Annual report 2022 for Flagship Pilot Study Convection-Permitting Third Pole (CPTP)

Status and progress during the year including scientific highlights, end to end perspective and participants engaged in the project

The Flagship Pilot Study Convection-Permitting Third Pole (CPTP) is the abbreviation for the project "High resolution climate modelling with a focus on mesoscale convective systems and associated precipitation over the Third Pole region", which was endorsed in 2019.

Scientific highlights

1) The CPTP project developed an overview paper that introduces the experimental design and first results from multi-model, multi-physics ensemble simulations of three case studies. The paper has been published in ***Climate Dynamics*** (*Towards Ensemble-Based Kilometer-Scale Climate Simulations over the Third Pole Region*, DOI: 10.1007/s00382-022-06543-3) and led by **Andreas Prein** (NCAR) and **Nicolina Ban** (University of Innsbruck) with contributions from other project members.The five modeling systems used by the project team show high performance across a range of meteorological situations (a monsoon case, a MCS case, and a snowfall event) and are close to having "observational quality" in simulating precipitation and near-surface temperature. This is partly due to the large differences between observational datasets in this region, which are the leading source of uncertainty in model evaluations. However, a systematic cold bias above 2000 m exists in most modeling systems. Model physics sensitivity tests performed with the Weather Research and Forecasting (WRF) model show that planetary boundary layer (PBL) physics and microphysics contribute equally to model uncertainties. Additionally, larger domains result in better model performance. Therefore, the CPTP WRF modeling community has already adapted their modeling strategy and will perform future simulations on the larger model domain (D2). A manuscript with an in-depth analysis of the MCS case led by **Julia Kukulies** (University of Gothenburg) is currently in the second round of revisions for publication in ***Journal of Climate***.

2) A 4-km-resolution convection-permitting model simulation (CPM) and a 28-km-resolution dynamical downscaling model simulation (DDM) using WRF were performed for one summer season (from 1st June to 31st August 2014) to better capture and reproduce the spatial and temporal distribution of precipitation over the TP. The simulations and four other gridded datasets (APHRODITE, GPM, ERA-Interim and ERA5) were evaluated against station observations, in terms of monthly and seasonal mean precipitation amount, frequency, intensity and the diurnal cycle. The six datasets show considerable differences in precipitation amount, which are mainly caused by differences in precipitation frequency. DDM shows substantial advantages over the reanalyses, which significantly overestimate precipitation and show an overly early diurnal peak. However, the excessive daytime convective precipitation and stronger nocturnal precipitation still exit in DDM. The CPM simulation reduces the overestimation of precipitation over the northern and eastern TP and better captures the observed diurnal cycle compared to the DDM simulation, adding value especially by capturing the late afternoon precipitation maximum in June. This work has been published in ***Climate Dynamics*** (How well can a convection-permitting-modelling improve the simulation of summer precipitation diurnal cycle over the Tibetan Plateau? DOI: 10.1007/s00382-021-06090-3) and led by **Zhaoyang Liu** (Fudan University)

3) The sensitivity of MCSs simulated by a global high resolution (~ 10 km), atmosphere-only climate model to different treatments of convection (with and without parametrized convection, and a hybrid representation of convection) have been investigated using the MetOffice Unified Model. The results show that explicit convection (i.e., non-parameterized) can better reproduce the observed pattern of MCS precipitation over the East Asian Summer Monsoon region. In general, explicit convection better simulates the diurnal variability of MCSs over eastern China and can represent the distinctive diurnal variations of MCS precipitation over complex terrain particularly

well, such as the eastern TP and the complex terrain of central-northern China. It is shown that explicit convection is better at simulating the timing of initiation and subsequent propagating features of the MCS, resulting in better diurnal variations and further a better spatial pattern of summer mean MCS precipitation. This work has been published in ***Climate Dynamics*** (Sensitivity of simulated mesoscale convective systems over East Asia to the treatment of convection in a high-resolution GCM, DOI: 10.1007/s00382-022-06471-2) and led by **Puxi Li** (State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences).

4) A 9 km resolution downscaling, using the Weather Research and Forecasting (WRF) model driven by ERA5, was conducted with a large domain (8°–50° N, 65°–125° E) for the period 1979–2019 (WRF9km). Precipitation values from WRF9km and ERA5 were evaluated against satellite observations. The results show that, compared with ERA5, WRF9km captured the climatological summer precipitation over the northwestern Tibetan Plateau (NWTP, 33°-36° N, 80°–90° E) with a much-reduced wet bias. Further analysis shows that the ERA5 overestimation is mainly caused by excessive convective precipitation, likely linked to strong vertical motions over the NWTP induced by an overestimated lower-level southerly wind. This work has been accepted for publication in ***Climate Dynamics*** (Wet bias of summer precipitation in the northwestern Tibetan Plateau in ERA5 is linked to overestimated lower-level southerly wind over the plateau. DOI: 10.1007/s00382-023-06672-3) and led by **Tinghai Ou** (University of Gothenburg). The downscaling products, WRF9km, can be downloaded from the project site (http://biggeo.gvc.gu.se/TPReanalysis/).

End to end perspective

1) *Communications between project members*: In this project, two working groups (WSs) are formed to better coordinate and conduct the overall aims of the CORDEX Flagship Pilot Study CPTP. WG1 focuses on high-resolution modeling, namely the "modeling WG", while WG2 focuses on data (analysis), namely "data WG". Each WG has two co-leaders besides the lead investigator of the CPTP project. Both WGs have their own email list and organize meetings within the group. We also arrange joint meetings that bring all members from the two WGs together when necessary. We have dedicated online storage for minutes of each meeting and detailed documentation, through which all the project members can have a good view of the current status of both WGs. Data from both groups are shared through the Tibetan Plateau Data Center (TPDC, https://data.tpdc.ac.cn/en/). We started an internal project newsletter to bundle information relevant to all project members and to reduce the number of emails. We will restart our seminar series with talks given by project members and external researchers on relevant topics and new studies. This is another opportunity for all project members to discuss specific topics.

2) *Outreach to stakeholders*: 1) 4 publications in internationally renowned journals to present new findings from this project. 2) Organized a session at EGU 2022, 'Meso-scale convection and disturbances in high-mountain environments' https://meetingorganizer.copernicus.org/EGU22/session/43873). 3) Information related to the progress of the project on the dedicated project page (http://rcg.gvc.gu.se/cordex_fps_cptp/) was and will be continually updated monthly. 4) Newly created project page on ResearchGate where other scientists can follow the project and its progress, publications from the project are linked there too (https://www.researchgate.net/project/Convection-Permitting-Third-Pole-High-resolution-climate-modelling-with-a-focus-on-mesoscale-convective-systems-and-associated-precipitation-over-the-Third-Pole-region). 6) Data generated by this project is archived and internally shared through the National Tibetan Plateau Data Center (TPDC: https://data.tpdc.ac.cn/en/), which will be publicly available after the internal evaluation has been finished.

3) *Collaboration with other research groups*: CPTP will collaborate with Cornelia Klein (Centre for Ecology and Hydrology, CEH), who will use CPTP simulations in one work package of the "**Land impacts on mesoscale convective systems**" project, led by Christopher Taylor (CEH). The project, for which Deliang Chen provided a letter of support, has been funded by NERC for a period of three years and started in June 2022. CPTP member Kalli Furtado (UK MetOffice) attended the project kick-off meeting at the end of June and presented an overview of the available data and the timeline of the CPTP project. Julia Curio and Cornelia Klein will coordinate the collaboration.

Participants engaged in the project

Currently, there are 25 international research groups participating in this FPS.

- Deliang Chen, Tinghai Ou, Julia Curio, Hui-Wen Lai, Julia Kukulies and Ruzhen Yao (University of Gothenburg, Sweden), Xuejia Wang (Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, China)
- Shaukat Ali, Global Change Impact Studies Centre, Pakistan
- Cesar Azorin-Molina, Spanish National Research Council, Centro de Investigaciones sobre Desertificación (CIDE-CSIC), Spain
- Danijel Belusic, Rossby Centre, Swedish Meteorological and Hydrological Institute, Sweden
- Rasmus Benestad, Norwegian Meteorological Institute, Norway
- Marie Ekström, Cardiff University, United Kingdom
- Xuejie Gao, Institute of Atmospheric Physics, Chinese Academy of Sciences, China
- Yanhong Gao, Fudan University, China
- William Gutowski, Iowa State University, United States of America
- Sanjay Jayanarayanan, Indian Institute of Tropical Meteorology, India
- L. Ruby Leung and Koichi Sakaguchi, Pacific Northwest National Laboratory, United States of America
- Andreas F. Prein, National Center for Atmospheric Research (NCAR), United States of America
- Madan Lall Shrestha, Nepal Academy of Science and Technology, Nepal
- Hans Christian Steen-Larsen, University of Bergen, Norway
- Shiori Sugimoto, Japan Agency for Marine-Earth Science and Technology, Japan
- Shuyu Wang and Jianping Tang, Nanjing University, China
- Kun Yang, Tsinghua University, China
- Tandong Yao and Xu Zhou, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China
- Xingcao Chen, Penn State University, United States of America
- Tianjun Zhou, Liwei Zou, Zhun Guo (Institute of Atmospheric Physics, Chinese Academy of Sciences), Puxi Li (Chinese Academy of Meteorological Sciences, China Meteorological Administration), China
- Nikolina Ban and Emily Collier, University of Innsbruck, Austria
- Stefan Sobolowski, Lu Li, and Laura Dietrich, NORCE Norwegian Research Centre, Norway
- Kalli Furtado and Peter Sheridan, MetOffice, United Kingdom
- Shabeh Ul Hasson, University of Hamburg, Germany
- Bodo Ahrens, Goethe University Frankfurt, Germany

Summary of each workshop/activity held during the year

Title, date, short description, location, website, links	Responsible person/-s	Funder

5th Modeling Working Group meeting, May 12, 2022, online meeting In the meeting, Andreas and Nikolina presented the main figures and findings from the case study simulations used in the project overview paper which had been submitted in April. Julia Kukulies presented results from an in-depth analysis of the MCS case. Further ongoing in-depth analysis of the three cases was discussed. Planned analyses of the year-long simulations were discussed and will be coordinated. It was also discussed how to proceed with decadal-long simulations.	Andreas F. Prein and Nikolina Ban	TPE STINT

Related publications during the year

Title, journal and link to publication	Author/-s	Date
Towards Ensemble-Based Kilometer-Scale Climate Simulations over the Third Pole Region. **Climate Dynamics**. DOI: 10.1007/s00382-022-06543-3. https://link.springer.com/article/10.1007/s00382-022-06543-3	Prein, A. F., N. Ban, T. Ou, J. Tang, K. Sakaguchi, E. Collier, S. Jayanarayanan, L. Li, S. Sobolowski, X. Chen, X. Zhou, H.-W. Lai, S. Sugimoto, L. Zou, S. u. Hasson, M. Ekstrom, P. K. Pothapakula, B. Ahrens, R. Stuart, H. C. Steen-Larsen, R. Leung, D. Belusic, J. Kukulies, J. Curio, D. Chen	2022-11-04
Characterizing basin-scale precipitation gradients in the Third Pole region using a high-resolution atmospheric simulation-based dataset. **Hydrol Earth Syst Sci**, 26(17): 4587-4601. DOI: 10.5194/hess-26-4587-2022. https://hess.copernicus.org/articles/26/4587/2022/	Jiang, Y., K. Yang, H. Yang, H. Lu, Y. Chen, X. Zhou, J. Sun, Y. Yang, Y. Wang	2022-09-14
Sensitivity of simulated mesoscale convective systems over East Asia to the treatment of convection in a high-resolution GCM. **Climate Dynamics**. DOI: 10.1007/s00382-022-06471-2. https://link.springer.com/article/10.1007/s00382-022-06471-2	Li., P., M. Muetzelfeldt, R. Schiemann, H. Chen, J. Li, K. Furtado, M. Zhuang	2022-09-01
How well can a convection-permitting-modelling improve the simulation of summer precipitation diurnal cycle over the Tibetan Plateau? **Climate Dynamics**. DOI: 10.1007/s00382-021-06090-3. https://link.springer.com/article/10.1007/s00382-021-06090-3	Liu, Z., Y. Gao, Y., G. Zhang	2022-01-25

Planned activities for next year

- Physical CPTP project meeting
- Start decadal simulations
- Continue seminar series
- Continue analyses of the WY2020 simulations
- Work on new proposals associated with the project framework
- Supervise several master theses using the experiments conducted
- Develop stakeholder outreach activities

Additional relevant information

Most of the information related to the progress of this project can be found on the dedicated project page, http://rcg.gvc.gu.se/cordex_fps_cptp/.

Contact person/-s

- Lead investigator: **Deliang Chen** (University of Gothenburg, Sweden)
- Co-leaders for WGI (modelling): **Andreas F. Prein** (National Center for Atmospheric Research (NCAR), USA) and **Nikolina Ban** (University of Innsbruck, Austria)
- Co-leaders for WGII (data): **Tandong Yao** (Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China) and **Hans Christian Steen-Larsen** (University of Bergen, Norway)

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The report is due the 15th of January each year and should be sent to ipoc@cordex.org.