

Investigating Shallow-Cumulus Fields Using RACORO, LES and Lagrangian Particle Tracking

David (Xin) Wei
Packard (Pak-Wah) Chan
Zhiming Kuang

Acknowledgement: Andrew Vogelmann, Satoshi Endo,
Chris Bretherton, Thijis Heus

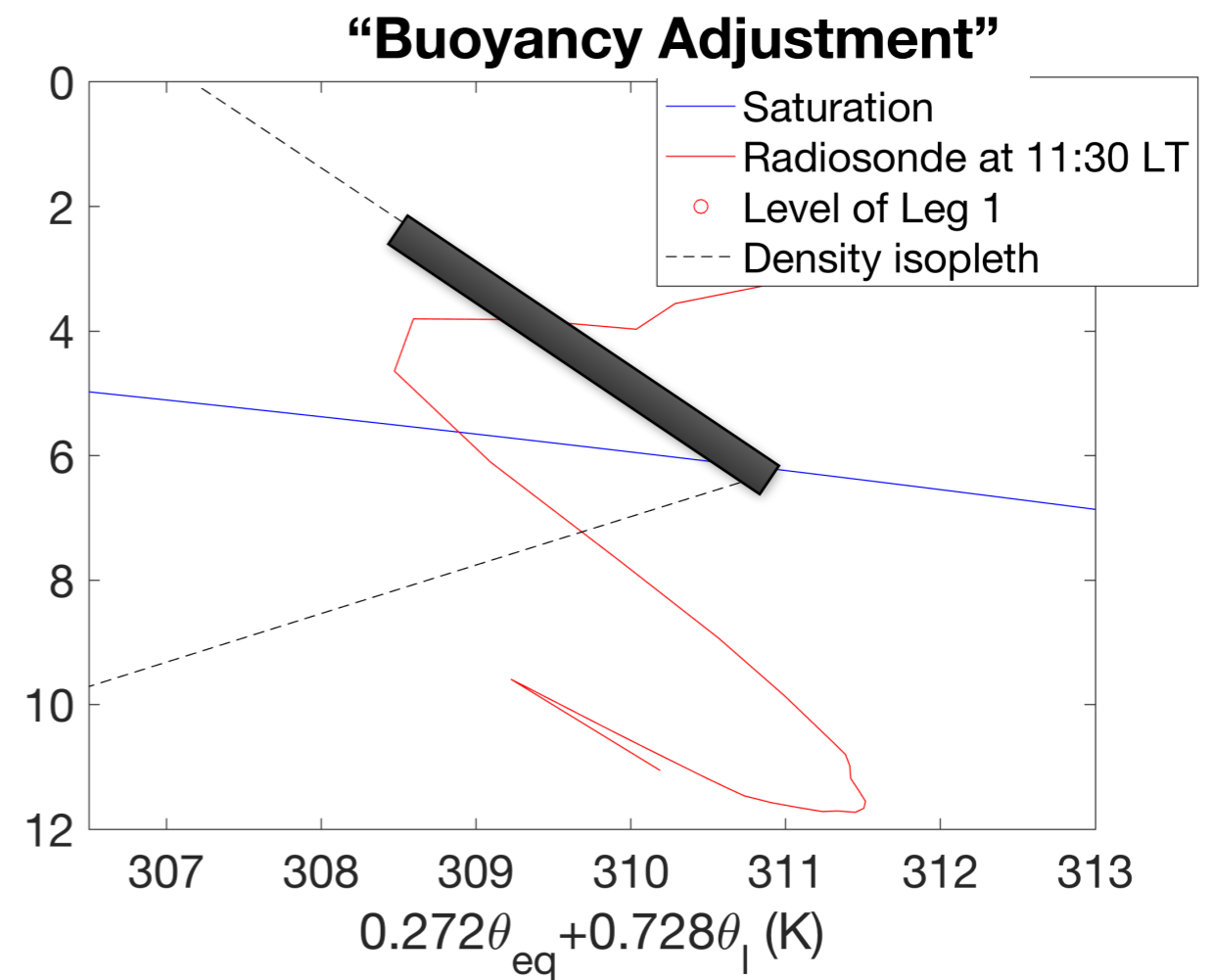
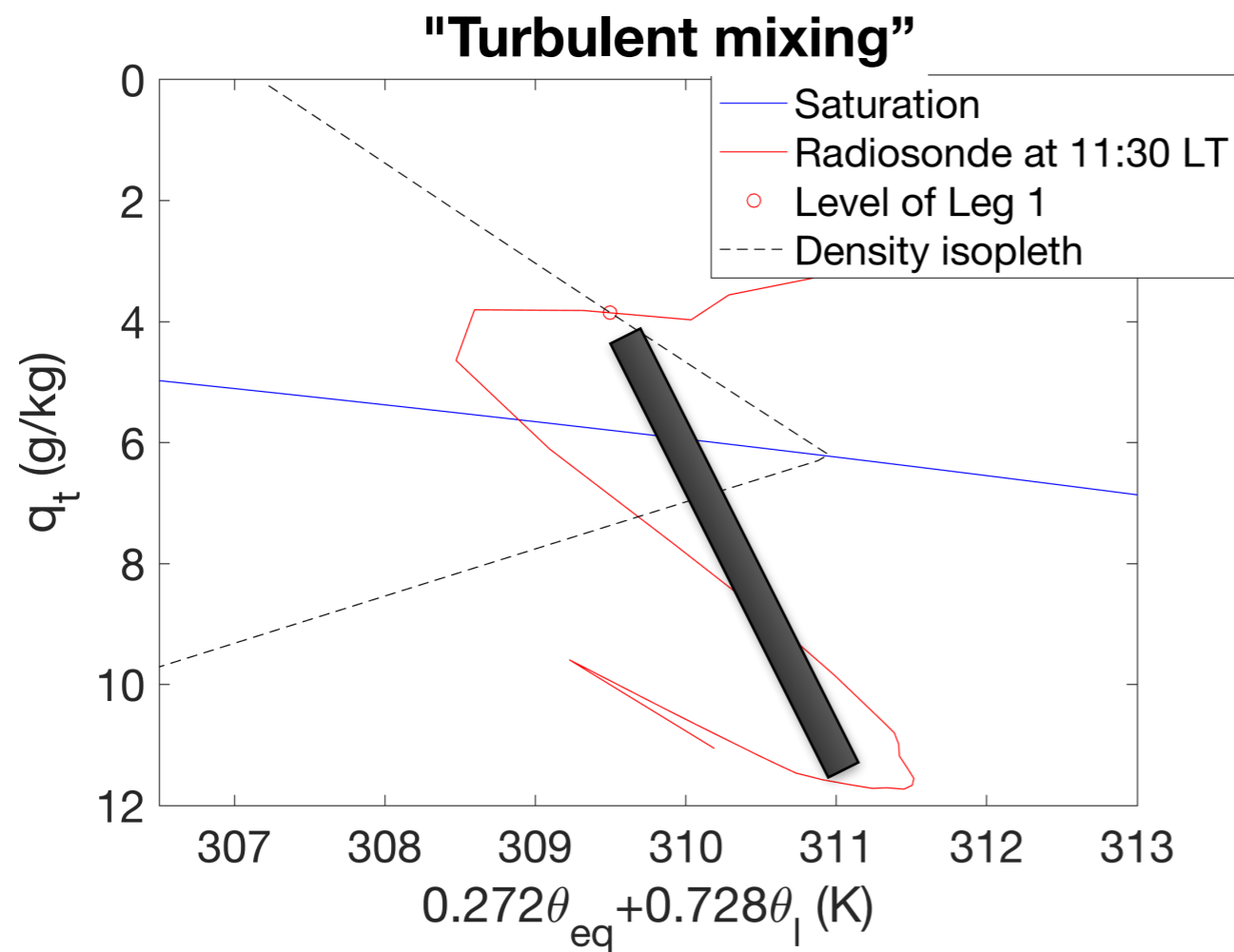
Two main concerns

- How well can large-eddy simulations (LES) **reproduce observations** of a shallow-cumulus field?
- How does LES help us **understand** the behavior of a shallow-cumulus field?

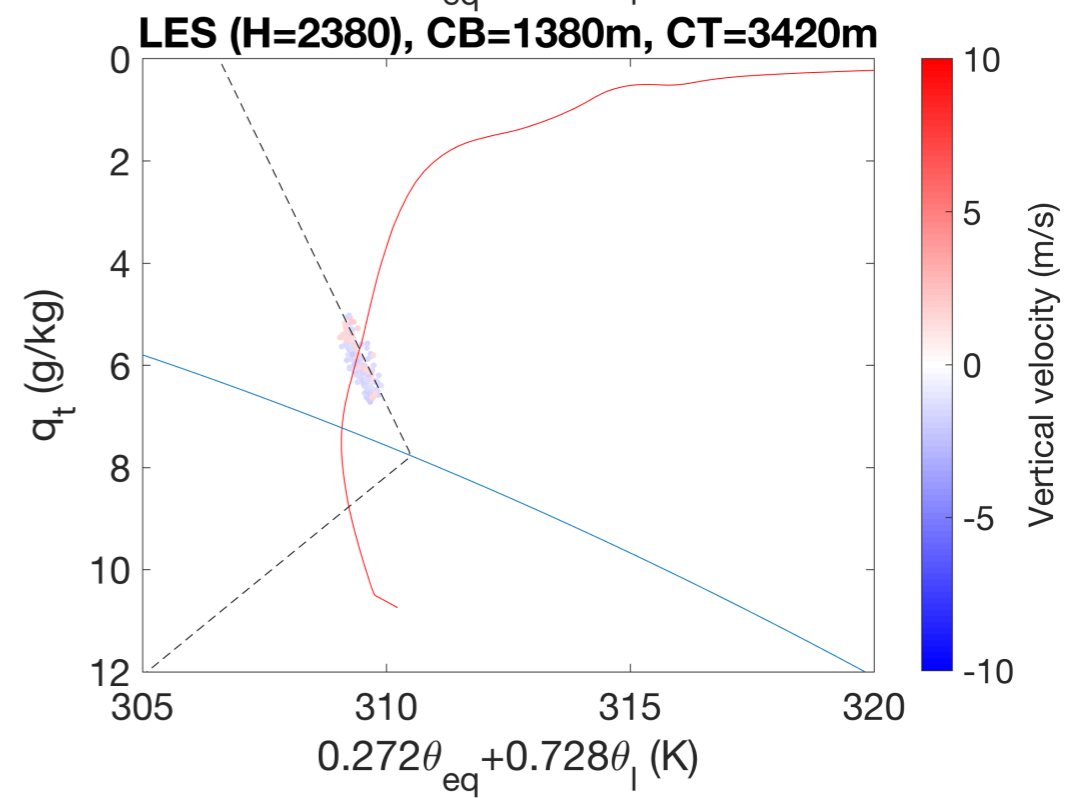
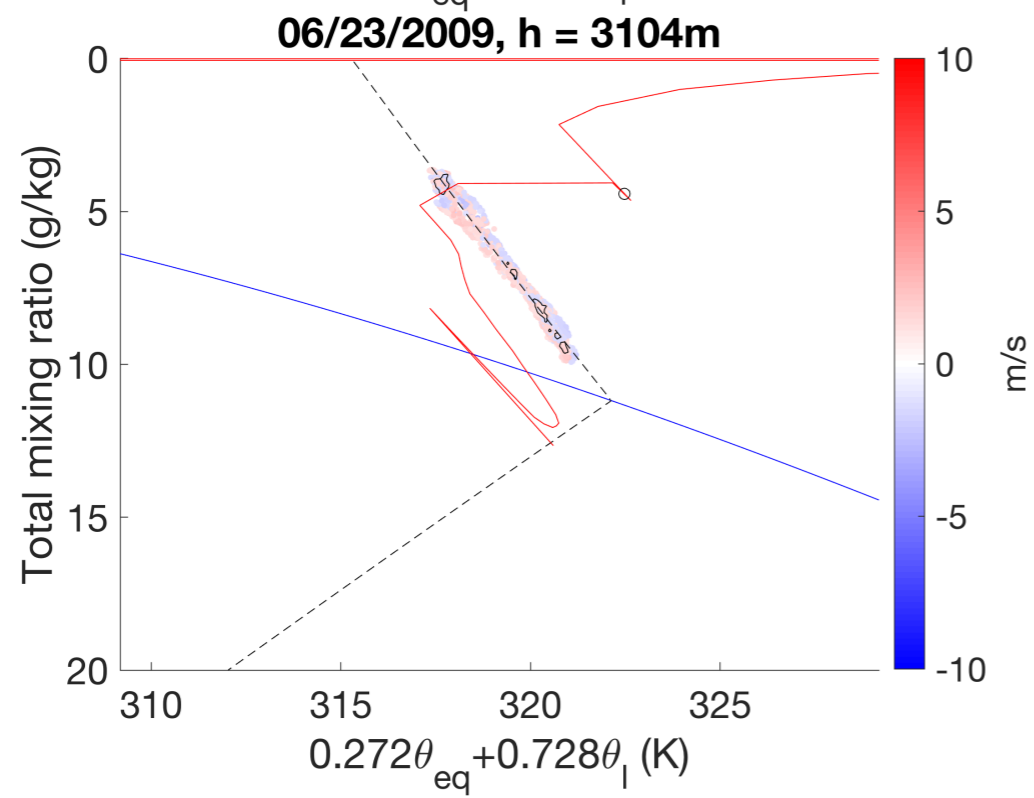
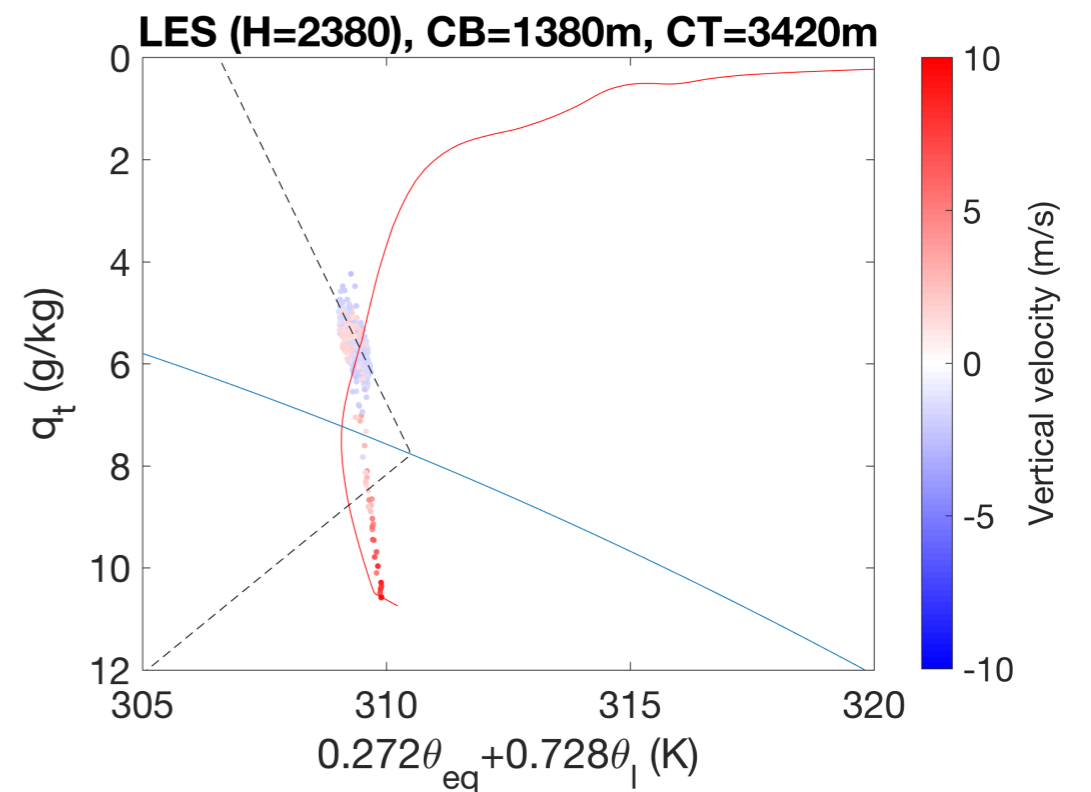
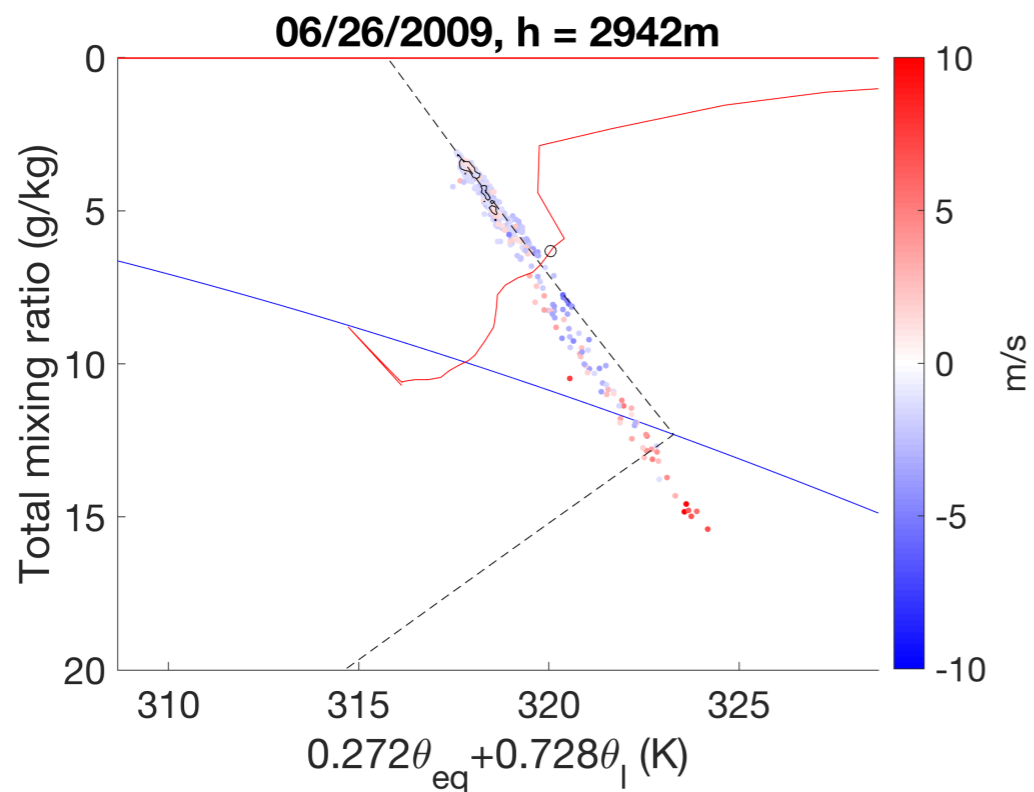
RACORO observations

- Routine AAF Clouds with Low Optical Water Depths (CLOWD) Optical Radiative Observations (RACORO)
 - Southern Great Plain
 - CLOWD: liquid water path $< 100 \text{ g / m}^2$
- Run from 22 January 2009 to 30 June 2009
- **Aircraft** measurement: 26 days for cloud sampling
- Spatial resolution: $\sim 6\text{m}$

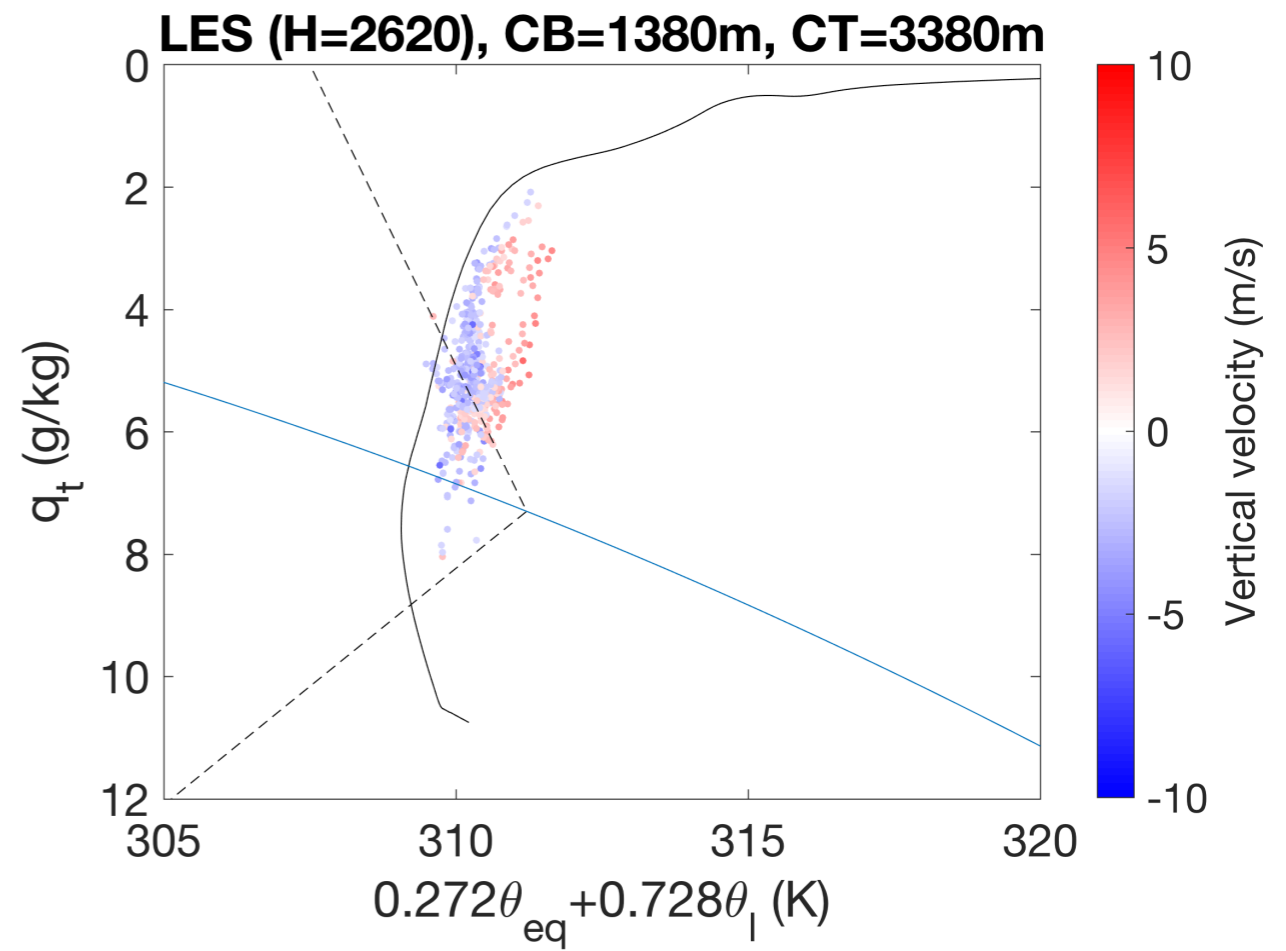
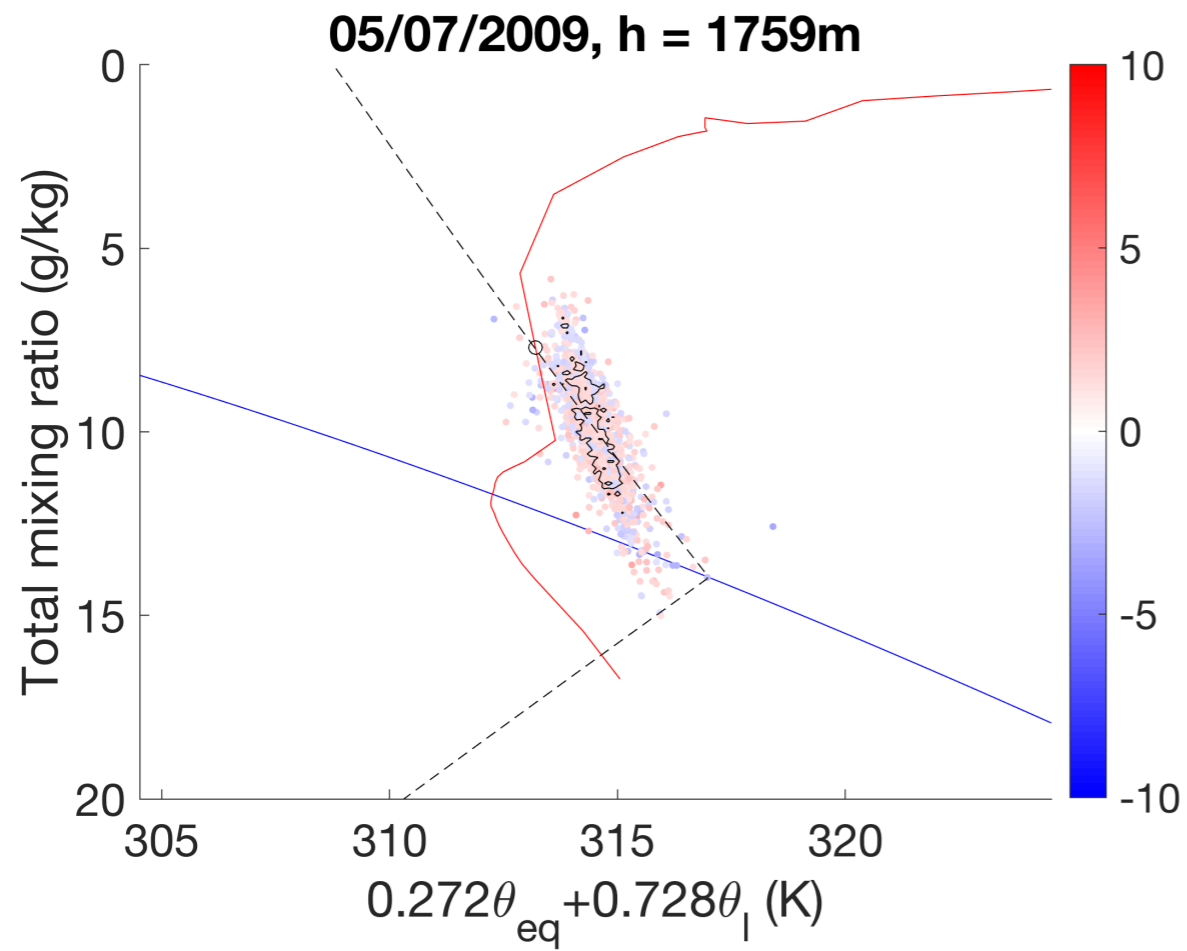
“Turbulent mixing” vs. “buoyancy adjustment”



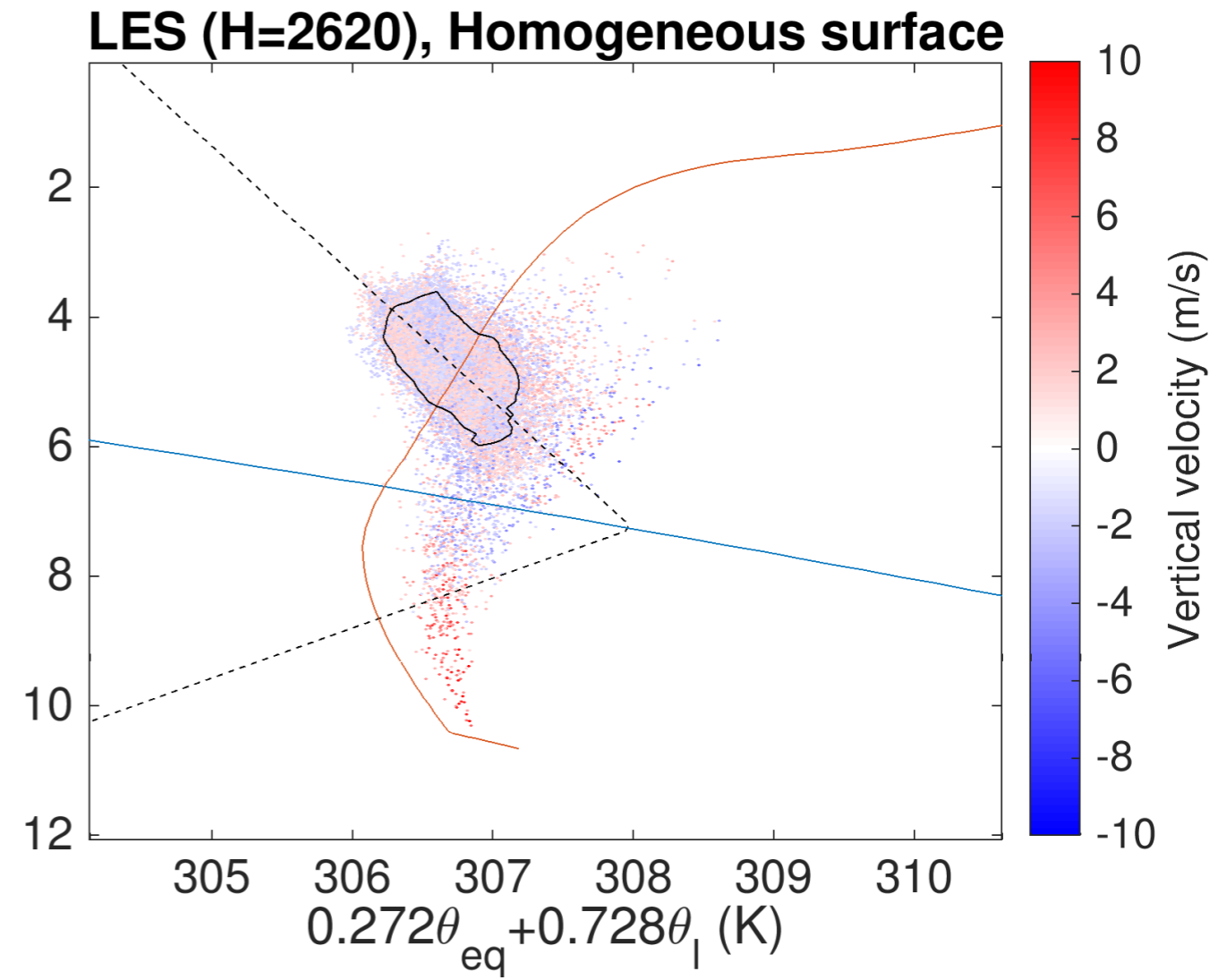
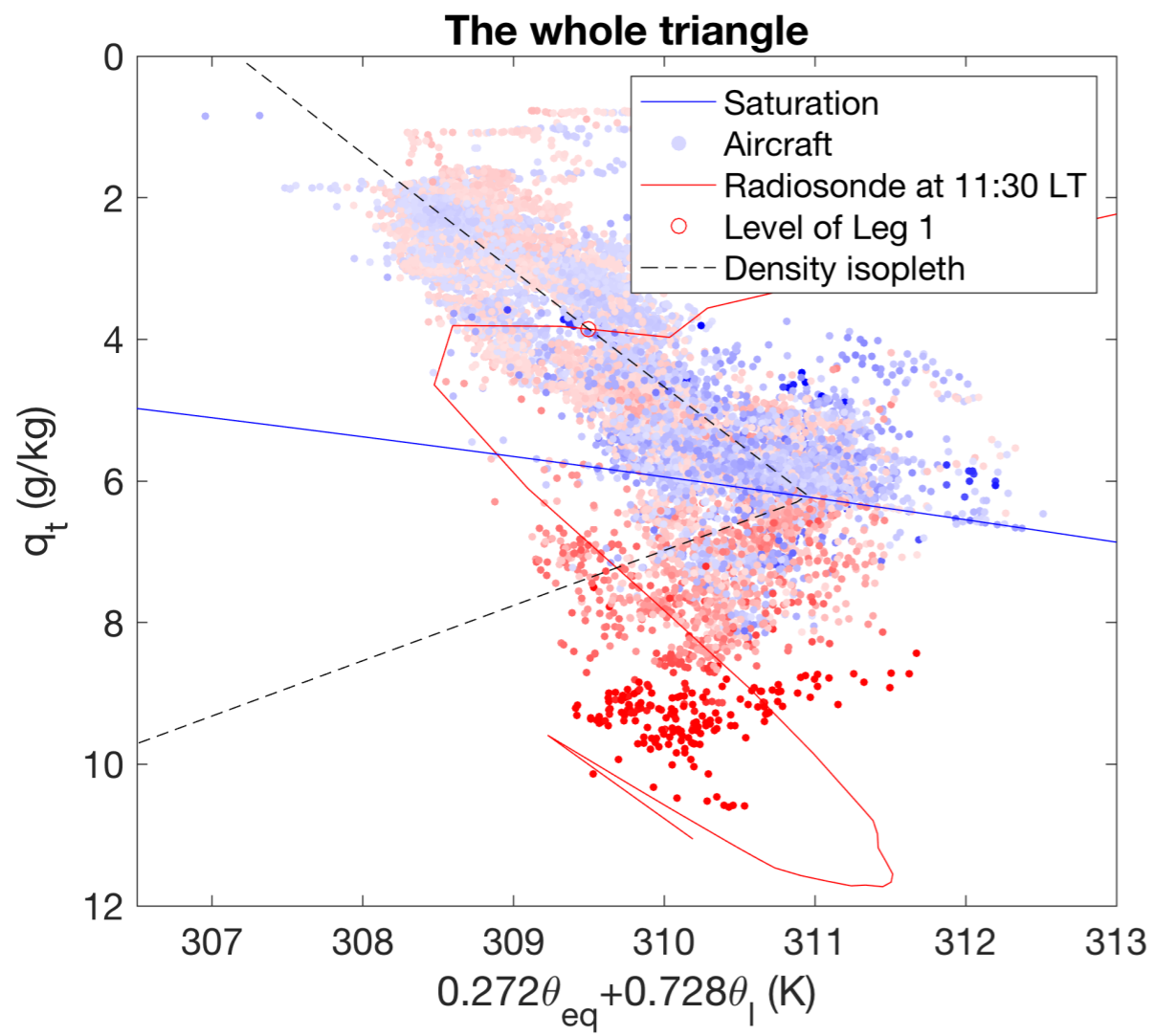
An overview of the cases



05/07



05/22

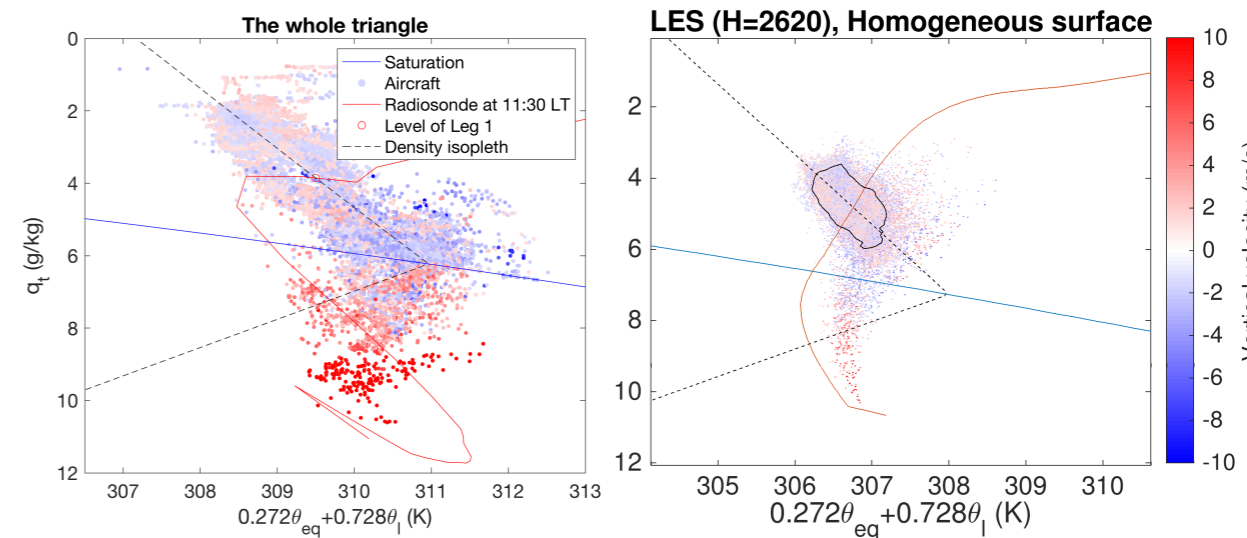


Endo et al., 2015

Two main concerns

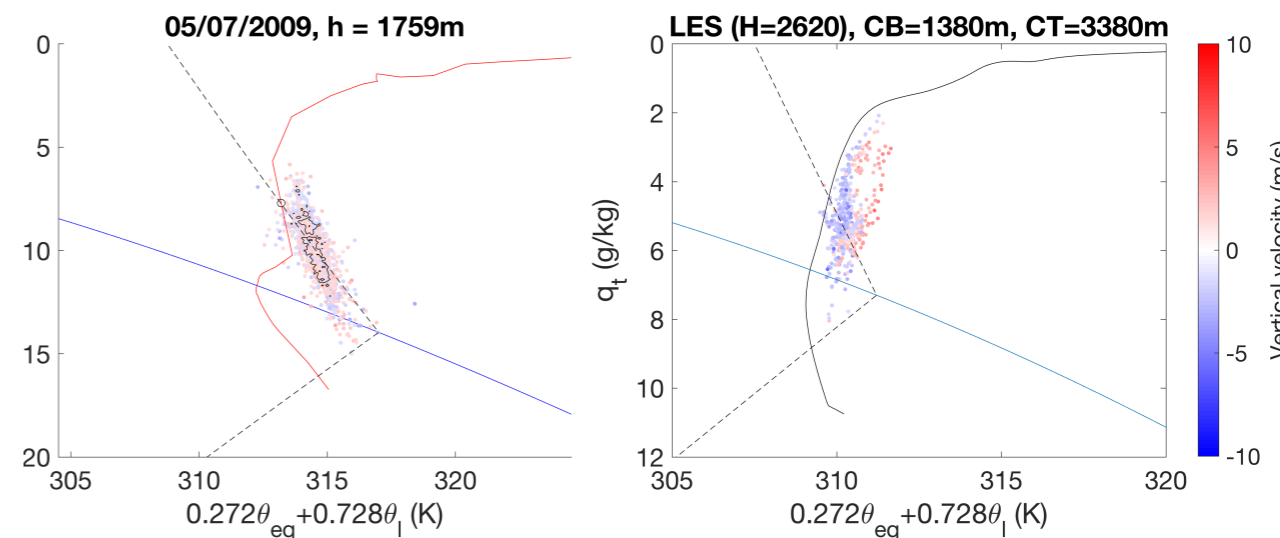
- How well can large-eddy simulations (LES) reproduce observations of a shallow-cumulus field?

- Case 05/22



- How does LES help us understand the behavior of a shallow-cumulus field?

- Case 05/07



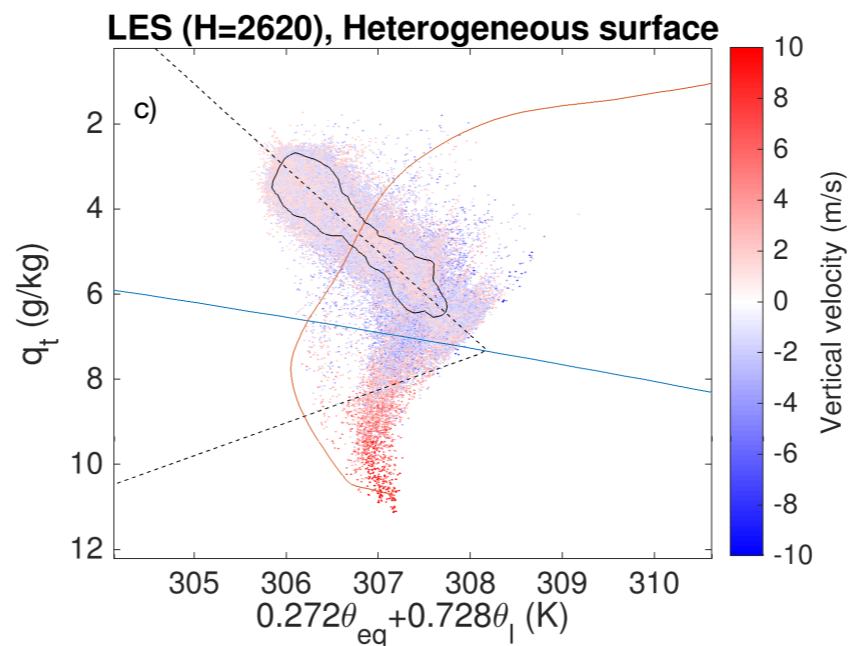
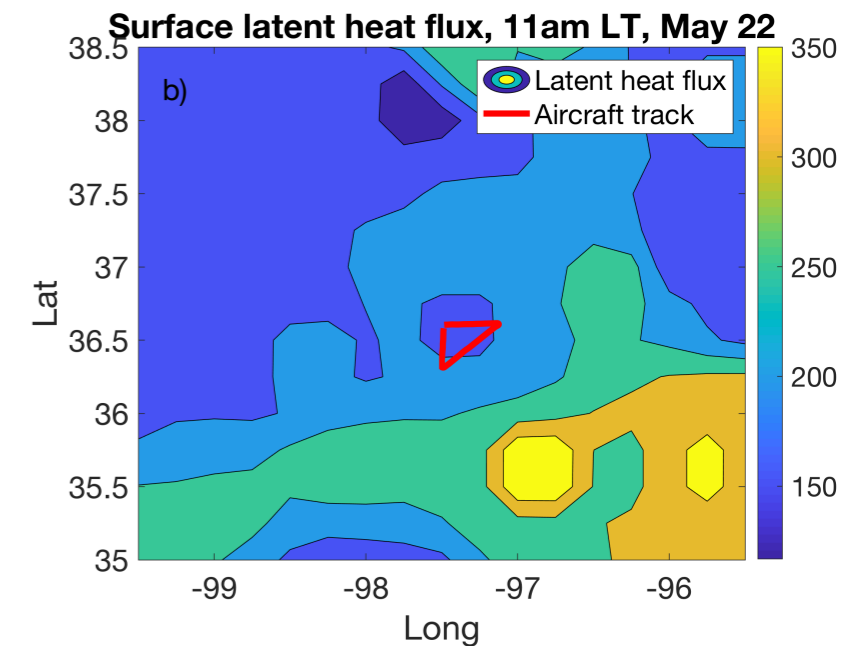
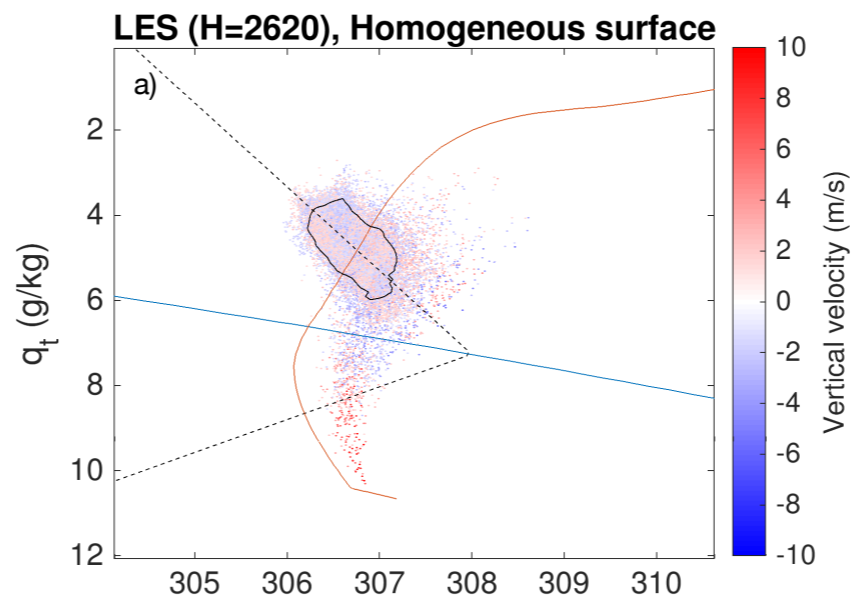
Case 1: 05/22

- **LES setup**

- Domain elongated in y direction by 8 times

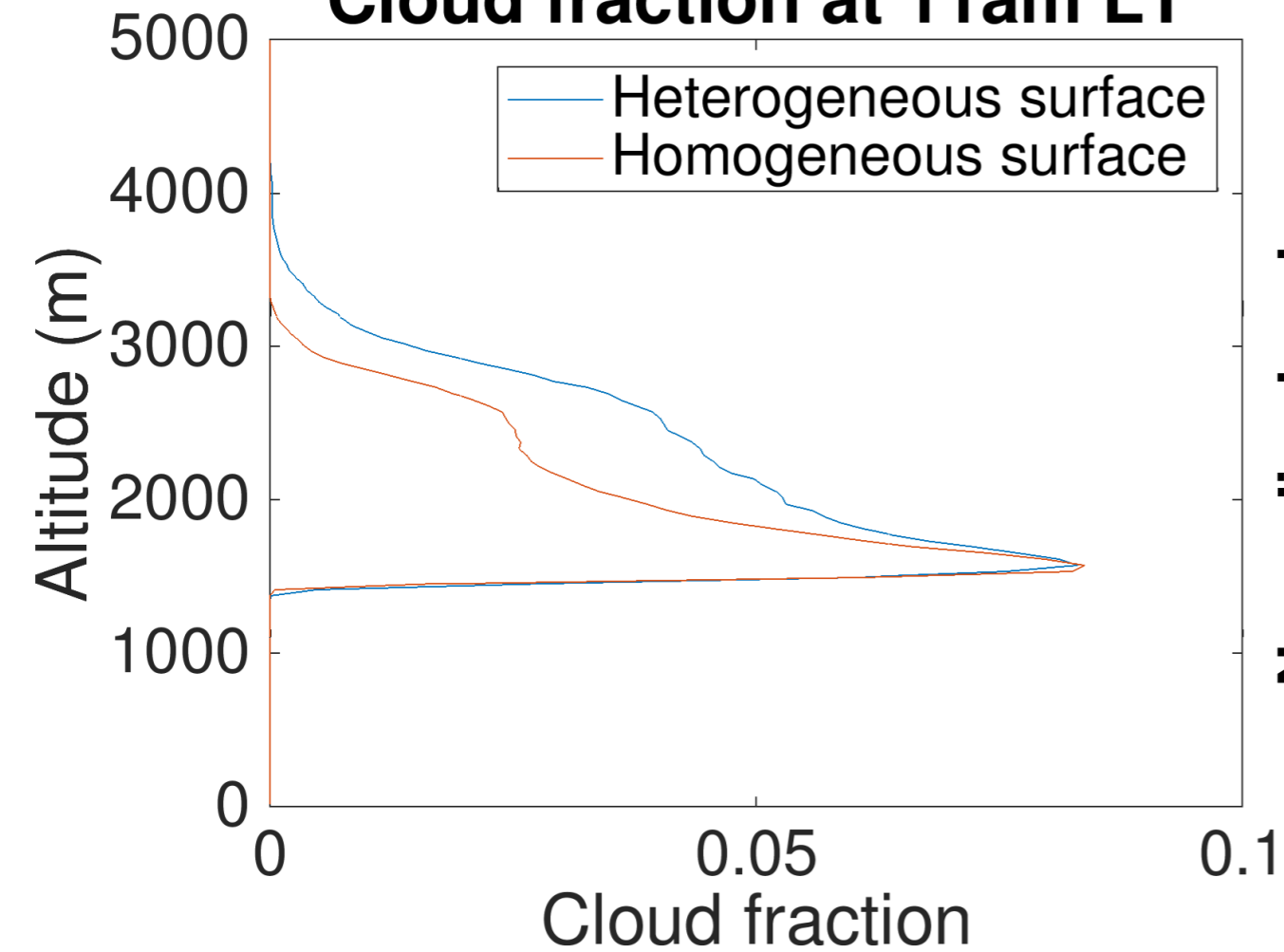
- **Heterogeneous surface**

- 1/8 of surface area has **50% higher surface fluxes** than the rest
- Mean fluxes equal those in the homogenous case

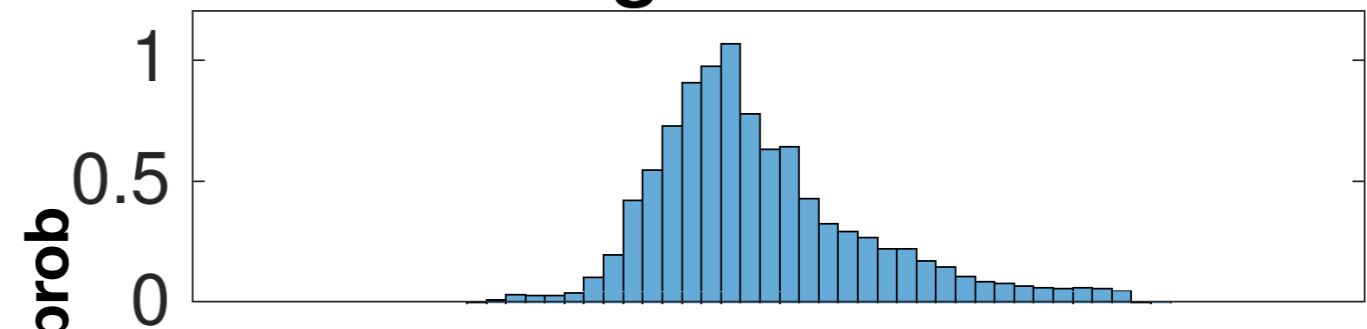


Cloud properties

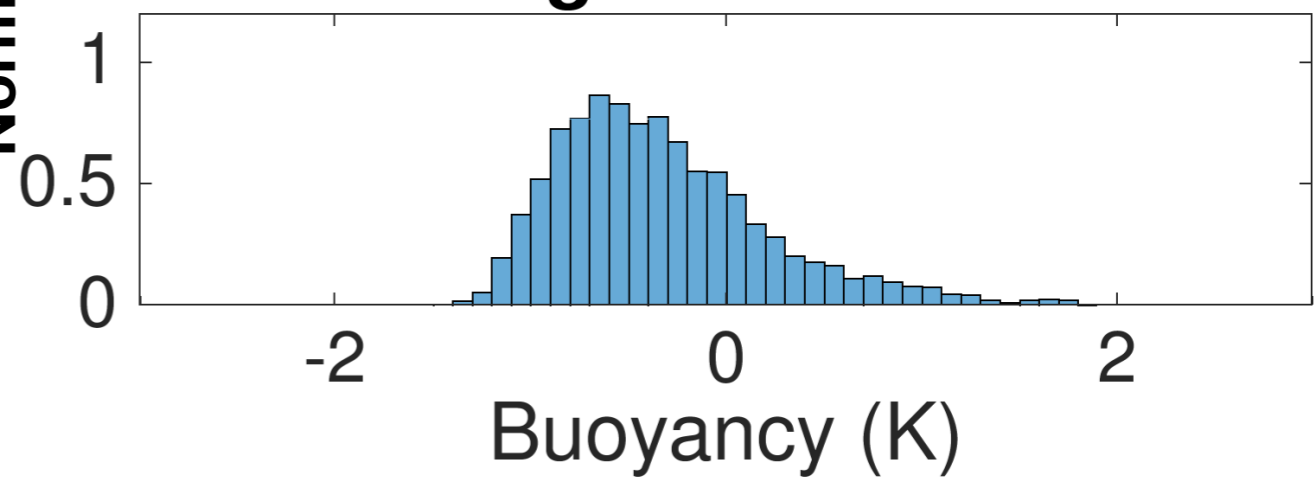
Cloud fraction at 11am LT



Heterogenous surface

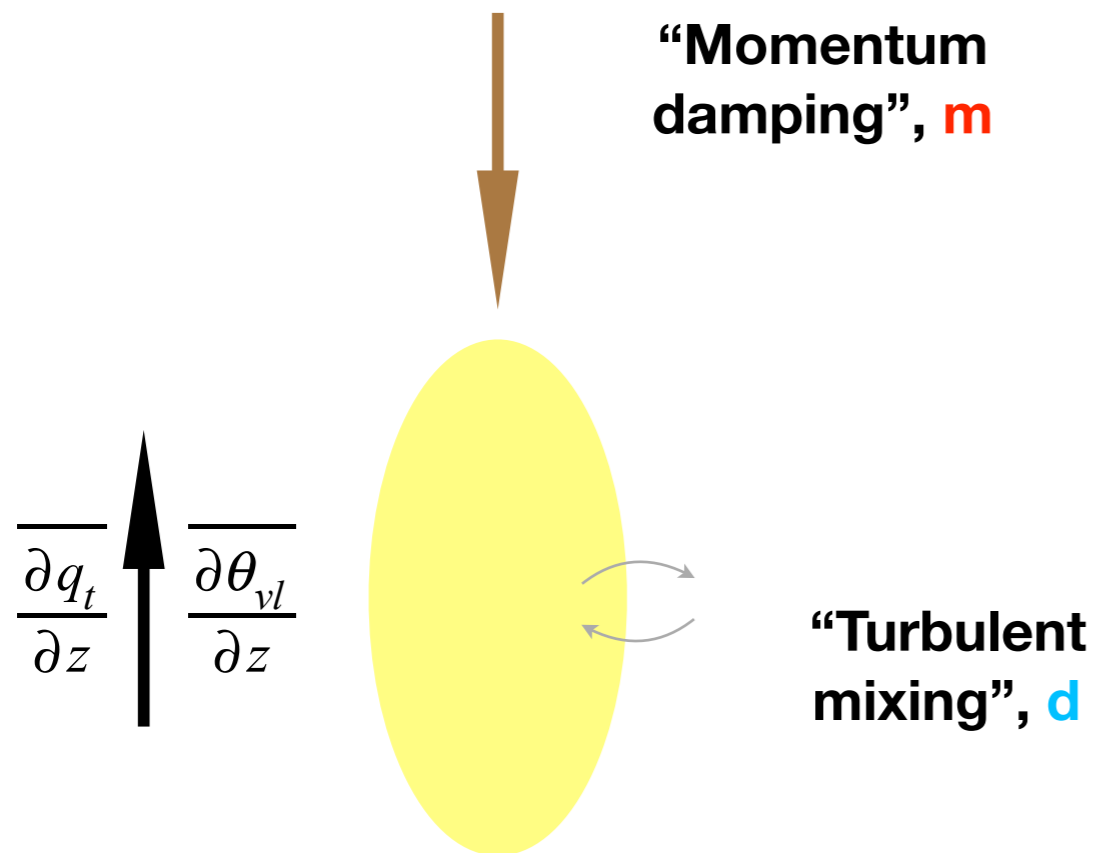


Homogenous surface



Dependence on length scale

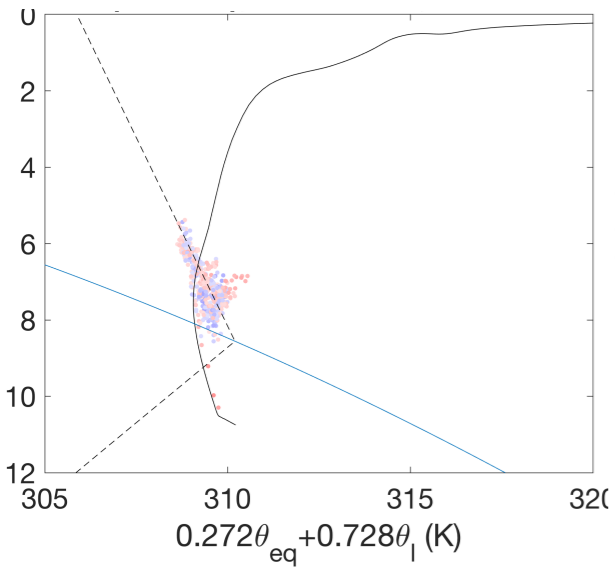
A damped oscillator



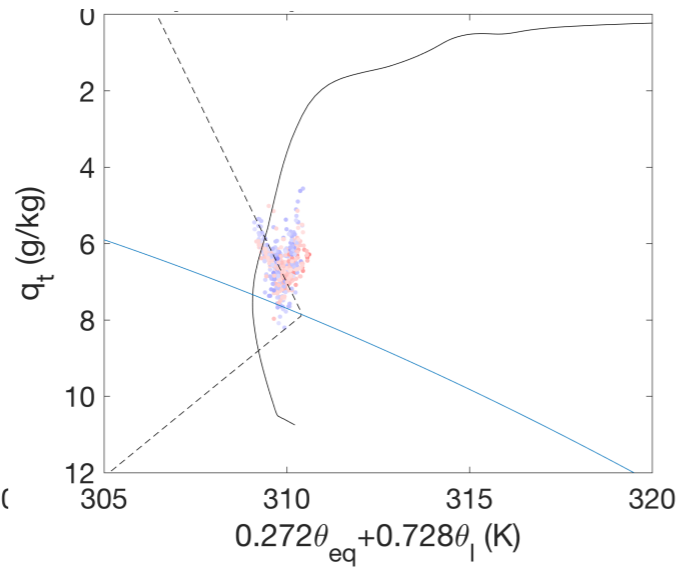
Bubble size	$1/d$ (s)	$1/m$ (s)
200m	4×10^2	1×10^2
1000m	7×10^3	3×10^2

Case 2: 05/07

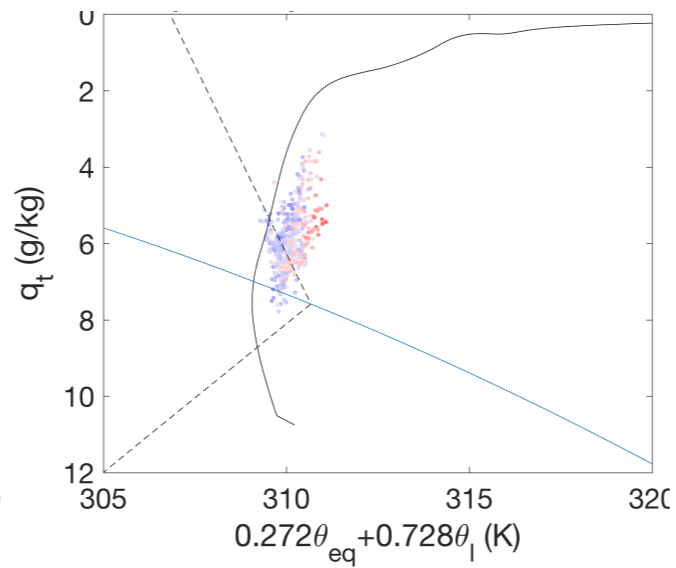
H=2100m



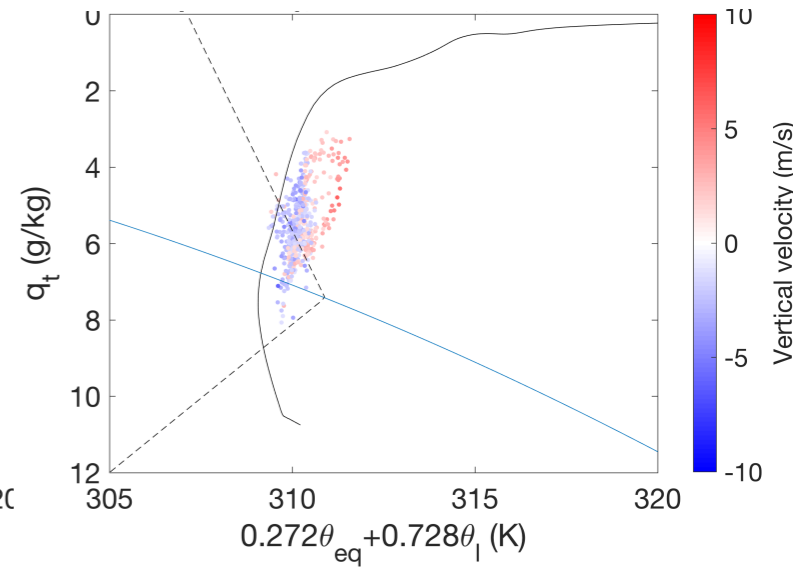
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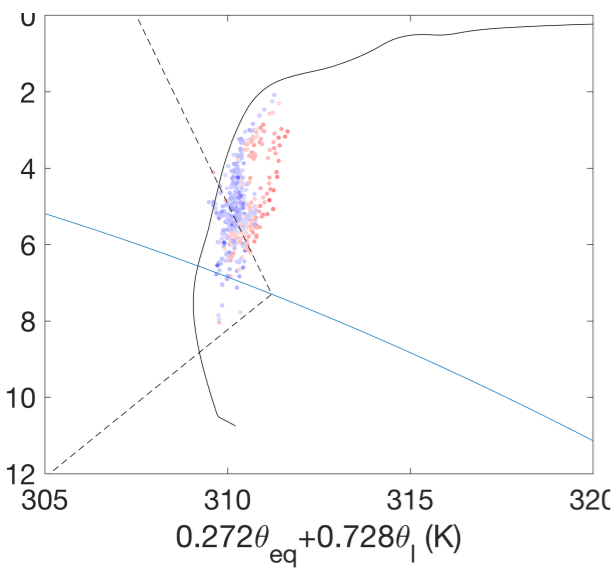
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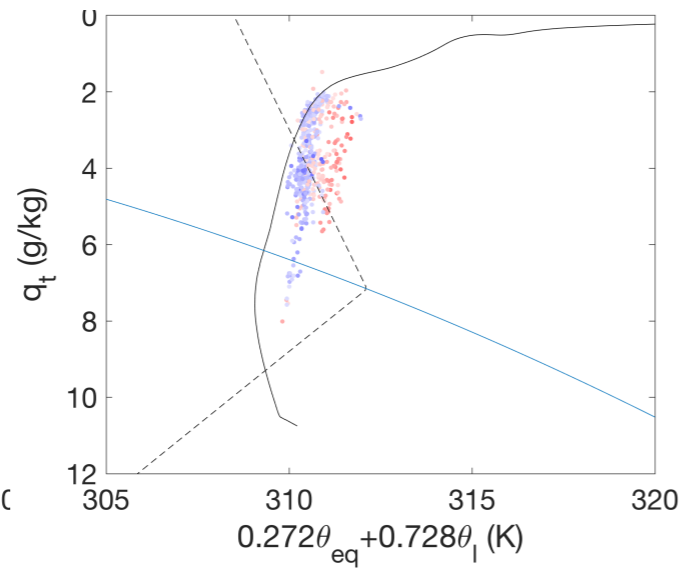
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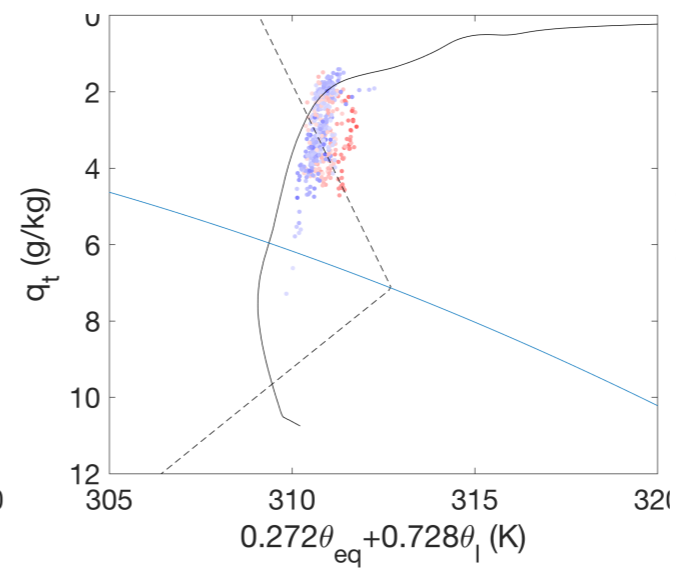
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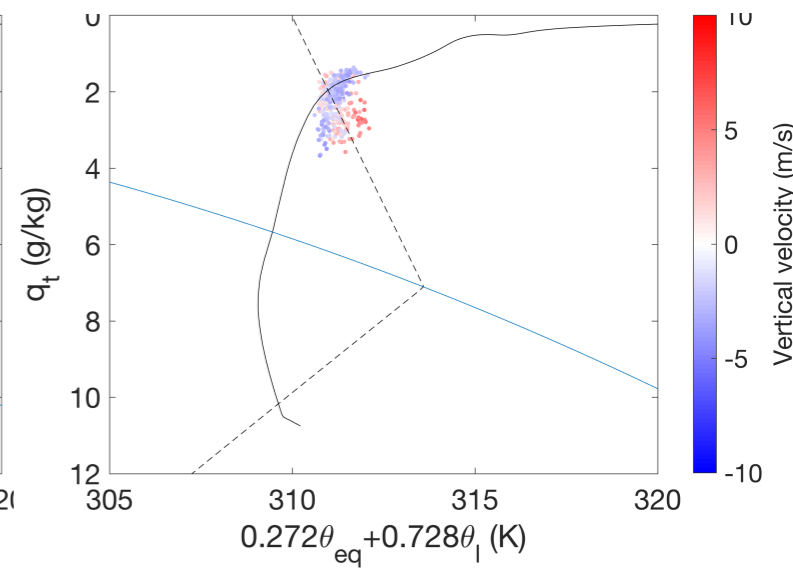
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H=2860m

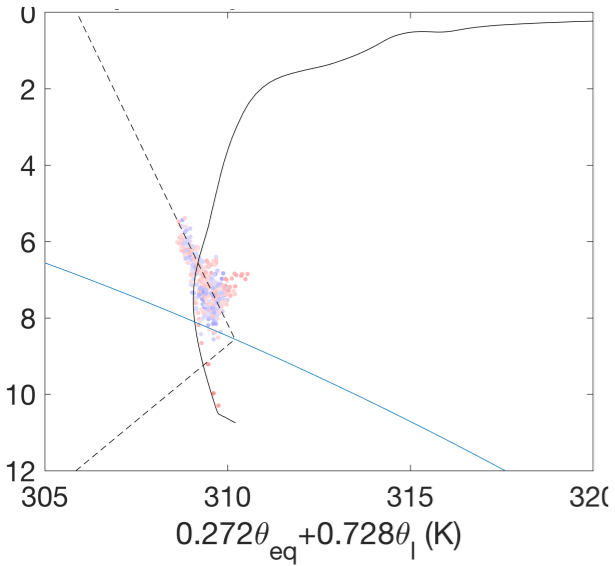


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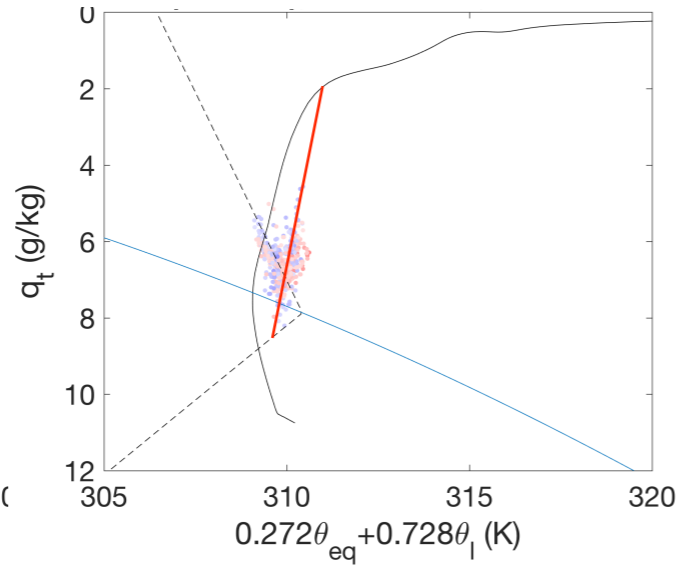


Case 2: 05/07

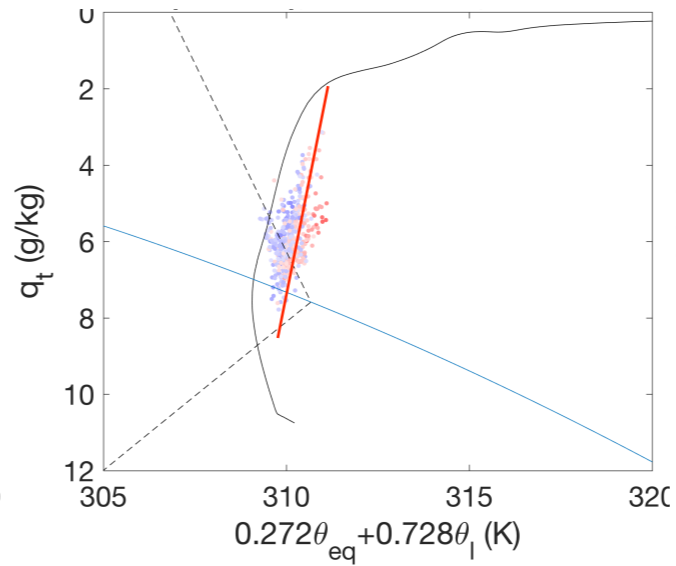
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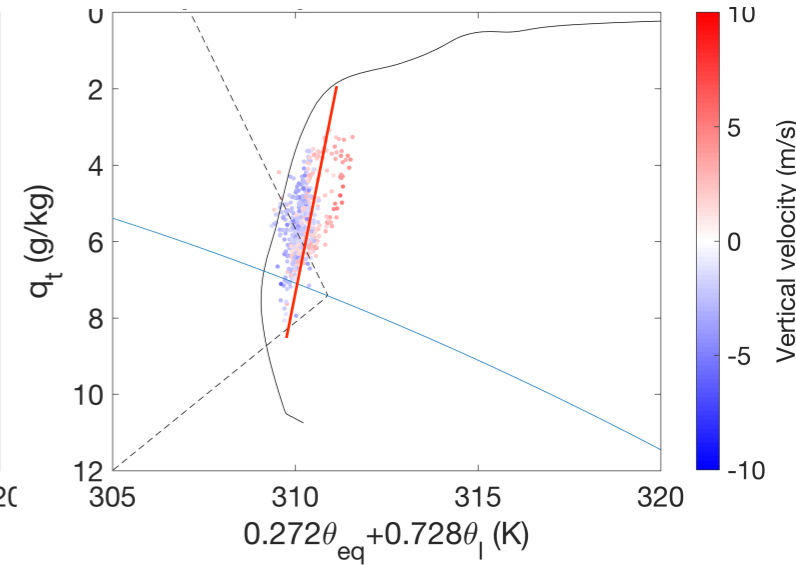
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H=2460m

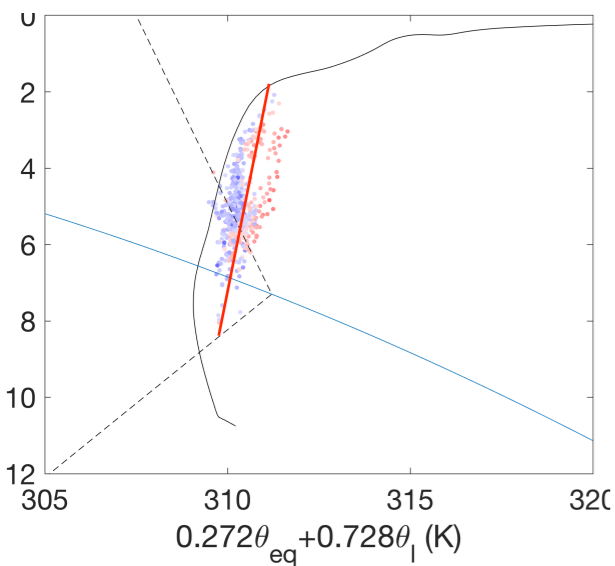


H=2540m

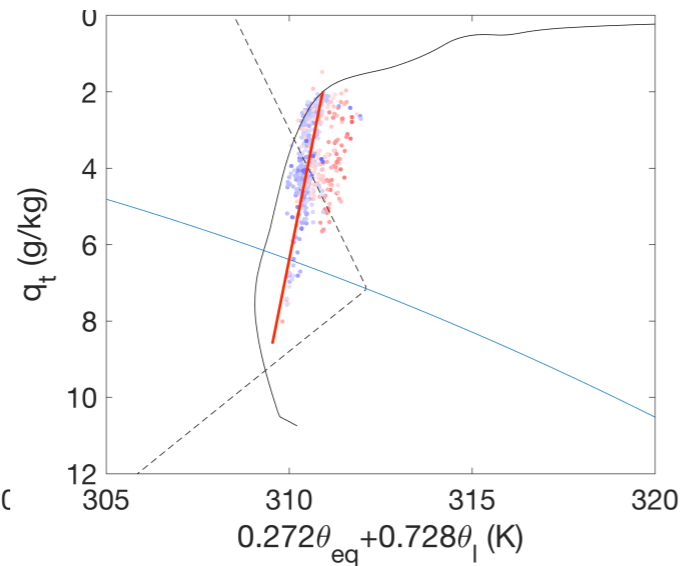


Same upper source

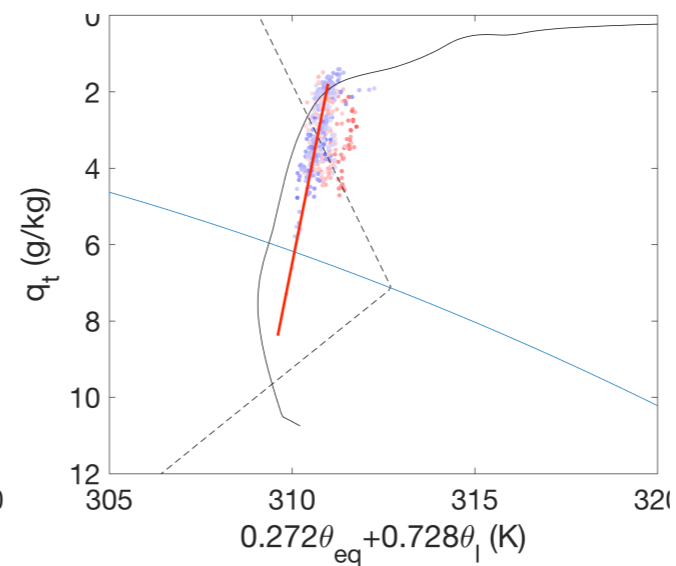
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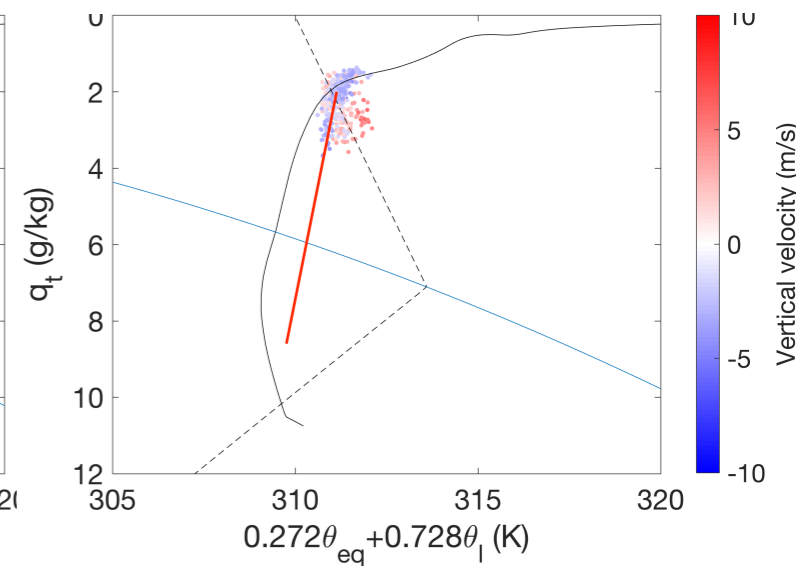
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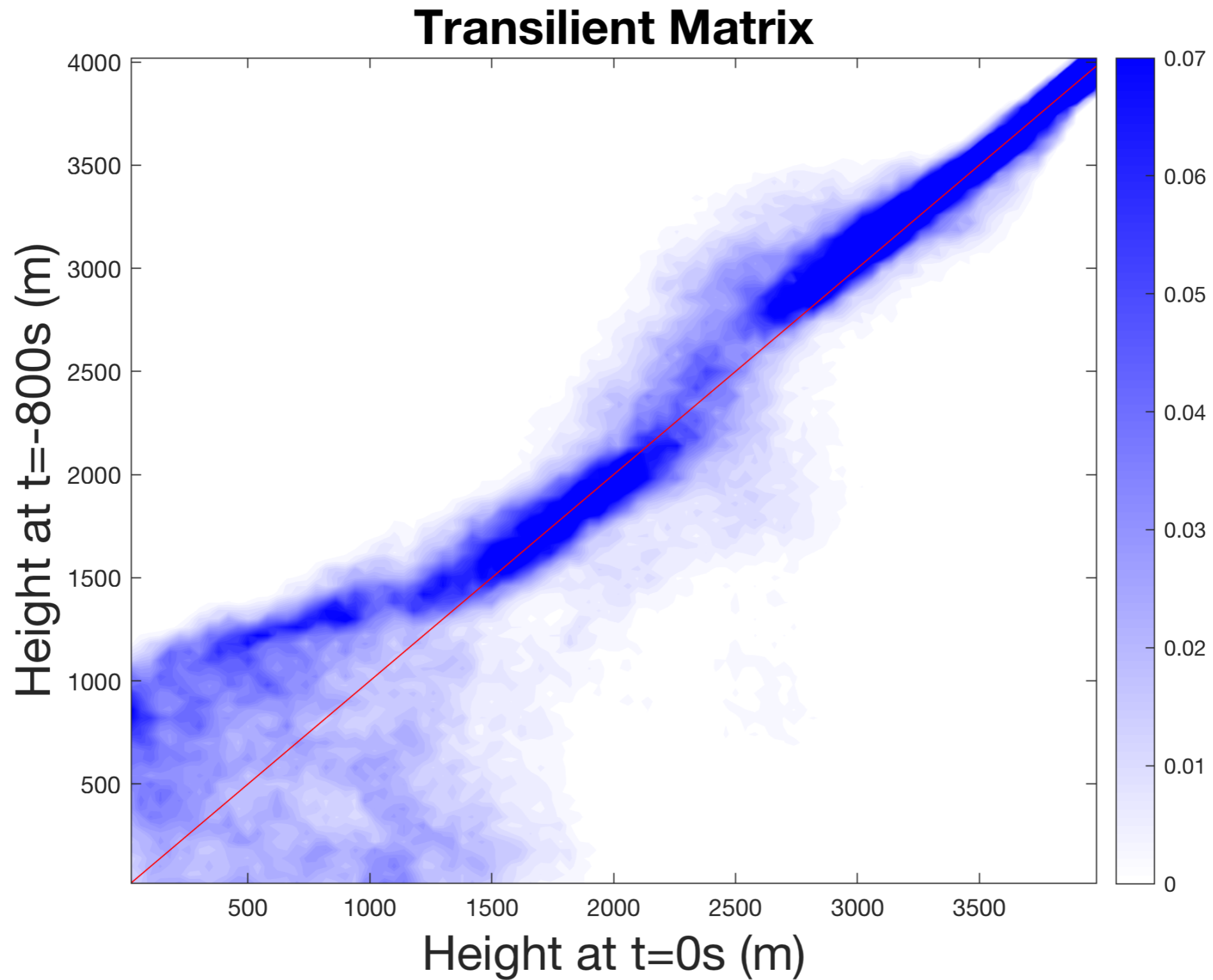
H=2860m



H=2980m



Descend ~ 500m

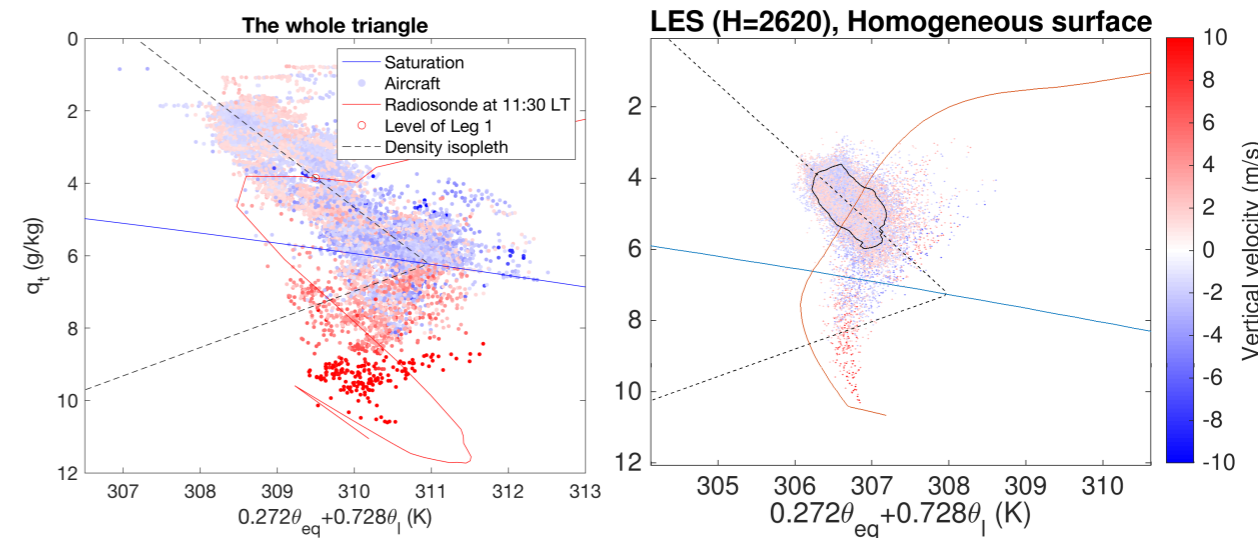


Two main concerns

Poster: A1 104, 3:30pm to 5pm today

- How well can large-eddy simulations (LES) reproduce observations of a shallow-cumulus field?

- Case 05/22
 - Surface heterogeneity



- How does LES help us understand the behavior of a shallow-cumulus field?

- Case 05/07
 - Significant descent

