The most promising route for yield prediction in future wind renewable developments is through modelling and simulation, and the use of Computational Fluid Dynamics (CFD). The automotive and aircraft industries have already replaced the majority of their wind tunnel tests with CFD and the aero-space industry is fast following suit. While CFD has the potential to be very useful for the study of the environmental flows encountered in the wind industry — because it can deliver data that is difficult to measure or observe, under cli

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Feasibility study for estimating the offshore shear layer from on shore measurements

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Abstract

This paper presents an open source computational fluid dynamics (CFD) study of air flow over a complex terrain. The open source C++ toolbox OpenFOAM has been used for the CFD analysis and the terrain considered is a scale model of Berlengas Island, which lies close to the Portuguese coast. In order to validate the CFD model, experimental work has been carried out in an open-section wind tunnel using hot-wire anemometry to measure the wind profiles above the island. In the majority of cases, the OpenFOAM CFD solutions show very good agreement with the experimental wind profile data, confirming that open source CFD solutions are possible for environmental flows over complex terrain. Such an analysis demonstrates the feasibility of estimating offshore boundary layer effects from onshore measurements.

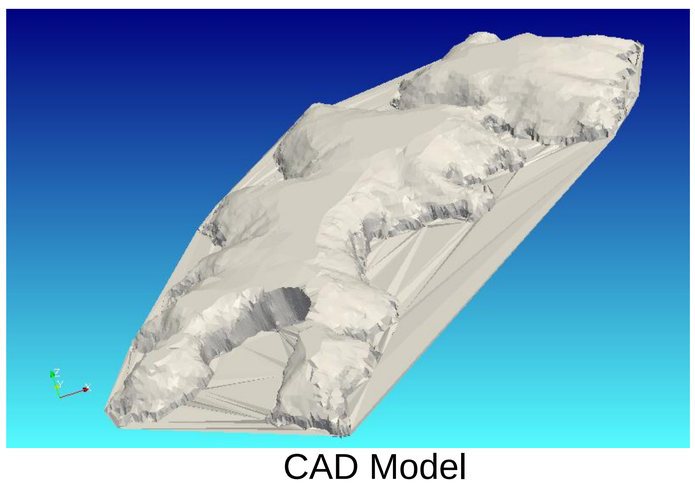
Objectives

The most promising route for yield prediction in future wind renewable developments is through modelling and simulation, and the use of Computational Fluid Dynamics (CFD). The automotive and aircraft industries have already replaced the majority of their wind tunnel tests with CFD and the aero-space industry is fast following suit. While CFD has the potential to be very useful for the study of the environmental flows encountered in the wind industry — because it can deliver data that is difficult to measure or observe, under climate conditions we cannot reproduce in a laboratory — it still faces major challenges, especially if there are significant variations in the land topography. The goal of this work is to use open source CFD to assess its efficacy in predicting flows involving complex terrain.

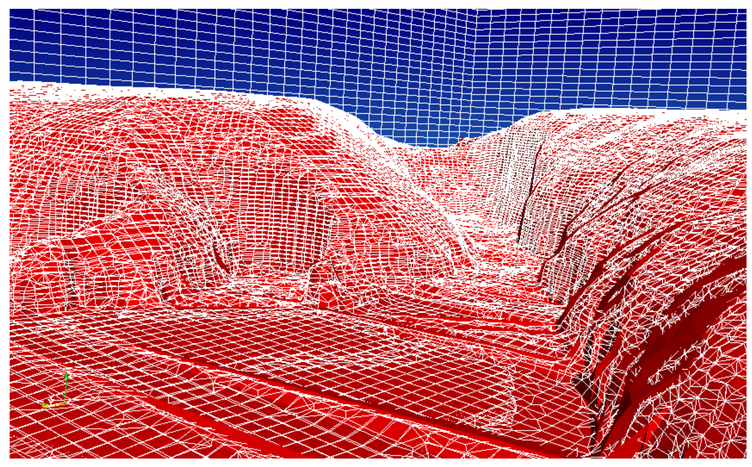
Methods

This paper considers an experimental and numerical analysis of air flow over a complex terrain in order to further assess the capabilities of open source CFD in such situations. The terrain considered is a scale model of Berlengas Island, which lies close to Lisbon on the Portuguese coast, as shown below. The work has been carried out as part of the EU Norsewind project [1] whose primary goal is to create an offshore wind atlas of European waters for use in wind exploitation. In order to validate our OpenFOAM CFD model, experimental work has been carried out in an open-section wind tunnel using hot-wire anemometry to measure the wind profiles above the island. The results build upon previous open source CFD work [2, 3] in that the level of topological complexity has been increased to include valleys, escarpments, steep cliffs and rocky outcrops. This paper makes a novel contribution to knowledge in the field of open source CFD applied to complex terrain and provides experimental data to validate the numerical results.

Berlengas Island

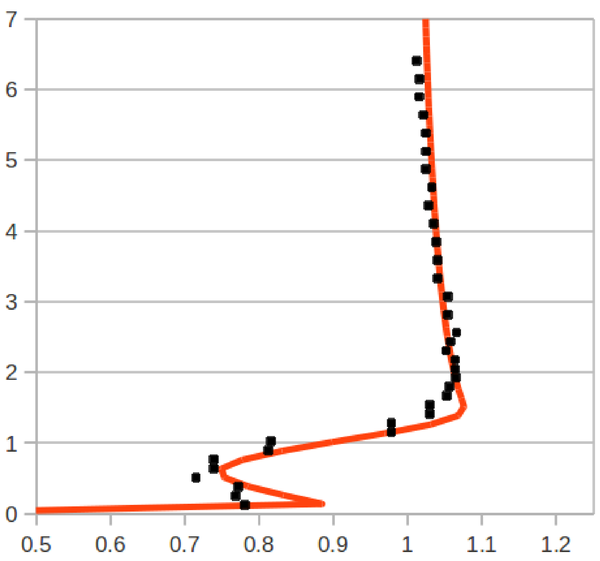


CAD Model

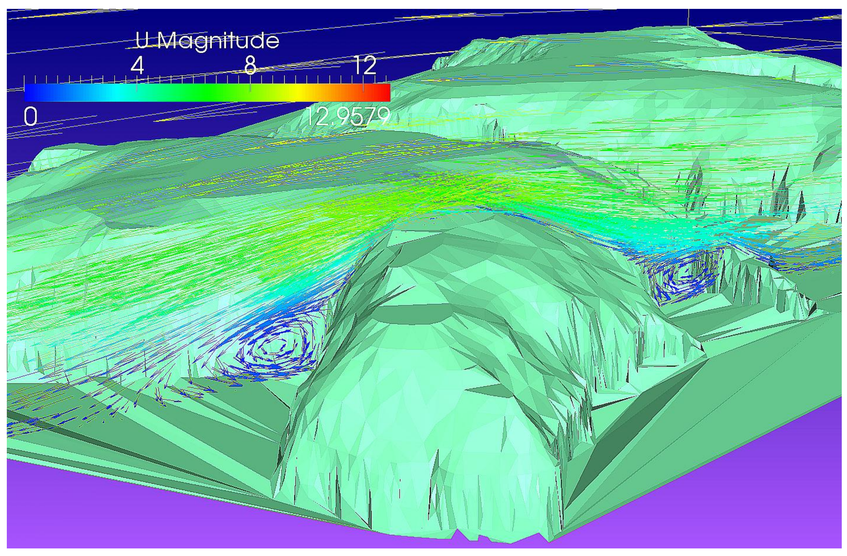


CFD Mesh

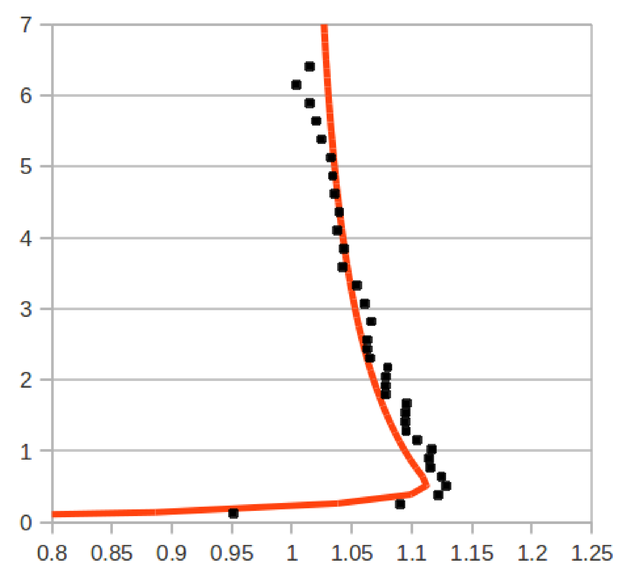
Results



CFD (line) and wind tunnel (symbols) comparison – 210°



Velocity vectors around island



CFD (line) and wind tunnel (symbols) comparison – 120°

Conclusions

The open source CFD code OpenFOAM has been used in a study of air flow over a complex terrain. Comparisons of OpenFOAM and wind tunnel studies show very good agreement for wind speed measurements above the island and flow separation and recirculation features in island canyons have been captured successfully. These results confirm that open source CFD solutions on a modest hardware budget are feasible for environmental flows over complex terrain. Finally, the cost benefits and open source nature of the OpenFOAM code mean that it has the potential reach a wider audience within the current wind energy analysis community.

References

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