Simulation vs. understanding

Isaac Held

WCRP Model Hierarchies Workshop
Princeton, November, 2016

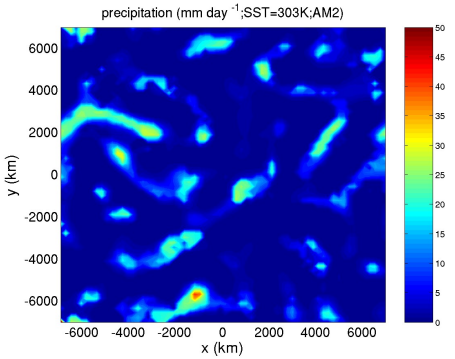
Simulation ~~vs.~~ AND understanding

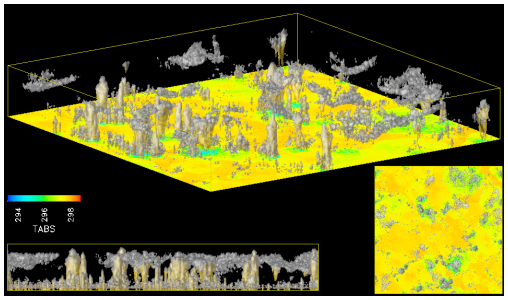
Isaac Held

WCRP Model Hierarchies Workshop
Princeton, November, 2016

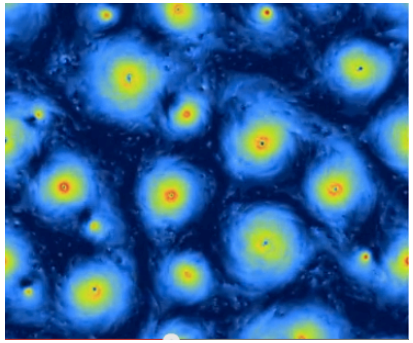
A hierarchy of geometries

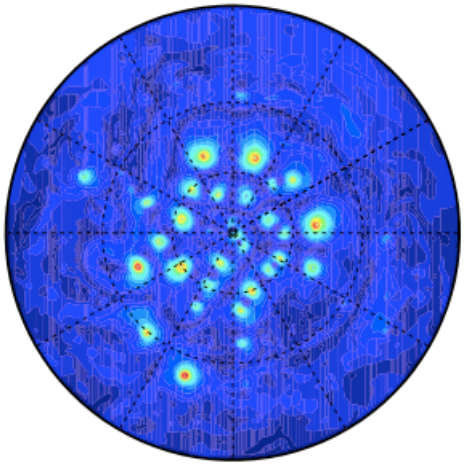
Non-rotating RCE



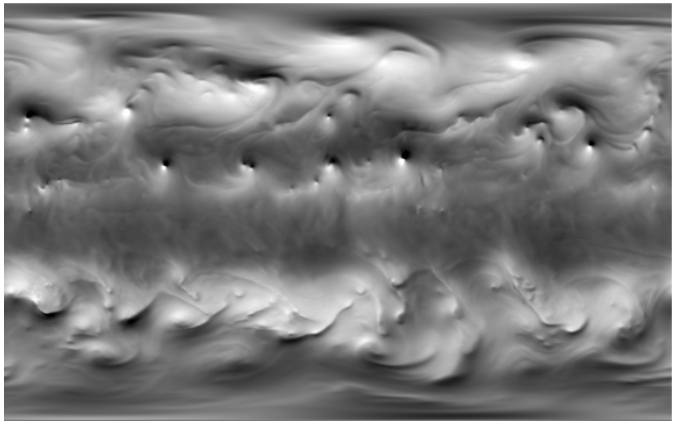


Rotating RCE: f-plane
or sphere



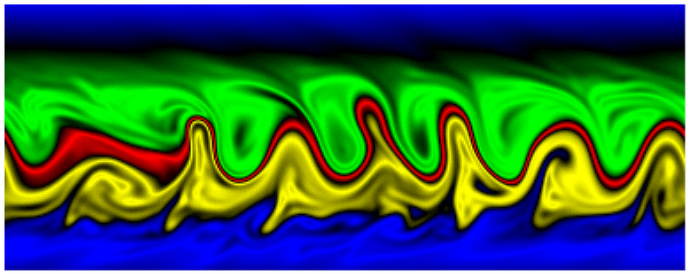


aquaplanet

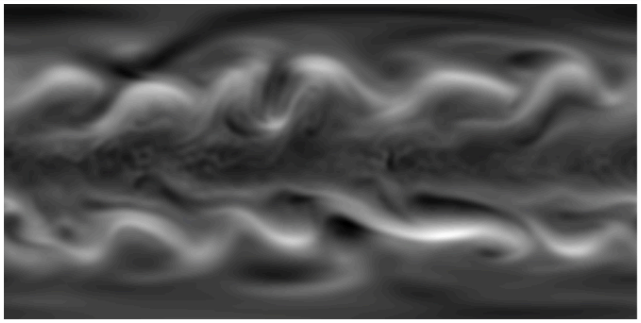


A hierarchy of dynamics

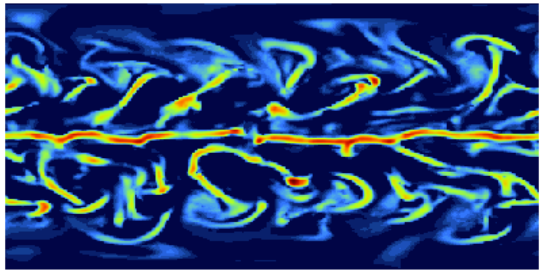
QG



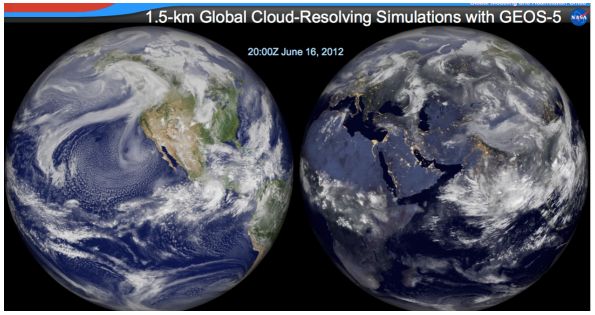
Dry dynamics on sphere



Moist dynamics on sphere with parameterized convection



Global non-hydrostatic

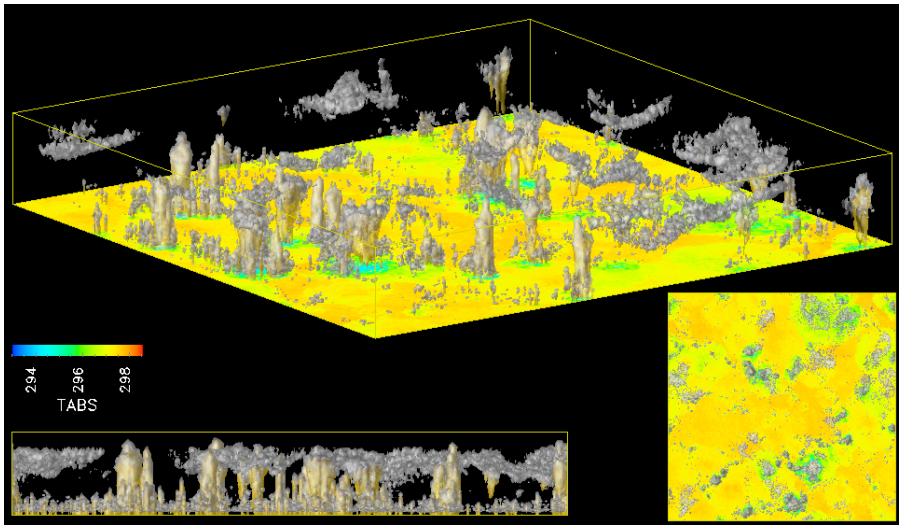


Why construct and study climate model hierarchies?

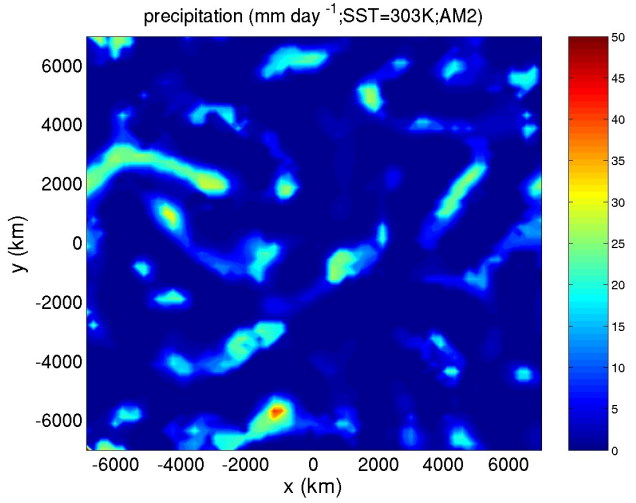
We want to contribute to solving important problems facing the world
(improving simulations)

We want to understand the climate system
(avoiding the obsolescence of simulations)

We want to help communicate the results of climate modeling
(emulating simulations)



P. Blossey, C. Bretherton



Held, Zhao, Wyman, 2006

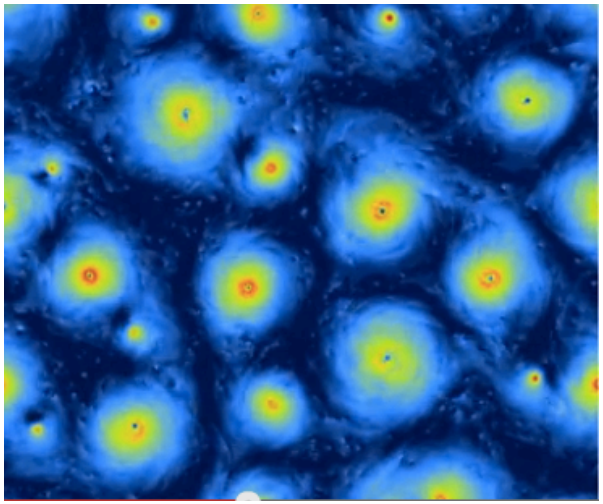
Non-rotating Radiative-Convective Equilibrium

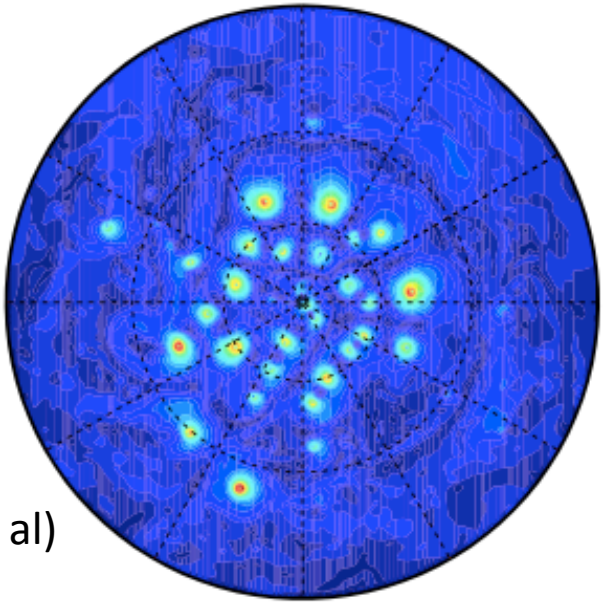
Is this a useful framework for testing convection parameterizations?

Can we understand differences in RCE behavior in different GCMs?

Can we show that cloud resolving simulations are robust (given a microphysical mechanism)?

Rotating radiative convective equilibirum





(Wenyu Zhou, et al)

As we move to higher resolution we taking GCM simulations of tropical cyclone climatology more and more seriously

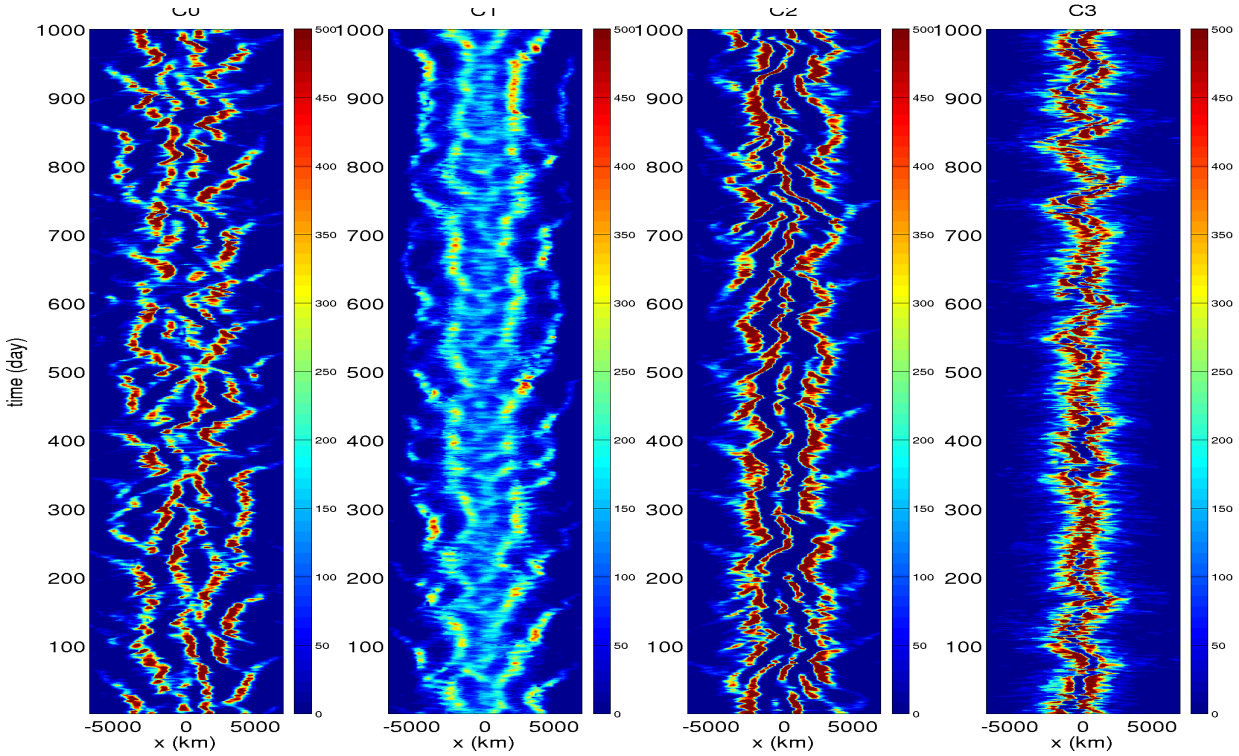
Is there an hierarchy of idelaized models that can help us understand differences between the TC response to warming in these GCMs? Can this lead to model improvements?

Do cloud resolving models give a convergent robust result for rotating RCE, providing a robust target for lower resolution models?

Mock Walker cell – non rotating – SST(x)

– 2D model with AM2.1 physics and resolution Ming Zhao (unpublished)

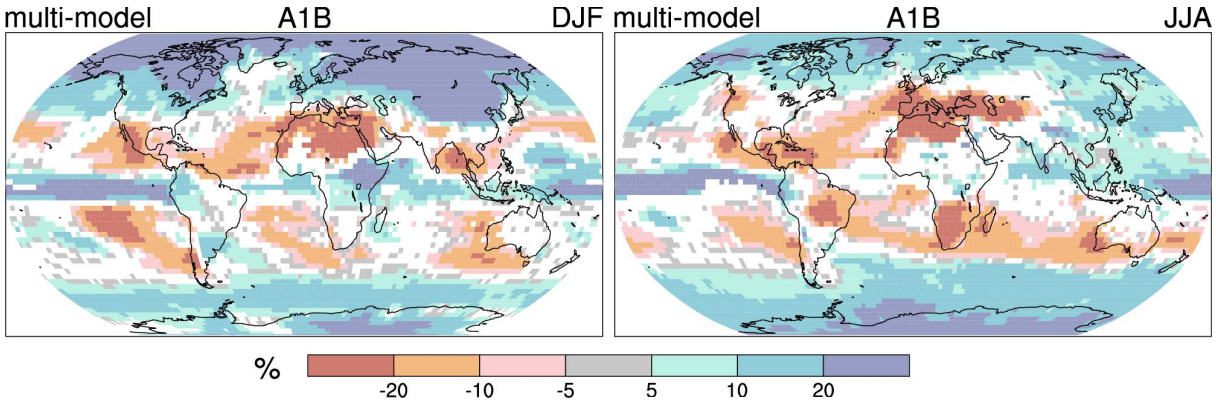
AM2 default **No Tok.&CCWF=0** **Conv. gustiness** **Non-local CMT**



What do you do with this?

Try to understand it? Is there still interest in this model?

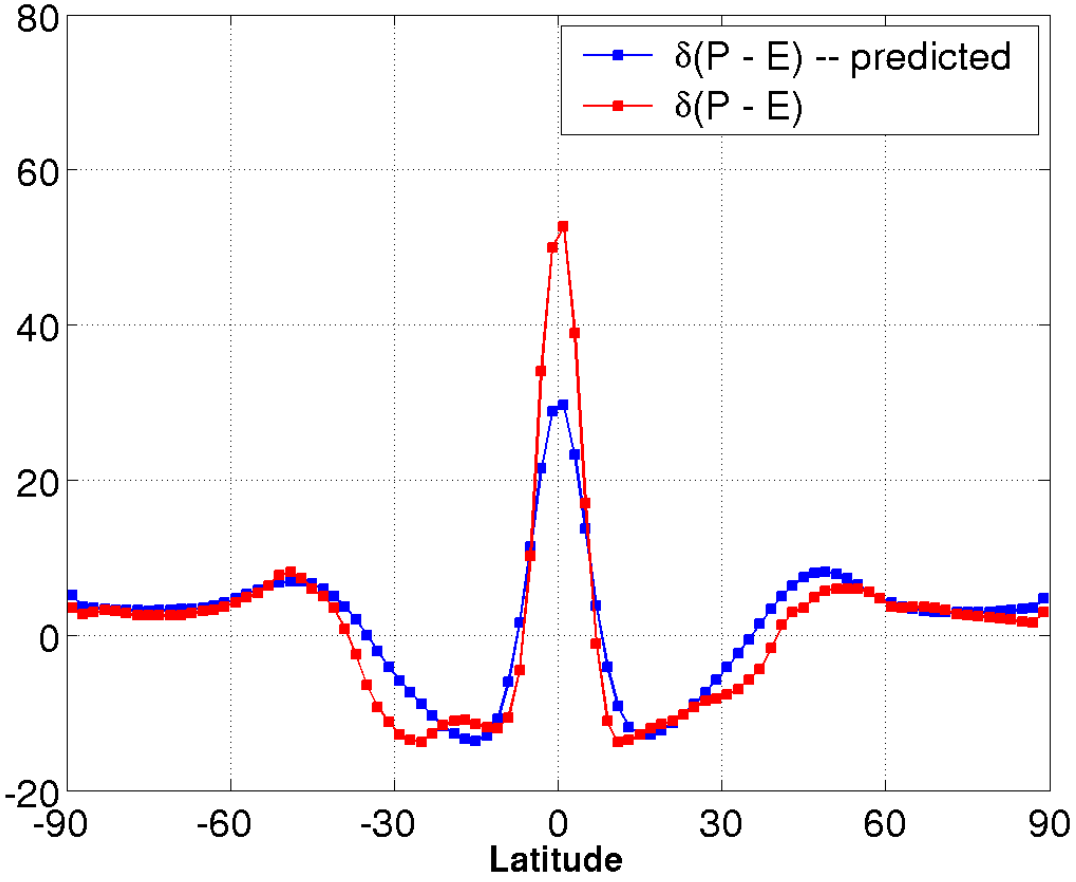
Can we get robust solutions with cloud-resolving models? (ie Z. Kuang)



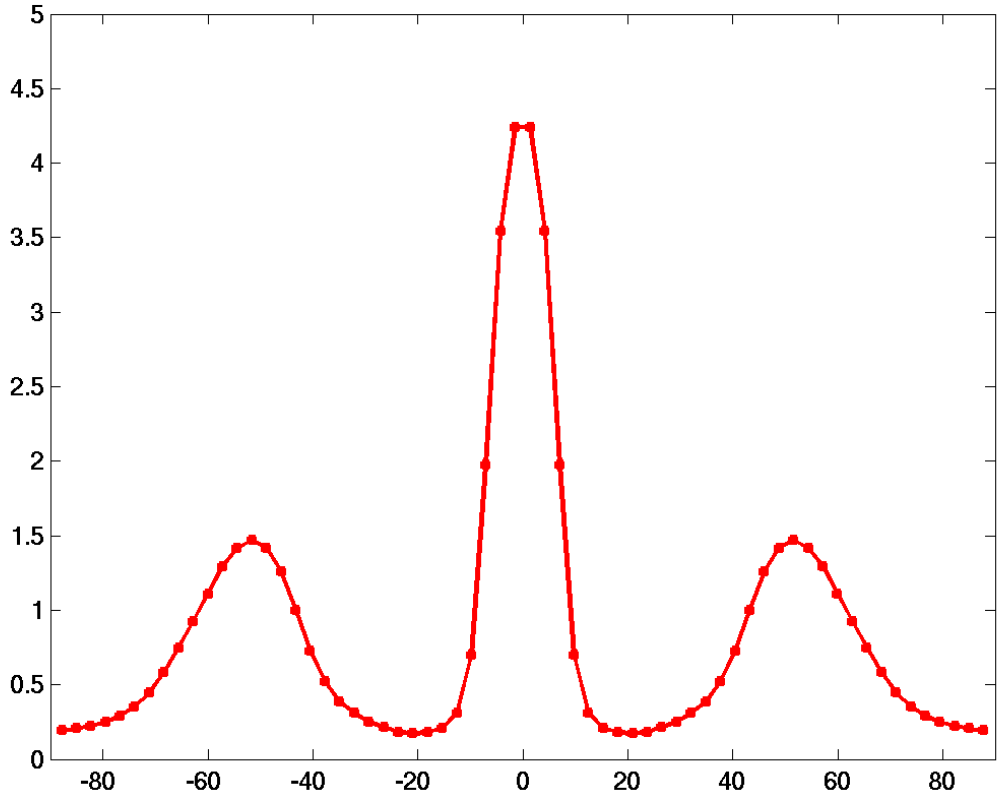
CMIP3 composite precipitation change in A1B scenario

"Wet gets wetter"

Aquaplanet GCM/slab ocean response to 2XCO2

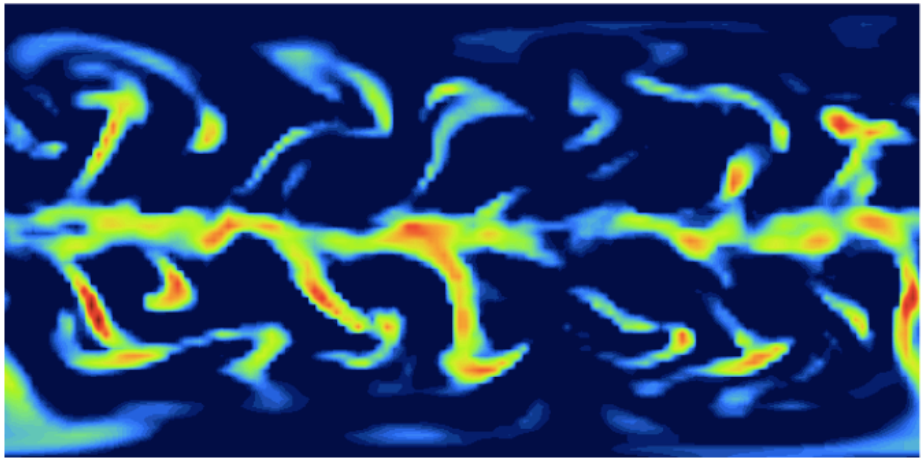


Dry dynamical core plus passive water-like tracer

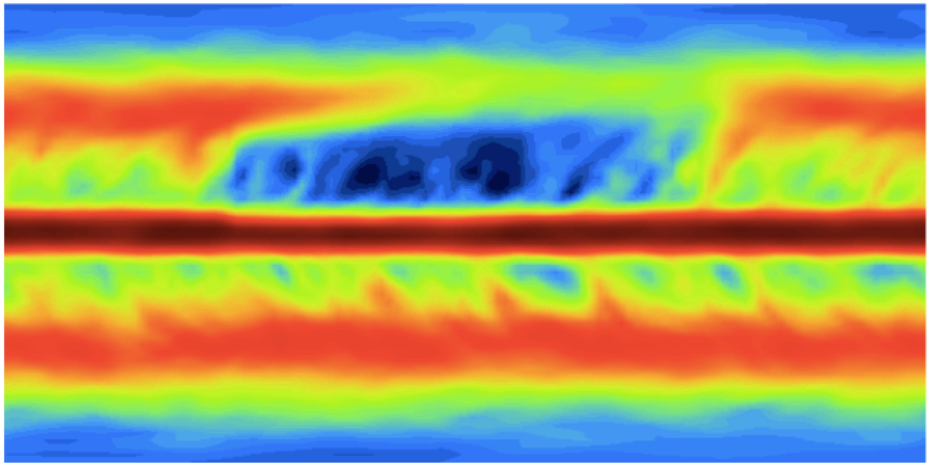


Precipitation

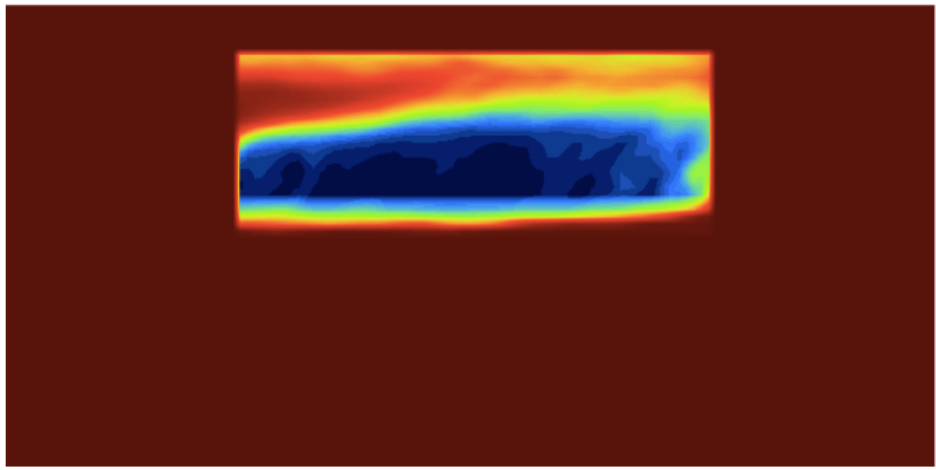
Dry model with passive water and bucket hydrology over rectangular continent



Daily precipitation



100-day average precipitation



100-day average “soil moisture”

Claim: Our understanding of the climate system
in the 21st century
will be embedded in elegant hierarchies of climate models

Elegant ⇔ Neither simpler nor more complex than they need to be

Hope: simulation models will eventually become elegant
by being subsumed within these hierarchies

Model hierarchies tell a story that is helpful (essential?)
in communicating our understanding
outside of the climate science community

We can't make up stories – our model hierarchy
justifies the stories that we tell