WIND IS WIND POWER
KNOWLEDGE

Uncertainties in WindSim

WindSim 14th User Meeting, Tønsberg 5-6 June 2019

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windsim

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- Uncertainties basics
- Existing studies
- Model Uncertainties
    - Available data
    - Uncertainties vs Distance
    - Uncertainties vs Speedup
    - Uncertainties vs Direction shift
    - Uncertainties vs Terrain complexity
- Conclusions

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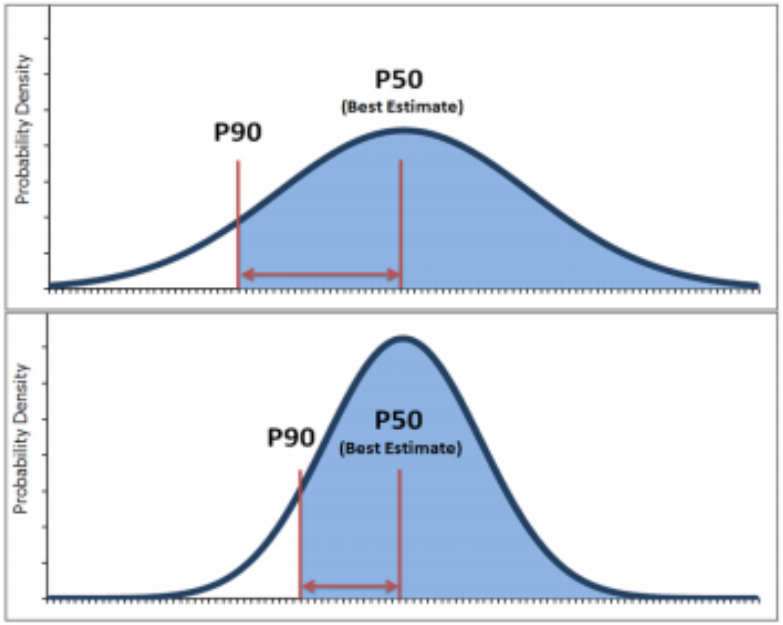
Uncertainties basics

In site assesment studies uncertainties propagate in each step of the calculation, from met-mast measurements to energy production.

The lower the uncertainty is, the higher is the P90



- P50 is the result of the WindSim energy module after losses
- P90 is the result of the uncertainty analysis

Uncertainties basics

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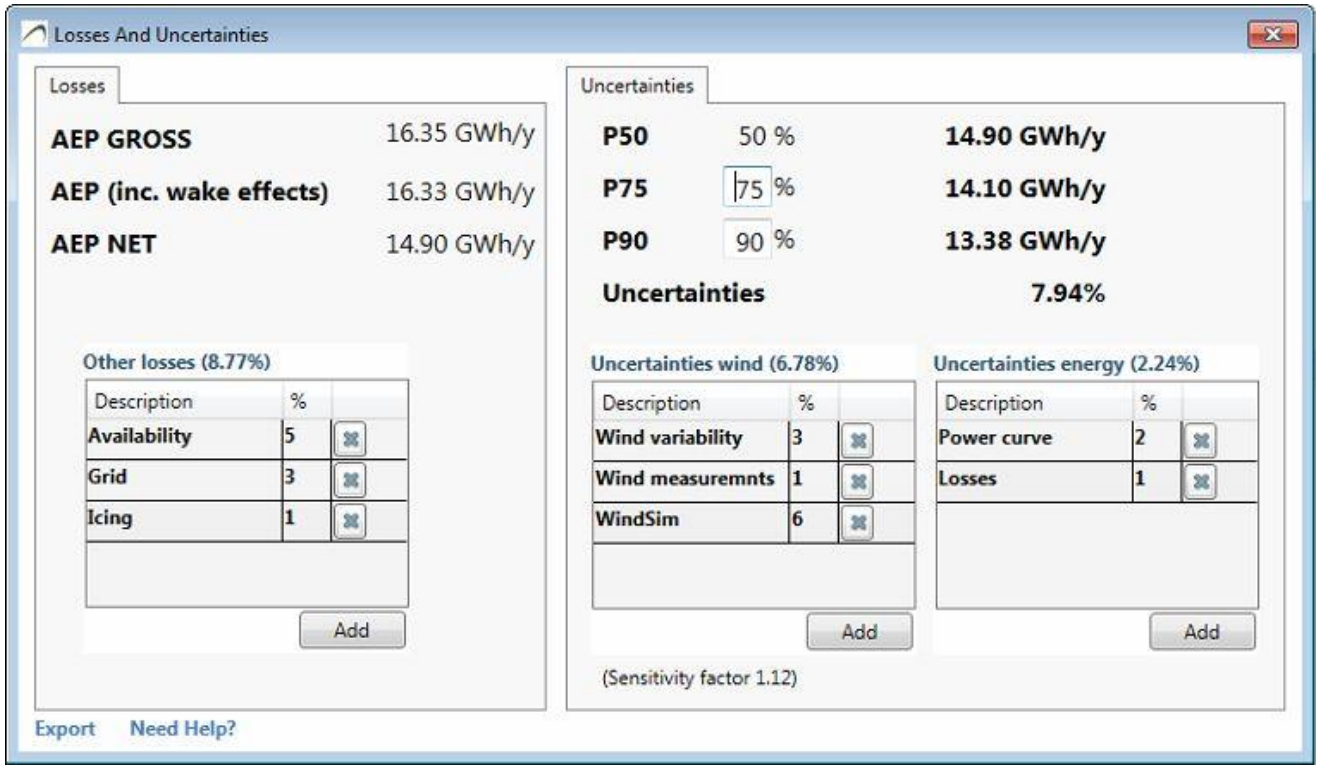

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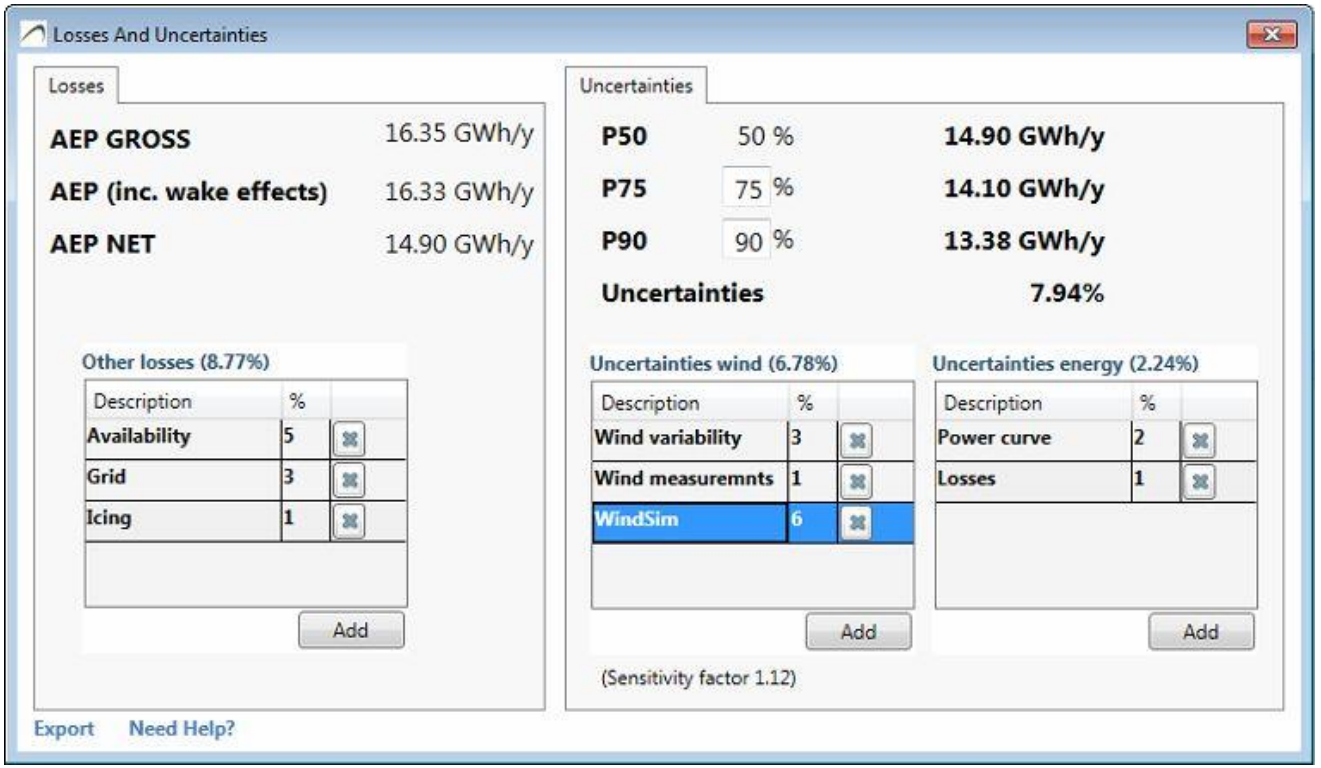

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Existing studies

The main work on this fiels is

- "*A systematic method for quantifying wind flow modelling uncertainty in wind resource assessment*". **Clerc, Alex, et al**. s.l. : Journal of Wind Engineering and Industrial Aerodynamics, 2012, Vol. 111. (later called "Clerc method")

It correlates the energy production error to the distance from the metmast, speed-up and directional variation. The model in that work is **using a linear solver**.

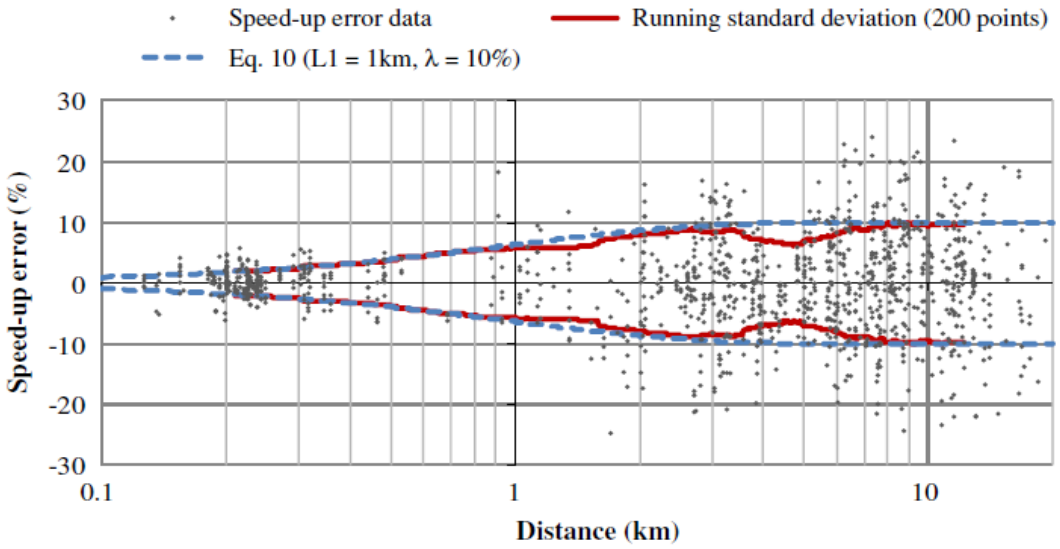


Fig. 4. Speed-up errors, ±1 running standard deviation of speed-up errors and u_D vs. distance.

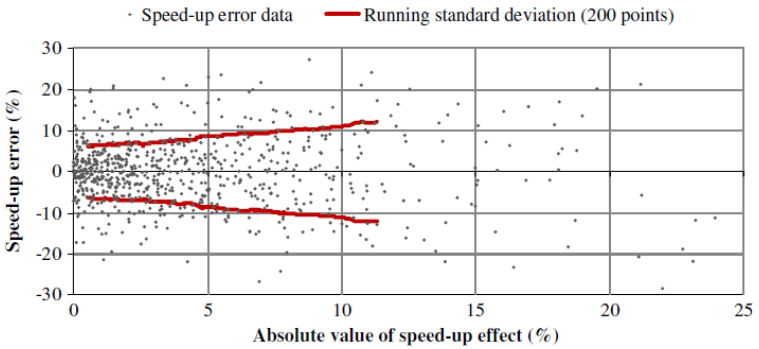


Fig. 5. Speed-up errors and running standard deviation of speed-up errors vs. $|\eta_S|$.

Eq. 10 $$u_D = \lambda(1 - e^{-D_{MT}/L_1})$$

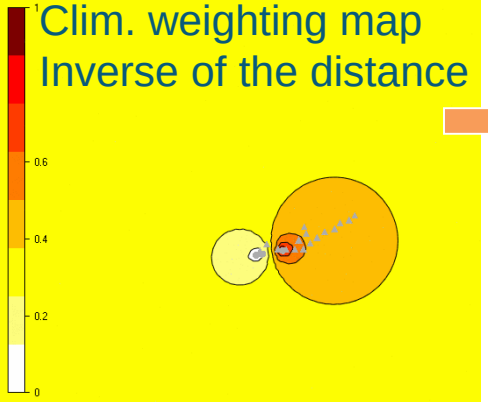
Existing studies

There is a lot of interest in uncertainty prediction in the wind energy community

- The prediction of the error would enable a better definition of the model uncertainties
- The prediciton of the errors in a layout with multiple met-masts enables to detect which is the best met-mast to predict power production at each turbine position
- The weighting of the met-mast measurments can be adjusted to minimize the final uncertainty of the model

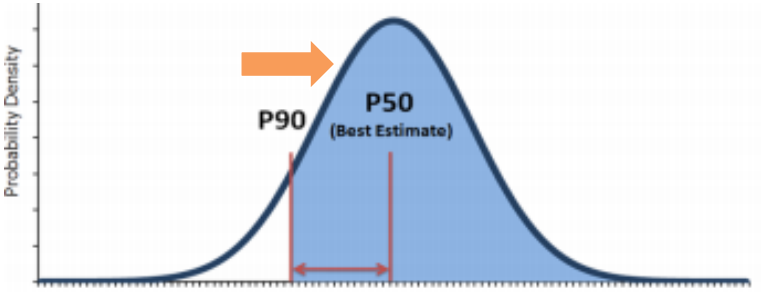
This last point is of high interest because it enables to increse P90 with low effort.

Clim. weighting map
Inverse of the distance



Becomes
Inverse of the error

Decreases the distance
P90 – P50



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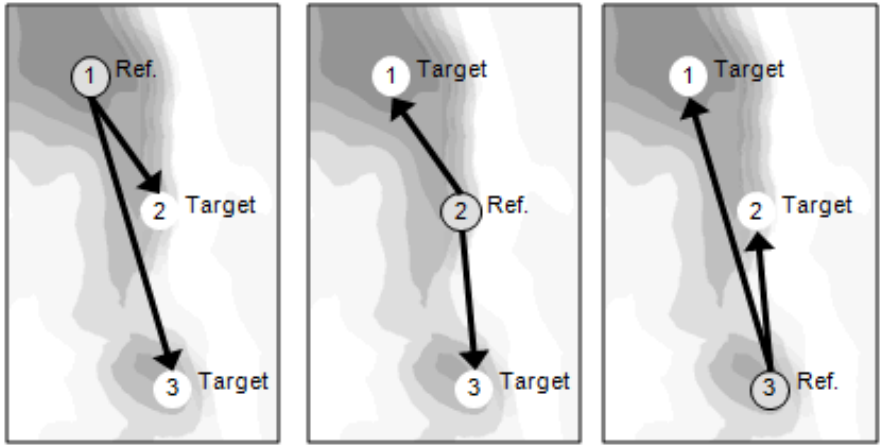
Available data

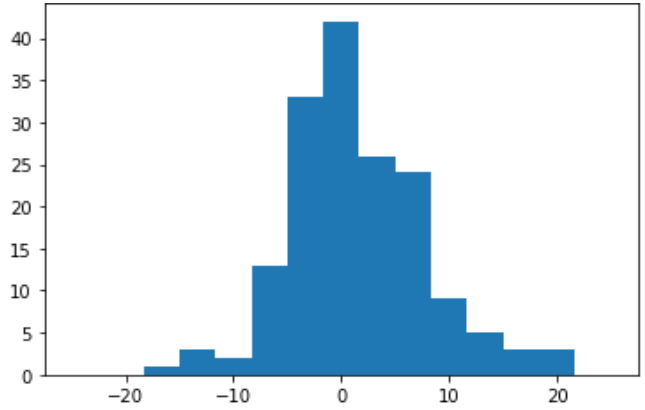
10 WindSim CFD models with about 80 couples of met-masts

The error is calculated using the data in the area between 3 to 25m/s as this is the speed when turbines are active

The cross-checking procedure in the wind resource module is used



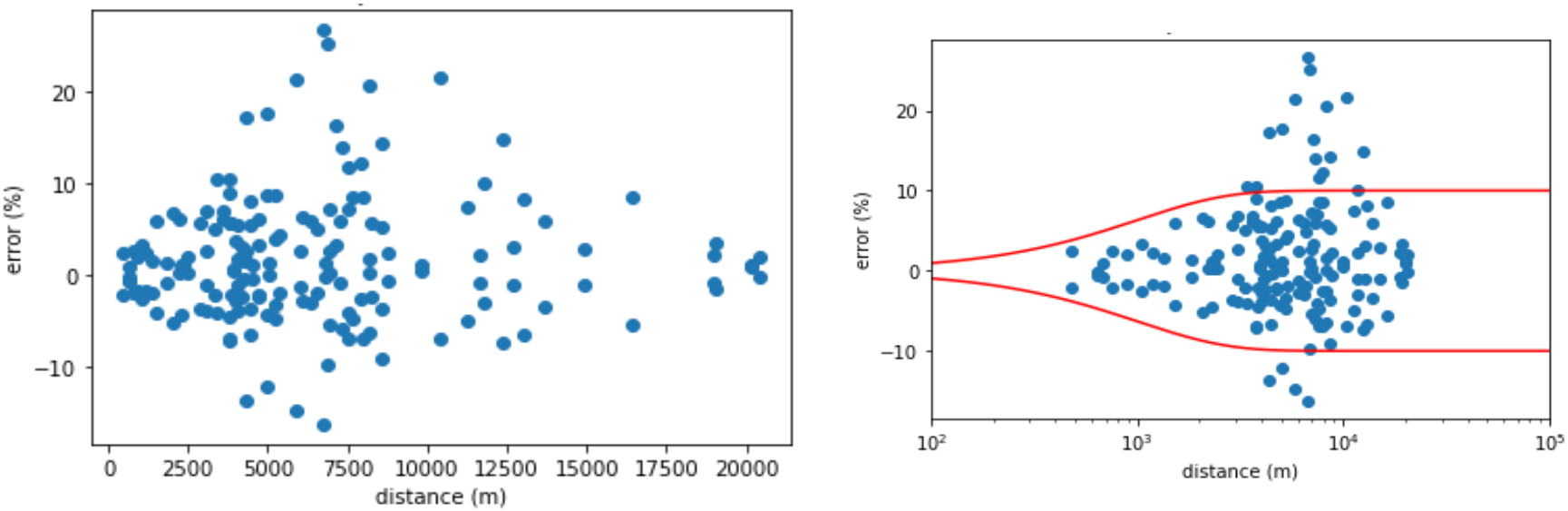
Cross-checking combinations in a project with three met-masts



Frequency distribution of Errors

Uncertainties vs Distance

Relation of the error with the distance:

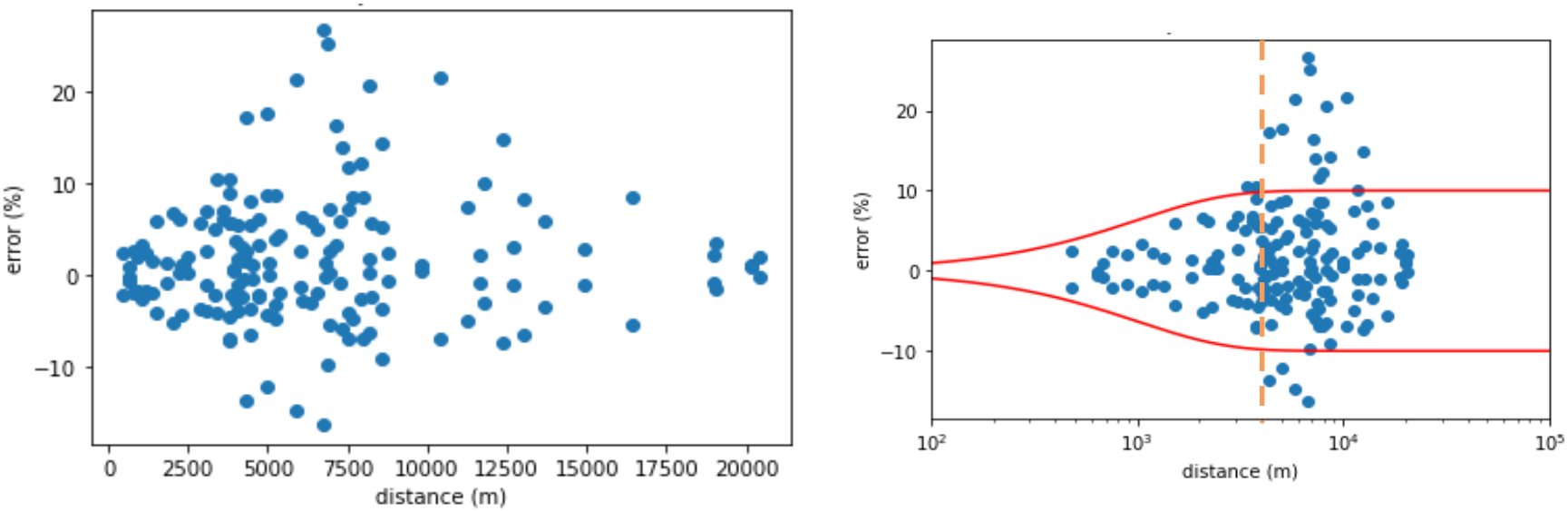


Relation of the error with the distance. The red lines are the ones proposed in Clerc method.

The comparison of the obtained points with the lines proposed in the Clerc method highlights a much lower error of the WindSim model for distances lower then 3 km.

Uncertainties vs Distance

Relation of the error with the distance:



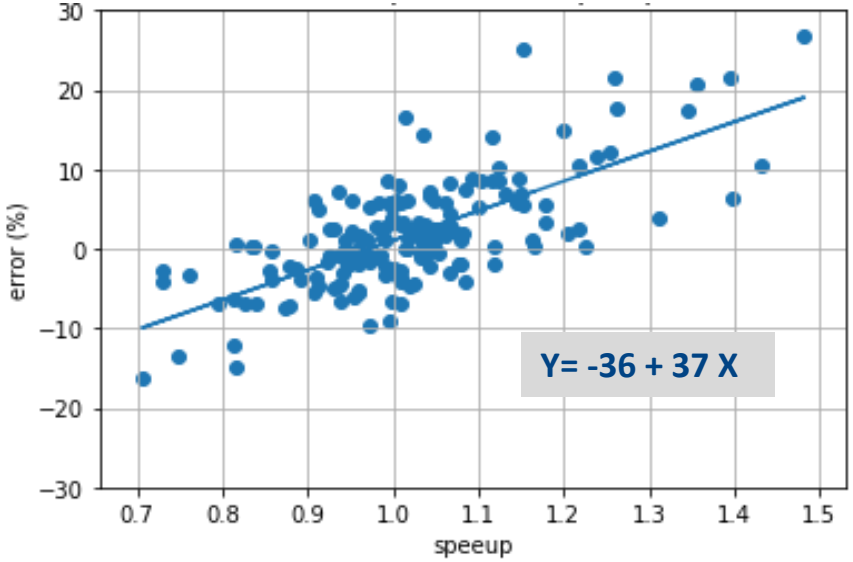
Relation of the error with the distance. The red lines are the ones proposed in Clerc method.

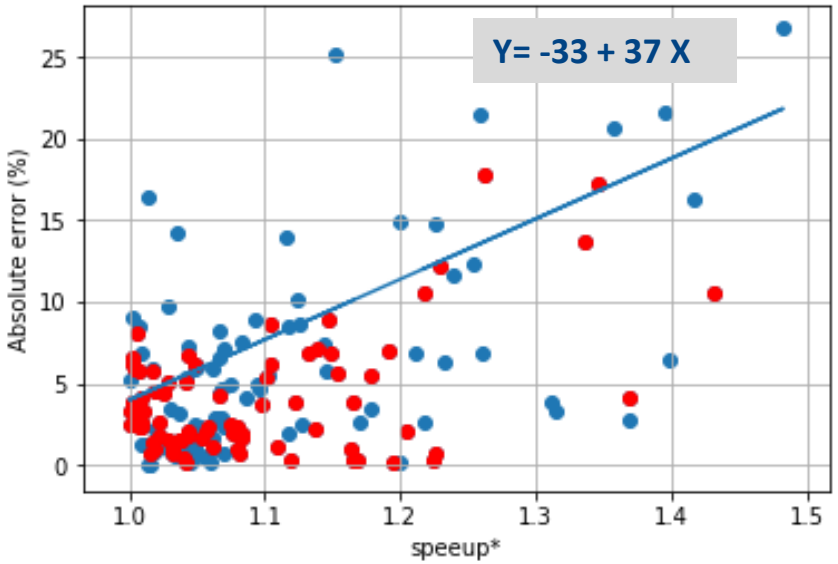
The comparison of the obtained points with the lines proposed in Clerc method highlights a much lower error of the WindSim model for distances lower then 3 km.

This highlights the good performance of the WindSim RANS-CFD compared to the linear model in that area

Uncertainties vs Speedup

Relation of the error with the speedup:



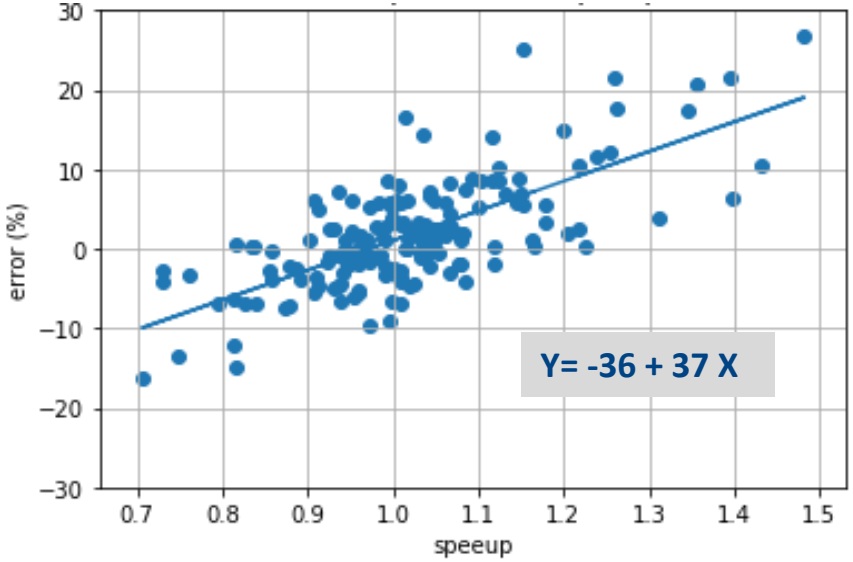


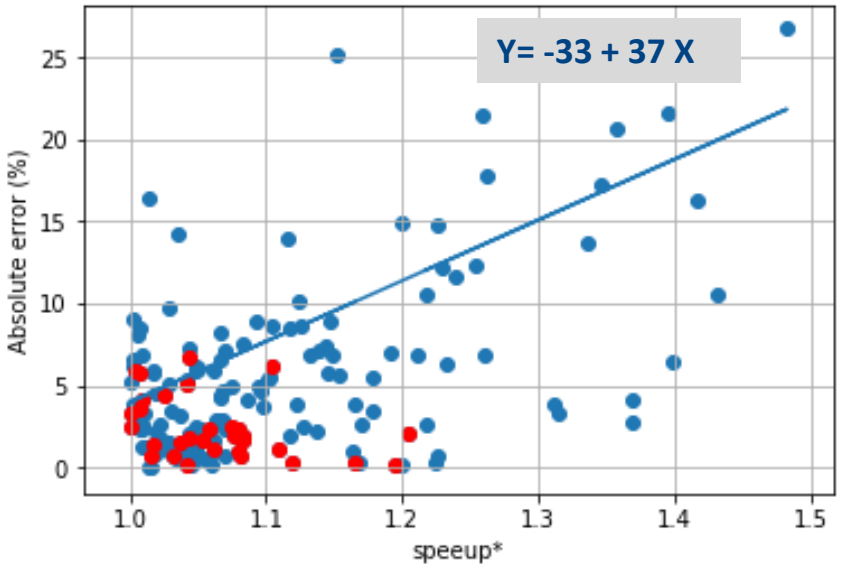
Relation of the error with the speedup. Linear fit and proposed line, red points are for distances lower than 5 km (80 points).

Where speedup* is the inverse of the speedup when the speedup is lower than 1

Uncertainties vs Speedup

Relation of the error with the speedup:





Relation of the error with the speedup. Linear fit and proposed line, red points are for distances lower than 3 km (32 points).

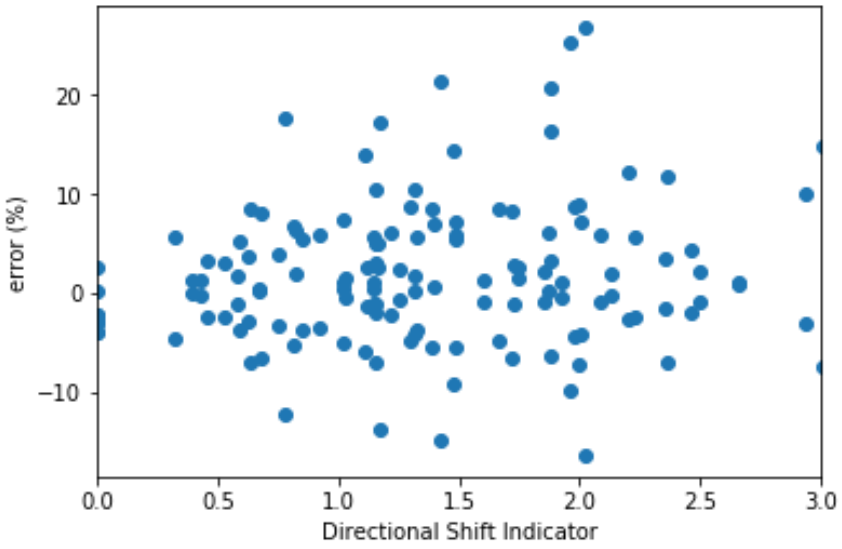
Where speedup* is the inverse of speedup when lower than 1

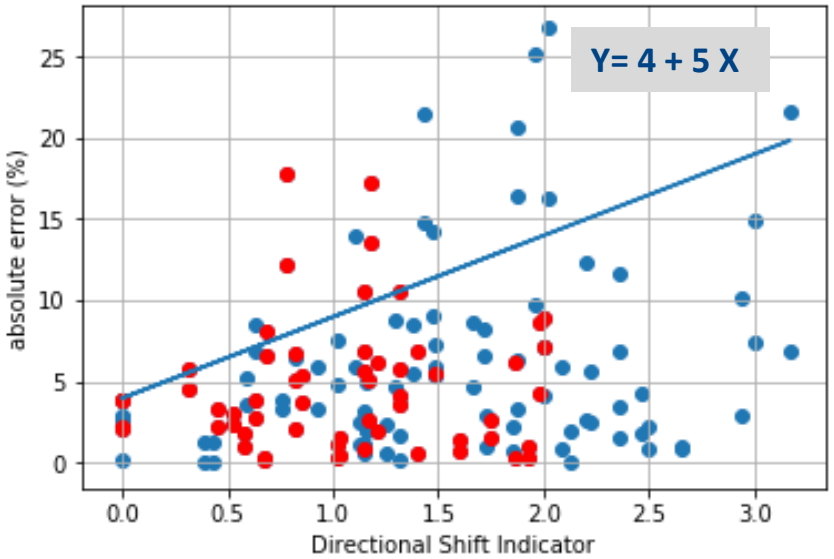
This highlights the loss of correlation of speedup with the error for distance lower than 3km

Uncertainties vs Direction shift

Relation of the error with the directional shift:

Directional shift indicator = Sum product (dir. shift by sector, frequency by sector)



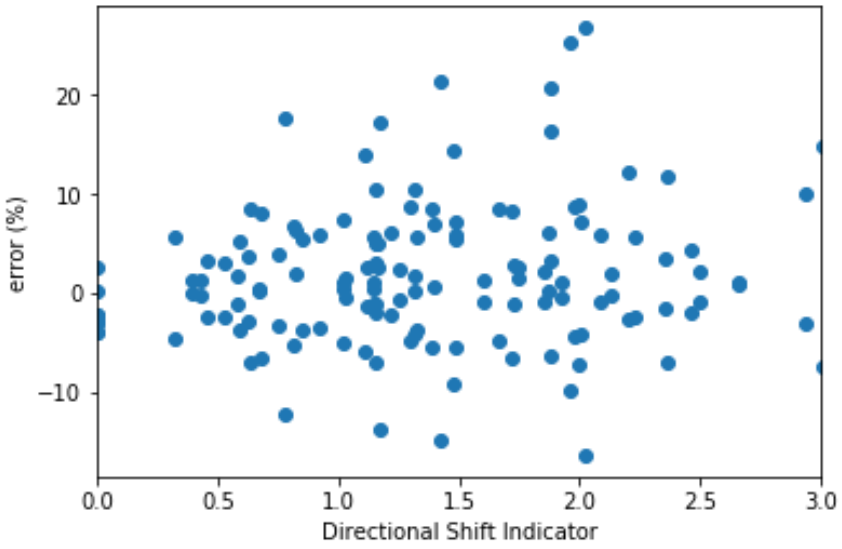


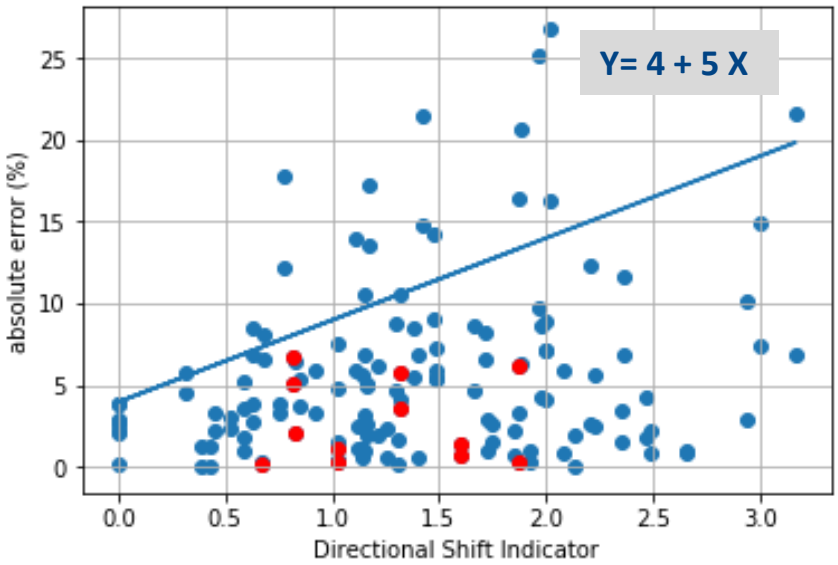
Relation of the error with the directional shift indicator. Proposed line, red points are for distances lower than 5 km (58 points).

Uncertainties vs Direction shift

Relation of the error with the directional shift:

Directional shift indicator = Sum product (dir. shift by sector, frequency by sector)



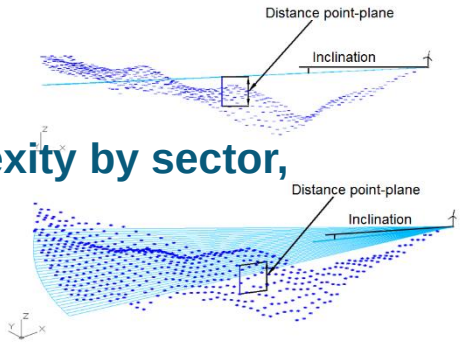


Relation of the error with the directional shift indicator. Proposed line, red points are for distances lower than 3 km (12 points).

This highlights the loss of correlation of directional shift indicator with the error for distance lower than 3 km

Uncertainties vs Terrain complexity

Relation of the error with the terrain complexity:



Terrain complexity indicator = Sum product (Terrain complexity by sector, frequency by sector)

Average of reference and target values

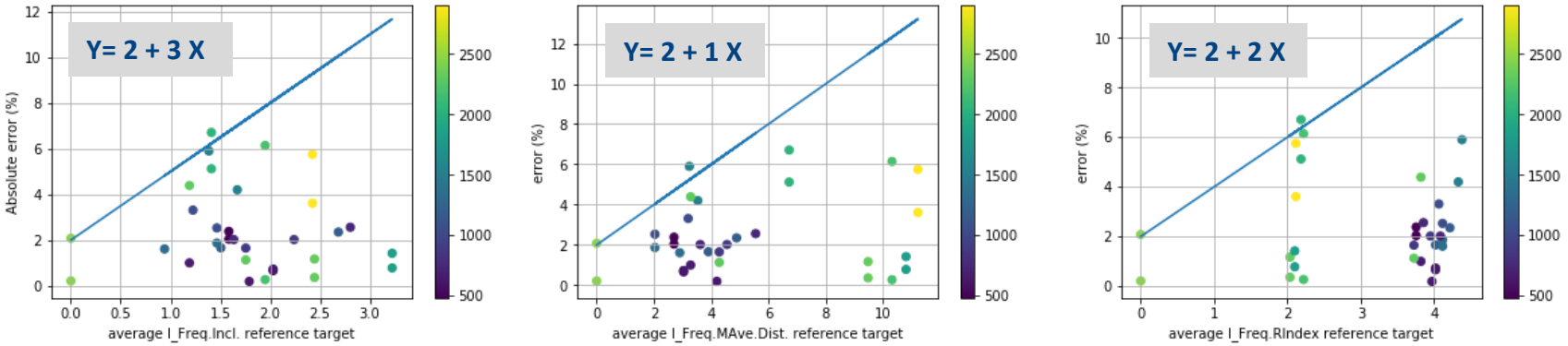
Relation of the error with the terrain complexity indicators.

The dependency of the error to the terrain complexity indicator is remarkable. It is also noticeable that the distance has an impact.

Uncertainties vs Terrain complexity

The error shows a dependency to the terrain complexity indicator for points with a distance less than 3km.

Relation of the error with the terrain complexity:



Relation of the error with the terrain complexity indicators colored by the distance, .

The plotted lines give a reference. The low amount of data limits the representativity of the results.

The complexity indicators seams to play a role for distances lower than 3 km while the other indicators do not.

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Conclusions

- The error of the WindSim model is an important research area for the improvement of site assessment studies and energy yield.
- The sites available in this study highlight a better performance than linear methods with an high improvement in short distances (3 km)
- The distance, speedup and the directional shift have a significant impact on the error for distances higher than 3 km
- The terrain complexity indicators show an effect on the error for shorter distances where the previous indicators affect the error less

Remarks:

- The limited number of couple of met-masts used in this studies limit the value of the study

Wishes:

- Extend the study with more sites… *Add yours!*

Thank you

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