

***Some theoretical questions about  
convective parameterization***

*Isaac Held*

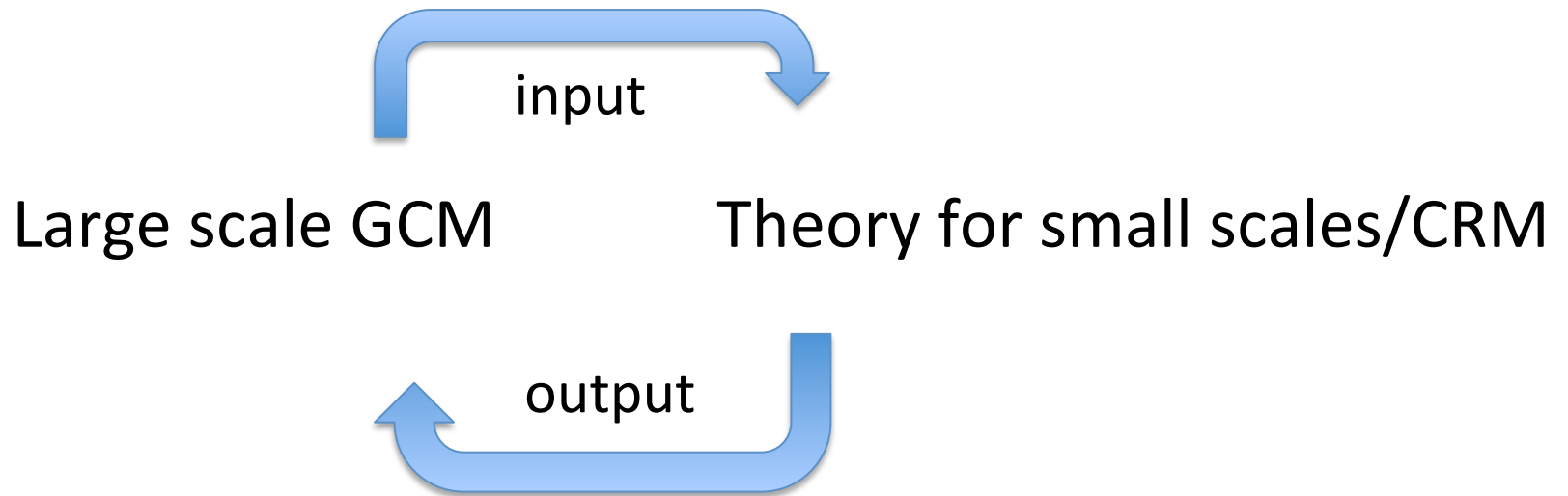
*Lorenz Center Workshop  
Feb 2014*

*Two types of parameterization:*

1) *Theory/model of sub-grid scale fluxes*  
*[Classic column physics convective closure;*  
*Superparameterization]*

2) *Lending the resolved scales a helping hand*  
*[Smagorinsky, Leith turbulence closures]*

*analogy with oceanic mesoscale eddy closure;*  
*the (in)stability of radiative-convective equilibrium*

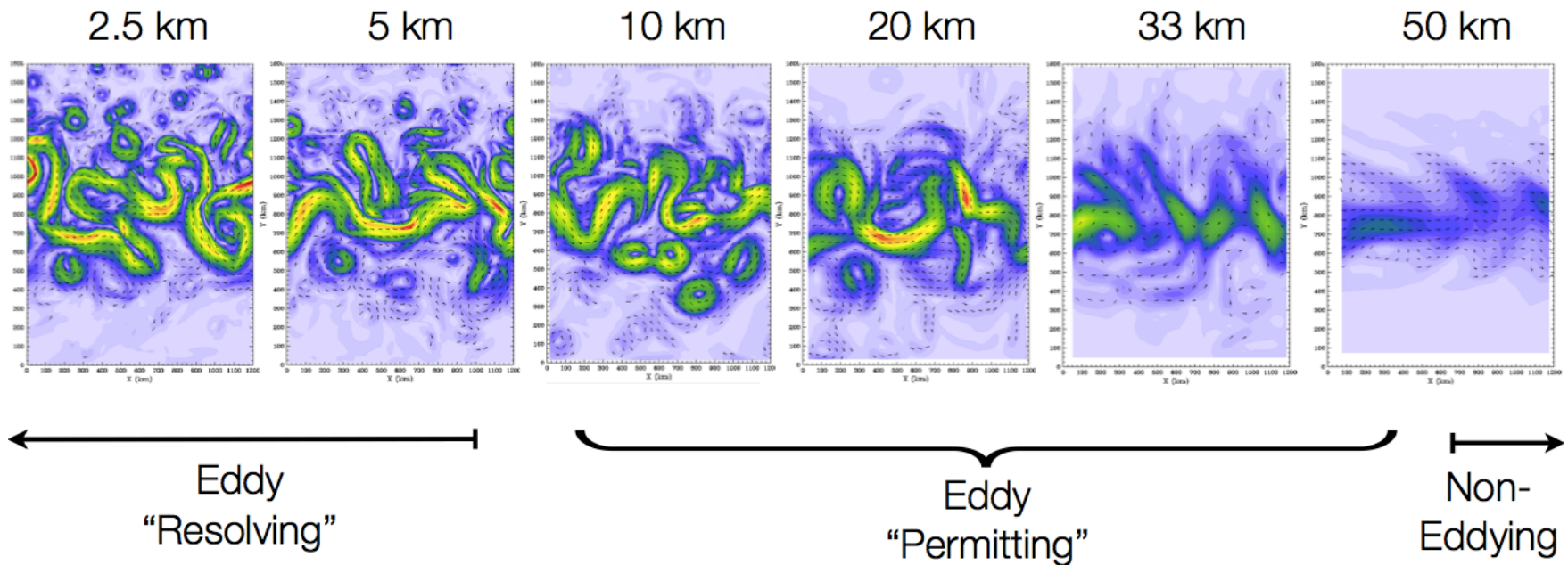


Is convection parameterizable? (What does that mean?)

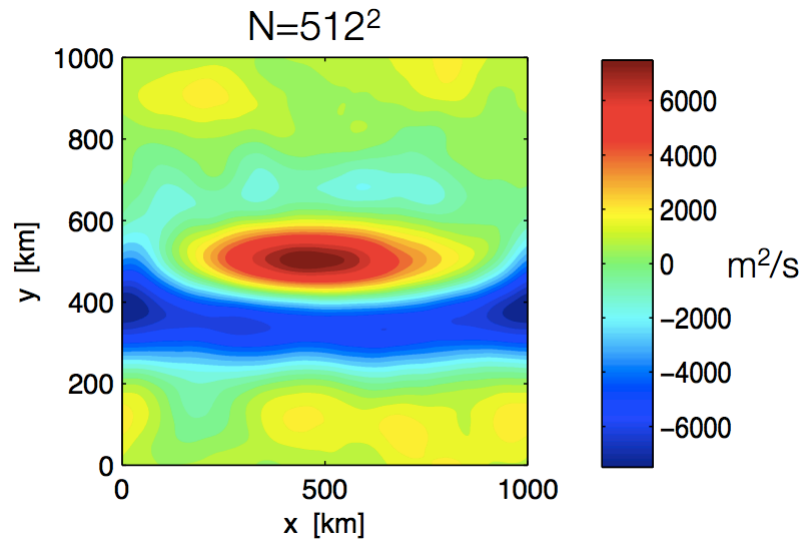
Can we mimic superparameterization with simpler model (without explicit fluid dynamics)?

Series of idealized simulations of zonal jet in 1200 km x 1600 km zonally re-entrant domain (from Hallberg 2013)

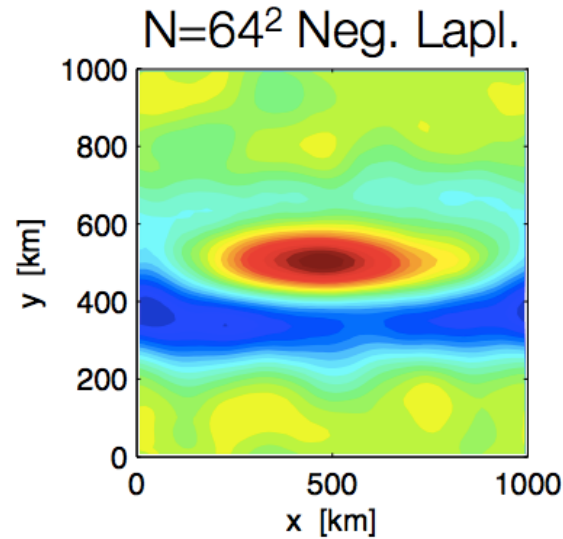
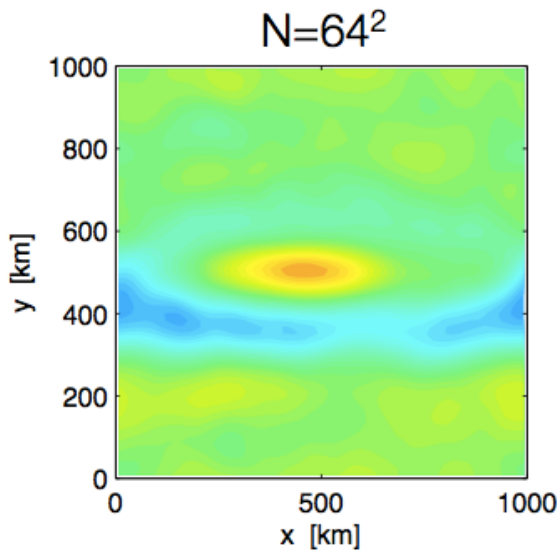
Snapshots of upper ocean velocity at various resolutions ( $k_d^{-1} \approx 30\text{km}$ ):



# Mean flow in simple 2-layer turbulent QG channel with isolated topographic feature

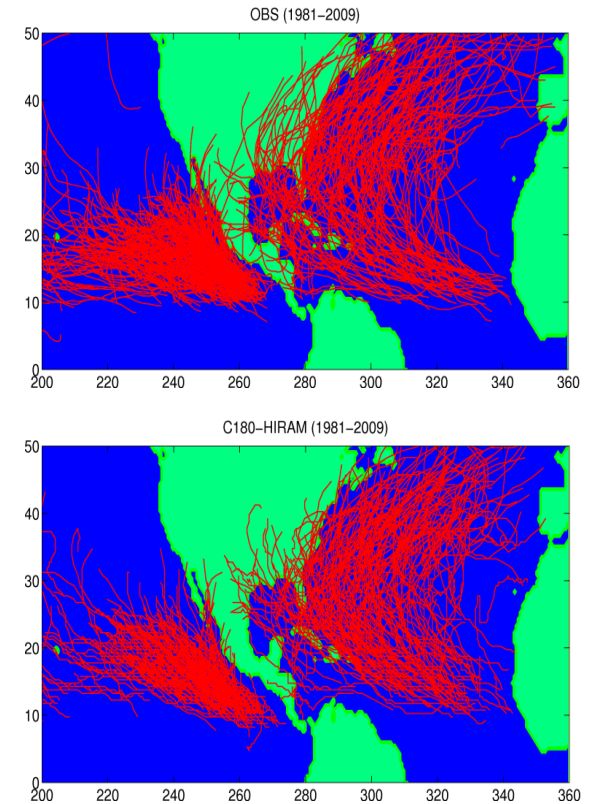
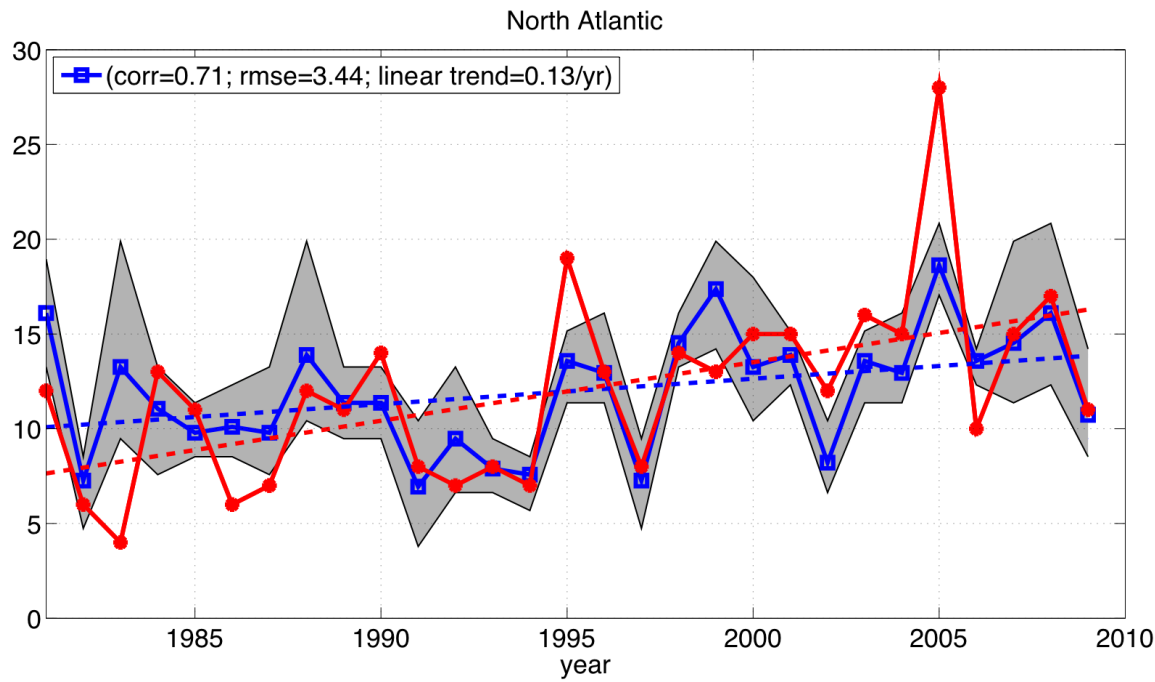


Malte Jansen  
To be submitted

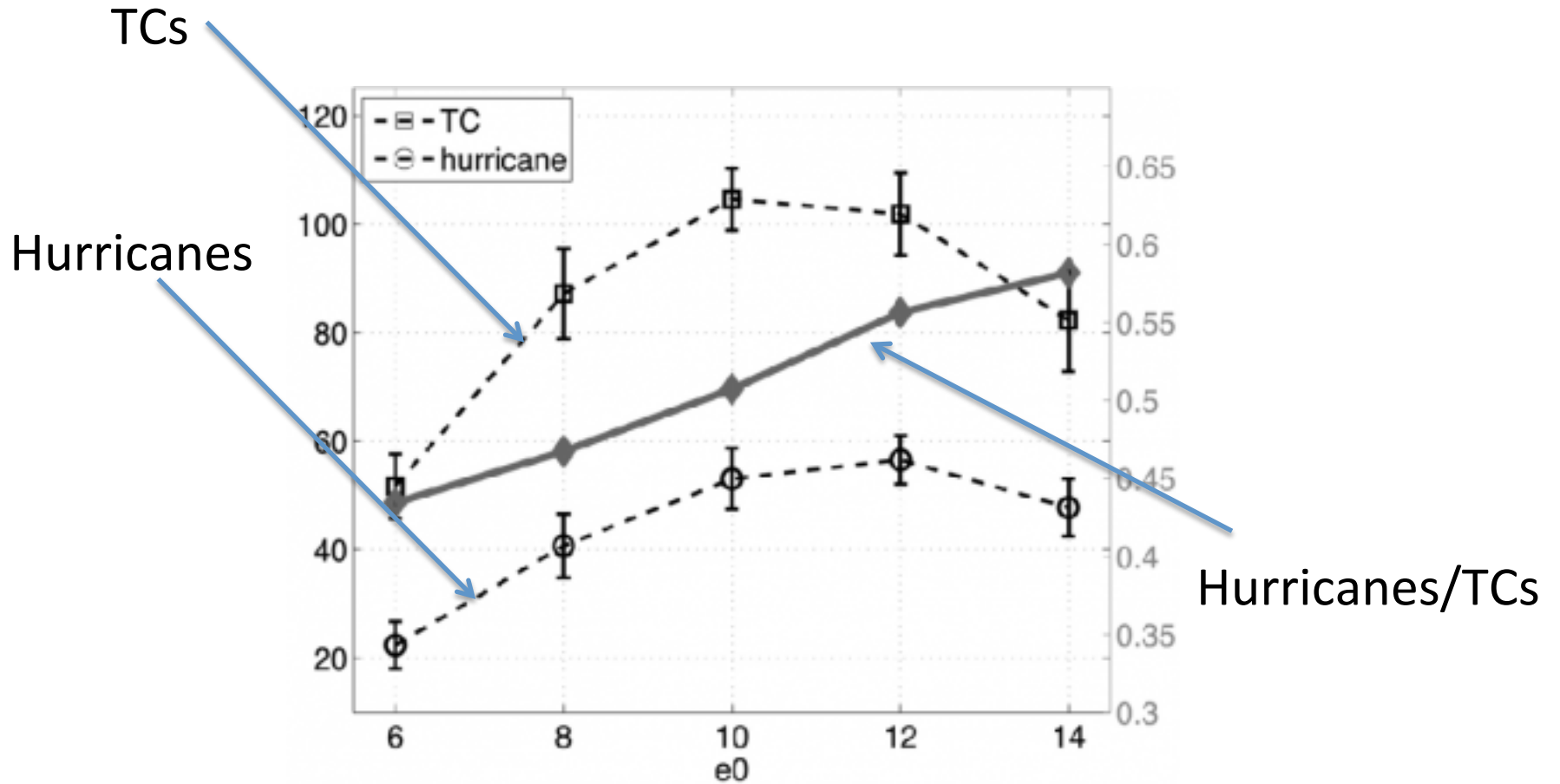


Low level  
streamfunction  
(driven by eddies)

# HiRAM 50 km



# Effect of change in convection scheme on TCs in HiRAM



Inhibiting parameterized convection =>

# Hypohydrostatic rescaling

*Can we decrease separation between balanced and convective dynamics?*

*small earth :  $a \rightarrow \alpha^{-1} a$*

*$\Omega \rightarrow \alpha \Omega$ ; other time scales must be reduced*

*alternatively,  $g$  is not parameter in hydrostatic core :*

*deep earth :  $g \rightarrow \alpha^{-1} g$*

*more simply :  $\frac{Dw}{Dt} \rightarrow \alpha^2 \frac{Dw}{Dt}$*

*$\alpha = 0 \Rightarrow$  hydrostatic*

*$\alpha = 1 \Rightarrow$  nonhydrostatic*

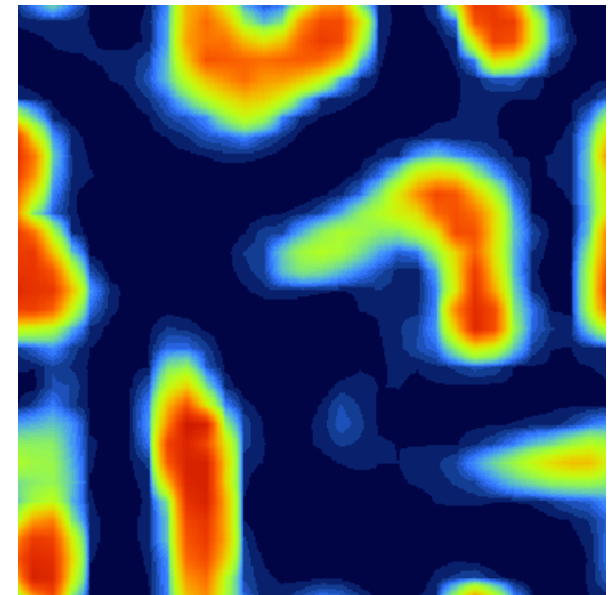
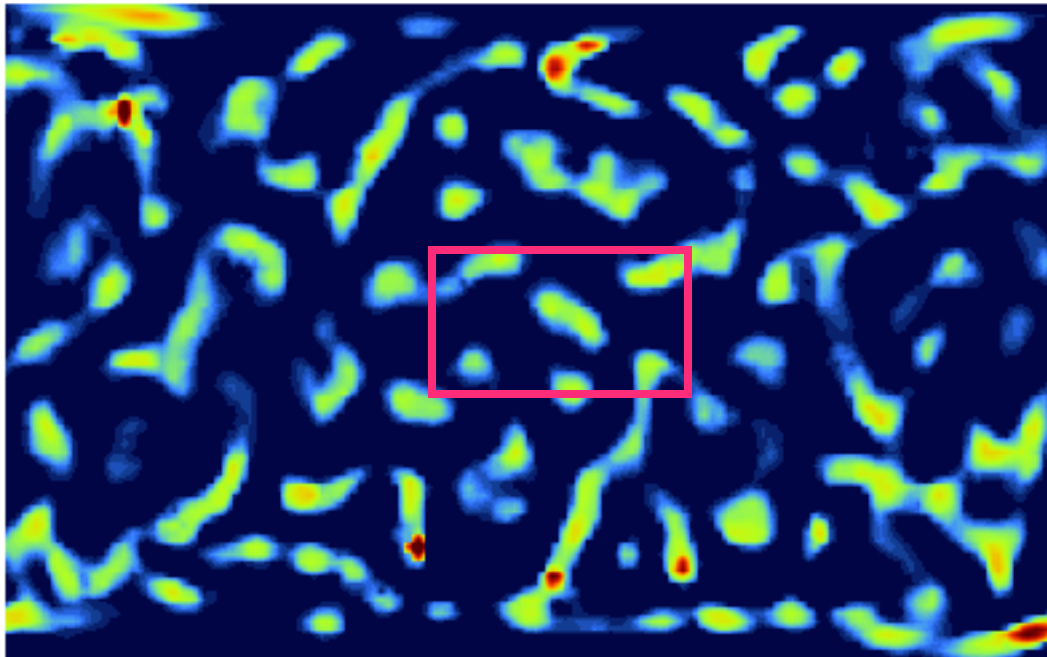
*$\alpha > 1 \Rightarrow$  hypohydrostatic*

Z. Kuang, C. Bretherton, O. Pauluis, S. Garner



Doubly-periodic: 200km grid, 32 x 32

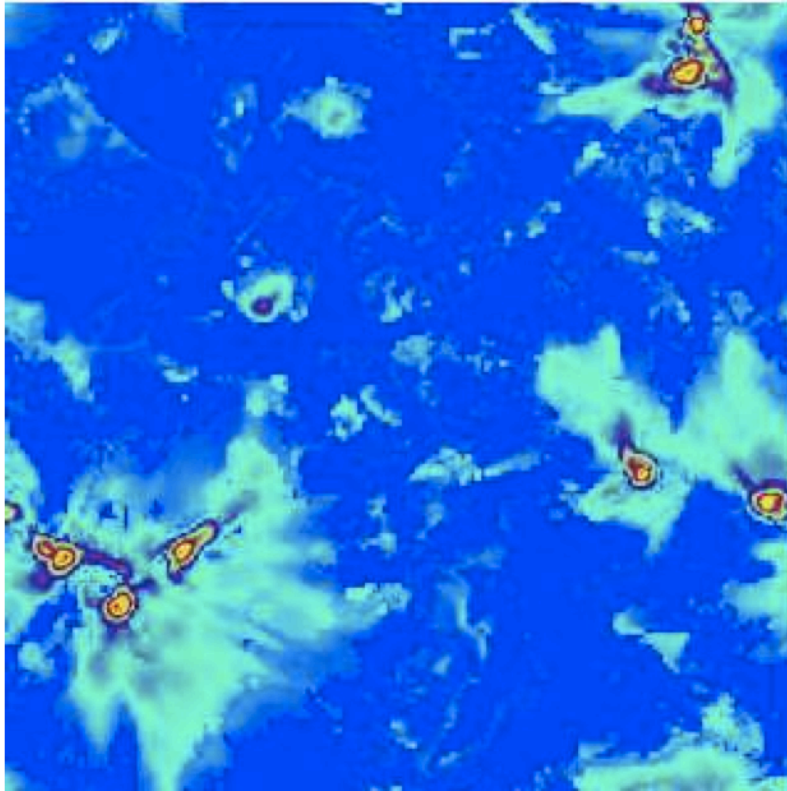
global



Fixed sst

Held, Zhao, Wyman, 2007 – RCE in a GCM (AM2.1)

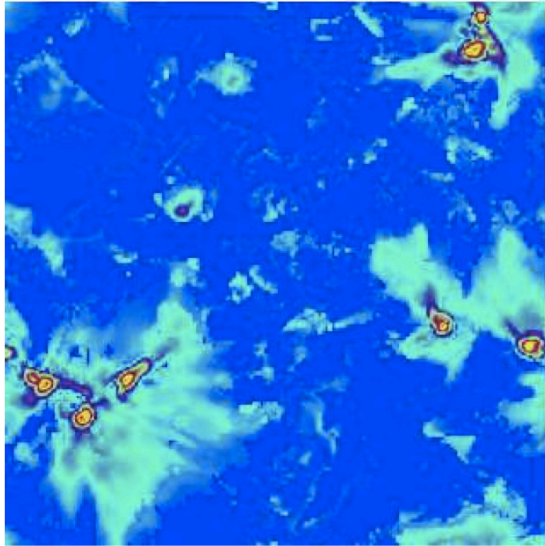
## Non-rotating RCE with standard 25km HiRAM



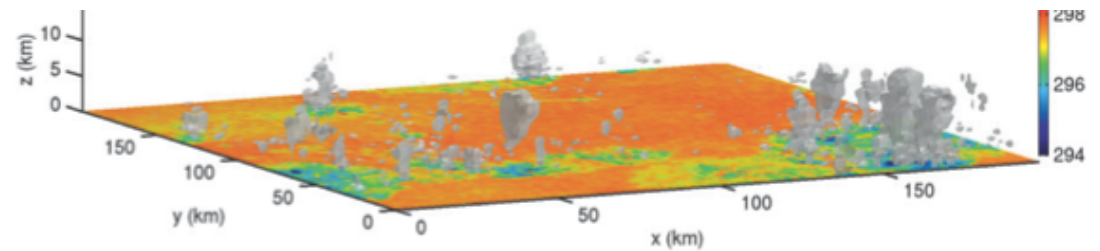
2500km x 2500km  
domain

Instantaneous  
precipitation

Horizontally uniform state **unstable**



25 km HiRAM – Wenyu Zhao



Caroline Muller – using SAM ( 1km)

*Perturb RCE with horizontally uniform cooling, moistening  
-- Kuang, etc*

*Should one test a parameterization scheme by perturbing  
its single-column RCE*

*Or, if RCE with this closure is unstable,  
should one perturb the GCM's RCE instead?*