

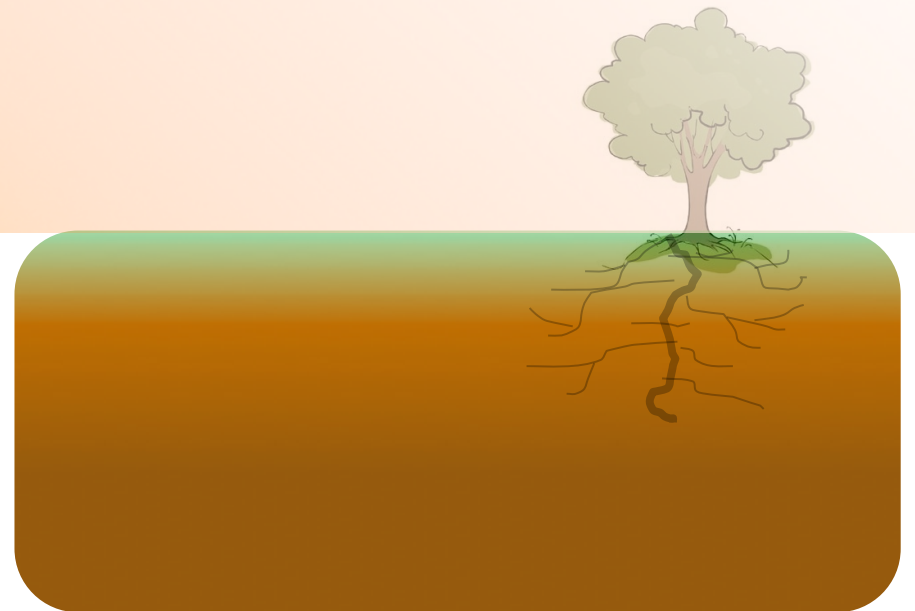
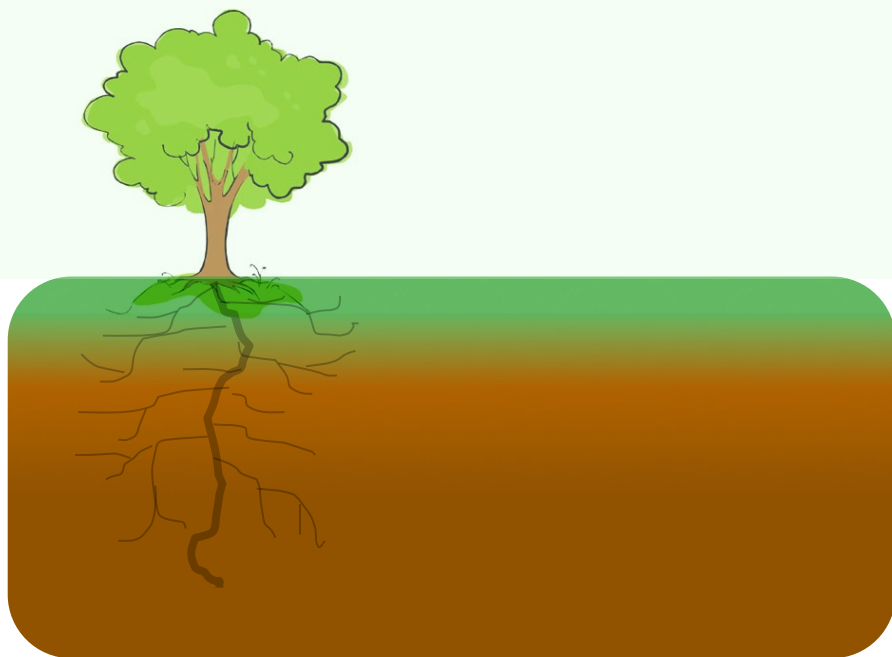
An aerial photograph of a city at dusk. The sky is a gradient of blue and orange. In the distance, a city skyline is visible with several tall buildings, some of which are illuminated. The foreground shows a complex network of roads and highways, with some buildings and green spaces scattered throughout.

Land-Convection Interactions: A Coupled Problem

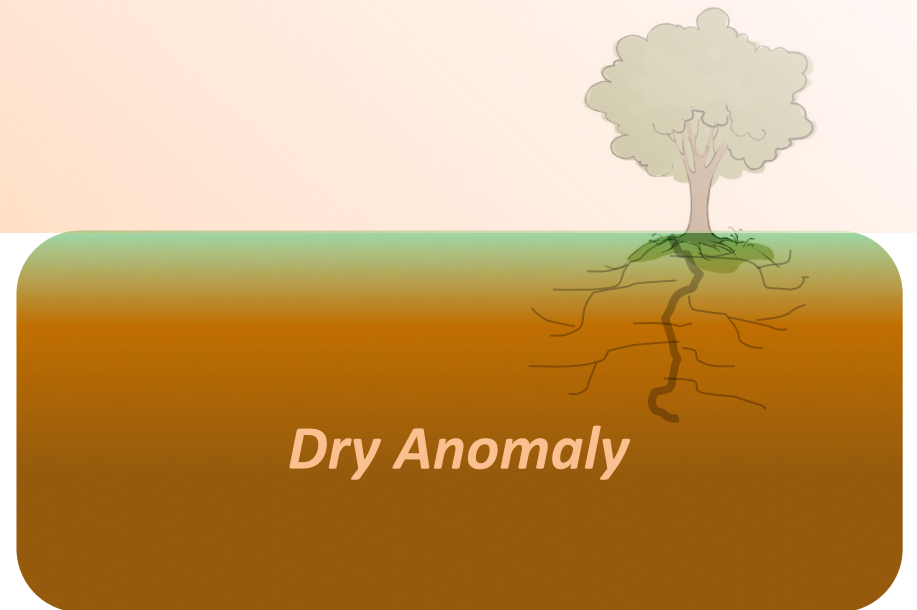
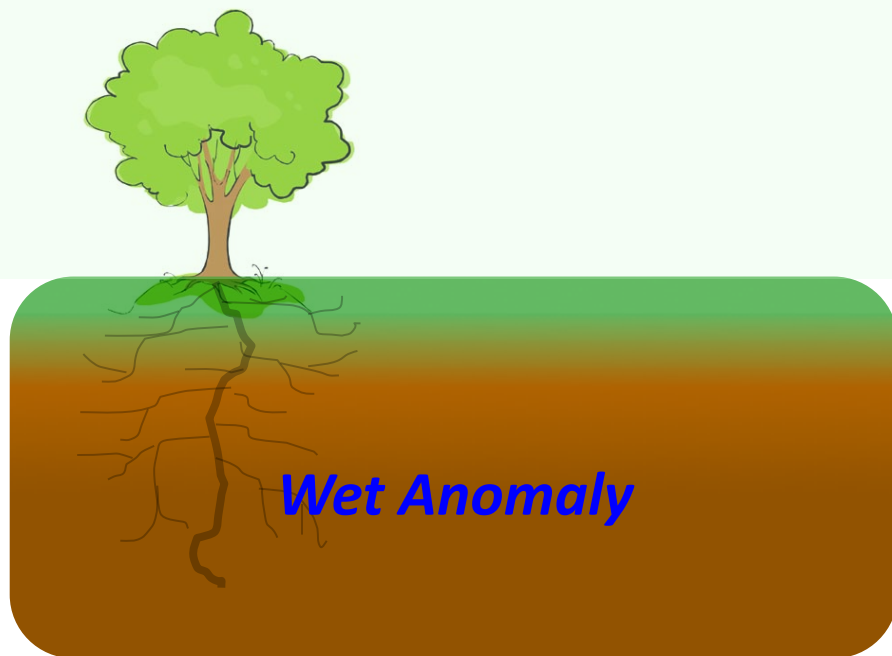
Ahmed B. Tawfik, Paul Dirmeyer
Center for Ocean-Land-Atmosphere Studies

Land-Convection Coupling

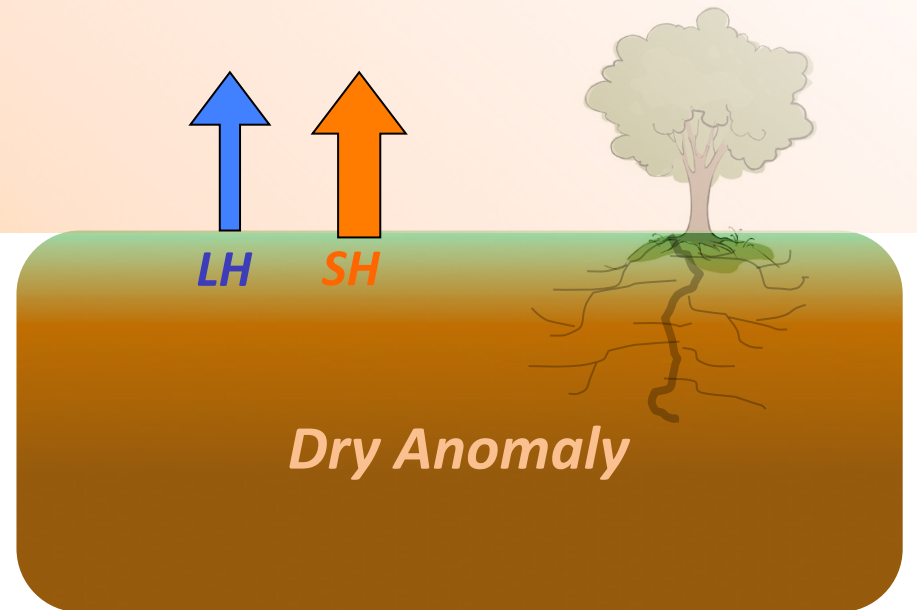
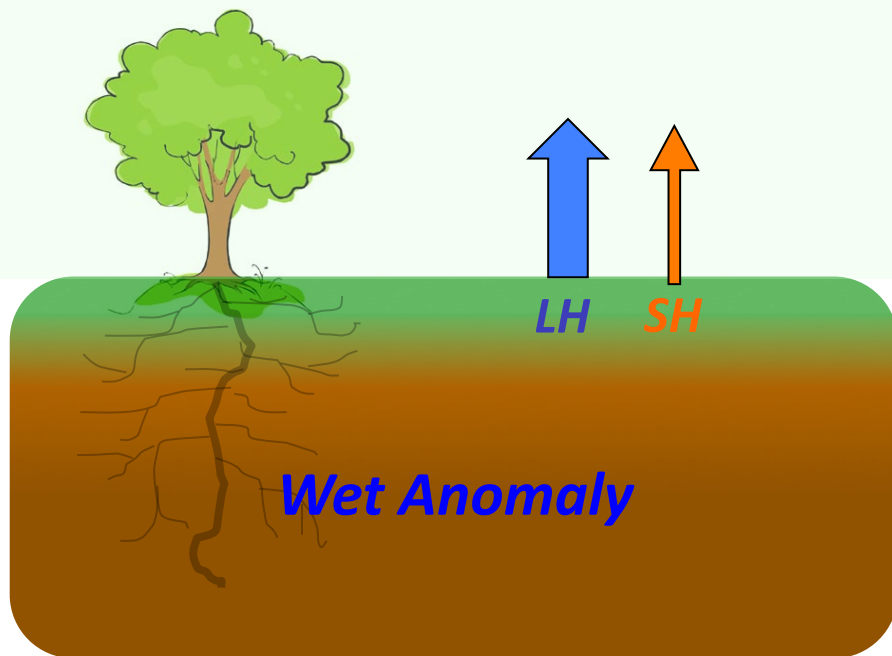
Coupling = Response of precipitation given a soil moisture perturbation



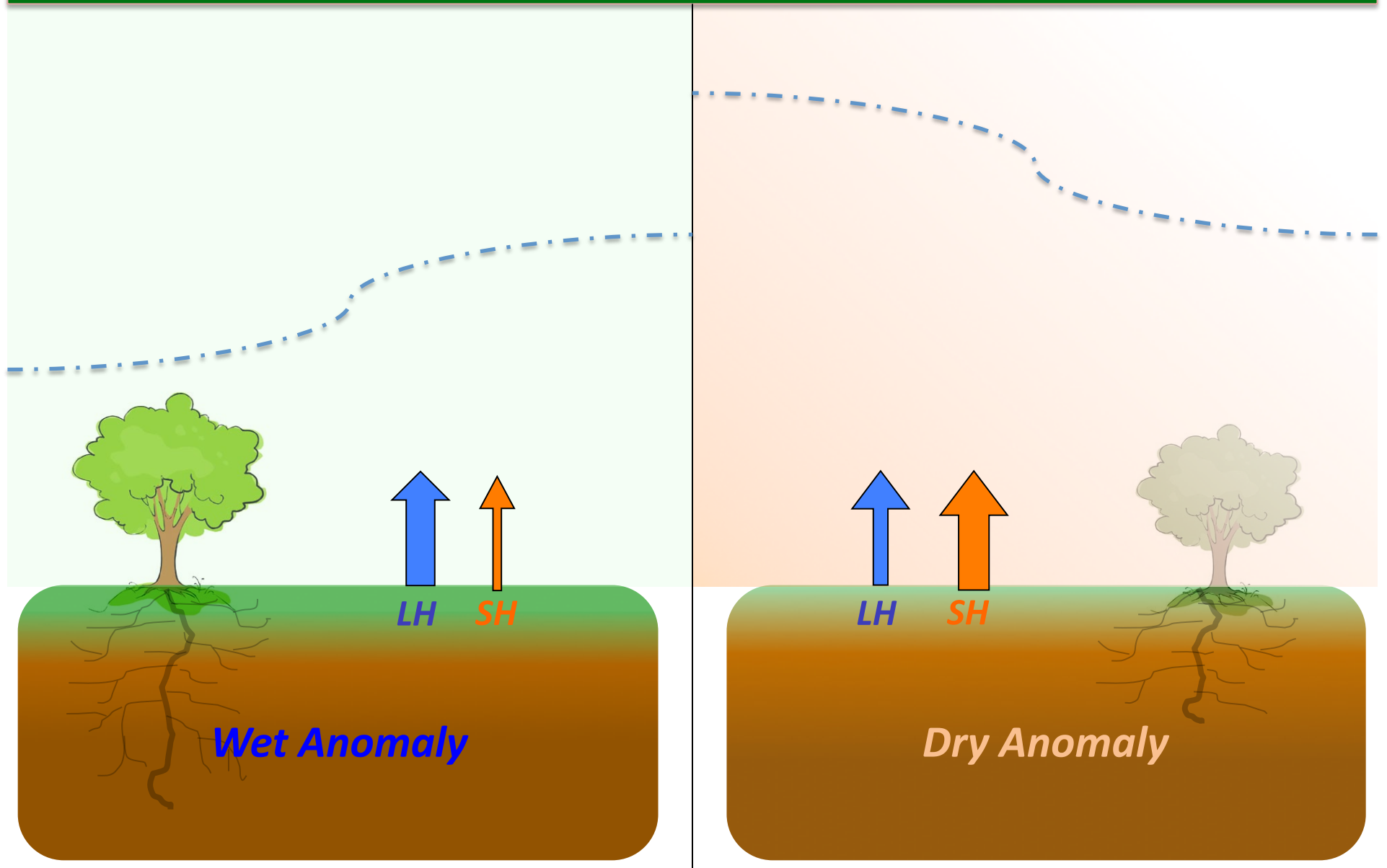
Land-Convection Coupling



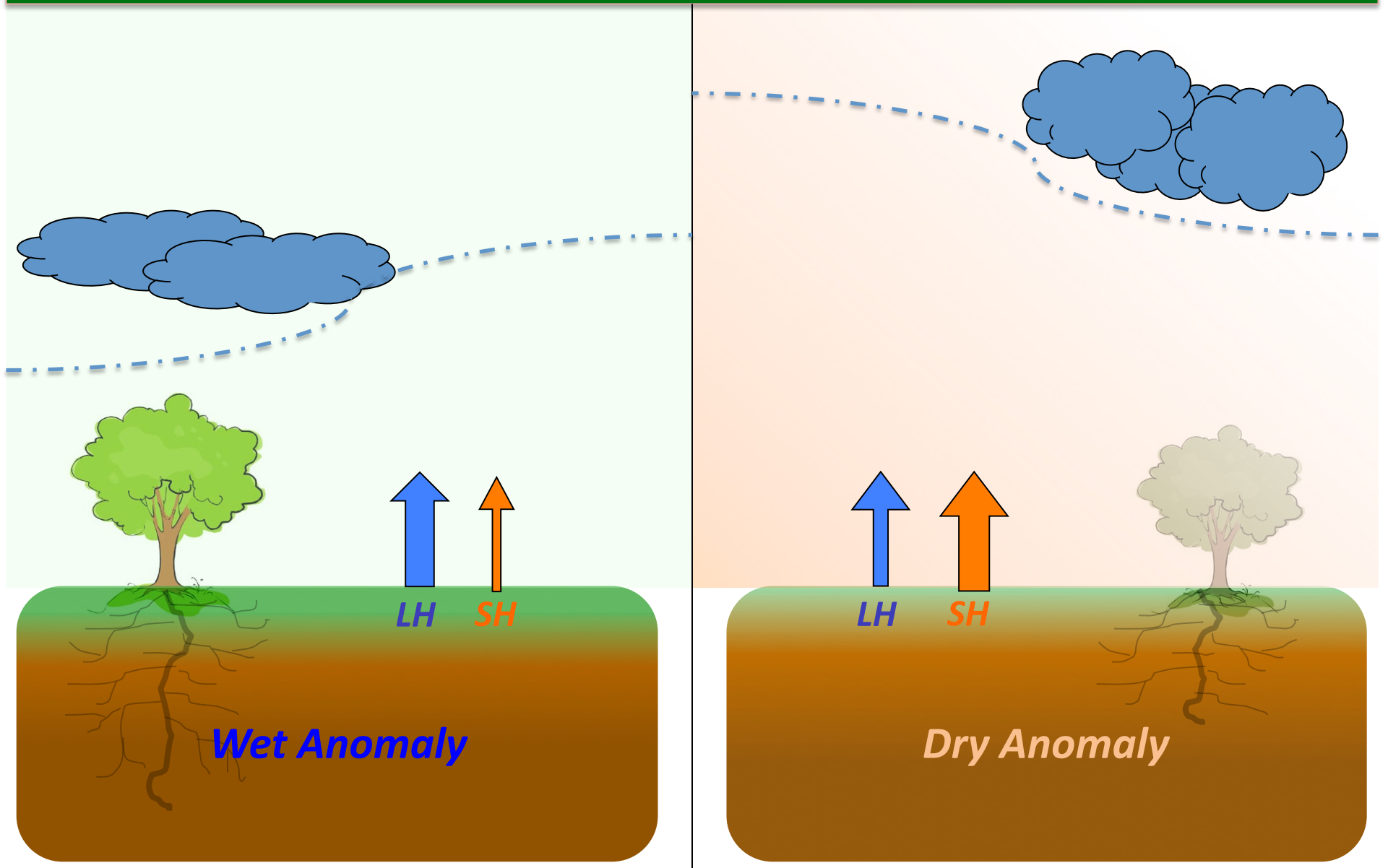
Land-Convection Coupling



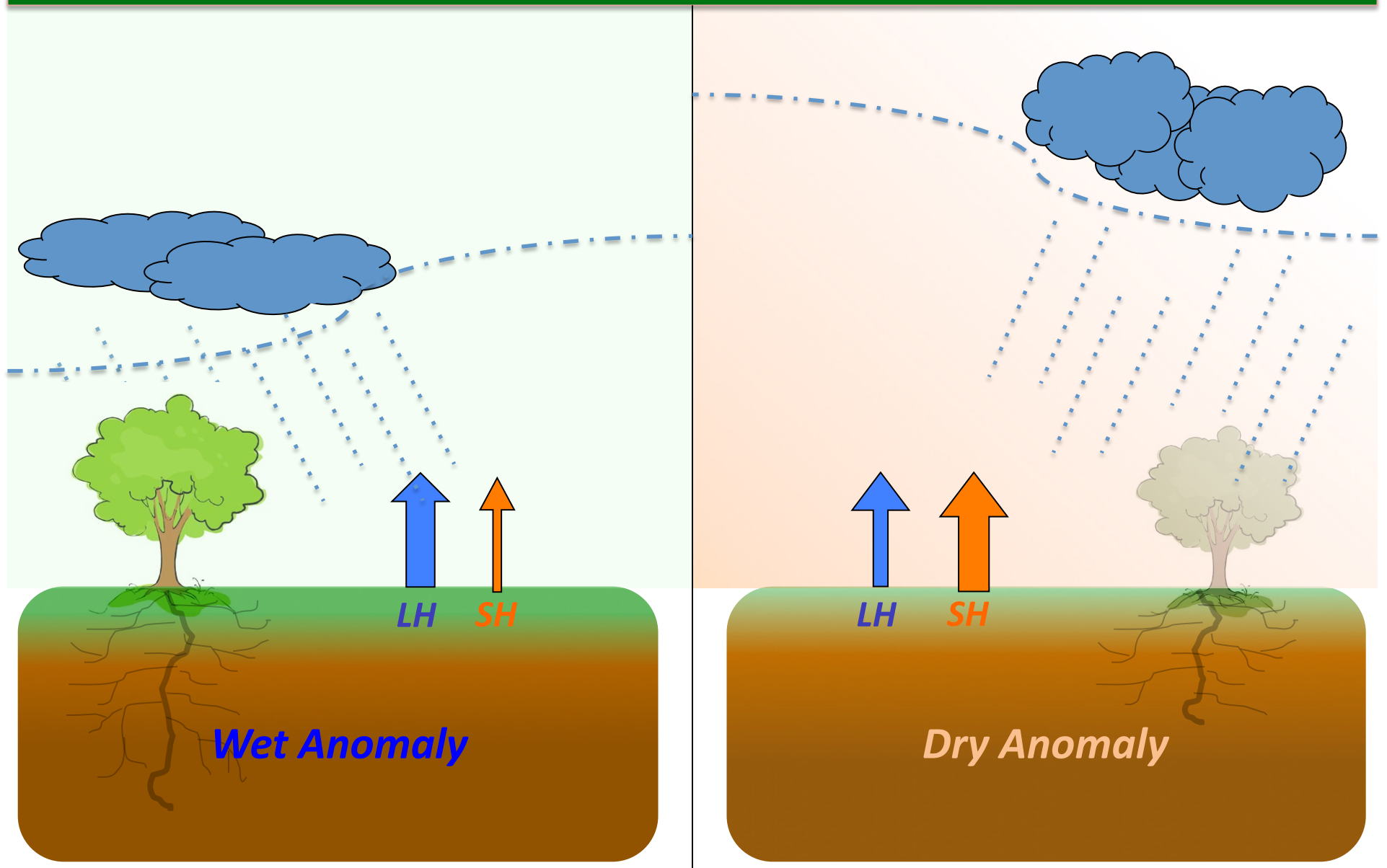
Land-Convection Coupling



Land-Convection Coupling

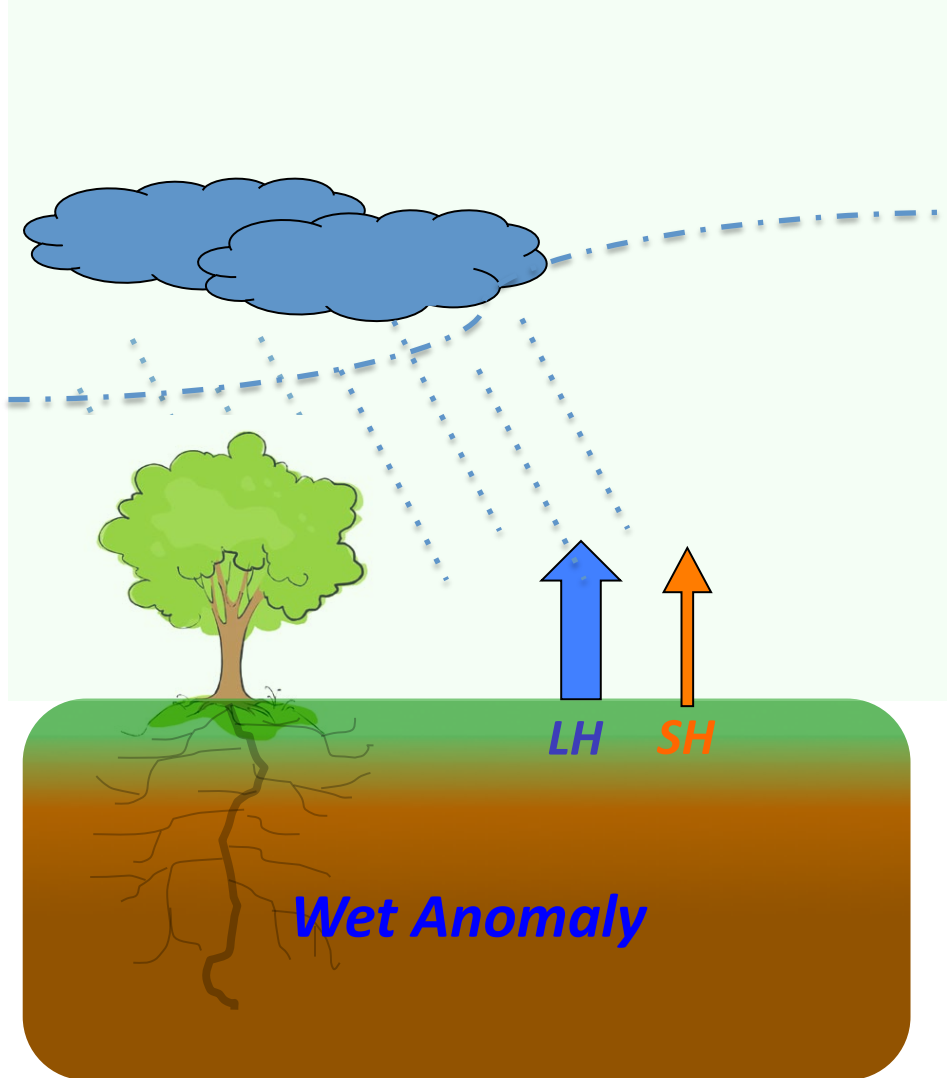


Land-Convection Coupling

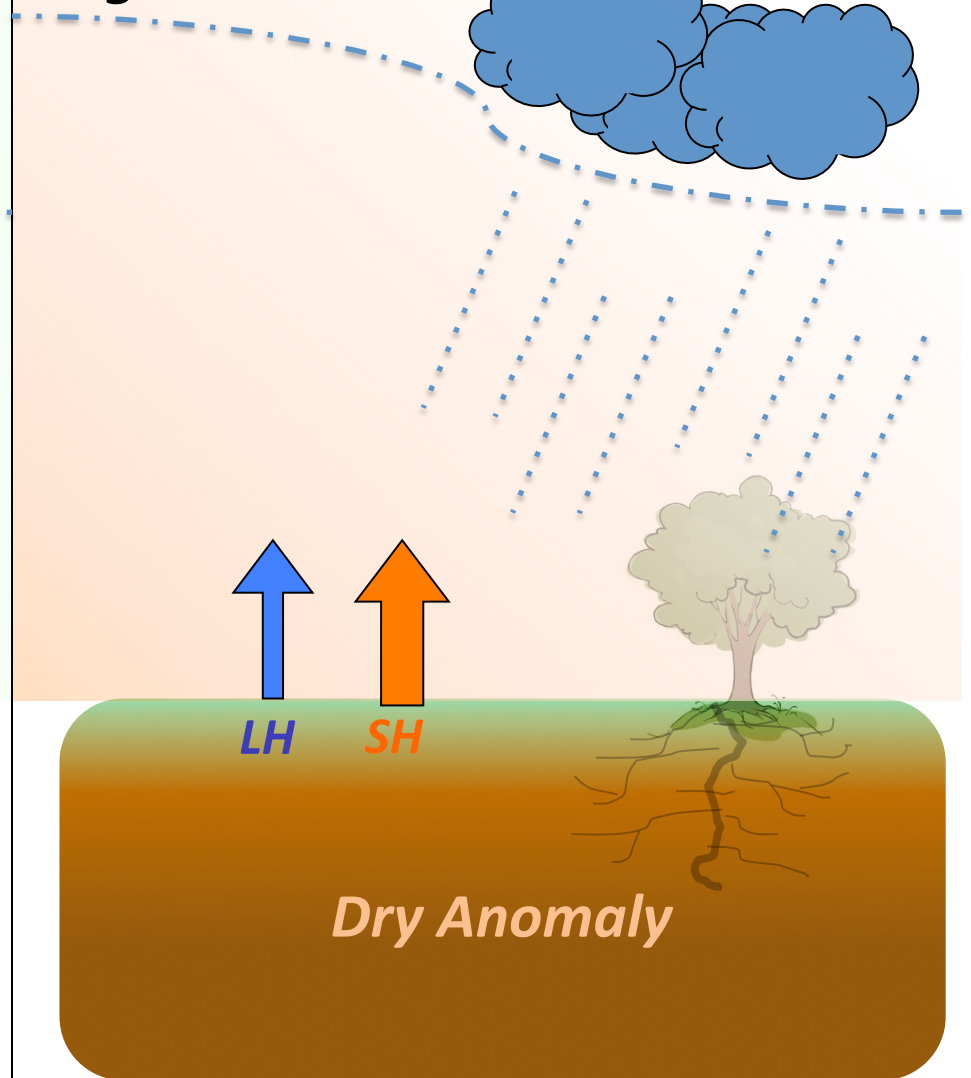


Land-Convection Coupling

Positive Feedback

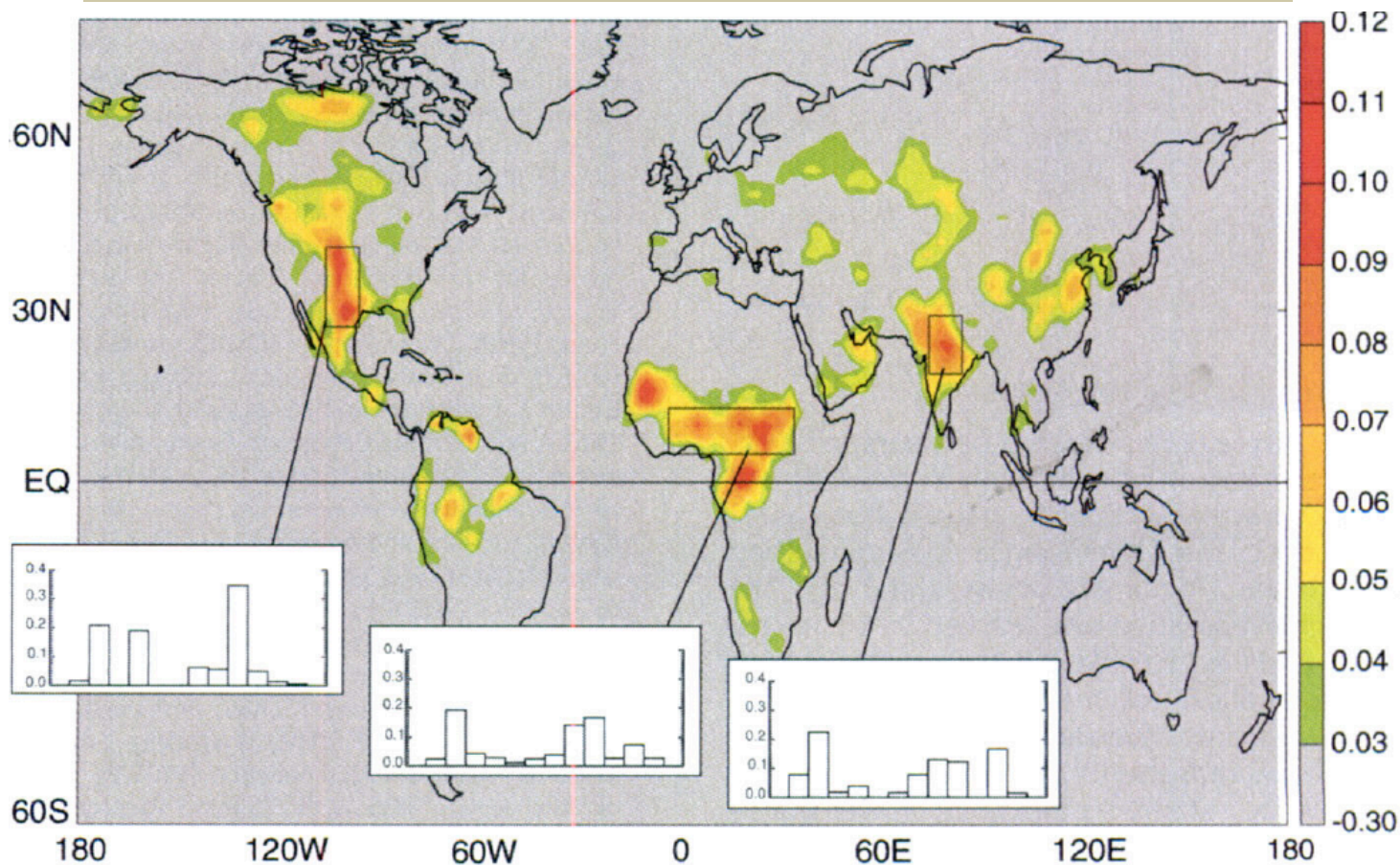


Negative Feedback



Model Land-Convection Coupling

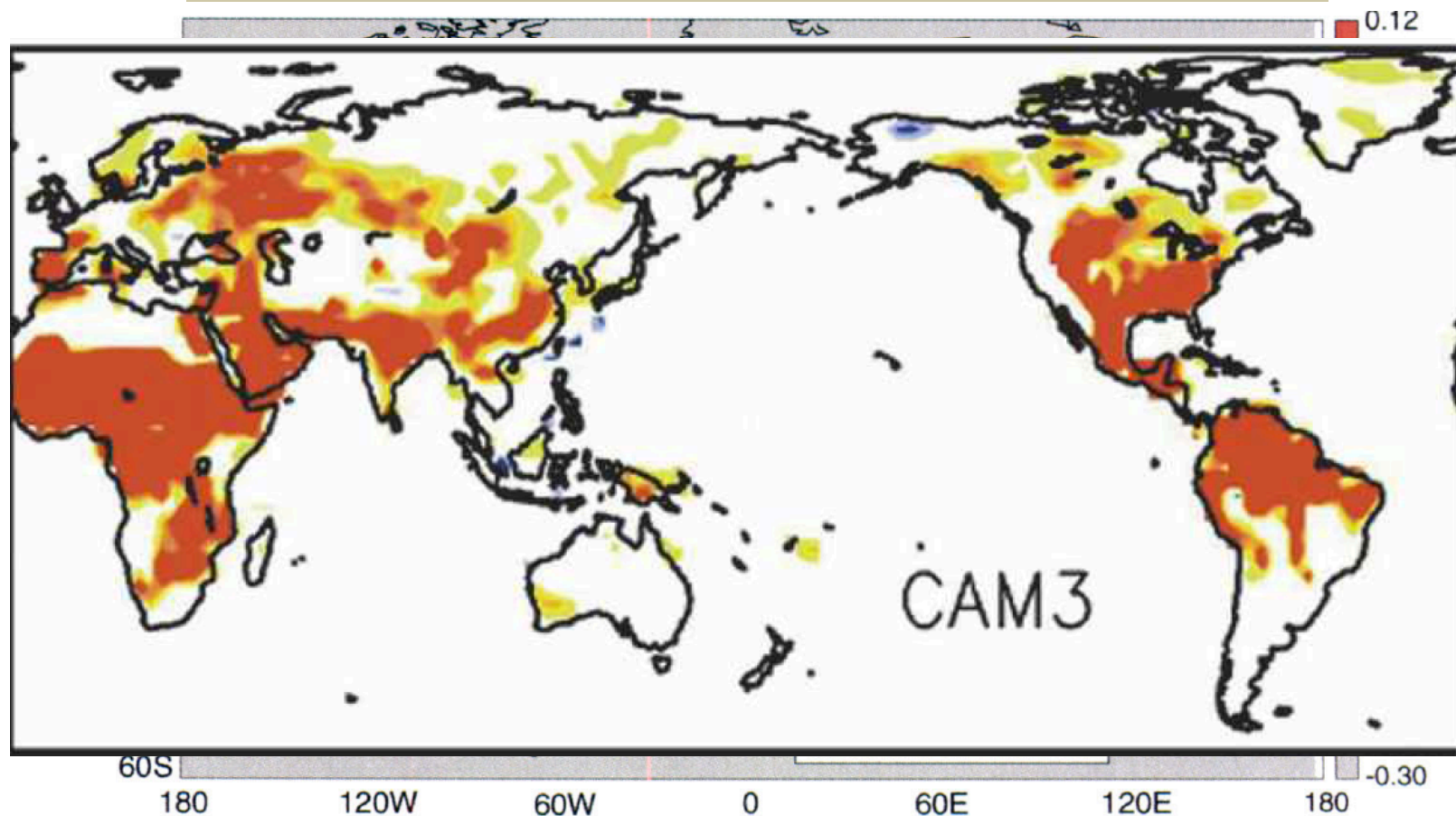
Positive Coupling Pattern from many GCMs



(Koster et al. 2004)

Model Land-Convection Coupling

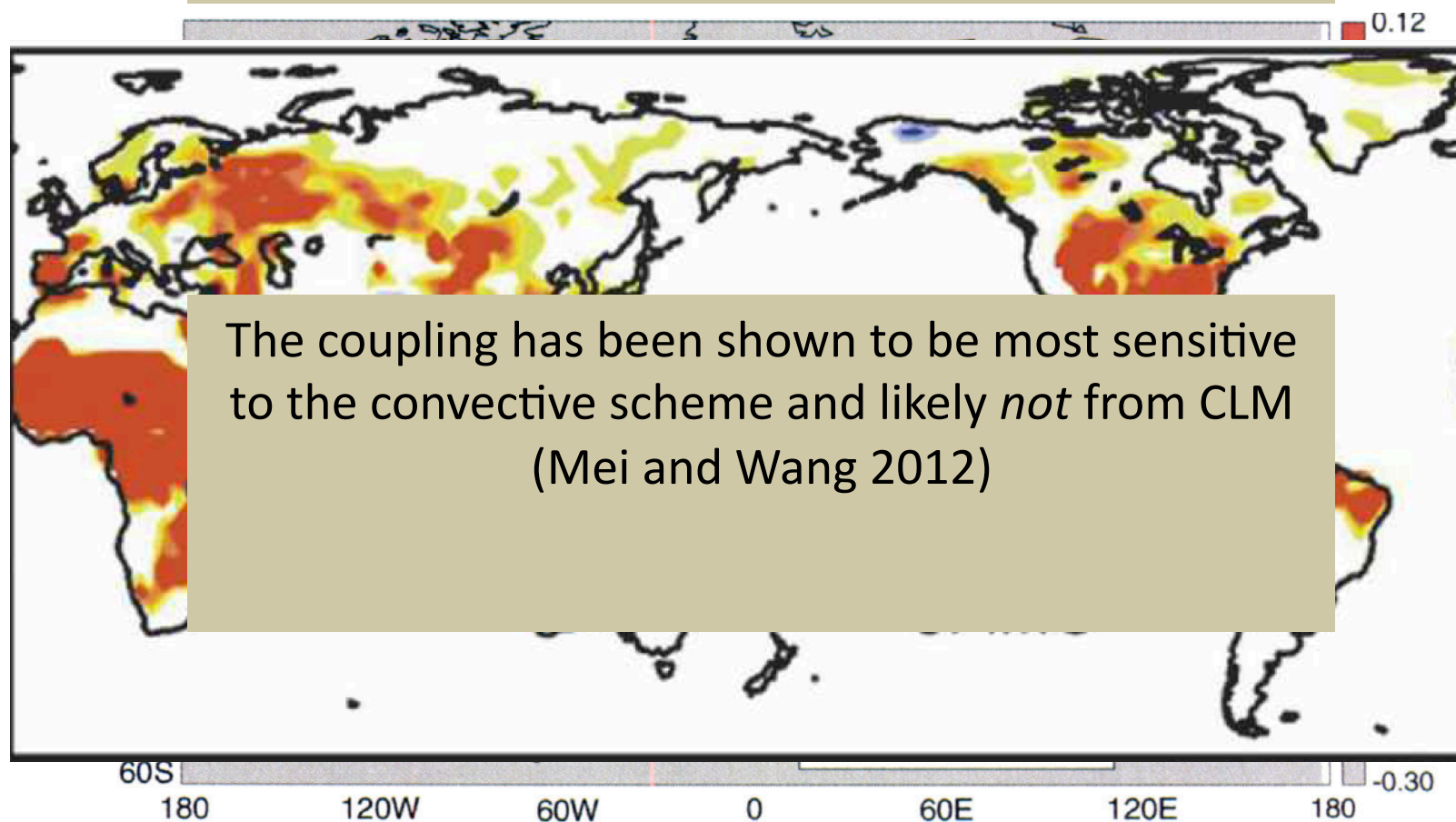
Positive Coupling Pattern from many GCMs



(Koster et al. 2006)

Model Land-Convection Coupling

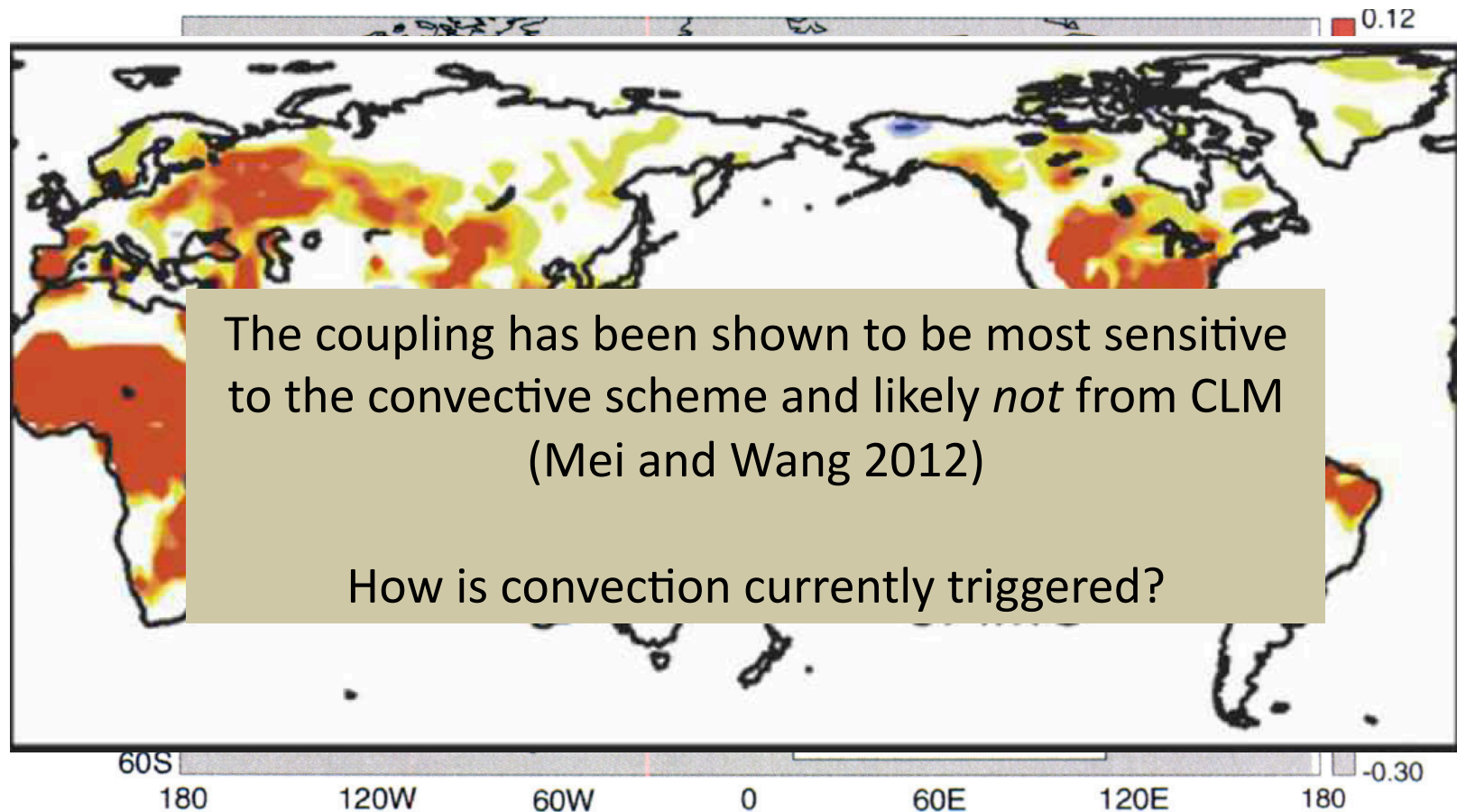
Positive Coupling Pattern from many GCMs



(Koster et al. 2006)

Model Land-Convection Coupling

Positive Coupling Pattern from many GCMs



(Koster et al. 2006)

Convective Triggering Mechanisms

- 1) **Current Trigger:** if $CAPE > 70 \text{ J/kg}$ then trigger convection
 - Evaluates the potential energy of a near-surface parcel
 - Can be sensitive to surface energy fluxes
 - more SH = more $CAPE$; more LH = more $CAPE$)

Convective Triggering Mechanisms

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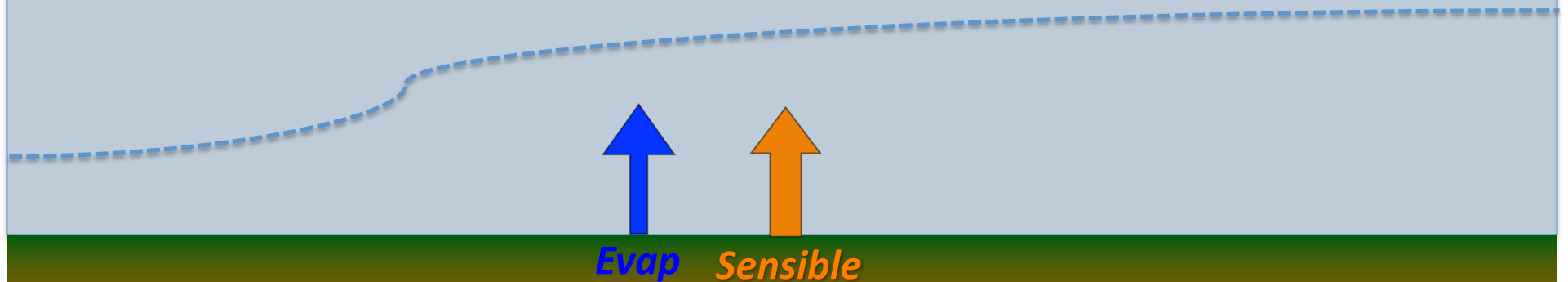
*** Ignores whether saturation has been reached

Convective Triggering Mechanisms

- 2) **New Trigger:** $RH \approx 100\%$ at PBL top
- Saturation due to buoyant mixing
 - Physically based

Convective Triggering Mechanisms

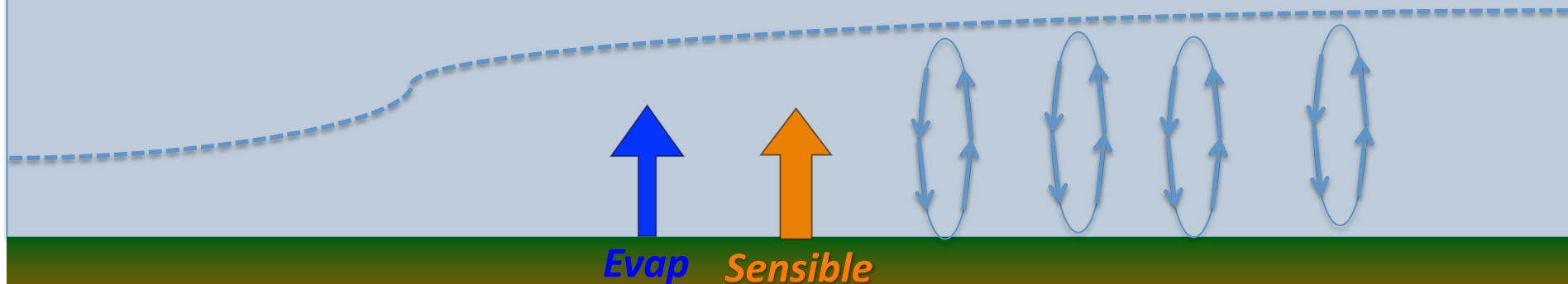
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Convective Triggering Mechanisms

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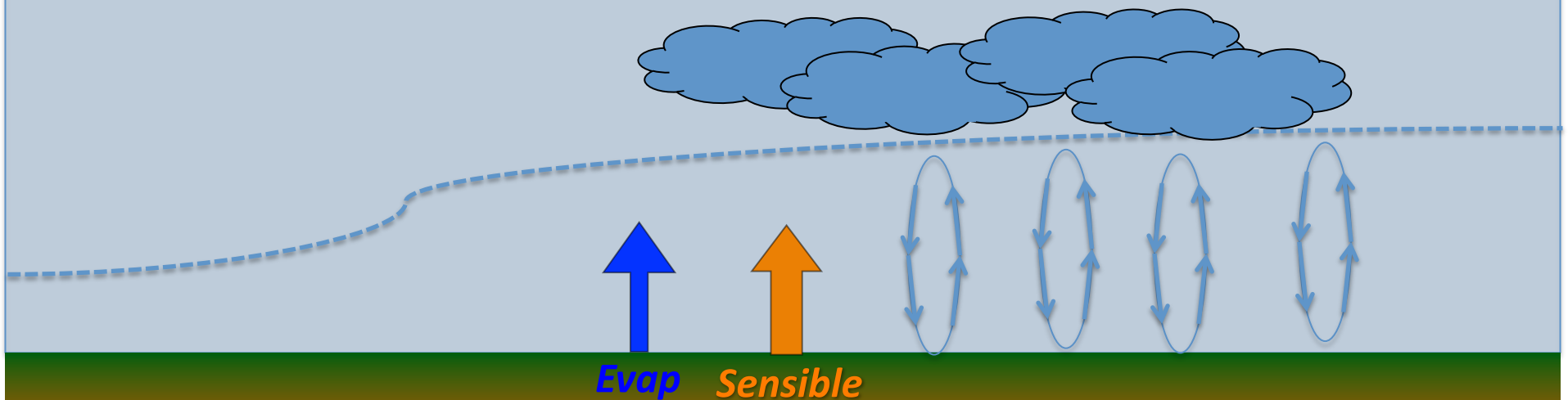
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- Physically based



Convective Triggering Mechanisms

2) New Trigger: $RH \approx 100\%$ at PBL top

- Saturation due to buoyant mixing or moistening
- Physically based

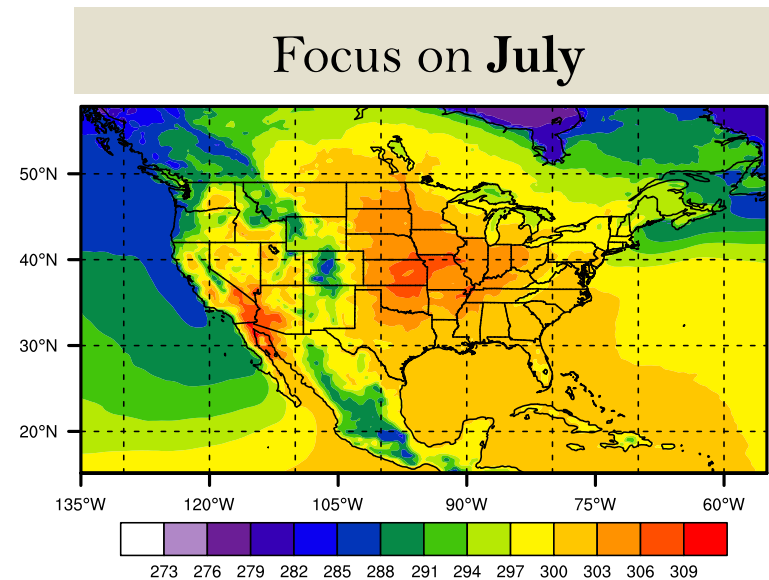


Questions Regarding Convective Coupling

- Does the *mean* land surface and near-surface change?
- *Where* is the greatest impact, globally?
- Does it change the soil moisture-precipitation *coupling*?

Simulation Design

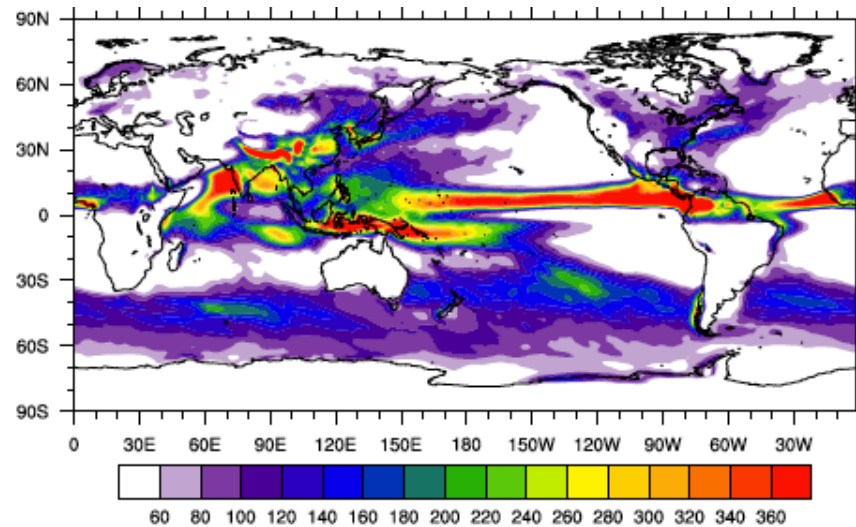
- Two simulations using CESM 1.2.0:
 - **1.00** degree
 - sim years: 2000-2010
- Components:
 - CAM 5.0 atmosphere
 - CLM 4.0 land surface
 - Data everything else
- Only differ in Convective **Triggering** Mechanism
 - CAPE triggering (instability)
 - Buoyant Condensation Trigger



Spatial Precipitation Change

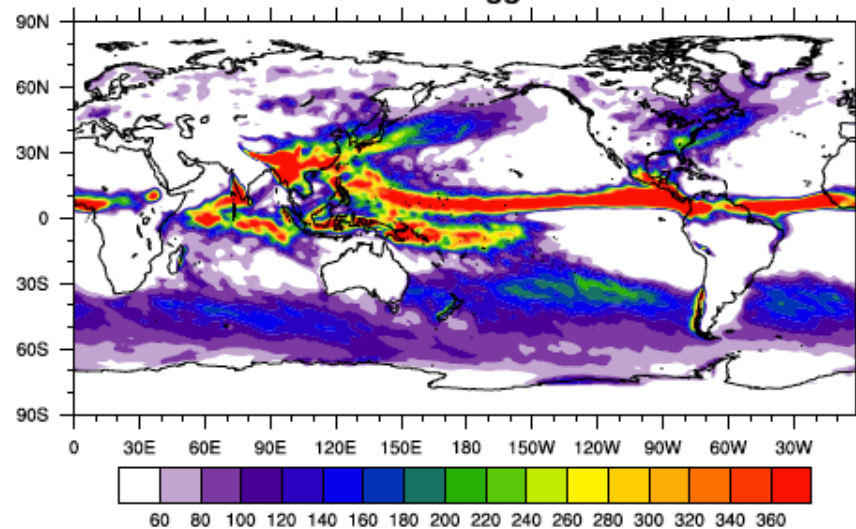
CAPE Trigger

Precipitation (mm)



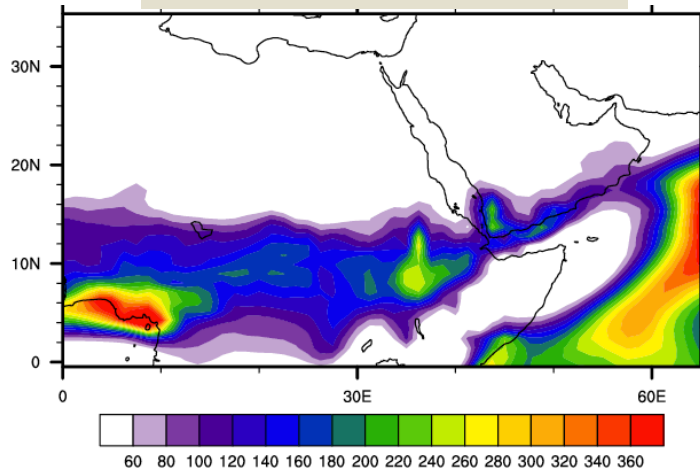
BCL Trigger

BCL Trigger

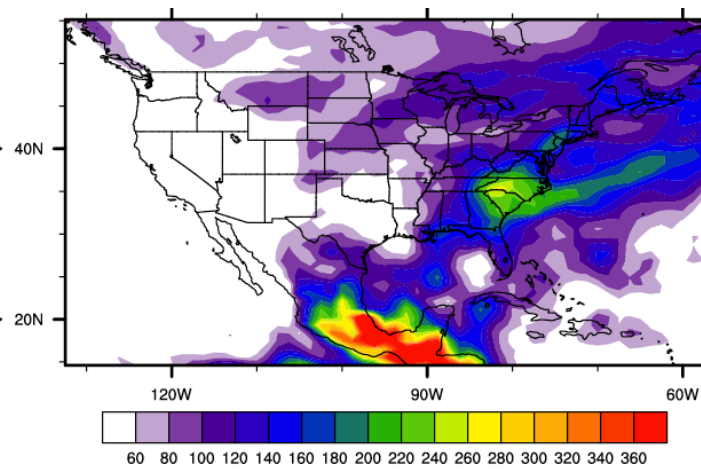
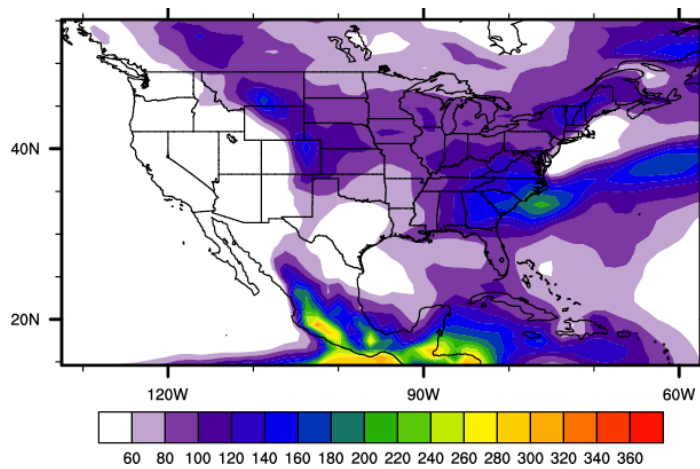
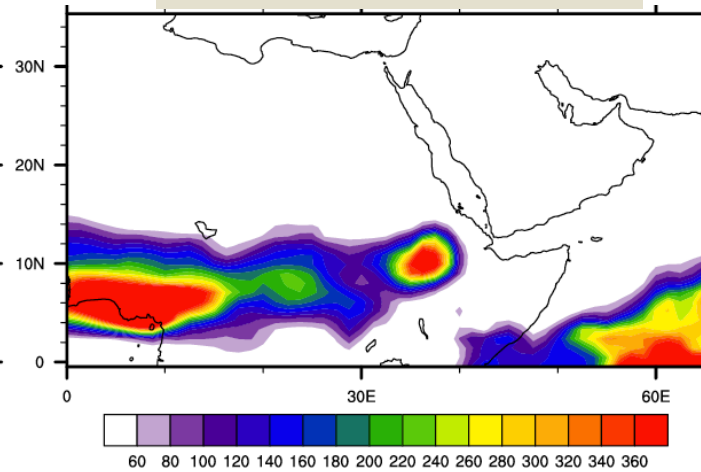


Spatial Precipitation Change

CAPE Trigger

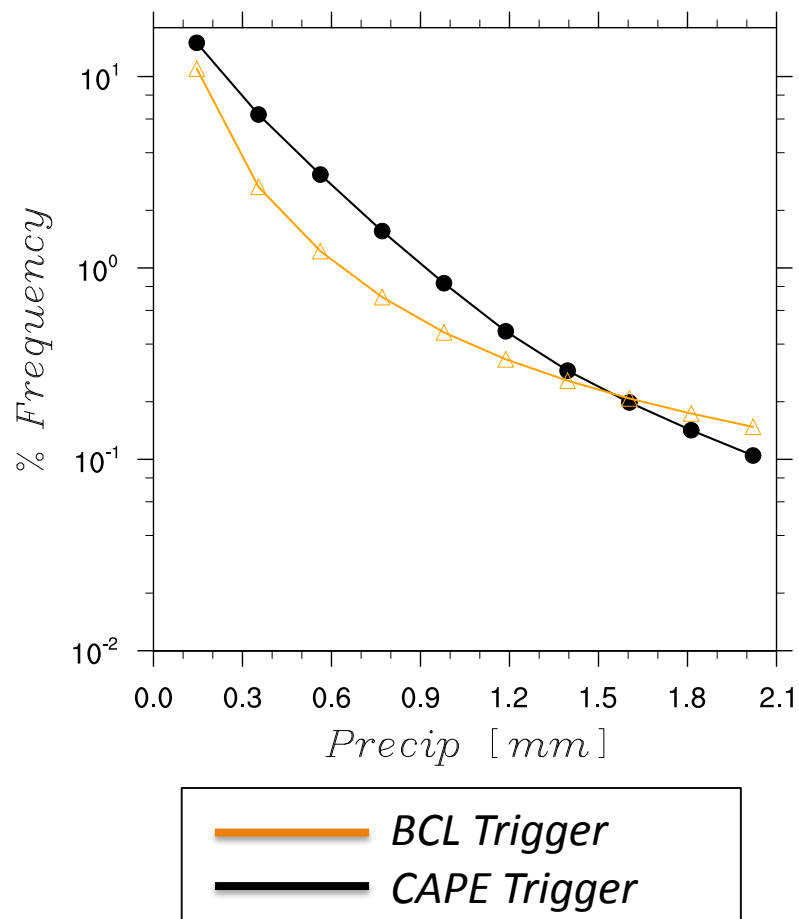


BCL Trigger



July 2010 Land Precipitation Distribution

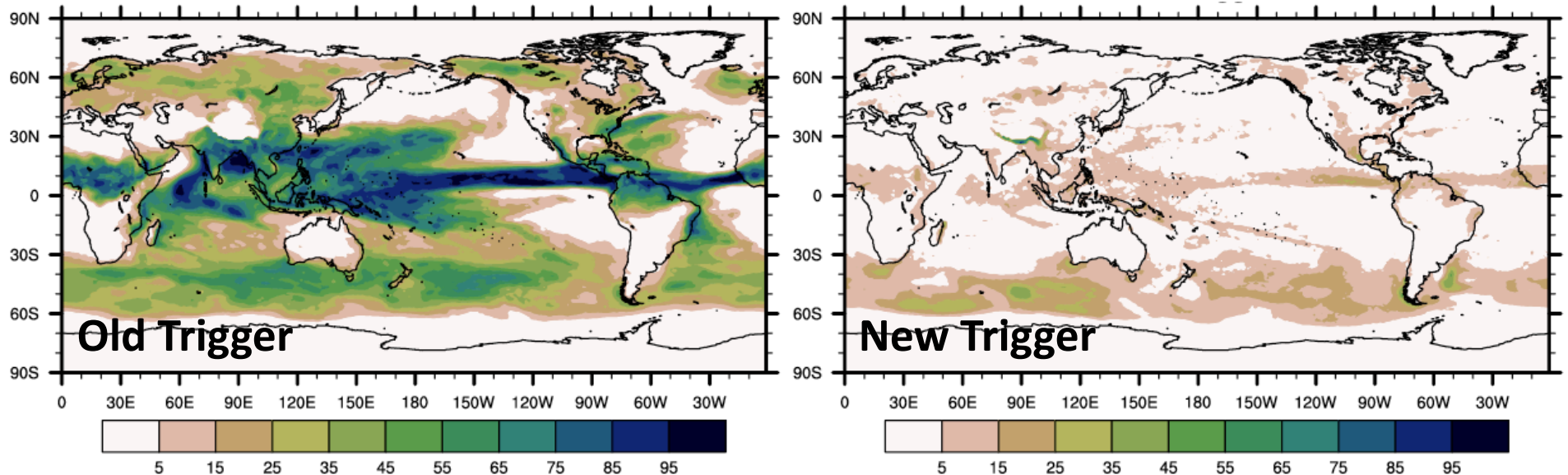
Probability Distribution of hourly precip



- **BCL trigger has:**
 - more heavy rain
 - less moderate and drizzle
- **CAPE is allowed to accumulated in BCL scheme**
- **How often does it rain?**

July 2010 Land Precipitation Distribution

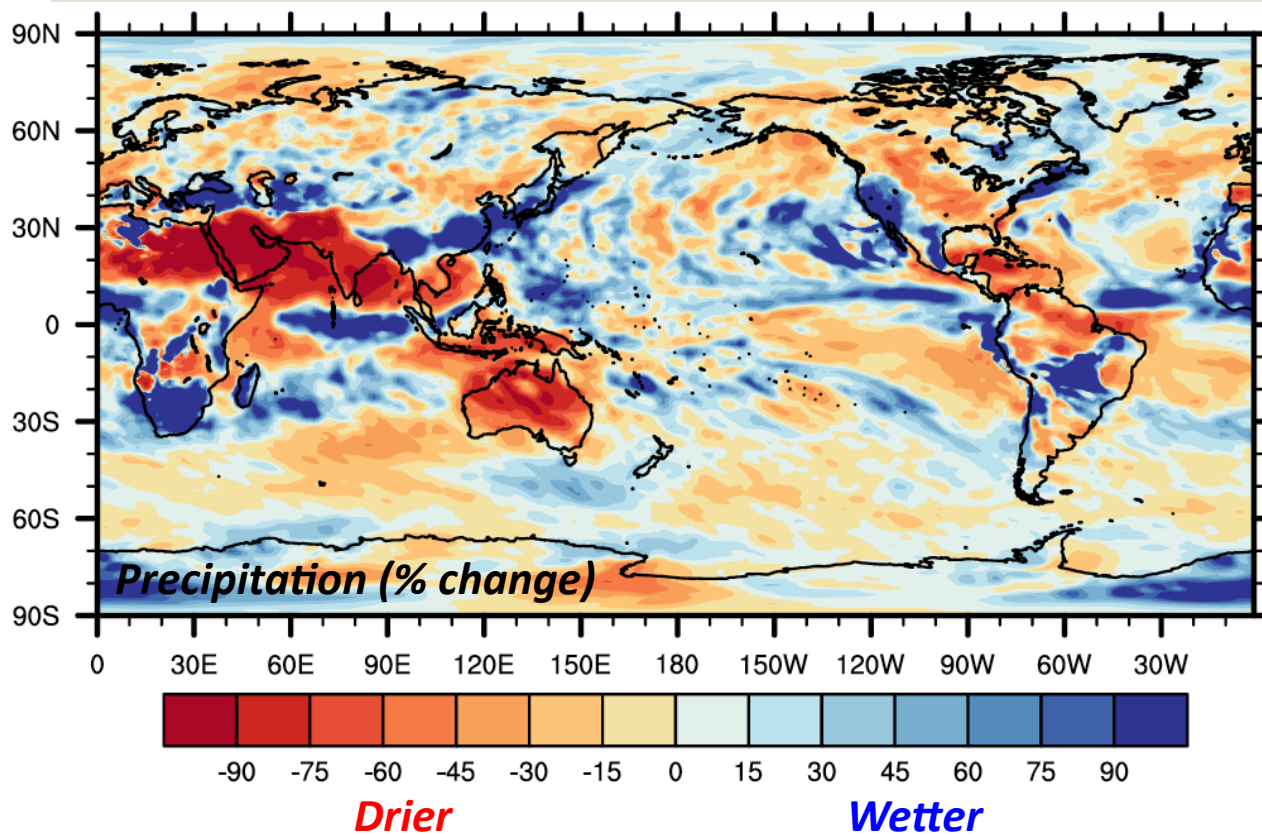
% of hours with Convective Precipitation



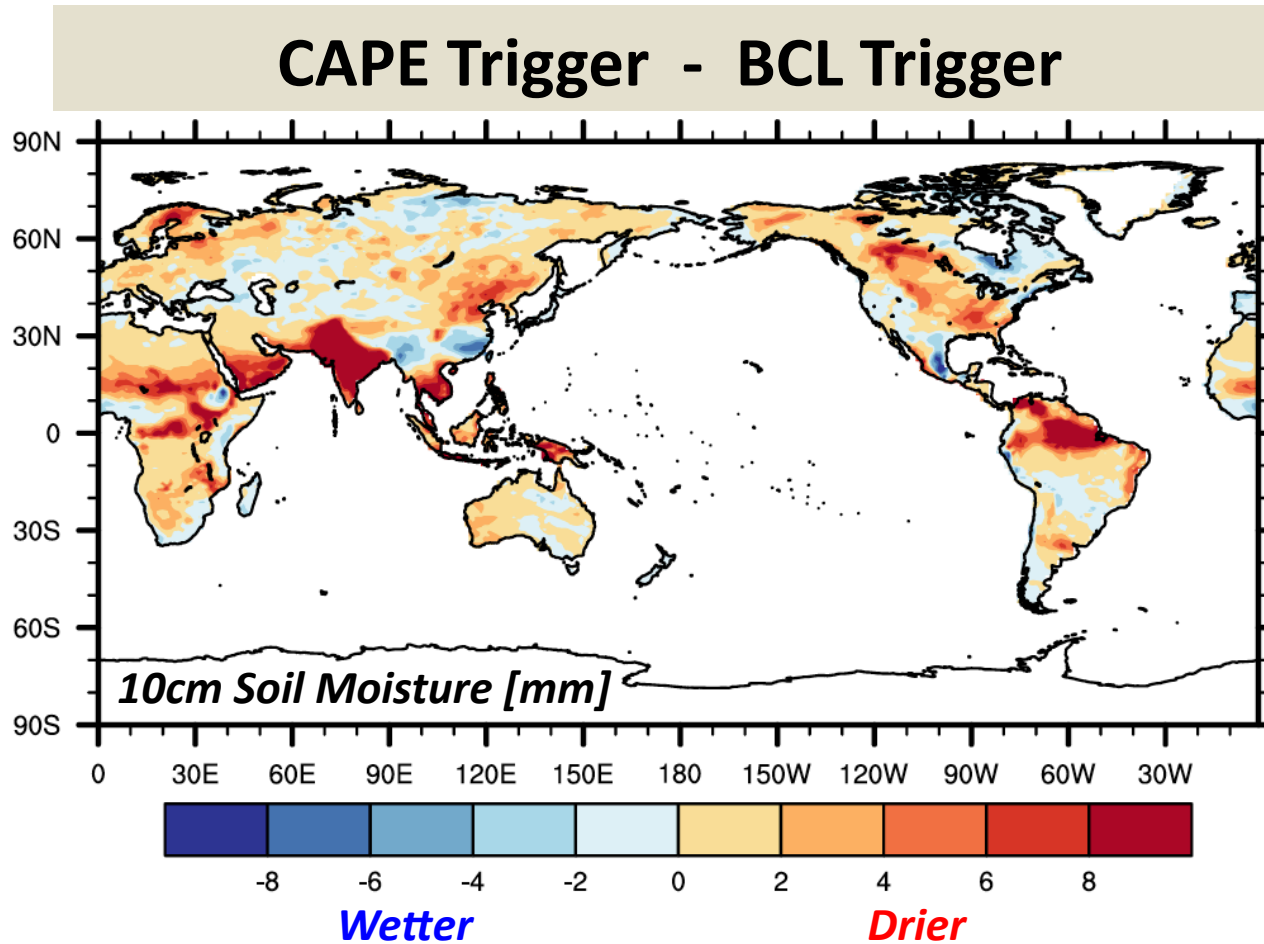
** (# of convective events / 744 hours in July)

Spatial Differences: 10-year Simulation

CAPE Trigger - BCL Trigger

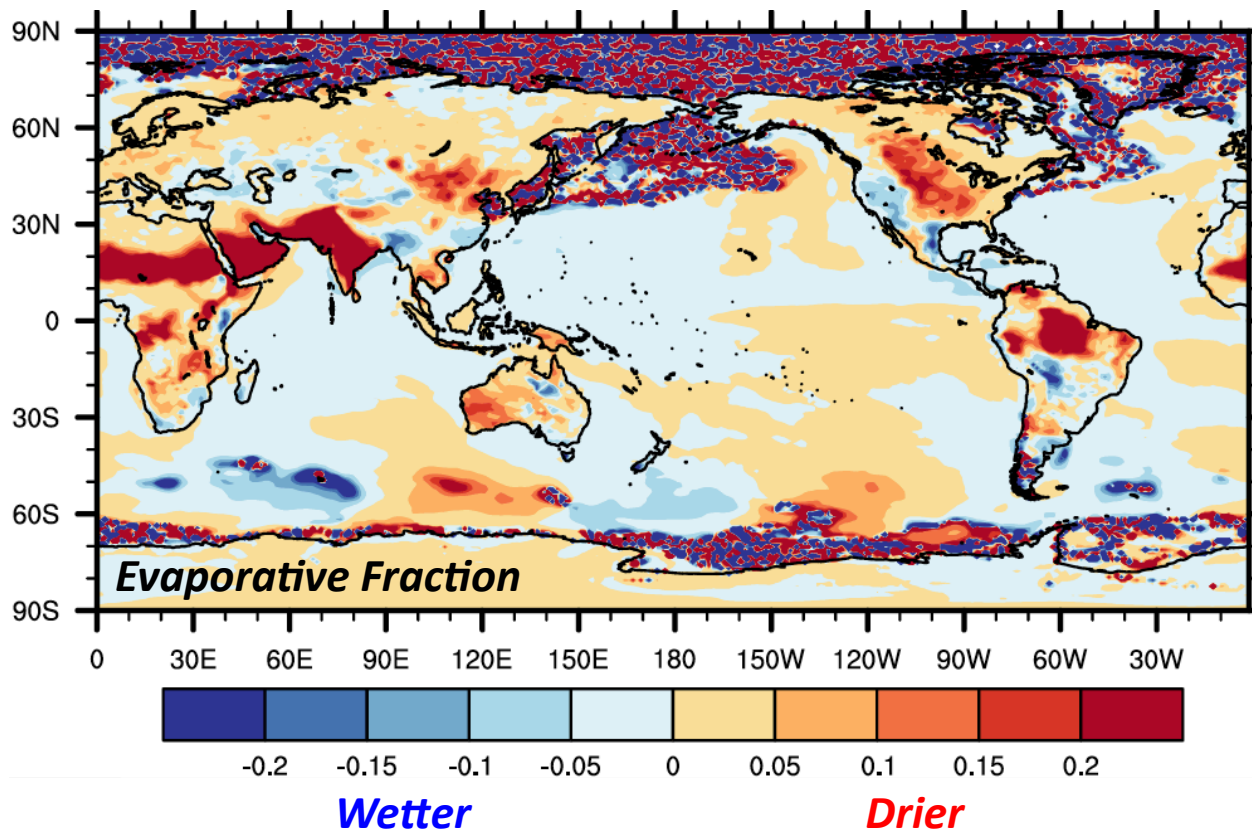


Spatial Differences: 10-year Simulation



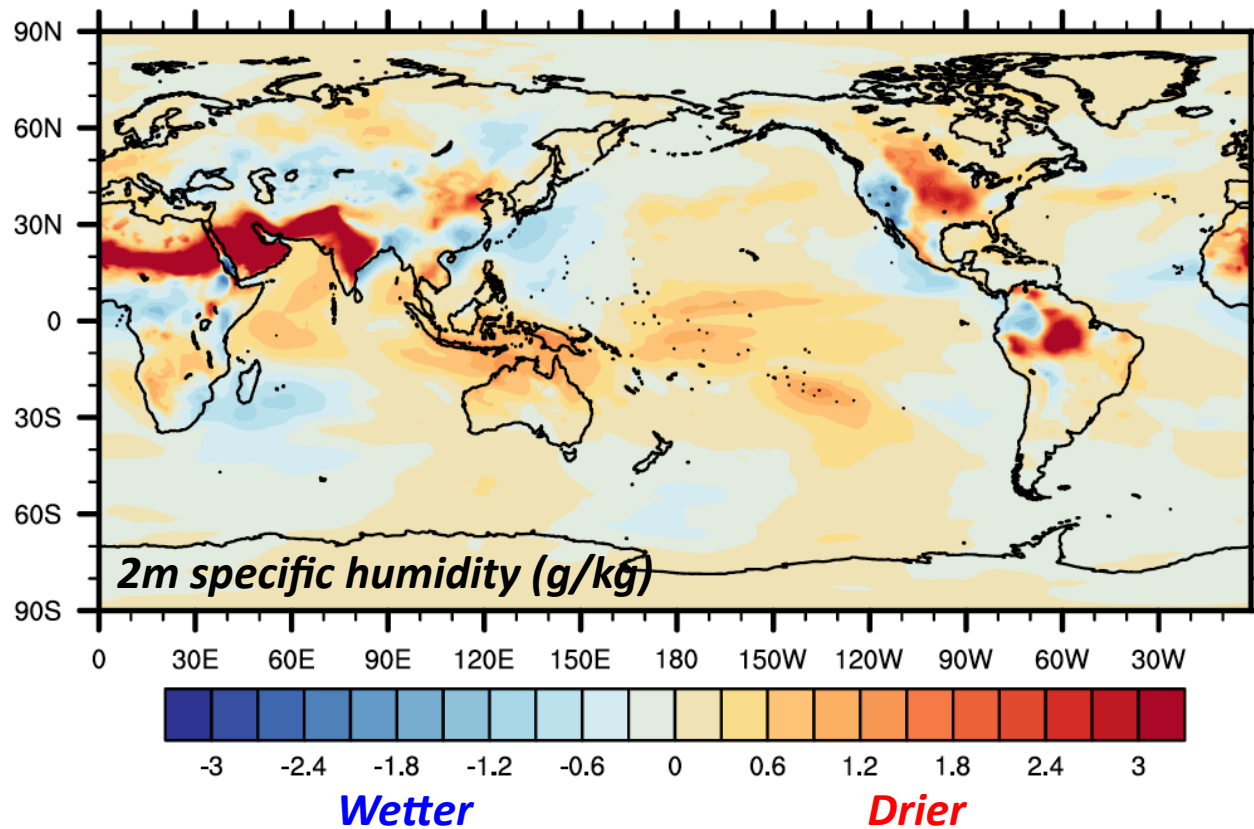
Spatial Differences: 10-year Simulation

CAPE Trigger - BCL Trigger



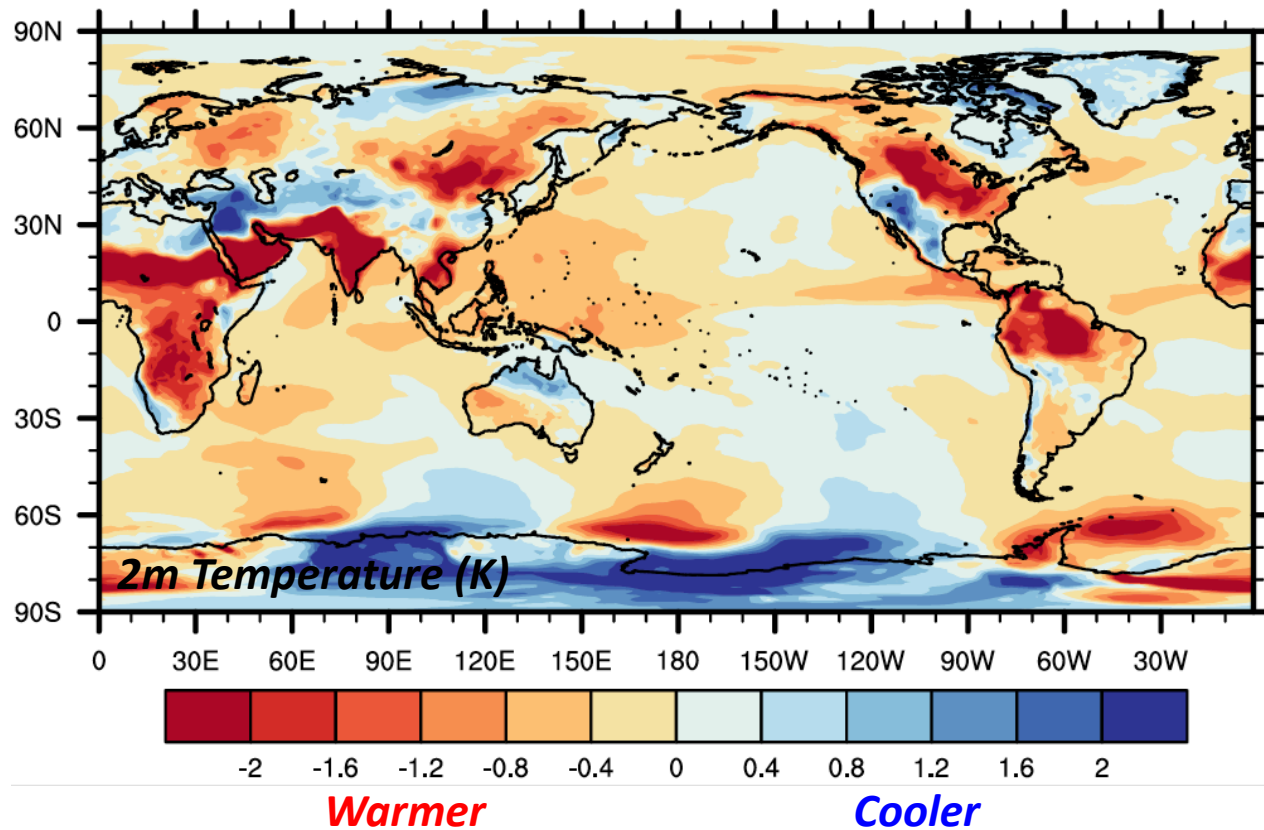
Spatial Differences: 10-year Simulation

CAPE Trigger - BCL Trigger



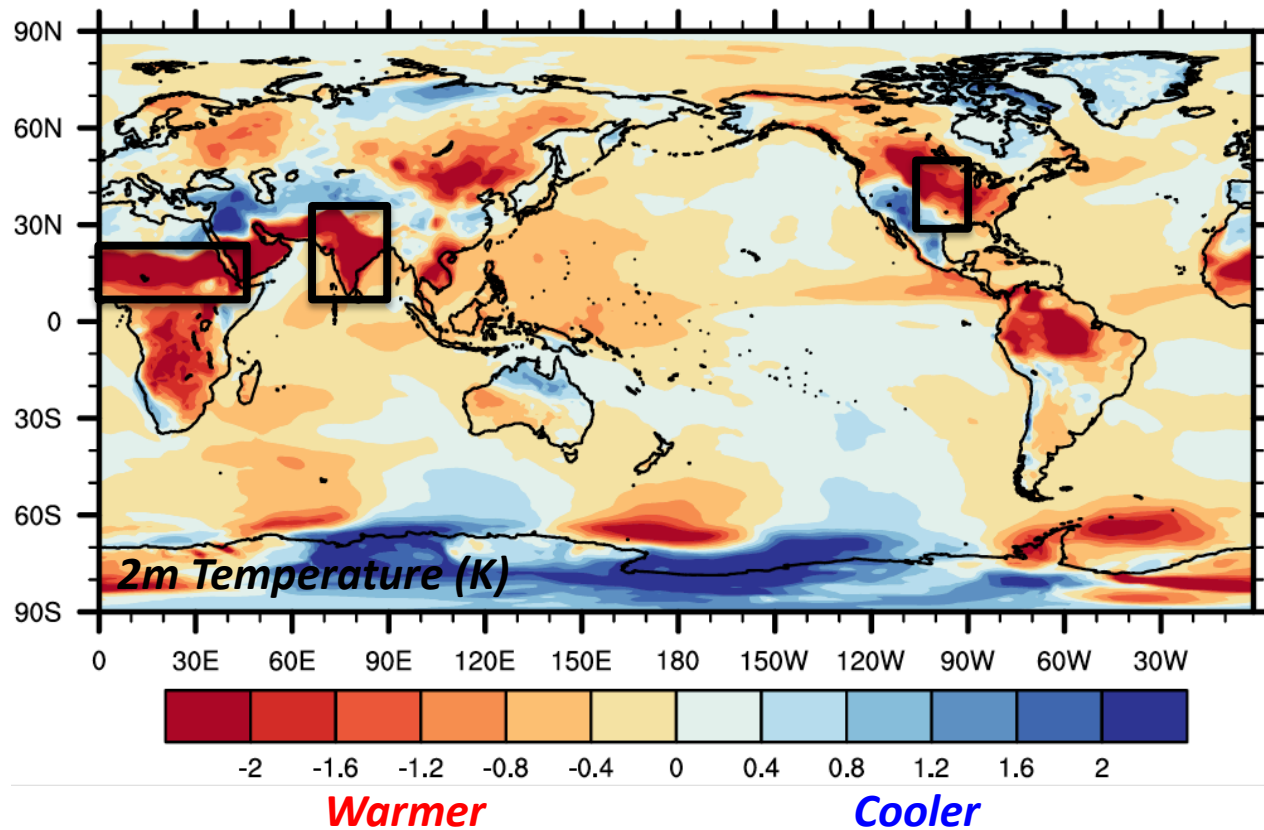
Spatial Differences: 10-year Simulation

CAPE Trigger - BCL Trigger



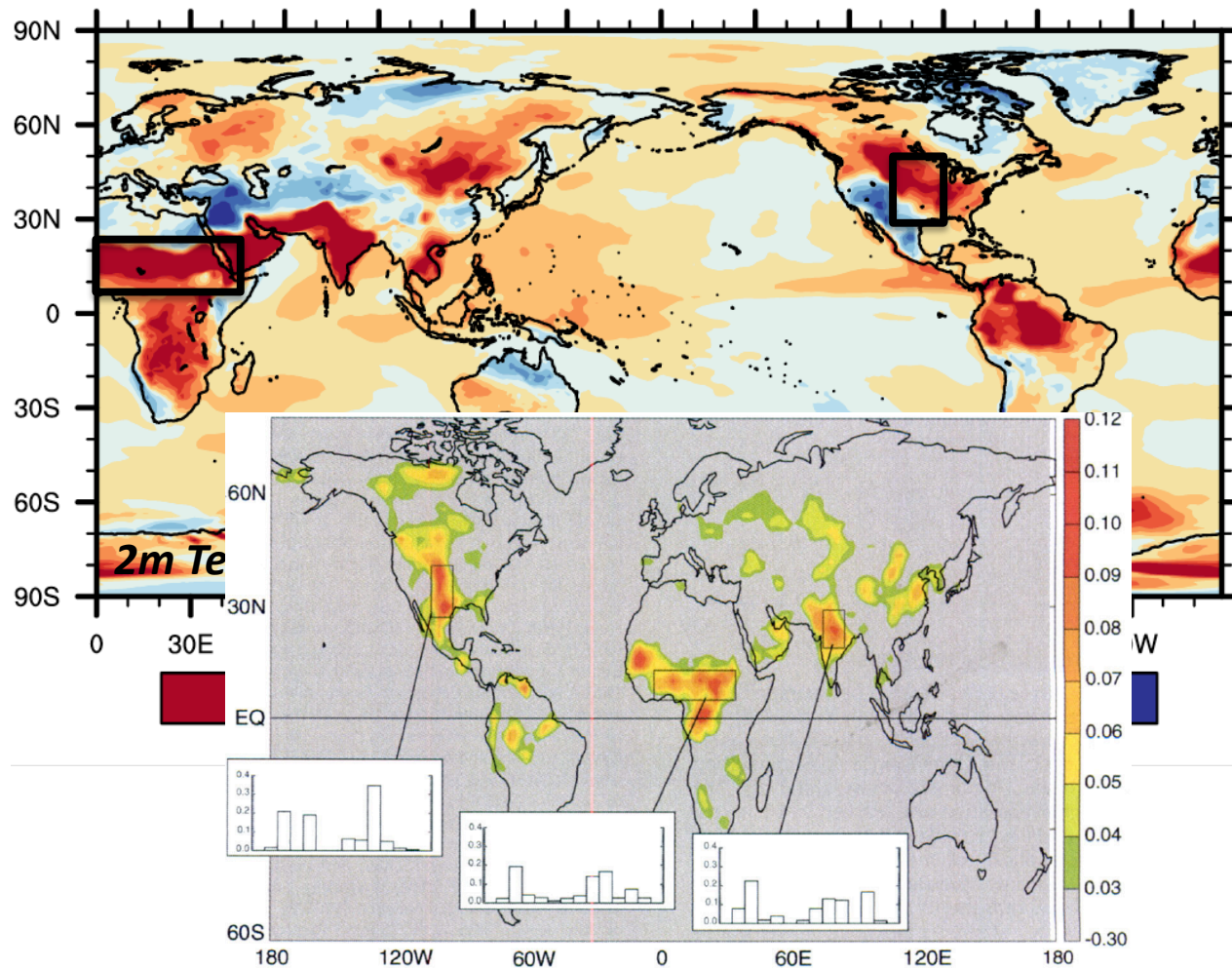
Spatial Differences: 10-year Simulation

CAPE Trigger - BCL Trigger



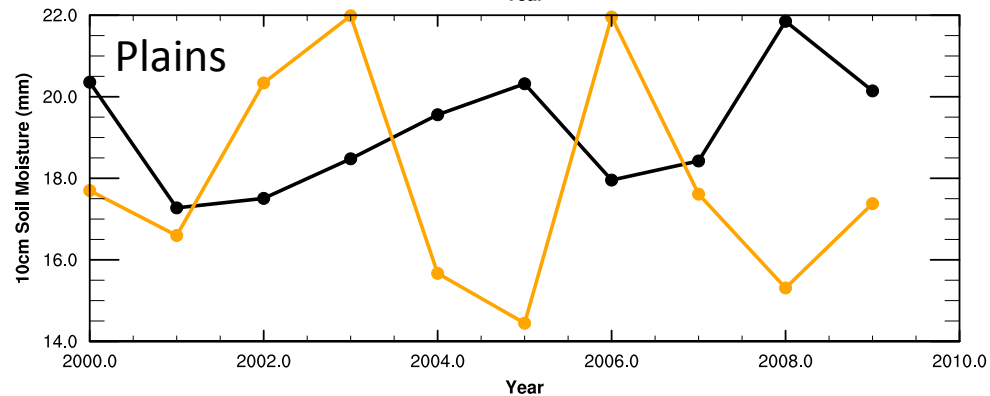
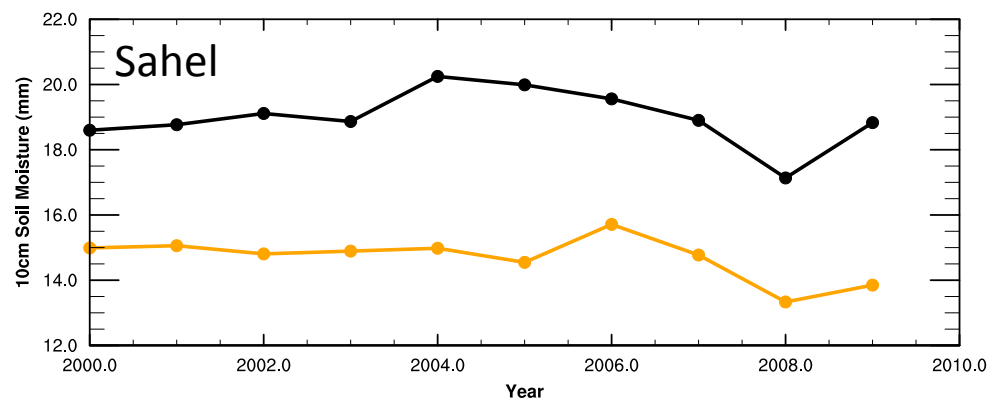
Spatial Differences: 10-year Simulation

CAPE Trigger - BCL Trigger



Inter-annual Variability for July

10cm Soil Moisture Inter-Annual Variability

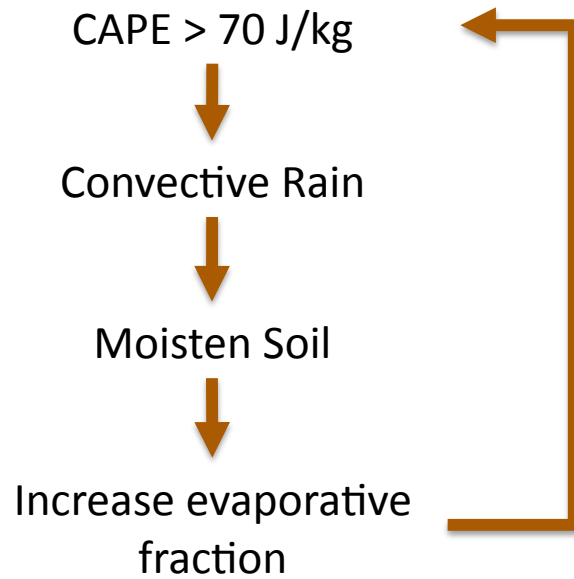


- On average BCL trigger produces drier 10cm soil
- Shift to drier overall regime for Sahel
- Variability increases over the Plains

Mechanism At Work

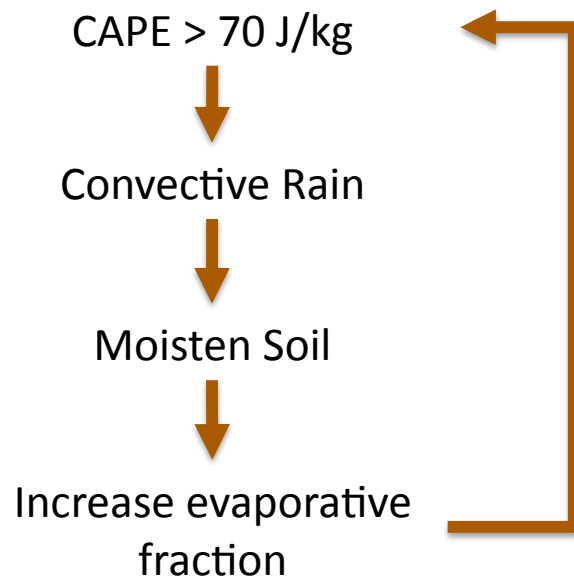
Under the Old Trigger

Under the New Trigger

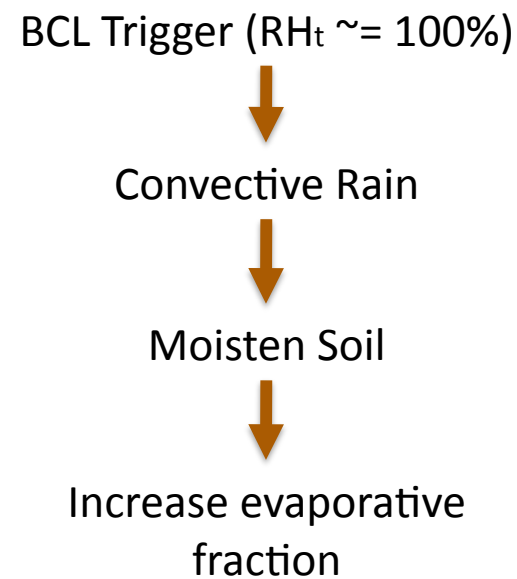


Mechanism At Work

Under the Old Trigger

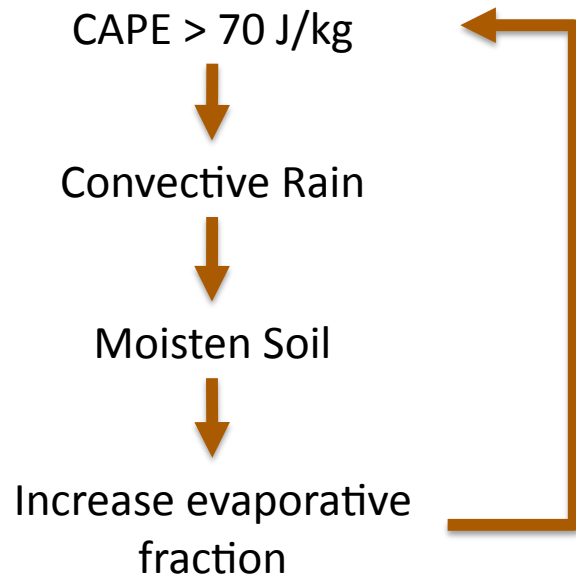


Under the New Trigger

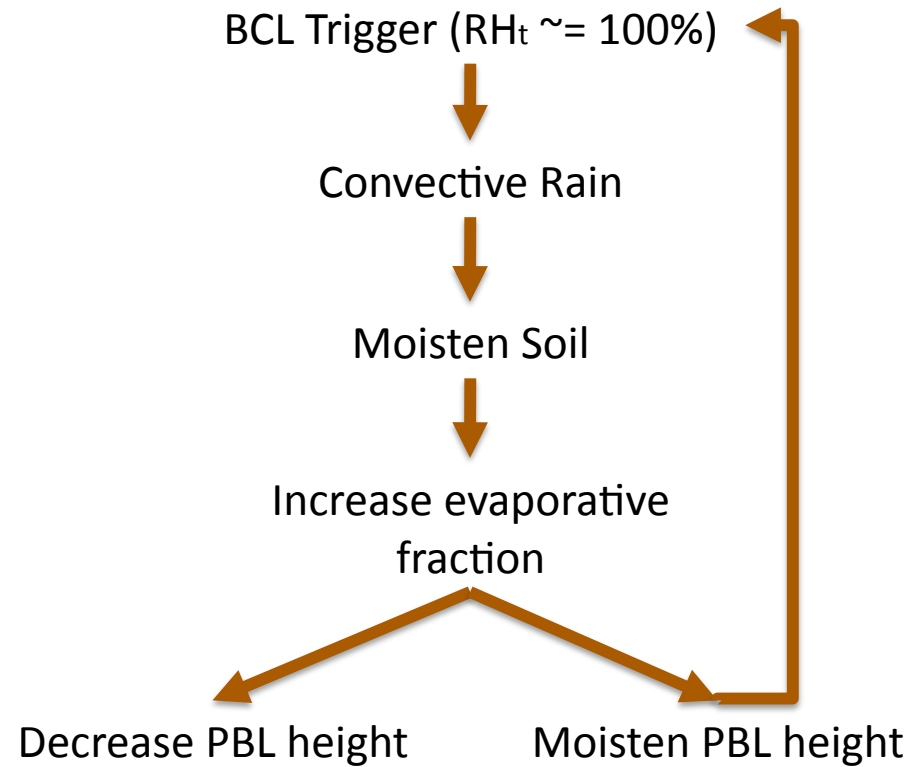


Mechanism At Work

Under the Old Trigger



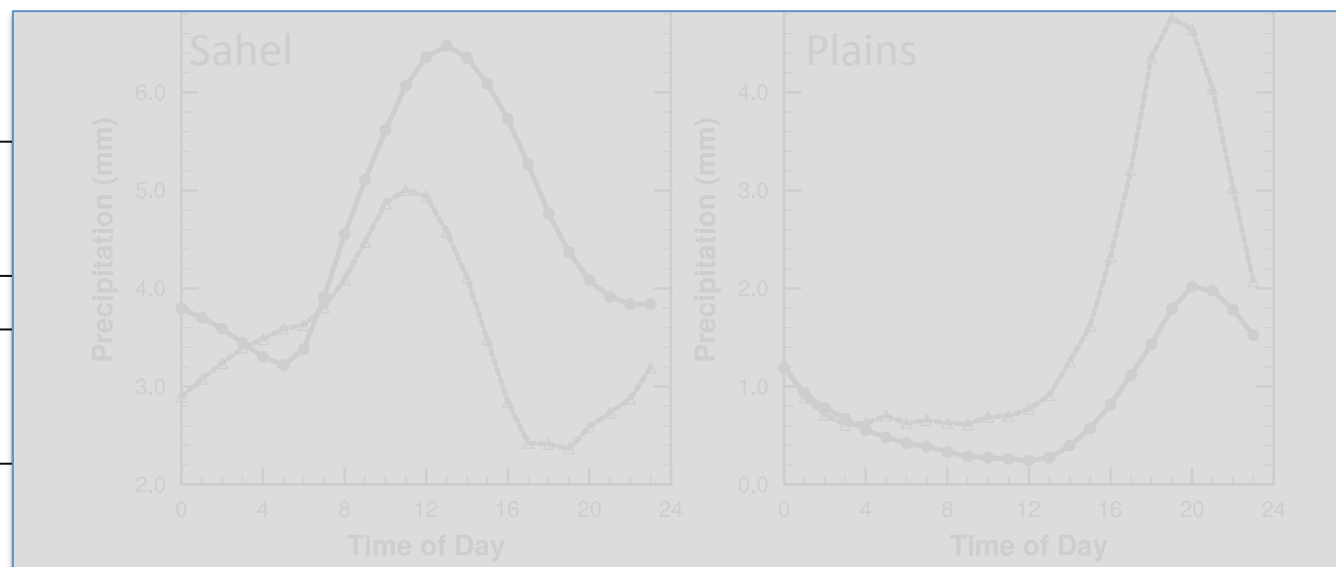
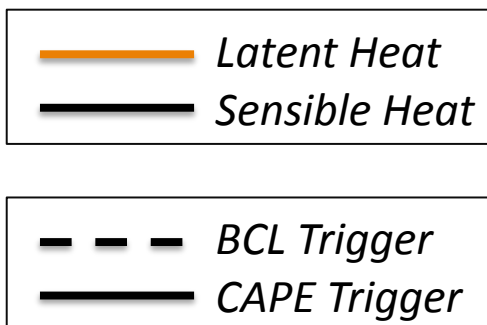
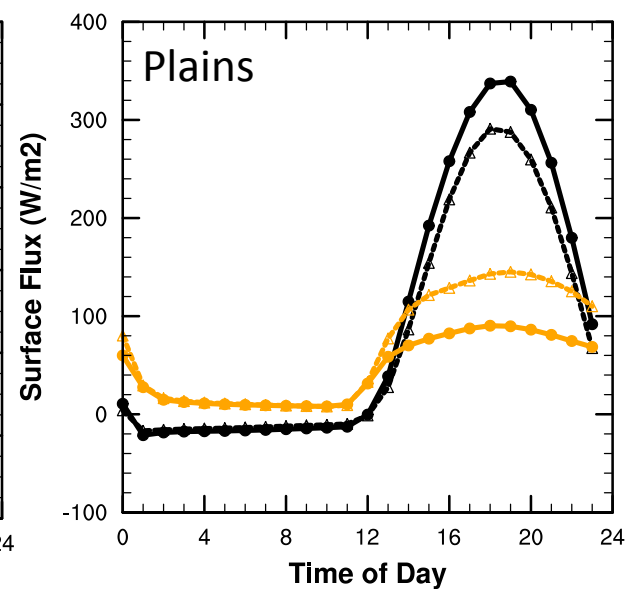
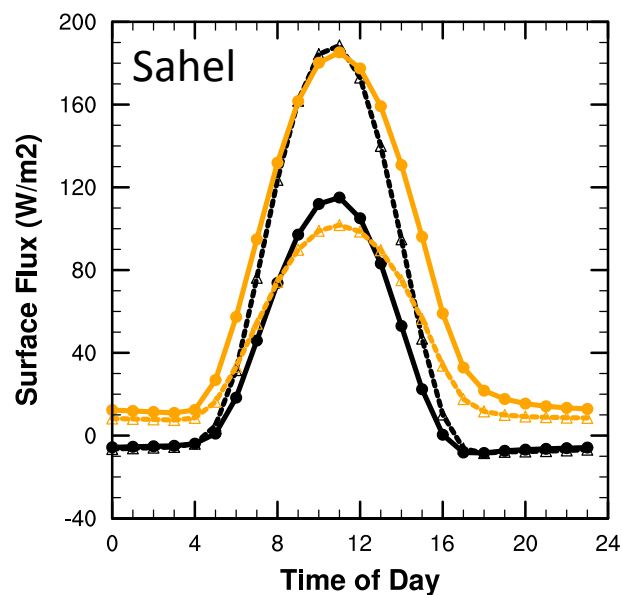
Under the New Trigger



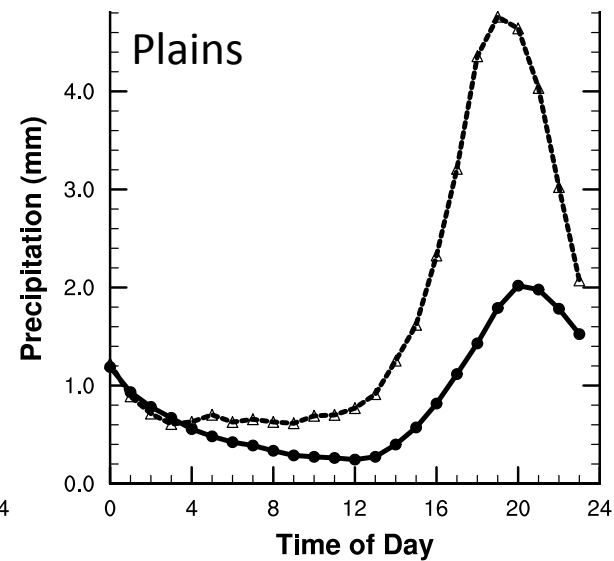
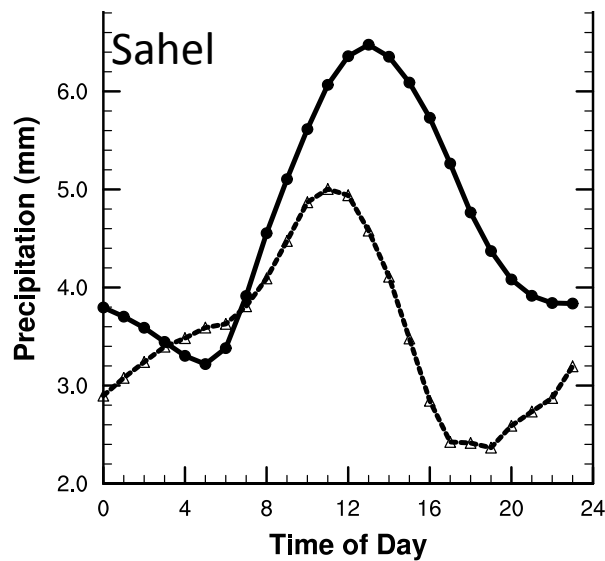
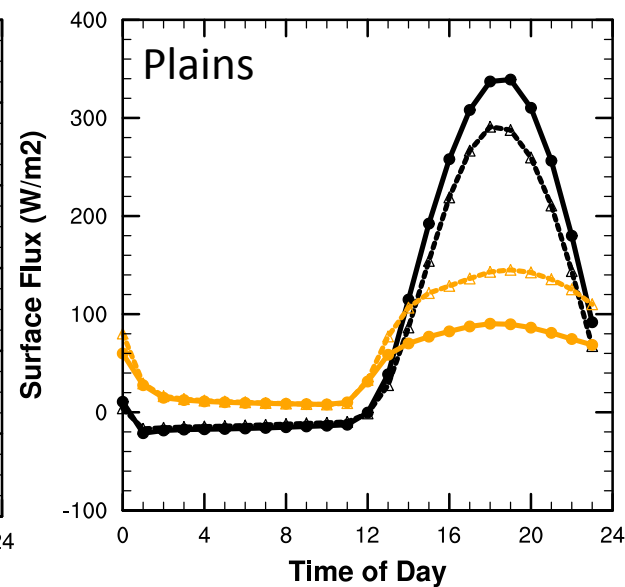
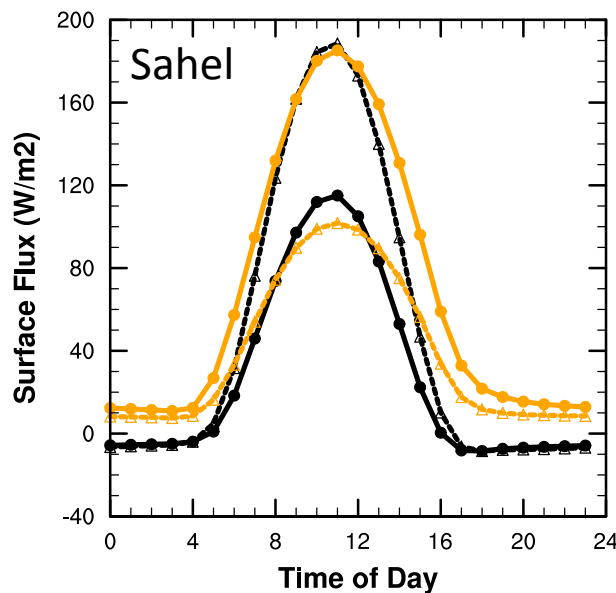
Summary and Thoughts

- Buoyant condensation trigger:
 - More heavy precipitation; less “drizzle” precipitation
 - Produced greatest response in typical “hotspot” regions
 - Hotspots became drier in general
 - Resulted in greater inter-annual variability for some regions
- What does “tuning” CLM mean in this context of spatially heterogeneous sensitivity?

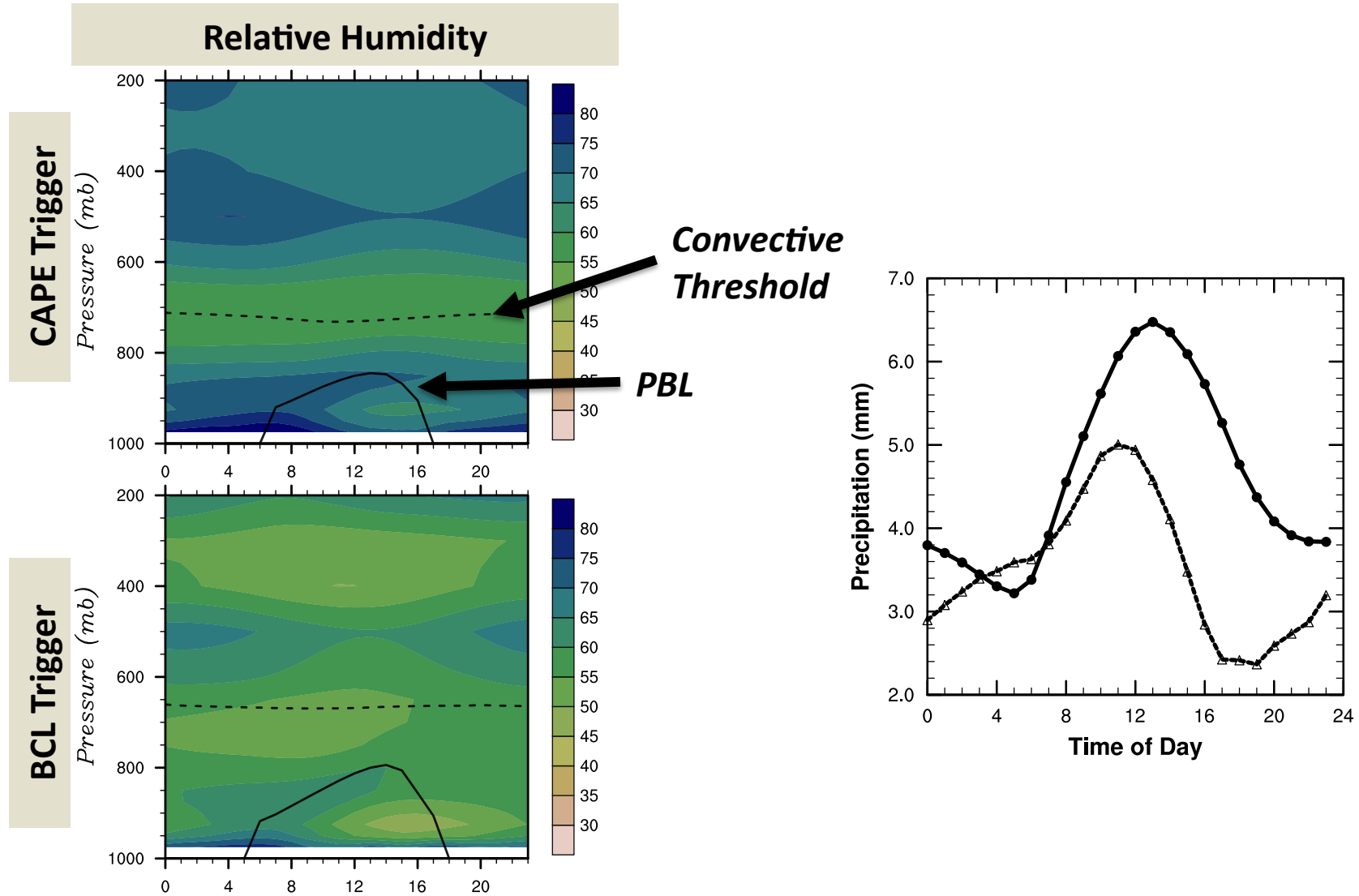
Diurnal Cycle: July 2010



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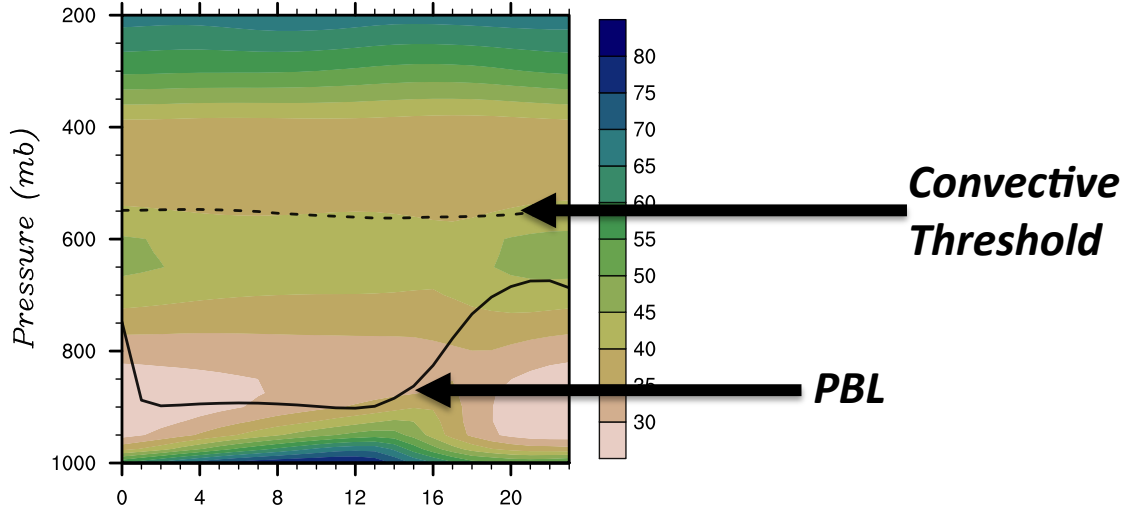
Relative Humidity Diurnal Cycle



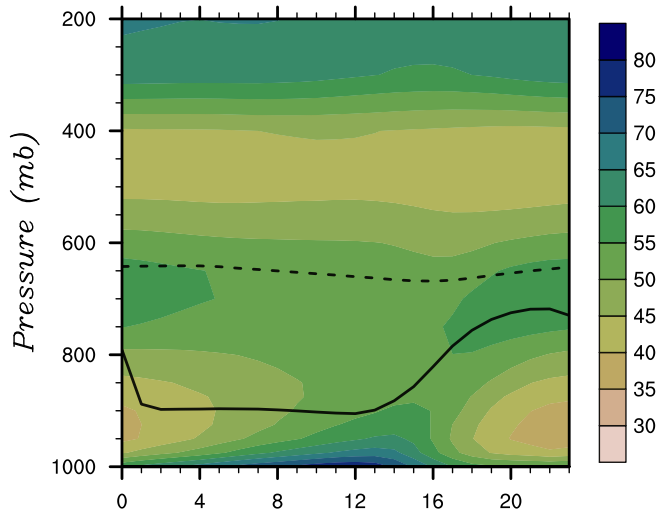
Precipitation Characteristics

Relative Humidity

CAPE Trigger



BCL Trigger



Convective Triggering Mechanisms

When **PBL** intersects the Buoyant Condensation Level (**BCL**)
Convection Happens

$$\text{BCL Deficit} = \text{BCL Height} - \text{PBL Height}$$

