Project: **1064**

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

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Report period: 2023-11-01 to 2024-10-31

Within ADEFE the focus is high-resolution climate modelling and climate impact. ADEFE results are used in the completed and ongoing DFG projects RG "Space-Time Dynamics of Extreme Floods" (SPATE) SP-2 "Atmospheric drivers of extreme floods", CRC "The Tropopause Region in a Changing Atmosphere" (TPChange, TRR301) SP-B3 "Tibetan pipe" and the EU project DISTENDER. 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 (http://www.medcordex.eu) and the latter to the WCRP CORDEX FPS CPTP (http://rcg.gvc.gu.se/cordex_fps_cptp/). Simulations for SPATE were done using the RCM COSMO-CLM. The simulations done for TPCHANGE and DISTENDER were done using the new RCM ICON-CLM in convection-parameterized and convection-permitting setups. The ERA5 downscaling with our coupled ocean-atmosphere RCM-setup COSMO-CLM/NEMOMed/TRIP has been completed. Here, we briefly report on **tasks 1-3** of the 2024 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, Gdansk, Lviw, nature reserves in Portugal, etc.) in km-scale resolution. All regions are within our formerly used MedCORDEX 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, we did this year mainly CMIP6 EC-Earth3-Veg simulations using ICON-CLM for the localized land-use scenarios, spanning the periods 2010-2020 for the historical climate simulation and 2040-50 under the SSPs 1-2.6, 2-4.5, 3-7.0, 5-8.5 for the future climate. For application in impact modelling, the 2-meter temperature and precipitation were bias-corrected. The main results highlight the impact of the integrated local land-use scenarios on the climate change signal (up to 1°C change locally between future and historical periods) compared to IPCC global land-use scenarios. Further, we also performed a reanalysis (ERA5)-driven simulation with the same configuration as a control run. Processing, evaluation, and data provision (within DISTENDER and to MedCORDEX) and -archiving is still ongoing. Publications comparing the convection-permitting and statistically downscaled km-scale simulation and multi-scale climate extremes are in preparation.

Task 2: km-scale climate simulations over Third Pole in the CORDEX CPTP domain for TPChange

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. Due to limited observational data and sparse monitoring stations, Regional Climate Models (RCMs) are vital for assessing climate change impacts in this area. Given the region's complex orography, we utilised the limited-area climate model ICON-CLM at convection-parameterized (Dx = 13 km) and convection-permitting (3.3 km) resolutions. Previous results published in Prein et al. (2023) have shown the good performance of ICON-CLM over the Third Pole region in test cases. Within the TPChange and CPTP projects, we performed this reporting-period decade-long simulations and several annual sensitivity simulations focusing on processes involved in water vapour transport into the upper troposphere/lower stratosphere (Singh et al. 2023, Collier et al. 2024, Singh et al. In prep.) and extremes (Poudel 2024, Singh et al. In prep.). The goal is a deeper understanding of the role of the Third-Pole Asian monsoon interplay in troposphere-stratosphere exchange.

Figure 1 shows an example of an event evaluation of several ICON-CLM simulations driven by the reanalysis ERA5. These references are satellite products (CMOPRH, IMERG) and reanalyses products (ERA5 (~30 km), IMDAA (12 km)). The sensitivity experiments with ICON-CLM are done with 13 km (S3 with only shallow convection parameterisation, S4 with shallow & deep convection parameterisation) and 3.3 km (S1 with shallow-convection parameterisation, S2 without shallow-convection parameterisation) grid-spacing. The km-scale simulation with shallow convection parameterisation performs best. It is interesting to note that the high-resolution reanalysis product IMDAA (which relies on a model with deep convection

parameterisation) performs worst in the precipitation pattern simulation. The ICON-CLM 13-km simulation without deep convection parameterisation performs better than the 13-km simulation with complete convection parameterisation in this region with strong orographic forcing (Singh et al. In prep).

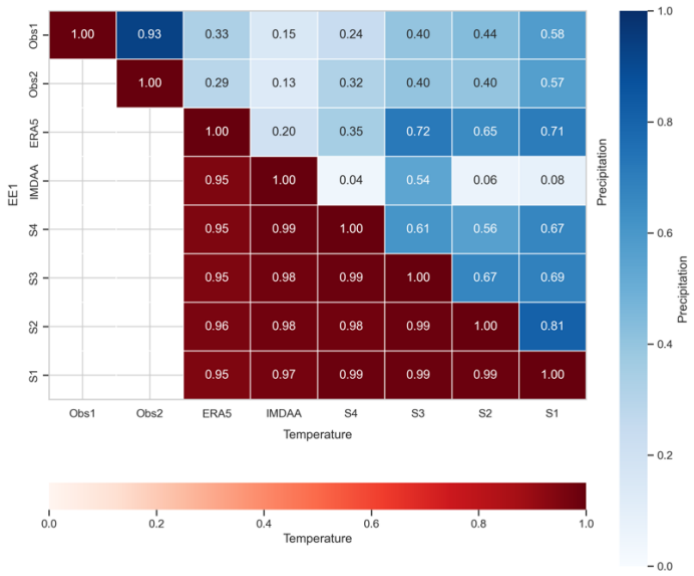

Figure 1 Spatial correlations between different references, reanalyses, and ICON-CLM simulations. See the text for details.

Task 3: post-processing

Within this task, we completed a requested ERA5-driven coupled COSMO-CLM/NEMOMed/TRIP simulation (for SPATE and MedCORDEX), post-processed former simulations, and archived the data in DKRZ's or GUF's long-term storage. Archiving of newer simulations is still ongoing. SPATE and MedCORDEX data have been shared widely and led to first publications (e.g., Merz et al. 2024, Berrocal et al. 2024). Third Pole selected simulation data has also been archived at the central CPTP storage at CAS. CMORization of newer simulations is pending because of not finalised CORDEX standards and rules.

References:

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