Climate Limited-area Modelling Community

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Towards a limited-area climate ensemble prediction system for decadal forecasts

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Within the German BMBF funded program MiKlip one main focus is on the decadal climate prediction on the regional scale. One general goal of the project LACEPS (A Limited-Area Climate Ensemble Prediction System) within MiKlip is the development of a limited-area ensemble prediction system for decadal forecast for the region of Europe employing the regional climate model COSMO-CLM. The ensemble should cover the spectrum of all possible outcomes given by the uncertainties in the model itself and in its input data with respect to the target parameters 2 m air temperature and precipitation. Three strategies are the base for the ensemble, the perturbation of initial conditions, model physics, and boundary data conditions and data.

COSMO-CLM Runs

All model simulations of LACEPS performed with COSMO4.8-clm17 on the Euro-CORDEX model domain using a horizontal grid resolution of 0.22° (approx. 25 km).

Hindcast Simulations

- Hindcast simulations for the perturbation strategies "Initialization" and "perturbation of physics"
- Driving data: MPI-ESM-LR decadal runs, baseline0 and baseline1
- Initial values for temperature/humidity in the soil and at soil surface: taken from ERA40 and ERA-Interim driven evaluation runs
- MPI-ESM-LR results for post processing and comparison purposes

Perturbation strategy „initial conditions"

Ensemble of 10 COSMO-CLM runs driven by 10 MPI-ESM-LR runs of baseline0 with different starting dates
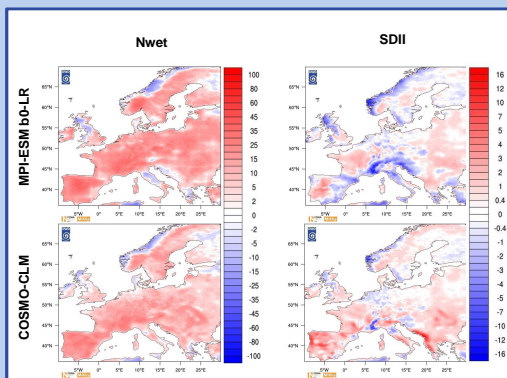
Ensemble mean bias (EMB) for the number of wet days Nwet (left column) and the simple daily intensity index SDII (mean precipitation amount of wet days, right column) for the MPI-ESM-LR data of baseline0 (top row) and the results from COSMO-CLM (bottom row) for winter (DJF) with respect to the perturbation strategy "initial conditions", considered time period: 2002-2005
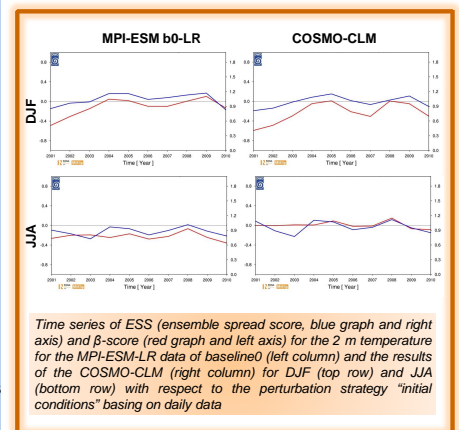
- Spread (standard deviation) of 2 m temperature in the order of the mean forecast error (ESS ≈ 1) in both model ensembles
- Spread slightly higher in COSMO-CLM during summer
- Temporal development of β-Score (deduced from form parameters of the Talagrand diagram) similar to ESS
- Ensemble mean bias in MPI-ESM-LR in winter positive and in summer negative → too small annual cycle of 2 m temperature (not shown here)
- Underestimation of annual cycle of 2 m temperature in COSMO-CLM as well due to the strong coupling to the driving model, but on a more negative ensemble mean bias (not shown)
- Less overestimation of number of wet days (Nwet) in COSMO-CLM than in MPI-ESM in most parts of Europe
- Regions of underestimation of SDII in MPI-ESM less pronounced or even overestimated in COSMO-CLM

Time series of ESS (ensemble spread score, blue graph and right axis) and β-score (red graph and left axis) for the 2 m temperature for the MPI-ESM-LR data of baseline0 (left column) and the results of the COSMO-CLM (right column) for DJF (top row) and JJA (bottom row) with respect to the perturbation strategy "initial conditions" basing on daily data

Comparison of perturbation strategies „initial conditions" and „model physics"

Ensemble of 10 COSMO-CLM runs driven by 10 MPI-ESM-LR runs with 10 COSMO-CLM runs with perturbed physics driven by 1 MPI-ESM-LR run (all baseline1)

Temperature: Initial conditions: Bias: Summer: strong negative bias; winter: slightly negative bias
Spread: Covers the range of observational data (E-OBS 8.0)
Model physics: Bias: Bias characteristics maintained
Spread: Large percentage of observational data outside of the ensemble results

SDII: Bias: Positive, in winter higher than in summer, when convective conditions prevail and a decoupling of COSMO-CLM from the driving MPI-ESM is supported
Spread: Ensemble does not cover the spread resulting from the observational data

Conclusions and Outlook
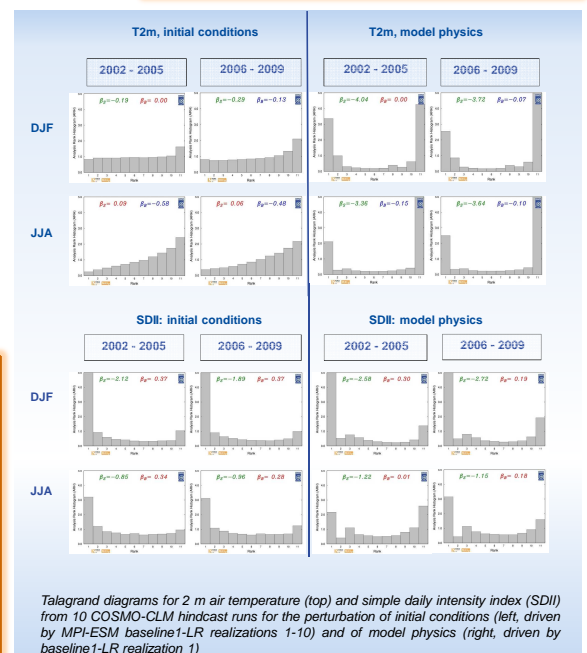
Perturbation of initial conditions:
- Spread of 2 m air temperature sufficiently large
- Spread in SDII inadequately

Perturbation of model physics
- Spread of 2 m air temperature very small under the perturbations considered up to now, much smaller than in the perturbations strategy „initial conditions"
- Spread of SDII inadequately, a change in the strategy may be necessary, e.g. perturbing more than one tuning parameter

Perturbation of boundary data:
COSMO-CLM simulations are planned with respect to this perturbation strategy

Talagrand diagrams for 2 m air temperature (top) and simple daily intensity index (SDII) (bottom) from 10 COSMO-CLM hindcast runs for the perturbation of initial conditions (left, driven by MPI-ESM baseline1-LR realizations 1-10) and of model physics (right, driven by baseline1-LR realization 1)