Midlevel Convective Clouds Observed During the ARM Mobile Facility (AMF) Deployment in Niamey, Niger, Africa

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Why study this?!?

Convective clouds:

- *impact the energy budget because of:*
  - ***A high shortwave albedo → scatters solar radiation → cooling effect at the surface***
  - ***Cold cloud tops → reduces outgoing infrared radiation → warming effect at the surface***

- *impact the water budget through the redistribution of water spatially and temporally.*

- *are a main driver in global circulation.*

- *are poorly represented in global climate models.*

Overview

- *Region: Niamey, Niger, Africa*

- *Climate: cT – Continental Tropical*
  - *– Strongly impacted by seasonal variation of the ITCZ, biomass burning, and Saharan dust*

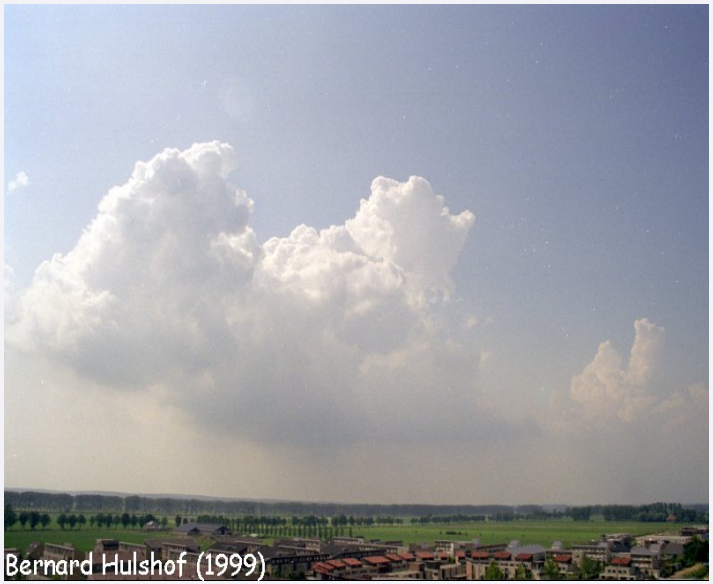
    [Miller & Slingo 2006]

- *Cloud Variation: Trimodal distribution of convective clouds*
  - ***Shallow Cumulus – (0-3 km)***
  - ***Cumulus Congestus – (4-9 km) ← ← ← Focus of Research***
  - ***Cumulonimbus – (10 km +)***

  [Johnson et al. 1999]

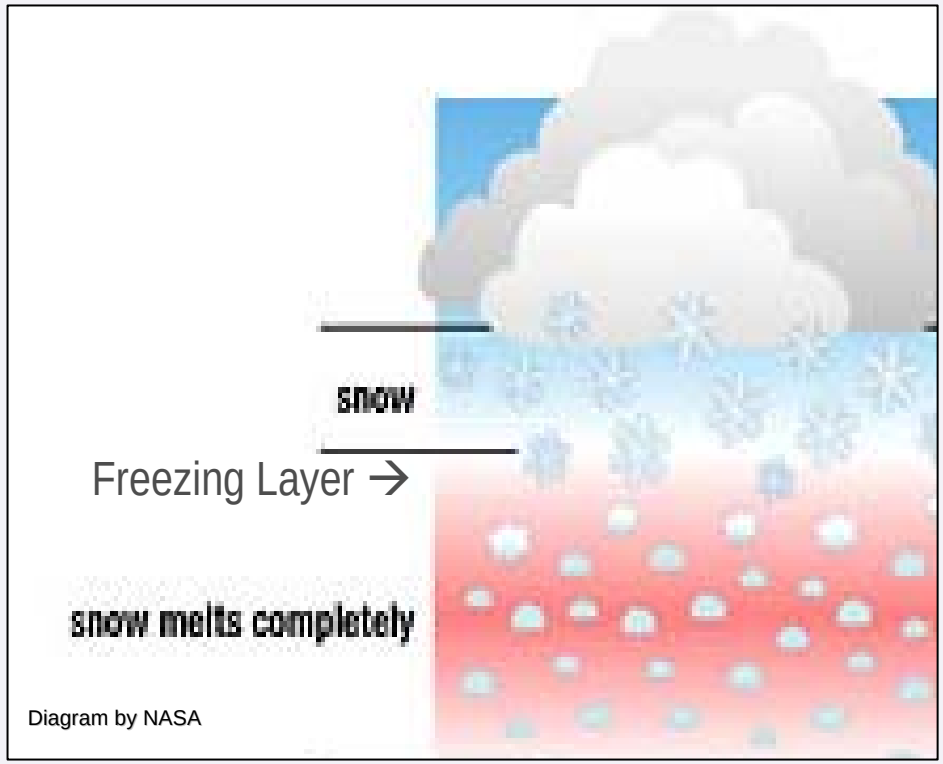
Research Question

- *What are the environmental factors that limit convective cloud growth?*

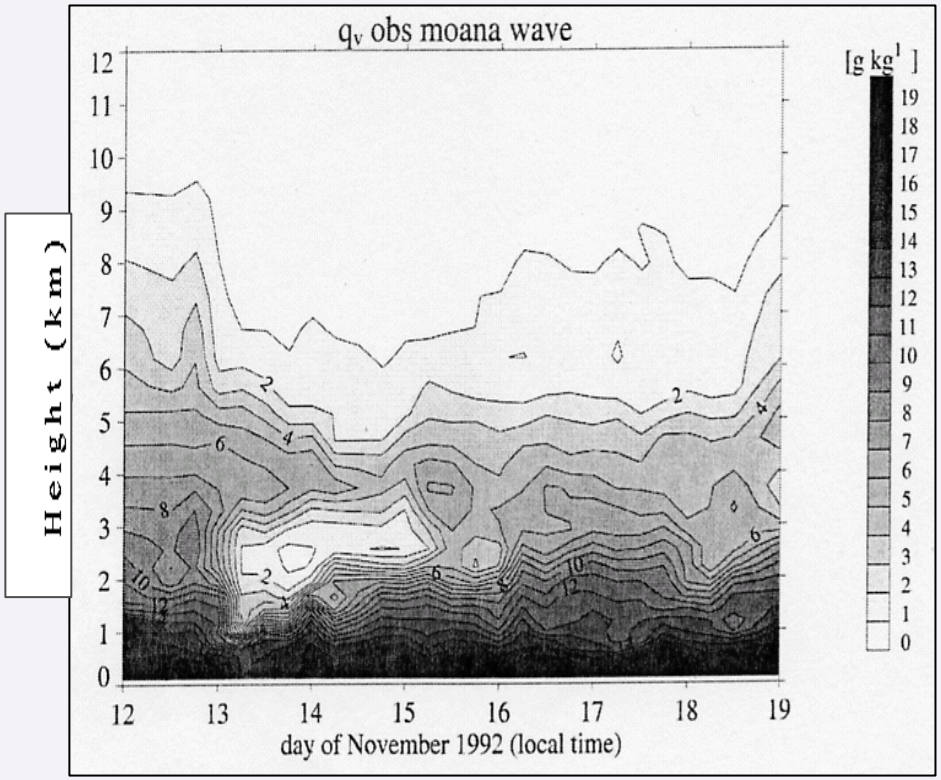


What causes the limitation of convective cloud growth?
Hypothesis I:

Stabilized Freezing Layer
- snowflakes fall through freezing layer and melt *- latent heat is removed at freezing layer resulting in a decrease in cloud's buoyancy* *[Johnson et al. 1999]*



What causes the limitation of convective cloud growth?
Hypothesis II:



[Redelsperger et al. 2002]

Drying of the Midlevel

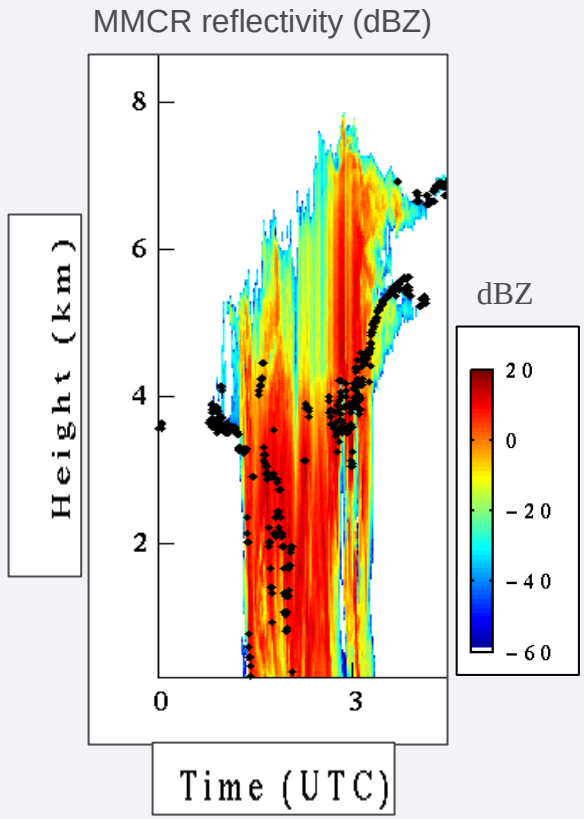
- advection of subtropical air on the synoptic scale (10^2 km & 3-4 days)

- dry air is entrained with the cloud, which is a dilution of the cloud's buoyancy

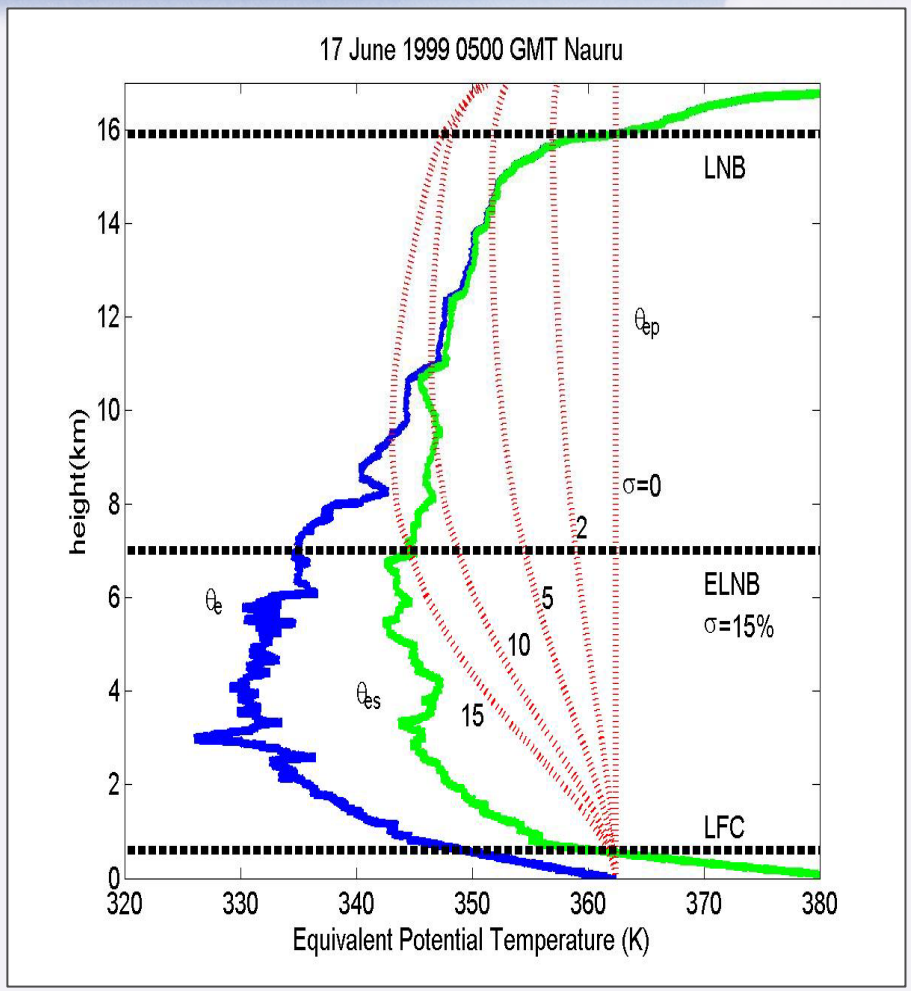
[Brown & Zhang 1997]

Methods

- ✓ *Select midlevel convective cloud samples.*
- ✓ *Estimate cloud top height.*
- ✓ *Use simple parcel model to calculate the thermodynamic profile of each sample.*
- ✓ *Use sensitivity test to learn which factor plays a role in limiting cloud top growth.*
- ✓ *Analyze Results.*



Entrainment and Level of Neutral Buoyancy (LNB)

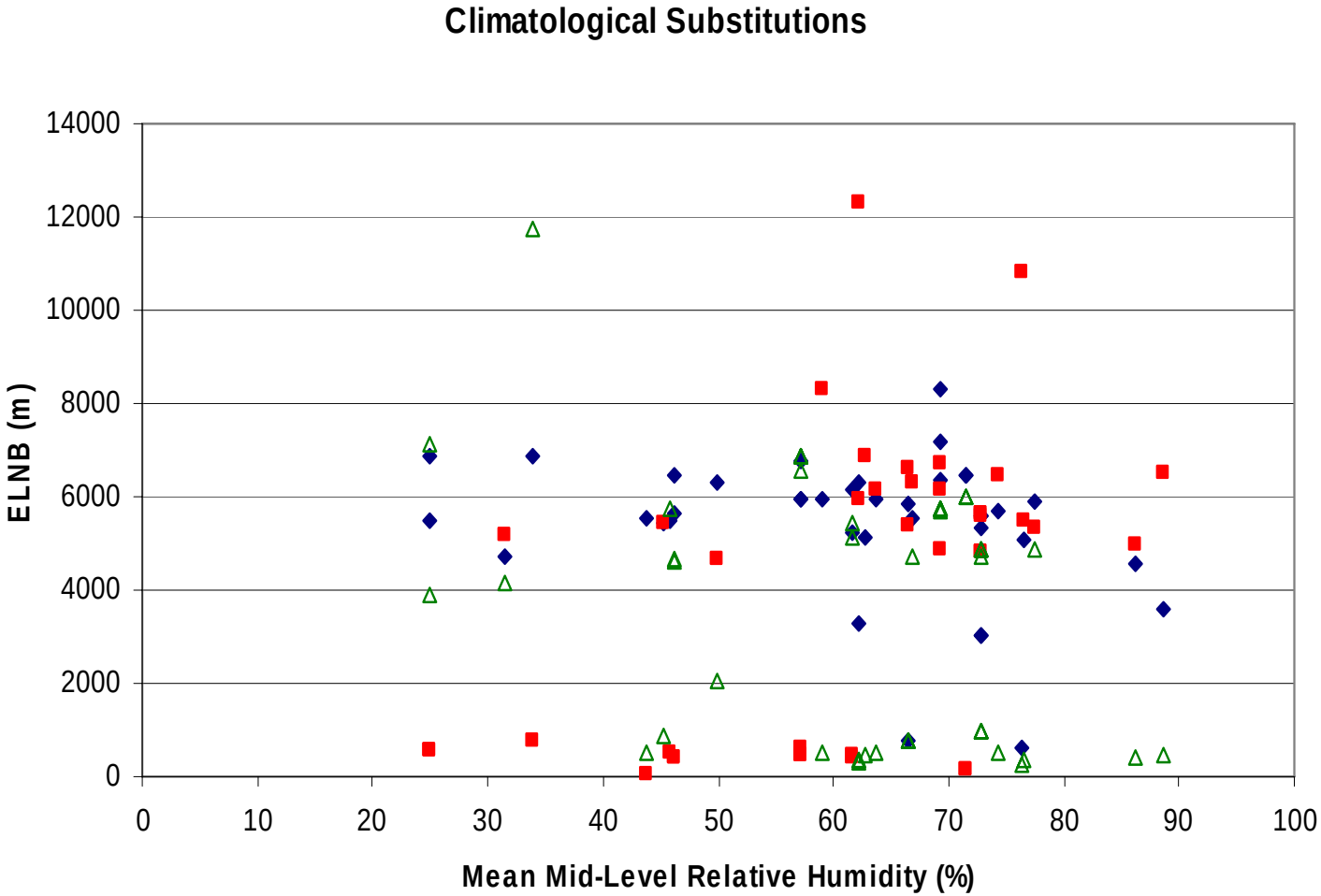


[Jensen and Del Genio 2006]

- *<u>Entrainment</u> – air outside of a cloud mixing with cloudy air*
  - *–increases mass of cloud*
  - *–decreases LNB*
  - *–has units of: % km^{-1}*

- *<u>LNB</u> – the level at which an air parcel attains the same density as its environment and therefore buoyancy is 0.*
  - ***–Assumption: adiabatic ascent***

Is Niamey conducive to deep convection?

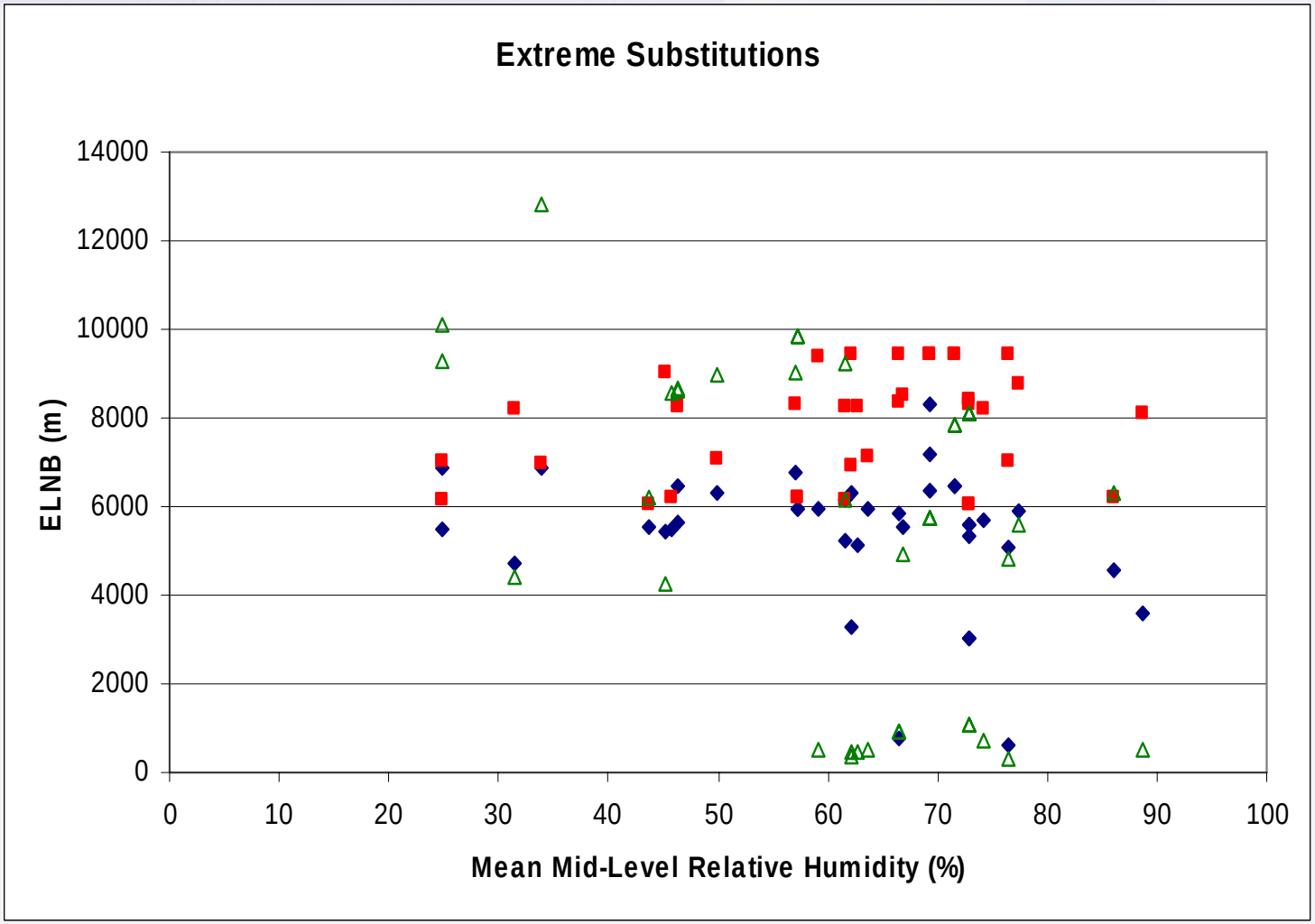


-Blue : ELNB for cloud observations

-Red : ELNB with Mean Temperature Profile

-Green: ELNB with Mean Relative Humidity Profile

Stabilized Freezing Layer?
or
Drying of the Midlevel?



Blue : ELNB for cloud observations

Red : ELNB with Unstable freezing layer removed

Green: ELNB with Moist Mid-Level

Conclusion

- *Currently, environmental parameters are being analyzed to see their impact on the entrainment rate and to gain a better understanding of our results.*

- *Although a stabilized freezing layer plays more of a role in limiting cloud top growth, neither play a major role.*

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