Report of the existing and planned ozone research activities of the European Union, prepared for the 8th meeting of WMO/UNEP Ozone Research Managers, Geneva, 2-4 May 2011

EUROPEAN UNION

European research on stratospheric ozone depletion and UV radiation

I. Introduction – past research actions

Stratospheric research has been a priority of the European Framework Programmes for Research and Technological Development (FPs) from the very beginning and has been coordinated at European level since the late 1980s. The early European Stratospheric Research Programmes (FP1-FP3, 1982-1994), focused on the investigation of potential severe Arctic ozone losses and increased UV radiation across Europe and the populated northern mid-latitudes. Research was implemented through 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).

Under the 4th Framework Programme for Research and Technological Development (FP4, 1994-1998) the focus was on basic processes affecting ozone depletion, in particular over Northern Europe. The Third European Stratospheric Experiment on Ozone (THESEO, 1998-2000) was a major component of this coordinated programme. Moreover, research addressed the mid-latitude lower stratosphere, the interaction with other layers of the atmosphere, the Arctic vortex, and exchanges processes between the Troposphere and the Stratosphere in the tropics and sub-tropics.

The intention of the 5th Framework Programme for Research and Technological Development (FP5, 1998-2002), Programme Energy, Environment and Sustainable Development (EESD) was to establish a solid basis of information on which European environmental legislation could be build on and to support international commitments such as the Montreal Protocol. FP5 was promoting interdisciplinary research and focused on understanding, quantification and prediction of stratospheric changes and changing of UV-radiation levels. The programme has been implemented through numerous projects organised via a number of research clusters addressing similar topics: UV radiation (ATUV), impact of aircraft emissions (CORSAIRE), ozone–climate interactions (OCLI), stratospheric ozone loss (SOLO).

The 6th Framework Programme for Research and Technological Development (FP6, 2002-2006) was designed to promote interdisciplinary research in a more integrated way. The Integrated Project (IP), a newly defined funding instrument, became a very effective implementation tool for stratospheric research at European level. Research focused on future stratospheric ozone levels and physical and chemical processes affecting ozone depletion, ozone-climate interaction and exchange processes between the Troposphere and the Stratosphere. FP6 research projects are listed in Table 1. In addition, the GMES (Global Monitoring for Environment and Security) initiative, also addressed stratospheric research aspects (related to pre-operational services).

In the 7th Framework Programme for Research and Technological Development (FP7, 2007-2013) integrated and interdisciplinary UV and stratospheric research continues under Theme 6 Environment and Theme 9 Space. Priorities are in line with those of FP6. On going FP7 research projects are listed in Table 2.

In the past effective links have been maintained with existing international atmospheric observational programmes such as the Network for the Detection of Atmospheric Composition Change (NDACC) and the Global Atmosphere Watch programme of the World Meteorological Organisation (WMO-GAW).

Overall, stratospheric research has greatly benefited from European Framework Programmes. They also provided effective co-ordination mechanisms to jointly use European research facilities, promote integrated interdisciplinary research thereby addressing the scientific problems in a more holistic way. As a result, European research has significantly contributed to the international Scientific Assessment of Ozone Depletion: 2010.

II. Stratospheric Research in FP6 (2002-2006)

The following section gives a more detailed overview of the FP6 stratospheric research projects and their activities:

Under FP6 European Commission supported 3 IPs focusing on ozone-climate interactions and UV radiation (SCOUT-O3, **Stratospheric-Climate Links with Emphasis on the Upper Troposphere and Lower Stratosphere)**, on quantifying the impact of emissions from the transport sector on climate and ozone depletion (QUANTIFY, Quantifying the Climate Impact of Global and European Transport Systems) and on atmospheric observations (GEOMON, Global Earth Observation and Monitoring of the atmosphere), respectively. In addition, research priorities of IP GEMS (Global and regional Earth-system (Atmosphere) Monitoring using Satellite and in-situ data) among others, included a component on the assimilation of gas-phase chemical species in the stratosphere and troposphere.

Furthermore, the European Commission funded a number of Specific Support Actions (SSAs) to underpin stratospheric research and relevant policies. ATTICA (European Assessment of Transport Impacts on Climate Change and Ozone Depletion) was designed to assess the impact of the transport sector (aviation, land traffic, shipping) on climate change and ozone depletion, and the HCFC-Workshop (5-6 April 2008, Montreal) was designed to help developing countries to path ways to reduce and early phase-out HCFCs consumptions and emissions, respectively.

2.1 Core objectives of SCOUT-03

The aim of SCOUT-O3 (Finalised May 2010) was to study and predict the evolution of the coupled chemistry/climate system with emphasis on reliable prediction of the future evolution of the ozone layer and surface UV. Forecasts were build on refined and improved models by exploiting existing data for model testing and validation and by provision of new data on fundamental processes. In order to meet these goals, 10 project activities were defined:

- Determination of air residence time (with major field campaign);
- The influence of clouds on the tropical UTLS (with major field campaign);
- Understanding the stratospheric water vapour trend and its consequences;
- The stratospheric aerosol layer – role of TTL and possible changes;
- Past UV changes, variability and trends;
- Ozone variability and past changes at mid-latitudes;
- Inter-annual variability in polar processes and likely changes in a changing atmosphere;

- Improved understanding of the Brewer-Dobson and general stratospheric circulation;
- Stratosphere/troposphere coupling – past and future;
- Predictions of ozone recovery, effect on climate change on recovery and the impact of the ozone changes on surface UV.

Campaigns

- Tropical aircraft campaign has been carried out November-December 2005, Darwin, Australia (Russian stratospheric research aircraft M55 Geophysica was contributing);
- Atmospheric research campaign with M55 Geophysica from July 31 to August 18, 2006 in Ouagadougou, Capital of Burkina Faso, West Africa;
- SCOUT-O3/AMMA tropical balloon campaign, Niger, July-August 2006;
- SCOUT-O3 UV radiation and aerosol campaign, Thessaloniki (Greece) July 2006 in Southern Europe;
- Balloon campaigns 2008.

2.2 Core objectives of QUANTIFY

The main goal of QUANTIFY (finalised in end of 2010) was to quantify the impact of global and European transport systems on climate and ozone depletion for the present situation and for several scenarios of future development. The climate impact of various transport modes (land transport, shipping, and aviation) has been assessed, including those of long-lived greenhouse gases like CO_2 and N_2O, and in particular the effects of emissions of ozone precursors and particles, as well as of contrails and ship tracks.

Several transport scenarios and potential mitigation options have been assessed to identify the most effective combination of short and long-term measures as input for policy- and industrial decisions. The project aimed to provide such guidance by focused field measurements, exploitation of existing data, a range of numerical models, and new policy-relevant metrics of climate change. The project focused on the following activities:

- Establishment of transport Scenarios and emission inventories;
- Regional dilution and processing (with emphasis on chemical conversion of ship emissions);
- Large –scale chemistry effects (impact of transport emissions on chemical composition for past and present day conditions);
- Long-term measurements of UTLS compounds;
- Aviation, shipping and clouds (generation and modification of clouds by emissions of different traffic modes, with emphasis on cirrus clouds);
- Radiative forcing and climate change (contribution from different modes of transport);
- Development of improved metrics of climate change;
- Synthesis of the results.

2.3 Core objectives of GEOMON

The goal of GEOMON is to sustain and analyze European ground-based observations of atmospheric composition complimentary with satellite measurements. It is a first step to build a future integrated European atmospheric observing system dealing with observations of long-lived greenhouse gases, reactive gases, aerosols, and stratospheric ozone. GEOMON is a European contribution to GEOSS (Global Earth Observation System of Systems) helping to optimize the European strategy of environmental monitoring in the field of atmospheric composition observations. Furthermore, the project is also relevant for the European GMES (Global Monitoring for Environment and Security) initiative integrating in-situ and satellite measurements. Main activities:

- Unify and harmonise the main European networks of surface and aircraft-based atmospheric measurements;
- Support data gathering at existing networks;
- Co-ordinate and access to data and data-products at a common data centre;
- Integrate surface measurements with those of satellites with emphasis on data gathered by NDACC stations;
- Develop new methodologies to use these data for satellite validation;
- Enable new ground based measurements complementary to satellites;
- Deduce biases and random errors in satellite observations, to identify long-term trends in tropospheric and stratospheric composition related to climate change.

2.4 Core objectives of GEMS

The GEMS project (Finalised end of 2009) has created the first-ever system for operational global monitoring and medium & short range forecasts of atmospheric chemistry and dynamics. An improved exploitation of the best available satellite and in-situ data has been achieved through assimilation into numerical models. By 2008, GEMS has produced near-real-time & retrospective analyses of greenhouse gases, reactive gases and aerosols in the troposphere and in the stratosphere on the regional and on the global scale. GEMS covered the atmospheric theme within the GMES initiative of the EC, and GEMS data products provide valuable new analysis & forecast products for the GMES Service Element. Focus was on:

- Global Greenhouse Gases;
- Global Reactive Gases;
- Data on depletion of stratospheric ozone and long-range transport of atmospheric pollution;
- Regional air quality;
- Data assimilation and production;
- Data validation.

2.5 Core objectives of ATTICA

The SSP ATTICA (finalized end of 2010) has provided a coherent series of assessments of the impact of transport emissions on climate change and ozone depletion. Three assessments cover the emissions of single transport sectors (aviation, shipping, land traffic) and the fourth assessment deals with metrics that describe, quantify, and compare in an objective way the effects of the transport emissions in the atmosphere. Finally, the synthesis summarises the key results of the individual reports in a coherent way, and is considered as a reference document for stake holders and environmental policy makers.

2.6 Core objectives of the HCFC technical workshop

The European Commission has organised an international technical HCFC workshop, 5-6 April 2008, Montreal, Canada, which focused on the options for reduction of consumption and early and phase-out of HCFC in developing countries between now and 2015. Furthermore, it helped to identify ways to further reduce consumption and dependence on HCFCs between 2016 and 2040. Specifically, the workshop has provided developing country stakeholders with the technical tools and information needed to phase-out HCFCs (e.g., information on viable alternatives, technology transfer, funding opportunities) and to build consensus among stakeholders on next steps for this important issue that faces all of the Parties to the Montreal Protocol.

III. Stratospheric and UV Research in the 7th Framework Programme (FP7, 2007-2013)

Under Theme 6: Environment (including Climate) UV and stratospheric research remains a priority in FP7. More general speaking, research under the Environment theme is supporting the implementation of relevant international environmental commitments, protocols, and initiatives concluded by the European Union and its Member States, such as the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto and Montreal Protocols, respectively. Research is considered as an essential component in the increasing efforts of the European Commission to combat climate change and stratospheric ozone depletion. Research includes health risks associated with changing UV radiation levels.

In addition, Programme 9. Space under the GMES initiative also supports a topic on 'pilot services atmosphere in new application fields' which also includes stratospheric aspects.

The FP7 2008 call (Programme Environment) included two topics on UV and stratospheric research, headline:

ENV.2008.1.1.2.1. Climate-chemistry interactions in the stratosphere related to ozone depletion
Projects funded: RECONCILE and SHIVA

ENV.2008.1.2.1.5. Quantification of changing surface UV radiation levels and its impact on human health
Project funded: ICEPURE

3.1 Core objectives of RECONCILE

RECONCILE (Reconciliation of essential process parameters for an enhanced predictability of Arctic stratospheric ozone loss and its climate interactions) addresses the effects of climate change on stratospheric ozone and its related feedback mechanisms. Furthermore, the project will make reliable forecasts of future ozone loss and recovery.

Work tasks include:

- Chemical kinetic parameter and alternative ozone destruction;
- PSC microphysics and heterogeneous chlorine activation;
- Atmospheric dynamics, mixing, vortex break-up;
- Climate-Chemistry modelling.

Campaigns, experiments

- Aircraft campaign (M55-Geophysica) Winter 2009/2010, Kiruna, Sweden;
- Match Campaign Winter 2009/2010 launching ozone sondes;
- Laboratory experiments on ClO dimer absorption cross section.

3.2 Core objectives of SHIVA

SHIVA (Stratospheric ozone: Halogen impacts in a varying Atmosphere) aims to reduce uncertainties in present and future halogen loading and ozone depletion resulting from climate feedbacks between emissions and transport of ozone depleting substances (ODS). The focus is on the impact of short and very short-lived substances (VSLS) in the tropical regions and its climate–sensitive natural emissions.

Work tasks comprise:

- The oceanic emission strength of halogenated gases;
- Their atmospheric transport/transformation from the surface to the lower Stratosphere;
- The past, present and future trend of the total halogen burden;
- Its impact on the past, present and future ozone in the Stratosphere Campaigns;
- Tropical campaign (Research Vessel Sonne, Falcon aircraft) will take place in late 2011.

3.3 Core objectives of ICEPURE

ICEPURE (The impact of climatic and environmental factors on personal ultraviolet radiation exposure and human health) will determine the adverse and beneficial health effects of UVR exposure and their relationship with climatic and environmental factors that modify the UVR spectrum.

- Measurement of personal UVR exposure;
- Development of new radiative transfer models;
- Determination of the beneficial and harmful biological effects of UVR;
- Review of the current health risks of UVR.

3.4 Core objectives of MACC

MACC (Monitoring Atmospheric Composition and Climate) is the current pre-operational atmospheric service of the European GMES programme. MACC provides data records on atmospheric composition for recent years, data for monitoring present conditions and forecasts of the distribution of key constituents for a few days ahead. MACC combines state-of-the-art atmospheric modelling with Earth observation data to provide information services covering European Air Quality, Global Atmospheric Composition, Climate, and UV and Solar Energy.

Core objectives among others are:

- Monitoring and Forecasting of Ultraviolet Radiation;
- Total Ozone Record;
- Near-real-time Ozone Monitoring;
- Near-real-time Ozone Forecasts;
- Monitoring of surface solar irradiance.

These projects build the back bone of European Commission stratospheric research, thereby maintaining a critical mass essential for future contributions to international ozone and UV assessments.

IV. Future activities

The complexity of the atmospheric processes, the scale of the scientific problems and the potential devastating impact on humans and the ecosystems caused by climate change, stratospheric ozone depletion and changing UV radiation require real interdisciplinary research collaboration. This has already started under the 5th and 6th Framework Programmes and, as indicated above, continues in the 7th Framework Programme, where research will be conducted in the coming years focusing on the climate-stratospheric interaction.

Open scientific questions to be considered in coming calls concern the exchange between the Troposphere and Stratosphere under changing climatic conditions; changes, interactions and feedback between atmospheric composition, the climate system, variations in the solar spectrum and its consequences for the Stratosphere

Table 1: Relevant research projects supported under FP6

SCOUT-O3 ***(Stratosphere-Climate Links With Emphasis On The UTLS)***
Co-ordinator: Prof. John Pyle, University of Cambridge, UK
Budget: 15.000.000 €
Starting date: 1 May 2005
Duration: 5 years
Web-link: http://www.ozone-sec.ch.cam.ac.uk/scout_o3/index.html

QUANTIFY ***(Quantifying the Climate impact of Global and European Transport Systems)***
Co-ordinator: Prof. Robert Sausen, DLR, DE
Budget: 8.388.172 €
Starting date: 1 March 2006
Duration: 5 years
Web-link: http://www.pa.op.dlr.de/quantify/

GEOMON ***(Global Earth observation and monitoring of the Atmosphere)***
Co-ordinator: Prof. Philippe Ciais, CEA, FR
Budget: 6.621.740 €
Starting date: 1 February 2007
Duration: 4 years
Web-link: http://geomon.ipsl.jussieu.fr/

GEMS ***(Global and regional Earth-system (Atmosphere) Monitoring using Satellite and in-situ data)***
Co-ordinator: Dr. Adrian Simmons, ECMWF, UK
Budget: 12.450.000 €
Starting date: 1 March 2005
Duration: 4 years
http://www.ecmwf.int/research/EU_projects/GEMS/

ATTICA ***(European Assessment of the Transport impacts on Climate and Ozone Depletion)***
Co-ordinator: Prof. Robert Sausen, DLR, DE
Budget: 680.000 €
Starting date: 1 June 2006
Duration: 3 years 6 months
Web-link: http://www.pa.op.dlr.de/attica/

HCFC workshop
Co-ordinator: ICF international
Budget: 300.000 €
Starting date: 1 January 2007
Duration: 1 year 6 months
The HCFC workshop, 5-6 April 2008, Montreal, Canada

Table 2: Relevant research projects supported under FP7

RECONCILE (Reconciliation of essential process parameters for an enhanced predictability of Arctic stratospheric ozone loss and its climate interactions)
Co-ordinator: Dr. Marc von Hobe, Forschungszentrum Jülich, DE
Budget: 3.500.000 €
Starting date: 1 March 2009
Duration: 48 months
Web-link: https://www.fp7-reconcile.eu/

SHIVA (Stratospheric ozone: halogen impacts in a varying atmosphere)
Co-ordinator: Prof. Klaus Pfeilsticker, University of Heidelberg, DE
Budget: 3.500.000 €
Starting date: 1 July 2009
Duration: 36 months
Web-link: http://shiva.iup.uni-heidelberg.de/

ICEPURE (The impact of climatic and environmental factors on personal ultraviolet radiation exposure and human health)
Co-ordinator: Prof. Antony Young, King's College London, GB
Budget: 3.500.000 €
Starting date: 1 February 2009
Duration: 36 months
Web-link: http://www.icepure.eu/

MACC (Monitoring Atmospheric Composition and Climate)
Co-ordinator: Dr. Adrian Simmons, ECMWF, UK
Budget: 11.700.000 €
Starting date: 1 June 2009
Duration: 29 months
Web-link: http://www.gmes-atmosphere.eu/

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