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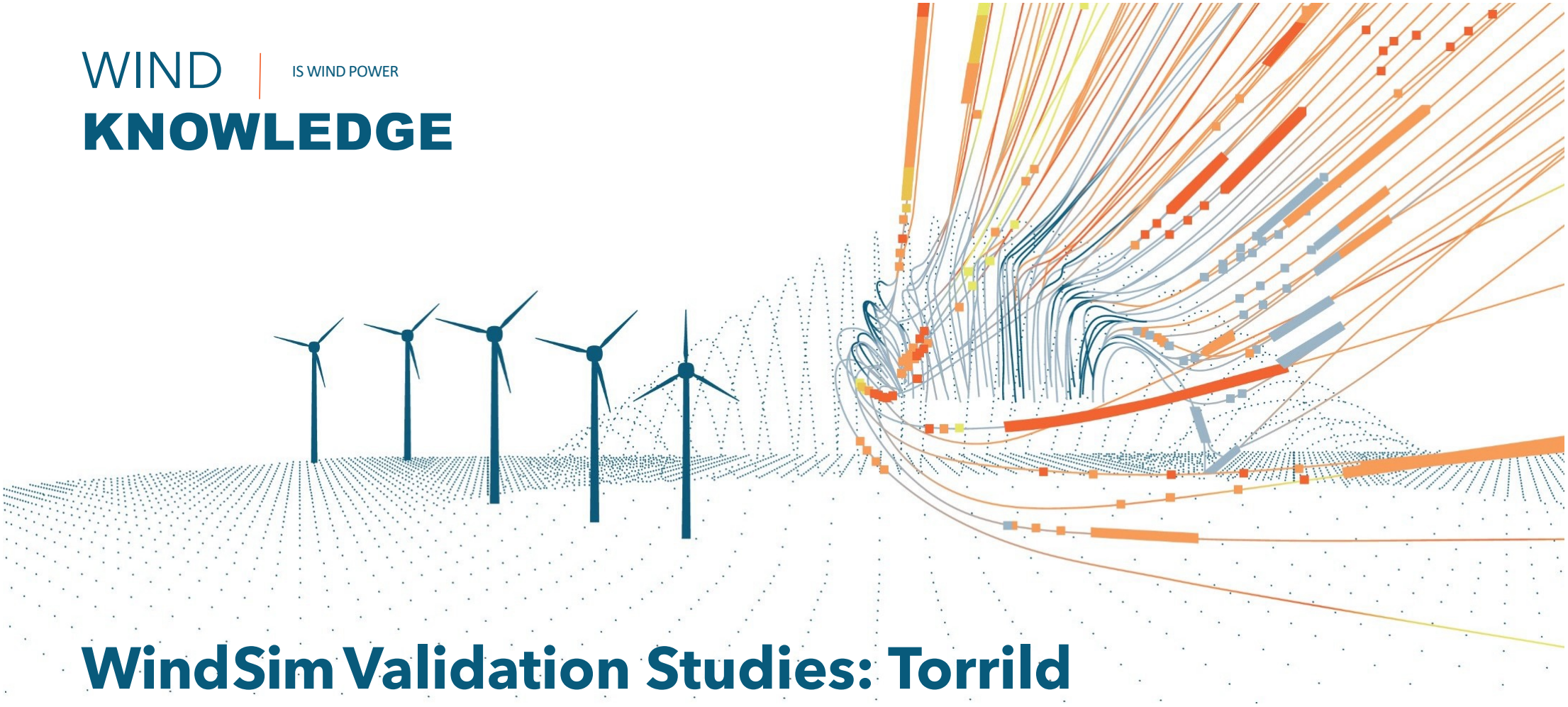

WindSim Validation Studies: Torrild

2025

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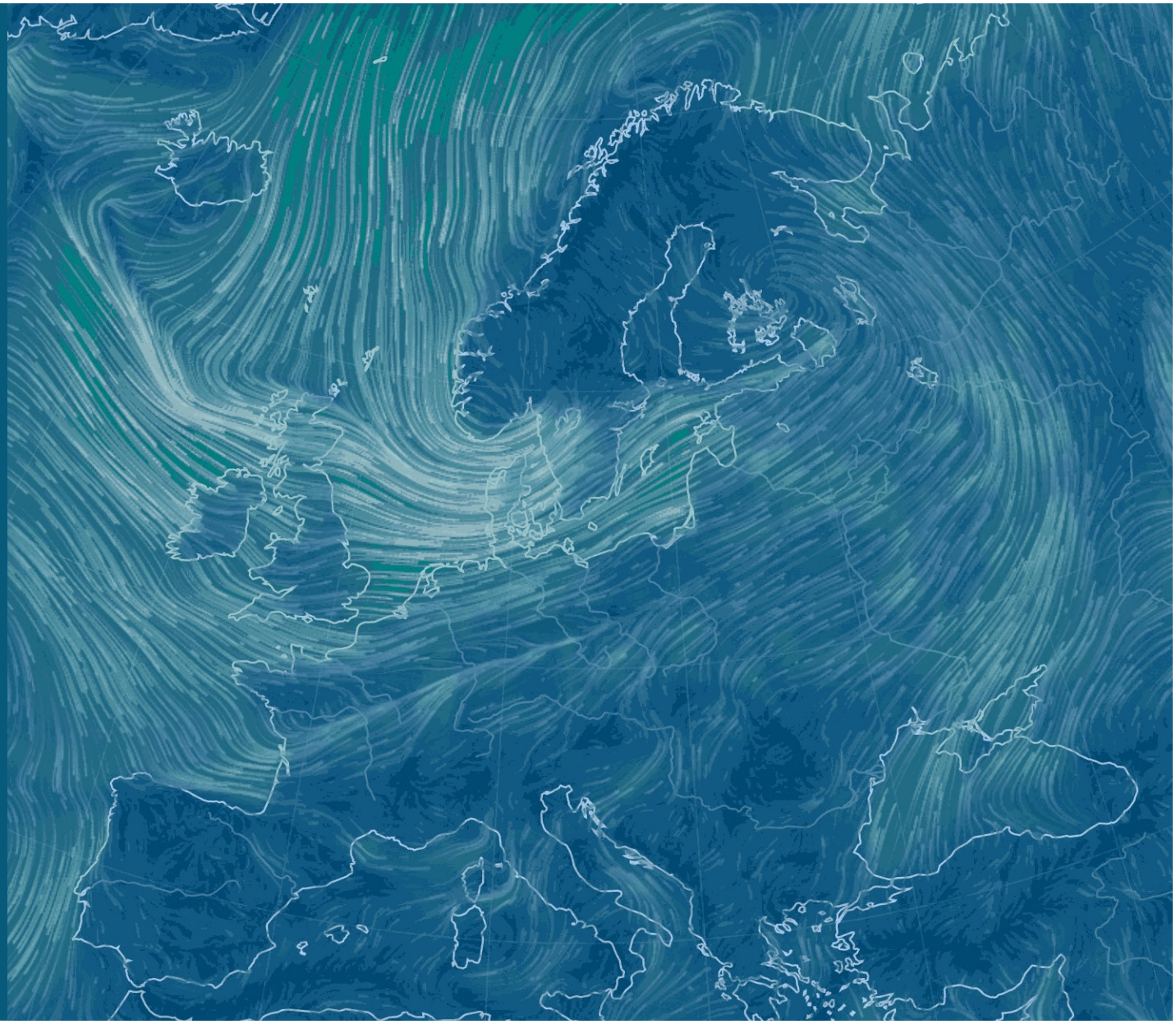
Torrild: Proven Accuracy in Semi-Complex Terrain



Torrild – Proven Accuracy in Semi-Complex Terrain

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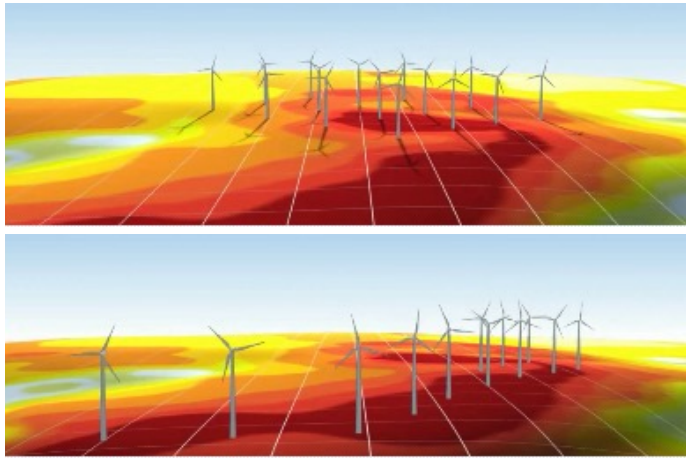
Objective:
- Validation of WindSim's ability to predict wind field variations and optimize energy production in semi-complex terrain.

Snapshot:
- Project: Torrild Wind Farm
- Comparison: WindSim CFD vs WAsP in blind test validation.
- Location: Denmark (Semi-complex terrain)
- Data Source: Torrild wind farm in Denmark with 15 Bonus 150 kW turbines with 30 meters hub height, EMD AS.
- Analysis Period: Climatology data from the period February to October 2000.

Key Validation Results:
- WindSim CFD accurately predicted a 25% difference in energy production between turbines in the Torrild wind farm.
- Simulations suggest a 10% increase in power production through optimized turbine placement.
- WindSim performed better in identifying speed-ups in semi-complex terrain compared to WAsP.



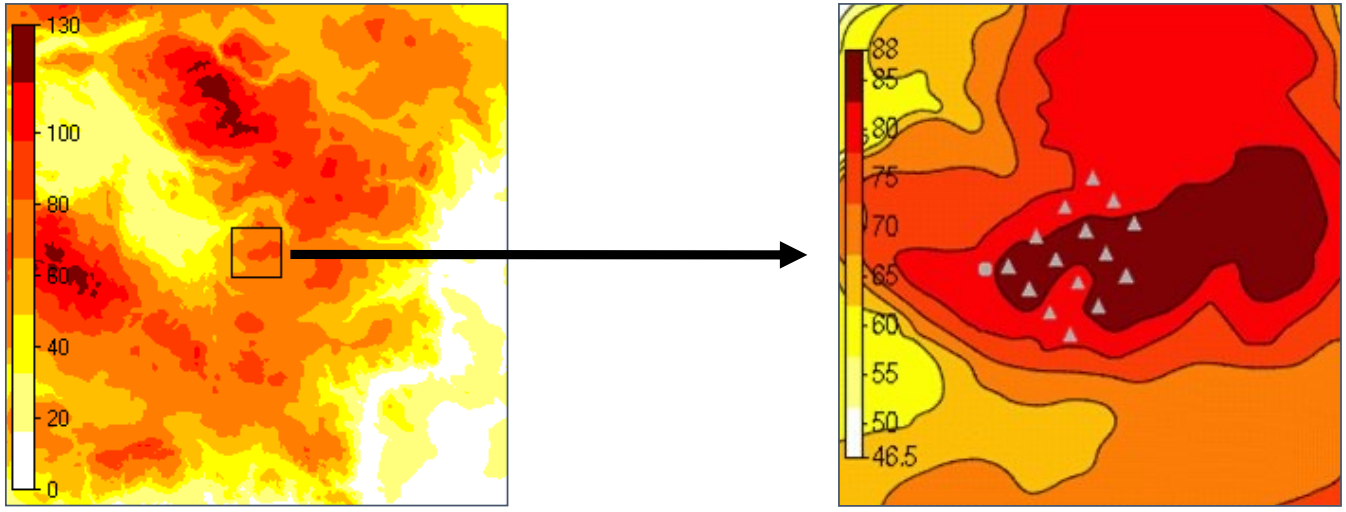
Optimized layout (lower) increased annual energy production by 10% compared to actual layout (upper)

Value Proposition:
- Accurate Micro-siting in Complex Terrain: WindSim outperforms linear models
- Proven in Real-World Conditions: Validations conducted as blind test.
- Energy Optimization: Simulations reveal wind speed variations that allow for better siting and higher energy production.

Summary:
- WindSim consistently provides accurate, validated energy production forecasts in semi-complex terrains.
- Access the full study here: Gravdahl A.R., Rorgemoen S., Thogersen M., "Power prediction and siting - When the terrain gets rough", The World Wind Energy Conference and Exhibition, Berlin, 2002
- Contact us for a personalized demo or case study to see how WindSim can optimize your wind resource assessments.

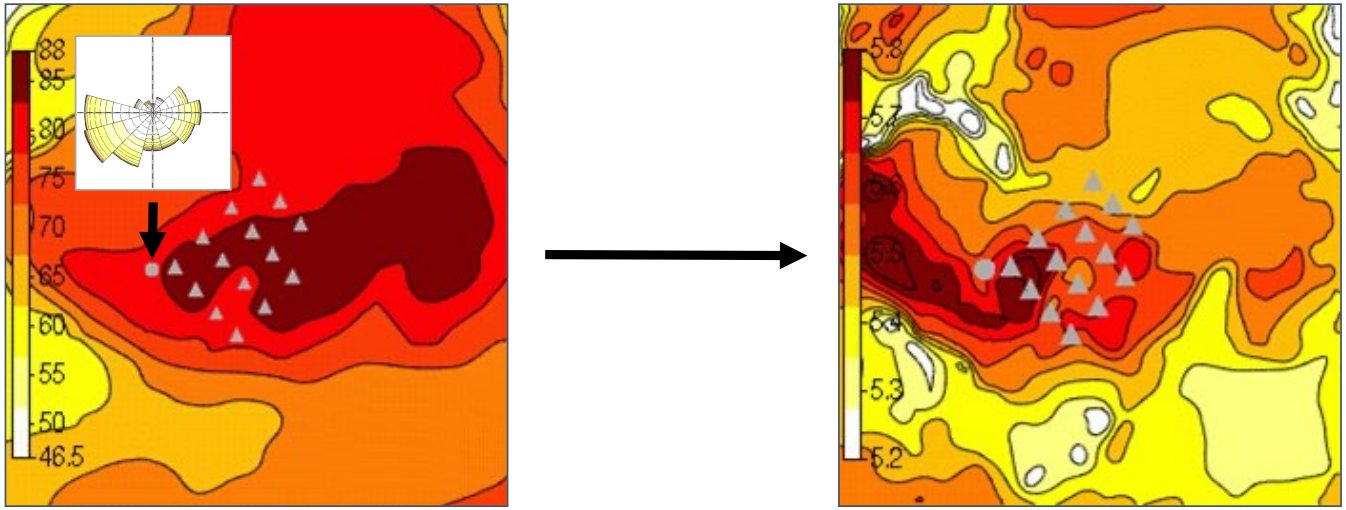
Torrild wind farm – Semi-complex terrain – Model

Location:	Torrild, Denmark, simple terrain
Wind farm:	15 Bonus 150 kW turbines with 30 meters hub height, height variation within wind farm is 6 meters
Climatology:	February to October 2000, measurement height 30 meters, mean wind speed 5.6 m/s
Models:	Nesting, 20x20 km into 2x2 km with resolution 20x20 meters, number of cells is 200 000
Reference:	Gravdahl A.R., Rorgemoen S., Thogersen M., "*Power prediction and siting - When the terrain gets rough*", The World Wind Energy Conference and Exhibition, Berlin, 2002



Digital terrain model with elevation in meters. Left side 20x20 km model, right side 2x2 km model with a 20x20 meters grid resolution

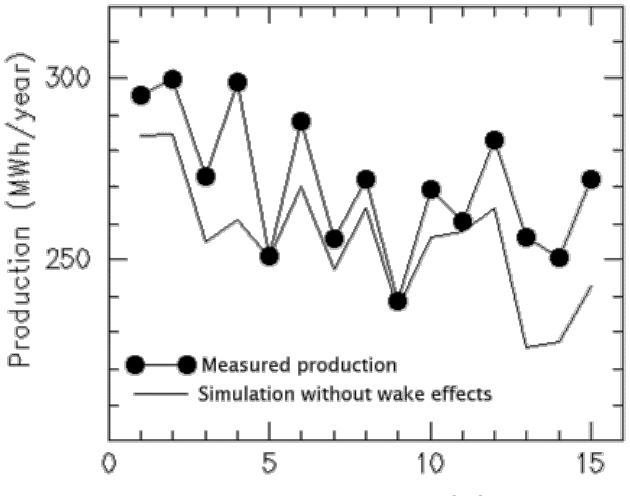
Torrild wind farm – Semi-complex terrain – Wind resource map



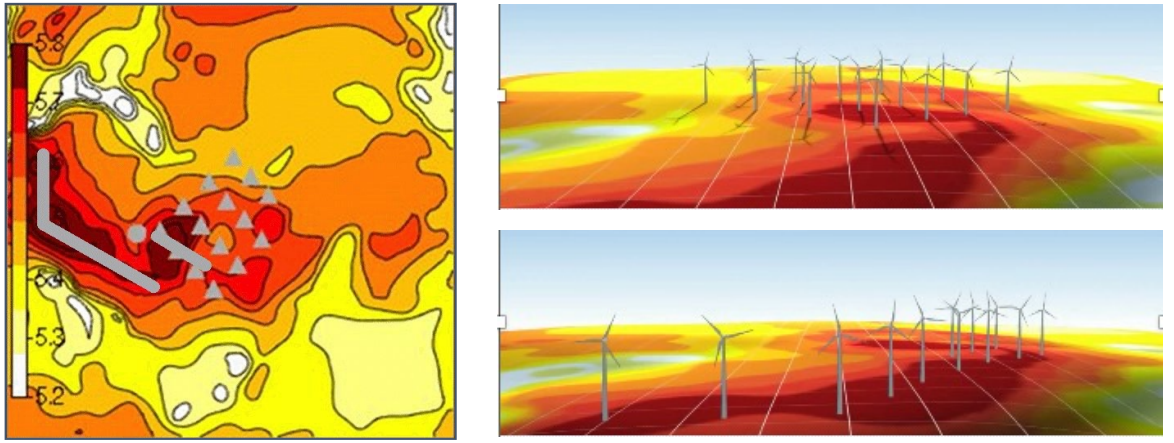
Elevation in meters (left) and wind resource map at 30 meters height (right), weighted against the climatology located at the grey circle

There is no simple coincidence between high wind speed areas and high altitude areas. Simulations shows that areas west of the wind farm display the best wind conditions. This area has terrain gradients perpendicular to the main wind directions, giving significant speed-ups
The high wind speed area west of the wind farm is less pronounced in the wind resource map produced by WAsP

Torrild wind farm – Semi-complex terrain – AEP variation



Measured and simulated production per turbine



Wind resource map at 30 meters height with the turbines marked as grey triangles with an alternative layout along grey line (left). Given layout and the alternative layout viewed from west (top and bottom right)

Difference in energy output between various turbines is 25%. Simulations do not include wake effects, hence the large variation is primarily induced by terrain effects
Alternative locations along the grey lines would according to simulation give a 10% increase in AEP

Torrild wind farm – EMD evaluation

https://www.emd-international.com/files/windpro/documentation/Case%20report02a%20-%20Torrild-WindSIM_Denmark.pdf

Torrild - WindSIM – Case study

Note: This study differs from the other case studies in format, while here another model; WindSIM is tested as alternative to the WAsP model. Therefore this case should be read additional to the Case 02 Torrild. Note also that the Torrild case is not the best for WindSIM, while it is not really complex regarding terrain steepness. It is where the terrain is so steep, that flow separation appear, WindSIM has its forces.

Discussion/Conclusion

The case study has demonstrated the application of the new tools available in WindPRO for linking existing data into a WindSim/WindPRO joint analysis. The ease of extracting the WindSim input files enables the user to gain the benefit of a second opinion analysis based on an alternative model to WAsP.

The actual case study from Torrild shows, that the site fits the WAsP model best – it is a typical Danish site – event if the orography is some of the 'roughest' that we may find in Denmark. The WindSim model seem to have problems with taking complex roughness into account, but it also seem to improve handling of the orography. In addition, it must be noted that the WindSim model has its strengths in sites with complex orography and not sites with complex roughness - as the current site.