APARC

Atmospheric Processes
And their Role in Climate

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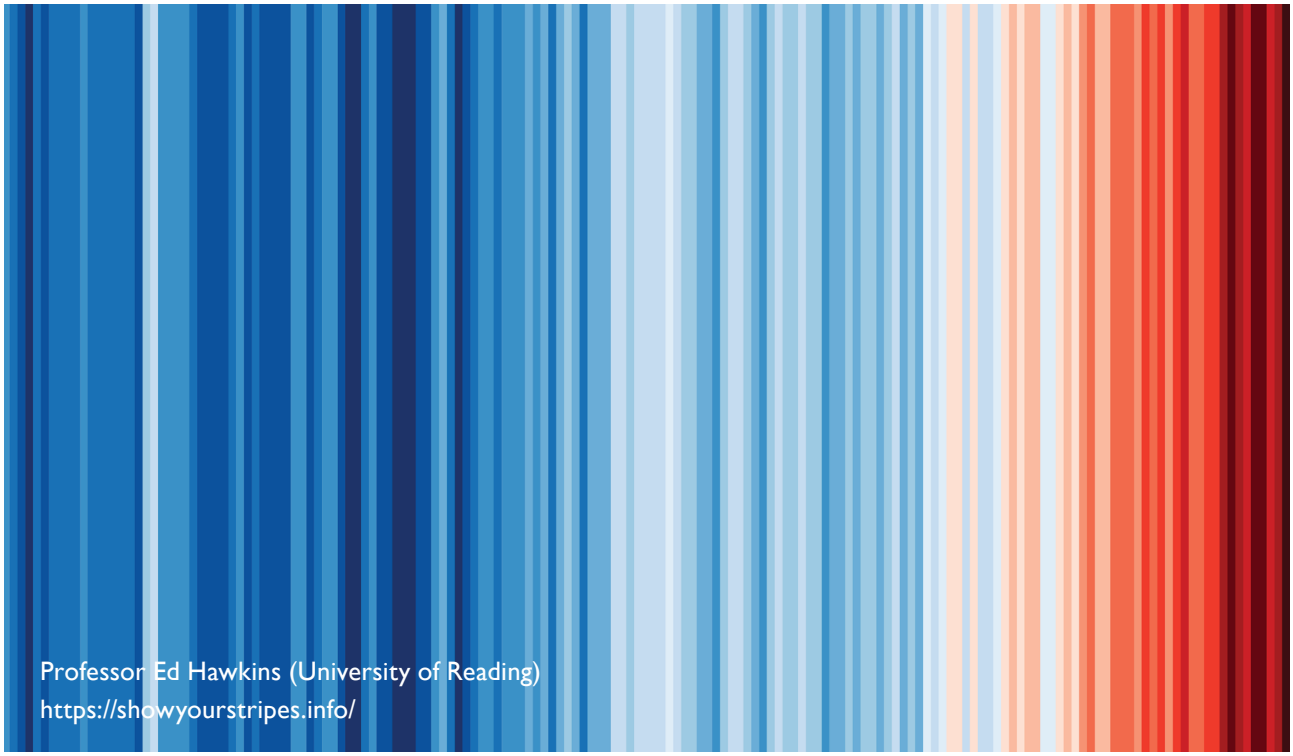

Professor Ed Hawkins (University of Reading)
https://showyourstripes.info/

The World Meteorological Organization (WMO) has confirmed that 2024 was the warmest year on record and the first that has reached more than 1.5°C above the pre-industrial level. In an era when understanding our atmosphere is more crucial than ever, the APARC co-chairs Amanda, Karen, and Olaf share their personal reflections on APARC's role in advancing climate science. Additionally, a number of reports are awaiting your attention, including studies related to the Asian monsoon, highlights from the OCTAV-UTLS working group meetings, a comprehensive review of last year's A-RIP workshop in Boulder, and news from the APARC SSG meeting. Enjoy!

Contents

WCRP World Climate Research Programme
WORLD METEOROLOGICAL ORGANIZATION
unesco Intergovernmental Oceanographic Commission
International Science Council

Personal reflections on the outlook for APARC

We are happy to reflect back on the first year of APARC and acknowledge our community's achievements in 2024. The new IPO team kindly hosted our Scientific Steering Group meeting in Jülich in October, where we discussed progress within our scientific activities and their plans for the future. It was wonderful to see the ambition and vision of our community for continuing their excellent work and are proud to have you all as part of the APARC family. We also reflect back on a year of exceptional and concerning events in the climate system. In addition to many impactful local weather and climate events, 2024 was the first year with a global average temperature exceeding the 1.5°C above preindustrial levels, a threshold noted by the Intergovernmental Panel on Climate Change (IPCC) and in the Paris Agreement that is associated with a substantial increase in the risk of climate disasters across the world. This serves as a stark warning to us all and highlights that APARC's work to provide fundamental scientific understanding of the atmosphere has never been more important. The IPCC recently held their Scoping Meeting of the Working Group Contributions to the Seventh Assessment Report and the WMO/UNEP Scientific Assessment of Ozone Depletion 2026 lead authors have been selected. We look forward to working with the Assessment teams over the coming years to ensure that the APARC community is well positioned to deliver the scientific evidence required to inform policy decisions on the climate. We are cognizant that our science is happening in a changing world that adds to uncertainty about what our future may hold. We continue to hope for the best and wish you all a successful and productive 2025.

APARC co-chairs Olaf Morgenstern, Amanda Maycock and Karen Rosenlof

Next APARC and APARC related meetings

Find more meetings at: www.aparc-climate.org/meeting

24 - 28 March 2025
QBOi - SNAP - QUOCA (QSQ) workshop
Cambridge, UK.

23 - 25 April 2025
VolImpact-SSiRC Workshop
Greifswald, Germany.

23 – 25 April 2025
ATC Spring Meeting
Graz, Austria

27 April – 02 May 2025
EGU General Assembly
Vienna, Austria

09 - 13 June 2025
6th ACAM Training School and Workshop
Bali, Indonesia

09 - 13 June 2025
Gravity Waves and FISAPS Symposium
Seoul, South Korea

15 - 20 June 2025
Stormtracks Workshop
Rosendal, Norway

20 - 25 July 2025
IAMAS-IACS-IAPSO Joint Assembly 2025 (BACO-25)
Busan, Republic of Korea

Report on the APARC OCTAV-UTLS ISSI Working Group Meetings, Bern, Switzerland

Paul S. Jeffery[1], Kaley A. Walker[1], Luis F. Millán[2], Peter Hoor[3], Michaela I. Hegglin[4,5,6], Gloria L. Manney[7,8], Harald Bönisch[9], Daniel Kunkel[3], Irina Petropavlovskikh[10], Hao Ye[5], Thierry Leblanc[11], and Franziska M. Weyland[3]

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Dates:
28 February – 3 March 2023
30 April – 3 May 2024

Organiser:
Luis Millán

Host Institution:
The International Space Science Institute (ISSI), Bern, Switzerland

Number Of Participants:
11 (2023) & 12 (2024)

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Activity Website:
https://www.aparc-climate.org/activities/octav-utls/

Logos/Sponsors:

Background

The upper troposphere – lower stratosphere (UTLS) is characterized by complex chemical, dynamical, and microphysical processes that lead to sharp gradients in trace gases across the tropopause. Large uncertainties in observation-based studies of long-term UTLS trace gas trends arise from this complexity, as well as from the competing transport processes established around the jet streams and the difficulties encountered in making measurements in this region. The goal of the OCTAV-UTLS activity is to exploit the capability of several dynamical coordinate systems to account for the drivers of dynamical variability which are related to transport barriers like the jets or tropopause, to aid in the analysis and interpretation of UTLS composition observations.

Introduction

The primary purpose of the OCTAV-UTLS (Observed Composition Trends And Variability in the Upper Troposphere and Lower Stratosphere) activity is to explore variability and trends in UTLS composition, the study of which is complicated by the inherent chemical, dynamical, and microphysical complexity of this region. This complexity arises from transport barriers such as the tropopause as well as the variability in chemical processes and transport/mixing processes characteristic of the UTLS, all of which establishes strong gradients in chemical species throughout the region. Not only does the tropopause inhibit transport (both vertical and horizontal) between stratospheric and tropospheric air, but variability in the tropopause

location can hinder quantification of the distribution of trace gases in the UTLS from observations. The radiative-dynamical processes responsible for the formation of the tropopause, which result in strong trace gas gradients, also drive the evolution of the tropopause over time. This in turn leads to cross-tropopause transport of chemical species (stratosphere-troposphere exchange, STE), particularly near the upper tropospheric jet streams. The large dynamical variability resulting from these processes complicates efforts to quantify and interpret the variability and trends of trace gas species in the UTLS. To distinguish the sources and impacts of geophysical variability on representations of trace gases in the UTLS, OCTAV-UTLS has been focusing on using dynamical coordinates that account for transport and/or dynamical features of the region, such as potential-vorticity-based equivalent latitude or tropopause-relative altitude. As different measurement platforms provide different spatial resolution and global coverage, typically with a trade-off between those two measurement characteristics, fully understanding the value of using such coordinate systems requires the analysis of observations from different measurement platforms to assess the consistency of mapping into different dynamical coordinates. Within the OCTAV-UTLS activity, this consistency is assessed using satellite, aircraft, balloon-borne, and ground-based measurements.

Two workshops for an OCTAV-UTLS subgroup were funded by a grant from the International Space Science Institute (ISSI) and hosted in Bern, Switzerland, from 28 February to 3 March 2023 and from 30 April to 3 May 2024. Eleven scientists from Europe and North America attended, either in person or online, the four-day meeting in 2023 and twelve attended in 2024 (including an early career researcher new to the OCTAV-UTLS activity). The primary goal of the 2023 ISSI OCTAV-UTLS workshop was to review how a set of over 30 different coordinate combinations represented UTLS ozone and its variability as seen in satellite, balloon-borne, aircraft, and ground-based instruments, to systemically assess their overall performance, and to synthesize the group's analysis into a manuscript for publication. The goal of the 2024 workshop was to extend this work by focusing on methods of calculating trends and measurement biases using the coordinates previously identified as having led to the largest reduction in binned climatological variability (hence, "best" performance in a broad sense). The 2024 discussion focused on performing this extended analysis and consolidating the findings for publication.

2023 Workshop

In attendance for the 2023 workshop were **H. Bönisch, M. Hegglin, P. Hoor, P. Jeffery, L. Millán, I. Petropavlovskikh**, and **H. Ye**, with **D. Kunkel, G. Manney, T. Leblanc**, and **K. Walker** attending virtually. The 2023 ISSI OCTAV-UTLS workshop began with **L. Millán** presenting the goals of the meeting, followed by an introduction to the ISSI organization by one of their representatives. Following this, **L. Millán** led the group through a recap of the previous meetings, highlighting how UTLS variability can complicate quantification and characterization of ozone trends and how using dynamical coordinate systems can help reduce the effects of this on assessment of geophysical variability. **L. Millán** also led discussion of the meteorological information and tropopause/jet characterization provided by the JETPAC software (Manney et al., 2011; Millán et al., 2023), used here in conjunction with MERRA2 (Modern-Era Retrospective analysis for Research and Applications, Version 2) to produce dynamical fields for the times and locations of measurements for the datasets used herein. An overview of results from previous OCTAV meetings continued with examples of zonally averaged multiyear climatologies of ozone relative standard deviation (RSTD; defined as the standard deviation normalized by the mean ozone concentration for each grid cell for a climatological period) from the measurement datasets currently used in this project (Aura-MLS, ACE-FTS, aircraft campaigns, lidars, and ozonesondes) in the dynamical coordinate systems the team is focusing on. Coordinate systems examined include combinations of pressure, altitude, or potential temperature (either as is or relative to the subtropical jet, WMO tropopause, 2 potential vorticity unit (PVU) dynamical tropopause, or 4.5 PVU dynamical tropopause) in the vertical, and latitude, equivalent latitude, or subtropical jet relative latitude in the horizontal. The recap concluded with recent work by **L. Millán** on remapping the RSTD calculated for different coordinate systems onto a uniform grid to facilitate directly comparing and quantifying the impact of these coordinates choices on representations of geophysical variability.

Ensuing group discussion opened with initial focus on the RSTD climatologies generated from Aura-MLS and ACE-FTS observations, as these two datasets provide the best global coverage of the datasets considered. Comparisons for these datasets indicated that an equivalent latitude horizontal coordinate combined

with a potential temperature (in some cases with respect to a dynamical tropopause) vertical coordinate were choices that most significantly reduced the binned variability in climatologies for the three-month period (December-January-February, DJF) assessed. However, other coordinate combinations were found to perform well for particular regions of the UTLS (e.g., tropopause-based coordinates for a span of about 2 km above and below the tropopause, jet-based coordinates within a span of about one to two hundred km poleward and equatorward of the subtropical jets). Similar patterns with respect to the different coordinate combinations were identified in climatologies from the CARIBIC-2, ozonesonde, and lidar datasets; however, because of their sparse spatial sampling, these effects were not as clear as for the satellite datasets. Additional discussion of the dynamical coordinate climatologies noted that while remapped and "raw" climatologies agreed as to which coordinate systems best represented real atmospheric variability, the issues persisted as to how to treat the remapping process due to ambiguities in remapping averaged fields, and how to best present the results of this coordinate analysis to clearly illuminate the value of particular coordinate combinations. These discussions and the issues they raised formed the main topics of discussion for the rest of the week.

Having identified the above main discussion points for the week, the latter half of the first day was spent outlining a manuscript on assessment of dynamical coordinate combinations. One format, suggested by **P. Hoor**, favoured a holistic approach that emphasized the use of dynamical coordinates in every section; another format suggested by **P. Jeffery**, favoured a reductionist approach that handled each section independently. Group discussion led to a middle ground format, and the reminder of the day was spent working on a draft, prepared in advance by **P. Jeffery** and **K. Walker**, and organizing content for the rest of the paper.

The second day began with examination of the mean and RSTD ozone plots produced for each of the five datasets in several sets of basic coordinates to illustrate general coordinate system properties and the benefits and caveats of using each coordinate systems in relation to attribution of the features in the RSTD plots. **H. Bönisch, M. Hegglin**, and **P. Hoor** were the main leaders of these dynamics focused discussions. Discussion also included the sensitivity of climatologies to vertical and horizontal resolution, appropriate binning and minimum number of measurements per bin, and which dataset(s) to focus on in the initial paper. It became evident that the remapping method was prone to interpolation errors and would thus require further refinement. **L. Millán** used suggestions from the group to create new versions of these plots, and the remainder of the day focused on examining these remapped climatologies and identifying areas for further improvement.

Discussion continued the third day as to how to assess the consistency of the impact of various coordinate systems between the various datasets and how to quantify the differences seen between these coordinates. Aura-MLS and ozonesonde climatologies were seen as the focus for the manuscript, as they represented the two extremes in the trade-off between spatial resolution and global coverage of the five datasets. Further refinements were made to the climatology and remapped variability plots. The workshop attendees, both virtual and in-person, assembled a section describing the datasets, with **H. Bönisch** contributing to the summary for CARABIC-2, **M. Hegglin** to that for Aura-MLS, **P. Jeffery** to that for ACE-FTS, **T. Leblanc** to that for Lidars, and **I. Petropavlovskikh** to that for ozonesondes. Additional manuscript editing was done throughout the day.

By and in the last day of the workshop, many of the open questions were resolved, including formulating explanations of the representation of geophysical variability in different coordinate systems and the consistency of that among the datasets. The group decided on how to present the remapped data to assess the impact of different coordinates while noting that the approach could potentially misrepresent variability if used for other purposes. Discussion of future work included polishing the manuscript, starting work on a second paper focused on the impact of sampling biases in dynamical coordinates, and planning an ozone trend paper using dynamical coordinates, which was the specific goal of the ISSI workshops as a subset of the overall OCTAV-UTLS activity goals.

2024 Workshop

The 2024 ISSI OCTAV-UTLS workshop saw in-person attendance from **H. Bönisch, M. Hegglin, P. Hoor, P. Jeffery, T. Leblanc, L. Millán, I. Petropavlovskikh, K. Walker**, and **F. Weyland**, with **D. Kunkel, G. Manney**, and **H. Ye** attending virtually.

The workshop began with a recap of the findings from the previous meeting and the status of the submitted manuscript (Millán et al., 2024). The initial focus for this meeting was on extending the work from assessment of ozone RSTD to the calculation of ozone trends. On the first day, **L. Millán** presented an overview of UTLS ozone studies from the past 15 years, emphasizing the poor agreement between previous UTLS ozone trend studies and motivating the use of dynamical coordinate systems. Discussion followed on the coordinate system(s) to use in this new analysis and the trend calculation methodology. **P. Hoor, L. Millán**, and **F. Weyland** suggested three main techniques for the trend analysis: a linear fit to deseasonalised data, multiple linear regression (MLR), and dynamical linear modelling (DLM). **L. Millán** showed calculations of the linear fit to deseasonalised data from Aura-MLS and ozonesondes, how those trends compared in different coordinate systems, and the uncertainties in those trends. This was done for each of the 33 coordinate systems examined previously. To complement this, **F. Weyland** showed their recent work applying DLM to a subset of the datasets and coordinate systems, focusing on pressure/latitude, potential temperature/equivalent latitude, and tropopause-relative potential temperature/equivalent latitude coordinates.

For the remainder of the day, the team broke into groups to discuss different aspects of planned work. **H. Bönisch, M. Hegglin**, and **P. Hoor** focused on how to determine which coordinate systems would be needed for a comprehensive view of UTLS ozone trends. **P. Jeffery, L. Millán, K. Walker**, and **F. Weyland** focused on ways to explore and compare the trend calculation techniques, while **T. Leblanc** and **I. Petropavlovskikh** focused on how to maximize information extraction from instruments with sparse spatial coverage, such as the ozonesonde and lidar datasets.

The second day of the meeting was used to define and start a draft of a UTLS ozone trend manuscript. The initial tasks included the identification of a subset of coordinates to focus on and the determination of appropriate spatial and temporal averaging intervals. To address the former, **L. Millán** generated trends using the linear fit of deseasonalised Aura-MLS and ACE-FTS data on both an annual and seasonal basis in pressure/latitude and potential temperature/equivalent latitude coordinates to help assess the agreement between the datasets. Seasonal trends yielded more robust agreement in the UTLS distribution of ozone than annual means. Following this, **P. Jeffery** and **L. Millán** focused on incorporating 4.5-PVU-tropopause-referenced potential temperature/equivalent latitude coordinates into this analysis and verifying the results, while **F. Weyland** focused on completing DLM for all datasets in these three coordinate systems. The remainder of the day also included further discussion of the results presented thus far and the implementation, testing, and assessment of differences between trend fitting methods.

Discussion continued the third day with emphasis on the trends calculated using the non-satellite datasets and on testing different regression models. It was decided to use the LOTUS model (Godin-Beekmann et al., 2022) for MLR trend calculation. **T. Leblanc** and **I. Petropavlovskikh** led discussion on how the sparser datasets might lead to regionally inconsistent trends due to poor zonal coverage. **H. Bönisch, M. Hegglin**, and **P. Hoor** led discussion of dynamical features of the UTLS that are important to consider for different latitude regions. The team also discussed **P. Jeffery's** recent work estimating sampling and measurement biases using MERRA2 reanalysis fields, sampled at the locations and times of measurements, produced by the JETPAC for datasets currently being used. A revised methodology for this bias assessment was proposed and the group decided on a set of metrics to be examined in this future study.

On the last day of the 2024 workshop, findings for the week were summarised, key material for the first trend publication was identified, and tasks were assigned to complete the initial ozone trend paper. It was decided to update the dynamical coordinate information for the datasets to 2023 (from 2020) where available, to expand the number of ozonesonde, lidar, and aircraft measurement datasets, and to use all three methods for trend calculations. Driving the extension of the datasets up to 2023 is the desire to explore the impact that the end point has on trend calculations, as it was noted that for some of the datasets, the trend in the lower stratosphere was negative if considered only to the end of 2020 but positive when the end date was increased. In addition to work for the specific activities of the OCTAV-UTLS ISSI subgroup, aspects of the broader OCTAV-UTLS activity were discussed, including how capacity building and outreach opportunities can be fostered in the suite of OCTAV-UTLS activities.

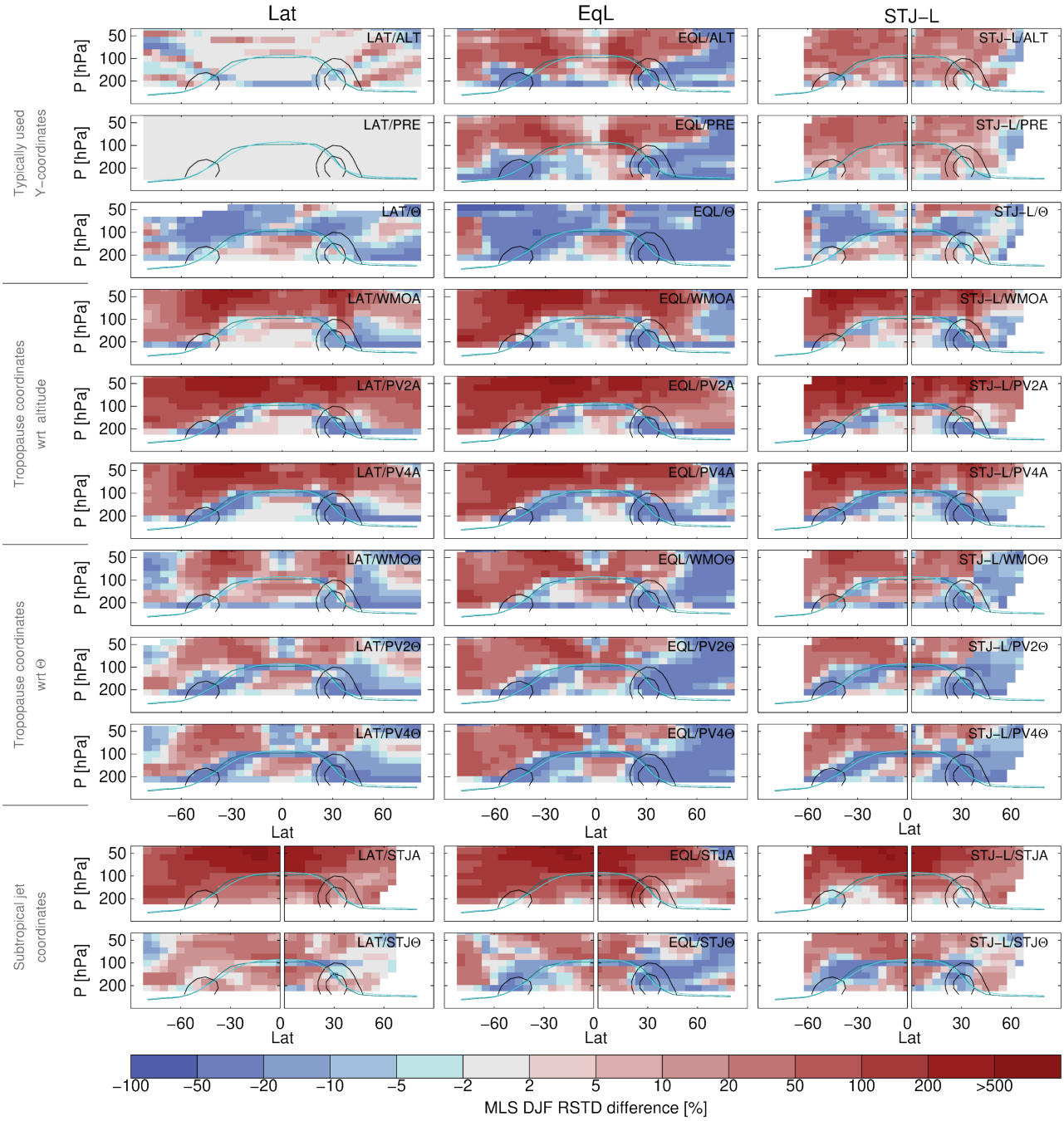

Figure 1: *Changes in relative standard deviation (RSTD) in different coordinate systems, as compared to the RSTD in latitude/pressure coordinates. The red colours indicate an increase in binned variability, while the blue colours denote a reduction in binned variability. The use of equivalent latitude/potential temperature coordinates leads to the most substantial reduction in binned variability across the UTLS. Figure from Millán et al (2024)*

References:

Godin-Beekmann, S., Azouz, N., Sofieva, V. F., et al.: Updated trends of the stratospheric ozone vertical distribution in the 60° S–60° N latitude range based on the LOTUS regression model, Atmos. Chem. Phys., 22, 11657–11673, https://doi.org/10.5194/acp-22-11657-2022, 2022.

Manney, G. L., Hegglin, M. I., Daffer, W. H., Santee, M. L., Ray, E. A., Pawson, S., Schwartz, M. J., Boone, C. D., Froidevaux, L., Livesey, N. J., Read, W. G., and Walker, K. A.: Jet characterization in the upper troposphere/lower stratosphere (UTLS): applications to climatology and transport studies, Atmos. Chem. Phys., 11, 6115–6137, https://doi.org/10.5194/acp-11-6115-2011, 2011.

Millán, L. F., Manney, G. L., Bönisch, H., Hegglin, M. I., Hoor, P., Kunkel, D., Leblanc, T., Petropavlovskikh, I., Walker, K., Wargan, K., and Zahn, A.: Multi-parameter dynamical diagnostics for upper tropospheric and lower stratospheric studies, Atmos. Meas. Tech., 16, 2957–2988, https://doi.org/10.5194/amt-16-2957-2023, 2023.

Millán, L. F., Hoor, P., Hegglin, M. I., Manney, G. L., Bönisch, H., Jeffery, P., Kunkel, D., Petropavlovskikh, I., Ye, H., Leblanc, T., and Walker, K.: Exploring ozone variability in the upper troposphere and lower stratosphere using dynamical coordinates, Atmos. Chem. Phys., 24, 7927–7959, https://doi.org/10.5194/acp-24-7927-2024, 2024.

Balloon measurements during the 2024 Asian Summer Monsoon

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The Asian Summer Monsoon is responsible for the transport of Pollution into the stratosphere in the form of trace gases and aerosols (Randel et al., 2010, Vernier et al., 2011). Pollutants can affect the radiative balance of the upper troposphere and lower stratosphere, impact the recovery of the stratospheric ozone layer and affect the formation of cirrus clouds. The Asian Tropopause Aerosol Layer (ATAL), which was discovered more than one decade ago through satellite observations has been the centre of numerous research activities. It underwent scrutiny after multiple airborne deployments from China, Nepal and India. While the size and shape of particles constituting the ATAL are largely known, it is more recently than those measurements revealed that Nitrate and organics may represent an unexpected contribution to the overall aerosol population thought to be largely sulfate.

During the summer 2024, teams from India, China, France and USA deployed at multiple locations to study the properties of the ATAL through 3 field campaigns.

SWOP
[Sounding Water vapor, Ozone and Particles; Coordinator: Jianchun Bian]

The SWOP campaign included five flights of Electro Concentration Cell (ECC) ozonesonde, Cryogenic Frost Point Hygrometer (CFH) and Compact Aerosol Backscatter Detector (COBALD) sondes, twice of which Portable Optical Particle Spectrometer was also attached. The flights were conducted at Lhasa station (91.14E, 29.66N) during August and September 2024. In addition, Lidar measurements were performed by a multiwavelength Raman lidar system (Raymetrics Inc, model LR331-D400), emitting in 355, 532 and 1064 nm of wavelength at Golmud (94.91E, 36.42N) during July and August 2024. The purpose of the SWOP campaign was to study the cirrus cloud statistics in the upper troposphere based on 14 years balloon soundings over the Tibetan plateau.

BEATS
[Balloon Experiments for Atmospheric composition and Troposphere-Stratosphere studies; Coordinator: Suvarna Fadvanis]

Seven successful flights of COBALD, CFH, and ozonesondes were conducted from the Atmospheric Research Test Bed (ART-CI) (77.24E; 23.57N) in Bhopal during August - September 2024. Preliminary data analysis shows clear indication of ATAL with thickness 1 km. There is persistent occurrence of tropopause-level cirrus clouds with varying optical depths over the region. A comparative study between radiosonde-measured horizontal winds and modern reanalysis datasets reveals that reanalysis wind data consistently underestimate wind speeds in the troposphere and lower stratosphere. A more in-depth analysis is underway to investigate the causative mechanism behind the formation of cirrus clouds, the radiative impact of tropopause-level cirrus, ozone intrusions into the upper troposphere, transport of water vapour into the lower stratosphere, and the distribution of ozone, water vapor and aerosol during the active and break phases of monsoon.

BATAL
[The Balloon measurement campaign of the ATAL; Coordinators: M. Venkat Ratnam, Jean-Paul Vernier]

The BATAL campaign took place from Hyderabad (India) between 18 July and 18 August 2024 where flights were conducted from the Balloon Facility of

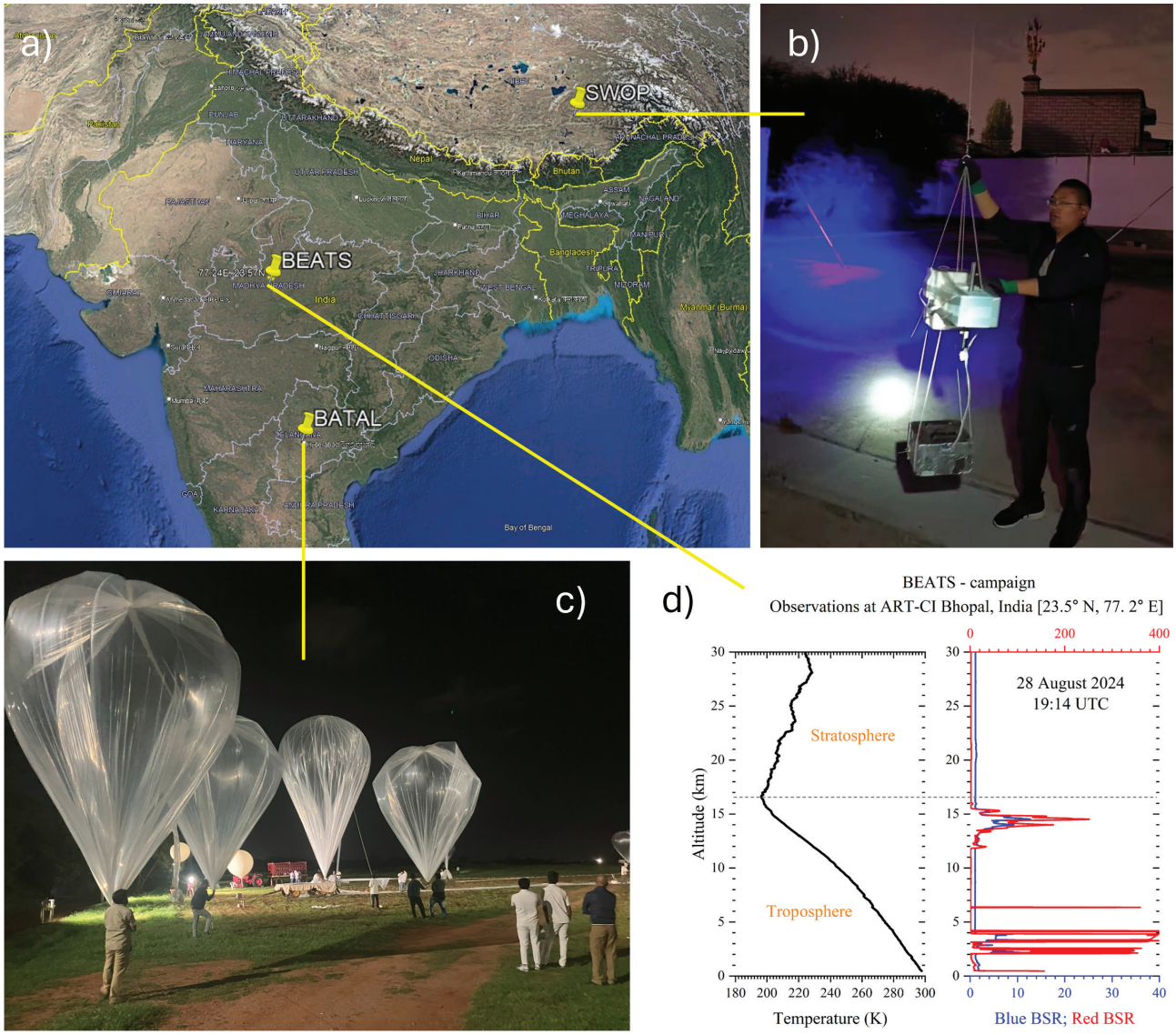

Figure 2: *a) Locations of the BATAL, BEATS and SWOP campaigns which took place during the 2024 Asian Summer Monsoon. b) balloon sounding at Lhasa where Dr. Zhixuan Bai holds the payloads before releasing during SWOP, c) launch preparation from the TiFR balloon facility in Hyderabad during BATAL. d) Preliminary results from the BEATS campaign showing enhanced Backscatter Ratio (BSR) from cirrus clouds near the tropopause (dashed line).)*

Tata Institute of Fundamental Research. A total of 10 Institutes from India, France and the US participated in the BATAL project including major agencies such as TiFR, ISRO, NASA Langley and CNRS. 70 people were associated with the BATAL project and 10 balloon flights associated with 30hours of total flight hours and 10 hours at tropopause-float altitude were conducted. A total of 20 instruments were launched during the BATAL project and 60 samples were collected for off-line chemical analysis in India (Ion Chromatography), France (Isotopic analysis and SEM/EDX).

The 3 major scientific objectives of the BATAL projects were to i) study the microphysical properties of the ATAL and Ruang volcanic plumes using multiple Optical Particle Counters ranging from a few nanometers size to several micron, ii) collect samples with the ATAL and Ruang volcanic plume to study their chemical composition and iii) the microphysical properties of ice clouds near the tropopause especially under convective influence of MCS over the Bay of Bengal.

References:

Randel WJ, Park M, Emmons L, Kinnison D, Bernath P, Walker KA, Boone C, Pumphrey H. Asian monsoon transport of pollution to the stratosphere. Science. 2010 Apr 30;328(5978):611-3. doi: 10.1126/science.1182274. Epub 2010 Mar 25. PMID: 20339030.

Vernier, J.-P., L. W. Thomason, and J. Kar (2011), CALIPSO detection of an Asian tropopause aerosol layer, Geophys. Res. Lett., 38, L07804, doi:10.1029/2010GL046614.

Report on the 2nd International Conference on the Asian Summer Monsoon Anticyclone (ASMA-2023)

Sanjay Kumar Mehta[1], Masatomo Fujiwara[2], Susann Tegtmeier[3], Suvarna Fadnavis[4], M. Venkat Ratnam[5], Karnam Kishore Kumar[6], Siddarth Sankar Das[6], Som Kumar Sharma[7], Rakesh V. Nair[8], Vinoj Velu[9], Chandan Sarangi[10] Narendra Ojha[7], Lokesh K. Sahu[7], Ajil Kottyail[11], Sabin T. P.[4], Munkund Gogoi[6], K. Mohankumar[11], M. N. Rajeevan[12]

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[9]Indian Institute of Technology, Bhuvneshwar; [10]Indian Institute of Technology, Madras, India; [11]ACARR, Cochin University of Science and Technology, Cochin, India; [12]Atria University, Bangalore, India

Dates:
11 - 13 September 2023

Scientific Organising Committee:
Dr. Sanjay Kumar Mehta, Dr. Masatomo Fujiwara, Dr. Susann Tegtmeier, Dr. Suvarna Fadnavis, Dr. M. Venkat Ratnam

Local Organising Committee:
Prof. A. Karthigeyan, Prof. P. Malar, Prof. Venkat Prasad Bhat, Dr. Arijit Sen, Dr. Rohit Dhir, Dr. Debabrata Sarkar

Host Institution:
SRM Institute of Science and Technology, Chennai, India

Number Of Participants: 74 participants

Contact:
ksanjaym@gmail.com

Conference Website:
https://www.srmist.edu.in/events/asma-2023/

Logos/Sponsors:

Overview

The 2nd International Conference on the Asian Summer Monsoon Anticyclone: Gateway of surface pollutants to the stratosphere (ASMA-2023) is being jointly organized by the Scheme for Promotion of Academic and Research Collaboration (SPARC), Govt of India, and the SRM Institute of Science and Technology (SRMIST) in association with Hokkaido University, Japan and University of Saskatchewan (USask), Canada at the Atmospheric Observation and Modelling Laboratory (AOML), Department of Physics and Nanotechnology during 11-13 September 2023. In the ASMA-2023 conference, we had one keynote speaker, 22 invited talks, 15 oral talks, and 21 attendees for the three-day event. There were 74 participants from India, Japan, Canada, Nepal, Bangladesh, and Sri Lanka. The conference started with a formal inaugural function including a lighting lamp followed by the welcome address by Sanjay Mehta (SRMIST, India) and the release of the abstract book by the dignitaries on the dais M. Rajeevan (NCESS, MOES, Govt. of India), Masatomo Fujiwara (Hokkaido University, Japan). The conference was divided into 8 oral sessions. Each oral session began with an invited talk and presentations from early career scientists and students. One young scientist award, three best oral presentations and two consolation prize are awarded. On the second day of the conference, a trip was arranged for the sightseeing at Mahabalipuram, Chennai.

Figure 3: *Inaugural function and release of abstract booklet at the ASMA Conference 2023.*

The session opened with a keynote talk by **M. Rajeevan**, who gave a "General Overview of Climate Change and the Asian Summer Monsoon" and discussed the monsoon circulation and precipitation in relation to climate change. The next talk is by **Y. Kawatani** (Hokkaido University, Japan) who describes the impact of mid-latitude SST fronts on the middle atmosphere through upward propagating atmospheric waves. The southern Himalayas, an important part of the Asian water tower, are facing rapid changes due to climate-related disasters in recent decades, presented by **Deepak Aryal** (Tribhuvan University, Nepal). **Shin-Ya Ogino** (Japan Agency for Marine-Earth Science and Technology, Japan) gave a presentation on the cause of a low-tropospheric high-ozone layer as observed over Hanoi, Vietnam. The ASMA is characterized by high amounts of pollutant gases (other than ozone) and aerosols that have a global impact via the eddy shedding mechanism, as presented by **Suvarna Fadnavis** (IITM Pune, India). **S. Sridharan** (NARL, Gadanki, India) then presented an overview of the formation and maintenance of cirrus clouds during the Asian monsoon season. Later, ozone variability and UTLS (Upper Troposphere and Lower Stratosphere) enhancement over the southern flank (**S. Ravindra Babu**, National Central University, Taiwan), comparison of ozonesonde measurements in the upper troposphere and lower stratosphere over northern India with reanalysis and chemistry-climate model data (**Archana Pradeep**, IITM, Pune, India), and the role of mesoscale meteorology and chemistry in the variation of pollutants including ozone over a tropical hill station in the Western Ghats (**Revathi S. Ajaykumar**, Space Physics Laboratory, VSSC, India).

The next session started with invited speaker **Masatomo Fujiwara** (Hokkaido University, Japan) who gave an overview of the SPARC Reanalysis Intercomparison Project (S-RIP) and preliminary plans for its phase 2 (S-RIP2). **Siddarth Shankar Das** (SPL, VSSC, India) discussed stratosphere-troposphere coupling processes over the ASMA region. **Venus Venugopal** (SPL, VSSC, India) presented the chemical kinetics of near-surface ozone at a suburban site in India. The impact of the Asian summer monsoon anticyclone on the variability and transport of carbon monoxide and methane was presented by **V K Patel** (IIT, Kharagpur, India). **Sameer Rawat** (Graphic Era Deemed to be University, Dehradun, India) has given a comprehensive presentation on a hybrid model to analyze the climatic parameters for forecasting and climate change. **Aravindhavel A.** (IITM Pune, India) delivered the characteristics of vertical and columnar properties of aerosols between boundary layer (BL) and free troposphere (FT). **Suresh** (University of Peradeniya, Srilanka) presented a review on the impact of gas composition and aerosols on ASMA. A synergistic approach using remote sensing observations and modeling is presented by **Vinoj V** (IIT Bhubaneswar, India) and provides the possibility for model-model or model-observation comparisons for aerosol transport. **Lokesh Kumar Sahu** (PRL, India) talked about the influence of convection on the vertical distribution of reactive trace gases over India. **Chandan Sarangi** (IIT Madras, India) presented the transport of north Indian pollution to the Bay of Bengal and peninsular India at high altitudes. **Sakia Shabnam Kader** (Bangladesh University of Engineering and Technology, Bangladesh) presented the spatio-temporal variations of convective available potential energy in Bangladesh and its effect on rainfall. The chemical kinetics of near-surface ozone at a suburban site in India was elucidated by **Vijay Kumar Sagar** (University of Hyderabad, Telangana, India). **Bhagavathiammal** (Anna University, Chennai, India) spoke about the five-year assessment of particulate matter (PM10 & PM2.5) in the state capitals of Andhra Pradesh and Telangana.

Figure 4: *Group photo of participants at the ASMA Conference 2023.*

Tropospheric aerosols play an important role in modifying the Earth's radiation budget and cloud properties. In addition to their columnar loading, the transport of boundary layer aerosols into the free troposphere and the resulting vertical distributions have a major influence on climate. The likelihood of increasing emissions and efficient venting of aerosols into the UTLS is sensitive to the various processes occurring in the northern hemisphere lower stratosphere. **Mukunda M. Gogoi** (Space Physics Laboratory, VSSC, India) gave a detailed presentation on Free tropospheric aerosols over South Asia: Understanding Vertical Transport and Impacts. **M. Venkat Ratnam** (National Atmospheric Research Laboratory, India) discussed trends and variability of aerosols and trace gases in the Asian summer monsoon anticyclone. **Som Kumar Sharma** (PRL, Ahmedabad) described the investigations of atmospheric boundary layer, clouds and pollutants under the Indian Lidar Network (ILIN) program. **Devika M V** (ACARR CUSAT, India) presented the role of monsoon extremes and the Asian summer monsoon anticyclone in the variability of the upper tropospheric moisture distribution. The outflow of Asian biomass-burning carbonaceous aerosol into the UTLS in spring: Radiative effects seen in a global model was discussed by **Prashant Chavan** (IITM Pune, India). **Narendra Ojha** (PRL, India) presented the results on the impact of monsoon on ozone and related trace species over the South Asian region from combined in-situ and satellite-based observations (MOPITT) with modeling analysis (CAMS and WRF-Chem). **Sabin T. P** (IITM, Pune) presented The Asian Summer Monsoon Overturning Circulation: Insights into Future Changes and its Potential Upper Tropospheric Links. **Karanam Kishore Kumar** (SPL, VSSC, India) presented precipitating and non-precipitating clouds using multi-frequency space-borne radar observations. **Sanjay Kumar Mehta** (SRM IST, India) explained the identification of ASMA based on tropical easterly and subtropical westerly jets during active and pause phases. **Pooja Purushotham** (SRM IST, India) presented the influence of various mesoscale phenomena on the extreme variability of the tropical tropopause over the tropics. **Musaid P. P.** (SRM IST, Kattankulathur, India) presented a study on the relative roles of advection and convection on the Asian summer monsoon anticyclone.

Pre-Conference Lectures on Asian Summer Monsoon Anticyclone: Under the SPARC program, we have trained the students, scientists and post-doctoral fellows from various leading institutes in India, Nepal, Bangladesh, Germany, etc. by conducting pre-conference lectures during 28 August - 08 September 2023. The MSc. students of Atmospheric Sciences, at SRMIST have also attended some pre-conference lectures. The pre-conference lectures were prepared to cover the basics of Asian summer monsoon, atmospheric dynamics, radiative transfer, convection, impact of cirrus clouds, as well as an advanced level of advances in Asian summer monsoon anticyclone, stratosphere-troposphere exchange processes, and active and paused monsoon conditions. A total of 24 lectures, eight assignments and two tests are given to the participants to successfully complete the course. The various professors and scientists from leading institutes accepted to take the course. M. Fujiwara (Hokaidao Univ, Japan), Susann Tegtmeier (USask, Canada), K. Mohan Kumar (CUSAT, India), Dr. S. Fadnavis (IITM, Pune), Karnam Kishore (SPL, VSSC, India), V. Rakesh (CSIR 4th Paradigm, India), Dr. Narendra Ojha (PRL, India), Chandan Sarangi (IIT, Madras) and Sanjay Mehta (SRM IST, India).

A-RIP Update and Planning Workshop Report

Jonathon S. Wright[1], Gloria L. Manney[2], Krzysztof Wargan[3], Beatriz Monge-Sanz[4], Masatomo Fujiwara[5], Mohamadou Diallo[6], V. Lynn Harvey[7], and Sean M. Davis[8]

[1]Tsinghua University, Beijing, China; [2]NorthWest Research Associates, Inc., USA; [3]NASA GSFC Global Modeling and Assimilation Office, USA; [4]University of Oxford, UK; [5]Hokkaido University, Sapporo, Japan; [6]Forschungszentrum Jülich GmbH, ICE-4, Germany; [7]Laboratory for Atmospheric and Space Physics, University of Colorado-Boulder, USA; [8]NOAA Chemical Sciences Laboratory, Boulder, Colorado, USA

Dates:
22 - 24 July 2024

Scientific Organising Committee:
A-RIP Activity Leads and Steering Group

Local Organising Committee:
V. Lynn Harvey, Sean Davis, and Adam Schneider

Host Institution:
Laboratory for Atmospheric and Space Physics (LASP) Space Sciences Center, University of Colorado at Boulder, Boulder, CO, USA

Number Of Participants:
>100 (36 on site)

Contact:
aparcrip@gmail.com
jswright@tsinghua.edu.cn

Conference Website:
https://s-rip.github.io/events/meeting2024/

Logos/Sponsors:

Furnishing the exclamation point on "July Science Jamfest 2024!", the newly renamed APARC Reanalysis Intercomparison Project (A-RIP; formerly S-RIP) held a kickoff and planning meeting in Boulder, Colorado, USA during 22-24 July 2024. Per **Luis Millán** and the Dictionary of American Regional English, a jamfest is a "meeting where there's a lot of talking," a mandate for which A-RIP is well practiced and perpetually poised to deliver. Following the headlining Quadrennial Ozone Symposium, the A-RIP workshop brought together more than 100 scientists developing and using reanalyses from around the world to share research and plan the next phase of systematic reanalysis evaluation and intercomparison.

Workshop topics included updates on the newest and forthcoming reanalyses and planning for topical studies. In addition to continuing topics such as the Brewer-Dobson circulation (BDC), the quasi-biennial oscillation (QBO), and the tropical and extratropical upper troposphere and lower stratosphere (UTLS), A-RIP includes new topical focus areas targeting gravity waves (which are increasingly resolved by the newest generation of atmospheric reanalyses) and the tropospheric circulation (including jets, storm tracks, teleconnections, extreme weather events, and monsoons) and its links to the stratosphere. Expanded topics from the S-RIP phase include the upper stratosphere, mesosphere, and lower thermosphere, as the upper limits of reanalysis products push toward ever lower pressures, the stratospheric polar vortex, stratospheric and tropospheric composition, and aerosols and air quality.

New Name, New Logo, New Faces

The first phase of the reanalysis intercomparison activity, which kicked off at the UK Met Office in Exeter on 29 April–1 May 2013, successfully concluded with the publication of the S-RIP Final Report (SPARC Report No 10: https://www.aparc-climate.org/sparc-report-no-10/) in January 2022 and a joint special issue comprising 53 publications in Atmospheric Chemistry and Physics and Earth

System Science Data (acp.copernicus.org/articles/special_issue829.html). During 2022 and into 2023, the activity leads publicized these results in a series of conference presentations and seminars around the world. In early 2023, S-RIP began planning for phase 2 of the activity, which was reorganized as A-RIP with the repositioning of SPARC as APARC at the beginning of 2024. During this time, **Lesley Gray** stepped down as activity co-lead and was replaced by **Jonathon Wright, Mohamadou Diallo** agreed to serve as outreach and capacity building coordinator for the activity, and a new steering committee was established (Table 1).

Figure 5: *Longtime A-RIP lead Masatomo Fujiwara receives a small token of our appreciation, a mug with the A-RIP logo on one side and the S-RIP logo on the other.*

Following more than 10 years of distinguished service leading the activity, **Masatomo Fujiwara** decided to step back from leadership in mid-2024, a decision that was announced at the workshop. A-RIP owes a great debt to Masatomo for his steady leadership, his patience, and most especially his kindness. His service to the activity was honored during the A-RIP kickoff meeting by co-leads **Gloria Manney** and **Jonathon Wright** (Figure 5). In the months following the meeting, **Kris Wargan** and **Beatriz**

Table 1: *Current A-RIP co-leads and steering committee members.*

Name	Institute	Role
Gloria L. Manney	NorthWest Research Associates, Inc., USA (also at New Mexico Institute of Mining and Technology)	Co-lead
Beatriz Monge-Sanz	University of Oxford, UK	Co-lead
Krzysztof Wargan	NASA GSFC Global Modeling and Assimilation Office, USA (also at Science Systems and Applications Inc.)	Co-lead
Jonathon S. Wright	Tsinghua University, Beijing, China	Co-lead
Sylvia Ampadu	University of Ghana	Early career representative
Blanca Ayarzagüena	Universidad Complutense de Madrid, Madrid, Spain	Steering committee
Sean Davis	NOAA Chemical Sciences Laboratory, Boulder, Colorado, USA	Steering committee
Mohamadou Diallo	Forschungszentrum Jülich GmbH, ICE-4, Germany	Outreach & capacity building coordinator
Masatomo Fujiwara	Hokkaido University, Sapporo, Japan	Steering committee
Yayoi Harada	Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, Japan	Steering committee, reanalysis centre contact
V. Lynn Harvey	Laboratory for Atmospheric and Space Physics, University of Colorado-Boulder, USA	Steering committee
K. Emma Knowland	National Aeronautics and Space Administration, USA	GAFIS liaison
Patrick Martineau	Japan Agency for Marine-Earth Science Technology (JAMSTEC), Tokyo, Japan	Steering committee
Froila Palmeiro	Centro Euro-Mediterraneo sui Cambiamenti Climatici, Lecce, Italy	Early career representative
Felix Ploeger	Forschungszentrum Jülich GmbH, ICE-4, Germany	Steering committee
M. Zeeshaan Shahid	University of the Punjab, Lahore, Pakistan	Early career representative

Figure 6: *In-person attendees at the 2024 A-RIP Kickoff and Planning Meeting.*

Monge-Sanz were introduced as new co-leads (Table 1). The decision to expand the co-lead team to four was taken in preparation for the broadened scope of A-RIP, as introduced below.

Thanks to the generous support of APARC, the Cooperative Institute for Research in Environmental Sciences (CIRES) and NorthWest Research Associates, Inc. (NWRA), we were able to fully or partially support the attendance of thirteen early career scientists to attend the meeting. APARC provided travel support to **Sylvia Ampadu** from the University of Ghana, **Muhammad Zeeshaan Shahid** from the University of the Punjab in Pakistan, **Petronille Dusingizimana** from the Université Félix Houphouët-Boigny in Côte d'Ivoire, **Cheikh Modou Noreyni Fall** from the University Cheikh Anta Diop in Senegal, and **Muhammad Mubashar Ahmad Dogar** from the Japan Agency for Marine-Earth Science Technology (JAMSTEC). We are immensely grateful to the APARC office for coordinating these awards and making sure everyone arrived safely as the Windows glitch dropped many into travel chaos.

CIRES provided support for the pre-workshop event and panel discussion for early career scientists, and CIRES and NWRA provided funding that allowed us to waive registration fees for all early career scientists. The active participation of these and other early career scientists greatly enriched the workshop, and we look forward to their further contributions to A-RIP and APARC. We are also grateful to the University of Colorado-Boulder Laboratory for Atmospheric and Space Physics (LASP), who provided the meeting space and infrastructure to support online attendance, and **V. Lynn Harvey** and **Sean Davis**, who served as local organizers. A total of 36 scientists attended in person (Figure 6).

Reanalysis Updates

The first day of the workshop focused on updates from reanalysis producers. **Kris Wargan** started the session with an update on meteorological reanalysis activities at the NASA Global Modeling and Assimilation Office (GMAO). NASA GMAO is preparing a new reanalysis product, MERRA-21C, which is expected to be released in 2026. MERRA-21C will include new and reprocessed observations at a finer horizontal resolution (25 km) than MERRA-2 (50 km) and a new hybrid 4D-EnVar analysis scheme. Notable changes include addition of six additional levels to the pressure-level product that improve resolution in the UTLS and updates to the aerosol model and analysis to include nitrates, brown carbon, and a dry PM2.5 product. Production of MERRA-2 will continue in parallel with MERRA-21C. Plans for a future coupled reanalysis are being discussed.

Laura Ciasto then described the forthcoming National Centers for Environmental Prediction (NCEP) Conventional Observation Reanalysis (CORe), which covers the period 1950-2023 at 3-hourly intervals. This reanalysis is designed for climate monitoring, as the choice to avoid satellite observations eliminates artifacts from introducing new satellite platforms. The reanalysis will be provided through third-party distribution centers similar to the NCEP-NCAR Reanalysis 1 after it is approved. Publications describing CORe and its performance in the stratosphere are in preparation.

To close the first session, **Hans Hersbach** provided an update on reanalysis development at the European Centre for Medium-Range Weather Forecasts (ECMWF). ECMWF's current flagship reanalysis, ERA5 (Hersbach et al. 2020), now boasts more than 167,000 users worldwide. Its follow-on, ERA6, will feature finer horizontal resolution (14 km) and one-way coupling with the ocean. Several new and reprocessed datasets will be included in the assimilation with a machine learning emulator used to provide an improved time-varying model bias estimation. In the stratosphere, ERA6 is better able to resolve gravity waves, resulting in a more complete picture of the QBO and the processes that drive it. Production is expected to start in early 2025 with an initial release planned for late 2026.

Dai Koshin introduced the JAGUAR-DAS Whole neutral Atmosphere Reanalysis (JAWARA) (Koshin et al. 2025). This reanalysis, which covers 20 years from September 2004 through April 2023 and extends up to 110 km, is an exciting addition to the current stable of high-altitude reanalysis products, most of which are difficult to access and cover relatively short periods. Participants in the A-RIP upper stratosphere-mesosphere-lower thermosphere (USMLT) topic group (led by **Lynn Harvey** and **John Knox**; see below) look forward to evaluating JAWARA in comparison to other reanalysis products in the upper stratosphere and mesosphere. JAWARA is publicly available through the link provided in the data inset.

Laura Slivinski then provided an update on the NOAA-CIRES Twentieth Century Reanalysis (20CR) project, including plans to extend the current version, 20CRv3 (Slivinski et al. 2019; see data inset), beyond its current end date of 2015. Extended reanalyses of this type are essential to obtaining larger samples of extreme events and providing a consistent, long-term context to recent extreme events. Examples include ice sheet melt, the North American "Dust Bowl" of the 1930s, the "year without a summer" in the late nineteenth century, and many others. Discussions around 20CRv4 include plans for assimilating additional observation types and including ocean-atmosphere coupling. Current plans to accomplish these extensions center around machine learning tools based on "replay" products using the operational Unified Forecast System (UFS). These UFS replay products, which were introduced in a separate presentation by **Adam Schneider**, provide a valuable source of coupled atmosphere-ocean data for analysis and emulator training and are publicly available via Amazon Web Services (AWS; see data inset).

Terence O'Kane then introduced the CAFE60 reanalysis (O'Kane et al. 2021), which was designed primarily for initializing decadal forecasts and features a 96-member ensemble. CAFE60 uses a strongly coupled atmosphere-ocean data assimilation in which assimilated ocean observations constrain both the atmosphere and ocean on monthly timescales. Accordingly, large-scale atmospheric fields in CAFE60 are consistent with the ocean boundary conditions but weather features in each ensemble member can evolve very differently. This setup opens interesting possibilities for evaluation within A-RIP, especially as more reanalysis centres move toward coupled data assimilation systems. CAFE60 is also publicly available via AWS (see data inset).

The penultimate talk in this session was delivered by **Yuki Kosaka**, who reported on the recently-released JRA-3Q (Kosaka et al. 2024), a full-input reanalysis intended to replace JRA-55. JRA-3Q uses an updated model and shows substantially reduced biases in the top-of-atmosphere energy balance compared to JRA-55. JRA-3Q is now available for the whole period from September 1947 onward and can be acquired from multiple sources (see data inset).

Finally, **Masayoshi Ishii** introduced the OCADA (Over-Centennial Atmospheric Data Assimilation) extended surface-input reanalysis (Ishii et al. 2024). The dataset, which comprises an 80-member ensemble covering 1850-2015, is intended to demonstrate the value of rescued archival data for reanalysis applications, while the name is a play on Takematsu Okada, who modernized Japan's meteorological services in the early twentieth century. Its utility has been demonstrated through dynamical downscaling of historical extreme events in the Northwest Pacific.

Between these two sessions, **M. Mubashar Dogar** delivered a flash presentation on identifying and separating signatures of volcanic forcing from natural variability, followed by a general overview of the S-RIP evaluation of dynamical fields in reanalyses (focusing on Chapter 3 of the S-RIP Final Report) by **Masatomo Fujiwara**. Masatomo continued with an initial outline of plans to expand this analysis during A-RIP, including updating the common grid data sets to facilitate additional intercomparison of newer reanalyses, conducting a detailed analysis of the transformed Eulerian mean terms and variable in current reanalyses (see Fujiwara et al. 2024), and

evaluating large-scale circulation responses to major modes of variability (QBO, El Niño-Southern Oscillation, the solar cycle, etc.). **Birgit Hassler** and **Gloria Manney** emphasized that A-RIP should assess longitudinally resolved climatologies, as these are difficult to construct with observations and will provide essential background for many of the A-RIP topic groups introduced below. If you are interested in contributing these assessments, please contact **Masatomo** or **Laura Ciasto** (Table 2).

New Area: Reanalyses of Atmospheric Composition

In addition to the meteorological reanalyses examined during S-RIP, A-RIP plans to conduct systematic evaluation and intercomparison of reanalyses of atmospheric composition (Figure 7), which were the primary focus of the second morning of the workshop. **Antje Inness** started proceedings with an in-depth introduction to the Copernicus Atmosphere Monitoring Service Reanalysis (CAMSRA) conducted by ECMWF (see data inset), which covers 2003 to present with updates roughly once every six months. Two reanalysis products have been published, EAC4 for aerosols and chemical pollutants (Inness et al. 2018) and EGG4 for greenhouse gases (Agustí-Panareda et al. 2023). The CAMS team is now working toward a new reanalysis, EAC5, which will cover the same period but feature higher resolution (~40 km compared to ~80 km), additional vertical levels, a new version of the underlying atmospheric model, and improved tropospheric and stratospheric chemistry. For example, additional stratospheric species will be simulated by using the Belgian Assimilation System for Chemical ObsErvations (BASCOE) model. Production is expected to start in the first quarter of 2025.

Brad Pierce then introduced the Real-time Air Quality Monitoring System-Aura reanalysis (RAQMS). RAQMS is designed to support air quality applications, for which it assimilates satellite retrievals of aerosol optical depth, carbon monoxide, ozone, and nitrogen dioxide. Meteorological fields are initialized from the NOAA Global Forecasting System and the data assimilation is conducted using a 3D-Var Gridpoint Statistical Interpolation (GSI) scheme. RAQMS has been used to evaluate variations in atmospheric composition associated with major climate modes, such as the El Niño-Southern Oscillation, and to constrain emissions estimates. Although there is currently no funding to continue the reanalysis component of this project, the chemical mechanisms are now implemented in the NOAA model.

Kris Wargan followed with a presentation summarizing current and planned development of composition reanalyses at NASA GMAO, which are built around the Constituent Data Assimilation System (CoDAS; Figure 7). CoDAS was originally developed for carbon but is designed to be "tracer agnostic" and thus suitable for both tropospheric and stratospheric constituents. CoDAS has been applied together with the StratChem chemistry module (Nielsen et al. 2017) in a replay to MERRA-2 to produce the MERRA-2 Stratospheric Composition Reanalysis of Aura Microwave Limb Sounder (M2-SCREAM) (Wargan et al. 2023). NASA GMAO is planning to produce a composition reanalysis including both tropospheric and stratospheric species as a companion product to MERRA-21C, with production expected to start this year.

On behalf of **Quentin Errera**, **Daniele Minganti** introduced recent developments in the BASCOE Reanalysis of Aura MLS (BRAM). Version 2 of BRAM (Errera et al. 2019), the current public version (see data inset), was driven by ERA-Interim, assimilated MLS version 4.2 retrievals, and covers September 2004 to August 2019. A more recent version based on ERA5, BRAM3, has been evaluated internally but has not been publicly released. Current efforts are focused on the development of BRAM4, which will also use ERA5 along with version 5 retrievals from Aura MLS. This version will include daily means and assimilation increments, as well as non-assimilated species. A-RIP scientists are particularly interested in analyzing the non-assimilated species, which are largely unavailable from other (non-model) sources.

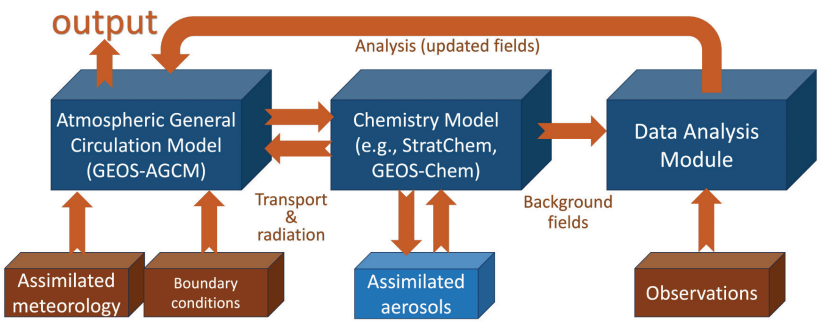

Figure 7: *Schematic illustration of chemical data assimilation, courtesy of Kris Wargan.*

The next presentation was by **Kazuyuki Miyazaki** on the Tropospheric Chemistry Reanalysis (TCR) (Miyazaki et al. 2020,). TCR, which is based on the Multi-model Multi-constituent Chemical Data Assimilation, is already providing essential mission support for many NASA activities, including Observing System Simulation Experiments (OSSEs). The reanalysis is used to constrain emissions, expand spatial coverage of trends in atmospheric composition, and to support greenhouse gas studies by providing distributions of co-emitted species. Kazu also provided advice and perspectives from the TOAR-II (Tropospheric Ozone Assessment Report II) chemical reanalysis working group. This activity is largely complementary to A-RIP, and we look forward to fruitful cooperation between the two activities.

Table 2: *A-RIP topic groups, group leads, and contact information.*

Topic Group	Current Topic Leads
Dynamics Overview	Masatomo Fujiwara [fuji@ees.hokudai.ac.jp] Laura Ciasto [laura.ciasto@noaa.gov]
Composition Overview	Sean Davis [sean.m.davis@noaa.gov] Daniele Minganti [daniele.minganti@aeronomie.be]
Data & Diagnostics	Patrick Martineau [pmartineau@jamstec.go.jp]
Documentation & Website	Jonathon Wright [jswright@tsinghua.edu.cn]
Outreach & Capacity Building	Mohamadou Diallo [m.diallo@fz-juelich.de] M. Zeeshaan Shahid [mzeeshanshahid@gmail.com]
Aerosols	M. Zeeshaan Shahid [mzeeshanshahid@gmail.com]
Air Quality & Tropospheric Composition	Kazuyuki Miyazaki [kazuyuki.miyazaki@jpl.nasa.gov]
Brewer-Dobson Circulation	Beatriz Monge-Sanz [beatriz.monge-sanz@physics.ox.ac.uk]
Extratropical UTLS: Transport & Composition	Luis Millán [lmillan@jpl.nasa.gov] Felix Ploeger [f.ploeger@fz-juelich.de]
Gravity Waves	Petr Šácha [petr.sacha@matfyz.cuni.cz] Corwin Wright [cw785@bath.ac.uk]
Monsoons	Jonathon Wright [jswright@tsinghua.edu.cn] Luna Dai [dailun@ust.hk] Cheikh Modou Noreyni Fall [cheikhmodou.fall@ucad.edu.sn]
Polar Vortex: Composition & Chemistry	Michelle Santee [michelle.l.santee@jpl.nasa.gov] Alyn Lambert [alyn.lambert@jpl.nasa.gov]
Polar Vortex: Dynamics & Variability	Simon Lee [shl21@st-andrews.ac.uk] Gloria Manney [manney@nwra.com]
Quasi-Biennial Oscillation	Mohamadou Diallo [m.diallo@fz-juelich.de] Laura Holt [laura@nwra.com] Joan Alexander [alexand@nwra.com]
Tropical Tropopause Layer	Mengchu Tao [mengchutao@mail.iap.ac.cn]
Tropospheric Circulation: Extremes	Bernat Jiménez Esteve [bernatji@ucm.es] Irina Rudeva [irina.rudeva@bom.gov.au]
Tropospheric Circulation: Jets & Storm Tracks	Gloria Manney [manney@nwra.com] Hilla Afargan-Gerstman [hilla.gerstman@env.ethz.ch]
Tropospheric Circulation: Teleconnections	Blanca Ayarzagüena [bayarzag@ucm.es] Froila Palmeiro [froila.palmeiro@cmcc.it]
Upper Stratosphere, Mesosphere, & Lower Thermosphere	Lynn Harvey [lynn.harvey@lasp.colorado.edu] John Knox [johnknox@uga.edu]

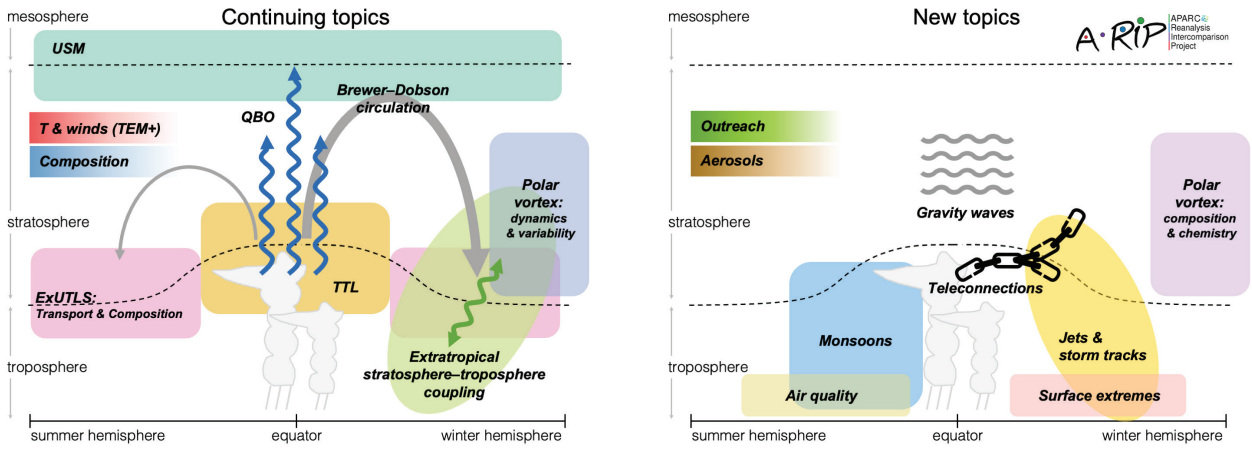

Figure 8: *Continuing topics from S-RIP (left) and new or expanded topics in A-RIP (right).*

To close the session, **Sean Davis** and **Kris Wargan** briefly summarized composition-related results from S-RIP (see Chapter 4 of the S-RIP Final Report) and asked for advice on what should be done next. The consensus view was that the activity should produce at least one overview paper to document and evaluate the composition reanalyses, and that the different focus areas covered by these reanalyses (some focused on troposphere, some on stratosphere, and some on the full depth of the atmosphere) may require more than one such paper. If you are interested in contributing or are using reanalyses of atmospheric composition in your work, please contact Sean, Kris, or Kazu to get involved (Table 2).

Continuing Topics from S-RIP

A-RIP will continue exploring reanalysis performance in several topic areas covered in the S-RIP Final Report (Figure 8, left panel), both by expanding the scope of diagnostics covered and considering new reanalysis products. These include the Brewer-Dobson Circulation (BDC; Chapter 5 of the S-RIP Final Report), the extratropical UTLS (Chapter 7), the tropical tropopause layer (Chapter 8), and the Quasi-Biennial Oscillation (QBO; Chapter 9).

Beatriz Monge-Sanz presented an overview of BDC studies conducted for S-RIP, which focused on transit times, trends, and age-of-air tracers. For A-RIP, this topic group intends to place a greater emphasis on evaluation of the composition reanalyses and the use of tracer studies to explore the roles of chemistry and dynamics in models. Beatriz further highlighted a recent study by **Petr Šácha** and co-authors that proposed a new decomposition method for advective BDC changes (Šácha et al. 2024) as a potential framework for reanalysis intercomparison, and emphasized the need to include more observational benchmarks in the analysis. **Daniele Minganti** then presented a short summary of his poster on the source of nitrous oxide anomalies in the northern mid-latitudes during early 2013 and early 2019, which he traced to QBO modulation of the BDC. **Moha Diallo** presented on the stratospheric circulation response to aerosol injections, which is relatively robust in the shallow branch of the BDC but highly uncertain in the deep branch. **Hongwei Sun** then closed the session with a presentation on Lagrangian analysis of stratospheric transport, focusing on aerosol-like passive particles. He showed that particle lifetimes are highly sensitive to the injection location, and that this sensitivity varies with the QBO phase.

Luis Millán, **Felix Ploeger**, and **Mengchu Tao** led a combined extratropical UTLS and TTL session. Luis started the session with a summary of Chapter 7 of the S-RIP Final Report, which included extensive analysis of the extratropical tropopause, jets, and vertical cross-tropopause transport. Plans for A-RIP include extending these frameworks to more reanalyses and revisiting tropopause diagnostics, including the cold point tropopause and the lapse rate tropopause. This effort will be aided by the Reanalysis Tropopause Data Repository compiled by **Lars Hoffmann** (see data inset). The focus of this topic group will be oriented more toward transport and composition, with the dynamical elements of Chapter 7 distributed among other topics. However, the group will emphasize dynamical coordinates in cooperation with the OCTAV-UTLS (Observed Composition Trends And Variability in the UTLS) activity to provide a different perspective on reanalysis performance. **Jens-Uwe Grooß** closed the session by summarizing planned A-RIP activities at Forschungszentrum Julich, including new sets of CLaMS (Chemical Lagrangian Model of the Stratosphere) simulations using ERA6 and other forthcoming reanalyses.

The QBO session was chaired by **Moha Diallo**, who started by presenting an overview of results from Chapter 9 of the S-RIP Final Report. The QBO is well represented in reanalyses, despite some differences in transition phases, largely due to data assimilation constraints. Future plans for this topic group include analyzing the sensitivity of the QBO to vertical resolution, equatorial wave forcing, and sea surface temperatures, as well as the influence of the QBO on atmospheric circulations and trace gas distributions. These activities will proceed in close cooperation with the recently launched QUOCA (Quasi-biennial oscillation and Ozone Chemistry interactions in the Atmosphere) activity. **M. Joan Alexander** presented an analysis of QBO-modulated upwelling in the upper troposphere, arguing that this pumping effect results from modulation of resolved tropical waves by the QBO. The results have implications for QBO influences on tropical convection and provide an explanation for the inability of models to reproduce the effect when strong nudging is applied. **Tobias Kerzenmacher** presented research on retrieving the residual circulation from satellite measurements of trace gases, comparing the results to ERA5, JRA-55, and ERA-Interim. Future work will include applying similar methods to the chemical reanalysis products

Expanded Topics: Polar Vortex, Monsoons, and USMLT

Several topics from the S-RIP phase are also greatly expanded in scope (Figure 8), including two topic groups organized around the stratospheric polar vortex (Chapters 6 and 10 of the S-RIP Final Report), a topic group organized around monsoons (Chapter 8.8), and an expansion of the upper stratosphere and lower mesosphere topic (Chapter 11) upward into the lower thermosphere (USMLT).

Gloria Manney introduced the stratospheric polar vortex dynamics and variability topic by describing how it has emerged from Chapter 6 of the S-RIP Final Report (Stratosphere-Troposphere Coupling). Major near-term efforts in A-RIP will include a new version of the Stratospheric Sudden Warming Compendium based in python, incorporation of new metrics and definitions of vortex events, and the application of additional vortex diagnostics, including moments and potential vorticity-based equivalent latitude and mixing diagnostics. Potential participants should contact Gloria or **Simon Lee** (Table 2). **Michelle Santee** then introduced the stratospheric polar vortex composition and chemistry topic, which is rooted in Chapter 10 of the S-RIP Final Report. Michelle summarized key points from each section of that chapter, most of which will be continued in A-RIP using newer and composition-focused reanalyses. The focus will remain on microphysical, chemical, and transport processes affecting composition, but extended to the whole stratosphere rather than only the lower stratosphere as in S-RIP. The topic needs a volunteer or volunteers to conduct chemical transport model simulations to support the analyses. If interested, contact **Michelle** or **Alyn Lambert** (Table 2). **Guochun Shi** completed the session with a short presentation on comparisons of model and reanalysis ozone products with microwave radiometer observations from ground-based sites.

Cheikh Modou Noreyni Fall opened the monsoon session with a presentation on the ability of reanalysis and observational products to reproduce wet and dry spells during the West African monsoon. Although the different data products agree well in seasonal mean rainfall, there are large discrepancies in how that rainfall is distributed within the season. Model and reanalysis limitations in this region are largely unaddressed and hinder detection and projection of global warming signals. To effectively address this problem, greater data coverage is needed. **Sompoke Kingkaew** contributed a recorded presentation introducing thunderstorm and air quality risk forecasting systems for Thailand, which performs well but remains limited by large uncertainties in aerosol-cloud interactions. **Jonathon Wright** closed the session with a brief review of Chapter 8 of the S-RIP Final Report and plans for the monsoon topic group in A-RIP. Whereas S-RIP focused solely on the upper-level circulation, composition, and clouds above the Asian monsoon, A-RIP is soliciting studies addressing any regional or global monsoon. Over the next two years, this topic group will work closely with the ACAM (Atmospheric Composition and the Asian Monsoon), CCMI (Chemistry-Climate Model Initiative), and LEADER (Large Ensembles for Attribution of Dynamically-driven Extremes) activities, which are all analyzing model simulations focused on periods that overlap in time with the reanalyses. Those interested should contact **Noreyni, Jonathon**, or **Luna Dai** (Table 2).

Lynn Harvey provided an overview of Chapter 11 and initial plans for the USMLT topic group, expressing the need for reanalyses and processed datasets that extend to higher levels (pressures less than 10 hPa), as well as a desire for more contributors. Potential participants should contact **Lynn** or **John Knox** (Table

2). Following Lynn's introduction, **Xinyue Wang** presented a study on the long-term impacts of the Hunga Tonga-Hunga Ha'apai volcanic eruption in the stratosphere and above, showing that the increase in water vapor produced a pronounced and prolonged cooling when it reached the mesosphere in mid-2023. This cooling was much larger in the mesosphere than at lower levels and appears to have resulted from reduced ozone due to an accelerated local HOx cycle. **Michal Kozubek** then reported on vertical coupling dynamics during sudden warmings, emphasizing the need for metrics that can quantify the effects of sudden warmings in the ionosphere. Metrics of this type will be targeted for inclusion in the new version of the Stratospheric Sudden Warming Compendium compiled by **Amy Butler**. Discussion in this session emphasized the myriad factors that need to be considered for USMLT studies related to solar and geomagnetic activity and posed several questions to address in further work.

Emerging Topics: Tropospheric Circulation and Extreme Events

Beyond the new focus on composition reanalyses, the other substantial expansion of scope in A-RIP is into the troposphere, which emerged in part from Chapters 6 and 7 of the S-RIP Final Report. Three subtopics are planned under the broad heading of Tropospheric Circulation (Figure 9): Jets and Storm Tracks, led by **Gloria Manney** and **Hilla Afargan-Gerstman**; Teleconnections, led by **Blanca Ayarzagüena** and **Froila Palmeiro**; and Extreme Events, led by **Bernat Jimenéz Esteve** and **Irina Rudeva**. Participants in these three subtopics will work closely together as A-RIP unfolds, along with the Monsoons and Stratospheric Polar Vortex: Dynamics and Variability topic groups. Interested participants are encouraged to contact any of the corresponding subtopic leads.

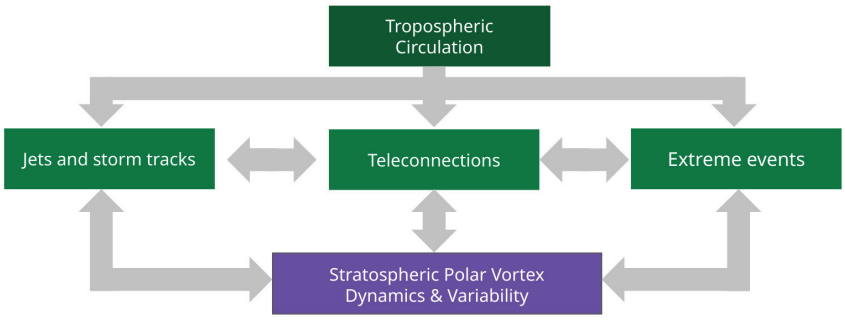

Figure 9: *Organisational diagram for the new tropospheric circulation topic and subtopics.*

Froila Palmeiro presented tentative plans for all three Tropospheric Circulation subtopics at the A-RIP workshop. Jets & Storm Tracks will focus on these features in both hemispheres with an emphasis on understanding and reconciling trends. Intercomparisons conducted for Chapter 7 of the S-RIP report will be extended to additional reanalyses with the aim of building and applying new sets of diagnostics. The Teleconnections subtopic aims to develop benchmarks for model evaluation with respect to large-scale patterns in both hemispheres, with a particular interest in reanalyses with an interactive ocean. The consistency (across datasets) and stationarity (across periods) of major modes will also be evaluated. The Extreme Events subtopic will start with a focus on blocking and wave breaking, with a view toward evaluating representations of temperature and precipitation extremes in reanalysis products. Special attention will be paid to drought indices and their dependence on land surface models and data assimilation treatments, and case studies will be selected for detailed analysis. All subtopics will aim to disentangle metric uncertainty, associated with the choice of metrics for describing tropospheric circulation features, from reanalysis uncertainty, associated with the choice of reanalysis.

Jan Stryhal followed this overview presentation and discussion by introducing a classification scheme for circulation systems and demonstrating its value as a tool for comparing datasets. The results provide compelling illustrations of inter-reanalysis consistency over time, from a narrow band in the mid-latitude Northern Hemisphere in the early twentieth century to most of the globe in the early twenty-first century. This framework will be used to evaluate the climatological significance of inter-reanalysis differences (e.g. for attribution studies and model validation), and for better establishing the links between large-scale circulation patterns and surface weather.

Jonathan Lee presented on the consistency and reliability of different reanalyses in capturing precipitation signals after SSWs, showing that the reanalyses are largely consistent in anomalies following SSWs despite large differences in mean precipitation. **Salif Diedhiou** closed the session by outlining a case study of an extreme rainfall case in Dakar, Senegal, using reanalysis and observational products.

Data and Diagnostics

One full session of the A-RIP workshop was dedicated to data and diagnostic tools that have been or are being developed to support A-RIP studies. **Birgit Hassler** introduced the ESMValTool framework, including a contextual history of the Coupled Model Intercomparison Project and the motivations behind the ESMValTool. Her presentation also provided several illustrations of ESMValTool applied to reanalysis products. Many reanalysis products have now been integrated into the ESMValTool, and the development team is keen to support additional reanalysis applications. Following the workshop, Birgit also generously led an afternoon-long tutorial on using the ESMValTool, demonstrating its preprocessing (ESMValCore) and analysis frameworks. The ESMValTool is available on the JASMIN system and can be used in the A-RIP workspace; contact Jonathon for details. The A-RIP community looks forward to a fruitful coooperation with the ESMValTool team over the coming years.

ESMValTool:
https://esmvaltool.org/

Rich Neale introduced the NOAA Model Diagnostics Task Force (MDTF) software, which is built around Process-Oriented Diagnostics (PODs). The MDTF program solicits applications from researchers to develop and formalize new diagnostics, and the individual PODs are largely independent of each other. Diagnostics of interest to A-RIP topic groups include several PODs targeted at Rossby waves, storm tracks, blocking, and the Madden-Julian Oscillation. Future requirements for the MDTF include a fuller use of high time-resolution reanalysis products, derived data for conserved quantities like moist static energy, and high-quality model validation benchmarks for the stratosphere.

Model Diagnostics Task Force:
https://www.gfdl.noaa.gov/mdtf-diagnostics/

Patrick Martineau described the Reanalysis Intercomparison Dataset (RID), a set of zonal-mean and single-level diagnostic fields preprocessed for many reanalyses. The RID, which extends the zonal mean dynamical and diabatic datasets produced for S-RIP (Martineau et al. 2018), currently covers the period 1830 to present with weekly automated updates. Zonal-mean fields include core variables and time derivatives (core, dt), eddy heat, momentum, and moisture fluxes (fluxes, moist), terms of the momentum equation (mom), and transformed Eulerian mean diagnostics based on the quasi-geostrophic (tem-qg) and primitive (tem-pi, tem-thermo) sets of equations. All diagnostics are calculated after interpolating reanalysis products to a common 2.5°×2.5° grid. The new version of the Stratospheric Sudden Warming Compendium will be based on the RID.

Reanalysis Intercomparison Dataset:
https://www.jamstec.go.jp/ridinfo/

Jonathon Wright closed the session with an overview of other datasets, analysis tools, and analysis frameworks that will be used during A-RIP. These include updating the three-dimensional common grid files for core variables prepared for S-RIP (pending), budget diagnostics for temperature, moisture, momentum, and combinations thereof that explicitly separate the assimilation increment from resolved advection and parameterized physics (in process), and other datasets prepared by A-RIP community members, such as the Reanalysis Tropopause Data Repository constructed by **Lars Hoffman**. Processing facilities will include JASMIN and the Jülich Supercomputing Center, with core variables from recent reanalyses possibly also added to Google Earth Engine. Several full reanalysis and related products are hosted on Amazon Web Services, including MERRA-2, CAFE60, and the UFS Replay introduced by **Adam Schneider** during the

Table 3: *Information and access links for reanalysis products discussed in this meeting report*

Reanalysis	Access or information link
20CRv3	https://doi.org/10.5065/H93G-WS83
BRAM2	https://strato.aeronomie.be/
CAFE60	https://registry.opendata.aws/csiro-cafe60/
CAMSRA	https://ads.atmosphere.copernicus.eu/datasets?q=cams+reanalysis
ERA-5	https://cds.climate.copernicus.eu/datasets?q=era5
JAWARA	https://jawara.nipr.ac.jp/home
JRA-3Q	https://jra.kishou.go.jp/JRA-3Q/index_en.html#MIRROR
M2-SCREAM	https://doi.org/10.5067/7PR3XRD6Q3NQ
MERRA-2	https://disc.gsfc.nasa.gov/datasets?keywords=merra-2
NCEP CORe	https://www.cpc.ncep.noaa.gov/products/CORe/pns/eval/ [data not yet available]
OCADA	https://climate.mri-jma.go.jp/pub/archives/Ishii-et-al_OCADA/
RAQMS-Aura	https://www.ssec.wisc.edu/staff/brad-pierce/research/aura-chemical-reanalysis/
TCR	https://tes.jpl.nasa.gov/tes/chemical-reanalysis/
UFS Replay	https://psl.noaa.gov/data/ufs_replay/

workshop (Table 3). In addition to making use of open-source analysis frameworks like ESMValTool and MDTF, we intend to provide a github repository for hosting small processing and data access scripts for community use. Finally, the documentation for reanalysis systems will be moving online shortly after the launch of our new website.

Reanalysis Tropopause Data Repository:
https://datapub.fz-juelich.de/slcs/tropopause/

JASMIN:
https://jasmin.ac.uk/

Jülich Supercomputing Center:
https://www.fz-juelich.de/en/ias/jsc

New A-RIP website:
https://aparc-rip.github.io
(under construction)

Links to data access or information on all reanalysis products discussed in the workshop report are provided in Table 3.

Emerging Topics: Aerosols and Air Quality

Motivated by increases in the number of aerosol reanalysis and data assimilation products (Xian et al. 2024) and interest across much of the A-RIP community in aerosol-radiation-climate interactions, we have initiated a topic group to focus on aerosol reanalysis products. This emerging topic is led by **Muhammad Zeeshaan Shahid**, who presented an intercomparison of observations and the MERRA-2 aerosol reanalysis over the Indo-Gangetic Plain. **Jonathon Wright** followed with an overview of aerosol reanalyses and potential effects on radiative heating in the Asian monsoon tropopause layer. We look forward to continued exploration of this topic, and welcome researchers who are interested in evaluating these products to get in touch with **Zeeshaan** (Table 2).

The aerosol topic will proceed in close cooperation with a separate topic group focusing on reanalysis-based products for monitoring air quality across scales. This topic will be led by **Kazu Miyazaki** with the cooperation of **K. Emma Knowland**, acting as GAFIS (Global Air Quality Forecasting and Information System) liaison to A-RIP. Through this topic, A-RIP will help to fulfill a focus on aerosol reanalysis products in the 2022-2026 GAFIS implementation plan. Along with Kazu's introduction of the Tropospheric Chemistry Reanalysis and **Brad Pierce's** overview of the RAQMS-Aura reanalysis, this session featured two recorded lightning presentations. **Samrat Santra** contributed an assessment of surface ozone distributions and variability in Kharagpur, India, while **Abebaw Bizuneh Alemu** presented a comparative study on spatial interpolation methods for estimating surface ozone concentrations over Ethiopia. Researchers interested in contributing to the A-RIP air quality topic are encouraged to contact **Kazu** (Table 2).

Emerging Topic: Gravity Waves

Gravity waves are poorly observed and not fully resolved by reanalysis models. As a result, their representations in reanalysis products have not yet been widely evaluated. However, the increasing vertical and horizontal resolution of reanalysis models is allowing these products to resolve progressively more of the gravity wave spectrum. This topic group is led by **Petr Šácha** and **Corwin Wright**.

Laura Holt (co-lead of the APARC Gravity Waves activity) started the gravity waves session by introducing the plans and objectives of the topic group. Previous studies of gravity waves in reanalysis products, which have focused primarily on ERA5, have confirmed that current reanalyses underrepresent gravity waves compared to observations. However, valuable information can still be extracted from resolved gravity waves in reanalysis products. To make full use of this information, we need to better understand how model resolution, numerics, convection, assimilation methods, and parameterised gravity waves affect the representation of resolved gravity waves in reanalyses. **Joan Alexander** suggested that a key target of this topic group should be to quantify "effective resolution" for gravity waves as a function of height in different reanalyses.

Following this overview, **Junhong Wei** presented an intercomparison of tropospheric and stratospheric mesoscale kinetic energy resolved by high-resolution global reanalyses. His results emphasize the presence of considerable discrepancies across reanalyses, as well as the central importance of resolution. Users interested in mesoscale variability will benefit from using the highest resolution products available. **Sylvia Ampadu** contributed a poster presentation on gravity wave activity over West Africa in ERA5, highlighting upward energy propagation during the June-July-August (JJA) period.

Outreach and Capacity Building Report

Mohamadou Diallo started the wrap-up session with a report on outreach and capacity building activities, including the new APARC Outreach Advisory Panel and the pre-workshop event for early career scientists. More details about the pre-workshop event can be found in the corresponding article in this issue. **Gloria Manney** and **M. Zeeshaan Shahid** agreed to represent A-RIP on the Outreach Advisory Panel. A-RIP aims to strengthen connections with other activities and organizations focused on capacity building in climate science, support trainings organized by related activities and organizations, and increase the availability and accessibility of online information about A-RIP and its activities.

Over the next several years, A-RIP plans to organize regional workshops and trainings in lieu of independent centralized meetings, ideally in cooperation with related activities. The first of these is a planned workshop "Data Science for Weather and Climate Research" and associated training school "Climate Data Analysis and AI in the Global South (AI4CLimate)" to be held in Dakar, Senegal, in late 2025. A-RIP is also organizing small side meetings at the ACAM

workshop in Bali, Indonesia, from 8-12 June 2025, and the BACO-25 Joint Assembly in Busan, South Korea, from 20-25 July 2025. We are currently considering our plans for 2026 and welcome suggestions.

Needs for the Dakar event include instructors for the training school, help preprocessing data and preparing modules for the training school, and assistance securing additional funding. If you are interested in helping to organize this event, including an A-RIP presentation, session, or side meeting in your workshop, or hosting a potential future A-RIP regional workshop and training, please contact the A-RIP leads at aparcrip@gmail.com.

Outlook

Thanks to the tremendous efforts of the local organizers and sponsors, the A-RIP Kickoff and Planning Meeting was a great success. The individual topic groups are continuing to ramp up and new participants are very welcome. Contributing to A-RIP is as simple as using more than one reanalysis. If you have work that qualifies or are interested in contributing to ongoing or future community studies, please get in touch or consider submitting your work to the A-RIP (S-RIP Phase 2) special issue in Atmospheric Chemistry and Physics and Weather and Climate Dynamics (acp.copernicus.org/articles/special_issue1242.html). Contact information for all topic leads is provided in Table 2.

We are currently producing or planning to produce several datasets to facilitate wider access to reanalysis products and intercomparison across multiple products (see data inset), as well as a new website for the activity that will be hosted at aparc-rip.github.io (the previous website, s-rip.github.io, will be archived). In addition to news, contact information, and community resources, the redesigned website will provide more interactive access to the type of reanalysis documentation provided in Chapter 2 of the S-RIP Final Report. Questions on data access or analysis tools, ideas for processed diagnostics or metrics to include in the intercomparison, and suggestions on which new aspects of reanalyses to document are all welcome.

A-RIP is also planning a series of webinars to be organized by early career participants, the first of which will feature **Dylan Jones** presenting recent work from the TOAR II chemical reanalysis working group (Jones et al., 2025). Stay tuned for details!

We look forward to working with the APARC community as this new phase of the activity unfolds.

References

SPARC Reanalysis Intercomparison Project (S-RIP) Final Report. Masatomo Fujiwara, Gloria L. Manney, Lesley J. Gray, and Jonathon S. Wright (Eds.), SPARC Report No. 10, WCRP-6/2021, doi: 10.17874/800dee57d13 (2022).

Agustí-Panareda, A. et al. Technical note: The CAMS greenhouse gas reanalysis from 2003 to 2020. Atmos. Chem. Phys. 23, 3829–3859 (2023).

Errera, Q. et al. Technical note: Reanalysis of Aura MLS chemical observations. Atmos. Chem. Phys. 19, 13647–13679 (2019).

Fujiwara, M. et al. Climatology of the terms and variables of transformed Eulerian-mean (TEM) equations from multiple reanalyses: MERRA-2, JRA-55, ERA-Interim, and CFSR. Atmos. Chem. Phys. 24, 7873–7898 (2024).

Hersbach, H. et al. The ERA5 global reanalysis. Q J Roy Meteor Soc 146, 1999–2049 (2020).

Inness, A. et al. The CAMS reanalysis of atmospheric composition. Atmos Chem Phys 19, 3515–3556 (2019).

Ishii, M. et al. Global Historical Reanalysis with a 60-km AGCM and Surface Pressure Observations: OCADA. J. Meteorol. Soc. Jpn. Ser II 102, 209–240 (2024).

Jones, D. et al. Assessment of regional and interannual variations in tropospheric ozone in chemical reanalyses, EGUsphere [preprint], doi: 10.5194/egusphere-2024-3759 (2025)

Kosaka, Y. et al. The JRA-3Q Reanalysis. J. Meteorol. Soc. Jpn. Ser II 102, 49–109 (2024).

Koshin, D., Sato, K., Watanabe, S. & Miyazaki, K. The JAGUAR-DAS whole neutral atmosphere reanalysis: JAWARA. Prog. Earth Planet. Sci. 12, 1 (2025).

Martineau, P., Wright, J. S., Zhu, N. & Fujiwara, M. Zonal-mean data set of global atmospheric reanalyses on pressure levels. Earth Syst Sci Data 10, 1925–1941 (2018)

Nielsen, J. E. et al. Chemical Mechanisms and Their Applications in the Goddard Earth Observing System (GEOS) Earth System Model. J. Adv. Model. Earth Syst. 9, 3019–3044 (2017).

O'Kane, T. J. et al. CAFE60v1: A 60-year large ensemble climate reanalysis. Part I: System design, model configuration and data assimilation. J Climate 1–48 (2021).

Šácha, P. et al. Disentangling the advective Brewer-Dobson circulation change. Geophys. Res. Lett., 51, e2023GL105919 (2024).

Slivinski, L. C. et al. Towards a more reliable historical reanalysis: Improvements for version 3 of the Twentieth Century Reanalysis system. Q. J. R. Meteorol. Soc. 145, 2876–2908 (2019).

Wargan, K. et al. M2-SCREAM: A Stratospheric Composition Reanalysis of Aura MLS Data With MERRA-2 Transport. Earth Space Sci. 10, (2023).

Xian, P. et al. Intercomparison of aerosol optical depths from four reanalyses and their multi-reanalysis consensus, Atmos. Chem. Phys., 24, 6385–6411 (2024).

2-Day Early-Career Scientists' Event at the A-RIP 2024 Planning Workshop in Boulder

Mohamadou A. Diallo[1], Sean M. Davis[2], V. Lynn Harvey[3], Jonathon S. Wright[4], Gloria L. Manney[5], Masatomo Fujiwara[6] and Krzysztof Wargan[7]

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Dates:
20 - 21 July 2024

Organising Committee:
Mohamadou A. Diallo (A-RIP ECS and outreach coordinator), Sean M. Davis (local organizer), Lynn V. Harvey (local organizer), Gloria L. Manney (A-RIP co-lead), Jonathon S. Wright (A-RIP co-lead), Masatomo Fujiwara (A-RIP co-lead), Krzysztof Wargan (new A-RIP co-lead)

Host Institution:
University of Colorado Boulder, CO, USA

Number Of Participants:
11

Contact:
m.diallo@fz-juelich.de
aparcrip@gmail.com

Conference Website:
https://s-rip.github.io/events/meeting2024/ecs.html

Logos/Sponsors:

APARC

LASP Laboratory for Atmospheric and Space Physics University of Colorado Boulder

CIRES

NWRA NorthWest Research Associates Since 1984

Introduction

With funding and logistical support from APARC and in-kind support from CIRES, LASP, and NWRA, a two-day event for early-career scientists (ECSs) was held during 20-21 July 2024 at the University of Colorado-Boulder preceding the A-RIP 2024 kickoff and planning workshop. The A-RIP ECS event was scheduled to follow the 2024 Quadrennial Ozone Symposium (QOS), which also took place in Boulder, Colorado, USA during 15-19 July, and attracted climate researchers from around the world. Organization of the A-RIP ECS event was led by **Mohamadou A. Diallo, Sean M. Davis, V. Lynn Harvey, Jonathon S. Wright, Gloria L. Manney, Masatomo Fujiwara,** and **Krzysztof Wargan.**

Participants in the A-RIP event included ECSs (i.e. undergraduate, masters, and PhD students, as well as postdoctoral fellows) from Africa, Asia, Europe, and North America who attended the QOS and/or A-RIP meetings in Boulder. The A-RIP ECS event attracted roughly 100 applicants from all around the world representing a variety of scientific backgrounds and career stages. However, due to funding limitations and visa application difficulties, only 11 ECS participants were able to attend in-person. Participants were selected on the basis of their scientific background, interests, and future plans to use reanalysis products.

Participation in the A-RIP ECS event was free of charge to all participants. Morning refreshments and lunch were provided for all ECSs on the first day (20 July) by CIRES, and accommodation and travel support were provided for six attendees by A-RIP thanks to the support of the APARC International Project Office and co-chairs. The organizers of the A-RIP ECS event express their deep gratitude to

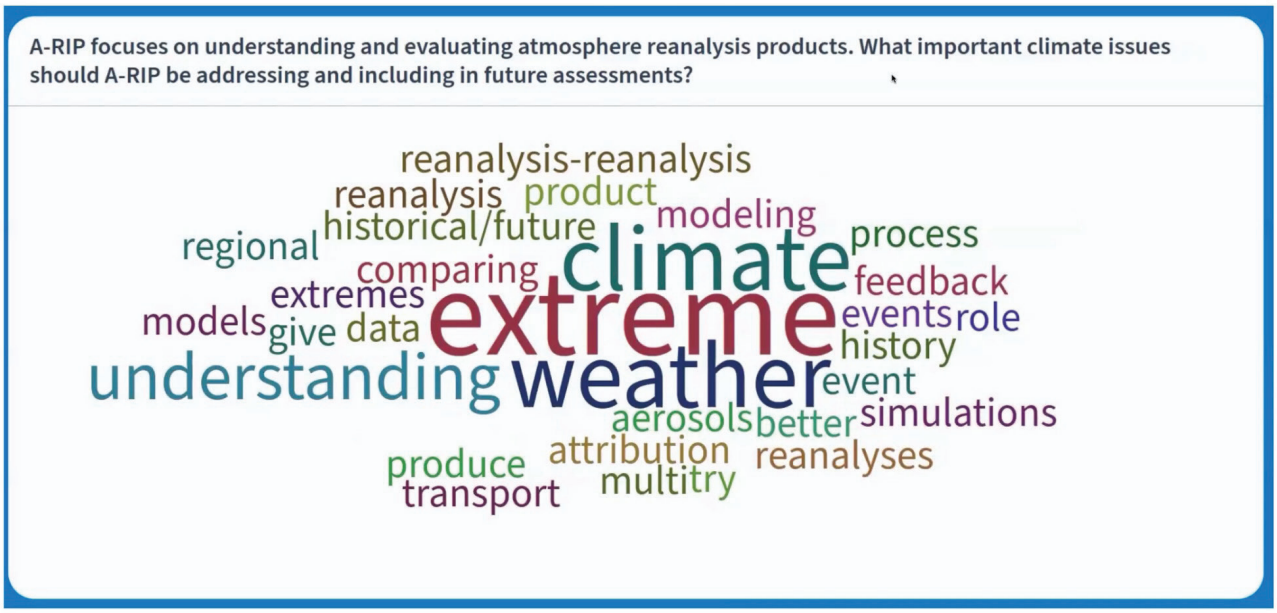

Figure 10: *Word cloud poll results from the pre-workshop event for early career scientists indicating desired focus areas for future A-RIP studies.*

WCRP APARC, CIRES, and NWRA for sponsoring the event and to the University of Colorado-Boulder for hosting the event. Special thanks are due to **Sean Davis, V. Lynn Harvey, Linda Pendergras, Lornay Hansen, Suzi Steigerwald,** and **Ines Tritscher**. Finally, we thank the invited speakers who participated in the career development panel, **Karen Rosenlof, Jose Jimenez,** and **Antara Banerjee,** for sharing their knowledge and time and making the ECS event possible.

With the aim of fostering exchanges between ECSs from the Global South and North and leading scientists from A-RIP, we divided the event into two parts, one indoors on the first day and the other outdoors on the second day.

The first day of the ECS event prioritized informal, small group, and one-on-one activities to encourage conversations among ECSs from different regions and backgrounds as well as the A-RIP leadership. The ECS event began with a short opening describing the goals of the event and plans for future ECS activities by Mohamadou Diallo. To better understand the impressions objectives of the ECS participants, Mohamadou Diallo organized word cloud polls (Figure 10) for the beginning and end of the first day with input from Jonathon Wright and Gloria Manney. The first interactive survey was followed by a presentation on the past, present, and future of A-RIP and related activities by Jonathon Wright, allowing the participants to familiarize themselves with the structure, research scope, and objectives of the A-RIP activity. Mohamadou Diallo then led a session of science "speed dating", which allowed ECS participants and A-RIP scientists to practice their "elevator pitch" while interacting one-on-one. This activity was rewarding for both parties and led to several fruitful discussions that continued beyond the intended time limit and into the coffee break. After the break, the meeting continued with 2-minute self-introductions by all participants.

Sean Davis then led a career development panel, with Karen Rosenlof, Jose Jimenez, and Antara Banerjee as invited speakers (Figure 11). **Karen Rosenlof** talked about her experience pursuing a career in a government research lab from both the WCRP/APARC and NOAA perspectives, **Jose Jimenez** shared his research background and experience in academia, and **Antara Banerjee** described her transition from academia to private industry. Following these self-introductions, **Sean Davis** led an interactive discussion with the panellists, ECSs, and A-RIP leadership, which gave rise to a very interesting set of exchanges with many different career perspectives represented. The panellists stressed the importance of networking, drafting a good "top-down" cover letter, and researching positions and institutes beforehand when applying for jobs. For quality of life, the panellists emphasized the need to learn how to say "no", set boundaries, and prioritize communication and social time. After summary remarks and the closing word cloud pool, the participants adjourned to a lunch break at The Sink sponsored by CIRES.

Figure 11: *Sean Davis introduces the career development panel discussion to participants in the A-RIP ECS workshop.*

Figure 12: *Participants in the group hike on the second day of the ECS workshop stop for a photo break.*

The second day was dedicated to outdoor activity, with a voluntary hike to the NCAR Mesa lab (Figure 12). The morning started lovely, with beautiful scenery and conversation to match along the hike. Even when the intended hike back down to Chatauqua Park was scuttled by a bank of clouds that threatened thunderstorms, the event was enjoyed by all.

The pre-workshop A-RIP event for early career scientists was a resounding success that bodes well for APARC outreach activities. Several of the ECS attendees have since stepped up to lead A-RIP topic groups, organize A-RIP webinars, and assist with periodic emails to the A-RIP community.

Mohamadou A. Diallo, in his service as scientific outreach officer in the new APARC IPO at Forschungszentrum Jülich, aims to encourage partnerships between ECSs and established scientists across the Global South and North. The APARC office is keen to support the organization of training activities for early-career scientists in conjunction with meetings led by or involving APARC activities. If you are interested in organizing such an event, please get in touch with us.

The 1st APARC Scientific Steering Group Meeting
Forschungszentrum Jülich, Germany: 28–30 October 2024

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The in-person meeting of the Scientific Steering Group (SSG) of APARC (Atmospheric Processes and Responses to Climate) was held in Jülich, Germany, from 28 to 30 October 2024. The meeting brought together key scientists and stakeholders from APARC, the World Climate Research Programme (WCRP), and other affiliated groups to discuss progress, priorities, and future strategies for atmospheric and climate research.

Participants included the SSG co-chairs (**Amanda Maycock, Olaf Morgenstern**, and **Karen Rosenlof**), in-person and online attendees from the APARC community, and representatives from the WCRP and its core and lighthouse activities. The agenda was structured to facilitate open discussions after presentations and during closed sessions, enabling the formulation of concrete action items.

Day 1: 28 October 2024

The first day set the stage with insightful presentations from APARC Activity Groups and updates from WCRP core projects and lighthouse activities.

Michelle Santee kicked things off with an exciting update on ACAM, announcing that the next ACAM meeting will take place in Bali, Indonesia, from 9 - 13 June 2025. This event will not only bring together leading researchers but also offer a training school for early-career scientists. Additionally, she highlighted the upcoming WMO International Workshop on Monsoons in Pune, India, in 2025.
Marc von Hobe followed with news from SSiRC, revealing plans for a specialised workshop in Greifswald, Germany, from 23 - 25 April 2025, focused on the impacts of volcanic eruptions. He also emphasized the ISSI Team on "Perspectives of Stratospheric Aerosol Observations".
Graham Mann shared updates on HTHH-related activities, noting a recent meeting in Paris and the ongoing review of an APARC report, which is anticipated to be published in 2025. This report is expected to influence the upcoming WMO Ozone Assessment in 2026.
Ryan Hossaini introduced an exciting new initiative focused on very short-lived chlorine species, aiming to establish lower boundary conditions for these substances in atmospheric models. Notably, apart from CH_3Cl, these species lack significant natural sources, making this work crucial for accurate modelling.
Robert Damadeo presented updates from LOTUS, emphasizing efforts to strengthen collaboration with OCTAV on UTLS issues. A key objective is to report ozone trends across various coordinates while expanding LOTUS tools to the polar regions.
Harun Rashid discussed ESMO, outlining its core themes of stratospheric ozone and temperature trends, and highlighted the need for closer ties with APARC.
Representing the Monsoon Panel, **Lin Wang** shared a major milestone: the upcoming Monsoon Panel meeting in Pune, scheduled for 17 - 21 March 2025.
Takeshi Horinouchi provided an overview of GPEX and its growing connections with APARC, while **Andrew Gettelman** delved into Digital Earths, stressing the need for enhanced vertical resolution (Δz) in kilometer-scale models. He also invited

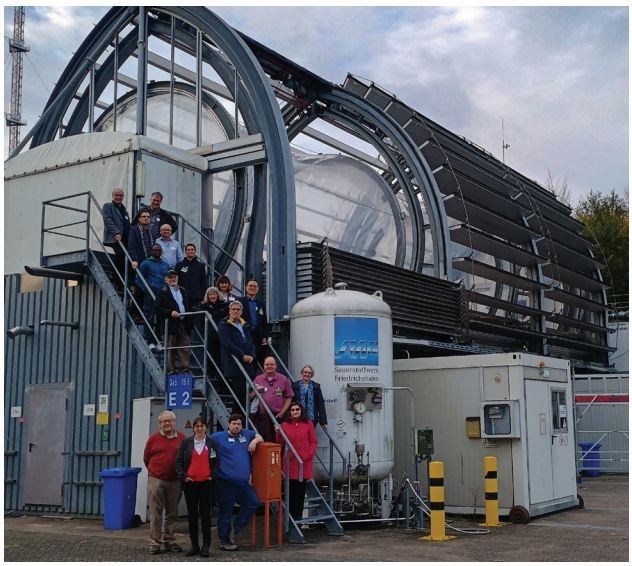

Figure 13: *Group photo of participants visiting the SAPHIR chamber at the Forschungszentrum Jülich. Image credit: Moha Diallo.*

Figure 14: *Group photo of the participants at the SSG meeting in Jülich, Germany. Image credit: Sascha Kreklau.*

attendees to participate in the upcoming "Pan-Hackathon" taking place from March to May 2025.

From a NASA perspective, **Rennie Selkirk** shared insights into aircraft campaigns and satellite advancements. He revealed that the NASA DC-8 will soon be retired in favour of a modern replacement. Additionally, NASA is currently evaluating four potential satellite missions, with two expected to move forward. Among these, Strive (focused on atmospheric composition) and ODYSEA Carbon I (carbon monitoring) are particularly relevant to APARC. However, he warned of a looming "data desert" for Earth's ozone layer following the planned decommissioning of NASA's Aura satellite (publication: Salawitch et al., The Imminent Data Desert, BAMS).

Further reports came from **Langley DeWitt** and **Sophie Szopa** on IGAC, **Sara Basart** and **Paolo Laj** on GAW, and **Charlotte Pascoe** on CEDA. The discussion emphasized the critical role of CEDA in data storage and access for APARC, though further conversations are needed to determine which data products will be most relevant moving forward.

The day concluded with a lively exchange of ideas, setting a productive tone for the remainder of the meeting.

Day 2: 29 October 2024

The second day of the meeting focused on key strategic decisions, budget discussions, and collaborative initiatives aimed at strengthening APARC's role within the scientific community.

The day began with a lively discussion on the organization of the 8th APARC General Assembly in 2026/2027. **Amanda Maycock** provided an overview of the previous General Assembly, which was structured as a three-hub meeting. This innovative format significantly reduced the event's carbon footprint, a benefit well-documented in a study by Kremser et al. (BAMS, 2024). Looking ahead, the next General Assembly is tentatively scheduled for end of 2026. **Hindumathi Palanisamy** noted that a CLIVAR meeting is planned for Indonesia in 2025, raising considerations about scheduling conflicts and collaboration opportunities.

The debate over hosting the event in a single location versus multiple hubs was particularly engaging. A single-location meeting would encourage more direct collaboration with colleagues and stakeholders, while the three-hub model would reduce travel-related CO_2 emissions and time constraints. **Karen Rosenlof** raised concerns about the financial implications of a multi-hub approach. Ultimately, the group agreed on the urgency of identifying potential hosts and finalising the event's structure and timeline soon.

Ines Tritscher (IPO) delivered an overview of APARC's budget for 2024 and future funding considerations.

Marc von Hobe and **Moha Diallo** reported on the Outreach Panel. There was a very successful three-day training school for ECRs in Kigali (attached to the WCRP Open Science Conference). An ECR training school is planned for Dakar/Senegal in October/November 2025.

Chris Lennard reported on the activities of the WCRP Academy - activities should be reported to the Academy to ensure a better distribution of planned activities.

Sophie Szopa (with **Wenshou Tian**) reported on the Assessment Coordination Panel. The next upcoming assessment is the WMO Ozone Assessment 2026. Papers contributing to this report must be accepted by (around) March 2026. APARC also contributes to IPCC reports and IPCC special reports. Overall, APARC should be more visible in the assessment communities.

Yaga Richter (with **Takeshi Horinouchi**) reported on the Partnership Advisory Panel. A particular focus should be on WCRP core activities, WCRP lighthouse activities, WWRP (polar) activities. Finally, the importance of a good link with the work of the IGAC was stressed.

Corwin Wright provided an update on gravity wave activities, emphasizing the link between high-resolution modelling and atmospheric dynamics. A key challenge is that gravity wave simulations require sponge layers at the upper boundaries of atmospheric models, which is not always necessary for other high-resolution applications, such as convection modelling.

Daniela Domeisen shared insights on DynVar, focusing on how stratospheric dynamics, including sudden stratospheric warmings (SSWs), influence tropospheric weather patterns. These dynamics can be linked to extreme cold spells and other weather anomalies.

Peter Hoor provided updates on OCTAV-UTLS, discussing trends in various atmospheric parameters, while **Scott Osprey** and **Clara Orbe** detailed progress on QBOi and QUOCA, noting that the QUOCA kick-off meeting is scheduled for 24-28 March 2025.

David Plummer highlighted developments in CCMi, underscoring the need for better alignment between CCMi and AerChemMIP experiments. Although the two initiatives have different priorities - CCMi focusing on process-oriented research and AerChemMIP supporting IPCC assessments - closer coordination would enhance efficiency. Simulations from groups outside AerChemMIP could still be valuable and hosted in the CCMi repository at CEDA. Improved collaboration would also strengthen CCMi's contributions to tropospheric chemistry, addressing a noted gap in its research focus.

Amy Butler provided updates on SNAP, while **Naomi Goldenson** introduced potential synergies between APARC and RIfS, particularly through the Global Extreme Platform and Cordex.

Gokhan Danabasoglu presented an overview of CLIVAR, an initiative running since 1995 with strong links to the Monsoon Panel. A recent CLIVAR special issue on ENSO highlighted research on tropical warming patterns (Watanabe, Nature, 2024) and mechanisms of tropical decadal variability.

Edward Hanna rounded out the session with an update on CliC, emphasizing its role in improving climate modelling and advancing research on ice-climate interactions.

Day 3: 30 October 2024

Jan Polcher provided updates on GEWEX, a project focused on understanding the water cycle. A major highlight was the ORCESTRA campaign, which employs high-resolution storm-resolving simulations (with a resolution better than 5 km) to refine our understanding of tropical convection and Kelvin waves. Another significant focus is Andex, a project dedicated to studying precipitation patterns in the Andes.

Andrea Steiner reported on the Atmospheric Temperature Change (ATC) initiative, revealing that the Hunga eruption led to radiative cooling of up to 4 K. This finding was recently highlighted in a paper published in Communications Earth & Environment (Stocker et al., 2024).

Felix Ploeger then shared updates on A-RIP (formerly S-RIP), detailing a recent meeting in Boulder, Colorado, which followed the Quadrennial Ozone Symposium. A special issue on A-RIP has been published in ACP/WCD, and a dedicated website provides the latest developments. **Amanda Maycock** introduced the idea of a joint workshop with other initiatives, which could open up opportunities for strategic funding.

Aurélien Podglajen presented on FISAPS, an initiative examining fine-scale atmospheric processes at resolutions below one kilometer. This includes high-vertical-resolution radiosonde observations and data from the Stratéole-2 long-duration, constant-density balloon campaigns. Since these observations require equally high-resolution models for comparison, there was also discussion on the potential use of High Altitude Platforms (HAPs).

Nathaniel Livesey reported on TUNER (Towards Unified Error Reporting), an activity largely driven by **Thomas von Clarmann**. A dedicated special issue has published 15 papers on the topic, and the initiative is now approaching its conclusion.

Wenjuan Huo provided insights into SOLARIS-HEPPA, which investigates the influence of solar activity on climate. Discussions included the possibility of linking this work to CMIP-7 research.

Chaim Garfinkel followed with an update on LEADER, an initiative focusing on large ensembles to analyse dynamically driven extreme climate events. This work has clear implications for the upcoming IPCC AR7 report, as well as the WMO Ozone Assessment scheduled for 2026.

Nadine Mengis addressed research on climate intervention (CI), emphasizing its growing importance in policy discussions. A lighthouse activity dedicated to CI was launched in February 2024, and the AGU has introduced an ethical framework to guide this research. Recent Nature articles have highlighted the policy dimensions of CI, yet a rigorous assessment of existing research remains a crucial missing piece.

Scott Osprey spoke on EPESC, which aims to explain and predict changes in the Earth system. He noted that current modelling approaches still face significant limitations when it comes to making accurate predictions.

Neil Harris then led a discussion on "Safe Landing Climates," which explored global economic risks and underscored the need for a fresh assessment of climate tipping points.

Finally, **Ted Shepherd** introduced the lighthouse initiative "My Climate Risk," which aims to develop a global network of "mycorrhizae" - a metaphor for the deep, interconnected analyses required to better understand climate risk.

The next virtual APARC SSG meeting will be held in spring 2025 and the next face-to-face APARC SSG meeting is planned for autumn 2025.

References

Kremser, S., A. Charlton-Perez, J. H. Richter, J. Santos, J. Danzer, and S. Hölbling. Decarbonizing conference travel: Testing a multi-hub approach. Bull. Am. Meteorol. Soc. 105: E21–E31 (2024). doi:10.1175/BAMS-D-23-0160

Stocker, M., Steiner, A.K., Ladstädter, F. et al. Strong persistent cooling of the stratosphere after the Hunga eruption. Commun Earth Environ 5, 450 (2024). https://doi.org/10.1038/s43247-024-01620-3

Watanabe, M., Kang, S.M., Collins, M. et al. Possible shift in controls of the tropical Pacific surface warming pattern. Nature 630, 315–324 (2024). https://doi.org/10.1038/s41586-024-07452-7

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