Decadal predictions for Europe: Regional downscaling of the MiKlip decadal experiments

Hendrik Feldmann (KIT) – with Marianne Uhlig, Sebastian Mieruch, Christoph Kottmeier (KIT), Claus-Jürgen Lenz, Barbara Früh (DWD), Kevin Sieck (MPI-M), Steffen Kothe (GUF) and other MiKlip participants

Outline

- The MiKlip Decadal Prediction System
- The Regionalization Module of MiKlip
- Results: Regional Decadal Predictions for Europe
  - Compared to the global simulations
  - Dependency on season, region and time
  - Potential added value
- Conclusions

The MiKlip Decadal Prediction System

- Model system
  - MPI-ESM global model (ECHAM6, MPIOM, JSBACH)
    - LR: T63 (~1.87°) 47 layers, ocean 1.5°
    - MR: T63, 95 layers, 0.4° tri-polar ocean
  - Initialized 10-year simulations starting 1960 – 2012
    - MPI-ESM-LR (Baseline0 = CMIP5 simulations)
      - decadal2000 means simulation period 2001 – 2010 (cf. CMIP5)
      - **10 members every 5 years** (1960, 1965,…, after 2000)
      - **3 members in-between years** (1961, 1962, 1963, 1964, 1966,..)

- 3 development stages by improving
  - Initialization, ensemble generation and model parameterizations
  - Development stage 1 (Baseline) has been finished recently

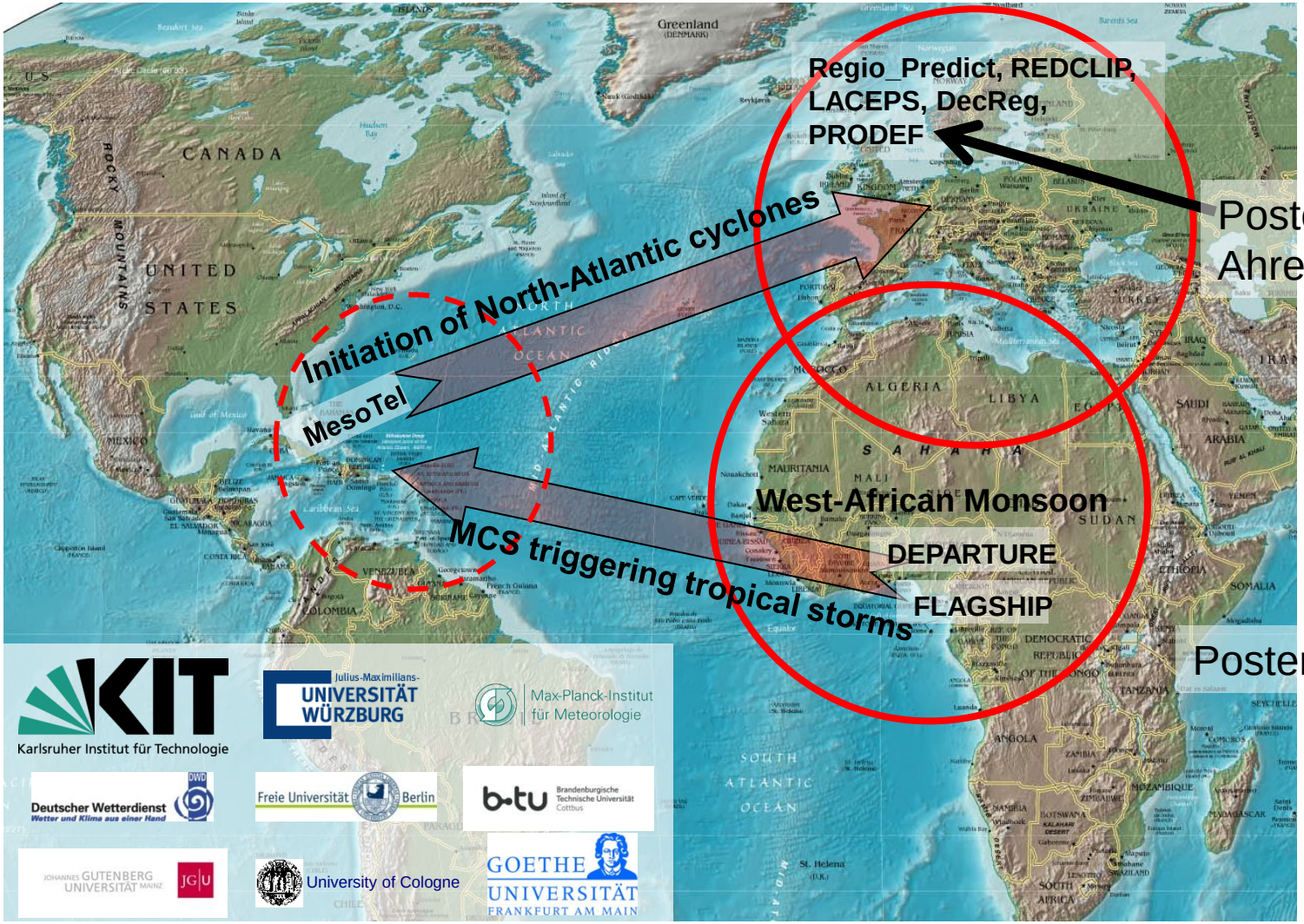
- Regional downscaling module
  - Developing a regional decadal prediction ensemble
  - Using COSMO-CLM and partly with REMO and WRF

Regional Decadal Predictions

- **Concept:**
  - What is predictable on regional scales (over land)?
    - Main interest of end users
  - Can regional downscaling contribute an added value?
    - by increasing the resolution in source regions of potentially predictability and feedback to the global model
    - by downscaling in selected target regions

- ***At this stage:***
  - *First assessment of the skill of the MiKlip baseline decadal predictions for Europe (from regional and global simulations)*
  - *Relation regional to global ensemble properties*
  - *Gain some ideas about a potential added value*
  - *Test of suitable metrics for the verification and analysis methods*

Focus Regions of the MiKlip Regionalization



Posters: Lenz Ahrens

Poster: Paxian

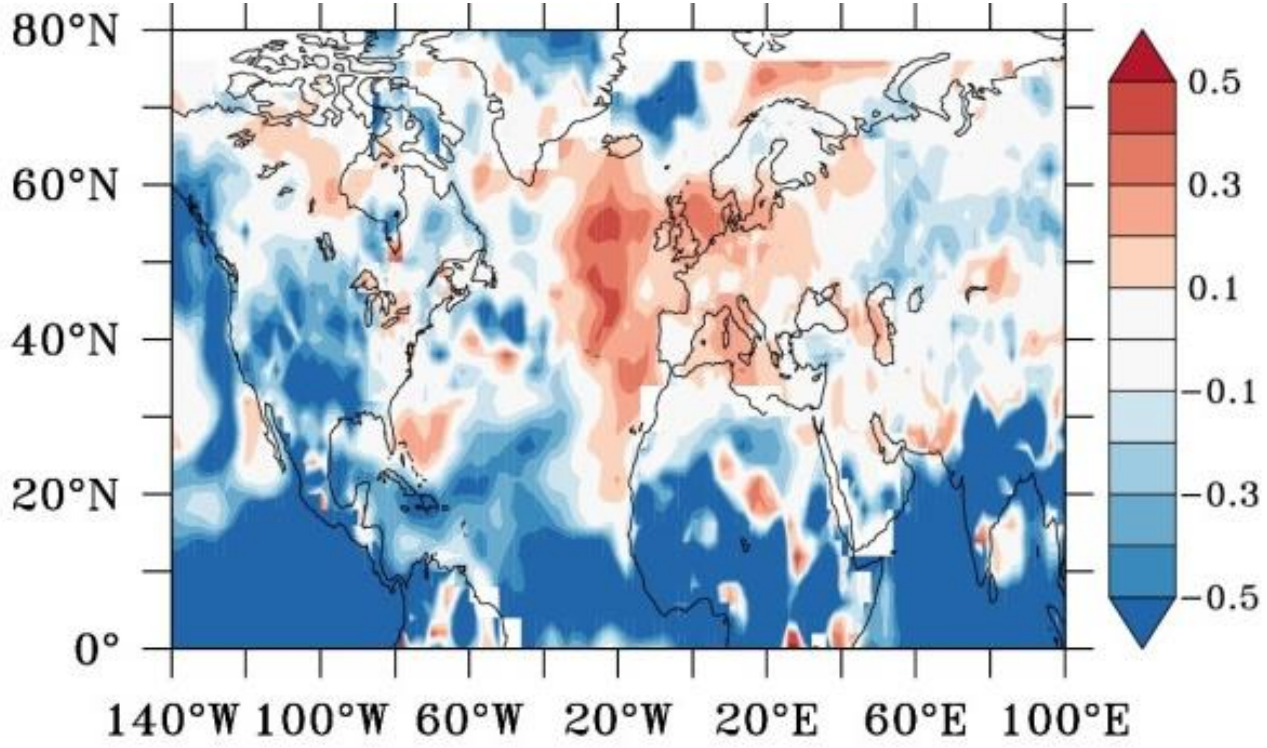
FONA Decadal Climate Prediction BMBF

MiKlip

MPI-ESM-LR Ensemble – MiKlip Baseline0 (CMIP5)

Surface Temperature North-Atlantic Sector

RMSE Skill Scores for year 2-5 – summer means



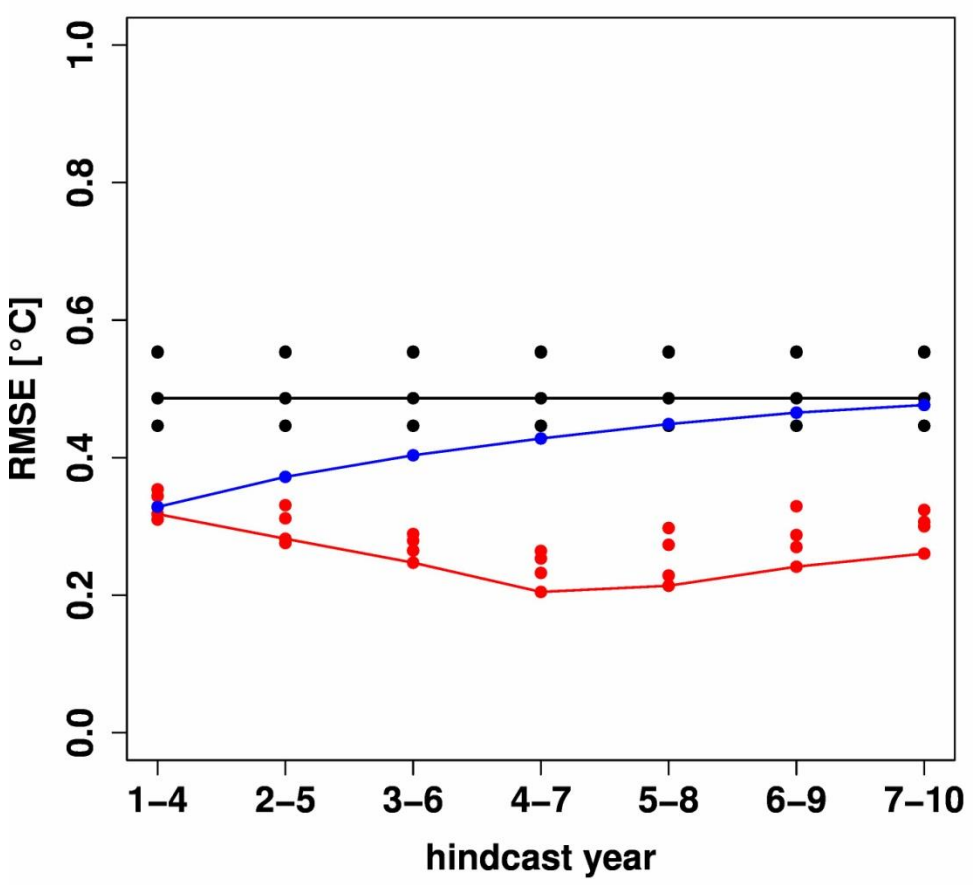
- **Skill score based on RMSE: 1- (RMSE_fc / RMSE_ref)**
- **Observations based on HADISST and GHCN-CAMS**
- **Ensemble mean**
- **Skill over EU linked with skill in the North Atlantic**

Müller et al. 2012, GRL (and Poster here)

FONA Decadal Climate Prediction BMBF MiKlip

North Atlantic Surface Temperature

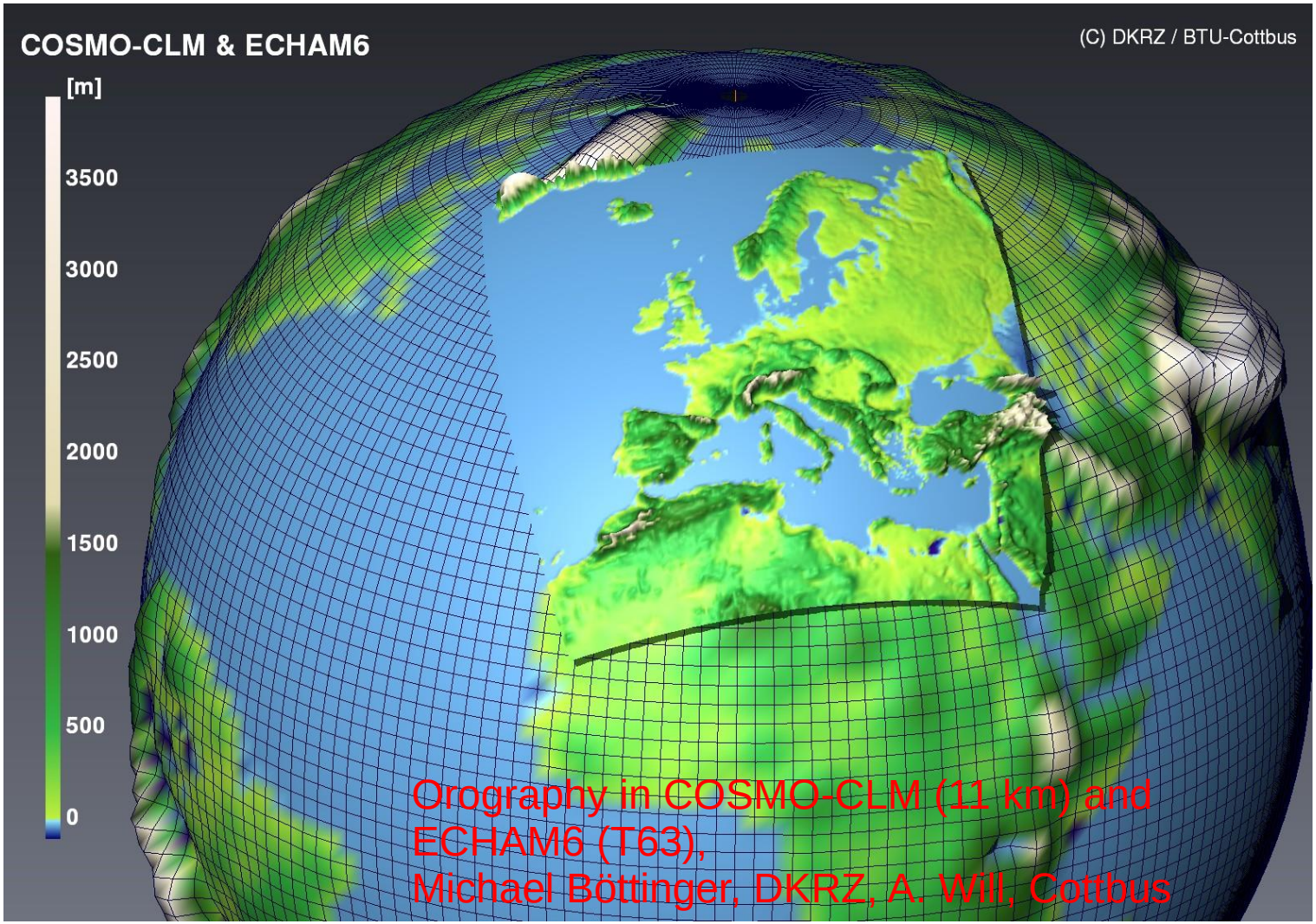
SST [40W-15W, 50N-60N] - RMSE Skill 4yr means



Müller et al. 2012, GRL
(and Poster here)

FONA Decadal Climate Prediction BMBF MiKlip

Regional Downscaling for Europe



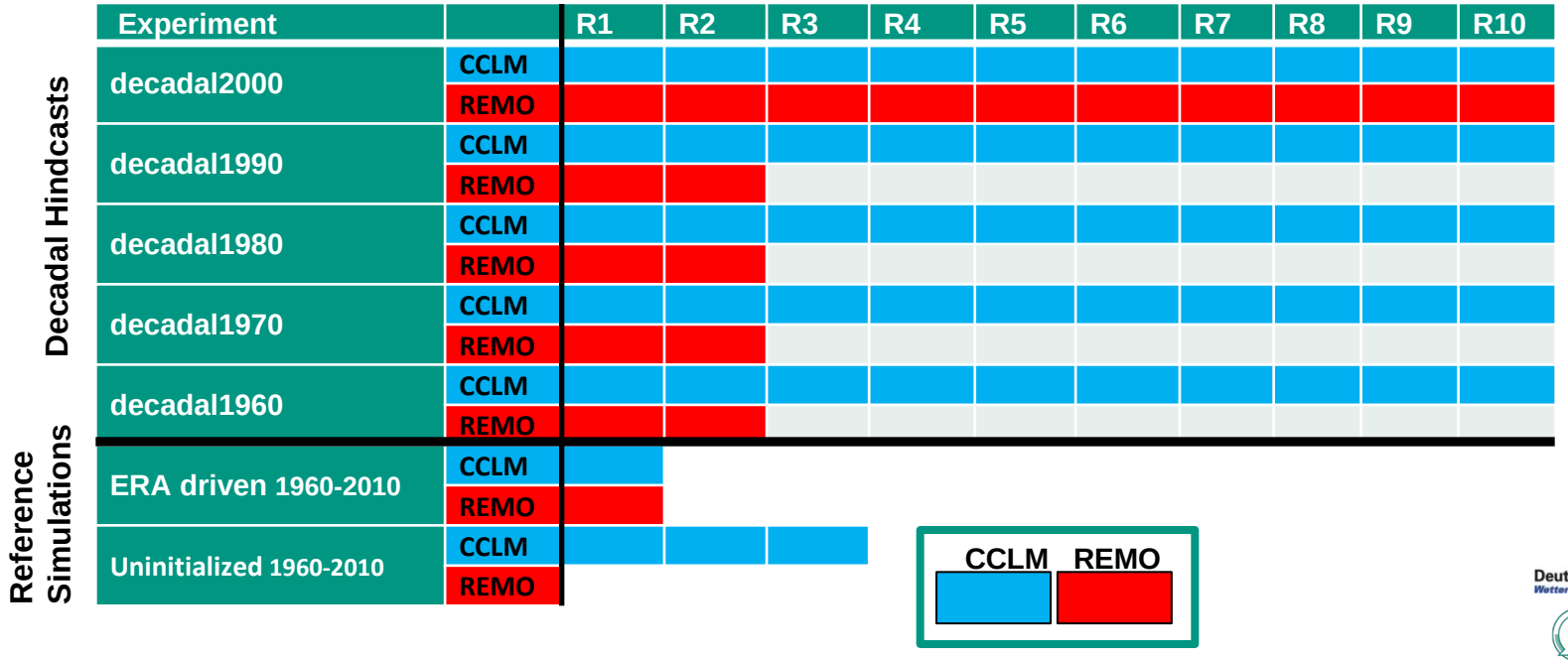
FONA Decadal Climate Prediction BMBF MiKlip

Regional Baseline Ensemble for Europe

with CCLM and REMO simulations performed by **DECREG, LACEPS, REDCLIP** and **Regio_Predict**

- CORDEX/ENSEMBLES domain, 0.22° resolution
- Downscaling of MPI-ESM-LR decadal simulations (Baseline0)
- Hindcasts all 10 realizations for 5 decades 1960, 1970, 1980, 1990, 2000
- Evaluations and reference simulations based on ERA40/ERAInterim and MPI-ESM-LR historical
- 2 Models (CCLM and REMO)
- Decadal simulations initialized using long-term ERA simulation

Simulation Plan



Karlsruher Institut für Technologie

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Max-Planck-Institut für Meteorologie

FONA Decadal Climate Prediction BMBF

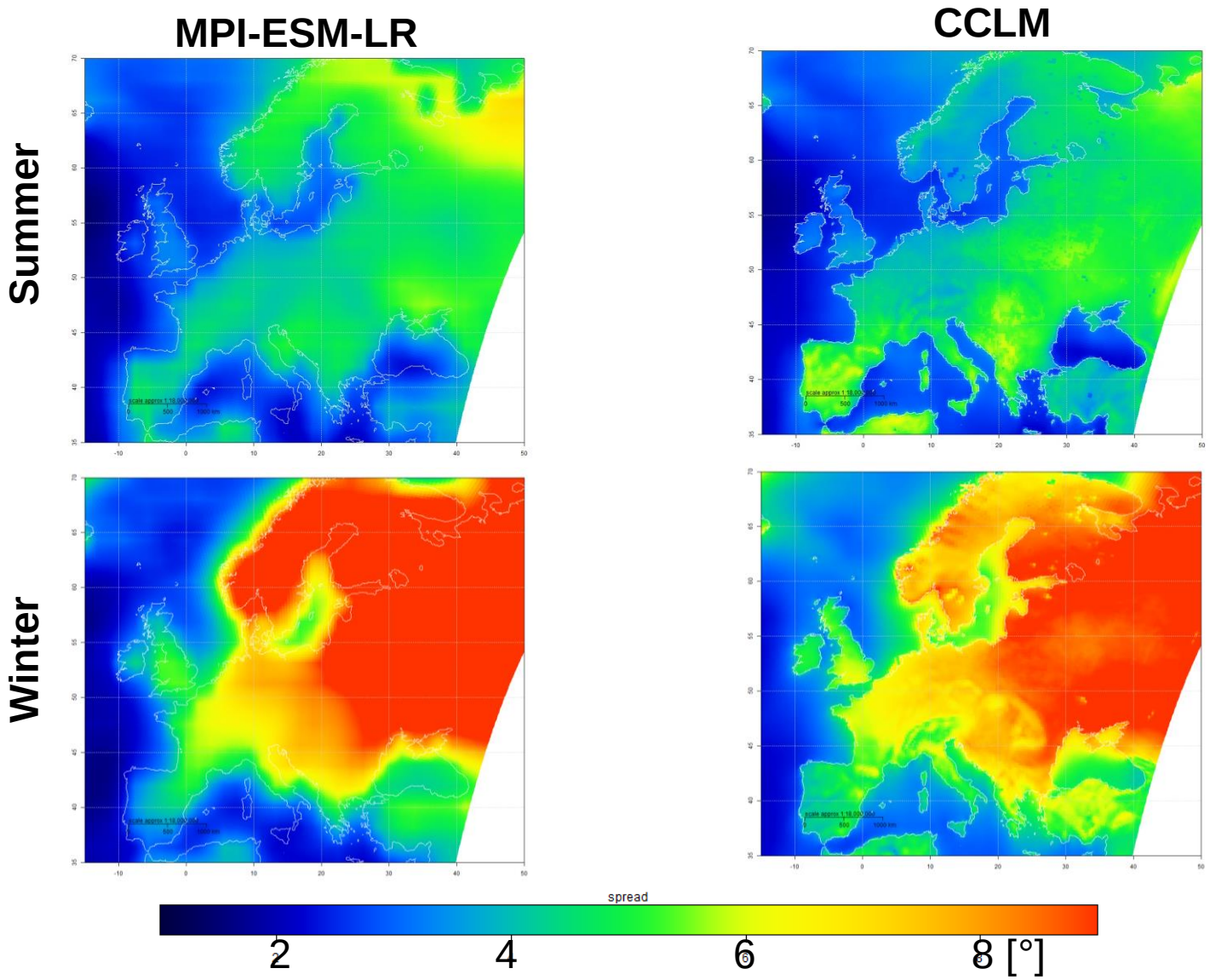
MiKlip

Skill of (regional) decadal predictions

- Skill CCLM and MPI-ESM-LR ensemble vs. E-Obs gridded observations
- MPI-ESM interpolated to E-Obs grid and height corrected (temperature)
- Anomalies of 2m-temperature and precipitation (until now)
- Hindcast period 1960 – 2010
- Skill scores with climatology as reference
- Here year 1-10 but also applied to 1st/2nd pentade

- Metrics for ensemble forecast verification in accordance with VECAP here
  - **Mean Square Skill Score (MSSS)** (Murphy et al., 1988; Goddard et al., 2012)
    - Accuracy - is the forecast close to the observation?
  - Categorical skill scores (CAWCR) – warmer/colder than climatology
    - Here: **Odds ration skill score (ORSS)**
    - *What was the improvement of the forecast over random chance?*

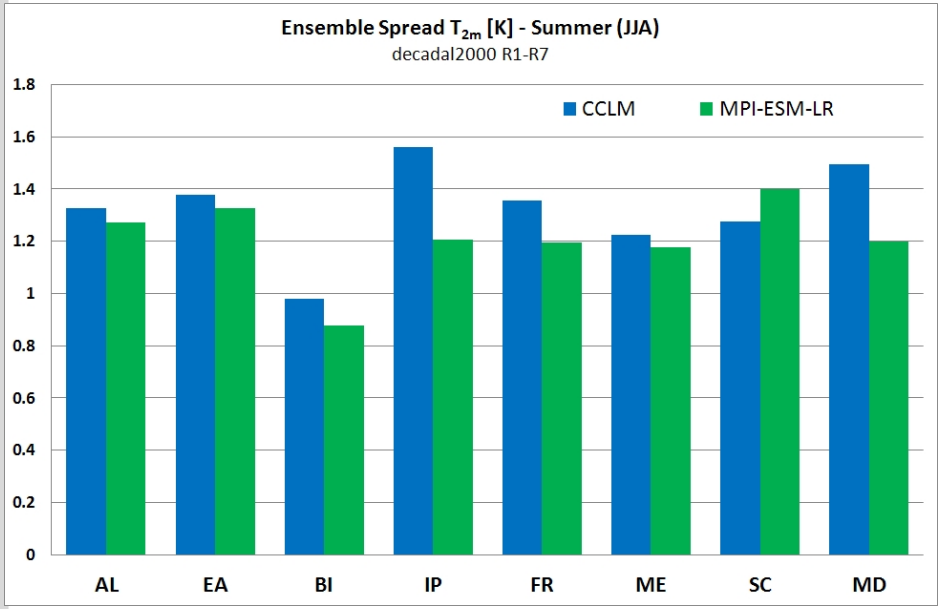
Ensemble Spread GCM and RCM Ensemble
T_{2m} CCLM and MPI-ESM-LR – decadal2000 (2001-2010)



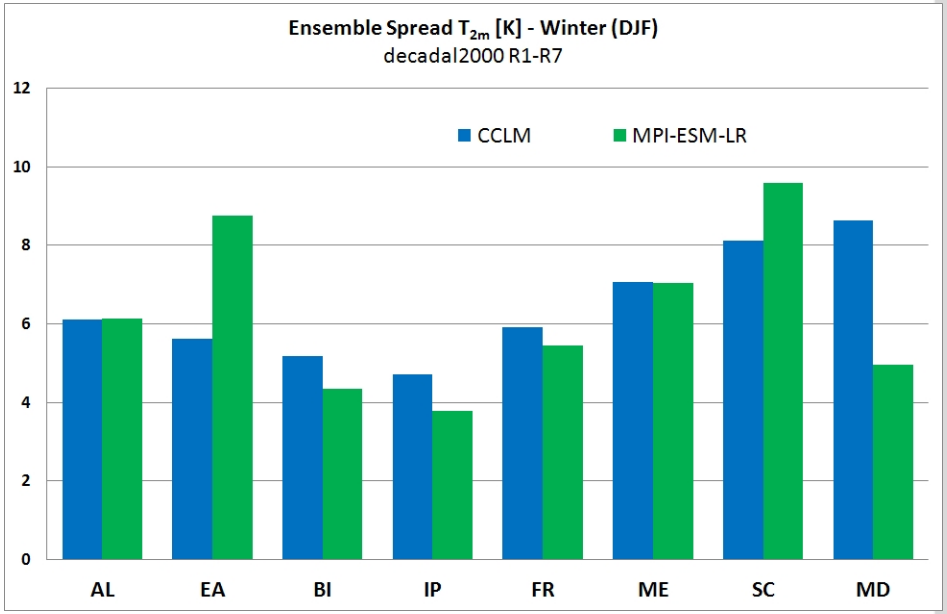
FONA Decadal Climate Prediction BMBF
MiKlip

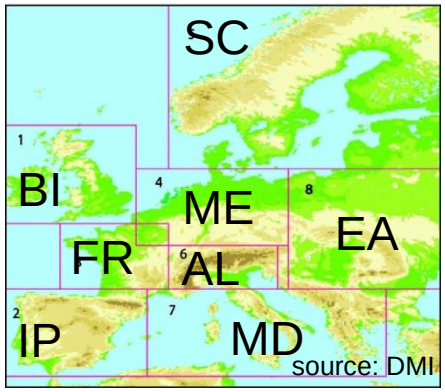
Ensemble Spread GCM and RCM Ensemble
T_2m CCLM and MPI-ESM-LR – decadal2000 (2001-2010)

Summer



Winter





ensemble spread of 2-m-temperature for the PRUDENCE regions

FONA Decadal Climate Prediction BMBF

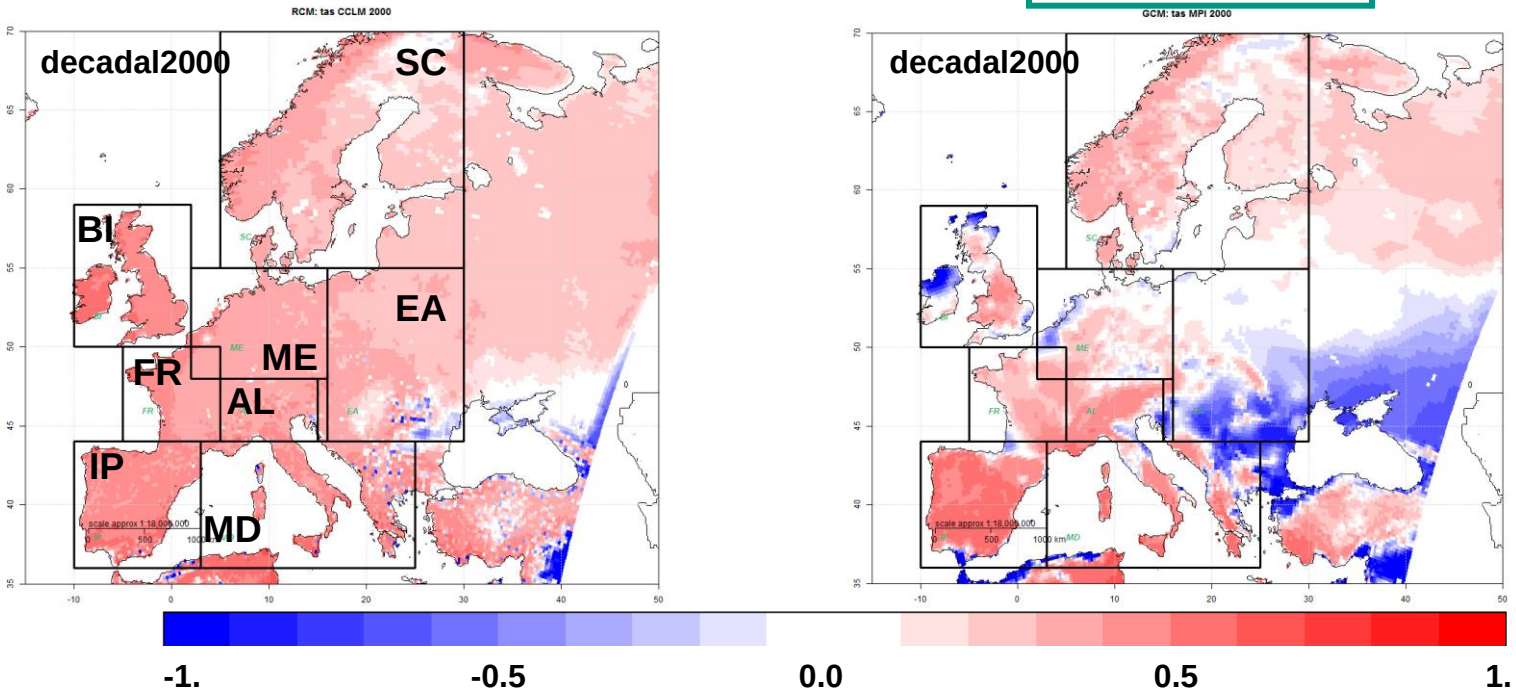
MiKlip

Mean Square Skill Score MSSS - Temperature 1960 – 2010

CCLM and MPI-ESM-LR MiKlip Baseline Ensemble

CCLM

MPI-ESM-LR*



¨ Interpolated to E-Obs grid, height corrected

$$MSSS = 1 - \frac{MSE}{MSE_{Reference}}$$

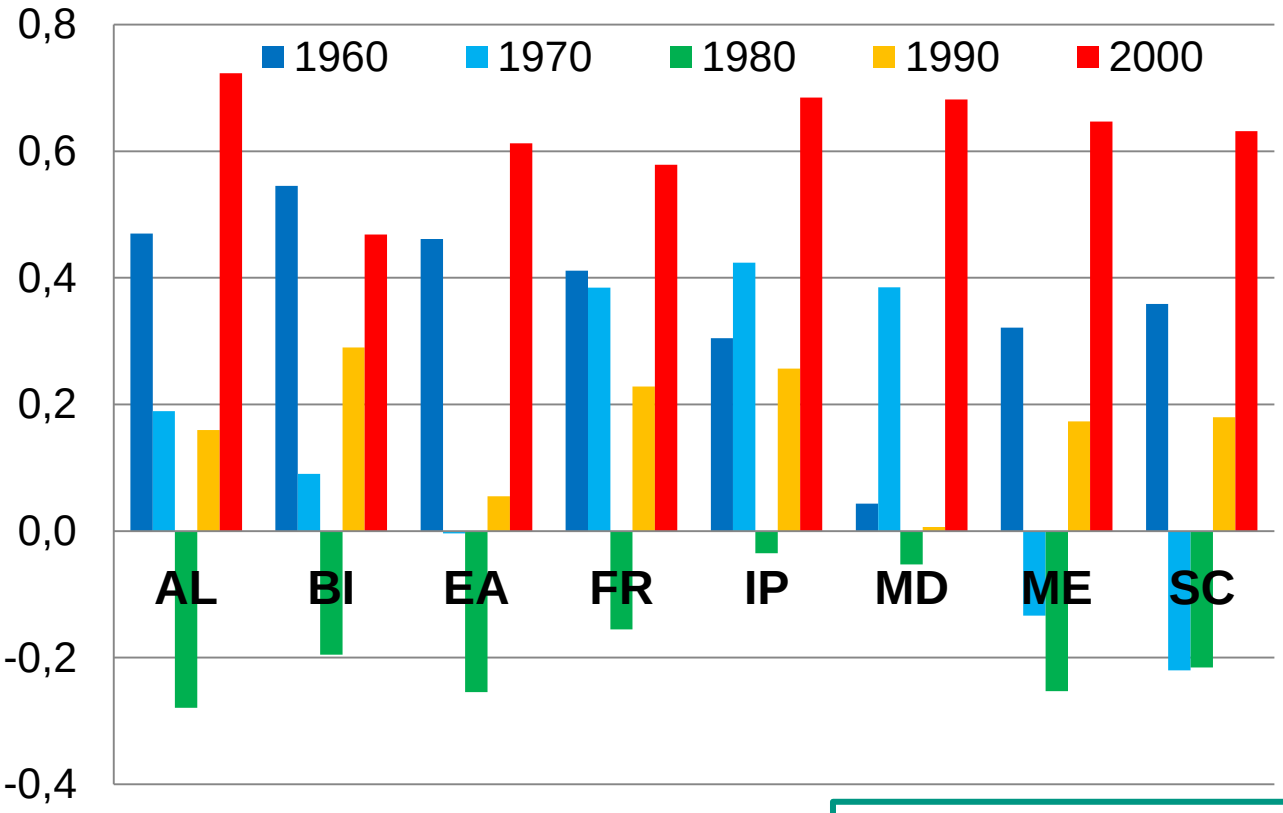
$$MSE = \frac{1}{N}\sum (C_i - O_i)^2$$

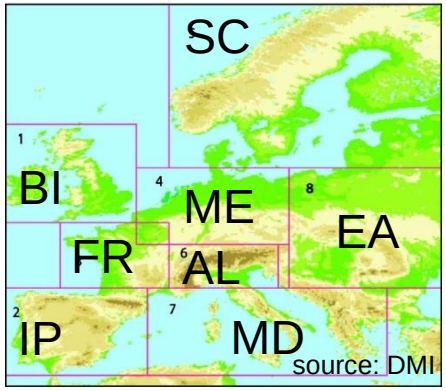
10 ensemble members
trend not removed
Observation: E-Obs
Reference: Climatology 1960 - 2010
based on anomalies year 1-10
MSSS perfect: 1, no skill: 0

FONA Decadal Climate Prediction BMBF MiKlip

Mean Square Skill Score MSSS Temperature 1960 – 2010

CCLM Baseline Ensemble vs E-Obs annual values





$$MSSS = 1 - \frac{MSE}{MSE_{Reference}}$$

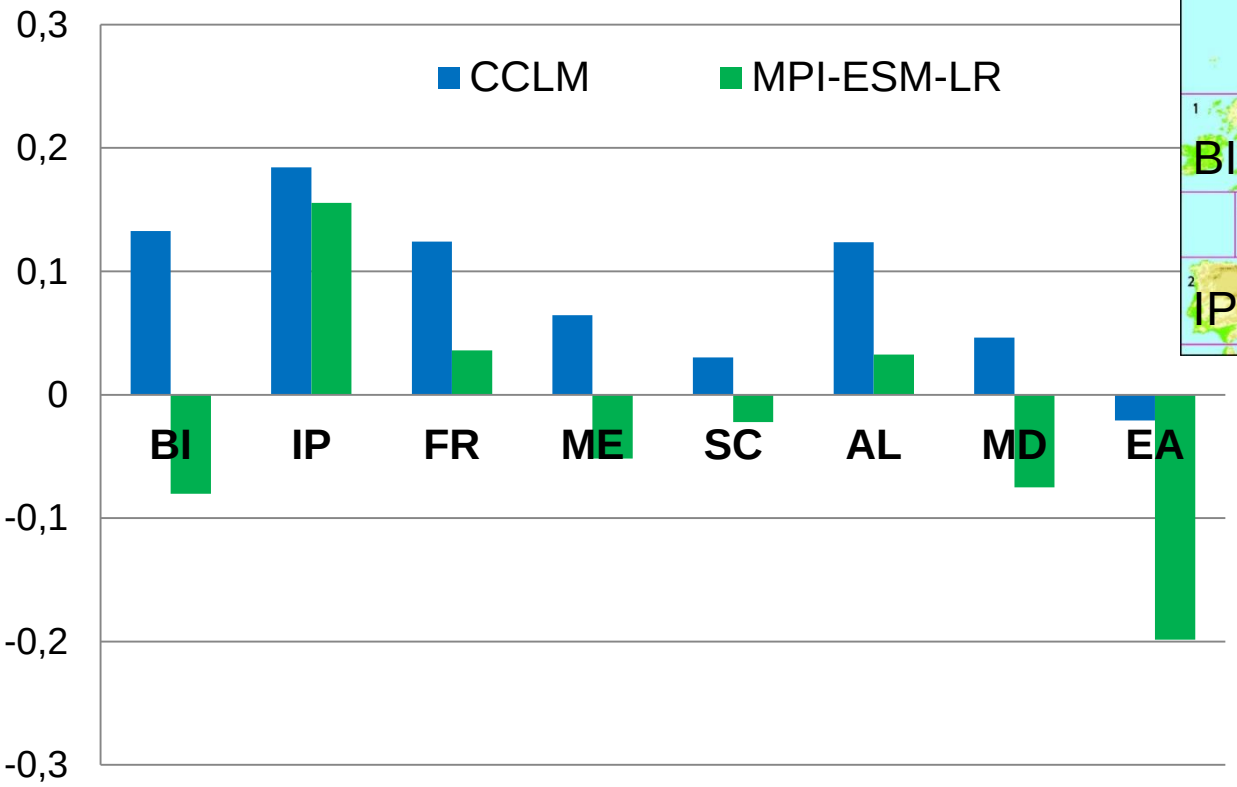
$$MSE = \frac{1}{N}\sum (C_i - O_i)^2$$

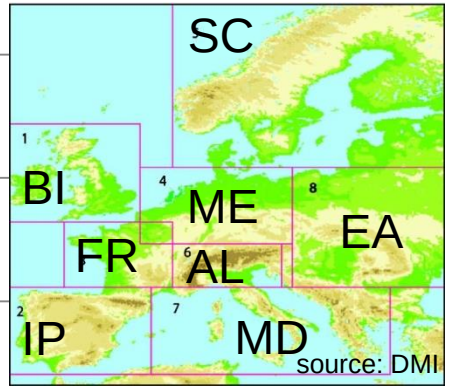
10 ensemble members
trend not removed
Observation: E-Obs
Reference: Climatology 1960 - 2010
based on monthly anomalies
MSSS perfect: 1, no skill: 0

Mean Square Skill Score MSSS Temperature 1960 – 2010

CCLM and MPI-ESM-LR MiKlip Baseline Ensemble vs E-Obs

annual values





$$MSSS = 1 - \frac{MSE}{MSE_{Reference}}$$

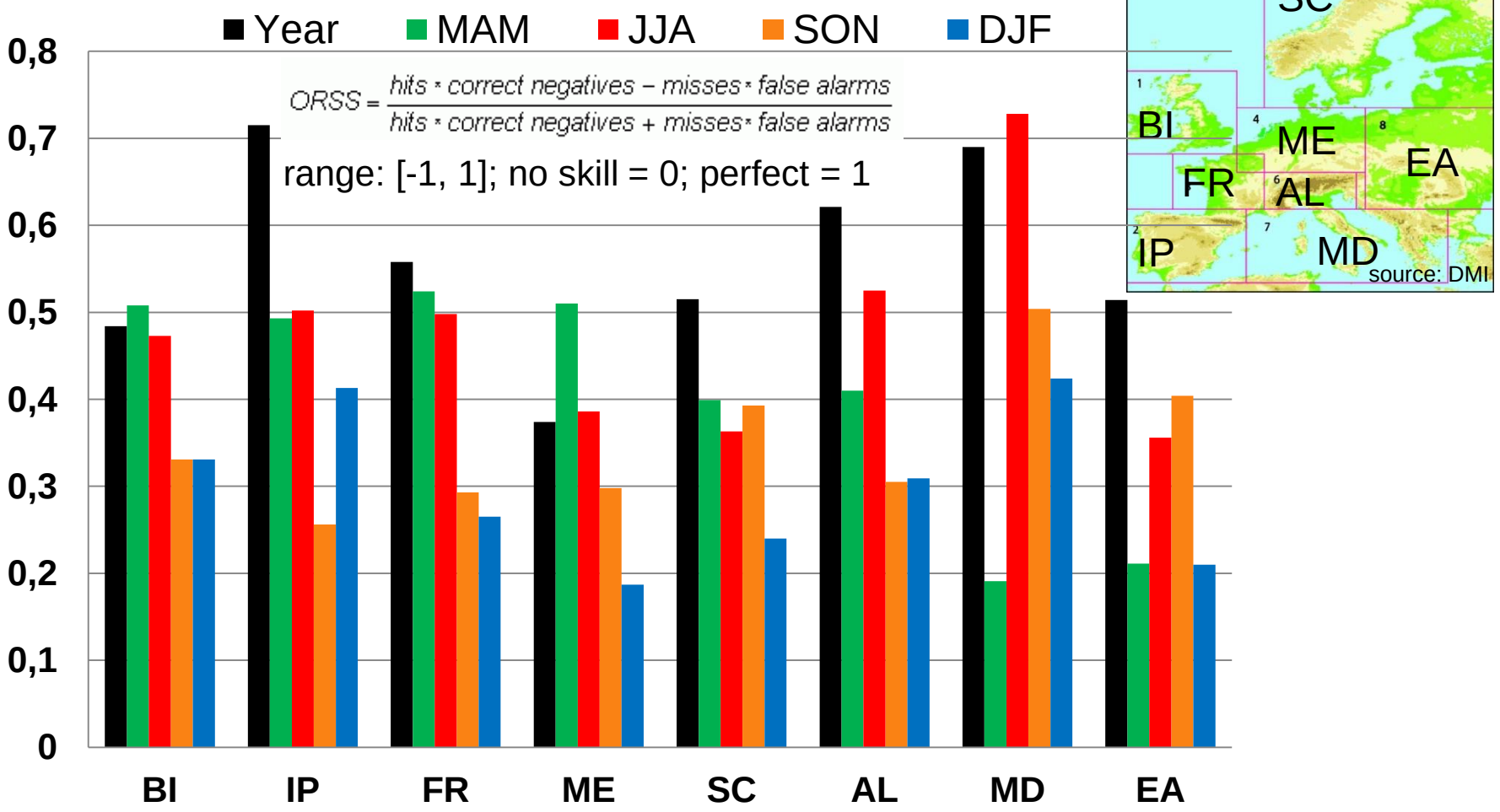
$$MSE = \frac{1}{N}\sum (C_i - O_i)^2$$

10 ensemble members
trend not removed
Observation: E-Obs
Reference: Climatology 1960 - 2010
based on monthly anomalies
MSSS perfect: 1, no skill: 0

Odds Ratio Skill Score (ORSS) CCLM Baseline Ensemble - T_{2m} 1960 – 2010

CCLM Baseline Ensemble vs. E-Obs, annual values year 1-10

Answers the question: What was the improvement of the forecast over random chance?



FONA Decadal Climate Prediction BMBF MiKlip

Conclusions

- There seems to be some decadal predictability for Europe in the MiKlip Baseline ensemble
  - Main source seems to be the climate trend (for temperature)
- There seems to be some added value in regional downscaling
- The skill varies with season, region and decade
  - With higher skill in southern and western Europe
  - Higher for year, spring and summer and lower in winter
  - Skill in last decade (decadal2000) seem to be higher than in earlier phases (e,g. decadal1980)

- Outlook:
  - Proper analysis of relevant temporal and spatial scales is currently analysed
  - Identification of valuable predictions beyond mean temperature and precipitation anomalies
  - Improvement of the global and regional prediction system in the next development stages
    - w.r.t initialisation, ensemble generation, coupling and model performance

Thank you for your attention