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# Challenges in Convection

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DOE Workshop on Community Modeling and Long-Term  
Predictions of the Regional-Scale Integrated Water Cycle

Washington, DC, 25 September 2012





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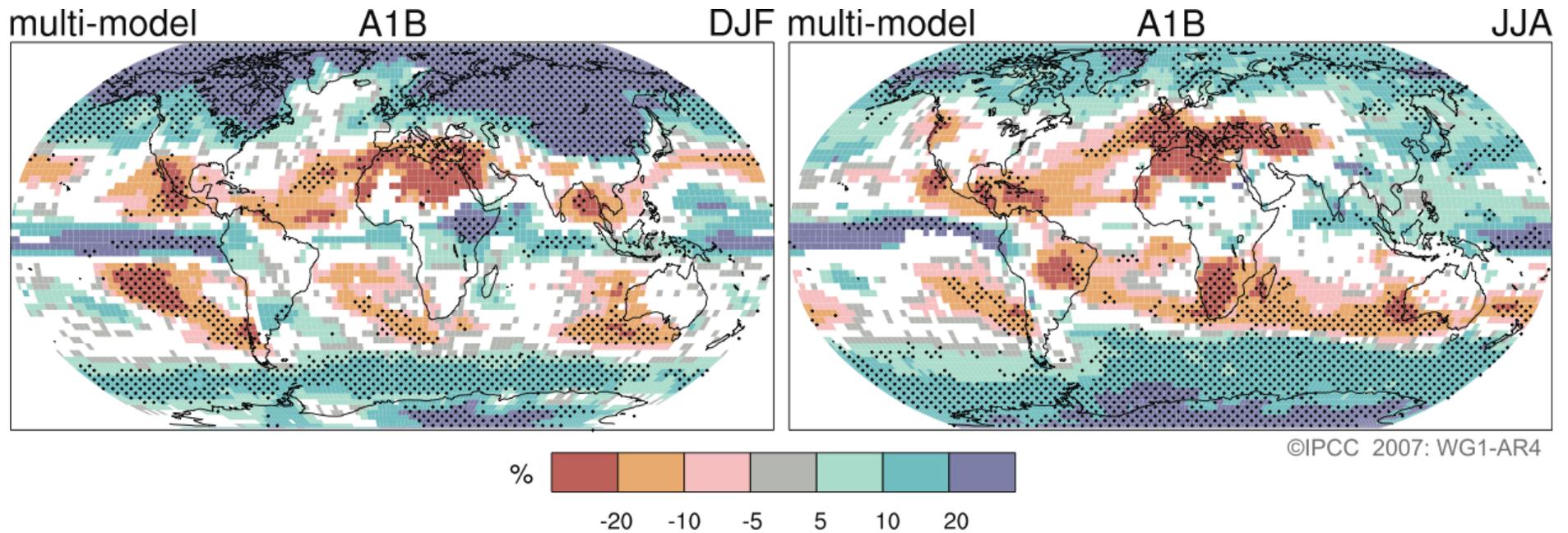
# Challenge I: Climate Spread in Predicted Changes in Precipitation



# Projected Change in Precipitation for NH Winter (DJF) and NH Summer (JJA)

**White Areas: Less than 66% of models agree on increase or decrease**

**Stippled Areas: More than 90% of models agree on increase or decrease**





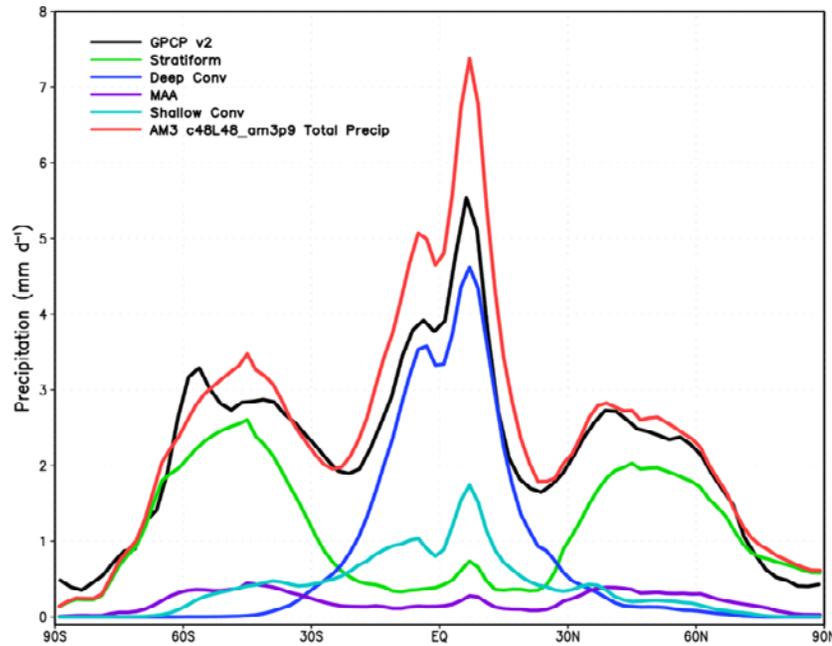
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# Challenge II: Robust Errors



Atmosphere  
with  
Prescribed  
SSTs

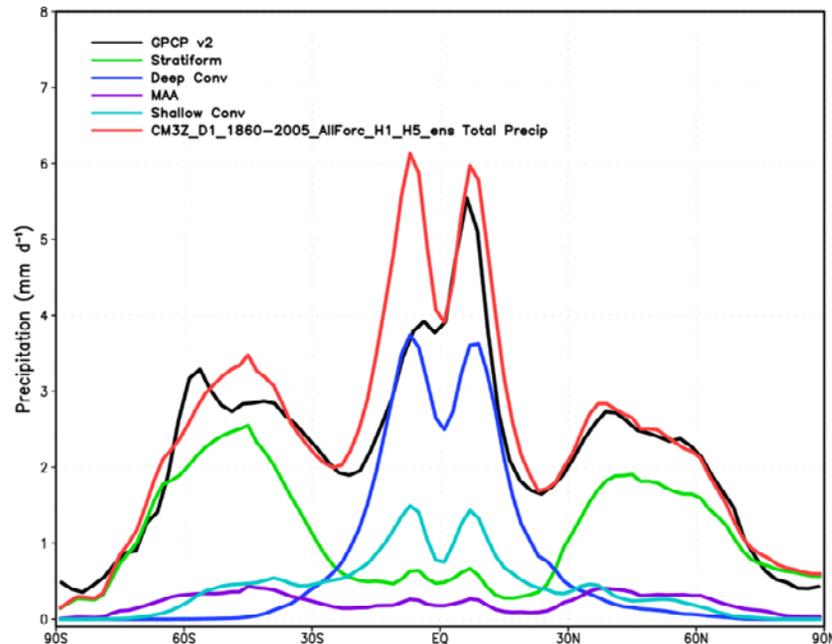
### Annual Precipitation



GFDL  
AM3

Kato *et al.* (2011, *J. Geophys. Res.*) indicate GPCP precipitation may be biased 15% to 20% low.

Coupled  
Ocean-  
Atmosphere  
Model



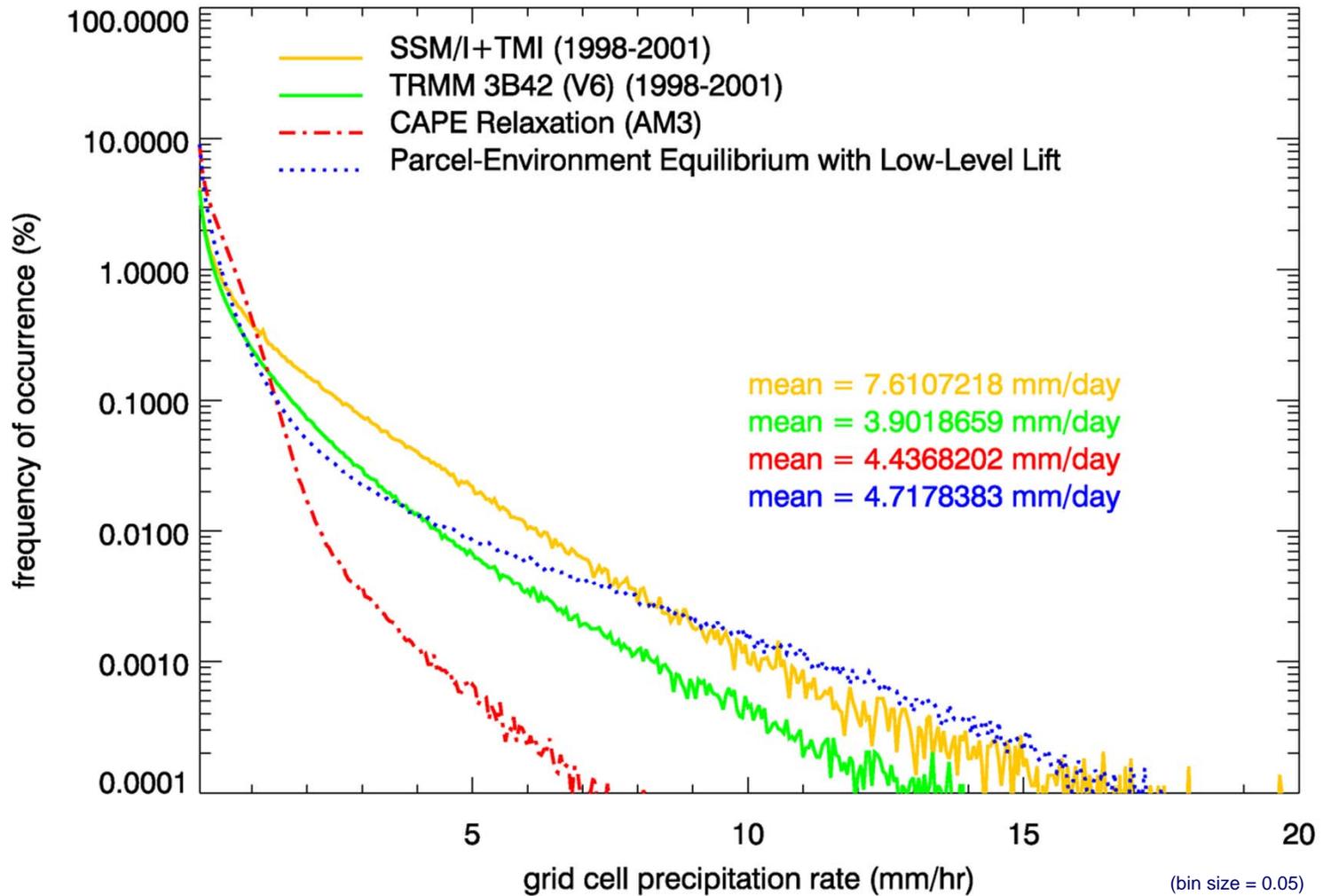
GFDL  
CM3



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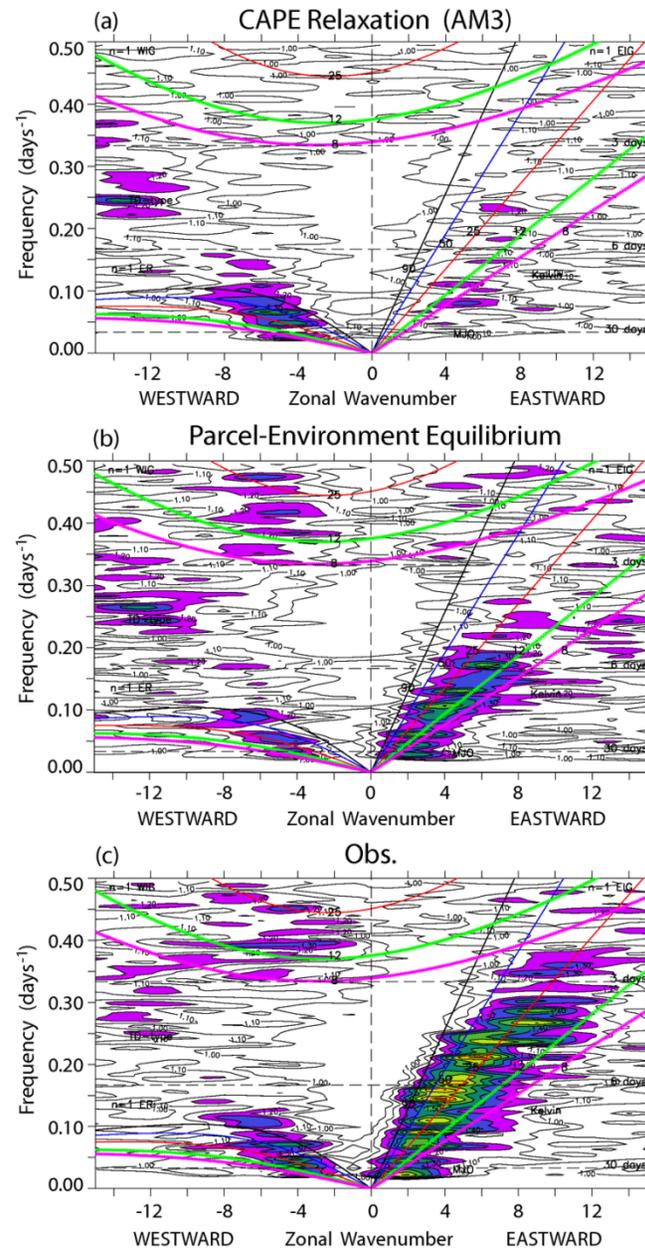
# Challenge III: Cumulus Parameterizations Implicated in Climate Model Inability to Simultaneously Simulate Mean State and Variability

### Precipitation Intensity Distribution Tropical Land (20S - 20N)



from Donner *et al.* (2011, *J. Climate*)

# Tropical-Wave Spectrum



from Donner *et al.* (2011, *J. Climate*)

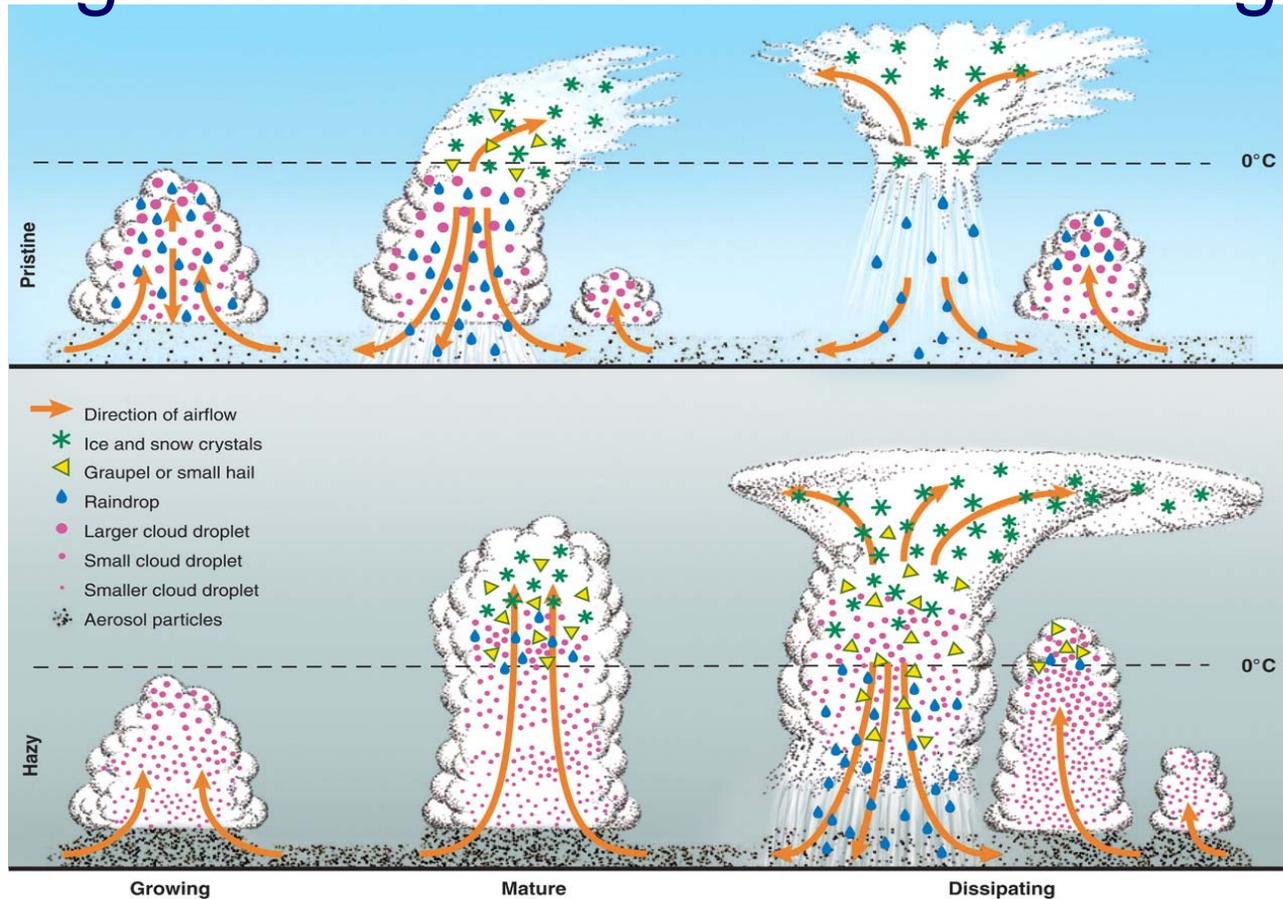


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# Challenge IV: Aerosols and Deep Convection



# Aerosol Interactions with Deep Convection: Invigoration? Anvil Radiative Changes?



from Rosenfeld *et al.* (2008, *Science*)

Lee *et al.* (2009, *ACP*) showed longwave MCS warming with increased aerosol offset 28% of shortwave cooling.

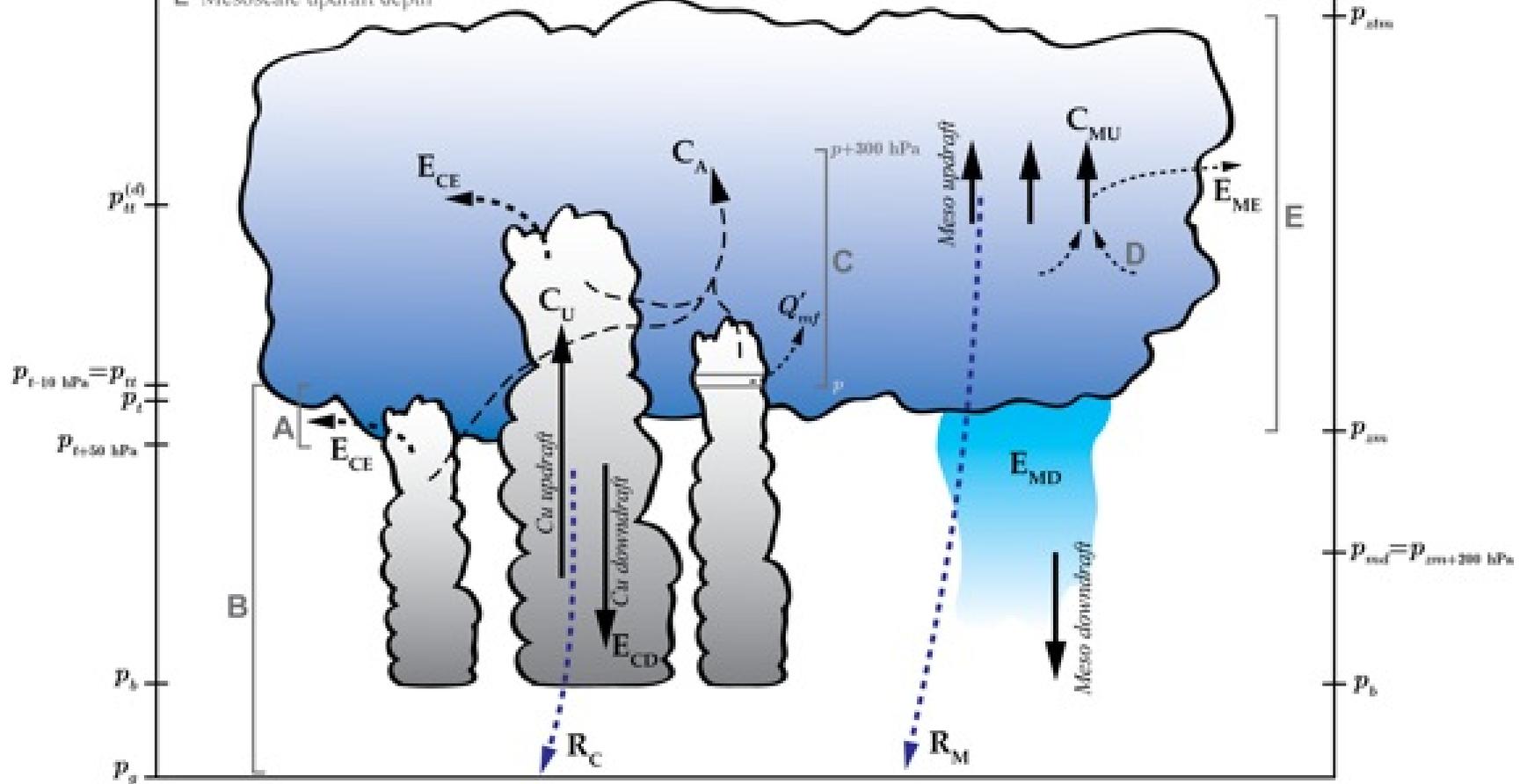


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# Challenge V: Convective Organization

## Donner Deep Convection Scheme

- A Uniform distribution of  $E_{CD}$ , evaporation from cumulus updrafts
- B Uniform distribution of  $E_{CD}$ , evaporation in cumulus downdrafts
- C Uniform distribution of water vapor, provided by cumulus updrafts, available to mesoscale clouds
- D Water vapor in cumulus environment advected by mesoscale updrafts
- E Mesoscale updraft depth



from Benedict *et al.* (2012, *J. Climate*, in press)