Future Projections of extreme events over Central Asia in CORDEX-CORE Simulations

Praveen Rai[1], Daniel Abel[1], Katrin Ziegler[1], Freddy Bangelesa[1], Timo Schaffhauser[2], Jingshui Huang[2], Felix Pollinger[1], Heiko Paeth[1]
[1] Institute of Geography and Geology, University of Würzburg
[2] Chair of Hydrology and River Basin Management, Technical University of Munich

Objective

Assessing the CORDEX-CORE RCMs in terms of extreme precipitation and temperature indices (list see Table 1) such as consecutive dry days (CDD), the representation of heavy precipitation events (R95p), extreme warm days (tx90p), as well as the heat wave duration index (HWDI) over Central Asia.

Background

The European-Union Funded Project "WATER EFFICIENT ALLOCATION IN A CENTRAL ASIAN TRANSBOUNDARY RIVER BASIN (WE-ACT)" aims to demonstrate a Decision Support System (DSS) for water allocation in a Central Asian transboundary river to increase shared benefits and foster the adaptation of water resources management and planning to climate change. The second Work-Package (WP2) of the project is mainly focused on an integrated modeling system to model & assess the water availability for the status quo, for future scenarios of climate change & allocation strategies from the use-cases.

As a part of WP2, we have carried out our analysis related to the projection of extreme climate indices over the Central Asia (study area shown in Fig. 1) to help our partners and stakeholders towards planning and developing a better DSS keeping in mind the climate extremes Central Asian countries will face in future. A total of 10 ensemble members from CORDEX-CORE (list see Table 2) (domain CAS and EAS: overlapping simulations from EAS in our analysis domain) are selected for the projection purpose. The RCP8.5 scenario, which follows a high impact pathway, has been selected to assess the regional climate change in Central Asia. For validation purpose, MSWEP (0.1°) for precipitation and ERA5-Land (0.1°) for temperature are used.

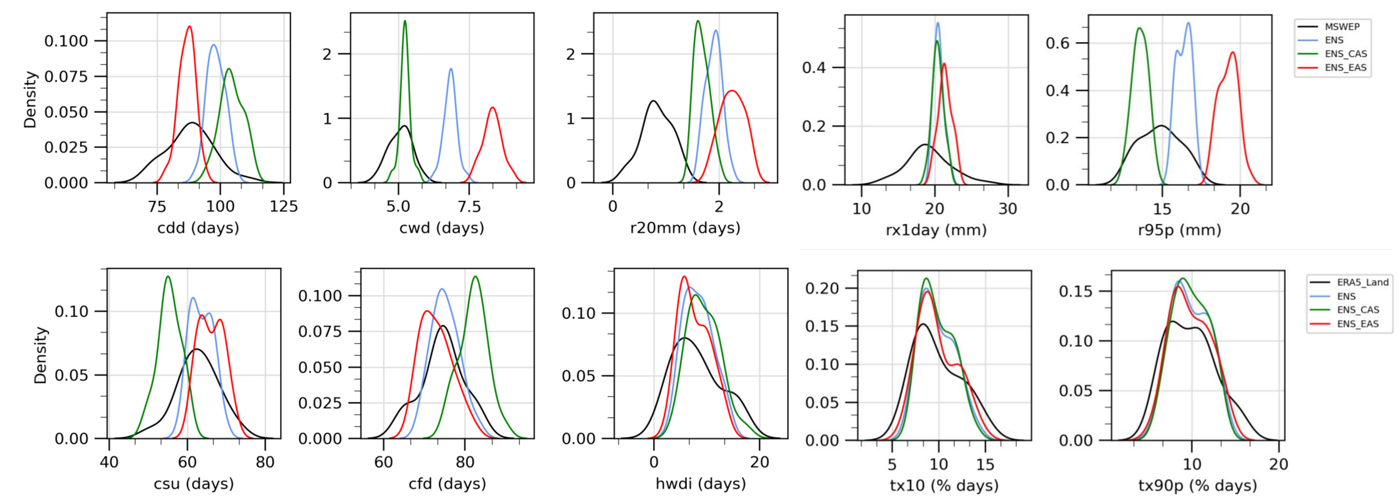

Fig. 3: Probability density function for precipitation (top panel) and temperature (bottom panel) indices for the reference period of 1981-2005.

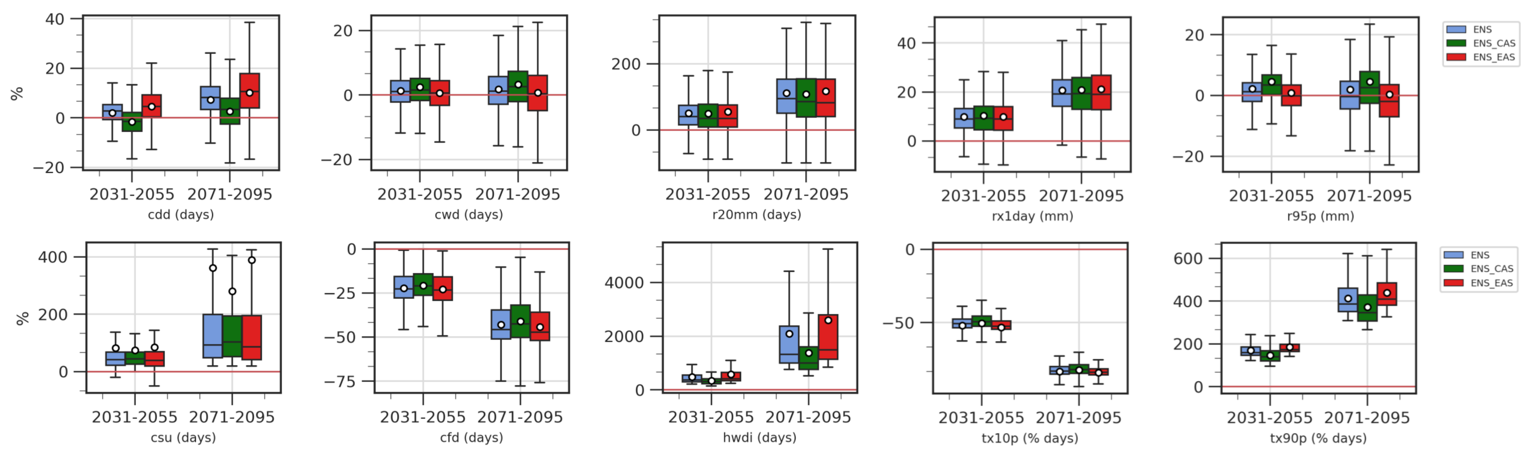

Fig. 4: Box and whisker plot for long-term change (in %) for precipitation (top panel) and temperature (bottom panel) indices for mid (2031-2055) and far (2071-2095) future.

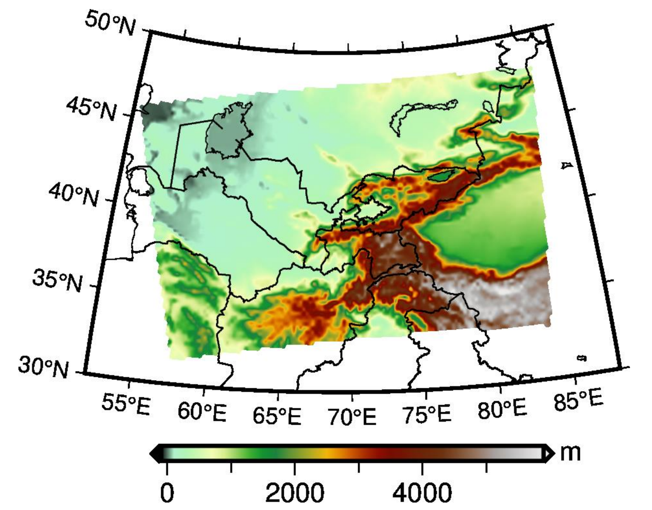

Fig. 1: Study area over which all analysis related to extreme climate indices have been performed.

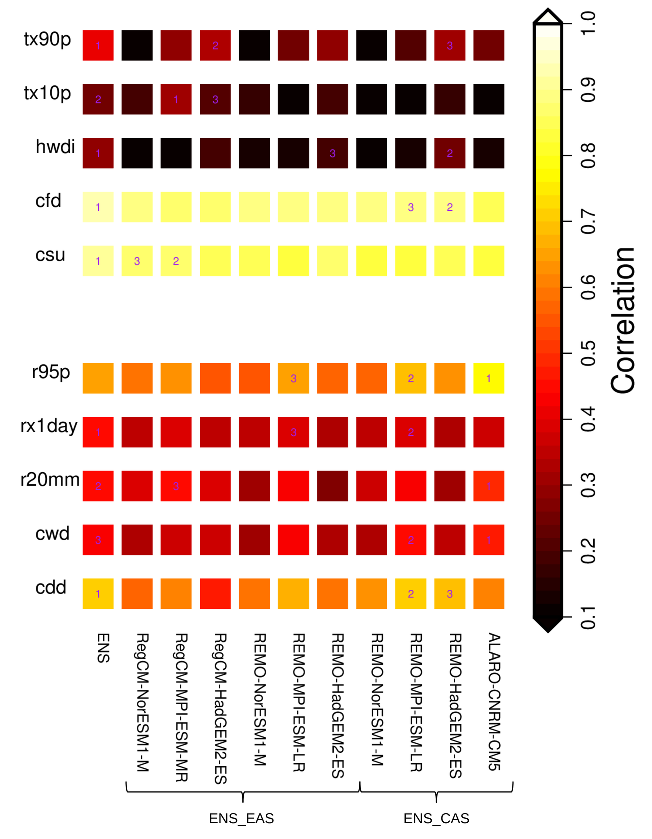

Fig. 2: Spatial correlation coefficient between the ENS and each model and the corresponding validation data for the reference period of 1981-2005 per index. Numbers within the boxes indicate the best performing simulation for each index.

For more information related to the we-act project, please visit the project website:

https://weact-project.eu/

Table 1: Used ECA indices for precipitation and temperature

Precipitation	
CDD	Consecutive dry days index per time period
CWD	Consecutive wet days index per time period
RX1DAY	Highest one day precipitation amount per time period
R20mm	Very heavy precipitation days index per time period
R95p	Very wet days w.r.t. 95th percentile of reference period
Temperature	
CSU	Consecutive summer days index per time period
CFD	Consecutive frost days index per time period
HWDI	Heat wave duration index w.r.t. mean of reference period
TX10p	Very cold days percent w.r.t. 10th percentile of reference period
TX90p	Very warm days percent w.r.t. 90th percentile of reference period

Table 2: Used RCMs

RCMs	Domain/ Resolution	Driving GCMs	References
REMO2015. v1	CAS / 0.22° (Daily)	MOHC-HadGEM2-ES MPI-M-MPI-ESM-LR NCC-NorESM1-M	Jacob et al., 2012
ALARO-0.v1		CNRM-CERFACS-CNRM-CM5	Top et al., 2021
REMO2015.v1	EAS / 0.22° (Daily)	MOHC-HadGEM2-ES MPI-M-MPI-ESM-LR NCC-NorESM1-M	Jacob et al., 2012
RegCM4-4.v0		MOHC-HadGEM2-ES MPI-M-MPI-ESM-MR NCC-NorESM1-M	Giorgi et al., 2012

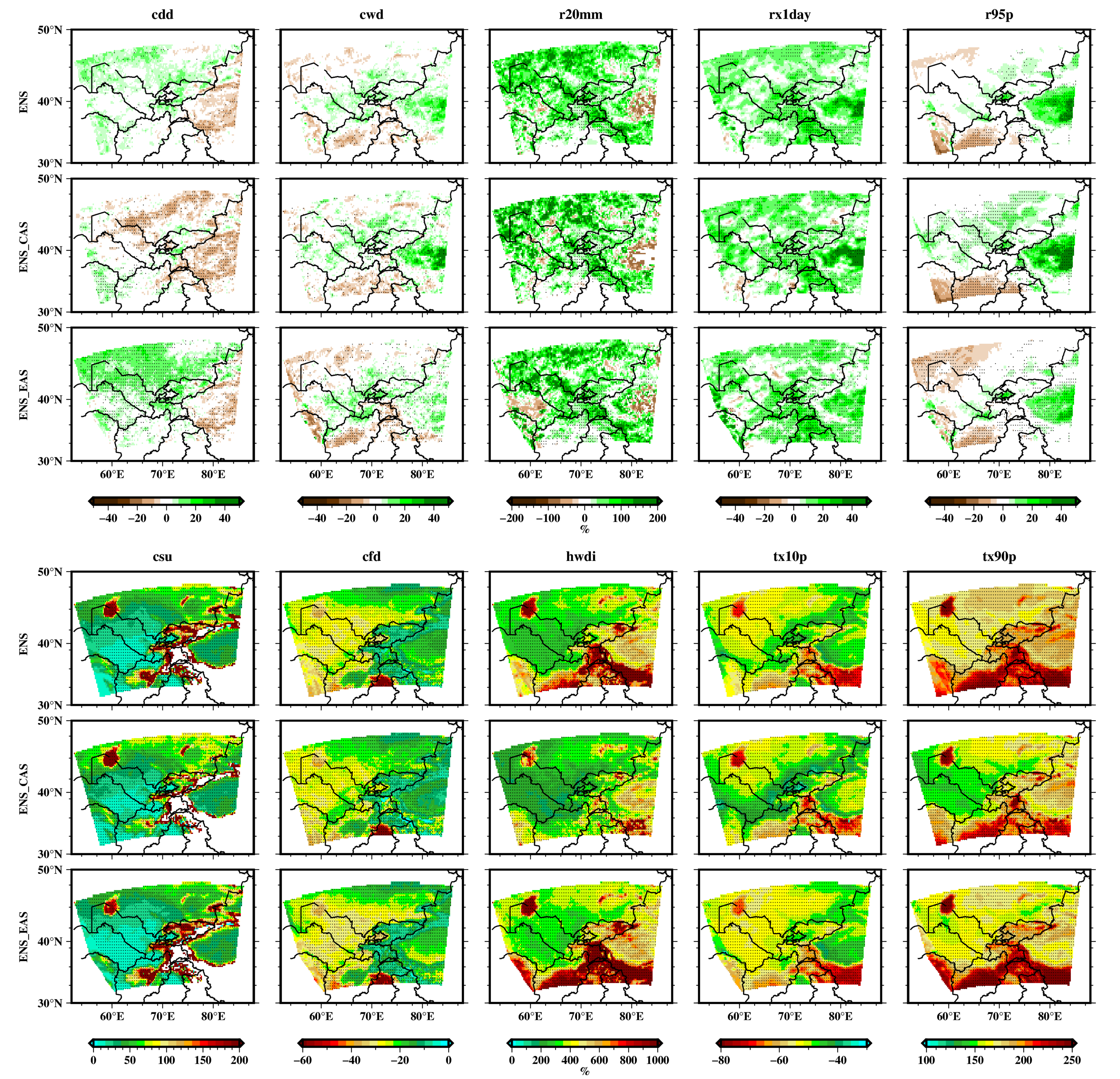

Fig. 5: Projected changes (in %, but all value ranges differ to make the spatial differences better visible!) of the mid-period (2031-2055) compared to the reference period (1981-2005) for ENS (ensemble with 10 members from both CORDEX-CAS and CORDEX-EAS), ENS_CAS (4 members), and ENS_EAS (6 members). Stippling denotes grid points where more than 70 % of the simulations agree on the sign of change.

Main findings and Outlook

- Temperature indices can be separated in bad (percentile based) and good (consecutive counting) performing ones, while for precipitation, all indices are in the middle range (Fig. 2). In most cases, ENS is the best performing one, while ALARO (and REMO with different GCMs for different indices) for precipitation is also good. For temperature, REMO and RegCM are among the best performers.
- Focusing on the temporal agreement between models and the validation data, we can see that the density function of all temperature indices fit much better (for all three ensembles) for the reference period. In contrast, the precipitation indices differ significantly, despite the RCMs being forced with the same GCMs: For all indices, the value range for the observational data is wider, only for cwd and cdd, ENS_CAS or ENS_EAS are fitted to the correct value of maximal density. Also, only for rx1day all three ensembles are similar, all other precipitation indices differ not only in the absolute value but also in the histogram curve (Fig. 3).
- The ensemble differences are also prominent but much smaller in comparison to the predicted changes for the future (Fig. 4). The box-plots indicate an increasing cdd along with more heavy raining events (r20mm) and higher rainfall amounts (rx1day), but no clear trend for cwd and r95p. Overall, all precipitation indices box-plots or at least the whiskers vary around 0, while the temperature indices have mostly higher change values with a clear direction, which additionally intensifies for the far-future period (extremely for hwdi).
- While positive and negative changes can be seen for precipitation indices, temperature indices only have one sign (positive trend for csu, hwdi, and tx90p, negative trend for cfd and tx10p), which are highly significant as nearly all changes can be found in more than 70% of the simulations for the whole domain (Fig. 5).
- An additional bias correction of the models output, which will serve as an input for the hydrological models used in WE-ACT project, is ongoing work and the derived indices can also be analyzed in the future work to make the findings of the presented analysis even more robust.

Funded by the European Union
weact-project.eu