First observations of the effects of shadow fronts on surface layer dynamics during ~~morning and~~ the evening ~~transitions:~~ transition MATERHORN-X Fall

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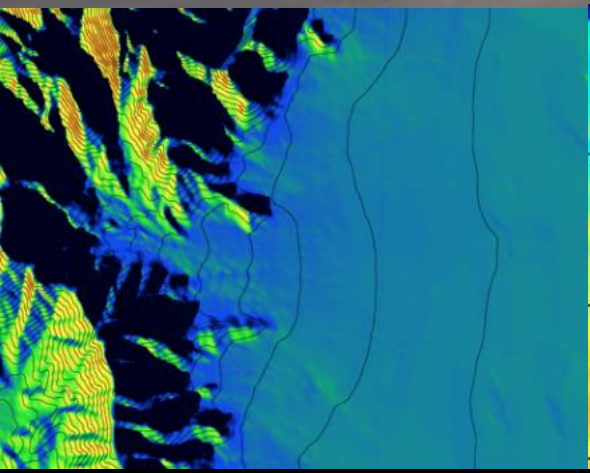
DACA 2013
Davos, Switzerland



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[4]Oregon State University
July 10, 2013

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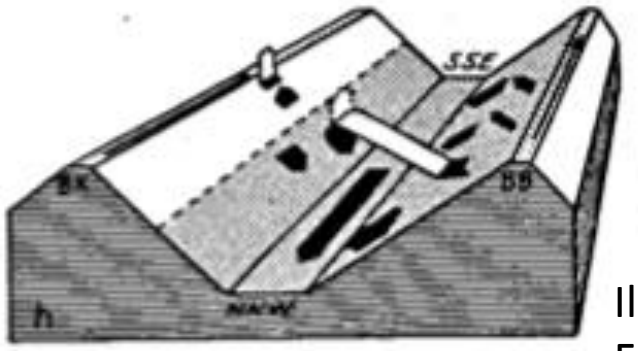
Evening Transition
Shadow Front – Dischma Valley

"The current is extremely sensitive to changes in the insolation, and a temporary shading of the slopes will cause an immediate response by the wind. Also, the differences in the starting time of the current is determined by the varying time at which insolation begins on slopes of different exposures."

- F. Defant (1951)



After sunset on the bottom and on the W-facing slope

Illustration of a Shadow Front in the Dischma Valley, From Hennemuth and Schmidt, 1985 referring to the work of Urfer Henneberger, 1970

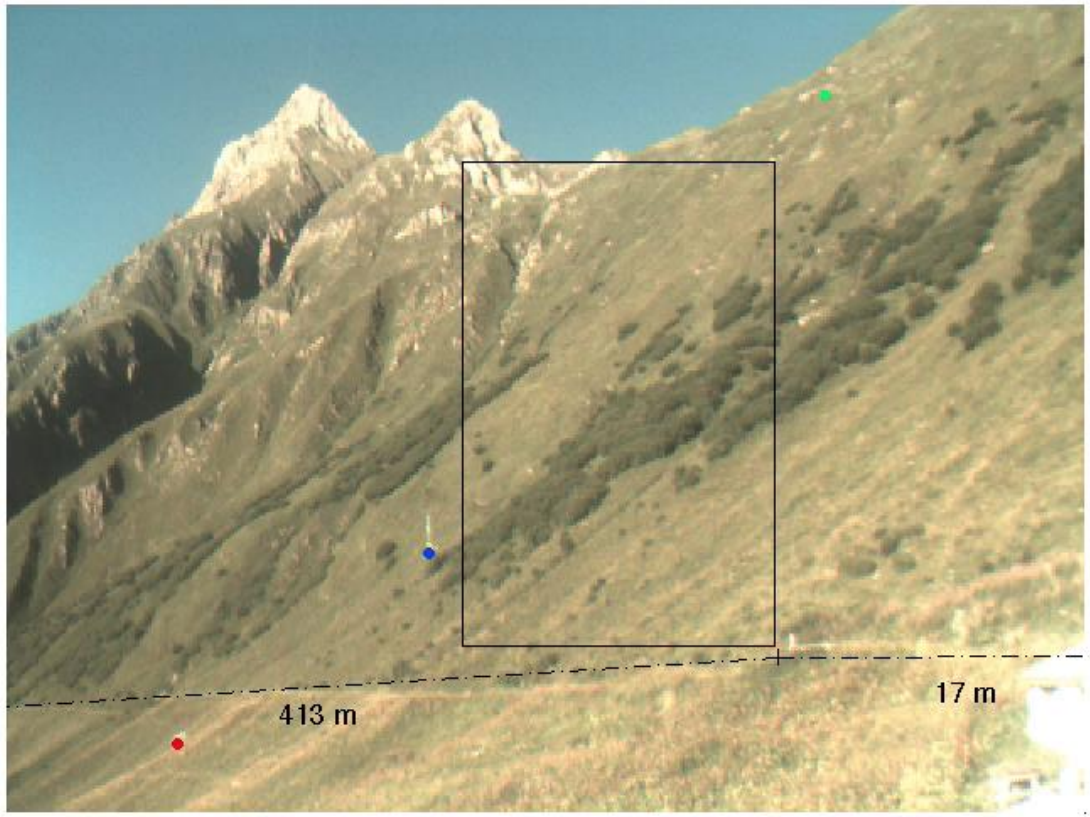
Shadow Front

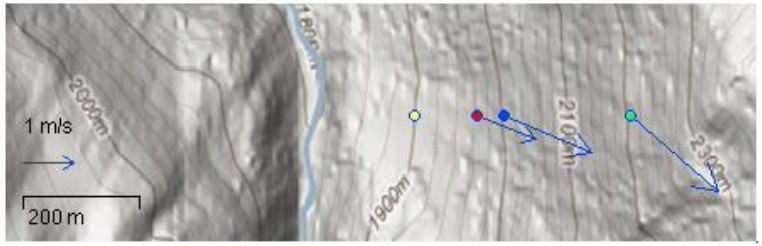
Nadeau et al. 2012 QJRMS– Swiss Experiment near La Fouly

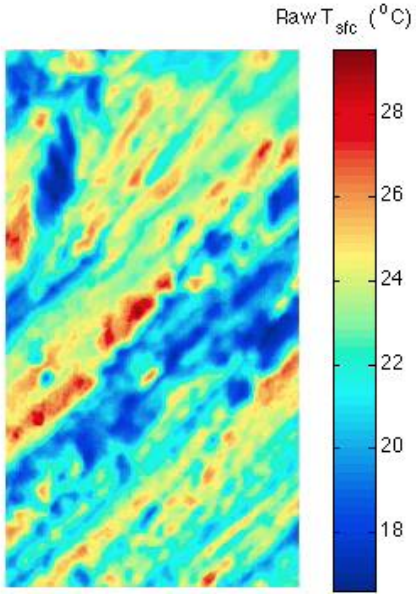
Intro

Val Ferret: 01-Sep-2010 18:00:25

West Facing Slope



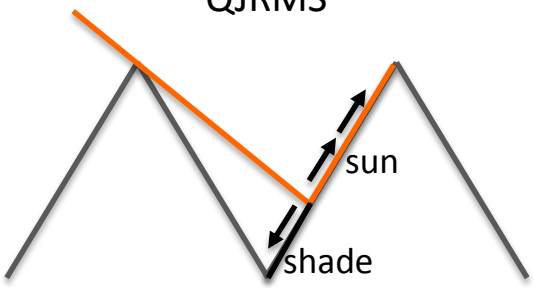




Shadow Front

Generalizing the Impact of Shadow Fronts on slope valley transition dynamics and turbulence

La Fouly-Suisse
Nadeau et al. 2012
QJRMS



Meteor Crater, Arizona
Martinez et al. 2013

East Slope
MATERHORN, Utah

Shadow Front

Generalizing the Impact of Shadow Fronts on slope valley transition dynamics and turbulence

La Fouly-Suisse
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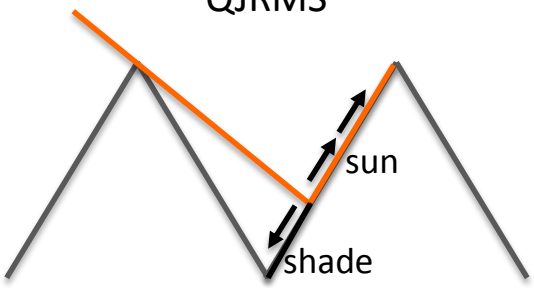
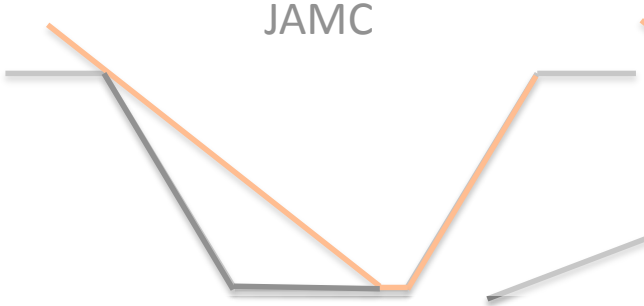
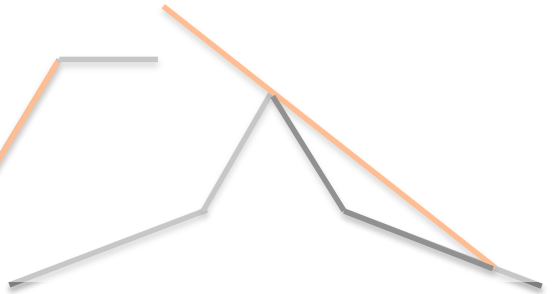
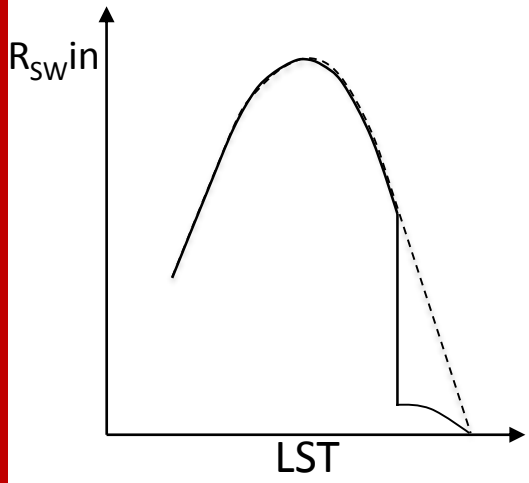


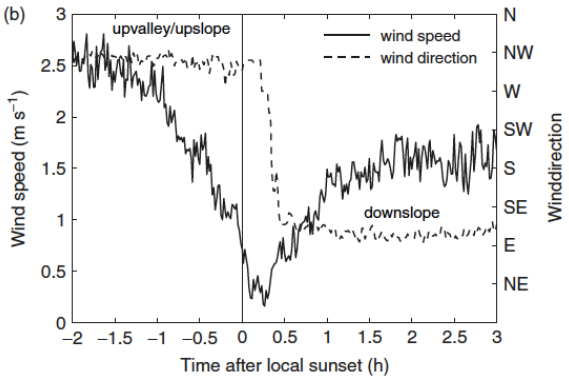
Meteor Crater, Arizona
Martinez et al. 2013
JAMC



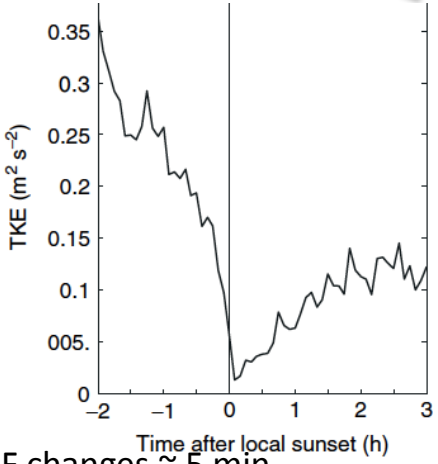
East Slope
MATERHORN, Utah







Wind changes ~ 20 min



Surface HF changes ~ 5 min

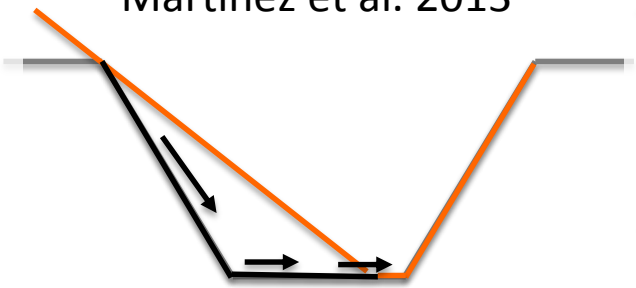
Shadow Front

Shadow Front

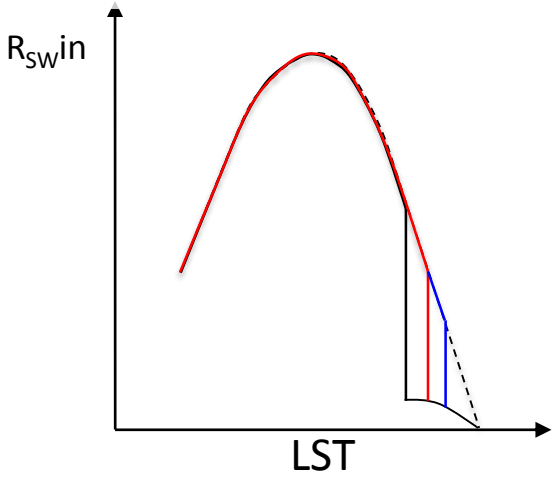
Generalizing the Impact of Shadow Fronts on slope valley transition dynamics and turbulence

La Fouly-Suisse
Nadeau et al. 2012
QJRMS

Meteor Crater, Arizona
Martinez et al. 2013



East Slope
MATERHORN, Utah

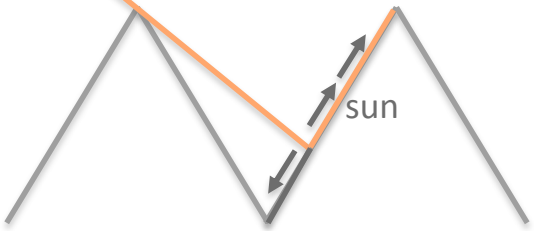


- 15 minutes after sunset inversions formed, sensible HF switches signs
- Delayed responses in Wind Direction Change: ~ 1hr after sunset on west upper slope to before sunset on crater floor
- Apparently, not as strong/immediate response to shadow

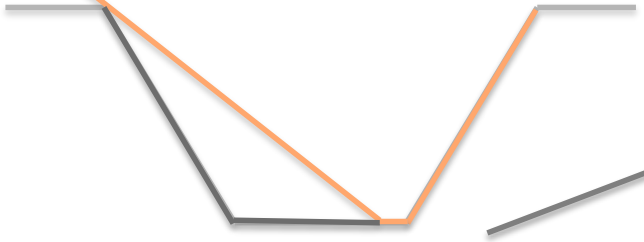
Shadow Front

Generalizing the Impact of Shadow Fronts on slope valley transition dynamics and turbulence

La Fouly-Suisse
Nadeau et al. 2012
QJRMS



Meteor Crater, Arizona
Martinez et al. 2013



East Slope of
MATERHORN, Utah

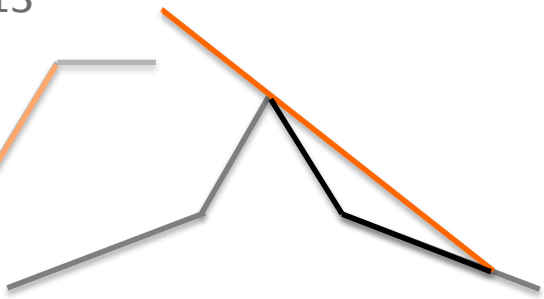


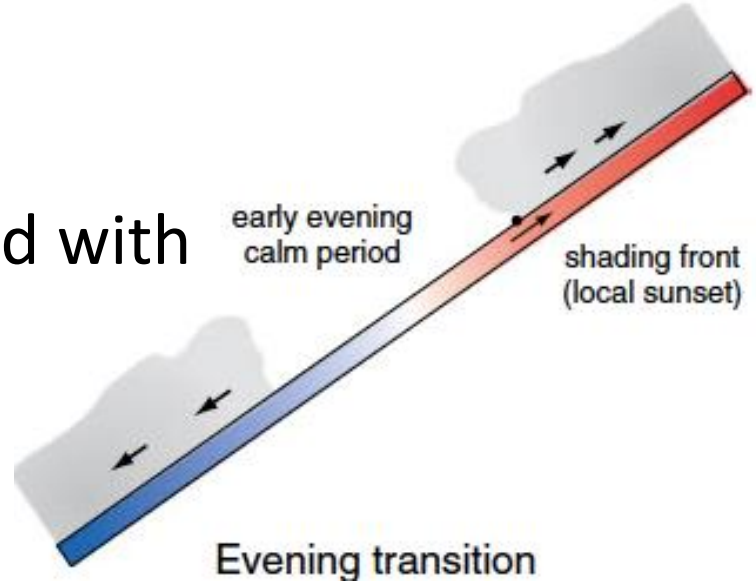
Photo Courtesy of Stephan DeWekker

Shadow Front

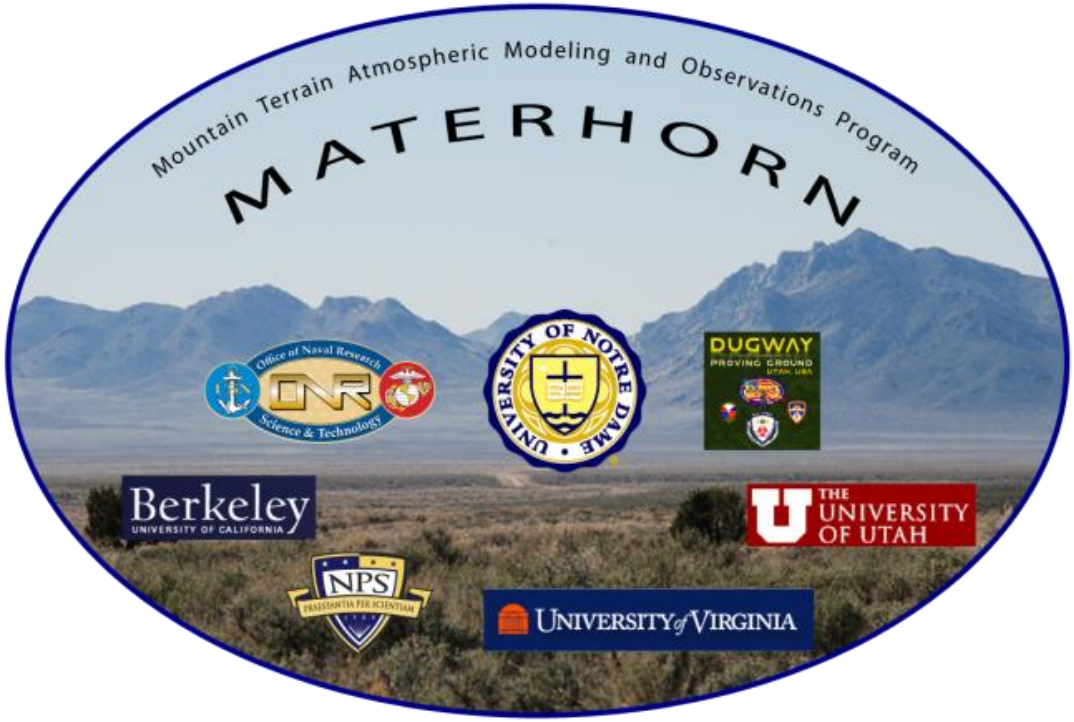
Shadow Front Notes from Steep Slopes:

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)



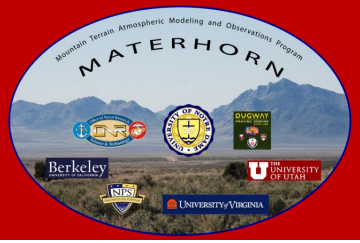
MATERHORN



Collaborators

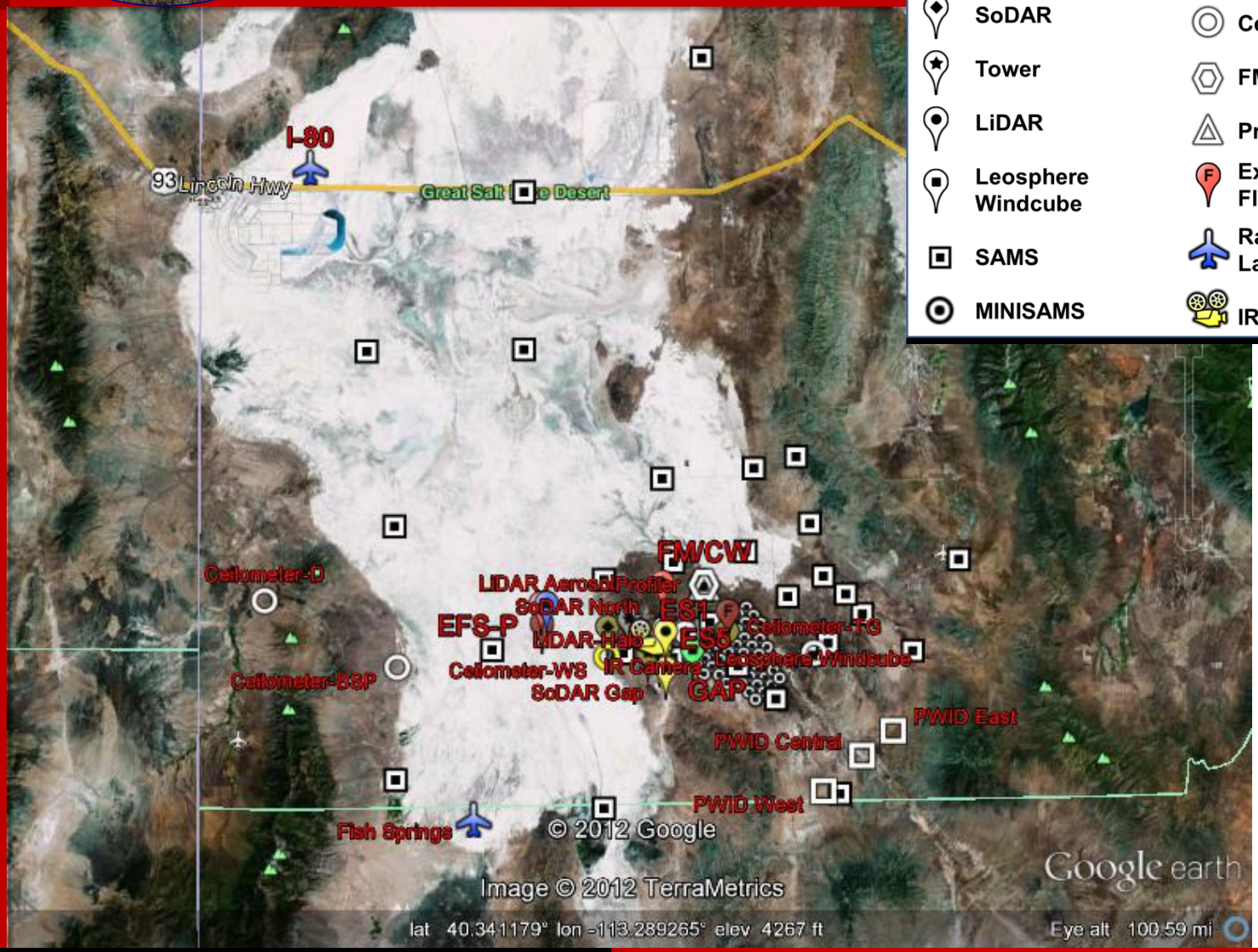
NCAR
Princeton University
Oregon State University
University of Colorado, Boulder

IIBR, Israel
University of Vienna, Austria
Institut Mational de la Recherche Scientifique
Army Research Laboratory

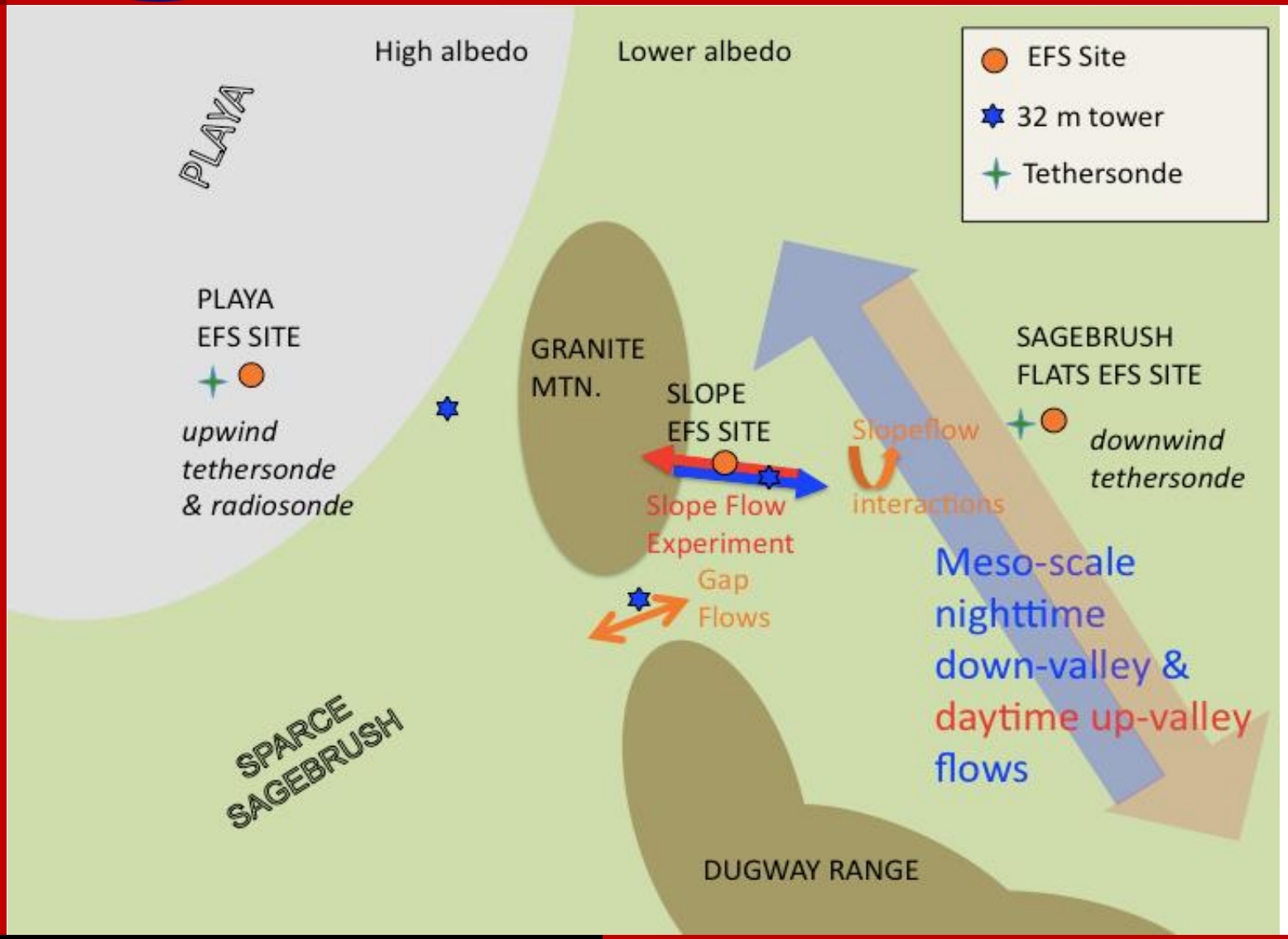


MATERHORN Goals

1. Identify and study the limitations of current state-of-the-science mesoscale models for mountain-terrain weather prediction
2. Develop scientific knowledge, technologies and tools to help realize leaps in predictability
3. **Identify and address knowledge gaps**, e.g.
   - **Transition periods**
   - Integrate across scales (dissipation scales of turbulence to synoptic scales)
   - **Poorly understood physical processes**
4. Utilize both traditional and novel techniques to attack the problem

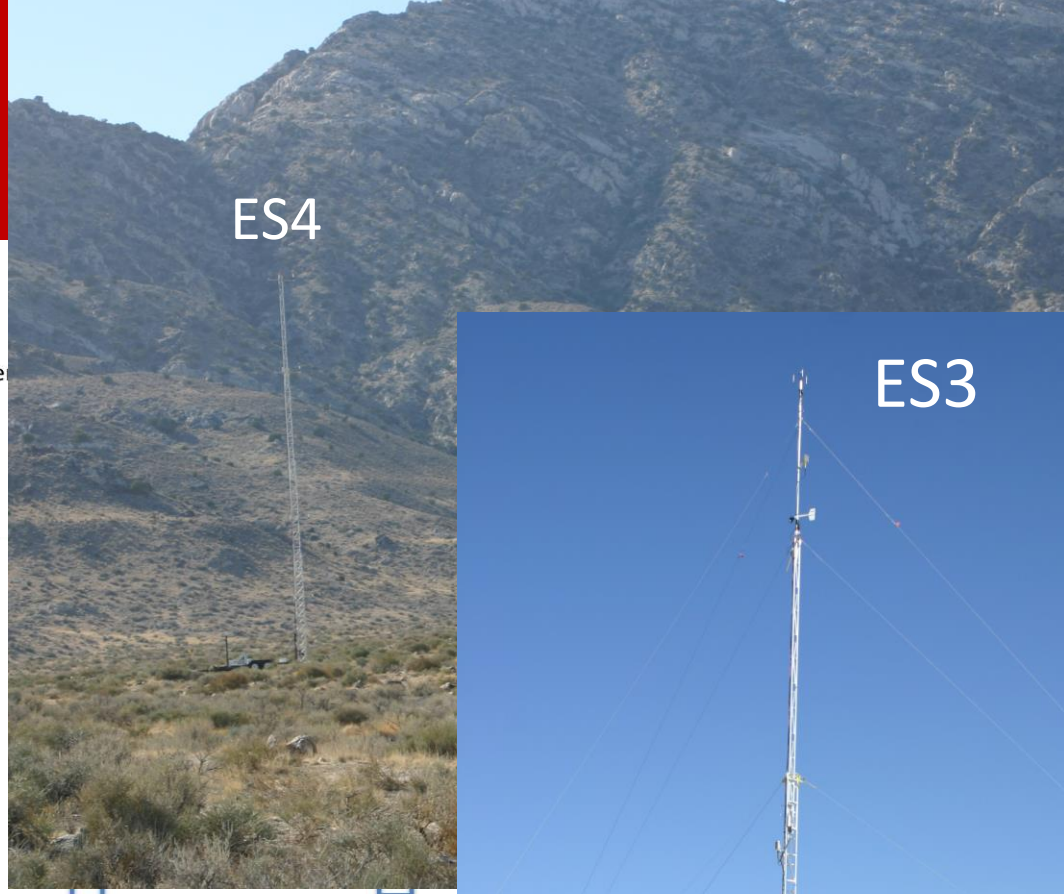

Instrument Type
(distinguish by shape)
Balloon
SoDAR
Tower
LiDAR
Leosphere Windcube
SAMS
MINISAMS
PWID
Ceilometer
FM/CW
Profiler
Extended Flux Site
Radiosonde Launch Site
IR Camera
I-80
93 Lincoln Hwy
Great Salt Lake Desert
Ceilometer-C
FM/CW
LIDAR Aerosol Profiler
SoDAR North
EFS-P
ES1
ES5
Ceilometer-TG
LiDAR-Halo
Leosphere Windcube
Ceilometer-WS
IR Camera
Ceilometer-BSP
SoDAR Gap
GAP
PWID East
PWID Central
PWID West
Fish Springs
© 2012 Google
Image © 2012 TerraMetrics
Google earth
lat 40.341179° lon -113.289265° elev 4267 ft
Eye alt 100.59 mi

Diurnal Flow Overview



MATERHORN-Fall

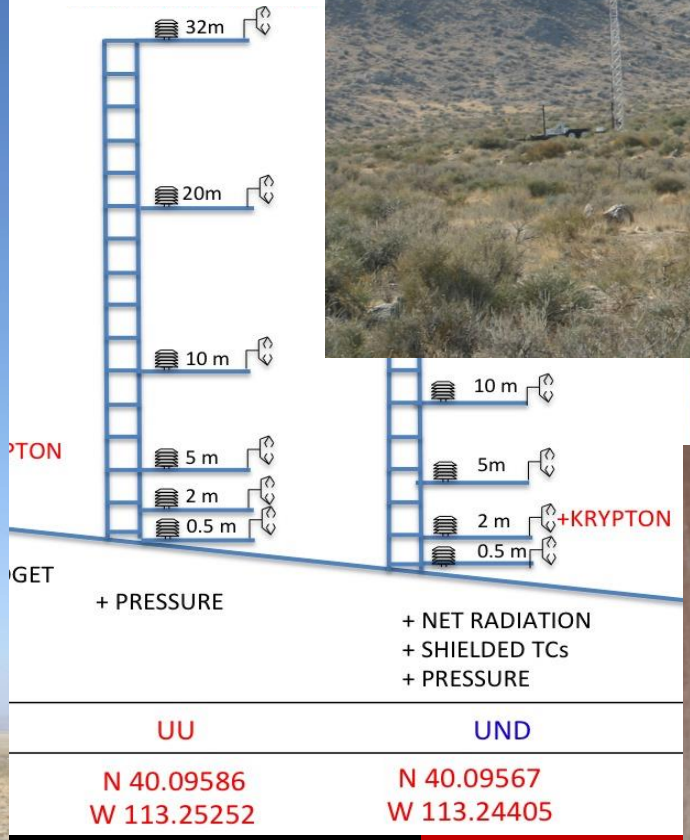
1. Conducted at the US Army Dugway Proving Grounds from 25 September through 21 October, 2012
2. Consisted of ten 24-hour long IOPs
   - 5 Quiescent (700mb winds < 5ms^{-1})
   - 4 Moderate (700mb winds 5-10ms^{-1})
   - 1 Transitional (dry cold front passage)
   - 6 “Nighttime” IOPs (1400LT start)
   - 2 “Daytime” IOPS (0200LT start)
   - 1 “Mini-IOP” (1200LT-2000LT)
   - 1 “Super-IOP” (0500LT-1200LT+1day)
3. 2 Precipitation Events (Sept 24, Oct 12)



Granite Mountain

PE ES4

DPG 32 m mobile towe
DPG sonics & T/RH

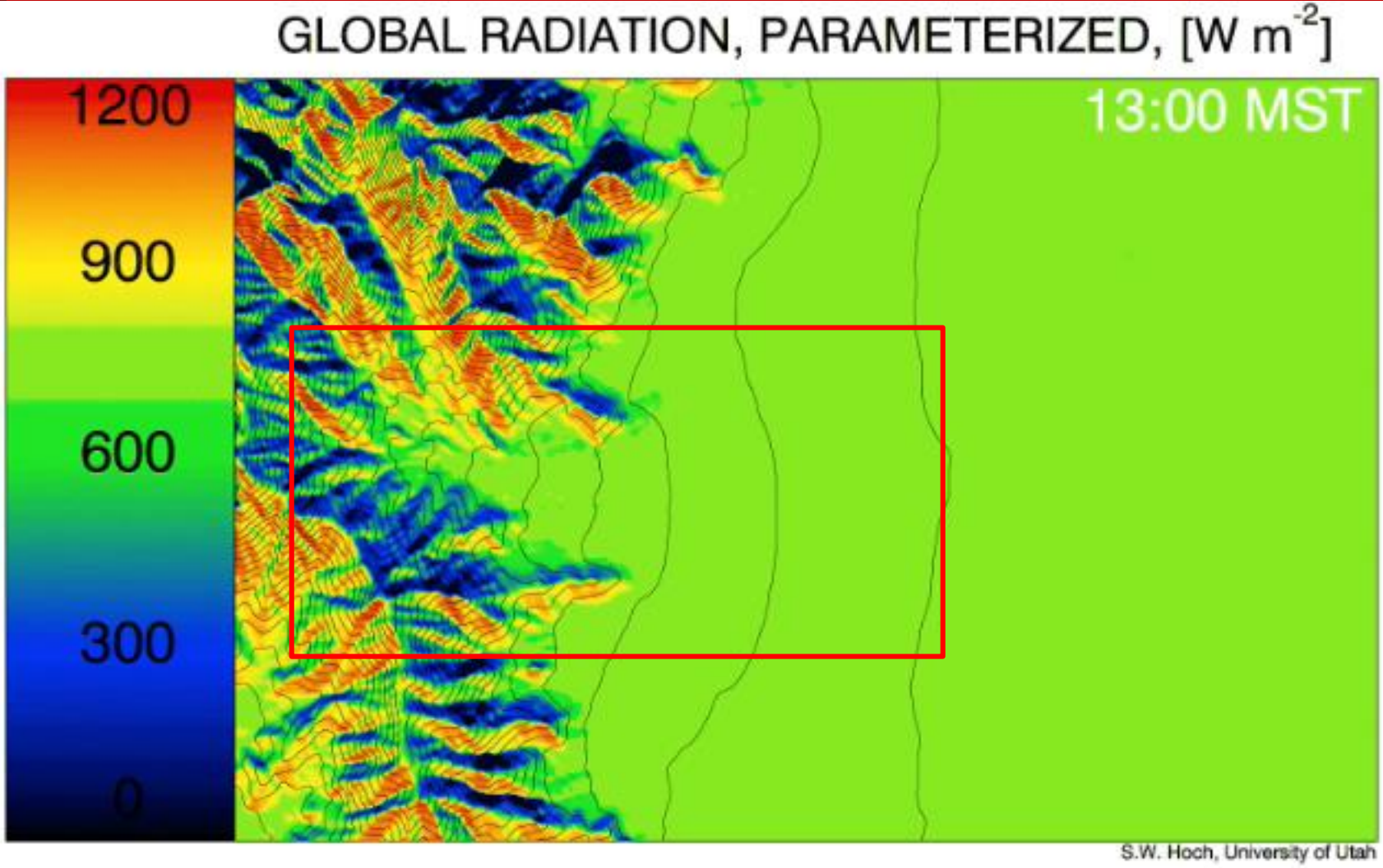


UU	UND
N 40.09586 W 113.25252	N 40.09567 W 113.24405

E.R. Pardyjak et al.

MATERHO

Shadow Front – IOP 8
18 October 2012

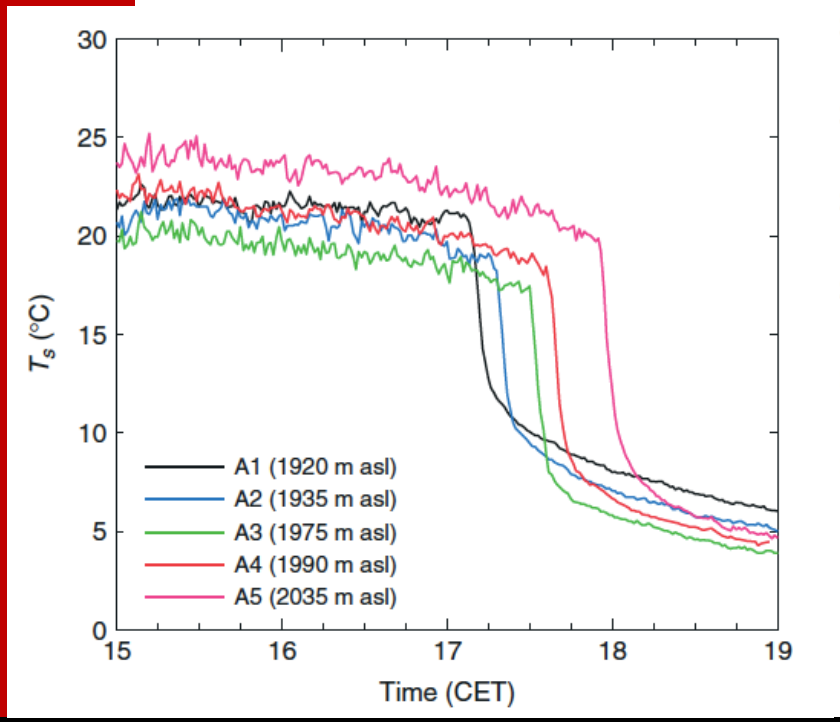


18 October 2003
Evening Transition Shadow Front

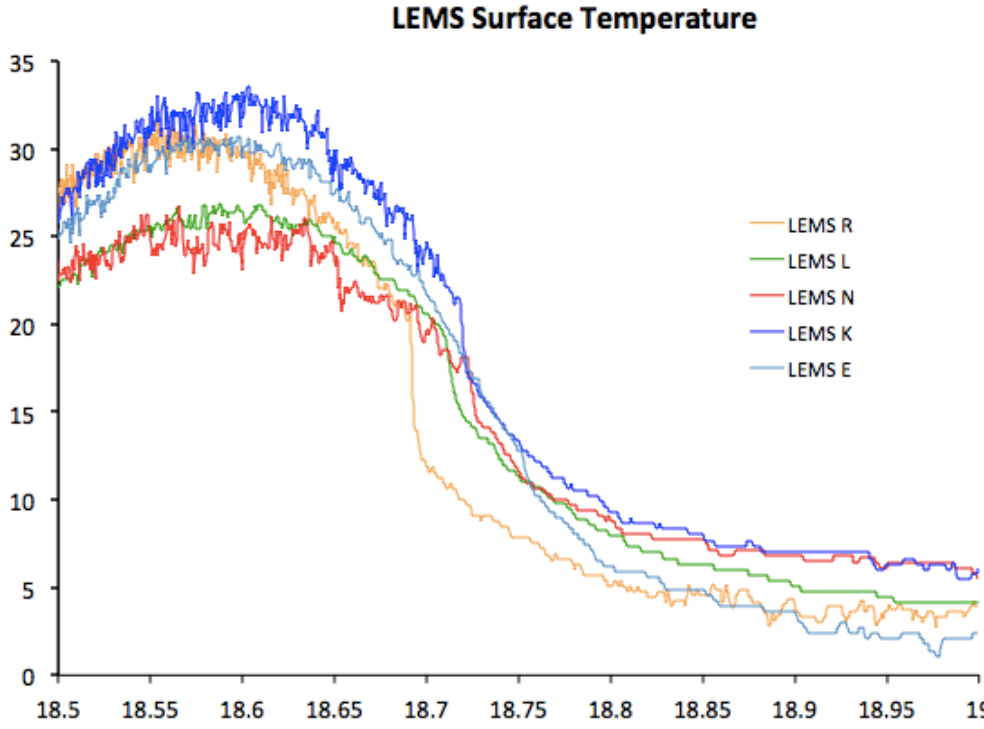
Surface Temperature

La Fouly

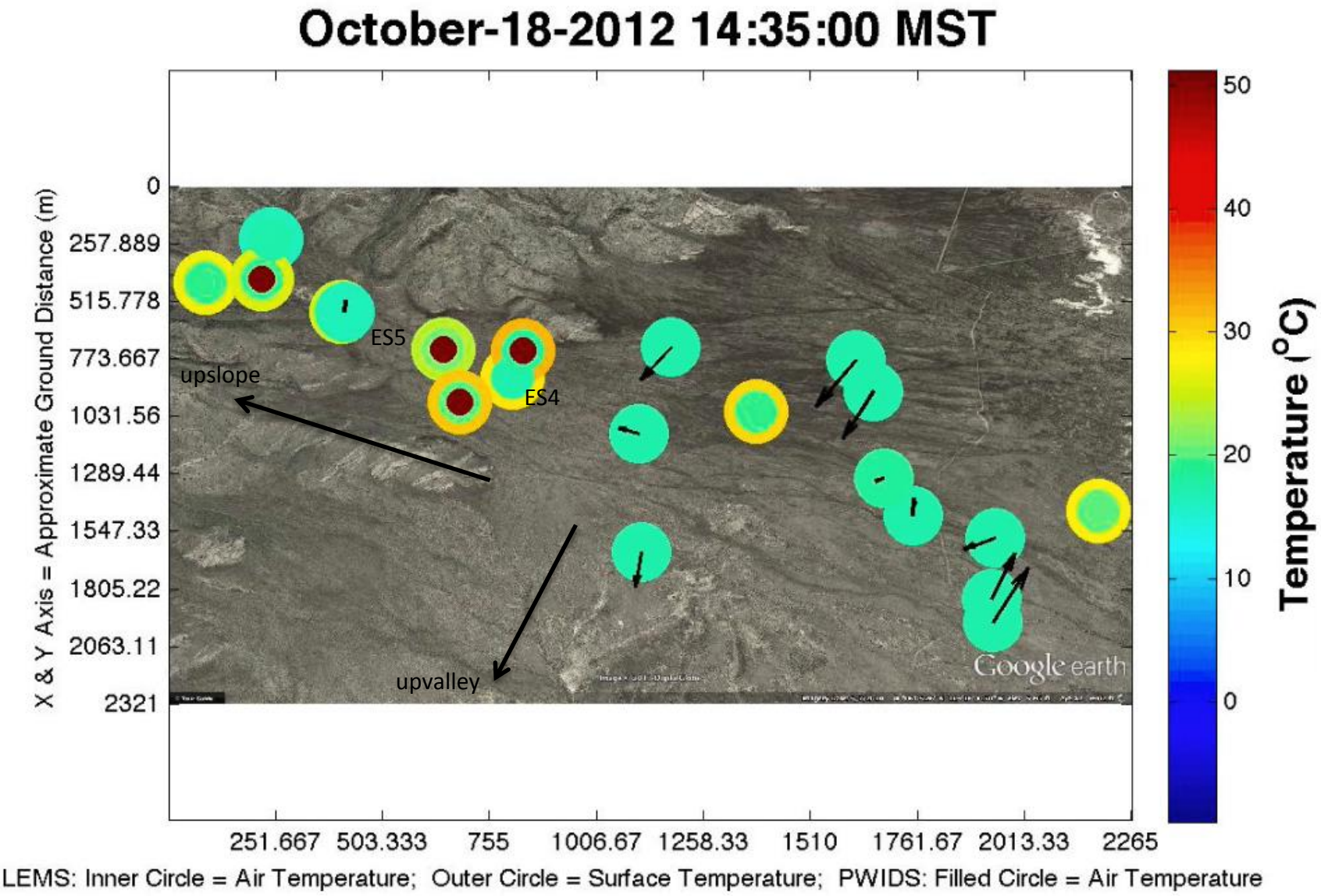
Nadeau et al. 2012



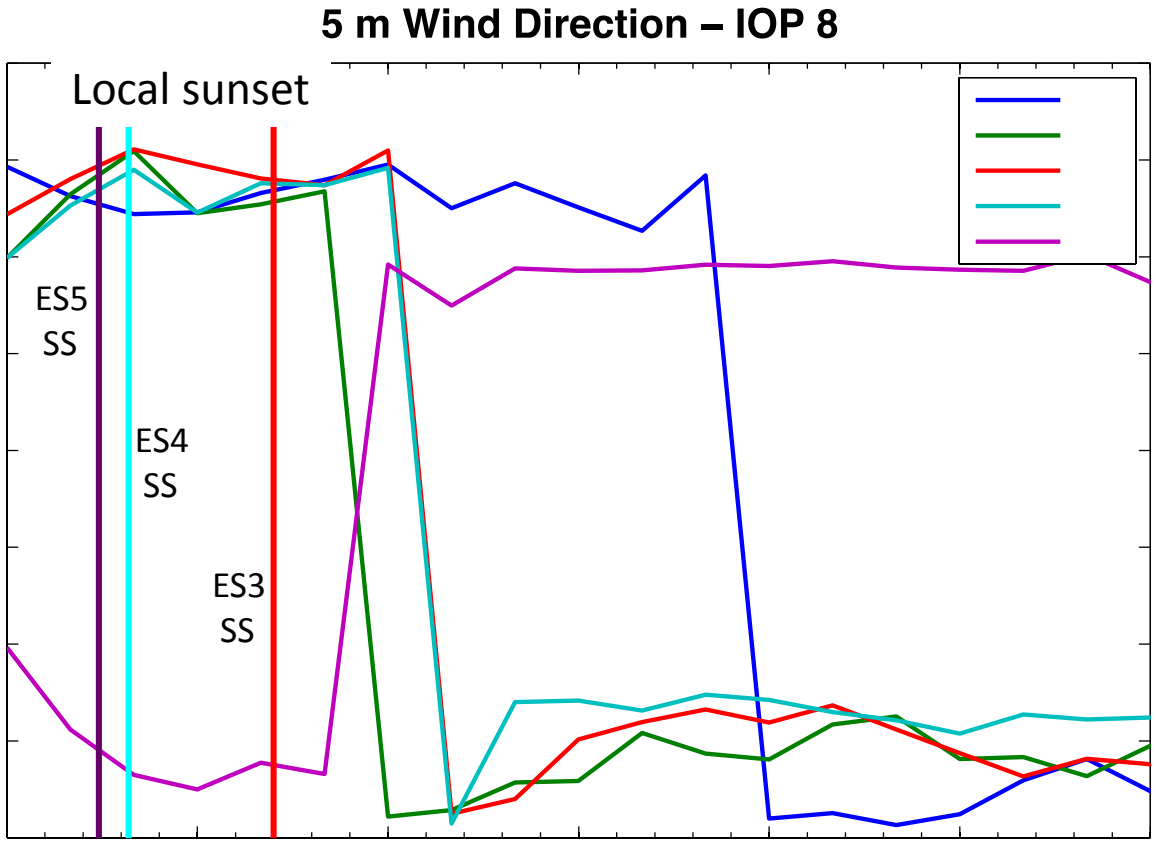
East Slope



LEMS Station Data

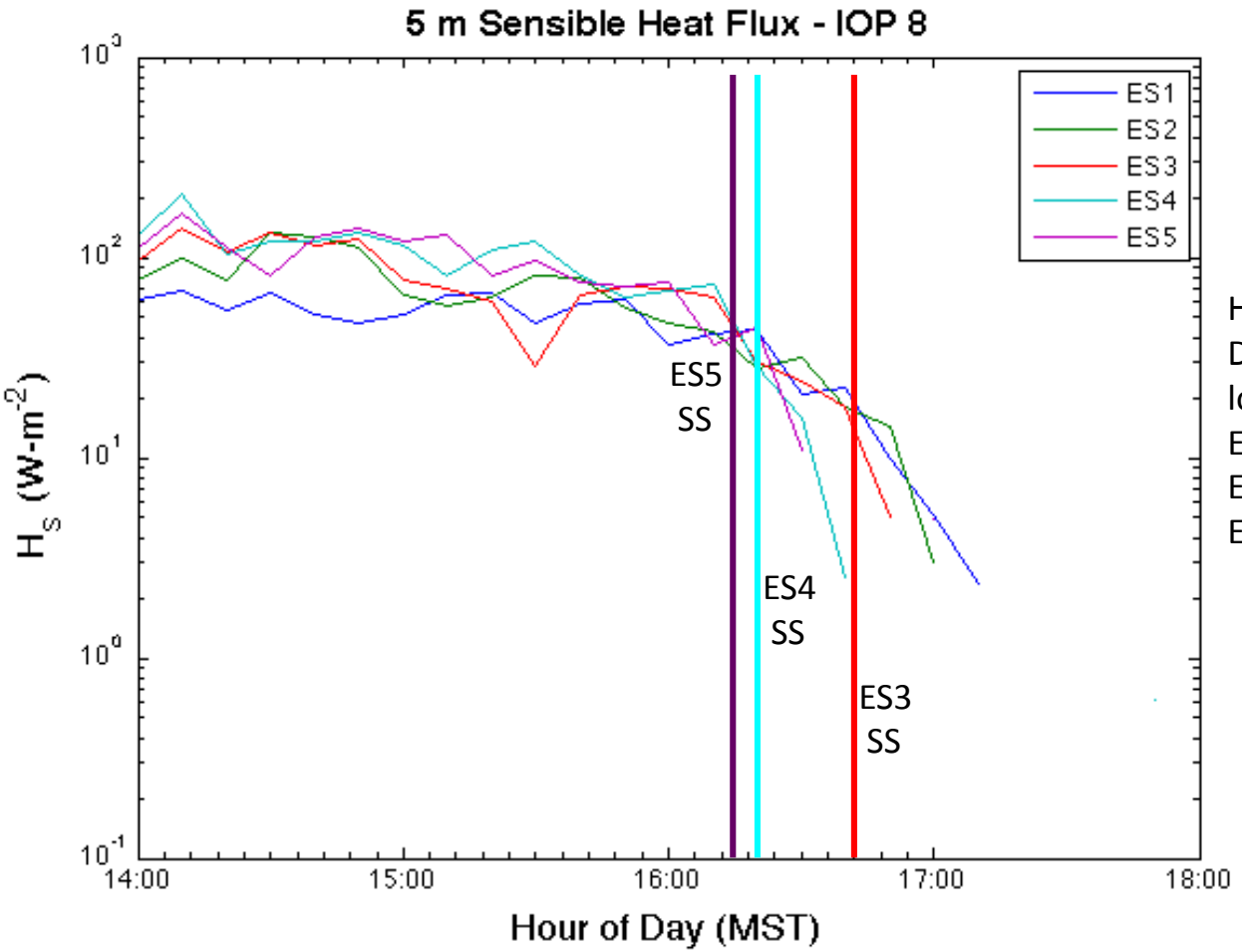


Wind Direction



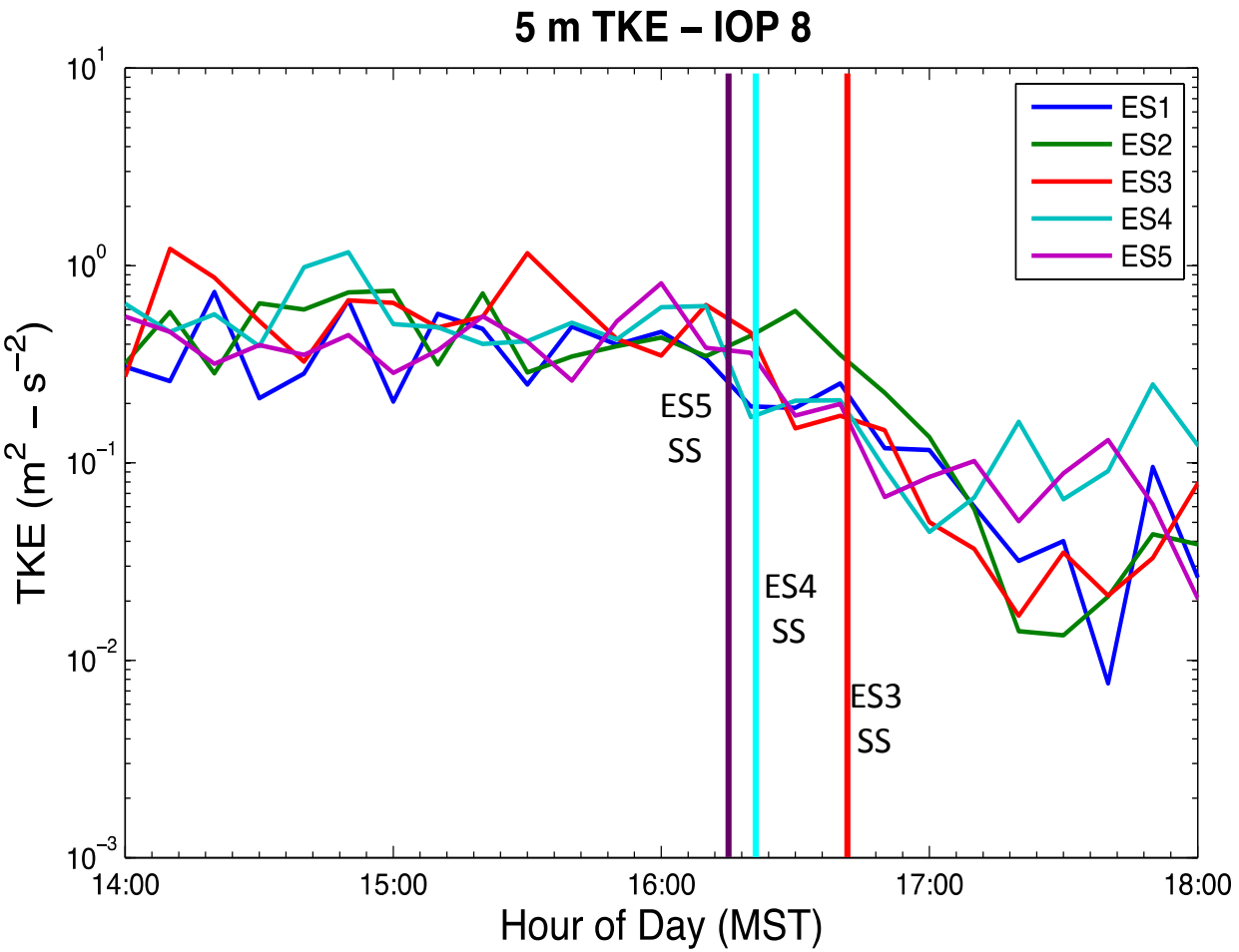
Wind Shift Delays from local sunset:
ES5 ~ 45 min
ES4 ~ 40 min
ES3 ~ 28 min

Near Surface Sensible Heat Flux



Heat Flux Delays from local sunset:
ES5 ~ 16 min
ES4 ~ 18 min
ES3 ~ 7 min

TKE Decay



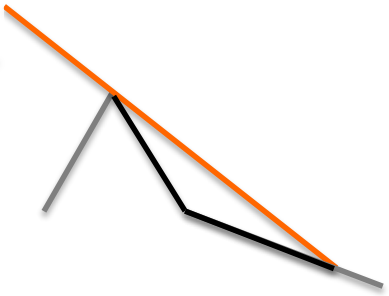
Summary

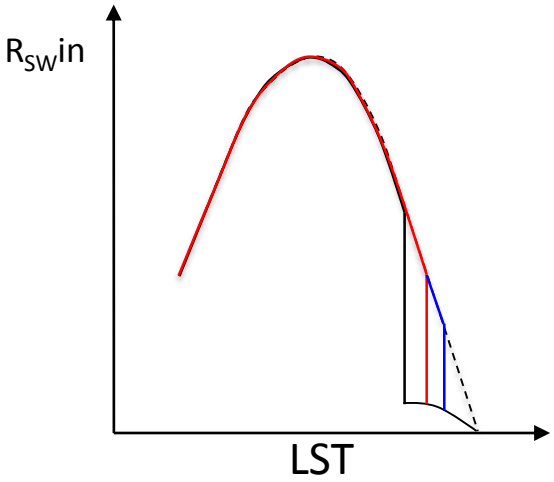
Generalizing the Impact of Shadow Fronts on slope valley transition dynamics and turbulence

La Fouly-Suisse
Nadeau et al. 2012
QJRMS

Meteor Crater, Arizona
Martinez et al. 2013

East Slope
MATERHORN, Utah





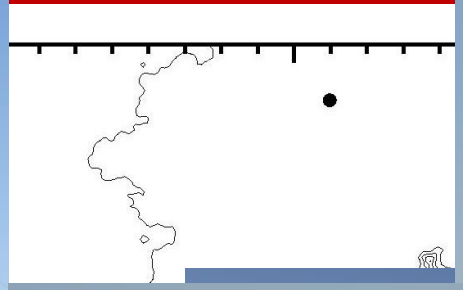
Observations of the Shadow Front at East Slope

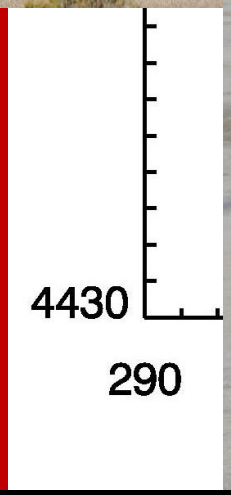
- Winds on East Slope do not transition with the shadow front as in LaFouly
- The surface temperature drop due to the shadow passage decreases with distance down the slope
- "Lost" Radiation from the slope decreases with distance down slope

Questions?

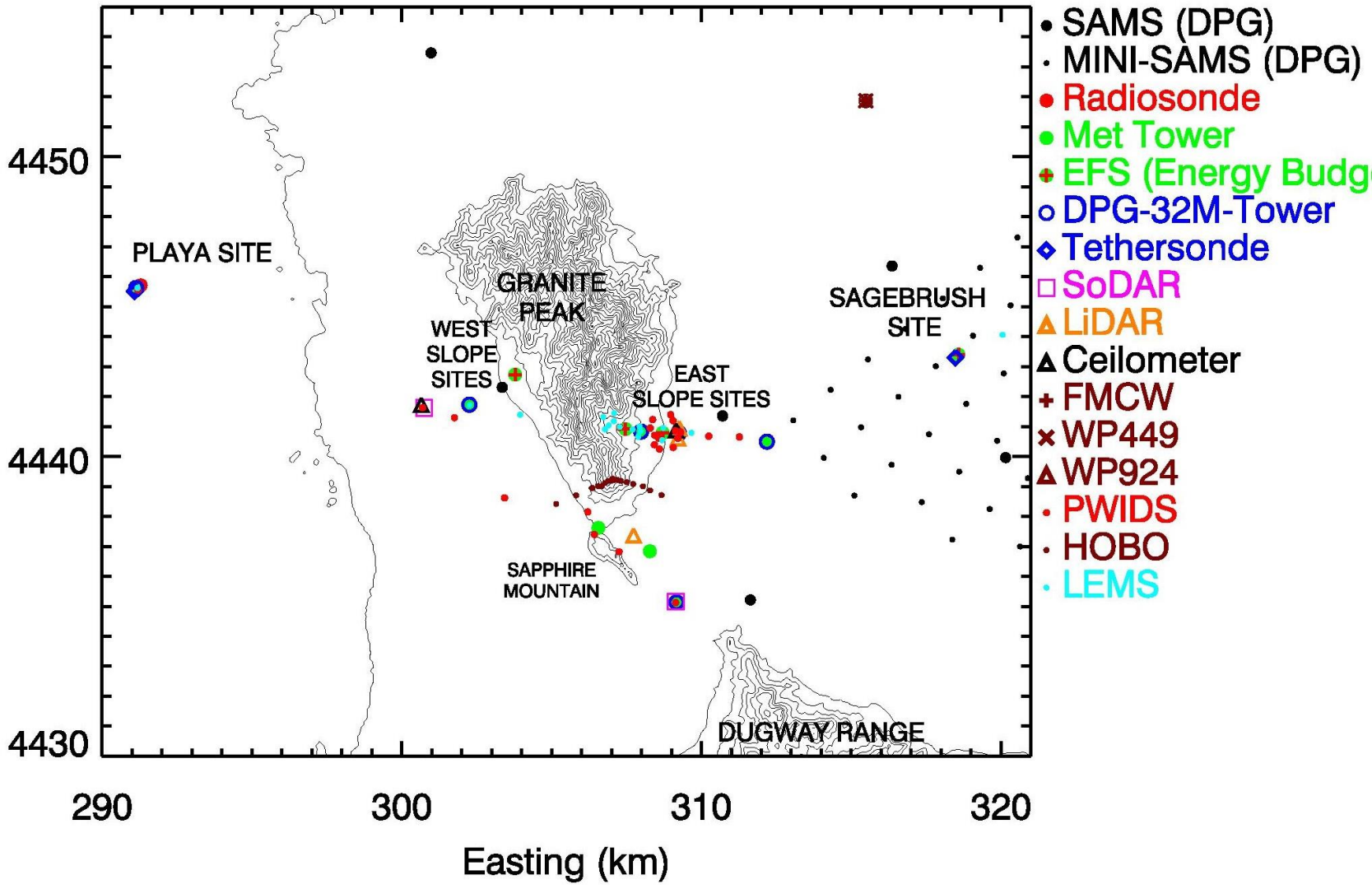
This research was funded by the Office of Naval Research Award # N00014-11-1-0709, Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) Program. Additional support for the Twin Otter was provided by the Environmental Sciences group at the Army Research Office (ARO).


ORN
DUGWAY
THE UNIVERSITY OF UTAH




4430
290

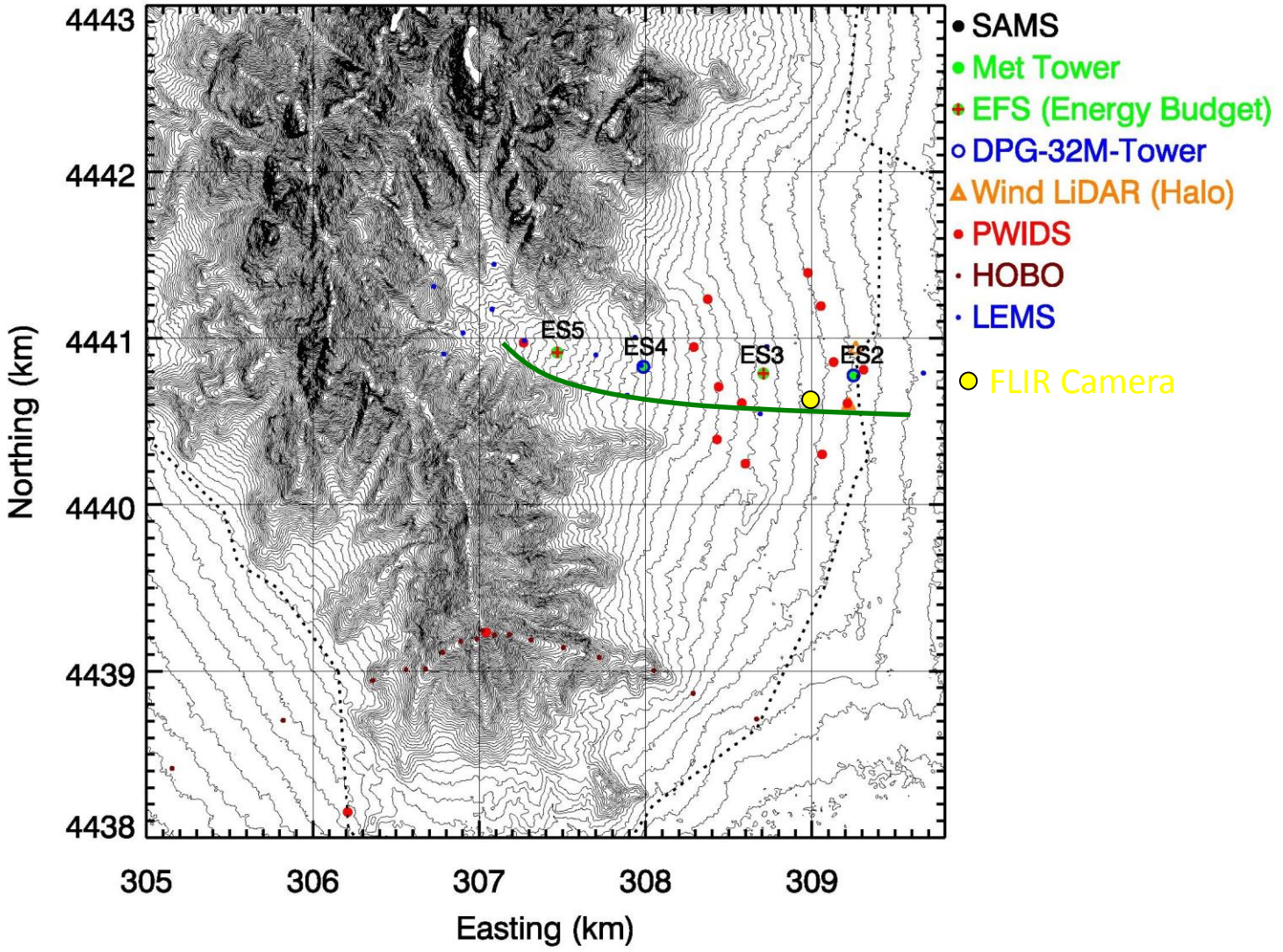
Overview



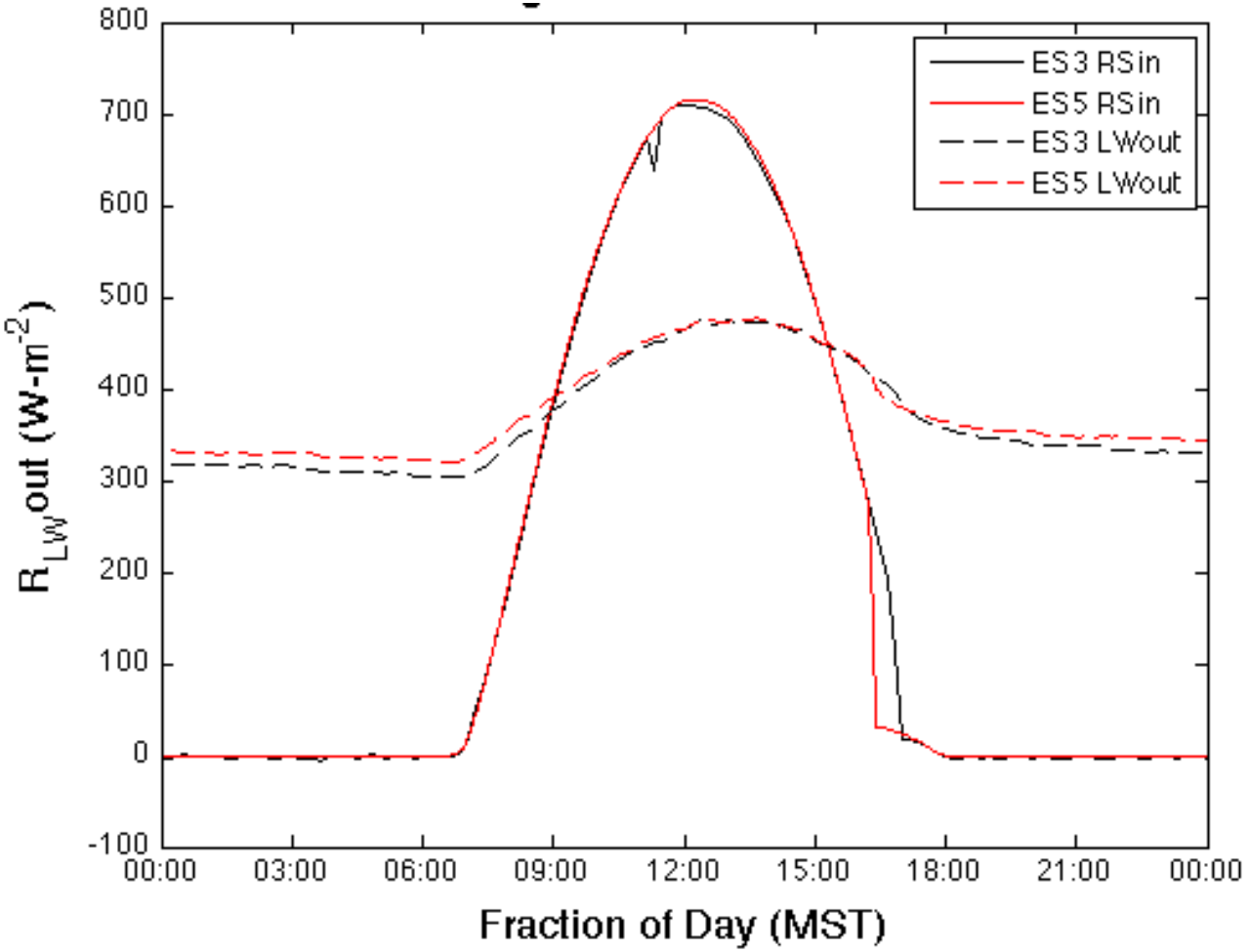
Experiment Details

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

East Slope



Radiation Balance



Radiation Balance