Development of a limited-area climate ensemble prediction system for decadal forecasts

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COSMO-CLM User Seminar
06 March 2013
Deutscher Wetterdienst, Offenbach am Main

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MiKlip – Mittelfristige Klimaprognosen (Decadal Climate Prediction)

➔ will develop a system for climate predictions for up to a decade ahead

numerical prediction models will be started from the recently observed climate state in order to forecast the near future of both natural variability and anthropogenic induced climate change

➔ decadal predictions will be improved during the 4 years lifetime of the project

➔ final goal: to establish a world-leading decadal climate prediction system which can be applied by an operational agency such as e.g. DWD

➔ programme funded by the German Federal Ministry of Education and Research:

  ➔ 35 projects

  ➔ 71 principal investigators, 83 payed positions

    ➔ in total more than 150 people involved

  ➔ at 25 German institutions at 20 locations

  ➔ project funding time: September 2011 to August 2015

  ➔ project budget: about 20M €

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Decadal
Climate Prediction
BMBF

MiKlip

http://www.fona-miklip.de/en/index.php

MiKlip – Mittelfristige Klimaprognosen (Decadal Climate Prediction)

programme subdivided into 5 modules:

➔ Module A: Initial Conditions and Initialization (provide initial conditions for the ocean, sea ice, land, and aerosols, improve these initial conditions, provide initialization procedures)

➔ Module B: Processes and Modelling (assess the effects of enhanced resolutions and of parameterizations and numerics, investigate mechanisms of decadal variability, coupling of additional climate subsystems)

➔ Module E: Validation (generation, supply, and application of new observational data products, development of process-oriented validation tools of the MiKlip system)

➔ Module D: Synthesis (constructing a decadal ensemble prediction system, integrating model improvements into the prediction system, constructing an evaluation framework, dissemination of prediction results, MiKlip coordination)

➔ Module C: Regionalization

  ➔ impact of regional scale processes on global predictability (2-way coupled simulations)

  ➔ downscaling of global climate prediction for northern/tropical Africa

  ➔ downscaling of global climate prediction for Europe

  ➔ develop a regional decadal climate ensemble prediction system for Europe

MiKlip – Module C (Regionalization) climate prediction for Europe

➔ Module D project FLEXFORDEC
   ➔ results from coupled MPI-ESM-LR/MPIOM for each decade from 1961-1970, 1971-1980, …, 2001 – 2010;
   ➔ 10 realizations each (10 different initialization dates for GCM runs) as data for RCM downscaling experiments

➔ downscaling runs performed with COSMO-CLM in Module C:

	r1	r2	r3	r4	r5	r6	r7	r8	r9	r10
decade 1961 – 1970	DWD	KIT	DWD	KIT	DWD	KIT	DWD	KIT	GUF	GUF
decade 1971 – 1980	DWD	KIT	DWD	KIT	DWD	KIT	DWD	KIT	GUF	GUF
decade 1981 – 1990	DWD	KIT	DWD	KIT	DWD	KIT	DWD	KIT	GUF	GUF
decade 1991 – 2000	DWD	KIT	DWD	KIT	DWD	KIT	DWD	KIT	GUF	GUF
decade 2001 - 2010	DWD	DWD	DWD	DWD KIT	DWD	DWD KIT	DWD	DWD	DWD	DWD

projects working on the regional decadal climate ensemble prediction system (1):

➔ Regio_Predict (IMK, KIT Karlsruhe)

    ➔ coordination of module C

    ➔ elaboration of and adaptation to standards (e.g. the output format of data
       provided on the project server)

    ➔ define predictable parameters on regional scales and on decadal time scales (long term
       anomalies, (e.g.droughts) anomalies in the frequencies of events (e.g. hot days, days with
       precipitation exceeding thresholds))

    ➔ estimate regional predictive skill of decadal predictions (global and regional predictions)

    ➔ determine the added value of regional predictions (regional versus global prediction)

       close collaboration with other module C projects
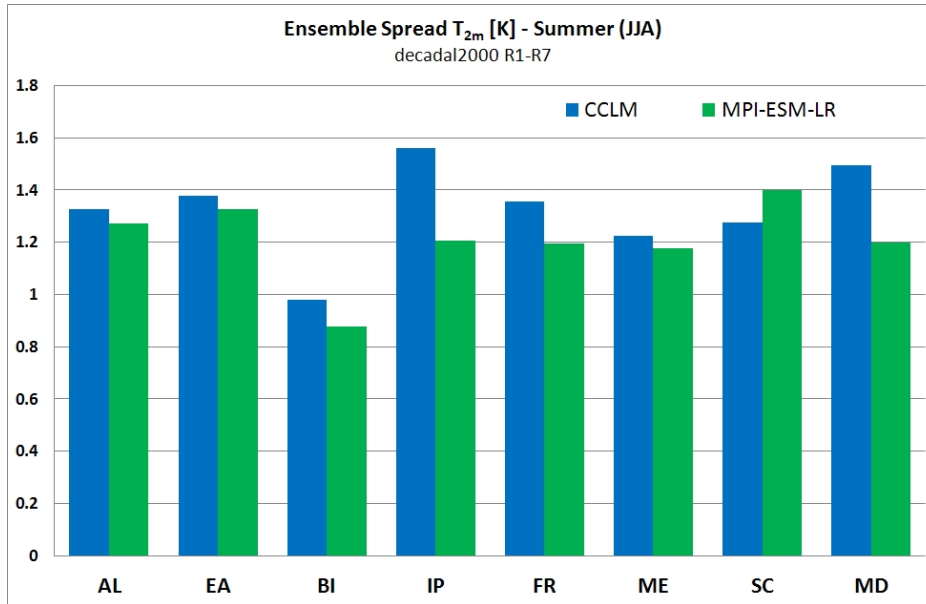   and with module E (development of validation tools)

MiKlip – Module C: Regio_Predict
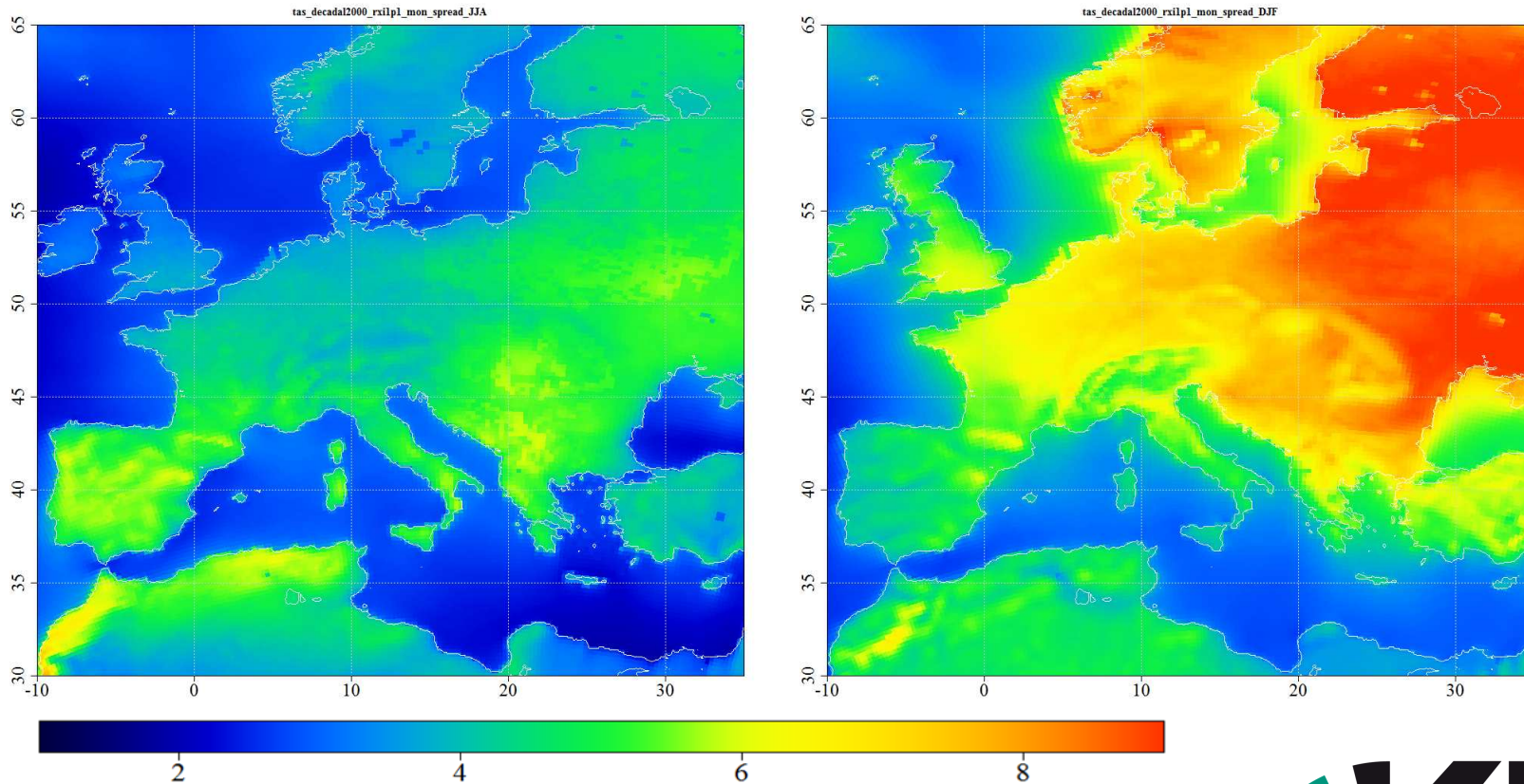
ensemble spread of COSMO-CLM hindcast runs
for the decade 2001 – 2010, realization 1 to 7,
summer (left) and winter (right)

MiKlip – Module C: Regio_Predict
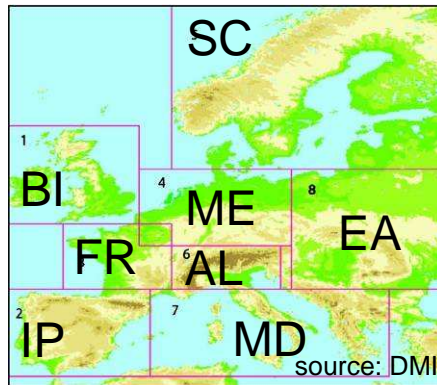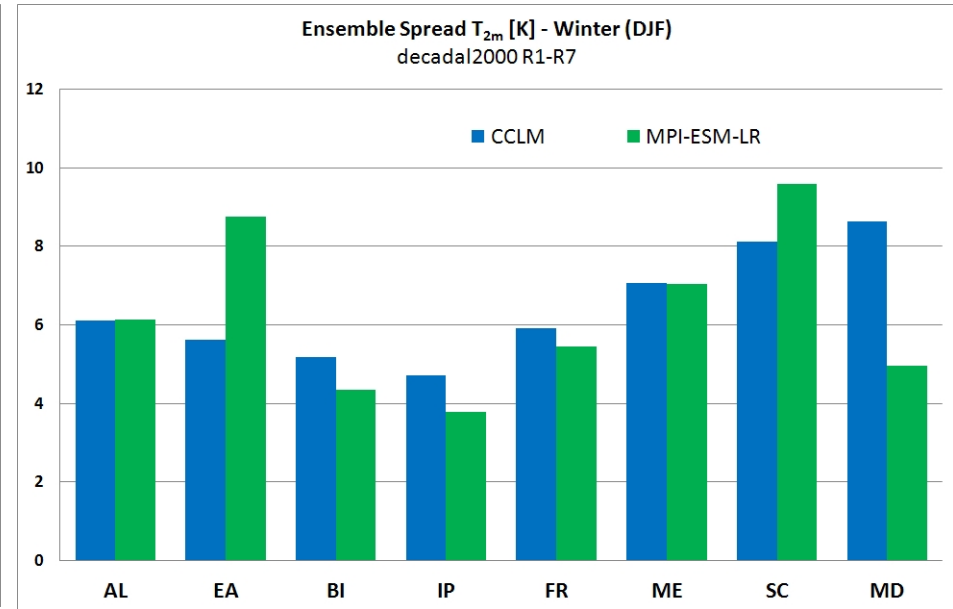
ensemble spread of 2-m-temperature of global (MPI-ESM-LR) and regional (CCLM) climate model for summer and winter season in the PRUDENCE regions

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Climate Limited-area
Modelling Community

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DWD

MiKlip – Module C (Regionalization) climate prediction for Europe

projects working on the regional decadal climate ensemble prediction system (2):

➔ DecReg (joint research project of KIT Karlsruhe, University of Frankfurt, others)

➔ provide optimized regional decadal forecasts by improving the initial- and boundary value treatment for the regional applications

➔ DecReg (University of Frankfurt)

➔ COSMO-CLM decadal hindcasts for Europe (contribution to the regional decadal ensemble prediction system)

➔ improvement of estimates of soil parameters and soil initial state by ensemble data assimilation methods (EnKF, LETKF)

➔ data assimilation in offline TERRA-ML in single-grid-point mode

➔ parameter estimation tests

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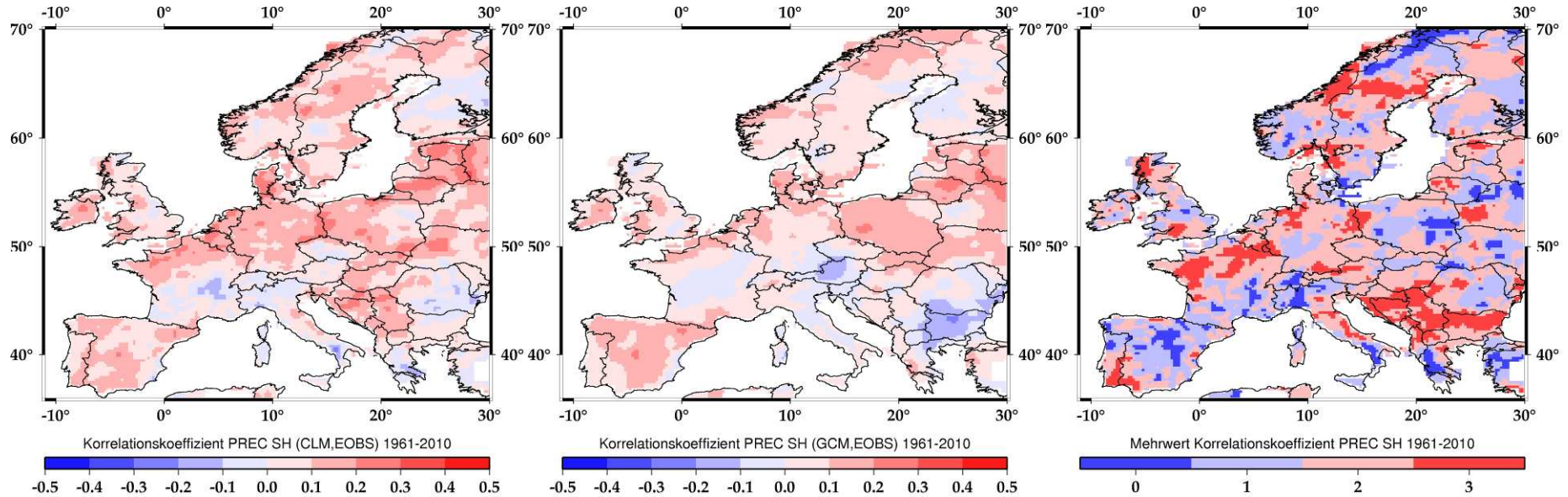# MiKlip – Module C (Regionalization) climate prediction for Europe

projects working on the regional decadal climate ensemble prediction system (3):

➔ DecReg (IMK, KIT Karlsruhe)

  ➔ COSMO-CLM decadal hindcasts for Europe (contribution to the regional decadal
    ensemble prediction system), high resolution simulations for Central Europe

  ➔ modeling and initialization of soil moisture and soil temperature

  ➔ application of

    ➔ quality control (correlation, RMSE, …)

    ➔ added value analysis

    ➔ ensemble analysis (forecast skill, reliability, resolution, …)

  ➔ analysis how to achieve forecast skill

    ➔ metrics

    ➔ resolution (spatial and temporal)

    ➔ variables, climate indices, …

  ➔ focus on extreme value analysis

  ➔ recalibration (implementation of Decadal Bayesian Model
    Averaging in FORTRAN on parallel architecture)

MiKlip – Module C: DecReg (IMK, KIT Karlsruhe)

Korrelationskoeffizient PREC SH (CLM,EOBS) 1961-2010

Korrelationskoeffizient PREC SH (GCM,EOBS) 1961-2010

Mehrwert Korrelationskoeffizient PREC SH 1961-2010

summer time precipitation 1961 – 2010, 3 ensemble members

left: mean anomaly correlation coefficient COSMO-CLM/E-OBS

center: mean anomaly correlation coefficient MPI-ESM-LR/E-OBS

right: potential added value: number of CCLM members showing large correlation than GCM, n>=2 higher correlations of CCLM members

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MiKlip – Module C (Regionalization) climate prediction for Europe

projects working on the regional decadal climate ensemble prediction system (4):

➔ LACEPS: A Limited-Area Climate Ensemble Prediction System (DWD)

    ➔ development of the ensemble climate prediction system for decadal forecast for Europe using the regional climate model COSMO-CLM

    ➔ LACEPS should span the space of all possible outcomes given by the uncertainties in the model and its input data with the aim to ascertain the likelihood of each outcome

    ➔ perturbation strategies for the ensemble prediction system transferred from probabilistic weather forecast:

        ➔ initial conditions

        ➔ model physics (mainly variation of parameterization constants)

        ➔ boundary conditions (SST, radiation, different horizontal resolution, …)

MiKlip – Module C: LACEPS (DWD)

time series of BIAS of annual mean 2-m-temperature for Europe in K wrt. E-OBS 6.0
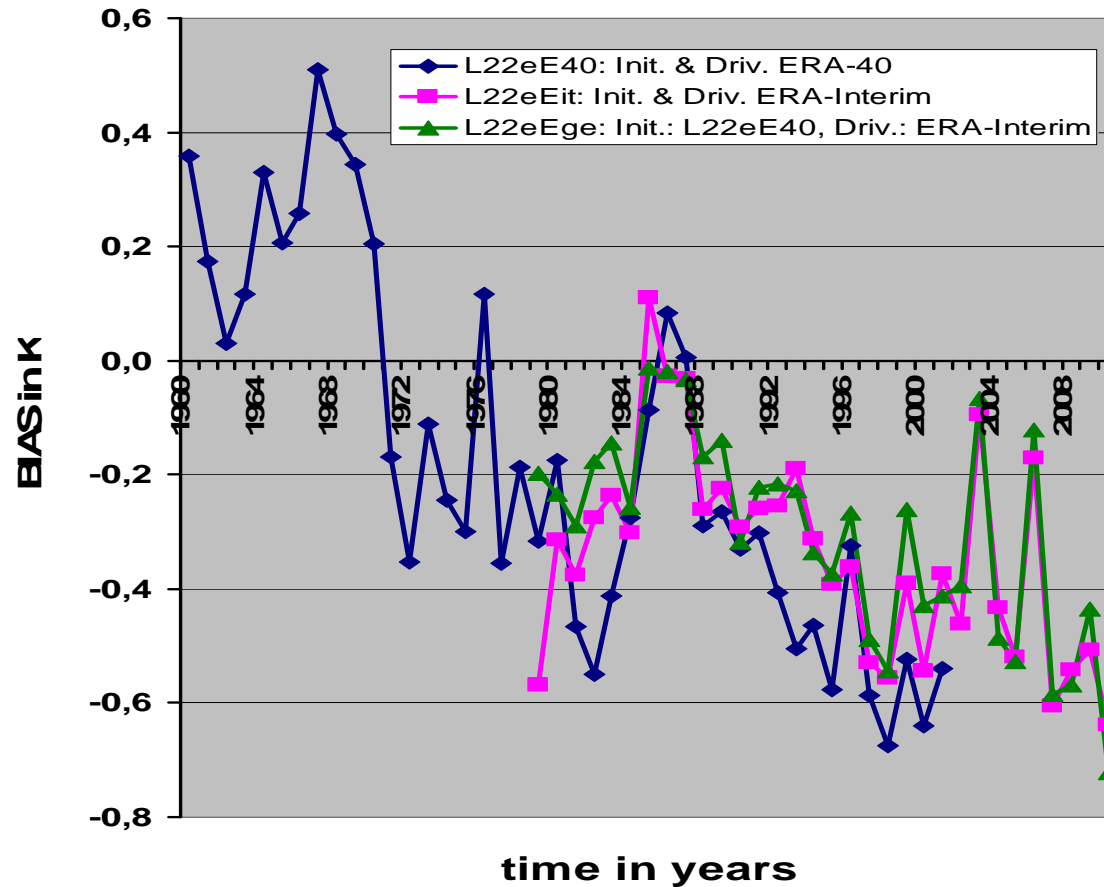
Evaluation runs:

L22eEit: driven & initialized
by ERA-Interim,
1979 - 2010

L22eE40: driven & initialized
by ERA-40,
1959 – 2001

L22eEge: L22eE40 extended
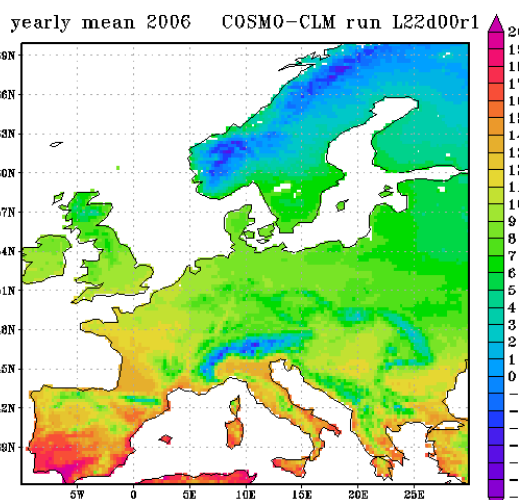by ERA-Interim driven started
in 1979,
in total 1959 – 2010
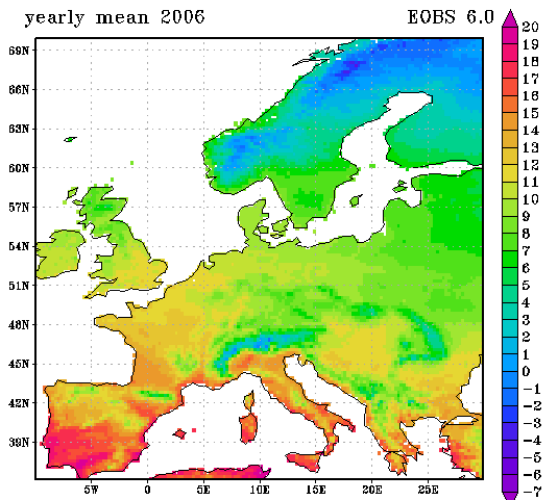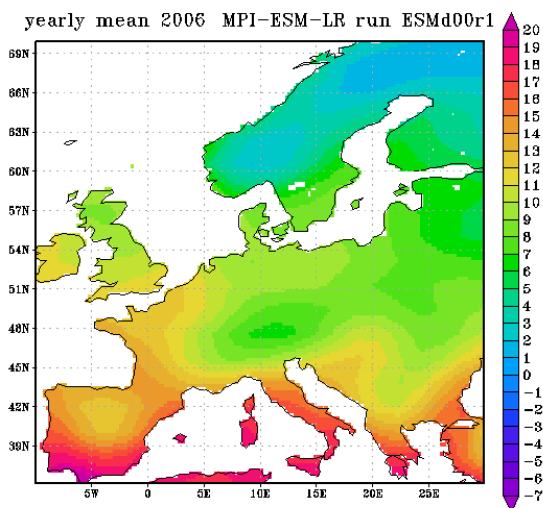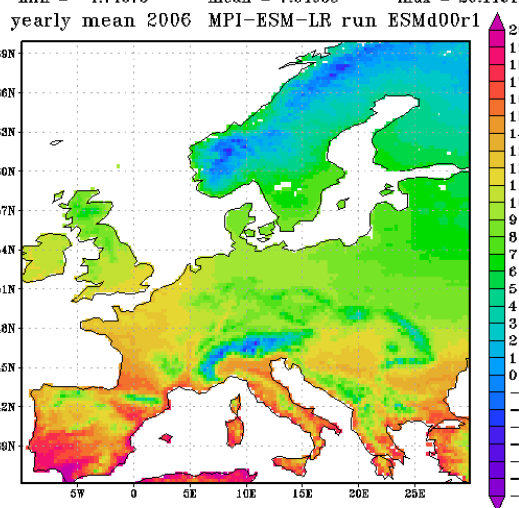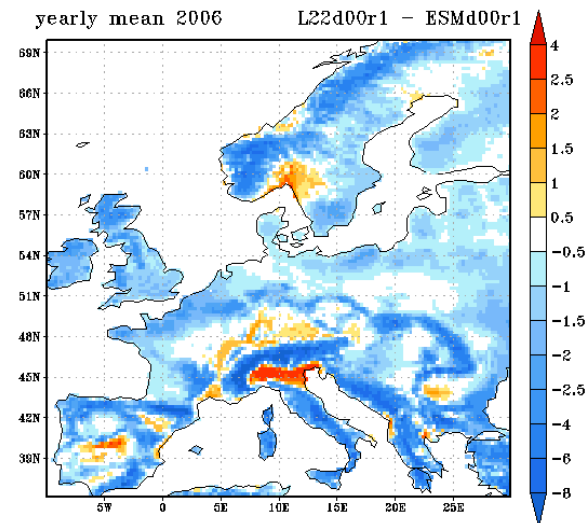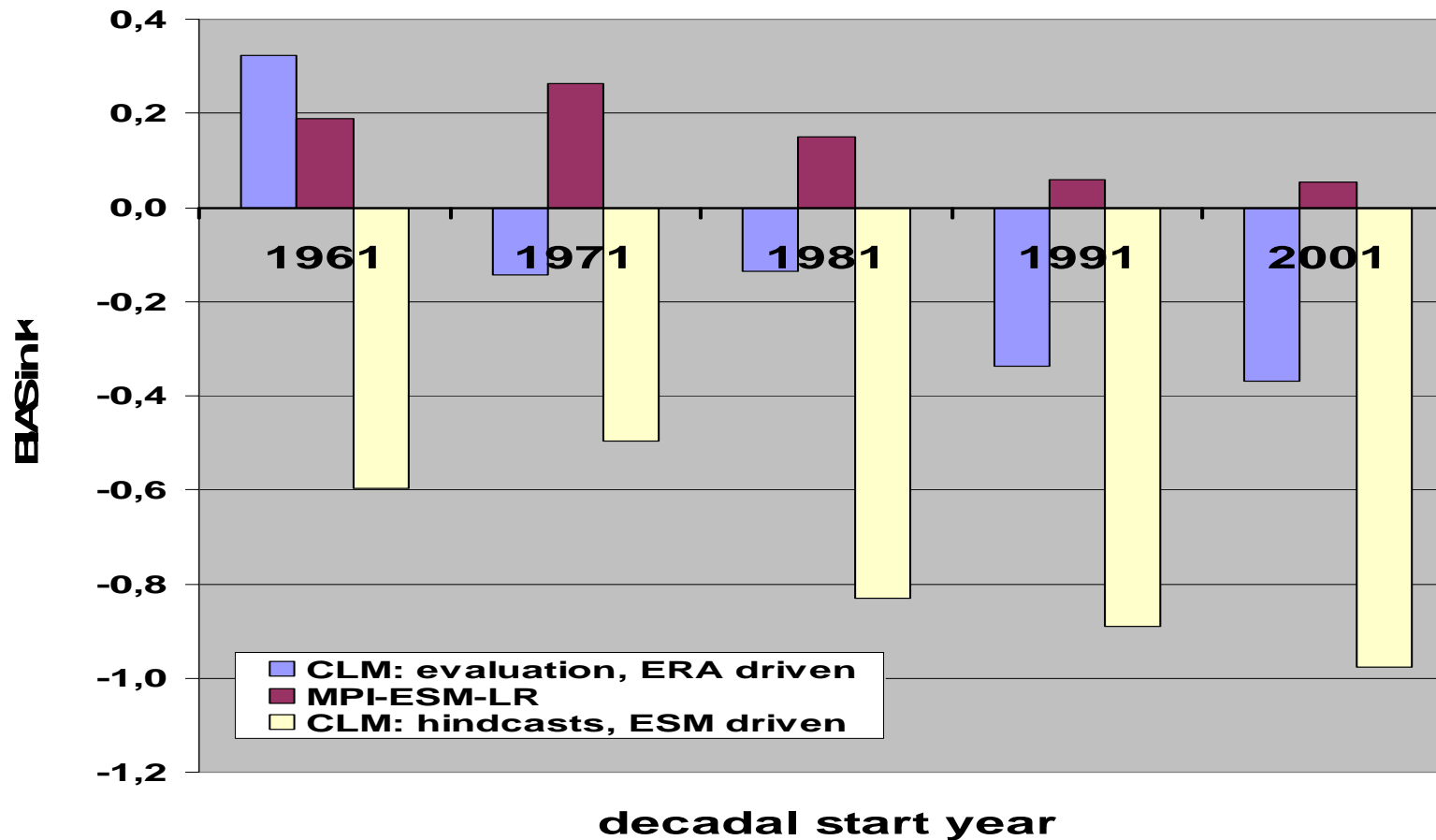
height correction of mean 2-m-temperature from driving model MPI-ESM-LR and from COSMO-CLM

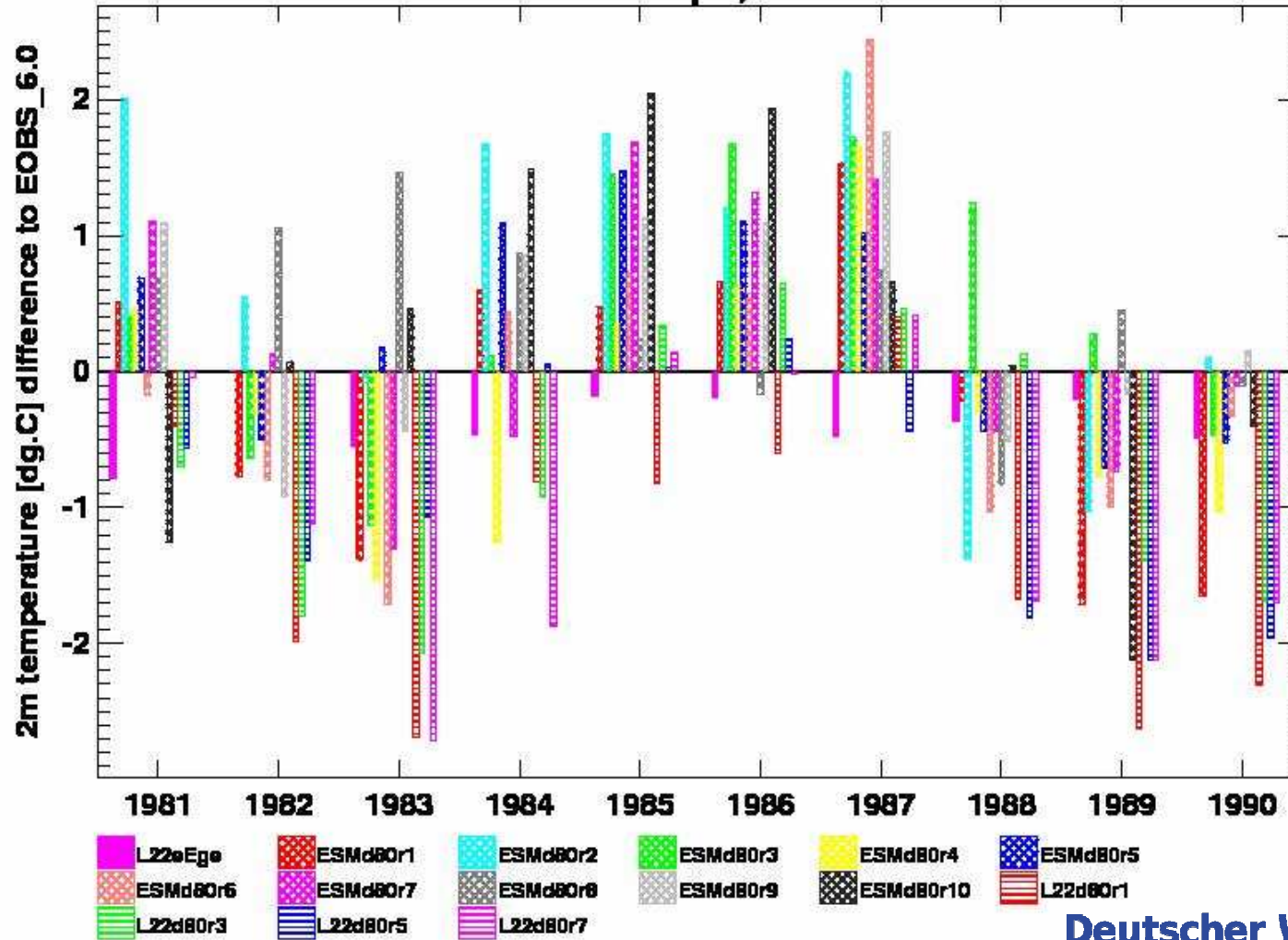decadal BIAS of height-corrected 2-m-temperature for Europe in K wrt. E-OBS 6.0

Legend:
- CLM: evaluation, ERA driven
- MPI-ESM-LR
- CLM: hindcasts, ESM driven

Y-axis: BIAS in K
X-axis: decadal start year (1961, 1971, 1981, 1991, 2001)

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Central Europe, Year
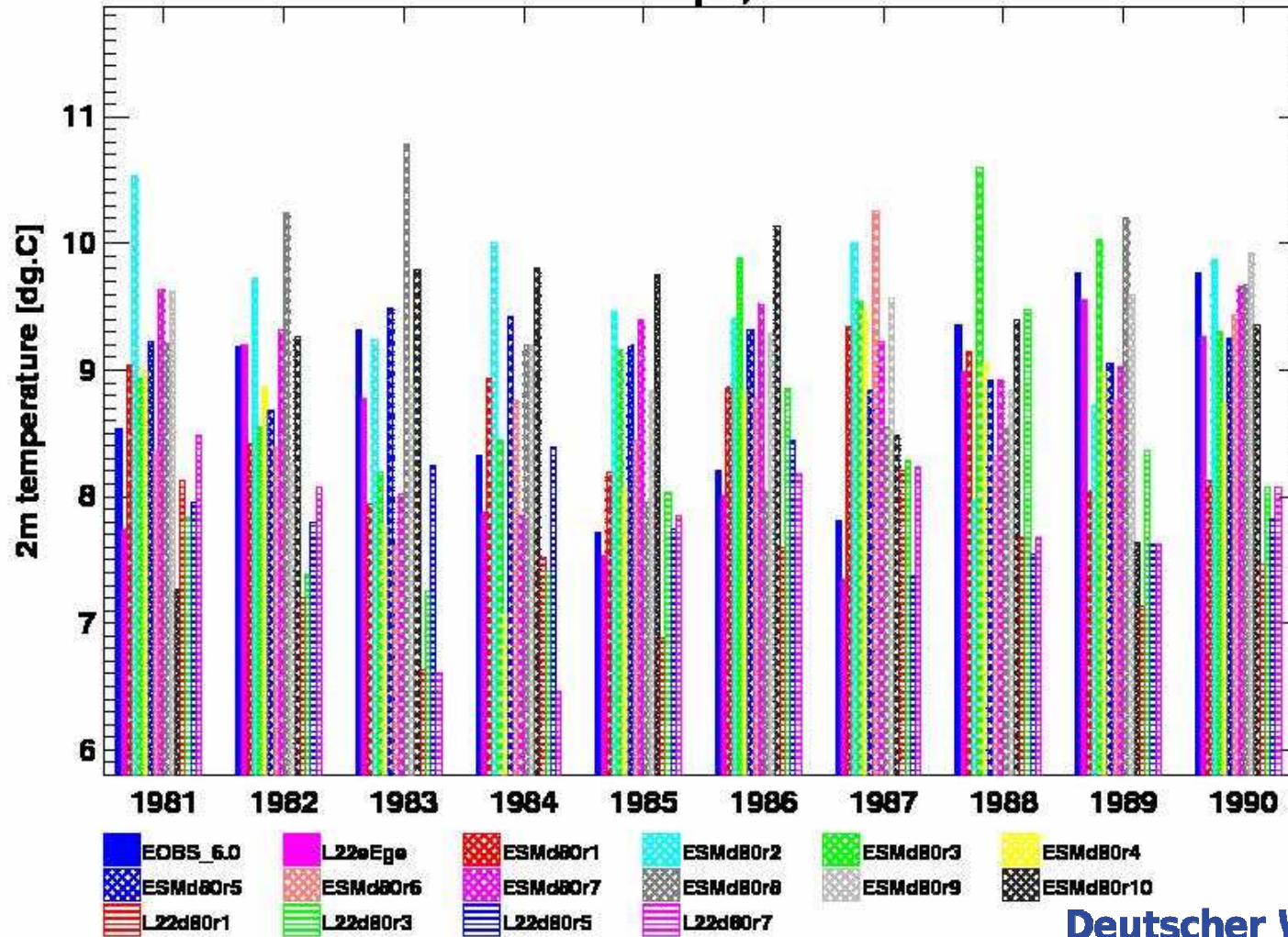
annual mean of 2-m-temperature

BIAS of annual mean 2-m-temperature wrt. E-OBS-6.0 data

Conclusions and Outlook

➜ real interannual variability shown by the E-OBS 6.0 data can not fully be found in the present driving MPI-ESM-LR data nor in the driven COSMO-CLM data

➜ further analysis on the variability will be done calculating the PDF on the base of daily instead of monthly and annual means

➜ in the present starting 2nd project phase about 40 COSMO-CLM runs are planned to investigate the influence of the perturbation strategies „physics", „boundary values" and „grid resolution" on the ensemble spread in close collaboration of the projects LACEPS, DecReg and Regio_Predict

MiKlip – Module C: DecReg (University of Frankfurt)
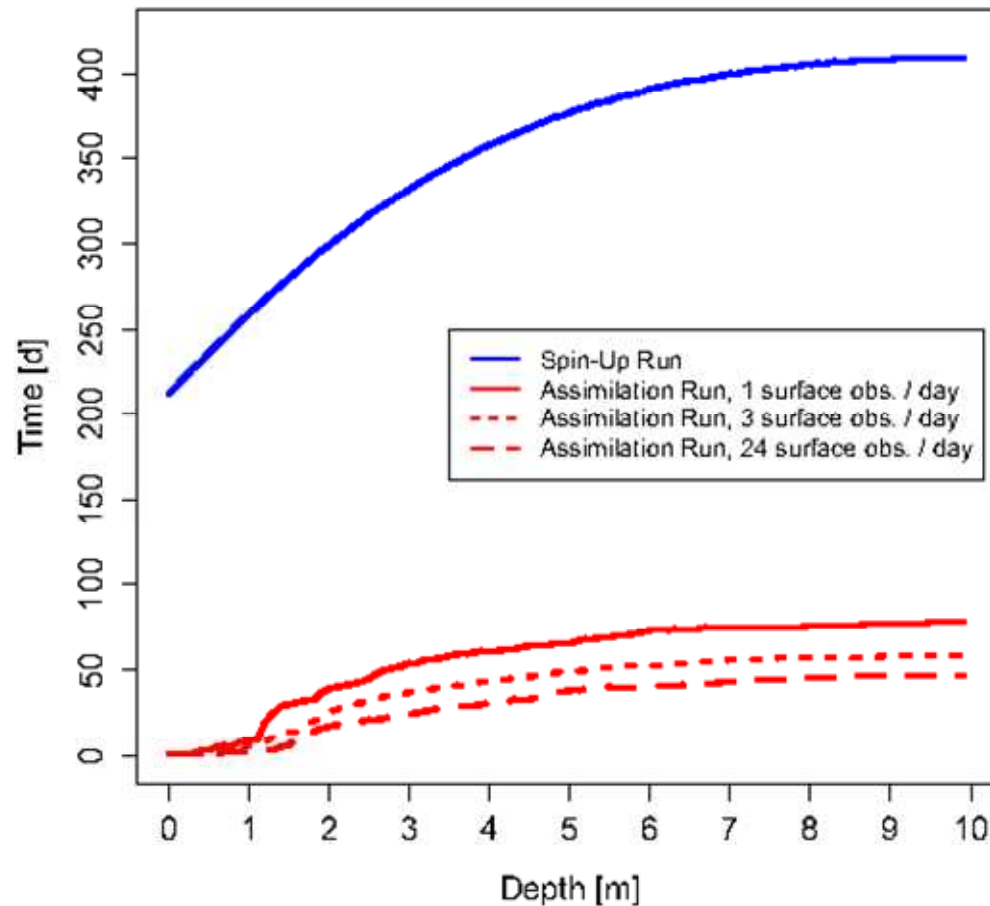
toy multi-level soil model:

spin-up run: sensible heat flux exchange with adjacent atmosphere

assimilation runs: soil surface temperature assimilated

data assimilation method works and needs much less time to converge to the real state in deeper soil layers

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