Decadal prediction skill in a multi-model ensemble

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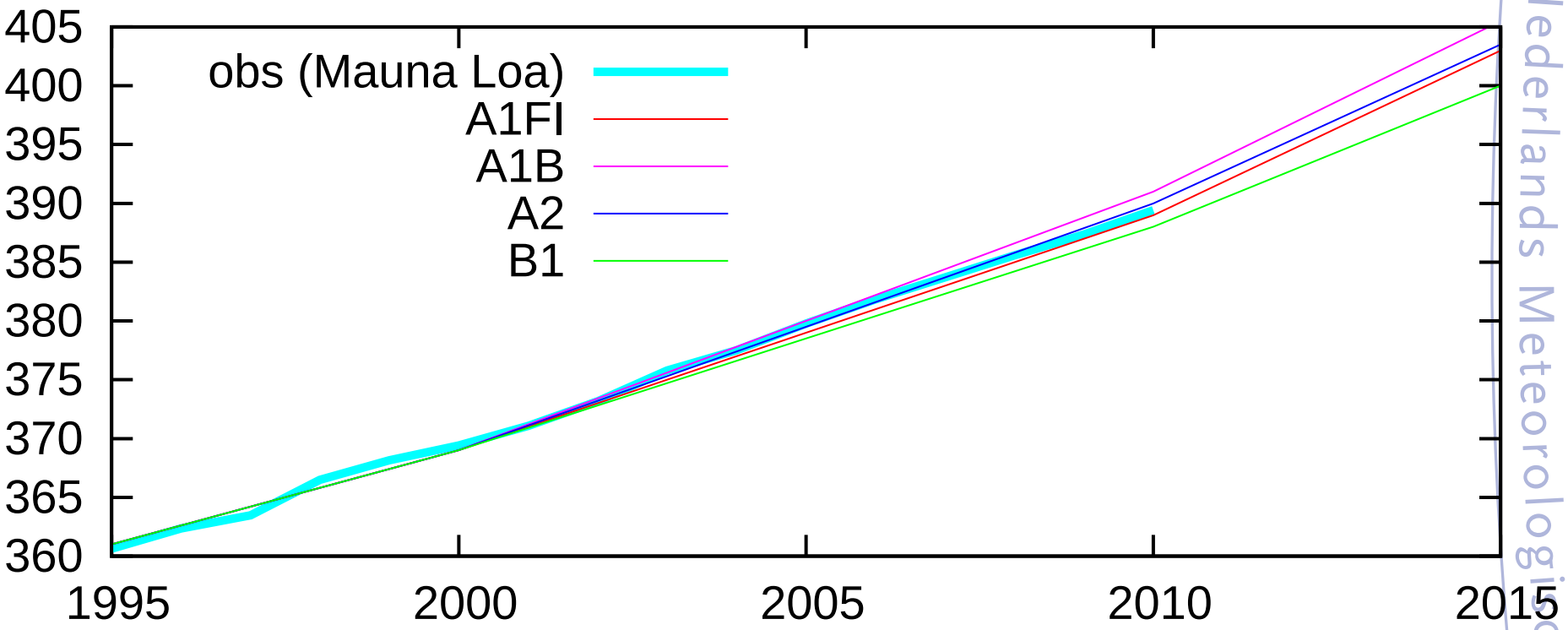
- Introduction
- Data, Methods
- Global temperature verification
- Local temperature verification
- Atlantic Multidecadal Oscillation
- Decadal ENSO
- Precipitation verification
- Sahel rainfall
- Conclusions

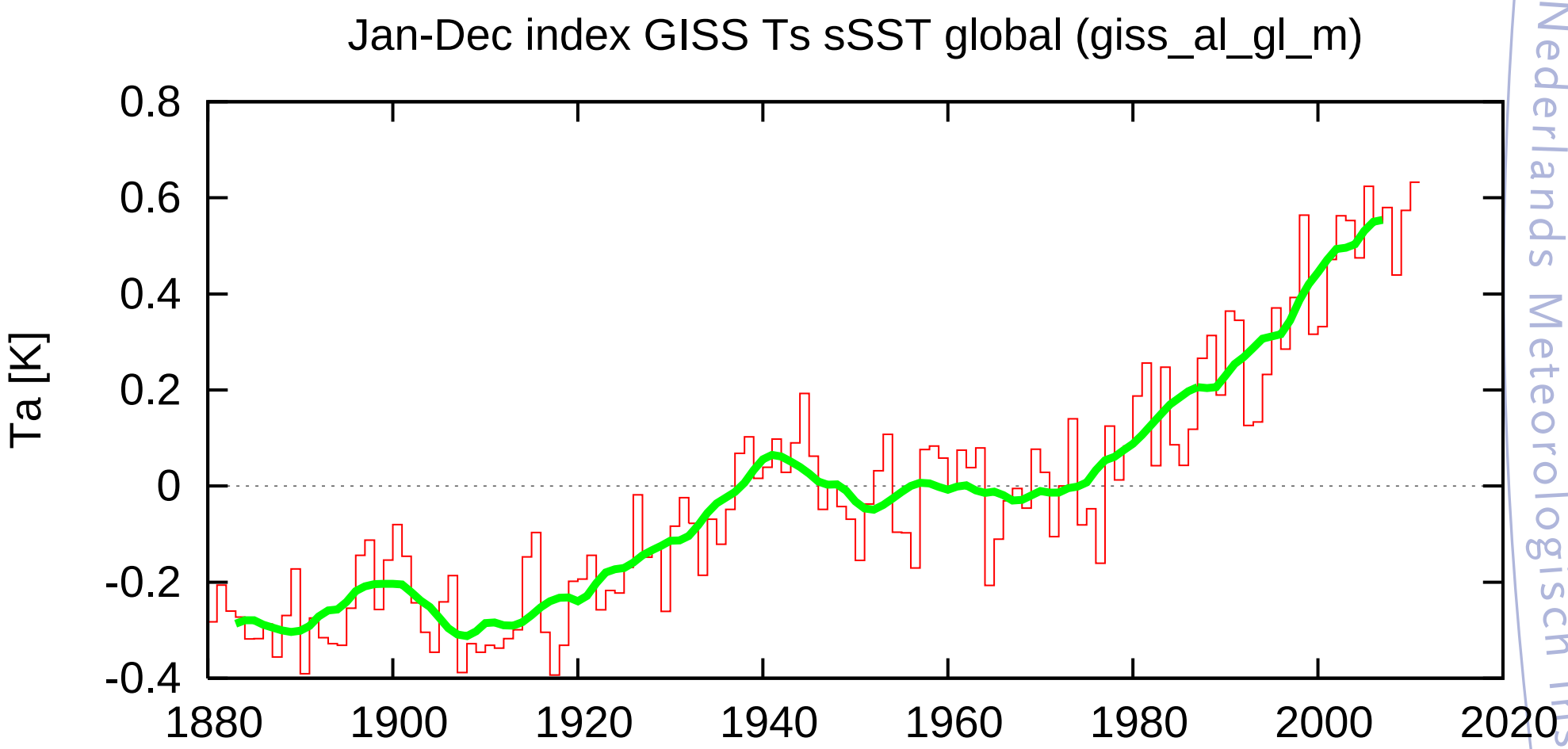
Oldenborgh, G.J. van, B. Wouters, W. Hazeleger and F.J. Doblas-Reyes, *Decadal prediction skill in a multi-model ensemble.* Resubmitted to Clim.Dyn.

Predicting CO_2 concentration is easy

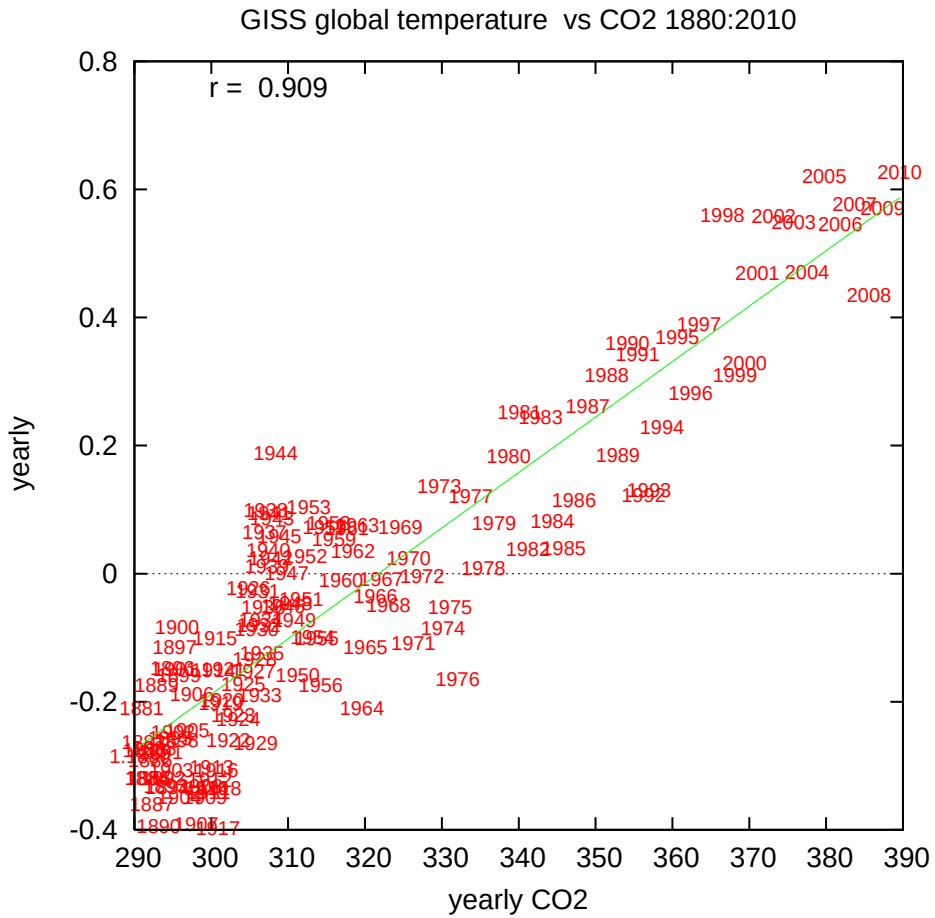


(well, the next 10 years)

Predicting T_{global}



Predicting T_{global} is easy



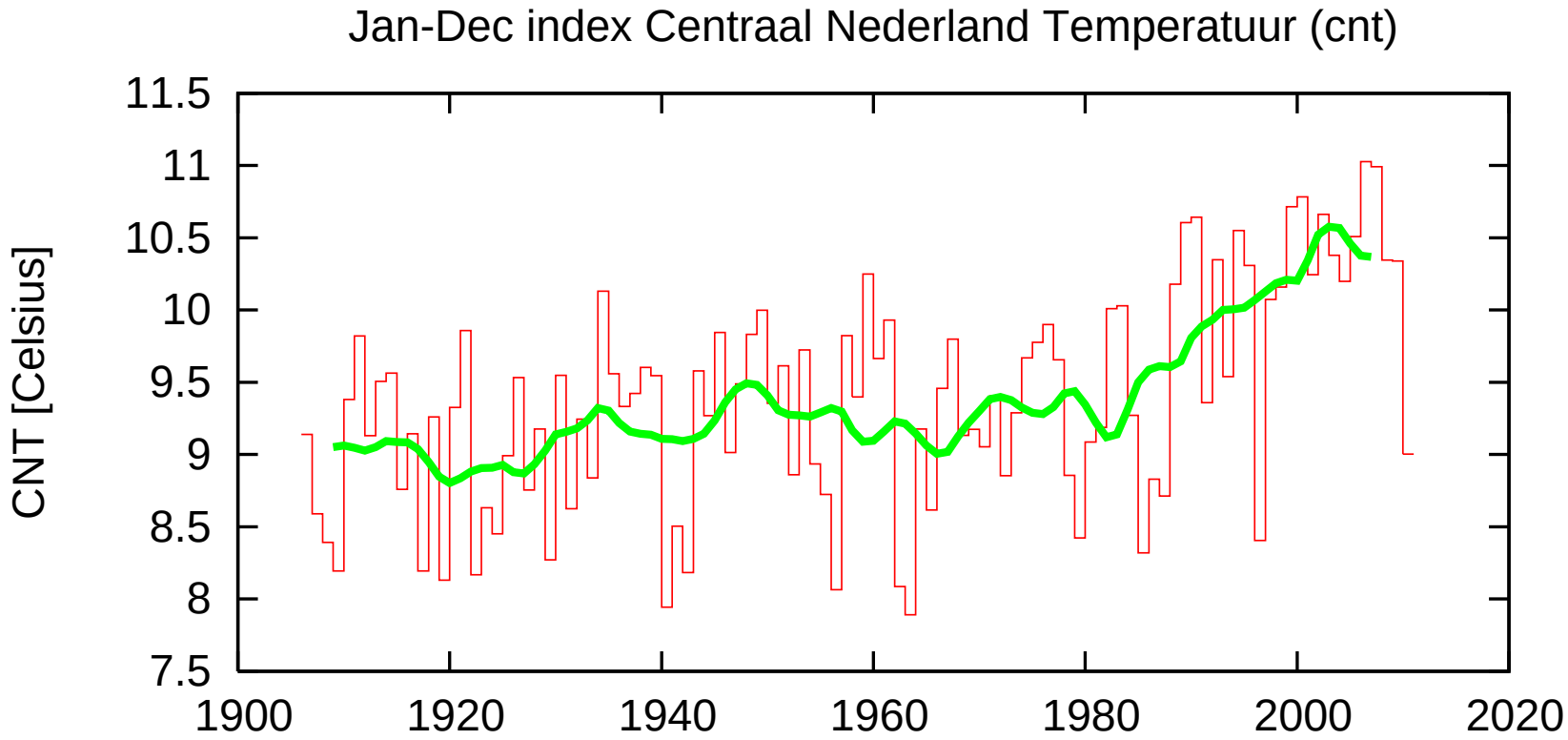
(well, the trend over next 10 years)

8.7 ± 0.3 mK/ppm

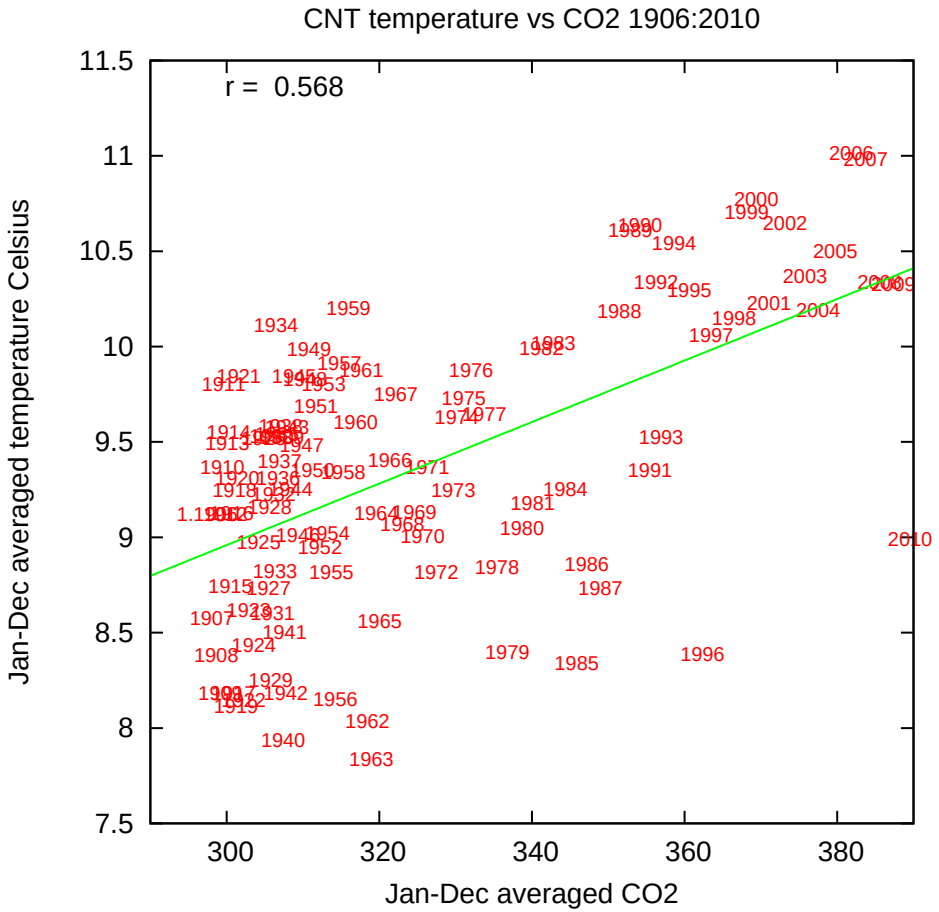
2.0 ppm/yr since 1995

$\Rightarrow 0.17 \pm 0.06$ K/10yr

Predicting local temperature



Predicting local temperature



16 ± 2 mK/ppm

2.0 ppm/yr since 1995

$\Rightarrow 0.32 \pm 0.05$ K/10yr

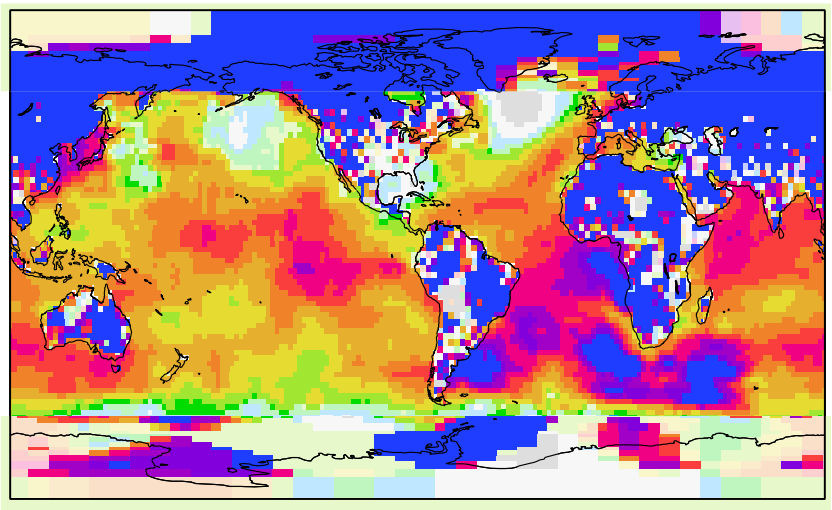
(well, the trend over next 10 years)

Can we do better?

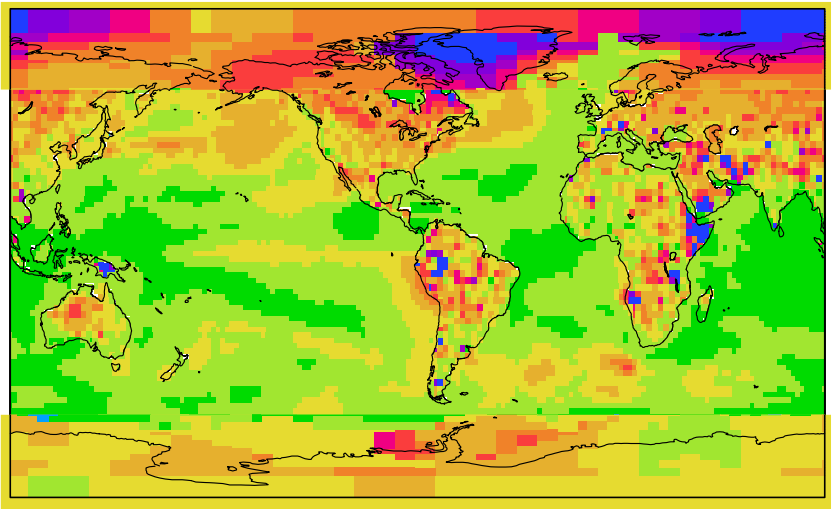
Can climate models improve

- the trend estimate?
- forecasting variability around the trend?

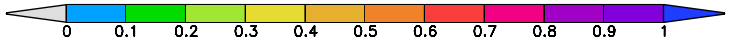
The temperature trend is larger than variability



Trend 1960–2010



S.d. of 4-yr mean residuals



Almost everywhere (observations)

Definitions of trend and variability

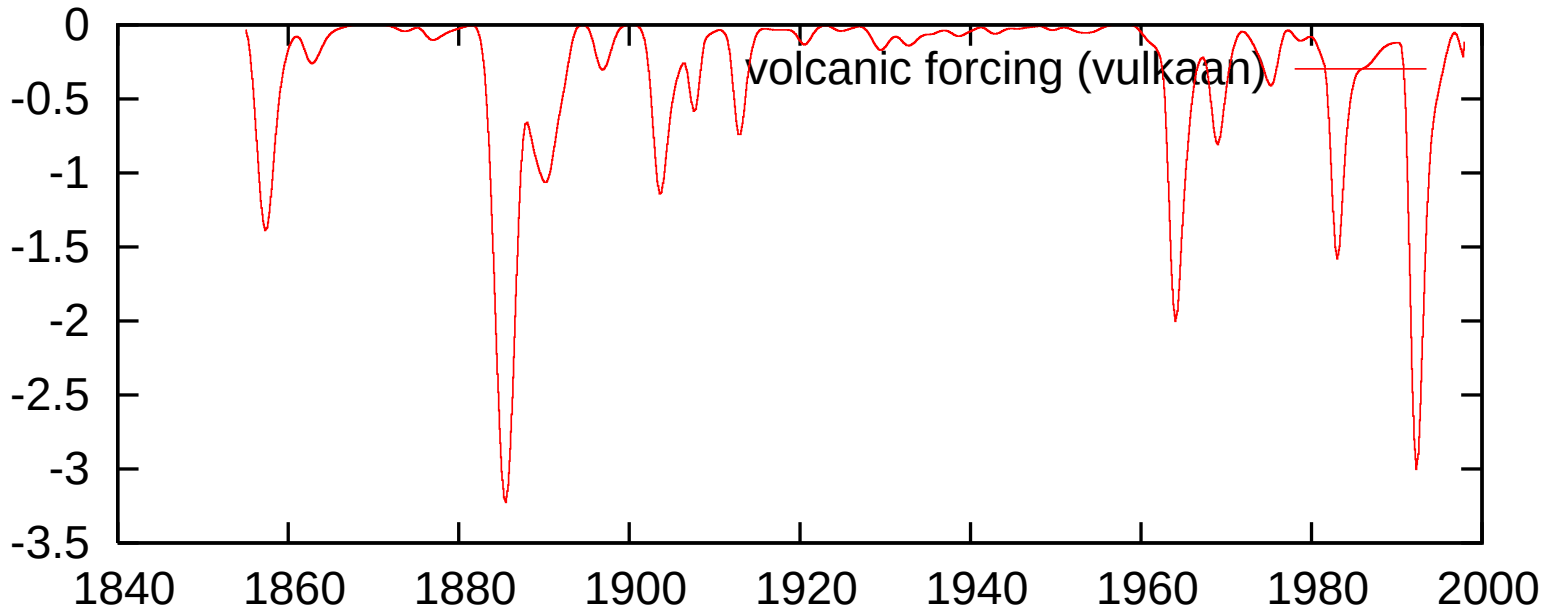
Trend Regression on CO_2 concentration (non-linear increase). Also includes multi-centennial natural variability, but mainly GHG-forced.

Variability Residuals of the regression, includes forcing not proportional to CO_2 (solar, volcanic aerosols, tropospheric aerosols) as well as the effects of initialisation.

Model ensembles

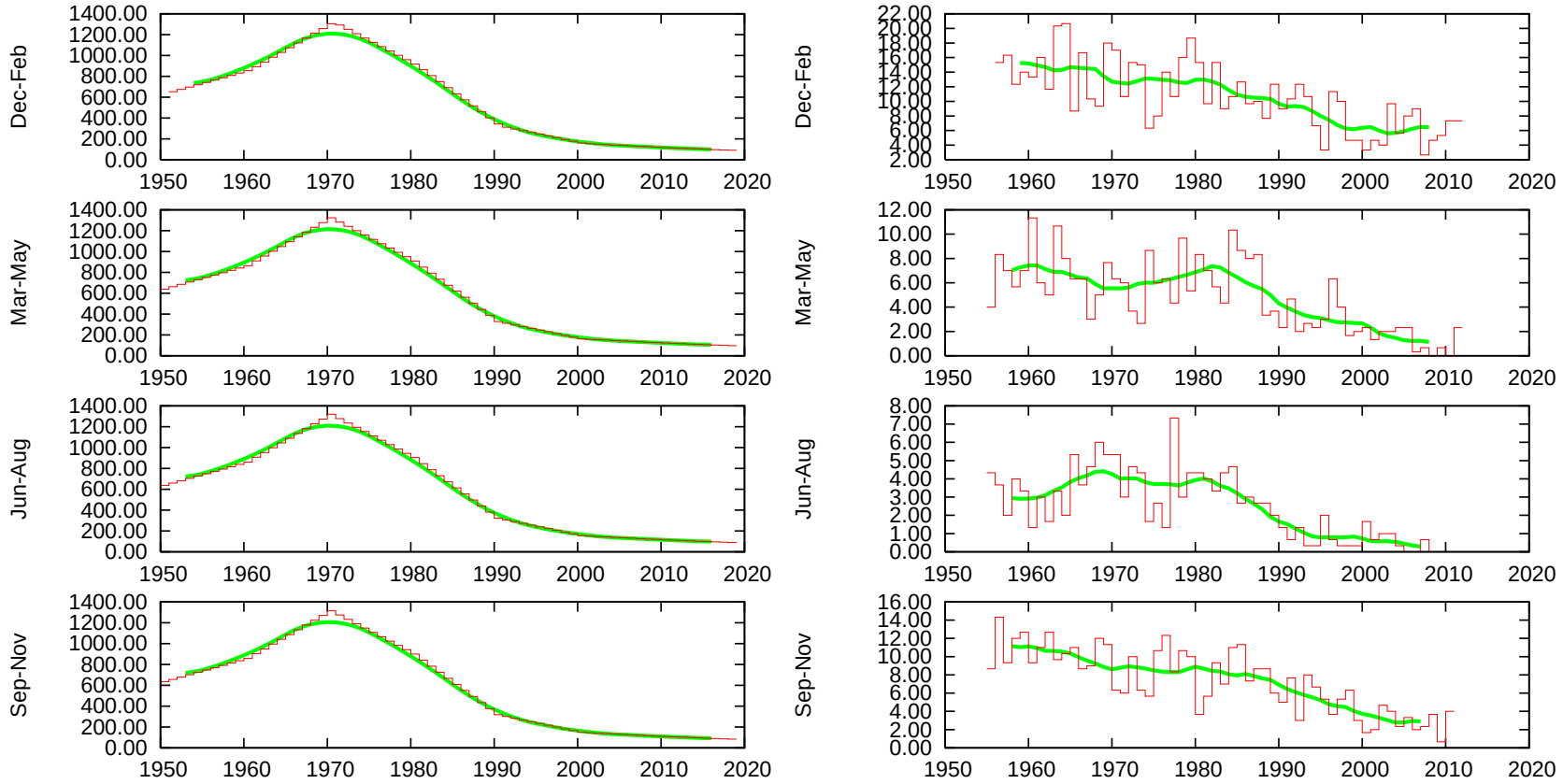
- ENSEMBLES decadal prediction experiment: 4 models, 10 yr runs, initialisation Nov 1 1960, 1965, . . . , 2005. No NoAssim runs.
- CMIP3 climate simulations, 23 models 20c3m+sresa1b, split into a subset with volcanic aerosols (CMIP3v, 11 models often also solar constant variability) and without (CMIP3n, 12 models).

Effects of volcanic eruptions



Big tropical volcanic eruptions are included in some climate model simulations of the past, but not in ENSEMBLES hindcasts as they cannot be predicted.

Tropospheric aerosols



RCP4.5 emissions 52°N 5°E # days max visibility $\leq$ 10km

Included in many models but not very realistically. Should be predictable to some extent.

Observations

- Global mean temperature from NCDC (checked against GISTEMP, HadCRUT3)
- ERSST from NCDC, GHCN/CAMS T2m from NCEP, GISTEMP 1200 for polar regions
- Precipitation from GPCC v5
- CO_2 concentrations from Mauna Loa

All model and observational data are available from climexp.knmi.nl

Bias correction

All models drift from the initial state to the model climatology. A bias correction is applied for each model separately that is constant in analysis time but varies with lead time. This is done by taking anomalies relative to the verification period in the forecasts and observations. No cross-validation (complicated to do properly with trend/variability definition).

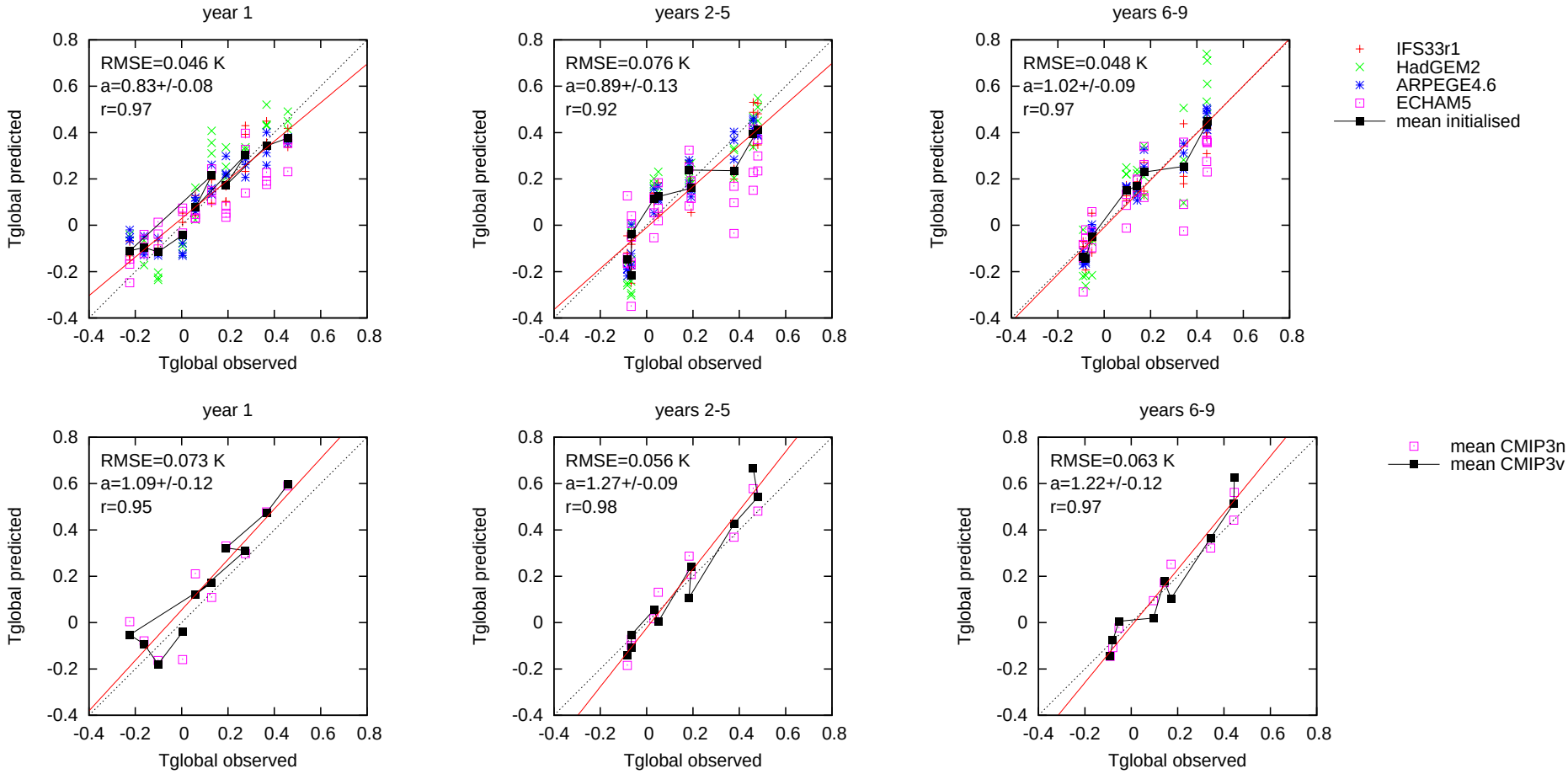
Verification measures

Keep it simple — best signal/noise ratio

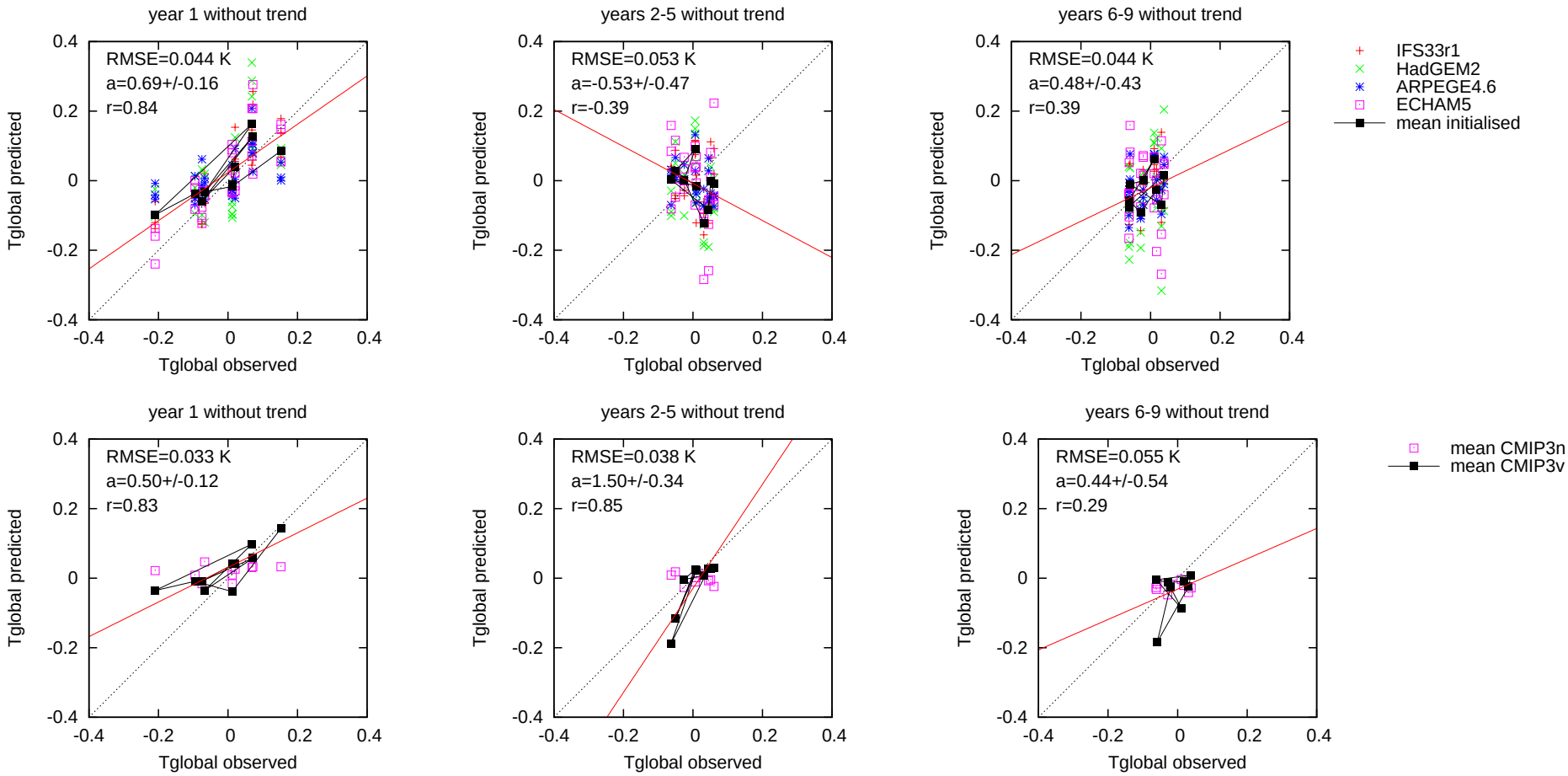
Correlation already includes the bias correction, same if cross-validation would have been used.

RMSE (Time series only)

Global mean temperature



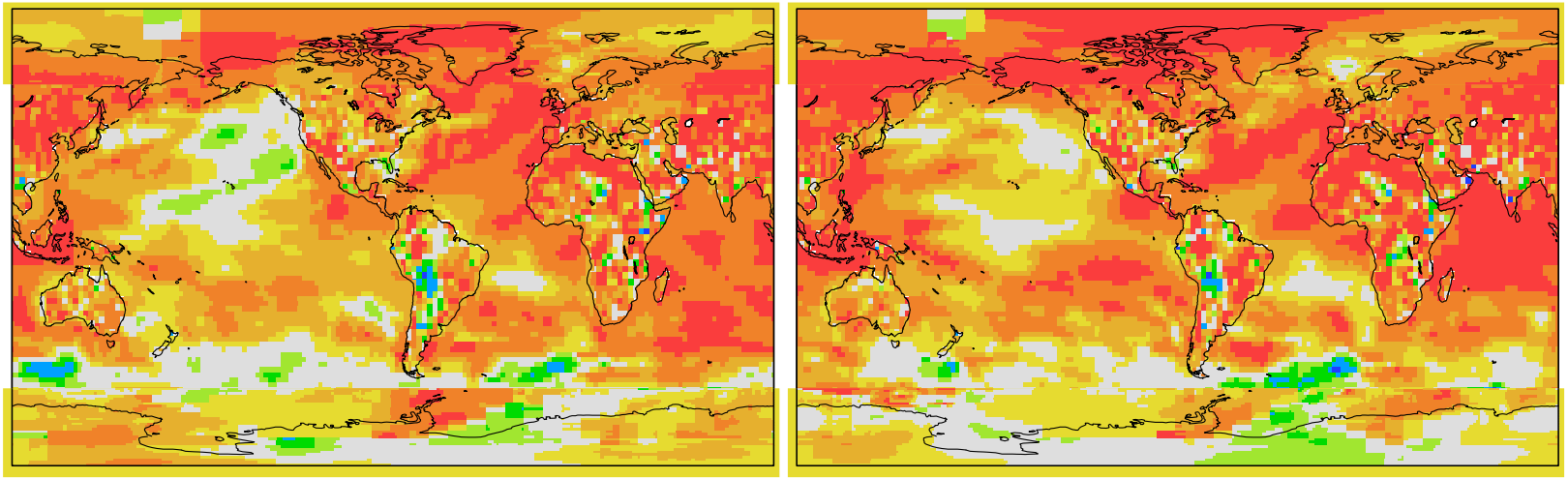
Global mean temperature without trend



Local SST/T2m skill: total

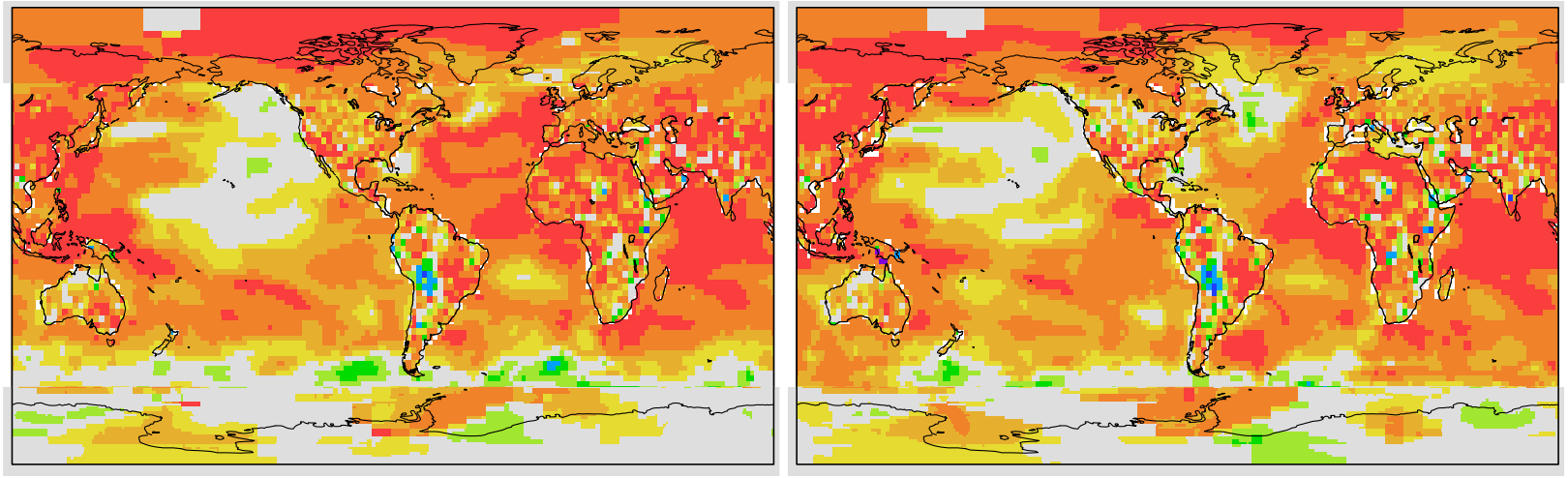
Hindcasts: years 2–5 years 6–9

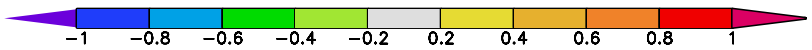
a b



CMIP3 with volcanoes 4-yr mean without volcanos

a b

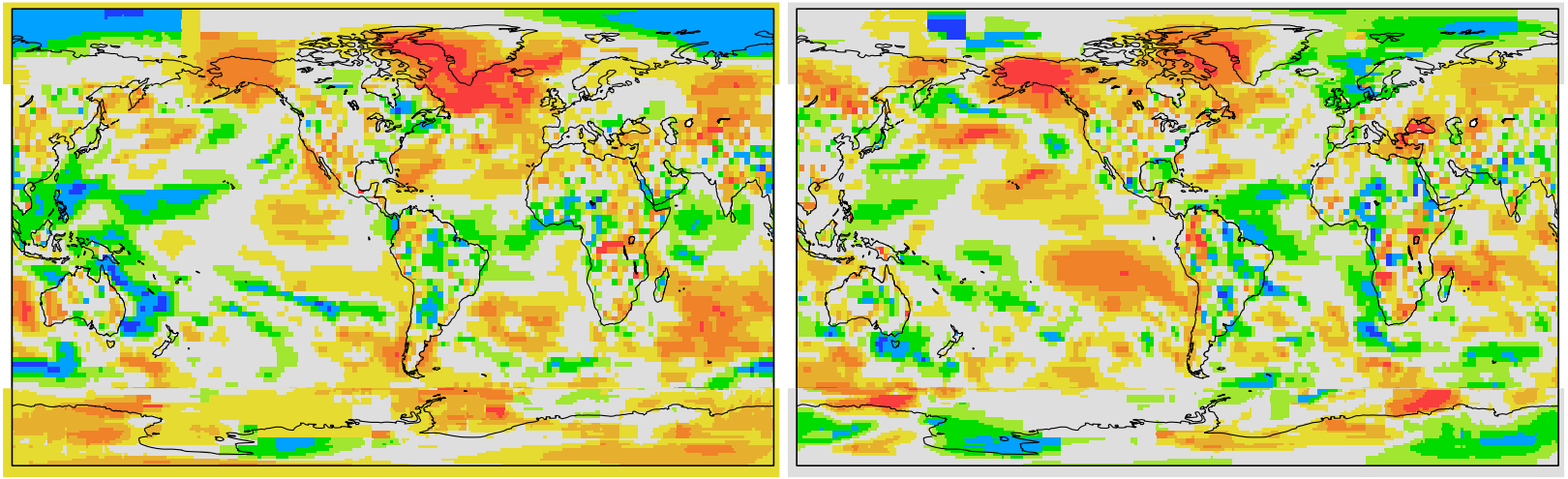




Local SST/T2m skill: beyond trend

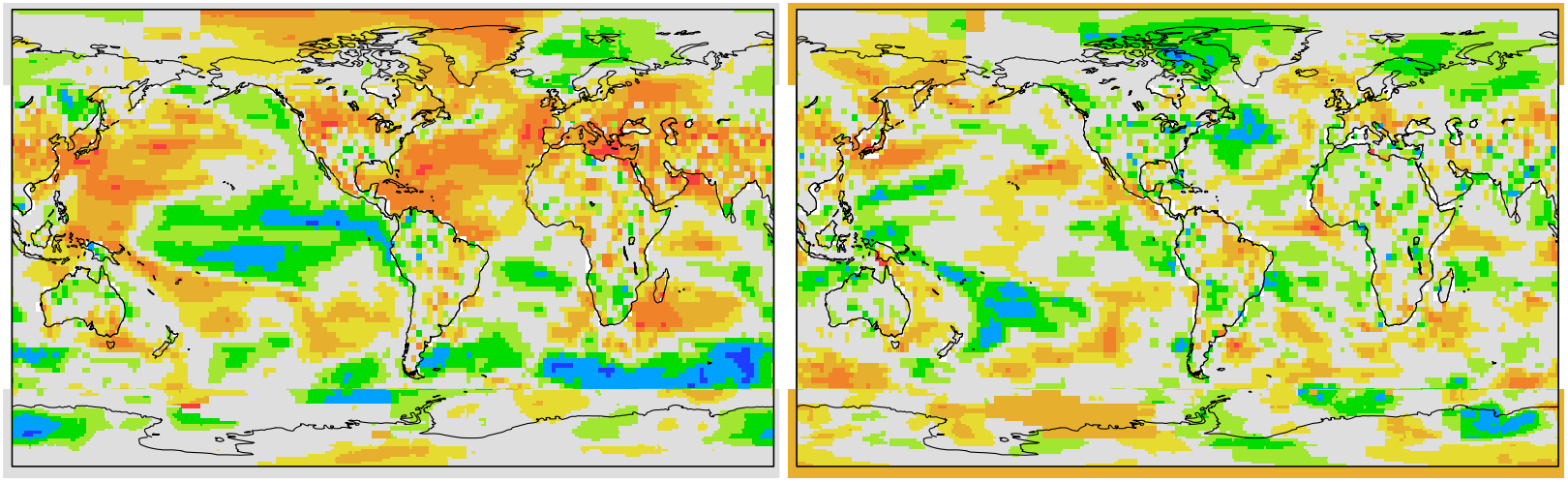
Hindcasts: years 2–5 years 6–9

c d



CMIP3: with volcanoes without volcanoes

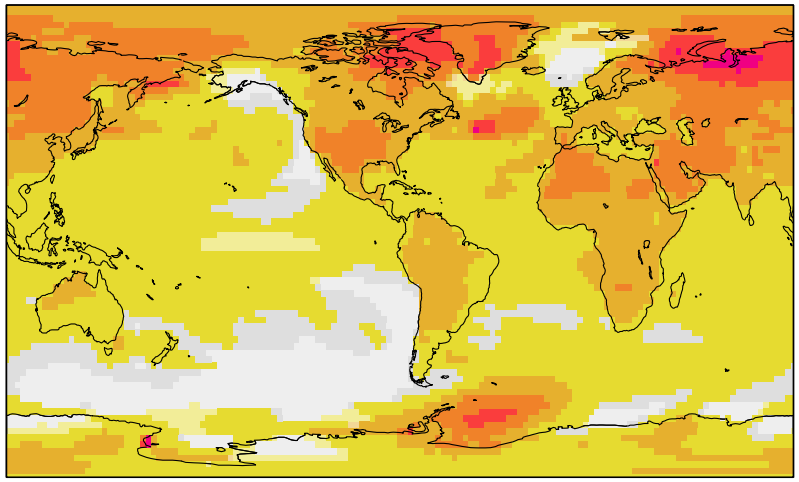
c d



Local SST/T2m trends

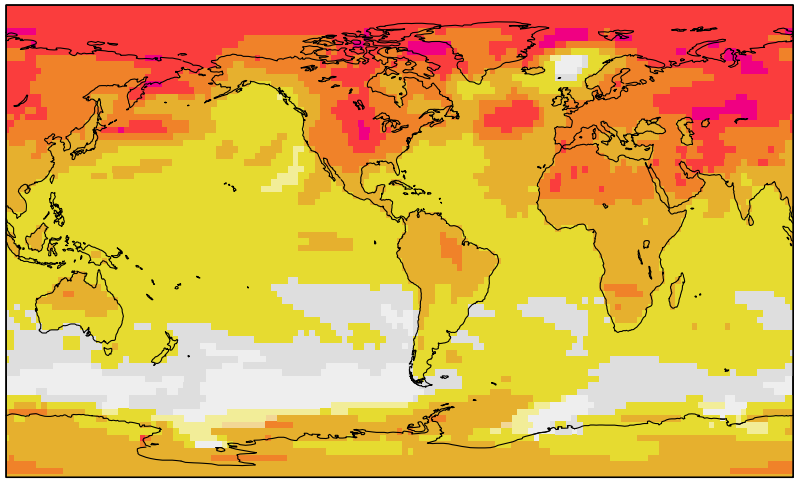
Trend: years 2–5

a



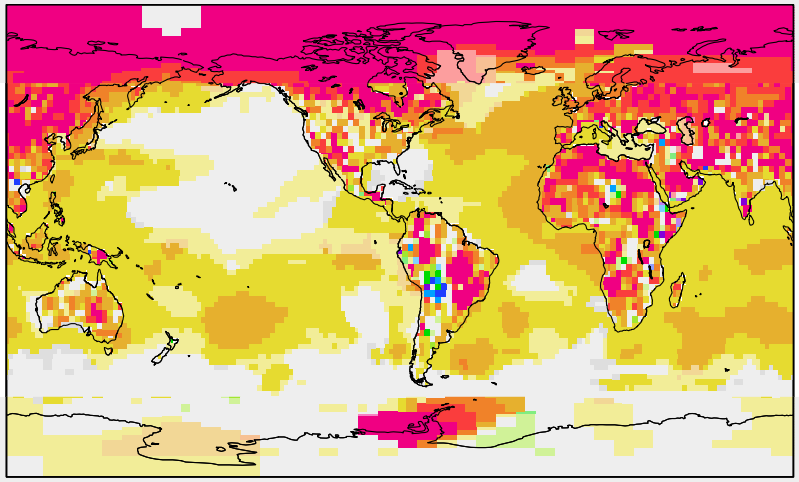
years 6–9

b



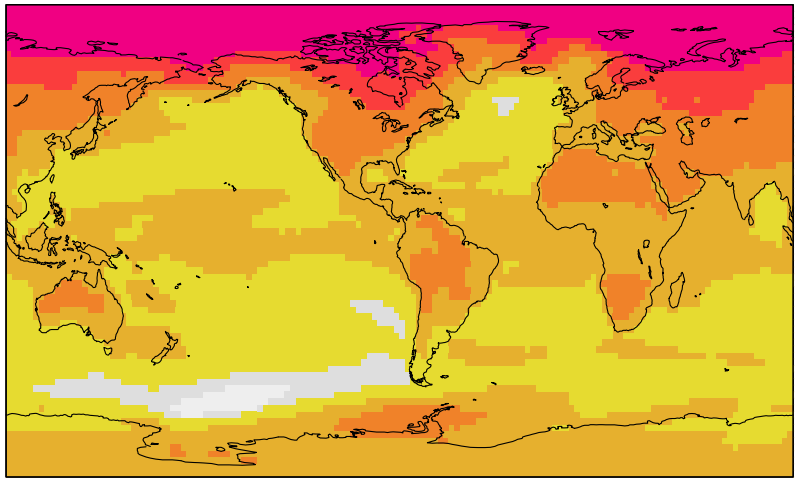
Trend: observations

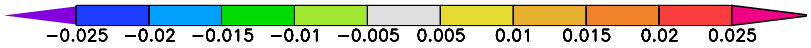
c



CMIP3 mean

d

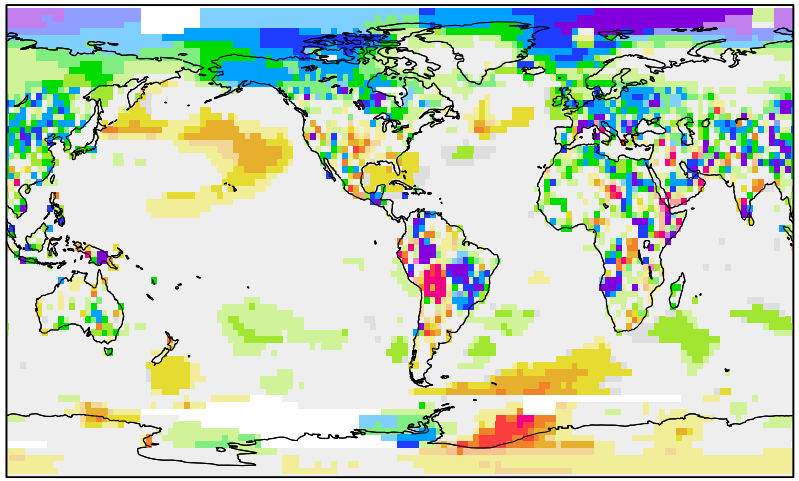




Local SST/T2m trends minus observed

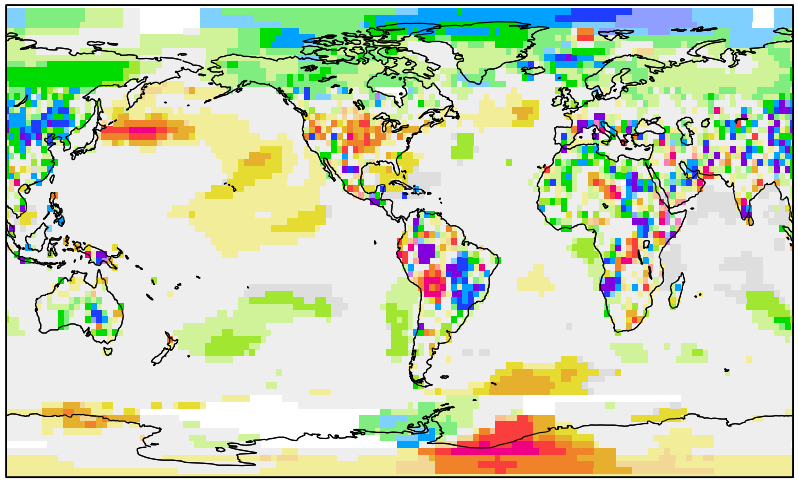
Trend: years 2–5 − observations

e



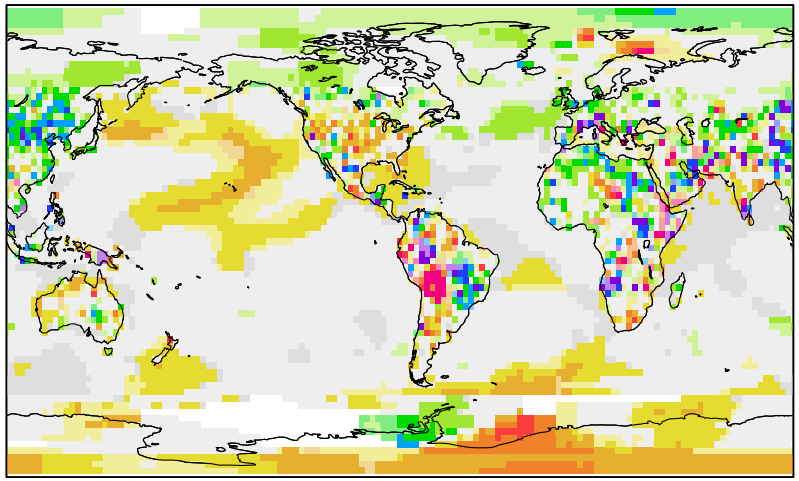
years 6–9 − observations

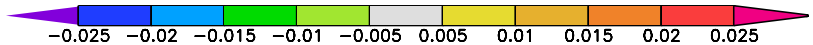
f



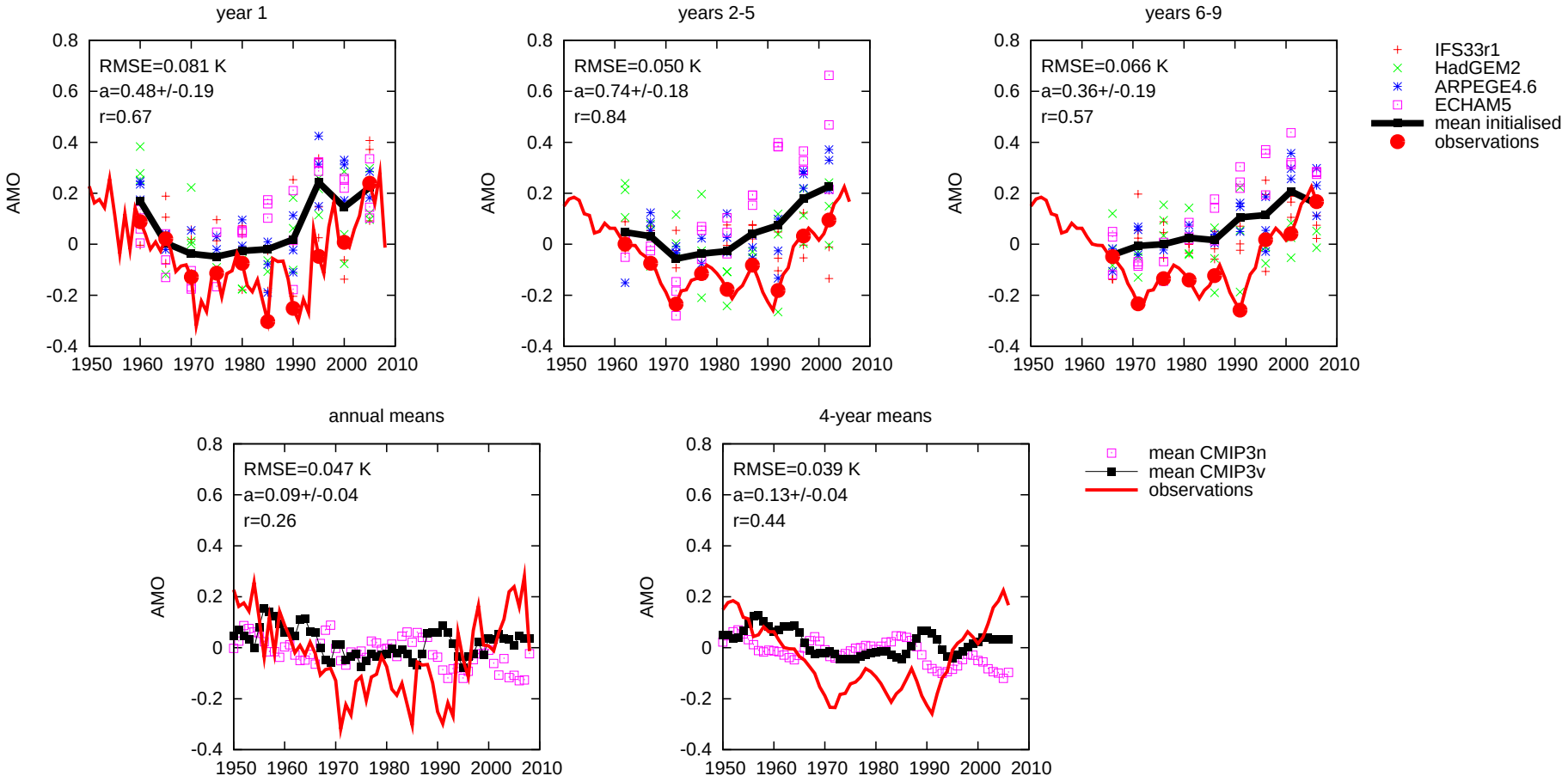
Trend: CMIP3 − observations

g





AMO



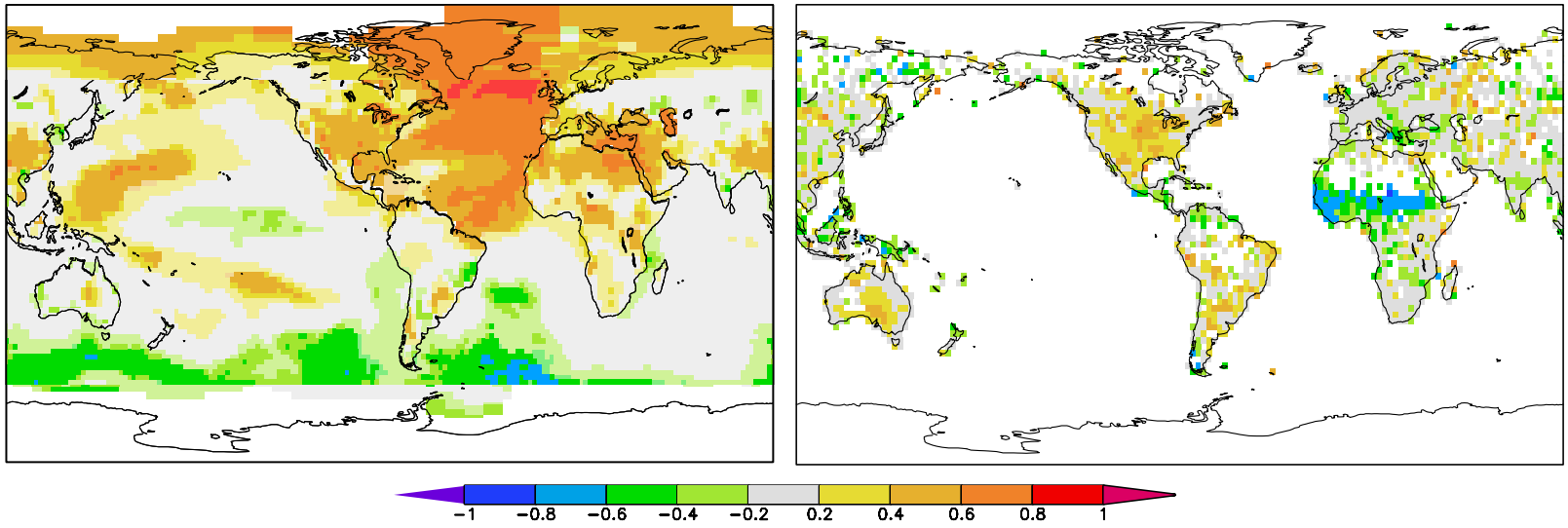
AMO index as in Trenberth & Shea (2006): SST anomalies EQ–60°N, 80–0°W minus global SST anomalies 60°S–60°N. Also orthogonal to trend over 1960–2009. No trend or bias corrections.

Observed AMO teleconnections

AMO temperature teleconnection

AMO precipitation teleconnection

a

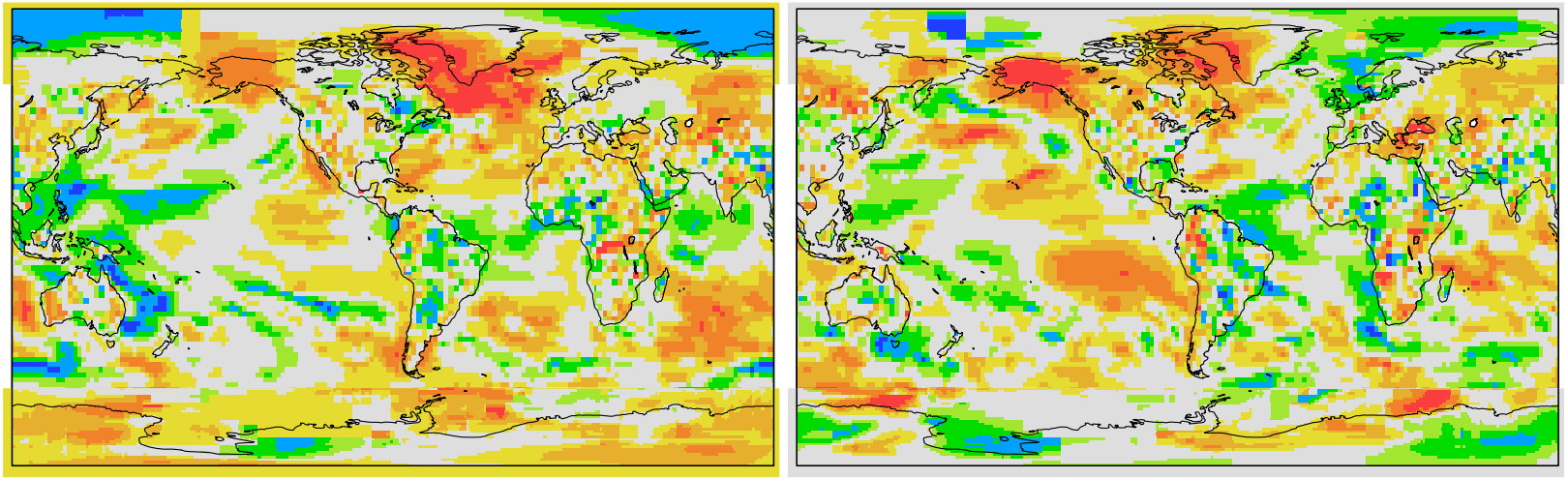


b

Local SST/T2m skill: beyond trend

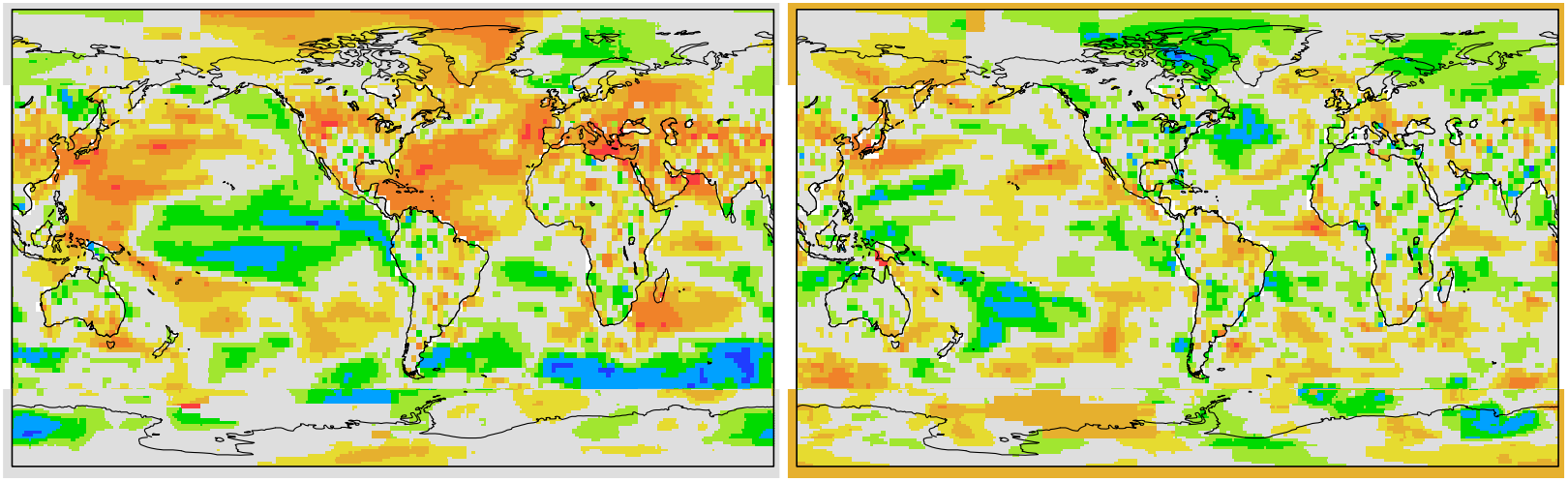
Hindcasts: years 2–5 years 6–9

c d

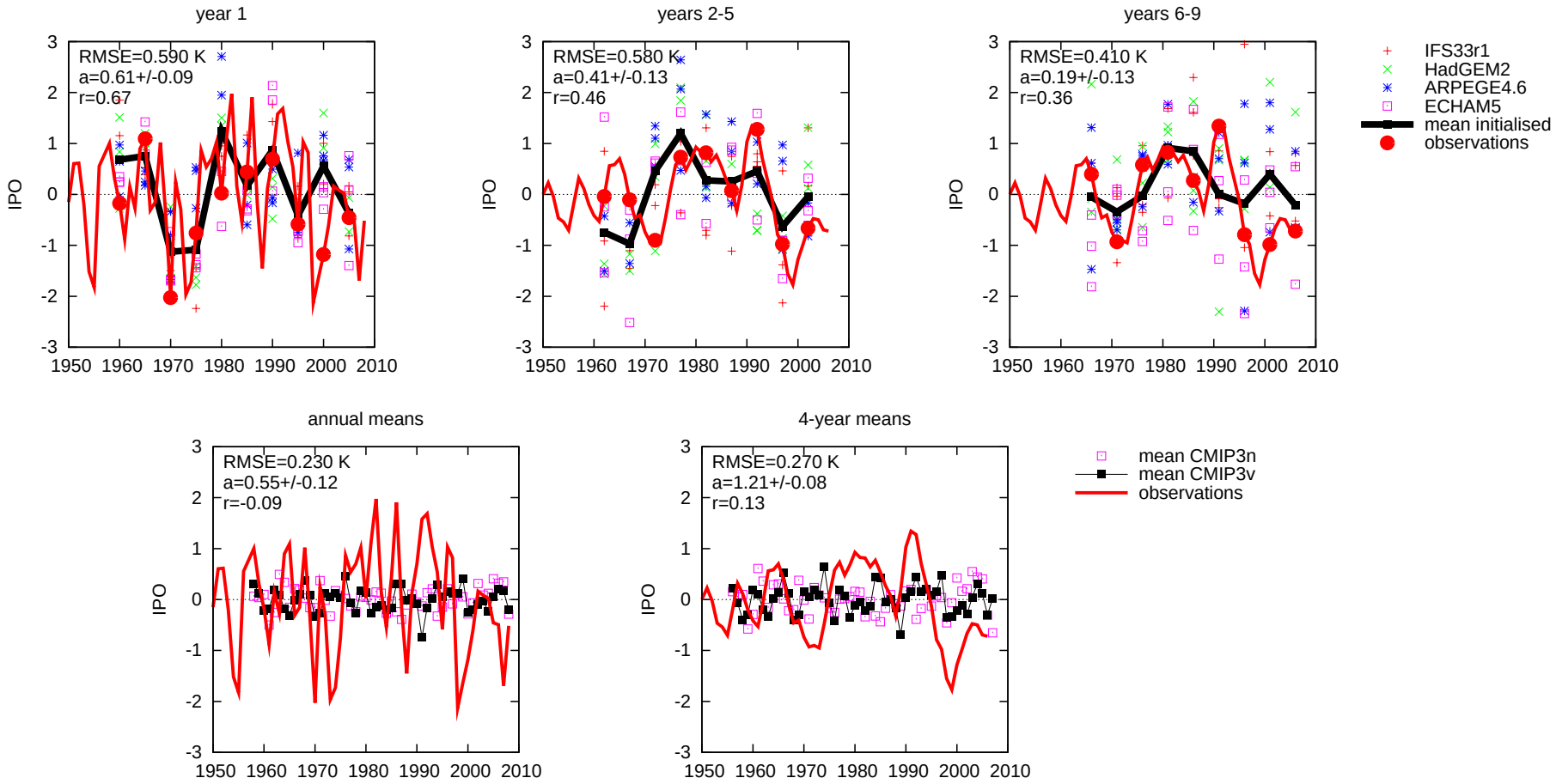


CMIP3: with volcanoes without volcanoes

c d



Decadal ENSO / IPO



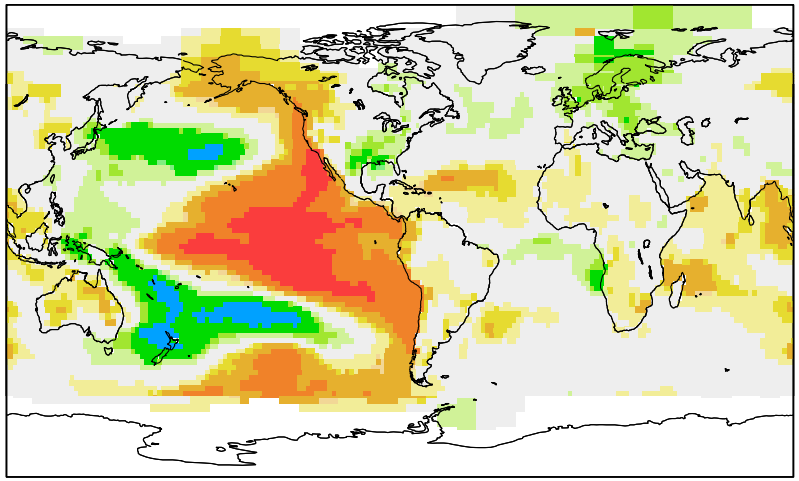
First EOF of detrended Pacifc SST (50°S–50°N, 100°E–90°W.

Observed decadal ENSO teleconnections

Temperature teleconnection

Precipitation teleconnection

a



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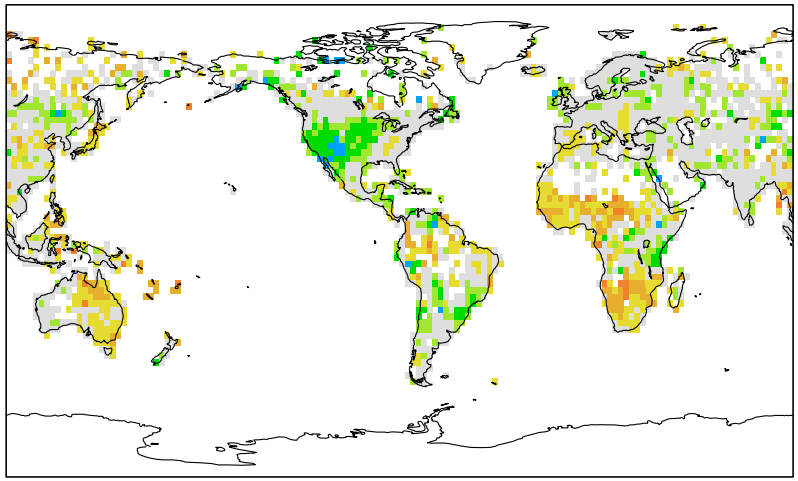

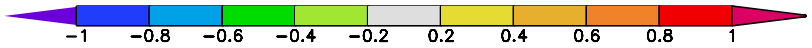

Local SST/T2m skill: beyond trend

Hindcasts: years 2–5 years 6–9

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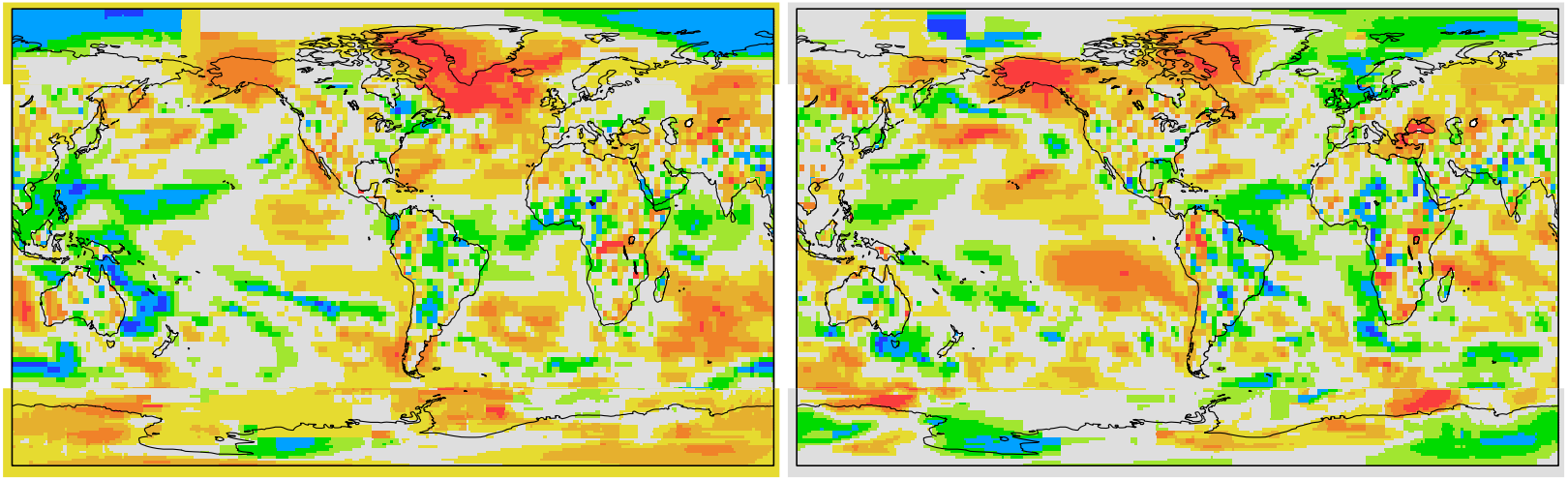

CMIP3: with volcanoes without volcanoes

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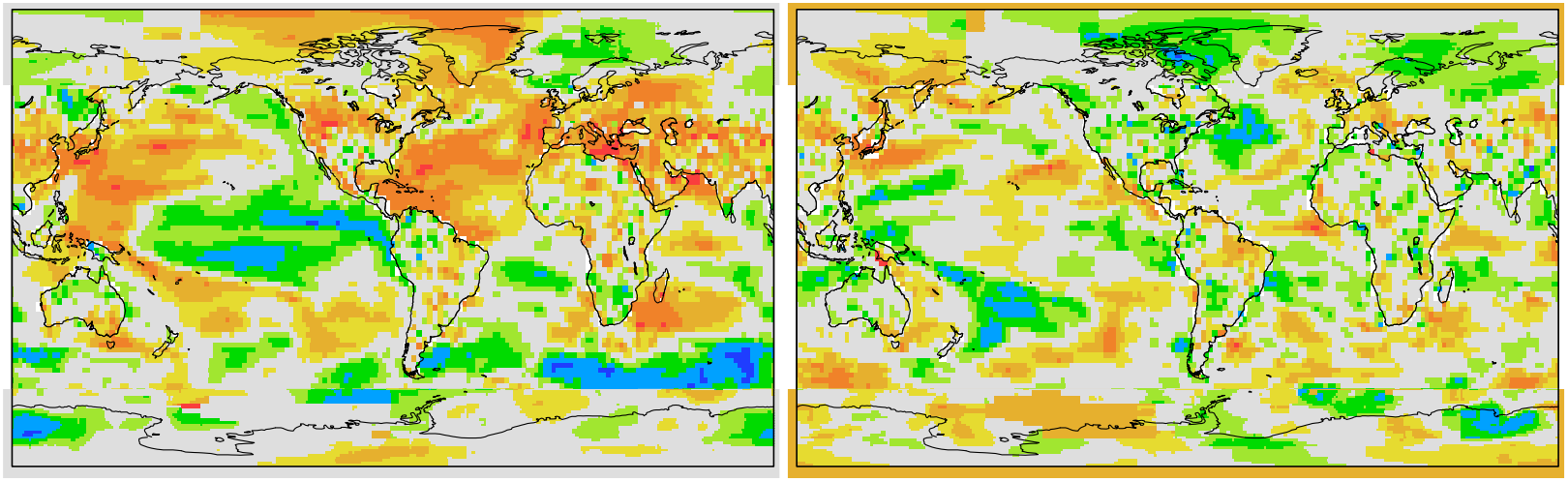
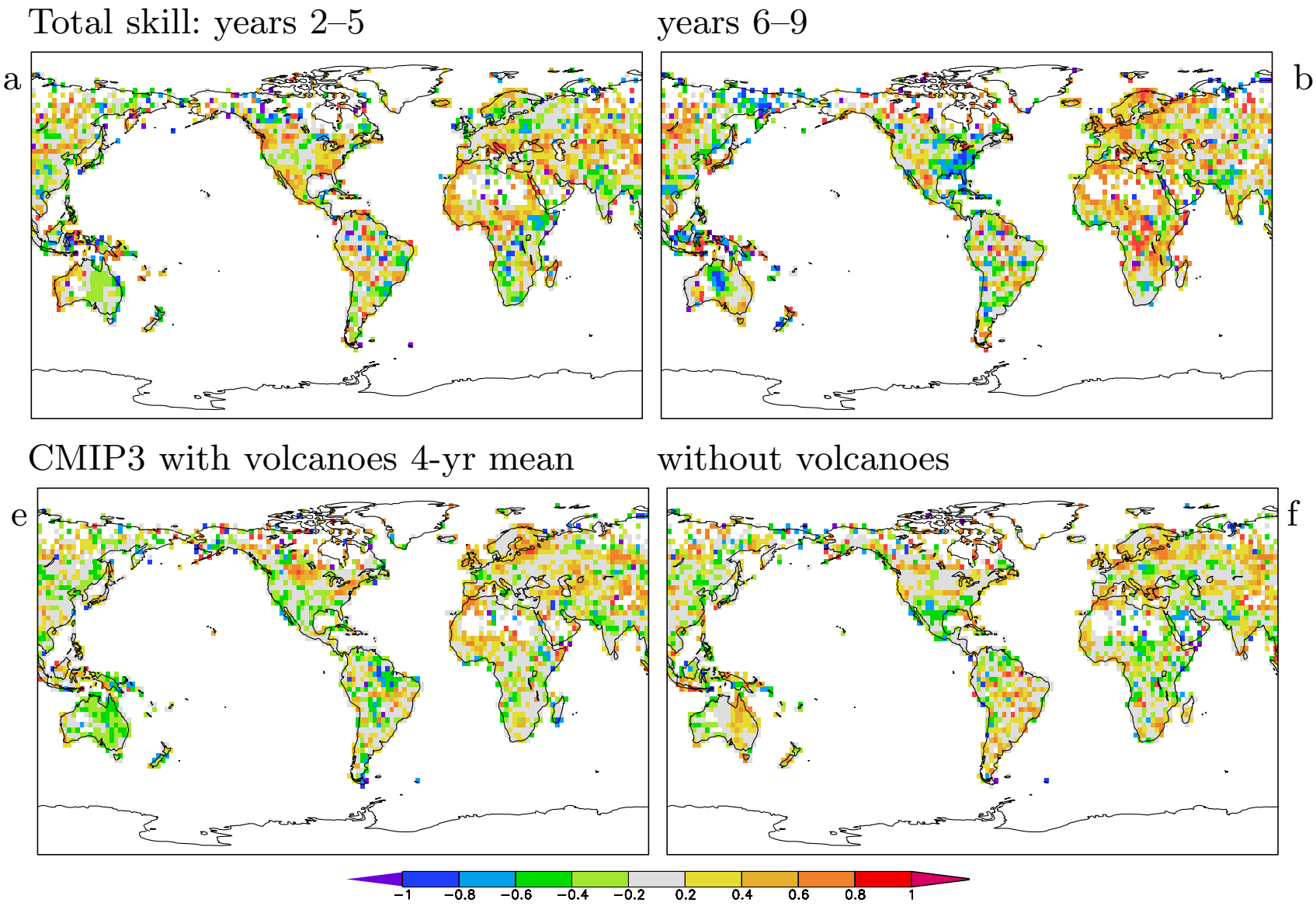
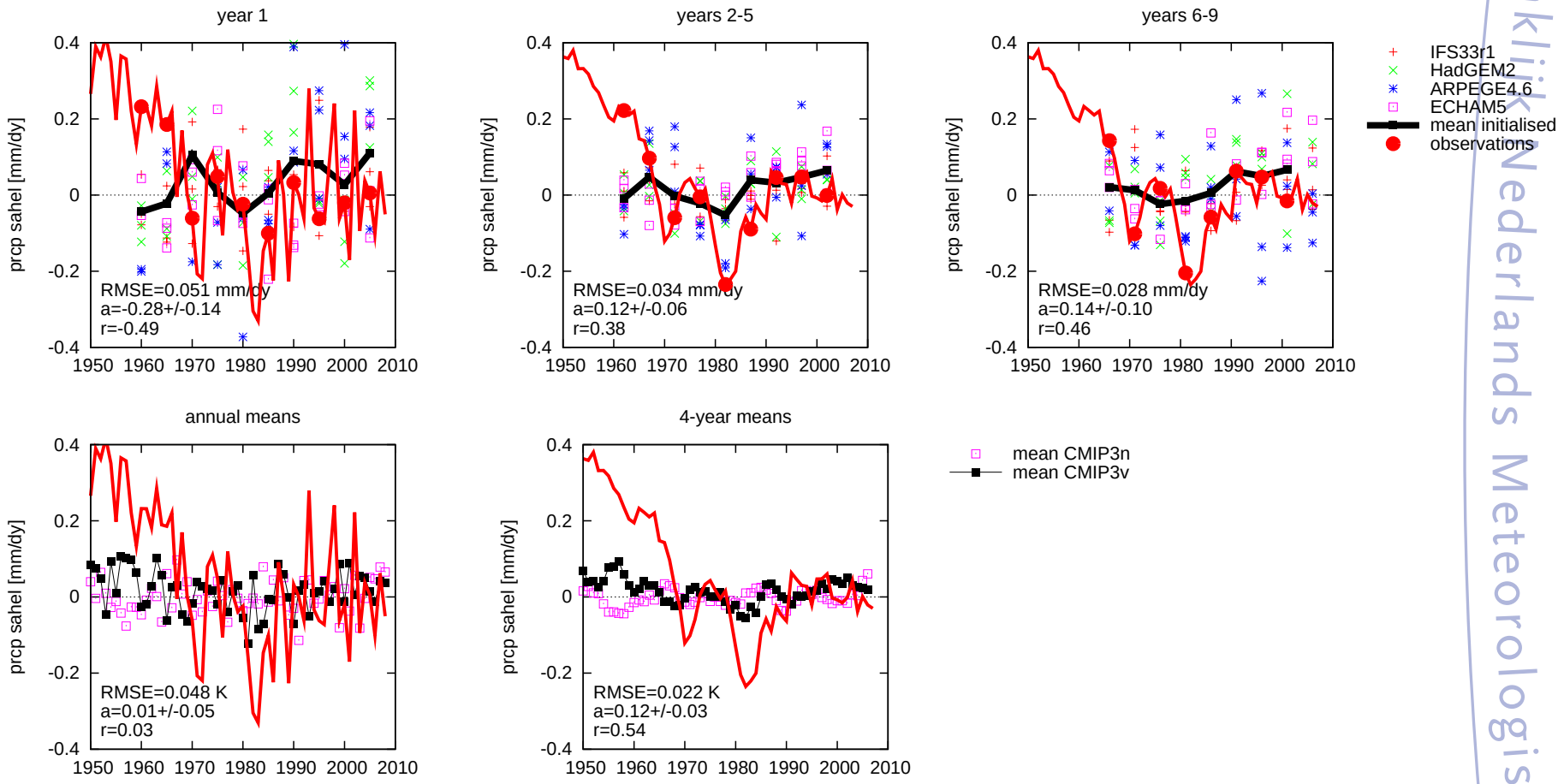


Precipitation skill hindcasts/CMIP3



Sahel rainfall



Precipitation 10°–20°N, 18°W–20°E. Slightly more skill in the CMIP3v ensemble than the initialised hindcasts, but no skill in CMIP3n. Volcanoes? Troposheric aerosols? Initialisation? Combination?

Conclusions

- A multi-model decadal hindcast ensemble shows good skill in temperature fields
- Most of it is due to the trend, which is not reproduced very well
- No skill in global mean temperature beyond the trend except in first year (watch out for volcanoes)
- Good skill in North Atlantic SST beyond trend $\Rightarrow$ AMO
- Some skill in East Pacific SST $\Rightarrow$ decadal ENSO / IPO
- Some skill in forecasting Sahel rainfall, both in the initialised hindcasts and in the uninitialised models with volcanic aerosols