Evaluation of Land-Atmosphere Coupling Processes in High Resolution Simulations

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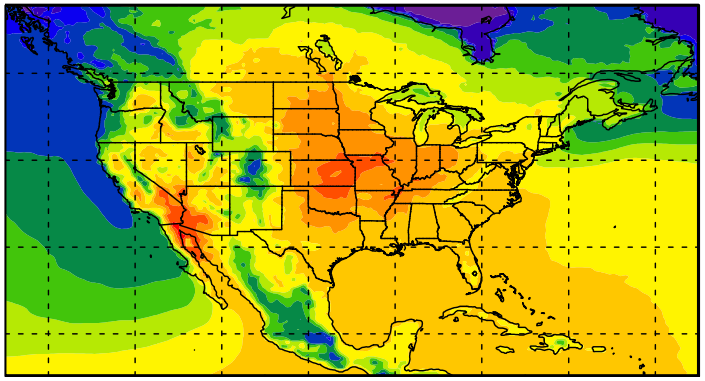
Simulation Design

- Two single summer simulations were performed using CESM 1.0.4:
  - **0.25** degree and **1.00** degree
  - Only differing in resolution
  - Out of Box Configuration
- **Hourly** output
- Runtime: May 1st 2004 through August 31st 2004
- Components:
  - CAM 4.0 atmosphere
  - CLM 4.0 land surface
  - Data everything else

Focus on **July** over the U.S.



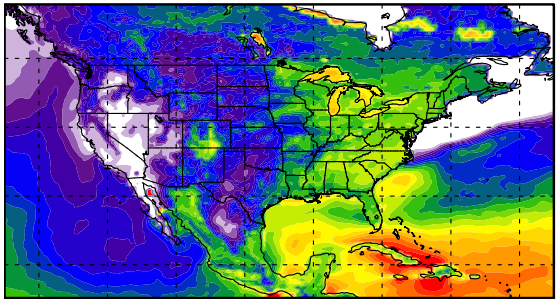
Spatial Differences Between Simulations

0.25 Degree

1.00 Degree

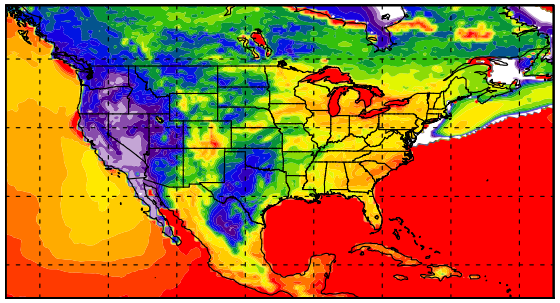
0.25 Minus 1.00
BLUE = 0.25 less
RED = 0.25 more

Latent Heat Flux



8 -32 -16 0 16 32 48 64 80

Evaporative Fraction



Spatial Differences Between Simulations

0.25 Degree

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BLUE = 0.25 less
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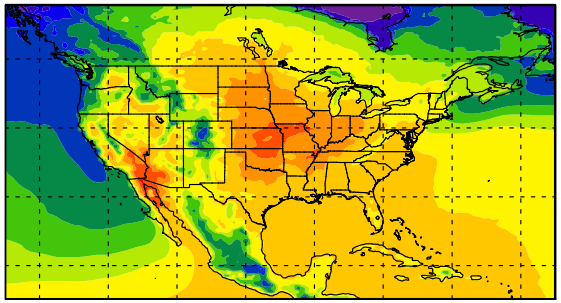
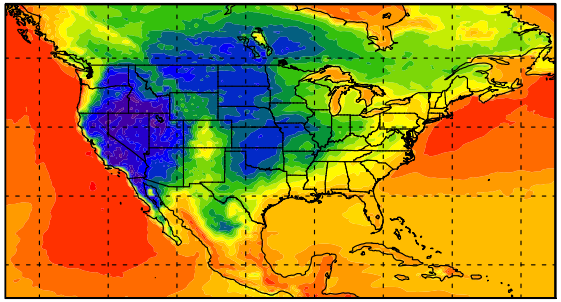
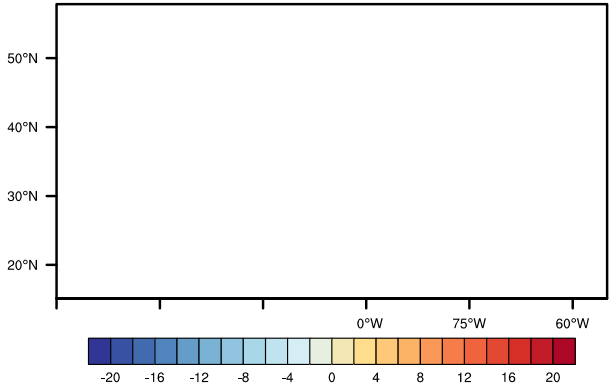
2-m Temperature



5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

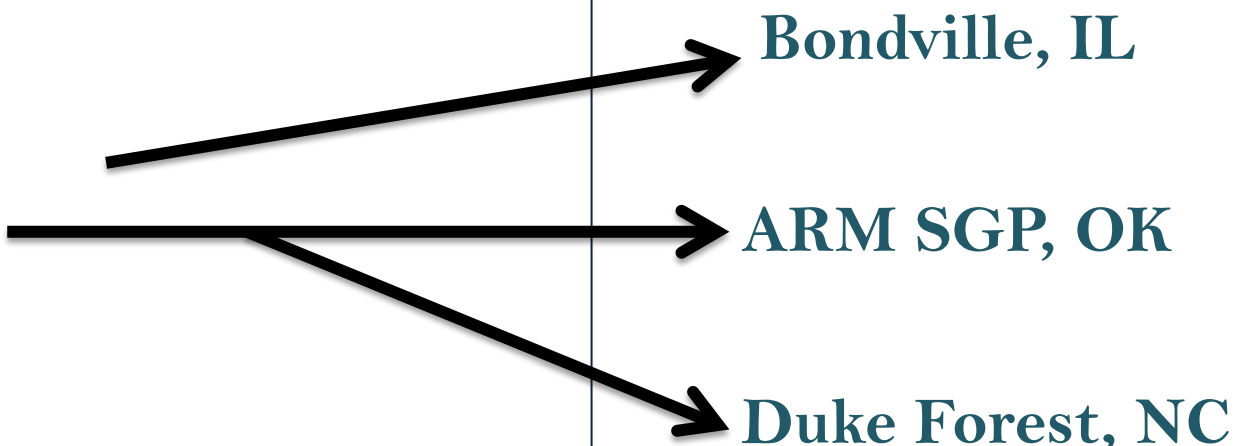
2-m Relative Humidity





Spatial Differences Between Simulations

Zoom in on 3 locations

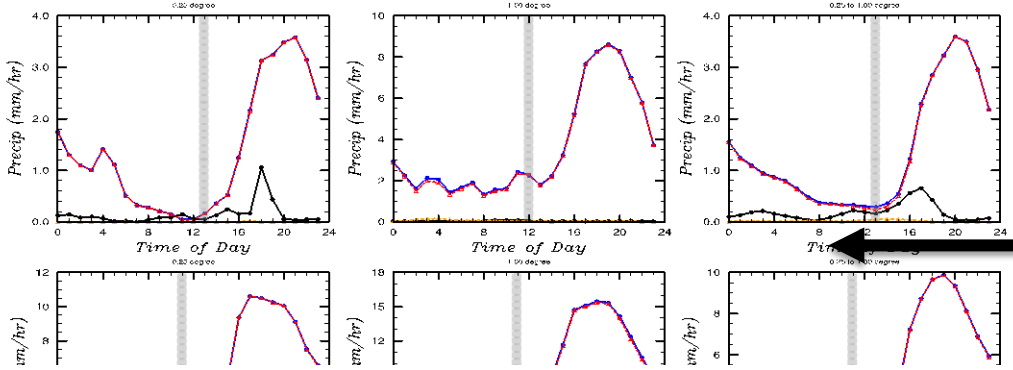


Precipitation Characteristics

0.25 Degree

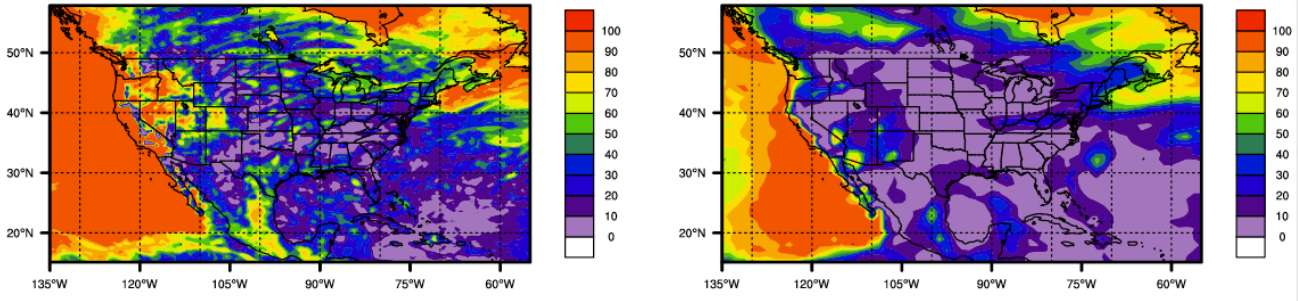
1.00 Degree

ARM

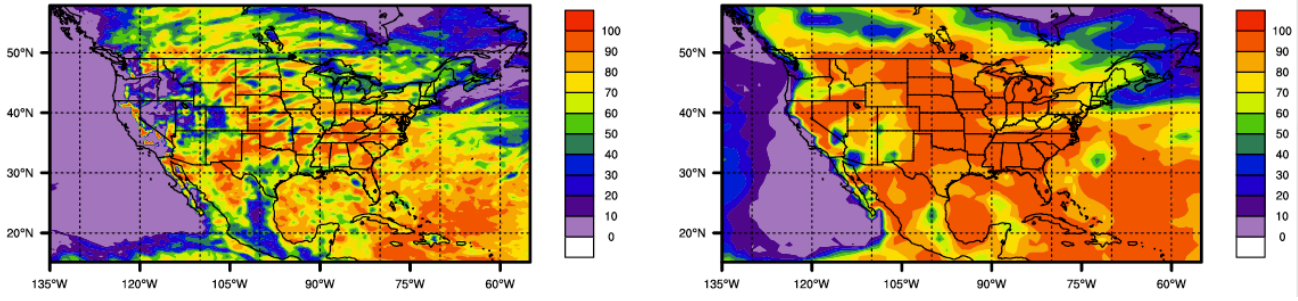


Convective
Z-M Convective
Shallow
~~Convective~~
Large-Scale

Sunrise

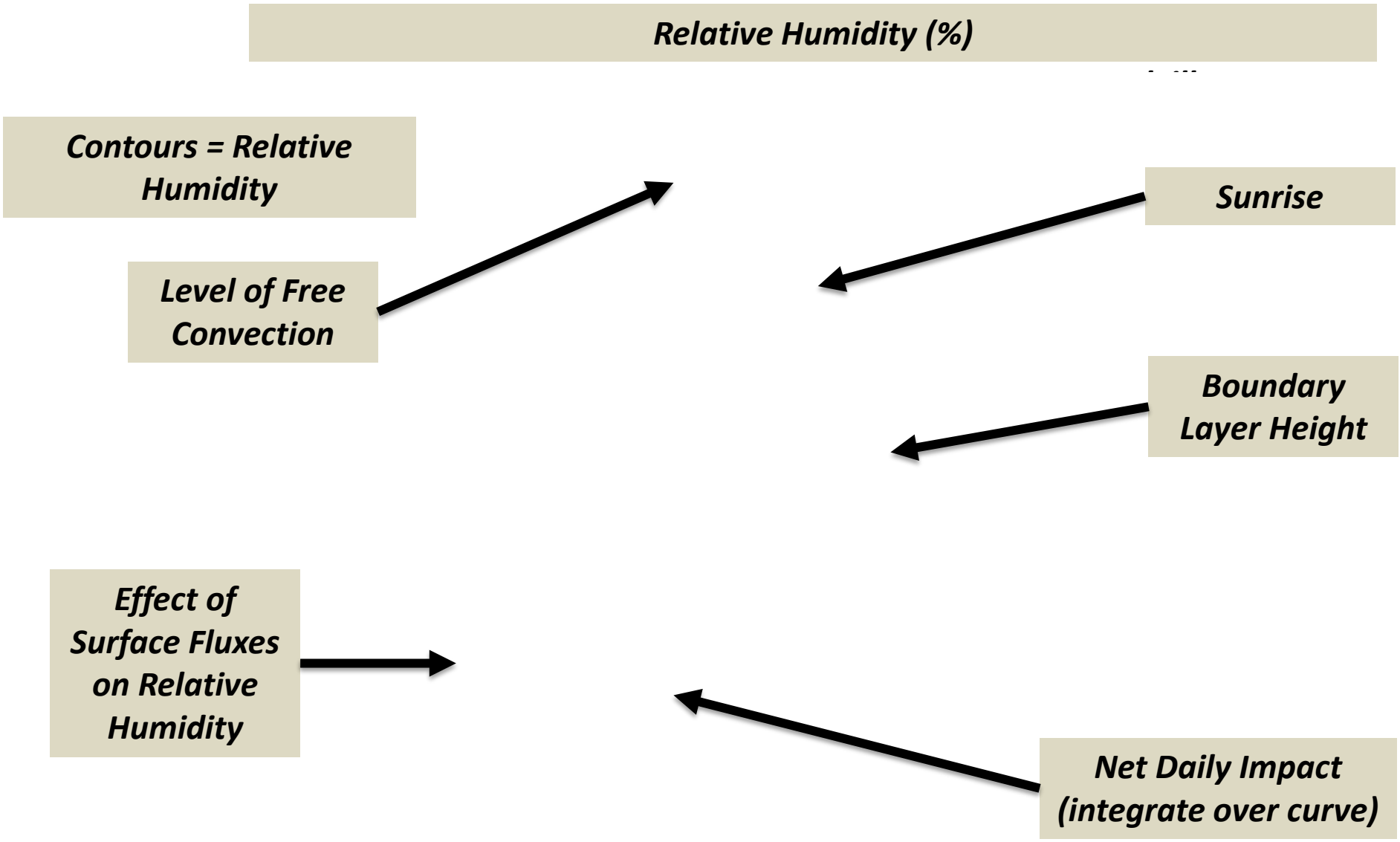


% Contribution of Large-Scale Precip



% Contribution of Convective Precip

Average Diurnal Vertical Cross-Section



Average Diurnal Vertical Cross-Section

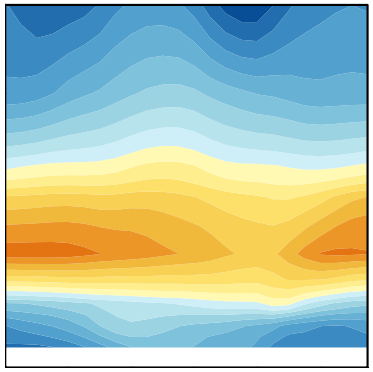
Relative Humidity (%)

ARM ***DUKE*** ***Bondville***

~700 mb

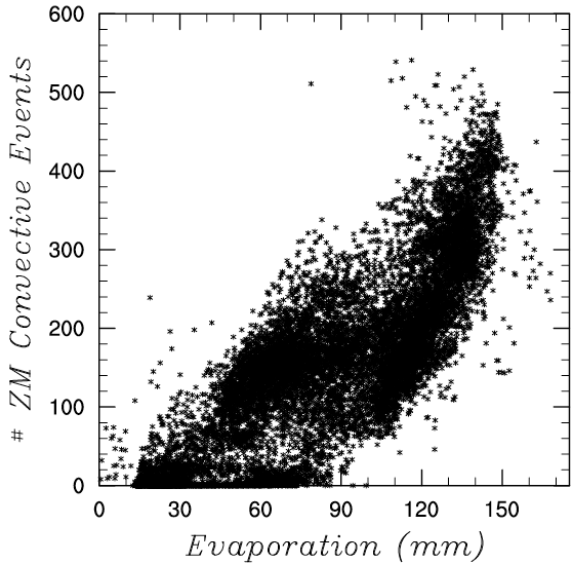
0.25 Degree

0.25 Degree Minus 1.00 Degree

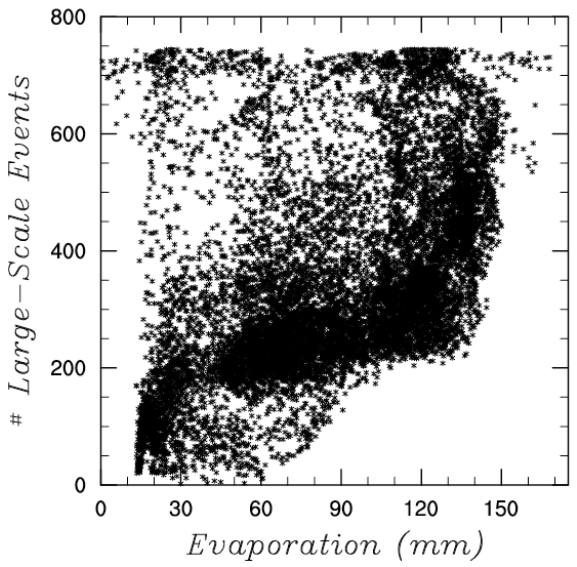


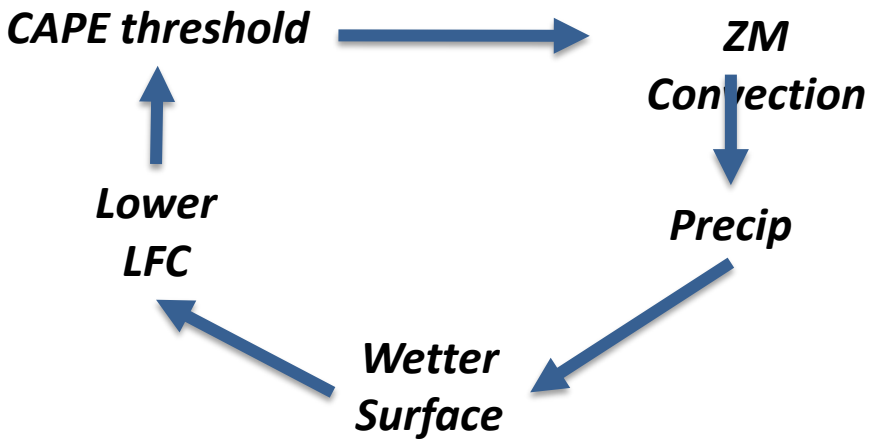
Land-Precipitation Scheme Interactions

Land-Convection



Land-Large Scale





- **Large-scale precip depends on relative humidity at all heights**

Summary

- **High resolution simulation yields:**
  - **Less evaporation (Plains)**
  - **Less cloud cover**
  - **Warmer**
  - **Less saturated near-surface**
  - **Free tropo more saturated**
- **Higher resolution shifts precipitation from convection parameterization to large-scale**
- **Positive feedback between land surface and deep convection**
  - **Wet surface tends to stay moist in coarse simulation**

Take Home Lessons

- **This is a coupled system problem!**

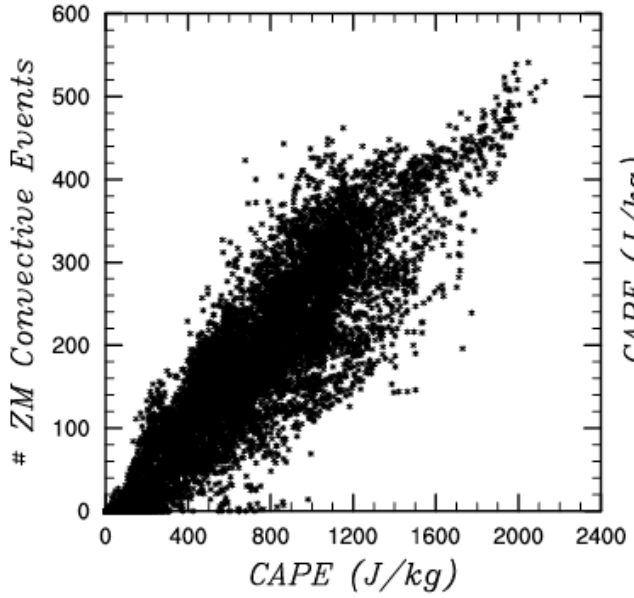
- **Moving forward:**
  1) **Wait for computers to get crazy efficient and do global cloud resolving simulations**

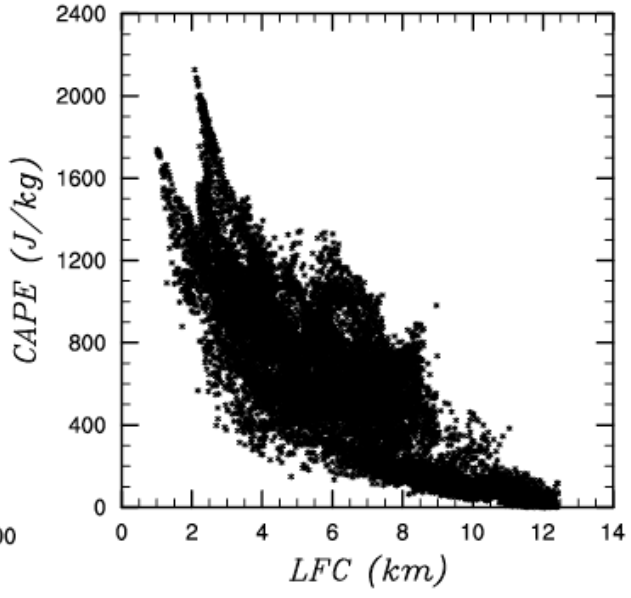
  1) **MUST keep other model components in mind when developing parameterization**

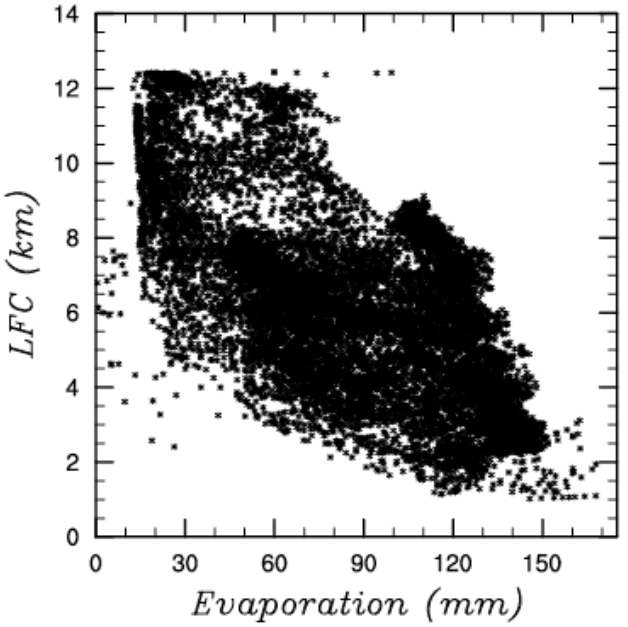
  2) **Land needs to talk to Atmosphere needs to talk to Landmosphere**

Land-Precipitation Scheme Interactions

Land-ZM Convective Scheme Interaction



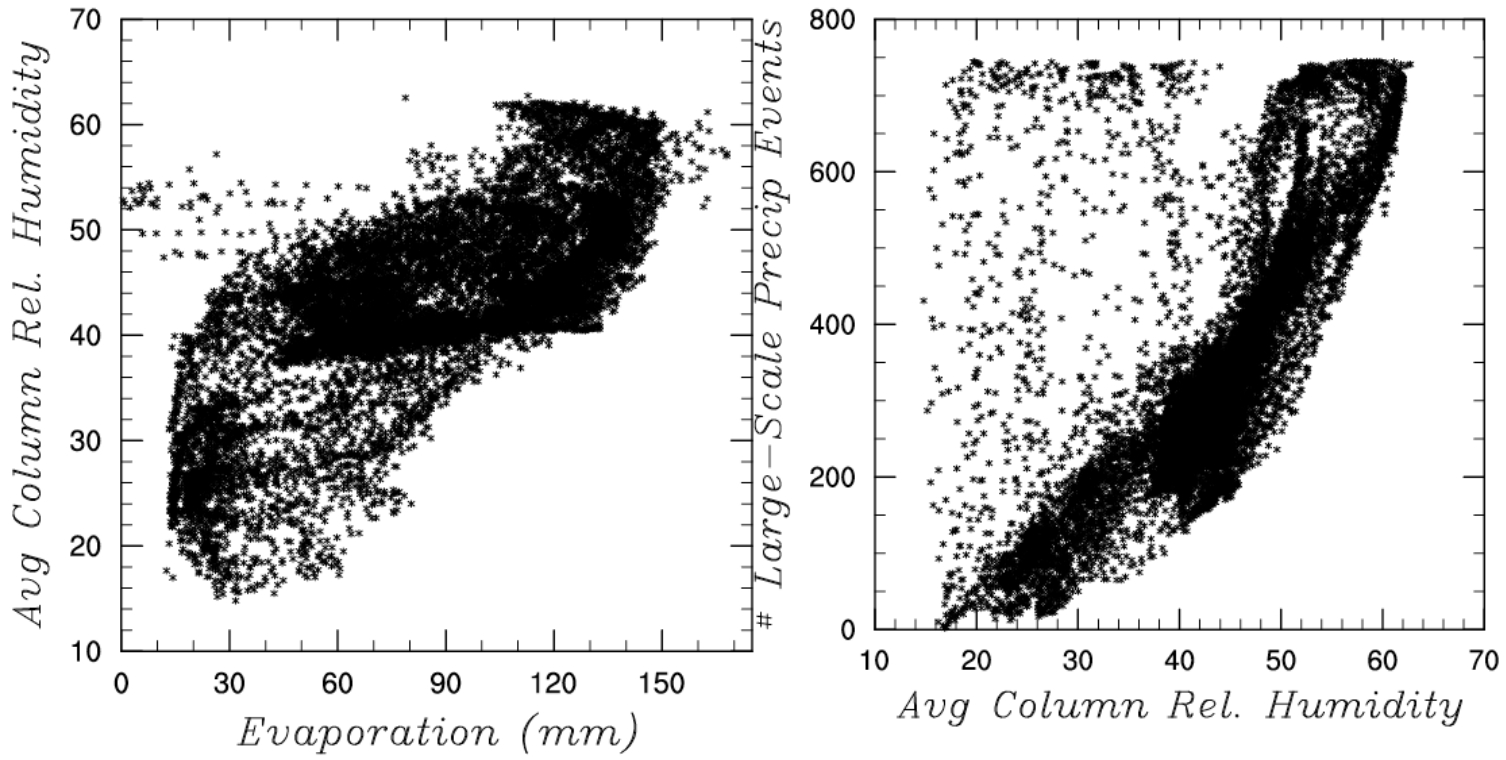




CAPE threshold exceeded → ***ZM Convection triggered*** → ***Precipitation*** → ***Wetter Surface*** → ***Lower LFC*** → ***CAPE threshold exceeded***

Land-Precipitation Scheme Interactions

Land-Resolvable Precipitation Scheme Interaction



- **Large-scale precipitation depends on relative humidity threshold depending on height in atmosphere**