

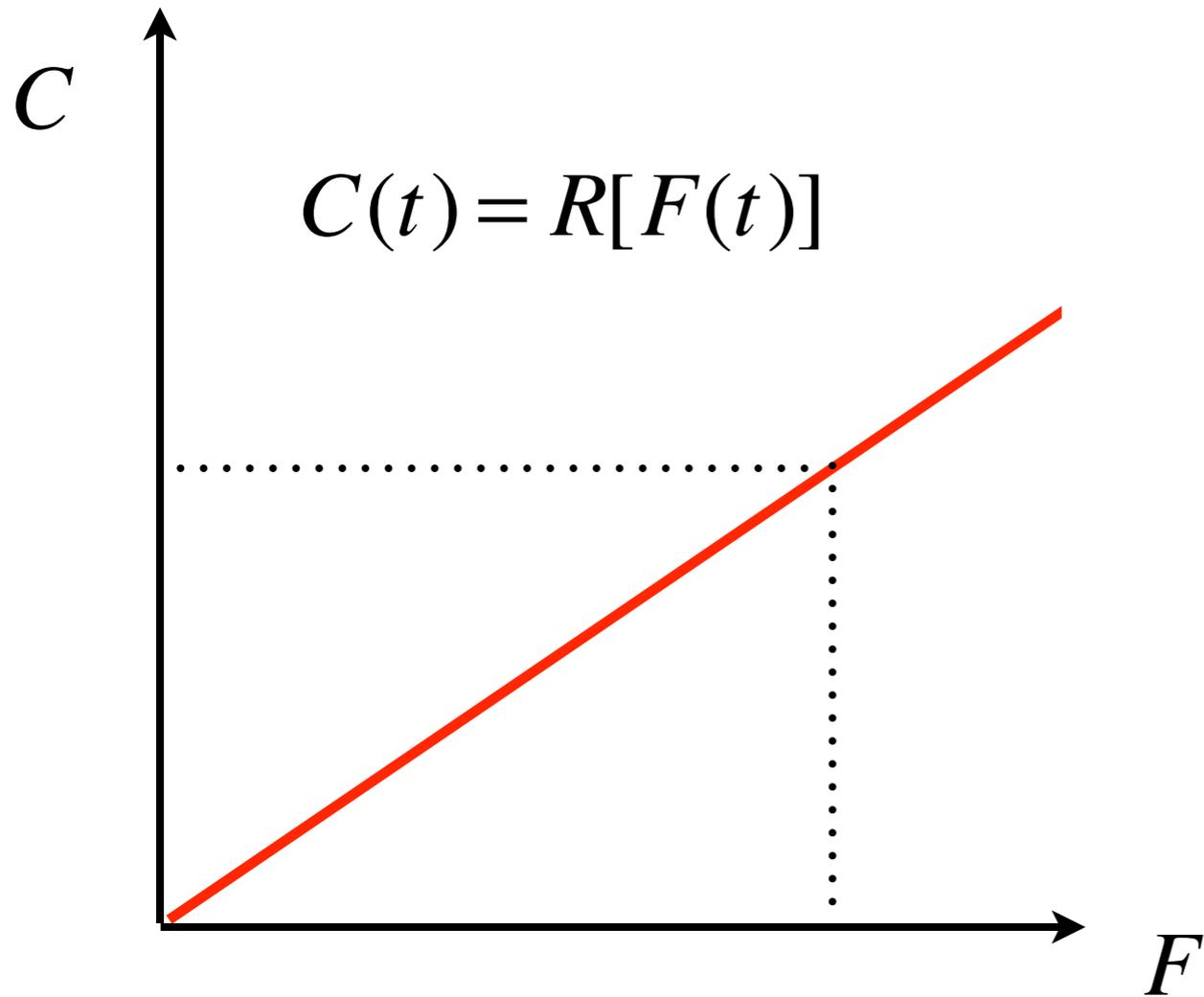
# Chaotic Convection in SP-CAM

David Randall, Mark Branson, and Radha Dutta

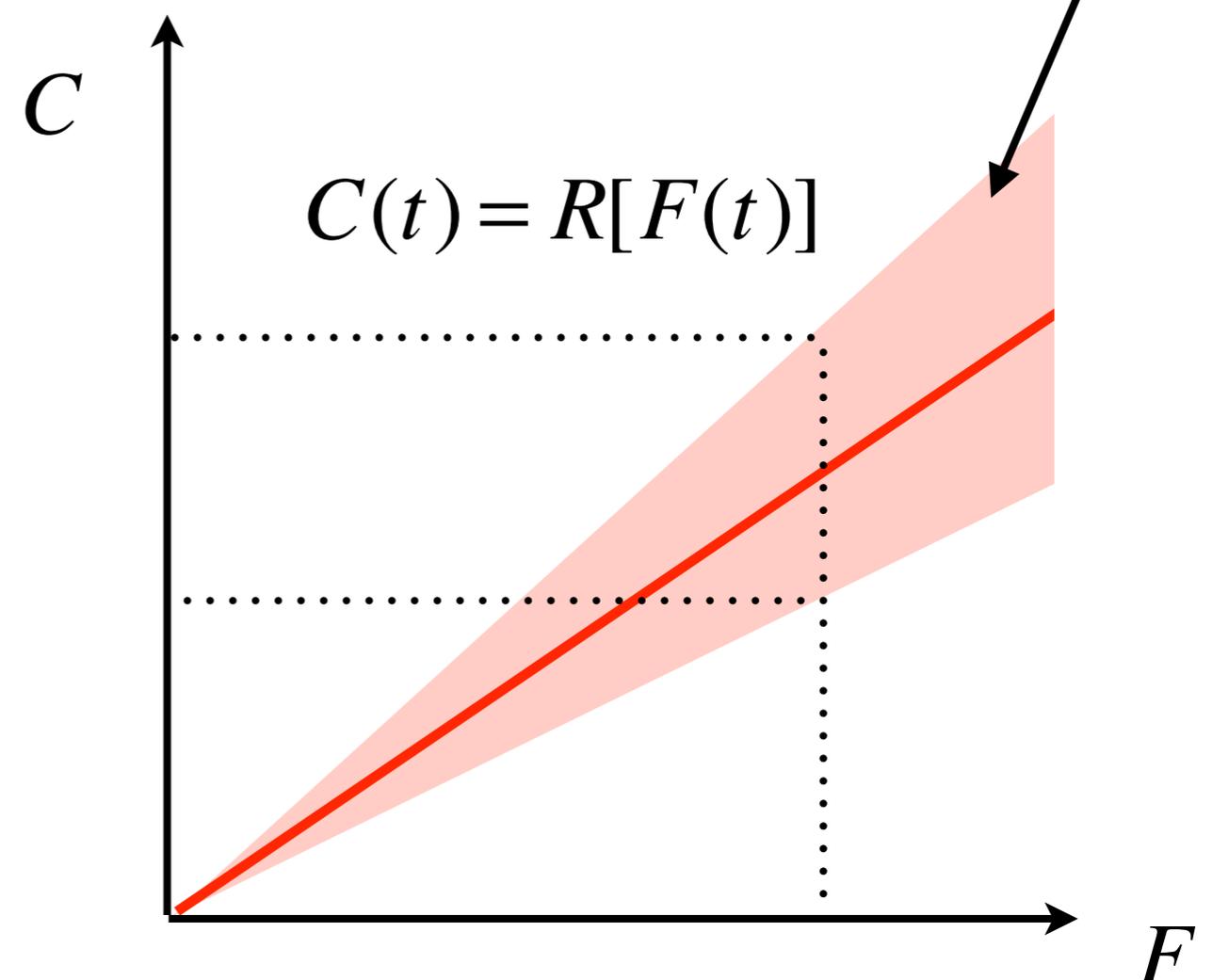


# Deterministic or not?

Width = constant x mean?



Deterministic convection



Non-deterministic convection

# **“Non-deterministic” clouds on unresolved scales are not fully controlled by the resolved-scale weather.**



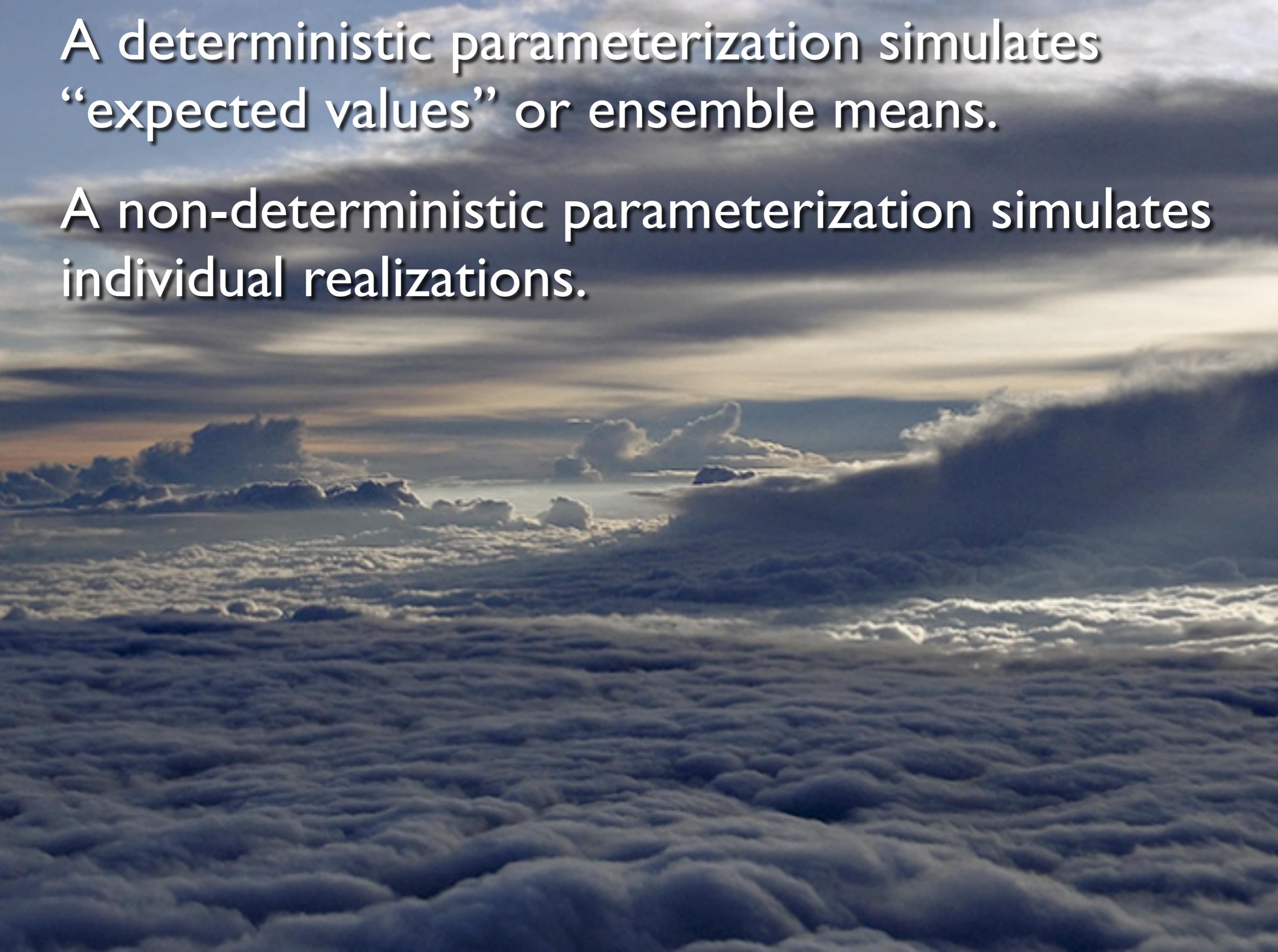
Deterministic  
parameterization



Non-deterministic  
parameterization

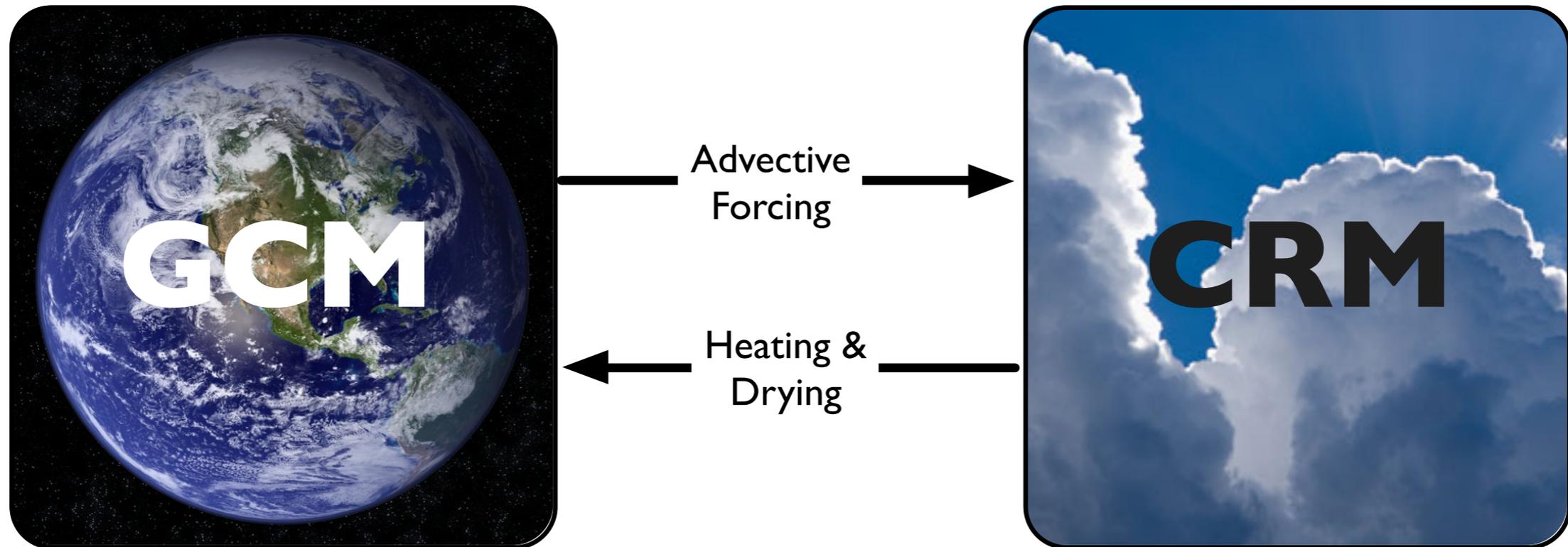
A deterministic parameterization simulates “expected values” or ensemble means.

A non-deterministic parameterization simulates individual realizations.



# SP-CAM

*Forcing and feedback*



**“Super-Parameterization”**

Each CRM runs continuously.

The CRMs do not communicate with each other except through the GCM.

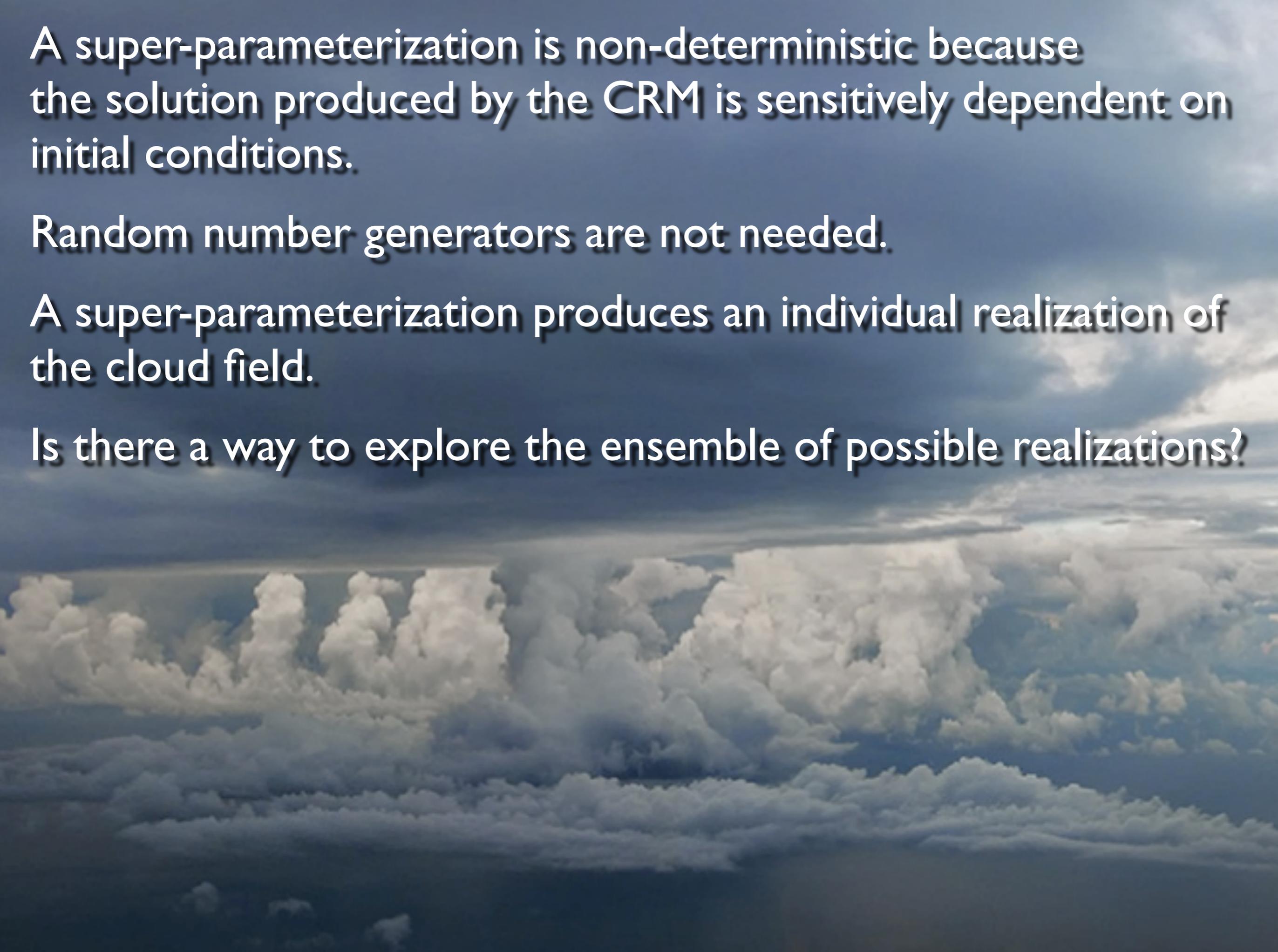
The CRMs and the GCM are coupled in such a way that they remain in synch.

A super-parameterization is non-deterministic because the solution produced by the CRM is sensitively dependent on initial conditions.

Random number generators are not needed.

A super-parameterization produces an individual realization of the cloud field.

Is there a way to explore the ensemble of possible realizations?



# Doppelgänger

Instead of one CRM per GCM grid column, include  $N$  copies of the CRM.

All copies see the same GCM weather.

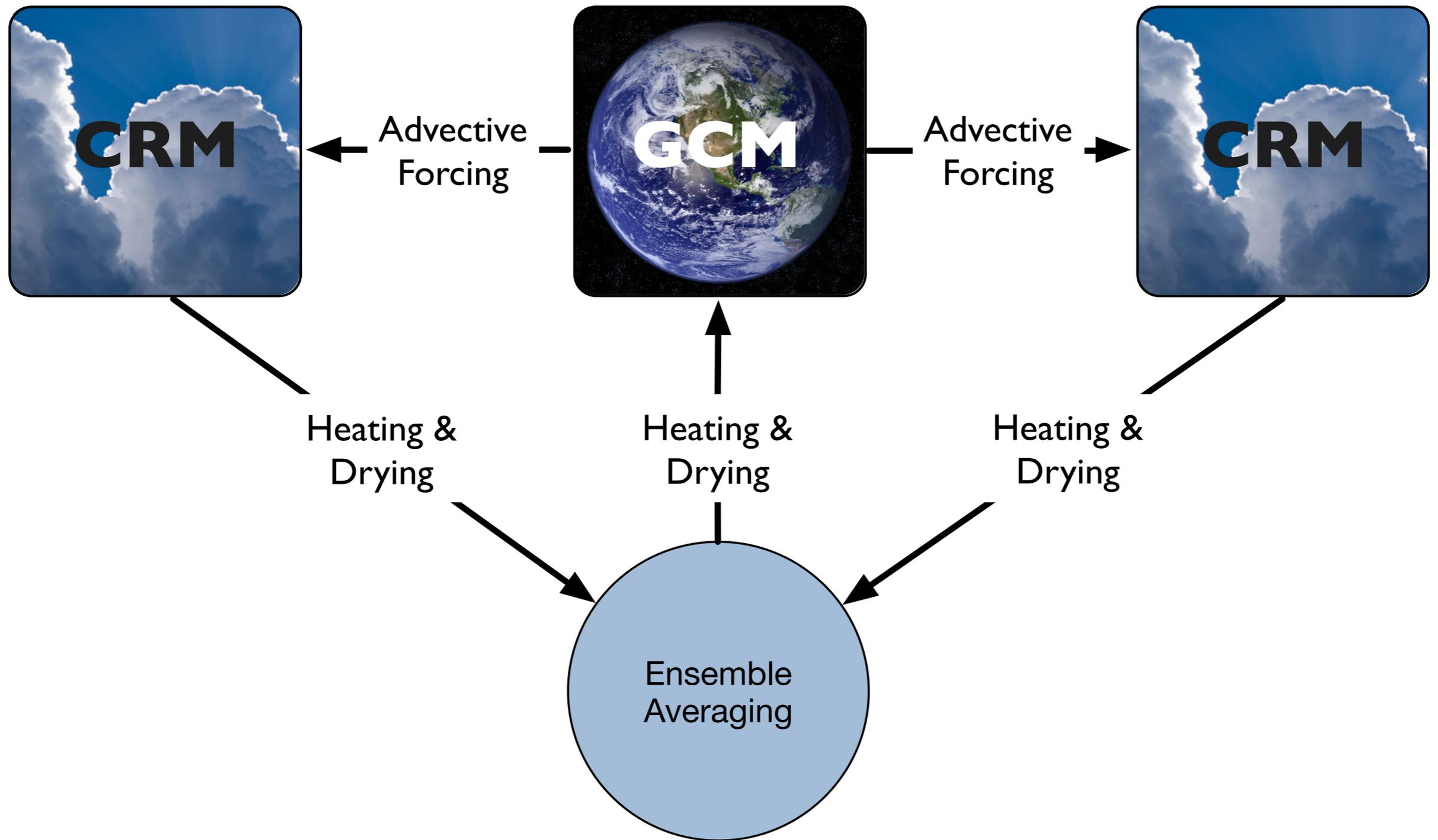
The CRMs start from slightly different initial conditions.

Each copy runs independently of the others.



# MP-CAM

Illustrated for the case  $N = 2$

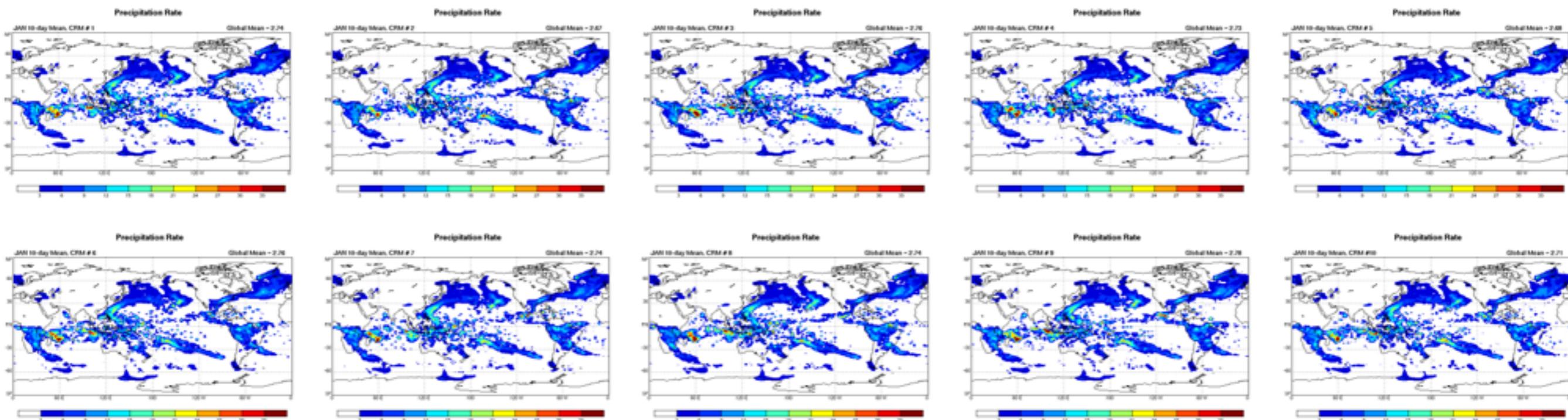


This is what a deterministic parameterization tries to do.

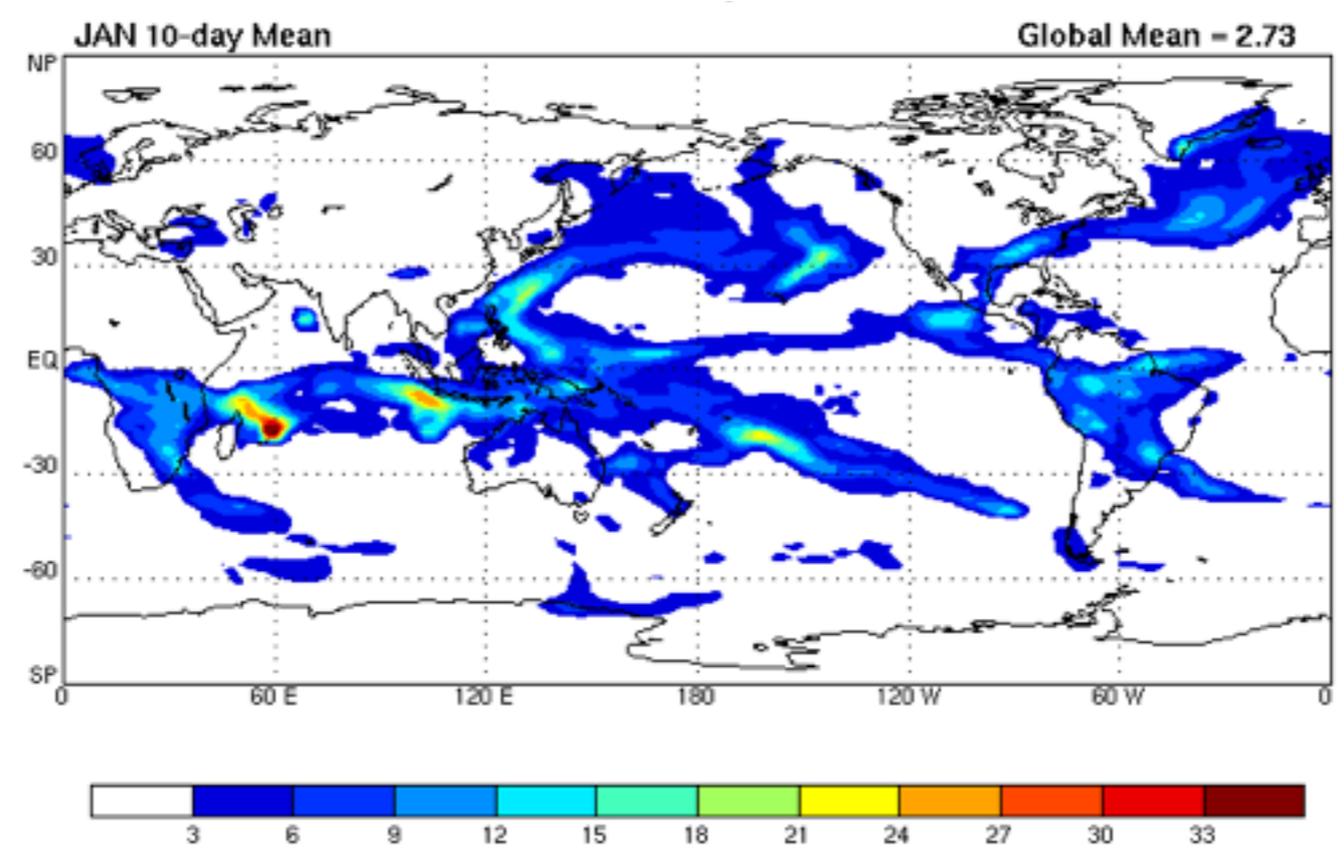
# Experimental Design

- The GCM uses a  $2.5 \times 2.0$  degree longitude-latitude grid, with the CAM's "finite-volume" dynamical core.
- We use 10 CRMs with 32 columns each, oriented north-south, with 4 km grid spacing.
- The GCM initial conditions are taken from an earlier simulation with the SP-CAM.





Individual realizations

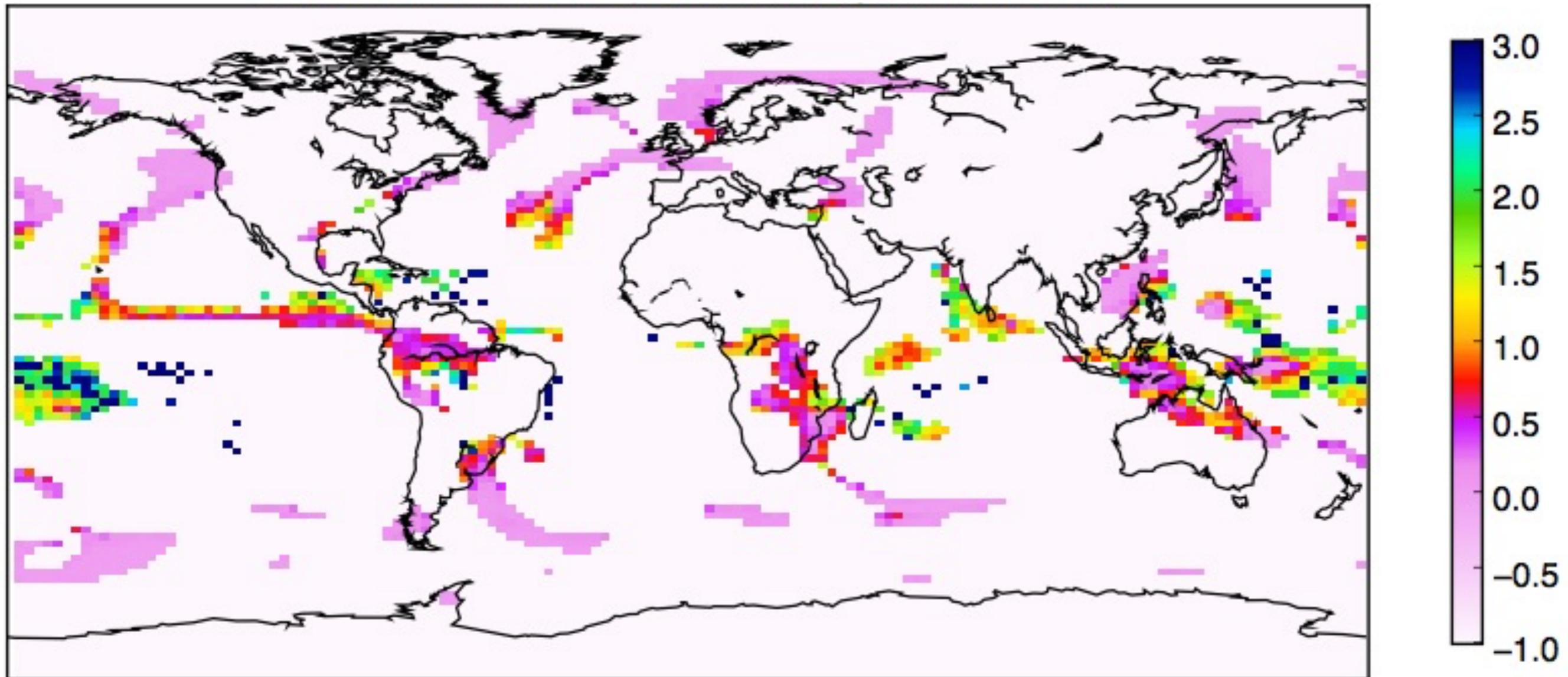


Ensemble average

# Where & when is strong precipitation predictable?

Standard dev / mean, plotted where the mean  $> 5$  mm day<sup>-1</sup>

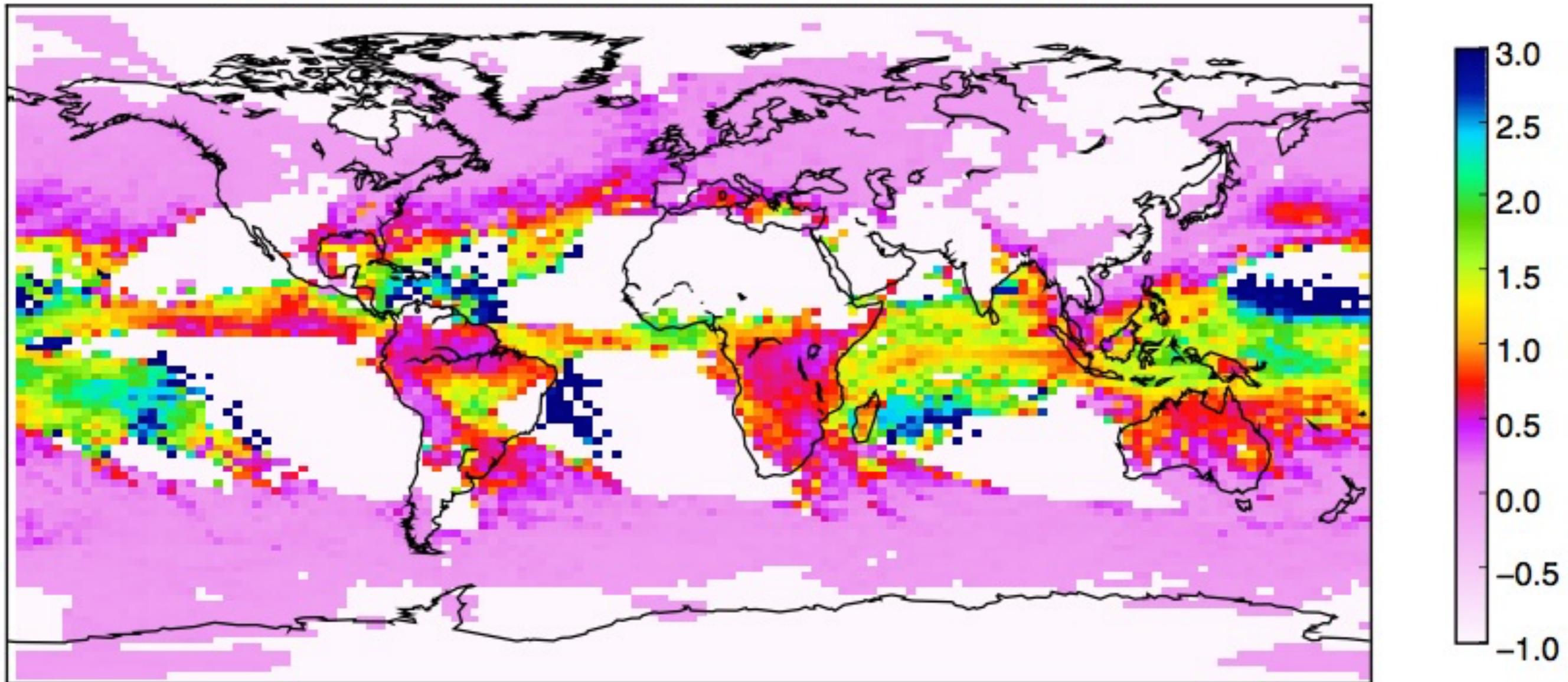
One day in January



The ratio has some spatial coherence, even though the CRMs communicate only through the GCM.

# Where & when is strong precipitation predictable?

Standard dev of daily values / daily mean, counted where the daily mean  $> 5 \text{ mm day}^{-1}$   
January average



The width of the distribution is not simply a constant times the mean.

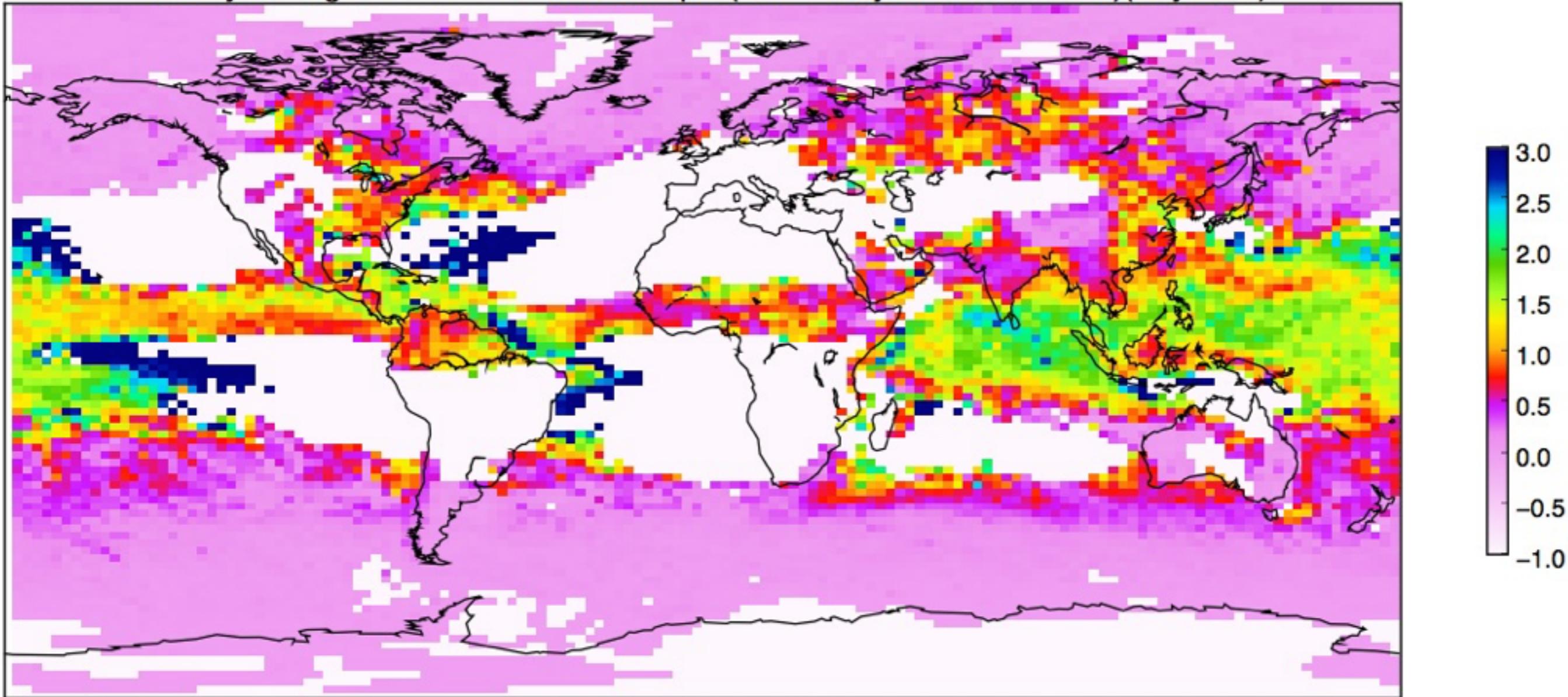
The least predictable precipitation is in the tropics.

The most predictable precipitation is in midlatitude storms, except on their equatorward sides.

# Same thing for July

Standard dev of daily values / daily mean, counted where the daily mean  $> 5 \text{ mm day}^{-1}$   
July average

Monthly Average of Ratio of Stdev/Mean plot( $>5 \text{ mm/day}$  Ensemble Mean)(July Data)

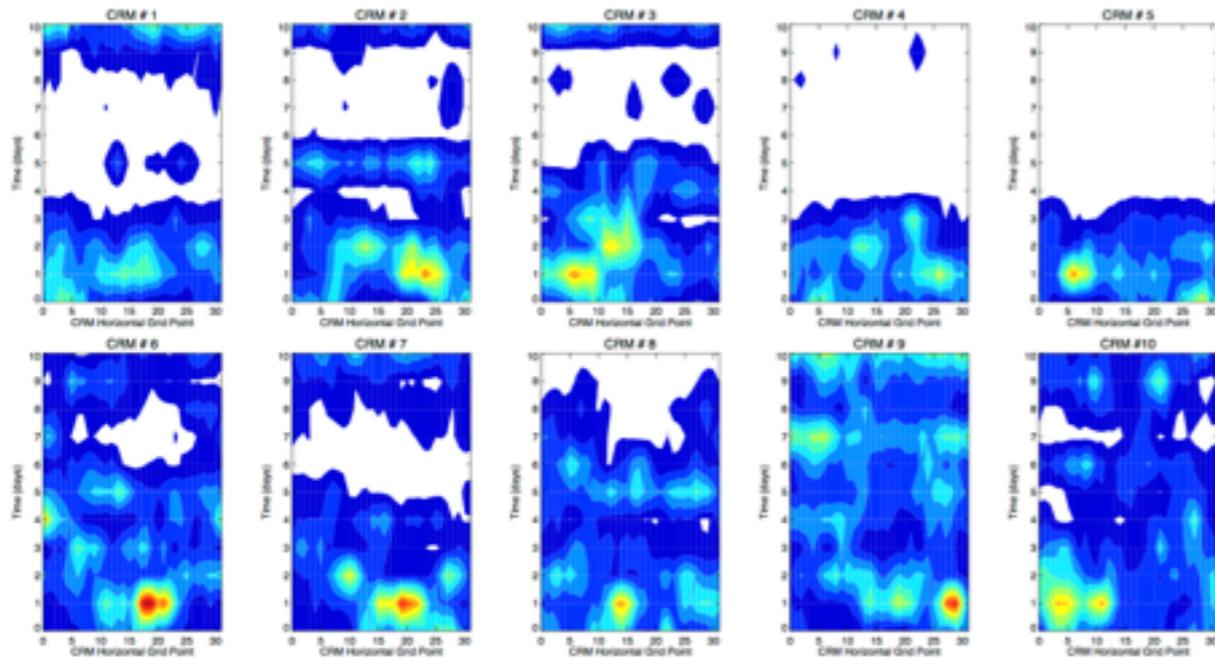


Lots of unpredictable precipitation over the NH continents.

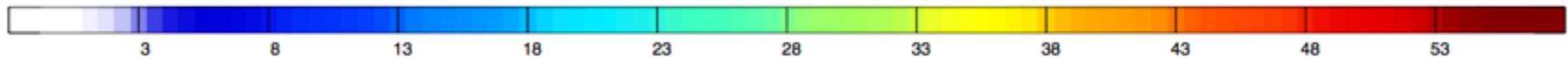
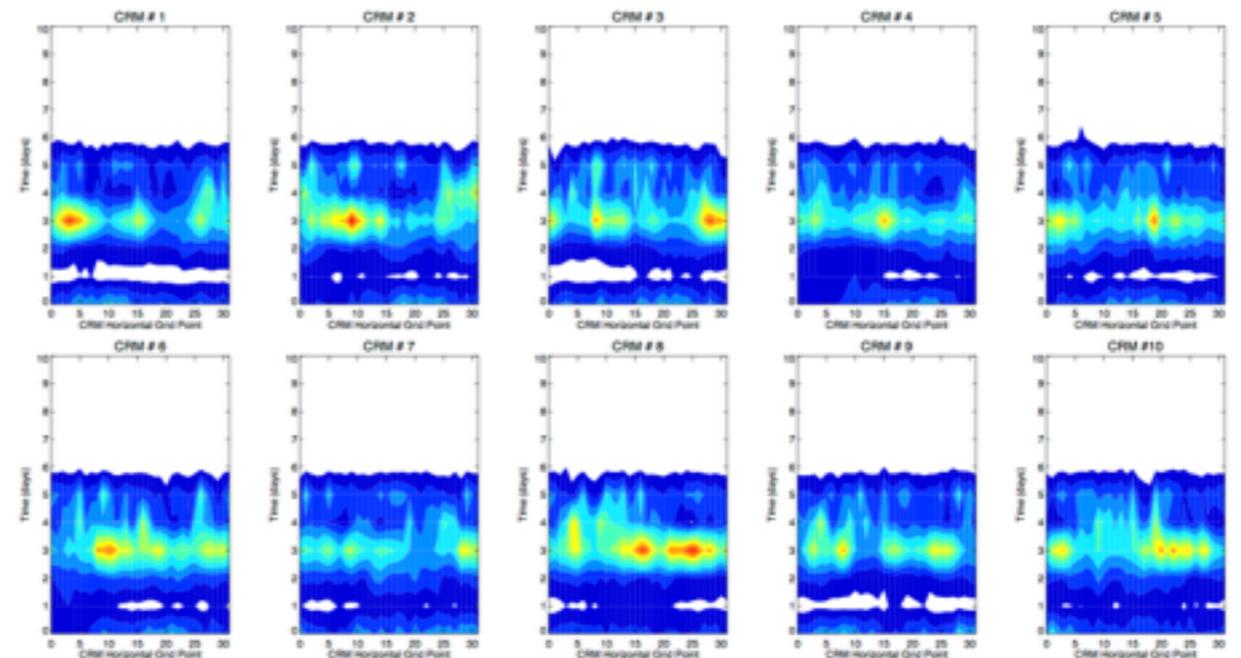
# Ten days in the life of two selected GCM columns

These are Hovmöller diagrams, with time increasing upward.  
The horizontal axis in each panel is horizontal distance in the CRM.

## Ten realizations at a tropical point



## Ten realizations at a midlatitude point



mm day<sup>-1</sup>

# Summary

## SP-CAM

- One realization of the cloud system
- Feedback from the single realization
- Non-deterministic parameterization

## MP-CAM

- $N$  realizations of the cloud system
- Feedback from the ensemble mean
- Deterministic parameterization
- Can examine individual realizations

# What we want to do with this

- Compare climate with ensemble-mean feedback to climate with feedback from one realization:
  - ▶ Systematic differences in extreme precipitation events?
  - ▶ Systematic differences in the MJO or other large-scale weather systems?
- Identify the specific weather regimes and physical mechanisms that are associated with strong but unpredictable convection. See Radha's poster on Thursday.