Prediction of Multi-year Droughts (DroughtClip, E45)

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Introduction

DroughtClips main objective is the analysis of the predictive skill for multi-year droughts on decadal time scales and includes:

- The preparation of extended hindcast experiments covering the time period of the entire 20th century
- Assessment of drought predictability with a special emphasis on long-term historical droughts, for example the "Dust Bowl" in the central US during the 1930s or the Sahel drought in West Africa in the 1970s and 1980s

20th century hindcast experiments

1. Atmosphere forced ocean model (MPIOM). The MPIOM forced with an ensemble of the 20th century atmospheric reanalysis recovers important parts of the observed North Atlantic mean climate and multi-decadal variability (MDV) for the period 1872-2010 (Müller et al. (2013)):

- North Atlantic Current, sub-polar gyre and associated northward heat and salinity transports are driven by MDV of an NAO-like pressure gradient (Figure 1, left) and thereby alter North Atlantic and Arctic MDV
- Arctic freshwater export (solid and liquid) affect the upper level salinity and convection in the Labrador Sea (Figure 1, right), which for the early period leads to a slowdown of the AMOC
- Prior 1900, the model salinity in the sub-polar gyre region indicates a strong damping of the general circulation structures (AMOC, SPG) and therefore need to be considered as model constrained. However, for the early 20th century (including the strong transitions in the 1920s and 1930s), sparse observation data indicate that the model experiments exhibits 3-dimensional view of the Arctic and Atlantic MDV

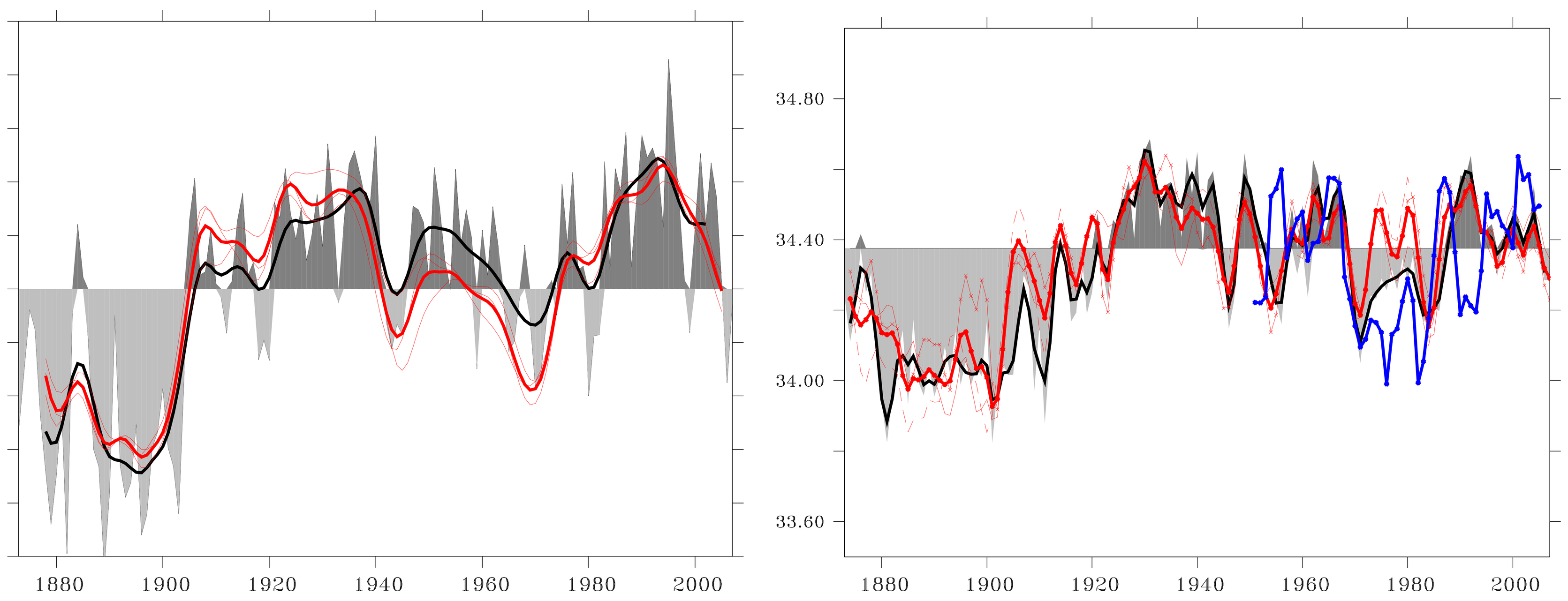

Figure 1. *Sub-polar gyre (left): 10 year running mean of first principal component (black: EM, thin red: EI and red: mean of EI) of mean barotropic streamfunction. The first EOF explains 66% of the total variance. PC is normalised and units for EOF are 10^9 kg/sec. Labrador Sea salinity (right): 3 year mean salinity (g/kg) in the Labrador Sea (52W-48W, 52N-57N) averaged between 0-100m; blue line: observations.*

2. Extended hindcast experiments. Salinity and temperature fields of the ocean forced runs are assimilated into MPI-ESM-LR and hindcasts are performed. Up to now one hindcast experiment is completed with a yearly initialisation from 1900 to 2010. Figure 2 shows (here global mean temperature), for the first time, decadal forecasts back to 1901 performed with a dynamical model.

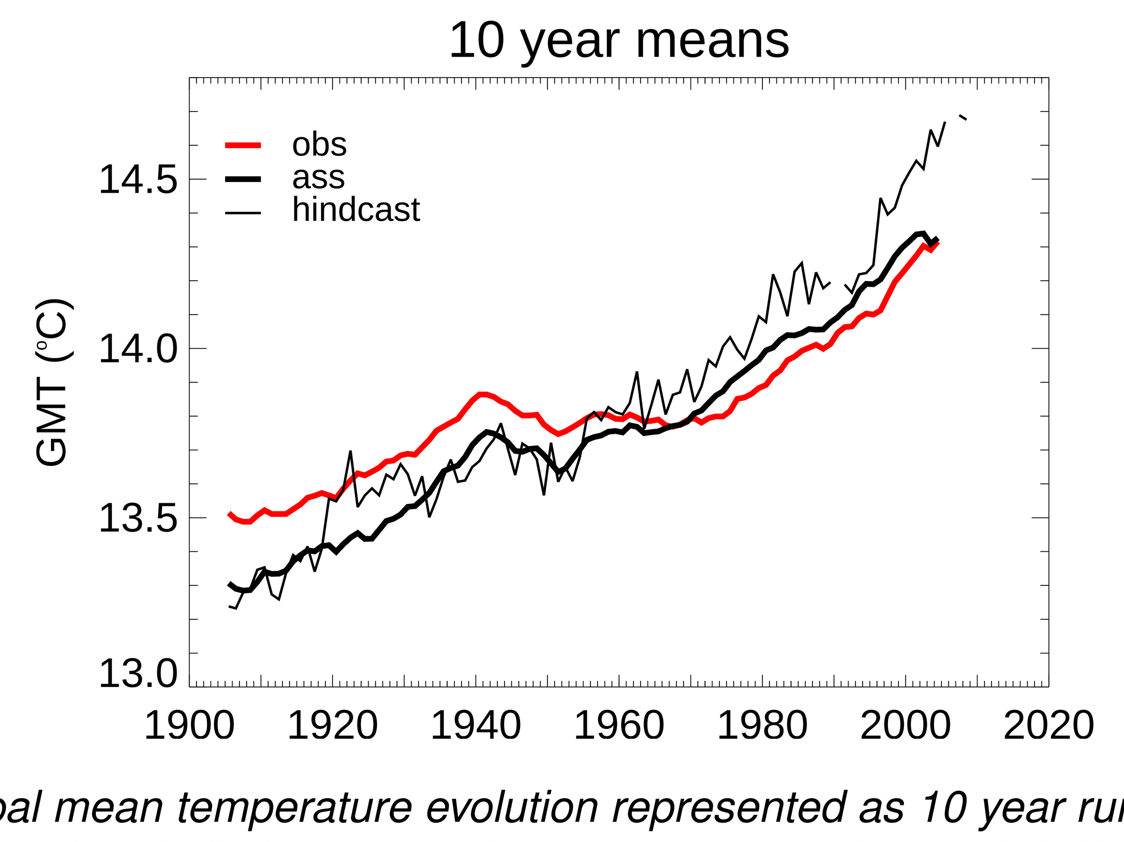

Figure 2. *Global mean temperature evolution represented as 10 year running mean series (observed and assimilation run) and 10 year mean of the yearly initialised forecasts.*

References

Goddard, L., et al., 2013: A verification framework for interannual-to-decadal predictions experiments, Climate Dynamics, 40, 245-272.

ICPO (INTERNATIONAL CLIVAR PROJECT OFFICE), 2011: Data and bias correction for decadal climate predictions . January. International CLIVAR Project Office, CLIVAR Publication Series No. 150.

Müller W. A., et al., 2013: A 20th century reanalysis forced ocean model to recover North Atlantic multi-decadal climate variability from 1872-2010, Climate Dynamics (in preparation).

Statistical improvement of predicted precipitation

Achieved skill-scores of precipitation predictions are rather low and restricted to small areas in actual decadal forecast systems (Goddard et al. (2013)). In general, predictions benefit from correcting the original model variables statistically. Here, the bias correcting method "Quantile mapping" (QM) is suggested, which is able to reduce the root-mean-squared error (RMS) more than an adjustement of the mean alone, the proposed method by the ICPO (2011). Monthly precipitation predicted with the baseline version 0 is considered below.

- QM adjusts for the mean, in addition the higher order moments are corrected (Figure 3, left)
- Even in cases where the RMS of the forecasts and after the adjustement for the mean are higher than that of a random forecasts, QM reduces the RMS close to the one of the climatology (Figure 3, right)
- The improvement with QM holds for global monthly precipitation over land and for time averages of one year or more (Figure 4 and 5))

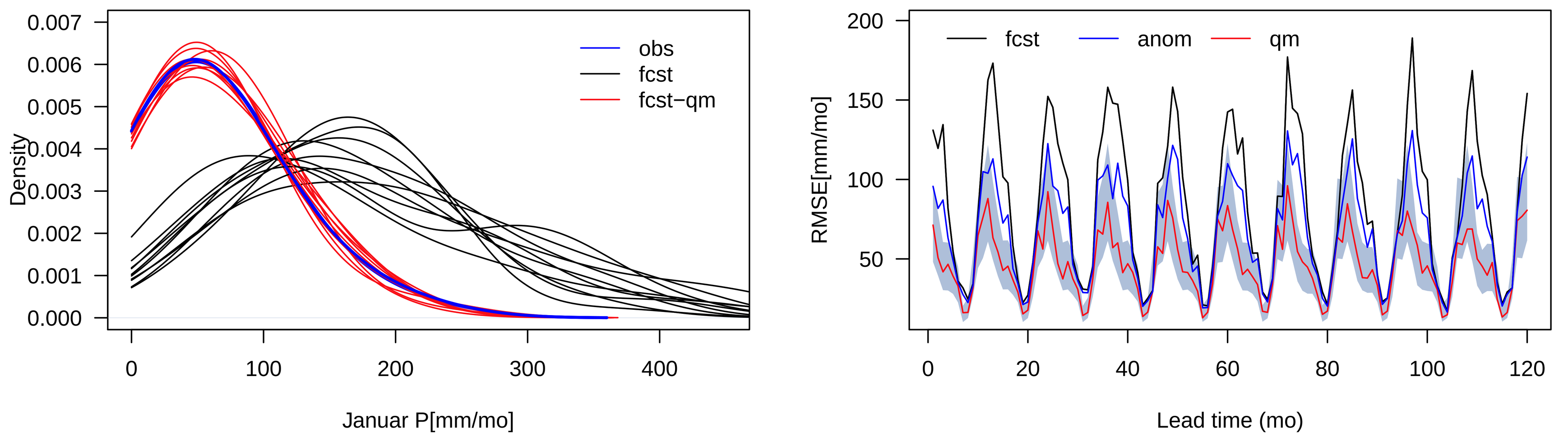

Figure 3. *Example gridpoint: leadtime dependent precipitation distributions for January (left), without (black) and with applied QM (red) compared to observations (blue). RMS (right) of the original forecast (black), with QM (red) and mean adjustment (anomalies, blue). The upper (lower) border of the gray shaded area are RMS of random (climatology) forecasts.*

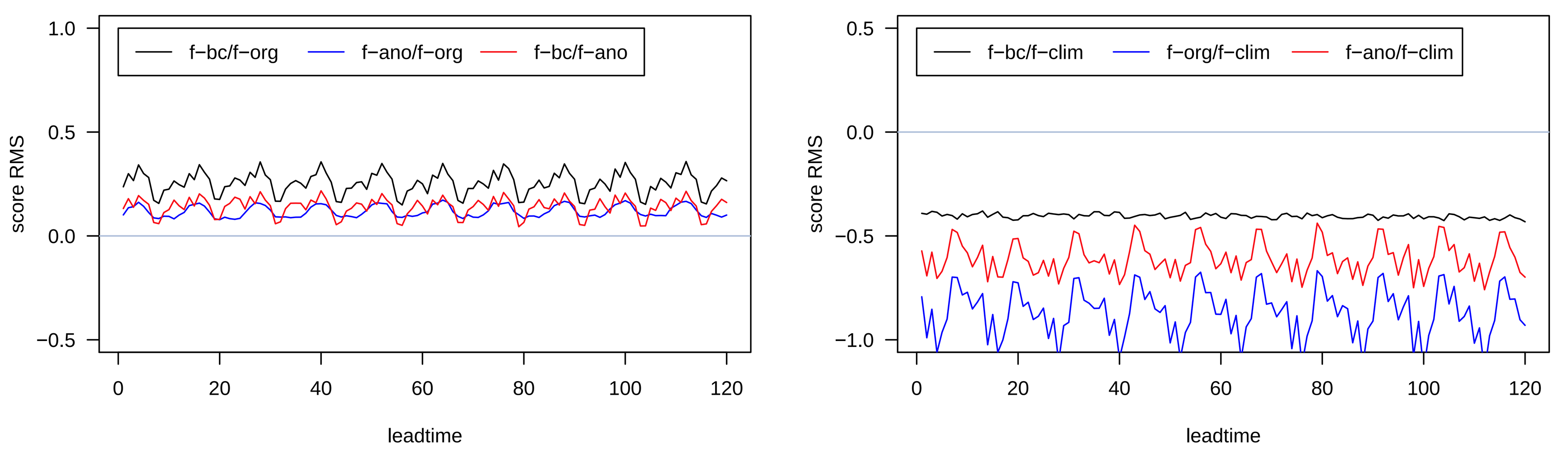

Figure 4. *Median of achieved scores at each gridpoint over land for monthly precipiation. RMS scores (left): QM (black) and mean adjustment (blue) in respect to the original forecast and a comparison of both (red). RMS skill-scores in respect to climatology (right): QM (black), mean adjustment (red) and original forecast (blue).*

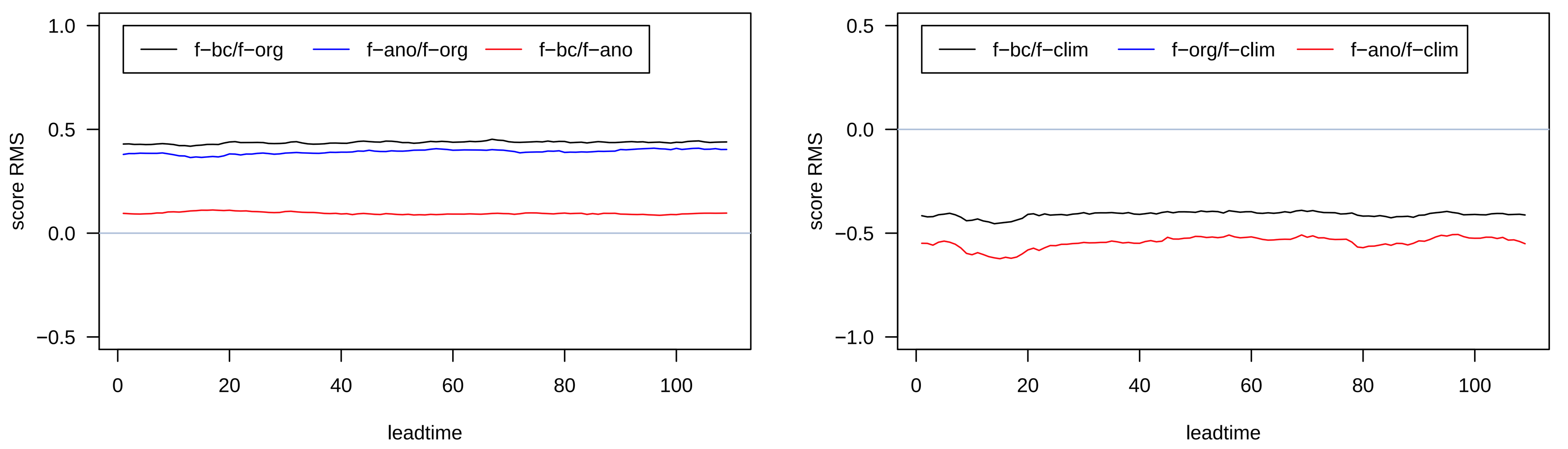

Figure 5. *Same as Figure 4, but for a time average of one year.*

Conclusions

- The 20th century hindcast experiments enable a better understanding about necessary hindcast sample size requirements for robust skill estimation. This is not only of relevance for persistent drought events but also for other climate quantities of interest. Therewith, the outcomes serve the development of validation strategies and further provide benchmarks and minimal requirements for the decadal prediction system
- Statistical correction methods for predicted climate variables are necessary to overcome climate model drift. An adjustement of the mean, in dependence of the leadtime, is applied usually First results show, however, that Quantile mapping is able to reduce the root mean square error even more. So, it is worth to further compare different bias correcting strategies and to analyse the impact on other climate variables of interest

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