Boundary layer structure and multi-scale flow interactions

(Materhorn-X: Airborne Doppler lidar and scale interactions)

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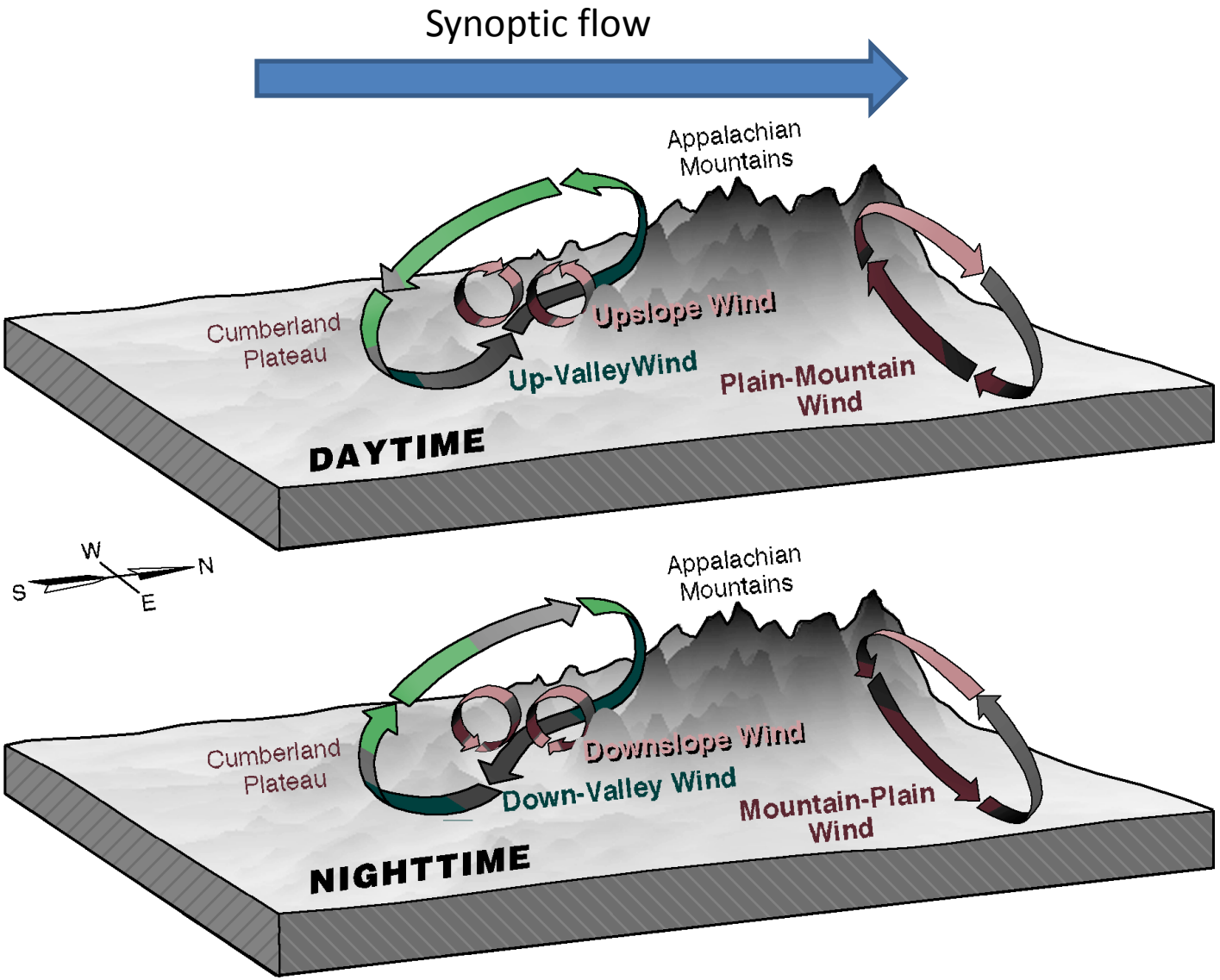
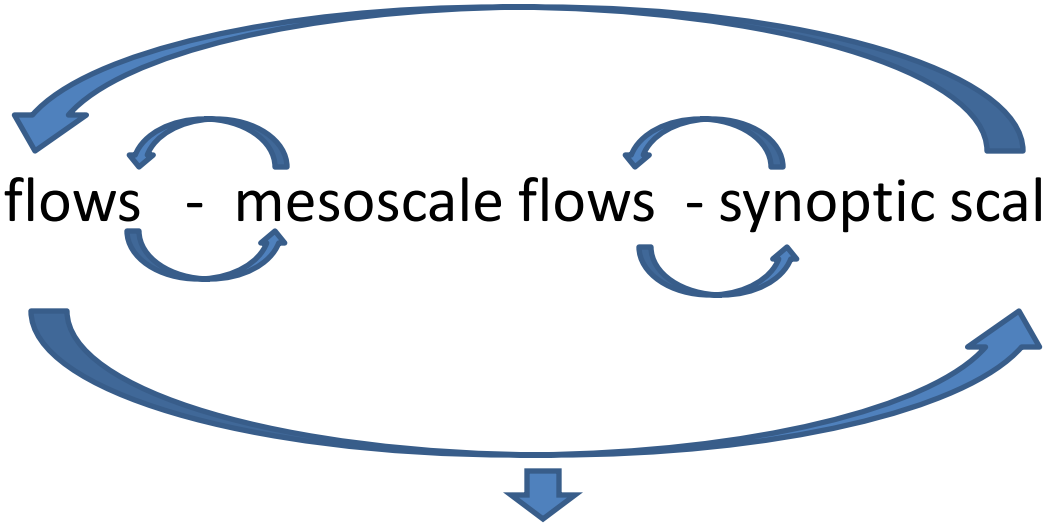
(Zeljko Vecenaj (post-doc, 2012))

MATERHORN kick-off meeting , 8 September 2011

Multi-scale flow interactions



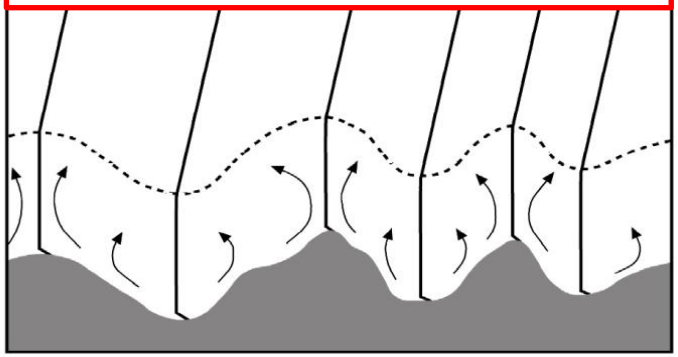
Whiteman, 2000



Convergence/divergence
wind shear
Turbulence
…

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

Effects on spatial and temporal variability of PBL structure



Planned work

- use of numerical forecasts and reanalysis products produced for the Dugway Proving Ground by NCAR to study dynamical and thermal aspects of the boundary layer structure (meso-scale – synoptic-scale interactions)

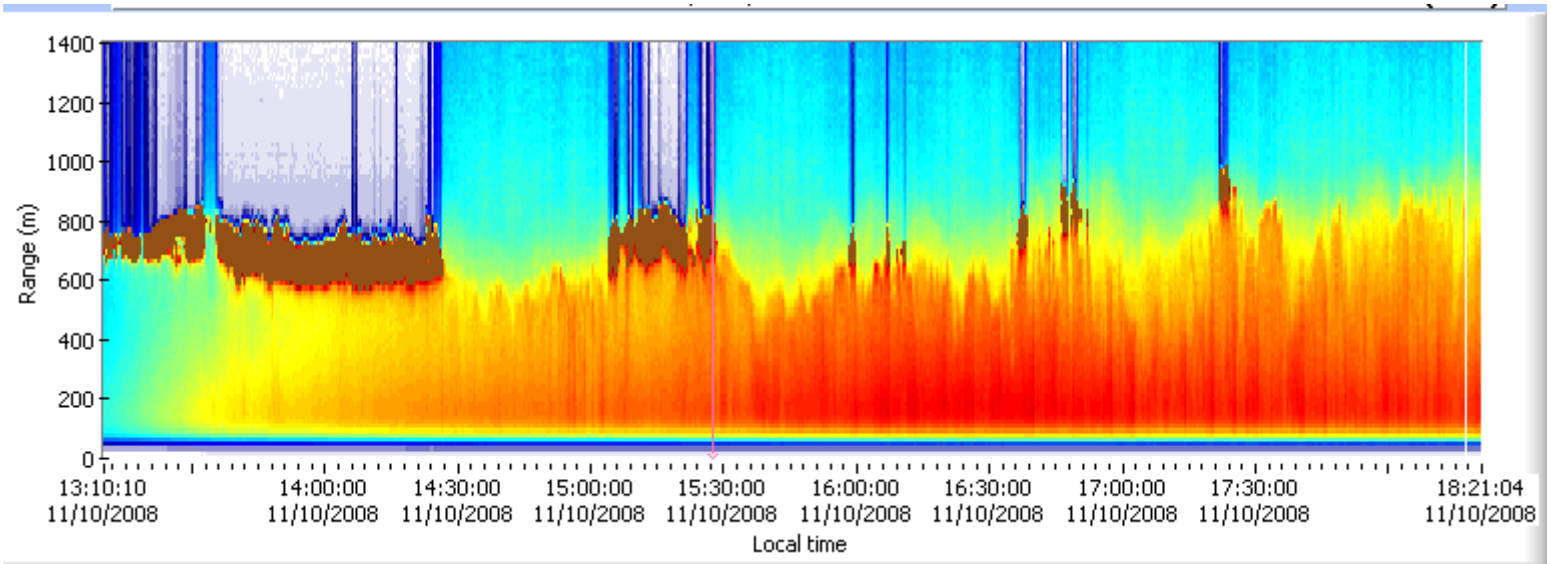
- provide guidance for the siting of Doppler and aerosol lidars and for the flight patterns to provide optimal coverage of local and meso-scale boundary layer structure

- operate an eyesafe, mobile scanning aerosol lidar (Leosphere ALS300) in staring and scanning mode, which will provide information on the boundary layer structure (local scale)

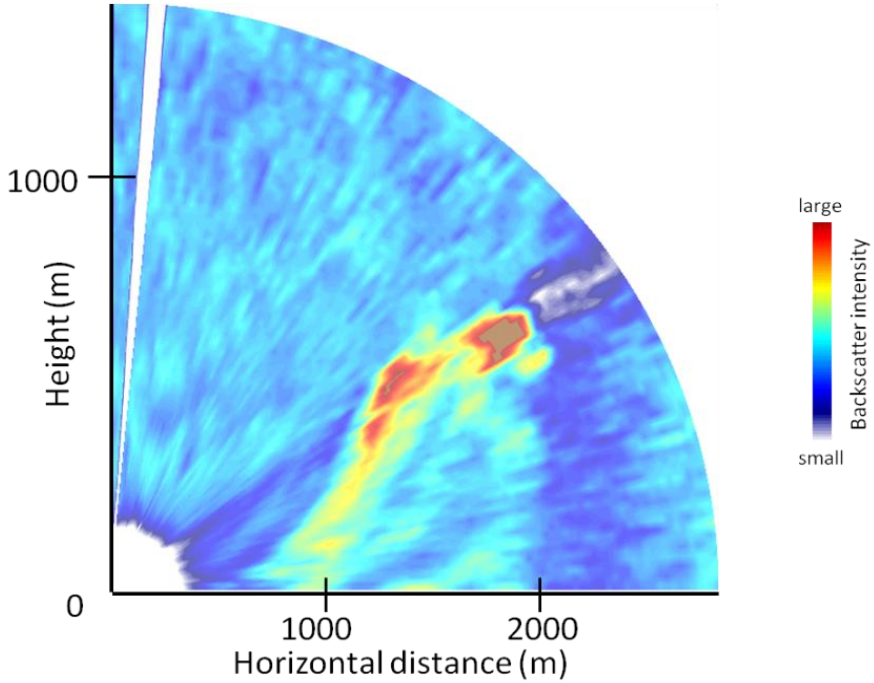
Specifications of Leosphere ALS300 lidar

range	50m - 15 km (depending on factors incl. aerosol loading and accumulation time)
temporal res	1s -30 s (or longer, depending on accumulation time)
Scanning speed	8 degr. /s
Laser source	flash-lamp pumped tripled Nd/Yag
pulse repetition freq.	20 Hz
Wavelength	355 nm
Pulse duration	4 ns
Pulse energy	16 mJ
Eye safety	IEC60825-1 2001

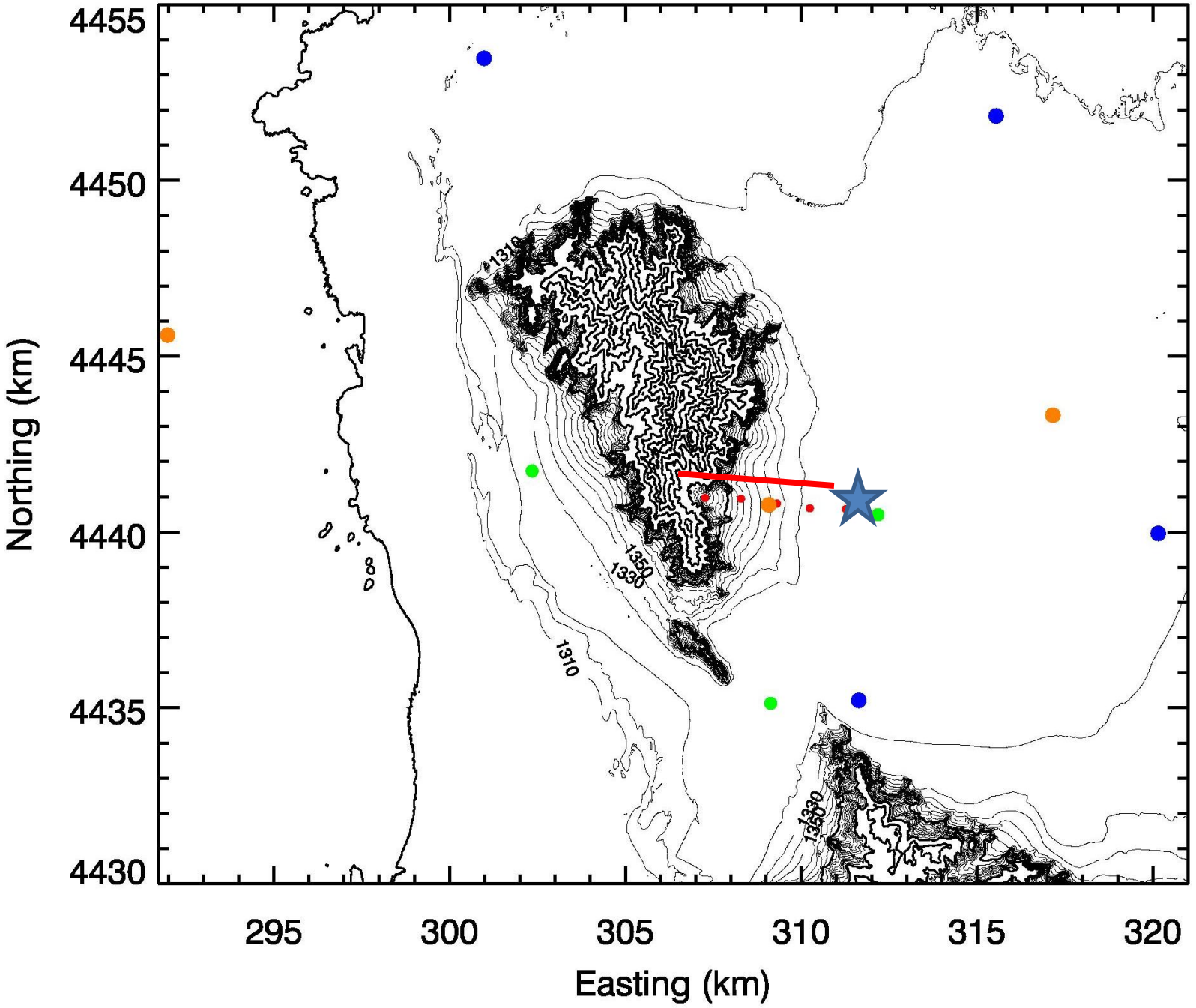
- Planetary Boundary Layer and residual layer heights
- Vertical backscatter and extinction profile
- Vertical Aerosol profile



SCANNING MODE



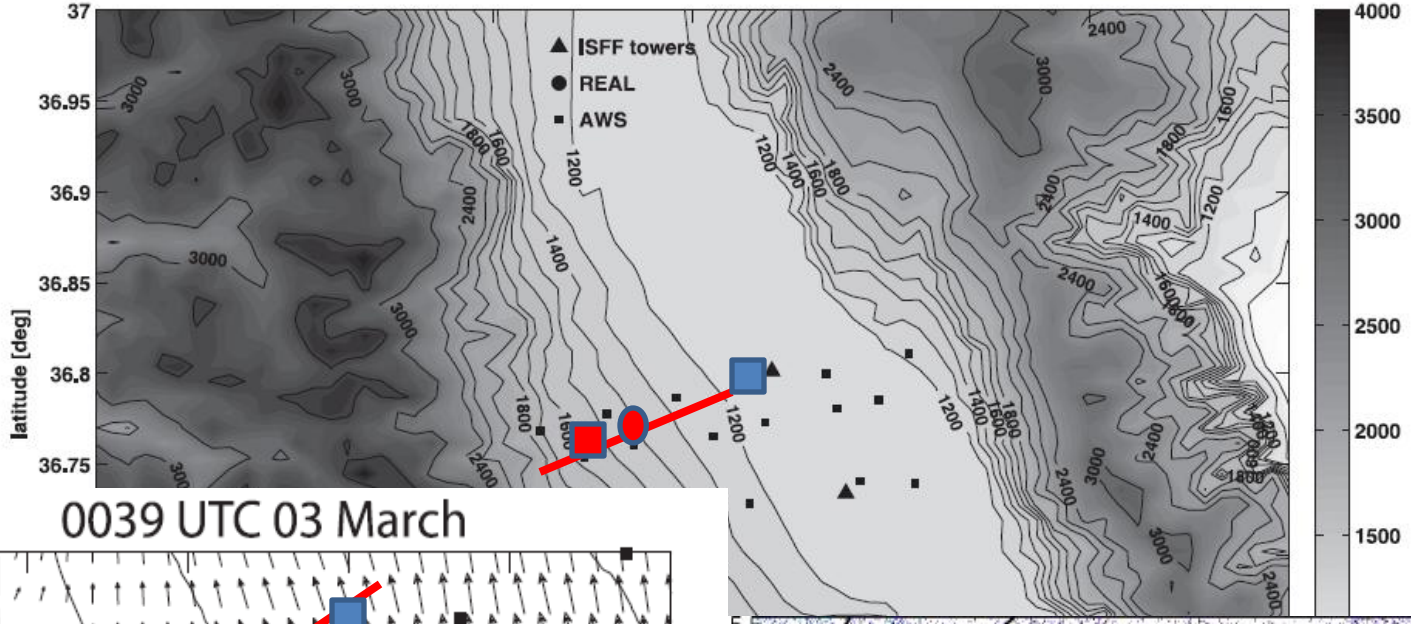
elevation ranges from ~ 2 degrees to 90 degrees to provide details on cloud cover and aerosol layer. A vertical scan can be completed within about ten minutes.

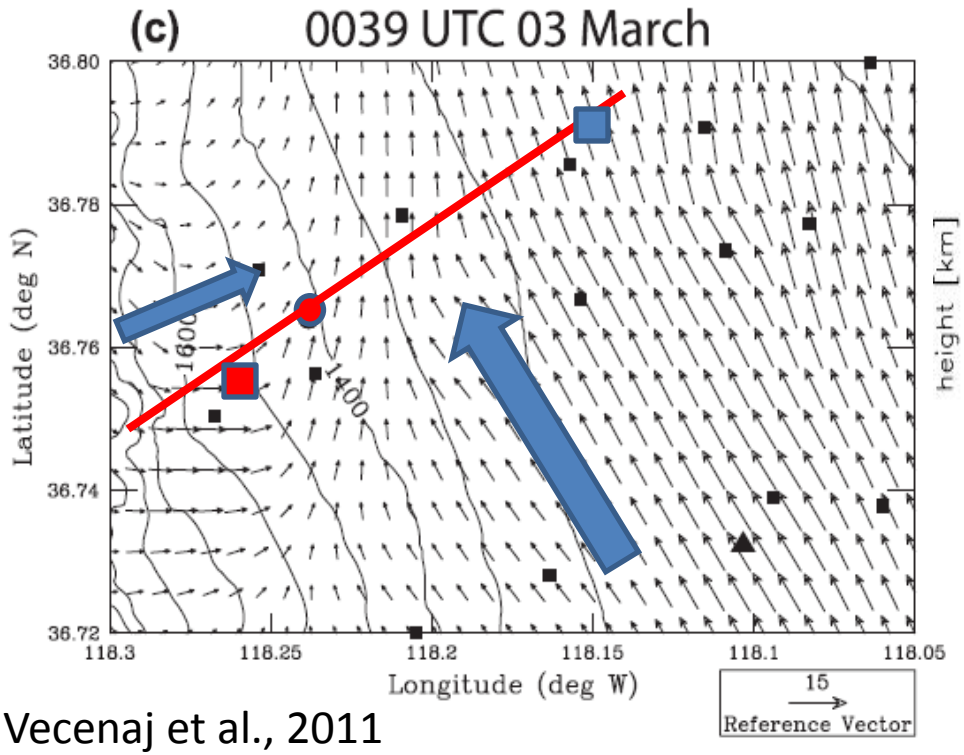

4455
4450
4445
4440
4435
4430
Northing (km)
295
300
305
310
315
320
Easting (km)
1310
1350
1330
1310
1350
1330

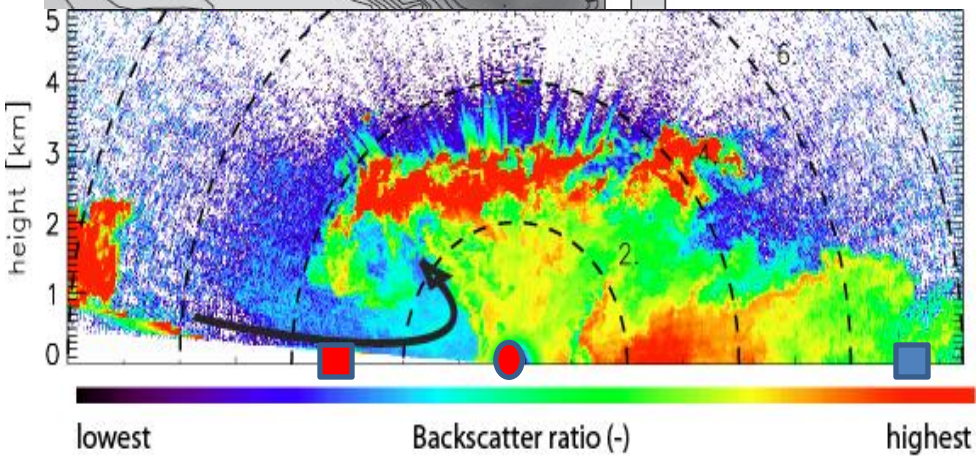
Ongoing work

- Structure of surface layer turbulence in T-REX
- Flow interactions in Salinas Valley using airborne Doppler lidar

MULTI SCALE FLOW INTERACTION AND SURFACE TURBULENCE STRUCTURE





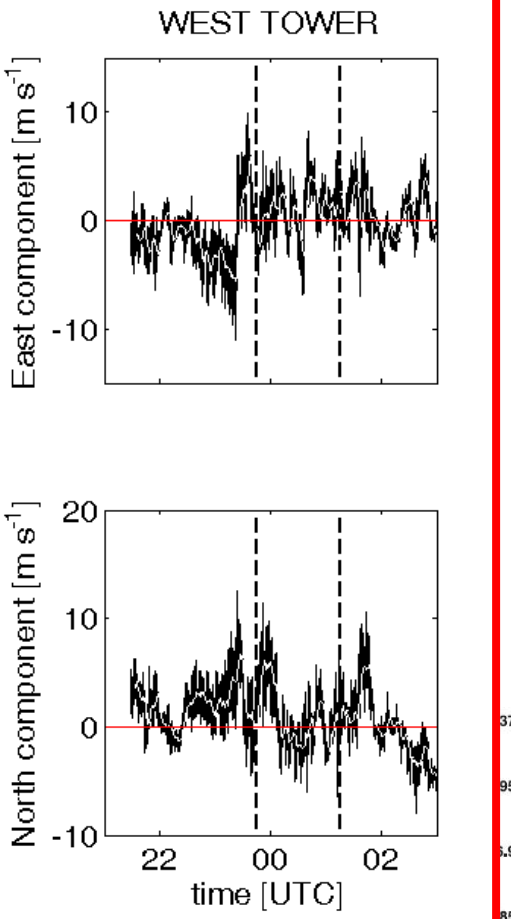


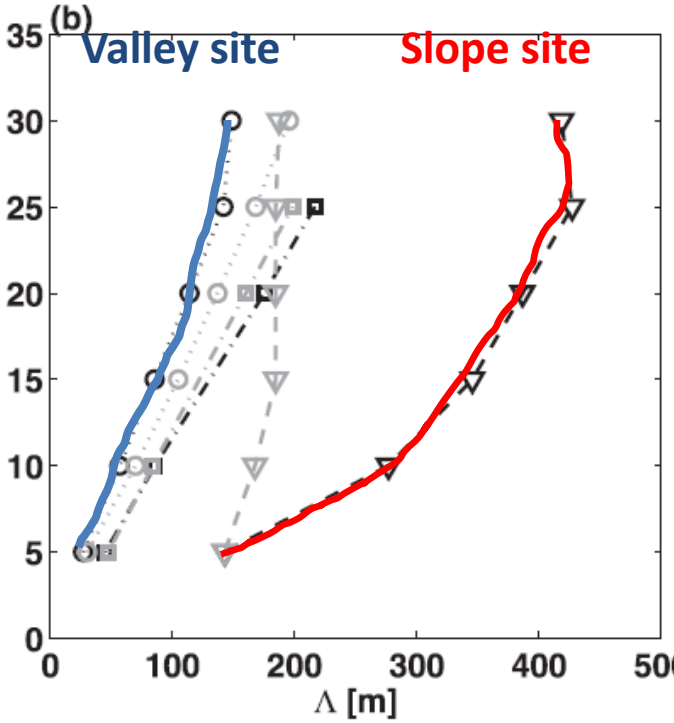
De Wekker and Mayor, 2008.

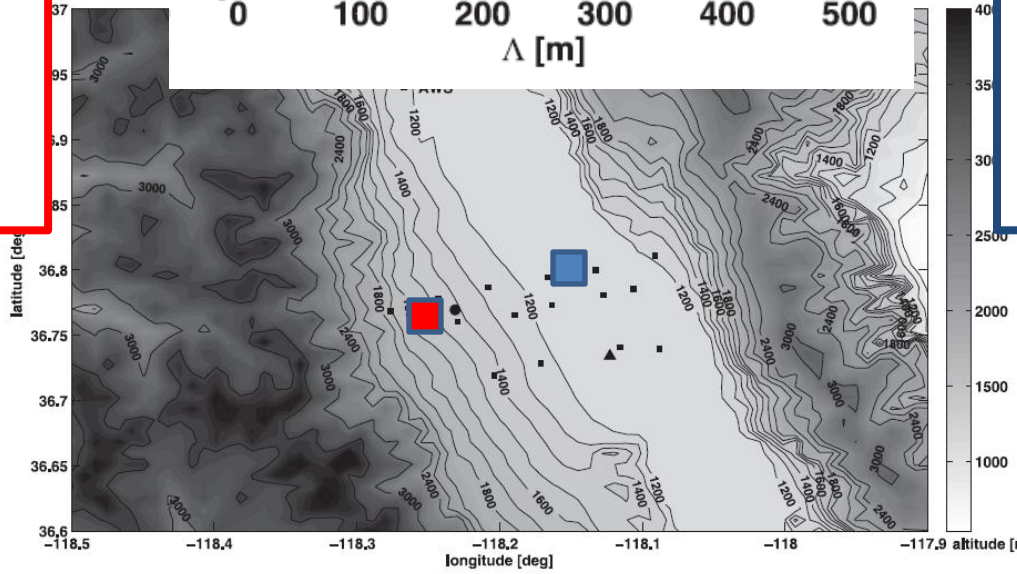
Vecenaj et al., 2011

Turbulence length scale

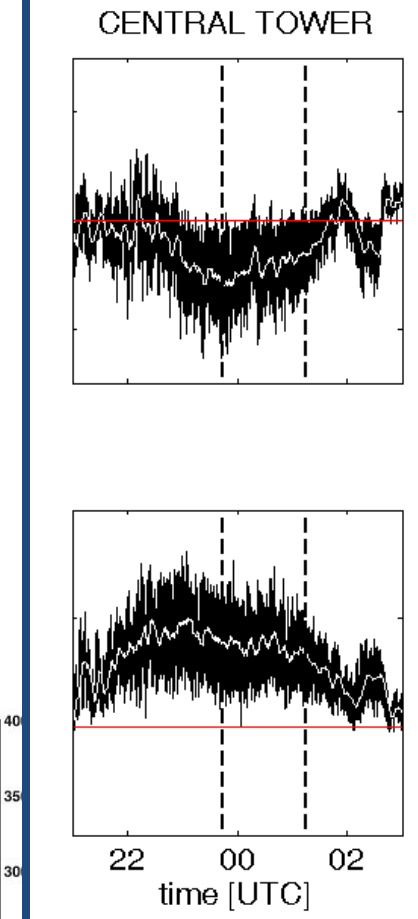
Slope site



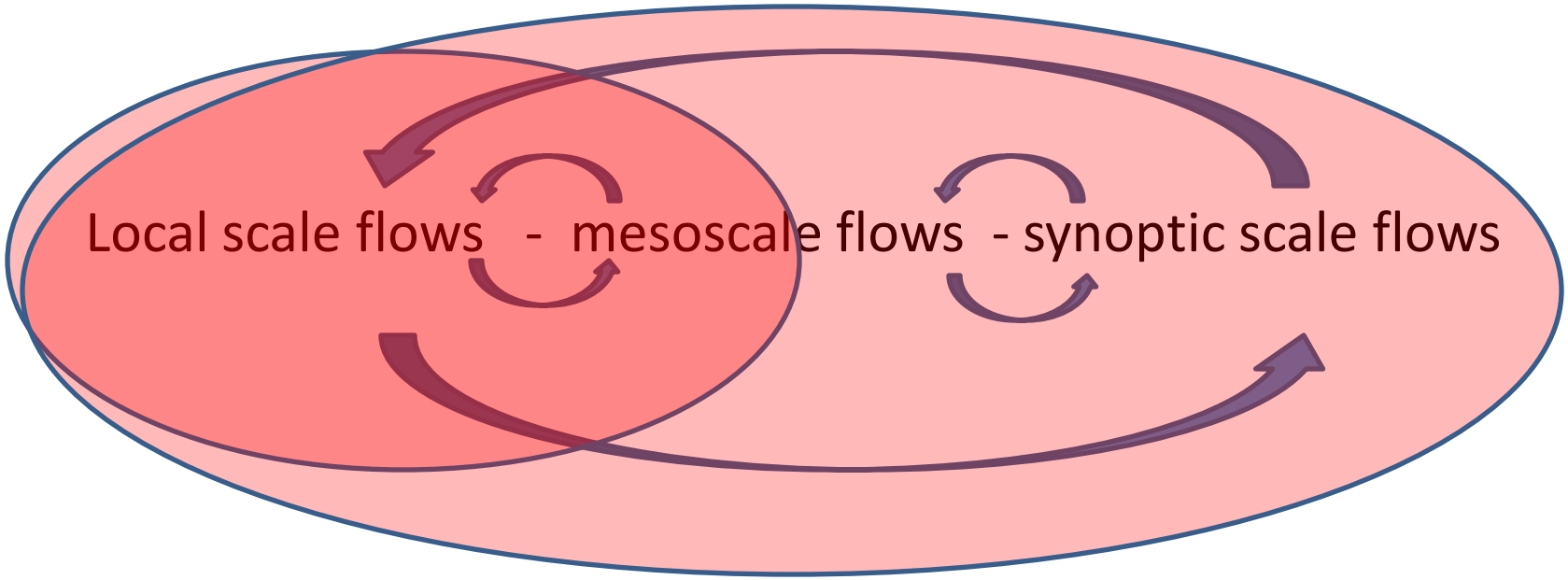




Valley site



Vecenaj et al., 2011



To capture interaction with mesoscale and synoptic scale, wind measurements at high spatial resolution over horizontals distances of at least a few tens of km are required.

→ Airborne Doppler lidar measurements, e.g. the Twin Otter Doppler Wind Lidar system (TODWL)

Airborne Doppler lidar over complex terrain

TODWL has been operated (since 2002) by CIRPAS (Center for Interdisciplinary Remotely Piloted Aircraft Studies), a part of the Naval Postgraduate School, Monterey, CA.

Dave Emmitt is the TODWL PI.

2µm coherent detection

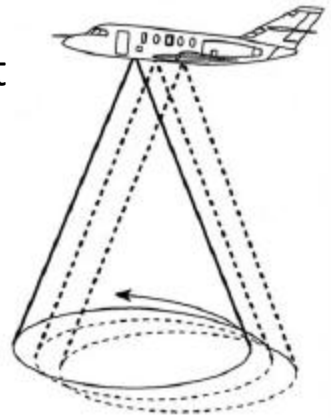
10 cm two axis scanner, side door mounted

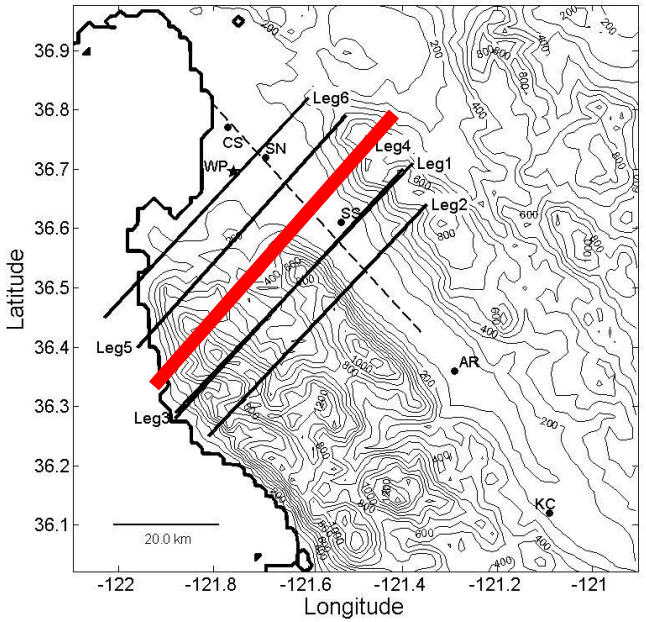
Range: .3 – 21km depending upon aerosols

Accuracy: < .10 m/s in three components

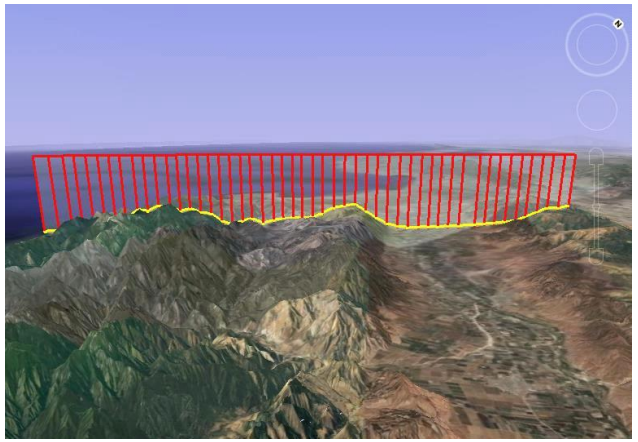
conical scans below the aircraft

azimuth angle steps of 30°

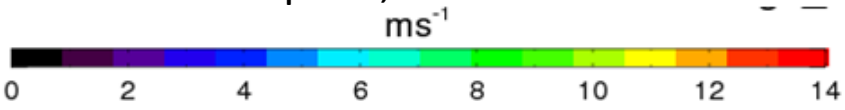




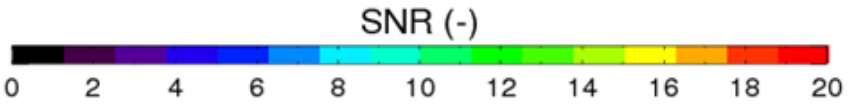
horizontal resolution: ~ 1500 m
vertical resolution: ~ 50 m

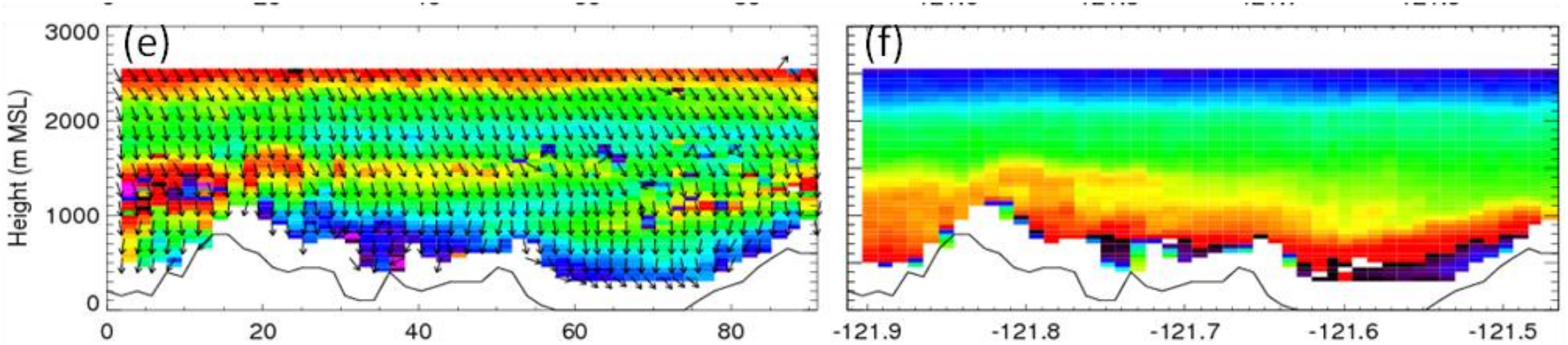


Wind speed, direction

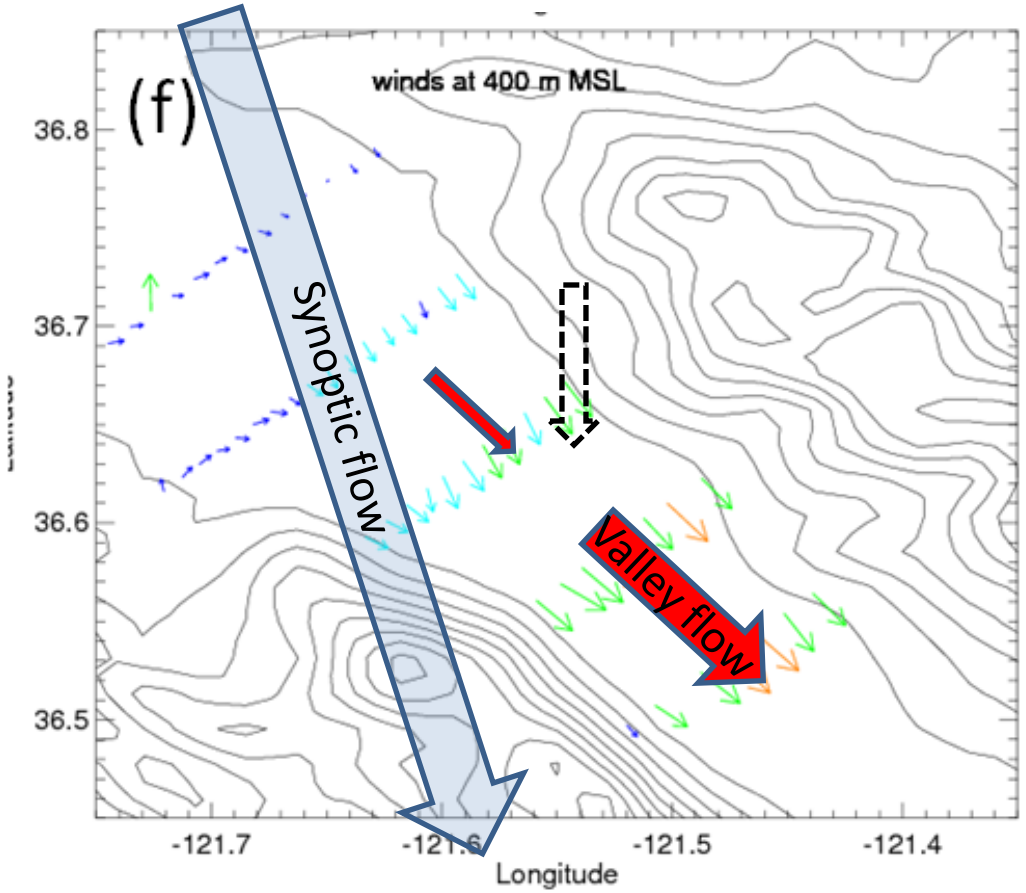


Signal to Noise Ratio (SNR)





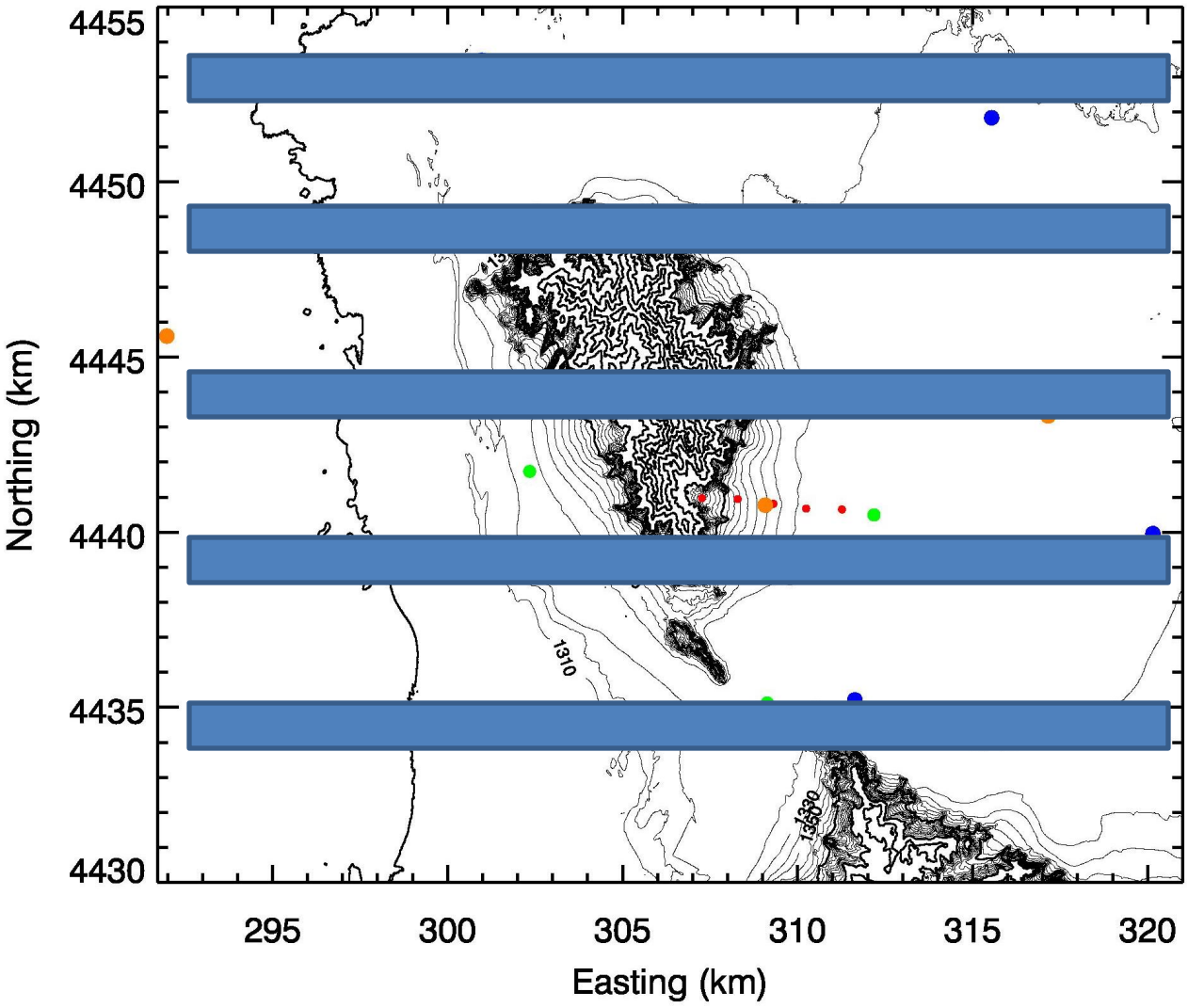
Interaction of sea-breeze/valley flow/synoptic flow and boundary layer growth



Accelerating valley flow
-> sinking motions

De Wekker et al. 2011, submitted to JAMC

POTENTIAL TODWL FLIGHT LEGS, E.G. 5 LEGS ~ 25 KM/LEG -> < 1 HOUR



PROCESS STUDIES, ASSIMILATION, NOWCASTING, MODEL EVALUATION, ETC