

# SPARC Reanalysis/analysis Intercomparison Project (*S-RIP*)

Masatomo Fujiwara (Hokkaido Univ., Japan)

Saroja Polavarapu (Env. Canada)

David Jackson (Met Office, UK)

- A project under the SPARC Data Assimilation Working Group
- Officially endorsed by the SPARC SSG in February 2012
- Reference: Fujiwara et al., *SPARC Newsletter*, No. 38, 14-17, January 2012

# Motivation

- Meteorological analysis data: Best estimate of the atmospheric state using observations with an assimilation scheme and a global forecast model
- “Reanalysis”: An analysis system using a single version of a model and assimilation scheme for a long-term period in the past
- Middle atmosphere/climate community has used reanalysis and analysis data sets
  - to understand atmospheric processes and variability
  - to validate chemistry-climate models (e.g., CCMVal)
  - for trend analyses
- There are currently **~8** global reanalysis data sets available worldwide
- Different reanalyses give different results for the same diagnostic, such as:
  - Global energy budget and hydrological cycle (Trenberth *et al.*, 2011)
  - Brewer-Dobson circulation (Iwasaki *et al.*, 2009)
  - Stratospheric vortex weakening and intensification events (Martineau and Son, 2010)
  - Polar winter lower stratospheric temperatures (Manney *et al.*, 2003, 2005a, 2005b)
  - Large-scale wave activity at the tropical tropopause (Fujiwara *et al.*, 2012)
  - Diurnal tides (Sakazaki *et al.*, 2012)
  - Temperature trends (Randel *et al.*, 2009; Xu and Powell, 2011a, 2011b)
  - Climatology of the middle atmosphere (*e.g.*, Randel *et al.*, 2002; Kishore *et al.*, 2009)
- Depending on the diagnostic, the different results may be due to differences either in the observational data assimilated, the assimilation scheme or forecast model, or any combination of these → **we need to investigate each diagnostic**

# Available Global Reanalyses

(see <http://reanalyses.org> for more details)

Product	Centre	Period	Resolution and <b>Lid Height</b> of the Forecast Model	Contact for S-RIP
NCEP-1 (R-1)	NCEP and NCAR	1948-present	T62, L28, <b>3 hPa</b>	W. Ebisuzaki
NCEP-2 (R-2)	NCEP and DOE AMIP-II	1979-present	T62, L28, <b>3 hPa</b>	W. Ebisuzaki
ERA-40	ECMWF	1957-2002	TL159 and N80 reduced Gaussian, L60, <b>0.1 hPa</b>	D. Tan
ERA-Interim	ECMWF	1979-present	TL255 and N128 reduced Gaussian, L60, <b>0.1 hPa</b>	D. Tan
JRA-25/JCDAS	JMA and CRIEPI	1979-present	T106, L40, <b>0.4 hPa</b>	K. Onogi
MERRA	NASA	1979-present	(2/3)x(1/2) deg., L72, <b>0.01 hPa</b>	S. Pawson
NCEP-CFSR	NCEP	1979-present	T382 (T574 for post 2010), L64, <b>0.266 hPa</b>	C. Long
NOAA-CIRES 20th Century Reanalysis (20CR) <sup>(*)</sup>	NOAA/ESRL PSD	1871-2010	T62, L28, <b>2.511hPa</b>	G. Compo & J. S. Whitaker

(\*) NOAA-CIRES 20CR assimilates only surface pressure reports and uses observed monthly sea-surface temperature and sea-ice distributions

- New reanalysis data sets coming soon (within a few years):
  - NCEP-CFSR-Lite, ERA-20C (and ERA-SAT), and JRA-55 (and JRA-55C)
- Some available “analysis” data sets:
  - Met Office stratospheric assimilated data, operational ECMWF and NCEP analyses, NASA GEOS-5, NOGAPS-ALPHA, etc.

# ***SPARC Reanalysis/analysis Intercomparison Project (S-RIP)***

- Coordinated intercomparison activity should be necessary . . . even if SPARC related diagnostics are only considered
- Consistent interaction between data users and reanalysis providers should be necessary . . . to ensure improvements in future reanalyses
- S-RIP:
  - An activity as the SPARC community
  - to create a communication platform between the SPARC community and the reanalysis centers
  - to understand current reanalysis products (and to reasonably interpret their differences)
  - to contribute to future reanalysis improvements in the middle atmosphere region
  - Structure: Preparation team + Scientific Working Group (~10 people; to be discussed in this workshop) + individual researchers/research groups who actually work on specific diagnostics

# Possible Diagnostics?

- Region of interest: Middle atmosphere, including UTLS and Stratosphere-Troposphere coupling
- Possible middle-atmosphere diagnostics include:
  - e.g., climatology, interannual variations, trends; BD circulation and age of air, Strato-Tropo coupling, UTLS, events (volcanoes, unstable/stable polar vortex), mass conservation, trajectories, etc.
  - more appropriate diagnostics grouping? (based upon impact on key trace gases that are important to stratosphere and climate; those affecting stratospheric ozone, water vapor, circulation, climate, etc. )
  - need to ensure overlap with the requirements of other SPARC activities (e.g., CCMVal, DynVar, Data Initiative, etc.)
  - the actual diagnostics will be *suggested* by the Scientific Working Group and *determined* by individual researchers (. . . but, does this really work?)
  - (not only *important* but also *scientifically challenging and exciting*)
- Suggestions of diagnostics from reanalysis data providers/technical experts: e.g.,
  - Transport fidelity (why are some reanalyses better than others?)
  - How can operational satellite instrument (TOVS/ATOVS) data be better assimilated? What is relative instrument bias? How can tides be better represented in analyses? (e.g., orbital drift) Can we integrate limb and other research satellite observations usefully?
  - How can we correct biases (in obs. & model) in middle atmosphere analyses?

# Schedule

- 2011: Discussion started
- January 2012: Proposal article in SPARC Newsletter
- February 2012: S-RIP officially endorsed by the SPARC SSG
  
- June 11-13, 2012: 9<sup>th</sup> SPARC DA workshop, New Mexico, USA (there will be an S-RIP session)
- June 25-29, 2012: SPARC workshop on the Brewer-Dobson circulation, Grindelwald, Switzerland
  
- Summer 2012: Scientific WG will be formed ←
  
- 2013-4: 2-3 dedicated workshops on S-RIP
- 2015-6: Write final (SPARC) report
  - Project duration expected to be 3-5 years for the first phase
  
- Post 2016:
  - additional phases because reanalysis centres envisage a 7-year period between new generations of reanalysis products (we need to establish a continuous evaluation system?)

# S-RIP Structure

## Preparation Team

(4 persons:

Fujiwara, Polavarapu, a co-chair of the SPARC Data Assimilation (Jackson), and David Tan as a representative of the reanalysis centers)

- reports the progress and issues to the SPARC SSG on regular basis
- makes the arrangements with the reanalysis/analysis centers
- makes the arrangements to form the Scientific Working Group
- responsible for website management, mailing list management, and processed data archiving management
- organizes workshops/sessions
- makes technical arrangement of the reports

## Scientific Working Group


(~10 persons:

Members to be considered; Fujiwara and Jackson will be the member)

- suggests the diagnostics and specific approaches of data analyses
- finds the researchers to lead each chapter of the final report and those to work on each of the diagnostics
- edits the final report and makes the reviewer assignments
- gathers all the necessary technical information of the reanalysis data sets for the interpretation of the comparison results

## All SPARC-related researchers

- perform the data analysis
- write journal papers
- contribute to the S-RIP workshops and reports



Some pilot studies by sub-groups of the Scientific Working Group??? (to show the importance, feasibility, and excitement)

- WG had better have some specific *research* projects (not just acts like an advisory board...)
- for some key diagnostics for the mid. atmos. and climate
- and/or to pursue new type of science (challenging & exciting)

# Some ideas for pilot studies . . .

(some subjects have already been investigated and will be presented today)

- Brewer-Dobson circulation & wave flux
  - How do satellite measurements with very broad weighting function constrain the RA system?
- QBO and SAO
  - Radiosonde winds (not tropospheric wave generations) are the key for RA systems to capture QBO; how to evaluate?
- Polar lower stratosphere issues; tropical tropopause issues; and extratropical UTLS issues
  - Temperature distribution
  - Transport and dehydration/ozone depletion
- Ozone in the RAs
  - Recent RAs assimilate satellite ozone measurements
- Trends
  - Homogenization of the RA time series?



# Summary and Current Issues

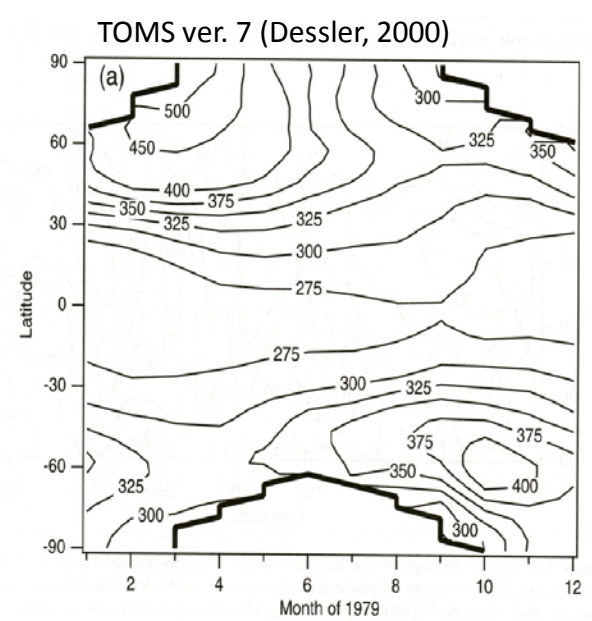
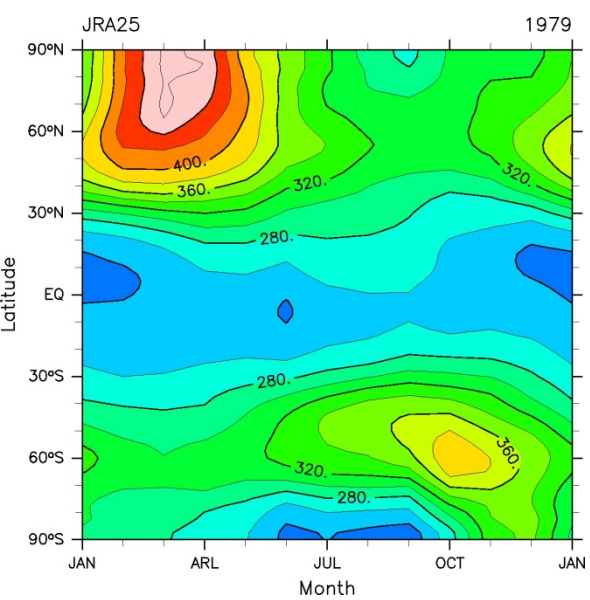
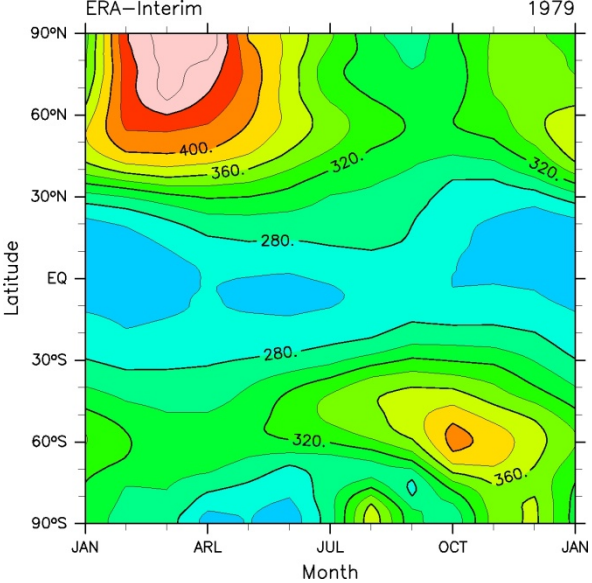
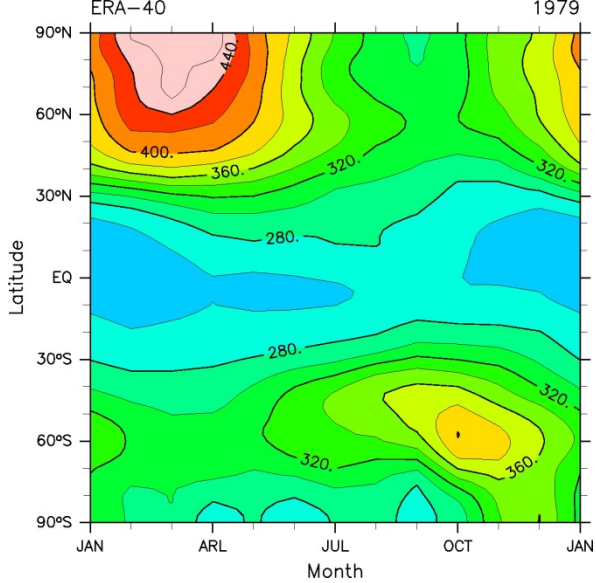
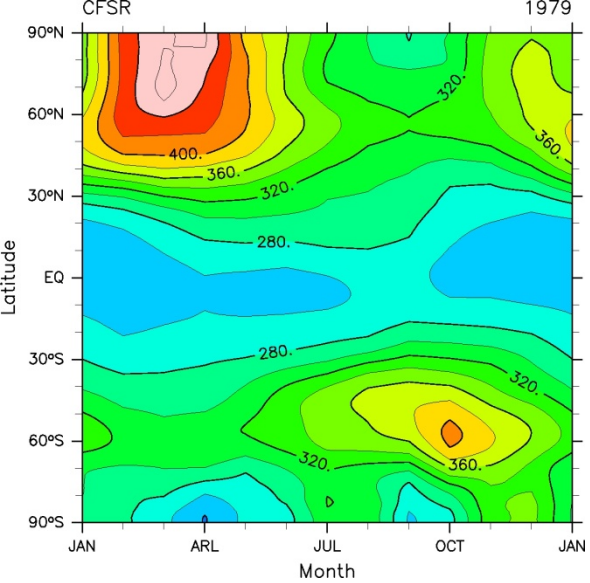
- S-RIP: Toward better understanding and future improvements of the RA products
- S-RIP has been set up; communication with RA centers was found to be very good
- Scientific Working Group to be formed
- Current Major Questions: (for the side meeting, S-RIP discussion, and other opportunities during this week)
  - ***How to activate S-RIP? How to get people involved?***
- 1. Responsibilities of the preparation team?
  - e.g., website preparation, session/workshop preparation, etc.
  - FAQ: data archive specially for S-RIP? (probably no, but. . . )
- 2. Scientific Working Group
  - Membership?
  - Responsibilities? (e.g., diagnostics, guidance, summarizing key information, etc.)
- 3. Some pilot studies? (“S-RIP is not only important but also scientifically challenging and exciting!”)
  - By sub-groups of the scientific working group? (WG had better have some specific science projects, not just act like an advisory board...)
  - e.g., residual circulation and age of air; QBO and SAO; TTL issues; polar LS temperature; ozone in RAs; inhomogeneity in temperature; etc.

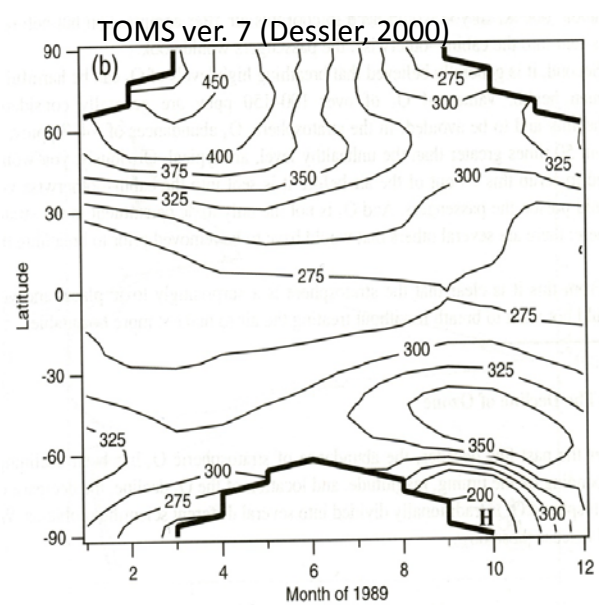
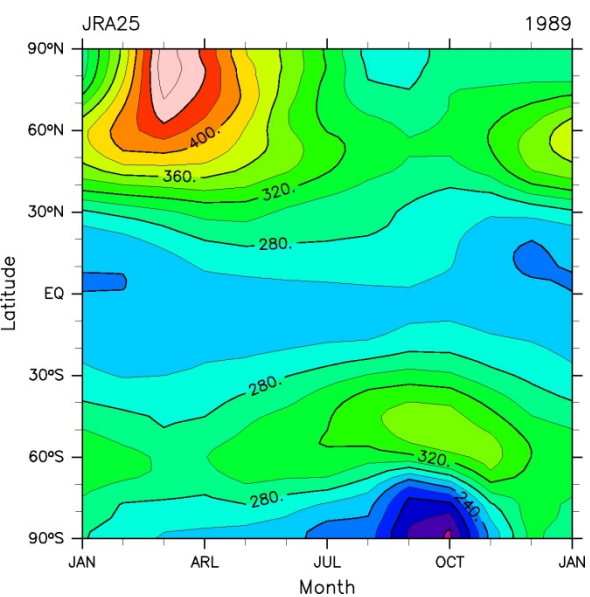
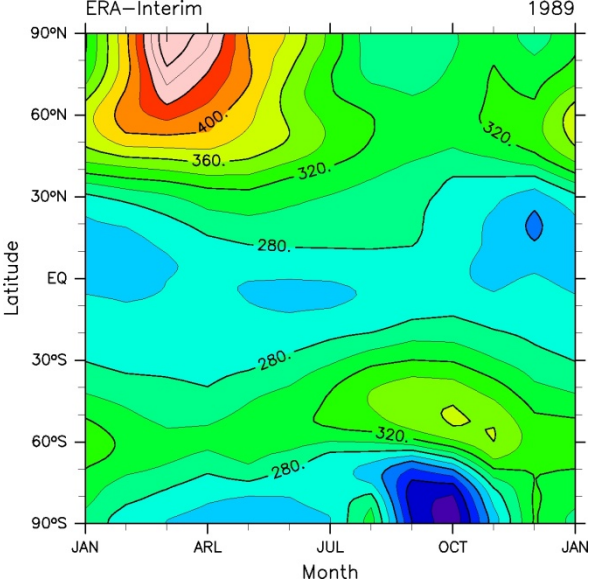
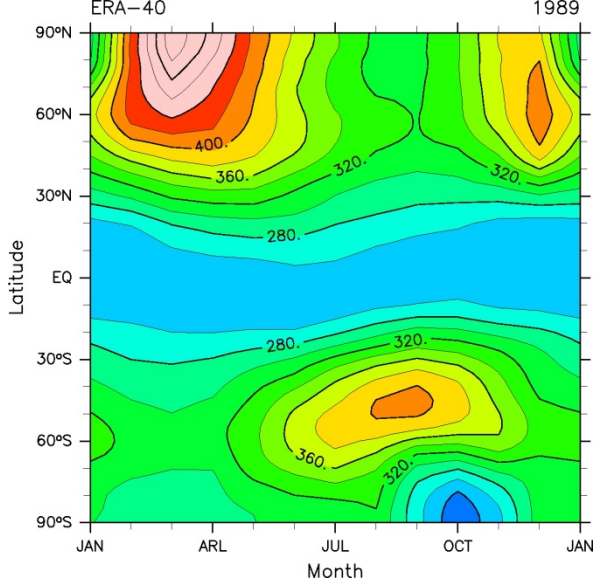
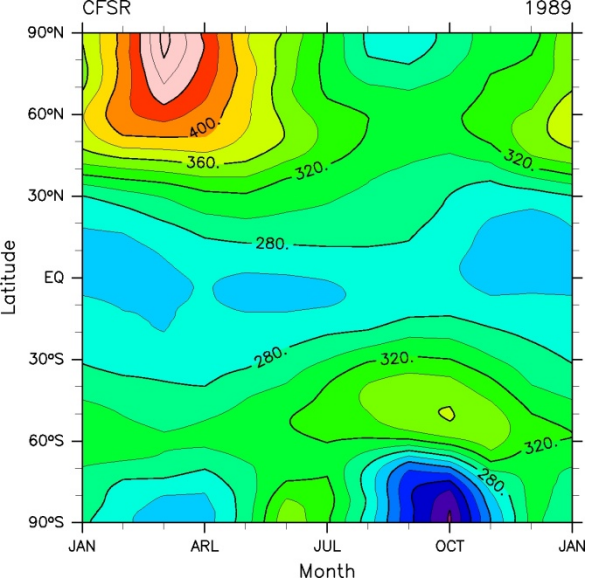
# Appendix

# Ozone in the Reanalyses

An example for  
“gathering all the  
necessary technical  
info of RAs (perhaps by  
Sci. WG)

- **NCEP1 & NCEP2**: (Kalnay et al., 1996; Kistler et al., 2001; Kanamitsu et al., 2002)
  - Zonally averaged seasonal climatological ozone used in the radiation computation (In NCEP2, the latitudinal orientation was reversed north to south)
- **ERA-40**: (Uppala et al., 2005; [Dethof and Holm, 2004](#))
  - TOMS and SBUV ozone retrievals (not radiance) are assimilated (1978-). Ozonesondes not assimilated.
  - Ozone in the ECMWF model is described by a tracer transport equation including a parametrization of photochemical sources and sinks
  - The ozone climatology is used in the radiation calculations of the forecast model.
- **ERA-Interim**: (Dee et al., 2011; [Dragani, 2011](#))
  - TOMS, SBUV, GOME (1996-2002), MIPAS (2003-2004), SCIAMACHY (2003-), MLS (2008-), OMI (2008-) are assimilated. SAGE, HALOE, and POAM are not assimilated.
  - Ozone model and radiation calculations are basically the same as ERA-40.
- **JRA-25**: (Onogi et al., 2007)
  - Ozone observations are not assimilated directly.
  - Daily ozone distribution is in advance using a CTM by MRI with “nudging” to the satellite total ozone measurements and provided to the forecast model (the radiative part).
- **MERRA**: (Rienecker et al., 2011)
  - SBUV2 ozone (version 8 retrievals) is assimilated for Oct 1978–present.
  - The MERRA AGCM uses the analyzed ozone generated by the DAS. (cf. a climatology for aerosol)
- **NCEP-CFSR**: (Saha et al., 2010)
  - SBUV profiles and total ozone retrievals are assimilated (but not bias-adjusted; should not be used for trend detection)
  - Prognostic ozone with climatological production and destruction terms computed from 2D chemistry models (for radiation parameterization)
- **20CR**: (Compo et al., 2011)
  - Ozone observations not assimilated. The ozone treatment for radiative calculations is similar to NCEP-CFSR.





No observations (SBUV, TOMS) during the polar night.  
 ERA-40 in southern hemisphere midlatitudes?

Discussion, Suggestions, etc.

# Side meeting discussion: Summary (1)

- Website
  - Server: Hokkaido Univ., then move to SPARC data centre?
  - Data info (each site; basic info, e.g., grid, period, format; tracking/changes info)
  - Format conversion info (and softwares)
  - Links to, e.g., reanalyses.org; NCAR data archive site, etc.
  - Data archive (analyzed data used in the figures of the report) (see CCMVal)
  - Archive of data processing/analysis programs in Fortran etc.
  - Wiki should be installed for communication

# Side meeting discussion: Summary (2)

- Working Group
  - Suggests *processes* first, and then the relevant diagnostics
  - Chapters of the final report
    - 1: Summary of the RA system info including obs data assimilated
    - 2-: Starting with simple fields (or “big picture”), i.e., temperature, winds, wave fluxes, ozone, etc.
    - Goal: evaluate specific diagnostic/region in each RA (Not just “this RA is good and that RA is bad”)
    - Intercomparison is valuable even if we have no direct/independent observations/validation info (e.g., BD circulation)
  - Member: should include people from each RA center (not just contact persons?)
  - Should hold a planning workshop (a big conference? gathering people from both SPARC and RA communities) to discuss the processes and diagnostics (in the beginning or at some point?)
  - →Start small, and evolve to the ideal state
  - →We need a small group to discuss in detail – i.e., a WG with ~10 people



# S-RIP discussion: Summary

- Summarized the side meeting discussion during the lunch time
- One chapter discussing why reanalyses cannot be used for trend studies
  - Discontinuity issues are summarized
- No-satellite-assimilation experiments would be very useful
  - JRA and ECMWF are preparing for this
  - We make some specific recommendations for such experiments?
- Put codes/algorithms for intercomparing specific diagnostics on the website to facilitate S-RIP
- WG will communicate through emails and telecon (e.g., webex, skype)
- WG members:
  - Gloria Manney (NWRA/New Mexico Tech, USA)
  - Sean Davis (NOAA/ESRL, USA)
  - Yulia Zyulyaeva (P.P.Shirshov Institute of Oceanography, Russia)
  - Simon Chabrillat (Belgian Institute of Space Aeronomy, Belguim)
  - Craig Long (NOAA/NCEP, USA)
  - David Jackson (Met Office, UK)
  - Masatomo Fujiwara (Hokkaido University, Japan)
  - Fujiwara will talk to some more people at BDC workshop (e.g., Kicki Krueger, Susann Tegtmeier, Thomas Birner, Michaela Hegglin)

# Wrap up, etc. of the DA workshop: S-RIP related notes

- “Vertical Resolution Project” proposed by Marv Geller
  - Sensitivity to vertical (and horizontal) resolution of models: QBO downward propagation, deep convection, extratropical tropopause and tropopause inversion layer, etc.
  - → relevant to S-RIP?
- S-RIP workshop or DA+S-RIP workshop?
  - Should be connected with another SPARC-related meeting for easier participation
- S-RIP Planning Workshop should be held as soon as possible (e.g., April in UK?; autumn this year is too early to organize)
  - → will be discussed within the S-RIP WG

