Technical University of Denmark

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

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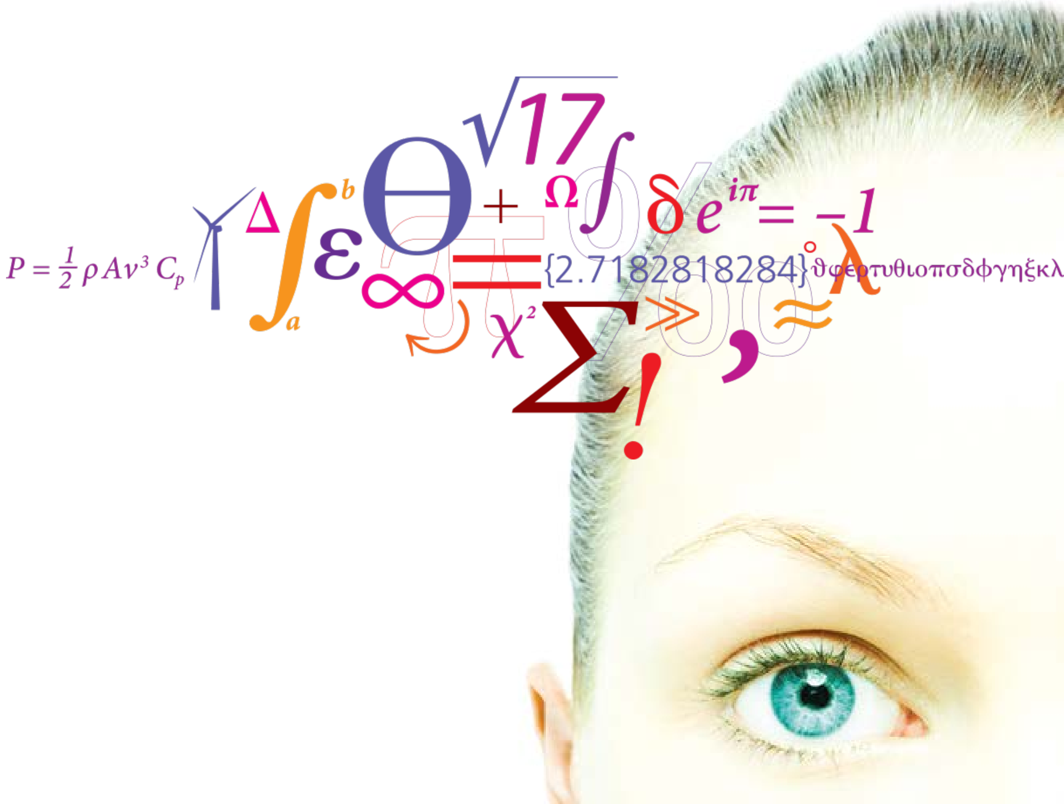
DTU Wind Energy
Department of Wind Energy

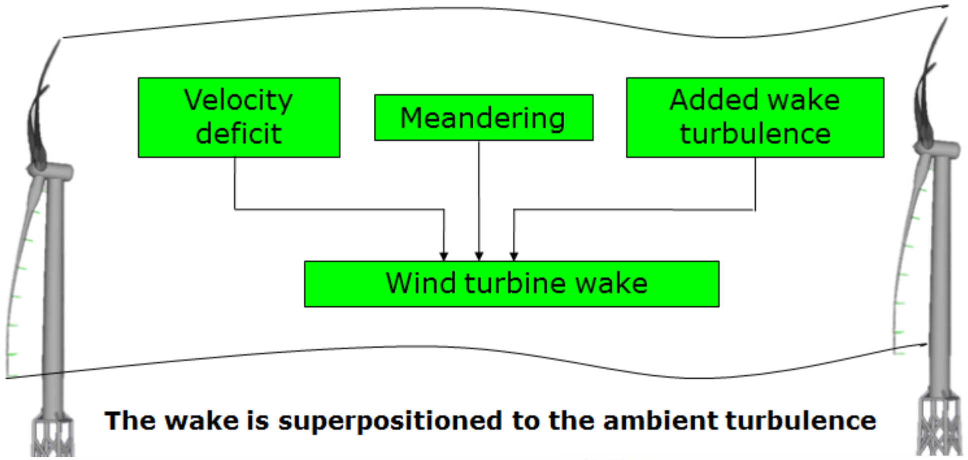


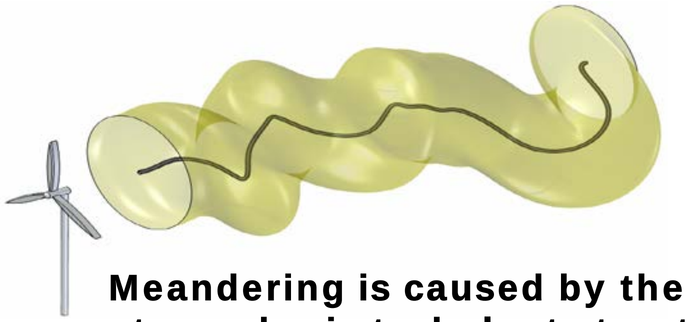
Background / Motivation

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





Meandering is caused by the large ambient atmospheric turbulent structures

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

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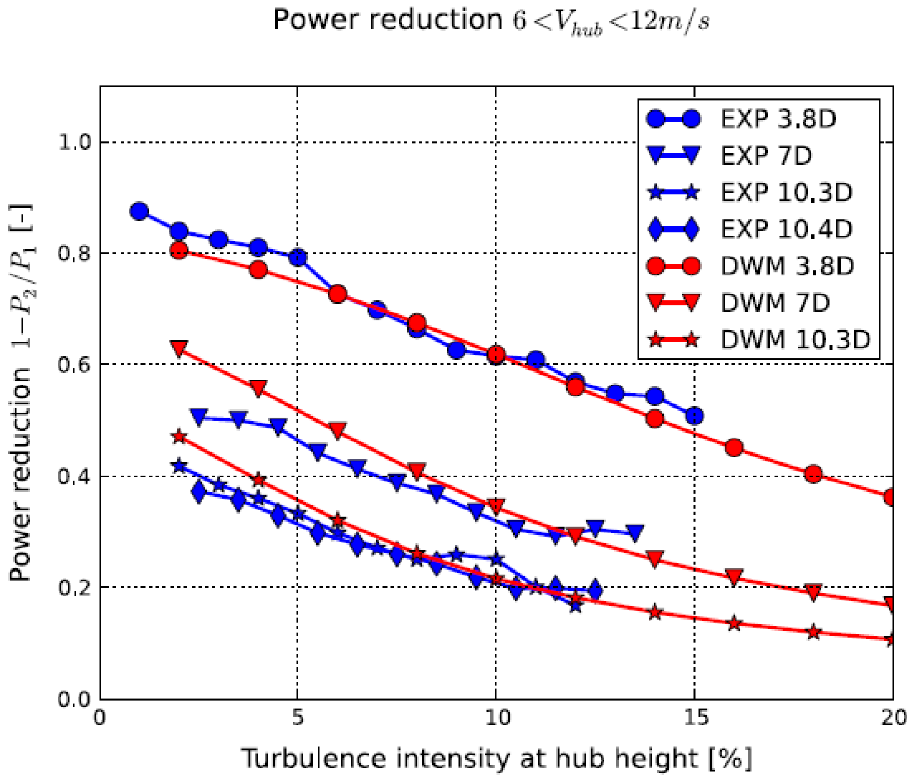
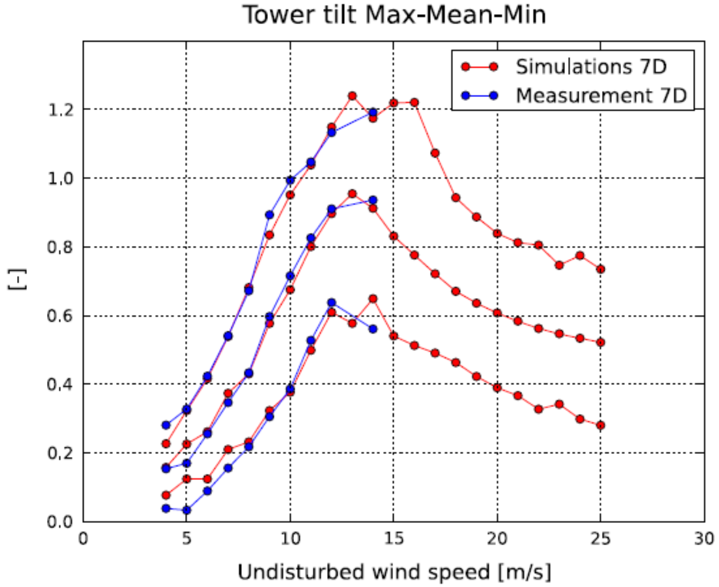
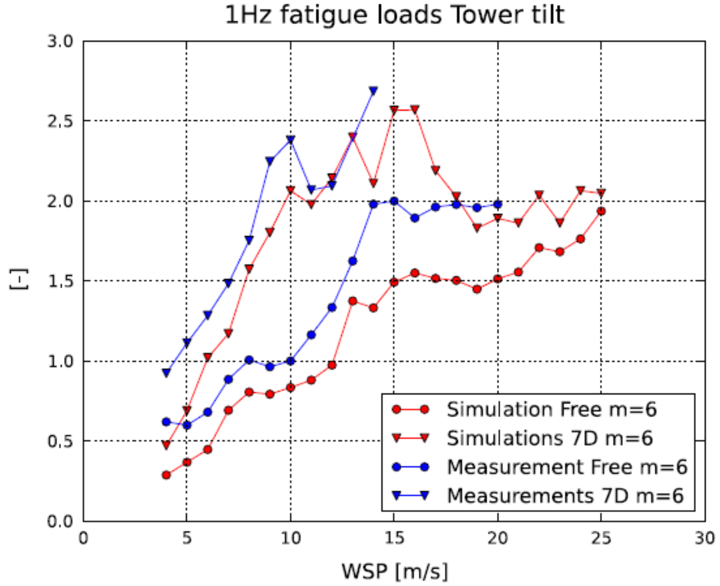
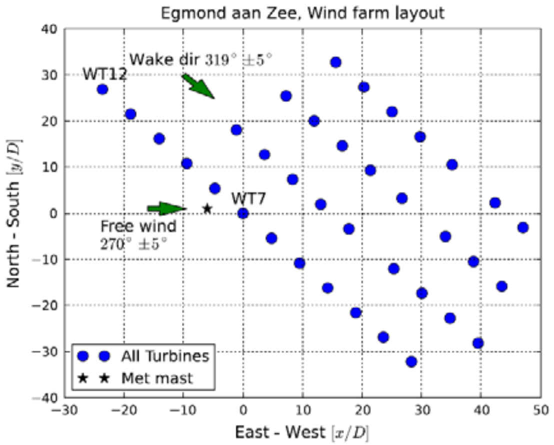
DTU









- **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**

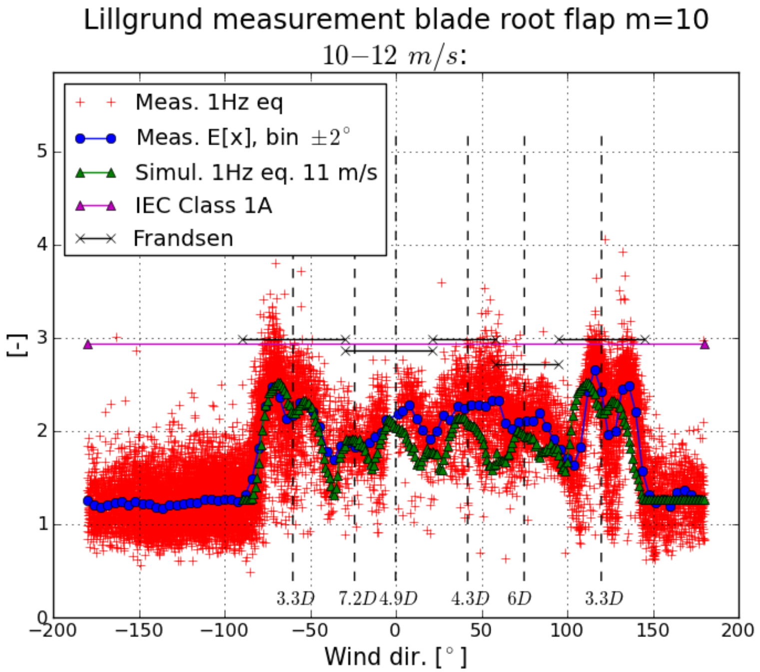
Previous results
Lillgrund - 2015

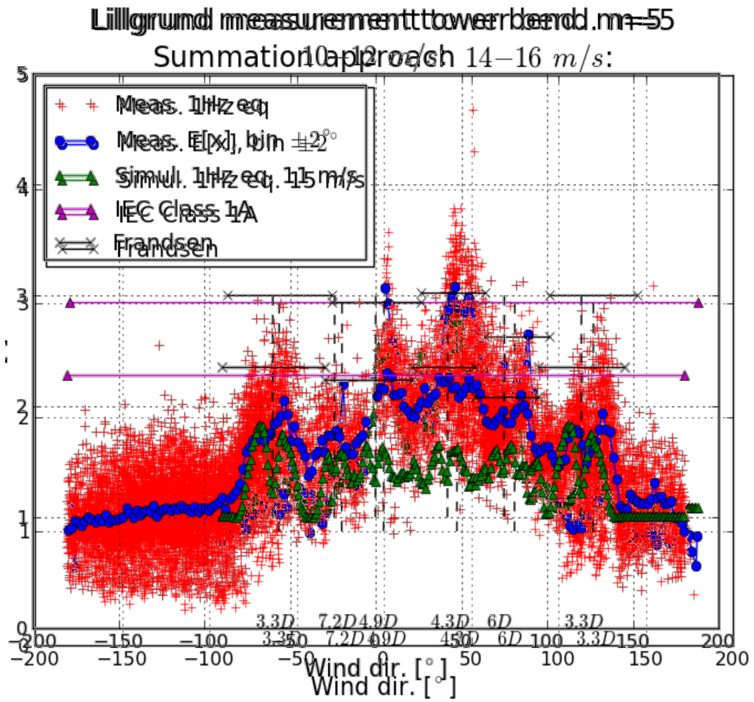
EWEA 2015 PARIS
EUROPE'S PREMIER WIND ENERGY EVENT

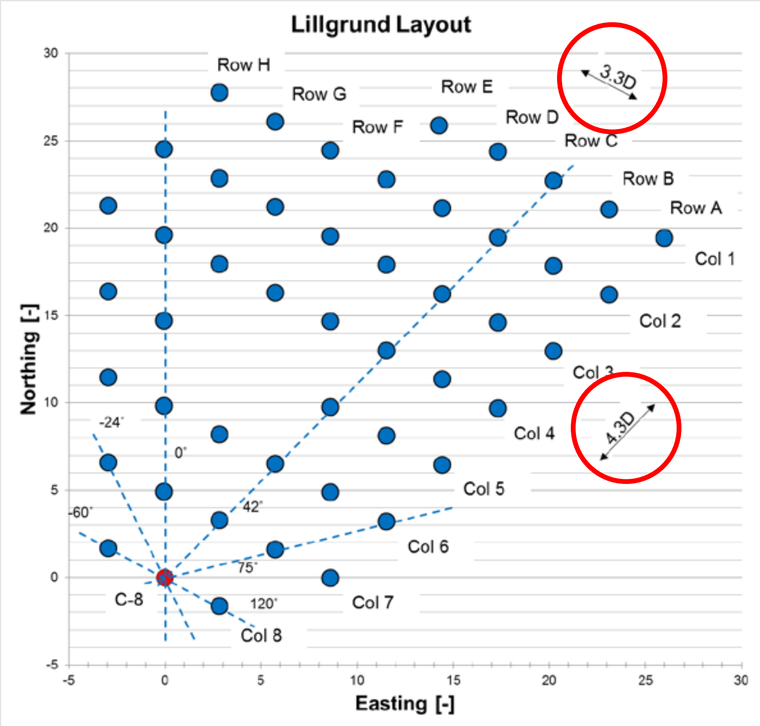
17 - 20 November 2015 | Porte de Versailles Pavillon 1, Paris, France

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







18-10 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**

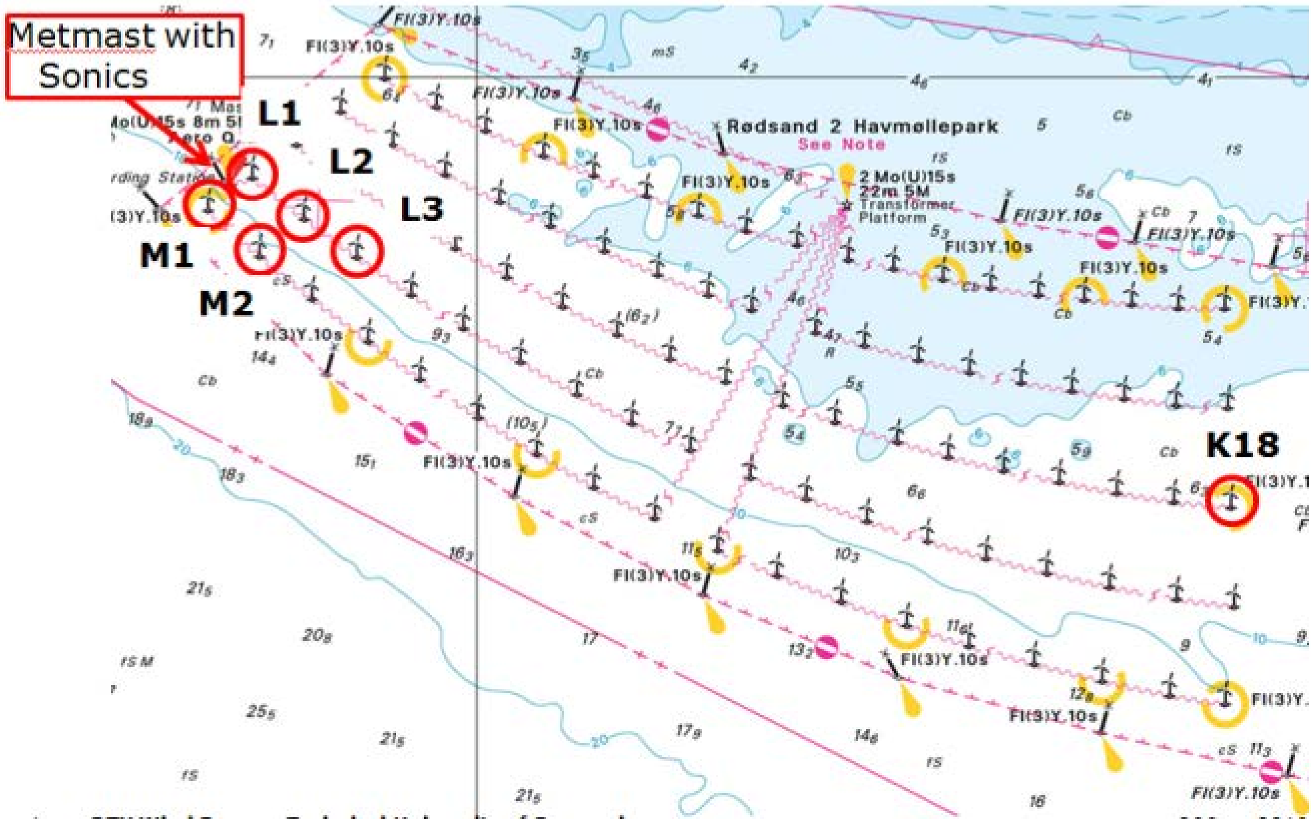
The Nysted II Wind farm

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.

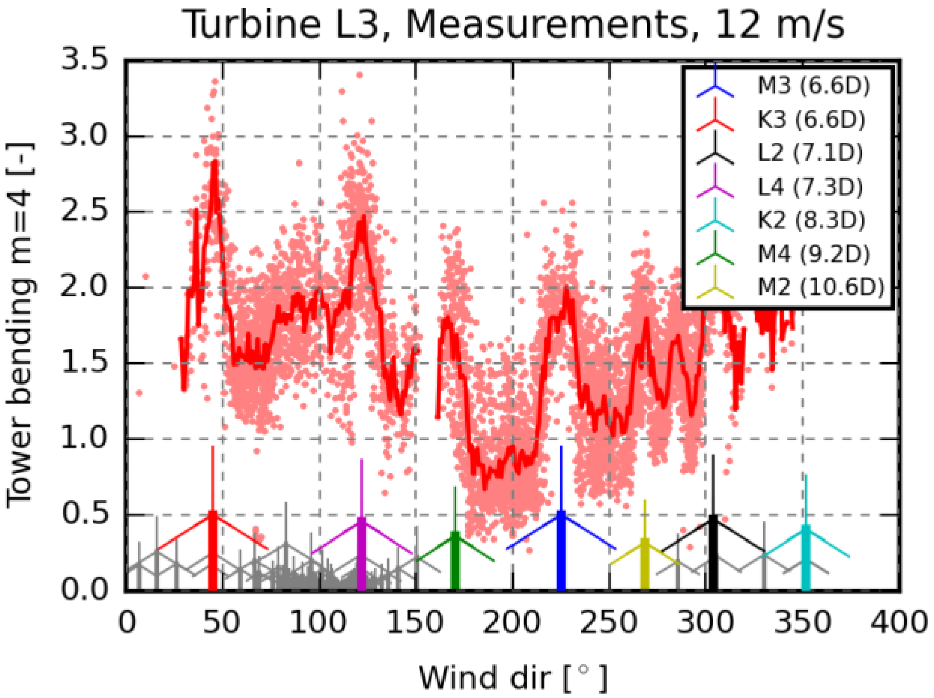
Furthermore access was granted to the SCADA data base of all turbines.

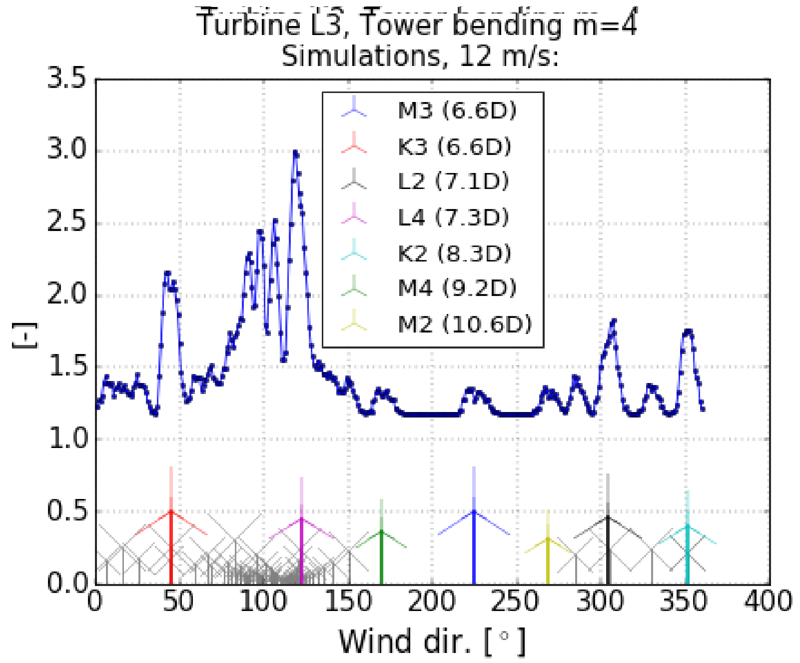
Wind conditions were estimated based on power and pitch angle of the outerly placed turbines.

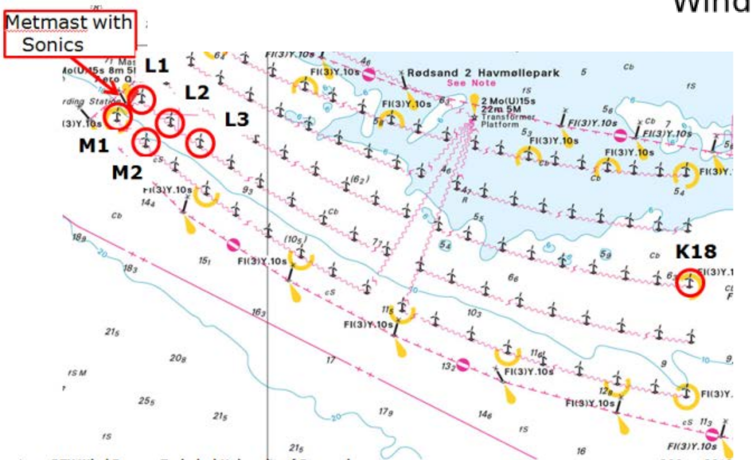


Results: Tower bending

8 m/s
12 m/s



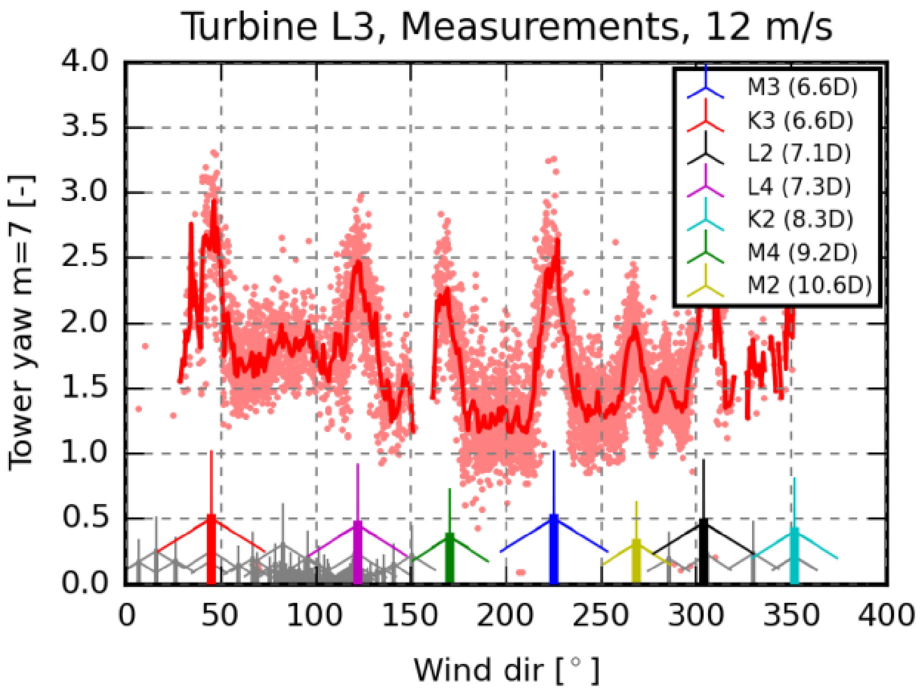


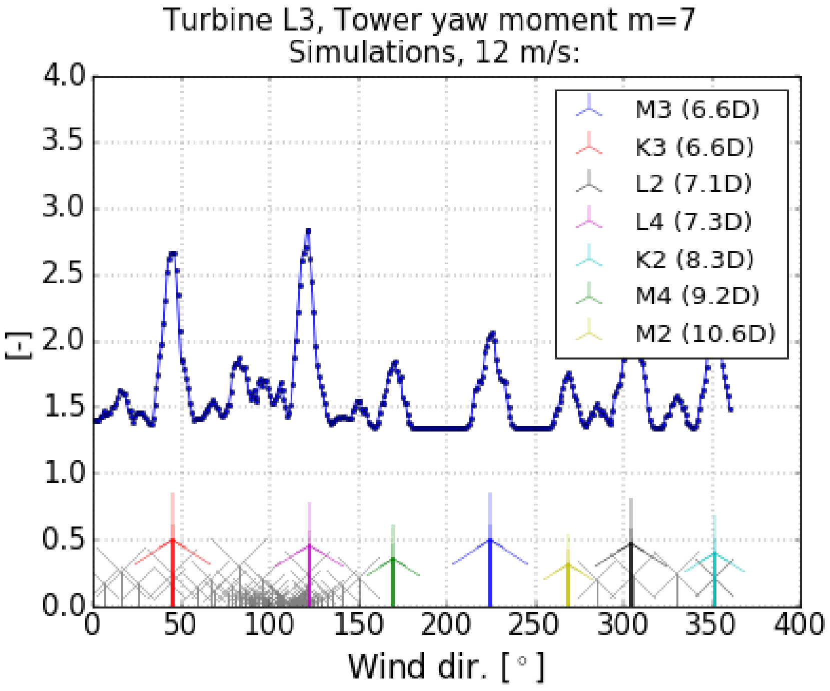


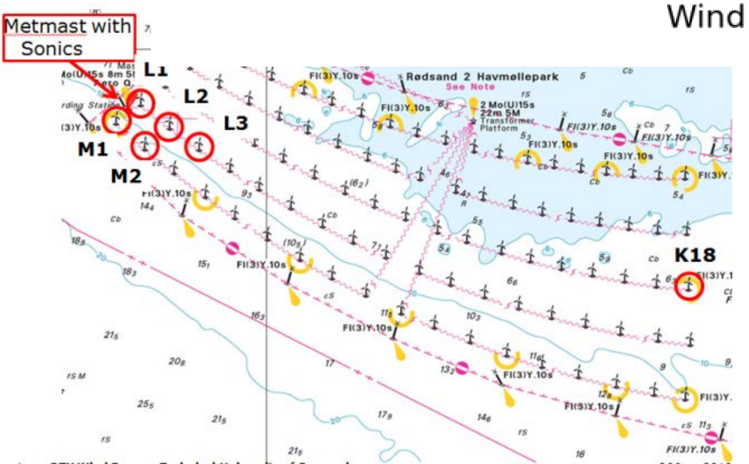
- **Fine match at 8 m/s (except for a small average offset)**
- **At 12 m/s:**
  Good agreement in the multiwake sectors
  Not so good agreement in the single wake sectors

Results: Tower yaw

12 m/s

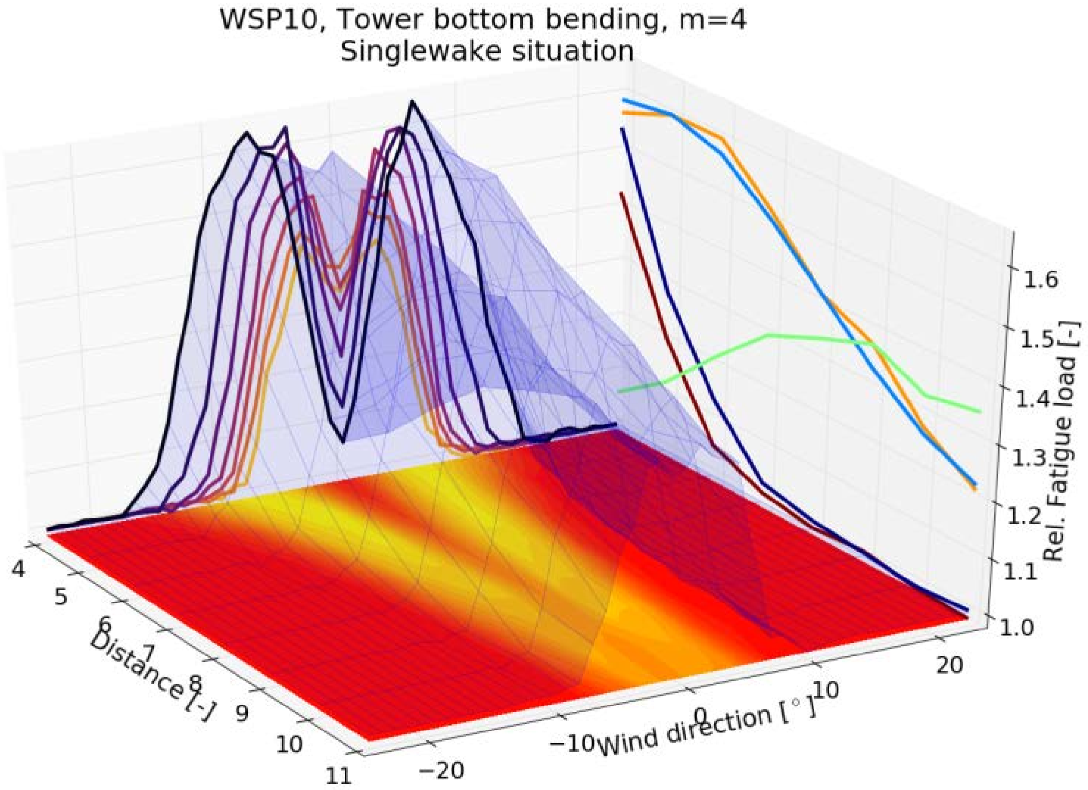


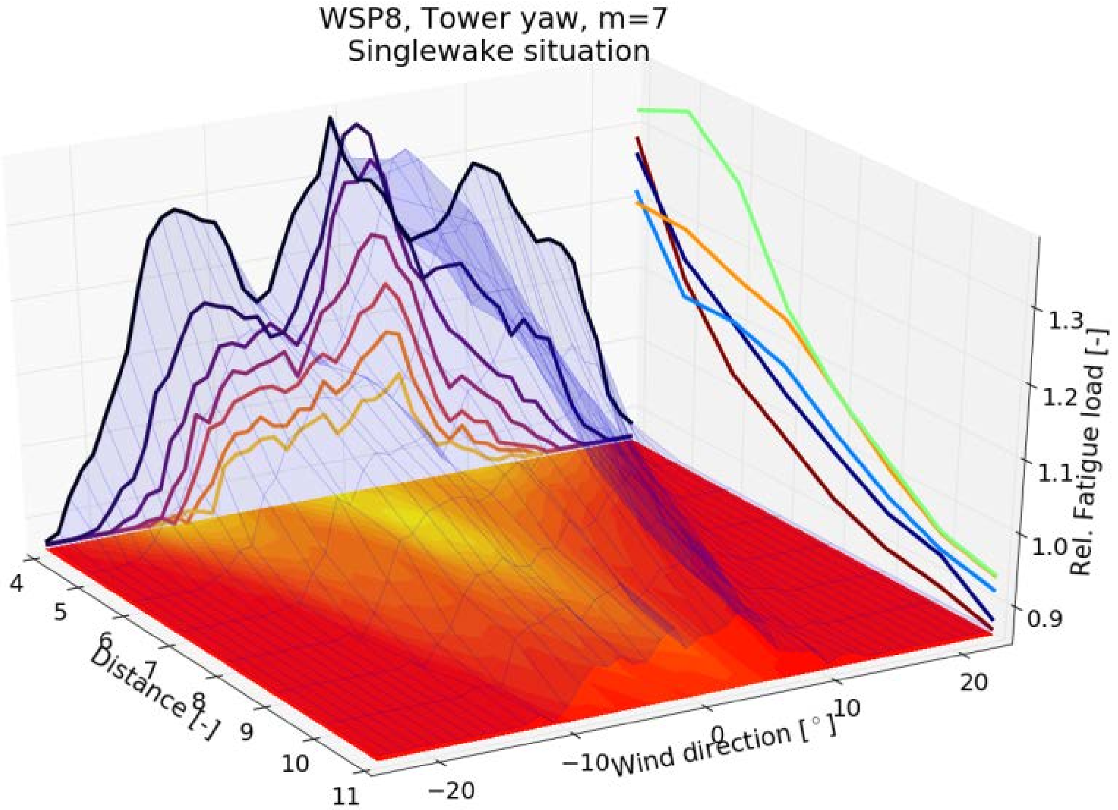




- **Fine match at 8-10m/s (except for a small average offset)**
- **At 12m/s:**
  Good agreement in the multiwake sectors
  Slight underprediction in the single wake sectors

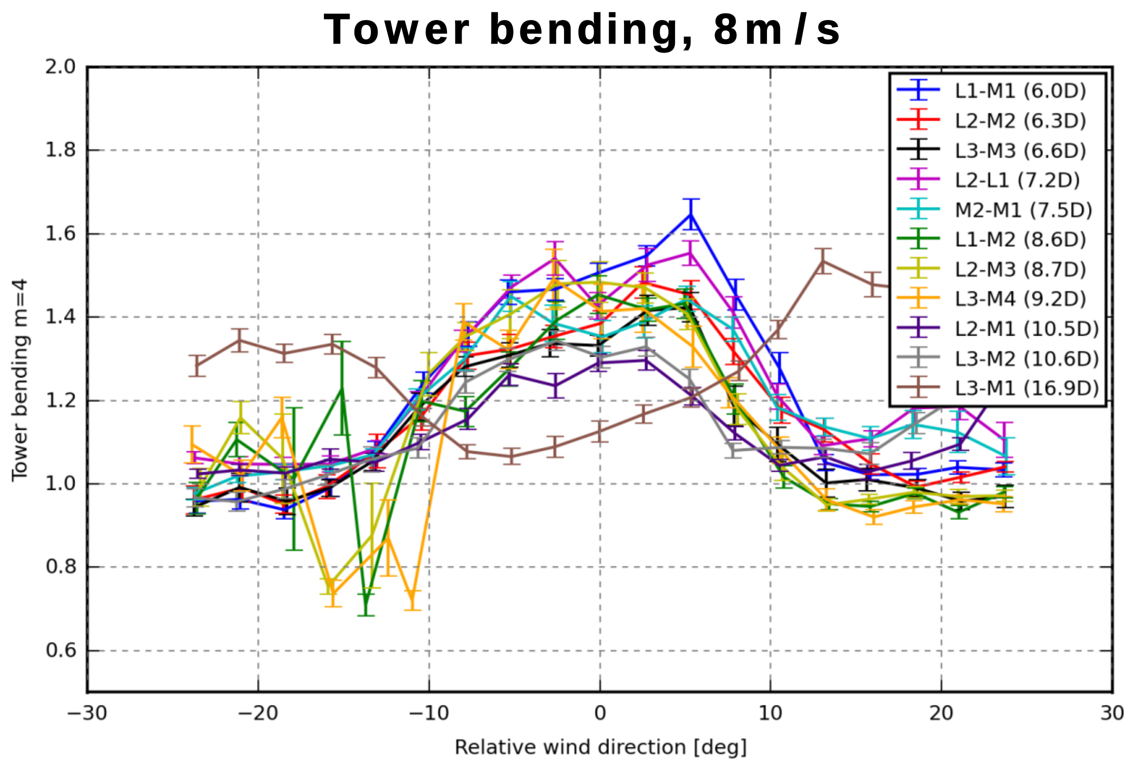
Loads as function of distance - simulations

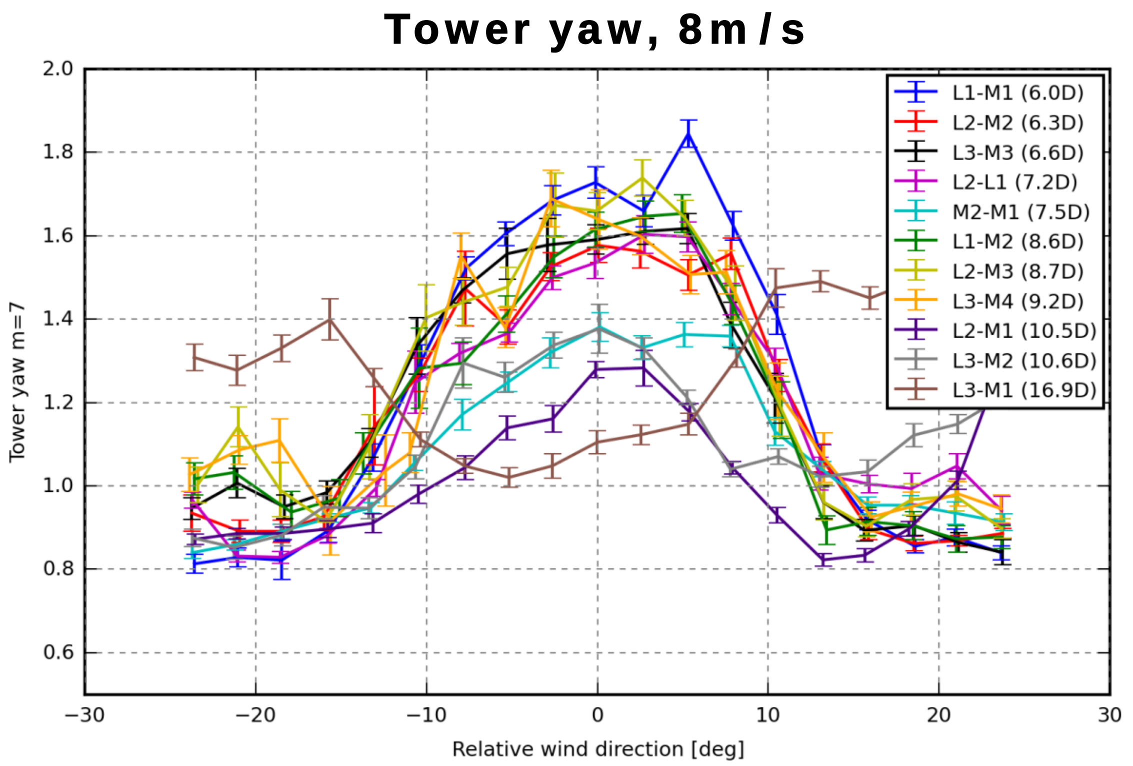




- In the center wake a local tower bending load maximum is seen at 7-8D spacing
- However, in general loads do decrease for increased spacing

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!