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A Windscanner Simulator

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Abstract

A windscanner is a system comprising three spatially separated wind lidar systems each with a fully-steerable scanner head. By steering the three beams to meet at a point, the 3D flow vector can be measured by combining these three independent radial wind speeds.

Since measurements are performed within a volume and not just at a point it is important to identify and characterize all the central effects arising from the volumetric sampling. The investigation of these effects is carried out by simulating the windscanner's measurement process. The simulation cases were performed for flat and complex terrain. For the each simulation case the wind speed vector from different heights was extracted and compared to the nominal point values. These simulations represent the foundation of a simulator which will be used to investigate and optimize the physical windscanner.

Objectives

The simulator is a multi-purpose application. It is used to investigate the measurement process of the windscanner system. Different applications of the windscanner will have different layouts of the placements in the field. With the simulator it is possible to test and optimize these layouts. After finding the most suitable placement following application of the simulator is to develop, test and optimize the scanning trajectories. The aim is to have the simulator capable to perform the preparation of the field campaigns.

Code

The code of the simulator was developed in Mathematica 8. It has various modules. Since the two types of the windscanners are developed in Risø DTU, the simulator has the two modules for handling the both types (the long-range and short-range windscanner). Simulations of the measurement process of the windscanners can be done for flat and for complex terrain. The code has two dedicated modules for this. The module for complex terrain has the connection with Risø's in-house CFD software ELLIPSYS®. Also, for a given scanning trajectory a special module calculates and exports the motor angles for the scanner heads.

Flat Terrain

The initial test of the simulator was done for the case of the flat terrain, mean wind speed and long-range windscanner (pulsed lidar). The weighting function of the windscanner was model using the pulse length of 328 ns (FWHM) and the flat time window of 400 ns [1-3]. The windscanners were placed on the ground with distance of 1 km among them (Figure 1.). Wind field was simulated for the one wind speed and one direction assuming that the wind speed is changing with a height (Power Law, α=0.2), but not horizontally. The three sets of the four different heights were used for the comparisons between the windscanner and point measurements. The results are displayed in Table 1.
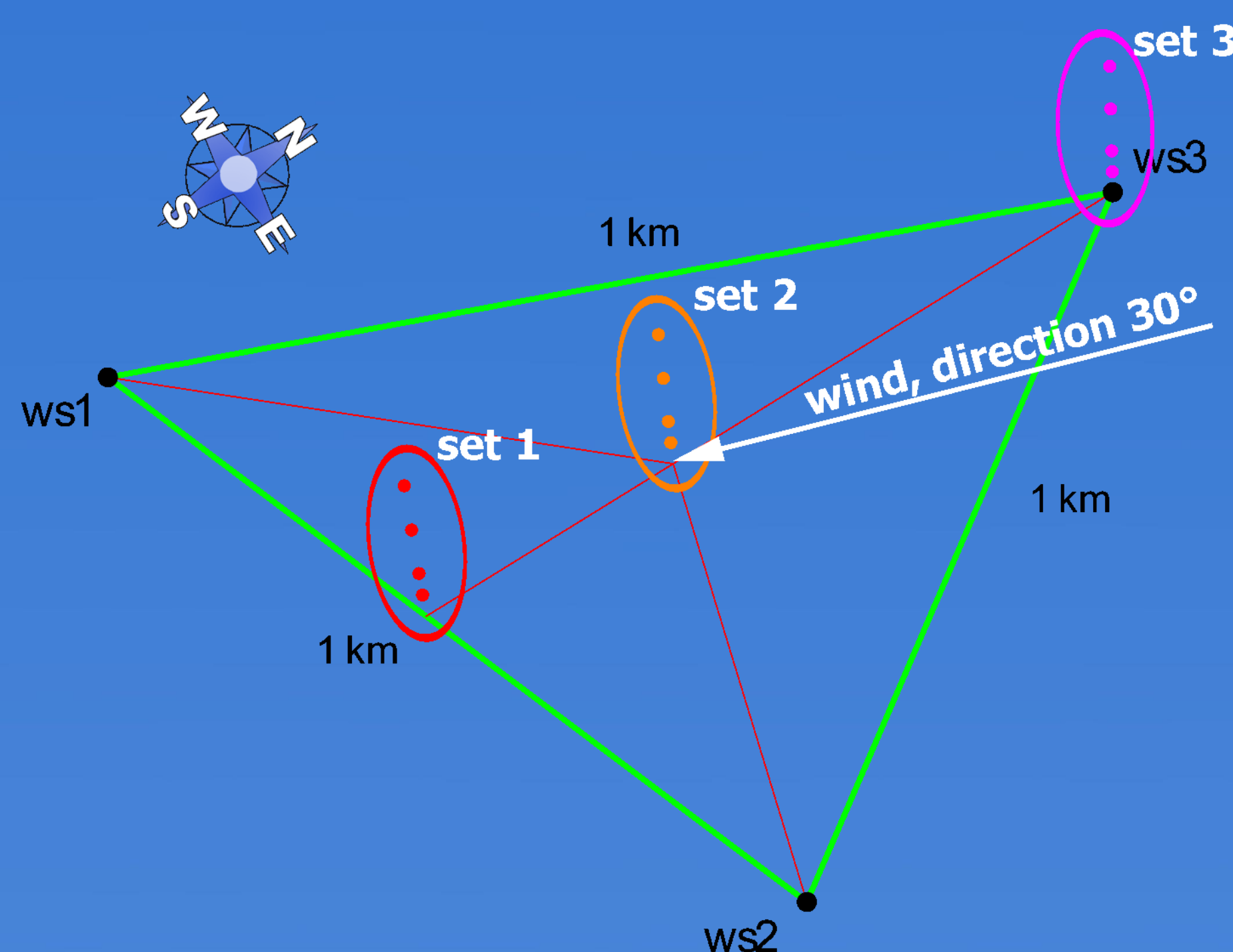
Figure 1. The positions of the windscanners and measuring points. The point ws3 is facing North.

	Set 1 – error %	Set 2 – error %	Set 3 – error %
60 m	0.0101642	0.0152208	0.0295863
75 m	0.010093	0.0151297	0.019799
100 m	0.00995109	0.0149366	0.0139332
150 m	0.00959184	0.014411	0.00973846

Table 1. The measurement error for each set (U(point)-U(ws))/U(point) [%]

Complex Terrain

The same lidar properties were used for the case of the complex terrain – the Askervein hill. The wind field was simulated using the CFD software ELLIPSYS® for the wind direction 210°. The placement of the windscanners is shown on the Figure 2. At the location 'mp' (Fig.2) the wind speed was extracted from four different heights. The results of the comparison between the windscanner's and point values are shown in Table 2.
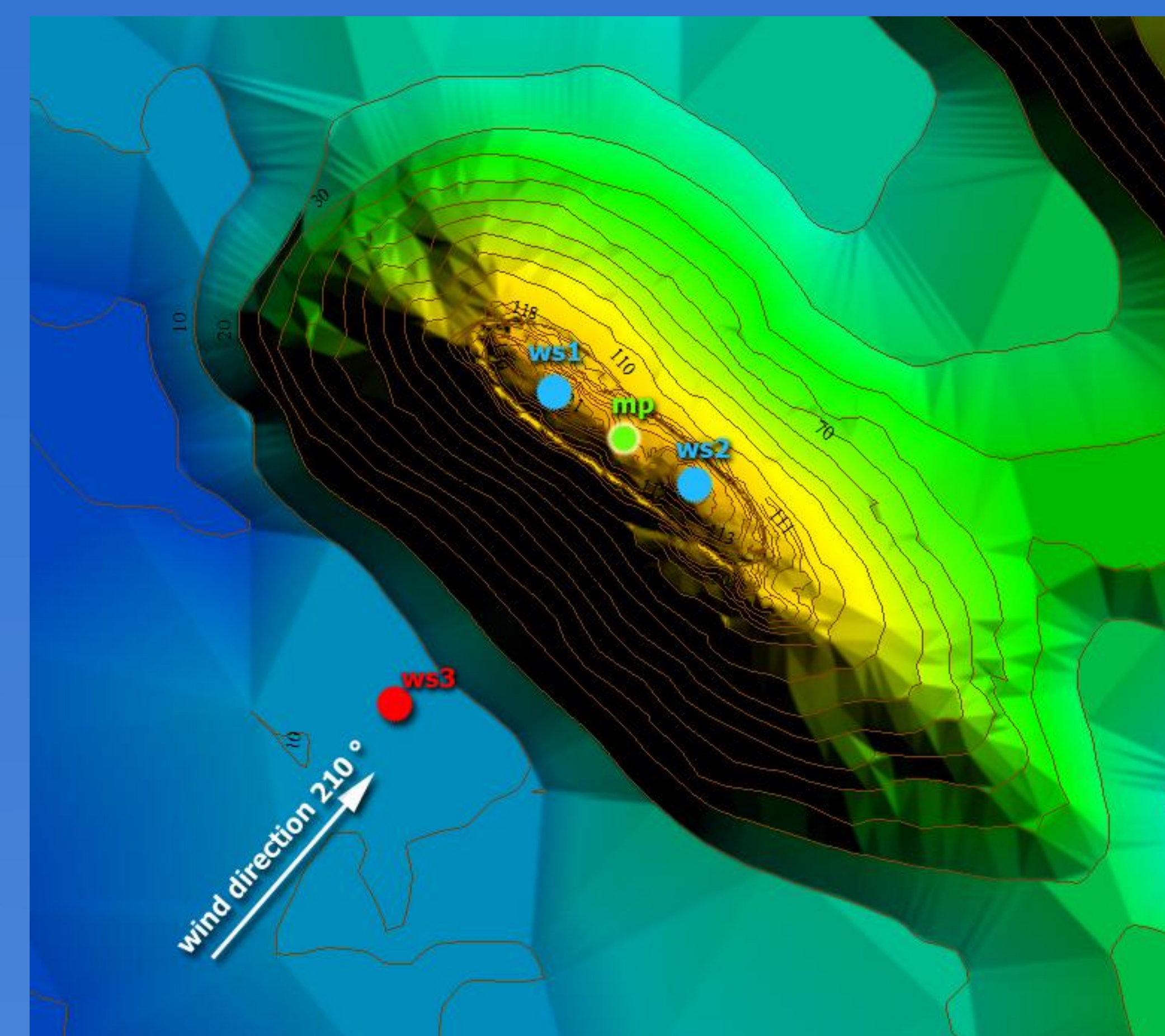
Figure 2. The positions of the windscanner and measuring point at the Askervein hill.

Height [m]	25	50	100	150
Error [%]	0.108166	-0.0115347	0.00677876	0.0192602

Table 2. The measurement error for 4 different heights (U(point)-U(ws))/U(point) [%]

Conclusion

Based on the results in Table 1 and 2 we can conclude that in the case of the mean wind speed the modeled windscanner system is measuring like a point measurement device (i.e. sonic anemometer). The errors are less than 1%, and in the most cases they can be neglected. The additional simulations cases are needed to confirm the behavior of the system. Nevertheless, it is important to investigate in details the weighting functions that governed the lidar measurement process.

References

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