Annual report 2021 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) Based on WRF with a 2 km horizontal resolution, physical processes driving nocturnal precipitation over the Himalayas during the mature monsoon seasons between 2003 and 2010 were investigated. Results show that water vapor was intensively transported to the Himalayas between midnight and morning at the synoptic scale, and then generated precipitation under the influence of mountain topography. A downslope wind, which occurred in association with nocturnal cooling of land surface, enhanced a moisture convergence and caused precipitation over the Himalayan slopes and foothills. Evaporative cooling from the precipitation also contributed to the cooling in the near-surface layer, which assisted an intensification of the nocturnal downslope wind. This work has been published in ***Journal of Hydrometeorology*** (*Cloud-resolving-model simulations of nocturnal precipitation over the Himalayan slopes and foothills*, DOI: 10.1175/JHM-D-21-0103.1), and led by **Shiori Sugimoto** (Japan Agency for Marine-Earth Science and Technology, Japan).

2) The characteristics and structure of mesoscale convective systems (MCSs) induced precipitation are analyzed in the Tibetan Plateau (TP) region based on infrared satellite imagery. Results show that MCSs produced 50%–80% of the total summer precipitation (60%–90% of summer heavy precipitation) in most parts of the boundary of the TP and the surrounding lower-elevation plains, whereas MCSs over the TP account for below 10% of the total summer precipitation (10%–30% of summer heavy precipitation). Results also show that MCSs that produce the largest amounts of heavy precipitation are characterized by longevity and large extents rather than by high intensities. These are mainly located in the populous areas south and east of the TP. This work has been published in ***Journal of Geophysical Research: Atmospheres*** (*The role of mesoscale convective systems in precipitation in the Tibetan Plateau region,* DOI: 10.1029/2021JD035279), and led by **Julia Kukulies** (University of Gothenburg, Sweden).

3) The Added-value of the convection-permitting model (CPM) is analyzed by comparing two sets of the Met Office Unified Model simulations— convection-parameterized version (large-scale model; LSM) and a CPM simulation. Results show that the precipitation and evaporation over the Tibetan Plateau (TP) are significantly improved in the CPM. There is more water vapor flowing out of the TP and less water vapor in the atmosphere converting into precipitation in the CPM, resulting in a reduced wet bias. CPM is free from the constrain of the convection parameterization scheme and therefore depicts the atmospheric water cycle over the TP better. This work has been published in ***Journal of Geophysical Research: Atmospheres*** (*Added value of a convection permitting model in simulating atmospheric water cycle over the Asian Water Tower*, DOI: 10.1029/2021JD034788), and led by **Yin Zhao** (Institute of Atmospheric Physics, Chinese Academy of Sciences, China).

4) Based on exclusive data recorded in the Khumbu valley and the Langtang valley in the Nepalese Himalayas and high-resolution modeling sensitive experiments, the effects of glacier-air interactions on the Himalayan glacier mass balance is investigated. Results show that summer glacier-air interactions enhance precipitation near glacier fronts due to the front-like convergence between cold, dry glacier winds and warm, moist monsoonal flows, while precipitation at glacier-dominated high elevations is suppressed, due to the reduced availability

of water vapor. This work has been published in ***Atmospheric Research*** (*Summer afternoon precipitation associated with wind convergence near the Himalayan glacier fronts*, DOI: 10.1016/j.atmosres.2021.105658), and led by **Changgui Lin** (Swedish Meteorological and Hydrological Institute/University of Gothenburg, Sweden)

5) Based on WRF, at a 0.033° (approximately 3.7 km) horizontal resolution, the added value of kilometer-scale modeling over the third pole region (i.e. Tibetan Plateau) is discussed. The results show that the kilometer-scale horizontal grid spacing simulation by WRF (WRF3) outperforms the ERA5 and the High Asia Refined regional reanalysis (HAR v2) in terms of smaller biases and root mean square errors, as well as higher spatial pattern correlation coefficients for 10-m wind speed and precipitation. Furthermore, WRF3 more realistically reproduces observed night-time precipitation peaks in the interior TP, while ERA5 and HAR v2 show erroneous afternoon precipitation peaks. This work has been published in ***Climate Dynamics*** (*Added value of kilometer scale modeling over the third pole region: a CORDEX CPTP pilot study*, DOI: 10.1007/s00382-021-05653-8), and led by **Xu Zhou** (Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China).

End to end perspective

1) *Communications within 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 also organized and will continue to organize regular seminar series that gather all project members for discussing specific topics.

2) *Outreach to stakeholders*: 1) 5 publications in internationally renowned journals to present new findings from this project. 2) Organized a session in EGU 2021, 'Meso-scale convection and disturbances in high-mountain environments' (https://meetingorganizer.copernicus.org/EGU21/session/40838). 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) 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.

Participants engaged in the project

Currently, there are 24 international research groups participated in this FPS.

- Deliang Chen, Tinghai Ou, Julia Curio, Hui-Wen Lai, and Julia Kukulies (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

Koichi Sakaguchi from Pacific Northwest National Laboratory (United States of America) and Peter Sheridan from MetOffice (United Kingdom) joined the project during the past project year.

Summary of each workshop/activity held during the year

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

4th Modeling Working Group meeting, November 3, 2021, online meeting In the meeting, Andreas and Nikolina presented the status of the case study simulations and an ongoing case study overview paper. Planning for in-depth analysis of the three case studies and how to evaluate model simulation are discussed. Coordination of year-long simulations is also discussed in the meeting.	Andreas F. Prein and Nikolina Ban	TPE STINT
CPTP seminar, 5 October, 2021, online Changgui Lin (University of Gothenburg/SMHI) gave a tall about one of his newly published works: "Summer afternoon precipitation associated with wind convergence near the Himalayan glacier fronts"	Julia Curio	TPE STINT
3rd Modeling Working Group meeting, June 28, 2021, online meeting In the meeting, the status of the coordinated case study simulation is presented by Andreas and Nikolina. Romilly and Hans Christian presented the collected observations over the study region. Requirement of data for model evaluation is then discussed. Year-long simulation is also discussed and the year 2019/20 is chosen as the target year.	Andreas F. Prein and Nikolina Ban	TPE STINT
CPTP seminar, 8 June, 2021, online Reinhard Schiemann from the National Centre for Atmospheric Sciences at the University of Reading, UK, presented results from the COSMIC project, COnvective-Scale Modelling in China.	Julia Curio	TPE STINT
CPTP seminar, 4 May, 2021, online Xu Zhou from Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China, gave a tall about one of his newly published works:" Added value of kilometer-scale modeling over the third pole region: A pilot study"	Julia Curio	TPE STINT
CPTP seminar, 2 March, 2021, online Rasmus Benestad from the Norwegian Meteorological Institute, Norway, gave a talk about a recent study on "Testing a simple formula for calculating approximate intensity-duration-frequency curves" (https://iopscience.iop.org/article/10.1088/1748-9326/abd4ab) The method presented could be used for the analysis of rainfall over the Tibetan Plateau, both from rain-gauges and high-resolution convective-permitting RCMs.	Julia Curio	TPE STINT
CPTP seminar, 9 February, 2021, online Prof Xin Li from the Institute of Tibetan Plateau Research in Beijing talked about the National Tibetan Plateau/Third Pole Environment Data Center (TPDC) he has been leading.	Julia Curio	TPE STINT

Related publications during the year

Title, journal and link to publication	Author/-s	Date
Cloud-resolving-model simulations of nocturnal precipitation over the Himalayan slopes and foothills. ***Journal of Hydrometeorology***, 22, 3171-3188, DOI: 10.1175/JHM-D-21-0103.1. https://journals.ametsoc.org/view/journals/hydr/22/12/JHM-D-21-0103.1.xml	Sugimoto, S., K. Ueno, H. Fujinami, T. Nasuno, T. Sato, H. G. Takahashi	2021-12-01
The role of mesoscale convective systems in precipitation in the Tibetan Plateau region. ***Journal of Geophysical Research: Atmospheres***, 126, e2021JD035279. DOI: 10.1029/2021JD035279. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021JD035279	Kukulies, J., D. Chen, J. Curio	2021-11-25

Added value of a convection permitting model in simulating atmospheric water cycle over the Asian Water Tower. ***Journal of Geophysical Research: Atmospheres***, 126, e2021JD034788. DOI: 10.1029/2021JD034788. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021JD034788	Zhao, Y. T. Zhou, P. Li, K. Furtado, L. Zou	2021-06-26
Summer afternoon precipitation associated with wind convergence near the Himalayan glacier fronts. ***Atmospheric Research***, 259, 105658, DOI: 10.1016/j.atmosres.2021.105658. https://www.sciencedirect.com/science/article/pii/S0169809521002106	Lin, C., K. Yang, D. Chen, N. Guyennon, R. Balestrini, X. Yang, S. Acharya, T. Ou, T. Yao, G. Tartari, F. Salerno	2021-05-01
Added value of kilometer scale modeling over the third pole region: a CORDEX CPTP pilot study. ***Climate Dynamics***, 57, 1673–1687, DOI: 10.1007/s00382-021-05653-8. https://link.springer.com/article/10.1007/s00382-021-05653-8	Zhou, X., K. Yang, L. Ouyang, Y. Wang, Y. Jiang, X. Li, D. Chen, A. Prein	2021-02-01

Planned activities for next year

- Submit a paper to present the whole project
- Submit a paper describing the CPTP modeling experimental design and overview analysis of coordinated experiments for three case studies that were performed during the first project year.
- Analyze and submit papers with in-deep analysis of coordinated experiments for three case studies
- Continue regular seminar series
- Finish the water year 2020 (WY2020; October 2019 to September 2020) test experiments
- Start analyses of the WY2020 simulations
- Start the multiple-year simulations, if possible
- 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/.

- 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)

Contact person/-s

If more space is needed just add rows in the table.
The report is due the 15th of February each year and should be sent to ipoc@cordex.org.