Toward Understanding Surface Sensible Heat Fluxes During Transitional Stability Over Contrasting Surfaces

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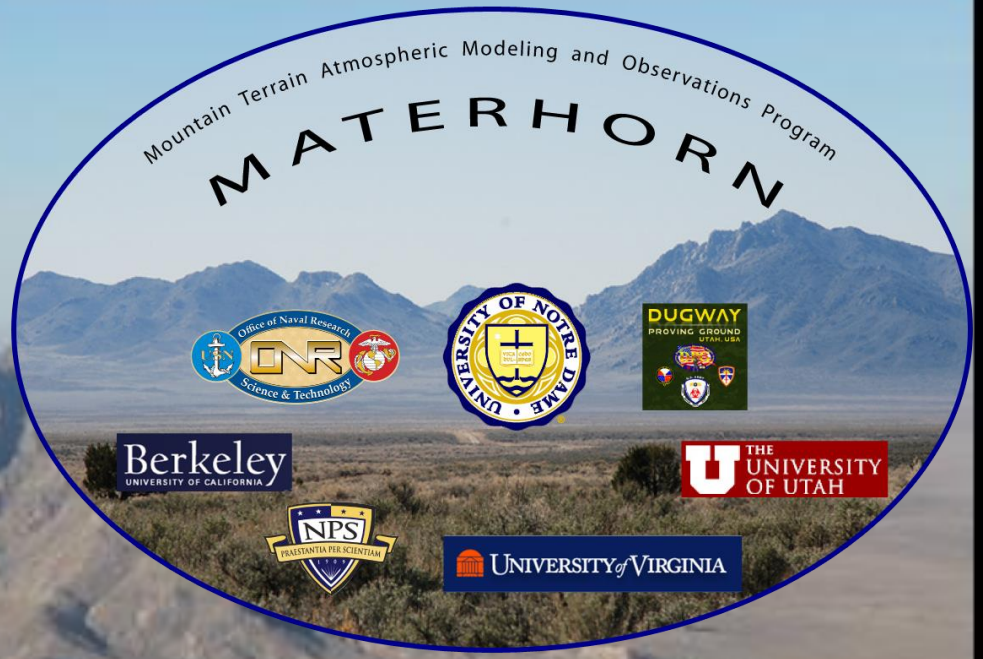
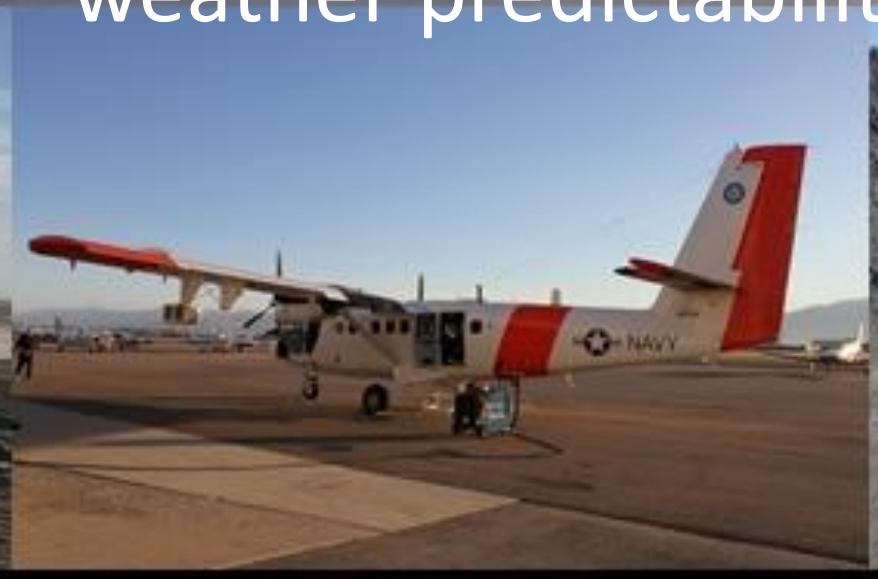
Background

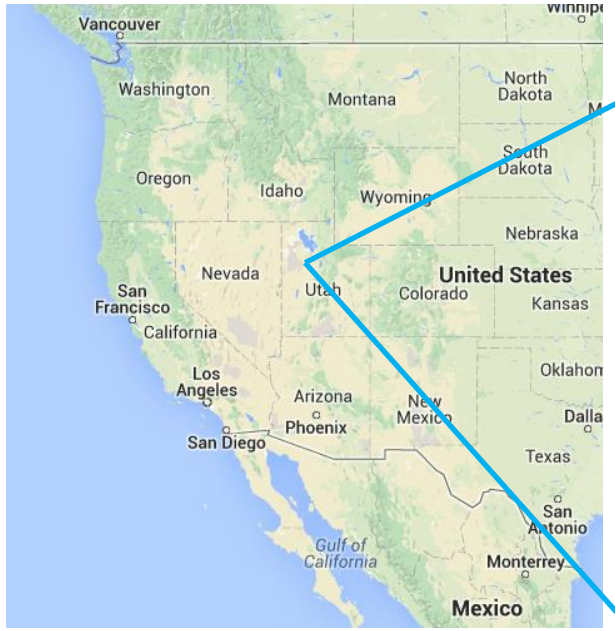
- Flux-Gradient relationships are key for Numerical Weather Prediction
- Monin-Obukhov Similarity Theory (**MOST**) is most common
- Data from the MATERHORN Program are being used to evaluate the applicability of MOST over **differing topography** and **surface types**

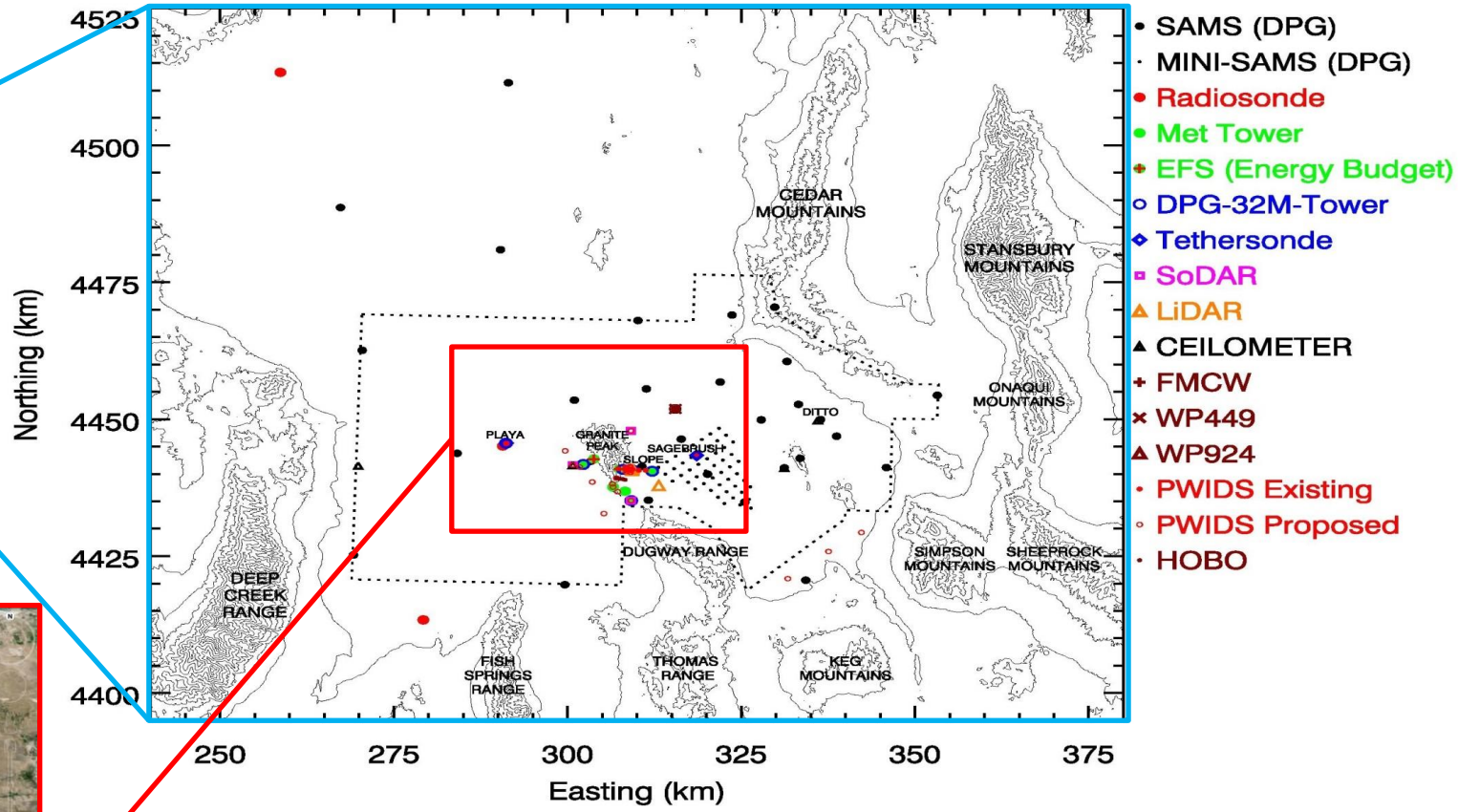
- ***GOAL: Obtain a more complete understanding of the relationship between surface fluxes and local gradients during the evening transition period.***



A three-year, multi-institution program designed to improve weather predictability over complex terrain







2 Field Campaigns

- Fall: 25 Sept. 2012 – 21 Oct. 2012
- Spring: 1 May 2013 – 31 May 2013

2 Sites of Interest

- Sagebrush
- Playa

Instrumentation

- Sonic Anemometers
- Finewire Thermocouples
- Temperature/RH

Playa

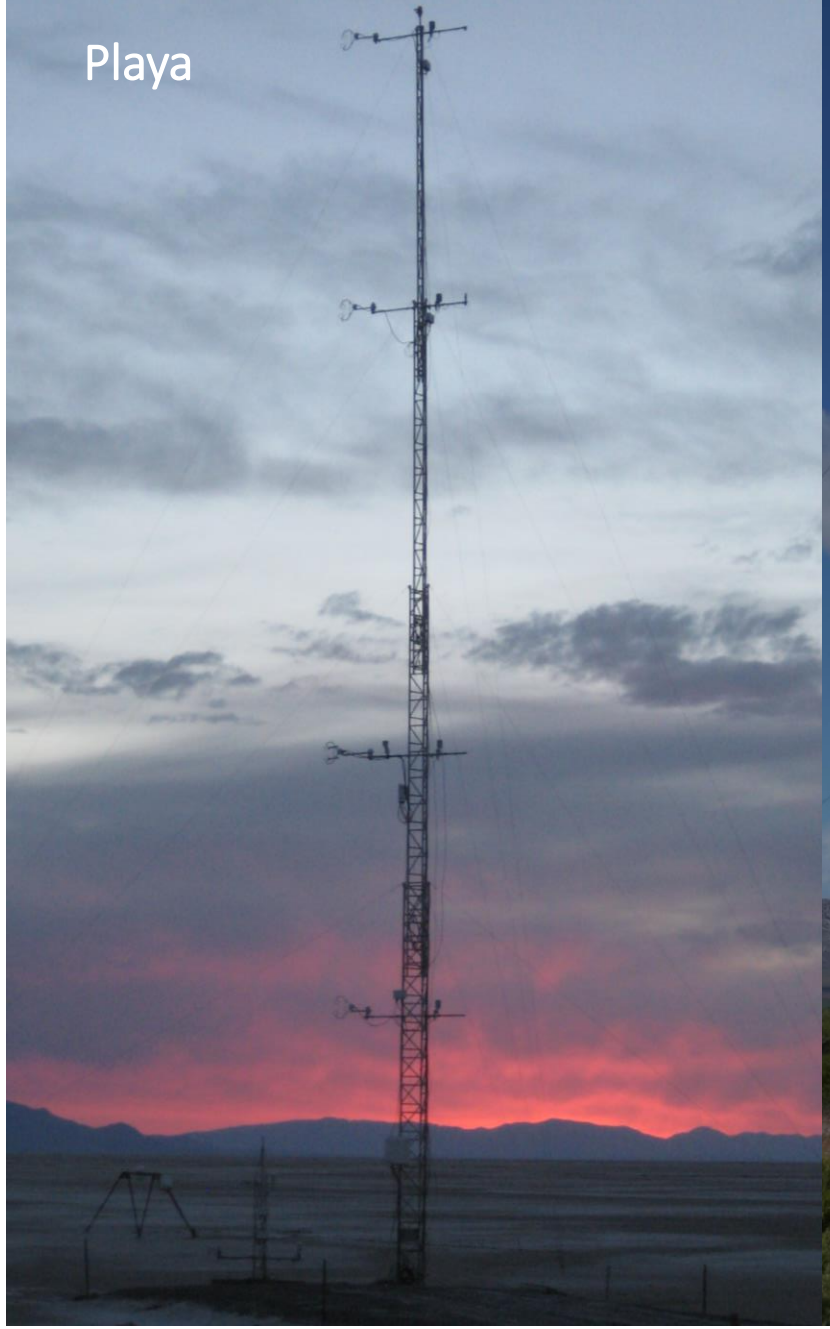
Heights: 28, 20, 5, 2, 0.5

- Higher Albedo (0.32)
- High Soil Moisture
- $z_0 \approx 1mm$
- No vegetation

Sagebrush

Heights: 20, 5, 2, 0.5

- Lower Albedo (0.26)
- Low Soil Moisture
- $z_0 \approx 25\ cm$
- Desert Steppe



When $\zeta \approx 0$ during transition

2 Issues Arise

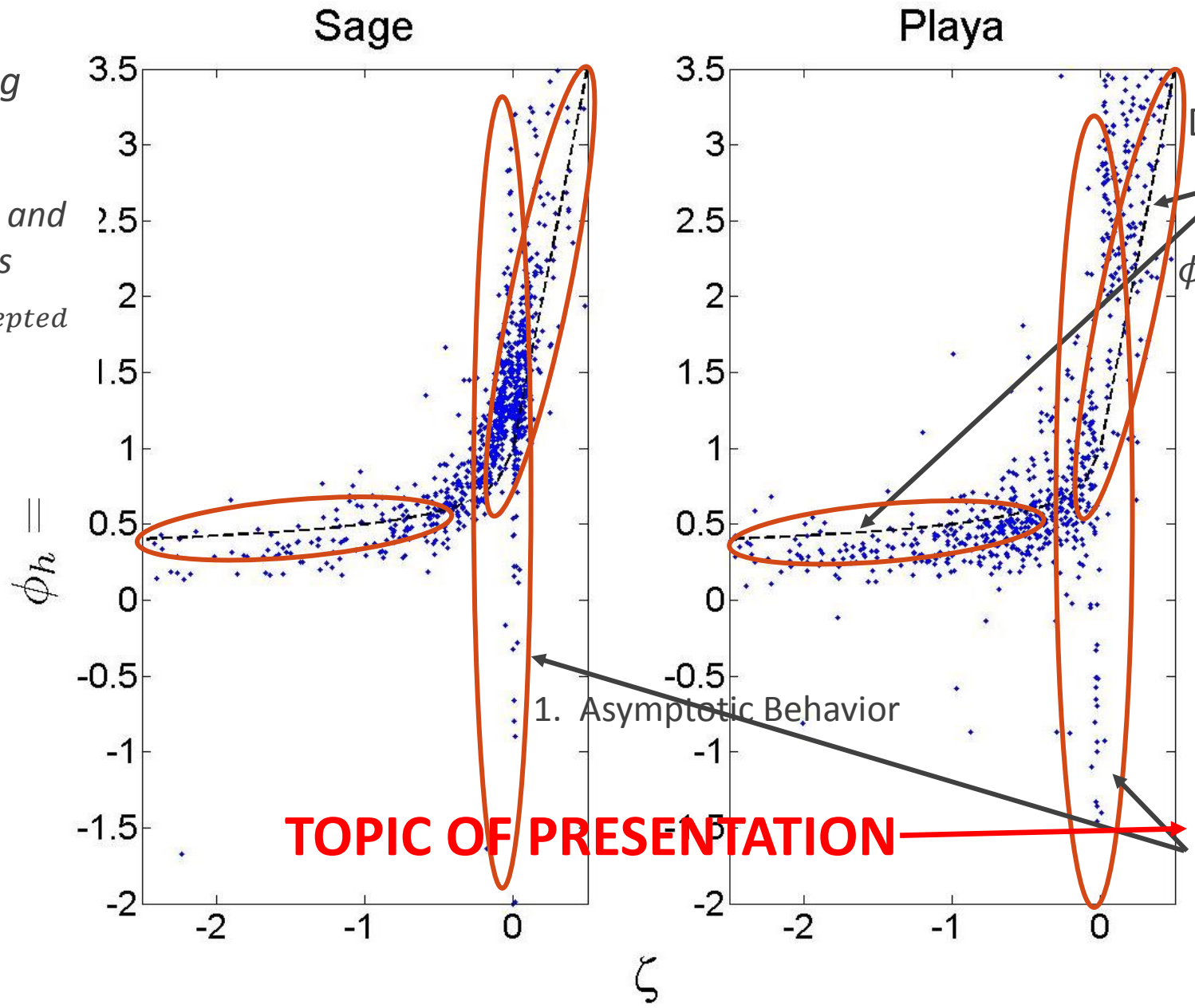
For Moderately stable and unstable conditions

$\phi_{h,measured} \approx \phi_{h,accepted}$

&

$H \propto -d\theta/dz$

MOST is Valid!



Dashed Line is the Accepted Form (Kansas, 1968)

$\phi_h = 1 + 5\zeta \; for \; \zeta \geq 0$

$\phi_h = (1 - 15\zeta)^{-0.5} \; for \; \zeta < 0$

1. Asymptotic Behavior

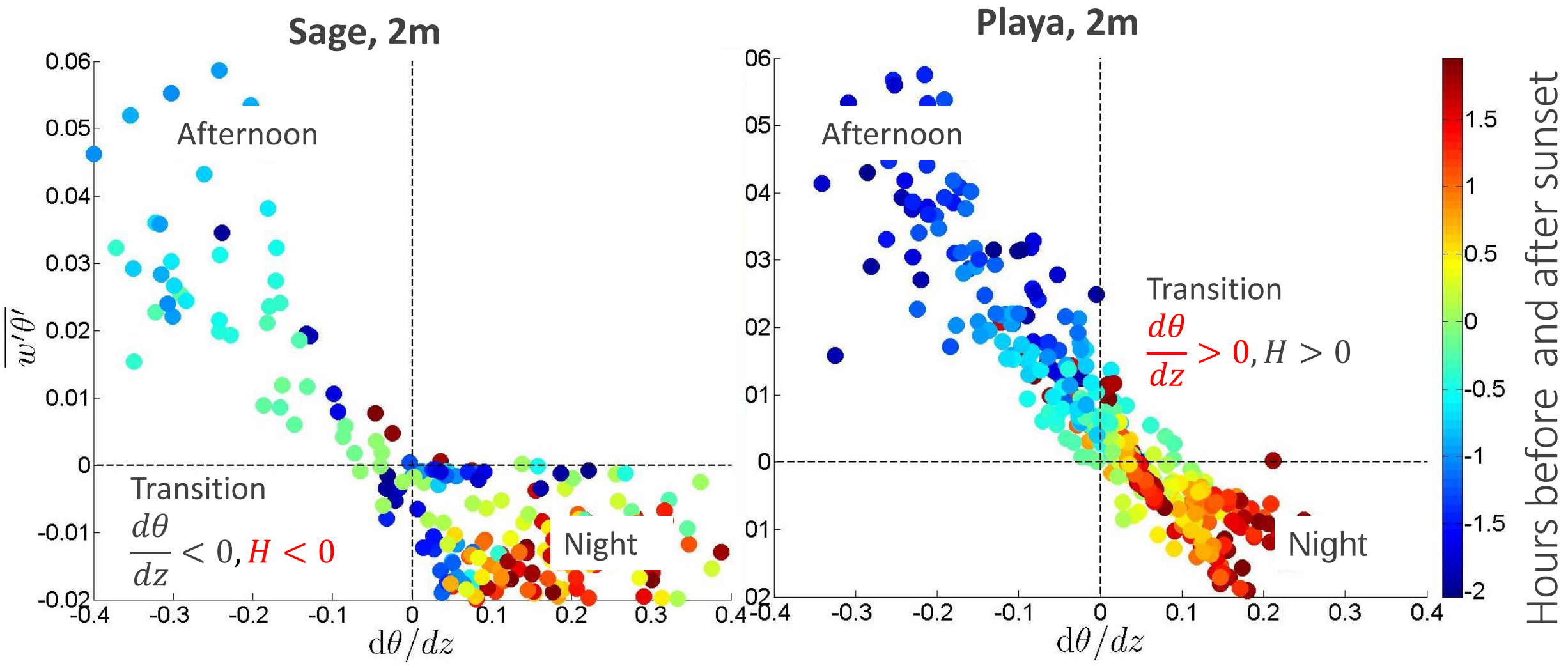
TOPIC OF PRESENTATION

2. $H \propto +d\theta/dz$

Counter-Gradient Heat Fluxes

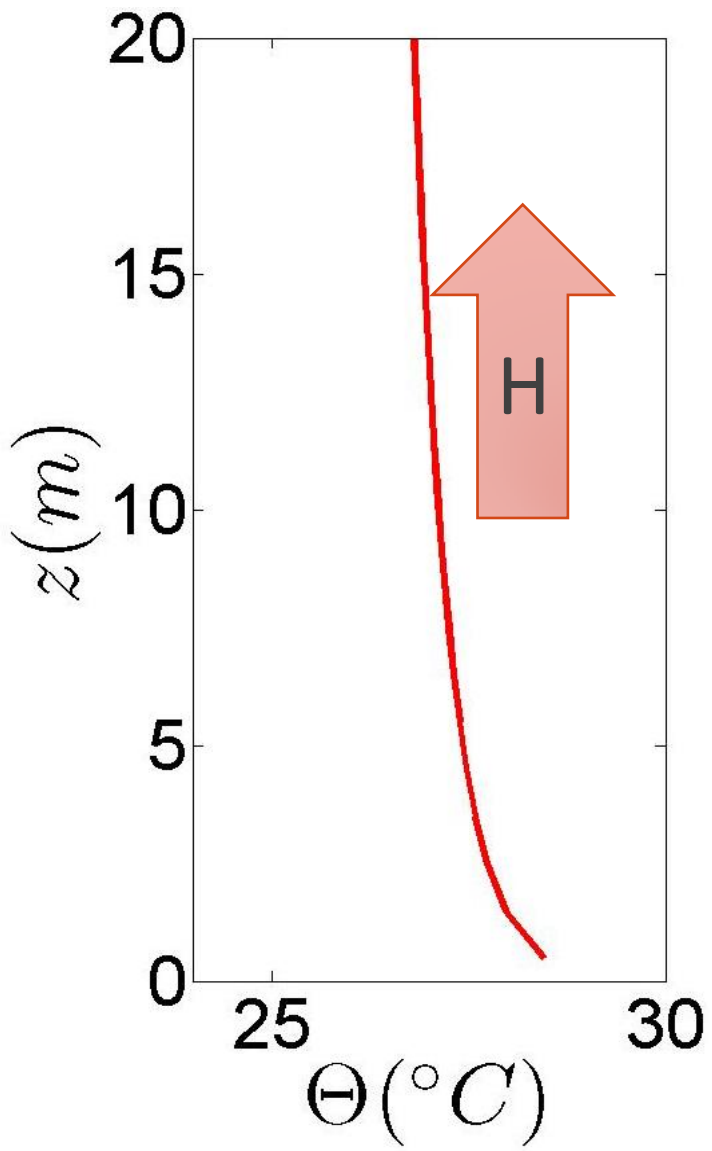
MOST is Invalid!

Quadrant Analysis

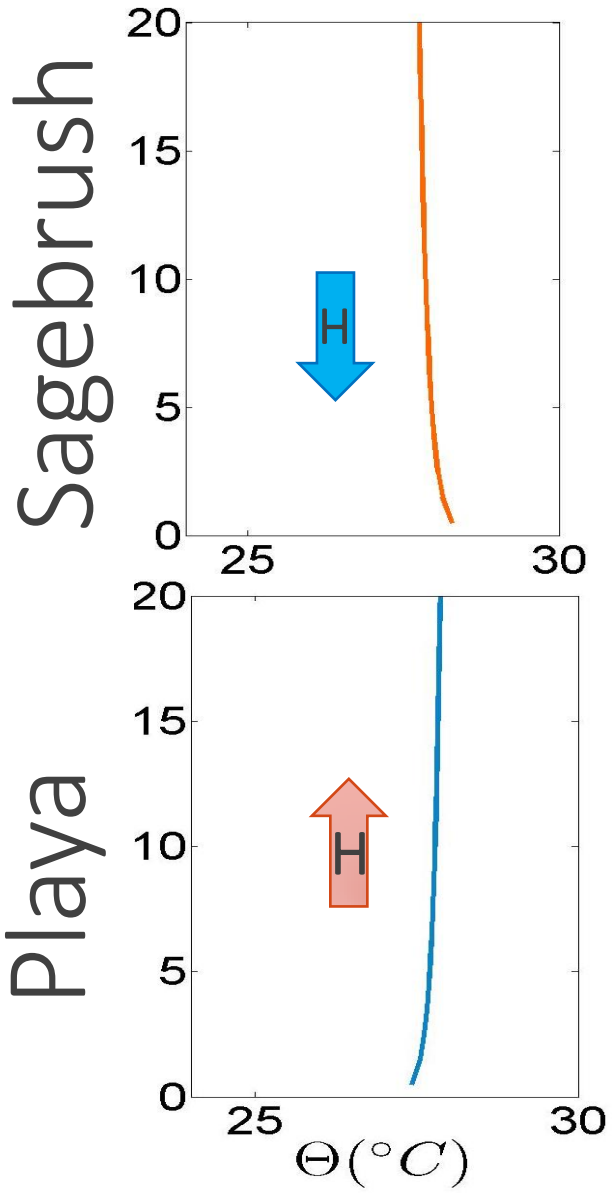


MAYBE THE PROFILES AND FLUXES LOOK LIKE THIS

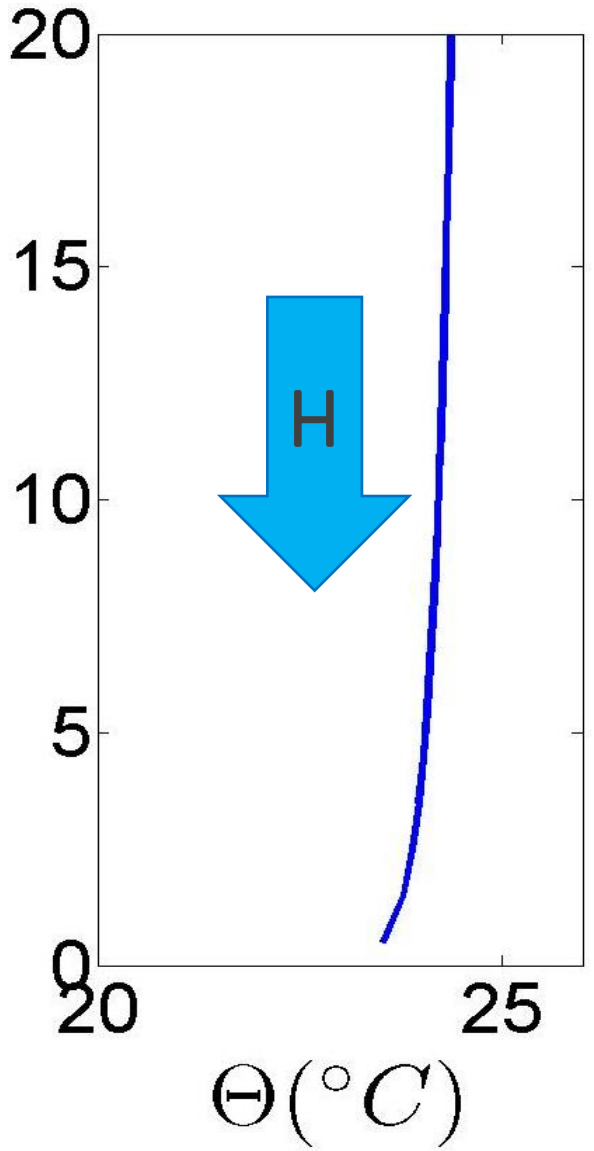
Afternoon



Transition



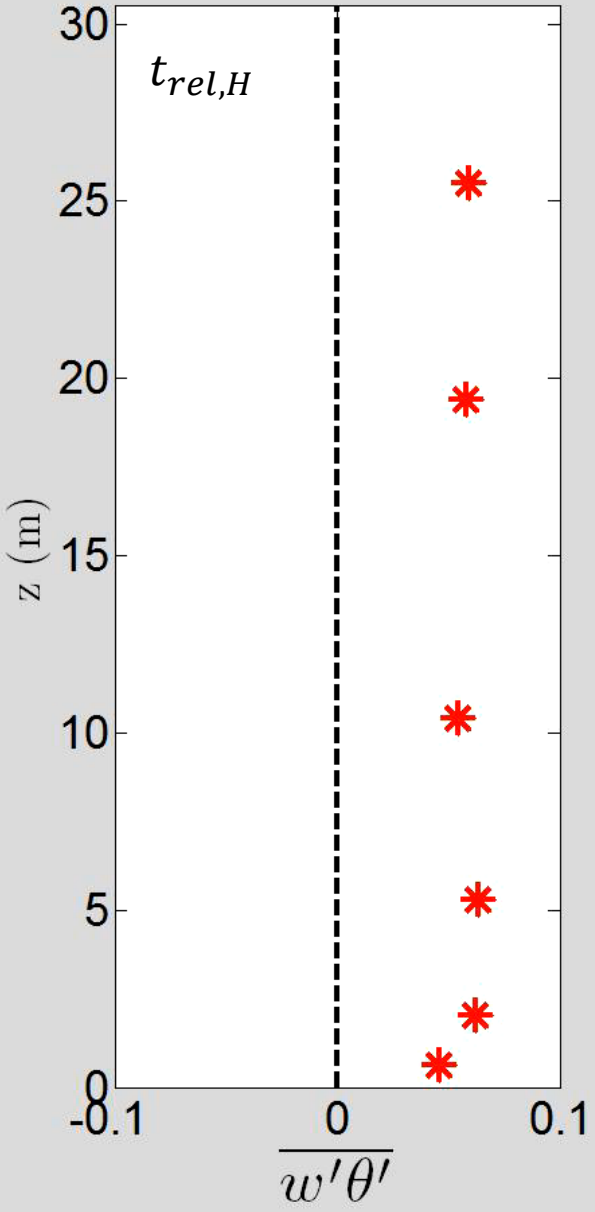
Night

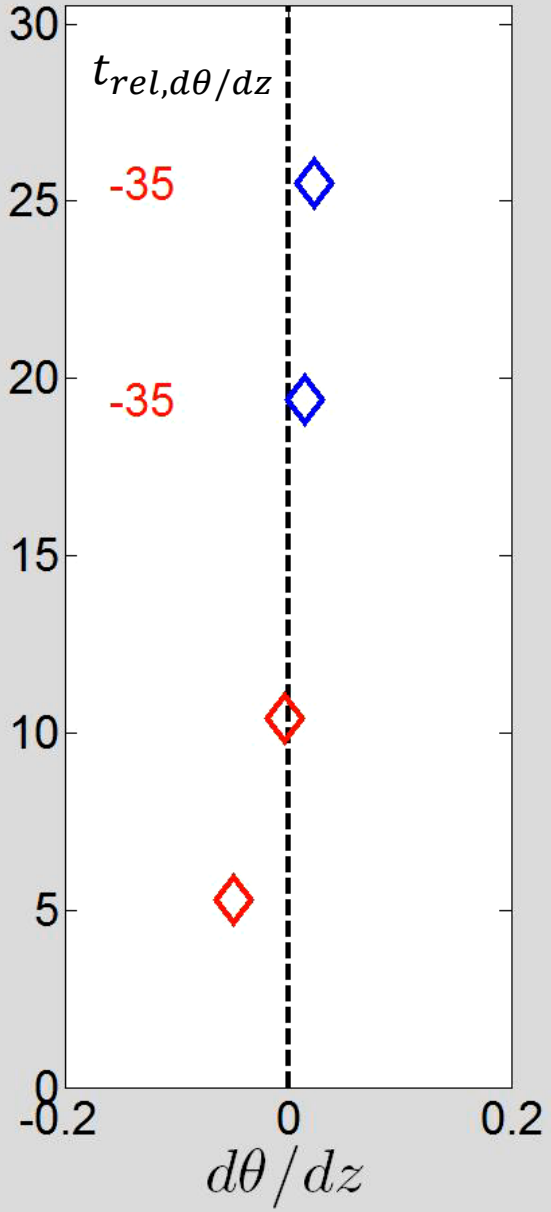


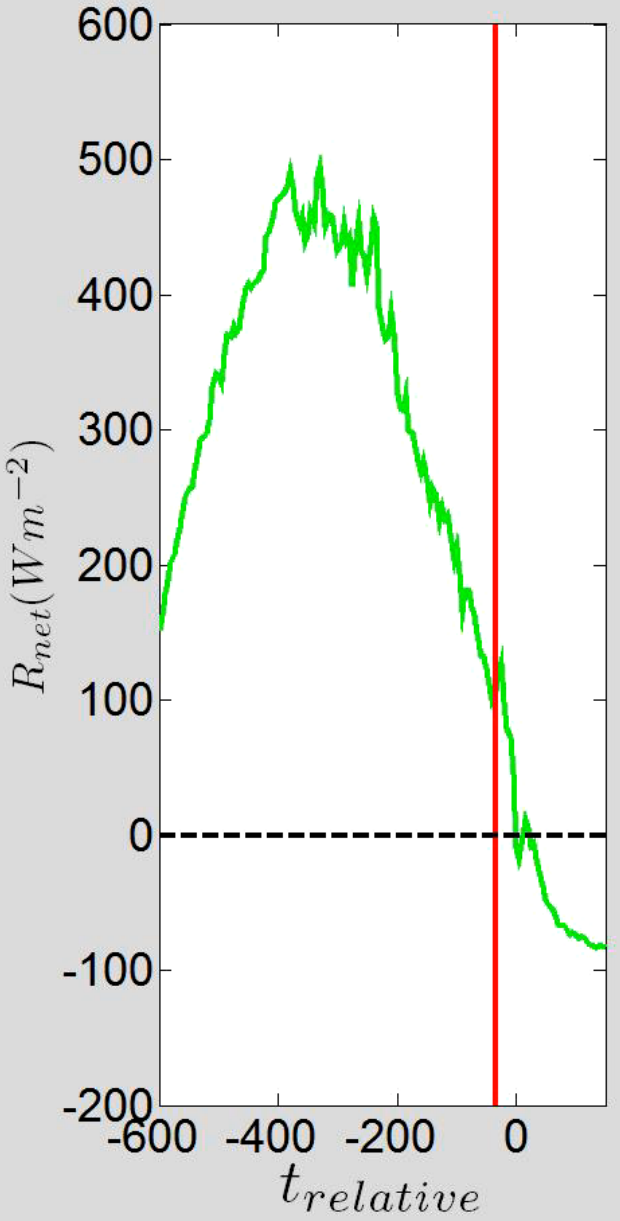
Questions

- Is this actually happening? What is causing this?
- What do the actual profiles look like?
- Define lag time as $\mathrm{t_{lag}} = t_{(H \to 0)} - t_{(d\theta/dz \to 0)}$
  How does lag time vary with height?
- How does lag time vary with stability?

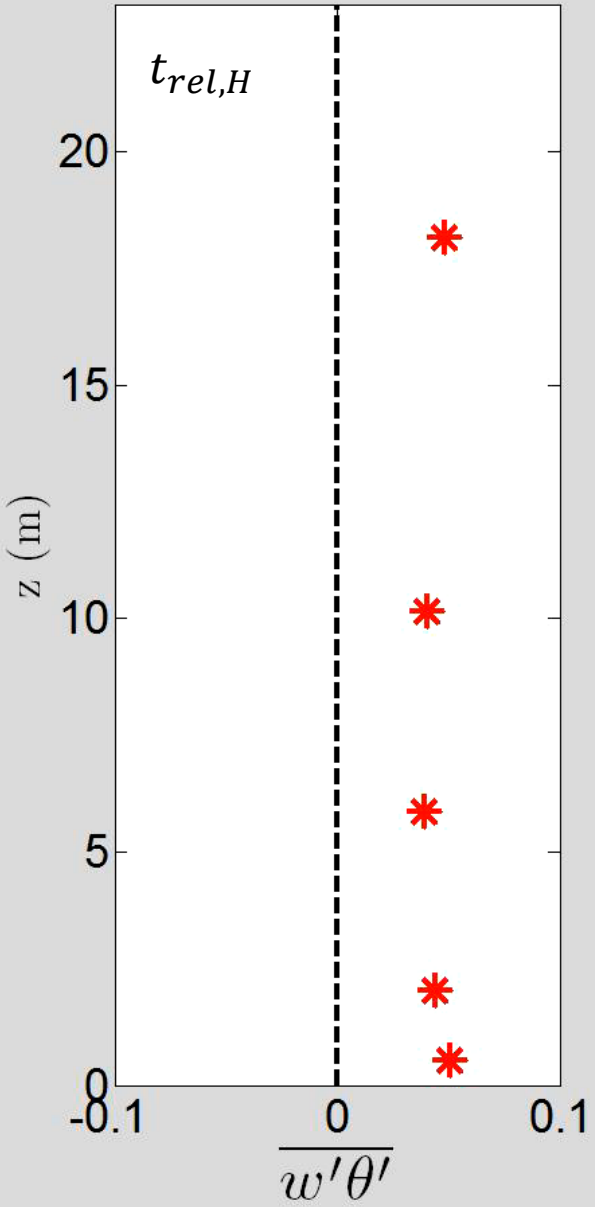
Playa Spring Campaign

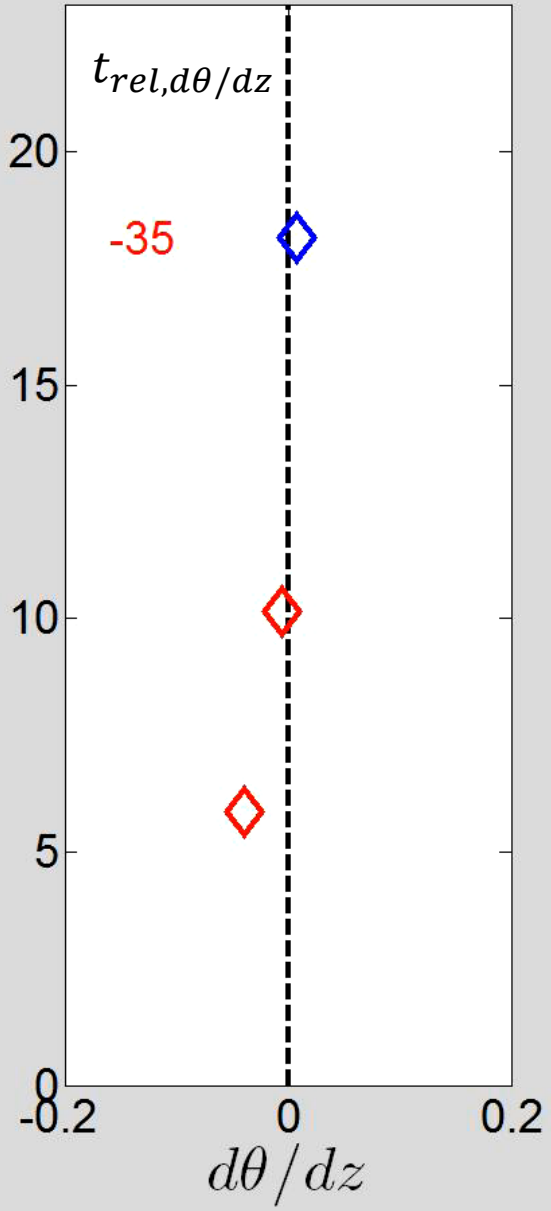


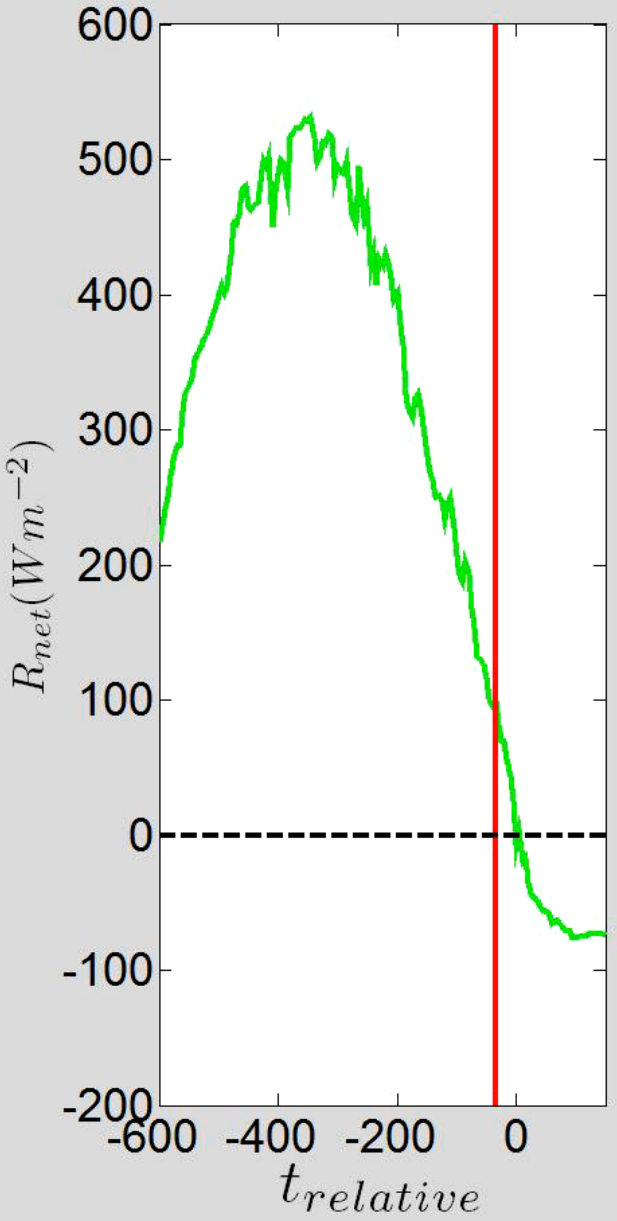


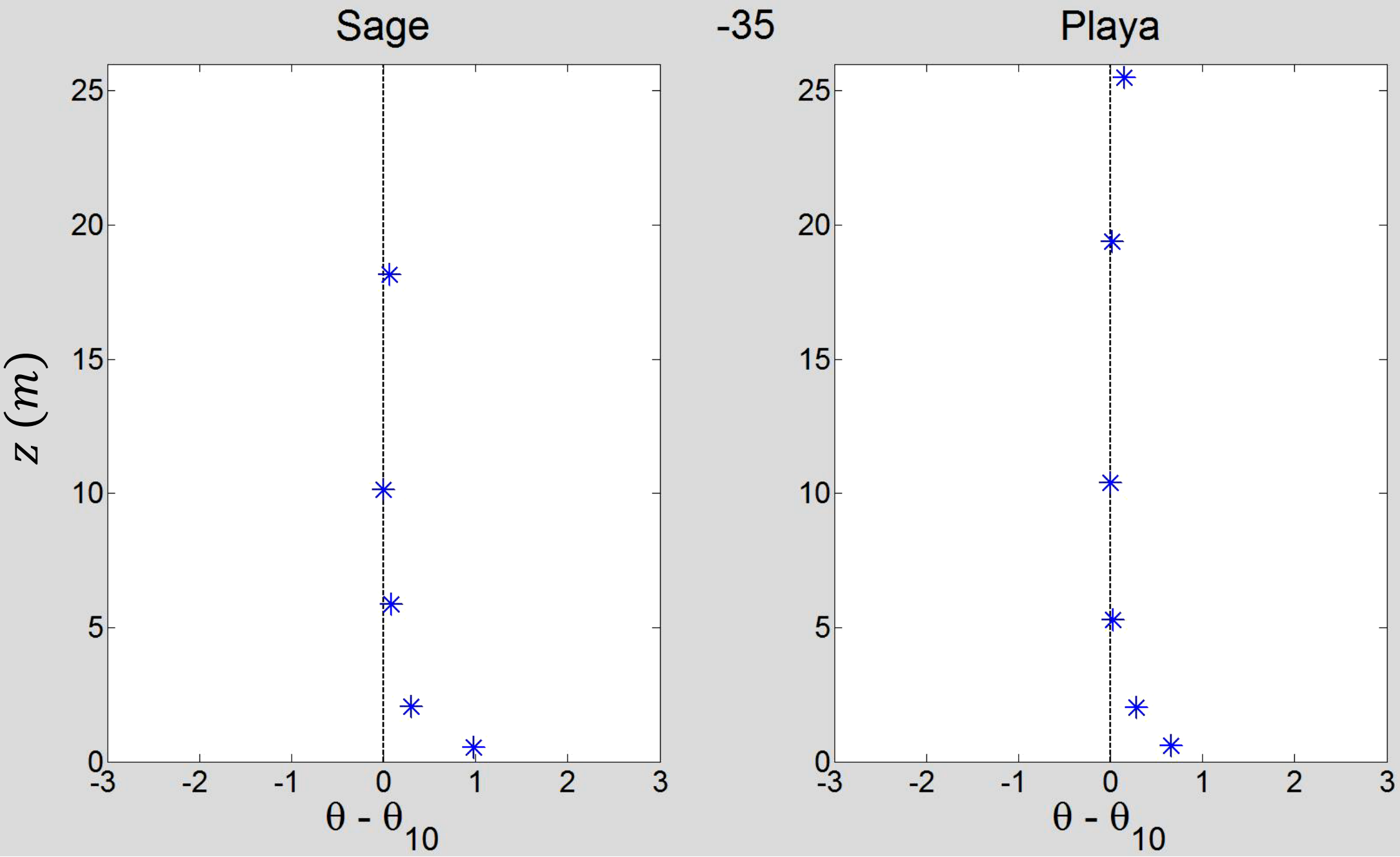


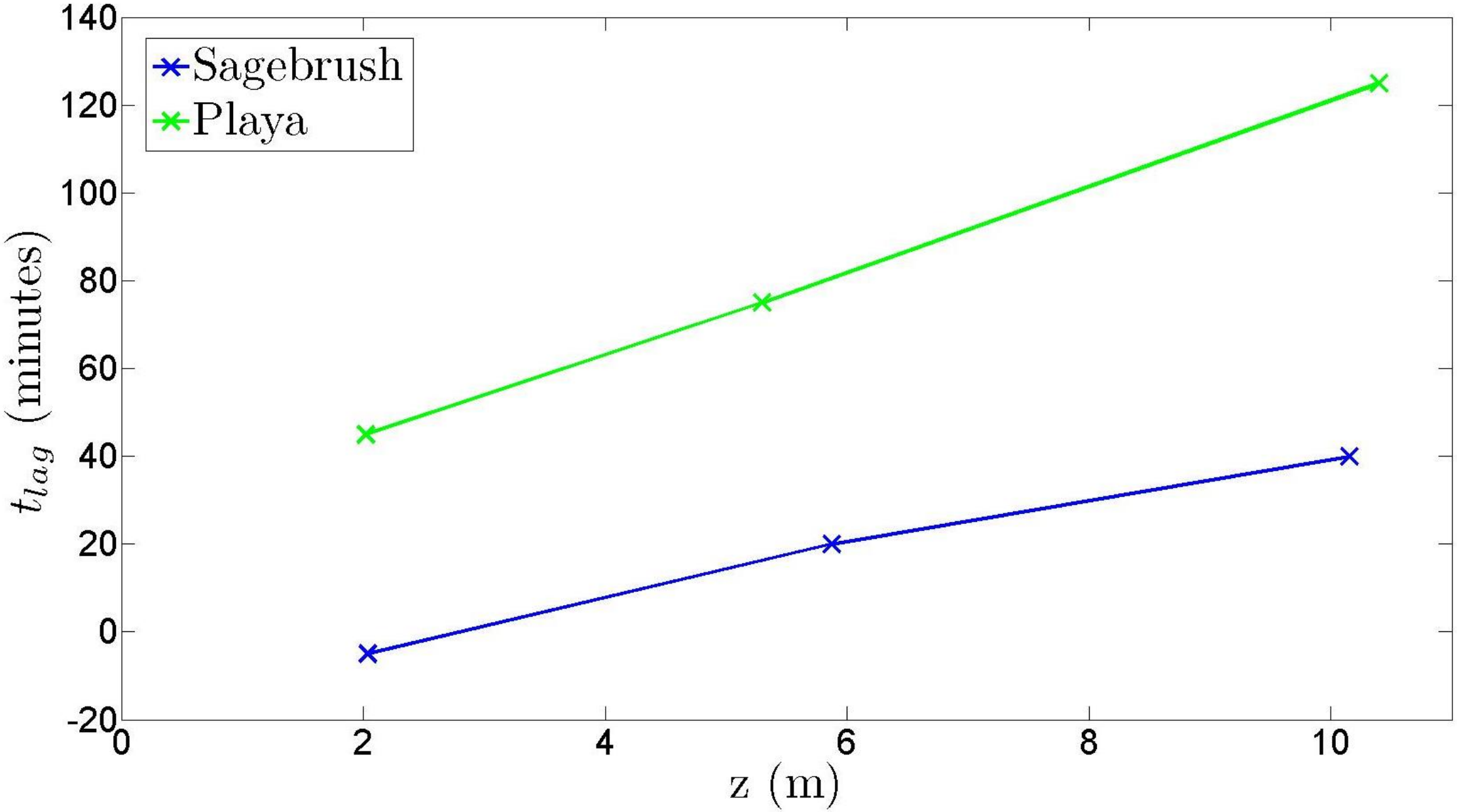
Sage Spring Campaign

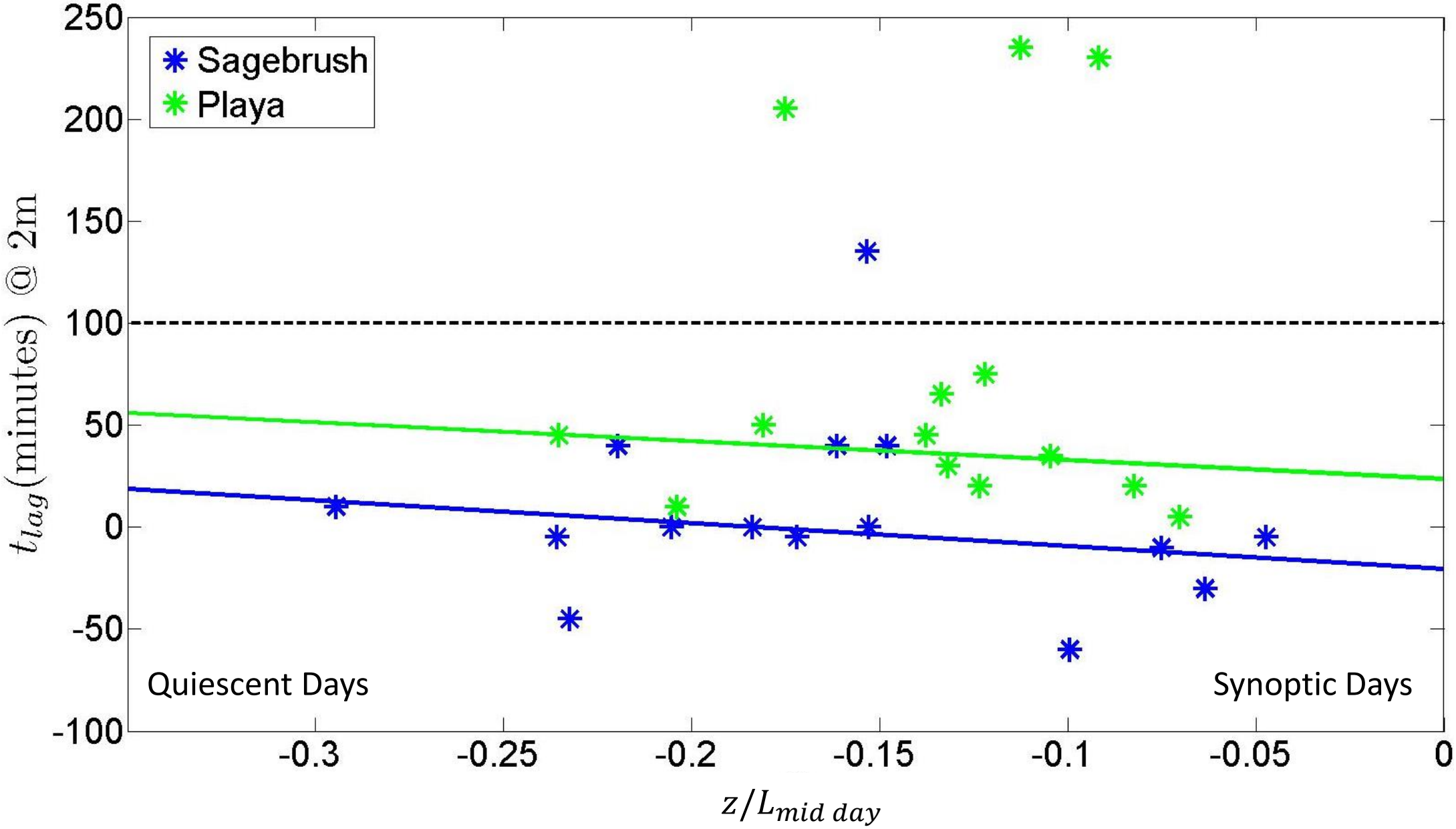







Sage
-35
Playa
z (m)
θ - θ10
θ - θ10
25
20
15
10
5
0
-3
-2
-1
0
1
2
3


Sagebrush
Playa
140
120
100
80
60
40
20
0
-20
0
2
4
6
8
10
t_{lag} (minutes)
z (m)


Sagebrush
Playa
250
200
150
100
50
0
-50
-100
t_{lag}(minutes) @ 2m
-0.3
-0.25
-0.2
-0.15
-0.1
-0.05
0
$z/L_{mid\ day}$
Quiescent Days
Synoptic Days

Conclusions

- Counter gradient heat fluxes are clearly occurring at the Playa site with $d\theta/dz$ changing sign before the sensible heat flux
- The observed time lag at the Sagebrush site is relatively short and it is unclear whether $d\theta/dz$ or H is changing signs first.
- $d\theta/dz$ is much stronger at the Sagebrush site and responds much more quickly to the evening transition
- The difference in lag times at Sagebrush and Playa is likely due to disparities in soil heat capacity and surface roughness
- The time lag increases with height at both sites
- There appears to be a positive correlation between stability and lag time

Questions?

2nd order Lagrange interpolating polynomial

$$f_2'(x) = \frac{2x - x_i - x_{i+1}}{(x_{i-1} - x_i)(x_{i-1} - x_{i+1})} f(x_{i-1}) + \frac{2x - x_{i-1} - x_{i+1}}{(x_i - x_{i-1})(x_i - x_{i+1})} f(x_i)$$

$$+ \frac{2x - x_{i-1} - x_i}{(x_{i+1} - x_{i-1})(x_{i+1} - x_i)} f(x_{i+1})$$