Milestone Summary Report: M5

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Work Package: *WP 2 – 'Parameters to flow models and global case studies'*
Milestone name: *M5 – Interim assessment of the effect of using novel data layers in flow models'*
Milestone status: *Completed*

Milestone description

T2.3 Case studies at global sites incl. validation:
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.

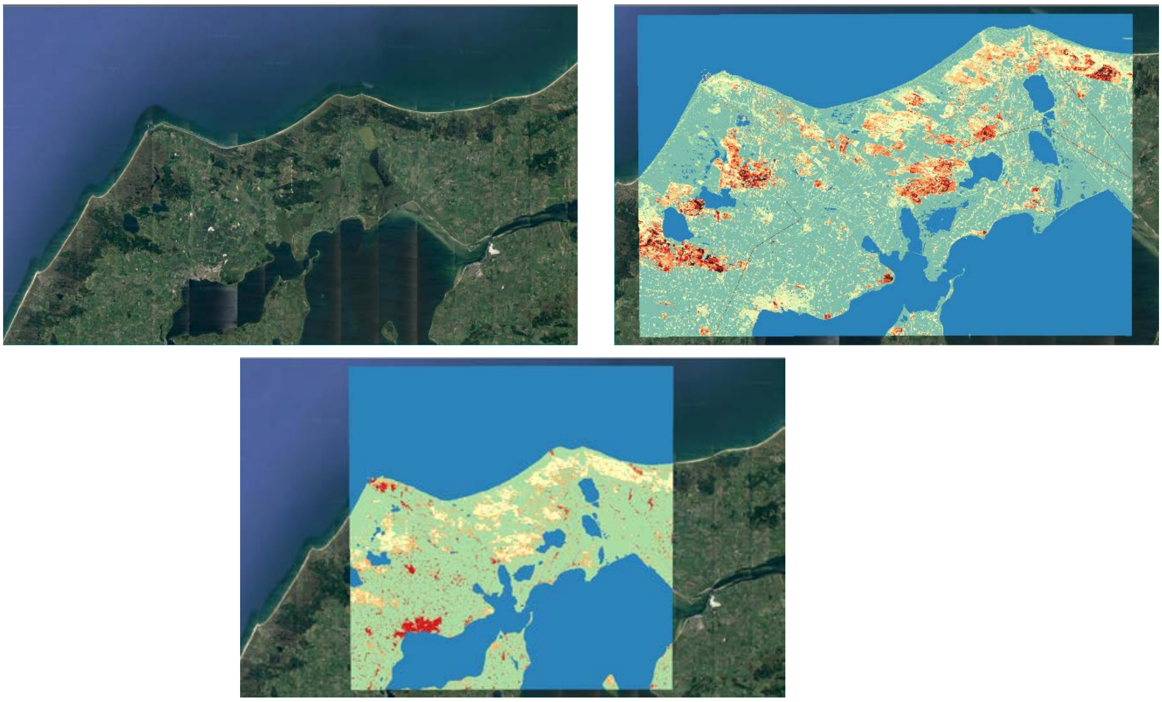
Expected outcome:
Interim assessment of the effect of using novel data layers in flow models (M5)
Report on the case studies incl. results of validation studies (D2.2)

Activities and tasks completed

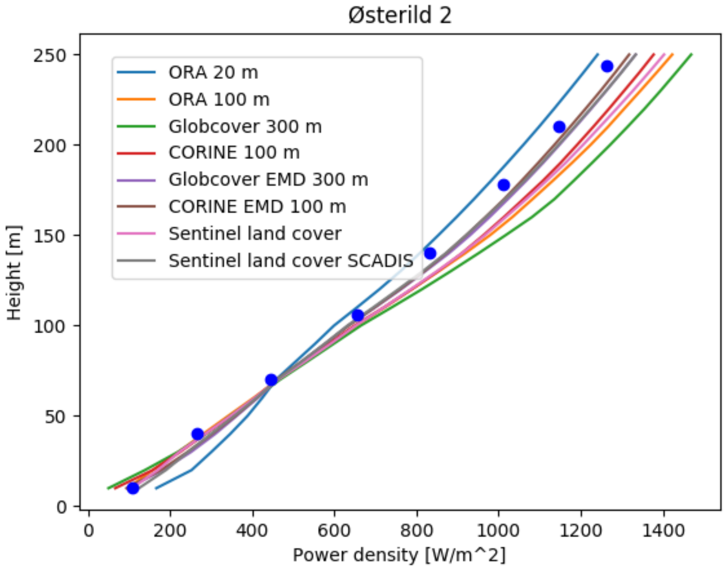
Interim assessment in connection with mesoscale modeling:
Vestas has tested tree height products from DHI GRAS in a WRF simulation over Southern Sweden. It showed improved estimation of wind speed near the surface. However, the initial positive bias was converted to a negative bias, indicating that the simple conversion from tree height to roughness that was used, is not as accurate as it should be. Therefore, in 2019 further investigations to include leaf area index in the conversion from tree height to roughness lengths will be performed. Leaf area index is therefore included in the requirement analysis.

Interim assessment in connection with microscale modeling:
At the Danish test site Østerild, a large amount of satellite based data layers, aerial lidar scans, and ground truth data have been collected and structured – ready to be used for sensitivity testing in a flow model.

The first visual comparison at the Østerild site reveales very good agreement between Google Earth, the ground-truth lidar scans, and the layer based on Sentinel 2 data from DHI GRAS. In addition, DHI GRAS has also provided maps of leaf area index and tree height. Using these roughness maps, we are able to provide the first comparisons between wind speeds observations from model predictions with the flow modeling tool WasP 12.1 and compare the results with some of the traditional sources for land cover information. Here we compare some results from the 250 m tall northerly meteorological mast at Østerild:



Comparison of a satellite layer from Google Earth (top left), the 'ground-truth' lidar scans (top right) and the landcover product from DHI (bottom).



Comparison of power density estimations from the observations (blue points) and the model predictions using different maps as model input. The ORA approach is based on the 'ground truth' lidar scans, whereas the maps based on Sentinel 2 data from DHI GRAS are labelled with 'Sentinel'. A first implementation to convert tree height and leaf area index to roughness has been labelled as 'SCADIS'.

It can be seen that there is large variation in the predicted power density, which indicates the impact and importance of using correct roughness maps in wind resource modelling. All model predictions fit well at 70 m because this height was used as input for the model.

Because these profiles are generated from the observed wind climate at only one height, it is more instructive to compare the WasP model by performing cross-predictions from one height to another one. The results of such a comparison, which gives 72 pairs of observed and modelled wind speed distributions, is shown in Table 1.

scheme	RMSEP	RMSEU
GLOB	42.36	9.00
MODIS	27.20	6.79
CORINE	20.92	6.04
ORA100	14.48	3.73
ORA20	14.32	6.38
SENTINEL	7.31	3.52
$SENTINEL_{ORA}$	5.14	4.20
$SENTINEL_{SCADIS}$	4.77	3.95

Table 1. Comparison of the root-mean-square error in power density (RMSEP) and wind speed (RMSEU) between model runs and observations from 72 vertical and horizontal cross-predictions at Østerild using different land cover maps as input from the WasP 12.1 model.

The errors between model and observations are highest for the GLOB, MODIS and CORINE land cover databases, which represent the current options for obtaining roughness information. Alternatively, the lidar scans results can be converted using the 'objective roughness approach' at resolutions of 20 and 100 m, which are labelled ORA20 and ORA100, respectively. The ORA approach is described in Floors et. al. (2018) and is based on simple conversion from tree height to roughness and displacement height. Finally, model runs are performed using the sentinel data: three approaches are attempted:

- Sentinel roughness and displacement maps by assigning ad-hoc roughness values to each of the landuse classes (label SENTINEL)
- Sentinel roughness and displacement maps based on land cover classes, but where the roughness of forest areas are prescribed using the ORA approach (label $SENTINEL_{ORA}$)
- Sentinel roughness and displacement maps based on land cover classes, but where the roughness of forest areas was determined by a simple canopy model (label $SENTINEL_{SCADIS}$)

Deliverables and outcomes

The interim assessment presented here suggests an improved accuracy of wind resource estimates when novel data layers from InnoWind are used as input to flow models instead of the global data sets that are typically used. This goes for both mesoscale and microscale model simulations. More sites must be analyzed in order to make firmer conclusions and this will be the main focus of InnoWind's third project year.

References

Floors, R., Enevoldsen, P., Davis, N., Arnqvist, J., and Dellwik, E (2018): From lidar scans to roughness maps for wind resource modelling in forested areas, Wind Energ. Sci., 3, 353-370, https://doi.org/10.5194/wes-3-353-2018.