SPARC
Stratosphere-troposphere
Processes And their Role in Climate

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Lenticular clouds over the tropical ocean. In a joint workshop, three SPARC activities defined common interests, and investigated the benefit from combining the knowledge about the Quasi Biennial Oscillation (a semi-annual reversal of the mean wind direction in the tropics), as well as about stratospheric and tropospheric influences on tropical convective systems and on fine scale processes in the atmosphere (see report on page 19). Joining forces will lead to enhanced understanding of the complex dynamics of the tropical atmosphere.

Photo credit: Katja Riedel Photography

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WCRP World Climate Research Programme
WMO
UNESCO
IOC
ICSU International Council for Science

Report on the 24th SPARC Scientific Steering Group Meeting 16-18 October 2017, Incheon, South Korea

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The 25th SPARC Scientific Steering Group (SSG) meeting was jointly hosted by colleagues affiliated at the Seoul National University (SNU) and the Korean Polar Research Institute (KOPRI). It took place at the Orakai Songdo Park Hotel in Incheon, South Korea, from 16 - 18 October 2017. The Korean SSG member (Seok-Woo Son) provided most valuable assistance with the technical arrangements. The meeting was followed by an Early Career Researchers (ECR) symposium during the afternoon of 18 October and a WCRP/SPARC local workshop on 19-20 October, both at the conference facilities of the nearby KOPRI (see page 7, this issue). Representatives of the National Institute of Meteorological Sciences (NIMS), which hosts the International Coordination Office of the WWRP Sub-seasonal to Seasonal (S2S) prediction project (**Yu-Kyung Kim**), and of the Korean Polar Research Institute (**Baek-Min Kim**) briefly introduced their institutions and underscored the high relevance of SPARC activities for their research tasks.

WCRP update

As already indicated in the previous SSG24-report, the World Climate Research Programme (WCRP) currently undergoes a review, organized by its co-sponsors WMO, IOC and ICSU, of which the report would be submitted to the executive bodies of co-sponsors before the end of 2017 (**Boram Lee**, WCRP Joint Planning Staff [JPS]/ SPARC liaison). The review would include assessments and recommendations on not only the scientific achievement of WCRP groups and activities, but also of the adequacy and effectiveness of WCRP operational structures. In addition, the WCRP Joint Steering Committee (JSC) has been leading the process of refreshing strategic planning for WCRP, and all Core Projects including SPARC and main WCRP activities have been actively participating. In both major processes, it has been reaffirmed that WCRP should not be diluted by moving away from underpinning, fundamental climate science into the applied science required for climate services. Meanwhile WCRP needs to be cognizant of what the users and stakeholders require from climate science, and should therefore maintain an active dialogue with them, either directly or through its co-sponsors. Further integrated community efforts have emerged as the main direction of WCRP's scientific strategy, such as integrated atmosphere-chemistry-climate research and seamless prediction by bringing together the expertise and experience of the weather prediction community and that of the climate modelling groups.

The SSG noted with concern on the still tight financial climate and reduced staffing at the JPS, which necessitates rationalization of overall administrative support and coordination across JPS and the international project offices. At the same time efforts are undertaken to restore support from the co-sponsoring organizations, especially for the core projects and to main WCRP activities.

SPARC activity reports

The Long-term Ozone Trends and Uncertainties in the Stratosphere (LOTUS) activity formed two working groups addressing "Multi-Instrument Data Integration" (MIDI) and "Regressions of Ozone Analyzed for Stratospheric Trends" (ROAST), respectively (**Irina Petropavloskikh**). Thirty participants attended the first LOTUS workshop on 13-15 March 2017, hosted by Laboratoire ATmosphères, Milieux, Observations Spatiales (LATMOS) at the Université Pierre et Marie Curie in Paris, France (more information at **https://events.oma.be/indico/event/23/overview**). The bulk of information about LOTUS is being collected and presented on the dedicated website **http://igaco-o3.fmi.fi/LOTUS**. A collaborative effort was initiated to prepare a Final Report that will be reviewed by SPARC and which will contain critical results to support the 2018 WMO/ UNEP Scientific Assessment of Ozone Depletion.

Within the Polar Stratospheric Cloud initiative (PSCi) a focus was put on comprehensive PSC-climatology papers based on long-term satellite data records obtained by the MIPAS and CALIOP instruments (**Larry Thomason** for **Michael Pitts**). These efforts are considered as a foundation for an intended broad review publication on topics as the spatial/temporal distribution, composition, and microphysical properties of PSCs as well as their improved representation in satellite retrievals and transport modelling studies.

The Stratospheric Sulfur and its Role in Climate activity (SSiRC) organized a three-day workshop with the aim of bringing together in-situ and space-based measurement teams, attended by 35 scientists from the US, Germany, Belgium and the UK (**Stefanie Kremser**). A proposal to the American Geophysical Union regarding a "Chapman Conference on Stratospheric Aerosol in the Post-Pinatubo Era: Processes, Interactions, and Importance" was accepted. The event is scheduled for 18-23 March 2018 in Santa Cruz de Tenerife, Spain. Under the umbrella of SSiRC, ETH Zurich and NASA compiled a new stratospheric aerosol forcing dataset for CMIP6-simulations. Field activities included contributions to a Balloon campaign of the Asian Tropopause Aerosol Layer (BATAL) during August and the StratoClim aircraft campaign out of Kathmandu, Nepal, from mid- July to mid-August.

The SPARC Reanalysis Intercomparison Project (S-RIP) constitutes a valuable communication platform between SPARC-related researchers and large reanalysis centres (**Michelle Santee**). Contributions to an inter-journal special issue appeared in Atmospheric Chemistry and Physics and in Earth Systems Science Data or are still under review. The entire collection consists of 18 articles. The revised version of the S-RIP interim report is about to be submitted to the team of external editors. The annual S-RIP workshop was scheduled for 23-27 October at ECMWF, as usual in junction with the SPARC Data Assimilation Working Group (DAWG; see report on page 26, this issue) .

DAWG was presented remotely (**Quentin Errera**), with reference to the joint workshop at ECMWF and previous technical tasks that had evolved into separate SPARC activities, e.g. SNAP and S-RIP. A review of the activity will be prepared until the SPARC General Assembly in 2018. In August, one of the co-chairs took part at the US-CLIVAR summit, where a strengthening of the links to SPARC was advocated. The Stratospheric Network for Atmospheric Predictability (SNAP) started its second phase with emphasis shifting towards analysis of data from the World Weather Research Programme (WWRP) project "Sub-seasonal to seasonal prediction" (S2S; **Andrew Charlton-Perez**). A review article was initiated about the stratosphere's impact on predictability within the S2S-models, which will provide a broad overview of S2S-relevant research being done within the SPARC community. Close links were maintained with SPARC activities QBOi and Data Assimilation.

The activity Atmospheric Temperature Changes and their drivers (ATC; **Andrea Steiner**) defined i) the temperature variability throughout the atmosphere including uncertainty in climate data records and ii) the attribution of atmospheric temperature changes as its two new foci. The co-chairs organized a dedicated session at EGU-2017. In cooperation with the S-RIP activity measured and re-analysed temperature trends were compared. Combined observational and model studies hinted at subtle connections, as e.g. from ozone extremes in the Arctic stratosphere to northern hemisphere surface climate.

The Atmospheric Composition and Asian Monsoon (ACAM) activity, a joint undertaking with the International Global Atmospheric Chemistry (IGAC) project, continued its series of regional workshops and associated training schools with a combined event in June 2017 in Guangzhou, China, which was attended by some 160 scientists and more than 40 students, respectively (**Laura Pan**). Eight missions of the high-flying research aircraft Geophysika out of Kathmandu, Nepal, during the EU-funded StratoClim campaign directly addressed core science issues of ACAM and managed to probe in-situ outflow regions of monsoon events up to heights of 20 kilometres.

The Chemistry-Climate Modelling Initiative (CCMI) constitutes another activity jointly undertaken with IGAC. It held its science workshop in June with around 100 participants, hosted by Météo-France in Toulouse (**Seok-Woo Son** for **Michaela Hegglin**). Internal communication was strengthened through the broad distribution of CCMI e-news. External visibility is being enhanced by formal publication endeavours as, e.g., an overview paper regarding the entire suite of global models participating in the first phase of CCMI, a review article about the Aerosol Chem-

istry Model Intercomparison Project, and an inter-journal special collection of 12 research articles which had been opened at Copernicus Publications (**www.atmos-chem-phys.net/special_issue812.html**).

The SOLARIS-HEPPA activity deals with solar and high energy particle precipitation influences on stratospheric and higher atmospheric levels; it consists of five working groups. These scheduled their annual workshop meeting for November in Paris, France (**Bernd Funke**, presenting remotely via web-interface). Various external forcing datasets were prepared for the global modelling studies in the CMIP6-exercise. A comparative study, juxtaposing output from eight atmospheric models with observations from seven satellite instruments, was undertaken for the perturbed northern-hemisphere winter of 2008/09 and the results were published.

The second Water Vapour Assessment activity (WAVAS-II) further contributed to the inter-journal special collection, which had been opened at Copernicus Publications (**www.atmos-chem-phys.net/special_issue830.html**; **Gabi Stiller** remotely). These include an intercomparison of satellite and ground-based microwave measurements. Results of coordinated studies were presented at international conferences in South Africa and Canada. A dedicated session was proposed for the EGU Assembly 2018. For the future, it was decided to concentrate on articles in research journals rather than producing a SPARC-report.

Marvin Geller, SPARC-founding co-chair back in 1992 and active contributor over the past 25 years, presented the Fine Scale Atmospheric Processes and Structures (FISAPS) activity. It had an international workshop during the previous week in Kyoto, Japan, jointly organized with activities QBOi and SATIO-TCS (see report on page 19, this issue). The collection and storage of full resolution datasets, such as high vertical resolution radiosonde data, was addressed. sThe next workshop is planned to take place in Europe.

The Quasi-Biennial Oscillation initiative (QBOi) produced several publications on experimental QBO-simulations for the present day and future climates (**Scott Osprey**). The initiative was integrated in the 19th Middle Atmosphere conference of the American Meteorological Society in June and co-organized the workshop in Kyoto in October. Follow-on sessions and side meetings will be planned for the General Assembly 2018, where also a closer link is to be established to the Belmont Forum, a grouping of the world's major funders of global environmental change research.

The Gravity Waves activity extended its focus from climate to also weather regimes, underscoring a seamless prediction approach (**Kaoru Sato**). Vertical profiles of momentum fluxes in general circulation models are considered as important diagnostics together with spectra of inertia-gravity waves in global analyses. The SPARC General Assembly 2018 is co-organized by one of the activity leaders and, thus, will be a natural focal point for scientific exchange across the activity.

The Dynamical Variability activity (DynVar) is having an internal discussion on how to redirect its focus after a decade of successful initiatives, e.g. DynVarMIP endorsed by the modelling intercomparison under CMIP6 (**Alexey Karpechko** for **Elisa Manzini**). "Variability and predictability of surface impacts and extremes" has been suggested as a new focus with close links to the WWRP projects "Sub-seasonal to seasonal prediction" (S2S) and "High Impact Weather" (HIWeather). A second focus could be to promote research based on the huge amount of model data available through CMIP-6 (cf. Eyring and Carlson 2017, SPARC-newsletter #48, pp. 11-17). The scope, membership, and leaders will be decided upon during the coming year.

SPARC emerging activities

Reports were also presented on the four emerging activities of SPARC. A structure for numerical experiments equivalent to the double CO_2 scenarios within CMIP, but for ozone and aerosols was sketched within Climate Response to Short-Lived Climate Forcers (SLCFs; **Neil Harris** for **William Collins**). Systematic scenario calculation at various modelling groups will only be possible onwards after completion of CMIP6. The possibility of a joint activity on SLCFs with the WMO Global Atmospheric Watch and with IGAC will be investigated.

The activity Towards Unified Error Reporting (TUNER) for space-borne temperature and composition sounders had its first workshop in Saskatoon, Canada, in June (**Nathaniel Livesey**). The International Space Science Institute in Berne, Switzerland, approved a proposal for a TUNER International Team, which scheduled its first meeting for December 2017. In August, the activity was presented at the IAMAS-assembly in Cape Town, South Africa.

***Figure 1**: Group photograph of the SPARC SSG meeting participants on 16 October 2017.*

In July 2017, the activity Observed Composition Trends And Variability in the Upper Troposphere and Lower Stratosphere (OCTAV-UTLS) held its first workshop in Boulder, USA (**Irina Petropavloskikh**), where expert groups were formed for categories of observing platforms and datasets got identified that are suited to determine the composition in the UTLS and its long-term changes. The years 2011 to 2013 were declared as initial test period. In June, the activity was presented at the Middle Atmosphere Conference of the American Meteorological Society.

During the week preceding the SSG meeting, the dynamics oriented activity Stratospheric And Tropospheric Influences On Tropical Convective Systems (SATIO-TCS) participated in the joint workshop with FISAPS and QBOi in Kyoto, Japan (**Shigeo Yoden**), where its scientific objectives were refined. An overview paper is planned for publication in the Bulletin of American Meteorological Society. Possible links with the Year of the Maritime Continent initiative (2017-2019) are being investigated.

General Assembly 2018

The state of preparation for the next quadrennial General Assembly of SPARC, scheduled for 1-5 October2018 in Kyoto, Japan, was presented in some detail regarding venue, intended timetable, the desire to give poster presentations a prominent position, and the links to the IGAC conference (**Kaoru Sato**). The Scientific Organizing Committee has two co-chairs (Harry Hendon and Amanda Maycock) and seven members. Contributions from the Belmont Forum of funding agencies combined with the EU joint initiative on Climate Knowledge (JPI Climate) will be an integral part of the programme. A large number of poster presentations is expected. Each poster will be on display for 2.5 days with the potential to attract numerous poster viewers and to ignite vivid discussions during several sessions accompanied with refreshments.

Partner projects

A report on the International Global Atmospheric Chemistry project (IGAC) was presented by **Hiroshi Tanimoto**. IGAC is a close partner of SPARC on chemistry-oriented activities, e.g. ACAM and CCMI. During the previous year the IGAC community sharpened its profile within the new Future Earth framework with strong foci on basic research, fostering the science community, providing leadership and building new capacity through early career support. IGAC will hold its 15th science conference in Takamatsu, Japan, in 2018 in the week prior to the SPARC General Assembly. The local organizing committees are in close communication in order to facilitate visits of both events, only 250 km apart, around the intermediate weekend at reasonable costs.

The Climate and Ocean: variability, predictability and change project (CLIVAR; **Jose Santos**), also a WCRP core project, concentrates on the marine component of the coupled ocean-atmosphere system, in particular with regard of systematic and multi-national observations. Its open science conference 2016 in

Qingdao, China, attracted more than 600 participants from 47 countries. Training of the next generation of researchers is regarded as essential for the continuing success of WCRP as the maintenance of a strong grounding in fundamental research. Recently a new Northern Oceans Region Panel (NORP) was approved jointly with the cryospheric core project CliC.

The Korean National Institute of Meteorological Sciences (NIMS) hosts the international coordination office of WWRP's Subseasonal to Seasonal prediction project (S2S; **Yu-Kyung Hyun**), a legacy project of the THORPEX initiative (2005-2015). With the aim of "bridging the gap between weather and climate" about a dozen of global modelling centres undertake coordinated ensemble forecasts up to two months ahead. The efforts of S2S prediction programme in the United States supported by NOAA were reported (**Judith Perlwitz**). It addresses a number of key questions in areas "processes and physics", "prediction approaches", and "prediction evaluation".

Space observations

Representatives from four space agencies provided updates of current activities and plans, which are of relevance for SPARC research. **Kenneth Jucks** (NASA; remotely) provided an overview of Earth science missions in categories "extended operations", "primary operations", "under implementation", and "being formulated", with a special focus on ozone research. The SAGE instrument has reached its third generation. A version is being commissioned for use aboard the International Space Station (ISS). The multi-decal SAGE ozone and aerosol datasets from 1979 onwards are regarded as an international standard for accuracy and stability. The Tropospheric Emissions: Monitoring Pollution (TEMPO) mission is scheduled for launch to a geostationary orbit in 2019. The release of the current decadal survey document is due by the end of 2017.

Lin Chen (Chinese Meteorological Administration [CMA], National Meteorological Satellite Center) gave a detailed summary regarding the current status and future programme of the Chinese meteorological satellite series FengYun, (FY) with currently eight platforms in orbit, six of them operational, partly in low earth and partly in geostationary orbits. The FY satellite data and application service provides near real time access and has more than 45 direct broadcasting users. Monitoring capacities for greenhouse gases are scheduled for mission FY-3D.

Hyo-Suk Lim (Korean Aerospace Research Institute) described the satellite application activities of the Republic of Korea with currently five platforms operational in low earth and one in geostationary orbit. Four launches are scheduled within the coming four years. Besides land and ocean surface observations as well as monitoring during disaster episodes global environmental monitoring is to begin after the launch start of KOMPSAT-2B to a geostationary orbit (scheduled for 2018).

Makoto Suzuki (Japan Aerospace Exploration Agency [JAXA], Earth Observation Research Center) presented the status of the Japanese meteorological satellite programme, highlighting monitoring missions such as GOSAT (since 2009), GCOM-C (launch early 2018), GOSAT-2 (launch 2018) and EarthCARE (launch ~2019). Experiences from the exploratory, limb sounding SMILES project are being fed into a new joint proposal for chemistry and dynamics of stratospheric and mesospheric levels. The need for scientific support from the SPARC, IGAC or SCOSTEP communities was emphasized.

Other SPARC news

Fiona Tummon (outgoing SPARC Office director) remotely reported about the SPARC capacity development. The office continued to actively support the Young Earth System Scientists (YESS) community, which has representatives in numerous countries around the planet. Specific workshops and training schools were held on Atmospheric composition and dynamics (in Réunion Island; 28 Nov. - 3 Dec. 2016), on Monsoon variability in a changing climate (in Jeju, Korea; 16 - 21 Jan. 2017), as 2nd ACAM training school (in Guangzhou, China; 5-9 June 2017), as 3rd South-East Asian school on tropical atmospheric science (SEASTAS; in Singapore; 24-27 July 2017), and as Stratosphere-troposphere interactions training school (at university of Cape Town, South Africa; 2-5 September. 2017).

During the afternoon of the 18 October a dedicated Early Career Researcher symposium took place in parallel to the SSG meeting with keynote lectures given by SSG-members (Harry Hendon, Laura Pan) and selected presentations by some of the SPARC-supported participants from Asian countries. Everybody joined the regional (Korea-China-Japan) scientific workshop during the next two days, when 32 oral presentations and 33 poster presentations served as crystallization points for vivid scientific exchange between some 80 scientists from 12 countries on four continents.

SPARC local workshop on "WCRP grand challenges and regional climate change"

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Dates:
18 - 20 October 2017

Organisers:
Baek-Min Kim (Korea Polar Research Institute), Joowan Kim (Kongju National University), Seok-Woo Son (Seoul National University), Yu-Kyung Hyun (National institute of Meteorological Science), Changhyun Yoo (Ewha Womans University)

Host Institution:
Korea Polar Research Institute

Number Of Participants: **79**

Sponsors:

KOPRI 극지연구소 Korea Polar Research Institute

SPARC Stratosphere-troposphere Processes And their Role in Climate

국립기상과학원 National Institute of Meteorological Sciences

WCRP World Climate Research Programme

한국기상학회 Korean Meteorological Society

Workshop webpage:
http://www.sparc-climate.org/meetings/WCRP_grand_challenges_and_regional_climate_change/

The SPARC local workshop was held on 18-20 October 2017 at the Korea Polar Research Institute in Incheon, Republic of Korea. Organized back-to-back with the annual meeting of the SPARC scientific steering group, this workshop brought local scientists working on the WCRP grand challenges and regional climate changes together with scientists outside of Asia leading the SPARC research activities. A total of 79 participants from 10 countries made this workshop very lively (see Figure 3). Various topics including stratosphere-troposphere dynamic coupling, Arctic climate change, climate prediction and attribution, and regional climate change were presented with the goal of exploring synergies and fostering scientific exchange.

ECR workshop

To promote capacity development in Asia, an Early Career Researcher (ECR) workshop was held in the afternoon of 18th October. This half-day-long pre-workshop consisted of three invited lectures and ECR's poster presentations. About 50 ECRs from 8 countries (see Figure 2) participated in this symposium. Ten of them were fully or partly supported by the SPARC and local organizing committee (LOC).

The three lectures provided unique perspectives of stratospheric dynamics, tropical meteorology, and observations. **Marvin Geller** introduced the history of middle atmosphere dynamics and reviewed recent developments. The spatiotemporal characteristics of the Madden-Julian Oscillation (MJO) and their modulation by Quasi-Biennial Oscillation (QBO) was explained by **Harry Hendon**, highlighting stratosphere-troposphere coupling in the deep tropics. **Laura Pan** introduced the CONTRAST (CONvective TRansport of Active Species in the Tropics) project and provided observational aspects on the stratospheric dynamics and tropical meteorology. Followed by the invited lectures, **Shipra Jain** introduced the Young Earth System Scientists (YESS) community and its activities. She emphasized that YESS community can provide a voice and leverage for a better future to serve society, and encouraged all participants to join YESS. Lastly, ECRs, who submitted an abstract to the SPARC local workshop, briefly introduced their poster(s) in a minute or two. All posters were lively discussed during the poster session on the next day.

Subseasonal, seasonal, and interannual climate prediction

In-Sik Kang, a WCRP JSC member, opened the workshop with a keynote speech on the role of the stratosphere in the boreal-winter seasonal prediction. He emphasized the role of both the SST and stratospheric memory that could substantially improve the seasonal prediction in the tropics and the Pacific-North American region during the late winter. This presentation was followed by three talks on subseasonal predictions. The processes of stratosphere-troposphere coupling and their impacts on predictability in the Southern Hemisphere were reviewed by **Harry Hendon**. He showed that a more skilful prediction by vertical coupling is available in the Australian seasonal prediction models during austral winter. **Yuna Lim** presented the QBO-MJO link in boreal winter and its impact on subseasonal-to-seasonal (S2S) prediction. By analysing the S2S prediction models, she showed that the MJO is better predicted during the easterly phase of the QBO than during the westerly phase. One of the emerging SPARC activities, Stratospheric And Tropospheric Influences On Tropical Convective Systems (SATIO-TCS) was overviewed by **Shigeo Yoden**. He also briefly discussed stratospheric influence on multi-scale interactions of moist convection in the tropics.

***Figure 2**: Group photo of the participants of the Early Caree Researcher workshop.*

Stratospheric polar vortex and vertical coupling

Opening the session on the stratosphere-troposphere coupling, **Andrew Charlton-Perez** provided a regime view on the coupling and proposed a minimal Markov model to better quantify the tropospheric response to stratospheric anomalies in the North Atlantic. This was followed by re-evaluation on the ENSO-SSW relationship by **Kanghyun Song** using seven SSW definitions in the literature. He showed that the ENSO-SSW relationship is highly dependent on the details of the SSW definition. Although more frequent SSWs during El Niño winters are common, SSWs during La Niña winters substantially differ across the definition. **Patrick Martineau** introduced his recent work on the lower-stratospheric control of SSW frequency in idealized model simulations. The highlight of his study was that stratospheric variability, including SSW frequency, is very sensitive to the temperature distribution in the lower stratosphere. The Holton-Tan relationship, linking the QBO with the polar vortex, was examined by **Judith Perlwitz** using 10 AMIP historical simulations. She showed that the Holton-Tan relationship is not robust when the QBO is in its westerly phase.

Gravity waves

A series of studies on middle-atmosphere gravity waves were presented. **Hye-Yeong Chun** presented spatio-temporal characteristics of convective gravity waves, their sources, and the associated cloud-top momentum fluxes. She also quantified contribution of small-scale convective gravity waves to the large-scale circulation in the middle atmosphere with an emphasis on their impacts on annual cycle in the mesosphere, Brewer-Dobson circulation, and QBO. Her presentation was further extended by **Min-Jee Kang**, who showed the results of reanalysis datasets. **Byeong-Gwon Song** reported gravity wave activities in the upper mesosphere at King Sejong Station, Antarctica (62.22°S, 58.78°W), operated by the Korea Polar Research Institute. Its close link to the jet stream was particularly highlighted.

UTLS and Ozone

Joowan Kim presented the thermal characteristics of the tropical tropopause layer in CMIP5 models and discussed their implications on the cross-tropopause water vapor transport and global climate changes. **Yan Xia** also evaluated CMIP5 models, but targeting on UTLS ozone biases, showing that UTLS ozone can radiatively warm the UTLS region and influence high cloud distribution by modulating humidity and static stability in the UTLS. Switching the subject to measurements, **Larry Thomason** introduced some features of the third Stratospheric Aerosol and Gas Experiment (SAGE III) on the International Space Station. This was followed by a presentation on the mesosphere temperature trend and the ozone recovery, which was given by **Gufran Beig**.

Polar climate

Jinro Ukita reviewed the Arctic-midlatitude climate linkage and presented modelling evidence of a strato-

spheric pathway. By analysing a set of AGCM experiments and reanalysis datasets, he showed that Arctic sea ice loss results in an increased poleward eddy heat flux and strengthening of upward wave propagation from the upper troposphere to the stratosphere in early winter, which can lead to a more frequent breakdown of the polar vortex. The Arctic sea-mid-latitude connection was further described by **Jiankai Zhang**, who showed that the sea-ice-induced planetary-scale waves have likely pushed the stratospheric polar vortex in February towards Eurasia in the last three decades. Consistent with these findings, **Hye-Jin Kim** demonstrated strong correlation between sea ice anomalies over the Barents-Kara seas and Eurasian winter surface air temperature. The influence of atmospheric circulations on Arctic sea ice and surface air temperature change was explored by **Ha-Rim**, who emphasized that Arctic surface air temperature is very sensitive to the moisture intrusion caused by the Barents Oscillation. **Seungmok Paik** identified possible causes of Arctic sea ice loss. He reported that the 2015 record minimum sea-ice extent in the Sea of Okhotsk was caused by both external forcings (56%) and internal variability associated with the North Pacific Oscillation (25%), highlighting the importance of external forcings. **Mee-Hyun Cho** and **Joo-Hong Kim** presented other aspects of Arctic climate change. By conducting AGCM experiments, Mee-Hyun Cho suggested that black carbons, emitted from high-latitude gas petroleum, have likely accelerated Arctic warming in the recent decade. Joo-Hong Kim analysed thermal evolution of late-summer melt ponds on sea ice. The importance of better constraining and understanding the internal heat transfer dynamics and the salinity of melt ponds was highlighted.

Regional climate

Various subjects in regional climate change and variability were also discussed. **Wen Chen** reviewed the stratosphere-troposphere interaction in boreal winter and its impact on cold extremes in East Asia. He showed that the time-scale of downward coupled stratospheric events is typically longer than that of non-downward events, emphasizing the importance of the formers for regional climate variability. This was followed by a presentation on the low-frequency nature of the Northern Annular Mode (NAM) in the context of mass circulation, which was given by **Yueyue Yu**. **Jinwon Kim** presented the impact of atmospheric river landfalls on the precipitation characteristics in the western US. The monsoon circulation and related variabilities in rainfall and chemical composition was presented by **Anu Xavier** and **Laura Pan**. Anu Xavier discussed the role of monsoon low-level jet in modulating extreme rainfall events across the southwestern coast of India. Laura Pan emphasized the needs for research collaborations on the interactions and couplings between the regional pollutant emissions and the monsoon dynamics to better understand their impacts on regional air quality and climate relevant stratospheric composition changes. As an example, it was shown by **Mijeong Park** that the carbon monoxide emitted from the recorded fire events in Indonesia was transported into the UTLS. This chemistry transport was evident only in satellite measurements but also in chemistry-climate model simulation. Continuing the theme of chemistry-climate interaction, **Fahim Khokhar** presented a long-term change and variability of short-lived climate pollutants in Pakistan and an anomalous shift in seasonal cycle of methane. On the Arctic carbon cycle, the study by **Su-Jong Jeong** concluded that Arctic carbon release in cold seasons could exceed the carbon update in a growing season under continuous warming condition. Focusing on hydrology, **Chang-Eui Park** discussed an emerging aridification in warm climate. He argued that limiting global warming below 1.5°C above pre-industrial level can notably reduce an emergent aridification compared to the 2°C warming.

Figure 3: *Group photograph of the participants of the local workshop on "WCRP grand challenges and regional climate change"*

Report on the first SPARC OCTAV-UTLS meeting, Boulder, CO, USA, 18-20 July 2017

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Dates:
18 - 20 July 2017

Organisers:
Gloria L. Manney (NorthWest research Assiociates, USA and New Mexico Institute of mining and Technology, USA), Irina Petropavlovskikh (NOAA, CIRES, USA), and Peter Hoor (University of Mainz, Germany)

Host Institution:
NorthWest Research Associates, USA

Number Of Participants: ~20

Sponsors:

Activity Webpage:
https://www.octav-utls.net

More than 20 scientists from over 15 institutions gathered for the first meeting of the emerging SPARC activity OCTAV-UTLS (Observed Composition Trends And Variability in the Upper Troposphere and Lower Stratosphere) on 18-20 July 2017 in Boulder, CO. The meeting was organized by the Co-leads of the initiative, Gloria L Manney, Irina Petropavlovskikh, and Peter Hoor, and was graciously hosted by North-West Research Associates (many thanks to local organizers Janet Biggs, Andy Frahm, and Joan Alexander). The activity emerged from the GAW/NDACC/SPARC UTLS observation meeting in Geneva in May 2016, which emphasized open questions from the SPARC data initiative (Hegglin *et al.,* 2016). The focus of the OCTAV-UTLS activity is on improving the quantitative understanding of composition trends and long term dynamical changes in the UTLS; understanding dynamical changes such as trends in STE and the BDC will help quantify trends in ozone, water vapour, and other species. Achieving these goals requires a detailed characterization of existing measurements in the context of the large dynamical variability in the UTLS, which introduces confounding variability and uncertainty in assessing long term changes in observations.

The first meeting was intended to bring together experts from different observational communities and on meteorological data analysis to discuss the quality and sampling characteristics (spatial and temporal coverage and resolution) and the representativeness of these observations. The activity will initially focus on the trace gases with the largest radiative impact, first ozone and then water vapour. Thus, the discussion on the first day centred around available ozone measurements in the UTLS, with discussion of water vapour measurements on the third day. Discussion on the second day focused on analysis tools to be used in OCTAV-UTLS to account for dynamical variations, including the capabilities and possible extensions of the software package JETPAC (JEt and Tropopause Products for Analysis and Characterization; Manney *et al.,* 2011) that will provide a common framework for analysing the composition data sets.

Tuesday morning saw a series of overview talks about the necessity for, goals of, and activities related to OCTAV-UTLS. **Michaela Hegglin** summarized the Geneva GAW/NDACC/

SPARC UTLS observations workshop (Hegglin *et al.*, 2016), emphasizing the importance of reducing uncertainty in UTLS trace gas observations to improving climate predictions. Following this, **Peter Hoor** summarized the activity proposal, the major goals of the activity and the planned methods. **Irina Petropavlovskikh** reported insights from the SPARC activity LOTUS (**http://igaco-o3.fmi.fi/LOTUS/**), which she also co-leads. The primary goal of LOTUS is to reduce the uncertainty in ozone trend estimates from existing data in the stratosphere.

Later the discussions turned to available ozone measurements from aircraft, satellite, lidar, and ozonesonde platforms. Aircraft data from both commercial airliners and dedicated science missions will be used within OCTAV-UTLS. Commercial airliners fly regularly and thus provide broader data coverage and statistics over long time periods. However, the measurements are generally limited to a narrow range of altitudes with quasi-horizontal flight tracks. **Valerie Thouret** and **Andreas Petzold** reported on the data available from the IAGOS project (**http://iagos.sedoo.fr/**), which includes IAGOS-core and IAGOS-CARIBIC. Within IAGOS-core, water vapour and ozone data are available since 1994. It thus allows derivation of trends; this database is growing by about 5 million data points each year. Based on this data set, **Yann Cohen** presented climatologies and trends of ozone and carbon-monoxide in different parts of the UTLS (vertically and regionally). In contrast, IAGOS-CARIBIC operates about four times a month with the goal of obtaining a more comprehensive picture of the chemical composition of the UTLS. **Andreas Zahn** gave an overview of the ozone measurements available since 2005 and how these data can be used for both climatological and process-oriented studies. Data from dedicated UTLS science missions mainly focus on specific processes. Although such missions are limited in time and to certain regions, large consistent data sets produced by combining these data have become available in recent years. Andreas Zahn also presented corresponding ozone measurements from recent HALO campaigns: TACTS covered the midlatitude UTLS over Europe in August/September 2012 and PGS the polar/sub-vortex UTLS in winter 2015/2016. Peter Hoor presented data from the SPURT mission covering the midlatitude UTLS over Europe in the early 2000's over two years. **Laura Pan** discussed the major results from the START08 campaign, which had flight tracks covering large parts of the central US and Canada. Soundings and lidar observations constitute point-source measurements, but with very fine vertical resolution and numerous stations providing many decades of measurements. **Bryan Johnson** gave an overview of ozone sonde measurements, presenting analyses of ozone sonde data showing large day-to-day variability and the annual cycle captured in the multi-decadal climatology over Boulder and other NOAA, NDACC and SHADOZ ozone sonde stations. Some of these data are available since 1971 and profiles typically extend up to an altitude of about 35 km. On behalf of **Herman G.J. Smit** he also talked about homogenization of ozone sonde data and evaluation of instrumental and processing errors as a function of altitude, which is necessary for long time trend analysis. Finally, **Irina Petropavlovskikh** showed examples of the Boulder ozone sonde data in relation to dynamical features that affect the vertical profiles of ozone (see, e.g., Figure 4). She showed the relationships of UTLS ozone variability to dynamical features such as jets and multiple tropopauses. **Thierry Leblanc** then introduced available lidar measurements from various networks (e.g., NDACC, TOLnet). He noted that accuracy and precision of ozone measurements can vary significantly in the UTLS, but also showed examples demonstrating how lidar measurements can be used to analyse air masses affected by stratosphere-troposphere exchange (STE).

The data sets with largest spatial coverage but the least horizontal and vertical resolution in the UTLS come from satellites. Initially, it is planned to incorporate six data sets in the analysis, all introduced by representatives of the respective instrument teams. All presentations focused on merits and drawbacks of satellite measurements in the UTLS and recent retrieval improvements. **Adam Bourassa** discussed the approximately 14-year data record from OSIRIS, followed by **Kaley Walker** , who described ACE-FTS UTLS measurement characteristics and highlighted some recent papers using those. MIPAS UTLS measurement characteristics for the record from 2004 to 2012 were shown by **Gabriele Stiller**. The approximately 12-year MLS dataset and the OMPS-LP were described by **Luis Millán** and by **Natalya Kramarova**, respectively. **Robert Damadeo** discussed the measurements from the suite of SAGE instruments (SAGE I, II, III) covering over 20 years. The vertical resolution

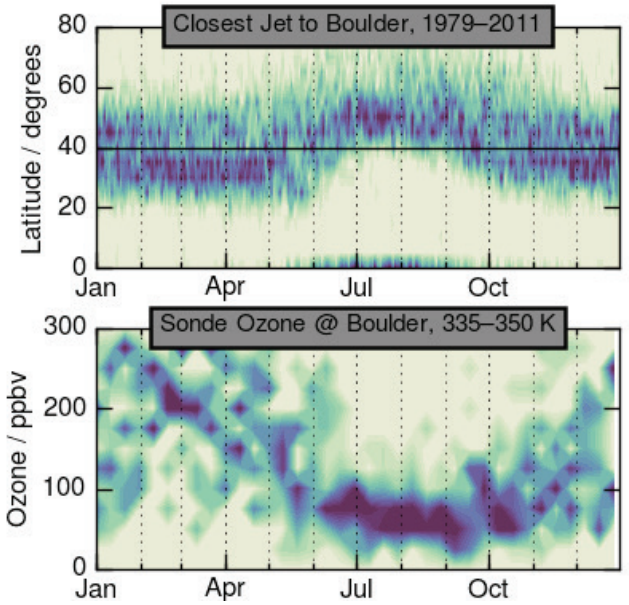

Figure 4: *(Top) Climatological (1979–2011) frequency distribution of the closest jet to Boulder from JETPAC analysis. (Bottom) Climatological frequency distribution of ozone sonde observations in the 335–350 K isentropic layer (near the level of the subtropical jet). The subtropical jet is usually equatorward of Boulder in winter, and poleward of it in summer (during the North American monsoon), consistent with high ozone values (largely stratospheric air) in winter and low values in summer (largely tropospheric air).*

of ozone in the UTLS from most of these instruments is roughly 1-2 km, but 2-3 km for MLS; uncertainties generally increase in the UTLS, but many studies have demonstrated that the measurements are still valuable there, and their broad coverage complements the observations from balloons, lidar, and aircraft.

The second day was intended to discuss common strategies and metrics for data analysis to account for variability induced by dynamical processes to get better statistics for trends. The uncertainties of a data point generally arise from uncertainties related 1) to the measurement technique or data retrievals/processing and 2) uncertainties related to the coordinate system used to interpret the data. The first uncertainty is inherent in the retrieved data, and must thus be accounted for but cannot be mitigated. However, by choosing appropriate coordinate systems based on the geophysical flow in the atmosphere and/or its thermodynamic state, dynamically-driven uncertainties can be significantly reduced.

To guarantee consistent treatment of the UTLS dynamics, the JETPAC tools will be used for all observations. JETPAC can use meteorological data from numerous reanalysis data sets to map the observations in geophysical coordinate systems, based on equivalent latitude, jet locations (e.g., subtropical or "polar" jet) and/or tropopause locations (both lapse rate and PV-based). Current and planned features of JETPAC were presented by **Gloria Manney** and **Luis Millán** in several talks; Figure 4 shows an example using JETPAC products to help interpret ozone sonde measurements at Boulder. New features may include Hadley cell coordinates (discussed by **Mark Olsen**) and additional tropopause definitions (e.g., based on isentropic PV gradients). Mark Olsen also showed how dynamical features such as QBO, ENSO affect the ozone mixing ratios using a jet-coordinate view derived from JETPAC. JETPAC was developed for satellite data, and has been extended to handle aircraft and profile (i.e., sonde and lidar) data. **Daniel Kunkel** addressed approaches for pre-processing aircraft data, which have much higher temporal and spatial resolution than the reanalysis data to be used for coordinate mapping. A similar discussion was led by **Thierry Leblanc** regarding the vertical resolution of lidar measurements. Additional discussions of methods to account for dynamical variability included tracer correlation studies (led by Peter Hoor), and using column ozone to identify STE in the extratropics (led by Mark Olsen). **Gloria Manney** also presented results from the SPARC Reanalysis Intercomparison Project that are pertinent to the selection of reanalyses to use for OCTAV-UTLS.

It was decided that ozone will be analysed in the first phase of OCTAV to define metrics and develop methods. Two test periods have been identified for the first consistent, comprehensive analyses of ozone data from all platforms, 2011-2013 and 2001-2003. JETPAC will be used as the central tool for comparison, and MERRA-2 as the initial reanalysis data set (though ERA-Interim and, eventually, ERA5 will also be used).

On day three the discussion turned to UTLS water vapour measurements. Water vapour is planned to be the focus after the development of methods for ozone since it is affected by microphysics in addition to dynamics. **Michaela Hegglin** showed climatologies from satellite measurements and their uncertainties. She pointed out that water vapour trends in the UTLS are very difficult to determine with rising tropospheric temperatures, and that there is a large discrepancy between satellite measurements and chemistry

Figure 5: *Group photograph of the OCTAV-UTLS Workshop participants in front of NWRA Boulder office.*

climate and reanalysis models. The necessity of addressing uncertainties in the UTLS is demonstrated by much larger differences between models and observations as altitude decreases from the stratosphere into the UTLS. Satellite water vapour data sets from the years after 2000 have been compared in the SPARC WAVAS II activity, which was summarized by **Gabi Stiller**. She showed that the difference from frost point measurements is small between 10-100 hPa, but increases in the UTLS. Aircraft water vapour data sets were presented for commercial and UTLS specific scientific missions: **Andreas Zahn** presented the data from IAGOS-CARIBIC and **Andreas Petzold** that from IAGOS-core. On behalf of **Martina Krämer** Andreas Petzold also talked about JULIA, the Juelich database for water vapour measurements. This database includes humidity measurements from 53 field campaigns with more than 418 dedicated flights and, combined with IAGOS data since 1996, constitutes the largest airborne humidity data set. Another database from dedicated science missions is available at DLR in Germany; **Stefan Kaufmann** compared these data to water vapour from the operational ECMWF IFS model. Finally, **Holger Vömel** pointed out the necessity of further in-situ balloon measurements of water vapour for trend estimates, since accurate stratospheric water vapour measurements from balloon are scarce.

The meeting was closed with a summary discussion led by **Peter Hoor** that can be encapsulated as follows: the overall goal of OCTAV-UTLS is to account for the transport barrier induced variability in UTLS tracer observations by using different observation platforms with common reanalysis data and consistent geophysically-based analysis methods. This will allow better quantification of UTLS composition trends, and provide deeper insight into the dynamical processes affecting UTLS composition. The participants agreed to prepare data sets for the initial test periods to conform with JETPAC input standards to begin the consistent analysis. The outcomes will be discussed in a follow up meeting in Mainz, Germany in June 2018. Updates and news will be made available on **https://www.octav-utls.net**.

Acknowledgements

OCTAV-UTLS is strongly supported by the Global Atmospheric Watch (GAW) program of WMO.

References

Hegglin, M.I., G. Braathen, T. Leblanc, G. Stiller, J. Tamminen, S. Tegtmeier, C. Voigt, and A. Engel, 2016: The GAW/NDACC/SPARC Upper Troposphere and Lower Stratosphere (UTLS) Observation Workshop. SPARC Newsletter 47, 39–43.

Manney, G.L., *et al.*, 2011: Jet characterization in the upper troposphere/lower stratosphere (UTLS): Applications to climatology and transport studies, *Atmos. Chem. Phys.*, **11**, 6115–6137.

IUGG-SPARC-EGU training school on Stratosphere-Troposphere Interactions

Elisa Manzini[1], Fiona Tummon[2], and Bernd Funke[3]

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Dates:
2 -5 September 2017

Organisers:
Elisa Manzini (Max Planck Institute, Hamburg), Bernd Funke (Instituto de Astrofísica de Andalucía, Granada), Babatunde Abiodun (CSAG, University of Cape Town), Fiona Tummon (SPARC Office, ETH Zurich; now University of Tromsø), Neil Holbrook (University of Tasmania, Hobart), Katja Matthes (GEOMAR, Kiel), and Olivia Rompainen-Martius (University of Bern, Bern)

Host Institution:
Department of Environmental and Geographical Sciences, University of Cape Town

Number Of Participants: 22

Sponsors:

Workshop Website:
www.sparc-climate.org/meetings/Training_school_on_stratosphere_troposphere_interactions_Sep2017

With the funding provided by the International Union for Geophysics and Geodesy (IUGG), a four-day training school on Stratosphere-Troposphere Interactions was organised from 2-5 September 2017. The school was kindly hosted by the Department of Environmental and Geographical Sciences at the University of Cape Town. The training school directly benefitted from the fact that many world-leading scientists from across the IUGG were in Cape Town for the IAPSO-IAMAS-IAGA general assembly (held from 27 August – 1 September 2017). The lecturers volunteered their time and funds to spend four days with an enthusiastic group of 22 early career researchers from across the world (see Figure 6). The training school organisers would like to express their deep gratitude to all the sponsors – IUGG, SPARC, the European Geophysical Union (EGU), and the Applied Centre for Climate & Earth Systems Science (ACCESS) - who made the training school possible. Data storage for all participants was kindly made available by CSIC (Spain).

The school comprised three days of lectures and exercises, with the fourth day being dedicated to small projects that the students worked on over the course of the school. The lectures covered a broad range of topics with a focus on stratosphere-troposphere interactions. The school started with a lecture on mid-latitude meteorology by **Nili Harnik**, followed by a lecture on tropical dynamics by **Joan Alexander**. Through these lectures the students were exposed to the phenomenology of tropospheric jets, the differences and properties of the eddy driven jet and the subtropical jet, the theoretical basis of baroclinic instability, as well as the variability of tropical precipitation, the coupling between convection and atmospheric waves, the role of latent heat for atmospheric waves of all scales, and the properties of tropical waves. Both lectures also covered wave mean flow interaction theory. A surprise guest lecture by **Ted Shepherd** on the psychology of climate science was held on the evening of the first day, before a small ice-breaker event also hosted at the University of Cape Town.

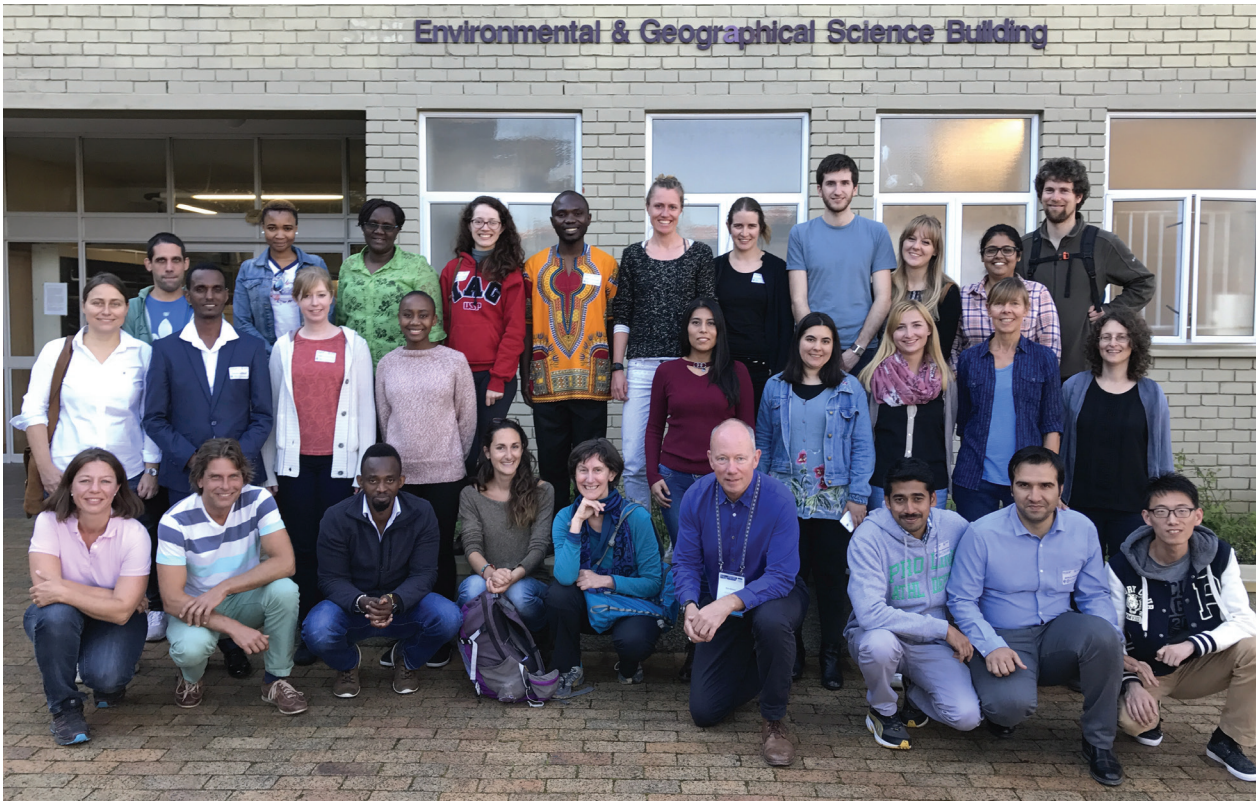

Figure 6: *Group photograph of the participants of the IUGG training school on Stratosphere-Troposphere Interactions in Cape Town*

The lectures on the second day dealt with stratospheric dynamics and chemistry, with one lecture by **Thando Ndarana** and the second by **Michaela Hegglin**. These two lectures provided the students with the fundamentals of stratospheric circulation patters, the difference between northern and southern hemispheres, as well as the basic of stratospheric ozone chemistry, history of the ozone hole, ozone-climate interactions, and stratospheric ozone recovery.

The topic of stratosphere-troposphere interactions was covered on the third day, with lectures on solar variability impacts by **Katja Matthes** and stratosphere-troposphere coupling mechanisms by **Mark Baldwin**. How solar irradiance varies on a number of time scales and the importance of the solar cycle as a source of decadal variability was stressed during the first lecture, which also included a brief discussion of the Atlantic meridional overturning circulation as a source of decadal climate variability. During the second lecture, Mark introduced the history of how the downward path of dynamical coupling between the stratosphere and troposphere became evident and his recent explanation for the mechanism of the tropospheric amplification of this coupling.

To facilitate active participation of the students, they worked on mini-projects throughout the training school, which were presented in plenary on the afternoon of the last day of the school. The students were highly engaged and presented some excellent work on a variety of topics, despite the limited time available. The mini-projects covered topics ranging from a comparison of the phases of the Southern Annular Mode through to looking at the links between the stratospheric polar vortex, the quasi-biennial oscillation, and the Madden-Julien oscillation. The mini-projects were further developed after the training school into short documents, which are now available on the SPARC website at: **www.sparc-climate.org/meetings/Training_school_on_stratosphere_troposphere_interactions_Sep2017** .

Overall, the training school was very successful, with all participants having a lot of fun while learning about a topic that is not yet taught in South African universities. Feedback from the group was extremely positive and it is our hope that we will be able to organise a similar training school soon!

Stratospheric Aerosol Workshop Report

Terry Deshler[1], Larry Thomason[2], Lars Kalnajs[3]

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Dates:
6 - 8 September 2017

Organisers:
Terry Deshler (University of Wyoming, USA), Larry Thomason (NASA, USA), and Lars Kalnajs (University of Colorado, USA)

Host Institution:
Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado

Number Of Participants: 30

Sponsors:

Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

Activits Website:
www.sparc-ssirc.org

The workshop, which was initiated by discussions at SPARC's SSiRC (Stratospheric Sulfur and its Role in Climate) activity workshop in Potsdam in April 2016, focused on facilitating communications and collaborations among scientists responsible for stratospheric aerosol observations. The workshop, convened by Terry Deshler, Larry Thomason, and Lars Kalnajs, was held at the Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado, from 6-8 September 2017. The thirty attendees, consisting of observationalists, using *in situ*, ground-based or space-based instruments, and a few modellers, were dominated by US scientists, but included participants from Germany, Belgium, and the United Kingdom.

The workshop was organized around four broad themes: 1) Developing strategies for understanding and closing differences among instruments. 2) Characterizing the continuity of the measurement record as instruments and measurement paradigms change. 3) Providing data users, particularly the climate modelling community, more robust and better-characterized data sets than normally obtained from single instruments. 4) Developing ideas for collaborative projects and proposal ideas.

Beginning the meeting, under themes 1) and 2), the following presentations were made. **Elizaveta Malinina** showed a comparison of SCIAMACHY and OSIRIS aerosol products, which resulted in satisfactory agreement. Highlighted in the discussion were questions about the assumptions used for the underlying aerosol size distribution and why number distribution is used, rather than a higher moment distribution such as surface area. **Ghassan Taha** evaluated OMPS LP aerosol extinction data and compared it with OSIRIS and CALIPSO. The comparisons with OSIRIS are encouraging, but again the main theme was on the importance of the aerosol phase function and single scatter angle for the limb scatter measurements, and the impacts these have on the viewing geometry and wavelength dependencies. The comparisons with CALIPSO were somewhat confounded by the requirement of a lidar ratio which can have significant uncertainties. Emphasizing this latter point, **John Barnes** discussed lidar issues in measuring stratospheric aerosol. The two primary issues were the need for a lidar ratio and the importance of the normalization altitude. John also described an imaging polar nephelometer he has developed to measure the phase function directly. Questions were raised about the sensitivity of such an instrument for stratospheric aerosol in background conditions.

Continuing with the emphasis on aerosol size distributions **Chuck Wilson** described requirements for *in situ* measurements of stratospheric aerosol. These included insuring that an adequate size and number concentration range is covered, accounting for modifications to particle size and number concentration in sampling inlets and characterizing instruments in the laboratory. When this is done the aircraft data are found to be in reasonable agreement with coincident satellite measurements. Building on the instrument characterization point, **Terry Deshler** presented new results on the retrieval of size distributions from *in situ* particle counter measurements. A new method was described for retrieval of aerosol size distribution from balloon-borne measurements which incorporated laboratory measurements of instrument counting efficiency. Such a method resolves a long standing disagreement between the balloon-borne *in situ* data and SAGE II under periods of low aerosol loading. This agreement has encouraged **Larry Thomason** to find a more direct role for *in situ* measurements for inferring aerosol properties from space based optical measurements. Long standing issues from the remote optical measurements relate primarily to difficulties in deriving aerosol surface areas from limited spectral resolution measurements. With the new found agreement of *in situ* estimates and remote measurements of extinction, the *in situ* data may provide a new test bed to explore aerosol moment retrieval algorithms.
In the realm of changes in instrument paradigms the basis for three new instruments and one measurement campaign were presented. **Richard Bevilacqua** described a new satellite instrument, the GLO (GFCR Limb Occulation) Sensor. GLO uses solar occulation for aerosol and gas filter correlation radiometers for four radiatively active trace gases and five long lived tracers. The instrument is designed to provide high resolution measurements in the upper troposphere and lower stratosphere (UTLS). A first deployment on a balloon is expected in September 2019. **Drew Rollins** described the NOAA Printed Optical Particle Spectrometer (POPS). This *in situ* instrument has been deployed on small balloons and aircraft and is small, light, and inexpensive, allowing non-recoverable deployments. The size range extends from 0.07 – 10 **µ**m in radius, matching the range of much heavier balloon-borne instruments. Flow rates are near 1 liter per minute limiting the sensitivity to concentrations of rare large particles. Continuing with balloon-borne instruments, **Lars Kalnajs**, described a new generation of *in situ* instruments for stratospheric aerosol and condensation nuclei (CN) measurements. Similar to POPS these instruments are small, light and relatively inexpensive. Here the goal is to replace the University of Wyoming *in situ* measurements with instruments that are much less expensive and less logistically difficult to deploy, making it feasible to extend the stratospheric aerosol measurements begun in 1971 in Wyoming. As in Wyoming, two instruments are involved, one to measure CN, the total aerosol population greater than 10 nm, and the second to measure particles in the radius range 0.15 – 10 µm, but at a higher flow rate for higher sensitivity to large particles.

Moving away from new instruments, **Troy Thornberry** described a proposed measurement campaign, "ACCLAIM: an airborne science mission to study UTLS aerosol properties and processes to improve stratospheric aerosol representation in climate models." The proposal is for four deployments of the WB-57 research aircraft from the West Pacific to Central America to the East Atlantic. Included in the science objectives are investigations of the sensitivity of satellite sensors, and models, to UTLS aerosol. Wrapping up the first day **Dan Murphy** presented a new analysis of PALMS (Particle Analysis by Laser Mass Spectrometry) data by size distribution. This approach provides information on aerosol source regions. Both organics and sulfates pass the tropopause about equally. In the stratosphere the sulfate mass peak grows considerably. Also described was a prototype of a cavity ring down instrument to measure extinction from a balloon. The instrument works in the lab, but is not yet ready for deployment. Wrapping up the afternoon sessions the rapporteurs noted the common themes stressing UTLS science, airborne instrument comparisons, links to satellite measurements, and the continuation of long term records. There was also significant discussion of new particle formation following the presentation of the PALMS data and some of the aircraft results shown in the morning with the NMASS which provides aerosol sizes as small as 3 nm.

The morning talks on Thursday focused on aerosol climatologies, relating to the third theme of the meeting. **Michael Höpfner** described a new climatology of stratospheric aerosol volume densities from MIPAS. With aerosol volume added to the MIPAS sulfur products, this instrument now supplies the whole budget of gas and particle phase sulfur in the stratosphere. **Larry Thomason** gave an overview on CMIP6 focusing on the observational SAGE II data upon which the climatology is based, and the construction of data for SAGE II data gaps, by relying on other observations to cover regions of poor coverage, instrument interruptions, or obscuration after Pinatubo. **Robert Loughman** dis-

cussed the importance of the phase function for both limb scattering aerosol extinction retrievals and estimations of the energy balance effects. He emphasized the impact uncertainties in the aerosol phase function have on limb scatter measurements as these measurements become the basis for recent and current aerosol climatologies. In particular he emphasized the need for size measurements in the 10-100 nm range. A major focus of the discussion was how to incorporate measurements from additional instruments to improve knowledge of size information including effective radius and surface area density. At present, information on these quantities is extrapolated from volcanic eruptions of the SAGE II era, despite the vast difference in eruption size compared to more recent events. Limb scatter measurements may be used to provide information on the aerosol phase function, while volume measurements from MIPAS may help to constrain quantities such as surface area density. However, how best to incorporate this new information remains an open question.

The last four talks addressed the impact of sudden geophysical events on stratospheric aerosol. **Graham Mann** compared observations of the volcanically-enhanced stratospheric aerosol layer from Agung in the 1960s to model simulations. The approach was to use a stratospheric aerosol microphysical model tested against Pinatubo to simulate the 1963 Agung eruption assuming several SO2 input levels. The model results were compared to limited *in situ* and lidar measurements, during the period following Agung, to optimize the SO_2 input. **Mike Fromm** shifted from volcanic aerosol to smoke with his last minute offer of a talk on observations of stratospheric smoke plumes from pyrocumulonimbus storms in British Columbia. The multiple fires led to the convergence of pyroCb anvil clouds leading to a UV aerosol index 30% higher than any previous TOMS-OMI-OMPS observation suggesting the smoke plume was either higher, thicker, or blacker than any previous smoke plume observed. Shifting back to volcanoes, **Yunqian Zhu** described the impact of volcanic eruptions on polar ozone depletion due to the Calbuco eruption in 2015 based on the community climate model WACCM coupled with the aerosol package CARMA. Attention was drawn to the possible impact of small volcanic eruptions on polar ozone loss. Being prepared for the next big volcanic eruption was the focus of **Mike Fromm**'s official talk for the meeting. The strategy proposed was to complete case studies of eruptions in the satellite era to identify the best products from satellite remote sensors to characterize the volcanic cloud. **Brian Toon**'s closing talk on measurements of future volcanic eruptions focused on the essential microphysical information: effective radius, extinction efficiency, sedimentation rate, surface area, and particle abundances at sizes less than 100 nm, to characterize the aerosol impacts on chemistry, radiation, cloud lifetime, and nucleation/growth potential. *In situ* information will be required in the thickest parts of the cloud where remote sensors will be blocked.

The Thursday afternoon break-out sessions were first divided into *in situ* and remote observations, then into *in situ* remote synergies and challenges for the observation of sudden geophysical events. The break-out sessions led to further follow on discussion about the opportunities for *in situ* instrument comparisons on imminent balloon flights planned for the new LASP OPC and CN counter, which could immediately include a POPS, and the possibility for future flights to include John Barnes's imaging polar nephelometer or Dan Murphy's cavity ring down extinction instrument. Additional discussions followed concerning opportunities for correlative measurements with the new SAGE III in orbit on the International Space Station.

Friday morning consisted of a review of the talks within the organized sessions by the rapporteurs, with an emphasis on the open questions within the workshop themes. Not surprisingly the primary open questions cantered on the information not immediately amenable to observation. This has to do with the aerosol phase function, critical to the limb scatter observations, and how to best represent the aerosol size distribution to model the phase function. In particular size information is limited at radii much less than 100 nm. Information in this region is also important for the microphysical modellers during both background and volcanic periods. The importance of continuity in the measurement records, whether through maintaining long term data sets, or insuring instrument overlap for transitions from, say the solar occultation paradigm to the limb scatter paradigm, was emphasized. To this purpose discussions continued regarding opportunities for correlative measurements across platforms and measurement techniques and for collaboration on existing measurement data sets. The meeting co-conveners all agreed that the initial doubts about the usefulness of such a workshop were entirely erased by the linkages that were either formed, or re-established, because of the workshop. Copies of all talks presented are available on the SSiRC web site under the meetings link, or follow this URL **www.sparc-ssirc.org/downloads/Workshop_Measurement_of_Stratospheric_Aerosol.zip**.

Report on the Joint SPARC Dynamics and Observations Workshop: SATIO-TCS, FISAPS and QBOi, Kyoto, Japan

James Anstey[1], Shigeo Yoden[2], Marvin Geller[3], Scott Osprey[4], Kevin Hamilton[5], Neal Butchart[6]

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Dates:
9 - 14 October 2017

Organisers:
James Anstey (Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada). Neal Butchart (Met Office Hadley Centre, UK), Marv Geller (Stony Brook University, New York, USA), Kevin Hamilton (University of Hawaii, USA), Scott Osprey (University of Oxford, UK), Shigeo Yoden (Kyoto University, Kyoto, Japan)

Host Institution:
Kyoto university, Kyoto, japan

Number Of Participants: 74

Sponsors:

Integrated Earth & Planetary Science Hub, Kyoto University

Workshop Website:
www-mete.kugi.kyoto-u.ac.jp/SPARCjws2017/index.html

Activity Websites:
www.sparc-climate.org/activities/emerging-activities/
http://www.sparc-climate.org/activities/fine-scale-processes/
http://users.ox.ac.uk/~astr0092/QBOi.html

Tropical weather, including organized large-scale phenomena such as the Madden-Julian Oscillation (MJO), is largely governed by interactions with moist convection acting across a range of spatial scales. The large-scale circulation of the overlying stratosphere, including the quasi-biennial oscillation (QBO), is largely driven by interactions with vertically propagating waves forced by tropospheric convection. Evidence from observations and models has increasingly indicated a significant downward dynamical coupling from the tropical stratosphere, including the recently discovered substantial influence of the QBO on the MJO. Phenomena with fine vertical scales likely play an important role in aspects of tropical stratosphere-troposphere coupling, and better use of observations to characterize such small scale variability may both improve our understanding and help to better constrain models.

To examine these and related phenomena, the Joint SPARC Dynamics and Observations Workshop was organized by three SPARC activities: Stratospheric And Tropospheric Influences On Tropical Convective Systems (SATIO-TCS), Fine-Scale Atmospheric Processes and Structures (FISAPS), and the Quasi-Biennial Oscillation Initiative (QBOi), and was held in Kyoto, Japan, 9-14 October 2017. Given the partial overlap of scientific interests among these SPARC activities, one goal of the joint workshop was to foster increased collaboration across their boundaries, and accordingly the week was centred on two days of plenary talks combining all three activities and spanning topics of mutual interest. The rest of the week was organized into more focussed sessions for the individual activities, and an effort was made to schedule as few parallel sessions as possible so as to encourage participants in one activity to attend sessions of the other activities. The workshop was hosted by Professor Shigeo Yoden of Kyoto University, and attended by 74 scientists from 13 countries. The workshop agenda, including the abstracts of all oral and poster presentations, is available online at the workshop website (**http://www-mete.kugi.kyoto-u.ac.jp/SPARCjws2017/index.html**).

Broadly, the workshop themes included: influences on organized tropical convection (such as the aforementioned QBO-MJO link), vertical propagation of tropical waves, fine-scale processes and structures, QBO dynamics (including the early-2016 QBO disrup-

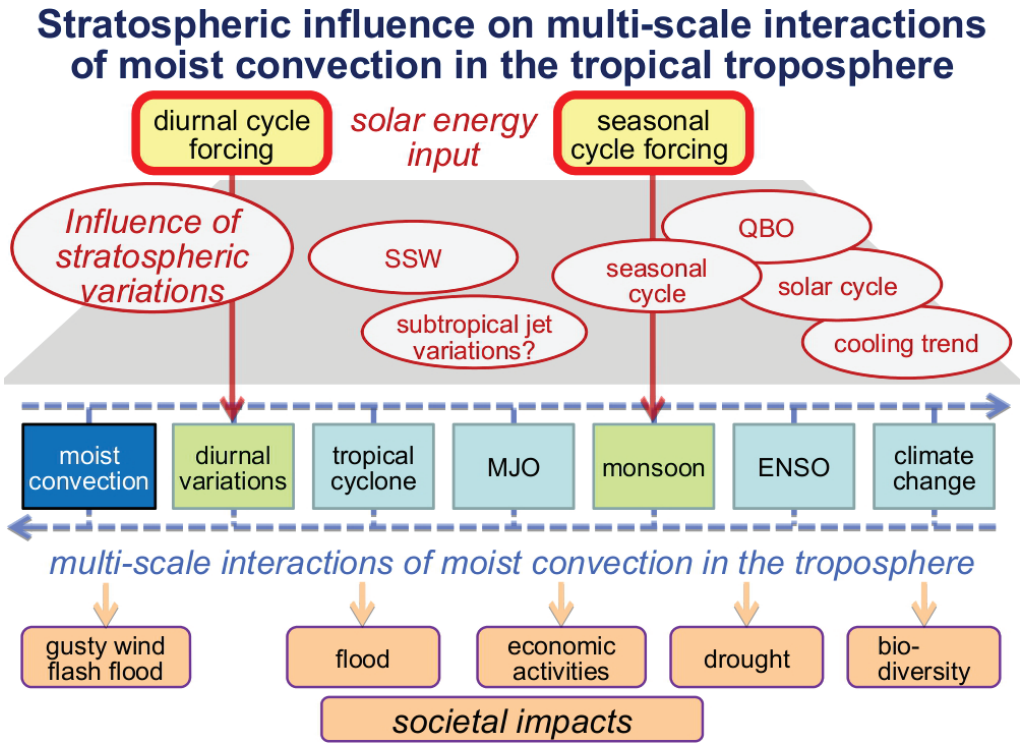

Figure 7: *Schematic overview of stratospheric influence on the tropical troposphere. Figure credit: Shigeo Yoden.*

tion), and stratosphere-troposphere coupling in the extratropics (including QBO influence at high latitudes).

While extratropical stratosphere-troposphere coupling has been a prominent SPARC focus for well over a decade, stratospheric influence on the tropical troposphere is only recently receiving more attention, and is the prime focus of the SATIO-TCS activity (Figure 7). Fully exploiting any potential predictability of tropical weather systems that originates from the stratosphere will likely require improving our understanding of, and ability to model, the QBO and its impacts, which is the focus of the QBOi activity. Relevant phenomena may include those exhibiting fine vertical scales, such as vertical mixing near the base of the QBO, cirrus formation near the tropical tropopause, or the fine-scale structure of the tropopause inversion layer (TIL) across which tropical stratosphere-troposphere coupling occurs. The main focus of the FISAPS activity is the use of high vertical-resolution radiosonde data (HVRRD) to characterize fine-scale processes that have systematic effects on the large-scale circulation, with the anticipated benefit of reducing model uncertainty (which is large in the case of the QBO). Thus there is substantial overlap between the research foci of all three of these SPARC activities, and complementarity between activities that have an emphasis on modelling (QBOi), observations (FISAPS), and a mix of the two (SATIO-TCS). The rest of this article will summarize the workshop proceedings, organized according to the aforementioned themes.

Influences on organized tropical convection

It has been known for some time that the QBO may influence tropical convection, and historical overviews were given by **Matt Hitchman** and **Marvin Geller**. The mechanisms for this influence are uncertain, but idealized models are being used to assess causality (**Tieh Yong Koh, Zane Martin, Adam Sobel, Shigeo Yoden**). In particular, **Adam Sobel** noted that the tropical precipitation response to a QBO-induced tropopause-level temperature perturbation may be non-monotonic. If tropical tropopause layer (TTL) temperature variability is the main driver leading to changes in tropical deep convection, it is important to understand the relative roles of radiative and wave-induced forcing in driving that variability (**Peter Haynes**). Mechanisms should also address why the QBO would influence the organization of convection (**Marvin Geller**). The organization of mesoscale convective clusters over tropical oceans as diagnosed with a new theoretical framework of self-organized criticality was discussed by **Chee-Kiat Teo**.

The observational record indicates that the QBO influence on seasonal-mean tropical convection is relatively weak but that its influence on MJO is somewhat stronger (Figure 8). **Seok-Woo Son** showed that a stronger MJO amplitude occurs under 50 hPa easterly QBO (QBO-E) than westerly QBO (QBO-W), and proposed that cirrus-induced radiative heating of the TTL, enhanced by the colder tropopause

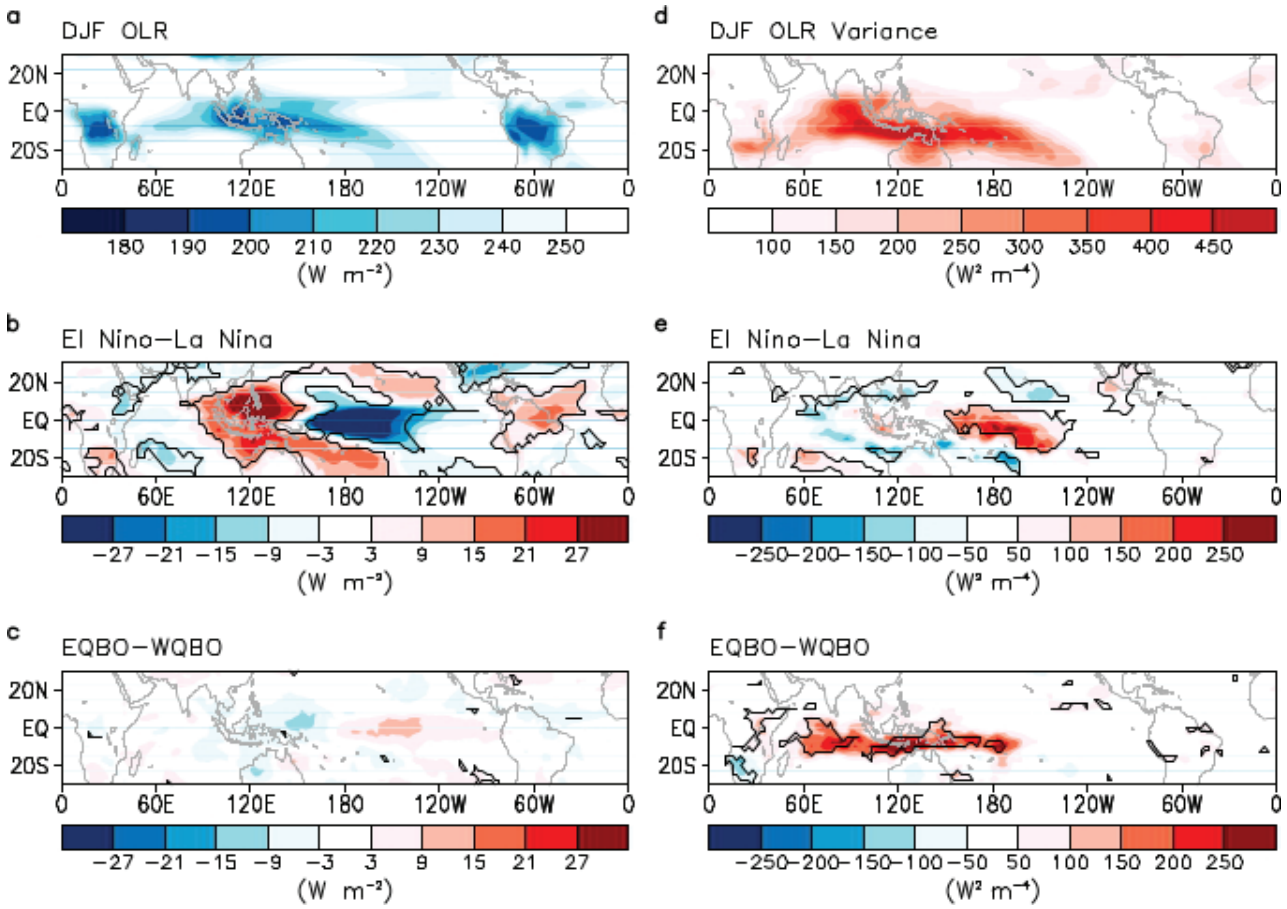

***Figure 8**: Comparison of seasonal-mean OLR and bandpass-filtered (20-100 days) OLR during December-February, for (a,d) climatology, (b,e) differences between El Niño and La Niña, (c,f) differences between easterly (EQBO) and westerly (WQBO) 50 hPa QBO. Black lines denote 95% statistical significance. From Son et al. (2017).*

that occurs during QBO-E, may act to destabilize the TTL, thereby enhancing deep convection. The MJO is more predictable, by about one week, during QBO-E (**Harry Hendon**). An ensemble of 10 models from the Subseasonal-to-Seasonal (S2S) prediction project (**http://s2sprediction.net/**) shows the same effect, with the multi-model mean increase in predictability being about 5 days, and all models showing the same sign of the effect (**Seok-Woo Son**). A note of caution, however, was indicated by the running correlation between QBO and MJO reconstructions spanning the whole 20th century, which showed a strong QBO-MJO correlation emerging only in the most recent 30 years of the record (**Harry Hendon**).

Global outgoing longwave radiation (OLR) data were analysed to show that convectively coupled waves also can respond to the QBO, with more uniform wave amplitudes observed during QBO-W (**Tri Wahyu Hadi**). The amplitude of the Boreal Summer Intra-Seasonal Oscillation (BSISO) was suggested to respond to the QBO, although the connection is stronger to the QBO winds at 20 hPa than to 50 hPa (where the winds correlate most strongly with the observed MJO; **Yayoi Harada**). On the other hand, the tropical easterly jet, which affects Indian summer monsoon rainfall, was shown to be clearly modulated by ENSO but displayed no clear connection to the QBO (**Nithya K**). The Asian summer monsoon anticyclone in the upper troposphere / lower stratosphere (UTLS) may also exhibit internal variability, as indicated by **Arata Amemiya** using an idealized numerical model.

QBO influence is of interest partly because of the very high predictability of the QBO, but it is not the only stratospheric perturbation that could affect the tropical troposphere. Cooling of the eastern Pacific tropical ocean over the last decade, related to the so-called "hiatus" in global warming, occurs concurrently with a poleward shift and strengthening of the Hadley Cell. This change in the Hadley Cell, representing a shift in the location of extreme deep convection, could be influenced by the effect of lower stratospheric cooling (due to increased CO_2) on the stability of the TTL (**Kunihiko Kodera**). Case studies indicating that an abrupt northward shift of convection can occur in response to lower stratospheric cooling due to fluctuations in the Brewer-Dobson circulation were presented by **Rei Ueyama**. A remote influence of Stratospheric Sudden Warmings (SSWs) on tropi-

cal convection was shown by **R. Remya** using radar data from Cochin, India (10N, 76E). MJO convection may respond to solar cycle forcing, particularly during times when QBO and solar influences interfere constructively to affect lower stratospheric stability (**Lon Hood**). An ENSO response to Arctic ozone changes was suggested by **Jianping Li.**

The link between tropical cyclones and upper-level conditions around the tropopause was also explored, with **Tetsuya Takemi** showing the strong effect of upper level temperature on cyclone intensification, **Matt Hitchman** discussing stratosphere-troposphere coupling due to tropical cyclone PV dipoles, and **Ravindran Babu Saginela** examining stratosphere-troposphere exchange over the North Indian Ocean associated with tropical cyclones.

Vertical propagation of waves

William Randel discussed temperature observations from Global Positioning System (GPS) satellites, highlighting the rapid rise in the number of soundings in recent years and the remarkable increases in data density expected in the near future. He used GPS sounding data to examine tropical wave activity, including the small-scale waves that provide a large contribution to the forcing of the QBO, and showed that the largest tropical temperature variances occur at the smallest spatial scales (Figure 9). Reanalyses also provide valuable datasets for examination of tropical waves, as assessed by **George Kiladis** who showed a strong association of stratospheric waves with the QBO, and also that stratospheric Kelvin wave activity is related to the MJO during December-February. Reanalyses represent a mixture of observational information and model simulation, which can be difficult to disentangle. **Corwin Wright** presented comparisons of gravity waves in reanalyses with satellite observations (SABER, HIRDLS and AIRS), sampling the reanalyses in the same way that the satellites sample the real atmosphere. Results suggested that inter-reanalysis differences are related to the reanalysis models' vertical and horizontal resolution, which is a model sensitivity that can strongly affect the QBO. **Kevin Hamilton** proposed that wave propagation and dissipation in models could be diagnosed by adding an artificial wave forcing near the tropopause to generate monochromatic waves that propagate into the stratosphere, providing a novel method for model intercomparison.

The behaviour of large-scale equatorial waves in the QBOi multi-model ensemble (hereafter "QBOi models") was presented by **Laura Holt**, who showed that Kelvin and Rossby-gravity modes at 50 hPa are fairly robust across the models, but often tend to have larger amplitude than found in the ERA-Interim reanalysis. In precipitation spectra these same modes show much more inter-model variation, with roughly half of the models showing realistic Kelvin modes and fewer still showing realistic Rossby-gravity modes. Effects of smaller-scale waves on the QBO were examined by **Yoshio Kawatani**, who found that the QBO period during El Niño was about 2 months shorter than during La Niña in a model where the QBO was driven entirely by resolved waves, but a model in which small-scale waves were parameterized using fixed sources showed no such effect.

Fine-scale processes

Marvin Geller gave an overview of FISAPS, whose scientific focus is to better characterize and understand atmospheric processes occurring on fine ver-

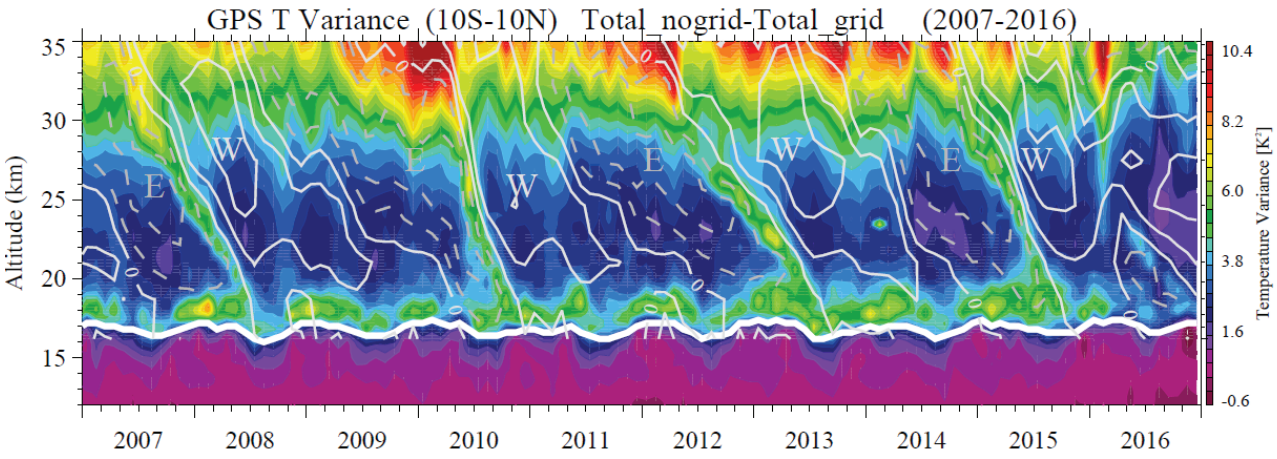

Figure 9: *Zonal variance of GPS daily temperature observations in the tropics (10S-10N) for zonal wavenumbers larger than 10 (horizontal wavelengths < 4000 km).White solid and dashed lines show the QBO winds.Thick white line shows the tropical tropopause. Figure credit:William Randel.*

tical scales (less than about 1 km). One important data source for such investigations is HVRRD. While HVRRD are potentially available at all worldwide radiosonde stations that transmit data to operational weather forecasting agencies, in practice only a limited number of nations make their data easily available to the worldwide research community. **Marvin Geller** gave a summary of the present HVRRD availability as well as an overview of how the data availability to the research community is likely to increase in light of the increasing demand for these data by the operational weather forecasting agencies. **Hye-Yeong Chun** showed how turbulence estimates using HVRRD compared to aircraft measurements of turbulence, and **Muhsin Muhammed** gave evidence of diurnal variations of turbulence in the troposphere and lower stratosphere at some Indian stations.

One potential application of HVRRD is obtaining atmospheric turbulence information, but the methods for doing this depend on relating the measured Thorpe scale to the Ozmidov scale. This is one of the principal challenges for FISAPS, which requires comparison of HVRRD estimates of turbulence to those measured by dedicated research measurements of atmospheric turbulence. One such dedicated research measurement method was discussed by **Franz-Josef Lübken**, who explained how the LITOS instrument (Leibniz Institute Turbulence Observations in the Stratosphere) can resolve the Kolmogorov microscale of turbulence. In the Antarctic, the PANSY radar has been used to examine turbulent dissipation in the troposphere and lower stratosphere (**Kaoru Sato**), and can be compared against observations by balloon-borne instruments (**Yoshihiro Tomikawa**). Direct numerical simulations (DNS) of turbulence were discussed by **Ling Wang**. The comparison between DNS modelling with HVRRD, LITOS, and other measurements of turbulence is a fruitful direction for FISAPS.

Since improved observational constraints on turbulent mixing could improve the modelling of large-scale dynamical variability such as the tropical tape recorder, **Marvin Geller** discussed a recently published paper by Glanville and Birner (2017), and suggested that determination of turbulent vertical mixing in the vicinity of the tropical tropopause should be one of FISAPS's goals. Gravity waves are another small-scale process with a large imprint on the large scale (e.g., the QBO), and are also poorly constrained in models. A new method for observing them using AIRS satellite data was discussed by **Neil Hindley**. A variety of fine-scale processes in the UTLS region will be observed by the upcoming Strateole 2 campaign, as described by **Albert Hertzog**. Long-duration balloons will perform 3-month flights at altitudes of 18 and 21 km, during both QBO phases, circumnavigating the global UTLS and measuring gravity wave momentum fluxes, cirrus microphysics, dehydration, and cross-tropopause transport.

QBO dynamics and the early-2016 QBO disruption

The QBO is strongly dependent on a number of processes that operate at small vertical and/or horizontal scales – such as gravity waves, radiative damping of waves, and vertical mixing – that are unresolved in typical atmospheric general circulation models (AGCMs) and not well constrained by observations. Understanding the ramifications of the resulting model uncertainty is a goal of the QBOi activity, which has assembled a multi-model ensemble of AGCMs that simulate the QBO with varying degrees of fidelity as shown by **Andrew Bushell**. His talk documented significant inter-model variability in the QBO amplitudes, and demonstrated that those QBOi models with fixed sources for their parameterized non-orographic gravity waves underestimated the typical cycle-to-cycle QBO variability.

An expected consequence of the model uncertainty is that modelled QBOs will not respond robustly to forcing, such as increased greenhouse gas concentration, or when the models are used for prediction from observed initial conditions. **Yaga Richter** showed that the QBOi models exhibit widely varying responses to climate-change forcing, including period shortening, lengthening, or the disappearance of the QBO altogether. **Tim Stockdale** and **Young-Ha Kim** assessed QBO predictability using the same models run in hindcast mode and found considerable inter-model variation in predictive skill in the lower (70 hPa) and upper (10 hPa) regions of the QBO. Investigations of particular sensitivities of individual models were also discussed. **Hiroki Kashimura** found strong sensitivity of the QBO in two AGCMs to horizontal resolution, diffusion, and numerical time step, with no indication of convergence. Inclusion of interactive ozone in a model was shown to lengthen its QBO period, suggesting that tuned gravity wave drag in models lacking interactive ozone could be unrealistically weak (**Jack Chen**, **Marvin Geller**). Representing the QBO impact on ozone, which is substantial and extends to high latitudes (**Tobias Kerzenmacher**), is an important aspect of modelling the QBO.

***Figure 10**: Group photograph of the workshop participants.*

The lack of a robust response of modelled QBOs to global climate forcing is likely a symptom of over-tuning of gravity wave parameterizations. A similar weakness in model formulation may lie at the root of the failure of current seasonal forecast systems to predict the 2016 QBO disruption. **Peter Hitchcock** described the dynamics of analogous disruptions occurring in the equatorial mean wind oscillations in a very idealized AGCM and characterized them as a two-stage process involving an initial trigger followed by a sustained feedback. This suggests that the evolution of the real disruption should be predictable following the activation of the trigger, possibly sometime in Dec 2015. **Rolando Garcia** discussed analogous events that are occasionally seen in free-running AGCMs. Notably he showed that under quadrupled CO_2 concentration, the NCAR WACCM exhibited three similar events in a 30-year simulation, two of which corresponded with El Niño events (as does the observed 2016 disruption). **Nagio Hirota** found, using large ensemble experiments, that not only El Niño ocean temperatures but also Arctic sea ice concentration could be important in generating the anomalous waves that forced the disruption. Changes in minor constituents (ozone, N_2O, and HCl) related to the disruption were discussed by **Toshihiko Hirooka**.

Extratropics

Although most attention at the workshop was on the tropics, one focus of the QBOi activity is to better understand the extratropical impacts (teleconnections) of the QBO. **Lesley Gray** showed observed QBO links to surface climate diagnosed by multiple regression analysis, including evidence of influence during early and late NH winter that appears to be distinct from QBO modulation of the stratospheric polar vortex. As with QBO links to tropical deep convection, these links may represent additional pathways for tropospheric influence beyond the conventional hypothesis of QBO-vortex coupling via a stratospheric pathway, often referred to as the Holton-Tan effect.

The stratospheric QBO-vortex coupling nevertheless remains of interest due to its persistence in the observed record to date and the fact that it has not been fully explained. **Hua Lu** examined mean-flow forcing diagnostics on isentropic levels and argued that, depending on the location of the forcing in the extratropical stratosphere, linear or nonlinear processes could contribute to inducing the Holton-Tan effect. **Richard Scott** placed coupling between the vortex and tropical winds in the context of stratospheric internal variability as seen in a hierarchy of models. An alternative framework for viewing QBO-vortex coupling was suggested, based on an idealized model with prescribed PV gradients representing the vortex and different QBO phases.

For the QBOi models, **James Anstey** showed that coupling between the QBO and the NH winter stratospheric polar vortex has appreciable inter-model variation, with the multi-model ensemble exhibiting on average a link that is weaker, but consistent in sign,

with the observed signal. The corresponding surface signal, which in observations resembles the NAO, varies strongly among models (and is not even consistent in sign). The lack of a coherent surface response in the models may implicate the models' ability to represent downward coupling due to stratospheric vortex variations accurately, as discussed by **Mark Baldwin**. Other mechanisms of vertical coupling may also be at play, such as downward reflection of planetary waves (**Hitoshi Mukougawa**). Observed variability also includes the imprint of other low-frequency influences besides the QBO, such as the 11-year solar cycle (**Hua Lu**).

Workshop outcomes

The participants generally agreed that holding this joint workshop was valuable and likely led to greater participation than would have been the case for individual workshops. Also, some new research horizons resulted from interaction among the different SPARC activities. In general, we recommend that more such joint workshops of SPARC activities be considered. The SPARC QBOi, SATIO-TCS, and FISAPS activities discussed their future plans, and all activities have some plans for future meetings, some in connection with the upcoming SPARC General Assembly in October 2018. FISAPS also discussed holding a small focussed workshop in the next year or so. For SATIO-TCS, this was the kick-off workshop and activity plans for the near future were discussed, including writing a review paper summarizing our current understanding and future challenges, opening a web page for the archive of related information, and forming sub-groups for various activities. For QBOi, plans were made for the coming year to complete the set of papers analysing the initial set of QBOi experiments described in Butchart et al. (2017), as well as to hold a side meeting at the SPARC General Assembly to decide on future directions for the activity.

Acknowledgements

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References

Anstey, J., Hamilton, K., Osprey, S., Butchart, N. and Gray, L., 2015: Report on the 1st QBO modelling and reanalyses workshop, 16–18th March 2015, Victoria, BC, Canada. SPARC Newsletter 45, 19–25.

Anstey, J., Osprey, S., Butchart, N., Hamilton, K., Gray, L. and Baldwin, M., 2017: Report on the SPARC QBO Workshop: The QBO and its Global Influence – Past, Present and Future 26–30th September 2016, Oxford, UK. SPARC Newsletter 48, 33-41.

Butchart, N., *et al.*, 2017: Overview of experiment design and comparison of models participating in phase 1 of the SPARC Quasi-Biennial Oscillation initiative (QBOi). *Geosci. Model Dev. Discuss.*, doi:10.5194/gmd-2017-187, in review.

Geller, M., Chun, H.-Y. and Love, P., 2016: FISAPS – An Emerging SPARC Activity. SPARC Newsletter 47, 8-10.

Geller, M., Haynes, P., Son, S.-W., and Yoden, S., 2017: Report on the International Workshop on Stratosphere-Troposphere Dynamical Coupling in the Tropics 22-24 October 2015, Kyoto, Japan. SPARC Newsletter 48, 17-21.

Geller, M., Chun, H.-Y. and Love, P., 2017: Fine-Scale Atmospheric Processes and Structures. SPARC Newsletter 49, 10-20.

Glanville, A.A. and Birner, T., 2017: Role of vertical and horizontal mixing in the tape recorder signal near the tropical tropopause. *Atmos. Chem. Phys.*, **17**, 4337-4353, doi:10.5194/acp-17-4337-2017.

Hamilton, K., Osprey, S., and Butchart, N., 2015: Modeling the stratosphere's "heartbeat". *EOS*, **96**, doi:10.1029/2015EO032301.

Son, S., Y. Lim, C. Yoo, H.H. Hendon, and J. Kim, 2017: Stratospheric Control of the Madden–Julian Oscillation. *J. Climate,* **30**, 1909–1922, doi:10.1175/JCLI-D-16-0620.1.

The 2017 S-RIP workshop and the 13th SPARC data assimilation workshop

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Dates:
23 - 27 October 2017

Organisers:
Rossana Dragani (ECMWF, UK), Beatriz Monge-Sanz (ECMWF, UK), Quentin Errera (Belgian Institute for Space Aeronomy, Belgium) John McCormack (Naval Research Laboratory, USA), Masatomo Fujiwara (Hokkaido University, Japan), Gloria Manney (NorthWest Research Associates, USA, and New Mexico Institute of Mining and Technology, USA), and Lesley Gray (University of Oxford, UK, and NERC National Centre for Atmospheric Science, UK)

Host Institution:
European Centre for medium Range Weather Forcasts

Number Of Participants: ~35

Sponsors:

Workshop Website:
https://events.oma.be/indico/event/18/overview

Activits Website:
http://www.sparc-climate.org/activities/data-assimilation
http://www.sparc-climate.org/activities/reanalysis-intercomparison

The 2017 SPARC Reanalysis Intercomparison Project (S-RIP) workshop and the 13th SPARC Data Assimilation Working Group (DAWG) workshop were held together at the European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading, United Kingdom on 23-27 October 2017. The first two days were dedicated to discussions related to S-RIP, focusing on progress on the S-RIP Report. The third day was a joint session for S-RIP and DAWG participants, while days four and five consisted of DAWG presentations. Six posters were presented throughout the week. On October 24 and 26, some participants enjoyed a guided tour of the ECMWF's supercomputer system. For more information on DAWG, see **http://www.sparc-climate.org/activities/data-assimilation**. For more information on S-RIP, see **http://www.sparc-climate.org/activities/reanalysis-intercomparison** and Fujiwara *et al.* (2017). The agenda of both meetings and the list of participants can be accessed by following the relevant links at **https://events.oma.be/indico/event/18/.**

S-RIP Workshop

The S-RIP is a coordinated activity to compare reanalysis data sets using a variety of key diagnostics and to write up two SPARC reports, the interim report (covering only Chaps. 1-4, see below for the chapter titles; currently under revision) and the full report (with updated Chaps. 1-4 and Chaps. 5-12; the manuscript to be submitted to the SPARC Office in August 2018). During the two-day workshop, one of the co-leads of each chapter presented an overview and progress report on the chapter, along with scientific talks relevant to the chapter (some S-RIP presentations were also in the joint session and posters). At the end of the workshop, general discussions were held on the contents of Chap. 12 (synthesis summary), on planned activities in 2018 (a possible two-day chapter-lead meeting in June or July, and a side meeting during the General Assembly), and on the future of this project after the full report is published.

Masatomo Fujiwara presented the progress on the project in the past year and update plans for Chap. 1 (Introduction). **Jonathon Wright, Craig Long,** and **Michaela Hegglin** presented the update plans for Chap. 2 (Description of the Reanalysis Systems), Chap. 3 (Climatology and Interannual Variability of Dynamical Variables), and Chap. 4 (Climatology and Interannual Variability of Ozone and Water Vapour), respectively. As a contribution to Chap. 4, **Kris Wargan** presented the approach, validation, and science for ozone in MERRA-2 reanalysis.

Beatriz Monge-Sanz presented the overview of Chap. 5 (Brewer–Dobson Circulation). **Bernard Legras** (on behalf of **Mohamadou Diallo**) discussed effects of natural variability on the Brewer-Dobson circulation and stratospheric water vapour in ERA-Interim and JRA-55 reanalyses, **Marta Abalos** presented an intercomparison of residual circulation diagnostics using four modern reanalyses, and **Simon Chabrillat** presented an intercomparison of mean age of stratospheric air since 1985 using five modern reanalyses. **Ed Gerber** presented both the overview of Chap. 6 (Stratosphere-Troposphere Coupling) and intercomparisons of the annular modes in reanalyses. **Hua Lu** (on behalf of **Andrew Orr**) discussed stratosphere-troposphere coupling associated with the Antarctic ozone hole, the uncertainties in zonal mean circulation, and wave forcing. **Cameron Homeyer** presented the overview of Chap. 7 (Extratropical Upper Troposphere and Lower Stratosphere). The overview of Chap. 8 (Tropical Tropopause Layer, TTL) was given by **Kirsten Krüger**, followed by two contributed presentations to this subject: **Bernard Legras** discussed heating rates and clouds in the TTL in ERA5 (for 2010-2016) versus ERA-Interim reanalyses, and **Matthias Nützel** showed the analyses and intercomparison of Asian summer monsoon characteristics. Chap. 9 (Quasi-Biennial Oscillation (QBO) and Tropical Variability) was presented by **Lesley Gray**, again followed by a presentation given by **Hua Lu**, who discussed the Holton-Tan effect and its mechanisms in modern reanalyses, and **Corwin Wright**, who discussed QBO-driving gravity waves resolved in reanalyses compared to satellite observations. **Michelle Santee** presented both the overview of Chap. 10 (Polar Processes) and observational and model comparisons of polar processing diagnostics in Arctic and Antarctic regions using MLS measurements and a chemical transport model BASCOE driven with five modern reanalyses. Finally, **Lynn Harvey** presented the overview of Chap. 11 (Upper Stratosphere and Lower Mesosphere), and **Toshihiko Hirooka** discussed the climatology and variability of the semiannual oscillation and the related tropical circulation.

Joint Session

The joint S-RIP/DA activities began with updates from four reanalysis centres. **Craig Long** presented an update on activities at NOAA/NCEP. **Kris Wargan** presented an overview of recent activities at NASA/GMAO that included a description of updates to the MERRA-2 system (Gelaro *et al*., 2017) and future plans that included development of a "replay" capability for generation of dynamically self-consistent chemical reanalyses and adoption of all-sky radiance assimilation for rainfall information. **Yayoi Harada** described JMA's upcoming JRA-3Q reanalysis (1947-present, to be released in 2022) with the global spectral model's TL959 dynamical core, an improved convection scheme, and the assimilation of GPS bending angle information in place of refractivity. The reanalysis centre updates concluded with **Rossana Dragani**'s discussion of recent ECMWF activities regarding the production plans for the new ERA5 reanalysis (2010-2016 already released; 1979-2009 will be released in 2018; 1950-1978 in 2019), with improved usage of various observational data including assimilation of 21-level SBUV V8.6 ozone data, and a proof-of-concept coupled ocean/atmosphere/ice reanalysis experiment named CERA-SAT (2008-2016).

The centre updates were followed by science presentations in areas of common interest to S-RIP and DA participants. These began with a presentation on the strength of the diabatic circulation and age of air by **Ed Gerber**, which emphasized the importance of trends in lateral gradients in age-of-air estimates. This was followed by an invited talk by **Peter Hoor** on the emerging OCTUV-UTLS activity and the use of both adiabatic and tracer-based coordinate systems for identifying chemical versus dynamical variability in UTLS composition. **Michaela Hegglin** then gave a presentation on variability and trends in upper tropospheric jets from five different reanalyses, which was followed by a presentation on empirical analysis of the Brewer-Dobson circulation through

Figure 11: *Participants at the 2017 S-RIP workshop and the 13th SPARC data assimilation workshop held together at ECMWF, Reading, UK.*

inversion of the continuity equation by **Thomas von Clarmann**. The session continued with an invited presentation by **Adrian Simmons** that described the ERA5 reanalysis and compared its performance to date with the ERA-Interim data set. This was followed by a presentation on solar cycle signals in atmospheric and oceanic reanalyses by **Stergios Misios**. The final science presentation of the joint session was an intercomparison of tidal and planetary wave signals in upper stratospheric and lower mesospheric reanalyses by **John McCormack**.

The joint S-RIP/DA session concluded with an invited presentation from **Judith Perlwitz** of the SPARC Scientific Steering Group on the future of SPARC and the role of the different activities and working groups in helping to identify strong scientific themes that are relevant to SPARC's mission.

SPARC DAWG Workshop

The Data Assimilation Working Group (DAWG) coordinates and promotes data assimilation research relevant to SPARC. This is done primarily through regularly held workshops that bring together data assimilators, data providers, modellers and users of data assimilation products to summarize the state of the art and identify outstanding issues for the SPARC Scientific Steering Group. This year's DAWG workshop focused on the following themes: (1) Development of new observing systems for the middle atmosphere; (2) Stratospheric data assimilation in support of assessing UTLS trends; (3) New data assimilation techniques and their application to stratospheric observations.

The first day of the DAWG workshop began with a combination of invited and contributed presentations on these themes. **Patrick LaLoyaux** delivered an invited presentation describing new variational bias correction and weak-constrained 4D-Var data assimilation methods to be implemented at ECMWF. Next, **Bruce Ingleby** discussed aspects of stratospheric radiosonde data assimilation that included processing of drift information to improve wind analyses in the lower stratosphere and the question of how to treat resolved gravity waves in sonde profiles. **Quentin Errera** gave a presentation on the BASCOE Reanalysis of MLS (BRAM) and suggested using this type of system to help identify and correct biases between different instrumental records. In his invited talk **Mark Olsen** described reanalysis-constrained model simulations using MERRA2 as a means to quantify cross-tropopause mass fluxes. **Nathaniel Livesey** then gave an invited presentation that began with an overview of current stratospheric limb profiler and nadir sounder instruments, and then discussed possible strategies for the SPARC DA community to pursue in order to help improve future prospects for spaceborne measurements that are needed for continued stratospheric reanalysis.

The remainder of the day was devoted to updates on other SPARC activities relevant to DAWG research themes. The first update was from **Federico Fierli**, who described the objectives and current efforts of the ACAM activity. This was followed by updates from **Andrew Charlton-Perez** on the SNAP activity and **Scott Osprey** on the QBOi activity. **Fuqing Zhang** delivered a report on the gravity wave activity and **Irina Petropavlovskikh** then delivered a summary of the LOTUS activity. The SOLARIS-HEPPA activity update was given by **Bernd Funke**, followed by an update on the Atmospheric Temperature Changes activity from **Amanda Maycock**. The final update was given by **Ed Gerber** describing the DynVar MIP activity, which was followed by a short group discussion that identified areas of common interest between these activities and DAWG that can aid the development of new scientific themes for SPARC.

The second day of the workshop was devoted to extension of DA systems to higher altitudes and the role of reanalyses for whole atmosphere modelling. **John McCormack** described results from observation sensitivity experiments using a high-altitude analysis system extending to the lower thermosphere that highlighted the importance of stratospheric limb sounder measurements for constraining analysed tidal signatures. **Kris Wargan** discussed the extension of the GEOS ozone observing system to include OMPS limp profiler data. **Nick Pedatella** presented recent results of analysis and forecast experiments describing the chemical and dynamical variability of the stratosphere and mesosphere during the 2009 sudden stratospheric warming. The session concluded with **Valery Yudin**'s discussion of tidal dynamics in whole atmosphere models that use specified meteorology from reanalysis data sets.

The DAWG workshop ended with a general discussion among the participants to help determine future directions for the group. From these discussions, three potential themes were identified: (1) Activities supporting the development of a new satellite limb sounder mission for the stratosphere and mesosphere; (2) Constituent assimilation and chemical reanalysis inter-comparisons; (3) The role of "high top" reanalyses for whole atmosphere modelling via model initialization, model validation, and specified dynamics (i.e., nudging). The possibility of a DAWG side meeting during the SPARC General Assembly in Kyoto next year was also discussed. Preparation of a SPARC newsletter article describing future plans for DAWG is planned for early 2018.

Acknowledgments

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References:

Fujiwara, M., *et al.,* 2017: Introduction to the SPARC Reanalysis Intercomparison Project (S-RIP) and overview of the reanalysis systems. *Atmos. Chem. Phys.*, **17**, 1417-1452, doi:10.5194/acp-17-1417-2017.

Gelaro, R., *et al.*, 2017: The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2). *J. Climate,* **30**, 5419–5454, doi:10.1175/JCLI-D-16-0758.1.

SPARC Office: move from Zurich to Oberpfaffenhofen

SPARC science relies on voluntary cooperation on a global scale. In this respect, the SPARC Office has been providing an organizational and scientific backbone for no less than a quarter of a century (see article on page 30, this issue). During the years 2012 to 2017 colleagues from the Institute for Atmospheric and Climate Science of ETH Zurich acted most efficiently at the interface of science and management on behalf of the World Climate Research Programme.

After a six-monthly transition period, the Institut für Physik der Atmosphäre of DLR in Oberpfaffenhofen (**www.dlr.de/pa/en**) is now acting as the fourth host-institution for the SPARC Office (**www.sparc-climate.org/about/SPARC Office**). We will try hard to keep the high standard set by **Johannes Staehelin**, **Fiona Tummon**, **Carolin Arndt** and **Petra Bratfisch.** And we are looking forward to interacting with many members of the broad SPARC community.

Hans Volkert, Mareike Kenntner, and Brigitte Ziegele

SPARC celebrates 25 years and the move of its International Project Office

Fiona Tummon[1,2], Carolin Arndt[1], Petra Bratfisch[1], Thomas Peter[1], and Johannes Staehelin[1]

[1]ETH Zurich, Switzerland, [2]now at the University of Tromsø, Norway (**fiona.s.tummon@uit.no**).

Date:
1 December 2017

Organisers:
Thomas Peter (ETH Zurich), Johannes Staehlin (ETH Zurich), Carolin Arndt (SPARC Office, ETH Zurich), Fiona Tummon (SPARC Office, ETH Zurich; now University of Tromsø), Petra Bratfisch (SPARC Office, ETH Zurich)

Host Institution:
ETH Zürich

Number Of Participants: ~60

Sponsors:

ETH zürich

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Office for the Environment FOEN

WCRP
World Climate Research Programme

Website:
http://www.sparc-climate.org/meetings/25-years-of-international-sparc-research/

Founded in 1992 largely in response to concerns about the consequences of stratospheric ozone depletion, the World Climate Research Programme's core project SPARC has evolved into a major international hub for facilitating atmospheric science. Over the years, SPARC's focus has expanded to go well beyond just the stratosphere to look at the troposphere-stratosphere system and impacts closer to the surface. The primary goal, however, has remained the same: to facilitate cutting-edge research to improve our understanding and prediction of atmospheric processes. Counting over 3000 researchers from around the world, over the past 25 years the SPARC community has become an internationally-recognised and lively scientific community. Over the past two and a half decades, eight comprehensive SPARC Science Reports as well as numerous well-cited scientific papers and newsletters have been published. SPARC's renowned expertise in data handling and modelling have contributed significantly to international assessments, such as the WMO/UNEP assessments of ozone depletion and the IPCC climate assessments.

A celebration was held on the afternoon of 1 December to recognise SPARCs 25th anniversary and the move of the SPARC Office, after six years in Zurich, to the German Aerospace Centre (DLR) in Oberpfaffenhofen. Located in the historical Semper Aula at the ETH Zurich, the event attracted just over 60 participants from the SPARC community in the region. After a warm welcome from **Thomas Peter**, previous SPARC co-chair, representatives from all of the Zurich SPARC Office's sponsors gave brief presentations. Understanding climate change and dealing with its impacts is a major focus of all the sponsors and thus supporting the SPARC Office was directly in line with the core priorities of the ETH Zurich (**Detlef Günther**), the World Climate Research Programme (**Deon Terblanche**), as well as the Swiss Federal Offices for the Environment (**José Romero**) and Meteorology and Climatology, Meteoswiss (**Bertrand Calpini**).

This was followed up by a look into the past, with **Thomas Peter** and **Johannes Staehelin** providing an overview of SPARCs achievements over the past 25 years. Stefan Reimann then highlighted the significant contribution of SPARC science to the WMO/UNEP Ozone assessments, all the way from the very first report (with yellow cover) to the upcoming 2018 report (with unknown cover colour!). Several SPARC activities have produced results that underpin these assessments, providing policy-

***Figure 12**: Impressions from the 25 years celebration: Neil Harris, SPARC Co-Chair, Cranfield University, UK - Lamont Poole, NASA Langley Research Center - Stefan Reimann, Empa, ETH Zurich - Guests listening to Thomas Stocker, University of Berne - Thomas Peter, former SPARC Co-chair, ETH Zurich, and Fiona Tummon, former SPARC Office director, now at the University of Tromso - Deon Terblanche, WMO - Group photograph of former and future SPARC Office staff with supporters and sponsors. These and more photos can be found at: www.sparc-climate.org/meetings/25-years-of-international-sparc-research/.*

relevant information to decision-makers around the globe. These include various incarnations of the stratospheric ozone trends activity, the temperature trends activity, CCMVal-1 and -2, the ozone-depleting lifetimes activity, and the carbon tetrachloride activity. Thereafter **Thomas Stocker** focused on the variety of ways in which SPARC-related research has fed into the IPCC reports. He emphasised the improvements to our understanding of natural climate forcers such as volcanic eruptions and solar radiation, as well as several SPARC activities which have helped reduce uncertainty related to stratospheric temperatures as well as various greenhouse gases such as water vapour. SPARC will continue to contribute both directly and indirectly to the upcoming IPCC assessment, through the various activities related to the coupled model intercomparison project (CMIP-6) and through fundamental research improving our understanding of the climate system, respectively.

The final session of the afternoon focused on the future. **Neil Harris**, current SPARC co-chair, gave a brief overview of current SPARC activities and then emphasised where SPARC could build on traditional strengths, including its international community and agenda-setting science, to continue effectively in the coming years. Two up-and-coming SPARC scientists detailed some fascinating new results related to evidence for continued decreases in lower stratospheric ozone (**William Ball**) and changing transport pathways through the stratosphere (**Hella Garny**). **Markus Rapp**, director of the Institute for Atmospheric Physics at the DLR in Oberpfaffenhofen, then introduced the new home for the SPARC Office as well as the new team: *Hans Volkert* (director), *Mareike Kenntner* (project scientist), *Brigitte Ziegele* (office manager), and *Winfried Beer* (IT). A surprise sing-along to a 1989 song about polar stratospheric clouds written and performed by **Lamont Poole** brought the afternoon presentations to a wonderful end. The event was rounded off by an excellent Apéro and time for new and old friends to continue the celebrations for a little while longer.

SPARC's success would never have been possible without the long-term commitment and support of the World Climate Research Programme and WMO, as well as the numerous SPARC Office hosts and sponsors, including the most recent SPARC Office sponsors in Switzerland: ETH Zurich, the Federal Office of Meteorology and Climatology (MeteoSwiss) and the Swiss Federal Office for the Environment. We warmly thank these sponsors for their very generous support over the past years! We wish the new SPARC Office every success in its new home at the DLR in Oberpfaffenhofen!

SPARC meetings

5 - 8 February 2018
The UTLS: Current status and emerging challenges
Mainz, Germany

23 - 24 April 2018
SOLARIS-HEPPA working group meeting
Karlsruhe, Germany

14 - 18 May 2018
SSiRC Steering Group meeting

11 - 15 June 2018
7th HEPPA-SOLARIS Workshop
Roanoke, Virginia, USA

June 2018
OCTAV-UTLS workshop
Mainz, Germany

27 - 28 June 2018
ATC workshop
Paris, France

1 - 5 October 2018
6th SPARC General Assembly
Kyoto, Japan
www-mete.kugi.kyoto-u.ac.jp/SPARC_GA2018/index.html

7 - 9 October 2018
SPARC Scientific Steering Group meeting
Kyoto, Japan

SPARC related meetings

5 – 9 February 2018
AMOS-ICSHMO 2018
Sydney, Australia

18 - 23 March 2018
AGU Chapman Conference on Stratospheric Aerosol in the Post-Pinatubo Era: Processes, Interactions, and Importance
Puerto de la Cruz, Santa Cruz de Tenerife, Spain

6 - 11 May 2018
GEWEX Science Conference
Canmore, Alberta, Canada

14 - 22 July 2018
42nd COSPAR Scientific Assembly and Associated Events: "COSPAR 2018"
Pasadena, CA, USA

25 - 29 September 2018
Joint 14th Quadrennial iCACGP Symposium/15th IGAC Science Conference 2018
Takamatsu, Japan

Find more meetings at: www.sparc-climate.org/meetings

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