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Computational and Experimental Study on the effect of flow field distortion on the accuracy of the measurements made by anemometers on the Fino3 Meteorological mast

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Abstract

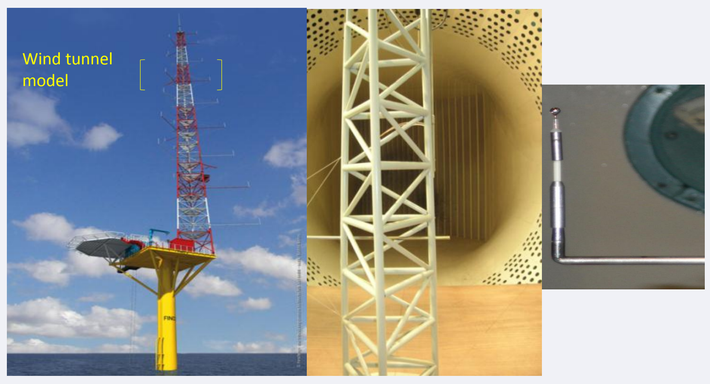
This paper reports on the experimental and computational modelling of the flow field around the FINO3 mast and provides an estimate of the amount of distortion that might be expected on instrumentation mounted on such a large structure. The open source C++ toolbox OpenFOAM was used for the CFD analysis. In order to validate the CFD model, experimental work was carried out in an open section wind tunnel using hot wire anemometry to measure the velocity profile around a sub-scale model of part of the FINO3 mast. The experimental data are in good agreement with the data from the CFD simulation

Objectives

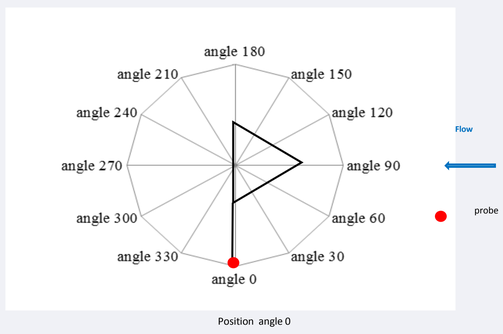
From the summer of 2009, the FINO3 mast located on an offshore platform 45 nautical miles north west of the island of Sylt off the Danish coast has been recording data to assess the technological and ecological challenges associated with offshore wind power. Research projects using the data from the mast generate new and useful results on foundation structures, wind and wave loads, lightning intensity, supply and a number of other offshore-related parameters. FINO3 is an area where several wind farms with a total of 320 power stations have been schedule for construction. To date the effects of flow distortion on the measurements made by the instrumentation mounted on the booms has not been quantitatively assessed and this has required the data to be filtered based on qualitative estimates of possible flow directions where it may be assumed that the flow passing over the instrumentation is unaffected by the mast structure. The goal of this work is to provide a quantitative assessment of the mast structure interference on the acquire data.

Methods

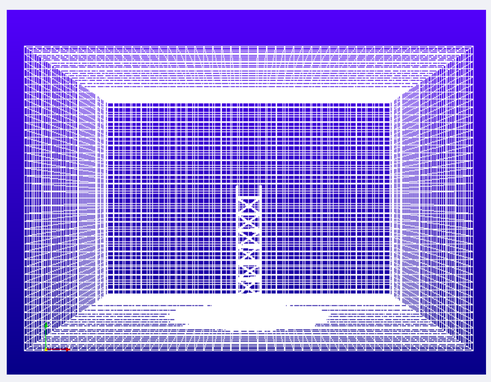
A model of part of the FINO3 mast was created at the scale 1/20. Flow velocities around the model were measured using a hot film probe attached at the end of the boom. To simulate the wind coming from different directions, the model was rotated around his centre in the wind tunnel.12 flow directions were considered. A single hot wire probe, taken velocity measurements upstream, was used to normalise all velocities measured around the model. The CFD simulation was carried out using the flow conditions based on the wind tunnel experiments. Separated meshes were created for each of the 12 flow directions considered and the problem was solved for each of the meshes.



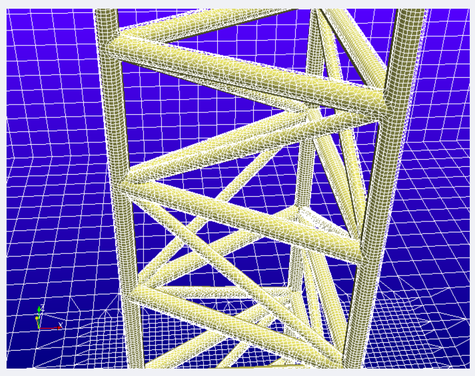
Model in the wind tunnel with measuring probe



Position of the model in the wind tunnel

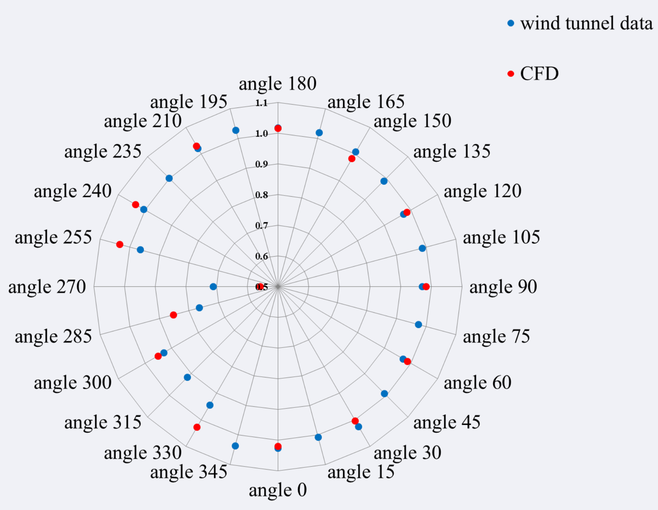


CFD mesh

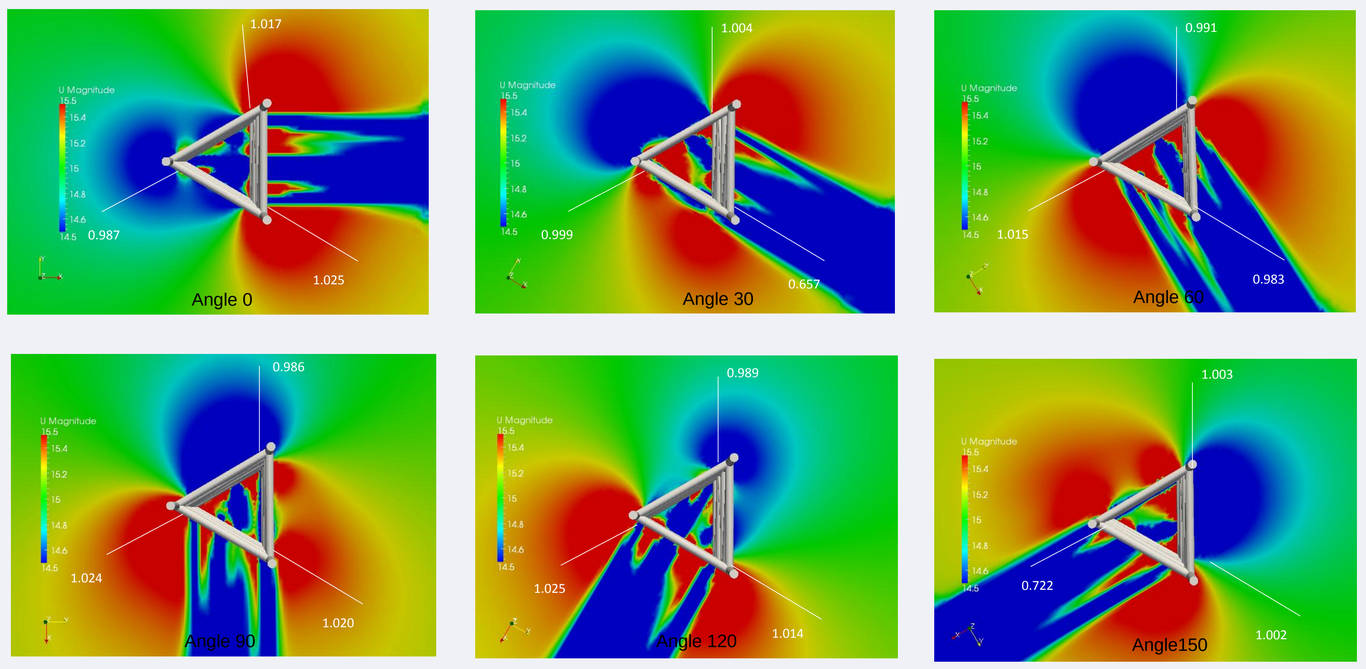


Surface mesh

Results



Non-dimensionalised velocity data around the model
Experimental and CFD data



Velocity contour for 6 flow directions with non-dimensionalised velocity at the end of each boom

Conclusions

Comparison of OpenFOAM and wind tunnel studies show good agreement for wind speed measurement around the mast. The CFD model can be used to get a good understanding of the interference effect due to the structure of the mast on anemometers mounted on the three different booms. The velocity contours allow to quantitatively assess the flow distortion on the measurements .

References

1.http://norsewind.eu