Analysis of turbulence models fitted to site, and their impact on the response of a bottom fixed wind turbine

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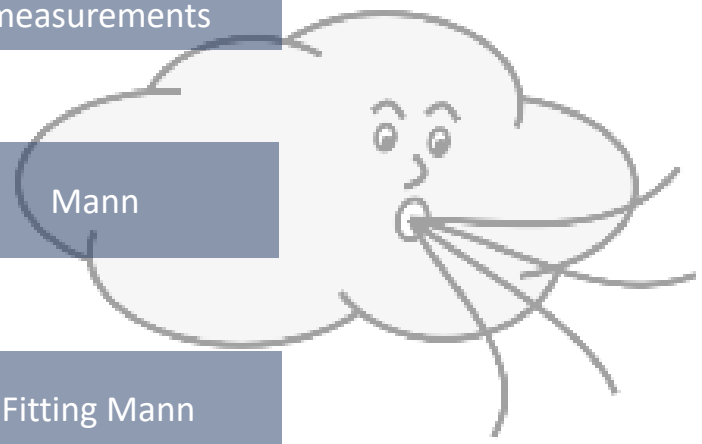
Motivation

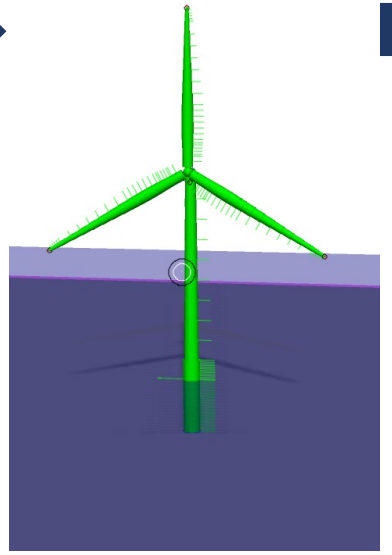
Incident wind

Model based on measurements

Mann

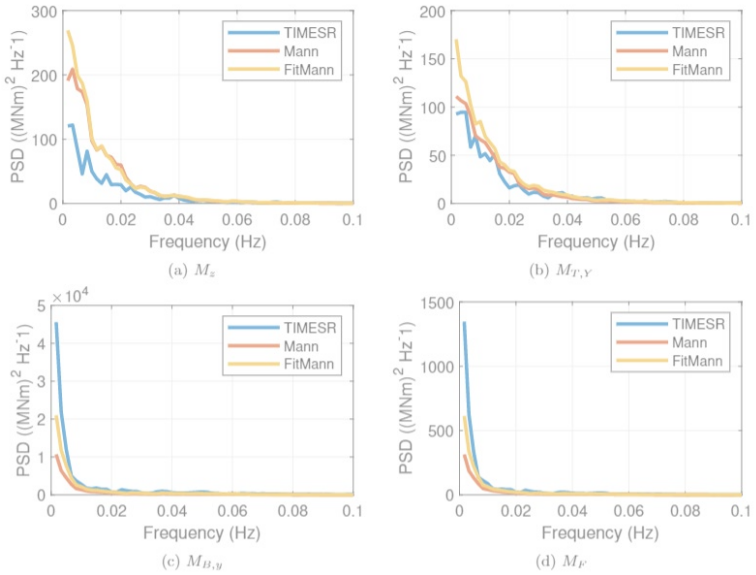
Fitting Mann





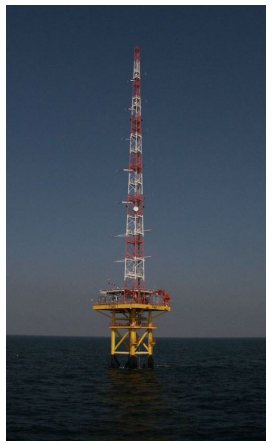
Design

Response



Overview of procedure

Incident wind



TIMESR

Mann

FitMann

Response

Turbulent structures
- Wind spectra
- Coherence

Overview of procedure

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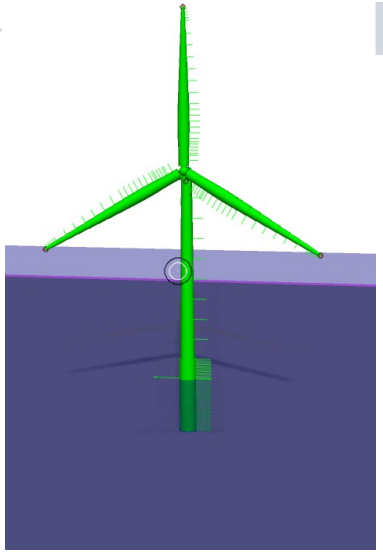


Response

- SIMA
- DTU 10 MW bottom fixed

Overview of procedure

Incident wind

TIMESR

Mann

FitMann

Response

Tower top yaw moment

Tower top bending moment fore-aft

Tower bottom bending moment fore-aft

Blade root flapwise bending moment

Turbulent structures
- Wind spectra
- Coherence

- SIMA
- DTU 10 MW bottom fixed

- Response spectra
- DEM
- Low-frequency region (<0.1 Hz)

Wind characteristics of the chosen situation

- 1 hour
- Neutral stratification
- U_{hub} = 12.4 m/s
- TI = 6 %
- α = 0.06
- 6 realizations

Wind field generation

Time series from FINO1

Coherence parameters from FINO1

Profile coefficients from FINO1

	Generator	Spectrum	Coherence	Profile
TIMESR	TurbSim Simulator	Wind spectra from measurements	Davenport	Logarithmic law
Mann	DTU Mann Generator	Mann	Mann	Power law
FitMann	DTU Mann Generator	Mann	Mann	Power law

TI from FINO1
Mann parameters from IEC standard

TI from FINO1
Mann parameters fitted to measurements from FINO1

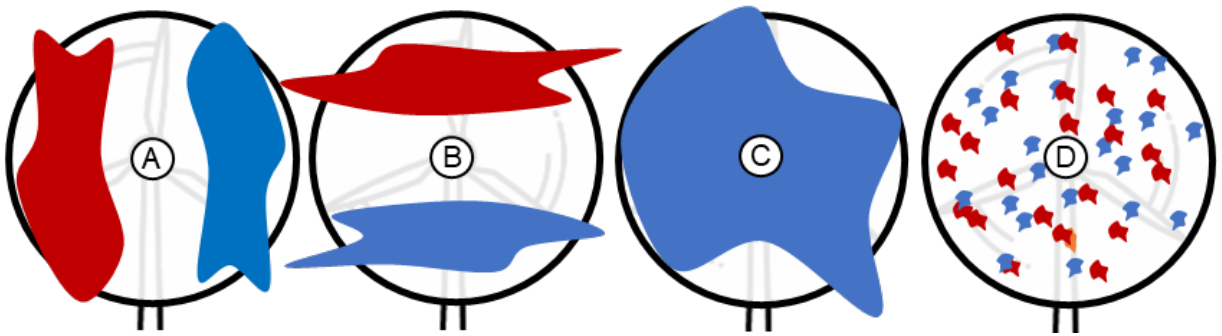
Impact on response

Wind spectrum:

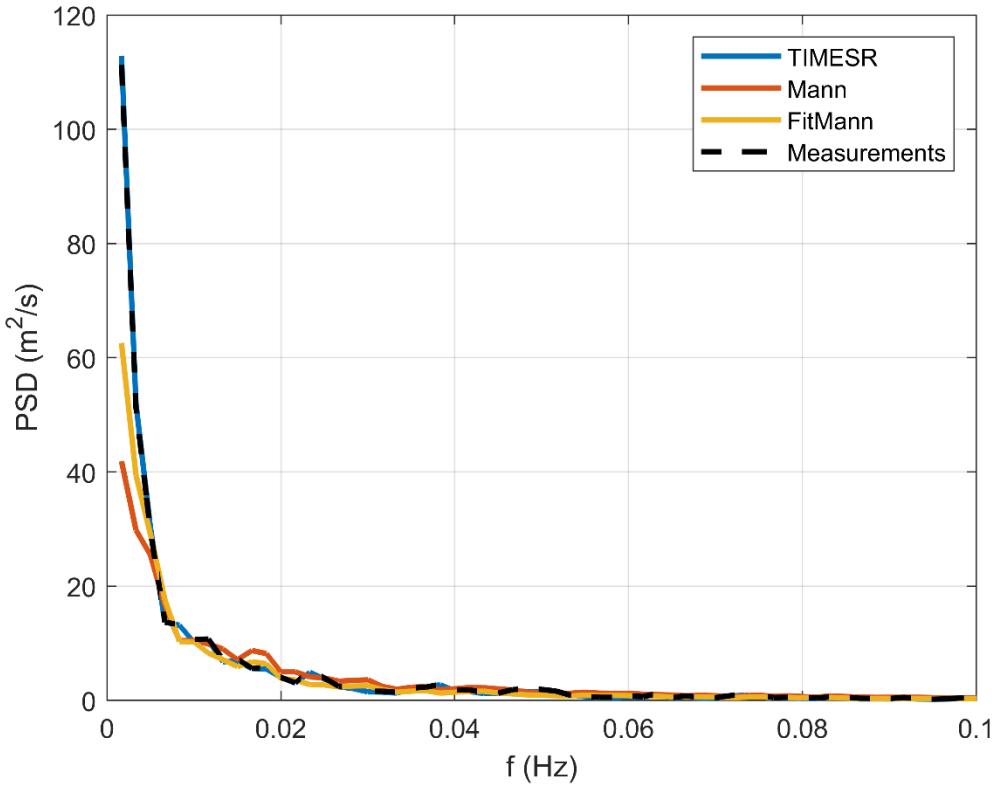
- Response in the low-frequency range is mainly quasi-static
- The shape of the wind spectrum is reflected in the response spectrum of the blade root and tower bottom

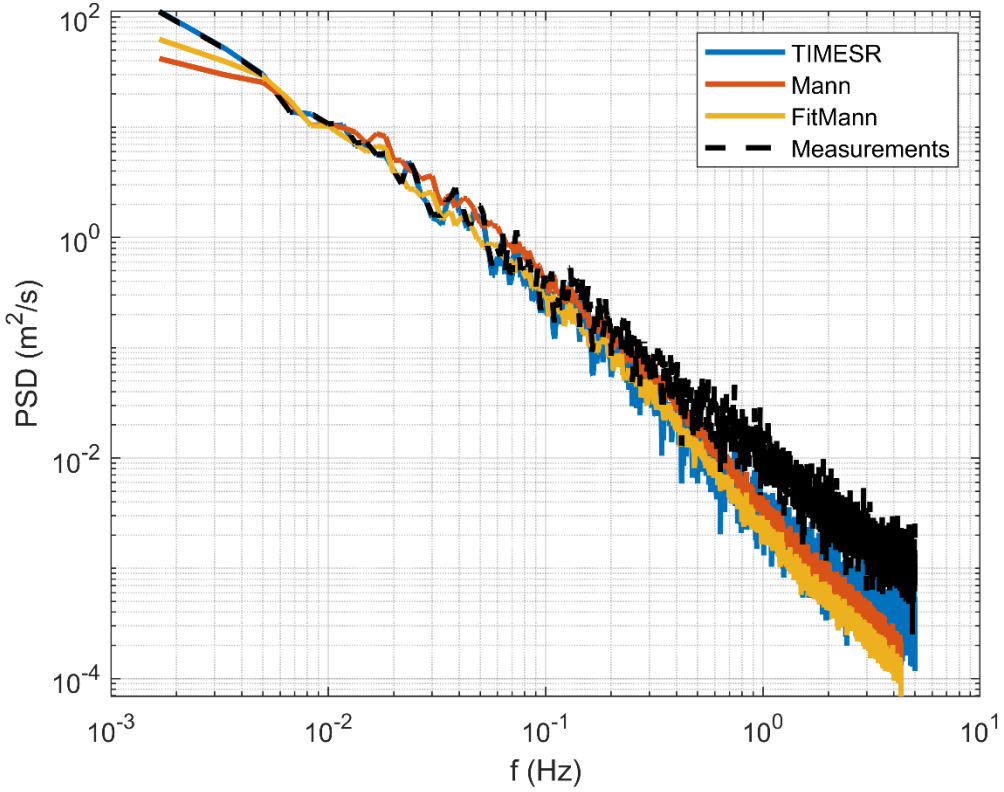
Coherence:

- High coherence: Uniform load over the rotor/blade causing large tower bottom fore-aft/blade root flapwise bending moments (C)
- Low coherence: Loads over rotor area partly cancels causing low tower bottom bending, but may cause large yaw and tower top bending (A, B, D)

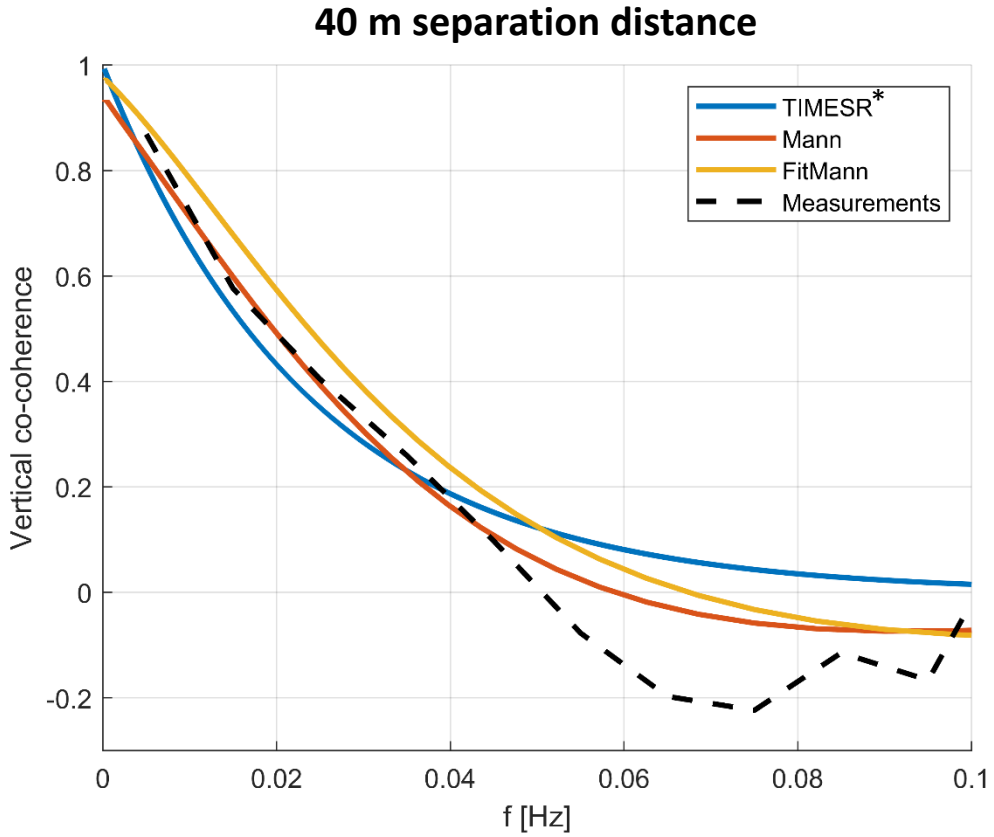


Wind spectra



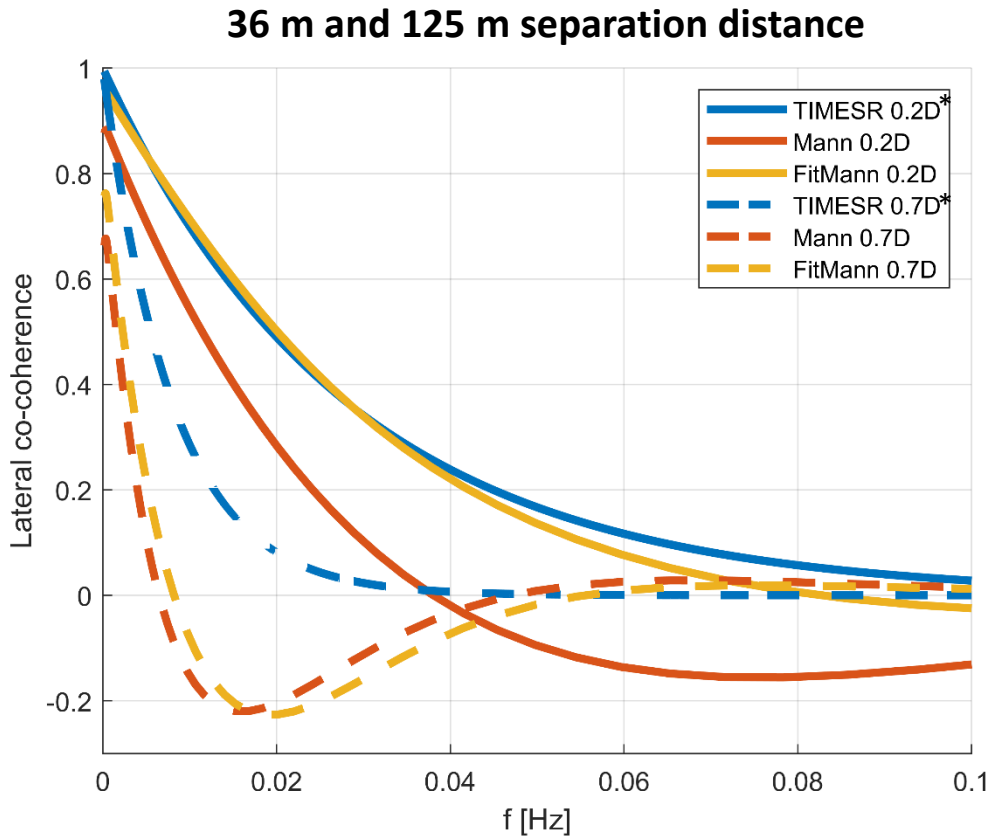


Similar vertical coherence



*Davenport coherence model

Low lateral coherence of (Fit)Mann



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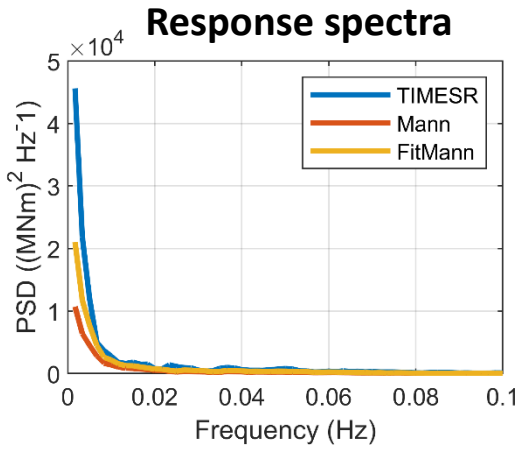
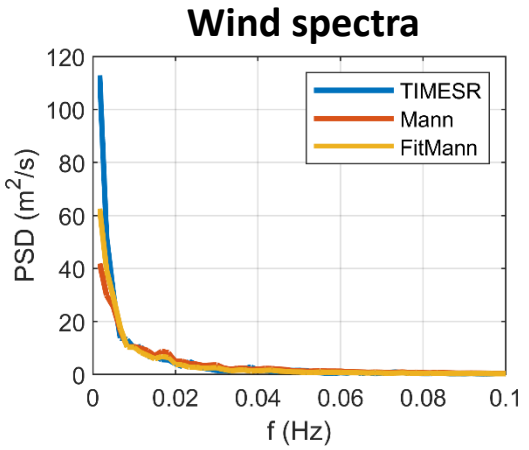
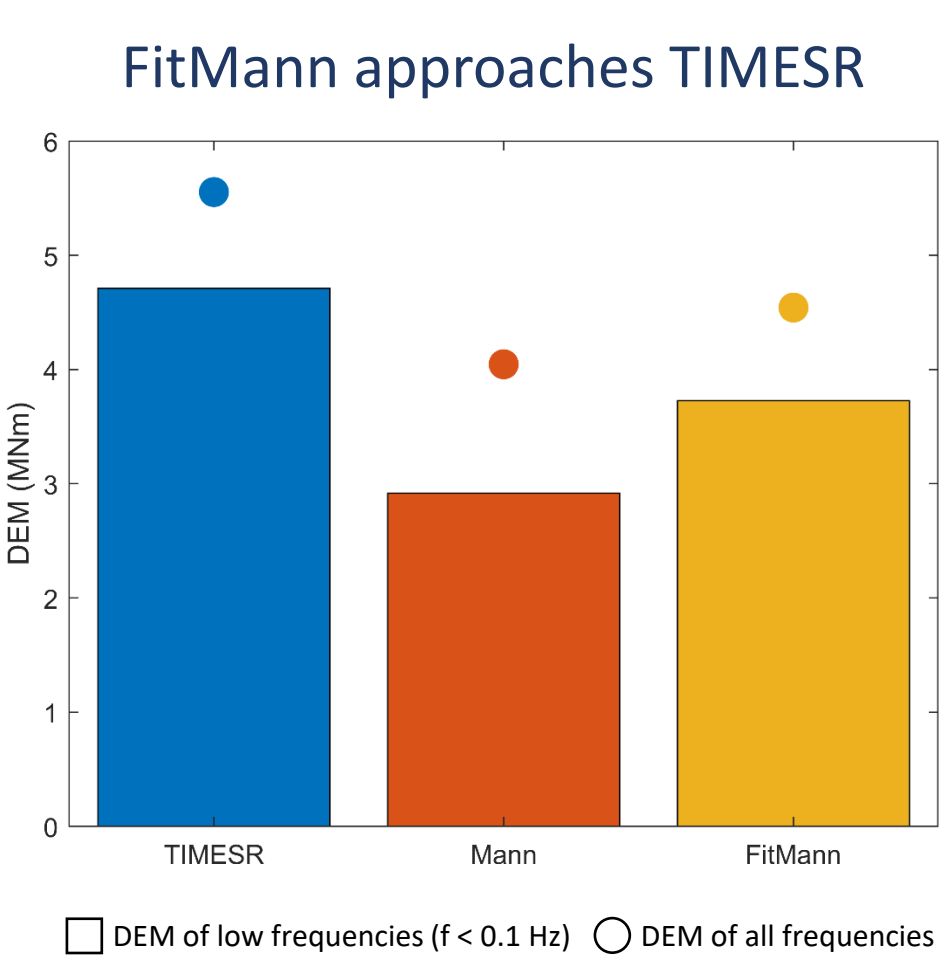
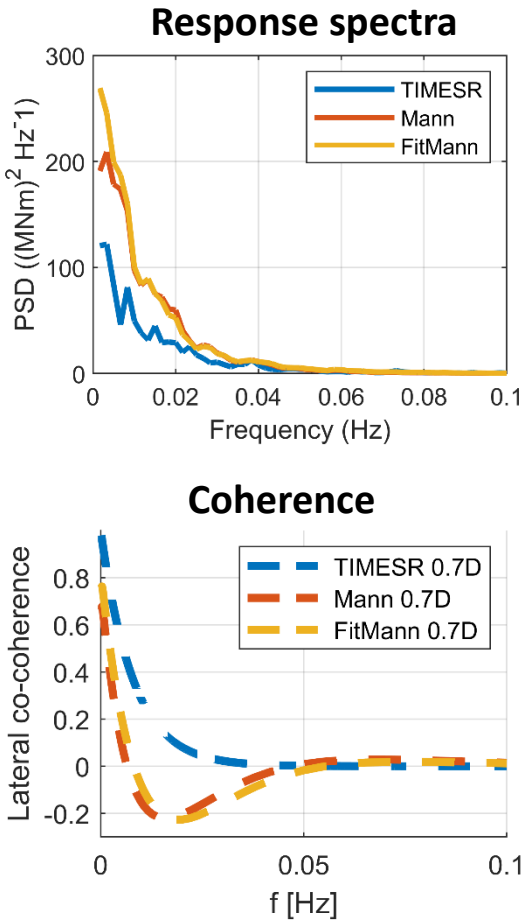
Tower bottom bending moment fore-aft



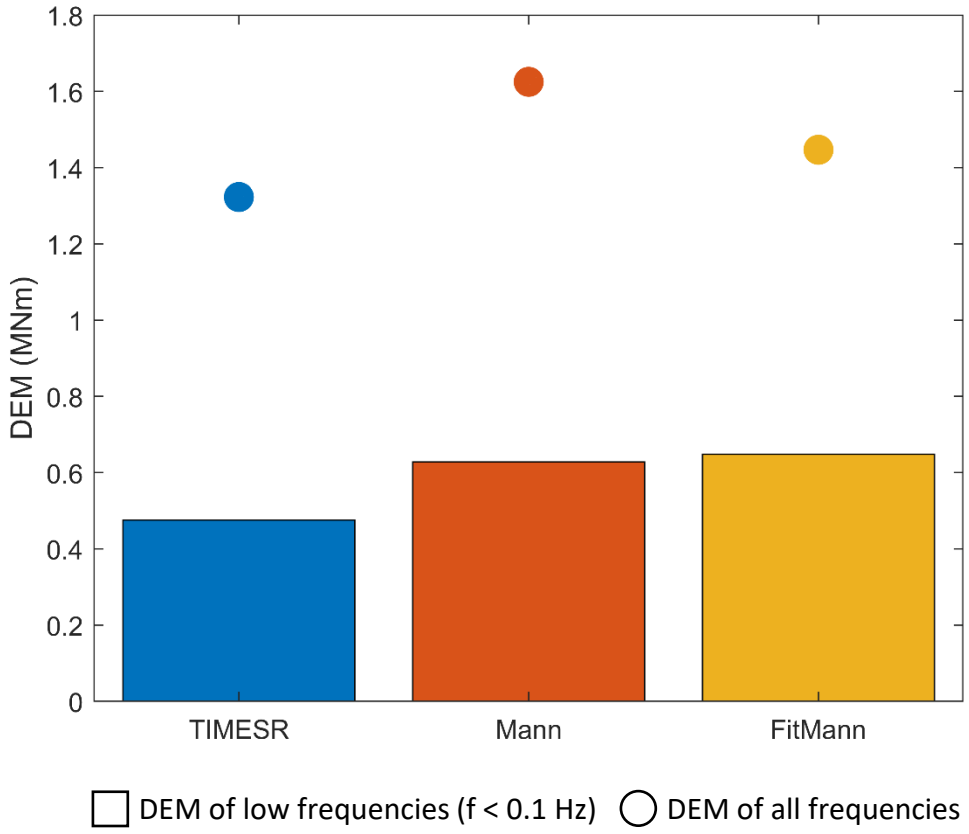




Tower top yaw moment



(Fit)Mann higher response than TIMESR



Blade root bending moment

The relative differences in response across methods are similar to tower bottom

- As both moments are heavily influenced by the shape of the wind spectra

Tower top fore-aft bending moment

The relative differences in response across methods are similar to yaw

- As both responses are influenced both by the wind spectra and the coherence

Conclusions and further work

The FitMann wind spectrum approaches the measured spectrum at low frequencies

⇨ FitMann gives more realistic tower bottom fore-aft and blade root flapwise bending moments than Mann

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Significant differences in response across methods observed

⇨ FitMann may improve results further when fitted to other stability conditions

Thank you

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