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The eighth session of the WCRP Scientific Steering Group on Stratospheric Processes and their Role in Climate (SPARC) was held in the Palacio San Martin of the Ministry of Foreign Affairs of the Republic of Argentina in Buenos Aires from 13-16 November 2000 (the week following the Second SPARC General Assembly, see section 1). The list of participants in the session is given in the Appendix.

The session was opened by the Co-chairs of the SPARC Scientific Steering Group, Dr. M.-L. Chanin and Professor M. Geller, at 0910 hours on 13 November. On behalf of all participants, the Co-chairs expressed warm gratitude to the Argentinian authorities for the excellent arrangements made and the facilities offered for the meeting. Appreciation was voiced especially to Embajador Raul Estrada Oyuela, Representante Especial para Asuntos Ambientales in the Ministry of Foreign Affairs and to Dra. Adriana Puigros, Secretary of Science and Technology for the help provided in the arrangements for the SPARC Scientific Steering Group itself, as well as for the SPARC Assembly the preceding week. Particular thanks were also due to Dr. P. Canziani, University of Buenos Aires, for his key role in preparing the arrangements for the SPARC Scientific Steering Group, on top of his outstanding work in ensuring the success of the SPARC Assembly.

The Co-chairs continued by welcoming all participants, in particular representatives of NASA, Dr. P. de Cola, and the WMO Global Atmosphere Watch (GAW), Dr. M. Proffitt. The attendance of such representatives from agencies or related activities contributed greatly to the success of SPARC Scientific Steering Group sessions. The Co-chairs also looked forward to the participation of a number of Argentinian scientists during the course of the session. It was of considerable value to hear of strong national stratospheric-related activities such as those in Argentina.

The main task of the session of the SPARC Scientific Steering Group was the customary review of progress in the principal projects and activities being undertaken in SPARC, including, of course, review of the status of stratospheric science based on the presentations and discussions at the SPARC Assembly. Following on from the Assembly, and as had been discussed at the seventh session of the SPARC Scientific Steering Group in Paris in November 1999, after several years of focussed SPARC initiatives, it was now timely to integrate the knowledge acquired across SPARC in order to progress towards the goal of an overall understanding of all aspects of stratospheric variability and change, its interactions with the troposphere, and its role in climate. Steps in this direction were taken at this session of the group (e.g., see section 3.4).

1. REVIEW OF SECOND SPARC GENERAL ASSEMBLY

The Second SPARC General Assembly ("SPARC 2000") took place as planned in Mar del Plata, Argentina, 6-10 November 2000. Dr. A. O'Neill, Chairman of the Scientific Organizing Committee for the Assembly, and the conveners of various Assembly sessions at the SPARC Scientific Steering Group (Drs V. Ramaswamy, T. Shepherd and S. Yoden), summarized the principal highlights and results. All who participated (over 300 scientists) regarded the Assembly as a considerable success and scientifically important and interesting. As well as 60 oral presentations, there were nearly 200 poster displays all centred round principal themes of SPARC (stratospheric processes and their role in climate; stratospheric indicators of climate change; modelling and diagnosis of stratospheric effects on climate; UV observations and modelling). Many organizations and bodies, national and international, offered sponsorship, assistance or support, enabling the attendance of many young scientists and students. The extensive participation from South American countries was particularly gratifying. The Conference attracted wide media attention. Two side events, a lecture by Nobel Laureate Dr. P. Crutzen, and an Argentine-wide competition amongst schoolchildren to depict graphically the ozone hole over Antarctica, were also very successful and had drawn several reports in the media. Organisationally, lessons learnt were that there had been too many oral presentations and not enough "prime" time had been allowed for viewing the posters. As is often a problem with a conference of this type, the standard of oral presentations was very varied, with speakers often over-running their allotted slots and there not being enough time for discussion. A summary of the main scientific highlights at the Assembly would be included in the next SPARC Newsletter (No. 16). The Assembly proceedings (summary of highlights and abstracts of papers presented) would be made available on a CD-ROM in a few months. The very high cost of printing and distribution of voluminous reports of this nature had, on this occasion, dissuaded the production of a hard copy version of the Assembly proceedings.

Scientifically, the Assembly clearly demonstrated the progress made in recent years in understanding dynamical, chemical, radiative and transport processes in the stratosphere. At the same time the importance of the stratosphere as an integral part of the climate system had become much more fully appreciated. Thus, increasing effort was being given to understanding the exchanges of mass, momentum, and energy between the stratosphere and troposphere, where complex non-linear processes were often involved, and improved knowledge of tropospheric/stratospheric coupling, the essential key, was still required. On the observational side, many papers gave evidence of the ability to synthesize the range of conventional and remotely-sensed data now available, leading to considerable advances in the understanding of variations in stratospheric features. This was underpinning convergence among the various tasks that have been undertaken in SPARC, lending weight to the SPARC Scientific Steering Group's views on adapting the overall strategy followed so far, namely that closer integration of activities and looking at changes in the observed fields of such variables as temperature, water vapour and ozone together, were required. The important role of upper tropospheric/stratospheric water vapour was also referred to repeatedly. In the Assembly, it was inevitable that the question of ozone depletion would be raised. It appeared that the decrease of ozone in the Arctic and Antarctic and other variations were now well understood quantitatively. It was also suggested that the seasonal depletion seen in ozone in mid-latitudes might not be entirely chemically driven. In the session on modelling and diagnosing stratospheric effects on climate, a popular subject was the Arctic Oscillation (or annular mode), including observational and numerical studies. In the latter, Arctic Oscillation patterns appeared to be affected by greenhouse gases, ozone, solar and volcanic forcings. Regarding the effects of the solar cycle, there was still considerable divergence: progress in quantifying this with a greater degree of confidence would depend on developing models with the capability of representing more fully the important coupled radiative/chemical/dynamical interactions that are involved. It seems also there are still many shortcomings in simulating accurately the behaviour of the coupled troposphere/stratosphere system in models. With respect to UV observations and modelling, one point commonly emphasized was the need to co-ordinate ground-based measurements of UV to provide ground-truth for estimates inferred from remotely-sensed data in the years to come. Several contributions indicated changes that could occur in UV consequent to changes in ozone, clouds and aerosols.

The SPARC Scientific Steering Group commended highly the Scientific Organizing Committee for the Assembly and the Local Organizing Committee (chaired by Dr. P. Canziani, University of Buenos Aires, Argentina) for their outstanding work in ensuring the success of the event, and expressed sincere gratitude to the numerous and generous sponsors.

2. MODELLING STRATOSPHERIC EFFECTS ON CLIMATE

2.1 Intercomparison of stratospheric models

Dr. S. Pawson reported on the status of the "GCM Reality Intercomparison Project for SPARC" (GRIPS), which has grown both in the number of research groups involved and the range of tasks being tackled. The first phase of GRIPS was focussed on a simple intercomparison of model stratospheric simulations, and as reported at the seventh session of the SPARC Scientific Steering Group, a wide range of skills was apparent. Detailed accounts of findings from the first phase of GRIPS have now been or are being published (as Pawson et al, Bulletin American Meteorological Society, 2000; Koshyk et al, Journal of Geophysical Research, 2000; and Amodei et al, to appear in Annales Geophysicae). New data from various modelling groups continue to be collected, with analysis now being focussed on mechanisms that may be involved in causing stratospheric variability (e.g. wave or diabatic forcing). Specific experimentation may also be organized designed to explore the sensitivity of the stratospheric circulation to various forcing mechanisms and their interaction.

The second phase of GRIPS is now underway, including an extended validation of models and carrying out controlled experiments to test parameterization schemes, including particularly investigation of radiative codes in use, of model responses to the formulation of mesospheric drag, and of gravity wave parameterization. Models have been shown to be very sensitive to the radiation code employed, and this is clearly a major factor affecting the convergence of different model simulations.

Progress has also been made in setting out the objectives and plans for the third phase of GRIPS. The main goal is to try to explain the observed variability in the stratosphere in the period 1979-1999, taking into account natural variability and known forcing mechanisms (changes in aerosol loading, solar variations, changes in atmospheric concentrations of ozone and carbon dioxide). As a further step, experiments will be run with imposed climate change scenarios from 2000 to 2020 (using the best possible predictions of trace gas concentrations).

2.2 Stratospheric reference climatology

A refined climatology of the means and variabilities of basic stratospheric parameters is needed for GRIPS, as well as a number of other SPARC initiatives. Dr. W. Randel recalled that a series of monthly global climatologies of temperature, zonal winds, and various atmospheric trace constituents (N_2O, O, CH_4, H_2O, O_3, NO_2, HNO_3, etc.) have 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. These data sets can now be accessed via the SPARC Data Centre (**http://www.sparc.sunysb.edu/**). Dr. Randel noted that a technical report was being drafted (to be published as a SPARC Report during 2001 "SPARC Intercomparison of Middle Atmosphere Climatologies") giving a basic description of the data sets, and attempting to quantify uncertainties and interannual variability, including identification of possible biases. A comparison would also be drawn with available rocket-sonde data.

2.3 Climate forcing in the stratosphere

As reported at the seventh session of the SPARC Scientific Steering Group, the review of stratospheric aspects of climate forcing in order to provide, for the use of the climate modelling community, the current best estimates of the relevant parameters has been completed (a full account was given in SPARC Newsletter No. 14, January 2000). The various data sets compiled or recommended (e.g. ozone as a function of latitude and height, stratospheric aerosols, changes in the solar constant since 1988 and variations in the solar spectrum during a typical solar cycle) are available at the SPARC Data Centre. Dr. D. Karoly reported that this work has fed into the consideration of the detection and attribution of a stratospheric role in climate change in the IPCC Third Assessment Report (see section 5.4 and article "Detection and Attribution of a Stratospheric Role in Climate Change: an IPCC Perspective" in SPARC Newsletter No. 16).

2.4 Stratospheric data assimilation

Dr. A. O'Neill emphasized to the SPARC Scientific Steering Group that focussed efforts in SPARC on stratospheric data assimilation offered good opportunities to encourage interdisciplinary exchange within the stratospheric community and links to numerical weather prediction centres. This was especially important in view of the new streams of stratospheric data coming on line from (research) satellites in the next few years (e.g., ENVISAT, the NASA EOS series, etc.). It was thus agreed that a review of the status of stratospheric data assimilation and specific related problems (including data availability) should be undertaken. This initiative would be co-ordinated with the JSC/CAS Working Group on Numerical Experimentation which has the leading role in WCRP for data assimilation questions.

It was noted that, a "Data Assimilation Research Centre" was being set up in the United Kingdom (with support from the UK National Environmental Research Council). Stratospheric analyses would be prepared using a modified 3DVAR NWP system, spanning the troposphere and stratosphere and incorporating a simple parameterization of ozone chemistry. A complementary off-line 4DVAR system, with more extensive chemistry enabling an advanced assimilation of chemical data, would also be developed. Collaborating centres included the NASA Goddard Data Assimilation Office, NCAR, the Centre National de la Recherche Scientifique, the Royal Netherlands Meteorological Institute, UKMO, ECMWF and a number of university groups.

3. LONG-TERM CHANGES IN THE STRATOSPHERE

3.1 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 progress made had been reported at previous sessions of the SPARC Scientific Steering Group and the first phase has now been completed. The results formed the basis of the chapter in the 1999 WMO/UNEP Ozone Assessment on stratospheric temperature trends. A summary was expected to be published in Reviews of Geophysics in February 2001, and a full account is in preparation as a SPARC report (to be published by NOAA). The work carried out also provided important input to the IPCC Third Assessment Report in particular for the discussion of radiative forcing of climate change, climate processes, and detection and attribution.

Dr. Ramaswamy reported that the intention was now to follow several complementary lines of activity. Firstly, the various stratospheric temperature data sets would be continuously updated and new comparisons made with recent model simulations (as a basis for inferring the possible causes of changes). Secondly, plans were in hand to extend the temperature analyses to the upper stratosphere and mesosphere in collaboration with the International Commission of the Middle Atmosphere (ICMA) and the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP). Thirdly, improved estimates of temperature trends in areas having high uncertainties (e.g. near the tropopause and stratopause) were required. Beyond this, it is clear that temperature trends are closely linked with changes in other stratospheric parameters (ozone, water vapour, dynamical activity, etc.), and activities will have to become increasingly integrated with the SPARC studies in these areas.

What has been strongly emphasized by the different groups of scientists who have been involved in this work has been the value of the SPARC umbrella under which coherent international research into stratospheric temperature trends (using both observations and models) has been carried out and plans for the future drawn up. It is viewed as important to keep the international “expert” SPARC temperature trends sub-group, comprising observationalists, modellers and diagnosticians together.

3.2 Understanding ozone trends

The first phase of SPARC activity in this area, providing an authoritative assessment of trends in the vertical distribution of ozone (published as SPARC Report No. 1 in 1998, and an essential foundation for the 1999 WMO/UNEP Ozone Assessment), has also now been completed. The work of SPARC in this respect had been greatly appreciated. A new effort was being planned to consider the question of stratospheric ozone changes and their causes (stimulated equally by the need to prepare for the drafting of the next WMO/UNEP Ozone Assessment due to begin in the middle of 2001). As noted in section 1, there was considerable discussion of these issues at the SPARC General Assembly. Thus, at the invitation of the Co-chairs of WMO/UNEP Ozone Assessment, SPARC would be participating in the organization of a workshop in March 2001 which would bring together leading scientists in the field of ozone trends research in order to take stock of the current state of scientific understanding, facilitate the formulation of common scientific viewpoints, and encourage prompt submission of peer-reviewed publications that would form the basis of the WMO/UNEP Assessment.

In the longer term, an evolution to studying trends of stratospheric parameters jointly (e.g. including temperature) was foreseen (as was similarly noted by the temperature trends group).

3.3 Stratospheric and upper tropospheric water vapour

Dr. D. Kley summarized the notable progress that had been made in the preparation of the comprehensive landmark Water Vapour Assessment. This had specifically looked into questions such as the concentration, distribution and variability (long-term changes or trends) of water vapour in the upper troposphere and lower stratosphere. The processes controlling the present distribution of upper tropospheric/lower stratospheric water vapour were also studied to the extent possible. The report has now been completed (published as SPARC Report No. 2 or WCRP-No. 113) (the executive summary would also be included in SPARC Newsletter No. 16).

Considerable urgency and priority has been attached to drawing up the assessment in view of the important role of water vapour, and the uncertainties associated with this, in estimating the climate changes likely to result from increases in atmospheric CO_2 concentrations. Among the key findings is that the concentration of stratospheric water vapour in the "overworld" (i.e. where the potential temperature is greater than 380K) is determined by dry air upwelling through the tropical tropopause, methane oxidation in the stratosphere, and transport by the poleward and downward (Brewer-Dobson) mean circulation. At the tropical tropopause, air is dried by a complex mix of processes that act on a variety of spatial and temporal scales. Water vapour in the upper troposphere is controlled by local and regional circulations and seasonal changes of upper atmosphere temperature. Regarding the trend in stratospheric water vapour, a 2ppmv increase since the middle 1950s is apparent: this is certainly significant in comparison with typical current stratospheric water vapour concentrations of 4-6 ppmv. The increase in the concentration of tropospheric methane since the 1950s (0.55 ppmv) is likely to be responsible for half of the increase in stratospheric water vapour over the period (photochemical oxidation of methane in the stratosphere produces approximately two molecules of water vapour per molecule of oxidized methane). It is not clear what is responsible for the remainder of the observed increase in stratospheric water vapour. In the upper troposphere, a twenty-year record of humidity is now available from instruments on operational satellites. However, assessing long-term trends is difficult because of the substantial natural variability in the large-scale circulation (e.g., during ENSO events), and the way that changes in temperature and water vapour can separately affect the (relative) humidity in the upper troposphere. Although statistically significant positive and negative long-term changes are apparent in different latitudinal bands, no striking overall global trend has been revealed in the analyses carried out so far. As to the measurements of water vapour (on which the above assessments are based, there has been a significant increase in the number and quality of observations in the stratosphere over the past 25 years, particularly with the advent of remotely-sensed data: the accuracy of the various satellite-based measurements in the upper troposphere are of sufficient quality for climatological and process studies and no major inconsistencies have been found that would inherently limit their use in describing the long-term behaviour of upper tropospheric humidity. On the other hand, the operational radio-sonde network does not produce water vapour data that are suitable for estimating long-term changes, process studies, or for validation of upper tropospheric humidity measurements. However, emerging data sets from improved quality quasi-operational aircraft and ground-based instrumentation show promise for process studies, climatological analyses and validation of water vapour content inferred from remotely-sensed data.

A series of recommendations has been made for improving the monitoring of water vapour in the upper troposphere and lower stratosphere. Among these is the need for further studies, including well designed intercomparison experiments and laboratory work, to quantify and understand the difference between various stratospheric water vapour sensors, particularly for in situ instruments that provide the critical high-resolution data used in studying the transport of water vapour between the troposphere and stratosphere and the processes involved. Also, strong validation programmes, including correlative measurements, should support the efforts to obtain improved measurements based on satellite data - this has been lacking in the upper troposphere. Better radiosonde observations of water vapour and wider exploitation of LIDARs are required. It was further pointed out that greater attention must be paid to the continuity of measurements in order to determine more accurately long-term changes in both the stratosphere and upper troposphere. However, reliance should not be placed on observations from one instrument or one approach: a range of complementary measurements was required. To be able to quantify dynamical effects which influence long-term changes, all measurements, whether satellite or in situ, should be collected with simultaneous methane observations. Satellite sensors with a history of high quality measurements should be included in future missions in the effort to monitor long-term changes in stratospheric and upper tropospheric water vapour. In order to gain a better understanding of the present distribution of water especially in the upper troposphere, a study of the role of convection was required, involving joint measurements of water vapour, cloud microphysical properties, and chemical species (providing a history of the air). Elsewhere, more (in situ and remotely-sensed) observations of the tropical tropopause were necessary to enhance knowledge of stratosphere-troposphere exchange in this region.

3.4 An integrated understanding of stratospheric climate change

As noted in the three foregoing sections, the SPARC studies of long-term changes in the stratosphere (of temperature, ozone, and water vapour), so far conducted separately, have now produced initial sets of results, all of which underlined that trends in one parameter are closely linked with changes in other parameters and that, increasingly, an integrated approach will be required. In the light of the fairly large body of information on the parameters that describe change in the stratosphere over the last two decades, the SPARC Scientific Steering Group agreed to take up the following questions:

(i) Are the different observed data variations providing a consistent picture of the stratospheric climate variations, including the possibility of a trend over the past two decades (e.g., ozone and temperature) upon which shorter time scale variations are superimposed?

(ii) Can 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 explanations of the causes of these changes?

There are many challenges in providing satisfactory answers such as the changes in ozone that are 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 sharp transient warmings in the aftermath of the volcanisms), the 11-year cycle in solar irradiance. SPARC is uniquely placed to tackle these issues, thereby providing valuable input to IPCC and the WMO assessments. The task would bring together many currently separate SPARC initiatives as well as being likely to involve interactions with other WCRP activities. In particular, AMIP-style model simulations will 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 should be undertaken, including a set of simulations without any "forcing" in order to understand the internal dynamical fluctuations of the modelled stratospheric climate system. Initially, the scope of the project would not be too ambitious, and an assessment would be made of what had been achieved after three years.

4. STRATOSPHERIC PROCESSES

4.1 Gravity wave processes and their parameterization

Progress continues to be made in the construction of a stratospheric gravity wave climatology based on high-resolution radiosonde data. Dr. R. Vincent noted that, following the workshop in Abingdon, UK, in July 1999 (reported at the seventh session of the SPARC Scientific Steering Group), data had been reanalysed and a further range of climatological and research products obtained, including climatologies of wave energies and propagation directions as a function of latitude. A number of articles for publication in the refereed literature, summarizing the overall work and research that have been involved in this project, were being prepared.

Dr. Hamilton outlined the developments in the planning of the international field experiment to investigate the gravity-wave field forced by tropical convection (the “Effects of Tropical Convection Experiment”, ECTE). During the six-week intensive observation period (late October-early December 2002) the intense diurnal convection that occurs over the Tiwi Islands, north of Darwin, Australia, will be investigated. A detailed plan of the scientific objectives and instrumentation to be deployed during the field campaign may be viewed at **http://www.princeton.edu/~kph/EXP2**.

Dr. Hamilton also described a preparatory campaign (the Darwin Area Wave Experiment, DAWEX), under the auspices of SPARC and the SCOSTEP project "Equatorial Processes Including Coupling" (EPIC), that would be undertaken late in 2001 (i.e. Austral spring). DAWEX was intended to characterize the wave field in the middle atmosphere over Northern Australia prior to the onset of, and then during, diurnal convection (known locally as "Hector"). DAWEX would involve only ground-based instrumentation (including the Australian Bureau of Meteorology Research Centre Doppler radar, balloons soundings from Darwin and from nearby locations operated by the Japanese Radio Science Centre for Space and Atmosphere, a radar to monitor winds in the mesosphere and lower thermosphere, and airglow imagers to observe the wave field near the mesopause and in the thermosphere), and thus the lead time for the implementation of this activity was shorter than for ECTE.

4.2 Lower stratospheric/upper tropospheric processes

Transport and mixing in the lower stratosphere and upper troposphere are fundamental to SPARC, and the key to many issues taken up by SPARC, e.g., the upper tropospheric/lower stratospheric ozone budget, mid-latitude water vapour distribution and tropical dehydration. However, there is still no overall strategy and theoretical framework for studying stratospheric-tropospheric exchange, paradigms that can be tested, or an obvious common measurement/diagnostic approach. Thus, the role played by SPARC in this area up to now is to keep under review the key questions that need to be addressed and to bring the different communities involved in this subject together in various focussed workshops. In view of the importance of the tropopause (where climate/ozone issues come together), a workshop on this topic was being arranged in Germany in April 2001 under the leadership of Drs T. Shepherd and P. Hayres. Questions that would be taken up included:

- what is the tropopause, how well is it known, why does it take the form that is observed?
- what is the role of the tropopause in upper tropospheric/lower stratospheric physical/chemical/dynamical processes and the implications for tropospheric chemistry/climate?
- how may the tropopause be expected to change in the future?

As well as the above initiative, Dr. Ravishankara reported that several joint SPARC-IGAC studies of chemical processes in the upper troposphere/lower stratosphere were going forward. Amongst these, the latest findings on the role of organic peroxy radicals in ozone photochemistry were reviewed in SPARC Newsletter No. 15 (and a formal paper is now in press in the Journal of Geophysical Research). A careful evaluation of recent laboratory measurements on the quantum yield of ozone photolysis has also been completed, and was being submitted to the Journal of Geophysical Research. The SPARC Scientific Steering Group judged this type of joint activity with IGAC to be extremely beneficial to both projects and crucial in the study of important upper tropospheric/lower stratospheric chemical reactions. Stimulating interactions between modellers, and field and laboratory chemists were being generated, with new people being brought in. The climatology of and trends in upper tropospheric ozone, now beginning to be considered by SPARC, was another area where co-operation could be fruitful.

Also, under this agenda item, Dr. S. Yoden reported on numerical experimentation at the University of Kyoto by himself together with Drs M. Taguchi and Y. Naito investigating interannual variations of the troposphere-stratosphere coupled system. Ten-year integrations were carried out with a hierarchy of models in order to understand intraseasonal and interannual variations in the polar stratosphere and the dynamical linkage to troposphere. The coupling process is fundamentally a two-way interaction involving the mean zonal flow and planetary waves. Large internal variability and a clear bimodality were found in the frequency distributions of the monthly mean polar temperature in the late winter period (in both the numerical experiments and the observed record) recalling the importance of non-linear dynamics which may lead to considerable amplification of the effects of (small amplitude) external forcings such as the solar cycle, volcanic eruptions etc. However, care is needed in drawing conclusions from limited period data either from a numerical experiment or observations, since, in the face of the large variability, a small number of samples can well give a misleading answer. A longer period data set would give, statistically, a more reliable estimate, but it is difficult to obtain data for a sufficiently long time. Nevertheless, the bimodality hints at the possibility of stochastic resonance so that a small amplitude periodicity in external forcing could be greatly amplified by transitions between the bi-modal states. In summary, Dr. Yoden emphasized that the troposphere-stratosphere coupled system is typically non-linear with large internal variability with a non-Gaussian frequency distribution. Thus, a linear approach should not be used in analysing the data from such a system or in investigating the response to external forcing.

4.3 Penetration of UV radiation into the lower stratosphere and troposphere

Increasing UV flux into the troposphere (consequent to decreasing stratospheric ozone) can enhance the photo-dissociation of the ambient chemical species leading to greater tropospheric concentrations of the hydroxyl radical and perturbations in the distribution and lifetimes of such compounds as CO, O_3, CH_4, H_2O_2, HCFCs, HFCs etc. It is essential to know the actinic flux distribution in the lower stratosphere and troposphere and to determine the climatology of photodissociation rate constants (J values) for various radicals as a function of altitude, and to make marked progress in model calculations. A joint SPARC-IGAC initiative was proposed in 1999 with the objectives of evaluating existing data (including J values and actinic flux measurements), considering the requirements for new instrumentation and organizing validations of computations of radiative transfer at UV wavelengths. This activity would fit well with and complement the joint SPARC-IGAC studies of chemical processes in the upper troposphere and lower stratosphere (see section 4.2). However, little progress has yet been made, and the connection with IGAC needs to be strengthened.

It was noted that a workshop on the impacts of UV took place in Mar del Plata on 11 November 2000, immediately following the SPARC General Assembly (see section 1). Despite the interest manifested by participants in the SPARC Assembly, it was not felt that this was a subject that should be taken up by SPARC at present.

5. OTHER SCIENTIFIC ISSUES

5.1 Dynamical coupling of the stratosphere and troposphere

Reports were given to the SPARC Scientific Steering Group at its 1999 session on two aspects of what are thought to be manifestations of the dynamical coupling of the stratosphere and troposphere, the quasi-biennial oscillation (QBO) and the Arctic Oscillation (AO). At the present session, Dr. M. Baldwin lead a discussion on the possible link between the AO and North Atlantic Oscillation (NAO). There are similarities between the AO and NAO in the surface pressure patterns and features derived as a leading "mode" of variability of the combined troposphere-stratosphere system. It was thus suggested that the AO and NAO could be different manifestations of the same underlying dynamical phenomenon: this is supported by evidence of a downward propagation of the AO signal. This opens up questions concerning the mechanism for the downward propagation of the AO, and thus whether there could be a stratospheric influence on the large-scale variability of the troposphere (and hence whether, with a prior knowledge of the state of the stratosphere, changes in the large scale circulation in the troposphere could be predicted!). The SPARC Scientific Steering Group agreed to keep under review any new scientific developments or results in this area, and to bring this topic to the attention of the Joint Scientific Committee (JSC) for WCRP bearing in mind the potential CLIVAR interest, and for the JSC to consider whether any joint SPARC/CLIVAR action would be appropriate.

5.2 Solar forcing and climate variability

As requested by the JSC, SPARC keeps under review research on solar forcing, its variability as a source of variations in climate, and possible underlying mechanisms. As noted last year, although changes in the solar spectrum are known to affect ozone, temperature and the actinic flux in the middle atmosphere, there is still no consensus whether tropospheric climate is influenced by these changes (this lack of consensus was clearly apparent at the SPARC General Assembly, see section 1). The data analysis planned in the European Project Solar Influence on Climate and Environment (SOLICE), and modelling activities in GRIPS and SOLICE, which are all still at an early stage, may help throw further light on this issue (although, again as noted in section 1, models with the capability of representing more fully the important chemical/dynamical/radiative interactions involved are required).

The SPARC Scientific Steering Group considered that research on links between solar forcing and climate variability is an example of a cross-cutting activity in WCRP where SPARC as well as at least GEWEX and CLIVAR, should be involved (SPARC studying mechanisms in the stratosphere; GEWEX, possible cloudiness variations linked to changes in solar output/cosmic rays; CLIVAR, a rigorous interpretation of the observed climate record).

5.3 Stratospheric aerosols

The subject of stratospheric aerosols has been a subject of discussion for many years, but no organized activity has been undertaken. The SPARC Scientific Steering Group agreed to invite a small group of experts to examine the existing climatologies, identify consistencies and inconsistencies, and to advise on steps required to obtain a better knowledge of the composition of stratospheric aerosols and their optical and chemical properties.

5.4 Review of the role of the stratosphere in climate change in the IPCC Third Assessment Report

Dr. D. Karoly summarized for the benefit of the SPARC Scientific Steering Group several of the main points raised in the IPCC Third Assessment Report on the role of the stratosphere in climate change. The full assessment of this role has proved difficult for a number of reasons including:

- uncertainties in trends in water vapour in the upper troposphere and lower stratosphere
- the relatively short observational record in the stratosphere
- the uncertainties in respect to the dynamical links between the stratosphere and troposphere

The SPARC Scientific Steering Group recalled that it was pursuing actively the issues of trends in water vapour in the upper troposphere and lower stratosphere (with the Water Vapour Assessment having recently been completed, see section 3.3) and the stratospheric-tropospheric links (with the organization of a workshop on the tropopause in April 2001, see section 4.2).

Other obstacles were the poor stratospheric resolution in climate models used for detection and attribution, the limited simulations of internal climate variability in the stratosphere, uncertainties in solar and volcanic forcing reconstructions and responses, and the absence of adequate coupling between stratospheric chemistry and circulation in climate models. Again, the SPARC GRIPS activity (see section 2.1) would advance work in these areas.

The main conclusion expressed regarding the role of the stratosphere in climate change was that stratospheric ozone depletion had been a major contribution to the observed cooling in the lower stratosphere over the last twenty years, but overall a much greater understanding and appreciation of the important role that stratospheric processes play in climate variability and change was evident.

6. OVERALL SPARC STRATEGY

At its previous session in November 1999, the SPARC Scientific Steering Group gave consideration to the overall strategy that had so far been followed in SPARC. Up to then, SPARC initiatives had been fairly focussed and dealt with in a fairly "self-contained" manner (by sub-project working groups). There is obviously a need for specific continuing efforts (e.g. refinement of a gravity wave climatology and the understanding the role of gravity waves in stratospheric dynamics; upper tropospheric/lower stratospheric chemistry and microphysics; the tropopause; solar forcing and climate variability; a range of specific modelling issues identified in GRIPS; and stratospheric data assimilation). However, it was considered timely to integrate the knowledge acquired across SPARC in order to progress towards the goal of an overall understanding of all aspects of stratospheric variability and change, interactions with the troposphere, and their role in climate. This was now being put into practice in the new SPARC initiative "An integrated understanding of stratospheric climate change" (see section 3.4). The Scientific Steering Group reiterated its intention that SPARC should remain in a position to provide the best available information on relevant stratospheric questions for the periodic international assessments such as those of IPCC and WMO/UNEP. This required a forward-looking approach to identify new questions that could arise.

7. INTERACTIONS WITH OTHER PROGRAMMES AND ACTIVITIES

As noted at several points in the preceding text, SPARC maintains strong links and/or interacts widely as appropriate and necessary with several other programmes. Especially noteworthy is the co-operation with IGAC (the joint SPARC-IGAC activity on upper tropospheric/lower stratospheric chemical processes, see section 4.2; the planned initiative on the penetration of UV radiation into the lower stratosphere and troposphere, see section 4.3; possible collaboration in considering climatologies of stratospheric aerosols and their properties, see section 5.3). However, an improved mechanism is needed to ensure that the joint planning necessary is carried forward in a timely and organized manner, and it was suggested that a small SPARC/IGAC liaison group might be formed for this purpose. This will be explored with the IGAC Scientific Steering Committee.

Reference has also been made to collaboration with SCOSTEP in several areas. In particular, it was suggested that a joint SPARC/SCOSTEP working group could be established to take up the issues of upper stratospheric temperature trends and solar influence on climate (it appeared that a grant could be made by ICSU to assist in the funding of this joint work). SPARC and SCOSTEP are also co-sponsoring the Darwin Area Wave Experiment, DAWEX (see section 4.1).

Extremely good co-operation continues between SPARC and the WMO Global Atmosphere Watch (GAW). Progress in several areas of SPARC depends fundamentally on the measurements made by the GAW network of ground-based ozone instruments and ozone sondes. These measurements are an essential complement to the increasing range of remotely-sensed ozone observations.

The SPARC Scientific Steering Group very much recognized the importance of the GCOS Upper Air Network (GUAN) and expressed its strong encouragement and support to the implementation of this network, in particular the regular provision of good quality high-level data.

8. THE SPARC DATA CENTRE

The SPARC Data Centre at the State University of New York at Stony Brook, supported by NASA, has now been in operation for more than a year. Ms P. Udelhofen, the manager of the Data Centre reported that good progress was being made in assembling key stratospheric data sets in a readily accessible form. Recent new additions included high-resolution temperature and wind observations from radiosondes, selected GRIPS model results, and data sets used in preparing the WAVAS report (water vapour measurements from aircraft campaigns, ground measurements and satellite data). A full account of the work of the Data Centre and the approach being followed was contained in SPARC Newsletter No. 15. The website **http://www.sparc.sunysb.edu/** may be consulted for the full list of data sets available, and for information on access and downloading.

9. 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, particular support has been given to the preparation of the SPARC water vapour assessment report (see section 3.3). Substantial efforts were devoted to seeking sponsors for the Second SPARC General Assembly, and assisting in the arrangements for the Assembly was a major task during 2000. Following the encouraging development reported at the twenty-first session of the JSC that a full-time support position in the SPARC Office had been offered by the French Centre National de la Recherche Scientifique, a suitable candidate had been found who began work in June 2000 and was providing very efficient management support. However, Ms. C. Phillips, working as a project scientist (half-time) in the SPARC Office, left in November: a suitable (post-doctorate) replacement was being sought.

10. NEXT SESSION OF THE SPARC SCIENTIFIC STEERING GROUP

At the kind invitation of Dr. K. Hamilton, the next session of the SPARC Scientific Steering Group, the ninth, will be held from 4 to 7 December 2001 at the Tokai University Pacific Center, Honolulu, Hawaii, USA.

11. CLOSURE OF SESSION

On behalf of all participants, Professor M. Geller and Dr. M.-L. Chanin reiterated gratitude to Dr. P. Canziani and the Argentinian authorities for the excellent arrangements made for the session of the SPARC Scientific Steering Group, the meeting facilities and hospitality offered. Participants had very much appreciated the opportunity of visiting Buenos Aires.

Professor Geller noted with considerable regret that, following the current session of the group, Dr. M.-L. Chanin would be relinquishing her position as Co-chair of the SPARC Scientific Steering Group, which she had held since the inception of the project in 1992. On behalf of all participants and, indeed, the entire SPARC and stratospheric science community, Professor Geller expressed appreciation and gratitude to Dr. Chanin for her outstanding contributions to SPARC during her period of service, which had helped SPARC to become such a prominent and effective WCRP activity and a principal focus for international stratospheric science. Dr. Chanin's personal efforts and inspiration had underpinned many of the important and successful initiatives organized by SPARC. Fortunately, however, SPARC did not yet have to say farewell to Dr. Chanin and could continue to count on her expertise and support for a further few years in her capacity as Director of the SPARC Office.

The eighth session of the SPARC Scientific Steering Group closed at 12.30 hours on 16 November 2000.

APPENDIX

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