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EMPLOYING CFD METHODS FOR DESCRIBING THE INFLUENCE OF OFFSHORE STRUCTURES ON WIND MEASUREMENTS

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Introduction

Large amount of meteorological data collected on offshore structures, such as platforms, masts and ships in the North Sea, often suffers from poor availability and poor quality. Thus it may not currently be used for validation of mesoscale models and must be disregarded as influenced by the structures. Performing an analysis on microscale can serve for understanding and predicting inconsistencies between measured and model data [1,2,3].

In this study we compare wind measurements influenced by a typical offshore structure (Draugen oil platform) with the corresponding numerical observations and demonstrate the usability of Computational Fluid Dynamics (CFD) for data validation and improvement of the meteorological models.

CFD model set up

Construction of the platform numerical model, meshing and calculations were performed using ANSYS simulation software, including ANSYS Fluent for CFD simulation and data post processing.

The geometry of the platform (Fig. 1) was simplified due to computational power limitations. We omitted small details which size was of an order of centimeters, and focused on big parts that are especially important for capturing the wakes. The fluid domain contained air, while the sea surface was flat. Thus the effect of waves was neglected.

Mesh generation:

- tetrahedral grid;
- mesh size adaption based on proximity and curvature;
- inflation at all platform parts;
- ~ 1.3 million cells.

Model physics:

- single phase air flow in the domain;
- SST *k-ω* turbulence model;
- steady state solution;
- velocity inlet boundaries (velocity vector specified);
- pressure outlets.

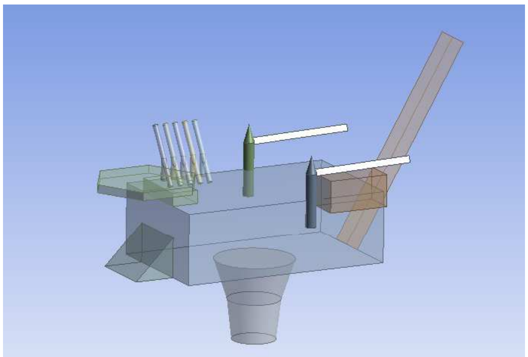

Fig. 1. CAD model of Draugen oil platform

Simulation results and data validation

Results were obtained at a probe located in accordance with the real equipment on Draugen. CFD model input was the CFSR [4] data. Simulation probe data was compared with the real measurements in terms of normalized wind speed bias from the reference value (Fig. 2). The reference value was the boundary condition velocity for the CFD model and the CSFR data for the real velocity measurements:

$$\text{Norm. bias} = \frac{\text{wind speed} - \text{wind speed ref. value}}{\text{wind speed ref. value}}$$

Wind speed was obtained for different wind directions stepped by 45º.

Due to natural wind variations not captured by the steady state simulation, the measurement data points were take in the range of ±20% from the reference wind speed.

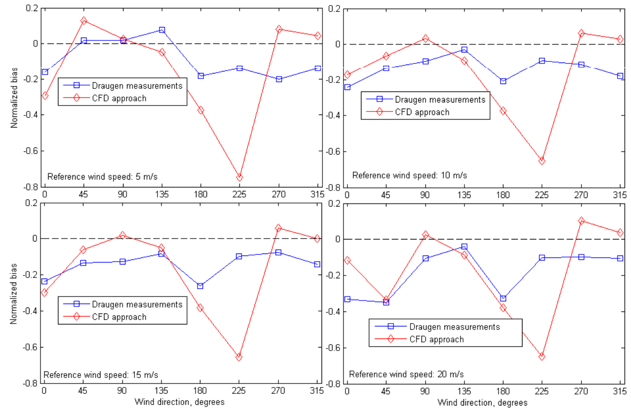

Fig. 2. Normalized bias of the wind speed measured at the platform and obtained during the CFD analysis plotted for different wind directions

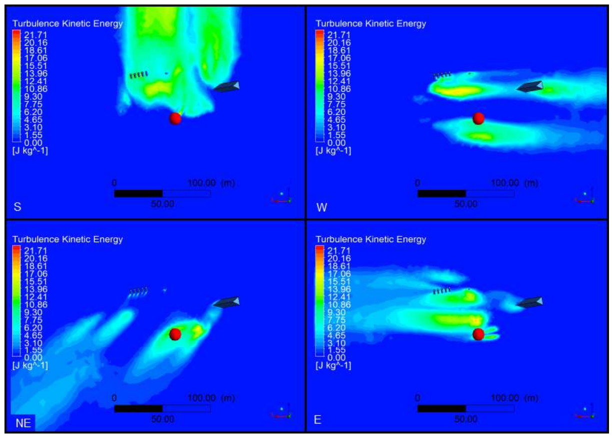

Fig. 3. Turbulent kinetic energy contours plotted on a cross-section plane for 4 cases with 15 m/s wind speed and different wind directions

Conclusions and discussions

The analysis results confirm that CFD methods can be used for prediction of structure influence on meteorological measurements and qualification of model data. The CFD analysis data points on Fig. 2 demonstrate similar tendency as the CFSR model data. Though some points do not line up very well, their inconsistency can easily be explained.

Special attention must be paid to the cases with north-east wind direction, where inconsistency of the CFD model is very high (points at 225 degrees on Fig. 3). On Fig. 3 it is seen that the observation point in NE-case was located in the middle of the turbulent wake with high kinetic energies, which led to significant velocity disturbance.

Turbulence is by nature the unsteady process which can hardly be resolved during a steady state analysis, where time-dependent fluctuations of both wind speed and direction are not captured. Though, a steady state result is sufficient for the basic description of the problem, transient or stochastic simulation should be performed in order to achieve better accuracy.

References:

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