Multi-year climate predictions: between wishful thinking and feasible decision support

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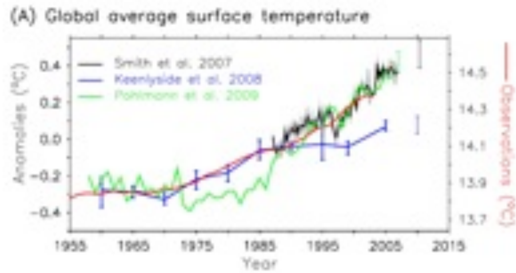
13th Swiss Global Change Day, 2012

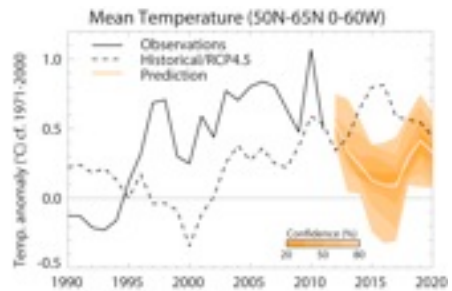
Max-Planck-Institut für Meteorologie

Overview

1. Background



2. Predictions of surface temperature for the coming decade



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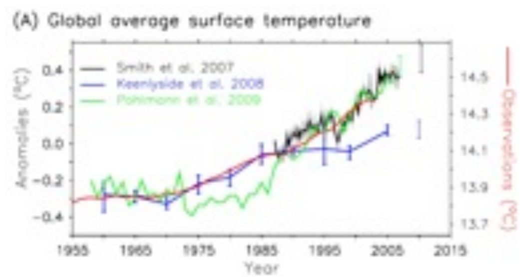
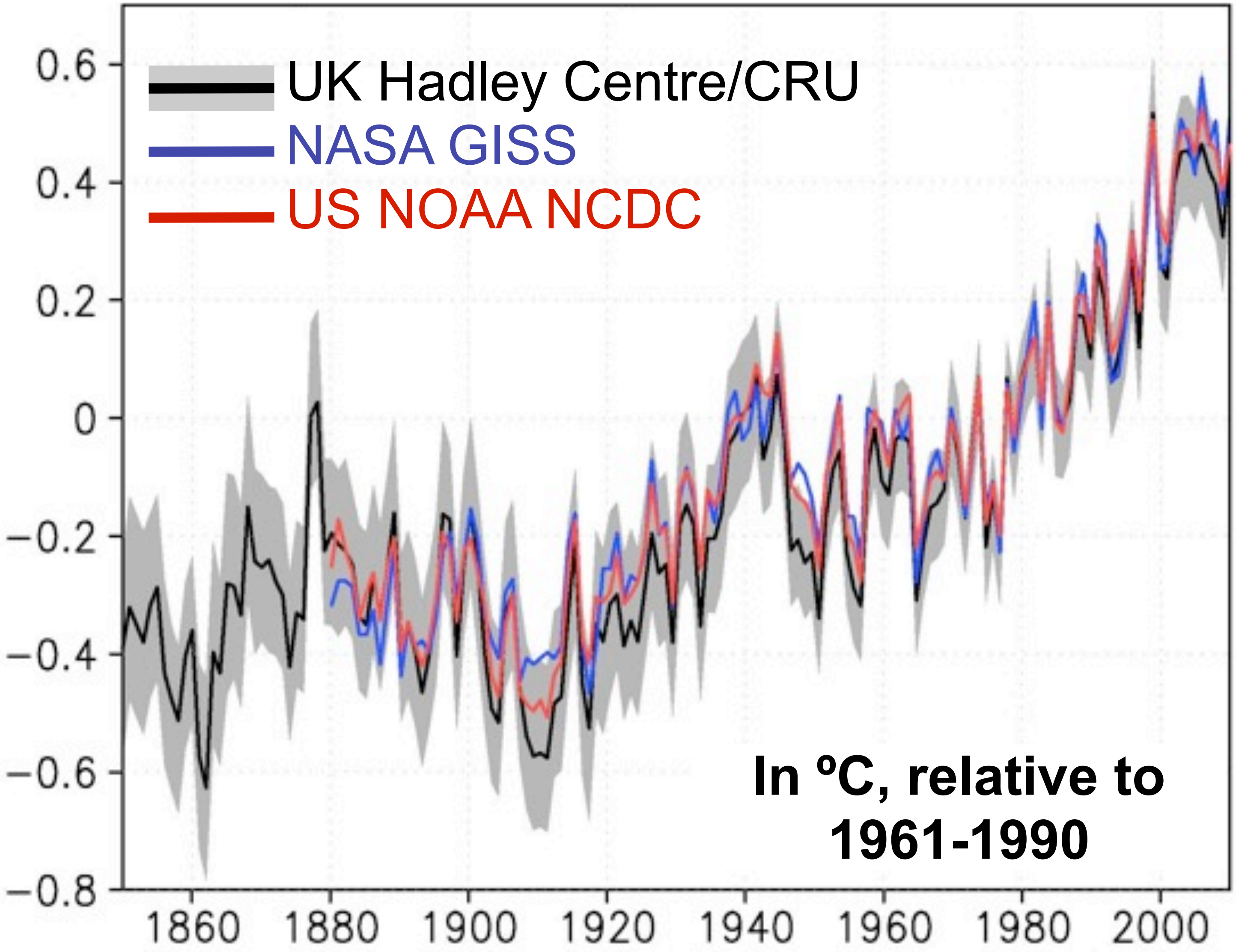
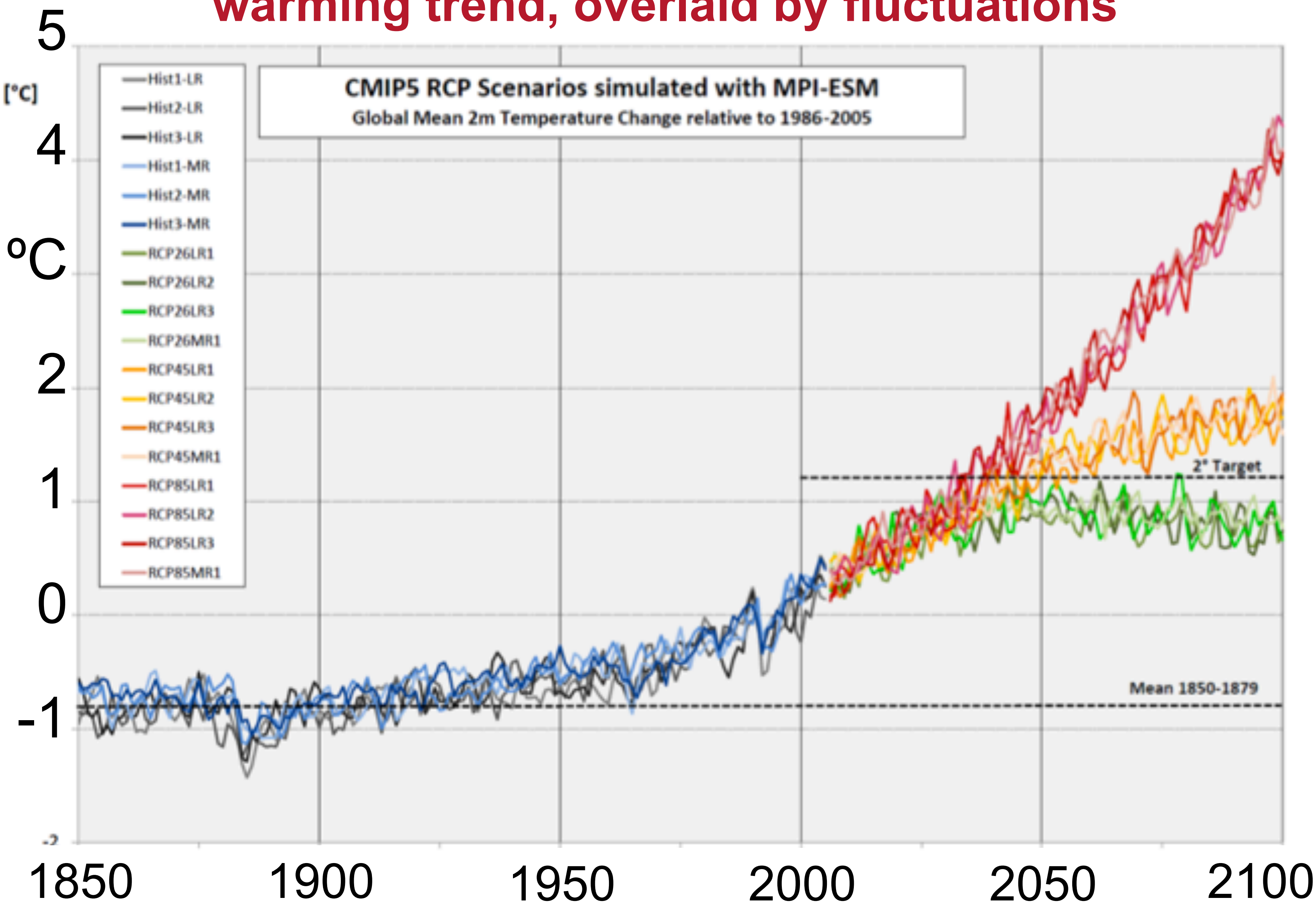


2. Predictions of surface temperature for the coming decade

Observed global-mean surface temperature shows long-term warming trend, overlaid by fluctuations



Simulated global-mean surface temperature shows long-term warming trend, overlaid by fluctuations



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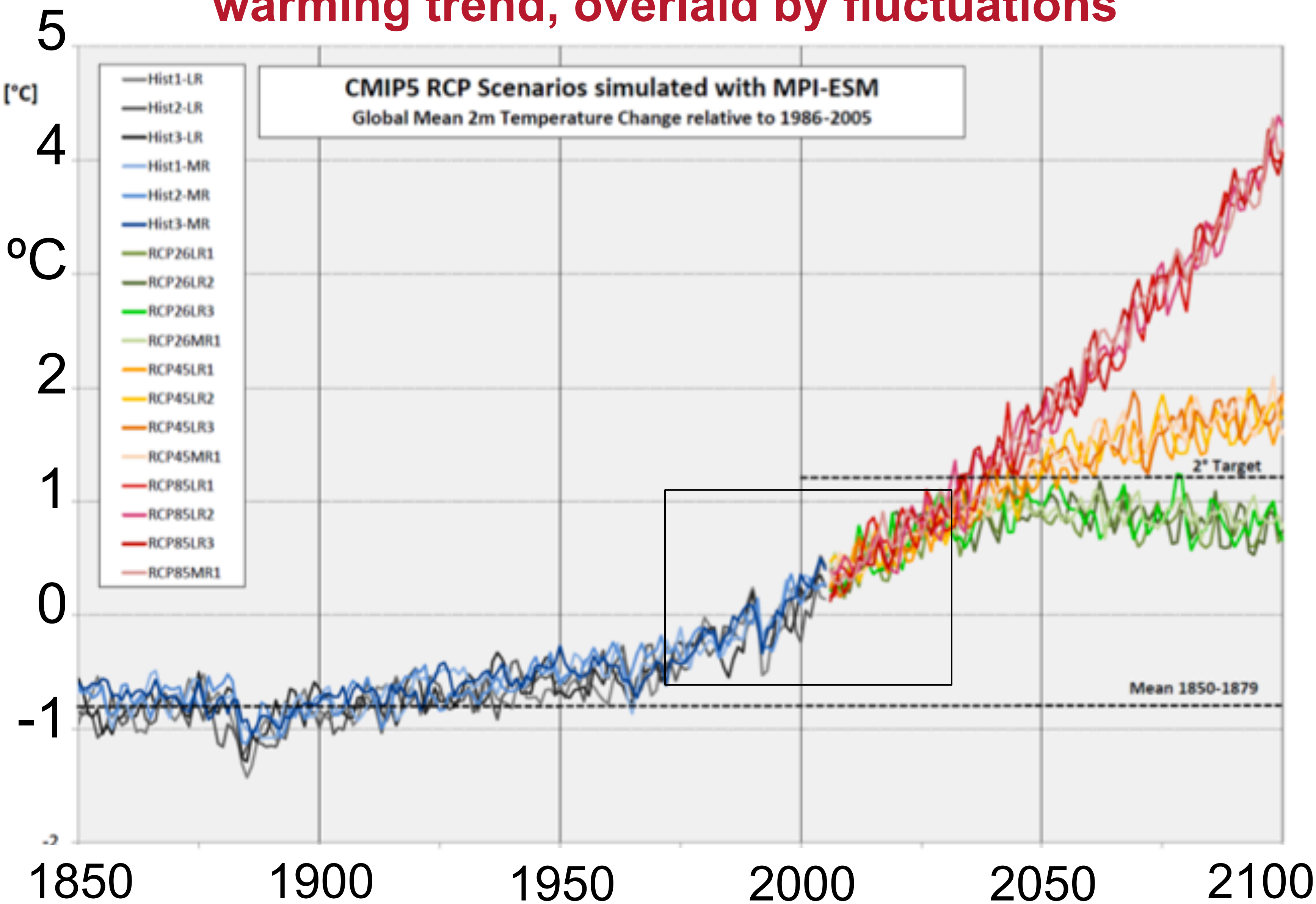
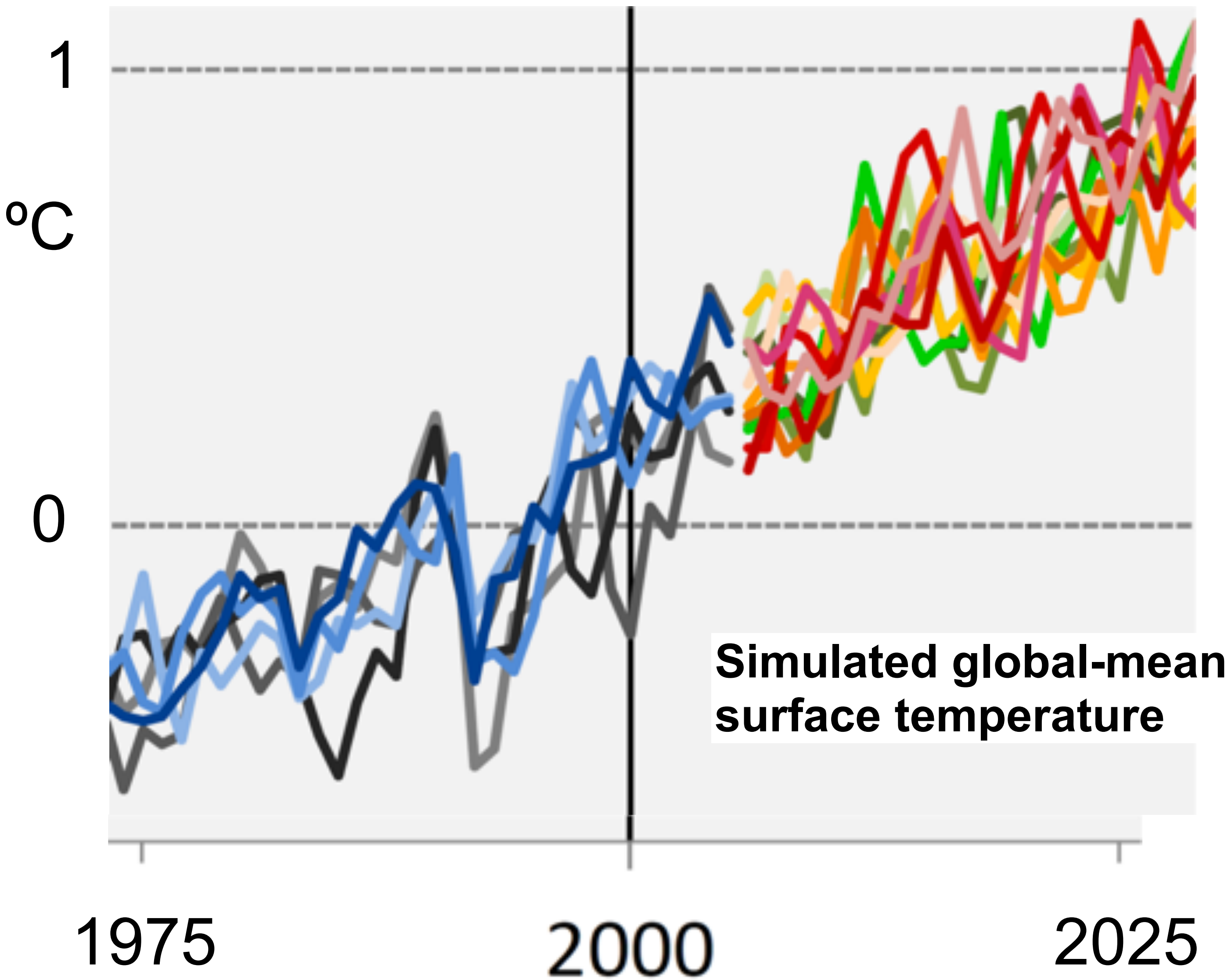


The shorter the period, the more important the fluctuations



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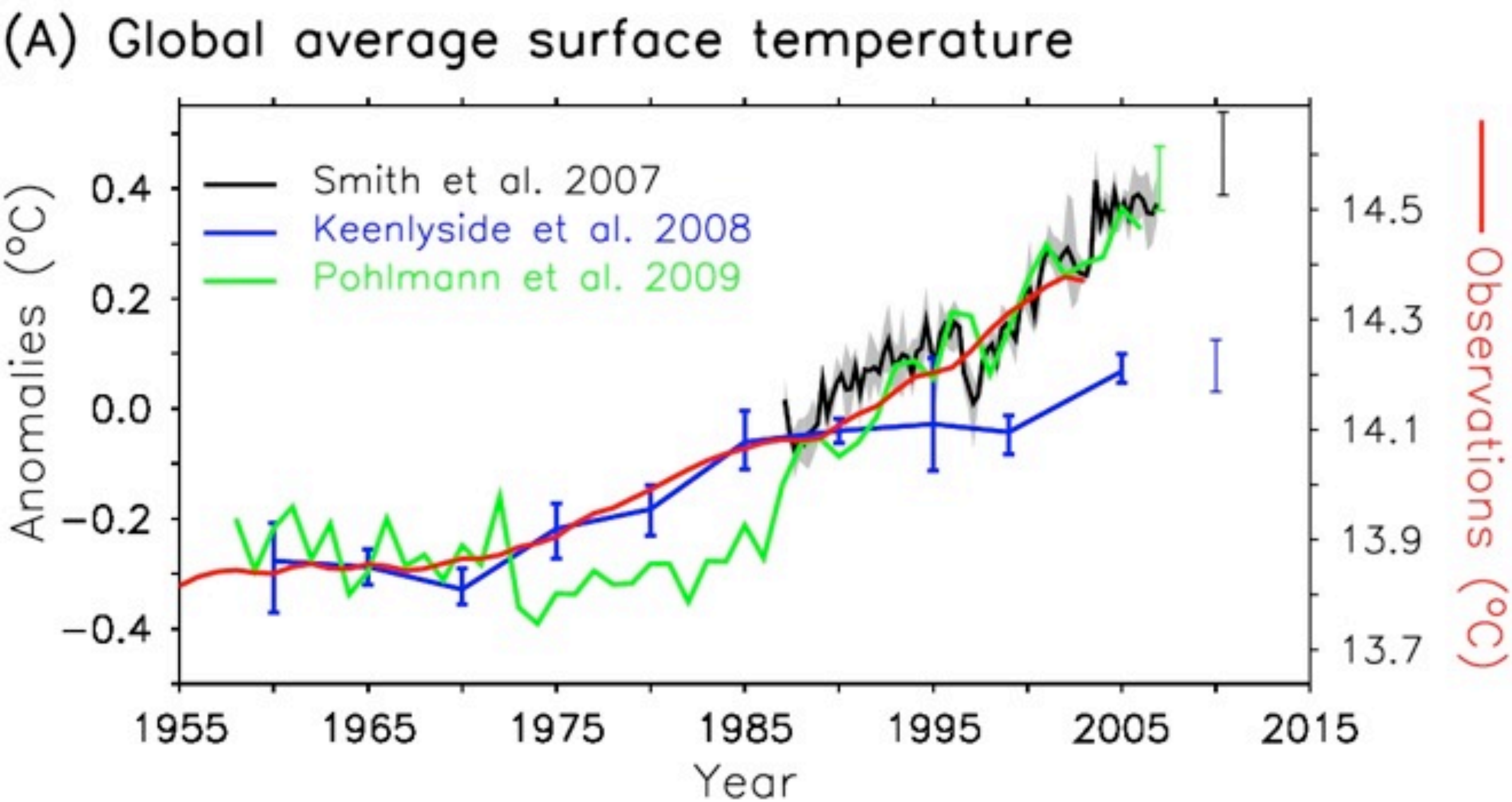
- **Climate projection:**
  - *One* **potential** future evolution of climate
  - Contingent on emissions or concentration scenarios
  - Initial state and climate variability not considered essential

- **Climate prediction:**
  - An estimate of the **actual** future evolution of climate
  - Predicts anthropogenic change **and natural fluctuations**
  - Initial state based on observations of slow climate components (ocean, others) – **Initialisation**
  - Retrospective predictions (hindcasts) allow us to assess prediction skill

Disagreement among prediction results are substantially influenced by initialisation procedures



- SAT predictions from the first three decadal prediction papers
- Keenlyside and Pohlmann used (almost) the same model

Hurrell et al. (2010)

It matters a great deal how we start (initialise) our coupled climate model MPI-ESM

- Run the uncoupled ocean component of our climate model over the period 1948-2011, driven at the surface by observed atmosphere from NCEP-NCAR reanalysis

- Then:
  - Identify the temporal anomalies of temperature and salinity in the state estimate, for each time and over full depth of the ocean
  - Insert anomalies into the coupled model in an “assimilation run”
  - Start coupled model on every 1 January, 1949-2012, of the assimilation run; run coupled model for 10 years (“hindcast”)
  - Assess quality of the hindcasts against observations

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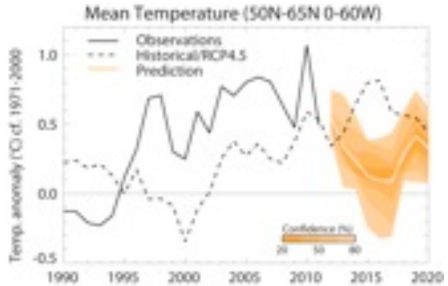
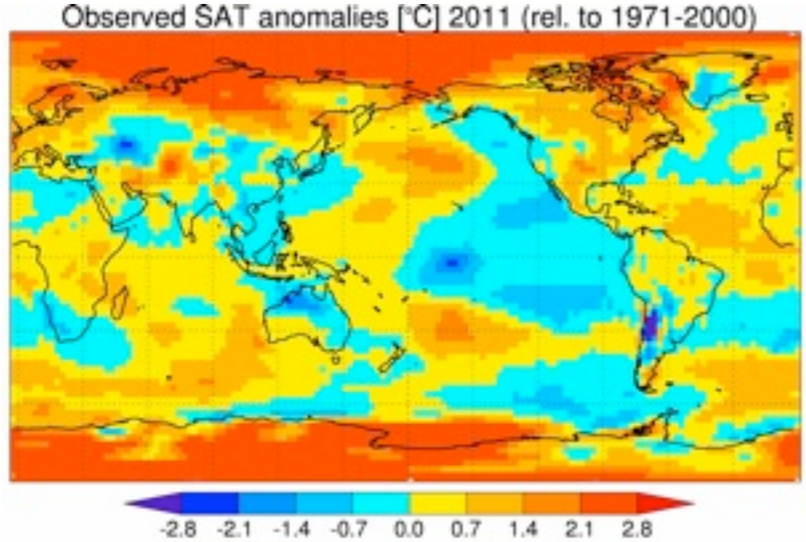
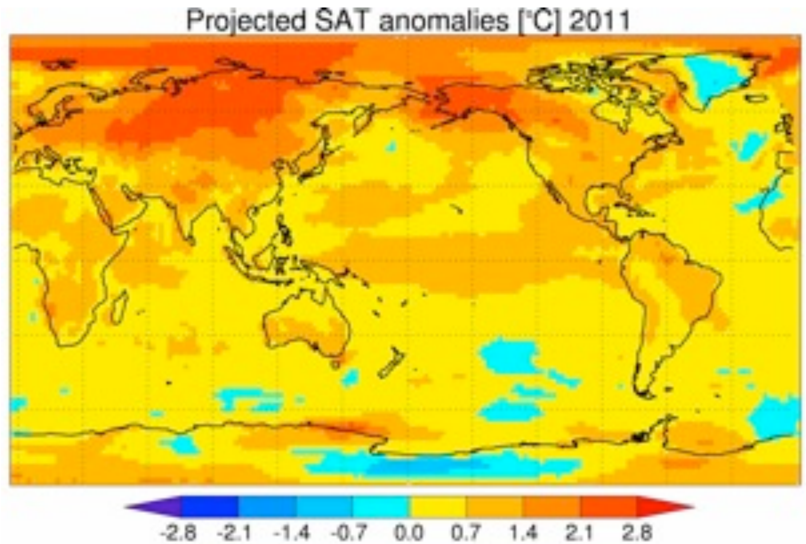


Uninitialised model reproduces observed pattern of 2011 surface temperature anomaly only poorly



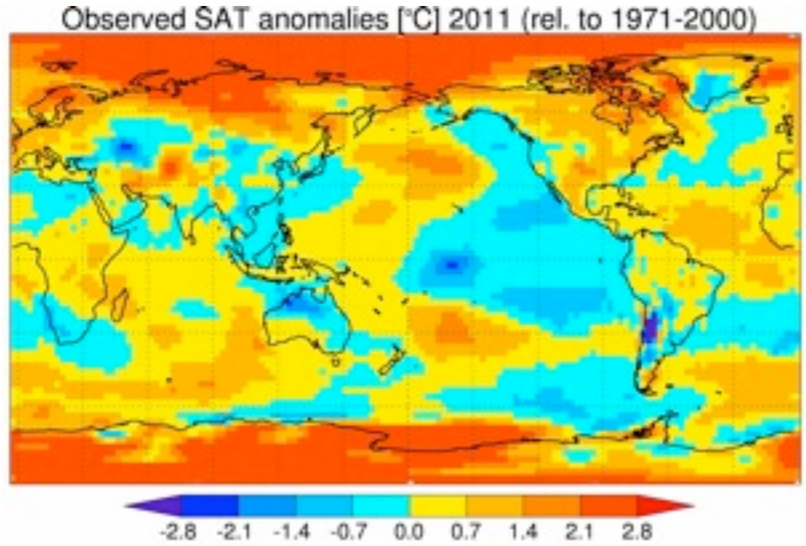
Observed



Uninitialised model

Müller et al. (in preparation)

First year of initialised prediction reproduces observed pattern of 2011 surface temperature anomaly very well



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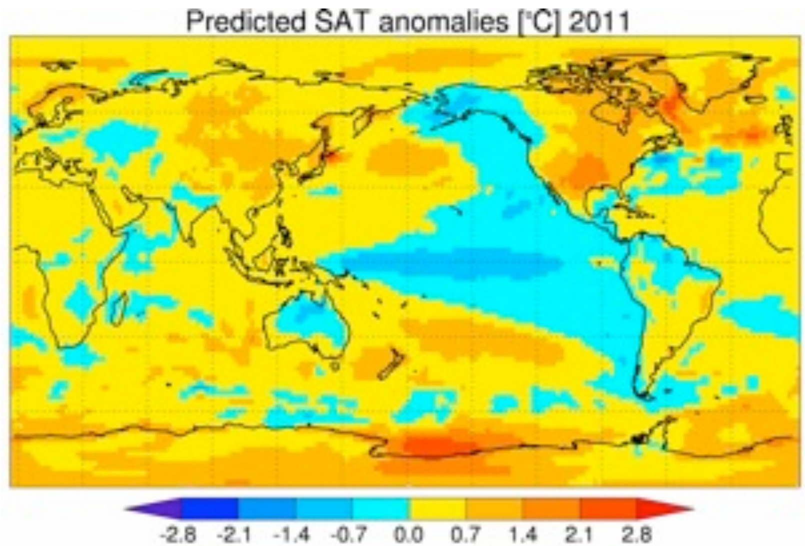
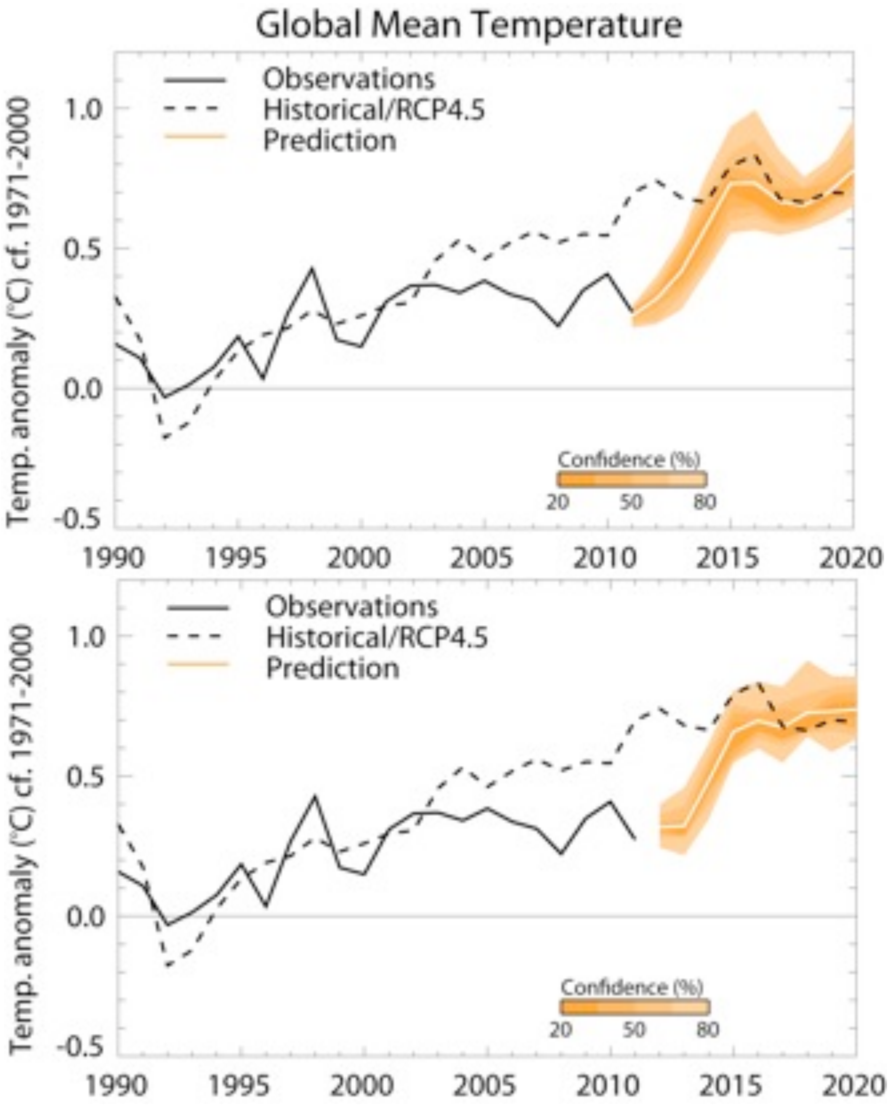


Initialised on
1 Jan. 2011

Müller et al. (in preparation)

However: we have little confidence in our predictions of global mean surface temperature for the coming decade



Initialised on
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Initialised on
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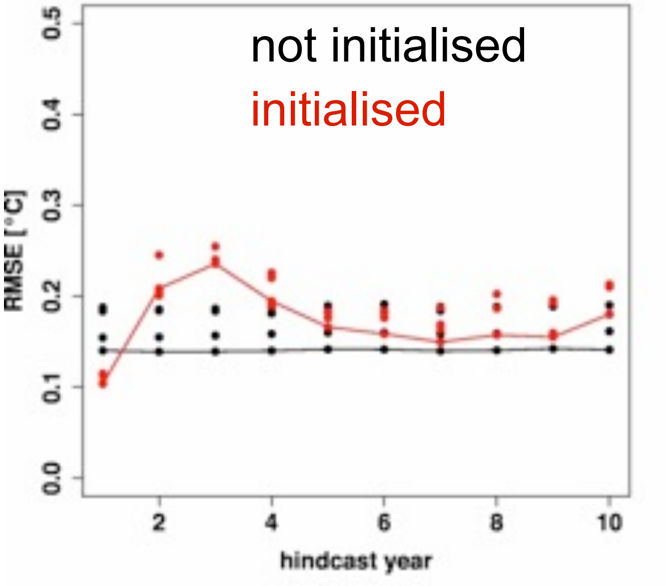
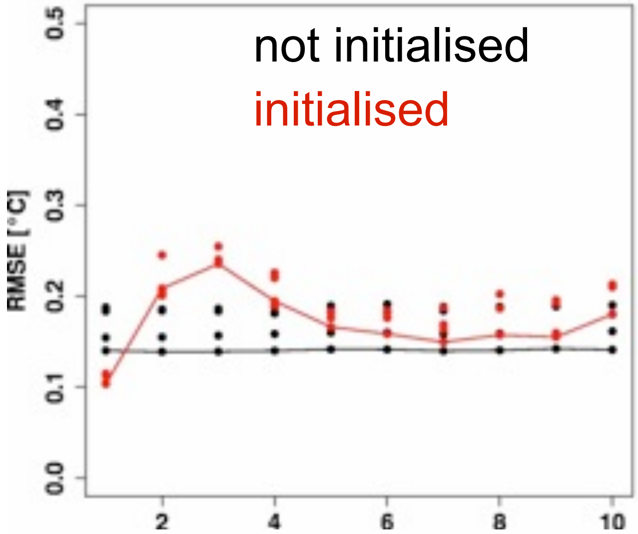
Global-mean surface temperature: no improvement of hindcast skill through initialisation beyond year 1



Mean error magnitude (RMS error) in global mean surface temperature

Müller et al. (in preparation)

Surface temperature in North Atlantic sector: clear improvement of hindcast skill through initialisation



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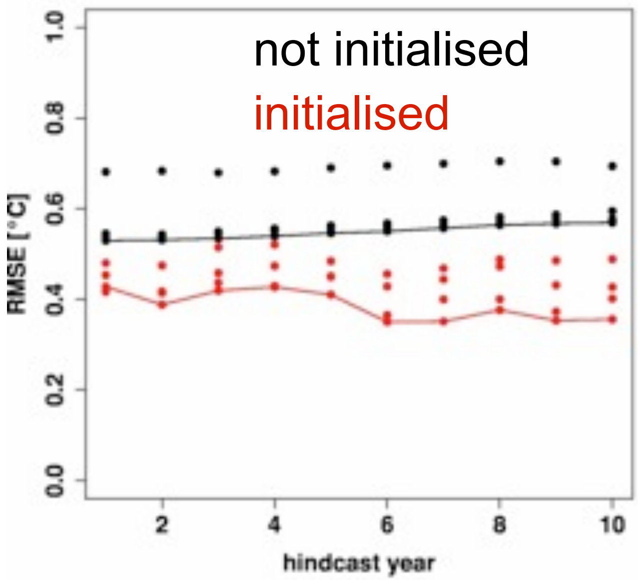
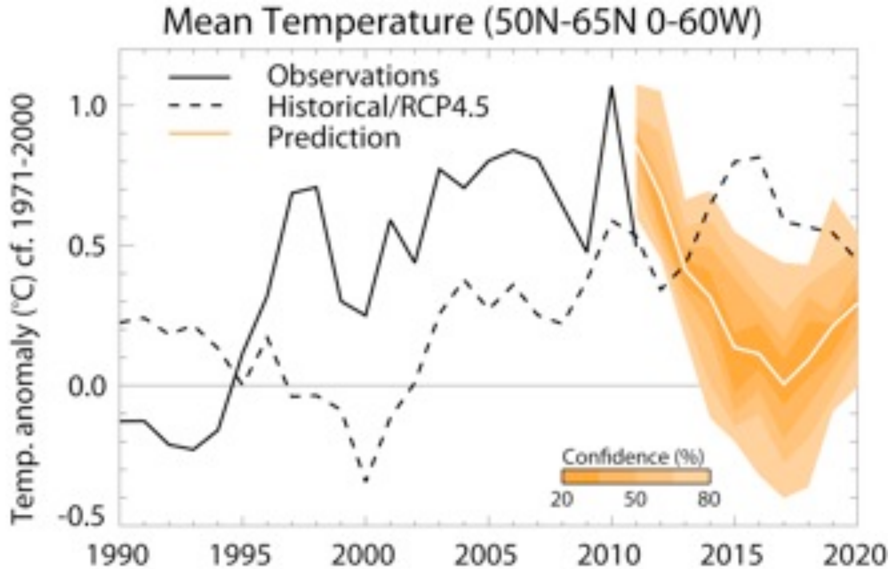
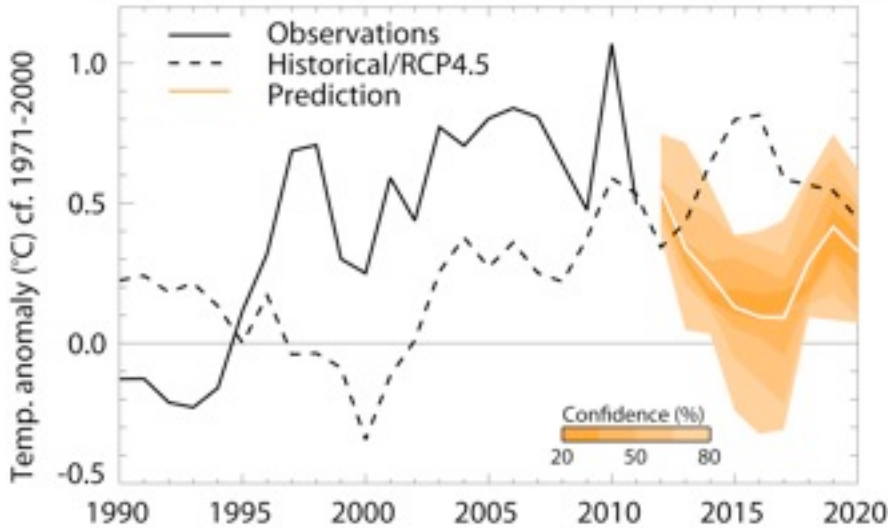


Mean error magnitude (RMS error) in North Atlantic surface temperature

North Atlantic sector: robust prediction of surface temperature reduction during this decade



Initialised on 1 Jan. 2011



Initialised on 1 Jan. 2012

Müller et al. (in preparation)

Colours: temperature anomaly relative to 1971-2000
Contour lines: RMSE reduction through initialisation

Animation: Michael Böttinger (DKRZ)

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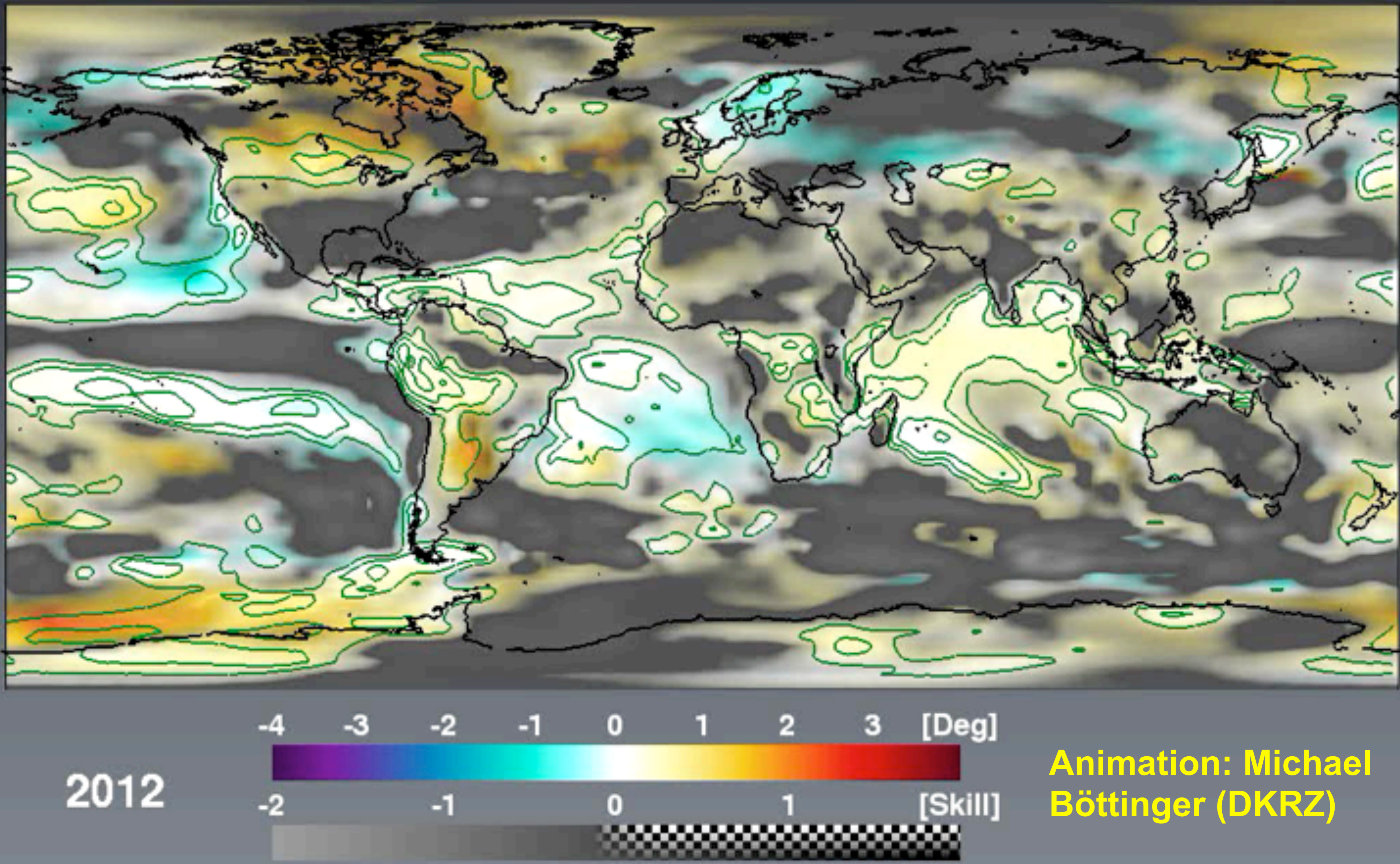

Animation: Michael Böttinger (DKRZ)

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  - Caveat: substantial weaknesses in multiyear predictions for tropics
- Robust forecast skill for surface temperature in North Atlantic regions, including Europe
  - Across model versions, initialisation procedure, and skill measure
  - We predict cooling of NA SST during the coming decade

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  - We have demonstrated skill for Atlantic circulation at 26.5ºN (Matei et al., *Science*, 2012)

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Thank you for your attention!