MATERHORN Spring and Fall Experiments and Some Initial Results

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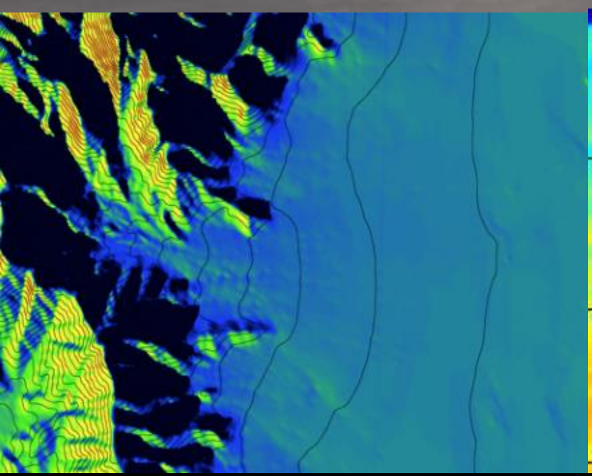
University of Notre Dame



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Experiment Details

1. **Tower Based Measurements**
   - DPG GMAST System
   - Extended Flux Stations (SEB)
   - Suite of supplemental turbulence measurements
2. **Ground-Based Remote Sensing**
   - Wind LIDARS (UU, UND, ARL)
   - SODAR/RASS (UU, UND)
   - RF Remote Soil moisture Sensing (UND)
   - Ceilometers, FMWC radar
3. **Aerial Measurements**
   - Twin Otter (CIRPAS, UVA)
   - DataHawk (CU) - UAS
   - Flamingo (UND) – UAS
4. **Balloon Measurements**
   - Radiosonde launches
   - Tethered Balloon soundings
5. **Fine Scale Turbulence**
   - In Situ Calibration of hot-Film probes
   - Flux divergence hot-wire measurements
6. **Other**
   - Distributed Temperature Sensing (DTS)
   - Infrared Surface Temperature measurements

MATERHORN Experiments

Fall Campaign

- Focus: Thermally Driven Winds/Dry
- 25 Sept - 21 Oct, 2012
- Consisted of ten ~24-hour long IOPs
  - 5 Quiescent (700mb winds < 5ms^{-1})
  - 4 Moderate (700mb winds 5-10ms^{-1})
  - 1 Transitional (dry cold front passage)
  - 6 “Nighttime” IOPs (1400LT start)
  - 2 “Daytime” IOPS (0200LT start)
  - 1 “Mini-IOP” (1200LT-2000LT)
  - 1 “Super-IOP” (0500LT-1200LT+1day)

Spring Campaign

- Focus – Synoptically forced/Moist
- 1 May – 31 May, 2013
- Consisted of ten 24-hour long IOPs (more difficult to classify – see Jim’s notes)
  - 1 Quiescent
  - 2 Quiescent aspects
  - 5 Moderate
  - 2 Moderate Transitional
- 2 Main Precipitation Events - 5 Days with some Precipitation

MATERHORN – X
Fall IOP Summary

IOP Summary Table (TB - tethered balloon, RS - radiosounding, NP - North Playa, SB - Sage Brush)

IOP Number	Dates and Time of Experiment in Mountain Daylight Time (UTC - 6)	TB	RS	Type	Flights	Last Precip
IOP 0	1400 MDT September 25 - 1400 MDT September 26	Playa data gap, NP, SB	None	Quiescent	None	Sept 24
IOP 1	1400 MDT September 28 - 1400 MDT September 29	Playa, SB, NP	SLTEST,NP	Quiescent	None	
IOP 2	1400 MDT October 1 - 1400 MDT October 2	Playa, SB data gap,NP	SLTEST,NP	Quiescent	None	
IOP 3	0200 MDT October 3 - 0200 MDT October 4	Playa,SB, No TBs late in IOP	SLTEST,NP	Transitional	None	
IOP 4	1400 MDT October 6 - 1400 MDT October 7	Playa, SB, NP	SLTEST,NP	Moderate	Twin Otter/ DataHawk	
IOP 5	1400 MDT October 9 - 1400 MDT October 10	Playa, SB, NP	SLTEST,NP,SB	Quiescent-moderate	Twin Otter/ DataHawk	
IOP 6	0200 MDT October 14 - 0200 MDT October 15	Playa, SB, NP	SLTEST,NP,SB	Quiescent	Twin Otter	Oct 12
IOP 7 (mini)	1200 MDT October 17 - 2000 MDT October 17	None	SLTEST,NP,SB	Transitional (mod-qui)	Twin Otter	Oct 16 (light)
IOP 8	0500 MDT October 18 - 1200 MDT October 19	Playa, SB, NP	SLTEST,NP,SB	Quiescent	Twin Otter	
IOP 9	1400 MDT October 20 - 1400 MDT October 21	Playa, SB	SLTEST,NP	Moderate	None	
						Oct 23
						Oct 24

MATERHORN-X
Spring Summary

IOP Summary Table (TB - tethered balloon, RS - radiosounding, NP - North Playa, SB - Sage Brush, CP - Callao Point C, ES - East Slope, SWG - Southwest of Granite Peak; NWG - North West Granite)

IOP Number	Dates and Time of Experiment in Mountain Daylight Time (UTC - 6)	TB	RS	Type	Flights	Last Precip
IOP 1	1400 MDT May 1 - 1400 MDT May 2	Playa, SB	Playa, SB	Moderate/ Quiescent	None	April 20
IOP 2	1400 MDT May 4 - 1400 MDT May 5	Playa, SB, ES	Playa, SB	Moderate	None	
IOP 3	0500 MDT May 7 - 1700 MDT May 7	None	SWG	Moderate	None	May 6
IOP 4	1400 MDT May 11 - 1400 MDT May 12	Playa, SB, ES	Playa, SB	Quiescent	None	May 7*
IOP 5	1200 MDT May 13 - 1200 MDT May 14	None	NWG, Playa	Moderate/ Transitional	None	
IOP 6	1200 MDT May 16 - 1200 MDT May 17	Playa, SB	Playa, NWG, Delta	Moderate/ Transitional GBCZ	None	
IOP 7	1715 MDT May 20 to 1400 MDT 21 May	Playa, SB	Playa, NWG, SB	Sandwhich Quiescent	None	May 18, 19
IOP 8	1400 MDT May 22 to 1400 MDT May 23	Playa, SB	Playa, NWG, Delta	Moderate	None	
IOP 9	1000 MDT May 25 to 1000 MDT May 26		Playa, SB	Moderate	None	
IOP 10	1400 MDT May 30 to 1000 MDT May 31	Playa, SB	Playa, SB	Moderate	None	May 28

*Note that the precipitation on May 7 was just local convection not sustained or range wide

MATERHORN-X IOP Summaries

- Can be found on Evernote – Team MATERHORN-X:
  - Spring IOP Summary Notes MATERHORN-2X Spring 2012
  - Fall IOP Summary Notes MATERHORN-X Fall 2012
- Includes useful “backdrop” information for many of the specific studies:
  - Summary Tables
  - Radiosonding Summaries
  - Playa Tethered balloon Quick Looks
  - Jim Steenburgh’s Synoptic Notes
- Daily Planning Meeting Notes have all of the weather briefings saved

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Current Science Efforts – Process Oriented - Parameterization Development

1) Along Slope Shadow Front Dynamics (Utah Team)

2) Monin-Obukhov Similarity Theory (Jensen)

Study known unknowns; uncover hidden physical processes

- H.J.S. Fernando

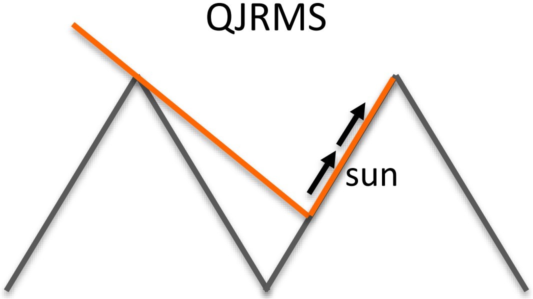
Team)

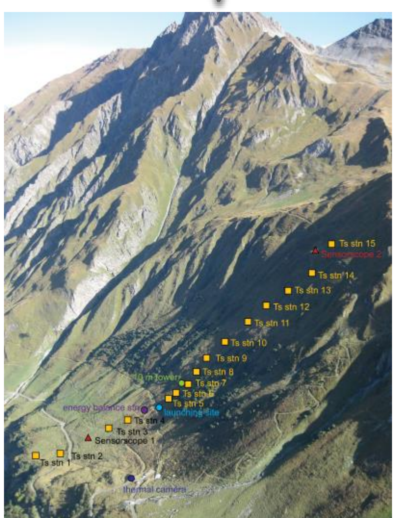
4) Soil Moisture Observations and Coupling to Atmospheric Transport (Nadeau, Hang)

Shadow Front

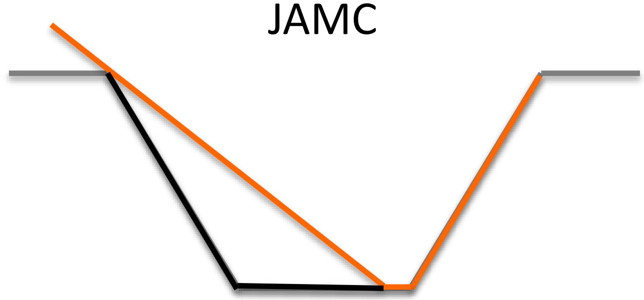
<u>Generalizing the Impact of Shadow Fronts</u> on slope valley transition dynamics and turbulence

La Fouly-Suisse
Nadeau et al. 2012
QJRMS

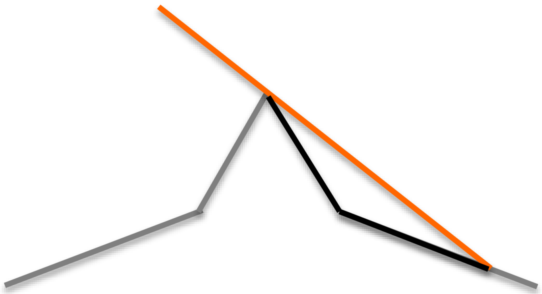




Meteor Crater, Arizona
Martinez et al. 2013
JAMC



East Slope
MATERHORN, Utah

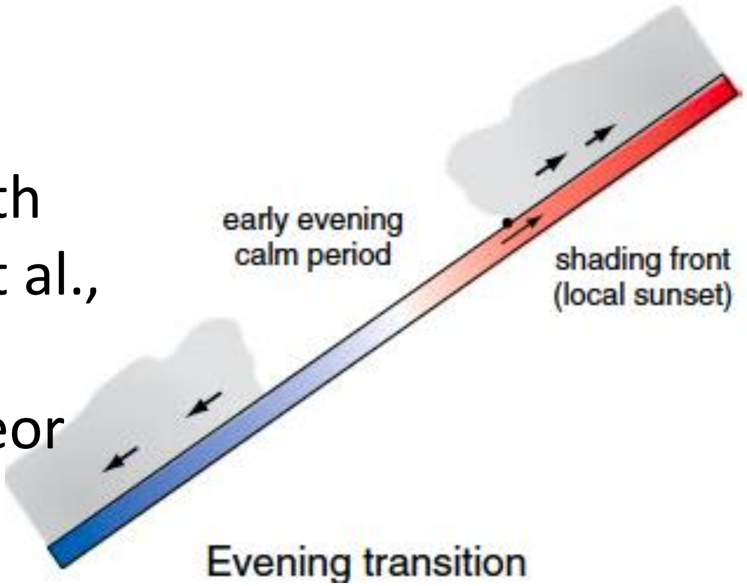


Shadow Front Science Questions

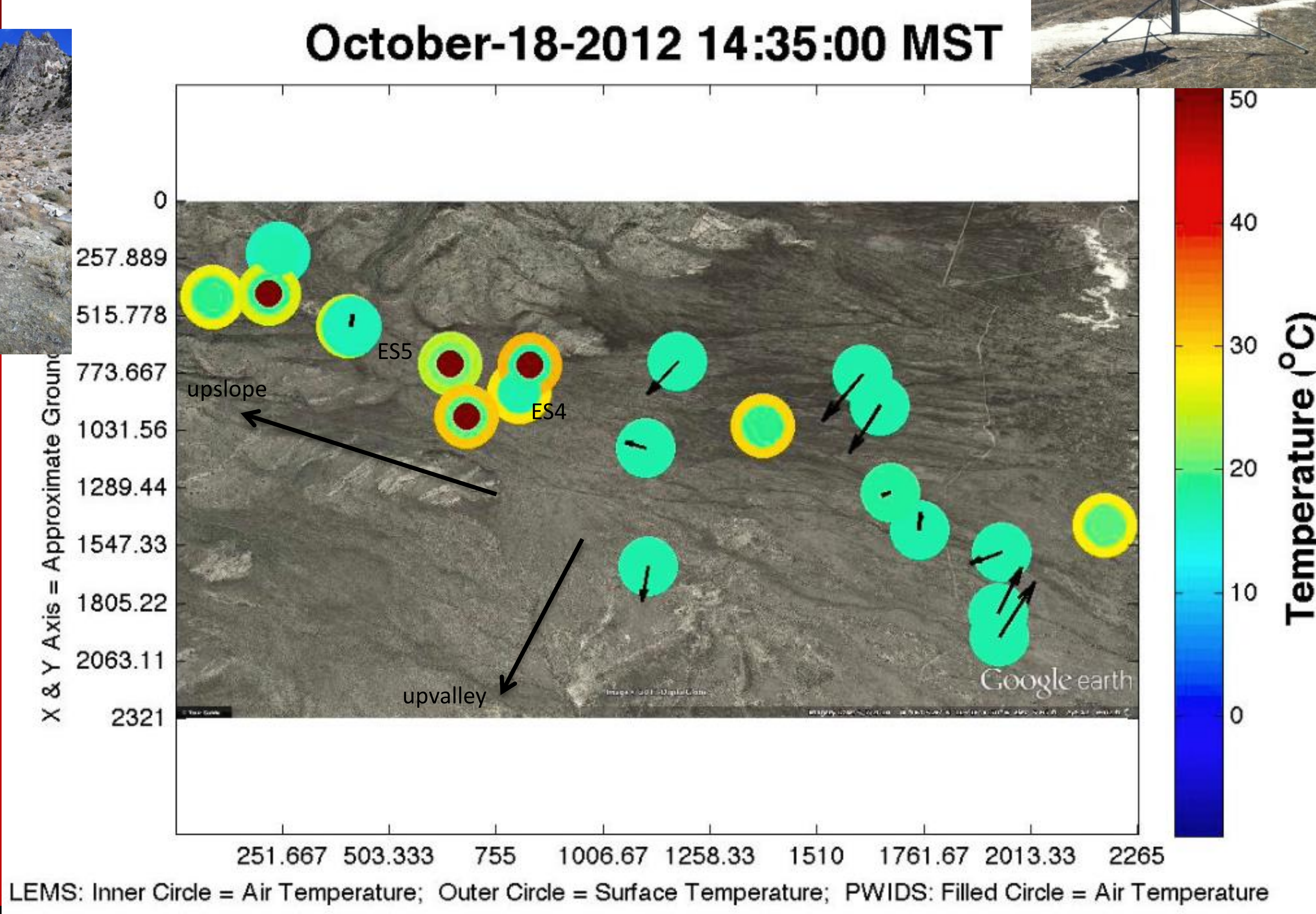
Shadow Front Notes from Steep Slopes:

1. Rapid transition in radiation, surface temperature
2. Winds transition up the slope following shadow
3. Shadow Front follows a balance between buoyancy and inertial forces (Hunt et al. 2003, JAS)

- Is East Slope of Granite Peak in a steep slope regime?
- Are there generalizations?
- Can TKE be locally modeled with simple model? (e.g., Nadeau et al., 2011)
- or more complicated Like Meteor Crater



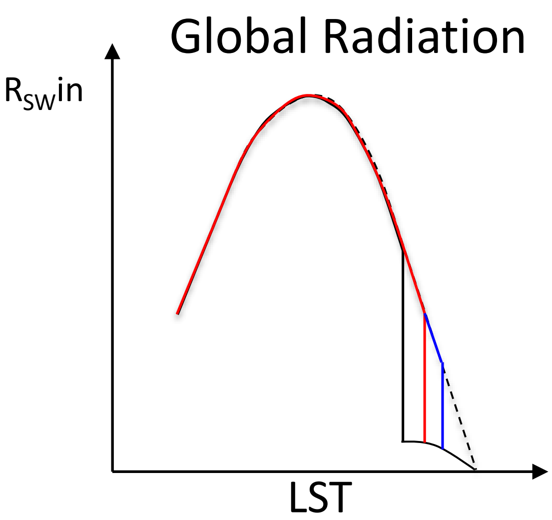
LEMS/PWID Station Data

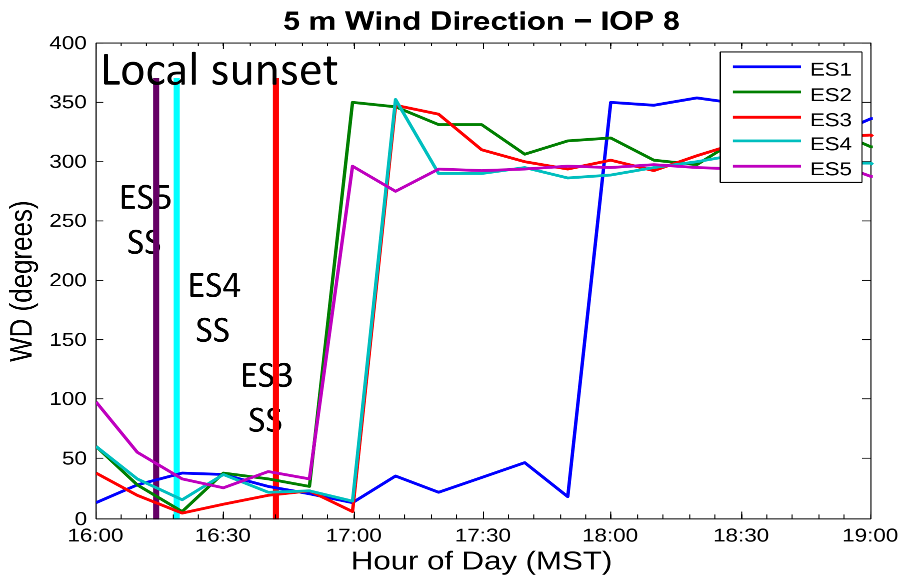


Shadow Front Summary

Observations of the Shadow Front at East Slope

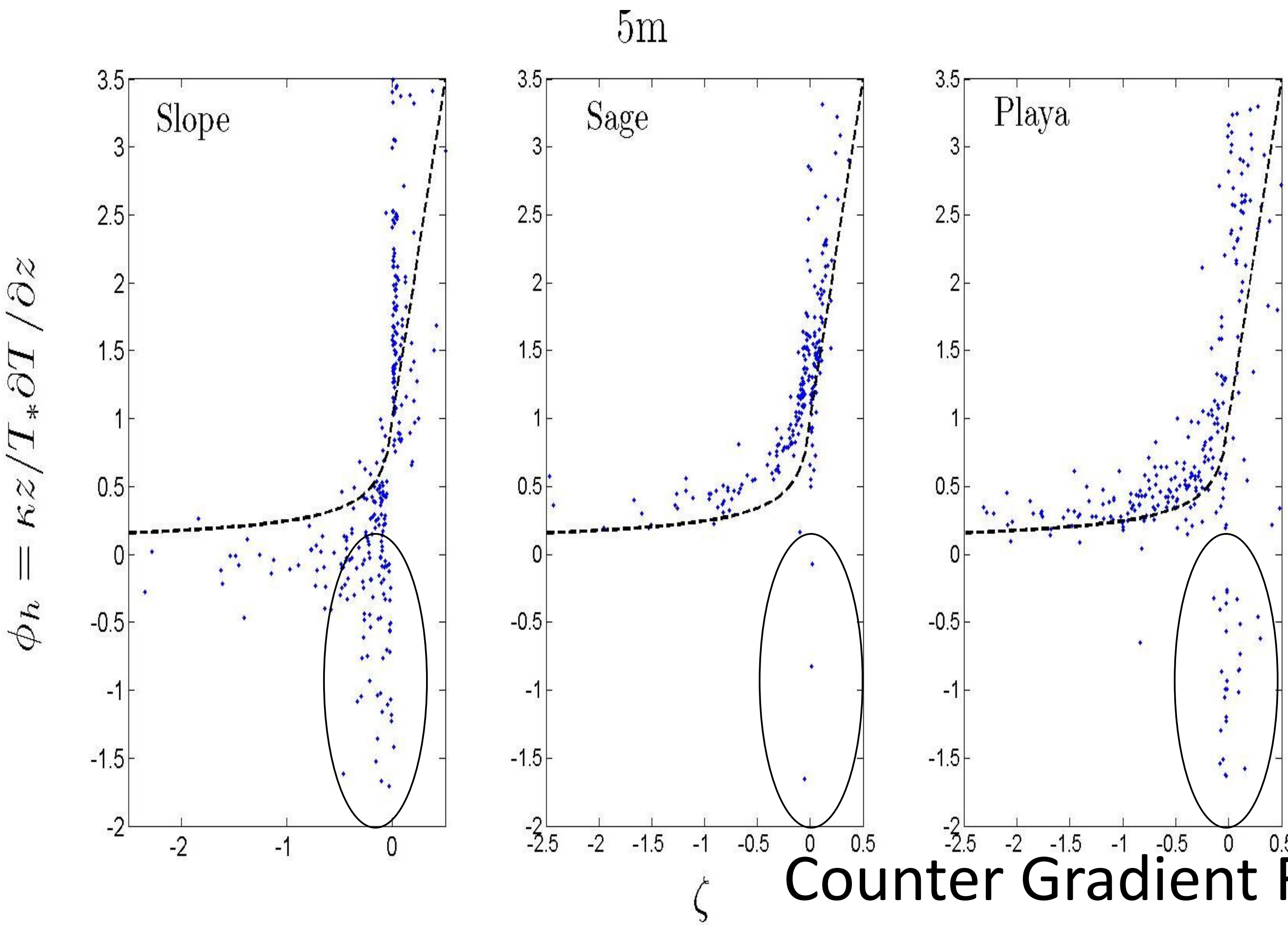
- Winds on East Slope do not transition with the shadow front as observed on steep slopes (e.g. Nadeau et al. 2013; Defant 1951)
- The surface temperature drop due to the shadow passage decreases with distance down the slope
- “Lost” Radiation from the slope decreases with distance down slope
- Sensible heat flux makes sense
- TKE does not follow as clear and obvious front





MOST Questions

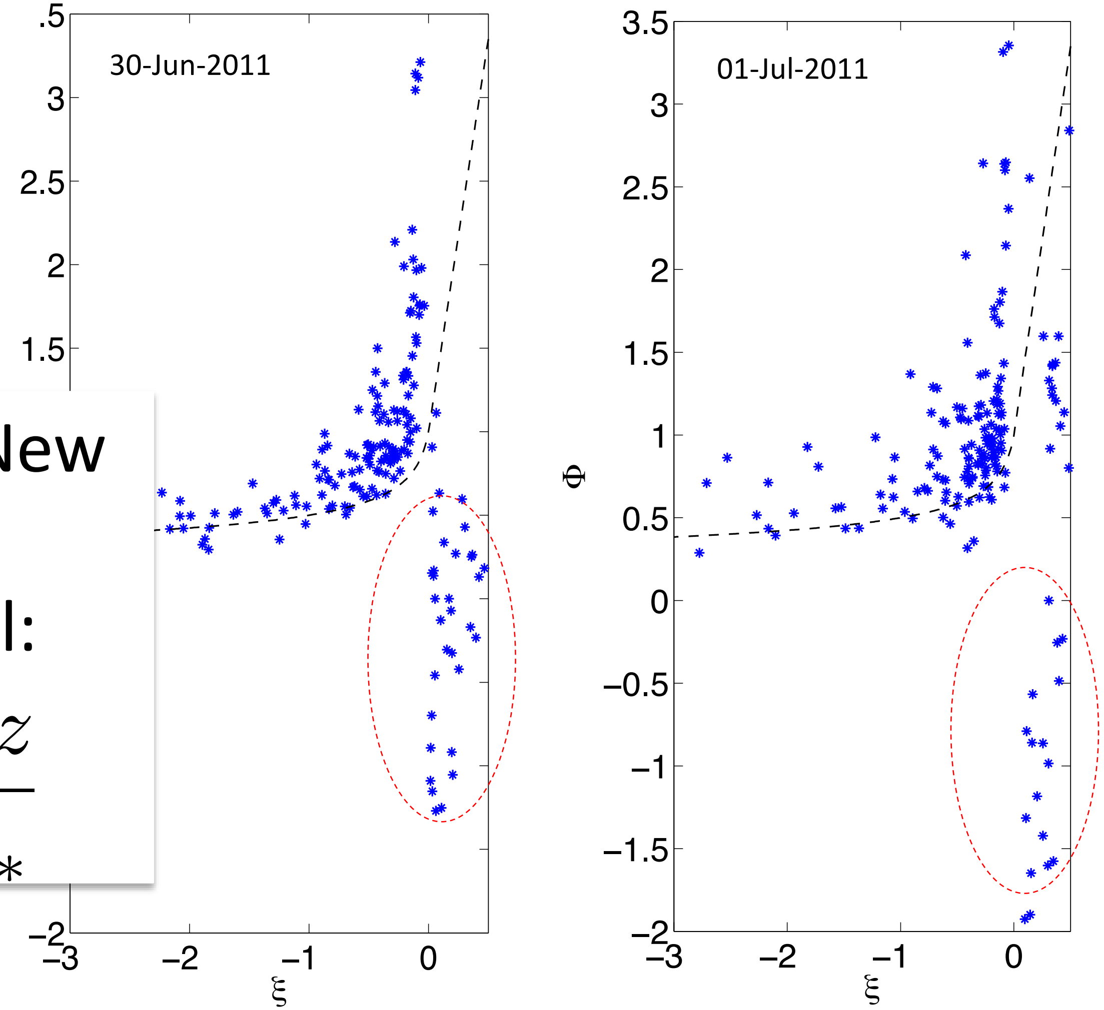
Temperature Gradients from MATERHORN



Counter Gradient Fluxes

MOST Questions

Temperature Gradients
BLLAST – France

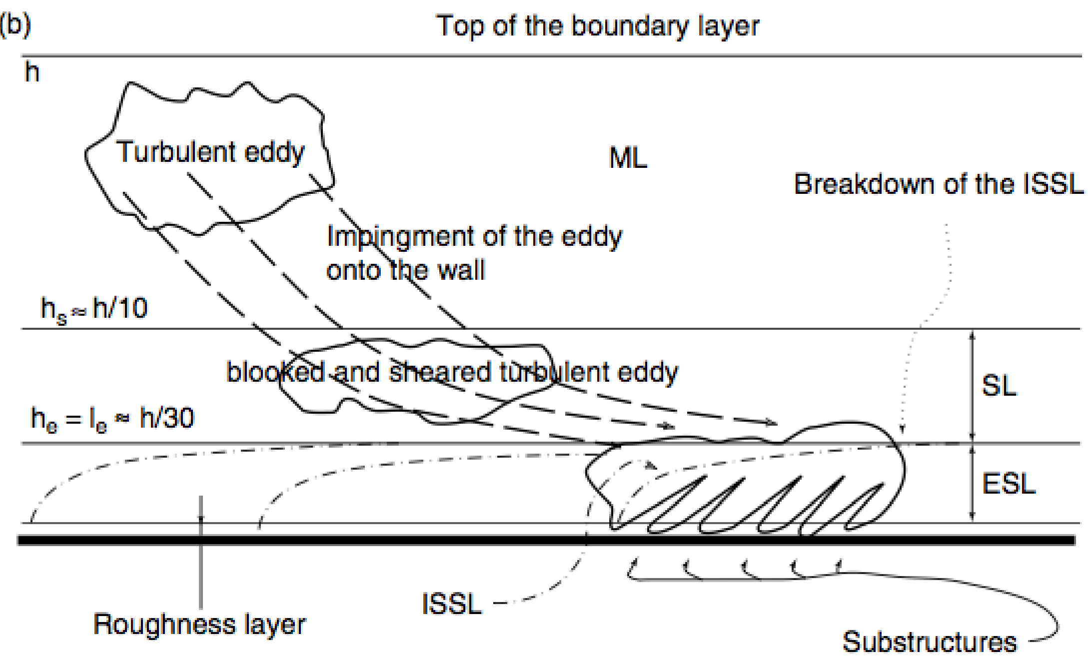


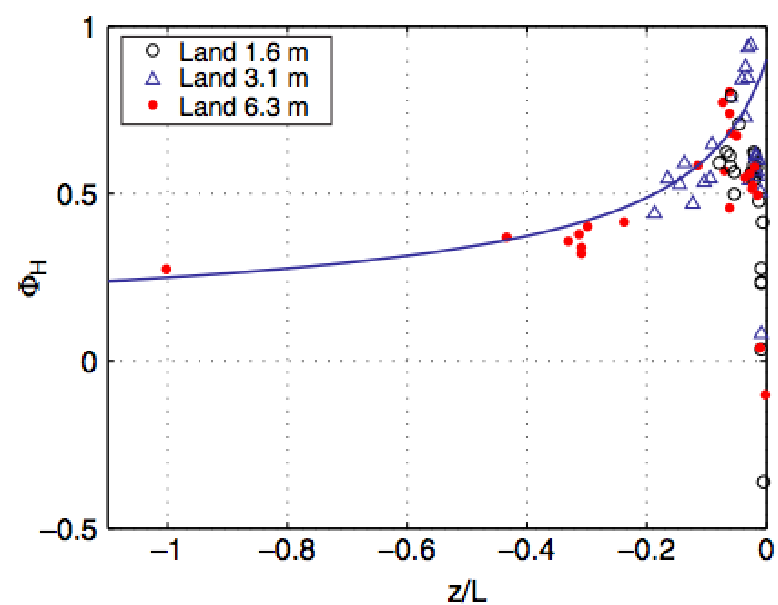
Currently Developing a New Parameterization – adjustment to classical:

$$\phi_a(z/L) = \frac{\partial \overline{a}}{\partial z}\frac{kz}{a_*}$$

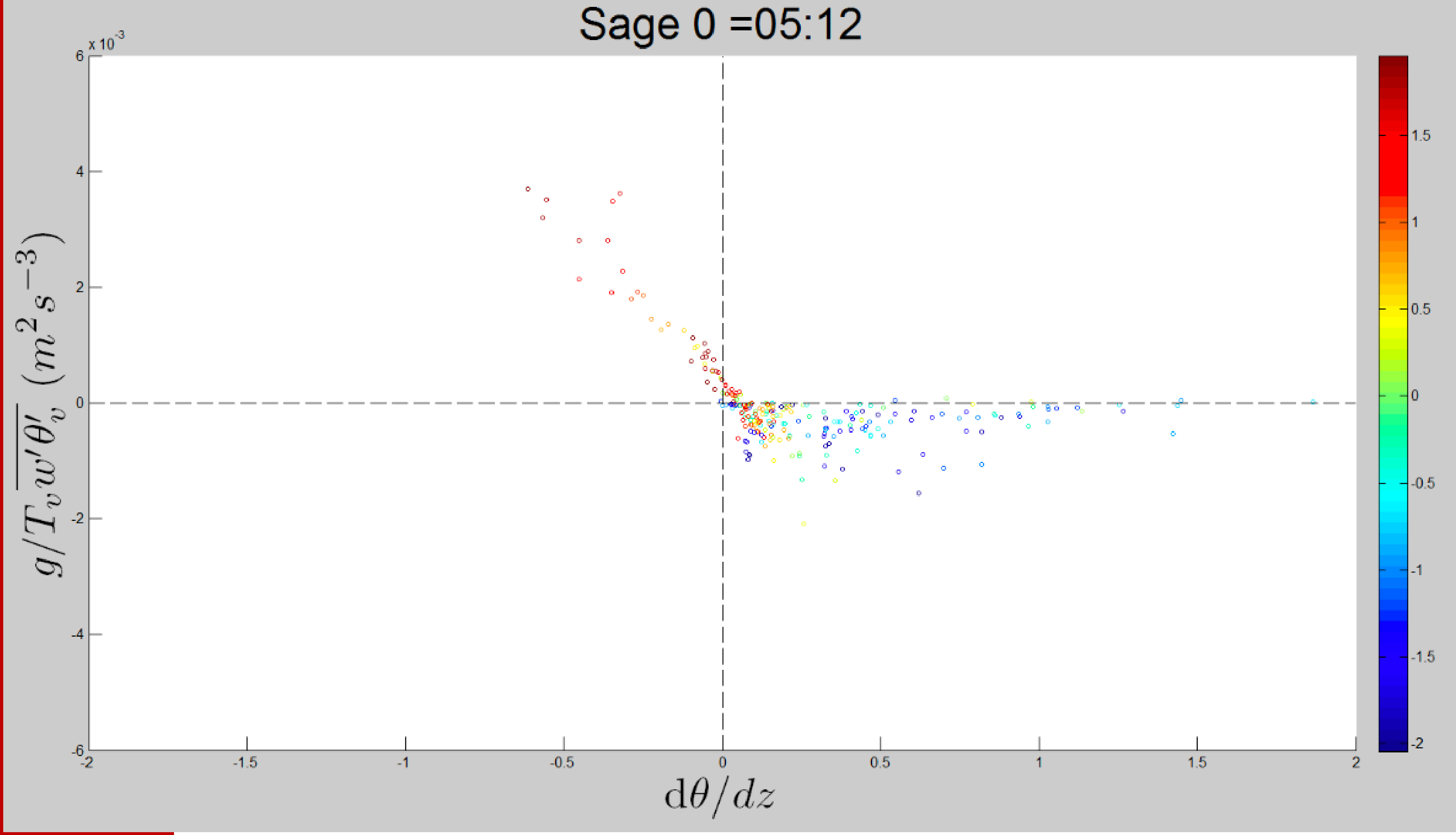
MOST – Detached Eddy's - Turbulence

Follows Developments of Townsend (1961), Marusic and Perry (1995), Carlotti and Hunt (2001), McNaughton (2002), Högström, Hunt, and Smedman (2002), Smedman et al. 2007 … "the unstable very close to neutral regime"





Morning & Evening Transition



Soil Moisture Measurements

Motivation:

- Soil moisture critical for accurate WRF simulations (Massey et al., 2013)
  - Spatial variability
- Better understand the land/atmosphere interactions (via ET)

Problem: Playa soil too <u>saline</u> to operate traditional soil moisture sensors

Solution: Use gravimetric method

▪ Gravimetric Method

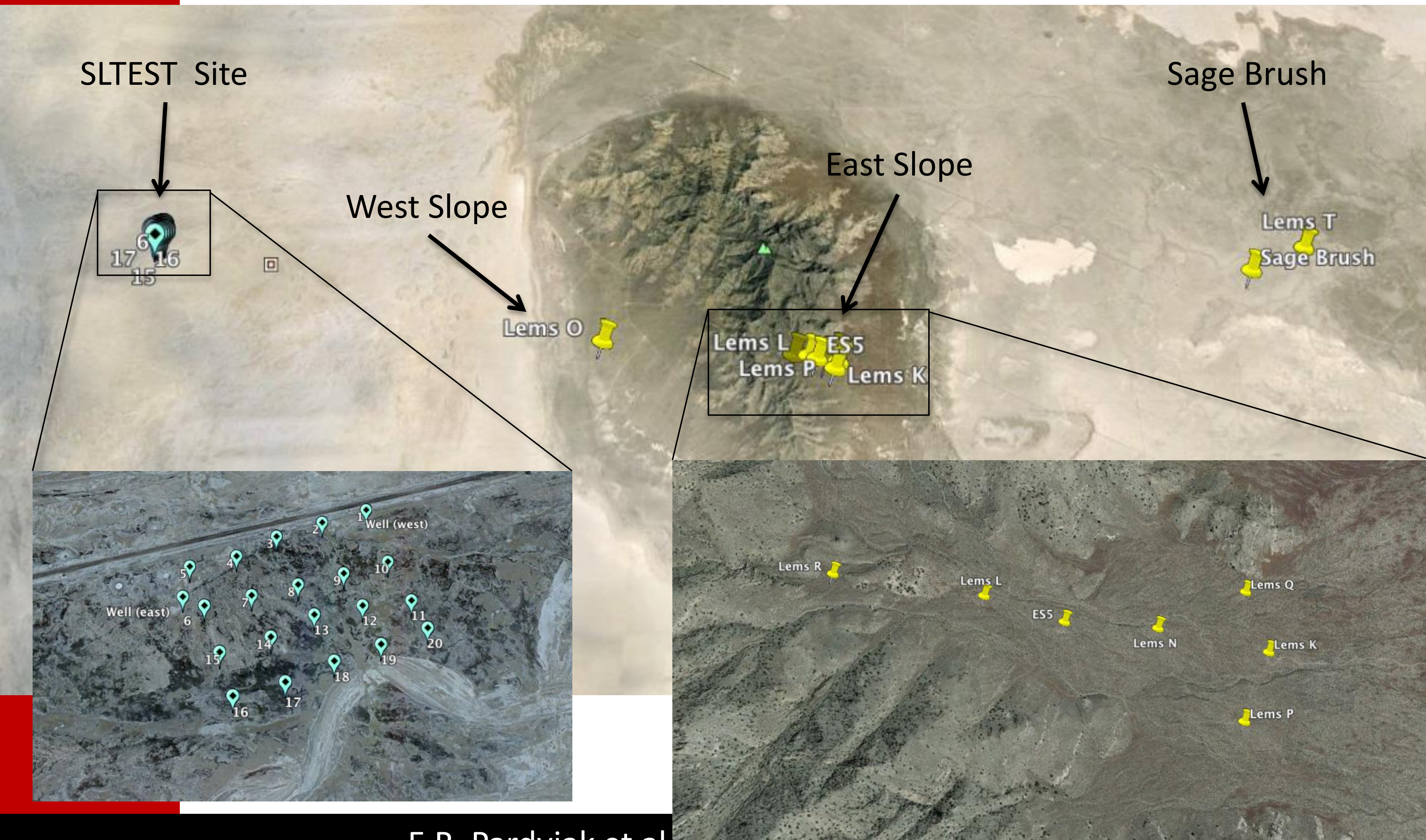
➕ simple and direct

➖ discontinuous and labor-intensive

In brief:

- extract 'wet' soil sample with hand auger
- weigh 'wet' sample
- bake sample for 24 h at 105°C
- weigh dry sample
- compute soil water content

Soil Moisture Measurements Sampling Locations



Soil Moisture Measurements

<u>Playa</u>

- 20 sampling sites (200 m x 250 m)
- Depths: 0-2 cm, 4-6 cm (17/20)
  0-10 cm, 24-26 cm (3/20)
- Frequency: Twice per IOP
- Monitoring of the water table depth

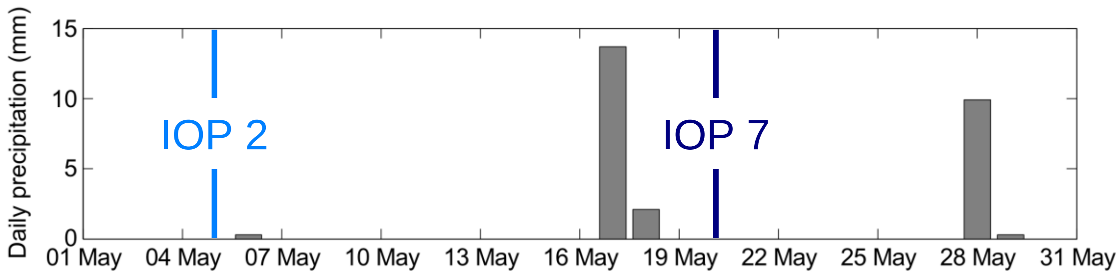
<u>Slope, Sage</u>

- Depths: 4-6 cm, 24-26 cm
- Frequency: Once per IOP

▪ Initial Field Observations

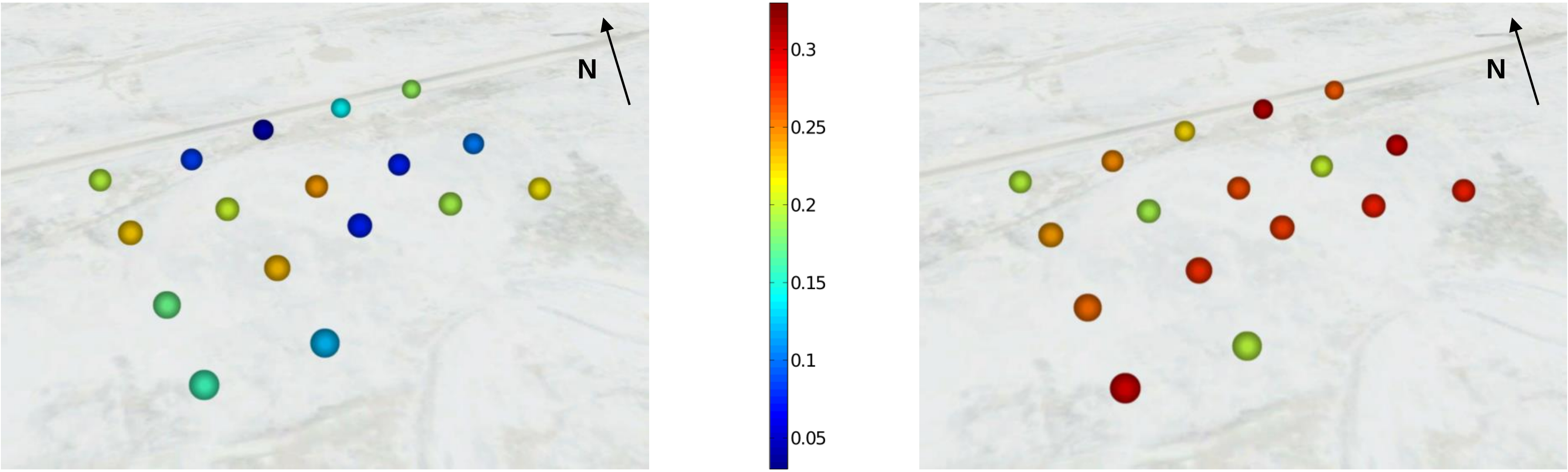
Presence of desiccation cracks

Soil Moisture Measurements Preliminary Results



Gravimetric water content – *w*

IOP 2 (dry) | (kg_w/kg_{ds}) | IOP 7 (wet)



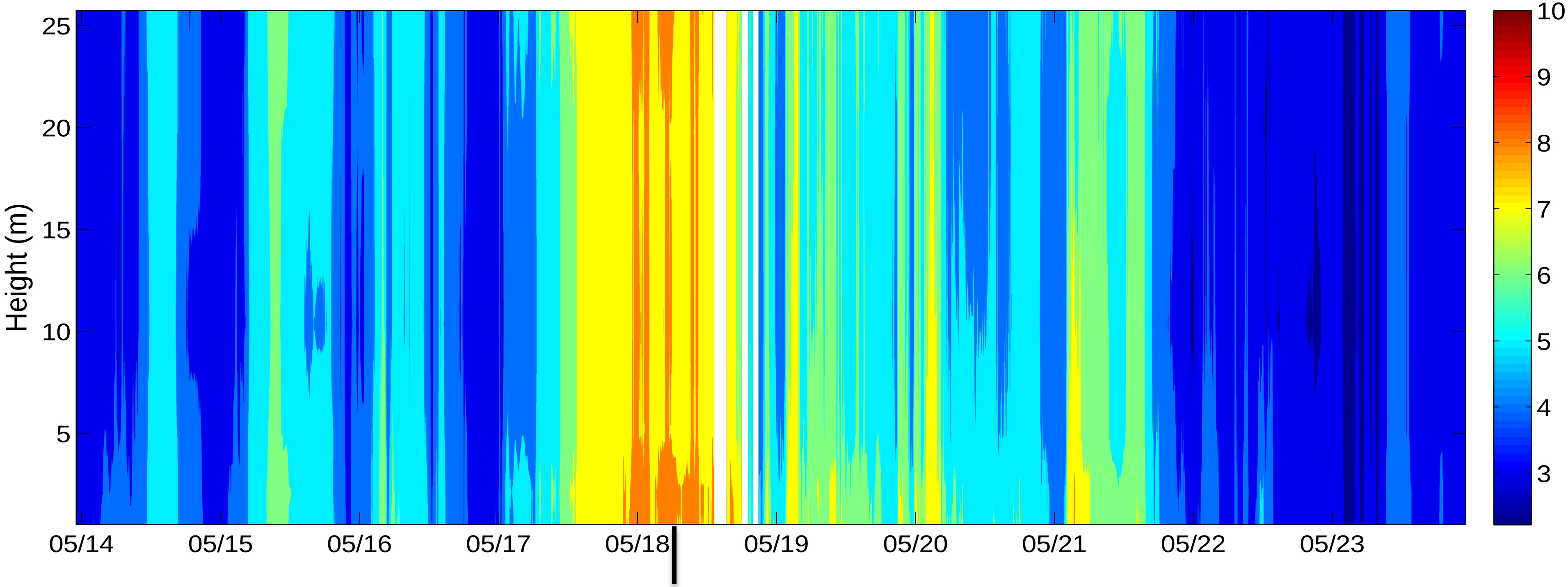
mean: 0.16 kg_w/kg_{ds}
standard deviation: 0.07 kg_w/kg_{ds}

mean: 0.19 kg_w/kg_{ds}
standard deviation: 0.04 kg_w/kg_{ds}

Future Work
Evaporation following a rain event

Air Specific Humidity - Playa

Units: g/kg



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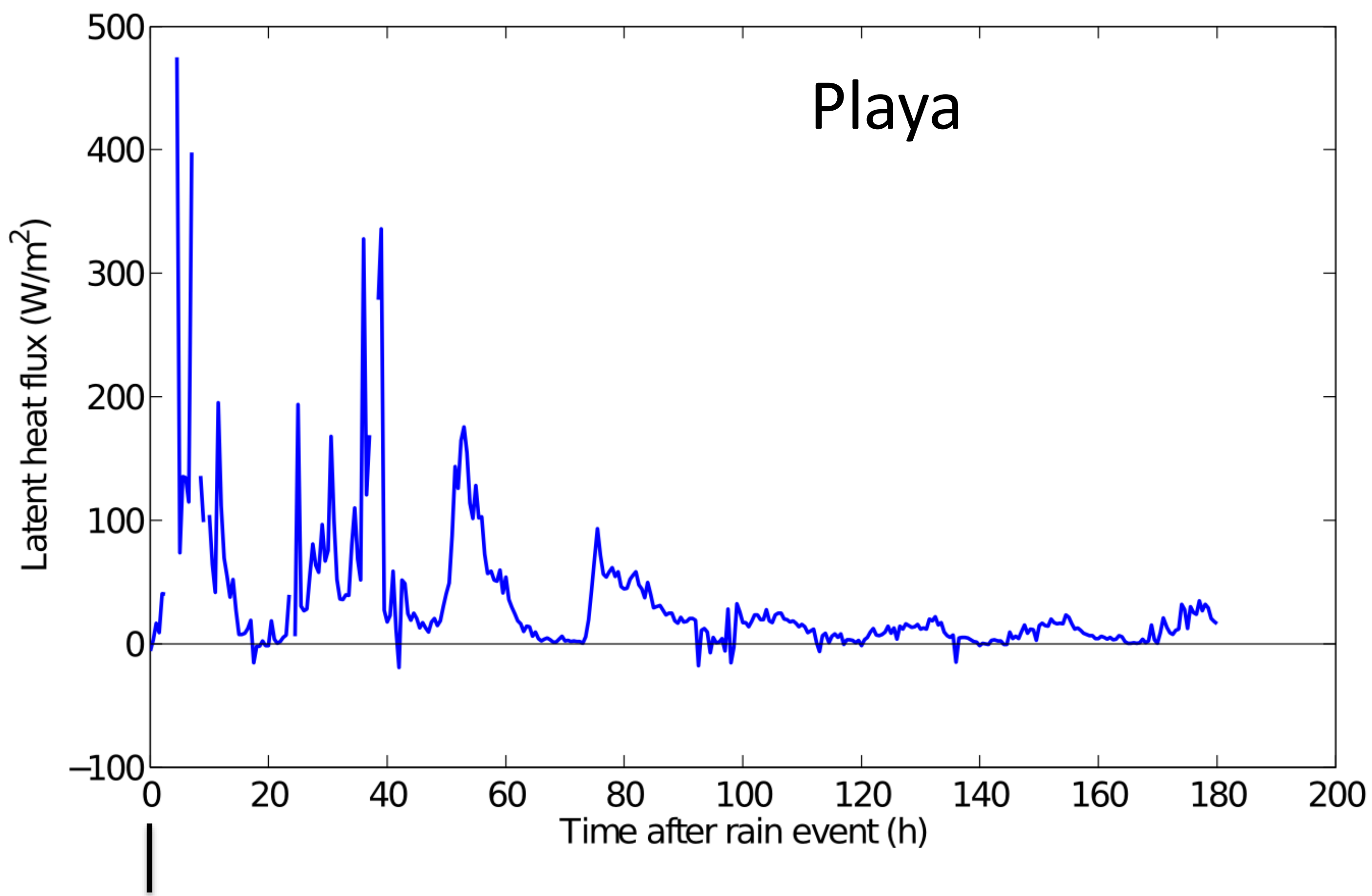
Future Work
Evaporation following a rain event

- quantify nighttime evaporation
- Identify factors controlling evaporative rates (soil tension, water vapor deficit, etc.)



Questions?

Intro

Site

Results

Summary

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MOST – Active/Inactive Turbulence

1) Follows Developments of Townsend (1961), Carlotti and Hunt (2001), McNaughton (2002), Högström, Hunt, and Smedman (2002)

Hypothesis: During the transition when u*->0 and Q goes to zero – inactive turbulence in the residual layer govern near surface dynamics – non-equilibrium

Soil Moisture Measurements
Water Table Depth