Annual Report

SPARC 2013

SPARC
Stratosphere-troposphere
Processes And their Role in Climate

Annual Report
SPARC 2013

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Overview from the Co-Chairs

The SPARC community was busy in 2013 organizing and preparing for our 5th General Assembly (GA), which took place in January 2014 in Queenstown, New Zealand. Although the SPARC GAs are normally held every 4 years, the last was held a little over 5 years ago in August/September 2008 in Bologna, Italy. The Scientific Organizing Committee for the 5th GA embraced SPARC's new emphasis that now includes those tropospheric processes that link to the stratosphere, in addition to SPARC's traditional stratospheric research interests. The GA themes included (1) chemistry, aerosols and climate; (2) dynamics and predictability of regional climate; (3) coupling to the upper atmosphere; (4) observational datasets, reanalyses, and attribution studies; and (5) tropical processes. Embracing key tropospheric and stratospheric climate processes is a natural progression for SPARC with its long-running focus on chemical and dynamical processes of the free atmosphere and their influence on climate; and this evolution is now explicit both in the SPARC name and the newly designed logo (officially launched at the GA in January 2014). SPARC's goals and objectives are expanding, and closely coordinated with partner organizations in the WCRP, WWRP, and IGBP. Read more about these collaborative connections in the Activity Reports included in this Annual Report. We hope the information here is not only a useful summary for our long-term friends and colleagues, but also a snapshot for those new to SPARC, or those who may be interested in becoming more involved in some of the new emerging and ongoing activities within SPARC described here.

SPARC co-chairs 2013: Greg Bodeker (left) and Joan Alexander (right).

SPARC concentrates on bottom-up driven research and it's success is built on the commitment of the community who dedicate their time to SPARC activities. As the co-chairs of SPARC we would like to take this opportunity to thank all those involved who have helped make 2013 a highly successful year for SPARC.

A Word from the Project Office

2013 was a busy year for the SPARC Office with several changes and new challenges. Anke Witten, former SPARC Office Manager, left us at the end of the year and we would like to thank her for her dedicated contribution to SPARC. She is replaced by Petra Bratfisch who began with us in November. All other members of the SPARC Office (Johannes Staehelin, Director; Carolin Arndt, Communications Officer; Fiona Tummon, Project Scientist; Diane Pendlebury, Project Scientist working at the University of Toronto) continue as before, most working on a part-time basis.

Besides our normal responsibilities (such as production of the SPARC newsletter and maintaining the SPARC website), the SPARC Office was very involved in supporting the organisation of one of SPARC's most important scientific events, the 5th SPARC General Assembly (GA), which took place in Queenstown, New Zealand, in January 2014. The SPARC Office helped coordinate and search for financial support for young scientists and scientists from developing nations, and assisted in the distribution of these funds. Furthermore, Carolin Arndt coordinated the development of the new SPARC visual identity involving the SPARC community. In addition, as an outreach activity we produced an article in the magazine "International Innovation", on 'Coordinating international atmospheric research', p.42-44, issue 118, 2013. For one of our sponsors we also prepared a fact sheet about the effects of the Montreal Protocol on the ozone layer and climate (currently available in German and French at www.sparc-climate.org).

The Zurich SPARC Project Office. From left to right: Carolin Arndt (Communications Officer), Johannes Staehelin (Director), Petra Bratfisch (Office Manager), and Fiona Tummon (Project Scientist). Not in photo: Diane Pendlebury (Project Scientist based in Toronto, Canada).

The SPARC Office also contributed to SPARC science activities. Carolin initiated the drafting of a short concept for SPARC's involvement in capacity development and helped organize a side event at the GA to capture the community needs in this field. Fiona Tummon contributed to scientific research

undertaken as part of several SPARC activities such as the Lifetime of Halogenated Source Gases Assessment , Ozone Profile Assessment – Phase II (Si2N), and the Chemistry-Climate Model Initiative (CCMI).

Being part of the Swiss Federal Institute of Technology (ETH Zurich), the SPARC Office is not a separate legal entity. This limits the flexibility of the use of financial resources to some extent and as a result a formal Amendment to the SPARC Office contract (regulating the use of SPARC Office sponsor support) was required to enable the use of available resources as a deficit guarantee for the SPARC GA. Further additional legal documents were required to allow continued support from the Federal Office of the Environment (FOEN) as a result of changes to their contractual rules. However, being part of ETH Zürich also has big advantages: no financial resources are required for infrastructure (offices, furniture, IT facilities) and services (shipping costs of SPARC newsletters, legal and IT support, and so on).

The SPARC Office would like to acknowledge the support of ETH Zurich, FOEN, the Federal Office of Meteorology and Climatology (MeteoSwiss), the Swiss National Science Foundation (SNF), the Canadian Space Agency, and WCRP, as well the excellent collaboration and support of the Joint Planning Staff, particularly Vladimir Ryabinin, SPARC liaison at the WCRP Joint Planning Staff in Geneva.

The SPARC Office team

Workshops and Meetings held in 2013

14 – 18 January
Lifetimes Document Review Meeting
Zurich, Switzerland

20 – 21 February
SPARC Data Requirements Workshop
Frascati, Italy

25 February – 1 March
Climatic Effects of Ozone Depletion in the Southern Hemisphere
Buenos Aires, Argentina

1 – 3 April
Stratosphere-troposphere Processes and their Role in Climate Workshop
Kyoto, Japan

22 – 26 April
Gravity Waves Group 'Forces & Sources' Meeting
Bern, Switzerland

22 – 26 April
Joint SNAP / DynVar Workshop
Reading, UK

29 April – 1 May
S-RIP Planning Meeting
Exeter, UK

13 – 17 May
CCMI 2013 Workshop
Boulder, USA

27 – 29 May
Research Applications of High-resolution Radiosonde Data
Stonybrook, New York, USA

17 – 21 June
DAWG Side Meeting at AMS Conference
Newport, USA

18 – 20 September
Ozone Profile (II) Review Meeting
Helsinki, Finland

26 – 27 September
Stratospheric Temperature Trends Meeting
Reading, UK

28 – 30 October
SSiRC Open Science Meeting
Atlanta, USA

4 – 6 December
WAVAS-II Meeting
Pasadena, California, USA

Participants of the 21st SPARC SSG held in Queenstown, New Zealand, from 19-21 January 2014.

SPARC Activity Report Summaries

IGAC/SPARC Chemistry-Climate Model Initiative (CCMI)

Activity Leaders: Veronika Eyring (stepped down end 2013), Jean-François Lamarque, Michaela Hegglin

The joint IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) (for further information see http://www.met.reading.ac.uk/ccmi/) coordinates existing and future IGAC and SPARC chemistry-climate model evaluation and associated modelling activities. The aim of this international activity is to study the chemistry and dynamics of the global stratosphere and troposphere as a single entity in global models, so as to better understand the multi-faceted interactions and feedbacks between them and their impact on climate and the ozone layer. Particular goals are to validate the performance of these models using new observations and process analyses, and to disentangle the different natural and anthropogenic drivers of observed atmospheric changes.

Achievements for 2013

IGAC/SPARC CCMI held its 2013 Science Workshop in May in Boulder, Colorado (USA), with approximately 130 participants attending. The goals of the workshop were to (1) improve process-oriented model evaluation, (2) improve the comparability between models and observations, and (3) discuss the simulations and analyses in support of upcoming assessments and process studies.

Other accomplishments include:

- The CCMI website was moved to Reading: www.met.reading.ac.uk/ccmi/
- With respect to Phase-1 (CCMI-1) simulations:
    - Forcings for the CCMI-1 simulations were made available
    - The data request for the CCMI-1 simulations was finalized
    - An overview of planned analyses by the community was assembled
    - An overview of participating models was made available
    - Setup of the BADC CCMI data archive is underway (BADC offered to host the CCMI data archive)
- CCMI provided input to the CMIP5 Survey and made several suggestions as to how the CCMI community could contribute to CMIP6
- Preparation for the 2014 Science Workshop has started, including the first announcement and setting up a new workshop website
- CCMI has written three articles in the past year, contributing to both the SPARC and IGAC newsletters (see Eyring *et al.,* 2013a; Eyring *et al.,* 2013b; Eyring *et al.,* 2013c).

23 modelling teams will participate in the first round of CCMI (see **Table 1**). Support for these teams is crucial to the success of CCMI. The CCMI-1 model data will again be hosted by BADC, while taking advantage of the Earth System Grid Federation wherever possible. CCMI follows CMIP standards in terms of data format and documentation. CCMI plans to apply as CMIP6 Satellite Model Intercomparison Project and to propose additional CMIP6 sensitivity experiments on atmospheric chemistry and aerosols in collaboration with AeroCOM. We also plan to help evaluating chemistry-climate interactions in the CMIP6-DECK simulations as well as to provide diagnostics and metrics to the ESMValTool for routine application on the ESGF.

The measurement community is also very much involved in CCMI. Since knowledge of data quality and representativeness is crucial to our activity, ongoing support for measurement teams from space agencies and other institutions benefit us in the long-term. Observations from different platforms are used: aircraft, balloon, and limb as well as nadir satellite instruments.

	Model Name	Modeling Center
1	**ACCESS**	University of Melbourne, Australia, and NIWA, New Zealand
2	**CCSRNIES-MIROC3.2**	NIES, Japan
3	**CESM-Superfast**	LLNL, USA
4	**CESM1-CAM4Chem**	NCAR, USA
5	**CESM1-WACCM4**	NCAR, USA
6	**CICERO-OsloCTM3**	CICERO, Norway
7	**CMAM**	EC, Canada
8	**CNRM-CCM**	Météo-France, France
9	**EMAC**	MESSy-Consortium (DLR, KIT, FZJ, FUB, UMZ, MPIC), Germany
10	**GEOSCCM**	NASA/GSFC, USA
11	**GEOS-Chem**	LAGEO, China
12	**GFDL-AM3**	NOAA-GFDL, USA
13	**GISS-E2-R**	NASA-GISS, USA
14	**HadGEM3-ES**	Hadley Centre, Met Office, United Kingdom
15	**LMDZrepro**	IPSL, France
16	**MIROC-ESM-CHEM**	NIES, Nagoya Univ., JAMSTEC, Japan
17	**MOCAGE**	GAME/CNRM, MétéoFrance, France
18	**MRI-ESM1r1**	MRI, Japan
19	**NIWA-UKCA**	NIWA, New Zealand
20	**SOCOLv3**	PMOD/WRC and IAC ETHZ, Switzerland
21	**ULAQ-CCM**	University of L'Aquila, Italy
22	**UMSLIMCAT**	University of Leeds, United Kingdom
23	**UMUKCA-UCAM**	University of Cambridge, United Kingdom

Table 1: List of models and modelling centres currently participating in CCMI-1.

Finally, through several of its scientific steering committee members, CCMI is currently developing a pathway to create a strong collaboration with AeroCOM to address questions on aerosols related to the WCRP Grand Challenges and CMIP6 analysis and uncertainties.

Plans for the Coming Year

A great amount of effort will be put into the evaluation of the CCMI-1 model simulations, which the model teams are currently preparing and starting to upload to the BADC data archive. More generally, we will retain the goals and deliverables of CCMVal and ACCMIP, which include:

- Make observational community an integral part of CCMI
- Emphasize process-oriented evaluation
- Ensure community-based deliverables.

Furthermore, we plan to contribute to the development of a community-wide diagnostic tool for the evaluation of Chemistry-Climate/Earth System models and to write a white paper on the IGAC/SPARC CCMI.

In addition, CCMI will contribute to the development of emissions databases for CMIP6 and will lead the development of an update of the IGAC/SPARC Ozone database (Cionni *et al*., 2011) for CMIP6. This database will be based as much as possible on observations, and is to be completed by the end of 2014.

The IGAC/SPARC CCMI 2014 Science Workshop was held in Lancaster from 20-22 May (local organiser: Paul Young). Around 130 participants attended the workshop.

References

Cionni, I., V. Eyring, J. F. Lamarque, W. J. Randel, D. S. Stevenson, F. Wu, G. E. Bodeker, T. G. Shepherd, D. T. Shindell, and D. W. Waugh, 2011: Ozone database in support of CMIP5 simulations: results and corresponding radiative forcing. *Atmos. Chem. Phys.,* **11**, 11267-11292, doi:10.5194/acp-11-11267-2011.

Eyring, V., J.-F. Lamarque, P. Hess, F. Arfeuille, K. Bowman, M. P. Chipperfield, B. Duncan, A. Fiore, A. Gettelman, M. A. Giorgetta, C. Granier, M. Hegglin, D. Kinnison, M. Kunze, U. Langematz, B. Luo, R. Martin, K. Matthes, P. A. Newman, T. Peter, A. Robock, T. Ryerson, A. Saiz-Lopez, R. Salawitch, M. Schultz, T. G. Shepherd, D. Shindell, J. Stähelin, S. Tegtmeier, L. Thomason, S. Tilmes, J.-P. Vernier, D. W. Waugh, and P. J. Young, 2013a: Overview of IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) Community Simulations in Support of Upcoming Ozone and Climate Assessments, *SPARC Newsletter*, **40**, p. 48-66.

Eyring, V., J.-F. Lamarque, I. Cionni, B. Duncan, A. Fiore, A. Gettelman, M. Hegglin, P. Hess, T. Nagashima, T. Ryerson, T. Shepherd, D. Shindell, D. Waugh, and P. Young, 2013b: Report on the IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) 2013 Science Workshop, *SPARC Newsletter*, **41**.

Eyring, V., J.-F. Lamarque, I. Cionni, B. Duncan, A. Fiore, A. Gettelman, M. Hegglin, P. Hess, T. Nagashima, T. Ryerson, T. Shepherd, D. Shindell, D. Waugh, and P. Young, 2013c: Event Summary: IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) 2013 Science Workshop, *IGAC Newsletter*, **50**.

Gravity Waves

Activity Leaders: Joan Alexander and Kaoru Sato

Biases in global model winds at tropopause levels and above affect and guide planetary wave propagation with attendant affects on general circulation, variability, and weather and climate extremes. The resolution and/or parameterization of gravity wave momentum fluxes in global models are key processes for reducing these wind biases.

Achievements for 2013

In 2013, the SPARC Gravity Wave activity published a review paper in the Journal of Climate and began new international projects aimed toward reducing uncertainties in gravity wave processes in global models. The review by Geller *et al.* (2013) documented the results of a first comparison of parameterized gravity wave momentum fluxes in standard coarse-resolution climate models with fluxes in high-resolution models that permit a spectrum of gravity waves. Analyses of high-resolution limb-sounding satellite observations also permitted a global comparison of fluxes estimated from these data. In addition, comparison with the most accurate observed gravity wave momentum fluxes, those derived from balloon campaign measurements, permitted a quantitative evaluation of the models at high southern latitudes. Some key results from this study are illustrated in **Figure 1** and include:

- Gravity wave momentum fluxes in different climate models with completely different formulations for parameterization of orographic and non-orographic gravity waves showed surprisingly similar values, presumably because the parameter settings were chosen to give realistic middle atmosphere circulation and temperature structure in all models.
- Many gravity wave parameterizations in the current generation of models greatly exaggerate momentum fluxes over polar regions, particularly in summer.
- Both satellite observations and high-resolution models are resolution limited. Horizontal resolution remains a key limitation, particularly for mountain waves. Vertical resolution quickly becomes a serious limitation when standard climate models are run at higher horizontal resolution.
- Long-duration isopycnal balloon measurements provide our best observational constraints for gravity wave momentum fluxes, but these are currently limited to south polar regions and campaign periods.

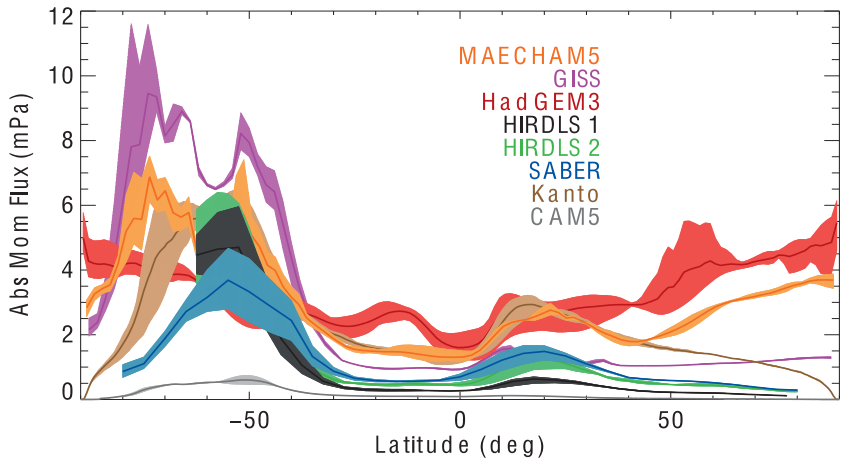

Figure 1: Zonal-mean absolute gravity wave momentum fluxes at 30km in July, comparing satellite observations (HIRDLS 1, HIRDLS 2, and SABER), parameterized waves in standard resolution climate models (MAECHAM5, GISS, HadGEM3), a high-resolution model without any gravity wave parameterization (Kanto), and a high-horizontal resolution version of a standard climate model (CAM5). The shading represents interannual variability among 3 years. See Geller *et al.* (2013)for more detail.

Also in 2013, three new studies were initiated at a meeting in Bern, Switzerland, held in April. They include:

- Atmospheric momentum budget comparisons among global models and reanalyses, including drag terms both at the surface and in the middle atmosphere. Part of this work is joint with the WCRP Working Group on Numerical Experimentation (WGNE).
- A review of the strength and possible sources of missing wave drag in the Southern Hemisphere utilising both wave observations and models.
- Tropical waves and relationships to Quasi-Biennial and El Niño Southern Oscillations. These projects are ongoing in 2014.

Plans for the Coming Year

The Gravity Waves Activity held a side meeting at the SPARC General Assembly on 16 January 2014, attended by over 40 participants. At the meeting an overview of the Gravity Wave Activity was given, as well as a presentation of recent progress, near-term plans, and opportunities for involvement. We are also soliciting broad community input on future directions for the activity.

The activity held its second ISSI-SPARC Team meeting in Bern, Switzerland, from 31 March – 4 April 2014. Data requests for the momentum budget and surface drag initiatives have been prepared. The group is expecting two publications from the ISSI team's work in 2014.

Long-range planning for a Chapman Conference in 2015 has also begun. A tentative focus will be on 'Gravity Wave Effects on Weather and Climate'. Fuqing Zhang, Joan Alexander, Kaoru Sato, and Kevin Hamilton will co-convene the conference, and we will prepare a proposal for the AGU and request significant support from SPARC/WCRP.

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Geller, M.A., *et al.*, 2013: A comparison between gravity wave momentum fluxes in observations and climate models. *J. Clim.*, DOI: 10.1175/JCLI-D-12-00545.1.

Solar Influences (SOLARIS-HEPPA)

Activity Leaders: Katja Matthes and Bernd Funke

This working group (renamed SOLARIS-HEPPA in 2012) was created to clarify the effects of solar influence on climate by radiation and particles, with special focus on the importance of middle atmospheric chemical and dynamical processes and their coupling to the Earth's surface with state-of-the-art chemistry-climate models (CCMs), as well as mechanistic models and observations (see **Figure 2** for a schematic diagram of different forcings and processes that are investigated within SOLARIS-HEPPA).

Achievements for 2013

- Solar forcing data and scenarios for CCMI (Chemistry-Climate Model Initiative; see p. 8-10) have been prepared and are available at the SOLARIS-HEPPA webpage (http://solarisheppa.geomar.de/solarisheppa/ccmi).
- A HEPPA-II project meeting was held at KIT, Karlsruhe, Germany from 6-7 May 2013 (with 18 participants).
- An assessment study of Energetic Particle Precipitation representation in models (including proxy-based parameterizations) has been initiated in conjunction with the ISSI project "Quantifying hemispheric differences in particle forcing effects on stratospheric ozone" (led by Dan Marsh).
- The new joint SOLARIS-HEPPA website (http://solarisheppa.geomar.de/solarisheppa/) was launched in December 2013.
- A HEPPA-SOLARIS Workshop summary of the 2012 Meeting held in Boulder, Colorado, USA, was published in SPARC Newsletter no. 40 (Matthes *et al.*, 2013).
- Analysis and comparison of solar signals in CMIP5 simulations was started as a new sub-activity (SolarMIP). A dedicated workshop was held from 29-30 October in Thessaloniki, Greece (with 10 participants).
- A white paper based on SOLARIS-HEPPA, EU-TOSCA, and CAWSES TG1 activities was submitted to SCOSTEP as input for the upcoming VarSITI program starting in 2014.

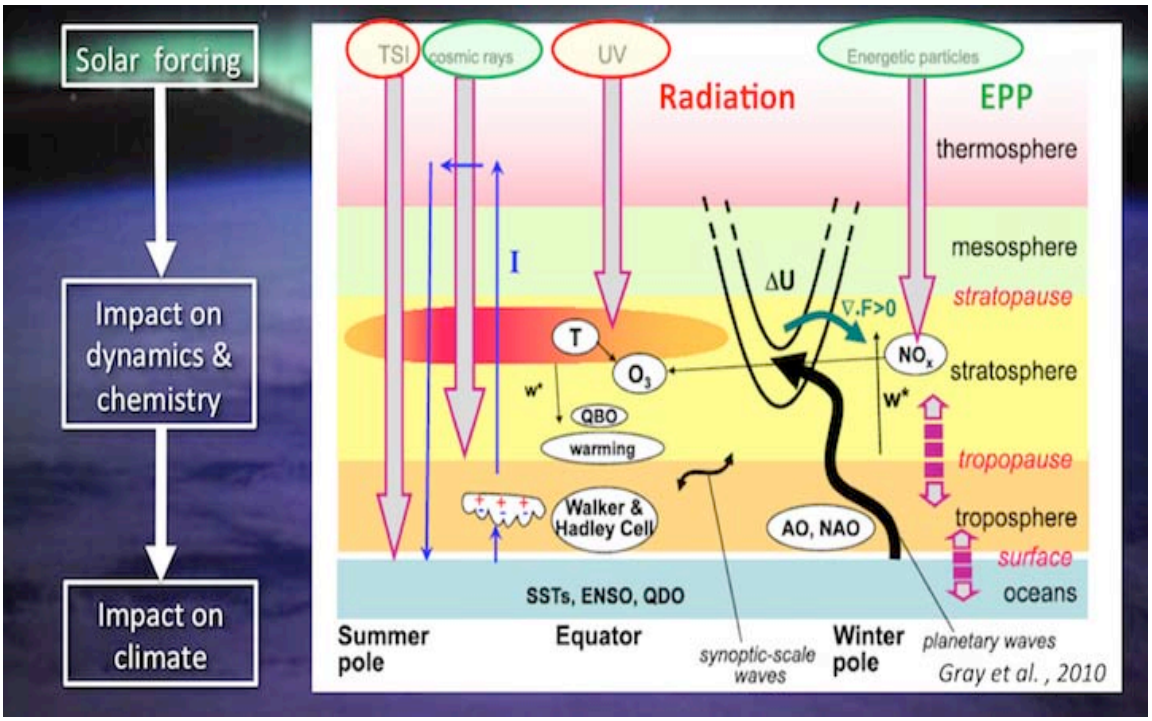

Figure 2: Solar forcings and coupling processes investigated within SOLARIS-HEPPA

Plans for the Coming Year

- Finalize the HEPPA-II intercomparison study: a final review meeting is planned during the HEPPA- SOLARIS Workshop to be held in Baden-Baden, Germany, in May 2014.
- Publish HEPPA-II results: planned publications include an overview paper and three dedicated papers on particular aspects, such as representation of model dynamics and intercomparison of observations.
- Publish SolarMIP results: planned publications include four papers on stratospheric signals, ocean-atmosphere interaction, and two dedicated to particular aspects/models.
- Contributions to the planned TOSCA undergraduate-level "handbook" on solar impacts on climate, which consists of a series of short topical chapters related to solar impacts on climate.
- Start SOLARIS-HEPPA coordinated evaluation of the solar cycle signal in CCMI hindcast simulations and satellite observations, including an assessment of analysis tools (multiple regression) and quantification of individual contributions to the solar signal.
- There will be a special solar session at the EGU (Vienna, Austria, 27 April - 2 May 2014 (http://www.egu2014.eu/home.html): CL5.12: Solar Influence on the Middle Atmosphere and Dynamical Coupling to the Troposphere and the Ocean, Convener: Katja Matthes, Co-Convener: Margit Haberreiter).
- May 2014: 5th international HEPPA (High Energy Particle Precipitation in the Atmosphere) meeting held jointly with SPARC/SOLARIS-HEPPA Meeting, Karlsruhe, Germany, from 5-9 May 2014 (funding for the attendance of young scientists will be made available).

Journal publications during 2013

- Ermolli, I. *et al.*, 2013: Recent variability of the solar spectral irradiance and its impact on climate modelling. *Atmos. Chem. Phys*., **13**, 3945–3977.
- Matthes, K., Funke, B., and C. Randall, 2013: Report on the 1st Joint SOLARIS-HEPPA Meeting, 9-12 October 2012, Boulder, CO, USA. *SPARC Newsletter*, **40**, pp. 33-37.

Dynamical Variability (DynVar)

Activity Leaders: Elisa Manzini and Edwin Gerber

DynVar focuses on modelling the dynamics and variability of the stratosphere-troposphere system, with particular emphasis on the two-way dynamical coupling between them (for example, see **Figure 3**). The activity aims to promote the development, use, and analysis of coupled atmosphere-ocean-sea-ice general circulation models (GCMs) with tops above the stratopause, and asks how the stratospheric circulation:

- affects the tropospheric mean climate?
- impacts climate variability on all timescales?
- impacts climate change?

Achievements for 2013

Over the past few years DynVar has been very successful in promoting the use of atmospheric GCMs with model tops above the stratopause and relatively fine stratospheric vertical resolution (that is high-top models). As documented by Charlton-Perez *et al*. (2013), about a third of the models used in CMIP5 had high tops. This success was facilitated in Europe by the COMBINE project (2009-2013), led by MPI-M (Hamburg, Germany), which in turn possibly encouraged the international community to follow suit.

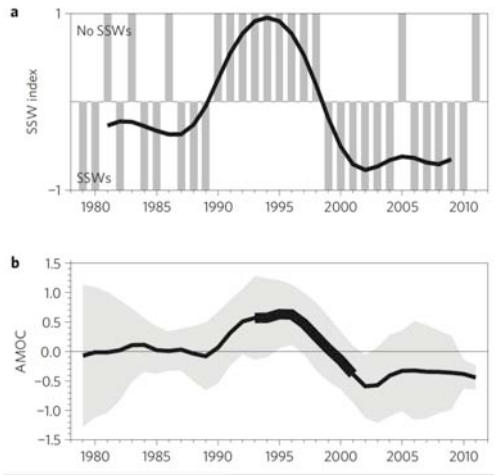

Figure 3: Observed stratospheric flow variations and their relationship to AMOC (Atlantic Meridional Overturning Circulation). **a**: Annual time series of the SSW (Stratospheric Sudden Warming) index; grey bars mark years with (-1) and without (1) major SSWs; the black line is a smoothed version of this. **b**: Multi-reanalysis estimate of annual mean AMOC variations at 45°N; thick black line denotes the common period for all 12 reanalyses and grey shading is the 1-standard deviation uncertainty interval. Figure from Reichler *et al*., 2012.

The call made by DynVar for the analysis of the stratosphere and stratosphere-troposphere coupling in CMIP5 models started to deliver peer-reviewed publications in 2013. These publications include works promoted within DynVar, as well as independent responses to the DynVar call for analysis, given the free availability of the CMIP5 model output. Several other publications are in preparation or under review (see p.16).

The 3rd DynVar workshop was held in April 2013, jointly with the SNAP activity. The workshop served to provide a forum for discussion of ongoing analysis of the CMIP5 and CLIVAR/WGSIP/SHFP multi-model ensembles, as well as for probing interest in the continuation of a link with CMIP. The response from the community was very positive. A report from the workshop was published in SPARC Newsletter no. 41 (Manzini *et al.*, 2013).

Presentations:

- February 2013: DynVar presentation at the SPIN workshop (Frascati, Italy).
- May 2013: DynVar presentation at the CLIVAR Scientific Steering Group meeting (Kiel, Germany). A proposal was made for collaboration with CLIVAR on the scientific basis of the decadal climate prediction part of the Regional Climate Information WCRP grand challenge.

Programmatics:

- In consultation with the DynVar Committee, it was decided to nominate a second Co-Chair. Edwin Gerber has kindly accepted to co-lead the DynVar activity with Elisa Manzini.
- We have established a link with the emerging Quasi-Biennial Osciallation initiative (QBOi),

which is aiming to focus on modelling the QBO. This initiative is currently led by Scott Osprey and has been added to the DynVar website under 'Research Topics and Group' (http://www.sparcdynvar.org/research-topics-groups-folder/).

Journal publications during 2013

- Gerber E.P., *et al*., 2012: Assessing and Understanding the Impact of Stratospheric Dynamics and Variability on the Earth System, *Bull. Am. Met. Soc*., http://dx.doi.org/10.1175/BAMS-D-11-00145.1.
- Charlton-Perez, A.J., *et al.*, 2013: On the lack of stratospheric dynamical variability in low-top versions of the CMIP5 models, *J. Geophys. Res. Atmos*., **118**, DOI:10.1002/jgrd.50125.
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- Hardiman, S.C., N. Butchart, and N. Calvo, 2013: The morphology of the Brewer–Dobson circulation and its response to climate change in CMIP5 simulations, *Q.J.R. Meteorol. Soc*., DOI: 10.1002/qj.2258.
- Kawatani, Y., and K. Hamilton, 2013: Weakened stratospheric quasi-biennial oscillation driven by increased tropical mean upwelling, *Nature*, **497**, DOI: 10.1038/nature12140.
- Reichler, T., J. Kim, E. Manzini, and J. Kröger, 2012: A stratospheric connection to Atlantic climate variability, *Nature Geoscience Letters*, **5**, DOI: 10.1038/ngeo1586.
- Shaw, T.A., J. Perlwitz, and O. Weiner, 2014: Troposphere-stratosphere coupling: Links to North Atlantic weather and climate, including their representation in CMIP5 models, *J. Geophys. Res*., DOI: 10.1002/2013JD021191.

Manuscripts submitted regarding the CMIP5 analysis:

- Manzini, E., A. Yu., A. Karpechko *et al.*, subm.: Northern winter climate change: Assessment of uncertainty in CMIP5 projections related to stratosphere – troposphere coupling, *J. Geophys. Res*.

Plans for the Coming Year

DynVar will continue to promote and work on analyses of CMIP5 model output, with the aim to produce several publications. In response to suggestions that DynVar extends its research to cover issues related to tropospheric dynamics, DynVar has started a review of its current research topics. A further issue is to explore the possibility that DynVar plays a more active role in CMIP6, proposing idealized experiments/diagnostics (including CMIP tables). Possible topics could include how to assess how the stratosphere responds to climate change and what defines a "well-resolved stratosphere".

DynVar has not planned any workshop for 2014. However, we would like to highlight that one of our members, Tiffanny Shaw, is proposing a WCRP workshop on modes of variability for 2015, in collaboration with Mark Baldwin. This workshop fits in very well with the DynVar research topics, and so DynVar is intending to provide any support needed. The next DynVar workshop is planned for mid-2016.

Trace Gas Climatologies (SPARC Data Initiative)

Activity Leaders: Michaela Hegglin and Susann Tegtmeier

The SPARC Data Initiative has entered its final year, and is about to finish the first comprehensive comparison of vertically resolved trace gas and aerosol observations from all available limb-viewing satellite instruments. The observational records include 25 different chemical trace gas species and aerosol, span the time period 1979-2010, and were collected by a number of national space agencies, including the CSA, ESA, NASA, JAXA, and the SNBS. These observations are generally used as the basis for empirical studies of stratospheric climate and variability, as well as for the validation of transport and chemistry in chemistry-climate models. Our knowledge of the quality of the different data sets is being improved with each of the new SPARC Data Initiative evaluations, which is crucial for rendering future scientific applications of the data sets more meaningful. The SPARC Data Initiative is thereby making a major contribution toward the characterization of measurement uncertainty (see **Figure 4**) and improving our knowledge of the state of the atmosphere.

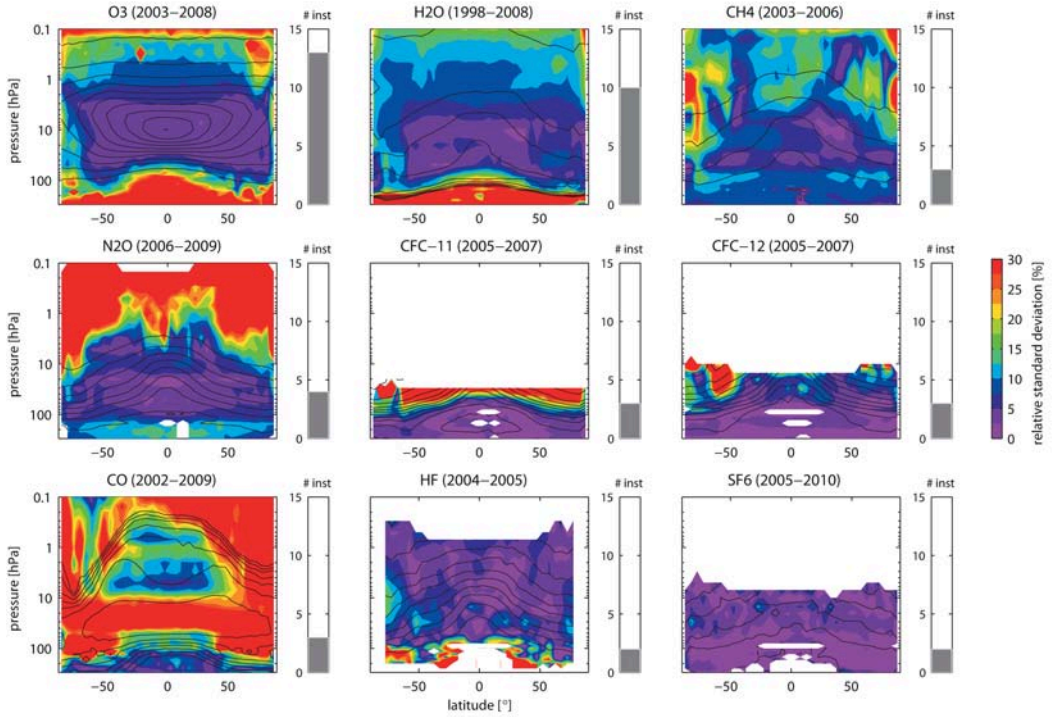

Figure 4: Synopsis of the uncertainty in the measured annual zonal mean state of longer-lived species. The uncertainty is given by the relative standard deviation over all instruments' multi-annual zonal mean data sets and is presented here for O_3, H_2O, CH_4, N_2O, CFC-11, CFC-12, CO, HF, and SF_6.

Achievements for 2013

The SPARC Data Initiative has made great progress in the past year, taking major steps towards the finalization of the SPARC Data Initiative report. The final review meeting to discuss a first draft of the Executive Summary of the SPARC Data Initiative report was held in Granada, Spain, and the comments of four reviewers have been implemented. Most chapters of the long-lived species (including CFCs, SF_6, and HF) have been finalized and typeset. Some others have gone through the second internal review and are now being revised before typesetting (N_2O, CO, HCl, CH_4, NO_x, NO_2, and NO). Most short-lived trace gas species evaluations have been finalized, but have to be written up into chapter form and go out for external review. Major milestones have been reached with the publication or submission of six papers to the SPARC Data Initiative special issue in the Journal of Geophysical Research.

Journal publications during 2013

- Hegglin, M. I. and the SPARC Data Initiative Team, SPARC Data Initiative, 2013: Comparison of water vapour climatologies from international limb satellite sounders, J. Geophys. Res., doi:10.1029/2013JD019614.
- Tegtmeier, S. and the SPARC Data Initiative Team, SPARC Data Initiative, 2013: Comparison of ozone climatologies from international limb satellite sounders, J. Geophys. Res., doi:10.1029/2013JD019877.
- Toohey, M. and the SPARC Data Initiative Team, 2013: Characterizing sampling bias in the trace gas climatologies of the SPARC Data Initiative, J. Geophys. Res., doi:10.1029/2013JD020298.
- Kreyling, D., H. Sagawa, I. Wohltmann, R. Lehmann, and Y. Kasai, 2013: SMILES zonal and diurnal variation climatology of stratospheric and mesospheric trace gasses: O_3, HCl, HNO_3, ClO, BrO, HOCl, HO_2, and temperature, J. Geophys. Res. Atmos., 118, 11,888–11,903, doi:10.1002/2012JD019420.
- Neu, J. L. and the SPARC Data Initiative Team, Intercomparison of Satellite O3 Climatologies in the Upper Troposphere/Lower Stratosphere (UTLS) using Tropospheric Emission Spectrometer (TES), J. Geophys. Res., DOI: 10.1002/2013JD020822.
- Tegtmeier, S. and the SPARC Data Initiative Team, subm.: SPARC Data Initiative: A comparison of CFC-11, CFC-12, HF, and SF_6 climatologies from international limb satellite sounders, J. Geophys. Res.

Furthermore, the SPARC Data Initiative ozone climatologies have been made publicly available through the SPARC Data centre (www.sparc-climate.org/data-center/data-access/sparc-data-initiative/).

Plans for the Coming Year

The last year of the SPARC Data Initiative will be dedicated to finalizing the report. This includes finishing first drafts, internal and external review of the rest of the short-lived species (HNO_3, HNO_4, N_2O_5, $ClONO_2$, HOCl, ClO, BrO, OH, HO_2, CH_2O, and CH_3CN), and the aerosol evaluations.

In addition, we intend to submit at least three more manuscripts to the *Journal of Atmospheric Research or Atmospheric Chemistry and Physics*:

- Hegglin, M. I. and the SPARC Data Initiative team, in prep.: Comparison of trace gas and aerosol climatologies from international satellite limb sounders.
- Tegtmeier, S. and the SPARC Data Initiative team, in prep.: Comparison of nitrogen species climatologies from international satellite limb sounders.
- Hegglin, M. I. and the SPARC Data Initiative team, in prep.: Comparison of aerosol climatologies from international satellite limb sounders.

Data Assimilation Working Group

Activity Leaders: David Jackson and Quentin Errera

Achievements for 2013

A Data Assimilation Working Group (DAWG) side meeting was held at the AMS Conference on Middle Atmosphere, Newport, USA, in June 2013. Recent progress in data assimilation (DA) was reviewed focusing on (1) extension of DA systems higher up to the mesosphere and increasing examples of mesosphere/stratosphere/troposphere linkages, and (2) increasing development of chemical DA. The latter highlighted recent results that show how ozone DA is used to diagnose model errors and performance, and noted the increasing number of chemical reanalyses being produced. There was also a summary of (3) SNAP and (4) S-RIP progress. These four themes will likely form the basis of the next DAWG workshop to be held in 2014.

Quentin Errera attended the SPARC data requirements workshop in Frascati, Italy, in February 2013. He presented data requirements on behalf of the SPARC DAWG. His talk focused on requirements for stratospheric chemistry DA and made recommendations from the SPARC DAWG related to winds and gravity waves. He highlighted the importance of limb sounding data for good quality DA of trace constituents and stressed the need to maintain and improve the range of such observations in the future. **Figure 5** shows the far sharper and more accurate representation of polar ozone when limb-sounding data from Aura MLS are added to the assimilation (right-hand panel).

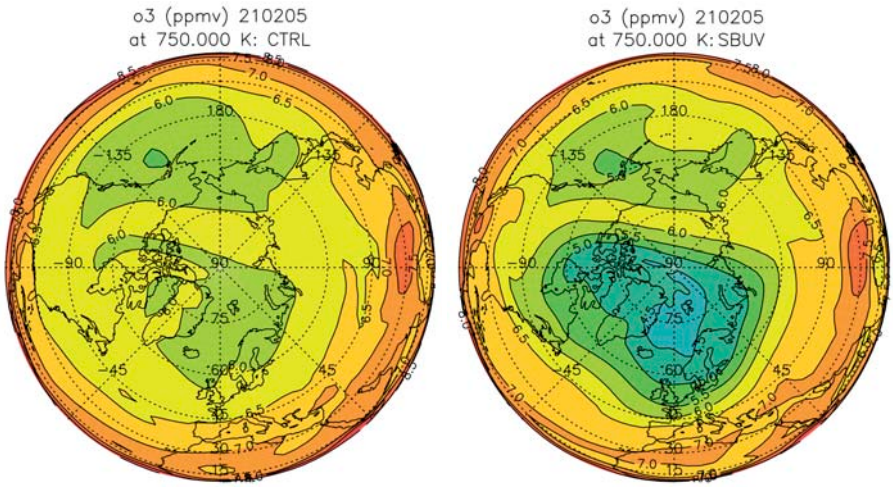

Figure 5: Ozone on the 750K isentropic surface on 21 February 2005: assimilation run using SBUV ozone data (left) and SBUV and Aura MLS ozone data (right). Reproduced from Jackson (2007).

Plans for the Coming Year

An ISSI Study Group on the 'Added-value of Chemical Data Assimilation in the Stratosphere and Upper-troposphere' (led by Richard Menard and Quentin Errera) will be held in Bern, Switzerland, in April 2014. Results and further actions shall be reported at the next DAWG Workshop. Ideas for a possible model vertical resolution project and/or gravity waves/model resolution project are currently in abeyance but may be revived.

References

Jackson, D., 2007: Assimilation of EOA MLS ozone observations in the Met Office data assimilation system. *Q. J. Royal Met. Soc.*, DOI: 10.1002/qj.140.

Water Vapour Phase II (WAVAS II)

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

Achievements for 2013

During 2013 the WAVAS-II activity organised the structure for two overview papers covering the main results stemming from this activity. The first is related to the issue of supersaturation and *in situ* measurements of water vapour, while the second is a comprehensive satellite data quality paper (see **Figure 6**). We have also determined that the final report will be an expansion of the papers, and include an updated description of the measurement techniques and retrievals. We held a workshop at the Jet Propulsion Laboratory, California, USA, in December 2013, and saw the results of comparisons between satellite and balloon-borne water vapour measurements for the stratosphere, discussed how to approach this for the upper troposphere, as well as how to approach error estimates and drift calculations, and assigned sections of the report to various individuals.

Plans for the Coming Year

In 2014 we plan on completing the supersaturation paper and getting the satellite data quality paper through an internal review and to the point of submission to a journal.

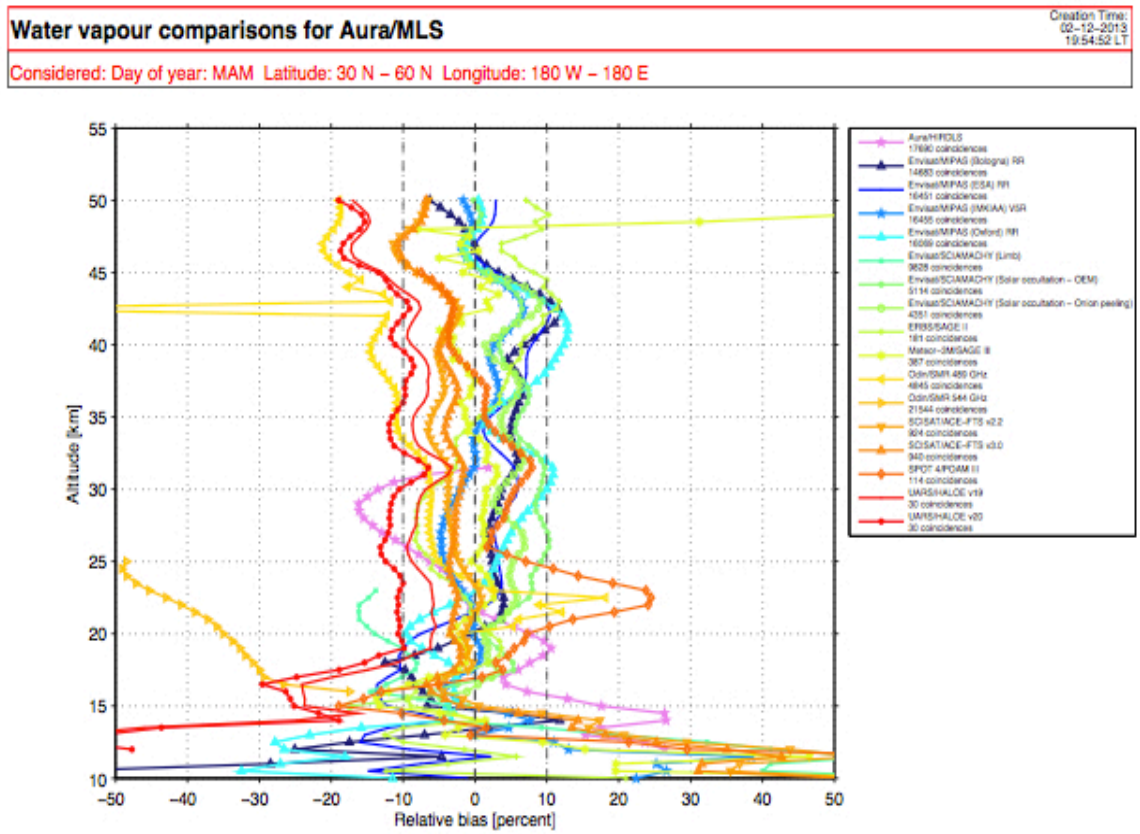

Figure 6: Relative bias profiles of all available satellite water vapour data sets compared to Aura-MLS for the northern mid-latitudes (30-60°N) in spring (March-May, MAM). The bias profiles were built by averaging over all difference profiles between coincident observations (MLS vs. the other satellite instrument) for MAM of all years covered by both instruments. The relative bias is expressed relative to the mean of the two profiles. Coincidence criteria ranged from 24 hours and 100km to 2 hours and 250km, depending on sampling density and orbiting details (such as local overpass time). The figure shows that most of the satellite data are largely within +/-10 % versus Aura-MLS over the entire stratosphere, while in the tropopause region and below we find a large spread between measurements, with large positive and negative biases.

Ozone Profile Phase II (SI2N Initiative)

Activity Leaders: Neil Harris, Johannes Staehelin, and Richard Stolarski

Achievements for 2013

The key results of the activity will be presented in a special issue jointly organized between Atmospheric Chemistry and Physics, Atmospheric Measurement Techniques, and Earth System Science Data: Changes in the vertical distribution of ozone – the SI2N report (Editors: P.K. Bhartia, N. Harris, M. Van Roozendael, M. Weber, R. Eckman, D. Loyola, J. Urban, C. von Savigny, M. Dameris, and S. Godin-Beekmann). The special issue already includes 22 published papers and 12 papers that are currently under review. The papers cover many studies from individual groups relevant to SI2N, dealing with important aspects such as data quality and trend analyses of ground-based ozone profile measurements (using NDACC and GAW observations) and different satellite data sets.

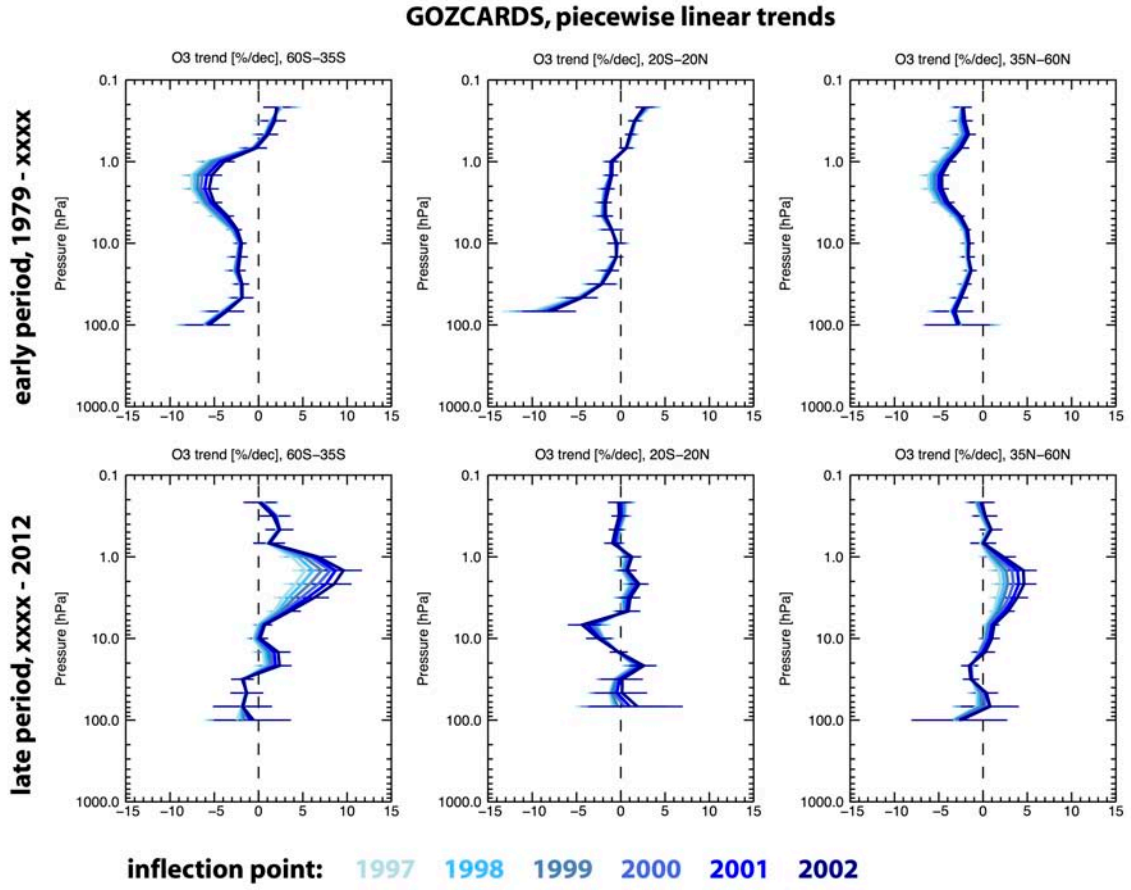

Figure 7: Vertical ozone trends calculated from the GOZCARDS dataset for (left) southern mid-latitudes, (middle) tropics, and (right) northern mid-latitudes. A multiple regression analysis was run from 1979-2012 with different inflection points - for years 1997 to 2002 (different blue shades). The top row shows trends for the first period (1979 - inflection point) and the bottom row for the second period (inflection point - 2012). The choice of inflection point strongly affects the magnitude of the calculated trend, most particularly in the southern mid-latitudes.

In a meeting that took place in Helsinki, Finland, from 18-20 September (attended by around 40 participants) the drafts of the three overview papers that summarize the main SI2N results were intensively discussed. Other papers published in the SI2N special issue and other relevant work were presented as posters to ensure that the main results of the individual contributions were adequately

covered by the three overview papers. One of the overview papers (dealing with ozone profile measurements) has been submitted, the other two (on the validation of satellite measurements with ground-based measurements, and on the analysis and interpretation of all trend results) are in preparation. Available results show that the tropical and mid-latitude ozone profile trends from different data are consistent for the 1980s and 1990s, whereas trends derived for the recovery period (from ~1998 onwards) are less consistent among the individual merged satellite data sets. In an additional paper an overview and comparison of the seven merged satellite data sets currently available will be presented.

Plans for the Coming Year

At the Helsinki meeting it was decided to keep the SI2N special issue open for new submissions until September 2014. In this way, additional information from SI2N might be used in the WMO/UNEP Ozone Assessment Report. Further papers will also result from the important data quality evaluation being carried out on ozone sonde data (Ozonesonde Data Quality Assessment (O3S-DQA)). The termination of SI2N as a SPARC activity is planned for the end of 2014. A workshop is planned (together with the SPARC Data Initiative activity) to explore the need for a new activity focusing on ozone (and possibly other trace species) in the tropopause region.

Lifetime of Halogen Source Gases

Activity Leaders: Malcolm Ko, Paul Newman, Stefan Reimann, and Susan Strahan

Achievements for 2013

The SPARC Activity "Lifetime of halogen source gases" culminated in the December 2013 publication of the SPARC Report No. 6: "Lifetimes of Stratospheric Ozone-Depleting Substances, Their Replacements, and Related Species" (SPARC, 2013). The report provides values for lifetimes and their uncertainties, an assessment of different lifetime definitions (*e.g.* steady-state *vs.* instantaneous lifetimes), and an estimate of lifetime changes resulting from a changing climate.

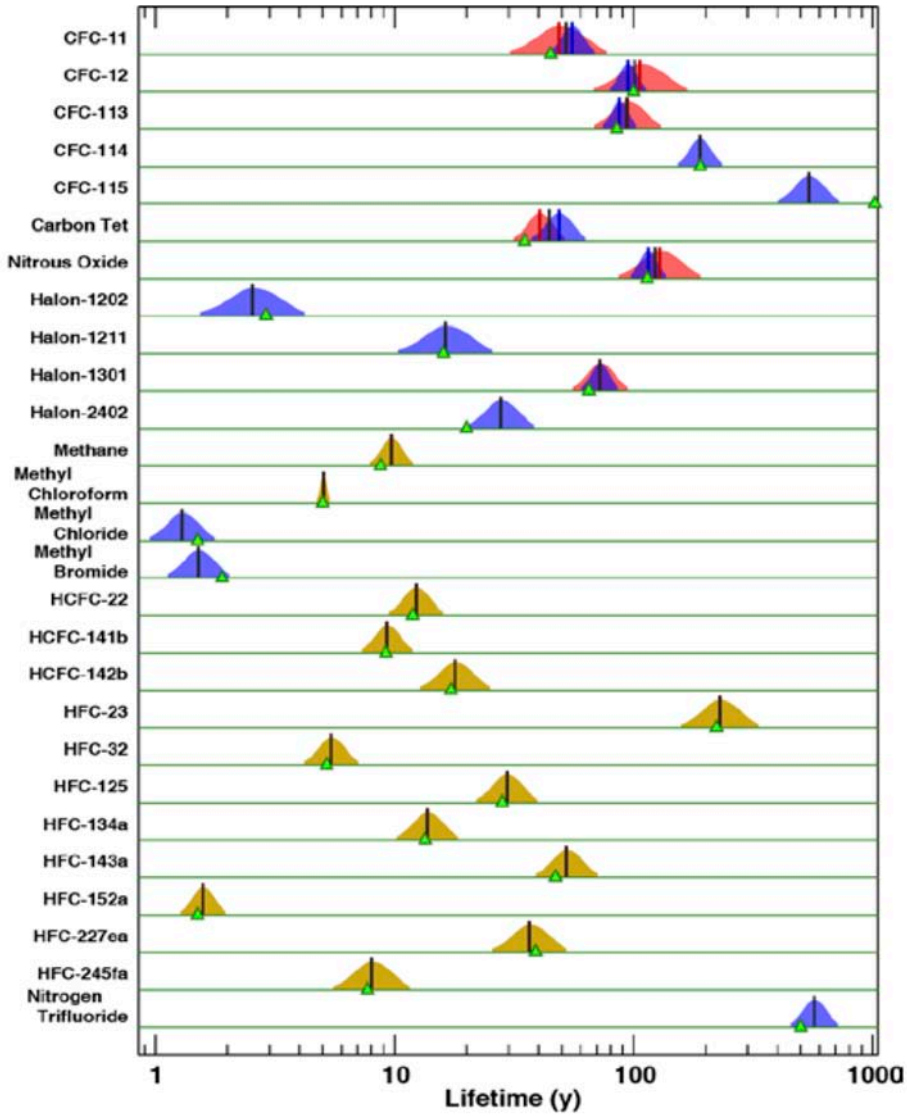

Figure 8: Recommended steady-state lifetime estimates (vertical black lines), lifetime estimates from models (blue) and observations (red). The estimated uncertainties from models (light blue) and observations (light red) are also shown. The uncertainty estimates for the HCFCs and HFCs (shown in green) are from the uncertainty in the retrieved OH concentration and uncertainties in the reaction rate constants. Lifetime estimates from previous reports (WMO, 2011; IPCC, 2007) are indicated by the green triangles.

This activity has accomplished a number of significant tasks, including (1) a refined discussion on the theory of lifetimes, (2) revisions to the photochemical data base used in chemistry-climate models to evaluate lifetimes, (3) new estimates and revisions to lifetimes based on observations, (4) lifetime estimates from modern CCMs, and (5) a set of recommended lifetimes based the combined new estimates (see **Figure 8**).

These lifetimes are used to estimate future concentrations of ozone depleting substances and greenhouse gases from emissions, and have direct impacts on the empirical estimates of ozone depletion potentials and global warming potentials. They also affect our metrics of both ozone depletion and climate change, as well as recovery dates for the return of ozone to 1980 levels. The implications of these lifetime revisions will be addressed in the 2014 WMO/UNEP Ozone Assessment report.

The final assessment report of the activity has been published online and the printed version was made available in March/April 2014.

References

SPARC, 2013: Lifetimes of Stratospheric Ozone-Depleting Substances, Their Replacements, and Related Species. M. K. W. Ko, P. A. Newman, S. Reimann, and S. E. Strahan (eds.), *SPARC Report*, **6**, WCRP-15/2013, available at http://www.sparc-climate.org/publications/sparc-reports/sparc-report-no6/.

Temperature Trends

Activity Leaders: William Randel, Dian Seidel, and David Thompson

Achievements for 2013

The Stratospheric Temperature Trends group held a workshop from 26-27 September 2013, hosted by Keith Shine, at the University of Reading, UK. The focus of the workshop was on reconciling different temperature records constructed from Stratospheric Sounding Unit (SSU) satellite measurements and discussing the current status of meteorological reanalyses for stratospheric temperature trend studies (see for example **Figure 9**). The meeting involving SSU principle investigators from NOAA and the UK Met Office and interested scientists from the climate research community facilitated substantive and detailed discussion. Progress was made towards reducing uncertainties in the two climate records derived from SSU data.

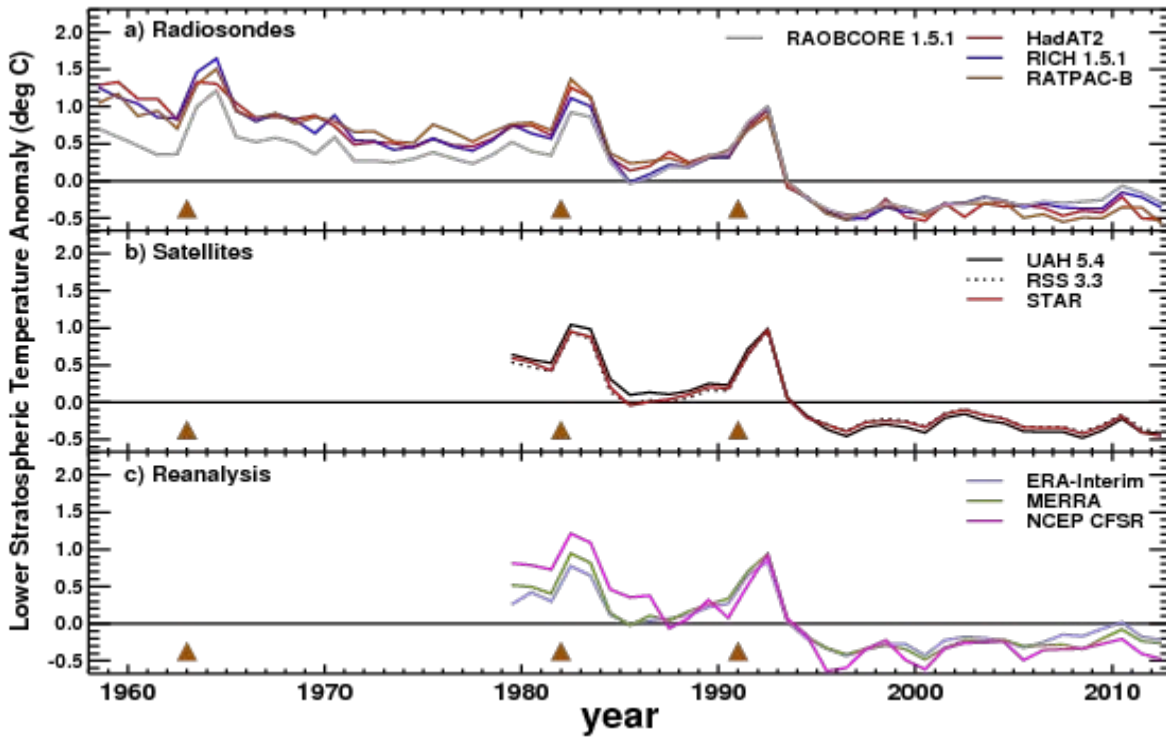

Figure 9: Global-average lower-stratospheric temperature anomalies from multiple datasets, including satellite and radiosonde observations and reanalyses. Triangles indicate dates of major volcanic eruptions. Courtesy: C.S. Long and J. R. Christy, 2013: Lower Stratospheric Temperature. in: State of the Climate in 2012, *Bulletin of the American Meteorological Society*, pp.14-15, ©American Meteorological Society. Used with permission.

Plans for the Coming Year

Motivated by the 2013 workshop, both SSU groups are preparing papers providing details of their data set construction methodology. The group is planning a peer-reviewed journal article to compare and describe the updated versions of the SSU data and resulting temperature variability and change.

Stratospheric Sulfur and its Role in Climate (SSiRC)

Activity Leaders: Markus Rex, Claudia Timmreck, Larry Thomason, Jean-Paul Vernier, and Stefanie Kremser

The main goals of SSiRC include (1) providing a coordinating structure for the various individual activities on stratospheric aerosol research already underway in different research centres; (2) encouraging and supporting new instrumentation and measurements of sulfur containing compounds, such as COS, DMS, and non-volcanic SO_2 in the UT/LS globally; and (3) initiating new model/data intercomparisons.

Figure 10: Participants of the 1st SPARC SSiRC workshop held in Atlanta, Georgia, USA, from 28-30 October 2013.

Achievements for 2013

The first SSiRC workshop was held at the Georgia Tech Global Learning Center in Atlanta, USA, from 28-30 October 2013, followed by a one-day SSiRC steering group meeting. 63 participants from around the world attended the workshop and shared recent accomplishments with the community (**Figure 10**). The main highlights of this very successful workshop included: (1) the improvement of the SAGE II retrieval algorithm (Damadeo *et al.,* 2013) and the Optical Particle Counter (OPC) processing algorithms led to a reduction of the large discrepancy between SAGE II and OPC measurements during background periods, as was reported in the SPARC Assessment of Stratospheric Aerosol Properties (SPARC, 2006); (2) a presentation of a promising novel data set of stratospheric SO_2 profiles derived from MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) measurements; (3) a discussion (led by Terry Deshler) about possible involvement of the SPARC community in the Google [X] Project Loon, http://www.google.com/loon/; and (4) the initiation of the SSiRC climate model initiative. The SSiRC coordination team is currently writing a summary about the outcomes and highlights of the first SSiRC workshop, which will be published in the SPARC Newsletter No. 43 (2014). All presentations given at the SSiRC workshop are publically

available at the newly established SSiRC webpage (http://www.sparc-ssirc.org/). The SSiRC webpage is regularly updated with activities currently under way as well as meetings planned. SSiRC's other major achievements in 2013 were:

- The SSiRC climate model initiative, encompassing 12 different groups, confirmed that they will perform a number of experiments to evaluate the ability of climate models to represent the stratospheric background sulfur budget, thus improving our understanding of the key processes maintaining the stratospheric aerosol layer and its role in the climate system. The experiments will include: (1) a background simulation (to understand the sources and sinks of stratospheric background aerosol), (2) a Pinatubo case study to evaluate a Pinatubo-like perturbation to stratospheric aerosol properties and radiative forcings across atmospheric global climate models with prognostic stratospheric aerosol modules, and (3) a transient run for the last decade (2000-2010), to address open questions regarding the observed increase in stratospheric background aerosol and possible links to the global warming hiatus.
- The start of StratoClim (Stratospheric and upper tropospheric processes for better understanding climate predictions), a collaborative project funded within the FP7 Environment Program of the European Commission http://www.aerosols-climate.org. The main goal of StratoClim is to produce more reliable projections of climate change and stratospheric ozone through a better understanding and improved representation of key processes in the Upper Troposphere and Stratosphere (UTS) employing an integrated approach bridging observations from dedicated field activities, process modelling on all scales, and global modelling with a suite of CCMs and ESMs. With stratospheric sulfur and aerosol as one of its key objectives, StratoClim is expected to become a backbone of the SSiRC activity.
- Establishment of the SSiRC capacity database featuring a comprehensive collection of links to available laboratory measurements, as well as *in situ* data sets from ground-based, aircraft, balloon, and satellite platforms.

Plans for the Coming Year

- Finalize the SSiRC workshop report for publication in SPARC Newsletter no. 43 (July 2014).
- Update and extend the SSiRC capacity database to include links to representative model output.
- We are planning a 2nd SSiRC steering group meeting at ISSI in Bern, Switzerland, in late 2014.
- Start writing a review paper about stratospheric sulfur and aerosol research (progress since the SPARC Report No. 4, 2006).
- Analysis of climate model output from the three experiments mentioned above to compare and evaluate the aerosol schemes within different models.
- Maintain and strengthen the collaboration with Google [X] Project Loon.
- Planning of a Chapman Conference to be held in 2015/16.
- Development of a process that will lead to a marked improvement of long-term merged aerosol data for CCMI/CMIP6 with a capacity to be maintained continuously into the future. A presentation regarding this process will be made at the May 2014 CCMI workshop.

References:

Damadeo, R. P., J. M. Zawodny, L. W. Thomason, and N. Iyer, 2013: SAGE version 7.0 algorithm: application to SAGE II. *Atmos. Meas. Tech*., **6**, 3539-3561.

SPARC, 2006: Scientific Assessment of Stratospheric Aerosol Properties (ASAP). *SPARC Report*, **4**, WCRP-124 WMO/TD- No. 1295, available at http://www.sparc-climate.org/publications/sparc-reports/sparc-report-no4/.

Emerging Activities (full activities as of January 2014)

SPARC Reanalysis Intercomparison Project (S-RIP)

Activity Leaders: Masatomo Fujiwara and David Jackson

Achievements for 2013

The S-RIP planning meeting was held at the Met Office, Reading, UK, from 29 April–1 May 2013, and was attended by 39 participants from research institutes/universities and reanalysis centres from around the world (**Figure 11**). We decided that the project would focus predominantly on reanalyses (not operational analyses), so we slightly changed the project name to SPARC Reanalysis Intercomparison Project (rather than SPARC Reanalysis/analysis Intercomparison Project). We finalized the title, outline, and co-leads for 12 chapters of the S-RIP final report and we also decided that we will finalize the "basic" chapters (*i.e.* Chapters 1-4) within two years and the "advanced" chapters (chapters 5-12) will evolve slightly more slowly, with an interim report every year. We will have dedicated S-RIP meetings every year and side-meetings at various occasions. Further details (such as chapter outlines) can be found in a SPARC Newsletter article (Fujiwara and Jackson, SPARC Newsletter no. 41).

A new and upgraded S-RIP website was launched in early December 2013 at http://s-rip.ees.hokudai.ac.jp/. The British Atmospheric Data Centre (BADC) kindly offered disk space and a virtual machine for S-RIP to archive processed reanalysis data, and we are currently discussing how best to use these facilities. Also, we have prepared a draft Implementation Plan for S-RIP that was submitted to the SPARC SSG for acceptance as a 'full activity'. This was granted at the 21st SPARC SSG meeting held in January 2014.

Figure 11: Participants of the S-RIP Planning Meeting held in Reading, UK, from 29 April – 1 May 2013.

Plans for the Coming Year

- January 2014: An S-RIP side meeting was held during the SPARC General Assembly. Chapter co-leads made a brief progress report and issues related to the data archive and communication using a wiki were discussed.
- September 2014: The 2014 S-RIP meeting will be held at the NOAA Center for Weather and Climate Prediction (NCWCP) in College Park, Maryland, USA for 2.5 days. The plan is to share the same week with the SPARC Data Assimilation workshop (for the remaining 2.5 days of that week).
- Rest of 2014: Continue analysing data and writing chapters.

Stratospheric Network for the Assessment of Predictability (SNAP)

Activity Leaders: Andrew Charlton-Perez and Om Tripathi

Achievements for 2013

In 2013 SNAP began in earnest, employing a Project Manager (Om Tripathi), who joined the University of Reading in February. Om's first task was to organise the first SNAP workshop, which was held in Reading from 22-24 April, jointly with the 3rd DynVar workshop. The first workshop was very successful in linking together the overlapping communities interested in stratosphere-troposphere dynamics and atmospheric predictability. Over 100 scientists attended the joint workshop and we had an enjoyable conference dinner on the Wednesday night in central Reading.

Following the workshop, detailed planning for SNAP was completed, informed by the discussion held on Friday morning of the workshop. We produced both an experimental protocol for the multi-model predictability experiment that SNAP will co-ordinate and a data plan for collecting and storing model output. Both of these documents were discussed in detail with the SNAP steering group and are available on the SNAP website (http://www.sparcsnap.org).

The SNAP steering group has held three meetings by tele-conference to keep track of progress made on completing the multi-model experiment and compiling the database of results. We have started to collect this data at the British Atmospheric Data Centre and plan to begin dissemination soon. We have also begun initial data analysis of all data currently available and Om presented this work at the recent American Geophysical Union Fall Meeting in San Francisco (see **Figure 12**).

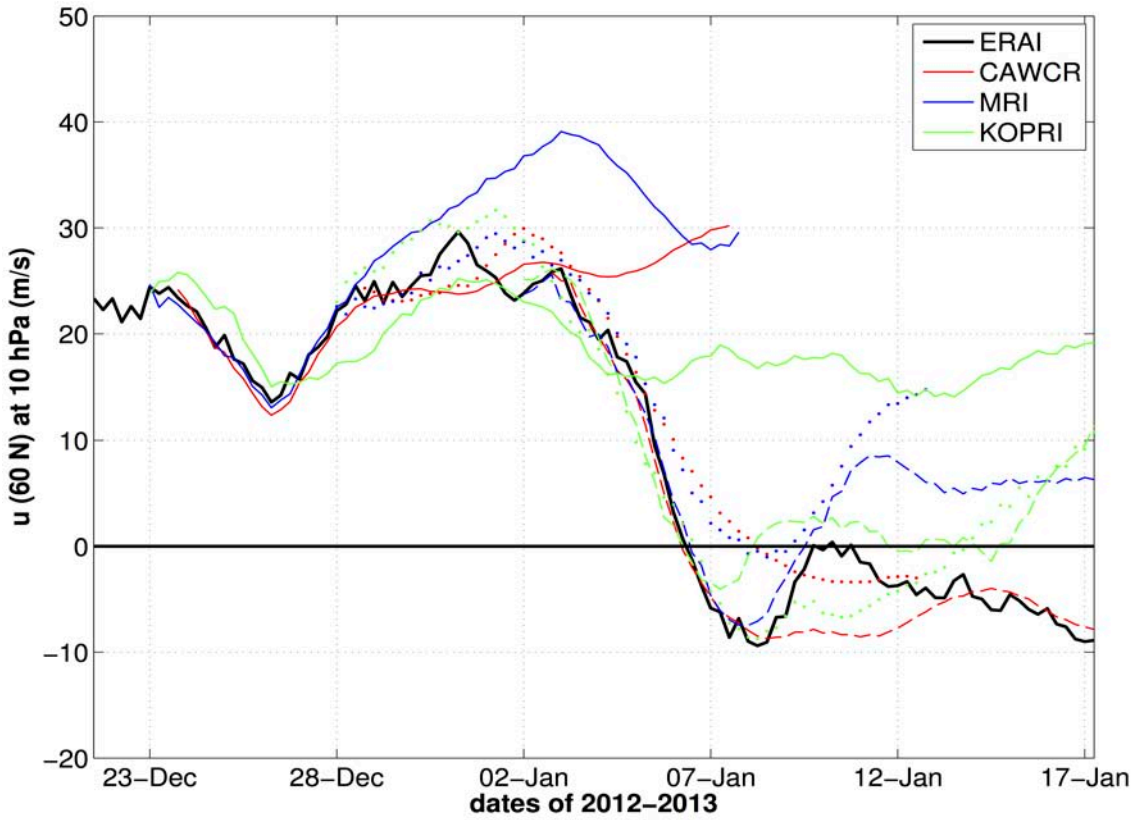

Figure 12: Some initial results from the SNAP experiment. Ensemble-mean forecasts of zonal mean zonal wind at 60N and 10hPa during the SSW event of January 2013. Different models are shown with different coloured lines and different start dates in different line styles.

We have also spent some of 2013 producing a community review paper on stratospheric predictability, which was submitted to the Quarterly Journal of the Royal Meteorological Society in early 2014. And, we were also extremely pleased that the SPARC SSG granted us full activity status at their recent meeting in New Zealand.

Journal publications during 2013

- Tripathi, O. P., M. Baldwin, A. Charlton-Perez, M. Charron, S. Eckermann, E. Gerber, R. G. Harrison, D. R. Jackson, B.-M. Kim, Y. Kuroda, A. Lang, C. Lee, S. Mahmood, R. Mizuta, G. Roff, M. Sigmond, S.-W. Son, subm.: Review: The predictability of the extra-tropical Stratosphere and its impacts on the skill of Tropospheric Forecasts, *Q. J. Roy. Met. Soc.*

Plans for the Coming Year

An important goal for the coming year is to develop links with the WWRP Sub-seasonal to Seasonal prediction project (S2S), with the aim of making use of their extensive database to gain a more detailed understanding of the potential gains in tropospheric predictability that might arise from stratospheric variability. Om attended the S2S workshop in Maryland, USA, in February 2014 and SNAP has had significant discussions with Frederic Vitart, one of the co-chairs of this activity, about formalizing links between SNAP and S2S. In the short term, SNAP will help to promote the forthcoming S2S database within the SPARC community and will do some initial analysis of S2S results to show how this data might be used.

In terms of our own SNAP experiments, we plan to produce at least one paper on the results of Phase 1 by the end of the year. We will also continue to collect data from partners with the aim of having a useful and rich data portal available to the community by boreal autumn 2014.

We will also continue to hold SNAP steering group tele-conferences, the next one in March 2014, to ensure the project is meeting community needs.

Links to other projects

CliC

In 2013 CliC (The Climate and Cryosphere; a WCRP core project) conducted a wide range of research activities focusing on the role of the cryosphere in climate. The project is working on its science plan and is preparing an implementation plan for the WCRP Grand Challenge "Cryosphere in a Changing Climate". As a part of this Grand Challenge activity, CliC is cooperating with SPARC on the development of the WCRP Polar Climate Predictability Initiative (see details below). The stratosphere exerts a discernible impact on the processes determining seasonal and longer time scale predictability of the troposphere, and so do some cryospheric variables, primarily, sea-ice and snow. Through the Stratospheric Historical Forecast Project and Sea-Ice Historical Forecast Project, CliC and SPARC are contributing to research on seasonal predictability coordinated by the WCRP Working Group on Seasonal to Interannual Prediction (WGSIP, see below). Studies of polar stratospheric ozone, where SPARC is the leading research community, and the diverse research on interactions of the ice sheets and the polar oceans, where CliC plays a key role, both create a new level of understanding of the polar climate system.

GEWEX

GEWEX (Global Energy and Water Cycle Exchanges Project; a WCRP core project) recently developed new science questions and imperatives directing the focus of its research framework for 2013 and beyond. In 2013 a SPARC representative attended the GEWEX SSG meeting held in Boulder, Colorado, USA, from 28-31 October - a useful opportunity to promote communication between the two WCRP core projects. The SPARC WAVAS-II activity is providing upper tropospheric/lower stratospheric humidity products for the GDAP Water Vapour Assessment (G-VAP) being led by GEWEX, and future possibilities for further partnerships between GEWEX and SPARC are being developed, particularly within the context of the WCRP Grand Challenges.

CLIVAR

A SPARC representative attended the CLIVAR (Climate Variability and Predictability; a WCRP core project) SSG in Kiel, Germany, in April 2013. This was the second time that a SPARC representative has attended a CLIVAR SSG meeting and presented SPARC science. This has been very useful to foster communication between the two projects, and it is proposed that this continues in future. Following the discussions carried out at this meeting, a proposal was made that SPARC contributes to the WCRP 'Regional Climate Information' Grand Challenge, specifically to its decadal prediction component. The motivation to include stratosphere-troposphere coupling in decadal prediction stems from the recognition that long time scale climate model simulations improve when stratospheric variability is well represented. Studies have indicated that stratospheric decadal variability is important for surface climate, in particular for the North Atlantic sector, and that the stratosphere can provide atmospheric memory for the turbulent troposphere on seasonal to interannual timescales. It can also act as a conduit for teleconnections and variability.

AOPC

The primary SPARC link to the Global Climate Observing System (GCOS) is through the GCOS Atmospheric Observation Panel for Climate (AOPC). Johannes Staehelin represented SPARC at the 18th AOPC meeting, which was held in early April 2013 in Geneva, Switzerland. As an outcome of SPARC engagement in that meeting, AOPC requested that the conclusions from the SPARC workshop on data requirements, held in Frascati, Italy, in February 2013, should feed into the wider GCOS assessment of requirements and implementation planning and SPARC is now working towards

achieving that. AOPC has also welcomed the SPARC initiative to resolve the discrepancies between the NOAA and UK MetOffice merged Stratospheric Sounding Unit data records. AOPC is interested in the new assessment of stratospheric water vapour being undertaken by SPARC and shares SPARC's concerns over the lack of provision for future limb-sounding satellite missions suitable for sensing water vapour, particularly in the upper troposphere and stratosphere. The SPARC Data Initiative has been an interest for AOPC as it provides strong guidance on the quality of various satellite-based data sets. Finally, AOPC has a vested interest in the SPARC activity to create merged satellite-based data sets of ozone, and merged ozonesonde vertical ozone products, and to assess the utility of those data sets for long-term ozone trend detection.

WGNE

QBOi (Quasi-Biennial Oscillation Initiative) is a new project focused on better representing tropical stratospheric variability in global climate models (GCMs). A summary of QBOi was presented at the WGNE (Working Group on Numerical Experimentation) meeting in March 2014 with the aim of WGNE endorsing the project. The relevance of QBOi to WGNE is that the QBO is the most conspicuous mode of interannual variability in the stratosphere. Statistically significant QBO teleconnections are found in the high latitude stratosphere and troposphere, and are thought to be important for seasonal forecasting. However, currently these impacts are not robustly captured in GCMs, and most models have difficulty reproducing an accurate QBO. Proposed QBOi activities will cover a range of topics including predictability of the QBO, interactions between QBO driving processes, resolution, and parameterizations, and intermittency of the tropospheric wave sources that drive the QBO. The QBOi is currently integrated as an emerging sub-project within DynVar (see p. 15-16).

WGSIP

WGSIP (Working Group on Seasonal to Interannual Prediction) is one of four modelling groups under WCRP and is chaired by Adam Scaife (Met Office, UK) and Francisco Doblas-Reyes (IC3, Spain). Primarily a research group, WGSIP aims to improve near-term climate predictions from months to years ahead. Many of the WGSIP members also come from WMO designated Global Producing Centres for seasonal forecasts and therefore also provide real time forecasts each month via the WMO Lead Centre for long-range forecasts at the Korea Meteorological Administration. WGSIP research activities include the development and maintenance of a database of retrospective seasonal forecasts for research users. This database is now up and running and serves data from more than 12 leading seasonal forecast systems from CIMA in Argentina (http://chfps.cima.fcen.uba.ar/). We welcome interaction with SPARC scientists to exploit this important and growing database, which is rapidly becoming the equivalent of the CMIP database but for seasonal forecasting. The links with SPARC are particularly relevant now, given the growing evidence for stratosphere-troposphere interaction on seasonal and longer timescales. Other recent WGSIP activities include development of a revised protocol for decadal prediction experiments in CMIP6 and coordination of real time decadal forecasts that we hope to serve to the wider community in support of the WMO Global Framework for Climate Services.

For further information on WMO Global Producing Centres:
http://www.wmo.int/pages/prog/wcp/wcasp/clips/producers_forecasts.html, and the CHFP database of seasonal forecasts: http://chfps.cima.fcen.uba.ar/.

WGCM

The 17th session of WGCM (Working Group on Coupled Modelling) was held in Victoria, Canada, from 1-3 October 2013. Much of the meeting was devoted to discussing an initial design for Phase 6 of the

Coupled Model Intercomparison Project (CMIP6). This initial design was based on responses to the CMIP5 Survey and discussions held during a workshop "Next generation climate change experiments needed to advance knowledge and for assessment of CMIP6" that took place in August 2013 in Aspen, Colorado, USA. The CMIP Panel is writing an EOS brief report that will be revised based on the outcomes of the WGCM17 session. More information can be found on the CMIP Panel website at http://www.wcrp-climate.org/index.php/wgcm-cmip/wgcm-aobut-cmip.

Veronika Eyring reported on on-going activities within the IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) on behalf of SPARC. CCMI is planning to help evaluate chemistry-climate interactions in models with interactive chemistry taking part in the CMIP experiments and also plans to provide related diagnostics and performance metrics for a CMIP benchmarking and evaluation tool.

The Polar Climate Predictability Initiative

During the past year, the Polar Climate Predictability Initiative (PCPI) has been fleshing out its implementation strategy. PCPI is working closely with the Polar Prediction Project (PPP) of the World Weather Research Programme, and there will be a joint PPP-PCPI International Coordination Office in Bremerhaven, Germany. Three of the six PCPI initiatives (those on reanalyses, seasonal prediction, and model error) will be carried out jointly with the PPP. Cecilia Bitz of the University of Washington has joined Ted Shepherd in leading the PCPI, and two champions for each of the six PCPI initiatives have now been identified. A first meeting of all initiative leaders will be held in Boulder, Colorado, USA, in April 2014.

The SPARC Data Centre

During 2013, the SPARC Data Center (SDC) continued to support the distribution of data and documents for active SPARC activities including the SPARC Data Initiative, the Gravity Wave activity, the "Lifetimes Report" (SPARC Report No. 6, 2013), as well as hosting data from past activities and providing access and information for the broader scientific community. The SDC began a transition of operations away from Stony Brook University where it has resided since its inception in 1999. The first phase of the transition, the integration of the SDC website into the main SPARC website, was completed in November 2013 (see http://www.sparc-climate.org/data-center/). Planning and preparations commenced for the second phase of the transition in which the current data holdings will be transferred to a new server at the Centre for Environmental Data Archival (CEDA) in the UK. The new SDC will offer similar resources to SPARC project scientists as the British Atmospheric Data Centre (BADC). With several SPARC activities that have high storage requirements already utilizing CEDA resources through BADC, the transition will also allow these data sets to be brought under the unified banner of the new SDC. Thanks to NASA for their continuous support of the SPARC Data Center, as well as for providing funds to make plans for the move of the SDC data holdings to the BADC.

Workshops and Meetings 2014

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

12 – 17 January
5th SPARC General Assembly
Queenstown, New Zealand

19 – 21 January
21st SPARC Scientific Steering Group Meeting
Queenstown, New Zealand

31 March – 4 April
Gravity Waves Meeting
ISSI, Bern, Switzerland

5 – 9 May
5th HEPPA-SOLARIS Workshop
Baden-Baden, Germany

20 – 22 May
2014 IGAC/CCMI Workshop
Lancaster, UK

8-12 September
Joint S-RIP and DAWG Workshop
College Park, Maryland, USA

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

Acronyms

AOPC – Atmospheric Observations Panel for Climate
BADC – British Atmospheric Data Centre
BAMS – Bulletin of the American Meteorological Society
CCMI – Chemistry-Climate Model Initiative
CCMs – 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
CMIP3 – Coupled Model Intercomparison Project 3
CMIP5 – Coupled Model Intercomparison Project 5
CSA – Canadian Space Agency
DynVar – Dynamical Variability
ESA – European Space Agency
GEWEX – Global Energy and Water Exchanges project
ICSU – International Council for Science
IGAC – International Global Atmospheric Chemistry
IGBP – International Geosphere-Biosphere Programme
IOC – International Oceanographic Commission of UNESCO
ISSI – International Space Science Institute
JAXA – Japanese Aerospace Exploration Agency
JSC – Joint Scientific Committee
NASA – National Aeronautics and Space Administration
NDACC – Network for Detection of Atmospheric Composition Changes
NWP – Numerical Weather Prediction
PCPI – Polar Climate Predictability Initiative
PPP – Polar Prediction Project
S2S – Sub-seasonal to Seasonal Prediction Project
SCOSTEP – Solar-Terrestrial Physics
SHFP – Stratosphere-resolving Historical Forecast Project
SNAP – Stratospheric Network for the Assessment of Predictability
SOLARIS-HEPPA –SOLAR Influences for SPARC – High Energy Particle Precipitation in the Atmosphere
S-RIP – Stratospheric Reanalyses Intercomparison Project
SSG – Scientific Steering Group
SSiRC – Stratospheric Sulfur and its Role in Climate
SSU – Stratospheric Sounding Unit
WCRP – World Climate Research Program
WDAC – WCRP Data Advisory Council
WGCM – Working Group on Coupled Modelling
WGNE – Working Group on Numerical Experimentation
WGSIP – Working Group on Seasonal to Interannual Prediction
WMAC – WCRP Modelling Advisory Council
WMO – World Meteorological Organisation
WWRP – World Weather Research Programme


WCRP
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