The SPARC-Reanalysis Intercomparison Project (S-RIP): Update and S-RIP Phase 2 (S-RIP2) Plans

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(Special Thanks to Phase 1 Co-Lead Lesley Gray!)

S-RIP Website

https://s-rip.github.io/

Final Report (EOR)

https://www.sparc-climate.org/sparc-report-no-10/

S-RIP Overview

- S-RIP started in 2013 for focused intercomparison of atmospheric reanalyses; overall goals:
  - to foster communications between SPARC-related researchers and reanalysis centres
  - to better understand the differences among current reanalysis products and their underlying causes
  - to provide guidance to reanalysis users by documenting the results of this reanalysis intercomparison
  - to contribute to future reanalysis improvements
- Phase 1 completed with publication of the S-RIP Final Report in January 2022 and completion of Phase 1 journal special issue
- Phase 2 planning began in 2022 and is continuing

Table: List of reanalysis systems considered during S-RIP Phase 1.

Reanalysis Centre (contacts for S-RIP)	Name of Reanalysis Product
ECMWF (R. Dragani)	ERA-40, ERA-Interim, ERA5 (ERA-20C, ERA-20CM), (CERA-20C)
JMA (Y. Harada, C. Kobayashi)	JRA-25, JRA-55 (JRA-55C, JRA-55AMIP)
NASA GMAO (K. Wargan)	MERRA, MERRA-2
NOAA/NCEP (C. Long, W. Ebisuzaki)	NCEP-NCAR R1, NCEP-NCAR R2, CFSR
NOAA & U.Colorado (G.Compo, J. Whitaker)	(20CR)

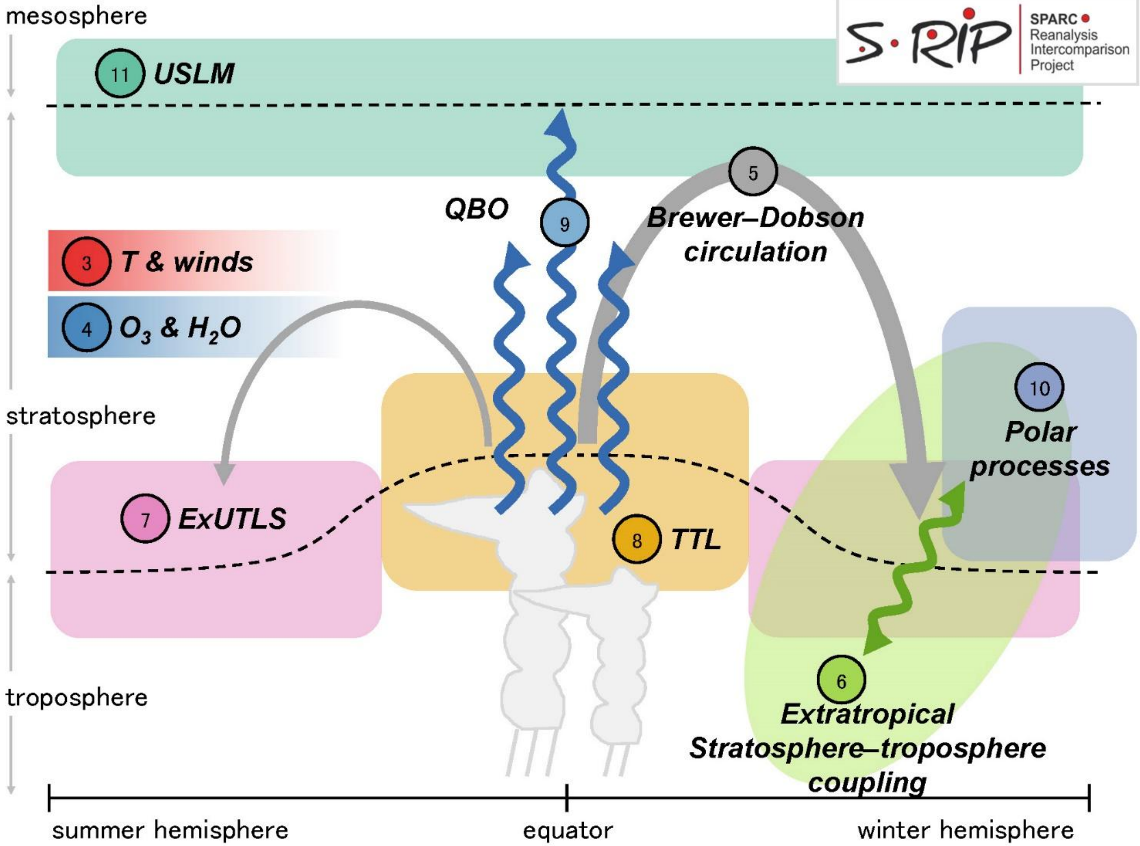
The S-RIP Planning Meeting (Met Office, UK, 2013)

S-RIP 2018 Chapter-lead Meeting (NWRA, Boulder, USA)

Achievements in 2022/2023: Phase 1 Completion

	Chapter Title	Chapter Co-leads
1	Introduction	M. Fujiwara, G. Manney, L. Gray
2	Description of the Reanalysis Systems	J. Wright, M. Fujiwara, C. Long
3	Overview of Temperature and Winds	C. Long, M. Fujiwara
4	Overview of Ozone and Water Vapour	S. Davis, M. Hegglin
5	Brewer-Dobson Circulation	B. Monge-Sanz, T. Birner
6	**Extratropical Stratosphere-Troposphere Coupling**	**E. Gerber, P. Martineau**
7	Extratropical Upper Troposphere and Lower Stratosphere (UTLS)	C. Homeyer, G. Manney
8	**Tropical Tropopause Layer**	**S. Tegtmeier, K. Krüger**
9	Quasi-Biennial Oscillation (QBO)	J. Anstey, L. Gray
10	Polar Processes	M. Santee, A. Lambert, G. Manney
11	**Upper Stratosphere and Lower Mesosphere**	**L. Harvey, J. Knox**
12	Synthesis Summary	M. Fujiwara, G. Manney, L. Gray, J. Wright

Co-leads: M. Fujiwara, G. Manney, L. Gray;
Report Editors: M. Fujiwara, G. Manney, L. Gray, J. Wright



- ACP/ESSD special issue on the S-RIP: 53 papers (closed 31 December 2022)
- S-RIP Report in SPARC Report series (final release January 2022; https://www.sparc-climate.org/sparc-report-no-10/)

Achievements in 2022/2023: Phase 1 Completion

Summary findings and recommendations

- **More recent reanalyses typically outperform earlier products**
- NCEP-NCAR R1 and NCEP-DOE R2 are unsuitable for many diagnostics and should generally not be used
- Conventional-input and pre-satellite reanalyses are useful for many diagnostics but should be carefully validated against full-input satellite era products
- **Studies relying on reanalysis products should use multiple reanalyses whenever possible**
- **All reanalyses show discontinuities (especially CFSR); trends and climate shifts identified in reanalysis products should be carefully validated and justified**
- Reanalysis products on model levels should be used for all studies when sharp vertical gradients or fine-scale vertical features are involved
- Several quantities, such as tendency terms, are handled and reported differently by different reanalyses
- ***Homogenized and continuing data records are essential for reanalysis production and evaluation***

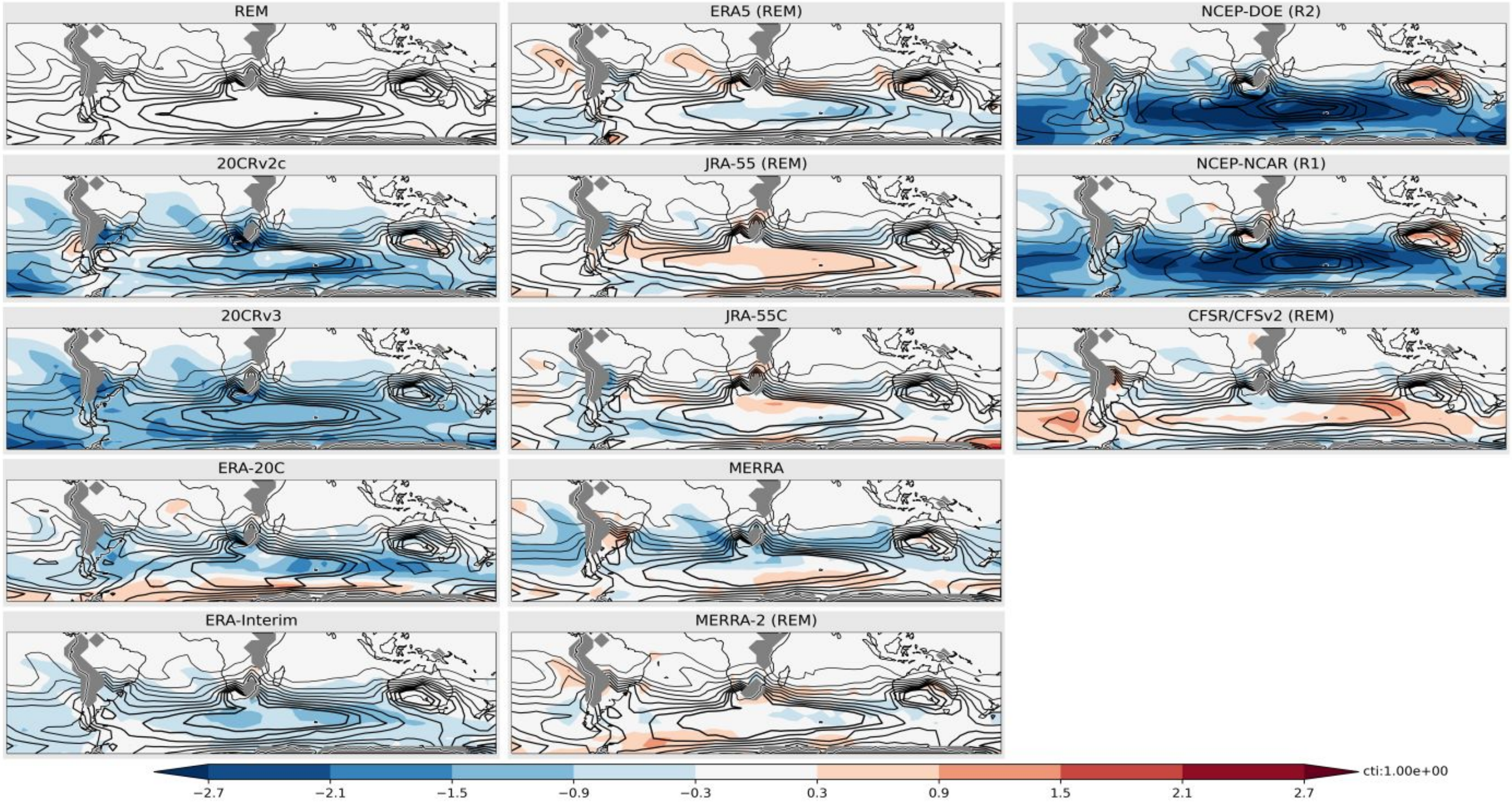
- Coordinated intercomparison
- Systematic documentation
- Guidance and recommendations for users and producers

- Long-term datasets for both dynamics and composition are essential for reanalysis production and evaluation, as well as for the scientific studies that rely on reanalyses

https://www.sparc-climate.org/sparc-report-no-10/

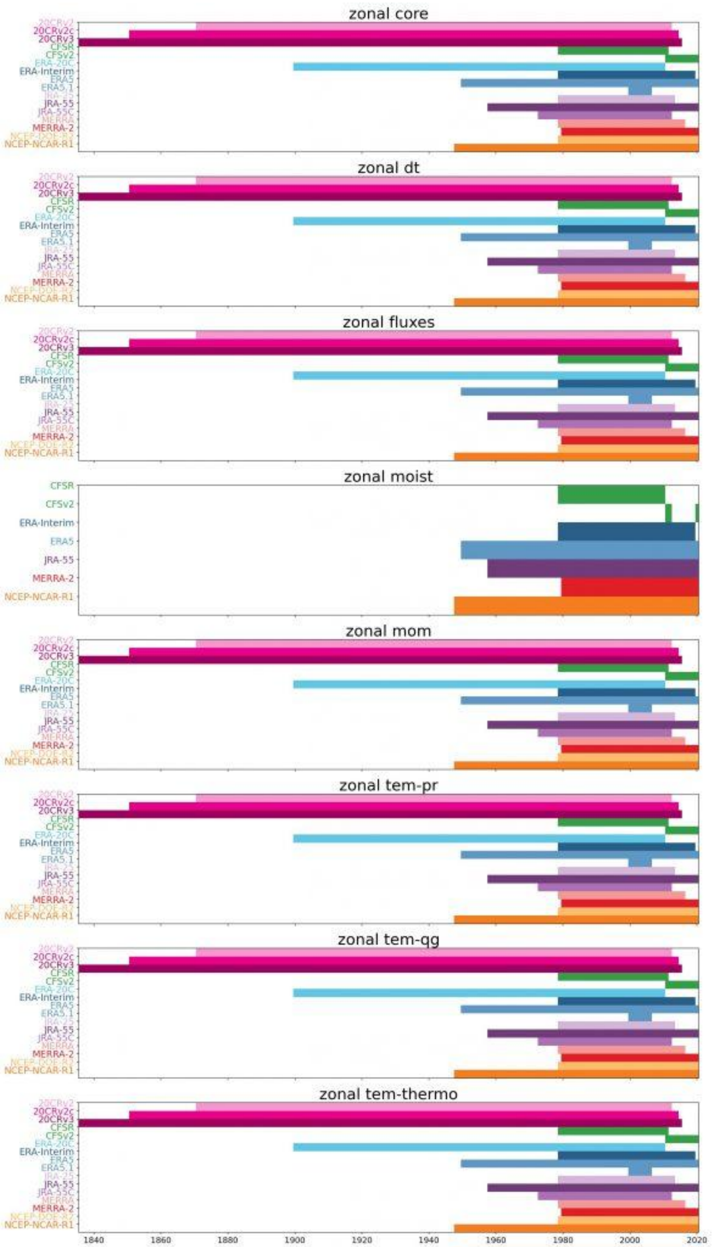
Achievements in 2022/2023: Phase 2 Special Issue

New inter-journal special issue on "The SPARC Reanalysis Intercomparison Project (S-RIP) Phase 2" in Atmospheric Chemistry and Physics (ACP) and Weather and Climate Dynamics (WCD):
https://acp.copernicus.org/articles/special_issue1242.html
https://wcd.copernicus.org/articles/special_issue10_1242.html
Opened: 1 January 2023
Closes: 31 December 2028



Example: Reanalysis Differences from REM of near-surface (850hPa) temperature variability. From Martineau et al (2023), submitted to Phase 2 Special Issue, https://doi.org/10.5194/egusphere-2023-1137

Achievements in 2022/2023: RID Dataset



Patrick Martineau, Reanalysis Intercomparison Dataset (RID), https://www.jamstec.go.jp/ridinfo/

- This is an extended version of the dynamical part of zonal mean data set by Martineau et al. (ESSD, 2018), with several new diagnostics and with ERA5 included.
- The image shows the periods of availability for each reanalysis and each diagnostic.
- Work is also in progress updating the heating rate part of the original dataset, as well as adding the available JRA-3Q data to this dataset

Achievements in 2022/2023: Presentations / Planning Activities

- Presentations highlighting results from the S-RIP Report at 2022 Fall AGU Meeting and 2023 AMS Annual Meeting
- Three S-RIP2 planning sessions (hybrid at SPARC General assembly, 2 online sessions in early November 2022)
- SPARC Newsletter Article on S-RIP Phase 2 (S-RIP2) plans:
  - Jonathon Wright, Gloria Manney, Masatomo Fujiwara, Planning and Proposal for Phase 2 of the SPARC-Reanalysis Intercomparison Project (S-RIP), SPARC Newsletter No. 60, January 2023.

Examples of some new / forthcoming reanalyses to be evaluated in S-RIP2:

Reanalysis System	Period	Source	Focus	Grid
JRA-3Q	1947–	Japan (JMA)	global atmosphere	40km, 0.01hPa top
CRA-40	1979–2018	China (CMA)	global atmosphere	34km, 0.27hPa top
R21C	1998–2025	USA (NASA)	global atmosphere	25km, 0.01hPa top
CORe (ensemble, conventional observations)	1950–	USA (NOAA)	global atmosphere	70km, 0.2hPa top
CAFE60 (ensemble)	1960–	Australia (CSIRO)	global atmosphere + ocean	200km, ~3hPa top

Examples of some chemical reanalyses to be evaluated in S-RIP2:

Reanalysis	Period	Source	Focus	Grid
CAMS-EAC4	2003–	ECMWF	whole atmosphere	0.75deg, 60L
BRAM2	2004–2019	BIRA-IASB	stratosphere/ UTLS	2.5x3.75deg, 37L
M2_SCREAM	2004–	NASA/GMAO	stratosphere/ UTLS	~50km, 72L
TCR2	2005–2019	NASA/JPL	troposphere	1.1deg, 32L
R21C-CHEM	1998–2025	NASA/GMAO	whole atmosphere	25km, 72L

Plans / Goals for the Next Year (and Beyond): S-RIP2

New / Outstanding Topics for S-RIP2:

- Evaluation of newer reanalyses (e.g., full evaluation of ERA5; initial evaluation of CRA-40 and JRA-3Q)
- Evaluations of reanalyses of atmospheric chemistry and composition, including those focused on both air quality applications and stratospheric/UTLS chemistry and transport.
- More extensive examination of stratosphere-troposphere coupling, including tropical processes
- Analysis of reanalysis representation of dynamical processes in the troposphere as well as the middle atmosphere; e.g., Rossby wave breaking, blocking, baroclinic storms, more detailed teleconnection (e.g., with ENSO and MJO) studies, etc.
- Analysis / comparison of extreme weather events (cold, heat, winds, precipitation) and their links to large scale dynamics and stratospheric influence.
- More complete analysis of SH processes, especially aspects of stratosphere-troposphere coupling and links to extreme weather events.
- In addressing these topics, we will also build online infrastructure for maintaining systematic documentation and evaluation of future reanalyses as they are released to the public.

Plans / Goals for the Next Year (and Beyond):

Additional S-RIP2 Goals – Building community and improving communications within and beyond SPARC:

- Outreach / Capacity Building: We are committed to focusing on outreach and capacity building in S-RIP2
  - Moha Diallo has been helping with some planning for this.
  - One focus will be capacity development efforts in the Global South
  - Moha will be an S-RIP contact with YESS to help us entrain more early career participation from around the world (including the SH, from which we had few / no participants in Phase 1)
  - We want to identify and work to remove barriers to S-RIP participation (e.g., related to accessing and processing large datasets)

- We will develop a more extensive web base and online presence:
  - Communication of our results and of information about the reanalyses will be centred online, with brief online annual reports and journal publications highlighted on our site being the primary means of disseminating results (rather than a single large SPARC report at the end of the project)
  - This will include topic descriptions, links among topics and papers on them, publication highlights, and detailed reanalyses information
  - We also plan to start holding webinars every 1–2 months to communicate about new products, learn about other SPARC activities, present newly published results, etc.

Plans / Goals for the Next Year (and Beyond):

Additional S-RIP2 Goals – Building community and improving communications within and beyond SPARC:

- Connections with other SPARC Activities: S-RIP has always had strong connections with several other SPARC Activities, which we will foster and expand in S-RIP2:
    - We will continue interactions with QBOi, DynVar, SNAP. OCTAV-UTLS, and ACAM
    - In particular, with the increased focus on tropospheric dynamics, closer ties with DynVar and SNAP will be valuable
    - We are also forming or hope to form collaborations with the CCMI, ATC, and GW activities, and are getting involved in the LTCF Activity on Hunga Tonga-Hunga Ha'apai

- Other WCRP Groups, CPs, LHAs:
    - We have formed some connections with WCRP TIRA (under ESMO) and CLIVAR
    - We hope to adopt and adapt model evaluation tools used within the CMIP community, e.g., ESMValTool

- Groups outside WCRP:
    - We are starting to establish collaborations with the Chemical Reanalysis Focus Working Group of TOAR-II and the Meteorology and Climate – Modeling for Air Quality (MAC-MAQ) project regarding evaluation of chemical reanalyses

Plans / Goals for the Next Year (and Beyond)

Activity Collaboration Groups: S-RIP topics are relevant to all three Activity Collaboration Groups:

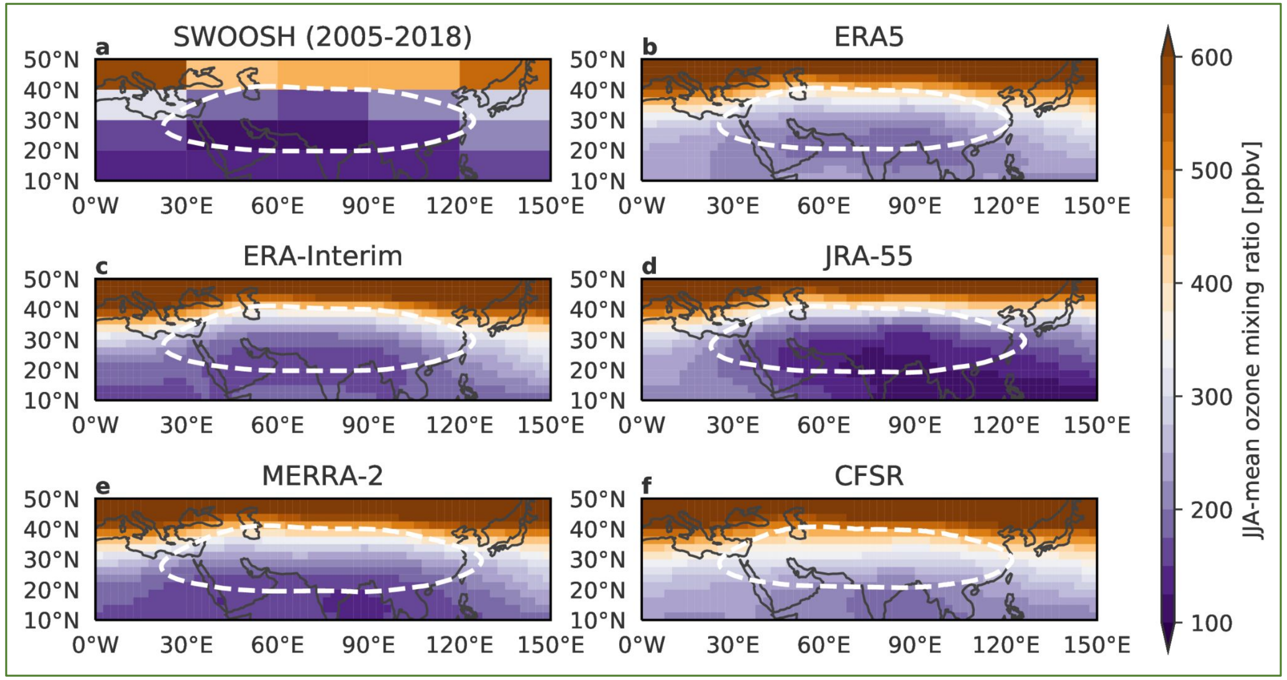
- S-RIP evaluates many diagnostics of “processes relating to atmospheric dynamics”; this will be expanded in S-RIP2 as we evaluate more tropospheric dynamics
- S-RIP evaluates many diagnostics of “process relating to atmospheric composition”; this will be expanded in S-RIP2 as we evaluate chemical reanalyses
- S-RIP evaluates many diagnostics of “processes relating to variability and trends across timescales

Outreach Advisory Panel: We hope the Outreach Advisory Panel will help with our expanded outreach and capacity building efforts in S-RIP2 that were outlined above

Partnership Advisory Panel: We hope the Partnership Advisory Panel can not only help foster the relationships we have started with several other groups, but also help identify other groups we may benefit from collaborations with

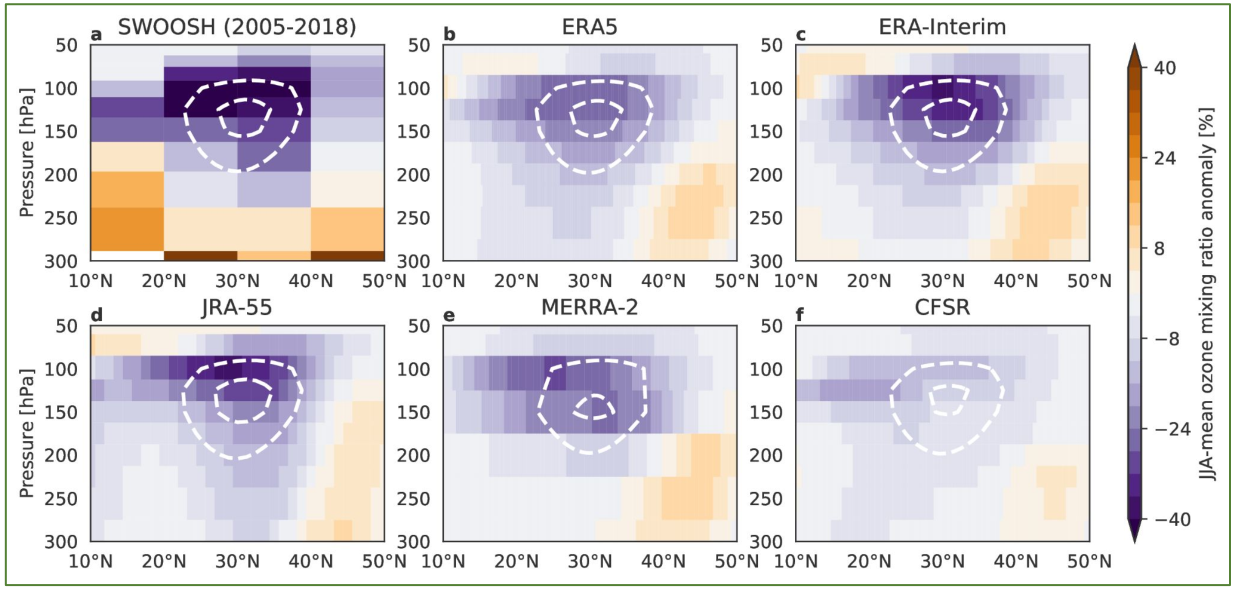
Assessments Coordination Panel: S-RIP has contributed substantially to the past two WMO Ozone Assessments, and to a lesser degree to IPCC reports. Our directions in S-RIP2 should position us to contribute more to these assessments.

S-RIP Report Chapter 8: TTL (Initial ASMA Evaluations)



Left: Reanalysis JJA mean 100hPa ozone averaged over 1980–2010, compared with SWOOSH combined satellite data over 2005–2018. Dashed white contour shows Asian summer monsoon anticyclone region.

Below: Latitude-pressure distributions of normalized anomalies in Jun-Jul-Aug mean ozone in Asian summer monsoon region (30–120E) relative to zonal-mean values, from SWOOSH (2005–2018) and reanalyses (1980–2010) .

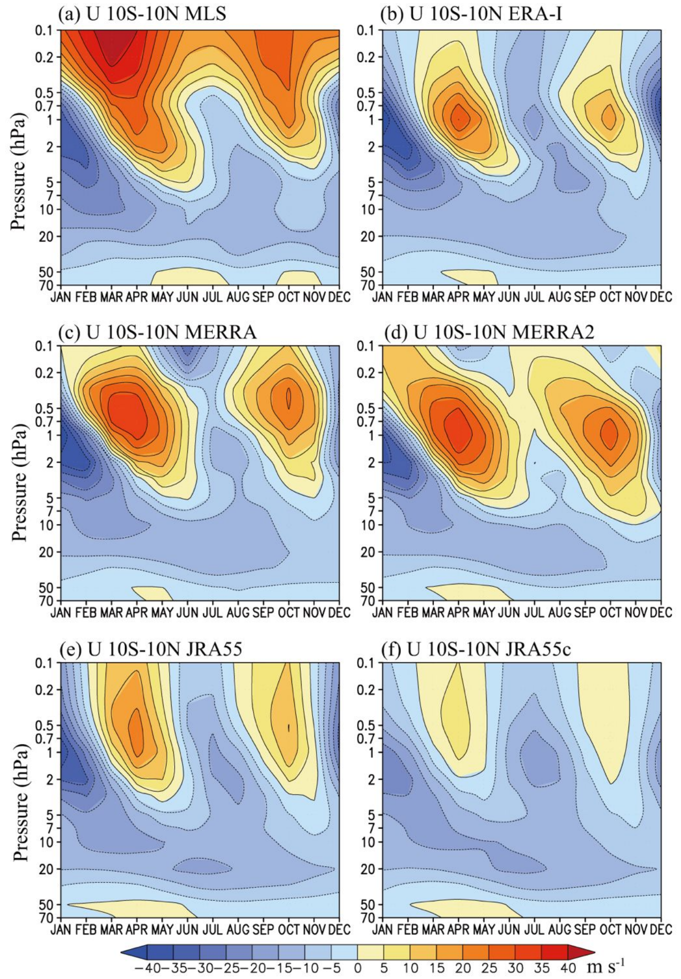


For Phase 2: We will extend monsoon-related evaluations in S-RIP Phase 2 to include (in addition to evaluating new reanalyses):

Trends and variability in a comprehensive set of dynamical fields, which will help assess the robustness of trends in area and intensity reported in the literature.

Trends and variability in ASMA composition from chemical reanalyses.

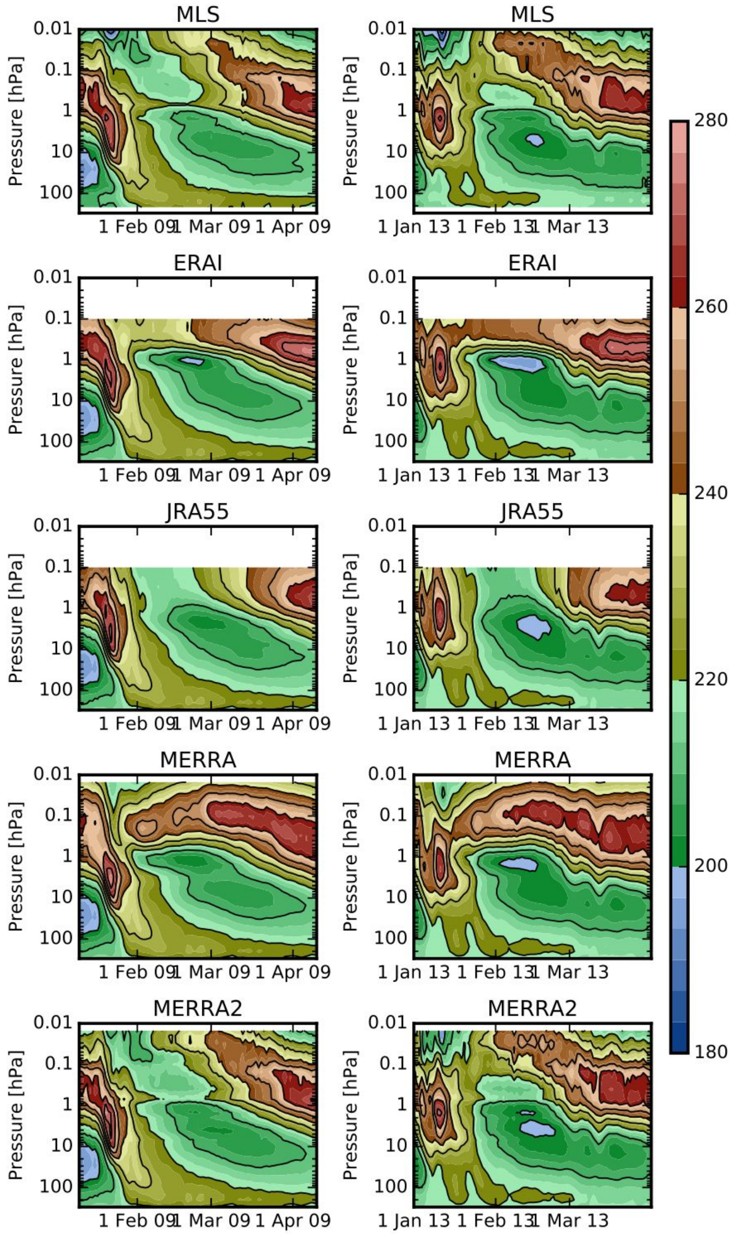
S-RIP Report Chapter 11: USLM (Limited Availability)



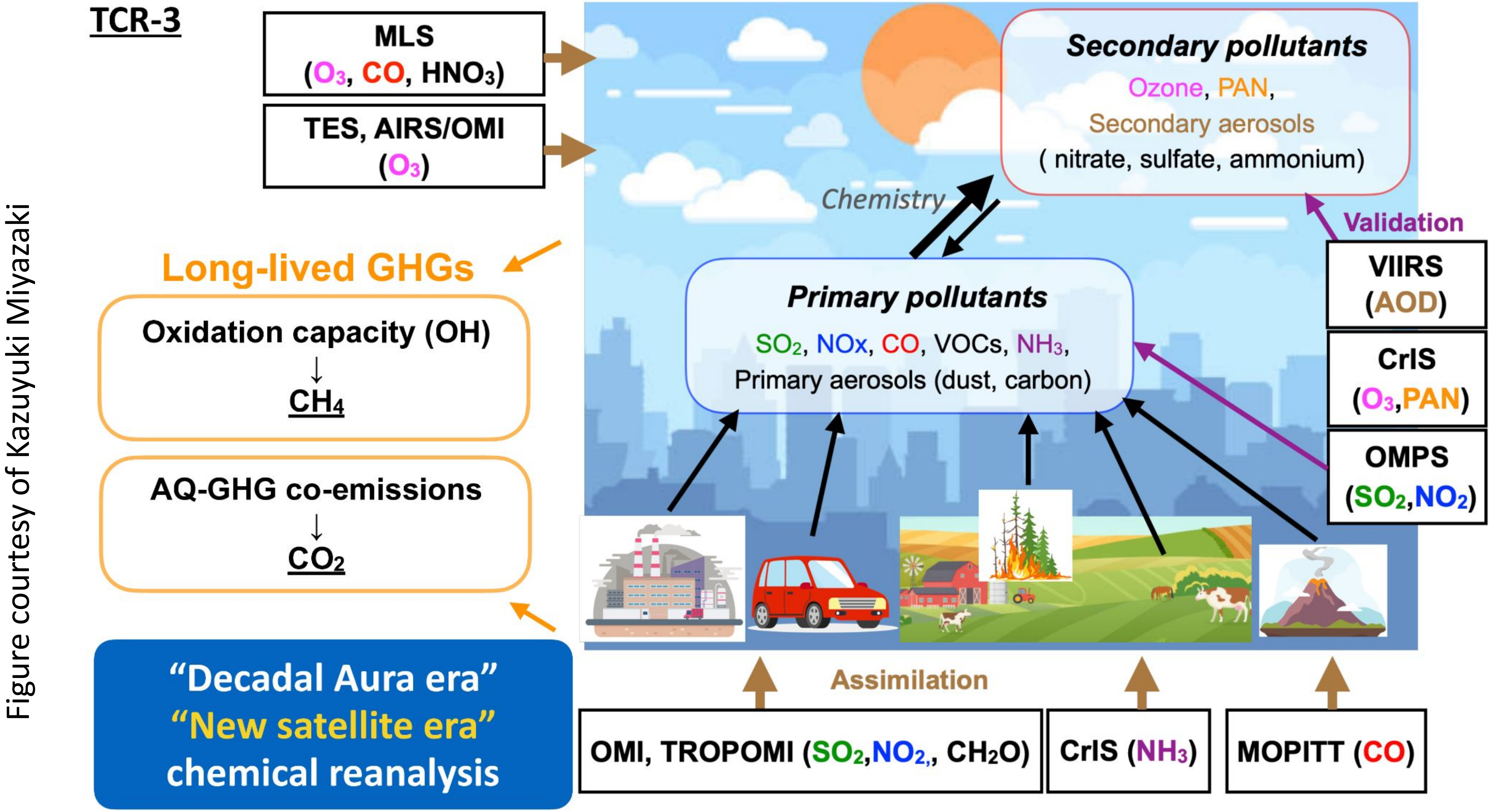
Left: Time-height sections of climatological zonal-mean zonal winds in 10S–10N, calculated from MLS GPH (2005–2016), and from reanalyses (1980–2016). (Adapted from Kawatani et al., 2020).

Right: Height-time sections of polar cap averaged (> 70N) temperatures from MLS (top) and reanalyses, from Jan through Mar in 2009 and 2013 (years with strong SSWs followed by elevated stratopause events).

For Phase 2: Many newer reanalyses have higher model tops, and some assimilated more data (e.g., USLM temperatures from research satellites) at the higher levels. These advances will make more comprehensive evaluations of the USLM possible, and further our understanding of this region.

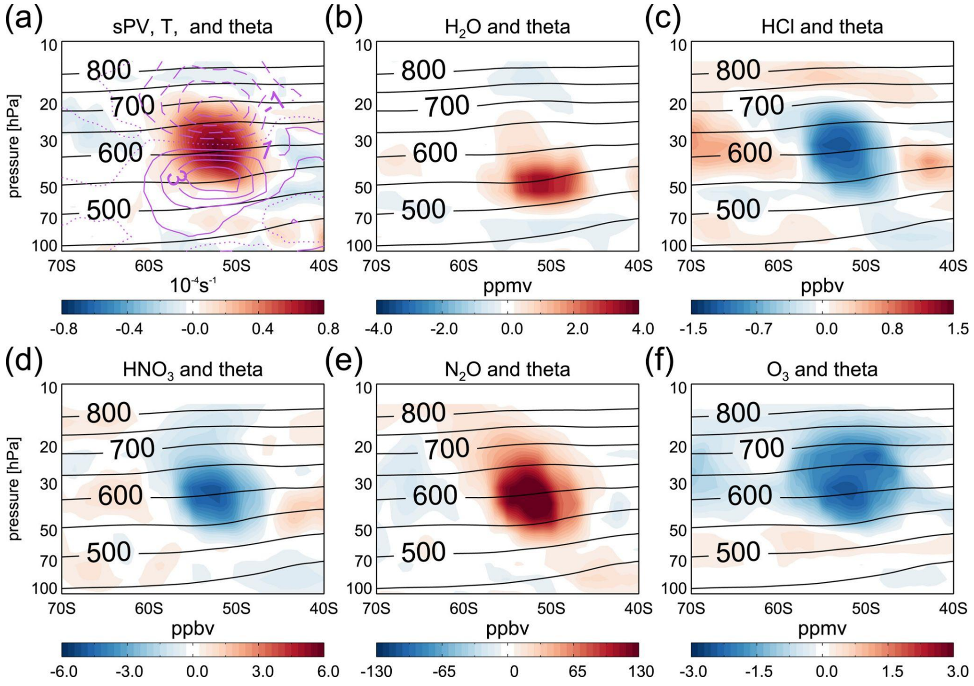


S-RIP2 Plans: Chemical/Composition Reanalyses



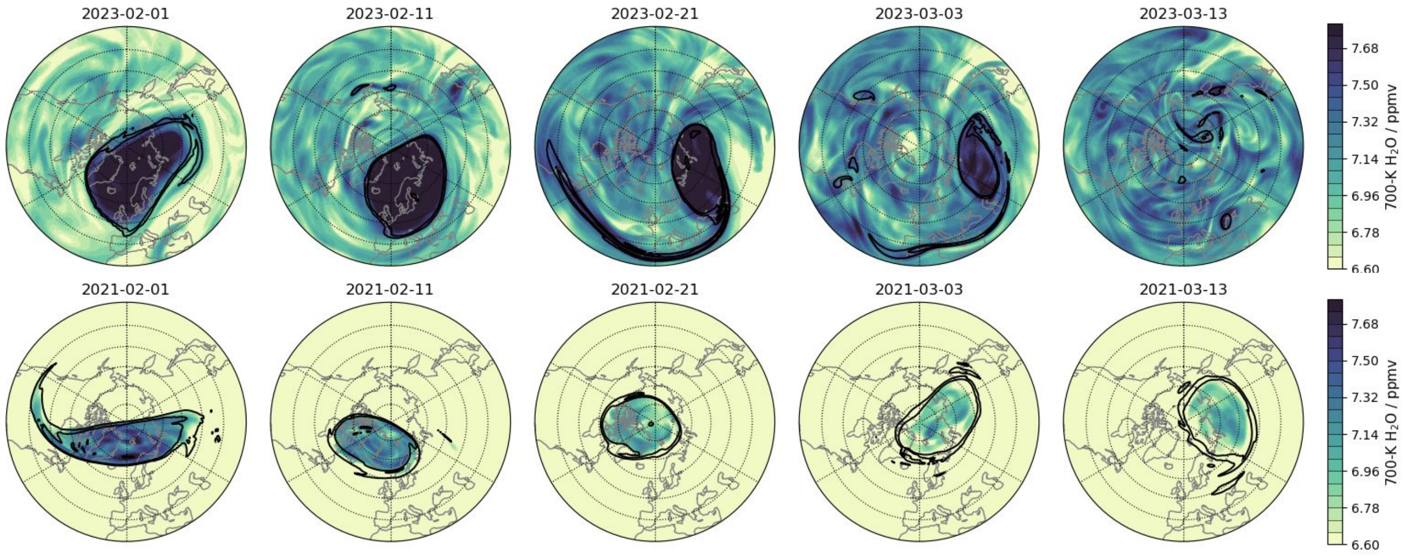
Above: Schematic of TCR-3, a new AQ-focused composition reanalysis (follow on to TCR-2), showing process and goals of chemical assimilation.

S-RIP2 Plans: Chemical/Composition Reanalyses



Examples of representation of stratospheric impacts of extreme events from MERRA-2 Stratospheric Composition REanalysis of Aura Microwave Limb Sounder (M2-SCREAM)

Left: M2-SCREAM anomalies in (a) PV and T, (b) H2O, (c) HCl, (d) HNO3, (e) N2O, and (f) O3 on 31 January 2020, following stratospheric injections from the Australian New Years Fires. (From Wargan et al., 2023, https://doi.org/10.1029/2022EA002632)



Right: M2-SCREAM H2O maps of NH middle stratosphere H2O in early 2023 compared to that in 2021, showing H2O in 2023 from Hunga Tonga-Hunga Ha'apai transported into the Arctic and mixed with vortex air during the February 2023 SSW (there was also a strong SSW in January/ February 2021).