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STRATOSPHERIC PROCESSES AND THEIR ROLE IN CLIMATE
A Project of the World Climate Research Programme

Report on the 11th Session of the SPARC Scientific Steering Group

Frankfurt, Germany, 22-25 September, 2003

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Introduction

Opening of the session, introductory comments

The eleventh session of the SPARC Scientific Steering Group (SSG) was held in a guesthouse of the Johann – Wolfgang Goethe University of Frankfurt am Main, Germany, from 22-25 September 2003, at the kind invitation of **U. Schmidt** of the Institute for Meteorology and Geophysics, University of Frankfurt am Main, and a member of the SPARC SSG.

Opening the session, the SSG co-Chairs, **A. O'Neill** and **A. Ravishankara,** welcomed the new SSG members, **D. Hartmann** and **J. Burrows,** and expressed their expectation that the new SSG members would make an excellent contribution to the project. The chairs noted with appreciation the attendance of all ex-officio members representing WMO/GAW (**M. Proffitt**), COSPAR (represented by **M.L. Chanin**), SCOSTEP (**M. Geller**) and NDSC (**M. Kurylo**), as well as the presence of **D. Parish** for the IGAC project and **T. Wehr** of the European Space Agency. They also thanked **U. Schmidt, M.-L. Chanin** and **C. Michaut** for their work in preparing the meeting, which resulted in excellent local arrangements.

After a round of self-introductions, the chairs briefly introduced the current status of SPARC development. The new directions of SPARC research were discussed at the 10th SSG meeting in Kyoto and presented to the 24th Session of the WCRP Joint Scientific Committee (JSC, 17-22 March 2003, Reading, UK) and the Committee approved them. The JSC session put forward a new initiative on the development of the Climate system Observational and Prediction Experiment (COPE), which was expected to become a major WCRP overarching theme for the coming decade. The chairs called on the SSG members to think how SPARC would fit within COPE and contribute to it. Evaluating the current status of SPARC, the chairs noted that stratosphere was getting more recognition in climate research and numerical weather prediction, as well as in modern observing systems. The general goals of the 11th SSG meeting would be to continue the discussion on how SPARC would evolve as a collective project. SPARC needs a new Implementation Plan that would move forward SPARC research and would also facilitate integration of the project into other WCRP activities.

WCRP comments

V. Ryabinin briefly described the most important activities of the WCRP projects, their recent achievements and main events. CLIVAR (Climate Variability and Predictability) activities are vast and include, among

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others, the continued development of the ARGO array, El Niño forecasting, unfolding monsoon studies in various parts of the world. In 2004, CLIVAR is holding the First CLIVAR Science Conference (Baltimore, USA, June 2004). GEWEX (Global Energy and Water Cycle Experiment) is active in developing the Co-ordinated Enhanced Observing Period (CEOP); it will include a very elaborate data-processing system, which includes specialised centres distributed around the world. The Arctic Climate System Study (ACSYS) is finishing in 2003 with a Final Science Conference held in St. Petersburg, Russia, in November 2003. Dramatic changes are being observed in the Climate and Cryosphere project (CliC), which is defining its main project areas and developing its implementation activities. The First CliC Science Conference will be held in 2005. In 2003, the Global Climate Observing System (GCOS) published its second report on the adequacy of climate observing systems. Stratospheric elements were sufficiently well represented in the report.

The JSC of WCRP, at its 24th session, considered the following outstanding science questions of the programme: hydrological cycle and its changes; modelling of clouds, radiation, and precipitation; sea level rise due to glacier/ice sheet melt; a possibility of an abrupt climate change due to a regime shift in the cryosphere; mechanisms of natural climate variations; effects of atmospheric composition on climate; anthropogenic impacts; inclusion of biosphere in climate models; and studies of the effect of bio-geochemical cycles on climate.

The JSC session decided to launch a new WCRP-wide activity called "Climate system Observational and Prediction Experiment" (COPE, 2005-2015). The first focus of COPE is to be the seasonal and interannual prediction, which will constitute the basis for the terms of references for a new task force.

Summarising his WCRP review, **V. Ryabinin** presented the following list of issues of high importance for SPARC in 2004/2005: SPARC Assembly in August 2004, move of the International Project Office from Paris, smaller budget at the Joint Planning Staff (JPS) of the WCRP; new tasks for WCRP as a whole, such as Task Force on Seasonal Prediction, possible changes in the WCRP structure, and the International Polar Year (IPY 2007-2008).

Report from the Gordon conference

V. Ramaswamy continued the introductory session by reporting on a Gordon Research Conference on Solar Radiation and Climate, which was held at the Colby-Sawyer College, New Hampshire, USA, on 13-18 July 2003. SPARC co-financed the conference, which summarised the current research on physical and chemical factors in the observed radiative properties and energy budget of the planet and this led to a consideration of how perturbations of the radiative energy budget affect climate variations at several time scales, from seasonal to interannual and decadal (see full report on page 18).

Strategic development of SPARC

On behalf of the two SSG co-Chairs, **A. O'Neill** addressed the session presenting new ideas on the strategic development of SPARC (see full paper on page 13).

Recent SPARC activities have been concerned with stratospheric indicators of climate change, study of stratospheric processes, development of modelling, various assessments and development of data assimilation. The recent deliverables have been: an assessment report "Stratospheric temperature trends: observations and model simulations" (paper awarded the WMO Norbert Gerbier-MUMM Award, 2003); a stratospheric reference climatology report, WMO/UNEP Ozone Assessment 2002, Chapter 4 of the publication "Global Ozone: past and future".

A. O'Neill summarized the expected future deliverables by SPARC:

- Temperature Trend Assessment Report.
- Aerosol Assessment Report.
- Review on Arctic Oscillation / North Atlantic Oscillation for stratosphere - troposphere system.
- Review of gravity-wave parameterizations.
- Review of scientific issues in the domain of chemistry and climate.
- A review on global circulation models / chemical transport models with focus on ozone and predictions of mid-latitude O_3 .
- A contribution to IPCC process.

A. O'Neill concluded his presentation by indicating the most important links of SPARC with other WCRP Projects.

In the subsequent discussion, the SSG members agreed that the three main streams of the future research were indeed the issues of highest priority for SPARC. The lack of a dedicated WCRP project addressing chemistry in troposphere was seen as a problem. The group felt that it was very important to move ahead from detection of trends towards their understanding and attribution. The meeting decided to embark on preparations of a new implementation plan for SPARC.

The stratosphere in the climate system: an overview

The introductory part of the session was concluded by a new SSG member, **D. Hartmann,** who gave an overview of the stratosphere in the climate system focussing mostly on dynamical aspects. His talk presented a list of research topics of importance for SPARC that included stratospheric warmings, mechanisms for the impact of the stratosphere on the troposphere, annular modes of variation and long-term trends, possible slow down of the Brewer – Dobson circulation in a warmer climate, explanation of trends in stratospheric water vapour, studies of radiation, convection and circulation of the tropical tropopause (see full report on page 15)

The New SPARC Strategies

Detection, attribution and Prediction of stratospheric changes

W. Randel presented this item on behalf of a group of SPARC specialists. He reported on the preparation of a one-day workshop on understanding seasonal temperature trends in the stratosphere, which was held in Silver Spring, USA, on 5 November 2003, following a symposium honouring the career of J.K. Angell. The workshop was being organised by the SPARC Stratospheric Indicators of Climate Change Initiative and addressed observations, model simulations of stratospheric temperature changes and their interpretation, and the effect of stratospheric variability and circulation on trends (see workshop report on page 24).

From the view-point of observations, two important issues were noted by **W. Randel.** They are the continuity of stratospheric temperature data sets and data on stratospheric water vapour changes. Changes in meteorological analysis procedures or in data characteristics strongly influence current stratospheric data sets. There are significant uncertainties in all analyses associated with the change of data source from TOVS to ATOVS Polar

Participants of the SSG in Frankfurt. From left to right.
First row: A. Ravishankara, A. O'Neill, V. Ramaswamy, M. Geller
Second row: S. Yoden, M.-L. Chanin, V. Yushkov, J. Burrows, M. Kurylo
Third row: K. Kodera, T. Shepherd, V. Ryabinin, M. Baldwin, W. Randel, P. Canziani,
Fifth row: T. Peter, F. Lübken, T. Wehr, U. Schmidt, D. Parrish, D. Hartmann, M. Proffitt

Orbiting Sounding products. This will affect future assessments, and for further studies it is important to recognise the inherent observational uncertainties. SPARC should encourage efforts to improve the observational record in the future. There must be work on a more integrated understanding of past changes, which would involve studies of trends in ozone, temperature and water vapour trends, as well as aerosol assessments. Modelling results should be more widely used to explain and verify the trends. The SPARC workshop following the Angell Symposium and a workshop on coupled climate models in Garmisch-Partenkirchen, November 2003, could be instrumental in finding better ways of studying the trends. Opportunities to link activities with those of GRIPS should be explored. SPARC has to develop other strategies for the attribution of stratospheric trends and this can contribute well to interests of wider communities, such as WMO, IPCC assessments and goals of environmental agencies. **V. Ramaswamy** concurred with points made by **W. Randel** and mentioned that high natural variability in the atmosphere created particular difficulties of water vapour trend analysis in the latitudinal belt from 60° to 90° of winter hemisphere.

According to the views of **S. Pawson,** "understanding the past" could be a new major direction for GRIPS. It could be a natural development of existing level-3 GRIPS activities. This would be a solid contribution to detection and attribution work of SPARC. A "climate – chemistry" component of GRIPS could form as a new level-4 activity, which would fit perfectly the new SPARC research directions. Successful implementation of these tasks would open the way for level-5 activities, which could be devoted to predictive experiments. It will be essential to have credible atmospheric global circulation models with full troposphere, robust radiation codes, parameterizations for hydrological cycle and other physical factors and with upper boundaries in the mesosphere. The SSG agreed with these comments and expressed a view that GRIPS leaders should seek to encourage the GRIPS community to participate fully in these scientific challenges.

The SSG requested **W. Randel, S. Pawson,** and **K. Kodera** to lead further development of SPARC activities in the area of change detection, attribution and prediction. The group felt strongly that GRIPS was able to contribute crucially in the stream of SPARC science.

Stratospheric chemistry and climate

A.R. Ravishankara introduced this item. Significant progress in reviewing the current state of affairs and in planning was achieved at a joint SPARC-IGAC Workshop on Climate-Chemistry Interactions held in Giens, France, on 3-6 April 2003 (see SPARC Newsletter N°21). The discussions at the workshop have highlighted five major topics: aerosols and climate, water vapour and clouds, stratospheric ozone and climate, tropospheric chemically active greenhouse gases (GHGs), stratosphere-troposphere (ST) interactions. A paper summarising the results of the workshop will be written in time for the 3rd SPARC General Assembly. It will be available on the SPARC and IGAC web sites.

Atmospheric measurements alone are not capable of providing reliable information on abundance of short-lived greenhouse species and, therefore, their representation in models requires extensive process studies. The aim of the new programme will be to reduce the uncertainties in chemically dependant climate forcings, for which aerosols are one significant issue. Aerosol forcing is regional, and the proposed approach will be to run high resolution regional models fed by well-defined measurements and then to scale up to global climate models. The aerosol indirect effect is a complex process involving interactions between the aerosols, dynamics, cloud microphysics and the gas phase. The aerosol indirect effect, too, requires a coupled approach of using high resolution models and well defined measurements. For the water vapour, the key question will be the mechanisms that control the humidity in the upper troposphere and stratosphere, as well as its long-term changes. There is a link to aerosols through cloud formation, evolution, their effects on radiation, precipitation and chemical composition of the atmosphere. Important climate-chemistry feedbacks need to be quantified, whilst models representing them need to be systematically compared. Satellite data should help to reduce uncertainties in data on emissions of aerosols and ozone precursors. Careful evaluation of such data as GOME and SCIAMACHY at highest possible resolution is needed to have solid confidence in the products. In order to address ST interactions, one needs to assess the representation in global models of the spatial distribution and temporal variability of constituents (including aerosols) in the lowermost stratosphere and tropical tropopause layer, and to establish metrics based on observations of long-lived stratospheric tracers. Without this it will be difficult to ensure realistic representation in models of the fluxes of mass, ozone and other constituents from the stratosphere to the troposphere.

The scientific problems, presented above, could form the foci of strong collaboration between SPARC and IGAC. The following topics are indicative of priorities:

- The role of UTLS aerosol and clouds in chemistry, in climate, and in their interactions: understanding and representing microphysical, chemical and radiative processes in numerical models.
- The role of convection (both deep and warm) in controlling UTLS water and chemical constituents.
- Tropical tropopause layer and climate-chemistry interactions.
- The extent and role of ST exchange in controlling the abundances of ozone and other species in the UTLS and, specifically, an accurate quantification of the ST exchange contribution to tropospheric and upper-tropospheric ozone budget.
- The use of tracers and their variability in observations and in models to identify and diagnose roles and contributions of processes, an assessment of the role of inter-annual variability in the circulation patterns affecting the distribution of chemical constituents in the stratosphere and troposphere.
- The role of lightning in the production and distribution of nitrogen oxides.
- Determination of the fundamental parameters in kinetics, heterogeneous chemistry (specifically aerosols and ice in upper troposphere), photolytic processes, spectroscopy, and optical properties *via* laboratory studies.
- Satellite observations of trace species and meteorological parameters in the troposphere and lower stratosphere, assimilation of satellite observations, evaluation of models by using satellite data.

J.P. Burrows picked up the last theme and tried to further elaborate the SPARC strategy in developing observations for studying climate - chemistry interactions. The classical view on this is that chemistry changing from both natural phenomena (e.g., volcanic emissions) and anthropogenic activity (e.g. pollution, emissions, land use etc.) results in changes in the surface spectral reflectance, the composition of trace gases and aerosol, which are both chemically and radiatively active, radiation, cloud cover, precipitation rates, i.e. weather (short term) and climate (in the medium and long term). However, the system is nonlinear and includes feedbacks.

Important issues are the extent and non-linearity of the coupling and interaction between the chemistry, weather and climate, and the attribution of the natural and anthropogenic contributions to changing and variable atmospheric composition and conditions. Emphasis needs to be focused on regional air quality, long-range transport and transformation of pollutants, the atmospheric lifetime and turnover of GHGs and aerosols.

For the stratosphere the questions are as follows. Will ozone recover from chlorine driven depletion as predicted? What is the role of tropopause height changes in ozone trends, in climate and chemistry interactions? What is the role of bromine? Will the dynamics and circulation remain stable and what will be the impact of a changing circulation on the chemical composition?

Additional scientific questions arise in connection with the mesosphere. Are the mesospheric composition changes a potential early warning signal for climate change? What is the nature of the noctilucent clouds, their cover and frequency? To what extent is the mesosphere an NO_x source for the stratosphere? Do we understand well enough all the processes involved in transformations between O_2 and O_3 in the mesosphere?

Some of these questions will be addressed by forthcoming satellite missions, which will provide a basis for first sensitivity studies. The goal will be to estimate, based on given instrument performance, the mean noise-induced error on geophysical parameters. The method is based on the radiative transfer simulation, instrument model and retrieval algorithm. It has been already applied in various sensitivity studies in the MIPAS, GOME, GOME-2, GOMOS and SCIAMACHY projects.

The integrated observing strategy, as seen by the current CEOS-IGOS-IGACO activities, comprises high resolution spatial and temporal measurements of key constituents. Three to four geostationary and two low orbit satellites would constitute the space segment, which should be complemented by ground based measurements and aircraft process studies campaigns. Continuity is an absolute requirement for the satellite systems.

Summarising his presentation, **J. Burrows** informed the meeting that a SPARC-IGAC 1st International UV/vis Limb Scattering Workshop took place in Bremen, Germany, on April 14-15, 2003 (see workshop report on page 31). He also named several ongoing European projects, which were presented to the SPARC SSG on 24 September 2003. He concluded by stating that more observations were necessary, that satellites were demonstrating some interesting capabilities, and that there was a true need to move towards an integrated observing system addressing key atmospheric constituents, comprising satellites, ground based measurements and campaigns with aircraft.

Following **J. Burrow**'s presentation a concern has been raised that at the moment the system was unable to provide continuity for trend analysis.

On behalf of **N. Harris, A. Ravishankara** presented the eight-year UK NERC funded thematic programme UTLS OZONE, which started in 1998 to study ozone in the UTLS. The Programme aims to make authoritative statements on chemical, dynamical and radiative processes controlling the distribution of ozone in the UTLS at middle latitudes. Studies related to pollution (from surface sources and from aircraft) and to chemistry/climate interactions will be in scope. In total, within the programme, 45 projects have been funded, which are summarised below.

Stratospheric humidity affects both radiative forcing of climate and stratospheric composition including ozone abundance. Current observational data are unable to tell us whether the humidity of air entering the stratosphere through the tropical tropopause is controlled by slow dehydration in weak mean ascent, or by rapid dehydration in dramatic overshooting cumulus clouds. Experiments performed within the UTLS OZONE Programme using a numerical cloud-resolving model clearly favour the slow-dehydration scenario.

Research within the UTLS OZONE Programme has identified a number of important oxygenated volatile organic compounds released from soot during oxidation by ozone. This is previously unreported in the literature (although water soluble species have previously been observed to be formed and retained under similar conditions). This observation may explain some of the measured complexity of organic species present in urban atmospheres.

Model simulations were used to investigate how the ozone layer will recover, as chlorine concentrations decrease during the next decades, but concentrations of GHGs increase. Results indicate that global ozone would decrease by 1% between 1979

and 2060 when the increases of greenhouse gas concentrations are ignored. When GHGs are included, ozone was found to increase by 0.5%. The work on the causes of observed temperature trends in the stratosphere has input directly into the WMO/UNEP Scientific Assessment of Stratospheric Ozone 2002, which supports the Montreal Protocol process, and which aims to protect the ozone layer.

As part of the UTLS OZONE Programme, the photodissociation quantum yields of acetone were measured over atmospherically relevant ranges of wavelength, pressure and temperature, and the lifetime of acetone in the UTLS is a factor of 2 longer when using the new quantum yields.

The UTLS OZONE discussions are ongoing regarding the possibility of installing equipment to measure trace gases on British commercial aircraft. A workshop "Aerosols in the UTLS" was held at the University of Oxford, 17-18 December 2003, organised jointly with the CWVC Programme. CIRRUS and ITOP campaigns will be held following launch of the new FAAM BAE-146 aircraft.

T. Peter then discussed related studies of cirrus clouds and tropical tropopause layer. Analysing the radiative properties of the clouds, he emphasised the need to better understand the nucleation of ice particles. Other issues are whether there is a trend in tropical tropopause layer water vapour concentrations, and/or whether there is a trend in cirrus coverage in the tropical tropopause layer. One needs to understand the relative roles of cirrus and deep convection in the dehydration mechanism. **T. Peter** emphasised the need for an explanation of the stratospheric humidity increase and he presented a number of related findings.

W. Randel presented a new initiative called Integrated Study of Dynamics, Chemistry, Clouds and Radiation of the UTLS. The scientific significance in this initiative stems from the importance of the radiative and chemical impacts of UTLS ozone, water vapour, cirrus clouds and aerosols. The initiative is based on active utilisation of new observational capabilities: aircraft HIAPER (2005) (see full report on page 34), the AURA satellite (2004) and other A-train platforms, GPS/COSMIC (2005). A UTLS community workshop was held in October 27-28, 2003 at NCAR, Boulder, USA. A science working group will be formed to plan integrated research using HIAPER and to optimise integration with satellite programs and multi-scale models.

The SSG requested **A. Ravishankara, J. Burrows** and **T. Peter** to lead further development of SPARC activities in the area of climate - chemistry coupling. Some experts outside the SPARC SSG could be invited to further strengthen the transition team.

ST dynamical coupling

M. Baldwin started the discussion of this topic and informed the meeting of a workshop "The Role of the Stratosphere in Tropospheric Climate", which took place in Whistler (BC), Canada, on 29 April-2 May 2003 (see report in SPARC Newsletter N°21 and **www.atm.damtp.cam.ac.uk/shuckburgh/Whistler/**). **M. Baldwin** was one of the workshop organisers. The purpose of the Whistler workshop was to improve the understanding of the role of the stratosphere in tropospheric climate on sub-seasonal to multi-annual timescales. The focus was on understanding the dynamical mechanisms that link the variability in these two regions.

The workshop was very successful. A short perspective and review paper will be prepared in the near future. A summary of the discussions at the workshop contains, *inter alia,* the following conclusions:

- The stratosphere influences the troposphere.
- Together with the tropical troposphere, the stratosphere is a player in determining the memory of the climate system.
- The influence is mainly during northern winter and southern spring.
- The stratosphere may play an important role in climate variations through downward coupling to SSTs, sea ice and the high-latitude oceans.
- The most pressing issue is to better understand the dynamical processes by which the tropospheric circulation responds to changes in the stratosphere.

M. Baldwin also presented some observational results depicting ST interactions by using a decomposition of the total atmospheric pressure variability into empirical orthogonal functions and considering the dominant pattern, the Northern Annular Mode (NAM). He showed several examples favouring the concept of the leading role of the stratosphere in variations extending through both stratosphere and troposphere, such as variations triggered by stratospheric warmings.

M. Baldwin was able to show that it was possible to develop a statistical approach to Arctic Oscillation (AO) Index Forecasting. Enhanced predictability showed that there was a not yet understood mechanism of ST coupling. An "amplifier" is needed to communicate circulation anomalies in the lowermost stratosphere to the surface and this amplifier likely involves both planetary and synoptic scale waves near the tropopause region.

M. Baldwin concluded that:

- Persistence and predictability of the AO depend on the long timescale of large circulation anomalies in the lowermost stratosphere.
- The most pressing issue in ST coupling is to better understand the dynamical processes by which the tropospheric circulation responds to changes in the stratosphere.
- This understanding may help to better predict not only the weather on monthly and seasonal time scales, but also the climatic effects of greenhouse gas increases, stratospheric ozone depletion, solar changes and volcanoes.

F.-J. Lübken added to the presentation a comment that mesosphere winds could act as early precursors of changes in stratosphere.

T. Shepherd continued the discussion of the ST coupling studies by reviewing the major peculiarities of the ST system. Firstly, the system is open because cooling to space takes place. Secondly, its angular momentum budget is tightly constrained. Apart from seasonal cycle, the short-term variability of the system is driven by variability in the Eliassen - Palm flux divergence, which is generated either by tropospheric wave sources or internally in stratosphere. This results in a stronger or weaker circumpolar vortex. The stratosphere can exhibit downward propagation of wind anomalies and has long-term memory compared with the troposphere. The studies of ST coupling receive considerable attention and are supported by funding agencies. There is need to strengthen the connections of the tropospheric science community, including IPCC.

A targeted workshop as a follow-on from the SPARC Assembly may be required. It could well be organised as a SPARC-WCRP workshop and would cover a range of time scales from seasonal to long-term ones.

S. Yoden presented to the SSG a series of experiments with so-called mechanistic circulation models, which con-

tained a simplified physical package in comparison with full climate models but enabled longer time integration (up to millennium) and ensemble experiments. The model included an imposed quasi-biennial oscillation. Seasonal composites of zonal mean temperature were analysed. Statistical analysis of the long series generated significant estimates of distributions, which can form the basis for understanding climate variability and change.

The SSG felt that **M. Baldwin, T. Shepherd** and **S. Yoden** could lead further development of SPARC in the area of ST coupling. It also requested **M. Baldwin** to represent SPARC in the WCRP task force on seasonal prediction.

Cross-cutting and Supporting Projects

Data Assimilation

A. O'Neill started his analysis with a list of data assimilation requirements for SPARC science. They include:
• Long term, global data sets for the troposphere and stratosphere, free of artificial trends.
• 3-D velocity fields with reduced data assimilation "noise" at an interval of several hours.
• Estimates of mass fluxes associated with sub grid-scale processes.
• Diabatic heating rates.
• Ozone, tracers and aerosols.
• Attention to bromine in the UTLS region.

To fulfil these requirements is the goal of the SPARC Data Assimilation (DA) initiative. A DA working group has been established, which
• Collects information on stratospheric data sets on meteorology and chemistry (quality, availability, software…);
• Undertakes process-focused quality assessments;
• Collects and documents information in DA systems;
• Liaises with space and other agencies on SPARC data needs.

In June 2003 SPARC organised two meetings on stratospheric DA, an ASSET/SPARC workshop in Florence, Italy, and an ECMWF/SPARC workshop in ECMWF, Reading, UK (see report in SPARC Newsletter N°21).

In the work on collecting information on stratospheric data sets, the group objectives are to:
• Overview most used datasets (UK Meteorological Office, ECMWF, NCEP, etc.).
• Prepare a web site with links to information on each dataset and related publications.
• Produce a test dataset for SPARC intercomparisons (a proposal is already available).

The aim of process-focused quality assessments is to compare different analyses using diagnostics tailored to particular problems. The developed diagnostics focus on the following issues:
• Polar processes (Arctic polar stratospheric clouds, chlorine activation, areas of low temperatures);
• Fine-scale structure and filamentation;
• Mixing and transport barriers;
• Wave propagation into stratosphere and effects on modelling studies;
• ST exchange and tropics, O_3 mini holes.

The group collects and documents information on stratospheric DA systems for global circulation models (e.g. DARC/UK Meteorological Office, ECMWF, Canadian Meteorological Service), chemical transport models (e.g. KNMI, BIRA-IASB, UPMC, DAO), and coupled systems (e.g., Météo-France). It liaises with space and other agencies on SPARC data needs and tries to anticipate their requirements.

Space agencies mostly require:
• Information on instruments (past, current and future) and how good they are;
• Feedback on observation strategies: what and how to measure;
• Exploitation of datasets: calibration/validation and quality-control, access by earth observation community to achieve best use of investment.

Meteorological services mostly need: stable, high-quality data (good resolution, good error characteristics, good coverage and near real time) with "pedigree"; data that can improve forecast skill (i.e. confront models with observations); to improve and extend services to society (e.g. "chemical weather").

Stratospheric processes

T. Shepherd and **A. Ravishankara** presented this item based on contributions from several scientists including **K. Hamilton** who submitted an analysis of the SPARC Gravity Wave Initiative activities.

Radiosonde Climatology
This SPARC-coordinated activity looks at the climatology of wavelike fluctuations in ultrahigh-resolution radiosonde wind and temperature data. It has involved participants from eleven countries and data at over 200 stations worldwide. Some of the individual participants in the project have submitted papers on analysis of their own national data. **R. Vincent** and co-authors are completing a draft of a journal paper discussing the climatology produced by analysis of the entire data set (a preview is available in SPARC Newsletter N°20). There is a question of how much of the original data used in the study can be made available through the SPARC Data Centre and contacts are made with the participants to see if they are willing (and are legally able) to send their data to the SPARC Data Centre. It is believed that the SPARC Data Centre is the only location where a substantial collection of the high-resolution balloon data will be conveniently available to the research community.

DAWEX Experiment
The DAWEX experiment (carried out October-December 2001) examined the middle atmospheric gravity wave field in the Northern Australian region and its relation to tropospheric convection. At a small workshop, which was held in Honolulu in December 2002 to discuss analysis of the results, the participants decided to produce coordinated manuscripts for submission to a special issue of a journal (see workshop report in SPARC Newsletter N°20).

Chapman Conference
The SPARC Gravity Wave Initiative co-chairs had produced a proposal to American Geophysical Union (AGU) to hold a Chapman Conference on Gravity Wave Processes and Parameterization. This proposal was accepted by AGU and the conference was scheduled for 10-14 January 2004 at Waikoloa, Hawaii. The Conference may be regarded as the sequel meeting to the earlier NATO Advanced Research Workshop on "Gravity Wave Processes and Parameterization in Global Climate Models" held in 1996, which was co-sponsored by SPARC.

Prospects for the Gravity Wave Initiative
Over the year 2004 the main projects that the Gravity Wave Initiative has pursued, namely the radiosonde climatology and the field experiment in Northern Australia, should be essentially completed. At the SSG 2004 it should be possible to give final reports on these projects and to review the Hawaii Chapman Conference. Many uncertainties in the gravity wave problem will still remain, and there may still be a useful role for SPARC in

coordinating some research activities. The more "engineering" aspects of the gravity wave parameterisation issue may be passed to the GRIPS initiative (and possibly also the DA initiative). An important remaining issue is possible SPARC involvement with future field experiments that includes studies of convective forcing of gravity waves. The US ARM program is planning a large campaign based in Darwin for January 2006. There is some European funding for a Geophysica/Falcon campaign in the western tropical Pacific region in 2006 or 2007.

The SPARC SSG meeting in Kyoto decided to look into possibilities of organizing an equatorial superpressure balloon campaign. **K. Hamilton** enquired with a few specialists and concluded that there was enthusiasm and interest for a campaign that would, at a minimum, produce a great deal of *in situ* wind data in the equatorial lower stratosphere. Such a campaign should be coordinated with stratospheric DA efforts. The SCOUT project, which was presented to the SSG later in the meeting (see below), is expected to stimulate a long duration balloon campaign at the Equator funded mostly by national sources. The COSPAR meeting of 2004 and the 3rd SPARC Assembly in August 2004 will provide an opportunity to discuss the scope for such a campaign (e.g. whether chemical measurements could be included in it), and find out how a SPARC group could facilitate national efforts.

Past and future "laboratory" Projects
As reported by **A. Ravishankara,** this activity started in 1999, when a peer-reviewed paper on small organic peroxy radicals was published in the J. of Geophysical Research (JGR). In 2002 laboratory data evaluation resulted in updated data for quantum yields for production of $O(^1D)$ in the ultraviolet photolysis of ozone, also published in JGR, 2002. **S. Solomon** (co-Chair of the IPCC Working Group 1) requested a SPARC sponsored study of the global warming potential of hydrofluorocarbons (HFC) 134a. Five groups of specialists are currently involved in this activity. Associated radiative forcings and their uncertainties will be estimated, mostly using line-by-line models with account of vertical profile of HFC, clouds, typical temperature profiles inclusive of tropopause. Some preliminary results were presented to the SSG session. There is some discrepancy of the results. Its origin will be investigated and the results will be recalculated. A paper was to be prepared for submission by the end of 2003.

SPARC Aerosol Assessment

T. Peter, also on behalf of **L. Thomason,** presented the status of ASAP, the SPARC Aerosol Assessment. After the kick-off meeting at CNES in November 2001, there have been an informal meeting at Spring AGU Washington, DC, in May 2002, and a lead authors meeting in July 2003.

The scope of the prepared report comprises aerosol processes, precursor gases, aerosol instruments and measurements, aerosol records and climatology, trend analysis, and related modelling. The aerosol record will be presented in the coordinates of equivalent latitude and potential temperature.

The main data sources for ASAP are measurements by SAGE (Stratospheric Aerosol and Gas Experiment), HALOE, optical particle counters and lidar data sets. From primary measurements of extinction, backscatter, size distribution, data sets of Surface Area Density (SAD), effective radius, volume/mass were derived for the period 1979-2003.

The following problems of measurements and analysis were noted. Satellite-based SAD tends to underestimate *in situ* measurements, particularly those including small particle sizes. The scale and ubiquity of the problem is not clear. Size-resolved (≥ 10 nm) aerosol observations in the stratosphere are therefore needed. The importance of meteorites and smoke is uncertain. There is significant uncertainty in trends, which makes it difficult to even detect their sign.

Extinction ratios (size) are inconsistent between models and measurements; modelled lower stratospheric tropical extinctions are too low for the measured SAD. Work is underway on processing data from major volcanic eruptions.

The assessment should be completed in 2004. A lead author meeting is being organised at the Atmospheric and Environmental Research Inc. in Lexington, USA, on 18-21 January 2004. The draft assessment report is expected in February 2004. After a peer-review, the assessment will be printed.

SPARC Data Centre

The aim of the SPARC data centre is to provide data to the SPARC scientific communities and their major programmes. **M. Geller** reviewed the status of the SPARC Data Centre. The web site is located at **http://www.sparc.sunysb.edu**. **X.L. Zhou** is the centre manager.

The SPARC FTP Server is located at **ftp://atmos.sparc.sunysb.edu/pub/sparc**. There is a link to numerous other data centres. The new acquisitions include: daily mean temperatures, geopotential heights, pressures, and saturation mixing ratio of water vapour at the tropical cold point tropopause, derived from ECMWF reanalysis; a data set of temperature field near the tropical tropopause; the US high resolution radiosonde data set, which includes data from 93 stations for 1998-2001 obtained from NOAA (data for 2002 will be put online when available).

The SPARC grant period is from February 2002 to January 2005 (inclusive) and work is underway to renew the grant and upgrade the data centre computer.

The idea of having a back-up centre was proposed and **S. Yoden** agreed to consider its possible location in Japan. The problem of data certification was raised along with the need to ensure high quality for all data available at the Centre.

Co-operation with IGAC/IGBP

This SSG session benefited from the participation of two scientists from IGBP, the Chair of the IGBP Scientific Committee **G. Brasseur** and **D. Parrish** of the International Global Atmospheric Chemistry project (IGAC).

G. Brasseur gave a broad introduction to the IGBP activities and its co-operation with the WCRP in the framework of the Earth System Science Partnership (ESSP). The goal of IGBP is to describe and understand Earth System dynamics focusing on the interactive biological, chemical and physical processes, the changes that are occurring in the dynamics and the role of human activities in these changes. At present the programme has entered its Phase II and has a new structure built around the three compartments of the environment: atmosphere, land, ocean, their respective boundaries and needed integration activities. **G. Brasseur** introduced all major components of the IGBP II and the four joint projects of the ESSP on water, food, global carbon and human health, as well as the Global Change System for Analysis, Research and Training (START). Areas where interactions occur with WCRP

projects were indicated. A new development in the ESSP is the start of the Integrated Regional Studies, which involve all sciences (natural, social, economic).

G. Brasseur introduced in more detail the IGAC and its two overarching questions: (1) What is the role of atmospheric chemistry in amplifying or damping climate change? (2) What effects do changing emissions and deposition, long-range transport, and transformations have on the chemical composition of the atmosphere and on air quality? The programme needs to operate across traditional organizational boundaries at regional to global scales, integrating traditional troposphere (IGAC), stratosphere (SPARC) and measurement (GAW, IGOS) programmes. It needs to develop strategies in concert with ocean and terrestrial scientists to quantify the exchange of chemical species between atmosphere/ocean/land/biosphere and to build a common interactive emission database.

D. Parrish presented activities of the Intercontinental Transport and Chemical Transformation (ITCT) task team within IGAC and concluded that UTLS and SPARC are of significant interest for IGAC. Possible joint actions of SPARC and IGAC could include coordination of measurements campaigns and development of joint observational strategy. There may be a need in high resolution (~100 m) observations in the tropopause layer as proposed by **G. Brasseur. D. Parrish** also emphasised the high efficiency of using aircraft observations for atmospheric chemistry observations, because the cost of one satellite is comparable to the cost of using tens of aircrafts.

Co-ordination with other programmes

European Space Agency (ESA), National Aeronautics and Space Administration of the USA (NASA)

T. Wehr from ESA gave a very comprehensive account of current and future ESA programmes and related activities (for additional information, see **http://www.esa.int/export/esaCP/index.html**).

Selected Earth Explorer Core Missions include GOCE and ADM-Aeolus and Opportunity Missions are Cryosat and SMOS.

Additional information and access to ESA data can be obtained *via* an Open Distributed Information and Services for Earth Observation (ODISSEO) at **http://odisseo.esrin.esa.it/**. **T. Wehr** also presented in more detail the Atmosphere and Climate Explorer Mission (ACE+), which will perform atmospheric profiling using radio occultation; stratospheric wind interferometer for transport studies (SWIFT) onboard GOSAT, which is a European-Japanese-Canadian stratospheric dynamics mission; WALES, which is intended to determine profiles of water vapour accurately and at high vertical resolution from space with global coverage, using Nadir-viewing water vapour Differential Absorption Lidar (DIAL) System.

T. Wehr drew attention to the fact that ESA/ESTEC was planning to issue an invitation to tender for a study of advances in the research in atmospheric chemistry and dynamics by development of coupled chemistry-dynamics DA models.

The Integrated Global Observing Strategy (IGOS) partnership approved a theme on Integrated Global Atmospheric Chemistry Observations (IGACO). The IGACO team is currently developing a strategy for the evolution of the global atmospheric composition observation system and the integration of data.

P. DeCola of NASA was unable to attend the session and **M. Kurylo** presented some of the related activities and especially the extensive program of aircraft atmospheric chemistry measurements, which extends from tropics to the polar regions.

COSPAR

M.-L. Chanin, Chair of the Scientific Committee of the next COSPAR General Assembly to be held in Paris, France, July 19-24, 2004, gave first hand information about this important event. She mentioned that two interdisciplinary lectures would be of direct interest for the SPARC Community. **P. Crutzen** will present the "First results from ENVISAT" and **C. Fröhlich** will give a talk on "Solar radiation and climate". There will also be a panel on "The role of space in monitoring global change" where the issue of long-term commitment to atmospheric observations will be raised.

Among the disciplinary sessions of COSPAR 2004, four are co-sponsored by SPARC (see **www.COSPAR2004.org**).

SCOSTEP

M. Geller represented the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP). After a brief reminder of the nature and structure of SCOSTEP (**www.ngdc.noaa.gov/stp/SCOSTEP/scostep.html**), he focussed his talk on the major SCOSTEP project entitled "Climate and Weather of the Sun-Earth System" (CAWSES), a new SCOSTEP Programme for 2004-2008.

There are four CAWSES themes: (1) "Solar Influence on Climate", (2)"Space Weather: Science and Applications", (3)"Atmospheric Coupling Processes", (4) "Space Climatology". The successful implementation of CAWSES will provide an integrated scientific framework for solar-terrestrial research in the future, and produce an informed basis for guiding later programmes under different solar conditions and changing anthropogenic influences.

NDSC accomplishments and the future

M. Kurylo updated the SSG on the progress in the development and activities of the Network for the Detection of Stratospheric Change (NDSC) of which the goals were defined in the SPARC Newsletter N°19 and at **http://www.ndsc.ws**. NDSC strives to ensure data quality and the investigators subscribe to a protocol designed to ensure that archived data are of as high a quality as possible within the constraints of measurement technology and retrieval theory.

German and European Research Programmes

A half-day of the meeting was devoted to a joint session with German and European scientists who presented an impressive review of national activities and their research under the framework of European Programmes. **U. Schmidt** opened the session and introduced the German colleagues.

German Atmospheric Research Programme AFO 2000

M. Dameris presented a very impressive Atmospheric Research Programme 2000, which is a component of the "Research for the Environment" of the German Federal Government. AFO 2000 has been in place since July 2000 (see **http://www.afo2000.de**).

The programme is divided into 4 theme groups: (1) "Surface-Atmosphere Interactions", (2) "Chemistry, Dynamics, Radiation, and their Interactions", (3) "Multiphase Processes", (4) "Atmosphere-System Analysis: Models and Data".

Mesospheric Research – an overview of German activities

F.-J. Lübken presented the results of several areas of mesospheric research

using data from various instruments and stations. Trends in the mesosphere have been obtained for the summer temperature, altitude and occurrence of noctilucent clouds, seasonal heights of polar mesospheric clouds.

UTLS
A new concept for atmospheric measurement campaigns for studies of ST exchange was presented by **A. Engel.** It is being implemented by the AFO 2000 project SPURT with the objective to investigate transport, mixing (and chemistry) in the extratropical tropopause region based on regular airborne observations of chemical composition (see full article on page 29).

Results of a 40-year simulation with ECHAM
V. Grewe presented new simulation results based on the ECHAM climate model, version E39/C, which is a ST fully coupled chemistry-climate model. The physical model package includes parameterizations of radiation, clouds, precipitation, convection, and diffusion. The chemistry module includes 37 species and 107 gas-phase reaction, methane oxidation, polar stratospheric cloud formation with 4 related heterogeneous reactions, parameterization of dry/wet deposition, lightning and surface emissions. Physical and chemical modules are interactively coupled at every time step. The goal of on-going experiments is to realistically simulate the Earth's atmosphere from 1955 to 2000. One out of three transient simulations was just finished and **V. Grewe** presented preliminary results.

New results from ENVISAT
ENVISAT has been successfully launched on the night from 28 February to 1 March 2002. German participants in the SSG session reported on their work with several sensors on the satellite.

H. Fischer has presented the status of the MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) and described an experiment with its data. The data will be processed to derive global distributions of temperature and more than 25 trace constituents. In addition, the detected broadband spectra will allow determination of polar stratospheric clouds properties and, in case of high load, aerosol amount.

J. Burrows presented new results as part of an extensive validation campaign of SCIAMACHY (see ESA Envisat home page at **http://envisat.esa.int** for near-real time and offline data) and some information about GOME on ERS-2. Germany is supporting a major part of the SCIAMACHY Validation Structure and there are 20 national projects involving ground-based and ship-born data from aircraft, balloons and satellites (see the SCIAMACHY homepage **http://www.schiamachy.de** and the SCIAMACHY Operations Support Team's site **http://atmos.af.op.dlr.de/projects/scops**).

The ENVISAT instrument GOMOS (Global Ozone Monitoring by Occultation of Stars) is providing: vertical profiles of ozone, NO_2, NO_3, O_2, H_2O, aerosols, temperature, turbulence. **A. Hauchecorne** presented the status of some related calibration/validation activities, which involved intensive intercomparison with independent data sources. The overall conclusions are that after 18 months of flight, GOMOS operates well and validation studies indicate no significant bias in O_3. The systematic data processing at ESA and the data distribution to principal investigators are expected to commence after the validation workshop at ESRIN in May 2004.

Sixth Framework Programme (FP) of the EC
M. Dameris presented SCOUT-O_3 (stratosphere-climate links with emphasis on the UTLS) as a new accepted project. The central aim of the project is reliable prediction of future evolution of the ozone layer and surface UV radiation with a focus on the interaction between the Montreal and Kyoto Protocols.

Process Oriented Validation of Chemistry/Climate Models
V. Eyring presented the preparations for a workshop 17-19 November 2003 in Grainau/ Garmisch-Partenkirchen, Germany on Process oriented validation of Chemistry/Climate Models (see full report on page 27).

SPARC Project Office and Future Plans

The SPARC office actively pursued its activities in 2003, namely contacts with the JPS of WCRP, WCRP projects, IGBP, other partner programmes, and the SPARC community of scientists; organization of SPARC meetings, compiling and editing SPARC Newsletters (two a year), updating the SPARC mailing list, maintaining the SPARC website, preparation of SPARC reports for publication. A new SPARC brochure will be prepared soon. The session warmly thanked the director and the office staff **M-L Chanin,** as well as **C. Michaut** and **Y. Koshelkov,** for their excellent support. During 2003, **Y. Koshelkov** has retired. A new SPARC scientist was hired for the office. **E. Oikonomou** started his duties on 1 June 2003 using a grant provided by ESA.

In 2004 the SPARC Office is expected to move from Paris. After many years of outstanding service, the director, **M.-L. Chanin,** will pass her duties to a new person in charge of the office. Activities to find a new home for the office were presented to the SSG. A proposal to move the office to the Department of Physics, University of Toronto, was submitted by **T. Shepherd** and **N. McFarlane** to several Canadian organisations. Expectations were high that the proposal would be considered favourably and approved. In that case, there would be a transition period. The operation of the office in Paris would not stop abruptly. **C. Michaut** agreed to visit the new office in Toronto and help to speed up operations there. Full transition to the base would be completed after the SPARC General Assembly 2004.

Next SSG Meeting and SPARC General Assembly 2004

T. Shepherd reviewed the preparations for the 3rd General Assembly of SPARC, 1-6 August 2004, Victoria, Canada. More information is available at **http://sparc.seos.uvic.ca**.

A particular emphasis for this General Assembly will be chemistry-climate coupling.

T. Shepherd and **A. Ravishakara** will co-chair the Scientific Committee and **N. McFarlane** will be the chair of the Local Organising Committee.

T. Shepherd and **N. McFarlane** proposed to hold the 12th Session of the SPARC SSG in Canada, after the SPARC General Assembly. This offer was accepted with appreciation and the dates for the session were set on 9-12 August 2004.

Closure of session

Before closing the session, the participants considered and agreed upon a list of follow-up actions. In particular, it was decided that a new Implementation Plan of SPARC should be prepared during the year 2004 and submitted for discussion at the next SPARC SSG session. Some SSG members were asked to lead the preparation of individual chapters.