Project: **1418**
Project title: **Coming Decade - Decadal climate predictions for Europe**
Principal investigator: **Christopher Kadow**
Report period: **2025-05-01 to 2026-04-30**

Throughout the reporting period, we mainly utilised HPC Levante at DKRZ for the simulation of version1 of the Coming Decade hindcast ensemble, with global and regional hindcasts (see 1 and 2 below), plus the subsequent analysis with CODES, including development of new analysis plugins (see 3 below). A substantial part of the allocated resources we also used for the improvement of ENSO representation in ICON XPP (see 4 below).

1) Global hindcasts with ICON XPP (UHH)

In the second year we continued to work towards the version1 of the Coming Decade ensemble hindcasts, based on ICON XPP "target configuration" R2B5L130/R2B7L72. Due to the high throughput in terms of disk space (>1PB in total) we planned and used rolling batches of 5 start years each during the production of the whole version1 hindcast set including global and regional hindcasts. Due to delays in the ICON XPP development, the production shifted into 2026 so that we applied for a top up of resources. Overall, we utilised >90% of allocated resources in each quarter in terms of CPU and disk space. Analysis of the global hindcasts revealed good skill in terms of 2m temperature (Figure 1a) in the tropics, but not in the North Atlantic region. To solve this issue, we performed additional tests with the "fast track" configuration R2B4/R2B6 of ICON XPP and HDint, which showed good skill globally as well as in the North Atlantic region (Figure 1b). Together with colleagues from the ICON XPP development group we were able to trace the issue back to an incorrect setup of HDext in ICON XPP during restart that had a substantial impact on the freshwater budget. This issue has been eventually solved in 2026, so that the planned version2 of the Coming Decade hindcasts can go ahead with a correct freshwater budget.

2) Downscaling and regionalisation (KIT)

We have implemented a dynamical downscaling framework with ICON to refine global decadal hindcasts produced by colleagues at the University of Hamburg using ICON XPP. To date, the first version of the regional-scale decadal hindcasts has been successfully generated, and the resulting datasets are now archived and ready for evaluation. In detail, global decadal hindcasts at 80 km (ICON-R02B05) grid spacing, initialized on 1 November each year from 1960 to 2023, were dynamically downscaled over Europe to 20 km (ICON-R02B07) grid spacing, and further refined to 5 km (ICON-R02B09) grid spacing over central Europe. The regional hindcasts were produced for three ensemble members at 20 km grid spacing and one member at 5 km, with lead times of up to five years. A comparison of seasonal mean total precipitation from the global (80 km) and regional (20 km) hindcasts against E-OBS version 32.0e for lead year 2-5 has been conducted (Figure 2). The regional hindcasts generally exhibit a reduction in both the magnitude of relative biases and the Root Mean Square Error (not shown) across most parts of Europe compared to the global hindcasts in all four seasons. This improvement provides encouraging evidence for the development of actionable decadal regional climate information over Europe, thereby facilitating more reliable near-term climate risk assessments.

3) CODES (DKRZ)

The focus of the second year of CODES was to adapt the ForecastBackend plugin, as well as all the plugins that are dependencies of it, such as Terciles, LeadtimeSelect, ProblEMS, Recalibration and CVPrepare to be interoperable with decadal datasets following both CMIP5 and CMIP6 standards. This includes the design and creation of testing routines for each plugin that can be run in an automated fashion, for example using GitLab CI/CD Pipelines. Additional focus was the provisioning of decadal datasets created by our project partners on the CODES platform, which involved the standardisation of these datasets (CMORization), among other steps. Said datasets were used in testing the compatibility with the ForecastBackend plugin chain. Till March 2026 a total number of 2780 plugin runs were initiated, out of which 1638 were finished successfully. Further work was the continued refactoring of the plugin codebase, which involved substantial improvements across code structure, performance, debugging, feature enhancements, and other development areas.

4) Improvement of ENSO representation in ICON XPP (MPI-M)

During the current reporting period, the work advanced from atmosphere-only tuning to a full evaluation of the optimisation framework in the coupled ICON XPP Earth system model. The six key atmospheric parameters identified previously were successfully applied in coupled simulations, leading to systematic improvements in ENSO characteristics, in terms of climatology, performance, feedback, and teleconnections (Figure 3). The results demonstrate that targeted parameter optimisation can substantially improve ENSO performance even at low model resolution. A major milestone of this reporting period is the dissemination of the results through a peer-reviewed publication currently under revision in GMD: Yu et al. (2026), "A Systematic Atmospheric Parameter Optimization method to Improve ENSO Simulation in the ICON XPP Earth System Model" (https://doi.org/10.5194/egusphere-2025-5736). The optimised parameter sets have also been tested in the ICON XPP development configuration and show consistent improvements, indicating their potential relevance for future CMIP7 simulations. Overall, the project has progressed from methodological development to coupled-model validation and scientific publication, providing both practical tuning strategies and new insights into the limitations of ENSO representation in climate models.

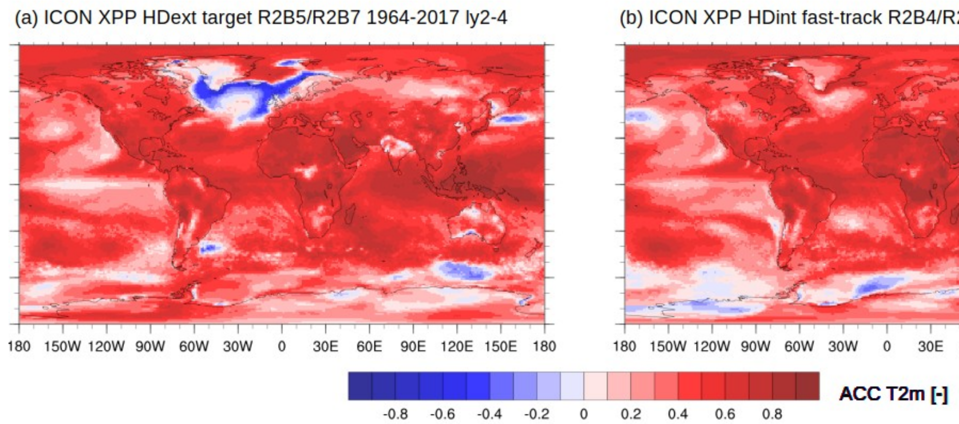

Figure 1: Anomaly correlation coefficients for 2m temperature with reference to ERA5 for lead years 2-4 in time period 1964-2017 for (a) version1 hindcasts with ICON XPP HDext R2B5/R2B7, where we discovered the bug in the freshwater budget during restart, and (b) hindcasts with ICON XPP HDint R2B4/R2B6 and correct freshwater budget.

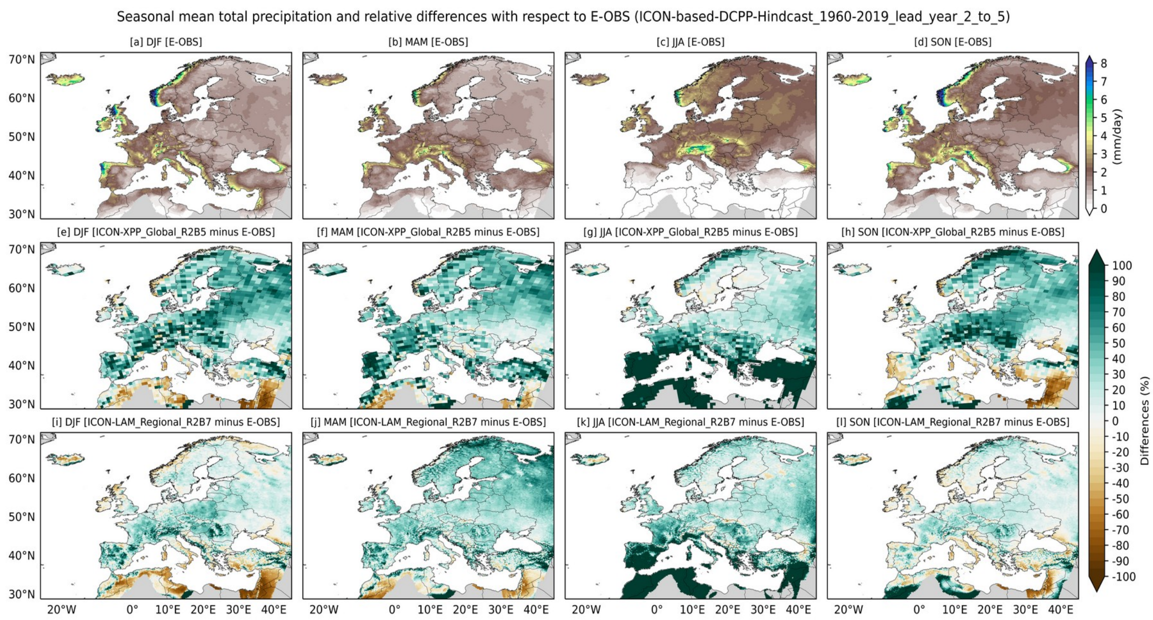

Figure 2: (a-d) Seasonal mean total precipitation over Europe in E-OBS, Relative differences with respect to E-OBS of seasonal mean total precipitation averaged 1965-2024 over lead years 2-5 from (e-h) global hindcasts, and (i-l) regional hindcasts.

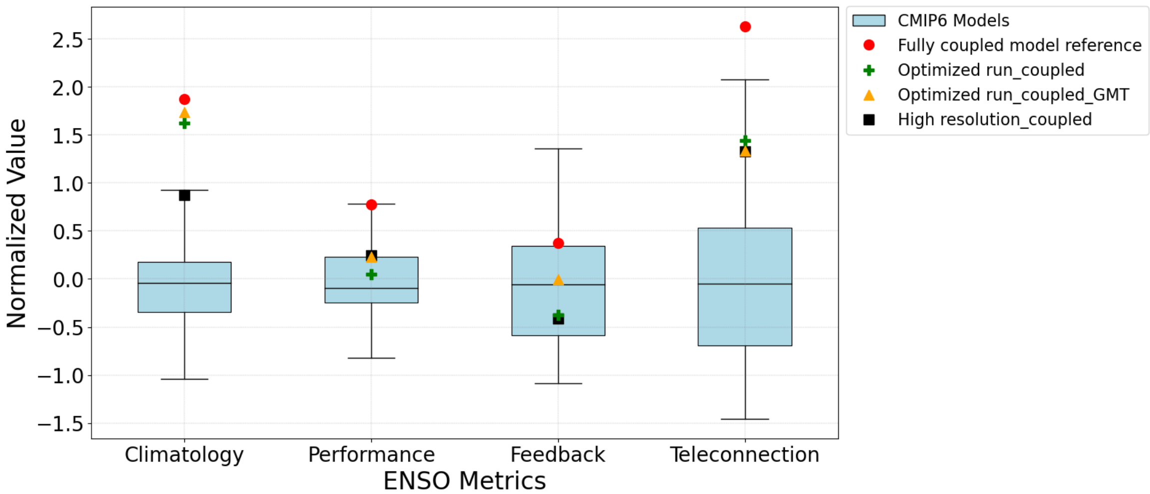

Figure 3: Summary of ICON XPP model performance across different categories of ENSO metrics, comparing the fully coupled reference run (red point), optimized coupled-model experiment (green cross), fully coupled high resolution run for ICON XPP model (black rectangle), optimized coupled-model experiment with global mean temperature (GMT) correction (yellow triangle).