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# ADVANCES IN CFD FOREST MODELING IN WIND RESOURCE ASESSMENT

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## Abstract

Forested areas are known to strongly affect the shape of the vertical wind and turbulence profiles in their vicinity and for some distance downstream. This has been a challenge for wind park developers who wish to build parks in or near forested areas, and the presence of forests can greatly complicate modeling approaches at estimating the energy yield for a park. Computational Fluid Dynamics (CFD) techniques are used to simulate the effects of forested areas by including porous cells with momentum sinks and turbulence sources in the computational grid of the CFD for areas of the grid which include forest. This approach is now enhanced by new remote-sensing datasets which can give the forest canopy heights across the site area, allowing the CFD model to more accurately account for variations in forest height and density. Whether these new data sets can improve the CFD results has been investigated on several forested sites and the results will be discussed in the following.

## Data base

Perhaps the most commonly used data source for site assessment in Europe is www.dataforwind.com. This data (here referred to as DFW) has a resolution of about 90m for the digital terrain and the roughness. The roughness is given as discrete values.

A resolution of 90m is not accurate enough to give reliable CFD simulations in complex terrain. The resolution of data sets used for CFD analysis in complex terrain should be 25m or better.

Intermap offers a new dataset with a horizontal resolution of 5m for both the terrain model and the continuous vegetation canopy height model. The data has been acquired by an airborne radar. The Intermap dataset is available for the majority of Europe now.

## Flat terrain

The met tower in Karlsruhe in southwestern of Germany is an ideal site for studying the flow behavior over flat terrain. The terrain height difference in the simulation area is less then 10 m and the wind coming from south is blowing several kilometers over an evenly forested area before reaching the measurement mast (Fig.1). The measurement mast has nearly a decade wind speed measurements up to 200 m.

From the Intermap vegetation height three main roughness heights where classified for the forested area while the DFW dataset classifies the forested area as one uniform roughness. For the CFD simulation with the Intermap terrain data we thus applied a forest with three different heights (25, 30 and 35 m) while for the simulation with the DFW data we used a forest with a single height (30m).

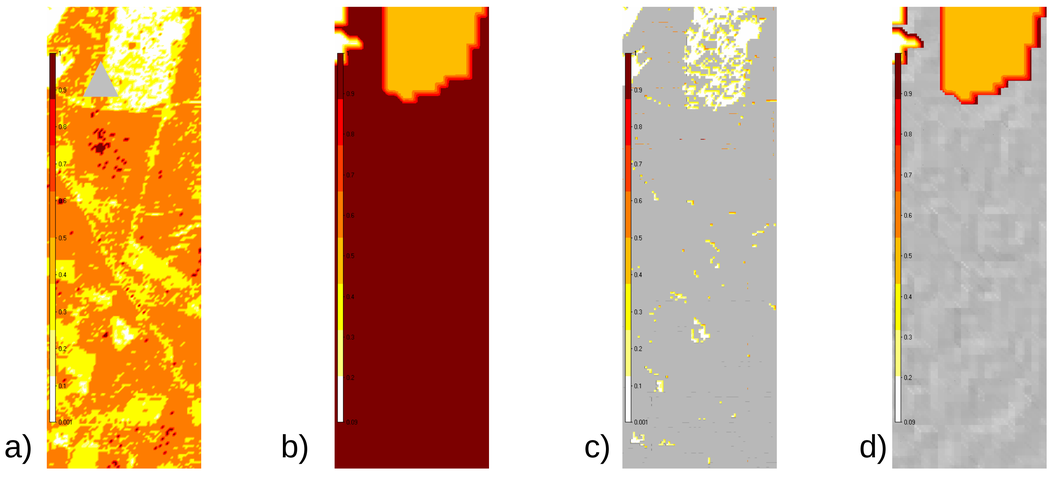



*Fig. 1: Roughness height distribution for the Intermap (a) and the DFW data (b) and forested area shaded in grey for the Intermap (c) and the DFW data (d). The grey triangle marks the measurement mast (a).*

The advantage of using different forest heights can be seen clearly when looking at the wind profile when simulating southerly wind. The wind profile in the forest is much better represented with the Intermap simulation (Fig. 2).

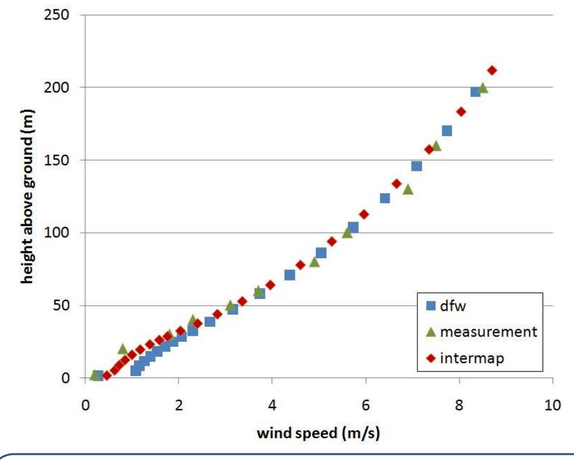
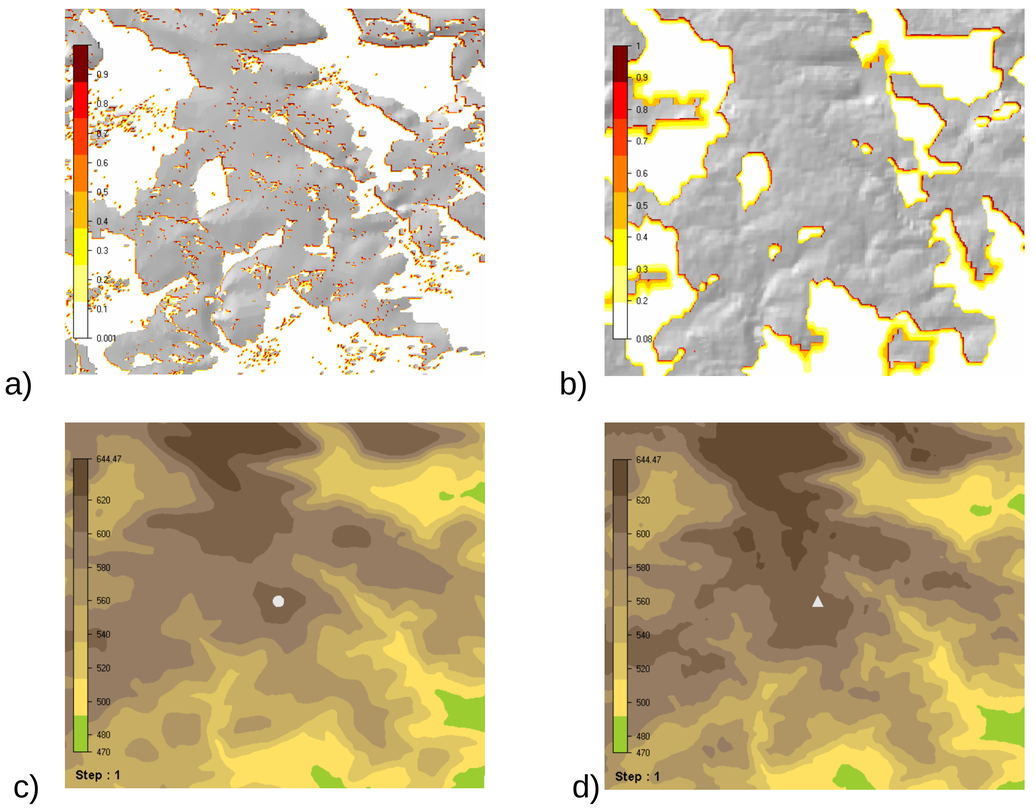



*Fig. 2: Simulated and measured wind speed for the 180 degree wind direction.*

## Complex terrain




*Fig, 3: Forested areas with the Intermap dataset (a) and with the DFW data set (b) shaded in gray. Also terrain height from the Intermap data set (c) and the DFW data set (d). The met mast position is given by the gray dot/triangle.*

Also in the case of a more complex forested site the simulation with the Intermap data shows better results than the simulation with the DFW data when the wind is blowing for a long time over the forested area before it reaches the measurement mast (Fig. 4).

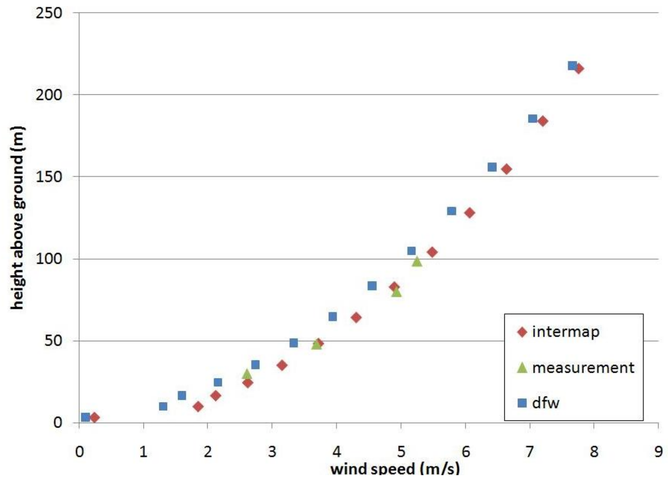



*Fig. 4: Comparison for the measurements, Intermap and DFW data for the 330 degree wind direction.*

## Conclusions

- A new high resolution (5m) dataset from Intermap is available which allows to account better for the effect of forested areas in CFD tools
- The commercial CFD tool WindSim has created a specialized interface to import and handle this data
- Due to the more diversified simulation of the forest the simulated wind profiles fit better to the observed ones

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