Simulering af laster på møller i wake

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Dynamic Wake Meander (DWM) model implementeret i HAWC2

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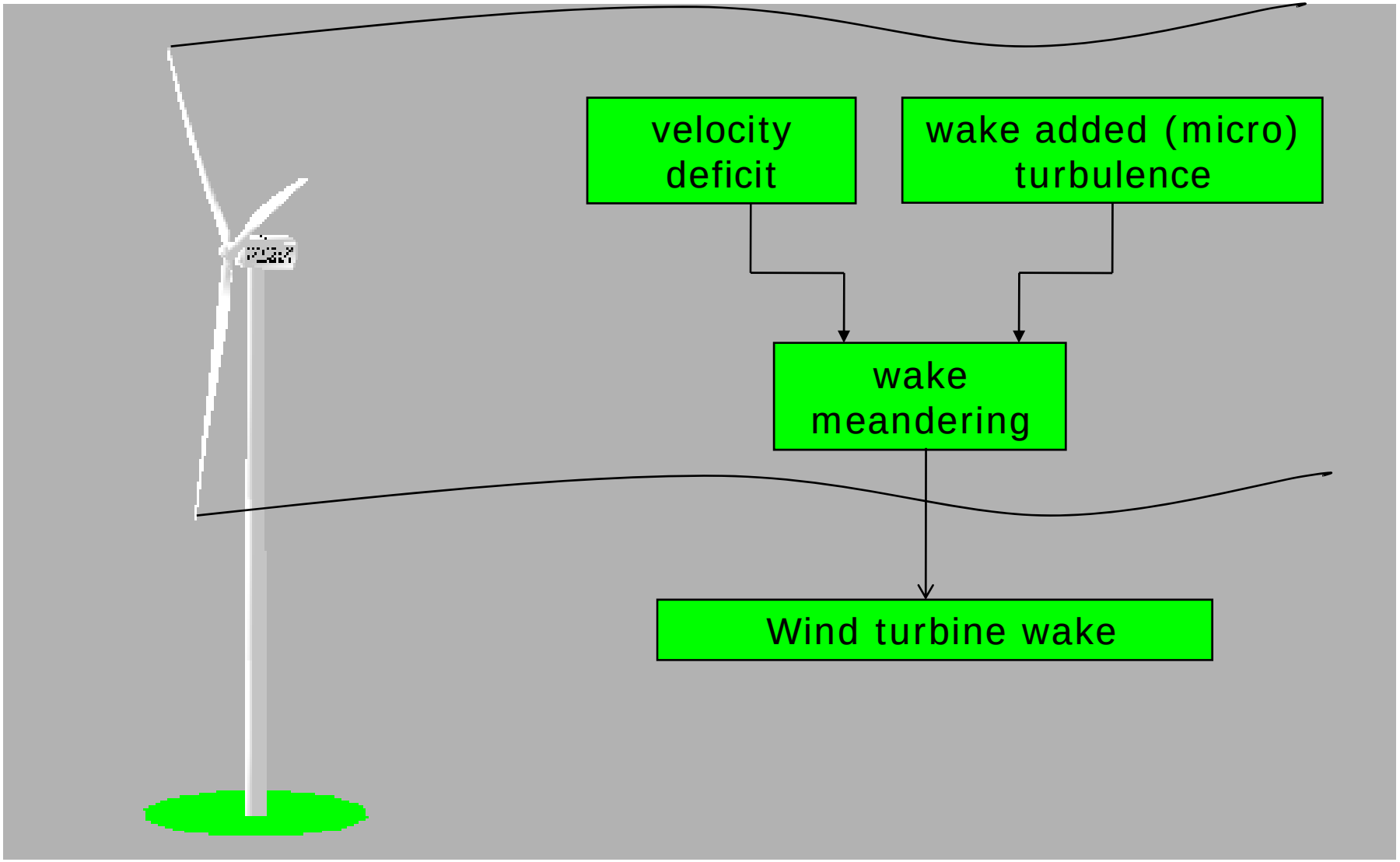
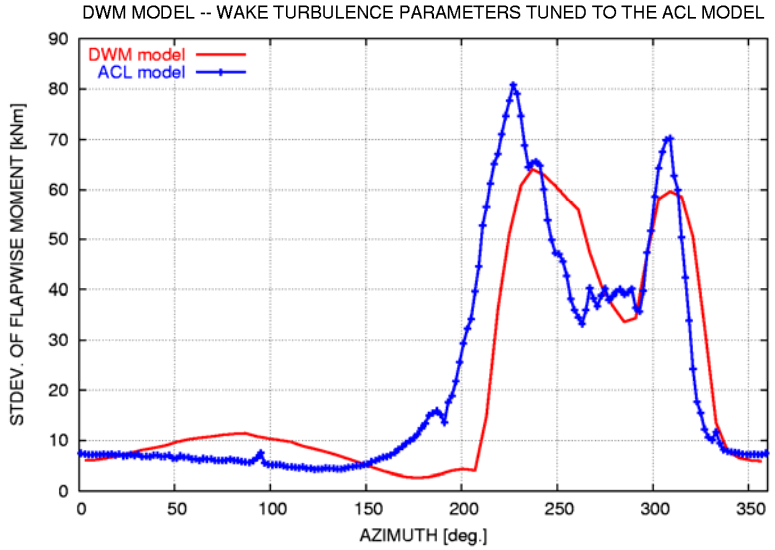
25. November 2008

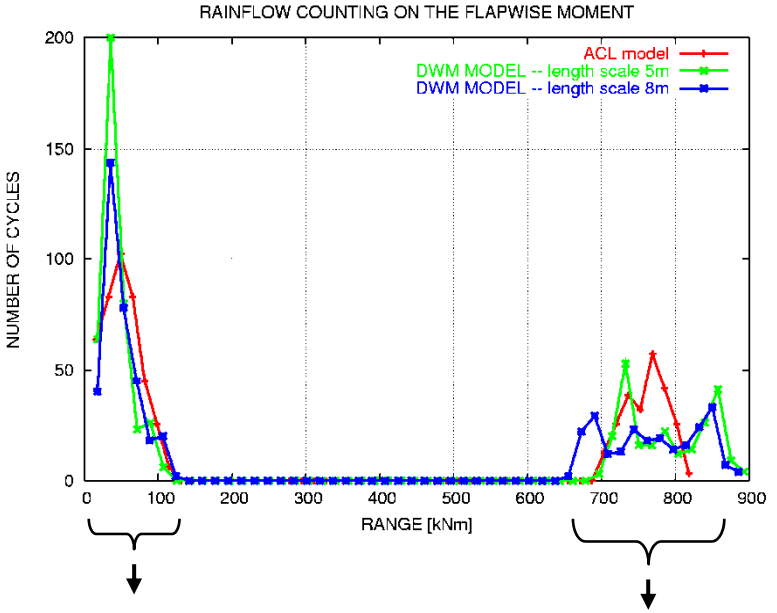
Risø DTU
National Laboratory for Sustainable Energy

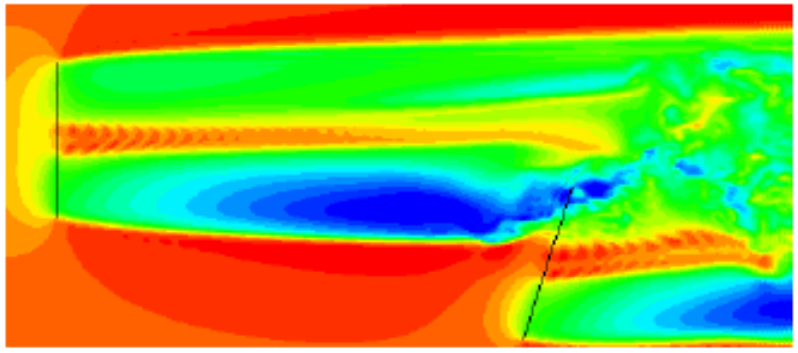
What is the wake?



Comparison of DWM and actuator line model no ambient turbulence





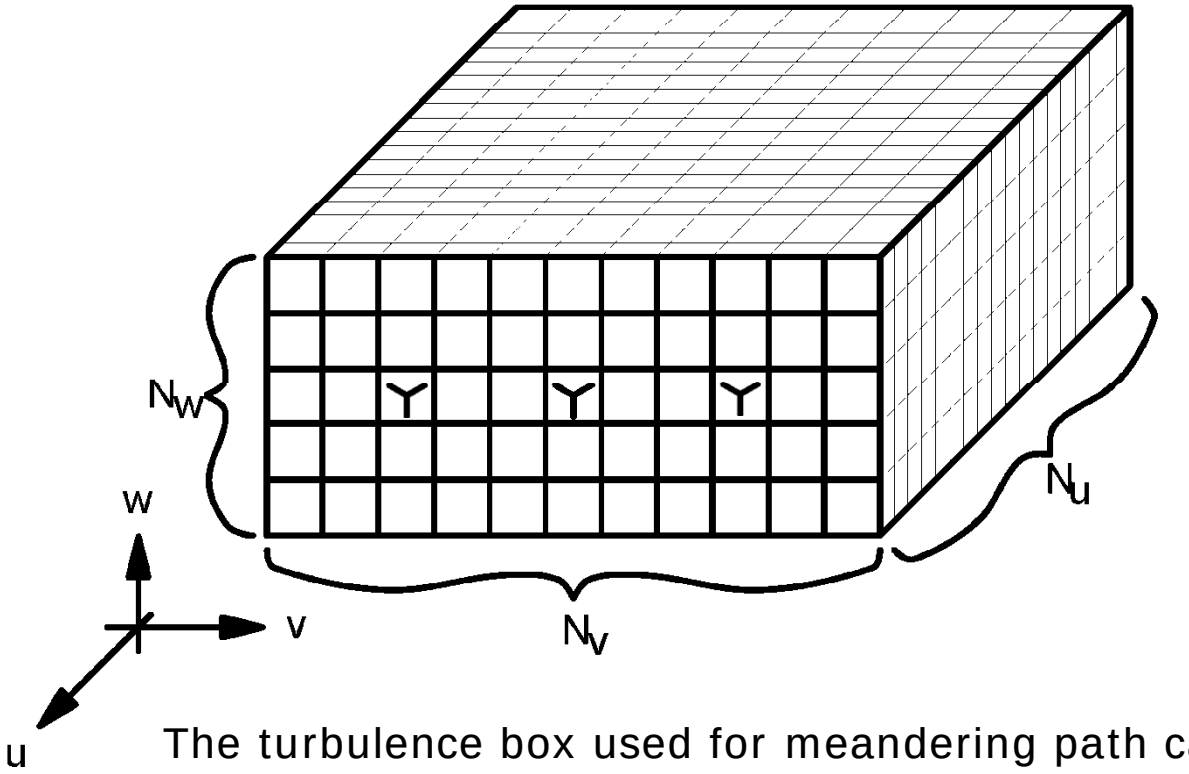


Influence of wake added turbulence

Influence of velocity deficit

The Meandering

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

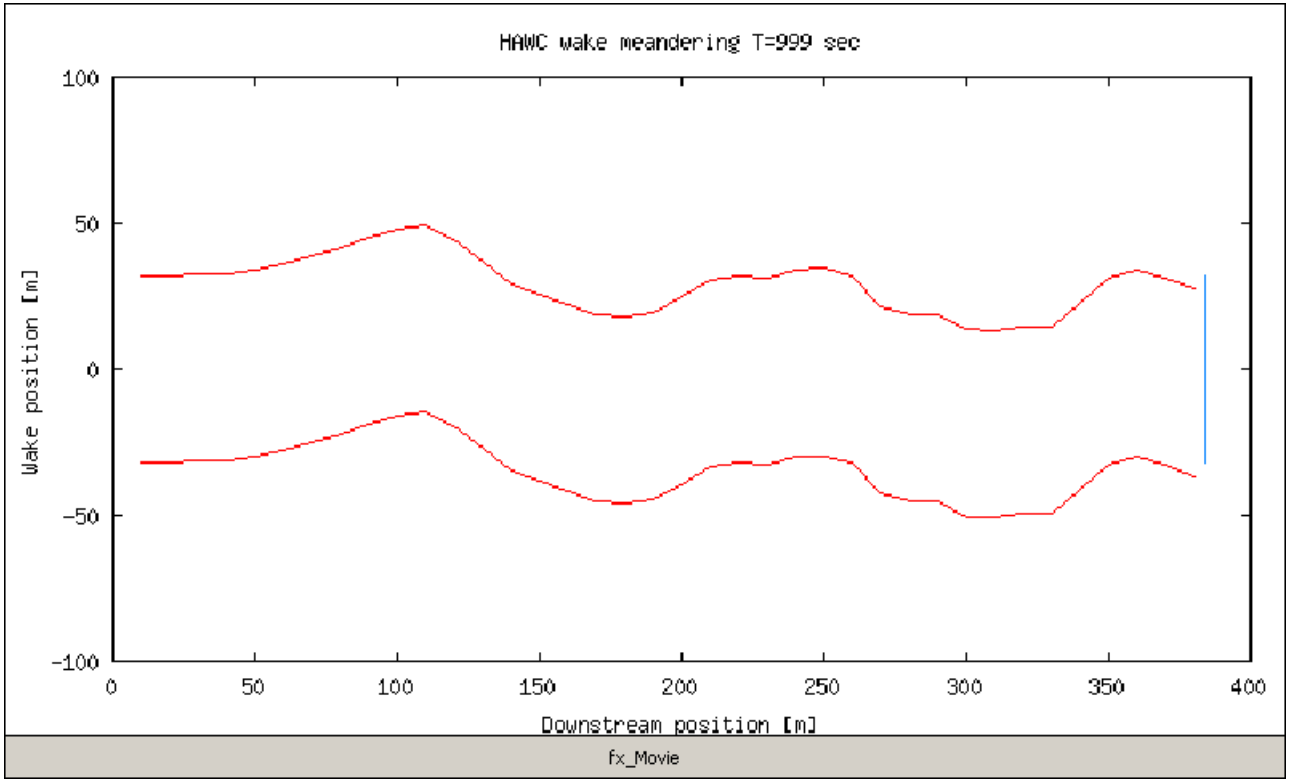


The turbulence box used for meandering path calculation

Simulation of wake deficit meandering

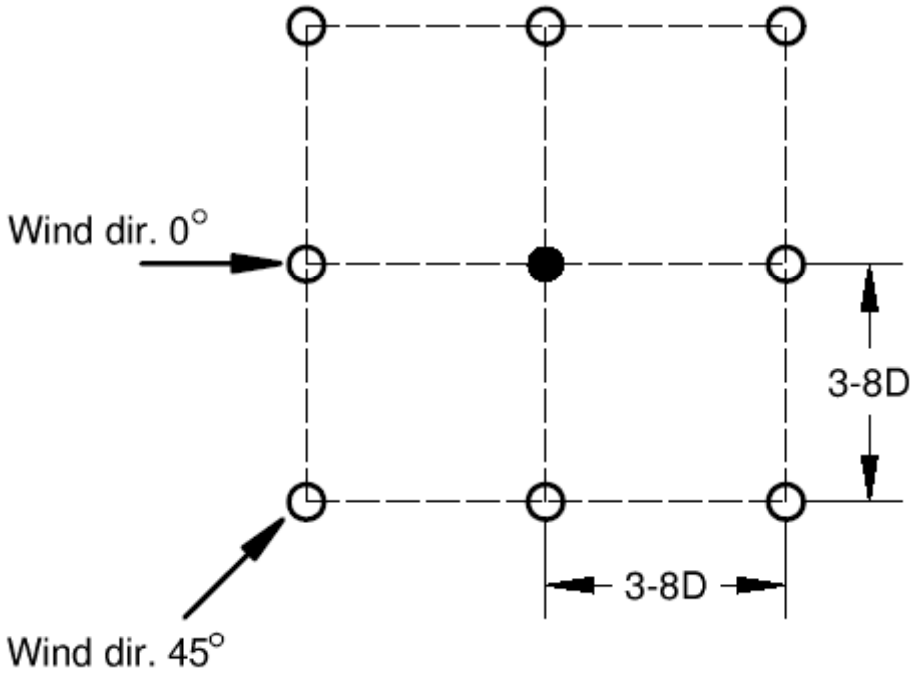
- A cascade of deficits are “released” at the upwind turbine

- The wake deficits are transported downstream affected by large scale lateral and vertical turbulence components.



Load analysis of wind farm

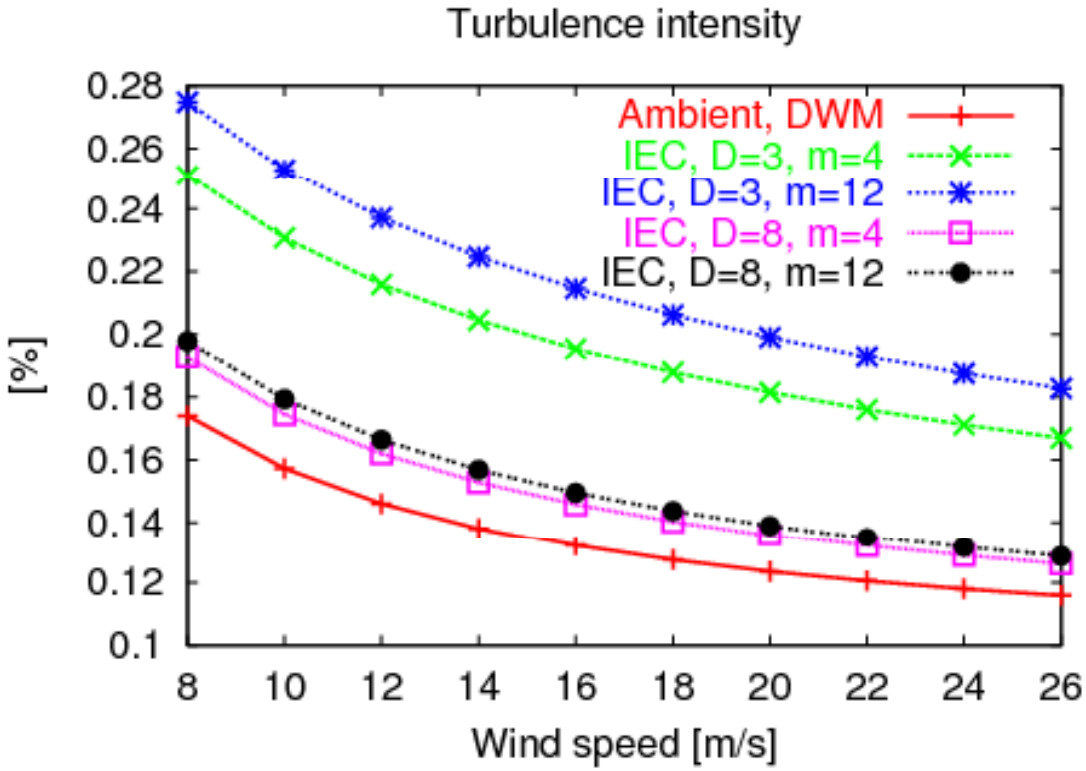
- 2 MW pitch regulated turbine in a square park configuration
- 8 neighbouring turbines of same type
- Uniform wind direction distribution
- Wind terrain class IC (high mean wind, low ambient turbulence)



Simulation for each 2 deg using 6 seeds.

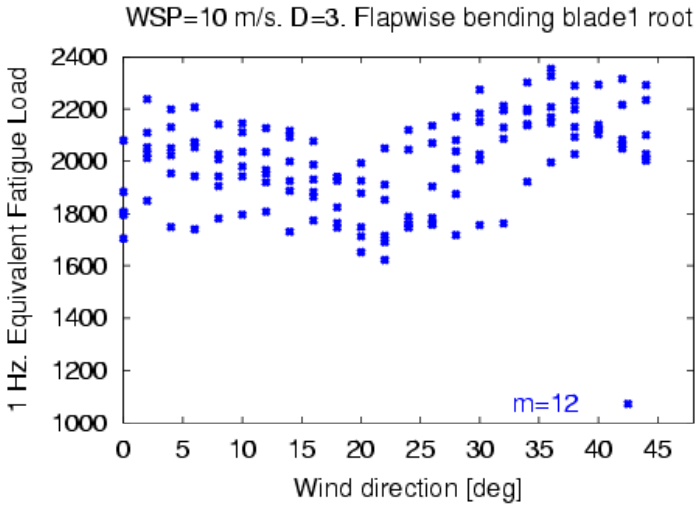
Total of 3312 DWM 10min. simulations

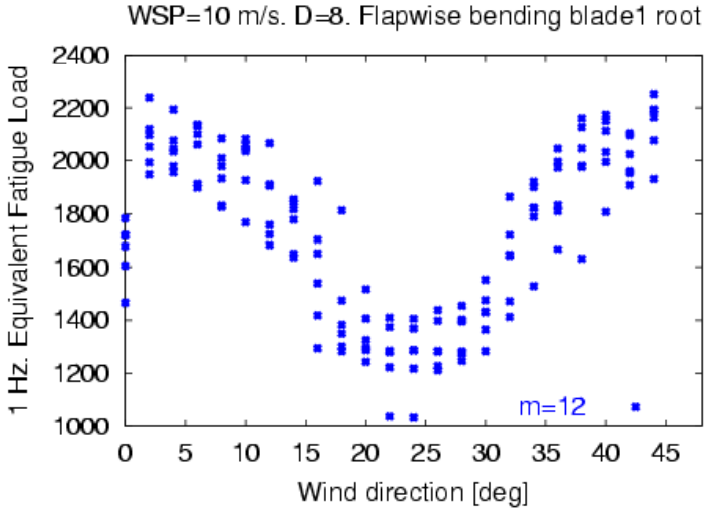
Used turbulence intensity for the IEC method

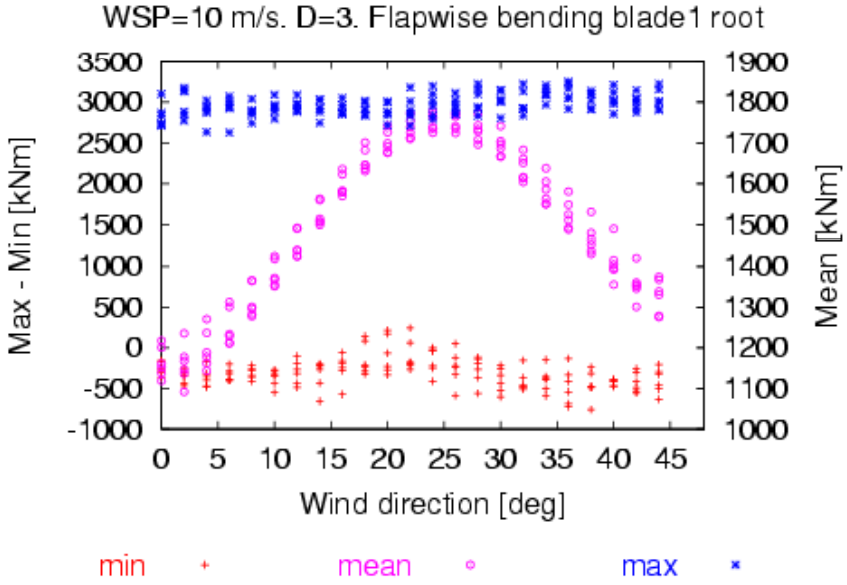


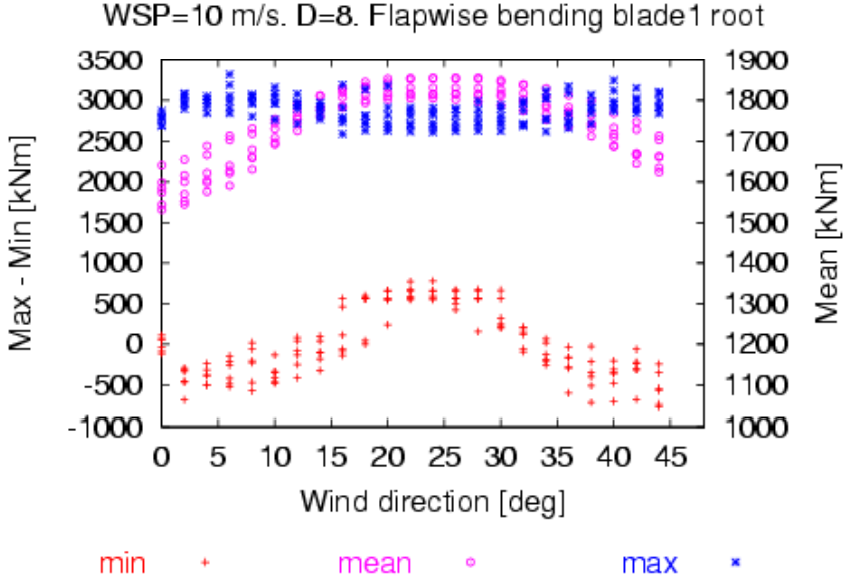
Ambient turbulence corresponds to class IC (high wind low turbulence)

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

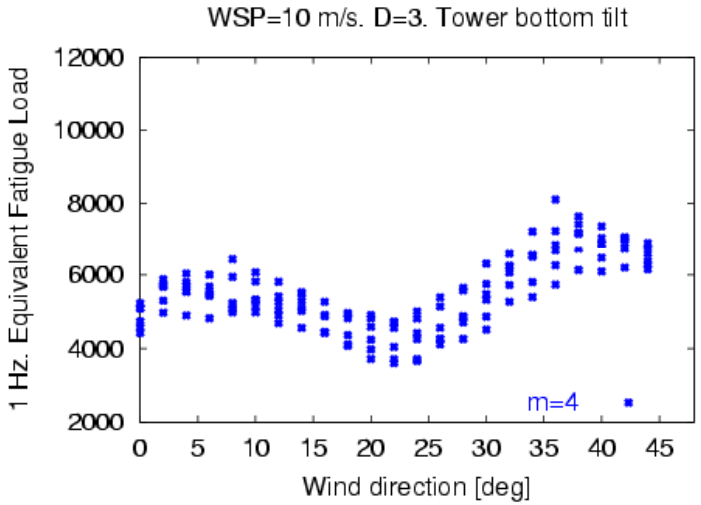


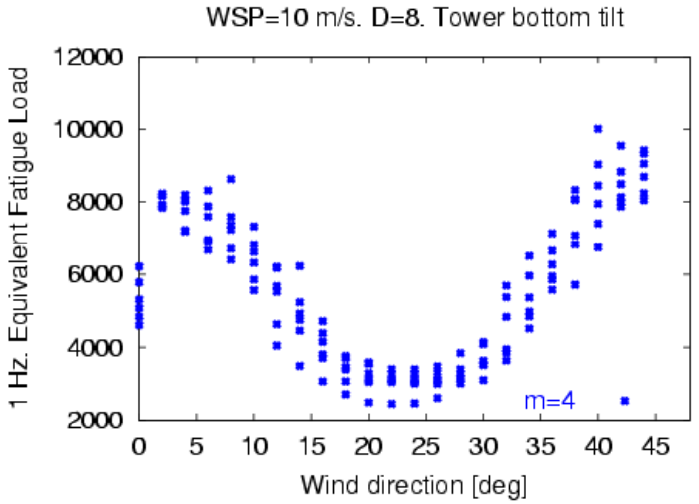


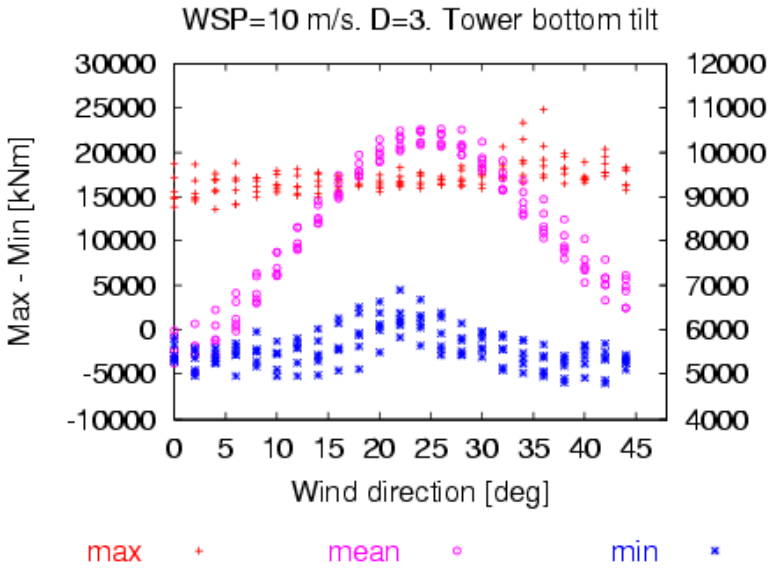


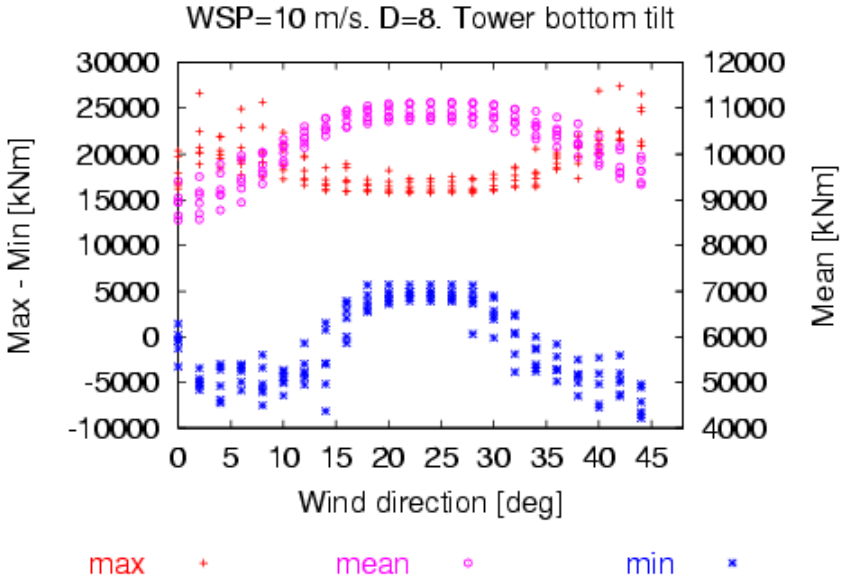


Influence from wind dir. at 10 m/s: Tower bottom tilt

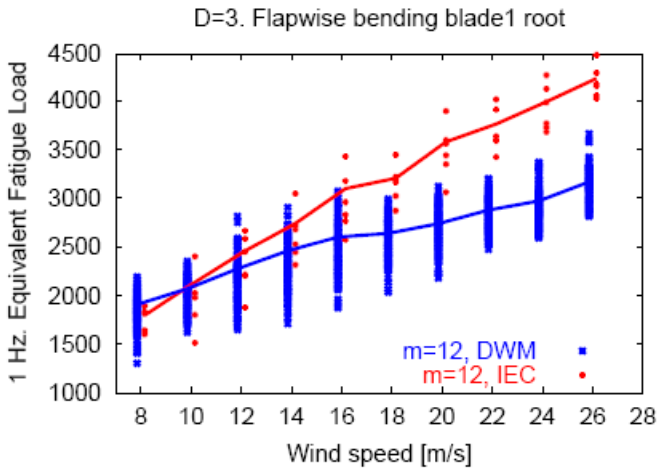


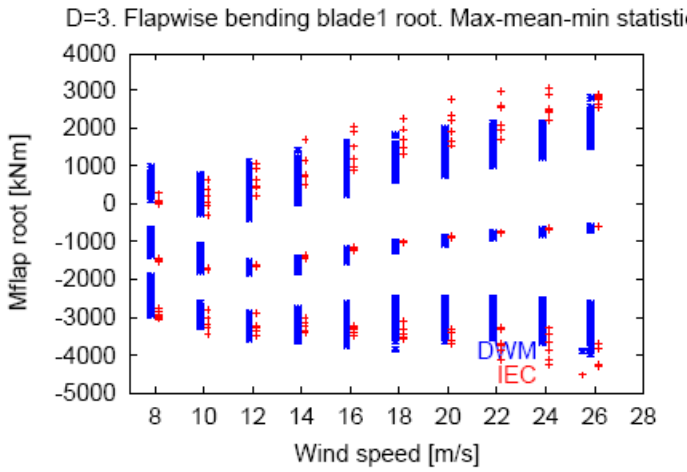


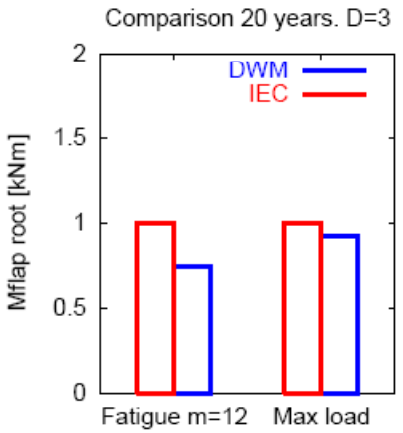


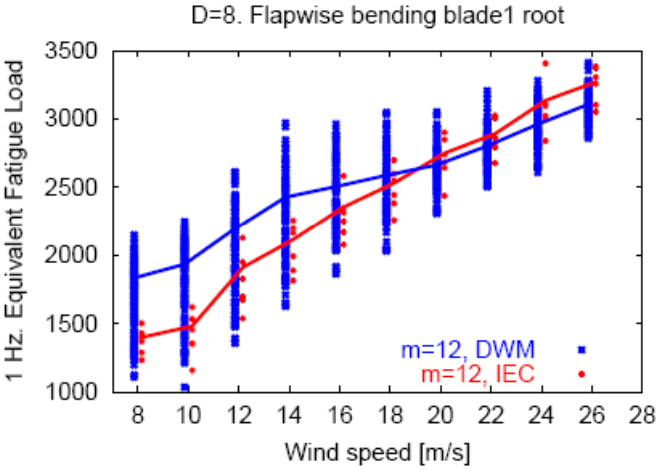


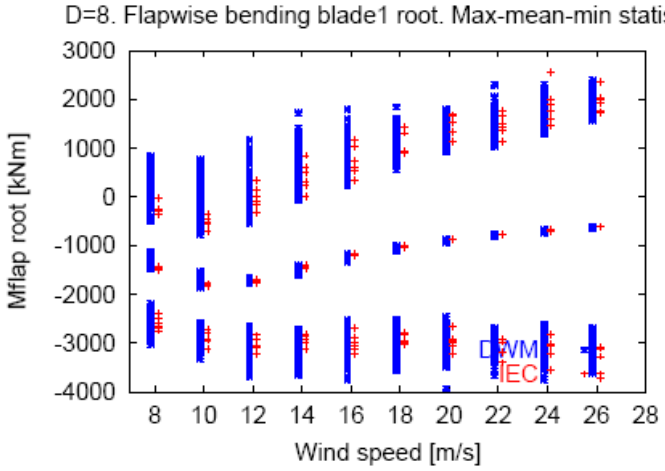
DWM – IEC Comparison 20 year production: Flapwise blade bending (pitching coo.)

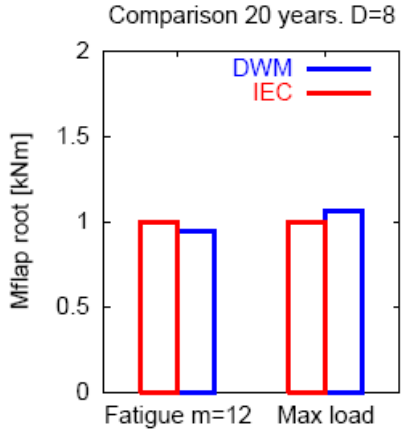




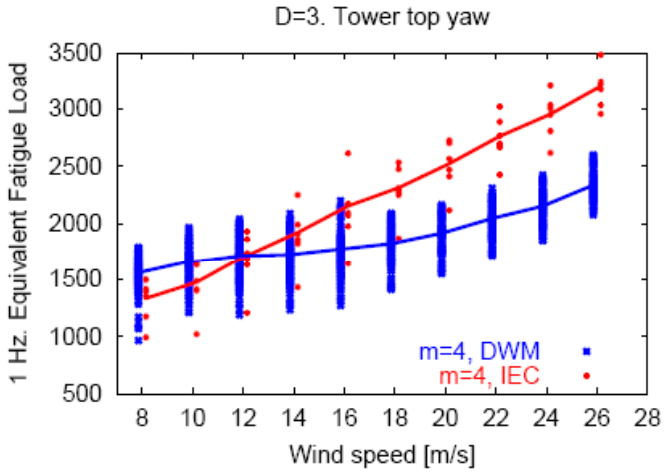


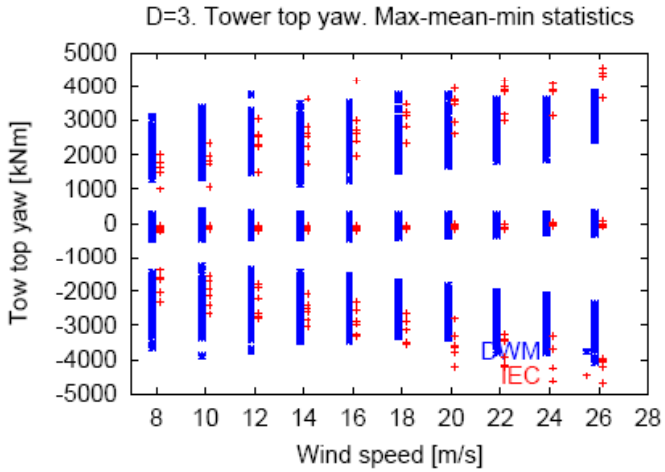


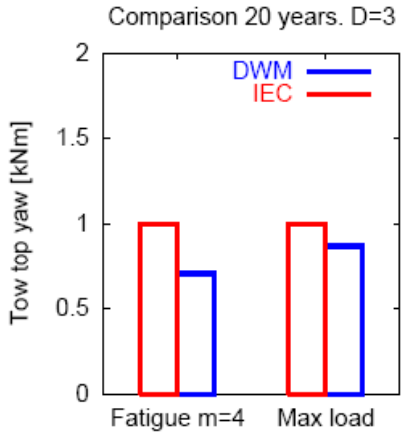


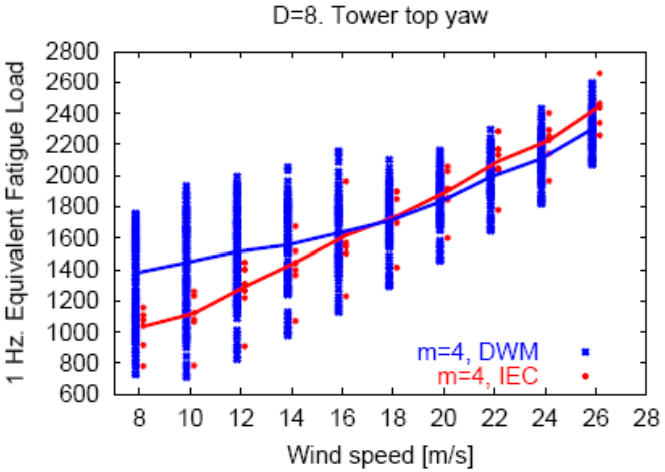


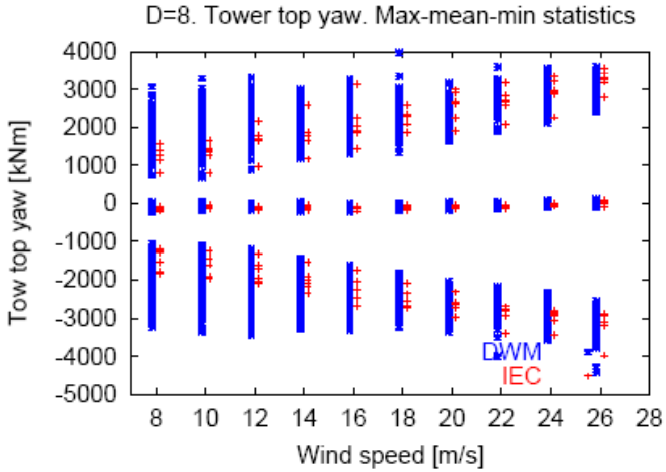
DWM – IEC Comparison 20 year production: Yaw bearing moment

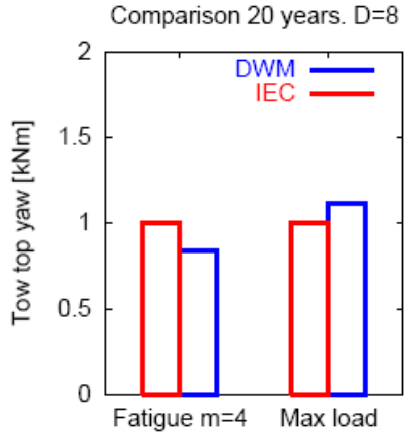




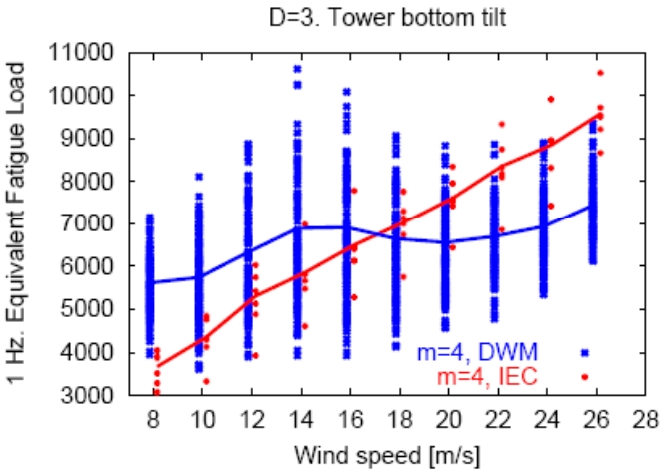


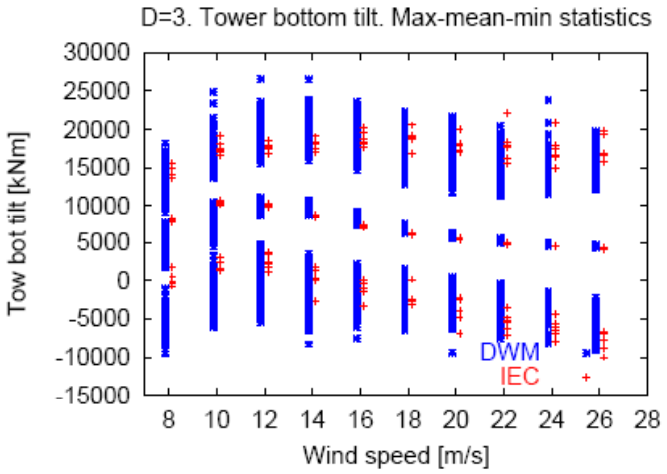


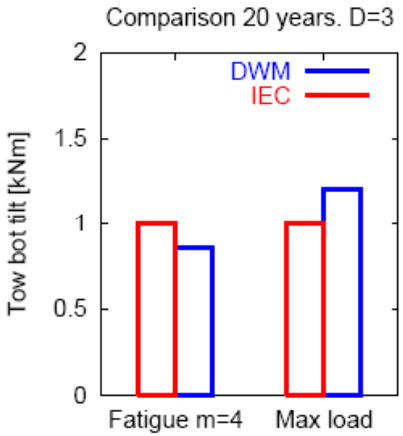


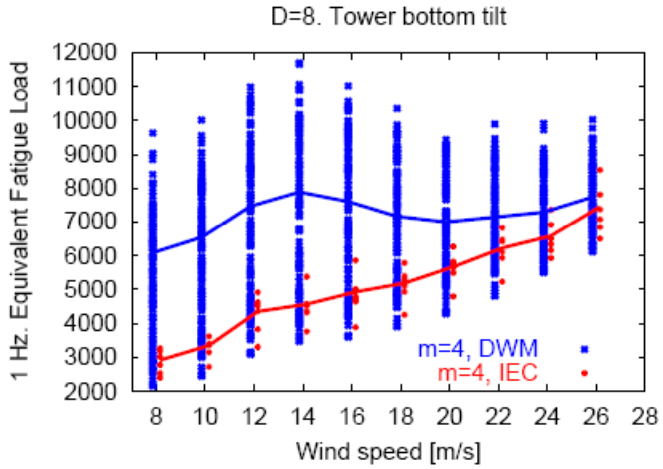


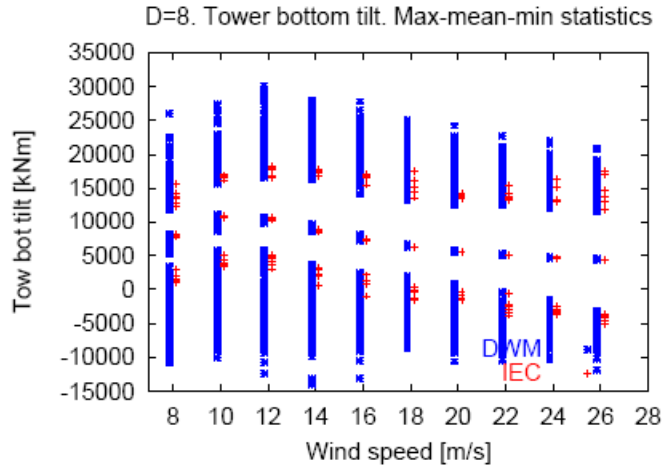
DWM – IEC Comparison 20 year production: Tower bottom tilt

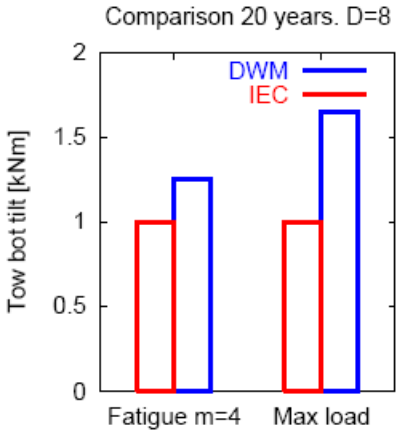




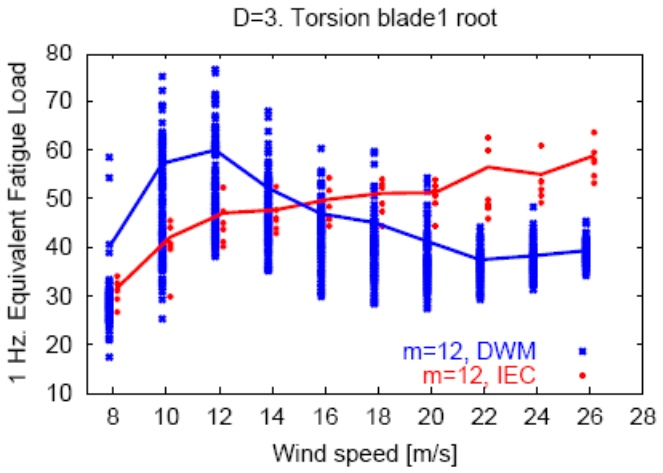


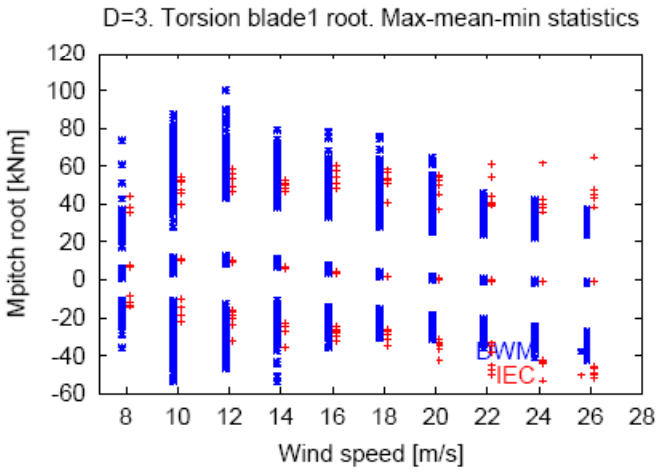


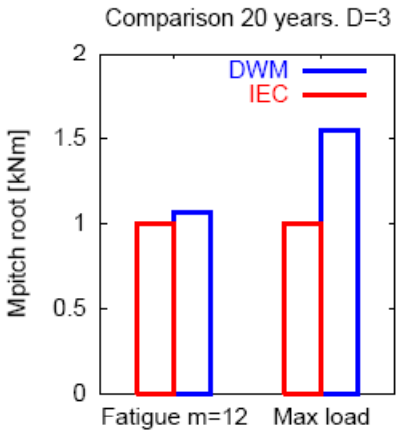


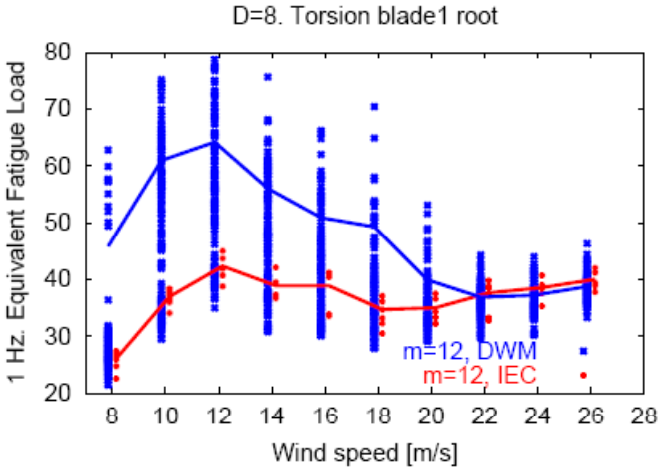


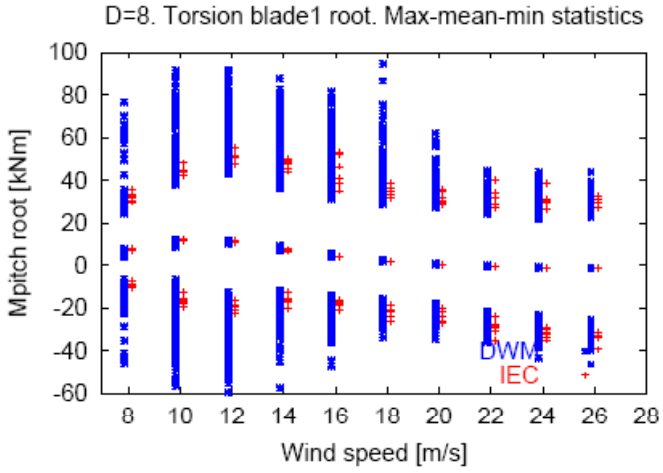
DWM – IEC Comparison 20 year production: Blade pitch moment at root

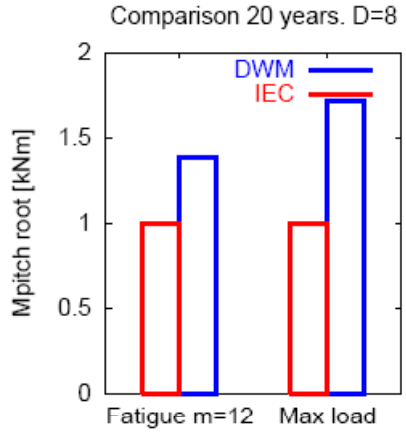












Conclusion

- 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.