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At the kind invitation of Dr. K. Hamilton, the ninth session of the WCRP Scientific Steering Group on Stratospheric Processes and their Role in Climate (SPARC) was held at the Tokai University Pacific Center, Honolulu, Hawaii, from 4 to 7 December 2001. The list of participants is given in the Appendix.

The session was opened by the Co-chairs of the SPARC Scientific Steering Group, Professors M. Geller and A. O'Neill, at 0900 hours on 4 December. On behalf of all participants, the Co-chairs expressed sincere appreciation for the excellent arrangements made and the facilities provided for the meeting. Particular thanks were due to Dr. K. Hamilton for his hard work in overseeing the local organization and logistics and to the International Pacific Research Center of the University of Hawaii, the formal host of the meeting.

The Co-chairs continued by welcoming all present, noting with particular pleasure the attendance for the first time of Dr. V. Yushkov (Central Aerological Observatory, Russian Federation) as a new member of the group, and Dr. A.R. Ravishankara ((NOAA Aeronomy Laboratory, USA), also a new member (although having previously taken part in several steering group meetings in his capacity as leader of the SPARC upper tropospheric/lower stratospheric chemistry initiative). It was noted with regret that neither Dr. P. Canziani, the third new member of the steering group, nor Dr. C. Granier, a longer-serving member, were able to attend. As well as the leaders or representatives of SPARC sub-projects and initiatives, the Co-chairs acknowledged with appreciation the participation of representatives from various agencies or activities which contributed significantly to the success of SPARC Scientific Steering Group sessions. These included: Dr. P. DeCola, NASA; Dr. J. Gille, COSPAR; Dr. M. Proffitt, GAW.

Following the customary review of progress in the principal activities in SPARC, an important task at this session of the group was to consider how to move forward with integrating the knowledge acquired across SPARC in the quest for an overall understanding of all aspects of stratospheric variability and change, interactions with the troposphere, and the role of the stratosphere in the global climate system. Preliminary ideas in this regard had been discussed at the eighth session of the group in November 2000. Another priority issue was that of chemistry/climate. SPARC, in conjunction with the IGBP International Global Atmospheric Chemistry (IGAC) project would have a major role here. In this respect, the work already undertaken by SPARC and the co-operation with IGAC had been greatly welcomed by the Joint Scientific Committee for the WCRP at its session in March 2001 and the plan to establish a joint SPARC/IGAC liaison committee to advance the activities required in a timely and organized manner endorsed. More generally, the JSC had voiced its satisfaction with the scientific approach and strategy being followed by SPARC, the results being achieved, the collaboration with other WCRP projects (e.g. with WGNE in stratospheric modelling), and the role being played in effectively bringing about closer co-operation between WCRP and IGBP.

The main discussions at the session and principal conclusions and recommendations for the further development of SPARC in various areas are summarized in the following paragraphs.

1. MODELLING STRATOSPHERIC EFFECTS ON CLIMATE

Intercomparison of stratospheric models

Dr. S. Pawson recalled that the primary goal of the "GCM Reality Intercomparison Project for SPARC", GRIPS, was to improve the representation of the stratosphere in coupled global climate models. In this respect, close co-operation was maintained with the Working Group on Coupled Modelling and the Working Group on Numerical Experimentation. As reported at the eighth session of the SPARC Scientific Steering Group, major efforts had been made in 2000 in collecting and summarizing the results of the first phase of GRIPS, an intercomparison of basic features of model stratospheric simulations. Findings had been published in the Bulletin of the American Meteorological Society and the Journal of Geophysical Research.

The past year had been one of consolidation. A number of activities within the first phase were being finalized (e.g., studies of the treatments of sudden warmings, tropospheric-stratospheric interactions). In the second phase of GRIPS (impacts of different parameterization schemes), tests of radiative codes were underway, to be followed by an investigation of gravity wave parameterizations. Studies of model response to formulations of mesospheric drag had been completed. The third phase of GRIPS was concerned with explaining the observed variability in the stratosphere taking into account natural variability and the forcing by changes in aerosol loading, solar radiation, and atmospheric concentrations of ozone and carbon dioxide. A few groups have begun the experimentation required (some in connection with the European projects "Solar Influence on Climate and the Environment" (SOLICE) and "Stratospheric Processes and their Impacts on Climate and the Environment" (EUROSPICE)).

A workshop of participants in GRIPS was expected to be held in Japan in March 2002 to review the overall status of the project. The further development of the third phase of GRIPS would be considered in relationship with the integrated approach to modelling and data activities now planned within SPARC as a whole (see section 5) and to tropospheric-stratospheric coupling (see section 3).

Professor S. Yoden gave a presentation on the "Frontier Research Programme for Global Change" in Japan, the ambitious and far-reaching initiative co-ordinated by the Japanese Science and Technology Agency. An extensive range of studies in the fields of climate variations, the prediction of droughts and floods in the seasonal to interannual time range, global warming, atmospheric composition, and ecosystem change was envisaged centred round a strong modelling effort (the "Earth simulator") and supporting observational programmes. Fifty research scientists have now been recruited. A key element was also the computer development required, involving a massively parallel system with computing nodes (vector-type multi-processors) tightly connected by sharing main memory. Assuming an efficiency of 12.5%, a peak performance of 40 Tflops was expected (640 processor nodes each with 8 processing elements with a peak performance of 8 GFlops i.e. 64 Gflops at each node). The total main memory was 10 T bytes (shared memory per node of 16 G bytes). The "Earth Simulator" site has been established in Yokohama (the Yokohama Institute for Earth Sciences), and the initial activity with the Earth Simulator was planned to begin in March 2002. A particular target would be to complete a highly advanced global warming prediction for the next IPCC assessment (probably 2006).

The SPARC Scientific Steering Group agreed that co-operation between SPARC, in particular GRIPS, and the "Earth Simulator" activities in the Frontier Research Programme for Global Co-operation was highly desirable, especially in relation to SPARC work on the atmospheric chemistry/climate issue. The next GRIPS workshop in Japan should take the opportunity to consider how best required collaboration and interactions could be organized.

Stratospheric reference climatology

A refined climatology of the means and variabilities of basic stratospheric parameters was needed for GRIPS, as well as a number of other SPARC initiatives. Dr. W. Randel reported that a series of monthly global climatologies of temperature, zonal winds, and various atmospheric trace constituents (N_2O, CH_4, H_2O, O_3, NO_2, HNO_3, etc.) has been assembled from UARS and other data (e.g., HRDI). Monthly and daily stratospheric circulation statistics have been inferred from available stratospheric analyses or reanalyses including those from NCEP, UKMO, Free University of Berlin, and NASA/GSFC. Other data compiled include upper-level radio-sonde winds from Singapore (as an indicator of the phase of the QBO) and statistics on tropopause height. Recently rocketsonde and lidar data have also been included, permitting the extension of the climatology of temperature and winds up to the middle mesosphere. These data sets could be accessed via the SPARC Data Centre (**http://www.sparc.sunysb.edu/**) (see section 7).

Comparisons of the various data sets have been carried out in order to identify biases, and parameters for which uncertainties are high. The comparison of the rocketsonde and lidar observations with global satellite data involved particular difficulties because of the sparse scattered nature of the former and the non-simultaneity of the records (most rocket series have been discontinued for many years). A technical report "SPARC Intercomparison of Middle Atmosphere Climatologies" summarizing the findings was being drafted and was expected to be published as a SPARC Report in mid-2002. It was hoped that it might be possible to include data from the ECMWF Reanalysis Project (ERA-40) in the intercomparisons, but this would only be done if it did not delay the preparation of the report.

Stratospheric data assimilation

SPARC was fostering activities in this area to ensure that the advances in data assimilation techniques in many operational centres were exploited to obtain global quality-controlled, internally consistent data sets of the dynamic and chemical state of the stratosphere (as well as, where possible, the upper troposphere and mesosphere). The data sets would be especially designed to support SPARC-related studies of chemistry-climate interactions, with attention initially being given to making full use of the data becoming available from the ENVISAT and EOS/AURA satellites. A range of error statistics related to the utilisation and/or validation of instruments and for validation of models would also be produced.

The type of effort to be undertaken included comparisons of global stratospheric analysed data sets prepared by active groups, assembly of documentation at the SPARC Data Centre on data production methods and data quality, and organization of workshops to consider how the methodology of data assimilation in the stratosphere could be refined (e.g., to include new variables such as aerosol loadings). It was also the intention to draw on analysed data sets to prepare reports on particular aspects of interest (e.g., stratospheric water vapour and its evolution).

A small SPARC working group bringing together representatives from several of the active leading centres preparing stratospheric analyses has been formed under the chairmanship of Professor A. O'Neill to guide the work necessary. Close co-ordination and liaison would be maintained with WGNE.

2. LONG TERM CHANGES IN THE STRATOSPHERE

Stratospheric temperature trends

The objectives of the first phase of SPARC activities in this area were the intercomparison of various relevant data sets (radiosondes, lidars, rocket-sondes, satellite measurements etc.) containing temperature values, assessment of the temperature trends apparent in the lower stratosphere and up to the level of the mesosphere, and evaluation of the extent to which these trends could be explained by specific causes. The first phase has now been completed (with results having been reported at previous sessions of the SPARC Scientific Steering Group). A summary of the work was published in Reviews of Geophysics in February 2001, and the findings were also an important input to the IPCC Third Assessment Report. A full account of the activity and results is being prepared for publication as a SPARC Report in 2002 (with support from NOAA).

Dr. V. Ramaswamy described the latest update of the temperature trend record. For the period 1979-2000, the earlier findings of a general cooling of the stratosphere were confirmed, but the significance was greater (this would be a particular contribution to the next WMO/UNEP Assessment due in 2002). Additional progress has been made in the correction of inhomogeneities in radiosonde observations, and improved trend estimates have been obtained from rocket-sonde data. New model simulations of temperature trends using updated information on changes in species such as ozone and carbon dioxide have also been produced with reasonable agreement between model results and the trends inferred from observed data up to 0.5hPa.

As agreed at the eighth session of the SPARC Scientific Steering Group, plans were being made to extend the temperature analyses to the upper stratosphere and mesosphere in collaboration with the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP). This subject came up at the Second Workshop on Long-term Changes and Trends in the Atmosphere in Prague, July 2001 (co-sponsored by SPARC). Taking into account results presented at the workshop and published papers, it appeared that, in mid-latitudes of the lower mesosphere, the temperature trend was around -2°K/decade. In the middle mesosphere, rocket measurements indicated a cooling of -7°K/decade, but lidar only -3°K/decade. The trend at the summer mesopause was small or close to zero. The next steps forward would be taken at a workshop being organized in Germany in May 2002. SPARC was contributing to the planning of this workshop and the SPARC experience in assessments of stratospheric temperature trends should be a sound basis for deciding on the activities needed for a state-of-the-art assessment of upper stratospheric and mesospheric trends.

Understanding ozone trends

The main activity in this area in the past year in which SPARC has been involved was a joint workshop organized by SPARC and the International Ozone Commission at the University of Maryland in March 2001, with the need to prepare for the WMO/UNEP Assessment in 2002 in mind. The workshop aimed to identify the major current issues concerning trends and to improve quantification of the contributions linked to, and uncertainties in, chemical and dynamic mechanisms, particularly in mid-latitudes. Attention was focussed on the dynamical influence on ozone trends. However, it was difficult to isolate separate dynamical forcings in terms of an ozone response. A comparison of statistical analyses including dynamical factors for certain baseline periods was being undertaken. With regard to Arctic ozone loss, a workshop was planned to be held in Germany in March 2002.

Also under this agenda item, Dr. T. Peter drew attention to the report "European Research in the stratosphere 1996-2000: Advances in our understanding of the ozone layer during THESEO" recently published by the European Commission. European research on stratospheric ozone and UV radiation was assessed and the achievements of co-ordinated European and nationally funded research programmes highlighted. The results from the Third European Stratospheric Experiment on Ozone (THESEO), a principal element of European stratospheric research in the period 1996-2000 featured strongly. The main findings included:

- large losses (20-30%) in the ozone column, up to 40-70% at altitudes around 18 km, have occurred in the Arctic in each of the five cold stratospheric winters since 1993-1994;
- stratospheric ozone amounts over mainland Europe started to decline in 1970s, with the biggest decrease (5-10% in the ozone column) in winter and spring;
- as a result of international controls on ozone-depleting gases agreed in the Montréal protocol, chlorine amounts in the atmosphere have begun to decline, but growth in bromine concentrations continued.

Dr. T. Peter also relayed information on projects involving the Geophysica aircraft supported by the European Commission. These included the Tropical Convection, Cirrus and Nitrogen Oxides Experiment (TROCCINOX) exploring the role of deep tropical convection on trace gas concentrations especially nitrogen oxides and on the formation and distribution of aerosol particles, and the European Polar Stratospheric Cloud and Lee-Wave Experiment (EUPLEX). These experiments would be very beneficial for SPARC-related activities and it was agreed that the co-Chairs of the SPARC Scientific Steering Group would write to the European Commission emphasizing the interest and support of SPARC.

Stratospheric and upper tropospheric water vapour

The comprehensive SPARC Water Vapour Assessment (published as SPARC Report No. 2/WCRP-113) which reviewed in depth the concentration, distribution, variability and trends of water vapour in the stratosphere and upper troposphere has attracted wide interest and was being extensively quoted (there have been many requests to use figures from the report). As well as being presented at a range of meetings, the results were being used as a benchmark and background material. An offer has been made for publication commercially as a book, and this question was being considered.

SPARC aerosol assessment

It has long been recognized that aerosols in the upper troposphere/lower stratosphere played a significant role in climate by way of radiative effects and in stratospheric chemistry (particularly through the impact on ozone). The magnitude of the influence of aerosols was highly variable and consequently complicates identification of causes of stratospheric changes, be they anthropogenic or otherwise. Accounting accurately for the effects of aerosols was an essential step in understanding and modelling climate/chemistry interaction properly. SPARC was therefore now planning a new initiative with the intention of providing a detailed assessment of the scientific understanding of upper tropospheric/lower stratospheric aerosols.

Drs L. Thomason and T. Peter were leading this activity on behalf of SPARC. The first step was a review workshop in Paris, November 2001. It was recognized that important issues to be addressed included quantifying the non-volcanic background stratospheric aerosol and whether there was a trend in this, the variation of key aerosol properties (e.g., surface area, density), the representativeness of satellite-based climatologies, and how well non-volcanic gaseous precursors and models could predict observed aerosol properties. It was proposed that a report be produced in less than two years, which should be a landmark in its field as had been the water vapour assessment. The report was expected to comprise:

- a review of aerosol processes including those that control polar stratospheric clouds and cirrus near the tropopause, and nucleation at the tropical tropopause and in the post-eruption stratosphere
- a review of non-volcanic aerosol precursors
- a comprehensive climatology of the fundamental physical characteristics of aerosols, but also including important parameters such as effective radius: primarily satellite-based (SAGE/HALOE), in combination with in situ measurements for validation and identifying shortcomings
- assessment of trends in long-term primary measurements, including identification and comparison of background periods
- descriptions of modelling (background) stratospheric aerosols and comparison of model results, source gas measurements and aerosol observations.

Writing groups have been established and group leaders were being designated.

3. STRATOSPHERIC PROCESSES

Gravity wave processes and their parameterization

Drs K. Hamilton and R. Vincent reviewed activities in this area and discussed future plans. A particularly exciting development was the initiation of the Darwin Area Wave Experiment (DAWEX), involving scientists from Australia, Japan and the USA, designed to characterize the wave field in the middle atmosphere over northern Australia excited by intense diurnal convection in this area (known locally as "Hector"). This field experiment stemmed from discussions at the fourth session of the SPARC Scientific Steering Group five years previously in 1996. Included were three five-day intensive observation periods in October, November and December 2001 during which there were three-hourly radio-sonde observations from three north Australian locations. In addition, ground-based air-glow imagers provided by groups in Japan and the USA, radars to monitor winds in the mesosphere and lower thermosphere, and a Doppler radar (from the Australian Bureau of Meteorology) were deployed. The analysis of the data collected was just beginning and was expected to take the next two years (with a series of papers and an overview foreseen by the end of 2003). The findings and results would very much help in the preparation of the larger-scale campaign "Effects of Tropical Convection Experiment" (ETCE) in 2005 or later.

In the future, attention would also be given to a detailed review of existing data sets and encouraging appropriate new observational and modelling projects needed to characterize the spectrum of gravity-wave momentum fluxes, including their geographical and seasonal variations, and short-term intermittency. The aim would be to exploit available data and limited area model results to provide as much guidance as possible for formulating the specification of sources and saturation mechanisms in parameterization schemes (although the actual "engineering" aspects of gravity wave parameterization would be left to GRIPS). As steps in this process, it was firstly planned to convene a conference in 2003 (possibly as a Chapman Conference) at which outstanding questions in gravity-wave parameterization would be reviewed (this could be considered as a follow up to the successful workshop on gravity wave processes and their parameterization in global models held in Santa Fe in 1996). Secondly, a small specialized workshop would be organized in 2004 to assess critically the status of knowledge of the gravity wave spectrum and consider the practical implications for the parameterization of gravity wave processes.

Lower stratospheric/upper tropospheric processes

Activities under this heading in SPARC were concerned with the transition region between the stratosphere and troposphere. In this region, the separation in time and space of chemical, radiative and dynamical processes was not feasible because of the strong coupling that exists between them. The key characteristics of this part of the atmosphere were the very low temperatures, sharp gradients (especially in the vertical), and rapid variations of water vapour, ozone and other species. Understanding in an integrated manner the processes in which the various species were involved was essential in evaluating lower stratospheric/upper tropospheric interactions, the role of the stratosphere in climate, and in the projection of long-term changes in ozone.

The main event in the past year was the organization of a workshop on the tropopause in Germany in April 2001 under the leadership of Dr. T. Shepherd together with Dr. P. Haynes (University of Cambridge, UK). Dr. Shepherd reported that the workshop had brought together a diverse group of scientists (over 70 participants including many young scientists) to consider various aspects of the tropopause region - what it was, why it took the form it did, how it affected climate, and how it might change in the future. There were intensive discussions on the crucial interface between the stratosphere and troposphere, and key questions on the issue of chemistry/climate interactions were formulated. The largest uncertainties, as might be expected, were related to coupled processes. However, even the quantitative picture of tropical dehydration was still far from complete with the role of convection and microphysics still only partly understood. Coupled chemical-climate modelling of the tropopause region was still also in its infancy, although this is the region where one might expect the largest sensitivities. Renewed attention was being given to the concept of the "tropical tropopause layer" (the transition region between the troposphere and stratosphere in the tropical zone with the characteristics of both), especially because it was a chemically active region. The general view was that net stratosphere-to-troposphere exchange was controlled by stratospheric wave drag (mainly at the planetary wave scale). Two-way exchange occurred on synoptic and sub-synoptic scales bringing tropospheric air into the lowermost stratosphere, especially in the summer. It was noted that the seasonal cycle of ozone was distinct in the stratosphere and troposphere, and that trends in ozone appeared to be linked to trends in tropopause height. A comprehensive review paper summarising the main conclusions and outstanding issues was being prepared which it was hoped would be a successor to the highly influential review paper of Holton et al, based on the findings of the SPARC/NATO workshop in Cambridge, UK in 1993 on stratosphere-troposphere exchange. At that time, the paradigm for global exchange was developed, but the focus was still very much on dynamics and transport. This now needed to be linked to climate, requiring the inclusion of radiation and chemistry in the conceptual framework. The review paper from the April 2001 workshop would thus be the basis for defining further research that would feed into joint SPARC/IGAC chemistry-climate activity (see section 4).

Dr. A. Ravishankara pointed to another event of importance for SPARC activities in this area, namely the publication of a review paper on the atmospheric chemistry of small organic peroxy radicals (Tyndall et al, J. Geo. Res., 106, D11, 12157-12182, 2001). To increase the scope of the global models on which assessments of the human impact on climate and air pollution were based, it was essential that state-of-the-art representations of chemical mechanisms were included, and the referenced paper included an evaluation of the atmospheric reactions, rate coefficients and available kinetic and product data for the most abundant peroxy radicals (CH_3O_2, $C_2H_5O_2$, $CH_3C(O)O_2$, $CH_3C(O)O_2$, $CH_3C(O)CH_2O_2$). The information and data in the paper would be used in a NASA/JPL evaluation, and also by the International Union of Pure and Applied Chemistry (IUPAC) in their next update. Assistance provided in this respect by the SPARC Data Centre (see section 7) has been very valuable. Workshops have also been held in the framework of joint SPARC/IGAC activities on nitrogen oxides in the upper troposphere/lower stratosphere (Heidelberg, Germany, March 2001) and on laboratory studies of upper tropospheric/lower stratospheric processes (Breckenridge, CO, USA, July 2001).

4. OTHER SCIENTIFIC ISSUES

Dynamical coupling of the stratosphere and troposphere

Dr. M. Baldwin and Professor O'Neill briefly reviewed developments in this area. The apparent coupling between the stratosphere and troposphere as indicated by correlations in time series of the Arctic Oscillation (AO) and North Atlantic Oscillation (NAO) remained a subject of considerable interest and debate. One report showed evidence that, by selecting time series of AO amplitudes after strong stratospheric warmings, there seemed to be downward propagation of anomalies from the stratosphere to the troposphere implying that knowledge of the state of AO in the stratosphere could increase predictive skill in the troposphere. Other work has given a measure of support to this suggestion, but the potential improvement in predictive skill was small (although statistically significant). It was likely that very strong events dominated the statistical results, and ensemble modelling experiments were needed to understand causal connections and mechanisms. The SPARC Scientific Steering Group agreed that it was important to clarify the dynamical stratospheric-tropospheric corrections suggested by the possible correlations between the AO and tropospheric variability, and would be ready, in collaboration with other groups (e.g. CLIVAR, ACSYS/CliC), strongly to promote research on this issue.

Dr. M. Shiotani (University of Kyoto) presented the results from and future plans for the Pacific component of SOWER (Soundings of Ozone and Water in the Equatorial Region) being led by Japan. Important data on the properties of the tropopause at San Cristobal and water vapour in the tropical upper troposphere/lower stratosphere (indicating a control of water vapour by Kelvin waves), and a range of ozonesonde observations had been collected over the period 1998 to 2000. The SPARC Scientific Steering Group had strongly encouraged SOWER since its inception and expressed keen support for the further planned activities, including a proposed equatorial network for water vapour observations, the establishment of a long-term record for ozone and water vapour, and setting up an equatorial atmospheric observatory in Indonesia. However, the continuity of upper air soundings at San Cristobal (a GCOS Upper Air Network station) appeared to be in question. The Co-chairs of the SPARC Scientific Steering Group agreed to write the Chair of the GCOS/WCRP Atmospheric Observation Panel for Climate drawing attention to this issue and underlining the scientific importance of maintaining regular soundings from San Cristobal.

Chemistry-climate interaction

A significant proportion of both the IGAC and SPARC research agendas had their ultimate application in understanding chemistry-climate interactions. For instance, a central problem in stratosphere-climate interaction was to predict how polar stratospheric ozone would evolve in the future, taking account of increasing greenhouse gas concentrations and the decreasing "effective chlorine" (resulting from the actions of the Montréal Protocol and its subsequent amendments). Substantial differences existed between present model predictions, perhaps consequent to different projections of planetary wave transports in the future stratosphere. In the troposphere, a key issue was to assess the future greenhouse warming from troposphere ozone, methane, etc. In reality, predicting how the future vertical structure of atmospheric ozone throughout the troposphere and stratosphere might change was necessary. Another problem was to investigate how the changing atmosphere might lead to changing upper troposphere-stratosphere water vapour concentrations. This could feed back to tropospheric-stratospheric chemistry, which in turn could affect tropospheric climate.

Another vital factor to be considered was cloud microphysics in the upper troposphere/lower stratosphere because of the effect on radiative forcing of the troposphere.

To make progress in these coupled climate-chemistry problems would require active collaboration between SPARC and IGAC. As a first step, it was proposed to convene a joint chemistry-climate workshop to plan an IGAC/SPARC "chemistry-climate" research agenda.

5. DEVELOPMENT OF SPARC SCIENTIFIC STRATEGY

As discussed at the eighth session of the Scientific Steering Group, SPARC studies of long-term changes in the stratosphere of temperature, ozone and water vapour had all now produced initial sets of results which had suggested that trends in one parameter were closely linked to the trends in the others, and that an increasingly integrated approach was required to understand stratospheric climate change. A new initiative "Understanding stratospheric climate change (1979-1998)" was accordingly being implemented, aiming to understand the observed trends of stratospheric temperature, ozone, and water vapour (also taking into account solar effects). A particular objective would be to elucidate upper tropospheric/lower stratospheric variability and its relationship to the overall climate system by building on and developing the modelling work carried out in the stratospheric temperature trends study and GRIPS, and the activities in stratospheric data assimilation. Strong interdisciplinary exchanges would also be encouraged.

Specifically the following questions would be taken up:

(i) Did the different observed variations providing a consistent picture of stratospheric climate variations, including the possibility of a trend over the past two decades, upon which shorter time scale variations were superposed?

(ii) Could model simulations, employing the known forcings that have acted upon the system over the past two decades, be used in conjunction with the observed data to reproduce the changes in the observed parameters, and thereby lead to identification of the causes of these changes?

(iii) Did conditions and processes in the stratosphere have an effect on tropospheric climate down to the surface?

There were many challenges in providing satisfactory answers such as the changes in ozone that were not the same from one decade to the next, aerosols from two volcanic eruptions perturbing the chemical and radiative budgets, temperature variations with different trends in low, middle and high latitudes (punctuated by transient increases in temperature in the aftermath of the volcanisms), the 11-year cycle in solar irradiance. The investigation of the coupling of stratospheric and tropospheric modes was also a question of major interest (see section 4) and could be of considerable significance for the behaviour of the overall climate system. AMIP-style model simulations would be planned, focussed on the stratosphere, specifying appropriate inputs such as (monthly-mean) greenhouse gases, ozone, water vapour and aerosols (but without interactive chemistry at least in the initial phase). An ensemble of runs from different initial conditions would be undertaken, including a set of simulations without any "forcing" in order to assess the role of the internal dynamical fluctuations of the modelled stratospheric climate system.

It was intended that this SPARC-led activity to understand stratospheric change should also have a significant role in providing insight into the behaviour of the upper troposphere down to the surface and the response to forcing factors. It was expected that important information and results would be produced for IPCC and WMO/UNEP Assessments. SPARC was uniquely placed to tackle the issues involved and this initiative should maintain the scientific momentum of SPARC, ensure a central role in key climate-related issues, and broaden the relationship of SPARC with the climate research community as a whole.

6. INTERACTIONS WITH OTHER PROGRAMMES AND ACTIVITIES

SPARC maintained strong links and/or interacted widely as appropriate and necessary with a number of other groups/activities in WCRP (in particular WGNE and WGCM). Closer co-operation needed to be developed with CLIVAR and ACSYS in the study of the role and variability of the Arctic Oscillation (see section 4). Outside WCRP, especially noteworthy was the co-operation with IGAC on upper tropospheric/lower stratospheric chemical processes (see section 3). The proposed collaboration between SPARC and IGAC in coupled chemistry-climate problems (see section 4) would bring the two projects still closer together. Reference was also made to the collaboration with SCOSTEP in the study of upper stratospheric/mesospheric temperature trends (see section 2): a joint workshop would be held in Germany in May 2002 to consider the activities needed.

Good co-operation continued between SPARC and the WMO Global Atmosphere Watch (GAW). Dr. M. Proffitt briefed the session on the status of GAW, especially noting the ozone bulletins that were produced every two to three weeks from September to December (i.e. during the end of the southern hemisphere winter when the Antarctic ozone hole was at its most prominent). An extensive article describing GAW, its monitoring programme, data centres etc. had been prepared for the latest SPARC Newsletter (No. 18, January 2002). In the interests of further developing collaboration, it was agreed that the GAW seasonal ozone bulletins would be posted also at the SPARC data centre. It was recognized that an outstanding issue of considerable mutual interest was the appropriate quantitative manner of measuring/specifying the intensity of the winter ozone hole in polar regions. It was recommended that a small joint SPARC/GAW group, under the leadership of Dr. D. Karoly, should examine the definition of a series of key indicators. (It was hoped that proposals from this group for possible standards would be available in time for the next WMO/UNEP assessment).

Dr. M. Kurylo, the ex officio member on the SPARC Scientific Steering Group representing the Network for Detection of Stratospheric Change (NDSC), was unable to attend this session of the group in person, but had forwarded suggestions regarding the development of interactions between SPARC and NDSC. This would include publication of a summary of the NDSC symposium in Arcachon, France, September 2001 (co-sponsored by SPARC) in a future SPARC Newsletter and of report of a workshop on spectroscopic needs for atmospheric sensing in San Diego, CA, USA, October 2001. These steps and others towards closer links between SPARC and NDSC were welcomed and encouraged by the SPARC Scientific Steering Group.

Liaison was maintained with COSPAR through Dr. J. Gille who recalled and urged SPARC to consider how to take full advantage of the expected launching in the coming years of many instruments that would provide important new stratospheric data (e.g., ENVISAT-GOMOS, MIPAS, SCIAMACHY, ADEOS-II/ILAS, HIRDLS, SAGE-III). Dr. J. Gille also drew attention to the plans for the next COSPAR Scientific Assembly, the thirty-fourth, to be held jointly with the 2002 World Space Congress, Houston, Texas, October 2002, and where several sessions would be closely related to SPARC.

Finally under this agenda item, the SPARC Scientific Steering Group noted that the Integrated Global Atmospheric Chemistry Observations (IGACO) theme had now been accepted by the Integrated Global Observing Strategy Partnership (IGOS-P), providing a new framework for integrated research and observations in tropospheric and stratospheric chemistry. A committee has now been established to develop an appropriate IGOS theme "report". This would be based to a considerable extent, at least for the stratosphere, on the report for an ozone pilot project (drafted by WMO, IGBP/IGAC, WCRP/SPARC and CEOS) (published as GAW Report No. 140, WMO/TD-No. 1046, "WMO/CEOS Report on a Strategy for Integrating Satellite and Ground-based Observations of Ozone").

7. THE SPARC DATA CENTRE

The SPARC Data Centre at the State University of New York at Stony Brook, supported by NASA, has continued to assemble key stratospheric data sets in a readily accessible form. Dr. P. Udelhofen, the manager of the Data Centre, noted that, since its establishment in 1999, the number of data sets had grown rapidly, with many being available on line. Of principal interest were reference data sets based on UARS measurements and model analyses, and high-resolution temperature and wind observations from radio-sondes for 1998 (soon to be augmented by additional years by purchase from NOAA). Solar forcing and historic ozone data had also been acquired, as had data from the GRIPS model intercomparisons. In relation to the water vapour assessment (see section 2), a range of humidity mixing ratio observations from ground-based, airborne and satellite instruments had been archived. Recently added items include collections of rocketsonde data, and small organic peroxy radical data (see section 3). The website **http://www.sparc.sunysb.edu/** gave information on the full list of data sets available, and on access and downloading.

8. THE SPARC OFFICE

As well as its regular responsibilities of compiling and editing SPARC Newsletters, updating the SPARC mailing list, maintaining contacts with the SPARC community of scientists, organizing various SPARC meetings and periodically revising the SPARC home page, a large number of reports and documents have been compiled in the past year. These included the SPARC Water Vapour Assessment and the proceedings of the SPARC 2000 General Assembly (produced as a CD-ROM). A new SPARC brochure and posters were edited for the Global Change Open Science Conference in July 2001.

9. PROPOSAL FOR THIRD SPARC GENERAL ASSEMBLY

The success of, wide interest in, and large attendance at both the First and Second SPARC General Assemblies (respectively in Melbourne, Australia, December 1996, and Mar del Plata, Argentina, November 2000) had been highly gratifying. The SPARC Scientific Steering Group duly agreed to arrange a Third Assembly and to accept a kind offer to host the event in Victoria, BC, Canada in 2004 (the exact dates proposed being 19-23 July).

10. NEXT SESSION OF THE SPARC SCIENTIFIC STEERING GROUP

At the kind invitation of Professor S. Yoden, the next session of the SPARC Scientific Steering Group, the tenth, would be held from 18 to 21 November 2002 in Kyoto, Japan. Taking advantage of the visit of the SPARC Scientific Steering Group to Japan, an international symposium on stratospheric variations and climate was being arranged the preceding week (12-15 November) in Fukuoka. All expected participants in the steering group session would be invited also to attend the symposium.

11. CLOSURE OF SESSION

On behalf of all participants, Professors M. Geller and A. O'Neill reiterated gratitude to Dr. K. Hamilton and the International Pacific Research Center of the University of Hawaii for kindly hosting the session of the SPARC Scientific Steering Group, the excellent arrangements made, and supporting facilities offered. The ninth session of the SPARC Scientific Steering Group closed at 11.50 hours on 7 December 2001.

APPENDIX

LIST OF PARTICIPANTS IN THE NINTH SESSION OF THE SPARC SCIENTIFIC STEERING GROUP

1. Members of the SPARC Scientific Steering Group

Professor M. Geller (Co-chair)	Marine Sciences Research Center State University of New York at Stony Brook Room 125, Endeavour Building Stony Brook, NY 11794-5000 USA Tel: +1-516-632-8686 Fax: +1-516-632-8915 E-mail: mgeller@notes.cc.sunysb.edu
Professor A. O'Neill (Co-chair)	Department of Meteorology Centre for Global Atmospheric Modelling University of Reading 2 Earley Gate, PO Box 243 Whiteknights Reading RG6 6BB United Kingdom Tel: +44-118-931-8317 Fax: +44-118-931-8316 E-mail: alan@met.reading.ac.uk
Dr. K. Hamilton	University of Hawaii International Pacific Research Center Honolulu, Hawaii 96822 USA Tel: +1-808-956-8327 Fax: +1-808-956-9425 E-mail: kph@soest.hawaii.edu
Professor D. Karoly	Monash University Department of Mathematics and Statistics PO Box 28M Clayton, Victoria 3800 Australia Tel: +61-3-9905-4416 Fax: +61-3-9905-3870 E-mail: david.karoly@sci.monash.edu.au
Dr. T. Peter	Institute for Atmospheric and Climate Science Hoenggerberg HPP L8.2 CH-8093 Zurich Switzerland Tel: +41-1-633-2756 Fax: +41-1-633-1058 E-mail: thomas.peter@ethz.de

Dr. A.R. Ravishankara	Atmospheric Chemical Kinetics Program NOAA/ERL Aeronomy Laboratory 325 Broadway, R/E/AL2 Boulder, CO 80303-3328 USA Tel: +1-303-497-5821 Fax: +1-303-497-5822 E-mail: ravi@al.noaa.gov
Professor U. Schmidt	Institut für Meteorologie und Geophysik, Room 303B Johann Wolfgang Goethe Universität Georg-Voigt-Strasse 14 Postfach 11 19 32 D-60054 Frankfurt am Main Germany Tel: +49-69-79-823-637 Fax. +49-69-79-828-331 E-mail: u.schmidt@meteor.uni-frankfurt.de
Professor T.G. Shepherd	Department of Physics University of Toronto 60 St. George Street Toronto, Ontario M5S 1A7 Canada Tel: +1-416-978-6824 Fax: +1-416-978-8905 E-mail: tgs@atmosph.physics.utoronto.ca
Dr. S. Yoden	Department of Geophysics Kyoto University Kyoto 606-8502 Japan Tel: +81-75-753-3932 Fax: +81-75-753-3715 E-mail: yoden@kugi.kyoto-u.ac.jp
Dr. V. Yushkov	Central Aerological Observatory 3, Pervomayskaya 141700 Dolgoprudny Moscow Region Russia Tel: +7-095-405-6150 Fax: +7-095-576-3327 E-mail: vladimir@caomsk.mipt.ru

UNABLE TO ATTEND:

Dr. C. Granier	Service d'Aéronomie du CNRS/IPSL Université Paris VI 4 place Jussieu Tour 14-15, 5ème étage Boîte 102 F-75252 Paris Cedex 05 France Tel: +33-1-44-27-50-16 Fax: +33-1-44-27-37-76 E-mail: clg@aero.jussieu.fr

Dr. P.O. Canziani

Departamento de Ciencias de la Atmosfera y los Oceanos
Universidad de Buenos Aires-FCEN
Pabellon II, 2do piso, Ciudad Universitaria
1428 Buenos Aires
Argentina
Tel: +54-576-3356/3364 ext. 22
Fax: +54-576-3356/3364 ext. 12
E-mail: osvaldo@santamaria.at.fcen.uba.ar
or osvaldo@atmos.washington.edu

2. Ex-officio members

Dr. J. Gille
(COSPAR)

University of Colorado
330 Mitchell Lane - Suite 275
Boulder, CO 80307
USA
Tel: +1-303-497-8062
Fax: +1-303-497-2920
E-mail: gille@ncar.ucar.edu

Dr. M. Proffitt
(WMO/GAW)

Atmospheric Research and Environment Programme Department
World Meteorological Organization
Case Postale 2300
CH-1211 Geneva 2
Switzerland
Tel: +41-22-730-8240
Fax. +41-22-730-8049
E-mail: proffitt_m@gateway.wmo.ch

3. Leaders/representatives of SPARC sub-groups/activities

Dr. M.P. Baldwin
(Quasi-biennial oscillation)

Northwest Research Associates, Inc.
14508 NE 20th Street
PO Box 3027
Bellevue, WA 98009-3027
USA
Tel: +1-425-644-9660 x. 323
Fax: +1-425-644-8422
E-mail: mark@nwra.com

Dr. S. Pawson
(Intercomparison of
stratospheric models)

NASA Goddard Space Flight Center
Data Assimilation Office - code 910.3
Greenbelt, MD 20771
USA
Tel: +1-301-614-6159
Fax: +1-301-614-6297
E-mail: pawson@dao.gsfc.nasa.gov

Dr. V. Ramaswamy
(Assessment of stratospheric
temperature trends)

NOAA Geophysical Fluid Dynamics Laboratory, R/E/GF
Princeton University, Forrestal Campus
P.O. Box 308
Princeton, NJ 08542
USA
Tel: +1-609-452-6510
Fax: +1-609-987-5063
E-mail: vr@gfdl.gov

Dr. W. Randel
(Stratospheric reference climatology)

National Center for Atmospheric Research
PO Box 3000
Boulder, CO 80307-3000
USA
Tel: +1-303-497-1439
Fax: +1-303-497-1492
E-mail: randel@ucar.edu

Dr. L.W. Thomason
(Aerosol assessment)

NASA Langley Research Centre
Atmospheric Sciences Division
Mail Stop 475
Hampton, VA 23693
USA
Tel: +1-757-864-6842
Fax: +1-757-864-2671
E-mail: l.w.thomason@larc.nasa.gov

Dr. R.A. Vincent
(Gravity wave processes)

Department of Physics and Mathematical Physics
University of Adelaide
Adelaide 5005, South 5001
Australia
Tel: +61-8-8303-5758
Fax: +61-8-8303-4384
E-mail: robert.vincent@physics.adelaide.edu.au

4. Agency Representative

Dr. P.L. DeCola

NASA Headquarters, Mail code YS
Office of Earth Science
Upper Atmosphere Research Program
300 E. St. SW, Room 5R31
Washington, DC 20546-0001
USA
Tel: +1-202-358-0768
Fax: +1-202-358-2770
E-mail: pdecola@hq.nasa.gov

5. Invited expert/observer

Dr. M. Shiotani

Radio Atmospheric Science Centre
Kyoto University
Gokasho
Uji-shi, Kyoto 611-0011
Japan
Tel: +81-774-33-53-43
Fax: +81-774-31-84-63
E-mail: shiotani@kurasc.kyoto-uc.ac.jp

6. SPARC Project Office and Data Centre

Dr. M.-L. Chanin
(Director, SPARC Office)

Service d'Aéronomie du CNRS
B.P. 3
F-91371 Verrières-le-Buisson
France
Tel: +33-1-69-20-07-94
Fax: +33-1-69-20-29-99
E-mail: marie-lise.chanin@aerov.jussieu.fr

Dr. Y. Kolshelkov
(Project Scientist, SPARC Office)

SPARC Project Office
Service d'Aéronomie du CNRS
BP 3
F-91371 Verrières-le-Buisson Cedex
France
Tel: +33-1-64-47-43-15
Fax: +33-1-69-20-29-99
E-mail: sparc.office@aerov.jussieu.fr

[permanent affiliation:

Central Aerological Observatory
Pervomayskaya Street 3
141700 Dolgoprudny
Moscow Region
Russian Federation
Tel: +7-095-408-61-16
Fax: +7-095-576-33-27
E-mail: maya@mk5883.spb.edu]

Ms C. Michaut
(Manager, SPARC Office)

SPARC Project Office
Service d'Aéronomie du CNRS
BP 3
F-91371 Verrières-le-Buisson Cedex
France
Tel: +33-1-64-47-43-72
Fax: +33-1-69-20-29-99
E-mail: sparc.office@aerov.jussieu.fr

Dr. P.M. Udelhofen
(Manager, SPARC Data Centre)

Institute for Terrestrial and Planetary Atmospheres
MSRC/Endeavour Hall
State University of New York at Stony Brook
Stony Brook, NY 11794-5000
USA
Tel: +1-631-632-8228
Fax: +1-631-632-6251
E-mail: petra@atmsci.msrc.sunysb.edu

7. Joint Planning Staff for the WCRP

Mr. R. Newson

World Climate Research Programme
c/o World Meteorological Organization
Case Postale No. 2300
CH-1211 Geneva 2
Switzerland
Tel: +42-22-730-8418
Fax: +41-22-730-8036
E-mail: newson_r@gateway.wmo.ch