

# CLIVAR/GEWEX MONSOONS PANEL

## Annual Report 2022

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## 1. Panel overview

### 1.1 Background

The CLIVAR/GEWEX Monsoons Panel (MP) was established in 2014 with the remit of: (a) taking a more global view of monsoon activities, enabling knowledge and best practice to be shared between the various monsoon regions and (b) to better coordinate monsoons research between GEWEX and CLIVAR, particularly in emphasizing the role of convection and the land surface in the monsoons. The MP membership encompasses the research interests of both CLIVAR and GEWEX as well as all the regional monsoons, with in-country membership where possible. While the MP takes a global view, it is also important to address region-specific details, particularly in engaging regional stakeholders and managing local knowledge exchange and up-skilling. Keeping this in view, the MP has established a sub-structure of working groups (WGs) dedicated to three monsoon regions, namely the Asian-Australian (WG-AAM), African (WG-AFM) and American (WG-AMM) Monsoons.

The three regional monsoons WGs are working towards enhancing understanding of the monsoons in those regions through various process studies with an emphasis on improving prediction skills in those respective areas. The primary focus of these groups is to build a partnership between operational met departments and researchers that is intended work on various strengths and limitations of the present climate models in predicting weather and climate in those regions. The regional working groups also establish sub-groups to focus on different topics. In these sub-groups, researchers beyond working groups, particularly Early Career Scientists (ECS), are engaged in various studies to address the significant issues of the regional WGs. The MP guides the WGs on multiple tasks and research priorities and in promoting cross-cutting activities and synergies among groups.

See Monsoons Panel web pages for Terms of Reference (ToRs), membership and previous reports:

- <http://www.clivar.org/clivar-panels/monsoons>
- <https://impo.tropmet.res.in/wcrp-monsoon.html>

Activities of the MP are supported by the International Monsoons Project Office (IMPO), hosted at Indian Institute of Tropical Meteorology (IITM), Pune, India, under a new agreement signed between WMO and IITM on 30<sup>th</sup> July 2021. IMPO also supports the monsoon activities of the Working Group on Tropical Meteorology Research (WGTMR) of the World Weather Research Programme (WWRP), facilitating the MP's linkages with WWRP monsoon activities.

### 1.2 MP's current main missions

The MP coordinates strategies, advises on plans and defines concrete activities to carry out studies on the suggested research priorities, including selecting, limiting, and concluding such activities as appropriate. MP encourages studies on priority themes by groups from different monsoon domains and facilitates and/or promotes collaboration among monsoon researchers. MP stimulates the interest of researchers and students in monsoon related problems by supporting and organizing

workshops, advanced schools, and promoting scientific sessions in conferences with focus on monsoons. MP also coordinates the formation and function of regional working groups and collaborates with the WCRP and WWRP substructures relevant to monsoon research regarding the organization of scientific meetings and regional working groups, as well as on relevant issues for advancing monsoon research. Finally, MP supports work in cooperation with regional, national, and multinational programs to enhance the understanding of monsoon systems and improve monsoon prediction from synoptic to decadal time scale and longer, setting strategic priorities for long-term climate projection. MP also has a mission to communicate existing products and provide guidance on their (adequate) application and limitations to the operational community, (relevant) impacts community and participate in relevant training activities.

The current goal of the MP is to identify the bottlenecks to further improve the skills of dynamical models in representing the monsoons on multi-spatiotemporal scales, including extreme weather. The activities lined up for addressing these activities include:

- Assess and improve the skill of monsoon rainfall in different regional monsoons and identify the bottlenecks in the dynamical models.
- Improve understanding of dynamical and physical processes associated with extreme events and identifying the lacuna in capturing these extremes in present-day models.
- Promote Research to Operations (R2O) activities to contribute with the Regional Climate Outlook Forums (RCOFs) and operational meteorological services.
- Build capacity by promoting ECS representation in the WGs and subgroups developing these activities

### **1.3 MP's 2022 Activities**

#### **1.3.1 Organizational Activities**

The last in person MP meeting was held in December 2019 during the American Geophysical Union conference in San Francisco, USA. Continued COVID-19 restrictions followed by budgetary constraints have prevented any further meetings, which has significantly impacted teamwork.

MP held 3 virtual meetings in 2022, which have served discussions to update the TORs, activities of regional WGs and future work plans. In addition, the two co-chairs also held a few infrequent teleconferences.

- WG-AFM held 6 virtual meetings to discuss on the writing of a review article on “Climate Modeling of Precipitation over Africa” and the activities of their 3 sub-groups (Viz., South & East Africa, West Africa, and Central Africa)
- WG-AAM held 3 virtual meetings to discuss on the activities of the group and its 3 sub-groups (Viz., Monsoon Processes and Teleconnections; R2O for monsoon seasons in SE Asia; High Impact Weather Events)
- WG-AMM has had only email exchanges among its members to discuss on their activity plans.

MP was actively involved in the selection and appointment of the 2 new Co-chairs of WG-AFM (Dr. Rondrotiana Barimalala) and WG-AMM (Dr. Ruth Cerezo-Mota) with the support of IMPO. The details of the current memberships of MP and the regional working groups are available at the following links:

- CLIVAR/GEWEX Monsoons Panel (14 members; Female: 7, Male: 7)
  - Co-Chairs: Prof. Leila M.V. Carvalho and Dr. Suryachandra Rao Anguluri
  - <https://impo.tropmet.res.in/wcrp-monsoon.html>;
- Asian-Australian Monsoons (17 members; Female: 6, Male: 11)
  - Co-Chairs: Dr. Gill Martin and Dr. Tieh Yong Koh
  - <https://impo.tropmet.res.in/mpwg-aam-members.html>;
- African Monsoons (21 members; Female: 8, Male: 13)
  - Co-Chairs: Dr. Rondrotiana Barimalala and Dr. Akintomide Afolayan Akinsanola.
  - <https://impo.tropmet.res.in/mpwg-afm-members.html>;
- American Monsoons (14 members; Female: 7, Male: 7)
  - Co-Chairs: Dr. Alice Grimm and Dr. Ruth Cerezo-Mota
  - <https://impo.tropmet.res.in/mpwg-amm-members.html>.

About seventeen (17) members of MP and its regional working groups are early career researchers.

### 1.3.2 Scientific Activities

MP Co-Chair Leila Carvalho attended the Pan-GEWEX- workshop in Monterrey, California, in July 2022. MP activities, including cross-cutting activities, were presented during the event. This workshop was attended by relevant GEWEX panels providing an important forum to discuss scientific achievements and how the MP mission aligns with other panels activities.

*Annalisa Cherchi contributed to a draft white paper on WCRP Global Precipitation Experiment as a representative of MP in GPEX tiger team. MP members also made several suggestions to the draft white paper.*

*Please also see Section 2.2.*

## 2. Achievements for 2022

### 2.1 Workshops

- The MP was actively engaged with the Seventh WMO International Workshop on the Monsoons (IWM-7) in collaboration with the World Weather Research Programme (WWRP), held online during 23-26 March 2022 hosted by the India Meteorological Department (<https://mausam.imd.gov.in/IWM7/>).
  - Several presentations (Invited/Oral) were made at this workshop by members of MP and Working Groups:
    - Leila Carvalho (MP): North and Central South American Low-Level Jets: Mechanisms and Association with Active and Break Phases of the South American Monsoon System
    - Suryachandra Rao A. (MP): SST Fronts/Gradients in the Bay of Bengal and their impact on Indian Summer Monsoon Rainfall at different Time Scales
    - Alice Grimm (WG-AMM): Interannual and Intraseasonal Variability of the South American Monsoon and its combination in the MJO Modulation by ENSO.
    - Hatsuki Fujinami (WG-AAM): Precipitation and its variability in the high elevation area of the Nepal Himalayas.

- Raghavendra Ashrit (WG-AAM): SEEPS and SEDI metrics for verification of model predicted extreme rain over India during recent monsoons
  - Keiran Hunt (WG-AAM): How Interaction between Tropical Depressions and Western Disturbances cause Heavy Precipitation
  - Keiran Hunt (WG-AAM): Modes of Coastal Precipitation over Southwest India and their Relationship to Intraseasonal Variability
  - Donald Sukma Permana (WG-AAM): Evaluation of Multiple Gridded Precipitation Datasets using Gauge Observations over Indonesia during Asian-Australian Monsoon period.
  - Shiromani Jayawardena (WG-AAM): Case Study: Subseasonal Prediction for Disaster Risk Reduction - May 2018 Extreme Rainfall Event in Sri Lanka
- AOGS 2022 Annual Meeting, virtual, 1-5 Aug 2022:
  - On 4 Aug 2022, the WG-AAM convened Session “AS40 - Asian-Australian Monsoon: Linking Research to Operational Needs” comprising a poster and an oral session.
  - 8 papers were presented in total (of which 3 were invited) and about 20 people attended the oral session.
  - This was the modest first session of a planned biennial series by the WG-AAM.
- Dr. Suryachandra Rao A, (MP Co-Chair) and Dr Thea Turkington (MP) actively participated in Third WMO Workshop on Operational Climate Prediction (OCP-3) during 20–22 September 2022 at Lisbon, Portugal.
- Dr. Suryachandra Rao A. (MP Co-Chair) actively participated in the Scoping Workshop on the WMO recognized entity supporting El Niño/La Niña information: Concept and Function, held at IITM during 6-8 December 2022.
- Marcelo Barreiro (WG-AAM) was co-organizer of the Workshop: Advancing subtropical climate dynamics: Diagonal convergence zones, droughts, and floods in past, present and future climates, ICTP virtual Meeting, 1-5 August 2022.
- Members of the working groups are actively involving in the upcoming WCRP OSC-2023.
  - Mouhamadou Bamba Sylla (MP), Benjamin Lamptey (WG-AFM), Tereza Cavazos (WG-AMM) are members of the Scientific Organizing Committee of WCRP OSC-2023.
  - Izidine Pinto (WG-AFM) is a Theme Lead for “Theme 2: Human Interactions with Climate” and a Convenor of the session “S24: Attribution of changes” in WCRP OSC-2023.
  - Mouhamadou Bamba Sylla (MP) is a Theme Lead for “Theme 3: Co-produced Climate Services and Solutions” and a Convenor of the session “S25: Regional climate change” WCRP OSC-2023.
  - Suryachandra Rao A. (MP) and Tereza Cavazos (WG-AMM) are Convenors of the session “S03: Global and regional monsoons” in WCRP OSC-2023.
  - Two Poster Clusters (PC) proposed by members of WG-AFM & WG-AMM and WG-AAM have been accepted by WCRP OSC-2023. Please see Sec 2.2 for the details.

## 2.2 Scientific results from activities

### ***Scientific Results from WG-AAM:***

The working group has organized themselves into subgroups focusing on three science themes and their scientific activities were:

#### 1) Monsoon Processes and Teleconnections (MPT) subgroup:

- A skill evaluation of rainfall from 11 model ensembles against a range of observational datasets was initiated. This highlighted the importance of understanding which observed precipitation dataset (e.g., IMD, GPCP, IITM)

should one believe to validate model skills. There are large differences in interannual variation of ISMR among the different datasets in some years. The number of rain gauges, and whether it is a fixed or varying network, can affect the observational dataset, as well as whether only stations over plains are incorporated; often, hilly stations are eliminated. Decision was to use GPCP and IITM for the model validation because a fixed network is considered better.

2) R2O for monsoon seasons in SE Asia (R2O) subgroup:

- In tandem with the ASEANCOF in May 2022, the subgroup conducted a survey on the plausible development of a monsoon index for South-East Asia.
- 9 out of 10 national meteorological and hydrological services (NMHS) in South-East Asia responded to the survey, 7 of which expressed interest in using such an index to help estimate the onset of monsoon seasons.
- The subgroup followed up with a review of several scientific papers representing various approaches to developing such an index. After discussion, it was decided to first explore a wind-based definition that incorporates regional clustering of rainfall patterns in South-East Asia, drawing upon research published by Lee and McBride (2016).
- The preliminary theoretical development of such a South-East Asian Monsoon Progression Index was completed by November 2022. The index is undergoing tests using NCEP/NCAR Reanalysis (CDAS) and ECMWF Reanalysis 5 datasets as of January 2023.

3) High Impact Weather events (HIW) subgroup:

- The subgroup is focusing on high impact events from recent years for (i) case studies in terms of observations and forecasts (ii) linking operational forecasts to decision making (iii) how monsoon research can best support hazard mitigation. (iv) do forecasting frameworks need to adjust to account for socio-economic /climate change.
- Case studies of high impact events from recent years were reviewed to see how they were observed and predicted, and how decision-making was affected. This includes both wet and dry events.
- It was noticed that sometimes there are large differences between probabilistic forecast warning and deterministic nowcast warning. For Nepal, there is a difficulty because forecasts are not high resolution enough for highly complex orography. Requires sharing between countries with higher resolution forecast systems.
- There were some discussions on how AI or Machine Learning could be used to enhance the warnings, and on the potential for involving social scientists to help understand public response to warnings.

**A new activity of WG-AAM this year was reviewing the 2022 Asian monsoon as experienced in different regions:**

- The group agreed that the summer 2022 was unusual. A meeting was held on 13 October 2022 to discuss how to bring together the group's operational forecasting and scientific research experience to understand this and encourage further work. It was agreed that there were multiple scales involved (both in time and space), leading to a combination of small/short scale features and large-scale situations.
- Potentially two studies may come from this:
  - Overview of this year's Asian Australian monsoon and how it related to large-scale conditions, and how this was manifest in regional monsoons and extreme events

- Forecasting of this year’s Asian Australian monsoon, how this was communicated and what actions were taken (or not taken) as a result.
- A poster cluster PC08: Extreme rainfall and temperatures over India: Forecasting challenge and role of ensemble prediction system with Drs. Raghavendra Ashrit and Partha Mukhopadhyay of WG-AAM as Convenors has been accepted by WCRP OSC-2023.

### ***Scientific Results from WG-AFM:***

With the size and the different aspects that drive the monsoon over different parts of the African continent, the WG-AFM is divided into 3 subgroups (the Western, Central and Southern and Eastern Africa) and their scientific activities were:

- For 2022, a review paper on “Climate Modeling of Precipitation over Africa: Progress, Challenges and Prospects” has been submitted to the International Journal of Climatology. The manuscript reviews our current knowledge of the modeling of the African precipitation and more importantly identifies the gaps that need to be addressed by the research community. The paper is led by the two co-chairs with the co-authorship of the three subgroups from the different African regions (Western, Central and Southern and Eastern Africa).
- The WG-AFM has started to have a short scientific presentation during their bi-monthly meetings. The aim is to discuss new/ongoing research ideas as well as to foster collaboration between the WG members.
- A poster cluster PC07: Advances in monsoon science & prediction: Theory, observations, modelling & climate services with Drs. Neil Hart, Akintomide Afolayan Akinsanola, Ross Dixon, Izidine Pinto & Rondrotiana Barimalala of WG-AFM and Drs. Moetasim Ashfaq, Ruth Cerezo-Mota & Tereza Cavazos of WG-AMM, as Convenors has been accepted by WCRP OSC-2023.

### ***Initiatives from WG-AMM***

- WG-AMM is looking into the feasibility of a second edition of the Workshop and Advanced School on the American Monsoons in 2023 (or 2024). A first request for financial support has been made, and response is awaited.
- Dr Alice Grimm (Co-Chair, WG-AMM) has submitted two activities (a roundtable and a conference on climate change and the monsoon in South America) to be included in the program of the 75th Annual Meeting of the Brazilian Society for the Progress of Science (SBPC), to be held in Curitiba in July 2023.

## **2.3 Scientific capacity building and career support**

- Dr. Suryachandra Rao (Co-Chair) organized AI/ML virtual training workshop for young researchers (Total: 110) in earth sciences at IITM in India during 9-10 May 2022.
- Organized a AI/ML session in earth sciences at international conference on advances in science of the earth: Relevance to the Society during 24-26 November, 2022 at Nanded University, India.



## 2.4 Knowledge exchange

- WG-AAM members participated in the IWM-7 and promoted this workshop among their teams and contacts.
- Several of the WG-AAM members are regular contributors to the Regional Climate Outlook Forums for the Asian-Australian region (SASCOF, ASEANCOF, EASCOF), allowing the group to provide guidance on model strengths and weaknesses and to reach out to stakeholders.
- WG-AAM had their first engagement with the operational community at ASEANCOF-18.
  - Prof. Tieh-Yong Koh presented the objectives and scope of work of the WG-AAM to the participants.
  - Some NMHS representatives shared that rainfall-based monsoon indices were operationally relevant to agriculture and disaster impact mitigation.
  - Koh opined that many weather phenomena spanning a wide range of spatiotemporal scales constitute monsoon (e.g., mesoscale convective system) and non-monsoon (e.g., tropical cyclone) rainfall.
  - A consensus was that a monsoon index based on prevailing seasonal winds with sensitivity to rainfall may be the appropriate hybrid approach to characterize monsoon seasons in South-East Asia.
- WG-AAM members were also active participants in SASCOF-22, which was conducted online during 26-28 April 2022 due to COVID- 19 pandemic.
  - Technical sessions on 26<sup>th</sup> April 2022 considered available seasonal prediction outputs from WMO Global Producing Centers (GPCs) and the Lead Centre for LRF MME, together with presentation of country forecasts and discussions.
  - Climate Services User Forum (CSUF) for Agriculture, Water and Health held on 27<sup>th</sup> April 2022 had user-oriented sessions focused on sharing, understanding and interpreting the seasonal climate outlook.
  - CSUF brought together experts in seasonal predictions and operational users from agricultural, irrigation, disaster risk reduction and health departments of South Asian countries creating a platform for understanding seasonal climate information to make effective use to manage climate risks in the region.
  - A presentation was made at this CSUF by Dr. Shiromani Jayawardena on the topic “Importance of integration of sub seasonal predictions to improve climate services in Sri Lanka - case study: Southwest monsoon 2019”
- Dr. H. Annamalai was invited by the organizers of SASCOF (April 2022) to talk about "Seasonal prediction of south Asian monsoon precipitation: recent advances and roadblocks". He recommended that SASCOF should review their predictions after the summer monsoon of 2022.

## 3. Plans for 2023 and beyond

- Mouhamadou Bamba Sylla (MP), Benjamin Lamptey (WG-AFM), Tereza Cavazos (WG-AMM) will contribute as Members of the Scientific Organizing Committee in WCRP OSC-2023.
- Dr. Suryachandra Rao A. (MP Co-chair) and Tereza Cavazos (WG-AMM) will contribute as Convenors of the session “S03: Global and regional monsoons” in WCRP OSC-2023.
- Izidine Pinto (WG-AFM) will contribute as a Theme Lead for Theme 2: Human Interactions with Climate and also a Convenor of the session “S24: Attribution of changes.” in WCRP OSC-2023.

- Mouhamadou Bamba Sylla (MP) will contribute as a Theme Lead for Theme 3: Co-produced Climate Services and Solutions and also a Convenor of the session “S25: Regional climate change” in WCRP OSC-2023.
- Members of WG-AFM, WG-AMM and WG-AAM will be actively involved in the organization of the 2 poster clusters as convenors at OSC-2023, namely,
  - PC07: Advances in monsoon science & prediction: Theory, observations, modelling & climate services with Drs. Neil Hart, Akintomide Afolayan Akinsanola, Ross Dixon, Izidine Pinto & Rondrotiana Barimalala of WG-AFM and Drs. Moetasim Ashfaq, Ruth Cerezo-Mota & Tereza Cavazos of WG-AMM, as Convenors
  - PC08: Extreme rainfall and temperatures over India: Forecasting challenge and role of ensemble prediction system with Drs. Raghavendra Ashrit and Partha Mukhopadhyay of WG-AAM as Convenors.
- An In-person meeting of MP & WG-AFM members is planned during OSC-2023 at Kigali (7 MP and 12 WG-AFM members have already indicated their availability, with 11 requiring Travel Support)
- WG-AAM’s “R2O subgroup” plans to have a first draft of a manuscript on the development of the South-East Asian Monsoon Progression Index sometime between end-2023 and 2024. This publication will be a collaboration between academic and operational researchers in WG-AAM and other selected scientists.
- WG-AAM’s “HIW subgroup” plans to develop (i) a white paper to quantify the state of forecasting systems (model forecasts to stake holder) across different regions and (ii) a review paper to document the gaps in R & D, R2O and stakeholder perception and how these differ across regions.
- WG-AAM’s “MPT subgroup” aims to produce a review paper on monsoon processes and teleconnections by summarizing existing literature and carrying out a preliminary evaluation of available coupled seasonal predictions and observations.
- WG-AAM members will participate in the EGU General Assembly 2023 session on “Monsoon systems in the past and present and under future climate change” (convened by Dr Andy Turner), and in the WCRP OSC-2023 session on Global and Regional Monsoons.
- The next session of the WG-AAM’s Biennial Series at AOGS annual meetings is targeted to take place in to be held in South Korea.
- WG-AFM’s “Western Africa subgroup” plans:
  - Organize a workshop on climate model output analysis for students and early career researchers. This activity aims to foster the next the generation of African climate scientists and modelers.
  - Build collaborative project ideas based on existing climate model outputs, such as the DYAMOND initiative
- WG-AFM’s “Central Africa subgroup” plans:
  - Completing the already started review paper on “the roles of Central Africa in modulating the regional monsoons over the continent”. This is because Central Africa as a region does not have a separate monsoon but located in between the other regional monsoons as a transition zone.
- WG-AFM’s “Eastern and Southern Africa subgroup” plans to write a paper on monsoon forecast at subseasonal to seasonal time scale.
- WG-AMM will organize two activities (namely, a conference and a round table) on Climate Change and South American Monsoon in the next meeting of the Brazilian Society for the Progress of Science (SBPC) (an annual congress), which will be held in Curitiba in July 2023. (Both activities have been approved).
- Special Issue on Global Monsoons in Meteorological Applications journal with Prof. Leila M.V. Carvalho, Dr. Suryachandra Rao A. and Dr. Akintomide Afolayan Akinsanola as Guest Editors is planned for late 2023/early 2024.



- MP and IMPO have plans to organize a Global Monsoon Research Summit in October-November 2024 at IITM, Pune, subject to availability of funds.
- The Inaugural Issue of Monsoon Matters, the flagship newsletter of IMPO, is planned to be released in March 2023. The theme identified for this issue is "Monsoons in a Warming Climate". Guest Editors proposed for the inaugural issue are Dr. R. Krishnan, Director IITM, Prof. Leila Carvalho, Co-Chair MP and Dr. Akintomide Afolayan Akinsanola, Co-Chair WG-AFM.

#### 4. Articles published in 2022 as part of MP activities (if any)

- An article on "CLIVAR/GEWEX Monsoons Panel and Its Activities" by MP Co-Chairs (**Suryachandra A. Rao, Leila M.V. Carvalho**), and Rupa Kumar Kolli (IMPO), was published in "SPARC Newsletter No.59 – July 2022", highlighting the relation of Monsoon circulations with stratosphere.
- Cavalcanti IFA**, Souza DC, Kubota PY, Coelho CAS, Figueroa SN, Baker, JCA. 2022: The global monsoon system representation in BAM v1.2 and HadGEM3 climate simulations. *International Journal of Climatology*. 42: 8089-8111, <https://doi.org/10.1002/joc.7694>.
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- Rao VB**; Govardhan D; Ashok K; **Kayano MT**; Fernandez JPR; Rosa M, 2022: A unified view of breaks in Indian, North American, and South American summer monsoons. *Theoretical and Applied Climatology*, 19p., <https://doi.org/10.1007/s00704-022-04234-x>
- Silverio, K. C., **A. M. Grimm**, 2022: Southern African monsoon: intraseasonal variability and monsoon indices. *Climate Dynamics*, 58, 1193-1220, <https://doi.org/10.1007/s00382-021-05954-y>
- Donald Sukma Permana**, Supari, Rheinhart CH Hutaaruk, Danang Eko Nuryanto, Nelly Florida Riama, 2023: Evaluation of Multiple Gridded Precipitation Datasets using Gauge Observations over Indonesia during the Asian-Australian Monsoon Period, *Mausam Special Issue on IWM-7* [In press]
- Ankur Srivastava, **Suryachandra A. Rao**, and Subimal Ghosh, 2023: Bay of Bengal upper-ocean stratification and the sub-seasonal variability in convection: Role of rivers in a coupled ocean-atmosphere model, *Mausam Special Issue on IWM-7* [In press]
- Akinsanola A. A., Wenhaji C. N., Ongoma V., Diallo I., Adeniyi M. O., Pokam M. W., Tamoffo A. T., Wainwright C. M., Dixon R. D., Barimalala R., Izidine Pinto, Hart N. C. G., Kilavi M., Faye A., Gudoshava M., Monerie P. -A., Nangombe S., Vondou D. A., Silverio K. C., James R.**, Rupa Kumar Kolli, Rajagopal E. N., Joseph Susmitha, **Lamprey B.**, 2023: Climate Modeling of Precipitation over Africa: Progress, Challenges, and Prospects, *Int. J. Climatology, Vol. 43*. [Under review]
- Shi, Y., **R. Wu**, R. Kripalani, and P.-J. Zhu, 2022: Asian rainfall anomaly patterns associated with interannual variations of early and peak summer rainfall over the Indochina Peninsula. *Int. J. Climatology*, **42(15)**, 7779-7793.
- Wang, Z.-Z., **R. Wu**, and Y.-Q. Wang, 2022: Impacts of the East Asian winter monsoon on winter precipitation variability over East Asia-western North Pacific. *Climate Dynamics*, **58(11-12)**, 3041-3055.

- k) Nash, D., **L. M. V. Carvalho**, C. Jones and Q. Ding, 2022: Winter and Spring Atmospheric Rivers in High Mountain Asia: Climatology, Dynamics, and Variability. *Climate Dynamics*. DOI: 10.1007/s00382-021-06008-z
- l) Gamelin, B., **L. M. V. Carvalho**, and C. Jones, 2022: Evaluating the influence of deep convection on upper tropopause thermodynamics and lower stratosphere water vapor: a RELAMPAGO case study using the WRF model. *Atmospheric Research* <https://doi.org/10.1016/j.atmosres.2021.105986>

## **5. Budget and other needs for 2023 (in CHF)**

*Please keep in mind that the overall budget of CLIVAR is limited and this needs to be distributed between all activities and the SSG meeting.*

MP with support from IMPO finalized and submitted the funding request for an in-person meeting of MP & WG-AFM during OSC-2023 in Kigali, Rwanda for the approval of SSGs of CLIVAR & GEWEX totaling to 10K CHF. *CLIVAR SSG has approved its share of 5K CHF and GEWEX SSG's approval for its share of 5K CHF is awaited.*