Boundary layer investigations

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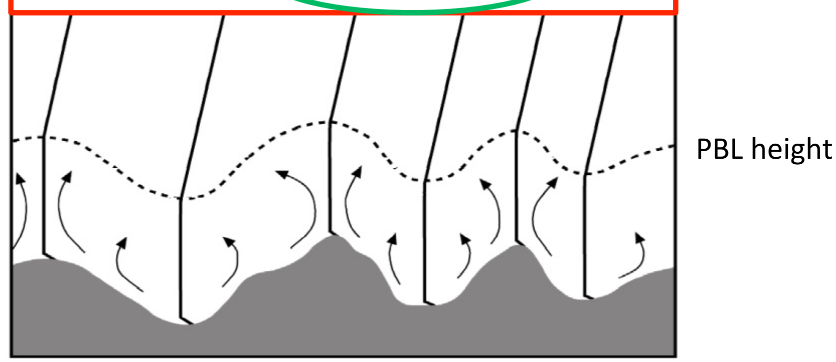
Local scale flows - mesoscale flows - synoptic scale flows

Convergence/divergence
wind shear
Turbulence
...

Effects on spatial and temporal variability of PBL structure



The extent to which these interactions and their effects on PBL structure are simulated affects mesoscale predictability

Main activities

- Turbulence analysis from T-REX data set

- CBL height analysis Dugway Proving Ground

- Experiment planning

Turbulence

to address degree of (non-)stationarity in surface layer turbulence time series of *u*, *v*, *w* and *T* within 30-min intervals in complex terrain during T-REX

to investigate the processes and mechanisms underlying the (non-)stationarity in Owens Valley

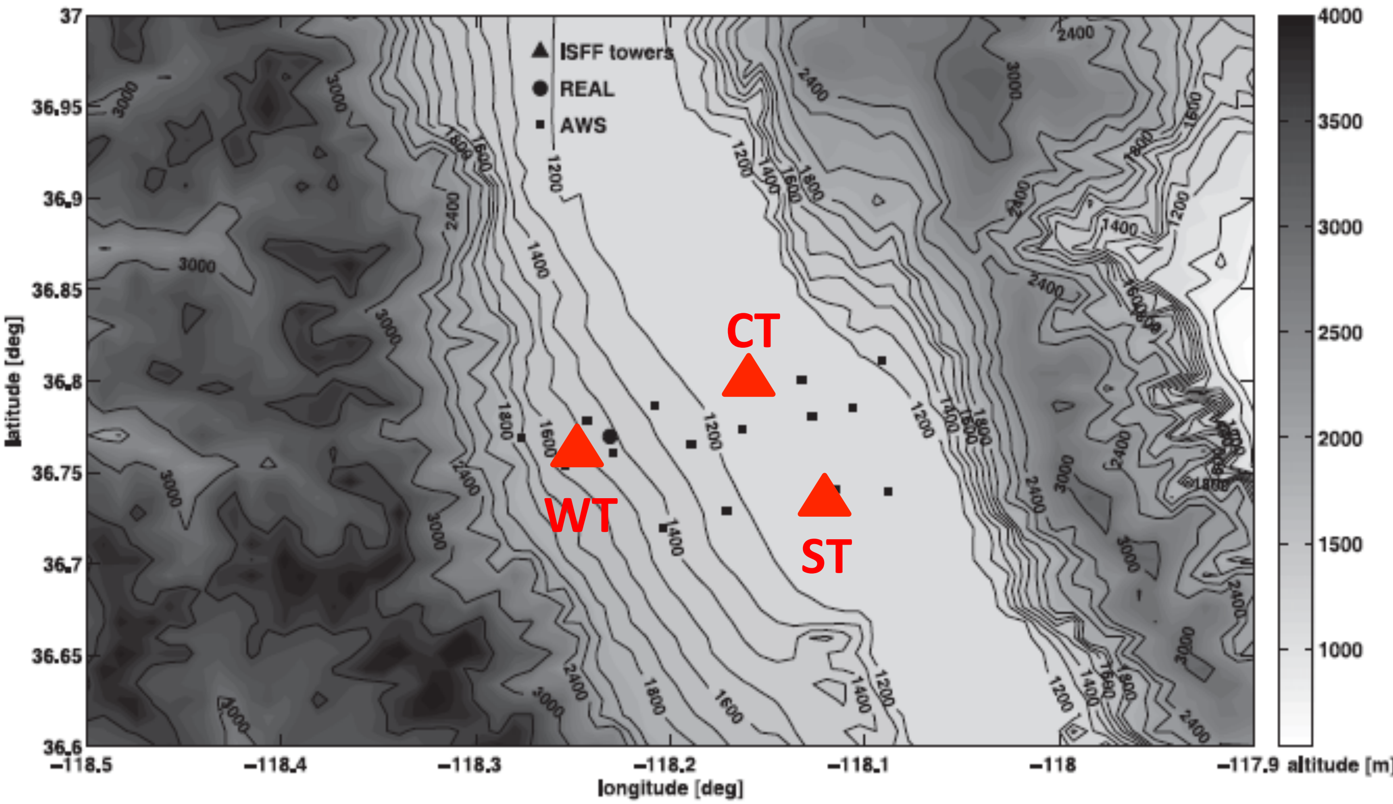
To use stationary portion of data to asses performance of widely used flat terrain similarity functions in complex terrain

To eventually modify these functions for complex terrain

DATA: T-REX experiment Owens Valley, California, March and April 2006

- Three NCAR-ISFF 30-m towers
- CSAT3 ultrasonic anemometers at heights of 5, 10, 15, 20, 25 and 30 m
- 60 Hz sampling frequency

More than 90% data coverage at all towers at all heights



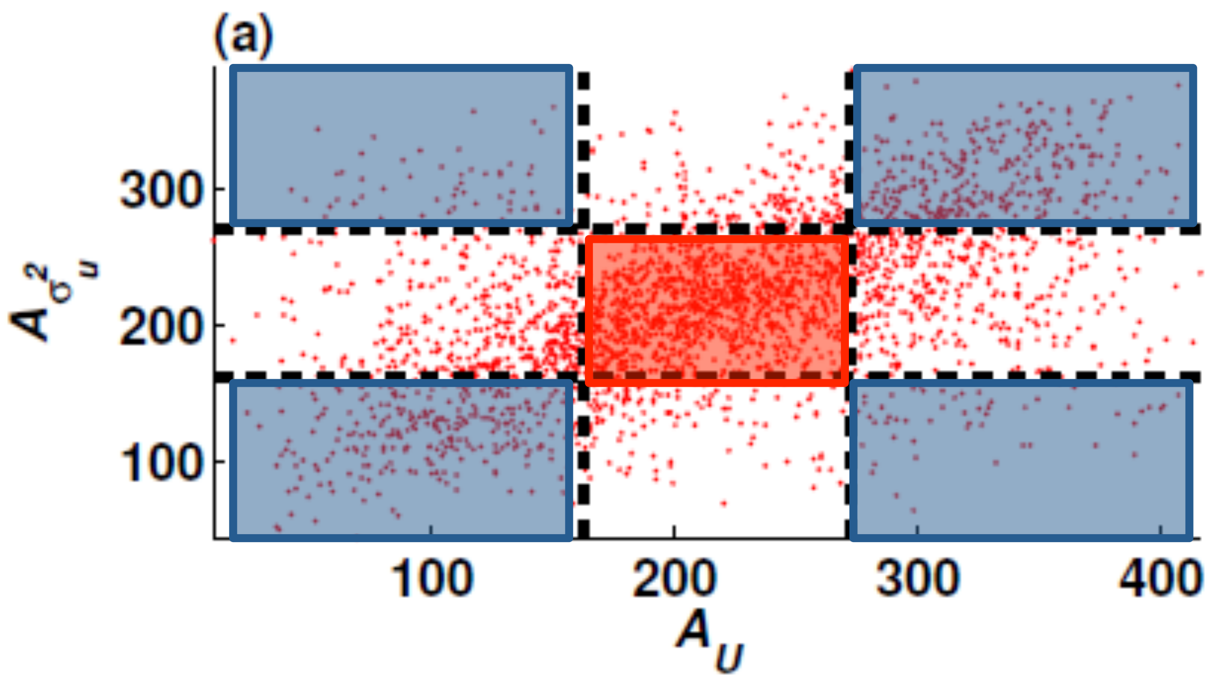
Determining stationarity

using a nonparametric statistical test for the absence of trends in time series of statistical moments . Also called Reverse Arrangement Test (RAT; after Bendant and Piersol 1986).

If statistic *"A"* has value between 162 and 272, test is passed at 95 % significance level

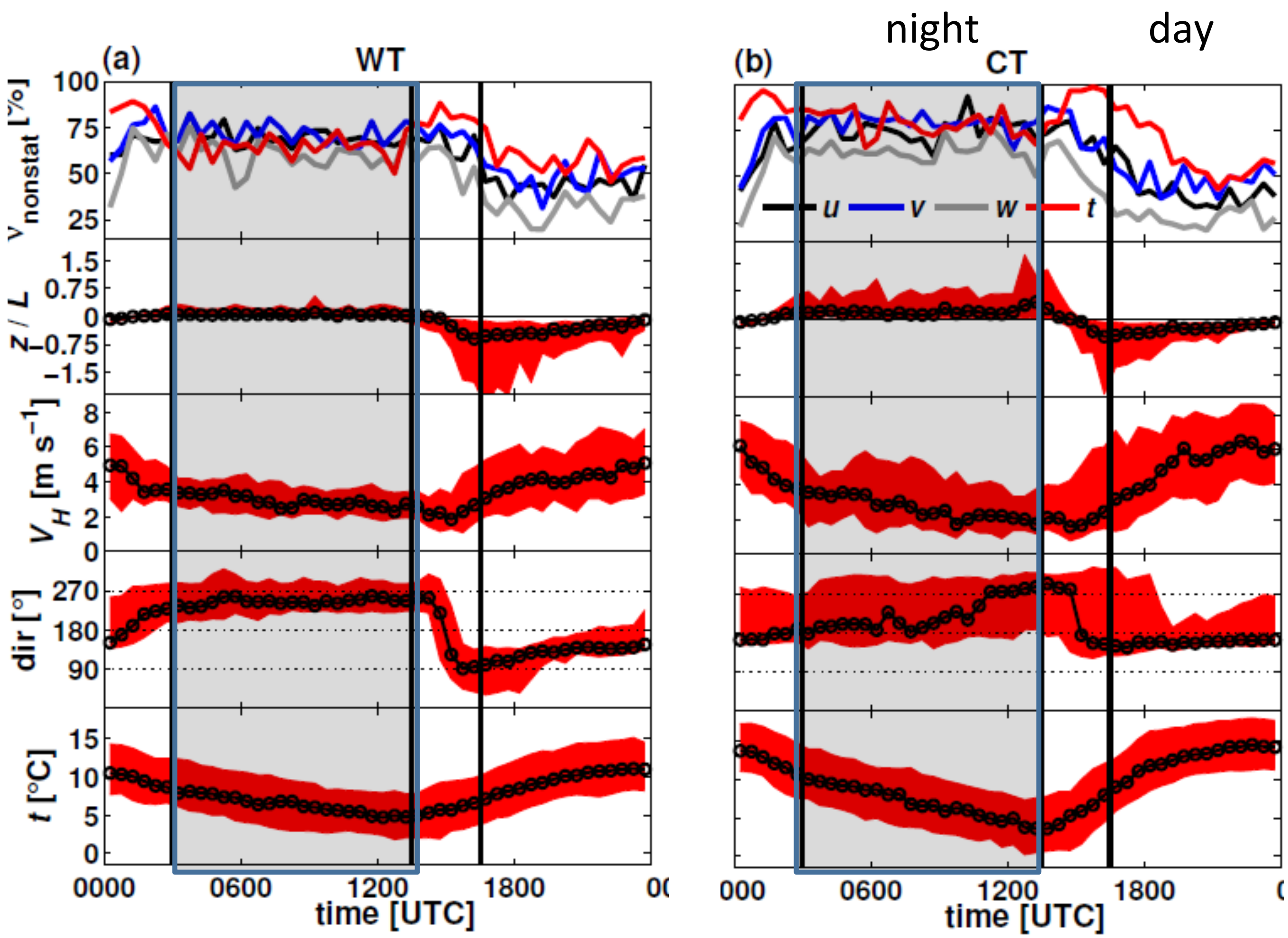
Pure stationary data (37.1% of all data)

Pure non-stationary data (25.9% of all data)



EXAMPLE: U wind component 10-m level at Central tower

Diurnal cycle of (non-)stationarity of *u*, *v*, *w* and *T*



Slope site

Valley site

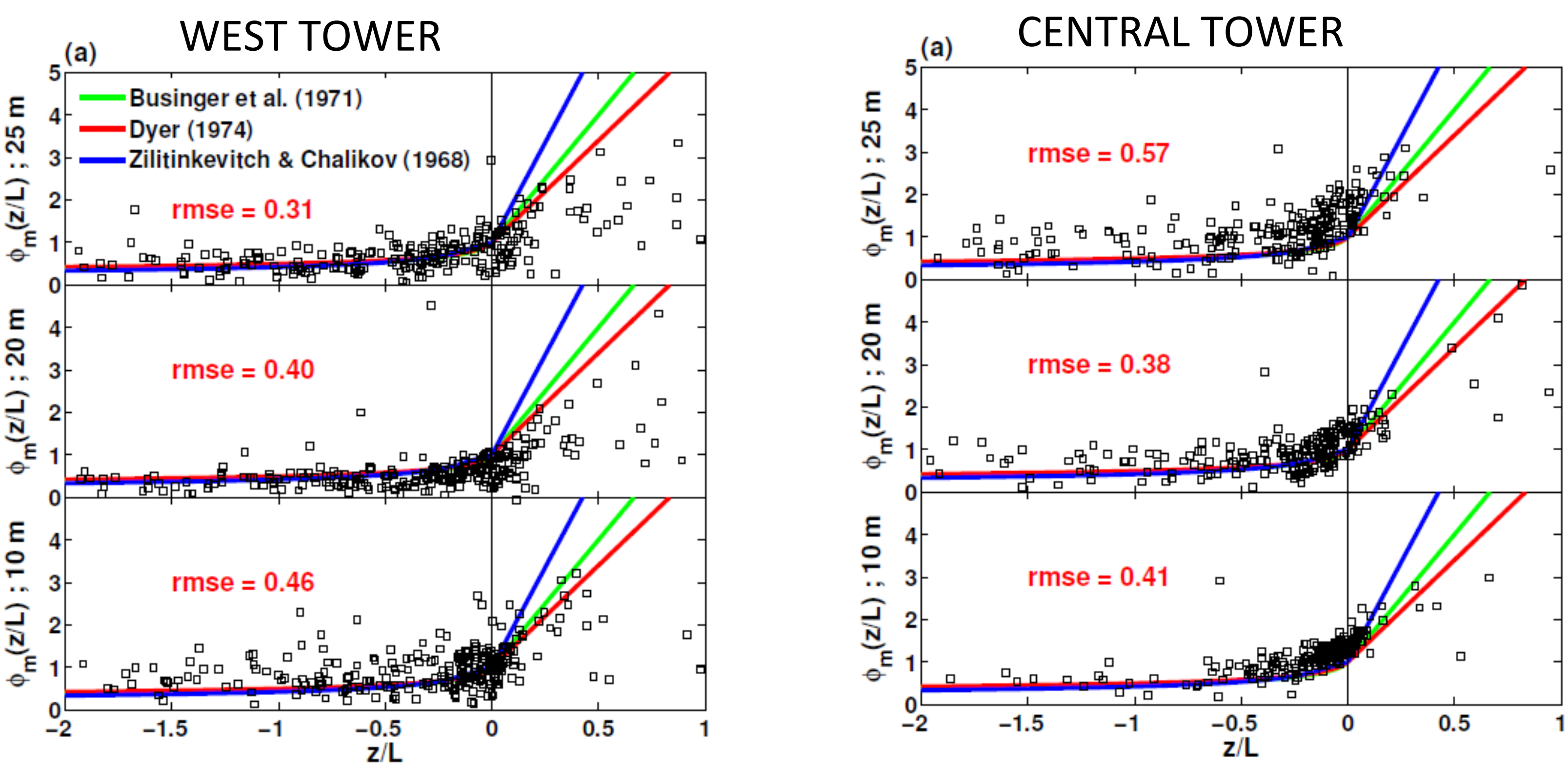
Assessing performance of similarity functions

Monin-Obukhov Similarity Theory (MOST) – widely used in surface layer parameterizations

Non-dimensional wind speed gradient $\partial u / \partial z \; kz/u_* = \phi_m(z/L)$ L = Monin-Obukhov length

e.g. Businger et al., 1971: $\phi_m(z/L) = (1-19.3z/L)^{-1/4}$ for unstable situation ($z/L < 0$)

$\phi_m(z/L) = (1+6z/L)$ for stable situation (z/L >



25 m

20 m

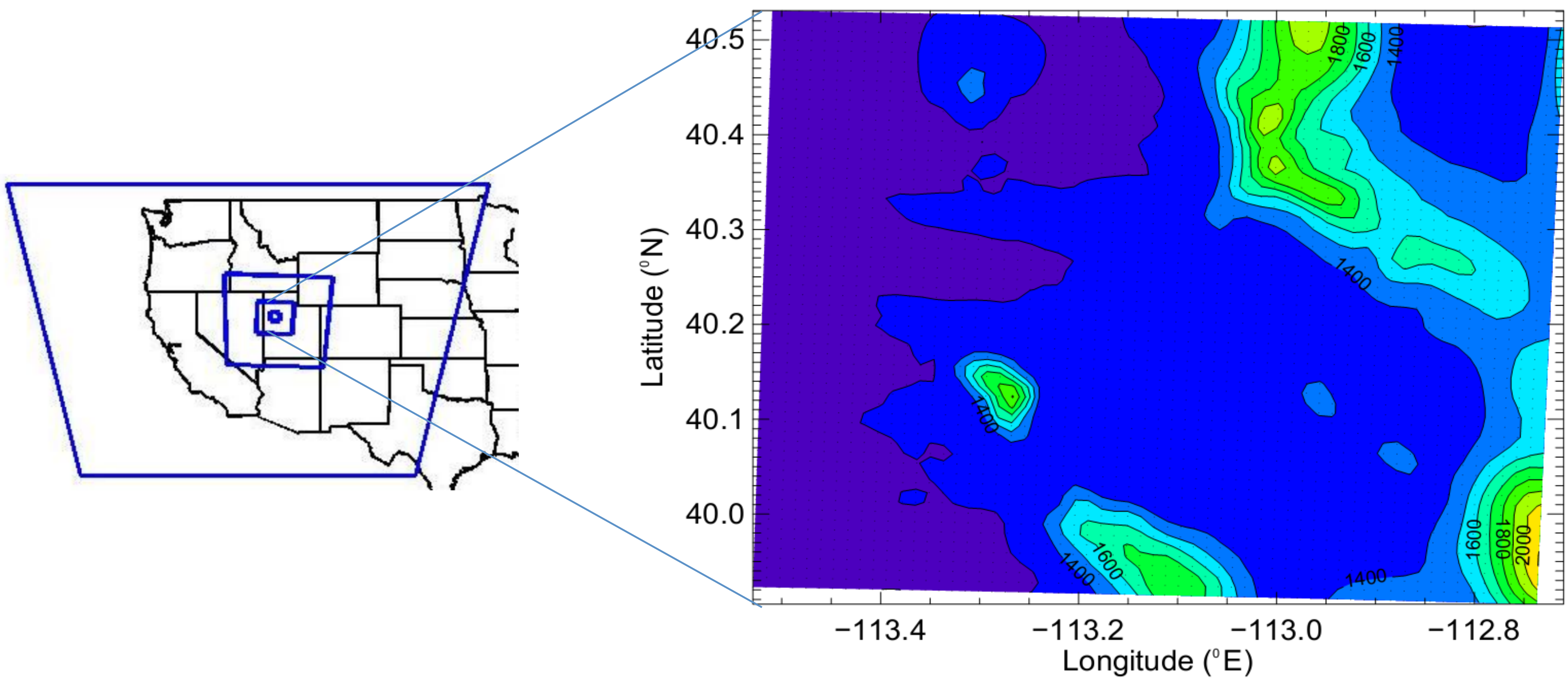
10 m

CBL heights

- To obtain estimates of CBL heights in the innermost domain (domain 4 at resolution of 1.1 km) of operational NCAR runs for DPG
- To investigate temporal and spatial variation of CBL heights
- To use these heights as guidance in flight planning
- (post-experiment) to evaluate simulated CBL heights with observed CBL heights (radiosondes, radar wind profilers, lidars)

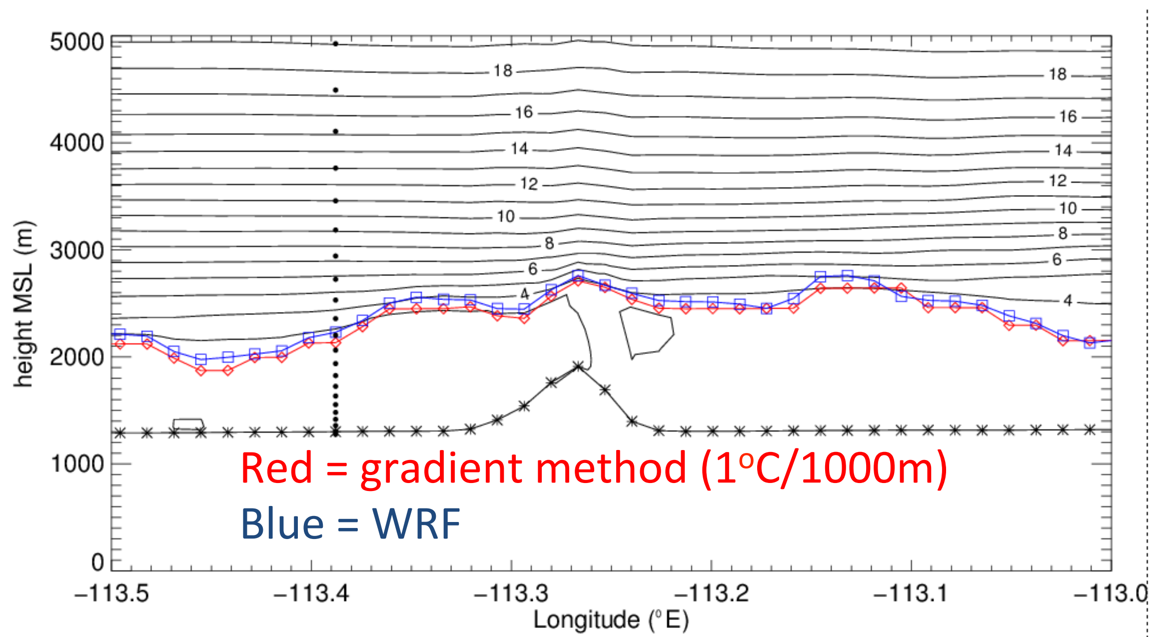
WRF –DPG model output for September, October, and November 2011

- 4 domains: 30, 10, 3.3, 1.1 km; 37 vertical levels; YSU PBL scheme, MO surface layer, NOAH LSM
- 48 hr simulations initialized at 02, 05, 08, 11, 14, 17, 20, and 23 UTC
- CBL heights at 16, 19, and 22 UTC ('analysis' files used for 17, 20, and 23 UTC runs)



Various methods for CBL height determination, e.g.:

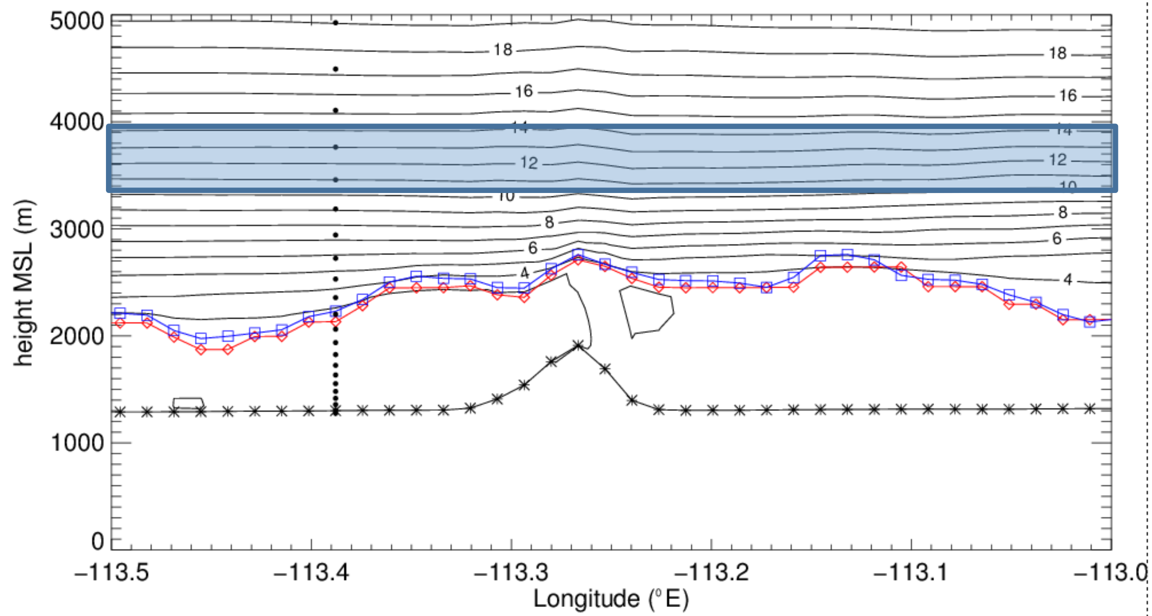
- Temperature gradient method
- Parcel method
- Richardson number method
- Turbulence kinetic energy method
- Internally in WRF (depending on PBL parameterization)



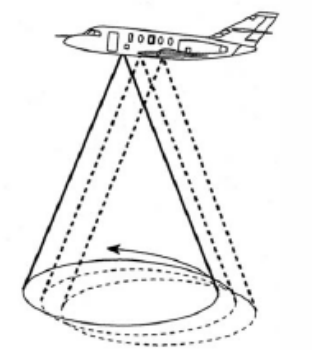
Example: potential temperature cross section
12 Oct 2011, 22 UTC

IMPORTANCE FOR FLIGHT PLANNING

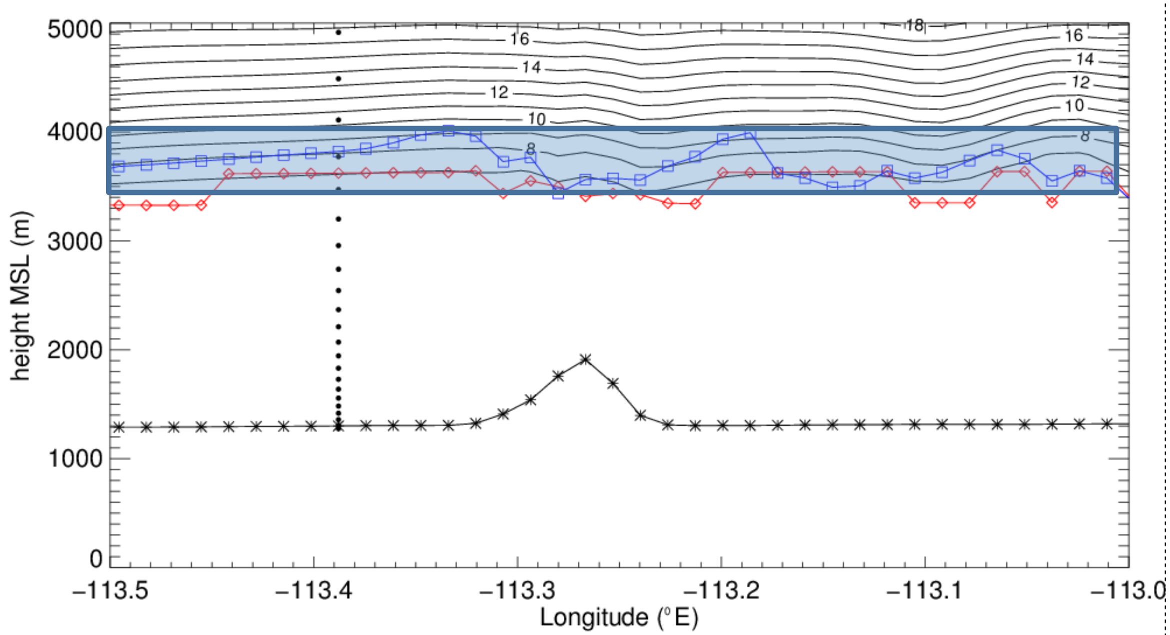
12 Oct 2011
22 UTC

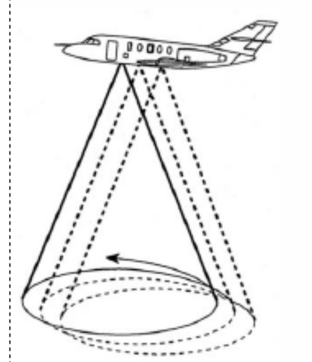


Airbone wind lidar

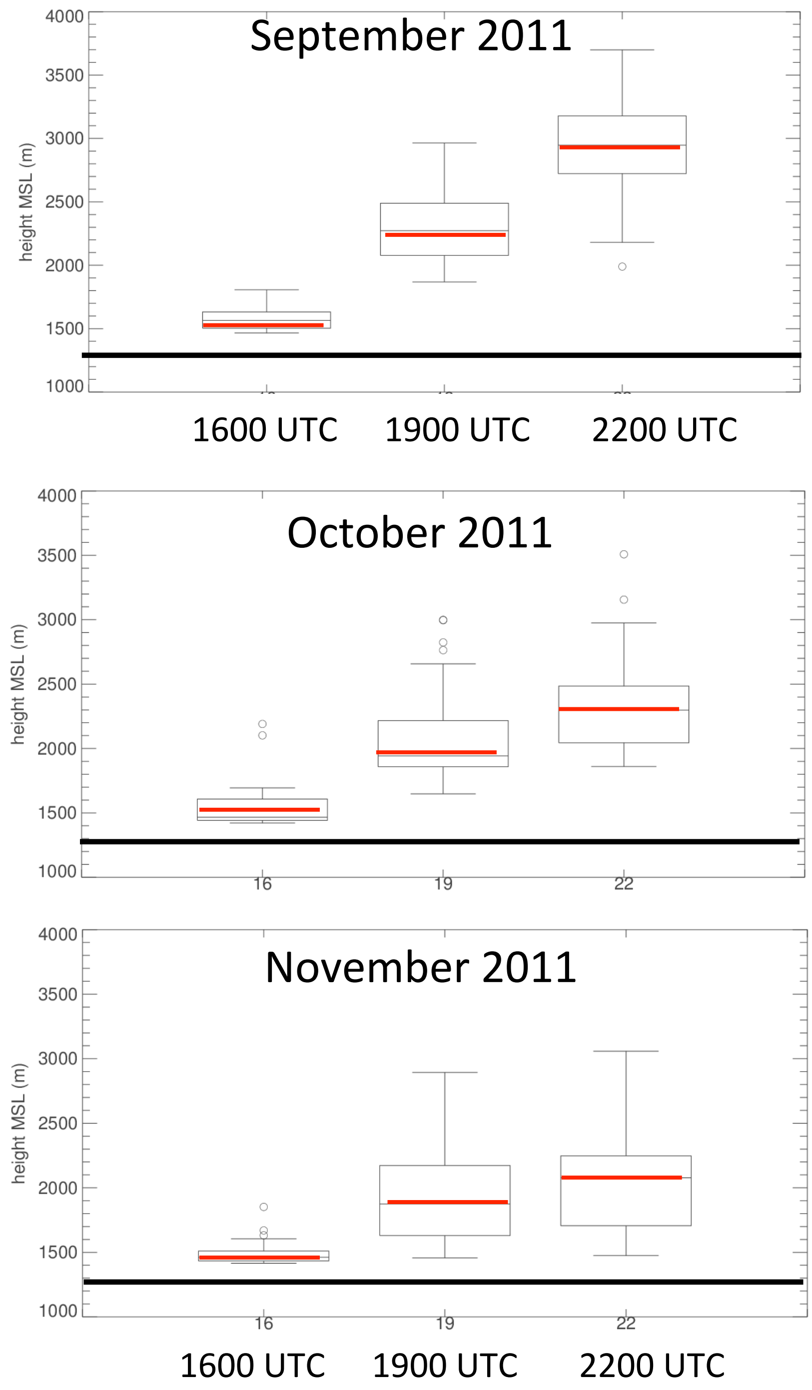


11 Oct 2011
22 UTC

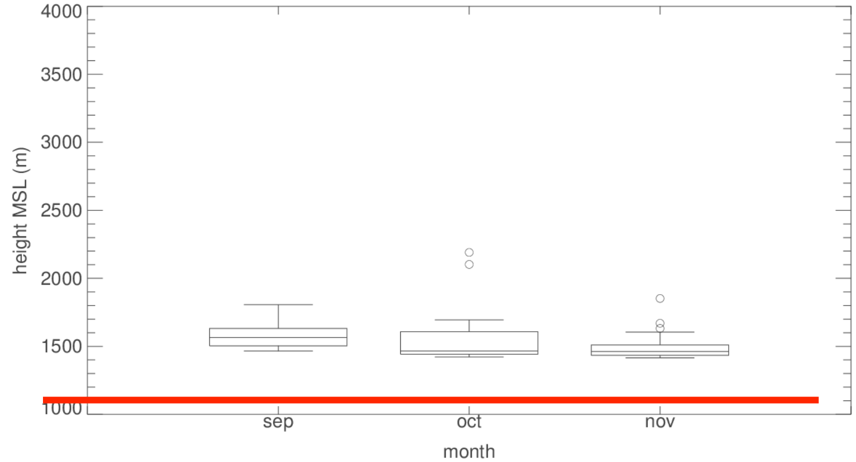




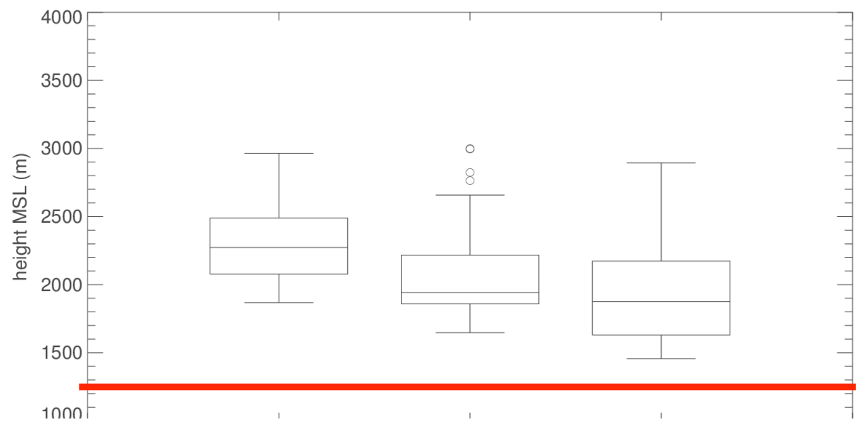
Temporal evolution of CBL in innermost domain (66x66km)



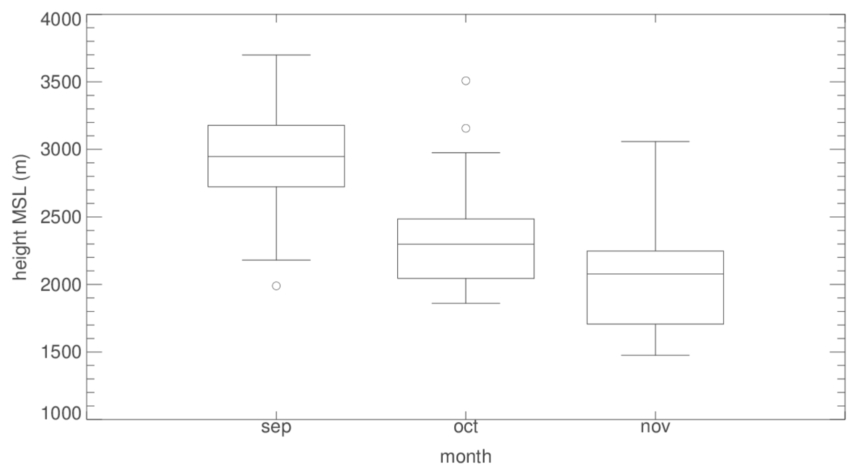
1600 UTC



1900 UTC

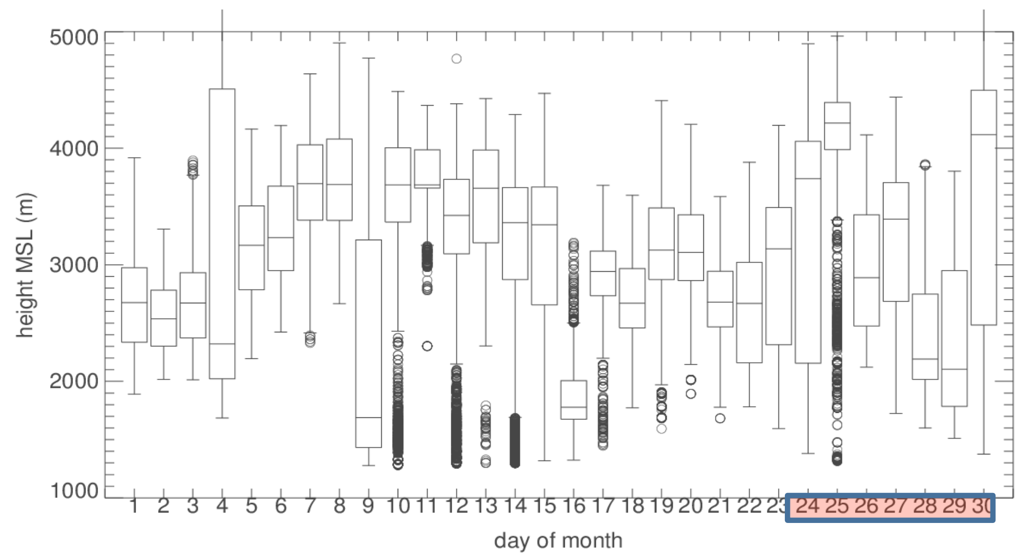


2200 UTC

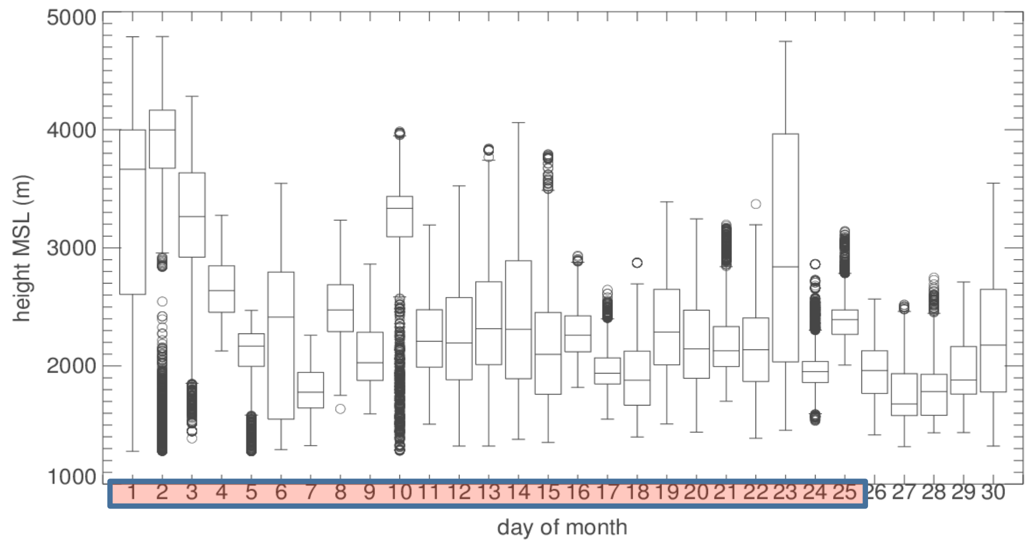


DAY-TO-DAY VARIABILITY OF CBL HEIGHT

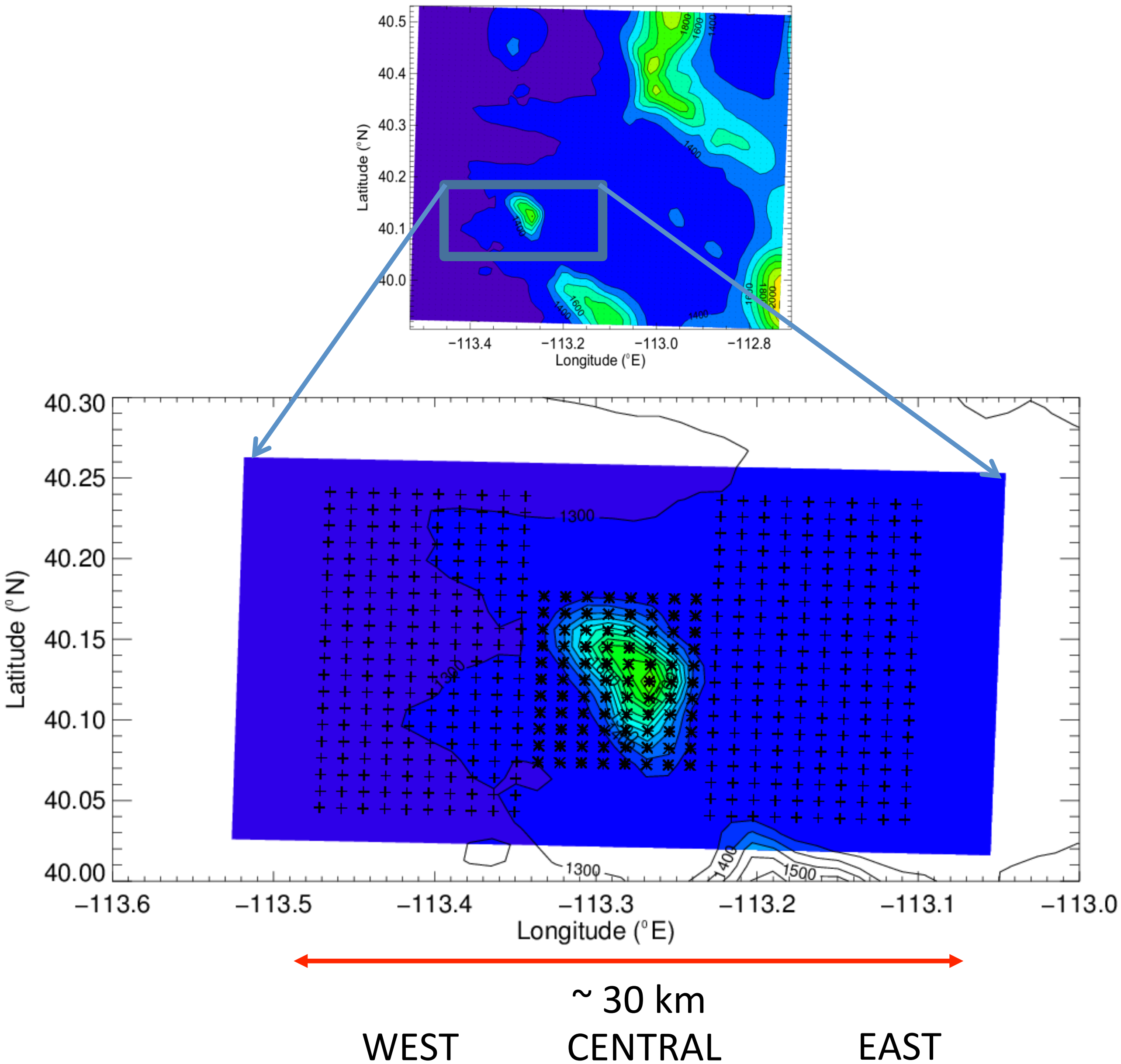
SEPTEMBER 2011



OCTOBER 2011

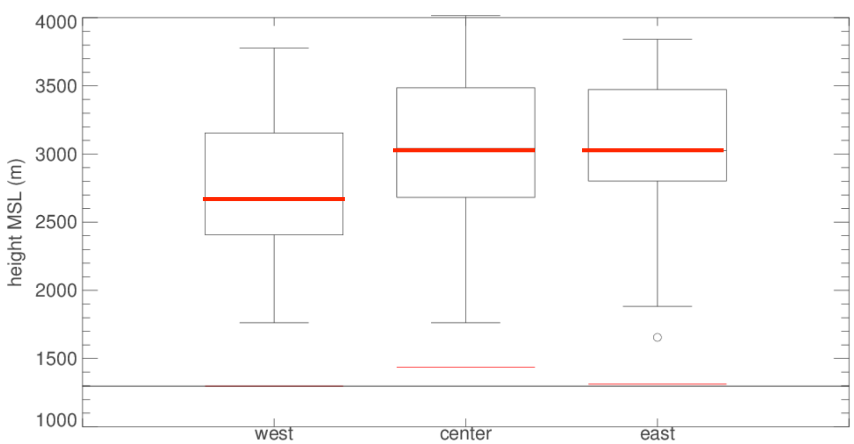


Investigating spatial variation of CBL heights



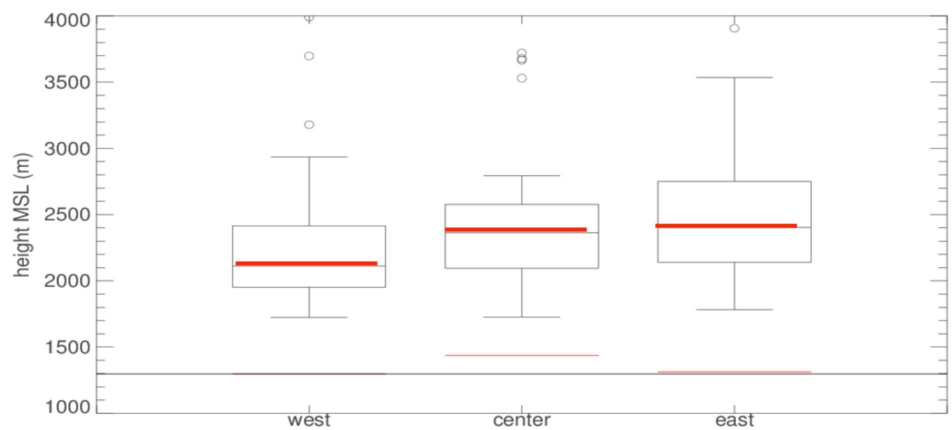
Spatial variation of CBL heights

SEPTEMBER 2200 UTC



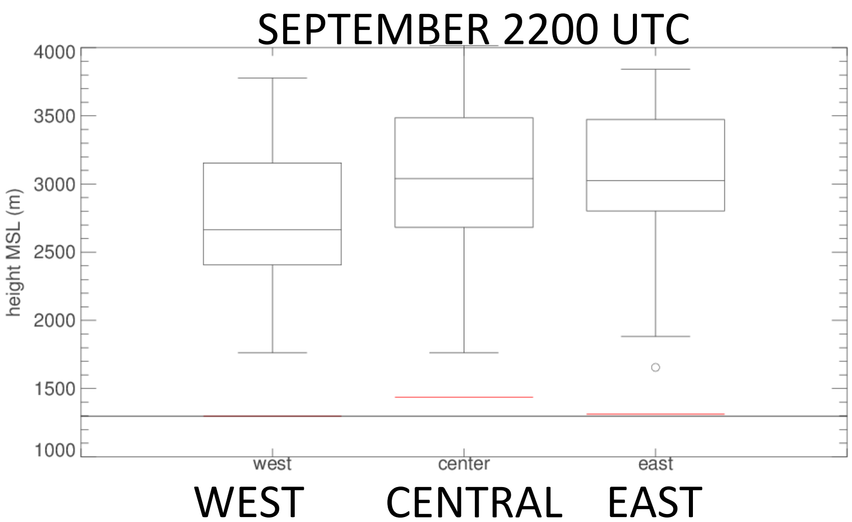
WEST CENTRAL EAST

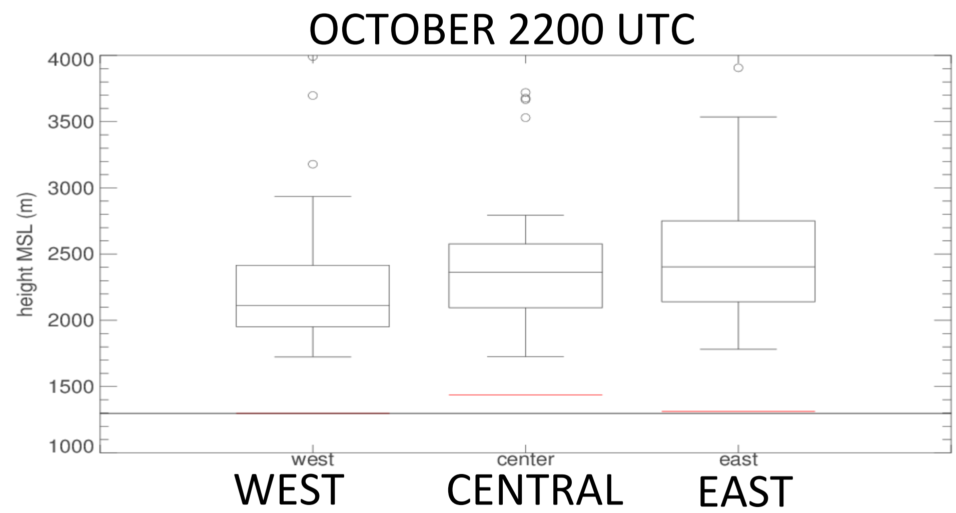
OCTOBER 2200 UTC



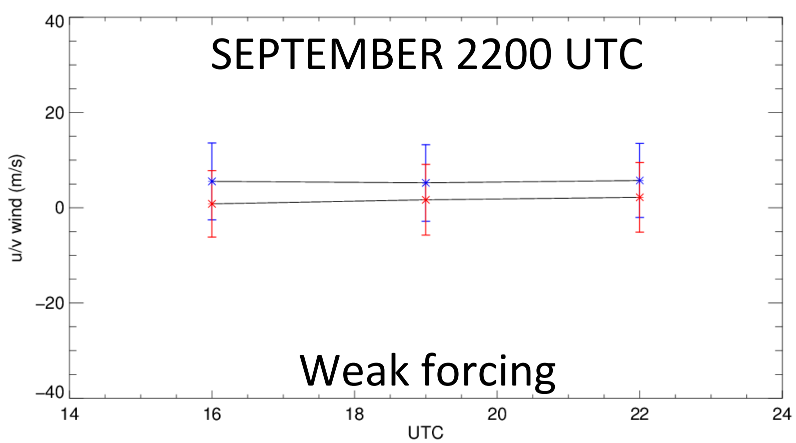
WEST CENTRAL EAST

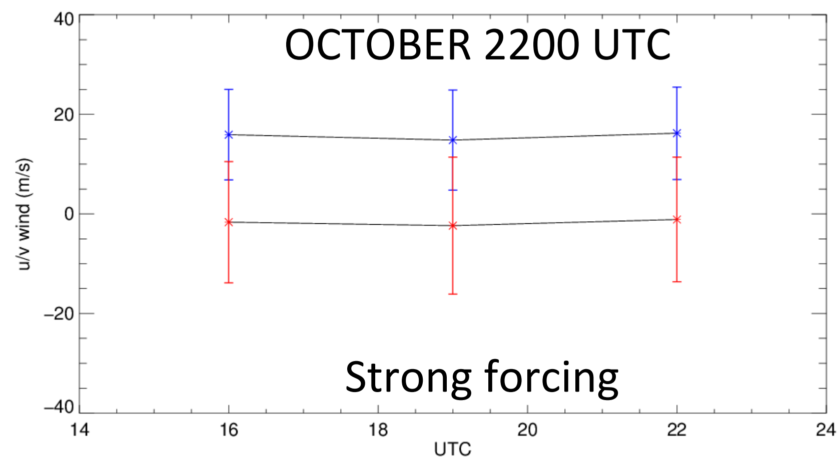
Spatial variation of CBL heights





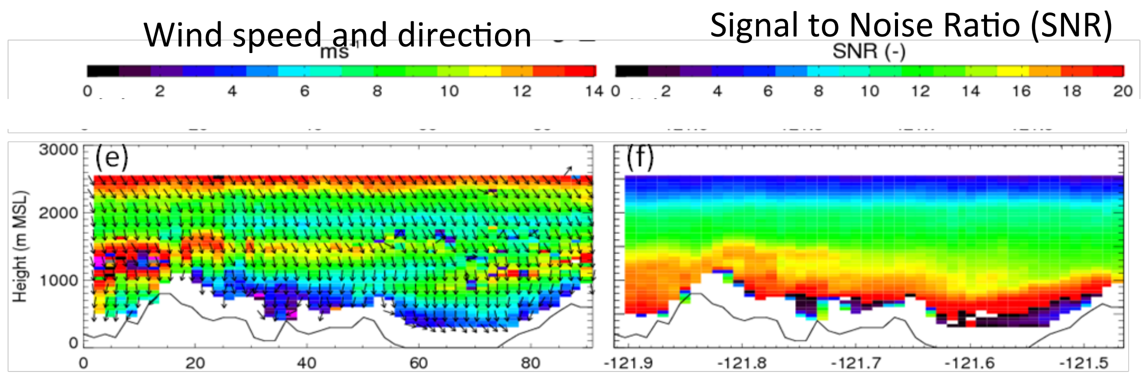
Average U (blue) and V (red) component wind between WRF levels 20 and 30 (~4-12 km MSL)



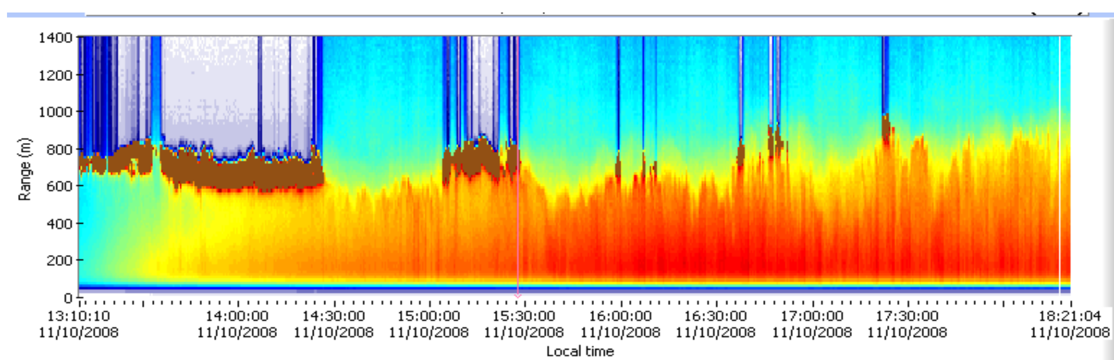


Upcoming experiment

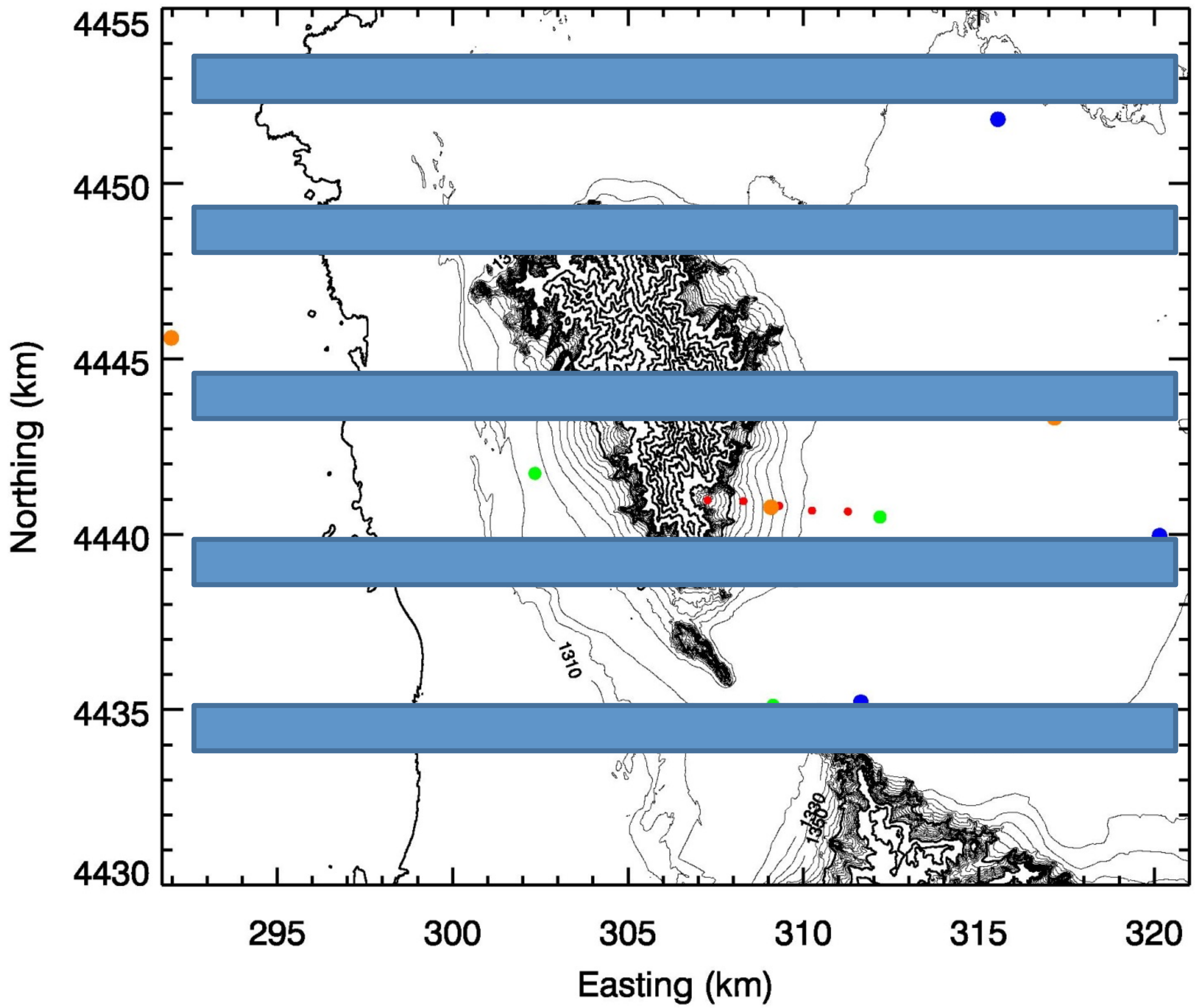
•Plan Twin Otter Doppler Wind Lidar (TODWL) flight and coordinate with UAV operations to provide optimal coverage of local and meso-scale boundary layer structure



•operate an eyesafe, mobile aerosol lidar (Leosphere ALS300) which will provide information on the boundary layer structure (local scale)



POTENTIAL TODWL FLIGHT LEGS, E.G. 5 LEGS ~ 30 KM/LEG -> < 1 HOUR



PROCESS STUDIES, ASSIMILATION, NOWCASTING, MODEL EVALUATION, ETC

- **De Wekker, S.F.J.**, K.S. Godwin, G. D. Emmitt, and S. Greco, 2012: Airborne Doppler lidar measurements of valley flows in complex coastal terrain. *J. Appl Meteor. Climat*. doi: http://dx.doi.org/10.1175/JAMC-D-10-05034.1.

Conference Presentations:

- **De Wekker, S.F.J.**, 2012: Convective Boundary Layer Heights in Mountainous Terrain. New Insights From Observations in the Appalachian Mountains. 17th AMS Conference on Air Pollution Meteorology with the A&WMA, New Orleans, LA, 22-26 January 2012.
- Večenaj, Ž., and **S.F.J. De Wekker**, 2012: Averaging Time Scale for Daytime Turbulent Flux Measurements in a Wide and Steep Valley. 17th AMS Conference on Air Pollution Meteorology with the A&WMA, New Orleans, LA, 22-26 January 2012.
- **De Wekker, S.F.J.**, J. Doyle, Q. Jiang, K. Godwin, E. Erfani, G. D. Emmitt, 2011: Investigation of multi-scale flow interaction in the Salinas Valley using a combination of airborne Doppler lidar data and a mesoscale numerical model. AGU Fall meeting, San Francisco, CA, 5–9 December 2011.
- Retallack, C., H. Fernando, E. Pardyjak, **S.F.J. De Wekker**, J.C Pace, 2011: The MATERHORN Experiment. AGU Fall meeting, San Francisco, 5–9 December 2011.

To be presented next week at 15th AMS Conference on Mountain Meteorology

- Večenaj, Ž., and **S.F.J. De Wekker**,2012: Nonstationarity in the surface layer over complex terrain during T-REX. 15th AMS Conference on Mountain Meteorology, Steamboat Springs, CO, 20-24 August 2012.

- Večenaj, Ž., and **S.F.J. De Wekker**,2012: Exploring Monin-Obukhov similarity in the surface layer over complex terrain during T-REX. 15th AMS Conference on Mountain Meteorology, Steamboat Springs, CO, 20-24 August 2012.