MATERHORN-X

A Multidisciplinary University Research Initiative (MURI)
Sponsored by the Department of Defense

Eric Pardyjak

MATERHORN kick-of Meeting
University of Utah – Salt Lake City
September 7, 2011

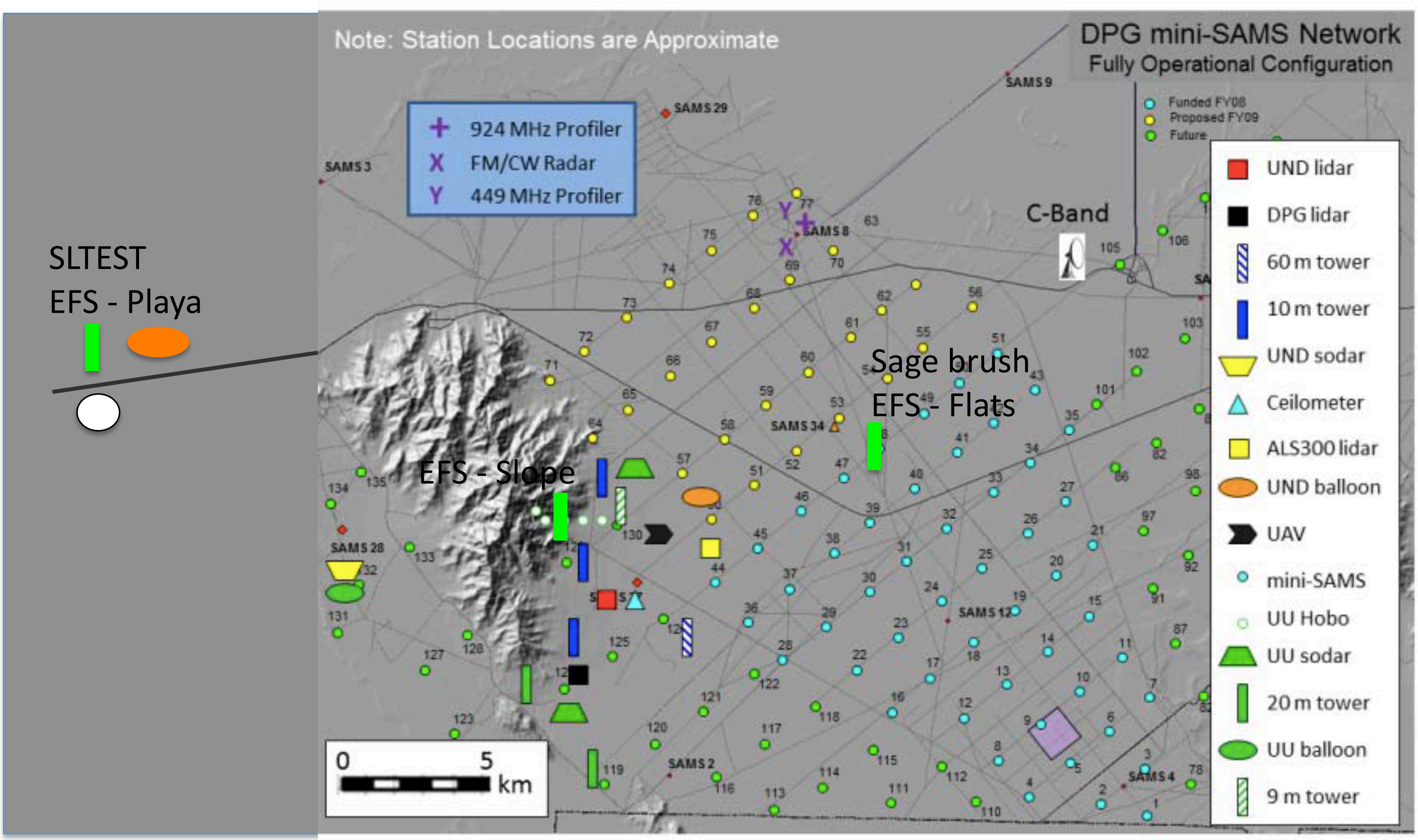
Outline

- Team Members
- Overview of Planned Experiments
- Focused Experiments/Hypotheses
- Current/Previous Work
- Planned Work

UTAH X-Team Members

- Faculty & Research Professors
  - Eric Pardyjak (Mech Eng), David Whiteman (Atmos. Sci.), Sebastian Hoch (Atmos. Sci.), J. Steenburgh (Atmos. Sci.)
- Graduate Students
  - Derek Jensen (MS), Daniel Alexander (MS)
  - Estel Blay (visiting PhD student)
  - Additional PhD student/Post-doc – TBH
- Undergrads (surface temperature stations)
- Possible Additional Participants
  - Marie Lothon – Research Scientist - CNRS France
  - David Pino - (Professor, LES) - Technical University of Catalonia, Barcelona, Spain

Overview



SLTEST
EFS - Playa
Note: Station Locations are Approximate
DPG mini-SAMS Network
Fully Operational Configuration
924 MHz Profiler
FM/CW Radar
449 MHz Profiler
Funded FY08
Proposed FY09
Future
C-Band
Sage brush
EFS - Flats
EFS - Slope
SAMS 3
SAMS 29
SAMS 9
SAMS 8
SAMS 34
SAMS 28
SAMS 12
SAMS 2
SAMS 4
UND lidar
DPG lidar
60 m tower
10 m tower
UND sodar
Ceilometer
ALS300 lidar
UND balloon
UAV
mini-SAMS
UU Hobo
UU sodar
20 m tower
UU balloon
9 m tower
0
5
km

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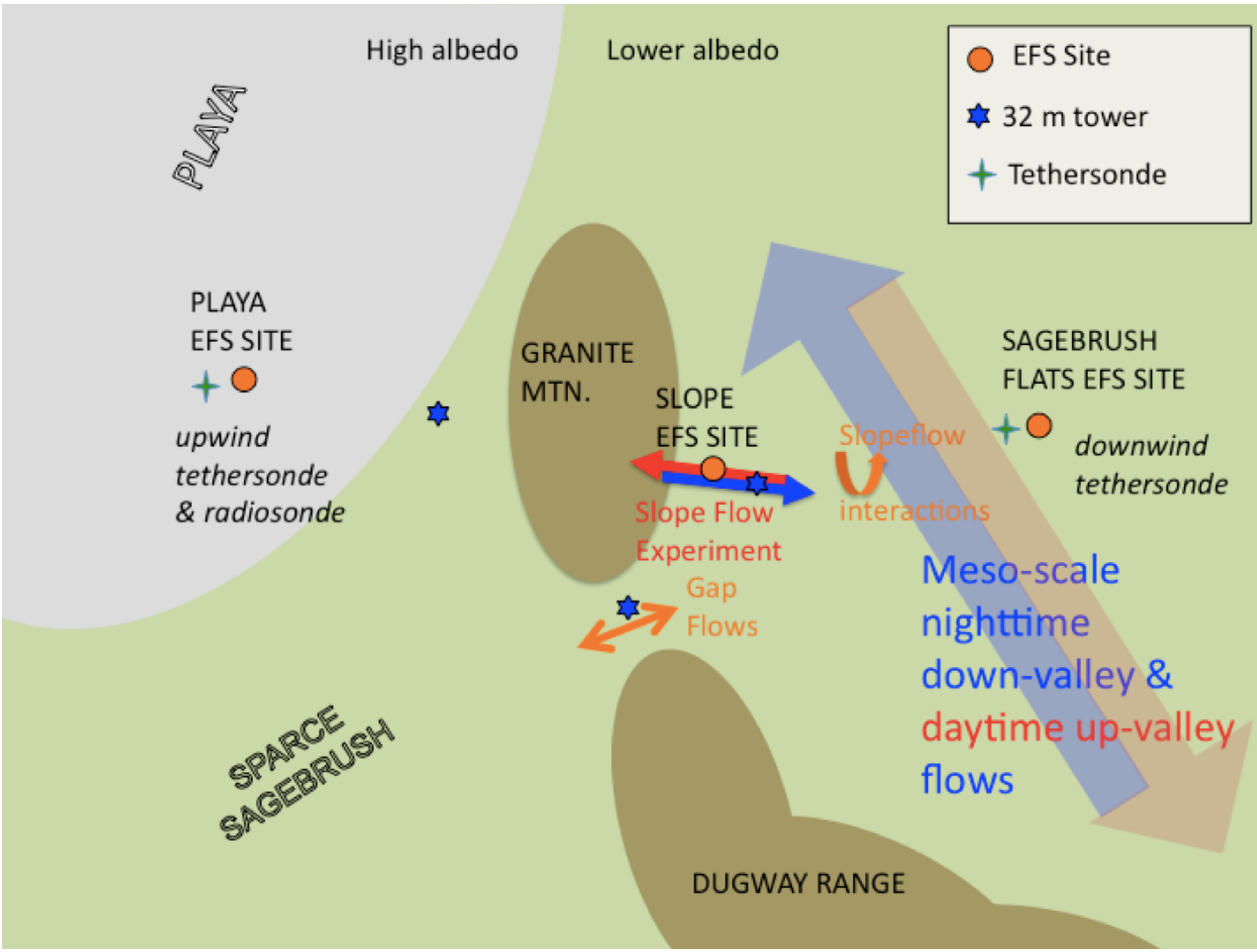
Overview



Experiment/Hypotheses

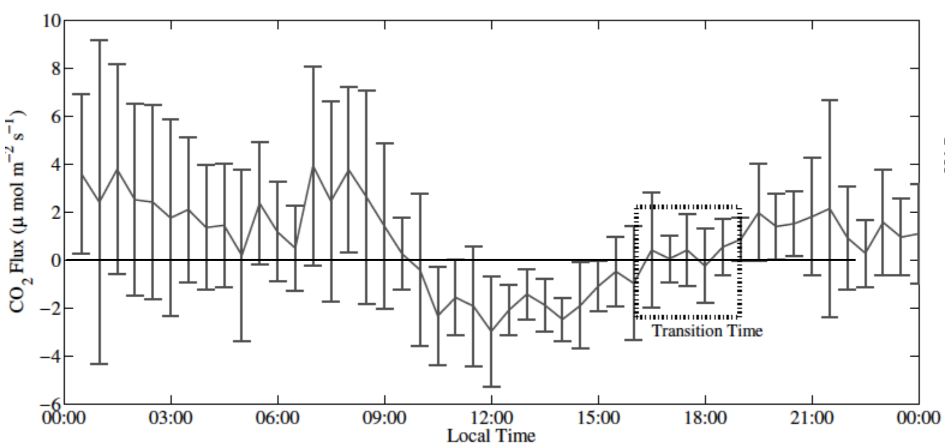
- **Surface Energy Budget and Flux Experiments**
  Hypothesis: The Monin-Obukhov Similarity Theory (MOST), which assumes horizontal homogeneity and stationarity, needs to be more thoroughly evaluated for mountainous terrain. Alternative formulations may be necessary
- **Fine-scale Turbulence and Transport Experiments (Playa and Slope sites)**
  Hypothesis: Understanding of fine-scale surface-layer processes (e.g. distorted turbulent eddies, coherent structures, dissipation mechanisms, and small-scale advection) may lead to greatly improved surface heat/mass/momentum/moisture flux parameterizations.
- **Stable Boundary Layer (SBL) Evolution Experiments**
  Hypotheses: Quantification of the evolution of SBL, for example its height and strength (i.e., buoyancy frequency), starting from the evening transition until the morning break up, requires delineation of the physics of two transition processes and processes responsible for the development of nocturnal stable stratification. In particular, understanding of non-equilibrium (evolving) turbulence in SBL will be crucial.

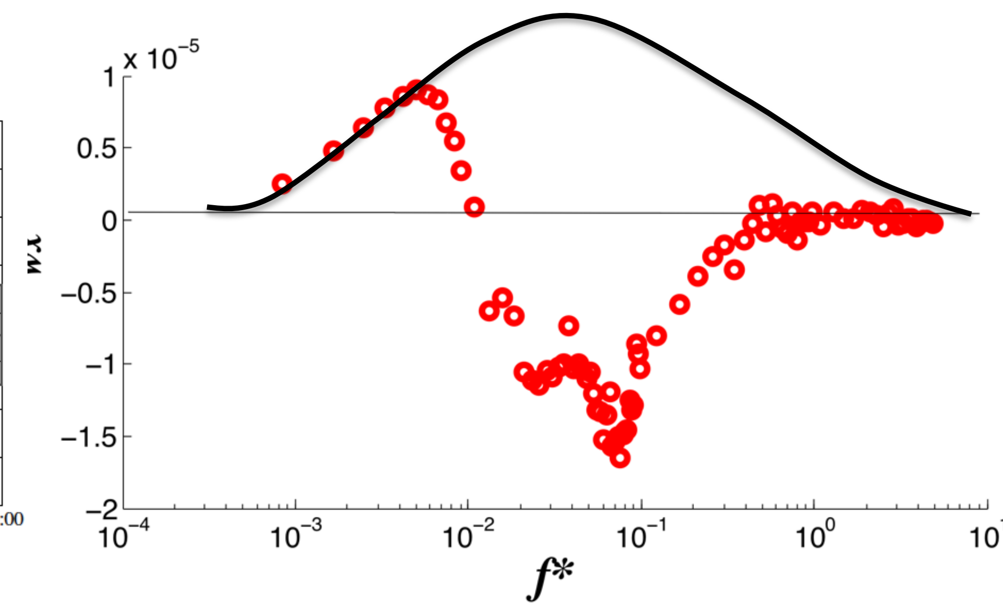
Broad Goals

- Improved understanding of Physics
  - Slope, transitory processes , boundary layer fluxes, multi-scale flow interaction
- Parameterization Development
- Model Validation
- Sensor Technology Development
  - Flux Richardson number probe
  - Low cost surface temperature sensors

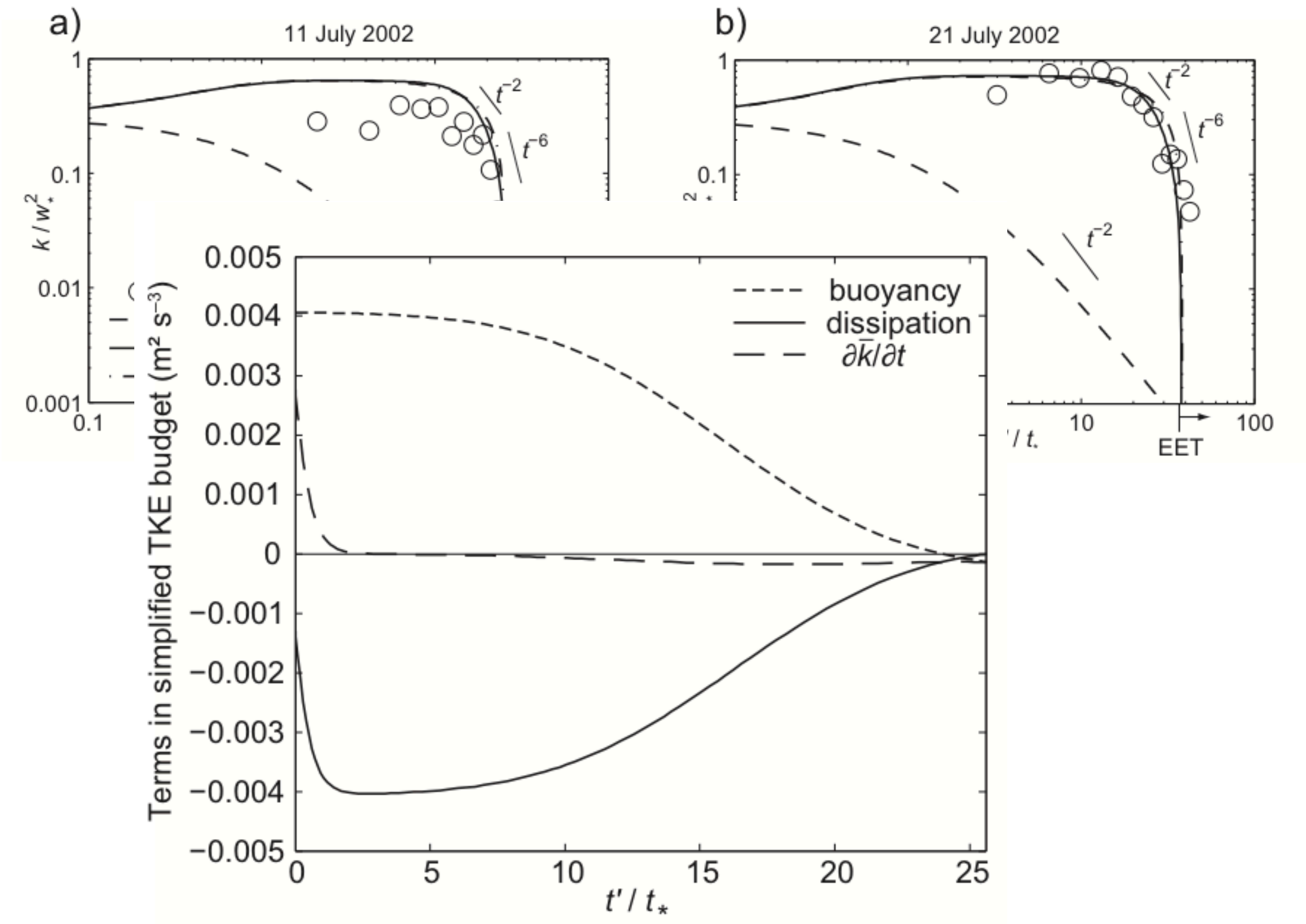
Improved Understanding of Physics

- Build on recent field observation campaigns
  - BLLAST Campaign in Lannemezan, France (June/July 2011)
  - Swiss Slope Experiment at La Fouly (2010) - EPFL
- BLLAST – Evening Transition Focus:
  - Poor understanding of Physical Processes during Transitory Periods
  - Validity of classical scaling
  - Scalar Fluxes (e.g. water vapor





Flat Terrain Decay



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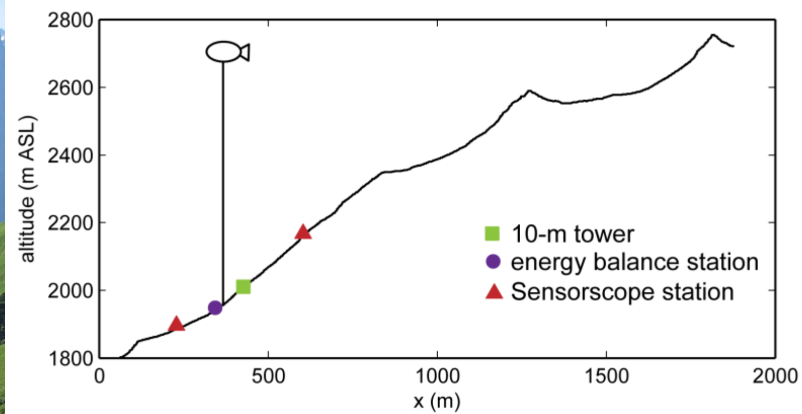
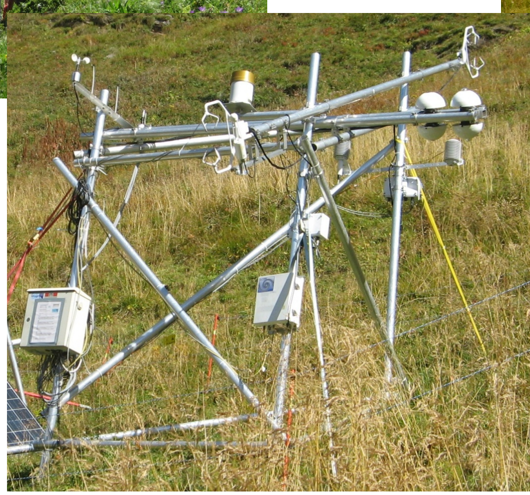
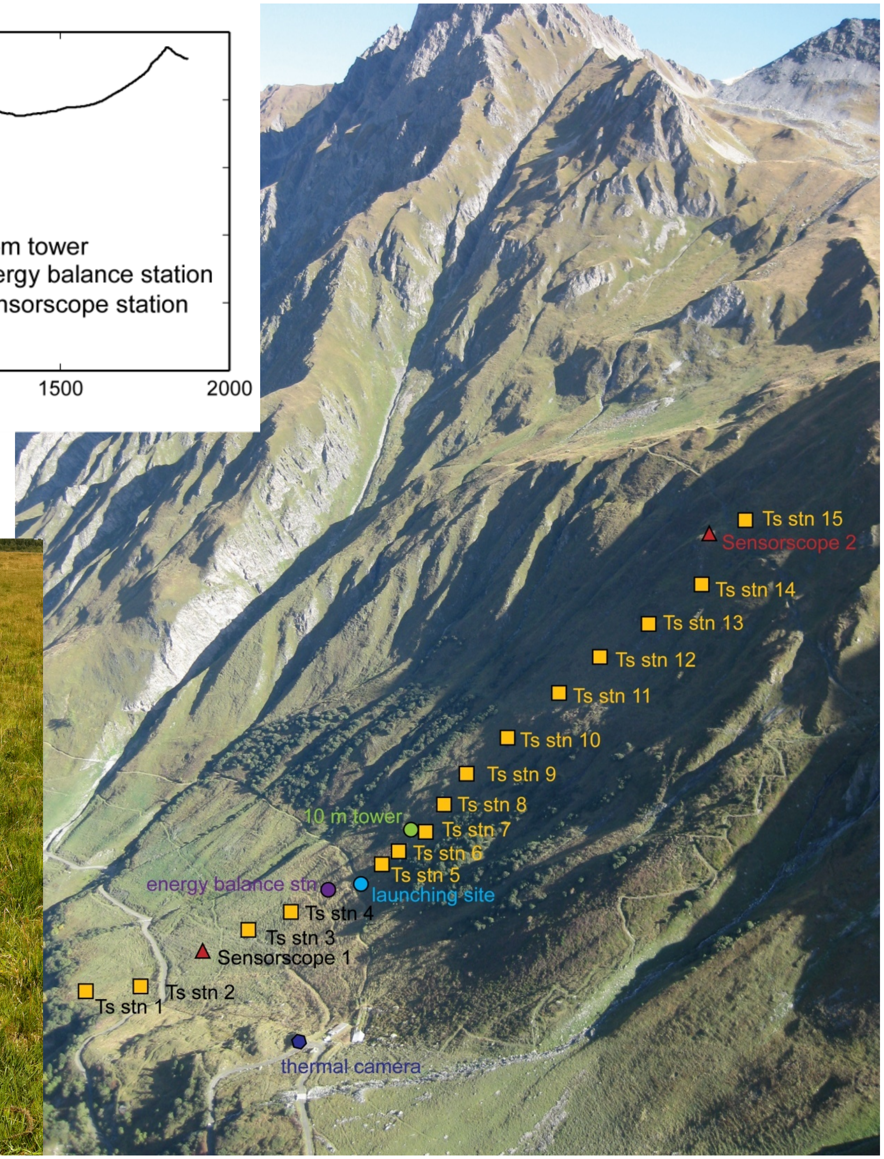
Recent Observations
Swiss Slope Experiment with EPFL





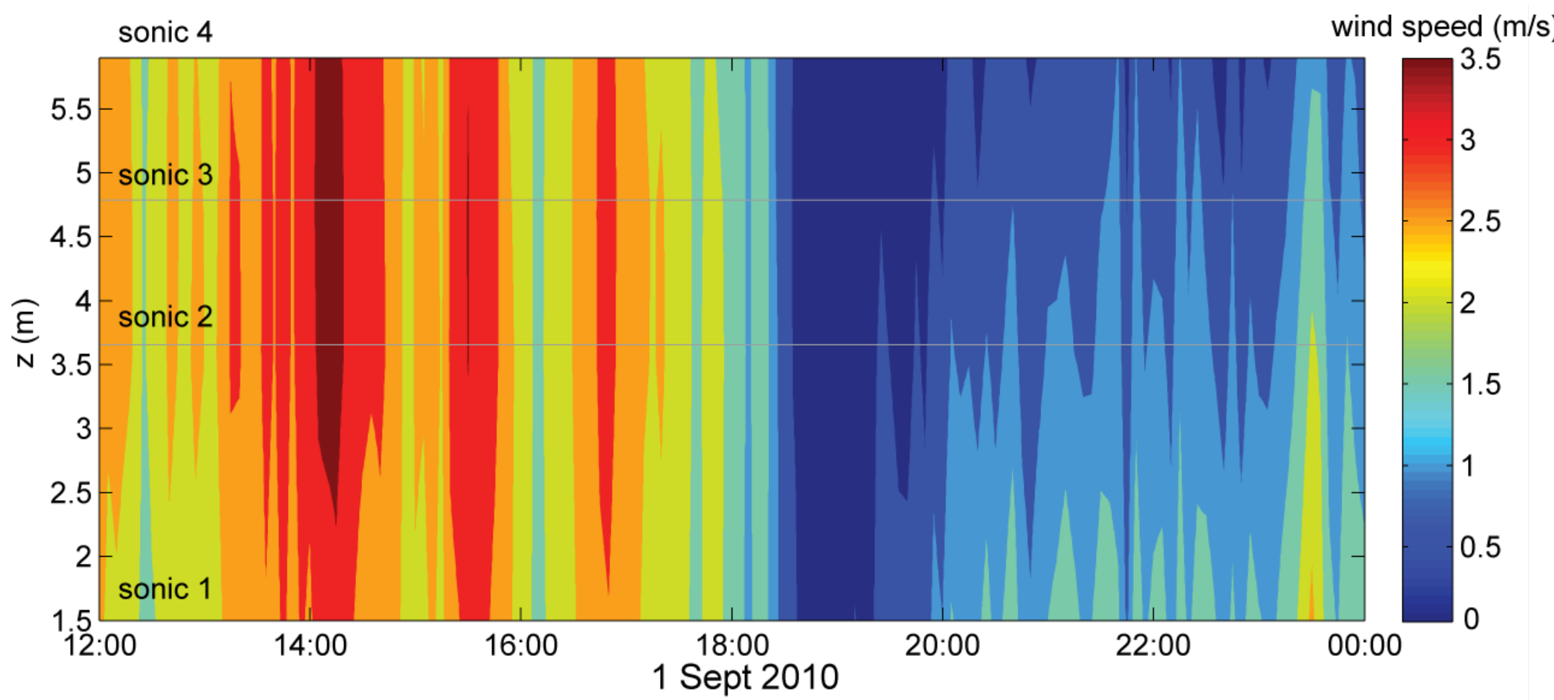


Recent Observations
Swiss Slope Experiment with EPFL

<u>Understanding Slope Transition Physics</u>

1. Rapid surface response to incoming solar radiation (Shadow Front)
2. Quiescent period - Collapse of turbulence
3. Build of near surface stable stratification
4. Skin flow formation

Lasts well into the night with fluxes measured at typical heights being in the "wrong direction" (very problematic for MOST type formulations)



Extended Flux Stations (EFS)

EC Stations that will measure the complete SEB, CO_2/H20 fluxes,

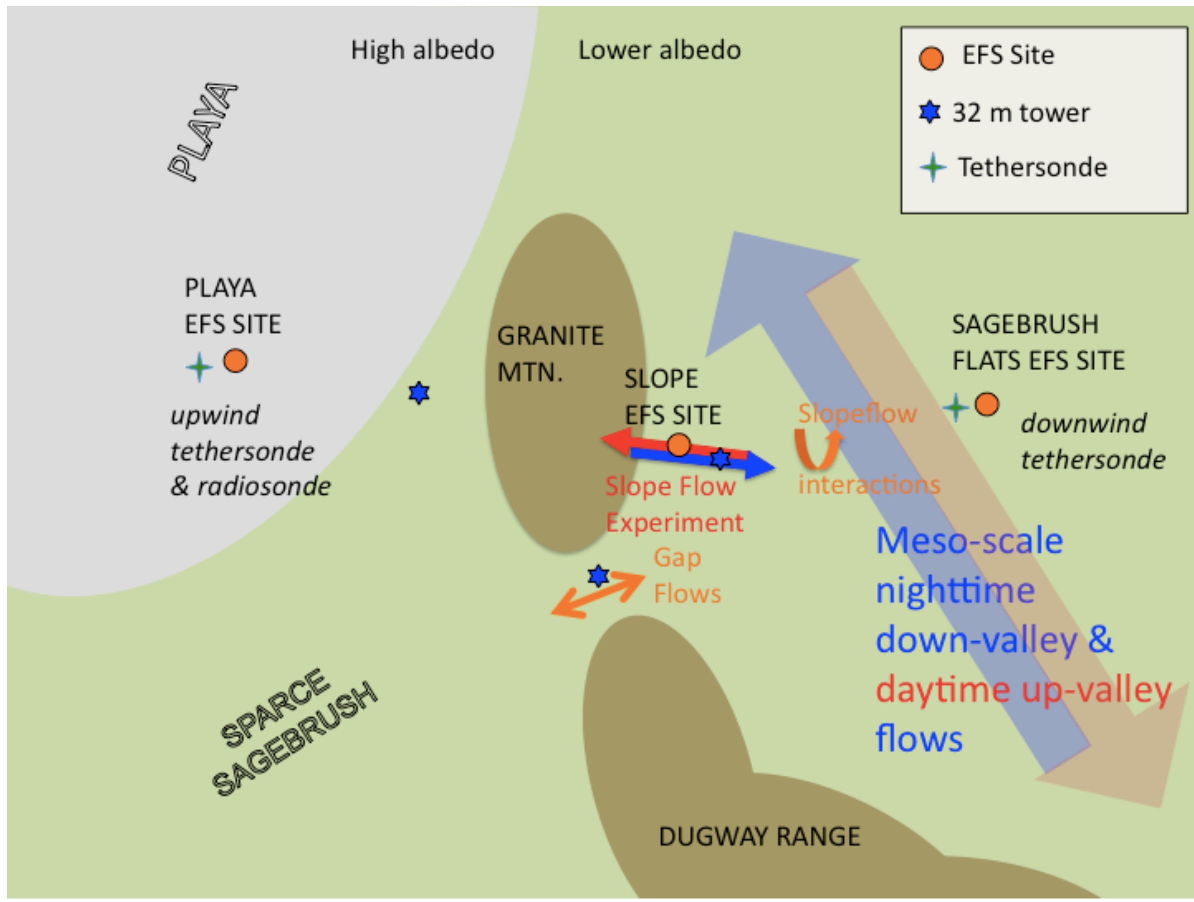
Plus +

- Turbulent winds at multiple heights
- High quality radiation measurements
- High quality fast-response temperature profile measurements
- Ground temperature, moisture measurement

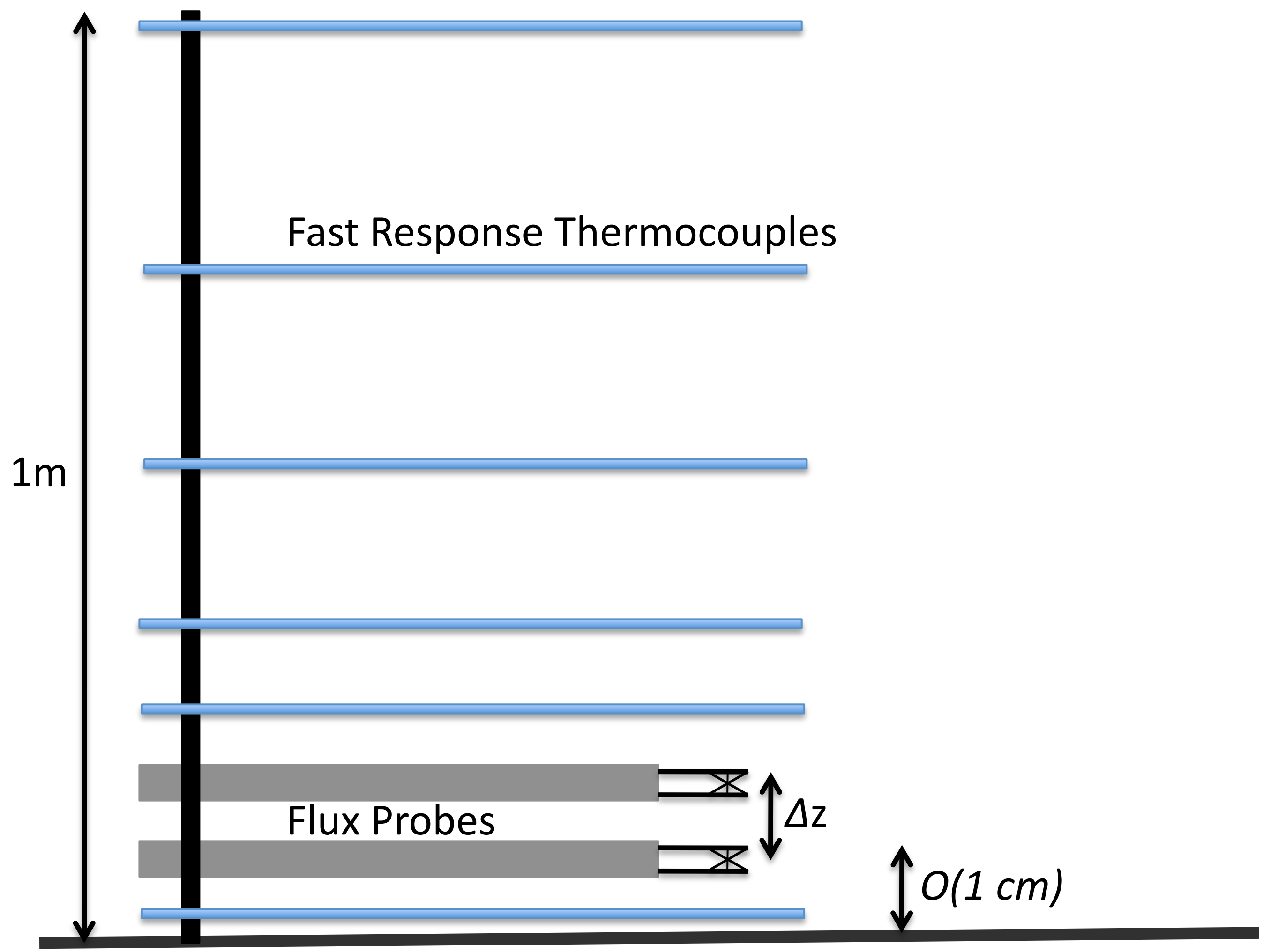
Extended Flux Stations (EFS)

Contrasting features:

- albedo,
- roughness
- Moisture availability
- slope angle



Fine Scale Salt Playa Measurements



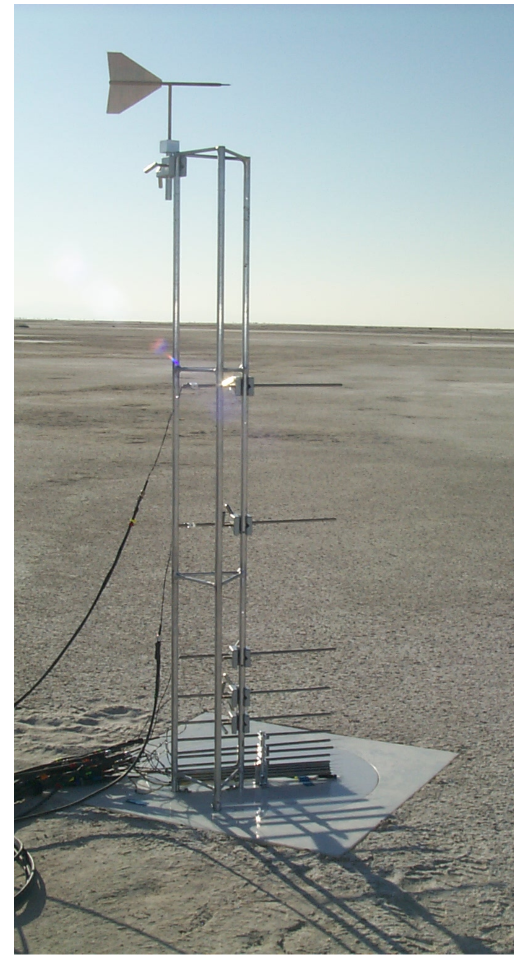
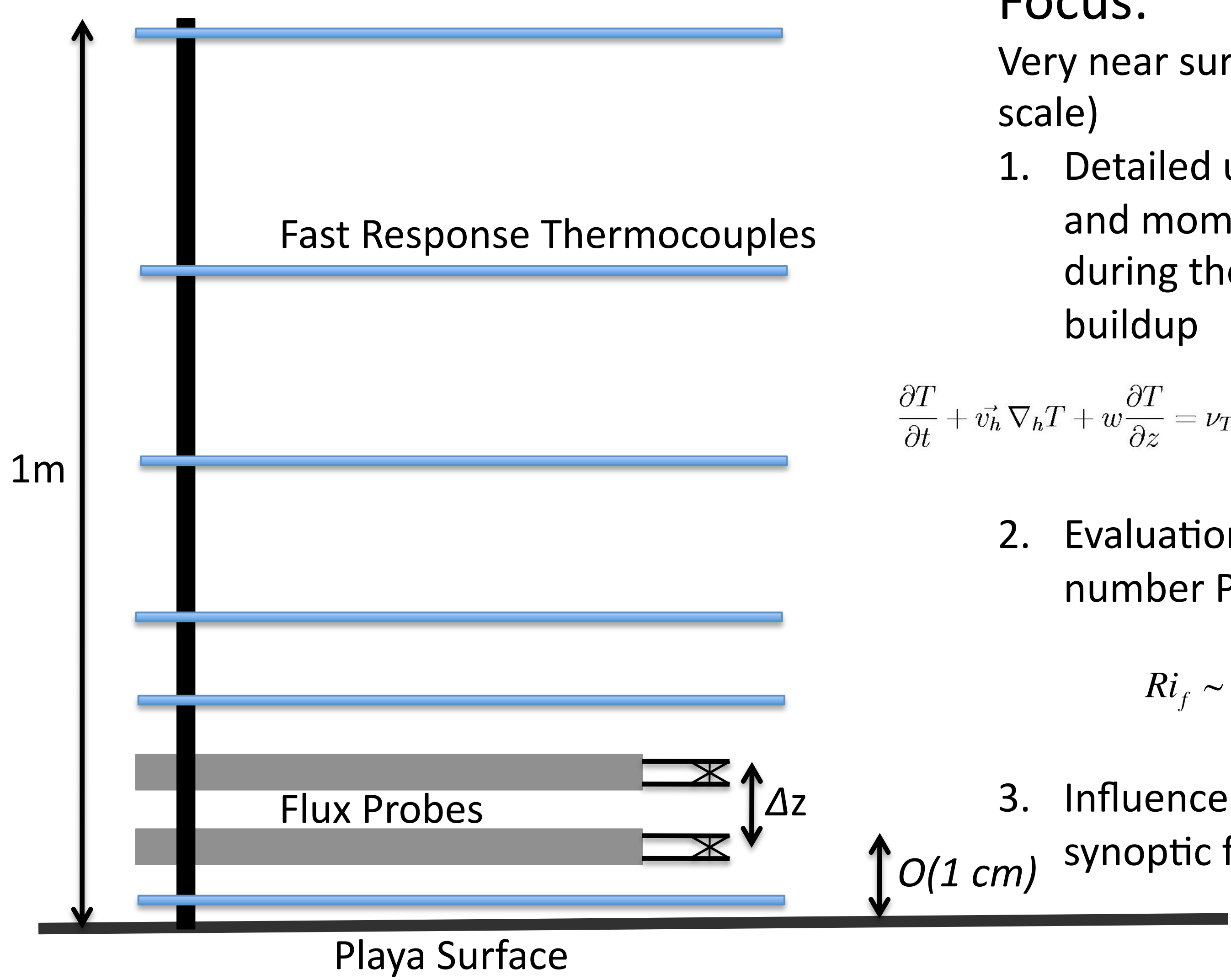


Photo from Klewicki/Metzger Group 2005 SLTEST Experiment

Fine Scale Salt Playa Measurements



Focus:

Very near surface processes (Sub-grid scale)

1. Detailed understanding thermal and momentum transport budget during the nocturnal inversion buildup

$$\frac{\partial T}{\partial t} + \vec{v_h}\nabla_h T + w\frac{\partial T}{\partial z} = \nu_T \frac{\partial^2 T}{\partial z^2} - \frac{1}{\rho c_p}\left(\frac{\partial SW}{\partial z} + \frac{\partial LW}{\partial z} + \frac{\partial H}{\partial z}\right)$$

2. Evaluation of Flux Richardson number Parameterizations

$$Ri_f \sim \frac{(g / T_v)\overline{w'T'}}{\overline{u'w'}(\partial U / \partial z)}$$

3. Influence of various levels of synoptic forcing

Planned/Ongoing work

Fall 2011

- Experimental Planning
  - Operational Plan Development
  - Organization
  - Equipment preparation & Testing

- Initial Team integration efforts
  - Working with T & M to optimize experimental outcomes