for the stratosphere. An extensive heterogeneous chemistry has been included. Photo dissociation coefficients are calculated on-line. Emissions of source gases are also included.
The Oslo CTM2 model is used in various experiments to look at the chemical changes in ozone. Past time slice runs have used emissions from the Edgar Hyde database to look at the chemical changes up to present. IPCC SRES scenarios have been used for calculating chemical changes in future ozone. Because of large uncertainties in future emissions in the source gases, several time slice runs with different scenarios have been performed. A specific run to look at changes in stratospheric ozone from 1990 through 2000 have been performed, and compared with observations.

[3] *Hansen, G., M. Chipperfield, T. Svenøe, A. Dahlback, and U-P. Hoppe, (1997)* Geophys. Res. Lett., 24, *799-802*
[4] *Hansen, G. and M. Chipperfield,(1999)* J. Geophys. Res., 104*, 1837-1845*
[5] *Orsolini, Y.J., G. Hansen, U.-P. Hoppe, G.M. Manney, and K.H. Fricke,* (1997) Q.J.R. Meteorol. Soc., 123, *785-800*
[6] *Orsolini, Y.J., H. Eskes, G. Hansen, U.P. Hoppe, A. Kylling, E. Kyro, J. Notholt, A. R. Van Der and P. Von Der Gathen, (2003) Q. J. R. Meteorol. Soc., 129, part B, 3265-3275*
[7] *Orsolini, Y.J., G. Hansen, U.-P. Hoppe, G.M. Manney, and K.H. Fricke, (1997)* Q.J.R. Meteorol. Soc., 123, *785-800*
[8] *Deshler, T., B. Nardi, A. Adriani, F. Cairo, G. Hansen, F. Fierli, A. Hauchecorne and L. Pulvirenti, (2002)* J. Geophys. Res., 105, *3943-3953*

Department of Physics: Daily integrated erythemal UV doses are calculated based on a radiative transfer model and measurements with available TOMS satellite instruments. Cloud optical depths used in the model are derived from reflectivity data from the same TOMS instruments. The calculated UV doses are used in UV effect studies (skin cancer and Vitamin D production in humans).

The Norwegian University of Science and Technology (NTNU)

NTNU has performed underwater measurements of UV in 2003 and 2005 in the Kara Sea, as well as Trondheimsfjorden as a part of the project MAREAS, see section 5.

Norwegian Institute for Air Research (NILU)

At NILU, a main focus is to understand the dynamical contribution to the variability in column ozone with a focus on the northern hemisphere mid and high latitudes. Leading modes of climate variability have been shown to induce a strong signature on the trend and year-to-year variability in ozone. These modes include planetary-scale components of the atmospheric circulation (the North Atlantic Oscillation, the Aleutian-Icelandic Seesaw) *(Orsolini, 2004*[9]*)* but also more regional patterns, e.g. those associated with blocking phenomena *(Orsolini and Doblas-Reyes, 2003*[10]*).*

Another topic is the study of dynamically induced low-ozone episodes (LOE). We explained occurrences of summertime LOEs over the northern high latitudes, and Scandinavia in particular, and looked at their impact on the UV erythemal dose at the ground *(Orsolini et al., 2003*[11]*).* An intense LOE occurred over Scandinavia during the European Heat Wave of the summer 2003 *(Orsolini and Nikulin, 2005*[12]*).*

We have studied the changes in atmospheric composition (HNO_3, NO_X), and ozone depletion occurring in the aftermath of the exceptional autumn 2003 solar storms (*Orsolini et al., 2005*[13]). A highly anomalous layer enriched in nitric acid was observed in the upper stratosphere following the storms, and then slowly descended throughout the winter. Simultaneous observations of NO_2, including the nighttime polar stratosphere, revealed strongly enriched NO_X layers following the storms. The formation mechanism for the nitric acid layer does not seem to involve polar stratospheric clouds or aerosols, but rather, is likely to involve heterogeneous chemistry on water ion clusters, a relatively new and unknown topic. In *Randall et al. (2005*[14]*),* a multi-satellite intercomparison (POAM, SAGE, MIPAS, OSIRIS) revealed a highly anomalous atmospheric composition in the spring 2004, with unprecedented ozone depletion and NO_x enrichment. It remains to be determined how the unusual meteorological conditions, and possibly, the solar storms in autumn, combined to give rise to this anomalous chemical composition.

Further, the ozone data from Tromsø have been used to establish a multi-decadal UV climatology at a nearby site (Skrova, Lofoten) with meteorological information *(Engelsen et al., 2004*[15]*).* For the same area, UV maps have been derived for the period 1984-2002, based on various satellite observation data *(Meerkötter et al., 2003*[16]*).* In the frame of the EU project UVAC, it was found that there is a positive correlation between maximum daily doses around 1 May and

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[9] Orsolini, Y. J., (2004) J. Meteor. Soc. of Japan, 82, vol. 3, 941-948.

[10] Orsolini, Y. J. and F.J. Doblas-Reyes. (2003) Q. J. of the Royal Meteorol. Soc., 129, 3251-3263, 2003.

[11] Orsolini, Y.J., H. Eskes, G. Hansen, U-P. Hoppe, A. Kylling, E. Kyro, J. Notholt, R. Van der A. P. Von der Gathen, (2003) Q. J. R. Meteorol. Soc., 129, 3265-3276.

[12] Orsolini, Y. J. and G. Nikulin, (2005) in press, Q. J. of the Royal Meteorol. Soc.

[13] Orsolini, Y. J., G.L. Manney, M. Santee and C.E. Randall, (2005) Geophys, Res. Lett., Vol. 32, No. 12, L12S01, 10.1029/2004GL021588.

[14] Randall, C.E., V.L. Harvey, G.L. Manney, Y. J. Orsolini, M. Codrescu, C. Sioris, S. Brohede and C. Haley, L.L. Gordley, J.M. Zawodny and J.M. Russell III, (2005) Geophys. Res. Lett., 32, No. 5, L05802, doi:10.1029/2004GL022003.

[15] Engelsen, O., G. Hansen, and T. Svenøe. (2004), Geophys. Res. Lett., 31, L12103, doi:10.1029/2003GL019241

[16] Meerkötter, R., J. Verdebout, L. Bugliaro, K. Edvardsen, G. Hansen (2003), Geophys. Res. Lett., 30, 18, 1956, doi: 10.1029/2003GL017850

cod recruitment, in contradiction to the work hypothesis assuming a negative influence of UV on cod eggs and larvae.

NILU, in collaboration with the Institute for Community Medicine at the University of Tromsø, pursue research on the relationship between UV exposure, diet and vitamin D status in humans. The project applies UV simulations based on meteorological modelling data, UV measurements, questionnaire forms from cohort investigations, and blood sample analyses.

DISSEMINATION OF RESULTS

Data reporting: Ozone

Total ozone measurements from the Dobson spectrophotometer in Oslo have been re-evaluated and published *(Svendby and Dahlback 2002*[17]*)*. The complete set of revised Dobson total ozone values from Oslo is available at The World Ozone Data Centre (WOUDC) http://www.msc-smc.ec.gc.ca/woudc/. There are established daily routines submitting ozone data from the University of Oslo to WOUDC. The re-analysed total ozone data for Tromsø will be submitted to the WOUDC database in the near future.

Figure 1: Location of ozonesonde stations that were part of the THESEO/THESEO 2000 campaigns.

At the joint ECMWF/WMO expert meeting on realtime exchange of ground based ozone measurements, held at ECMWF in 1996, the requirements for ozone data for Numerical Weather Prediction (NWP) in realtime were outlined. ECMWF had developed the operational data assimilation system to include ozone retrieval from SBUV and GOME, and requires independent high quality profile data from ground-based systems. For daily validation, monitoring and troubleshooting, it was found that ozone measurements should be available at the centre within 12–24 hours after the sounding.

NILU has collected ozone measurements from Arctic balloon flights through the Nadir database since 1988. Files are transferred and stored in the NASA-AMES 2160 format, and an automatic script has been set up to convert incoming data into the CREX format that is used at ECMWF. This script also performs a series of data quality checks, and can do simple corrections on erroneous input files.

Data reporting: UV

NILU has submitted spectral UV measurements from Norway to the European UV database (EUVDB). In the framework of the EU project EDUCE, described in section 5, NILU has developed quality assurance software for spectral UV measurements. The QA software is applied automatically to all UV data submitted to EUVDB.

[17] *Svendby, T.M. and Dahlback, A. (2002), J. of Geophys. Res., 107, 4369. doi: 10.1029/200JD002260.*

Information to the public

Ozone

Daily total ozone values for Oslo are available at http://www.fys.uio.no/plasma/ozone/. The latest measured raw data profiles and the latest analysed ozone data from the ALOMAR Observatory at Andøya are available at http://alomar.rocketrange.no/alomar-lidar.html.

UV

NILU has developed a web portal for dissemination of air quality data including UV forecasts for Norway, www.luftkvalitet.info/uv. The content of the UV web pages are:

- UV forecast for three days for Norway and some common destinations for Norwegian tourists
- The UV forecast is given for clear-sky, partly cloudy and cloudy conditions
- Measured UV doses and total ozone values measured at the Norwegian stations
- Facts on UV radiation and the ozone layer

In addition the public may receive UV forecasts for user-selected locations by means of SMS or e-mail. The web application has been developed by NILU in co-operation with the Norwegian Radiation Protection Authority, Storm Weather Center, the Norwegian Pollution Control Authority and the Norwegian Meteorological Institute. During 2005/2006 the UV forecast model would be improved as well as the web-application.

Finally, UV indices and cloud effects measured by a GUV-instrument at the Department of Physics, University of Oslo, are presented and updated every 30 min at: http://www.fys.uio.no/plasma/ozone/.

Relevant scientific papers

The ozone and UV measurements performed in Norway give rise to research in collaboration with national and international partners. The reference list below gives an impression of the international collaboration and ongoing research in the Norwegian ozone and UV scientific community since 2002.

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PROJECTS AND COLLABORATION

Norwegian institutions and scientists are participating in numerous international and national projects. The following gives an overview of the most important projects related to ozone and UV research in Norway.

International projects

CANDIDOZ *Chemical and Dynamical Influences on Decadal Ozone Change* (2002-2005) This EU project aims to identify the earliest signs of ozone recovery. Long-term mid-latitude and polar ozone data sets and global meteorological data are used to assess the roles of chemistry and transport on ozone changes in the Northern Hemisphere stratosphere. Multi-decadal total ozone measurement series are used to empirically investigate the role of dynamical processes on ozone variability. Chemical transport models are used to assess the relative roles of chemistry and transport on ozone changes. CANDIDOZ also considers the possible consequences of climate-ozone interaction. Web-site: http://fmiarc.fmi.fi/candidoz/

EDUCE *European Database for UV Climatology and Evaluation* (2000-2003) is a scientific EU research project designed to investigate the ultraviolet (UV) radiation climate in Europe. Web-site: http://www.muk.uni-hannover.de/~martin/

HIBISCUS *Impact of tropical convection on the upper troposphere and lower stratosphere (UTLS) at global scale* (2002-2005). The main objective of this EU-project is to study dynamical, microphysical, radiative and chemical aspects of the UT/LS related to deep convection in the tropics. Web-site: http://www.aero.jussieu.fr/projet/HIBISCUS/en/many/index.html

INSPECTRO *Influence of clouds on the spectral actinic flux in the lower troposphere* (2002-2005). The overall objective of this EU project is the characterisation of the UV radiation field in the cloudy atmosphere. The objective will be achieved through a combination of theoretical and experimental approaches. Web-site: http://imk-ifu.fzk.de/inspectro/

NDSC: The Network for the Detection of Stratospheric Change is a set of high-quality remote-sounding research stations for observing and understanding the physical and chemical state of the stratosphere. Ozone and key ozone-related chemical compounds and parameters are targeted for measurement. The NDSC is a major component of the international middle atmosphere research effort and has been endorsed by national and international scientific agencies, including the International Ozone Commission, the United Nations Environment Programme, and the World Meteorological Organization. Web-site: http://www.ndsc.ncep.noaa.gov/

OUILT: *Quantification and Interpretation of Long-Term UV-VIS Observations of the Stratosphere* (2001-2004). The general aim of the EU project was to use the existing ground-based, satellite and balloon-borne UV-visible data as well as 3D atmospheric modelling tools for quantifying ozone loss in the past, to monitor its development in the present and to investigate its relation to active halogen and nitrogen species. Web-site http://nadir.nilu.no/quilt/index.php

SCENIC: *Scenario and aircraft emission and impact studies on chemistry and climate* (2002-2005) The aim of the EU project SCENIC was to study the atmospheric impact of possible future fleets of supersonic aircraft using state-of-the-art atmospheric models and realistic supersonic fleet scenarios. Web-site: http://www-scenic.ch.cam.ac.uk/

SCOUT-O3: Stratospheric-Climate Links with Emphasis on the Upper Troposphere and Lower Stratosphere (2004-2008). This is an integrated project funded by EU. The central aim of the project is to provide scientific knowledge for global assessments on ozone depletion and climate change for the Montreal and Kyoto Protocols. The SCOUT-O3 project aims to provide new knowledge for EU and national governments, which could be used to develop the European position for sustainable development. SCOUT-O3 involves the research efforts of 59 partners with more than 100 scientific groups; and takes full advantage of new and existing research facilities developed at a national level. Web-site: http://www.ozone-sec.ch.cam.ac.uk/scout_o3/

SOLICE: *Solar Impacts on Climate and the Environment* (2000-2003) One of the main objectives of the EU project SOLICE was to assess the impact of the solar variability on stratospheric ozone, radiative forcing on climate and surface UV.

Web-site: http://www.imperial.ac.uk/research/spat/research/SOLICE/

UVAC: *The Influence of UVR and Climate Conditions on Fish Stocks: A Case Study of the Northeast Arctic Cod* (1999-2003) In the frame of this EU project UV climatology were established based on ground-based and satellite measurements of total ozone and cloud coverage. These were combined with marine-biological data sets and field surveys in order to find a possible impact of UV radiation and other climate parameters on the recruitment of Northeast Arctic cod and major elements of its food chain like *Calanus finmarchicus*. Web-site: http://www.nfh.uit.no/prosjektvis.aspx?id=90

VINTERSOL: Validation of INTERnational Satellites and study of Ozone Loss (2002-2004) was a major European field campaign studying stratospheric ozone loss. VINTERSOL was the fourth major European project of its kind, succeeding EASOE (European Arctic Stratospheric Ozone Experiment), SESAME (Second European Stratospheric Arctic and Mid-latitude Experiment) and THESEO (Third European Stratospheric Experiment on Ozone). VINTERSOL-related projects are EUPLEX, HIBISCUS, MAPSCORE, QUOBI, UFTIR, CANDIDOZ, GOA and TOPOZ III. Web-site: http://www.ozone-sec.ch.cam.ac.uk/VINTERSOL/

National projects

AerOzClim: Aerosols, Ozone and Climate (2003-2006). This project is financed through Norwegian Research Council. The main objective of AerOzClim is to improve our understanding of aerosol- climate and ozone-climate interactions, by developing and applying global models in combination with analysis of data, to study processes involved, and to provide improved parameterisations for climate models. Web-site: http://www.geo.uio.no/forskning/atmosfare/prosjekter/AEROZCLIM/

COZUV: Coordinated Ozone and UV project (1999-2002). The main objective for the COZUV project was to investigate the stratospheric ozone layer in the Northern Hemisphere with various instrumental techniques and to develop and use a three-dimensional chemical transport model. Web-site: http://www.nilu.no/projects/cozuv/

FARIN: *Factors Controlling UV radiation in Norway* (2002-2006). The Norwegian Research Council funds the project. The main objective of the project is to quantify the various factors controlling UV radiation in Norway, including clouds, ozone, surface albedo, aerosols, latitude, and geometry of exposed surface including a comprehensive instrument comparison with spectral and broad band meters included in the project. The project applies both UV measurements (incl. the Norwegian GUV network) and radiative transfer modelling. Web-site: http://www.nilu.no/farin/

LLAE *Light and Life in African Environments* (2002-2006). In this project a network of NILU-UV instruments has been established in the African tropical belt: Serrekunda (Gambia), Kampala (Uganda), and Dar-es-Salaam (Tanzania). Further, 3 instruments are located in Kilimanjaro (Tanzania) at 1800 m, 3700 m and 5700 m. Total ozone columns, UV-doses and cloud effects are derived from the measurements at all sites. The project is funded by Norwegian Council for Higher Education's Programme for Development Research and Education.

MAREAS *Material fluxes from the Russian Rivers Ob and Yenisey: Interactions with climate and effects on Arctic Seas* (2003-2006) The main objectives of the project are to improve flux assessments of DOC, nutrients and contaminants from the Ob and Yenisey rivers in Russia and to study the hydro-optical properties of the Kara Sea. The linkage between DOC, UV light regimes, primary production and contaminant will also be elucidated.

UTLS-Air: *Chemistry in the upper troposphere and lower stratosphere - impact of aircraft emissions* (2003-2006). The overall scientific aim of this project is to improve our understanding of the processes controlling the chemistry in the upper troposphere-lower stratospheric region with a special focus on aircraft impact. The present and future impact of aircraft will be studied. Web-site: http://folk.uio.no/asovde/utls-air/home.html

FUTURE PLANS

A short description of the forthcoming plans are summarised below.

- Department of Geosciences, University of Oslo plans to study the solar – stratospheric relations as a part of more general studies of stratospheric ozone in IPY (International Polar Year) activities.
- NILU has deployed a NILU-UV instrument at the Norwegian Antarctic Troll Station (71º S). Analysis, development, and applications to effect studies are forthcoming.
- Further efforts will be put into the re-evaluation of the Svalbard total ozone data 1950-1962; especially measurements in the ZC mode are not finished yet. More recent data from this site are stored in the WOUDC database (since 1984), but a comparison with TOMS and SAOZ measurements shows significant offsets. Therefore, these data should be quality-assessed.
- The historical Tromsø data before 1950 contain many days where a profile analysis using the Umkehr method may be applicable. The period is very interesting as there were several winters with frequent PSC displays and low ozone values in late winter. However, for such a study funding has to be secured first; it is not achievable in the frame of ongoing monitoring.
- There have also been made efforts to move the Tromsø Dobson instrument, which has not been operated since autumn 1999, to a new site (Bahir Dar, Ethiopia, 10ºN), but so far all applications to fund this transfer have been rejected.

NEEDS AND RECOMMENDATIONS

At present, ozone monitoring has a very weak financial basis in Norway. In order to secure a continuous operation of both total ozone monitors and profiling instruments, predictable multi-annual funding schedules should be established in order to free operations from additional funding pathways, e.g. satellite validation projects and short-time research projects. There is a certain need of stable long-term economic support to be able to run instruments properly and continuously since this often is not a part of a research project. The re-evaluation of the historical ozone series has very clearly revealed the importance of observational continuity to establish high-quality long-term data sets, which are essential for climatologically studies in a wider sense.

We also recommend an even closer international collaboration on UV radiation, particularly with respect to quality assurance of measurements, databases and forecasting. Our suggestion is that this collaboration should be supported financially, e.g. through UN.

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