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EWEA 2012 – Copenhagen, Denmark

April 16 2012

Outline

Background (1/2)

Knowledge of the vertical wind speed profile and wind shear is important when, i.a.:

- predicting winds at higher/lower levels (somehow done)
- predicting wind power outputs (almost not done)
- predicting loads (almost not done)
- predicting wake effects (almost not done)
- performing power curve measurements (on the way)
- performing thrust curve measurements (almost not done)

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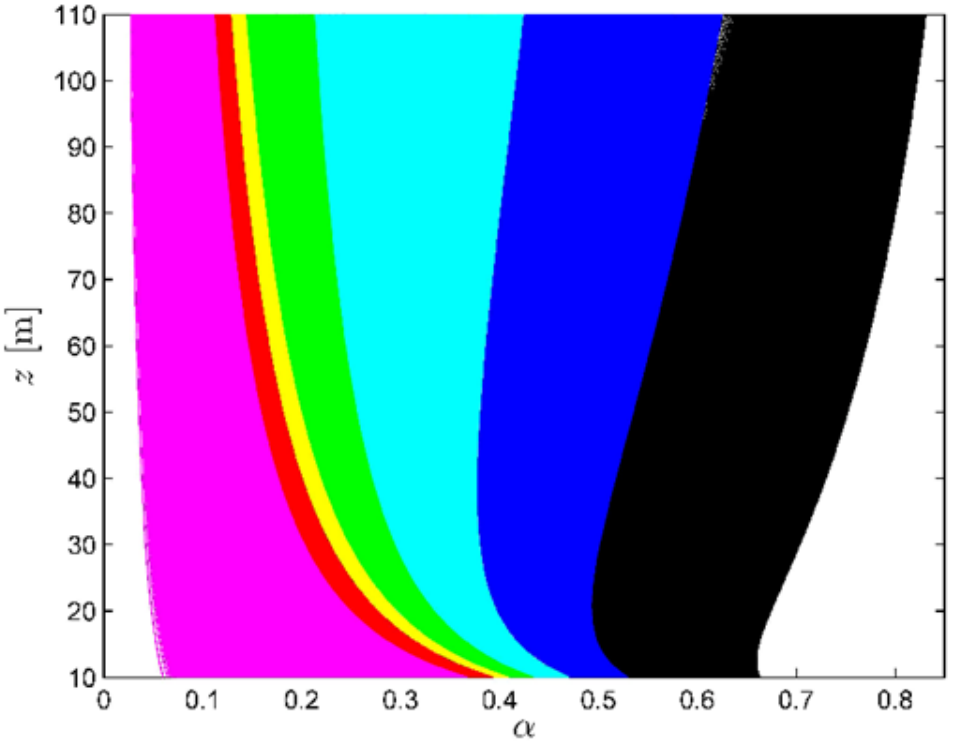
Combining the power law with MOST, i.e,

$$u = u_r \left(\frac{z}{z_r}\right)^{\alpha} +$$

$$\frac{du}{dz} = \phi_m \frac{u_*}{\kappa z} \rightarrow$$

$$\alpha = \frac{\phi_m}{\ln\left(z/z_o\right) - \psi_m}$$



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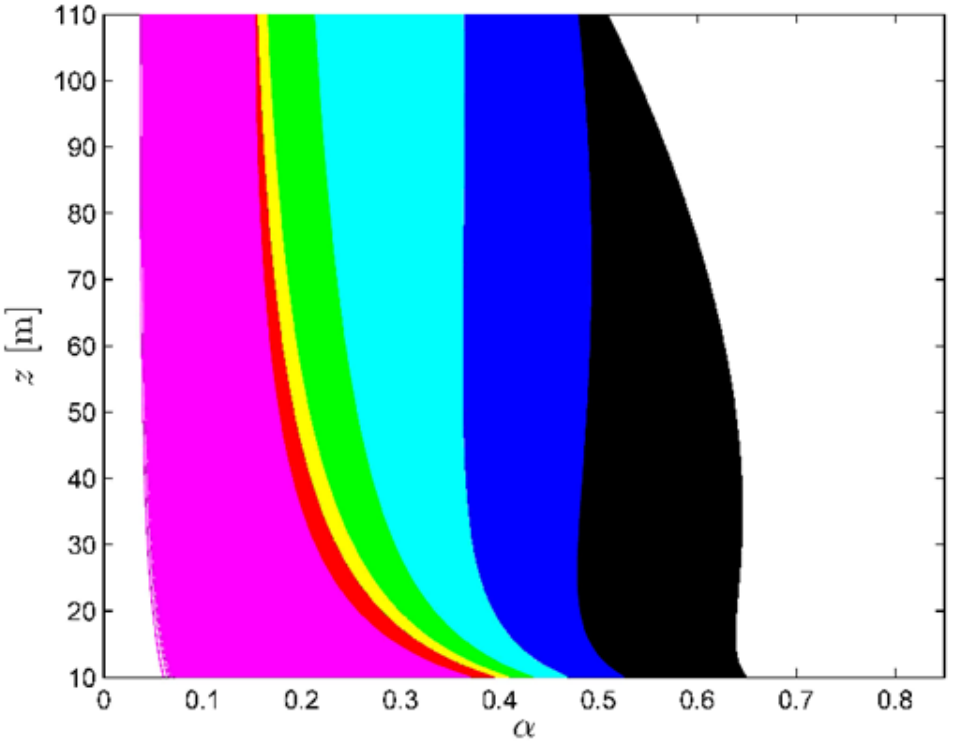
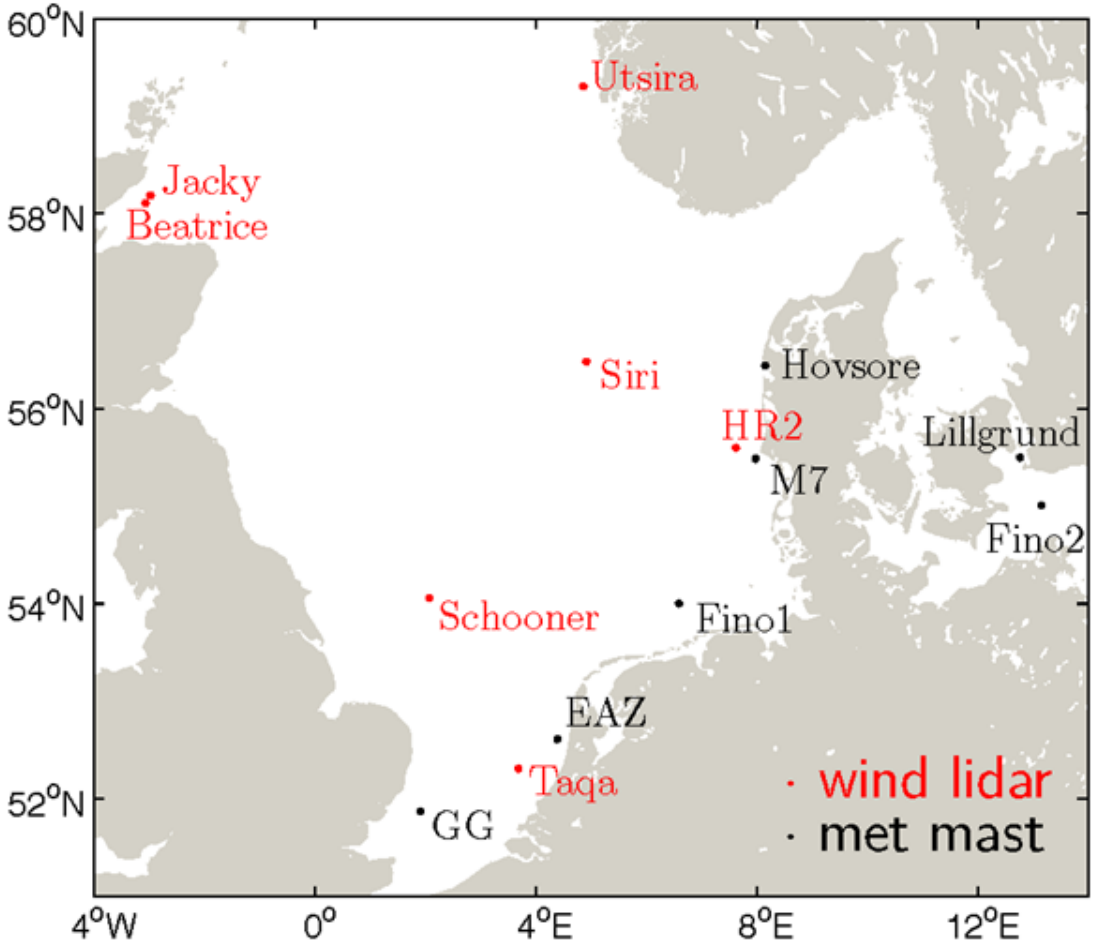


NORSEWInD network

For wind shear analysis



DTU Wind Energy
Department of Wind Energy

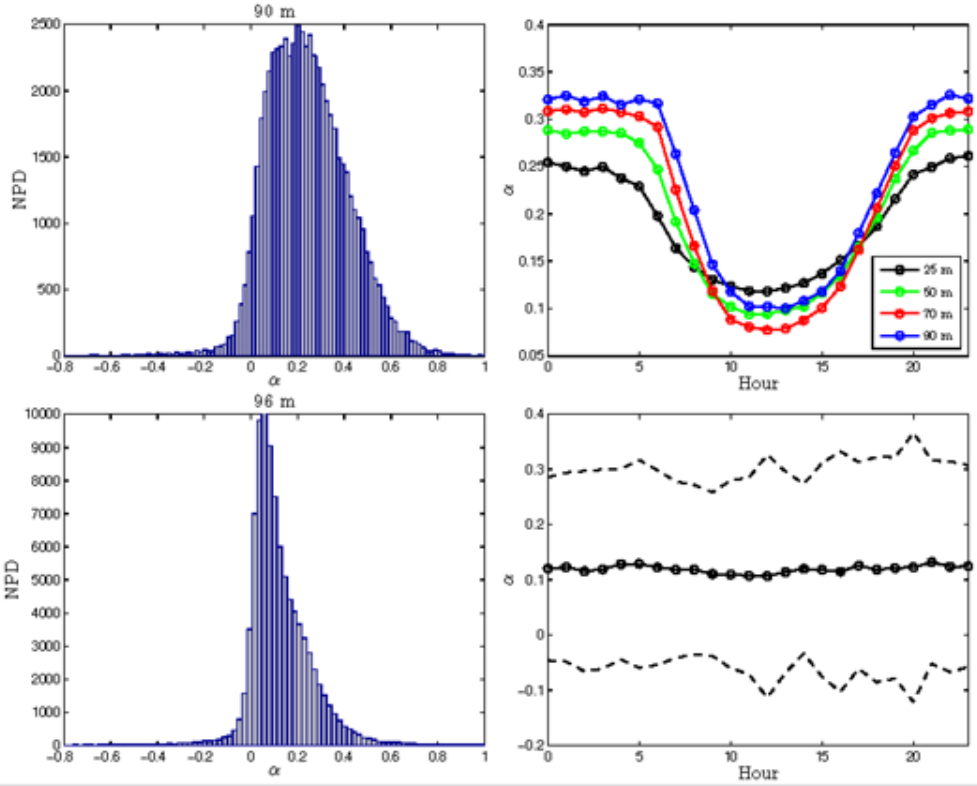
DTU

The challenge – facts

- No measures of stability at NORSEWInD lidar nodes
- Not all mast nodes have means to derive stability
- Offshore shear values similar to onshore but different behavior:

Hovsore

Horns Rev II



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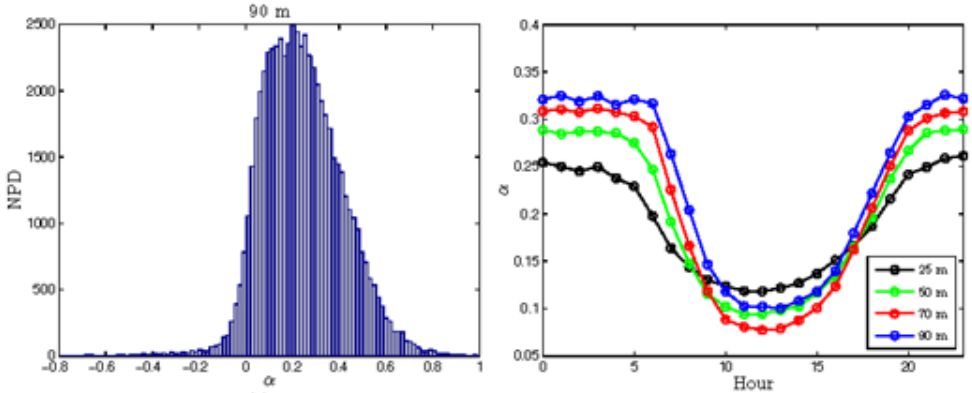

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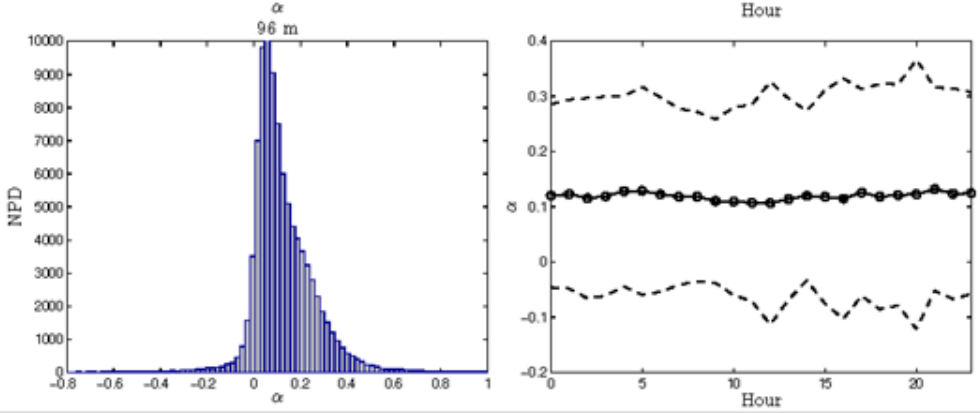

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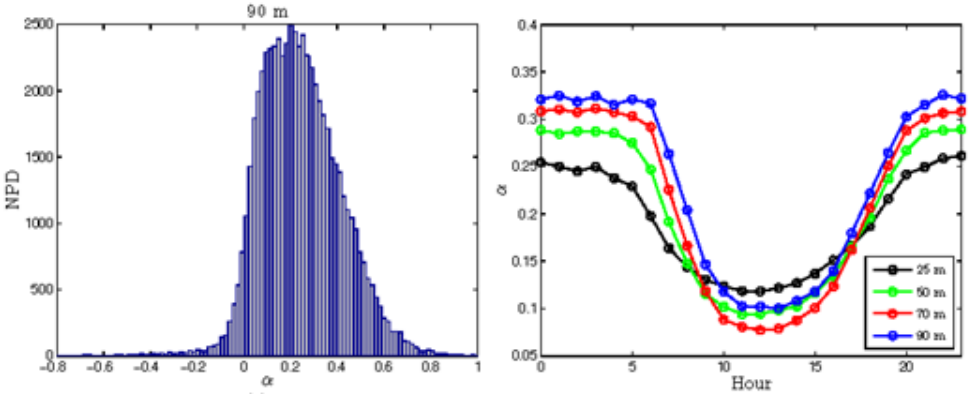

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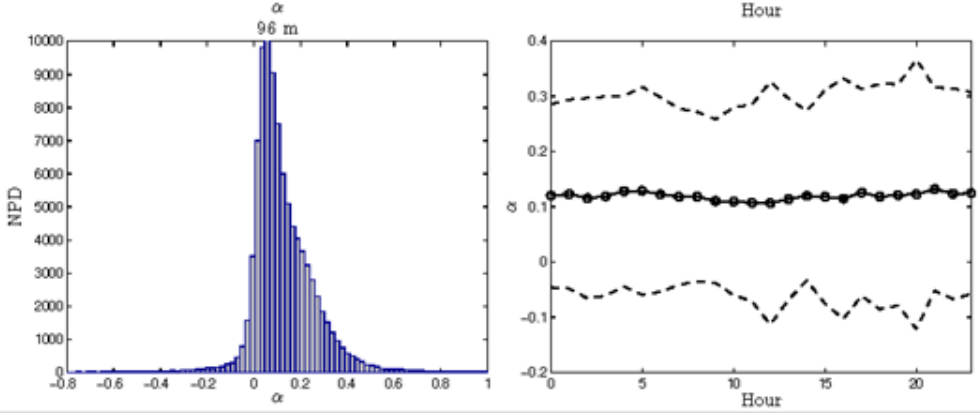
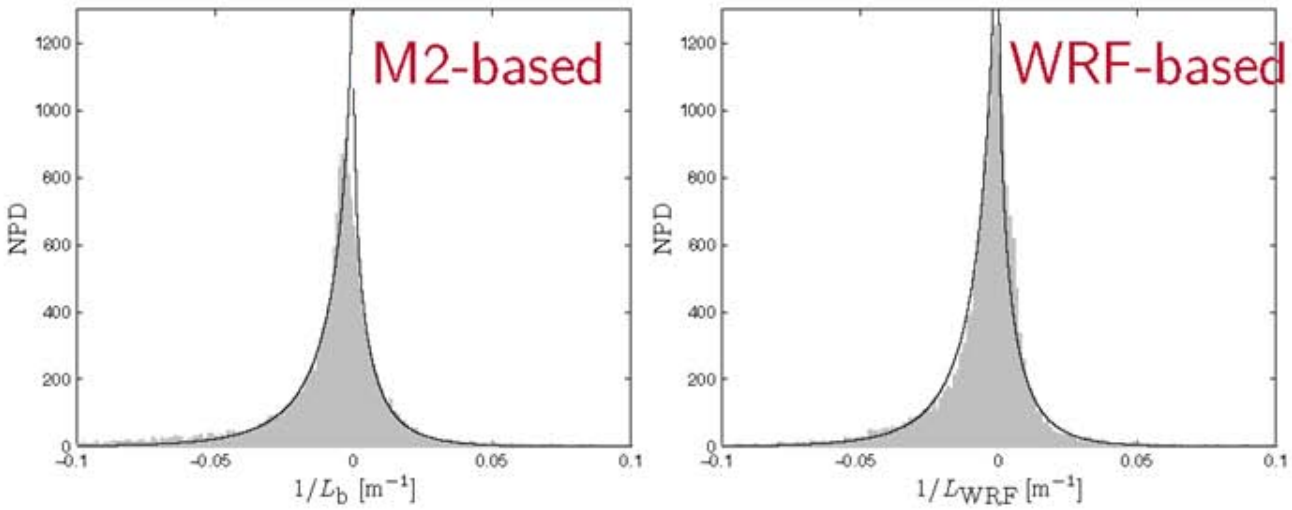


Long-term analysis – Horns Rev I (M2) + WRF



$$P = n_{\pm}\frac{C_{\pm}}{\sigma_{\pm}}\frac{\exp\left[-\left(C_{\pm}\left|1/L\right|/\sigma_{\pm}\right)^{2/3}\right]}{\Gamma\left[1+3/2\right]}$$

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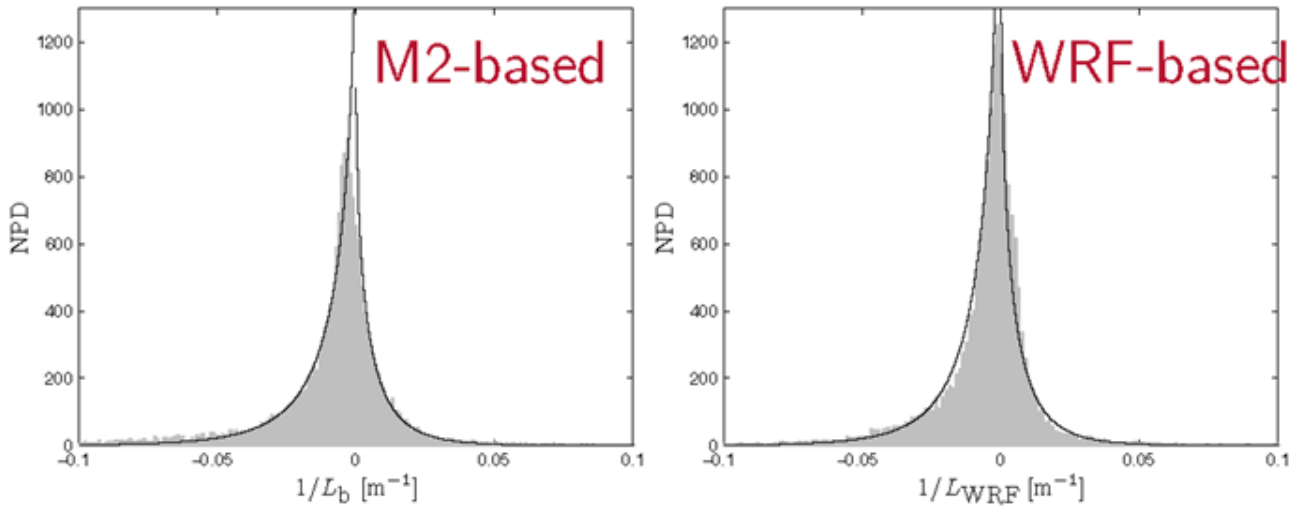

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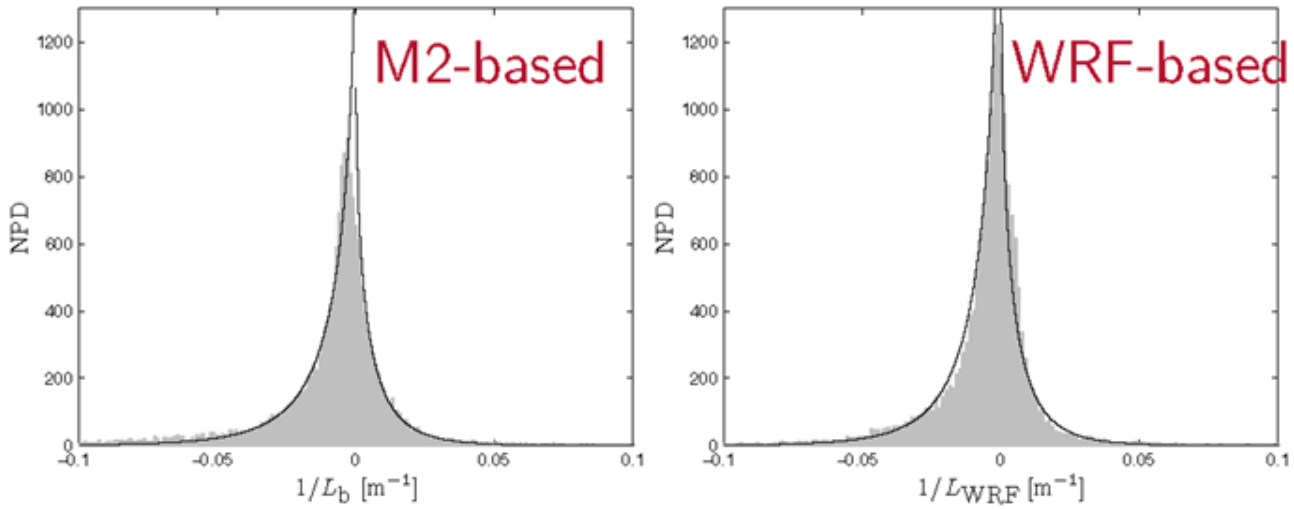

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z_i and L_m are mean values of BLH and middle BL length scale

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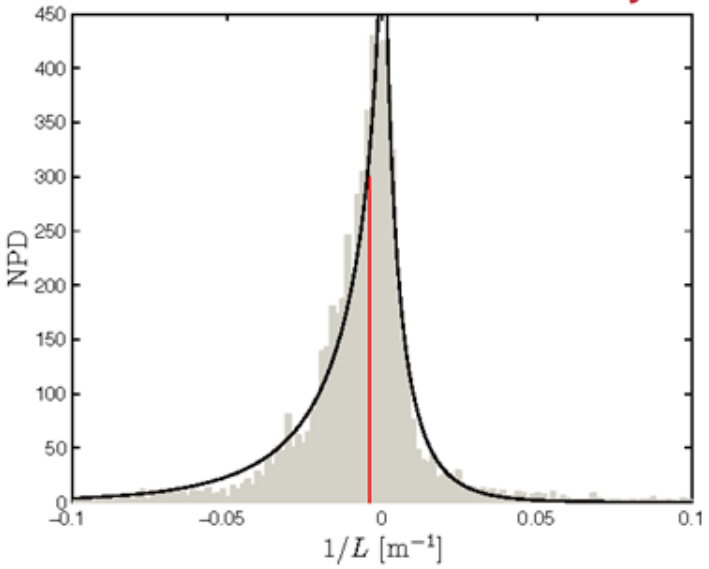
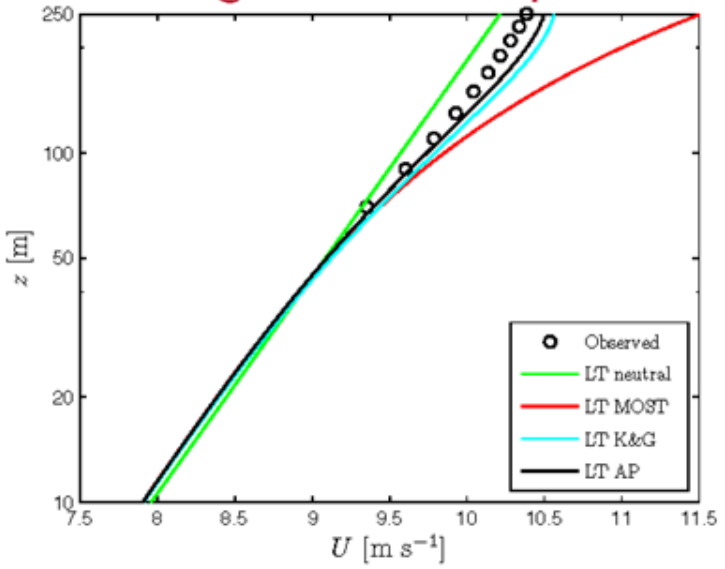
Results – Taqa (1 yr, 74%)

WRF-PDF of stability

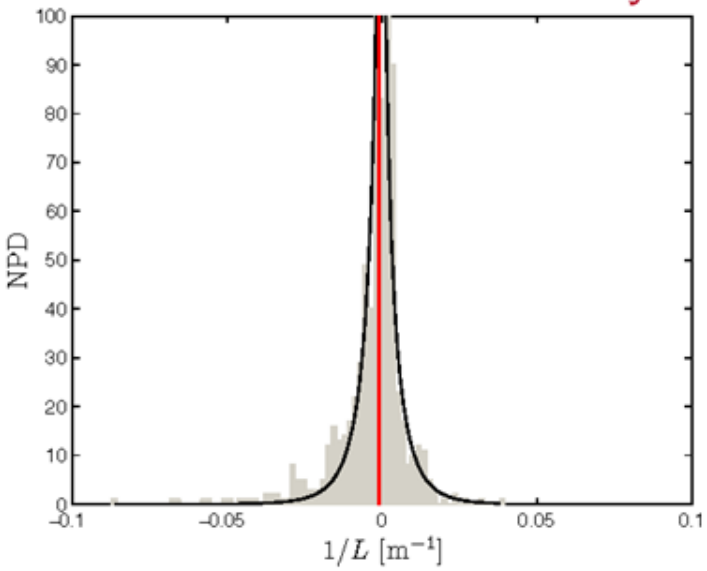


Long-term wind profile



Results – Siri (1 year, 12%)

WRF-PDF of stability



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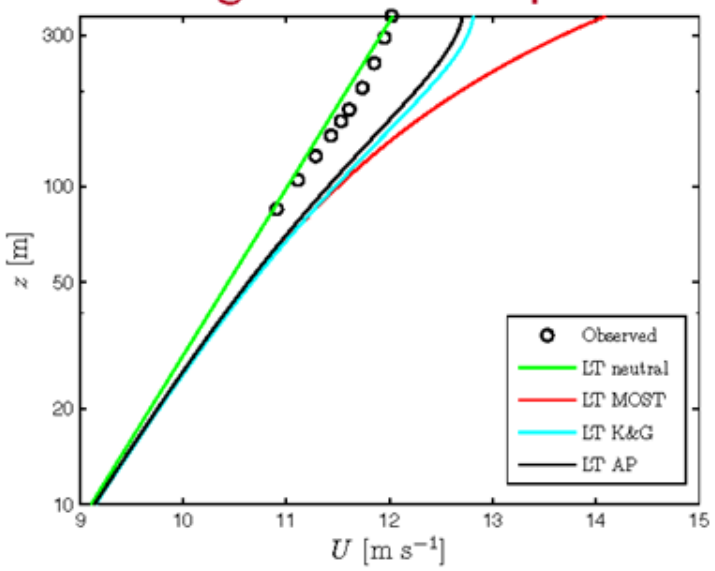
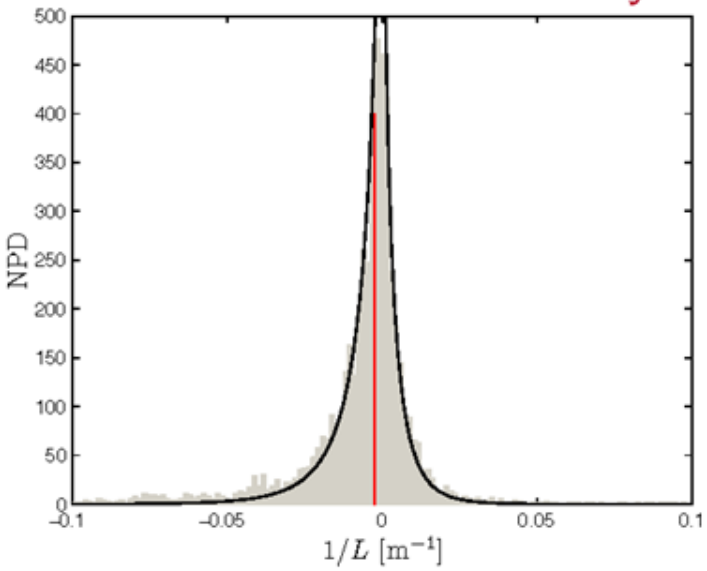


Results – Utsira (2 yr, 32%)

WRF-PDF of stability



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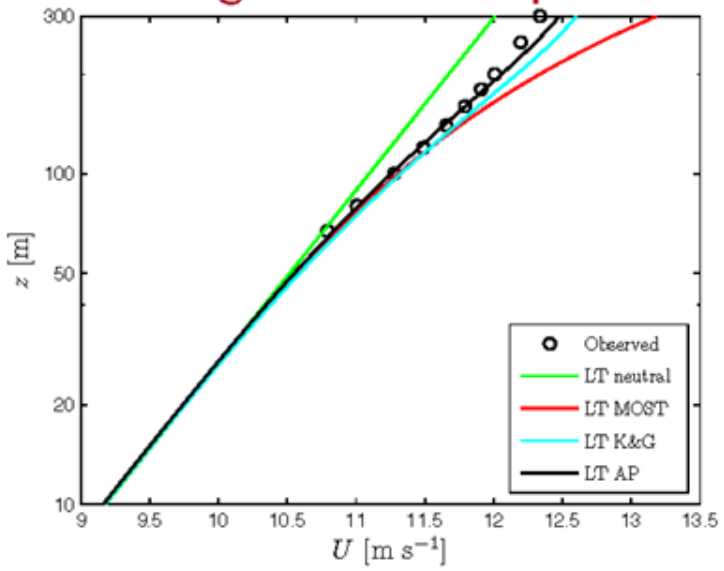
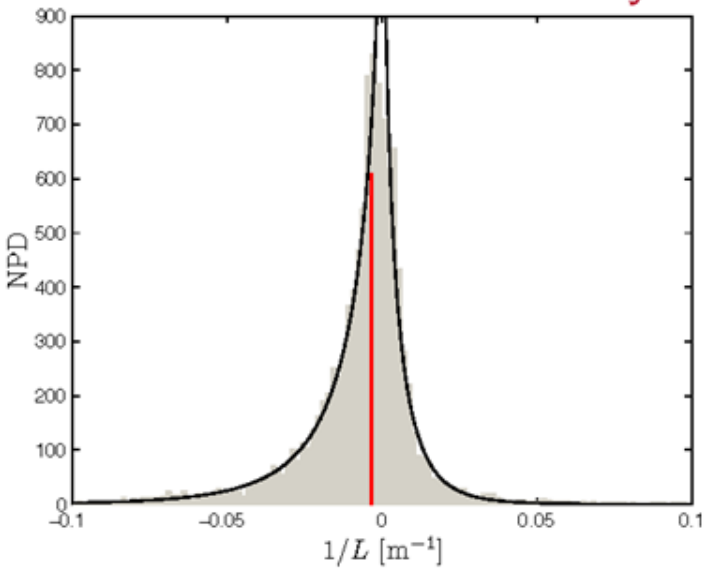


Results – Horns Rev II (+2 yr, 62%)

WRF-PDF of stability



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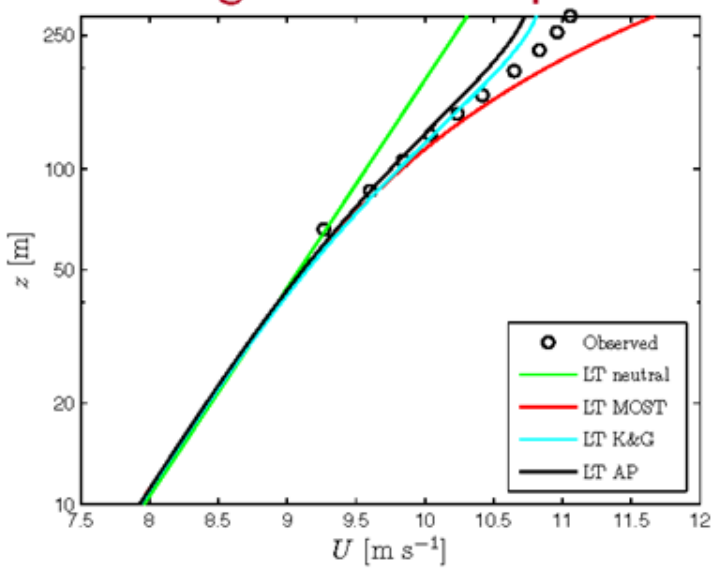

Summary

- We need observations of the wind profile/wind shear (not only at hub height)
- The wind shear is dependent on (in order) stability, roughness and height (among others)
- Offshore shear range close to onshore but different behavior (daily/monthly)
- PDF$(1/L) \Rightarrow$ PDF(α)
- In the long-term NWP models may provide means to estimate the long-term stability correction
- The long-term wind profile needs to be corrected with the long-term stability correction: predicting winds > 100 m needs z_i and other parameters

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Thanks for your attention!