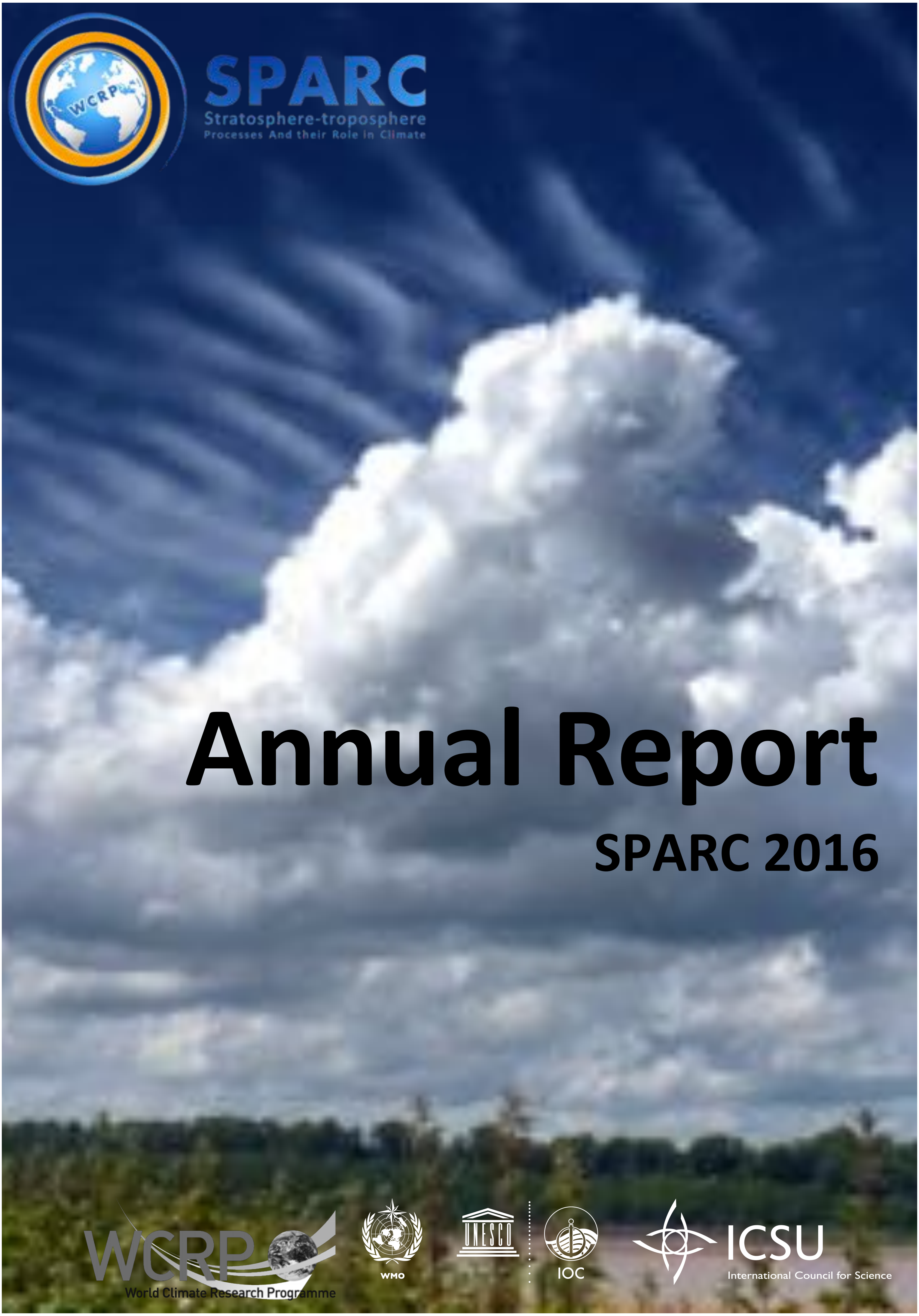

SPARC
Stratosphere-troposphere Processes And their Role in Climate

Annual Report

SPARC 2016

World Climate Research Programme

WMO

UNESCO

IOC

ICSU International Council for Science

SPARC
Annual Report
2016

Prepared by:
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Cover photo: *https://www.flickr.com/photos/mwf2005/14387394862/*

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Overview from the Co-Chairs

A major part of our activities in 2016 has been the implementation of the "whole atmosphere" approach laid out in the 2015 SPARC strategy (www.sparc-climate.org/publications/implementation-plans). The three themes are Atmospheric Dynamics and Predictability, Chemistry and Climate, and Long-Term Records for Climate Understanding. Ensuring that we reach the aims laid out in the strategy will mean extending our activities further into the troposphere so that SPARC more truly is a whole atmosphere programme. This is being achieved by supporting workshops, changing the balance of Scientific Steering Group, introducing some new activities and enhancing our links with the WCRP Grand Challenges.

Participants of the 24th SPARC Scientific Steering Group meeting held at the MPI's Harnack House in Berlin, Germany, from 1-4 November 2016

In 2016, SPARC supported several cross-cutting workshops in conjunction with other parts of WCRP and WMO. These workshops included ones on: Atmospheric Blocking with WWRP (Reading, UK); the Dynamics, Transport and Chemistry of the Asian Monsoon Upper Troposphere-Lower Stratosphere (Boulder, USA), the joint WMO-GAW/SPARC workshop on Observations in the Upper Troposphere-Lower Stratosphere (Geneva, Switzerland), and Drag Processes and their links to Large-scale Circulation with WGNE (Reading, UK). In 2016, numerous papers were published illustrating SPARC's significant contribution to CMIP6, through development of forcing data sets and CMIP6-Endorsed MIPs. In addition, the SPARC Scientific Steering Group held an open meeting on collaborations between SPARC and the WCRP Grand Challenges (Berlin, Germany) in order to identify productive synergies. We anticipate that this will lead to closer links between SPARC and these Grand Challenges in the near future.

Further, a report was commissioned to look into the sizeable discrepancy between the top-down and bottom-up estimates of carbon tetrachloride highlighted in the last WMO/UNEP Scientific Assessment. This report was finished in July 2016 and its findings have already been presented to the Parties of the Montreal Protocol. This illustrates SPARC's enduring ability to respond rapidly to requests from policy-makers as well as to coordinate and promote science issues which require longer-term collaborative research.

Finally, the value of support from national agencies and programmes to achieving SPARC science was illustrated by the extent and quality of work presented at the final meeting of the German SHARP programme of which SPARC was a co-sponsor. SPARC's success exists because of the extent and support of such support. In a time of tightening budgets it is important to build on and extend these links.

Thanks to everyone in the SPARC community and other WCRP colleagues for your time, energy, and enthusiasm that continue to make SPARC the vibrant project that it is.

Neil Harris and Judith Perlwitz

A Word from the Project Office

This year has again been a busy and productive one for the SPARC Office. In 2016 SPARC held or co-sponsored 15 workshops and one training school for which the SPARC Office organised the distribution of SPARC/WCRP travel support. The SPARC Office was particularly involved in the workshops on 'Atmospheric Blocking' and 'Dynamical Variability', for which we developed webpages and handled registration. As usual, we also helped organise the 24th SPARC SSG meeting, held in Berlin, Germany, in conjunction with a regional workshop entitled "Challenges for climate science – Synergies between SPARC and the WCRP Grand Challenges". This particular workshop was very useful in terms of establishing where SPARC could contribute most to the WCRP Grand Challenges. Finally, to honour the career of Johannes Staehelin, the SPARC Office organised a one-day symposium 'Ozone Research – Quo Vadis' in May 2016. Several renowned international scientists from the field were invited and overall the day provided an excellent occasion to establish the state of the art of ozone research, both stratospheric and tropospheric.

We continued efforts to ensure smooth communication within the SPARC community and beyond, through our website, eNews bulletins, the biannual SPARC newsletter, as well as by representing SPARC at various national and international meetings. As of early 2016, SPARC has also been active on social media (Facebook and Twitter), through efforts of both the SPARC Office and motivated members of the SPARC community. Considerable time has also been dedicated to the development of an extensive community database, which presently includes almost 2500 active addresses (both email and postal) and has been significantly updated over the past year.

The SPARC Office helped with the production of the 7th SPARC science report entitled 'Solving the mystery of Carbon Tetrachloride', which served as valuable input to the Parties of the Montreal Protocol. Furthermore, extensive work has gone into the layout and production of the 8th scientific report comparing satellite trace gas climatologies. This report is due to be published in hard and digital copies in March 2017. Finally, Fiona has also been involved in handling the review of the S-RIP (SPARC Reanalysis Intercomparison Project) Interim Report and the SPARC Office will help produce this report in digital version in the coming months as well.

Fiona contributes to the work of the SPARC Office at a level of 50%, and continues to devote the rest of her time to SPARC scientific activities (this latter 50% being supported by the Swiss National Science Foundation). At present she is contributing to two SPARC activities, namely 'Atmospheric Composition in the Asian Monsoon (ACAM)' and the 'Chemistry Climate Modelling Initiative' (CCMI). Johannes continues to work on a report for MeteoSwiss on the history of observations from Arosa, Switzerland. This report will provide an extensive overview of activity at this important measurement station and is to be completed in 2017.

The SPARC Office would warmly like to acknowledge the support of ETH Zurich, the Swiss Federal Office of Meteorology and Climatology (MeteoSwiss), and WCRP, as well the excellent collaboration and support of the WCRP Joint Planning Staff in Geneva.

The SPARC Office Team

Workshops & Meetings held in 2016

16 –1 9 February
SPARC workshop Stratospheric Change and its Role in Climate Prediction (SHARP)
Berlin, Germany

7 – 11 March
Workshop on dynamics, transport and chemistry of the UTLS Asian monsoon
Boulder, CO, USA

6 – 8 April
Workshop on Atmospheric Blocking
Reading, UK

25 – 26 April
Atmospheric Temperature Changes Workshop
Graz, Austria

25 – 28 April
2nd Workshop on Stratospheric Sulfur and its Role in Climate
Potsdam, Germany

16 – 20 May
Atmospheric Gravity Waves: Sources and Effects on Weather and Climate
State Collage, PA, USA

24 – 27 May
Joint GAW/SPARC Workshop on UTLS Observations
Geneva, Switzerland

6 – 10 June
SPARC DynVar Workshop & S-RIP Meeting (BDC+STC)
Helsinki, Finland

13 – 17 June
6th International HEPPA-SOLARIS Workshop
Helsinki, Finland

12 – 15 September
WGNE/SPARC Drag Processes Workshop
Reading, UK

26 – 30 September
12th SPARC QBO Workshop
Oxford, UK

17 – 19 October
SPARC DA Workshop
Victoria, BC, Canada

19 – 21 October
S-RIP 2016 Workshop
Victoria, BC, Canada

24 – 28 October
SPARC Polar Stratospheric Clouds Initiative Meeting
Bern, Switzerland

31 October – 1 November
WCRP/SPARC Workshop: Challenges for Climate Science
Berlin, Germany

1 – 4 November
24th SPARC Scientific Steering Group Meeting
Berlin, Germany

30 November – 2 December
WAVAS II Meeting
Karlsruhe, Germany

SPARC Activity Report Summaries

Atmospheric Composition and the Asian Monsoon (ACAM)

Activity Leaders: Laura Pan and James Crawford

Achievements in 2016

Several meetings were organised by ACAM throughout 2016. A workshop on Dynamics, Transport, and Chemistry of the UTLS Asian Monsoon was held at NCAR from 7-11 March 2016. A summary of the workshop was published in the July issue of the SPARC newsletter and September issue of Advances in Atmospheric Sciences. Details about the workshop can be found at: https://www2.acom.ucar.edu/asian-monsoon. Special Sessions focused on ACAM science were sponsored at the EGU and AOGS meetings.

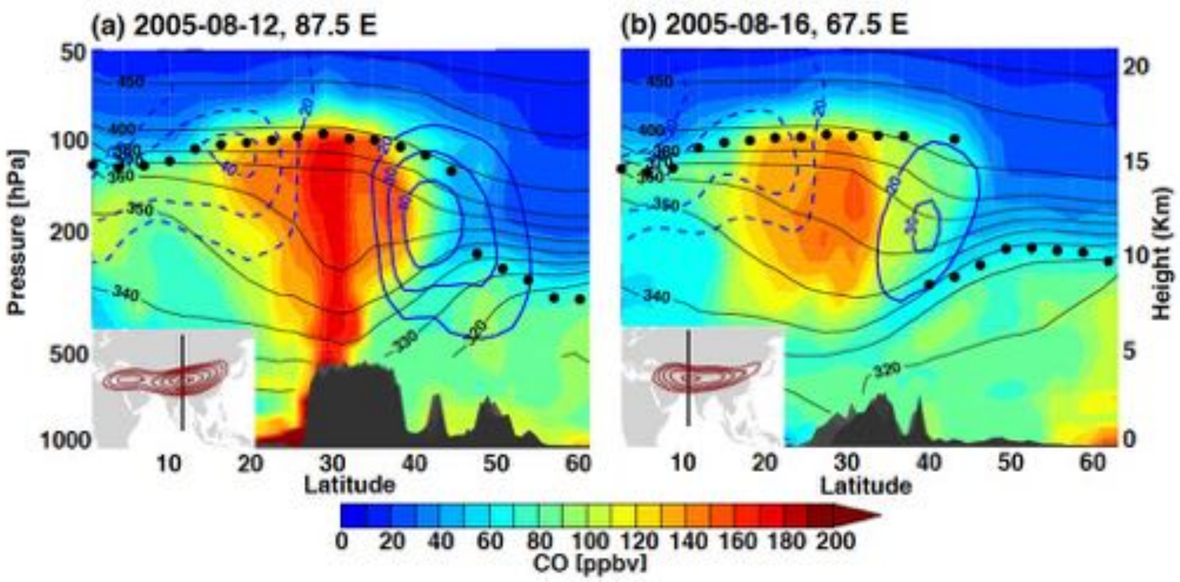

Figure 1: A model analysis of transport by the Asian monsoon system (CESM1/WACCM run in specified dynamics mode). The figure highlights the vertical transport of carbon monoxide, a pollution tracer, from the boundary layer to tropopause level in the centre of the anticyclone associated with the Asian summer monsoon. It also shows the sub-seasonal scale dynamics and the emission origin of the upper troposphere CO. Panels (a) and (b) show CO mixing ratio latitude-pressure (altitude) cross-sections for two selected longitudes and days representing the Tibetan (a) and Iranian (b) modes of the anticyclone, respectively. The locator map of each cross-section is shown in the lower left corner. Additional fields shown are the tropopause height (black dots), selected isentropes (K, thin black lines), locations of the easterly and westerly jets as indicated by selected zonal wind contours (m/s, blue dash and solid, respectively). Figure from Pan *et al.*, 2016.

Planning for the 3rd ACAM biennial workshop and the 2nd ACAM training school reached major milestones, including: 1) conference facilities have been identified and reserved, 2) the local organizing committee has been formed with representation from eleven Asian countries, and 3) significant sponsorship commitments for the workshop have been secured.

Finally, the ACAM Field Campaign Working Group played a significant role in coordinating a number of ground-based measurement campaigns surrounding the European StratoClim campaign (test flight in 2017).

Plans for the Coming Year

In the coming year ACAM will hold its 3rd ACAM biennial workshop and 2nd training school in June at Sun Yat-Sen University in Guangzhou, China. The activity leaders will also continue to develop working group activities to establish ACAM science-relevant data sharing and collaborations with the global modelling community (*e.g.*, CCMi and AeroCom). Last but not least, local measurement activities will be coordinated during the StratoClim Campaign.

References

Pan, L., *et al.*, 2016: Transport of chemical tracers from the boundary layer to stratosphere associated with the dynamics of the Asian summer monsoon. *J Geophys. Res. Atmos.*, **121**(23), 14149-14174.

SPARC Newsletter No. 47, 2016: Workshop on dynamics, transport, and chemistry of the UTLS Asian Monsoon. By R. Müller *et al.*, p. 24.

Activity website: www2.acom.ucar.edu/acam

Atmospheric Temperature Changes and their Drivers (ATC)

Activity Leaders: Amanda Maycock, Andrea Steiner, and Bill Randel

Achievements in 2016

The main achievements of the activity on Atmospheric Temperature Changes and their Drivers (ATC) were the relaunch and establishment of the ATC group, hosting a first Activity Workshop, and establishing plans to produce a community research paper by the end of 2017.

ATC group establishment: The ATC activity was established in early 2016 with new scientific foci on evaluating climate data records and their uncertainties - from the troposphere to the mesosphere - and on the attribution of observed and modelled temperature changes to key radiative and dynamical drivers. Given the expanded remit of the group compared to the former Stratospheric Temperature Trends activity, the group membership was reviewed and new members were appointed. The ATC membership now includes 21 members and 3 co-chairs, comprising expertise across a broad range of topics covered by the activity's remit. Joint memberships were also established with other relevant SPARC activities including: CCMI (Martin Dameris), HEPPA/SOLARIS (Amanda Maycock), S-RIP (Craig Long), WAVAS (Karen Rosenlof), SSiRC (Valentina Aquila), as well as to non-SPARC groups (e. g., GCOS GRUAN – Thierry Leblanc). The ATC group also includes new team members with expertise in tropospheric (Ben Santer, Leopold Haimberger) and mesospheric (Michael Schwartz) temperature changes and their drivers (Qiang Fu, Diane Ivy). More information and the full list of ATC members are given on the activity's webpage: www.sparc-climate.org/activities/temperature-changes.

Workshop: The ATC activity held its first workshop from 25-26 April 2016 in Graz, Austria. The workshop was organised by Andrea Steiner and Amanda Maycock. It was hosted by the Wegener Center for Climate and Global Change, University of Graz, providing meeting facilities, coffee breaks and lunch. The meeting was attended by more than half of the ATC members along with some additional participants interested in ATC topics. We thank SPARC for providing financial support for participants' travel and in particular for enabling the participation of early-career scientists.

The aims of the workshop were on the development and evaluation of climate data records from observational data sets and reanalyses, and on the understanding of the drivers of atmospheric temperature changes in observations and models. Plans were discussed for the ATC activity to begin work on a community paper providing information on updated climate temperature records from different observational sources, their consistency, and uncertainties. Preliminary plans were also discussed for some coordinated analysis of atmospheric temperature variability and trends in CCMI simulations in coordination with other interested groups. A full meeting report appeared in the July 2016 SPARC Newsletter (Maycock *et al.*, 2016).

Several relevant papers have been published by ATC activity members this year on observational records including merged stratospheric temperature records from AMSU and SSU (Zou *et al.*, 2016) and SSU, MLS, and SABER measurements (Randel *et al.*, 2016). Stratospheric temperature changes have been analysed for different time periods based on different observational data sets (Funatsu *et al.*, 2016; Randel *et al.*, 2016; Seidel *et al.*, 2016). Updated and improved satellite retrievals of the temperature of the mid- to upper troposphere (TMT) and their agreement with model-derived TMT values have been recently assessed by Santer *et al.* (2016). Publications on radiative and dynamic influences on polar stratospheric temperature trends by Ivy *et al.* (2016), the effects of different forcing agents on historical temperature trends (Aquila *et al.*, 2016), and on the contribution of ozone to future stratospheric temperature trends by Maycock (2016) contribute to the ATC topic on the drivers of temperature changes.

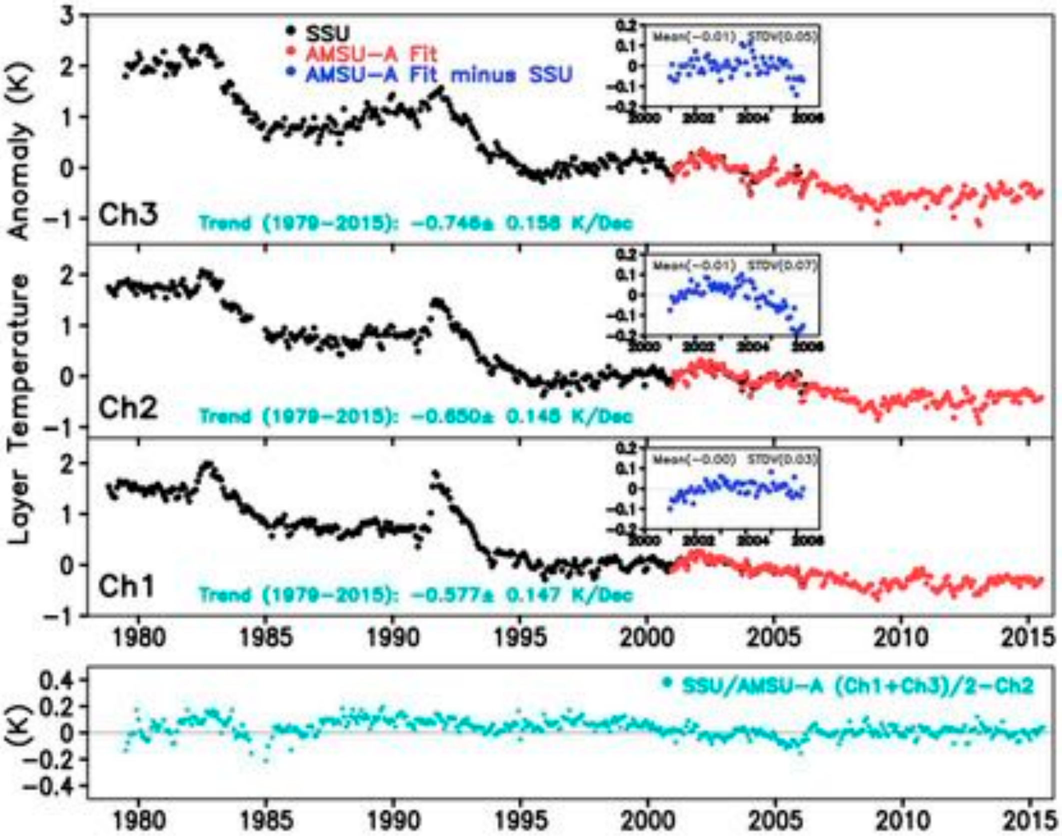

Figure 2: Timeseries of global mean stratospheric temperatures and their linear trends over 1979-2015 for the merged SSU/AMSU-A record sampled for the three SSU channels. Figure from Zou and Qian (2016).

Plans for the Coming Year

Going forwards the next focus for the ATC activity is on producing a community publication on climate data records for temperature and their uncertainties – plans are currently being put in place to achieve this. The activity co-chairs have also organised a session for the EGU General Assembly 2017 entitled "Past and future atmospheric temperature changes and their drivers". We plan to hold a splinter meeting at the EGU meeting for ATC members to discuss the joint publication. In order to ease communication between activity members we plan to create an email list and collect information on group news to be compiled into a regular (~biannual) short newsletter/report also as input for the SPARC newsletters. The 2nd Workshop of the ATC activity is planned for 2018.

References

Aquila, V., *et al.*, 2016: Isolating the roles of different forcing agents in global stratospheric temperature changes using model integrations with incrementally added single forcings. *J. Geophys. Res. Atmos.*, **121**, 8067–8082.

Ivy, D. J., *et al.*, 2016: Radiative and dynamical influences on polar stratospheric temperature trends. *J. Clim.*, doi:10.1175/JCLI-D-15-0503.1

Randel, W. J., *et al.*, 2016: Stratospheric temperature trends over 1979-2015 derived from combined SSU, MLS and SABER satellite observations. *J. Clim.*, doi:10.1175/JCLI-D-15-0629.1.

Santer, B. D., *et al.*, 2016: Comparing tropospheric warming in climate models and satellite data. *J. Clim.*, **30**, 373-392.

Seidel, D. J., *et al.*, 2016: Stratospheric temperature changes during the satellite era. *J. Geophys. Res. Atmos*., **121**, 2015JDO24039.

SPARC Newsletter No. 47, 2016: Report on the 1st Atmospheric Temperature Changes and their Drivers (ATC) activity workshop. By: Maycock, A. C., *et al.*, p. 36.

Zou, C.-Z., and H. Qian, 2016: Stratospheric temperature climate data record from merged SSU and AMSU-A observations. *J. Atmos. Oceanic Techn*., http://dx.doi.org/10.1175/JTECH-D-16-0018.1

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

IGAC/SPARC Chemistry-Climate Model Initiative (CCMI)

Activity Leaders: Bryan Duncan and Michaela Hegglin

Achievements in 2016

The CCMI modellers have once again contributed the elephant's share of this year's achievements, working on finishing the CCMI phase-1 model simulations and uploading more than 50 TB of output to the BADC CCMI data archive (http://badc.nerc.ac.uk/home/index.html). The modelling groups who are participating in the CCMI MIP can be found at: http://blogs.reading.ac.uk/ccmi/participating-models.

CCMI researchers have begun using these simulations for science evaluations related to stratospheric and tropospheric ozone and to identify key issues in the performance of the available models, relate these issues to radiative, physical, and chemical processes, and thereby feed back on model development. To provide an overview of ongoing evaluations, CCMI has updated the planned science analyses document with input from CCMI data users around the world (see www.met.reading.ac.uk/~qr903932/CCMI-website/Wordpress_PDFs/CCMI1_PlannedAnalysis_20161208.pdf). These analyses are expected to be presented at the 2017 CCMI science workshop to be held in Toulouse, France, in June.

Model Name	REF-C1 (1960-2010)	REF-C2 (1960-2100)	REFC1SD (1980-2010)
ACCESS CCM	1	2	
CCSRNIES MIROS3.2	3	1	1
CESM1 CAM4-chem	3	3	1 (NASA MERRA)
CESM1 WACCM	5	3	1 (NASA MERRA)
CHASER (MIROC-ESM)	1	1	
CMAM	3	1	1
CNRM-CM5-3	4	2	2
EMAC	2	3	4
GEOSCCM	1	1	1
GFDL-AM3			1 (Lin *et al.* 2014)
GFDL-CM3		5	
HadGEM3-ES	1	1 (+2)	(2)
LMDz-REPROBUS	1 (L39)	1 (L39)	1 (L39)
MRI-ESM1r1	1	1	1
MOCAGE	1	(1)	1
NIWA-UKCA	3	5	
SOCOL	4	1	
TOMCAT			1
ULAQ-CCM	3	3	
UMSLIMCAT	1	1	
UMUKCA-UCAM	1	2	1
Total	**39**	**38**	**19**

Table 1: Numbers of CCMI-1 reference simulations (REF-C1, REF-C2, and REF-C1SD) by model. Numbers in brackets denote simulations that were still incomplete in February 2017 (from Morgenstern *et al.*, 2017).

CCMI held a side meeting at the 2016 IGAC Science Conference from 26-30 September 2016 in Breckenridge, Colorado, with around 30-40 participants attending. Communication with the CCMI community is being enhanced through quarterly CCMI e-News, which highlight recent developments within CCMI and provide new directions to the CCMI community.

CCMI published an overview paper on the CCMI phase-1 models (Morgenstern *et al.* (2017), www.geosci-model-dev.net/10/639/2017) and the CCMI community is starting to publish CCMI-related science papers in the joint special issue of ACP/AMT/GMD (www.geosci-model-dev.net/special_issue10_812.html). CCMI also contributed to the AerChemMIP overview paper (Collins *et al.*, 2017, www.geosci-model-dev.net/10/585/2017). Finally, a SPARC newsletter article on the 2015 science workshop published by Hegglin et al. (2016).

Plans for the Coming Year

By spring 2017 the transfer of CCMI phase-1 simulations to the BADC and ESGF is expected to be finalized by the different CCMI modelling groups. Scientific evaluations of the CCMI phase-1 simulations are currently still ongoing and will be strongly enhanced to address major outstanding questions related to stratospheric ozone depletion and recovery given the gearing up of the WMO ozone assessment report activities. CCMI publications are hence envisaged to peak in 2017. The CCMI community is encouraged to submit their papers to the joint CCMI special issue in ACP/ESSD/AMT/GMD (see www.atmos-chem-phys.net/special_issue812.html), however other journals will be targeted as well.

CCMI will further strengthen the activities going on in the three focus groups on (1) tropospheric OH and ozone budgets, (2) specified dynamics simulations, and (3) ocean-atmosphere coupling in CCMI models.

Over the coming year, the CCMI leadership (co-chairs and SSG) will discuss a new timeline and plans for CCMI in consultation with the broader CCMI community.

References

Morgenstern, O., *et al.*, 2017: Review of the global models used within phase 1 of the Chemistry-Climate Model Initiative (CCMI). *Geosci., Model Dev.*, **10**, 639-371.

SPARC Newsletter No. 26, 2016: Report on the IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) 2015 Science Workshop. By M. Hegglin *et al.*, p. 37.

Activity Website: www.met.reading.ac.uk/ccmi

Data Assimilation Working Group

Activity Leader: Quentin Errera and John McCormack (as of November 2016)

Achievements in 2016

The SPARC Data Assimilation Working Group (DAWG) provides a forum for data assimilators, data providers, modellers, and end-users to share results and discuss future research directions relevant to current SPARC themes. The 2016 DAWG workshop was held on 17-19 October in Victoria (BC, Canada). As with the preceding two workshops, this meeting was held in conjunction with the SPARC Reanalyses Intercomparison Project (S-RIP) workshop on 19-21 October in order to foster close collaboration between researchers in the fields of both stratospheric data assimilation and reanalysis. The first two days of the DAWG workshop offered presentations of new research in stratospheric and mesospheric data assimilation and modelling by invited speakers from leading operational numerical weather prediction centres. The invited presentations were supplemented by a broad range of contributed presentations representing both researchers and end-users of data assimilation products. The third day of the workshop was a joint session of both DAWG and S-RIP activities.

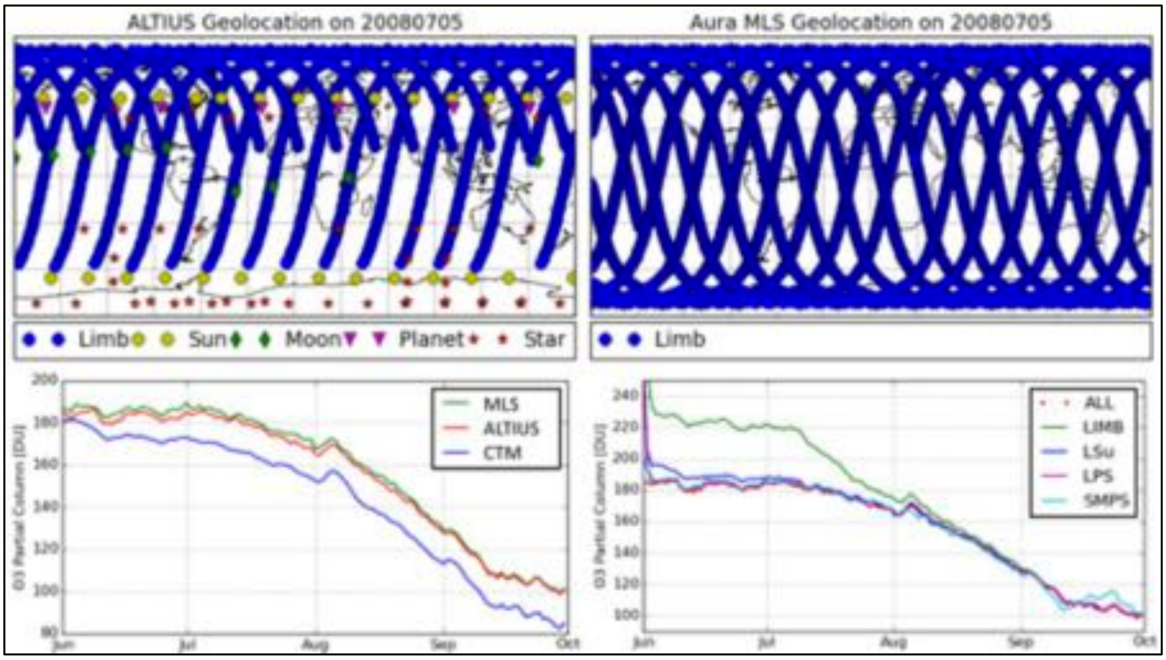

Figure 3: During the 2016 workshop, the Atmospheric Limb Tracker for Investigation of the Upcoming Stratosphere (ALTIUS) mission was presented. ALTIUS has been endorsed by the ESA Earth Watch program and is expected to launch sometime in 2020-2021, providing profiles from limb UV measurements during daytime and occultations (sun, stars, moon and planets) during nighttime.

One highlight of the 2016 DAWG workshop was a preview of the upcoming ALTIUS mission by Emmanual Dekemper of the Belgian Institute for Space Aeronomy. Figure 3 shows simulated stratospheric ozone analyses created using assimilation of Aura MLS observations by the Belgian Assimilation System for Chemical ObsErvations (BASCOE) and geolocation of ALTIUS measurements.

The upper row shows the expected geolocation of ALTIUS (left) as compared to Aura MLS (right) for 5 July 2008. The lower left figure shows the time series of ozone partial column between 10-100hPa and 90°S-60°S from MLS assimilation as well as from ALTIUS assimilation of pseudo-observations and from a chemistry transport model simulation (no assimilation). Despite the lower number of observations, especially over the pole during the polar night, ALTIUS agrees very well with MLS. The lower right figure also shows the ozone partial column obtained from ALTIUS assimilation for: all observations (ALL); limb daytime observations (LIMB); limb and solar occultations (LSu); limb, planet, and star occultations (LPS); and all but limb observations (SMPS). Clearly, all modes are necessary to get the right amount of ozone during the polar winter. In particular, solar and stellar observations are necessary to constrain ozone during the polar night and limb observations are necessary when the sunlight returns at the end of the polar night.

More information about this and other presentations from the 2016 DAWG workshop can be found at the workshop website: https://events.oma.be/indico/event/12/. The financial support from WCRP/SPARC enabled a scientist from a developing country (Cameroon) to attend the DAWG workshop.

In addition to the workshop, several members of DAWG wrote a white paper for the NASA decadal survey to promote a new limb sounding satellite mission. DAWG leader Quentin Errera also represented SPARC at the 2016 GCOS conference (Amsterdam, Holland) with a poster to promote this mission.

Plans for the Coming Year

In 2017, DAWG will hold its workshop at ECMWF (Reading, UK) from 25-27 October. As for past years, it will be held jointly with an S-RIP workshop (23-25 October). Themes for this year's workshop will likely include development of new observing system simulation experiment (OSSE) capabilities for the stratosphere, the role of stratospheric data assimilation in support of assessing trends in the state of the upper troposphere/lower stratosphere, and continuation of relevant DAWG topics such as implementation of new data assimilation techniques and extension of current data assimilation systems into the upper stratosphere and mesosphere.

Activity Website: www.sparc-climate.org/activities/data-assimilation

Dynamical Variability (DynVar)

Activity Leaders: Elisa Manzini and Edwin Gerber

Achievements in 2016

A major achievement of DynVar over the past couple of years has been to organize participation of the atmospheric dynamics and stratosphere-tropospheric coupling communities in CMIP6. These discussions culminated in the establishment of DynVarMIP, a diagnostic model intercomparison project endorsed by CMIP6 and described in the 2016 publication: The Dynamics and Variability Model Intercomparison Project (DynVarMIP) for CMIP6: assessing the stratosphere–troposphere system, by Gerber and Manzini in the journal Geoscientific Model Development. Approximately ten model centres have committed to providing extended diagnostics of the atmospheric circulation as part of DynVarMIP.

Figure 4: Participants of the 2016 DynVar Workshop held at the Finnish Meteorological Institute in Helsinki.

During 2016, DynVar held a workshop in Helsinki, kindly hosted by Alexey Karpechko and the Finnish Meteorological Institute, which was attended by about 70 scientists from 4 continents. Travel support for early career scientists was provided by WCRP-SPARC and the US NSF. In addition to providing a forum to discuss research in atmospheric dynamics, the workshop provided the opportunity to openly discuss the DynVarMIP (the GMD paper was in review at the time). The open comments submitted after the workshop to the GMD DynVarMIP paper greatly improved the DynVarMIP data requests. The workshop outcomes were reported in the January 2017 SPARC newsletter (Gerber *et al.*, page 26).

Briefly, the DynVarMIP proposes a set of diagnostics to enable a mechanistic approach to confront model biases and understand the underlying causes behind circulation changes. The DynVarMIP primarily addresses CMIP6 key science questions on the origin and consequences of systematic models biases in the context of atmospheric dynamics.

Plans for the Coming Year

DynVar is now entering the phase of waiting for the CMIP data sets and self-organizing to respond to the research call of DynVarMIP.

References

Gerber, E.P., and E. Manzini, 2016: The Dynamics and Variability Model Intercomparison Project (DynVarMIP) for CMIP6: Assessing the Stratosphere-Troposphere System. *Geosci. Model Dev.*, **9**, 3413-3425.

SPARC Newsletter No. 48, 2017: The large-scale Atmospheric Circulation: Confronting Model Biases and Uncovering Mechanisms SPARC/DynVar and S-RIP Workshop. By E. Gerber *et al.*, p. 26.

Activity Website: www.sparcdynvar.org

Gravity Waves

Activity Leaders: Joan Alexander, Kaoru Sato, and Fuqing Zhang
Dr. Fuqing Zhang, Professor of Meteorology at Penn State University, joined as co-leader of the SPARC Gravity Wave Activity beginning in June 2016.

Achievements in 2016

The activity leaders were busy in 2016 organizing and hosting two major meetings that included many in the gravity wave community.

The SPARC Gravity Wave activity held its 5th Symposium at Penn State in State College, Pennsylvania from 16-20 May 2016. The first of these symposia was held in 1986, with a focus on parameterization of gravity wave drag in global models. These symposia, held once every five years, have provided a forum to focus on timely issues relevant to gravity wave processes. This year, the symposium brought together researchers interested in gravity wave influences on weather together with the traditional SPARC focus on climate processes. The keynote address was given by Louis Ucellini, Director of the US National Weather Service. Session topics included: (1) Weather-significant gravity waves, (2) Convective gravity wave generation, (3) Jet-frontal generation, (4) Turbulence and energy spectra, (5) Cirrus Clouds, (6) Explicit simulation, (7) Airglow and upper atmosphere, (8) Parameterizations and large-scale circulation effects, and (9) New observational results (particularly the DEEPWAVE campaign and Antarctic PANSY radar).

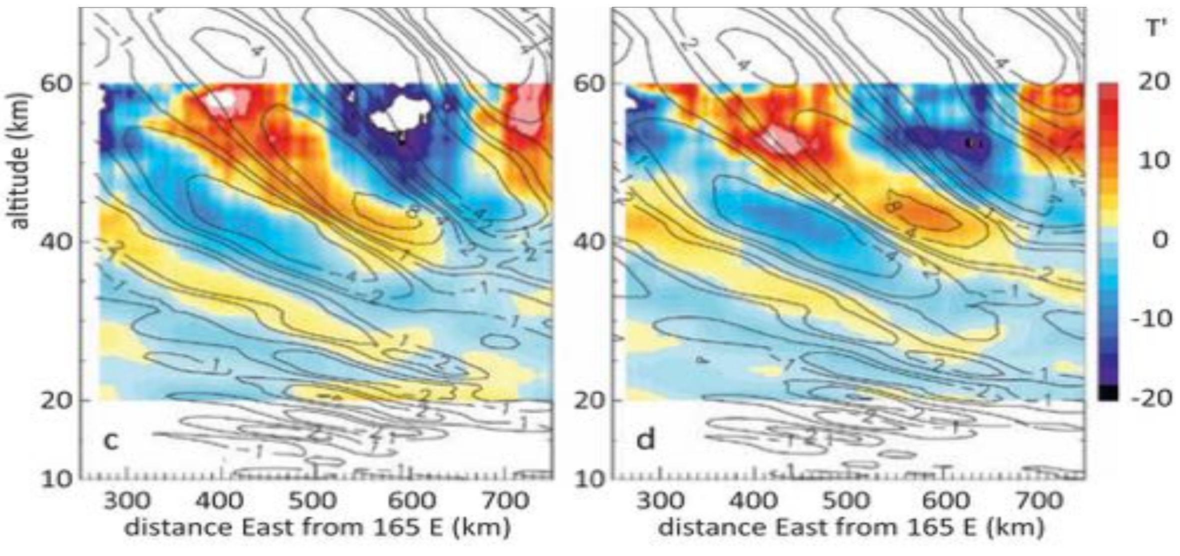

Figure 5: Results from the DEEPWAVE campaign showing temperature anomalies as measured by an airborne Rayleigh lidar (color) from two flights over Mt. Cook, New Zealand. ECMWF forecast system/analysis temperature anomalies interpolated to the position/time of the aircraft are also shown (contours) revealing remarkably accurate prediction of the horizontal and vertical structure of the observed waves. The amplitudes of the waves in the forecast are similar to the observations below ~40 km, but are significantly underestimated above. Note also the smaller horizontal-scale waves above 40km in the observations that are missing from the forecast. Figure from Fritts *et al.* (2016).

Outcomes of the meeting were summarized in the January 2017 issue of the SPARC Newsletter. The Symposium ended with a group meeting to discuss future directions of the field in the two focus areas of weather and climate in terms of required observations and modelling needs, as well as a discussion about future directions for the SPARC Gravity Wave activity in particular. The discussion focused on the roles of gravity waves in predictability across a range of timescales from weather to near-term climate. Key observational needs were identified related to gravity waves from jet-frontal sources, where such observations could lead to improved models across these timescales.

Second, the International Symposium on the Whole Atmosphere (ISWA) was held at the University of Tokyo campus this year September 14-16. This meeting brought researchers interested in gravity waves together with those interested in dynamics at all levels of the atmosphere from the surface to the ionosphere. (http://pansy.eps.s.u-tokyo.ac.jp/iswa).

Plans for the Coming Year

Motivated by presentations and discussions during the recent gravity wave symposium, a focus area for the SPARC gravity wave activity will be on data-model integration to better understand and parameterize the dynamics and impacts of gravity waves across different spatio-temporal scales. Near-term progress is needed in several areas including:

(1) Systematic evaluation of the fidelity of explicit representation or misrepresentation of gravity waves within increasingly high resolution regional to global models and analysis products utilizing all available observations. For example, what are the minimum required horizontal and vertical resolutions required to simulate observed gravity waves? How predictable are gravity waves processes at different wave scales? What are the impacts of gravity waves on predictability across weather and climate timescales?

(2) Development work for advanced data assimilation methods that can utilize the diverse set of in-situ and remotely sensed gravity wave observations. In particular, a focused workshop to identify and discuss the key obstacles and available tools is a high priority for the next year.

References

Fritts, D. C., *et al.*, 2016: The Deep Propagating Gravity Wave Experiment (DEEPWAVE): An airborne and ground-based exploration of gravity wave propagation and effects from their sources throughout the lower and middle atmosphere. *Bull. Amer. Meteor. Soc.*, doi:10.1175/BAMS-D-14-00269.1.

SPARC Newsletter No. 48, 2016: Report on the SPARC Gravity Wave Symposium. By F. Zhang *et al.*, p. 22.

Activity Website: www.sparc-climate.org/activities/gravity-waves

Polar Stratospheric Clouds Initiative (PSCi)

Activity Leaders: Michael Pitts, Ines Tritscher, Lamont Poole, and Thomas Peter

Achievements in 2016

Several papers arising from the PSCi activity have been published or are in preparation. Spang *et al.* (2016) presented a new infrared PSC classification scheme based on the combination of a well-established two-colour ratio method and multiple 2D brightness temperature difference probability density functions. The entire Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) measurement period was processed with this new classification approach to produce an updated MIPAS PSC climatology. Comparisons to the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) have been performed and the potential for detailed PSC process studies has been shown in examples. Lambert *et al.* (2016) used satellite-borne measurements collected over the last decade (2006–2015) from the Aura Microwave Limb Sounder (MLS) and CALIOP to investigate the nitric acid distribution and the properties of PSCs in the early winter Antarctic vortex.

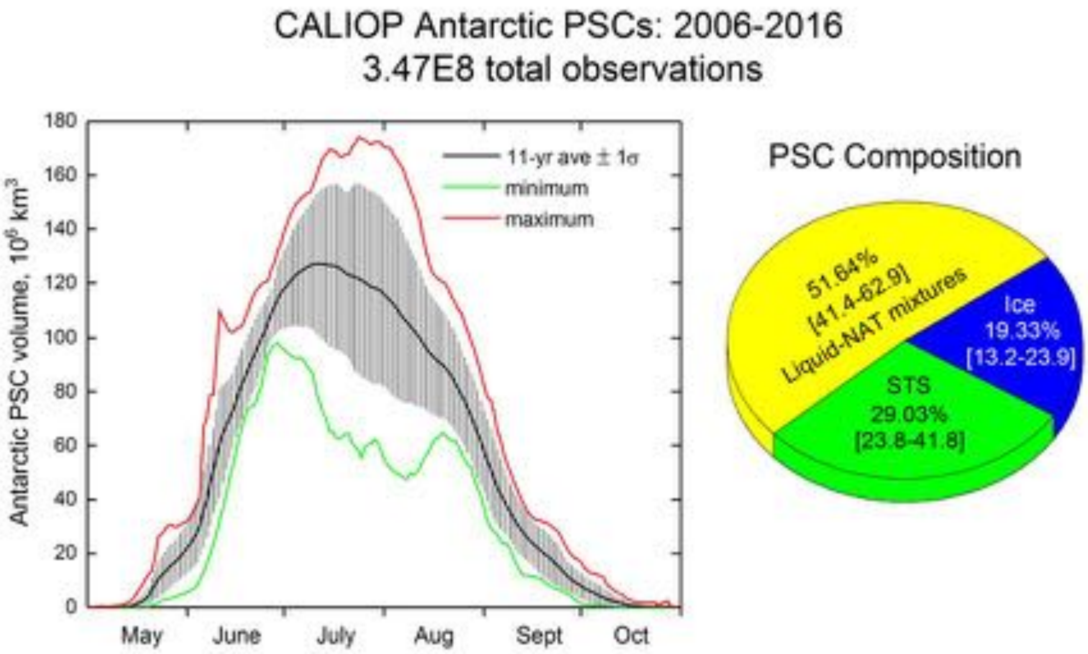

Figure 6: (Left) Time series of Antarctic PSC spatial volume for 2006-2016: 11-year average ±1std, minimum and maximum in any year. (Right) Composition breakdown of PSC observations for the same period: 11year average percentages and [minimum, maximum] percentages in any year.

Woiwode *et al.* (2016) examined MIPAS-STR observations over the Arctic and found evidence of large, highly aspherical NAT particles that may play an important role in denitrification of the polar stratosphere. Besides denitrification, also dehydration of the polar stratosphere will soon be represented in the Chemical Lagrangian Model of the Stratosphere (CLaMS). Tritscher *et al.* (in preparation) are working on an improved representation of PSCs in CLaMS. Pitts *et al.* (in preparation) are developing a decadal climatology of PSCs from CALIOP spaceborne lidar data using an improved PSC detection and composition classification algorithm. This algorithm includes a number of modifications that improve the detection of tenuous PSCs and discrimination between ice and NAT mixtures. An example of the unique data that CALIOP is providing is shown in Figure 6, which shows mean spatial coverage of PSCs and its variability over the past 11 years for the Antarctic, along with a breakdown of the observations by composition.

The second PSCi workshop was held at ISSI-Bern from 24-28 October 2016 and attended by 14 team members. The main objectives were to define the basic content and timeline for producing the comprehensive PSC review paper targeted for Reviews of Geophysics. In addition, we identified a number of papers that need to be completed in the coming months that will feed into the review paper.

The project employed an undergraduate intern during the summer of 2016 to work with the University of Wyoming Optical Particle Counter (OPC) balloon long-term data record from McMurdo, Antarctica to better characterize PSC particle sizes and number densities. The results of this study will be summarized in a paper.

Plans for the Coming Year

The PSCi team plans to finalize all additional papers that will feed into the review paper. We will then develop detailed outlines of each review paper chapter and identify potential figures. The third PSCi workshop will be held at ISSI-Bern in November 2017 with the goal of finalizing the first draft of the review paper.

References

Spang, R., *et al.*, 2016: A multi-wavelength classification method for polar stratospheric cloud types using infrared limb spectra, *Atmos. Meas. Tech.,* **9**, 3619–3639.

Lambert, A., M. Santee, and N. Livesey, 2016: Interannual variations of early winter Antarctic polar stratospheric cloud formation and nitric acid observed by CALIOP and MLS, *Atmos. Chem. Phys.,* **16***,* 15219–15246.

Woiwode, W., *et al.*, 2016: Spectroscopic evidence of large aspherical β-NAT particles involved in denitrification in the December 2011 Arctic stratosphere, *Atmos. Chem. Phys.,* **16***,* 9505-9532.

Activity Website: www.sparc-climate.org/activities/polar-stratospheric-clouds

Quasi-biennial Oscillation Initiative (QBOi)

Activity Leaders: James Anstey, Neal Butchart, Kevin Hamilton, and Scott Osprey

Achievements in 2016

Following the March 2015 Victoria workshop, an experiment and data protocol was created for the phase-one QBOi experiments: a set of five types of GCM experiment for coordinated intercomparison. Most of the groups have finished running these experiments and eleven of these groups have uploaded their results to the shared data archive at the BADC.

The activity held its second workshop, from 26-30 September 2016, in Oxford, UK. Funding was gratefully received from the UK NERC and Finnish Meteorological Institute, while early career researcher travel funding was welcomed from WCRP-SPARC. Plans for five core papers, analysing the results of the phase-one experiments, were actively agreed on by participants at the workshop. A Quarterly Journal of the Royal Meteorological Society special collection will be created for these QBOi papers. Another paper, to be submitted to Geoscientific Model Development (GMD), will describe the experiments and models participating in the phase-one QBOi experiments, to document the current state of the project and serve as a reference for the other papers. The workshop has been described in the January 2017 SPARC newsletter.

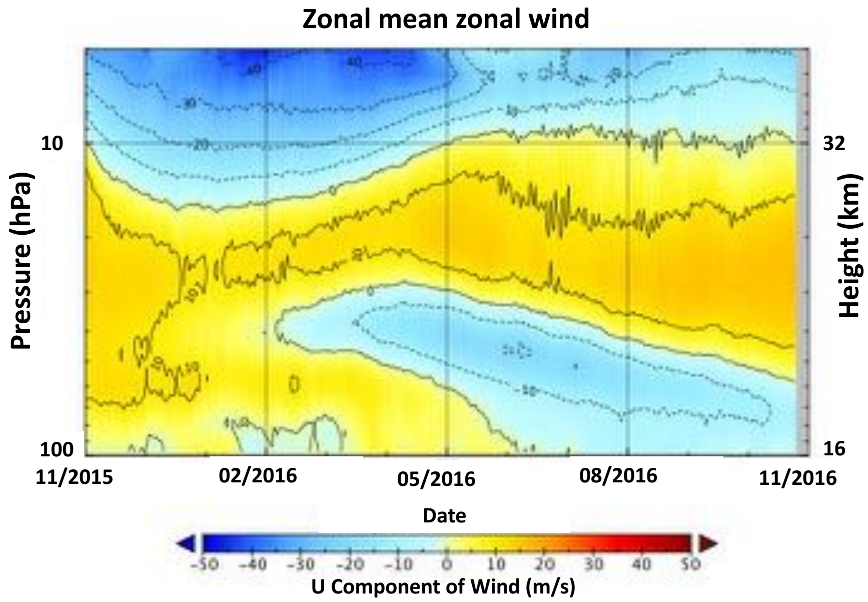

Figure 7: Vertical profile timeseries of 6-hourly zonal-mean zonal wind from the ECMWF Operational Analysis showing the recent disruption of the QBO and its recovery. Units are m/s.

An unanticipated outcome of QBOi was the Osprey *et al.* 2016 Science paper on the unprecedented QBO disruption of early 2016. The author team was built on the QBOi steering committee and UK Met Office seasonal forecasters who first alerted us of the disruption. The close collaboration already in place for QBOi allowed for a quick coordinated analysis and subsequent paper.

A paper detailing a proposed set of metrics to describe the morphological characteristics of the QBO in models and reanalyses, which was a focus of discussion at the 2015 Workshop in Victoria, has been submitted to GMD.

Following a Coordinated Research Action on climate predictability and inter-regional linkages, the activity has benefited from funding coordinated under the auspices of the Belmont Forum and JPI-Climate. This is directly funding QBOi research groups and co-supporting co-aligned meetings with the Globally Observed Teleconnections in Hierarchies of Atmospheric Models (GOTHAM) consortium.

Plans for the Coming Year

A workshop is planned for October 2017 in Kyoto, Japan. This workshop is to be held with the SPARC FISAPS and SATIO-TCS activities, to help identify opportunities for joint ventures (e.g. drivers of recent QBO variability) and to reduce travel.

Most data for the phase-one QBOi experiments has been uploaded to the project CEDA archive. The core papers are expected to be submitted by June 2017 so that their results can be presented and discussed at the October 2017 workshop. We anticipate that completion of the phase-one core papers will provide the foundation for discussion of phase-two QBOi experiments as well as cross-cutting initiatives at the October 2017 workshop.

Plans for the proposed QBO position/review paper were put on hold due to the rapidly changing position in our understanding of the QBO resulting from the 2016 disruption. Preparation of the position/review paper will be revisited during the next year.

References

Osprey, S. M., *et al.*, 2016: An unexpected disruption of the atmospheric quasi-biennial oscillation. *Science*, **353**, 1424-1427.

SPARC Newsletter No. 48, 2017: Report on the SPARC QBO Workshop: The QBO and its Global Influence – Past, Present and Future. By J. Anstey *et al.*, p. 33.

Activity Website: http://users.ox.ac.uk/~astr0092/QBOi.html

Stratospheric Network for Assessing Predictability (SNAP)

Activity Leaders: Andrew Charlton-Perez and Gregory Roff (stepped down; as of November 2016 Amy Butler)

Achievements in 2016

Over the past year, SNAP has been able to make a significant change in direction towards partnership with the WWRP/WCRP sub-seasonal to seasonal (S2S) prediction project. In the early part of the year we published a new plan for our activity in the January 2016 edition of the SPARC newsletter, including new science questions which focus on this change of direction. An example of the kind of work which is possible using this data was published in the paper by Tripathi *et al.* (2015) entitled "Enhanced long-range forecast skill in boreal winter following stratospheric strong vortex conditions".

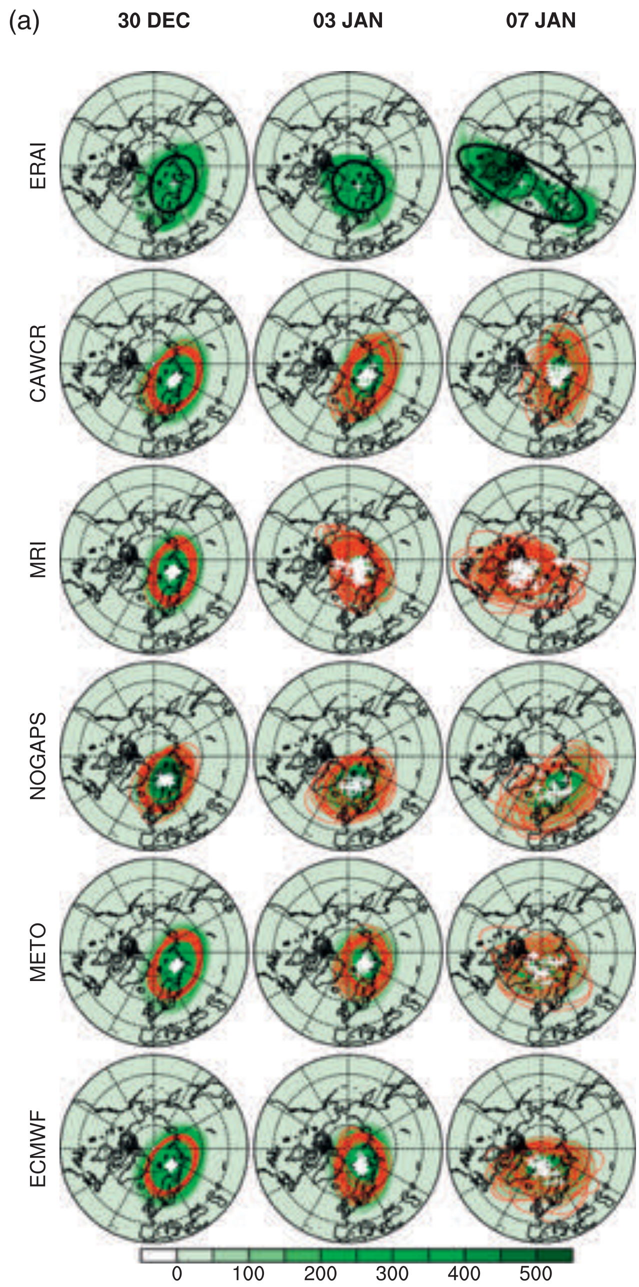

Figure 8: An example of the analysis conducted in phase-1 of SNAP. Comparison of vortex evolution for forecasts of the January 2013 stratospheric sudden warming event from a number of different operational models. Coloured ellipses are the equivalent ellipse calculated using elliptical diagnostics. Green-filled contours denote the potential vorticity (PV) values relative to the mean PV values between 45°-90°N calculated by subtracting the mean PV value between 45°-90°N from modified PV.

SNAP activity leaders attended a number of events, including the DynVar meeting in June and the QBOi workshop in October, to promote this change of direction. At these workshops, SNAP worked to build a community of scientists interested in leading the analysis of the S2S and other sub-seasonal forecast data sets to explore the role of stratosphere-troposphere coupling on forecast skill.

The SNAP team also completed publication of work from phase 1 of SNAP by producing a review of the predictability of the January 2013 stratospheric sudden warming event in a number of operational forecast systems (see Tripathi, *et al.*, 2016)

Plans for the Coming Year

Over the next year there are a number of key plans:

- Appoint a new co-lead and refresh steering group: Unfortunately Greg Roff had to step down as co-lead of the project. We thank him for his hard work in establishing and promoting SNAP. Recently we proposed that Amy Butler take on the role of co-lead. We have also written to members of the steering group asking if any of them would like to stand down at this stage with the aim of refreshing and reviewing this group in the coming months.
- Continue to promote and co-ordinate analysis of sub-seasonal forecast data: On our website we are collecting information about projects that members of the SNAP community are working on to enable community collaboration and interaction.
- Write a chapter on sub-seasonal predictability and the stratosphere in a forthcoming book: As a means of bringing together the community to focus on SNAP issues and key questions SNAP scientists will co-author a chapter in a forthcoming book on sub-seasonal predictability. This group will include Amy Butler, Andrew Charlton-Perez, Daniela Domeisen Pete Hitchcock, Chaim Garfinkel, Alexey Karpechko and Isla Simpson.

Reference

Tripathi, O.P., *et al.*, 2015: Examining the predictability of the Stratospheric Sudden Warming of January 2013 using multiple NWP systems. *Monthly Weather Review*, **144** (5), 19351960.

Activity Website: www.met.reading.ac.uk/research/stratclim/snap/index

Solar Influences (SOLARIS-HEPPA)

Activity Leaders: Bernd Funke and Katja Matthes

Achievements in 2016

Several new SOLARIS-HEPPA working groups have been established to systematically analyse the CCMI experiments with respect to the solar (irradiance and particle) forcing (see also SPARC newsletter No. 46). This activity is the first joint analysis of SOLARIS-HEPPA in addition to the comprehensive solar forcing recommendation produced for CMIP6. So far, the impact of solar irradiance signals and energetic particles have been analysed separately in observations and (chemistry) climate models. However, the new experiments available from within the SPARC CCMI activity will allow a joint evaluation of solar cycle signals with a special focus on their respective relevance for surface climate. One outstanding question is whether the 2-year lagged signal in the North Atlantic is due to atmosphere-ocean interaction or whether energetic particles also play a role. The new working groups are:

- WG1 (lead: Ulrike Langematz and Gabriel Chiodo) Stratospheric Signal: This WG will analyse the solar irradiance and particle effect on the stratosphere in both historical (1960-2010) and future (2010-2100) simulations, *i.e*. REF-C1 and REF-C2.
- WG2 (lead: Kleareti Tourpali and Stergios Misios) Surface Signal: This WG will analyse the solar irradiance and particle effect on surface climate taking atmosphere-ocean coupling processes into account in both historical (1960-2010) and future (2010-2100) simulations, i.e. REF-C1 and REF-C2.
- WG3 (lead: Eugene Rozanov, Amanda Maycock, and Alessandro Damiani) Comparison with (satellite) observations: This WG will compare the observed solar signal resulting from solar irradiance and particle forcing in the atmosphere with the specified dynamics experiments covering the satellite era from 1980-2010 (i.e. REF-C1SD).
- WG4 (lead: Rémi Thiéblemont and Will Ball) Methodological Analysis: This WG will do a thorough comparison of existing statistical approaches to analyse solar signals in model and observational data. In a first step a multiple linear regression (MLR) code will be made available on the SOLARIS-HEPPA website. In a second step the limitations of the MLR will be discussed and other (non-linear) statistical methods will be tested for their applicability to solar signals in the atmosphere.
- WG5 (lead: Miriam Sinnhuber and Hilde Nesse Tyssøy) Medium Energy Electrons (MEE) Model-Measurement intercomparison: The WG will compare observed chemical responses to MEEs in the mesosphere with available model simulations that account for MEE ionization, e.g., by including the newly available MEE parameterisation for CMIP6 (Matthes *et al.*, 2016).

The 6th HEPPA-SOLARIS workshop took place at the Finish Meteorological Institute in Helsinki, Finland, from 13-17 June 2016 (http://heppa-solaris-2016.fmi.fi/). The workshop covered a whole week and included ample discussion time after talks and posters. Several splinter meetings took place most of which were dedicated to setting up the new SOLARIS–HEPPA working groups for the analysis of solar signals in CCMI data.

The CMIP6 solar forcing data set has been finalised and is available on the SOLARIS-HEPPA website. The data set includes irradiance and particle forcing for the piControl, the historical simulation (1850-2014), and a future reference scenario (2015-2300). Additional data sets for sensitivity studies (piControl with solar cycle variations, extreme Maunder minimum-type future scenario) are also available. The description of the solar forcing has been written for the CMIP6 special issue in GMD (Matthes *et al.*, 2016) and is currently under revision.

The detection and attribution model intercomparison project (DAMIP) protocol has been published in the same CMIP6 GMD special issue (Gillett *et al.*, 2016). DAMIP includes SolarMIP experiments, in particular a solar-only historical simulation (hist-sol) that will allow for a better characterisation of the solar signal on various spatial and temporal scales.

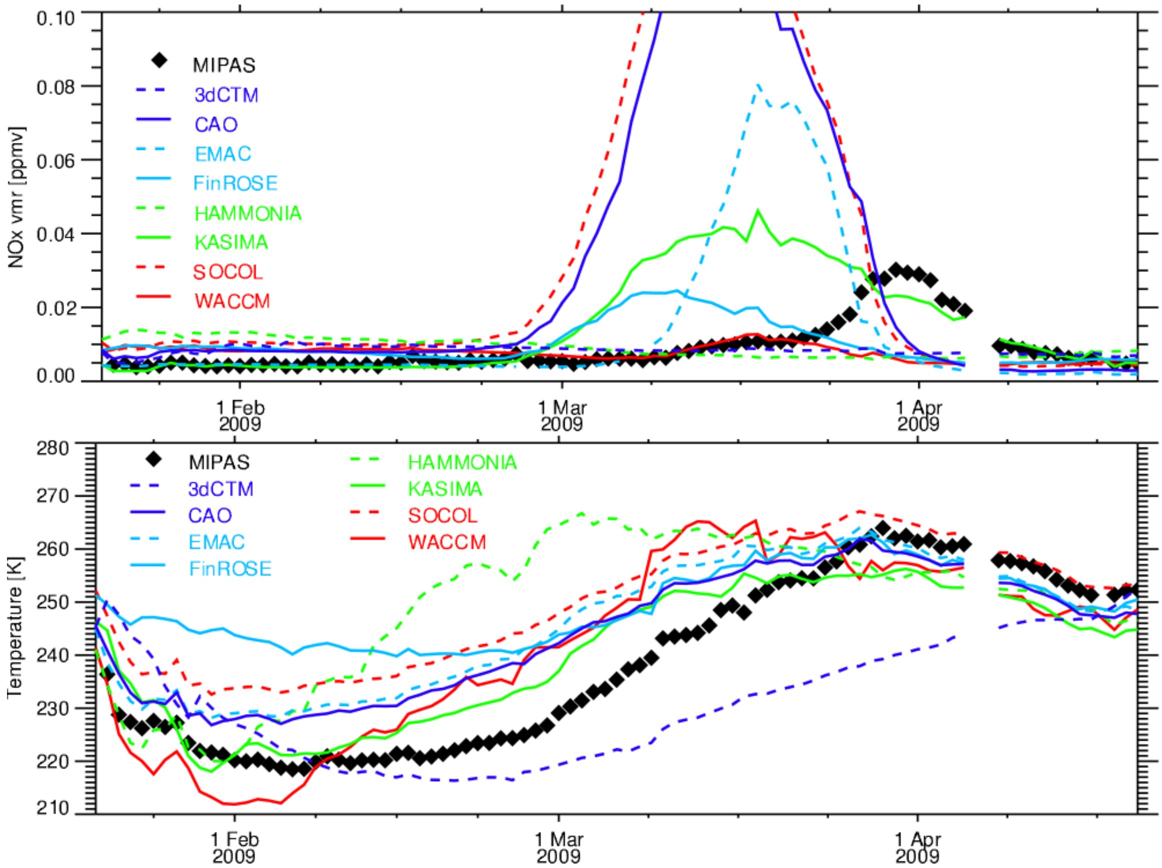

Figure 9: Observed (MIPAS) and modelled temporal evolutions of NO_x at 0.5hPa (top) and of temperature at 0.2hPa (bottom) between 70–90°N during the elevated stratopause event in 2009. Modelled NO_x peaks show a large spread in magnitude and occur systematically too early. Temperatures at 0.2hPa are overestimated by most models during the event, hinting at too strong lower mesospheric descent as a cause for the earlier NO_x peak occurrence in the models. (Reproduced from Funke *et al.*, 2017).

The HEPPA-II study compared simulations from eight atmospheric models with tracer and temperature observations from seven satellite instruments in order to evaluate the energetic particle indirect effect (EPP IE) during the perturbed northern hemisphere winter of 2008/2009. Models are capable to reproduce the EPP IE in dynamically and geomagnetically quiescent northern hemisphere winter conditions. However, the results also emphasise the need for model improvements in the dynamical representation of elevated stratopause events (see Figure 9). The outcome of this study has recently been published (Funke *et al.*, 2017).

Finally, a paper on the comparison of the solar signal in CCMVal *vs* CMIP5 experiments is currently in preparation and will be submitted to ACP soon.

Plans for the Coming Year

SOLARIS-HEPPA activities in 2017 will focus on the coordinated analysis of the solar signal in CCMI simulations within the recently founded SOALRIS-HEPPA working groups (including coordination of a series of papers). In this context, a SOLARIS-HEPPA working group meeting is planned for 6-9 November 2017 in Paris, France.

Additionally, the investigation of the CMIP6 pre-industrial control experiment with solar cycle variability but no long- term trend included (see Matthes *et al.*, 2016 for details) is envisaged. The PI control experiment with solar cycle variability included may reproduce decadal scale climate variability better. This does not yet represent a formal MIP, but might become one in the future.

References

Gillett, N. P., *et al.*, 2016: The Detection and Attribution Model Intercomparison Project (DAMIP v1.0) contribution to CMIP6, . *Geosci. Model Dev*., **9**, 3685-3697, doi:10.5194/gmd-9-3685-2016.

Matthes, K., *et al.*, 2016: Solar Forcing for CMIP6 (v3.1), *Geosci. Model Dev. Discuss*., doi:10.5194/gmd-2016-91.

Funke, B., *et al.*, 2017: HEPPA-II model–measurement intercomparison project: EPP indirect effects during the dynamically perturbed NH winter 2008–2009, *Atmos. Chem. Phys*., **17**, 3573-3604, doi:10.5194/acp-17-3573-2017.

Activity Website: http://solarisheppa.geomar.de

Solving the Mystery of Carbon Tetrachloride (CCl4 or CTC)

Activity Leaders: Paul Newman, Qing Liang, and Stefan Reimann

Achievements in 2016

The 'Solving the Mystery of Carbon Tetrachloride' workshop was held in Dübendorf, Switzerland, from 4- 6 October 2015, with participants from 16 different countries. Attendees included scientists, technologists, engineers, industry experts, and policymakers. Results from the workshop and the activity were published in July 2016 in the 7th SPARC science report 'SPARC Report on the Mystery of Carbon Tetrachloride' (www.sparc-climate.org/publications/sparc-reports/sparc-report-no7). The report was reviewed both internally, and by nine independent referees.

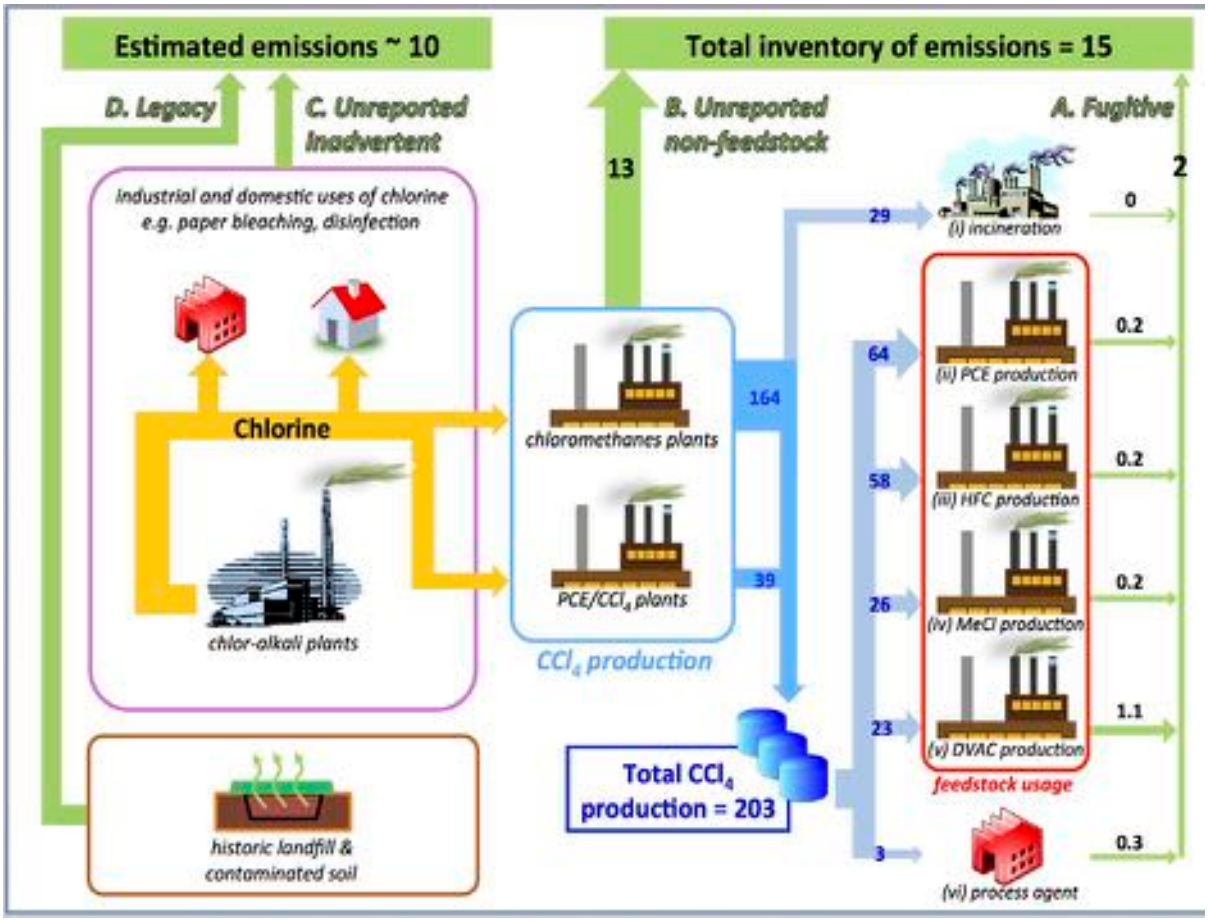

Figure 10: Schematic of CCl_4 routes from pre-CCl_4 production of chlorine gas in chlor-alkali plants (left), production (middle), usage (right), and emissions of CCl_4 (top) (Gg/yr). Production and use of chlorine gas are shown in yellow, industry production in blue, usage in greyish blue, and CCl_4 emissions in green. UNEP report numbers are shown in blue. Estimates are courtesy of David Sherry (Nolan Sherry & Associates). Global legacy emissions are estimated based on results from Fraser *et al.* (2014).

Major findings from the SPARC 2016 report include closing the gap between global bottom-up and top-down carbon tetrachloride (CCl_4) emission estimates. Four pathways were identified to contribute to the on-going emissions (bottom-up):

- Fugitive emissions: PCE, HFC, methyl chloride and DVAC production, incineration, and process agents (2Gg/yr)
- Unreported non-feedstock emissions: chloromethanes plants and PCE plants (13Gg/yr)
- Unreported inadvertent emissions: chlor-alkali plants (unknown quantity)
- Legacy emissions: landfills and contaminated sites (~10Gg/yr)

The new industrial bottom-up emissions estimate includes emissions from chloromethanes plants (13Gg/yr) and feedstock fugitive emissions (2Gg/yr). When combined with legacy emissions and unreported inadvertent emissions (~10Gg/yr), this yields 20±5Gg/yr.

Observation-based estimates (top-down):

- The sum from four regional emissions estimates is 21±7.5Gg/yr, but this is not a complete global accounting. These regional top-down emissions estimates also show that most CCl_4 emissions originate from chemical industrial regions – not necessarily major population centres.
- CCl_4 is destroyed in the stratosphere, oceans, and soils. The total lifetime has been increased from 26 to 33 years. With this new total lifetime, the global top-down emissions calculation decreases from 57 (40-74) Gg/yr in WMO (2014) to 40 (25-55) Gg/yr.
- Emissions can be calculated from the inter-hemispheric gradient, yielding 30 (25-35) Gg/yr.

These new emissions estimates reconcile the CCl_4 budget discrepancy when considered at the edges of their uncertainties. Although the new bottom-up value (20±5Gg/yr) is still less than the aggregated top-down values (35±16Gg/yr).

Plans for the Coming Year

The activity has officially ended, however, we plan on publishing the main results from the activity in an EOS newsletter article. Furthermore, we will present research recommendations to Ozone Research Managers and their meeting in March 2017. We may also collaborate with the WMO SAP/TEAP to form a joint working group for estimating emissions of CCl_4 in support of their quadrennial assessments.

Reference

Fraser, P., *et al.*, 2014: Australian carbon tetrachloride (CCl4) emissions in a global context. *Environ. Chem.,* 1**1**, 77-88.

Activity website: www.sparc-climate.org/activities/previous-activities/#c1960

SPARC Reanalysis Intercomparison Project (S-RIP)

Activity Leaders: Masatomo Fujiwara, Gloria Manney, and Lesley Gray

Achievements in 2016

We set up an inter-journal special issue in the journals Atmospheric Chemistry and Physics (ACP) and Earth System Science Data (ESSD) titled "The SPARC Reanalysis Intercomparison Project (S-RIP)". As of January 2017 there are nine published papers (www.atmos-chem-phys.net/special_issue829.html). As a contribution to this special issue, the S-RIP co-leads, chapter leads, reanalysis-centre colleagues, and others have submitted a paper titled "Introduction to the SPARC Reanalysis Intercomparison Project (S-RIP) and overview of the reanalysis systems" as a review article. This paper was published at the end of January 2017 (Fujiwara *et al.*, 2017).

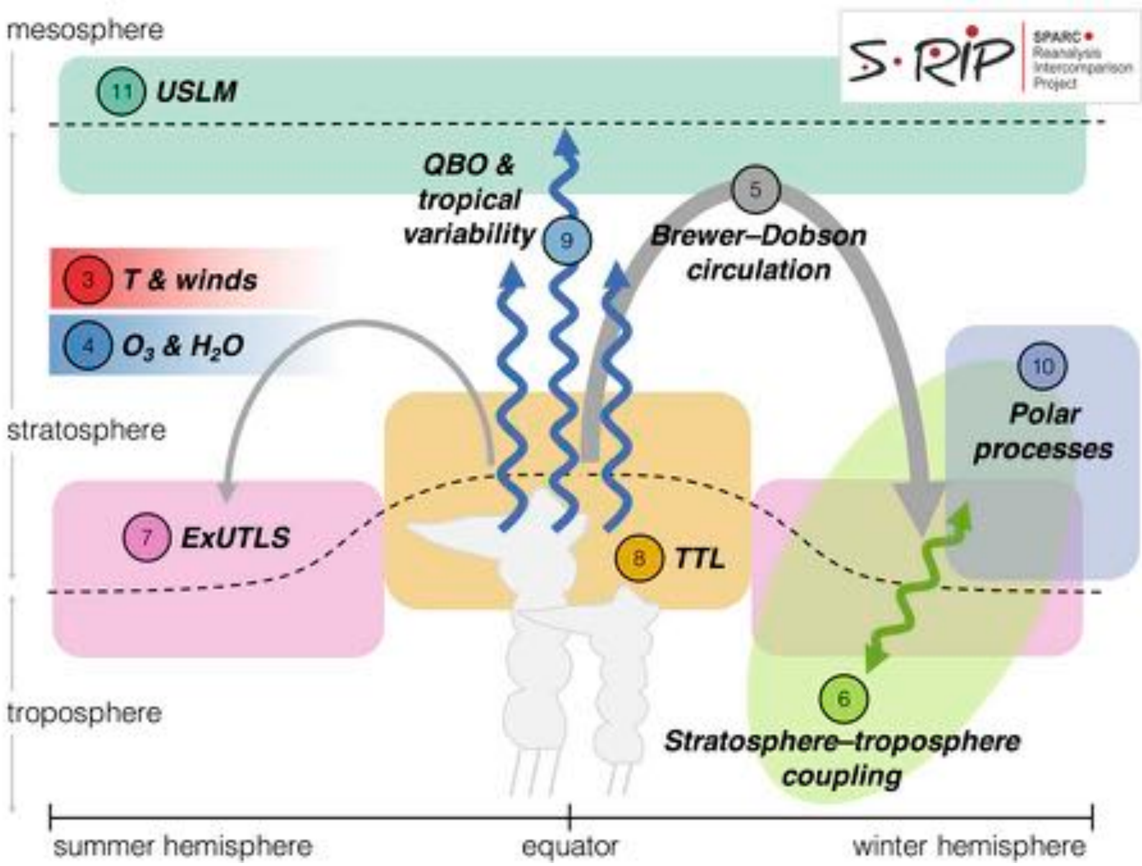

Figure 11: Schematic illustration of the atmosphere showing the processes and regions that are covered by chapters in the planned full S-RIP report. The numbers refer to the chapter numbers. After Fujiwara *et al.* (2017) with modifications.

The manuscript of the S-RIP interim report, covering the basic chapters (i.e., Chapters 1 to 4), has been completed. As of February 2017, it is under review, being handled by three external editors: Judith Perlwitz, Seok-Woo Son, and Vincent-Henri Peuch.

The annual S-RIP workshop was held from 19-21 October 2016 in Victoria, Canada. The SPARC Data Assimilation activity had a workshop in the same location from 17–19 October, with a joint workshop on 19 October. James Anstey was the local host for both of these workshops.

Plans for the Coming Year

The S-RIP interim report will be completed and published in 2017. From 25-27 October 2017, we will have the annual S-RIP workshop, at ECMWF, UK, where the SPARC Data Assimilation group will also hold their annual workshop from 23-25 October. There will be a one-day joint session with S-RIP on 25 October, similar to previous workshops.

Reference

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.

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

Stratospheric Sulfur and its Role in Climate (SSiRC)

Activity Leaders: Markus Rex, Claudia Timmreck, and Larry Thomason

Achievements in 2016

The SSiRC steering group led the effort that produced an overview paper entitled 'Stratospheric aerosol – observations, processes, and impact on climate' that appeared in Reviews of Geophysics (Kremser *et al.*, 2016). Stefanie Kremser, who was formerly an Early Career Scientist with the SSiRC SSG, led this effort along with 33 co-authors from 10 countries. This paper serves as an update of the SPARC Assessment of Stratospheric Aerosol Properties (ASAP) (SPARC, 2006). The American Geophysical Union's Eos recognized this publication with both an interview of Stefanie (Cook, 2016) and in an Eos 'Vox' column (Robock, 2016).

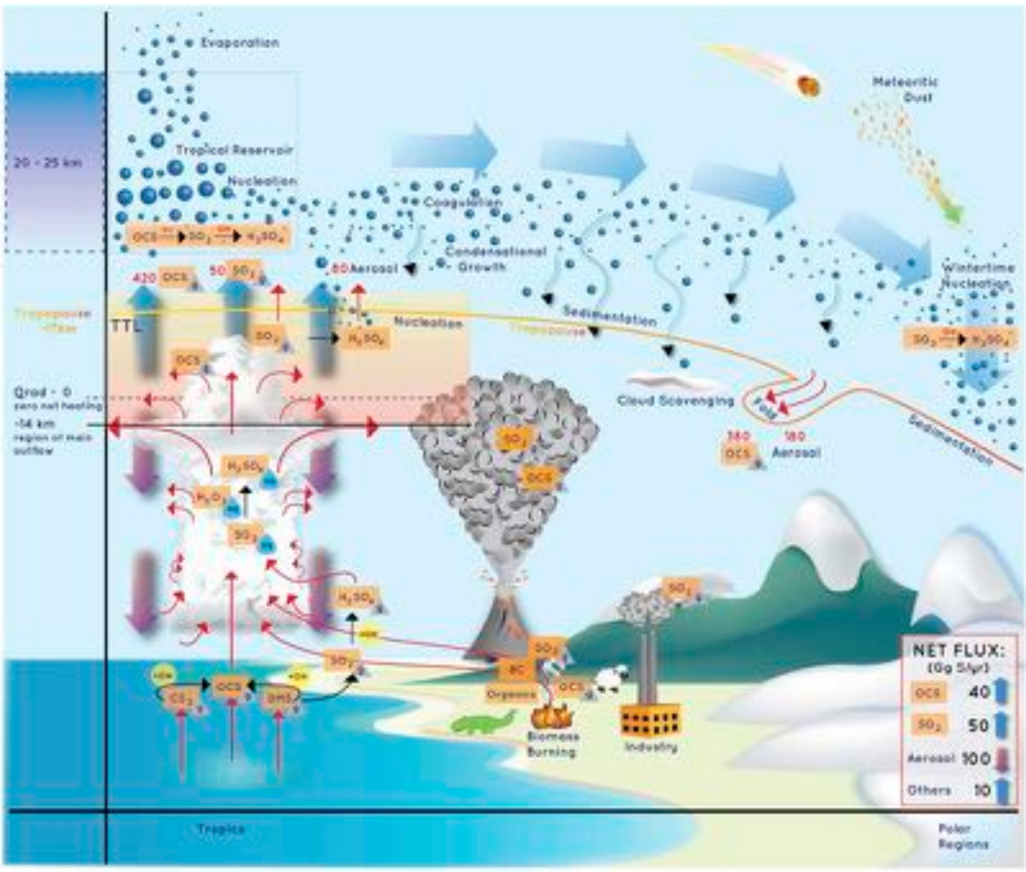

Figure 12: Schematic of the relevant processes that govern the stratospheric aerosol life cycle and distribution. The large blue arrows indicate the large-scale circulation, while the red arrows indicate transport processes. The black arrows indicate chemical conversions between compounds. The different chemical species are marked as either gas phase (grey triangle) or aqueous phase (blue drop). The blue thin arrows represent sedimentation of aerosol from the stratosphere to the troposphere. Note that due to its long tropospheric lifetime, carbonyl sulfide (OCS) does not necessarily require deep convection to be transported into the TTL (as shown in the figure). The red numbers represent the flux of OCS and sulfur dioxide (SO_2) as well as the flux of aerosol in GgS/yr based on model simulations from Sheng *et al.* (2015). The approximate net flux of sulfur containing compounds across the tropopause is shown in the grey box (Sheng *et al.*, 2015), where the 10 GgS/yr contribution from "others" can be mostly attributed to dimethyl sulfide (DMS) and hydrogen sulfide (H_2S). Other chemical compounds shown in this figure are carbon disulfide (CS_2), sulfuric acid (H_2SO_4), and black carbon (BC).

Markus Rex hosted a workshop held in support of the SPARC Stratospheric Sulfur and its Role in Climate (SSiRC) activity at the Alfred Wegener Institute (AWI) in Potsdam, Germany, from 25-28 April 2016. About 70 scientists from 14 countries attended the meeting, including a number of students and early career researchers. The workshop consisted of oral and poster presentations as well as focused small groups and more broadly ranging plenary discussions (see www.sparc-ssirc.org). The workshop was summarised in the SPARC Newsletter (Kremser and Thomason, 2016).

An application for a SSiRC-themed Chapman Conference has been submitted to the AGU with a targeted time period of early 2018. The proposed meeting is entitled 'Stratospheric aerosol during the past 20 years: Processes sustaining the aerosol, interactions with climate and chemistry, and importance for historical analogues', and has Terry Deshler (University of Wyoming), Larry Thomason (NASA Langley Research Center) and Mian Chin (NASA Goddard Space Flight Center) as conveners.

A new model intercomparison activity 'ISA-MIP' has been established in the framework of SSiRC. ISA-MIP will compare interactive stratospheric aerosol (ISA) models using a range of observations to constrain stratospheric aerosol forcing uncertainties, to improve the models, and to provide a sound scientific basis for future work. The experimental design was finalised at the SSiRC workshop in Potsdam and will be described in an overview paper (Timmreck *et al.*, to be submitted to GMD). Model experiments will start in 2017.

A CMIP6 Model Intercomparison Project on the climatic response to Volcanic forcing (VolMIP) has been established and the experiments have been defined (Zanchettin *et al.*, 2016). VolMIP aims to understand the dominant mechanisms behind simulated post-eruption climate evolution, climate dynamics and decadal variability. The SSiRC community is closely linked and contributes substantially to the forcing descriptions. For instance, a new stratospheric aerosol data set has been developed for CMIP6. The data set has several improvements over the previous versions and is a collaborative effort between SSiRC participants at ETH Zurich, NASA JPL, NASA Langley Research Center, Northwest Research Associates, and the University of Saskatchewan (Thomason *et al.*, to be submitted).

Major volcanic eruptions affect climate and stratospheric chemistry for years, with consequences on the earth hydrological cycle and biosphere. In order to prepare for the next major volcanic eruption, SSiRC is organising a group to develop a response plan for the next major eruption (VolRES) in order to forecast and mitigate its impact. Approximately 100 scientists within the broader SSiRC community have indicated interest in participating. We are working on a response plan outline that we will discuss with the team.

Finally, the SSiRC steering team was successful with an application for a 'SSiRC International Team' at the International Space Science Institute in Bern, Switzerland. The first team meeting was held from 30 January to 2 February 2017 in Bern, Switzerland.

Related Activities

As a part of his attendance at the SSiRC workshop, supported by MPI, Juan-Carlos Antuña met with Ilya Serikov and the lidar team from the Group of Observations and Studies at the MPI Department of the Earth Atmosphere and Hirsch Lutz, the department chair. The research conducted at GOAC (Grupo de Óptica Atmosférica de Camagüey) was presented with emphasis on the application of lidar measurements for stratospheric aerosols and cirrus clouds research. As a part of this discussion, Juan-Carlos and MPI scientists conferred on the current state of the GOAC lidar system and the requirements for returning this system to scientific readiness. As a result, MPI has agreed to provide excess equipment that will allow the engineers from the National Radar Centre (co-located with the Camagüey Meteorological Center) to rebuild the lidar system. The official notification by MPI to Cuban scientific authorities for the donation of the lidar parts was completed at the end of August and the process of getting the approval of Cuban authorities for receiving the shipment is underway.

Plans for the Coming Year

SSiRC will continue many of its ongoing activities, including ISAMIP, VolRES, and VolMIP. The SSiRC Chapman conference, if accepted, will be organised and a second ISSI team meeting will be held within the coming year.

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Robock, A., 2016: Blowin' in the Wind: Observing Stratospheric Aerosols. *EOS*, Editor's Vox, available at https://eos.org/editors-vox/blowin-in-the-wind-observing-stratospheric-aerosols.

Sheng, J. X., *et al.*, 2015: Global atmospheric sulfur budget under volcanically quiescent conditions: Aerosol-chemistry-climate model predictions and validation. *J. Geophys. Res.*, **120**, 256-276.

SPARC, 2006: Assessment of Stratospheric Aerosol Properties (ASAP). SPARC Report No. 4, WCRP-124, WMO/TD No. 1295, 348 pp.

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Activity Website: www.sparc-ssirc.org

Trace Gas Climatologies (SPARC Data Initiative)

Activity Leaders: Michaela Hegglin and Susann Tegtmeier

Achievements in 2016

The SPARC Data Initiative ozone data sets have been available through the SPARC Data Centre since the end of 2013, and have been requested by a large number of international scientists since then. The SPARC Data Initiative CFC-11, CFC-12, HF, and SF_6 data sets have also recently been transferred to the SPARC Data Centre. Additionally, the four data sets have been made available through PANGAEA (doi:10.1594/PANGAEA.849223). An appropriate home for the rest of the trace gas climatologies is being investigated and a final data archive will hopefully become available by early summer.

Implications of the results for model-measurement inter-comparisons are provided in Chapter 5 of the SPARC Data Initiative report (SPARC, 2017; see **Figure 13** for H_2O seasonal cycle in the tropical tropopause layer). Examples of how knowledge of uncertainty and inter-instrument differences can be used to improve comparisons are provided and particular diagnostics appropriate for model evaluations are recommended. Metrics for model evaluations based on SPARC Data Initiative observational data sets are currently further developed and will be published in 2017 as a journal publication.

The SPARC Data Initiative is nearly ready for print, with all chapters including the Executive Summary and Introduction having been finalised. It is expected that the report will be printed and published in late March 2017, to be distributed thereafter. Once the final report is published the activity will officially come to an end.

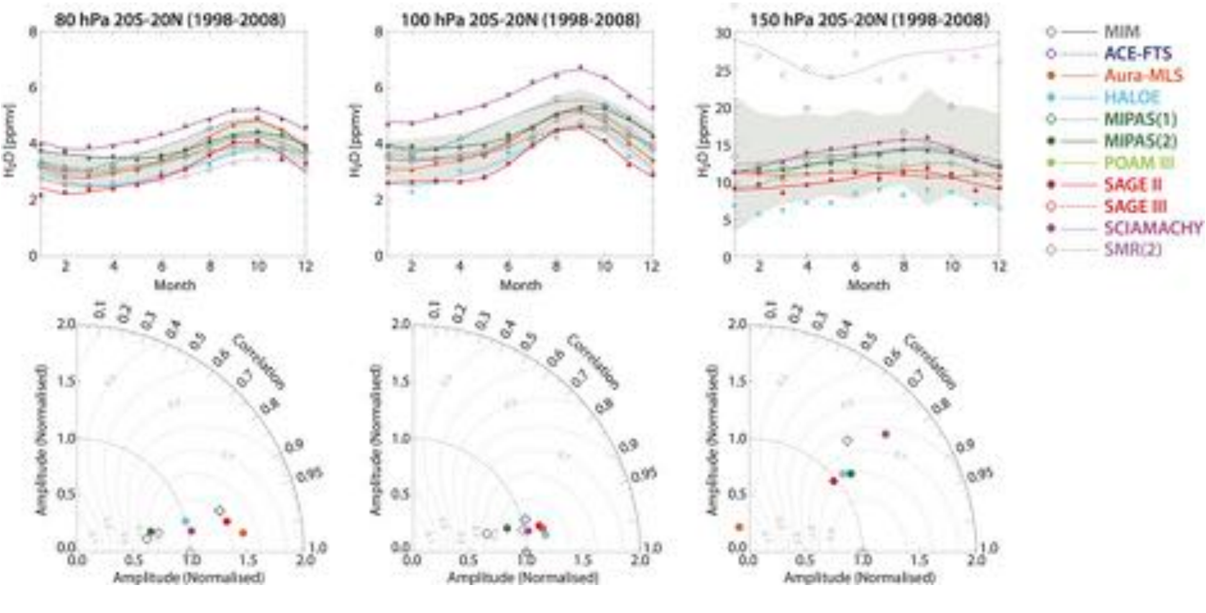

Figure 13: Seasonal cycles of H_2O in the tropics for 1998-2008 for all available satellites. Seasonal cycles and corresponding Taylor diagrams of monthly zonal mean H_2O averaged over 20°S-20°N are shown at 80hPa (left column), 100hPa (middle column) and 150hPa (right column). Coloured lines represent fits including an annual and a semi-annual component to the available monthly data points. The grey line indicates the multi-instrument mean (MIM) and the grey shading ±1σ (from SPARC, 2017).

Reference

SPARC (2017) of The SPARC Data Initiative: Assessment of stratospheric trace gas and aerosol climatologies from satellite limb sounders. By M. I. Hegglin and S. Tegtmeier (eds.). SPARC Report No. 8, WCRP-5/2017, DOI 10.3929/ethz-a-010863911, available at http://www.sparc-climate.org/publications/sparc-reports/sparc-report-no8/.

Activity Website: www.sparc-climate.org/activities/trace-gas-climatologies

Water Vapour Phase II (WAVAS II)

Activity Leaders: Karen Rosenlof, Gabriele Stiller, and Thomas Peter

Achievements in 2016

Following the activity meeting held from 8-11 December 2015, in Boulder, CO, the author team has been working on the publication of several papers related to the activity. A joint ACP/AMT/ESSD special issue for publication of WAVAS-II-related papers has been opened and welcomes contributions directly originating from the WAVAS-II activity, as well as papers related to the data sets assessed within WAVAS-II. So far, five papers have been published or are in review. Guest editors of the special issue are James Russell III, Karen Rosenlof, Stefan Buehler, and Gabriele Stiller.

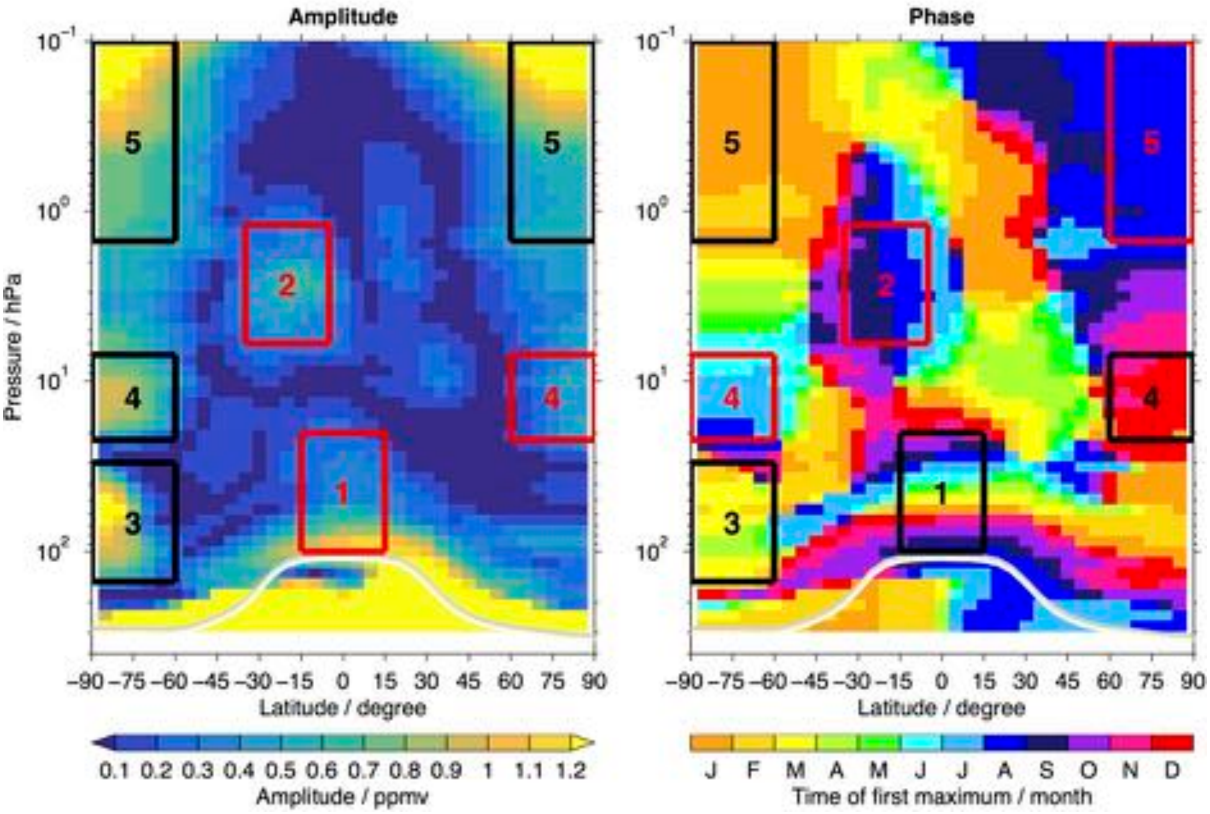

Figure 14: Example of the annual variation characteristics as a function of latitude and altitude based on the MLS v3.3/3.4 data set. The left panel shows the amplitude of the seasonal variation, while the right panel shows its phase. The phase is represented by the month in which water vapour exhibits its annual maximum in the regression fit. The light grey and white lines indicate the mean tropopause (averaged from 2000-2014) as derived from the MERRA reanalysis data. The red and black boxes mark regimes of large seasonal variation. The colour variation of the boxes is for better contrast only. White areas indicate where there are no data. (Figure from Lossow *et al.*, 2017).

In parallel, the assessment work has continued, for example, by implementing the recommendations made at the quality assessment meeting in December 2015, and updating the data records with new versions. For the quality assessment of upper tropospheric humidity (UTH), data from radio soundings have now been considered as well. Telecons were held on 20 May and 25 August 2016 for coordination of the remaining assessment actions. An activity meeting was then also held from 30 November to 2 December at KIT in Karlsruhe, Germany. All key authors of the papers/report (11 people) attended this meeting. Kaley Walker spent some additional days at KIT to coordinate the writing of the data characterization paper. William Read and Gabriele Stiller attended the GEWEX G-VAP workshop at EUMETSAT in Darmstadt, Germany, from 22-23 September 2016, and presented the WAVAS-II work in general, and the UTH assessment in particular.

Plans for the Coming Year

WAVAS II plans to continue working on the papers related to the different assessment methods, and work towards the final SPARC report. At least 12 papers have been identified as an immediate outcome of the WAVAS-II activity that are currently in preparation. These papers should be submitted within the next year. There will be at least one more workshop for the review of the report; the next one is scheduled for 20-22 June 2017 in Toronto, Canada, and will be hosted by Kaley Walker of the University of Toronto.

Reference

Lossow, S., *et al.*, 2017: The SPARC water vapour assessment II: comparison of annual, semi-annual and quasi-biennial variations in stratospheric and lower mesospheric water vapour observed from satellites. *Amos. Meas. Tech.*, **10**, 1111-1137, doi:10.5194/amt-10-1111-2017.

Activity website: www.sparc-climate.org/activities/water-vapour-ii

Emerging Activities

Fine Scale Atmospheric Processes And Structures (FISAPS; full activity as of November)

Activity Leaders: Marvin Geller, Hye-Yeong Chun, Peter Love

Achievements in 2016

FISAPS was launched in 2015 and became a full SPARC activity in November 2016. This year, we submitted a FISAPS review paper to the Bulletin of the American Meteorological Society. We also have been in contact with the operational community about their plans for obtaining more high vertical-resolution radiosonde data, and there is some discussion about plans for archiving these increased data with greater global coverage. We also have been working with the leadership of the QBOi and SATIO-TCS SPARC activities on the organisation of workshops to be held in Kyoto, Japan, during the period of 9-14 October 2017.

Figure 14, from the submitted review paper, illustrates the present status of BUFR format radiosonde data processed by the British Meteorological Service during the month of December 2016 as a function of the number of vertical levels reported. The amount of high vertical-resolution radiosonde data used in operational forecasts is steadily increasing. It is a challenge to make these data available to the research community to be used to study such diverse subjects as atmospheric gravity waves, atmospheric turbulence, tropopause structure, and boundary layer depth.

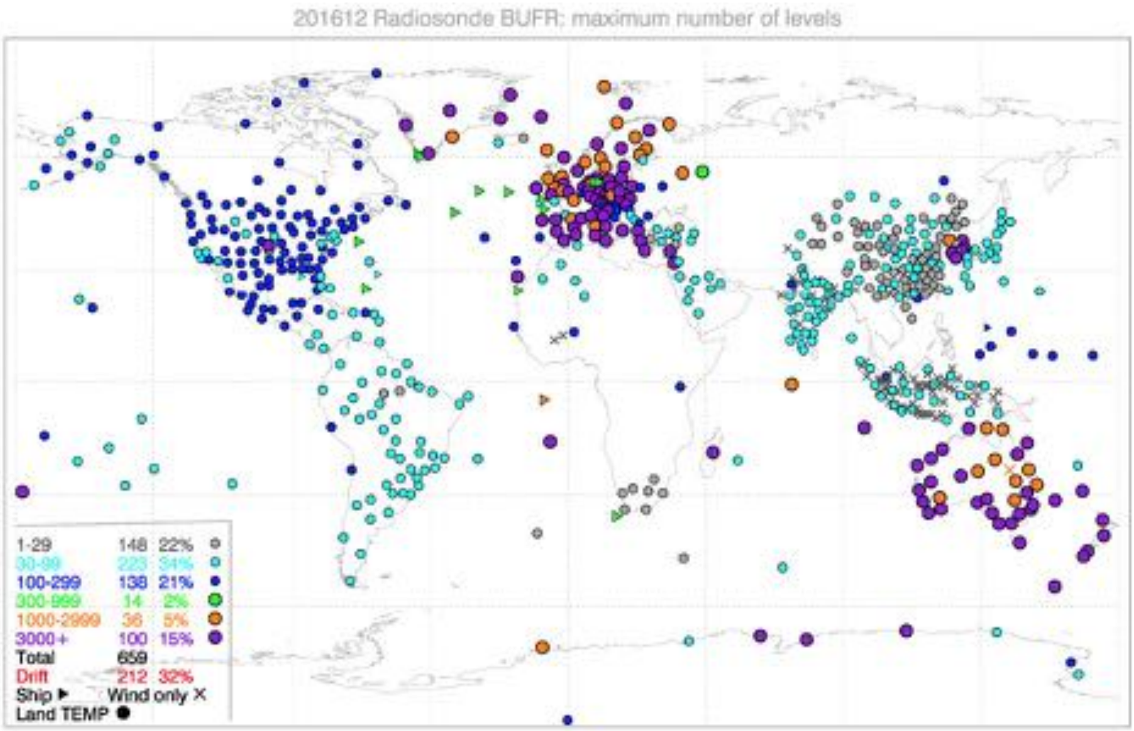

Figure 14: Summary of BUFR format radiosonde reports for 1-31 December 2016 decoded by the UK Met Office, plotted by station. The colour indicates the maximum number of levels per report (grey 1-29, light blue 30-99, dark blue 100-299, green 300-999, orange 1000-2999, purple >3000; the percentages in the key are relative to the number of stations plotted). Courtesy of Bruce Ingleby.

Plans for the Coming Year

We hope that the FISAPS review paper will appear during 2017. We look forward to reporting on the results of the first FISAPS workshop to be held in Kyoto, Japan, in October 2017. We expect research results to be discussed at this workshop, and also to have discussions with national agencies about their plans for making their high vertical-resolution data available to the research community. We also plan discussions relating to the relatively new high-resolution GPS data and also to research high-resolution sounding data. At this workshop, we will also make plans for the next FISAPS workshop, hopefully in Europe in 2018, and FISAPS activities in 2018 and beyond.

Reference

Geller, M. A., *et al.* (subm.) Fine-Scale Atmospheric Processes and Structures. *Bull. Amer. Meteor. Soc.*

Activity Website: www.sparc-climate.org/activities/fine-scale-processes

Long-term Ozone Trends and Uncertainties in the Stratosphere (LOTUS; full activity as of November)

Activity Leaders: Irina Petropavloskikh, Daan Hubert, and Sophie Godin-Beekman

For the WMO/UNEP 2018 Ozone Assessment, a clear understanding of ozone trends and their significance as a function of altitude and latitude is still needed. A previous activity sponsored by SPARC, IO3C, IGACO-O3/UV and NDACC (SI2N) aimed at evaluating the trends from long-term ozone profile records (ground-based and satellites, including merged satellite data records). However, a clear evaluation of uncertainties in trend studies and in particular the consideration of errors linked to the sampling and stability of (merged) data sets could not be achieved by the end of SI2N. Since then, new merged satellite data sets and long-awaited homogenized ozonesonde data sets are being produced. There is thus a strong interest in the scientific community to use these newer observations to evaluate ozone recovery and to understand their limitations in determining the significance of long-term trends. In order to address the issues left pending after the end of SI2N, a comprehensive evaluation of all long-term data sets together with their relative drifts is needed. Evaluation of error propagation in ozone trend calculation is also required.

The LOTUS project aims to:

- Update and extend stratospheric ozone observations to recent years;
- Improve our understanding of crucial yet poorly known sources of uncertainties in trend retrieval;
- Investigate how uncertainties interact and propagate through the different stages of analysis chain;
- Re-evaluate current best practice(s) and possibly establish more suitable alternatives.

During the LOTUS activity, several new satellite and ground-based ozone profile data sets will be updated and made available to the community. A SPARC Report will accompany this data release and discuss the progress made on several key open issues identified by previous assessments, most notably on the understanding of uncertainties in the trend analysis chain. An important part of the report will be devoted to an update of the assessment of long-term trends and their significance, in different regions of the stratosphere. A section will list further requirements on data sets and analysis methods that have been identified during the project.

The timing of LOTUS is driven by the objective to provide timely input to the 2018 WMO/UNEP Ozone Assessment. This means that all data sets, regression analyses, and the SPARC Report will be finalized and published by March/April 2018.

Activity Website: http://www.sparc-climate.org/activities/ozone-trends/

Observed Composition Trends And Variability in the Upper Troposphere and Lower Stratosphere (OCTAV-UTLS)

Activity Leaders: Gloria Manney, Peter Hoor, Irina Petropavlovskikh

The distribution of tracers in the Upper Troposphere and Lower Stratosphere (UTLS) shows large spatial and temporal variability, caused by competing transport, chemical, and mixing processes near the tropopause, as well as variations in the tropopause itself. This strongly affects quantitative estimates of the impact of radiatively active substances, including ozone and water vapour, on surface temperatures, and complicates diagnosis of dynamical processes such as stratosphere troposphere exchange (STE). The community thus faces the challenge of optimally exploiting the existing portfolio of observations to better understand the physical composition of the UTLS, including past long-term changes in trace gas distributions and the processes that control them.

This activity will focus on improving the quantitative understanding of the UTLS's role in climate and the impacts of stratosphere-troposphere exchange (STE) processes on air quality. Achieving this goal requires a detailed characterization of existing measurements (from aircraft, ground-based, balloon, and satellite platforms) in the UTLS, including understanding how their quality and sampling characteristics (spatial and temporal coverage, resolution) affect the representativeness of these observations.

One key aspect of this activity will be to develop and apply common metrics to compare UTLS data using a variety of geophysically-based coordinate systems (*e.g.*, tropopause, equivalent latitude, jet-focused) using meteorological information from reanalysis data sets. This approach will provide a framework for comparing measurements with diverse sampling patterns and thus will leverage the meteorological context to derive maximum information on UTLS composition and its relationships to dynamical variability.

The activity will produce recommendations for data comparisons in the UTLS region based on specific techniques/instruments. We will provide an assessment of gaps in current geographical/temporal sampling of the UTLS region that limit determining variability and trends, and suggest future measurement strategies that would help fill those gaps.

Activity Website: http://www.sparc-climate.org/activities/emerging-activities/#c1878

SATIO-TCS – Stratospheric And Tropospheric Influences On Tropical Convective Systems

Activity Leaders: Marvin Geller, Peter Haynes, Shigeo Yoden

The standard paradigm for interpreting and explaining stratosphere-troposphere coupling have been based on balanced dynamics; the non-local aspects of potential vorticity (PV) inversion, planetary wave propagation, wave mean flow interaction in both troposphere and stratosphere. SATIO-TCS has its focus on stratosphere-troposphere coupling in the tropics, where no comparable interpretive paradigm exists. Observational, global modelling, and cloud-resolving modelling all point to an important stratospheric influence on tropical convection and convective systems, and the multi-scale dynamics of these systems is likely to play a vital role in determining the tropical response to changes in the stratosphere.

There is observational evidence that stratospheric variations, such as stratospheric sudden warming (SSW) events, the equatorial quasi-biennial oscillation (QBO), and anthropogenic cooling trend in the lower stratosphere, influence tropospheric variability in the form of moist convection or its large-scale organization into meso-to-planetary-scale systems, which include cloud clusters, tropical cyclones, the Madden-Julian Oscillation (MJO), and likely monsoon systems. Some global general circulation models and regional cloud-resolving models show similarities to these observations, but such modelling studies are still in their infancy.

SATIO-TCS seeks to promote the science on stratosphere-troposphere coupling (upward and downward) in the tropics, focusing on its influences on moist convection and organized convective systems, since there is a strong need for more coordinated studies with a wide variety of research activities, including observations, data analyses, and numerical model studies. Coordinated research activities will also contribute to the WCRP Grand Challenges on 'Clouds, Circulation and Climate Sensitivity', 'Weather and Climate Extremes', and 'Near-term Climate Prediction'. SATIO-TCS will also link with other WCRP projects, for example, GEWEX and CLIVAR, as well as international observational campaigns such as the Years of Maritime Continent (YMC) for 2017-2019.

The main scientific objectives of this activity are:

- Discover new phenomena/relationships by observations and data analyses, deeper understanding of the stratosphere-troposphere dynamical coupling related to such phenomena/relationships by data analyses and experiments with a hierarchy of numerical models;
- Prediction of such phenomena using state-of-the-art numerical models after improving the related modules, with several specific targets such as the combination of influences of SSW, QBO, or stratospheric cooling trend, on moist convection, cloud clusters, tropical cyclones, the MJO, and monsoon circulation.

It is anticipated that SATIO-TCS will produce an introductory review paper on this field of research and hold workshops resulting in peer-reviewed publications in international journals. The activities of SATIO-TCS will naturally contribute to SPARC's efforts in capacity building, given its emphasis on topics of great interest to many developing nations in the tropics.

Activity Website: http://www.sparc-climate.org/activities/emerging-activities/#c1880

SLCFs – Climate Response to Short-lived Climate Forcers

Activity Leader: Bill Collins

The route from emission of a short-lived pollutant to climate impact involves a chain of many processes and spans many academic fields (gas-phase and heterogeneous-phase chemistry, aerosol physics, cloud physics, climate dynamics). This activity will focus on the last of these, the climate response to a given forcing.

The main scientific questions addressed by this activity are:

1. How does the atmosphere adjust to changes in short-lived climate forcers (SLCFs), and what is the contribution of these rapid adjustments on the effective radiative forcing (ERF)?
2. How does the climate respond to different patterns of these ERFs?
    - Is the global climate sensitivity the same as for CO_2?
    - Does the climate respond on the same timescales as for a CO_2 forcing?
    - How does the spatial pattern of the response relate to the spatial pattern of the forcing?

Activity Website: http://www.sparc-climate.org/activities/emerging-activities/#c1881

Towards Unified Error Reporting (TUNER)

Activity Leaders: Thomas von Clarmann, Doug Degenstein, Nathaniel Livesey

The goal of TUNER is to provide a complete and consistent data characterization in terms of uncertainty, resolution, and content of *a priori* information, for the largest possible number of space-borne temperature and composition sounders. Specific objectives are:

1. An inventory of the error estimation tools used by past and current satellite missions will be made. The same applies to tools for resolution estimates and *a priori* content.
2. The used tools will be assessed for consistency and completeness.
3. Strategies will be defined to complete the error estimates and to make them consistent.
4. Missing error and resolution estimates will be provided for the most important data.
5. Recommendations on the use of the error estimates will be established for each instrument.

Activity Website: http://www.sparc-climate.org/activities/emerging-activities/#c1882

SPARC Capacity Development

During 2016 SPARC continued to work hard on maintaining an active capacity development programme. Besides the usual distribution of WCRP travel funds for participation in SPARC meetings and workshops, several other activities were organised throughout the year. SPARC SSG member Seok-Woo Son continued to grow the Asia-Pacific working group, establishing more local contact points across the region and participating in a highly successful '2nd South-east Asia Training School on Tropical Atmospheric Sciences' jointly organised with Shigeo Yoden and Tren Tan Tran. Thando Ndarana, also SPARC SSG member, is helping to establish a university-level course on middle atmospheric dynamics in South Africa; the first such course to be offered in South Africa. This course will hopefully stimulate interest in SPARC-related research in southern Africa and provide a focus point for further development of a regional interest group. Further promotion of SPARC research was ensured through the co-sponsorship of a training school on 'Atmospheric Composition and Dynamics' held on Réunion Island in late 2016. SPARC has also continued to promote the Young Earth System Scientists (YESS) network and encourages early career members of the SPARC community to become involved in this fast-growing and influential network.

A proposal for a training school on stratosphere-troposphere interactions was successfully submitted to IUGG and the school will take place directly after the IAPSO-IAMAS-IAGA conference happening in Cape Town, South Africa, in late August 2017. The training school is jointly supported by SPARC, the University of Cape Town, ACCESS, and the Climate Systems Analysis Group, and a number of well-renowned SPARC scientists have volunteered to teach during the four-day training school. Finally, a one-day training school will be organised in conjunction with the 2017 SPARC SSG meeting taking place in Seoul, South Korea.

Contributions to WCRP Grand Challenges

SPARC contributes to several of the WCRP Grand Challenges, four of which were the topics of discussion at the regional workshop held in conjunction with the 2016 scientific steering group meeting.

Clouds, Circulation and Climate Sensitivity

The Grand Challenge on 'Clouds, Circulation and Climate Sensitivity' aims to understand how clouds and circulation are coupled and how they feed back on each other and climate, both at present and in the future. SPARC provided organisational support for a workshop on Atmospheric Blocking, an atmospheric phenomenon which is known to play a crucial role in modulating mid-latitude circulation. Atmospheric blocking also significantly affects surface weather, leading to large-scale cold spells in winter and persistent heat waves in summer. The workshop aimed to provide a more objective classification of blocking, to evaluate current understanding of blocking episodes and their long-term trends, and to isolate the mechanisms responsible for biases in models regarding the simulation of blocking events.

Climate Extremes

The workshop on Atmospheric Blocking also provided input to the Grand Challenge on 'Weather and Climate Extremes'. This Grand Challenge is focused on observing, understanding, and simulating extreme weather and climate events, thus providing information that society and stakeholders across the board have been increasingly requesting. This is particularly important since there is more and more evidence that weather and climate extremes are changing as climate changes.

Melting Ice and Global Consequences

As part of the WCRP Grand Challenge "Cryosphere in a Changing Climate", SPARC and CliC are coordinating the WCRP Polar Climate Predictability Initiative (PCPI, see details below). Other areas where SPARC could further contribute to this Grand Challenge are related to the relationship between polar climate change and mid-latitude circulation patterns (see CliC section below).

Near-term Climate Prediction

SPARC contributed to the development of the Grand Challenge on 'Near-term Climate Prediction', which was accepted in 2016 as one of two new WCRP Grand Challenges. This Grand Challenge aims to facilitate research that will improve interannual to decadal-scale climate predictions and thus provide for the development of routine decadal prediction services. It aims to fill the gap between seasonal-to-interannual predictions and multi-decadal climate projections to ensure a truly seamless provision of climate services. The Grand Challenge will work closely with operational forecast centres from around the world, as well as with many projects and working groups within and beyond the WCRP.

Carbon Feedbacks in the Climate System

The second new Grand Challenge to be accepted in 2016 is focused on 'Carbon Feedbacks in the Climate System'. Again, SPARC was involved in the development of this Grand Challenge, which aims to improve our understanding and simulations of the land and ocean carbon cycles. Major questions the Grand Challenge will address include whether climate-carbon feedbacks will amplify climate changes over the 21st century and how highly-vulnerable carbon reservoirs will respond to a warming climate and changing extremes.

Links to other projects

CliC

SPARC collaborates with CliC (Climate and Cryosphere, WCRP core project) on the WCRP Polar Climate Predictability Initiative (PCPI) as well as the Year of Polar Prediction (YOPP), which is to begin in mid-2017 and run until mid-2019. Both the atmosphere and cryosphere affect climate predictability from seasonal to longer time-scales; working together with CliC will contribute to pushing our understanding of these processes further through the Stratospheric Historical Forecast and Sea-Ice Historical Forecast projects. SPARC and CliC will also continue to collaborate on issues such as the interaction between polar climate change and lower latitude atmospheric circulation patterns, or biogeochemistry of sea-ice.

GEWEX

SPARC and GEWEX, the WCRP Global Energy and Water Exchanges project, have continued to work together in 2016. SPARC is involved in the developing GEWEX Upper Troposphere Clouds and Convection (UTCC) PROcess Evaluation Study (PROES). An initial workshop was held in Paris, France, in October 2015, where issues related to the interplay between convection and clouds, particularly in the upper troposphere, were discussed. The UTCC activity will provide an excellent opportunity to bring scientists from several communities together to explore the impacts of high altitude clouds on climate through both modelling and observational studies. Furthermore, it will be highly complementary to work carried out in the emerging SPARC SATIO-TCS activity.

CLIVAR

CLIVAR (Climate Variability and Predictability), also a WCRP core project, deals with climate aspects related to the atmosphere and ocean as well as on the interactions between atmosphere and ocean relevant to climate variability and climate change. Through focused research on climate dynamics and predictability, SPARC and CLIVAR are contributing to improving climate predictions at scales from sub-seasonal through decadal to the centennial. In 2016 CLIVAR organised a major Open Science Conference in Qingdao, China, which provided a dynamic forum for the WCRP community to review progress towards an improved understanding of the dynamics, interactions, and predictability of the coupled ocean-atmosphere system. An extremely successful early career researchers event was also organised in conjunction with the main meeting.

IGAC

SPARC collaborates extensively with the International Global Atmospheric Chemistry project (IGAC; a Future Earth project), particularly through two joint activities, the Atmospheric Composition and Asian Monsoon (ACAM) and Chemistry Climate Model Initiative (CCMI) (see above). Potential areas for new joint activities include composition and transport in the tropics as well as short-lived climate forcers, the latter of which is an emerging SPARC activity. The 2018 IGAC Science Conference is taking place the week before the 2018 SPARC General Assembly, both in Japan. As was done in 2008, the science programmes of both conferences will be organised as such that participation in the two will be of interest to much of the SPARC and IGAC communities.

The Polar Climate Predictability Initiative

The Polar Climate Predictability Initiative (PCPI) aims to advance understanding of the sources of polar climate predictability on timescales ranging from seasonal to multi-decadal, which stems from the unique persistence of signals in ice and snow as well as through exchange with the atmosphere and the ocean at all depths. PCPI is a sub-initiative of the "Melting Ice" Grand Challenge, and is jointly supported by CliC and SPARC. PCPI is also closely related to WWRP, in particular the joint WWRP/WCRP Polar Prediction Project (PPP). PCPI organised a number of workshops in 2016, including on polar predictability as well as on feedbacks in polar regions and how they are represented in climate models.

The SPARC Data Centre

The SPARC Data Centre (SDC) continues to provide support for SPARC activities, facilitating the distribution of data and documents and providing access to data for the international climate research community. This includes data for several active SPARC activities including the SPARC Data Initiative, CCMI, the Gravity Wave activity, and WAVAS-II, as well as several past activities such as CCMVal-II and the SPARC Lifetimes activity, amongst many others. Following the migration of data from Stony Brook University and the SPARC International Polar Year data from University of Toronto in late 2014 the SDC data holdings now reside at the Centre for Environmental Data Archival (CEDA) with the SDC website integrated into the main SPARC website hosted at ETH Zurich acting as the web portal. With the establishment of the new SDC catalogue in 2016, all SPARC data holdings now reside at CEDA under the unified banner of the SDC. Peter Love, the SDC scientist, remains the SPARC-CEDA liaison for data ingestion and the migration process and continues to provide scientific support for SDC users.

SPARC Scientific Steering Group 2016

Judith Perlwitz, Co-chair

Neil Harris, Co-chair

Julie Arblaster

Gufran Beig

Mark Baldwin

Alexey Karpechko

Olivia Martius

Thando Ndarana

Michelle Santee

Kaoru Sato

Hauke Schmidt

Seok-Woo Son

Tianjun Zhou

Planned Workshops and Meetings 2017

This list is updated throughout the year as further meetings/workshops are planned.

30 January – 2 February
SPARC SSiRC ISSI Meeting
Bern, Switzerland

13 – 15 March
LOTUS Workshop
Paris, France

5 – 9 June
3rd ACAM Workshop
Guangzhou, China

13 – 15 June
3rd SPARC/IGAC CCMI Science Workshop
Toulouse, France

15 – 16 June
TUNER Project Meeting
Saskatoon, Canada

20 – 22 June
WAVAS II Meeting
Toronto, Canada

18 – 20 July
1st OCTAV-UTLS Workshop
Boulder, Colorado, USA

6 – 8 September
Workshop on the Measurement of
Stratospheric Aerosol
Boulder, Colorado, USA

9 – 14 October
QBOi/FISAPS/SATIO-TCS Joint Workshop
Kyoto, Japan

16 – 17 October
SPARC Regional Workshop
Seoul, South Korea

17 – 20 October
25th SPARC Scientific Steering Group Meeting
Seoul, South Korea

23 – 25 October
S-RIP 2017 Workshop
Reading, UK

25 – 27 October
SPARC Data Assimilation Workshop
Reading, UK

8 – 9 November
SOLARIS-HEPPA Working Group Meeting
Paris, France

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

Acronyms

ACAM – Atmospheric Composition and the Asian Monsoon
ATC – Atmospheric Temperature Changes and their Drivers
BADC – British Atmospheric Data Centre
CCl4 (or CTC) – Solving the Mystery of Carbon Tetrachloride
CCMI – Chemistry-Climate Model Initiative
CCM – Chemistry-Climate Models
CCMVal2 – Chemistry-Climate Model Validation project 2
CEDA – Centre for Environmental Data Archival
CliC – Climate and Cryosphere project
CLIVAR – Climate Variability and Predictability project
CMIP5 – Coupled Model Intercomparison Project 5
DynVar – Dynamical Variability
FISAPS – Fine Scale Atmospheric Processes and Structures
GEWEX – Global Energy and Water Exchanges project
IGAC – International Global Atmospheric Chemistry
JSC – Joint Scientific Committee
LOTUS – Long-term Ozone Trends and Uncertainties in the Stratosphere
NASA – National Aeronautics and Space Administration
NDACC – Network for Detection of Atmospheric Composition Changes
NWP – Numerical Weather Prediction
OCTAV-UTLS – Observed Composition Trends and Variability in the Upper Troposphere and Lower Stratosphere
PCPI – Polar Climate Predictability Initiative
PSCi – Polar Stratospheric Clouds initiative
PPP – Polar Prediction Project
QBOi – Quasi-biennial Oscillation initiative
SATIO-TCS – Stratospheric And Tropospheric Influences on Tropical Convective Systems
S2S – Sub-seasonal to Seasonal Prediction Project
SLCFs – Climate Response to Short-lived Climate Forcers
SNAP – Stratospheric Network for the Assessment of Predictability
SOLARIS-HEPPA –SOLAR Influences for SPARC – High Energy Particle Precipitation in the Atmosphere
S-RIP – SPARC Reanalyses Intercomparison Project
SSG – Scientific Steering Group
SSiRC – Stratospheric Sulfur and its Role in Climate
SSU – Stratospheric Sounding Unit
TUNER – Towards Unified Error Reporting
WAVAS II – Water Vapour Phase II
WCRP – World Climate Research Program
WGCM – Working Group on Coupled Modelling
WGNE – Working Group on Numerical Experimentation
WGSIP – Working Group on Seasonal to Interannual Prediction
WMO – World Meteorological Organisation
WWRP – World Weather Research Programme


SPARC
Stratosphere-troposphere
Processes And their Role in Climate
WCRP
World Climate Research Programme
WMO
UNESCO
IOC
ICSU
International Council for Science