Lidar Performance Estimation with WAsP Engineering

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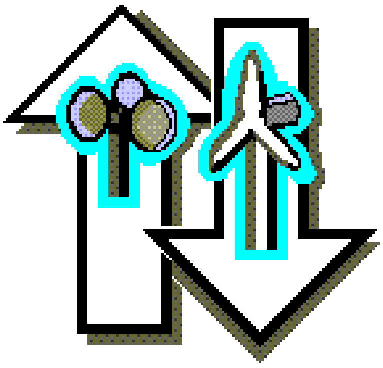


Abstract

The lidar measurements, vertical wind profile in any height between 10 to 150 m, are based on assumption that the measured wind is a product of a homogenous wind. In reality there are many factors affecting the wind on each measurement point which the terrain plays the main role. In 2008, a method to investigate this problem is developed in WAsP Engineering 2.0 by means of a script. The script compares the simulation of a lidar and a met.mast. This technical note describes how to use the script. An example case is taken in to account through a complete operation. The example works also for trial users.

Contents

1 Introduction

Conically scanning lidars assume the flow to be homogeneous in order to deduce the horizontal wind speed. However, in mountainous or complex terrain this assumption is not valid implying an erroneous wind speed. The magnitude of this error can be measured by collocating a meteorological mast and a lidar at a site. Previous studies shows the maximum error is in the order of 10% [1].

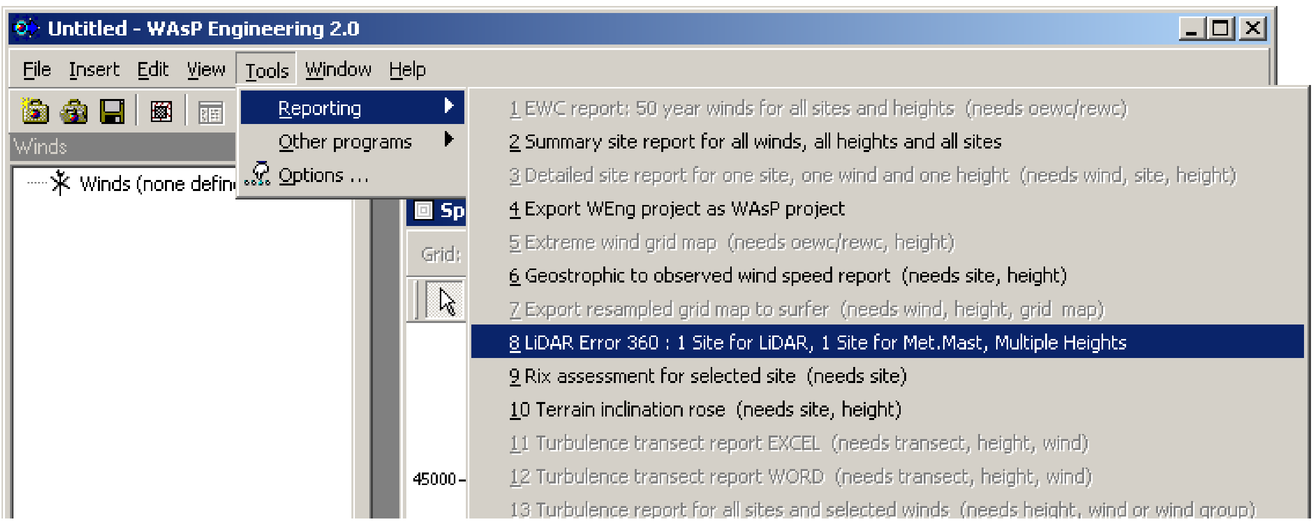
In order to predict the error for various wind directions the flows at both sites, in 2008, a method is developed for WAsP Engineering 2.0 by means of a script. The script is used for real life experiments and results are given in references [1, 2]. This document is an example on how to use the lidar simulation script and works through a complete operation. First the needed files are listed and install instructions is given, after that the example is described step-by-step. In our scenario, at the middle of the example complex terrain there is a met.mast which has equipped with anemometers in three different heights; 30 m,50 m and 70 m. We would like to setup a lidar close to the met.mast to measure the same heights. The final goal is to understand estimation error of the lidar compared to the simulated met.mast.

2 Needed Files

Two directory addresses are important to define before starting the example. These are based on the directory you setup the WAsP Engineering. Main install directory for the software is usually under "**C:/Program Files/Wasp**" which will be refered as **$InstallDirectory** in this document. The second one is the WAsP application folder which is usually setup under "**C:/Documents and Settings/All Users/Application Data/WAsP**" and will be refered as **$ApplicationDirectory**. This directory is "hidden" by default in Windows system but you may see the directory by clicking the option "**Show hidden files and folders**" under "**Explorer / Tools / Folder Options / View**".

2.1 Lidar Script

The script used in this example is publically avaliable at **http://www.WAsP.dk** under **Download / Scripts** section. The user should download this script and put it under "**$InstallDirectory/Internal scripts/Wasp Engineering**". After doing that you will see the script in the "**Tools/Reporting**" section in WAsP Engineering.



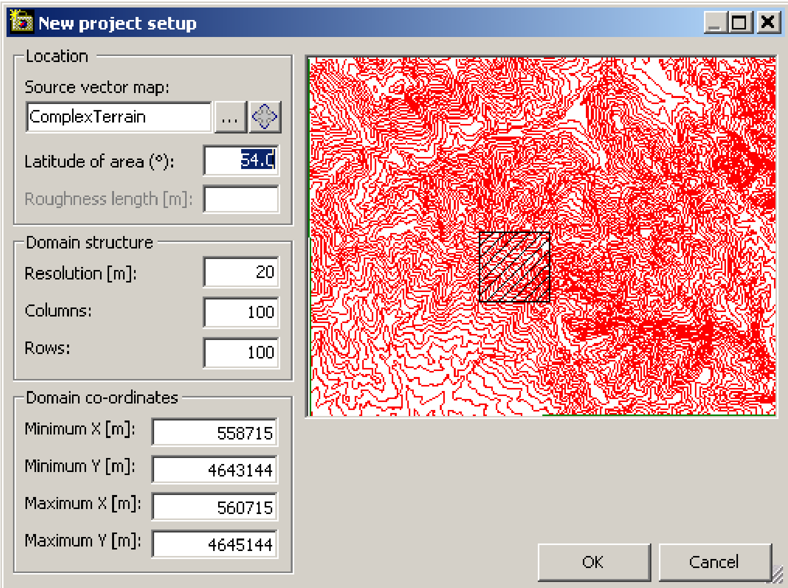
2.2 Terrain Map

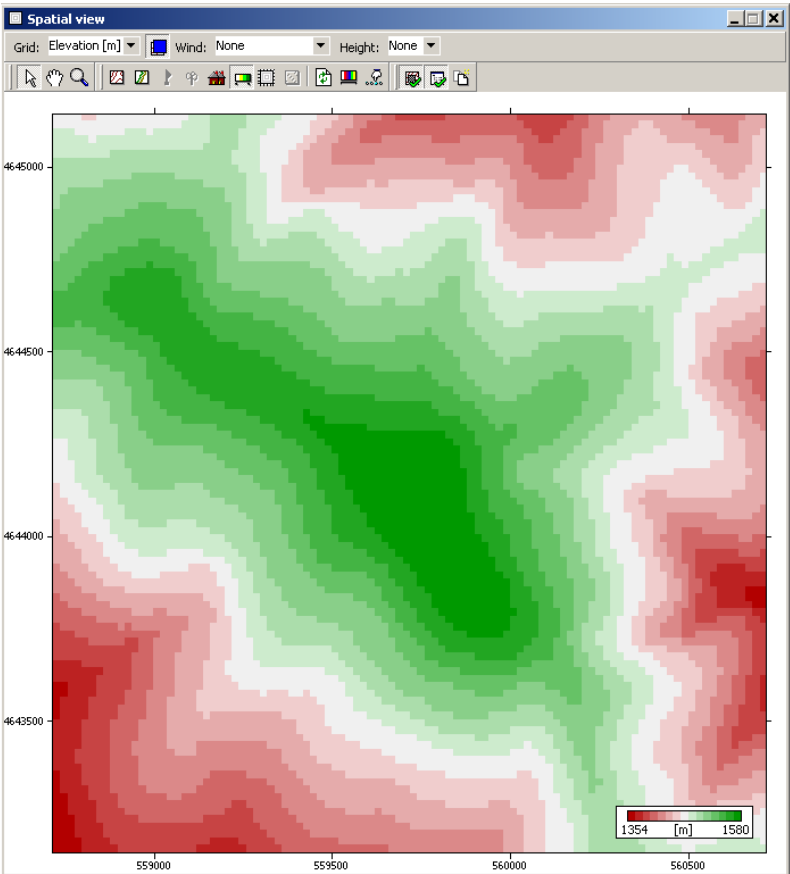
WAsP Engineering 2.0 comes with example maps which can be used freely by registered or trial users. The map we will use is called "ComplexTerrain". File is under **$ApplicationDirectory/maps/**. ComplexTerrain is an imaginary site made for such testing. The terrain is wide and have stable roughness, 0.03 m. We will only use a 2km x 2km section of the map and define it while loading the map into WAsP Engineering.

3 The example

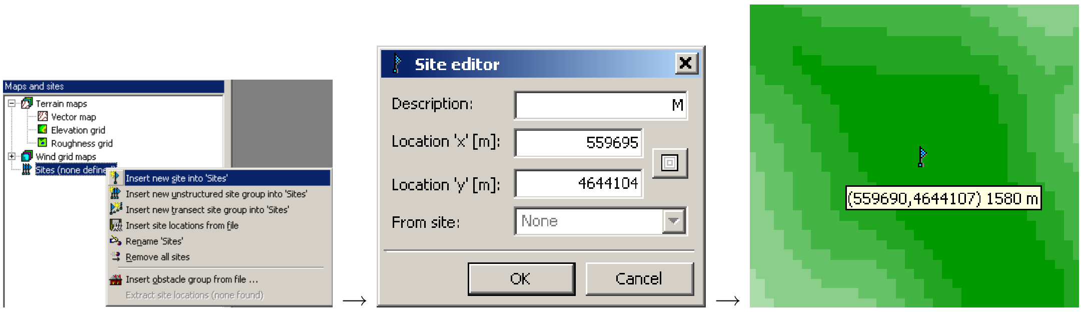
Below we described an example step-by-step. The setup is chosen to make the script run faster. You may also try the same example lowering the resolution size and enlarging the used map. Previous studies show that map size minimum of 5 km x 5 km and minimum 10 m resolution give better results. It is advised to use 10 km x 10 km map with 5 m resolution after the initial test for best results [1].

1. Run WAsP Engineering 2.0 and load the ComplexTerrain map. Set the resolution to **20** m and columns/rows numbers to **100**. Minimum **X** and **Y** points are **558715** and **4643144**. Maximum **X** and **Y** points are **560715** and **4645144**. This definition creates a **2** km map locating a hill in the middle.

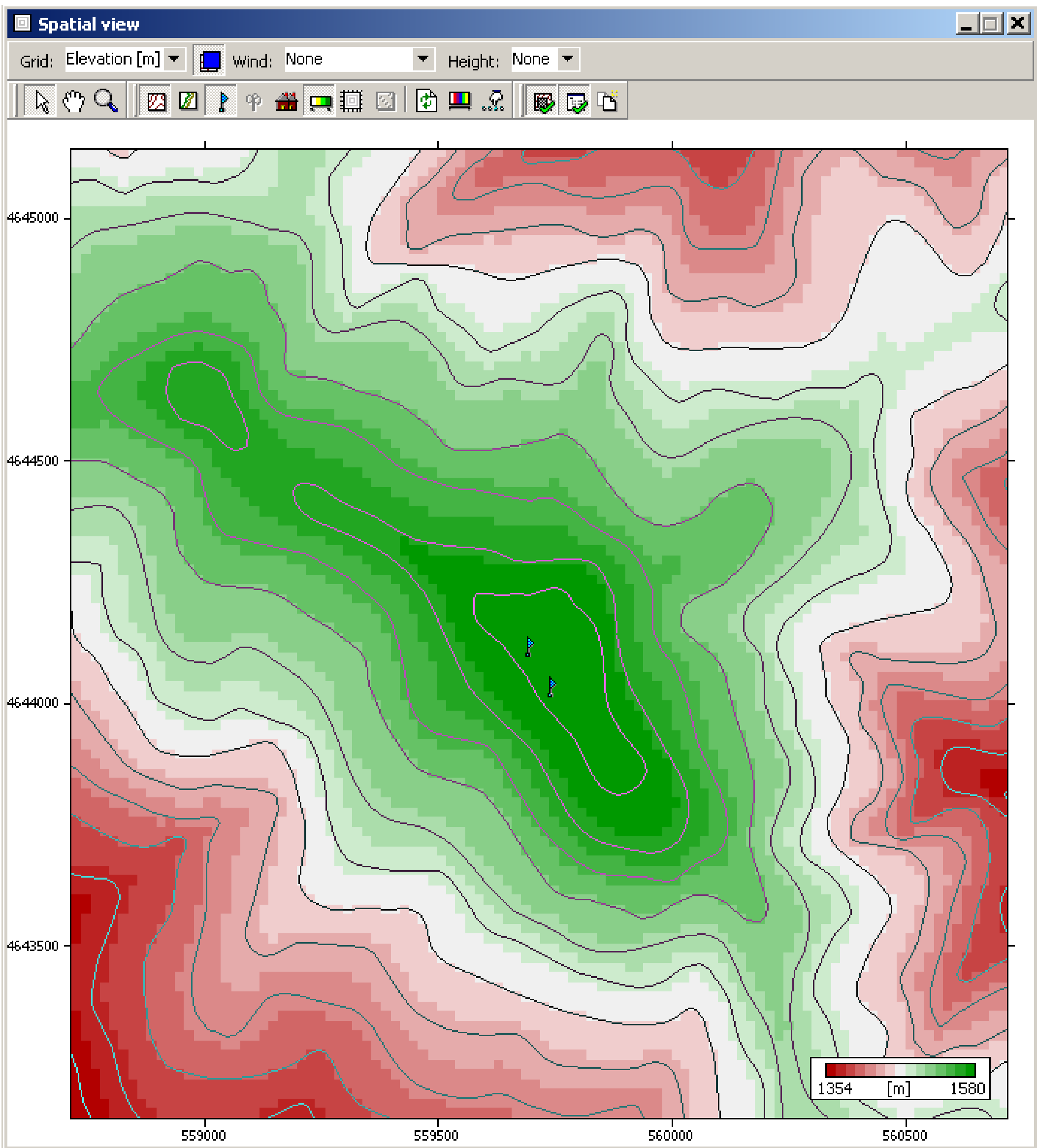




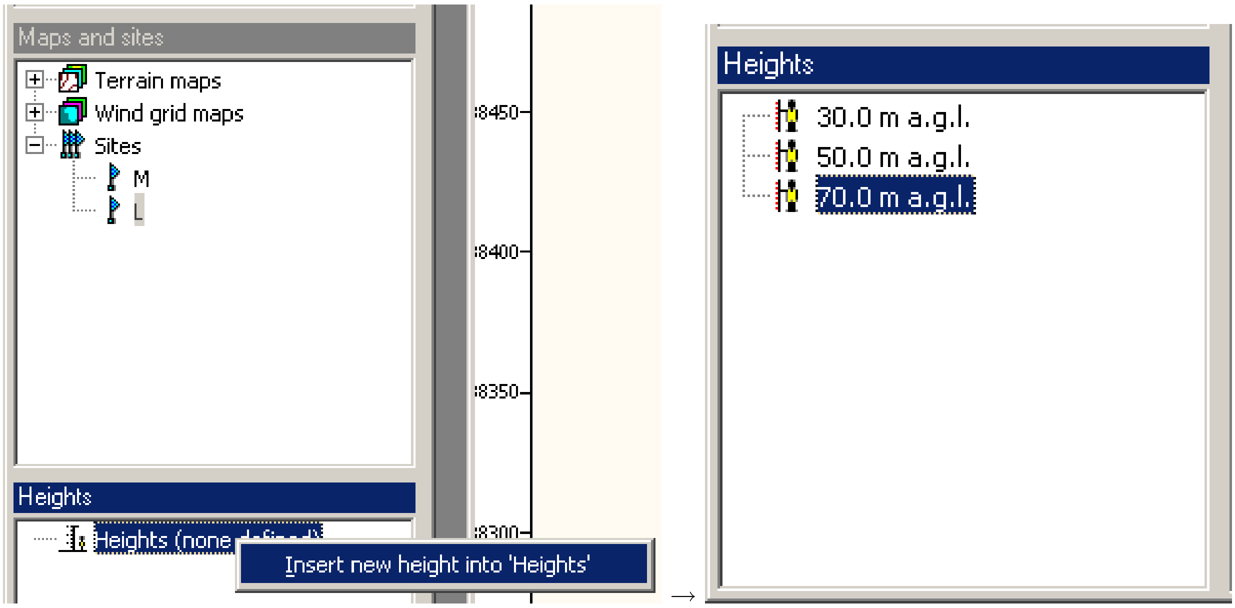
2. Locate the met.mast in the middle of the flat area on top of the hill. To do this simply right click on "**Sites**" and choose "**Insert new site...**". The Description of the site *must be* "**M**". Locations for the **X** and **Y** coordinates for the met.mast in this example is **559695** and **4644104**, respectively. After you insert the site if you click on green flag at the toolbar you will see the located site on the vector map.



3. Now, let's say we would like to located the lidar South-East of the met.mast which should be a similar situation in real life where we use the rest of the flat area on the hill. To do this again right click on "**Sites**" and choose "**Insert new site...**". The Description of the site *must be* "**L**". Locations for the **X** and **Y** coordinates for the met.mast in this example is **559741** and **4644021**, respectively.

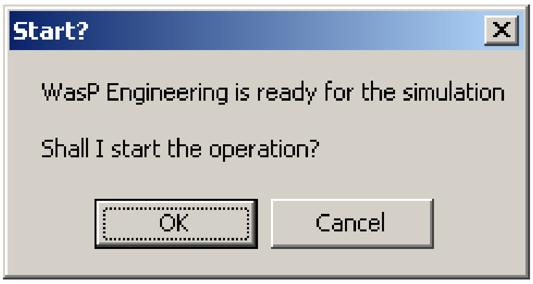


4. Now, we can insert the heights into heights section in any order we want. For our example we use three anemometers located on the met.mast at 30 m, 50 m and 70 m. So right click on the "**Heights**" and choose "**Insert new height...**" and insert three different heights one-by-one.

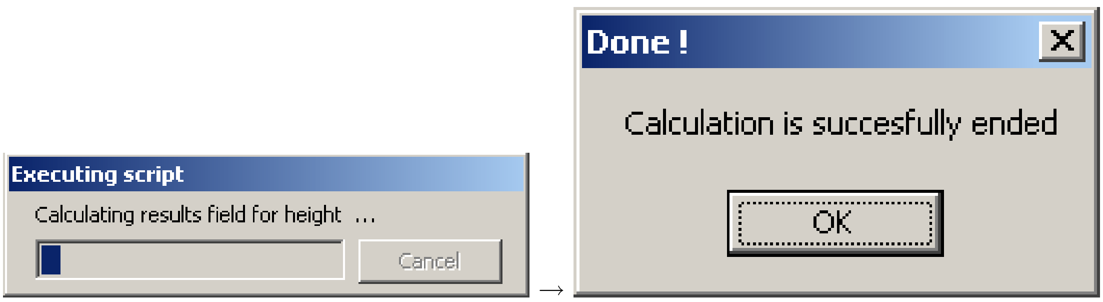


5. Now, go to "**Tools / Reporting**" and click on "**LiDAR 360...**".

6. First, the code will check input parameters (e.g. the sites) and if the setup is correct will ask you to continue. Click ok "**OK**" if no error messages returned.



7. The script will run the Microsoft Excel and start to create the report. The script indicator will show the process and it may take some time to finish the whole operation.



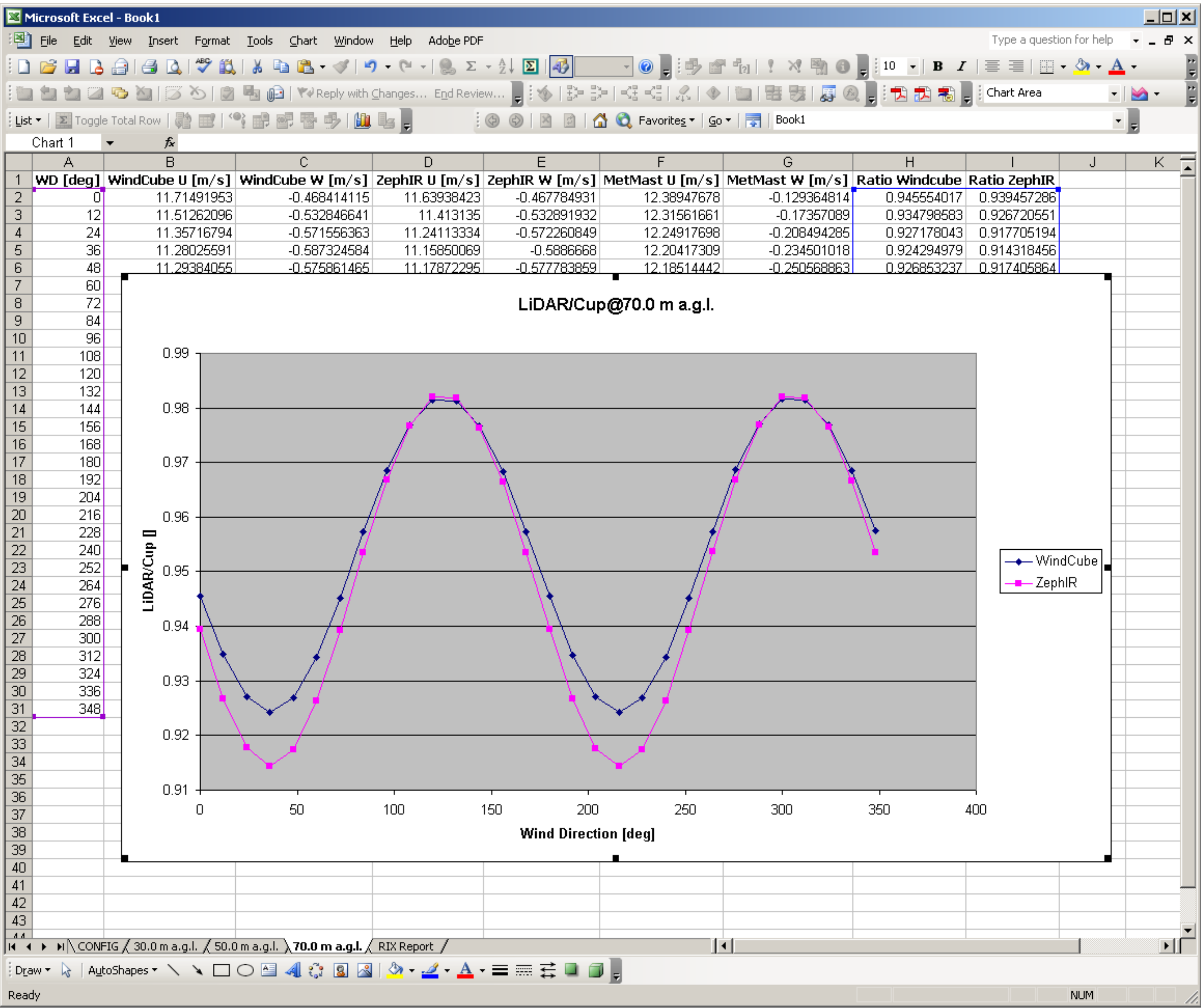
4 Results

The Excel file will have at least three sheets. The first one is the information about the setup, including project and site information. After that there will be number of sheets according to how many different heights you have entered. These sheets are the main results. Each sheet includes results for the met.mast, Leosphere WindCube and QinetiQ ZephIR. The script makes simulation based on a windspeed, 12 m/s, measured at met.mast location at 45 m. The ratios listed in last two columns are the ratio between lidar and met.mast simulations which can be seen in the generated graph.

In the graph, one can see the ratio for Windcube and ZephIR differs. This is due to the fact that they both calculate the wind speed in different ways. The x axis is the wind direction and y axis is the ratio. Values below 1 means the lidar is lower estimating where the values above 1 means the lidar is over estimating. For our example the biggest error occurs in South-West direction. This is expected because the met.mast and lidar are located very close to the edge of the hill where nearly half conical circle of the lidar takes measurements before the edge where there is a possible speed-up which leads to an error. This is also the case in real life.

Another point is the used stable roughness value. Using a stable roughness value has an effect on the results where it makes the result symmetric. This is due to fact that WAsP Engineering is a linear flow model and in case of stable roughness value opposite wind directions will give the same result. This is preferred in this example as well as in the previous studies because the results detonate the terrain effect which is the dominant in a complex terrain for the flow. One can also try the same example after editing the roughness map. In that case the results will not be symmetric.

The last sheet of the Excel file is the RIX value information and created by using the met.mast location. See reference [3] for more details on RIX values. We included this information in Excel sheet in case the user would like to see if there is a correlation between the error and the terrain slope.



5 Conclusion

WAsP Engineering 2.0 can predict the lidar performance in complex terrain by means of a script and report back in an Excel sheet. The explained method can be used in many different scenarios like; putting the lidar and the met.mast to the same location and making a direct comparison and etc. The script is open source and can be edited by the user.

Acknowledgements

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References

[1] Ferhat Bingöl, Jakob Mann, and Dimitri Foussekis. Conically scanning lidar error in complex terrain. *Meteorologische Zeitschrift*, April 2009. Accepted for publication.

[2] Ferhat Bingöl, Jakob Mann, and Dimitris Foussekis. Modeling conically scanning lidar error in complex terrain with WAsP Engineering. Report Risø–R–1664(EN), Risø National Laboratory for Sustainable Energy - DTU, November 2008.

[3] Niels G. Mortensen, Amy J. Bowen, and Ioannis Antoniou, editors. *Improving WAsP predictions in (too) complex terrain*, Proceedings of the 2006 European Wind Energy Conference and Exhibition. EWEA, February 2006.