

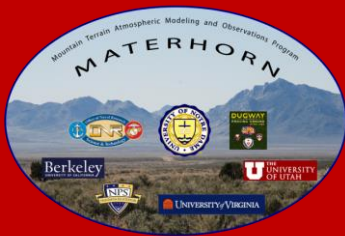
# Evening transition characteristics on a slope in an arid environment

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21st Symposium on Boundary Layers and Turbulence  
Leeds, England



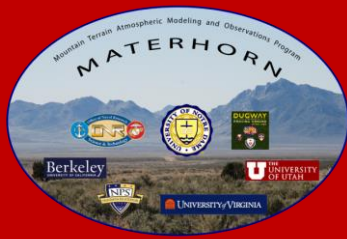
<sup>1</sup>University of Utah  
<sup>2</sup>University of Notre Dame  
<sup>3</sup>Universita Del Salento, Lecce, Italy  
<sup>4</sup>Oregon State University  
June 11, 2014  
This research is supported by  
Office of Naval Research  
Award # N00014-11-1-0709



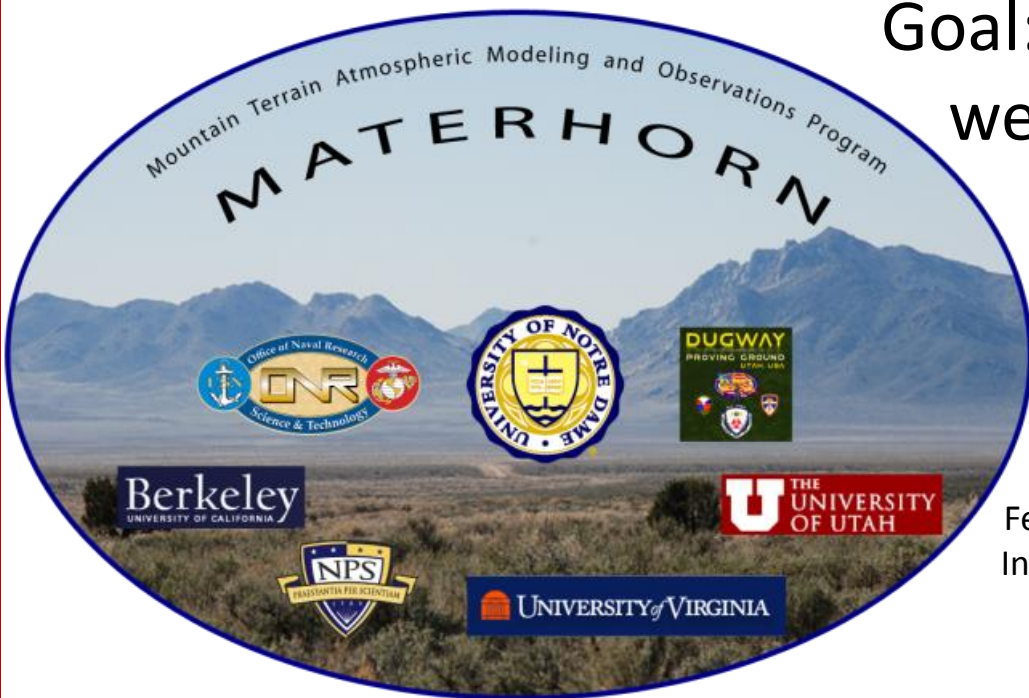
# Motivation

- 1) Better understand physical processes associated with transition periods in complex terrain
- 2) Develop appropriate parameterizations
- 3) Recent experiments that have identified unique aspects of transitions in complex terrain
  - Nadeau et al., QJRMS, 2012 – Steep Swiss Slope
  - Martinez et al., JAMC, 2013 – Meteor Crater Arizona

Intro  
Site  
Results  
Summary



# MATERHORN Project



Goal: Improved numerical weather Prediction in complex terrain

Fernando & Pardyjak, Field Studies Delve Into the Intricacies of Mountain Weather, *Eos Trans. AGU*, **94**(36), 313-35, 2013.

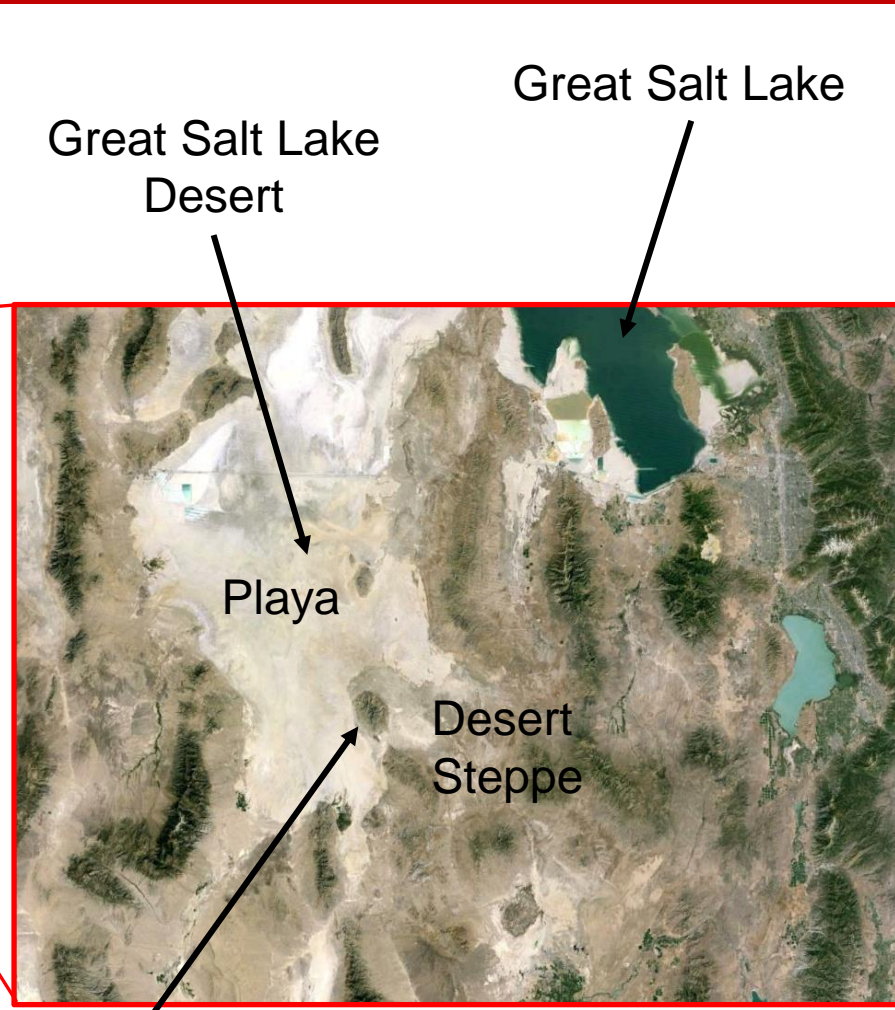
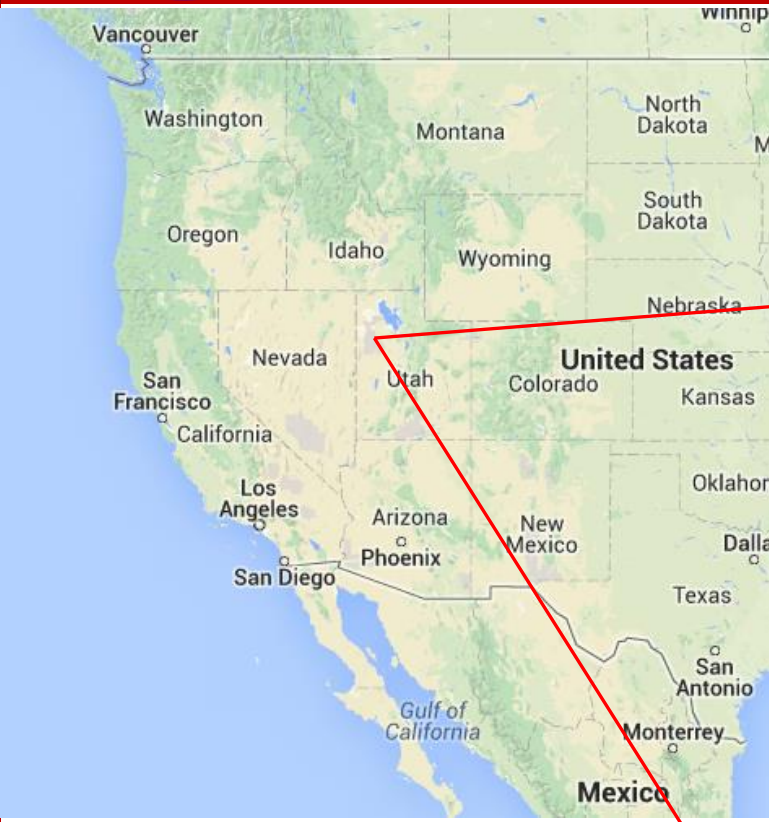


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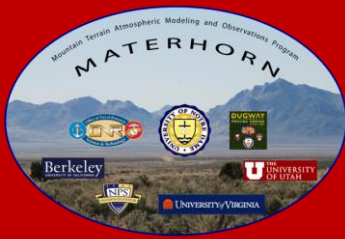


# Dugway Proving Ground – Utah's West Desert

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- Site
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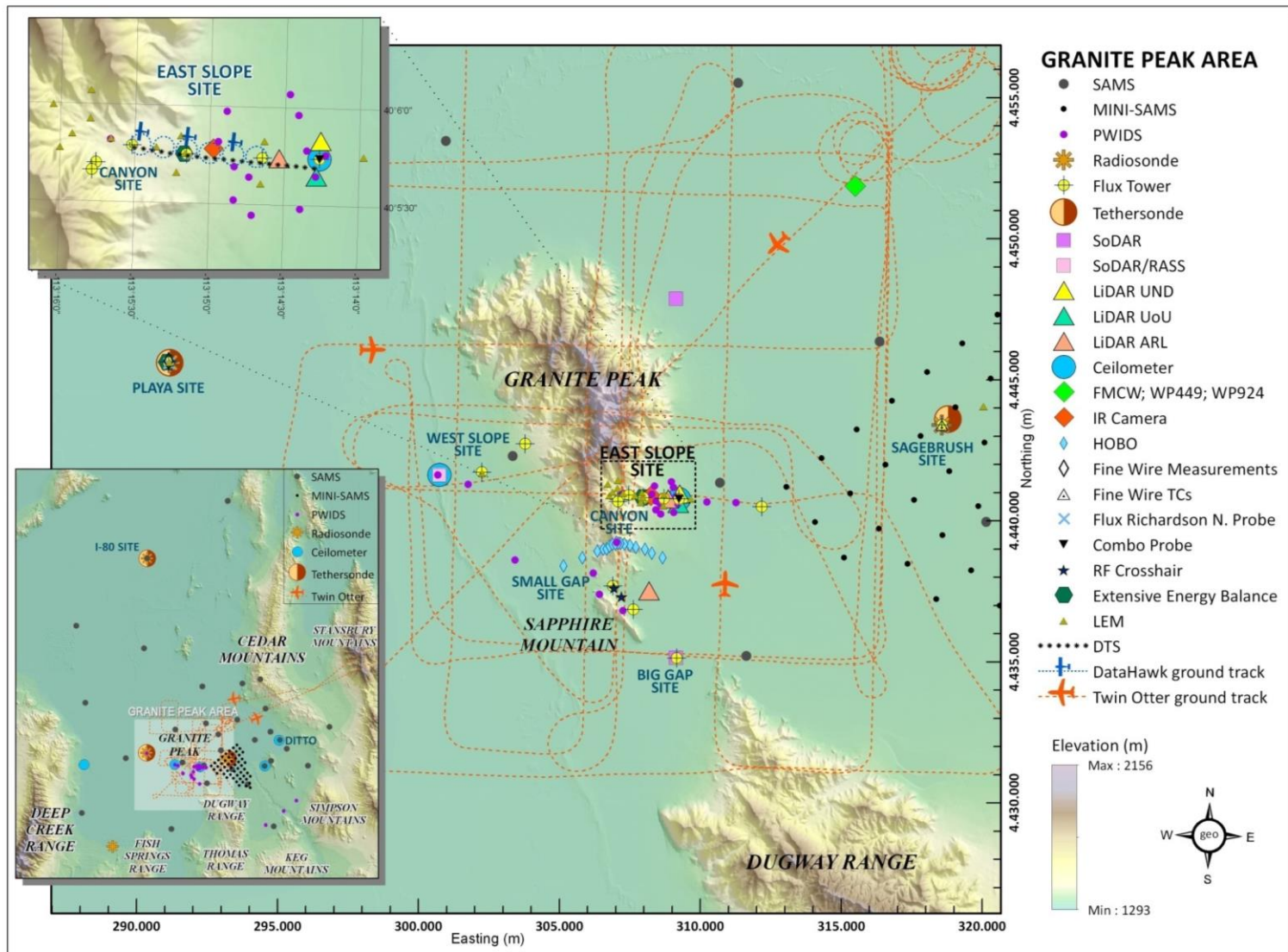


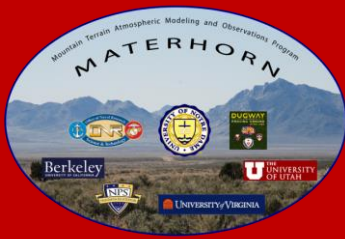
Fall Campaign 2012 – 10 IOPs  
Spring Campaign 2012 – 10 IOPs



# Dugway Proving Ground – Utah's West Desert

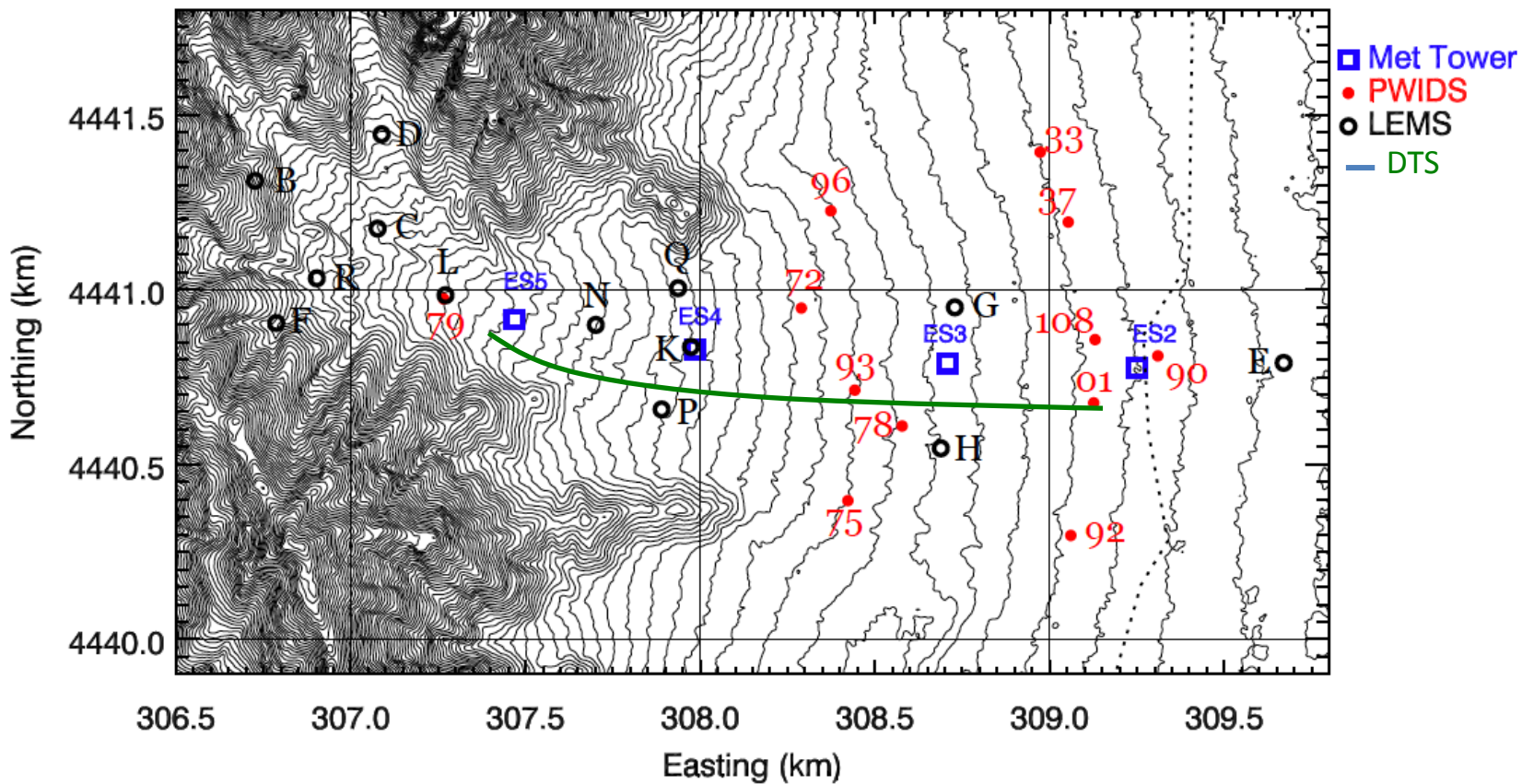
Intro  
Site  
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# Focus Area East Slope of Granite Peak

- Intro
- Site
- Results
- Summary





# East Slope Experiment

Intro

Site

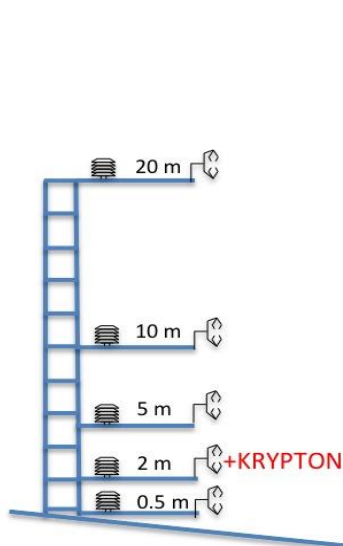
Results

Summary

## East Slope of Granite Mountain

### ES5 / EFS-SLOPE

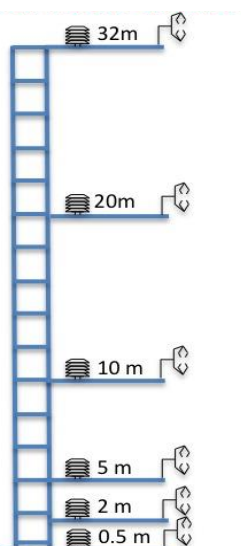
UU 20m tower  
1 sonic & all T/RH from DPG



+ FULL RADIATION BUDGET  
+ SOIL HEAT FLUX  
+ FINE WIRE TCs  
+ PRESSURE

### ES4

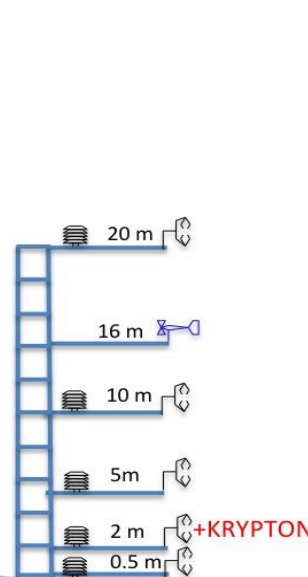
DPG 32 m mobile tower  
DPG sonics & T/RH



+ PRESSURE

### ES3

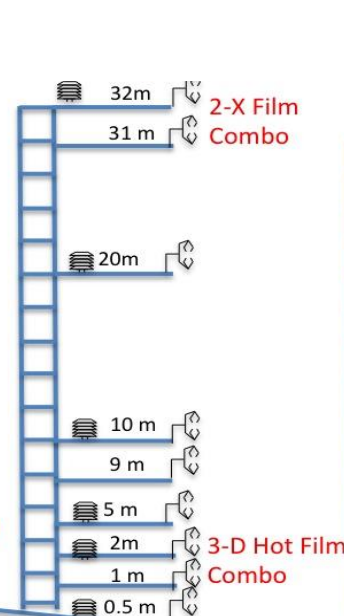
UND 20m tower.



+ NET RADIATION  
+ SHIELDED TCs  
+ PRESSURE

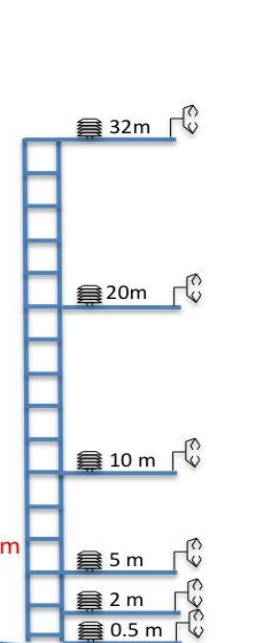
### ES2

DPG 32m tower.

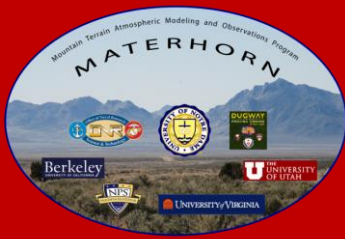


### ES1

Existing DPG 32m



+ PRESSURE



# Focus Area

# East Slope of Granite Peak

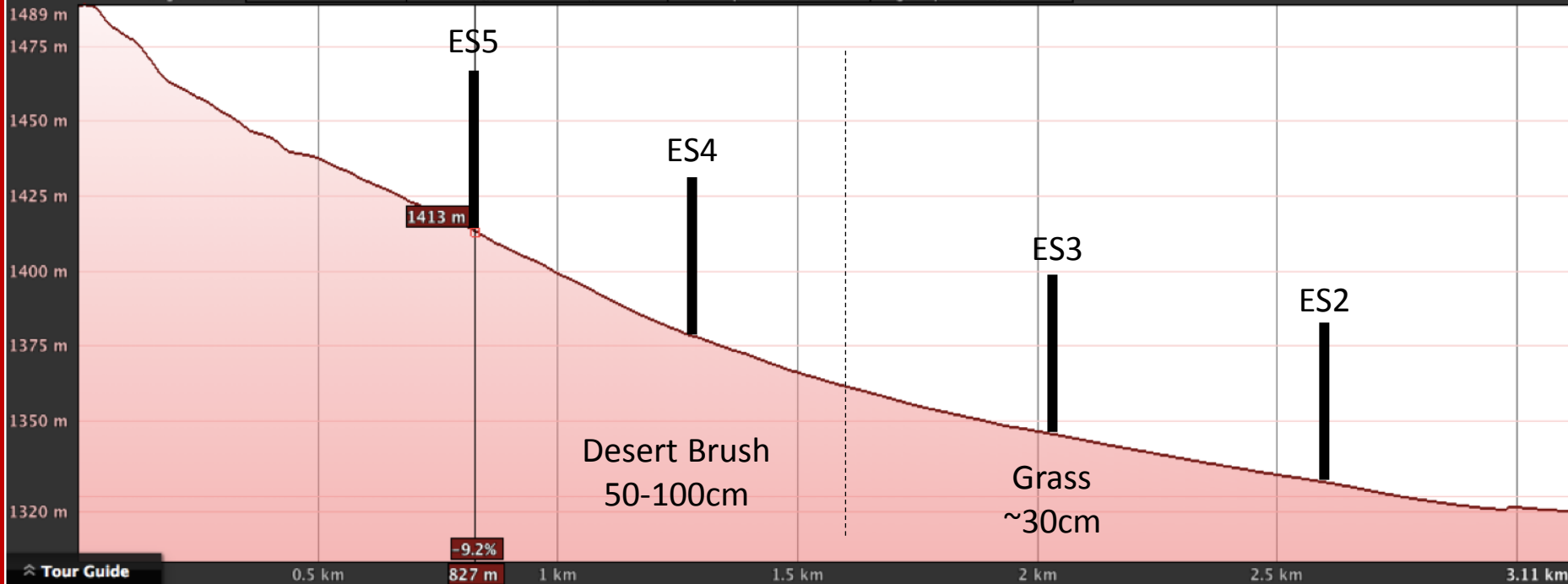
Intro

Site

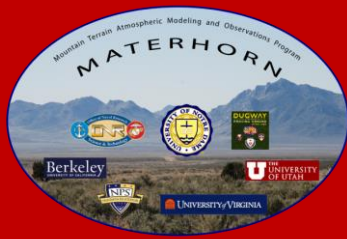
Results

Summary

Graph: Min, Avg, Max **Elevation: 1320, 1378, 1489 m**  
 Range Totals: **Distance: 3.11 km** **Elev Gain/Loss: 1.30 m, -170 m** **Max Slope: 9.6%, -23.2%** **Avg Slope: 3.9%, -5.5%**

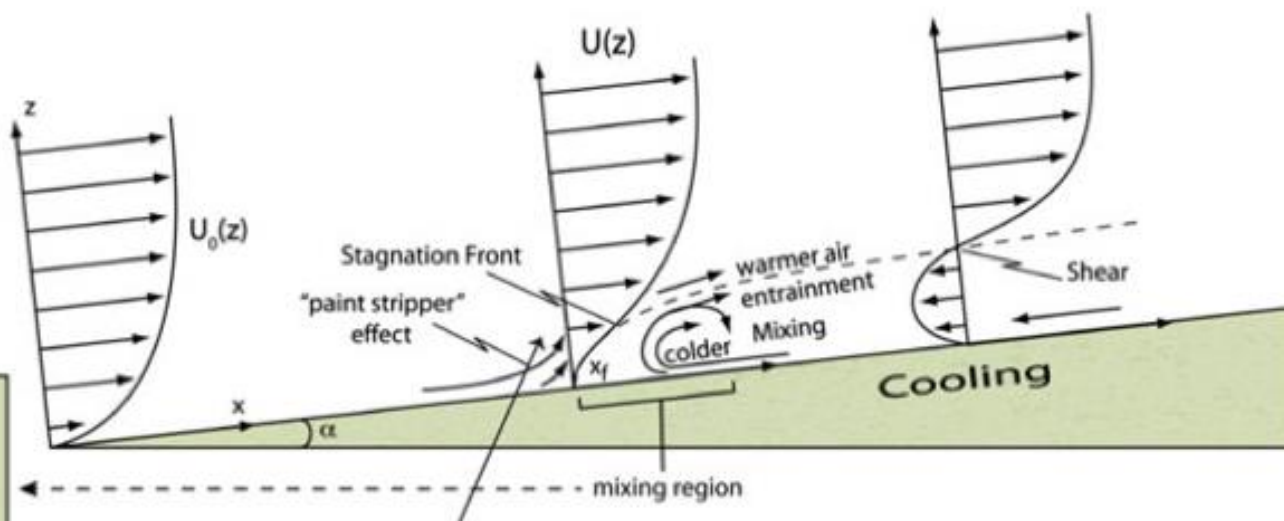






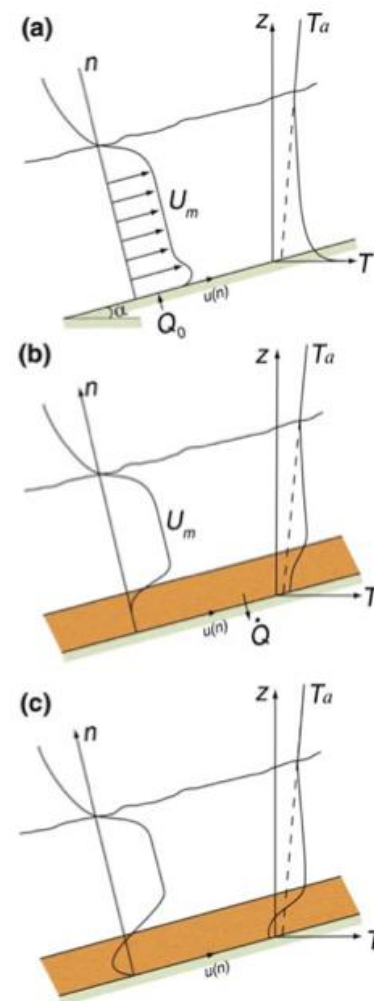
# Transition Theories: Assume Uniform Slope

## Front (Hunt et al. 2003)



From Fernando et al. 2013 BLM

## "Sliding Slab" (Prandtl)





# Computed Global Radiation October 17, 2012

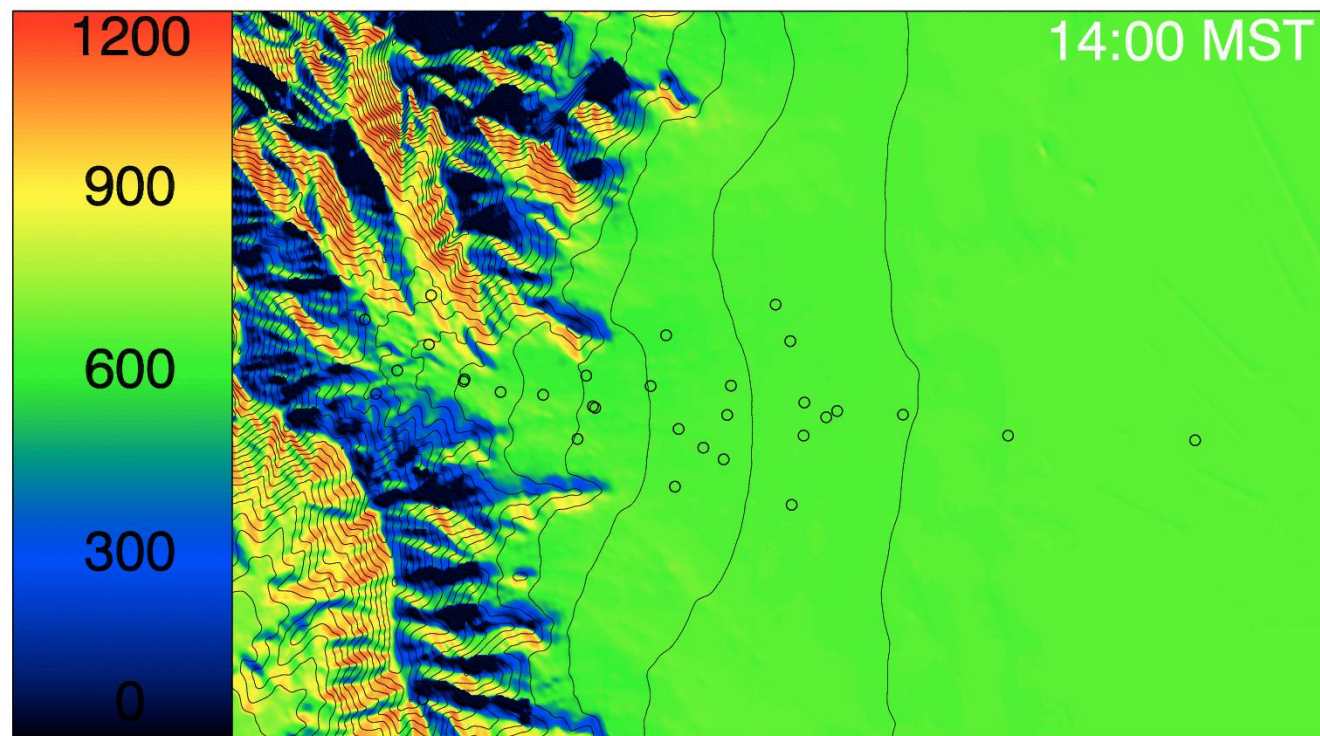
Intro

Site

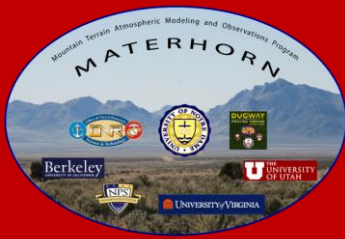
Results

Summary

## GLOBAL RADIATION, PARAMETERIZED, [ $\text{W m}^{-2}$ ]

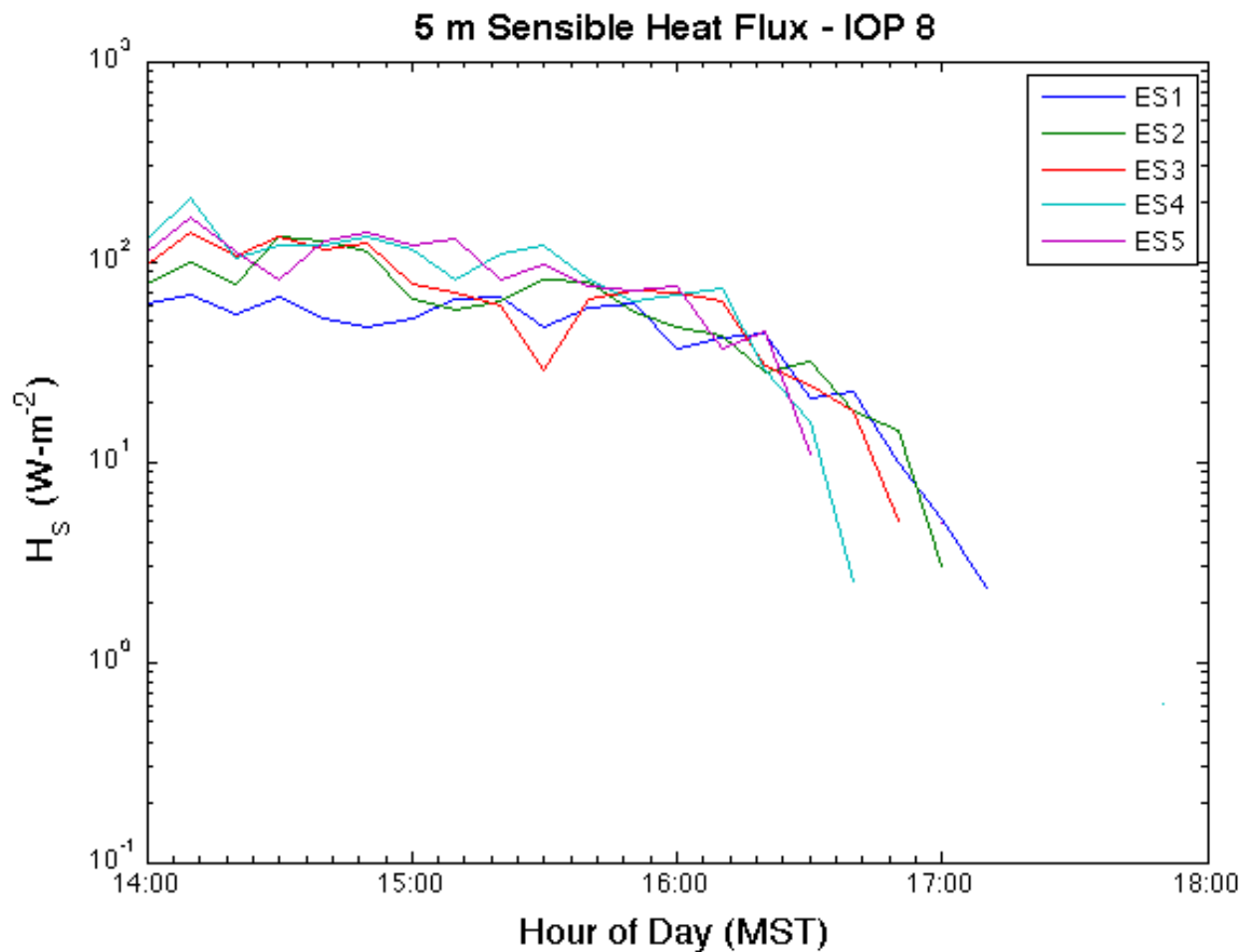


S.W. Hoch, University of Utah



# Near Surface Sensible Heat Flux

Intro  
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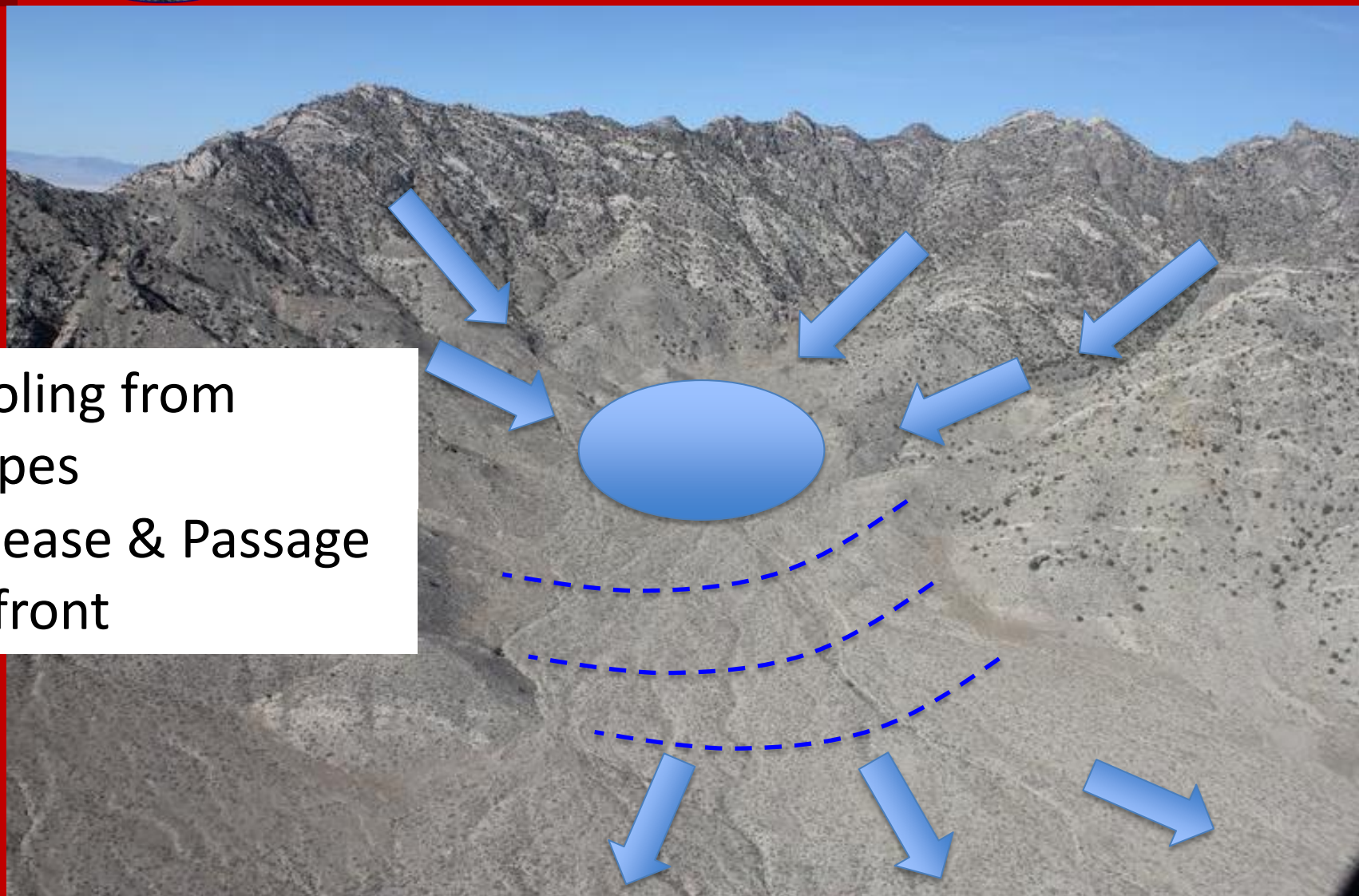




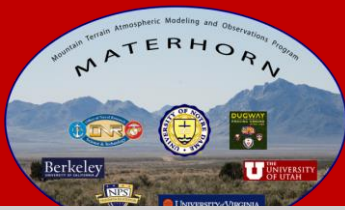
# Transition Hypotheses

## Non-local Front: Pooling

- Intro
- Site
- Results
- Summary



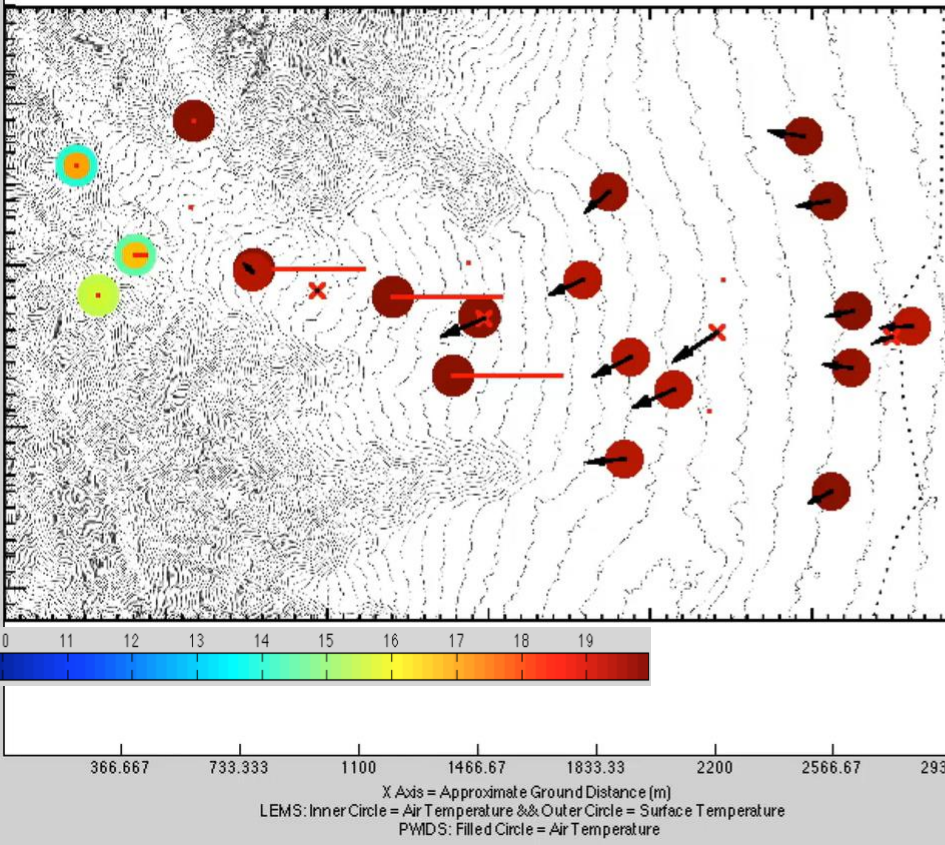
1. Pooling from slopes
2. Release & Passage of front



# Slope Transition

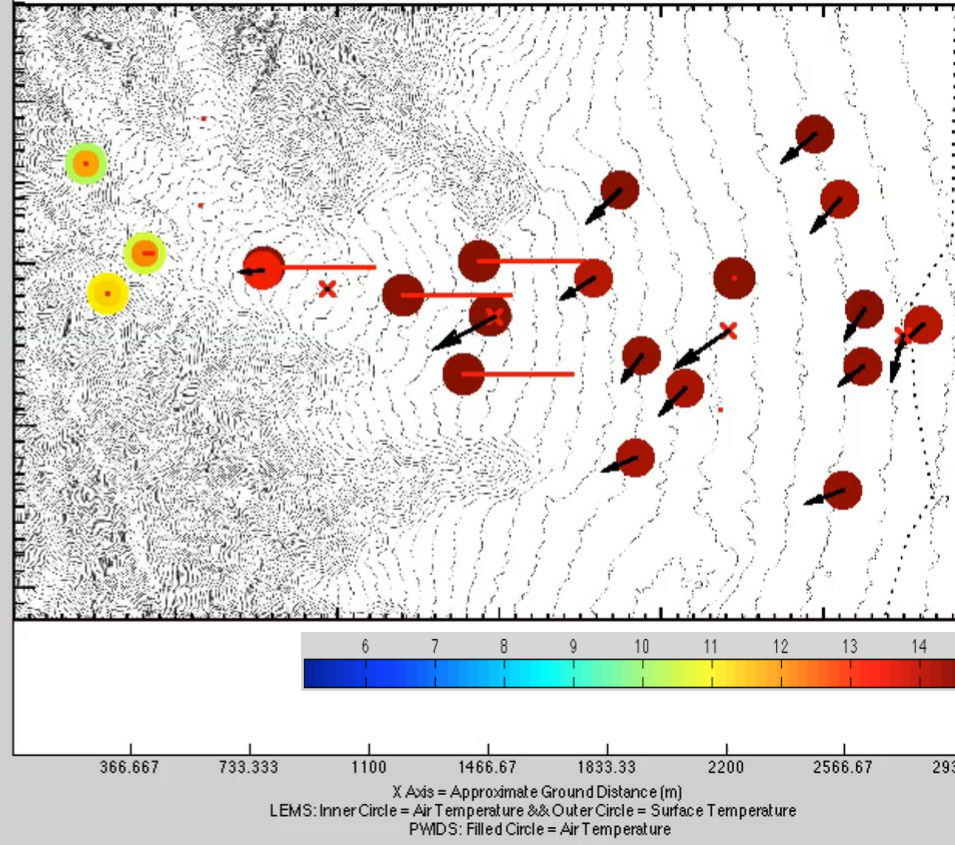
October-14-2012 16:00:00 Mountain Standard Time

## Non-local Front



October-17-2012 16:00:00 Mountain Standard Time

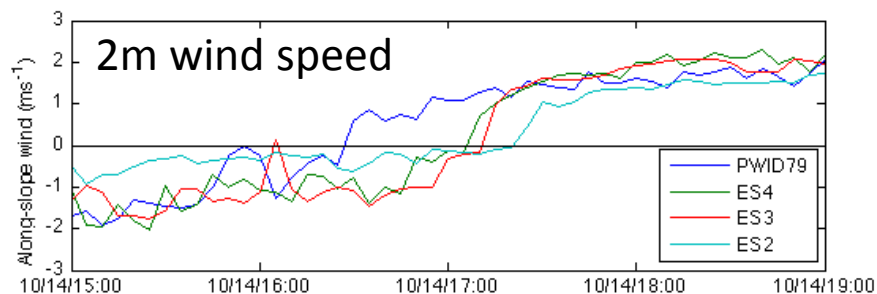
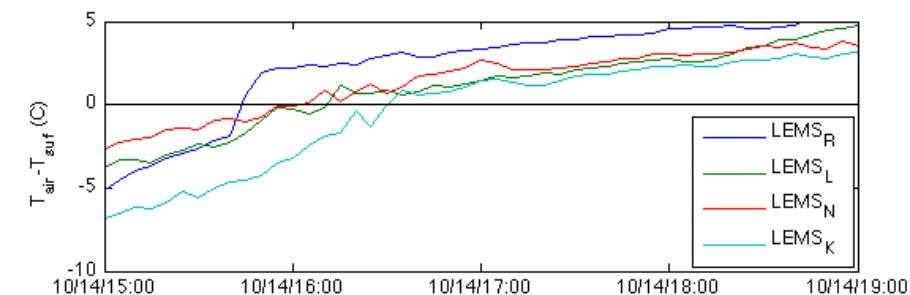
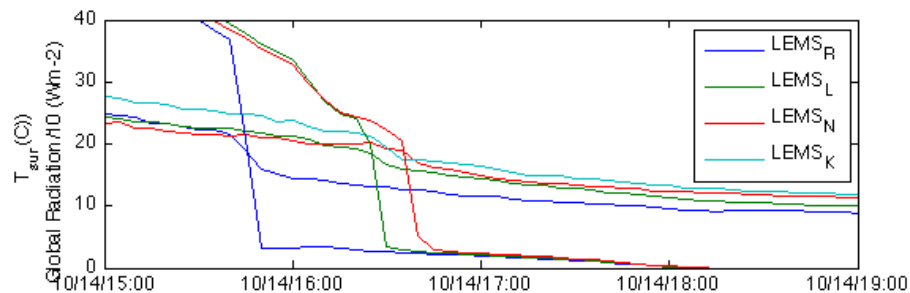
## “Sliding Slab” Transition



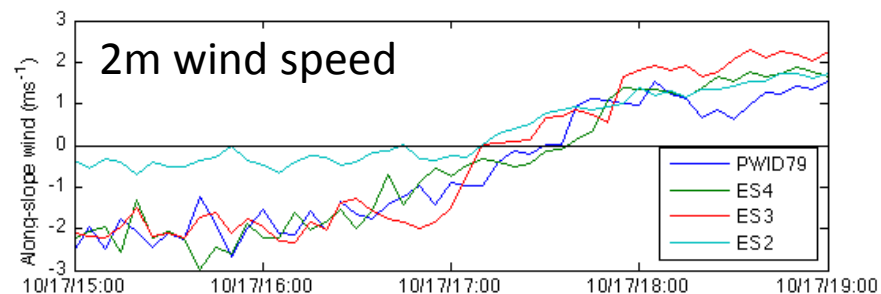
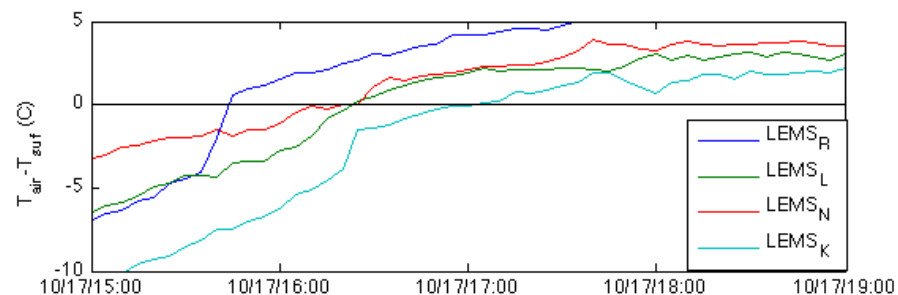
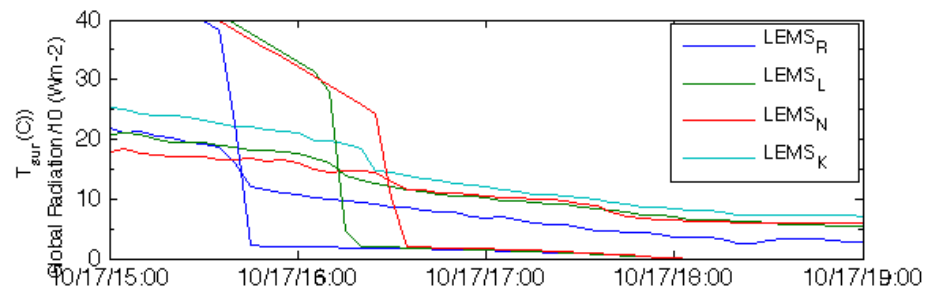


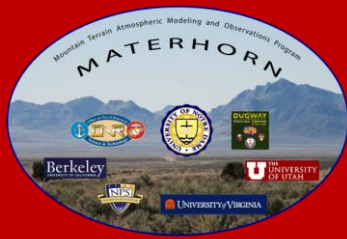
# Transition Comparison

## Non-local Front



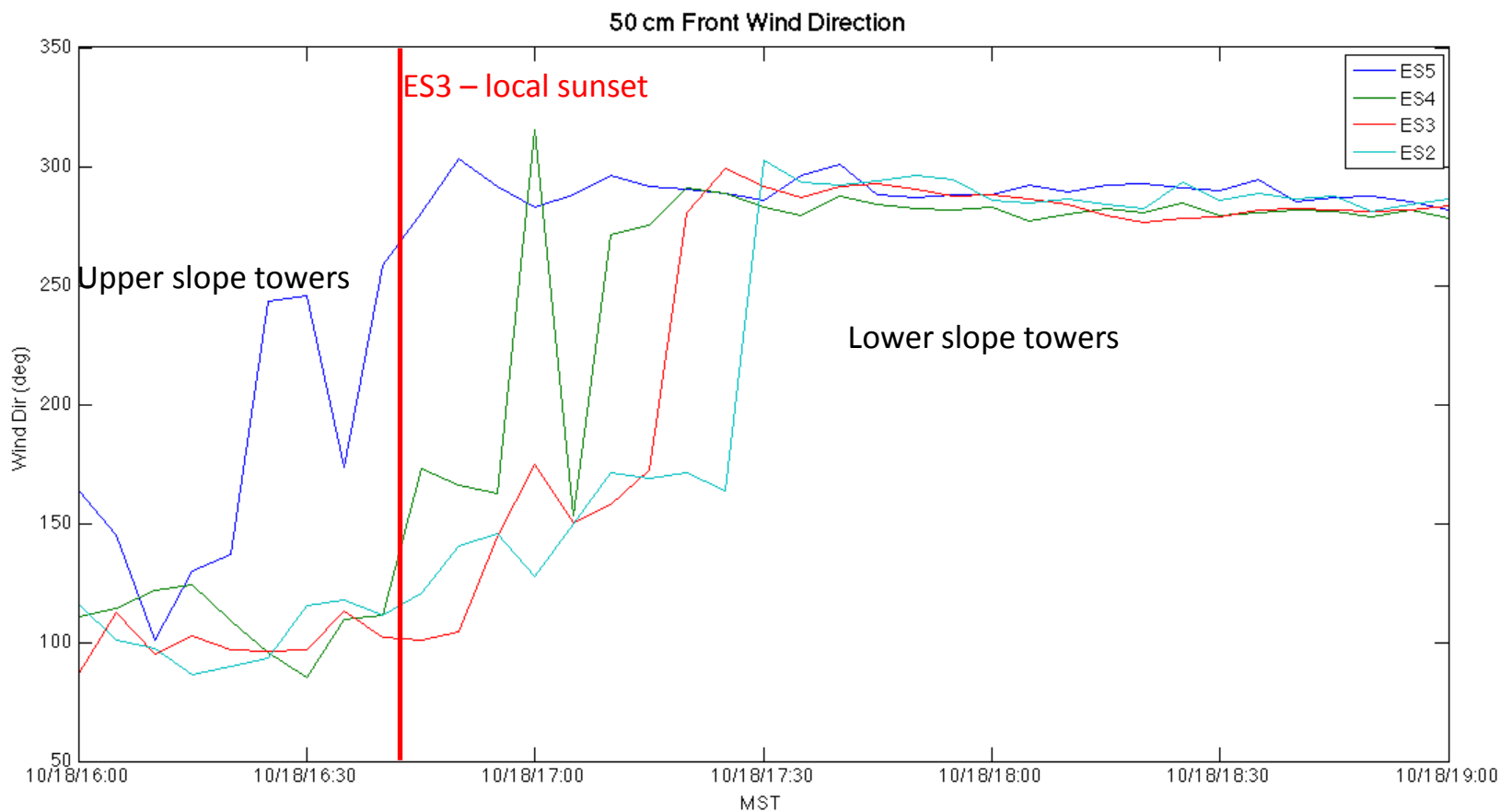
## “Sliding Slab” Transition

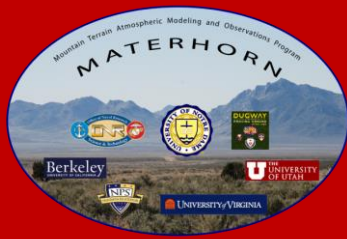




# Front Wind Direction

## Front – 50 cm (Near Surface) Wind Direction





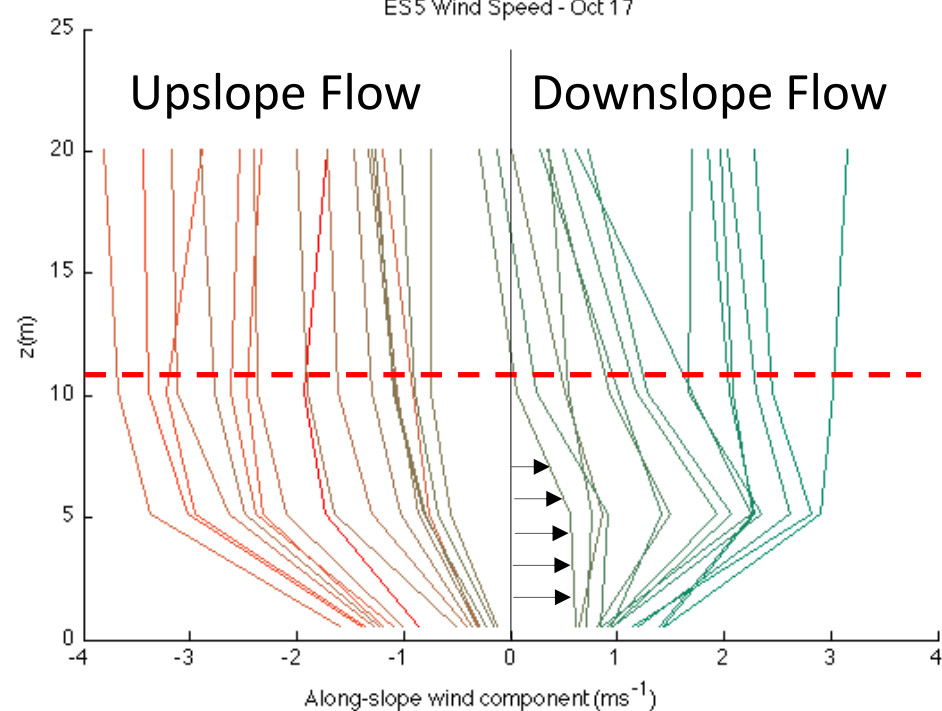
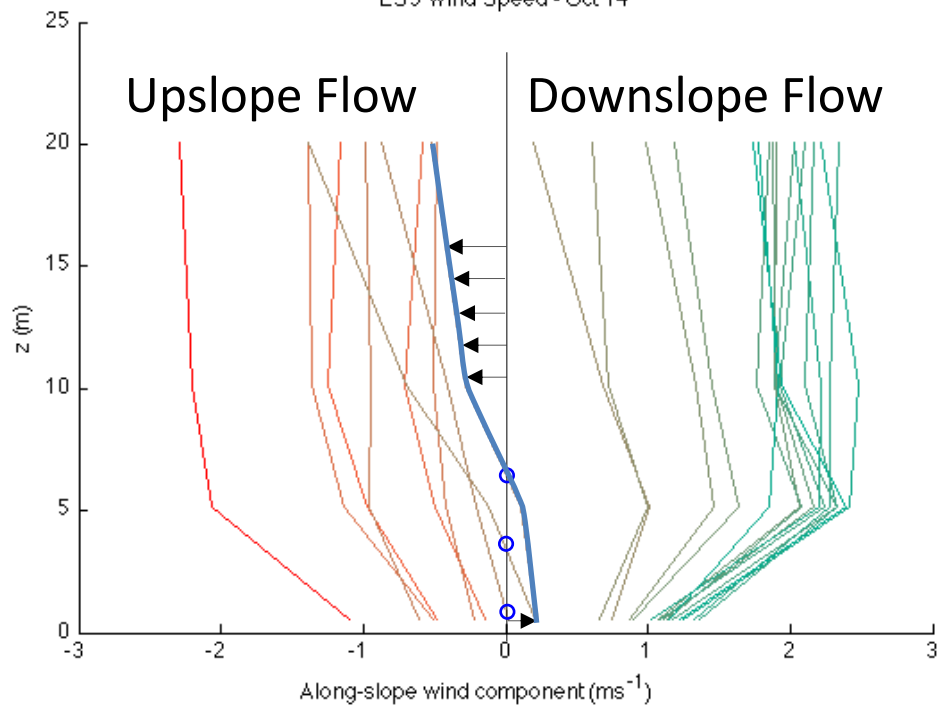
# Transition Profiles

## Non-local Front

## “Sliding Slab” Transition (Local)

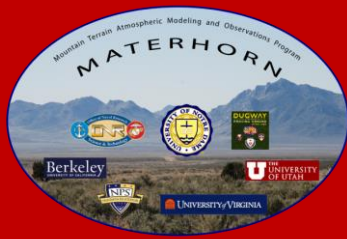
ES5 Wind Speed - Oct 14

ES5 Wind Speed - Oct 17



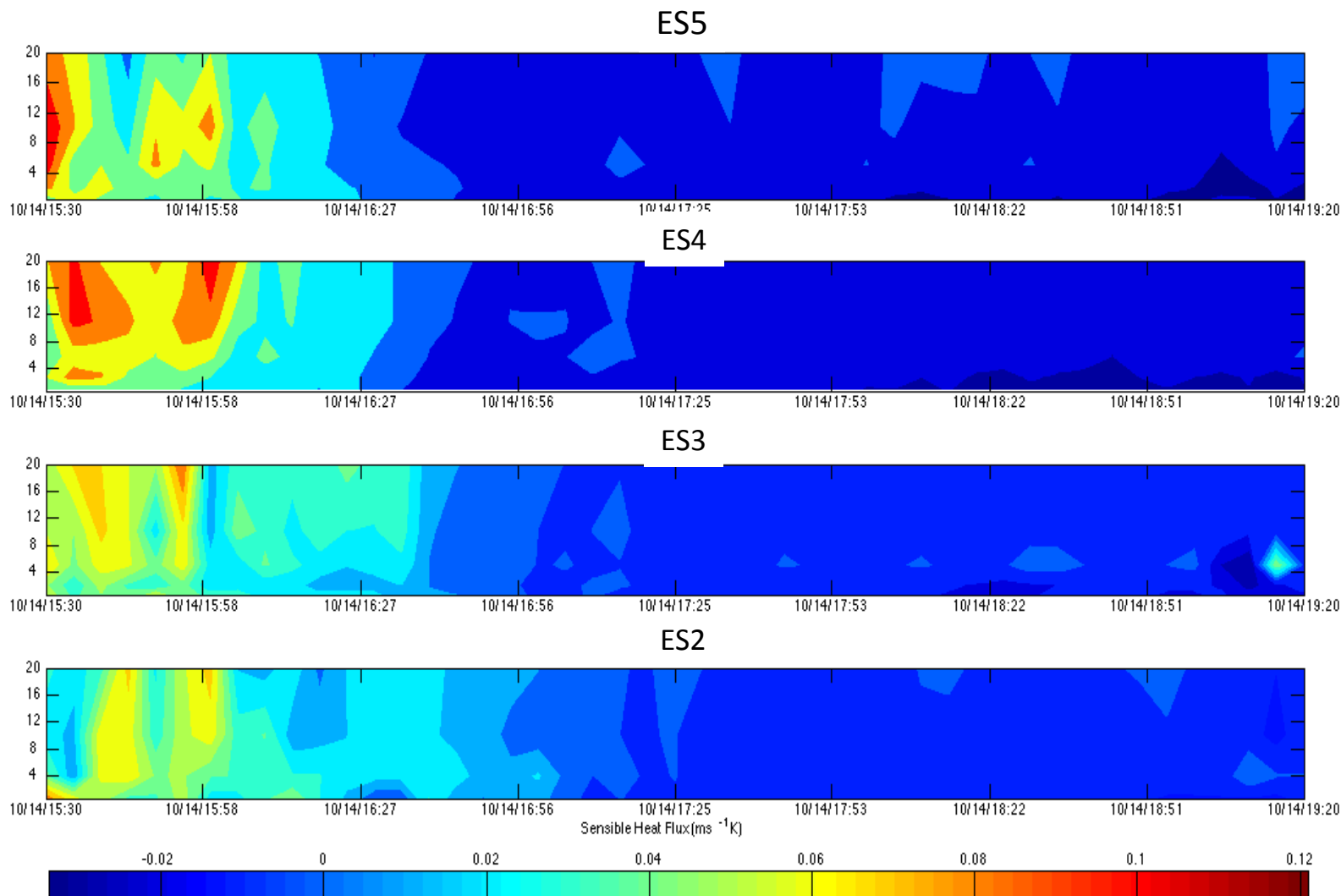
See Fernando et al. 2013 BLM for discussion on these two transitions





# What leads to the different transition forms?

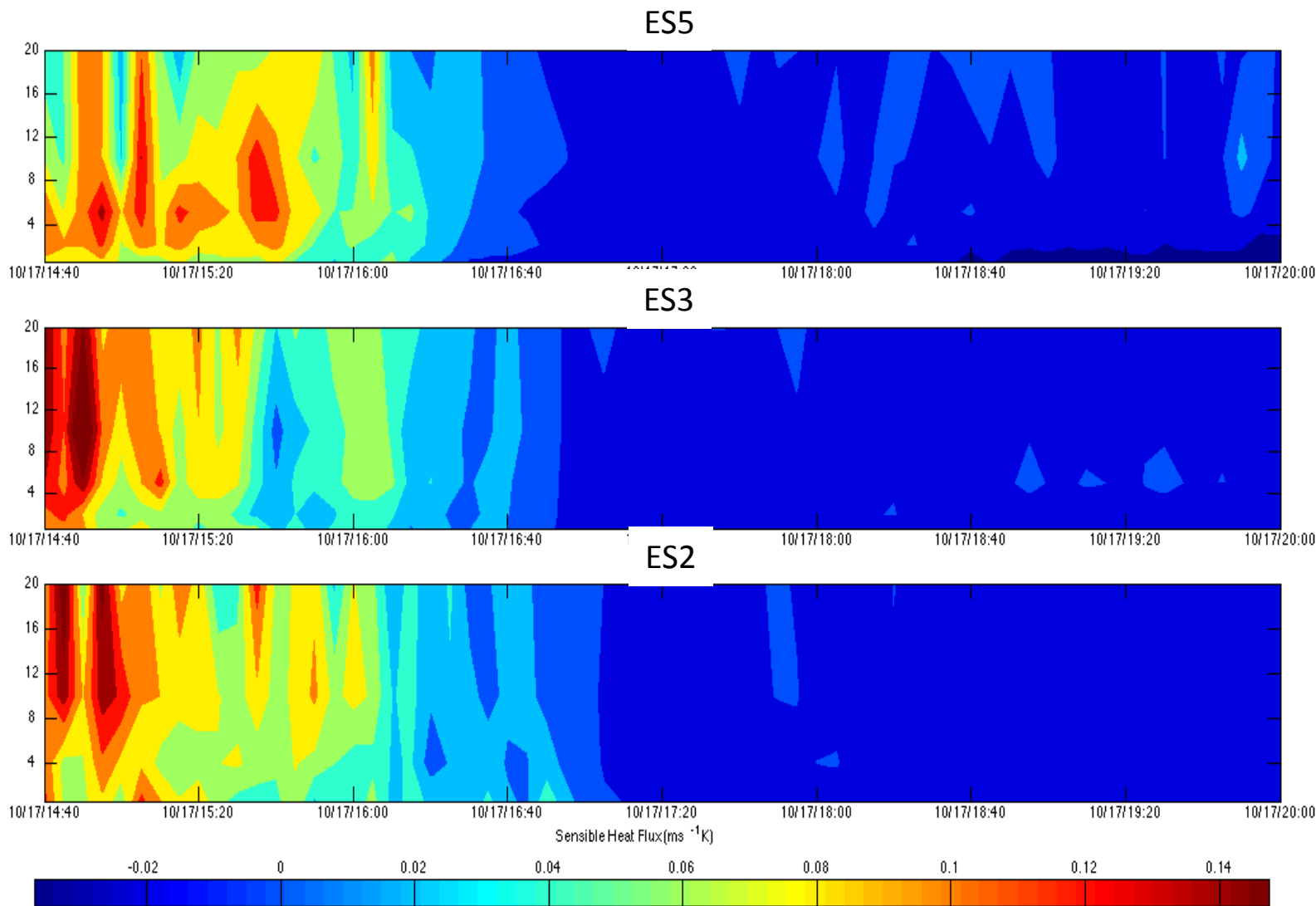
## Sensible Heat Flux: Non-local Front



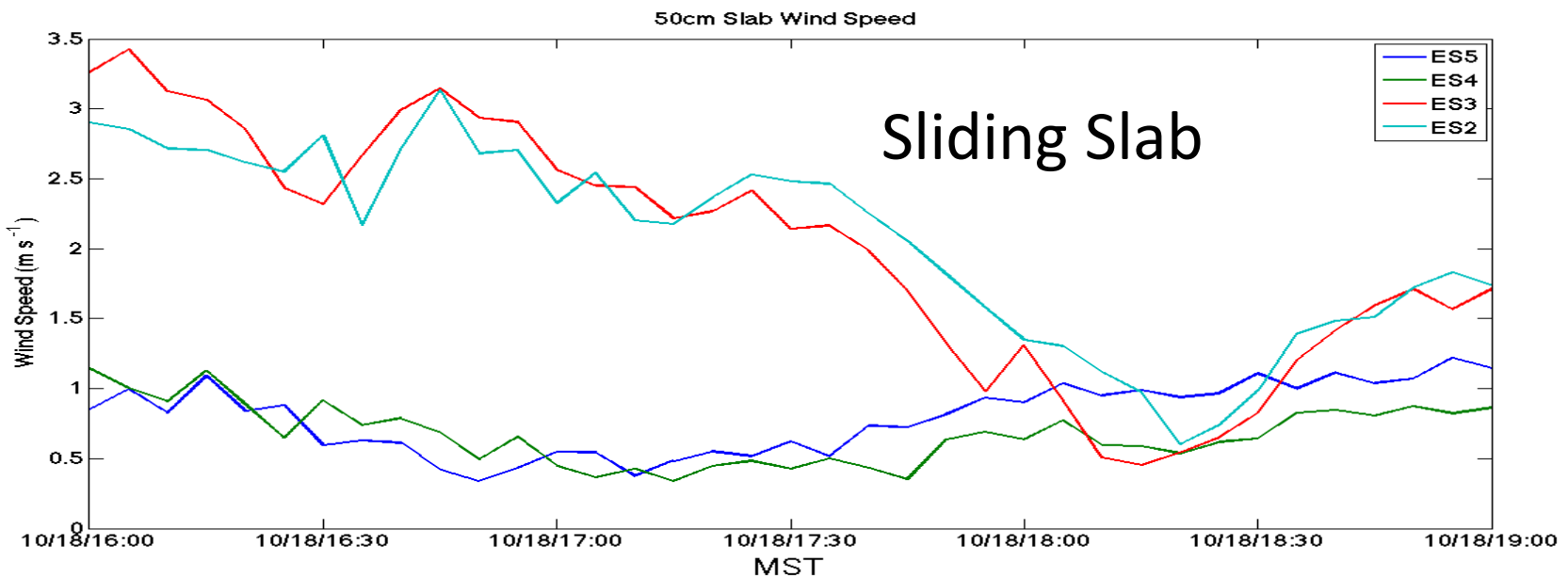
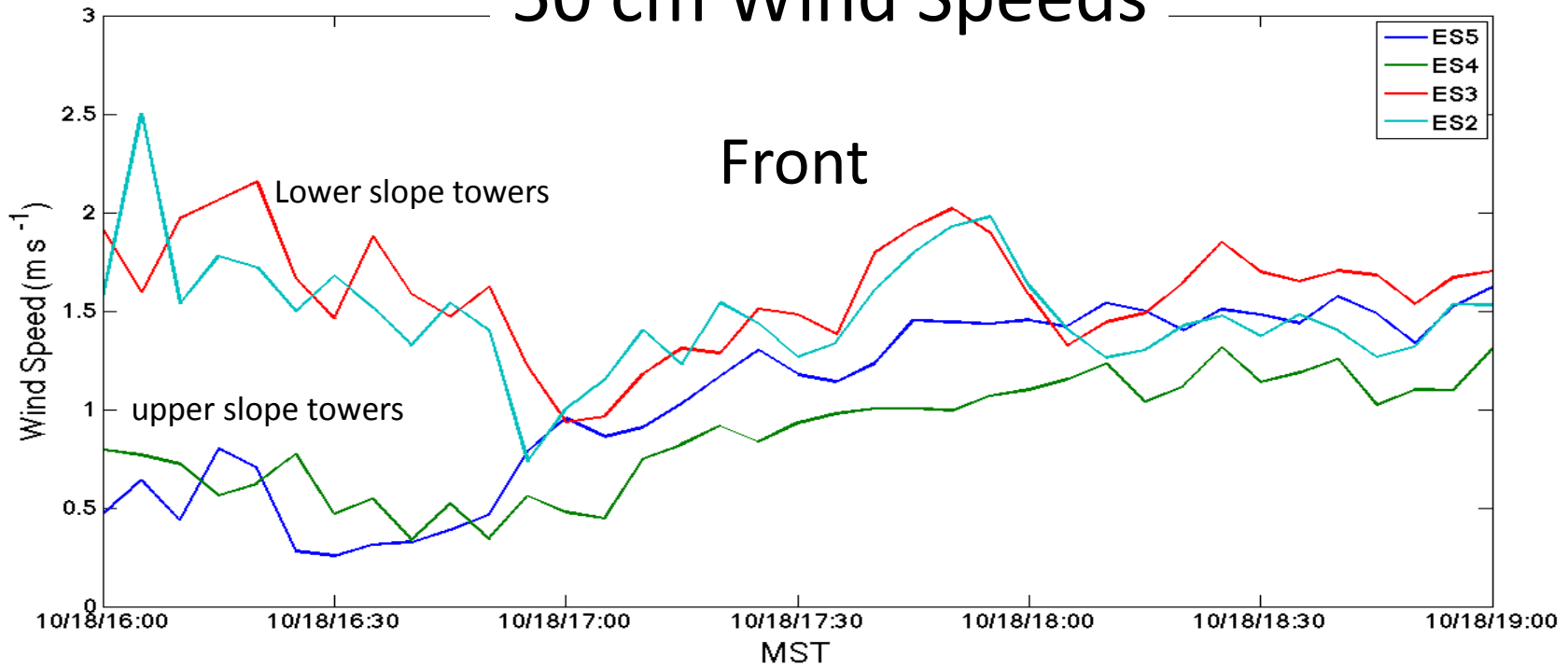


# What leads to the different transition forms?

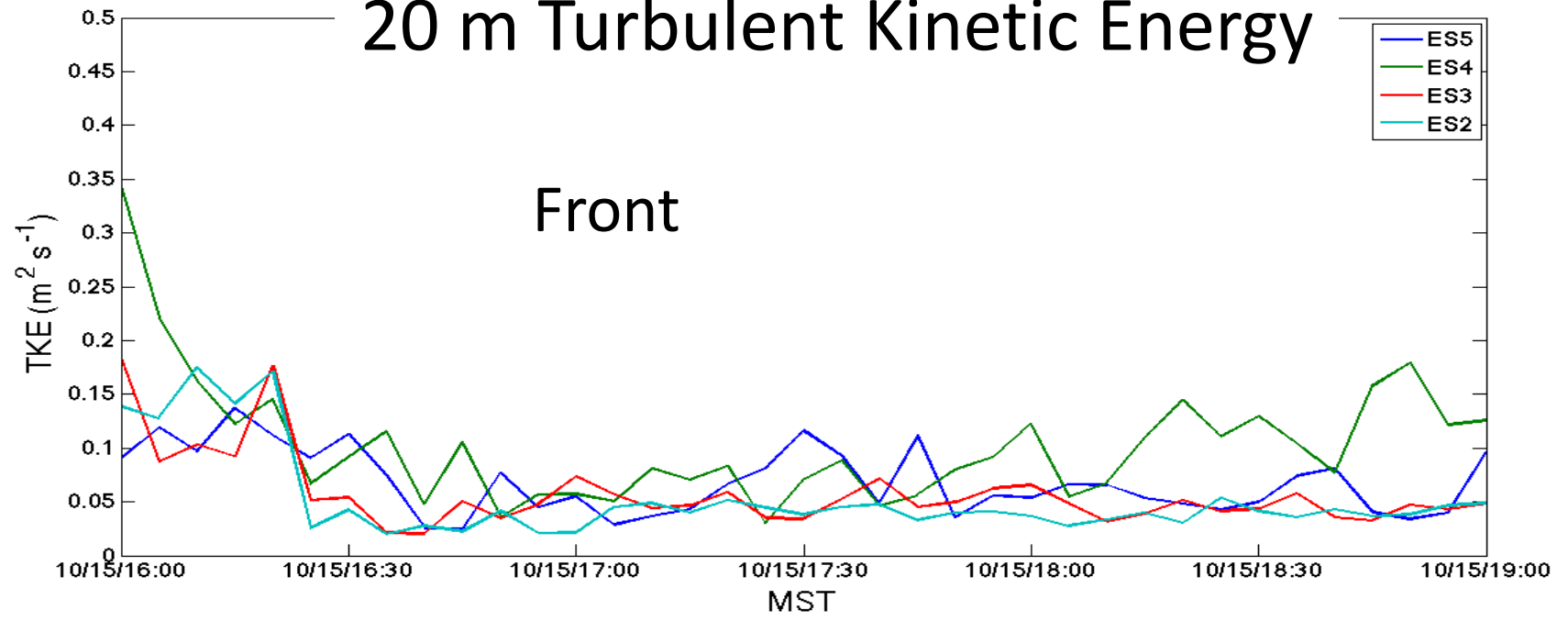
## Sensible Heat Flux: "Sliding Slab" Transition



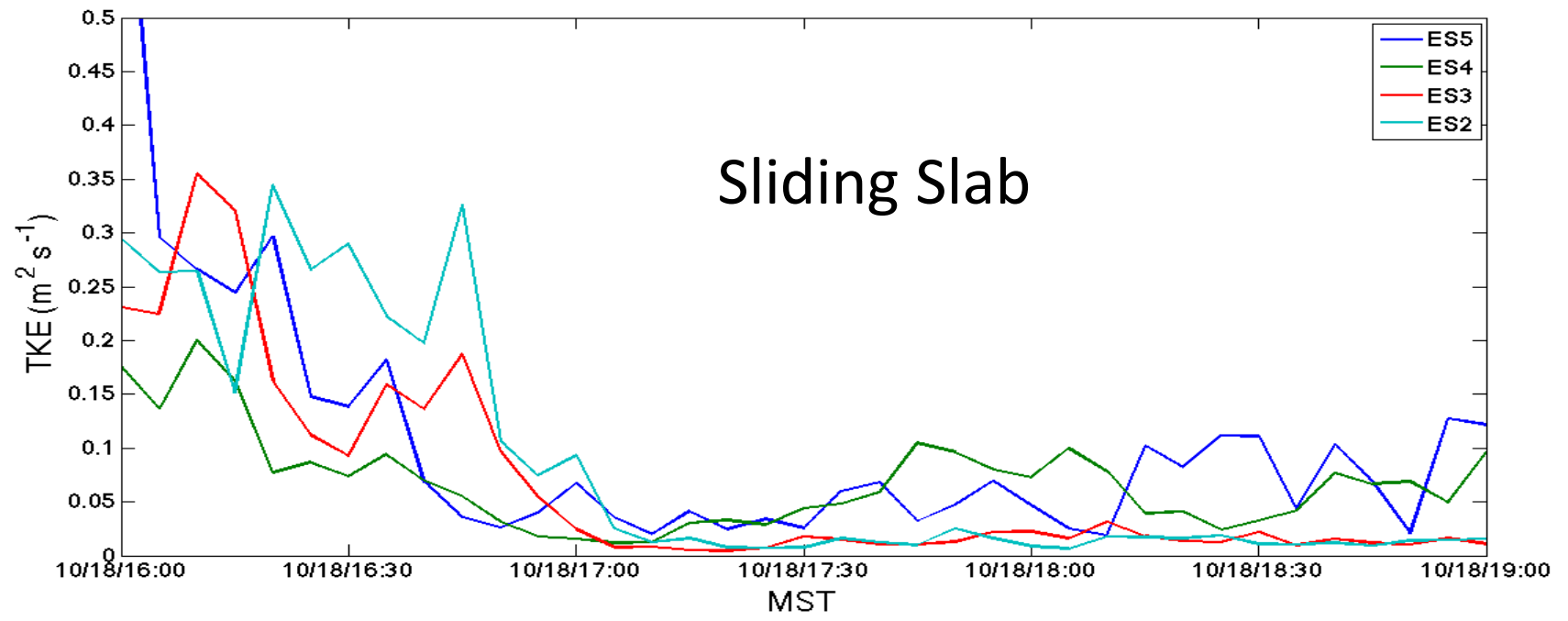
# 50 cm Wind Speeds



# 20 m Turbulent Kinetic Energy



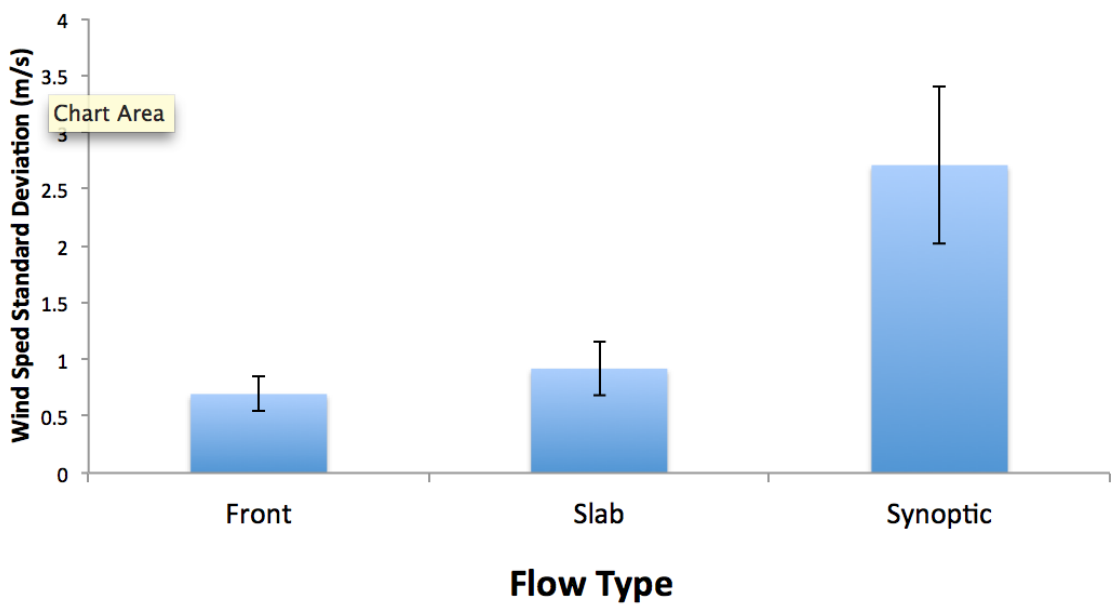
20m TKE



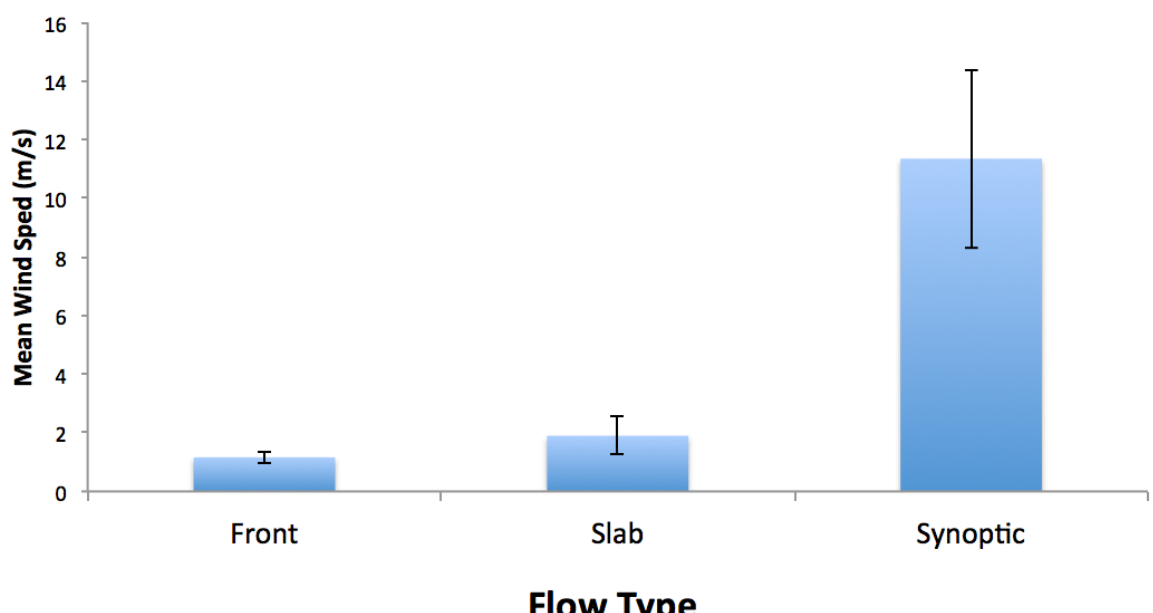


# Large Scale Influence

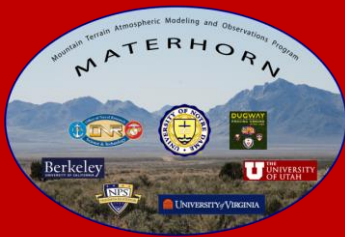
### Mean Ridgtop Wind Speed Fluctuations



### Mean Ridgtop Wind Speed



- 10 Cases
- 4 Frontal
- 4 Slab
- 2 Synoptic



# Summary

- 1) Multiple Transition Phenomena:
  - Evidence of the existence of both
    - Non-local Front
    - Slab-cooling
- 2) Weak shadow front forcing
- 3) What leads to the different Phenomena?  
Synoptic Forcing and/or Ambient Turbulence?

This research was funded by the Office of Naval Research Award # N00014-11-1-0709, Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) Program. Additional support for the Twin Otter was provided by the Environmental Sciences group at the Army Research Office (ARO).

Intro  
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# Wind Direction Transition

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