

Validation of the dynamic wake meander model with focus on tower loads

Paper

Larsen, Torben J.; Larsen, Gunner Chr.; Pedersen, Mads Mølgaard; Enevoldsen, Karen; Madsen, Henrik

Publication date:
2017

Document Version
Peer reviewed version

[Link back to DTU Orbit](#)

Citation (APA):

Larsen, T. J., Larsen, G. C., Pedersen, M. M., Enevoldsen, K., & Madsen, H. A. (2017). Validation of the dynamic wake meander model with focus on tower loads: Paper 854 [Sound/Visual production (digital)]. Wake Conference 2017, Visby, Sweden, 30/05/2017

DTU Library

Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

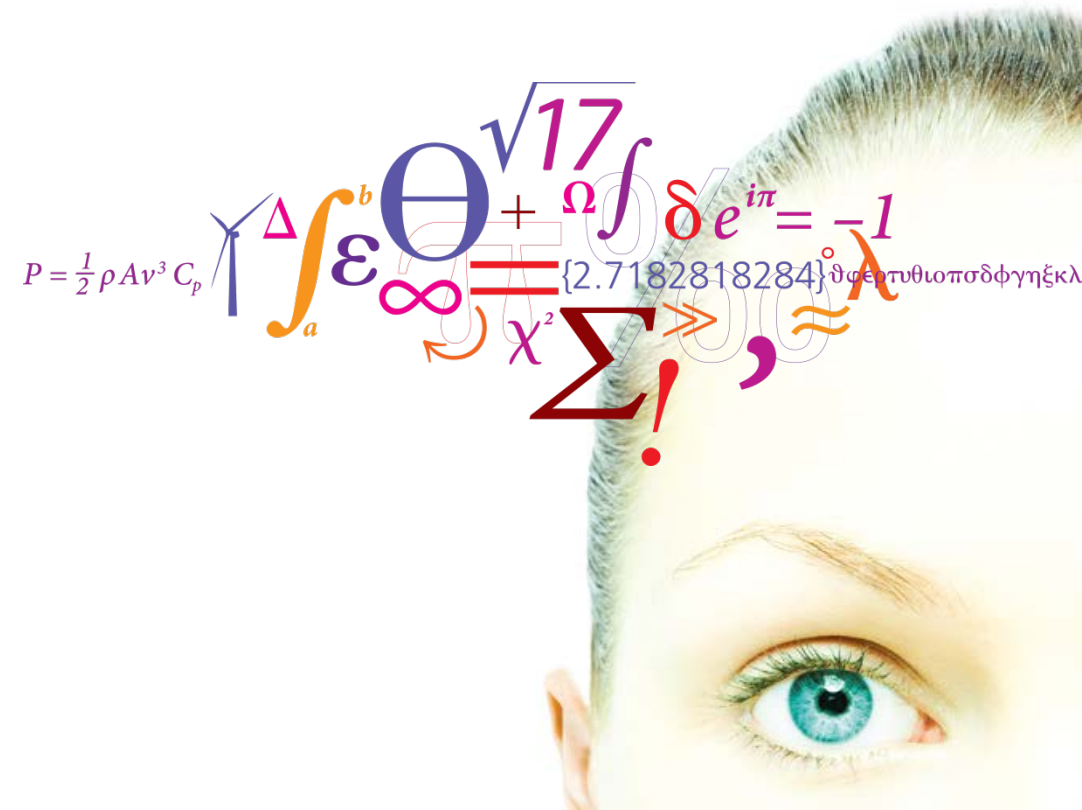
Validation of the Dynamic Wake Meander model with focus on tower loads

Torben J. Larsen, Gunner C. Larsen, M.M. Pedersen,
K. Enevoldsen, H.A. Madsen

2017 Wake Conference, Visby, Sweden,
30 May–1 June 2017.

Acknowledgements:
Vattenfall for the measurements
Funded by Danish PSO under the ForskEl program

DTU Wind Energy
Department of Wind Energy

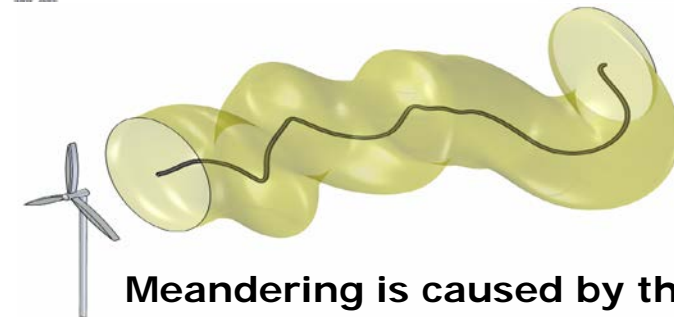
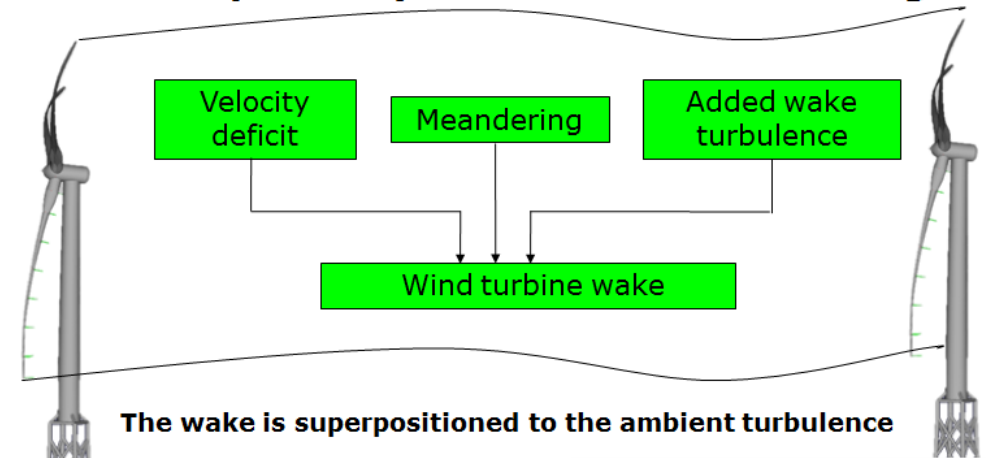


Background / Motivation

In the original EU Topfarm project (2002-06) a significant part of the DWM development occurred.

- The meandering motion is essential for the loading process. It takes some time downstream for the meandering build up magnitude of motion
- Therefore, one could expect especially tower loads to be less loaded for very small spacing distance.
- For very large spacing distance the deficit depth is very small and tower load must also be low again
- One could therefore imagine that tower loads in wind farms are highest for a certain distance

Principle of Dynamic Wake Meandering



Previous results Egmond aan Zee - 2012

RESEARCH ARTICLE

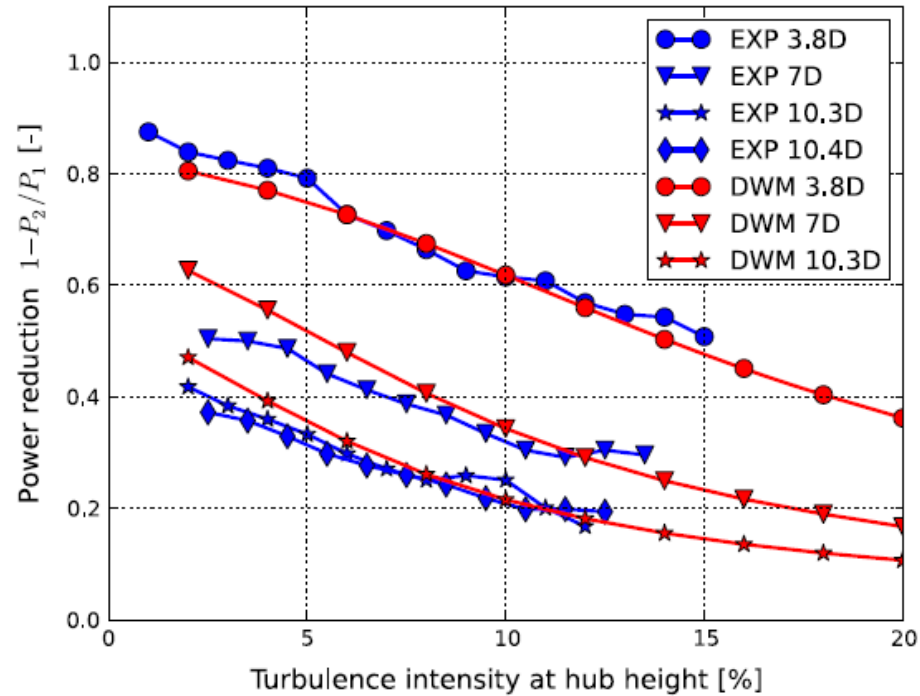
Validation of the dynamic wake meander model for loads and power production in the Egmond aan Zee wind farm

Torben J. Larsen, Helge Aa. Madsen, Gunner C. Larsen and Kurt S. Hansen

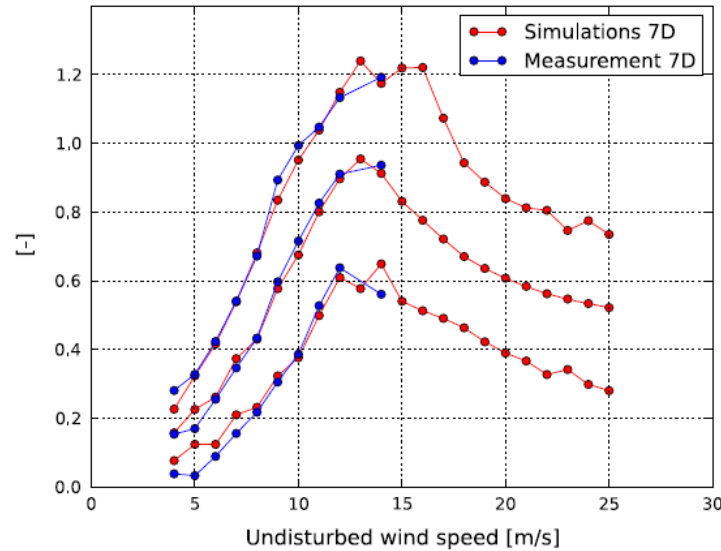
Technical University of Denmark, Wind Energy Division, Building 118, PO Box 49, 4000 Roskilde, Denmark



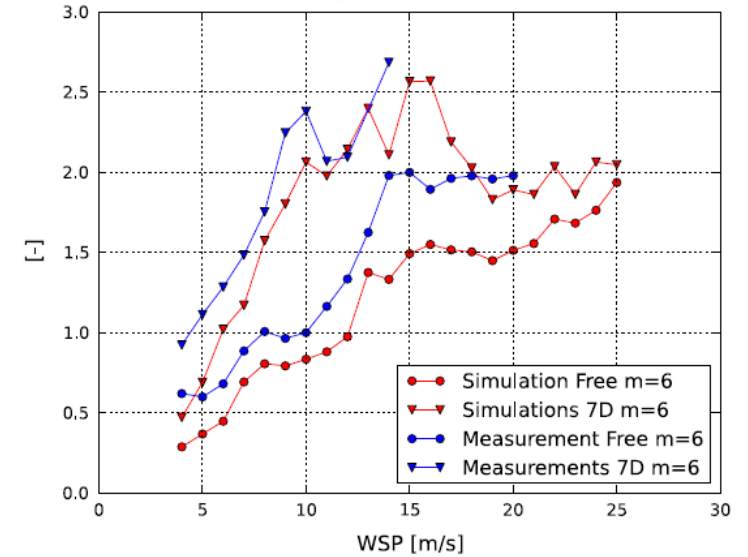
Power reduction $6 < V_{hub} < 12 \text{ m/s}$



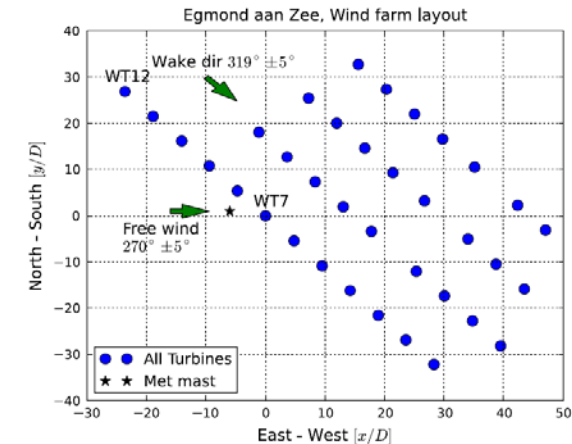
Tower tilt Max-Mean-Min



1Hz fatigue loads Tower tilt



- A good match in both power and load level is seen
- Perfect match on blade loads
- Yaw and tower loads are also good, though more difficult



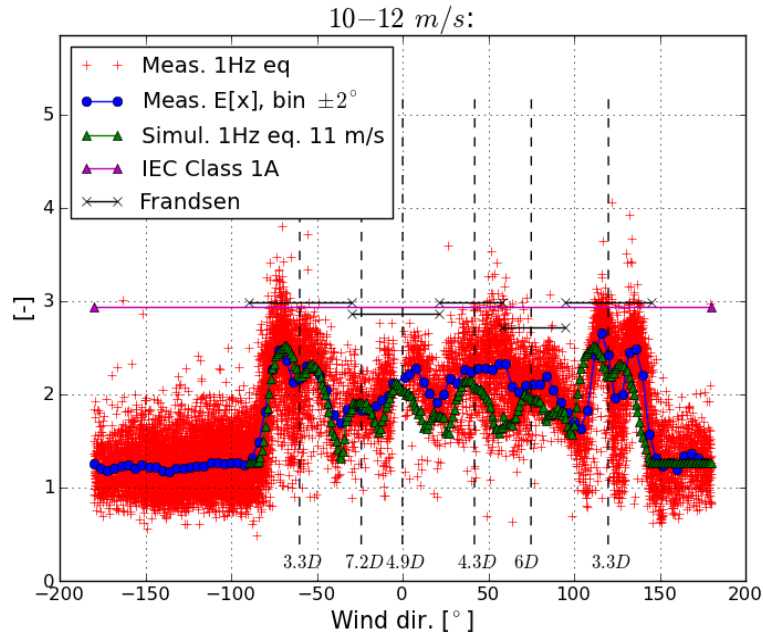
Previous results Lillgrund - 2015

17 - 20 November 2015 | Porte de Versailles Pavillon 1, Paris, France

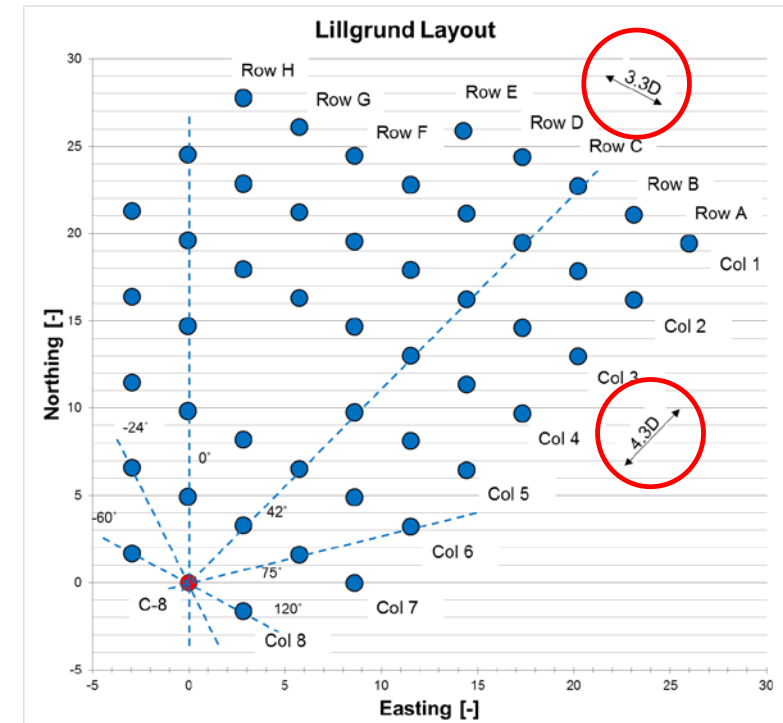
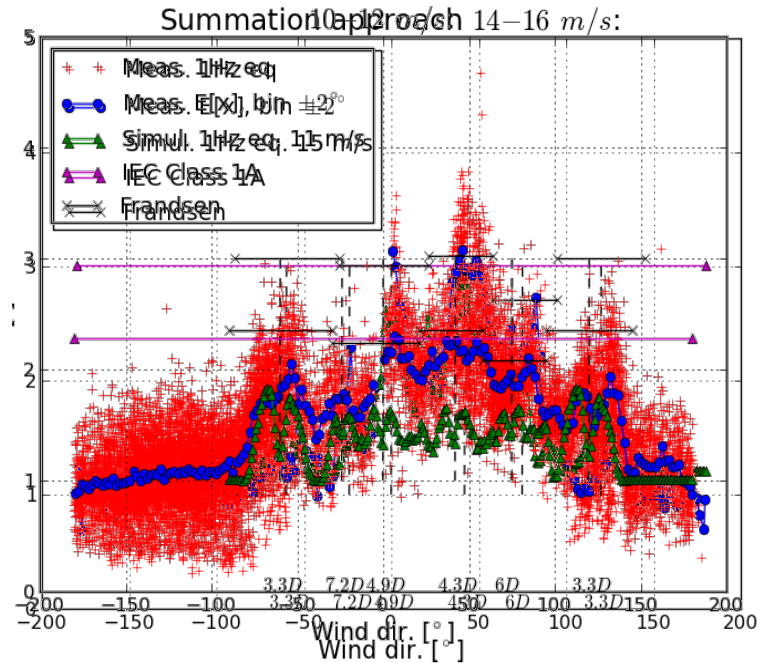
Wake effects above rated wind speed. An overlooked contributor to high loads in wind farms.

T.J. Larsen, G. Larsen, H.A. Madsen and S.M. Petersen

Lillgrund measurement blade root flap $m=10$



Lillgrund measurement tower bend $m=55$



~~10-12~~ 10-11 m/s

- Generally a very good to excellent agreement is seen
- Blade loads seem to be easier to match than tower loads
- A slight underprediction of tower loads is seen near rated WSP
- High wind speed situations are highly important

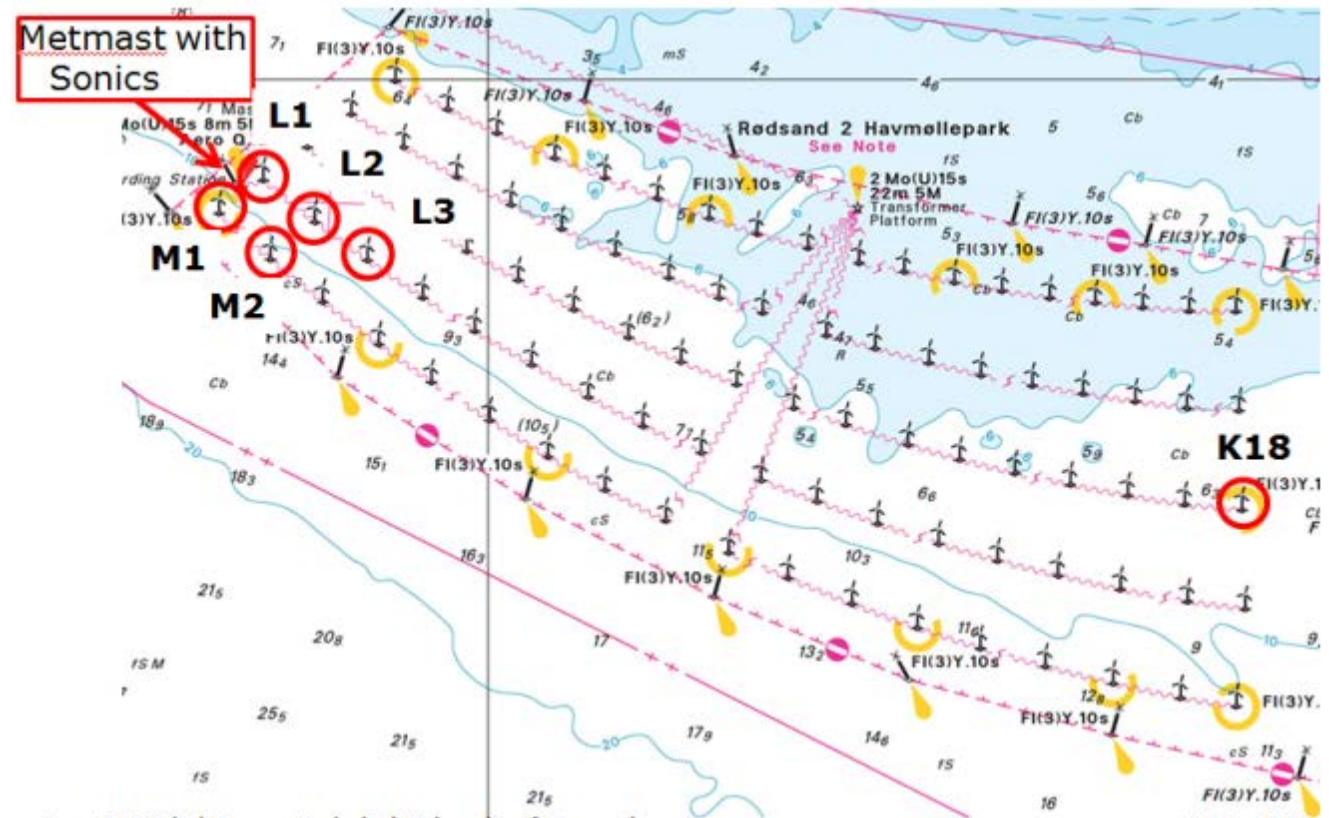
The Nysted II Wind farm

In 200? A new wind farm was being installed.

When the tower sections were at land, it was possible to install strain gauges in the towers. Tower top and bottom bending moments were measured.

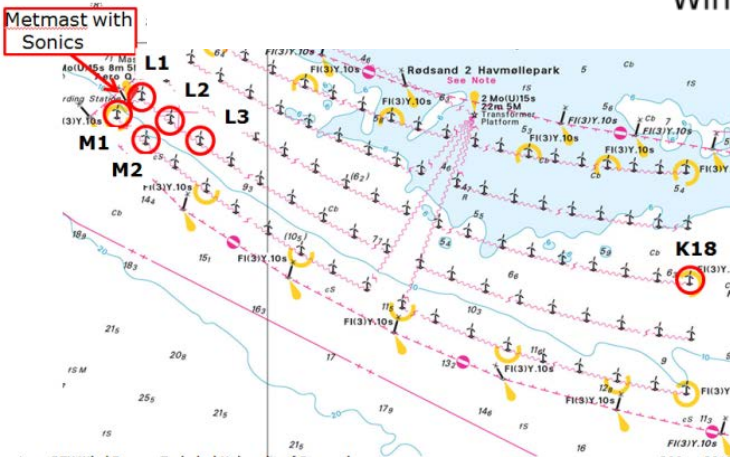
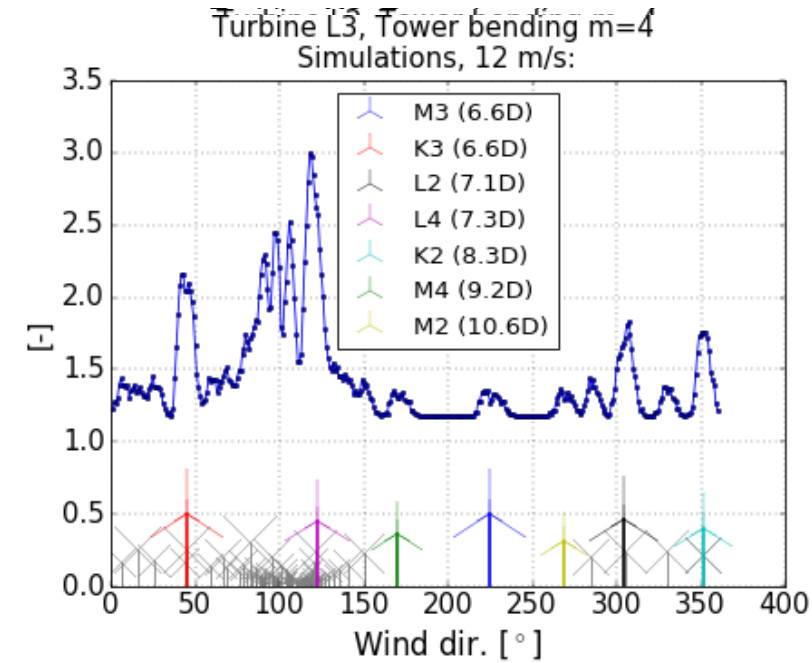
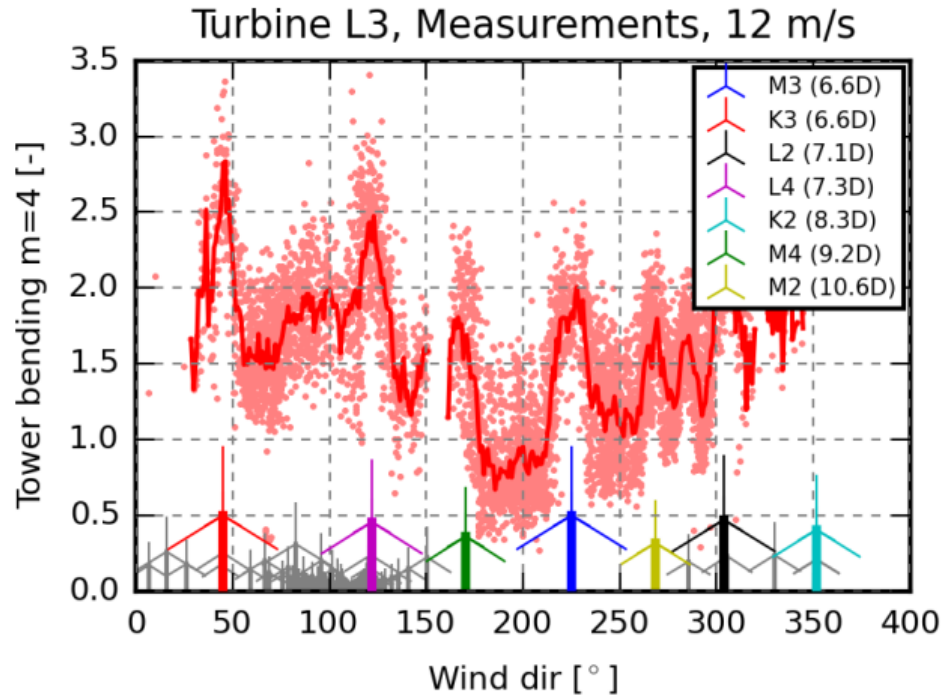
Furthermore access was granted to the SCADA data base of all turbines.

Wind conditions were estimated based on power and pitch angle of the outerly placed turbines.



Results: Tower bending

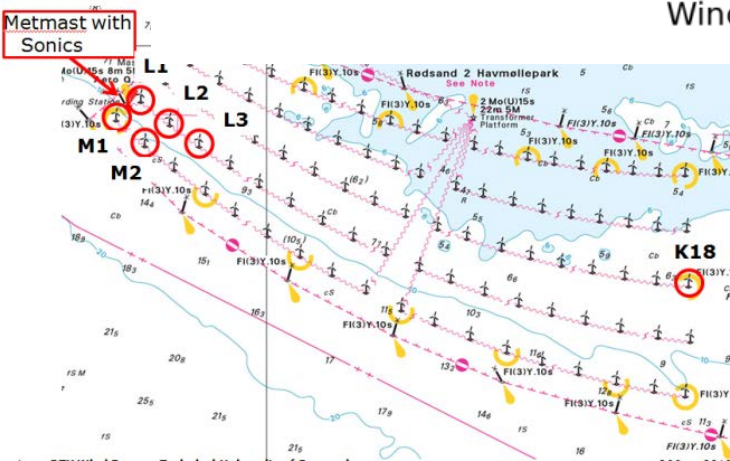
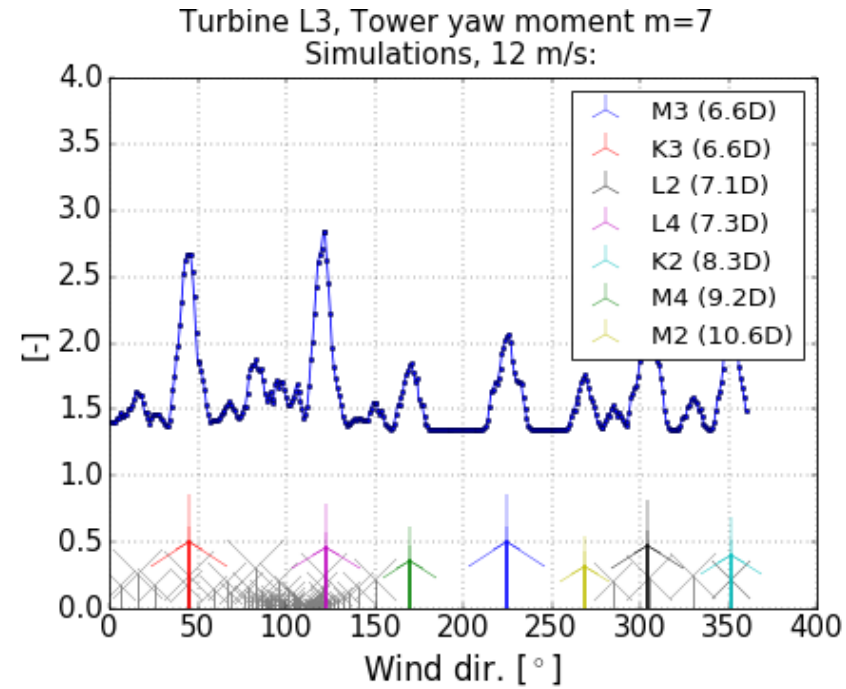
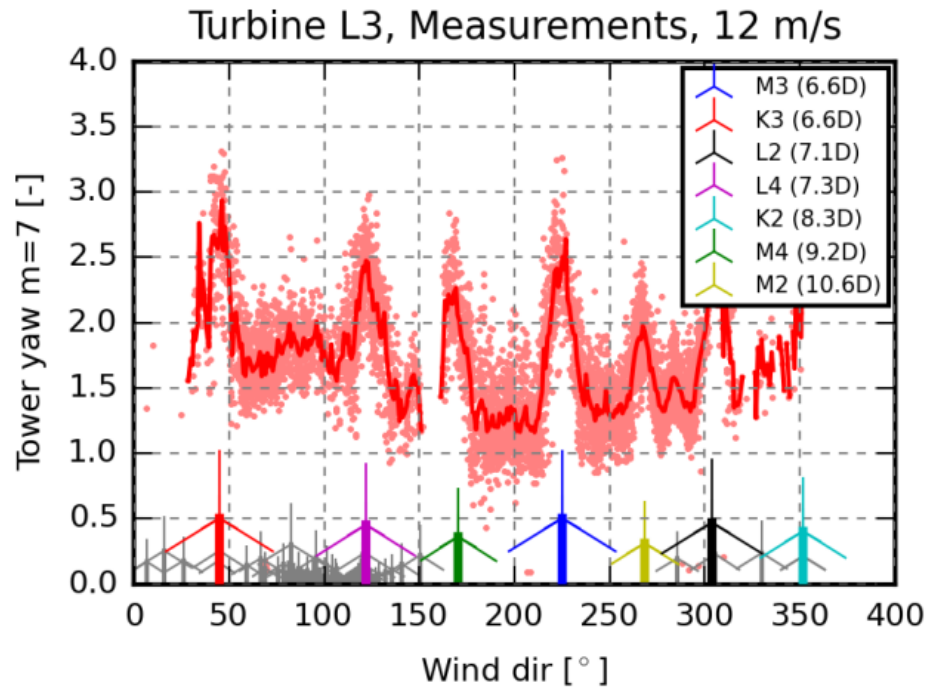
82m/s



- Fine match at 8m/s (except for a small average offset)
- At 12m/s:
 - Good agreement in the multiwake sectors
 - Not so good agreement in the single wake sectors

Results: Tower yaw

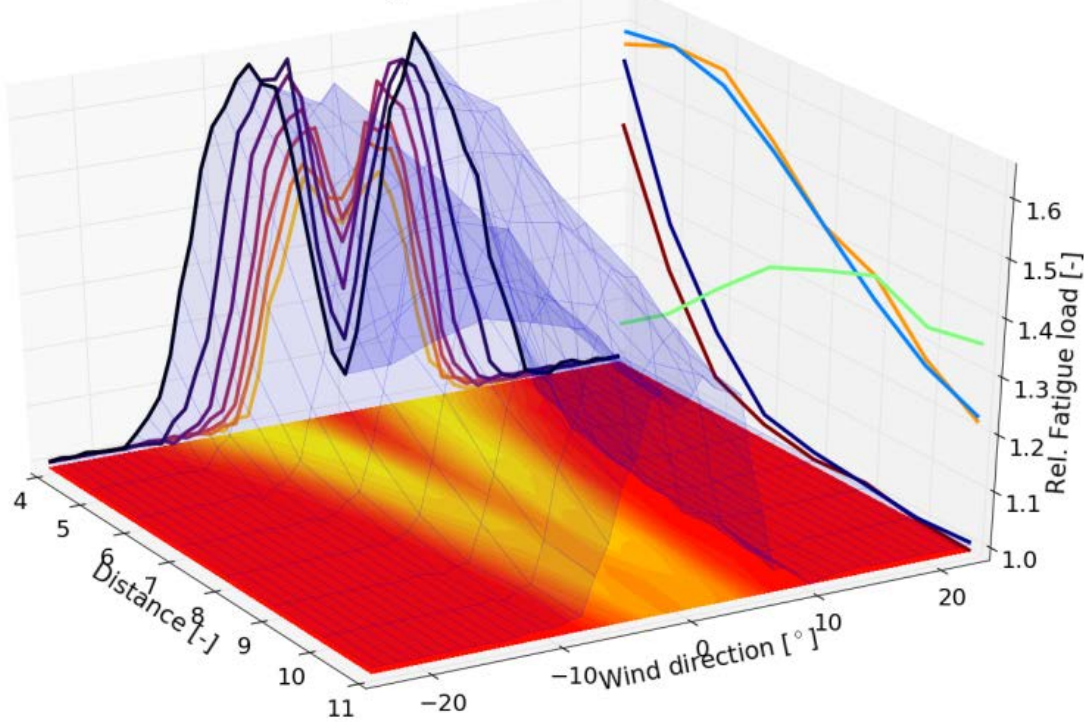
10 m/s



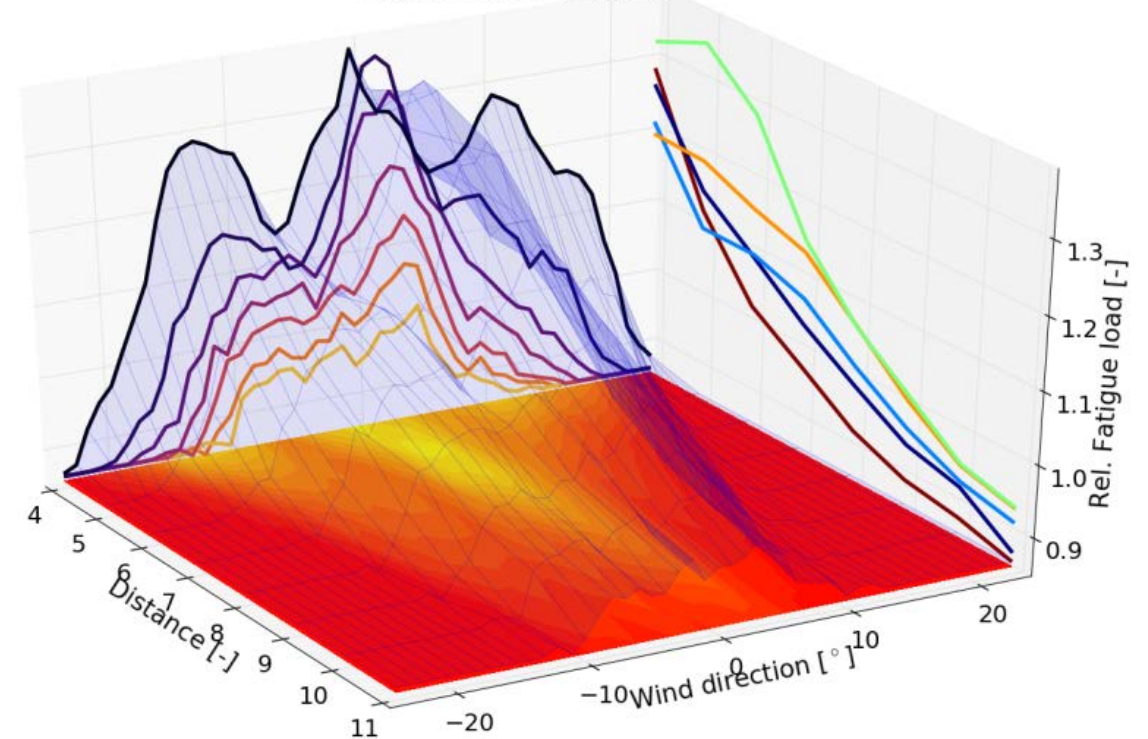
- Fine match at 8-10m/s (except for a small average offset)
- At 12m/s:
 - Good agreement in the multiwake sectors
 - Slight underprediction in the single wake sectors

Loads as function of distance - simulations

WSP10, Tower bottom bending, $m=4$
Singlewake situation

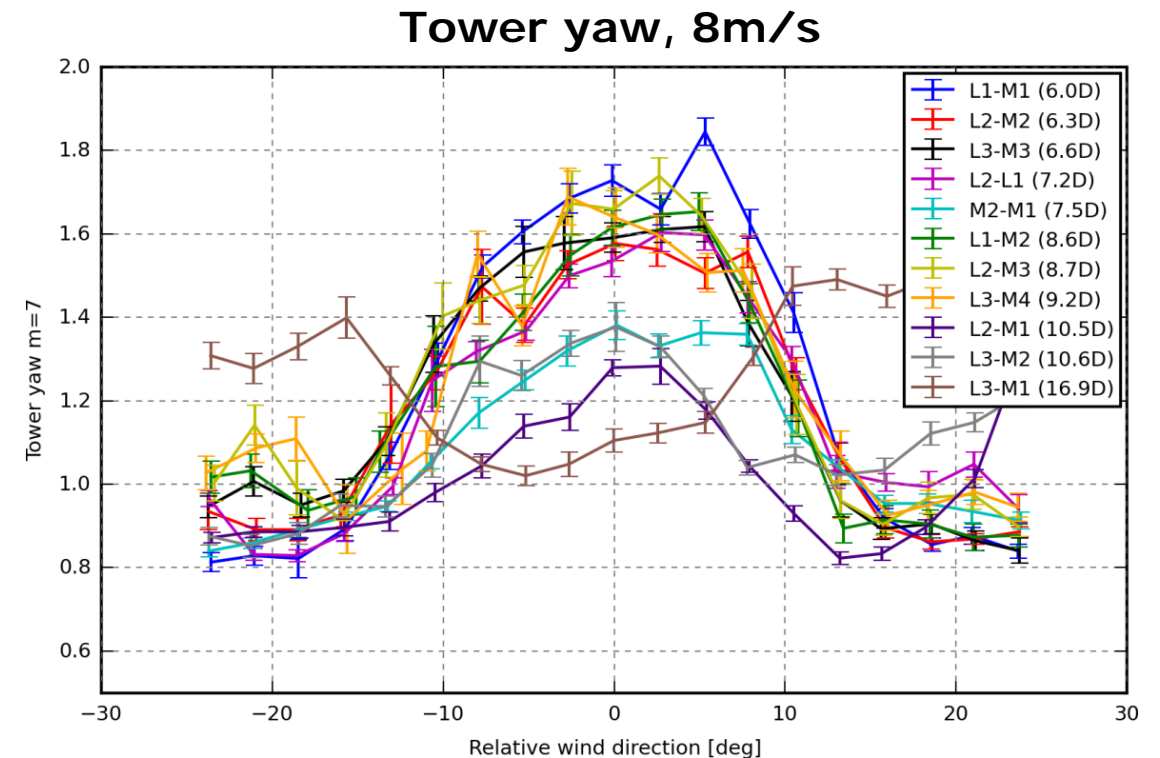
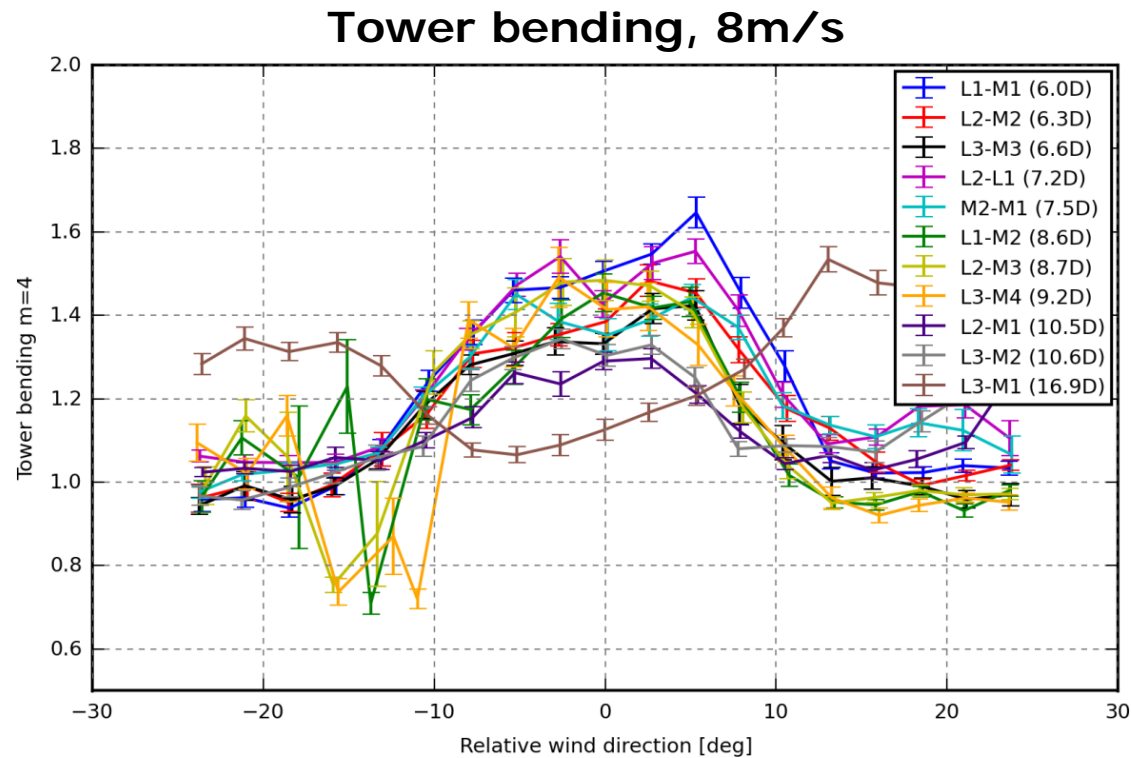


WSP8, Tower yaw, $m=7$
Singlewake situation



- In the center wake a local tower bending load maximum is seen at 7-8D spacing
- However, in general loads do decrease for increased spacing

Loads function of distance - measurements



- A flat load plateau is seen from 6-9D spacing (6-7D spacing for the yaw)
- For increased distances the loads do decrease

Conclusion

- A new set of fullscale measurements are presented and compared to DWM
- The load match supports previous findings from the Lillgrund study at low and high WSP
- However, there seem to something missing near rated WSP
 - Tower loads are predicted slightly too low near rated WSP
 - Could this be due to the highly nonlinear controller behaviour on the upstream turbine?
- Tower load levels (below rated) are at the same load level between 6 and 9D spacing
- Yaw load levels has similar trend but start to decrease above 7D spacing.

Thank you!