Improving ENSO in a Climate Model
Tuning vs. Flux correction

by tuning?

or by flux correction?

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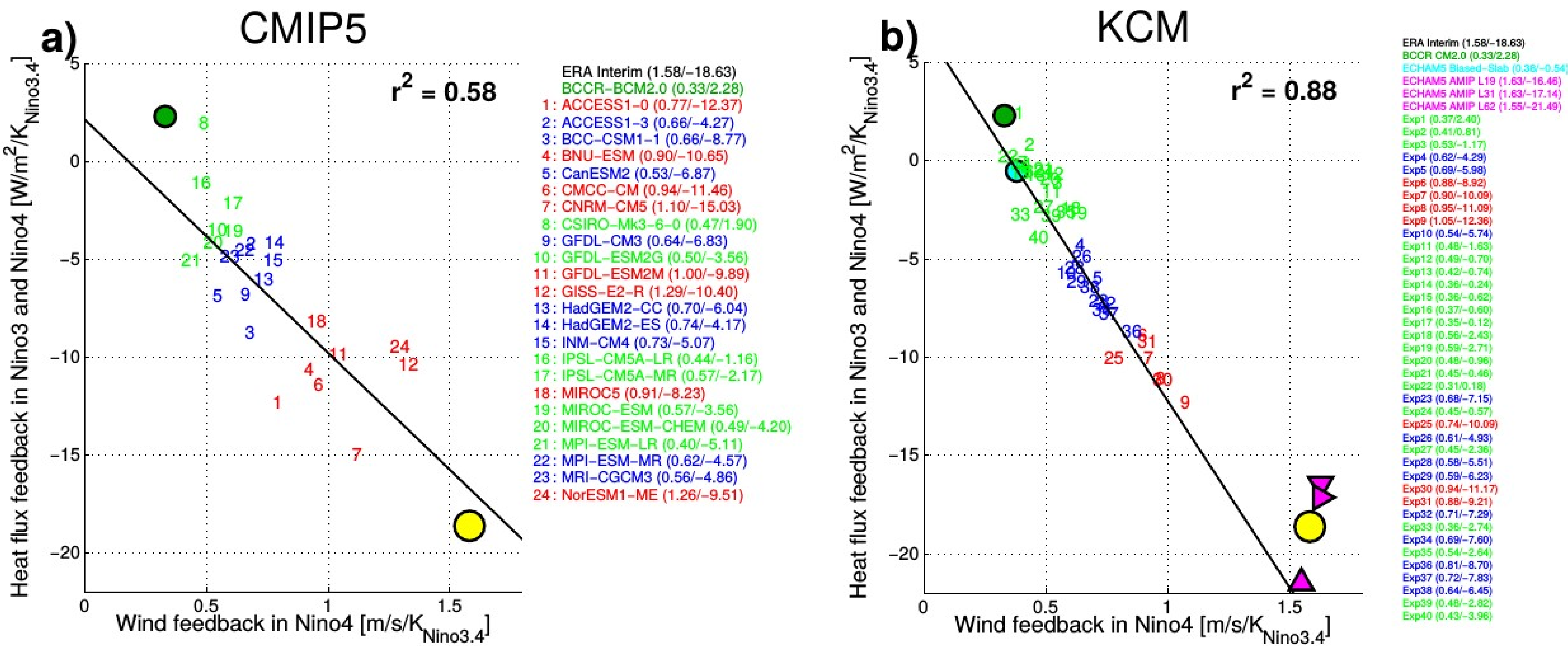
GEOMAR

Motivation: Atmospheric feedbacks in a perturbed physics ensemble of KCM

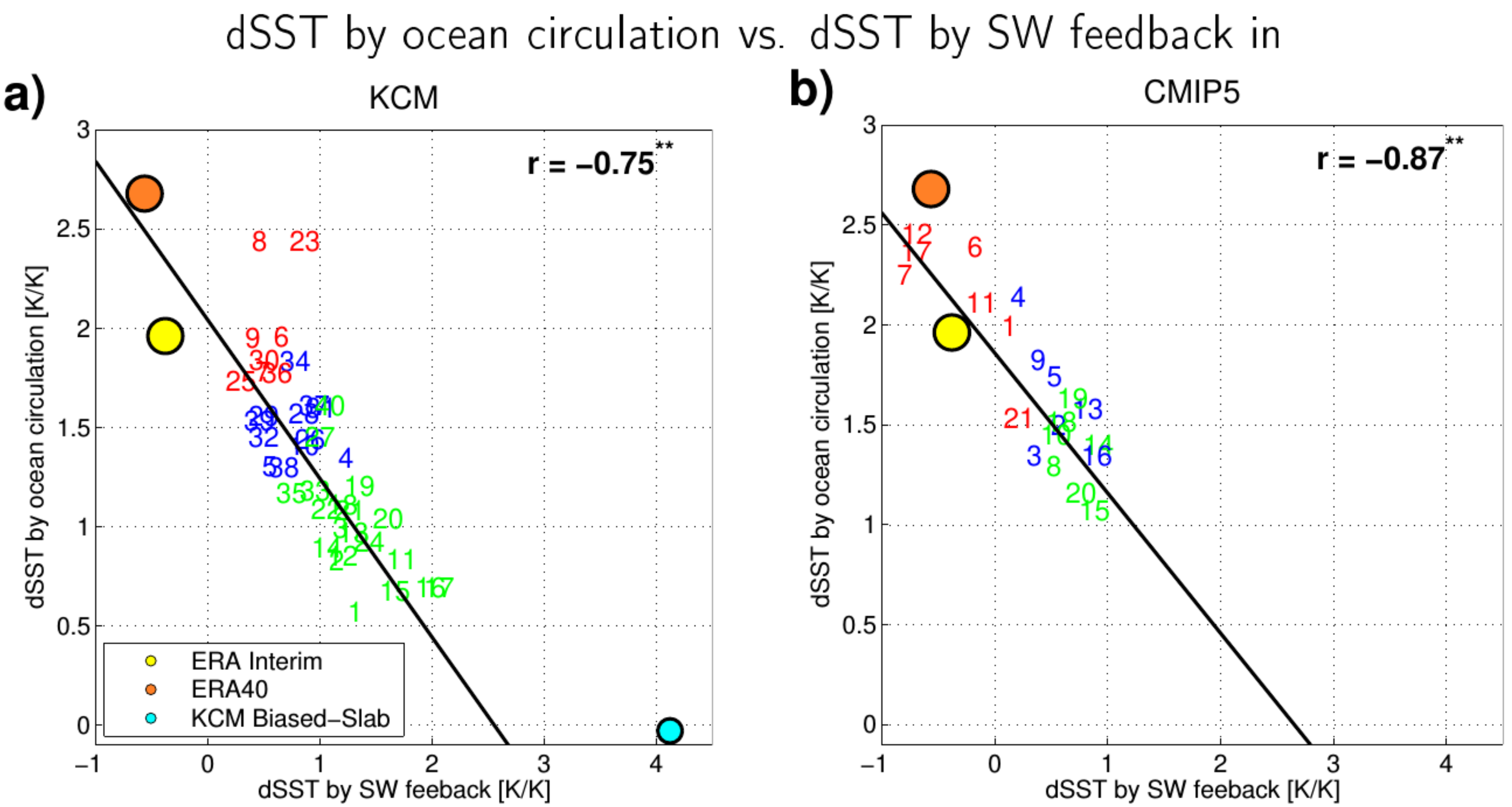
Zonal wind vs. net heat flux feedback in



By changing the convection parameters, a similar spread in ENSO atmospheric feedbacks as in CMIP5 can be generated in KCM!

Bayr et al. (2018), Clim Dyn

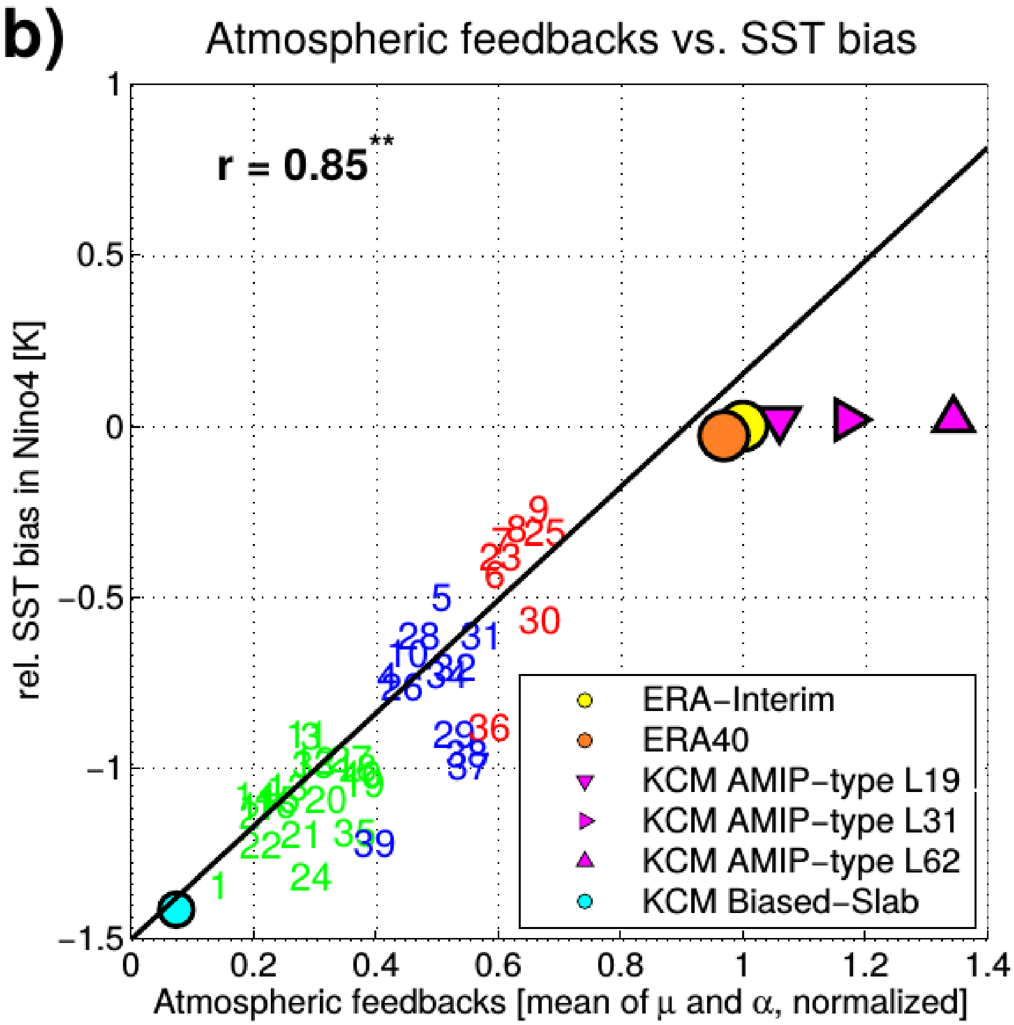
Motivation: Error compensation leads to biased ENSO dynamics



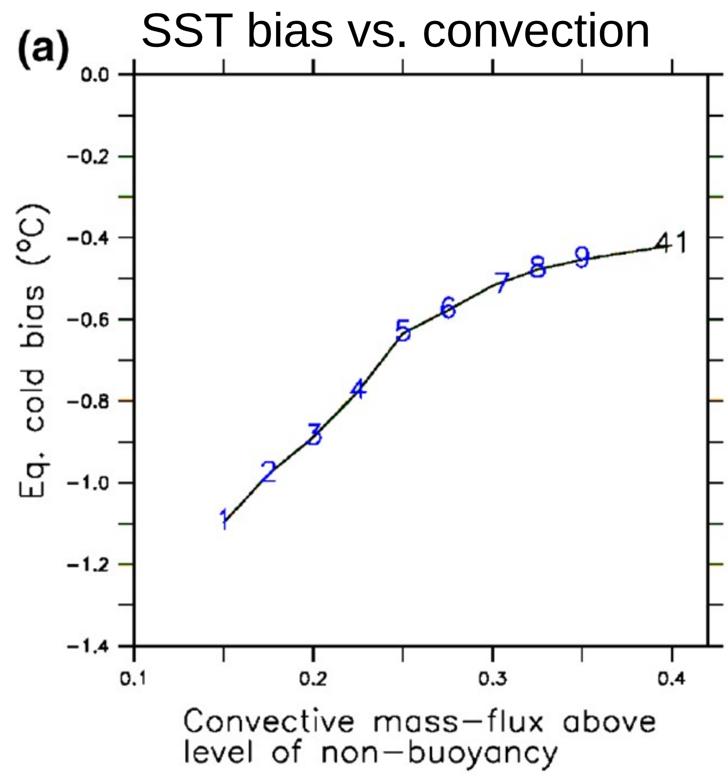
Underestimated wind feedback leads to weaker SST changes by ocean dynamics, which is compensated by a biased SW feedback

Bayr et al. (2018), Clim Dyn

Motivation: Atmospheric feedbacks depend on equatorial cold SST bias



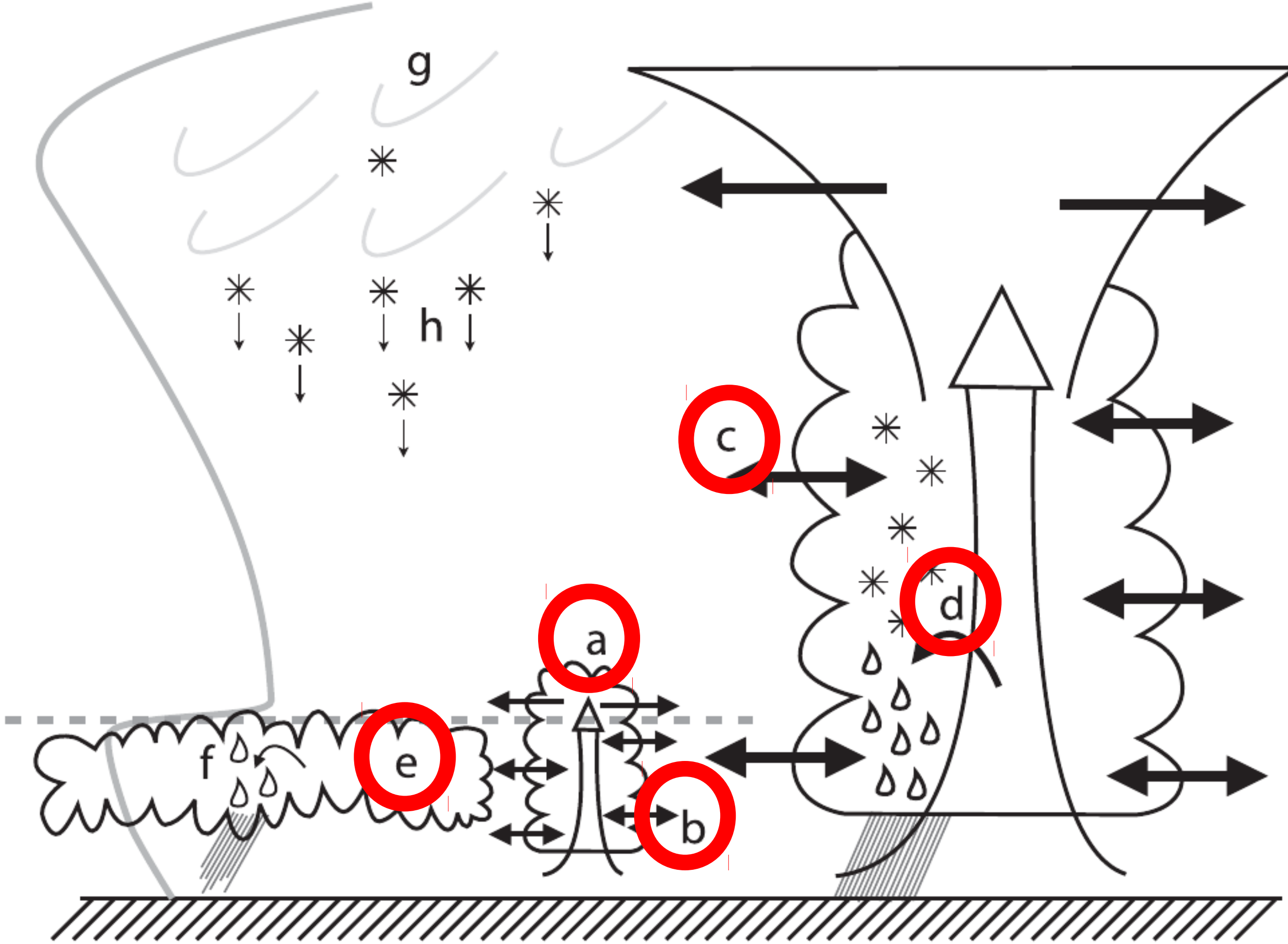
Bayr et al. (2018), Clim Dyn



Wengel et al. (2018), Clim Dyn

Equatorial cold SST bias can be tuned by convection parameters

“Tuning” parameters in convection parametrisation



Mauritsen et al. (2012)

Convection parameters are used to tune the climate model to the correct global mean temperature

a) convective cloud mass-flux above the level of non-buoyancy
b) entrainment rate for shallow convection
c) deep convective cloud lateral entrainment rate,
d) convective cloud conversion rate from cloud water to rain
e) liquid cloud homogeneity
ocean model: vertical eddy diffusivity

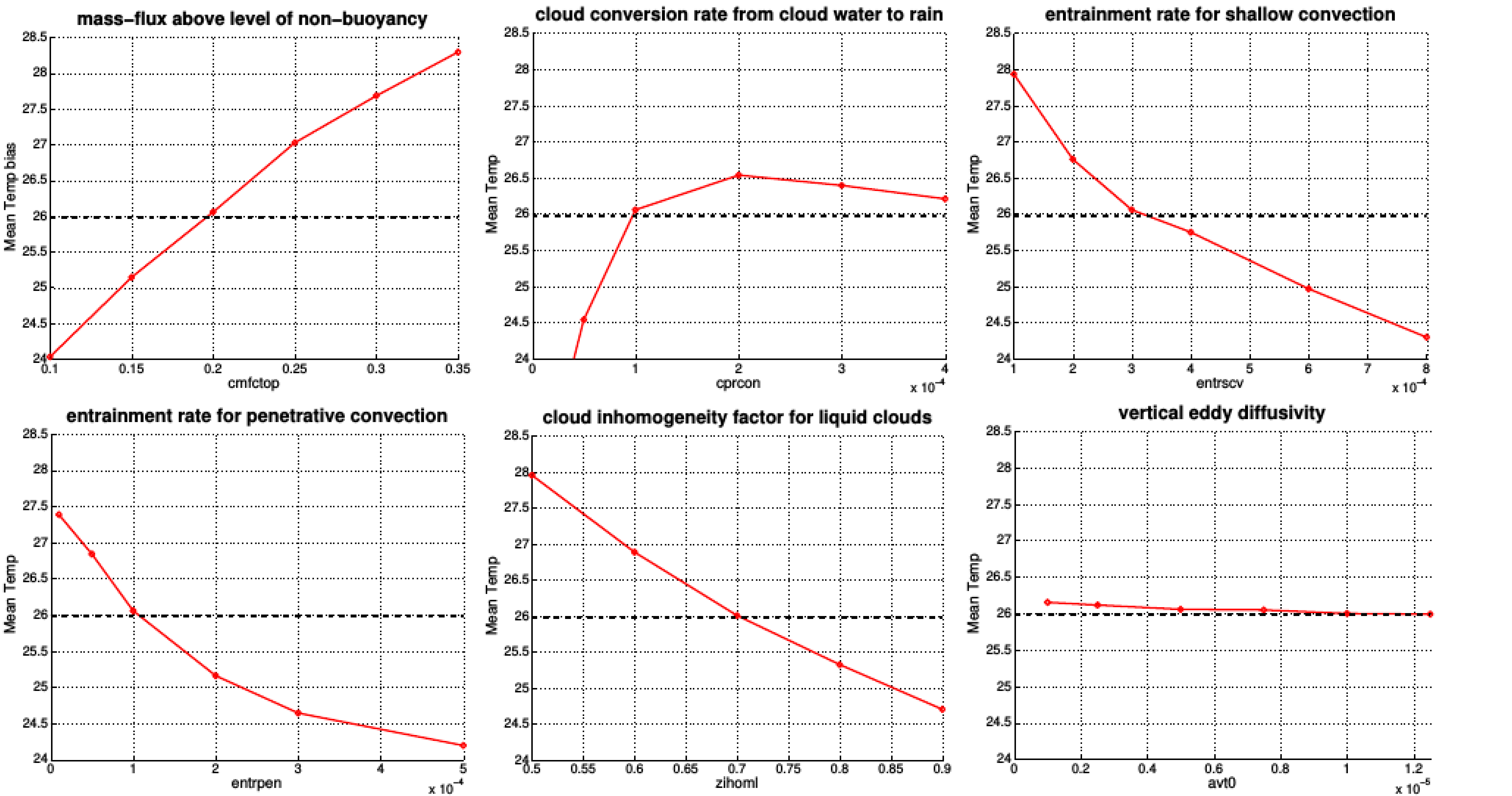
Data of Obs and KCM

- Observations and reanalysis data:
  HadISST, ERA40, ERA Interim and SODA reanalysis

- Perturbed physics ensemble of the Kiel Climate Model (KCM) 1.4.0 with
  - ECHAM5 with T42 (2.8°x2.8°) L31
  - Nemo Orca2 (~2°x2°)
  - Tuning of 5 different convection parameters based on Mauritsen et al. (2012)
  - Tuning by changing the ocean diffusivity

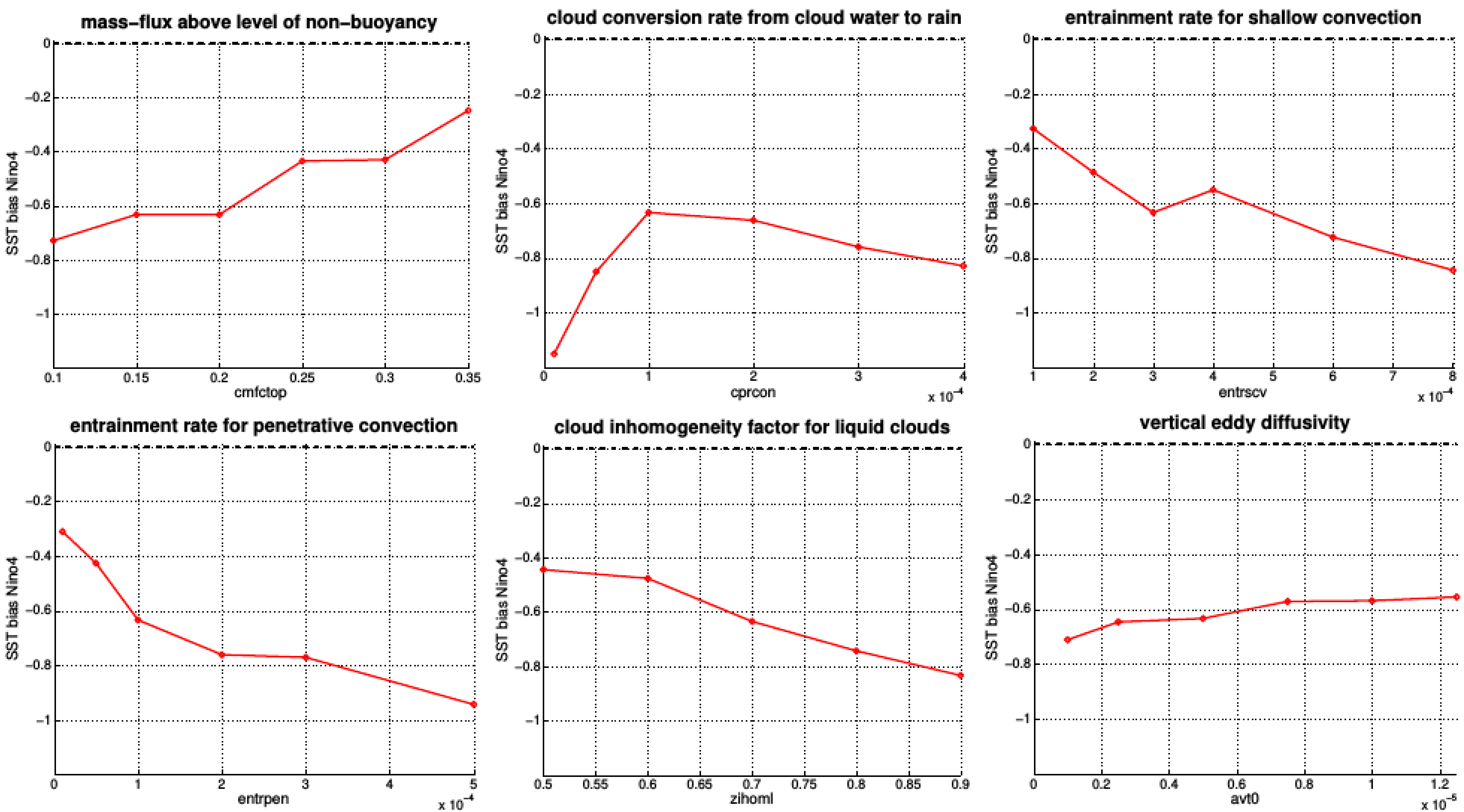
- For comparison: Heat flux corrected KCM experiment

Mean state temperature



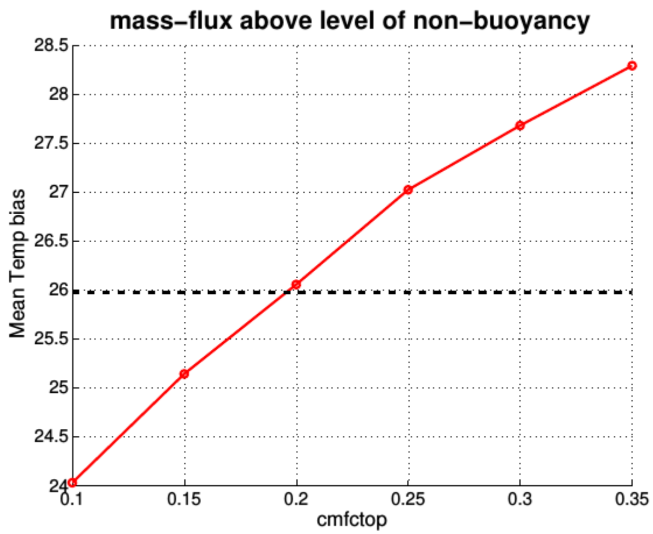
The parameters have influence on mean temperature...

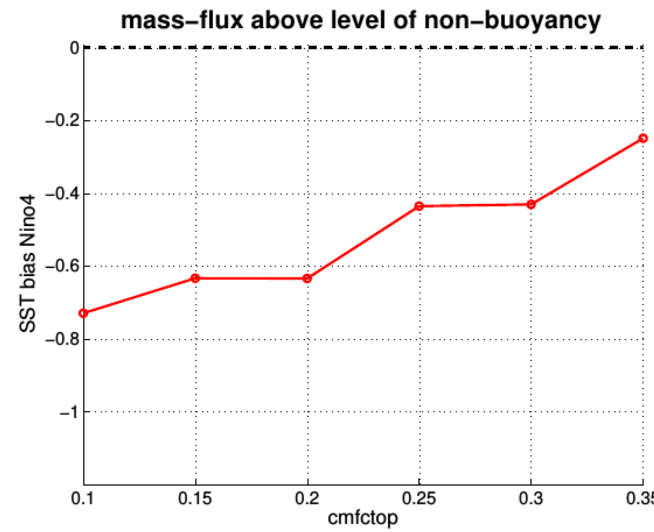
SST bias in Nino4

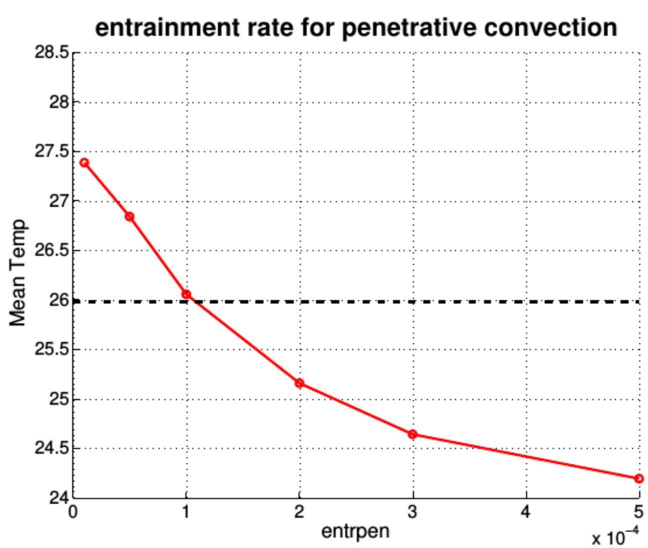


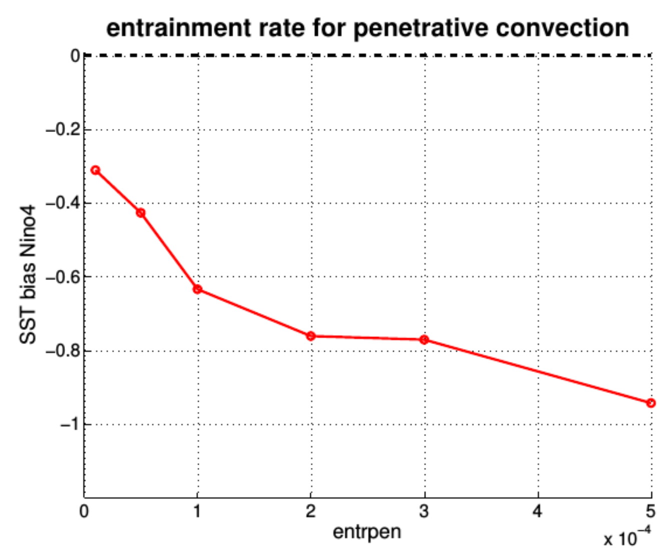
… but also on the SST bias in Nino4!

Tuning of
mean temperature vs SST bias in Nino4



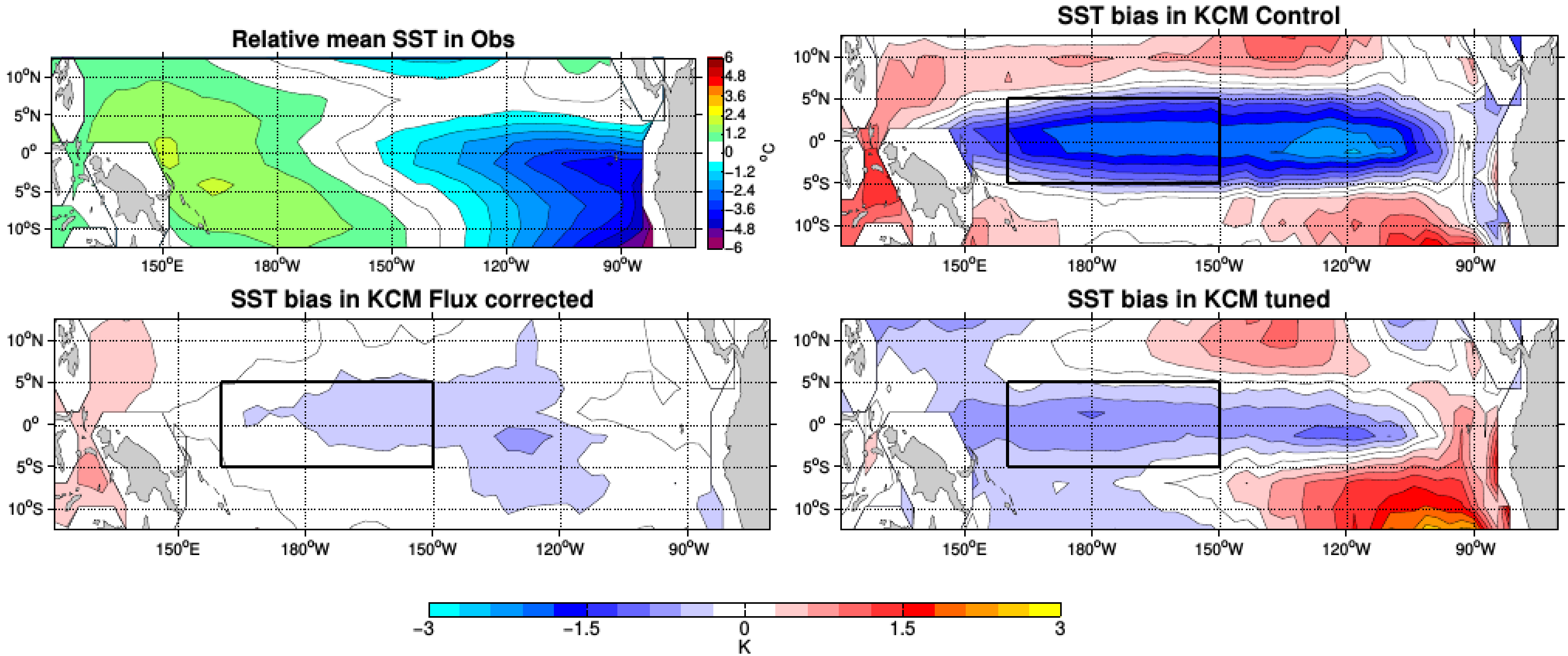






Some parameters have a stronger influence on mean temperature, others on the SST bias => SST bias is tunable!

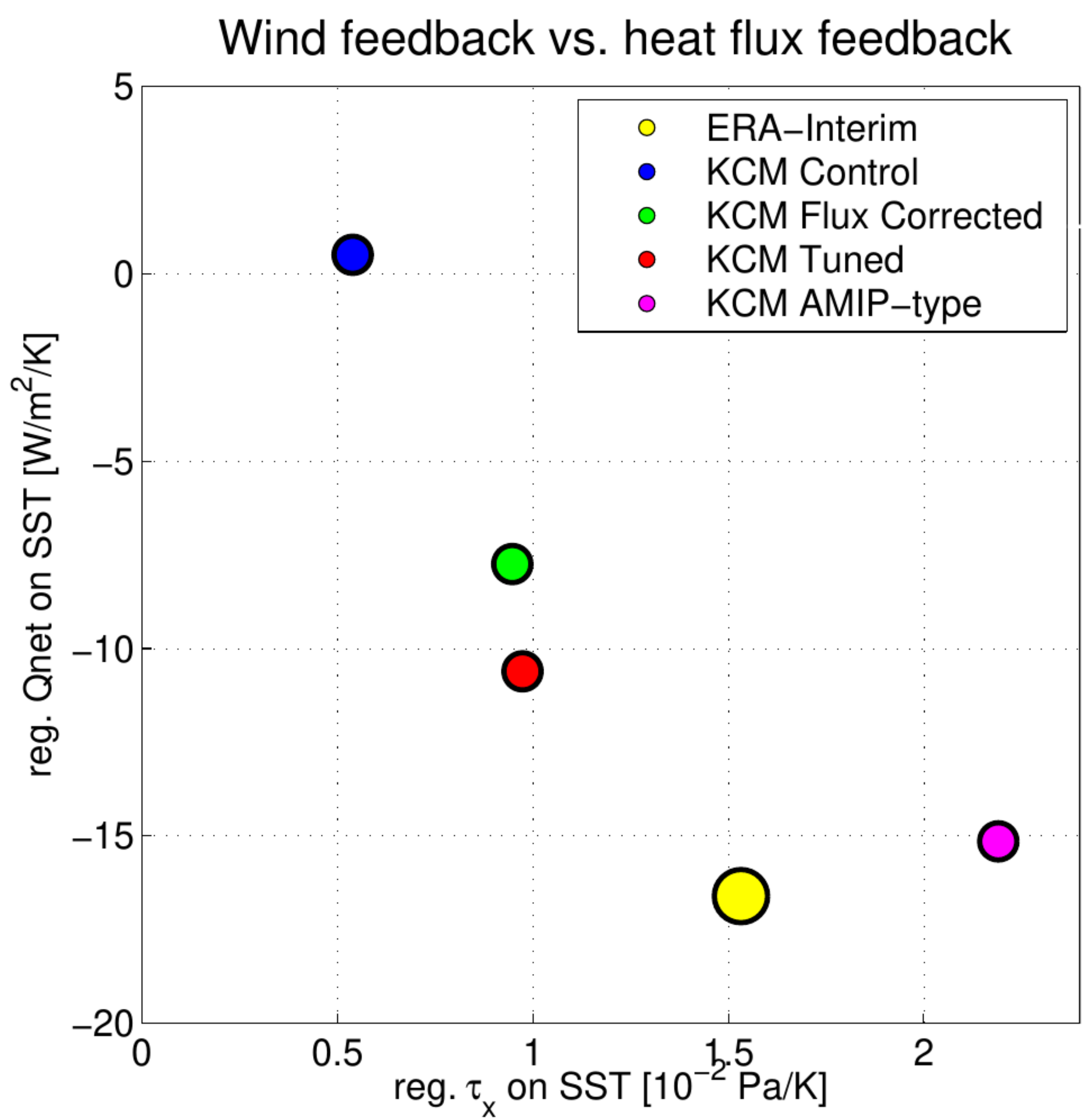
SST bias in KCM



It is possible to reduce the SST bias by flux correction or tuning!

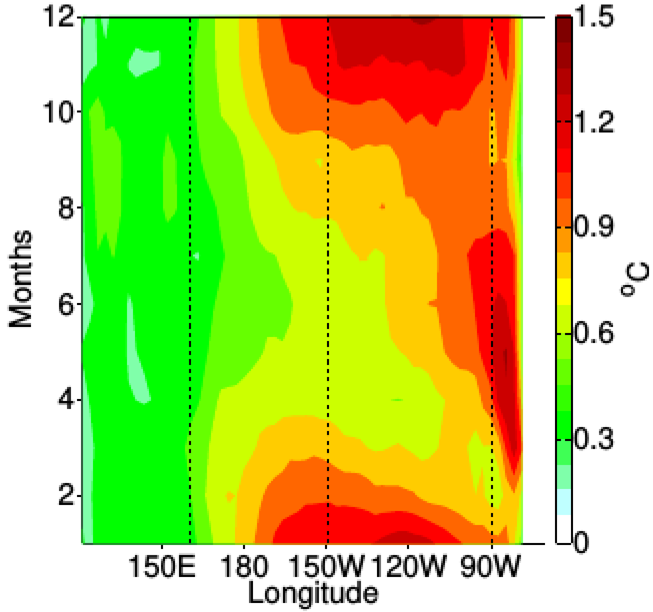
Which one is the better way to improve ENSO?

ENSO atmospheric feedbacks



Flux correction and tuning improve the atmospheric feedbacks! Tuning a bit more than flux correction!

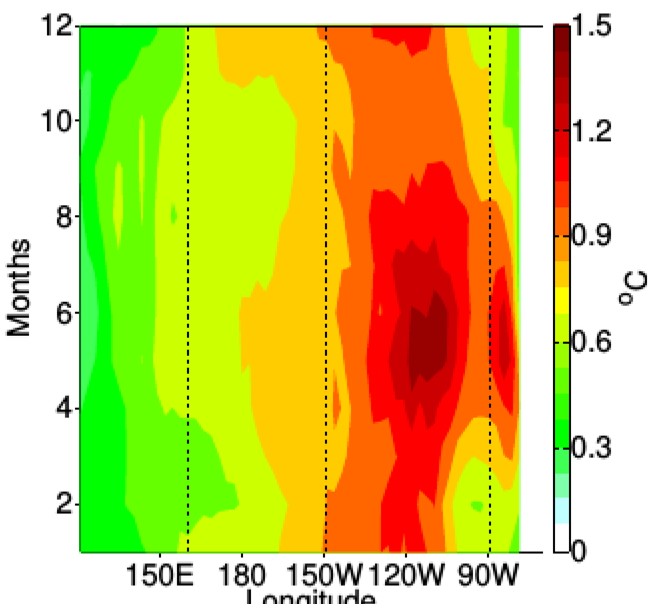
Observations



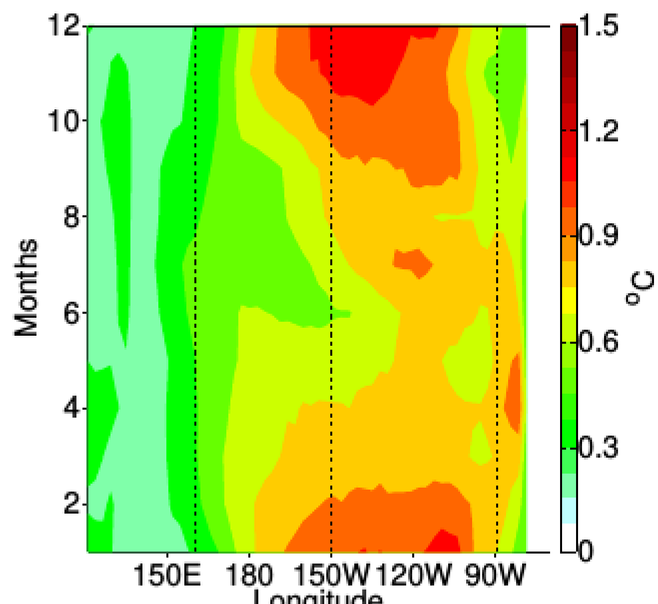
Phase locking

KCM Control has the strongest variability in boreal summer! Flux corrected and tuned KCM in boreal winter!

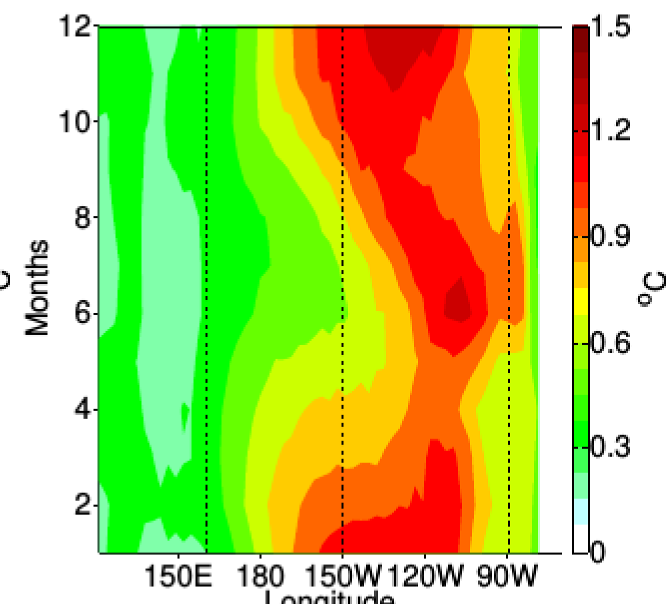
KCM Control



KCM flux corrected



KCM tuned



Important ENSO properties 1

	Mean SST	SST bias	Phase locking	Std Nino3.4	U10 feedback	Qnet feedback
HadISST	27.4	0.00	1.70	0.75	1.57	-18.36
KCM Control	27.7	-1.29	1.09	0.79	0.37	-0.06
KCM Flux corrected	26.9	-0.26	1.56	0.80	0.92	-8.66
KCM Tuned	27.2	-0.64	1.75	0.88	1.04	-12.18

Tuning improves the phase locking and atmospheric feedbacks

a bit more than flux correction!

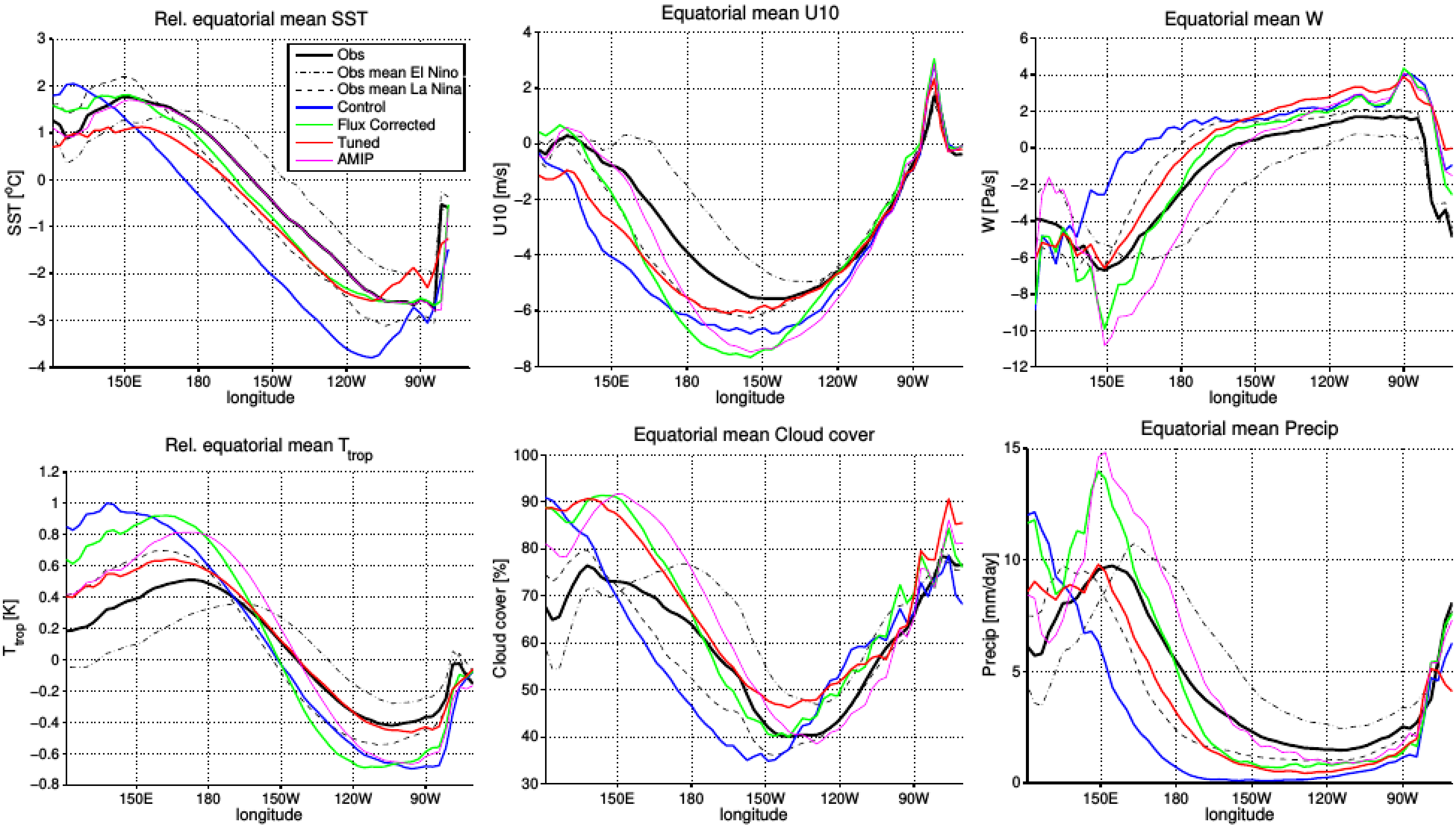
Important ENSO properties 2

	Nonlin-earity	Frq 1-3 yrs	Frq 3-8 yrs	frq ratio	skew Nino3	skew Nino4	diff skew N3-N4
HadISST	0.36	29.63	31.15	1.05	0.71	-0.39	1.10
KCM Control	0.04	53.53	47.46	0.89	-0.12	-0.19	0.07
KCM Flux corrected	0.11	68.46	18.60	0.27	-0.32	-0.62	0.29
KCM Tuned	0.15	52.31	48.75	0.93	0.23	-0.37	0.59

Flux correction reduces the 3-8 yrs variability in Nino3.4

and enhances negative skewness in Nino3.

Equatorial Mean State



In the flux corrected model the atmospheric mean state shows similar biases than the AMIP-type experiment.

Tuning makes the tropospheric temperature more realistic!

Summary

- It is possible to improve ENSO by tuning and flux correction (phase locking, atmospheric feedbacks, nonlinearity,...)
- The equatorial SST bias can be reduced by tuning, at least in KCM! => when you are tuning a climate model, you can tune ENSO simultaneously
- Flux correction also improves ENSO, as the SST bias is strongly reduced, but the atmospheric mean state biases remain!
- Cautionary note: It is hard to find out, if ENSO is getting better by tuning for the right reason!

Thanks for your attention!

Reference:

Bayr, T., M. Latif, D. Dommenget, C. Wengel, J. Harlaß, and W. Park, 2018: Mean-State Dependence of ENSO Atmospheric Feedbacks in Climate Models. *Clim. Dyn.*, doi:10.1007/s00382-017-3799-2.

ENSO and the equatorial SST bias