A Unified Convection Parameterization in CAM using CLUBB and SILHS Sampled Subcolumns

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UWM

NCAR

CAM 5

Deep Convection

Zhang and McFarlane (1995)

ZM Local Single Moment Microphysics

Shallow Convection

Park and Bretherton (2009)

PB Local Single Moment Microphysics

Macrophysics: Park

Microphysics:
Morrison and Gettelman (2008)

PBL: Bretherton and Park (2009)

CAM 5

4 Different Cloud and Convection Equation Sets

3 Different Microphysics Equation Sets

CAM-CLUBB-SILHS

Deep Convection
CLUBB-SILHS
Morrison and Gettelman (2008)

Shallow Convection
CLUBB-SILHS
Morrison and Gettelman (2008)

Macrophysics: CLUBB-SILHS

Microphysics:
Morrison and Gettelman (2008)

PBL: CLUBB-SILHS

CAM-CLUBB-SILHS

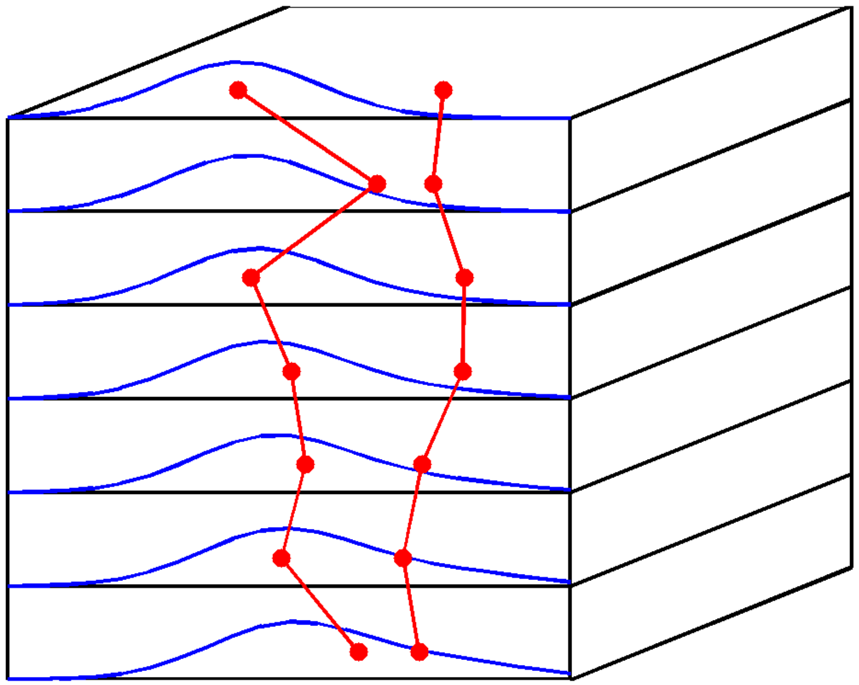
1 Cloud and Convection Equation Set

1 Microphysics Equation Set

How do we do this?
Using subcolumns as a generic interface between CLUBB's moist convection and MG1.0 microphysics

Subgrid Importance Latin-Hypercube Sampler (SILHS)

- Created at UWM and implemented in their local single-column model.
- Subcolumns are generated by sampling the PDF produced by the Cloud Layers Unified by Binormals (CLUBB) shallow cloud and macrophysics parameterization.



See http://clubb.larson-group.com
and Larson and Schanen, 2013 (Geoscientific Model Development)

The Benefits of Unified Convection and Unified Microphysics in CAM

- ☑ Consistent treatment of clouds around the planet
- ☑ Simplifies budgets and tuning to a single tendency and parameter set
- ☑ Ability to simulate aerosol effects in all cloud types
- ☑ Theoretically scale insensitive convection makes increasing resolution easier
- ☑ More physically realistic

CAM-CLUBB (5.5 Candidate)

Deep Conv:
Zhang and McFarlane (1995)
Local Single Moment Microphysics

Shallow Conv:
CLUBB
Microphysics:
Morrison and Gettelman (2008)

Macrophysics:
CLUBB
Microphysics:
Morrison and Gettelman (2008)

PBL: CLUBB

CAM-CLUBB (5.5 Candidate)

Deep Conv:
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Local Single Moment Microphysics

Shallow Conv:
CLUBB
Microphysics:
Morrison and Gettelman (2008)

Thursday, February 19

1:15p Vince Larson *CLUBB: How It Works*
1:30p Peter Bogenschutz *Update of CAM-CLUBB Simulations*

Global Simulations

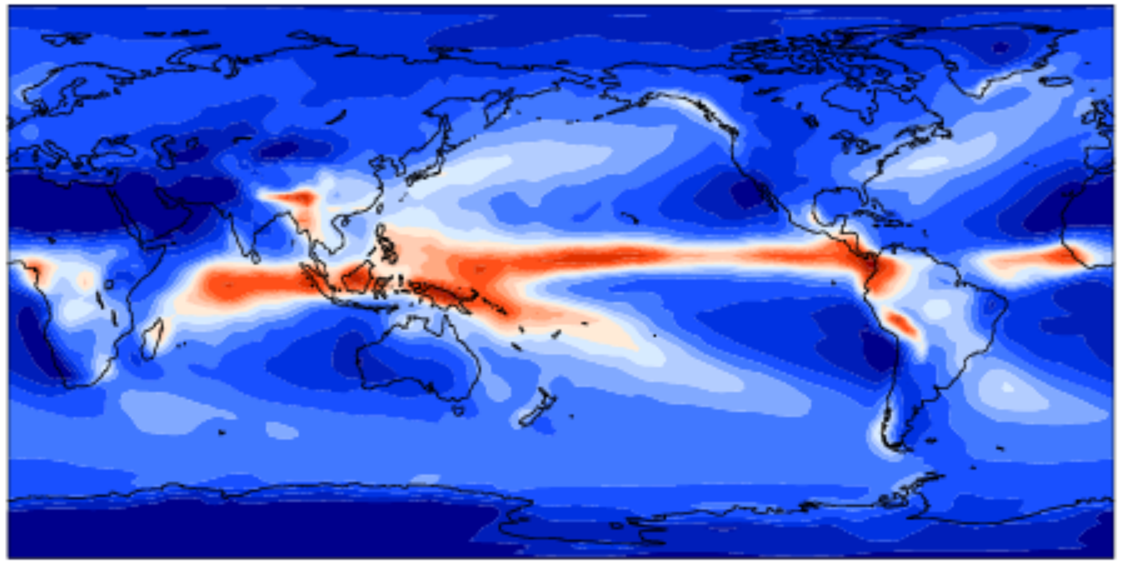
- Using a development version of CAM 5.3
- Finite Volume dycore at **2-degrees** and **1-degree**, 30 minute time step between SILHS sampling, 30 vertical levels, and 10 subcolumns.
- CLUBB is the only convection parameterization, and MG 1.0 is the only microphysics parameterization.
- ZM deep convection turned off.
- **10** and **6** years of simulation with fixed SSTs.

Total Precipitation

CLUBB-SILHS 2°

SILHS_NoZM_cnm_issio7_PO130 (yrs 1-10)

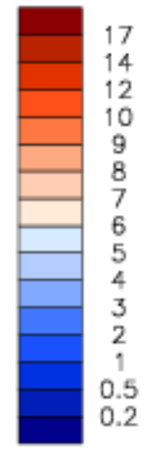
Precipitation rate mean= 2.77 mm/day



RMSE=1.20

ANN

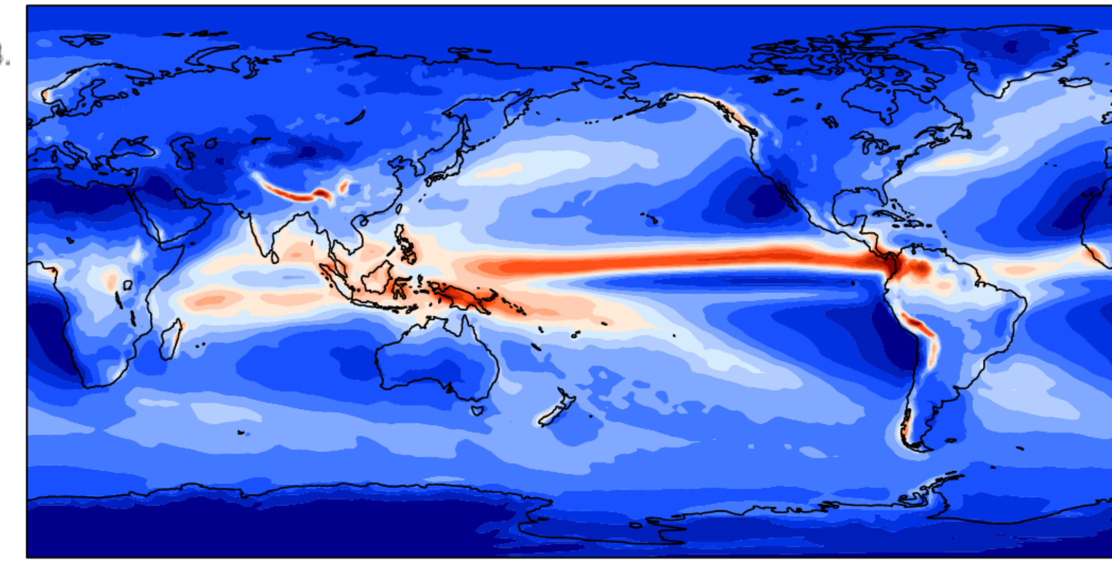
Min = 0.00 Max = 18.



CAM 5.3 1°

f.e13.F2000C5.f09_f09.cam5.3.release.001 (yrs 2-6)

Precipitation rate mean= 3.01 mm/day

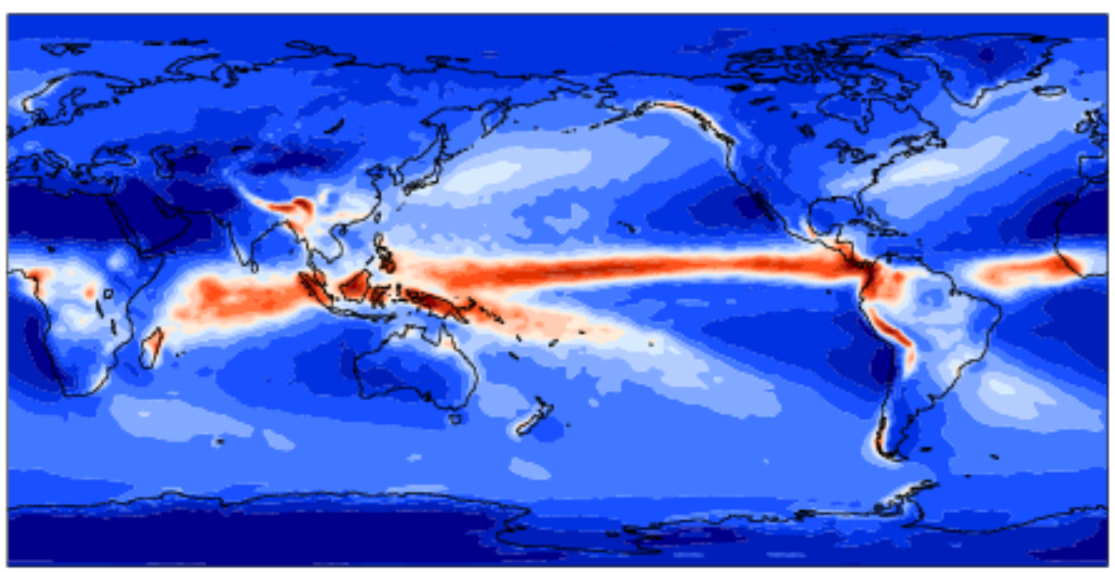


RMSE=1.14

CLUBB-SILHS 1°

SILHS_NoZM_cnm_issio7_dcs390_1deg_PO130_var (yrs 1-6)

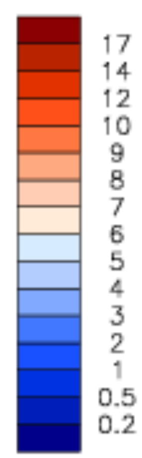
Precipitation rate mean= 2.78 mm/day



RMSE=1.33

ANN

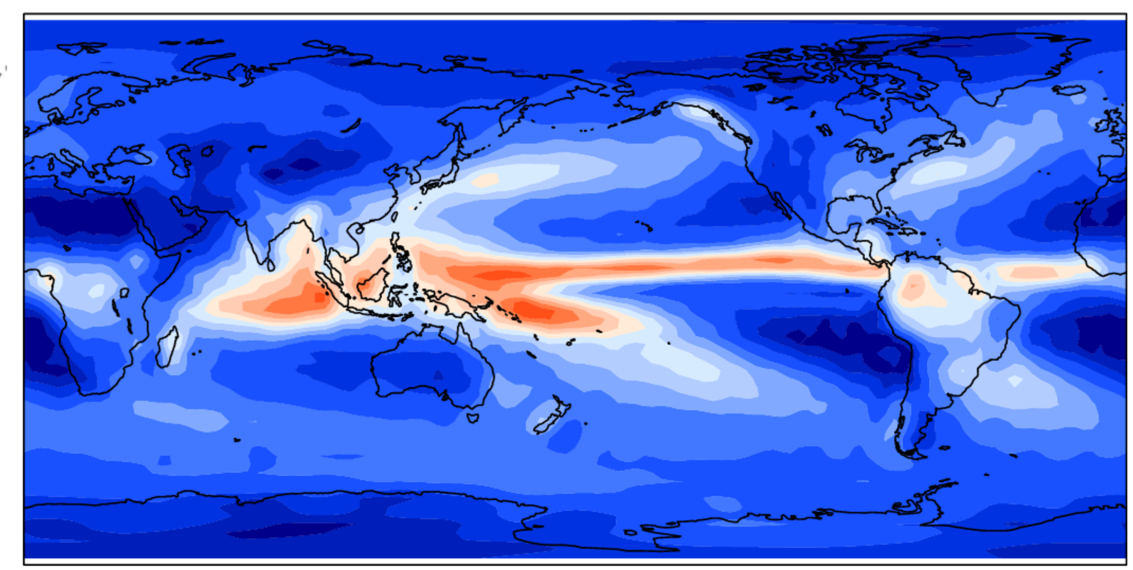
Min = 0.00 Max = 28.



OBS

CMAP 1979-1998

Precipitation rate mean= 2.69 mm/day

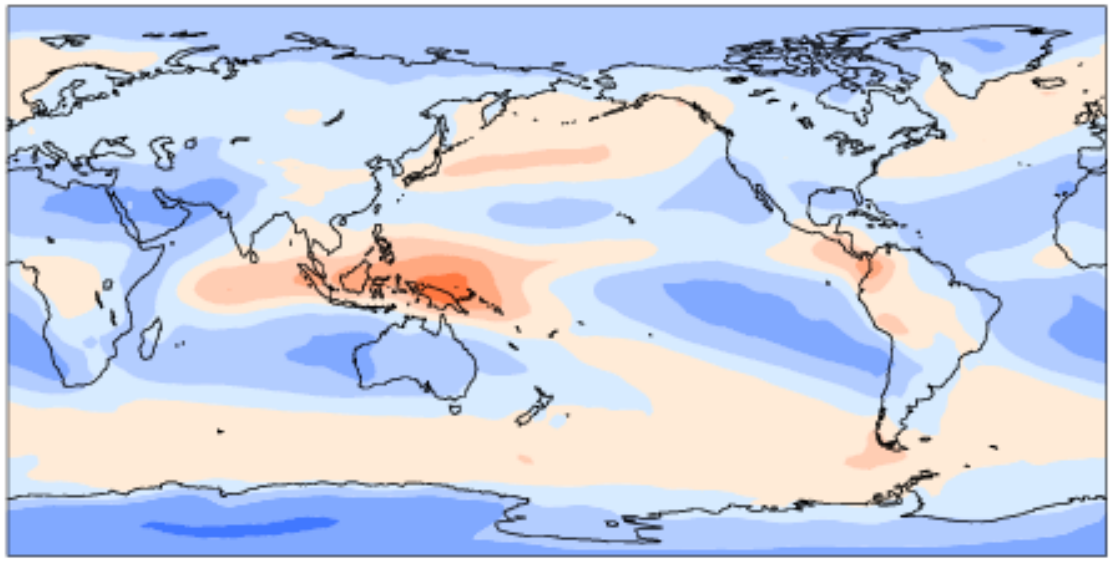


Long Wave Cloud Forcing

CLUBB-SILHS 2°

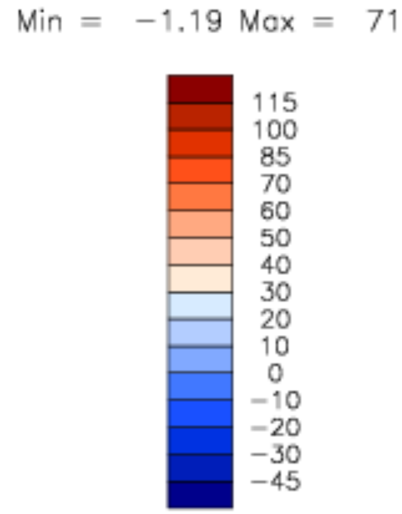
SILHS_NoZM_cnm_issio7_PO130 (yrs 1-10)

TOA LW cloud forcing mean= 25.41 W/m^2



RMSE=5.88

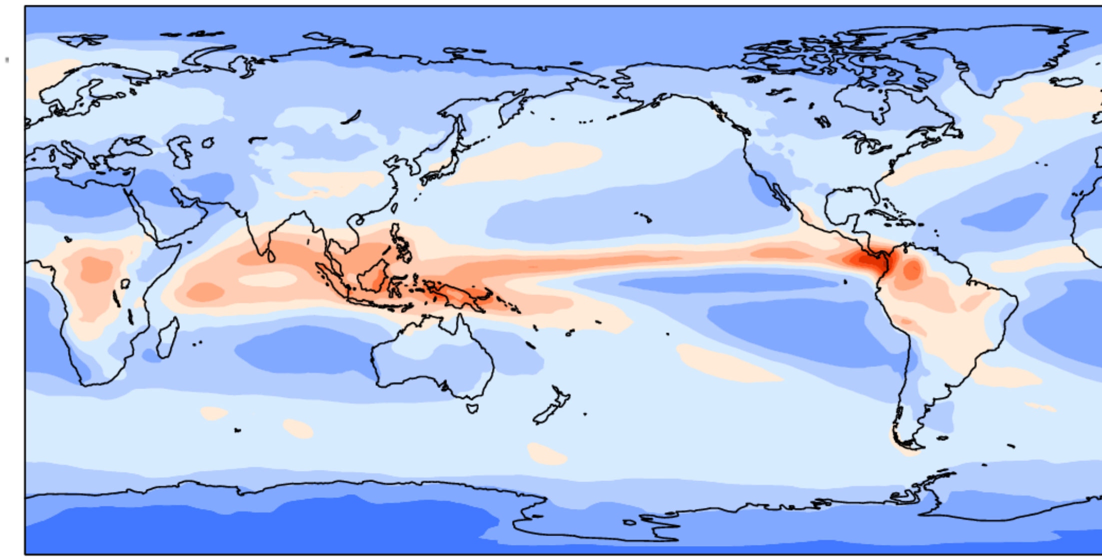
ANN



CAM 5.3 1°

f.e13.F2000C5.f09_f09.cam5.3.release.001 (yrs 2-6)

TOA LW cloud forcing mean= 22.48 W/m^2

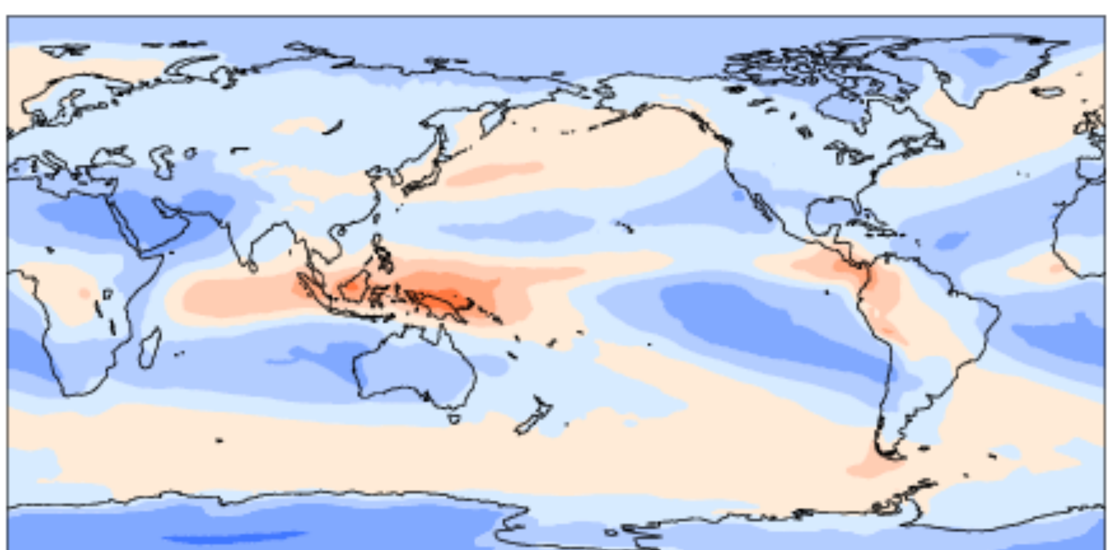


RMSE=6.63

CLUBB-SILHS 1°

SILHS_NoZM_cnm_issio7_dcs390_1deg_PO130_var (yrs 1-6)

TOA LW cloud forcing mean= 25.18 W/m^2



RMSE=6.00

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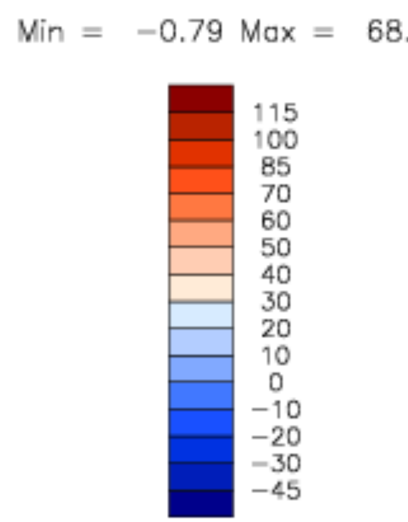
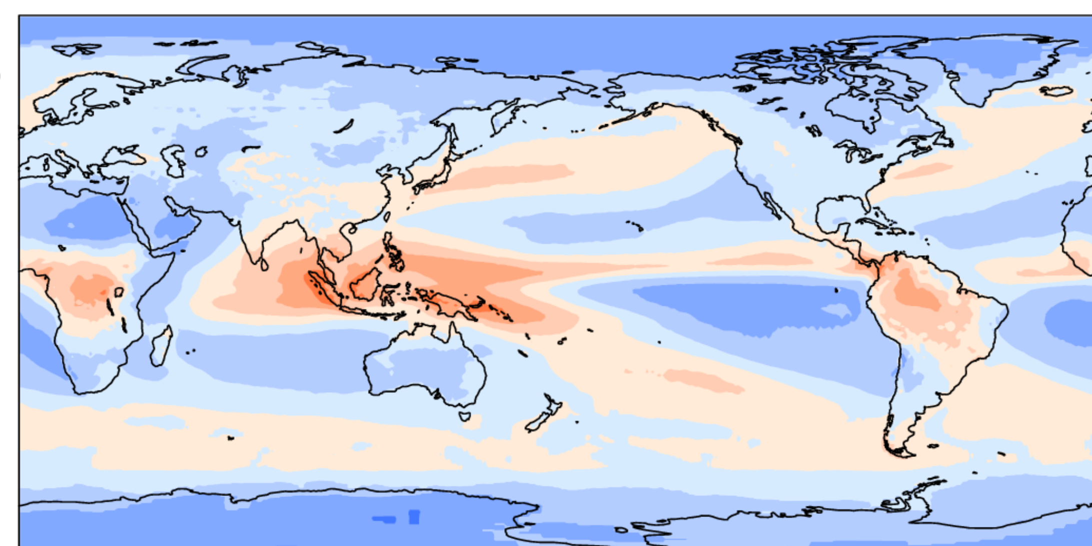


OBS

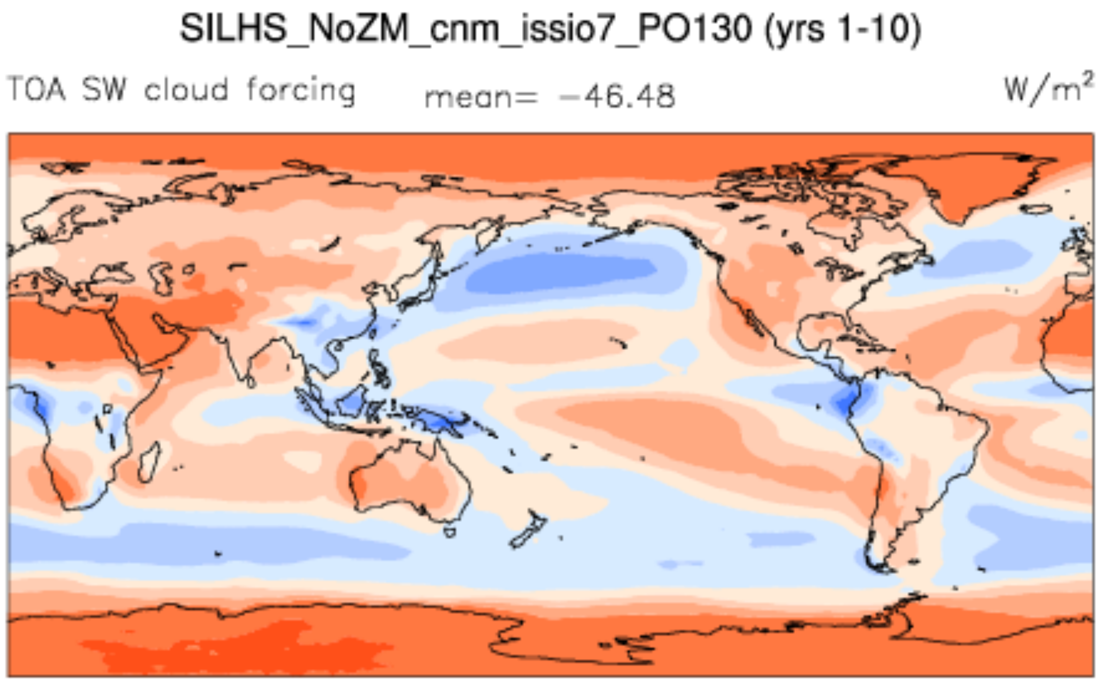
CERES-EBAF

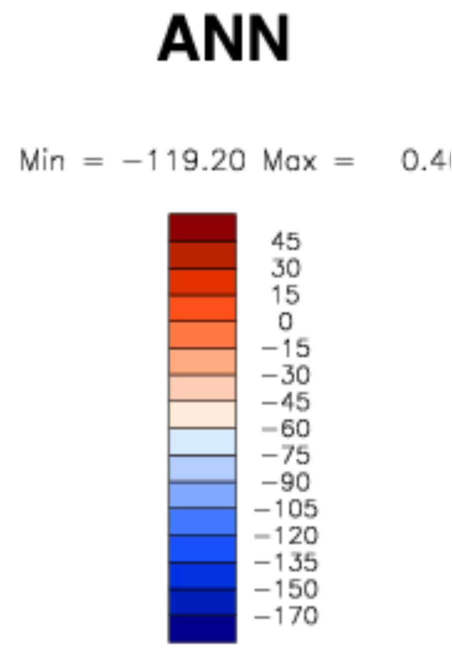
TOA LW cloud forcing mean= 26.06 W/m^2



Short Wave Cloud Forcing

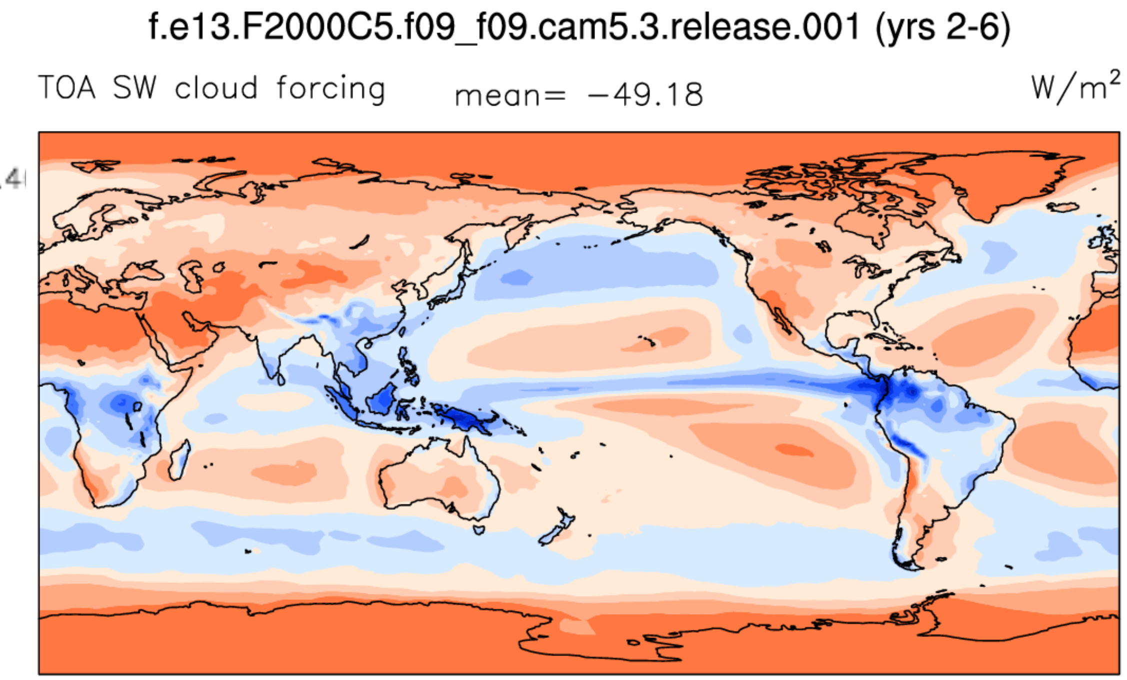
CLUBB-SILHS 2°





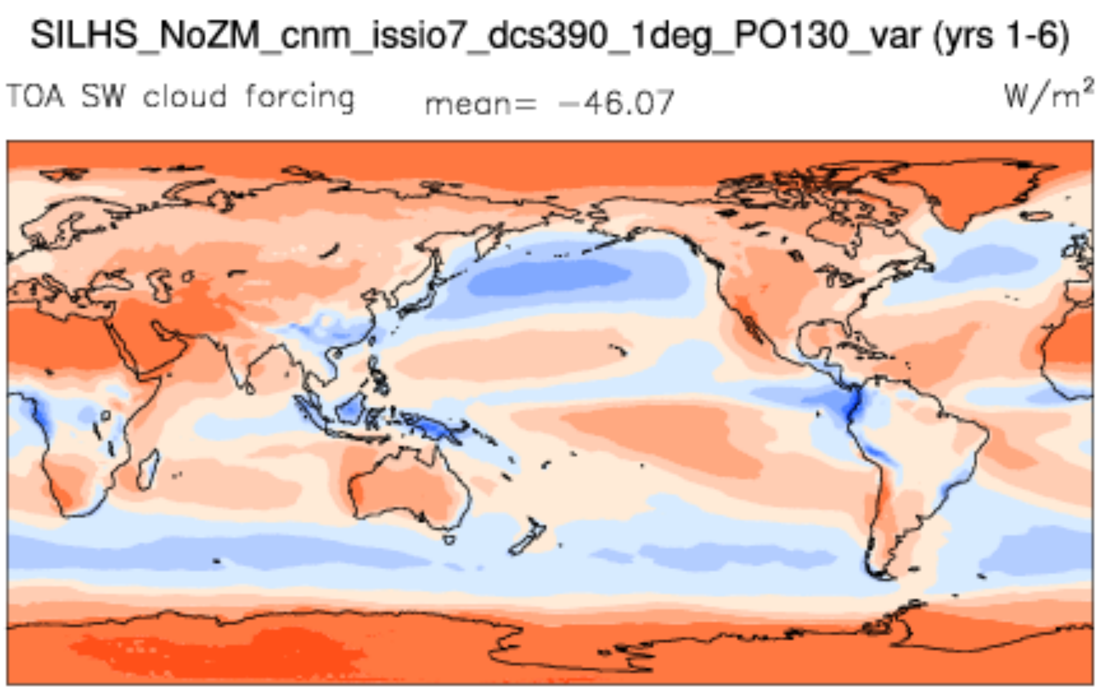
RMSE=9.95

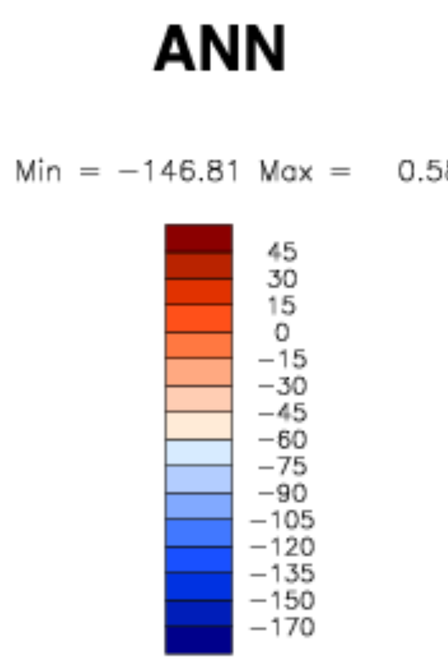
CAM 5.3 1°



RMSE=13.62

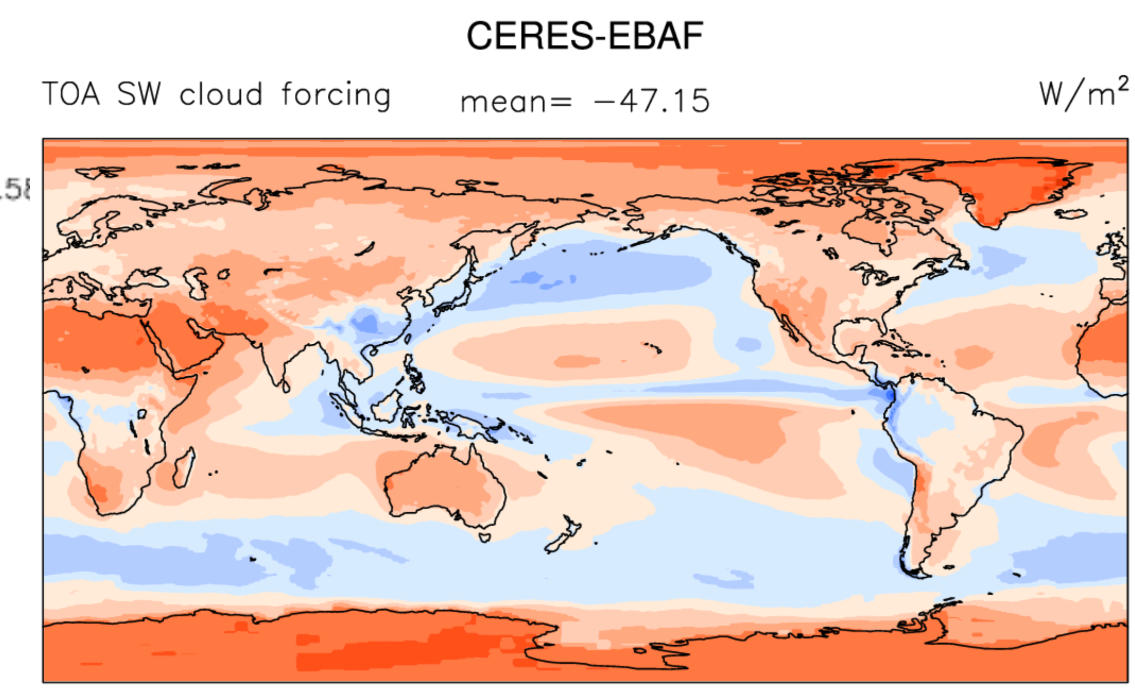
CLUBB-SILHS 1°





RMSE=9.15

OBS

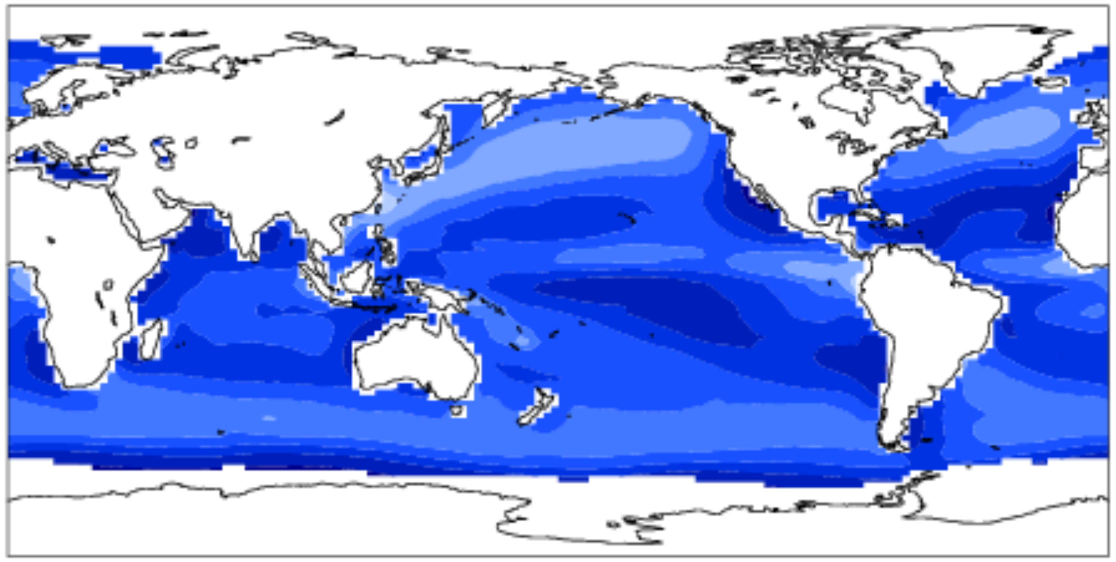


Liquid Water Path

CLUBB-SILHS 2°

SILHS_NoZM_cnm_issio7_PO130 (yrs 1-10)

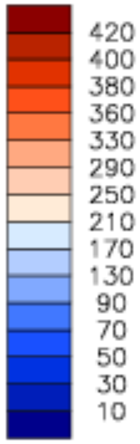
Total grd−box cloud LWP mean= 56.44 g/m²



RMSE=28.01

ANN

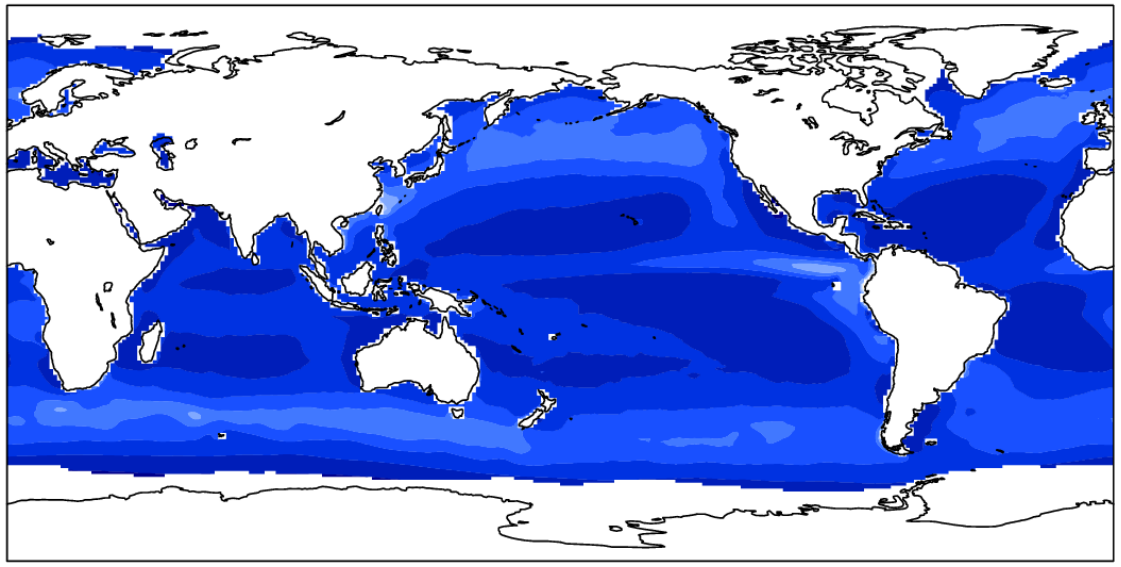
Min = 0.87 Max = 167.



CAM 5.3 1°

f.e13.F2000C5.f09_f09.cam5.3.release.001 (yrs 2-6)

Total grd−box cloud LWP mean= 41.25 g/m²

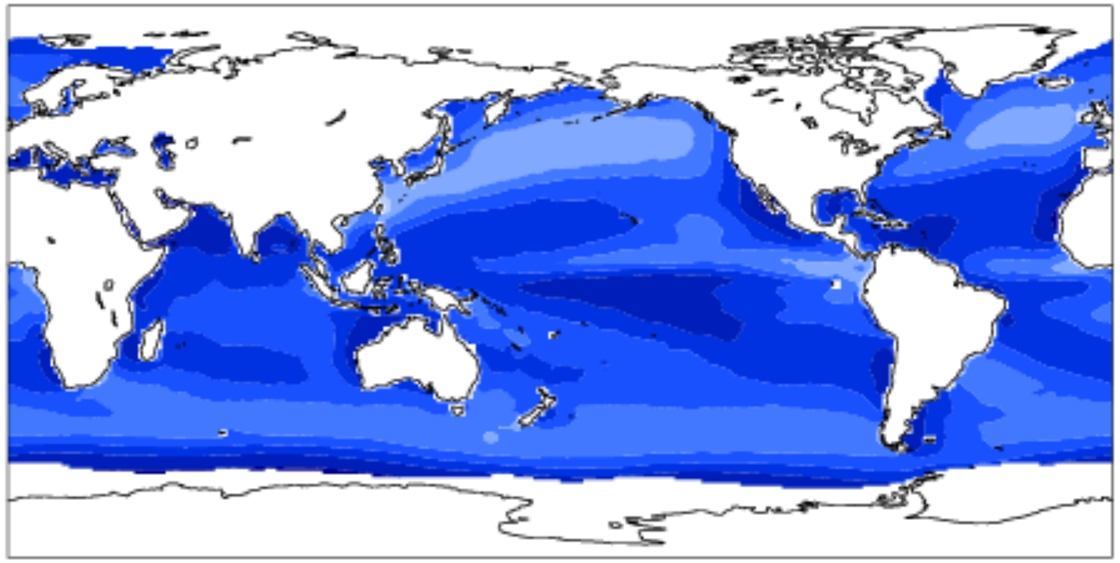


RMSE=41.44

CLUBB-SILHS 1°

SILHS_NoZM_cnm_issio7_dcs390_1deg_PO130_var (yrs 1-6)

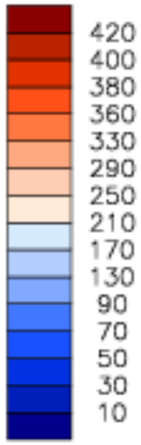
Total grd−box cloud LWP mean= 55.64 g/m²



RMSE=27.47

ANN

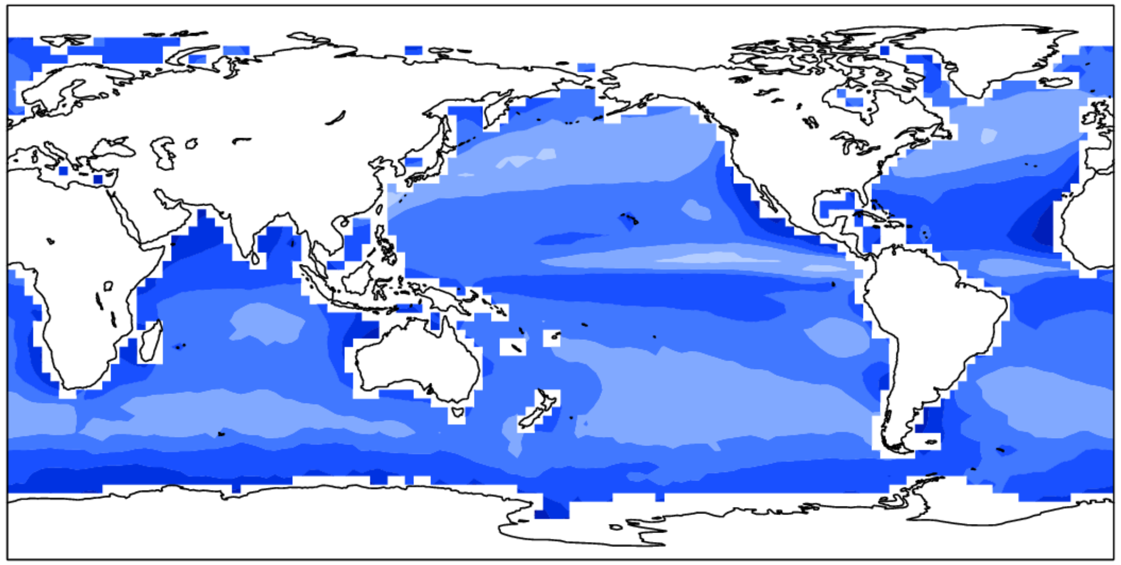
Min = 0.42 Max = 207.



OBS

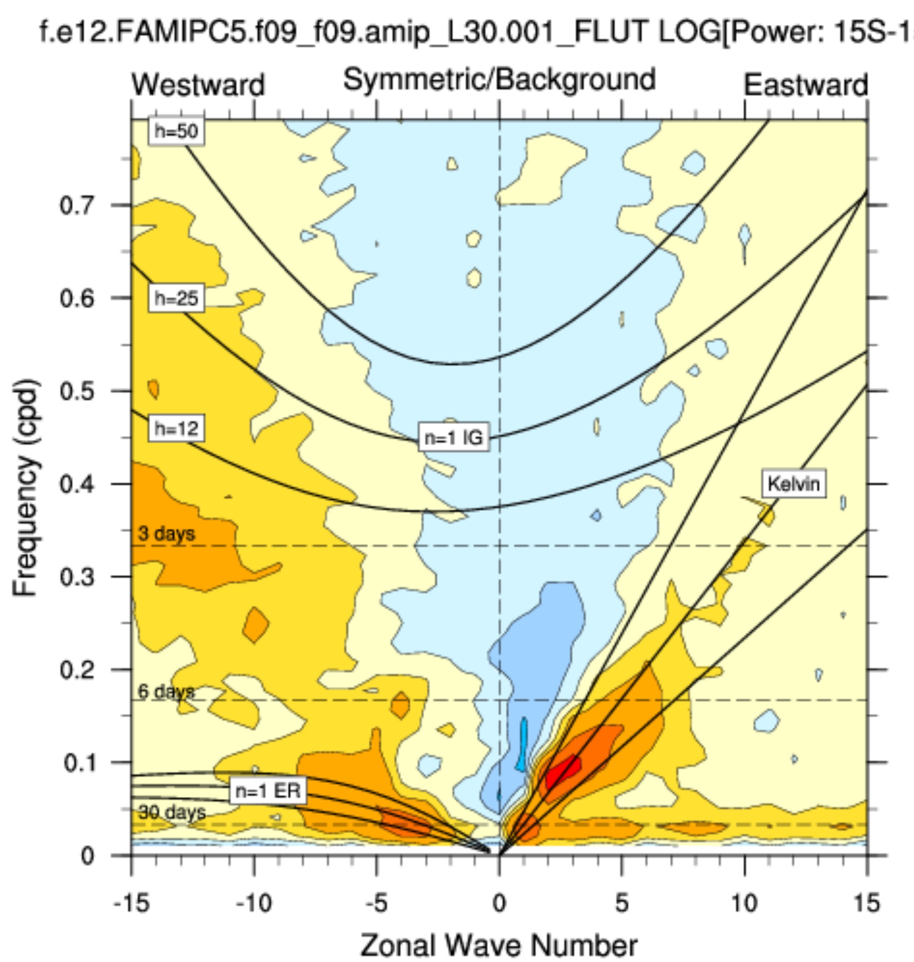
NVAP

Total grd−box cloud LWP mean= 78.94 g/m²

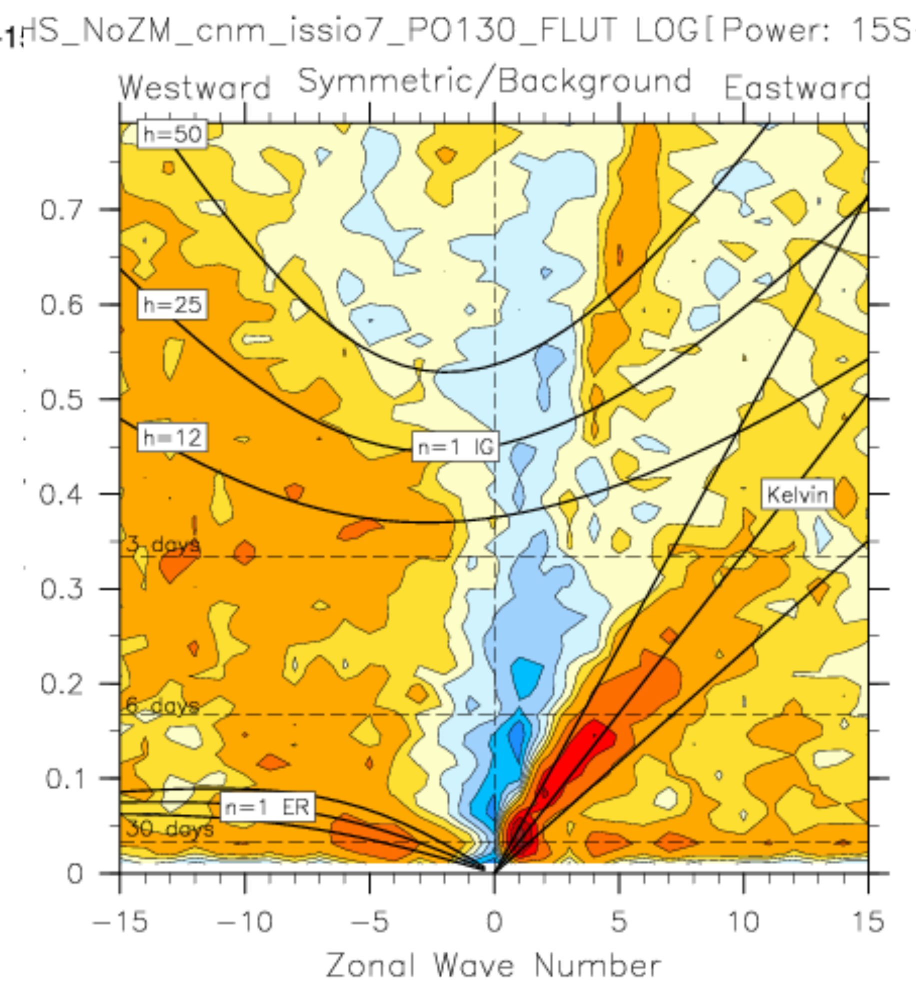


Tropical Wave Variability

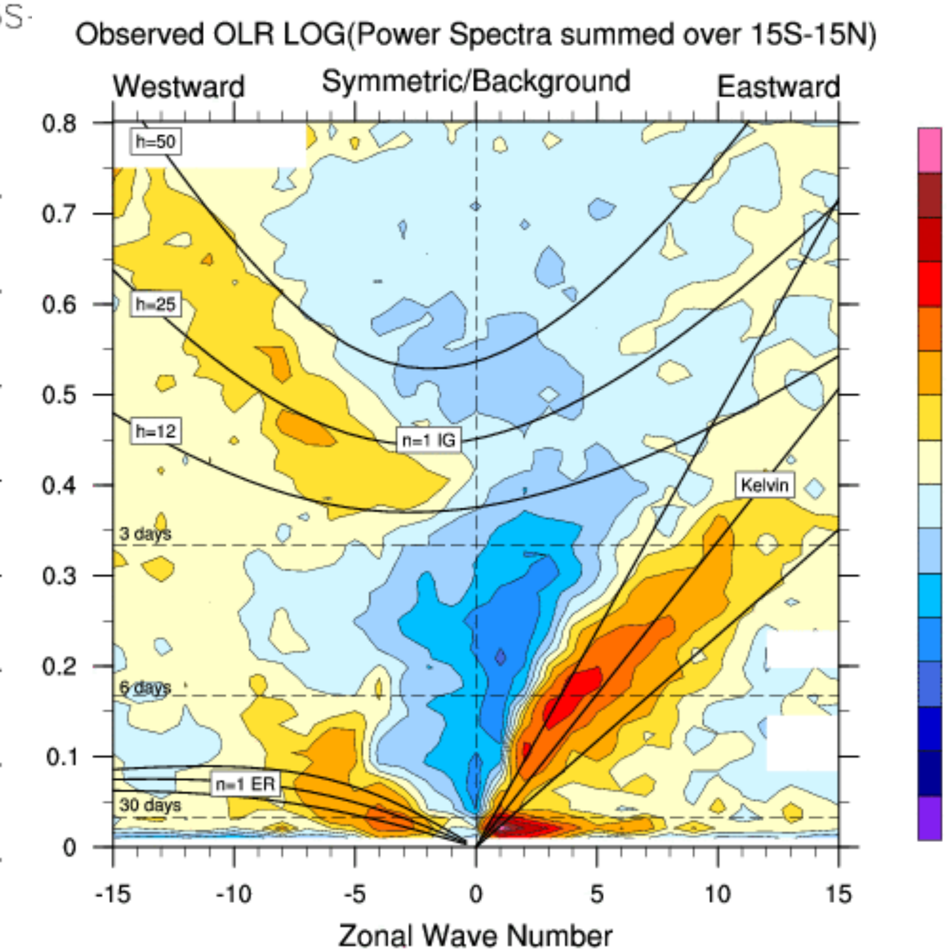
CAM5



SILHS No ZM

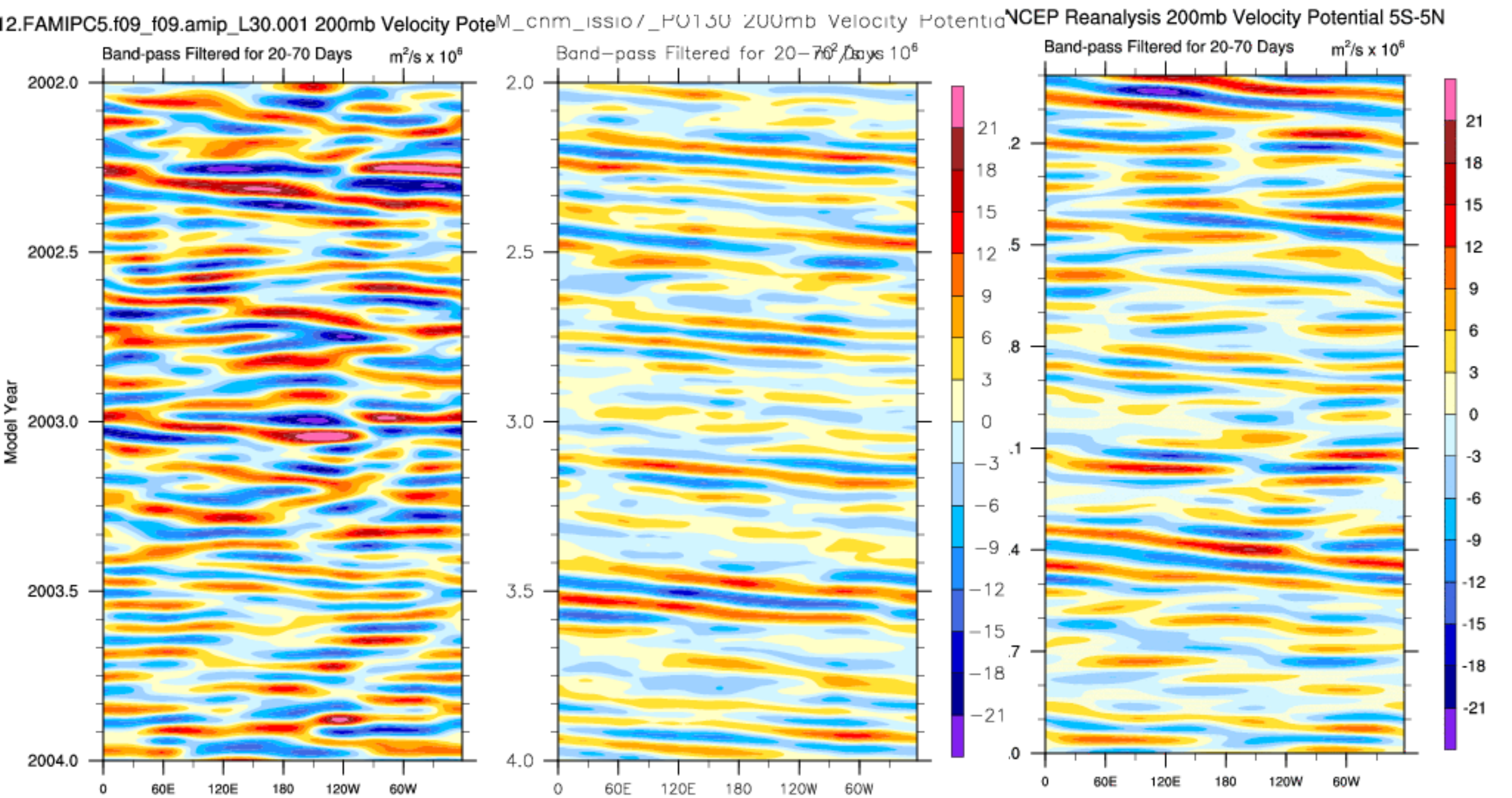


OBS



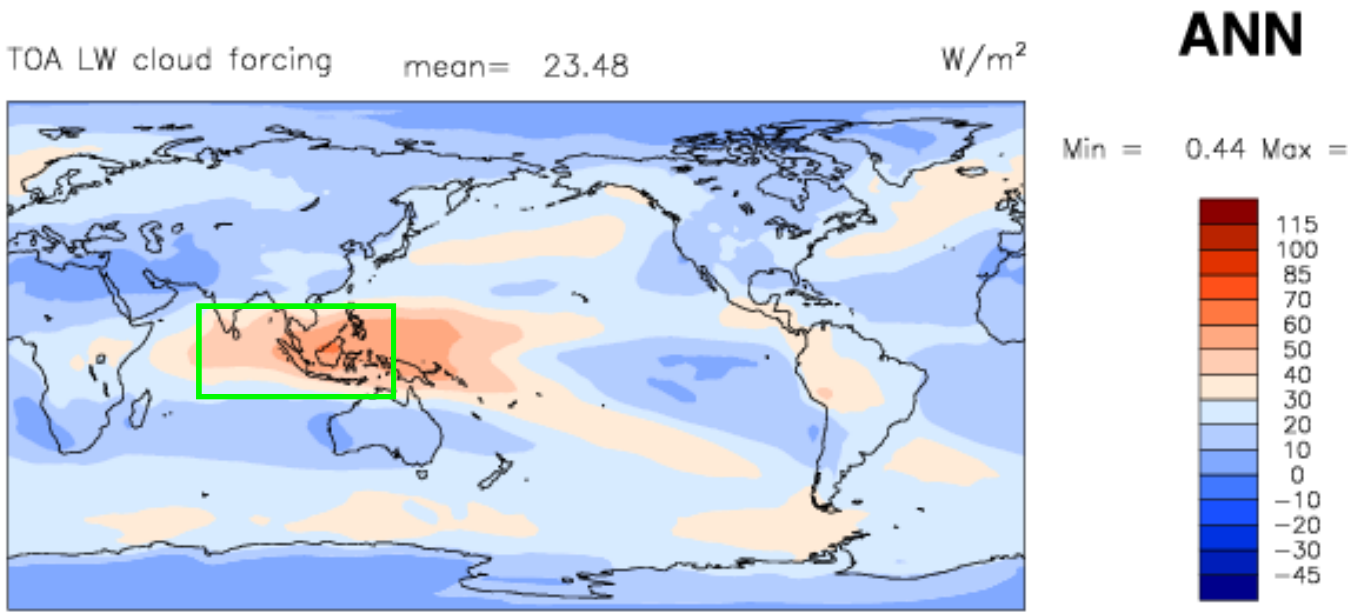
Tropical Wave Variability

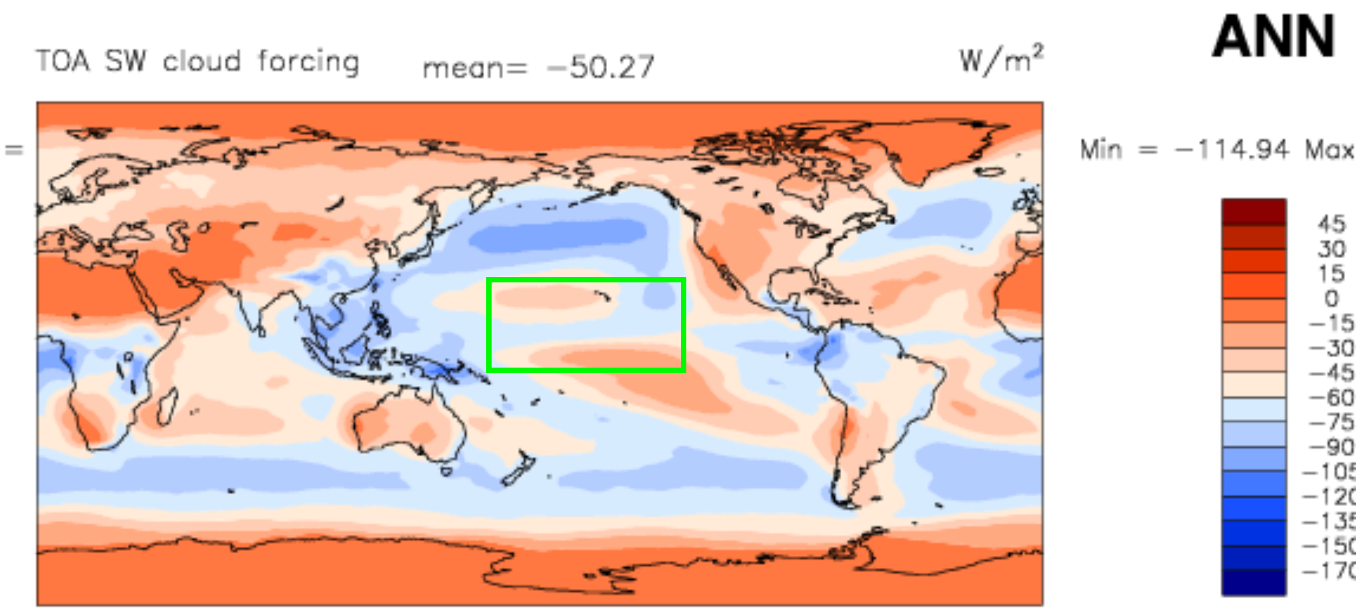
CAM 5.3 1° | SILHS 2° | OBS



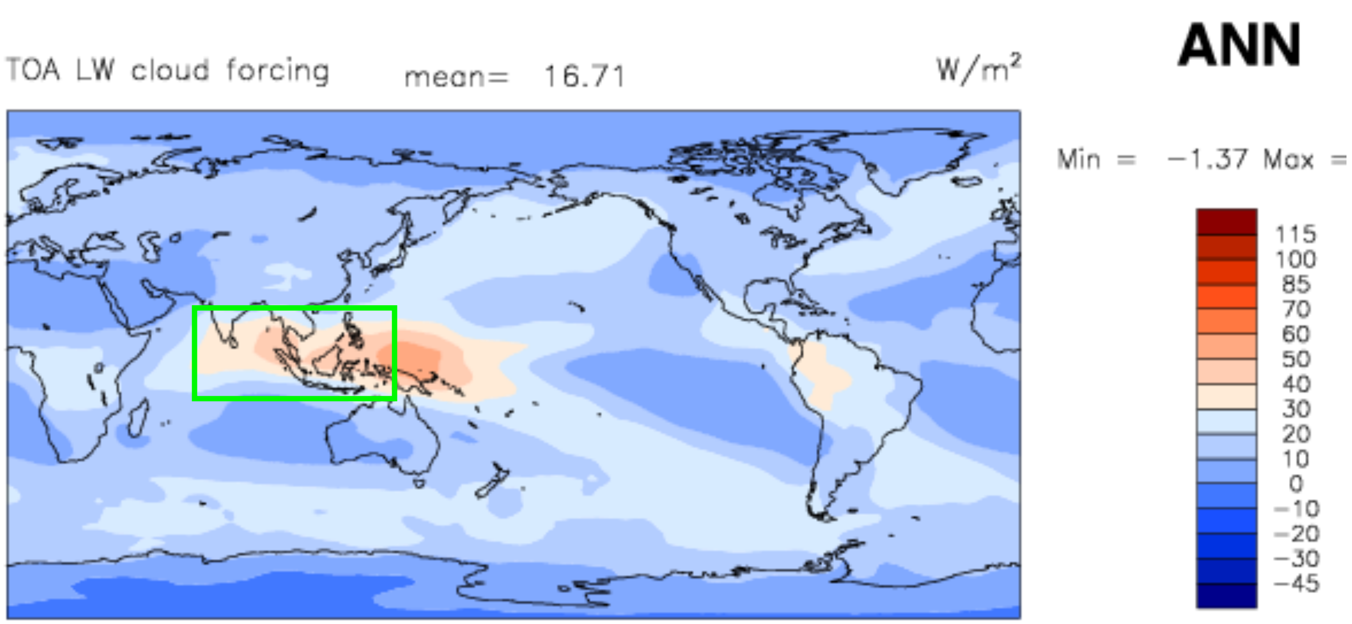
The Impact of Subcolumns

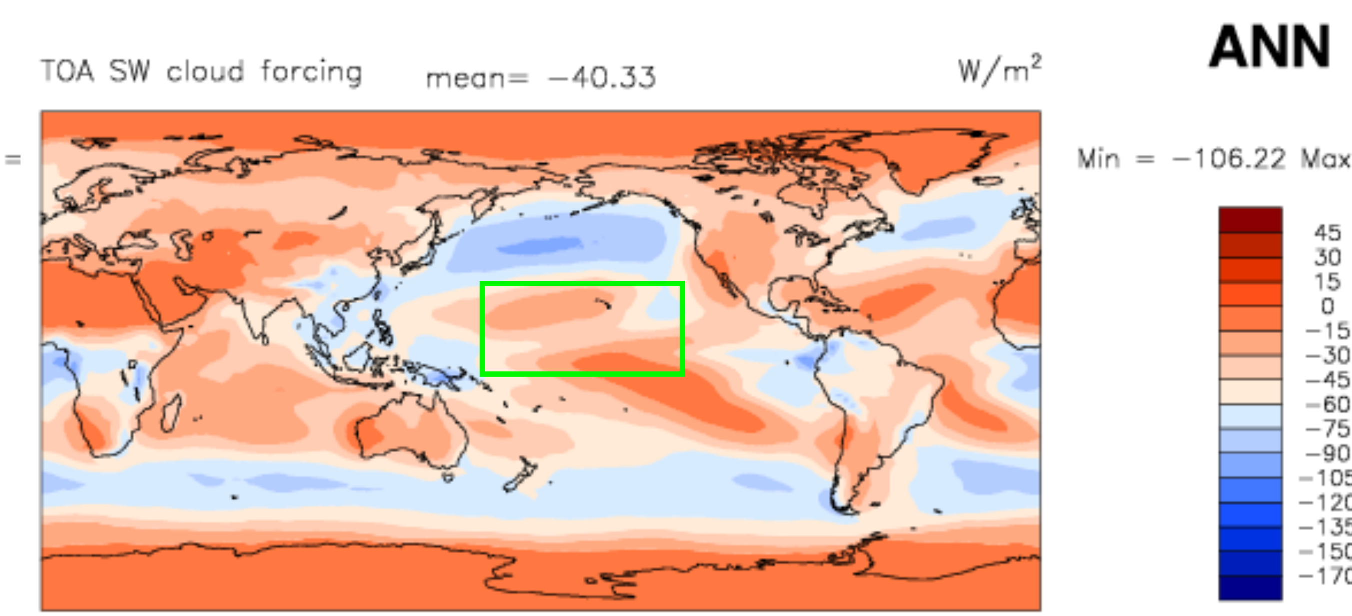
CAM-CLUBB-SILHS





CAM-CLUBB No SILHS No ZM





Summary

- We have build a version of the Community Atmosphere Model with a unified convection parameterization and a unified microphysics parameterization.
- Simplified and more realistic representation of clouds and sub-grid variability provided by the SILHS sampler and CAM subcolumns.
- Corrects CAM 5.3 biases in a double ITCZ.
- Better RMSE values for SWCF, LWCF and Liquid Water Path.
- Better tropical wave variability with an improved MJO and much improved Kelvin Wave dispersion.

Future Opportunities and Community Projects

- A single convection parameterization will allow for aerosol-cloud interaction studies across all cloud types.
- CLUBB's scale insensitivity will help CAM towards higher resolution.
- Architecture currently ready for MG 2.0 microphysics (with prognostic precipitation).
- Model needs to be tested in coupled mode.
- CAM-SILHS is being extended to study aerosol wet deposition at PNNL.
- Future possibilities for new science abound! Contact katec@ucar.edu or vlarson@uwm.edu with questions or ideas!