Coherence of turbulent wind under neutral wind condition at FINO1

Charlotte Obhrai, University of Stavanger, charlotte.obhrai@uis.no
Lene Eliassen, Norwegian Technical and Scientific University, lene.eliassen@ntnu.no

University of Stavanger
uis.no

1/26/2016

Overview

- Motivation
- Methods
- Results
- Conclusion

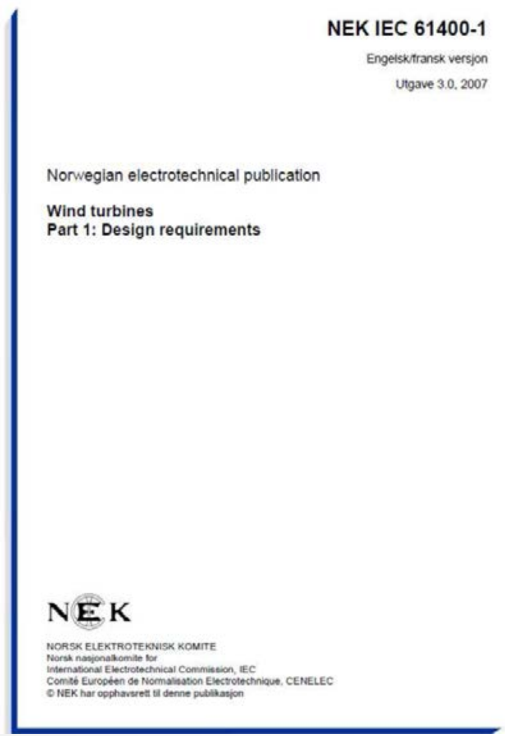
University of Stavanger

Overview

- Motivation
- Methods
- Results
- Conclusion

University of Stavanger

Turbulence models in the IEC 61400


NEK IEC 61400-1

Engelsk/fransk versjon

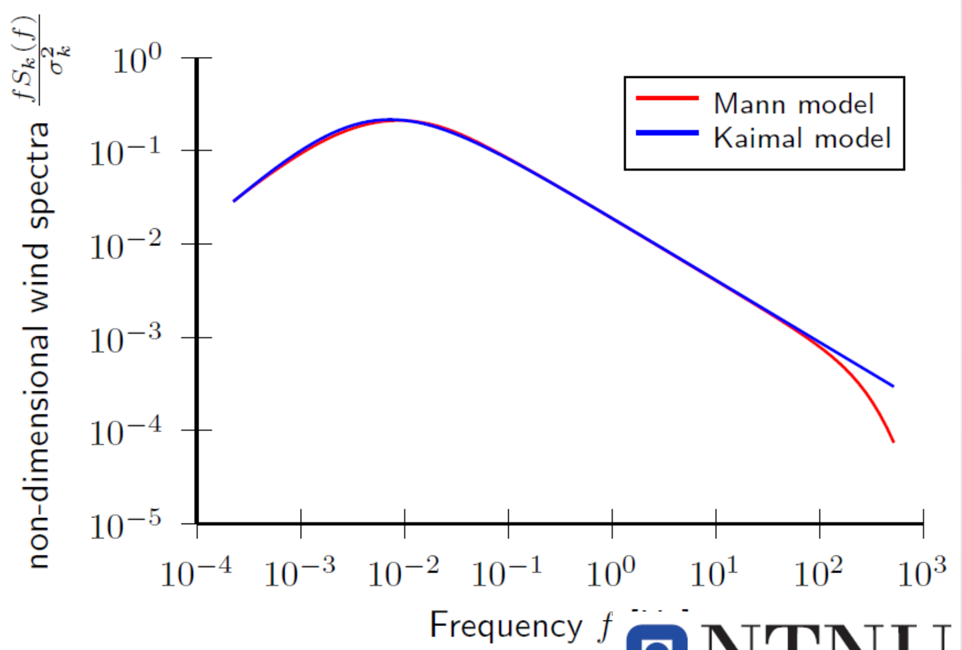
Utgave 3.0, 2007

Norwegian electrotechnical publication

Wind turbines
Part 1: Design requirements

NEK

NORSK ELEKTROTEKNISK KOMITE
Norsk nasjonalkomite for
International Electrotechnical Commission, IEC
Comité Européen de Normalisation Electrotechnique, CENELEC
© NEK har opphavsrett til denne publikasjon



University of Stavanger

Simulated wind (app B.2 IEC 61400-1)

- Kaimal spectrum
- IEC coherence function:

$$\gamma(r,f) = e^{\left[-12\left(\left(f\cdot r/V_{hub}\right)^2+\left(0.12\cdot r/L_c\right)^2\right)^{0.5}\right]}$$

- Reduced frequency:

$$f\cdot r/V_{hub}$$

University of Stavanger

NTNU

Simulated wind (app B.1 IEC 61400-1)

- Mann turbulence model:

$$\Phi_{11}(k_1,k_2,k_3) = \frac{E(k_0)}{4\pi k_0^4}\left(k_0^2 - k_1^2 - 2k_1(k_3 + \beta(k)k_1)\zeta_1 + (k_1^2 + k_2^2)\zeta_1^2\right) \tag{B.1}$$

$$\Phi_{22}(k_1,k_2,k_3) = \frac{E(k_0)}{4\pi k_0^4}\left(k_0^2 - k_2^2 - 2k_2(k_3 + \beta(k)k_1)\zeta_2 + (k_1^2 + k_2^2)\zeta_2^2\right) \tag{B.2}$$

$$\Phi_{33}(k_1,k_2,k_3) = \frac{E(k_0)}{4\pi k^4}\left(k_1^2 + k_2^2\right) \tag{B.3}$$

$$\Phi_{12}(k_1,k_2,k_3) = \frac{E(k_0)}{4\pi k_0^4}\left(-k_1k_2 - k_1(k_3 + \beta(k)k_1)\zeta_2 - k_2(k_3 + \beta(k)k_1)\zeta_1 + (k_1^2 + k_2^2)\zeta_1\zeta_2\right) \tag{B.4}$$

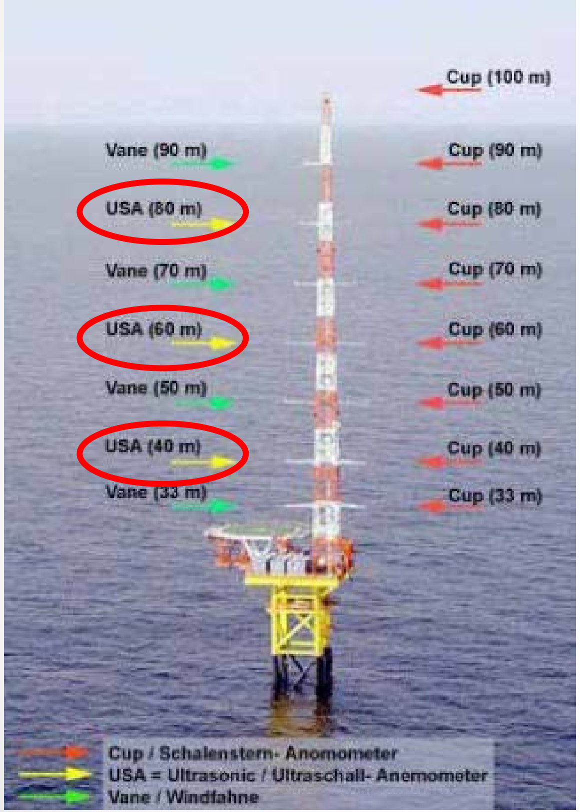
$$\Phi_{13}(k_1,k_2,k_3) = \frac{E(k_0)}{4\pi k_0^2 k^2}\left(-k_1(k_3 + \beta(k)k_1) + (k_1^2 + k_2^2)\zeta_1\right) \tag{B.5}$$

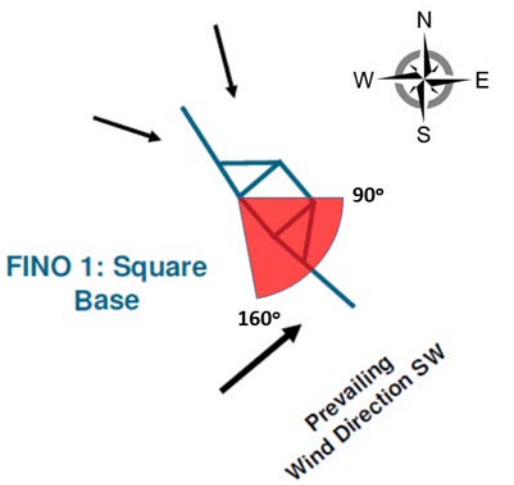
$$\Phi_{23}(k_1,k_2,k_3) = \frac{E(k_0)}{4\pi k_0^2 k^2}\left(-k_2(k_3 + \beta(k)k_1) + (k_1^2 + k_2^2)\zeta_2\right)$$

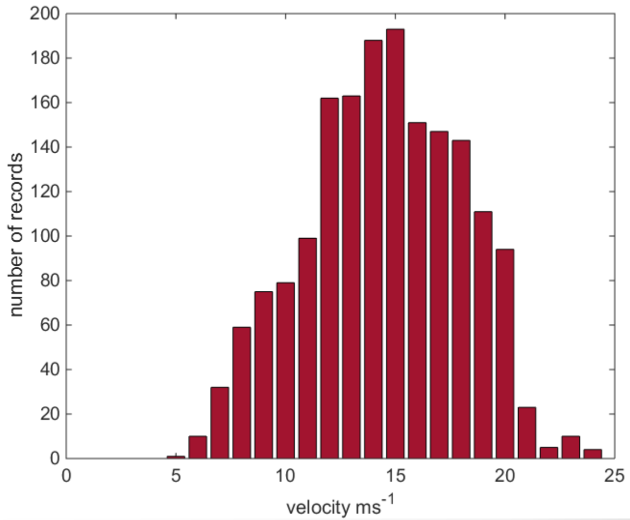
Overview

- Motivation
- Methods
- Results
- Conclusion

FINO 1

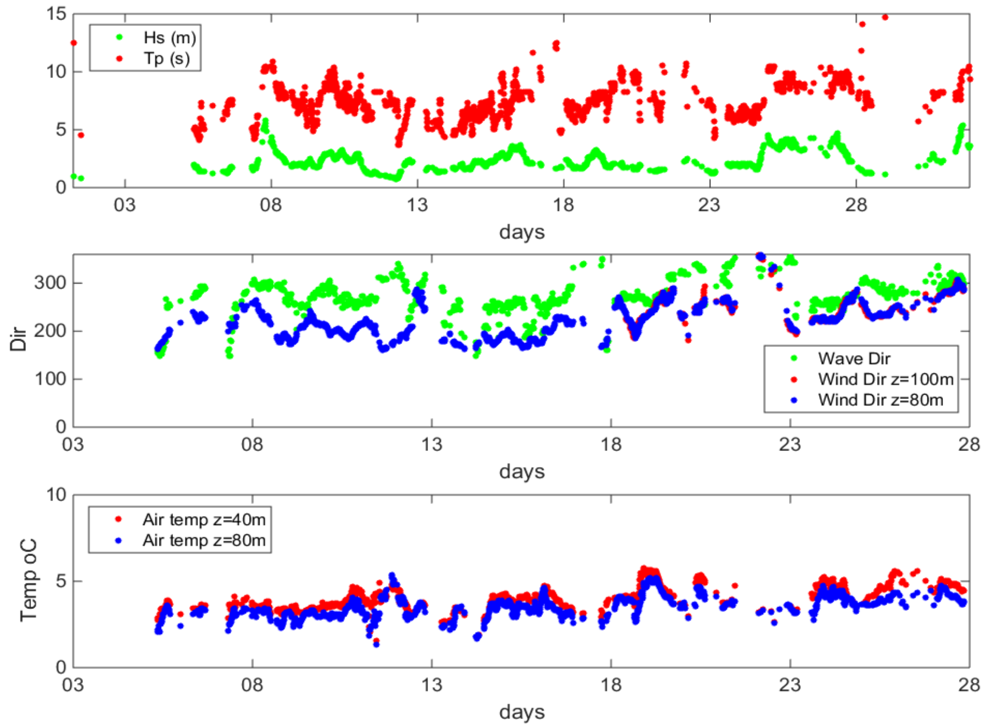






University of Stavanger

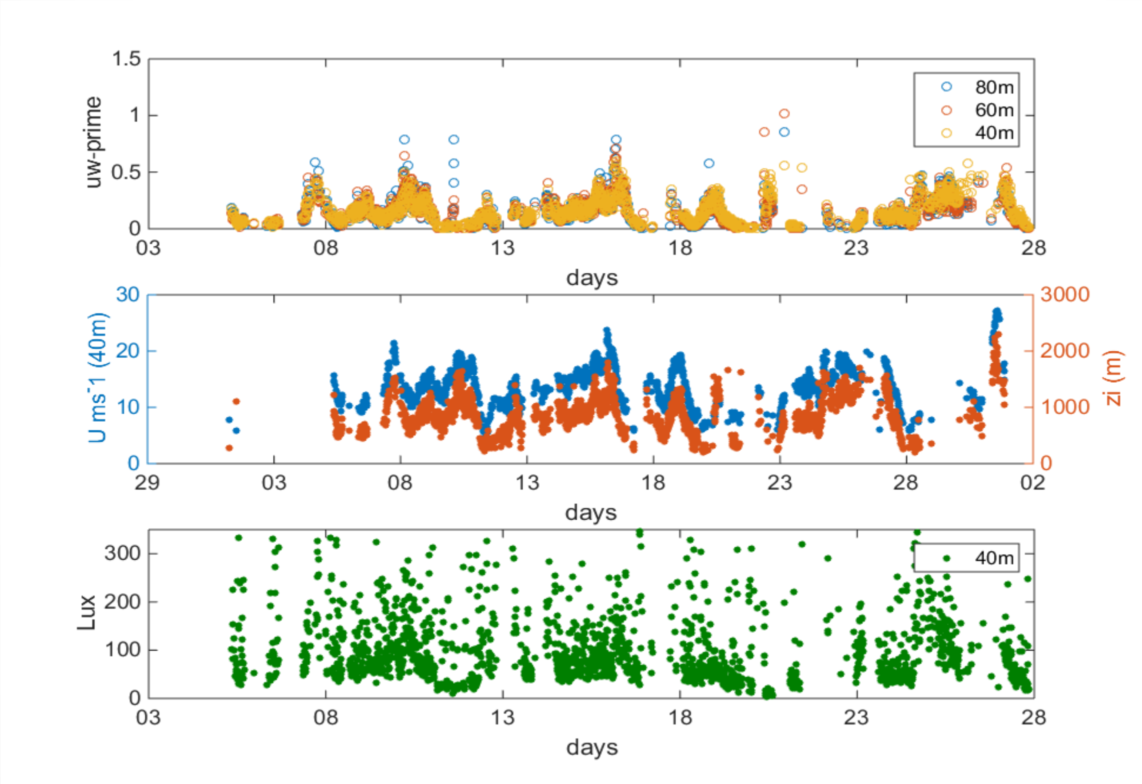
10 min averages



University of Stavanger

NTNU

10 min averages



University of Stavanger

NTNU

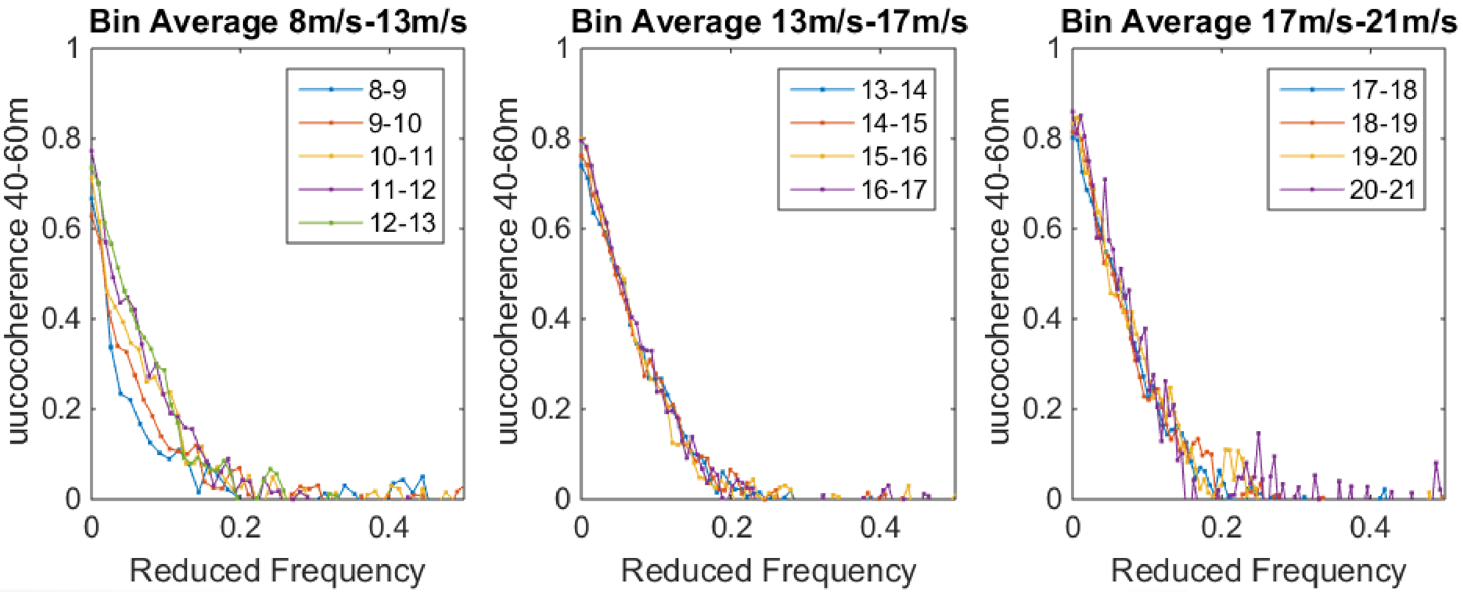
Overview

- Motivation
- Methods
- Results
- Conclusion

University of Stavanger

NTNU

uu cocoherence 20 m seperation

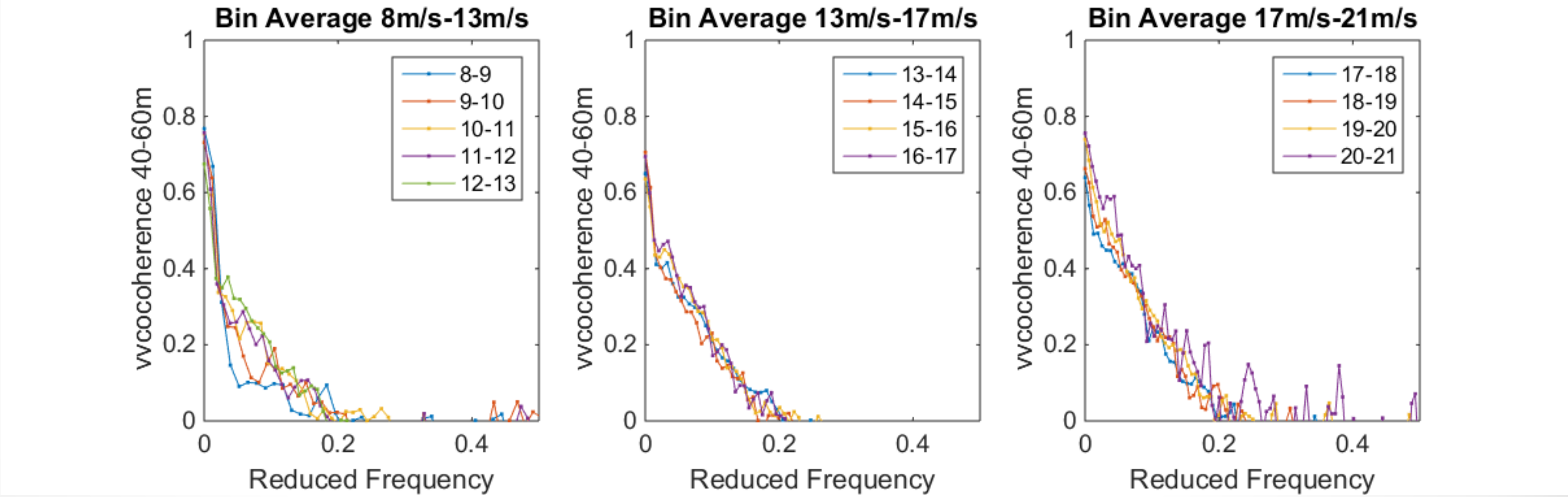


$f \cdot r / V_{hub}$

University of Stavanger

NTNU

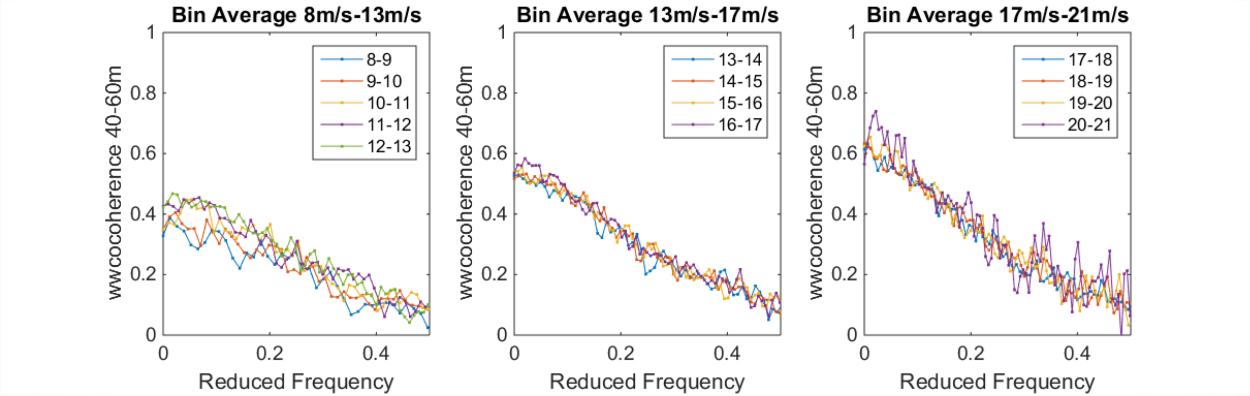
vv cocoherence 20 m seperation



University of Stavanger

NTNU

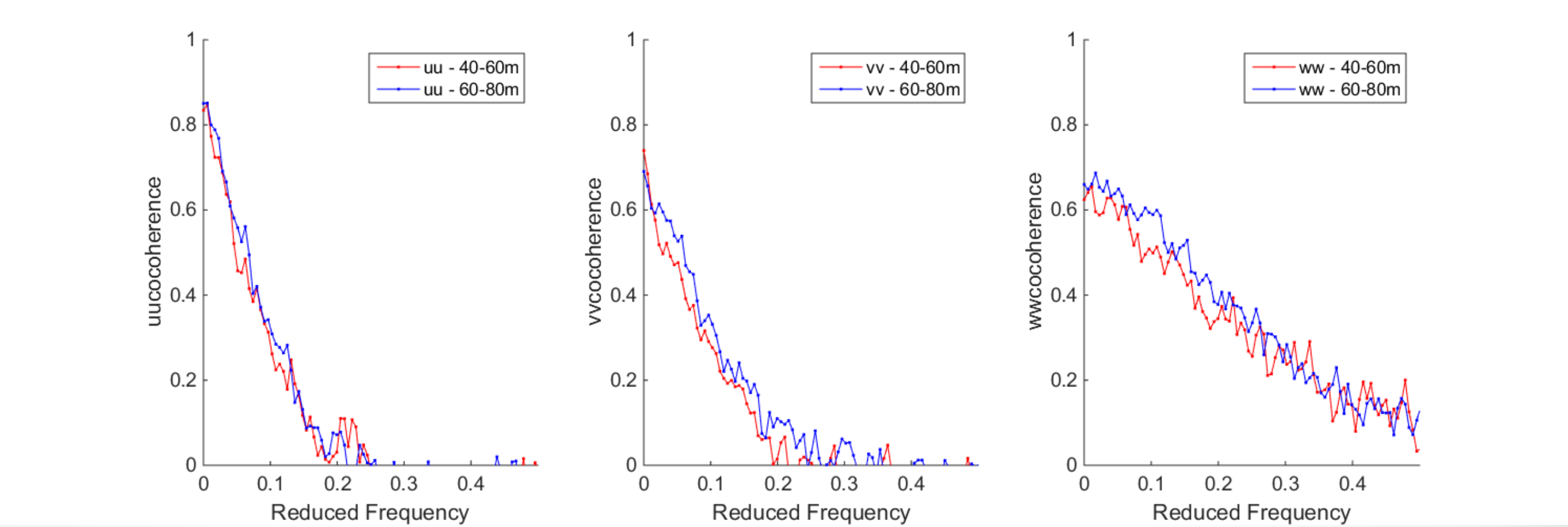
ww cocoherence 20 m seperation



University of Stavanger

NTNU

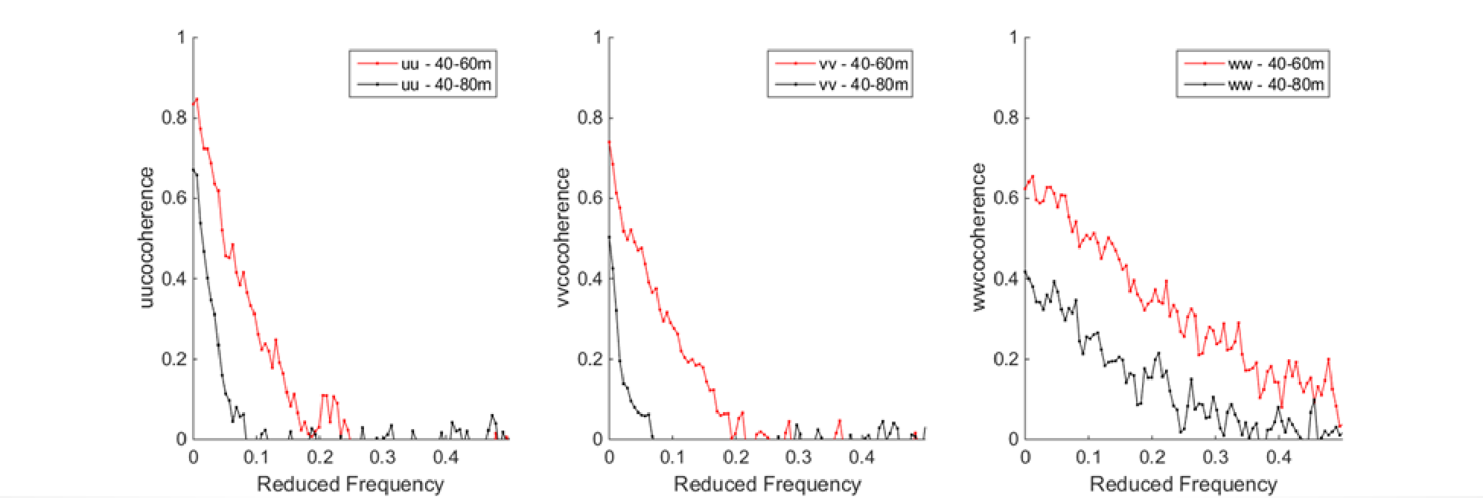
40-60m and 60-80m (20 m separation)



University of Stavanger

NTNU

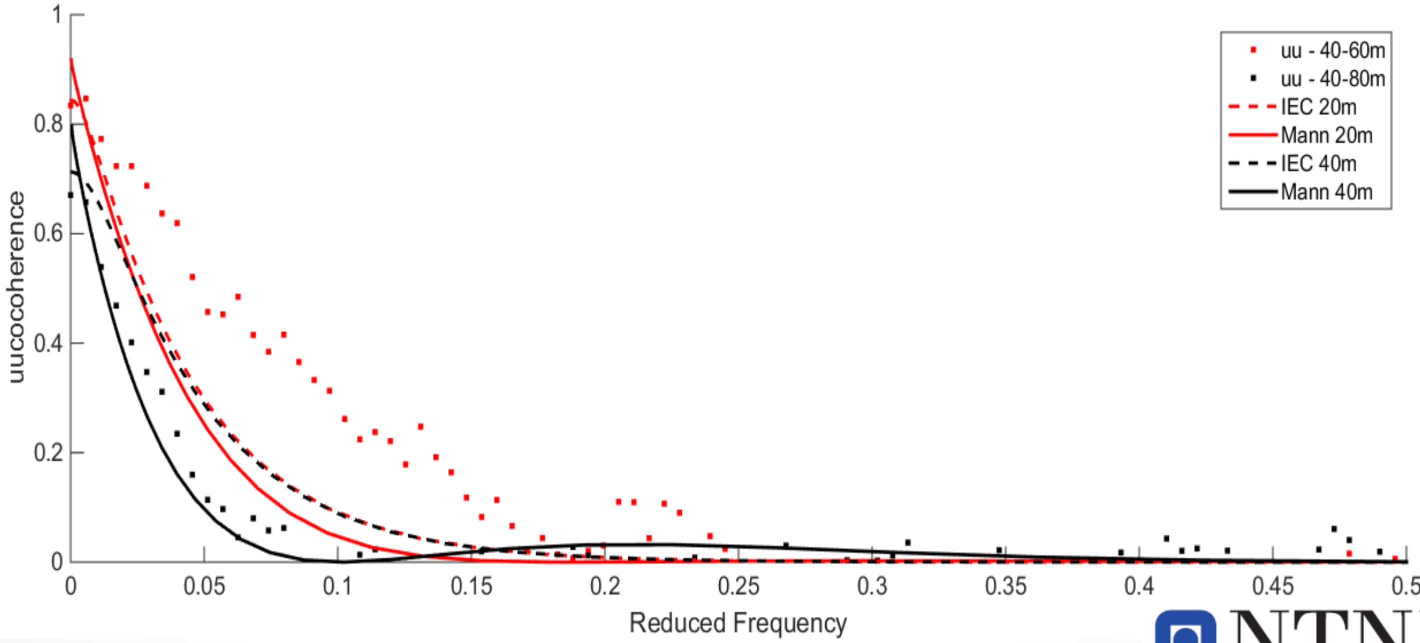
Compare 40m and 20 m separation



University of Stavanger

NTNU

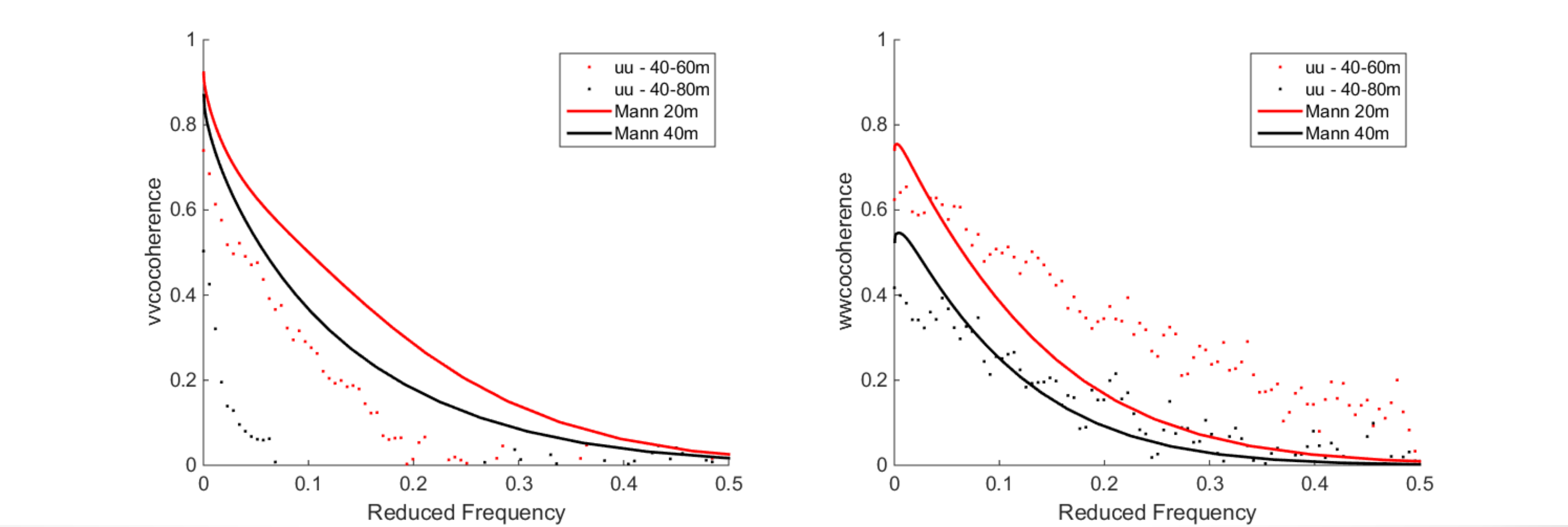
Compare to the coherence in IEC 61400-1



NTNU

University of Stavanger

Compare to the coherence in IEC 61400-1



University of Stavanger

NTNU

Conclusion

- IEC coherence function is dependent on the reduced frequency ($^{f \cdot r}/_{V_{hub}}$) and less on the separation.
- Mann model show a good agreement with measured values at 40 m separation for the uu and ww cocoherence, and tends to show a lower value at 20 m separation for these cocoherences.
- Further work:
  - Consider stability as a variable
  - Fit the manns model to the measurements
  - Investigate the wind from a whole year

University of Stavanger

NTNU