SPOOKIE: The Selected Process On/Off Klima Intercomparison Experiment

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Selected Process On/Off Klima Intercomparison Experiment (SPOOKIE)

Aims

- Establish relative contributions of different areas of model physics to:
  - Inter-model spread in cloud feedback
  - Common aspects of cloud feedbacks (e.g. tendency to be positive)

Approach

- Repeat CFMIP-2 AMIP/AMIP Uniform +4K experiments, switching off or simplifying different model schemes in turn

Pilot Experiments

- Start by switching off convective parametrization

Convection off (convoff) Experiments

What do we expect to see?

Hypotheses

- Zhang et al. (2013) argue that positive subtropical feedback is caused by enhanced entrainment of dry air into the boundary layer from the free troposphere in models with active shallow convection.

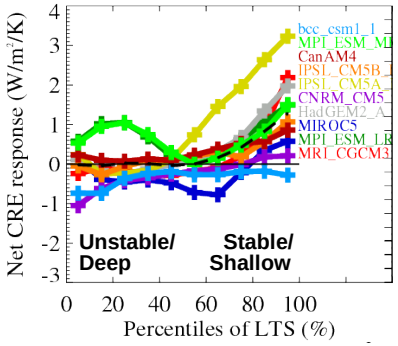
  - If this is the sole cause of positive subtropical feedback, then convoff feedbacks will be neutral or negative.

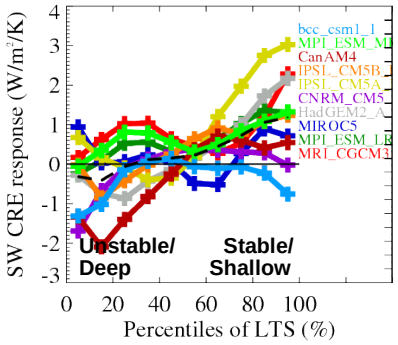
- Sherwood et al (2014) argue that positive shallow cloud feedback (and much of its spread) is related to the strength of lower tropospheric mixing by convective parametrizations and shallow large scale circulations.

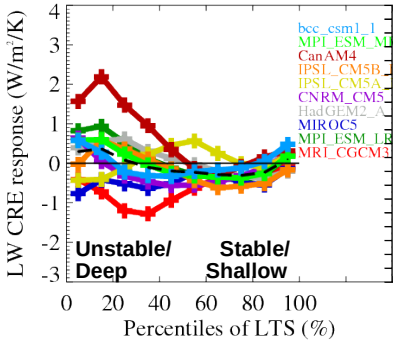
  - Hence some reduction in magnitude and spread would be expected in the absence of convective parametrization.

amip4K Cloud feedbacks over tropical oceans [30^{o}N/S]

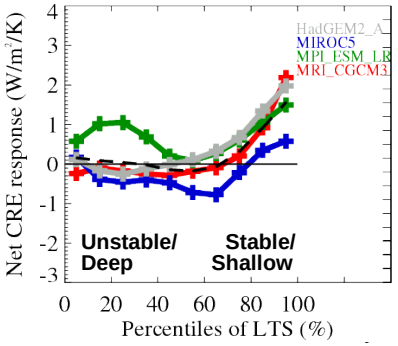
All Standard Models

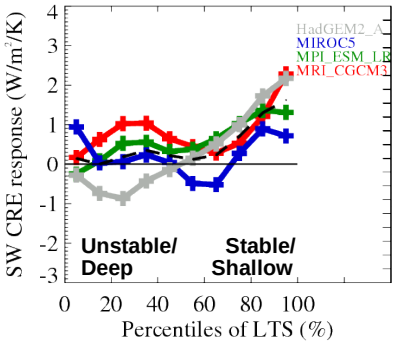


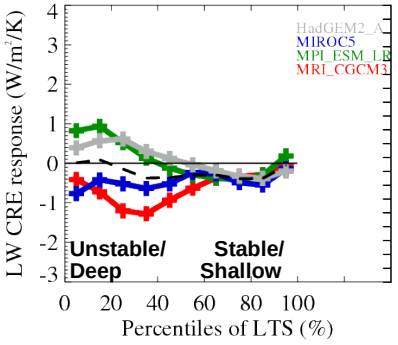




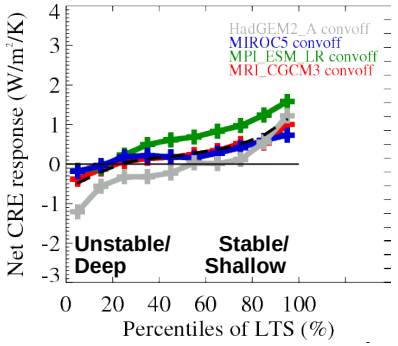
SPOOKIE Standard models

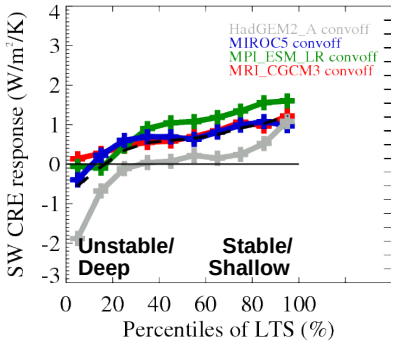


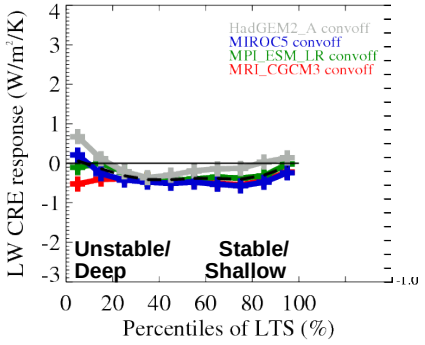




SPOOKIE ConvOff models







Net Cloud Feedback*

Shortwave Cloud Feedback*

Longwave Cloud Feedback*

***Includes cloud masking**

amip4K Cloud feedbacks over tropical oceans [30^{o}N/S]

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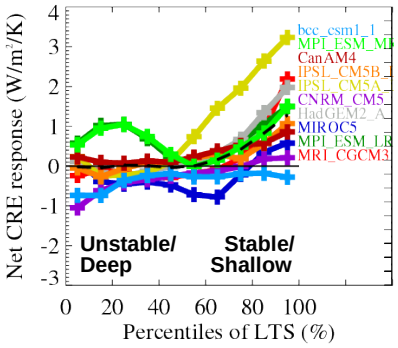

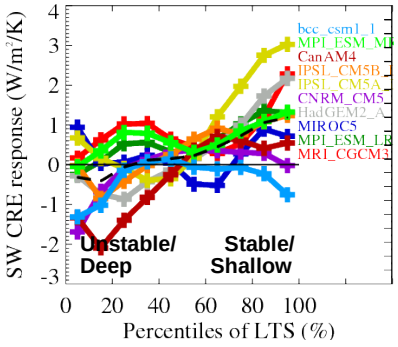

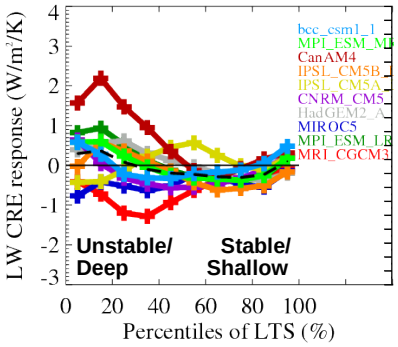

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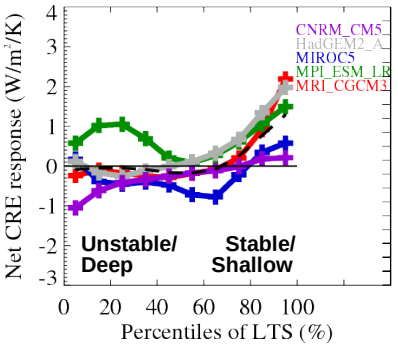
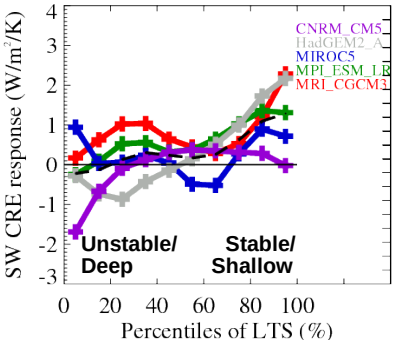
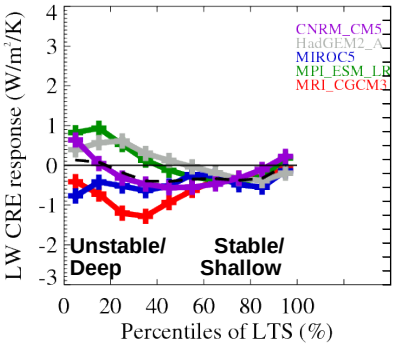
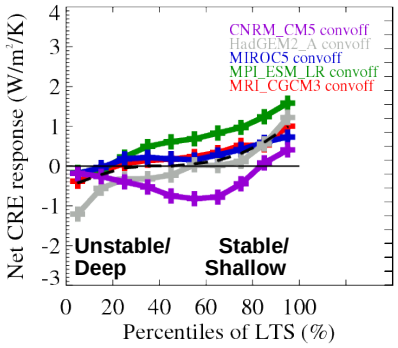
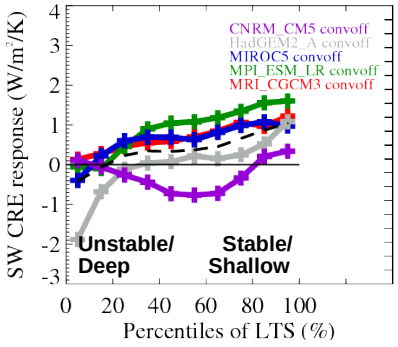


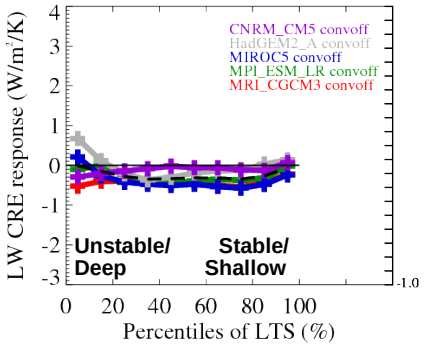




SPOOKIE ConvOff models







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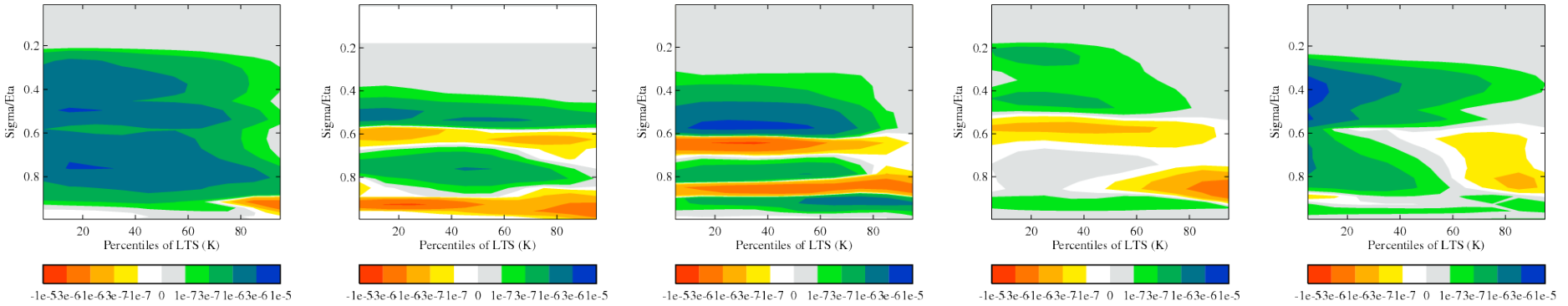
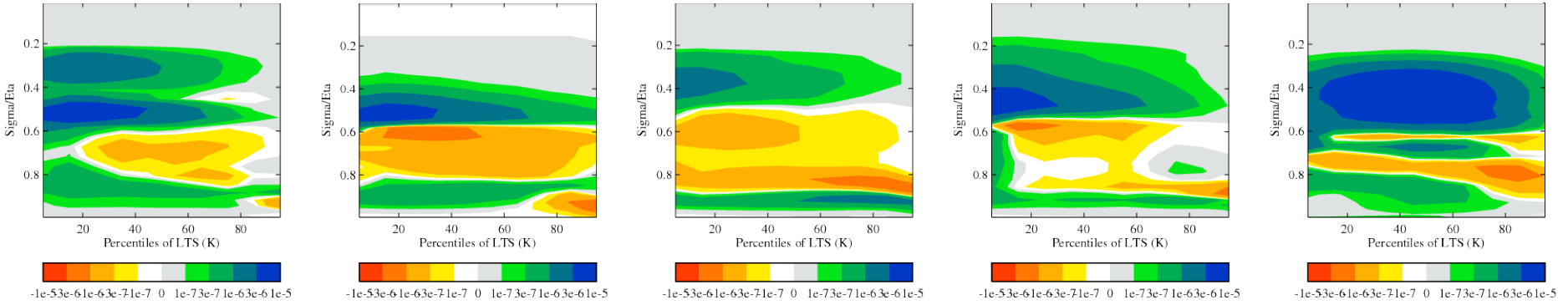
AMIP +4K Response of Cloud Liquid Water (g/g/K)

Standard models



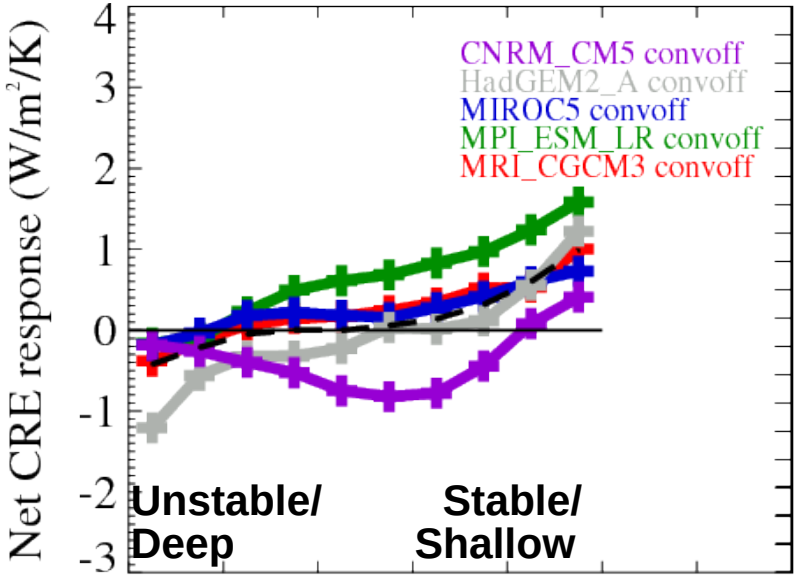
Conv Off models



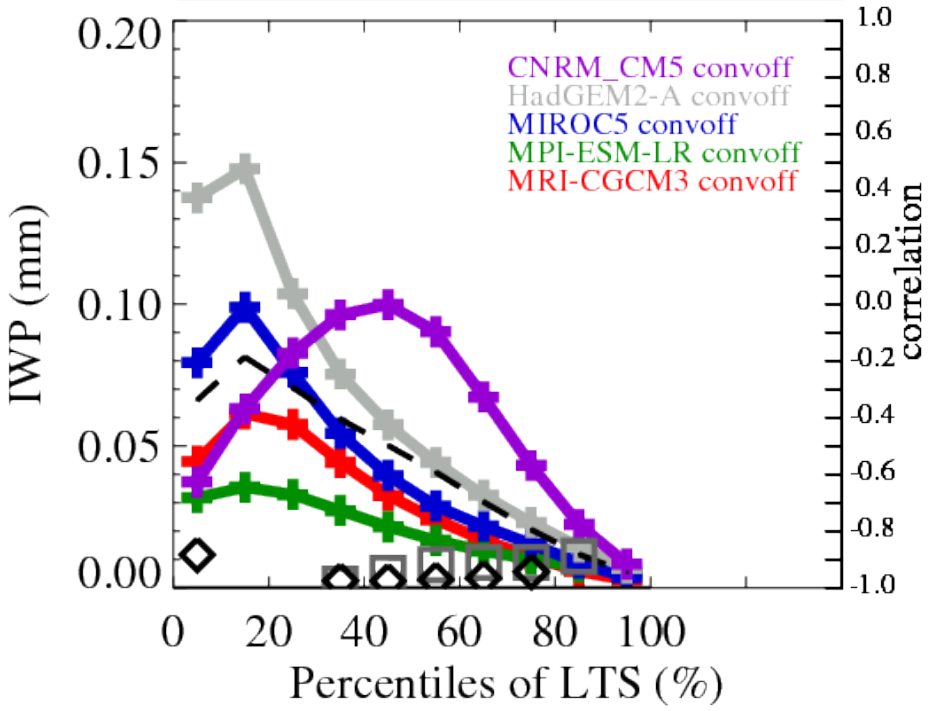
MRI-CGCM3 MPI-ESM-LR MIROC5 HadGEM2 CNRM-CM5

SPOOKIE ConvOff models

Net Cloud Feedback



AMIP Control Ice Water Path (mm)



Black diamonds indicate significant correlations with cloud feedbacks in same regime

Grey squares indicate a significant correlation with cloud feedback area average over tropical oceans

Ideas for SPOOKIE Phase II

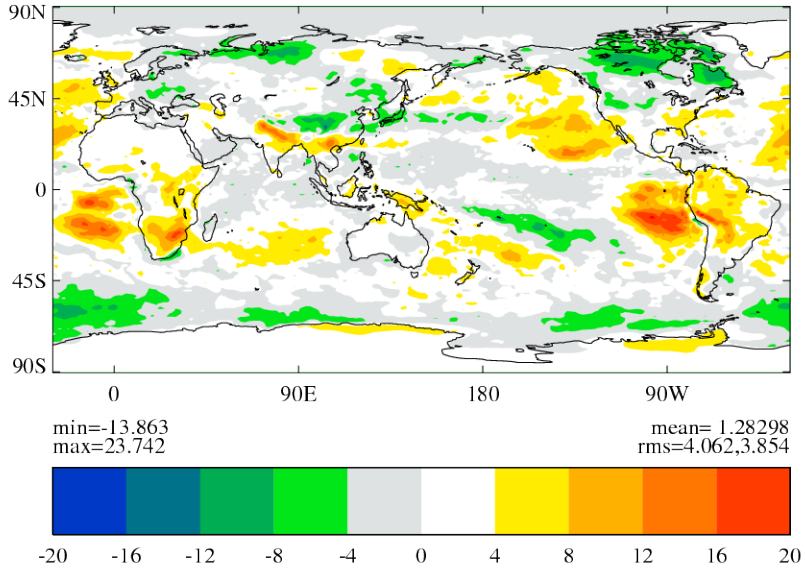
Are the impacts of convection on shallow cloud feedback local or remotely forced?

We can run experiments where we suppress convection in different regimes - e.g.

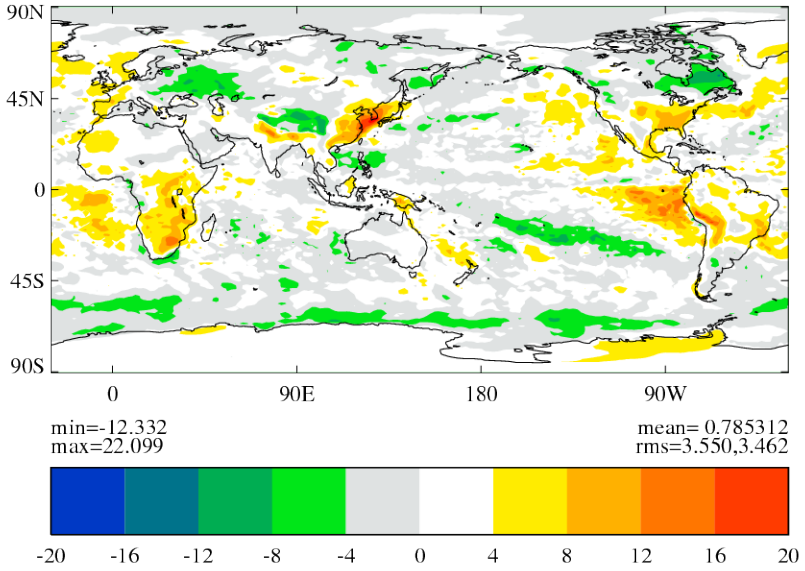
- Subtropical shallow cloud regimes with SSTs between 290-300K in amip and 294-304K in amip4K

Convection Off in the Subtropics

Standard HadGEM2-A



HadGEM2-A Convection Off [290-300K]



Amip 4K Response in Net CRE

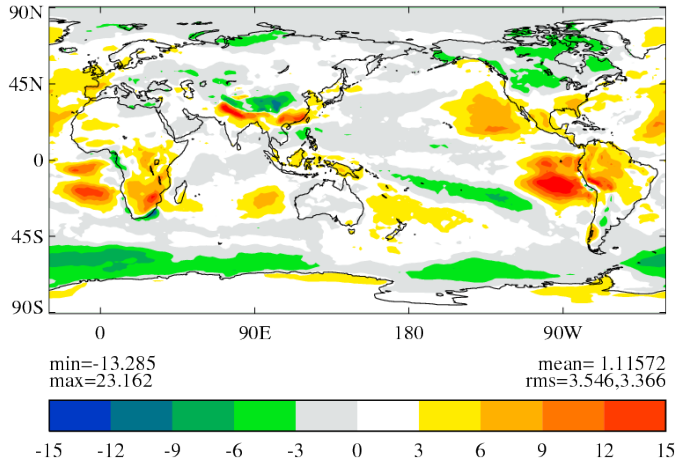
More Ideas for SPOOKIE Phase II

Understand reasons for convective parametrization differences

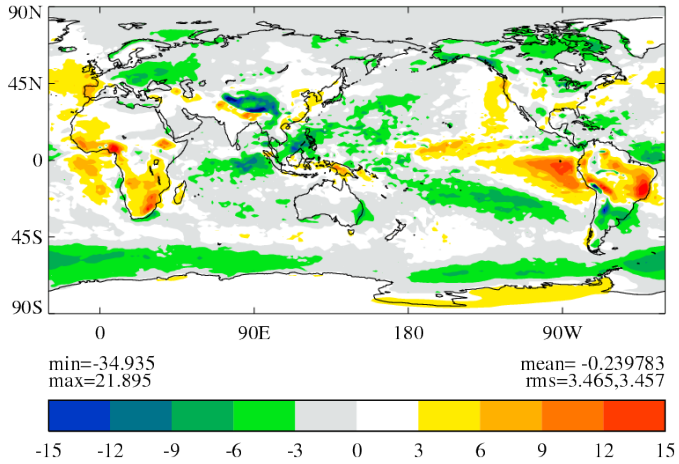
- How important is lateral entrainment? (e.g. Rougier et al. 2009).
  - Run with no convective entrainment/detrainment
- How important is convective precipitation efficiency? (Zhao 2014)
  - Rain out all convective cloud water (precip efficiency=1)
  - Can switch off convective precipitation (precip efficiency=0)

HadGEM2-A Convection Experiments
amip 4K CRE Response

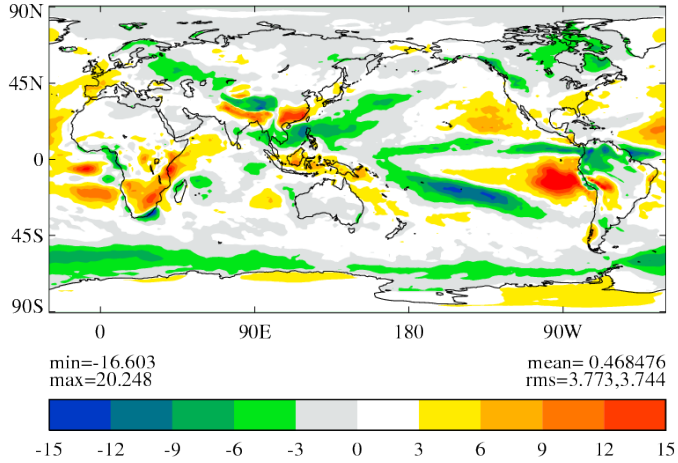
Standard Model



Convection Off



Weak Convective Precip Efficiency



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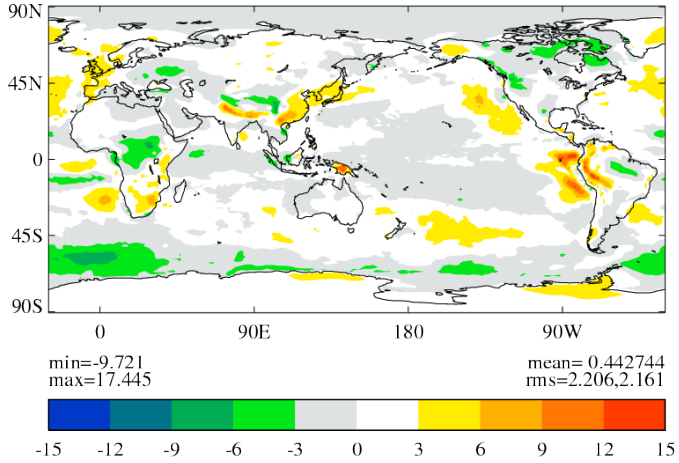

Summary and Conclusions

- Models are viable without parameterized convection at present resolutions
- Models are able to reproduce positive subtropical cloud feedback without parametrized convection
- Four models show convergence in deep and shallow tropical cloud feedbacks as well as other quantities without parametrized convection
- Convoff models with more ice in the control climate have less positive cloud feedbacks – mixed phase feedback?
- Future work could investigate the remote impacts of convection and different aspects of convective formulation such as entrainment and precip efficiency
- The CFMIP experiments provide an efficient platform for investigating cloud feedback mechanisms using sensitivity experiments