

Progress towards the atmospheric component of the next generation GFDL climate model

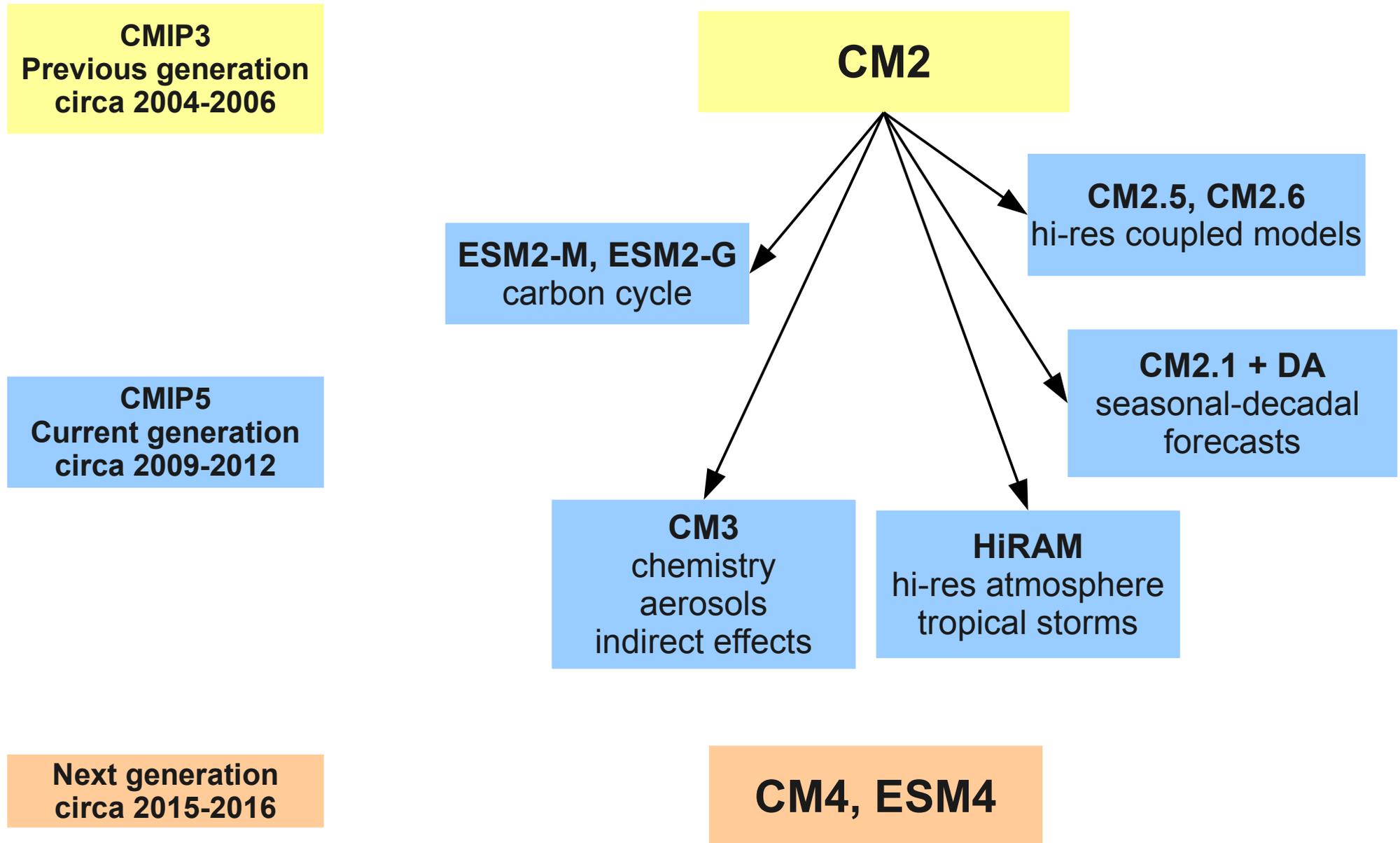
Chris Golaz, Ming Zhao, Huan Guo

and the entire
GFDL Model Development Team (MDT)

NOAA Geophysical Fluid Dynamics Laboratory
Princeton, NJ



Brief history of GFDL climate models



GFDL CM4 climate model

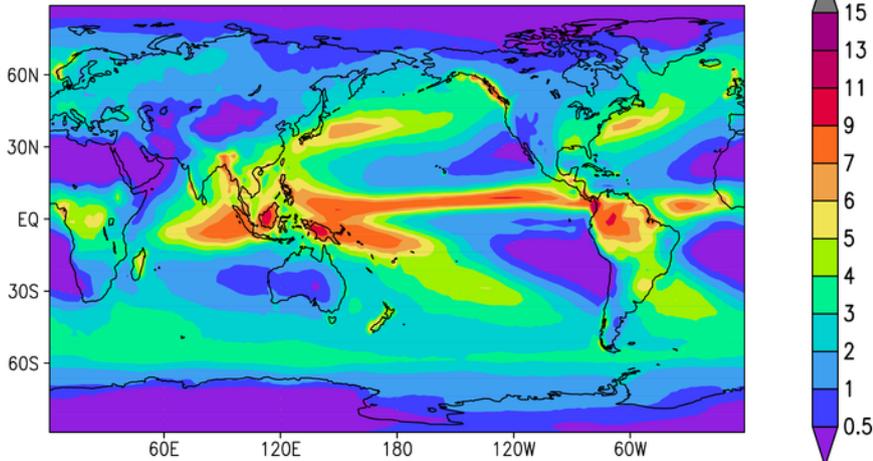
- **Next generation CM4**
 - AM4 atmosphere, **1/2 deg** resolution
 - plus 1 deg atmosphere option
 - MOM6 ocean, **1/4 deg** resolution
 - plus 1 deg ocean option
 - ...
- **Previous generation CM3**
 - AM3 atmosphere, **2 deg** resolution
 - MOM4 ocean, **1 deg** resolution

AM4 physics

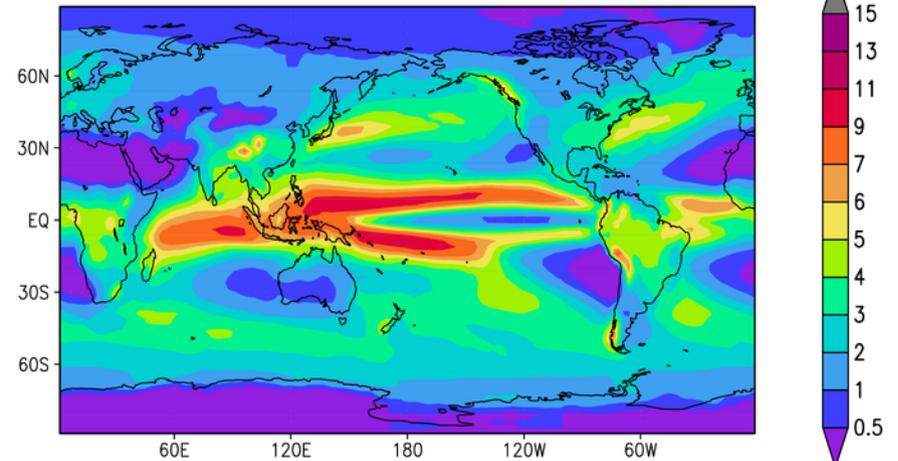
- Various physics updates under considerations
 - Convection (formulation and closure)
 - Large-scale cloud, microphysics
 - Radiation
 - Aerosols
 - PBL
 - ...
- **Motivation:** increase physical realism while also improving simulation fidelity.
- AM4 prototype atmospheres are now being evaluated **coupled** with MOM6 prototypes.

Annual precipitation

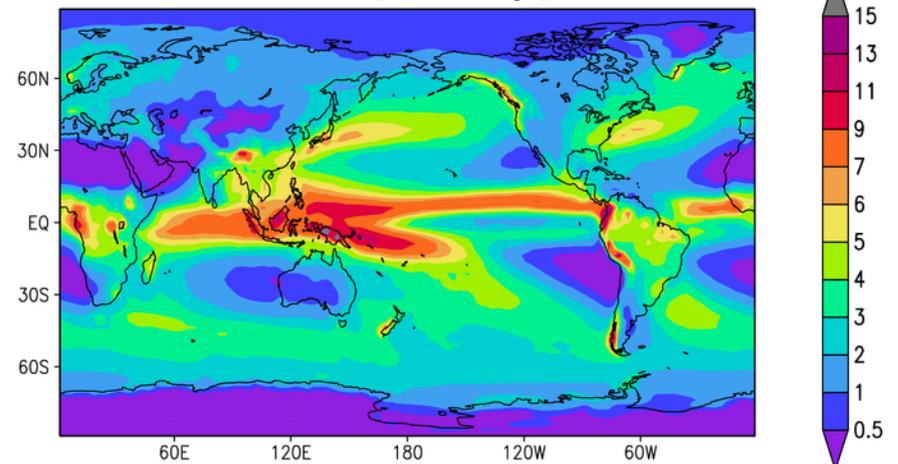
Observations (mm/day)
GPCPv2.2



Models
CM3



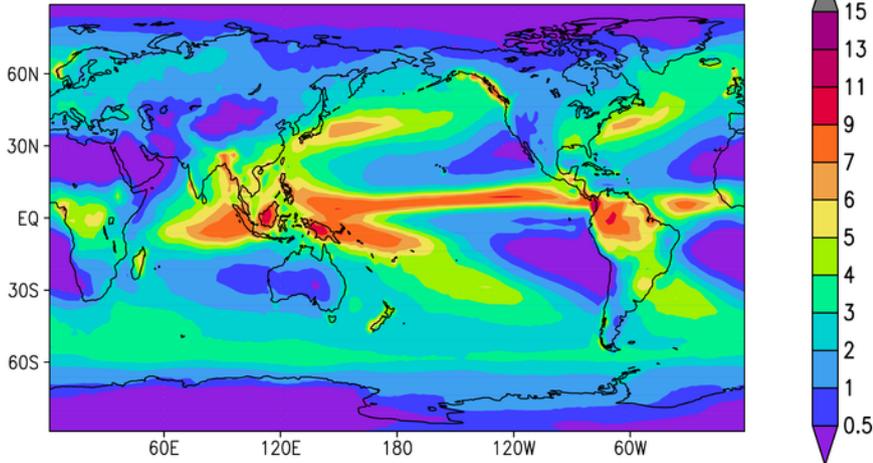
CM4 prototype



Present-day coupled simulations
30 year climatology

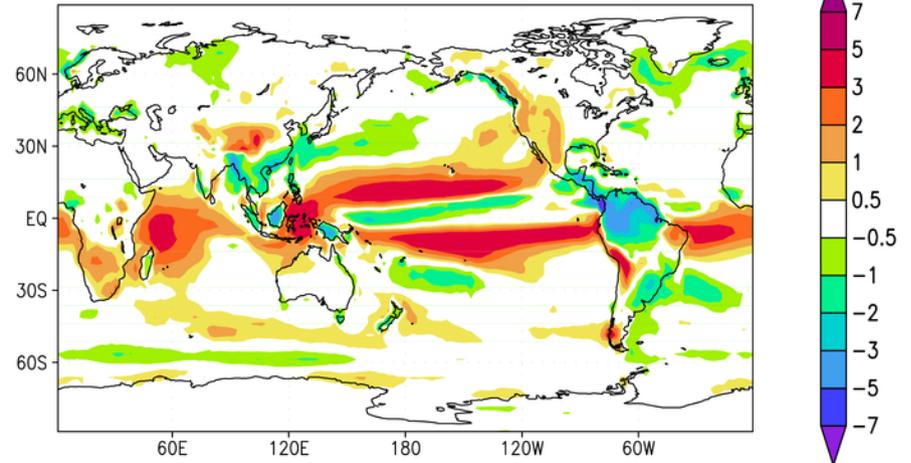
Annual precipitation

Observations (mm/day)
GPCPv2.2



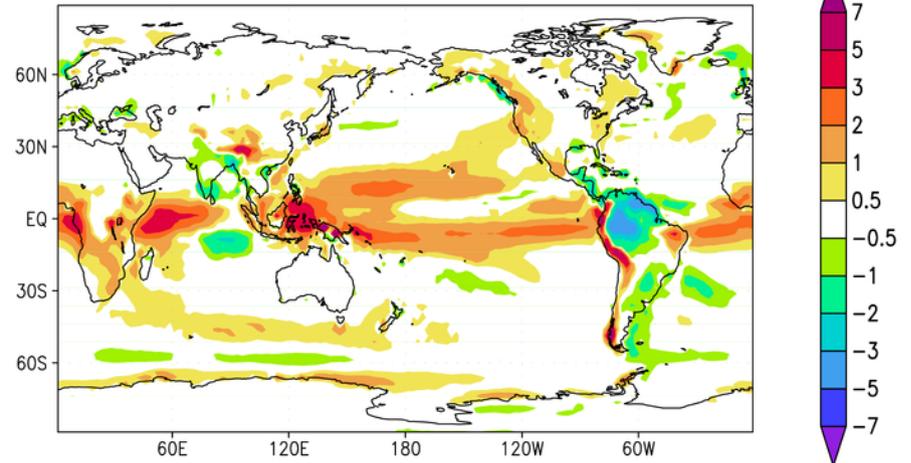
mean = 2.68, std = 1.916

Model minus observations
CM3



bias = 0.29, corr = 0.81, rms = 1.28

CM4 prototype

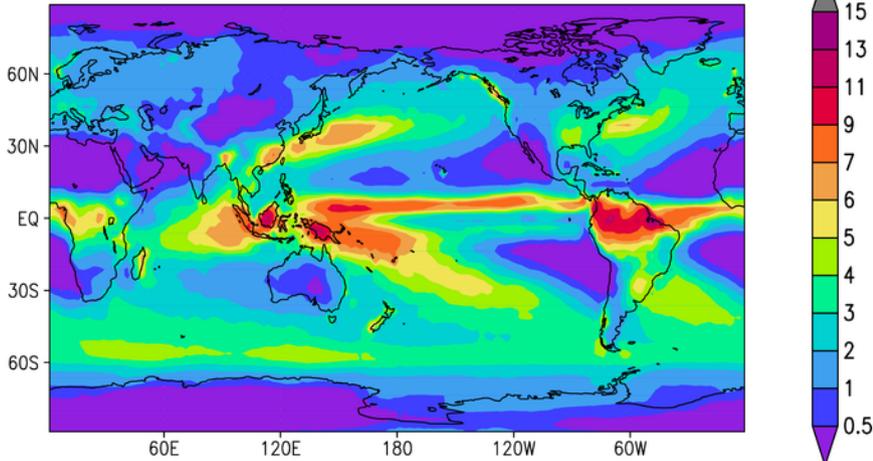


bias = 0.34, corr = 0.89, rms = 1.03

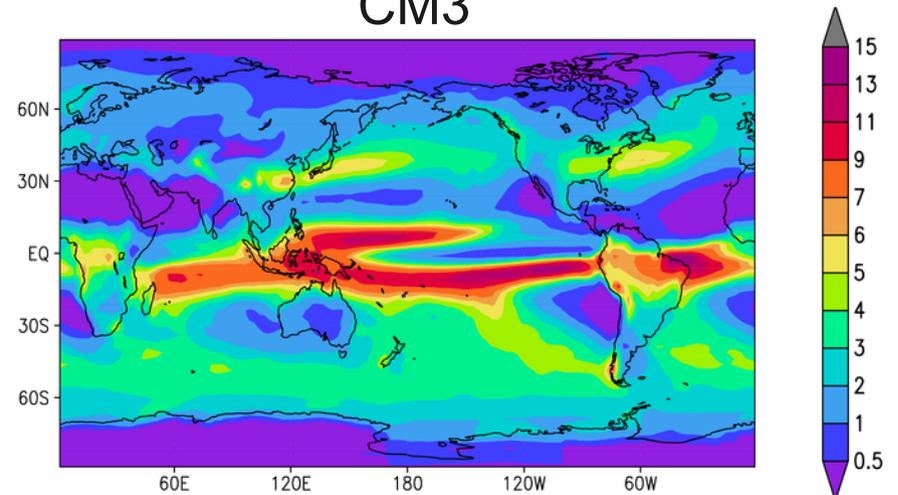
Present-day coupled simulations
30 year climatology

MAM precipitation

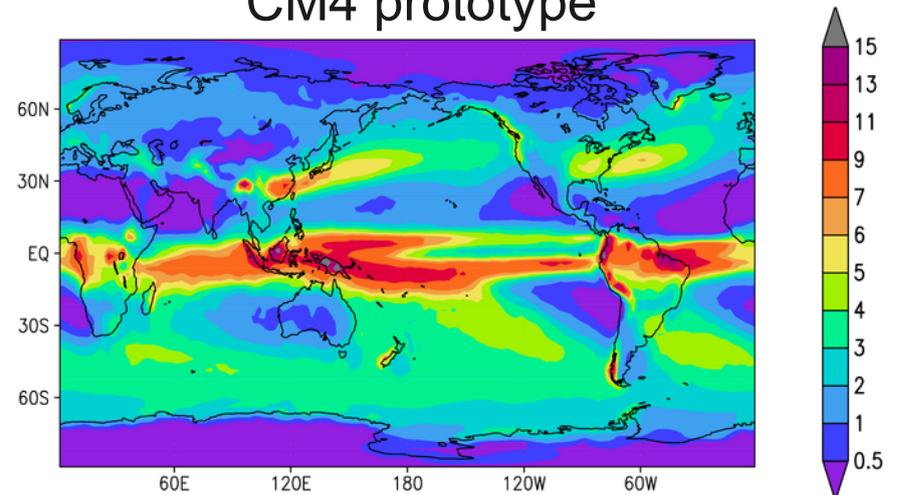
Observations (mm/day)
GPCPv2.2



Models
CM3



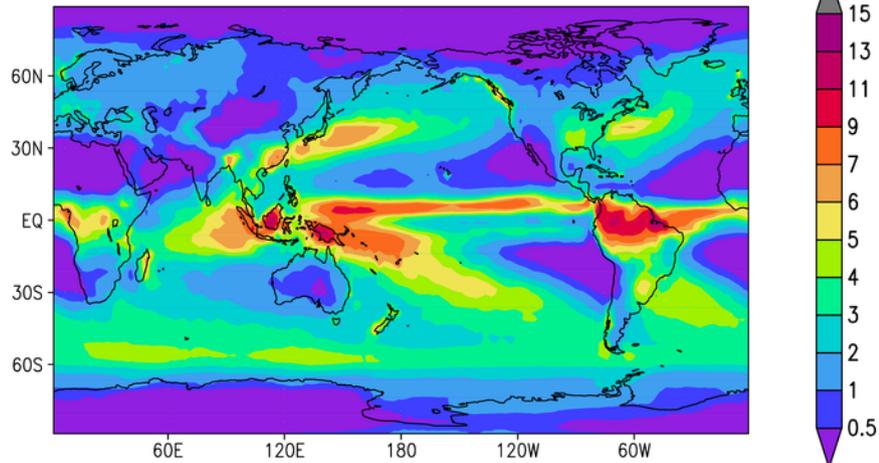
CM4 prototype



Present-day coupled simulations
30 year climatology

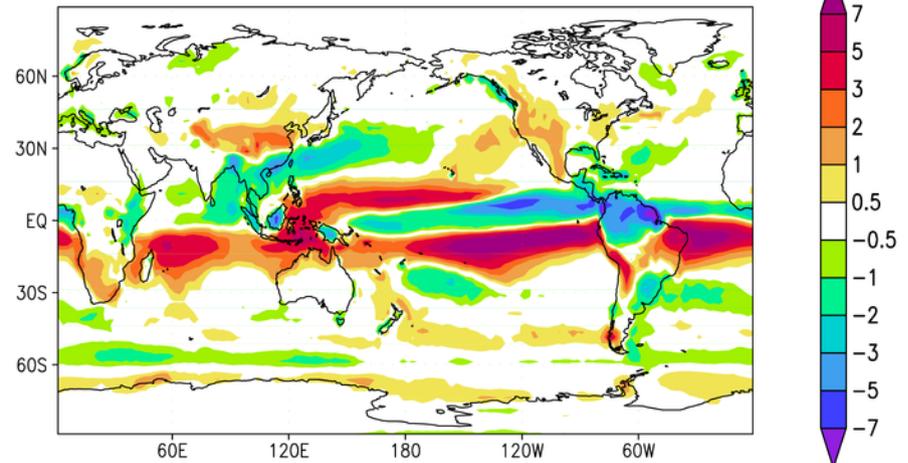
MAM precipitation

Observations (mm/day)
GPCPv2.2



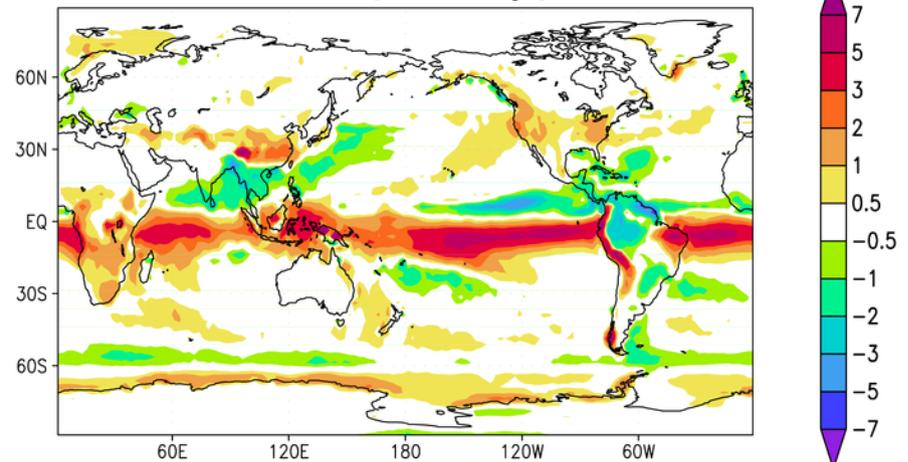
mean = 2.65, std = 2.047

Model minus observations
CM3



bias = 0.30, corr = 0.67, rms = 1.92

CM4 prototype

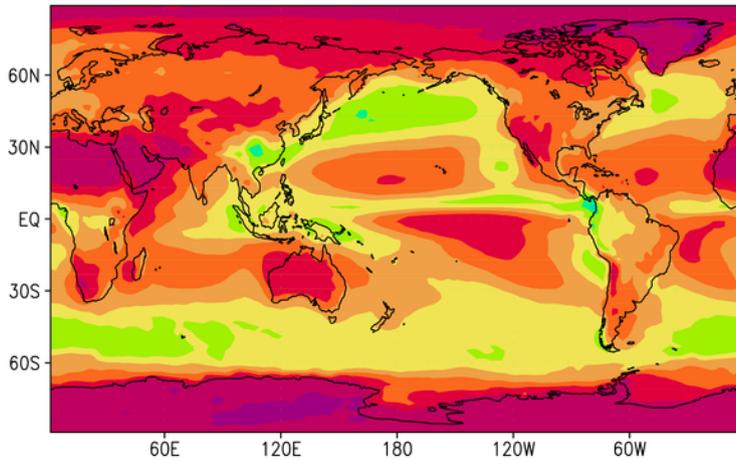


bias = 0.37, corr = 0.84, rms = 1.36

Present-day coupled simulations
30 year climatology

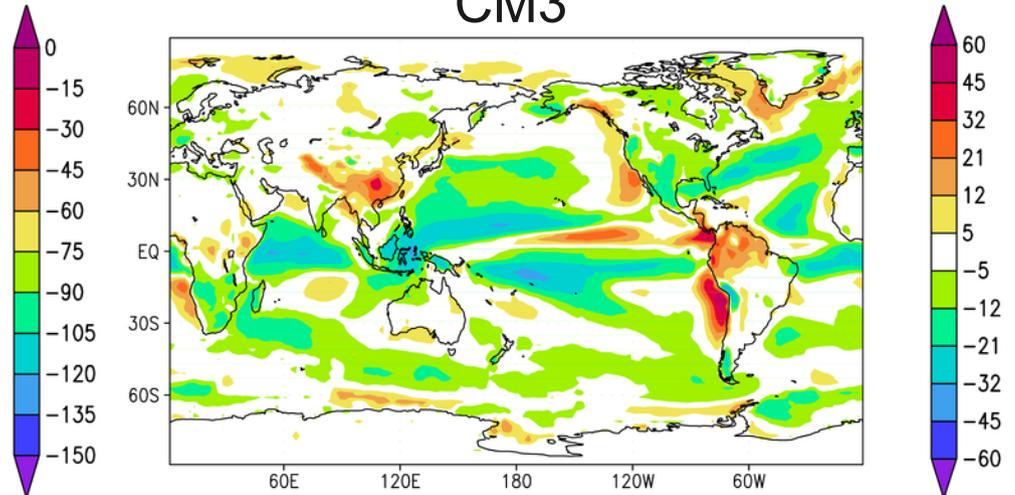
Shortwave cloud radiative effects

Observations (W m^{-2})
CERES-EBAF 2.7



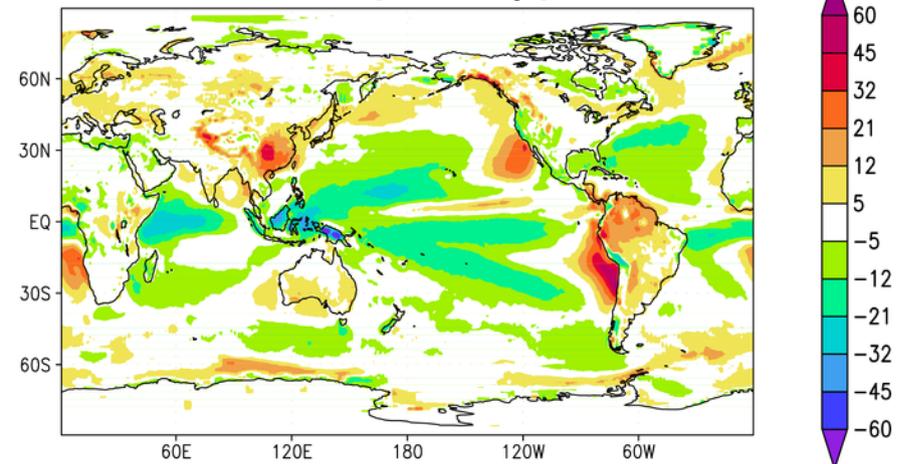
mean = -47.17, std = 20.37

Models minus observations
CM3



bias = -3.71, corr = 0.89, rms = 10.94

CM4 prototype

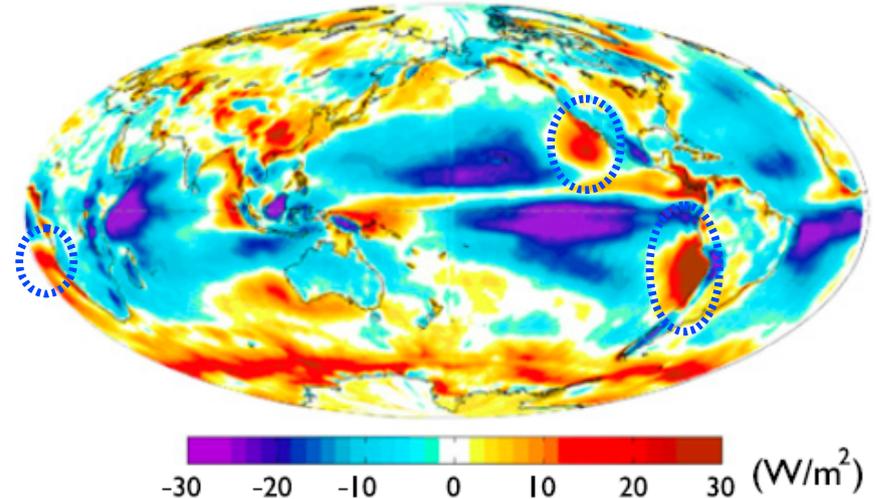


bias = -1.30, corr = 0.90, rms = 9.36

Present-day coupled simulations
30 year climatology

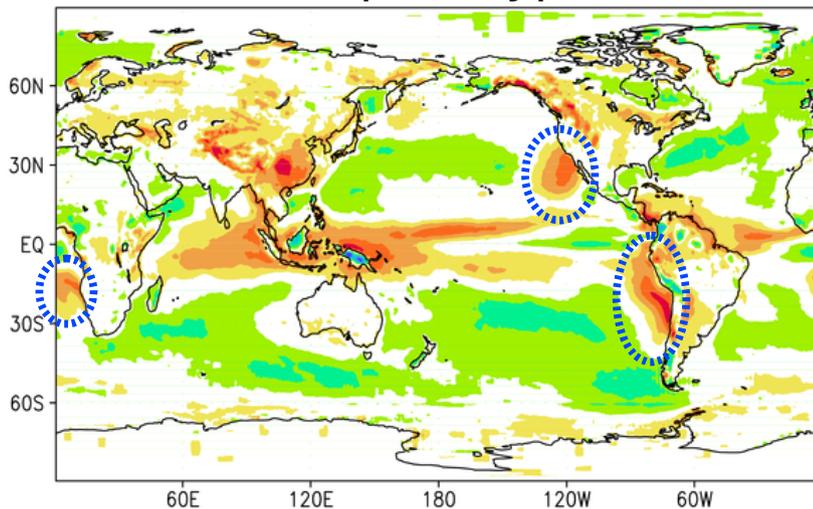
Biases in marine stratocumulus Shortwave cloud radiative effect

Biases in 20 CMIP5 models
Hwang and Frierson (2013)



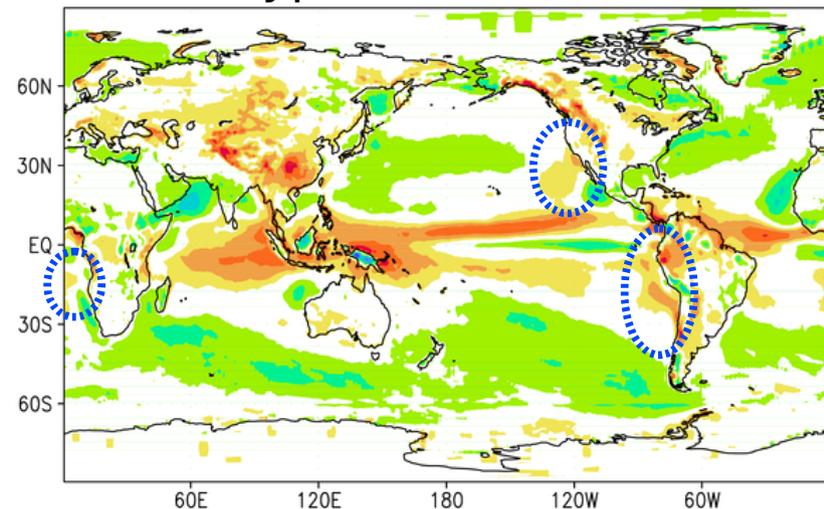
Atmosphere simulations with fixed SST

AM4 prototype d



bias = 0.60; corr = 0.91; rms = 9.0

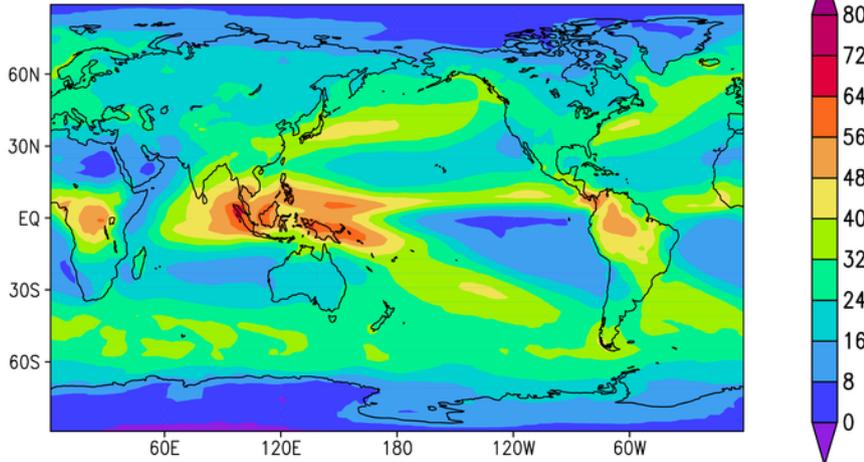
Prototype d + alternate PBL



bias = 0.31; corr = 0.91; rms = 8.9

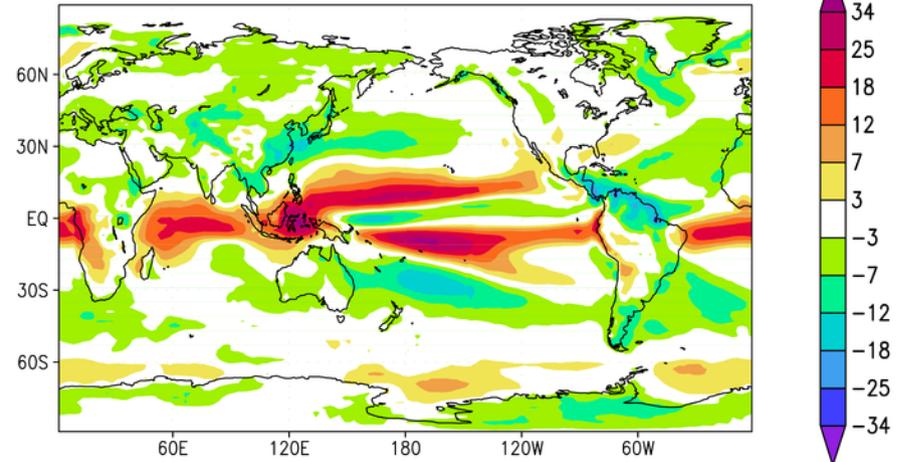
Longwave cloud radiative effects

Observations (W m^{-2})
CERES-EBAF 2.7



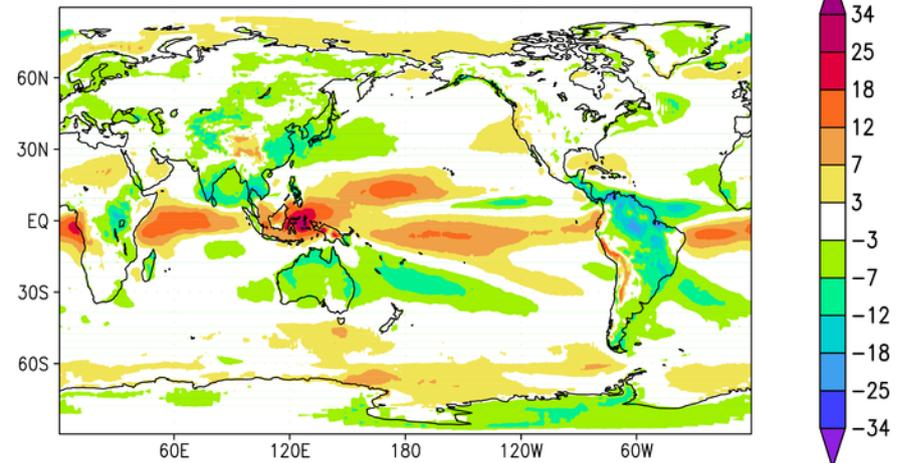
mean = 26.07, std = 11.17

Models minus observations
CM3



bias = -0.03, corr = 0.84, rms = 7.58

CM4 prototype

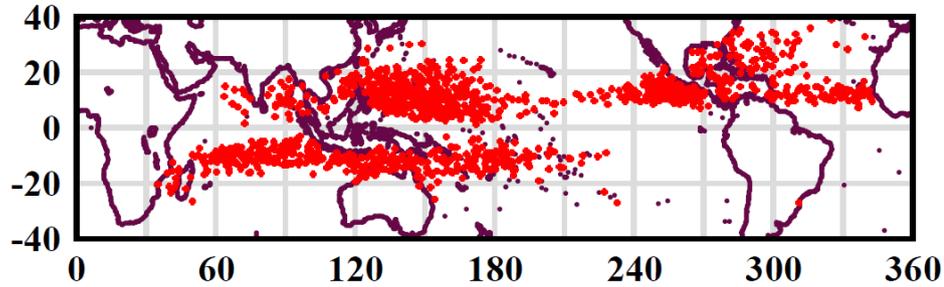


bias = 0.02, corr = 0.90, rms = 5.17

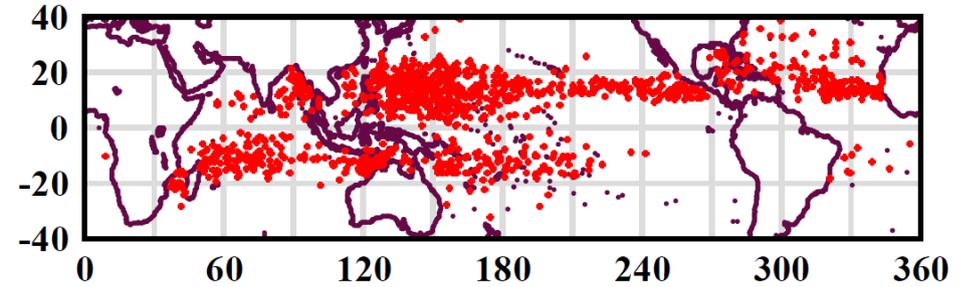
Present-day coupled simulations
30 year climatology

Tropical cyclones

Obs



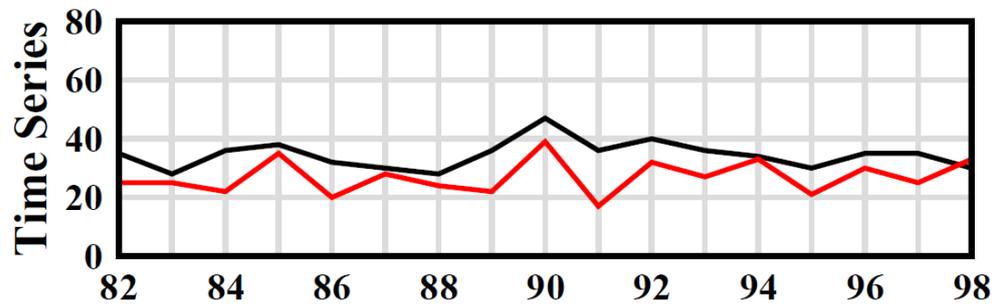
Model



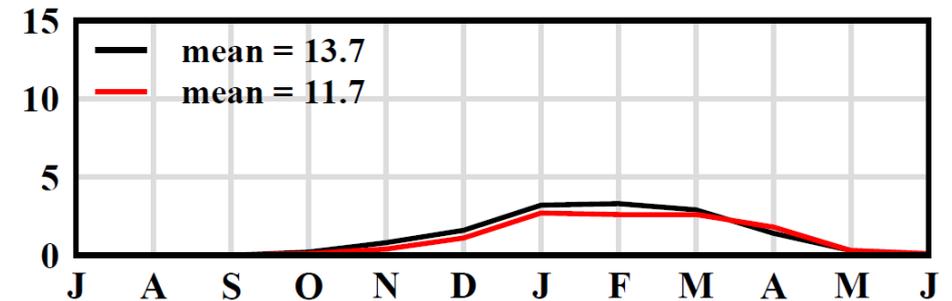
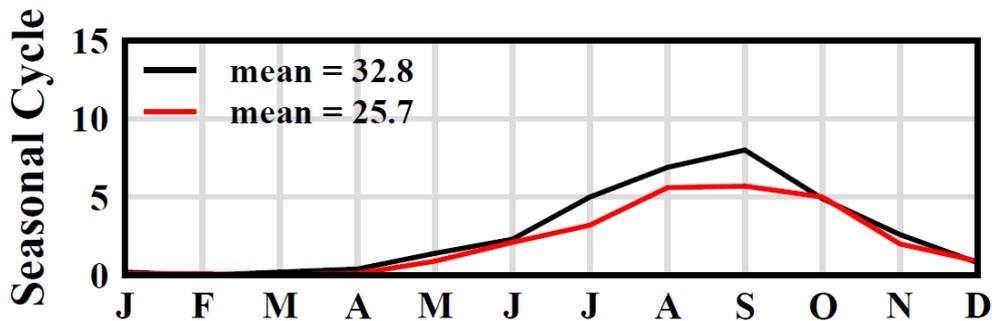
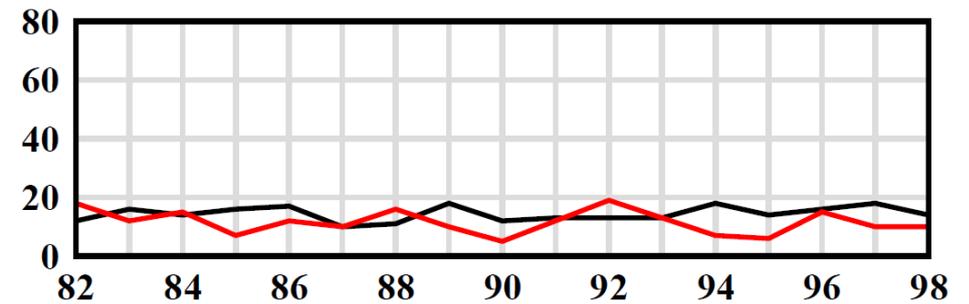
Tropical cyclone counts

— Obs
— Model

Northern Hemisphere

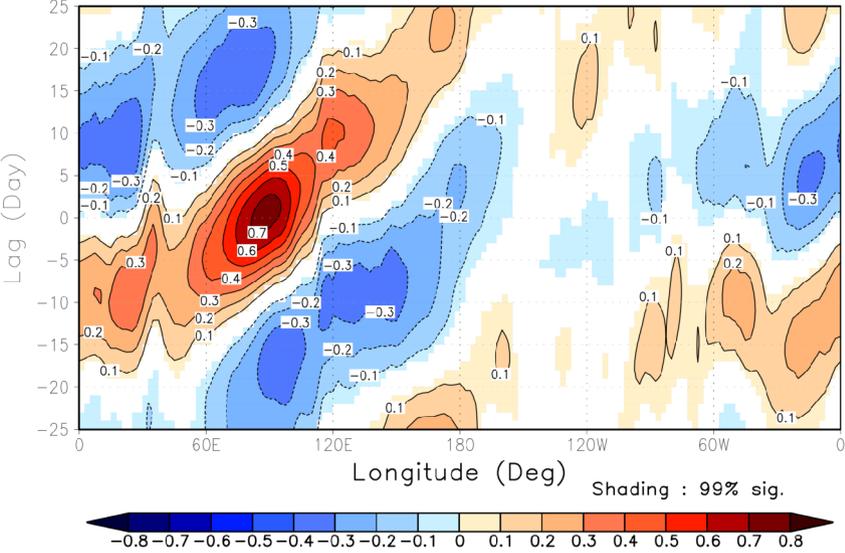


Southern Hemisphere

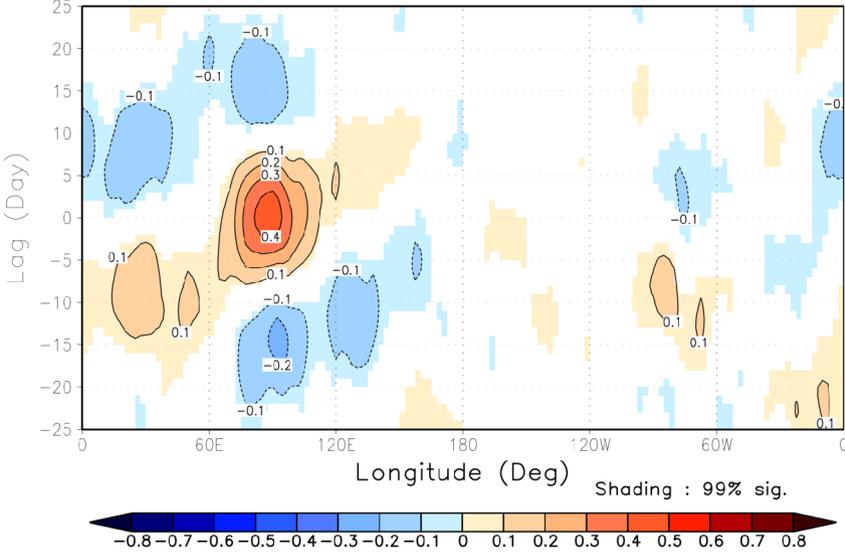


Madden-Julian Oscillation (MJO) OLR Lag correlation, Winter (Nov-Apr)

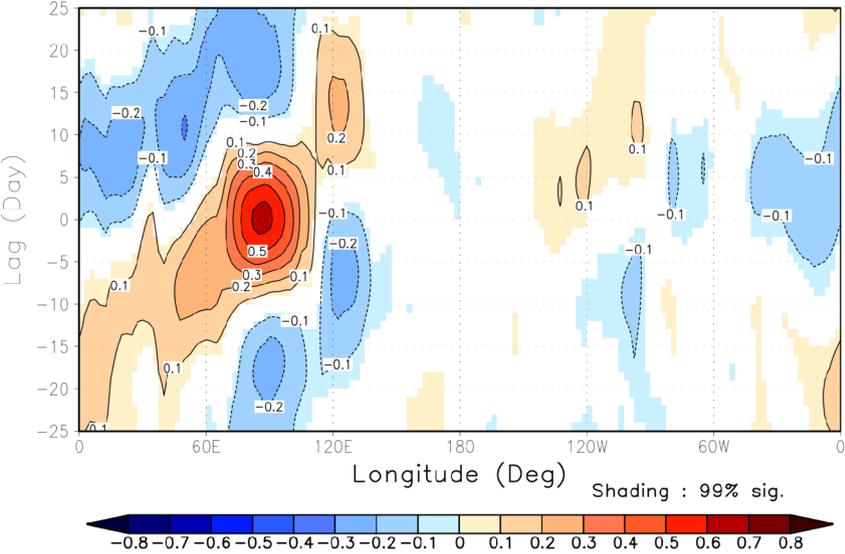
Observations



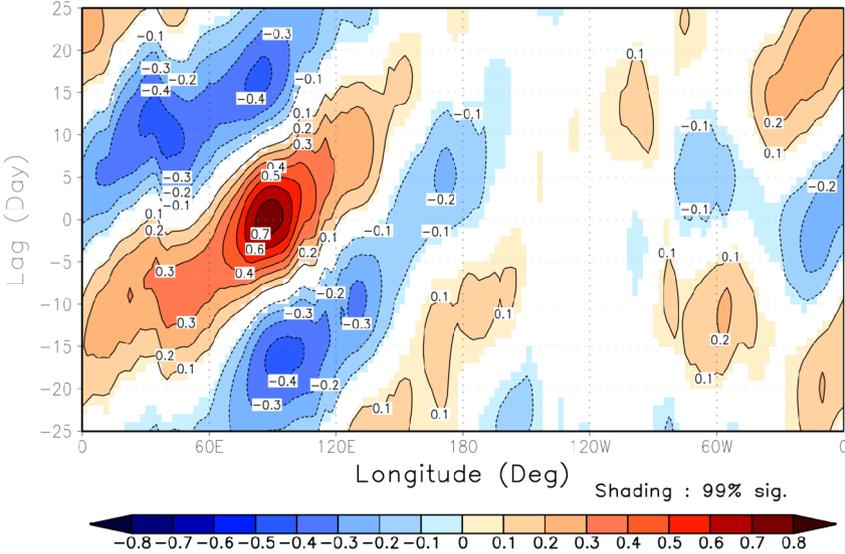
HiRAM-like convection



AM3-like convection



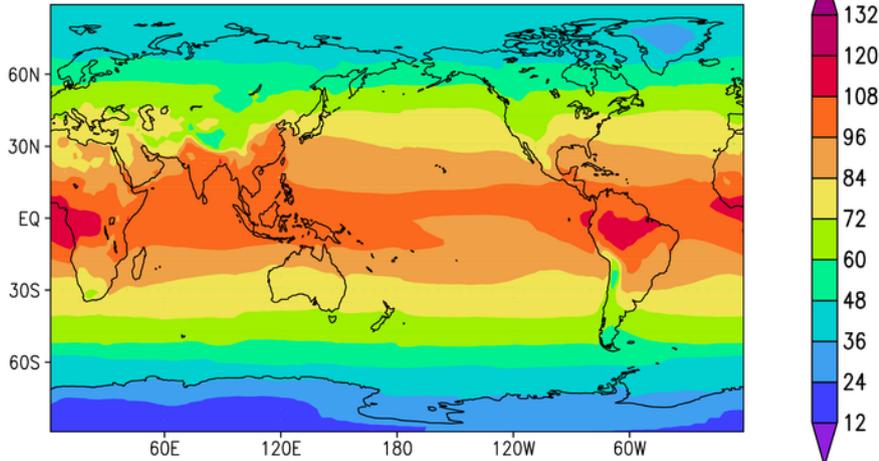
CM4 prototype



New shortwave water vapor continuum

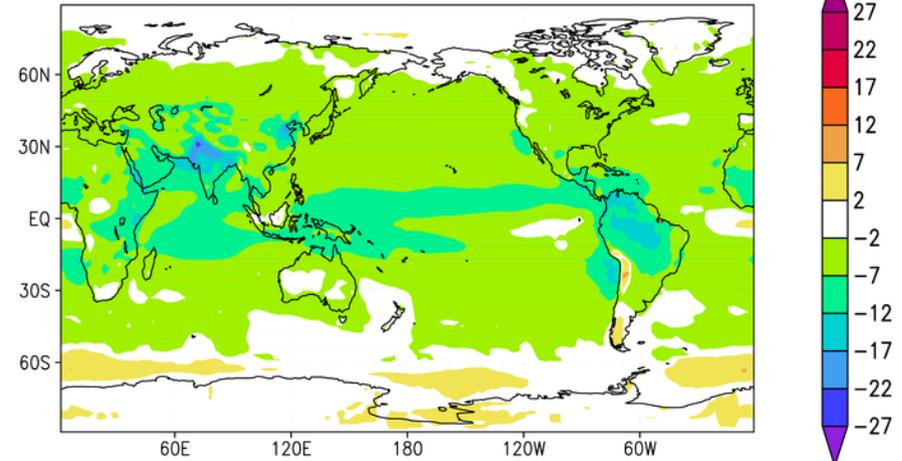
SW absorbed in the atmosphere

Observations (W m^{-2})
CERES-EBAF 2.7



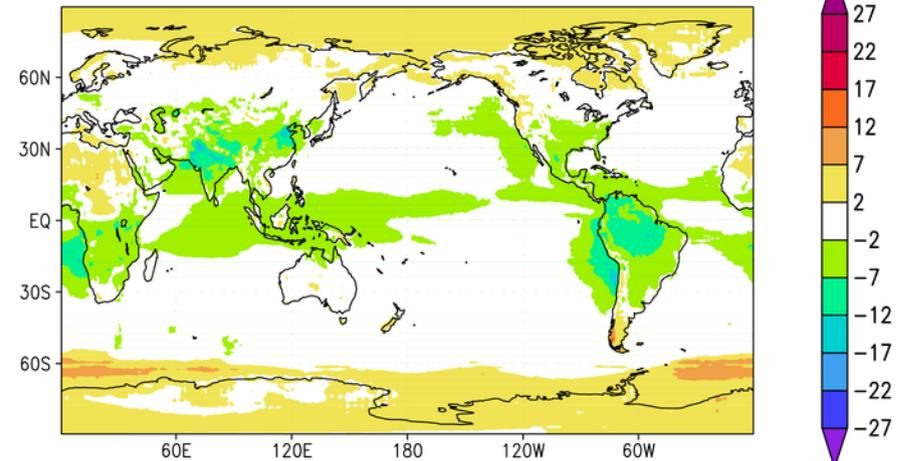
mean = 77.85, std = 20.43

Models minus observations
CM3



bias = -4.29, corr = 0.99, rms = 5.49

CM4 prototype



bias = -0.77, corr = 0.99, rms = 2.94

Present-day coupled simulations
30 year climatology

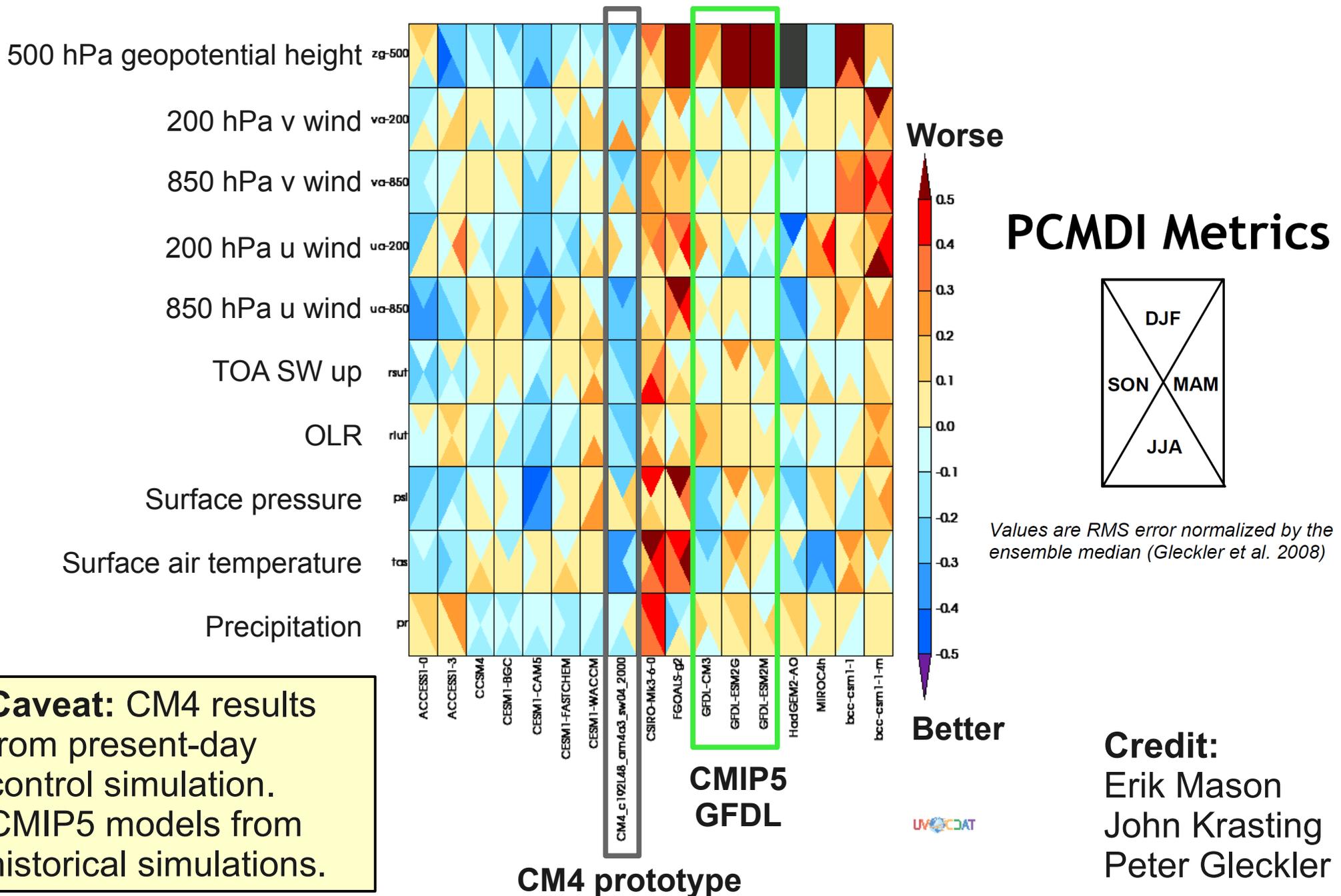
Credit:

David Paynter

Dan Schwarzkopf

Stuart Freidenreich

Comparison with other CMIP5 models



Summary

- AM4/CM4 is starting to take shape.
- Targeting
 - higher horizontal resolution than CM3, for both atmosphere and ocean,
 - increased physical realism.
- Improved simulation fidelity
 - mean (clouds, precipitation, ...)
 - variability (TC, MJO, ...)
- **Nothing is final until finalized!**