Deliverable Summary Report: D2.2

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Work Package: *WP 2 – 'WP2: Parameters to flow models and global case studies'*
Deliverable name: *D2.2 – 'Case studies completed for min. 6 sites'*
Deliverable status: *Completed*

Deliverable description

T2.3 Case studies at global sites incl. validation (Vestas, Vattenfall, DTU WE)

The 10 sites selected in Task 2.2 will be used for validation of flow models runs with novel satellite based inputs. The effect of using new satellite based input layers will be quantified through comparisons of the modelled wind speed and wind resources with site observations.

Expected outcome:

- Interim assessment of the effect of using novel data layers in flow models (M5)
- Report on the case studies incl. results of validation studies (D2.2)

Activities and tasks completed

- DTU identified 9 sites from their databases of sites.
- DTU performed quality control for the wind measurements at all sites.
- Extent and projection of the maps was chosen to be 40x40 km in the UTM coordinate system
- Vattenfall is currently looking at the results at a site in Scotland (Dumfries) using WindPro
- DTU space is currently processing the coherence data for the last three sites from Siemens, which form the basis for the tree height maps
- Report on the case studies incl. results of validation studies has been presented to all partners

Deliverables and outcomes

Site selection and data preparation

Table 1: Sites where flow models have been (green) or will be (white) evaluated.

Order (priority)	Name
1	Østerild, Denmark
2	Ryningsnäs, Sweden
3	Sweden
4	Perdigao, Portugal
5	Risø, Denmark
6	Humansdorp, South Africa
7	Alaiz

8	Mast 2 of MEWA
9	Mast 3 of MEWA
10	Dumfries
11	Vattenfall Sweden
12	Site G
13	Site H
14	Site I

The green sites have been fully processed and have been used for model validation. Due to confidentiality of some of the sites, the locations are not given.

Østerild, Ryningsnäs and the confidential Swedish site have been given high priority, because they are located directly in the forest and the landscape is highly heterogeneous and challenging for wind resource models. Despite their complexity the sites of Perdigao and Alaiz were included because they have many high quality measurements available that are also used in other ongoing projects. Furthermore it also provides an interesting opportunity to see whether the new land cover maps improve the flow model performance in complex terrain as well.

Two recently installed masts in Mexico and one in South Africa were included because it will be interesting to compare the performance in different parts of the world; the ICESAT2 data, that are used for calibration, have non-uniform coverage and particularly at MEWA mast 3 was not very promising. The quality control of the wind measurements showed that a suitable period could be identified for all sites.

Wind resource assessment at the sites
An extensive analysis of the results at 9 of the 10 sites shown in green in Table 1 has been performed. The main result is shown in Fig. 1. The relative errors in predicted power density is shown for 3 traditional land cover databases (first three bars, ESA, GLOBCOVER and MODIS) and the new maps based on Sentinel and machine learning techniques that are the result of WP1. Several setups of the new maps were performed (last 5 bars). All of the new approaches have much lower errors (~9%) in power density than the land cover databases (>10%). This shows that the WAsP model benefits from the newly created data layers.

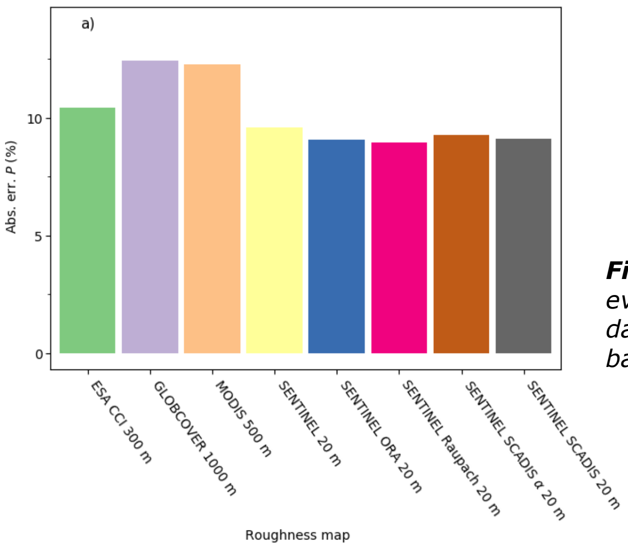

Figure 1 *Mean relative error in power density at all evaluated sites using traditional land cover databases (first three bars) and the new Sentinel based satellite maps (remaining bars).*

Publication of test results

For maximum impact it was decided to publish the results in a well-known wind energy journal. This document is currently in preparation and the main results are promising. The following items are reported in this article:

- Description of the new roughness processing in the WAsP model that was created to be able to deal with displacement length
- Description of 3 ways of converting land cover classes, tree height and leaf-area index into a roughness length and displacement height.
- Description of the 9 sites and why the performance is different from site to site
- Model evaluation using cross-predictions (predicting the wind climate from one location to another one): the key error metric is the relative error in power density, which is most important for the annual energy production of wind turbines.

The main conclusions of the article are that:

- The sentinel based maps perform significantly better than standard landcover databases
- The difference between the different forest parametrizations is small, but the Raupach (1994) model generally has the lowest errors.
- Using lidar data for calibration can further improve the description of land cover, particularly in forested areas with small-scale clearings (where wind measurement campaigns are frequently performed).
- Also areas with rather poor coverage of ICESAT2 data resulted in reasonable roughness maps.

Deviations and solutions

It was decided to let industry partners participate in the evaluation to build trust in the newly created maps. During the project discussions it became clear that a larger number of sites was needed to develop trust in the new models. Therefore the list of sites was extended with two sites from Vattenfall and three from Siemens, although the target of an evaluation at 6 sites has already been reached.

References

Floors, R. et al. The impact of surface roughness description on wind resource modelling Wind Energy Science (in prep.)

Raupach, M. R. (1994). Simplified expressions for vegetation roughness length and zero-plane displacement as functions of canopy height and area index. Boundary-Layer Meteorology, 71(1–2), 211–216. https://doi.org/10.1007/BF00709229