Simulation vs. understanding

Isaac Held

WCRP Model Hierarchies Workshop
Princeton, November, 2016
Simulation vs. AND understanding

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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)
Non-rotating Radiative-Convective Equilibrium

P. Blossey, C. Bretherton

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)?

Held, Zhao, Wyman, 2006
As we move to higher resolution we taking GCM simulations of tropical cyclone climatology more and more seriously.

Is there an hierarchy of idealized 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– 2D model with AM2.1 physics and resolution  Ming Zhao (unpublished)

<table>
<thead>
<tr>
<th>AM2 default</th>
<th>No Tok.&amp;CCWF=0</th>
<th>Conv. gustiness</th>
<th>Non-local CMT</th>
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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)
Aquaplanet GCM/slab ocean response to 2XCO2

“Wet gets wetter”

CMIP3 composite precipitation change in A1B scenario
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