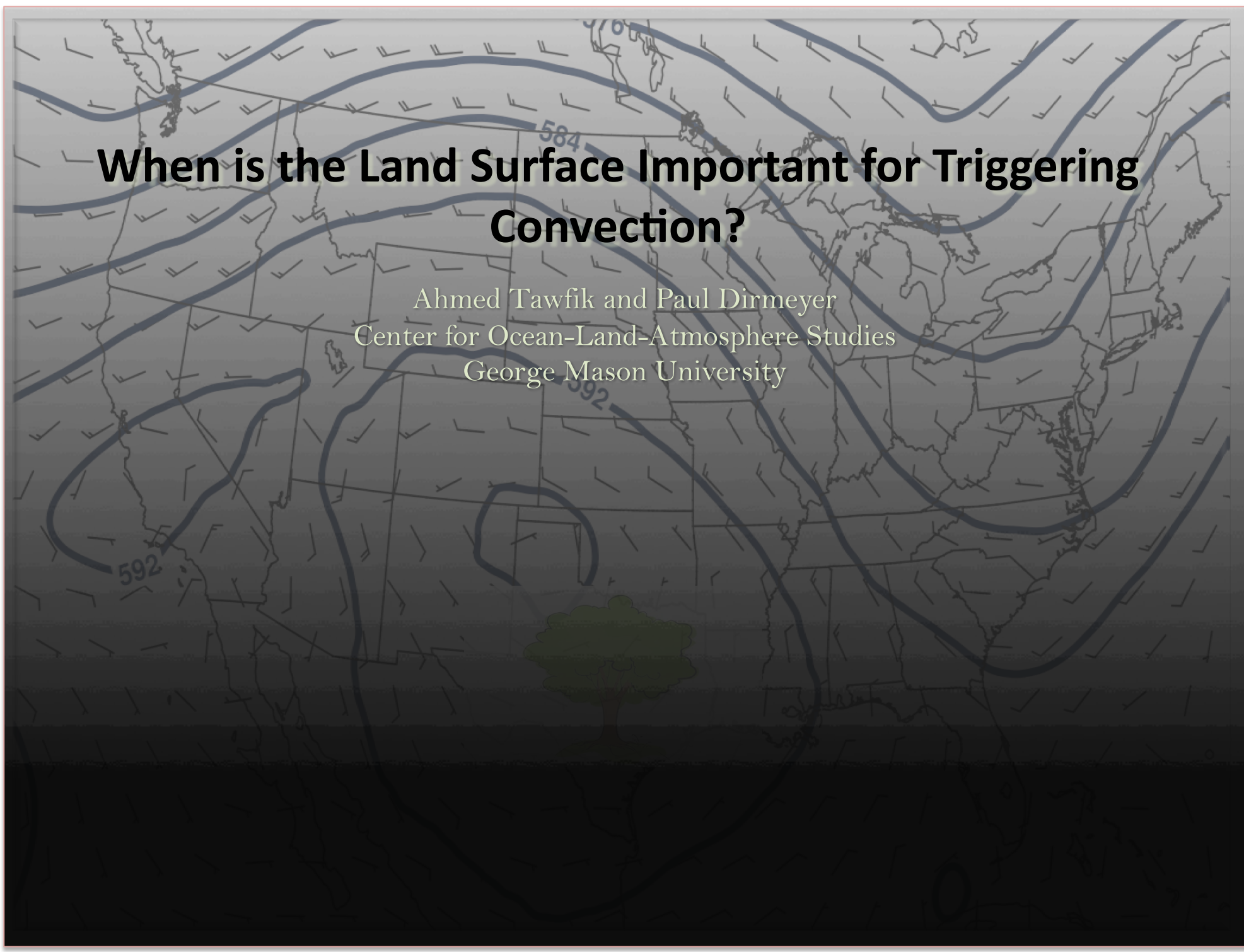

When is the Land Surface Important for Triggering Convection?

Ahmed Tawfik and Paul Dirmeyer
Center for Ocean-Land-Atmosphere Studies
George Mason University

When is the Land Surface "Important"?

Steps to address this question

1. **Diagnose (snapshot):**
   - **Separate "atmospheric" state from "surface" state**

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3. **Potential Predictability ???**

When is the Land Surface "Important"?

1. **Diagnose (snapshot):**
   - ***Introduce Heated Condensation Framework (HCF)***
     - ***Quantifies how close atmosphere is to moist convection***
     - ***Does not require parcel selection***
     - ***Uses typically measure quantities***
     - ***Is "conserved" diurnally***
     - ***Can be used any time of year or any time of day***
   - ***Make prescriptive statements such as:***
     - ***"Land surface unlikely to produce convection"***
     - ***"Require X increase in θ_{2m} and Y additional moisture for triggering convection today"***

Heated Condensation Framework

HCF contains a suite of variables

Threshold Variables:

BCL = Buoyant Condensation Level [m]
θ_{BM} = Buoyant mixing temperature [K]

Necessary inputs to achieve threshold:

q_{def} = Moisture input required [kg/kg]
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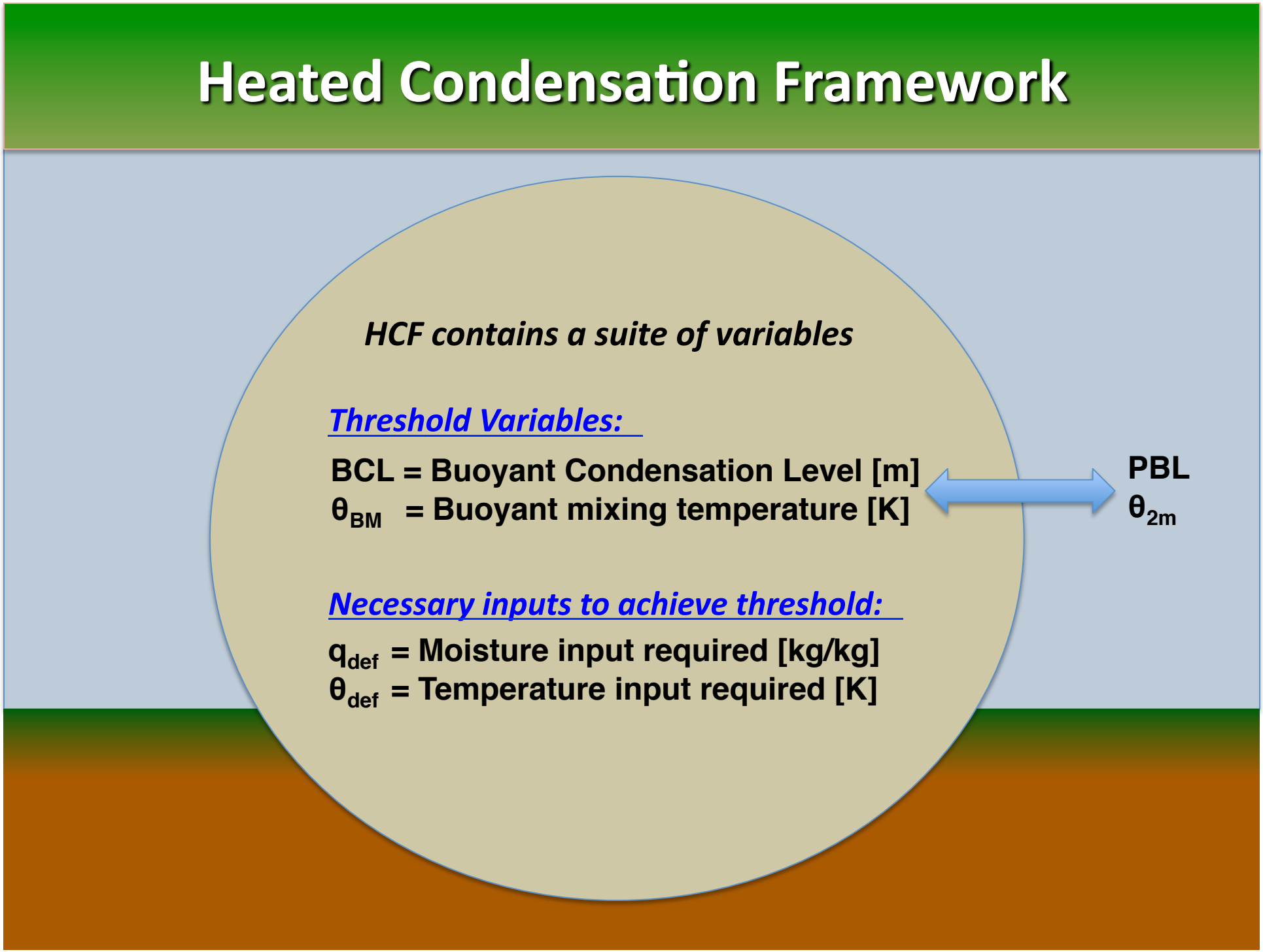

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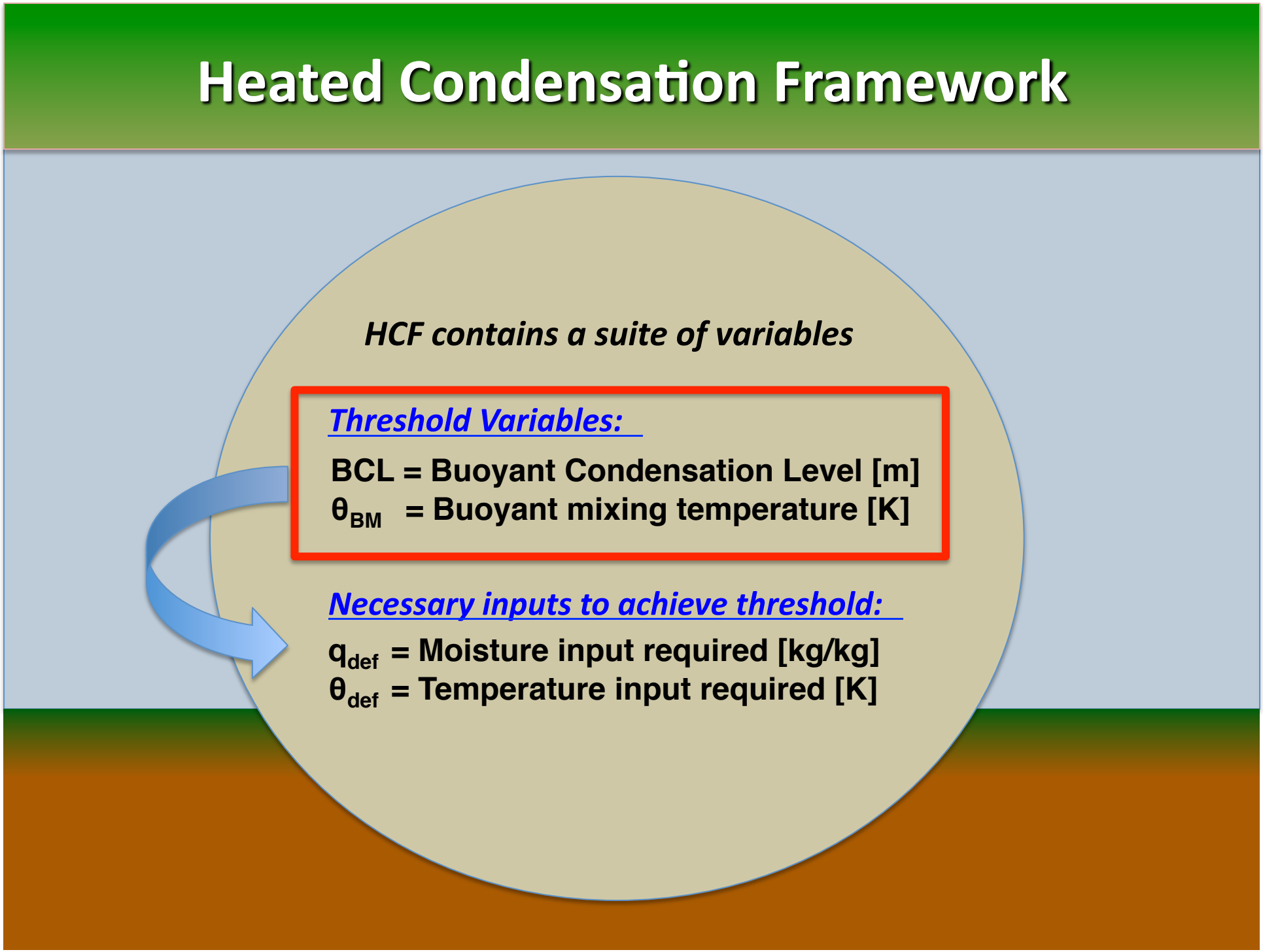
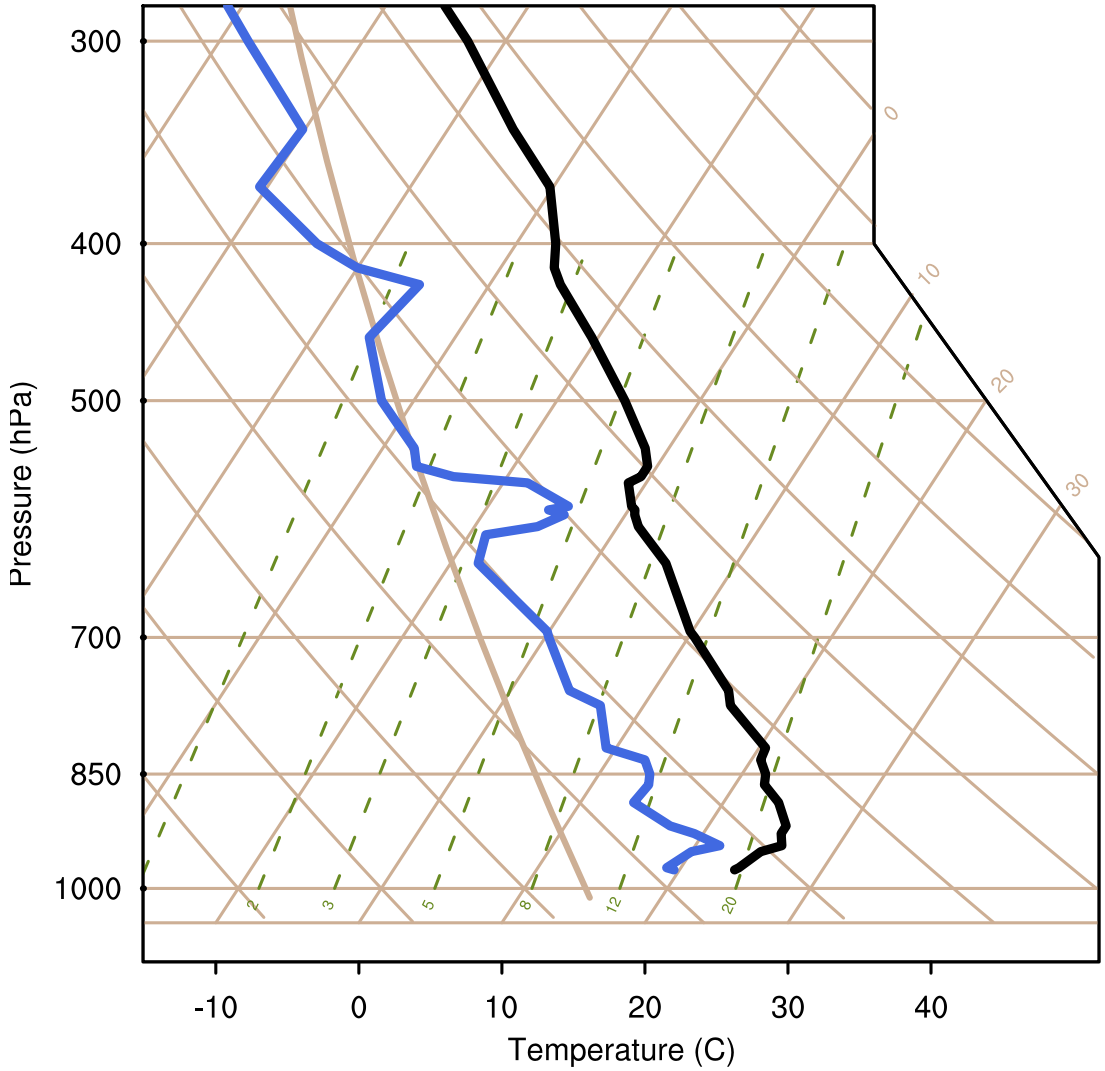
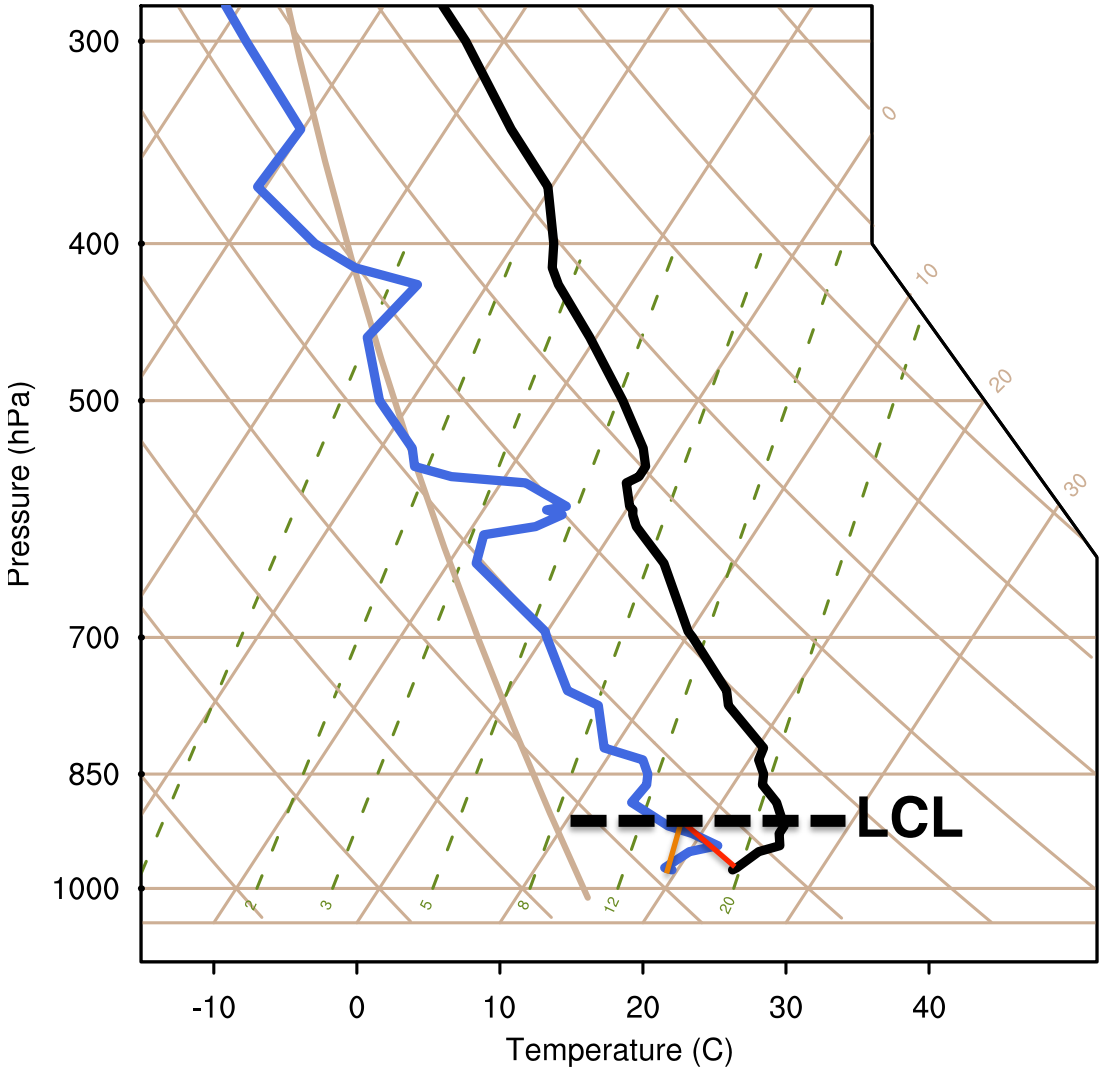


Traditional Metric



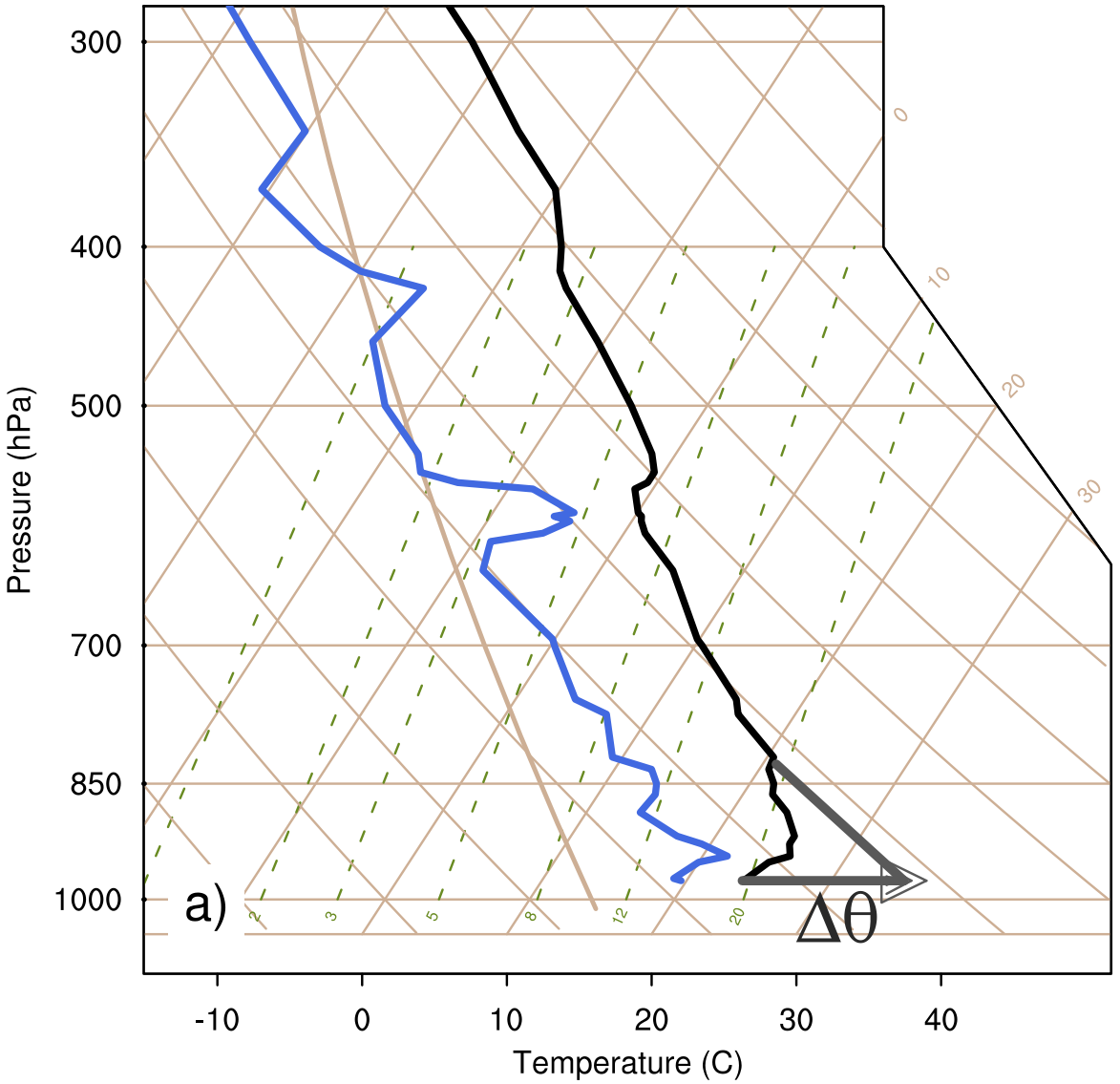
Calculating HCF Variables



Calculating HCF Variables

Step 1:

- **Increment 2-meter temperature**
- **find where it intersects profile**

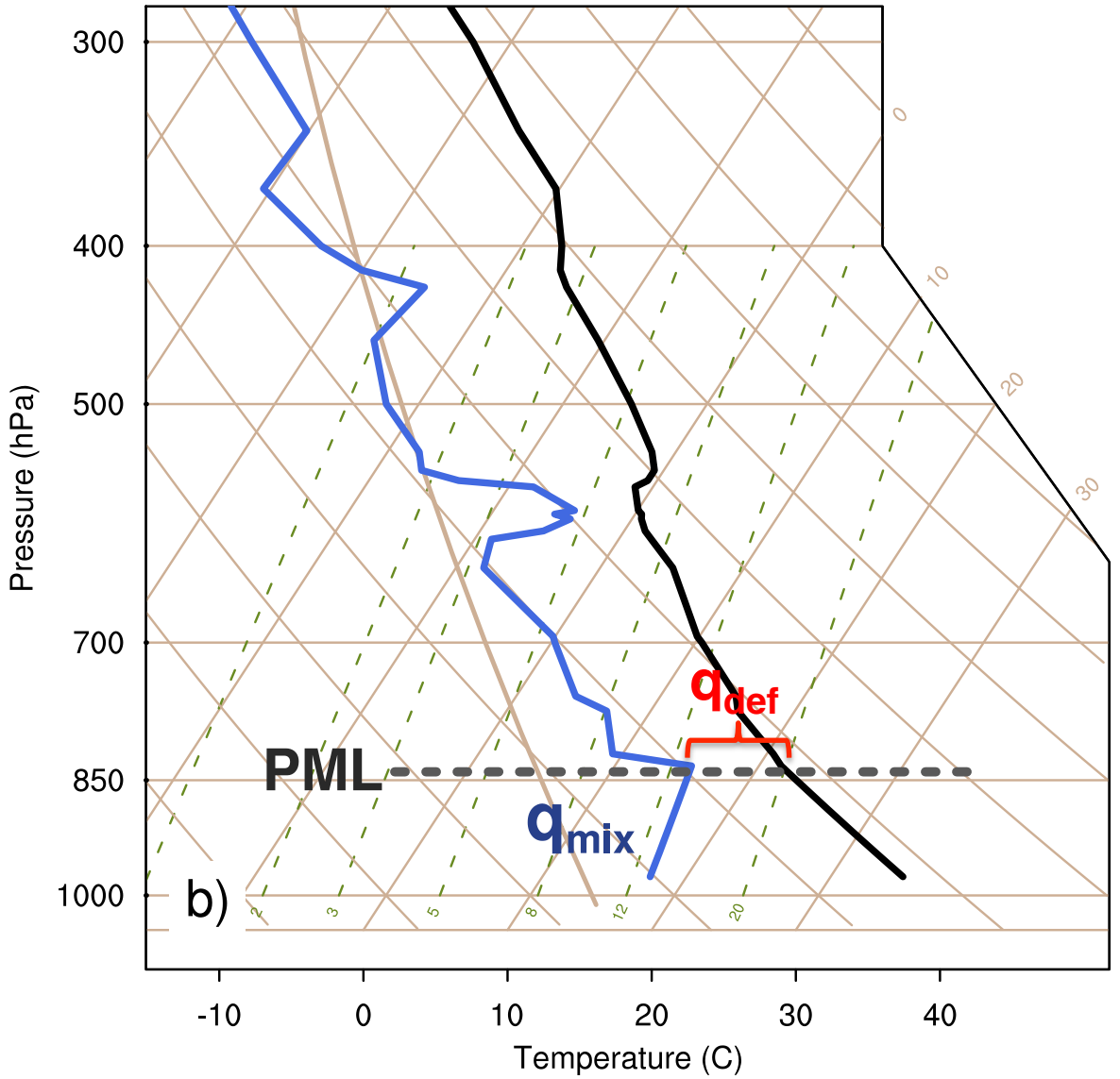


(Tawfik and Dirmeyer 2013 *GRL*)

Calculating HCF Variables

Step 2:

- **Mix moisture profile to the potential mixed level (PML)**
- **New mixed moisture = q_{mix}**
- **Saturation deficit at PML = q_{def}**



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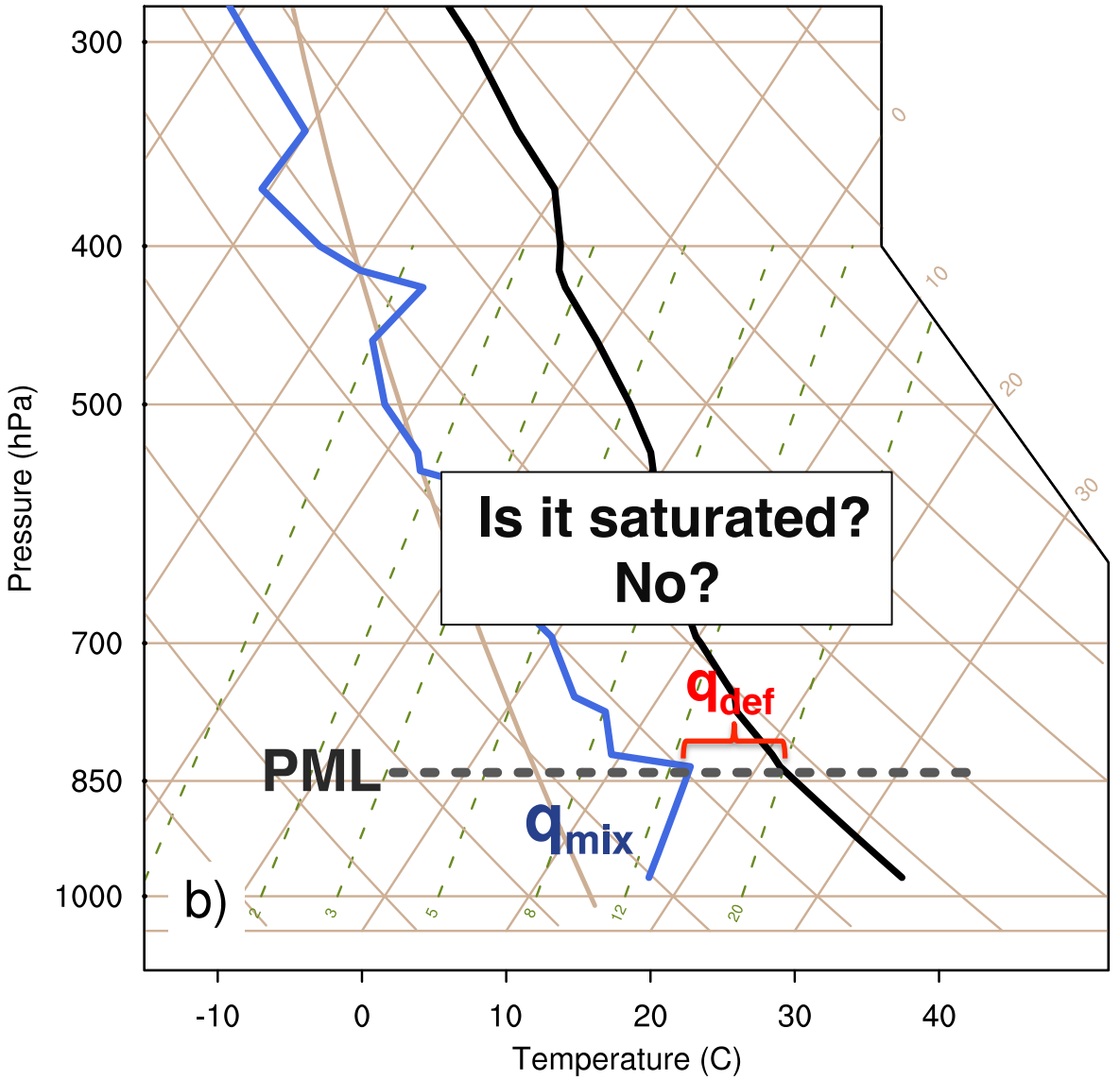

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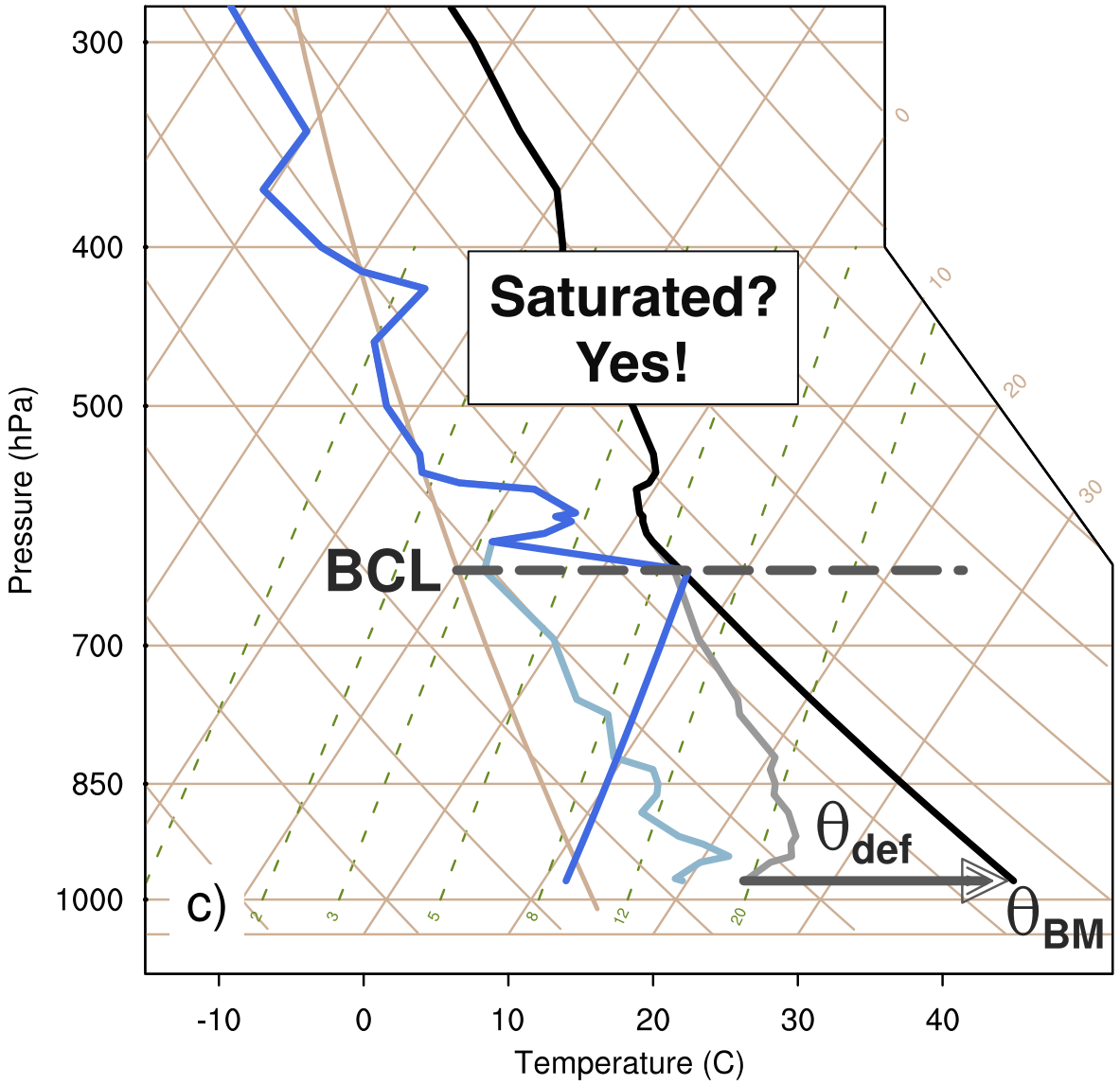
Calculating HCF Variables

Step 3:

- **Add more heat at surface until saturation occurs**

** **Note: BCL is reached when $q_{def} = 0$**



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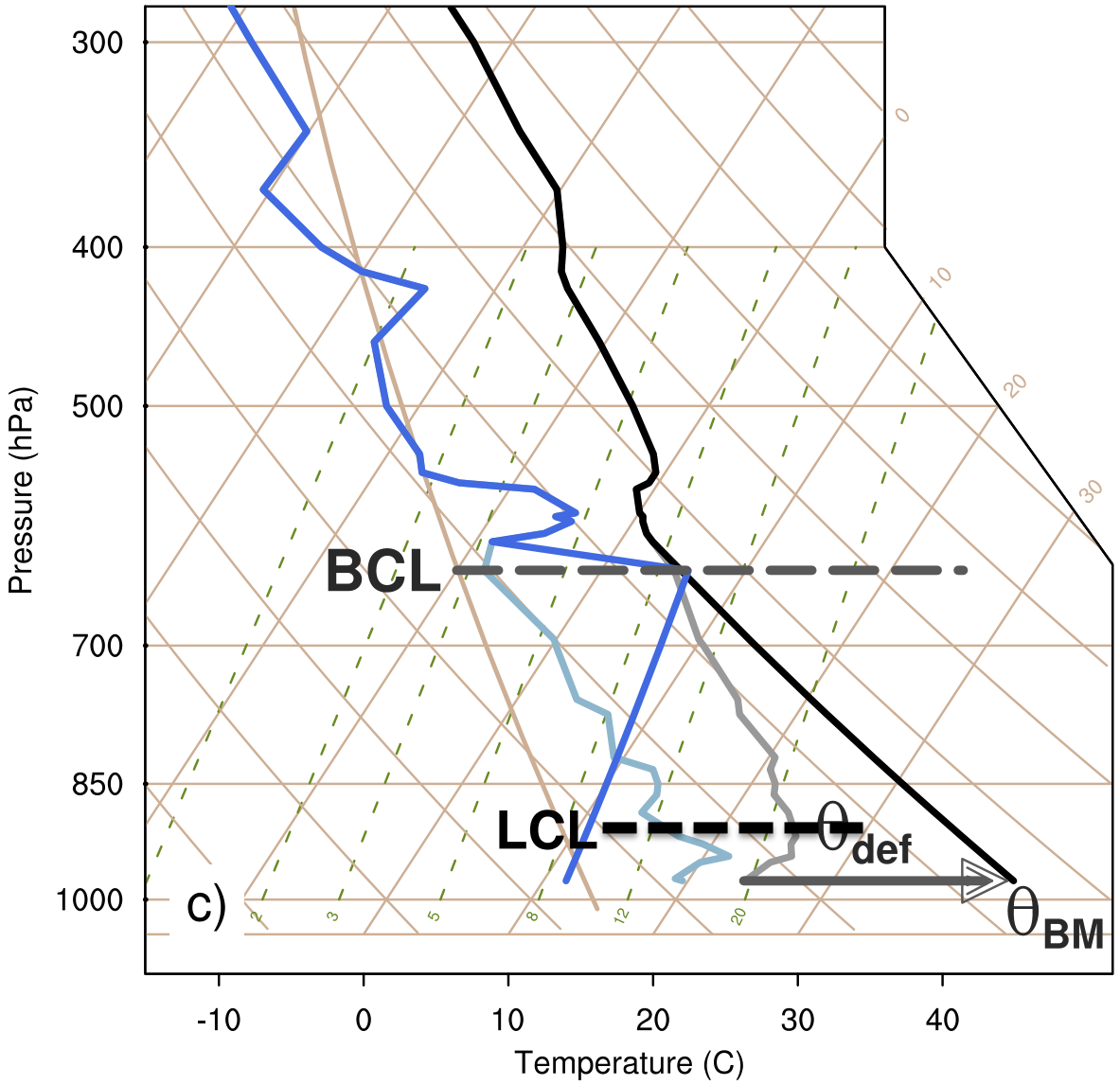
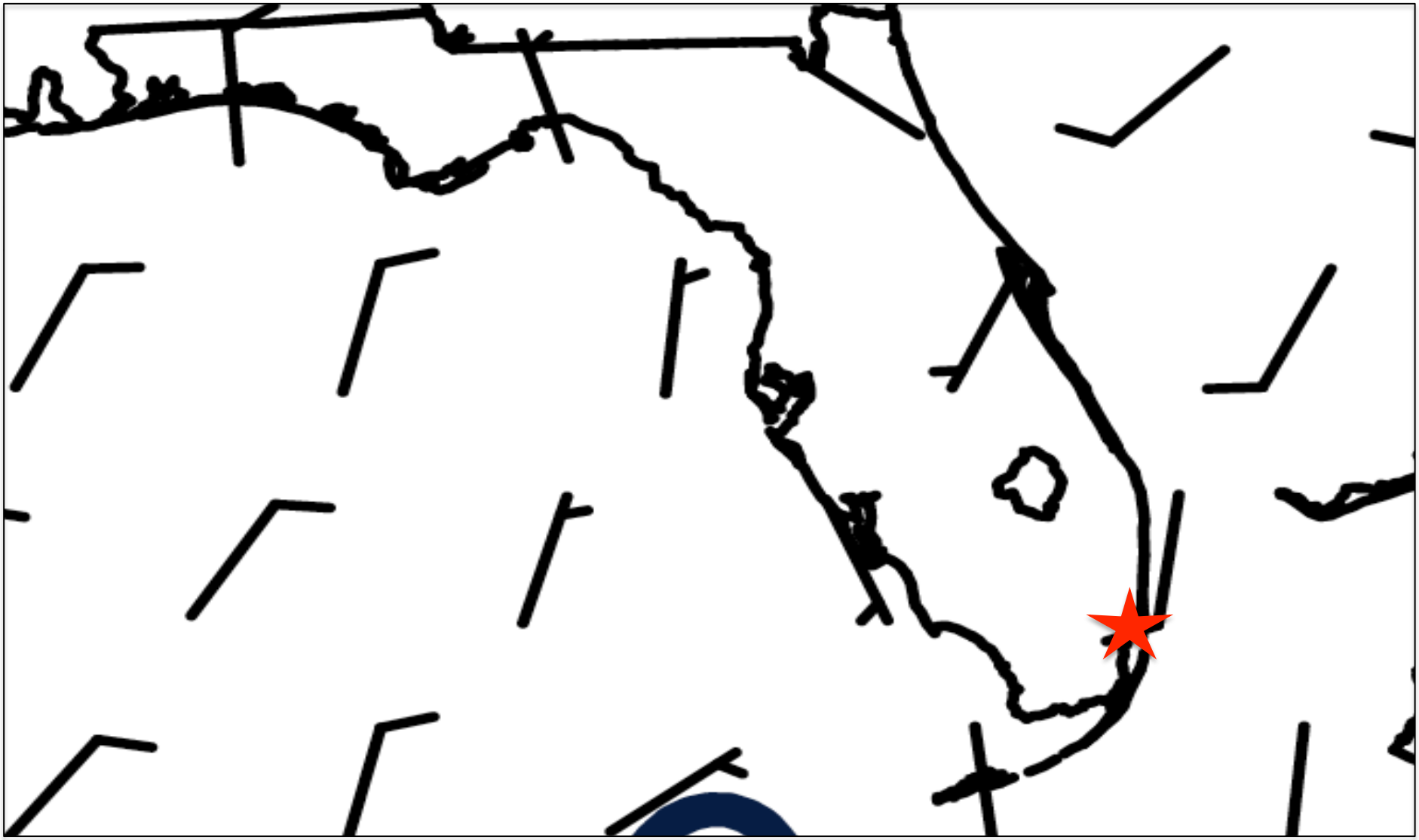


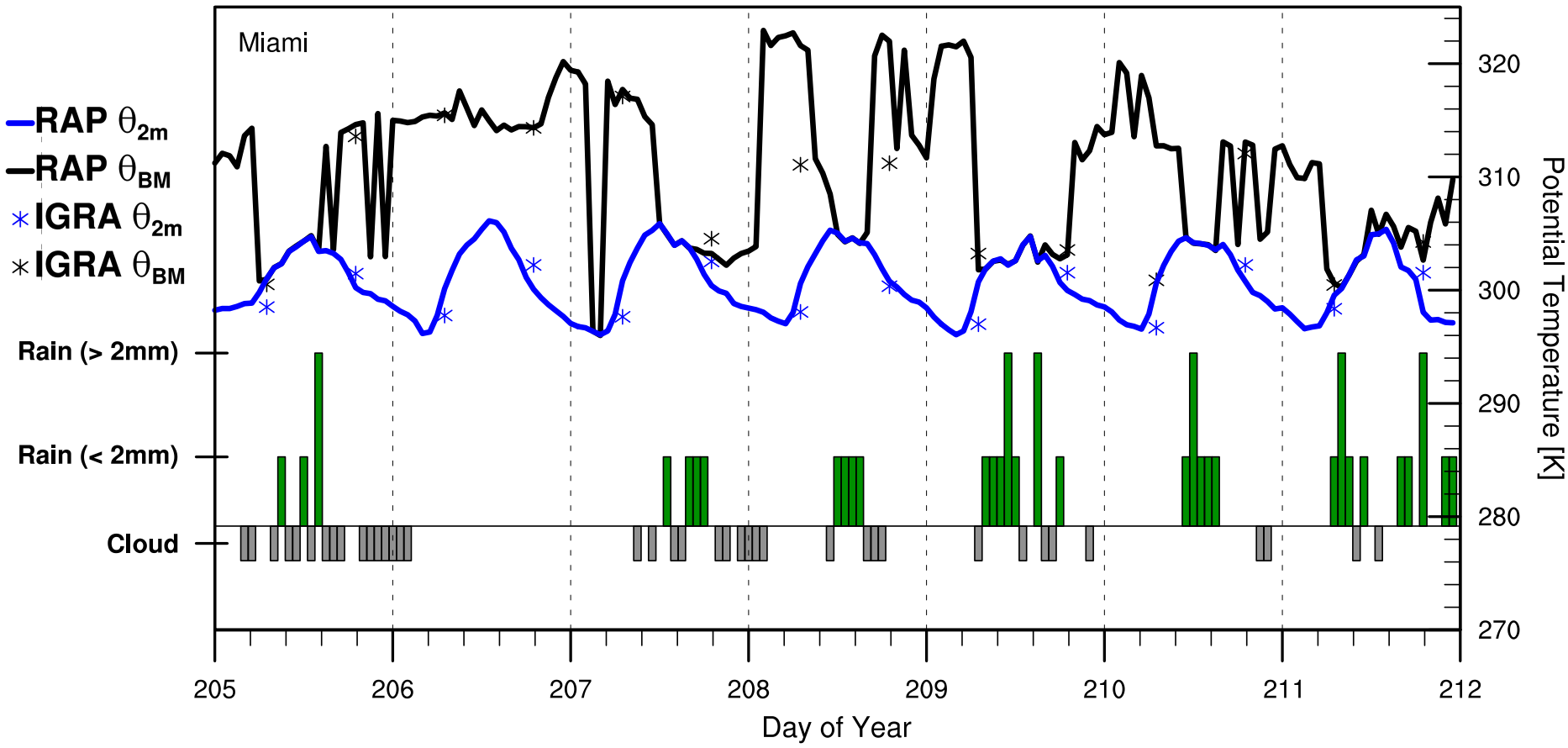
(Tawfik and Dirmeyer 2013 *GRL*)

Captures Hourly Land-Sea Breeze



Captures Hourly Land-Sea Breeze

Miami, FL: Hourly Changes in θ_{BM}, θ_{2m}, and Rain/Clouds for a week



*** **Black-Blue intersection** *should* **= convective triggering**

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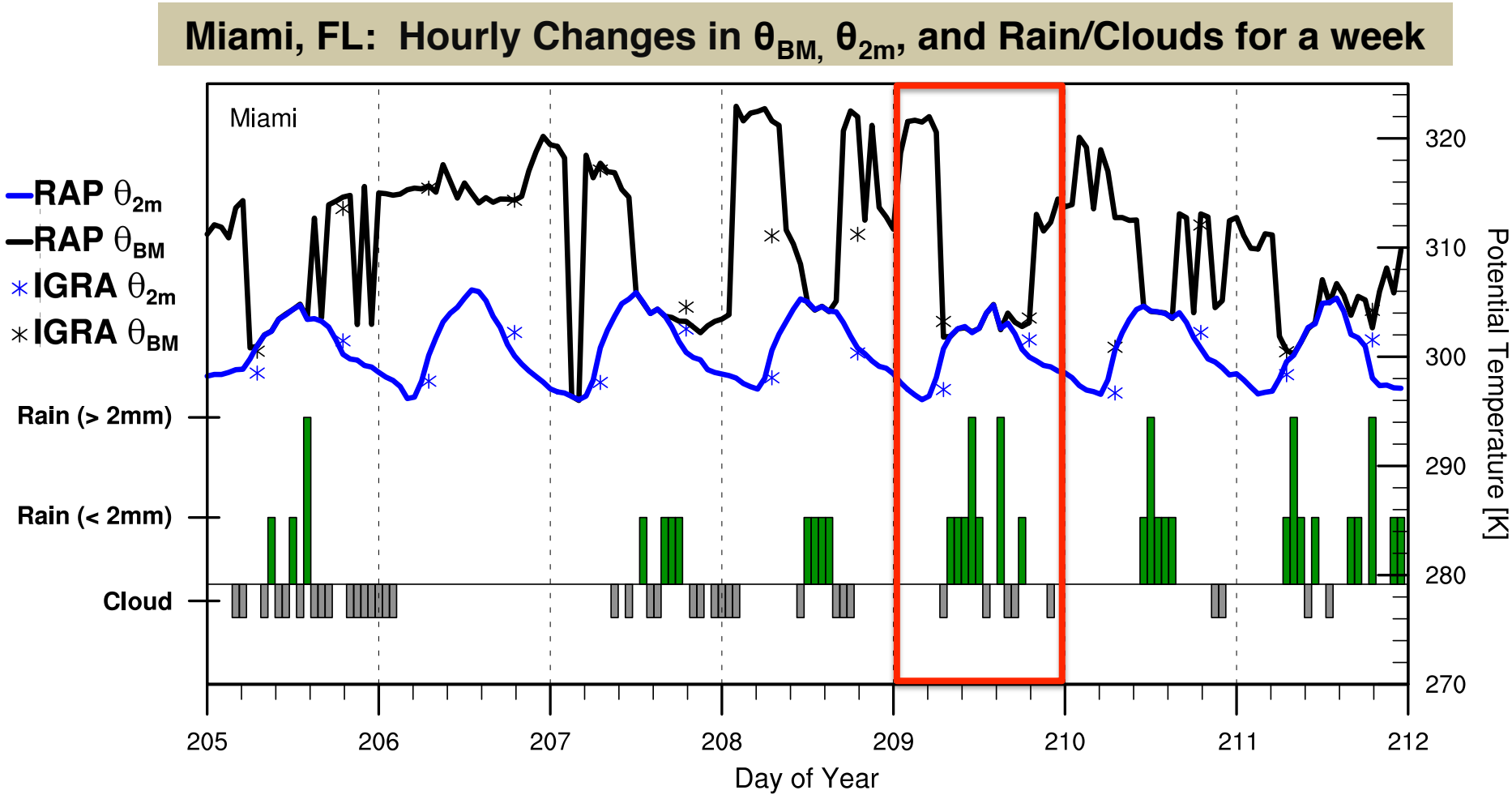

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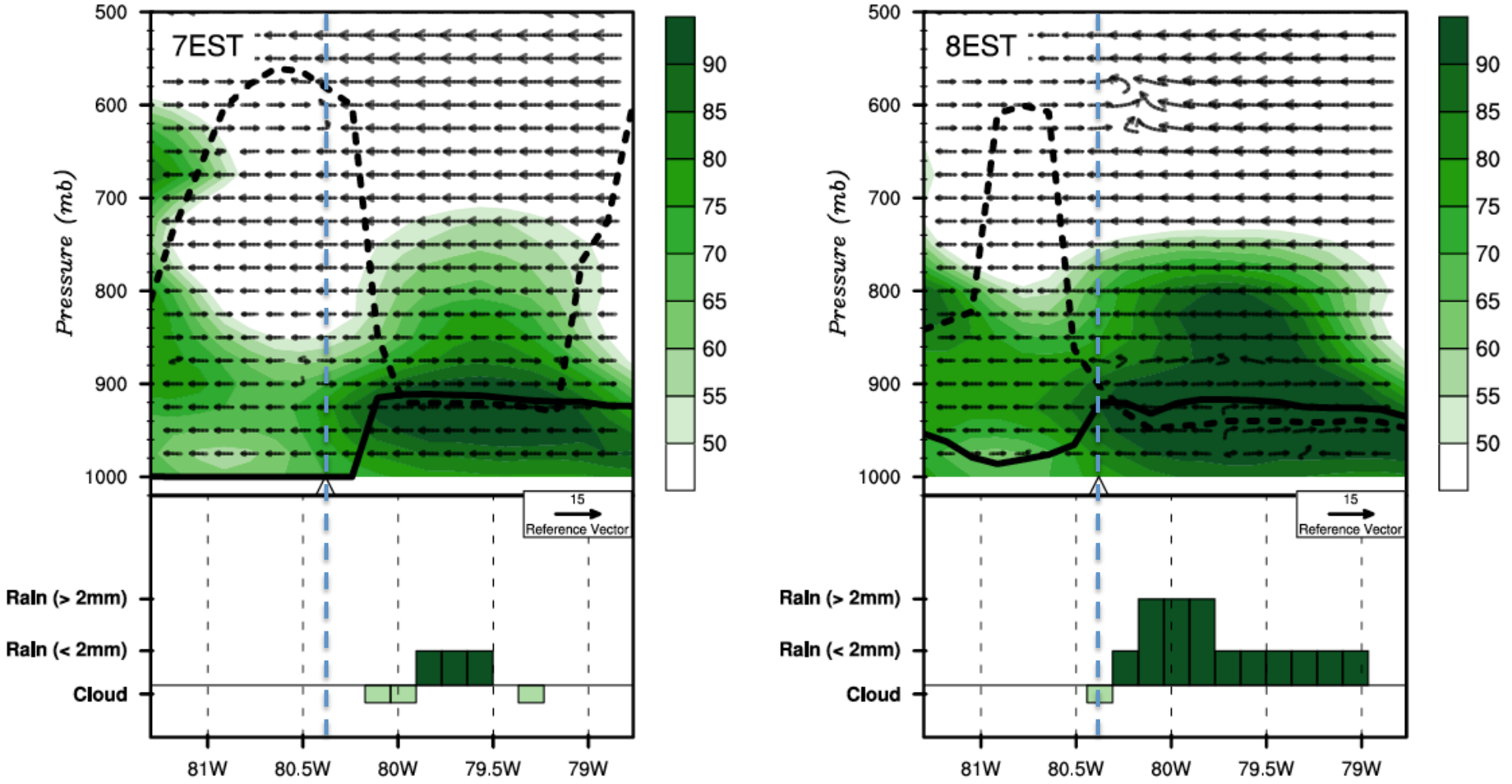
Captures Hourly Land-Sea Breeze

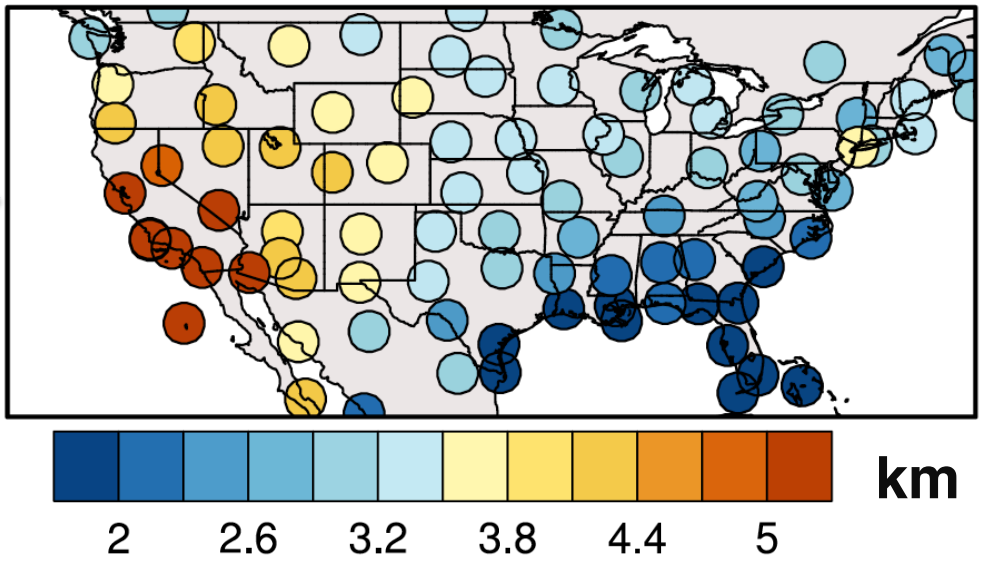
Vertical Cross-section of Relative Humidity; BCL = Dashed; Solid = PBL



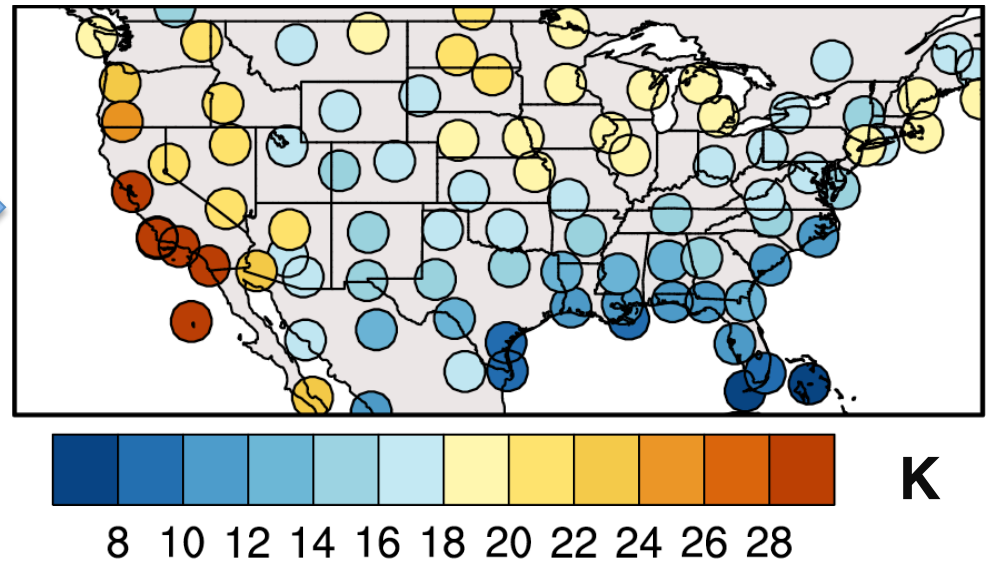
40-yr JJA Climatology of 12Z Sounding

- **Lower BCL = more saturated with respect to convection**
- **Captures expected pattern where moist convection is most likely**

BCL Height



Necessary Heat



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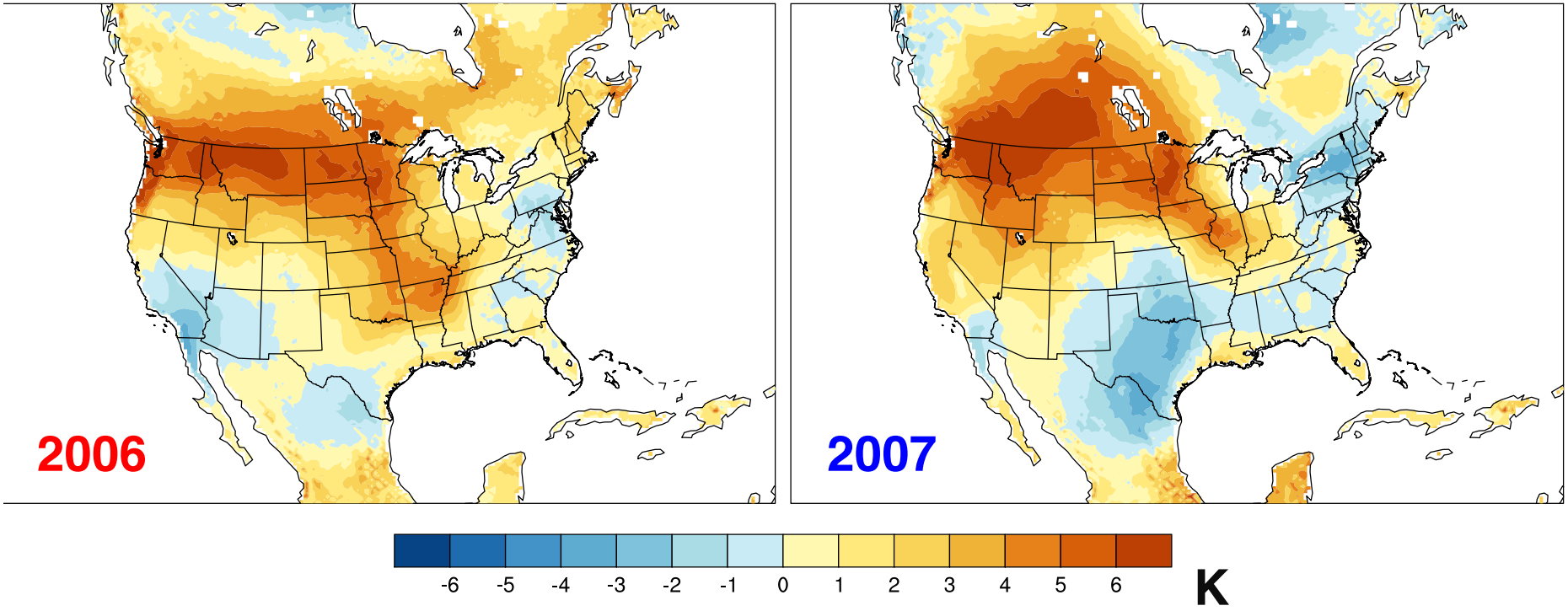
Drought year versus Wet Year

NARR: Theta_BM Threshold Anomaly July



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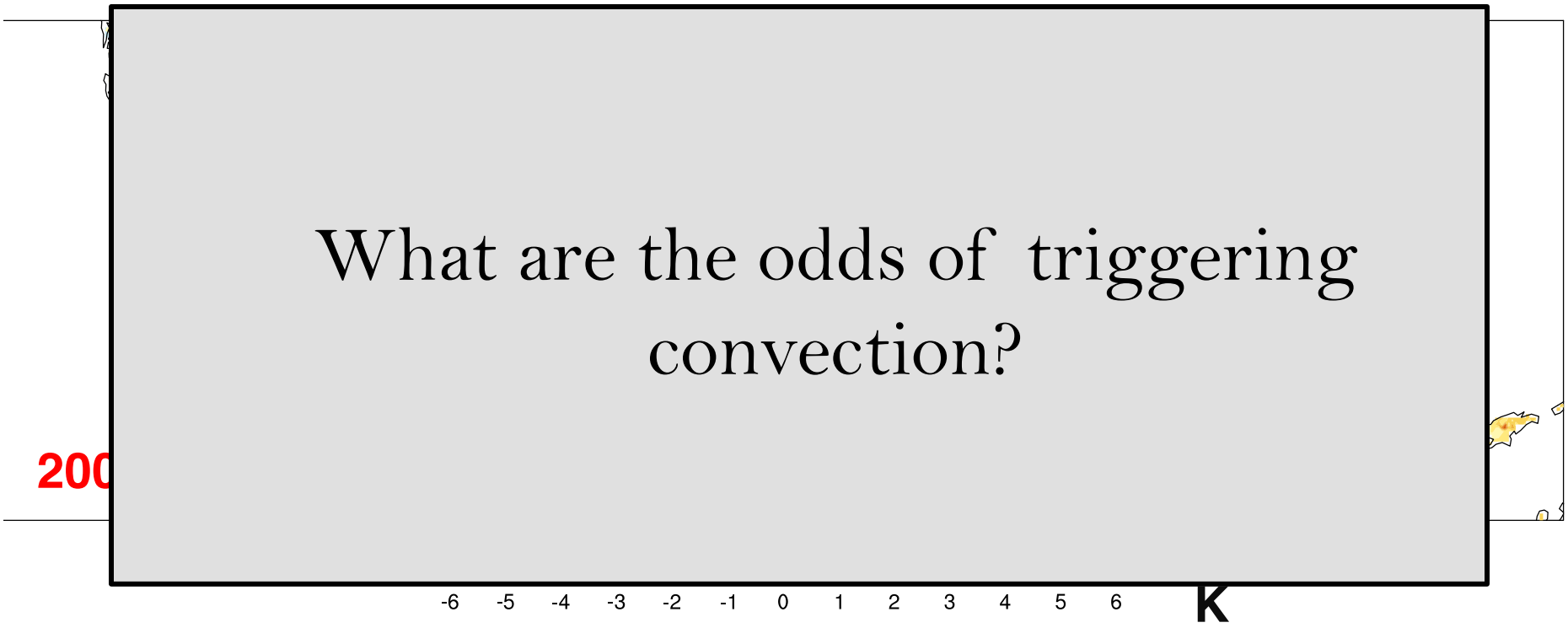
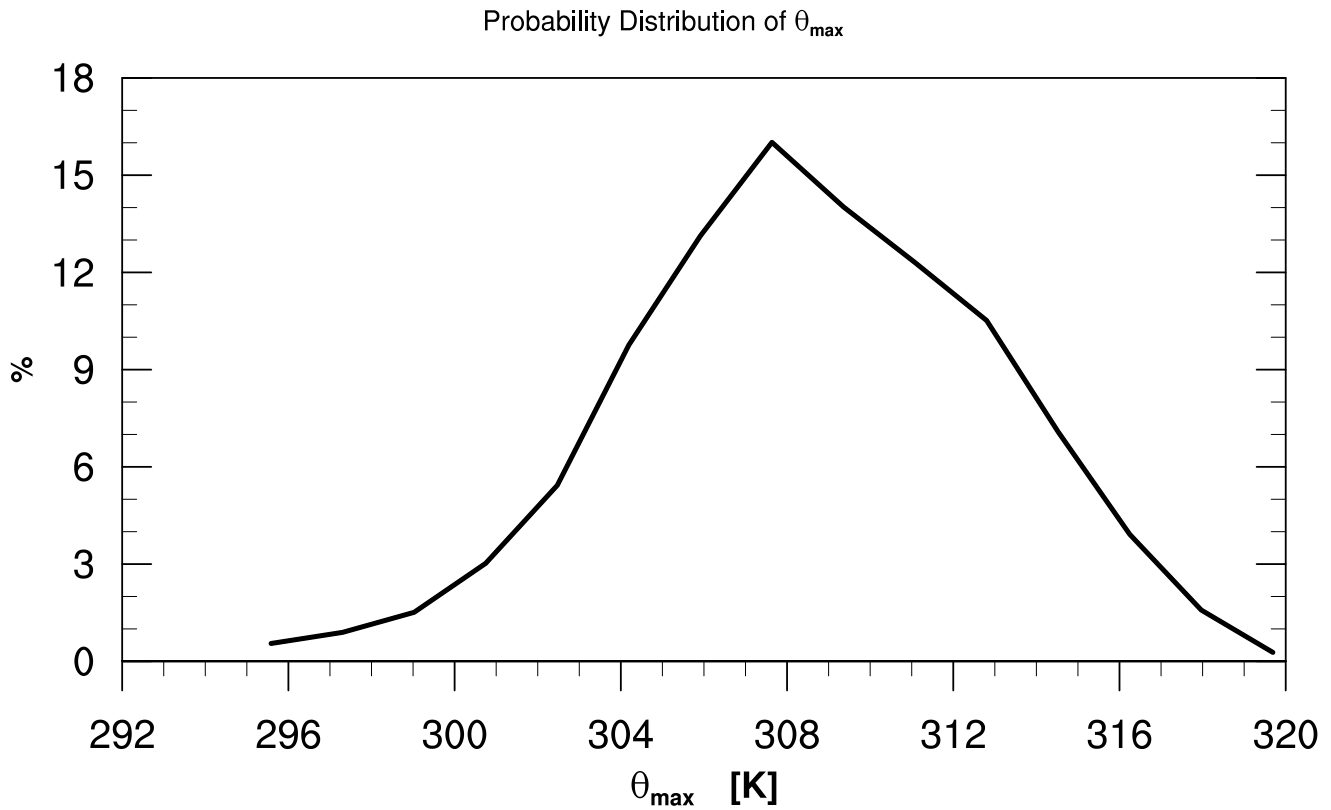


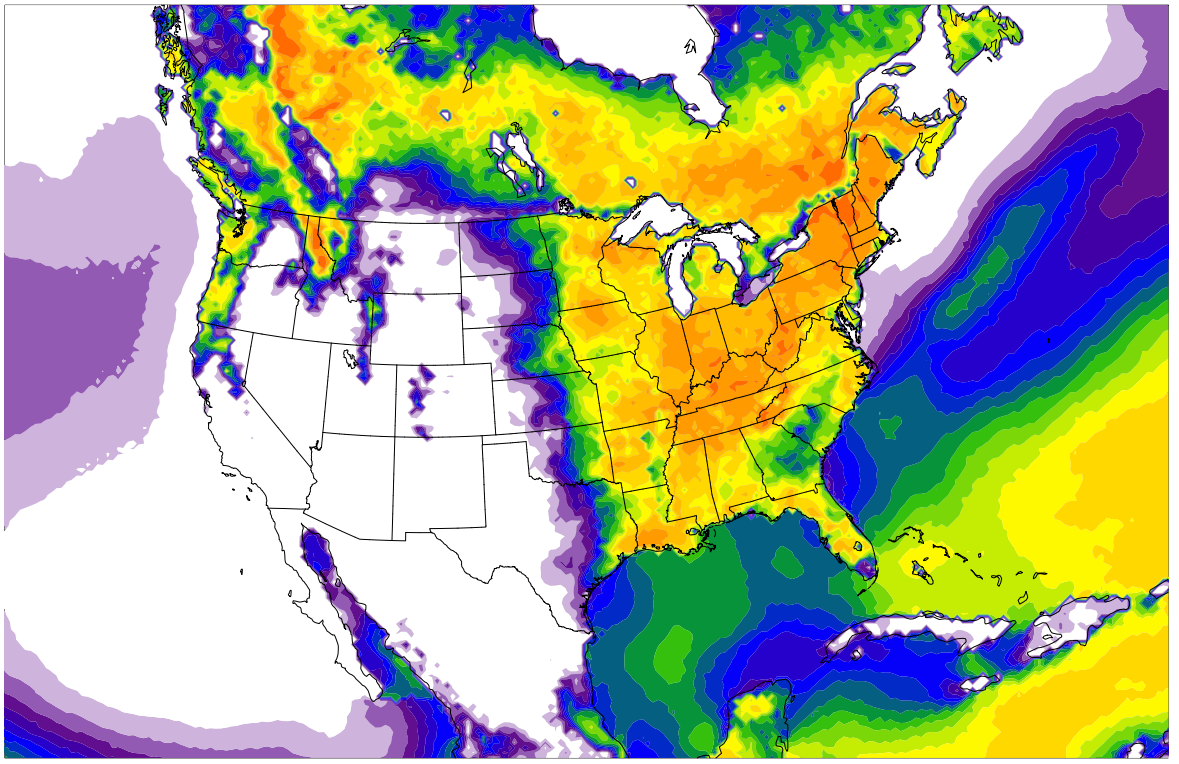
Odds of Triggering Convection

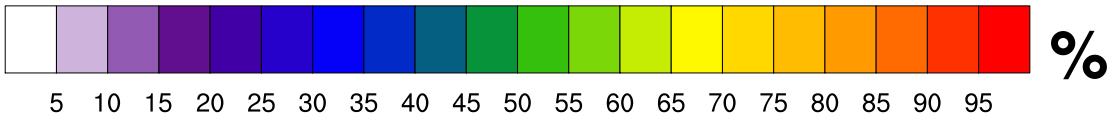
- Need long-term data: Use NARR, ARM-Best Estimate, and RUC
- Evaluate the PDF of daily maximum potential temperature, θ_{max}
- Find probability of θ_{max} reaching or exceeding θ_{BM}



Odds of Triggering Convection

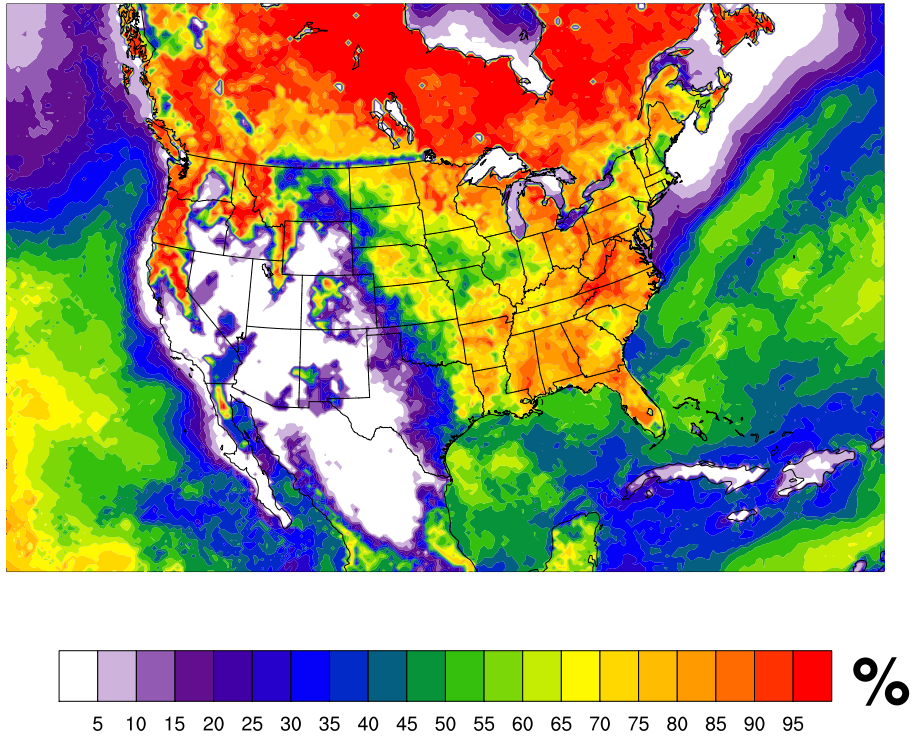
NARR: Average Probability of Reaching BCL for July





Odds of Triggering Convection

NARR: Inter-annual Range



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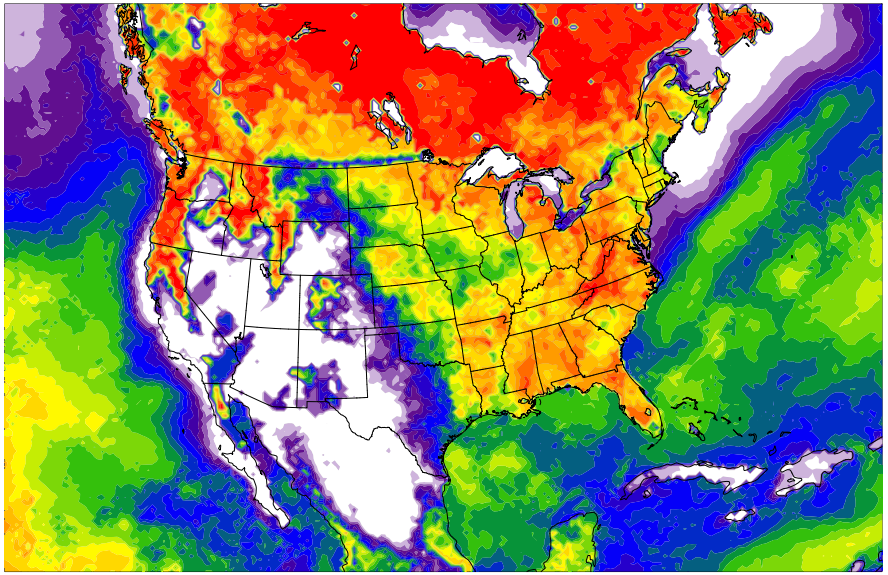
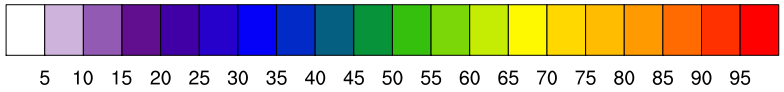
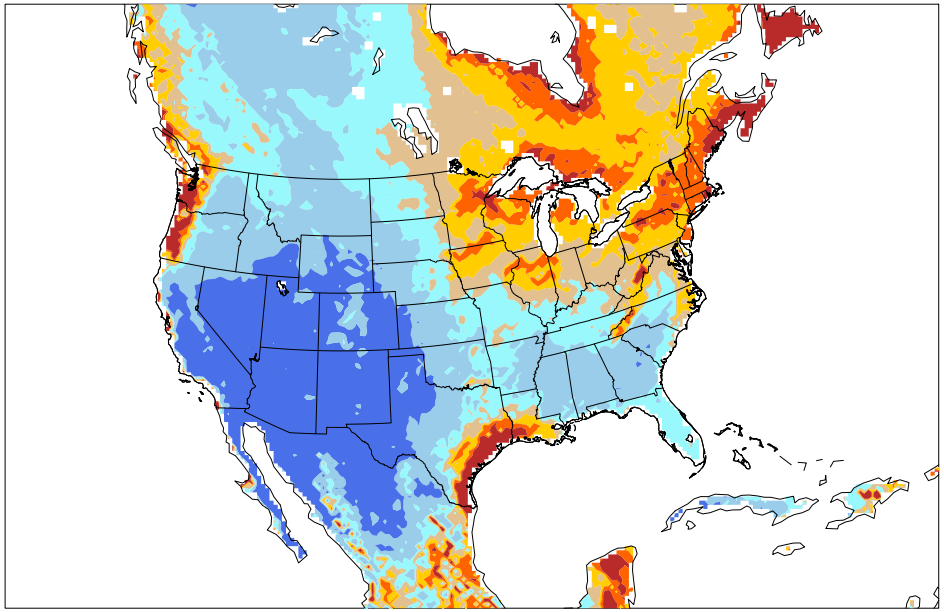
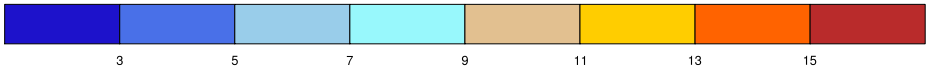




%

NARR: Diurnal Range of θ_{BM}

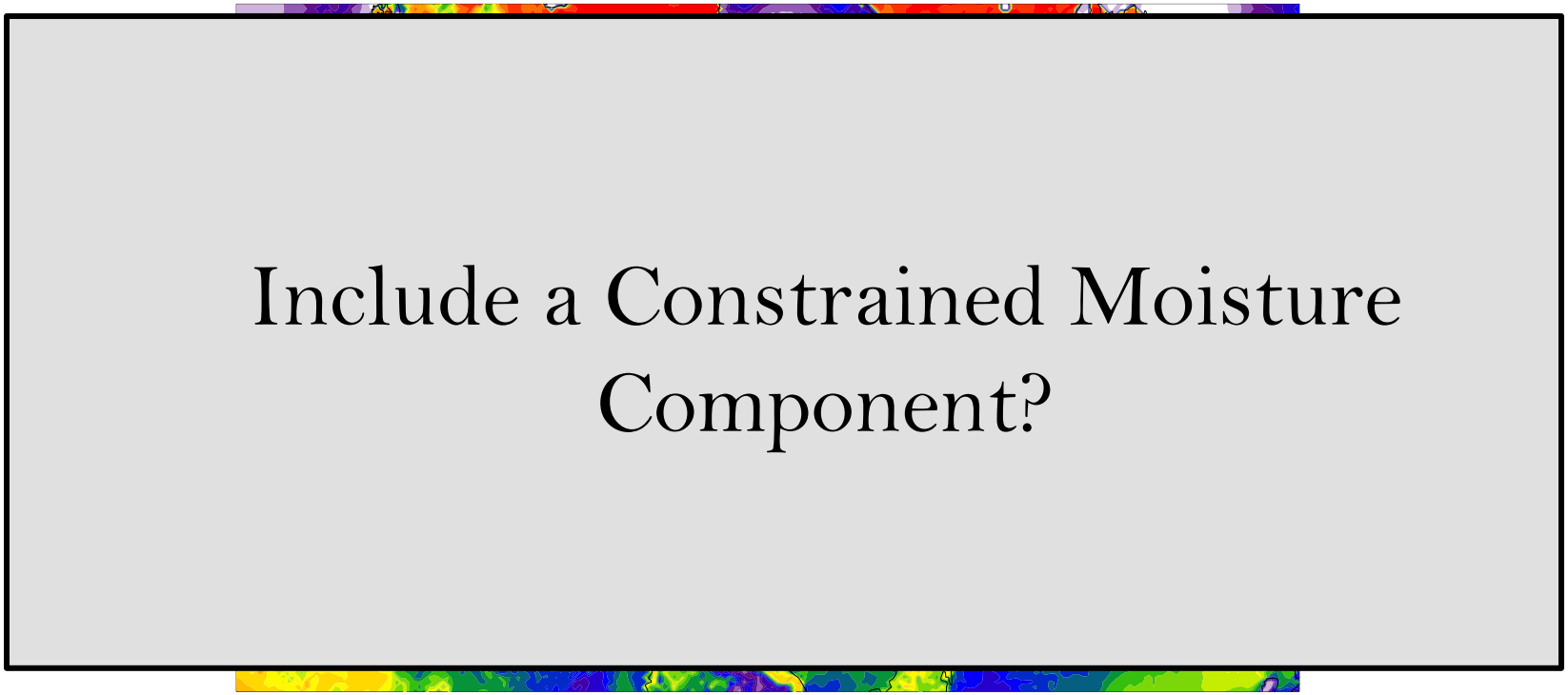


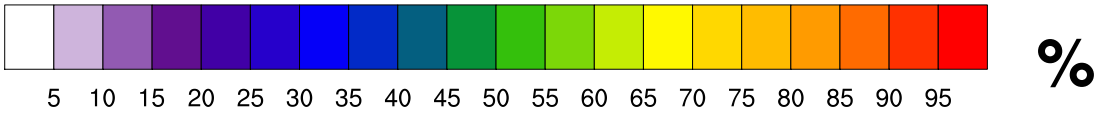


K

Odds of Triggering Convection

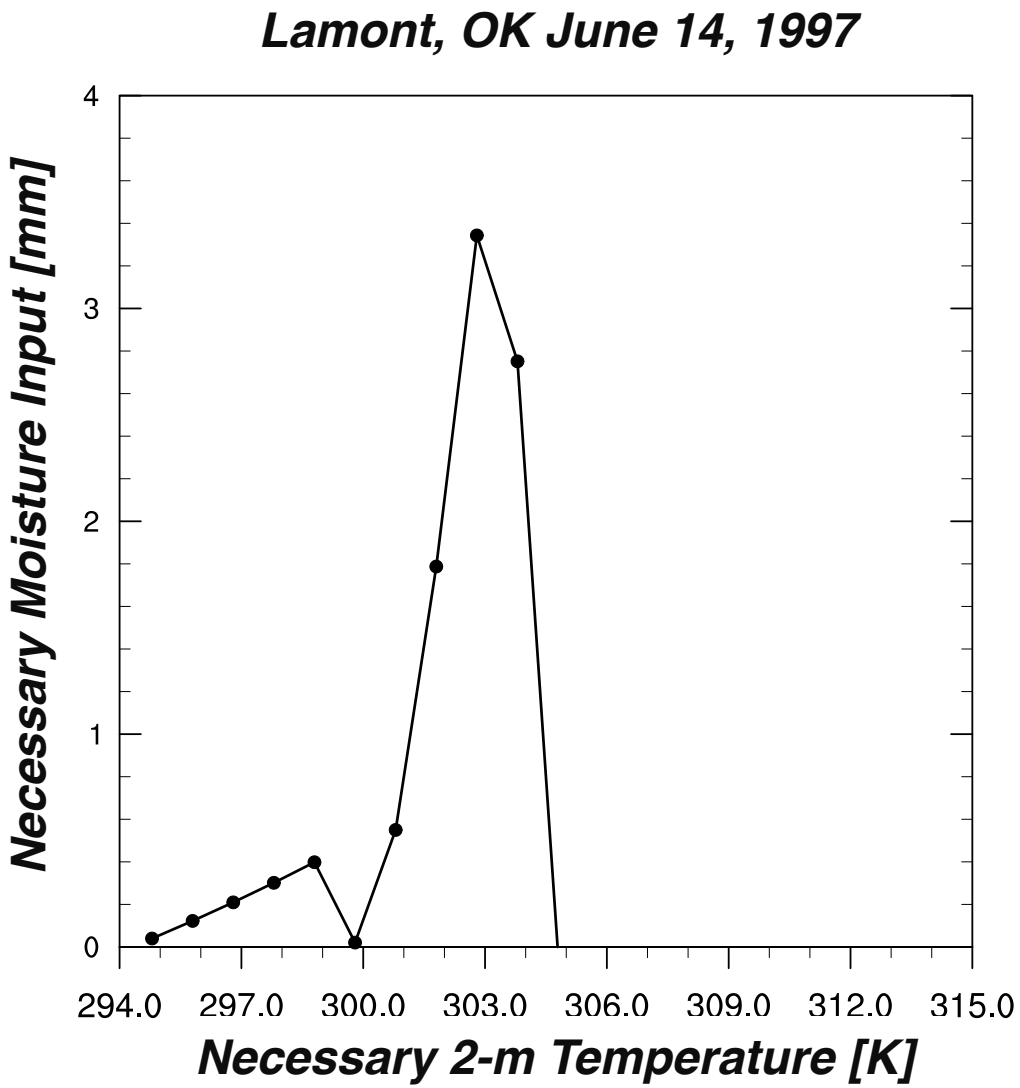
NARR: Inter-annual Range of Probability of Reaching BCL for July





Fluxes Necessary for Moist Convection

- **Recall: X-Y pair correspond to necessary moisture (Y) given some temperature (X)**
- **Inflection defines "main" inversion**
- **Where moisture necessary = 0 defines θ_{BM}**



Local Versus Non-Local

- **Brute force evaluation of LoCo using NARR**

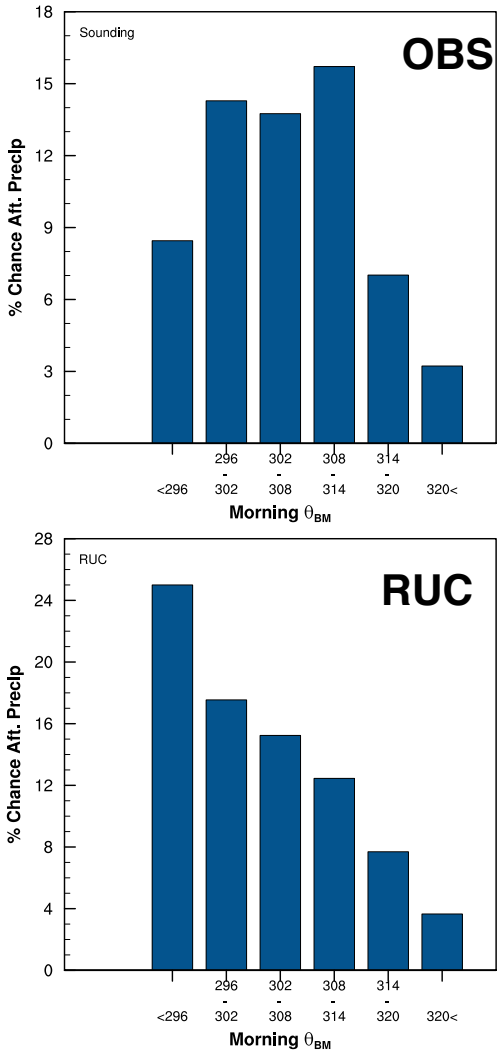
$$\frac{\partial \theta_{BM}}{\partial t} = \left.\frac{\partial \theta_{BM}}{\partial t}\right|_{Local} + u\frac{\partial \theta_{BM}}{\partial x} + v\frac{\partial \theta_{BM}}{\partial y}$$

Local Forcing ***Non-local Forcing***

Local Versus Non-Local

Predictability?

ARM-BE: Chance of Afternoon Precipitation JJA



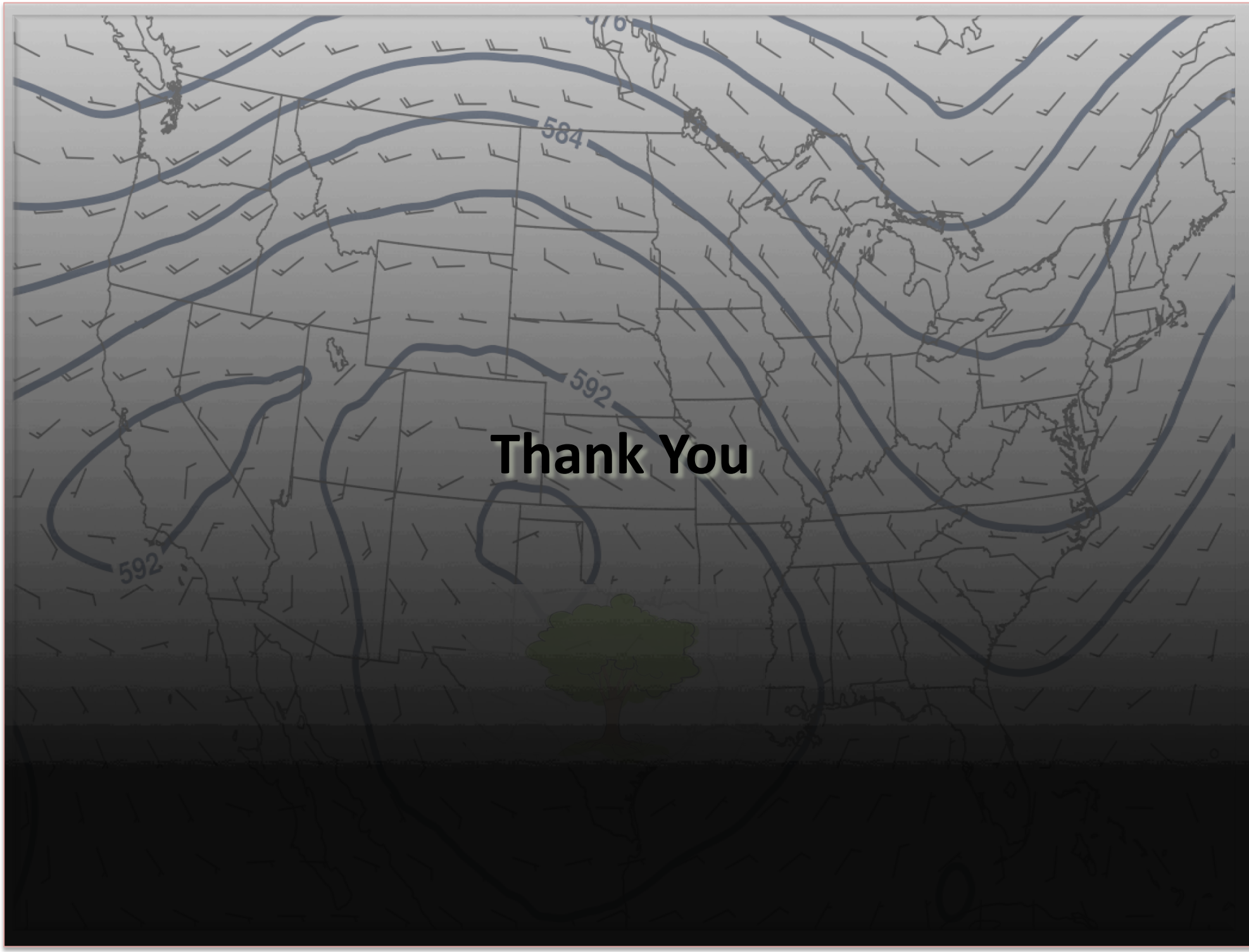
Summary

Summary:

- **BCL height and θ_{BM} are transferable quantities**
- **When constructing BCL, possible identify necessary moisture and heat inputs for moist convection to be triggered**
- **Change in BCL over time may reveal importance of surface fluxes**

Moving Forward:

- **Give a daily LoCo "land-atmosphere coupling index"**
- **Use HCF to compare models and observations related to moist convection and surface flux forcing**
- **Implement as trigger in models**



Thank You