Coordinated ozone and UV project

COZUV

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Project contents

The project encompasses all the major Norwegian research groups in the field of stratospheric ozone and UV research. The duration is from 1. January 1999 to 31 December 2000, i.e. two years. The following tasks will be carried out:

- Investigation of the ozone layer over North Polar and middle latitudes with various instrumental techniques, such as spectrometers, ozonesondes and an ozone lidar.
- Final development and use of a 3-D chemical transport model.
- Diagnosis of chemical ozone loss through analysis of experimental observations and comparison of measurements with modelling results.
- Investigation of transport mechanisms between the polar vortex and middle latitudes through case studies found by observations close to the vortex edge.
- Study of the coupling between ozone change and climate change in the stratosphere and upper troposphere.
- Scenario calculations in order to investigate the consequences of temperature change in the stratosphere and various degrees of compliance with the Montreal protocol.
- Development of methods to measure global, direct and radiance distribution of UV, to improve UV dose calculations derived from instruments with different characteristics, during all weather conditions.
- To investigate the influence of clouds on the surface UV radiation.
- To use existing surface UV radiation measurements together with existing radiation models to investigate the connection between UV radiation and ozone, cloud optical depth and surface albedo for several locations in Norway.

There will be close collaboration between the involved groups in order to ensure a coherent effort.

The project participants

The following researchers participate in the projectl:

From NILU: Geir O. Braathen, Frode Stordal, Arve Kylling, Bill Arlander, Georg Hansen, Yvan Orsolini, Bojan Bojkov, Inga Fløisand, Trond Svenøe and Anak B. Bhandari.

From University of Oslo, Dept. of Geophysics: Ivar S.A. Isaksen, Bjørg Rognerud, Jostein Sundet and Michael Gauss.

From NTNU: Berit Kjeldstad and Trond Morten Thorseth

From NDRE: Eivind Thrane and Ulf-Peter Hoppe.

What is the problem?

The massive ozone destruction which takes place every spring in Antarctica is a well known and well documented problem. During the last winters it has become evident that chemical depletion of ozone also takes place inside the Arctic polar vortex. Although the amount of ozone destruction varies from year to year, with 1998 being a year with moderate ozone destruction, there are signs that the situation gets progressively worse, with 1995/96 and 1996/97 as the two worst winters so far (CEC, 1997). The long term decline in ozone at middle latitudes in the Northern Hemisphere is also a matter of great concern since it affects densely populated areas in North America, Asia and Europe. The mechanisms responsible for the this long term ozone decline are not known, but it is likely that both transport and chemistry are important. There is a large need to quantify the role transport and chemistry play in the observed ozone decrease. Because of the expected increase in chlorine and bromine during the next few years, with a peak around year 2000, there is a risk of more severe ozone depletion in the near future. There are large uncertainties in projected future emissions of chlorine and bromine gases, with the most recent estimate showing practically no decline in the emissions over the next 10 to 20 years. This is significantly different from previous estimates (WMO, 1994), showing that there are severe risks for ozone depletion in the future. The cooling of the stratosphere due to increased levels of greenhouse gases increases the risk for ozone depletion through formation of polar stratospheric clouds (PSCs).

Decreases in total ozone give increased levels of UV radiation. This may effect both the biosphere and the chemistry in the atmosphere. In addition to ozone, clouds, aerosols and surface albedo also affect the UV radiation field. Hence, accurate and precise measurements of all these parameters are required to eliminate non-ozone effects on the UV radiation field and thus be able to detect UV radiation trends.

It is also of great importance to establish knowledge about trends in UV radiation. Several sites measure UV in Norway, but the time series are not long enough to give reliable information on trends. There is a need for more information on instrument characteristics and how the various instruments in Norway behave relative to each other. Factors that influence the transfer of UV radiation through the atmosphere, such as ozone, aerosols and clouds also need to be studied in more detail.

What are the scientific objectives of COZUV?

The overall scientific objectives are:

- To quantify the degree and geographical extent of chemically-induced ozone loss in the Arctic and at mid-latitudes during the winter and spring of two consecutive years (1998-99, 1999-2000).
- To improve the quantification of ozone loss processes in the Arctic region to reduce discrepancies between observed and modelled decreases. This necessitates an improved description of heterogeneous processes taking place on polar stratospheric clouds, and a realistic description of transport processes in the region during situations with extensive ozone depletion.
- To obtain a better understanding of the processes leading to ozone loss at midlatitudes. This will include a more realistic description of the transport between the Arctic region and the mid-latitudes, and chemical processes responsible for the ozone loss at midlatitudes and the transition region.
- Use the results obtained from the above points to improve predictions of future ozone layer changes as a function of temperature changes (changes in climate gases) and changes in ozone depleting substances (ODS). This will contribute to international assessments on ozone depletion (Montreal Protocol) and climate change (IPCC).
- Derive methods to be able to compare UV measurements performed with instruments with different optical characterisations during all weather conditions. To increase the knowledge about UV radiance distribution under different atmospheric conditions (e.g. broken cloud conditions). Develop a method to monitor effects of broken clouds on global spectral UV irradiance measurements.
- To measure the UV radiation field (actinic flux) in the troposphere and lower stratosphere to get a better understanding of the altitude variations of the UV radiation field and factors influencing it.
- To understand the effects of clouds on surface UV radiation.

These objectives will be reached through a combination of measurements and modelling.

What methods will be used?

To meet the scientific objectives outlined above we will carry out 9 tasks or work packages:

- To implement and run 3-D chemical transport models (CTMs) to study: a) The chemical loss of ozone in the arctic vortex, b) the ozone loss and the exchange between the vortex and mid latitudes, and c) long term (year to decades) ozone changes. To improve the description of the chemistry, particularly the heterogeneous chemistry and photodissociation rates for inclusion in the 3-D CTMs.
- To implement and run a high-resolution transport model in order to study the transport mechanisms between the tropics and mid-latitudes and between the Arctic and middle latitudes. Ozone lidar measurements will be compared to high resolution dynamical modelling based on realistic meteorology in order to describe the exchange of air masses between polar and middle latitudes.
- To measure the vertical distribution of ozone through ozonesonde measurements from two Norwegian sites (Kjeller and Ørland).
- To measure total columns of ozone, NO_2, OClO and BrO with a UV-Visible spectrometer deployed at Ny-Ålesund (SAOZ) and three spectrometers located at Andøya (SYMOCS-1, SYMOCS-2 and Bentham DTM 300).
- To measure vertically and temporally resolved ozone profiles with an ozone lidar located at the ALOMAR observatory at Andøya, Northern Norway.
- To analyse the degree of chemical ozone loss by various techniques: 1) Through comparisons between measurements and model results. Data from satellites and various international networks will be used in addition to the Norwegian data. Observations will be compared to both chemically active model runs and passive model runs, where the chemistry is turned off; 2) Through analysis of the ozone mixing ratio from sonde and lidar data at isentropic levels. The degree of ozone loss caused by lee-wave PSCs will be assessed.
- To measure simultaneously direct and global spectral UV irradiance. A sun tracker will be further developed to measure polarised and unpolarised radiance in all directions. Rapid changes in cloud conditions will be followed by fast multichannel measurements. Correction of data due to different instrument characterisation and other quality control procedures will be done. Comparison between different UV measurements and available models will be performed.
- To launch balloons carrying a twelve channel NILU-CUBE instrument to measure the UV radiation field in the UV throughout the troposphere and lower stratosphere.
- To apply a three-dimensional radiative transfer model to describe the effects of clouds and surface albedo.

How will the results be disseminated?

The data and results from this project will be disseminated through publications in peer-reviewed scientific journals, progress reports to the Norwegian Research Council, participation in international conferences, information to the environmental authorities, and through information on the World Wide Web. There will also be an emphasis on the exchange of data between the partners of the project.

Policy issues

The results from this project will give policy-makers the necessary basis for negotiations on revisions of the Montreal Protocol. The writing of IPCCs Third Assessment Report (TAR) will start in 1999 and finish in 2001. Ozone as a climate gas is likely to get more attention than in previous assessment reports, particularly changes of ozone in the tropopause region. The COZUV project will contribute to this assessment.