In-Depth Progress Report

to the 29th Meeting of the Technical Committee on Meteorology
Nice, September 30 to October 1, 2004

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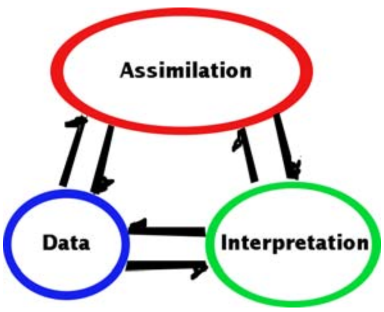
1 Objectives of the Action

The main objective of the Action is to advance the understanding of the state of the global upper troposphere and lower stratosphere, and the role of the dynamical, chemical, and radiative processes in this altitude region. COST Action 723 will provide value-added quality-controlled datasets of geophysical parameters (e.g., ozone and water vapour) which are believed to be important for the study of radiative, dynamical, and photochemical processes in the tropopause altitude region (5 km above and below the tropopause). Hitherto, there has been little information on these geophysical parameters in this region. The Action will contribute toward making the best use of observations, models and assimilation algorithms, and toward the definition of new strategies for future research.

2 Working Groups (WGs)

The Action consists of three working groups:

- **WG1:** Data and Measurement Techniques
- **WG2:** An assimilated Ozone and Humidity Dataset
- **WG3:** Assessing the State of the UTLS and Understanding the Relevant Processes



These areas are tightly related, as indicated by the figure to the right. Therefore, the three WGs have to be linked together by common meetings and workshops.

3 Activities

The COST 723 Opening Workshop took place on March 11-13, 2004, at ESTEC, Noordwijk, the Netherlands. It included 27 oral presentations and 26 poster contributions. All presentations can be found at:
http://www.cost723.org/meetings/ws1/contributions.html.

A special issue of the journal Atmospheric Chemistry and Physics (ACP) of the European Geophysical Union (EGU) is being devoted to the workshop. The editors are William Lahoz and Danny McKenna. Details of submitted papers can be found at http://www.cost723.org/publications/.

The workshop was also used to plan working group activities and for an MC meeting. It was decided to have a COST 723 summer school in Cargese (France) in fall 2005. The summer school is planned to focus on UTLS measurement techniques, data assimilation, and modelling studies. It should comprise approximately 15 lecturers and 50 to 60 participants.

The next MC meeting was decided to be in parallel to a WG3 workshop on cirrus clouds, to be hosted by Klaus Gierens in Oberpfaffenhofen, Germany. It was further decided to have a number of smaller expert meetings for the different WGs over the summer (see below).

3.1 Working Group 1

The assessment of UTLS measurement capabilities at the WG1 meeting in Bern in autumn 2003 and at the Opening Workshop at ESTEC in spring 2004 showed that ozone is reasonably well covered by existing databases (NDSC, GAW, WOUDC). The most prominent open issue on the global scale was found to be the inconsistency and uncertain quality of different humidity data sets. This will therefore be a focus of WG1 activities. Because of the strong dependence of relative humidity on temperature, temperature information is also crucial. A systematic survey of all humidity and temperature data available to the Action was conducted and is documented at http://www.cost723.org/wg/wg1/.

The aim of WG1 is to assess (and possibly improve) the quality of the different datasets by intercomparison studies, including direct in situ comparisons, as well as comparisons using satellite instruments as transfer standard. Available instruments/datasets are:

- Radiosonde (operational / research) (Brzoska et al. 2004)
- Lidar
- Operational met. Satellites (Buehler et al. 2004, Jimenez et al. 2004)
- Envisat (MIPAS / SCIA)
- Champ
- In-service aircraft (MOZAIC)

- Microwave (uplooking / limb-looking) (Gerber et al. 2003)

To improve the quality of radiosondes, a measurement campaign was carried out in Sodankylä, Finland, from February 11 to 25, 2004. Scientific aims of the campaign were:

1. The improvement/validation of research-type hygrometers/radiosondes like Meteolabor Snow White hygr., NOAA frostpoint hygr., CAO Flash Lyman alpha hygr., Lindenberg FN sonde, and Vaisala RS90 routine sonde. The aim is to define an optimal working range (related to temperature, water vapour mixing ratio and relative humidity, pressure) for each of the participating hygrometers/radiosondes.

2. The creation of a “standard water vapour mixing ratio profile” by in-situ measuring hygrometers/radiosondes in the height range 300 hPa to 10 hPa for the campaign time period.

3. The validation/improvement of the solar radiation correction of the RS90 latest version, RS80, and Snow White SRS-C34 temperature sensors.

4. The study of the influence of the balloon wake on the temperature measurements, mainly for stratospheric day and night conditions.

5. The study of the relative humidity of Arctic stratus under ice supersaturated conditions related to the investigation of the frequency of the liquid and the ice phase in supercooled clouds.

6. The study of the relative humidity during PSC-events in a height range 100 hPa to 30 hPa.

7. The study of the water vapour budget in the northern stratosphere; first data for a meridional cross-section between Ny-Alesund (78°N), Sodankylä (68°N) and Lindenberg (52°N).

8. The start of climatological long-time studies based on improved/corrected upper air humidity measuring techniques for the station Ny-Alesund, Sodankylä and Lindenberg.

Results of the campaign will be discussed at a dedicated expert meeting in Lindenberg, Germany, on August 24 to 27, 2004, hosted by Ulrich Leiterer.

Another dedicated expert meeting, to improve water vapour measurements with lidar, was held in Matera, Italy, on July 13, 2004, hosted by Gelsomina Pappalardo, and chaired by Philippe Keckhut. Water vapour Raman lidar is a very promising technique to probe the upper troposphere and the tropopause region. However this new technique has strong calibration requirements. The goal of this workshop was to bring the main teams involved on water vapour Raman lidars together and to discuss the main issues. It was decided to use the opportunity of the EOS Aura satellite (launched July 2004) as a geographical transfer standard to compare the measurements of the different existing or emerging lidars. Minutes of the meeting can be found at http://www.cost723.org/meetings/wg1_3/.

3.2 Working Group 2

The participants in WG2 have continued to work on the assimilation of data (in particular ozone and water vapour). Many of the participants in WG2 are partners in the EU Framework V project ASSET ("Assimilation of Envisat data"; http://darc.nerc.ac.uk/asset). The participants in WG2 have given presentations at a number of international workshops, and have participated (as organizers and lecturers) at a number of Summer Schools.

Data assimilation is been used to incorporate novel observations (e.g. ozone and stratospheric water vapour), and to evaluate research satellite data (e.g. Envisat). Details of the use of assimilation techniques to evaluate Envisat data are provided in: http://envisat.esa.int/workshops/acve2/presentations.

The work in WG2 aims toward incorporating chemical data (e.g. ozone, water vapour from Envisat) into assimilation systems. Three approaches can be identified:

(1) Assimilation into a General Circulation Model (GCM).

In this approach, the standard operational observations are assimilated, plus research satellite observations (e.g. GOME, Envisat). The models generally incorporate a simple parameterization of the chemical sources and sinks of ozone (e.g. the Cariolle scheme), although a hierarchy of chemical parameterizations can be implemented. An advantage of this approach is that it allows for radiation/chemistry/dynamics feedbacks. A disadvantage of this approach is that the chemical formulation often tends to be simple. The assimilation schemes used tend to be variational (3d-var; 4d-var). Kalman filter schemes are not used due to their high computing requirements.

Examples of this approach are provided by the Met Office/DARC (Struthers et al. 2002, Lahoz et al. 2004), and the ECMWF (Dethof 2003).

(2) Assimilation into a Chemistry-transport Model (CTM).

In this approach, a sophisticated chemical model (typically including photochemistry and heterogeneous reactions on aerosols and PSCs), is forced by winds and temperatures from an external source (typically a GCM or analyses derived from a GCM-based assimilation system). An advantage of this approach is that it allows for highly sophisticated chemical models. A disadvantage of this approach is that it does not allow for radiation/dynamics/chemistry feedbacks. The assimilation schemes used are variational or simplifications of the Kalman filter.

Examples of this approach are provided by KNMI (Eskes et al. 2003), BIRA-IASB (Errera and Fonteyn 2001), GMAO (Štajner et al. 2001), UPMC (Marchand et al. 2004) and U. Köln (Elbern et al. 1997).

(3) Assimilation into a coupled GCM/CTM model.

In this approach, the advantages of a GCM and a CTM are combined by coupling a GCM to a CTM. The coupling can involve a CTM external to the GCM, or a chemistry subroutine embedded in the GCM. In the former case, the assimilation schemes applied to the GCM and the CTM can be different.

An example of this approach is provided by Météo-France (see ASSET project web-site).

A particular challenge is the assimilation of water vapour in the troposphere and stratosphere. The large variation in water vapour amounts between the troposphere and stratosphere (four orders of magnitude) and the almost discontinuous gradient around the hygropause, make it difficult to assimilate water vapour. A number of problems arise from these characteristics of the water vapour distribution. These are: (i) ill-conditioned vertical transform of the background error covariance matrix, and (ii) unrealistic stratospheric increments. If untreated, these problems will lead to unrealistic water vapour analyses.

Besides the problems arising from this large variation of water vapour, there is an issue concerning what is the best control variable for assimilating water vapour: relative humidity (RH) or specific humidity. In the troposphere, RH provides a better representation of clouds and precipitation; in the stratosphere, RH has very low values, which makes specific humidity better suited. The choice of water vapour control variable is being discussed in the literature (Hólm et al. 2002, Dee and da Silva 2003).

The DARC/Met Office and ECMWF (among others) are working on developing the assimilation of water vapour in the troposphere and stratosphere.

3.3 Working Group 3

Working Group 3 is organizing a workshop on cirrus clouds and their supersaturated environment. It is planned to take place on October 11-12, 2004, at Oberpfaffenhofen, Germany, hosted by Klaus Gierens.

Cirrus clouds cover on the average 20-30% of the Earth, and even much more when sub-visible cirrus is included. Cirrus clouds are an important modulator of the radiative energy flow in the Earth's atmosphere, and they are able to both heat or cool the atmosphere, depending on their micro-physical and radiative properties, their geographical location and altitude, and on time of the day. They are part of the hydrological cycle and affect the humidity field in the upper troposphere. They allow heterogeneous chemistry to occur and hence play a role in regulation of tropospheric ozone. Finally, they are part of the weather system. So far, cirrus clouds are generally perceived as isolated objects, having certain micro-physical and radiative properties. However, they are situated in an environment that has properties allowing (1) cirrus clouds to form and (2) to persist for a while. Generally the properties of this environment have received much less attention than the imbedded cirrus clouds.

There has been some research on so-called ice-supersaturated regions in the recent years. However, also these regions have been treated as isolated objects, and in all studies data sets have been cleared from cloud influences as much as possible before analysis. Evidently, there must be a strong relationship between cirrus clouds and their supersaturated surroundings. The goal of the Oberpfaffenhofen workshop is to raise the awareness of the current "one-dimensional perception" of cirrus, and to trigger research into the new "system analytic" direction of considering supersaturated airmasses in interaction with their embedded cirrus clouds.

3.4 Short Term Scientific Missions

Only two STSMs were approved so far. One is for Marion Müller to go to the Institute for Atmospheric Sciences and Climate, ISAC-CNR, Rome, Italy (Federico Fierli), to work on the evaluation of H_2O data assimilation in a high-resolution transport model using balloon-borne stratospheric water vapour measurements taken during the LAUTLOS campaign.

The second mission is for Barbara Brzoska to go to the Finnish Meteorological Institute, Sodankyla, Finland (Esko Kyro), to gain experience with research-type humidity radiosondes and to work on the homogenization of the water vapour measurements by different radiosonde types.

4 History and Status

In total 17 countries are participating in COST-723: Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Spain, Sweden, Switzerland, and United Kingdom.

Important events:

September 9-10, 2002: MC meeting 1 in Brussels.

April 8, 2003: Unofficial meeting in Nice to discuss the problematic situation created by the general COST moratorium due to the move of COST to the ESF.

October 6-7, 2003: WG1+MC meeting in Bern, made possible by availability of funds on short notice.

December 1-2, 2003: WG2/Asset meeting in Brussels.

March 11-13, 2004: Opening workshop at ESTEC, Noordwijk.

July 13, 2004: WG1 Lidar workshop in Matera, Italy.

Initially, the Action was planned to start with the Opening Workshop, which should have taken place 6 months after the first MC meeting, in other words in March 2003. The moratorium has delayed the Action by approximately one year.

5 Upcoming Events

August 24-27, 2004: WG1 LAUTLOS radiosonde meeting in Lindenberg.

October 11-12, 2004: WG3+MC Cirrus workshop in Oberpfaffenhofen.

May 2005: Midterm workshop.

September 26 to October 8, 2005: COST 723 Summer school in Cargese.

6 COST 723 Website

A dedicated domain has been created for the COST 723 website. The address is: http://www.cost723.org/. The website contains general information about the Action and meeting material. It also hosts mailing lists for MC and WGs, as well as an address database of all COST 723 members. Results of the Action are continuously added, as they become available.

7 COST 723 at other Meetings

The COST 723 members gave a number of presentation at the EGS-AGU-EUG assembly in Nice in spring 2003, some of which are collected on the COST 723 website.

Other meetings and conferences that COST 723 members have attended or will attend are the ASSET/SPARC workshop (June 2003), the IUGG (August 2003), the 3rd WMO workshop on impact studies (March 2004), the ACVE-2 (May 2004), the

SPARC meeting (August 2004), and the ERS/Envisat Symposium (September 2004). The above list is not exhaustive.

Besides the conferences, COST 723 members have also helped organize several summer schools: the NATO ASI Summer School (May 2002), the 1st ESA Summer School (August 2003), the Oxford/RAL Spring School (March 2004), and the 2nd ESA Summer School (August 2004). An outcome of the NATO ASI Summer School was the book: *Data Assimilation for the Earth System*, edited by R. Swinbank, V. Shutyaev, and W.A. Lahoz, published by Kluwer, The Netherlands.

8 Budget Matters 2005

The two major budget items for 2004 are the Opening Workshop and the WG1-3/MC meeting in autumn. A budget estimate can be found in the following table.

Item	**Cost [kEuro]**
Midterm Workshop (10 persons for each WG + 5 MC = 35 persons)	30
Smaller WG expert meetings (10 persons for each WG = 30 persons)	25
COST 723 Summer school	25
Total	**80**

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