SPARC
Stratosphere-troposphere
Processes And their Role in Climate

Newsletter n° 52
January 2019

www.sparc-climate.org

Typhoon Trami photographed from the International Space Station. It caused a full stop on air traffic and train connections on the Sunday before the opening of the 6th SPARC General Assembly in Kyoto, Japan, which was attended by well over 350 scientists from all over the world and offered the opportunity to take stock of what has been achieved, where gaps in the portfolio of research undertaken by SPARC need to be filled, and to define where SPARC needs to be moving to remain responsive to the needs of both its members and the users of SPARC research products. Also, a number of side-meetings of various SPARC activities took place (see reports in this newsletter).

Photo credit: © ESA/A.Gerst, CC BY-SA 3.0 IGO

Contents

25th SPARC Scientific Steering Committee meeting 2

Personal reflections on the outlook for SPARC..... 7

Report on the 6th SPARC General Assembly, Kyoto, Japan 8

Impressions from the SPARC General Assembly..... 14

Report on the 7th HEPPA-SOLARIS Workshop.... 16

S-RIP activities in 2018 19

Report on the 2nd Atmospheric Temperature Changes and their Drivers (ATC) Activity Workshop 21

Report on the SATIO-TCS side meeting and related discussions at the 6th SPARC General Assembly 2018 24

Opportunities for Early Career Scientists..... 27

SPARC and SPARC-related meetings..... 28

WCRP World Climate Research Programme
WORLD METEOROLOGICAL ORGANIZATION
UNESCO United Nations Educational, Scientific and Cultural Organization
Intergovernmental Oceanographic Commission
International Science Council

25th SPARC Scientific Steering Committee meeting

Hans Volkert[1] , Neil Harris[2], and Judith Perlwitz[3]

[1]SPARC Office, Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany, (**Hans.Volkert@dlr.de**), [2] Centre for Environmental and Agricultural Informatics, Cranfield University, UK, [3] Physical Sciences Division, NOAA Earth System Research Laboratory, Boulder, CO, USA.

The 26th SPARC Scientific Steering Group (SSG) meeting took place at International Community House in Kyoto, Japan, from 6 to 8 October 2018, organised by the Japanese SSG member, Kaoru Sato (Tokyo university) with significant assistance by Shigeo Yoden and Masato Shiotani (both from Kyoto university). It immediately followed the 6th SPARC General Assembly (see separate report on page 8). Neil Harris guided through the agenda and Judith Perlwitz joined via a live weblink from Boulder.

WCRP update

The SSG received a brief update on the overall coordination of the World Climate Research Programme (**Boram Lee**). The WCRP Joint Scientific Committee (JSC) has been developing a new Strategic Plan (SP) 2019-2028, taking into account the review of WCRP Co-sponsors that took place in 2017. Further input from the WCRP core projects, *e.g.* SPARC, the Grand Challenges and various Working Groups will be sought to develop the Implementation Plan for the SP. Besides the regular reporting on the work of the JSC (including the results of the 39th JSC session in Nanjing, China, in April 2018) and other WCRP groups, the new WCRP Coordination Office for Regional Activities (CORA) was newly launched, with the purpose of assisting in integration and synergising of regional activities within WCRP.

The SSG noted ongoing changes in the international framework of WCRP and its co-sponsors; a major rotation of the JSC membership at the end of 2018 including the current chairperson, Guy Brasseur (**www.wcrp-climate.org/about-wcrp/about-governance**), a new arrangement of the JPS leadership by the new WMO Chief Scientist / Research Director Pavel Kabat in his capacity of overseeing all the WMO research programmes (GAW, WWRP and WCRP), and the merger and creation of the International Science Council (ISC) from the former ICSU.

The subsequent discussion centred on the future contribution and role of the WCRP core projects, like SPARC, within the broader WCRP and WMO context. The necessity of maintaining and growing a strong research community was strongly emphasised by the SSG members, in order to ensure continuous science development, to provide a trusted route for the voluntary engagement of scientists, and to integrate and engage Early Career Scientists for future science leadership. There was considerable frustration with the speed at which the plans were being developed and with the wide number of options still being discussed. This frustration was heightened by the publication of the IPCC Special Report on Global Warming of 1.5°C with its call for an urgent response during the SSG meeting.

In the light of the uncertainty, the SSG agreed that SPARC needs to maintain its focus to address key scientific questions that will contribute to the short- and long-term science goals, especially for challenges that are really 'grand'. In parallel, it would contribute fully to the discussions about the future structure of WMO and WCRP, and would stress the need for continuity and the need to evolve gradually in order to keep the international research community engaged. The importance of the SPARC International Project Office is again underlined, with acknowledgement to the host (DLR, Oberpfaffenhofen, Germany), as the key infrastructure to support the research community for atmospheric dynamics and chemistry.

SPARC activity reports

Each year the SSG review the progress in SPARC's activities and assess which are progressing well, which need revitalising and which are coming to their natural conclusion. Due to it being held in conjunction with the General Assembly, the meeting was shorter than usual as many results had already been presented.

The Long-term Ozone Trend and Uncertainties in the Stratosphere (LOTUS) activity successfully contributed to the 2018 WMO/UNEP ozone assessment (**Sophie Godin-Beekmann**, **Irina Petropavlovskikh**). An extended LOTUS-report was accepted in July by its review board and is being published as SPARC-report no. 9, a joint effort sponsored by

SPARC, the International Ozone Commission (IO_3C) of the International Association of Meteorology and Atmospheric Sciences (IAMAS), and WMO's Global Atmospheric Watch (GAW). Sample results were presented, among them multiple regression trend analyses involving eight combined records derived from satellite data and model data from simulations undertaken within the chemistry-climate model initiative (CCMi). In the upper stratosphere ozone is found to increase again ("recovery"), while in the lower stratosphere variability, uncertainty and discrepancies between observation and simulation can be considerable.

The second Water Vapour Assessment activity (WAVAS-II) presented an overview of relevant satellite retrievals since 1985, augmented by balloon measurements in the lower stratosphere and surface-based moisture observations at upper stratospheric and mesospheric levels (**Kaley Walker**). The "golden age" decade after 2000 witnessed a maximum of simultaneous humidity measurements from space platforms. Reference was made to Walker's presentation at the General Assembly and a special journal issue (*cf.* **www.atmos-chem-phys.net/special_issue830.html**).

The Atmospheric Composition and Asian Monsoon (ACAM) activity, a joint effort with the International Global Atmospheric Chemistry (IGAC) project, announced a change in leadership: **Hans Schlager** and Mian Chin taking over from Laura Pan and James Crawford. During the past years the scientific community for Asian Monsoon studies was strengthened, in particular through annual meetings with numerous early career scientists from the Asian countries. For 2019, a combined international workshop and training school is scheduled in Kuala Lumpur, Malaysia. New and existing aircraft and balloon data will continue to be scrutinised with regard to aerosols, acids and nitric acid trihydrate (NAT). Data analyses and modelling studies concentrate on the topics "aerosol-monsoon interactions", "impacts on PBL processes", and "impacts on UTLS processes".

For the Polar Stratospheric Clouds initiative (PSCi) **Michael Pitts** presented a seven-section-outline of a broad review entitled "Recent advances in our understanding of PSCs" to be submitted to Reviews of Geophysics. Daily reference data sets were highlighted from the MIPAS (*cf.* **https://datapub.fz-juelich.de/slcs/mipas/psc/**) and CALIPSO (**https://eosweb.larc.nasa.gov/project/calipso/calipso_table**) instruments that are publicly available. As in the past, PSCi receives core support from the NASA CALIPSO/Cloudsat science team in the US and German funding agencies DFG and HGF.

The Data Assimilation Working Group (DAWG; **Quentin Errera**) proposed its new four-themed structure, to be active during the next quadrennium: 1) limb sounding observations in support of SPARC; 2) chemical re-analyses; 3) data assimilation for upper stratosphere and mesosphere; and 4) new data assimilation techniques in the stratosphere. Interested institutions and persons were identified. The envisaged overview publications should pave to way to a "next generation" S-RIP exercise.

As ACAM, the Chemistry-Climate Modelling Initiative (CCMi; **Michaela Hegglin, David Plummer**) is jointly undertaken with IGAC. With the first phase of CCMi winding down, a new mission statement defines the activity as the international forum for coordinated inter-model chemistry-climate comparisons. A timeline was presented including a science workshop in 2019 (Hongkong) and the next assessment reports for IPCC in 2021 and for ozone in 2022.

The activity dealing with the Dynamical Variability of the atmosphere (DynVar; **Edwin Gerber**) is redefining its research foci and leadership. During the past eleven years it has been instrumental in sparking off specific activities like SNAP and QBOi as well as the diagnostic model intercomparison project DynVarMIP, comprising output from 13 modelling centres as part of CMIP6. A four-day international workshop is scheduled for October 2019 in Madrid, Spain (**www.sparcdynvar.org/dynvar-workshop**) in order to take stock and develop the new directions.

In its second phase, the Network for Atmospheric Predictability (SNAP; **Amy Butler**) continued the cooperation with the joint WCRP/WWRP's Subseasonal to Seasonal prediction project (S2S). The recently created S2S database is used to determine the role of the stratosphere for the climate predictability near the surface. Currently the SNAP team involves 16 institutions in eight countries.

For the Fine Scale Atmospheric Processes and Structures (FISAPS) activity, the SPARC co-founding chair **Marvin Geller** (via remote link) officially announced a change in leadership, with Thomas Birner (now Univ. Munich, Germany) co-chairing together with Hye-Yeaong Chun (Yonsei Univ., Korea).

A three-day workshop was scheduled for early November 2018 in Kühlungsborn, Germany with stratospheric turbulence as a special focus (**https://www.iap-kborn.de/en/current-issues/events/fisaps2018**).

Ongoing work of the Gravity Waves activity was presented by **Kaoru Sato** (local co-chair for the General Assembly). She introduced three new directions, 1) high latitude and global observations by radar, 2) estimation of the gravity wave contribution to the Brewer-Dobson-circulation using reanalysis data, and somewhat related 3) inferring the gravity wave drag though data assimilation methods. All approaches were underpinned with sample results and publications. For direction 3) the International Space Science Institute (ISSI) is to support an international, 5-day workshop in April 2019 in Berne, Switzerland. A gravity wave symposium is being planned for 2021 in Germany.

The Quasi-Biennial Oscillation initiative (QBOi; **Scott Osprey**) completed its first phase, during which 12 modelling centres contributed coordinated simulation output from 17 different models to a common data archive. The technical description was published and results regarding topics as QBO in present-day climate versus future scenarios with two- and four-fold CO_2 content, equatorial waves and teleconnections are scheduled for submission to a special collection in the Quarterly Journal of the Roy. Met. Soc.

The SPARC Reanalysis Intercomparison Project (S-RIP; **Masatomo Fujiwara**) is preparing the 2019 publication of a complete SPARC report as final outcome of five years of coordinated work. The S-RIP inter-journal special issue in Atmospheric Chemistry and Physics / Earth System Science Data (ESSD; **www.atmos-chem-phys.net/special_issue829.html**) contains 24 articles in Oct. 2018, with 5 more anticipated. It includes the 4 chapters constituting the interim report (see also report on page 19).

Atmospheric Temperature Changes (ATC; **Andrea Steiner**) held its second workshop during two days by the end of June in Paris, France (*cf.* report on page 21). Updated findings of the activity on stratospheric temperature trends appeared as a frontier article in Geophysical Research Letters (doi: 10.1029/2018GL078035). For 2019 a review article is planned addressing the challenge of keeping the average global temperature increase below 1.5 or 2 K, as formulated in 2015 at COP-21 in Paris.

In 2018, the Stratospheric Sulfur and its Role in Climate activity (SSiRC; **Jean-Paul Vernier**) organised a 6-day international conference on stratospheric aerosol in the post-Pinatubo era on Tenerife island, Spain for 90 participants from more than 10 countries. Afterwards the steering group met at ISSI in Berne and identified science links to the majority of the other SPARC activities and related experimental campaigns.

The Solar Influences on climate / High Energy Particle Precipitation in the Atmosphere) activity (SOLARIS-HEPPA; **Bernd Funke**, via remote link) structures its work in five working groups (WG), with coordinated CCMI analyses as a common aim. The WG-leads had a meeting in April in Karlsruhe, Germany. A science workshop took place in Roanoke, USA (see report on page 16). Strong links to activities SSiRC, LOTUS and ATC were stressed.

Emerging activities

The emerging activity Stratospheric And Tropospheric Influences On Tropical Convective Systems (SATIO-TCS; **Shigeo Yoden**, local co-chair for General Assembly) focusses on the tropics as geographical region and moist convection as chief physical mechanism for time-scale of a day or shorter. Reference was made to a broad presentation at the General Assembly stressing links to QBOi and FISAPS which were further built during a common workshop in 2017 and a side meeting during the GA (see report on page 24). A review article about the stratosphere-troposphere coupling in the tropics is about to be submitted.

Observed Composition Trends And Variability in the Upper Troposphere and Lower Stratosphere (OCTAV-UTLS; **Peter Hoor** and **Irina Petropavlovskikh**) aims to disentangle the chemical and dynamical influences on composition trends in the UTLS. Science questions are formulated taking into account a comprehensive suite of datasets from different platforms and applying standardised metrics. A workshop was scheduled for early November 2018 in Mainz, Germany.

Towards Unified Error Reporting (TUNER; **Nathaniel Livesey**) is the third emerging activity. Following a successful application, the TUNER team held a first four-day workshop at ISSI in December 2017. For TUNER publications, a special issue was set-up with the journal Atmospheric Measurement Techniques (**https://www.atmos-meas-tech.net/special_issue921.html**)

Figure 1: *Around a long table: SSG members, activity leads and guests listening to Makato Suzukis's presentation.*

with so far three accepted articles. The next workshop in Berne is scheduled for April 2019.

Given the progress made in these emerging activities, the SSG declared in its final session that all three are fully emerged and from now on are ordinary SPARC activities. The short-lived climate forcers (SLCFs) activity will be resumed as emerging activity after the completion of the model runs for the current CMIP phase.

Partner Projects

Michel Gutter, member of the IGAC scientific steering group, explained the IGAC perspective of the links of this Future Earth project to SPARC, mainly through activities ACAM and CCMi, and reported on the joint 14th iCACGP / 15th IGAC conference (**http://icacgp-igac2018.org/**), which had taken place in Takamatsu, Japan during the week prior to the SPARC General Assembly. Some 700 participants, including numerous early career scientists, from the worldwide atmospheric chemistry community with a focus in air quality and dispersion at tropospheric levels discussed latest research results and celebrated 60 years of the international Commission of Atmospheric Chemistry and Global Pollution (iCACGP within IAMAS).

Oksana Tarasova (remote) gave a presentation on the activities in GAW and their interaction with SPARC. Neil Harris then updated the SSG on the state of on-going discussion between SPARC, GAW and IGAC about stronger collaboration on a few focussed topics. Progress is being slowed down by the lack of clarity about how WMO wants to restructure its research programmes. There is clear value in working closer together if conditions allow. A workshop on this topic was held at WMO in early November 2018.

Proposed joint activities of the CLIVAR/GEWEX monsoon panel and SPARC envisage different areas of common interest and expertise (**Tianjou Zhou**). Teleconnection pathways towards monsoon dynamics were found to take in parts stratospheric routes, especially from the North-Atlantic sector and polar regions; monsoon circulations tend to actively modulate conditions over the Pacific region, where El Niño anomalies originate; monsoon variability tends to control the transport of trace gases and aerosols into the stratosphere. Regarding decadal climate predictions the role of volcanic aerosols should be better quantified and their dynamical impacts investigated, as it is proposed for the numerical experiments under the heading VolMIP in CMIP6.

The SSG welcomed this initiative and agreed to set up a task force to identify how SPARC could best contribute. Additionally, the Chinese initiative "Third Pole Environment" (TPE), aiming inter alia at improved observations from the Himalayas, could be involved.

Space observations

Due to the compact nature of SSG-26, the regular space observation section only featured two Japanese presentations. **Makoto Suzuki** (Japanese Aerospace Exploration Agency [JAXA], Earth Observation Research Center) gave an update about the broad meteorological satellite programme undertaken in Japan and its definite plans until 2021. The "global change observation mission – water" spacecraft (GCOM-W or Shizuku, launched in 2012) is still in operation, while the follow-on satellite for "mission – climate" (GCOM-C or Shikisai) was successfully launched in 2017. Sample results of both low orbit systems were presented. The new generation Himawari-8 (launched 2014) and -9 (launched 2016) missions in geostationary orbits provide a large number of products, which can be accessed via a web-interface at **www.eorc.jaxa.jp/ptree**, including aerosol information and wildfire detection outside the scope of the standard observations for numerical weather forecasting.

Masato Shiotani, who also had acted as a local co-chair for the 6th General Assembly, described the ambitious plan of a revised superconducting submillimetre-wave limb-emission sounder (SMILES-2) after the 9-month exploratory SMILES mission, which ended in April 2010 and had provided inter alia ozone distributions in the 28 km-level. The new plan encompasses a proof of technology, but also targets at daily variations in stratospheric ozone in the 20-to-60-km-range.

Other SPARC news

Since January 2018, the SPARC office has been working at and staffed by the Institut für Physik der Atmosphäre (IPA) situated at the Oberpfaffenhofen campus of Deutsches Zentrum für Luft- und Raumfahrt (DLR; **Hans Volkert**) near Munich in southern Germany. Contributions to the planning and preparation of the 6th General Assembly and the following SSG-meeting were made in close cooperation with the LOC in Japan. Support for several SPARC workshops was organised and the administration of financial assistance gradually taken over from WCRP (as formally arranged in a Letter of Agreement). The coordinating scientist, Mareike Kenntner, received a symbolic token of gratitude for her sustained efforts during the past year.

SSG-member Olivia Martius (retiring from the group at the end of 2018) was thanked for her dedication during the past three years and for her help in linking SPARC to research on atmospheric predictability, not least through her role as co-lead of the WCRP Grand Challenge on Extremes. The next call for membership from 2020 onwards is scheduled to appear in late summer 2019.

Four locations for the 27th SSG-meeting are being considered: Pune, India; Melbourne, Australia; Boulder, USA; and Madrid, Spain. A final decision will be made early in 2019.

Discussion on: The future of SPARC

Don't just read about it - contribute!

What do you (not) like about the current SPARC?
How could we improve SPARC? What do you miss?
What are your ideas / your vision for the future of SPARC?

→ ***What is 'THE BIG QUESTION' (climate) science needs to answer?***
→ ***Why is SPARC the right project to help answering this question?***
→ ***What could SPARC do to help?***

We value all input - especially from those who truly are the future of SPARC:
Early career scientists, this is your chance to have a say!

Send your thoughts to: **office@sparc-climate.org**

Personal reflections on the outlook for SPARC

The recent SPARC General Assembly in Kyoto was stimulating in many ways. Most notable were the number of attendees, the quality and enthusiasm of the presentations and discussions, and the keen interest in SPARC's future and its role in climate science. The fundamental health and vitality of the truly international SPARC community was apparent to all.

The final weekend of the General Assembly coincided with the release of the IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels. The IPCC findings made clear the urgency of starting to reduce the emissions of all greenhouse gases as well as the need for accurate climate information to support strategies for adaptation and mitigation. This report was followed by the UN's COP-24 conference which amid much political posturing did agree the rules for implementation of the Paris Agreement. Based on the experience with the Montreal Protocol, agreeing these rules is a real step forward, which coupled with the periodic revision of the targets, gives hope that the Agreement might succeed. There is a long, long way to go before we know if that is the case.

The new WCRP Strategic Plan is a great opportunity to make a real contribution to achieving that. The implementation of the plan is now under discussion, and it is still far from clear whether that will involve a complete make-over of WCRP or whether WCRP can evolve to meet the new challenges. Our strongly held view is that WCRP must be allowed to evolve, as a root and branch reform aimed at producing a theoretically logical structure could set back scientific progress in WCRP by several years and leave it side-lined in the public climate debate.

An evolutionary approach would allow the communities in the core projects, grand challenges and other facets of WCRP to use their expertise to work out how best to implement the new, more integrated strategy. An increase in the number of collaborative activities building on existing strengths and developing new ones is essential, and our discussions indicate that there is a general willingness to make this happen. Maintaining core strengths is also required.

Atmospheric sciences should be a vital component of this approach as they are required to improve predictability, to understand changes in composition, and to understand the decadal changes in past climate. We thus envision a period where SPARC scientists are actively involved in WCRP-led collaborative programmes that address key climate questions (e.g. a holistic understanding of convection). In parallel, a number of activities of similar size and ambition to our current ones would be maintained. SPARC would continue to support the Montreal Protocol process and help WCRP make the Paris Agreement as successful. In this way SPARC and WCRP more broadly could continue to contribute most effectively to the on-going climate debate.

Early career scientists should contribute fully to this debate and to influencing the future role of SPARC and WCRP more broadly. Their generation will be implementing the Paris Agreement and so they will need to monitor the success or otherwise of the measures taken. The earlier the young scientists take responsibility, the better. We urge them to participate in SPARC activities and to take leadership of the ECS forum we are developing.

Neil Harris and Judith Perlwitz (SPARC co-chairs)

Report on the 6th SPARC General Assembly, Kyoto, Japan

Harry H. Hendon[1], Amanda C. Maycock[2], and the members of the Scientific Steering Committee

[1]Australia Bureau of Meteorology, Australia, (**harry.hendon@bom.gov.au**) [2]University of Leeds, UK, (**a.c.maycock@leeds.ac.uk**)

The 6th SPARC General Assembly (GA) was held 30 September - 5 October 2018 in the historically important and culturally rich city of Kyoto, Japan. The GA was held combined with a joint Belmont Forum/JPI-Climate meeting (Joint Programming Initiative "Connecting Climate Knowledge for Europe") and was back-to-back with the Joint 14th iCACGP Quadrennial Symposium/15th IGAC Science Conference, which took place in Takamatsu, Kagawa, Japan during the previous week. SPARC General Assemblies are opportunities to take stock of and celebrate what has been achieved in the SPARC project, to identify where gaps in the portfolio of research supported by SPARC need to be filled, and to define where SPARC needs to be moving to remain responsive to the needs of both its members and the users of SPARC research products.

The year-long organization of the GA was thrown into last minute turmoil due to back-to-back landfalling typhoons in Japan during September 2018. Typhoon Jebi, which was the strongest typhoon to strike Japan in the past 25 years, struck Osaka and Kyoto on 4 September, causing loss of life and widespread damage to property and infrastructure including the Kansai international airport. Remarkably, the airport and train systems were brought back to normal in under 2 weeks, but then Typhoon Trami passed just to the south of Kyoto on the eve of the GA. This was the closest many of us had ever been to the eye of a tropical cyclone. Although the damage in Kyoto was much less than caused by Jebi, effectively all international and interstate transportation was cancelled on the Sunday before the opening ceremony causing significant travel disruption for many participants. The LOC and SOC decided to adapt the programme to accommodate the disruption, including rescheduling the traditional taiko drumming troupe that provided a spectacular opening to the GA on Monday afternoon.

The conference was attended by 382 participants from 31 countries, 120 of them registered as Early Career Scientists. As for previous GAs, the main presentation format was poster sessions complimented by a small number of oral presentations in plenary. Over 400 posters were presented during the week.

Figure 2: *Traditional drummers open the General Assembly with thunder.*

Dates:
30 September - 5 October 2018

Scientific Organising Committee:
Harry H. Hendon (co-chair; Australia Bureau of Meteorology, Australia), Amanda C. Maycock (co-chair; University of Leeds, UK), Masatomo Fujiwara (Hokkaido University, Japan), Johann Muller (Agence Nationale de la Recherche, France), Laura Pan (National Center for Atmospheric Research, USA), Olivia Romppainnen-Martius (University of Bern, Switzerland), Seok-Woo Son (Seoul National University, Rep. of Korea), Don Wuebbles (University of Illinois, USA), Paul Young (Lancaster University, UK), Tianjun Zhou (Chinese Academy of Sciences, China)

Local Organising Committe co-chairs:
Kaoru Sato, University of Tokyo
Masato Shiotani, Kyoto University
Shigeo Yoden, Kyoto University

Meeting venue:
Miyakomesse in Okazaki, Kyoto, Japan

Number Of Participants: **382**

Co-organisers:

SPARC Stratosphere-troposphere Processes And their Role in Climate
WCRP World Climate Research Programme
Meteorological Society of Japan 日本気象学会 1882創立
SGEPSS Society of Geomagnetism and Earth, Planetary and Space Sciences
Japan Geoscience Union

Sponsors:

(Inoue Foundation)

(Kyoto University Foundation)

(Kyoto Convention & Visitors Bureau)

Local Supporters:

Integrated Earth & Planetary Science Hub, Kyoto University

Website:

www-mete.kugi.kyoto-u.ac.jp/SPARC_GA2018/

Posters were displayed in two sessions each spanning 2.5 days with three science themes covered in each session (see below). Each session was comprised of six blocks with each colour coded poster being 'active' in its respective block. This new approach to the poster scheduling meant that a spread of posters from different themes were active at any one time, so presenters had a chance to see posters from their themes in the other blocks. The poster sessions were garnished by refreshments and local sweets kindly arranged by the LOC.

The GA scientific program was built around six themes that reflected both long-standing and emerging areas of SPARC science:

1. Connections of Atmospheric Composition and Chemistry to Weather and Climate
2. Climate Prediction from Weeks to Decades
3. Role of Atmospheric Dynamics for Climate Variability and Change
4. Atmospheric Impacts and Interactions Related to Tropical Processes
5. Advances in Observation and Reanalysis Datasets
6. SPARC Science for Society

The following sections summarise some of the science highlights from each session, but this only scratches at the surface of the excellent and diverse range of science that was presented during the week.

Connections of Atmospheric Composition and Chemistry to Weather and Climate

The theme had three keynote presentations, six additional oral presentations, and 113 poster presentations covering topics including: aerosol observations and analysis, volcanic emissions and analysis, stratospheric ozone, dynamics and long range transport of pollutants, trace gas observations and analysis, the Asian summer monsoon, the upper troposphere and lower stratosphere (UTLS), and climate analyses. The theme provided a bridge to the Joint 14th iCACGP Quadrennial Symposium/15th IGAC Science Conference held during the previous week.

The oral presentations highlighted new understanding of the role of ozone depletion substances (ODSs) in driving the Brewer Dobson circulation (BDC) through two different chemical and radiative pathways. In a model study, the ODS warming impact on sea surface temperatures was found to dominate the global annual mean BDC response, while the ozone hole impact was larger but regionally and seasonally confined (**Marta Abalos**, keynote). The BDC is important for stratospheric ozone variability and trends; other presentations in the theme discussed the challenges and recent progress in characterising past ozone trends in midlatitudes (**Leonie Bernet**) and the tropical lower stratosphere (**William Ball**).

Another key topic in the theme related to the Asian summer monsoon (ASM) and its role in transporting Asian pollutants into the upper troposphere and lower stratosphere, leading to enhanced aerosol formation that is important for radiative forcing of climate. The first airborne measurements were described of SO_2, H_2SO_4, NO, HNO_3, and NO_y in the ASM Anticyclone between 12 km and 20 km based on observations during the StratoClim campaign with the Geophysica aircraft in Kathmandu, Nepal, in July/August 2017 (**Hans Schlager**, keynote). The importance of the ASM for transport of bromoform emissions from the ocean into the stratosphere was also highlighted (**Alina Fiehn**). The difficulty of capturing large-scale tropospheric transport in models was demonstrated in simulations from the Chemistry Climate Model Initiative (CCMI), which leads to poor constraints on modeled distributions of key tropospheric species (**Clara Orbe**, keynote).

Another topic in the theme addressed modeling the response of the climate system to external forcing, including: the effect of volcanic eruptions on the hydrological cycle (**Seungmok Paik**), the role of the ozone layer in the response to natural (solar) and anthropogenic (CO_2) forcings (**Gabriel Chiodo**) and the reduction in the global land monsoon precipitation due to increasing anthropogenic aerosols (**Tianjun Zhou**).

Climate prediction from weeks to decades

The presentations in the theme covered the possible mechanisms and sources of climate predictability on a range of time scales from subseasonal and seasonal to decadal and centennial scales. There were two keynote presentations, six contributed oral presentations and nearly 40 poster presentations.

An emerging area that was highlighted in the theme was subseasonal-to-seasonal (S2S) prediction, where recent progress in understanding how knowledge of the state of the stratosphere, along with conventional approaches based on the Madden-Julian Oscillation and the El Niño-Southern Oscillation, could improve S2S predictions (**Amy Butler**, keynote). The importance of the coupling between the tropics and the mid-latitudes, the Arctic and the mid-latitudes, the ocean and the atmosphere and the stratosphere and the troposphere were also highlighted as prime sources of predictability across timescales (**Daniela Domeisen**, keynote).

As an example of the stratosphere-troposphere coupling, other presentations in the theme assessed prediction of sudden stratospheric warming (SSW) in operational models. It was shown that in S2S prediction models SSWs can be predicted at lead time of 8 to 12 days (**Alexey Karpechko**) and further that such predictability is sensitive to the initial conditions in the upper stratosphere (**Shunsuke Noguchi**). Ensemble reforecasts with different initial conditions revealed that satellite observations in the upper stratosphere become important for the forecast skill starting about 5 days before the SSW, thereby influencing the predictability in the troposphere.

Other presentations in the theme considered predictability on longer timescales. In the Northern Hemisphere, skilful predictions of the winter North Atlantic Oscillation (NAO) index using an empirical model including autumn Arctic sea ice extent, early winter stratospheric circulation and North Atlantic sea surface temperatures was described (**Lei Wang**). The influence on longer timescales of the 11-year solar cycle on the winter NAO was examined using large ensembles of hindcast decadal predictions (**Tobias Spiegl**). Two papers addressed the predictability of the extratropical circulation in the Southern Hemisphere from the perspective of interannual variations in the delay of the break-up of the Antarctic polar vortex and its relation to the seasonal transition of the midlatitude jet in austral spring (**Nicholas Byrne**). Another paper analysed the predictability of the Southern Hemisphere extratropical circulation from the perspective of height-time domain empirical orthogonal function analysis, which identified a coupled stratosphere-troposphere mode that was examined in high- and low-top seasonal prediction systems (**Eun-Pa Lim**).

Role of Atmospheric Dynamics for Climate Variability and Change

The theme addressed global teleconnections, their mechanisms, and their statistical detection in reanalysis and model data. There were two keynote presentations, six contributed oral presentations and 143 poster presentations.

A teleconnection pathway linking the Australian Monsoon with the west Pacific pattern and associated extremes in the east Asian region was introduced (**Hisashi Nakamura**, keynote) and questions by the audience addressed the missing role of the MJO in this teleconnection pattern. Teleconnection pathways between the MJO and stratospheric warming events were also discussed (**Wang**).

Figure 3: *Full plenary hall during the opening presentations of the General Assembly.*

One focus of the theme was on coupling and interactions between stratospheric and tropospheric dynamics. This included recent progress in understanding the connection between tropical convection and the tropical stratosphere (**Chaim Garfinkel**, keynote) and the tropospheric response to downward propagating tide from the stratosphere (**Takatoshi Sakazaki**, keynote).

These include a direct pathway where Rossby waves excited in the tropics reach the extratropics and from there the stratosphere and an indirect pathway where the MJO related Rossby waves influence the position and waviness of the jet itself and thereby the planetary wave patterns that reach the stratosphere.

Some of the key processes that influence the tropical tropopause layer on seasonal to interannual timescales as identified from observations and models were discussed (**Joowan Kim**, keynote). Variations in the width of the tropical belt and their characterisation by different indices were discussed (**Sean Davis**). Indices capturing the behaviour of the subtropical jet are not well correlated with indices directly capturing the poleward branch of the circulation. A Matlab package to compute Hadley cell width proxies is now available (TropD, Adams *et al.*, 2018). Questions from the audience pointed to the importance of considering vertical trends in the location of the subtropical jet and asked for recommendations of which index to use for analyses of long-term trends in the tropical width.

At high latitudes, a teleconnection chain extending from Arctic sea ice into the stratosphere was demonstrated using a novel statistical method called Causal discovery algorithms (**Marlene Kretschmer**) but the mechanism was only captured by 50% of the analysed global circulation models. Subsequent questions from the audience acknowledged the potential for the Causal discovery method to be applied to a wide range of teleconnection process chains.

Atmospheric Impacts and Interactions Related to Tropical Processes

More than 70 presentations contributed to this theme, with research topics covering the full range of tropical dynamics and composition.

A significant fraction of the presentations in the poster session focused on the interactions between modes of dynamical variability in the troposphere and stratosphere, including interactions between QBO, ENSO and MJO. This topic was further highlighted by some of the oral presentations showing the dependence of the organisation of moist convection by the QBO in idealised numerical experiments (**Shigeo Yoden**) and the QBO modulation of the impact of ENSO on the Asian summer monsoon, as reflected by the strength of the South Asian High (**Wen Chen**).

The representation of tropical waves, QBO and MJO in global models and reanalysis datasets was a topic of significant interest in this theme. Analyses of the resolved equatorial waves and wave-driving of the QBO in QBOi models (**Laura Holt**) and the resolved equatorial waves in reanalysis datasets (**George N. Kiladis**) were presented.

Atmospheric constituents and transport in the tropics were of significant interest, especially for components that have important contributions to the climate forcing such as ozone, stratospheric water vapour, and cirrus clouds near the tropopause. New airborne observations showing evidence of deep convective transport of water vapour into the stratosphere in the Asian summer monsoon from the recent StratoClim campaign (**Sergey Khaykin**) and an analysis of long term records of aerosol and cirrus cloud using satellite observations, ground based lidar measurements, and balloon borne in situ measurements from India (**Amit K. Pandit**) were presented. Dynamical variability and trends in the tropical tropopause region and the lower stratosphere were other topics of significant interest in the poster sessions. Research work contributed includes the widening of the tropics, connections between tropical convection and the tropopause properties, and impact of gravity waves in the tropopause region.

Advances in Observation and Reanalysis Datasets

The theme had two keynote and six contributed talks, and nearly 80 poster presentations. Presentations covered on-going improvements in the observational data sets, evaluation of multiple-instrument records and global atmospheric reanalyses, and new observational technologies.

The importance of satellite-based climate data records and the "golden age" for satellite observations of the middle atmosphere over the last 10-15 years (at its peak there were twelve limb or occultation sounders operating) was discussed (**Nathaniel Livesey**, keynote), including the scientific and programmatic landscape for extending and augmenting the record from such instruments, with a focus on the findings of the US National Academy's "Decadal Survey" of spaceborne Earth Science priorities. The new records for ozone, nitrogen dioxide, and other species are becoming available from the Stratospheric Aerosol and Gas Experiment (SAGE) III on the International Space Station, with both solar and lunar occultation capabilities (**David Flittner**). Results were also presented from the SPARC Water Vapour Assessment II (WAVAS-II) using 40 water vapour data sets from 15 satellite instruments and several water vapour isotopologue data records from 1986 to 2016 (**Kaley Walker**).

First results of the very ambitious and impressive Atmospheric Profiling Synthetic Observation System (APSOS), which comprises data of five lidars, a cloud radar, and a spectroradiometer, at the Yang Ba Jing observatory on the centre part of Tibetan Plateau were presented (**Daren Lyu**, keynote); the data will start to become available to the wider research community once it underwent quality control. The value of long-term ozonesonde measurements for the last 20 years as part of the Southern Hemisphere ADditional OZonesondes (SHADOZ) project was demonstrated and recent work to improve the homogenisation and uncertainty evaluation of tropical balloon ozone profile data was presented (**Jaquelyn Witte**).

Another topic covered by many presentations was recent work using reanalysis datasets and their intercomparisons. Long-term changes in upper-tropospheric jet latitude, altitude, and strength in different regions and seasons for the period 1980–2014 are analysed using five modern reanalyses, MERRA, MERRA-2, ERA-Interim, JRA-55, and NCEP CFSR (**Michaela Hegglin**). The advantages and limitations of various reanalysis data sets for representing key characteristics of the tropical tropopause layer (TTL) including its basic structure and long-term changes were presented (**Susann Tegtmeier**). Finally, the representation of extratropical annular mode variability in conventional reanalysis datasets was compared with those where only surface observations are included (**Edwin Gerber**); it was found that the annular mode in the Northern Hemisphere is well characterised with conventional observations at least from 1958 onward.

SPARC Science for Society

This theme covered the challenging area of making SPARC science societally relevant. There were three keynote presentations, five contributed oral presentations and 14 poster presentations.

In the first keynote presentation in the theme, **Guy Brasseur** reviewed the new WCRP Strategic plan and the review of the WCRP, and whose discussion was picked up and expanded in the Roundtable Discussion. **Rob Carver** outlined the Loon project, which is attempting to provide enhanced internet coverage by flying transceivers on long-life balloons that float between 15 km and 25 km in the stratosphere. The location of the balloons is controlled by altering their buoyancy, which requires good depiction and prediction of the winds. Loon has advanced machine learning to be able to better predict the winds and balloon locations and is now able to "park" the balloons in a limited horizontal range. The project offers a unique high vertical resolution data set of winds (over the course of their 1-3 month life, their altitude is altered ~20,000 times) and offers the possibility of carrying other meteorological payloads but with a sub-kilogram weight constraint. **Erica Key**, the Executive Director of the Belmont Forum, explained the importance of tackling scientific problems that can lead to societal benefit and the current projects that are supported through the Belmont Forum. The GA was jointly hosted with the Belmont Forum, which held a side meeting during the GA where the 8 projects funded under the Climate2015 call discussed their progress to date. The projects cover predictability (InterDec), regional to global teleconnections (INTEGRATE, BITMAP, GOTHAM), palaeoclimate (PACMEDY) and high impact events (CLIMAX, HIWAVES3, PREREAL).

The contributed oral presentations discussed the "what-if-no Montreal Protocol" scenario, which demonstrated the enormously beneficial outcome to the biosphere of the phasing out of ozone depleting substances beginning in 1987.

Figure 4: *Winners of the Early Career Scientist Poster Awards, with SOC co-chairs Amanda Maycock (left) and Harry Hendon (right).*

Other topics included the interplay between air quality and climate change mitigation (**Don Wuebbles**), the evaluation and delivery of essential climate variables as part of the Copernicus Climate Service (**Federico Fierli**), and climate change impacts on agriculture and food production (**Taoyuan Wei**) and extreme weather events (**Karin van der Wiel**). In general, it was noteworthy how many abstracts in all sessions, and not just those from the Belmont Forum /JPI projects, were aimed at providing information of use to non-climate scientists.

Roundtable Discussion

The GA was concluded by a roundtable discussion, led by Neil Harris (co-chair SPARC) on the future of SPARC science. The focus of the roundtable discussion was on the priority for the science that SPARC should undertake, rather than a discussion of how WCRP may be organised in the future. A consensus emerged that SPARC has been extremely successful and unique by bringing together dynamics and chemistry, and remote sensing instrumentation with theoreticians and modellers. SPARC science, which ties together tropospheric and stratospheric dynamics and chemistry, is needed now more than ever in order to tackle emerging problems such as the role of Asian summer monsoon for the global stratospheric aerosol burden, the impact of volcanic eruptions on climate change and variability, and the potential predictability of terrestrial climate originating in stratospheric processes. Community-wide action and collaboration are required in order to anticipate satellite missions to continue to monitor key aspects of the global climate, and SPARC can provide this platform. The key message from the roundtable was that SPARC science is strong and is now needed more than ever: it is a challenge to SPARC to effectively elucidate these scientific challenges in response to the recommendations in the recent WCRP review.

Early Career Scientists poster awards

For early career scientists attending the GA, a meet and greet with experienced SPARC scientists was arranged on the first evening of the conference. This gave everyone the chance to get connected, between different nationalities and career stages.

Ten early career scientists (ECS) received awards for the best poster presentations which were generously supported by Project Loon. The recipients were: Silvia Bucci (LMD), Roberta D'Agostino (MPI), Kevin DallaSanta (NYU), Annelize van Niekerk (UK Met Office), Patrick Martineau (Uni. Tokyo), Bianca Mezzina (BSC-CNS), Niall Ryan (Uni. Toronto), Ryosuke Shibuya (JAMSTEC), Jacob Smith (Uni. Cambridge), and Ryan Stauffer (NASA).

Acknowledgements

The SOC are indebted to the indefatiguable Local Organizing Committee, The University of Tokyo and Kyoto University for providing local support, as well as to the International SPARC Project Office based at DLR for making the GA a success. This included managing the travel awards, designing the program, sending letters of acceptance to the authors, and managing the last minute changes to the programme resulting from Typhoon Trami. The LOC members were: Kaoru Sato, Masato Shiotani, Shigeo Yoden (LOC co-chairs); Hideharu Akiyoshi, Nawo Eguchi, Masatomo Fujiwara, Takeshi Horinouchi, Yoshio Kawatani, Takenari Kinoshita, Chiaki Kobayashi, Masashi Kohma, Yuhji Kuroda, Kazuyuki Miyazaki, Takatoshi Sakazaki, Satoshi Sugawara, Masakazu Taguchi, Yoshihiro Tomikawa, and Shingo Watanabe.

The GA would not have been possible without the generous support from our co-organizers and sponsors: The Meteorological Society of Japan, the Society of Geomagnetism and Earth, Planetary, and Space Sciences and the Japan Geoscience Union, and from our sponsors: EUMETSAT, NASA, Project Loon, StratoClim, ETH Zurich, Inoue foundation for Science, The Kyoto University Foundation, the Murata Foundation, SECOM Science and Technology Foundation, and the Kyoto Convention and Visitor Bureau. The support for ECS and scientists from developing countries is especially appreciated.

Impressions from the SPARC General Assembly

Photos: Masashi Kohma (plenary) and Hans Volkert

Organisation

Plenary after opening

Oral presentations and discussion

Early Career Scientist events

Plenary after opening

Discussion at poster and with panel

Report on the 7th HEPPA-SOLARIS Workshop

Bernd Funke[1], Katja Matthes[2,3], Brentha Thurairajah[4], and Scott Bailey[4]

[1]Instituto de Astrofísica de Andalucía, CSIC, Spain, [2]GEOMAR Helmholtz Centre for Ocean Research Germany, [3]Christian-Albrechts-Universität zu Kiel, Germany, [4]Center for Space Science and Engineering Research, Virginia Tech, USA.

Date:
11 - 14 June 2018

Organisers:
Scott Bailey, chair (Virginia Tech, USA), Bernd Funke (Instituto de Astrofísica de Andalućia, Spain), Kuni Kodera (GEOMAR Helmholtz Centre for Ocean Research, Germany), Daniel Marsh (National Center for Atmospheric Research, USA), Katja Matthes (GEOMAR Helmholtz Centre for Ocean Research, Germany), Jerry Meehl (National Center for Atmospheric Research, USA), Hilde Nesse Tyssøy (University of Bergen, Norway), Cora Randall (University of Colorado, USA), Craig Rodger (University of Otago, New Zealand), Esa Turunen (Sodankylä Geophysical Observatory, Finland), Pekka Verronen (Finnish Meteorological Institute, Finland)

Host Institution:
Center for Space Science and Engineering Research, Virginia Tech, Blacksburg, VA, USA

Number Of Participants: **29**

Sponsors:

Background:
This workshop continued the series of meetings organized since 2008, focussing on observational and modeling studies of the influences of solar radiation and energetic particle precipitation on the atmosphere and climate. Since 2012, these workshops are co-organised by the SPARC's SOLARIS-HEPPA activity.

Activitiy webpage:
http://solarisheppa.geomar.de/solarisheppa/

The 7th HEPPA-SOLARIS Workshop was held 11 - 14 June 2018 in Roanoke, Virginia, USA. The focus of the workshop was on observational and modelling studies of the influences of solar radiation and energetic particle precipitation on the atmosphere and climate. Sessions were held on: solar and precipitating particle variability; solar photon and particle effects on the stratosphere and above; dynamical processes influencing the coupling of altitude regions; solar and particle effects on the troposphere and climate system; and tools for assessing solar and precipitating particle influences. All sessions included ample discussion time after talks and posters. There were 35 presentations including 7 posters. Participants came from eight countries (USA, Norway, Spain, Finland, United Kingdom, Germany, Japan, Brazil). An open process for nominating invited talks led to a broad set of presentations by early career scientists and led to very stimulating discussions.

Solar and precipitating particle variability

After a welcome by the local organising committee (chaired by Scott Bailey), the first session on solar and precipitating particle variability started with the presentation by **Wei Xu** on the role of Bremsstrahlung X-rays during energetic electron precipitation events. The authors demonstrated how the impulse response to monoenergetic beams can be used to invert X-ray measurements and reconstruct the precipitation and suggested that spaceborne imaging of X-ray backscatters may be a promising means to monitor precipitation events. **Robert Marshall** provided estimates on energetic electron precipitation fluxes from sub-ionospheric Very-Low-Frequency (VLF) transmitter signals, and found that the relationship between these inputs and the measured VLF signal was not straightforward. The invited talk by **Shin-ichiro Oyama** summarised coordinated observations with ground-based instruments and satellites to study energetic electron precipitation (EEP) and auroral morphology at the substorm recovery phase, and discussed the optical data based on knowledge of the dependency of the EEP on auroral morphological changes. **Hilde Nesse Tyssoy** presented inter-comparisons of the POES/MEPED loss cone electron fluxes with the CMIP6 parametrisation, to understand the potential uncertainty in the EPP impact applying the CMIP6 particle energy input in order to assess its subsequent impact on the atmosphere. **Steven Kaeppler** discussed the synergetic use of incoherent scatter radar observations in conjunction with satellite observations to study energetic particle precipitation, and presented preliminary PFISR observations that showed frequent occurrence of D-region ionisation events during both quiet-time and storm-time conditions.

Solar photon and particle effects on the stratosphere and above

This session started with an invited talk by **Emma Bland** on SuperDARN radar measurements of HF radio attenuation during the September 2017 solar proton events, showing that the temporal evolution of the SuperDARN-derived radio attenuation closely follows radiometer measurements of cosmic noise absorption. Brief periods of enhanced attenuation at mid-latitudes following the arrival of M- and X-class solar flares were also observed. **Katharine Duderstadt** provided new estimates of impacts on atmospheric chemistry from radiation belt electrons using observations from FIREBIRD and the Van Allen Probes. The relative importance of the enhancement of atmospheric HO_x and NO_x and subsequent destruction of ozone with respect to solar protons was presented in an effort to explain a missing source of upper atmospheric NO_x in models that include only solar protons and auroral electrons. **Stefan Bender** presented an empirical model of nitric oxide in the mesosphere from SCIAMACHY/Envisat satellite observations, with the ultimate goal of filling measurement gaps in current measurements and to validate and improve current chemistry-climate models (CCMs). The invited talk by **Christine Smith-Johnsen** focused on the nitric oxide response to the April 2010 electron precipitation event. Using various satellite data sets and the WACCM climate model, they found that medium energy electrons (>10 keV) are important for the direct production of NO well into the lower mesosphere. A revised model for NO equilibrium in the thermosphere was presented by **Justin Yonker**, showing that the use of revised temperature-dependent rate coefficients resulted in improved model/data agreement. **Josh Pettit** gave an invited presentation on the relative roles of solar flares and energetic electron precipitation in middle atmosphere chemistry, simulated with the WACCM model. The variability and trend of the stratospheric reactive nitrogen budget as derived from MIPAS observations in comparison with climate model simulations was discussed by **Bernd Funke**. A particular emphasis was given to the role of energetic particle precipitation on the global NO_y budget. The invited talk by **Cissi Lin** focused on the effects of energetic particles in thermospheric nitric oxide cooling during shock-led storms, which has been investigated by incorporating observed electron fluxes from the Defense Meteorological Satellite Program (DMSP) spacecraft into the Global Ionosphere-Thermosphere Model (GITM). The results indicate that shock-led storms tend to result in 35–45 % more of NO cooling during storm-time compared to storms without shocks. **Karthik Venkataramani** discussed chemiluminescent emissions from nitric oxide with a particular emphasis on energy loss rate and efficiencies, and showed that the energy loss rate due to the nascent vibrational excitation forms 15-40 % of the total emissions from nitric oxide on the dayside thermosphere under quiescent conditions, but only causes a 2-3 % reduction in the exospheric temperature.

Posters related to this session dealt with the quantification of energetic particle precipitation influences on the budgets of stratospheric NO_y and ozone using a new 'tagging' scheme in the WACCM model (**Dan Marsh**), and comparisons of modelled and observed chemical impacts of particle precipitation in the middle atmosphere (**Thomas Reddmann**).

Dynamical processes influencing the coupling of altitude regions

The third session started with a talk by **Michael Denton** on the impact of solar proton events on Northern Hemisphere stratospheric ozone variability and the role of the polar vortex as seen in ozonesonde data from various sites, suggesting that the rapid transport of long-lived NO_x species plays a role in causing indirect ozone destruction. **Brentha Thurairajah** discussed gravity wave variability in terms of polar vortex position and its effect on ozone, and reported that the ozone in the vortex jet is higher than in the vortex core. **Pekka Verronen** highlighted the connection between descending odd nitrogen, stratospheric ozone, shortwave heating, and temperature from 147 years of WACCM simulations, indicating EPP-induced polar ozone variability of 12-24 % in the mesosphere, and 5-7 % in the middle and upper stratosphere. The responses of mesospheric water vapour to solar cycle and dynamical forcings in HALOE observations were discussed by **Ellis Remsberg**. They found responses to the Lyman-α flux varying from strong negative values in the uppermost mesosphere to very weak, positive values in the tropical lowermost mesosphere. However, the effects of those H_2O responses to the solar activity extend to the rest of the mesosphere via dynamical processes related to the ENSO. **Cora Randall** summarised the status and results of the NASA Project "Response of the Atmosphere to Impulsive Solar Events", a 5-year targeted science team effort whose primary goal is to investigate how the Earth's atmosphere responds to impulsive solar events.

Figure 5: *Participants of the HEPPA SOLARIS workshop in Ranoke, USA, 11 - 14 June 2018.*

SOFIE/AIM observations were presented by **Scott Bailey**, highlighting the transport of polar winter lower-thermospheric nitric oxide to the stratosphere in terms of the strength and timing of stratospheric sudden warmings. **Charles Bardeen** presented new simulations of the 2003 Halloween solar storms using WACCM-X. Comparisons between free running and specified dynamics simulations suggest a coupling of the lower atmosphere with the upper atmosphere that has a significant effect on total electron content. The role of nitric oxide and gravity waves in the long-term thermospheric energy budget were discussed by **Cissi Lin**, using the Global Ionosphere Thermosphere Model simulations.

Posters related to this session focused on the production and transport mechanisms of polar MLT region NO in AIM/SOFIE observations and SD-WACCM simulations (**Koen Hendrickxs**) and the dynamical response of the middle atmosphere to geomagnetic forcing in coupled chemistry-climate models (**Miriam Sinnhuber**).

Solar and particle effects on the troposphere and climate system including atmosphere and ocean-atmosphere coupling

This session started with an invited overview on the SOLARIS-HEPPA analysis of solar signatures in the CCMI simulations by **Katja Matthes**. It was followed by another invited presentation by **Hua Lu** on the solar cycle modulation of the North Atlantic Oscillation and the role of Rossby wave breaking, internal wave reflection and critical layer instability. **Katja Matthes** compared solar irradiance and auroral effects in two chemistry-climate models. Their simulations revealed significant differences between the Northern and Southern hemisphere dynamical signals and that 45 years of model simulations are not enough to generate statistically reliable signals.

Posters related to this session focused on the potential influence of elevated stratopause events on the lower atmospheric circulation in the MRI-ESM model (**Shunsuke Noguchi**), a statistical analysis of the effects of Forbush Decreases on climate (**Williamary Portugal**), and the role of internal and external drivers in the decadal variability of the Northern Hemisphere winter circulation (**Kalevi Mursula**).

Tools for assessing solar and precipitating particle influences including measurements, models and techniques

Esa Turunen started this session with a presentation on new emerging data of atmospheric forcing by relativistic electron precipitation from the EISCAT_3D incoherent scatter facility and its complementary research infrastructure, enabling, for the first time, to continuously map the 3D electric currents in the ionosphere, and continuous vector wind measurements in the mesosphere. **Scott Bailey** gave an overview on the proposed EPPIC-2 mission, which aims at determining how precipitating solar and magnetospheric energetic particles drive the ionisation patterns in the lower thermosphere and middle atmosphere of Earth, and how they ultimately impact the electrical, chemical, and dynamical properties in the upper and lower regions of the atmosphere. The session concluded with the invited presentation by **Max van der Kamp** on a model providing long-term datasets of energetic electron precipitation including zonal dependence. This model can be used to produce ionisation rate datasets over any period of time for which the geomagnetic Ap index is available and will enable simulations of EEP impacts on the atmosphere and climate with realistic variability.

Future plans

The next HEPPA-SOLARIS workshop will be held in Bergen, Norway, during June 2020, and will be hosted by the Birkeland Centre for Space Science.

Acknowledgements

We would like to thank WCRP/ SPARC for its support, as well as sponsorship from Virginia Tech (the host institution) and SCOSTEP's VarSITI programme. We especially thank the local organising committee for an excellent venue and organisation of the meeting.

S-RIP activities in 2018

Masatomo Fujiwara[1], Gloria Manney[2,3], Lesley Gray[4,5], Jonathon Wright[6], and Sean Davis[7]

[1]Hokkaido University, Japan, (**fuji@ees.hokudai.ac.jp**), [2]NorthWest Research Associates, USA, [3]New Mexico Institute of Mining and Technology, USA, [4]University of Oxford, UK, [5]NERC National Centre for Atmospheric Science, UK, [6]Tsinghua University, Beijing, China, [7]NOAA Earth System Research Laboratory, USA.

Dates:
25 - 29 June 2018
&
5 October 2018

Organisers (chapter-lead meeting):
Masatomo Fujiwara (Hokkaido University, Japan), Gloria Manney (NorthWest Research Associates; New Mexico Institute of Mining and Technology, USA), Lesley Gray (University of Oxford; NERC National Centre for Atmospheric Science, UK), Jonathon Wright (Tsinghua University, Beijing, China), Sean Davis (NOAA Earth System Research Laboratory, USA)

Host Institution:
NorthWest Research Associates (NWRA), Boulder, CO, USA
&
General Assembly side meeting
at Miyakomesse in Okazaki, Kyoto, Japan

Number Of Participants: **~20 & ~25**

Sponsors:

SPARC Stratosphere-troposphere Processes And their Role in Climate
WCRP World Climate Research Programme
NWRA NorthWest Research Associates Excellence in Basic & Applied Research
(chapter-lead meeting)

Activity Website:
http://s-rip.ees.hokudai.ac.jp/

We have made excellent progress towards completion of the S-RIP report in this past year, and would like to say a big 'thank-you' to all our chapter-leads and contributors for their hard work – we are almost there! As of writing this article, in mid-November 2018, we are finalising the full S-RIP report manuscript ready for review submission, with plans for publication by the end of 2019 following the review process and necessary copy-editing.

In 2018, there were two meetings of the SPARC Reanalysis Intercomparison Project (S-RIP, **https://s-rip.ees.hokudai.ac.jp**): (1) the S-RIP chapter-lead meeting hosted by and held at the NorthWest Research Associates (NWRA), Boulder, USA during 25-29 June 2018 (organised by the authors of this article); and (2) the side-meeting on 5 October 2018 during the SPARC General Assembly (GA) in Kyoto, Japan. There were several S-RIP related publications in 2018 (see, *e.g.*, the inter-journal special issue on "The SPARC Reanalysis Intercomparison Project (S-RIP)" in Atmospheric Chemistry and Physics (ACP) and Earth System Science Data (ESSD)). One key publication was by Martineau *et al.* (2018), who presented S-RIP zonal mean data sets based on various reanalysis products. The aim of S-RIP had originally been to publish an interim report before the full report in the SPARC report series; it has been decided that, because there are three overview papers already published in ACP (Fujiwara *et al.*, 2017; Long *et al.*, 2017; Davis *et al.*, 2017) that can be regarded as an interim activity report, the interim report would have been needless duplication.

S-RIP Chapter-lead Meeting

There were ~20 participants at the meeting, including 14 chapter co-leads and 2 reanalysis-centre representatives (Figure 6). The first three days consisted of presentations on the status and potential issues for Chapters 1-11 (Figure 7), and general discussion on the content of Chapter 12 (Synthesis Summary). The rest of the week was set aside for break-out sessions for individual chapters.

Figure 6: *Participants at the S-RIP Chapter-lead Meeting at the NorthWest Research Associates (NWRA), Boulder, USA, 25-29 June 2018.*

One of the important decisions during the general discussion was to include a table of recommendations, evaluations, and ratings for selected diagnostics for all reanalysis products at the end of each chapter and in Chapter 12. The following five ratings have been defined: (1) Demonstrated suitable (*i.e.*, the reanalysis product could be directly validated using observational or physical constraints and was found to be in close agreement with expectations); (2) suitable with limitations (*i.e.*, the reanalysis product could be directly validated using observational or physical constraints and exhibited limited agreement; or, suitable constraints were unavailable but reanalysis products were consistent beyond specific limitations as described in the text); (3) use with caution (*i.e.*, the reanalysis system contains all elements necessary to provide a useful representation of this variable or process, but that representation has evident red flags); (4) demonstrated unsuitable (*i.e.*, the reanalysis system is unable to represent processes that are key for this diagnostic); and (5) unevaluated (not examined).

S-RIP Side Meeting at the SPARC General Assembly

The S-RIP side meeting was held during lunchtime on the final day of the SPARC GA. There were ~25 participants including 10 chapter co-leads and 4 reanalysis centre representatives. After an overview of past S-RIP activities including the results from the S-RIP chapter-lead meeting, most of the time was spent on the discussion of potential future activities of the S-RIP after the publication of the S-RIP Report (*i.e.*, in 2020 and beyond).

Several planned new reanalysis products are expected in the coming years: ERA5 (1950-present will be available by the end of 2019), a Chinese reanalysis CRA-40 (probably around 2020), "MERRA-3" (around 2021), JRA-3Q (in 2022), and CFSv3 (around 2020-22). Therefore, it may be reasonable to re-start the full activity around 2022. During 2020-2021, we will keep the S-RIP website up-to-date and maintain a scaled-down formal group to monitor, communicate, and coordinate S-RIP-related activities; it is also noted that Masatomo Fujiwara will continue to be a part of the WCRP Task Team for Intercomparison of ReAnalyses (TIRA, **https://reanalyses.org/atmosphere/wcrp-task-team-intercomparison-reanalyses-tira**) as the liaison of S-RIP and SPARC. We will also seek more direct connections with the modelling (*e.g.* CCMI, CMIP) and observational (*e.g.* NDACC) communities by organizing side meetings or sessions with an S-RIP focus. There was also a request to hold capacity-building type regional

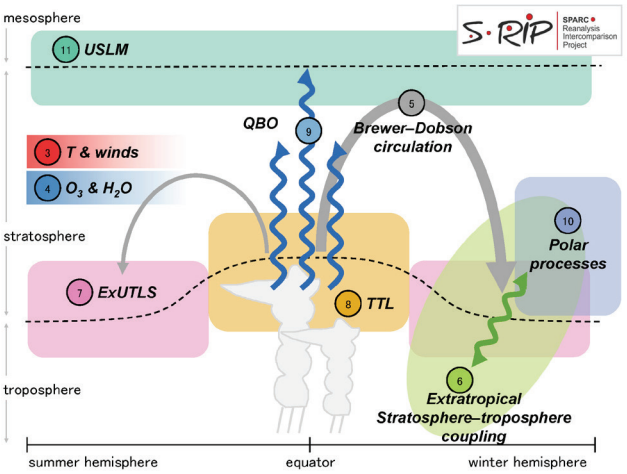


Figure 7: *The latest version of the S-RIP schematic illustration showing the processes and regions that will be covered by chapters in the planned S-RIP report. The number indicates the chapter number. Other chapters include the Introduction (Chap. 1), Description of the Reanalysis Systems (Chap. 2), and Synthesis Summary (Chap. 12). Revised from Figure 1 of Fujiwara et al. (2017).*

workshops, e.g., in India. During the Scientific Steering Group (SSG) meeting that followed the GA, there were some suggestions for new diagnostics such as the Madden-Julian Oscillation, including its interaction with the stratosphere; tropospheric circulations; and weather systems (e.g., storm track, blocking, extremes, and other near-surface weather features). There is as yet no fixed plan for the period after 2020. We welcome everyone's comments and suggestions.

Acknowledgments

The S-RIP chapter-lead meeting was supported by SPARC and NWRA. We thank all the contributors to the S-RIP.

References:

Davis, S. M., *et al.*, 2017: Assessment of upper tropospheric and stratospheric water vapor and ozone in reanalyses as part of S-RIP, *Atmos. Chem. Phys.*, **17**, 12743-12778, **https://doi.org/10.5194/acp-17-12743-2017.**

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, **https://doi.org/10.5194/acp-17-1417-2017**.

Long, C. S., *et al.* 2017: Climatology and interannual variability of dynamic variables in multiple reanalyses evaluated by the SPARC Reanalysis Intercomparison Project (S-RIP), *Atmos. Chem. Phys.*, **17**, 14593-14629, **https://doi.org/10.5194/acp-17-14593-2017**.

Martineau, P., *et al.*, 2018: Zonal-mean data set of global atmospheric reanalyses on pressure levels, *Earth Syst. Sci. Data*, **10**, 1925-1941, **https://doi.org/10.5194/essd-10-1925-2018**.

Report on the 2nd Atmospheric Temperature Changes and their Drivers (ATC) Activity Workshop

Andrea K. Steiner[1] and Amanda C. Maycock[2]

[1]Wegener Center for Climate and Global Change, University of Graz, Austria, [2]School of Earth and Environment, University of Leeds, UK

Dates:
27 - 28 June 2018

Organisers:
Andrea Steiner (Wegener Center, University of Graz, Austria), Chantal Claud (LMD, CNRS, France), Philippe Keckhut (LATMOS, UVSQ, France)

Meeting venue:
Sorbonne University, Paris, France

Number Of Participants: 17

Sponsors:

Activity Website:
https://www.sparc-climate.org/activities/temperature-changes/

The SPARC Atmospheric Temperature Changes and their Drivers (ATC) activity held its second workshop on 27-28 June 2018 at Sorbonne University in Paris, France. The workshop was organised by the ATC co-chair **Andrea Steiner** (University of Graz) and the local hosts **Chantal Claud** (LMD, CNRS) and **Philippe Keckhut** (LATMOS, UVSQ). We thank the local organisers for hosting the workshop, for providing meeting facilities, coffee breaks and sponsoring the workshop dinner. We also thank SPARC for providing travel support to help some participants attend the meeting. The workshop was attended by 17 scientists including ATC members and guests interested in ATC topics (Figure 8).

The morning session on the first day focused on atmospheric temperature changes. **Andrea Steiner** presented temperature trends from different observational data sets including from Global Positioning System (GPS) radio occultation (RO) as well as a community paper by **Maycock *et al.* (2018)** entitled "Revisiting the mystery of stratospheric temperature trends". Several ATC members contributed to this updated model-data comparison of stratospheric temperature trends over the satellite era (1979-2016) using simulations from the Chemistry-Climate Model Initiative (CCMI) and revised and extended satellite temperature records. The study was also assessed in support of Chapter 5 of the WMO/UNEP 2018 Scientific Assessment of Ozone Depletion. Results showed improved agreement between trends in revised stratospheric satellite observations and trends from recent CCMI models, mainly stemming from the improved satellite data. Larger cooling of global stratospheric temperatures over the first half of the data record (1979-1997) and weaker global cooling over 1998-2016 reflect differences in upper-stratospheric ozone trends between these periods of ozone decline and recovery (Figure 9). The Frontier Article in Geophysical Research Letters was recently featured as an Eos research spotlight (Shultz, 2018).

Latitudinal and seasonal stratospheric temperature trends from Advanced Microwave Sounding Unit (AMSU) measurements on the Aqua satellite for 2002 to 2016 were presented by **Chantal Claud**. Stratospheric cooling is significant globally and in the tropics for AMSU channels above 25 km. At high latitudes, uncertainties in zonal and seasonal trends are large due to high variability there. High consistency was found in stratospheric trends from Aqua AMSU and GPS RO observations by **Sergey Khaykin** whereas he showed that ERA-Interim underestimates cooling in the stratosphere.

Figure 8: *Participants of the second SPARC ATC activity workshop held at Sorbonne University in Paris, France, 27-28 June 2018.*

Torsten Schmidt investigated tropopause variability using GPS RO data including multiple tropopauses and changes in the tropical belt. **Bill Randel** presented his ongoing work on tropical tropopause temperatures from 40 years of radiosonde data. He showed that Microwave Sounding Unit (MSU) data are useful for identifying discontinuities especially in the early part of the radiosonde record.

The afternoon session focused on updates on atmospheric data sets. Stratospheric radiosonde measurements back to 1950 for assimilation into ERA5 were presented by **Leo Haimberger** who also discussed their uncertainty in the stratosphere. **Ben Ho** reported on the development of temperature climate records from GPS RO and showed that RO data are useful for identifying and correcting biases in radiosonde temperature in the upper troposphere and lower stratosphere. **Carl Mears** introduced an updated version of MSU/AMSU lower stratospheric temperatures (v4.0) with new diurnal cycle adjustment based on observations. An improved version of high-resolution temperature profiles (HRTP) from the GOMOS instrument on Envisat was presented by **Victoria Sofieva** highlighting their use for studying small-scale features and gravity waves. A new stratospheric temperature record was introduced by **Alexandrea Laeng** based on merged HAlogen Occultation Experiment (HALOE) and Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) data from 1991 to 2012. **Michael Schwartz** provided an update on the Mesospheric/Upper Stratospheric Temperature and Related Datasets (MUSTARD) project led by JPL, which will delivers a long-term combined record from limb sounding radiometers and occultation instruments. The MUSTARD temperature dataset is planned to become available to the wider community soon.A comparison of a 40-year temperature lidar series with satellite observations was carried out by **Robin Wing** who analysed biases in the representation of the stratopause. **Alain Hauchecorne** presented a new dataset of temperature profiles from 35 km to 85 km using the Rayleigh scattering at limb from GOMOS daytime observations in the frame of the ESA MesosphEO project (Hauchecorne *et al.*, 2018).

On the second day, **Qiang Fu** presented a study on the effect of hydrometeors on MSU/AMSU temperatures since one concern is the presence of signals in the measurements other than thermal emission by molecular oxygen. These include emission and scattering by cloud water, precipitation. Heavy precipitation causes a significant depression in satellite-observed brightness temperatures that can be corrected by simple linear regression. They found that correcting the mid-troposphere (TMT) or lower troposphere (TLT) monthly anomalies by removing the hydrometeor contamination does not significantly influence estimates of tropical mean temperature trends, but it could affect the pattern of temperature trend over the tropical oceans (Pahlavan *et al.*, 2018). **Kunihiko Kodera** discussed the possible influence of lower stratospheric cooling on the tropospheric circulation. A reduction of static stability in the tropical tropopause layer from cooling near the tropopause could strengthen deep convection penetrating into the tropical tropopause layer, in particular over the continents of Africa and Asia. They suggest that this is a fundamental factor causing the recent decadal change in the tropical troposphere and the ocean by a poleward shift of the rising branch of the summertime Hadley cell. **Lorenzo Polvani** presented a

model fingerprinting study on ozone depleting substances as a major driver of Brewer-Dobson circulation (Polvani *et al.*, 2018). They found that phasing out of ozone depleting substances by the Montreal Protocol would result in considerably reduced trends in the Brewer-Dobson Circulation in the 21st century.

A key aim of the workshop was to progress work towards a second community paper on atmospheric temperature trends from updated observational records. On the second day, we held a dedicated session for group discussion on data sets and initial results and for consolidating the draft structure, figures and content of the community paper. Updated information about the ATC activity can be found on the SPARC webpage: **www.sparc-climate.org/activities/temperature-changes.**

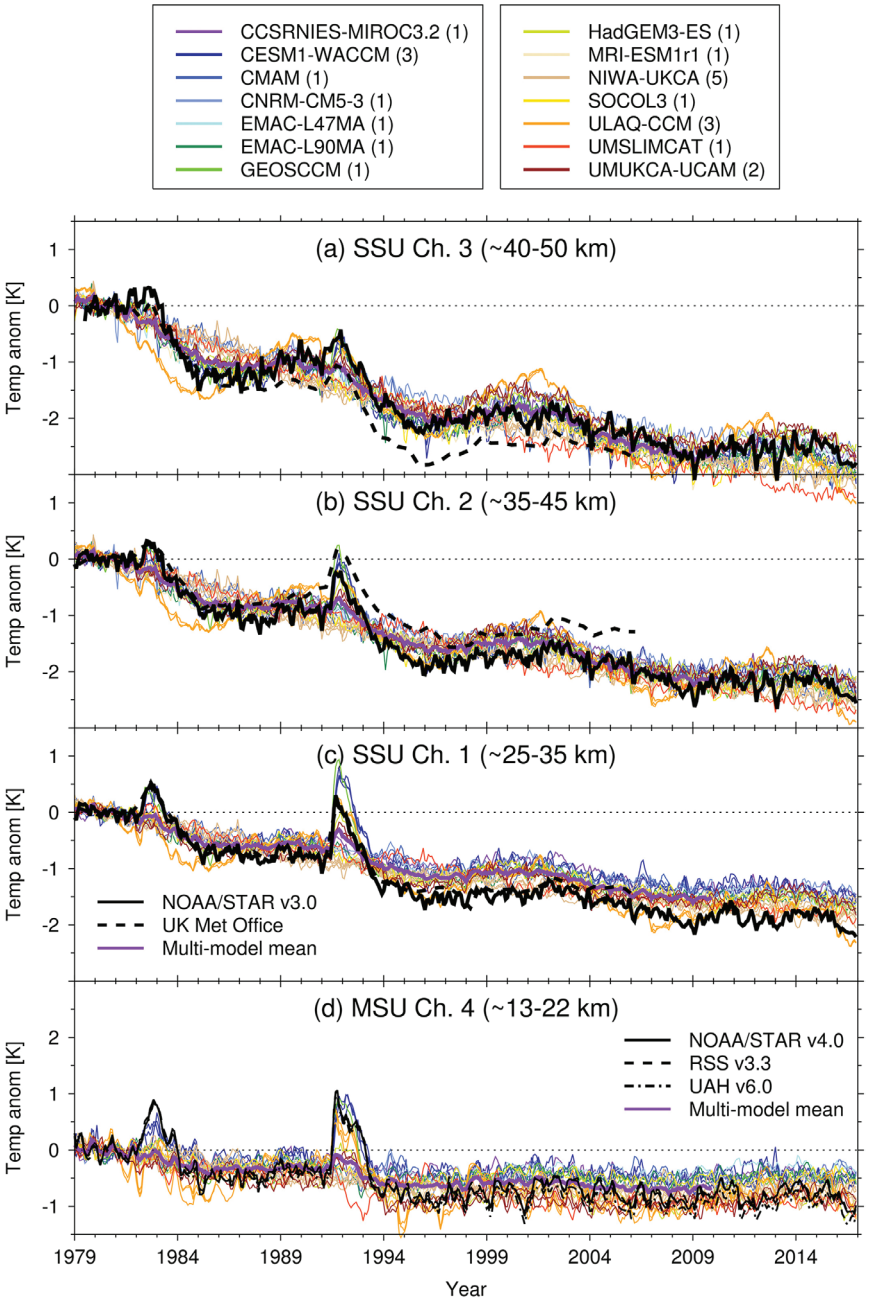


Figure 9: *Time series of global monthly mean temperature anomalies for the period 1979–2016 for the data sets and altitude ranges stated in the figure. Anomalies are shown relative to a baseline of 1979-1981. The multimodel mean is shown in thick purple. Note the UK Met Office Stratospheric Sounding Unit (SSU) data set is shown as 6-month averages. (a) SSU channel 3 (~40-50 km). (b) SSU channel 2 (~35-45 km). (c) SSU channel 1 (~25-35 km). (d) MSU channel 4 (~13-22 km). Taken from Maycock et al. (2018).*

References:

Hauchecorne, A. *et al.*, 2018: A new MesosphEO dataset of temperature profiles from 35 to 85 km using Rayleigh scattering at limb from GOMOS/ENVISAT daytime observations. Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-241.

Kodera, K., *et al.*, 2018: Impact of tropical lower stratospheric cooling on deep convective activity: (I) Recent trends in tropical circulation, *Atmos. Chem. Phys. Discuss.*, **doi:10.5194/acp-2018-128.**

Maycock, A. C., *et al.*, 2018: Revisiting the mystery of recent stratospheric temperature trends, *Geophys. Res. Lett.*, **45**(18), 9919–9933, **doi:10.1029/2018GL078035**. (Frontier article)

Pahlavan, H. A., Q. Fu, and J. M. Wallace, 2018: The effect of hydrometeors on MSU/AMSU temperature observations over the tropical ocean, *J. Atmos. Ocean. Tech.*, **35**, 1141–1150, **doi:10.1175/JTECH-D-17-0190.1**.

Polvani, L. M., *et al.*, 2018: Significant weakening of Brewer-Dobson circulation trends over the 21st century as a consequence of the Montreal Protocol. *Geophys. Res. Lett.*, **45**, 401–409, **doi:10.1002/2017GL075345**.

Shultz, D., 2018: Satellite observations validate stratosphere temperature models, *Eos*, **doi:10.1029/2018EO109113**, published on 21 November 2018.

Report on the SATIO-TCS side meeting and related discussions at the 6th SPARC General Assembly 2018

Peter Hitchcock[1], Peter H. Haynes[2], Matthew H. Hitchman[3], Tieh-Yong Koh[4], Takatoshi Sakazaki[5], and Shigeo Yoden[5]

[1]Cornell University, Ithaca, USA (**aph28@cornell.edu**), [2]University of Cambridge, Cambridge, UK (**P.H.Haynes@damtp.cam.ac.uk**), [3]University of Wisconsin-Madison, Madison, USA (**matt@aos.wisc.edu**), [4]Singapore University of Social Sciences, Singapore, Singapore (**tykoh@suss.edu.sg**), [5]Kyoto University, Kyoto, Japan (**zaki@kugi.kyoto-u.ac.jp; yoden@kugi.kyoto-u.ac.jp**)

Date:
4 October 2018

Organisers:
Shigeo Yoden (Kyoto University, Japan), Matt Hitchman (University of Wisconsin-Madison, USA), Peter Haynes (University of Cambridge, UK)

Meeting venue:
General Assembly side meeting
at Miyakomesse in Okazaki, Kyoto, Japan

Number Of Participants: **32**

Sponsors:

Background:
SATIO-TCS is a SPARC activity focused on enhancing our understanding of the coupling between stratospheric processes and tropospheric convective systems, particularly in the tropics.

Workshop Website:
https://www.sparc-climate.org/activities/satio-tcs/

On Sunday, September 30th, the tropical convective system Typhoon Trami exerted its influence on the SPARC working group Stratospheric and Tropospheric Influences On Tropical Convective Systems (SATIO-TCS). The working group's side meeting, originally scheduled for the Sunday, was held instead during a lunch break of the SPARC General Assembly (see page 8) on Thursday, October 4th. It was attended by 32 participants.

Interest in the downward influence of the stratosphere on tropical convection has grown rapidly since the still-recent discovery of the pronounced influence of the Quasi-Biennial Oscillation (QBO) on the Madden Julian Oscillation (MJO). The broader question of such stratospheric influences in tropical convection has, however, a longer history, spanning a vast range of temporal and spatial scales and involving a diverse array of atmospheric phenomena (Figure 10). Nearly thirty presentations, both oral and poster, were given at the SPARC General Assembly on related topics, including but not limited to the effects of the downward propagating solar tide on the diurnal cycle of convection (**T. Sakazaki**), the impact of the QBO on MJO predictability (**Y. Lim**), and the impacts of the stratospheric sudden warming on tropical cyclone development (**N. Eguchi**).

A central goal of SATIO-TCS is therefore to promote and facilitate research on these interactions and influences. The side meeting thus began with a brief introduction of all related poster presentations.

An initial deliverable for SATIO-TCS is to provide a review of existing research in related areas to provide an up to date reference for researchers to engage with the literature. Two separate review papers are now planned. The first will focus on observational studies of the relationship between the QBO and the tropical troposphere. The second paper will present a broader context, discussing modelling and theoretical studies including influences from polar stratospheric variability. An overview of the first paper was presented by **Matt Hitchman**, who highlighted the 'direct effect' of the QBO on the tropical and subtropical tropopause through the associated meridional circulation (Figure 11).

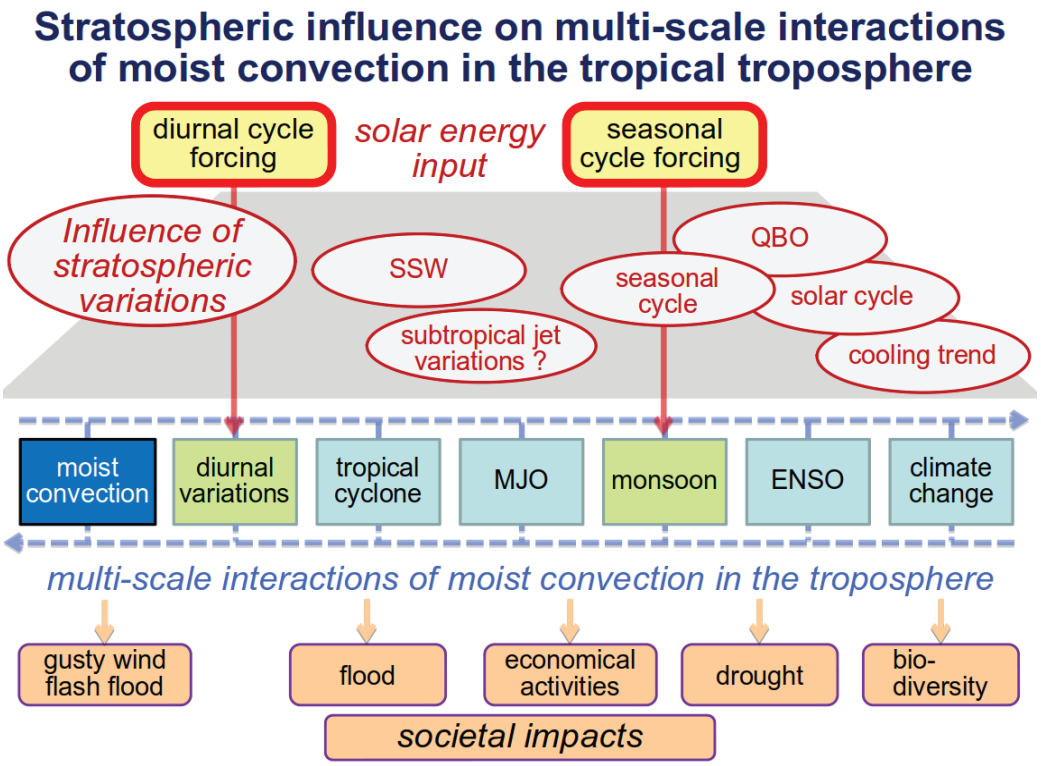


Figure 10: *Multi-scale interactions of moist convection in the troposphere and influence of the stratospheric variations on them.*

This can be contrasted with more 'indirect' pathways through the extratropical stratosphere or troposphere that have also been discussed. When QBO shear is easterly just above the tropopause, anomalous ascent is expected over the equator, closed by descent in the subtropics in either hemisphere. This has a measurable impact on tropopause heights, and is correlated with enhanced convective activity, particularly in DJF over regions of active deep convection. Details of the mechanism(s) by which the convection is modulated remain unclear, but the observed impacts are more consistent with the temperature signal than with the QBO shear itself.

Several other presentations were given highlighting SATIO-TCS related studies. **Lon Hood** discussed how the state of the stratosphere affects teleconnections between the MJO and the extratropical circulation during boreal winter. **Harry Hendon** discussed the sensitivity of convectively coupled waves to the Quasi-Biennial Oscillation.

The remainder of the lunch break, as well as an additional meeting on Friday among a smaller group of SATIO-TCS core members, was devoted to discussions of next steps.

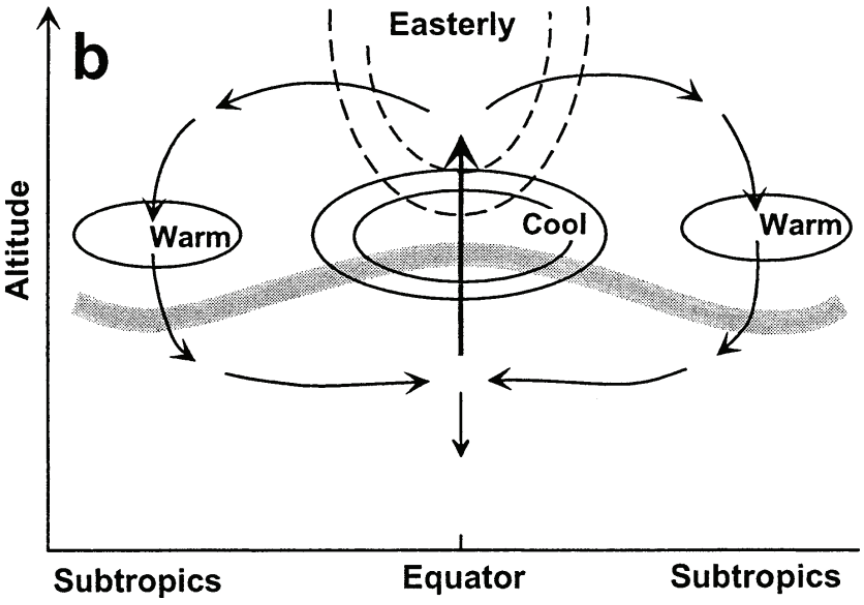


Figure 11: *Easterly QBO shear is associated with anomalous ascent over the equator and subtropical descent in either hemisphere, as well as corresponding temperature anomalies. From Collimore et al. (2003).*

In addition to the review papers that are under way, a mailing list has been generated from participants and a website is under construction to serve as a point of communication for interested parties. It was decided that current understanding and in particular modelling of the mechanisms driving the top-down influence on convection was not sufficiently advanced to warrant organising a SATIO-TCS-specific modelling effort. It was instead felt that a more effective strategy would be to coordinate efforts with other related modelling activities, both within and outside of SPARC, either through additional analysis of existing output or through the development of specific experimental protocols. Establishing and strengthening links with QBOi, DynVar, S2S and SNAP (which focus on sub-seasonal to seasonal prediction), as well as RCEMIP (which focuses on the intercomparison of efforts to model radiative-convective equilibrium) were seen as particular priorities.

Finally, the opportunity for future presentations of SATIO-TCS-related science was discussed. Although no specific stand-alone meetings are planned for 2019, several upcoming relevant meetings were highlighted, including the January AMS meeting in Pheonix, the April EGU meeting in Vienna, the June AMOS Annual Meeting 2019 and the International Conference on Tropical Meteorology and Oceanography in Darwin, the July 27th IUGG General Assembly in Montreal, and the July-August AOGS 16th Annual Meeting in Singapore.

References:

Collimore, C.C., Martin, D.W., Hitchman, M.H., Huesmann, A., and Waliser, D.E, 2003: On the relationship between the QBO and tropical deep convection. *J. Clim.*, **16**, 2552-2568. doi:10.1175/1520-0442(2003)016<2552:OTRBTQ>2.0.CO;2

URLs:

DynVar	**http://www.sparcdynvar.org/**
RCEMIP	**http://myweb.fsu.edu/awing/rcemip.html**
QBOi	**http://users.ox.ac.uk/~astr0092/QBOi.html**
SNAP	**http://www.met.reading.ac.uk/~stratclim/snap/intro.php**
S2S	**http://www.s2sprediction.net/**

AMOS-ICTMO 2019	**https://amos2019.org.au/**
AMS 99th Annual Meeting (20th Conf. on Middle Atmosphere)	**https://ams.confex.com/ams/2019Annual/meetingapp.cgi/Program/1303**
EGU General Assembly 2019	**https://www.egu2019.eu/**
27th IUGG General Assembly	**http://iugg2019montreal.com/**
AOGS 16th Annual Meeting	**http://www.asiaoceania.org/aogs2019/public.asp?page=home.htm**

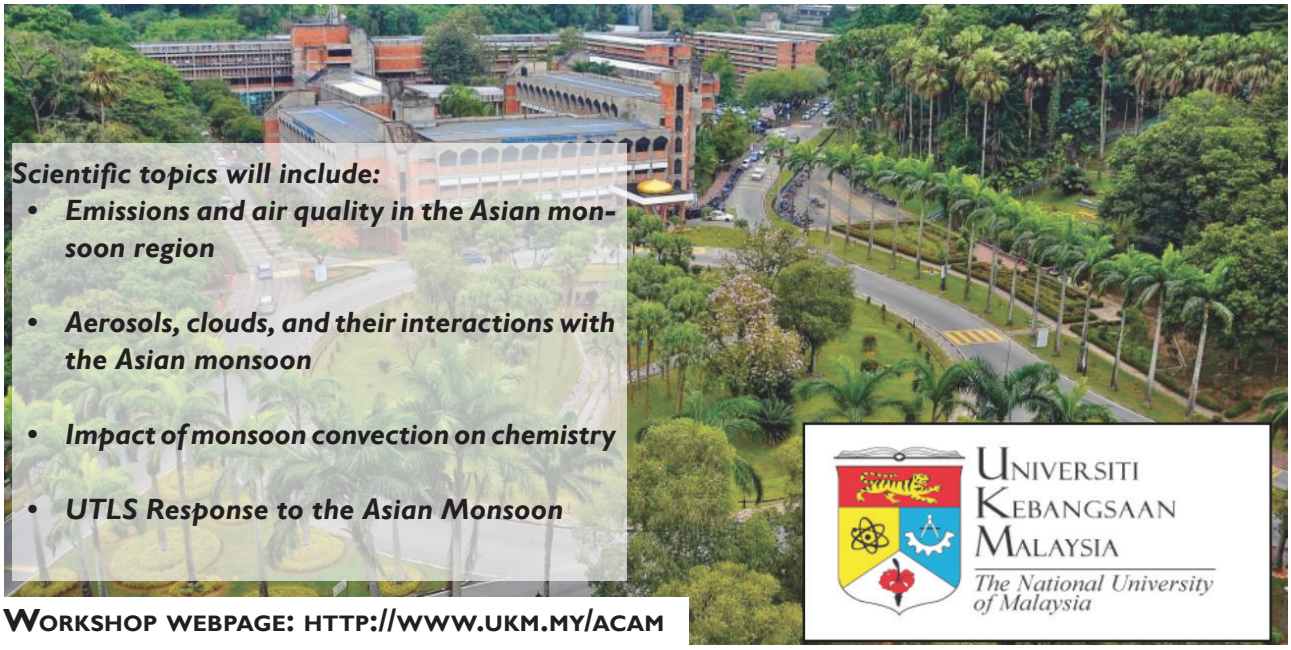
Figure 12: *Thirty two participants attended the SATIO-TCS side meeting.*

Opportunities for Early Career Scientists

ACAM training school:

"Earth system modelling and observations to study Earth in a changing climate"

24 - 25 June 2019 (prior to the ACAM workshop)
Universiti Kebangsaan Malaysia (UKM), Bangi, Malaysia



Scientific topics will include:

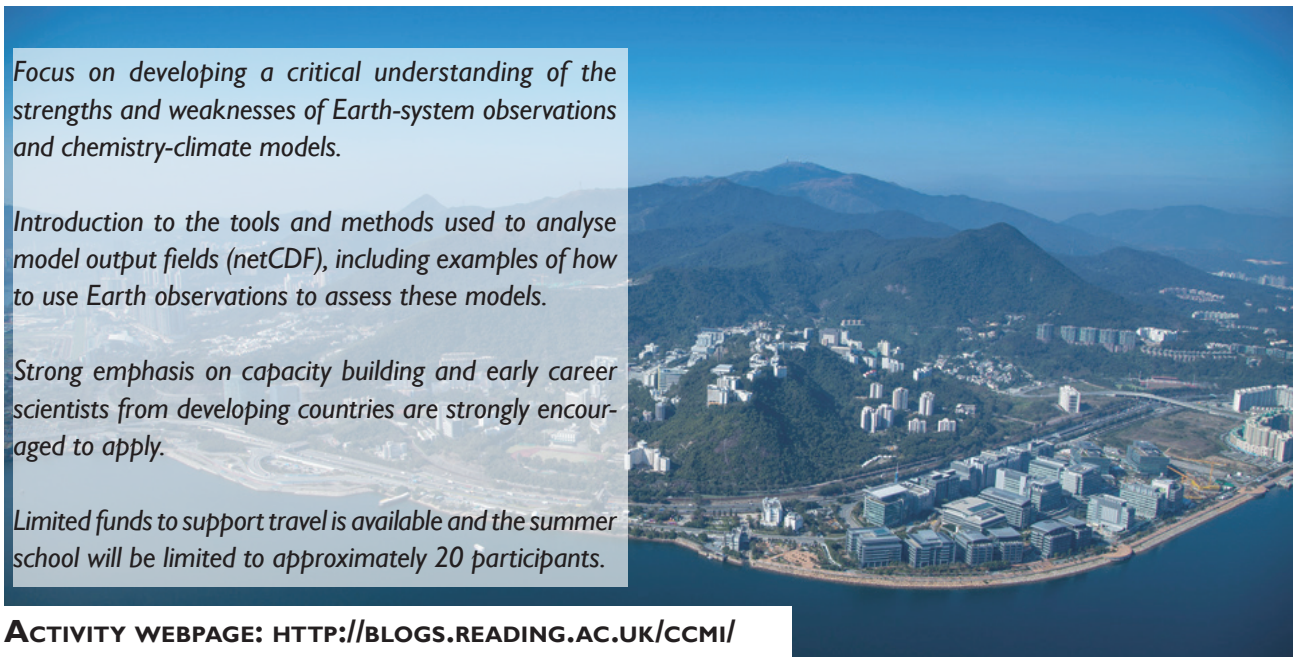
- ***Emissions and air quality in the Asian monsoon region***
- ***Aerosols, clouds, and their interactions with the Asian monsoon***
- ***Impact of monsoon convection on chemistry***
- ***UTLS Response to the Asian Monsoon***

Workshop webpage: http://www.ukm.my/acam

CCMi training school:

"Earth system modelling and observations to study Earth in a changing climate"

4 – 6 August 2019 (prior to the CCMi workshop)
Chinese University of Hong Kong (CUHK) in Hong Kong



Focus on developing a critical understanding of the strengths and weaknesses of Earth-system observations and chemistry-climate models.

Introduction to the tools and methods used to analyse model output fields (netCDF), including examples of how to use Earth observations to assess these models.

Strong emphasis on capacity building and early career scientists from developing countries are strongly encouraged to apply.

Limited funds to support travel is available and the summer school will be limited to approximately 20 participants.

Activity webpage: http://blogs.reading.ac.uk/ccmi/

SPARC meetings

25-27 March 2019
International Symposium on: The Unexpected Increase in Emissions of Ozone-Depleting CFC-11
Vienna, Austria

1-5 April 2019
TUNER ISSI International Team meeting
Bern, Switzerland

1-5 April 2019
ISSI international team meeting on: New Quantitative Constraints on Orographic Gravity Wave Stress and Drag
Bern, Switzerland

2-5 April 2019
SSiRC Scientific Steering Group meeting
Forschungszentrum Juelich, Juelich, Germany

6-10 May 2019
40th Session of the WCRP Joint Scientific Committee (invitation only)
Geneva, Switzerland

24-28 June 2019
ACAM Atmospheric Composition and Asian Monsoon Workshop & Training school
Kuala Lumpur, Malaysia

4 - 9 August 2019
CCMi Summer school and workshop
Hong Kong

SPARC related meetings

25-29 March 2019
CMIP6 workshop and WGCM session
BSC, Barcelona, Spain

1-4 April 2019
Workshop on Predictability and Dynamics - TIGGE & S2S
ECMWF, Reading, UK

7-12 April 2019
EGU General Assembly
Vienna, Austria

7-9 May 2019
Workshop on Atmospheric Convection and Air-Sea Interactions of the Tropical Oceans
Boulder, CO, USA

13- 17 May 2019
ESA Living Planet Symposium
Milan, Italy

11 - 14 June 2019
AMOS Annual Meeting 2019 and the International Conference on Tropical Meteorology and Oceanography
Darwin, Australia

8-18 July 2019
27th IUGG General Assembly
Montreal, Québec, Canada

28 July - 2 August 2019
AOGS 16th Annual Meeting
Singapore

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

Publication details

Editing
Mareike Kenntner & Hans Volkert
Design & layout
Brigitte Ziegele & Mareike Kenntner
Distribution & print (on demand)
DLR - IPA, Oberpfaffenhofen

ISSN 1245-4680

SPARC Office

Director
Hans Volkert

Office Manager
Brigitte Ziegele

Project Scientist
Mareike Kenntner

Contact
SPARC Office
c/o Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
Institut für Physik der Atmosphäre
Münchener Str. 20
D-82234 Oberpfaffenhofen, Germany
email: *office@sparc-climate.org*