Investigation of the spatio-temporal variability of atmospheric boundary layer depths over mountainous terrain observed with a suite of ground-based and airborne instruments during the MATERHORN field experiment

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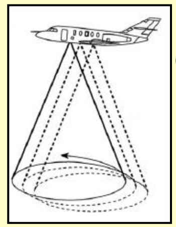
1. Introduction

Within the first field experiment of Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) program conducted at Dugway Proving Ground (DPG, Utah, USA) between 25 September and 24 October 2012, a suite of ground-based and airborne instruments were deployed to collect high spatio-temporal resolution information on the atmospheric state variables and other passive tracers (e.g., aerosol backscatter) of boundary layer dynamics. In particular, a coherent Doppler lidar onboard a Navy Twin Otter aircraft was deployed to aid in characterizing turbulence features within the ABL as well as the spatial heterogeneity of the top of the ABL (so called, z_i) over an extended area around a steep isolated mountain (i.e. Granite peak).

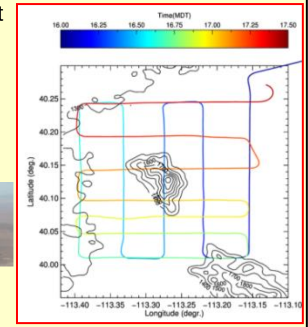
2. Twin-Otter Doppler Wind Lidar (TODWL)



Conical scans below the aircraft
Azimuth angle steps of 30°
20-25 s for full 360 scan

Granite Peak, DPG, Utah

2-µm coherent detection
Side door mounted 3-d scanner
Range: 0.3 – 21 km
Accuracy: < 0.10 m/s in three components
Temporal resolution is aerosol profiles: 0.25 s
Vertical resolution: 50 m
Aircraft speed : 50 m/s
North-south and east west legs of ~20-30 km



An example flight pattern (RF03) performed during MATERHORN-X1

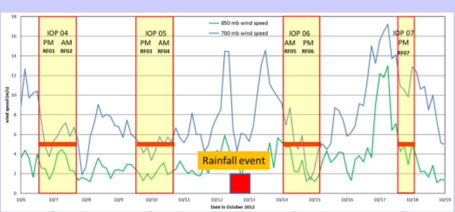
3. Objectives

Applying Haar wavelet transform on the TODWL-derived high-resolution aerosol backscatter profiles, the spatial variability in z_i around the Granite Peak is investigated to:

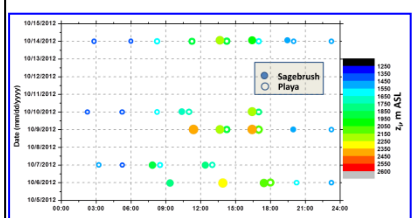
1. determine the roles of both the complex topography and the changes in the surface forcing owing to the land-surface heteorogity on the spatial variability in z_i in a mesoscale domain.

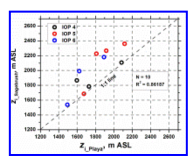
2. characterize the ABL thermodynamic features and the z_i variability during the selected IOPs so that scientific community can use these information for myriad research purposes (e.g., scaling of turbulence features, CBL parameterization, idealized simulation, model evaluation as well as data assimilation)

4. TODWL missions

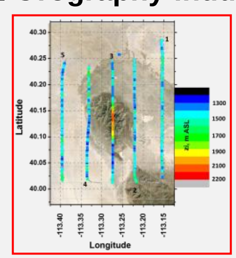


5. Radiosonde-based analyses of z_i



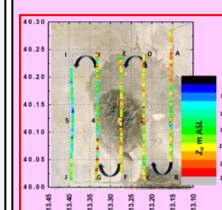


6. Orography-induced modification



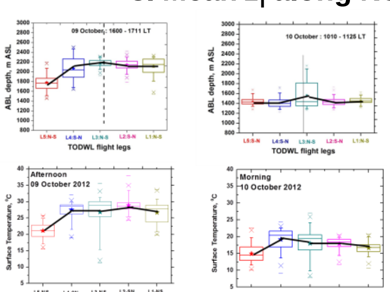
North-South (or South-North) legs in the morning on **10 October 2012.** Temp. Res.: 0.25 s

7. East-west gradient in z_i



09 Oct 2012 afternoon measurements indicating higher z_i over the eastern side of the Granite peak than over the western side.

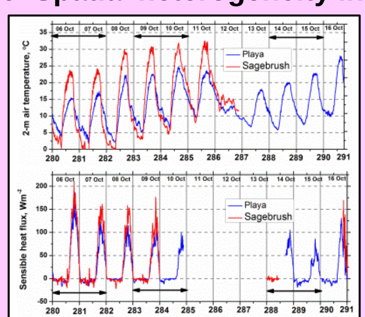
8. Mean z_i along NS legs



Box-and-whisker plots of z_i and surface temperature along the north-south flight legs performed on 09 October afternoon (left) and 10 October morning (right).

Similar patterns in z_i and surface temperature can be seen illustrating surface forcing on z_i.

9. Spatial heterogeneity in the surface forcing



The diurnal course of near-surface temperature (upper) and sensible heat flux (lower) at both Playa (blue-solid line) and Sagebrush (red-solid line) sites during different IOPs (marked by arrows). Temp. Res: 5 minutes

10. Summary and conclusion

- The CBL structure in the morning is highly inhomogeneous, the afternoon CBL structure tends to be horizontally homogeneous w.r.t underlying orography, however, remnant spatial variability is attributed to the land-surface heterogeneity and relevant forcing.
- Surface moisture variability and resulting SHF played a decisive role in generating east-west gradient in z_i.
- RS-based observations confirm the WE gradient z_i

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