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Review article

Introduction to the SPARC Reanalysis Intercomparison Project (S-RIP) and overview of the reanalysis systems

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- . . as a contribution to an ACP-ESSD inter-journal Special Issue (SI) on "The SPARC Reanalysis Intercomparison Project (S-RIP)" http://www.atmos-chem-phys.net/special_issue829.html
- . . as the project/SI overview paper, based on planned S-RIP report Chapter 1 (Introduction) and Chapter 2 (Description of the Reanalysis Systems)
- "Collaboration between the SPARC community and the reanalysis centres"

1. Introduction [*Motivation and goal of S-RIP, from S-RIP Chapter 1*]

2. Current reanalysis systems [*Sects. 2-6 are from Chapter 2, led by Jonathon Wright*]

    2.1. ECMWF reanalyses [ERA-40, ERA-Interim, ERA-20C]

    2.2. JMA reanalyses [JRA-25, JRA-55]

    2.3. NASA GMAO reanalyses [MERRA, MERRA-2]

    2.4. NOAA/NCEP and related reanalyses [R-1, R-2, CFSR, 20CR]

[*11 products from 4 centres*]

3. Forecast model specifications

    3.1. Selected physical parametrizations

    3.2. Boundary conditions

4. Data assimilation

5. Input observations

    5.1. Conventional data

    5.2. Satellite radiances

    5.3. Other satellite data sets

- *Information on key components was summarized (i.e., key for SPARC sciences)*
- *Tables were used to facilitate comparison of different reanalysis systems*
- *Some information was provided directly by reanalysis-centre co-authors (not explicitly written in the reanalysis reference papers)*

6. Ozone and water vapour [*Very important species for SPARC sciences*]

    6.1. Ozone

    6.2. Water vapour in and above the upper troposphere

7. Summary and outlook

[*With 4 Tables, 10 Figures, 194 references; 36 pages in total*]

Learning experience

- for both data users and data producers -

[*Oldness of the system – Many data users still use e.g., R-1*]
[*Horizontal grids & vertical levels with top level for the models – Important for SPARC*]

Table 2. Basic specifications of the reanalysis forecast models. Approximate longitude grid spacing is reported in degrees for models with regular Gaussian grids (F*n*) and in kilometres for models with reduced Gaussian grids (N*n*). Wavenumber truncations for models with Gaussian grids are reported in parentheses.

Reanalysis system	Model*	Horizontal grid spacing	Vertical levels	Top level
ERA-40	IFS Cycle 23r4 (2001)	N80 (T_L159): $\sim$125 km	60 (hybrid $\sigma - p$)	0.1 hPa
ERA-Interim	IFS Cycle 31r2 (2007)	N128 (T_L255): $\sim$79 km	60 (hybrid $\sigma - p$)	0.1 hPa
ERA-20C	IFS Cycle 38r1 (2012)	N80 (T_L159): $\sim$125 km	91 (hybrid $\sigma - p$)	0.01 hPa
JRA-25	JMA GSM (2004)	F80 (T106): 1.125°	40 (hybrid $\sigma - p$)	0.4 hPa
JRA-55	JMA GSM (2009)	N160 (T_L319): $\sim$55 km	60 (hybrid $\sigma - p$)	0.1 hPa
MERRA	GEOS 5.0.2 (2008)	1/2° latitude × 2/3° longitude	72 (hybrid $\sigma - p$)	0.01 hPa
MERRA-2	GEOS 5.12.4 (2015)	0.5° latitude × 0.625° longitude	72 (hybrid $\sigma - p$)	0.01 hPa
R1	NCEP MRF (1995)	F47 (T62): 1.875°	28 (σ)	3 hPa
R2	Modified MRF (1998)	F47 (T62): 1.875°	28 (σ)	3 hPa
CFSR (CDAS-T382)	NCEP CFS (2007)	F288 (T382): 0.3125°	64 (hybrid $\sigma - p$)	$\sim$0.266 hPa
CFSv2 (CDAS-T574)	NCEP CFS (2011)	F440 (T574): 0.2045°	64 (hybrid $\sigma - p$)	$\sim$0.266 hPa
20CR	NCEP GFS (2008)	F47 (T62): 1.875°	28 (hybrid $\sigma - p$)	$\sim$2.511 hPa

* Year in parentheses indicates the year for the version of the operational analysis system that was used for the reanalysis.

Learning experience

- for both data users and data producers -

[*Execution streams: Data users are often unaware of… *]

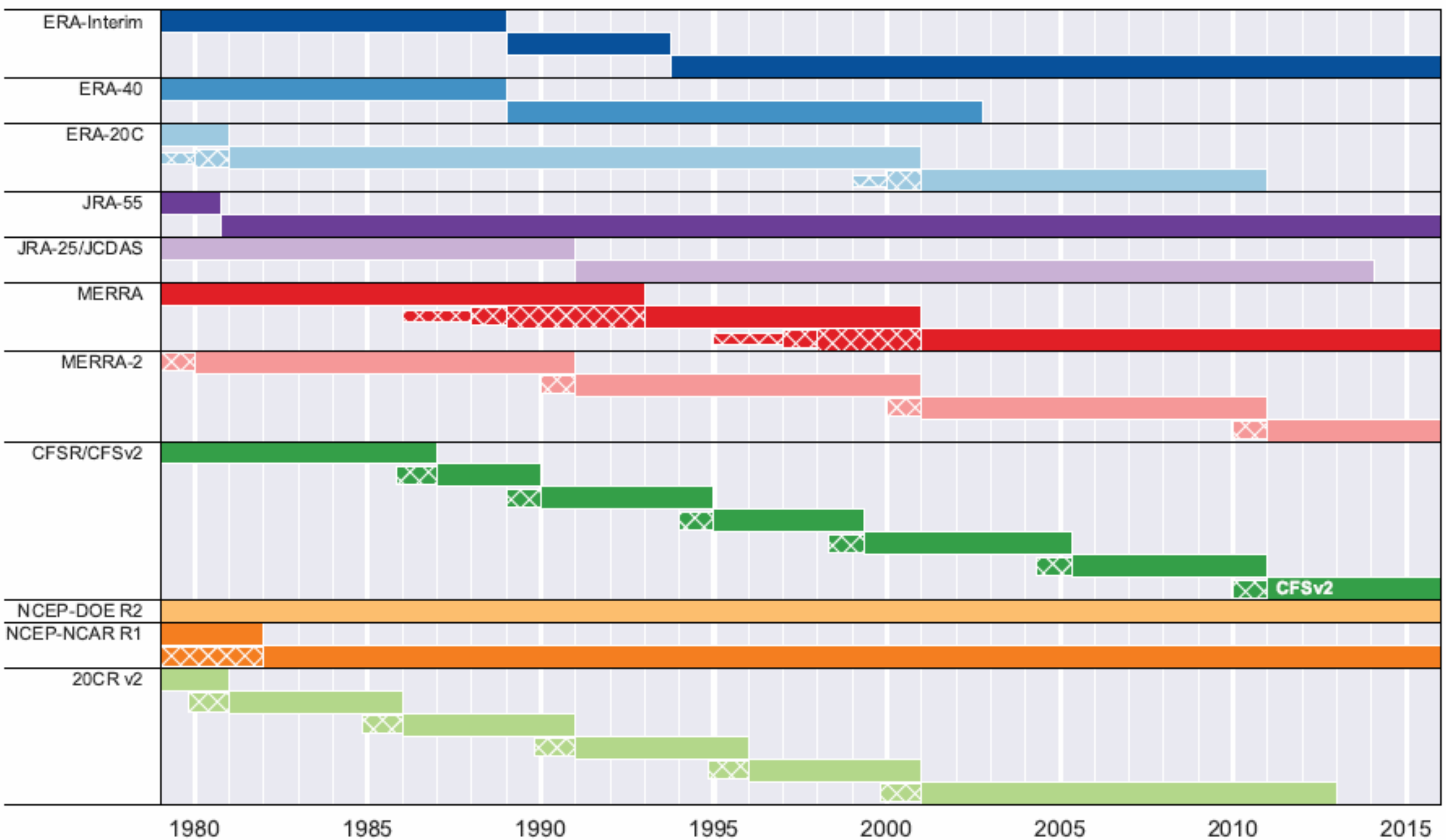


Figure 2. Summary of the execution streams of the reanalysis systems from January 1979 through December 2015. The narrowest cross-hatched sections indicate known spin-up periods, while the wider cross-hatched sections indicate overlap periods.

(*Final notes – S-RIP and TIRA?*)

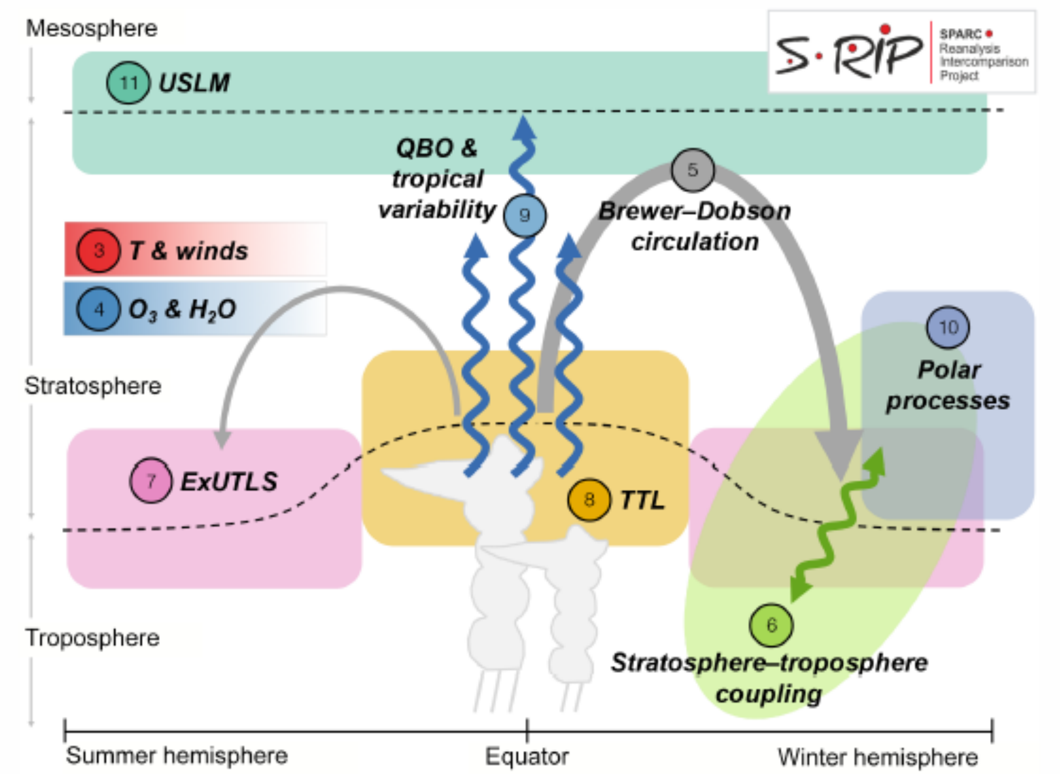


Figure 1. Schematic illustration of the atmosphere showing the processes and regions that will be covered by chapters in the planned full S-RIP report. Domains approximate the main focus areas of each chapter and should not be interpreted as strict boundaries. Chapters 3 and 4 cover the entire domain.

2012: S-RIP was proposed (*an article in SPARC Newsletter; talks at several conferences/meetings*)

- *"Reanalysis intercomparison is very important. Someone should do it."*
- *But, it was found that some young/ postdoc scientists (data users) were willing to contribute to this even as a chapter lead*

2013: Kick-off meeting

(annual workshops – opportunity for learning)

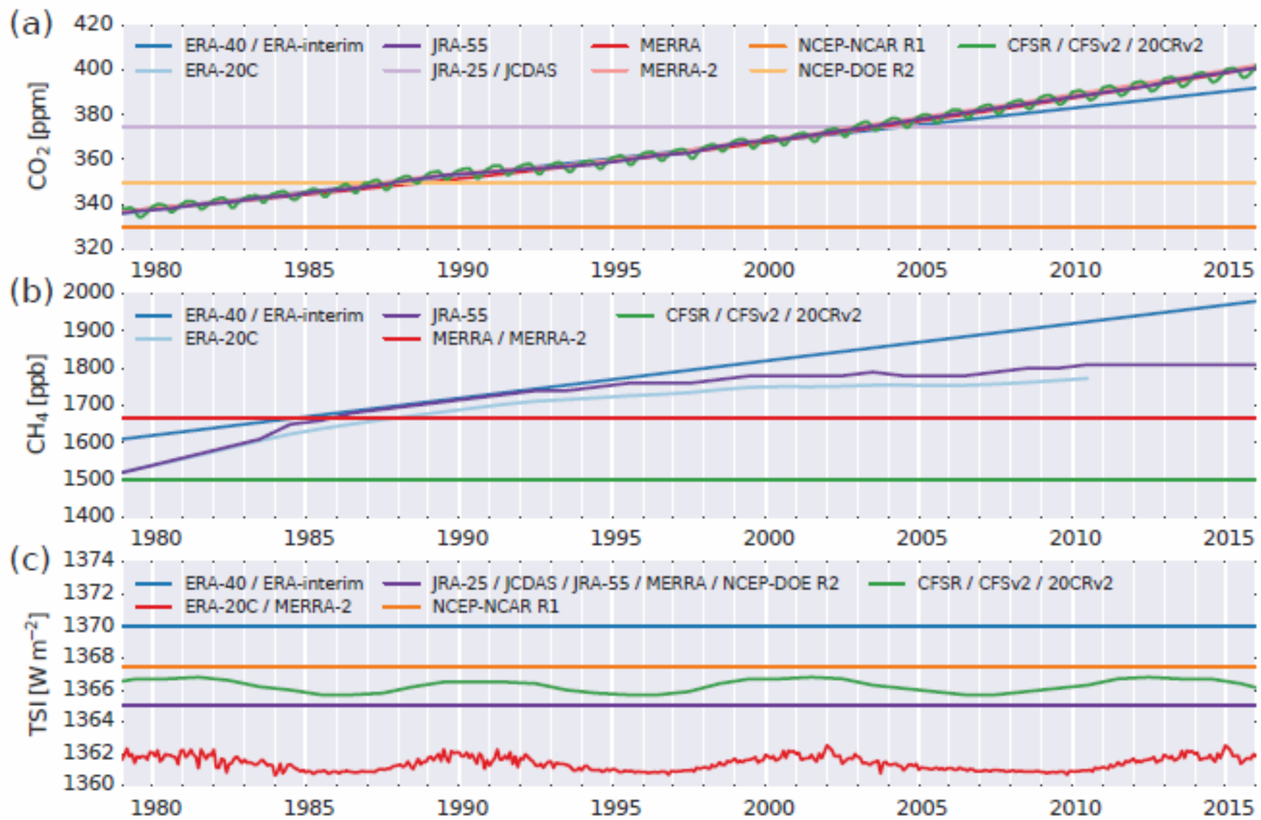
2015 → 2017: S-RIP Interim Report (currently in review)

2018: S-RIP full Report, and the end of 1st phase

2019 and beyond: 2nd phase? (*Merged with TIRA??; e.g., targeting IPCC AR6? ("WG contributions finalized in 2021")*)

Learning experience

- for both data users and data producers -



TSI: total solar irradiance [e.g., *11-year solar cycle*]

Figure 4. Time series of boundary conditions for **(a)** CO_2, **(b)** CH_4, and **(c)** TSI used by the reanalysis systems from 1979 through 2015. The CH_4 climatology used in MERRA and MERRA-2 varies in both latitude and height; here, a "tropospheric mean" value is calculated as a mass- and area-weighted integral between 1000 and 288 hPa to facilitate comparison with the "well-mixed" values used by most other systems. ERA-20C also applies rescalings of annual mean values of both CO_2 and CH_4 that vary by latitude, height, and month; here, the base (global annual mean) values are shown. Time series of TSI neglect seasonal variations due to the ellipticity of the Earth's orbit, as these variations are applied similarly (but not identically) across reanalysis systems. See text for further details.

Learning experience

- for both data users and data producers -

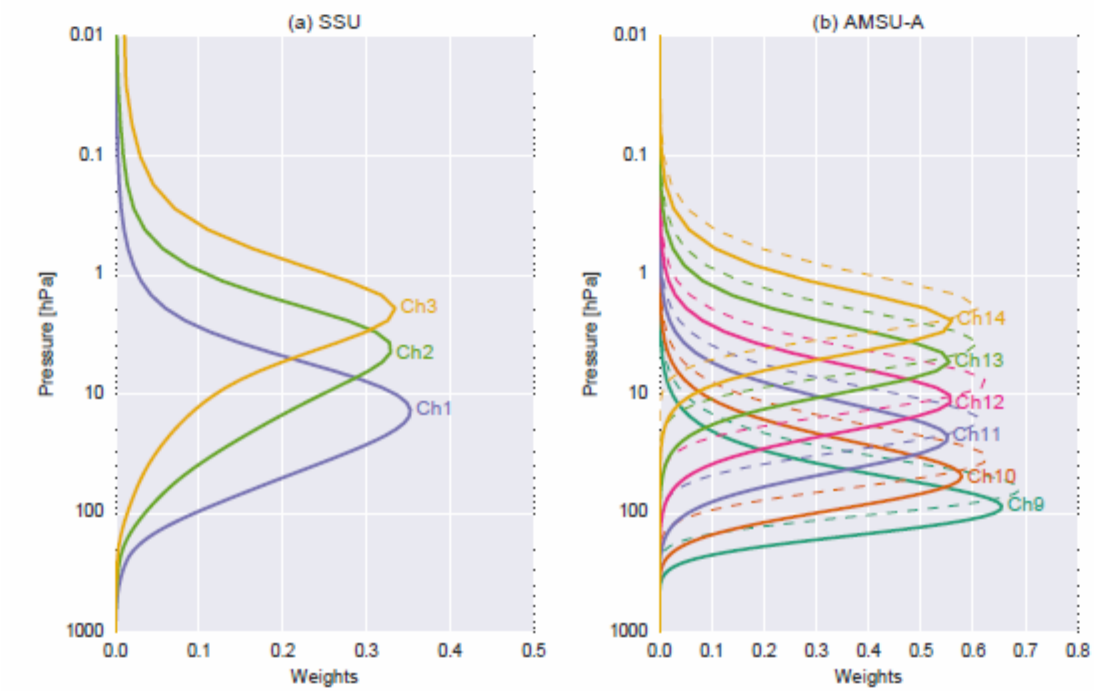


Figure 7. Vertical weighting functions of radiance measurements for **(a)** the TOVS-suite Stratospheric Sounding Unit (SSU) instrument (1979–2005) channel 1 (centred at ∼ 15 hPa), channel 2 (∼ 5 hPa), and channel 3 (∼ 1.5 hPa) and **(b)** the ATOVS-suite Advanced Microwave Sounding Unit A (AMSU-A) instrument (1998–present) temperature channels 9–14 at near-nadir (1.67°, solid lines) and limb (48.33°, dashed lines) scan positions. SSU channels 1 through 3 may also be referred to as TOVS channels 25 through 27.

The introduction of ATOVS suite of instruments in 1998 is still the most influential event for temporal homogeneity in the stratosphere even for more recent reanalyses.