Report on the 22nd Session of the SPARC Scientific Steering Group 13-16 January 2015, Granada, Spain

Johannes Staehelin[1], Joan M. Alexander[2], Neil R.P. Harris[3], and Fiona Tummon[1]

[1]SPARC International Project Office, Zurich, Switzerland, **johannes.staehelin@env.ethz.ch**, [2]Northwest Research Associates, Boulder, CO, USA, [3]University of Cambridge, Cambridge, UK

Neil Harris (SPARC co-chair) opened the meeting, particularly welcoming the new SSG members and thanking the local organizers of the meeting (Bernd Funke and colleagues). **Joan Alexander** (SPARC co-chair) continued with the introduction, emphasizing that one of the main aims of the meeting was to provide input to the new SPARC implementation plan.

Dave Carlson (director of the WCRP (World Climate Research Programme) JPS (Joint Planning Staff)) presented on behalf of Guy Brasseur (new chair of the WCRP JSC (Joint Steering Committee)). Opening with a new vision for WCRP, Dave highlighted WCRP's mission, namely to study and predict Earth system variability and change for use in practical applications of direct relevance and benefit to society. WCRP has so far been very successful in pursuing this goal, but nevertheless needs to remain focused and agile to react to a changing environment. A view of the entire system is required, looking at the atmosphere, ocean, land, and cryosphere through cycles such as energy, water, and trace species (*e.g.* carbon and nitrogen), which link all sub-components of the Earth system. Particular focus will be on analysis and prediction of seasonal to decadal variability, as well as on the regional scale. To do this, all available tools will need to be used in innovative ways: models, observations, and reanalyses, with new aspects such as oceans and chemistry being included in the latter. The six WCRP Grand Challenges will need to serve as focus points and stimulate cooperation among the core projects. Furthermore, there are plenty of opportunities to enhance collaboration with partner programmes (*e.g.* IGBP (International Global Biosphere Programme), GEO (Global Earth Observations), GFCS (Global Framework for Climate Services), and the WWRP (World Weather Research Programme)). He also mentioned that WCRP presently has to cope with budget problems, implying reduced funding available to support WCRP projects.

SPARC activity reports

Each of the SPARC activities had time in plenary to report on their achievements during the past year and their future plans, in particular for the upcoming year.

Gabi Stiller emphasized in her report on WAVAS-2 (Water Vapour Assessment, phase 2), that water vapour is an important greenhouse gas but that open questions still remain concerning transport of this species from the troposphere to the stratosphere. Satellite measurements of water vapour cover the period from 1980 onwards (mostly limb-sounding instruments, but also four nadir-viewing instruments). The comparison of satellite observations with ground-based measurements from hygrometers and microwave radiometers shows that in some regions of the atmosphere satellite observations compare within +/- 10%, but problems remain in the UTLS (Upper Troposphere/Lower Stratosphere). A further pair-wise comparison of co-located (zonal mean) satellite data with the long sonde series from Boulder (Colorado, USA) showed that the representativeness of the sonde data from this site remains a problem. The group is aiming to submit a paper about the quality assessment of these data in early summer 2015 and will also work towards putting together a full SPARC report about the activity, including more complete documentation.

Katja Matthes started her presentation about SOLARIS-HEPPA (SOLARIS: Solar influences in SPARC, HEPPA: High Energy Particle Precipitation in the Atmosphere) by highlighting that the effect of solar forcing on climate on the global scale is small, but that on the regional scale it is important in particular seasons. For example, electron particle precipitation (EPP) can have an effect similar in magnitude to the effect of UV solar radiative forcing

changes on the North Atlantic Oscillation (NAO) such processes are generally not included in climate models. Further work looking at the simulated response to the solar signal (maximum versus minimum in the 11-year solar cycle) shows that models with interactive chemistry show a realistic temperature response. On the other hand, the CMIP5 (Coupled Model Intercomparison Project, Phase 5) models that used prescribed ozone fields did not show a robust signal in the lower stratosphere, perhaps pointing to the lack of seasonality and full latitudinal coverage in the prescribed ozone dataset. A new recommended dataset is being developed for CMIP6 within the context of the SPARC CCMI activity (see below). SOLARIS-HEPPA is developing solar and EPP forcing datasets for the CMIP6 simulations, and has also proposed a model intercomparison project (MIP), SolarMIP (see **www.wcrp-climate.org/index.php/modelling-wgcm-mip-catalogue/modelling-wgcm-mips** for a full outline of all proposed MIPs), for CMIP6. The group intends to carry out more idealized experiments and is working with CCMI on two scenario runs.

Neil Harris reported some key results from SI2N (SPARC, International Ozone Commission, IGACO (Intergrated Global Atmospheric Chemistry Observations), and NDACC (Network for Detection of Atmospheric Composition Change)). The activity has tackled several issues related to determining long-term ozone profile trends, for example, the propogation of errors and combining trends from multiple data sets. Further issues investigated in this activity were related to combining datasets from multiple sources, which is complicated by the fact that individual instruments may have drifts and errors. The adequate treatment of errors in such cases is complex and the community needs to improve how to assess such uncertainties and their implications for the estimation of long-term trends. In this respect, even though they might not always provide representative records, ground-based networks are absolutely crucial to making accurate estimates of instrument drift. The SI2N activity will be completed in 2015, however, certain questions stemming from the work of this group could evolve into a new SPARC activity. In particular, focus on the tropical tropopause layer (TTL) and the need for a coupled approach to provide a consistent understanding of ozone, temperature, water vapour, and aerosol records in this region.

In his presentation on stratospheric temperature trends **Bill Randel** reviewed the work of the last few years, which has largely focussed on uncertainties in stratospheric temperature observations. This included the homogenisation of radiosonde data and merged satellite datasets, in particular differences between two versions of the merged Stratospheric Sounding Unit (SSU) datasets. Another focus was on reanalyses, including the question of whether they are good enough to use when looking at stratospheric temperature trends, since there are issues related to jumps in the record due to the introduction of different satellite instrument records. Several groups are looking at how to extend the SSU datasets (with AMSU (Advanced Microwave Sounding Unit), MIPAS (Michelson Interferometer for Passive Atmospheric Sounding), or SABER (Sounding of the Atmosphere Using Broadband Emission Radiometry)). The improved homogenised datasets should be carefully compared with most recent models. The group discussed its future, particularly in terms of leadership changes, at a recent workshop held in Victoria, Canada (see page 19 for further details).

Joan Alexander started her presentation on the gravity waves activity by emphasizing the non-linear interaction between gravity waves and stratospheric circulation, with even small changes strongly affecting circulation patterns. Super-pressure balloons have been used to measure gravity wave momentum fluxes for up to nearly an entire season. These data serve as an excellent reference with which models can be evaluated. High resolution ECMWF (European Centre for Medium Range Weather Forecast) data compares spatially very well with the balloon observations, but need to be multiplied by a factor of five to obtain the same range of values. Such high resolution (~10km), gravity wave-permitting models are able to simulate many of the sources of gravity waves, such as tropical convection and winter hemisphere jet sources. These models, however, still suffer from severe circulation biases. The number of articles published about gravity waves and their effect on climate has been growing, and the group would like to write a review paper in 2015 to provide an overview of recent progress. The activity is also organising a dedicated conference 'Atmospheric gravity waves: sources and effects on weather and climate' to be held in May 2016. Similar to the temperature trends activity, the gravity waves group is thinking about the future of the activity, with perhaps a structure similar to SPARC's working group on data assimilation (DAWG; see below) and increased collaboration/

meetings in conjunction with other groups such as DynVar, WCRP's WGNE (Working Group on Numerical Experimentation), CCMI, *etc.*

In her presentation about DynVar (Dynamical Variability) **Elisa Manzini** explained that an effort was begun several years ago to link with CMIP5, in particular to encourage the use of high-top models. Most recently DynVar submitted their own diagnostic MIP to CMIP6. This MIP asks modelling groups to output variables needed for the understanding of dynamical processes. This also has links with the gravity wave activity, through a request for variables used to diagnose gravity wave drag. DynVar has continued to promote the use of high-top models since recent work has shown that stratospheric changes contribute as much to uncertainty in sea-level pressure predictions as tropical upper tropospheric warming and Arctic surface warming. This has implications for uncertainty reduction in estimates of climate sensitivity, sea-ice changes, as well as in decadal predictions. The group has planned several activities, including a workshop on storm tracks contributing to the WCRP grand challenge on 'clouds, circulation, and climate sensitivity' (Grindelwald, Switzerland, August 2015), as well as a DynVar workshop to be held in June 2016 in Helsinki, Finland. The activity has also been working on a publication aiming to produce a consistent definition of sudden stratospheric warmings (SSWs). Enhanced connections with SPARC's CCMI activity (see below) as well as with CLIVAR's (Climate Variability, WCRP core project) climate dynamics panel are likely in the future.

Andrew Charlton-Perez mentioned that SNAP (Stratospheric Network for the Assessment of Predictability) has recently published a review paper in the Quarterly Journal of the Royal Meteorological Society (Tripathi *et al.*, 2014) as well as a paper in Monthly Weather Review, both of which focus on the question: which types of stratospheric dynamic events are influencing tropospheric predictability? Looking at one particular event (a southern hemisphere SSW in 2013), they found that some models can accurately predict the event with a lead time of 10 days, however, once shifting to a lead time of 15 days fewer models were able to predict the event accurately. The activity has strong connections with the WWRP (World Weather Research Programme) S2S (sub-seasonal to seasonal predictions) project and in particular they will be making use of the large operational forecast database this project has established. The activity is relatively small and is currently funded until February 2016, however it is hoped that the momentum built by the group will ensure that activities continue thereafter. SNAP has also been very successful in building a strong community within WCRP, WWRP, and numerical weather prediction centres.

On behalf of Masatomo Fujiwara, **Michaela Hegglin** presented the progress of S-RIP (SPARC Reanalysis Intercomparison Project). The activity has so far looked at nine different reanalyses, and the British Atmospheric Data Centre (BADC) is hosting some of the derived diagnostic products. The first part of their overview report is expected to be published online during 2015. Some first results have appeared in the literature (Mitchell *et al.*, 2014) and these show that the characteristic temperature response to four sources of variability (quasi-biennial oscillation (QBO), solar cycle, El Niño southern oscillation (ENSO), and volcanoes) is remarkably consistent between reanalyses. This is largely because of the observations assimilated, not because of the underlying forecast models used to produce the reanalyses. There is definitely a need and demand for the intercomparison of reanalysis products to be extended into the troposphere, however, this may be taken up sooner by other groups because it is beyond the scope of their initial report.

The SPARC data assimilation working group (DAWG; presented by **Quentin Errera**) provides a forum for data assimilators, data providers, modellers, and users that focus on SPARC themes. Recent work from the group has focussed on using data from OMPS (Ozone Mapping and Profiler Suite), which can be assimilated effectively in both the troposphere and stratosphere. The MERRA-2 (Modern-ERA Retrospective Analysis for Research and Application version 2) dataset show improvements because of a newly-tuned gravity wave drag parameterisation, and has recently been released to the public (see **http://disc.sci.gsfc.nasa.gov/mdisc**). A study group has been established to look at the added value of assimilating chemical data, which at present is not often carried out despite the wealth of atmospheric composition observations available. In a further step the group would like to produce a reanalysis of stratospheric chemical composition, which could be of great use for a number of applications, such as model validation or producing merged datasets. For example, the Canadian Middle Atmosphere Model (CMAM) has been used as a transfer function to remove biases between different datasets to

produce a long-term water vapour dataset (Hegglin *et al*., 2014). The DAWG is organising a second joint meeting with S-RIP to be held in Paris, France, from 12-16 October 2015.

The SPARC Data Initiative (SDI) is nearing completion and the group is hoping to complete their final report in 2015. **Susann Tegtmeier** presented an overview of the activity as well as some recent results. Neu *et al*. (2014) analysed ozone in the UTLS region, comparing various limb-sounding instruments with measurements from TES (Tropospheric Emission Spectrometer) and ozonesondes. Largest differences between datasets were found in the tropics, although these differences were reduced with the application of the TES averaging kernels. The SDI data, which are available on the BADC, are ideally suited to model validation and provide a narrowed range of observational uncertainty compared to other data previously used for such purposes. The activity will continue collaboration with CCMI on model validation with SDI products, and would like to contribute to the development of diagnostics for the Earth System Model Validation (ESMVal) tool.

In her summary about SSiRC (Stratospheric Sulfur and its Role in Climate) **Claudia Timmreck** reported that the group is working on a review paper on the sulfur cycle, which will be submitted to Review of Geophysics in mid-2105. SSiRC have asked the question of whether the community is ready to respond to a volcanic eruption in terms of a mechanism for a rapid response measurement campaign. The recent eruption of the Kelud volcano was a first example of such a rapid response campaign, where balloon-borne observations were launched to monitor the volcanic plume. These measurements are vital to understanding microphysical processes occurring within the atmosphere after an eruption and to predict the climate response to volcanic aerosols. Initial results from the Kelud campaign compare well with satellite measurements from CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation). SSiRC is currently working on a proposal for a standard rapid deployment mechanism. Volcanoes are a 'wild card' in future climate projections as well as perhaps in shorter-term predictions, and it is vital that models can robustly simulate the response to volcanic eruptions. At present, there are still large differences among models, for example in the clear-sky radiative response to volcanoes in CMIP5. SSiRC is contributing to VolMIP (part of CMIP6), which will focus on just such issues. In addition, the group is also producing the volcanic forcing for CMIP6.

Michaela Hegglin reported on CCMI (Chemistry Climate Modelling Initiative), a joint activity with IGAC. Many preliminary results from phase one of the activity were presented at the CCMI workshop that took place in Lancaster, UK, in May 2014. Some modelling groups are still working on the current set of simulations (phase-1), whilst others have already completed most simulations and have begun uploading them to the BADC. To do this, the data have had to be 'CMORised' (Climate Model Output Rewriter). Although this is somewhat time consuming, it means the data are fully compatible with the CMIP6 protocol and this will ease any future efforts to submit data, for example, for AerChemMIP. CCMI worked hard during 2014 to develop the AerChemMIP proposal for CMIP6, better defining the key questions addressed by this MIP through participation in the Aspen Global Change Institute workshop and IPCC/WCRP 'lessons learnt' workshop. CCMI will be complementary to AerChemMIP, in particular by meeting the needs of the next ozone assessment. Finally, the activity will also be contributing to CMIP6 through developing updated stratospheric and tropospheric forcing data.

Emerging and new activities

Laura Pan presented ACAM (Atmospheric Composition and the Asian Summer Monsoon), a new joint activity with IGAC. Recent research has shown the importance of the Asian summer monsoon (ASM) in global circulation and its impacts on stratospheric chemistry, a response to the very deep convection that occurs in the region in summer. In turn, it has been suggested that the regional aerosol loading can affect the monsoon leading to a strong feedback of chemistry on climate, which might have large implications for the regional population. Satellite observations continue to provide evidence of the importance of the ASM but very few *in situ* observations are available to better understand local sources of aerosols and trace species, as well as their transport, climate feedbacks, and for the evaluation of chemistry-climate models (CCMs). Carrying out experimental studies in the region is challenging for several reasons, most notably because of infrastructural and geopolitical issues. Building the regional community is expected to be one way to deal with some of these challenges, while working with the international community will help to develop infrastructure and expertise in the region. The second

ACAM workshop was held in Bangkok, Thailand, together with a regional training workshop.

Michael Pitts presented a proposal for a new SPARC activity studying polar stratospheric clouds (PSCs), which largely stemmed from a workshop held in August 2014 in Zurich, Switzerland. After more than two decades of research, much is known about PSCs, but some important questions still remain, particularly how future polar stratospheric cooling may enhance PSC formation and induce ozone losses, and how the relevant processes are represented in CCMs. New observational capabilities have stimulated new research and it was felt it was time to write a review paper to provide a summary of these new developments and to identify remaining research questions. Another new SPARC activity proposal was presented by **Scott Osprey**: QBOi (quasi-biennial oscillation initiative). The main goal of this activity will be to develop a better representation of tropical stratospheric variability in GCMs. Only four CMIP5 models spontaneously produced a QBO and there is large variability in the QBO signal simulated. The reason for this divergent behaviour is not always evident. One common bias is that the simulated QBO never extends low enough, which might have implications for tropical-extratropical teleconnections and influences on tropical cyclone activity. Furthermore, there is no simple set of criteria that guarantees a proper representation of the QBO in models. This feature is, however, one of the longest predictable atmospheric phenomena and being able to simulate it properly has important implications for predictability at seasonal to interannual scales. The group held their first workshop in March (see page 19), which was aimed at better defining the focus of the activity. The group wants to prepare their results in a final report as well as through peer-reviewed papers from individual modelling groups. Both the QBOi and PSC activities were formally accepted as emerging SPARC activities.

IGAC and WCRP bodies

IGAC (International Global Atmospheric Chemistry; presented by **Claire Granier**) has several core activities focused around atmospheric processes including microphysics and deposition, atmospheric chemistry, and emissions (both anthropogenic and natural). Two activities are jointly carried out with SPARC (ACAM and CCMI, see above) and all activities are strongly linked with various aspects of sustainability, such as energy, transportation, urbanization, and climate engineering. IGAC also has regional working groups for China (planned to be extended to include all of Asia) and the Americas. As part of IGBP (International Geosphere-Biosphere Programme), IGAC will be integrated into Future Earth by the beginning of 2016. IGAC views this as a genuine opportunity to enhance connections with laboratory, field, and modelling studies on emissions, atmospheric processes, and atmospheric composition. The Future Earth strategic research agenda, released in December 2014, includes atmospheric chemistry in several of the research priorities. With respect to WCRP, IGAC would like to enhance collaboration with SPARC to address both Future Earth priorities and WCRP Grand Challenges.

Sonia Seneviratne (co-chair) gave an overview of the WCRP core project GEWEX (Global Energy and Water Exchanges). The project focuses on water and energy, and coordinates its research through four panels, of which GDAP (GEWEX Data and Assessments Panel) and GASS (Global Atmospheric System Studies) are probably most relevant to SPARC. GEWEX is also leading two of the grand challenges on water availability and extremes. A future SPARC contribution to the water availability grand challenge would be most welcome, as would collaboration on the extremes grand challenge (this is currently planned through organisation of a joint workshop on blocking and extremes to be held in early 2016). There are also potential connections with SPARC on the issue of predictability of extremes and the role the stratosphere plays in this.

Gerhard Krinner (co-chair) presented the WCRP CliC (Climate and Cryosphere) core project, mentioning that there are many overlaps between the project and the 'Cryosphere' grand challenge (now 'Melting ice' grand challenge). A white paper was recently finalised by the grand challenge team, targeting (1) seasonal, interannual, and longer-term predictability of the polar climate (see also PCPI below); (2) enhanced analysis of model intercomparisons (related to CMIP and the polar arm of the Coordinated Regional Climate Downscaling Experiment (CORDEX)); (3) a focused effort on developing ice-sheet models; and (4) improvement of the representation of permafrost in climate models. CliC has a similar structure to SPARC, with limited lifetime activities, but in addition CliC has a number of working groups that are more permanent (*e.g.* a working group on sea-ice modelling). The Year of Polar Prediction (YOPP) is scheduled for 2017-2018 and this might present the need for further SPARC-CliC collaboration beyond what is

already planned within PCPI. The focus group on jet stream linkages with Arctic change may also benefit from collaborations with SPARC.

The Polar Climate Predictability Initiative (PCPI), jointly led by SPARC and CliC, was presented by **Ted Shepherd**. Polar climate predictability cuts across all elements of WCRP and is also a core focus of the WMO Global Integrated Polar Prediction System (GIPPS). The group has been very active and has several activities planned for 2015, including an ISSI workshop on polar feedbacks, a joint workshop with PAGES (Past Global Changes), and is also planning activities for the YOPP. Recent work has focused on emergent constraints, such as the relationship between summertime Arctic sea-ice albedo and seasonal sea-ice retreat in CMIP5 models. Large differences in the way that models simulate this relationship may be one reason for significant differences among models in simulated long-term trends of sea-ice.

Several of the WCRP working groups and councils were presented at the meeting (WGNE – working group on numerical experimentation (**Ayrton Zadra**), WGSIP – working group on seasonal to interannual prediction (**Adam Scaife**), WMAC – WCRP modelling advisory council (**Joan Alexander**), WGCM – working group on coupled modelling (**Veronika Eyring**), and WDAC – WCRP data advisory council (**Kaoru Sato**)). A few highlights relevant to SPARC are mentioned here, but for further details the reader is referred to the JSC meeting report (see page 14). Recent work using data from the WGSIP Climate-system Historical Forecast Project (CHFP) has shown that high-top models provide improved skill in producing seasonal forecasts for the extra-tropics. The CHFP database offers an excellent resource and WGSIP would encourage the community to make further use of these data. WMAC stressed enhanced awareness of needs for model development in all core projects, and asked that meeting organizers consider including a special session on this topic in any events planned. WDAC were very interested in SPARC's S-RIP activity and have made reanalyses one of the main foci of their next meeting to be held later this year. They will also be organizing a special workshop focused on 'Input observations for reanalyses' joint with this meeting. WDAC were also very supportive of SPARC's use of open access journals to present results from its activities and they very much highlighted the need for digital object identifiers (DOIs) for all published datasets. The preparations for CMIP6 are well under way and the WGCM has organised a special issue in Geoscientific Model Development (GMD) that opened in April. SPARC will contribute significantly to CMIP6 in numerous ways, participating in several MIPs (*e.g.* AerChemMIP, VolMIP, SolarMIP, GeoMIP, DA (data assimilation)-MIP, DCPP (decadal prediction), diagnostic MIP), producing forcing data (for ozone, the solar cycle, and aerosols), as well as to the ESMVal model diagnostic tool.

Ted Shepherd and **Mark Baldwin** discussed SPARC's contribution to the WCRP grand challenges. The grand challenge on 'Clouds, Circulation, and Climate Sensitivity' is focused on four key topics, two of which have clear connections with SPARC, namely storm tracks and tropical rain belts. The storm tracks workshop to be held in Grindelwald, Switzerland, in August and organised by SPARC will focus on several questions, for example, why aren't models able to accurately simulate storm tracks? SPARC can contribute as a community to many of the grand challenges, in particular to the 'Extremes' grand challenge through SPARC's expertise in dynamics.

Space agency reports

Claus Zehner started his presentation about the European Space Agency (ESA) by mentioning that ESA currently has a large Earth observation programme, with four types of missions [satellite acronyms are not explicitly spelled out, the reader is referred to each space agency website]: (1) METEOSAT (meteorological satellites), (2) Earth Observation satellites, (3) Copernicus Sentinel missions (more for operational use), and (4) third party missions. At present, three Earth explorers and one Sentinel satellite are in orbit. All data from the Earth Observations missions are being used to develop Essential Climate Variables through ESA's Climate Change Initiative (CCI). From 2009 onwards, several Earth explorers have been launched (GOCE (2009-2013), SMOS (2009-), CryoSat2 (2010-), Swarm (2013-)) and the ADM-aeolus satellite is planned for launch in early 2016). This latter satellite is to focus particularly on tropospheric and stratospheric winds. The Sentinel satellites are to provide long-term space-based monitoring for the COPERNICUS programme. Sentinel 1a launched in April 2014 and Sentinels 1b-d are planned for launch over the next 15 years. Sentinel 5P will be launched in 2016 and Sentinels 4 and 5 will be nadir viewing, mainly aimed to support air quality modelling. In terms of future Earth observation satellites, Earth Explorer 7, with the EarthCARE mission (a joint European-Japanese venture), is planned for launch in

2020 and will monitor biomass. Two missions are currently competing to get on to the Earth Explorer 8 satellite: CarbonSat (greenhouse gas monitoring) and FLEX (chlorophyll observations of terrestrial vegetation).

Ken Jucks presented an update from NASA (National Aeronautics and Space Administration). He started off by focusing on several new NASA missions. The OCO mission has been providing excellent measurements of CO_2 since it's launch in July 2014. The CATS mission is currently on board the International Space Station (ISS) and uses a lidar instrument to provide range-resolved profile measurements of atmospheric aerosols and clouds. SAGE-III will be launched in 2016, also on the ISS, and will hopefully remain operational until at least 2024. The TEMPO mission looking at tropospheric emissions and monitoring of pollution has been selected for Earth Venture, as have two surface carbon cycle missions. OMPS (a joint mission between NASA and NOAA (National Oceanic and Atmospheric Administration) is also currently in orbit and includes both nadir and limb sounders; a follow-on for the SBUV and OSIRIS instruments. OMPS provides ozone profile retrievals as well as aerosol measurements, and is complementary to OSIRIS and the future SAGE-III mission on ISS. NASA will also continue to work on joint polar satellite programmes with NOAA. Several instruments providing data that have been widely used by the SPARC community are on board the Aura EOS satellite, which has been in orbit since 2004. These include HIRDLS, which stopped functioning in 2008; TES, which is still operating despite some technical issues; MLS, which has lost two channels but nevertheless is still functioning well; and OMI, which has a partial blockage of it's field of view but works well otherwise. NASA needs to respond to the needs set out in the decadal survey produced by the US National Research Council, the next of which is due in 2017. At an atmospheric composition workshop last summer, open science questions and the data needed to address them were reviewed. It is hoped that output from this meeting will contribute to the next decadal survey. NASA is also coordinating several sub-orbital activities, one of which is the ATTREX campaign (currently on-going).

Thomas Piekutowski gave an overview and update from the Canadian Space Agency (CSA). Their current missions include MOPITT, OSIRIS, and SciSat satellites, all of which continue operating despite their old age. A new concept being investigated is microsatellite missions, of which two could be of interest to SPARC: CATS (a continuation of OSIRIS) and TICFIRE (to measure thin ice clouds). Development of the SHOW and FIRR instruments is still ongoing and the SHOW instrument might fly on the NASA ER-2 aircraft. This instrument has already been flown successfully in the UTLS region on a balloon. The FIRR instrument will also hopefully fly over the Artic on the Alfred Wegner Institute's Polar6 aircraft.

Makoto Suzuki gave an update on JAXA (Japan Aerospace Exploration Agency) as well as several other Japanese SPARC-related activities. The Japanese Meteorological Agency (JMA) successfully launched the GMS-8 satellite to measure cloud, aerosol, SO_2, biomass burning, and total column ozone. The GOSAT satellite (in orbit since 2009) continues to measure CO_2 and CH_4 columns, with a follow-up satellite, GOSAT-2, planned for launch in 2017. For the moment there are no missions planned for after 2018, even though the last satellites were proposed almost 20 years ago (in 1995). JAXA's Institute of Space and Astronaut Science (ISAS) has a number of atmospheric-related activities. These include the SMILES instrument (a mission run in collaboration with the Japanese National Institute of Communication and Technology), a GPS occultation observing programme, lightning and sprite observations from space with the JEMS/GLIMS instrument on board the ISS, as well as airglow and gravity wave observations from space with the ISS-IMAP/VISI instrument also on board the ISS. ISAS has a small science programme for which a limb-sounding mission application could be made. Despite the small budget, a SMILES-2 proposal would likely have a good chance of getting selected, although the budget for such an instrument might need to be supported by other space agencies and/or in combination with another instrument. A SMILES-2 type of instrument would be able to measure a large number of trace species extending into the upper stratosphere, mesosphere, and lower thermosphere. However, stratospheric chemistry is not a core topic of interest at ISAS (which is largely dynamics focused), therefore it would perhaps be useful to integrate some dynamics observations into the proposal to have a better chance of success.

There is a growing awareness within the community of the looming gap in vertically-resolved atmospheric composition observations (when the Aura MLS instrument stops functioning). **Michelle Santee** briefly gave an overview of the current situation, highlighting the fact that given the

very long record of data available, it would be possible to use the data to show which science questions *cannot* be answered without these data. However, this is not an easy issue to address since it requires a strategy that can be used to decide which measurements are important to answer science questions of relevance to society. Considerable work has gone into producing a document that looks into this issue in depth, and which will hopefully be published in a high-impact journal as well as contribute to the US decadal survey. A further idea from the community is to produce a paper focusing on a survey of satellite-based limb sounding observations.

Other presentations

Greg Bodeker discussed SPARC data requirements. This issue was first raised at the 19th session of the SSG in February 2012, and was followed up one year later by a meeting dedicated to this subject held in Frascati, Italy, in February 2013. SPARC activity leaders were asked to summarise their data needs in short documents as input for this meeting. The WMO Global Atmosphere Watch (GAW) has set the provision of real-time data as a high priority and the question was raised as to whether SPARC should look into this issue. SPARC has also provided input for the WMO rolling review of requirements, which is a great opportunity for SPARC to articulate its data needs (SPARC can provide input at any time since it is a rolling document). GAW has a task team on observational requirements with many members currently from data providing institutes, although it might be useful to have some SPARC representation on this task team as well (GAW would certainly welcome this development). NDACC have proposed the idea of a centralised data-processing centre, which would lead to better homogeneity of data from their observational network, however, issues around finding long-term funding to support this are still being discussed. Finally, Greg also mentioned that SPARC could strengthen its connections with the NDACC 'Theory and Analysis' working group.

SPARC items

A significant amount of time was dedicated to discussing the new SPARC implementation plan. This was done by breaking into three sub-groups each of which focused on one of the new SPARC themes, namely 'atmospheric dynamics and predictability', 'chemistry and climate', and 'long-term climate records'. A draft version of the implementation plan was presented at the WCRP JSC meeting in April (see page 14) and the plan will be finalised at the next SPARC SSG meeting.

Thando Ndarana gave a report back on the SPARC Capacity Development workshop held just prior to the SSG meeting in Granada (see the report on page 12). **Bernd Funke** provided a brief report about the local workshop also held prior to the SSG meeting (see page 10 for further details).

Martin Juckes presented an update on the SPARC Data Centre (SDC), which is hosted at the BADC and currently holds about 18TB of data from a wide variety of SPARC activities. Certain datasets are published through the BADC and made publicly available, whilst other datasets are simply hosted at the BADC for the duration of an activity and usually not made public. The BADC has provided technical support for the development of a CMIP-style data protocol for CCMI, whose final data will be published through the ESGF (Earth System Grid Federation). BADC produced automated testing for CCMI output data to ensure that they follow the required conventions. BADC is also very involved in CMIP6 and is working on a data standardisation process for all MIPs. Recently, new computing facilities have been acquired and this will hopefully ensure faster data transfers and the possibility to do data analyses on BADC servers. BADC is also contributing to the ESMVal tool, ESA CCI, and the European COPERNICUS programme.

Johannes Staehelin briefly presented SPARC communication tools, which include the SPARC website, eNews bulletins (issued every two months), biannual newsletter, SPARC annual report, and SPARC science reports. The SPARC Office was tasked with carrying out a WCRP-wide survey on atmospheric dynamics, material of which was presented at the 36th WCRP JSC meeting.

In other news from the SPARC Office, **Thomas Peter** informed the meeting participants that the SPARC Office would be able to stay in Zurich, Switzerland, until the end of 2017. Planning for the next home of the SPARC Office will need to begin this year however, as it would be important to have some sort of overlap between the two offices. This will be discussed in some detail at the next SPARC SSG meeting.

To end off the meeting, Joan Alexander (for **Kaoru Sato**) presented a proposal from the Japanese SPARC community who have offered to host the next SPARC General Assembly. This would likely take place in late 2018 (between September-November) in Kyoto. This proposal will be further discussed at the next SSG meeting to be held in Boulder,

USA, from 9-13 November 2015.

Reference List

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