Project: **1064**

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

Principal investigator: **Bodo Ahrens**

Report period: 2022-11-01 to 2023-10-31

Within ADEFE the focus is high-resolution climate modelling and climate impact. ADEFE results are used in the 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) 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. The ERA5 downscaling with our coupled ocean-atmosphere RCM-setup COSMO-CLM/NEMOMed/TRIP will go on in the coming weeks (Oct. 2022 proposal's **task 1**). We exploited the project resources also to compile CMIP5-driven coupled MedCORDEX simulations for successful upload to the DKRZ ESGF node. Here, we briefly report on the **tasks 2-4** of the proposal.

Task 2: Convective permitting downscaling of Vb-cyclones

In this task we did km-scale (Dx=3 km) convection-permitting simulations of Vb-events with COSMO-CLM driven by ERA reanalysis data in our extended MedCORDEX simulation domain (which includes the tracks of Vb-cyclones) to study the amplifying impact of convective precipitation on flood generation. Targeting climate time scales we tested the convection-fraction diagnostics of Poujol et al. (2020) against these km-scale simulations and applied the diagnostics to CMIP6 EC-Earth3-Veg driven coupled COSMO-CLM/NEMO-Med performed earlier within ADEFE. The main result is that the mean convective fraction of precipitation of ca. 30% in the historical climate changes to ca. 60% in a simulated future climate end of the 21st century under scenario SSP5-85 for Vb-events. The results lead to two publications (Hamouda et al. 2023, Hamouda et al. subm.).

Task 3: Convection permitting downscaling over Europe

Our task within the EU project DISTENDER is to provide km-scale historical and future climate scenarios with and without local adaptation and mitigation measures. These scenarios have to be provided for different regions (Austria, metropolitan areas Turino, Gdansk, Lviw, nature reserves in Portugal, etc.). All regions are within our formerly used MedCORDEX domain. Thus, we opted for this large domain with a slightly reduced grid resolution of 3.9 km (following the arguments in Ahrens & Leps 2021). Given the compute resources and the DISTENDER requirements, we did this year CMIP6 EC-Earth3-Veg simulations with ICON-CLM for the periods 2010-2020 and 2040-50 under the SSPs 1-2.6, 2-4.5, 3-7.0, 5-8.5. For application in impact modelling, the T2m and precipitation was bias corrected. Aiming a longer and more GCMs additionally statistical downscaling was applied. The

figure illustrates some results.

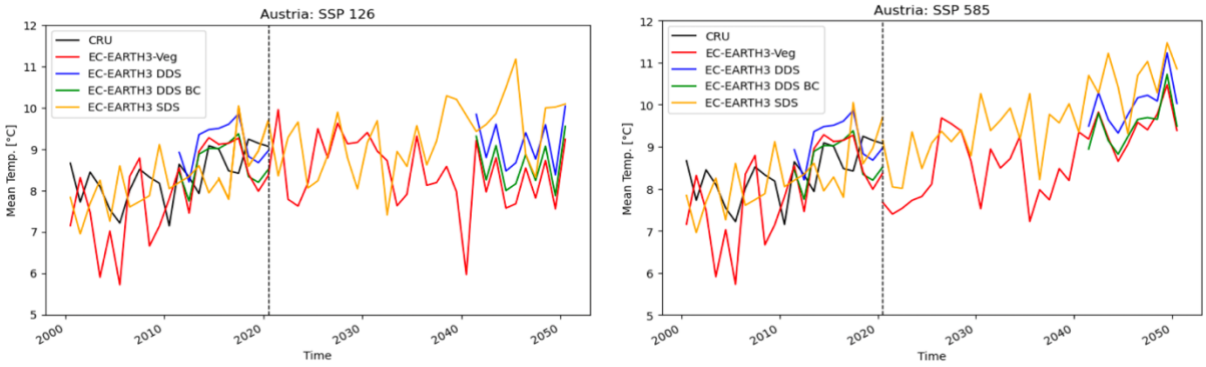

Figure 1 Illustration of DISTENDER results. The panels show spatially averaged T2m time series for region AUSTRIA as simulated by EC-EARTH3-Veg, dynamical downscaling (DDS) with ICON-CLM (Dx=3.9 km), DDS with bias correction and statistical downscaling (SDS) under SSP 1-2.6 & 5-8.5. For reference, the observation-based CRU time series is given in the historical period. DDS was performed in the periods (2010-20, and 2040-50).

Task 4: Convection Permitting Scale model simulation over the Third Pole region

Vertical mixing processes because of deep ABL and convection over high Tibetan plateau and mountain ranges are of scientific interest, but the Third Pole climate change is also of high (supra-)regional impact. Based on event simulations and inter-model comparisons using km-scale resolution (Prein et al. 2023), we optimized our km-scale (grid-spacing 3.3 km) ICON-CLM set-up for the Third Pole domain (changed to radiation scheme ECRad, added vertical layers etc.). One of the found data challenges is that hourly lateral forcing (available from ERA reanalysis but not from CMIP6 models) is key for minimization of lateral spin-up of mesoscale convective complexes even in the very large computing domains used. One-year long ICON-CLM simulations performed very well in evaluation of simulated lightning (Singh & Ahrens, Revised) and precipitation (Yu et al., Cond. Accepted). Planned climate-like simulations are delayed (lack of data storage space) and hopefully possible soon.

References:

Ahrens, B., N. Leps (2021). Sensitivity of Convection Permitting Simulations to Lateral Boundary Conditions in Idealised Experiments. Journal of Advances in Modeling Earth Systems, 13(12) http://doi.org/10.1029/2021MS002519

Poujol, B, Sobolowski, S, Mooney, P, Berthou, S. A physically based precipitation separation algorithm for convection-permitting models over complex topography. Q J R Meteorol Soc. 2020; 146: 748– 761. https://doi.org/10.1002/qj.3706

Publications:

Collier, E., N. Ban, *B. Ahrens, …, P. Pothapakula, P. Singh*, …. The First Ensemble of Kilometer-Scale Simulations of a Hydrological Year over the Third Pole. In prep. for Clim. Dyn.

Hamouda, M.E., C. Czakay, C. Primo, A. Hoff, B. Ahrens (2023) Zu Atmosphärischen Ursachen für Extreme Hochwasserereignisse in Mitteleuropa / On Atmospheric Drivers for Central European Flood Events. Hydrologie und Wasserbewirtschaftung (HyWa), 67, 209–219. DOI: 10.5675/HyWa_2023.5_2

Hamouda, M.E., C. Czakay, B. Ahrens. On Convection During Vb-Cyclone Events in Present and Warmer Climate. GRL. Submitted.

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Singh, P., B. Ahrens Modeling Lightning Activity in the Third Pole Region: Performance of a km-Scale ICON-CLM Simulation. Atmosphere. Revised

Yu, H., A. Prein, … B. Ahrens, ..., P. Singh ... Kilometer-Scale Simulations Can Outperform Satellite-Based Quantitative Precipitation Estimates in Heavy Rainfall Characteristics. BAMS. Cond. Accepted.