The Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) Program: A Progress Report

By

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ONR FY 2011 Multidisciplinary University Research Initiative (MURI)

TOPIC #7:

Improved Meteorological Modeling in Mountain Terrain

Topic Chiefs:
Dr. Ronald J. Ferek and Dr. Daniel Eleuterio (ONR)

Additional support:

Army Research Office
(Dr. Gordon Videen and Dr. Walter Bach)

Air Force Weather Agency
through ARL

www.nd.edu/~dynamics/Materhorn

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Julian Hunt (U. London)

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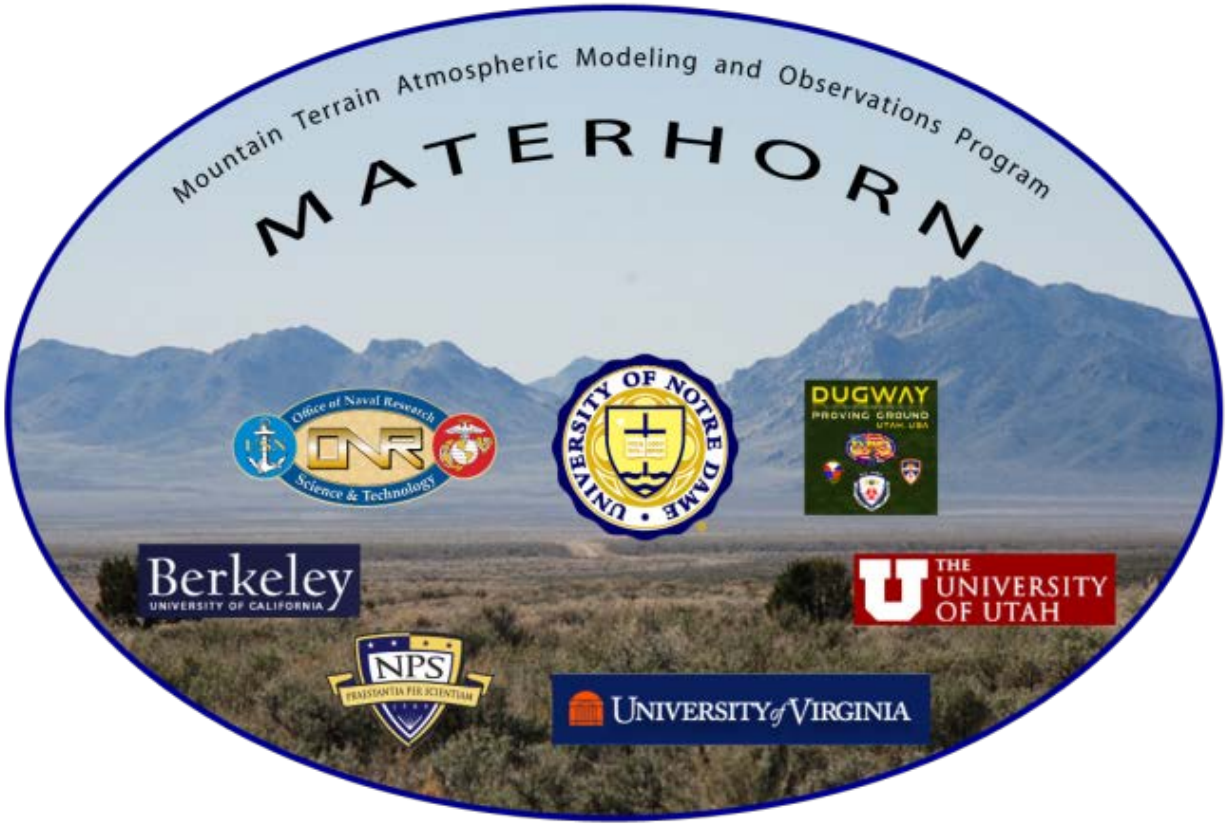
Multidisciplinary **U**niversity **R**esearch **I**nitiative MURI



Collaborators

NCAR
NOAA
Princeton University
Oregon State University
University of Colorado

IIBR, Israel
University of Bergen, Norway
University of Vienna, Austria
École Polytechnique De Montreal, Canada
University of Lecce, Italy

Some Scientific Barriers…..

(1) Near-surface atmospheric wind and temperature predictions in complex terrain – poor

(2) Accurate measurements of *model relevant* parameters (soil properties, surface energy balance) – lean

(3) Near-surface temperature forecasts - very sensitive to soil moisture

(4) Holistic (multi-scale) observations of large to small-scale processes – rare

Mat componenta

MATERHORN has four components working symbiotically across institutions and disciplines

Modeling	(MATERHORN-M)
Experiments	(MATERHORN-X)
Technology Development	(MATERHORN-T)
Parameterizations	(MATERHORN-P)

MATERHORN-X (1,2,3)

Granite Mountain Atmospheric Science Test bed (GMAST)

US Army Dugway Proving Ground (1252 sq. miles)

Calm Winds (FALL) – October 1 - 31, 2012

Synoptic Winds (SPRING) – May 1-30, 2013

20 Intensive Operational Periods IOPs (24-36 hrs)

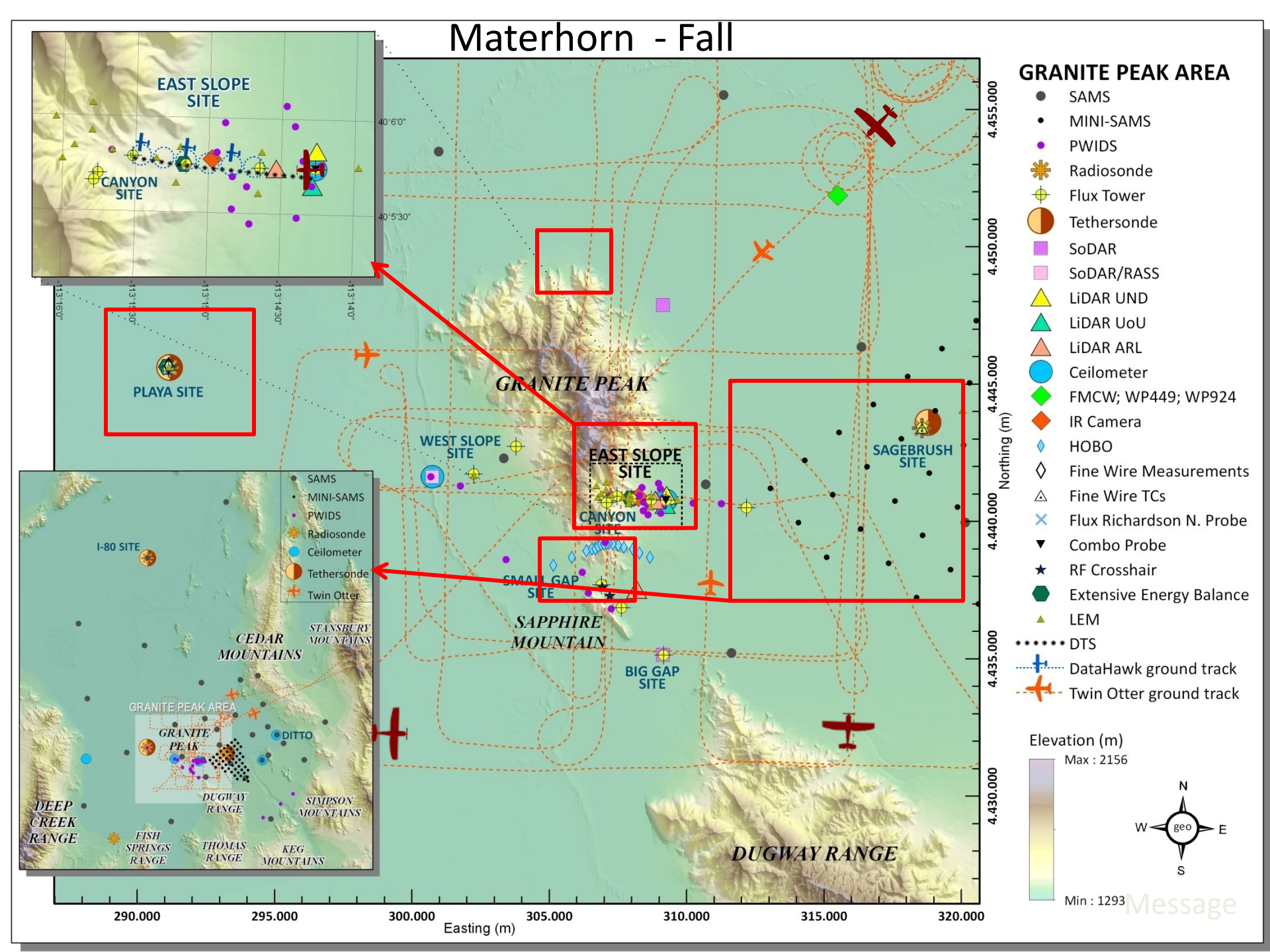
5 Intensive Operational Locations IOLs

~ 55 TB Data

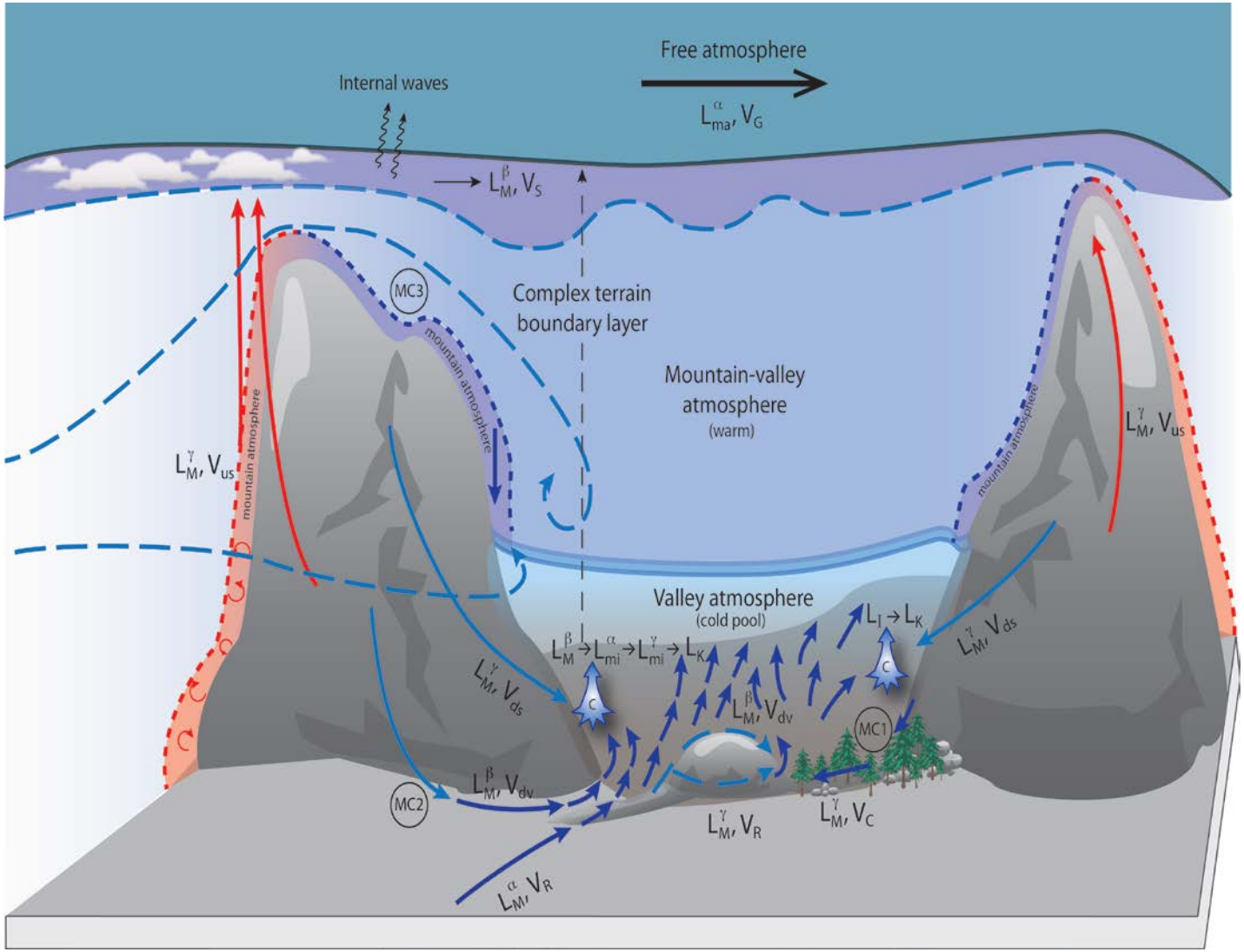
pics

MATERHORN-X

instruments


Materhorn - Fall
EAST SLOPE SITE
CANYON SITE
PLAYA SITE
WEST SLOPE SITE
GRANITE PEAK
EAST SLOPE SITE
CANYON SITE
SAGEBRUSH SITE
SMALL GAP SITE
SAPPHIRE MOUNTAIN
BIG GAP SITE
DUGWAY RANGE
I-80 SITE
CEDAR MOUNTAINS
STANSBURY MOUNTAINS
GRANITE PEAK AREA
GRANITE PEAK
DITTO
DUGWAY RANGE
SIMPSON MOUNTAINS
DEEP CREEK RANGE
FISH SPRINGS RANGE
THOMAS RANGE
KEG MOUNTAINS
SAMS
MINI-SAMS
PWIDS
Radiosonde
Ceilometer
Tethersonde
Twin Otter
GRANITE PEAK AREA
SAMS
MINI-SAMS
PWIDS
Radiosonde
Flux Tower
Tethersonde
SoDAR
SoDAR/RASS
LiDAR UND
LiDAR UoU
LiDAR ARL
Ceilometer
FMCW; WP449; WP924
IR Camera
HOBO
Fine Wire Measurements
Fine Wire TCs
Flux Richardson N. Probe
Combo Probe
RF Crosshair
Extensive Energy Balance
LEM
DTS
DataHawk ground track
Twin Otter ground track
Elevation (m)
Max : 2156
Min : 1293
N
W
E
S
geo
Northing (m)
4.455.000
4.450.000
4.445.000
4.440.000
4.435.000
4.430.000
Easting (m)
290.000
295.000
300.000
305.000
310.000
315.000
320.000

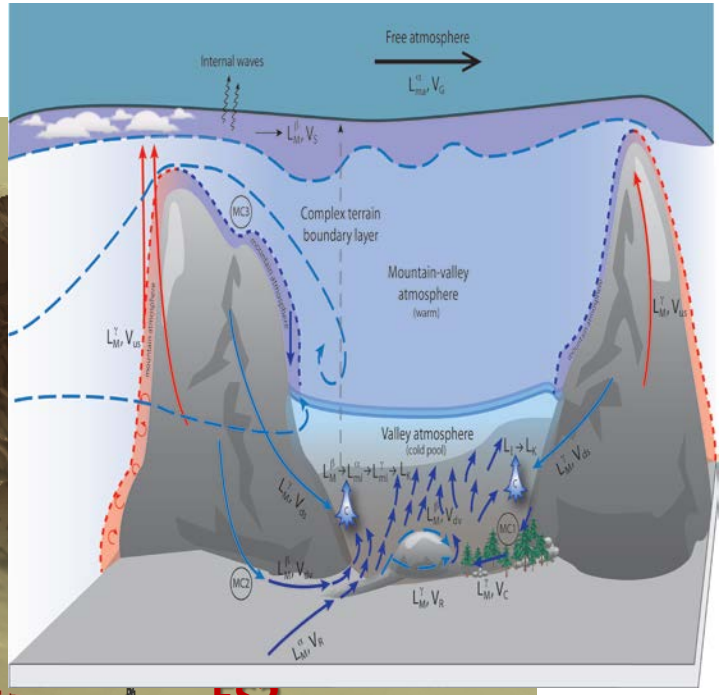
Summary of some results



$$L^{\alpha}_{Macro} \dashrightarrow L^{\beta}_{Macro} \dashrightarrow L^{\gamma}_{Macro} \dashrightarrow L^{\alpha}_{Meso} \cdots\cdots \dashrightarrow L_{Kolmogorov}$$

example

East Slope of Granite



L^{α}_{Meso} - - >

ES5

ES4

ES2

600

700 m

600 m

L_K

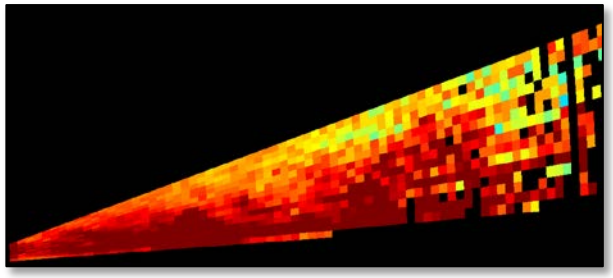
L^{β}_{Meso} - - >

- - - > L^{α}_{Meso}

N

Lidar

Gravity Currents Collide



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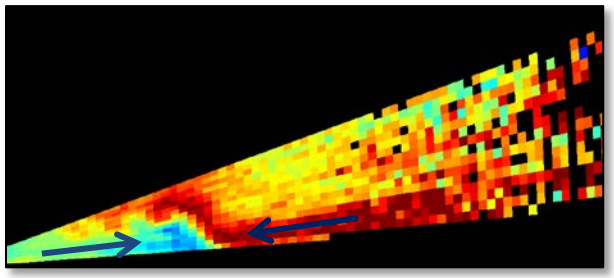

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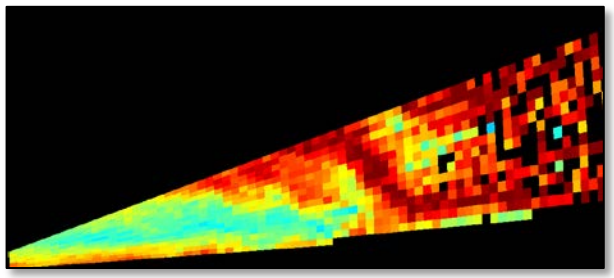

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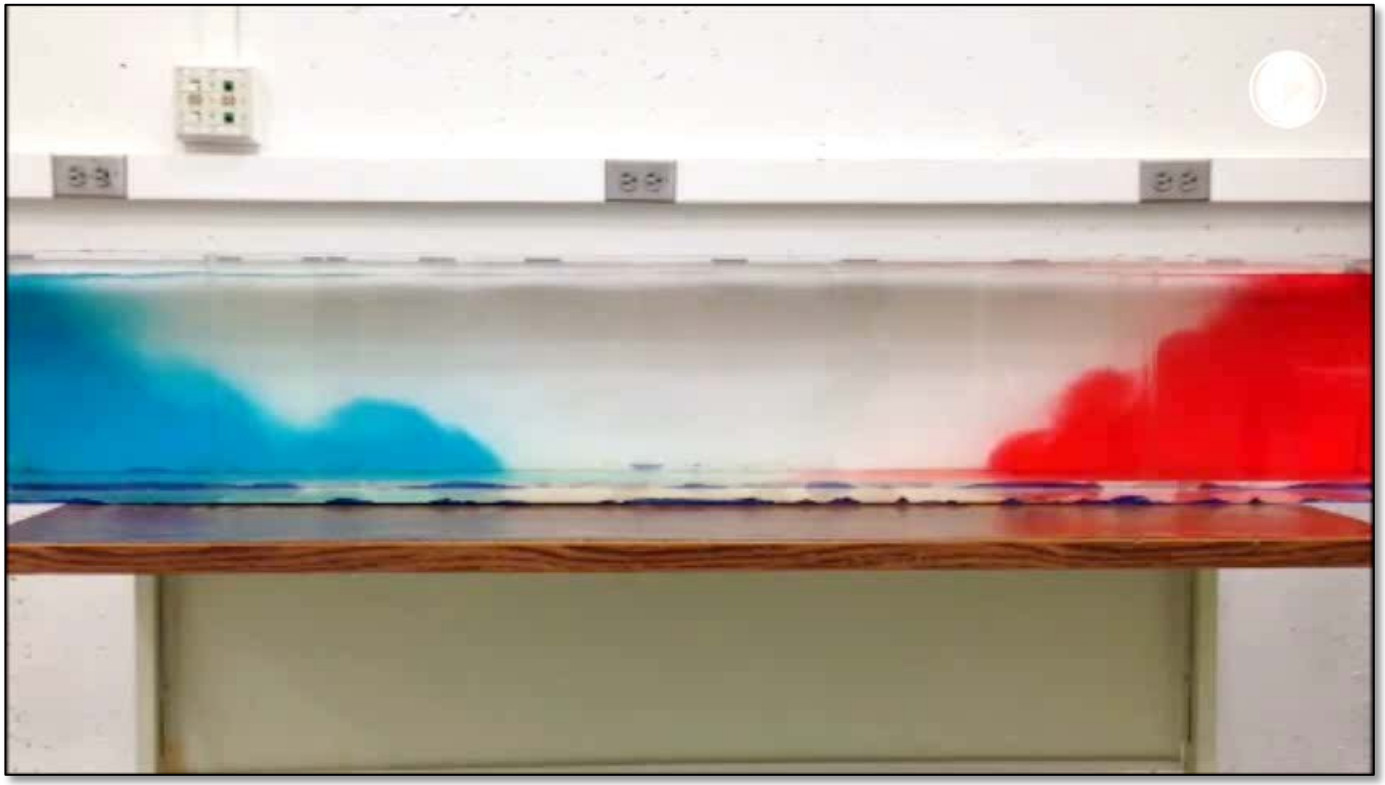


Hocut,, Hoch and Wang

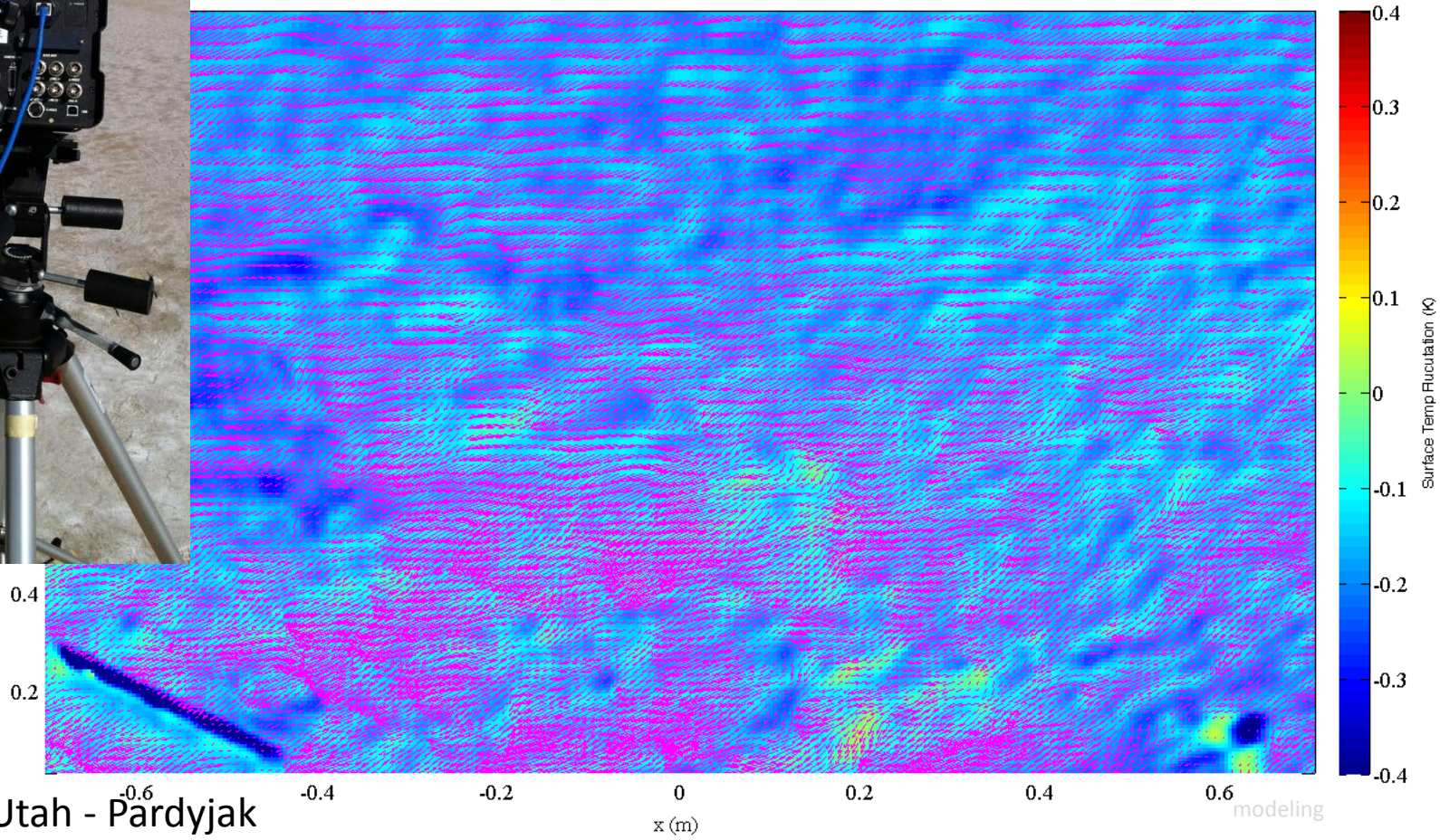
TOWDL

TODWL data reveal - thermally driven upvalley flows (Oct 9, afternoon flight)

imagery

High Resolution Thermal Image Velocimetry

Understanding near surface temperature and velocity fluctuations

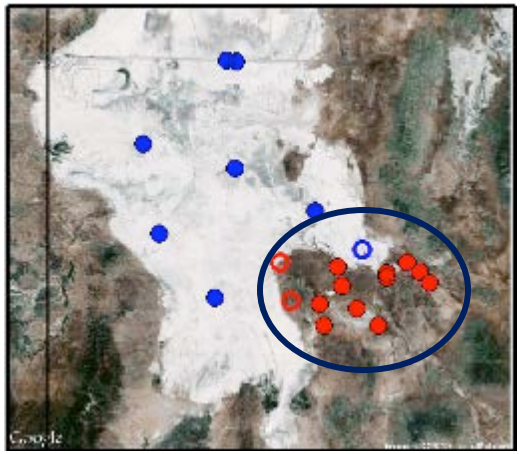


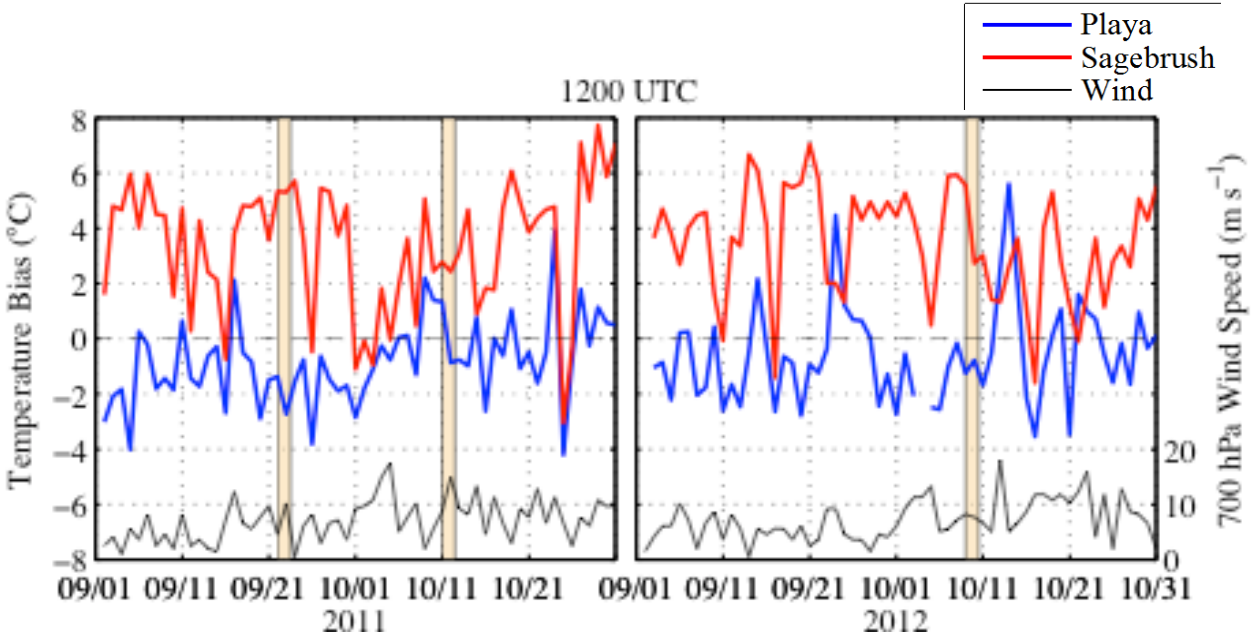
University of Utah - Pardyjak

modeling

MATERHORN-M

Example - Improving Surface Forecasts



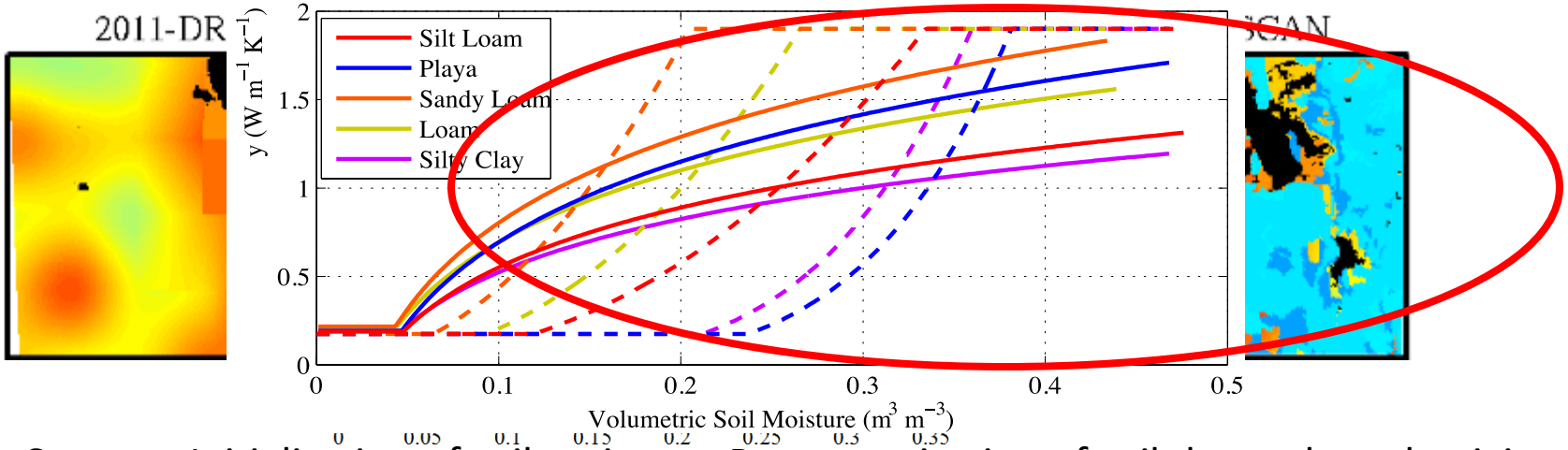


Issue: Atmospheric models (e.g., WRF) are too warm at night over the sagebrush region at DPG (systemic)

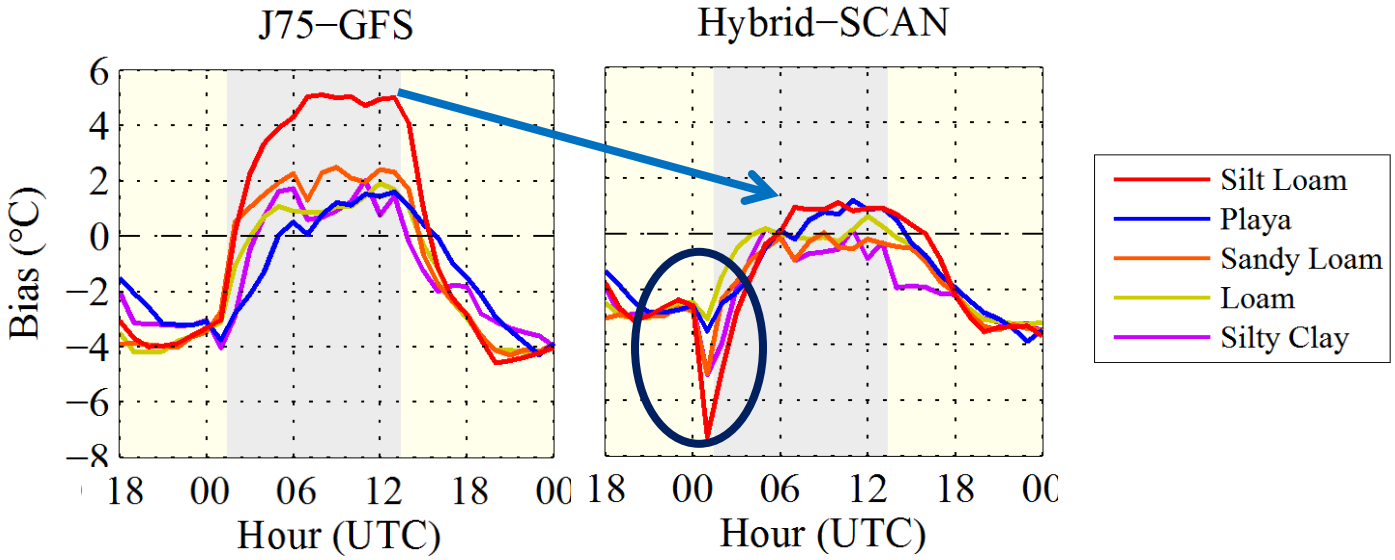
Implications: Poorly simulated NBL -> errors in the prediction of near-surface winds and turbulence, dust emissions and transport, etc.

Massey, Steenburgh, Pu (Utah), Hacker (NPS/NCAR)

Example - Findings and Advances



Error Sources: Initialization of soil moisture; Parameterization of soil thermal conductivity



Advances: Improved initialization and parameterization of soil characteristics

Remaining Challenge: Improving soil moisture analyses in data sparse regions

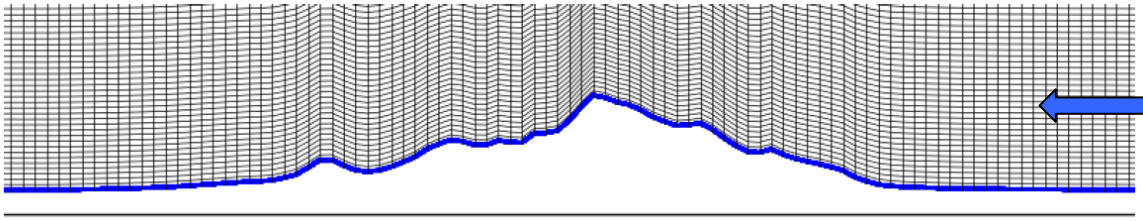
MATERHORN-P

Improve mixing parameterizations via improved physics

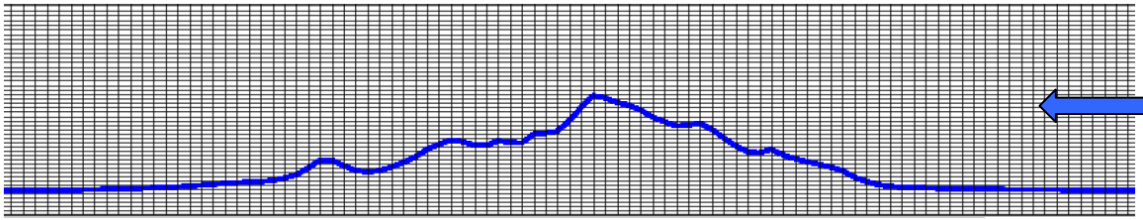
(observations, high resolution simulations, laboratory experiments)

Implement them in models

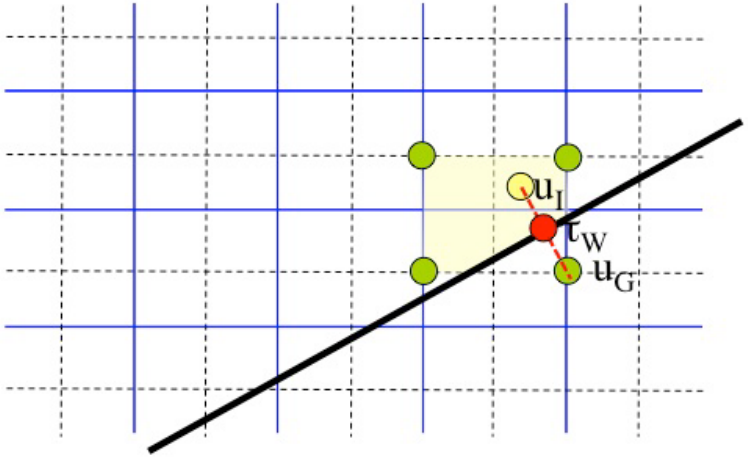
Ex: Immersed boundary method (IBM) development



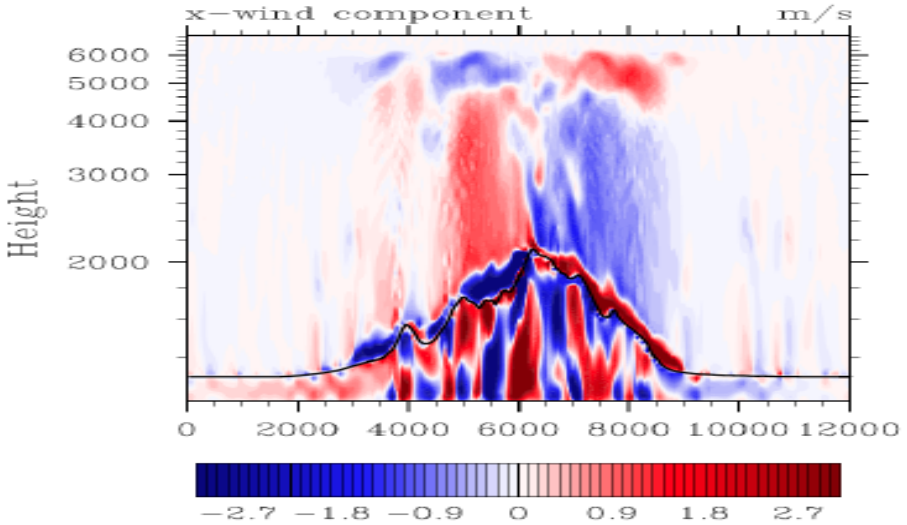
Terrain following coordinates (traditional WRF)



Immersed boundary method (terrain immersed within Cartesian grid, WRF-IBM)



New algorithm development for surface similarity theory (log law)



Preliminary simulations of drainage flows over Granite Mountain with WRF-IBM

MATERHORN - T


The MATERHORN
Fog Aerosol Sampling System
(FASS)
Overview by P.F. Dunn (AME-ND)
September 6, 2013


Keep unravelling mysteries
Fog experiment in 2015!
www.nd.edu/~dynamics/Materhorn