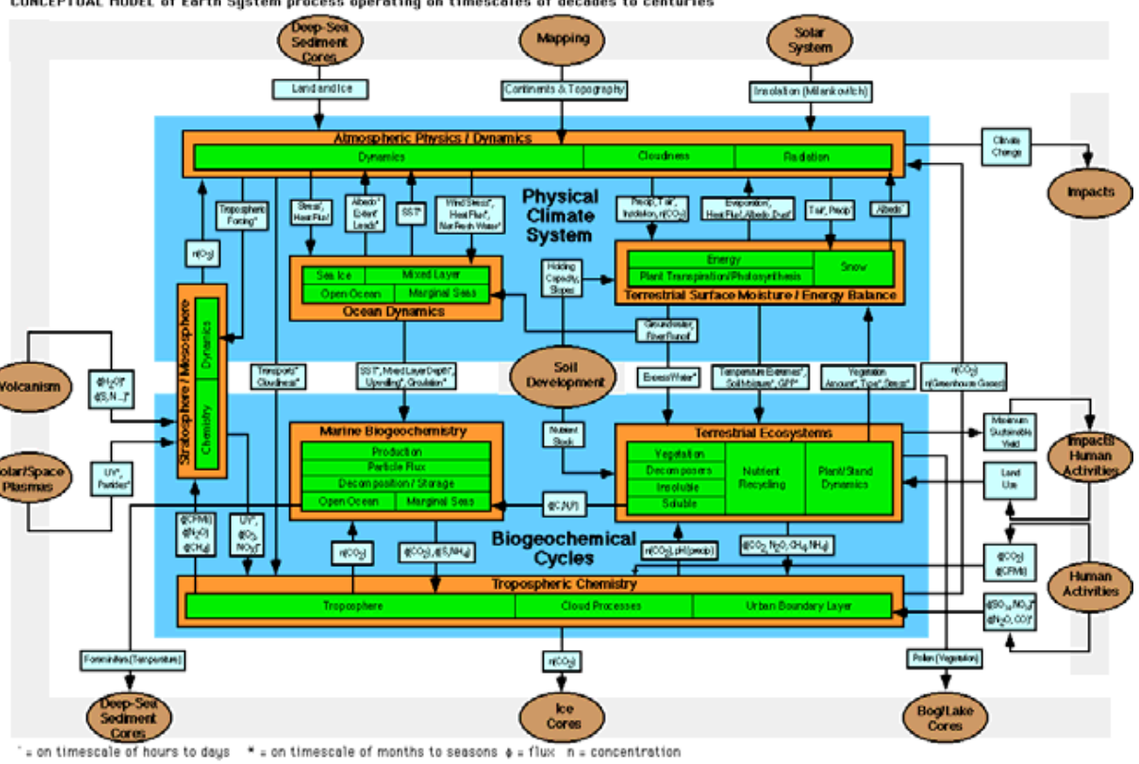
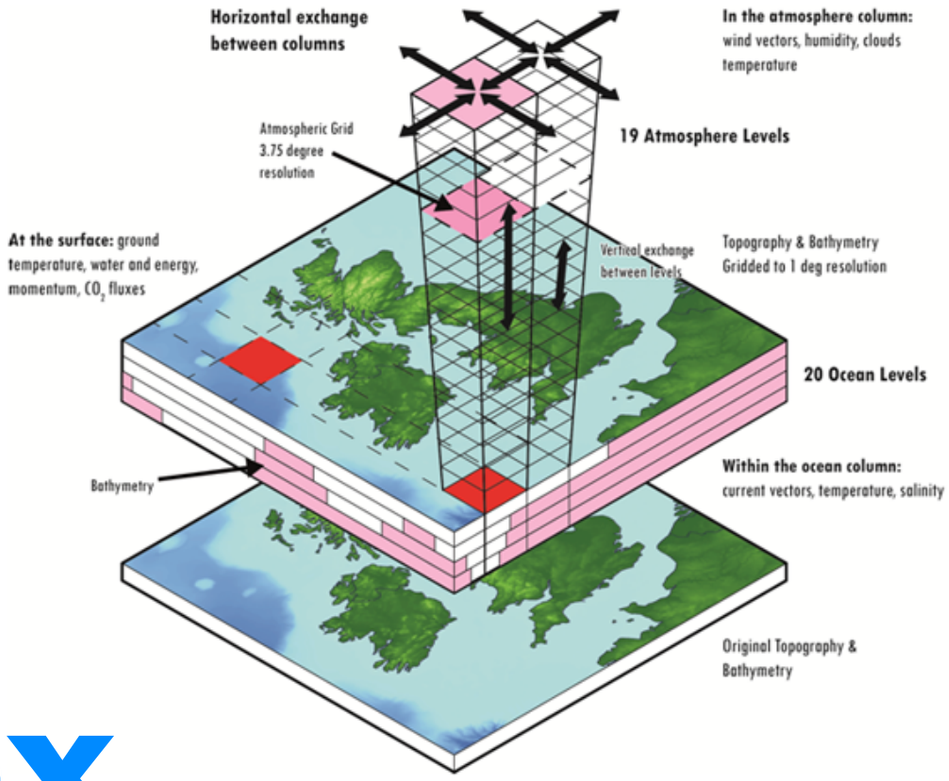
Simple

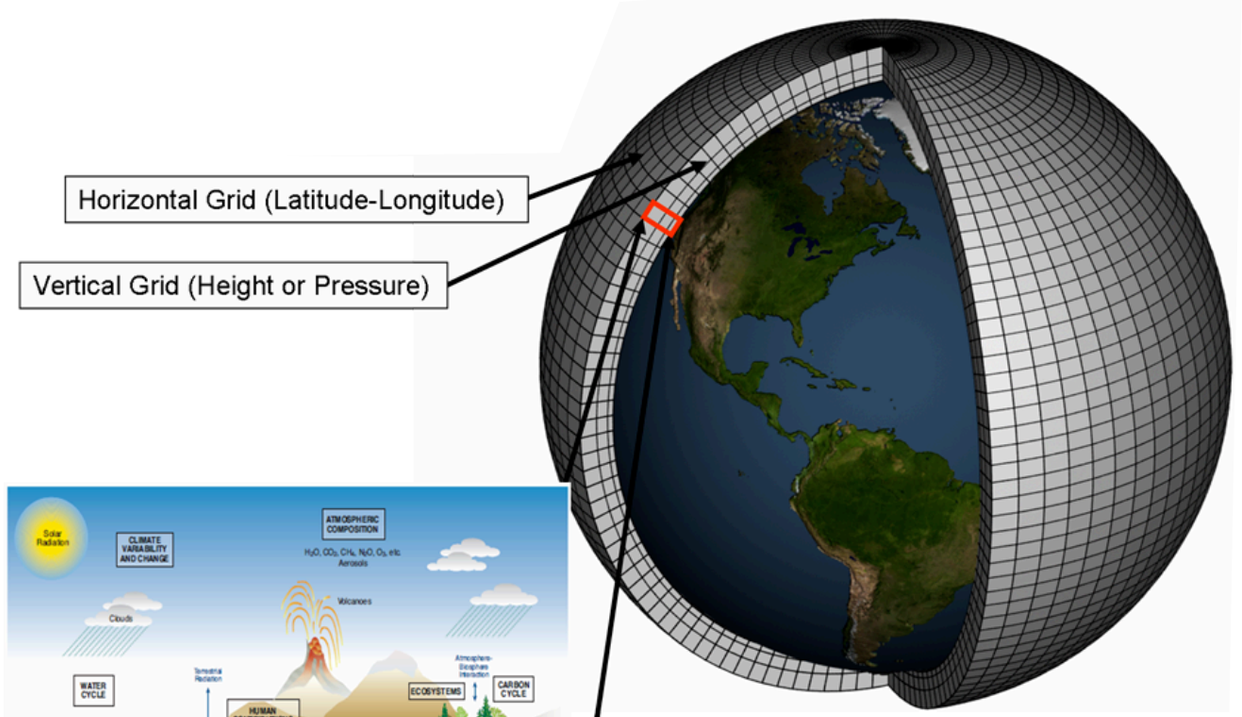
Brian Medeiros

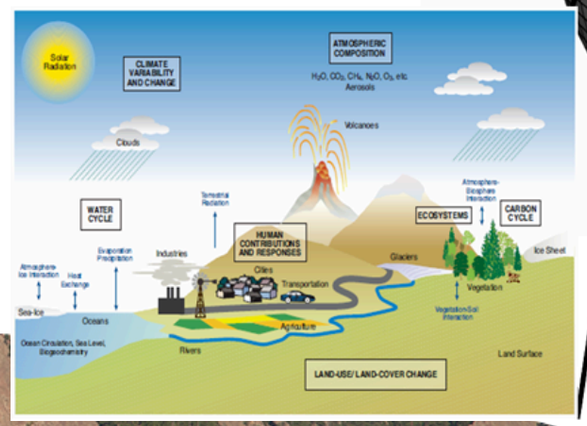
CGD
Climate & Global Dynamics
a Laboratory of NCAR





Complex





credit: getech, wikipedia,

CGD Climate & Global Dynamics a Laboratory of NCAR

reductionism noun

re·duc·tion·ism | \ ri-ˈdək-shə-ˌni-zəm \

Definition of *reductionism*

1 **:** explanation of complex life-science processes and phenomena in terms of the laws of physics and chemistry

also **:** a theory or doctrine that complete reductionism is possible

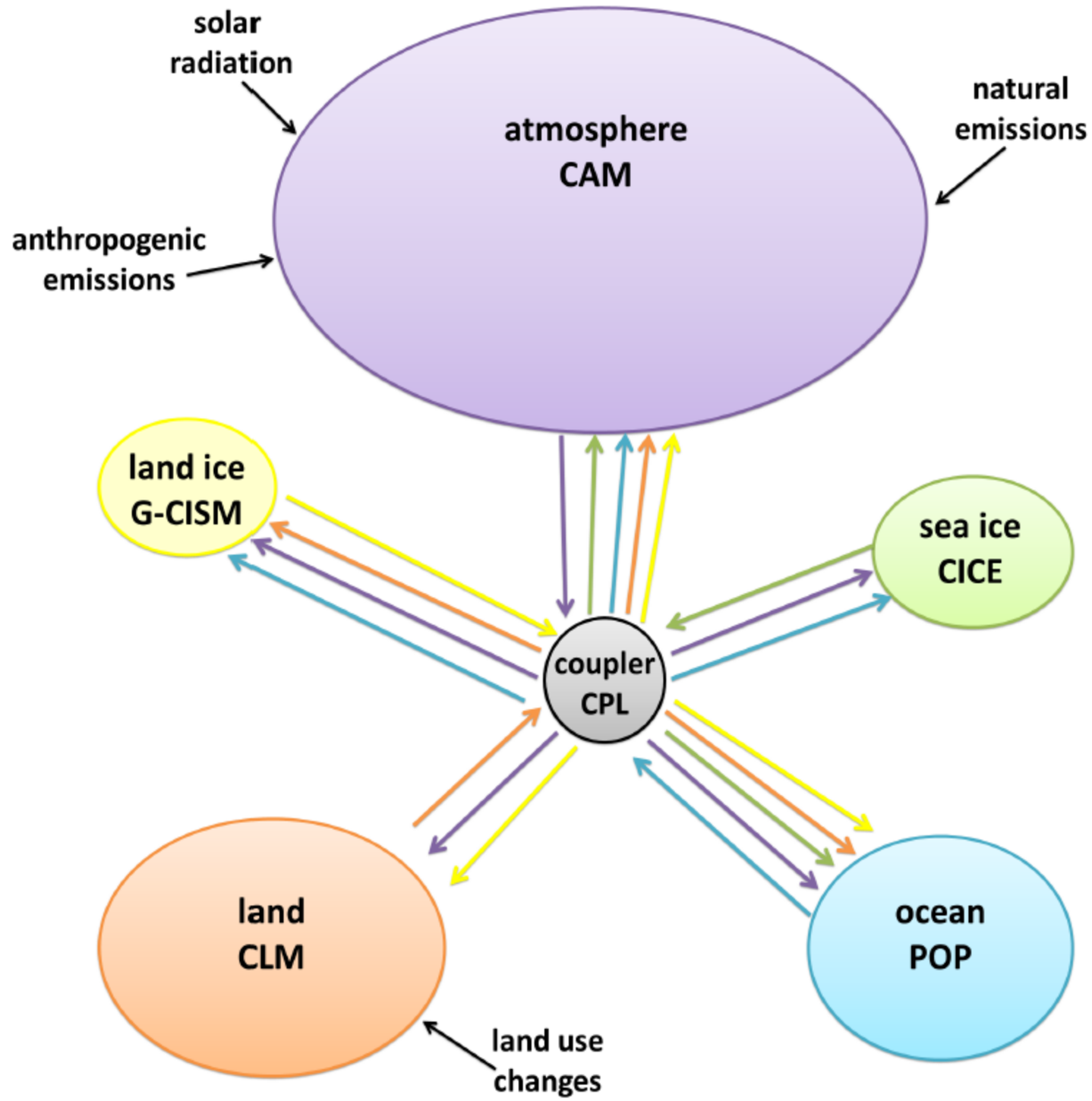
2 **:** a procedure or theory that reduces complex data and phenomena to simple terms

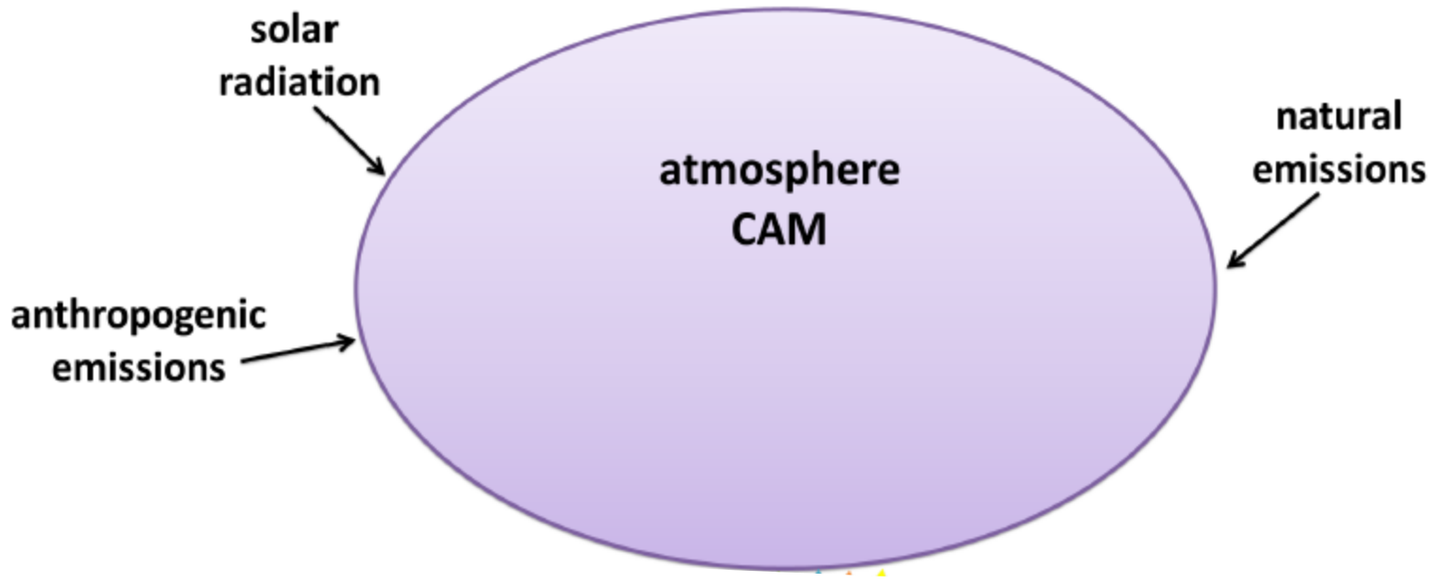
Further reading

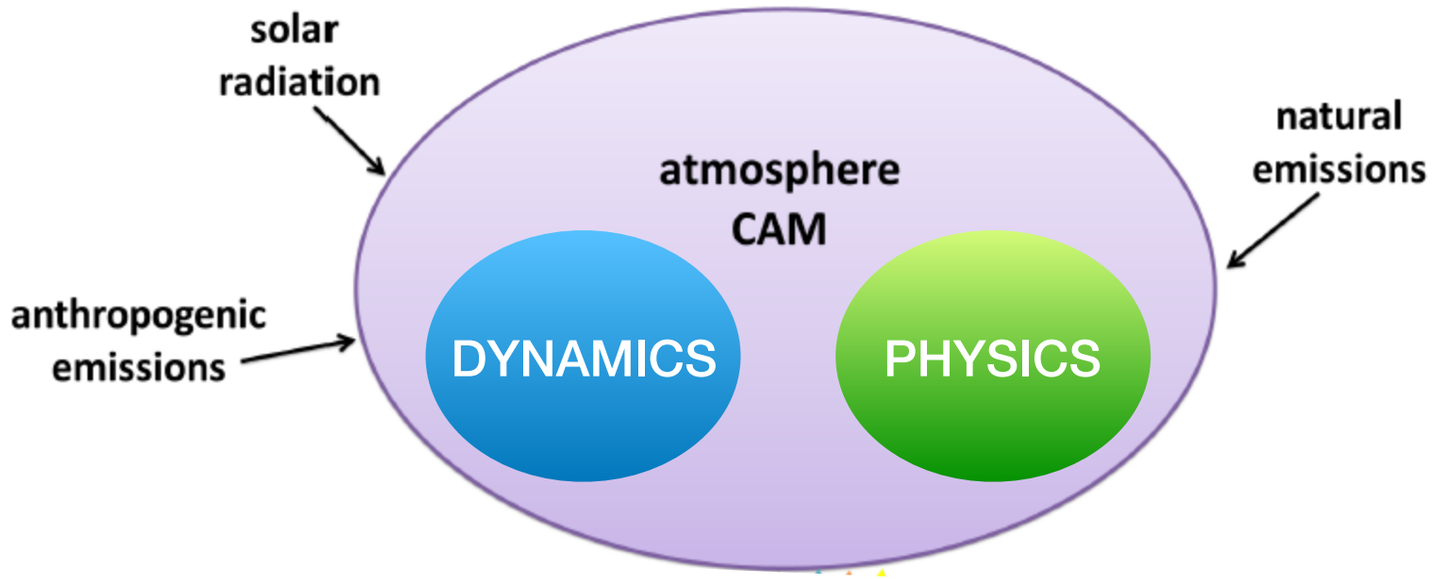
CU ATOC core class titles

- Atmospheric Thermodynamics and Dynamics
- Introduction to Physical Oceanography
- Dynamics of the Atmosphere and Oceans
- Introduction to Atmospheric Radiative Transfer and Remote Sensing
- Atmospheric Chemistry
- Biogeochemical Oceanography
- Physics and Chemistry of Clouds and Aerosols
- Introduction to Fluid Dynamics
- Marine Chemistry and Geochemistry
- Paleoceanography and Paleoclimatology

Reducing the climate system

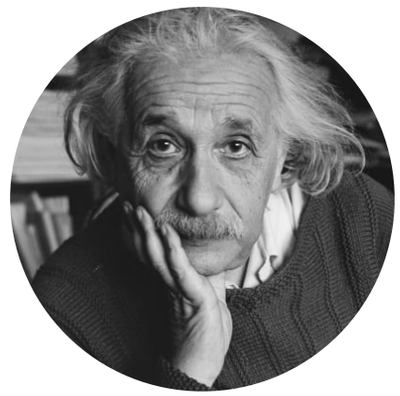



solar
radiation
atmosphere
CAM
natural
emissions
anthropogenic
emissions

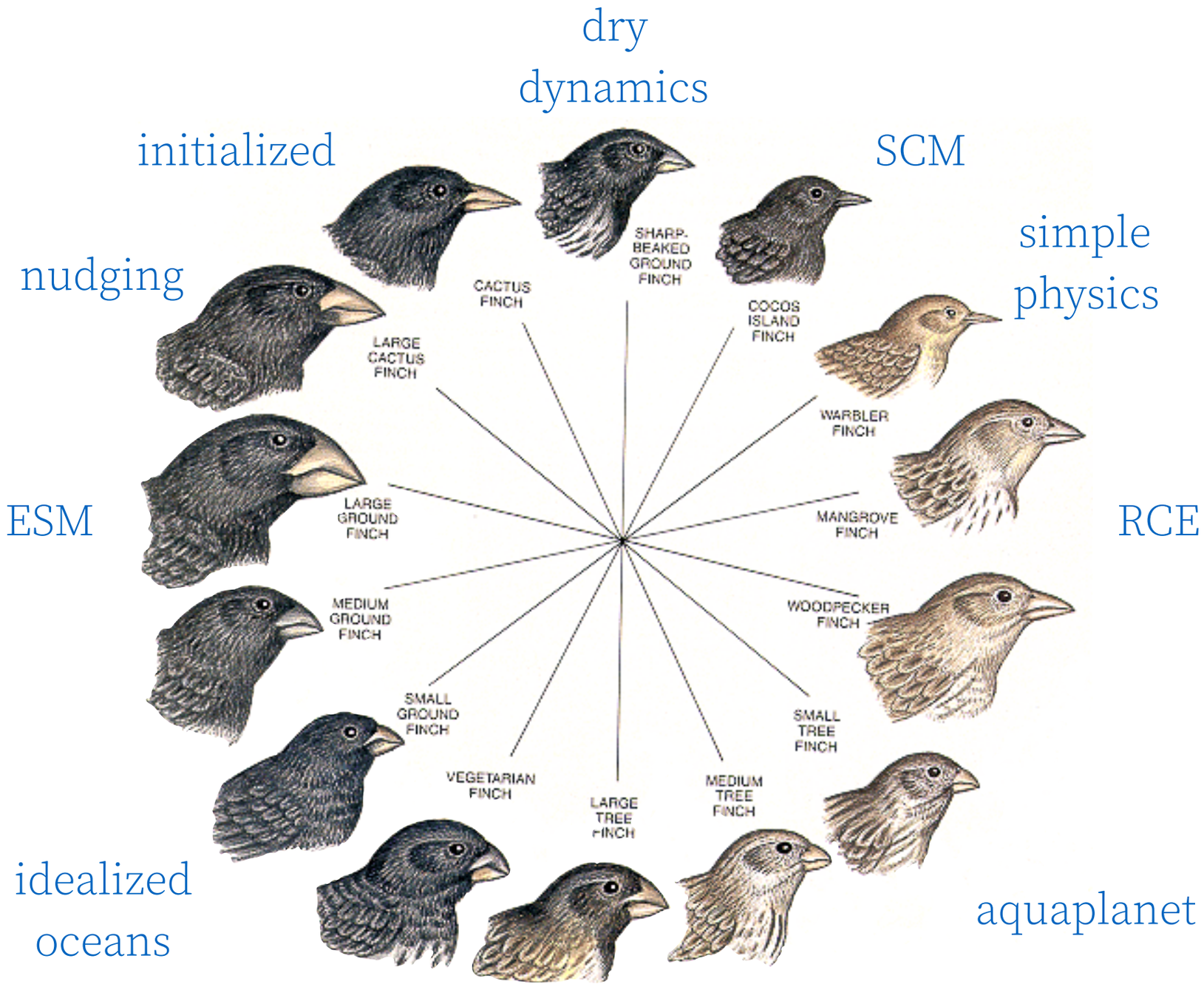


The nature of the idealization must be amenable to the problem at hand.

EVERYTHING SHOULD BE MADE AS SIMPLE AS POSSIBLE, BUT NOT SIMPLER



Different tools for different jobs



What's in the tin?

Dynamics

Physics

FADIAB	adiabatic
FDABIP04	Adiabatic (baroclinic lifecycle)
FHS94	Held-Suarez Idealized Physics
FKESSLER	Kessler warm microphysics
QPC4	Aquaplanet, prescribed SST, CAM4
QPC5	Aquaplanet, prescribed SST, CAM5
QPC6	Aquaplanet, prescribed SST, CAM6
QSC4	Aquaplanet, slab ocean, CAM4
QSC5	Aquaplanet, slab ocean, CAM5
QSC6	Aquaplanet, slab ocean, CAM6
FSCAM	Single column model
"PORT"	Radiative transfer
"SD"	Specified dynamics

One-liner to change prescribed "APE" SST.

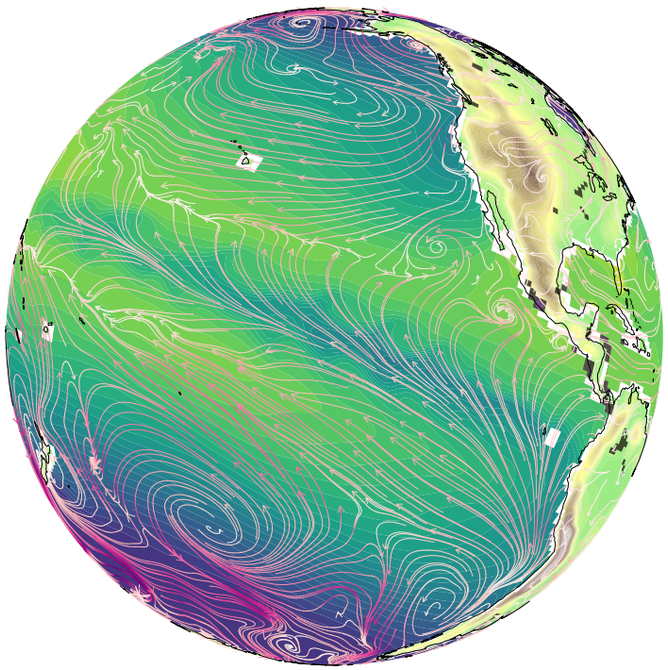
Ability to use SST dataset.

http://www.cesm.ucar.edu/models/simpler-models/

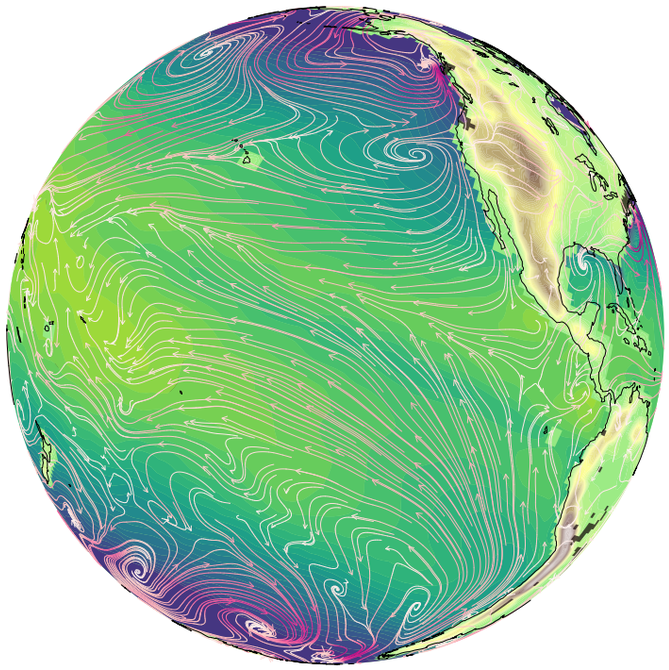
PUBLICATIONS

POLVANI ET AL., EOS, 2017
BENEDICT ET AL., JAMES, 2017
MEDEIROS ET AL., JAMES 2016
GETTELMAN ET AL., JAMES 2019

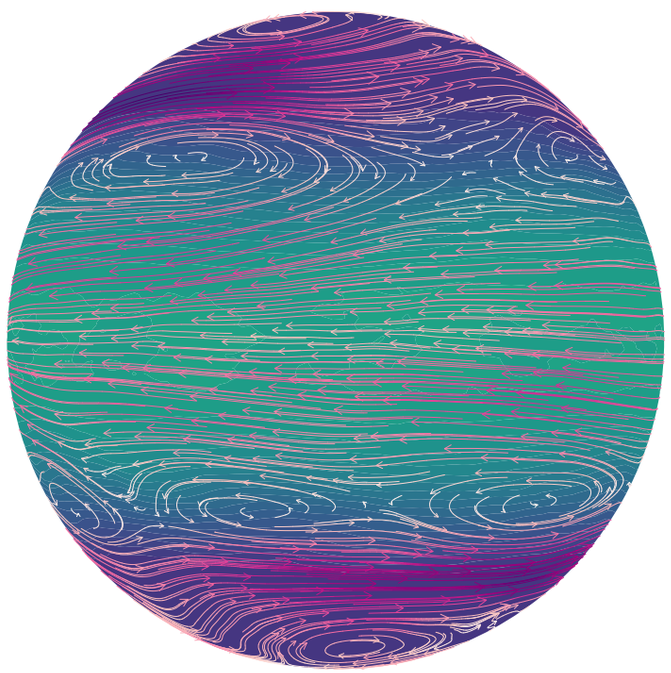
RCE	Radiative convective equilibrium on the sphere
GrayRad	Frierson gray radiation aquaplanet



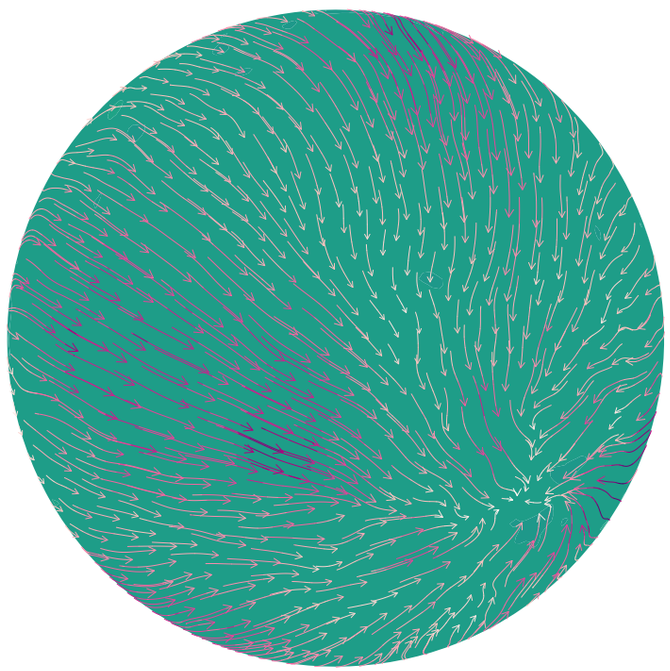
Earth System



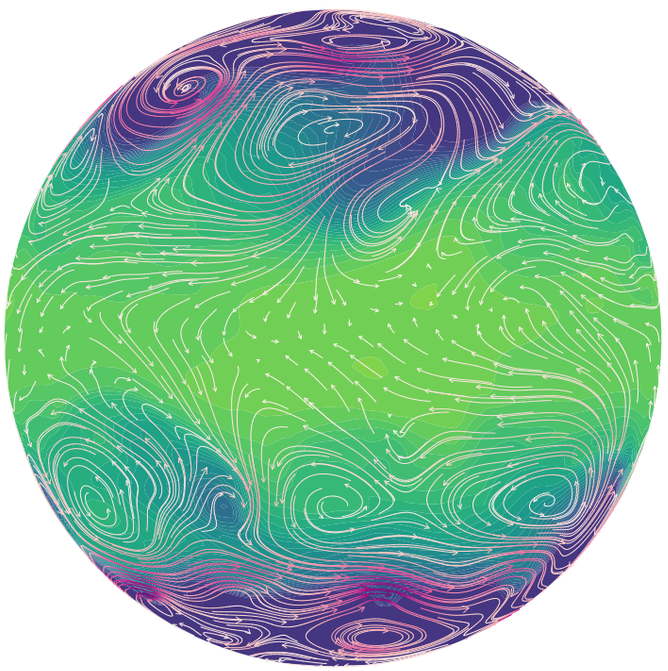
Atmosphere



Aquaplanet

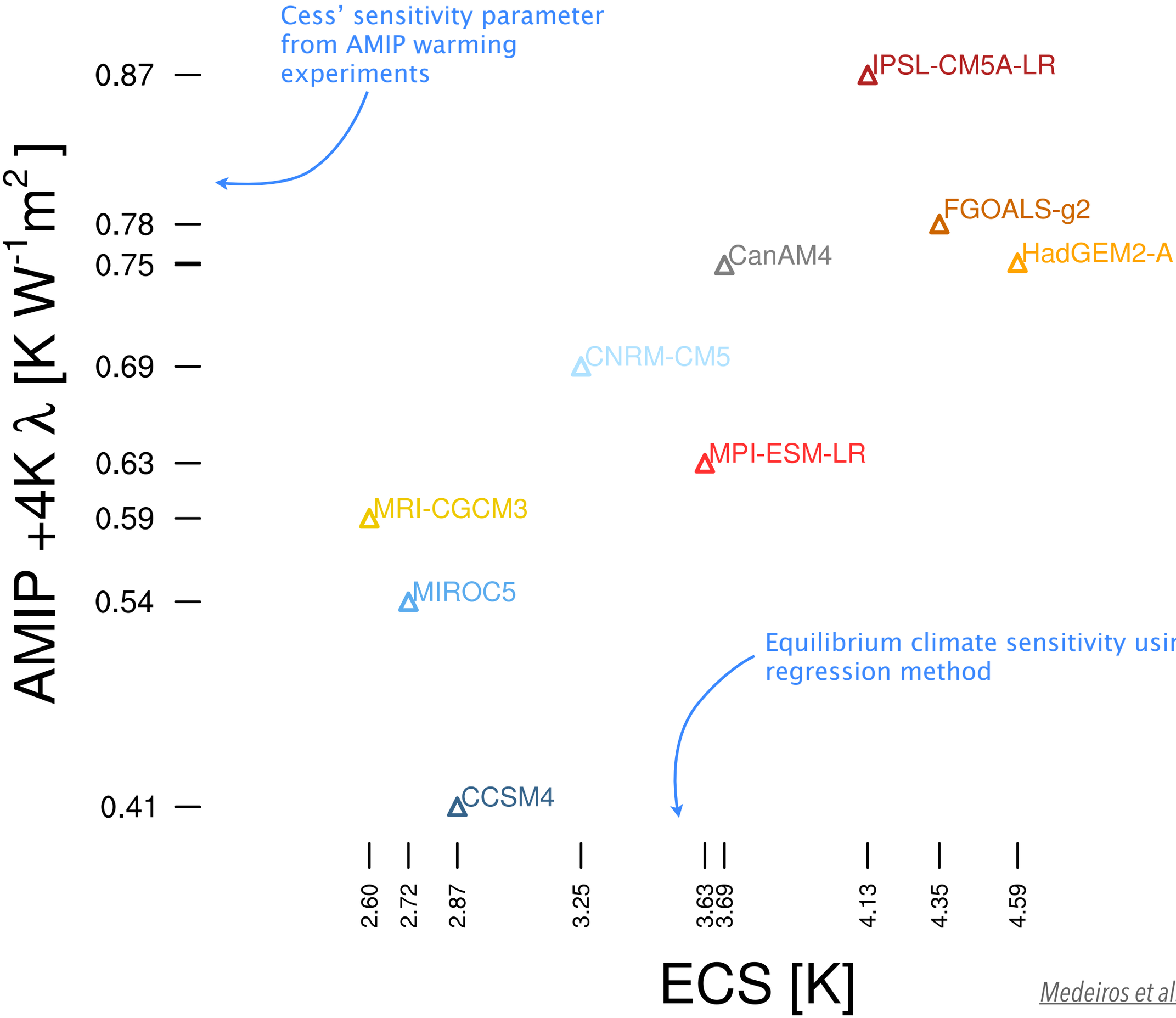


Radiative-Convective Equilibrium



Idealized Dry Physics

Maher et al. 2019



Medeiros et al. 2015

SENSITIVITY PARAMETER [K W^{-1} m^{2}]

1.23
1.14
1.05
0.96
0.87
0.78
0.69
0.6
0.51
0.42
0.33

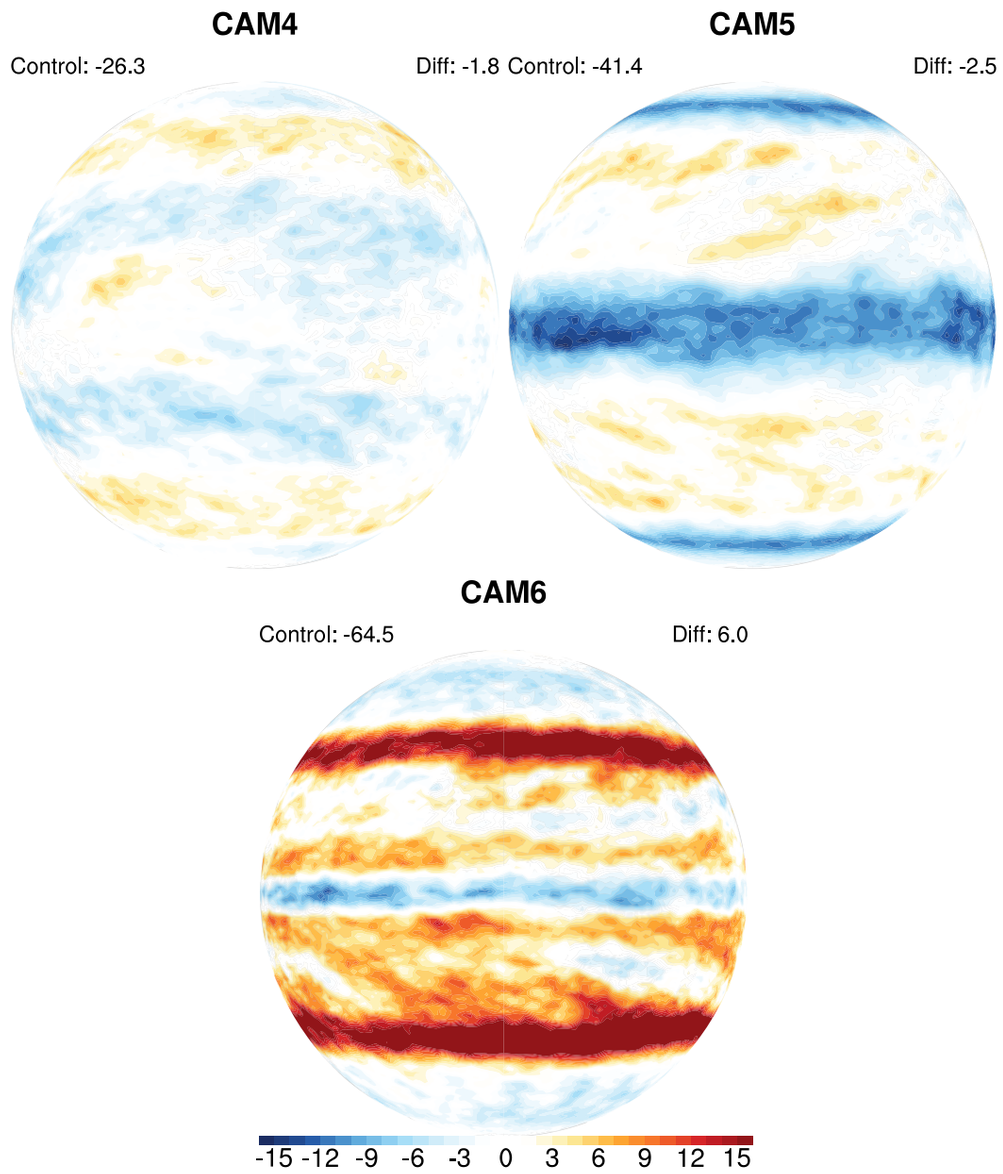
CNRM-CM5
FGOALS-g2
FGOALS-s2
HadGEM2-A
IPSL-CM5A-LR
MIROC5
MPI-ESM-LR
MPI-ESM-MR
MRI-CGCM3
CCSM4
NICAM-09

GLOBAL
TROPICS
AMIP
AQUA

-0.6
-0.38
-0.17
0.05
0.26
0.48
0.69
0.91
1.12
1.34
1.55

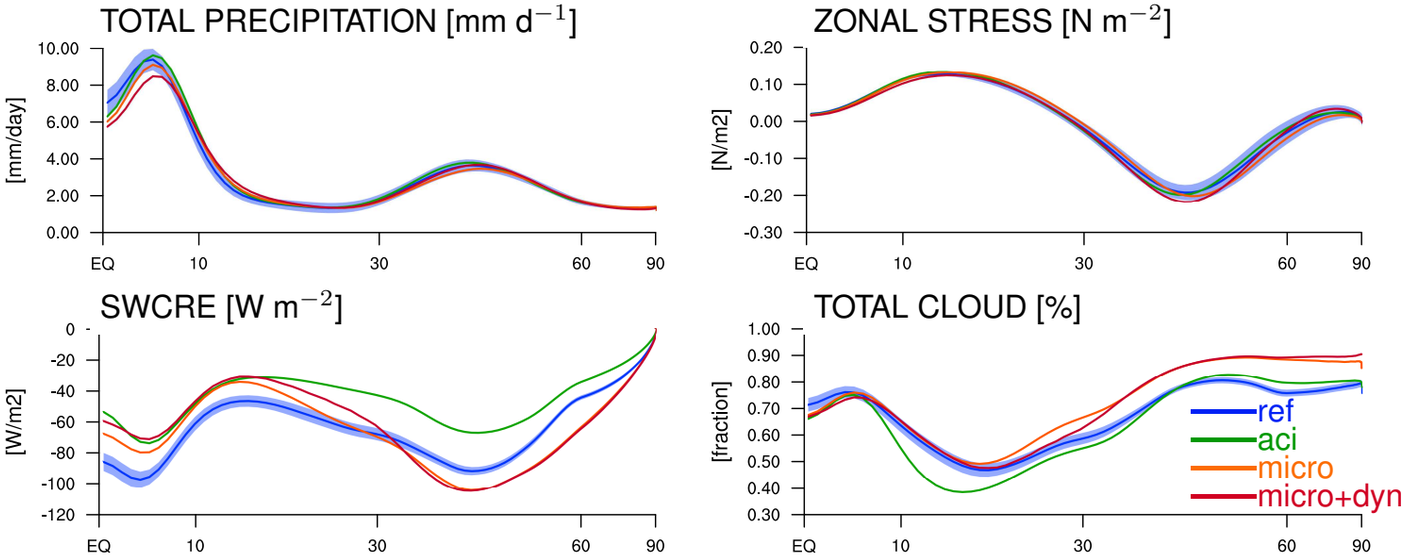
CLOUD EFFECT PARAMETER

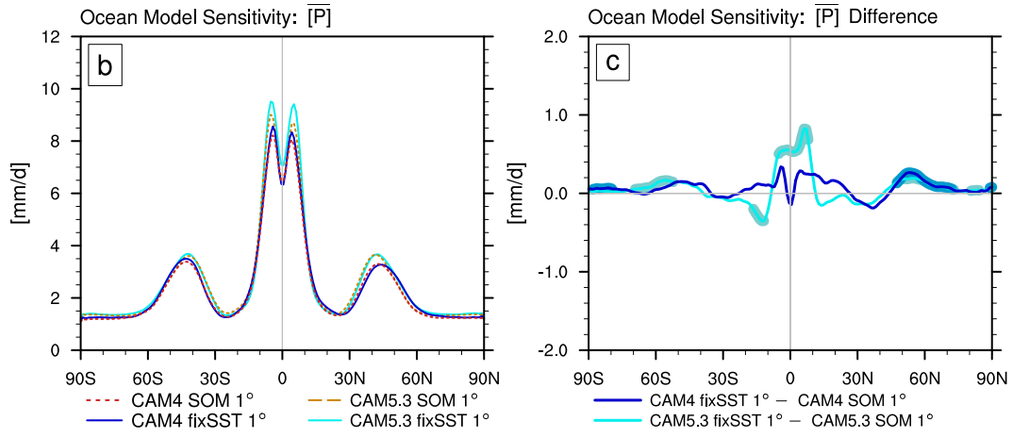
Response to external forcing (warming)

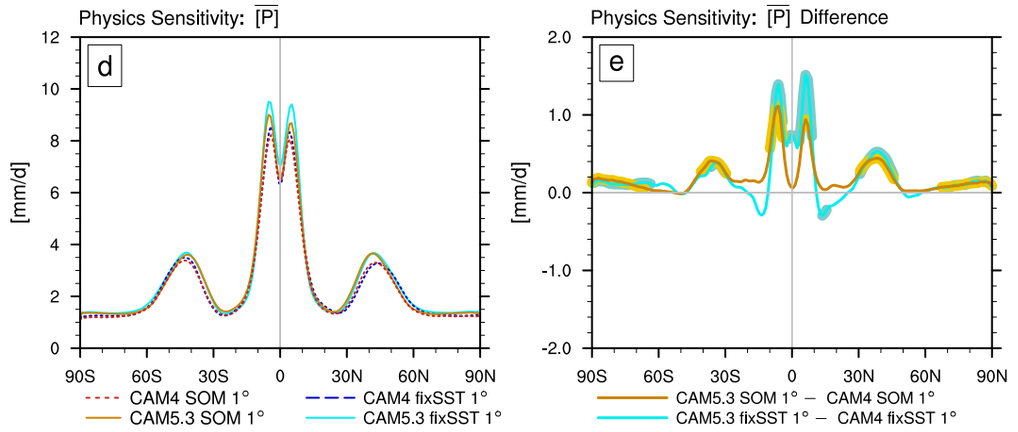


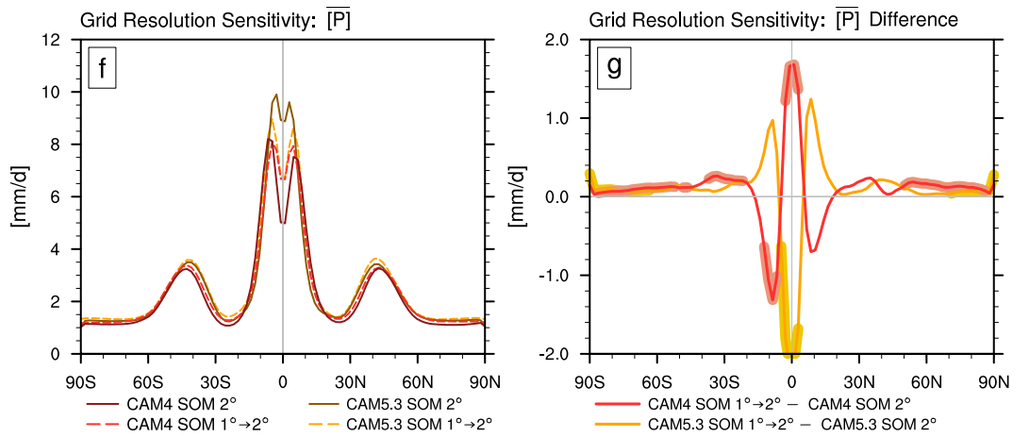
Change in CRE for CAM aquaplanets under SST+4K.

Sensitivity to model structure









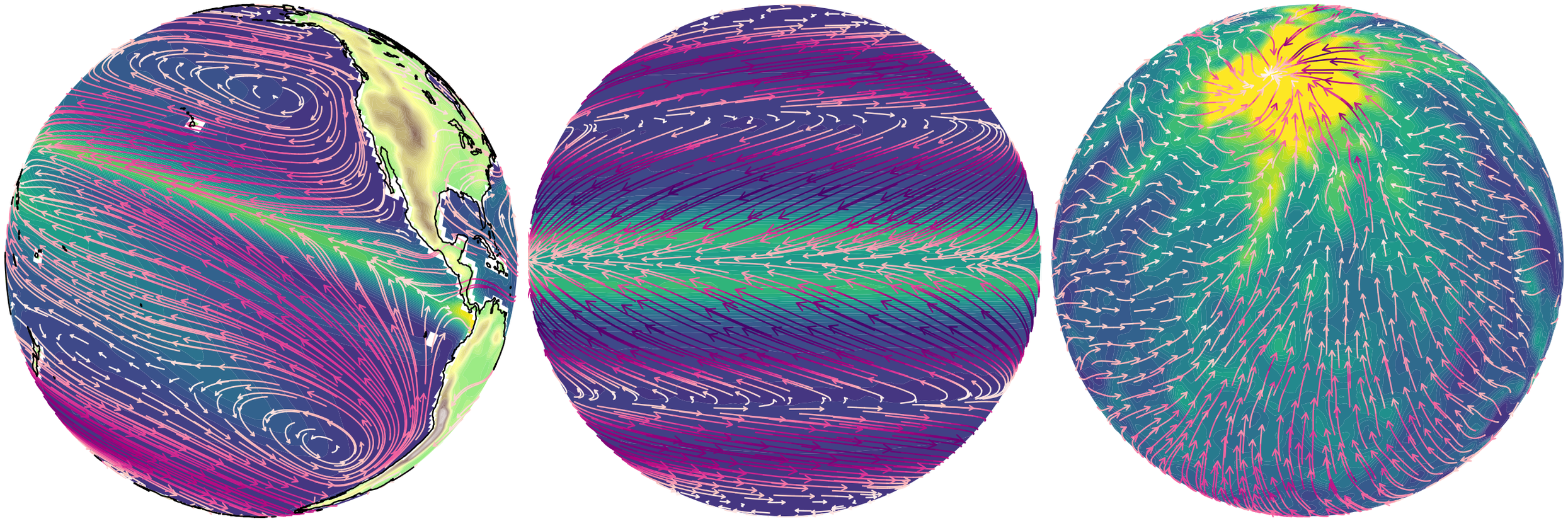
Changes with aerosol assumptions, microphysics, and dynamical core (Medeiros et al. 2016).

Precipitation sensitivity to physics package, air-sea coupling, and resolution (Benedict et al. 2017)

“AMIP”

AQUAPLANET

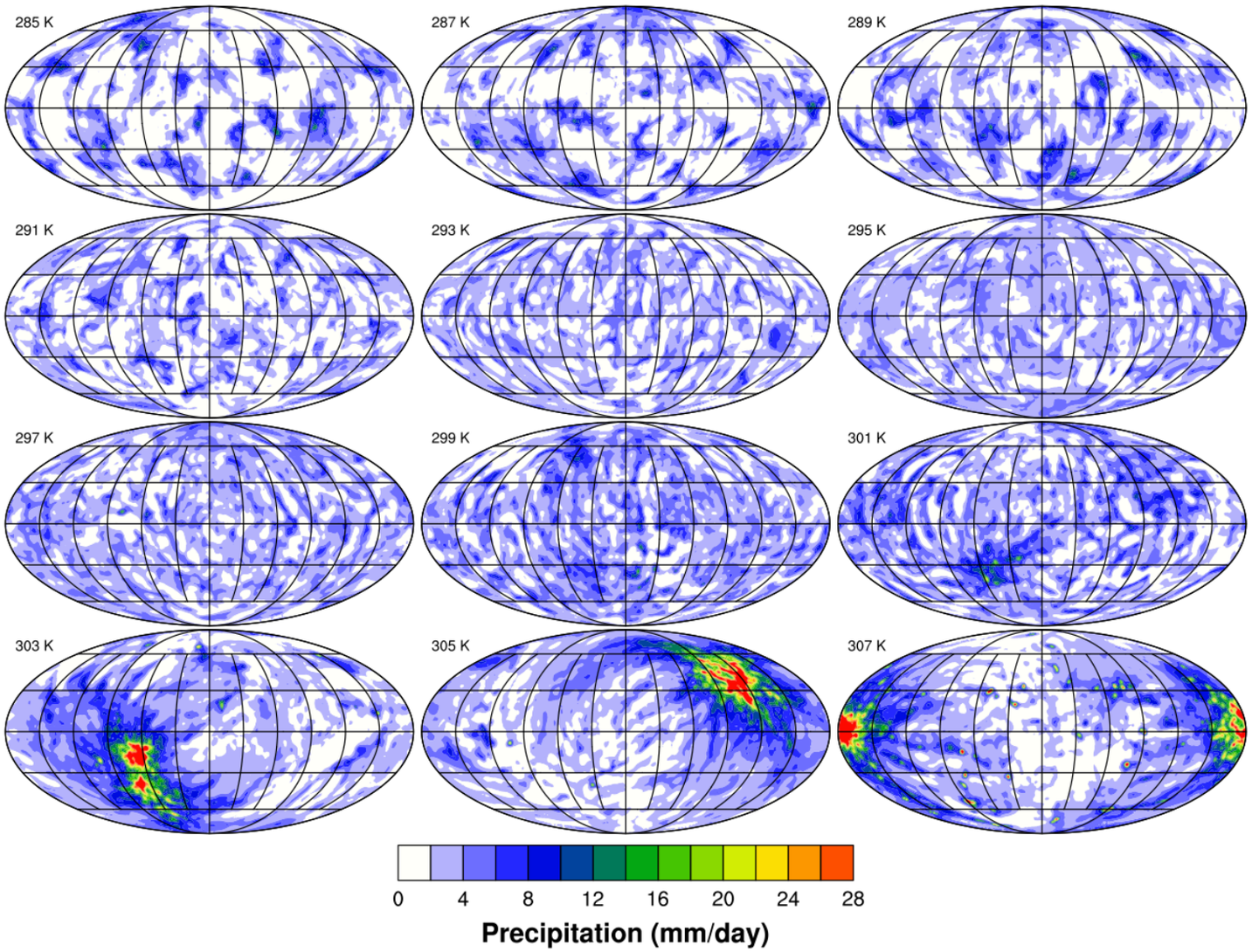
RCE

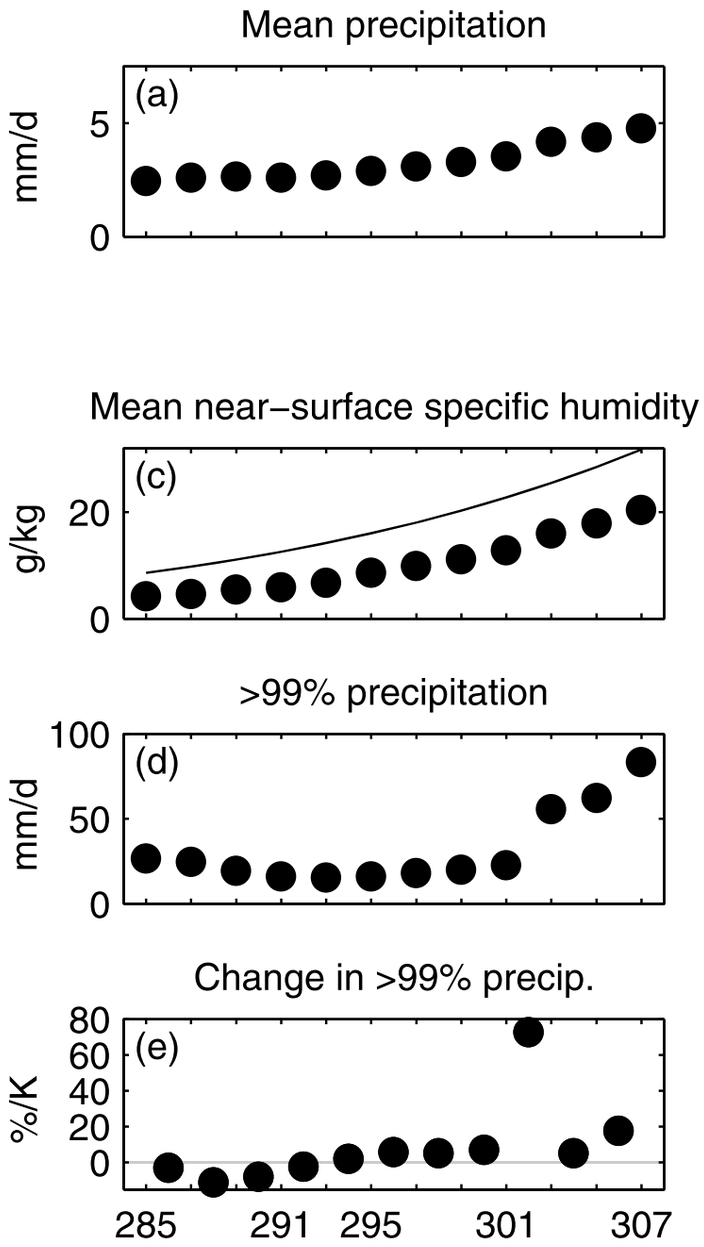


Land/Topography/Ice
Seasonality

Uniform SST
No diurnal cycle
Uniform insolation
No rotation

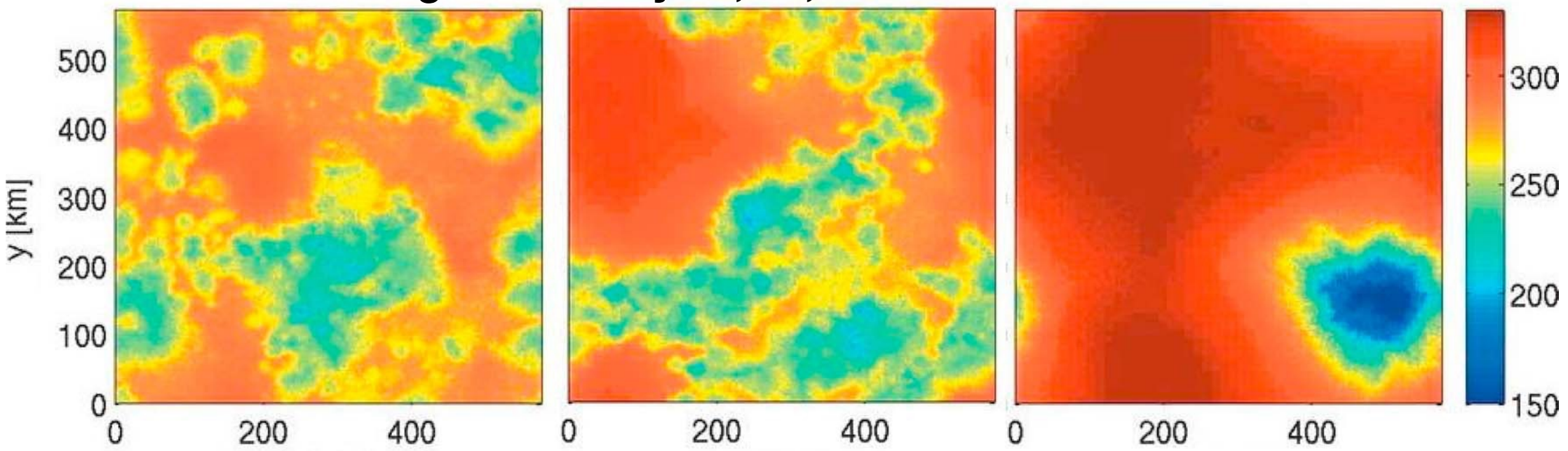
RCE: precipitation changes with T_{sfc}

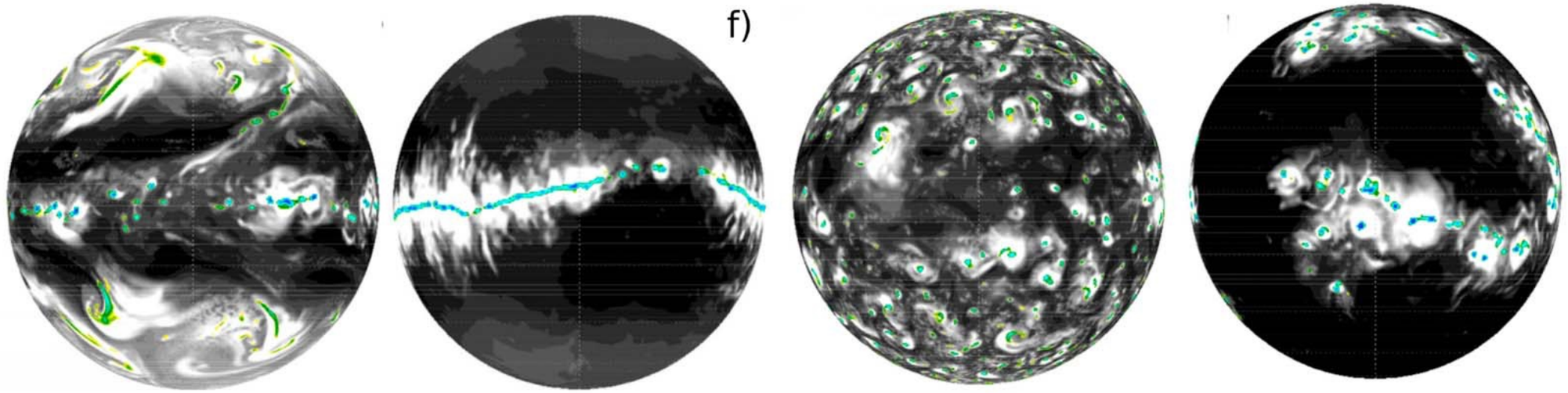




Pendergrass et al. GRL 2016

Cloud-resolving model: day 10, 20, 50





AQUAPLANET **Non-rotating** **RCE (rotating)** **RCE (non-rotating)**

Maher et al. 2019

Thinking about RCE in a SCM…

Geophysical Research Letters

Atmospheric Science | Free Access

Multiple equilibria in a single-column model of the tropical atmosphere

A. H. Sobel, G. Bellon, J. Bacmeister

First published: 20 November 2007 | https://doi.org/10.1029/2007GL031320 | Cited by: 43

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Abstract

[1] A single-column model run under the weak temperature gradient approximation, a parameterization of large-scale dynamics appropriate for the tropical atmosphere, is shown to have multiple stable equilibria. Under conditions permitting persistent deep convection, the model has a statistically steady state in which such convection occurs, as well as an extremely dry state in which convection does not occur. Which state is reached depends on the initial moisture profile.

Requirements:

- Ocean surface with fixed SST
- No Coriolis effect
- No seasonal cycle (every day should be the same)
- No diurnal cycle (constant sunshine)
- [reduced insolation]

Hints:

- Consider the available IOPs
- Coriolis in SCAM? What controls Coriolis strength?
- Why are there seasons?
- Why does sunshine vary by location?

Preliminary solution outline

Configuration change:

Modify the csh script to change to an ocean IOP (e.g., cgilsS6) (or location)

Namelist change:

Turn off seasons: modify orbital parameters in user_nl_cpl

Source code modifications:

Turn off Coriolis:

`physconst.F90 (physconst_readnl) and put in src.cam`

Uniform insolation:

`modify solar zenith angle calculation in`
`shr_orb_mod.F90 (suggest: cos(0.73391095))`

Stretch goals

Boundary Condition change: Make SST constant

`/opt/ncar/inputdata/atm/cam/sst/sst_HadOIBl_bc_1x1_2000climo_c180511.nc`

- Idealized modeling enables a reductionist approach to understanding the climate system.
- There is a long history of such modeling (in fact, the evolution of models parallels this approach)
- CESM2 has enhanced support for simpler/idealized configurations (probably more than any other earth system modeling platform); more still coming.
- The CESM developers encourage the community to establish needs for additional configurations, and are willing to collaborate to implement them. *But they need to be configurations of widespread appeal.