

Technical University of Denmark



Simulering af laster på møller i wake

Larsen, Torben J.; Aagaard Madsen , Helge; Larsen, Gunner Chr.

Publication date:
2008

[Link back to DTU Orbit](#)

Citation (APA):

Larsen, T. J., Aagaard Madsen, H., & Larsen, G. C. (2008). Simulering af laster på møller i wake. Paper presented at Vinddag 2008, Risø, Denmark.

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.

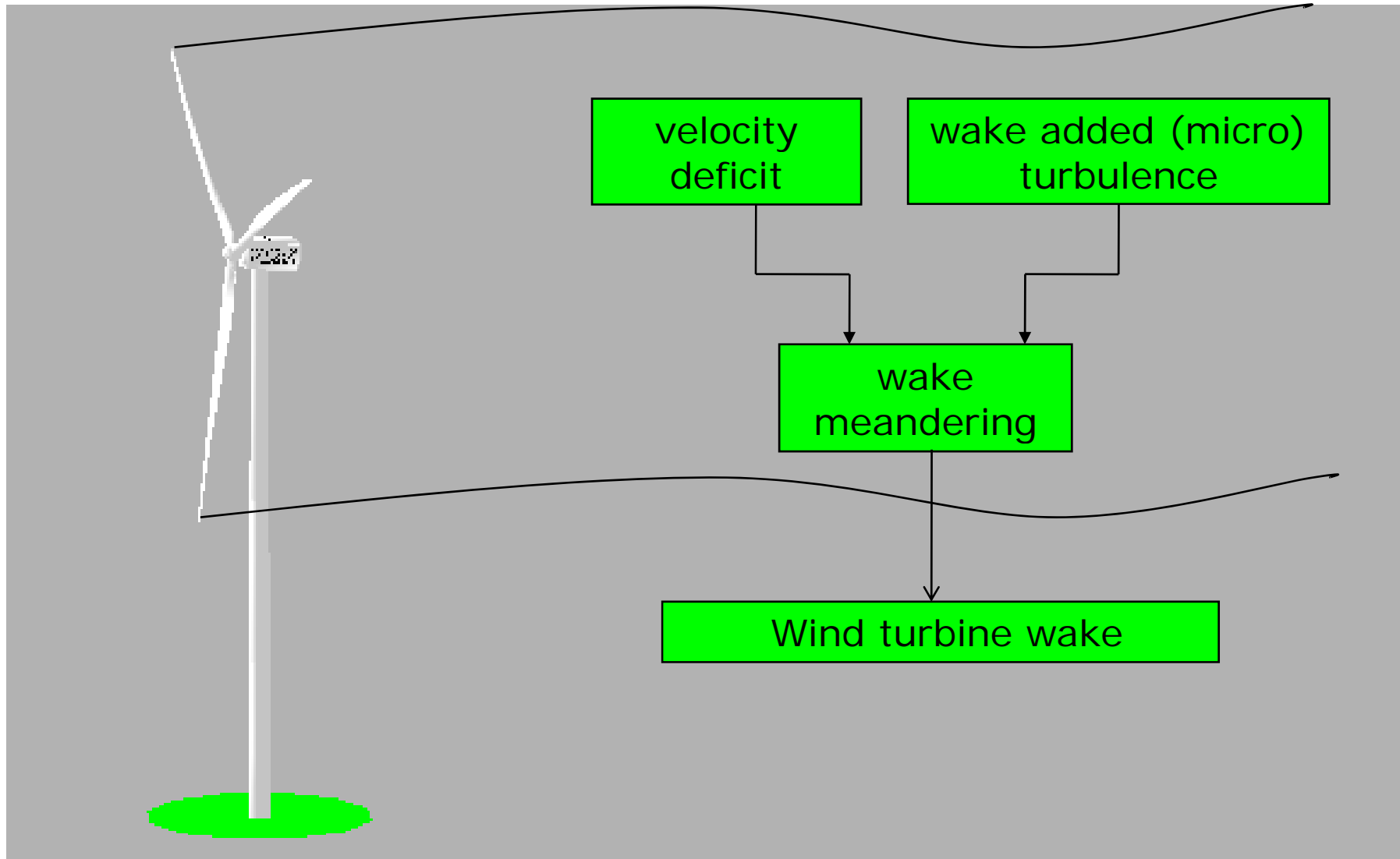
Simulering af laster på møller i wake

Dynamic Wake Meander (DWM) model
implementeret i HAWC2

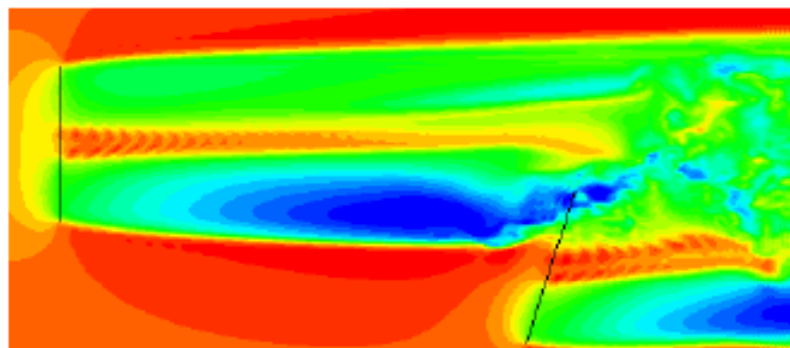
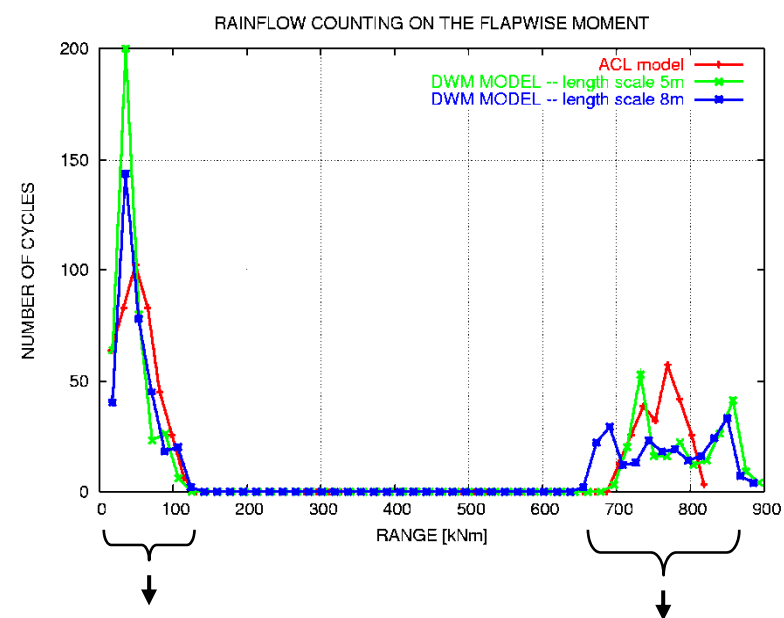
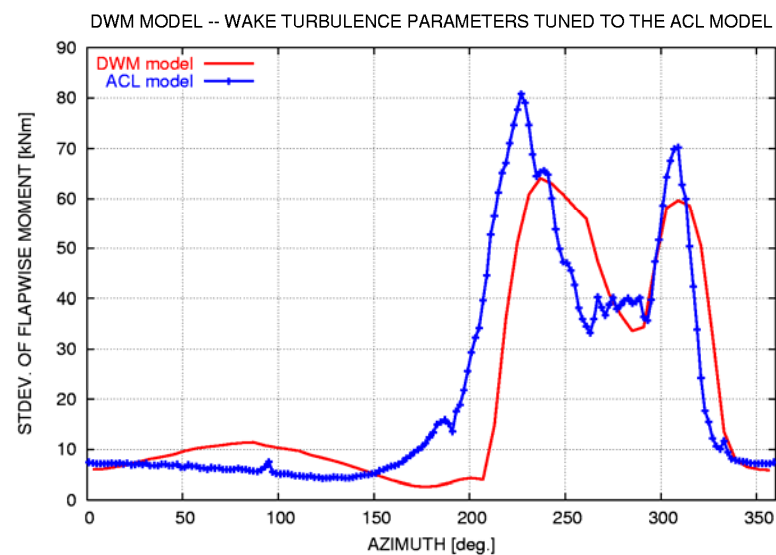
Torben J. Larsen, Helge Aa. Madsen, Gunner Larsen

Vinddag, Risø-DTU
25. November 2008

What is the wake?



Comparison of DWM and actuator line model no ambient turbulence

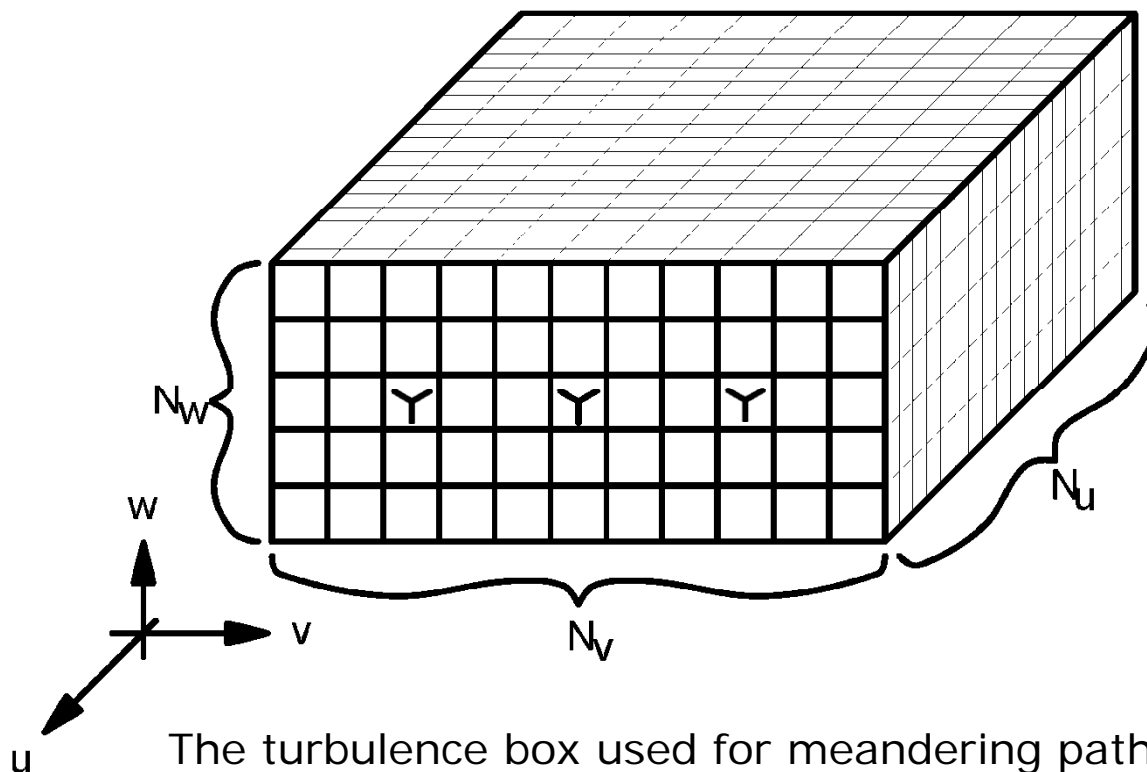


Influence of wake added turbulence

Influence of velocity deficit

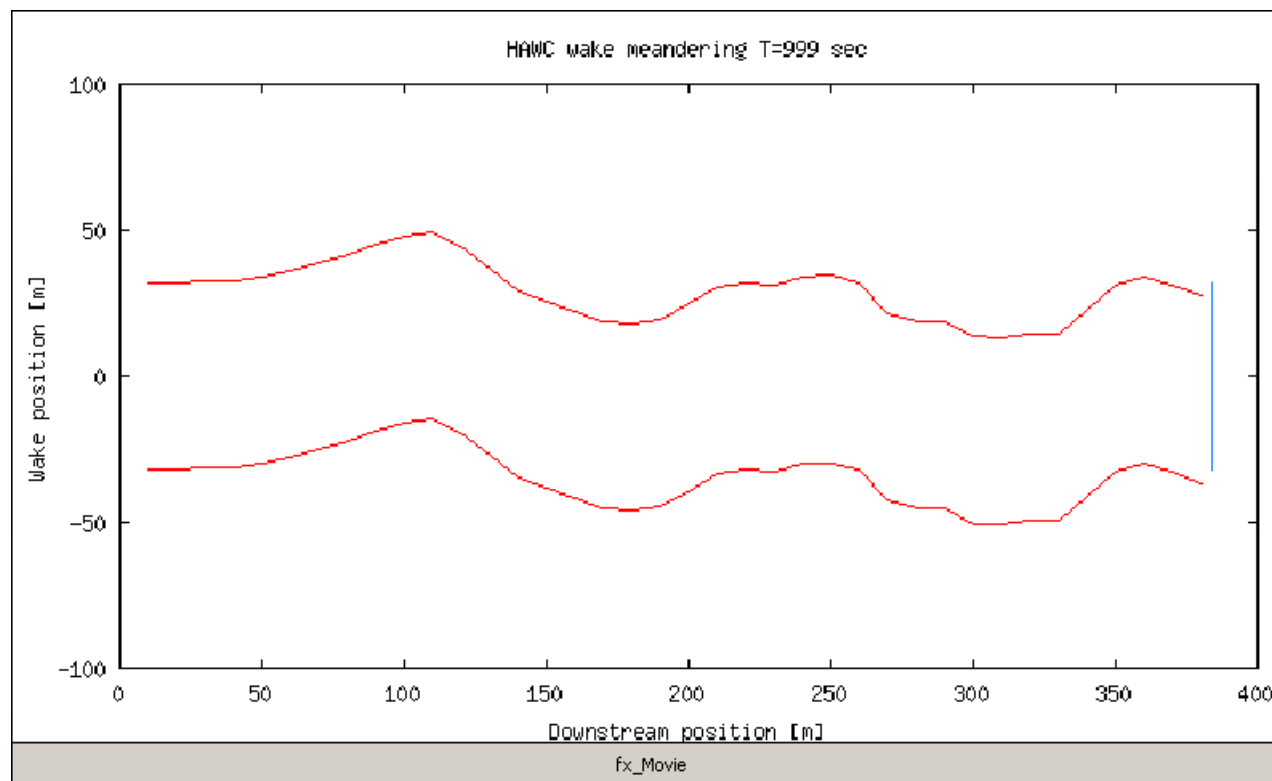
The Meandering

- A cascade of wake deficits are released from the upstream turbine
- Each deficit will be transported downstream affected only by ambient large scale turbulence (like smoke from a chimney)



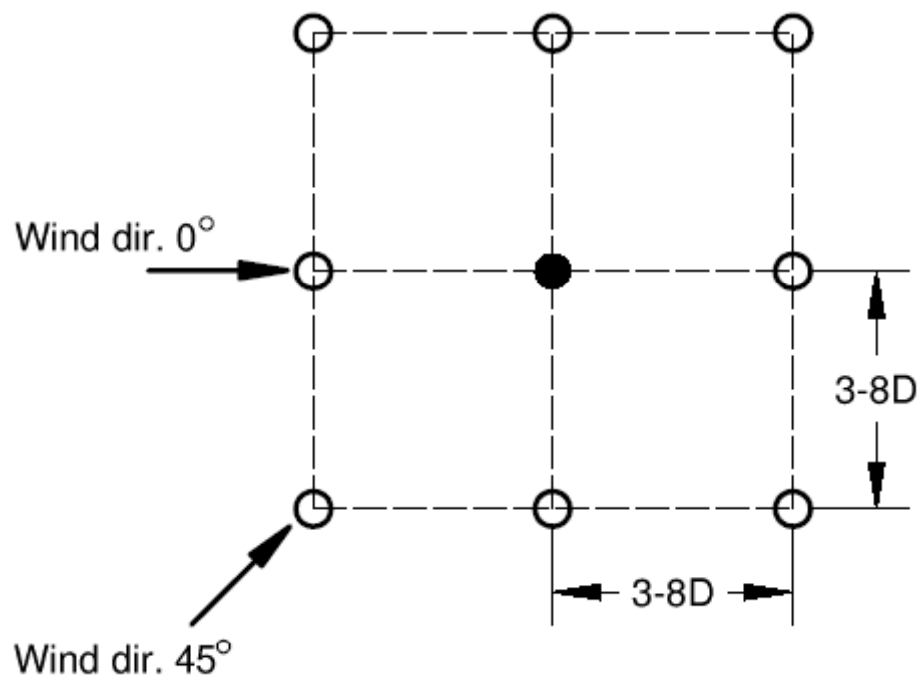
Simulation of wake deficit meandering

- A cascade of deficits are “released” at the upwind turbine
- The wake deficits are transported downstream affected by large scale lateral and vertical turbulence components.



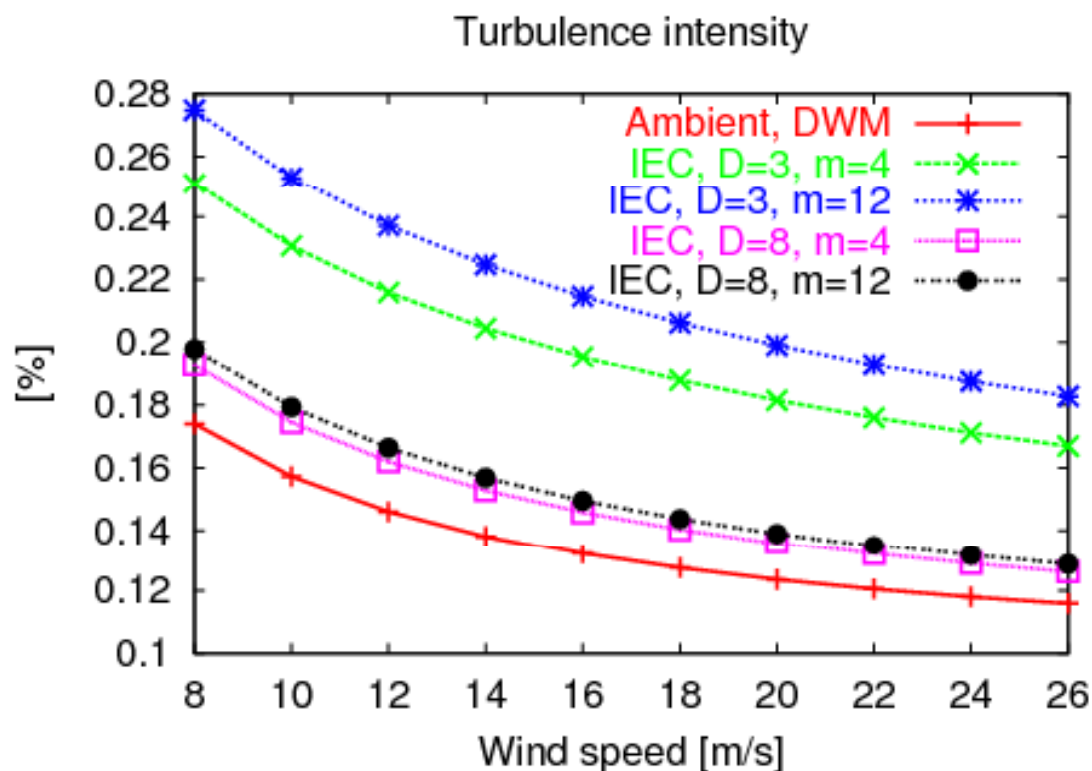
Load analysis of wind farm

- 2 MW pitch regulated turbine in a square park configuration
- 8 neighbouring turbines of same type
- Uniform wind direction distribution
- Wind terrain class IC (high mean wind, low ambient turbulence)



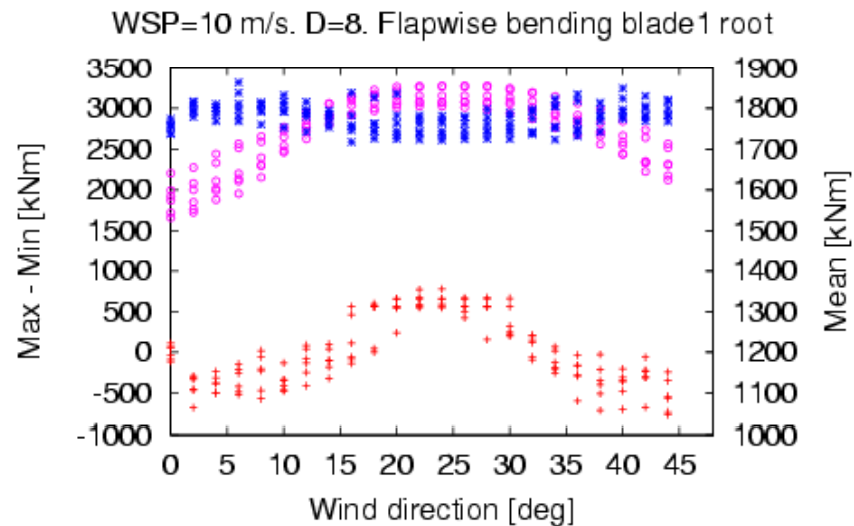
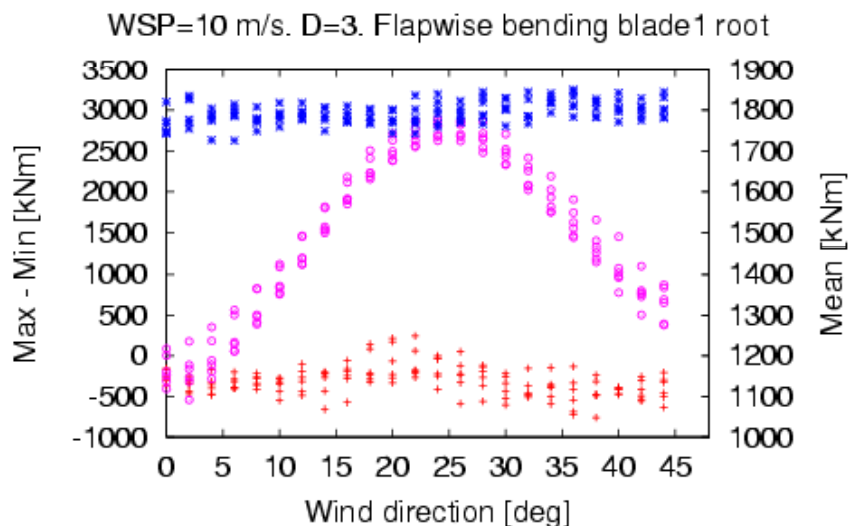
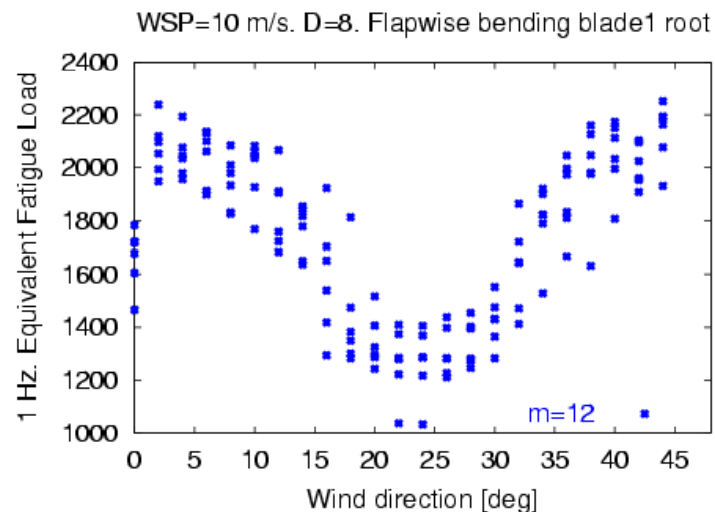
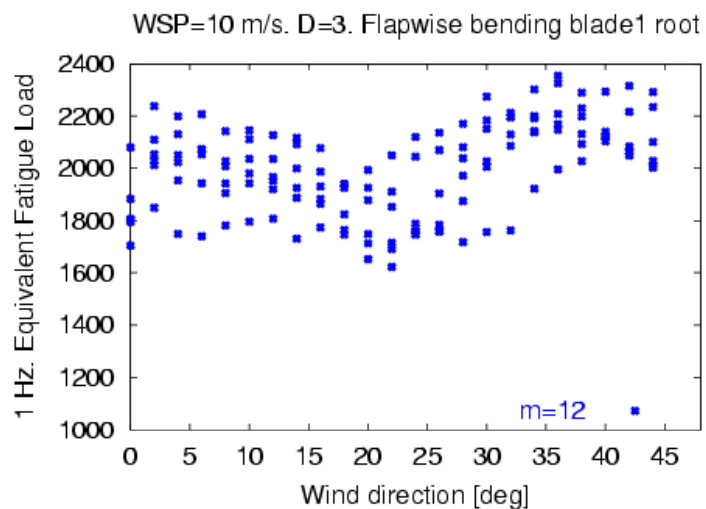
Simulation for each
2 deg using 6 seeds.
Total of 3312 DWM
10min. simulations

Used turbulence intensity for the IEC method



Ambient turbulence corresponds to class IC (high wind low turbulence)

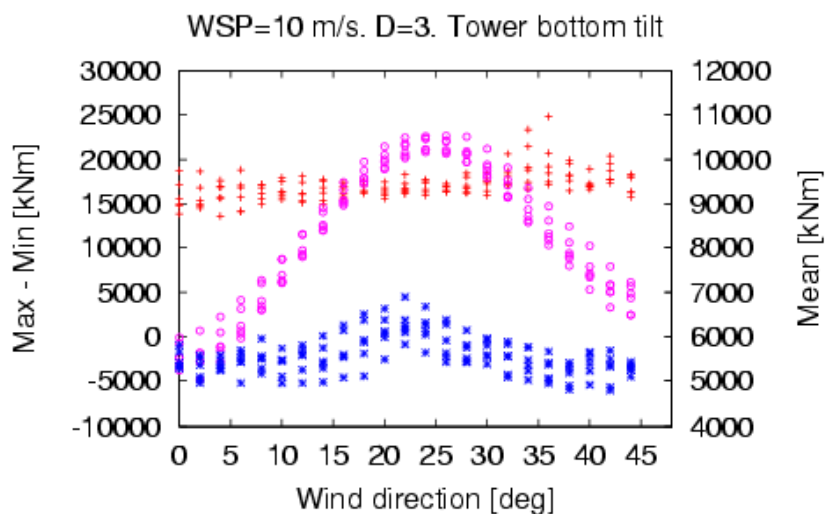
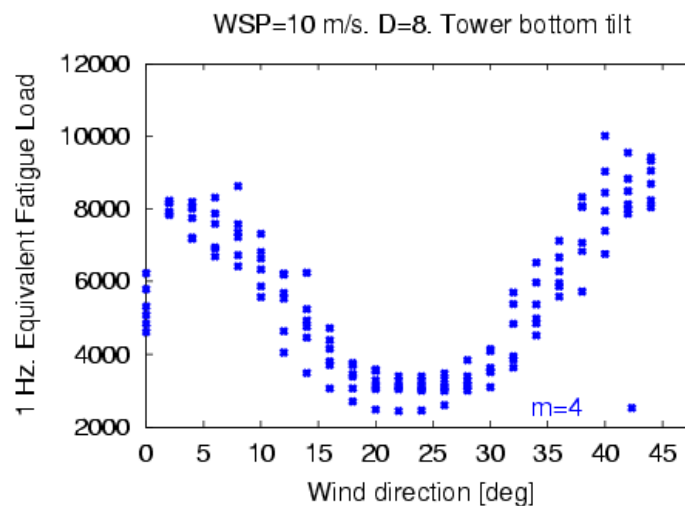
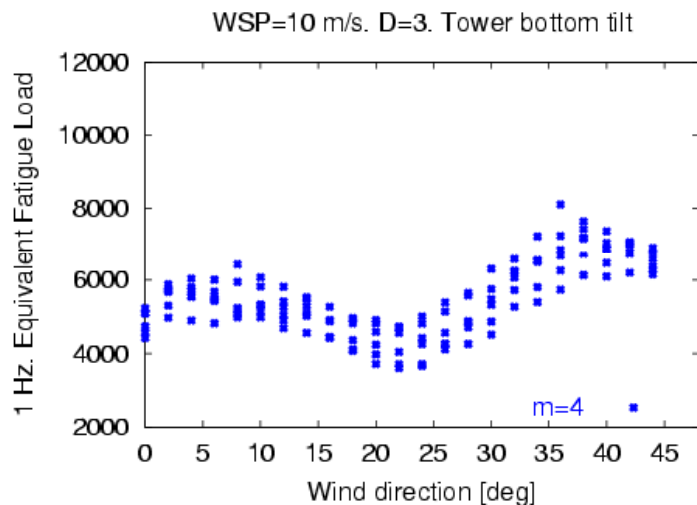
Influence from wind dir. at 10 m/s: Flapwise blade bending



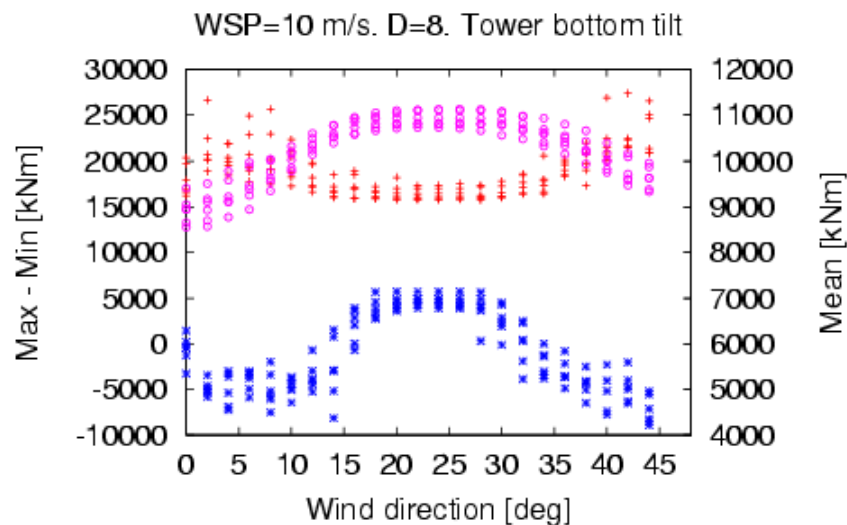
min + mean o max *

min + mean o max *

Influence from wind dir. at 10 m/s: Tower bottom tilt

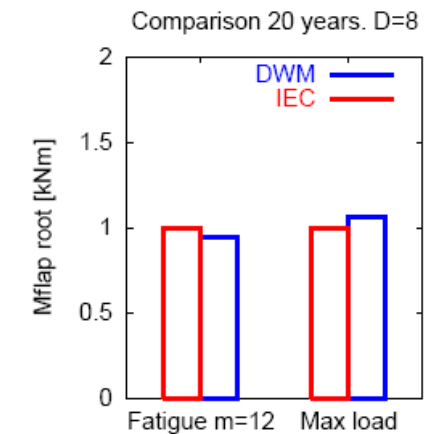
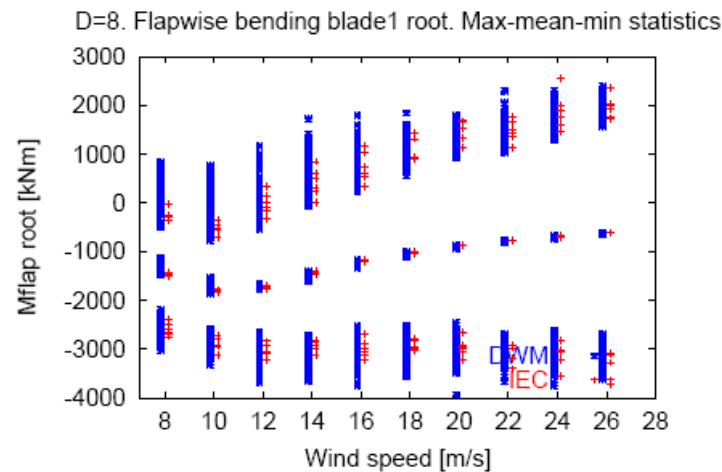
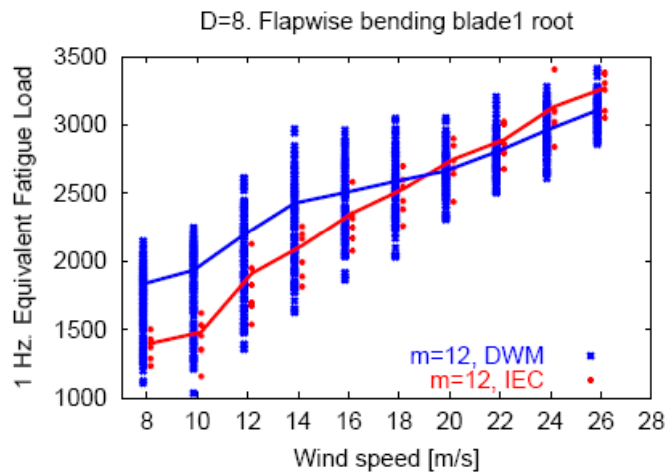
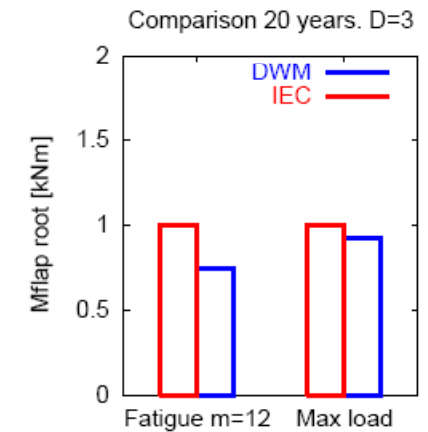
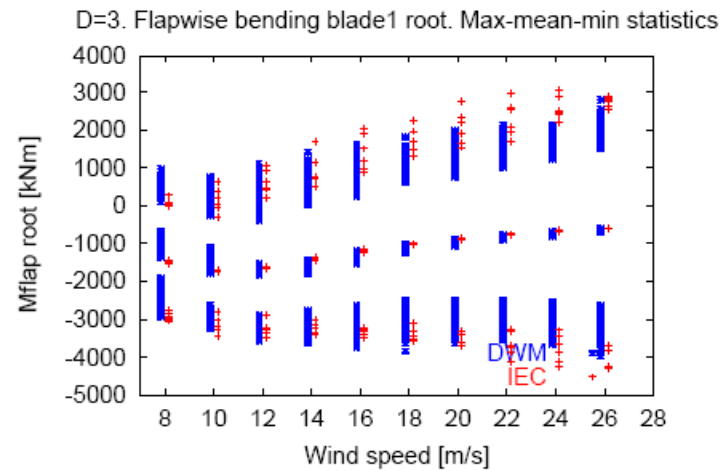
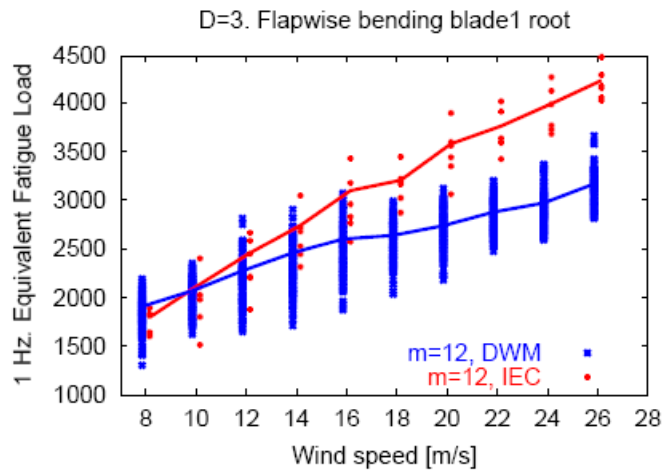


max + mean ○ min ×

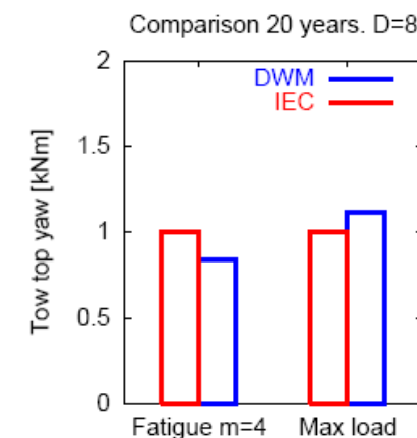
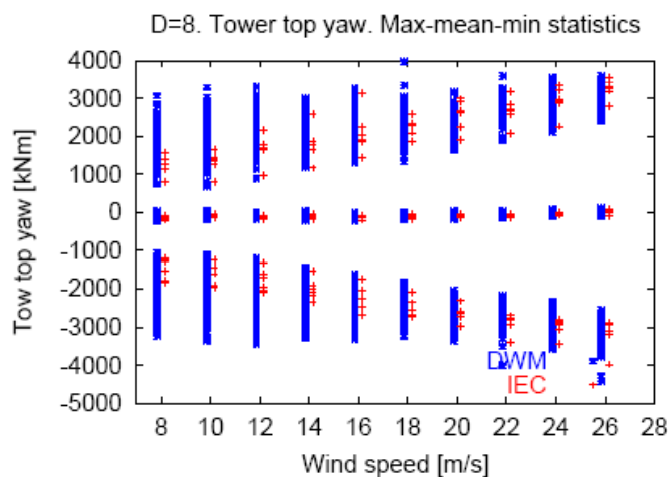
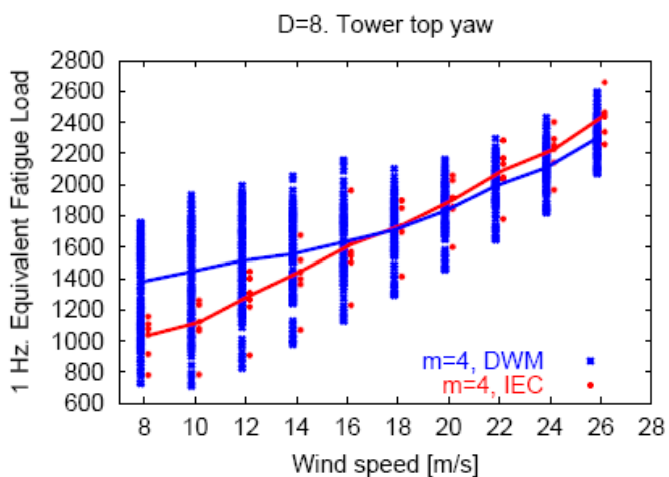
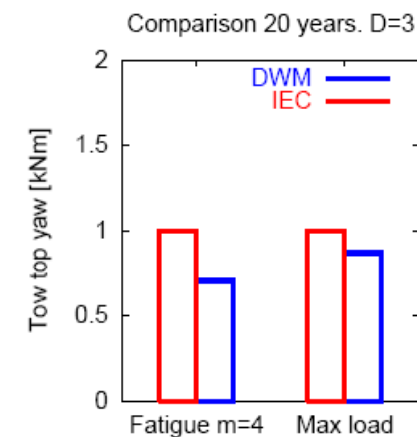
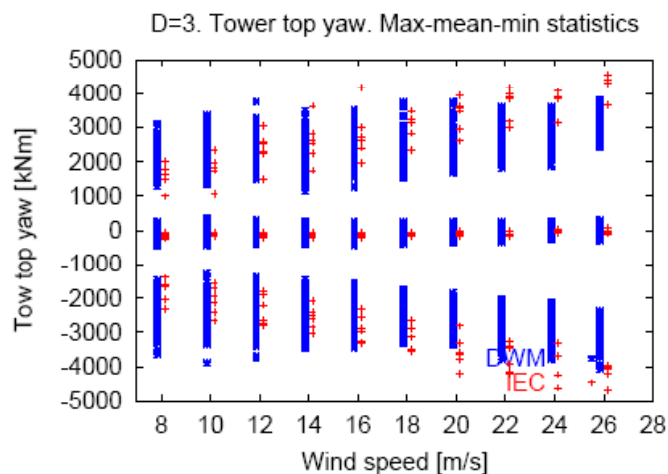
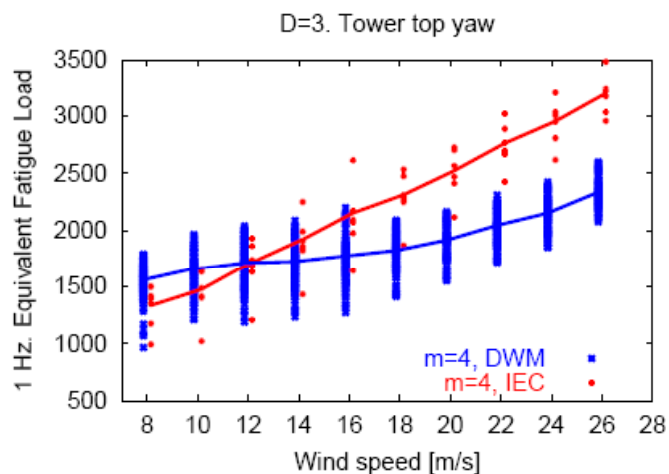


max + mean ○ min ×

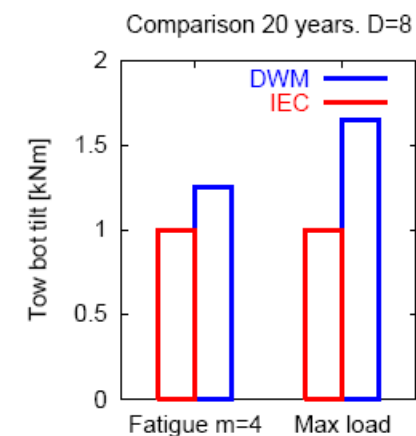
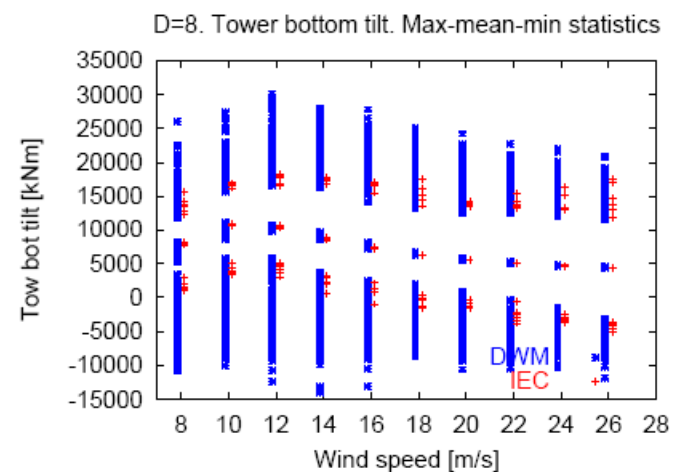
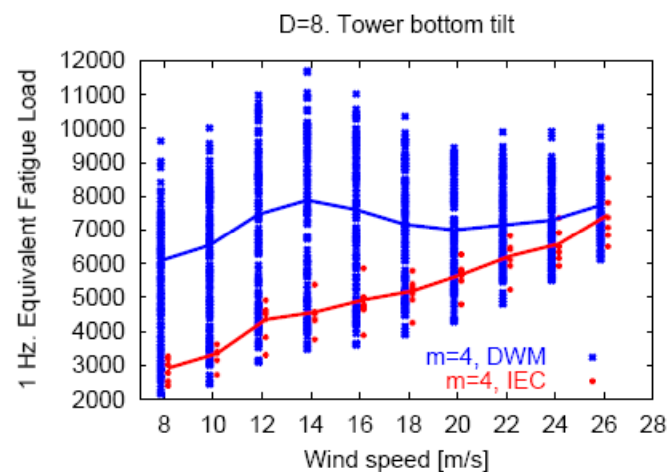
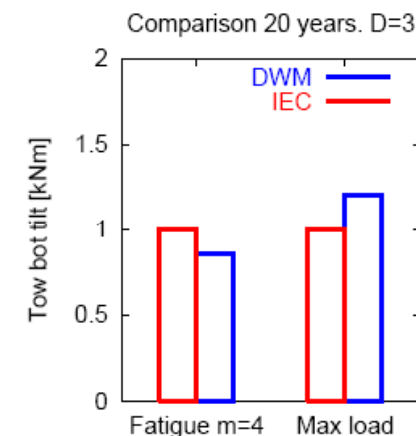
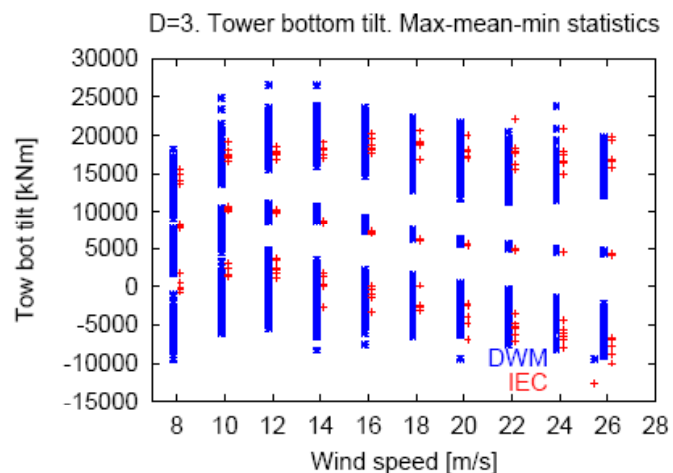
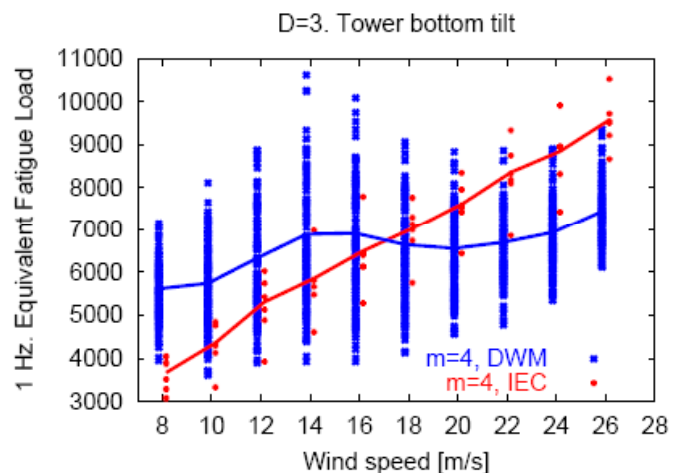
DWM – IEC Comparison 20 year production: Flapwise blade bending (pitching coo.)



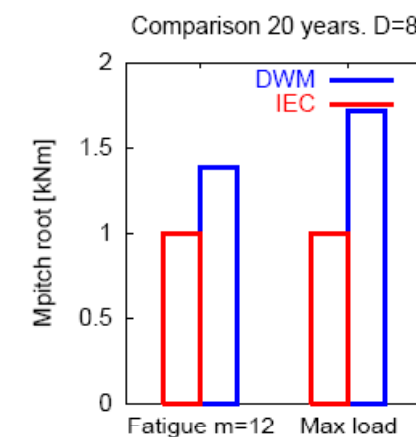
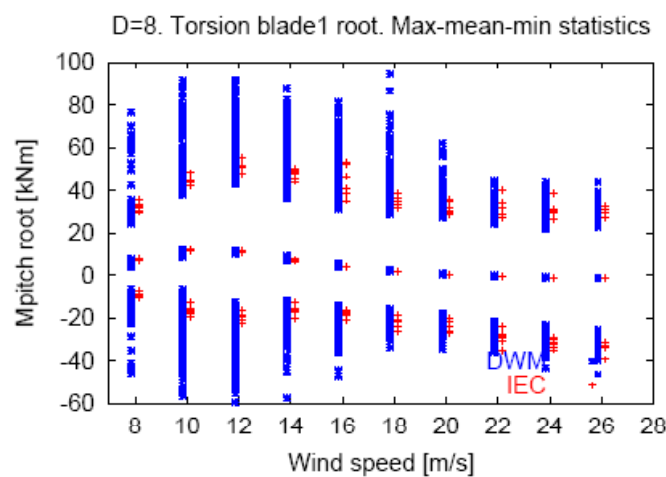
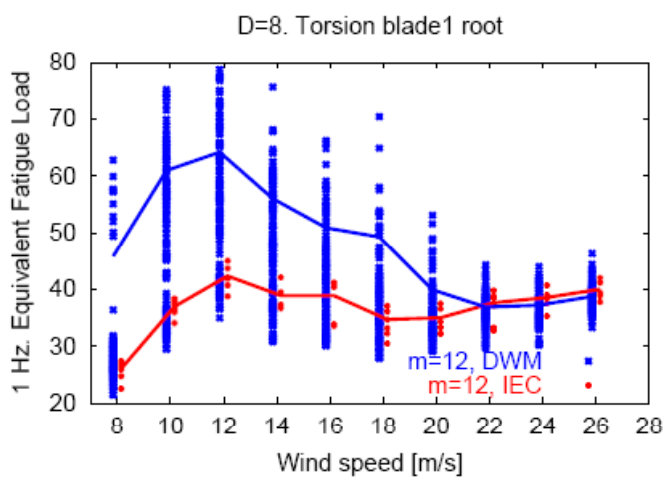
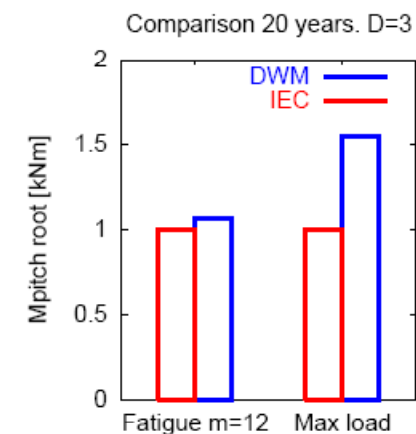
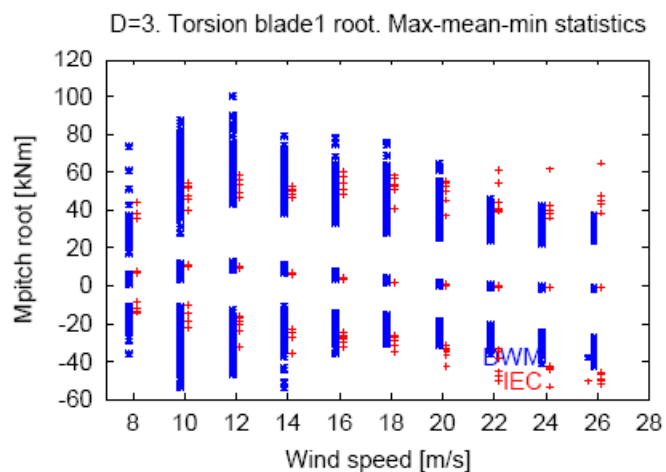
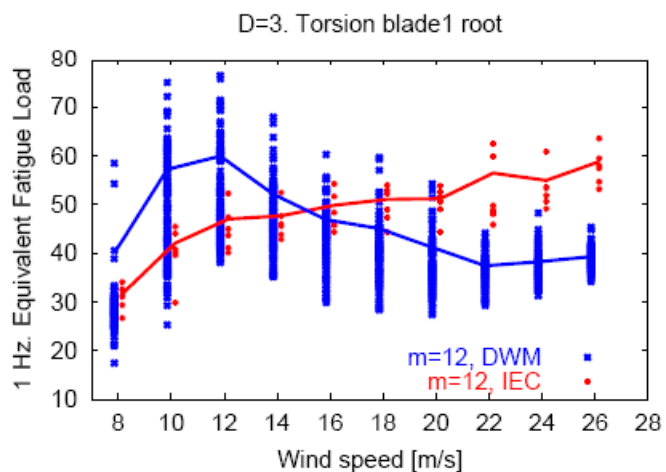
DWM – IEC Comparison 20 year production: Yaw bearing moment



DWM – IEC Comparison 20 year production: Tower bottom tilt



DWM – IEC Comparison 20 year production: Blade pitch moment at root



Conclusion

- New improved implementation of DWM model in HAWC2 demonstrated.
- In the used square grid park configuration the turbine *never experiences free flow direction at 3D spacing*.
- *Tower loads increase with increased row distance*. (At least up to 8 diameters spacing.) Possible explanation is the meandering effect.
- For 3D spacing the IEC loads are conservative regarding flapwise blade bending, for the yaw, driving torque and flapwise bending, whereas the loads on tower and blade torsion are non-conservative. Max load for tower +20% and blade torsion +55%
- For 8D spacing there is good agreement between the two models regarding yaw, driving torque and flapwise blade bending. A significantly higher load level is seen with the DWM model regarding tower loads and blade torsion. Fatigue +25% and max. load +60% for tower and blade torsion.