24th Meeting of the SPARC Scientific Steering Group & Local Workshop

31 October – 4 November 2016, Berlin, Germany

February 2017

WCRP Publication No.: 4/2017

Disclaimer

Cover image: Creative Commons CC0. Pixabay: https://pixabay.com/en/way-clouds-seat-belts-direction-427984/

Contents

The 24th SPARC Scientific Steering Group (SSG) meeting was hosted at the Max Planck Institute's Harnack House in Berlin, Germany, from 1-4 November 2016. The meeting followed a one-day science workshop focused on SPARC's contribution to the WCRP Grand Challenges.

1. WCRP Update

The WCRP continues to focus on its mission of facilitating analysis and prediction of the Earth system through its core projects and grand challenges, which now include two recently approved grand challenges on near-term climate predictions and carbon cycle-climate interactions (**Boram Lee**, WCRP/SPARC liaison). The WCRP will undergo a major review by its co-sponsors (WMO, IOC and ICSU) in 2018 and so a document outlining WCRP's achievements and future strategic direction is currently being drafted. All WCRP projects, working groups, and grand challenges will provide input to this document, which is to be completed by the 38th session of the WCRP Joint Scientific Committee to be held in April 2017. WCRP continues to improve its working procedure to promote fundamental climate science, part of which will be to establish best practices for assessing progress of the grand challenges as well as core projects. Furthermore, WCRP is working to refresh its communications, both internal and external, and is currently carrying out a survey to establish where to make effective improvements.

WCRP recently held a scoping meeting on regional activities (10-11 October 2016, Hamburg, Germany), which developed a set of recommendations to define, support and improve coordination of scientific activities for regional applications. It highlighted the fundamental gap in the availability of data for providing regional climate information, as well as the difficulty in doing so even when data is available. Once the recommendations are endorsed, a call for a regional climate information coordinator will be issues to WCRP sponsors, donors, and partners in the world with the hope of establishing a clear contact point for all WCRP regional activities. These activities are strongly linked with WCRP's capacity development strategy, which has also recently focused on supporting early career researchers by actively engaging them in WCRP strategic discussions and officially endorsing YESS (the Young Earth System Scientists community). This group has been very active, recently having published a white paper on the frontiers of Earth system science, and helping to organise a very successful early career symposium at the CLIVAR Open Science Conference, amongst other things.

The SSG was informed of increasing pressure for funds within WCRP due to financial restrictions of its co-sponsors, which will increase difficulties in supporting SPARC's science coordination. As the fundamental measure to address these ongoing concerns, WCRP re-emphasized the critical need to demonstrate the scientific leadership of the core projects in terms of their respective research foci.

The WCRP Data Advisory Council (WDAC) coordinates all data and observation activities across WCRP and ensures cooperation with major partners such as the Global Climate Observing System (GCOS). Over the past few years SPARC has continuously highlighted the possible looming gap in limb-sounding observations (**Susann Tegtmeier**) and this has now been noted in the new GCOS implementation plan. This plan also includes several action items, two of which are relevant to this issue: a review of the availability of climate data records,

and the identification of gaps in the availability of these records. Together with WDAC, GCOS has established a data prize to recognize an early- to mid- career scientists for outstanding work in data generation, management, preservation or monitoring. WDAC has also recently established a Task team on the Intercomparison of Reanalysis (TIRA), with Masatomo Fujiwara serving as the SPARC representative. First results from this effort will be presented at the 5th WCRP international reanalysis conference, which will take place from 13-17 November 2017 in Rome, Italy.

The WCRP Model Advisory Council (WMAC) plays a similar role to WDAC, but is focused on modelling (**Judith Perlwitz**). After a very successful model development summer school held in 2015, the group is organising a second school in 2017 in Brazil. The next WMAC meeting will be held together with several other WCRP modelling working groups to facilitate planning for the next 5-10 years and provide input to WCRP's future strategic plans. They will also work on tying to coordinate several of activities within WCRP focused on making decadal predictions, including the new grand challenge on near-term climate predictions. Discussion during the SPARC SSG meeting also focused on raising awareness about the relevance of including chemistry in models on various timescales. How important chemistry is for various prediction purposes is still very much an open research question, and one that WCRP, together with the World Weather Research programme (WWRP), should certainly continue to focus on.

Quentin Errera represented SPARC at the 2016 meeting of the Working Group on Numerical Experimentation (WGNE), which is joint between WCRP and the WMO Commission for Atmospheric Sciences. This link could prove useful to encourage more climate modelling groups to get involved in the WGNE focus areas, particularly as more and more modelling centres are moving towards seamless models that can be used across all timescales. In this regards, WGNE is organising a systematic errors workshop that will be held from 19-23 June in Montreal, Canada, and hopes to bring representatives from both the weather and climate modelling communities together.

2. SPARC Activity Reports

The Stratospheric Network for Atmospheric Predictability (SNAP) has concluded the first phase of the project, which produced several well-cited papers examining the influence of the stratosphere on climate predictability at various timescales (**Andrew Charlton-Perez**). They have also been encouraging cooperation with other projects, including the SPARC DynVar and QBOi activities (see below) as well as the WCRP/WWRP Sub-seasonal to Seasonal (S2S) project. Their revamped website (www.sparcsnap.org) now has real-time diagnostics of annular modes and the probability of occurrence of sudden stratospheric warmings. Amy Butler will be joining Andrew as new co-lead of the activity, while Greg Roff, who steps down, is warmly thanked for his leadership of the activity.

The Stratospheric Reanalysis Intercomparison Project (S-RIP) also has new co-leads, with Gloria Manney and **Lesley Gray** joining Masatomo Fujiwara in running the activity. The group has been working hard on the interim S-RIP report, which is nearing completion and will be published in 2017. To complement the report, which will include many technical details, there is an S-RIP special issue open in Atmospheric Chemistry and Physics that includes papers that serve as an "entry point" to the reanalyses and science covered in more depth in the report.

S-RIP has held joint meetings with the Data Assimilation Working Group (DAWG; **Quentin Errera**) for the past two years, and will do so again in 2017 with a workshop that will be held in

Reading, UK, from 23-27 October 2017. The themes of the workshop are yet to be decided, but may focus on things such as the representation of the stratosphere and mesosphere in data assimilating models or novel assimilation techniques. John McCormack will join Quentin to co-lead and further develop the activity.

The second Water Vapour Assessment activity (WAVAS-II) is finalising much of its work, with several papers having been or going to be submitted to a special joint journal issue between Atmospheric Chemistry and Physics, Atmospheric Measurement Techniques, and Earth System Science Data (**Gabriele Stiller**). These papers include descriptions of the various satellite and in situ water vapour products available, comparisons of these data, and analyses of variability and trends. The group have also been cooperating with the GEWEX G-VAP activity, which also focuses on comparing and understanding water vapour records, but mainly for the troposphere.

The Chemistry-Climate Modelling Initiative (CCMI), a joint SPARC-IGAC (International Global Atmospheric Chemistry) activity, has worked hard over the last year to ensure most of the phase-1 model data are available on the British Atmospheric Data Centre (BADC) server (**Michaela Hegglin**). They have also refreshed the steering committee, with Bryan Duncan replacing Jean-François Lamarque as co-lead with Michaela, and improved communication within the activity by issuing quarterly news emails. The group contributed to the overview paper describing the Coupled Model Intercomparison Project – Phase 6 (CMIP6) AerChemMIP project, and are working to finalise the CCMI ozone forcing dataset in support of CMIP6. CCMI will continue analysing the available model data over the coming year, with results being presented in a joint special issue between Geophysical Model Development, Atmospheric Chemistry and Physics, Atmospheric Measurement Techniques, and Earth System Science Data. This work has been facilitated by three focus groups that will produce key publications on tropospheric OH and ozone budgets, the specified dynamics simulations, and an overview of the entire CCMI activity. The group will hold its next workshop from 12-17 June 2017 in Toulouse, France.

The SOLARIS-HEPPA activity is also actively engaged in analysing the CCMI output, with five different working groups focusing on aspects ranging from the stratospheric solar signal to the impact of energetic particles on climate (**Katja Matthes**). Over the past year SOLARIS-HEPPA has produced the solar forcing dataset for CMIP-6, as well as a number of key papers outlining the impact of the solar signal on climate variability and predictability. This includes an overview paper of the DAMIP, a CMIP-6 project, that will cover experiments looking at the impact of solar forcing on detection and attribution of climate change. The activity will hold their next workshop in Paris, France, from 6-8 November 2017.

Michelle Santee provided an overview of progress made by the Polar Stratospheric Clouds Initiative (PSCi). So far the group has met three times, with the last two meetings being focused on a review paper that they are aiming to submit to Reviews of Geophysics by January 2018. The paper is being led by Michael Pitts and Ines Tritscher, and will provide a comprehensive overview of the distribution, formation processes, composition, and chemical processing of polar stratospheric clouds.

During 2016 the Atmospheric Composition in the Asian Monsoon (ACAM; also joint with IGAC) activity transitioned its formation committee into a scientific steering committee, which includes members from the four ACAM working groups (**Laura Pan**). ACAM helped organise a very successful workshop on Dynamics, Transport, and Chemistry in the Asian Monsoon Upper Troposphere/Lower Stratosphere in March 2016 and is working on organising the third biennial

workshop to be held in Guangzhou, China, from 5-9 June 2017. Associated with this workshop will be the second ACAM training school. The group continues to work on developing capacity in the Asian Monsoon region, particularly through involvement in various field campaigns.

The Stratospheric Sulfur and Its Role in Climate (SSiRC) activity has, similar to several other SPARC activities, been involved in developing CMIP-6 projects (**Claudia Timmreck**). Their focus has been on VolMIP, which aims to understand the climatic responses to volcanoes. In 2016 SSiRC also produced a review paper on stratospheric aerosols and worked on a paper regarding the atmospheric sulfur budget, which is to be submitted soon. The group has also been very involved in several observational campaigns and in developing a response plan for a future campaign in the event of a major volcanic eruption. SSiRC is hoping to organise a Chapman Conference focused on "Stratospheric aerosols during the past 20 years" in 2018 on the island of Tenerife, Spain.

Amanda Maycock presented the Atmospheric Temperature Changes (ATC) activity, which she is co-leading with Andrea Steiner and Bill Randel. The activity is focused on understanding atmospheric temperature variability and trends in climate records and attribution of changes to radiative and dynamical drivers. Recent progress was presented at the group's first workshop in April 2016. This includes the production of new long-term merged temperature records for the stratosphere and mesosphere, comparison of model and satellite observations in terms of the magnitudes of tropospheric temperature changes, and an analysis of the consistency of GPS radio occultation observations. The group is organising a session at the European Geophysical Union's 2017 Conference and will likely plan a second ATC workshop for 2018 as well.

This year the Dynamical Variability (DynVar) activity held a major workshop in Helsinki, Finland, from 6-10 June 2016, which brought together the DynVar community, including representatives from various modelling centres (**Alexey Karpechko**). DynVar were also heavily involved in developing the DynVarMIP as part of CMIP-6. This MIP specifies and extra list of output diagnostics that will be used to help understand consistent model biases of various aspects of atmospheric dynamics, such as sea level pressure change or the mean position of the mid-latitude jets.

The Quasi-Biennial Oscillation initiative (QBOi) has largely focused on their phase one experiments over the past year (**Scott Osprey**). These experiments were designed to better understand differences between models able to reproduce the QBO and will serve as a basis for several papers to go into a special collection of the Quarterly Journal of the Royal Meteorological Society in 2017. The background work already done made it possible to very quickly put together a paper in response to the disruption in the QBO in mid-2016 (Osprey et al., 2016). Together with SNAP and the Gravity Waves activity, QBOi would like to organise a joint workshop on the 2016 QBO disruption event, likely to be held in Asia in late 2017. More news on this workshop will be posted on the SPARC website and in the eNews bulletin.

The SPARC Gravity Waves activity organised one of its major five-year conferences in 2016 at Penn State University (**Joan Alexander**). The symposium brought together a large number of scientists from both the weather and climate communities to focus on topics ranging from convective gravity wave generation to new observational results from the DEEPWAVE campaign and PANSY radar system. Results from recent studies indicate that typical gravity wave parameterisations underestimate the amplitudes of these waves by up to a factor of 10, with even the most advanced parameterisations still underestimating amplitudes by up to a factor of three. They also found that vertical resolution and numerical schemes play a very

important role in accurately resolving waves and reducing dissipation in models. In the coming years the group, with Fuqing Zhang joining as a third co-lead, will focus on model predictability, particularly through encouraging modelling groups to incorporate newer gravity wave parameterisations.

Marv Geller presented progress made by the emerging FIne-Scale Atmospheric Processes and Structures (FISAPS) activity. Over the past year they have been developing an overview paper outlining recent progress made using high-resolution radiosonde observations as well as areas for new research that the activity will focus on. This includes, for example, recovering higher resolution signals from lower resolution historical data using spline-fitting techniques to extend records back to the 1960s. In addition to completing the paper, the group will be working on extending membership, in particular to help obtain further data, and will be organising a joint workshop together with the QBOi in 2017. The SSG accepted FISAPS as a full activity given the progress made over the past year.

3. New SPARC Activities

A record number of five proposals for new SPARC activities were presented, on various topics across SPARC's three scientific themes. **Daan Hubert** gave an overview of the Long-term Ozone Trends and Uncertainties in the Stratosphere (LOTUS) activity, which developed in response to issues raised in the last WMO/UNEP Ozone Assessment and the completed SPARC Si2N activity. These include differences in trend estimates as well as the uncertainties associated with these estimates. The activity will be coordinated by Daan, Irina Petropavlovskikh, and Sophie Godin-Beekman, with two science teams focused on "multi-instrument dataset integration" (MIDI; led by Viktoria Sofieva and Robert Damadeo) and on "regressions of ozone analysed for stratospheric trends" (ROAST; led by Robert Damadeo and Birgit Hassler). The MIDI team aims to extend and update ozone profile datasets to correct them as best as possible before running trend analyses, while the ROAST team will then use these datasets to assess the impact of using different statistical techniques to estimate long-term trends. Overall, it is hoped that an ensemble of datasets (including uncertainties) and techniques will be developed to provide a much better estimate of long-term ozone trends in the stratosphere. The activity will publish its results in peer-reviewed journals in time for the WMO/UNEP 2018 Ozone Assessment. It was accepted as a full activity.

An activity focused on Short-Lived Climate Forcers (SLCFs; **Bill Collins**) aims to understand the climate system's physical response to changes in radiative forcing from SLCFs. This includes aspects of the surface climate, such as surface temperature and precipitation, as well as other large-scale atmospheric features such as circulation patterns. For the moment, most of the planned activities are model-based, with experiments loosely based on the protocols developed for the Precipitation Driver Response Model Intercomparison Project (PDRMIP). There is however, plenty of scope to combine investigations with observational estimates of radiative forcing and emissions studies. The activity is very much in the development phase, with planning of experiment design to follow on from the CMIP-6 AerChemMIP project in 2018 and model simulations to be started in late 2018. The activity would clearly link with IGAC (see below) as well as the WCRP grand challenges on Clouds, Circulation, and Climate sensitivity; Carbon-climate interactions; and near-term climate predictions. Results from the activity would also be highly relevant to understanding the climate impacts of various air quality policies around the world.

Peter Hoor presented a proposal for an activity on Observing Composition Trends And Variability in the Upper Troposphere/Lower Stratosphere (OCTAV-UTLS). The region is very sensitive to changes in radiatively active gases such as ozone, methane, and water vapour and thus has a significant impact on much of the atmosphere. However, the UTLS is a highly variable region and definitions of the tropopause can have significant results on estimates in trends of chemical species. The activity aims to address the issue of understanding which tropopause definitions are ideal for various radiatively active species and using this information to reconcile and better understand limitations in the available observational datasets. They will use data from satellites, balloon- and aircraft-borne instruments, as well as ground-based remote sensing.

The fourth proposed activity called Towards UNified Error Reporting (TUNER) was presented by **Thomas von Clarmann** on behalf of his co-leads Doug Degenstein and Nathaniel Livesey. The activity aims to assess the best ways to report satellite measurement uncertainty estimates, since currently there is a very wide range in how these are reported. The activity team so far includes investigators from 12 satellite missions who will then implement the recommendations developed into their datasets. TUNER thus provides a key link between data providers and users, with strong links to many of SPARC's other activities as well as NDACC (see below), who have faced similar challenges in terms of their ground-based observational networks.

Historically, SPARC activities on stratosphere-troposphere exchange have focused on the mid-latitude regions, where balanced dynamics prevail. The Stratospheric and Tropospheric Influences On Tropical Convective Systems (SATIO-TCS; **Marv Geller**) activity aims to focus rather on the tropical regions, where weather systems involved multi-scale interactions with moist convection. Many studies over the past decade have shown that the stratosphere can significantly influence tropospheric variability in the tropics, and vice versa. This activity aims to better understand and predict stratosphere-troposphere interactions in the tropics using coordinated observational data analyses, theoretical studies, and experiments with a hierarchy of numerical models. SATIO-TCS links well with the WCRP Grand Challenges on Clouds, Circulation, and Climate Sensitivity; Near-term Climate Predictions; and Climate Extremes. The activity will also help develop capacity, particularly in the Asian region, where they already organized one training school in 2016. SLCFs, OCTAV-UTLS, TUNER, and SPATIO-TCS were all accepted as emerging activities.

4. Partner Projects

The International Global Atmospheric Chemistry project (IGAC; **Mark Lawrence**) has been redefining itself, particularly in light of IGBP's move to Future Earth. The project continues to facilitate atmospheric chemistry research across the globe and functions in a similar way to SPARC, with two joint activities between both projects: CCMI and ACAM. A major focus for IGAC in 2016 was its biennial science conference, held in Breckenridge, Colorado, in late September. Of almost 500 participants, 200 were early career researchers and a very successful early career programme was organised both before and during the conference. The 2018 IGAC conference will be held the week prior to the 2018 SPARC General Assembly and also in Takamatsu, Japan, just 2.5 hours away from Kyoto, the location of the SPARC conference. The science programmes will be developed to encourage participation from the SPARC and IGAC communities in both conferences.

Martine de Mazière presented an overview of the Network for the Detection of Atmospheric Composition Change (NDACC), whose observations are used widely throughout the SPARC community. Most recently, measurements of carbon tetrachloride and carbonyl sulfide were used in SPARC report no. 7 ("Solving the Mystery of Carbon Tetrachloride") and the SSiRC stratospheric sulfur overview paper, respectively. New products from the network include temperature and wind profiles from microwave radars, which can be obtained under most atmospheric conditions and therefore provide good data coverage. NDACC are completing an activity homogenising long-term ozonesonde records, and hope that the data will be made available soon. NDACC is maturing as a reference network and recognised as a key data provider for supporting validation activities around the globe, including by the Copernicus Atmospheric Monitoring System. Finally, to celebrate 25 years of NDACC/NSDC (the NDACC precursor network) observations, a joint special issue has been opened in Earth System Science Data, Atmospheric Chemistry and Physics, and Atmospheric Measurement Techniques.

5. Space Observations

The issue of a looming gap in limb-sounding observations of atmospheric composition was touched on again by **Joan Alexander**. These observations are vital for monitoring essential climate variables such as water vapour, as well as for assessing the efficacy of the Montreal Protocol. Although the SAGE-III instrument will be launched on board the international space station soon, its sampling will be very sparse. The only instrument that is planned to continue into the future is OMPS, which measures ozone and aerosols, however, there are no firm plans for any instrument that could measure water vapour, methane, or other species important in the stratosphere and UTLS. The SPARC community has kept advocating for the continuation of limb-sounding observations wherever possible, including most recently as input for the NASA decadal survey.

To discuss this survey and give an update on a wide range of other NASA activities, **Kenneth Jucks** joined the meeting remotely. The Aura science team will be reviewed in the coming months as part of the regular biennial "senior review" process. There is also an ongoing review of the SAGE-III launch system, which was found to have a fault preventing it from launching as planned in November 2016. NASA is currently selecting a commercial telecommunications satellite for launch of the TEMPO instrument, the first of Earth Venture instrument series and which is aimed at observing air pollution around the globe. Several other missions stemming from the last NASA decadal survey will launch in the near future, including NI-SAR, SWOT, GEI, ECOSTRESS; CLARREO-pathfinder, and the OCO-3 which will be installed on board the international space station. The final report for the upcoming NASA decadal survey will be released in late 2017 and it is possible to still provide input to the various committees involved in providing the report. NASA has also conducted a large number of airborne campaigns over the past year, including KORUS-AQ, focused on air quality; POSIDON; ATOM, which has obtained global-scale cross-sections of atmospheric constituents including several reactive gases; ORACLES, focused on aerosols and their interaction with clouds and impacts on radiative forcing; and ACTA, aimed at measuring greenhouse gas fluxes over the Americas.

Quentin Errera briefly outlined the Altius mission, which will go some ways to 'fill the gap' in limb-sounding observations of the stratosphere. The mission was officially recognised as part of the ESA Earth Watch programme in December 2016 and will be based on PROBA micro-satellites on a polar orbit making both limb and occultation observations. The team expects to measure ozone and hopefully also water vapour, methane, aerosol, and polar stratospheric

clouds. A third group of constituents, including OClO, BrO, and NO_3, will be measured if possible. The aim is to launch the instrument in late 2020 with a proposed lifetime of approximately three years.

6. Other SPARC News

2016 was a busy year in terms of SPARC's capacity development efforts (**Fiona Tummon**). The SPARC website now includes a 'How to get involved' page which also provides a useful page of links to SPARC-related online courses and teaching material. SPARC has been actively promoting the Young Earth System Scientists (YESS) community and, as usual, has supported many early career researchers to attend SPARC workshops and a training school on atmospheric composition and dynamics, held on Réunion Island. The Asia-Pacific working group is still growing and was involved in the "Southeast Asia School on Tropical Atmospheric Science (SEASTAS)", which was held joint with a workshop on Extreme Weather in a Changing Climate in the Maritime Continent (**Seok-Woo Son**). Work is underway to develop a university-level course on middle atmosphere dynamics in southern Africa, which will hopefully stimulate interest across the region in SPARC-related science (**Thando Ndarana**). Several activities are planned for 2017, including the 2nd ACAM training school (Guangzhou, China), an atmospheric dynamics training school (Cape Town, South Africa), the 3rd SEASTAS school in Singapore, as well as regional science workshop joint with the 25th SPARC SSG meeting, which will be held in Seoul, Korea, in September or October 2017.

In other good news, the Deutsches Luft- und Raumfahrt (DLR; German space agency) have offered to host the international SPARC project office as of mid-2017. **Hans Volkert** will serve as director and, together with the current team in Zurich, will help ensure a smooth transition to the new location in Oberpfaffenhofen. The DLR team will take over all duties as of 2018.

The 2018 SPARC General Assembly will be held from 1-6 October 2018 at the Miyakomesse, a major conference centre in Kyoto, Japan (**Kaoru Sato**). Organisation of the event is already underway, with the science programme to be made public in mid-2017. Various early career researcher events are also being planned, potentially in collaboration with IGAC.

The meeting was brought to a close on Friday afternoon. The 25th SPARC SSG meeting in conjunction with a regional science workshop will be held in Seoul, Korea, in late 2017.

7. WCRP/SPARC Workshop: "Grand Challenges for Climate Science – Synergies between SPARC and the WCRP Grand Challenges"

64 scientists from 15 nations met in Berlin to discuss science related to SPARC and the WCRP Grand Challenges (GCs). WCRP has identified seven GCs (www.wcrp-climate.org/grand-challenges) representing areas for specific focus in scientific research for WCRP in the coming years. Progress in these areas will lead to actionable information for decision makers. Organized back-to-back with the annual meeting of the SPARC scientific steering group, this workshop brought together scientists active in GC research, in SPARC activities, and scientists that thus far have had fewer links to WCRP, with the goal of exploring synergies and fostering

scientific exchange. The discussions concentrated on four of the GCs where links to SPARC seem most obvious. For each of these four research areas, one scientist involved in the GC presented ideas and ongoing work, followed by a few invited presentations covering specific related topics, and a lively poster session.

Guy Brasseur, Chair of the WCRP Joint Scientific Committee, opened the workshop with an overview of the programme, including its organisation into thematic working groups, the four core projects (CLIC, CLIVAR, GEWEX, and SPARC), and the seven GCs covering topics cutting across the core projects (see Fig. 1). He emphasized that it is timely "to start developing a new perspective for WCRP that responds to the societal challenges of the next decades, and puts more emphasis on regional aspects, on natural variability, and on possible surprises." Regional approaches for WCRP are based on three legs: foundational climate science, application-oriented climate science, and trans-disciplinary engagement.

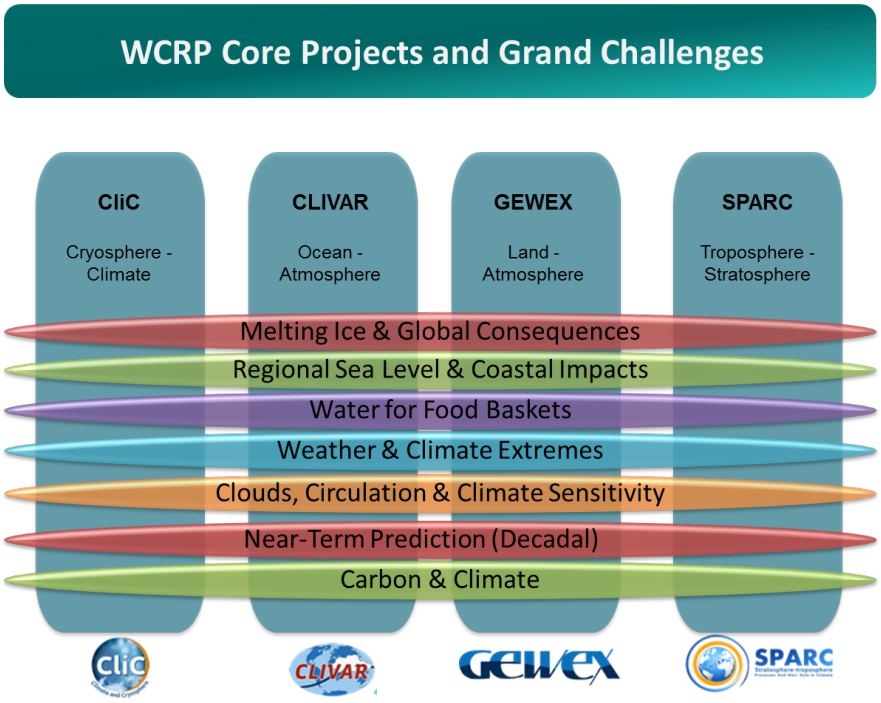

Fig. 1: *The four WCRP core projects (CLIC, CLIVAR, GEWEX, and SPARC) and the seven Grand Challenges covering topics cutting across the core projects (figure adapted from the workshop presentation by Guy Brasseur).*

7.1 Clouds, Circulation and Climate Sensitivity

Ted Shepherd introduced the GC on "Clouds, Circulation and Climate Sensitivity". He pointed out that the growing emphasis on regional climate, as presented by Guy Brasseur, and on Near-Term Climate Prediction (see below), is exposing the limitations in our understanding of atmospheric circulation and its response to climate change. As examples, he mentioned the uncertainty of climate projections for Europe (including the Mediterranean) being largely related

to the way different models simulate large-scale circulation, and even in the tropics, where models disagree most, circulation has a profound influence.

Ice formation in clouds and the relevance of small-scale uncertainties in cloud microphysical processes for large scales were the topic of **Corinna Hoose**. She emphasized the relevance of a changing cloud-phase distribution in a warming world and that this distribution, being dependent on the frequency, season, and location of occurrence of different cloud types, will also be impacted by circulation changes.

Hella Garny gave an overview of changes in the large-scale circulation of the middle atmosphere and its impact on chemistry and climate. She identified key open questions that concern past middle atmosphere circulation changes (e.g. how to reconcile them and what role transport, mixing, and gravity waves play), and the quantification of the influence of the middle atmosphere on the troposphere.

Gabi Stiller reviewed the role of stratospheric water vapour in climate change. Obviously, stratospheric water vapour has a large impact on radiative forcing and hence for climate change. However, she highlighted that the puzzle of water vapour entry into the stratosphere is not yet solved. Trends in water vapour itself and in cold-point temperatures are not in agreement, in observations, models, or reanalyses.

7.2 Near-Term Climate Prediction

The GC on "Near-Term Climate Prediction" was introduced by **Judith Perlwitz**. Such predictions are intended to fill the gap between long-term centennial projections and seasonal forecasts. The three objectives of the GC are a) research and development to improve predictions on the interannual to decadal timescale, b) to collate and synthesize existing projections, and c) to develop structures for future routine decadal predictions.

The German MiKlip project, that aims to develop an operational decadal climate prediction system, was presented by **Wolfgang Müller**. Among the lessons learned so far in this project are: initialisation is crucial but still a challenge (model-consistent assimilation would be nice to have for this); key processes for prediction skill (e.g. North Atlantic heat content) have been identified, but models may need improvements to benefit from this knowledge; bias-correction methods improve prediction skill but also need further improvement.

Claudia Timmreck emphasized the role of large volcanic eruptions for near-term climate predictions. Once such an event occurs the resulting forcing needs to be taken into account for the predictions. She showed that the skill of hindcasts up to a decade in length lose a large part of their skill if volcanic events are ignored.

Katja Matthes gave an overview of the effects of solar variability on climate and highlighted its role for near-term climate predictions. For instance, it has been shown that there is predictive skill for the NAO on timescales of up to one year ahead, partly resulting from knowledge about the solar forcing. She also noted that not only the solar forcing (in radiation and particles) but also a consistent representation of its effect on stratospheric ozone is crucial.

Two further presentations concentrated on timescales shorter than one year. **Daniela Domeisen** reviewed the involvement of the stratosphere in seasonal predictions, showing that it is clear that seasonal prediction skill is much higher for the tropics than for the extra-tropics. In particular, Europe is a region for which the skill is currently low. However, there are

predictors that can provide skill, most of which are relevant for the winter season, in particular those acting via the stratosphere (e.g., QBO, ENSO, or solar forcing).

The even shorter sub-seasonal timescale was covered by **Andrew Charlton-Perez**, who presented the Stratosphere Network for the Assessment of Predictability (SNAP) and its relevance to the WCRP GCs. As for the other timescales, one fundamental interest of SNAP is to understand the dynamics of coupling between the stratosphere and troposphere. Andrew emphasized the importance of the state of the polar vortex, the MJO, and the QBO for predictive skill.

7.3 Climate Extremes

Olivia Martius introduced the GC on "Climate Extremes" which has two perspectives: service and science. While there is a huge public demand for information on extremes, we still have to improve our understanding of causes and mechanisms of variability and change in extremes, as well as their predictability. The GC focusses on four types of extremes: heavy precipitation, storms, heatwaves, and droughts. A link to SPARC is in particular provided by the relevance of circulation, because extreme events are often related to specific circulation patterns as blocking events.

In his presentation **Kai Kornhuber** concentrated on dynamical changes relevant to summer extremes. He argued that the mid-latitude summer circulation is less thoroughly studied than the winter circulation, even though it is possibly more sensitive to relatively subtle changes. There is some evidence for zonal flow and storm tracks weakening under climate change and possible drivers of this were discussed.

A complementary view on extremes was provided by **George Craig** who presented the HIWeather project of the World Weather Research Programme (WWRP). The project aims to achieve a dramatic increase in resilience to high impact weather through improving forecasts on timescales from minutes to two weeks. To achieve this, the project is working to improve the links between forecasters (i.e. meteorologists) and decision makers. With respect to WCRPs regional activities (see above), it would certainly be useful to benefit from the WWRP's experience.

7.4 Carbon feedbacks in the Climate System

Finally, the workshop covered the GC on "Carbon feedbacks in the Climate System" and other trace gases relevant to SPARC. **Tatiana Ilyina** presented this GC, which aims to understand how biogeochemical cycles and feedbacks control CO_2 concentrations and thus impact the climate system. Guiding questions of this GC concern a) the drivers of land and ocean carbon sinks, b) the potential for amplification of climate change via carbon cycle feedback, and c) greenhouse gas fluxes from highly vulnerable carbon reservoirs.

Atmosphere-ocean coupling via trace gases was the topic of **Susann Tegtmeier**, who pointed out that oceanic trace gases are important for atmospheric chemistry and climate, and that it is necessary to better understand the processes involved. Improved observations will be necessary to accomplish this. An example of an open question on this topic is the "missing source" of atmospheric sulfur, which is necessary to reconcile atmospheric observations of trace gases concentrations and various emission source estimates.

Bill Collins provided an overview of short-lived climate forcers (SLCFs) and made the point that quantifying the climate impacts of SLCFs is crucial a) for deducing historical climate sensitivity to CO_2, b) to make near-term climate predictions, and c) to quantify the climate impacts of air quality policies. He proposed a new SPARC activity to coordinate research focusing on understanding the climate effects of SLCFs, particularly on the regional scale.

The Harnack House, the conference venue of the Max Planck Society in Berlin, provided a stimulating environment for discussion among researchers from different backgrounds and rooted in different research fields. We hope that fruitful collaborations will result from this meeting. Although the topics presented were very diverse, it became clear that there are strong links from SPARC to all the four GCs covered in this workshop. Such links include the relevance of large-scale circulation in understanding regional climate change and extremes, as well as the importance of factors such as solar forcing QBO, volcanoes in advancing the skill of predictions on annual to decadal time scale.

Annex 1: List of Participants

SPARC SCIENTIFIC STEERING GROUP

Neil R. P. Harris
Cranfield University
Centre for Atmospheric Informatics and Emissions Technology
College Road, Bedfordshire
Cranfield MK43 0AL, UK
Email: Neil.Harris@cranfield.ac.uk

Judith Perlwitz
University of Colorado
Cooperative Institute for Research in Environmental Sciences
Campus Box 216 UCB
Boulder, CO 80309, USA
Email: judith.perlwitz@noaa.gov

Mark P. Baldwin
University of Exeter
College of Engineering, Mathematics and Physical Sciences
Harrison Building, Room 324
North Park Road
UK-Exeter EX4 4QF, UK
Email: m.baldwin@exeter.ac.uk

Gufran Beig
Indian Institute of Tropical Meteorology,
Physical Meteorology & Aerology
Division, NCL PO
Dr. Homi Bhabha Rd, Pashan
Pune - 411 008, India
Email: beig@tropmet.res.in

Alexey Karpechko
FMI Finnish Meteorological Institute
P.O Box 503
FI-00101 Helsinki, Finland
Email: alexey.karpechko@fmi.fi

Thando Ndarana
CSIR Council for Scientific and Industrial Research, Climate Technology Centre and Network (CTCN)
P.O. Box 395
Pretoria 0001, South Africa
Email: thando.ndarana@gmail.com

Olivia Romppainen-Martius
University of Bern, Institute of Geography
Mobiliar Gruppe für Klimafolgenforschung
Hallerstrasse 12
CH-3012 Bern, Switzerland
Email: olivia.romppainen@giub.unibe.ch

Michelle L. Santee
NASA Jet Propulsion Laboratory
California Institute of Technology
MS 233-200, 4800 Oak Grove Drive
Pasadena, CA 91109, USA
Email: michelle.l.santee@jpl.nasa.gov

Kaoru Sato
University of Tokyo, Department of Earth and Planetary Science
Graduate School of Science
Room 847, Faculty of Science Building 1, 8F, Hongo 7-3-1, Bunkyo-ku
Tokyo 113-0033, Japan
Email: kaoru@eps.s.u-tokyo.ac.jp

Hauke Schmidt
Max Planck Institute for Meteorology
The Atmosphere in the Earth System
Terrestrial Remote Sensing
Bundesstr. 53
D-20146 Hamburg, Germany
Email: hauke.schmidt@mpimet.mpg.de

Seok-Woo Son
Seoul National University, School of Earth and Environmental Sciences
Building 501, Office #424
1 Gwanak-ro, Gwanak-gu
Seoul 151-742, Republic of Korea
Email: seokwooson@snu.ac.kr

Tianjun Zhou
Chinese Academy of Sciences
Institute of Atmospheric Physics
PO Box 9804
40, Huayan Li, Beijing 100029, China
Email: zhoutj@lasg.iap.ac.cn

SPARC ACTIVITY LEADERS

Joan Alexander
NorthWest Research Associates, Inc. - CoRA
3380 Mitchell Lane
Boulder, CO 80301, USA
Email: alexand@nwra.com

Andrew Charlton-Perez
University of Reading
Department of Meteorology
PO Box 243, UK-Reading RG6 6BB, UK
Email: a.j.charlton-perez@reading.ac.uk

William Collins
University of Reading
Department of Meteorology
Lyle Building, 303A
UK-Reading RG6 6BX, UK
Email: w.collins@reading.ac.uk

Quentin Errera
Institut d'Aeronomie Spatiale de Belgique (BIRA-IASB)
Avenue Circulaire, 3
B-1180 Brussels, Belgium
Email: quentin.errera@aeronomie.be

Marvin A. Geller
Stony Brook University
School of Marine and Atmospheric Sciences
111 Endeavour Hall
Stony Brook, NY 11794-5000, USA
Email: Marvin.Geller@sunysb.edu

Lesley J. Gray
University of Oxford
Clarendon Laboratory, Atmospheric, Oceanic and Planetary Physics
Parks Road
UK-Oxford OX1 3PU, UK
Email: gray@atm.ox.ac.uk

Michaela I. Hegglin
University of Reading
Department of Meteorology
Lyle Building, 302A
UK-Reading RG6 6BX, UK
Email: m.i.hegglin@reading.ac.uk

Peter Hoor
Johannes Gutenberg University Mainz
Institute for Atmospheric Physics (IPA)
J.-J.-Becherweg 21
D-55128 Mainz, Germany
Email: hoor@uni-mainz.de

Mark Lawrence
IASS Institute for Advanced Sustainability Studies e. V., Cluster SIWA - Sustainable Interactions With the Atmosphere
Berliner Str. 130
D-14467 Potsdam, Germany
Email: mark.lawrence@iass-potsdam.de

Katja Matthes
GEOMAR Helmholtz Centre for Ocean Research Kiel, Ocean Circulation and Climate Dynamics, Marine Meteorology
Düsternbrooker Weg 20
D-24105 Kiel,Germany
Email: kmatthes@geomar.de

Amanda Maycock
University of Leeds
School of Earth and Environment
Woodhouse Lane
UK-Leeds LS2 9JT, UK
Email: A.C.Maycock@leeds.ac.uk

Scott Osprey
University of Oxford, Clarendon Laboratory, Atmospheric, Oceanic and Planetary Physics
Parks Road
UK-Oxford OX1 3PU, UK
Email: sosprey@atm.ox.ac.uk

Laura Pan
NCAR National Center for Atmospheric Research, Atmospheric Chemistry Observations & Modeling Laboratory
UTLS Studies
PO Box 3000
Boulder, CO 80307-3000, USA
Email: liwen@ucar.edu

Gabriele P. Stiller
Karlsruhe Institute of Technology (KIT)
Institute for Meteorology and Climate Research (IMK), Atmospheric Trace Gases and Remote Sensing (ASF)
Hermann-von-Helmholtz-Platz 1
D-76344 Eggenstein-Leopoldshafen
Germany
Email: Gabriele.Stiller@kit.edu

Susann Tegtmeier
GEOMAR Helmholtz Centre for Ocean Research Kiel, Ocean Circulation and Climate Dynamics, Marine Meteorology
Düsternbrooker Weg 20
D-24105 Kiel, Germany
Email: stegtmeier@geomar.de

Claudia Timmreck
Max Planck Institute for Meteorology
The Atmosphere in the Earth System
Bundesstr. 53
D-20146 Hamburg, Germany
Email: claudia.timmreck@mpimet.mpg.de

WCRP REPRESENTATIVES

Guy Brasseur
Max Planck Institute for Meteorology
Environmental Modelling
Bundesstr. 53
D-20146 Hamburg, Germany
Email: guy.brasseur@mpimet.mpg.de

Boram Lee
Senior Scientific Officer
World Climate Research Programme
World Meteorological Organization
7 bis, Avenue de la Paix
Case Postale 2300
CH-1211 Geneva 2, Switzerland
Email: blee@wmo.int

AGENCY DELEGATES AND OTHER INVITEES

Martine de Mazière
Institut d'Aeronomie Spatiale de Belgique (BIRA-IASB)
Avenue Circulaire, 3
B-1180 Brussels, Belgium
Email: martine.demaziere@aeronomie.be

Hans Volkert
DLR - German Aerospace Center
Institut für Physik der Atmosphäre (IPA)
Münchner Str. 20
D-82234 Oberpfaffenhofen, Germany
Email: Hans.Volkert@dlr.de

SPARC International Project Office

Fiona Tummon
SPARC International Project Office
ETH Zuerich, Universitätstrasse 16
CH-8092 Zurich, Switzerland
Email: fiona.tummon@env.ethz.ch

Carolin Arndt
SPARC International Project Office
ETH Zuerich, Universitätstrasse 16
CH-8092 Zurich, Switzerland
Email: carolin.arndt@sparc-climate.org

Petra Bratfisch
SPARC International Project Office
ETH Zuerich, Universitätstrasse 16
CH-8092 Zurich, Switzerland
Email: petra.bratfisch@env.ethz.ch

Annex 2: Agenda

Monday, 31 October 2016

WCRP/SPARC Workshop: "Grand Challenges for Climate Science – Synergies between SPARC and the WCRP Grand Challenges"

1300	Welcome/Aims of the workshop	Workshop SOC
1310	WCRP priorities for next 5-10 years	Guy Brasseur
1330	GC1: Clouds, circulation & climate sensitivity	Ted Shepherd (skype)
1400	Ice formation in clouds - small-scale uncertainties and their relevance for large scales	Corinna Hoose
1420	The role of changes in MA circulation for chemistry and climate	Hella Garny
1440	The role of stratospheric water vapor for climate	Gabi Stiller
1500	Discussion: SPARC/GC1 links	
	TEA	
1550	GC6: Near-term climate prediction	Judith Perlwitz
1620	Predictability after volcanic eruptions	Claudia Timmreck
1640	Lessons from the SNAP activity	A. Charlton-Perez
1700	Miklip – Assessment of decadal climate prediction	Wolfgang Müller
1720	Solar variability and climate predictability	Katja Matthes
1740	Discussion: SPARC/GC6 links	
	Posters & Ice breaker	
2000	CLOSE	

Tuesday, 1 November 2016

WCRP/ SPARC Workshop continued.

0900	Seasonal prediction and the involvement of the stratosphere	Daniela Domeisen
0920	GC3: Climate extremes	Olivia Romppainen
0950	Extremes	Dim Comou
1010	HiWeather project	George Craig
1030	Discussion: SPARC/GC3 links	
	COFFEE	
1120	GC7: Carbon feedbacks in the climate system	Tatiana Ilyina (skype)
1150	Atmosphere ocean coupling through trace gases	Susann Tegtmeier
1210	Short-lived climate forcers	Bill Collins
1230	Discussion: SPARC/GC7 links & Final discussion	
1300	CLOSE	

SPARC SSG Meeting

14:00 to 15:30 Welcome, WCRP update, new SPARC activities		
14:00-14:15	Welcome & meeting goals	Co-chairs
14:15-14:35	WCRP update	Boram Lee
14:35-15:00	Short-lived climate forcers	Bill Collins
15:00-15:30	Discussion	All
15:30-16:00 ***Coffee break***		
16:00 to 17:30 SSG closed session		

Wednesday, 2 November 2016

9:00 to 10:30 Predictability and long-term records		
9:00-9:20	SNAP	Andrew Charlton-Perez
9:20-9:40	S-RIP	Lesley Gray
9:40-10:00	Data assimilation working group	Quentin Errera
10:00-10:20	WAVAS-II	Gabi Stiller
10:20-10:30	Discussion	All
10:30-11:00 ***Coffee break***		
11:00-12:30 Atmospheric Composition		
11:00-11:20	CCMI	Michaela Hegglin
11:20-11:40	SOLARIS-HEPPA	Katja Matthes
11:40-12:00	PSCi	Michelle Santee
12:00-12:30	Limb-sounding observations	Joan Alexander
12:30-13:30 ***Lunch***		
13:30-15:00 Upper Trop/Lower Strat		
13:30-13:50	ACAM	Laura Pan
13:50-14:10	SSiRC	Claudia Timmreck
14:10-14:30	Atmospheric Temperature Changes	Amanda Maycock
14:30-15:00	OCTAV-UTLS	
15:00-15:30 ***Coffee break***		
15:30-17:00 SPARC Office/Partner projects		
15:30-15:55	SPARC Office report	Fiona Tummon
15:55-16:15	New home for the SPARC Office	Hans Volkert
16:15-16:45	IGAC	Mark Lawrence
16:45-17:00	Discussion	All

Thursday, 3 November 2016

9:00 to 10:30 Atmospheric Dynamics		
9:00-9:20	DynVar	Alexey Karpechko
9:20-9:40	QBOi	Scott Osprey
9:40-10:00	Gravity Wave activity	Joan Alexander
10:00-10:20	FISAPS (emerging)	Marv Geller
10:20-10:30	Discussion	All

10:30-11:00 ***Coffee break***		
11:00-12:30 New SPARC activities + NDACC		
11:00-11:30	LOTUS - Stratospheric Ozone Trends	Daan Hubert (remote)
11:30-12:00	TUNER	Thomas von Clarmann (rem.)
11200-12:30	NDACC	Martine de Mazière
12:30-13:30 ***Lunch***		
13:30-15:00 WCRP panels + NASA		
13:30-13:50	WMAC	Judith Perlwitz
13:50-14:10	WGNE	Quentin Errera
14:10-14:30	WDAC	Susann Tegtmeier
14:30-14:50	NASA	Ken Jucks (remote)
14:50-15:05	Altius Mission	Quentin Errera
15:05-15:30 ***Coffee break***		
15:30-17:00 SSG closed session		

Friday, 4 November 2016

9:00 to 10:30 SPARC Capacity development & new activities		
9:00-9:30	SPARC capacity development	Thando Ndarana
9:30-10:00	SATIO-TCS	Marv Geller
10:00-10:30	Discussion – New activities	All
10:30-11:00 ***Coffee break***		
11:00-12:30 Planning 2017 + General Assembly 2018		
11:00-12:00	General Assembly 2018	Kaoru Sato
12:00-12:30	Planning for coming year	Co-chairs
12:30 ***Lunch & Adjourn***		

Annex 3: Acronyms and Other Abbreviations

ACAM	Atmospheric Composition in the Asian Monsoon (SPARC/IGAC activity)
ATC	Atmospheric Temperature Changes (SPARC activity)
BADC	British Atmospheric Data Centre
CCMI	Chemistry-Climate Modelling Initiative (SPARC/IGAC activity)
CLIVAR	Climate and Ocean – Variability, Predictability, and Change (WCRP Core-Project)
CMIP	Coupled Model Intercomparison Project (WCRP)
CORDEX	Coordinated Regional Climate Downscaling Experiment (WCRP)
DAWG	Data Assimilation Working Group
DynVar	Dynamical Variability activity (SPARC activity)
FE	Future Earth
FISAPS	FIne-Scale Atmospheric Processes and Structures activity (SPARC activity)
GCs	WCRP Grand Challenges
GCOS	Global Climate Observing System
IGAC	International Global Atmospheric Chemistry
LOTUS	Long-term Ozone Trends and Uncertainties in the Stratosphere (SPARC activity)
NDACC	Network for the Detection of Atmospheric Composition Change
OCTAV-UTLS	Observing Composition Trends And Variability in the Upper Troposphere/Lower Stratosphere (emerging SPARC activity)
PSCi	Polar Stratospheric Clouds Initiative (SPARC activity)
QBOi	Quasi-Biennial Oscillation initiative (SPARC activity)
SATIO-TCS	The Stratospheric and Tropospheric Influences On Tropical Convective Systems (emerging SPARC activity)
Si2N	Second Ozone Profile activity (SPARC activity)
SLCFs	Short-Lived Climate Forcers activity (emerging SPARC activity)
SSiRC	Stratospheric Sulfur and Its Role in Climate (SPARC activity)
SNAP	Stratospheric Network for Atmospheric Predictability (SPARC activity)
SOLARIS-HEPPA	Solar Influences on Climate (SPARC activity)
S-RIP	Stratospheric Reanalysis Intercomparison Project (SPARC activity)
SPARC	Stratosphere-troposphere Processes and their Role in Climate
SSG	Scientific Steering Group
TIRA	(WDAC-)Task team on the Intercomparison of Reanalysis
TUNER	Towards UNified Error Reporting (emerging SPARC activity)
UTLS	Upper Troposphere/Lower Stratosphere
YESS	Young Earth System Scientists
WAVAS-II	Second Water Vapour Assessment activity (SPARC activity)
WCRP	World Climate Research Programme (WMO, IOC and ICSU)
WDAC	WCRP Data Advisory Council
WGNE	Working Group on Numerical Experimentation
WMAC	WCRP Model Advisory Council
WMO	World Meteorological Organization
WWRP	World Weather Research Programme

The
World Climate Research Programme (WCRP)
facilitates analysis and prediction of Earth system change for use in a range of practical applications of direct relevance, benefit and value to society.