Lessons learned from more than 10 years use of OpenFOAM® at Vestas

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This presentation gives an overview of the usage of OpenFOAM to build fully automated processes for wind resource assessment, site suitability and new concepts design at Vestas Wind Systems A/S during the last more than 10 years.

An OpenFOAM based multi-fidelity platform (VestasFOAM) is used for both predictive and forensic micro-siting of wind farms at Vestas as well as for new designs assessment. For predictive analyses, a fully automated VestasFOAM process can be launched by siting engineers without any prior knowledge of CFD. The process includes many in-house developed pre- and post-processing tools, a commercial meshing tool, and an OpenFOAM steady RANS solver, using a modified k-ε turbulence model adjusted to comply with the atmospheric boundary layer physics. Relevant outputs are: Spatial variability of wind speed, turbulence intensity, inflow angle, wind shear and wind direction. Data from meteorological mast measurements on the site are used to scale the wind speed distributions as well as the other wind flow parameters for site suitability and resource assessment. For forensic analyses, several levels of model fidelity can be utilized: from unsteady RANS for the simulation of the diurnal cycle, through Hybrid RANS/LES model to identify the risk of turbines experiencing rapid wind flow changes outside their design specifications, up to Large Eddy Simulation with Actuator Line Models to simulate wake interactions of wind turbines in a wind farm. Fig. 1,2,10 and 11 show some of the typical outputs generated from VestasFOAM.

For run time optimization purposes, most recently a comparison study between different versions of OpenFOAM (2.1.x vs. 6) and different compilers (gcc vs. intel) was performed. The wind siting tutorial of OpenFOAM-6 has been used for the performance comparison. Results can be found in Table 1.

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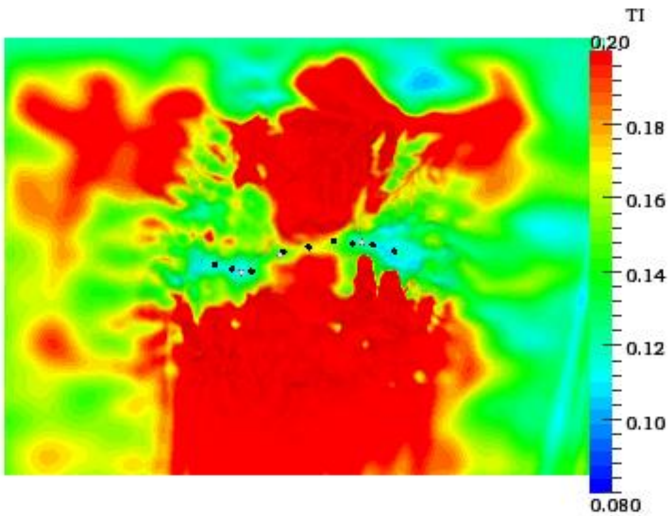

Fig 1: Turbulence intensity at turbine hub height

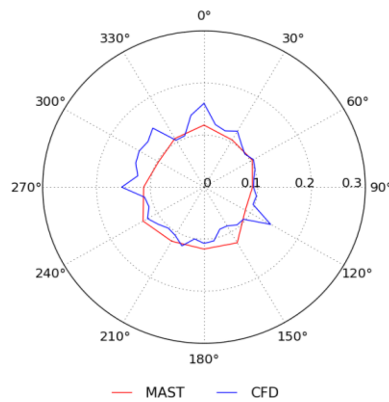

Fig 2: Turbulence intensity measured vs. CFD

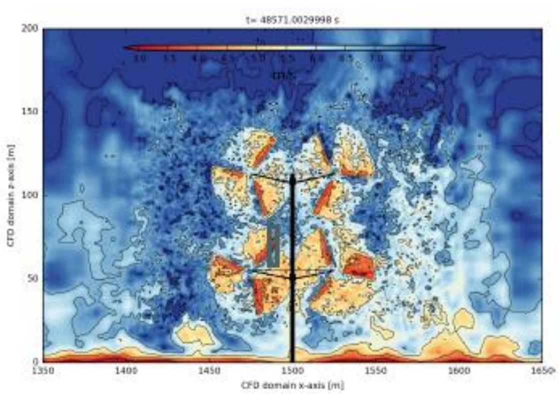

Figure 10 Instantaneous flow field at the MRWT rotor discs seen from downwind. The transition from very fine mesh to fine mesh is clearly seen with a sudden change of the eddy sizes.

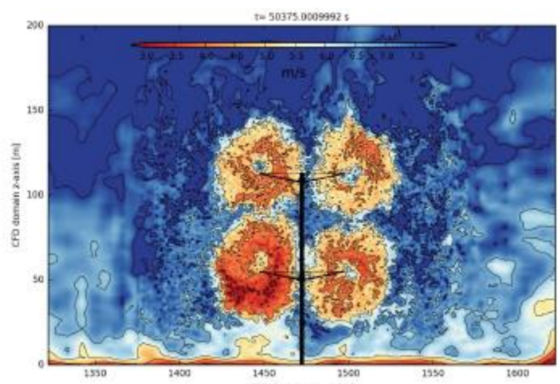

Figure 11 Instantaneous flow field at 1D downstream seen from downwind. One can clearly see the highly loaded T1 SRWT as opposed to his neighbor T2, due to the turbulent inflow.

Compiler	Runtime [s]	Compiler	Runtime [s]
gcc 4.8.5	319.6	intel openmpi	319.0
gcc 4.8.5 – optimized	320.2	intel openmpi – optimized	333.3
gcc 7.3.0	329.8	intel intelmpi	324.6
gcc 7.3.0 – optimized	327.2	intel intelmpi – optimized	325.7

Table 1: Runtimes of OF-6 wind farm tutorial using different compilers and optimization flags