Atmospheric boundary layer wind profile at a flat coastal site - wind speed lidar measurements and mesoscale modeling results during a summer period

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Atmospheric Boundary Layer wind profile at a flat coastal site – wind speed lidar measurements and mesoscale modeling results during a summer period

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Tall Wind and VSABLA Projects

The problem

The wind profile above the surface layer up to 1 kilometer is presently a challenge for

- meteorological forecasts
- wind energy assessment studies
- air pollution applications
- Aviation
- mesoscale models valiadation, etc

as high resolution (in time and space) measurements were rarely available until recently.

Additional complexity is related with coastal areas!

Outline

- **Case studies using wind profiler data**
- **Climatology of the vertical profiles of wind and turbulence – long range wind lidar data with high resolution in space and time in coastal area**
- **First results and future work**

Case studies using wind profiler data

The mesoscale meteorological models have difficulties to predict the profiles, due to complex phenomena taking place in nature that are not accounted for in the ABL parameterizations currently used.

Worldwide an effort is going on to emphasize the important role of boundary layer research in various direct applications, such as wind energy, air pollution, aviation and in weather forecast models.

A profile evaluation study started recently within COST728,

Using windprofiler data in time and frequency domain for the

evaluation of meteorological drivers employed in chemistry transport

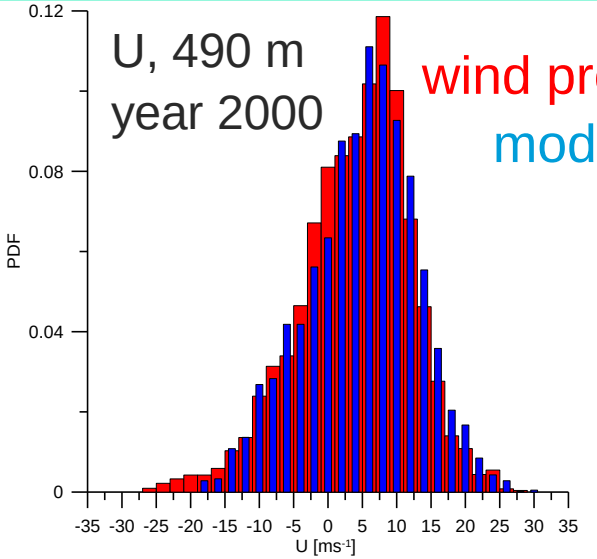
Modelling (ISTP09 -International Symposium on Tropospheric Profiling, 19-23/10/2009, Delft, RIVM, KNMI, TU-Delft)

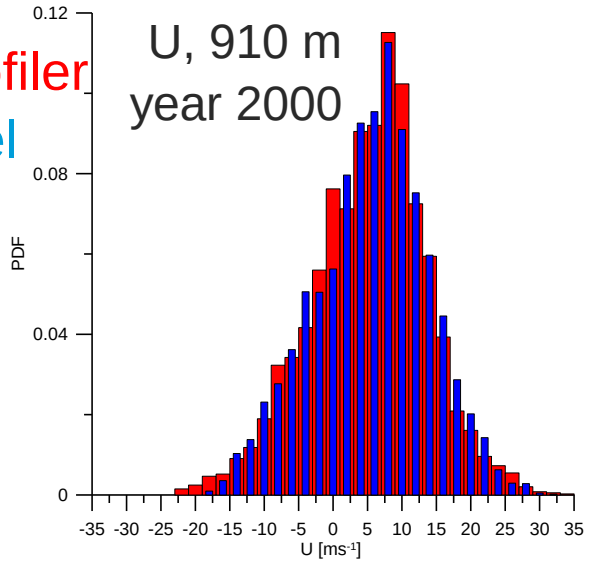
M. Quante, V. Matthias, S.-E. Gryning, E. Batchvarova, A. Aulinger, C. Chemel, G. Geertsema, B. Geyer, H. Jakobs, A. Kerschbaumer, M. Prank, R. San José, H. Schlünzen, J. Struzewska, B. Szintai, R. Wolke

Case studies using wind profiler data

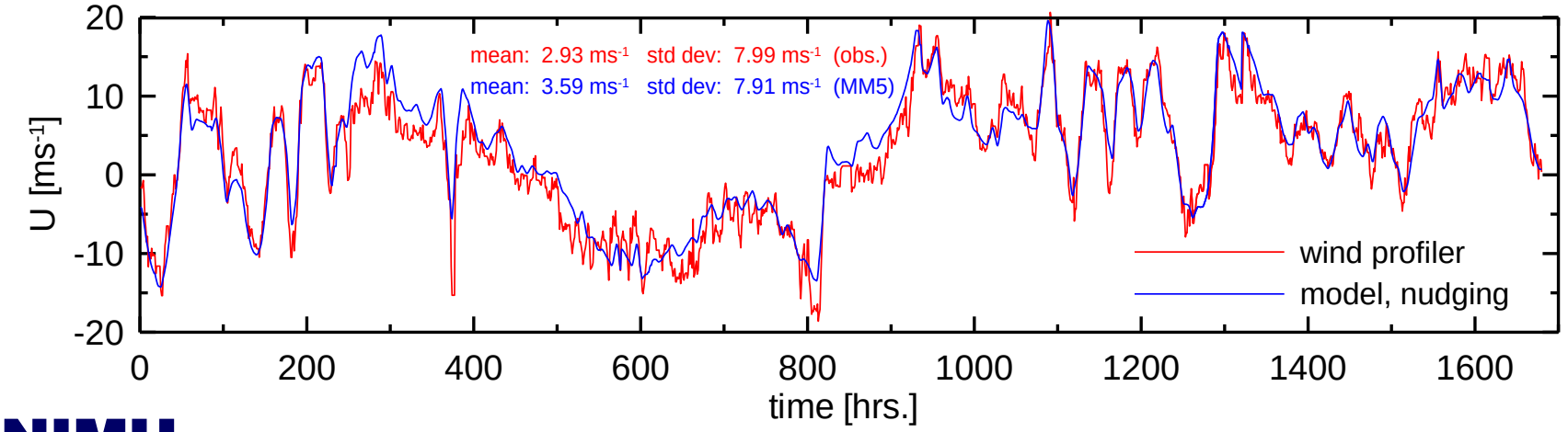
CWINDE Profiler data (Myles Turp), UKMO vs *MM5, 54 km grid resolution; full nudging*

Location:Camborne, UK wind profiler



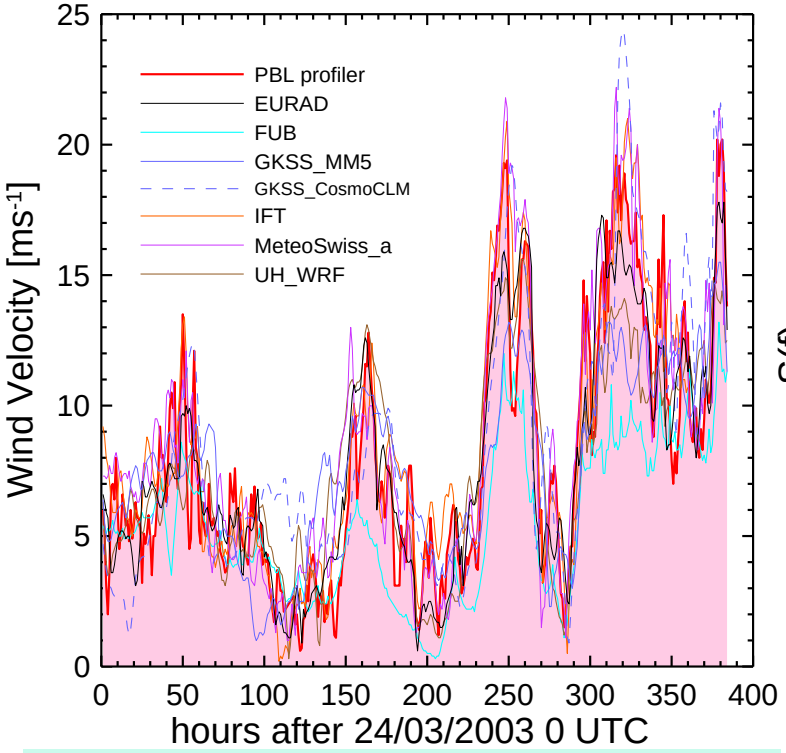


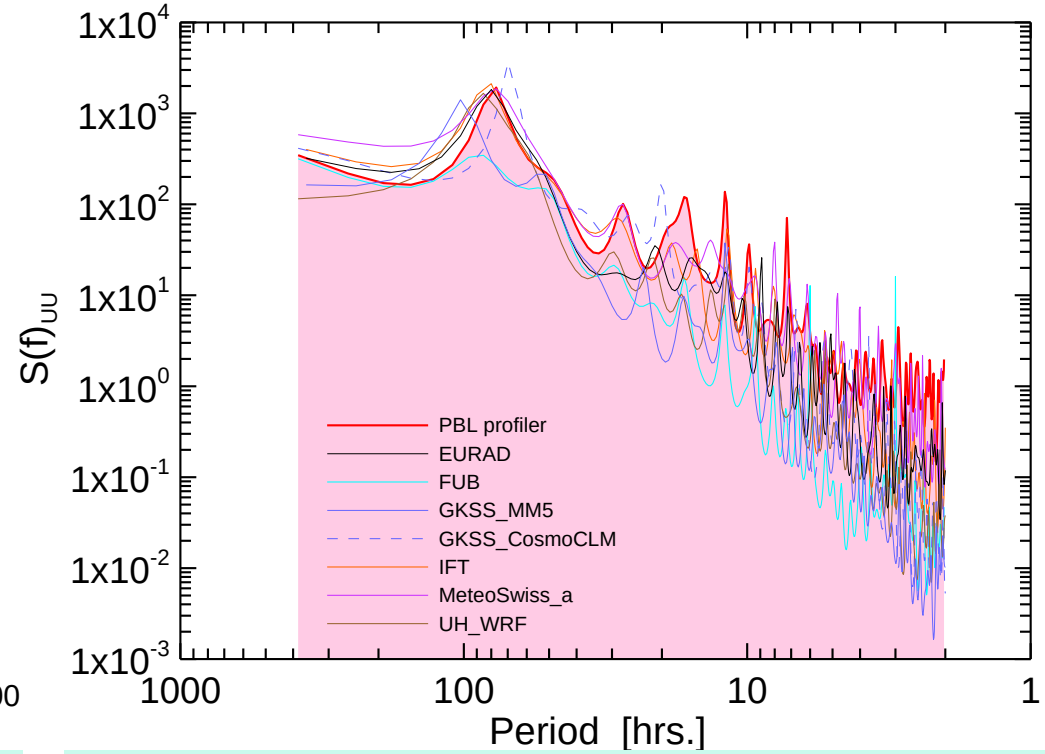
910 m, days 100 to 169 of the year 2000



Case studies using wind profiler data

Wind velocity at Lindenberg at about 500 m asl, 24.02.2003 to 11.03.2003, Wind profiler data and seven models



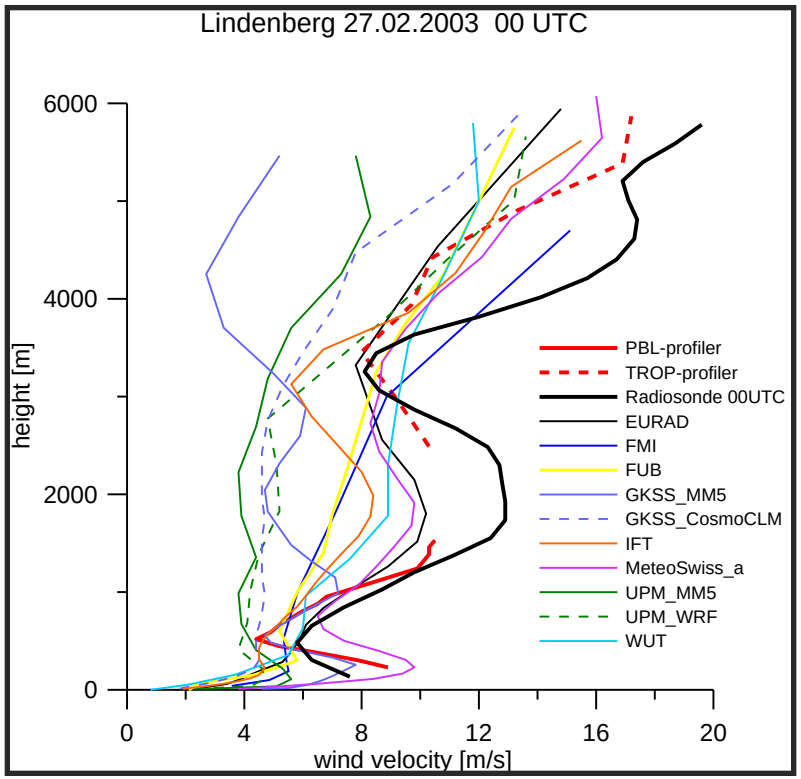


systematic deviations – phase / amplitude in time series

High resolution of models (< 5km) needed to capture intraday fluctuations – power spectra

Case studies using wind profiler data

Lindenberg, at specific hour

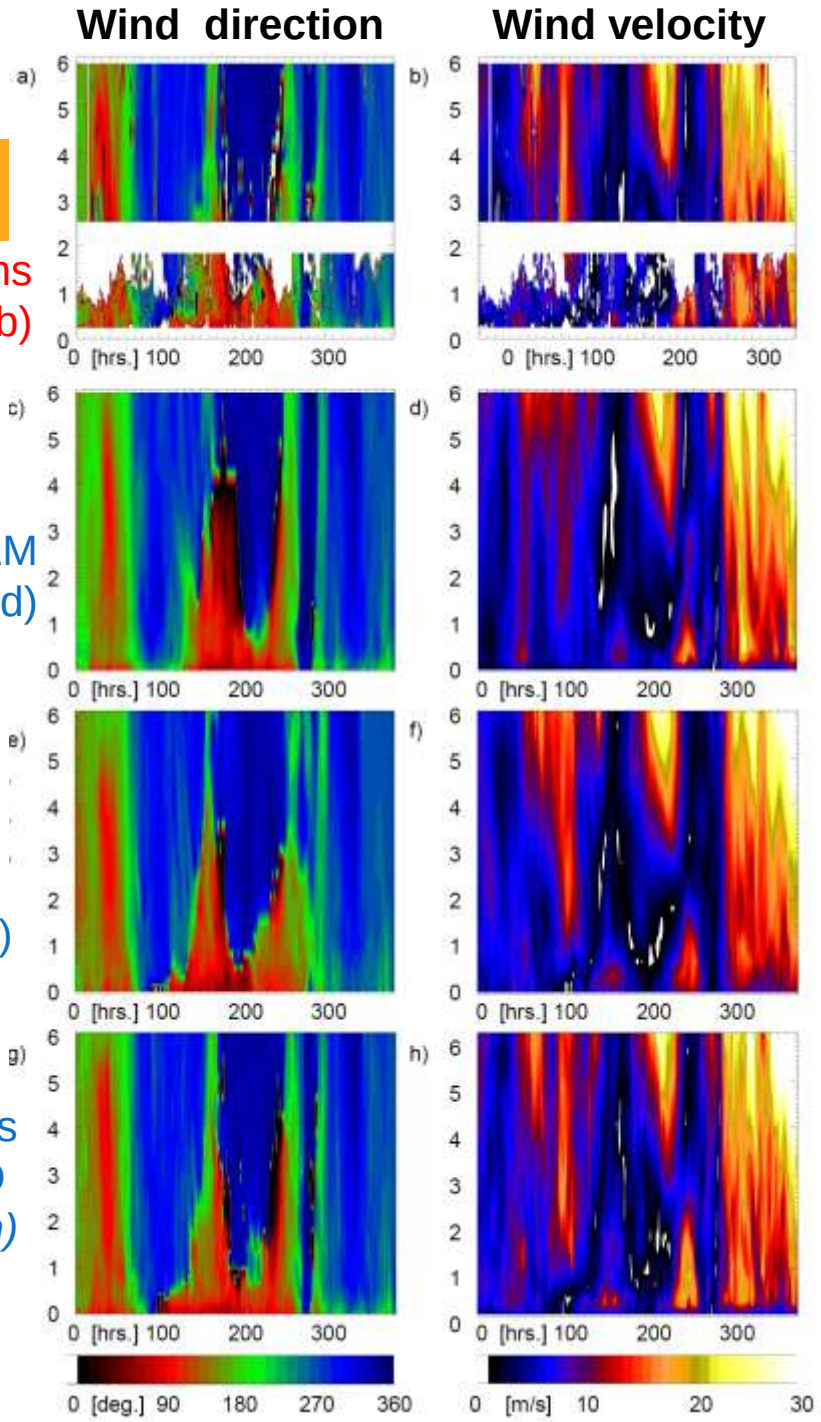


Observations (a, b)

COSMO-CLM (c, d)

UPM-WRF (e. f)

Meteo Swiss - COSMO (g. *h*)

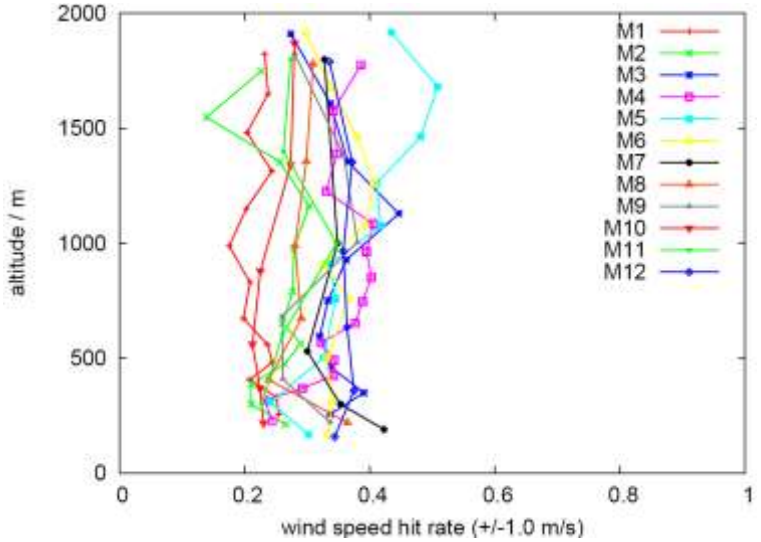


NIMH

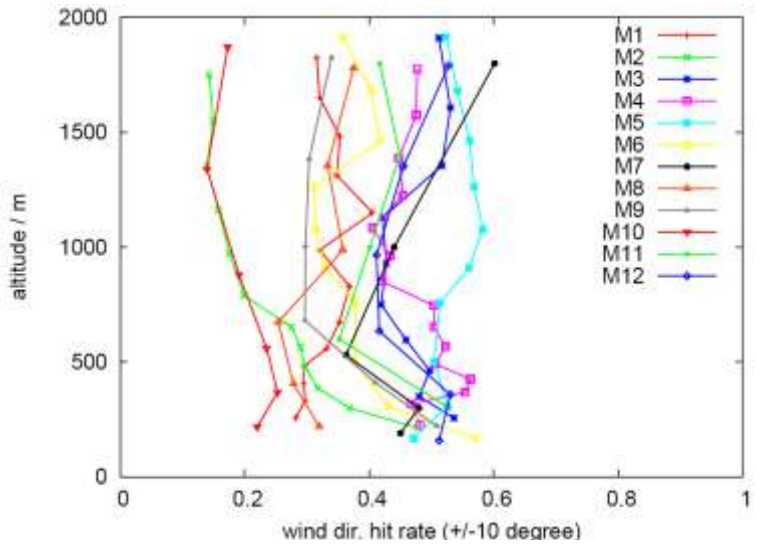
10th EMS,

Bulk statistics at Lindenberg, 24.02.2003 to 11.03.2003; hourly data

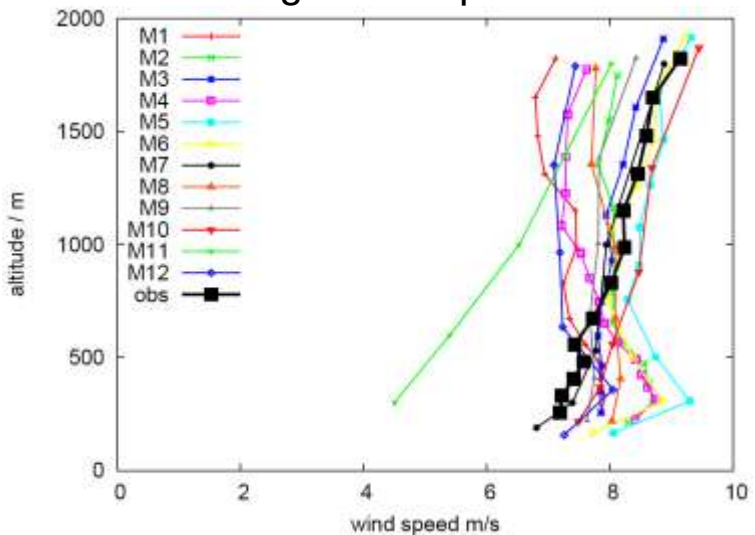
Wind speed hit rate



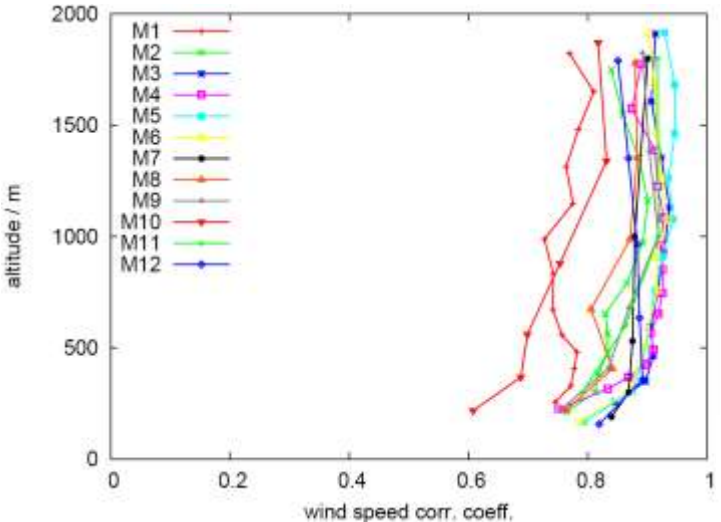
Wind speed hit rate



Average wind speed



Wind speed correlation coeficient



Climatology of the vertical profiles of wind and turbulence

At coastal areas as Høvsøre, the ABL is characterised by complex vertical structure and diurnal variability.

The analysis of measurements requires to distinquish marine and land flows.

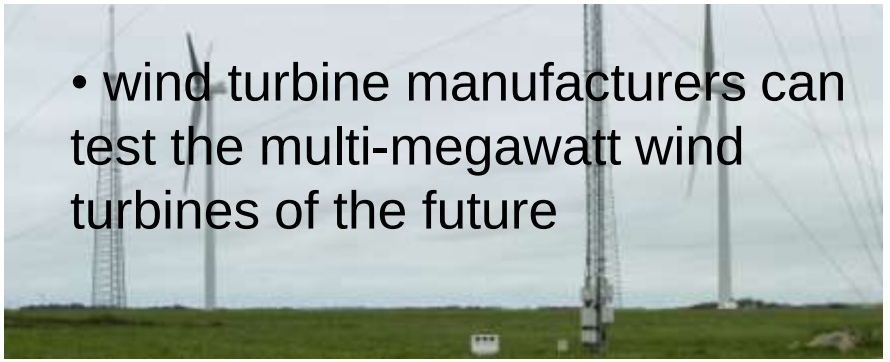
The mesoscale models used need to be run on high resolution (1-2 km) to achieve correct representations of coastal line and ABL structure.

At Risoe a verison of WRF is run on forecast mode

Climatology of the vertical profiles of wind and turbulence

Test centres for large-scale wind turbines and related meteorology

At Høvsøre for 10 years now

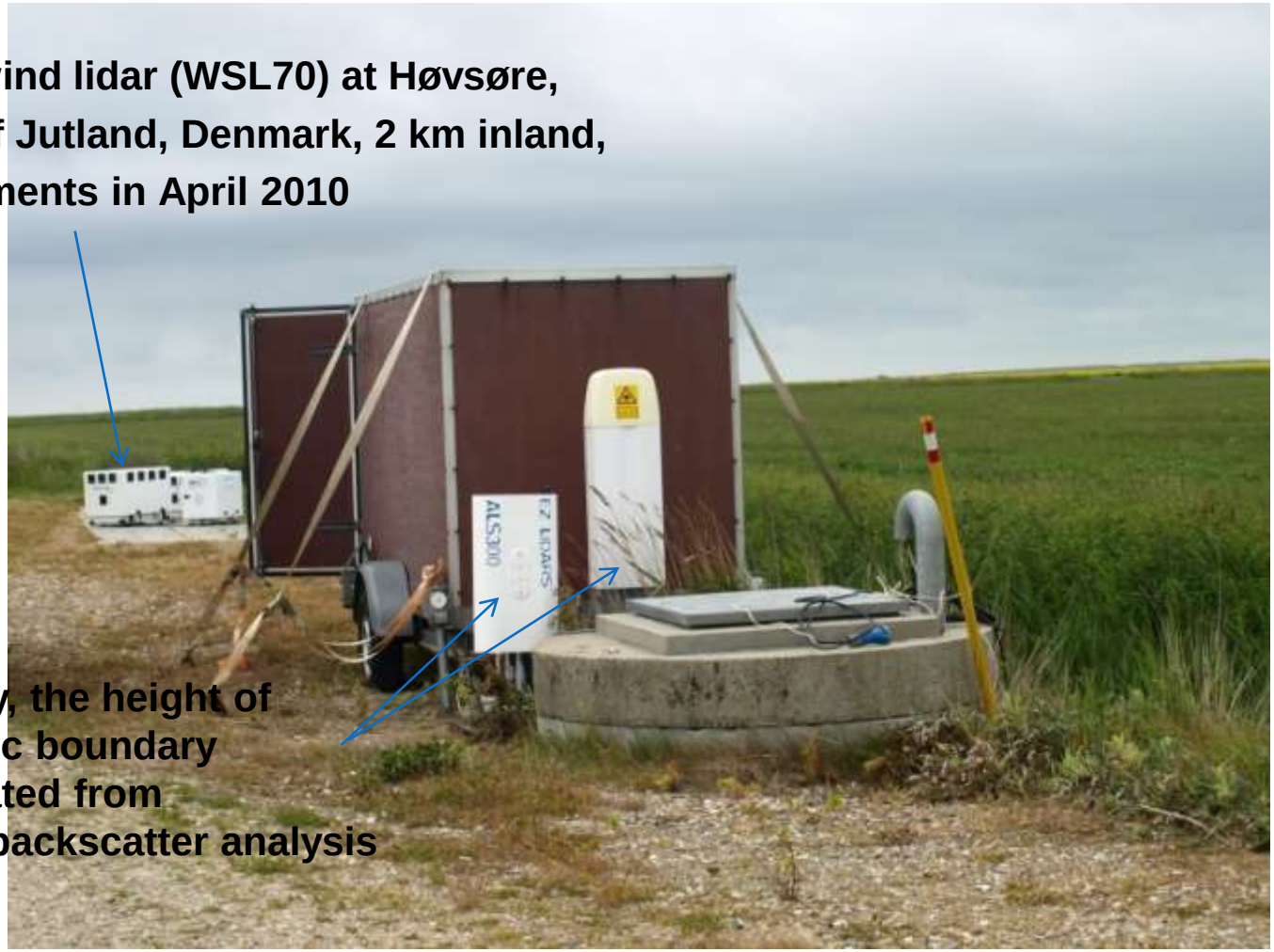


- wind turbine manufacturers can test the multi-megawatt wind turbines of the future

- scientists can test new instrumnets and gather long term profile measurements of meteorological parameters, both mean values and turbulence
  - on masts (up to 160 m)
  - with sodars and lidars (up to 300; 1000 m; …)

Climatology of vertical profiles of wind

The long range wind lidar (WSL70) at Høvsøre, the West coast of Jutland, Denmark, 2 km inland, started measurements in April 2010

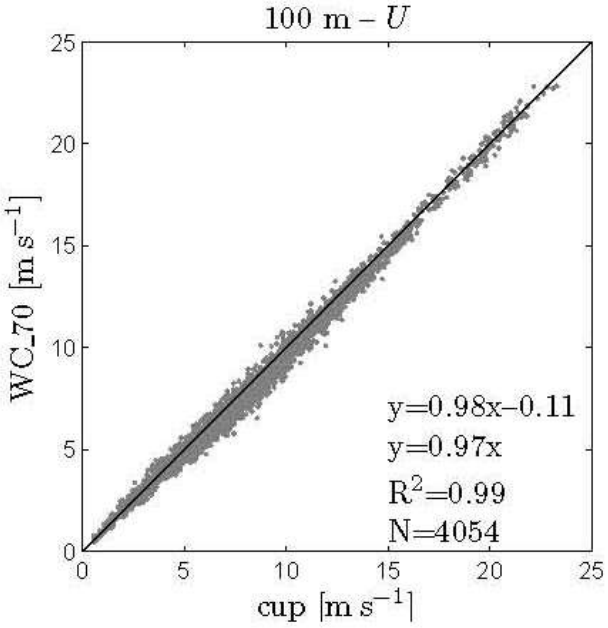


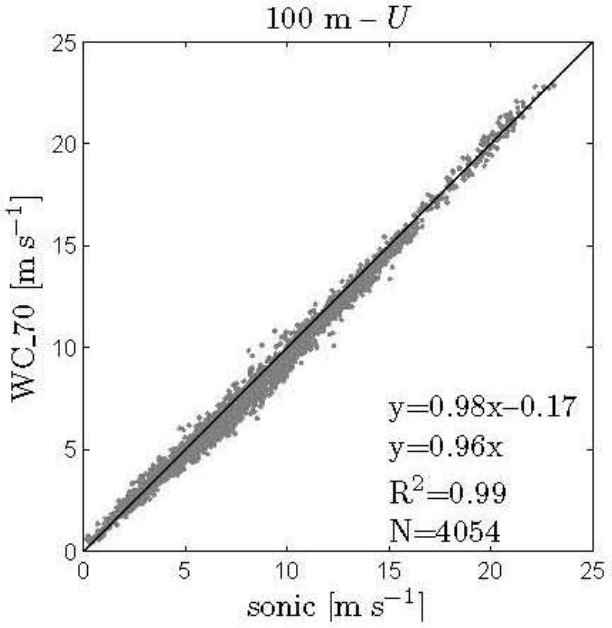
Simultaneously, the height of the atmospheric boundary layer is estimated from aerosol lidars backscatter analysis

Climatology of vertical profiles of wind

Wind Lidar vs cup and sonic

Comparaison of wind speed (U) measured by long-range lidar (100-2000 m, 50m resolution), cup anemometer and sonic,

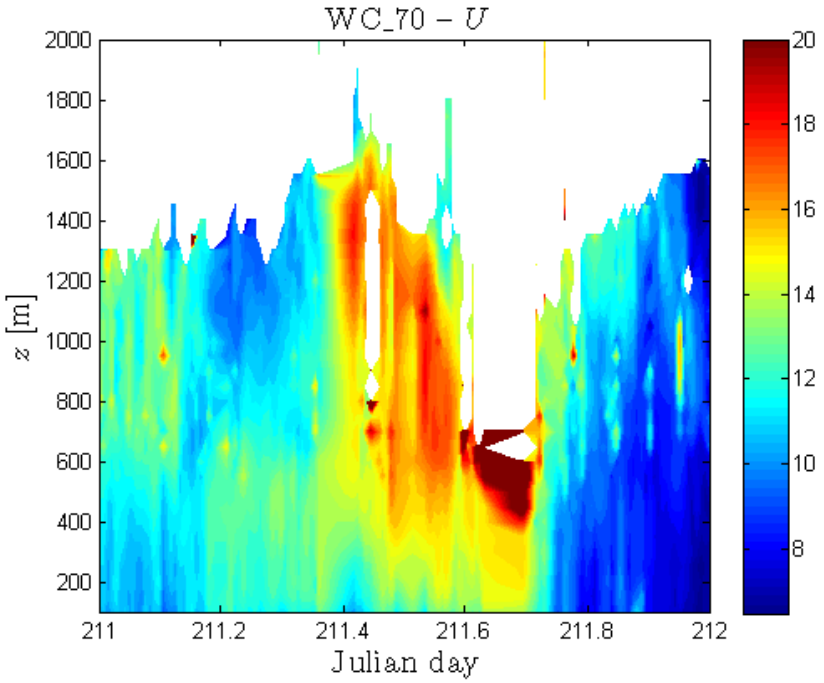




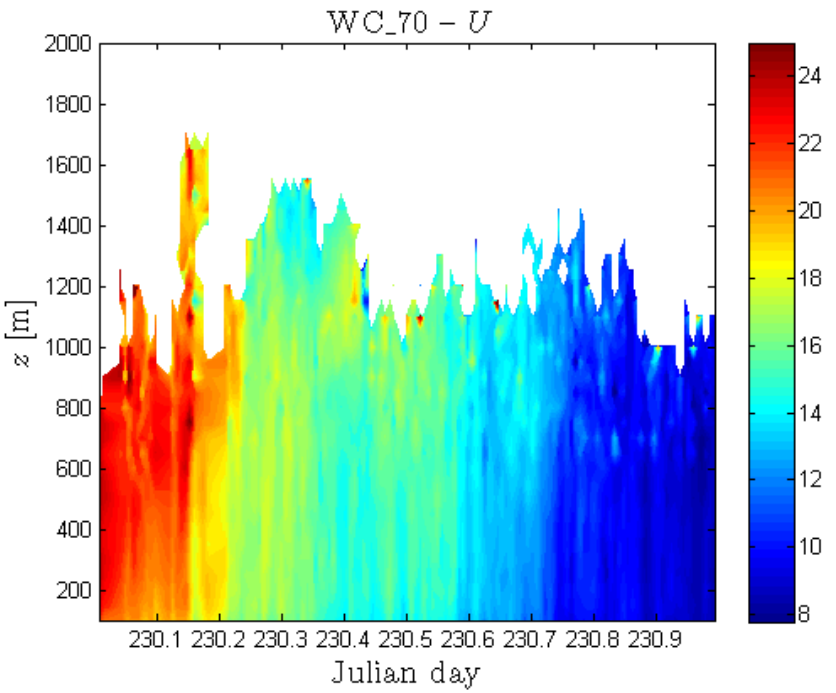
Climatology of vertical profiles of wind

Profiles of Horizontal wind speed

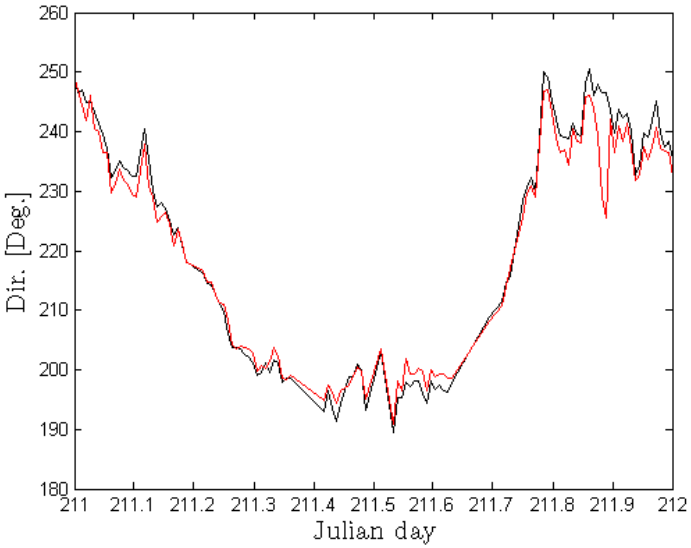
31 July 2010 (JD 211)
Horizontal wind speed

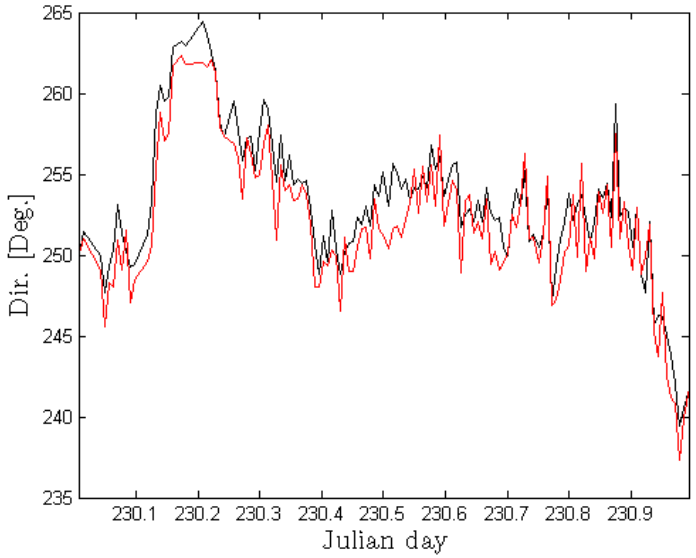


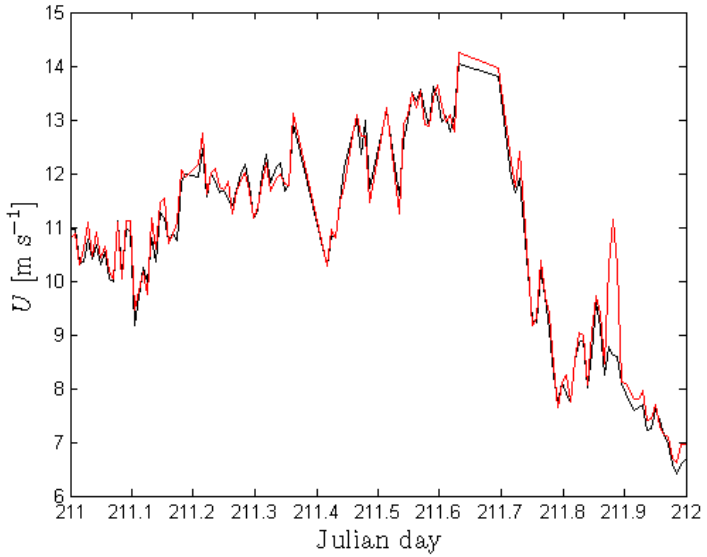
19 August 2010 (JD 230)
Horizontal wind speed

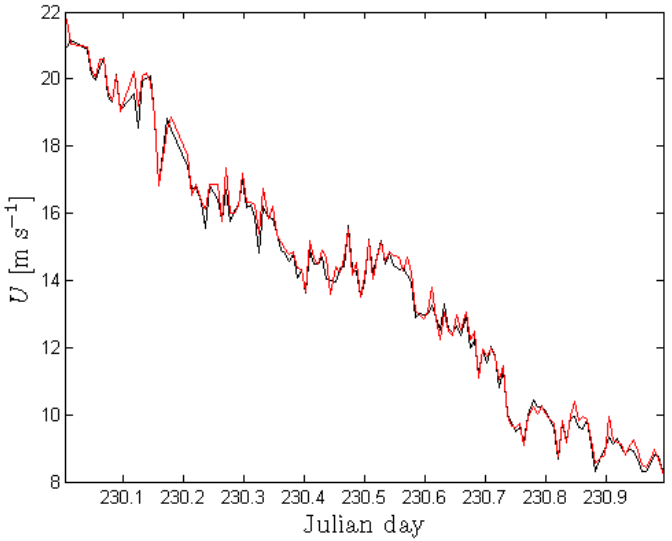


Climatology of vertical profiles of wind









Wind direction and wind speed for 31 July and 19 August 2010 at 100 m

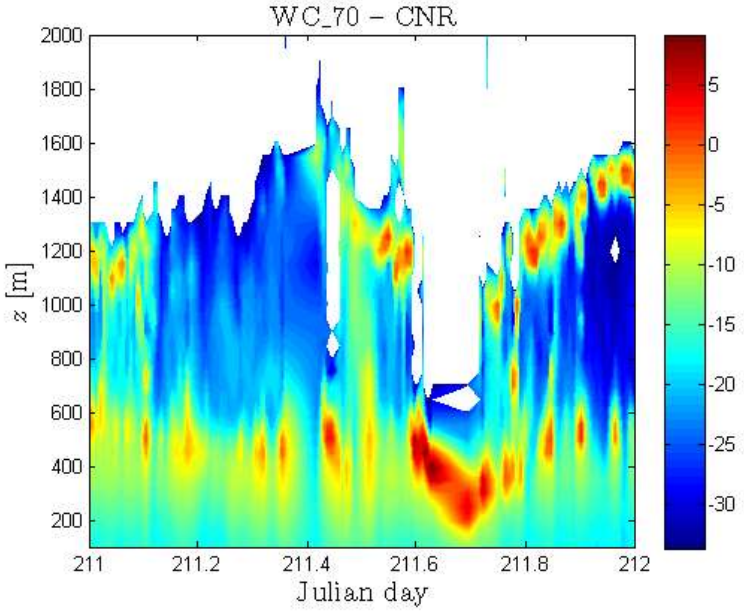
Red WC_70

Black Vane/ Cup

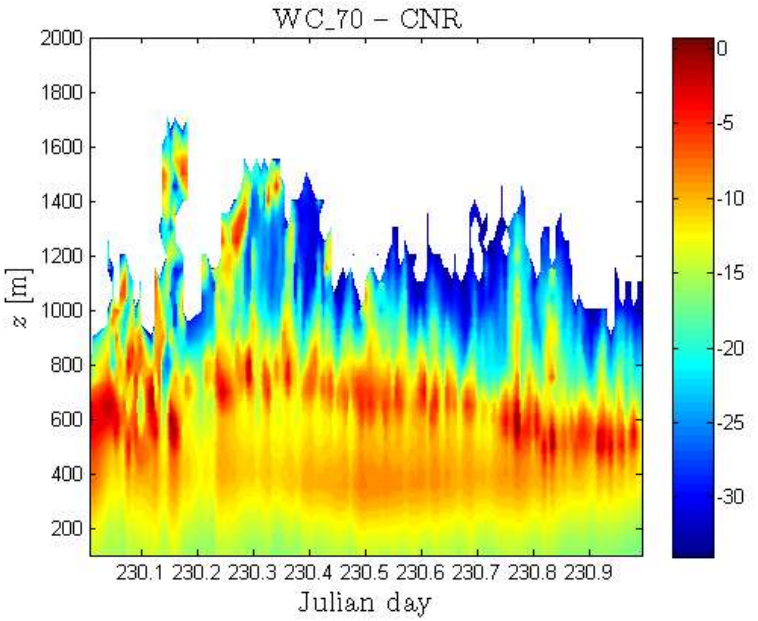
Climatology of vertical profiles of wind

Availability of data with regards to meteorological conditions

CNR, 31 July 2010 (JD 211)



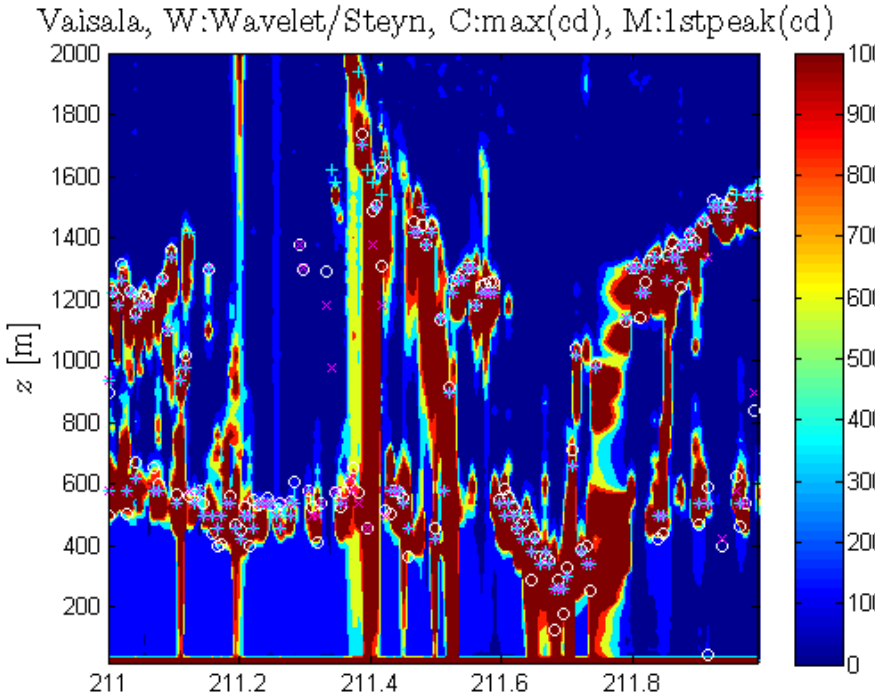
CNR, 19 August 2010 (JD 230)



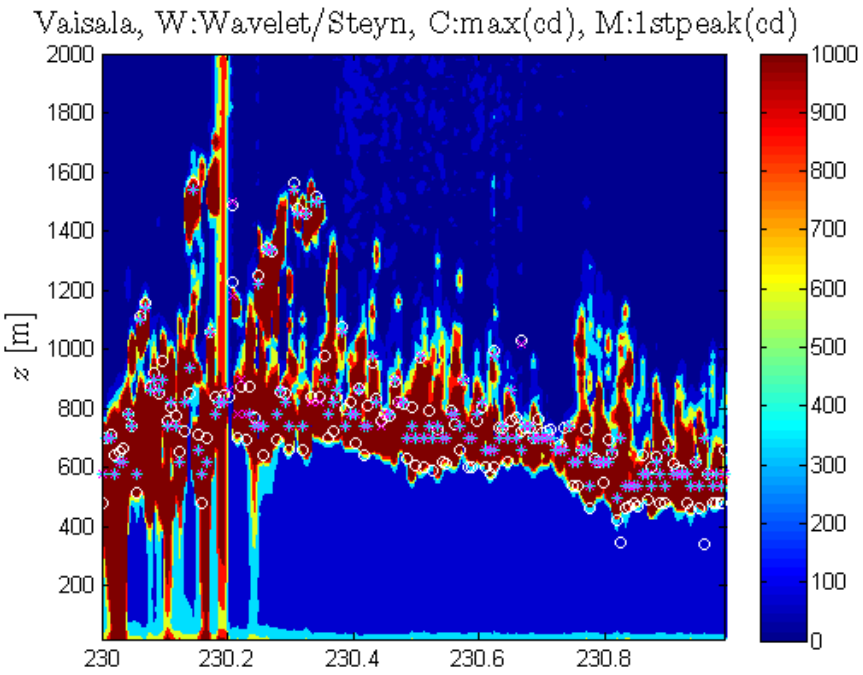
CNR, the Carrier to Noise Ratio indicates measurement quality and is calculated from raw spectra. CNR is equivalent to signal to noise ratio

Climatology of vertical profiles of wind

Aerosol lidars operating simmultaneously give information on clouds and ABL depth



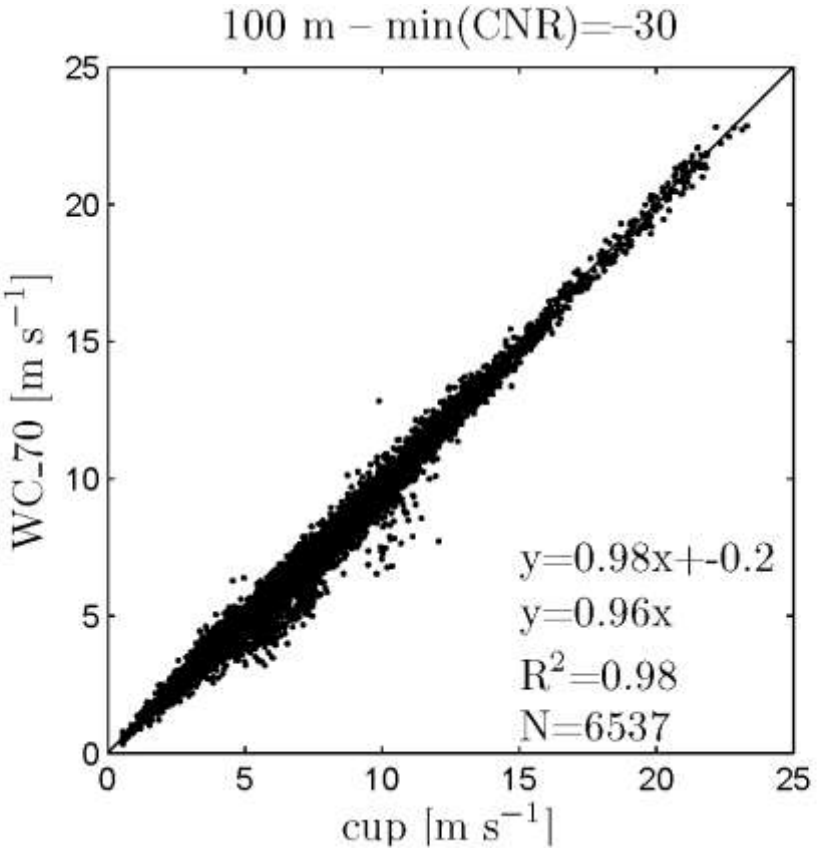
31 July 2010



19 August 2010

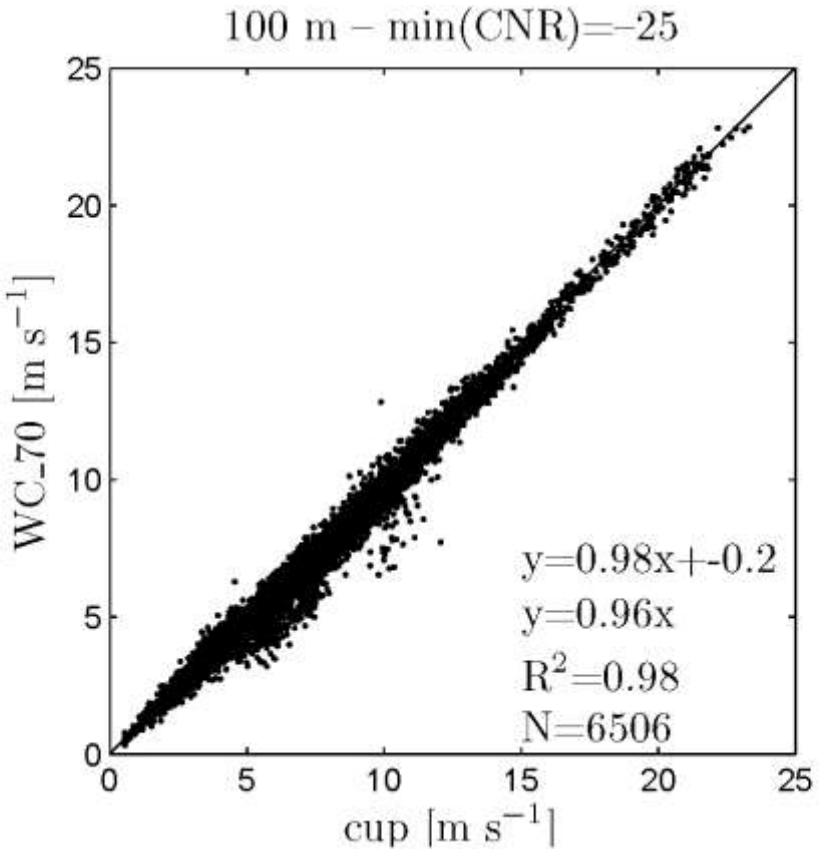
Climatology of vertical profiles of wind

The effect of CNR value on lidar/cup comparison **-30**



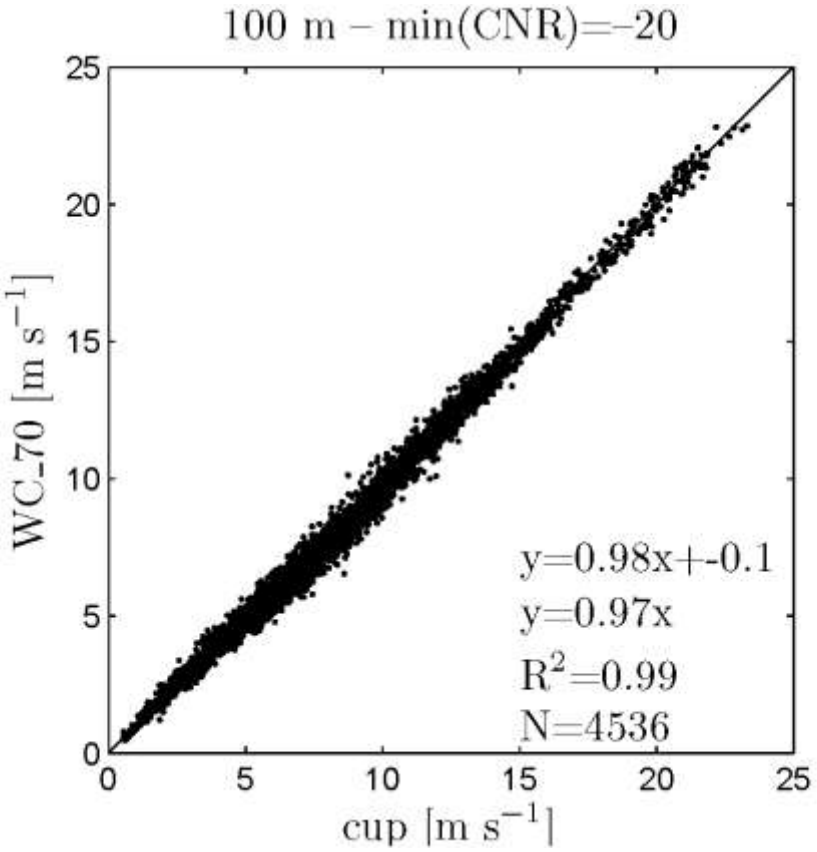
Climatology of vertical profiles of wind

The effect of CNR value on lidar/cup comparison **-25**



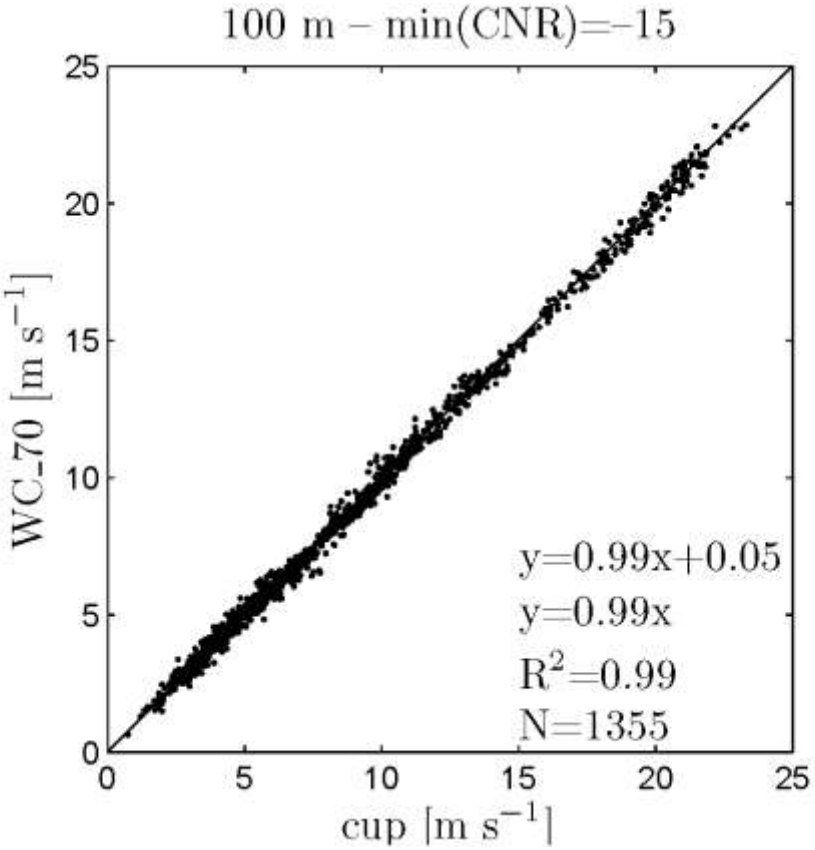
Climatology of vertical profiles of wind

The effect of CNR value on lidar/cup comparison **-20**



Climatology of vertical profiles of wind

The effect of CNR value on lidar/cup comparison **-15**

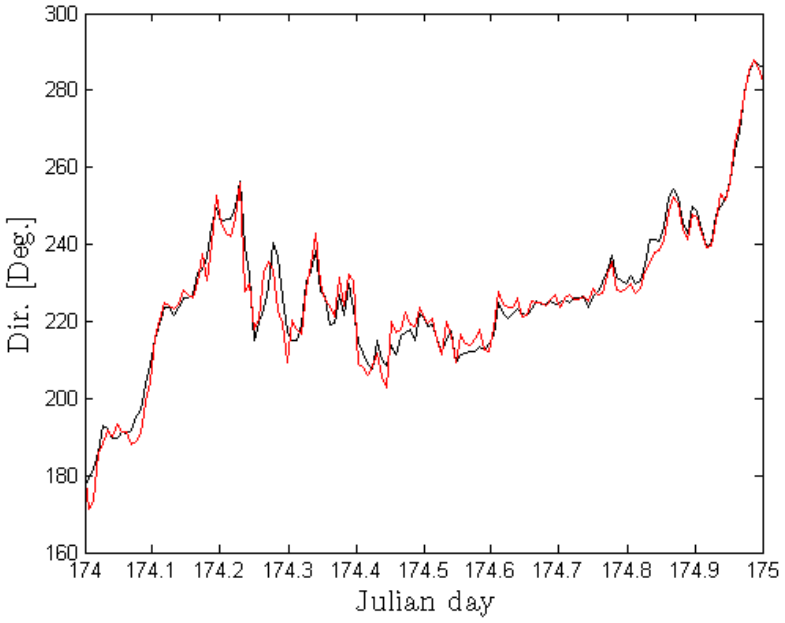


Climatology of vertical profiles of wind

24 June 2010 (JD 174) analysis with CNR -20

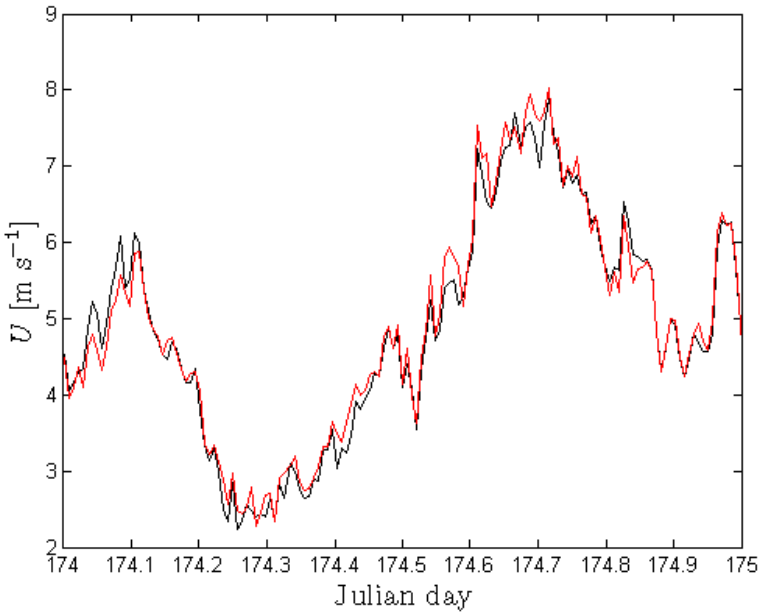
Wind direction at 100 m

Lidar / Vane



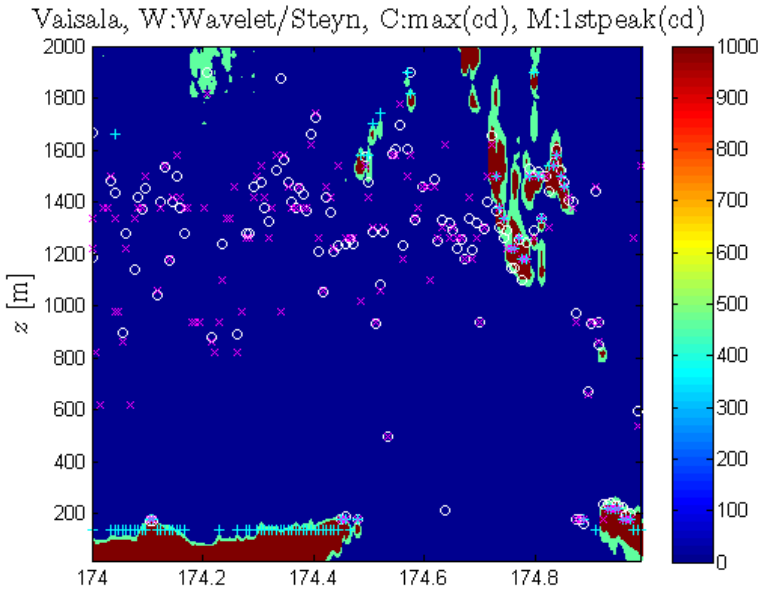
Wind speed at 100 m

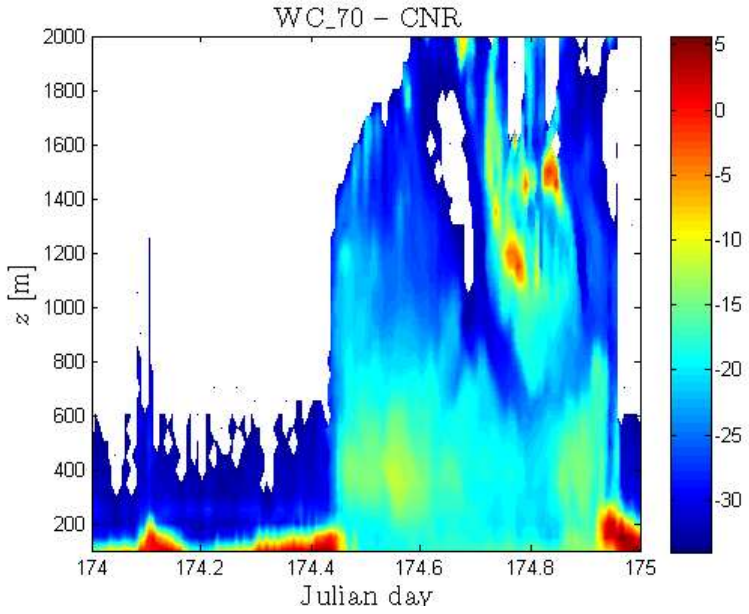
Lidar / Cup

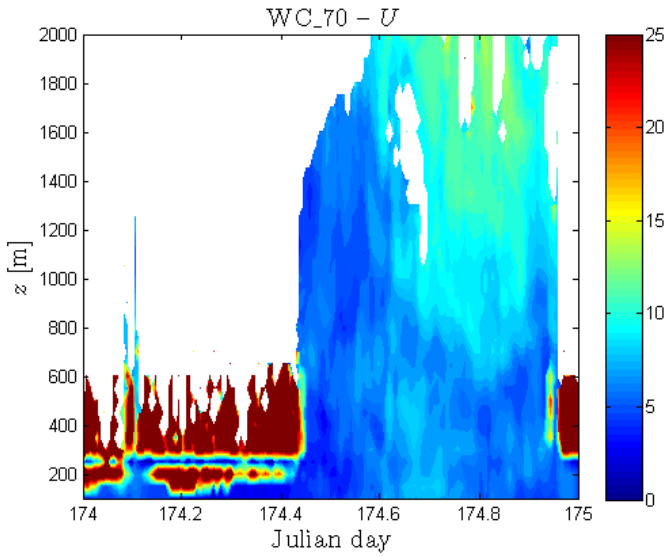


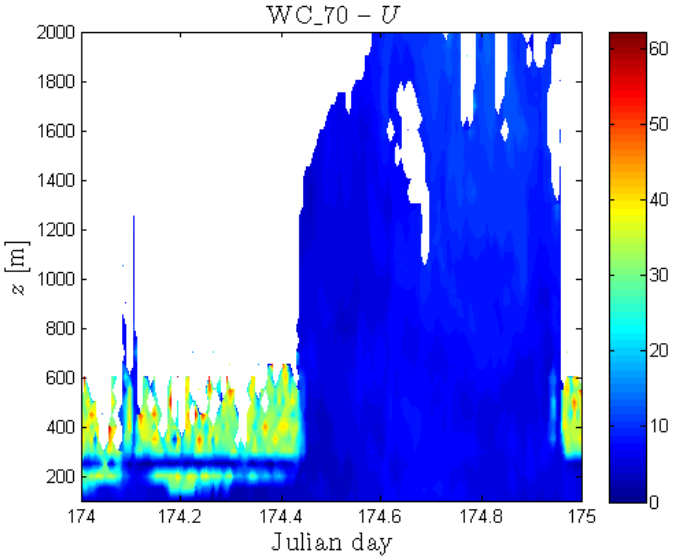
Climatology of vertical profiles of wind

Aerosol lidar CL31, WC_70 CNR, WC_70 Horizontal wind speed









Left – resolution For max 25 m/s,

Right – 60 m/s

DTU

RISØ

First results and future work

1) During the summer of 2010 Høvsøre was unique place in Europe with lidar measurements within the entire ABL.

2) The comparisons of long range wind lidar data with cup and sonic anemometer at 100 m on the nearby standing mast show very good agreement. This makes possible to use the data with confidence for hier levels, given the CNR ratio is appriate.

3)The analysis showed that cloudy conditions were prevailing and accordingly the hight reached by the wind lidar was reduced, compared to clear skys.

4) WRF is run on forecast mode for Denmark with high resolution (2 Km) at Risoe. Comparisons will be made after further check of availability of wind lidar data.

DTU

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ACKNOWLEDGEMENT

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VSABLA (PIEF-GA-2009-237471)

Thank you for your attention!