The Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) Program: The First Field Experiment (MATERHORN-X1)

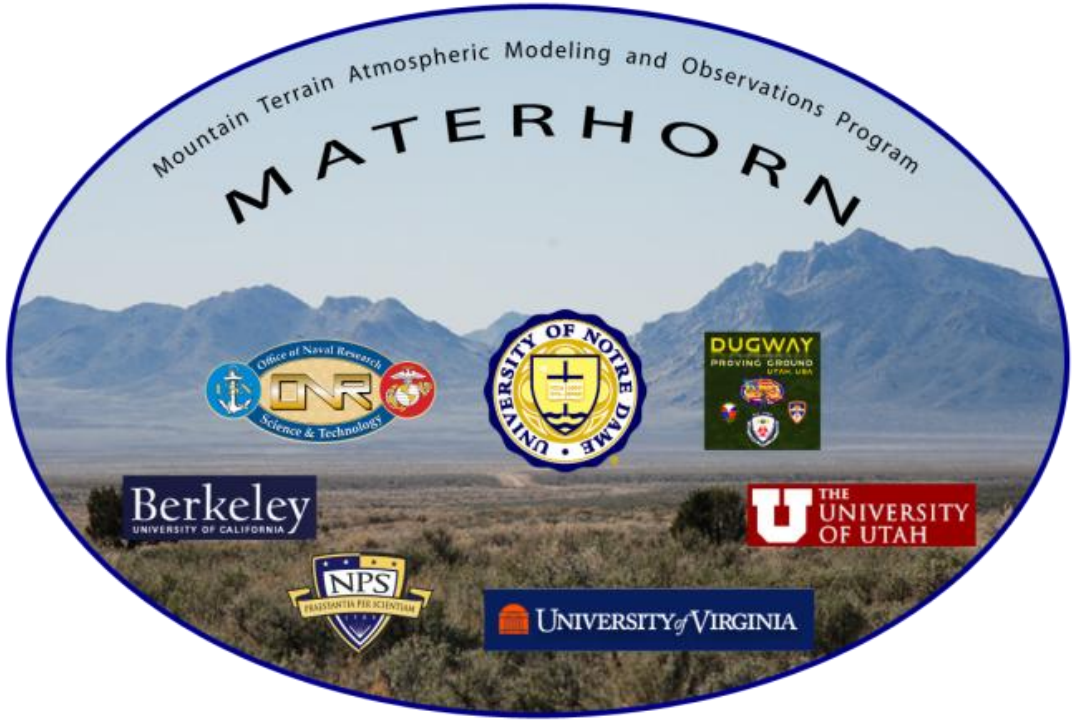
H.J.S. Fernando[1], **E. Pardyjak[2]**, D. Zajic[3],
S. De Wekker[4] and J. Pace[3]
S. Hoch[2], S. Di Sabatino[1], L. Leo[1], M. Jeglem[2], J. Massey[2], J. Steenburgh[2], D. Jensen[2],
V. Kulandaivelu[2], C. Higgins[5], A.Grachev[6]

[1]University of Notre Dame
[2]University of Utah
[3]US Army Dugway Proving Grounds
[4]University of Virginia
[5]Oregon State University
[6]CIRES, University of Colorado, and NOAA/ESRL

December 3, 2012

This research is supported by Office of Naval Research Award # N00014-11-1-0709

MATERHORN-X Team



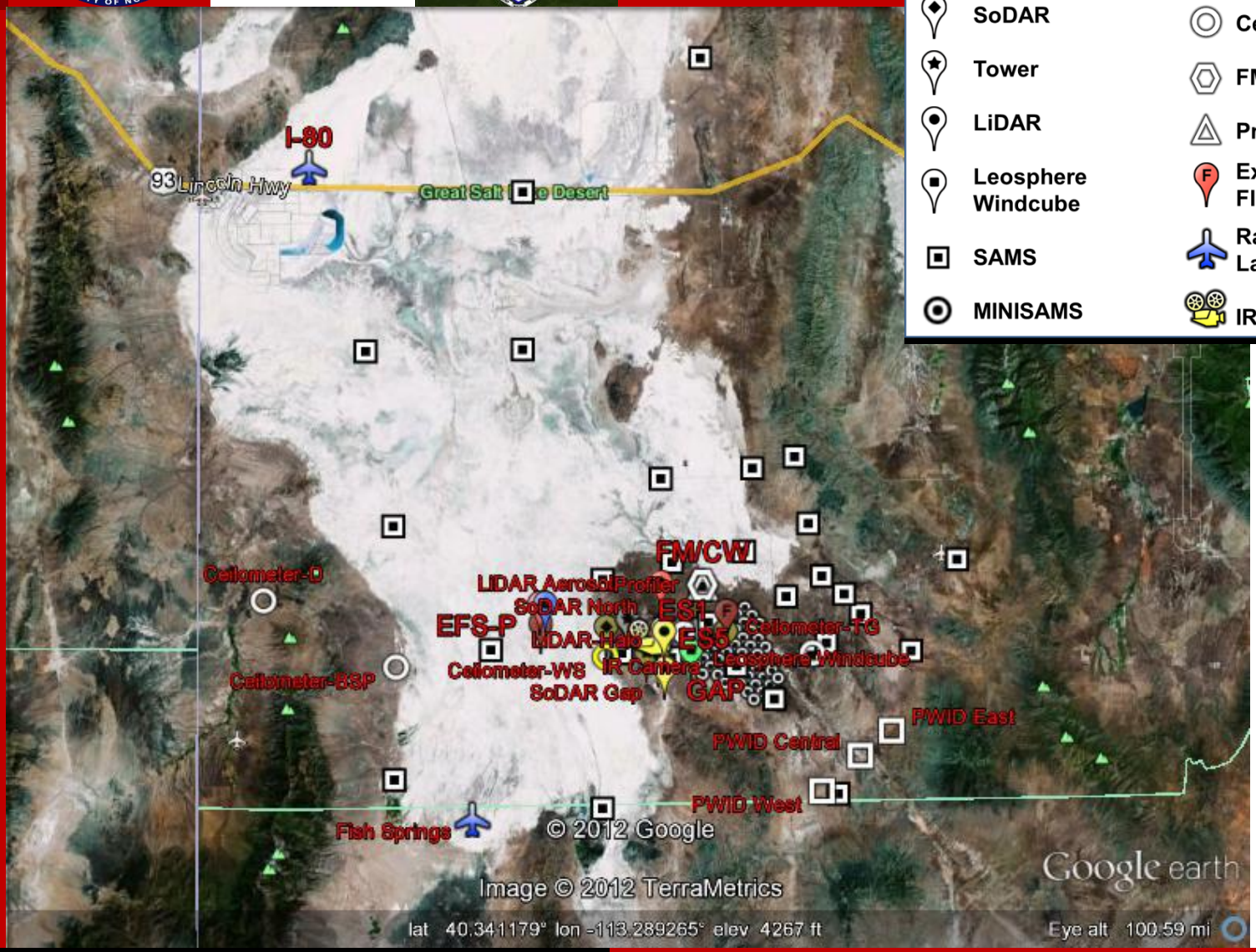
Collaborators

NCAR
Princeton University
Oregon State University
University of Colorado, Boulder

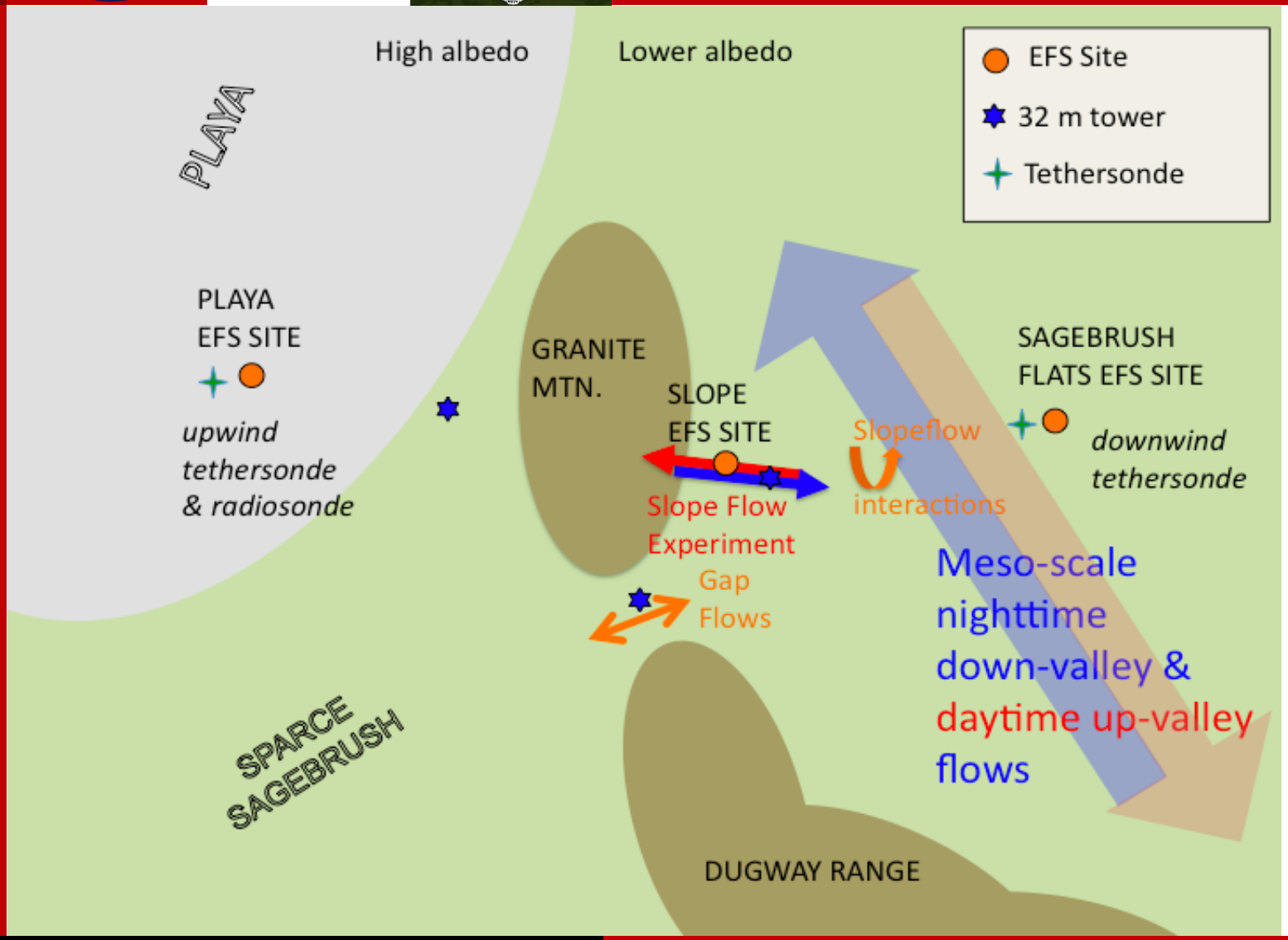
IIBR, Israel
University of Bergen, Norway
University of Vienna, Austria

MATERHORN Goals

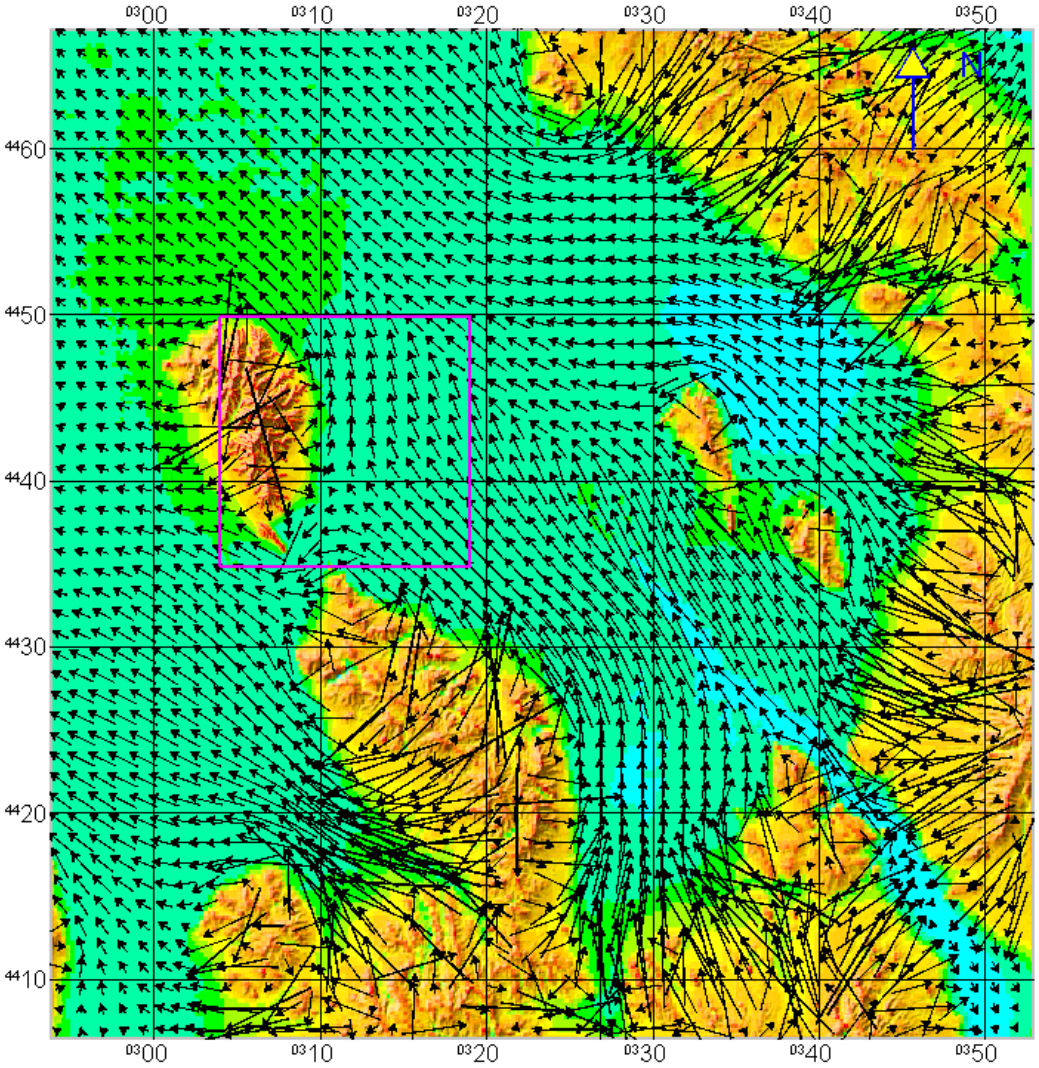
1. Identify and study the limitations of current state-of-the-science mesoscale models for mountain-terrain weather prediction
2. Develop scientific knowledge, technologies and tools to help realize leaps in predictability
3. Identify and address knowledge gaps, e.g.
   - Transition periods
   - Integrate 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-0
FM/CW
LIDAR Aero&Profiler
SoDAR North
ES1
EFS-P
LIDAR-Halo
ES5
Ceilometer-T6
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



Diurnal Flow Overview



Cold–Air Drainage Model KLAM 21

Deutscher Wetterdienst
Modell KLAM_21
V2.008t

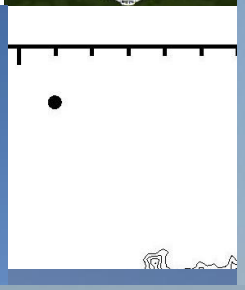
MATERHORN-I

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)

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


UNIVERSITY OF UTAH
FEB. 28TH
MDCCCL
ENVIRONMENTAL FLUID DYNAMICS
UNIVERSITY OF NOTRE DAME
UNIVERSITY of VIRGINIA
DUGWAY
PROVING GROUND
UTAH, USA



Addressing Near-Surface Small scale issues

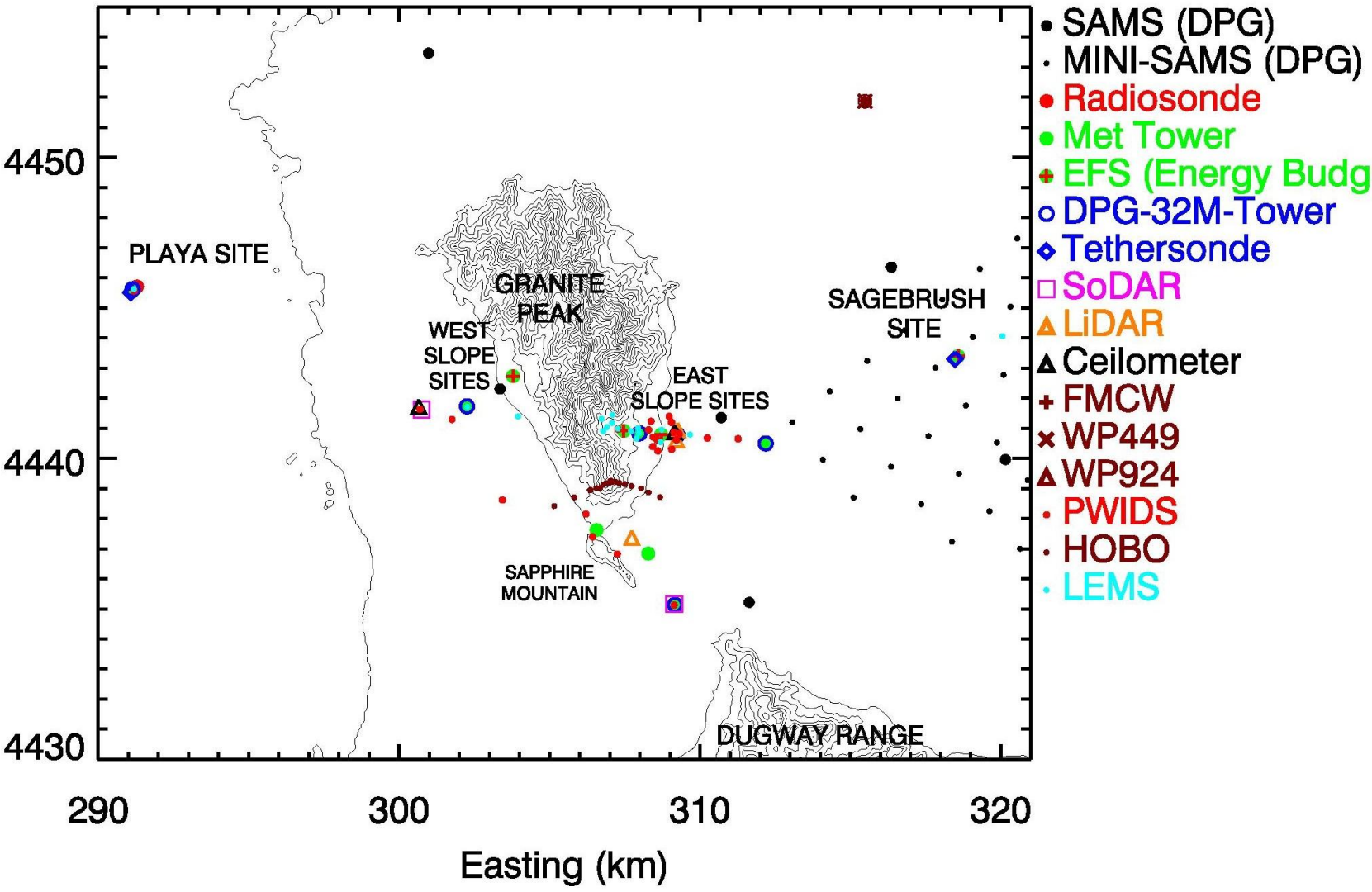
Intro

Site

Results

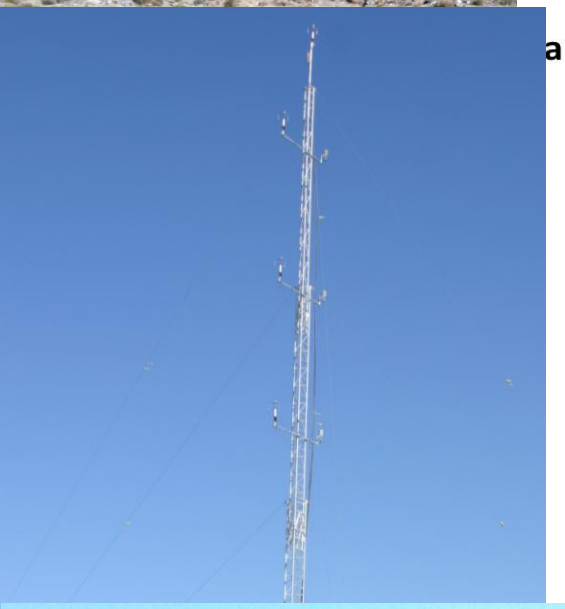
Summary

Overview



UNIVERSITY of VIRGINIA

DUGV PROVING

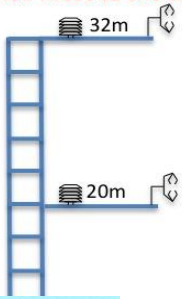


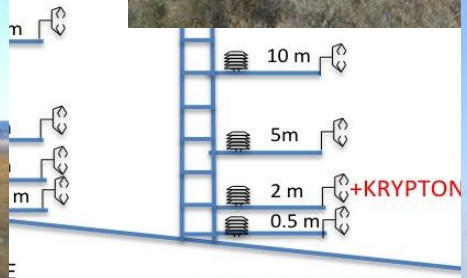
anite Mountain

ES4

DPG 32 m mobile tower
DPG sonics & T/RH

Edited heights & one extra level
2 m and 0.5 m level on small mast to the side?





+ NET RADIATION
+ SHIELDED TCs
+ PRESSURE

UND

86 N 40.09567
252 W 113.24405

MATERHO

Distributed Temperature Sensing

C. Higgins Oregon State

Airborn Doppler Over Complex Terrain

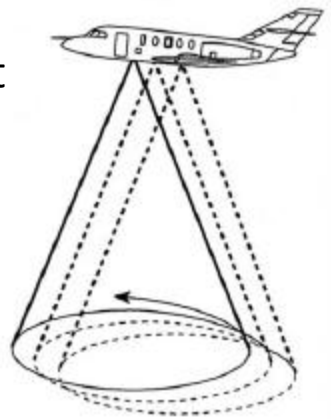
TODWL (Twin Otter Doppler Wind Lidar) has been operated (since 2002) by CIRPAS (Center for Interdisciplinary Remotely Piloted Aircraft Studies), a part of the Naval Postgraduate School, Monterey, CA.

Addition TO Measurements –

- In situ fluxes, surface temperature, Met variables

conical scans below the aircraft

azimuth angle steps of 30°



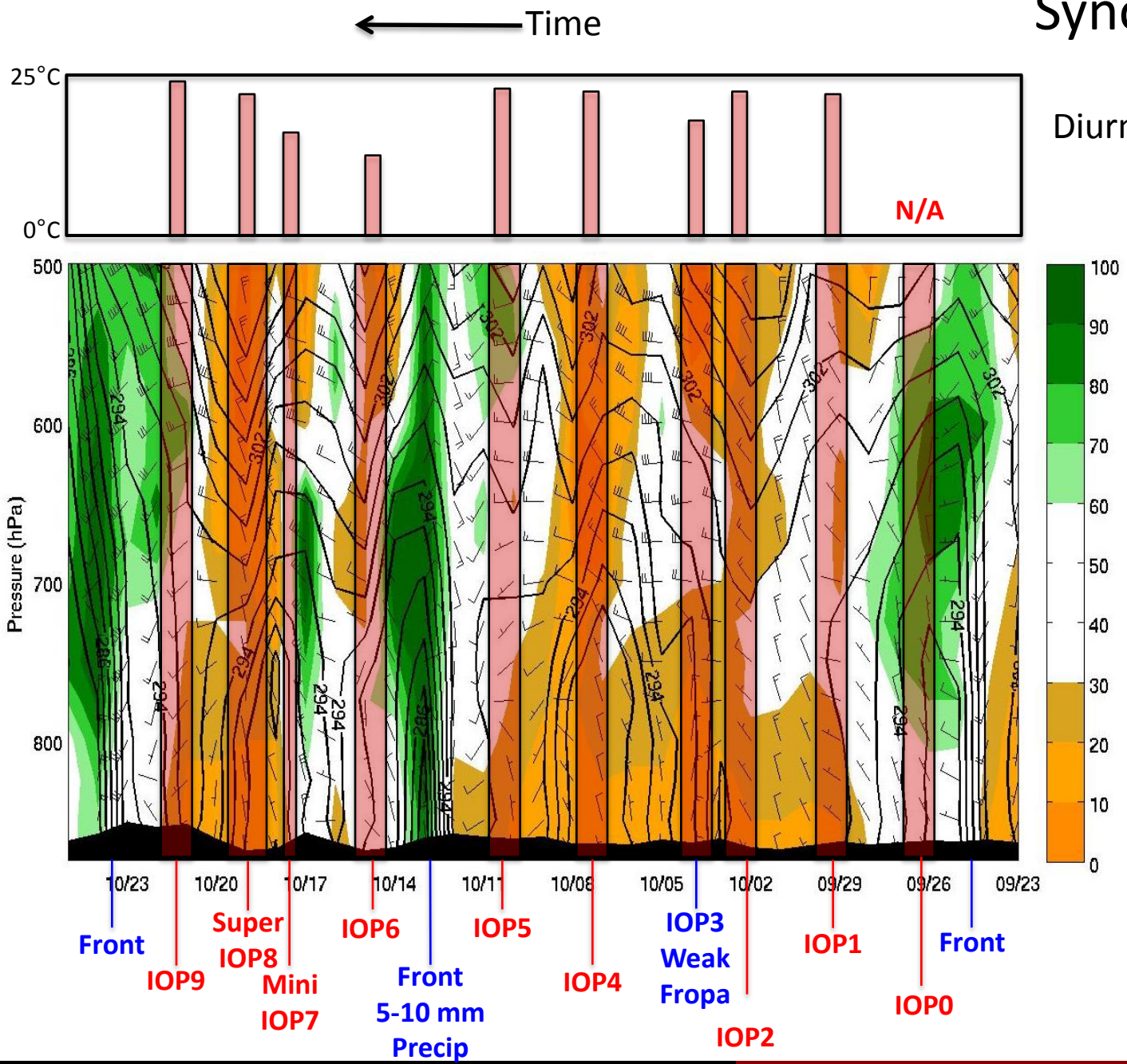
2µm coherent detection

10 cm two axis scanner, side door mounted

Range: .3 – 21km depending upon aerosols

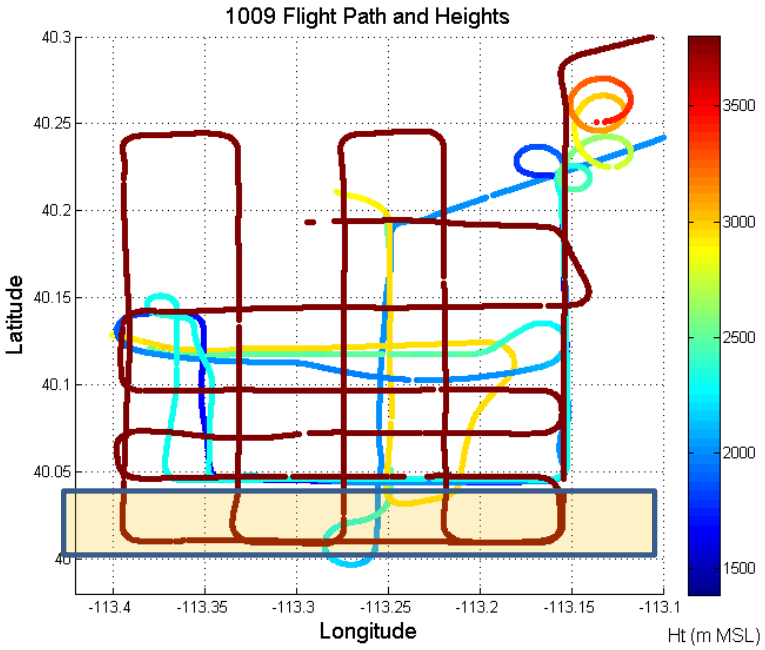
Accuracy: < .10 m/s in three components

Synoptic Summary

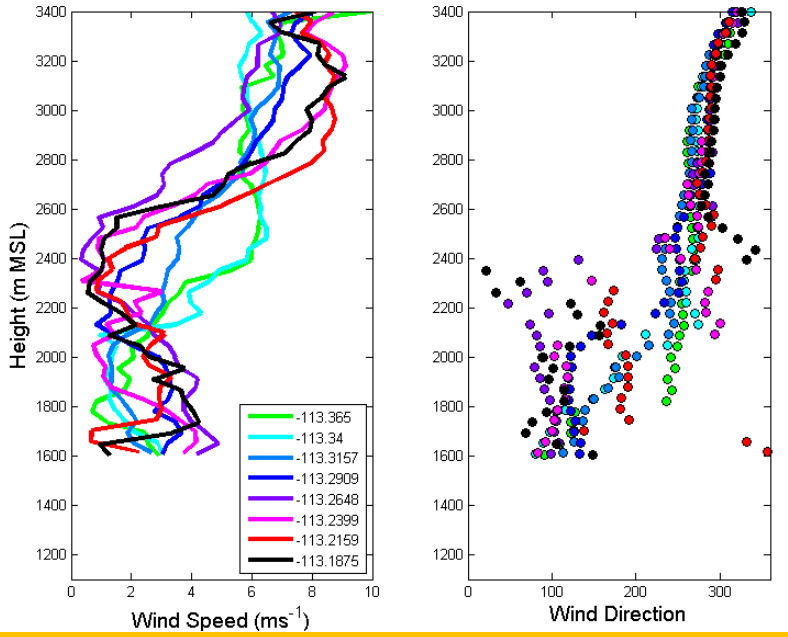


Twin Otter Doppler Wind LIDAR

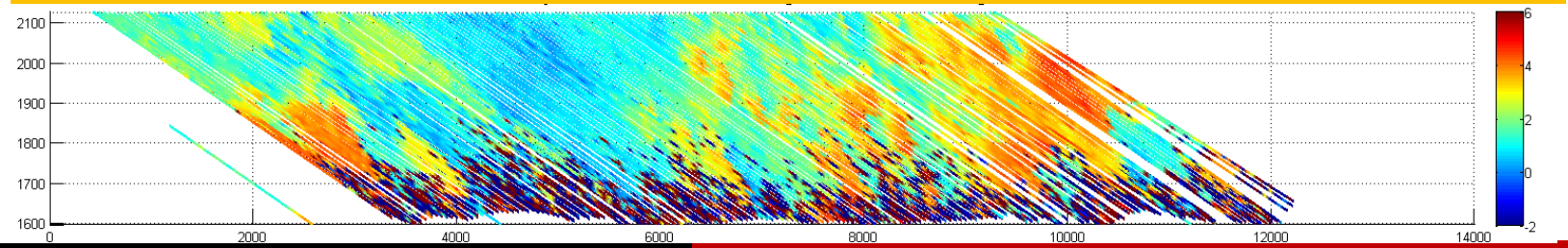
9 October afternoon mission



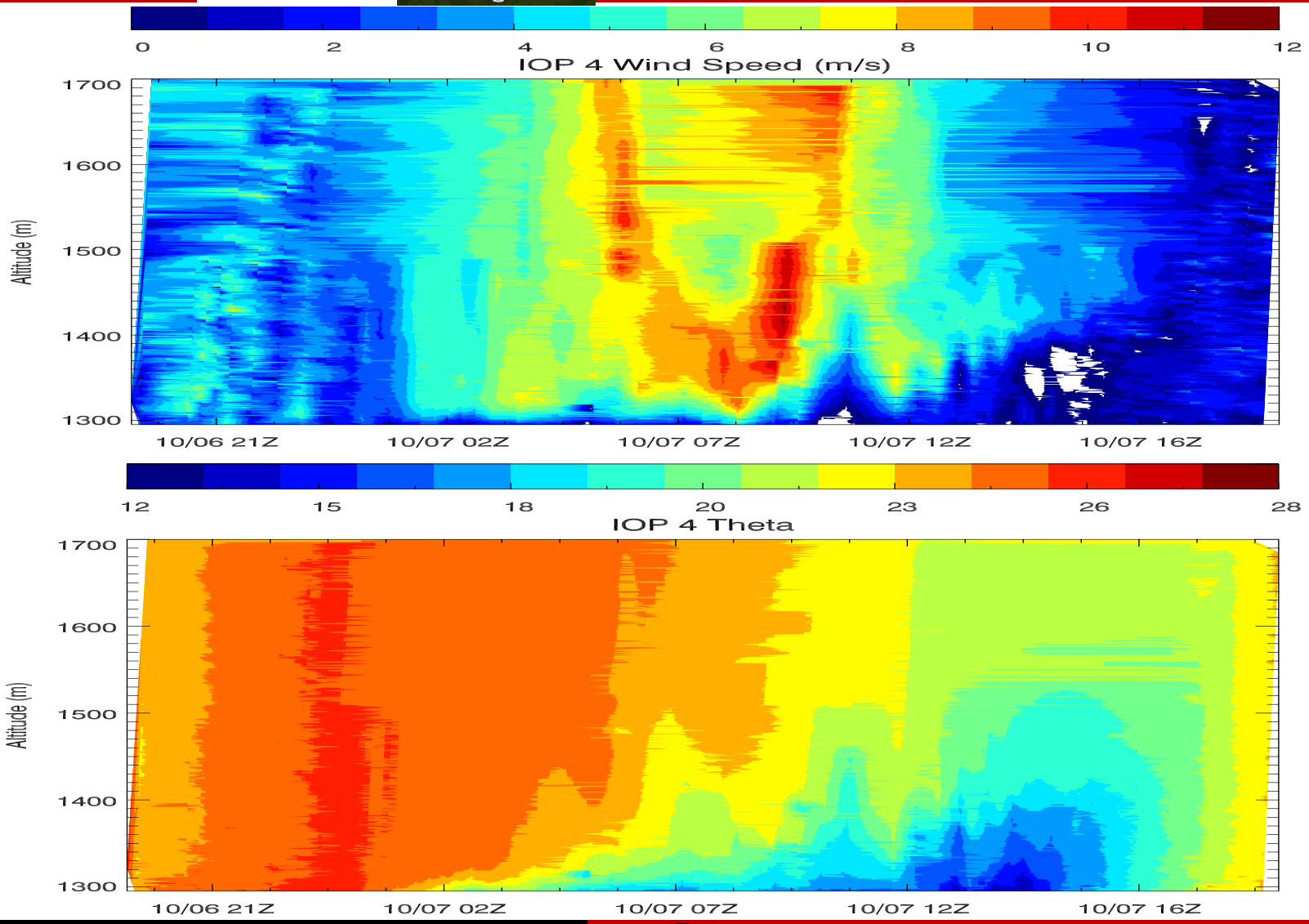
spatial variability of horizontal wind speed and wind direction along southern leg



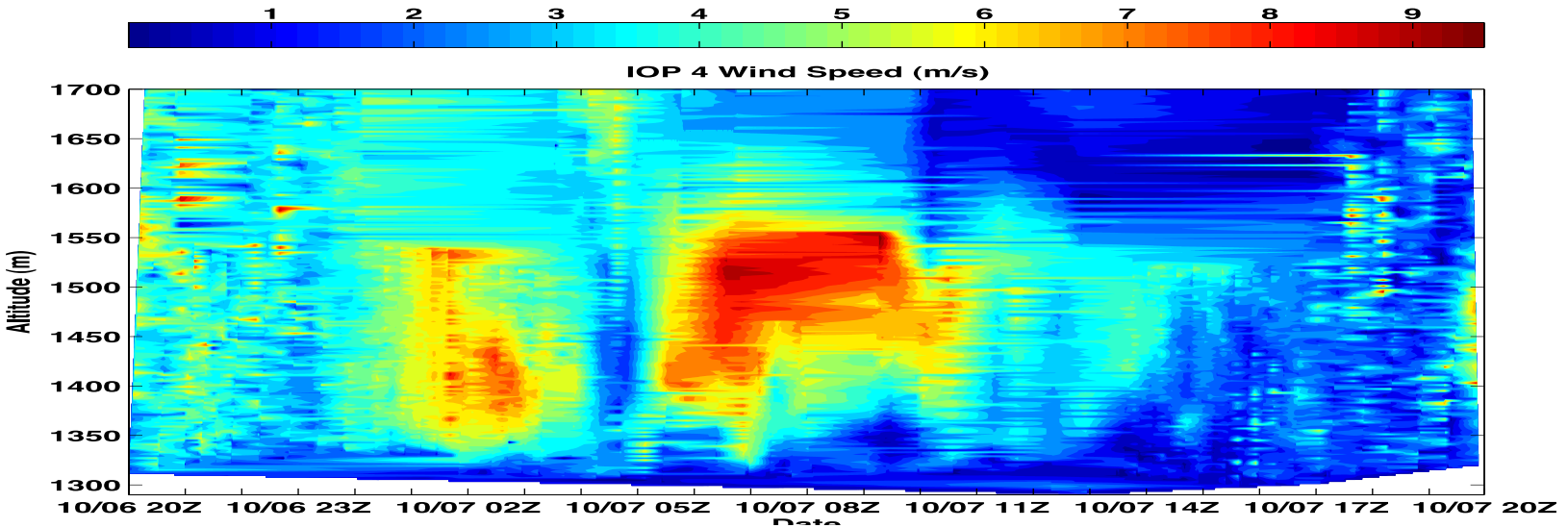
Spatial variability of vertical winds showing semi-organized structures along southern leg

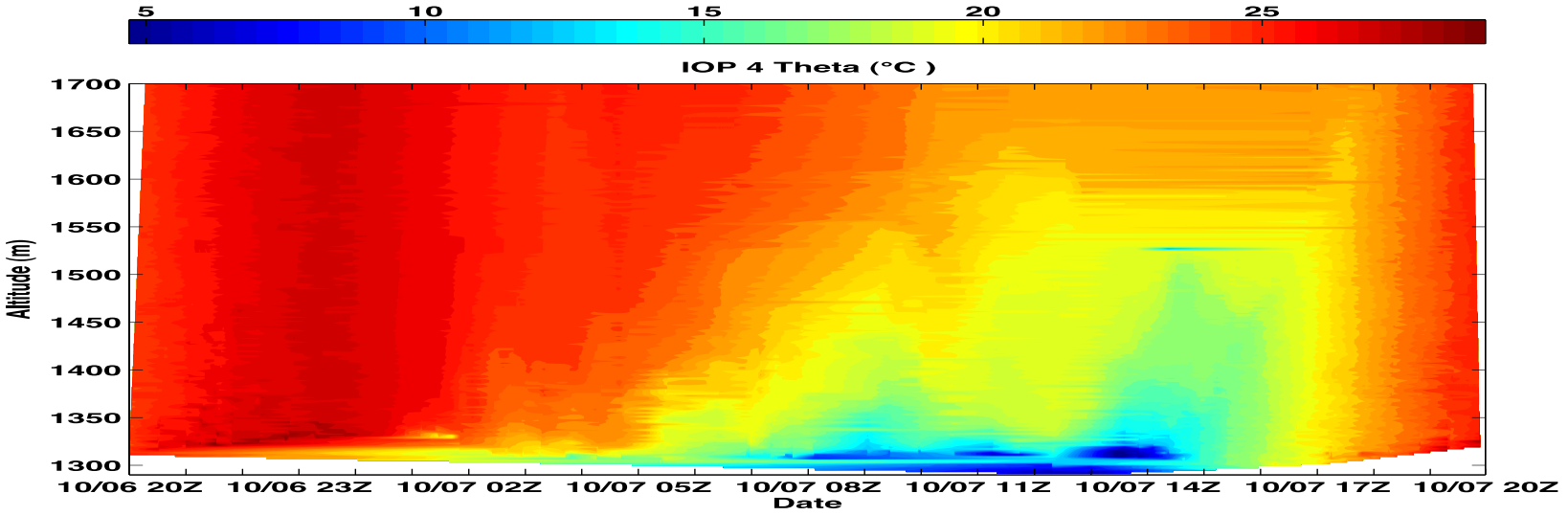


Tethered Balloon Playa – Wind & Temperature Structures



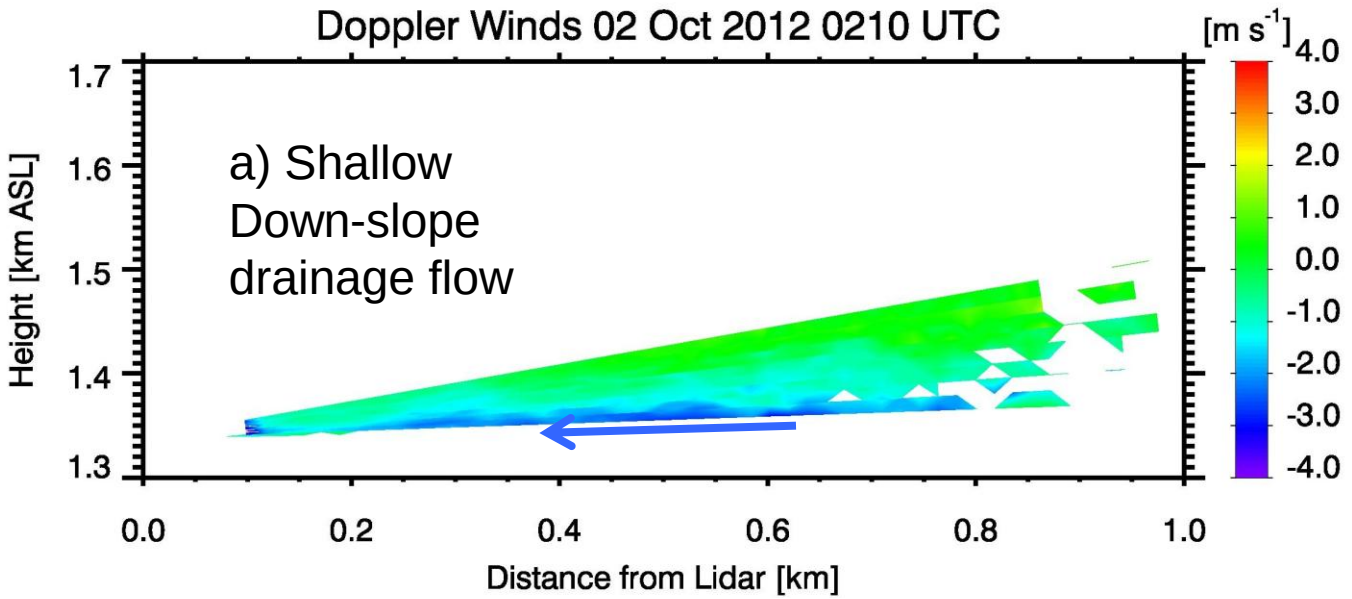
Tethered Balloon Sage – Wind & Temperature Structures

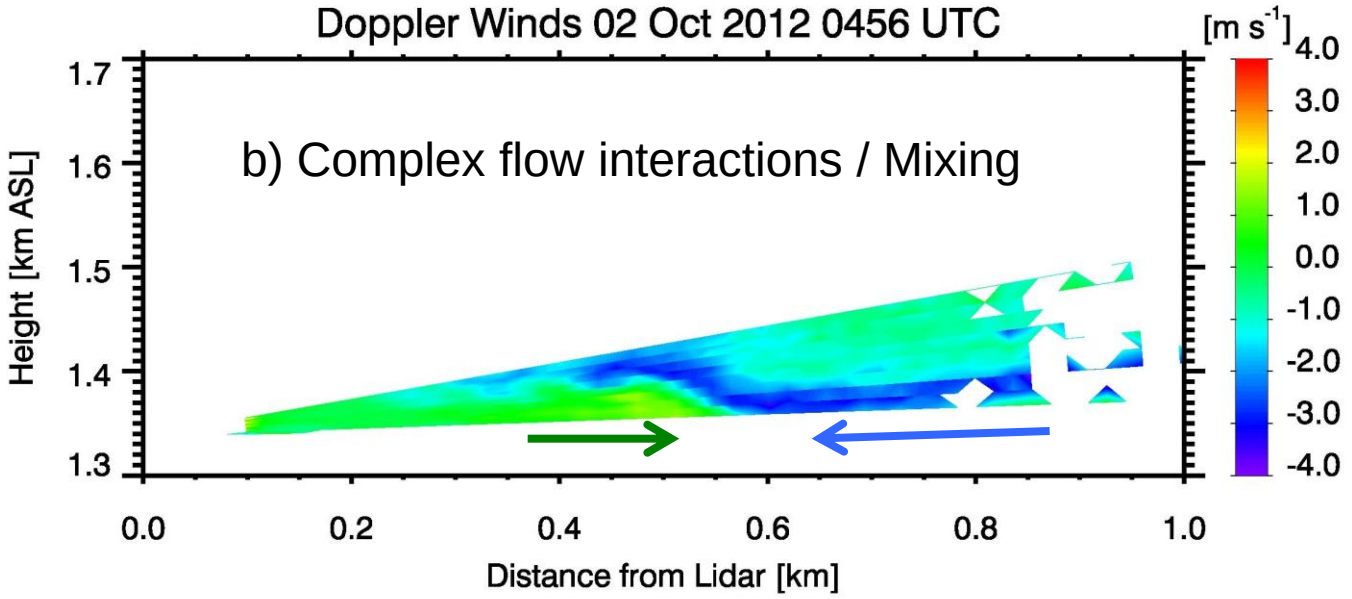




LIDAR Observation – East Slope of Granite Peak

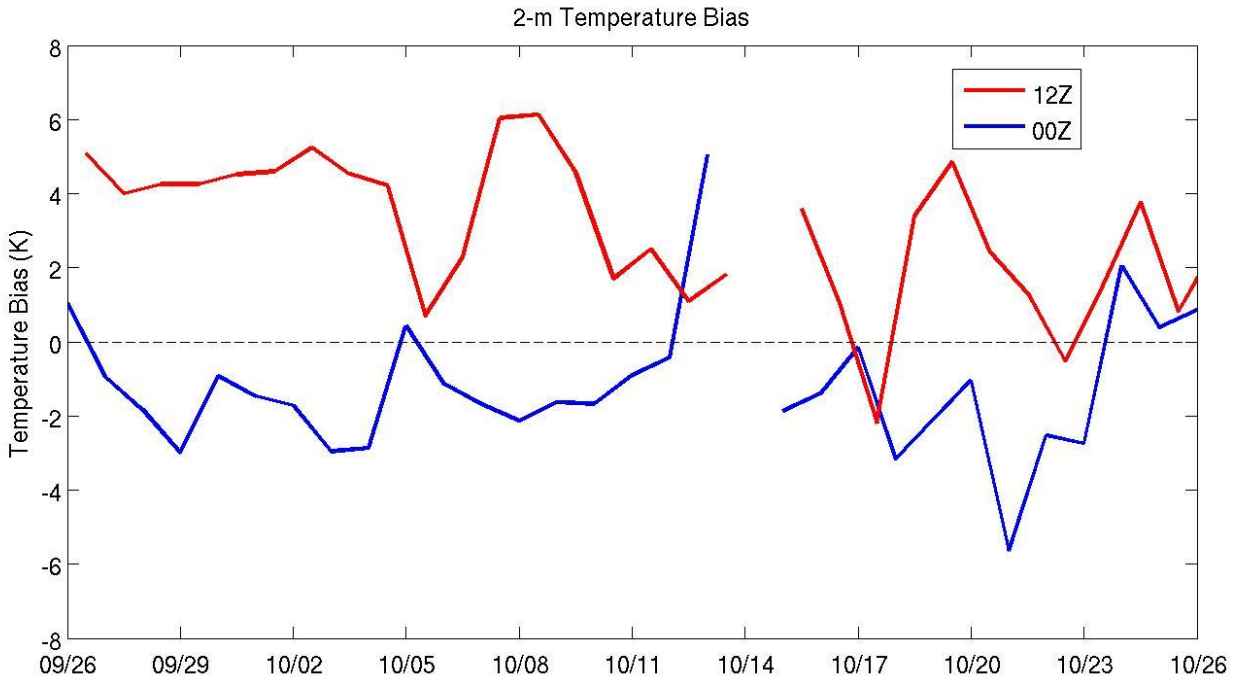
Flow away from / towards LiDAR



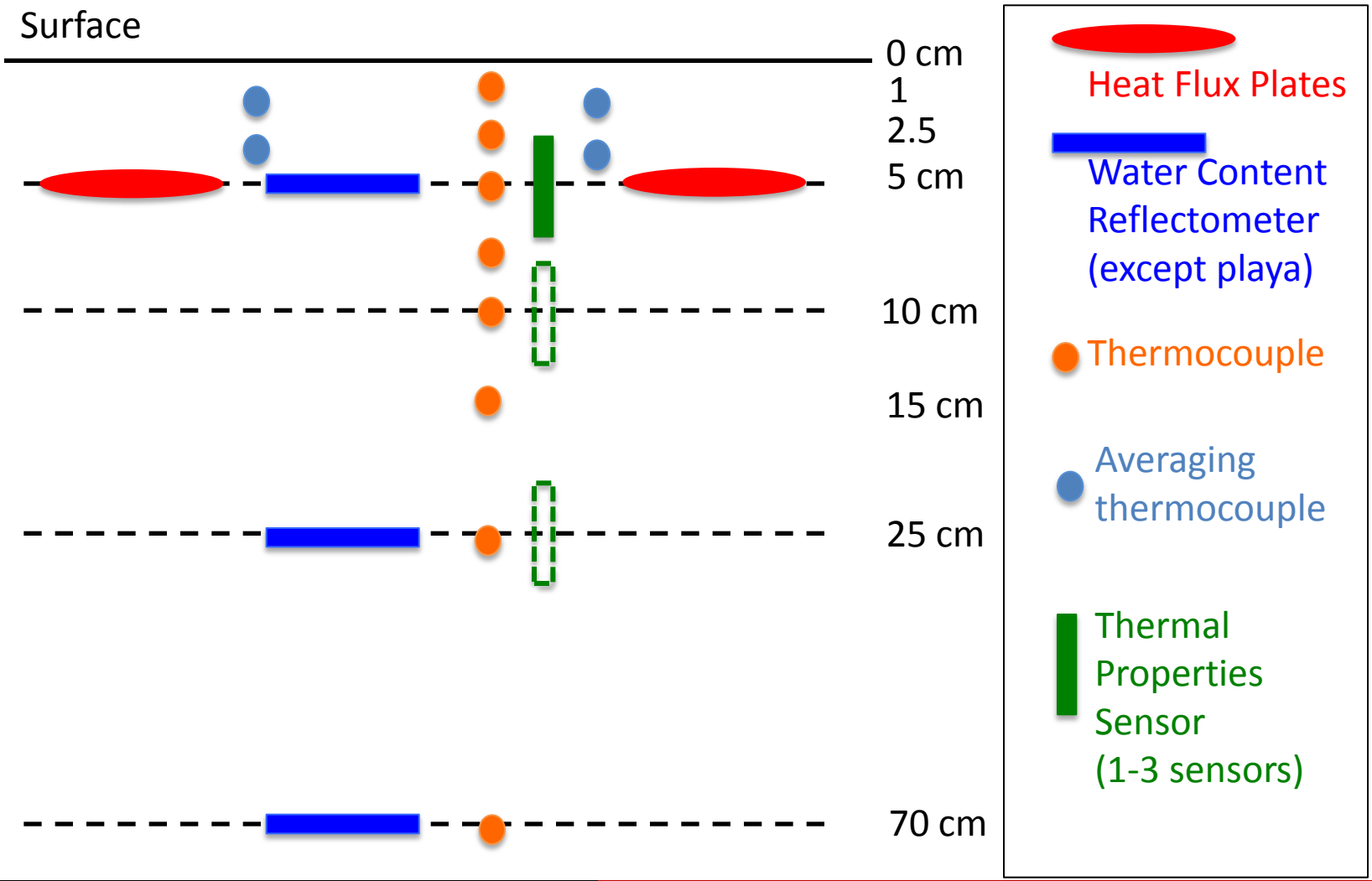


Addressing WRF Temperature Biases

- Operational WRF runs show a consistent morning warm bias, and afternoon cold bias, especially in the first half of the field campaign

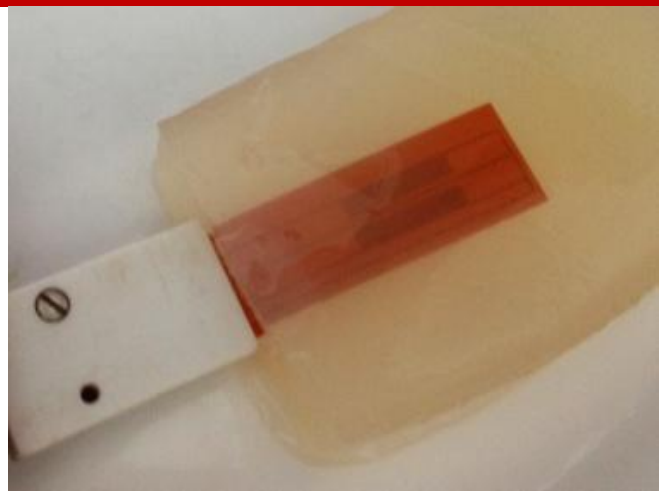


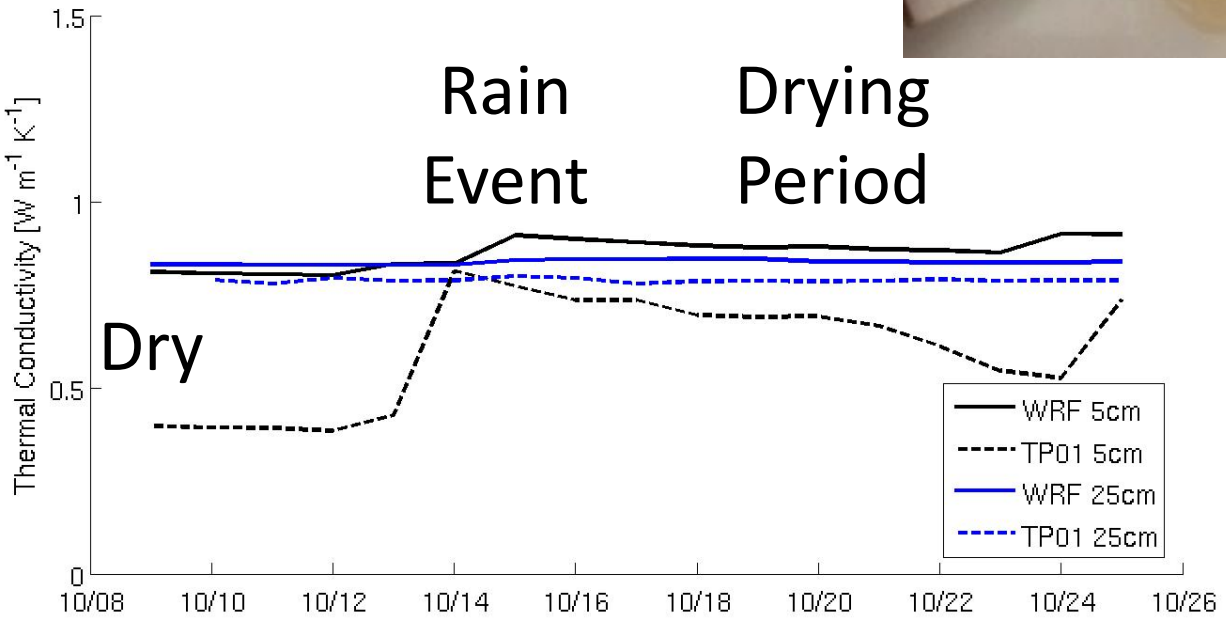
Subsurface EFS Measurement



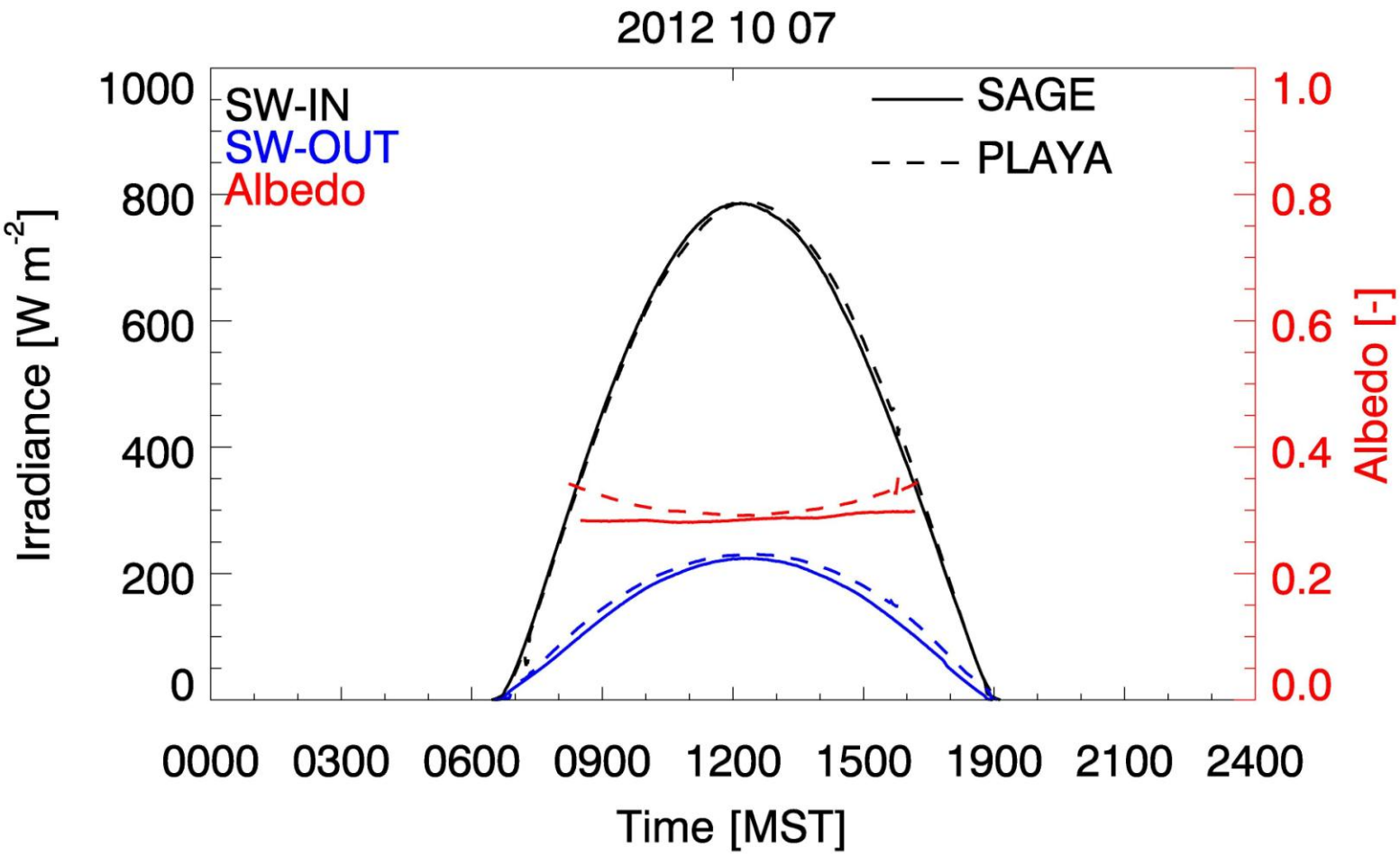
Addressing WRF Temperature Biases

TP01 – Thermal property measurement

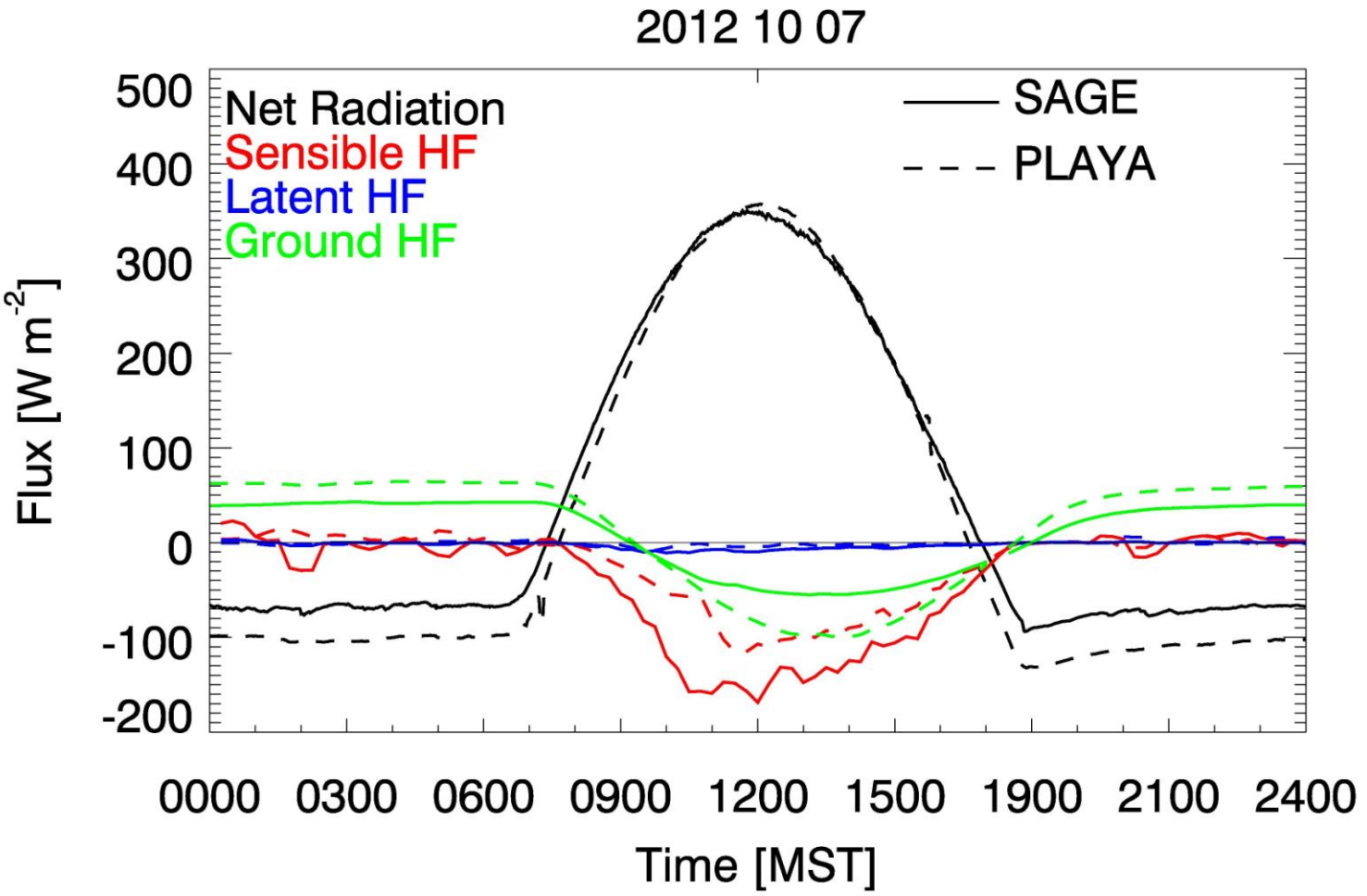




Radiation Balance Observation – Sagebrush vs. Playa



Energy Balance Observation – Sagebrush vs. Playa



Summary

1) Successfully completed fall campaign
2) Beginning QC/QA and analysis of the data
3) Preparing for the Spring MATERHORN-II Campaign
4) Working closely with modelers to address specific issues

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).