PO.202

Modelling Windcube + FCR accuracy with neural networks

L. Touzeau, P. Mazoyer
Leosphere

Introduction

Current standards recommend the use of an adapted wind reconstruction such as Windcube's FCR for Lidar measurements in complex terrain ([1]). It is well understood that terrain orography is the main parameter accounting for Lidar accuracy in complex terrain ([2]).

Following the 2015 study on the Windcube+FCR performances ([2]), Leosphere developed a more advanced methodology to anticipate Windcube's accuracy with and without FCR in any terrain, by wind sector and measurement heights.

This poster aims to:

1. **Explain the method used to estimate the Windcube's accuracy in any terrain with and without FCR**
2. **Show validation results against real life measurements**
3. **Present a typical use case of the method: estimation of the best Windcube location on a terrain**

Algorithm for accuracy estimation

Leosphere accuracy estimation method is based on:

- A database of Windcube's accuracy with and without FCR on various type of terrains : simple, moderately complex and complex
- A neural network used to generalize Windcube performance in any terrain

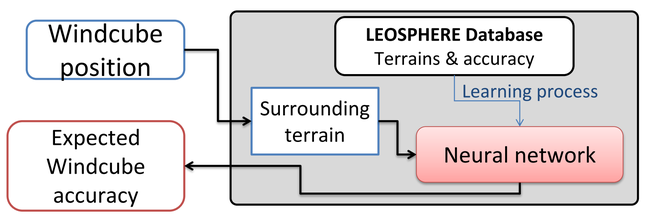

Figure 1 : Global scheme of the Windcube accuracy model

Windcube accuracy database

In order to obtain a representative database of terrains and their related accuracy, the two following sources are used:

- **Real life campaigns**: where Windcube+FCR measurements have been compared to mast-mounted anemometers measurements (8 terrains available)
- **Simulations:** Lidar accuracy is derived on theoretical terrains by means of CFD simulations. Simulations provide a fine resolute mesh of wind speed then Windcube wind speed reconstruction is applied and compared to get a simulation of accuracy ([3],[4])

Generalization with a Neural Network

The neural network has been calibrated with the accuracy database, which is composed of more than 15 000 terrains and their related measurement accuracy. During the learning process, the neural network analyzes the relation between terrain and Windcube accuracy and can then calculate the Windcube accuracy in any terrain (Figure 2).

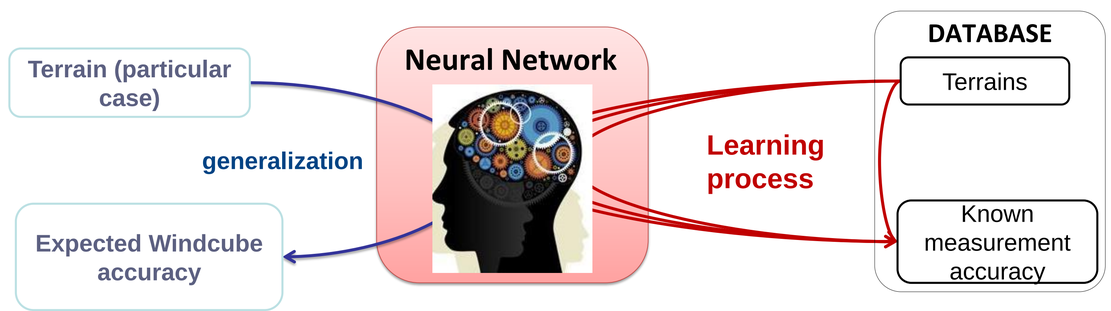

Figure 2 : Generalization with a neural network

Validation results

Accuracy depending on terrain types

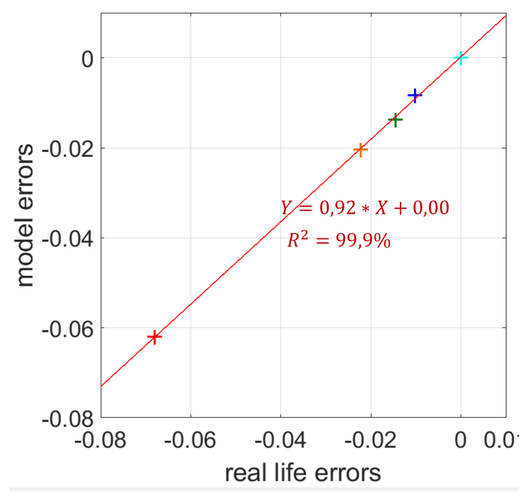

Figure 4: Validation of the model by comparison with mast-measurement campaigns without FCR

The deviation from 5 measurement campaigns in various terrain have been compared to their corresponding estimated average deviations (Figure 4):

- Flat
- Moderately complex
- Moderately complex and forested
- Complex
- Highly complex

Results show a very good agreement between predicted and observed results we observe a good correlation of 99,9 %.

Limitations arise in highly complex terrain where we a deviation of 0,9%.

Accuracy depending on measurement height and direction

The mean measurement deviation has been studied by varying the measurement height (Figure 5) and the wind direction (Figure 6), and has shown good correlation with the measurement campaigns. The model dependency on the measurement height shows less than 0,5% deviation with real life measurements. For some wind sectors, there is deviations between model and real life measurement, a confidence index permits to identify the wind sectors in which deviations is estimated with lower confidence.

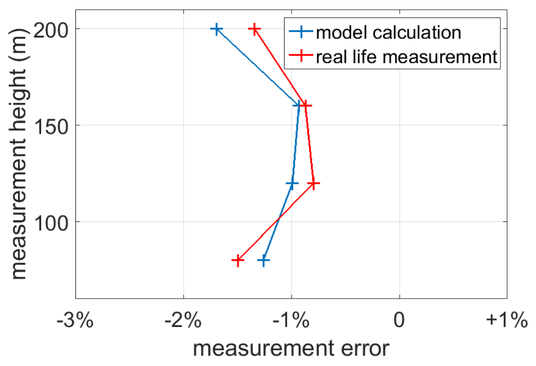

Figure 5: Validation of the dependence on the measurement height without FCR

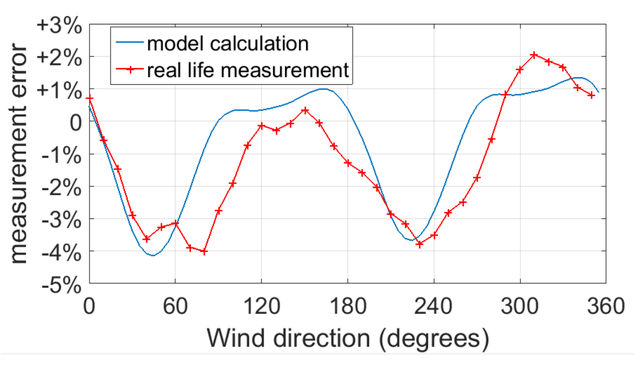

Figure 6: Validation of the dependence on the wind direction without FCR

Example of use on a complex terrain

The method can automatically generate **maps of Windcube accuracy** with and without FCR (Figure 7). This method can help prepare the campaign: according to the needs of the campaign (measurement height, wind sectors), it is possible to find Windcube's best location and resulting expected accuracy , and advise on the need and benefit of adding the FCR correction.

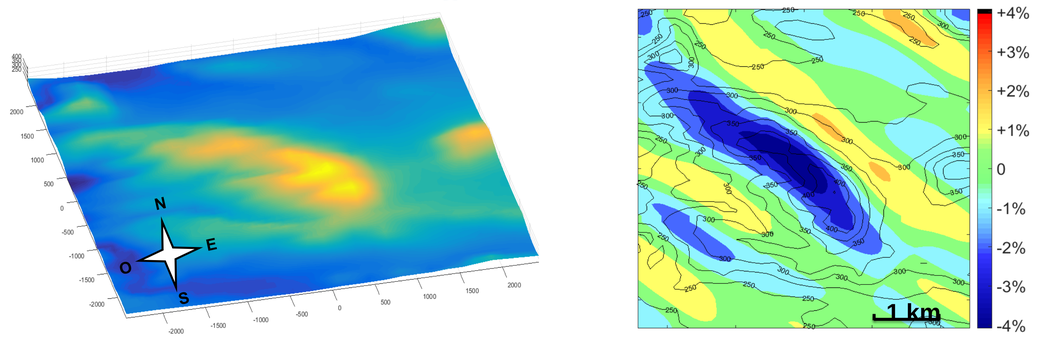

Figure 7: Map of Windcube accuracy without FCR on a complex terrain

Conclusion

- ✓ Following previous developments, Leosphere has improved its method to estimate Windcube's accuracy in any terrain with and without FCR
- ✓ This new method, based on neural networks, has been successfully validated against real life Lidar measurements
- ✓ This will allow to design more efficiently Windcube's campaigns in light with specific campaign objectives
- ✓ Model efficiency will be continuously improved by inputting more parameters such as roughness or atmospheric stability.

References

1. Cartography of Windcube v2 performances with FCR, Leosphere, EWEA 2015
2. Windcube+FCR test in Hrgud, Bosnia & Herzegovina Final Report, DTU Vindenergi, 2014
3. FGW e.V., *Technical Guidelines for Wind Turbines Part 6: Determination of Wind Potential and Energy yield, Revision 9*, April 2014
4. LiDAR-mast deviations incomplex terrain and their simulation using CFD, Fraunhofer IWES, 2015