

# EUROPEAN UNION

## European research on stratospheric ozone and UV radiation after THESEO

### Introduction

Stratospheric research has been coordinated at a European level since the late 1980s, building on a number of trans-national collaborative initiatives and EC projects developed during the 1980s. Prior to 1996, a major emphasis of the European stratospheric research programme had been the investigation of the possibility of severe Arctic ozone losses and increased UV radiation throughout Europe and the populated northern mid-latitudes. Results from a series of national and international programmes including the European Arctic Stratospheric Ozone Experiment (EASOE, 1991-92) and the Second European Stratospheric Arctic and Mid-latitude Experiment (SESAME, 1994-95) concluded that the winter polar stratosphere over northern Europe was primed for severe ozone losses and that large losses had occurred in some winters in the early 1990s. The emphasis since 1996 has shifted to improving our understanding of the processes affecting ozone over Europe. The Third European Stratospheric Experiment on Ozone (THESEO 1998-2000) has been a major element of this coordinated programme. The principal aim of THESEO was to improve understanding of processes controlling ozone loss over populated areas. Accordingly, the research was focussed on the mid-latitude lower stratosphere, the linkage to other layers of the atmosphere, the Arctic vortex, the tropics and sub-tropics. During the 1999/2000 winter, a close cooperation was achieved with the USA sponsored SOLVE (SAGE III Ozone Loss and Validation Experiment).

The mechanism which has been used to effect coordination in Europe has consisted of the EC Research DG, national agencies, the EU Science Panel on Stratospheric Ozone and the European Ozone Research Coordination Unit (EORCU). The Science Panel, consisting of experts on stratospheric ozone, has provided advice to the EC regarding the implementation and possible future directions of the research in this area. EORCU works closely with the EC Research DG and the Science Panel, and liaises with EC project coordinators, other scientists and with national programmes. Effective links are maintained with existing international observational programmes such as the Network for the Detection of Stratospheric Change (NDSC) and the Global Atmosphere Watch programme of the World Meteorological Organisation (WMO-GAW) which already provide a large degree of coordination for the large number of European groups who participate, with groups such as the International Ozone Commission and the WCRP programme Stratospheric Processes And their Role in Climate (SPARC) and with the research programmes in other countries.

The additional benefits of having a research programme coordinated at the European level have helped European scientists to make major advances to the understanding of the stratospheric ozone and UVB issue and to contribute significantly in international assessments and research experiments carried out in support of the Montreal and Kyoto Protocols.

### Research clusters

The stratospheric issues are currently addressed within the work programme for Area 2.1.2 Stratospheric Ozone Depletion in the Global Change, Climate and Biodiversity Key Action of the EC's Environment and Sustainable Development Programme (part of the 5<sup>th</sup> Framework Programme 1998-2002):

#### *2.1.2 Stratospheric ozone depletion, in support of the Montreal Protocol.*

The target is the quantification and prediction of ozone depletion in the stratosphere and the increase of UV-radiation levels at the Earth's surface. This focuses on the quantification of anthropogenic and natural emissions of ozone depleting substances and their transformations; reduction of the uncertainties in stratospheric-tropospheric exchange processes and the impacts of aircraft emissions; quantification of ozone loss in the stratosphere over Europe and the linkages

with the polar, tropical regions and the upper troposphere; understanding of stratospheric cooling and its links to tropospheric global warming, and better quantification of its impacts; accurate determination of the atmospheric UV radiation field and its changes in the European region."

As a result of call for proposals, during the last years in this area, 30 research projects are currently supported by the EC on stratospheric ozone and UV radiation (Table 1). They include the CRUSOE concerted actions entitled "Coordination of Research into Understanding of Stratospheric Ozone over Europe" which supports EORCU. These projects together with national activities are coordinated in the following five clusters:

1. Stratospheric ozone loss (SOLO)

The main objective is to quantify the ozone depletion in the northern and middle latitudes throughout the year. The research involves measurements made by balloons, aircraft, ground-based and satellite instruments which are used to understand the causes of chemical ozone loss under various atmospheric conditions. The analysis of THESEO data continues to take place during and after extensions of these projects. These studies help to improve our understanding of the long term trends observed over polar and mid-latitudes.

2. Coordination of Research for the Study of Aircraft impact on the Environment (CORSAIRE)

The main objective is to address persisting uncertainties concerning the upper tropospheric and lower stratospheric processes in the tropopause region where the aviation emissions occur. The main areas of research are the formation and evolution of contrails and particles and the ozone budget in the upper troposphere and lower stratosphere region. This work includes improved predictions of aviation-induced future changes in climate and providing the aviation and aeronautics communities and decision-makers with options to reduce future changes in climate impact from aircraft emissions.

3. Atmospheric UV radiation (ATUV)

The main objective is to study the evolution of the UV radiation at the earth's surface and in the atmosphere over the last ten years or so. The existing databases are developed to provide additional products, in particular a European UV climatology using spectral UV irradiance measurements from 26 stations in Europe and a database of actinic flux suitable for use by a wide user community.

4. Ozone-climate interactions (OCLI)

The main objective is to study the physical and chemical impacts on climate in the past caused by variations in stratospheric ozone and to study to what extent these variations can be explained by natural and/or anthropogenic forcing. The cluster simulates also future temperature, ozone radiative forcing and UV radiation amounts for various scenarios of future greenhouse gas emissions and halogen concentrations in order to investigate the impact of the Montreal and Kyoto Protocols.

5. Global atmospheric observations (GATO)

The main objective is the coordination of scientists involved in making atmospheric measurements to provide broad European and global coverage of ozone and related species. This research is an important contribution by Europe to the international observational programmes. The work in GATO involves the use of data from ground based, balloon, aircraft and satellite measurements, including data from new campaigns. GATO aims also to help ensure that all field and satellite measurements made within the European programme are available for validation and for scientific analysis.

Each cluster have a liaison group whose purpose is to ensure coordination within the cluster, e.g. establishing scientific links between projects and planning workshops or other meetings. The cluster liaison groups are made up of project coordinators, Science Panel members, EORCU, and the Research DG.

An important way of achieving good links between the projects is through the use of workshops and meetings to discuss and present results. A range of gatherings can be used for this ranging from specially organised workshops on particular topics, to the use of special sessions at conferences (e.g. EGS) through to larger meetings such as the Quadrennial Ozone Symposia and the SPARC Assemblies. It should be noted that the Sixth European Symposium on Stratospheric Ozone will be organised in September 2-6, 2002 at Göteborg, Sweden.

### ***VINTERSOL campaign***

VINTERSOL (Validation of INTERNATIONAL Satellites and study of Ozone Loss) is a major European field campaign studying stratospheric ozone. VINTERSOL ('Winter sun' in the Scandinavian languages) will take place from late 2002 until mid 2004. It is the latest major European field campaign to study ozone loss. Like the previous European campaigns, VINTERSOL relies jointly on support from national funding agencies and from the EC's Environment and Sustainable Development programme.

An important new dimension for VINTERSOL is the involvement of several European satellite instruments. Measurements from the ERS-2 GOME satellite instrument (operational since 1995) and from the POAM III instrument on the SPOT IV satellite (operational since 1998) will continue to be used. In addition, measurements from the ODIN satellite (launched in February 2001) and ESA's new ENVISAT satellite will be validated and, in time, analysed. VINTERSOL is thus being mounted in conjunction with the validation campaign for ENVISAT satellite, and it will significantly extend the scope and duration of the validation activities, so enhancing the quality of the measurements made by these satellite instruments. The increasing international dimension to earth observation studies is also evident, as there will be cooperation with the validation campaigns for the NASA SAGE III instrument (SOLVE-2) and the NASDA ILAS satellite.

There are four main phases to VINTERSOL in which detailed studies of atmospheric processes will be made:

- a small balloon campaign in the tropics in late 2002;
- intensive Arctic ozone loss studies in the 2002/03 winter/spring;
- ozone loss studies in the Antarctic winter and spring 2003; and
- balloon and aircraft studies in the tropics in early 2004.

In addition, a number of measurement and modelling projects will run continuously through this period yielding information on the longer time-scale processes in the stratosphere. The VINTERSOL planning document can be made available through the EORCU web page ([www.ozone-sec.ch.cam.ac.uk/](http://www.ozone-sec.ch.cam.ac.uk/)).

### **European Assessment**

The EC published in late 2001 its second assessment on European research in the stratosphere. It took almost two years and over 100 scientists to prepare this assessment which is based on European research efforts during the last few decades and the analysis of 40 years of atmospheric data. It provides a thorough review of the progress of the European research programme on stratospheric ozone, UV radiation and aircraft impact on the atmosphere during 1996-2000, including THESEO. The results of the assessment endorse the position of the EU concerning the international agreements on ozone depletion (Montreal Protocol) and climate change (Kyoto Protocol), as well as the International Civil Aviation Organisation's regulation of the impact of aviation emissions. The assessment concludes among others that the occurrence of ozone mini-

holes over Europe increases and any ozone layer recovery could only become measurable around 2010 at the earliest.

### **Future activities**

Possible future directions of atmospheric research including stratospheric ozone and UV radiation, were described by the European scientific community in a recent document entitled "A global strategy for atmospheric interdisciplinary research in the European Research Area (AIRES in ERA)". The report identifies the environmental issues and scientific areas for atmospheric research that will be most relevant for the future implementation of the ERA and the 6<sup>th</sup> Framework Programme 2002-2006. In parallel, the European Commission proposal for the 6<sup>th</sup> Framework Programme under its priority on Sustainable Development, Global Change and Ecosystems does include stratospheric ozone research in relation to the Montreal Protocol. The 6<sup>th</sup> Framework Programme is expected to be adopted by the European Council and the European Parliament later in 2002.

### **Table 1 : Research projects and clusters**

#### **Stratospheric Ozone Loss (SOLO) cluster**

**CIPA** (*Comprehensive investigations of polar stratospheric aerosols*)

**THESEO 2000 – EUROSOLVE** (*Improved understanding of stratospheric ozone loss by measurements and modeling contributing to THESEO and SOLVE*)

**SAMMOA** (*Spring-to-Autumn Measurements and Modeling of Ozone and Active species*)

**TOPOZ III** (*Towards the Prediction of Stratospheric Ozone III: The Partitioning of the NOy Components*)

**QUOBI** (*Quantitative Understanding of Ozone losses by Bipolar Investigations*)

**EUPLEX** (*European Polar Stratospheric Cloud and Lee Wave Experiment*)

#### **Atmospheric UV radiation (ATUV) cluster**

**ADMIRA** (*Actinic flux determination from measurements of irradiance*)

**EDUCE** (*European database for Ultraviolet Radiation Climatology and Evaluation*)

**INSPECTRO** (*Influence of clouds on the spectral actinic flux in the lower troposphere*)

#### **Ozone-Climate Interactions (OCLI) cluster**

**SOLICE** (*Solar influences on climate and the environment*)

**DETECT** (*Detection of changing radiative forcing over the recent decades*)

**EUROSPICE** (*European project on stratospheric processes and their impact on climate and the environment*)

**PARTS** (*Particles in the upper troposphere and lower stratosphere and their role in the climate system*)

**CANDIDOZ** (*Chemical and Dynamical Influences on Decadal Ozone Change*)

#### **Global Atmospheric Observations (GATO) cluster**

**AMIL2DA** (*Advanced MIPAS-Level-2 Data Analysis*)

**GOA** (*GOME Assimilated and Validated Ozone and Nitrogen Dioxide Fields for Scientific Users and for Model Validation*)

**MAPSCORE** (*Mapping of Polar Stratospheric Clouds and Ozone levels relevant to the Region of Europe*)

**QUILT** (*Quantification and Interpretation of Long-Term UV-Visible Observations of the Stratosphere*)

**SOGE** (*System for Observation of Greenhouse Gases in Europe*)

**Coordination of Research for the Study of Aircraft impact on the Environment (CORSAIRE) cluster**

**MOZAIC-III** (*Measurement of Ozone, Water vapour, Carbon monoxide and Nitrogen oxides by Airbus in-service aircraft (MOZAIC-III) - O<sub>3</sub> and H<sub>2</sub>O budgets in the UT/LS*)

**TRADEOFF** (*Aircraft emissions: Contribution of different climate components to changes in radiative forcing-tradeoff to reduce atmospheric impact*)

**INCA** (*Interhemispheric differences in cirrus properties from anthropogenic emissions*)

**STACCATO** (*Influence of Stratosphere-Troposphere Exchange in a Changing Climate on Atmospheric Transport and Oxidation Capacity*)

**UTOPIHAN-ACT** (*Upper tropospheric ozone : processes involving HOx and NOx. The impact of aviation and convectively transported pollutants in the tropopause region*)

**CARIBIC 3** (*Civil aircraft for regular investigation of the atmosphere based on an instrument container*)

**HIBISCUS** (*Impact of tropical convection on the upper troposphere and lower stratosphere at global scale*)

**SCENIC** (*Scenario of aircraft emissions and impact studies on chemistry and climate*)

**TROCCINOX** (*Tropical convection, cirrus and nitrogen oxides experiment*)

**Concerted actions**

**CRUSOE** (*Coordination of Research into and Understanding of Stratospheric Ozone over Europe*)

**CRUSOE II** (*Coordination of Research into Understanding of Stratospheric Ozone over Europe II*)

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Additional information on this European stratospheric research: <http://www.ozone-sec.ch.cam.ac.uk/>

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