SPARC Reanalysis Intercomparison Project (S-RIP) Planning Meeting

29 April – 1 May, 2013, Exeter, UK

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The SPARC community has been using reanalysis datasets to understand atmospheric processes and variability, and to validate chemistry-climate models. Currently, there are eight global atmospheric reanalysis datasets available and four more will be available soon (**Table 4**). The SPARC Reanalysis Intercomparison Project (S-RIP) is an emerging SPARC activity that was proposed last year (Fujiwara *et al.*, 2012). The goals of S-RIP are to create a communication platform between the SPARC community and reanalysis centres, to understand current reanalysis products, and to contribute to future reanalysis improvements. By August 2012, the working group (WG) with 11 members had been formed, and the reanalysis centre contacts for the project had been confirmed. The WG discussed chapter titles, co-leads, and initial contributors to the final SPARC report and planned a kick-off meeting. This article summarizes the discussions held during the S-RIP Planning Meeting hosted at the Met Office, Exeter, UK, from 29 April-1 May 2013. There were 39 participants, 20 oral presentations, and 21 poster presentations.

Meeting outline

The purposes of the meeting were to finalize the report outline, to determine the diagnostics list and observational data required for validation for each chapter, to agree on the general guidelines and protocols, and to define the project timetable. Based on past SPARC activities (*e.g.*, SPARC CCMVal, 2010), the WG initially proposed 11 chapters. The first four "basic" chapters are the Introduction, Description of the Reanalysis Systems, Climatology and Interannual Variability of Dynamical Variables, and Climatology and Interannual Variability of Ozone and Water Vapour. The following, "advanced" chapters were initially proposed to be: The Brewer-Dobson Circulation, Stratosphere-Troposphere Coupling, The Upper Troposphere and Lower Stratosphere (UTLS), Polar Processes, The Quasi-Biennial Oscillation (QBO), The Upper Stratosphere and Lower Mesosphere (USLM), and Gravity Waves. Prior to the meeting two co-leads were confirmed for most of the chapters. At the meeting, all chapters, except for the introduction, were given one hour for a presentation by the co-leads and discussion with the participants. The Brewer-Dobson Circulation session included short invited talks by some of the main contributors to the chapter (**Hella Garny, Gabriele Stiller, Bernard Legras**, and **Howard Roscoe**). For each chapter, the co-leads and two rapporteurs prepared a one-page summary slide for the wrap-up on the final day. The finalized chapter list with the co-leads' names is shown in **Table 5**. We decided to divide the UTLS chapter in two, one focusing on the extra-tropical UTLS (ExUTLS) and the other on the Tropical Tropopause Layer (TTL), with a section in the ExUTLS chapter summarizing overlapping issues between the two chapters. Also, issues related to transport processes and gravity waves will be distributed to various chapters (**Simon Chabrillat** and **Nedjeljka Žagar** led the discussion on these issues at the meeting). There were also a large number of poster presentations that stimulated discussion.

At the meeting it was also decided that the project would focus solely on reanalyses (although some chapters may include diagnostics from operational analyses). Therefore, we decided to slightly rename the

Table 4: Available global atmospheric reanalysis datasets:

Reanalysis Centre	Name of the Reanalysis Product
ECMWF	ERA-40, ERA-Interim, [ERA-20C], [ERA-SAT]
NOAA/NCEP	NCEP/NCAR (R-1), NCEP/DOE (R-2), NCEP-CFSR
JMA	JRA-25/JCDAS, [JRA-55]
NASA	MERRA, [MERRA-2]
NOAA – CIRES	20CR

project to the SPARC Reanalysis Intercomparison Project, (*i.e.*, "analysis" has been dropped from the name suggested in the original proposal). For most of the chapters, we will compare newer reanalyses, *i.e.*, MERRA, ERA-Interim, JRA-25/JCDAS, NCEP-CFSR, and 20CR. We also aim to include JRA-55, ERA-20C, ERA-SAT, MERRA-2, etc., when available. Some chapters may include older reanalyses such as R-1, R-2, and ERA-40, because they have been heavily used in the past and are still being used for certain studies, and to gain insight into potential shortcomings of past research results. At the beginning of each chapter an explanation will be given as to why specific reanalyses were included/excluded. The intercomparison period is 1979-2012, *i.e.*, "the satellite era," but some chapters will also consider the pre-satellite era before 1978.

On the first day of the meeting, before starting the chapter discussion, there were seven presentations by reanalysis centres. **David Tan** presented introductory comments on reanalyses and then talked about both the JMA's activities (JRA-25/JCDAS and JRA-55), on behalf of Yayoi Harada, and the ECMWF's activities (ERA-Interim, ERA-20C, ERA-SAT, etc.). **Craig Long** presented NOAA's activities (R-1, R-2, CFSR, and 20CR), while **Paul Berrisford** presented routine diagnostics activities for various reanalyses carried out at ECMWF. **Steven Pawson** presented NASA's activities (MERRA and MERRA-2) remotely. **Adrian Simmons** discussed detailed comparisons of MERRA and ERA-Interim temperatures and assimilated observations.

S-RIP Report outline

The chief outcome of the meeting was the drafting of plans for Chapters 2-11 of the S-RIP final report. These plans are briefly summarized as follows:

Chapter 2. Description of the reanalysis systems

This chapter shall include a detailed description of the forecast model, assimilation scheme and observational data assimilated for each reanalysis, together with information on each reanalysis "stream" and on what data are archived.

Chapter 3. Climatology and interannual variability of dynamical variables

A climatology of major dynamical variables, created from an ensemble of the newer reanalyses for the period 1979-2012 (1979-2001, allowing comparison with ERA-40, in the appendix) will be created on both standard pressure levels and potential temperature levels. Various key plots of the ensemble climatological means and individual reanalysis anomalies from these means will be created and presented in an online atlas. Inter-reanalysis variations will be quantified. Observations for validation include radiosondes, lidars, rocketsondes and various satellites, whose data were not assimilated in the reanalyses.

Chapter 4. Climatology and interannual variability of ozone and water vapour

This chapter will include a detailed evaluation of ozone and water vapour in the reanalyses using a range of observations obtained from sonde, aircraft, and satellite instruments. The diagnostics considered will include climatological evaluations, seasonal cycles, interannual variability, and trends. Other, more event-based diagnostics such as the tape recorder, QBO, and polar dehydration will be used to understand differences in the climatological evaluations, while detailed analysis of these processes will be covered in the "advanced" chapters.

Table 5: List of chapters and names of co-leads:

	Title	Co-leads
1	Introduction	Masatomo Fujiwara, David Jackson
2	Description of the Reanalysis System	Masatomo Fujiwara, David Tan, Craig Long
3	Climatology and Interannual Variability of Dynamical Variables	Craig Long, Masatomo Fujiwara
4	Climatology and Interannual Variability of Ozone and Water Vapour	Michaela Hegglin, Sean Davis
5	Brewer-Dobson Circulation	Thomas Birner, Beatriz Monge-Sanz
6	Stratosphere-Troposphere Coupling	Edwin Gerber, Yulia Zyulyaeva
7	ExUTLS	Cameron Homeyer, Gloria Manney
8	TTL	Susann Tegtmeier, Kristin Krüger
9	QBO and Tropical Variability	James Anstey, Lesley Gray
10	Polar Processes	Monica Santee, Alyn Lambert
11	USLM	Diane Pendlebury, Lynn Harvey
12	Synthesis Summary	Masatomo Fujiwara , David Jackson

In addition, relevant information on the assimilated ozone and water vapour, and the prognostic representation of these fields in the reanalyses will be summarized.

Chapter 5. Brewer-Dobson circulation

This chapter will evaluate stratospheric circulation using diagnostics such as the age-of-air (mean age and spectrum), metrics for the strength of mixing barriers, and residual circulation quantities. Tendencies for heat and momentum as well as analysis increments will be considered. Eulerian chemistry transport models and trajectory calculations will be used. Results will be validated against satellite, ground-based, balloon, and aircraft observations of SF_6, CO_2, and NO_2, including the recent MIPAS data sets. Both climatological results and trends in the main diagnostics will be examined.

Chapter 6. Stratosphere-troposphere coupling

This chapter covers two-way coupling between the troposphere and stratosphere, focusing in particular on extra-tropical coupling on daily to intraseasonal time scales, and how this shorter-term variability is modulated on interannual time scales (*e.g.*, by ENSO). The chapter will synthesize and compare established approaches with more recent metrics to characterize planetary wave coupling and blocking, coupling of the zonal mean flow (*e.g.* the annular modes), and the mechanism(s) connecting the stratosphere and troposphere (*e.g.*, changes in tropopause height). There has been recent discussion on how to best characterize Stratospheric Sudden Warmings (SSWs). The established and alternative definitions of SSWs and the resulting impact on diagnostics of stratosphere-troposphere coupling will be explored.

Chapter 7. Extra-tropical UTLS

The diagnostics to be produced will include various tropopause identification methods, multiple tropopauses, the tropopause inversion layer, UTLS jet characterization, estimates of horizontal boundaries between the ExUTLS and TTL, trajectories, and Rossby wave breaking. This chapter will also have a section that reviews common diagnostics for the ExUTLS and TTL.

Chapter 8. TTL

The diagnostics shall include the general TTL structure (cold point and lapse rate tropopause, *etc.*), clouds and convection (cloud fraction profiles, OLR, *etc.*), diabatic heat budget, transport (Lagrangian cold point, residence time based on vertical winds and heating rates, *etc.*), wave activity, and long-term changes (*e.g.*, tropical belt widening).

Chapter 9. QBO and tropical variability

Diagnostics for this chapter will include analysis of the tropical QBO, its extra-tropical teleconnections (as well as other relevant teleconnections such as with ENSO and the solar cycle), its zonal momentum budget, and spectral characteristics of tropical waves including modal analysis and equatorial wave energetics. Observations for validation include operational and campaign radiosondes, rocketsondes, and satellites such as HIRDLS and SABER. Information regarding non-orographic gravity wave parameterization (if present) and analysis increments may also be utilized.

Chapter 10. Polar processes

This chapter will cover the formation of polar stratospheric clouds, chlorine activation, denitrification and dehydration, and (possibly) chemical ozone loss in the lower stratospheric winter polar vortices. Focus will be on process-oriented and case studies. The chapter will also include a review of previous works showing significant biases in lower stratospheric temperature, winds, or vortex strength/structure/evolution rendering some reanalyses (*e.g.*, R-1, R-2, and ERA-40) unsuitable for polar process studies.

Chapter 11. USLM

This chapter will look at diagnostics including the Semi-Annual Oscillation, climatology of the winter polar vortex, SSWs focusing on stratopause evolution and mesospheric cooling, various waves (tides, two-day wave, and normal modes), inertial instability of the tropical stratopause, and Hadley circulation of the stratopause region. Observations including SABER, MLS, the NDACC database, and CMAM20 (a model nudged to reanalysis), will be used for validation purposes and to extend our knowledge of the state of the middle atmosphere. NOGAPS–ALPHA may also be considered for case studies.

Overview of the project schedule

We shall finalize the "basic" chapters (*i.e.*, Chapters 1-4) within 2 years. The "advanced" 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.

We welcome your contributions to this project. Please contact the authors of this article and/or the co-leads of the relevant chapters directly. Up-to-date information will be made available through the S-RIP website (temporally at **http://wwwoa.ees.hokudai.ac.jp/~fuji/s-rip/**).

Acknowledgments

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References

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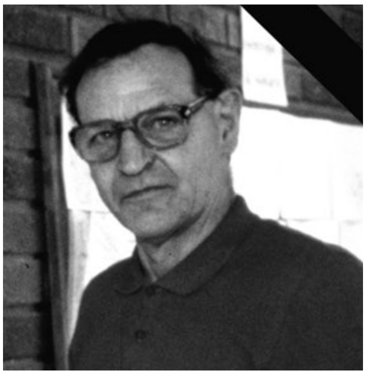

Joe Farman
† 11 May 2013

Joe Farman, the leader of the team which first reported the existence of the Antarctic Ozone Hole, passed away on Saturday 11th May 2013. The publication of this finding in *Nature* was a truly seminal moment in atmospheric science, by the then almost unknown team of Joe, Brian Gardiner, and Jonathan Shanklin at the British Antarctic Survey (BAS). The immediate reaction of most active researchers was disbelief – even if the observations were right, the proposed link to the degradation products of chlorofluorocarbons (CFCs) seemed unlikely, to put it mildly. However, what was not immediately realised was the level of care that had been put into ensuring that the ozone measurements were correct, or that the simultaneous meteorological measurements (also started in 1957) showed no major dynamical change during the period when the Antarctic spring ozone values were declining so rapidly. Chemistry had to be the cause – and yet it surely couldn't be! Their careful analysis of the measurements was soon confirmed and within a remarkably short period the main chemical processes had been elucidated by the international community.

Joe's career seems very unorthodox from a modern perspective. Prior to the Nature paper, Joe had been working quietly with just two scientific publications in the 29 years since he had joined BAS, having been lured from de Havilland Propellors (where he worked on missile guidance systems) by the prospect of Antarctica. After the Nature paper, he immediately moved into a very prominent position, both scientifically and publically. His character did not change – working with Joe was always both rewarding and frustrating – but, for a private man, he showed a remarkable facility for dealing with the press, the political world and the public. His impact here was based on his scientific integrity. He did not like anyone making claims they could not back up. That included himself – while he was an excellent critic, he often struggled to come up with suggestions that he was happy with. Presumably this was one of the reasons that the Nature paper took a while to emerge. The brave and unambiguous link of ozone depletion to CFCs made in that paper could only be proposed because all other options had been considered and rejected.

After Joe retired from BAS in 1990, he joined us in the European Ozone Research Coordinating Unit. For the following 23 years he came in nearly every day, following the development of polar ozone loss in each Arctic and Antarctic winter. He made important contributions to the European Arctic Stratospheric Ozone Experiment and subsequent pan-European field campaigns exploring ozone loss. He also provided sage advice on all aspects of the stratospheric ozone research programme in Europe, which was often a valuable counterpoint when dealing with the European Commission and various national interests.

A service to mark Joe's passing was held in the chapel of his much-loved Corpus Christi College, Cambridge, where he studied as an undergraduate and was later a Fellow and Honorary Fellow. He is survived by his wife Paula, whom he met in 1959. He will be greatly missed by those who knew him, and his life will be honoured and remembered by many for years to come.

By Neil Harris and John Pyle