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# Report on the 18th Session of the SPARC Scientific Steering Group

## 2-5 February 2011, Pune, India

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The 18th Session of the SPARC SSG was held at the Indian Institute of Tropical Meteorology (IITM) in Pune, India, and was hosted by SSG member Dr. P. C. S. Devara as well as IITM Director and WCRP Joint Scientific Committee (JSC) member Prof. B. Goswami.

### Opening session

**T. Shepherd** and **T. Peter** (SSG co-chairs) opened the meeting by welcoming all participants, particularly the new members of the SSG and the incoming Director of the SPARC Office, J. Stähelin, and warmly thanking the local organisers of the meeting.

**A. Busalacchi** (WCRP JSC chair) described the planned changes within the WCRP (to be implemented by 2013), which include the strategic evolution of the Core Projects and the establishment of two coordinating councils (one on modelling, the other on climate observations and analysis). Structural changes within the WCRP have been discussed over the last several years (see *e.g.*, Report on the 30th Session of the JSC in SPARC Newsletter No. 33). As part of the overall restructuring, the mandate of SPARC will be expanded to provide a greater emphasis on the couplings and processes of the stratosphere/troposphere system, which implies that tropospheric processes should be addressed in a more explicit way (see further discussion below). Outstanding challenges for the WCRP include how to organise activities on regional climate prediction, how to structure cross-cutting activities, and how to optimally connect the various WCRP activities to the users' needs (see Report on the 32nd Session of the JSC in this issue of the SPARC Newsletter).

A major activity of the WCRP in 2011 is the Open Science Conference (OSC), which will take place from 24-28 October 2011 in Denver, USA. **V. Ryabinin** (WCRP Joint Planning Staff) described the plans for the OSC, including the substantial financial support for early-career scientists and scientists from developing countries, and T. Shepherd (member of the OSC Programme Committee) documented the extensive representation of SPARC within the plenary speakers and session conveners. All SPARC activities were encouraged to make a strong showing at the OSC, *e.g.*, through poster clusters, to develop the connections with tropospheric activities that will be needed for the future evolution of SPARC, and to ensure that SPARC science is well integrated into the WCRP cross-cutting activities.

**P. C. S. Devara** presented an overview of the regional workshop held at IITM immediately preceding the SSG meeting (see the full workshop report in this issue of the newsletter), which was followed by a discussion of the implications for SPARC. There was a consensus that

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SPARC needed to more actively embrace monsoon research, and that a first step in this direction could involve two specific research activities in collaboration with the Indian community: one focused on the role of the stratosphere in the predictability of monsoon onset, and another focused on the role of the monsoon in determining chemical distributions within the Tropical Tropopause Layer, possibly including a field experiment.

## Chemistry-Climate Interactions

**P. Newman**, **A. R. Ravishankara** and **G. Bodeker** presented different aspects of the recently published "Scientific Assessment of Ozone Depletion: 2010" of WMO/UNEP (the WMO/UNEP Ozone Assessment). Many scientists engaged in SPARC contribute in various ways to the Ozone Assessments, which are produced every four years for the parties that signed the Montreal Protocol. The speakers identified expected needs for the anticipated 2014 assessment to which SPARC could respond through its various activities. These include: updating model simulations; weighting multi-model projections; inferring tropospheric impacts of stratospheric changes; constraining the impact of geoengineering on stratospheric ozone; understanding lower stratospheric ozone trends; inferring changes in the Brewer-Dobson circulation from trace gas measurements; comparing observed and modelled changes in tropospheric ozone; and further constraining the impact of very short-lived halogen species. P. Newman made the case that a better quantitative understanding was needed of the lifetimes of important halogen source gases (*e.g.*, CFC-11, $CCl_4$), since evidence has emerged that in many cases the actual lifetimes may be considerably longer than those currently assumed in the Ozone Assessment, and in the scenarios used to drive the CCMs. This represents a major uncertainty in reconciling top-down and bottom-up emissions estimates, and in model projections. It was decided to initiate a new SPARC activity to respond to this need. The comprehensive review will include an overview of the theory of estimating lifetimes using models and observations; an update of the kinetic data that determine lifetimes; lifetimes deduced from observed trace-gas distributions; and model estimates of lifetimes, which will require new CCM runs. Groups that contribute to CCMVal will therefore be critical participants in the initiative. The results are expected to be an important input to the next WMO/UNEP Ozone Assessment.

**V. Eyring** reported on the SPARC Chemistry-Climate Model Validation (CCMVal) activity. Over the last decade, there has been a significant growth in the number and maturity of three-dimensional stratospheric CCMs, such that they now represent a mainstream input into the Ozone Assessment. The evaluation of the strengths and weaknesses of the suite of models is a challenging task. CCMVal has pursued a two-pronged approach. On the one hand, it has coordinated the definition of simulation protocols to ensure that multi-model analyses are comparing 'apples with apples', and it has developed robust multi-model statistical analysis methods. These efforts in themselves have reduced the uncertainty in quantifying the model projections. In parallel with these efforts, CCMVal has introduced a novel approach to compare the results of the individual models in a systematic way by developing performance metrics to separate and grade model performance with respect to key physical processes, as compared with observations. The results of this effort were published last year as a peer-reviewed SPARC report (see the publications section on the SPARC web page, also SPARC Newsletter No. 35), as well as in about a dozen associated refereed journal publications. While the individual models show different strengths and weaknesses, they also show common features, such as the enhancement of the Brewer-Dobson circulation from climate change that will lead to larger column ozone amounts in the extratropics (super recovery) and reduced amounts over the tropics (compared to 1960). As a result, the models consistently predict an increase in ozone flux from the stratosphere into the troposphere over the 21$^{st}$ century. The models also indicate that the stratospheric ozone layer started to experience ODS-induced ozone depletion well before 1980, which is used as the reference for ozone depletion in the WMO/UNEP Ozone Assessments.

Future CCMVal activities will not only aim to continue to improve stratospheric model validation, but also plan to extend the validation of CCM simulations to tropospheric chemistry; note that no similar effort for validation of tropospheric chemistry models has been made in the past, although such model validation is an important task. The planning of the next phase, CCMVal-3, should therefore include discussions and coordination with the tropospheric CCM community. For this purpose the next CCMVal workshop, planned for spring 2012, will explicitly address this issue and invite tropospheric modellers.

With regard to the IPCC AR5, an AC&C/SPARC ozone database[1] was created in collaboration with the SPARC/IGAC cross-cutting activity Atmospheric Chemistry & Climate (AC&C) in response to a request from the CMIP5 activity of the WGCM (CMIP: Coupled Model Intercomparison Project, see further discussion below). This database includes a merged tropospheric and stratospheric ozone time series from 1850-2100 for use in CMIP5 simulations.

**M. Chipperfield** discussed the status of the cross-cutting activity AC&C, a joint effort of IGBP (the International Geosphere-Biosphere Programme) and WCRP, carried out by their core projects IGAC (International Global Atmospheric Chemistry) and SPARC, respectively. AC&C has defined three modelling activities: (1) Hindcasts 1980-2007: To evaluate tropospheric CTMs and CCMs with respect to past trends and variability. (2) Vertical Distributions: To investigate upper tropospheric chemistry, convection, scavenging, and strat-trop exchange. (3) Atmospheric Chemistry & Climate Model Intercomparison Project (ACC-MIP): To perform time slice runs and emission sensitivity studies complementing CMIP5 (formerly Activity 4).

The ACC-MIP Activity (3) is making progress, with tropospheric chemistry runs in support of AR5 being performed. Two early runs contributed to the combined troposphere-stratosphere ozone database provided to CMIP5 as ozone forcing for models without interactive ozone. Progress in Activities (1) and (2) has been slower than hoped for, partly owing to the involvement of many AC&C scientists in the recent WMO/UNEP "Integrated Assessment of Black Carbon and Tropospheric Ozone"[2]

[1] http://cmip-pcmdi.llnl.gov/cmip5/forcing.html?submenuheader=2#ozone_forcing
[2] http://news.sciencemag.org/sciencenow/Integrated%20Assessment%20of%20Black%20Carbon%20low%20res.pdf

and in the UNECE HTAP report on "Hemispheric Transport of Air Pollution 2010"[3], but partly also because plans for model runs appear to have not been sufficiently coordinated.

The present development of AC&C needs to be seen in the context of the extended mandate given by the WCRP to the new project that emerges from SPARC, calling for an intensification of AC&C-like activities in SPARC, and close collaboration with IGBP/IGAC will become even more important. The extensive discussion of AC&C at the 18th session of the SPARC SSG concluded that:

- the situation with little apparent progress of some AC&C Activities needs to be remedied;
- CCMVal groups should be encouraged to participate in the Hindcast and ACC-MIP Activities, to the extent they are able;
- the next CCMVal workshop should be with the full participation of tropospheric AC&C scientists on the organising committee and a broad invitation to all AC&C modellers;
- there should be a broad-based community discussion of where the AC&C community wants to go in the future, and to consider wider scientific opportunities and imperatives, in particular extending the CCMVal models into the troposphere.

The co-chairs of IGAC and SPARC will develop an action plan to accelerate progress in AC&C.

## Detection/Attribution/Prediction

**J. Stähelin** reported on a new joint activity on "Past Changes in the Vertical Distribution of Ozone" of SPARC, IGACO-$O_3$/GAW and $IO_3C$ (International Ozone Commission), aimed at updating observed trends in the vertical distribution of stratospheric ozone. Important satellite instruments stopped operation in 2005 (SAGE II, HALOE). While other satellite instruments exist to continue the stratospheric ozone record, their products have not yet been assessed in such a way as to enable trend assessments in the vertical distribution of ozone. As a result, it was not possible to comprehensively assess ozone profile changes after the 2006 WMO/UNEP Ozone Assessment. This new activity intends to construct merged satellite data sets as well as homogenized long-term ground-based measurements to get an update of global stratospheric ozone trends (see report in this issue of the newsletter). This is also of scientific interest because model predictions suggest that climate change and ozone depleting substances will modify ozone profiles in different ways (see CCMVal discussion above). This new activity started with a workshop in Geneva in January 2011 and is planned to complete in time for the results to be used by the 2014 Ozone Assessment.

**C. Schiller** presented an update on SPARC WAVAS-2 (Water Vapour Assessment-2). The main aim of the assessment is to assess past trends in stratospheric water vapour, and to understand what controls both the magnitude of water vapour entering the stratosphere and the drivers of temporal changes. The report is currently planned to include: (i) data quality problems including sensor characterization by measurements in the AIDA cloud chamber during AquaVit2007 and recent instrumental comparisons from aircraft measurements, (ii) problems concerning supersaturation, taking into account the improved characterization of the instruments, (iii) an upper tropospheric and stratospheric water vapour climatology, including long-term changes, and (iv) a synthesis. Unfortunately the activity is not advancing as quickly as planned.

## Stratosphere-Troposphere Dynamical Coupling

**A. Scaife** summarised the work of WGSIP (Working Group on Seasonal to Interannual Prediction), focusing on results relevant to SPARC. The representation of the stratosphere has been identified as one of the most important opportunities for improvement of seasonal forecast skill in current seasonal prediction systems. In WGSIP's Stratospheric Historical Forecast Project (SHFP) it has been shown that the effects of ENSO on European weather forecasts depend on the representation of the stratosphere in the models. Further analysis of the SHFP archive will be carried forward by the SPARC DynVar activity (see below). It was noted that solar variability could play a more important role than previously believed in driving NAO variability. The CMIP5 decadal predictions could provide another opportunity to assess the role of the stratosphere in driving tropospheric variability, but it is not yet clear how many of the models contributing to this activity will have a well-resolved stratosphere.

**E. Manzini** reported on the SPARC DynVar activity, which has recently been rejuvenated through a workshop held in Boulder in November 2010. The workshop attracted enthusiastic participation, including a large number of early-career scientists. At the workshop it was decided that DynVar should take a more focused approach, oriented around understanding the two-way dynamical connections between the stratosphere and the troposphere, and take advantage of the archives of model simulations provided by the SHFP and the high-top models contributing to CMIP5. In particular, DynVar will coordinate several CMIP5 synthesis papers. For a full understanding of stratosphere-troposphere connections it is important that the DynVar community actively engage with the coupled atmosphere-ocean modelling community. Therefore, the DynVar community has decided to actively participate in the CMIP5 Analysis Workshop to be held in March 2012, rather than holding a separate DynVar workshop in 2012.

**J. Alexander** reported on the SPARC Gravity-Wave Working Group, which was rejuvenated several years ago under a more focused mandate to better quantify gravity wave momentum fluxes in observations and models. The goal is to develop methods to merge observational data sets into a coherent set of constraints for improvement of model parameterizations of gravity-wave drag. Recently the working group has published a review paper (Alexander *et al.*, QJRMS, 2010), initiated an ISSI (International Space Science Institute) International Team activity to develop methodologies to merge different observational data sets, and held a Chapman Conference on gravity waves in Spring 2011 (see report in this issue of the newsletter).

**K. Matthes** reported on SOLARIS, the working group on effects of solar influence on climate. Solar influence on climate is a vast and complex research topic, which has obtained much visibility in climate research. SOLARIS focuses on the solar influence on chemical and dynamical processes

[3] http://www.htap.org/activities/2010_Final_Report/EBMeeting2010.pdf

in the middle atmosphere, including their coupling with the Earth's surface, by using CCMs, mechanistic models and observations. The activity is closely coordinated with the CCMVal and DynVar activities. SOLARIS also provides recommendations on solar irradiance data sets for CCMVal and CMIP5. A recent focus involves examining the possible effect of aliasing between the solar signal and other sources of variability (*e.g.*, SSTs) on the variability of the tropical lower stratosphere, where the significance of the solar signal has been controversial (see the report in SPARC Newsletter No. 36). The SSG approved the recommendation of SOLARIS to strongly coordinate with the HEPPA activity (High Energy Particle Precipitation in the Atmosphere; see also the report in SPARC Newsletter No. 36), which currently lacks a formal home.

## Cross-Cutting issues

**M. Hegglin** reported on results from the SPARC Data Initiative, which aims to intercompare vertically-resolved chemical trace constituent measurements derived from satellite instruments (extending from the upper troposphere to the mesosphere, but with a primary focus on the stratosphere). Accurate knowledge of trace species concentrations (including their variability) is crucial not only for their intrinsic value but also for validation of numerical simulations; the SPARC CCMVal Report noted that for some species the satellite products appear to contradict each other, and recommended an assessment of the various data products currently available to support future model evaluations. The species analysed in the data initiative will include a variety of trace gases not covered in other SPARC activities ($CH_4$, $N_2O$, $HNO_3$, $NO_x$, HCl, ClO, OClO, HOCl, HF, BrO, $SF_6$, CO and others), while the analysis of ozone, aerosol and water vapour climatologies will support other ongoing SPARC activities focused on characterizing long-term changes. This work will also complement "data merging" activities currently being carried out by NASA and ESA. The outcome of the SPARC Data Initiative will be a peer-reviewed SPARC Report in the spirit of that produced 10 years ago on middle atmosphere dynamical climatologies. The activity is also being facilitated through an ISSI International Team activity, and all major instrument teams are well engaged.



**S. Polavarapu** presented the progress of the SPARC Data Assimilation Working Group, which was created in 2002 to coordinate and promote data assimilation relevant to SPARC. Data assimilation is a versatile tool commonly applied to several domains in modern atmospheric sciences. The Data Assimilation Working Group has operated through annual workshops, whose foci vary in order to develop connections with different scientific communities. The last SPARC Data Assimilation workshop, held in June 2010, covered seamless prediction, model error, stratosphere-troposphere coupling, and the role of data assimilation in air quality and climate (see the Report in SPARC Newsletter No. 36). It is unclear exactly how the SPARC Data Assimilation Working Group should evolve within the expanded scope of SPARC, but there seems to be no doubt that the issues addressed by the Working Group are central to progress in many areas of climate research. David Jackson of the UK Met Office will be joining Saroja Polavarapu as a co-leader of the SPARC Data Assimilation Working Group.

T. Shepherd reported on the WCRP Workshop on Polar Predictability (see the Report in SPARC Newsletter No. 36), which was held in Bergen in October 2010. Much of our knowledge concerning physical processes in the polar regions is well established, however the understanding of many of the feedbacks between the different components of the polar climate system and the causality of important modes of variability need further research. The nature of the feedbacks appears to be somewhat different in the two hemispheres, which is reflected in the different scientific questions being asked: for the Arctic the most burning issue is arguably the rate of warming and sea-ice loss, while for the Antarctic it is the response of the ocean, carbon uptake and the West Antarctic ice shelf to circulation changes. The workshop demonstrated the need for a cross-cutting WCRP initiative to address these topics. SPARC will be involved, but to be effective the activity would need to engage virtually every component of the WCRP.

## Coordination with other programmes

**C. Jakob** reported on activities within WGNE (Working Group on Numerical Experimentation). He noted that WGNE plays a unique role within the WCRP by providing a direct link to the operational weather prediction centres. A stronger link to the WCRP core projects is being developed by adding *ex officio* members from the core projects: SPARC is now represented on WGNE by S. Polavarapu. This provides new scientific opportunities for SPARC that could be pursued through joint projects, workshops, *etc*. For example, the SPARC Gravity Wave Working Group could look at high-resolution AMIP (Atmospheric Model Intercomparison Project) simulations. DynVar could become involved in developing diagnostic subprojects focused on the role of the stratosphere for the Transpose-AMIP activity (which seeks to identify climate model errors through short-term forecasts), or could examine verification of stratospheric forecasts. It was suggested that the SPARC Data Assimilation Working Group work together with WGNE to consider defining coordinated experiments concerning the role of the stratosphere in climate and weather forecast models. WGNE will be leading a workshop on physics in climate models in Spring 2012, and Norm McFarlane was nominated to represent SPARC on the Scientific Organising Committee of this workshop.

C. Jakob also reported on developments concerning the GCSS (Global Cloud System Study) within GEWEX. There was a proposal that within the restructured GEWEX, GCSS would evolve into a new project with its own Steering Group. SPARC welcomed this development as it would provide a mechanism to revive the Tropical Tropopause Layer initiative, by providing a clear entry point for SPARC into GEWEX expertise, which could lead to focused joint activities.

**R. Molinari**, the new Director of the CLIVAR IPO, provided a high-level overview of CLIVAR activities and discussed potential synergies with SPARC. It became clear that, particularly concerning monsoons, there will be opportunities for future cooperation between the two WCRP core projects.

V. Eyring reported on activities of the WGCM (Working Group on Coupled Modelling) related to the IPCC AR5. Within WGCM, standard experimental protocols for studies of coupled ocean-atmosphere general circulation models were developed through CMIP. It was noted that NASA is facilitating the use of its observational data for the AR5 by proving a "users' guide" and making the data available in a form similar to model data, analogous to the work being done by the SPARC Data Initiative for the Ozone Assessment. V. Eyring also presented the input of SPARC to the WGNE/WGCM climate model metrics panel, which will come from experience gained in CCMVal.

T. Shepherd spoke about the ESA-SPARC initiative and the SPARC measurement requirements document requested by ESA to support this initiative. The ESA programme "Support to Science Element (STSE)" is aimed at developing "science partnerships" through strategic links with major international scientific programmes in order to enhance the international use of ESA and "ESA Third Party" (*e.g.*, Canadian or other European) data. Such collaborations already exist with other WCRP core projects (GEWEX and CliC) within a broader ESA-WCRP cooperation agreement, and with other international programmes, such as iLEAPS (Integrated Land Ecosystem-Atmosphere Processes Study) and SOLAS (Surface Ocean Lower Atmosphere Study). These collaborations are funded in response to requirements documents produced by the scientific community. In this way, ESA is allowing its investments in data set development to be driven by the needs of the relevant international user communities. In response to a request from ESA in spring 2010, a workshop was held in October 2010 in Zürich which was attended by representatives of the five SPARC activities engaged in analysis of satellite observations: ozone profile trends, water vapour trends, temperature trends, stratospheric aerosols, and the SPARC Data Initiative. This choice was made in light of the tight timeline for launching the first phase of the ESA-SPARC initiative. The workshop participants produced a draft "measurement requirements document" to move forward on its initiatives, which was presented at the SSG meeting, approved in principle, and finalized shortly afterwards, before being submitted to ESA. This document will drive work packages through the ESA STSE.

The first phase of the ESA-SPARC initiative is expected to last for two years, likely followed by subsequent phases in which more complex uses of ESA data could be considered. The discussion at the SSG meeting also highlighted the value of this sort of user-driven assessment for other observational data as well, not only from other space agencies but also from ground-based networks. It was decided that the next SPARC SSG meeting should include a longer and more wide-ranging and broadly-based discussion of SPARC measurement needs.

### *Geoengineering*

**A. Robock** presented a comprehensive overview on geoengineering ("Smoke and mirrors: Is geoengineering a solution to global warming?"), which has a large visibility in environmental politics, but is also an increasing component of scientific research (it will figure in several chapters of the IPCC AR5). The term was introduced in the atmospheric science community by Paul Crutzen and Tom Wigley in 2006, when they suggested the idea of temporary geoengineering as an emergency response against climate warming. They suggested that cooling of the Earth's surface might be achieved by artificial injection of sulphur dioxide into the lower stratosphere, mimicking the effect of volcanic eruptions, which have had a demonstrable cooling effect on climate. Today, a variety of possible methods are discussed as "geoengineering". However, risks (depending on the individual method) might include: regional climate change, including a global reduction of precipitation with regional droughts; rapid reversal of the cooling effect when the application is stopped; continued ocean acidification; ozone depletion; effects on plants by changing the partitioning between direct and diffuse light; and unknown impacts on cirrus clouds. Even if the risks would be judged to be acceptable, the technical feasibility of any particular method needs to be ensured and the costs need to be properly quantified. T. Peter presented new results regarding geoengineering related to injection of sulfur dioxide into the stratosphere, taking into account the problem of enhanced stratospheric ozone depletion. Several modelling groups within the SPARC CCMVal community are currently engaged in studies of geoengineering. A. Robock described the geoengineering model inter-comparison project that he is leading (GeoMIP) within the context of CMIP5 (although not formally part of it). He encouraged the participation of the SPARC community, especially to focus on the impact on stratospheric ozone. The SSG welcomed GeoMIP as an official SPARC activity.

## The future of SPARC

**G. Asrar** (Director of the WCRP JPS) chaired a panel discussion on the future of SPARC. This included a discussion of whether SPARC should change its name. This topic is covered in more detail in a separate article elsewhere in this issue.

## SPARC infrastructure and upcoming meetings

SPARC gratefully acknowledges the generous support for the SPARC International Project Office from the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS), the Canadian Space Agency, Environment Canada and the University of Toronto. After 8 years, however, the SPARC office now is in the process of moving from Toronto (Canada) to Zürich (Switzerland) because of a lack of continued funding resources in Canada with the demise of CFCAS, which has been the primary sponsor of the Toronto office. For the new office in Zürich, SPARC has been fortunate to have obtained financial support from ETH Zürich, MeteoSwiss, and the Swiss Federal Office of the Environment. 2011 is the transition year during which the office in Toronto will remain operational, while the office in Zürich gradually builds its capabilities, to ensure a smooth handover.

Norm McFarlane was the Director of the SPARC office in Toronto for many years. T. Peter thanked him on behalf of SPARC for his continuous, altruistic efforts, his enthusiasm and his wisdom. Norm McFarlane resigned as office director at the end of the SSG meeting and passed the responsibility on to Johannes Stähelin.

The next SPARC SSG meeting is planned to take place in Zürich in early 2012.

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# "Future of SPARC and WCRP – post-2013"

## Moderated panel discussion followed by an open discussion

### Panel members: Ted Shepherd, Tom Peter, A. R. Ravishankara
### Moderator: Ghassem Asrar

**A panel discussion on the future of SPARC and WCRP was held during the 18th Session of the SPARC Scientific Steering Group, 2-5 February 2011 in Pune, India. How should SPARC react to the changing demands facing the WCRP?**



**Ghassem Asrar**, Director of WCRP, opened the panel discussion by pointing to the future function and structure of WCRP and its projects. Most of the activities of WCRP belong to the recently established "Global Framework for Climate Services (GFCS)", which promises to harmonize climate research with the needs of stakeholders. To this end, newly devised Core Projects and Modelling and Observations Councils would be formed to provide leadership and coordination post-2013. The current plan is that after 2013 there would continue to be four Core Projects, which would be built on the heritage of the existing Core Projects but would focus more on the interfaces between the physical climate system components, namely: (a) Land-Atmosphere, (b) Ocean-Atmosphere, (c) Cryosphere, and (d) Stratosphere-Troposphere. SPARC will evolve into the Stratosphere-Troposphere project, *i.e.*, its mandate will need to include a much stronger tropospheric component than has been the case so far. Exactly how this evolution of the Core Projects would be implemented in practice is a matter of current discussion. Moreover, the role of cross-cuts (*e.g.*, monsoons) will need to be revisited. The Joint Scientific Committee (JSC) of WCRP had requested that the current Core Projects consider the future structure and report to the next JSC meeting their views on the implications for the sub-structure of the Core Projects within the future WCRP.

### From the Chairs

Following G. Asrar's introduction, the three panellists presented their thoughts on the future of SPARC. **A. R. Ravishankara (Ravi)**, former co-chair of SPARC 2003-2007, focused on several points:

1. *Voluntary nature*. He reminded everybody of the voluntary nature of WCRP activities, which are meant to coordinate and facilitate climate research. Therefore, SPARC activities must be of direct interest to scientists and must help them in their research efforts. He also noted that this voluntary nature of the activities can bring in new people and even "unlikely players", and helps to avoid being insular. To some extent, the ability of SPARC to work with others can be viewed as a measure of its maturity and interest in tackling new challenges.
2. *WCRP and SPARC*. WCRP has looked to SPARC to bring "chemistry" into WCRP. Indeed, SPARC should be at the forefront of this issue.
3. *Ozone assessments*. He expressed his hope that SPARC will continue to contribute significantly to the WMO/UNEP Ozone Assessment. He stated that "SPARC has done a yeoman service in many areas" that has helped the ozone assessment by setting up projects such as CCMVal, providing the "work force" for the assessments, *etc*. In return, he believed that SPARC has been greatly helped by its association with the assessment activity. The assessments have been one of the measures of SPARC contribution to societal issues.
4. *Stratosphere and climate*. The time has come to move from stratospheric ozone depletion to stratospheric changes and their influences on surface and global climate. In this context water vapour in the UTLS was an important topic for SPARC, which he suggested could be taken up as an overaching theme for many of its activities. This could include connections between measurements and modelling, a strengthening of lab work, and developing connections to weather.
5. *Lab studies and data evaluations*. He stressed the importance of laboratory studies and data evaluations and suggested to continue thinking about developing and supporting assessments of laboratory data. This cadre of scientists was getting thin and its value would be starkly visible when it is lost. He suggested strengthening this link with IGAC, and to think about expanding it to GEWEX.
6. *Depth vs. Breadth*. Finally, Ravi made a plea to keep the depth in important fields. He said that "it may not look sexy or interesting to all – but it will provide fruits that will be appreciated." The balance between keeping depth and breadth at the appropriate levels makes it possible for organisations like SPARC to succeed.

Next, **Tom Peter,** co-chair of SPARC, introduced the following issues:

1. *Tropospheric processes*. SPARC's envisaged future evolution and the balance in SPARC's activities between stratospheric and tropospheric processes is the greatest opportunity and challenge for SPARC during the next two or three years. Questions that require the community's attention are: As we certainly cannot and do not want to encompass the whole troposphere from the ground to the tropopause, on what basis do we constrain our tropospheric activities? And do we need or want a new name to reflect the change? Or should we keep the brand "SPARC"?
2. *Societal values*. In any future endeavours, SPARC should ask what it is that we deliver of value to society. We should analyse the pipelines that we feed into: upward, where high-level organisations such as WMO/UNEP and IPCC make use of our work; and downward to users, such as weather and climate services or individual scientists.
3. *Modelling and data initiatives*. SPARC is well set up with its modelling and data initiatives, such as CCMVal or the SPARC Data Initiative. CCMVal would

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now go into its second round and would naturally pick up on tropospheric issues. He stressed that also these initiatives should be based on SPARC's general model of "bite-sized" deliverables.

4. *Capacity building*. SPARC should keep capacity building aspects in all that we do.
5. *Collaborations across WCRP boundaries*. There is an urgent need to work with other communities, in particular IGAC and IGBP; we should pay close attention to how we treat AC&C. Other groups may think and plan differently, so we should allow for this in order to avoid untenable expectations.

Ghassem Asrar agreed that different communities would feel and operate differently, and that bridging gaps will be one of the challenges ahead. He then turned to **Ted Shepherd**, the other co-chair of SPARC:

1. *Community feeling*. Ted reminded everyone of the "SPARC – Quo Vadis?" presentation that he gave on behalf of the co-Chairs during the 2008 General Assembly of SPARC in Bologna. In that presentation he had posed the provocative question of whether SPARC, with its strong stratospheric focus, would have a place in the future WCRP as it appeared at that time. There was a very strong community reaction, with a vigorous plea to keep the SPARC community and culture together. The balance and integration within SPARC between various aspects of stratospheric science, *e.g.*, modelling *vs.* observations and physics *vs.* chemistry, was much appreciated by the community, as was SPARC's emphasis on having activities with a clear focus, deliverables, and timeline. This response should be taken into account in the present discussion.
2. *Continuity in evolution*. Many SPARC scientists are also working on tropospheric issues, and furthermore the presentations at the (Pune) SSG meeting had made it evident that most SPARC activities are already addressing or planning to address connections with the troposphere, as this is where the science is naturally heading. This means that with respect to many issues it will not require a change in direction within SPARC to establish a closer link to tropospheric processes, rather a broadening of the scope of SPARC activities to allow the present developments to continue.
3. *Scientific Steering committee (SSG)*. SPARC should consider getting tropospheric scientists onto the SPARC SSG in order to facilitate the current development. In particular if we could find colleagues from the tropospheric community who are excellent in their science and have a proven interest in stratospheric science, we should aim to nominate them for the SSG.

### *Plenary discussion*

Ghassem Asrar then opened the discussion for the plenary. The subsequent summary mentions only some of the more important (from the co-chairs' perspective) discussion points, while the full discussion touched upon a multitude of more detailed issues.

### *Extension into the troposphere*

Several SSG members expressed their view that SPARC was evolving in a reasonable manner. Concerning the question of whether SPARC should change its name in order to better reflect the representation of tropospheric processes, **John Burrows** (SSG), **Marv Geller** (SCOSTEP) and **David Fahey** (SSG) concluded after some discussion that a name change would indeed be advantageous, but that we should not change the stratospheric emphasis and should attempt to keep the acronym and logo. **Greg Bodeker** (SSG) added that the acronym and logo were not as important as maintaining the community, and that therefore it would be important to clarify that we are not moving into the troposphere, but extending down into it. **Alan Robock** (Geoengineering) stated that SPARC is a great brand – "if it ain't broke, don't fix it".

**Michaela Hegglin** (Data Initiative) stated that so far as SPARC is concerned, the extension into the troposphere is evolution, not revolution, and is being driven in large part by the scientific tools: both chemistry-climate models and satellite measurements are providing increasing capabilities across the UTLS which are driving major scientific efforts on the coupling between troposphere and stratosphere. SPARC should not try to "take over the troposphere" but should let the science drive its evolution.

### *Exciting science questions*

**Norm McFarlane** (outgoing SPARC Director) asked which exciting new science questions would require international coordination – things that no single organisation could do, but where SPARC could facilitate research. This question triggered several discussion streams.

**Greg Bodeker** suggested that the question of what maintains the background level of stratospheric sulphur could be a new goal-oriented SPARC project. There is a need to understand the stratospheric sulphur budget before the next big volcano goes off or geoengineering applications are developed, so implementing sulphur interactively in the models instead of prescribing it is an important task. Trends of $SO_2$ at the tropopause might constitute an anthropogenic component. **Paul Newman** added that stratospheric sulphur was an under-considered and under-funded topic. **Alan Robock** agreed that such an activity would complement the GeoMIP activity and could help in handling the scientific questions raised by the next big eruption, and suggested that the time has probably come for another PMIP (Pinatubo Model Intercomparison Project) exercise. **Ken Jucks** (NASA) added that SPARC should consider putting forward these recommendations to the space agencies.



**Mike Kurylo** (NDACC) and **David Fahey** supported Ravi's suggestion to consider the topic of stratospheric humidity as a SPARC theme, but also demanded fixed deliverables and deadlines, as stratospheric humidity is a wide paint brush, so particular goals need to be scaled to an achievable time frame and to the resources available.

**Elisa Manzini** (DynVar) argued that there are many exciting science questions focused around stratosphere-troposphere dynamical coupling, not just in terms of the large-scale dynamics (already a focus of SPARC), but also on smaller scales through convection and gravity waves. She suggested that the use of global convection-resolving models could lead to some very exciting science. **Norm McFarlane** pointed out that even though a TTL initiative had not emerged from the Victoria workshop because of the daunting nature of the scientific questions, there was still widespread interest in this topic.

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A guest to the SSG, **Dev R. Sikka**, who has made pioneering contributions to monsoon meteorology, droughts, tropical cyclones and numerical weather prediction, made the specific recommendation that an investigation of atmospheric signals in early monsoon onset could become a productive topic for SPARC, which links the stratosphere and the troposphere, has a major impact on the water vapour budget, and is of high societal relevance.

**Veronika Eyring** (SSG, CCMVal) argued that the SPARC activities in chemistry-climate modelling would need to broaden, not just to include tropospheric chemistry but also to evolve into a more integrated approach to Earth System Modelling. **Alan Robock** noted that SPARC already has a unique role within the CMIP5 constellation so is well placed to make this happen. However, **Johannes Stähelin**, incoming Director of the SPARC Office, noted that even a mere extension of the CCMVal activities into the troposphere would require good support from the tropospheric groups, *e.g.*, from IGAC and IGBP on the chemistry side.



*Improving observational data sets and observing systems*

Although the WCRP is not in the business of making sustained observations, it has a critical role to play in supporting and enhancing the observational network. Much of the discussion centred on these topics.

**Michelle Santee** (SSG) emphasised the value of long-term data sets, and raised the concern that the post-2013 era may also be the post-limb (ENVISAT, Aura, Odin, SciSat-1) era. **Saroja Polavarapu** (Data Assimilation) stated that SPARC must make the case to the operational prediction centres for the value of limb measurements, to complement the operational nadir measurements. **Thomas Piekutowski** (CSA) suggested that it would be beneficial for SPARC to make more scientific use of operational data (*e.g.*, from IASI), to strengthen the links with the operational centres.

**Saroja Polavarapu** also raised the issue of how to support ground-based networks, which, unlike space-based measurements, do not have the industry lever behind them. **Mike Kurylo** suggested that making better use of observations makes a better case for continued and new observations, and that SPARC has a particular role in making that happen. In particular, SPARC can help show the value of using the full suite of observational data products, both space-based and ground-based, which allows a better understanding of the value and limitations of particular data products within this broader context. **Claus Zehner** (ESA) added that from the space agency perspective, SPARC activities have always been particularly effective because of their focus on clear deliverables including valuable documents and data sets.

**Saroja Polavarapu** pointed out that data assimilation provides another perspective on measurement requirements, and the development of coupled data assimilation (*i.e.*, coupled to the Earth's surface) and surface flux inversion may help quantify the combined value of ground-based and space-based measurements. **Ted Shepherd** added that a greater focus on seasonal and sub-seasonal prediction within SPARC would similarly provide another perspective on measurement requirements for initialization and validation.

*Capacity building*

Finally, **Roseanne Diab** (SSG) reminded everybody of the need to integrate capacity development into the mainstream programme of SPARC. There was a brief discussion, which rapidly concluded that the 2012 SSG meeting in Zurich should have a dedicated agenda item devoted to this issue.

Ghassem Asrar thanked all participants for their useful input and closed the panel discussion.

♦

# *Should SPARC change its name?*

## Tom Peter and Ted Shepherd, SPARC co-Chairs

The WCRP is undergoing an internal restructuring which will see revised mandates for the four core projects to respond to scientific developments since those mandates were originally established — in most cases, around 20 years ago. SPARC is being asked to develop a stronger focus on stratosphere-troposphere coupling. This will involve a stronger engagement with tropospheric processes than has been the case so far. CLIVAR and GEWEX are being asked to focus on, respectively, ocean-atmosphere and land-atmosphere coupling, while CliC will continue to focus on cryosphere-climate coupling. Each core project is in the process of determining what this development implies for its programme of activities; see, for example, the report on the Panel Discussion at the last meeting of the SPARC Scientific Steering Group (SSG) elsewhere in this newsletter. As part of this process, the core projects are also being asked to consider whether a name change might be appropriate, to reflect the revised mandates. In the case of SPARC, this question was raised as part of the Panel Discussion to get a first impression of the views of the SSG. But any name change would also need the support of the SPARC community. The purpose of this appeal is to initiate such a discussion, for further consideration at the next SSG meeting in February 2012.

It can be argued that SPARC's name remains appropriate if "climate" is understood to include the troposphere — indeed it could be argued that SPARC's name is more appropriate now than it was originally. It can also be argued that the SPARC "brand name" has strong resonance within the community, among both scientists and funding agencies, based on its track record of delivering extremely useful, value-added scientific products. However, one can argue that so long as the legacy is clear and the core principles of the project are maintained, the community will transfer their loyalty (*e.g.*, NDSC has changed to NDACC without loosing its impact). Moreover, a name change provides an opportunity for people outside the project to take notice of the project's evolution. Given the increasing focus on climate services, it can be argued that having the word "troposphere" in the new core project's name would make it easier for scientists and agencies to justify their investment in it — not only those presently involved in SPARC, but also those we will need to involve in the future in order to achieve our scientific goals.

A possible middle ground is to change the name but not the acronym, in order to maintain some continuity while signifying the evolution: *e.g.* Stratosphere-troposphere Processes And their Role in Climate (SPARC)[1]. The bottom line, of course, is that whatever decision we will make concerning a name change has to serve the scientific agenda of the new core project, and that means serving the scientific community that will be represented by it. So we need your feedback on this question, and would therefore like to open a web-based discussion on this topic.

To this end we ask you to please visit the SPARC website **http://www.atmosp.physics.utoronto.ca/SPARC** where you will find a link to a blog, which you will find useful to express your own opinion and to react to the opinions of other participants. A lively discussion would be great, *e.g.* discussing what the enlarged mandate will mean for the character of SPARC, and how to best cope with this. Opinions on the name might vary between not changing the name at all and choosing a new name without resemblance to the old one. We are interested in your opinion and hope for your input and support in this important matter. Should we change SPARC's name?

[1] *Other proposed names that were discussed by the SSG included " Stratospheric and tropospheric Processes And their Role in Climate", "Stratosphere-troposphere couPling And its Role in Climate", or "Stratospheric and related tropospheric Processes and their Role in Climate". There were also name suggestions that would require a change of the acronym, but in the SSG discussion these did not receive broad support – and you might well have a different opinion.*

# Report on the 32th Session of the Joint Scientific Committee of the World Climate Research Programme

## 4-8 April 2011, Exeter, UK

**J. Stähelin,** ETHZ, Switzerland (johannes.staehelin@env.ethz.ch)
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### Report on WCRP Developments

The Joint Scientific Committee (JSC) oversees the work of WCRP with its four core projects CLIVAR, GEWEX, CliC and SPARC, and a large number of Working Groups and cross-cutting activities. **A. Busalacchi** (chairperson of the JSC) introduced the new JSC members and reported on recent WCRP developments. He emphasised that the WCRP will focus its climate research increasingly on societal needs. Indeed, science products of the WCRP are part of the "Global Framework for Climate Services (GFCS)", which underlines the importance of user-oriented research. Particularly important GFCS products are those connected to the regional scale. For SPARC, whose traditional focus is on global problems, this is a challenging development. Busalacchi stressed that the WCRP needs to provide the scientific basis for the GFCS, and he reminded everybody that the WCRP is currently in the process of revising its structure. This entails, for instance, the extension and revision of the mandates of the core projects, and the establishment of two councils (one for modelling and another for climate observations and analysis), as well as a number of "grand challenges" (see below).

**G. Asrar** (Director of WCRP) reported on developments of the Joint Planning Staff, the programme personnel and budget of WCRP. He also reported on important activities such as CORDEX (COordinated Regional climate Downscaling EXperiment), which allows for training of scientists in emerging and developing countries, *e.g.* in Africa, for which CORDEX has a particular focus (see below).

**J. Hurrell** (in his role as Chair of the OSC Scientific Organising Committee) reported that the preparation of the WCRP Open Science Conference (OSC), is well advanced, but that turning the OSC into an outstanding scientific event with high international visibility will require continuing efforts. The OSC will take place 24-28 October 2011 in Denver, USA. It intends to cover all relevant aspects of climate research within and to some extent beyond WCRP.

### Global Framework for Climate Services and Sponsors Roundtable

All sponsors of the WCRP presented their views and needs. **J. Lengoasa**, representing the World Meteorological Organization (WMO), reported on the status of the GFCS. He pointed to the important role of the dialogue with politicians, and emphasised that politicians expect the GFCS to provide guidance for decisions on various options, including their financial consequences.

The International Council for Science (ICSU) was represented by **L. Goldfarb**. She reported on the "ICSU Visioning" process, from which the "Initiative on Earth System Research on Global Sustainability" was developed.[1] Within this initiative, ICSU pursues a holistic approach towards defining its five "Grand Challenges" (Forecasting – Observing – Confining – Responding – Innovating), exploring options and proposing steps for their implementation. In this process, the dialogue with stakeholders has high priority. Goldfarb argued that the WCRP would clearly see itself as contributing to "forecasting" and "observing", but that it should discuss how it could contribute to the other three Grand Challenges as well. ICSU is also supporting the United Nations Conference on Sustainable Development (Rio+20), which will take place 4-6 June 2012 in Rio de Janeiro, Brazil. The WCRP was asked to help name appropriate experts for the Global Environmental Change programmes in ICSU/UNESCO regional science and technology workshops, which will take place in conjunction with the Rio+20 Conference.

**W. Watson-Wright** spoke on behalf of the Intergovernmental Oceanographic Commission (IOC) and identified the following topics as goals of mutual interest for IOC and WCRP: stratification in temperate seas and oceanic gyres, upwelling systems and changes in wind regimes, the thermohaline circulation, and sea-level rise. Participants agreed that strengthening the observing system should be a high priority. **E. Lindstrom** (chair of the GCOS Ocean Observation Panel for Climate, OOPC) discussed the framework for ocean observing systems in order to obtain an integrated network of sustained ocean observations. A multitude of important oceanic observations are currently performed, but continuity needs to be ensured, which requires a multidisciplinary approach building on existing structures and best practices. This also requires introducing "Essential Ocean Variables" as the common language, assessing the "readiness" based on feasibility, and connecting its observation requirements to the needs of society and of the research community.

### Reports by Partner Organisations

Partner organisations of the WCRP also presented their programmes and views. **S. Seitzinger** reported on current activities and plans of the International Geosphere-Biosphere Programme (IGBP). IGBP is based on an Earth System approach, and several of the projects of IGBP are of interest to WCRP. IGBP's Earth System definition includes human, social and economic interactions, thus is much broader in scope than WCRP. IGBP will work towards its vision in partnership with other organisations and hopes for more collaboration with

[1] http://www.icsu-visioning.org/wp-content/uploads/Grand_Challenges_Nov2010.pdf

WCRP. WCRP-related studies address for example climate and air quality, the impact of nitrification, megacities, and the impact of potential future geoengineering applications. IGBP is organising a major conference in early 2012 entitled "Planet under Pressure". They welcome contributions from SPARC and AC&C (Atmospheric Chemistry and Climate), the joint project of SPARC and IGAC (International Global Atmospheric Chemistry, a project of IGBP). This conference will also serve as a platform to highlight key outcomes from the WCRP OSC.

**A. Simmons** explained that the Global Climate Observing System (GCOS, a joint undertaking of WMO, the United Nations Educational Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and ICSU) provides scientific and technical guidance for the observation of climate variables and for transmission of fundamental climate data. He expressed concern that the apex might have been reached in terms of climate observations. GCOS sees a tendency for slippage in the USA, while Europe and Canada continue to look strong. Since the observing system serves many purposes, it might sometimes be easier to justify climate observations if they can be shown to also improve forecasts for severe weather, for example.

**D. Wallace** presented SOLAS, the Surface Ocean - Lower Atmosphere Study. He identified a need to reinvigorate the surface flux working group, and to get GEWEX and SOLAS, amongst others, together in one discussion group. A co-hosted workshop on surface fluxes would be a good starting point.

**G. Brunet** presented two research initiatives of the World Weather Research Programme (WWRP) – "Sub-seasonal to Seasonal Prediction" and "Improvement of Weather and Environmental Prediction in Polar Regions".

## Core Project Reports

The pillars of WCRP are the four core projects, GEWEX, CLIVAR, CliC and SPARC. **K. Trenberth**, the chair of the GEWEX SSG, gave an overview of the most important activities of the project over the past year. The main science questions that GEWEX is trying to answer concern the flow of water and energy throughout the atmosphere and the land-surface, and how these are changing in response to climate change and anthropogenic activity. Challenging problems remain concerning the homogeneity of important long-term measurements such as optical thickness, high clouds, and precipitation amount, with particularly large inhomogeneities evident whenever measurements of individual satellite instruments need to be merged. Activities concerning research on monsoons and extremes were discussed, as they might not be adequately addressed in the new WCRP structure and could become a major project or a grand challenge. Within its new mandate, the core mission of GEWEX will focus on the interaction between land and atmosphere, while continuing to embrace the global energy and water cycles, as well as monsoons and extremes as cross-cutting activities. GEWEX has developed a strategy to implement the new mandate, implemented a new internal structure, and produced vision and mission statements. The proposed new name of the core project is "Global and regional Energy and Water Exchanges" (GEWEX), implying that the present acronym will be retained.

The activities of CLIVAR (Climate Variability and Predictability) were presented by the two co-chairs, **J. Hurrell** and **M. Visbeck**. CLIVAR has a very wide portfolio: much, but not all, of its science falls under the label 'ocean-atmosphere' including existing critical interactions with GEWEX, CliC and SPARC. J. Hurrell presented the general work related to modelling of climate change, with important tasks realised within the Working Group on Coupled Modelling (WGCM, see below), a very relevant activity in the context of the upcoming 5th Assessment Report (AR5) of the IPCC. M. Visbeck presented the activities of CLIVAR related to the oceans. In future, CLIVAR plans to extend its cooperation with certain activities of the IGBP. The new mandate of CLIVAR highlights the interaction between the ocean and the atmosphere even more, and the CLIVAR SSG will discuss the implications of the revised organisation of WCRP for CLIVAR in its upcoming meeting. It was importantly noted by some that tackling the challenges connected with anthropogenic climate change, which has previously been largely the remit of CLIVAR, now requires strong scientific collaboration across all of WCRP.

The most important activities of CliC (Climate and Cryosphere) were summarized by **G. Casassa** the Vice-Chair of CliC. The aims of CliC are to assess and quantify the impacts that climatic variability and change have on components of the cryosphere, and the consequences of these impacts for the climate system. In addressing this aim, CliC also seeks to determine the stability of the global cryosphere and provides inputs and expertise to enable the prediction of the climate system's cryospheric parameters. The long-term goals include the prediction of the Arctic and the Antarctic climate system, prediction of the terrestrial cryosphere, and improved assessment of past, current and future sea-level variability and change. One of the present foci of CliC is to understand the factors that determine sea-level in order to be able to predict future sea-level rise. One of the concerns regarding predictability, which might also have implications for the future work of SPARC, is that the interaction of Arctic sea-ice with the atmosphere is not sufficiently well represented in coupled models.

**T. Peter** and **T. Shepherd,** co-chairs of the SPARC SSG, presented an overview of the most important activities and high-lights of SPARC over the last year. The publication of the peer-reviewed CCMVal Report was a major milestone, pioneering the systematic use of process-oriented performance metrics to evaluate chemistry-climate models against measurements, which is a rapidly growing area of climate research. The CCMVal Report was the result of a strong community-based research effort. It provided key input into the 2010 WMO/UNEP Scientific Assessment of Ozone Depletion. The CCMVal modelling results are also providing climate-relevant information, as it has now been clearly demonstrated that the ozone hole has been the principal driver of past changes in summer-time surface climate in the southern hemisphere. The recovery of the ozone hole is predicted to largely offset the effects of greenhouse gas increases on future summer-time circulation changes. The SPARC presentation also highlighted impressive progress and engagement of the scientific community in several SPARC activities — the SPARC Data Initiative, DynVar, SOLARIS, and gravity waves — and noted the new activity on analysis of ozone profile changes, the ESA-SPARC initiative, and GeoMIP (see Report on the SPARC SSG meeting in this issue of the newsletter). Uncertainties in tropical dynamical features in reanalysis products were identified as the potential focus of a future SPARC activity. In the discussion, it was stated by the JSC that the approach taken by SPARC to organise the analysis and reconcile data sets could be used as a model by other groups.

Under its new mandate, SPARC becomes responsible for interactions between the stratosphere and troposphere. This implies that SPARC needs to extend its activities into the troposphere, to an extent yet to be fully determined. It was emphasised that this evolution is happening naturally within virtually every SPARC activity, as this is where the science is heading, and that SPARC's overall scope should likewise be driven by the science. An important step in this direction is the extension of CCMVal into the troposphere, where previously only stratospheric chemistry-climate models were assessed. It follows that no drastic reorganisation of SPARC is required in order to facilitate its future evolution. The results of the preliminary discussion concerning a possible name change for SPARC (see the "Future of SPARC and WCRP – post-2013" in this issue) were also presented.

In a separate presentation, T. Peter reported on AC&C, the SPARC/IGAC cross-cutting activity "Atmospheric Chemistry & Climate". AC&C is a joint effort of IGBP and WCRP, carried out by their core projects IGAC and SPARC, respectively. AC&C pursues three modelling activities: (1) Hindcasts 1980-2007: To evaluate tropospheric CTMs and CCMs with respect to past trends and variability. (2) Vertical Distributions: To investigate upper tropospheric chemistry, convection, scavenging, and strat-trop exchange. (3) Atmospheric Chemistry & Climate Model Intercomparison Project (ACC-MIP): To perform time slice runs and emission sensitivity studies complementing CMIP5 (formerly Activity 4). From a SPARC perspective the activity would benefit from a bottom-up approach, *e.g.*, from a workshop, to develop a clear timeline and get community buy-in (from both IGAC and SPARC). For more detailed information on AC&C developments see the "Report on the 18th Session of the SPARC Scientific Steering Group" in this current issue. The JSC welcomed the approach by the SPARC and IGAC co-chairs to elaborate an action plan for the next phase of AC&C, which is currently in progress.

The SPARC co-chairs further reported on the nomination by the SPARC SSG of Dr. Greg Bodeker (New Zealand) as the new co-chair to replace Tom Peter – for consideration of the JSC. The recommendation was later approved by the JSC.

## Reports by Working Groups, Panels and Task Forces

Much of the research of the WCRP is performed within working groups in close collaboration with the climate science community.

**J. Meehl** reported on the work of WGCM (Working Group on Coupled Modelling). An important task of WGCM is CMIP (Coupled Model Intercomparison), which uses a standardized experimental protocol for studying the output of coupled ocean-atmosphere general circulation models. CMIP5 co-ordinates the climate simulations relevant for AR5, including decadal hindcasts and prediction simulations, centennial-timescale projections, and "atmosphere-only" (prescribed SST) simulations for especially computationally-demanding models. Within this framework several groups run additional experiments with atmospheric chemistry.

**A. Brown** reported on the activities of WGNE (Working Group on Numerical Experimentation). A major current focus of WGNE is to test physical parameterizations in climate models by making short-term weather forecasts within the framework of the Transport-AMIP project. **A. Scaife** presented results of WGSIP (Working Group on Seasonal to Interannual Prediction). He showed some new results illustrating that some model biases in variability are associated with errors in the underlying model climatology, and can be bias-corrected. He emphasised the need to improve the representation of sea-ice in weather forecast models. Greater participation by the sea-ice community (and CliC) will be required to fully exploit the predictability of sea-ice thickness identified by the WCRP Workshop on Polar Predictability.

**F. Giorgi** presented results from CORDEX, the COordinated Regional climate Downscaling EXperiment, for which Africa is the domain of highest priority (although other areas are studied as well). The activities include scientists from the statistical downscaling community. CORDEX is very important for the WCRP as it connects directly with the regional user communities for climate change, health, and food supply. Giorgi pointed to problems of validating regional models with observations, because the available measurements (*e.g.*, for precipitation) sometimes significantly disagree with each other. The regional models are credible, but there is also the issue of how the information is being used. It is important to communicate what the models can and cannot do. There is only one modelling group from Africa contributing to this effort, and the regional groups need to take more ownership. He further argued that CORDEX should be just one component of a larger regional prediction initiative.

T. Shepherd reported on the WCRP Workshop on Seasonal to Multi-decadal Polar Predictability (see Report in SPARC Newsletter No. 36), which was held in Bergen, Norway in October 2010. It was decided that some form of WCRP cross-cutting activity was needed in this area, and that the next step was to develop an implementation plan drawing on all parts of the WCRP, as well as relevant partners such as WWRP.

WCRP plans to replace WOAP (WCRP Observations and Assimilation Panel) with the WCRP climate observations, analysis and information council. **S. Gille** reported on the progress of the task team to develop the transition from WOAP to the new council, and **M. Manton** presented the progress of WOAP's TGDM (Task Group on Data Management). A. Busalacchi reported on a WCRP Modelling Coordination Meeting, which recommended that a modelling council be formed to ensure an effective dialogue with partners and to promote model development. **G. Flato** presented the results of a task team on the role of WCRP research in climate services. WCRP represents the research community providing the scientific basis for the GFCS. Users and clients have particular needs and demands, and identifying climate information needs will help to coordinate and prioritize efforts across WCRP and promote best practices.

## Presentations by Space Agencies

Presentations were given by representatives of space agencies (ESA, NASA, EUMETSAT). **M. Doherty** reported on the ESA Earth Observation programme, including an overview of the Climate Change Initia-

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tive. He made the point that government agencies had to be engaged to fund this programme, and that scientists have a key role to play in advocating that the data be made freely available. He felt that this message is not being communicated publicly and clearly enough. **E. Lindstrom** spoke about NASA's programme. In order to engage the science dimensions in NASA, it would be useful to have the grand challenges posed by WCRP. Concerning sustained ocean observations, he sees an opportunity to better connect the observing systems to the information outcomes needed for science and society. **J. Schulz** provided a review of EUMETSAT. He stressed that monitoring of the climate system should be just as high a priority as its prediction, and that the two issues are inseparable. He also pointed to a possible opportunity for collaboration with WCRP, as EUMETSAT embarks on building the ocean component into its mission. During the subsequent discussion, the group expressed interest in helping the position of EUMETSAT, and pointed to opportunities for expansion and further engagement from the WCRP standpoint.

## New structure of WCRP

Several times during the meeting the new structure of WCRP was discussed, with the discussion chaired by **D. Griggs** (outgoing vice chair of JSC). According to the discussions that have taken place during several earlier JSC meetings, the core projects have obtained revised mandates (see core project reports above), which should be implemented over the next two years. Coordination of modelling, and of observations and analysis activities across the WCRP will occur through respective councils, whose terms of reference are being developed. Several crucial organisational aspects for the WCRP nevertheless remain unresolved: how to organise regional climate prediction activities, how to organise the various cross-cutting activities, and how to connect to the user community. At previous JSC meetings it was suggested that WCRP define limited-term "grand challenges" that would link the work of the different core projects to a clear societal benefit. A few straw proposals for "grand challenges" were discussed but no decision was made on whether this was a useful approach. It was decided to postpone this decision until the next JSC meeting, which will take place immediately after the OSC in October 2011.

## ANNOUNCEMENT

### NOW AVAILABLE!

Twenty Questions and Answers about the Ozone Layer: 2010 Update

By David W. Fahey,
NOAA Earth System Research Laboratory
And Michaela I. Hegglin,
University of Toronto

From the UNEP/WMO Scientific Assessment of Ozone Depletion: 2010

This outreach document is intended to bring the ozone depletion story to a broad scientific and public audience. This expanded edition highlights (i) the beneficial dual role of the Montreal Protocol in protecting the ozone layer and climate and (ii) projections of future stratospheric ozone abundances. These projections include expected reductions of ozone depleting substances (ODSs) and changes in stratospheric temperatures and transport caused by climate change.

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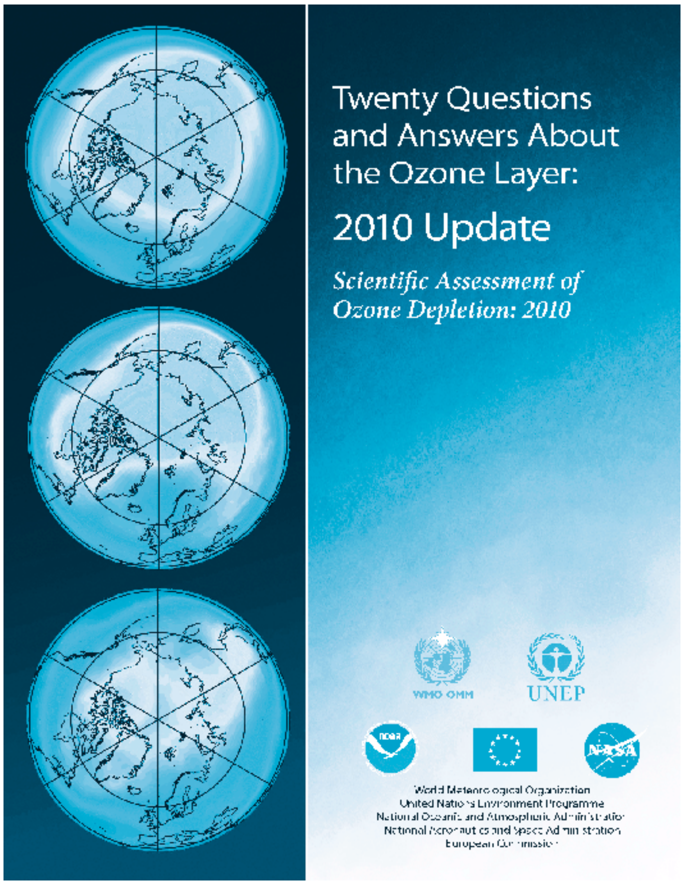

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# The Workshop on Tropical Stratosphere-Troposphere: Implications on Indian Monsoon and Climate

## 31 January – 1 February 2011, Pune, India

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A two–day workshop emphasising SPARC-related research activities in India was held immediately prior to the SPARC SSG meeting at the Indian Institute of Tropical Meteorology (IITM) in Pune, India. This is the third such local workshop held back-to-back with a SPARC SSG meeting. As was the case for the previous workshops in Bremen (2007) and Kyoto (2009), the underlying motivation for holding this workshop was to focus attention on Indian research of interest to SPARC, and to engage the SSG and participants from the international SPARC community in discussion of future research activities and objectives than could be encouraged by SPARC. The workshop was well attended and included over 70 participants from several research institutions in India, as well as several SSG members and other invited participants from the international community.



The theme of the workshop, "Tropical Stratosphere-Troposphere: Implications on Indian Monsoon and Climate," was chosen to provide a focus for the programme while providing a comprehensive overview of the diverse range of research activities in India. The workshop's opening session included a welcoming address by **B. N. Goswami**, Director of the IITM, an inaugural addresses by **R. K. Shevgaonkar**, Vice-Chancellor of the University of Pune, and a keynote address by **T. G. Shepherd**. The main scientific programme was organised into four sessions of oral presentations. Posters were presented in viewing periods on the afternoon of the first day and during the morning break of the second day. The remainder of this report is devoted to summarizing the key presentations in these sessions.

### Session I: Monsoon, Climate, Model Predictability and Data Assimilation

**V. Ryabinin** gave an overview of the World Climate Research Programme (WCRP) under the subtitle "Evolving Science Partnership for Sustained Support to Emerging Climate Services". He began his talk by noting that the recent survey of the World Economic Forum pointed to the significantly reduced ability of governments and societies to deal with major new shocks, including extreme environmental events, as a result of the recent financial crisis. Climate change is perceived as the highest priority among the list of the top ten economic risks when assessed on the basis of both likelihood and impact. This assessment brings the role of the WCRP into focus. Its basic mandate is to encourage and coordinate research to improve understanding of climate predictability and the human influence on climate *"for use in an increasing range of practical applications of direct relevance, benefit and value to society" (WCRP Strategic Framework 2005-2015).*

The intermediate and long-term plans for the WCRP will focus on implementation of the Strategic Framework COPES (Coordinated Observation and Prediction of the Earth System), in conjunction with current WCRP core projects and activities in the near term (up to 2015). In the longer-term, there will be an emphasis on more effective interfacing with the users of climate information products. The forthcoming WCRP Open Science Conference, with the overarching theme of climate research serving society, is the key forum for presentation and discussion of the key ideas and research elements that will underpin WCRP activities in the future. In the meantime, the WCRP will to carry out its mandate to (a) provide scientific knowledge on climate variability and change, (b) facilitate research on climate projections and predictions on time scales of seasons to centuries, (c) put major emphasis on regional climate variability and change with special attention to extreme events, (d) support development and delivery of climate information for decision makers, (e) facilitate training of climate scientists around the world.

**D. R. Sikka** presented a broad overview of research issues and activities in India related to the monsoon climate, predictability in models, and data assimilation. He noted that the weather and climate in the Indian monsoon region has a number of features that involve the coupling between the stratosphere and troposphere. Injection of stratospheric ozone into the troposphere occurs in the winter season. During summer, deep convection plays an important role in the stratosphere-troposphere exchange, particularly in regard to tropospheric water vapour. The role of the Himalayan region is central to many of these processes. Modelling is now a key component of many research programmes, as well as in operational applications in the India Meteorological Department (IMD). A number of new observational tools are now available in India and being extensively being used by Indian researchers, including a new Tropo-Strato-Meso radar network and lidar observations for aerosol studies.

Continuing the theme of seasonal prediction activities in India, **M. Rajeevan** gave a talk focused on the prediction of the monsoon. Operational seasonal forecasting at the IMD has hitherto relied mainly on statistical models, which are known to have limited scope and skill, are constrained by such issues as epochal variation of predictor-rainfall relationships, and have a limited representation of processes contributing to observed monsoon variability. However, during the past decade there has been extensive experimentation using comprehensive numerical models for seasonal forecasts. The IITM is now running the NCEP coupled climate forecast system operationally, and is experimenting with other forecast systems. For example the EU funded ENSEMBLES project has focused on producing objective probabilistic estimates of uncertainty in seasonal and longer-term predictions, and the DEMETER project (Development of a European

Multi–model Ensemble System for seasonal to inter-annual prediction) provided an opportunity to examine simulations of the monsoon. Seasonal prediction systems in the ENSEMBLES project have improved in all aspects, mainly due to increased resolution and better representation of physics processes. However, climate models (*e.g.*, those used for IPCC assessments) continue to exhibit a number of monsoon simulation biases. Examples include excessive rainfall over the equatorial Indian Ocean and a related, excessively strong coupling between rainfall and sea surface temperatures (SST).

M. Rajeevan noted a number of past studies concerning stratospheric influence on the Indian monsoon. Rainfall associated with the monsoon exhibits a quasi-biennial periodicity, pointing to a link between monsoon variability and the quasi-biennial oscillation (QBO), and in fact stratospheric winds at Balboa Island were used by the IMD as a predictor in an earlier statistical prediction system. However, more studies of the coupling between the monsoon and stratospheric processes are now needed. They should utilise the available long time series of observations, in conjunction with coupled climate models.

## Session II: Stratosphere-Troposphere Dynamical Coupling and Structures

**T. Shepherd** gave an overview talk entitled "Mechanisms of Stratosphere-Troposphere Coupling in the Subtropics". He noted that the structure of eddy zonal momentum fluxes is a key aspect of the atmospheric circulation, is responsible for maintaining the westerlies and is linked to surface winds through momentum balance. Wave-induced momentum transfer (from Rossby waves and gravity waves) drives meridional circulations through Eliassen-Palm (EP) flux convergence (wave drag). The subtropical wave drag from synoptic scale waves extends continuously into the lower stratosphere where it provides an important component of the wave-driving for the Brewer-Dobson circulation (BDC). The wave-driven BDC raises and cools the tropical tropopause while lowering and warming the extra-tropical tropopause.

The key role of the subtropical jets in shaping the subtropical wave drag, and the associated stratosphere-troposphere coupling is manifest in such phenomena as the zonally symmetric mid-latitude response to El Niño Southern Oscillation (ENSO) and the strengthened BDC associated with climate change induced by enhanced carbon dioxide concentrations in the atmosphere. Recent theoretical and modelling studies have also related the monsoon onset with transitions from a linear regime, in which the mean meridional flow is constrained by momentum flux divergence, to a non-linear regime, in which the angular momentum is homogenized and there is no circulation constraint.

**B. V. Krishna Murthy** discussed the structure of the tropical tropopause layer (TTL) and its seasonal variations as determined from site-specific measurements of vertical profiles of temperature and ozone. In practice, different definitions of the tropopause are in use, related to the structural features of different variables and processes: the cold point tropopause (CPT), the lapse rate tropopause (LRT), the convective tropopause (COT), the ozone tropopause, and the clear sky radiative tropopause. However, the LRT and CPT, calculated with vertical profiles of temperature, are most commonly used. Time series of daily variations of the LRT and CPT show that they generally well correlated. The COT is identified as a level where the temperature corresponds to cloud top temperatures in radiosonde profiles. It may also closely correspond to the level in the upper troposphere where the potential temperature lapse rate has a minimum. The TTL can be defined as the region between the COT and the CPT. Station data (*e.g.*, from the Gadanki site) show that the depth of this region varies seasonally. During the summer monsoon season the level of the CPT is the lowest and the level of the COT is the highest. Multiple tropopause levels, as determined in accordance with the WMO definition, also occur, most frequently in the December to February period and have some latitudinal structure. These occurrences may be related to several different processes including horizontal advection, cirrus cloud formation, and modulation by gravity-wave activity.

**K. Rao** also discussed variations in the TTL structure as revealed by observations during undisturbed (relatively low rainfall) and disturbed conditions in the Bay of Bengal from the JASMINE (Joint Air-Sea Monsoon Interaction Experiment) and BOBMEX (Bay of Bengal Monsoon Experiment) campaigns in 1999. There are strong links between Indian monsoon variability on intra-seasonal time scales, and variations in convective activity over the Bay of Bengal. Disturbed and undisturbed periods are clearly evident in time series of brightness temperatures from METEOSAT, revealing the marked lowering of the brightness temperature in disturbed periods. There are pronounced differences in vertical humidity profiles between disturbed and undisturbed periods, with the upper troposphere being substantially moister in disturbed periods. In general the CPT is approximately 1.1$^{o}$ cooler and 470 m lower in altitude during disturbed periods. However the minimum lapse rate in potential temperature is higher and warmer, corresponding to higher values of equivalent potential temperature at the surface and convective available potential energy (CAPE). This situation is indicative of deeper, more energetic convection, and thus it was suggested that overshooting convection might contribute to the vertical shrinking of the TTL during disturbed periods. Parcels that overshoot the level of neutral buoyancy in the upper troposphere will become progressively colder than the environment and may result in general cooling of the vertical profile when mixing with ambient air. The associated vertical extent of the TTL is reduced by approximately 1.3 km.

## Session III: Tropical Tropopause Processes and Stratosphere-Troposphere Exchange

**T. Peter** discussed the impact of geoengineering on the TTL. The particular proposal under consideration was that of maintaining an increased stratospheric aerosol burden to compensate for radiative forcing at the surface, expected from increasing $CO_2$. Large volcanic eruptions, such as that of Mt Pinatubo, provide natural analogues that can be studied and may help to determine the consequences of implementing such a proposal. The dilemma of geoengineering proposals is that they may distract attention from the more fundamental issue of addressing the root cause of climate change induced by human activity. However, the appeal of mitigating these effects through geoengineering remains and must be evaluated using the best available scientific knowledge. It was noted that a recent report of the Royal Society has identified as a central issue related to geoengineering, as being a reliance on unproven and potentially dangerous geoengineering technologies that may nevertheless become necessary if emissions leading to increased atmospheric concentrations of $CO_2$ cannot be sufficiently reduced.

The work reported upon by T. Peter involved carrying out geoengineering model experiments based on a postulated injection of $SO_2$ at the equator at an altitude of 20 km. To this end, the SOCOL 3D chemistry climate model was coupled to the AER 2D stratospheric aerosol model. The AER 2D model employs a size-segregated aerosol model and permits evolution of the size distribution of aerosol particles in response to the stratospheric injection. The nonlinearity of the injection-burden relationship is an important factor in the results. Larger injections lead to more efficient coagulation, larger particles and greater sedimentation, resulting in a relatively lower aerosol loading. The overall conclusion of this work is that continuous direct stratospheric injection of $SO_2$ near the equator is an inefficient and costly geoengineering method. In contrast to conclusions from previous studies, the sizes of the aerosol particles may be substantially larger than those associated with volcanic eruptions. These larger particles have a lower albedo and are therefore less effective in offsetting the radiative forcing from increasing $CO_2$ concentrations. In addition, there are serious consequences for the TTL and the stratosphere. Potential effects include warming of the tropopause, moistening of the stratosphere, changed stratospheric dynamics, and additional ozone loss. Alternative strategies involving spatially distributed injections of sulphate aerosols from aircraft can be investigated. Initial evaluations of such schemes suggest that this method may be more efficient and cost-effective, but there could be detrimental consequences for cirrus clouds. There are also many modelling uncertainties that need to be quantified.



**K. Mohanakumar** gave an overview of the role of the Asian summer monsoon on stratospheric-tropospheric coupling in the tropics. The Indian summer monsoon (ISM) exhibits strong interannual variability that is controlled by several local and remote processes. There is also intraseasonal variability, manifested by active and break phases. About 75% of the water vapour transport in the upper troposphere in the ISM region from June to September is contributed by the monsoon circulation. Knowledge of the distribution and variability of upper tropospheric humidity (UTH) can, therefore, give insight into the mechanisms of monsoon variability. The interannual variations in UTH correspond well with those of rainfall, showing a clear reduction in 2002 and 2009 (examples of dry monsoon years with reduced rainfall). Drying of the upper troposphere over the Arabian Sea in 2002 was a result of an unusually long monsoon break from the end of June to mid-July, associated with dry air from Arabia capping the convection above the boundary layer. In contrast, 2009 exhibited a much larger-scale upper tropospheric drying over the entire monsoon region almost throughout the season.

The impact of moisture on large-scale intra-seasonal variability can be understood as a feedback process that involves moist convection, UTH and the large-scale flow. Further understanding of the stratosphere-troposphere exchange (STE) processes in this region, along with a better understanding of the association between the stratospheric QBO and the tropospheric circulation over the monsoon region, is needed for the long-term prediction of the ISM. The interannual variability of monsoon rainfall patterns over Asia shows a biennial tendency, referred to as the Tropospheric Biennial Oscillation, in which strong monsoon years are associated with westerly anomalies in the lower stratosphere and easterly anomalies in the upper troposphere. The reverse is noted during the years of weak monsoons.

**K. Parameswaran** examined in detail the characteristics of the minimum lapse rate and CPT in the tropical latitudes (30°S to 30°N) over the Indian longitude sector (70°E to 90°E) using the available radiosonde data (1994-2005), as well as radio occultation (RO) measurements (2006-2009). Observations from these two data sets are found to be remarkably consistent. While the TTL thickness is very small (~ 2.6 km) over the oceanic region near the equator with minimal interannual variability, over the continent at latitudes north of 5°N it increases with latitude, and has a maximum thickness during winter and minimum thickness during summer. The TTL thickness is well correlated with the height of convective tropopause, but poorly correlated with the altitude of the CPT.

**M. Venkat Ratnam** discussed the relationship between the tropical easterly jet (TEJ) and the ISM. The TEJ is a pronounced feature of the tropospheric circulation over the Arabian Sea and India in the summer months. There is a westerly wind reversal with a corresponding monsoon low level westerly jet (MLLJ) in the lower troposphere. Data from several research instruments available at the National Atmospheric Research Laboratory (NARL) in Gadanki, as well as NCEP and ERA data were used to examine the variability of these features and the tropopause. In general, the reanalysis data under-estimate the intensity of the TEJ and MLLJ. The shear above (below) the jet maximum shows a slightly increasing (decreasing) trend in the recent years particularly during July and August. No trend is observed in jet intensity using reanalysis data sets either over Gadanki or over the jet core during the ISM, although MST radar and GPS radiosonde observations show an increasing trend (~1 m/s/year), particularly since the year 2000. Quite different characteristics of the TEJ are found during dry and wet spells over Gadanki, with higher jet intensity and height, lower wind reversal height, and higher shear 1 km below the jet during wet spells.

**J. Burrows** gave a presentation outlining the high-lights of SCIMACHY, a satellite that incorporates both limb occultation and nadir measurements, most relevant to the SPARC community. He gave an introduction to the SCIMACHY mission and various data products such as $O_3$, BrO, $H_2O$, PSC, aerosol extinction profiles, tropospheric cloud top heights, $NO_2$, CH4, and noctilucent clouds. He emphasised the efficacy of each product, and urged the SPARC community to effectively use these data products for various applications in atmospheric sciences.

**S. Dhaka** spoke about the relationship of solar variability and dynamically controlled seasonal and annual variation of the tropopause temperature over the long-term over India. In this context, he addressed the issues related to variations in CAPE, outgoing longwave radiation (OLR) and solar variability with respect to the tropopause temperature over Delhi, Kolkata, Cochin and Trivandrum in India. His studies pointed out that decreases in OLR lead to cooler temperatures.

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*Local workshop participants*



## Session IV: Cross-Cutting Issues

**S. L. Jain** gave an overview on the status of the ozone hole over Antarctica and its recovery. He provided an historical review of stratospheric ozone, the ozone hole and dynamics over the polar regions. He also discussed the Laser Heterodyne technique developed at the National Physical Laboratory in New Delhi for vertical profiling of ozone, and showed some results obtained over Maitri utilising this experimental facility. The factors responsible for the development of the ozone hole over Antarctica each spring include very low stratospheric temperatures, the existence of the polar vortex, polar stratospheric clouds, and heterogeneous chemical reactions. The depth and area of ozone hole are governed by the amount of chlorine and bromine over Antarctica in the stratosphere. Recent observations indicate that although chlorine and bromine compounds have been regulated by the Montreal Protocol, because the lifetimes of these compounds are large, the recovery of the ozone layer will continue for some time to come.

**P. Newman** presented a talk entitled "What Would have Happened to the Ozone Layer if CFCs had not been Regulated?". He emphasised the importance of the Montreal Protocol and its amendments, which have been instrumental in protecting the ozone layer by phasing out the use of CFCs. He used GEOS-4 CCM (a fully coupled radiative-dynamical-chemical model) to predict the future ozone under a scenario that did not include the controls implemented on CFC use, and concluded that two-thirds of the ozone layer would have been destroyed by 2065, and that surface warming by CFCs of about 1-3 K by that time would have occurred. He also talked about the interactions between UV radiation and radiative forcing in the stratosphere.

**S. Lal** gave a presentation on the effects of transport on the distribution of ozone in the troposphere. He described balloon flights from various campaigns over marine regions surrounding India that measure the vertical distributions of trace gases such as the Indian Ocean Experiment (INDOEX), and the Integrated Campaign for Aerosols, gases and Radiation Budget (ICARB). The INDOEX results revealed higher concentrations of ozone (~70 ppbv) and other gases measured over Arabian Sea off the Indian coast, with a large gradient (7 ppbv/lat) from north to south. The ICARB results indicated that there is a strong horizontal confluence of ozone-rich air into a region of convective transport of ozone-deficient air, and that ozone in the free-troposphere over the Bay of Bengal is affected by convection, whereas over the Arabian Sea it is affected by downward transport.

**P. Pradeep Kumar** addressed the issue of whether cosmic rays could affect clouds, and discussed possible mechanisms of how they might do so. In his talk, he discussed the possible of enhancement of cloud cover by cosmic influx. Modulation of the cosmic influx on the global electric circuit produces ice nuclei when a cloud evaporates. The studies show that the lower troposphere, despite a lower ionization rate, might be a favourable region for galactic cosmic ray influence due to the higher concentration of precursor gases.

**S. Ramachandran** presented the effects of volcanic aerosols on the weather, climate, radiation and stratospheric dynamics. A particular emphasis was given to the results from various studies of the Mt. Pinatubo volcanic eruption. He concluded his talk by summarizing the effects of volcanic aerosols on the radiative forcing, thermodynamic effects (winter warming and summer cooling) and chemistry (heterogeneous chemistry-ozone depletion).

### Poster Session

A poster session was also held. There were over 20 poster presentations by students and employees of universities and research institutions in India, which covered a wide range of topics including dynamical variability of the stratosphere such as sudden stratospheric warmings and the QBO, characteristics of the TTL, stratospheric ozone and variability particularly during the ISM, lidar and radar observations of aerosols, winds, water vapour, modulation of the atmosphere by ENSO, UTLS and STE processes, and latitudinal variation of the tropopause over India.

### Conclusions and Future Plans

The workshop concluded with a special session "Panel Discussion", which highlighted the following:

- SPARC efforts to address the monsoon issues in relation to the STE processes.
- Dynamical aspects of the STE processes, which may play a vital role in the regional monsoon dynamics.
- Geoengineering techniques and their regional influences, benefits and consequences
- The need for more observations using next-generation observational facilities under the SPARC umbrella.
- Prioritization of regional monsoon prediction model developments.
- Effects of aerosols on the thermal structure of the stratosphere.
- Detailed studies on the ITCZ, Hadley circulation and STJ impacts on the monsoon.
- Effect of lower troposphere dynamics on the monsoon circulation.
- The need for more participation in the calibration and measurement campaigns with international committees, which help to improve the quality of observations on regional as well as global scale.
- The update of reanalysis products with the latest observations.
- The development of manpower to strengthen the study of the influence of STE processes on the Indian monsoon under the guidance of SPARC.

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# Report on the Chapman Conference on Atmospheric Gravity Waves and Their Effects on General Circulation and Climate

## February 28 – March 4, 2011, Honolulu, USA

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Gravity waves represent an important component of atmospheric variability over a broad spectrum. The spectral range of significant gravity wave power in the real atmosphere stretches across the typical truncation scale in contemporary global simulation models, making both the explicit representation of gravity waves and the parameterization of sub-grid scale wave effects necessary and potentially problematic. Gravity waves are generated by a variety of processes including the interaction of surface winds with topography, deep convective storms, and unbalanced flow in the jet stream, and these waves act to transport mean momentum between the surface and atmosphere, and between different layers of the atmosphere. As the waves dissipate, convergence of their momentum flux is known to drive important circulation changes at altitudes ranging from the upper troposphere and stratosphere into the mesosphere, thermosphere and ionosphere. These circulation changes are now known to have wide-ranging effects in numerical weather prediction, climate change response patterns, forecasts of stratospheric ozone recovery, and space weather and radio communications. The global scale of these issues requires global knowledge of gravity wave properties despite the fact that the scales of the waves themselves are too small to be fully simulated in a global model, or fully sampled in global observations. The problem of gravity waves and their effects on the general circulation thus requires a broad range of studies, those using local high-resolution observations, limited-area wave-resolving models, global models, and global observational data sets such as those acquired from satellites.

In 2004, K. Hamilton, T. Tsuda, and R. Vincent convened a SPARC-supported Chapman Conference on "Gravity Wave Processes and Parameterization" (see SPARC Newsletter No. 23). Since then, improvements in computational power have allowed many global models to explicitly resolve some of the relevant gravity wave scales, but many others are still not represented, and it is not clear how realistic the resolved waves in the models are. Recent work on dynamical coupling of the troposphere with the middle atmosphere shows that gravity waves can have a significant influence on the general circulation even in the lower atmosphere, and so global climate simulation models need to adequately treat the effects of atmospheric gravity waves that are not explicitly resolved. Concerns about significant changes in the circulation of the atmosphere in response to anthropogenic influences suggest the need for quite sophisticated treatments of the gravity wave effects. Adequate parameterizations will require an understanding of the processes that generate gravity waves so that realistic feedbacks between changing climate and gravity wave effects can be included in global models. Responding to these contemporary concerns, a Chapman Conference on "Atmospheric Gravity Waves and Their Effects on General Circulation and Climate" was held in Honolulu, hosted by the International Pacific Research Center, and cosponsored by WCRP and SPARC. Topics included high-resolution gravity wave-resolving global models and satellite observations, gravity wave effects on large-scale circulation and other climate processes, parameterization methods, observational studies of convective and other sources, numerous theoretical advances, and descriptions of several new observational projects.

## Gravity Waves and the Large-scale Circulation

Gravity waves can have a direct effect on climate *via* changes in the large-scale circulation. An opening talk by **R. Garcia** described how changes in parameterized gravity waves improved the frequency of sudden stratospheric warming (SSW) events in the WACCM model, but simultaneously degraded the simulation of polar surface pressures and sea-ice formation. Gravity waves also affect ozone hole chemistry, but attempts to improve the parameterization in this region have caused unwanted changes near the mesopause in WACCM. These examples illustrate difficulties in tuning gravity wave parameterizations, but also highlight their importance in climate processes. WACCM can model the quasi-biennial oscillation (QBO) with a parameterized spectrum of tropical low-frequency, long horizontal wavelength inertia-gravity waves. Interestingly, the parametrization includes effects of waves with scales that are potentially resolvable in the model, but the realistic QBO simulation still requires the supplemental parameterized fluxes. The HadGEM model using a traditional parameterization of shorter-scale, higher-frequency gravity waves also generates a QBO-like oscillation, but with different input fluxes (**A. Bushell**). Other

*Workshop participants*

presentations showed models with realistic QBOs without parameterized waves if run at sufficiently high horizontal and vertical resolutions (**T. Krismer**, **Y. Kawatani**). It is clear a variety of approaches with different wave representations can generate a QBO, but observational results are only beginning to help to distinguish among them.

However, different treatments of the parameterized waves can produce very different responses to climate change (**K. Shibata**). One gravity-wave resolving model predicts a longer QBO period in a future, warmer climate due to stronger tropical upwelling (**Y. Kawatani**), while another approach with resolved plus parameterized waves predicts a shorter QBO period in the future despite increased tropical upwelling (**N. Butchart**). Most climate models predict that the mean overturning circulation (Brewer-Dobson circulation, BDC) in the stratosphere will increase in the future, and that orographic gravity wave drag plays an important role in the acceleration of this circulation. Presentations at the meeting showed that longitudinal variations in orographic gravity wave drag could interact with resolved waves to cancel these effects on the BDC, showed the importance of nonorographic wave drag at subtropical latitudes, and illuminated how acceleration of the BDC can lead to seemingly paradoxical increases in age-of-air depending on the latitude-height pathways of air parcels in the stratosphere (**E. Gerber**, K. Okamoto/**K. Sato**).

Several presentations discussed the role of gravity waves during SSWs, and their role in the formation of an elevated stratopause and mesospheric descent following SSW events (**P. Hitchcock**, **C. Zuelicke**, **Y. Orsolini**, **A. Chandran**, **C. Yamashita**, V. Limpasuvan/**Y. Orsolini**, **F. Zhang**). Although details vary among different models, most agree that filtering of orographic waves is important in the formation of the elevated stratopause, and that gravity waves drive the slow descent of the stratopause in these events, while others stressed that *in situ* generation of gravity waves may be an important process not treated in current parameterizations. **Figure 1**, presented by C. Yamashita, shows a series of snapshots of the 1 hPa vertical velocity and geopotential height through the sudden warming of 2008-2009 as seen in high resolution global analysis data. The evolution of the gravity wave field through the event is quite dramatic.



## Other Gravity Wave Effects

In addition to their effects on the large-scale circulation, gravity waves can influence climate through their effects on clouds (**L. Pfister**, **V. Noel**, **S. Alexander**, **C. Bardeen**), and they are important components in the formation and properties of tropical cirrus, polar stratospheric clouds, and polar mesospheric clouds. In current climate models running at 1-2$^o$ resolution, parameterized gravity wave drag remains a key process for modelling mesosphere and lower thermosphere circulations (**A. Medvedev**), but heat flux effects are also important at these higher altitudes (**E. Becker**, **E. Yigit**, **A. Liu**). Global studies of gravity wave interactions with the diurnal tide have achieved new levels of sophistication using state-of-the art climate models with parameterized waves and/or explicitly resolved convectively generated waves (**D.

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**Ortland**, **X. Lu**).

## High Resolution "Gravity Wave-Resolving" Global Simulations

**S. Watanabe** reviewed the history of gravity wave studies in high resolution global simulation models, noting the trend to finer resolution as computing power has increased. However, even the most computationally intensive global models available today will have significant limitations. Fine vertical as well as horizontal resolution is required because the vertical scales of gravity waves vary dramatically depending on the vertical shear and stability profile, and wave dissipation at very short vertical scales can be crucial for problems such as wave forcing of the QBO. To study wave driving of the meridional overturning circulation further requires a very deep model, including levels from the surface through the mesosphere, such that global "gravity wave-resolving" models must generally make some compromises and choices depending on the scientific problem investigated. Despite the possible constraints resulting from the finite resolution, global models do provide self-consistent nonlinear simulations of the gravity wave field over a wide spectral range, and this allows assessment of some key processes, including the spontaneous wave generation and the three dimensional propagation of waves. A number of presentations investigated these and other processes, and described results from various types of models.

Analysis of low-latitude results from global models provided insights into the representation of tropical inertia-gravity waves in different model systems (**S. Evan**, **N. Zagar**, **Y. Kawatani**), and showed impacts due to model depth and vertical resolution that have implications for wave forcing of the QBO. In the extra-tropics too, lack of vertical resolution near the tropopause and tropopause inversion layer can lead to errors in their representation caused by errors in the vertical structure of gravity waves and their mixing effects (**K. Miyazaki**). Other presentations looked at tropospheric circulation issues at high resolution, including complex circulations around topography that have implications for orographic waves and the parameterization of topographic drag in the atmosphere (**K. Hamilton**), and the representation of wave frequency spectra in comparison to observations (**C. Tsuchiya**).

## Gravity Wave Observations

Particularly exciting new observational techniques allow characterization of the spatial dependence of the gravity wave field, permitting an understanding of the relationships with wave sources (**A. Hertzog**, **A. Grimsdell**, **J. Alexander**, **C. Wright**, **J.**

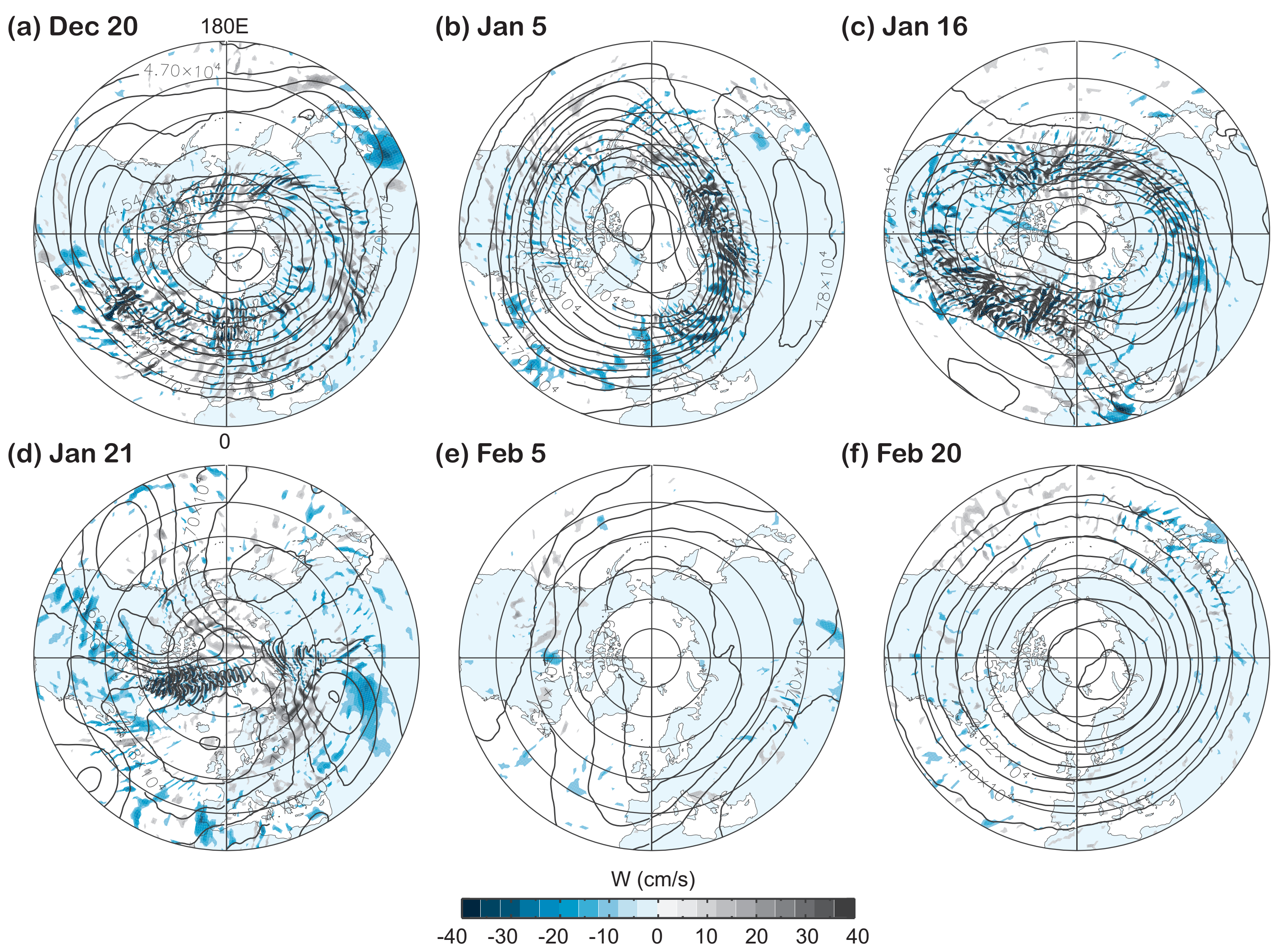


*Figure 1. The 1 hPa geopotential height (400 m contour interval) and vertical velocity (shading) at individual times during the 2008-2009 winter. Data are from the ECMWF T799 analyses. Presented by C. Yamashita, H.-L. Liu and X. Chu (Yamashita et al., 2010).*

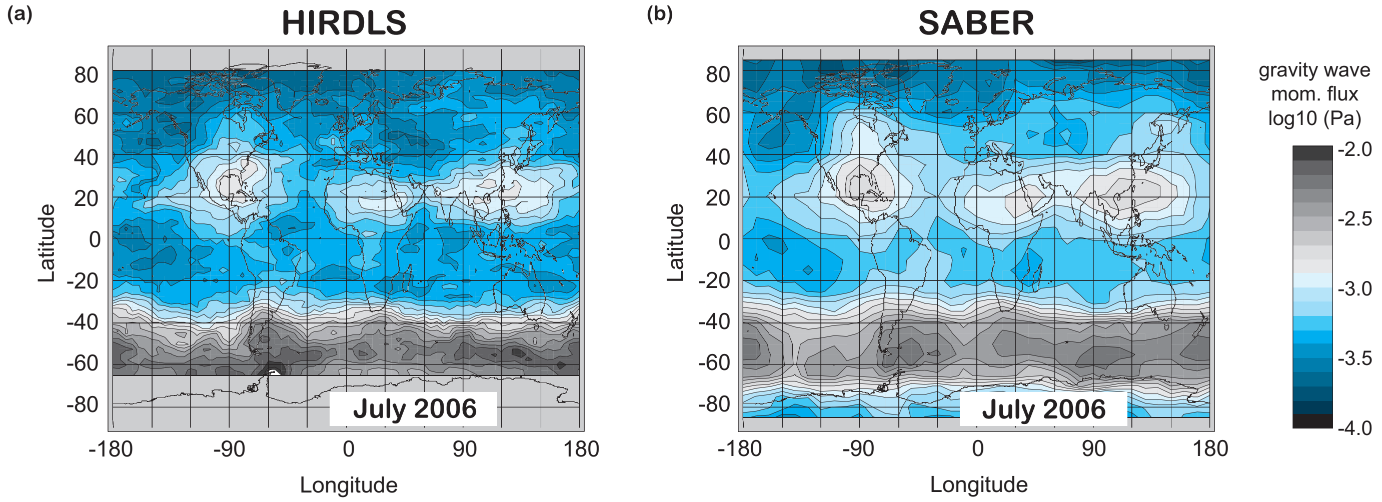


*Figure 2. Gravity wave momentum fluxes derived from two different satellite measurements at an altitude of 30 km during the month of July 2006. Left: High Resolution Dynamics Limb Sounder (HIRDLS). Right: Sounding of the Atmosphere with Broadband Emission Radiometry (SABER). Presented by M. Ern, P. Preusse, and S. Kalisch (Ern et al., 2011).*

**Yue**, **D. Nath**, **R. Vincent**, **J. E. Kim**, **J. Gong**, **V. Narayanan**) and/or climatological variations (**M. Ern**, **S. Alexander, J. Gong**, **S. John**, **Z. Li**, T. Demissie/**P. Espy**, **G. Swenson**, **V. Narayanan**, **A. Guharay**, Z. Yu/**X. Chu**, **G. Baumgarten**, **B. Williams**, **S. Alexander**). These include long-duration balloon observations, and satellite and ground-based remote sensing methods using both limb and nadir scanning methods (HIRDLS, SABER, AIRS). **Figure 2**, presented by M. Ern, shows global comparisons of gravity wave momentum fluxes derived from two different satellite measurements. Several studies using COSMIC GPS occultation data highlighted the sensitivity to the definition of the "background atmosphere" for the purpose of isolating the gravity waves (**T. Horinouchi**, **A. Haser**, **P. Soria**), with particular examples in the tropics and during disturbed vortex conditions at winter high latitudes.

A variety of major new observational projects were also described: (1) the Antarctic MST/IS PANSY radar due to begin observations in the next year (**K. Sato**), (2) SAANGRIA, a proposal for intensive aircraft and ground-based observations of gravity waves in the southern Andes and Antarctic Peninsula region (D. Fritts/**S. Eckermann**), (3) SAFAR, an ongoing CAWSES-India programme of intensive radar, lidar, and sonde launches to observe wave effects in the upper atmosphere related to convection (**V. Ratnam**), (4) PREMIER, a proposed ESA satellite mission with infrared and microwave limb imaging capability (P. Preusse/**M. Ern**), (5) Concordiasi, a 2010-11 Antarctic long-lived-balloon campaign with 30-fold improvement in temporal resolution over that available from the 2005 VORCORE experiment (**A. Hertzog**).



Analysis of the existing data is revealing new information about the nature of waves above topographic and convective sources,

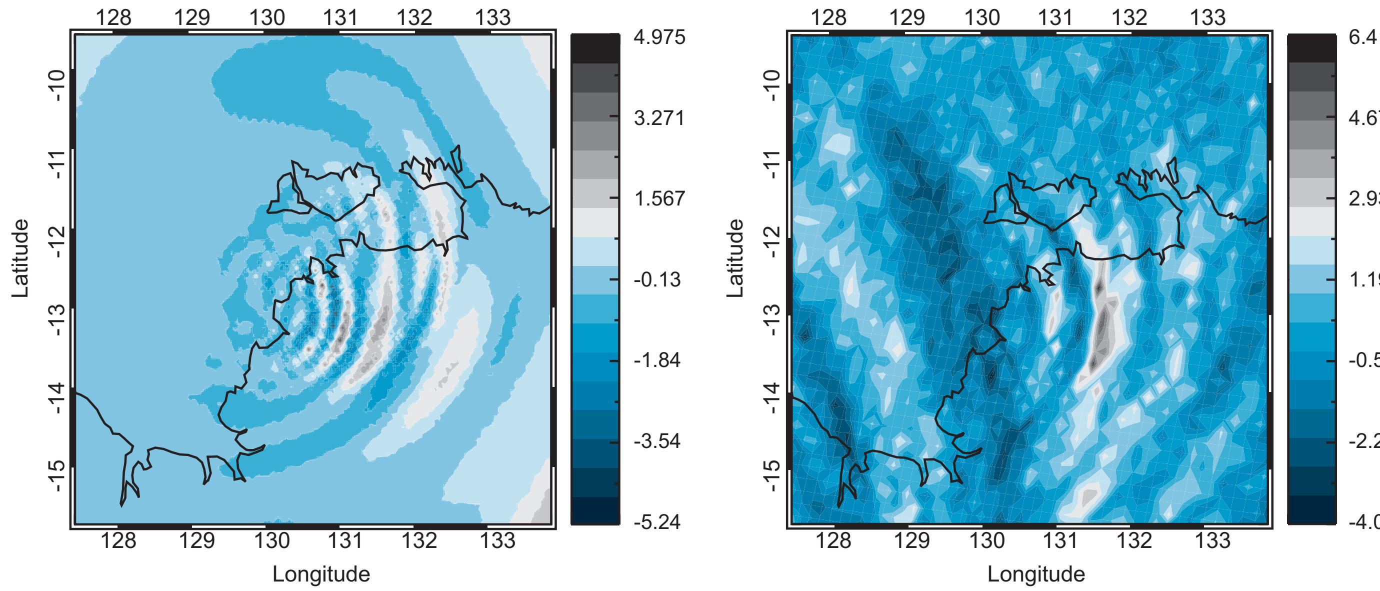


*Figure 3. Gravity waves in the stratosphere over convection in the Darwin, Australia area as seen in both a model forced by radar-observed precipitation (left) and an observation from the AIRS satellite (right) (Grimsdell et al., 2010). The units are radiance perturbations (W m$^{-2}$ sr$^{-1}$ cm).*

and the new measurements promise further exciting discoveries and more realistic treatments of gravity wave processes in future climate models. **Figure 3**, presented by **A. Grimsdell**, shows the comparison of gravity waves in the stratosphere above convection from both an AIRS satellite observation and a model forced by radar-observed precipitation in the area.

## Parameterization methods

Both observations and models are being used to evaluate and improve parameterizations of gravity wave drag (**D. Murphy**). Intermittency in gravity waves is observed as a distribution with a very long high-amplitude tail that is not treated realistically in today's parameterizations (**A. Hertzog**). Other observed effects that are missing in current parameterizations include significant lateral wave propagation and important mountainous island sources (**M. Ern**, **P. Preusse**, **H.-Y. Chun**, **J. Alexander**). Observed and modelled wave properties are also being used to constrain input parameters for existing parameterization schemes (**M. Pulido**, **P. Love**, **H.-J. Choi**). Presentations showed results from climate model experiments both with new convective source parameterizations (**H.-Y. Chun**, **Y.-H. Kim**) and with existing spectral schemes applied in new stochastic ways, allowing important computational savings (**S. Eckermann**, **F. Sassi**).



## Gravity Wave Dynamics

New theoretical results were presented on wave drag and breaking processes (**D. Durran**, **S. Eckermann**, **O. Buhler**, **P. LeLong**), wave-wave interaction and propagation effects (**D. Ortland**, **J. Vanderhoff**, **M. Hills**, **B. Sutherland**), and 3-dimensional methods for diagnosing gravity wave mean flow effects (**S. Miyahara**). Several papers focused on wave emission from unbalanced flows (**S. Wang**, **N. Sugimoto**, **P. Williams**, **C. Yamashita**, **J. Wei**, **F. Zhang**, **R. Plougonven**). The results highlighted how different jet source mechanisms evolve on different time scales, and how the addition of moist processes tends to reduce both the spatial and temporal scales of the emitted waves. Simulations of wave emission from the jet stream have matured to the point that they are now being compared in detail with observations. Other numerical and theoretical studies focused on typhoons, convection, and secondary wave emission sources and effects on the local environment, both in the troposphere and above (**S.Y. Kim**, **T. Shaw**, T. Lane/**F. Zhang**, **M. Reeder**, **R. Plougonven**).

## Summary

It was clear from many presentations at the conference that gravity wave studies have benefitted enormously from the increased activity in recent years, in developing and applying global atmospheric models that include serious representations of the middle atmosphere. With successful simulations of the mean wind and temperature structure throughout the atmosphere, such models can be analysed to understand the role of gravity waves in maintaining such key global circulation features as the QBO and the BDC. Papers at the conference highlighted the range of exciting investigations that can now be executed, from studying the role of gravity wave forcing of the mean flow in operational short-term weather forecasts, to self-consistent simulations of the expected responses to increased greenhouse gas concentrations. Global observations with sufficient resolution are also providing unprecedented detail on key wave characteristics needed to test the global models and better quantify the wave global circulation effects. Progress in understanding the processes of wave generation, propagation, and dissipation continues *via* coordinated studies employing both observations and gravity-wave resolving models.

The conference programme, abstracts, and copies of presentations can be found online at the following link: **http://www.soest.hawaii.edu/iprc/meetings/workshops.php**

## Acknowledgements

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# The New Initiative on Past Changes in the Vertical Distribution of Ozone

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## Introduction

Over three and a half decades have passed since Molina and Rowland postulated that anthropogenic chlorofluorocarbons could deplete the ozone layer (Molina and Rowland, 1975), and over two and a half decades have passed since the discovery of the ozone hole (Farman *et al*., 1985). In this time, the countries of the world have produced and signed the Montreal Protocol limiting the production of ozone-depleting substances (ODSs), and leading to reductions in their atmospheric concentrations (WMO, 2011). As we proceed towards the expected ozone recovery from the influences of ODSs, scientific questions concerning the detection and attribution of that recovery have come to the fore. Answering many of these questions will require a critical examination of the pattern and time sequence of ozone change.

These questions can be split into two main categories:
(i) long-term ozone changes associated with the declining concentration of ODSs and from the increases in greenhouse gases; and
(ii) short-term ozone changes (related to, *e.g*., volcanic eruptions, QBO or ENSO), which will moderate the longer-term changes.

Within each category a number of important questions can be identified. The questions associated with the long-term changes are often relevant for both science and policy. Can we identify the effects of the reduction of ODS concentrations on ozone amounts? Is ozone increasing? If so, is the increase statistically significant? Where is it increasing? Can we separate the causes of the ozone changes over the recent decades? How much of the ozone depletion was and how much of the stabilisation/recovery is due to ODS changes? What was the peak ozone depletion resulting from ODSs and how well is that modelled? What are the impacts of climate variability and of climate change? In particular, is there a significant ozone trend in the tropical lower stratosphere as a result of the acceleration in the residual circulation (*e.g*., Ray *et al*., 2010)?

The questions associated with the shorter-term ozone changes are primarily scientific in nature and are associated with improving our understanding of atmospheric processes (*e.g*., by testing current models). These can be related to the various modes of internal variability (QBO, ENSO, *etc*.), or to external forcings such as volcanic eruptions, or the 27-day or 11-year cycles in solar variability (*e.g*., Fioletov, 2009).

For all of these, accurate knowledge of the altitude, latitude, and seasonal structure of the ozone response is required. To address the long-term questions, it is important to have a set of stable measurements extending over decades. For the short-term questions, it is as important to have good spatial and temporal coverage. For both issues, it is critical that the quality of the measurements used is as high as possible, and that the quality is known. To this end, a workshop was convened in January 2011 with the support of SPARC, the International Ozone Commission (IOC) and the ozone focus area of the Integrated Global Atmospheric Chemistry Observations (IGACO-O3) programme. Over 50 experts attended who are familiar with satellite, ground-based and airborne measurements, as well as in methods of preparing combined data sets. These experts agreed to set up a joint initiative to assess the current knowledge and understanding about the measurements of the vertical distribution of ozone, with the aim of providing input to the next WMO Scientific Assessment of Ozone Depletion anticipated for 2014. This article describes the current state of the measurements, the on-going projects in this area and the structure and plans for the initiative. The initiative is being organised under the auspices of SPARC, IOC, IGACO-O3 and the Network for the Detection of Atmospheric Composition Change (NDACC).

## Ozone Measurements

High quality measurements of total ozone are now made routinely by several systems which are stable to ~1% per decade. These systems all show the same regional patterns in the total ozone evolution over the last 30 years, most notably the lack of a long–term trend in the tropics, and different evolutions of total ozone in the Northern and Southern hemispheres (see **Figure 1**). Once identified, such patterns need to be explained in terms of the halogen loading, the volcanic signals, polar ozone depletion and the influence of dynamical forcing from the troposphere (*e.g*., Harris *et al*., 2008). However, it is hard to be completely sure about these explanations using only total ozone measurements. Information about changes in the 3-dimensional spatial nature of the ozone concentrations would place significantly tighter constraints on the possible explanations.

During the 1990s, ozone profile trends deduced from different instruments (satellite instruments SAGE I and II, SBUV, and ground-based instruments) showed substantial discrepancies. A cooperative effort was organised to resolve the differences which resulted in the first SPARC Assessment Report (SPARC/IOC/GAW, 1998). The core of the report was the recognition that the SAGE record was the only one that could provide global coverage of ozone changes in the lower stratosphere, while both SAGE and SBUV could provide global coverage in the upper stratosphere. Ground-based measurements with longer records (ozonesondes, Umkehr) were assessed for consistency where sufficiently long records existed (principally northern mid-latitudes). Shorter records (*e.g*., HALOE, lidar and other newer techniques used at NDACC stations) were used for

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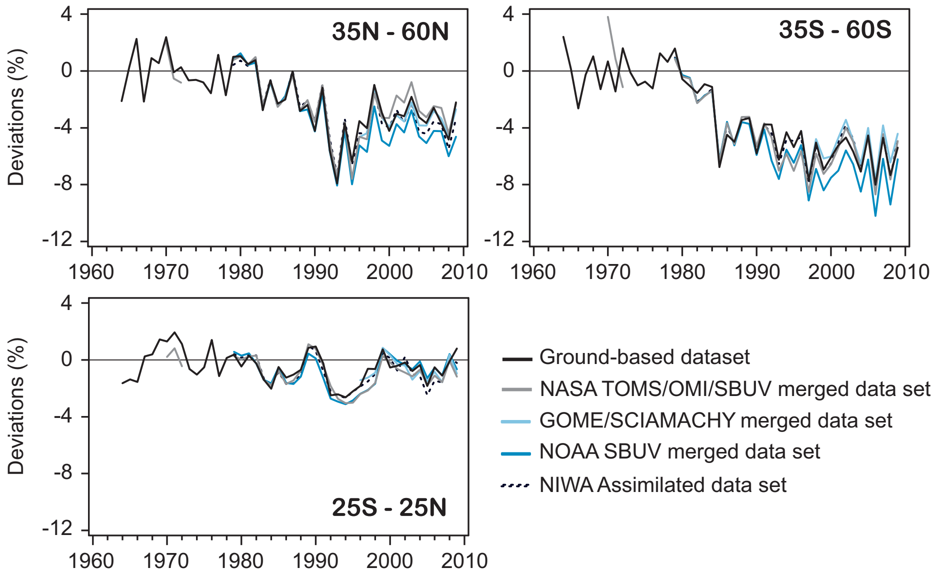


*Figure 1. Annual mean area-weighted total ozone deviations from the 1964–1980 means for the latitude bands 25°S–25°N, 35°N–60°N, and 35°S–60°S, estimated from different global data sets: ground-based (black), NASA TOMS/OMI/SBUV(/2) merged satellite data set (gray), National Institute of Water and Atmospheric Research (NIWA) assimilated data set (black dashed), NOAA SBUV(/2) (blue), and GOME/SCIAMACHY merged total ozone data (light blue). Each data set was deseasonalised with respect to the period 1979–1987. The average of the monthly-mean anomalies for 1964–1980 estimated from ground-based data was then subtracted from each anomaly time series. Deviations are expressed as percentages of the ground-based time average for the period 1964–1980. Adapted from Chapter 2 of WMO (2011).*



validation. Trends based on a combined SAGE, SBUV, Umkehr and ozonesonde record at northern mid-latitudes showed that (a) most of the total ozone trend at northern mid-latitudes resulted from trends in the lower stratosphere; and (b) a secondary trend maximum occurred at 40 km where gas phase chemistry was expected to dominate. Elsewhere, it was hard to say much categorically about the trends as a result of the larger uncertainties.

It is now 15 years since that assessment took place. In that time, the stratospheric halogen loading has started to decrease, the impact of Mt Pinatubo has decreased and the importance of dynamical effects in determining lower stratospheric ozone over decades is more clearly recognised. All three factors make analysis of the ozone record trickier. On the measurement side, SAGE II continued until 2005, giving a 21-year record. While there has been no global follow-up to the first two SAGE instruments, many new satellite instruments have been launched since 2000. To date there has been no thorough assessment of how well these new measurements agree with each other or – most importantly for studies of long-term changes – the SAGE record. The ground-based records are also 15 years longer, and with their improved geographic coverage have the potential to provide a global view about ozone changes in their own right (Steinbrecht *et al*., 2009). However, due to the lack of rigorous evaluation between satellite instruments, few trend analyses using satellite ozone profile data have been performed since the WMO (2007) report, *i.e*., the satellite records did not provide significant updates of the long-term changes for the WMO (2011) report. The SBUV (/2) instrument series now provides the only internally consistent satellite record, and even that has issues associated with the orbits of the different instruments. Biases between some of these instruments are comparable with long-term ozone changes (*e.g*., Terao and Logan, 2007; Fioletov *et al*., 2008) and make the combined record difficult to use for the trend estimates. **Figure 2** shows the time periods each instrument type has operated over. It is clear that the key to having a continuous record for both ground-based and satellite instrument types is now ensuring that measurements from individual instruments are comparable.

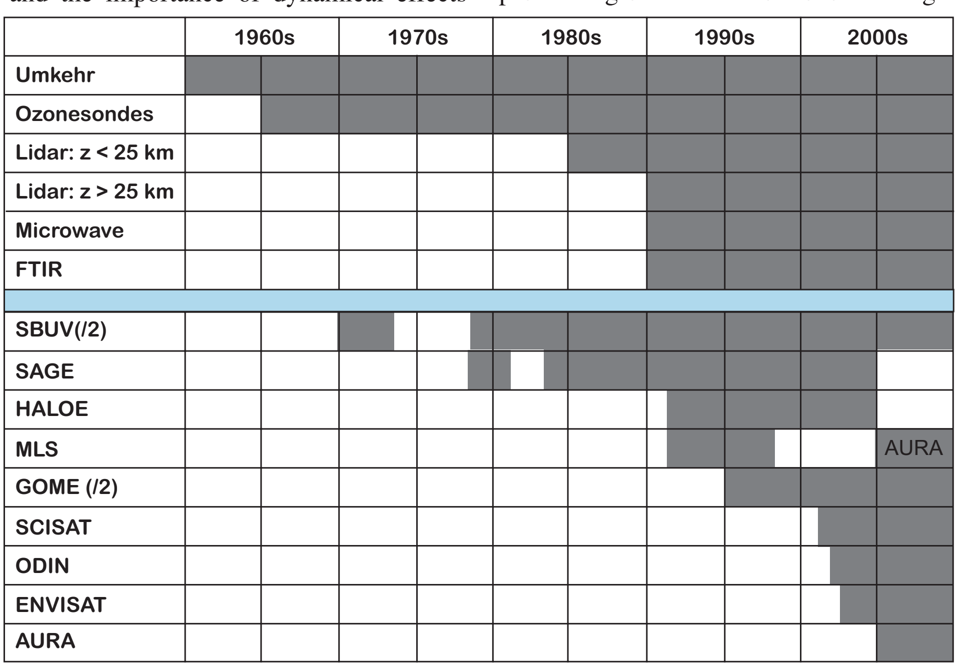


*Figure 2. Periods of operation of the main instrument systems that measure the vertical distribution of ozone. Ground-based measurement systems are shown in the top part of the figure; satellite-based instruments in the bottom half. The geographic coverage and numbers of the ground-based instruments has increased over the years.*

## Workshop Outcome: the Second Ozone Initiative

There is thus limited knowledge of the changes in the vertical distribution of ozone that have occurred globally since 2005, a situation which is unsatisfactory given the importance of the scientific issues discussed above and the size of the investment in the ozone monitoring systems. The workshop in Geneva was held to discuss how to improve our knowledge and understanding of the past changes in the vertical distribution of ozone, and covered the following topics:

• satellite data retrieval, quality and records;

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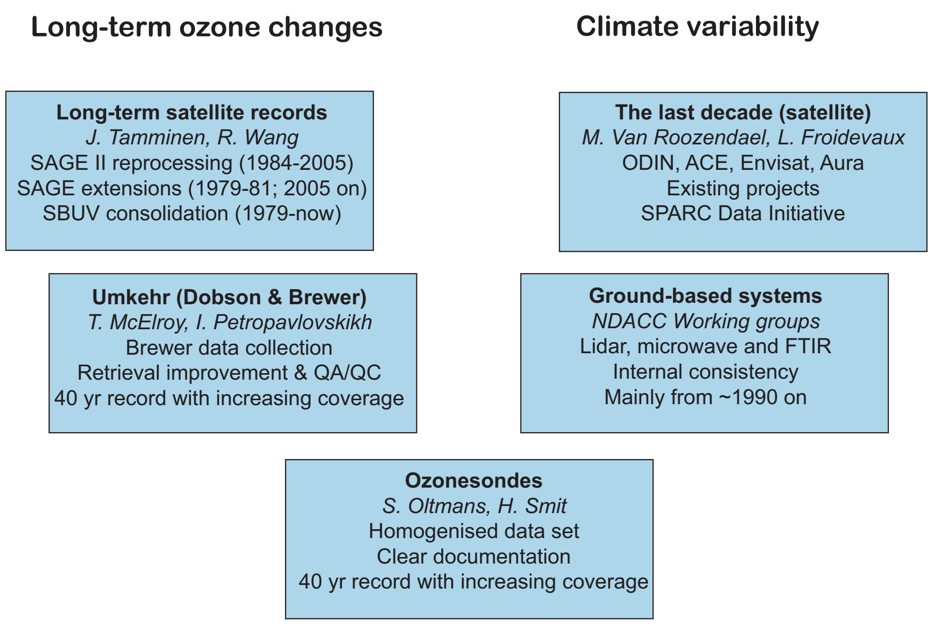


*Figure 3. Schematic of the five main working groups in the second ozone initiative. The sixth working group looking at the different approaches to combining data sets is led by G. Bodeker and N. Harris. The remit in these six work packages will be re-assessed at the second workshop.*

- ground-based measurements retrieval, quality and records;
- procedures for merging ozone measurements from different sources; and
- definition of a new ozone initiative.

From the workshop it become clear that real opportunities exist to make progress in improving our understanding of the existing measurement record, and that a new ozone initiative would provide valuable information for the next WMO Ozone Assessment, anticipated in 2014. A number of formats for the initiative ranging from a full SPARC assessment (as with the first ozone report) to a set of coordinated papers or technical reports (shorter, more focused on single issues) were discussed. The work required is heterogeneous and it was decided to pursue the latter option for a year or so, before discussing the outcomes and the way ahead at a second workshop in the first half of 2012. The preferred option is to write a summary assessment based on the work in the six working groups described below, which should be published separately either as papers or technical reports, published under the auspices of the space agencies, IGACO-O3 or SPARC, for example. The working groups are shown in **Figure 3**, and the timetable is shown in **Figure 4**.

There is a lot of work already going on within existing projects and programmes, which could be enhanced by a degree of international coordination. The major space agencies involved (US National Aeronautics and Space Administration (NASA), Canadian Space Agency (CSA), European Space Agency (ESA) and the national space agencies in Europe) all have projects aimed principally at improving the measurement record over the last decade. These projects are focusing on the measurements (including ozone among a range of species) made by instruments on the ENVISAT, AURA, ODIN and SCISAT satellites, and are already contributing to the SPARC Data Initiative. They will also work closely together in the new ozone initiative, largely sticking to their existing work-plans but also developing a few collaborative initiatives to ensure that the quality of the data over the last decade is well understood and that the strengths and weaknesses of each ozone data set for studies of climate variability (*e.g.*, spatial and temporal coverage and resolution) are well characterized and documented. M. van Roozendael and L. Froidevaux are coordinating this working group.

The work by this group is complemented by the work from the group on long-term satellite measurements. The main aim here is to improve our knowledge of processes in the lower stratosphere by extending the SAGE record from 2005. In the first instance, this will be tried using the measurements made by the GOMOS instrument because of the similarity in the measurement approach (solar occultation for SAGE and stellar occultation for GOMOS) and the three years of simultaneous measurements. It is very important to have confidence in this extension and so other instruments (*e.g.*, OSIRIS, SCIAMACHY) will also be tried. It is possible that the SAGE II data will be reprocessed using recent reanalyses – more interestingly in terms of the length of the record, SAGE I (1979-1981) will be reprocessed in order to make it more consistent with the SAGE II measurements, and to remove the need for an altitude offset when considering the combined record. This work with SAGE will be performed in conjunction with further work on consolidating the SBUV(/2) record.



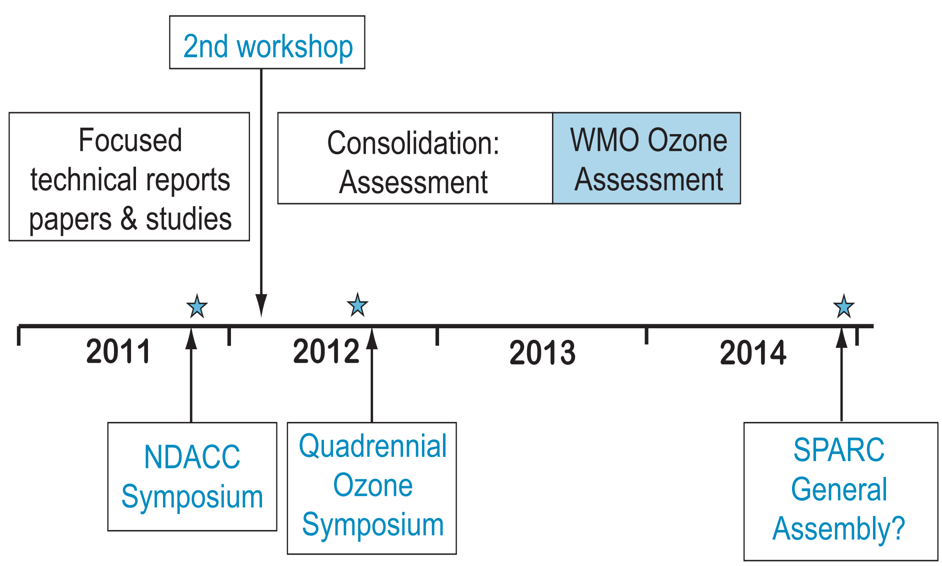


*Figure 4. Timetable for the work organised within the second ozone initiative. Full use will be made of existing plans, projects and meetings particularly in the first year of the initiative. A consolidation of the results (most likely in a short assessment) will be produced in time for the anticipated WMO Ozone Assessment in 2014.*

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In between these two satellite-based groups are the ground-based working groups whose results will contribute to our understanding of the longer-term changes and to the variability in the last decade. The geographic coverage of all the instrument types has improved significantly through the on-going efforts of WMO and NDACC, and while the longest records (over 40 years) are limited to northern mid-latitudes, the coverage now is quasi-global. The NDACC working groups are set up to continuously assess and assure the data quality of their ground-based measurements. The working groups (led by S. Godin-Beekman, T. Leblanc, N. Kämpfer, G. Neduloha, J. Hannigan and M. De Mazière) on lidar, microwave and FTIR instruments will take the lead within the new ozone initiative to ensure that the NDACC instruments contribute to the initiative on the requisite time scales. Full use will be made of existing working group meetings and the NDACC science meeting in La Réunion in November 2011.

In a similar manner, working groups on ozonesondes (led by S. Oltmans and H. Smit) and Umkehr measurements (T. McElroy and I. Petropavlovskikh) will work to produce improved measurement records. For ozonesondes, the aim is two-fold: First, to produce a fully homogenized data set for more than a decade, and hopefully quite a bit more, based on recent work characterizing differences between ozonesonde types. Secondly to provide or identify full, clear documentation about the homogenization process and about the quality of ozonesonde measurements generally to allow the recent record to be linked to the older records. The main thrust of the Umkehr working group is to provide a consistent set of ozone profiles from the Brewer instruments. The measurements from the sparser Dobson network are already of high quality, and there is a real opportunity to expand the spatial scale of the Umkehr network if the Brewer data can be worked up.



A common theme to all the working groups described above is that they entail combining the measurements from different instruments. In many cases these instruments are of the same basic design, but almost invariably improvements have been made over the years. While these improvements are generally a good thing, they do complicate matters when it comes to studying long-term changes. Matters are even more complicated when measurements from different instrument types are combined – and that is essential if the SAGE record is to be extended. Accordingly, a sixth working group (led by G. Bodeker and N. Harris) will assess the different approaches to producing multi-instrument ozone data, based on experience with ozone and other geophysical data sets.

## Looking Ahead

The time is right for a second ozone initiative – there is a real need for better information about the long-term changes in ozone as well as in ozone's response to climate variability. A flexible plan was agreed upon in Geneva, which allows us to respond to the results from the first year's diverse activities and to re-define the priorities and the plans. The working groups described above will discuss their findings at a second workshop to be held in the first half of 2012. This discussion will lead to a clearly defined plan for the second half of the new ozone initiative so that the findings can be used in the preparation of the next WMO Ozone Assessment. Updated information about the initiative can be found at http://igaco-o3.fmi.fi/VDO/index.html.

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## PROGRAMME DESCRIPTION

The conference is organised by devoting each day to a major science theme that reflects an integrative aspect of the WCRP programme. Specifically, each day will include plenary presentations from both established and early-career experts on challenges and advances addressing major, cross-cutting issues. The work of individual scientists will be featured through daily and interactive poster sessions - an integral and major aspect of the OSC. Each day will also include two or three parallel sessions. These sessions will feature both oral and poster-oral presentations on major, integrative scientific topics. The OSC will conclude with plenary discussions focusing on outstanding challenges and the future pathway of the WCRP.

## Future SPARC and SPARC-related Meetings

### 2011

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| **27 June – 8 July** | **International Union of Geodesy and Geophysics Assembly on "Earth on the Edge: Science for a Sustainable Planet",** Melbourne, Australia; http://www.iugg2011.com |
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| **24-28 October** | **WCRP OSC - Climate Research in Service to Society**, Denver, CO, USA http://www.wcrp-climate.org/conference2011/index.html |
| **7-10 November** | **NDACC Symposium,** Reunion Island, France http://www.reunion.fr |
| **5-9 December** | **AGU Fall Meeting**, San Francisco, CA, USA; http://sites.agu.org/fallmeeting/ |

### 2012

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| **22-26 January** | **AMS 92nd Annual Meeting**, New Orleans, LA, USA; http://www.ametsoc.org/MEET/annual/index.html |
| **22-24 February** | **Workshop on Stratospheric Sudden Warming and its Role in Weather and Climate Variations,** Kyoto, Japan; http://www-mete.kugi.kyoto-u.ac.jp/Kyoto2012/ |



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