

The recirculation zone of the Bolund peninsula

Flow Center presentation
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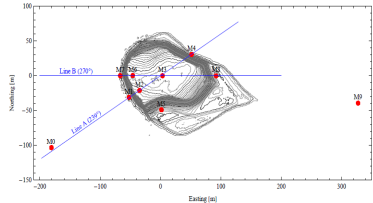
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Table of contents

- 1 The WindScanner field measurements
 - The experiment
 - The WindScanner
 - Determination of the undisturbed inflow
- 2 Results
 - Determination of boundary layer height
 - BL height - wind direction dependency
- 3 Conclusion

experimental setup

- **Location:** Bolund, Roskilde Fjord
- **Date:** October 2011,
- **Duration:** approx. 24h
- **Positioning:** distance of 20 m from the Bolund escarpment
- **Alignment:** predominant wind direction, on 270° axis, west facing



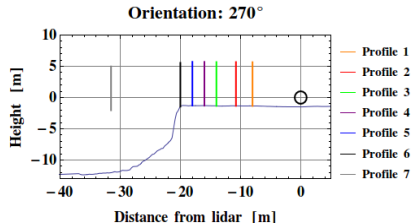
The WindScanner

- **Type:** laser anemometer, part of windscanner.dk project at DTU Wind Energy
- **Mode of measurement:** continuous wave, coherent Doppler lidar with wavelength of $1.5 \mu\text{m}$, directed by two independently moving prisms
- **Signal processing:**
 - sampling at 100MHz of the backscatter signals
 - application of a 512-point FFT in real time that produces 200000 laser Doppler spectra → average of 500 Doppler spectra
- **Output:** data streaming rate of 390 Hz

Experimental setup - Mode of measurement

Collection of:

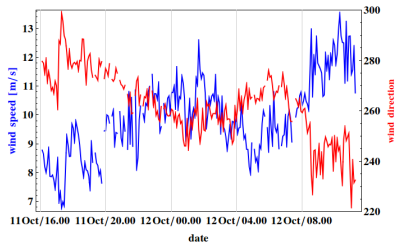
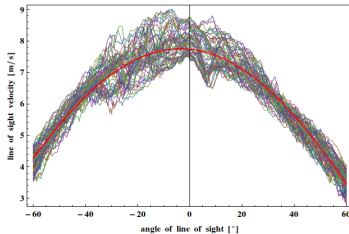
- 7 vertical profiles above land with distances of 8 m, 10.75 m, 14 m, 16 m, 18 m, 20 m, 31 m from the instrument, to analyze the recirculation zone
- 1 horizontal arc extending 60° , 90 m away from the instrument, 13 m above the water, to determine direction and speed of the undisturbed inflow
- 1 vertical profile above the water, determine the inflow



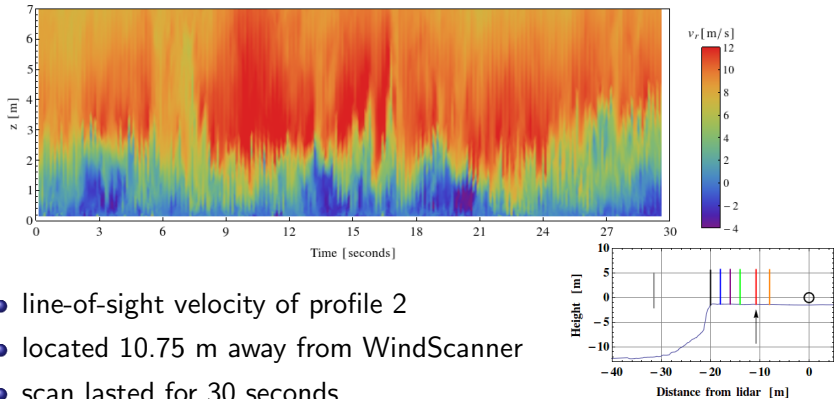
undisturbed inflow

scan of horizontal arc delivers wind speed and direction of inflow

1. calculation of angle of the line of sight relative to the instrument coordinates
2. sinusoidal fit to solve for two unknown parameters, wind speed and wind direction



Results



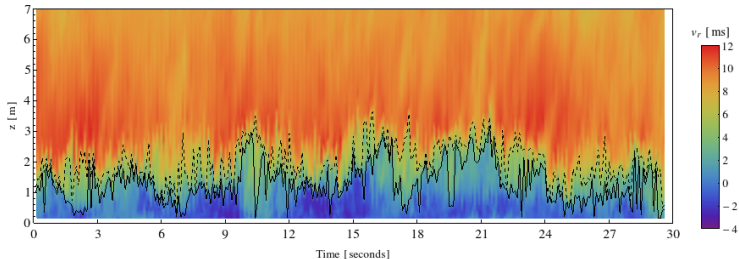
- line-of-sight velocity of profile 2
- located 10.75 m away from WindScanner
- scan lasted for 30 seconds
- results in vertical velocity of 300 consecutive scans

Determination of boundary layer height

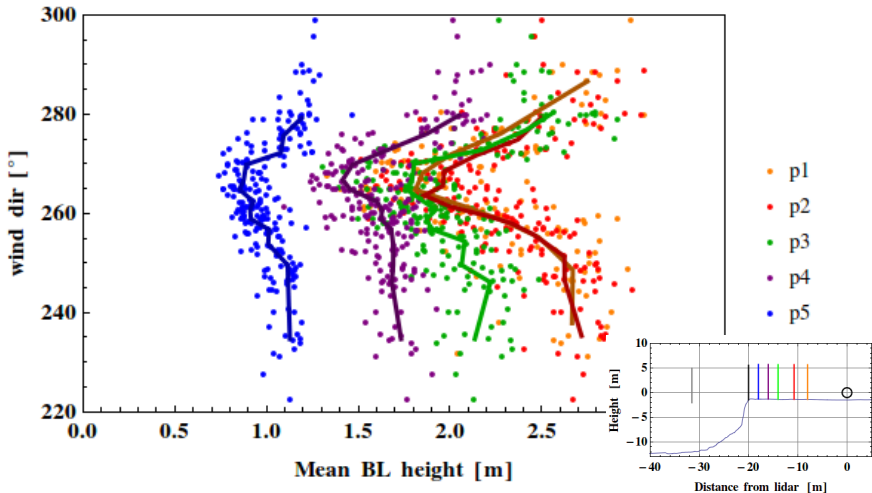
2 methods for determine the boundary Layer (BL) height

1. $\max\left[\frac{dv(z)}{dz}\right] \rightarrow \text{dashed line}$

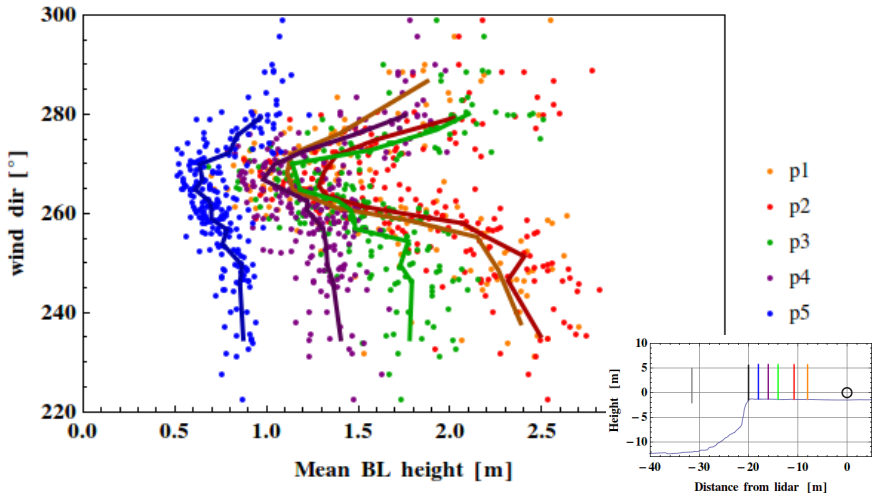
2. $\max\left[\frac{1}{z_n - z} \int_z^{z_n} v(z) dz - \frac{1}{z} \int_0^z v(z) dz\right] \rightarrow \text{solid line}$



BL height - wind direction dependency, 1. method



BL height - wind direction dependency, 2. method



Conclusion

- WindScanner measurements deliver high resolved vertical profiles of the recirculation zone of the Bolund escarpment
- vertical profiles show detailed structure of the unsteady flow over the escarpment
- vertical profiles resolve turbulent layer close to the ground and laminar layer above
- the combined view of all vertical profiles display the development and growing of the turbulent boundary layer
- precise definition of BL height was possible through high frequent measurements of vertical wind speed
- high dependency of BL height on wind direction

Thank you for your attention!