The Tall Wind project - exploring the wind profile and boundary-layer height in the atmosphere's first kilometer over flat terrain

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The Tall Wind project – exploring the wind profile and boundary-layer height in the atmosphere's first kilometer over flat terrain.

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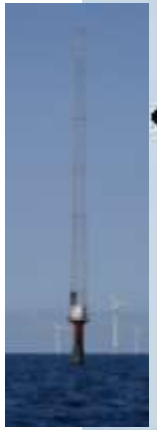
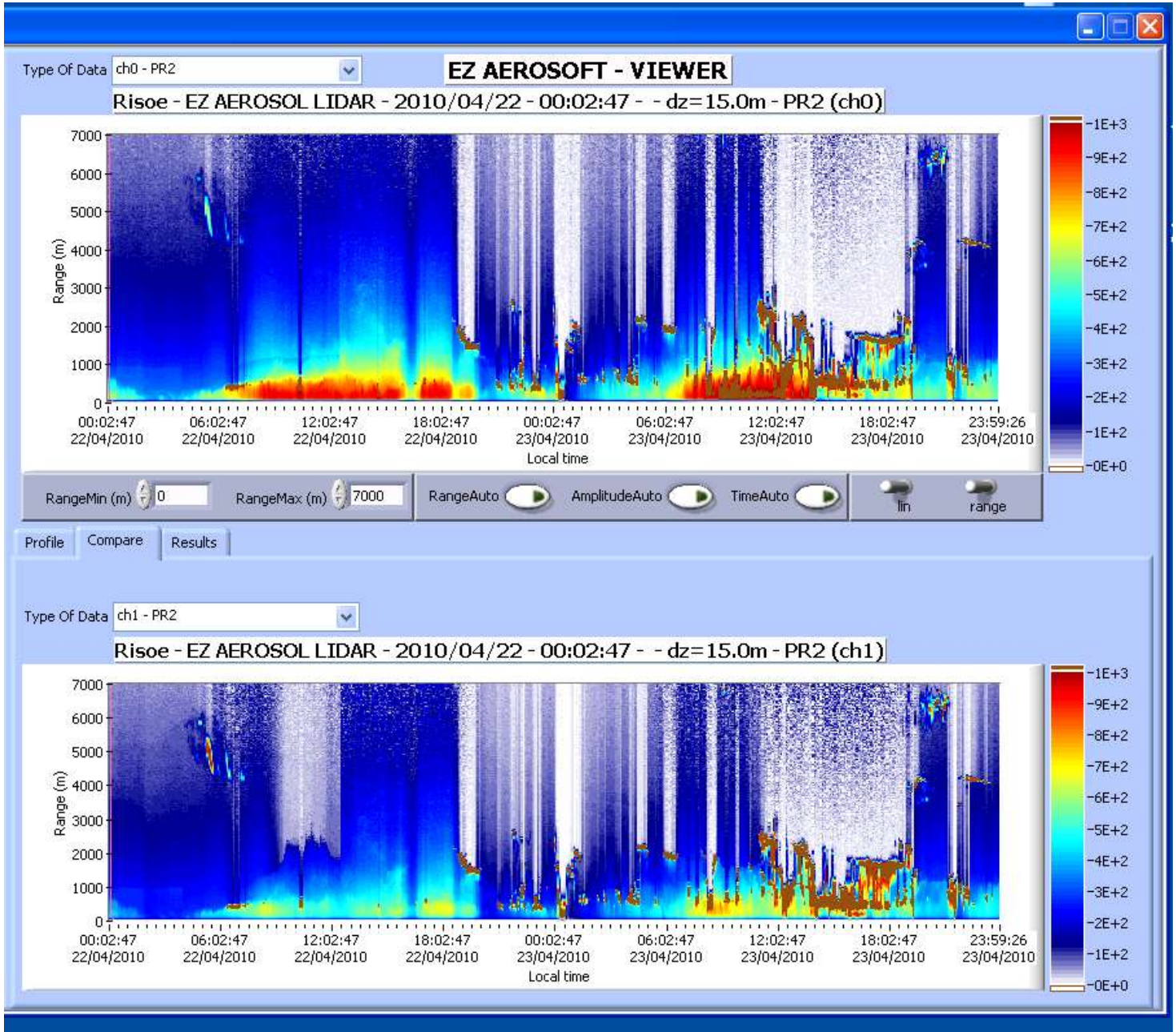
Measuring sites

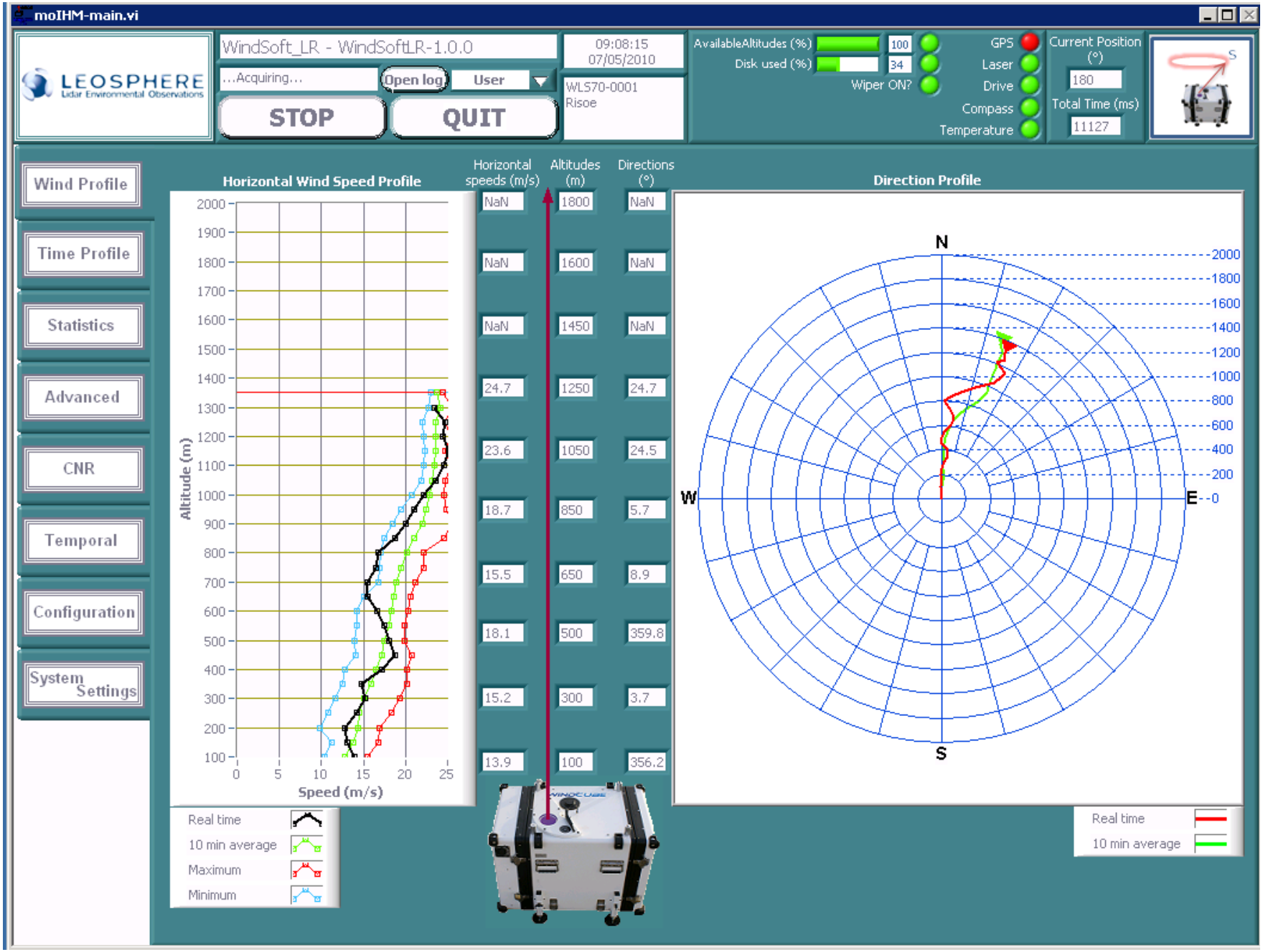


The study of the wind profile over flat homogeneous terrain in The Tall Wind project is based on a combination of measurements, data analysis and modelling. The idea is to supplement existing long-term measurements of turbulence and wind speed at tall well instrumented meteorological masts (at Høvsøre to reflect low roughness over rural area; and at Hamburg to reflect high roughness such as urban conditions) and at Horns Rev 2 (off-shore, not instrumented with turbulence instruments). Additional measurements will address the wind profile up to 500 to 1000 meters by use of a newly developed commercial pulsed wind Lidar (WSL70). The height of the planetary boundary layer will be determined from aerosol backscatter with a new meteorological Lidar (ASL 300).

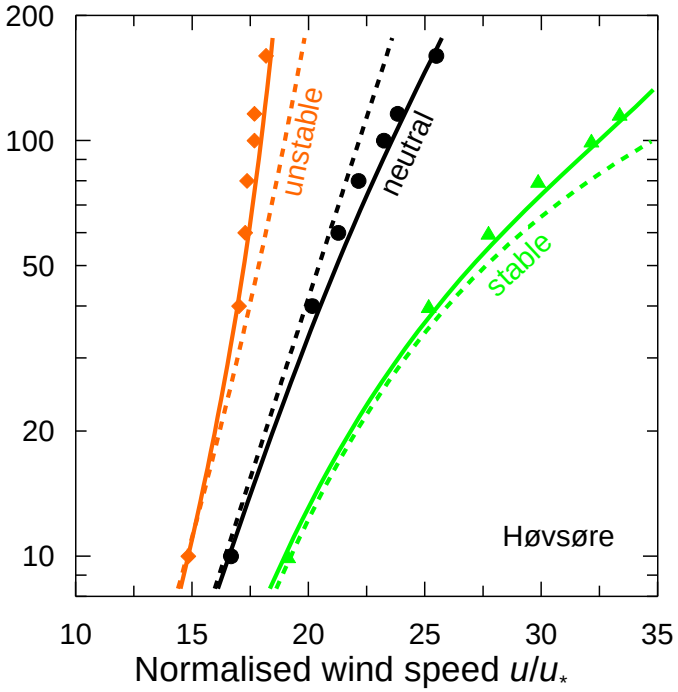
Aerosol lidar

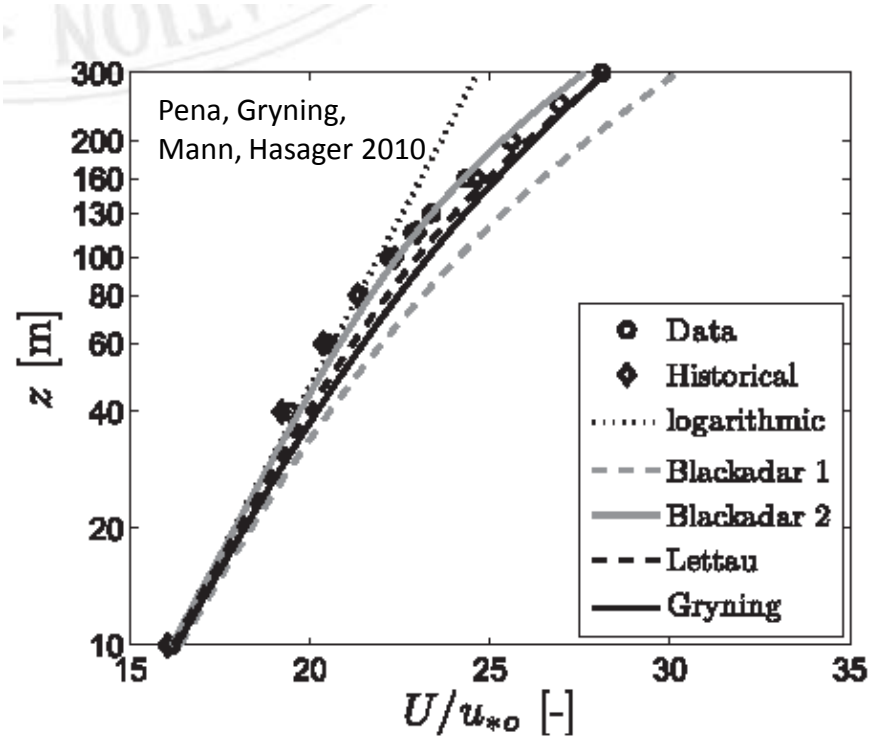


Wind lidar


moIHM-main.vi
LEOSPHERE
Lidar Environmental Observations
WindSoft_LR - WindSoftLR-1.0.0
...Acquiring...
Open log
User
STOP
QUIT
09:08:15
07/05/2010
WLS70-0001
Risoe
AvailableAltitudes (%)
Disk used (%)
Wiper ON?
GPS
Laser
Drive
Compass
Temperature
Current Position (°)
Total Time (ms)
Wind Profile
Time Profile
Statistics
Advanced
CNR
Temporal
Configuration
System Settings
Horizontal Wind Speed Profile
Altitude (m)
Speed (m/s)
Horizontal speeds (m/s)
Altitudes (m)
Directions (°)
Direction Profile
N
S
E
W
Real time
10 min average
Maximum
Minimum

Short term averaged wind profile (i. e. 0.5 hour)





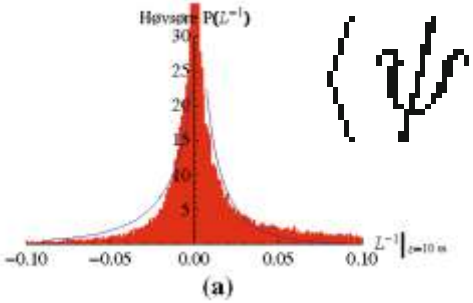
$$U = \frac{u*_o}{\kappa}\left[\ln\left(\frac{z}{z_o}\right) + \frac{z}{l_{\mathrm{MBL}}} - \frac{z}{z_i}\frac{z}{2l_{\mathrm{MBL}}}\right]$$

Climatological wind profile (1 month to several years)

$$\left\langle \frac{kU}{u_{*0}} \right\rangle (z) = \int \ln(z/z_0) P(z_0) dz_0 - \int \psi(z/L) P(1/L) d(1/L)$$

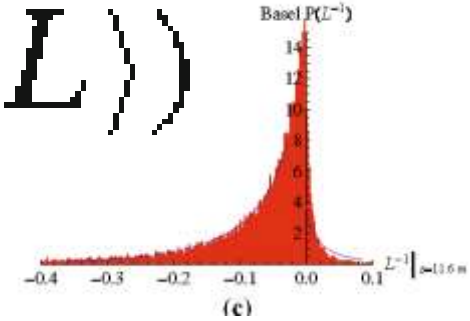
$$\left\langle \frac{kU}{u_{*0}} \right\rangle (z) = \ln\left(z/z_{0m}\right) - \left[\langle \psi \rangle (z) - \langle \psi_0 \rangle\right],$$

Where $\langle \psi \rangle (z)$ is the long term stability correction based on a given stability distribution. To determine the climatologically wind profile we need a representation of P(1/L) in measurable quantities –is worked out in Kelly and Gryning (2010).



(a)

$$\langle \psi(z/L) \rangle \neq \psi(z/\langle L \rangle)$$



(c)

$$\left\langle \frac{kU}{u_{*0}} \right\rangle (z) = \ln (z/z_{0m}) - \left[1 - \frac{z}{h_{\text{eff}}} \right] \langle \psi \rangle (z) - \frac{z}{h_{\text{eff}}} \frac{1}{z} \int_{z_0}^{z} \langle \psi \rangle (z) dz$$

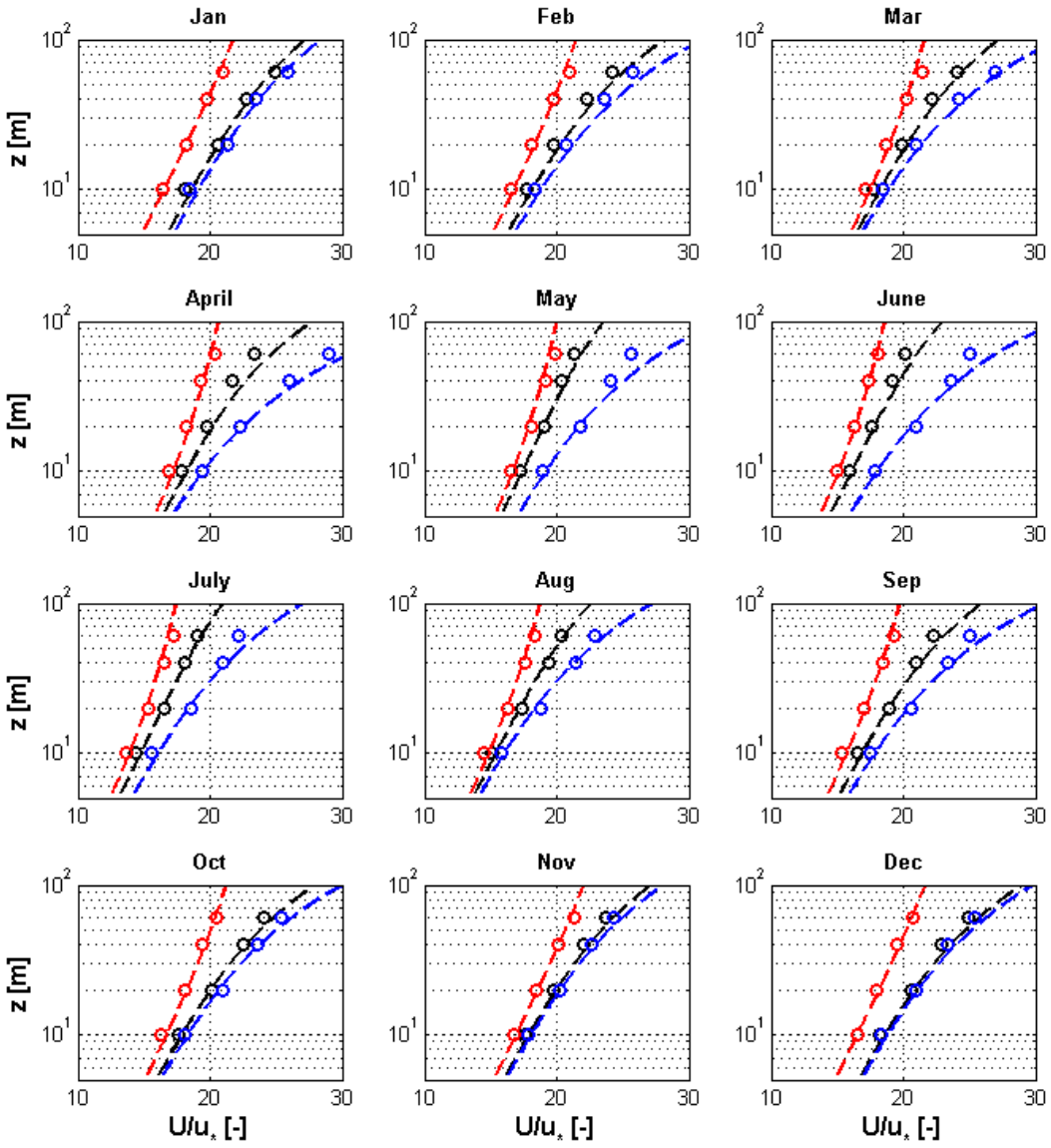
$$+ \frac{h_{\text{eff}}}{2L_{\text{mid}}^{\text{eff}}} \left[1 - \left(1 - \frac{z}{h_{\text{eff}}} \right)^2 \right],$$

For applied use we work on the suggestion:

$$\left\langle \frac{kU}{u_{*o}} \right\rangle (z) = ln \left(\frac{z}{z_0} \right) - \left[1 - \frac{z}{h_{eff}} \right] \langle \psi \rangle (z) - \frac{z}{h_{eff}} \langle \psi \rangle (z/2) + \left[1 - \left(1 - \frac{z}{h_{eff}} \right)^2 \right]$$

Kelly and Gryning (2010) Boundary-Layer Meteorology.

Monthly mean wind profiles at Høvsøre



Climatological wind profile

Red: unstable only

Black: all measurements

Blue: stable only

Andreas Blatt,
master thesis Risø DTU, 2010

The ultimate goal of Tall Wind Project is to come up with:

- recommendations for parameterizations for applied use of the wind profile above the surface layer
-recommendations for the measurements and instruments requirements that can provide the necessary input for yield assessments and constitute a design load basis for wind turbines.

It is realized that this is a very ambitious goal but the data set we hope to achieve will be internationally unique and an excellent basis for the research leading to better tools for the prediction of the energy yield and design basis for large wind turbines.

Thanks for your attention

ACKNOWLEDGEMENT

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