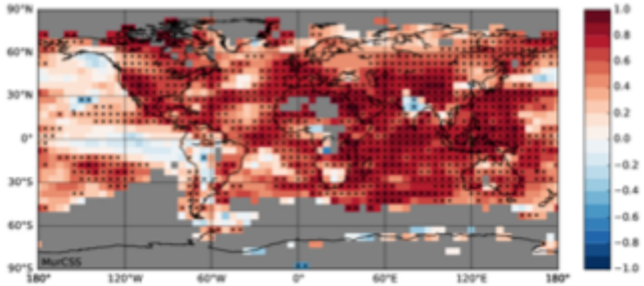
# MiKlip – „Mittelfristige Klimaprognosen“

**Wolfgang A. Müller (MPI)**

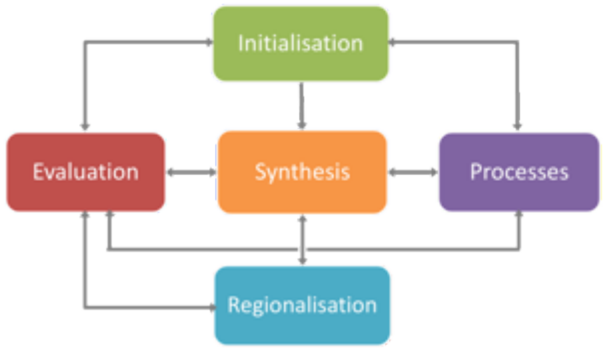
panWCRP 2017, Exeter

# MiKlip – Development Stages (DS)



DKRZ
DEUTSCHES KLIMARECHENZENTRUM

by freva

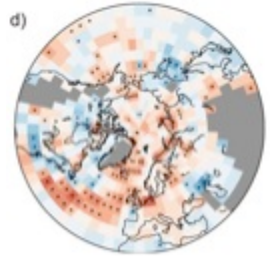



- Ams at developing an decadal climate prediction systems for operational use based on MPI-ESM
- Concept of development stages:
  - provision of latest model and set of hindcast stored at MiKlip Data Server (DKRZ) and Online Evaluation System (Freva, FU Berlin)
  - evaluation of hindcast, development of new initialization methods and initial conditions, downscaling for Europe
  - collection of recommendation, testing, and implementation into the central prediction system
  - Ideally 2-3 yr cycle, much faster than model development and CMIP
- DS1-3 have been undertaken, DS4 underway (CMIP6 version)

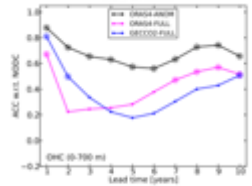
**Marotzke et al., 2016, BAMS**

# MiKlip - Lessons learned (a selection)

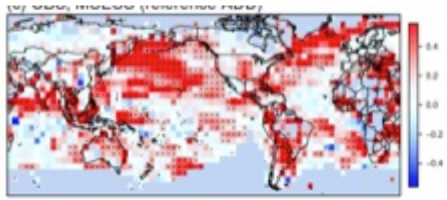
- Skillful processes and the confidence of provision of climate information a decade ahead



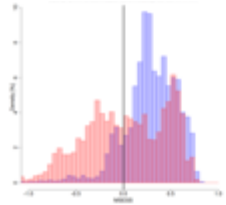

- Anomalie, full field initialization and the need for a model-consistent assimilation



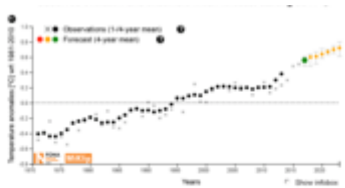
- Bias adjustment as a powerful tool to improve reliable climate information



- An added-value of downscaling for Europe

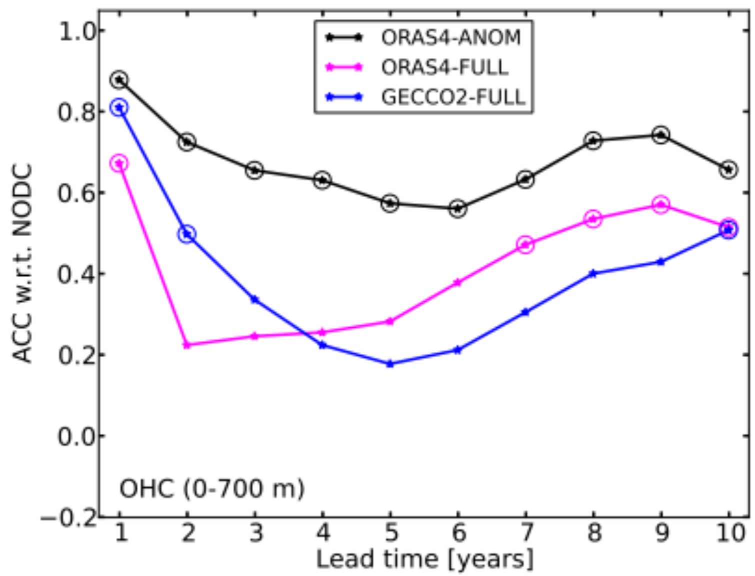


- The MiKlip web page for decadal climate forecasts and a long way to provide an operational product



# The initalization struggle

- So far, no preferred initialization method
- Anomaly initialization (AI) has been convenient approach to avoid drift (e.g. Smith et al. 2007, Keenlyside et al., Pohlmann et al. 2009, …), however
  - AI seems counterintuitive as initial conditions close as possible to observations
  - some drift remain
- Full fields initialization (FF) is considered as alternative (e.g. Smith et al. 2013, Hazeleger et al., 2013, Polkova et al., 2014, Carassi et al., 2014, Belucci et al., 2015, Volpi et al., 2016 …), however
  - large drift and bias adjustment required
- Flux corrections (Magnusson et al. 2012, Polkova et al. 2014)
- For DS3 FF was recommended
- MPI-ESM-LR (2x15 members, GECCO2, ORAS4)



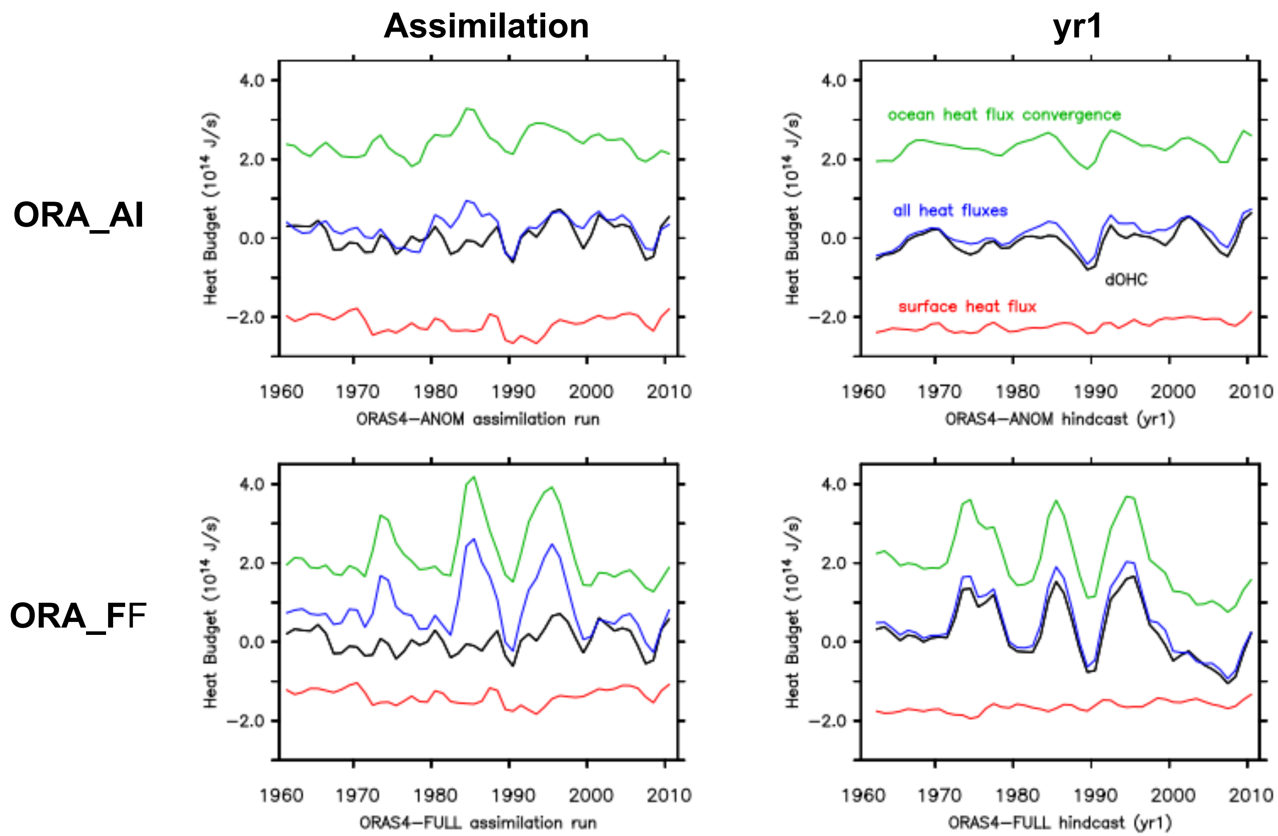

OHC, SPG region, ACC w.r.t NODC,
Circles hindcast outperform historica

Drop of skill for full field initalization!

**Kröger et al., submitted, Clim Dyn**

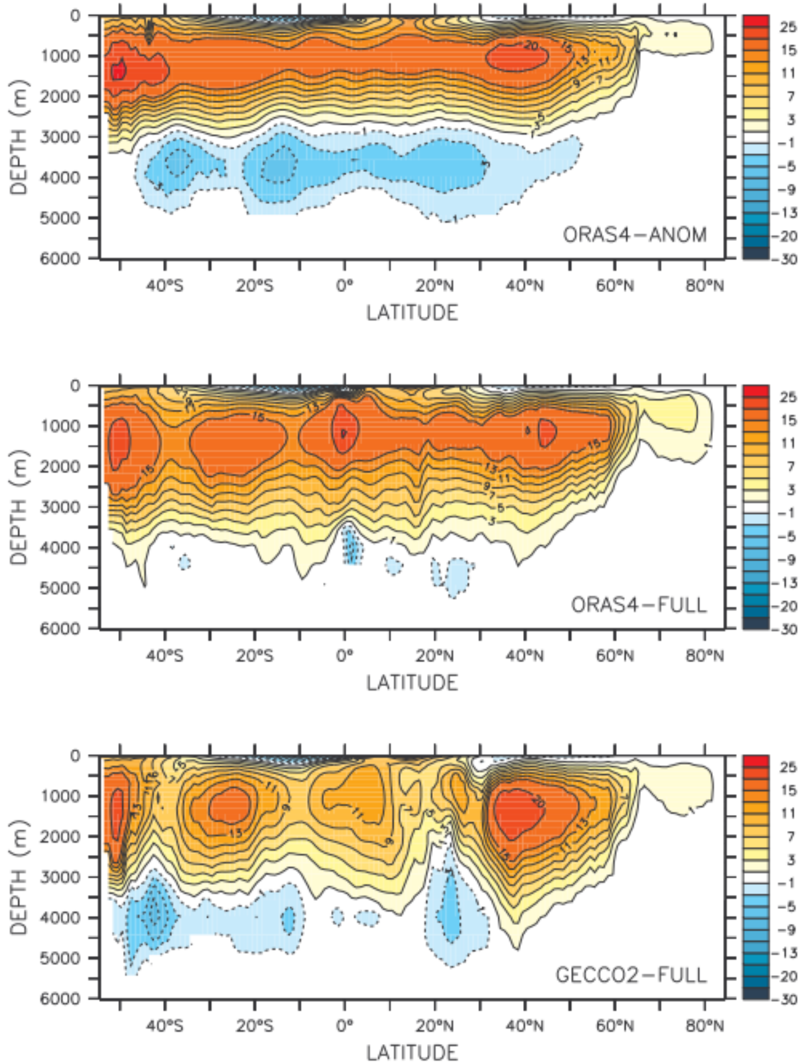
# Ocean Heat Content (OHC) Budget, SPG Region, 0-700m

## Change of OHC (dOHC) = lateral + surface heat fluxes




- In assimilation, dOHC is NOT balanced by surface and lateral heat fluxes (FF>AI)
- Deviations stem from large anomalous heat flux convergence through lateral boundaries
- The free running model (hindcast) then balances dOHT towards lateral heat fluxes
- Why so much difference in assimilation and predictions?

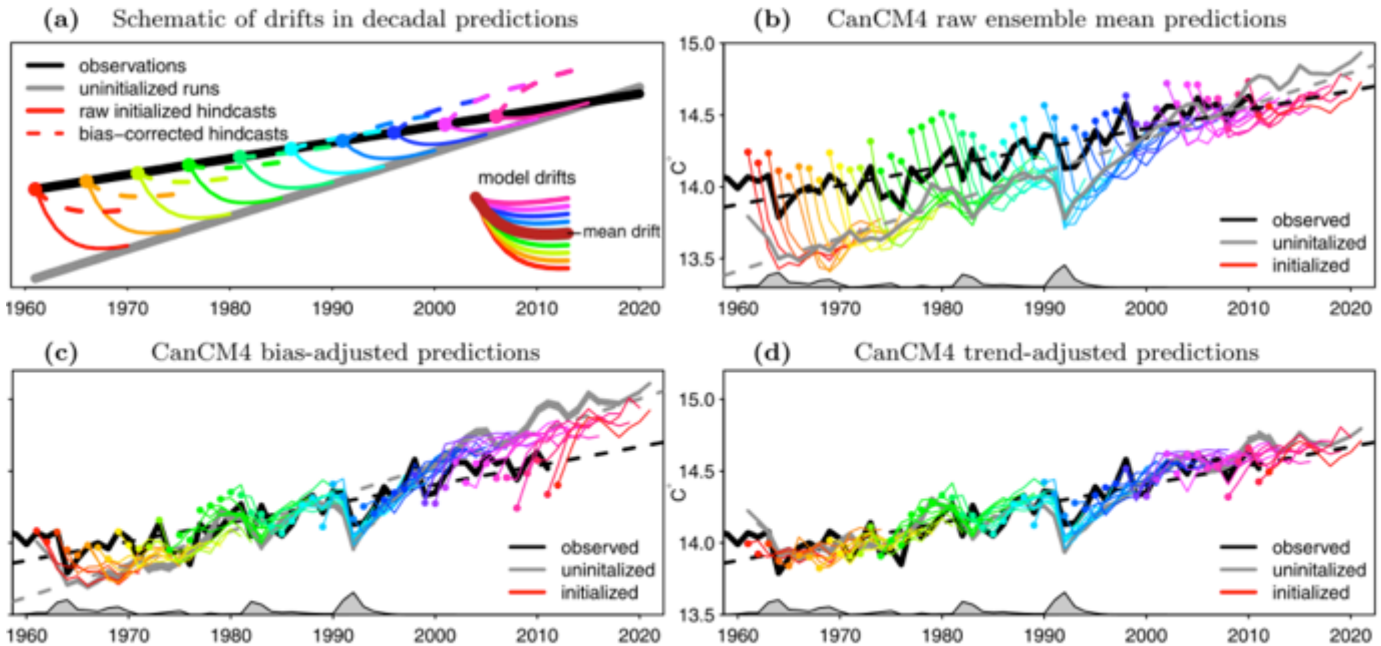
# AMOC in assimilation experiments




- AMOC explains much of the ocean heat transport in the North Atlantic
- In FF experiments, AMOC is disturbed by strong vertical motions, which explains the deviations in heat transport
- This effect is larger when using GECCO2 than ORAS4
- We hypothesize this result from model-inadequate assimilation of re-analyses (e.g. model topography and reanalysis bottom flow are not be balanced)
- Appropriate assimilation methods are required (Brune et al, 2017, Ensemble Kalman Filter)

# The bias struggle

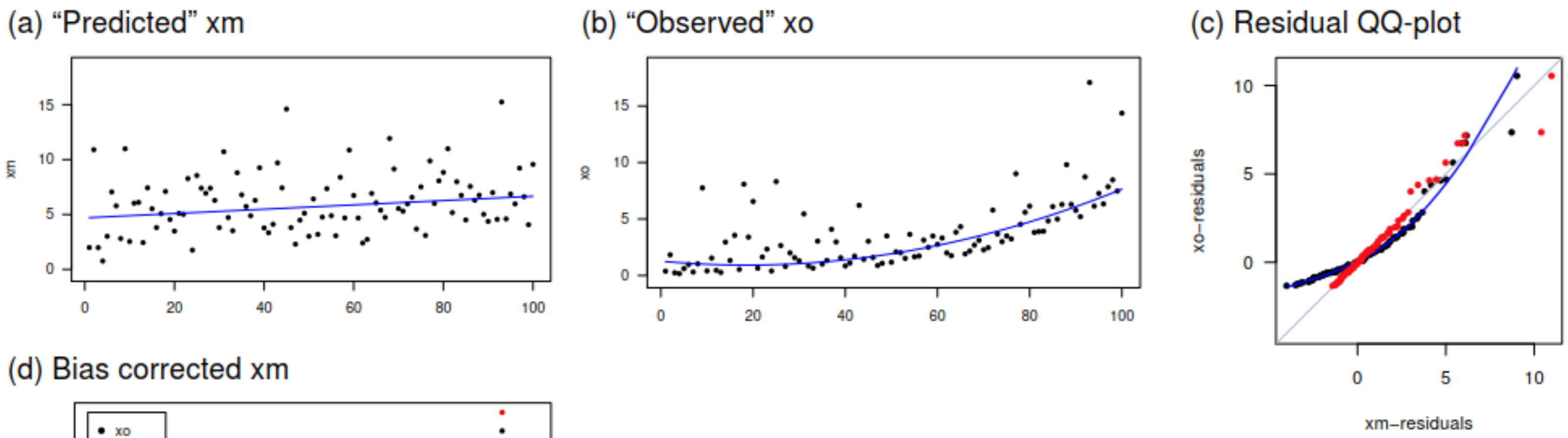
- Early basic bias correction (mean bias adjustment, DCPP/CMIP5&6, ICPO 2011, Boer et al., 2016)
- Since then more sophisticated methods developed accounting for:
    - lead time and start date (Fyfe et al., 2011, Kharin et al. 2012, Kruschke et al., 2015),
    - plus observational states (Fuckar et al., 2014)
    - ensemble dispersion (Eade et al., 2014, Sansom et al., 2016, Pasternack et al. 2017)
- Review of bias adjustment for seasonal and decadal predictions is underway (Grieger et al., FUB, Miklip), in coorperation with WCRP DCPP
- Two new methods: Quantile Remapping (Sienz et al, in prep), Calibration (Pasternak et al., 2017)




CanESM (adapted from G. Boer)

# Quantile Remapping

- The recommended method based on mean bias correction is not applicable for skewed variables (e.g. precipitation)
- New method based on constrained B-spline regression (CBS), which additionally corrects higher order moments
- Enables additional drift correction



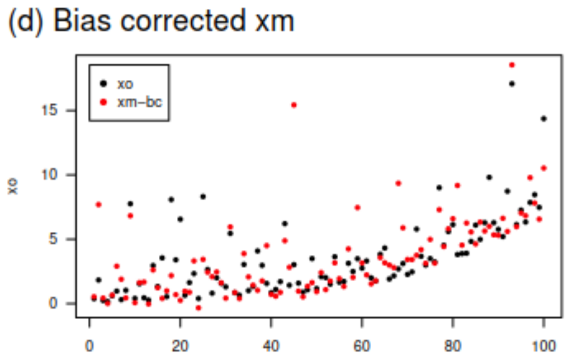
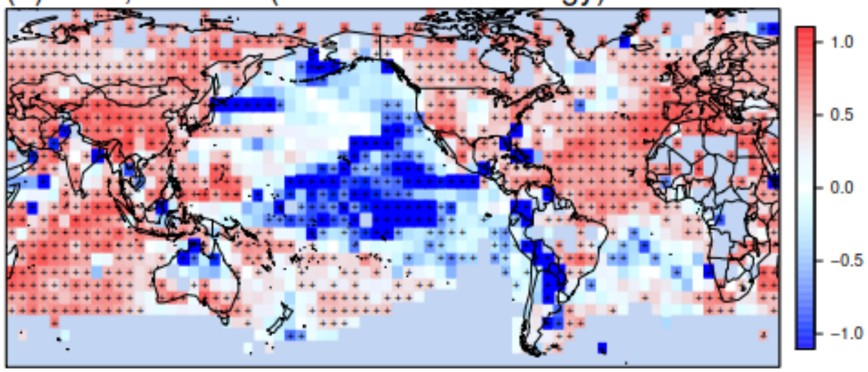



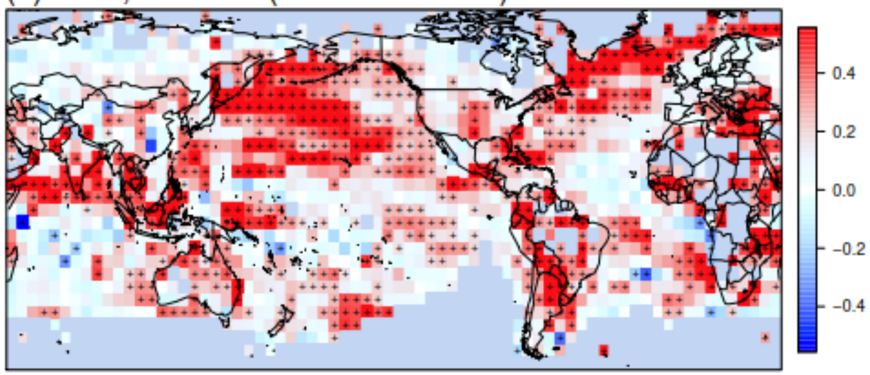

**Fig. 1.** Example with simulated data: “predicted” (“observed”) values follow a linear (exponential) trend with moderate (strong) skewness. (a) “predicted” and (b) “observed” data with trend estimates (blue). (c) Residual quantile-quantile plot before (black) and after (red) bias correction and estimated transfer function (blue). (d) “Observed” (black) and bias corrected (red) values with cross-validation applied.

# Quantile Remapping applied to MiKlip system

(b) ADD, MSESS (reference climatology)

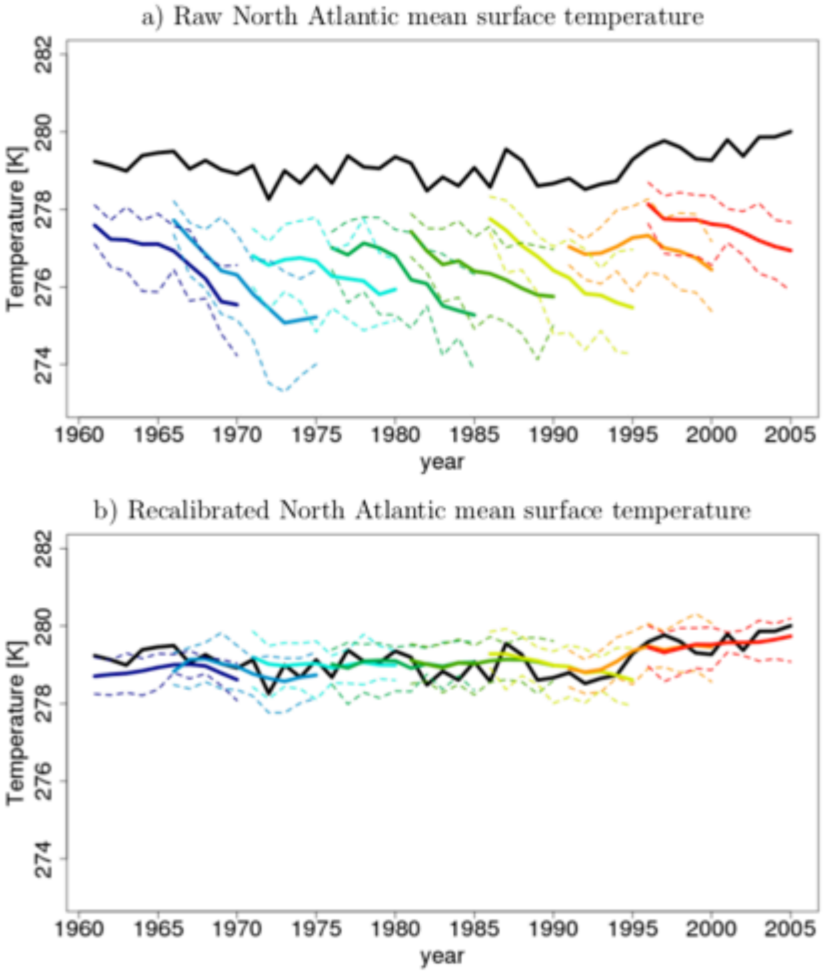



(c) CBS, MSESS (reference ADD)

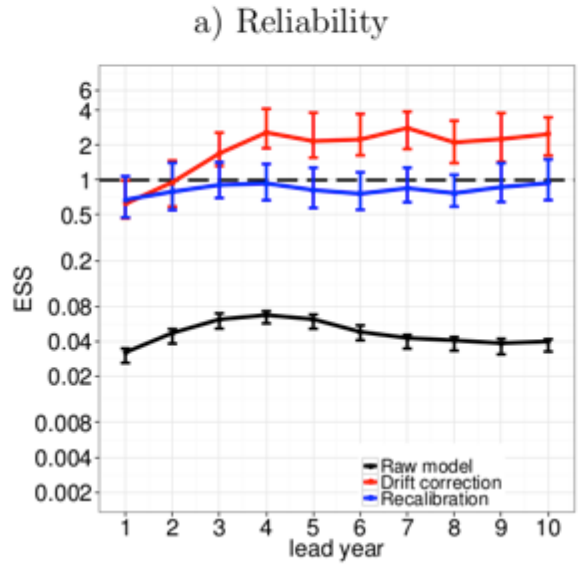



- TAS predictions for a large ensemble (45 member), yr2-5, 1960-2015, different initialization methods
- Mean Squared Error Skill Score for standard approach (ADD with climatology as reference) and CBS (with ADD as reference)
- CBS>ADD all over the place
- CBS>ADD also in terms of reliability and sharpness (e.g. CRPSS)

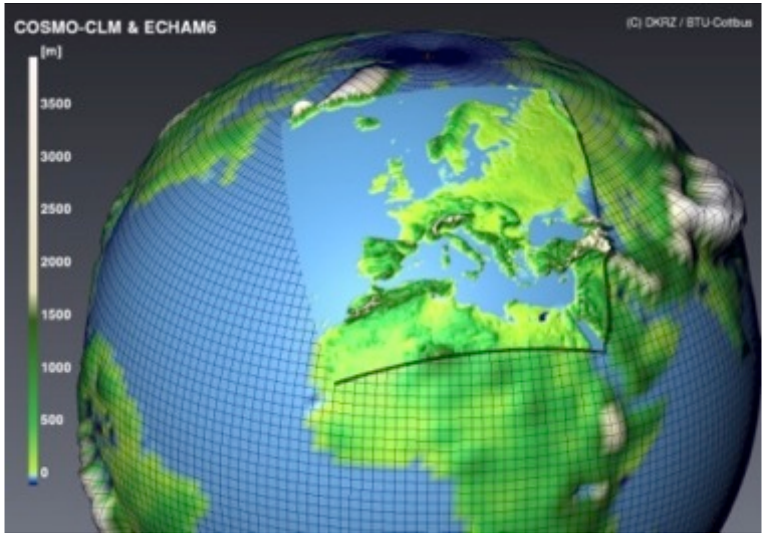
# Calibration of DCP




- Calibration correct ensemble dispersion and sucessfully applied in seasonal climate prediction (e.g. Weigel et al., 2009)
- For decadal prediction, the situation is different, e.g. trend, short sample etc
- Calibration method developed by Pasternak et al., based on a parametric approach
- Improvement of reliability, MSESS and others by calibration of decadal climate predictions



# Downscaling of MiKlip DCP for Europe

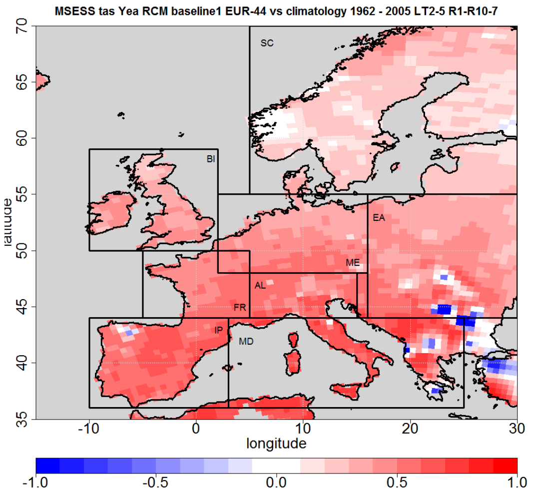



- There is a huge gap between provision of climate information from a GCM perspective and demands from end-users perspective
- Regional climate models (RCMs) can act as „mediators“ and can provide „higher“-frequency climate informations
- In MiKlip this is/has been applied for DCP for Europe and Africa (only first phase)
- „Proof-of-concept“ is the added-value, some results show the value of using RCMs (e.g. Feldmann et al., 2017, Reyers et al., 2017, Moemken et al., 2016, Mieruch et al., 2014 ….)

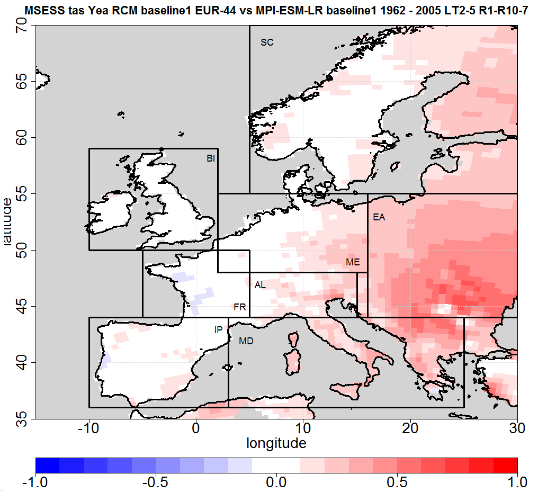
**See also poster Module C, Feldmann et al.**

# Added-value of RCM DCP for Europe

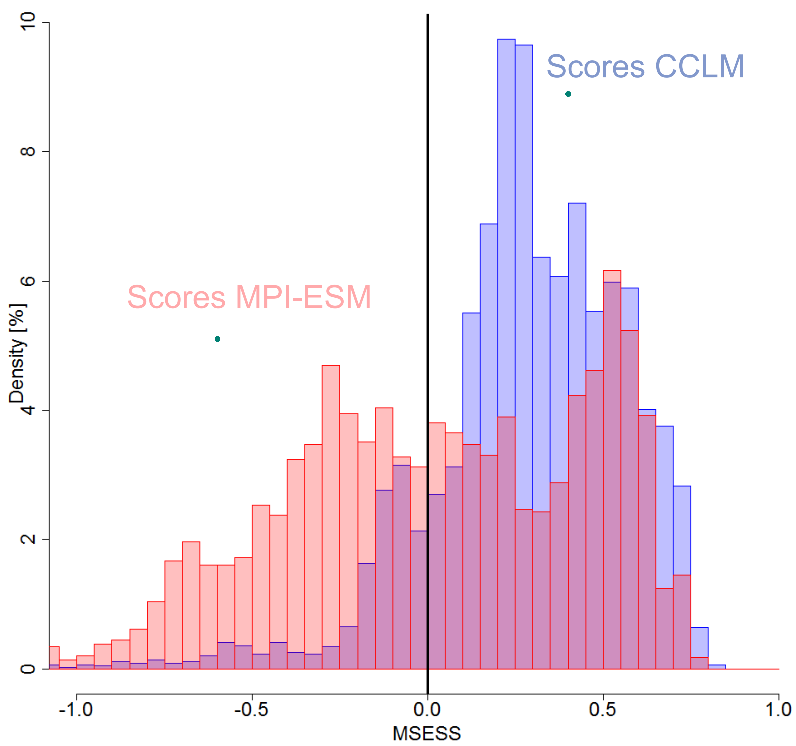
**Tas, rmsess, yr2-5,CCLM+REMO, Ref Climatology**



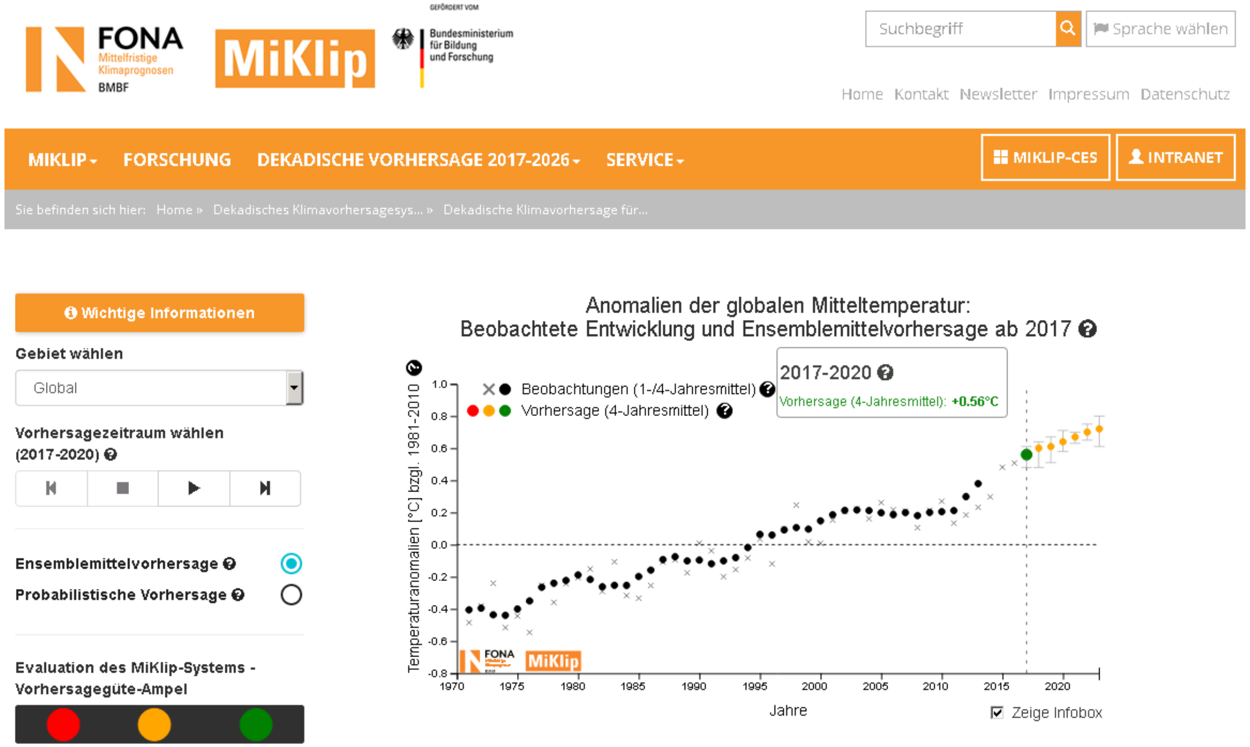

**Tas, rmsess, yr2-5, MPI-ESM, Ref CCLM+REMO**




**MSESS Distribution**



# Regular Decadal Climate Forecasts on the MiKlip Web Page



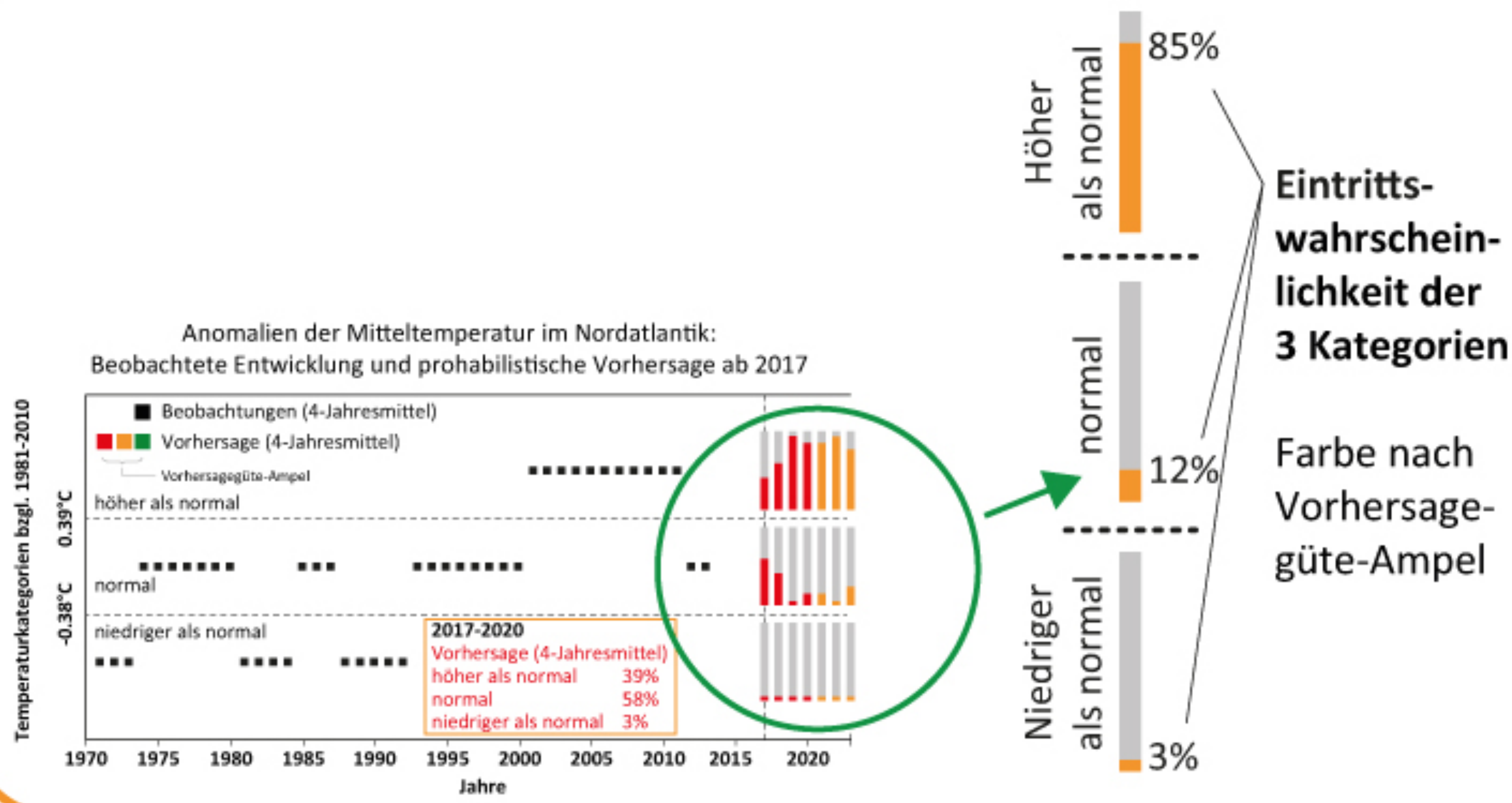

- Web page providing decadal climate forecast launched 01.2017
- provides actual temperature forecasts on a global and regional scale
- provides background information related to decadal climate forecasts
- designed to be user-friendly by e.g. implementation of traffic lights for skill assessment

https://www.fona-miklip.de/decadal-forecast-2017-2026/

Max-Planck-Institut für Meteorologie

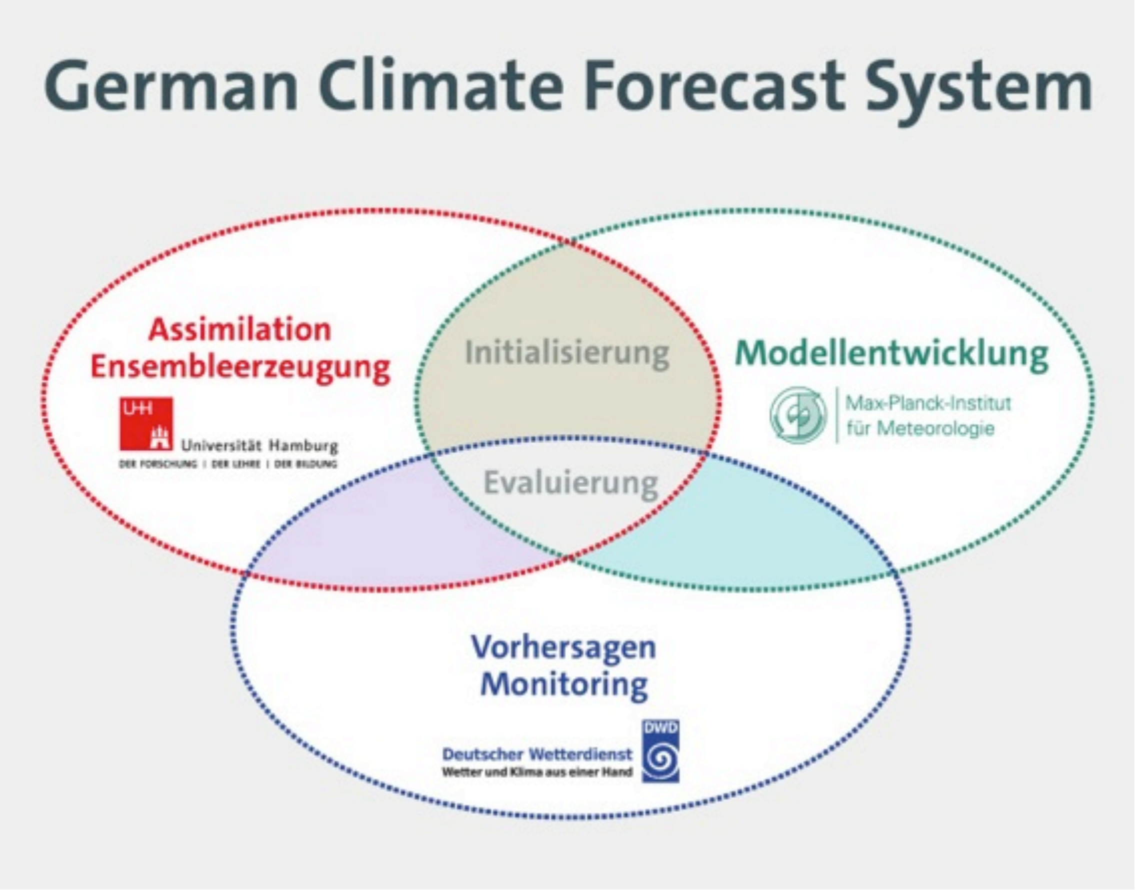
# Probability Forecasts

## Here: North Atlantic region




- New: Next Release (01.2018) including RCM forecast for Europe

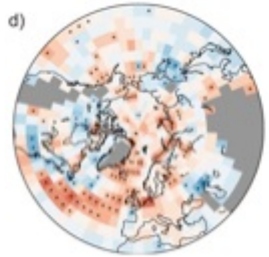
# Towards operational decadal climate forecasts - A Blueprint



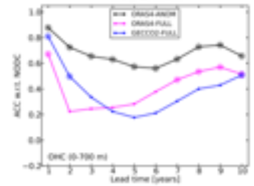

- Joint cooperation DWD-UHH-MPG
- Operational seasonal climate forecasts based on MPI-ESM, released every month

# MiKlip- An almost decade-long retrospective

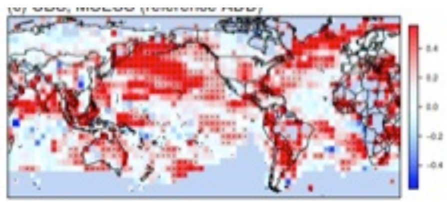
- Have explored number of skillful processes and increased the confidence of provision of climate information a decade ahead



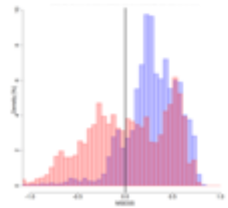
- Have explored capacities of current initialization methods, and realized the need for a model-consistent assimilation



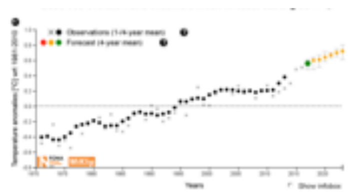
- Have established the bias adjustment as a powerful tool to improve reliable climate information for DCP



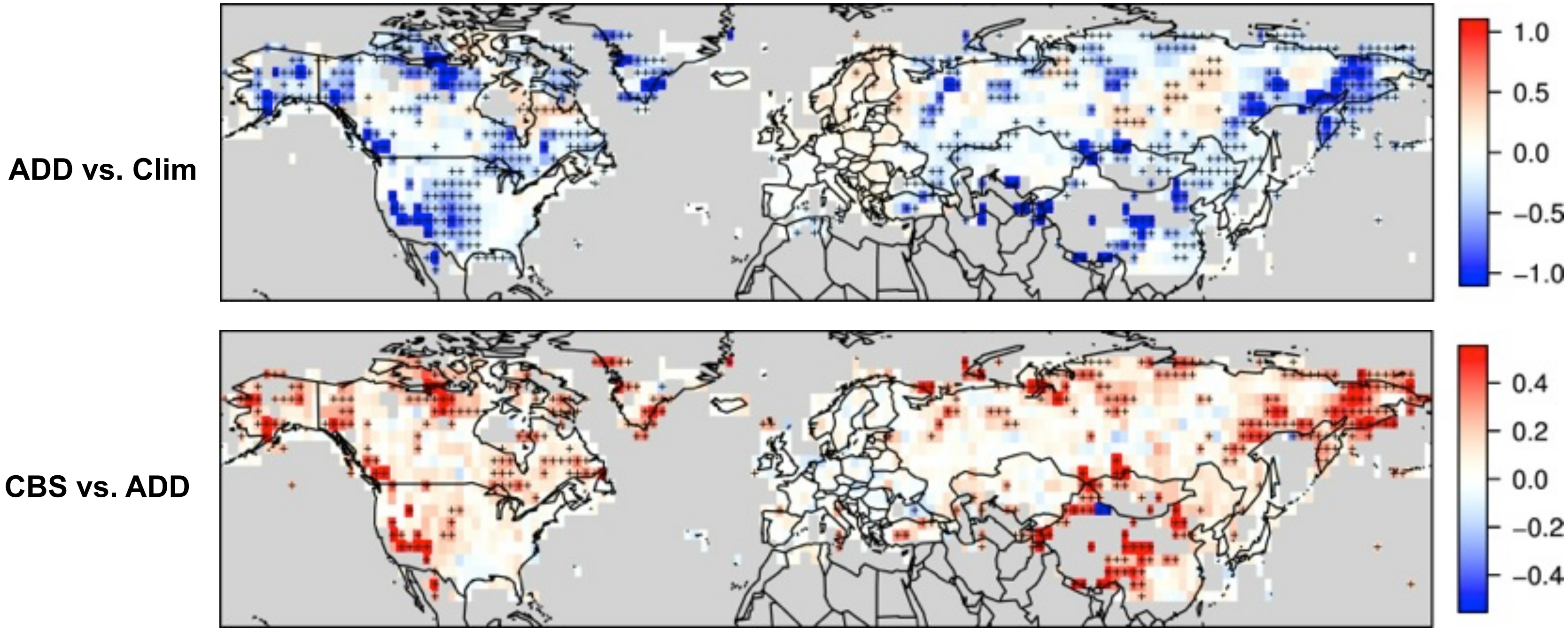
- Have downscaled DCP for Europe, and provided added-value of using RCMs



- Have established the MiKlip system in an international context, and provide regular decadal climate forecasts

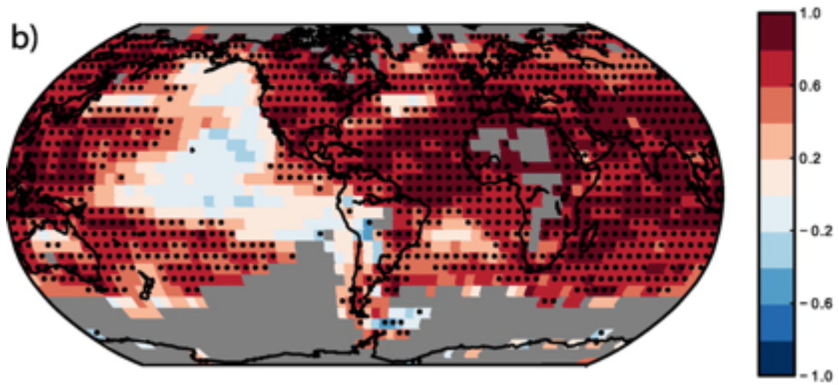


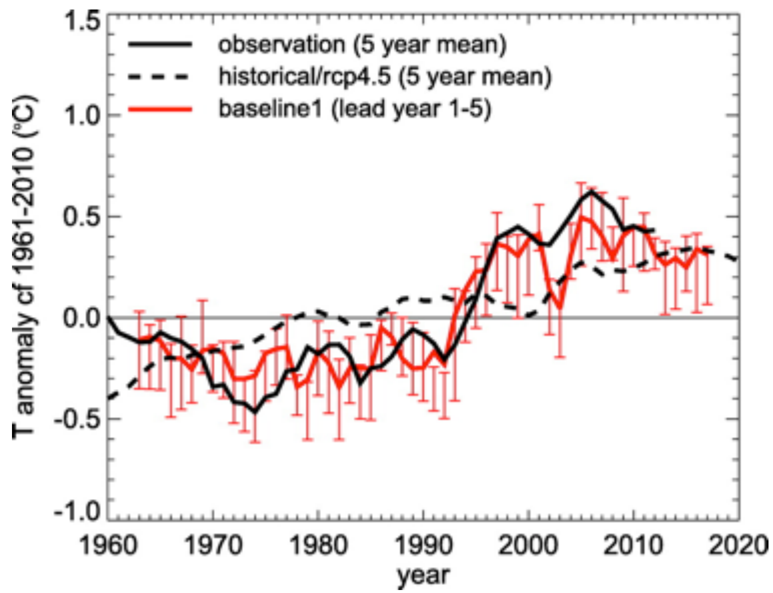
# Quantile Remapping applied to MiKlip system




- Predictions for total precipitation, yr2-5
- Mean Squared Error Skill Score for standard approach (ADD with climatology as reference) and CBS (with ADD as reference)
- Bias adjustment provides a powerful tools to improve Climate Prediction Information

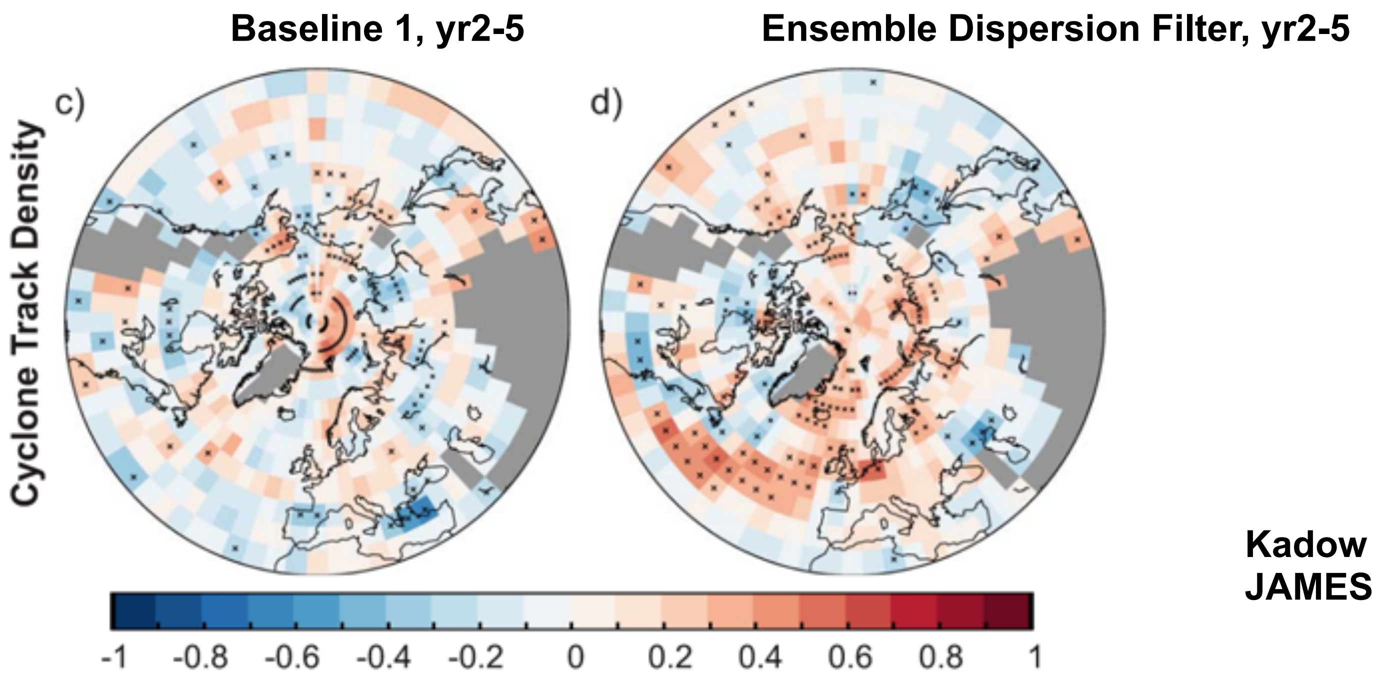
# Forcing and internal variability both sources of predictions skill




- TSURF, baseline 1, yr2-5, ACC, Hindcast w.r.t HadCRU, reference forecast climatology (baseline 1, DS2)
- Much of TSURF skill driven by external forcings and provides useful climate informations
- Other regions, such as the North Atlantic ocean provides source of prediction skill based on internal variability
- Key diagnostics provide skills years to decade ahead: SST (Pohlmann et al. 2009), ocean heat content (Kröger et al. 2012), AMOC (Matei et al. 2014), sub-polar gyre (Lohmann and Matei, 2017) …

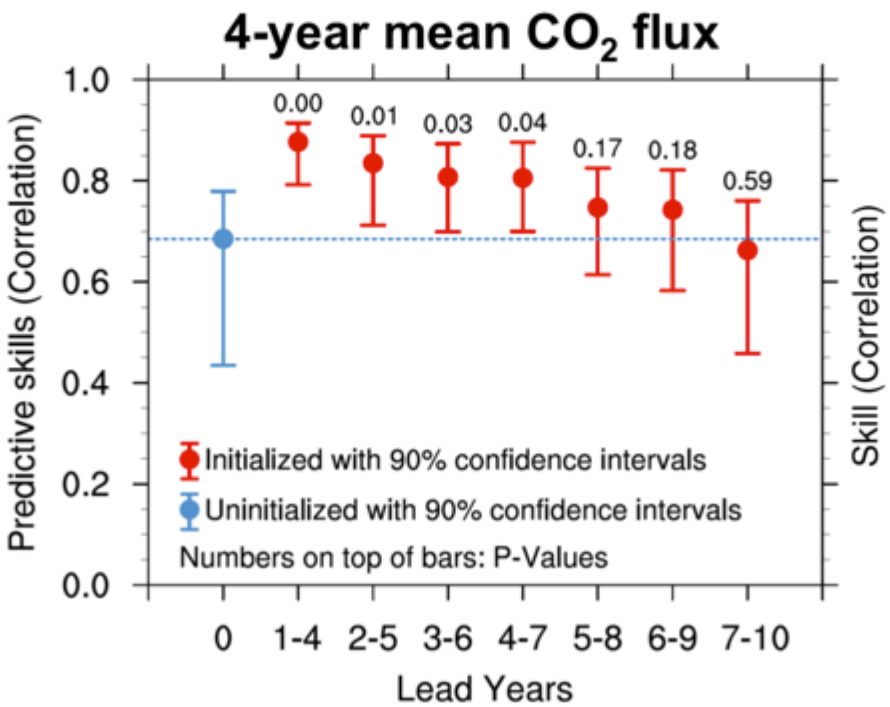
# Still a challenge: skill on continental scale, but ...




**Kadow et al., 2017 JAMES**

- Skill on continental scale still difficult to achieve, however, key processes reveal forecast skill several years ahead
- winter cyclone track density (Kruschke et al. 2015, Kadow et al. 2017), wind speed and energy potentials over Europe (Moemken et al., 2016)
- EU/Eurasian summer temperatures (Müller et al. 2012, Sienz et al., 2015, Monerie et al., 2017 submitted)
- Sahelian rainfall (Mohino et. al., 2017), volcanic eruptions (Timmreck et al. 2016)

# Earth system predictability
# forecast skill of ocean carbon uptake




**Li et al., 2016**
**Nature Communications**

- Prediction skill of earth system components such as CO2 uptake in the western subpolar-gyre up to 4-7yr (baseline 1, DS2)
- Mainly maintained in winter and attributed to improved physical state of the ocean
- Offers opportunities for other earth system components