Project: **1064**

Project title: **Atmospheric Drivers of Extreme Flood Events (ADEFE)**

Principal investigator: **Bodo Ahrens**

Report period: **2024-11-01 to 2025-10-31**

Within ADEFE the focus is high-resolution climate modelling and climate impact. ADEFE results are used in the completed DFG project RG “Space-Time Dynamics of Extreme Floods” (SPATE) SP-2 “Atmospheric drivers of extreme floods” and the ongoing projects EU DISTENDER, DFG CRC “The Tropopause Region in a Changing Atmosphere” (TPChange, TRR301) SP-B3 “Tibetan pipe”, and IDEA S4S FS-SP. In this reporting period, the focus has been, i.e. most resources spent, on km-scale climate-like simulations in Europe and the Himalayas-Tibetan Plateau. The former simulations are also a contribution to WCRP MedCORDEX (medcordex.eu) and the latter to the WCRP CORDEX FPS CPTP (rcg.gvc.gu.se/cordex_fps_cptp). The simulations done for TPChange and DISTENDER were done using the new RCM ICON-CLM in convection-parameterized and convection-permitting setups. We also performed test simulations with JSBACH Standalone and contributed to an improved snow formulation. Here, we briefly report on **tasks 1-3** of the 2025 resource requests.

Task 1: km-scale climate simulations over Europe in the MedCORDEX domain for DISTENDER

In this task, within the EU project DISTENDER, the main target is to provide km-scale historical and future climate scenarios using the climate model ICON-CLM with and without local adaptation and mitigation measures. These scenarios have to be provided for different regions (Austria, MA Turino, Spain, nature reserves in Portugal, etc.) in km-scale resolution. All regions are within our formerly used Med-CORDEX domain (which includes, e.g., the Vb-cyclone tracks). Thus, we opted for this large domain with a comparably coarse, still convection-permitting horizontal grid-spacing of 3.9 km (following the arguments in Ahrens & Leps 2021). This resolution is still fine enough to investigate the organisation of mesoscale convective systems (Assmann, 2024). Given the computing resources and the DISTENDER requirements and data availability, this year we extend the temporal coverage of the performed CMIP6 EC-Earth3-Veg simulations using ICON-CLM. The historical simulation extended-back 10 years (excluding 1 year spin-up and 2 years overlap with the performed historical simulation). For the future simulations, we extended SSP1-2.6 and SSP5-8.5 with 5 years to cover the period 2041-2055. Post-processing, evaluation, and data provision (within DISTENDER and to MedCORDEX) and -archiving is still ongoing.

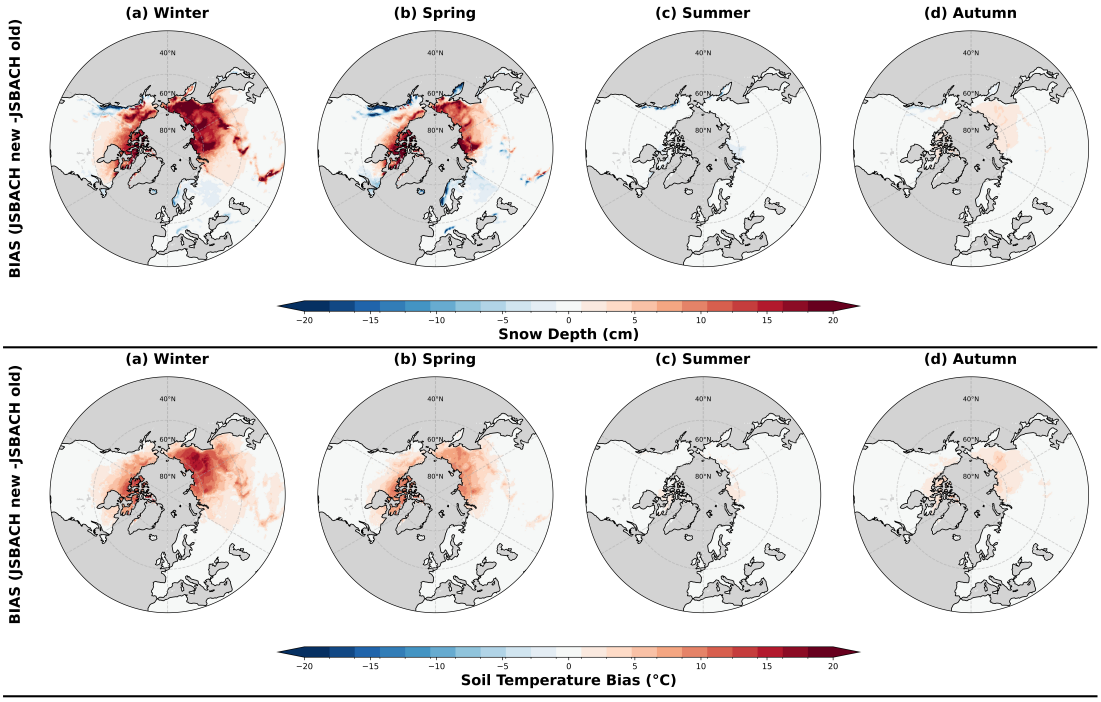
In terms of publication, an article comparing the convection-permitting and statistically downscaled km-scale simulation and multi-scale climate extremes is accepted. An article about the atmospheric blocking and climate extremes in Germany is submitted and currently in review. Furthermore, a couple of articles are in preparation which describe the applied approach for performed dynamical downscaling, and the impact of land-use change on climate and extremes under future scenarios.

Task 2: km-scale climate simulations over the Third Pole and South Asia in the CORDEX domain

The Himalayan Mountains and the Tibetan Plateau, often called the Third Pole region, are critical to numerous synoptic and regional atmospheric processes affecting billions of people. Given the regions complex orography, we utilised the limited-area climate model ICON-CLM at convection-parameterized (Dx = 13 km) and convection-permitting (3.3 km) resolutions. Our previous study has demonstrated the robust performance of ICON-CLM over the Third Pole region in test simulations (Prein et al., 2023). Within the TPChange and CORDEX-CPTP projects, we conducted decade-long simulations along with several annual sensitivity experiments to investigate key processes governing water vapour transport into the upper troposphere and lower stratosphere (UTLS) (Singh et al., 2023; Collier et al., 2024; Singh and Ahrens, 2025) and to explore extreme events (Singh et al., 2025; Singh and Ahrens, in prep.). The overarching objective is to enhance understanding of the coupled dynamics between the Third Pole and the Asian monsoon system, particularly their role in troposphere–stratosphere exchange. Results from the ICON-CLM simulations show a significantly improved representation of water vapour in the UTLS region compared to ERA5, with closer agreement to satellite observations.

Task 3: Standalone CLM and JSBACH simulations with focus on Frozen Soils

We conducted the JSBACH simulations on DKRZ, which initially exhibited a significant cold soil bias caused by issues in the snow scheme. We addressed this by revising the snow aging formulation, which substantially improved the model’s performance, as shown below.



ICON-MPIM: https://gitlab.dkrz.de/icon/icon-mpim/-/merge_requests/958

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