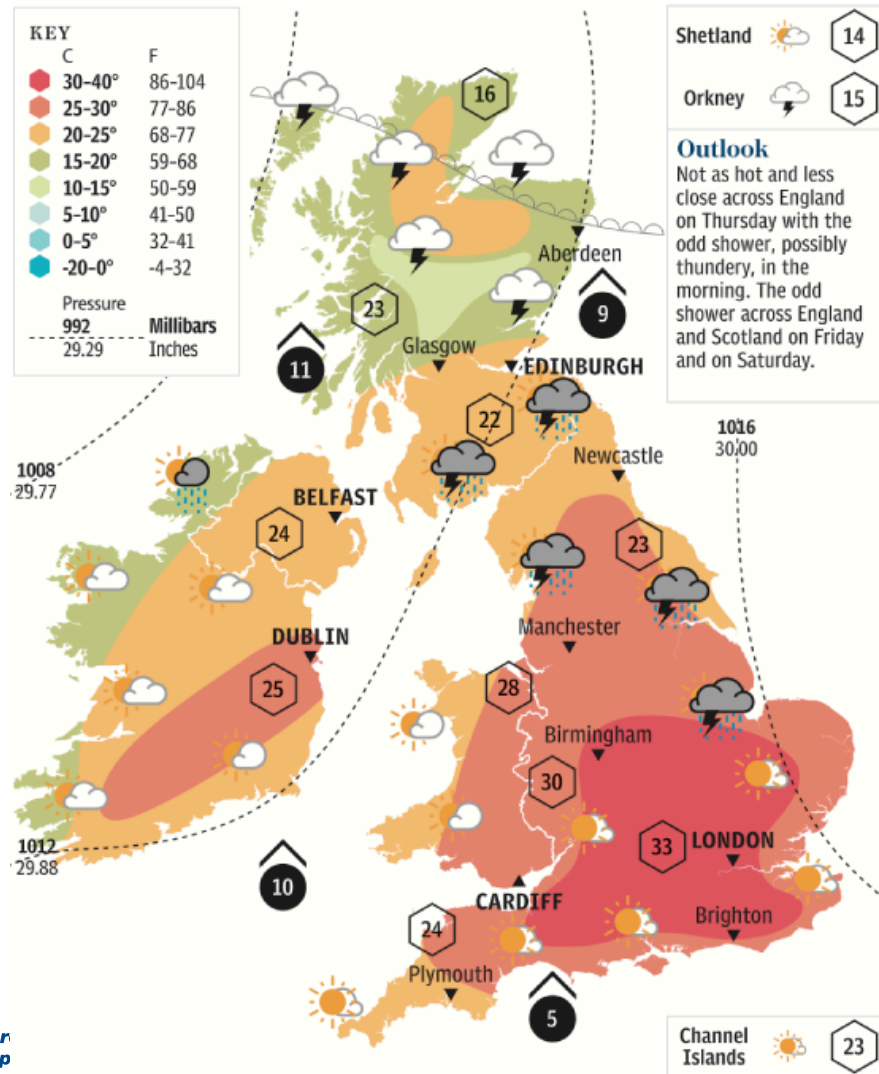www.bsc.es

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Towards reliable extreme event attribution

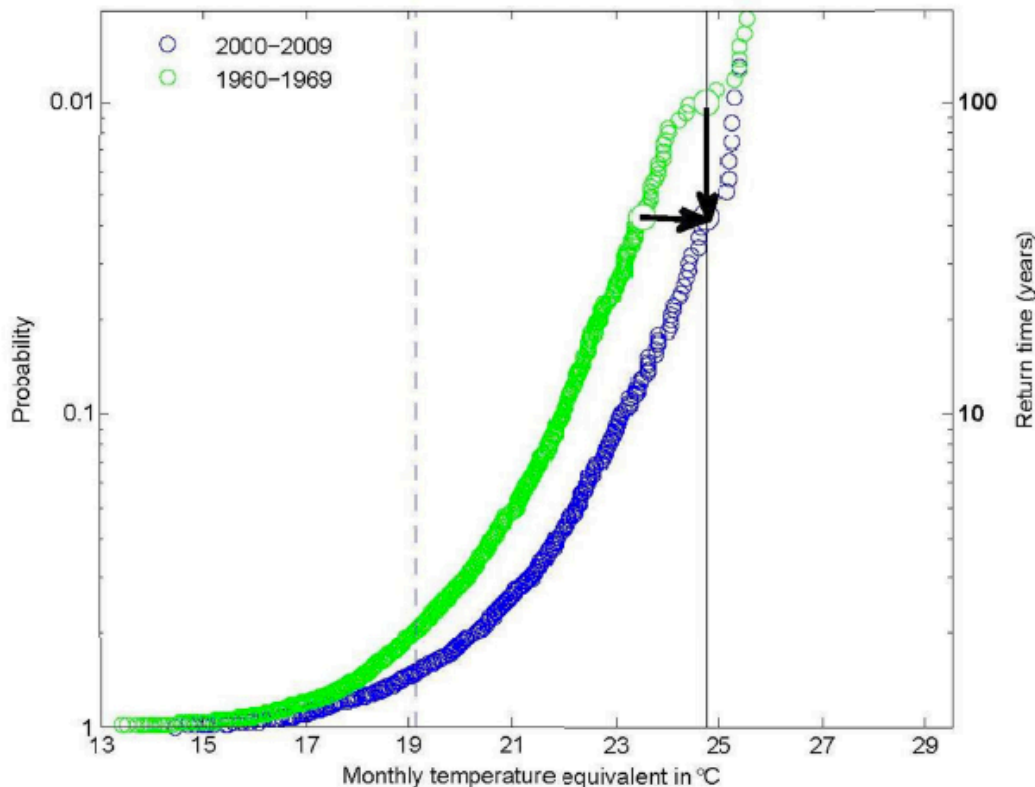Omar Bellprat, Virginie Guemas, Francisco Doblas-Reyes

Eucleia

What has been the role of climate change?

Attribution of extreme events

The attribution question: **has climate change increased the probability and intensity of a *class of events*?**
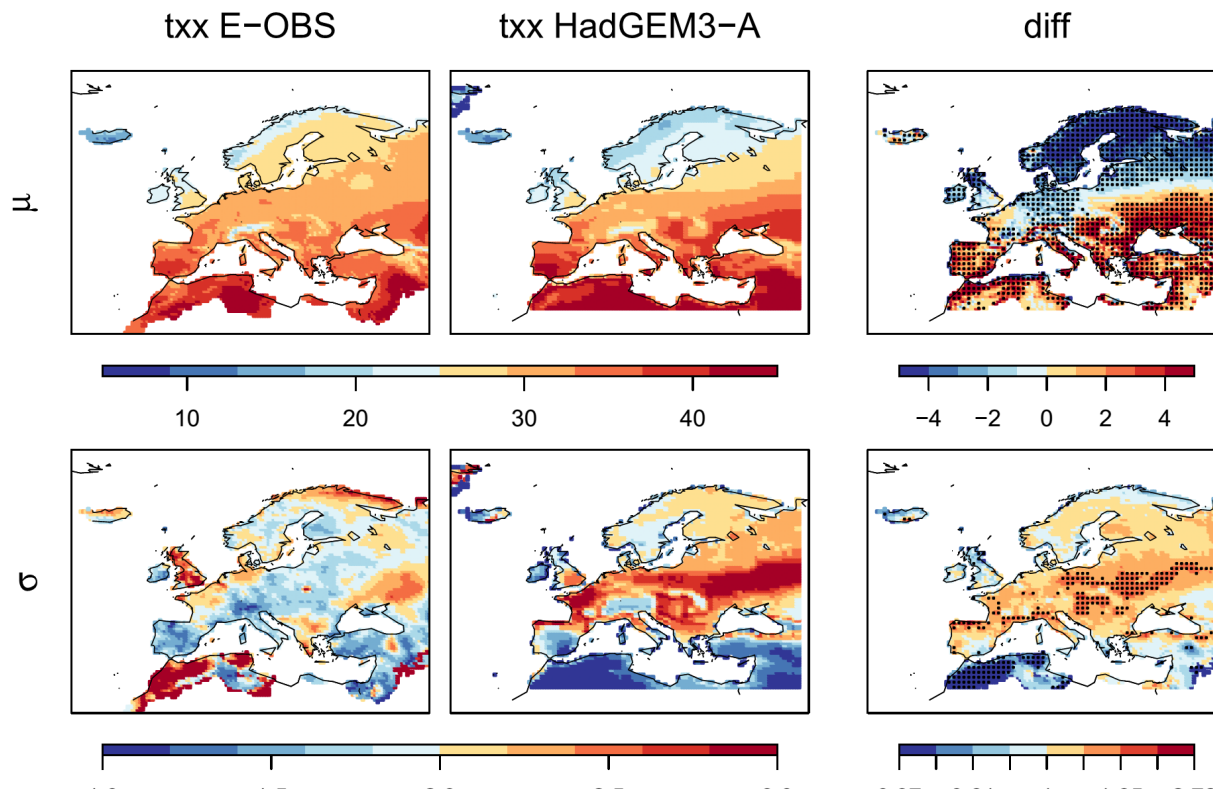

P_{ALL}= Probability under present day condtions

P_{NAT}= Probability in past or „no climate change conditions"

FAR= 1 – P_{NAT} / P_{ALL}

Otto et al., (2012)

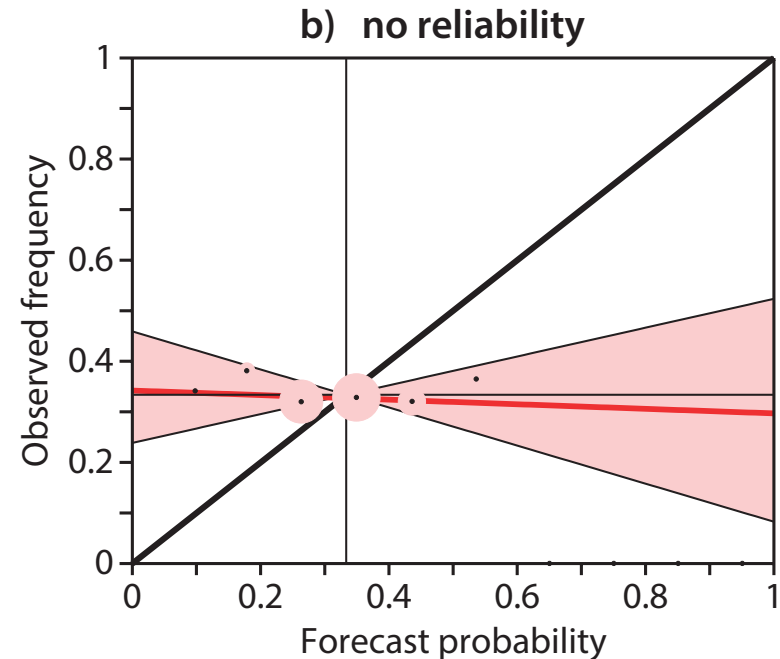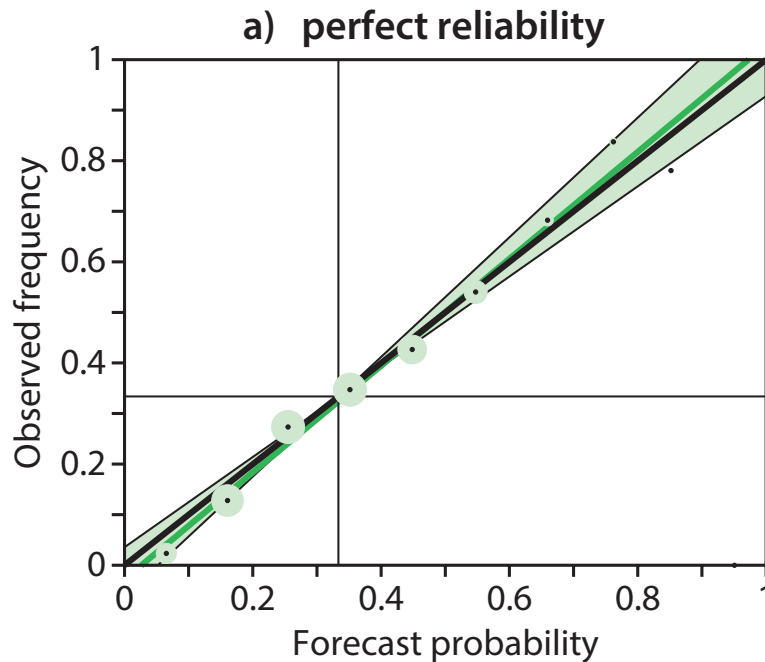# Accuracy of attribution statements

How much can we trust P_{ALL} and P_{NAT} simulated by a model?

Assumption is made here that a correct climatology gives correct simulated P_{ALL} and P_{NAT}

Vautard et al., (2017)

Evaluating simulated probabilities

When rain > 100 mm is simulated with 80% probability does it actually rain > 100 mm in 80% of the time?

Weisheimer and Palmer (2014)

Weather and climate prediction

Q1: Can we the reliability assessment from weather and climate prediction to assess simulated probabilities in the context of event attribution?

Q2: Can we use the initialized model simulations (seasonal forecasts) to judge the models ability to simulate the forced response of extreme events?

Weather and climate prediction

Q1: Can we the reliability assessment from weather and climate prediction to assess simulated probabilities in the context of event attribution?

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The EUCLEIA prototype

60km resolution, 85 levels
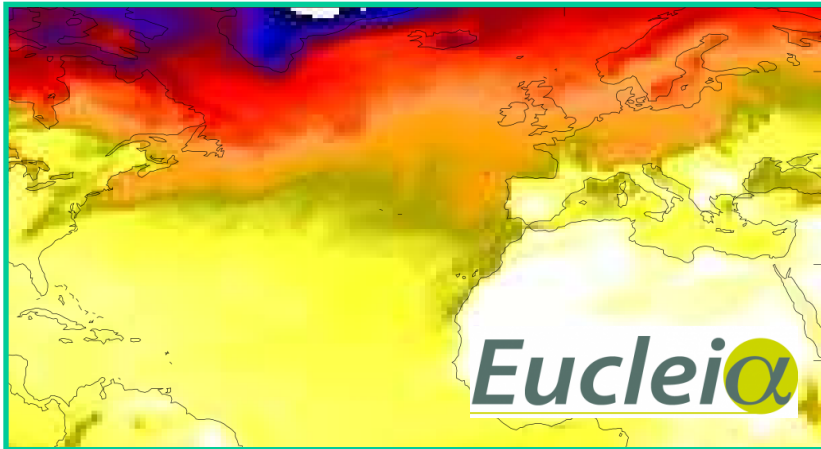
SST forced HadGEM3-A
Period: 1960 –2013
Ensemble: 15 members
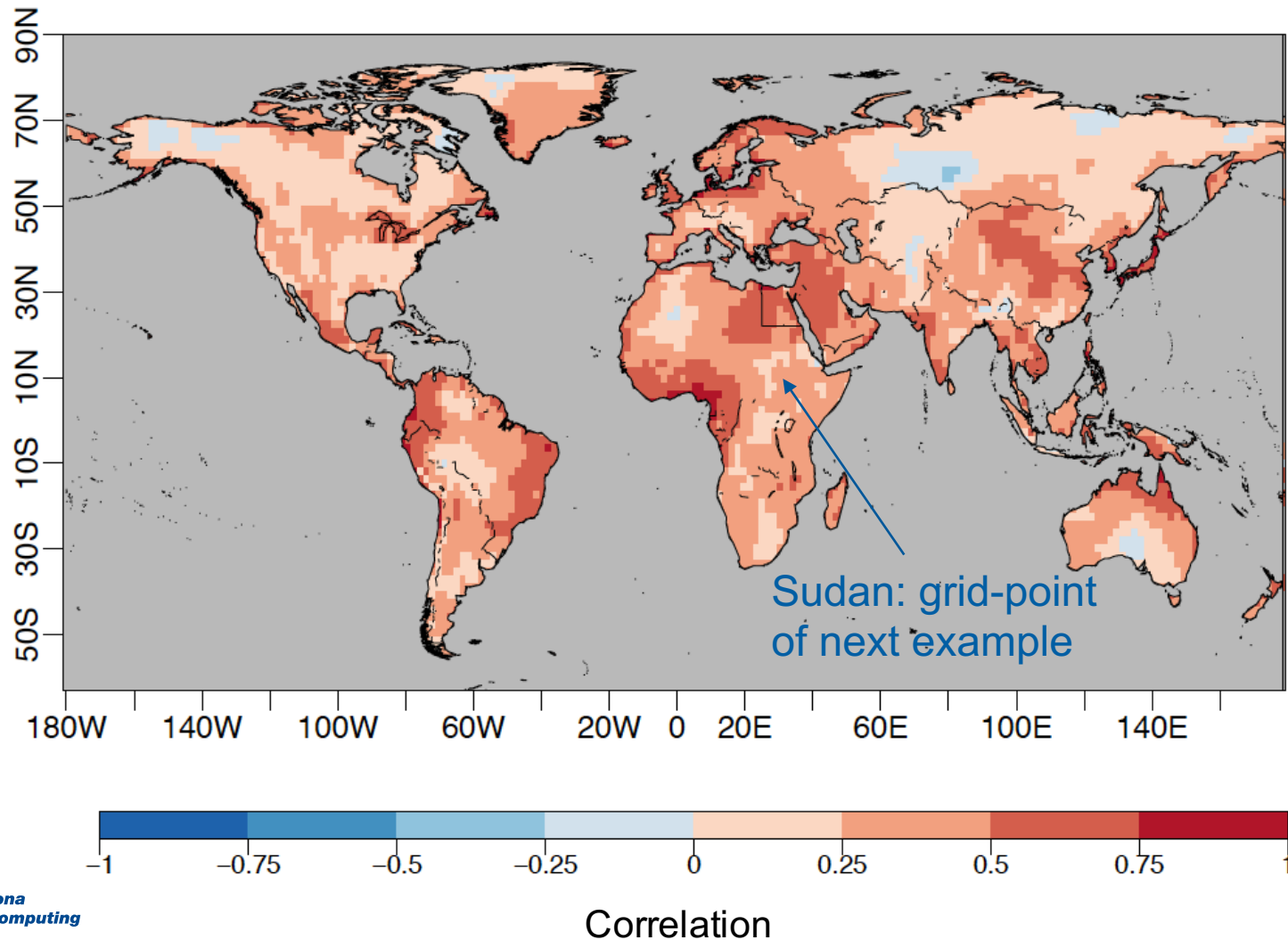
ALL: forcings. HadISST
NAT: forcings. HadISST $- \Delta t_{anth}$

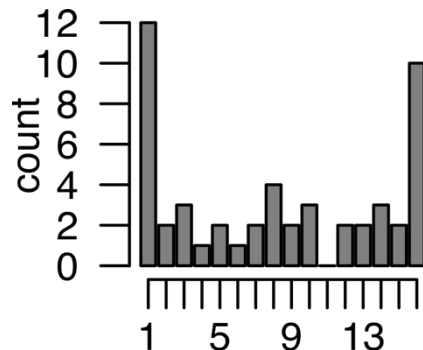As weather@home (Massey et al., 2015) or
CLIVAR C20C+ (Folland et al., 2013)

Ciavarella et al., (2017)

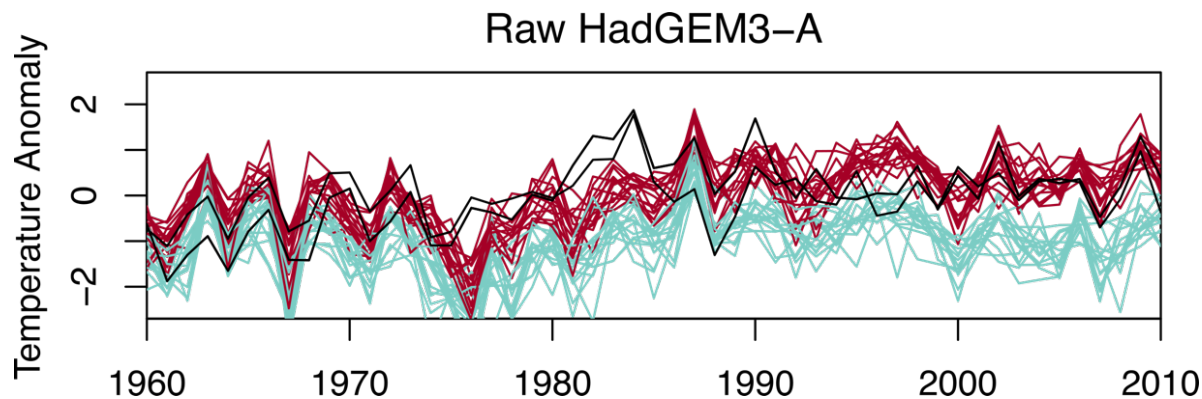# HadGEM3-A has "skill"

Detrended ensemble mean correlation mean JJA temperature

Sudan: grid-point of next example

Correlation

Attribution of hot summers in Sudan

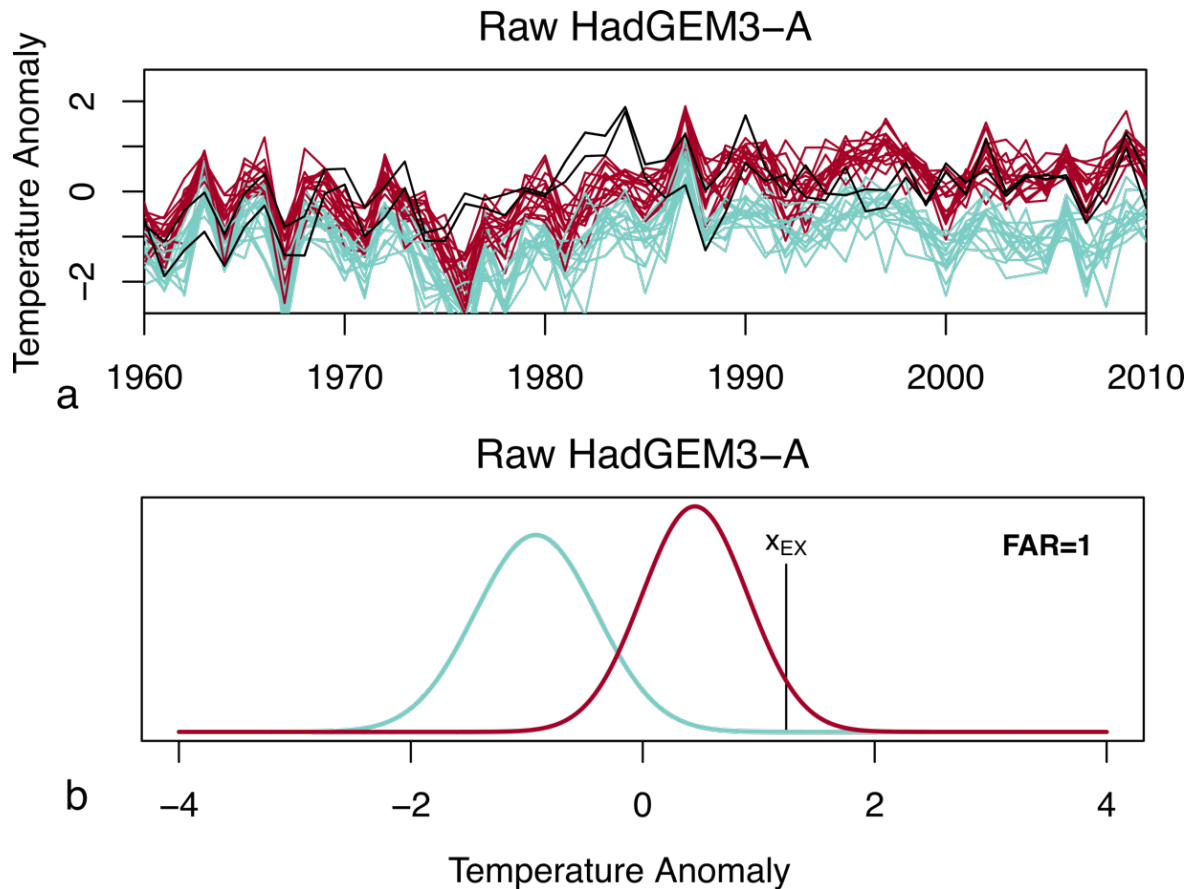Model has the correct variability/trend but ensemble is overconfident

Raw HadGEM3–A

Ranked histogram: counts the position of the observations in the ensemble.

Typical case of *unreliable probabilites*

Attribution of hot summers in Sudan

Overconfident ensemble leads to overestimation attributable risk

Unreliable ensembles are a pervasive problem in weather and climate forecasting and calibration methods have been developed
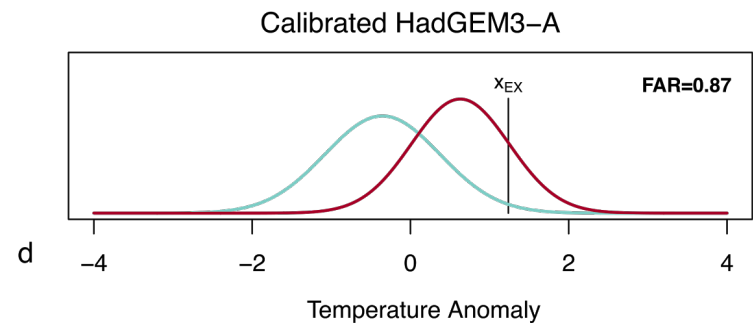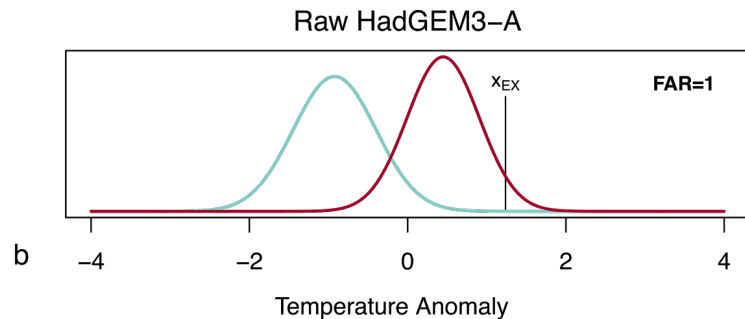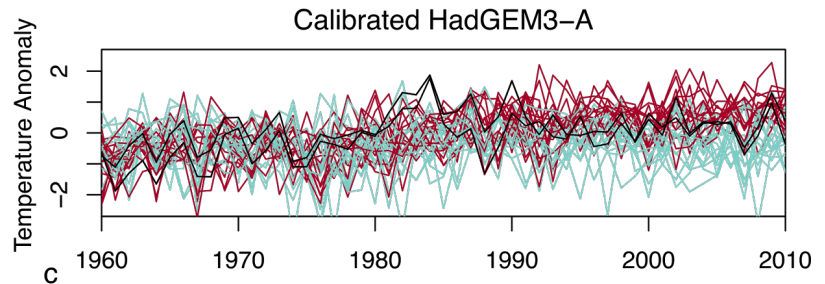
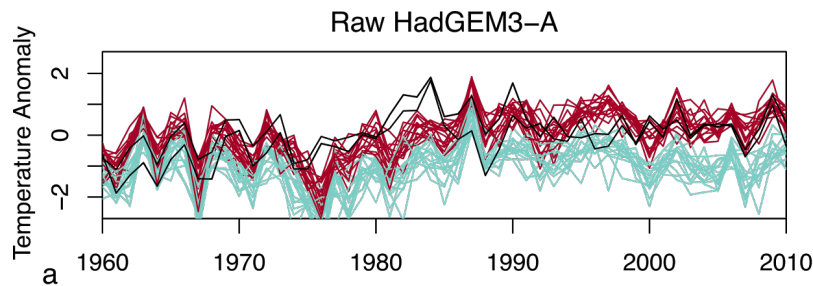$$y_{CAL} = \alpha y_M + \beta y_E + \gamma y_T$$

ensemble mean   ensemble spread   long-term trend

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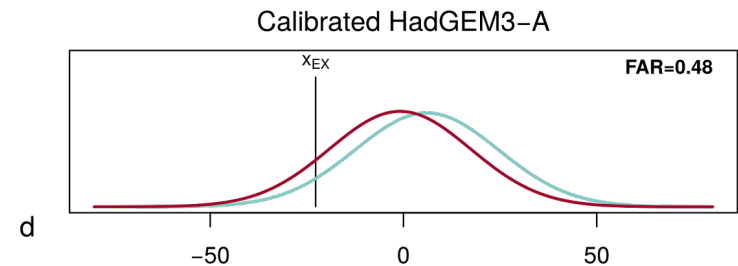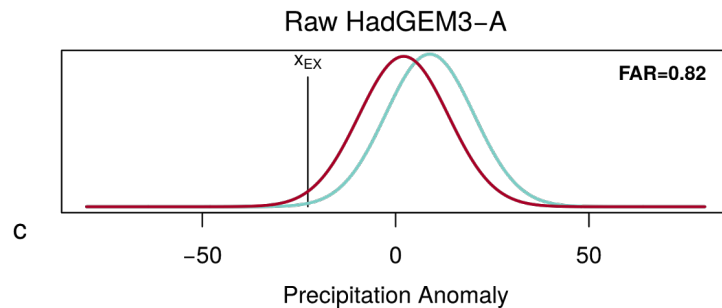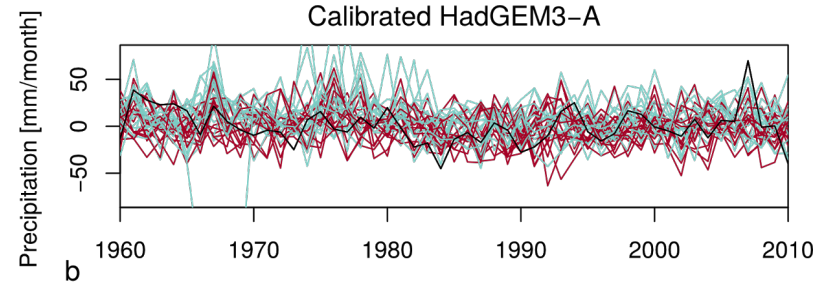Center
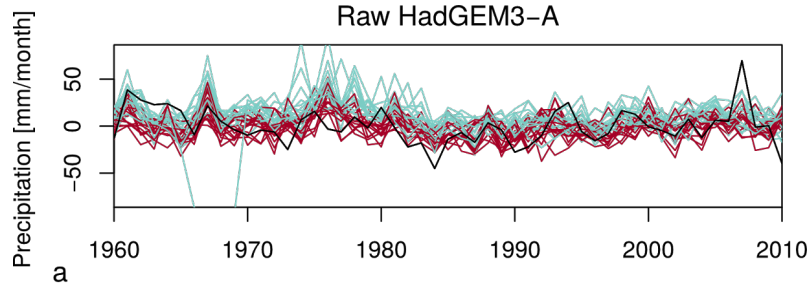*Centro Nacional de Supercomputación*

BSC

Effect of calibration

Ensemble calibration **reduces attributable risk**. Effect small because climate change indeed strongly favours hot events
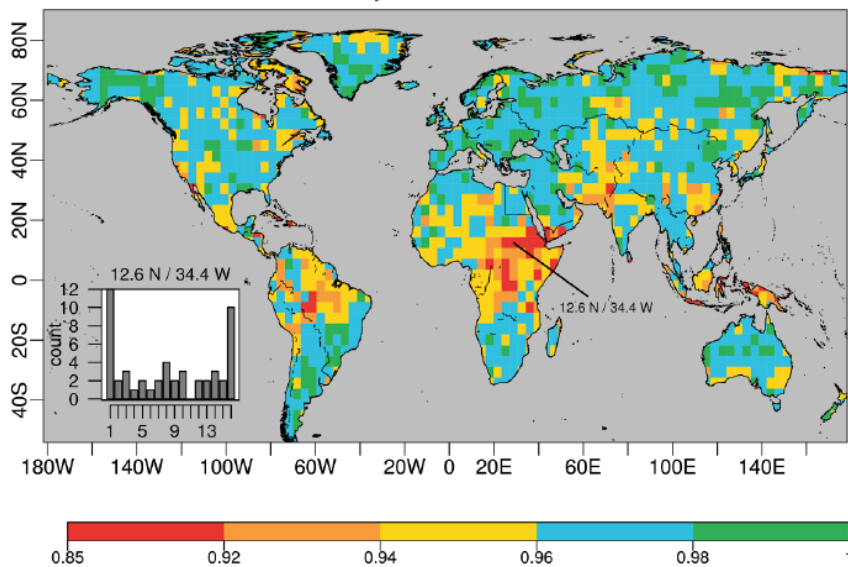
Effect of calibration

Effect is larger on **dry precipitation** case (lower signal-to-noise ratio)
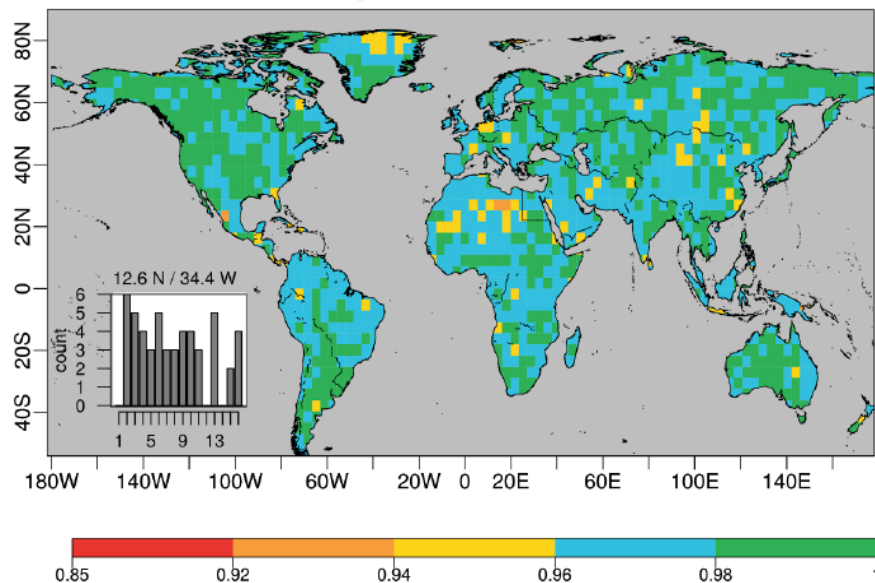
Reliability of HadGEM3-A for hot summers

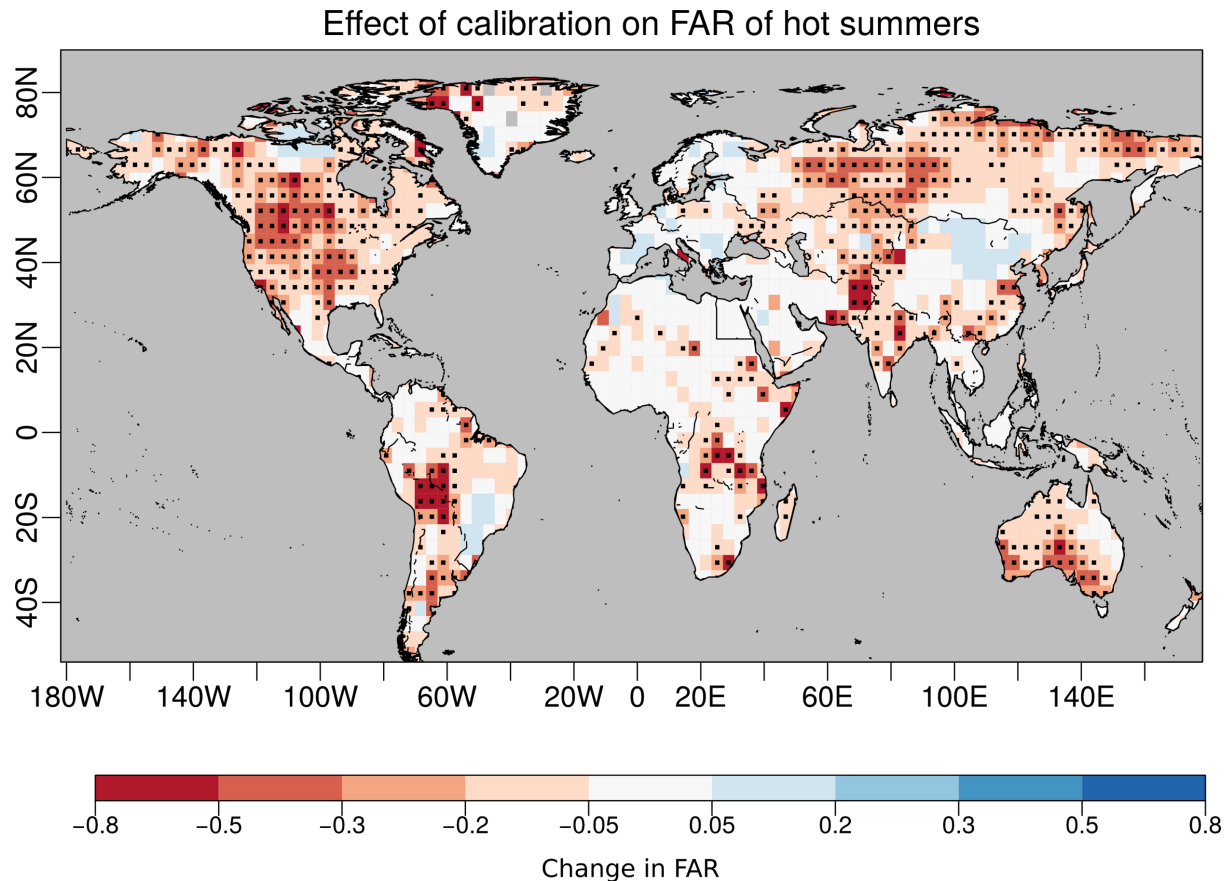Reliability is a concern over many regions and calibration improves it

Effect can be quite large even for hot summer attribution cases

Effect of calibration on FAR of hot summers

Change in FAR

A coupled event attribution approach

Coupled predictions where the climate change signal is removed in the assimiliation? Would allow prediction and attribution at the same time
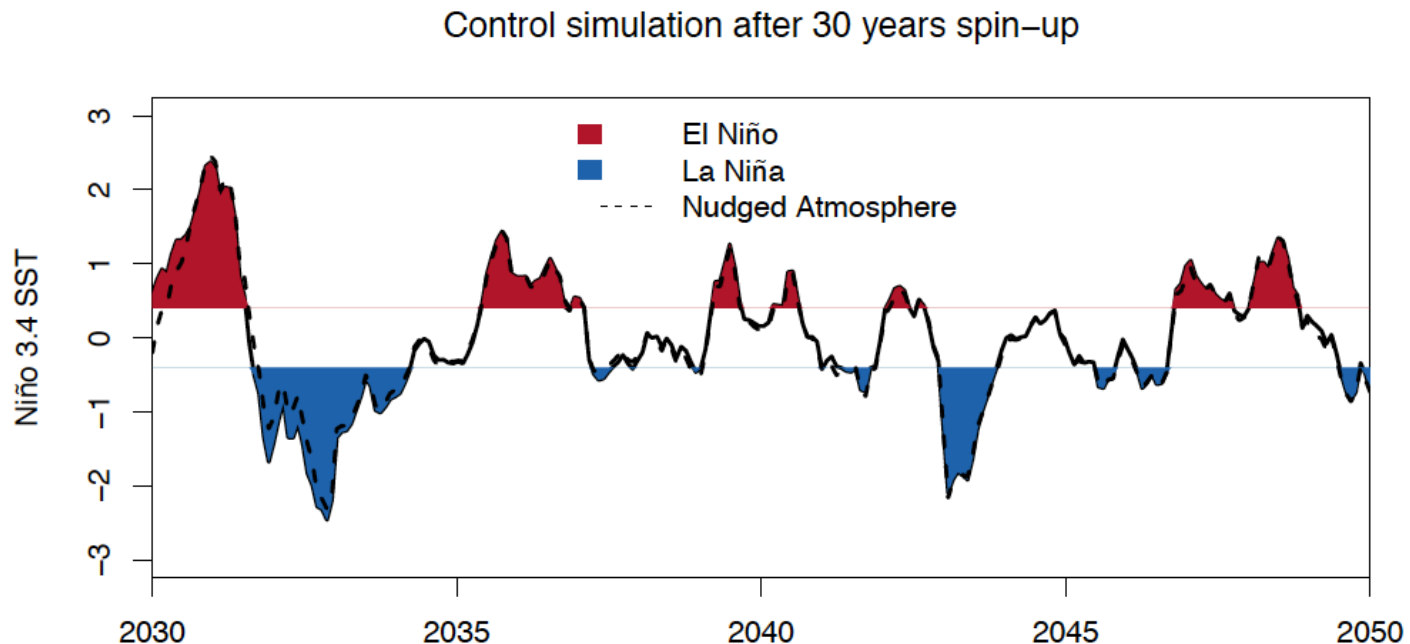
Control simulation after 30 years spin-up

Weather and climate prediction

Q1: Can we the reliability assessment from weather and climate prediction to assess simulated probabilities in the context of event attribution?

Q2: Can we evaluate the forced climate response from the reliability of initialized model simulations?

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Reliability from initialized predictions

Should we trust the the forced climate response in simulations which give unreliable probabilities in the first place?
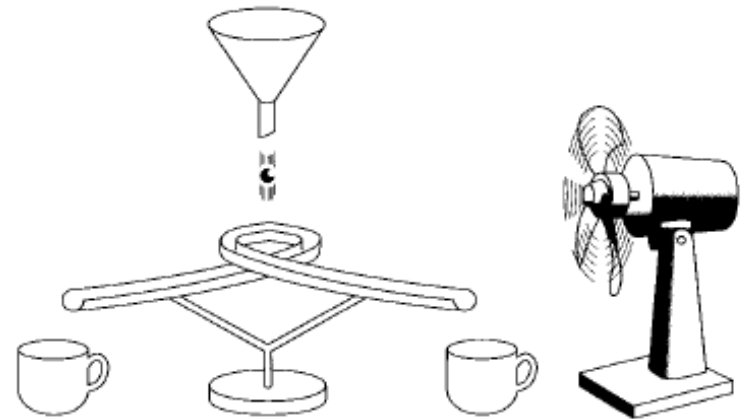

Weisheimer and Palmer et al., (2014)
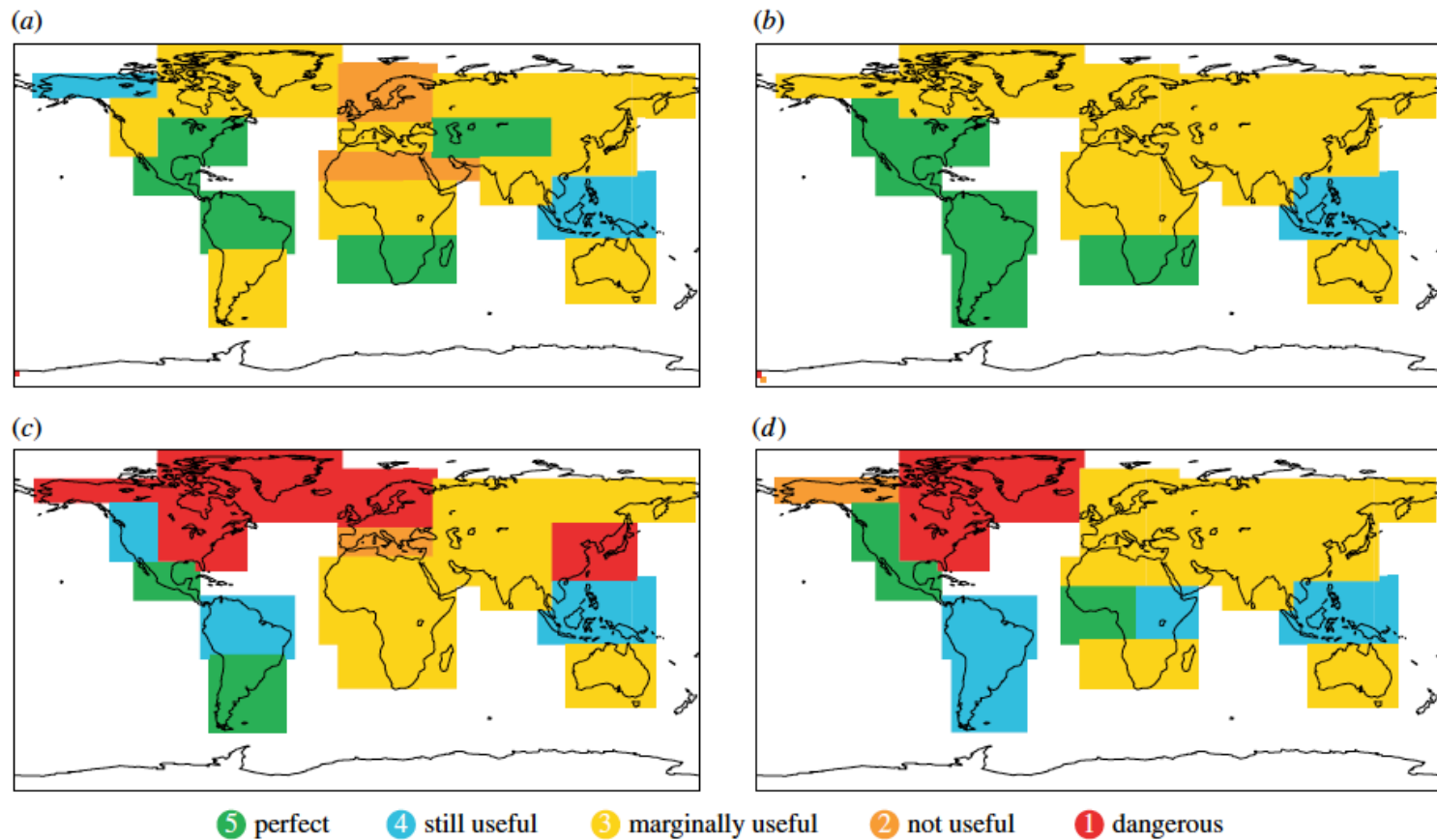
Reliability from initialized predictions

Initialization could tell about the trustworthiness of the forced response
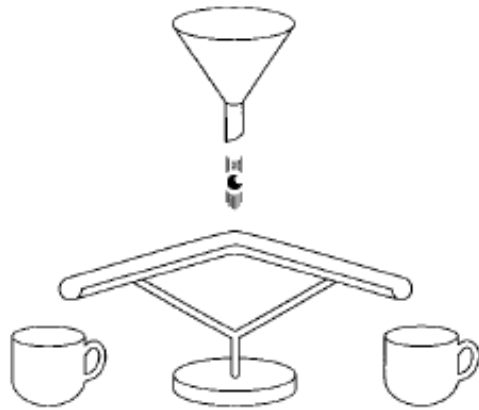
MODEL

REALITY

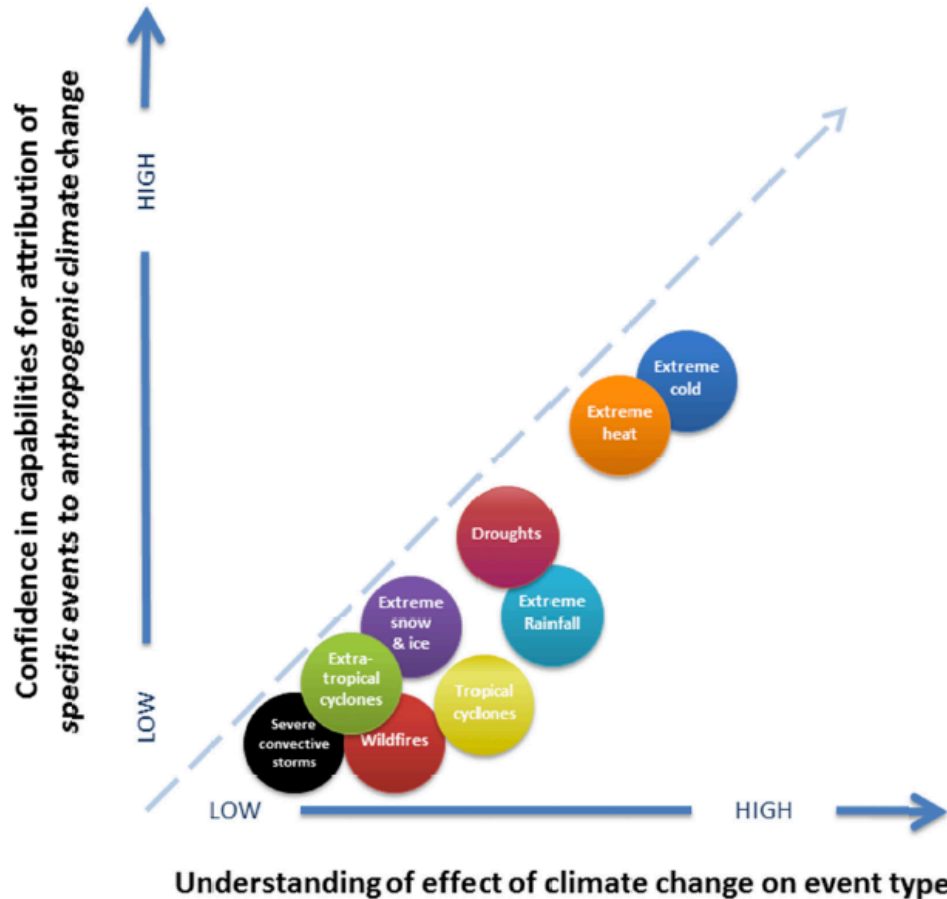*Palmer et al., (1999)*

What should be our guidline for event attribution?

NAS (2016)

Summary

❰❰ Reliability is a concern in event attribution and past studies might have overestimated the attributable risk

❰❰ Simulated probabilities can be calibrated as done in weather and climate forecasting to improve trustworthiness

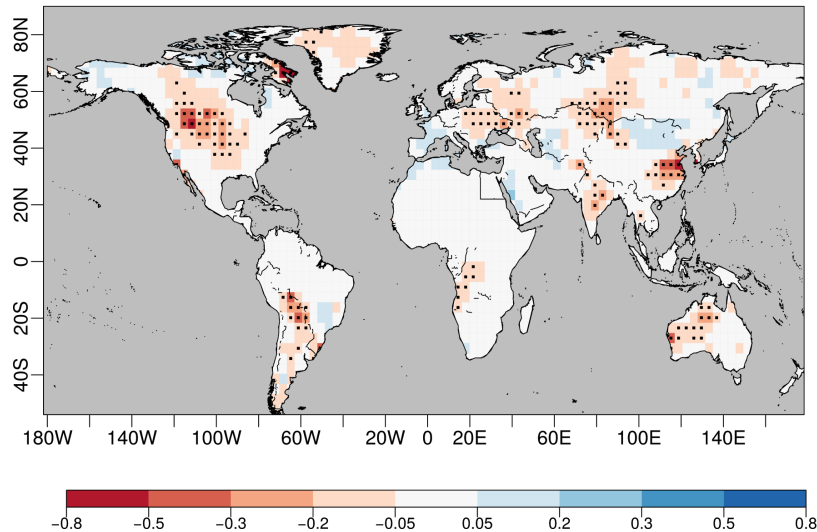**❰❰** What should be our guideline on which kind of events we have enough confidence?

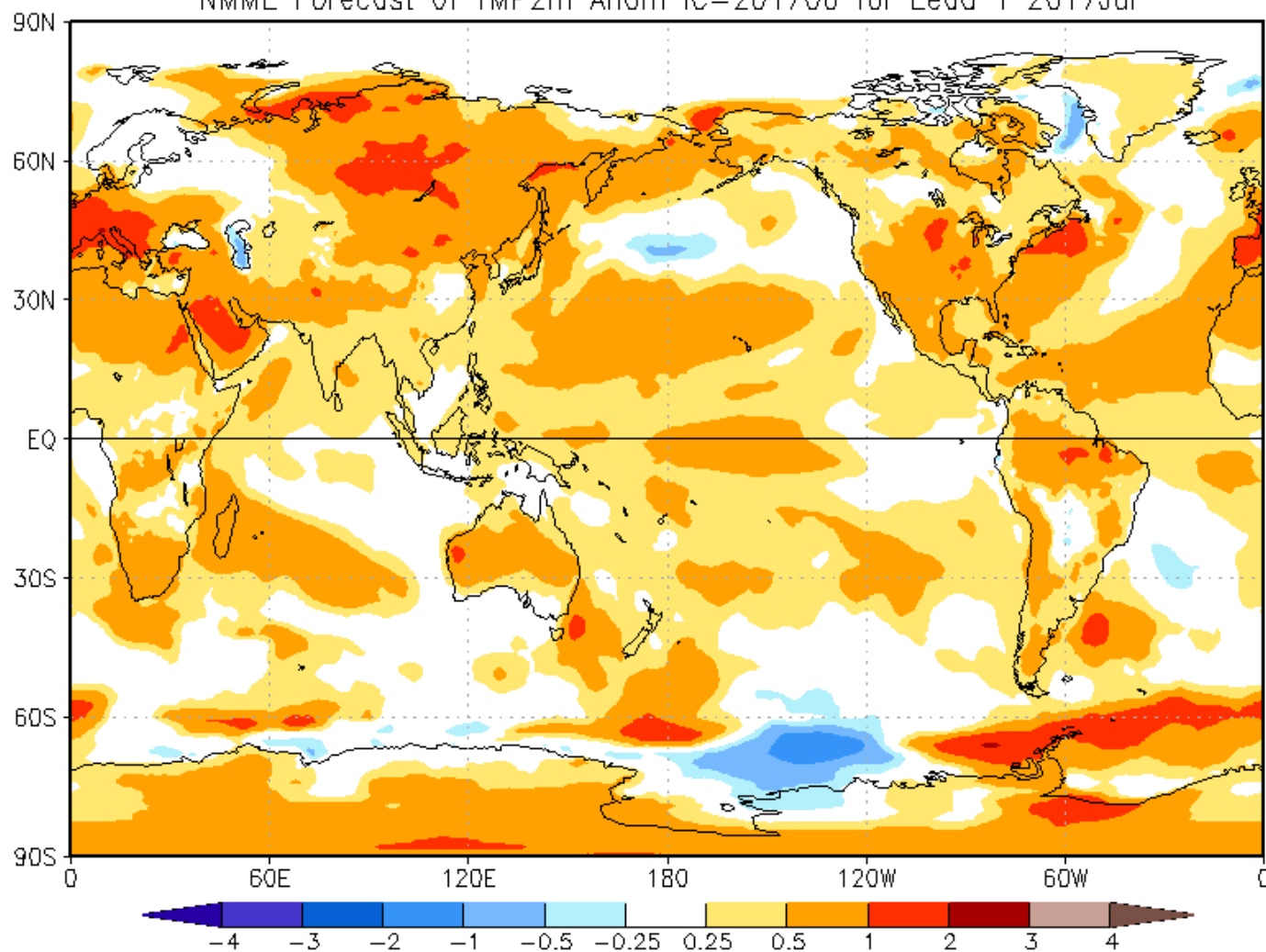# Extra slides

Impact of ensemble and trend correction
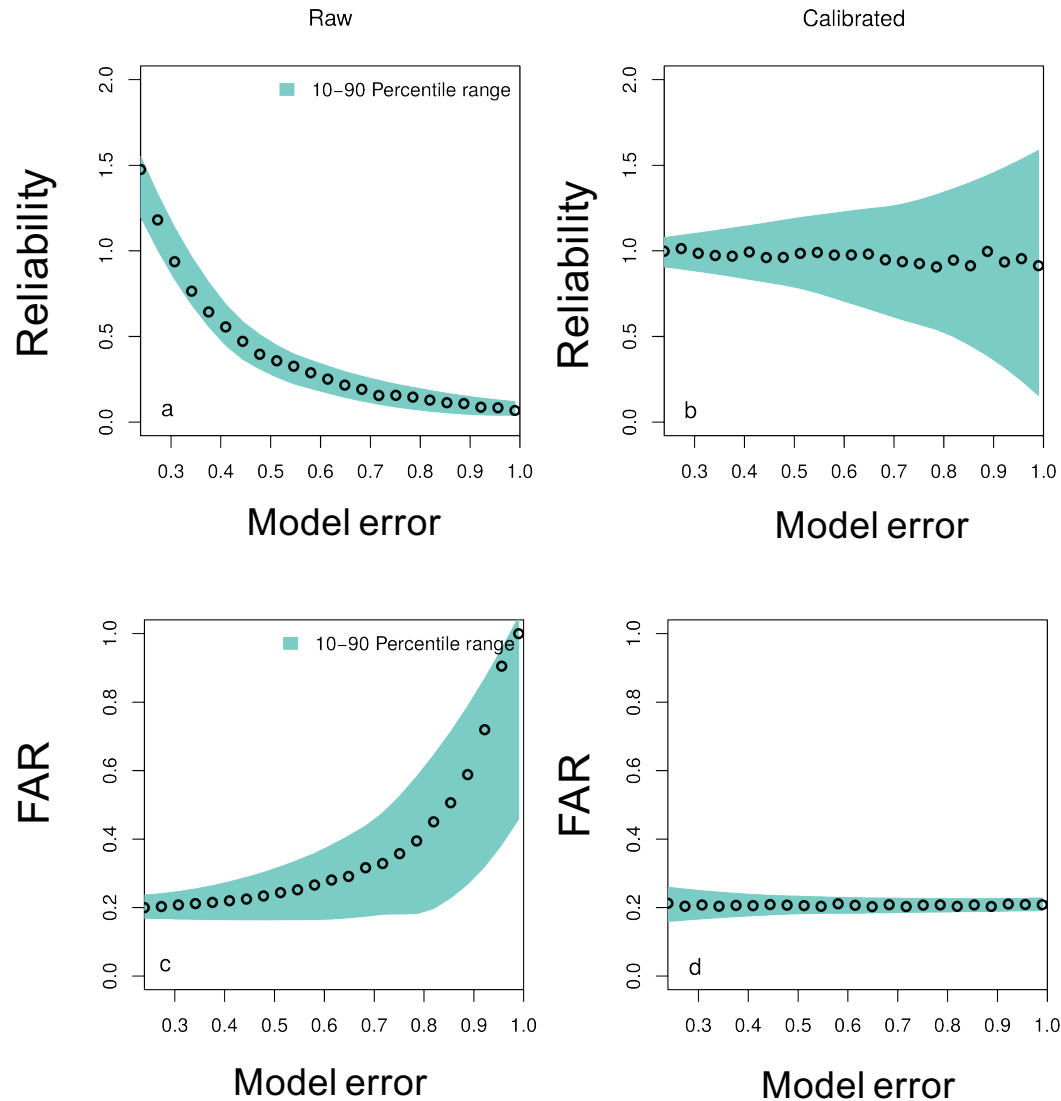

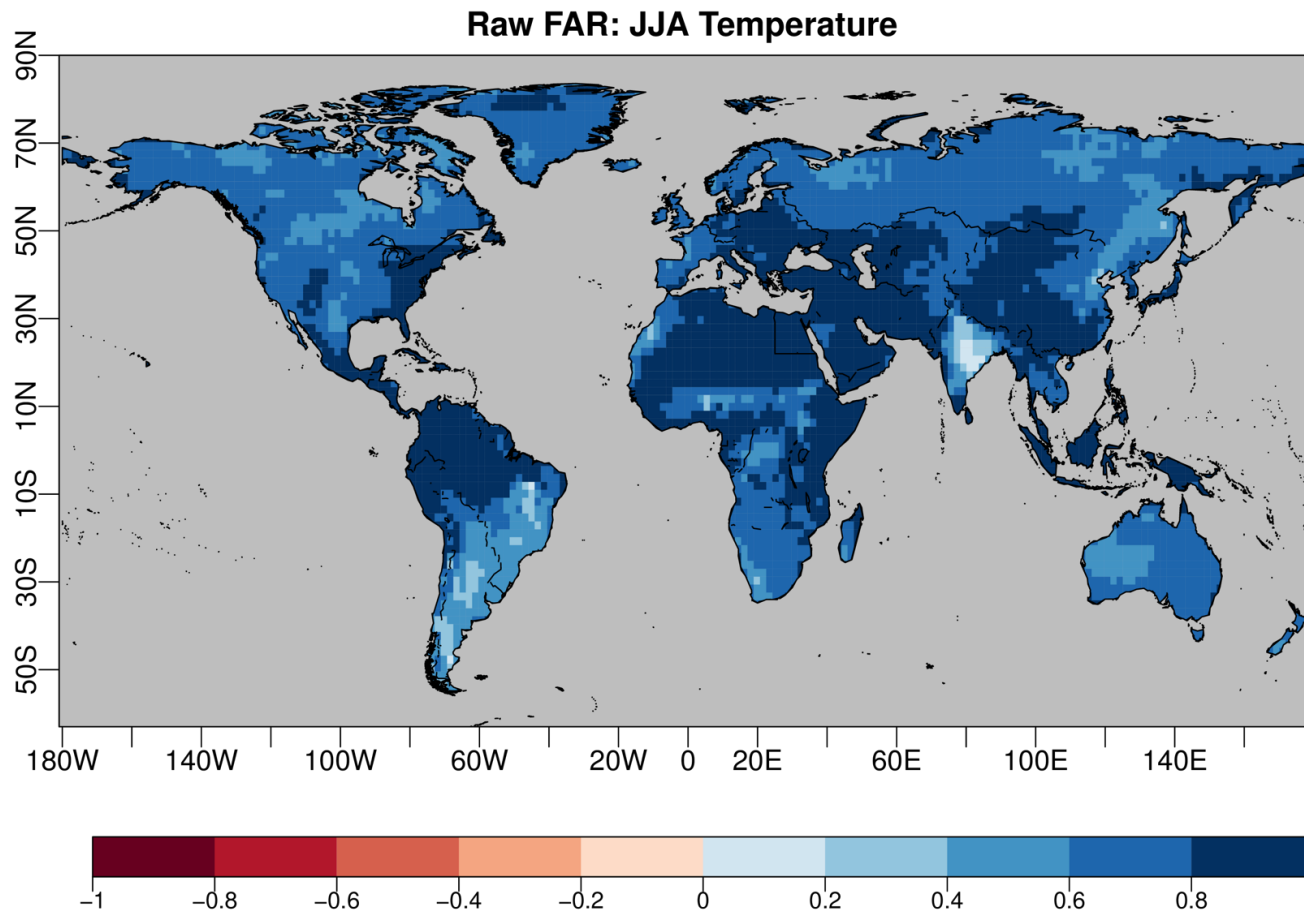Effect from ensemble inflation
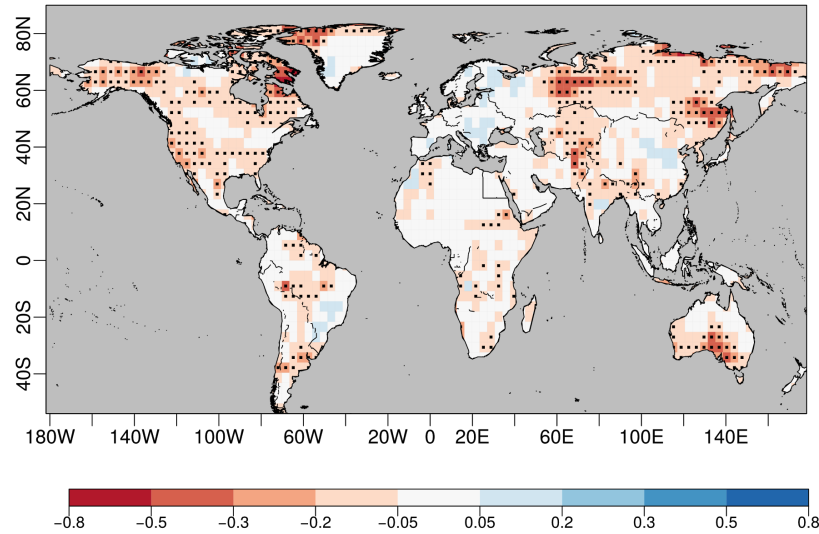
Effect from trend correction
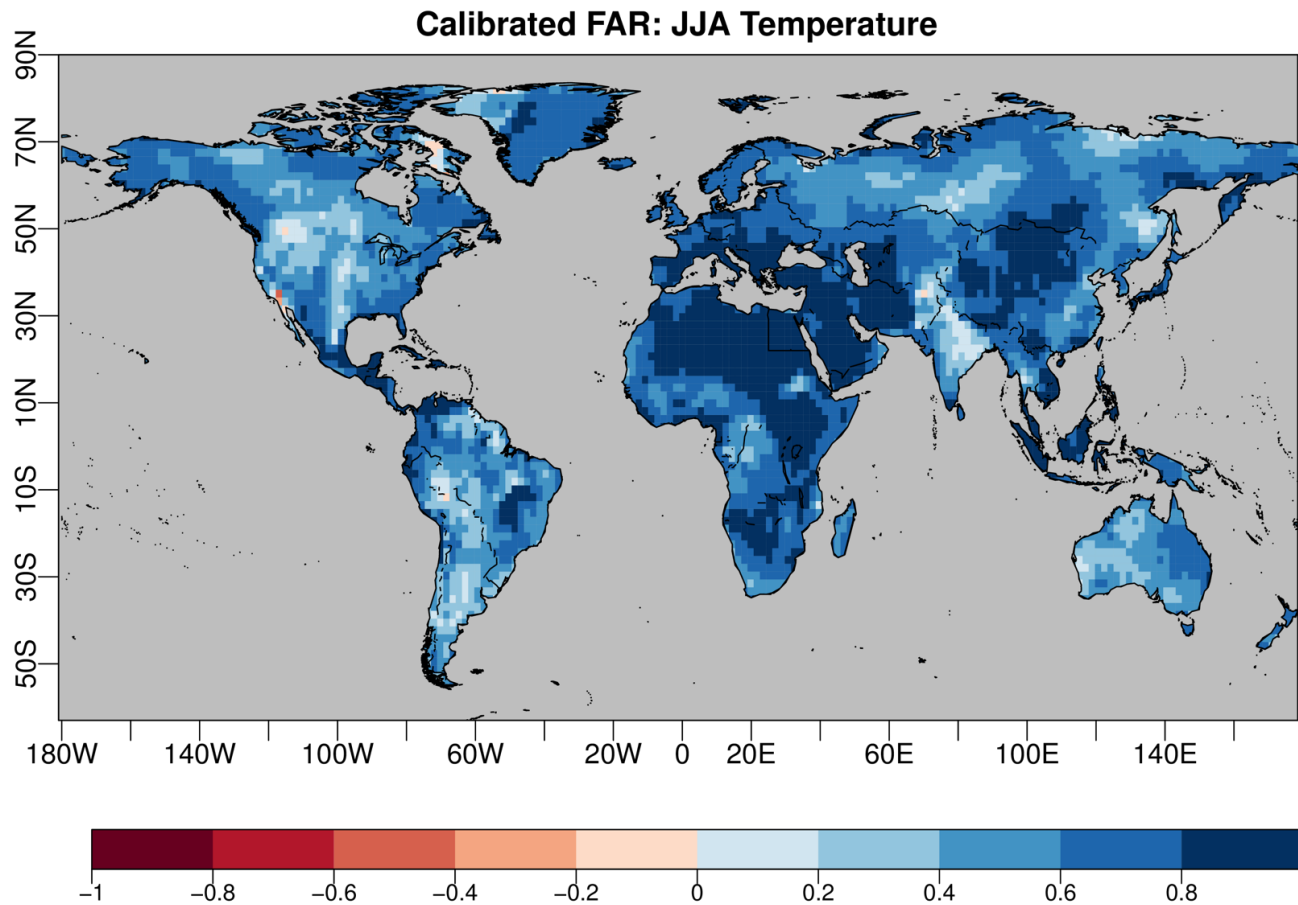
NMME Forecast of TMP2m Anom IC=201706 for Lead 1 2017Jul

Calibration in a statistical model

Bellprat and Doblas-Reyes (2016)

Raw FAR

Raw FAR: JJA Temperature

Calibrated FAR

Calibrated FAR: JJA Temperature

How to correct reliability

Reliability can be corrected by ensemble inflation

Calibrated Hindcast

$$\widehat{F_{t,e}} = \alpha \overline{F_t} + \beta F_{t,e}$$

Variability
Observations

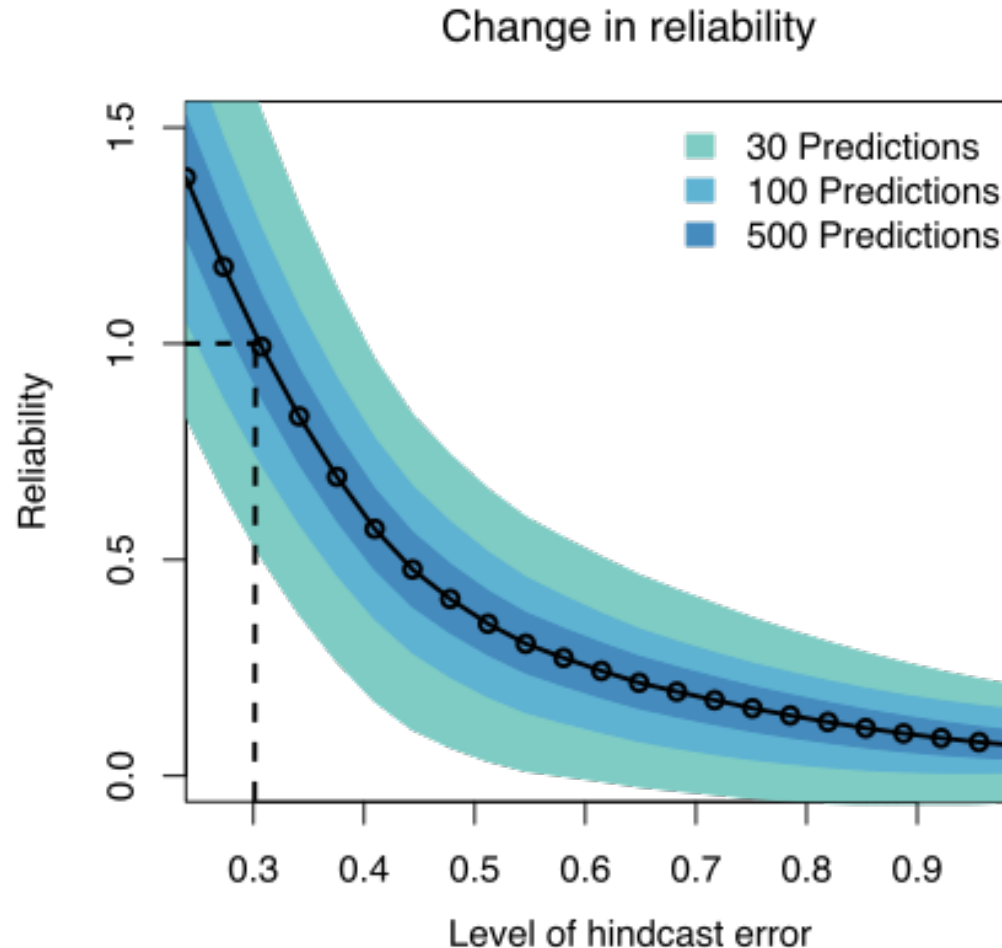$$\alpha = |\rho| \frac{\sigma_o}{\sigma_{em}} \qquad \beta = \sqrt{1 - \rho^2} \frac{\sigma_o}{\sigma_e}$$

Variability
Mean Forecast

Variability
Esemble

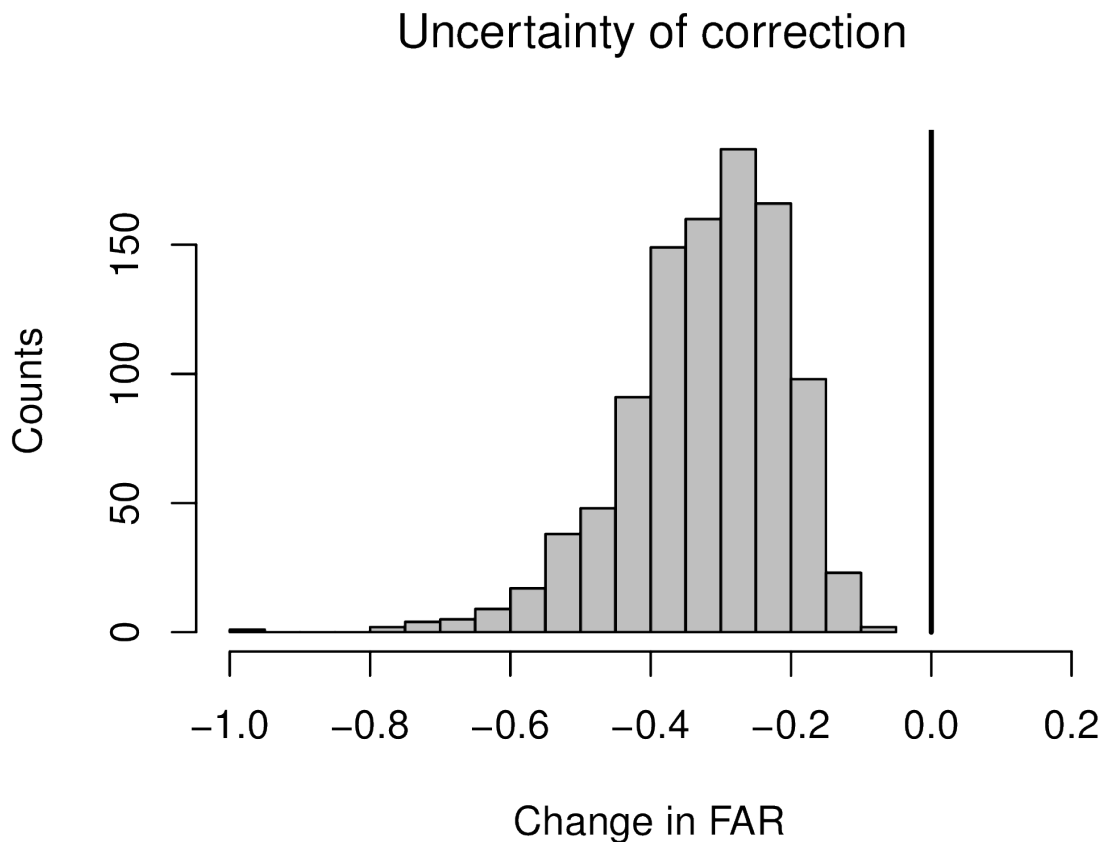*Von Storch (1999), Doblas-Reyes et al. (2005)*

Reliability and sample size

Reliability can be varied at any level, 0=no reliability, 1=perfect
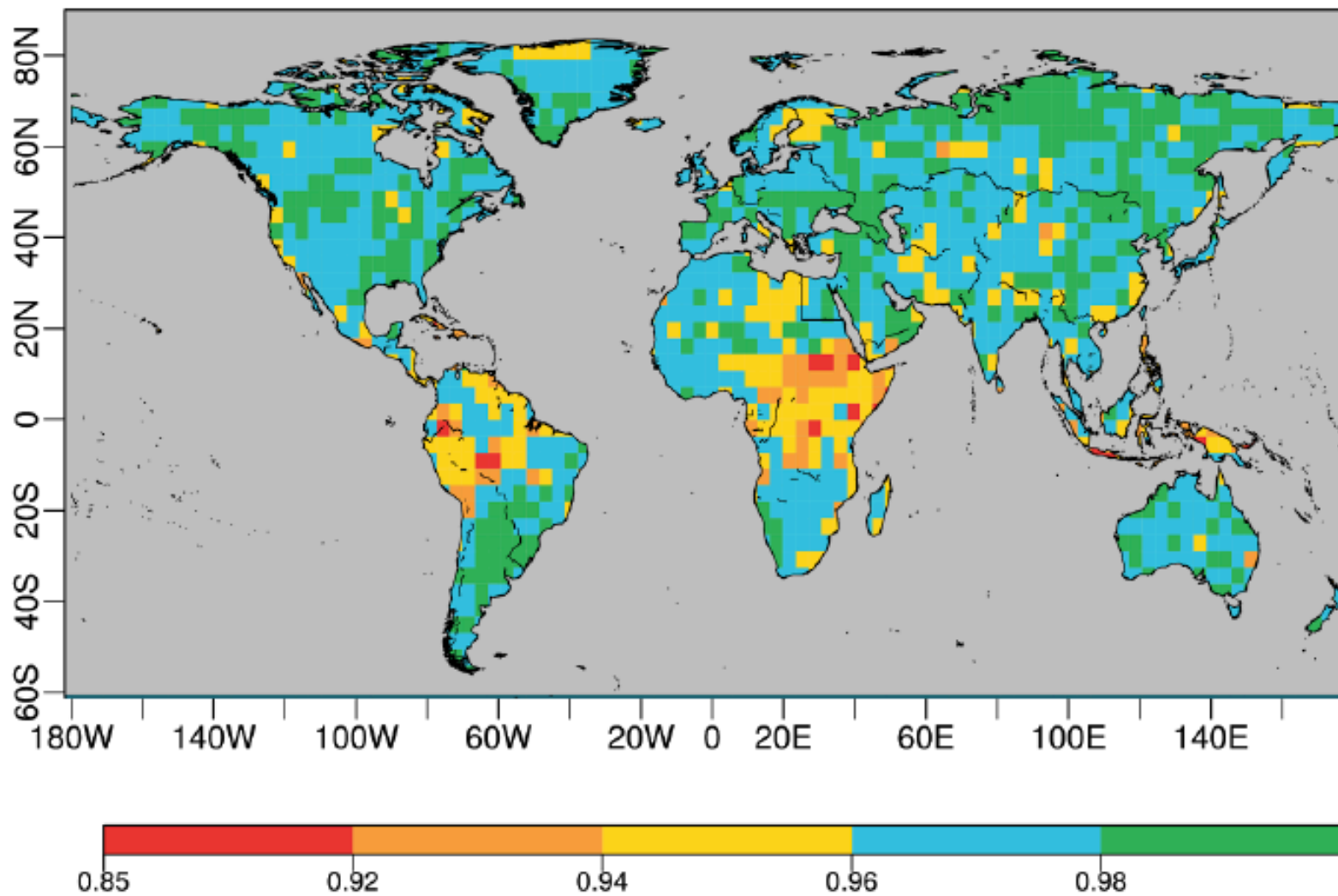

Change in reliability

Is the change significant?

Boot-strapping uncertainty of calibration due to limited sample size and uncertain inflation parameters

Uncertainty of correction

Reliability C20C+ Mutlimodel Raw

Raw FAR

Raw FAR: JJA Temperature