APARC

Atmospheric Processes
And their Role in Climate

Newsletter n° 62
March 2024

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Changing a single letter can sometimes make a big difference. You may have already noticed some changes over the past few weeks. SPARC is now APARC. And the IPO has moved to its new location at the Forschungszentrum Jülich. Let's take these changes as a chance ... all together.

Contents

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

Personal reflections on the outlook for APARC

It has been a season of change in 2024 so far. We are very excited to launch in this newsletter our new name APARC (pronounced ay-parc) – Atmospheric Processes and their Role in Climate. There is a new logo and updates to the website will follow in due course. This is an exciting evolution for the project and we look forward to the whole SPARC community joining us on the APARC journey.

We are also delighted to see the launch of our new APARC International Project Office (IPO) hosted at FZ Juelich in Germany. FZ Juelich has been a close friend of SPARC for many years and we are confident they will be a supportive host. In this newsletter, the new IPO team introduce themselves to you. The IPO are in the process of establishing themselves and learning about the project, so please be patient as they get up to speed.

We are also delighted to welcome from January 2024 the new APARC co-Chair, Dr Olaf Morgenstern from NIWA in New Zealand. Olaf has been a member of the SPARC community for many years, particularly through the CCMVal and CCMI projects, and brings valuable experience of chemistry-climate modelling. He was Lead Author on the IPCC Sixth Assessment Report.

New beginnings also bring goodbyes. We send our deepest thanks to Dr Mareike Heckl and Dr Sabrina Zechlau from the former IPO and to DLR for having been such a welcome home for the project for the last 6 years. We wish Mareike and Sabrina the very best with the new roles. We also send our very best wishes to Prof Seok-Woo Son who has stepped down as co-Chair after 4 years. Seok-Woo has been a fantastic champion for SPARC and helped to navigate considerable changes within WCRP. He leaves APARC in a strong position and we are pleased that Seok-Woo will remain engaged as an ongoing member of the APARC community.

New short term activities are underway. These include an assessment of the impacts of the Hunga volcanic eruption and they will have an open science meeting in April, and a project on VSLSs. Both of these will lead to reports that should feed into the 2026 WMO Ozone Assessment. A new emerging activity to use large ensembles for attribution of extremes is just starting. Expect reports on these activities in future newsletters.

We were deeply saddened to learn of the loss of a respected member and friend of the SPARC community, Dr Thomas von Clarmann. Thomas was a leader in the TUNER activity and contributed to multiple activities over the years. You will find an obituary from some of Thomas' close colleagues in this newsletter. We send our deepest sympathy to Thomas's wife Gabi Stiller and his wider family at this sad time.

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

The new IPO introduces itself

Rolf Müller[1], Ines Tritscher[1], Lars Hoffmann[2], Olaf Stein[2], Mohamadou Diallo[1], and Michaela Hegglin[1]

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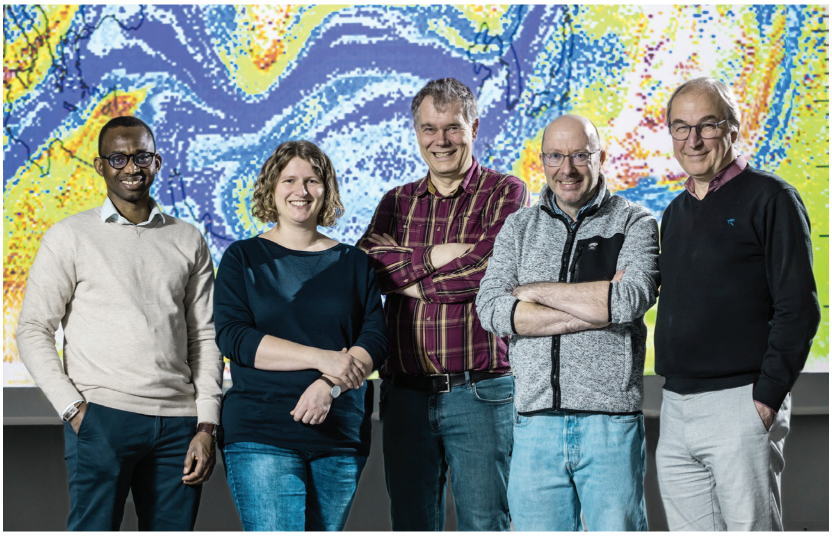


Figure 1: *The new IPO team at Jülich; from left to right: Mohamadou Diallo, Ines Tritscher, Olaf Stein, Lars Hoffmann, and Rolf Müller.*

The year 2024 will bring changes for the SPARC community. SPARC will be called APARC from now on. Atmospheric Processes And their Role in Climate - that's the new name in full. The evolution to APARC reflects what has already become common practice within our community over the last decade; more and more of our science topics address the whole atmosphere system. We are excited that WCRP has supported the development of a new logo for APARC, which you will find at the top of the newsletter and on the new APARC website. WCRP itself is now in the process of adopting a new logo, offering individual logos and a common (color) scheme for all core activities, giving them a joint appearance.

The IPO, the International Project Office, has also changed. You will now find the IPO at the Forschungszentrum Jülich (in English: Research Centre Julich), Germany. Michaela Hegglin has been Director of the Institute of Energy and Climate Research - Stratosphere (IEK-7) for almost two years now and is herself very active in the APARC community. She has worked intensively to bring the APARC office to Jülich. Michaela was able to convince the Earth system scientists at the Jülich Supercomputing Centre (JSC) to join forces.

From now on, Rolf Müller (Director of the IPO), Ines Tritscher (Scientific Officer), Mohamadou Diallo (Scientific Outreach Officer) from IEK-7, as well as Lars Hoffmann (Scientific Officer) and Olaf Stein (Scientific Officer) from JSC will be active for you. We are looking forward to supporting the activities and helping with the delivery of the APARC science implementation plan. Figure 1 shows the new APARC office team. The research at Forschungszentrum Jülich is directly related to APARC; several scientists at Forschungszentrum Jülich, including the members of the IPO, have contributed significantly to APARC (or its predecessor SPARC) over the years and many are still active today. Because members of the Forschungszentrum Jülich have already experience working in the APARC framework, we hope that the IPO activities at Jülich will be ramped up rapidly in a successful way.

Please use the new e-mail when contacting the APARC IPO (aparc-office@fz-juelich.de). Further, we now have a new website, where you can find all kind of current information on APARC related science, on upcoming conferences and also an early career scientist's corner (https://www.aparc-climate.org).

After Paris, Toronto, Zurich and Munich, Jülich is now the fifth station of the APARC office. We are looking forward to a good cooperation with you and hope to be able to support you with your scientific ideas and plans in the best possible way. We would also like to take this opportunity to thank Mareike Heckl, Sabrina Zechlau, Brigitte Ziegele and the whole team at DLR once again for the work for APARC in the last years!

FISAPS Workshop Report

on Research Using High Vertical-Resolution Radiosonde Data

Marvin Geller[1], Hye-Yeong Chun[2], Thomas Birner[3], William Randel[4], and Robert Sharman[4]

[1] Stonybrook University, New York, USA; [2] Yonsei University, Seoul, Korea; [3] Ludwig-Maximilians-University, Munich, Germany; [4] National Center for Atmospheric Research, Boulder, Colorado, USA

Dates:
30 August - 1 September 2023

Scientific organising Committee:
Marvin Geller, Hye-Yeong Chun, Thomas Birner, William Randel, and Robert Sharman

Host Institution:
UCAR Foothills Laboratory in Boulder, Colorado

Number Of Participants:
66 (from 14 countries)

Contact:
marvin.geller@stonybrook.edu

Conference Website:
https://cpaess.ucar.edu/meetings/fisaps-workshop-research-using-high-vertical-resolution-radiosonde-data

Sponsors:

Meeting Overview

The FISAPS Workshop on Research Using High Vertical-Resolution Radiosonde Data was held on August 30, 31, and September 1, 2023 at the UCAR Foothills Laboratory in Boulder, Colorado. The US National Science Foundation provided financial support for this workshop through a research grant to Marvin Geller. The goals for this workshop were to stimulate research using newly available global high vertical-resolution (10 m or less) radiosonde data and also to look at synergies among radiosonde data, GPS radio occultation data, and aviation atmospheric data. This workshop had strong international participation with 66 registrants from 14 different countries. It was a hybrid workshop with both in-person and remote electronic participation. On the first day, we had 26 in-person and 18 remote participants. On the second day, we had 24 in-person and 19 remote participants, and on the third day, we had 22 in-person and 18 remote participants.

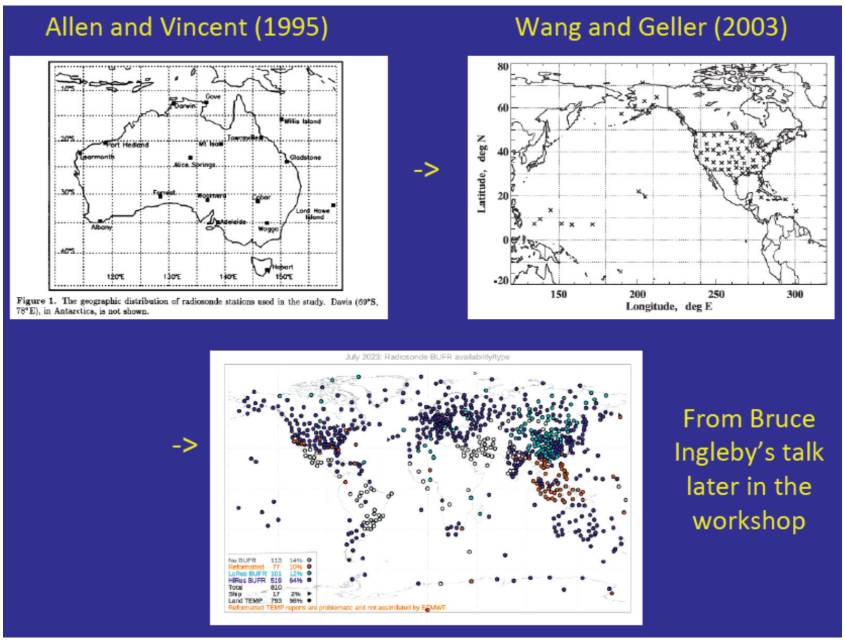


***Figure 2:** Slide from Marvin Geller's introductory talk showing availability of high resolution radiosonde measurements over time.*

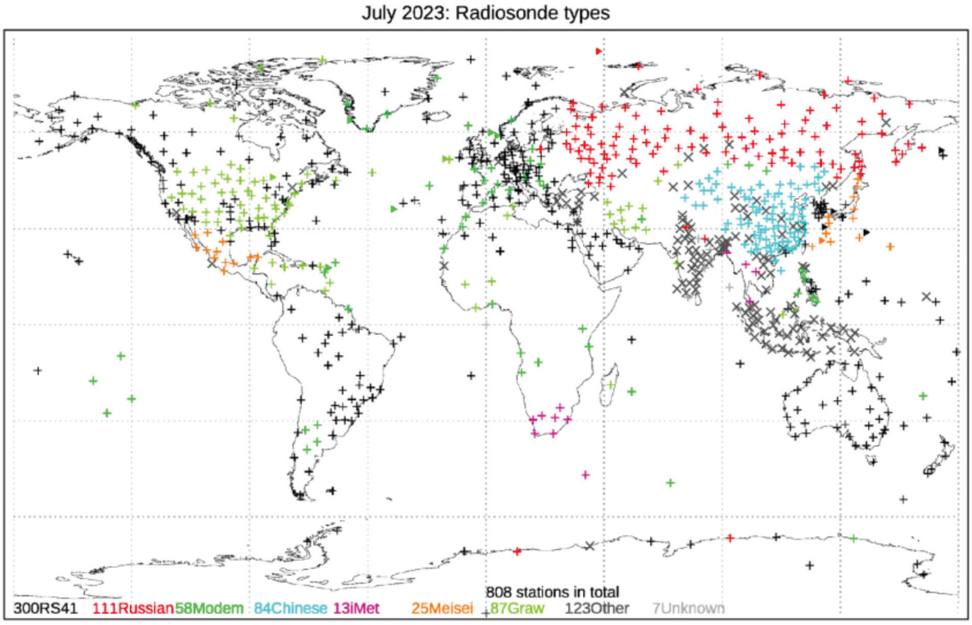


Figure 3: *Slide from Bruce Ingleby's talk showing different radiosonde sensors providing high resolution measurements.*

1st Workshop Day

The workshop began with welcoming from **Marvin Geller** on behalf of FISAPS and **Karen Rosenlof** on behalf of SPARC. **Jessica Martinez**, from UCAR, explained some of the logistics of the workshop site. This was followed by an introductory talk by Marvin Geller. Figure 2 is from his presentation and illustrates the motivation for the workshop.

Figure 2 shows the evolution of the availability of high vertical-resolution radiosonde data from a 1995 publication to a 2003 publication to the present situation. Clearly, this data availability has grown from regional data over Australia to data from the United States operated radiosonde network to a truly global network of High Vertical-Resolution Radiosonde Data (HVRRD). Marvin Geller's introductory talk was followed by a talk by **Robert Vincent** on some of the history behind HVRRD research and also some of the history of SPARC's involvement in this research area, which dated from the very beginnings of SPARC.

Vincent's talk was followed by a talk by **Bruce Ingleby**. The title of his talk was "Operational high resolution radiosonde data: the good, bad and the unknown." He showed the global coverage of HVRRD, but he cautioned that users must be aware of some of the potential problems in these data, which include variable quality, errors, and differing instrumentation. For instance, Figure 3 illustrates the different radiosonde instrumentation now in use. It was clear from Bruce Ingleby's talk that users of HVRRD will have to proceed with caution in the use of these data.

Imke Durre followed with a talk on HVRRD at NOAA's National Center for Environmental Information (NCEI). She discussed the migration from TAC (Traditional Alphanumeric Codes) to BUFR (Binary Universal Form for the Representation of meteorological data) data. She also discussed how IGRA (Integrated Global Radiosonde Archive) plans were to include HVRRD. **Patricia Pauley** gave a presentation on the use of HVRRD in U. S. Navy numerical weather prediction models. She showed examples of radiosonde mandatory level profiles, mandatory plus significant level profiles, as well as HVRRD profiles. She discussed the impact of radiosonde data on the U. S. Navy numerical weather prediction. She also showed examples of various types of errors one can find in radiosonde data and also what the future may hold in available radiosonde data.

Hye-Yeong Chun showed some results from a previously published paper on turbulence derived by applying the Thorpe method to US HVRRD. In a paper she and Han-Chang Ko published in 2022, they introduced the concept of *EE* (the Layer-Mean effective eddy dissipation rate) over an altitude interval *Z*, defined by $EE = (\epsilon \cdot THTL)/Z$, where *THTL* is the average thickness of turbulence layers occurring in *Z*. They then looked at the correlations between *EE* and various factors that could affect *EE*. Dr. Chun then showed some results from a paper in preparation that shows turbulence characteristics calculated from Thorpe analysis using the global HVRRD network similar to that shown in Figure 2. Finally, she showed some results for projections of aviation flight-level turbulence characteristics with future climate change. **Masashi Kohma** presented a paper that showed comparisons between turbulence parameters derived from Thorpe analyses of HVRRD and PANSY radar data at Syowa station in the Antarctic. He showed that a direct comparison between the turbulence characteristics indicated that the radar results were substantially smaller than the Thorpe results in the 1.5-9 km altitude region, but that the comparison improved above 11 km. The Thorpe/radar comparison was substantially improved when machine-learning methods were employed; however, the machine learning results failed to correctly identify strong sporadic events.

David Fritts showed some observations of nearly continuous turbulence at altitudes from the ground to 100 km. This included very high vertical-resolution balloon and rocket research data, radar data showing Kelvin-Helmholtz instability and gravity wave breaking events, and imaging data. He also showed direct numerical simulation results showing similar structures. His modeling results highlighted characteristic "tube and knot" turbulent structures that result in increased turbulent mixing. He argued that new generation gravity wave parameterizations will have to be developed in light of those new modeling results. **Dale Lawrence** showed the configuration and some results from his novel HYFLITS turbulence measurements system. This is a low-cost balloon measurement system that measures turbulent parameters on balloon and parachute descent. Instrument costs per sounding, exclusive of ground-station, are about $1,500. He showed comparison between results from HYFLITS and the more costly German LITOS instrument. He indicated that launches of 44 HYFLITS payloads are planned at Syowa Station in early 2024. **Abhiram Doddi** showed results from a study to evaluate the methodologies used to evaluate the dissipation rate of turbulent kinetic energy, ε, from one-dimensional measurements. He did this by sampling results from direct numerical simulations of turbulence. He concluded that spectral measurements provide accurate distribution of ε for mature (stationary homogeneous isotropic) turbulence, but that spectral measurements can underestimate ε for unsteady (early-stage) turbulence.

The final paper of the workshop's first day was given by **Yufang Tian**, who showed some recent research progress based on measurements from the high-resolution radiosonde network in China and the Beijing MST radar observations. In 2011, this network consisted of 120 radiosonde stations utilizing L-band sounding systems. She showed results for boundary layer heights, trends in tropopause heights, gravity waves, and turbulence from this Chinese radiosonde network, as well as some turbulence results for the troposphere-lower stratosphere from MST measurements.

2nd Workshop Day

Matti Lehmuskero, of Vaisala, started the second day of the workshop by describing the Vaisala RS 41 family of radiosonde instrumentation and data processing. He described the instrumentation for measuring temperature, humidity, pressure, wind, and GPS location and the subsequent processing applied to the raw measurements. For instance, Figure 4 shows the radiation corrections of Vaisala Radiosonde RS41 temperature measurement at various pressure levels and solar angles at ground level, with a ventilation speed 6 m/s. These radiation corrections are applied for soundings as a function of the radiosonde pressure level, latitude, and date and time of the sounding. He also described corrections applied to the humidity and pressure measurements, as well as for pendulum effects on the wind. **Holger Vömel** followed with a talk on HVRRD humidity measurements. He discussed nine of the humidity sensors presently being used in radiosonde measurements and their calibrations. He described the nature

hPa/deg.	-7.0	-4.0	-2.0	0.0	3.0	10.0	30.0	45.0	60.0	90.0
1000	0.00	0.00	0.00	0.00	0.01	0.03	0.08	0.10	0.11	0.11
500	0.00	0.00	0.02	0.03	0.05	0.09	0.15	0.17	0.18	0.19
200	0.00	0.02	0.06	0.09	0.13	0.19	0.27	0.29	0.31	0.32
100	0.00	0.05	0.10	0.16	0.21	0.29	0.39	0.42	0.44	0.45
50	0.00	0.10	0.18	0.24	0.32	0.42	0.55	0.58	0.60	0.62
20	0.01	0.18	0.29	0.39	0.49	0.63	0.81	0.85	0.88	0.9
10	0.05	0.27	0.42	0.53	0.65	0.83	1.04	1.10	1.14	1.16
5	0.09	0.37	0.55	0.68	0.83	1.05	1.31	1.39	1.42	1.45

Figure 4: *Radiosonde solar radiation temperature corrections (K) from Matti Lehmuskero's presentation.*

of the dry bias, the instrument response times, problems arising from sensor icing, and the nature of measurement biases. Finally, he gave information on the various data archives from which HVRRD humidity information can be accessed. **Ling Wang** gave a talk describing a study of temperature fluctuations in US raw and processed HVRRD. He showed an example of the radiation corrections and smoothing of small-scale fluctuations in the processed in comparison to the raw data. He showed the methodology used to define the temperature fluctuations as the deviations from 2nd-order polynomial fits over various altitude intervals (Δz). He showed that the temperature fluctuations over attitude segments of Δz = 100 m for both the raw and processed data were greater under daytime relative to nighttime conditions, particularly in the stratosphere, with those day/night differences being less in the processed data. For Δz > 1,000 m, the temperature fluctuations look like those from gravity waves. He also showed that the previously noted discontinuity at some radiosonde locations in unstable layer occurrences using the raw data is diminished, but not eliminated in the processed data. He closed his talk by hypothesizing that the small-scale daytime temperature fluctuations were a result of uncorrected radiation effects as the temperature sensor swung and rotated. **Marvin Geller** followed this talk by describing how the differences in the temperature fluctuations in the raw and processed HVRRD affected his previously published results on atmospheric unstable layers. He noted that the previously described 00Z/12Z differences in unstable layer occurrences used the raw data, and that those 00Z/12Z differences largely disappeared when the processed data were used. He also described how the previously noted "notch" in unstable layers, where the number of thin unstable layers were diminished and the number of thicker unstable layers were enhanced in the deep tropics at altitudes around 12 km, became less prominent when processed data were used but looked the same in nighttime measurements when either raw or processed data were used. Finally, he noted that previously described discontinuity in unstable layer occurrences at some radiosonde stations were diminished, but not eliminated, when processed data were used.

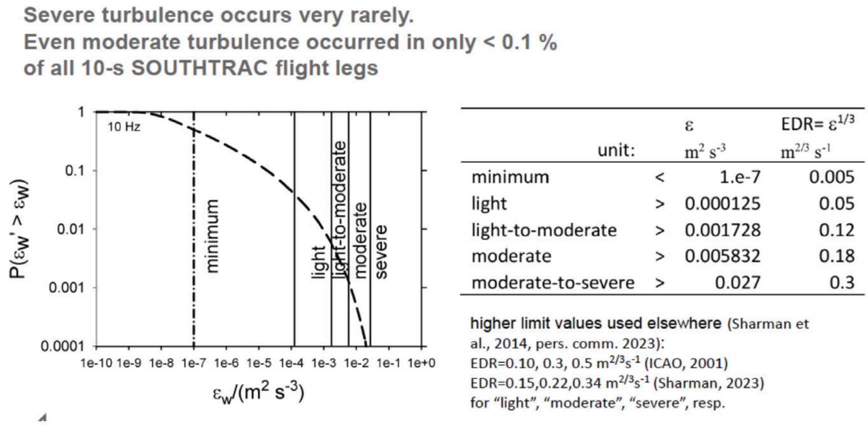


Figure 5: *Slide from Ulrich Schumann's presentation highlighting turbulence measurements in the SOUTHTRAC aircraft campaign.*

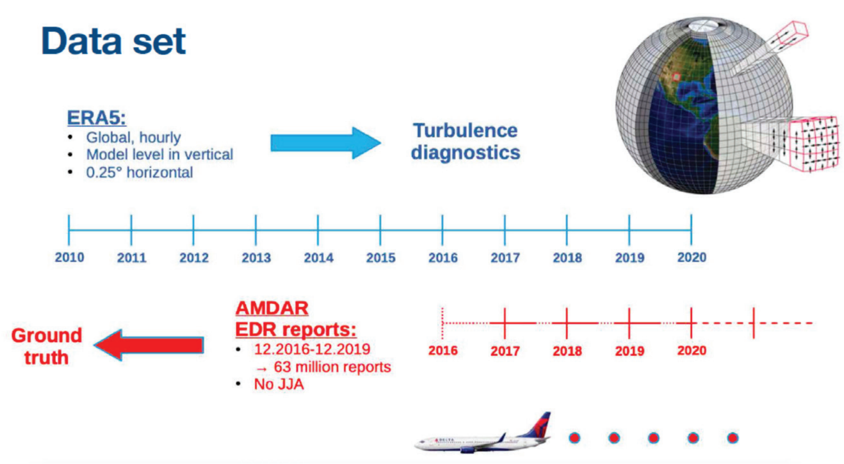


Figure 6: *Slide from Thorsten Kaluza's presentation on turbulence observations from operational aircraft and diagnostics using ERA5 data.*

Clark Amerault discussed the assimilation of boundary layer height (BLH) estimates from HVRRD in COAMPS, the US Navy's Coupled Ocean/Atmosphere Mesoscale Prediction System. Assimilation of BLHs in COAMPS is still in its developmental stage, and using HVRRD has been important in for testing purposes. **Michael Fromm** gave a presentation on using HVRRD for observational studies of volcanic stratospheric clouds. His study showed that there is likely a signature of rotational winds accompanying these clouds.

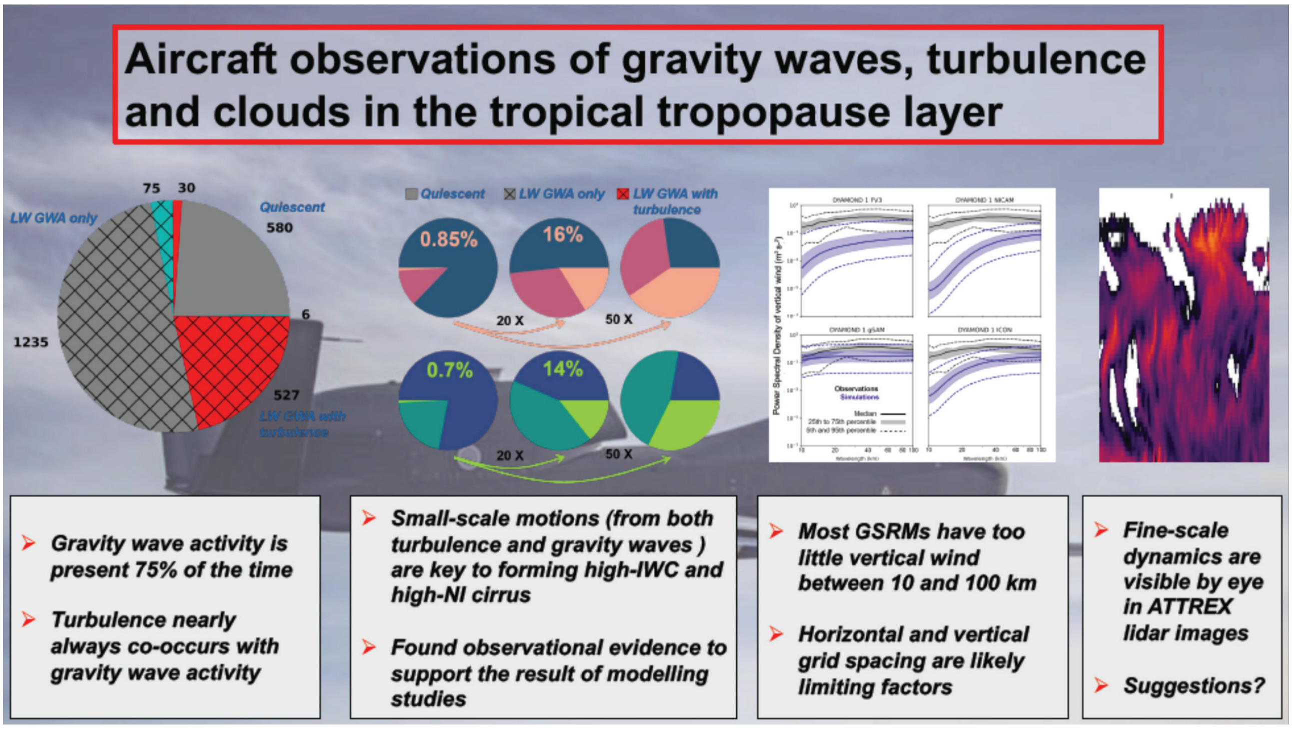


Figure 7: *Slide from Rachel Atlas' talk on turbulence and waves in the tropical tropopause layer.*

Robert Sharman gave a presentation on methods for prediction of aircraft turbulence and their validation. He indicated that for aviation, $\varepsilon^{1/3}$=EDR is the preferred observation/forecast metric, where again ε is the dissipation rate of turbulent kinetic energy, and that semi-empirically based diagnostics can provide operationally useful forecasts of CAT (Clear-Air Turbulence) and MWT (mountain-wave turbulence) using coarse resolution NWP model output. He indicated that HVRRD are useful to compare statistics of observational data, especially in the stratosphere. **Wiebke Deierling** gave a presentation on Aviation Turbulence Nowcast Systems. Development of such systems is important given that current systems provide valuable tactical guidance to aviation to deal with turbulence hazards, and forecasts are challenging because turbulence events are rare and not well measured. She showed examples of such nowcasts together with aircraft reports of turbulence. **Han-Chang Ko** showed results of estimating turbulence using operational HVRRD together with comparison with aircraft turbulence reports. A complication for such comparisons is that aircraft seek to avoid regions of forecasted high turbulence. Having said this, horizontal distributions of both EDRs from radiosonde data and flight data show large values over the Rocky Mountains. However, they show large differences in vertical and temporal distributions in terms of their peak location and timing.

Ulrich Schumann's presentation was on Measurements of High-Altitude Turbulence from Research Aircraft. Some of his findings were as follows. In the stably stratified atmosphere near the tropopause, dissipation is anisotropic and often not log-normally distributed. There, the Kolmogorov model provides reliable dissipation rates only for $\varepsilon > \varepsilon_{MIN} \sim 10^{-7}\ m^2 s^{-3}$. He indicated that measurements indicate that strong turbulence occurs only rarely (see Figure 5). Instead, observations suggest mainly anisotropic wavy motions without inertial-range turbulence. Their measurements with the BAHAMAS system on the German research aircraft HALO during SOUTHTRAC and other field campaigns are available and should be a valid measure for "clear air turbulence". **Thorsten Kaluza** presented a paper on Data-driven Identification of Turbulent Flow in the Extratropical UTLS Based on ERA5 and Automated Aircraft Turbulence Reports. Figure 6 shows a schematic that illustrates the ERA5 and aircraft reports he used to train his random forest classifier.

3rd Workshop Day

The third day began with a presentation from **Paul Williams** on Climate Change and Aircraft Turbulence. He began by speaking about some innovative instrumentation that can be piggybacked onto a standard radiosonde ascent to measure turbulence. The instrumentation consists of an accelerometer that responds to the increased pendulum motion that occurs as the radiosonde flies through a turbulent

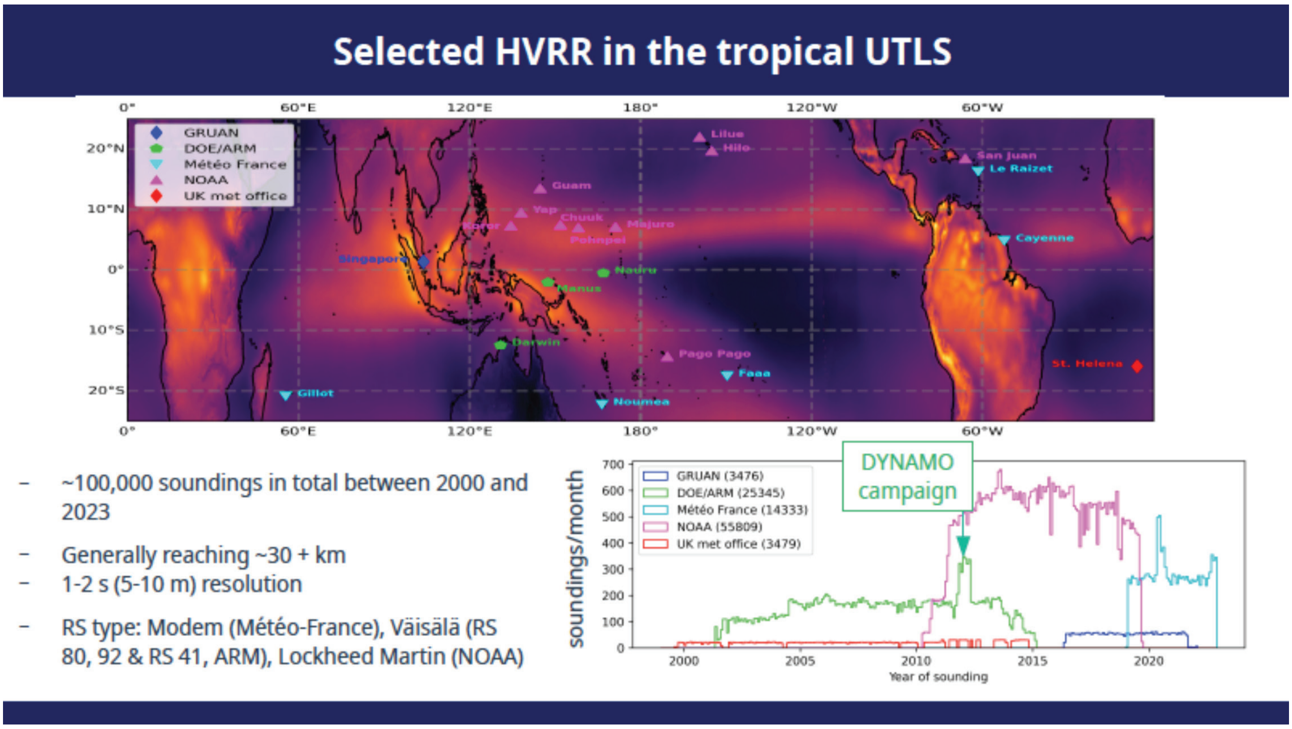


Figure 8: *Slide from Aurelien Podglajen's talk on HVRR turbulence measurements in the tropical UTLS*

layer. The second part of his talk dealt with increases in aircraft turbulence that have been reported over the past several decades being consistent with projections of increased aircraft turbulence accompanying projections of global warming over the next several decades. **Rachel Atlas** presented a talk on Aircraft observations of gravity waves, turbulence and clouds in the tropical tropopause layer. Her summary slide is shown as Figure 7. The ATTREX flights in 2013 and 2014 showed gravity wave activity being seen about 75% of the time in flying through the tropical tropopause transition layer, and that turbulence almost always accompanied the gravity wave activity. Such small-scale motions were found to be key in forming cirrus clouds. She also examined the results from a high-resolution global model and found that this model was deficient in producing the vertical velocities associated with gravity waves and turbulence, likely due to their limited resolution. **Aurelien Podglajen** presented a talk on Quantifying turbulence in the tropical UTLS and its impact on transport using HVRRD. This study used about 100,000 measurements from the deep tropical HVRRD stations shown in Figure 8. He used both Thorpe and Richardson Number methods to extract turbulence information from these soundings. He also evaluated the effective turbulent mixing from the observed sporadic nature observed turbulent layers. Some of his conclusions were the following. The contribution of turbulence/irreversible small-scale mixing to the tracer budget remains poorly constrained and estimates vary by order of magnitude. Thorpe and low Ri layers show relationships with equatorial waves (stronger in the stratosphere) and convection (stronger in the troposphere). Shear layers associated with the quasi-biennial oscillation (QBO) appear to exert a strong control on stratospheric turbulence occurrences. Preliminary diffusivity estimates from Thorpe analysis of radiosonde seem to disagree with tracer budget-based estimates, but the strong sensitivity to HVRRD data processing and the effects of daytime noise need to be clarified.

Ling Wang gave a talk on Analysis of Atmospheric Gravity Waves Using U. S. Radiosonde Data. His talk reviewed various published analyses, all based on U. S. HVRRD. He showed derived gravity wave total energies (kinetic plus potential) in the troposphere and lower stratosphere. Other derived quantities included gravity waves' intrinsic frequencies, vertical and horizontal wavelengths, fraction of upward energy, directions of horizontal propagation, and best-fit source spectra. He also showed some results derived from the fluctuating radiosonde vertical velocities. The previous results were derived from fluctuations of radiosonde-measured quantities over fixed altitude segments in the troposphere and lower stratosphere. He also showed gravity wave parameters derived from fluctuations from time-averages of radiosonde soundings.

Bill Randel followed this by giving his talk on Sub-grid scale thermal variability in the UTLS from radio occulta-

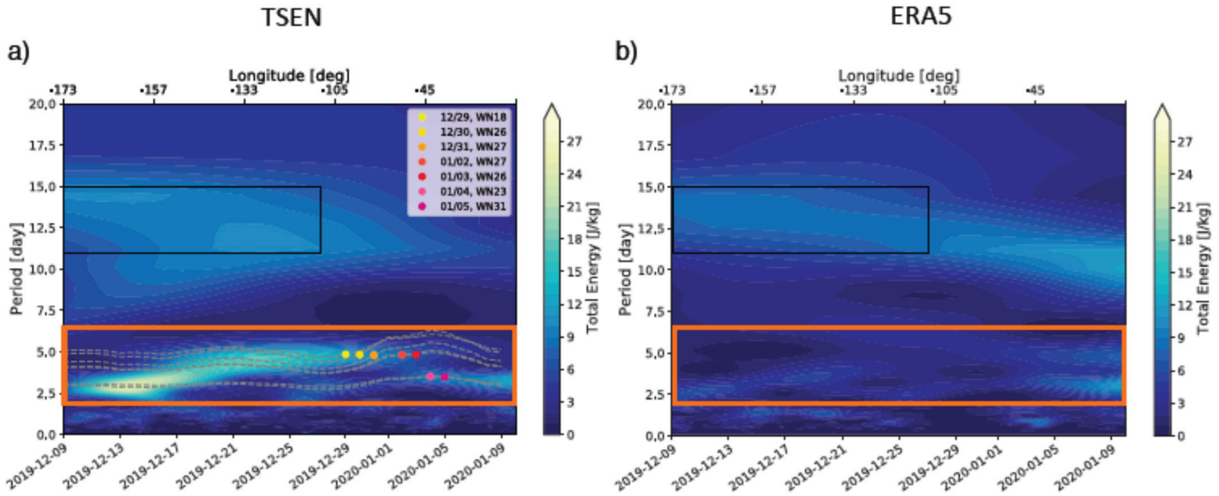


***Figure 9:** Comparison of tropical lower stratosphere balloon frequency spectra of wave energy (left) and ERA5 results (right) from Martina Bramberger. TSEN is the total wave energy per unit mass.*

tion. He showed how the number of radio-occultation (RO) of atmospheric temperatures has increased with time, with currently over 10,000 measurements per day. He showed how the RO measurements of large-scale waves agreed with theoretical expectations, but the main thrust of his talk was quantifying small-scale fluctuations that exhibit behavior consistent with gravity waves. These sub-grid waves were the temperature fluctuations with respect to background gridded (4° latitude x 10° longitude) fields. These sub-grid scale waves showed large values associated with jets and deep convection. **Paul Staten** presented a progress report on his new methodology for deriving wave characteristics from GPS RO data. His approach showed some promise, but he indicated that significant challenges remained.

Marvin Geller gave an update on studies of the "notch" in unstable layers, where there were less thin unstable layers and more thick layers, at altitudes centered at about 12 km, that had been previously reported, He showed that this feature, which had been previously reported at the Koror station was also present at other stations in the deep tropics. He also showed evidence that led him to his hypothesis that this feature was associated with the previously reported static stability minimum at this altitude in the deep tropics. By analyzing the "notch" feature at stations near the higher latitude boundary of the deep tropics, he showed that the characteristics of this "notch" feature at those stations were consistent with the annual variation in the latitudinal extent of this stability minimum feature. **Joan Alexander's** talk was on Fine-vertical-scale Waves near the Tropical Tropopause: Observations and Impacts. She indicated that waves with short vertical wavelengths are likely very important in forcing the QBO and are most effective at modulating the cold-point tropopause and thus affecting stratospheric dehydration. She was able to identify short vertical wavelength (~ 1 km) Kelvin waves using balloon-borne RO data from the long-duration super pressure balloons of STRATEOLE-2. **Martina Bramberger** followed up with a talk on Fine-scale Waves and Shallow Mixing Layers in the TTL and Lowermost Stratosphere. She reported observations of short wavelength (~ 875 m) eastward propagating inertia-gravity wave with periods on the order of 2-6 days and horizontal wavenumbers on the order of 18-31. These waves are very much underrepresented in ERA5 reanalyses (as is illustrated in Figure 9), but give rise to cooling of the stratosphere and are associated with increased amounts of cirrus clouds. She also reported on results from a new measurement technique on STRATEOLE-2 balloons, RATS – Reeldown Atmospheric Temperature Sensor.

Thomas Birner made a presentation asking the questions "To what extent are fine-scale processes and structures near the tropopause important for climate?" He showed some observational evidence of a significant correlation between the sharpness of the mid-latitude tropopause inversion layer (TIL) and the mean zonal wind such that a stronger TIL is correlated with an equatorward jet shift. He also showed results of a mechanistic model where the sharpness of the TIL was imposed, which led to the same result. He also argued that the tropopause-level moist bias in current climate models is due to overly dispersive transport and that vertical mixing might play a significant role in regulating transport just above the tropical tropopause.

K. P. Aathira gave a presentation on Characteristics and long-term trends in tropopause parameters obtained from US high-resolution rawinsonde data.

She used U. S. HVRRD to study tropopause heights and temperatures at 66 U. S. radiosonde stations and their trends. She found that 14% of the stations showed a significant positive trend in the tropopause altitude, while 48% showed a positive trend though not significant, and 4% showed a significant negative trend. She also found that 76% of the stations showed a negative trend in tropopause temperature but only 10% were significant. **Ajil Kottayil** gave a talk on High-frequency Radar observations of vertical velocity in the tropical UTLS over Kochi, India. He showed evidence of frequent detection of trapped gravity waves in the UTLS and he also showed significant correlation between measured vertical velocity variances and deep convection.

The workshop agenda, along with the slides shown, can be accessed at https://cpaess.ucar.edu/events/24511/agenda/ and recordings of all the talks and related discussions can be accessed at FISAPS Radiosonde Workshop Video Recordings.

The workshop ended with a discussion on the future of FISAPS. The attendees were asked the following questions.

1. Should FISAPS continue to exist as a SPARC activity?
2. If FISAPS continues to exist, how should its goals evolve?

The answer to the first question was a resounding yes. There is a significant atmospheric research community concerned with analyzing high vertical-resolution atmospheric data. This includes those analyzing high vertical-resolution radiosonde observations, those involved in analyzing atmospheric measurements from aircraft, the community involved in forecasting turbulence for aircraft operations, and those involved in analyzing GPS radio-occultation data. Furthermore, there is increasing activity in high-resolution atmospheric modeling, and that community will require high-vertical resolution data for comparison to modeling results. Finally, a great deal of high vertical-resolution atmospheric data are becoming available, but those data are not always easy to access and utilize, so FISAPS should put increased emphasis on training activities on the use of those data. Given this discussion, it was suggested that FISAPS change its name and statement of goals. It was suggested that the acronym FISAPS be retained, but that it stand for Fine vertical Scale Atmospheric Processes and Structures, and that its new statement of goals be the following.

"The goals of the FISAPS (FIne vertical Scale Atmospheric Processes and Structures) activity of SPARC are to

- increase access to, and usability of high resolution atmospheric data, with resolution of vertical scales finer than 1 km, including HVRRD, GPS-RO, radar, aircraft, lidar, constant-density balloons, and NWP model output, and to
- facilitate collaborations among the high-resolution modeling community, the data analysis community and high-resolution data experts to advance weather and climate research and applications."

SGG nomination call 2024

The call for nominations to APARC's Scientific Steering Group (SSG) is now open. The SSG currently comprises 12-14 researchers from around the world with a wide range of expertise in atmospheric dynamics and chemistry. They guide APARC's priorities and activities, working together with the SSG co-chairs and the APARC project office.
Please note that you can either nominate a candidate or nominate yourself. The SSG takes a strategic view of APARC's role, so we are looking for individuals with a broad view of atmospheric science and climate change as well as expertise in their own field. Scientific expertise, career stage as well as gender and geographical balance are considered. The initial term of service is for four years (January 2025 - December 2028), with a possible extension of two years.

You find all relevant information and the online form to submit your nomination at the APARC website: https://www.aparc-climate.org/.

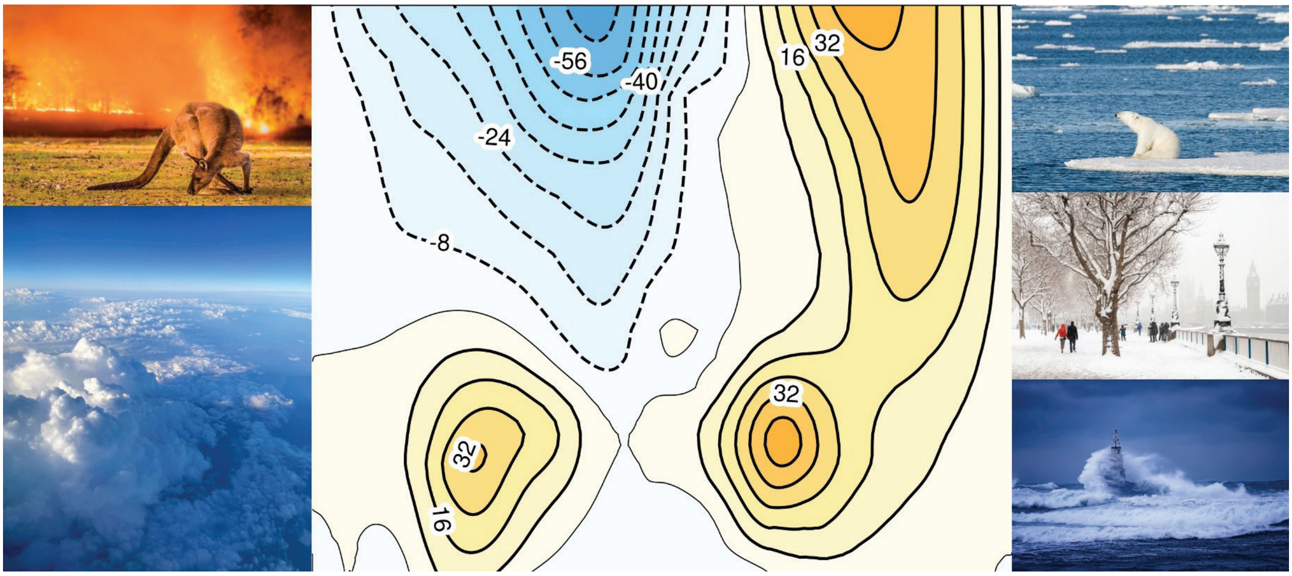
In case you have any questions, do not hesitate to contact the IPO: *aparc-office@fz-juelich.de*

APARC Dynvar & SNAP Workshop:

The Role of Atmospheric Dynamics for Climate and Extremes

Daniela I.V. Domeisen[1,2], Amy H. Butler[3], Chaim I. Garfinkel[4], Alexey Karpechko[5], Thomas Birner[6], and Hella Garny[7]

[1] University of Lausanne, Switzerland (daniela.domeisen@unil.ch); [2] ETH Zurich, Switzerland; [3] NOAA Chemical Sciences Laboratory, Colorado, USA; [4] Hebrew University, Jerusalem, Israel; [5] Finnish Meteorological Institute, Helsinki, Finland; [6] Ludwig-Maximilians-University, Munich, Germany; [7] Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen, Germany



Dates:
9-13 October 2023

Scientific organising Committee:
Thomas Birner, Amy Butler, Daniela Domeisen, Chaim Garfinkel, Hella Garny, and Alexey Karpechko

Local Organising Committee:
Thomas Birner and Hella Garny

Host Institution:
Meteorological Institute at Ludwig-Maximilians-University Munich, Germany

Number Of Participants:
138 (from 22 countries)

Contact: **daniela.domeisen@unil.ch**

Conference Website:
https://www.sparc-climate.org/meetings/the-role-of-atmospheric-dynamics-for-climate-and-extremes/

A joint Atmospheric Processes and their Role in Climate (APARC) DynVar and SNAP Workshop was held on 9 - 13 October in Munich, kindly hosted by LMU Munich. We would like to express our sincere thanks to the local organizing committee for an excellent organization of the workshop and great hospitality. The conference location was right next to the "English Garden", a large public park in the center of Munich.

Support from WCRP Stratosphere-Troposphere Processes and their Role in Climate (SPARC, the retired name for APARC), the Waves to Weather (W2W) project (a collaborative research center, funded by the German Research Foundation), and the US National Science Foundation enabled the attendance for 50 Early Career Scientists (ECS) and researchers from underrepresented countries, and provided childcare for conference attendees.

Sponsors:

Waves to Weather NSF APARC

Figure 10: *The in-person attendees of the joint DynVar/SNAP workshop.*

Meeting Overview

The workshop was the 6th workshop of the DynVar activity and the 3rd time it was organized jointly with SNAP, highlighting the strong synergies between these two APARC activities. Both DynVar and SNAP focus on atmospheric dynamics, but DynVar is focused primarily on climate variability and change, and SNAP on predictability on sub-seasonal to seasonal timescales. The workshop was attended by a wide range of researchers interested in large-scale atmospheric dynamics and predictability. Overall, 138 participants from 22 countries attended the meeting, of which 68% were ECS and 34% were female.

The meeting was overshadowed by the attacks on Israel and an escalation of violence in the Middle East, which unfortunately limited the participation for many of the Israeli scientists who had been planning to join the meeting.

Figure 11: *Scientific organizing committee:*
Top left to right: Hella Garny, Amy Butler, Daniela Domeisen, Chaim Garfinkel, Thomas Birner. Below: Alexey Karpechko.

Figure 12: *The 22 countries (red) where participants were from.*

The meeting accommodated 75 oral presentations (38% of all speakers were female, and of the 13 invited/keynote speakers 38% were female) and 66 posters. The presentations were organized into 12 sessions. There were sessions devoted to stratospheric circulation changes and interactions with chemistry, biases in stratosphere-troposphere coupling in S2S models and impacts on surface predictability, and upward wave coupling and predictability of stratospheric events. Other sessions continued the trend towards a more holistic whole atmosphere approach started already at the previous DynVar/SNAP workshop in Madrid, including sessions on tropical processes, S2S predictability of extremes, extratropical dynamics, and climate models and biases. Relatively new topics for APARC were on Arctic and mid-latitude linkages, weather regimes, and North Atlantic decadal variability. The session on "Circulation and climate change" was the largest one in terms of the number of talks, which reflected the growing interest of the APARC dynamics community in this societally relevant topic.

On Tuesday evening the conference dinner was held in the atmospheric cellar at Augustiner Keller, a famous Munich tavern. Wednesday afternoon was free for social activities; the unseasonably warm weather allowed many of us to do a local hike to the Andechs monastery outside of Munich.

Figure 13: *Conference dinner at Augustiner Keller.*

Figure 14: *Hike to the Andechs monastery.*

Keynote talk

The keynote presentation to the meeting was delivered by **Paul Kushner**. In his talk, Paul discussed what we have learned about stratosphere-troposphere coupling since the DynVar activity was founded in 2007. The initial efforts included using simplified or idealized models to represent stratosphere-troposphere coupling, and to investigate if and to what extent the stratosphere indeed influences the troposphere, which was not initially a view that all members shared. Over the ensuing 15 years, the stratospheric influence on the troposphere has become widely accepted, although Paul noted that some skepticism on the magnitude of its role remains. Paul suggested that a similar situation currently exists with the influence of Arctic Amplification on lower latitudes, and that the topic could be ripe for targeted efforts within the atmospheric dynamics community to make substantial progress, in addition to efforts by several existing international activities.

Invited talks

There were 12 invited talks in addition to the keynote. **Tim Woollings** highlighted an emerging poleward jet shift in both hemispheres despite relatively weak trends in the upper tropospheric/lower stratospheric temperature gradient and emphasized a discrepancy between observed and simulated trends. **Christiane Jablonowksi** demonstrated how select CMIP6 models have persistent biases in stratospheric water vapor and transport processes. **Dillon Elsbury** showed how most CMIP6 models struggle to simulate the Holton-Tan effect, and suggested a connection to how potential vorticity gradients are captured regionally. **Marta Abalos** showed that models consistently predict an acceleration of the Brewer-Dobson Circulation both historically and in the future, but in the historical period this acceleration has only been observed in the shallow branch and not the deep branch. **Marina Friedel** used specifically designed experiments to isolate the role of Arctic ozone on springtime surface climate, and showed that in the experiment with non-interactive ozone, the impacts are weaker. **Noel Keenlyside** (talk presented by **Nour-Eddine Omrani**) suggested that the feedback between Atlantic Multi-decadal Variability and the North Atlantic Oscillation could lead to a delayed coupled stratosphere-troposphere-ocean oscillation. **Zachary Lawrence** illustrated that there are common biases in stratosphere-troposphere coupling in S2S forecast models, and the location and structure of the biases help to identify their sources.

Several of the invited talks summarized the progress on the SNAPSI project, a S2S forecast modeling intercomparison project led by SNAP that nudges the zonal-mean stratospheric winds during three sudden stratospheric warming (SSW) events to isolate the role of the stratosphere on surface impacts and predictability. **Peter Hitchcock** provided an overview of the SNAPSI protocol and showed that different tropospheric initial conditions alter the surface response to the same stratospheric nudging. **Hera Kim** showed that for the 2018 SSW, most systems did not capture the SSW in the first initialization, and this led to larger errors in the prediction of the troposphere. **William Seviour** demonstrated a large (~4-8x) but lead-dependent stratospheric contribution to relative risk for several extreme weather metrics. **Blanca Ayarzagüena** showed that both tropospheric precursors and the state of the stratosphere were important for models to capture the 2018 SSW. **Hamid Pahlavan** demonstrated that free-running S2S forecasts struggle to maintain QBO easterlies in particular, which may be related to how well the models capture tropical wave processes.

Figure 15: *Scientific discussion in the main lecture room.*

Updates for DynVar

The future of the DynVar activity and its role in the renewed APARC structure was discussed at a lunch session. Several participants praised the role of DynVar in leading research and contributing to workshops and training throughout its long history. The importance of having a home for people interested in atmospheric dynamics, which DynVar is, was a recurrent message in the discussion. The possibility of transformation of DynVar into a "dynamics panel" within APARC was perceived as a reasonable option if it ensures more of a voice for dynamics. Such a panel could serve as a clearing house for research questions and promote specific short term activities, e.g. specifically designed experiments to understand dynamical mechanisms. Exploring new topics, such as summer tropospheric dynamics, heat extremes, Arctic amplification, contributing to the new Large-Ensemble Single Forcing MIP (LESFMIP) and organizing training schools were also proposed as activities for future DynVar.

Updates for SNAP

During the SNAP lunch discussion, we heard from **Steve Woolnough** from the WWRP Sub-seasonal Applications for aGriculture and Energy (SAGE) and **Bill Merryfield** from the WCRP ESMO/WGSIP projects. These groups are likely to be the location for S2S-related research going forward, as the S2S Project concluded at the end of 2023. The discussion was primarily focused on how SNAP should engage with these communities moving forward. In addition, we discussed potential future SNAP projects (post-SNAPSI, ~1-2 years from now).

Figure 16: *Keynote talk by Paul Kushner.*

Possible future projects include

1. a second SNAPSI phase with different events targeted (e.g. strong vortex or final warming), and/or with ozone and water vapor concentrations specified so as to explore the role of composition biases for surface climate predictability.
2. Revisiting the ability of S2S hindcasts to capture surface predictability associated with stratospheric processes (as in Domeisen et al 2020a: https://doi.org/10.1029/2019JD030920 and 2020b: https://doi.org/10.1029/2019JD030923) but with two key changes: 1) updated model version; 2) considering dynamical processes in the troposphere as well.
3. Exploring the ability of seasonal or decadal forecasts (C3S or DCPP) to capture surface predictability associated with the stratosphere or large scale dynamical processes in the troposphere.
4. Exploring the relative importance of tropical vs. stratospheric variability for surface predictability by nudging the tropics vs. nudging the stratosphere.

Breakout Discussions

The breakout group discussions on the scientific future of the field revolved around three questions: Why, What, and How. The word cloud in Figure 17 summarizes the responses from the different breakout groups.
The first breakout tackled outstanding questions in atmospheric dynamics and extremes and tried to motivate "why" DynVar/SNAP should prioritize certain topics. The most frequent response involved "understanding", "model", and "biases". The discussion revealed that model biases are a major issue when interpreting coupled climate model simulations and forecasts. It was emphasized that high-top models are often more comprehensive in many aspects of the climate system, not just a representation of the stratosphere, which limits the insights that may be gained by simply dis-

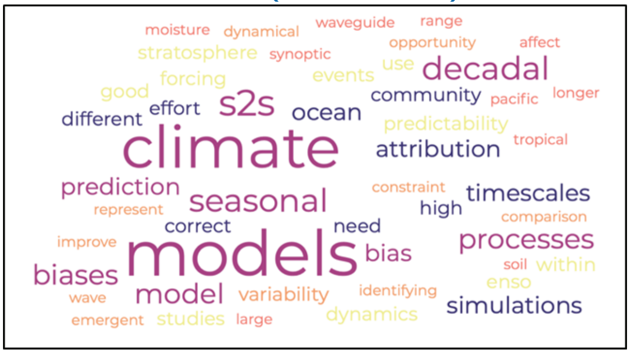
tinguishing high and low top models as often done in the past. Future model intercomparisons should perhaps focus more on representation of parametrized processes (e.g., related to clouds, chemistry, gravity waves) as well as horizontal and vertical resolutions. Process and mechanistic understanding can be gained from coordinated and "clean" multi-model experiments in which a certain process is targeted. Another major area of priority is better understanding of coupling across components, such as interactions across the atmosphere and the ocean, cryosphere, biosphere, and composition.

Breakout #2 focused on "what" analyses could be done to better constrain processes and model biases. The word cloud for this discussion highlights that the major tools for analysis of atmospheric dynamics and extremes are still climate models. The S2S database and other seasonal forecasts were identified to offer a rich opportunity to test mechanisms, find statistically robust relationships, and attribute events to common drivers. Novel statistical tools such as explainable AI, linear inverse modeling, or emulators may offer additional insights into model biases as well as offering new methods for projections and predictions. Emergent constraint analysis may be a way to select more skillful models based on past performance for narrowing uncertainties in future projections.

Breakout #3 focused on "how" tools and simulations could be used for prediction and projection. The word cloud for this discussion emphasizes the word "use", which nicely highlights the large amount of available data in ongoing and planned projects and provides a significant opportunity for making progress on the major questions in our field. It was stressed that there is much to be gained by exploiting this existing data in new and creative ways. During the course of the week, one new data resource was discussed in some detail– the Single Forcing Large Ensemble MIP (part of the WCRP Lighthouse Activity "Explaining and Predicting Earth System Change"), the analysis of which is being proposed to APARC in the near future as Limited-term cross-Activity focused project. Links between modeling and observational communities are deemed to be vital, which necessitates straightforward communication channels to modeling centers. A large part of the discussion centered around the concept of nudging (as opposed to different forcings), ideally across a hierarchy of model complexity, as a way forward for mechanistic understanding.

Why? (Breakout #1)

What? (Breakout #2)



How? (Breakout #3)

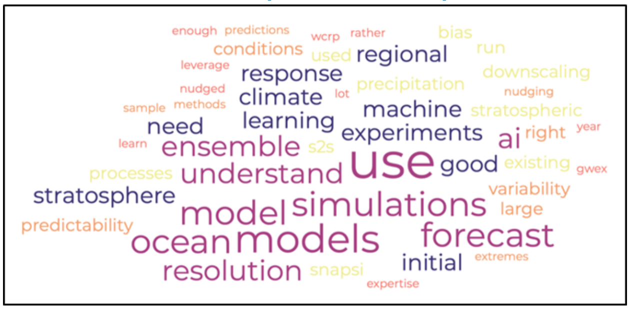


Figure 17: *Word cloud based on the answers from the breakout group discussions.*

Ongoing activities

One important topic during the workshop was highlighting all the ongoing and planned projects within APARC that generally include a wide range of complex and collaborative model simulations and have a strong focus on atmospheric dynamics. We here provide a brief list of these projects and the main contact person:

- **SNAPSI**: Peter Hitchcock (aph28@cornell.edu)
- **QBOi nudging**: Neal Butchart (neal.butchart@metoffice.gov.uk) and Martin Andrews (martin.andrews@metoffice.gov.uk)
- **CCMI-2**: David Plummer (David.Plummer@ec.gc.ca)
- **Single forcing large ensemble MIP**: Chaim Garfinkel (chaim.garfinkel@huji.ac.il)
- **S-RIP phase 2**: Jonathon Wright (jswright@tsinghua.edu.cn)
- **Hunga Tonga**: Paul Newman (paul.a.newman@nasa.gov)
- **DynVarMIP**: Edwin Gerber (epg2@nyu.edu)

APARC Training School on "Climate Data Analysis and Artificial Intelligence in the Global South (AI4Climate)"

Mohamadou A. Diallo[1], Michaela I. Hegglin[1,3], Amadou T. Gaye[2] and Theodore G. Shepherd[1,3]

[1]Forschungszentrum Jülich, Jülich, Germany; [2]University of Cheikh Anta Diop, Dakar, Senegal; [3]University of Reading, UK

Dates:
29-31 October 2023

Organisers:
Dr. Mohamadou A. Diallo,
Prof. Dr. Michaela I. Hegglin,
Prof. Dr. Theodore G. Shepherd,
Prof. Dr. Amadou T. Gaye,
and from the University of Rwanda:
Prof. Dr. Damien Hanyurwimfura,
Dr. Jennifer Batamuliza,
Dr. Celestin Kurujyibwami,
and Prof. Dr. Charles Ruranga

Host Institution:
University of Rwanda - College of Science and Technology (UR-CST), Kigali, Rwanda.

Number Of Participants: **30**

Training School Website:
https://www.sparc-climate.org/2023/09/08/2-3-days-of-climate-data-science-ai-training-school-at-the-university-of-rwanda-on-october-29th-31st/

Training School GitHub:
https://github.com/mdiallofzj/APARC_AI4Climate_School

Feedback Survey:
https://github.com/mdiallofzj/APARC_AI4Climate_School/tree/main/Feedback_Survey/

Sponsors:

Background

With funding from APARC - Atmospheric Processes And their Role in Climate and in-kind support from the Forschungszentrum Jülich and the University of Rwanda, the first three-day training school on *"Climate Data Science and Artificial Intelligence in the Global South (AI4Climate)"* was held from 29 to 31 October at the University of Rwanda - College of Science and Technology (UR-CST). APARC's AI4Climate Training School was scheduled to follow the WCRP Open Science Conference in Kigali from 22 to 28 October, which attracted climate researchers from around the world. The organisation of the APARC AI4Climate Training School was led by **Mohamadou A. Diallo**, **Michaela I. Hegglin**, **Amadou T. Gaye**, and **Theodore G. Shepherd**, in collaboration with the UR-CST.

The APARC AI4Climate Training School targeted early career scientists (ECS, i.e. undergraduate, masters, and PhD students, as well as postdoctoral fellows) from the Global South and North, who attended the WCRP OSC in Kigali, as well as ECSs from UR-CST and countries close to Rwanda such as Kenya, Ethiopia, Uganda, and Tanzania. Despite the limited time available to organise the training school, APARC's AI4Climate school attracted more than 280 applicants from all around the world with a variety of backgrounds. Due to limited funding, 30 ECS participants from the Global South and North were selected on the basis of their background in mathematics, computer science, and climate science, as well as their current interests and future plans (Fig. 18). Participation in APARC's AI4Climate training school was free of charge. Catering, local transport, and accommodation were covered by APARC funding for the trainees as well as for the speakers, who were senior and early-career scientists. In addition, travel support was provided to trainees. The organisers of the APARC AI4Climate training school would like to express their deep gratitude to WCRP APARC for sponsoring the event, to our wonderful host UR-CST, in particular to

Damien Hanyurwimfura, **Jennifer Batamuliza** and **Celestin Kurujyibwami**, and to all the lecturers of the training school for having volunteered their knowledge and time and who made the training school possible. Finally, we also thank the IT of UR-CST, **Baptist Mugiraneza**, for the technical support and the Manager of Chem-Chem restaurant, **Joseph Baguma**, and his team for taking care of the school.

Detailed Programme

The three-day AI4Climate training school was divided into lectures in the morning and computer exercises in the afternoon, covering a wide range of topics with a focus on atmospheric climate sciences and the use of Python Machine Learning (ML) and Artificial Intelligence (AI) tools for climate and weather research. The primary aim of the school was to encourage innovation and help support weather and climate services for the generation of user-relevant information on a sub-seasonal-decadal scale.

The first day of the AI4Climate training school was devoted to an overview of climate change and its impacts, climate model evaluation, and an introduction to the Python jupyter-notebook. The school began with a short introduction to WCRP, APARC, and the FZJ by **Michaela I. Hegglin**, followed by a presentation by **Theodore G. Shepherd** on his personal experience of research within WCRP/APARC (formerly SPARC). These talks enabled the trainees to familiarise themselves with the structure, research activities, and objectives of the WCRP, APARC, and FZJ. **Mouhamadou B. Sylla** spoke about regional climate change information from satellite observations and climate models, with a focus on Africa. During the presentation, the trainees learned about the state of the art and information gaps on climate change impact and adaptation in Africa. The first interactive computer exercise began with **Emmanuel Masabo**, who introduced the trainees to jupyter-notebook and its potential using a case study on basic statistics in Python. This jupyter-notebook exercise prepared the students for the following lecture on the introduction to the Earth System Model Evaluation Tool (ESMValTool) by **Birgit Hassler**. This lecture was followed by a practical session during which trainees learned about this community diagnostic and performance metrics for the evaluation and analysis of Earth system models (i.e., CMIPs & CCMIs) in relation to reanalyses and observations through examples of ESMValTool recipes.

The first day ended with a general presentation on atmospheric reanalysis and the SPARC-Reanalysis Intercomparison Project (S-RIP), given by **Gloria L. Manney**, co-lead of S-RIP. This lecture enabled the trainees to discover the various components of atmospheric reanalyses, namely the operational weather forecasting models, the input observations, and the data assimilation systems, as well as the usefulness of reanalyses for studying weather and climate processes and for validating global circulation and chemistry-climate models. Finally, the trainees were also made aware of the comprehensive work carried out during phase 1 of the S-RIP initiative through a summary of the findings and recommendations, as well as the objectives and goals of the next phase 2 of the S-RIP initiative.

Lectures on the second day focused on understanding atmospheric processes and causal inference. A lecture on the African monsoon circulation was given by **Cheikh M. N. Fall**, who introduced participants to the processes and impacts of the monsoon circulation on society, as well as the lack of climate information on monsoon changes for resilience. After the lecture, the participants introduced themselves, which created an excellent atmosphere as it allowed the students to relax, show their various research interests, and create great interactions both between the students themselves and between the students and the lecturers.

In the next lecture, **Elena Saggioro** addressed the topic of causal inference in climate and weather research, explaining to participants how causal networks can be used to draw causal inferences from data by incorporating physical (causal) reasoning into statistical analysis. Just before lunch, AI4Climate participants were pleased to receive a visit from **Ignace Gatare**, Principal of UR-CST, who expressed his pleasure at hosting APARC's first AI4Climate training school and the great opportunity that the school represents for the UR-CST as well as for all ECS participants in terms of high quality education and networking for a diverse-leadership, equity, integrity and open access to climate science. In the afternoon, practical work on causal inference began with four sample computer exercises on quantifying teleconnection pathways, addressing issues related to common factors, mediators, indirect and direct causal links, as well as the approach to controlling confounding factors in a complex causal network.

The third and final day of the training school was devoted to the topic of ML/AI for climate and weather science. The first lecture was dedicated to demystifying AI used for climate and weather research by **Fiona Spuler**. In this lecture, trainees were introduced to the difference between AI, machine learning, and statistics, an overview of machine learning methods and applications in climate and weather science. In addition, Fiona Spuler also addressed current open issues in machine learning such as interpretability, uncertainty, physical consistency, handling extremes and causality, and finally showed an application study on clustering using variational autoencoders. The second lecture focused on artificial neural networks (ANN) and was presented by **Mohamadou A. Diallo**. In this lecture, trainees learned how to build an artificial neural network from zero to hero, including data preprocessing and architecture selection and understanding the important mathematical steps currently incorporated in open ML/AI libraries (Sklearn, tensorflow). Trainees also learned how to handle data splitting for training, testing and cross-validation of the ANN model, how to handle overfitting and regularization as well as how to use visualization tools for explainability such as layered relevance propagation (LRP).

Finally, trainees were also exposed to learning resources and concrete examples of publications using ML/AI, as well as ethical issues. The morning lectures concluded with a joint presentation by **Fiona Spuler** and **Jakob Wessel** on advanced ML/AI methods using variational autoencoders, deep learning, and transformers to identify patterns in large-scale traffic. Jakob Wessel joined the training school after meeting Mohamadou A. Diallo on the plane to the WCRP OSC meeting, confirming Carl Sagan's assertion that the Earth is a little blue dot where we are more connected to each other through our network circle than we often realize. The afternoon session began with a hands-on exercise in Python on dimensionality reduction and clustering methods by **Fiona Spuler** and **Jakob Wessel**, and was followed by the final session of the training school on a computational exercise on ANN kitchen and deep learning in Python by **Mohamadou A. Diallo**.

Legacy

One month after APARC's AI4Climate training school, the material has been collected and published on Github (https://github.com/mdiallofzj). To evaluate the success of the training school, AI4Climate organized a feedback survey (https://github.com/mdiallofzj/APARC_AI4Climate_School/tree/main/Feedback_Survey/). As the survey shows, AI4Climate was a great success, and feedback from trainees was extremely positive, to the extent that 95% of trainees would be interested in getting involved in the APARC AI4Climate community to foster new collaborations, and 87% in hosting an APARC AI4Climate Training School Hub at their home institutions. This excellent result bodes well for APARC outreach activities, and for Mohamadou A. Diallo's role as scientific outreach officer at the new FZJ APARC IPO, which aims to encourage partnerships between early-, mid-career and established scientists across the Global South and North, as well as to lead the organization of APARC Training School activities for early-career scientists in the Global South and North.

Figure 18: *Group photograph of the participants of the APARC AI4Climate training school in Kigali, Rwanda.*

Impact of chlorinated very short-lived substances on stratospheric ozone (VSLS-MIP)

Ryan Hossaini[1], Lucy Carpenter[2], Martyn Chipperfield[3], Doug Kinnison[4], Susann Tegtmeier[5]

[1] Lancaster University, UK (r.hossaini@lancaster.ac.uk); [2] University of York, UK; [3] University of Leeds, UK; [4] NCAR, USA; [5] University of Saskatchewan, Canada.

Halogenated very short-lived substances (VSLSs) are defined as trace gases whose local lifetimes at the surface are shorter than 0.5 years. A large fraction of VSLS emissions are destroyed in the troposphere, yet they can make a significant contribution to stratospheric halogen levels, especially if emissions occur in regions with rapid transport to the stratosphere. Brominated and iodinated VSLSs are predominantly of natural oceanic origin, whereas chlorinated species have mostly anthropogenic emission sources. Unlike long-lived ozone depleting substances (ODSs) such as chlorofluorocarbons, these chlorinated VSLSs are not controlled under the Montreal Protocol, but have offset some of the Protocol's benefits by slowing the rate of stratospheric chlorine decline (Hossaini et al., 2019). Thus, they have the potential to delay ozone layer recovery.

This new APARC community activity will address many emerging and important issues concerning the impacts of VSLSs on stratospheric ozone concentrations and trends. These issues warrant a comprehensive and authoritative assessment through a model intercomparison project (MIP). Given the many uncertainties related to their impacts, such an assessment of VSLSs requires a multi-model approach and an international effort, which is being performed in the framework of this new APARC activity.

The primary objectives of VSLS-MIP are to:

- Assess the impact of industry-related emissions of chlorinated VSLSs on stratospheric ozone.
- Assess new metrics (including integrated ozone depletion (IOD) and stratospheric ozone depletion potential (SODP)) for evaluation of the impact of VSLSs on ozone depletion.
- Evaluate the impact of VSLSs on long-term trends (past and future) in lower stratospheric ozone.

The planned outcomes are:

1. A set of community model simulations for (i) 1990s to present day and (ii) the future utilising common spatially-resolved industrial emissions of major VSLSs. Some of the models will also use state-of-the-art iodine schemes and investigate the role of iodine through specified surface emissions of industrial iodinated VSLSs.
2. Multi-model assessment of ozone and halogen changes due to VSLSs.
3. Evaluation of metrics for VSLS impacts on ozone.
4. Peer-reviewed publications based on multi-model assessments of (i) historical impacts, (ii) projections and future impacts, (iii) policy metrics.

The expectation is for the assessment of historical impacts and some results on policy metrics to be completed in time for inclusion in the 2026 Ozone Assessment. We welcome participation from interested modelling groups worldwide.

For more information please contact Ryan Hossaini (r.hossaini@lancaster.ac.uk) or see the website https://lec-atmos.org/initiatives/vsls-mip1/

References

Hossaini, R., Atlas, E., Dhomse, S.S., Chipperfield, M.P., Bernath, P.F., et al., Recent trends in stratospheric chlorine from very short-lived substances. J. Geophys. Res. Atmos., 124, 2318-2335, doi: 10.1029/2018JD029400, 2019.

Quadrennial Ozone Symposium (QOS)

15–19 July 2024 in Boulder, Colorado

https://qos2024.colorado.edu/

The 2024 Quadrennial Ozone Symposium is the 36th meeting of Ozone Scientists that began with the "Conference on Ozone and Atmospheric Absorption" in Paris in May 1929. The previous meetings have been highlighted with our growing understanding of processes affecting atmospheric ozone, its observations, photochemistry, impacts on air quality and human health, as well as the existential threat of ozone layer depletion by chlorofluorocarbons and halons. This 36th symposium will highlight keynote and invited presentations on wildfire aerosol impacts on ozone, new findings of the Hunga eruption impact on the stratosphere, the anniversaries of the Aura satellite and IAGOS observations, increased awareness of ozone and stratospheric impacts on surface climate, and new satellite data from the Korean GEMS satellite and the NASA TEMPO instrument.

Side meetings:

LOTUS meeting: 13-14 July 2024

S-RIP2 kickoff meeting: 20-24 July 2024

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

First announcement of the 2nd Ozone_CCI User Workshop

28-29 May 2024, two half-day virtual sessions (virtual meeting)

Background: The European Space Agency's Climate Change Initiative (CCI) aims to realise the full potential of the long-term Earth Observation archives collected by ESA and Third-Party missions. Since 2010, the Ozone_CCI team (https://climate.esa.int/en/projects/ozone/about) has been developing, maturing, generating and sustaining multiple complementary multi-decadal satellite ozone Climate Data Records (CDRs) tailored for climate monitoring, climate research and climate modelling applications. The CCI portfolio consists of total and tropospheric ozone column data products as well as vertically resolved ozone products by nadir and limb-viewing sensors.

Objectives: The main objectives of this workshop are (a) to bring together scientists involved in the generation of ozone CDRs, as well as (potential) users of ozone CDRs, and the broader ozone and climate communities, (b) to present the state of the art in ozone CDR production, (c) to discuss results from major CDR users (e.g., stratospheric and tropospheric ozone assessments, UT/LS studies, evaluation of climate modelling, data assimilation and reanalysis), (d) to collect and update user requirements for CDRs, and (e) to discuss remaining challenges for the generation of ozone CDRs.

Organising team: M. Dameris, D. Hubert, M. van Weele, N. Kalb, C. Retscher

Further information can be found at https://events.spacepole.be/e/Ozone_cci_2nd_User_WS
The report about the first workshop in the SPARC newsletter can be found at
https://www.aparc-climate.org/wp-content/uploads/2021/07/SPARCnewsletter_Jul2021_web.pdf

In memory of Thomas von Clarmann

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Thomas von Clarmann passed away on 13 January 2024 at the age of only 64. It is difficult to accept that he is no longer with us. We have suddenly and unexpectedly lost an excellent and sharp-minded colleague, a good friend, and an outstanding scientist of our community.

Figure 19: *Thomas von Clarmann (Photo: Gabriele Stiller).*

Thomas was born on 15 September 1959 in Bavaria, Germany. He studied meteorology at the Ludwig-Maximilian University in Munich. During his PhD studies at the Institute of Meteorology and Climate Research (IMK) in Karlsruhe, which is now part of the Karlsruhe Institute of Technology (KIT), he developed retrieval algorithms for the balloon-borne Michelson Interferometer for Passive Atmospheric Sounding (MIPAS-B). He received his PhD degree from the University of Karlsruhe in 1989. In the following years, his work was focused on the analysis of MIPAS-B infrared limb emission spectra and atmospheric research with the resulting trace gas profiles. In 1994, he was appointed head of the satellite remote sensing group at the IMK. He habilitated on remote sensing in the infrared spectral range in 2004. Following that, he was a lecturer at the Faculty of Physics and the Faculty of Civil Engineering, Earth and Environmental Sciences, KIT. He was also a visiting professor at the Paul Sabatier University in Toulouse, France, in 2009.

For more than two decades Thomas has played a leading role in the data analysis of MIPAS-Envisat infrared limb emission spectra and related atmospheric research. He was the initiator and architect of the MIPAS data processing at IMK (von Clarmann et al., 2003, 2009), and the driving force behind continuous improvements of the widely used data products, even after the end of the Envisat mission. Through his active involvement in many long-term SPARC activities such as the SPARC Data Initiative (SDI, on stratospheric trace gases), Water Vapour Assessment (WAVAS), and Solar Influences on Climate (SOLARIS-HEPPA), Thomas contributed significantly to the successful scientific exploitation of these data.

Thomas' main research area of interest and expertise, however, was on the theoretical aspects of the inverse radiative transfer problem, specifically in the context of utilizing remotely sensed atmospheric data for scientific purposes. His critical, philosophically informed thinking prompted him to challenge existing dogmas, leading to the development of novel concepts and methodologies for the treatment of a priori information in remote sensing data, the appropriate consideration of measurement uncertainties, validation strategies, and trend estimation from disparate remote sensing datasets. With this motivation, Thomas instigated and became the main lead of the SPARC activity Towards Unified Error Reporting (TUNER), which aims to provide a complete and consistent data characterisation in terms of uncertainty, resolution, and content of a priori information, for the largest possible number of space-borne temperature and composition sounders. It is largely thanks to his efforts that the TUNER activity has developed guidelines for current and future missions to use a robust framework for describing these quantities (von Clarmann et al., 2020).

In recent years, Thomas also became passionate about the idea of deriving the atmospheric mean circulation from observed tracer fields. This resulted in the development of a highly-innovative inverse method (Analysis of the Circulation of the Stratosphere Using Spectroscopic Measurements - ANCISTRUS; von Clarmann and Grabowski, 2016; von Clarmann et al., 2021) that has been successfully applied to MIPAS-Envisat data (see Fig. 20).

Apart from his leading role in SPARC activities, Thomas served the atmospheric community as an advisor for space mission projects such as ALTIUS. He was also a reviewer of the 2018 WMO/UNEP ozone assessment. As long-time journal editor for Atmospheric Chemistry and Physics and Atmospheric Measurement Techniques, Thomas was passionate about interdisciplinary open-access publishing. He was also instrumental as both an initiator and executive editor of the Encyclopedia of Geosciences.

Thomas' significant contribution to atmospheric science and remote sensing has inspired the work of many scientists around the world, and will continue to influence the work of future generations. We will always remember his easily recognisable voice, his dedication, his fairness, his loyalty, and his enthusiasm. We were privileged to work with Thomas, to share valuable and influential experiences, and to enjoy many stimulating discussions be they at meetings, over meals, and at the brewpub.

All our thoughts go to his wife and scientific companion Gabriele Stiller, their daughter Verena, family, and friends.

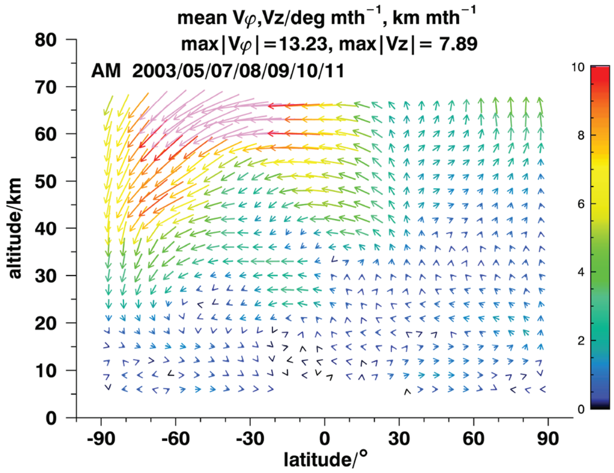

Figure 20: *Effective circulation vectors as a function of altitude and latitude as derived by means of the ANCISTRUS approach from MIPAS measurements of long-lived tracers recorded in the months April and May, averaged over the years 2002-2012 (from von Clarmann et al., 2021).*

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