Dugway Proving Ground

RECENT DEVELOPMENTS AT GMAST AND PREPARATION FOR MATERHORN

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Overview

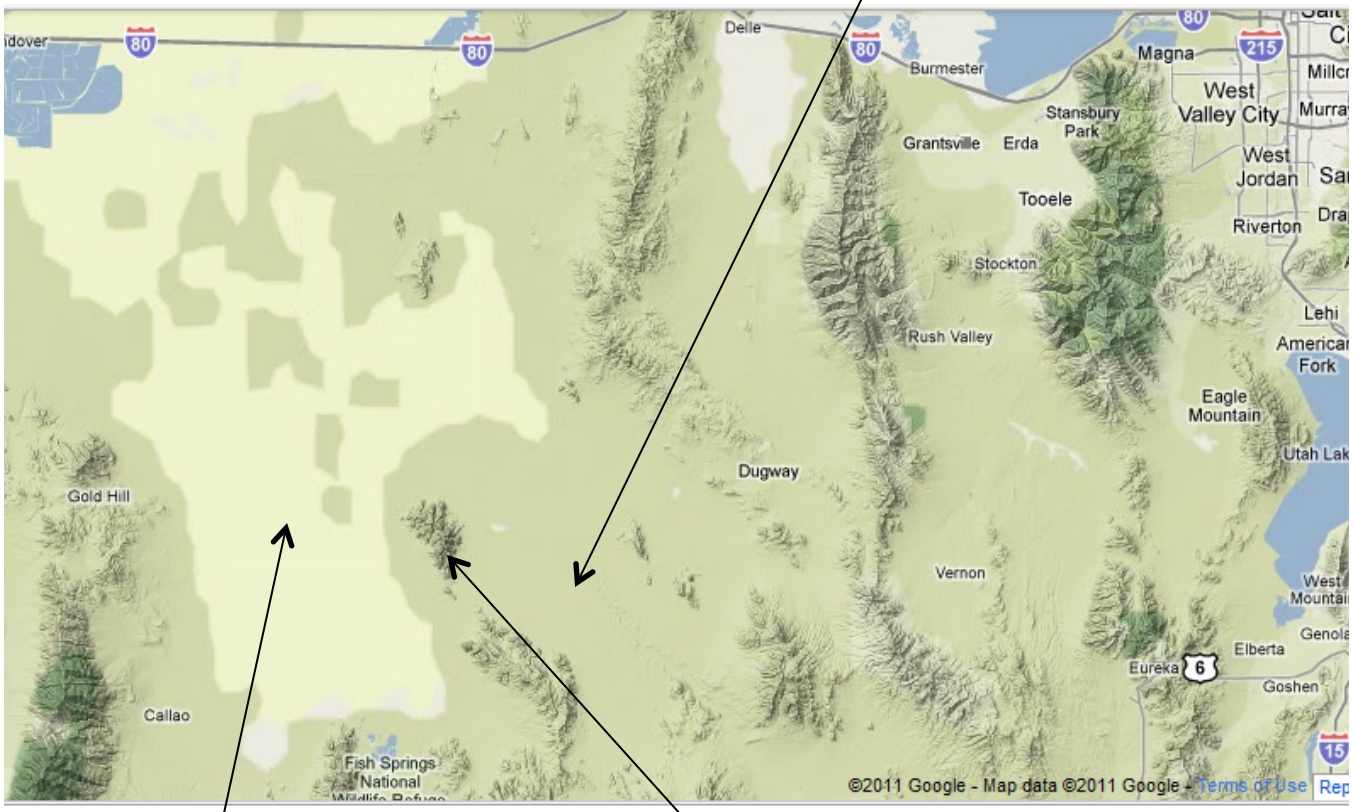
- Meteorology Division at Dugway Proving Ground
- Overview of Granite Mountain Atmospheric Sciences Testbed (GMAST)
- MOUNTAIN TERRAIN ATMOSPHERIC MODELING AND OBSERVATIONS (MATERHORN) project

Background

- U.S. Army Dugway Proving Ground (DPG) conducts outdoor testing of chemical and biological simulants
  - Accurate weather predictions are key
- Airflow patterns across most of DPG are well-understood
- Areas near the mountains pose challenges
  - Thermally driven flows known to disrupt pattern
  - Mechanical interaction with large-scale winds may induce effects aloft
- Seeking scientific investigators to study effects of mountains on DPG's weather

DPG Location

Primary DPG test ranges



Extremely smooth playa

Granite Mountain

Desert Conditions

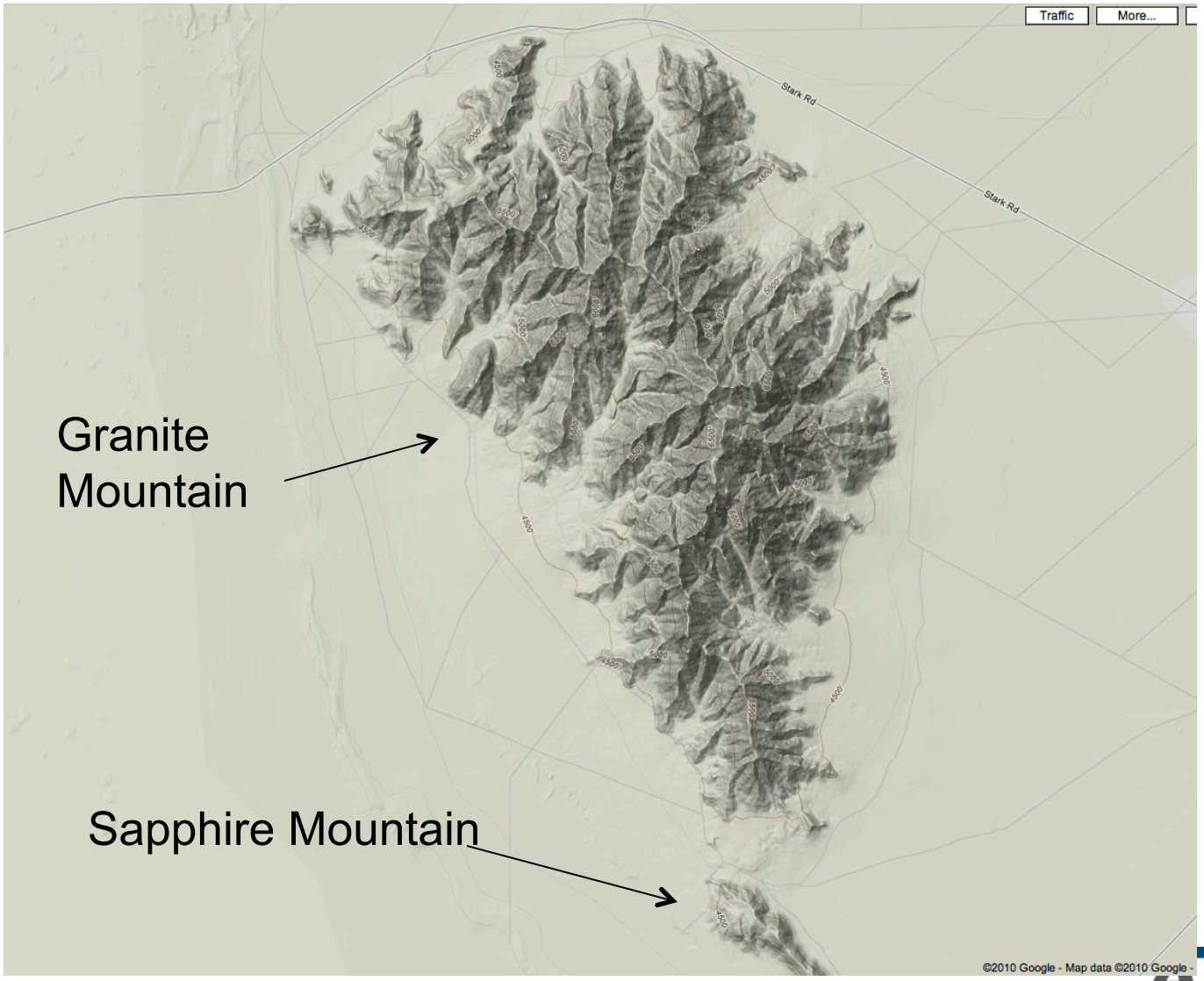
Generally fairly flat terrain

Isolated mountains

Thermally driven wind patterns during stable summertime nights

Very smooth upwind fetch west of Granite Mountain

Granite Mountain



2156 m
(7074 ft) elevation

853 m
(2800 ft) above valley floor

Surface is primarily granite

Note gap between Granite Mountain and Sapphire Mountain

Granite Mountain Atmospheric Sciences Testbed (GMAST)

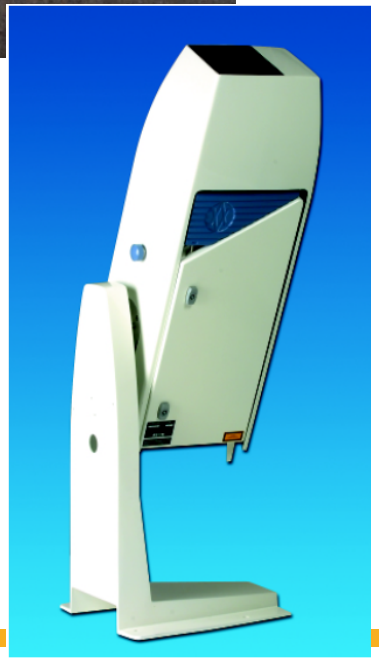
- Combine long-term data collection with intensive observation periods

- Visiting scientists will augment the DPG data baseline
  - Bring additional equipment, personnel
  - Use DPG data collection system when possible
  - Limited funding needs for DPG labor

- Opportunity to conduct repeated studies, comparing results with other scientists working in the same domain
  - Standard reference feature (such as Askervein Hill)

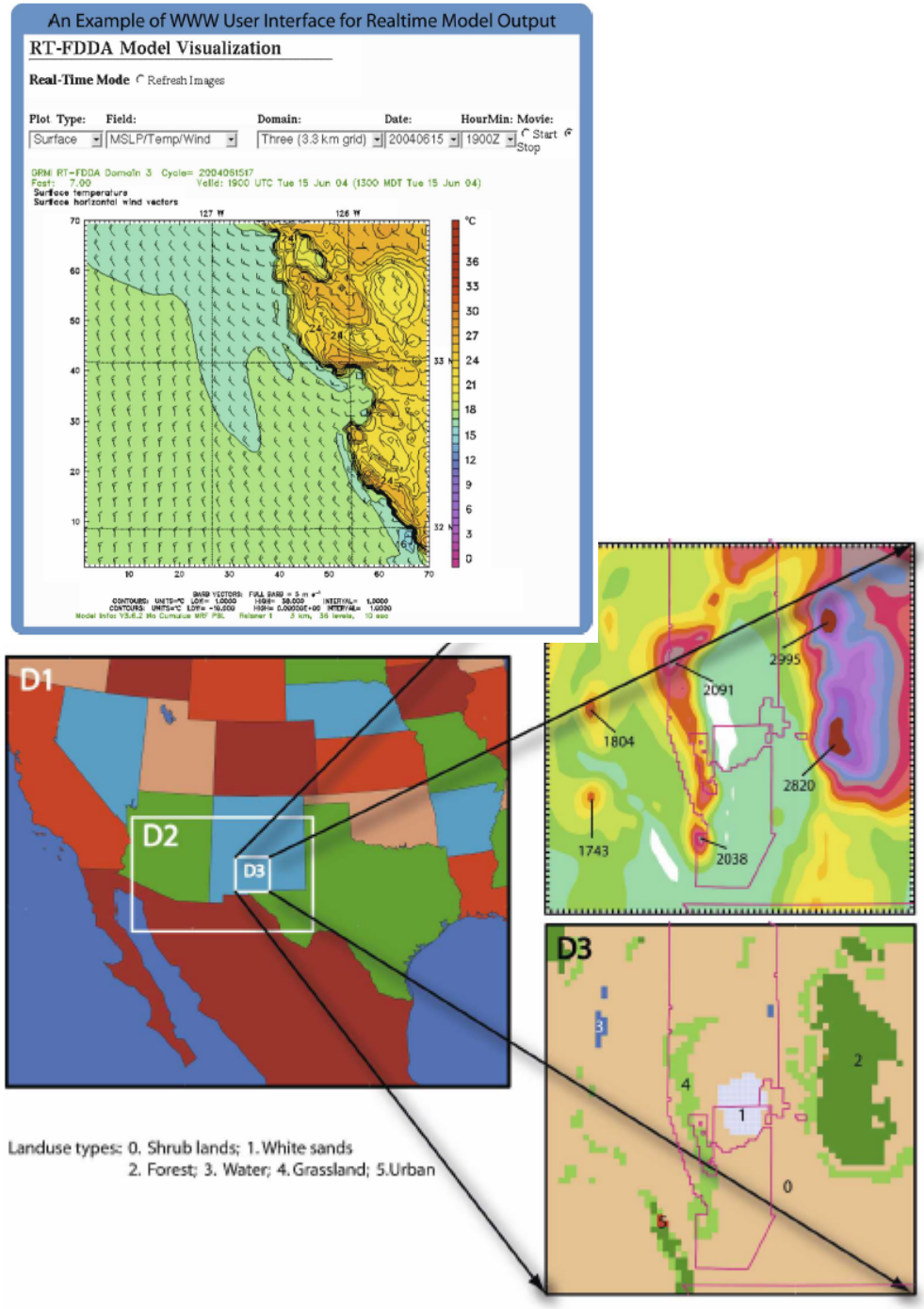
DPG Instrumentation

- Very dense network of meteorological sensors
  - 82 fixed 10-m towers, 9 portable 32-m towers, 113 portable 2-m towers
  - Radars, Sodars, lidar, lightning arrays, ceilometers etc.

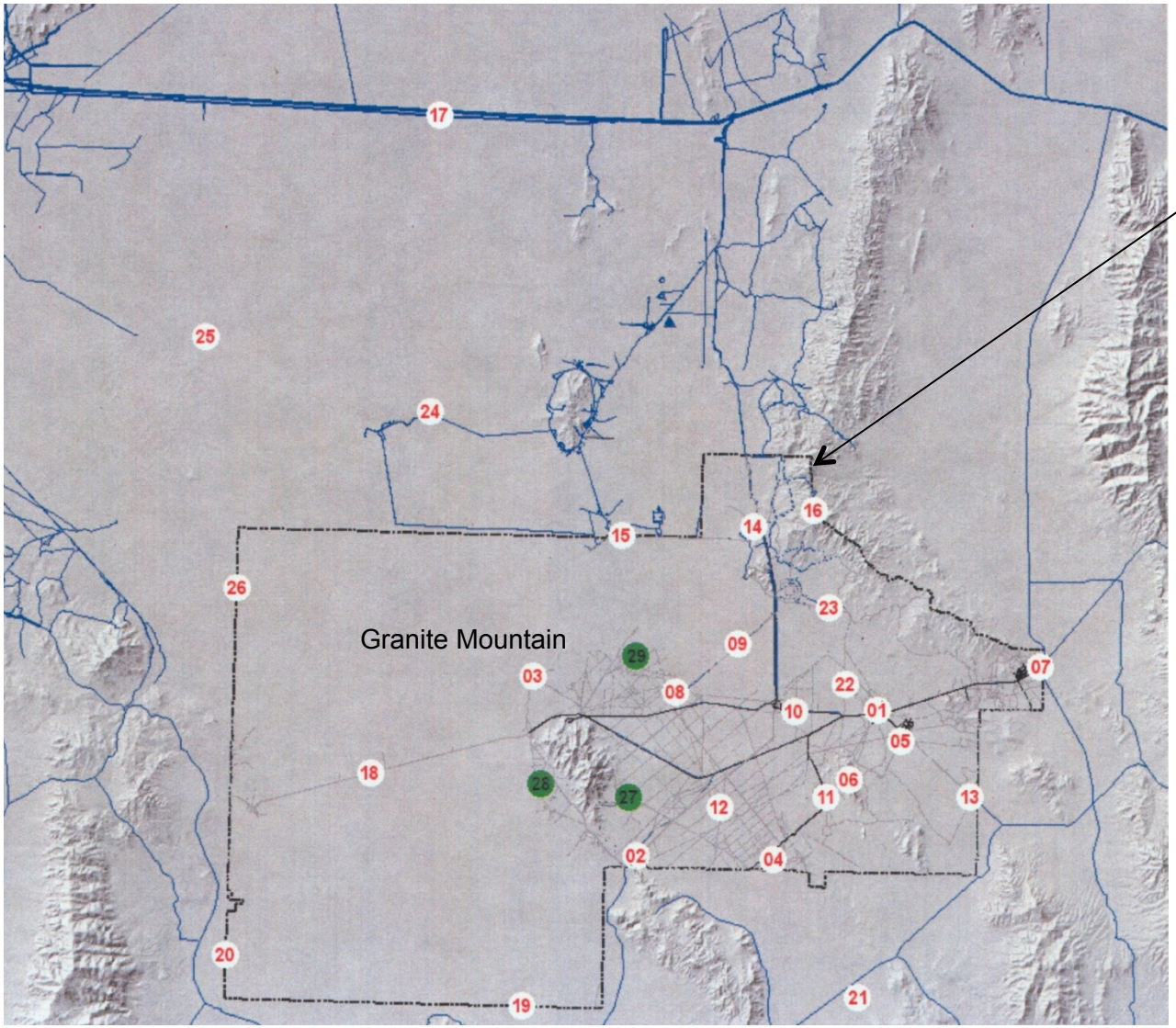


Weather forecast and data acquisition

- Excellent numerical weather modeling
  - Four-Dimensional Weather (4DWX)
  - 1.1 km resolution WRF runs 8 times per day
  - 3.3 km resolution 30 member ensemble runs 4 times per day
- Automated data retrieval and archival, and QC/QA
- Highly skilled forecaster staff



SAMS Network (2009)

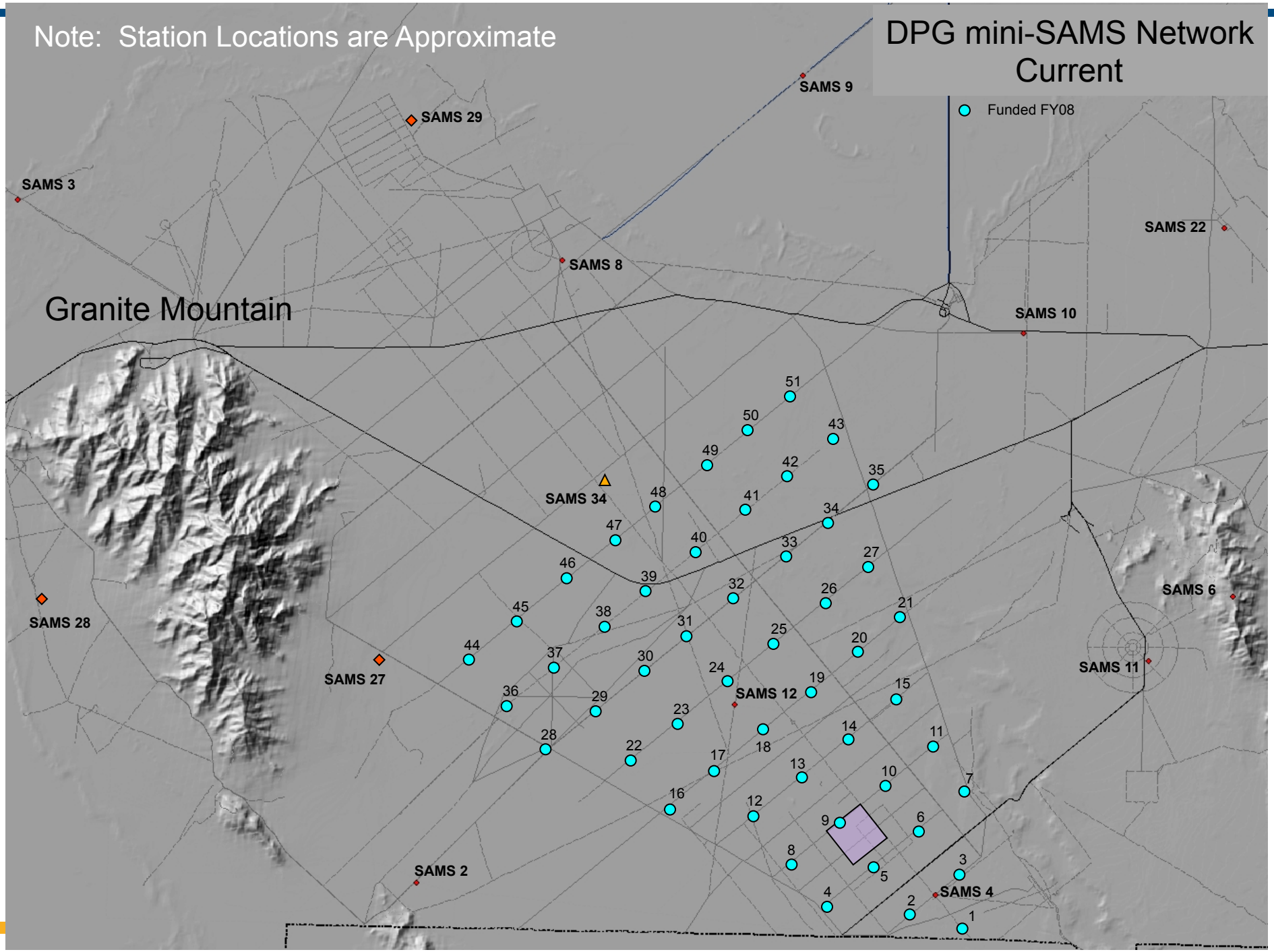


Black line shows DPG border

Surface Atmospheric Measurement System

10-m towers

Extensive instrumentation


Note: Station Locations are Approximate
DPG mini-SAMS Network
Current
Funded FY08
Granite Mountain
SAMS 9
SAMS 29
SAMS 3
SAMS 22
SAMS 8
SAMS 10
SAMS 34
SAMS 6
SAMS 28
SAMS 27
SAMS 11
SAMS 12
SAMS 2
SAMS 4
51
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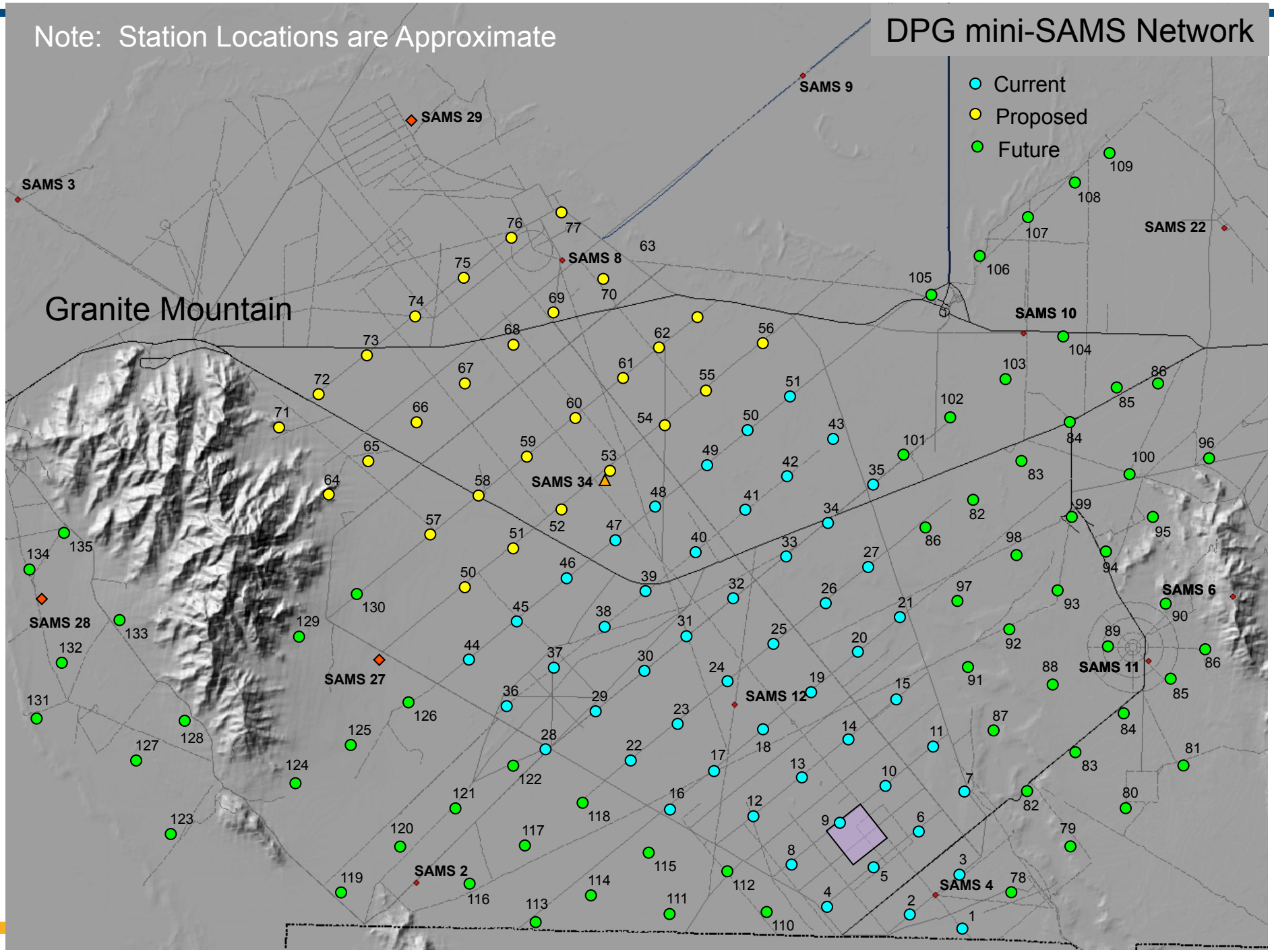
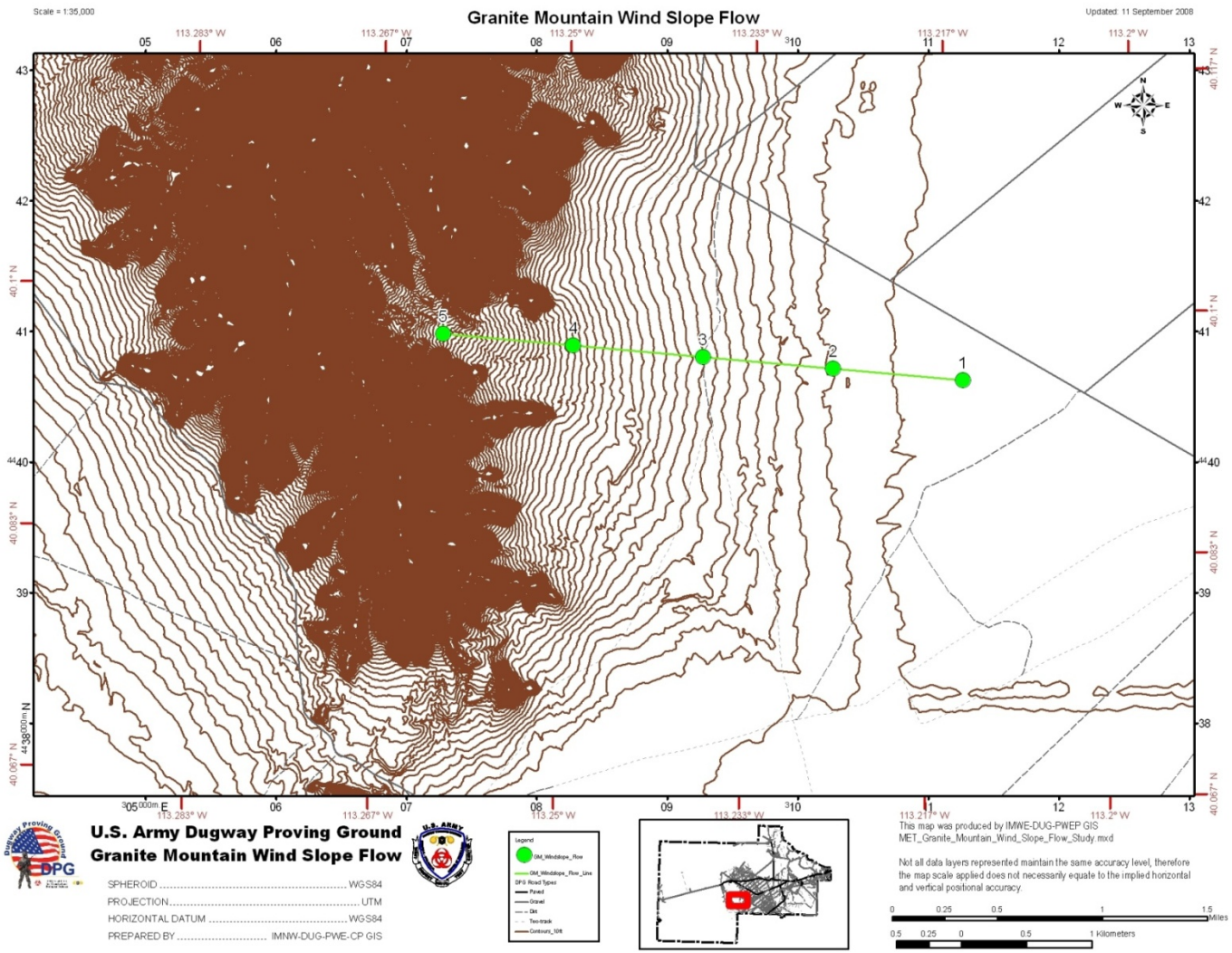

Note: Station Locations are Approximate
DPG mini-SAMS Network
Current
Proposed
Future
Granite Mountain
SAMS 3
SAMS 29
SAMS 9
SAMS 8
SAMS 22
SAMS 10
SAMS 34
SAMS 28
SAMS 27
SAMS 12
SAMS 11
SAMS 6
SAMS 2
SAMS 4

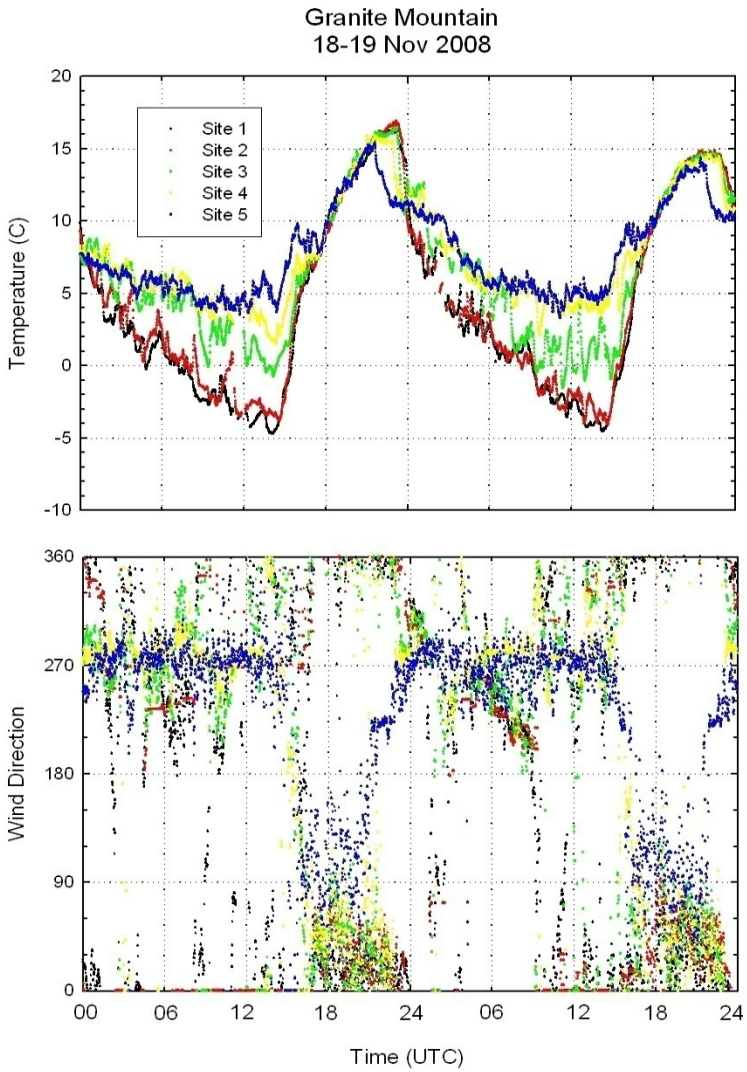
GMAST Deployment



Five 2-m towers deployed down a major channel on east face of Granite Mountain

Studying thermally driven flows

Sample of Data Analysis



PWIDS 1 elev 1447 m, PWIDS 5 elev 1312 m

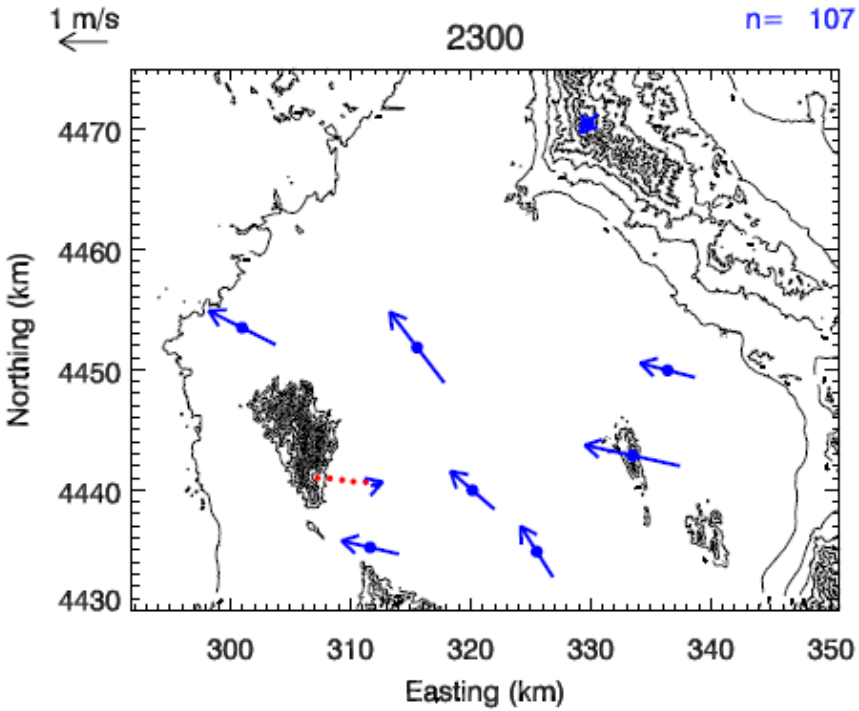
10 °C inversion develops during night -- height difference 135 m along the slope. Half of this between the center and lowest PWIDS (within lowest 25 m)

Note change in temperature as inversion depth reached each PWIDS

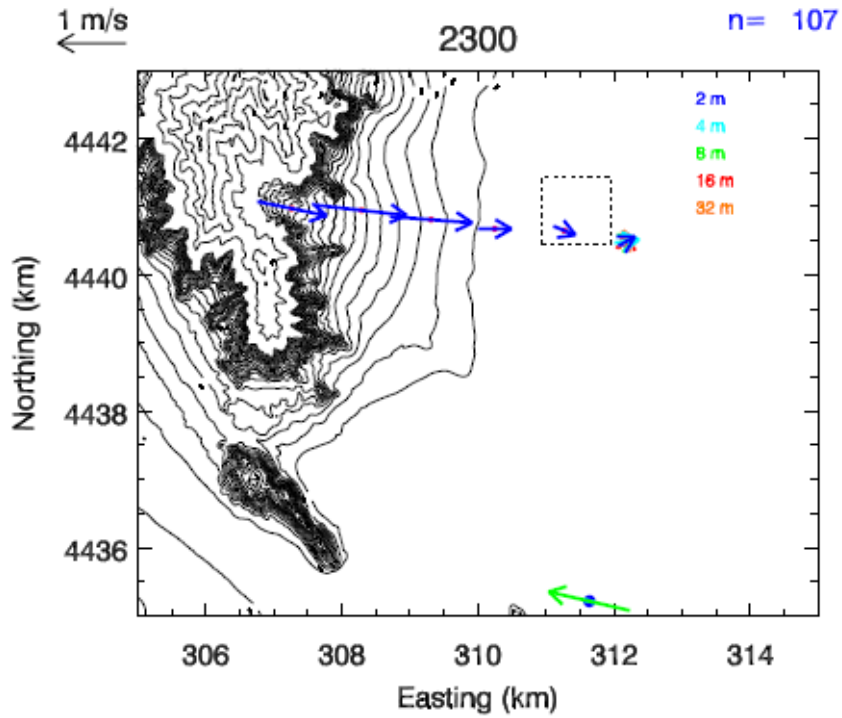
Shallow, very stable surface inversion on plain: 32-m tower data (not shown) reports 7-8 °C inversion in lowest 32 m

Wind direction shows nighttime drainage flows from the east side of Granite Mountain

Example of Flow Interaction



Large scale drainage flow from southeast at 2300 MST (0600 UTC)



Granite Mountain drainage flow from west at 2300 MST (0600 UTC)

JJA, SAMS wind speed < 3 m s^{-1}

Potential Areas for Studies

- Effect of background winds on mountain drainage flows
  - How do winds west of Granite Mountain compare to drainage flows on eastern slope?
- Effect of large-scale drainage flows on Granite Mountain downslope winds
  - How do depths and strengths of inversions affect this interaction?
  - Use network of taller towers
- Effect on drainage flows of inversion structure
  - Relate strength of drainage flow to inversion structure
  - How does gap north of Sapphire Mountain affect flows?
  - Use towers, microwave radiometers, and tethered balloons to evaluate temperature structure
  - Use sodars and towers to measure flow across gap

Potential Areas for Studies

- Effect of local topography on drainage flow homogeneity
  - Canyon walls may channel flow
  - Intensive field study could support numerical modeling research
- Energy budget effects on drainage flows
  - Study sensible and radiative flux divergences
  - Attempt to identify energy balance
- Studies of mechanical interaction between airflow and mountain
  - Downwind waves, rotors, etc
  - Use lidars, tethered balloons

Potential Areas for Studies

- Link field studies and numerical model development
  - Place sensors to correspond to critical sites in model structure
  - Collect data elements most relevant to model forcing
  - Could support LES, RANS model development
- Conduct data assimilation technique development and verification
  - Isolate critical processes
  - Evaluate 3DVAR, 4DVAR, ensemble Kalman filtering

DPG Support

- DPG's interest is the data collected, and the improved understanding of airflow near Granite Mountain
- DPG provides access to our assets
  - Unique topography & instrumentation network
  - Numerical modeling & data archival
  - Secure location
- Visiting scientists concentrate on field study design
  - Avoid need for expensive network of sensors, and data collection/ archival
  - Concentrate on specialized instrumentation, field study

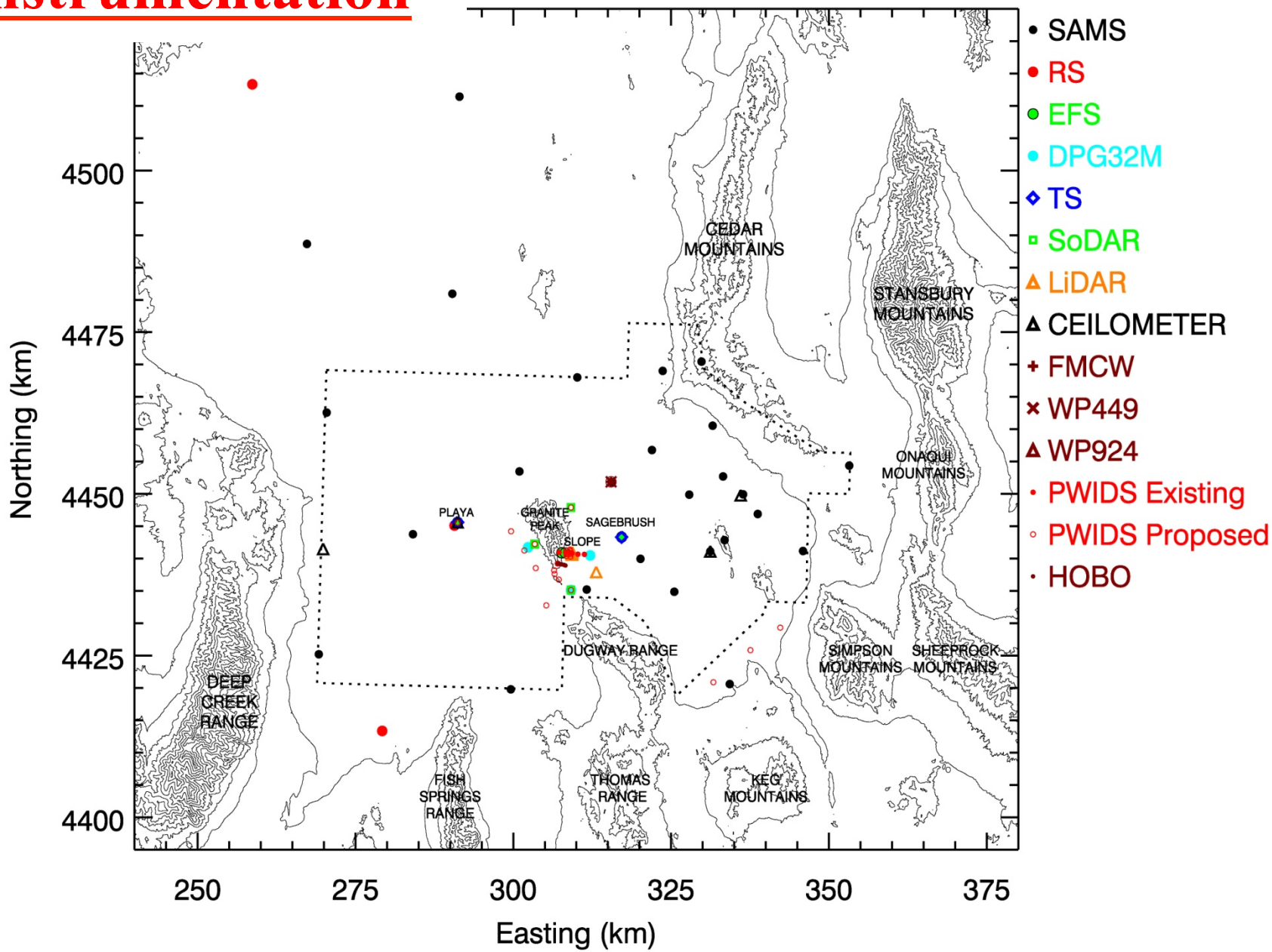
MATERHORN project

- MOUNTAIN TERRAIN ATMOSPHERIC MODELING AND OBSERVATIONS (MATERHORN)
- Collaboration of universities and government
- Two large field tests that will utilize GMAST facility
- Designed to identify and study the limitations of current mesoscale models for mountain terrain weather prediction and develop tools to improve predictability
- Project components:
  - Modeling Component (MATERHORN-M)
  - Technology Component (MATERHORN-T)
  - Parameterization Component (MATERHORN-P)
  - Field Experiment Component (MATERHORN-X)

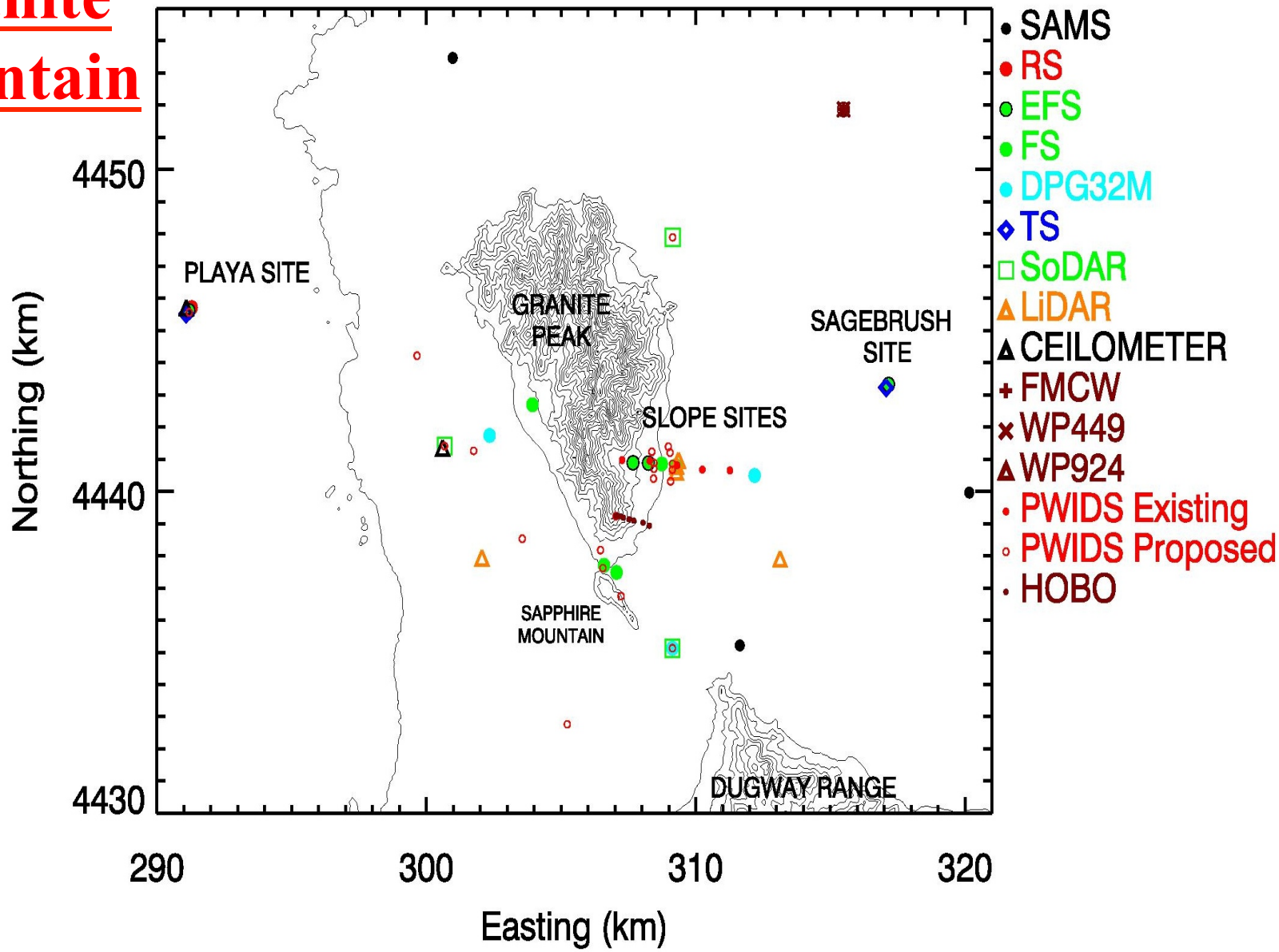
MATERHORN-X

- The scientific objective of MATERHORN-X is a comprehensive study of the interaction of small and large-scale motions in complex terrain
- Support the efforts to improve flow predictability via understanding of model errors, error growth and predictability limits
- The collected data will facilitate model validation, data assimilation and development of physics-based parameterizations
- MATERHORN-X test schedule:
  - 25 Sept. – 25 Oct. 2012: MATERHORN-X-FALL at DPG
  - 22 April – 19 May 2013: MATERHORN-X-SPRING at DPG
  - Date to be determined: MATERHORN-X-Fog in SLC

Instrumentation



Granite Mountain



East Slope of Granite Mountain

Slope Experiments

ES5 / EFS-SLOPE

UU 20m tower
1 sonic & all T/RH from DPG
On concrete pad.

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?

ES3

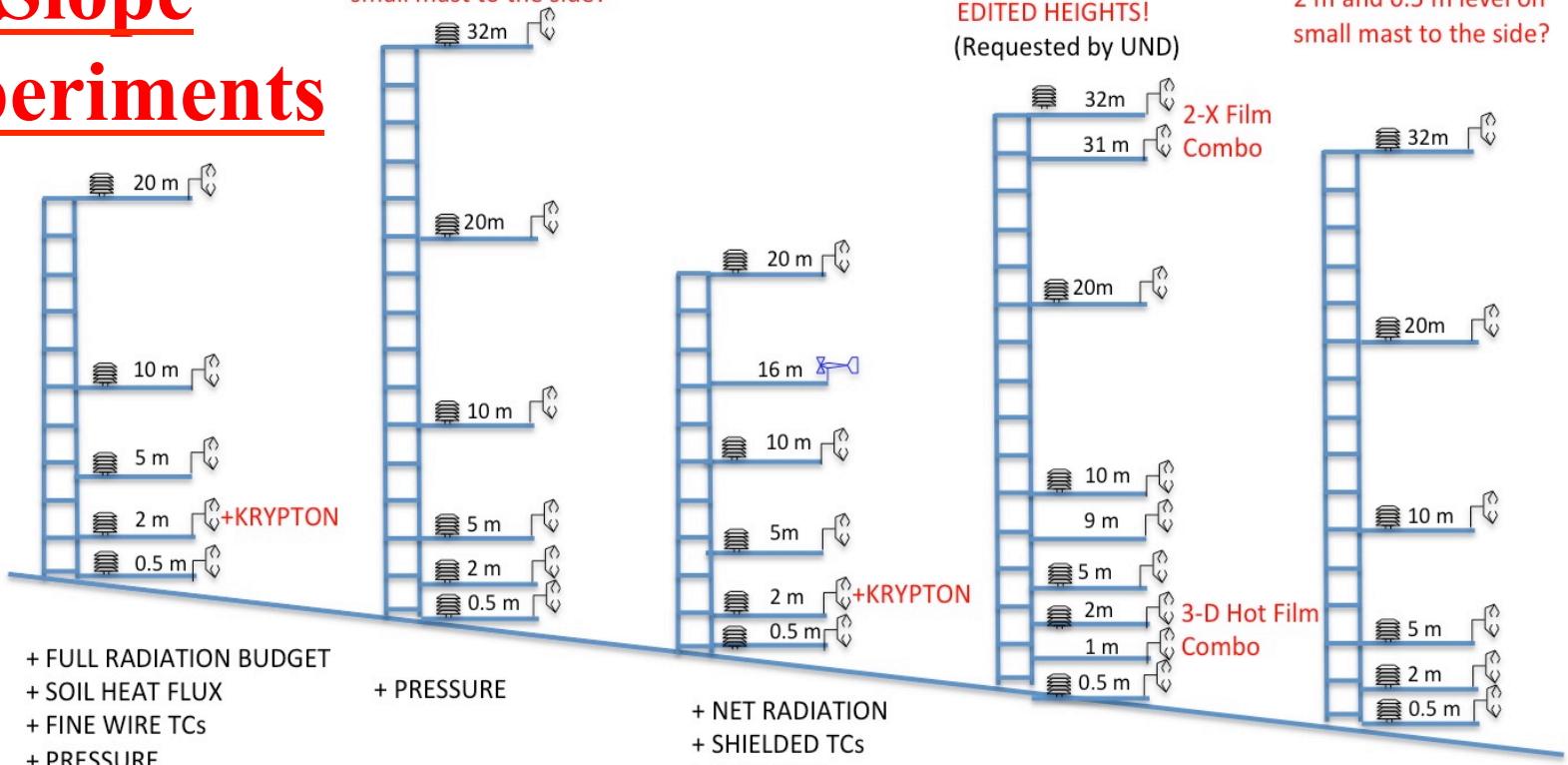
UND 20m tower.
EDITED HEIGHTS!
On concrete pad.

ES2

DPG 32m tower.
Edited heights & one extra level
2 m and 0.5 m level on small mast to the side?
EDITED HEIGHTS!
(Requested by UND)

ES1

Existing DPG 32m tower. Wind birds changed to sonics.
Edited heights & one extra level
2 m and 0.5 m level on small mast to the side?



+ FULL RADIATION BUDGET
+ SOIL HEAT FLUX
+ FINE WIRE TCs
+ PRESSURE

+ PRESSURE

+ NET RADIATION
+ SHIELDED TCs
+ PRESSURE

+ PRESSURE

Responsible: UU	UU	UND	UND	UU
N 40.09652 W 113.25861	N 40.09586 W 113.25252	N 40.09567 W 113.24405	APPROX: N 40.09587 W 113.23733	N 40.0938 W 113.2032

NAY ING GROUND

Test execution

- Three types of Intensive Observation Periods (IOP)
- 10 IOPs during both DPG MATERHORN campaigns
- At least one day between two consecutive IOPs
- Equipment setup will start in middle August 2012
- Dry run at the end of August 2012

IOP Type	Definition 700mb wind speed	Number Fall 2012	Number Spring 2013	Start – End
Quiescent	< 5 m/s	6	4	1200LT -1200LT
Moderate	5 m/s – 10 m/s	3	4	1200LT -1200LT
Transition	Variable, could be >10m/s, front passage	1	2	Flexible (timed around the event)

Summary and plans

- 2012 and early 2013: prepare and conduct MATERHORN field tests
- GMAST
  - Attract complex terrain research groups
  - Granite mountain will become reference feature
- Expand instrumentation network
- Improve forecasting capabilities and accuracy
- New atmospheric dispersion and transport tests