Microclimate analysis with Envi-met

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Abstract

For this report a research has been carried out on the micro-climate in a neighbourhood of Capelle aan den IJssel, which is a community near to Rotterdam, the Netherlands.

In order to study such a micro-climate, the program ENVI-met (version 3.1) has been used. This specific software allows the simulation of micro-climates on a specific date and for a certain amount of time. In this case the simulation was done for a daily cycle on the 23rd of January 2020.

In this report the effect of wind-direction on wind speed has been analysed. There were 3 scenarios used; one for a perfect north-eastern wind (45 degrees), on for the default mode of the program (90 degrees) and one for a south-western wind (225 degrees).

Contents

1. Introduction

The purpose of this report was to carry out an analysis and give a graphical representation on a chosen micro-climate. The analysis could be done using the software ENVI-met (version 3.1). The software uses various physical foundations such as thermodynamics, fluid mechanics, general physical laws and the $\kappa - \eta$ closure to make a simulation. The retrieved data can be transformed into a graphical representation with the program LEONARDO, which is included in the software.

For this project I chose an area within Capelle aan den IJssel in the Netherlands. In figure 1 the top view is visible.
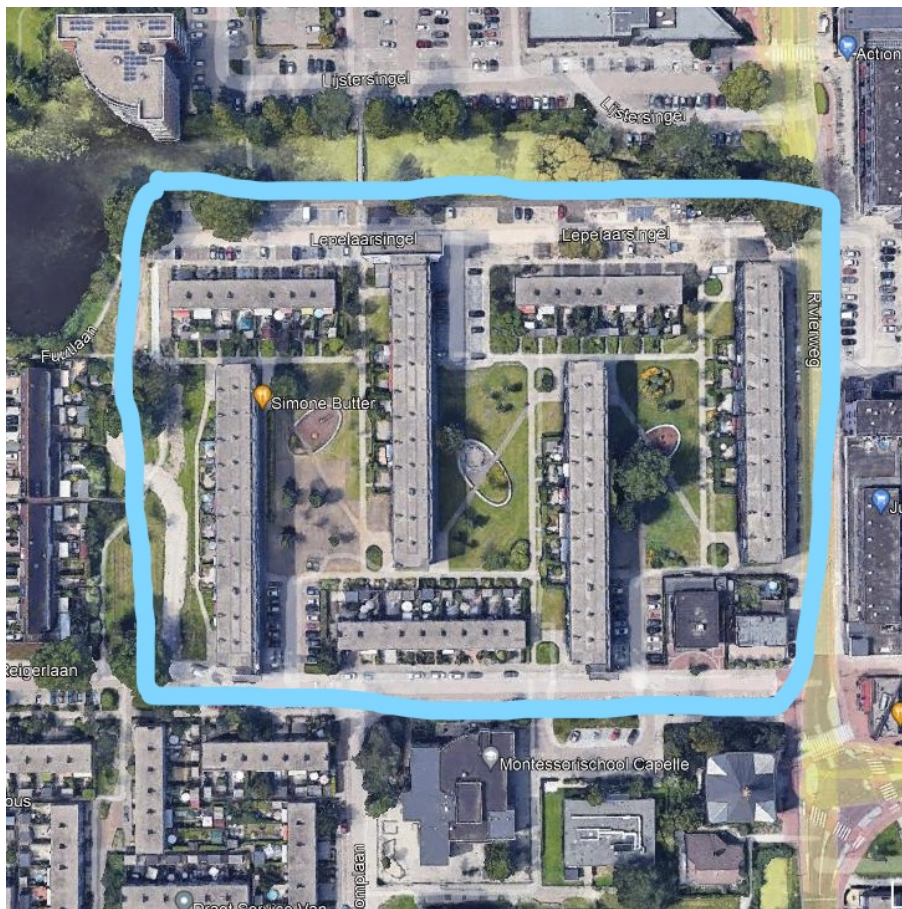

Figure 1: This is a snapshot from Google-earth and represents the top view of the chosen area

The goal of the analysis is to find a relationship between the wind-direction and the wind speed in this particular area.

2. Experimental method

2.1. Data

In figure 2 is the general configuration data given. In this part I only changed the wind degrees. The simulation was done for a perfect North-Eastern wind at 45 degrees, the default mode of 90 degrees and a perfect South-Western wind at 225 degrees. Moreover the simulation runs for 24 hours from 6:00 am on the 23rd of January, 2020.

```
% ---- Basic Configuration File for ENVI-met  Version 3 ---------------
% ---- MAIN-DATA Block -------------------------------------------------
Name for Simulation (Text):              = MySim
Input file Model Area                    =[INPUT]\Capelle2.in
Filebase name for Output (Text):         =MySim
Output Directory:                        =[OUTPUT]
Start Simulation at Day (DD.MM.YYYY):     =23.01.2020
Start Simulation at Time (HH:MM:SS):      =06:00:00
Total Simulation Time in Hours:           =24.00
Save Model State each ? min               =60
Wind Speed in 10 m ab. Ground [m/s]       =3
Wind Direction (0:N..90:E..180:S..270:W..)  =90
Roughness Length z0 at Reference Point    =0.1
Initial Temperature Atmosphere [K]        =293
Specific Humidity in 2500 m [g Water/kg air] =7
Relative Humidity in 2m [%]               =50
Database Plants                           =[input]\Plants.dat


        ( -- End of Basic Data --)
        ( -- Following: Optional data. The order of sections is free. --)
        ( -- Missing Sections will keep default data. --)
        ( Use "Add Section" in ConfigEditor to add more sections )
        ( Only use "=" in front of the final value, not in the description)
        ( This file is created for ENVI-met V3.0 or better )
```

Figure 2: This is the general part of the configuration

In figure 3 the manually adjusted variables are visible. In this part we changed the values for the initial temperature layers (upper, middle and deep). I retrieved these values [1] from the KNMI which is the official Meteorologic institute of the Netherlands. This institute measures the soil temperatures at 4 points in the Netherlands. The closest one to my area in Capelle aan den IJssel is Wilhelminadorp.

```
[SOILDATA] _____Settings for Soil
Initial Temperature Upper Layer (0-20 cm)   [K]=278.8
Initial Temperature Middle Layer (20-50 cm) [K]=279.6
Initial Temperature Deep Layer (below 50 cm)[K]=281
Relative Humidity Upper Layer (0-20 cm)         =50
Relative Humidity Middle Layer (20-50 cm)       =60
Relative Humidity Deep Layer (below 50 cm)      =60
[BUILDING]_____Building properties
Inside Temperature [K]                      = 293
Heat Transmission Walls [W/m²K]             =1.94
Heat Transmission Roofs [W/m²K]             =6
Albedo Walls                                =0.2
Albedo Roofs                                =0.3
[PMV] _____Settings for PMV-Calculation
Walking Speed (m/s)                         =0.3
Energy-Exchange (Col. 2 M/A)                =116
Mech. Factor                                =0.0
Heattransfer resistance cloths              =0.5
```

Figure 3: This is the manually added features of the configuration

2.2. Methodology

When ENVI-met 3.1 is downloaded and you open the program, you get to a starting bar. This bar contains 6 buttons, that leads to different programs; an editor, a configurator, a simulator, an analysator, a saving-program and one that leads you to the help-page.

2.2.1. Editing

For the simulation a grid is needed. With the editor function in ENVI-met we can build the area we want to experiment on. To use the editor, open the "startbar". With the first button you get to the space were you can create an Area.

- In "file", go to "Change settings/New model"

- Adjust your dx, dy, dz; in this particular model I choose dx,dy = 5 and dz = 2. I kept the grid of size 40 x 40 x 20. This could be adjusted up to 90 x 90 x 20 (the grid should not be to large)

- In the same bar you can adjust the rotation. This is convenient if your model is not perfectly aligned with the north. In this model we had to rotate -11.25 degrees.

- Build your area, with the "edit building/vegetation" function; consider the height of the blocks. For this model we estimated a 4-storage flat is around 12 meter high.

- Build the vegetation in the area; for this you pick the type of vegetation and use the left mouse button + shift to add this to the model. It is advised to clear the setting for buildings, so you don't accidentally add building-blocks instead of grass.

- Click on the round button next to "Edit soils" and pick the type of soil you want to use. In this case I only added "pavement" on the places there was a road. The other spaces underneath the building and so on, kept the default-mode soil.

- Go once more to "Change settings/New model" and adjust the grid to 50 x 50 x 20, so that there will be enough space around the edges.

- After adjusting the grid, the model can be a bit out of place. You can place the model in the middle using the 5th button from the left.

- Save the model under C:$\backslash ENVImet31\backslash input$ and close the program

NB. In order to get the right measurements for the model, I used Google-earth. The exact size of the building lengths could be retrieved with the "lineal"-function.

2.2.2. Configuration

For the configuration we use the second button on the ENVI-met startbar.

- Open the program in the starting bar

- Go to "file" and choose "New configuration"

- Name the configuration as you like

- "link" the configuration to the model with "Input file Model Area". Since you saved your model in the input-file of the program, you only have to change the part after "[INPUT]" to "$\backslash MODELNAME.in$

- You can change the "Filebase name for Output (Text)", but leave the "Output Directory" as it is

- For the relative and specific humidity, the default mode is sufficient. The rest of the variables can be changed as to what is necessary for your model. In this model we did 3 configurations with 3 different values for the wind degrees.

- Under "Add section", you can add more specific data on different subjects. I added [BUILDING], [SOILDATA], [PMV]. Do keep in mind these values are stationary.

- Save the configuration under C:$\backslash ENVImet31\backslash input$ and close the program

2.2.3. Simulation

For the simulation we use the 3rd button on the ENVI-met starting bar.

- Open the program

- Under "Active Envi-met project" change [PROJECTS] to [HOME] to find your model quicker

- Click on "load configuration model" and choose the configuration we saved earlier

- Under "Test Model" choose "Test configuration" and check if any mistakes occur. If there are mistakes, you have to troubleshoot in your configuration or model (depending on the output of the test round)

- Now run your model under "Run Model". This may take a few minutes

- the results are now saved in the "output" file of Envimet. However, with every run all the results are stuffed together in one folder. That is why I made a new folder within the output before I adjusted my configuration and did a new run. The results were saved like this "$C:\backslash ENVImet31\backslash output\backslash atmosphere\backslash NEWFOLDER$"

- Adjust the configuration you have made, save it and following the steps above once more

2.2.4. Analysing the result

The results can be analysed with the LEONARDO-program. This is the 4th button on the starting bar.

- Open the LEONARDO-program

- Go to "Tools" and choose "DATA Navigator" and choose the file you want to analyse. I choose the data from the "atmosphere" folder in the output

- Under "Variables in file" you can choose the data you want to analyse. For our research I choose "wind speed (m/s)". To add this variable; click on the variable and then click on the little black arrow next to "data".

- Click on "Extract 2D cut" and a picture will emerge

- Click on the round button "Vector" on the general adjustment bar.

- in the same bar, you can find "2D Settings". Click on this and go to "Vector/particle". In order to make the vectors more visible you can adjust the vector length from 0.5 to 0.04, then click on "apply".

- you can save the figures in LEONARDO by making it a bitmap. For convenience reasons, I used a snipping tool on my computer.

3. Results

For the result, I will check the different wind fields at 3 points in time and compare those. The sun goes up at 8:30 pm in January. For this reason I choose 1 point in time just after the sun rises, one point in time at the peak of sunlight, and one point of time where the sun has gone down.The field will be compared at at 9:00 am, 16:00 pm and 23:00 pm.

The graphs of the wind fields can be found in Appendix A. I have found the following, while analysing these graphs:

- In all cases high speeds were found around the edges of the grid. This is due to empty space and this will not be taken in account in this research

- The south-western wind has higher speeds during the day than the north-western wind and the default mode wind. The default mode has lower speeds during the day.

- In all cases the wind speed was higher in the morning.At 16:00 pm the maximum wind speed had decreased. From 16:00 to 23:00 pm the wind speed did decrease, but barely.

- The wind speed distribution became more steady during the day; the distribution of high-speed and low speed area's within the area's almost stay the same, but the colours grew closer together and so the the wind speed stabilised. This is true for all cases.

- For the perfect north-western and the perfect southwestern winds, the wind degrees distribution almost remained the same between 16:00 and 23:00 pm. There were slight differences with the distribution at 9:00 pm, but not as obvious.

- All wind-types became parallel to the buildings when they were very close to the building

- The north-eastern wind incoming at 45 degrees and the south-western wind at incoming at 225 degrees, have the strongest bending around the buildings. They also have relatively higher speeds close to the building, than the default mode has.

4.   Discussion

Since we only evaluated one neighbourhood for different scenario's on the same day, the results can not give an overall valid conclusion. For now I found a conclusion linking the bending of the wind to it's speed. However, the model I am analysing is relatively simple. The actual soil, the heat transmission through the building and so on, can also influence the result. Moreover, even if the model was to be more accurate, it should be analysed on more than one day. With a further extended database the analysis would be more valid.

5.   Conclusion

In this report I tried to find a relation to wind speed and wind direction in a neighbourhood in Capelle aan den IJssel, the Netherlands. I conclude that:

- Wind speed decreases stronger during the day than during the night

- Wind speed stabilises within the neighbourhood during the day

- the stronger the wind has to bend, the stronger the wind speed seems to become. However, this relationship was not very strongly visible and could be non-existent; further research should be done.

References

[1] Bodemtemperatuur wilhelminadorp (1989). `https://www.knmi.nl/nederland-nu/klimatologie/bodemtemperaturen`. Accessed: 13-01-2022.

Appendix A
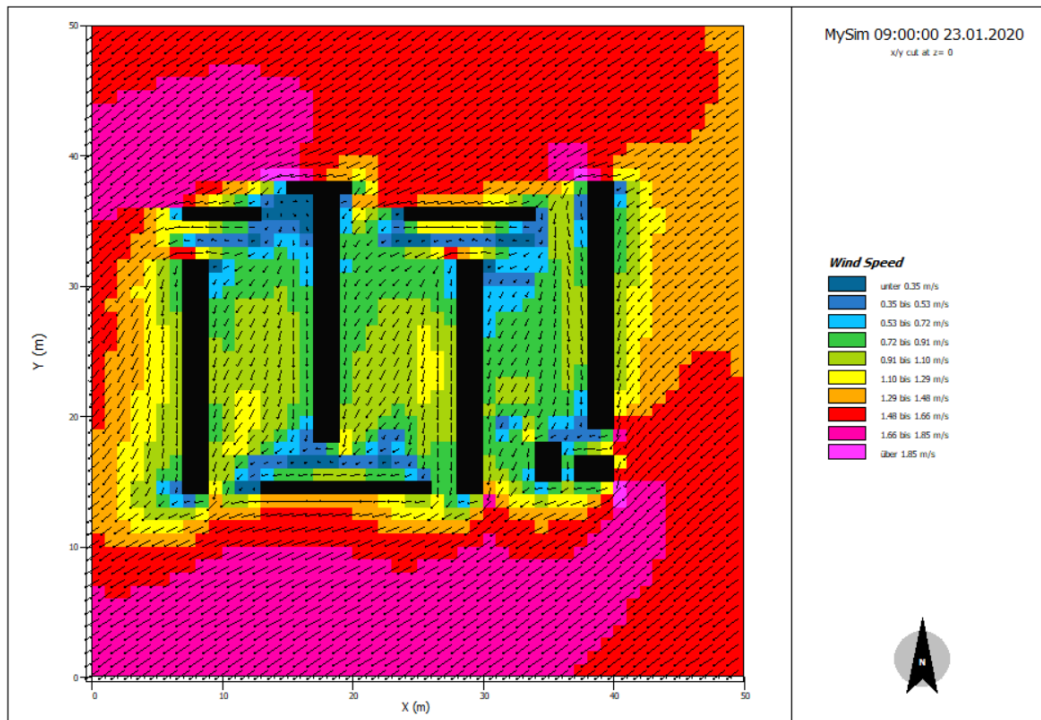
((a)) Wind speed at 9:00 am for a perfect north-eastern wind at 45 degrees
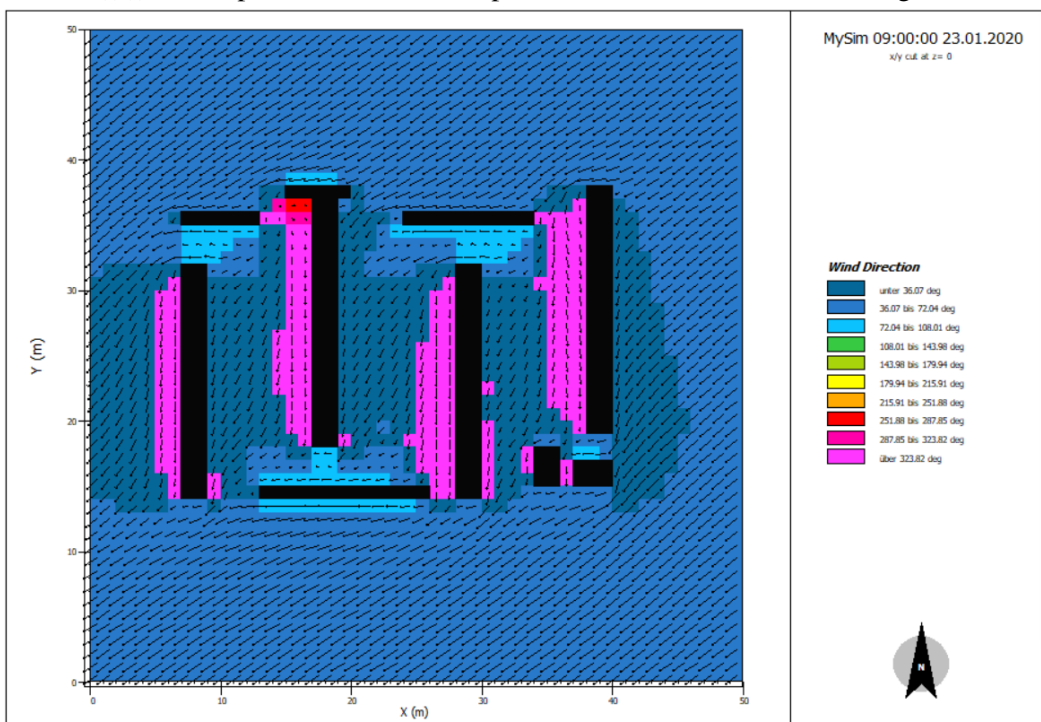
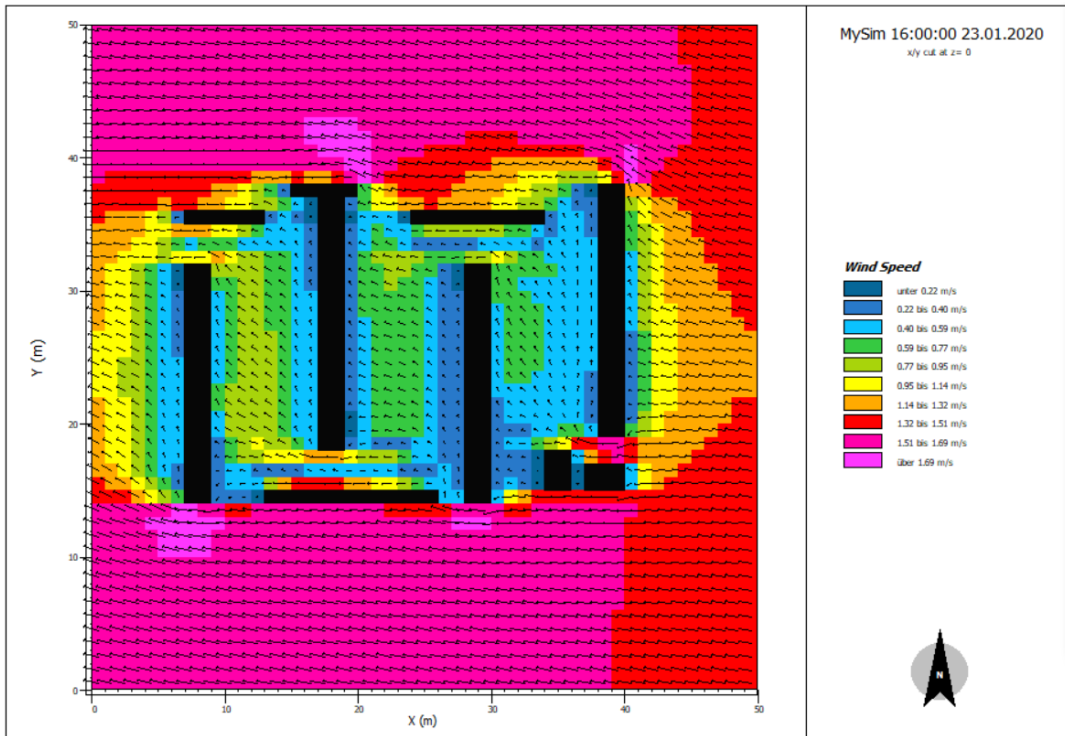((b)) Wind degrees distribution at 9:00 am for an incoming north-eastern wind at 45 degrees

Figure 4
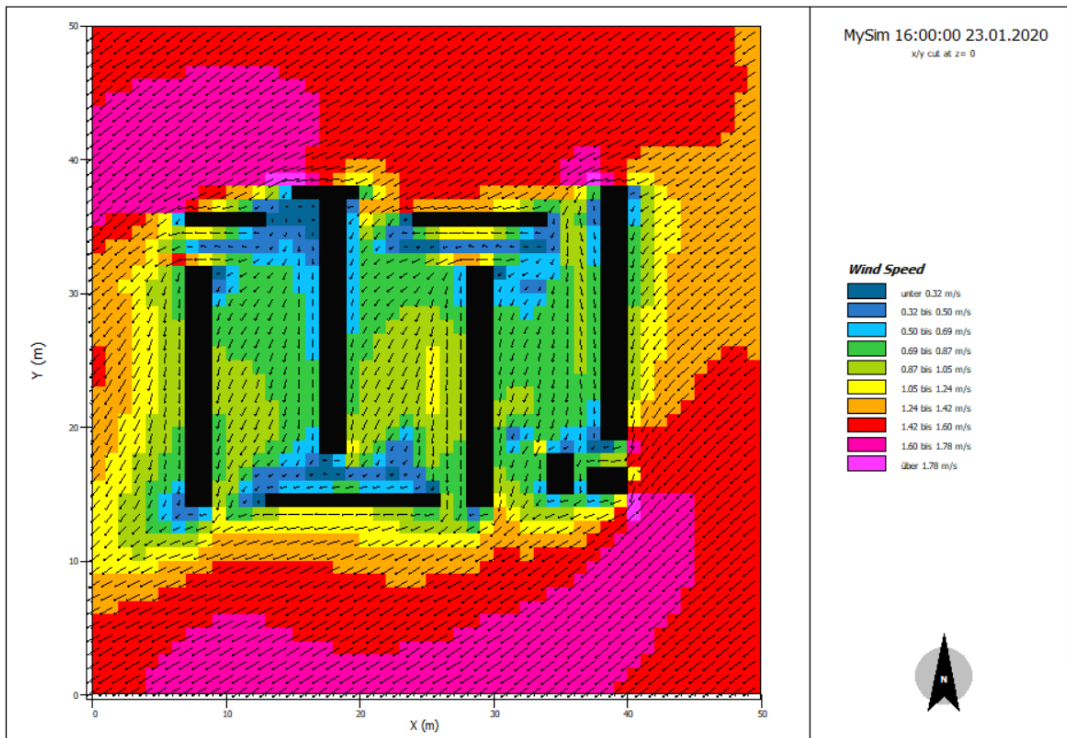
((a)) Wind speed at 16:00 pm for a perfect north-eastern wind at 45 degrees
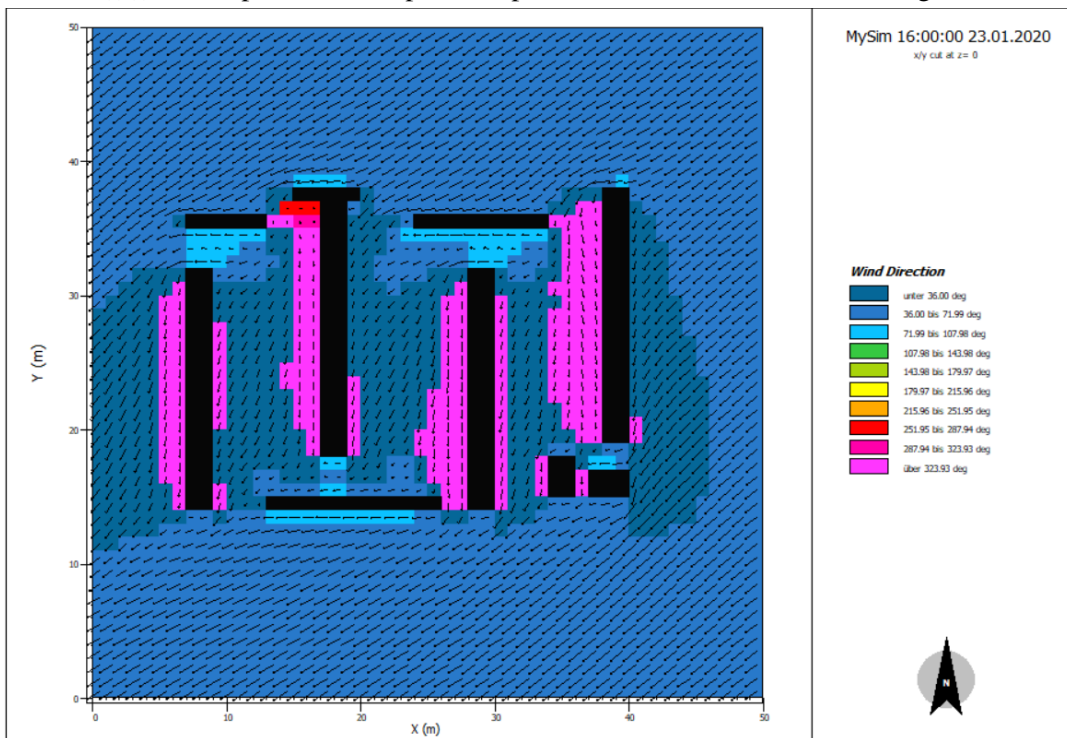
((b)) Wind degrees distribution at 16:00 pm for an incoming north-eastern wind at 45 degrees

Figure 5
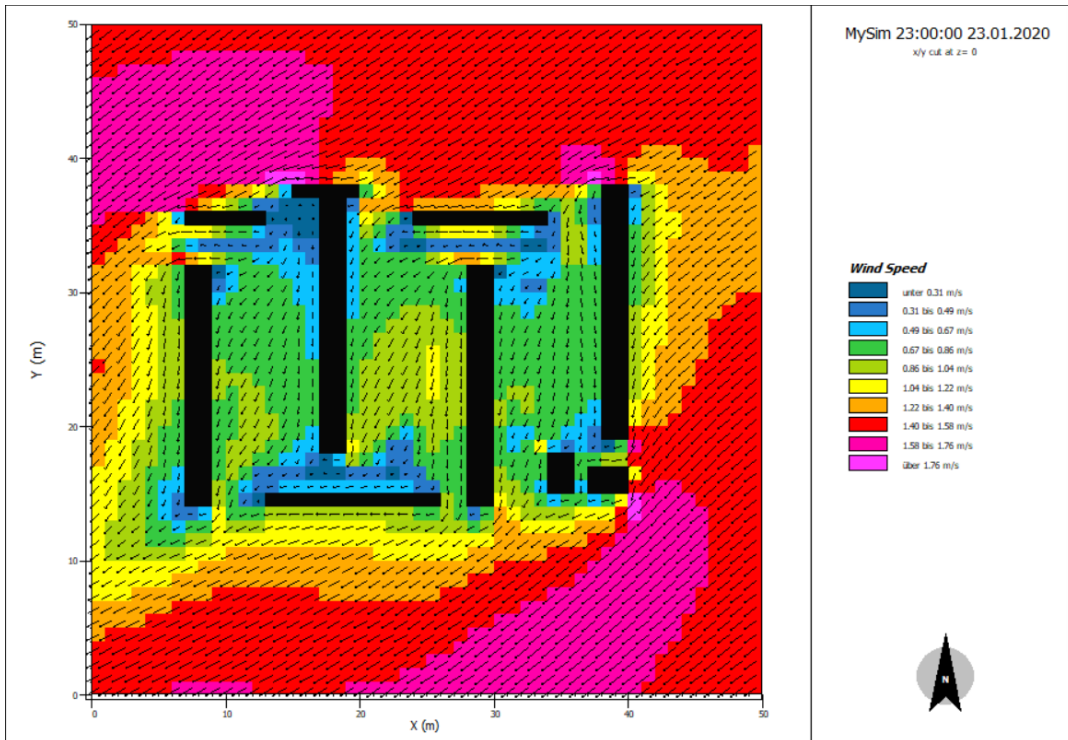
((a)) Wind speed at 23:00 pm for a perfect north-eastern wind at 45 degrees
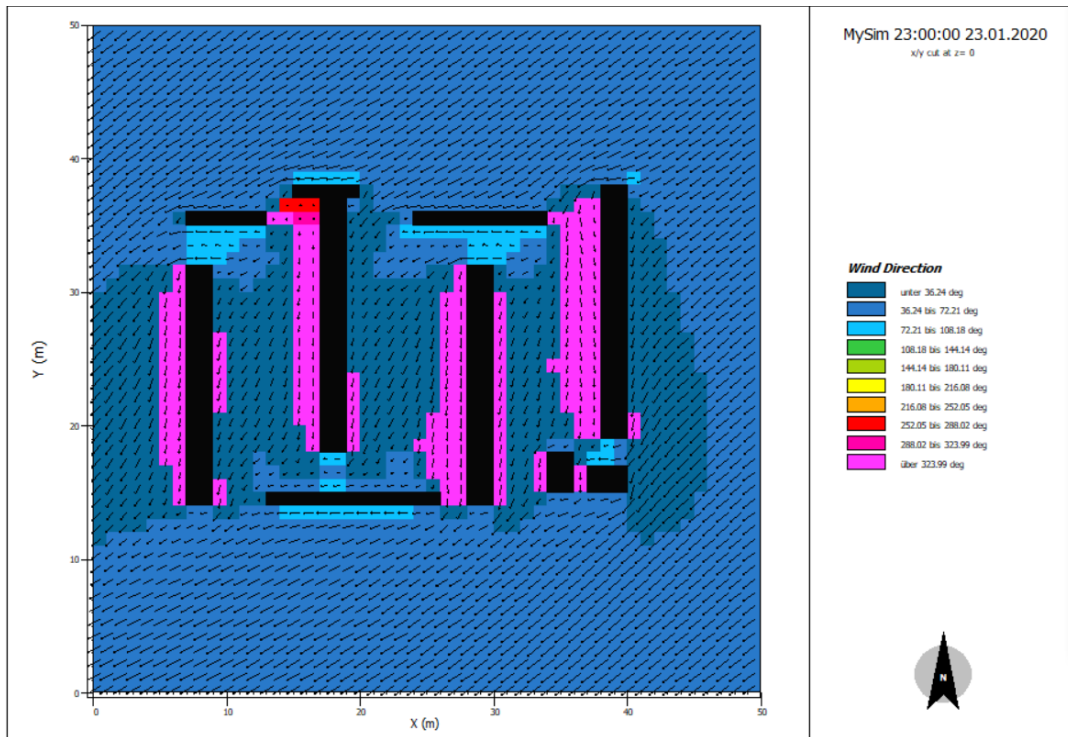
((b)) Wind degrees distribution at 23:00 pm for an incoming north-eastern wind at 45 degrees

Figure 6
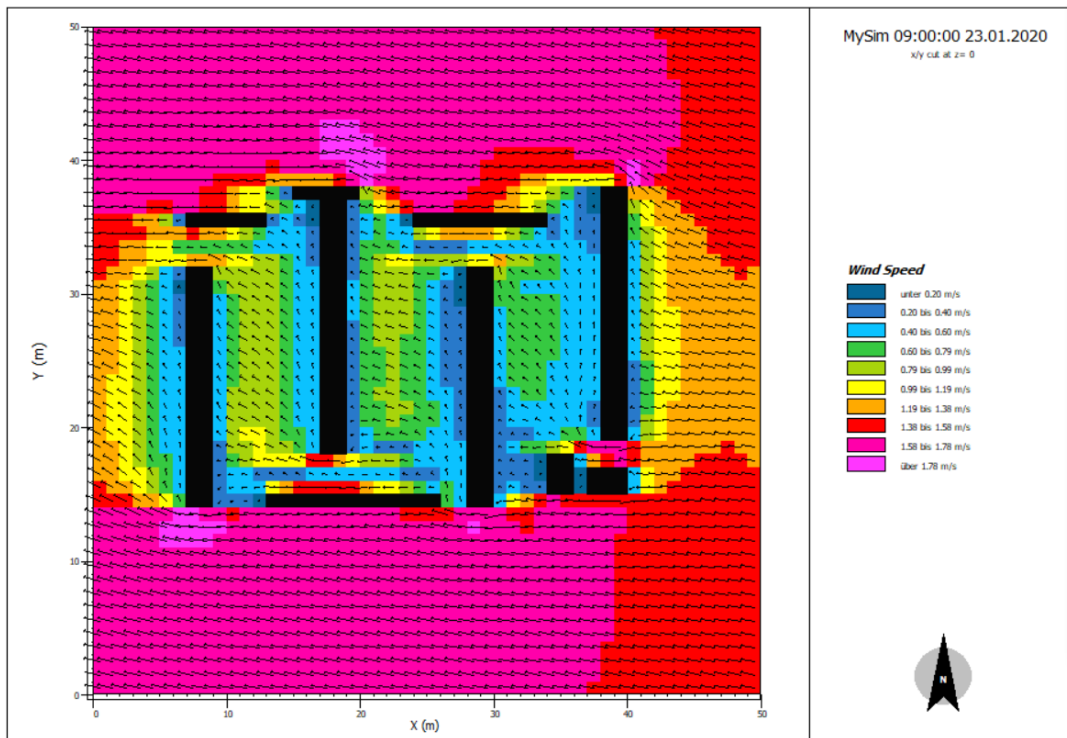
((a)) Wind speed at 9:00 am for a wind at 90 degrees (default mode)
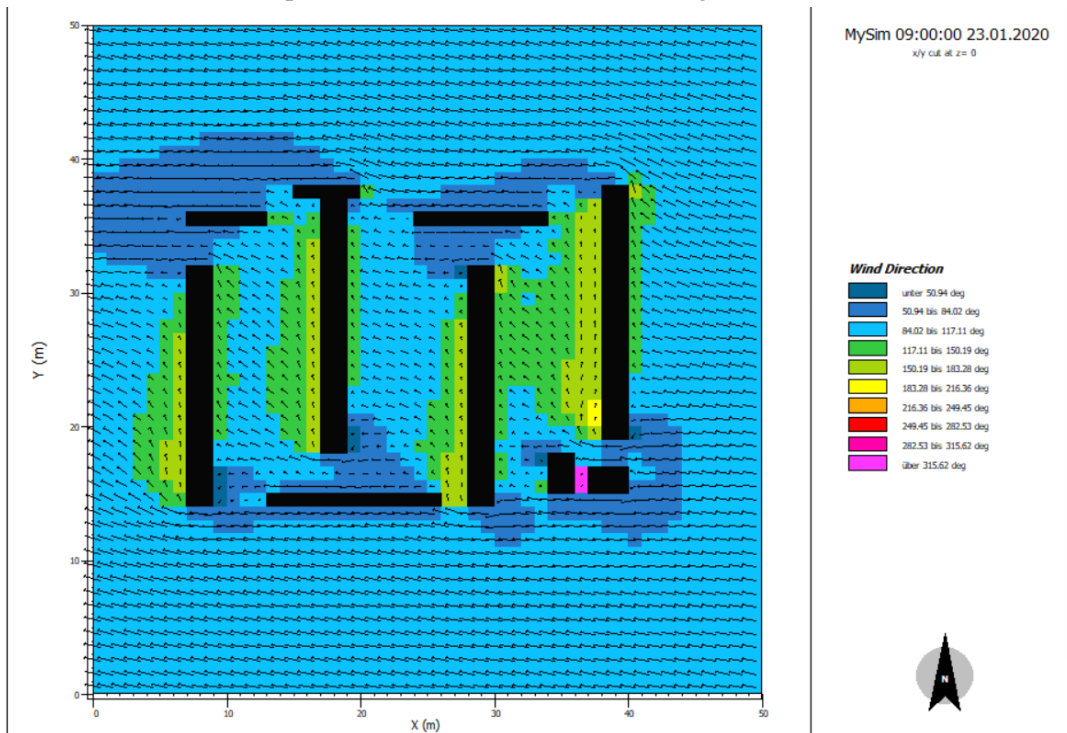
((b)) Wind degrees distribution at 9:00 am for an incoming wind at 90 degrees

Figure 7

((a)) Wind speed at 16:00 pm for a wind at 90 degrees (default mode)
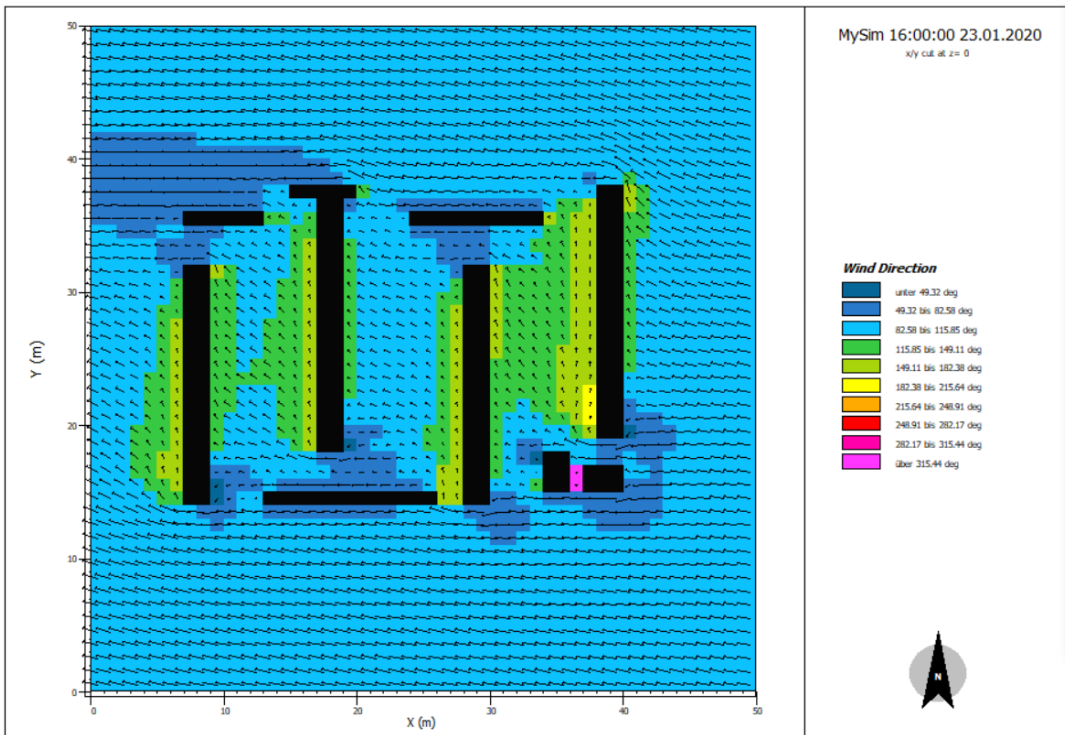
((b)) Wind degrees distribution at 16:00 pm for an incoming wind at 90 degrees

Figure 8
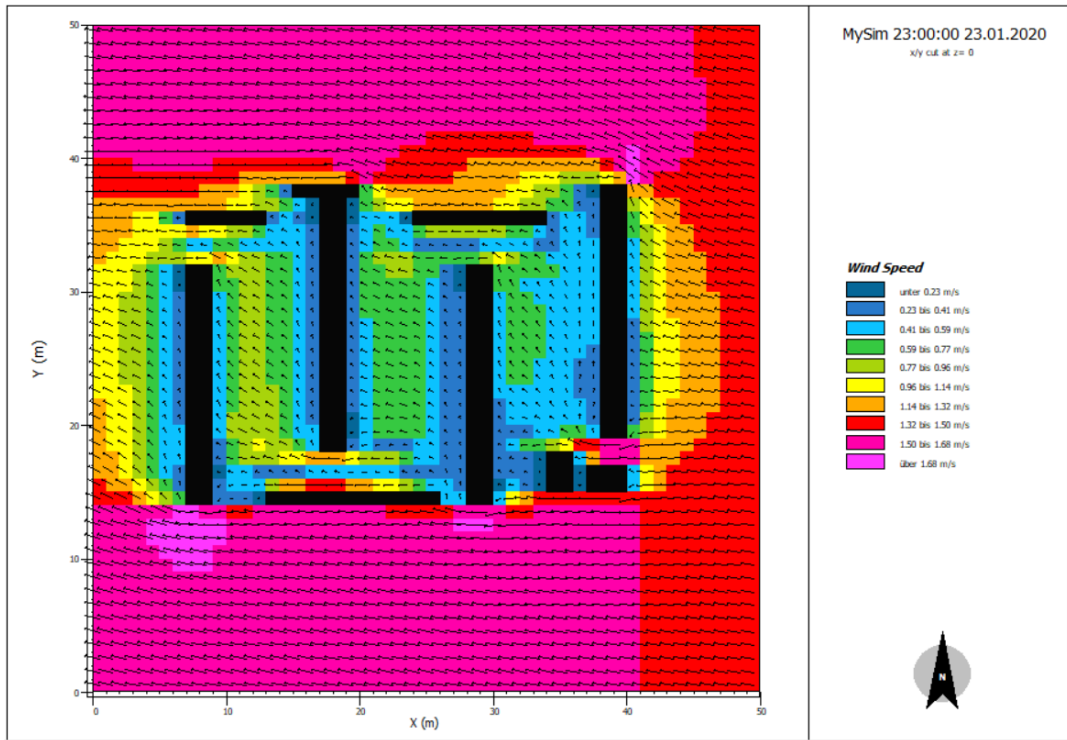
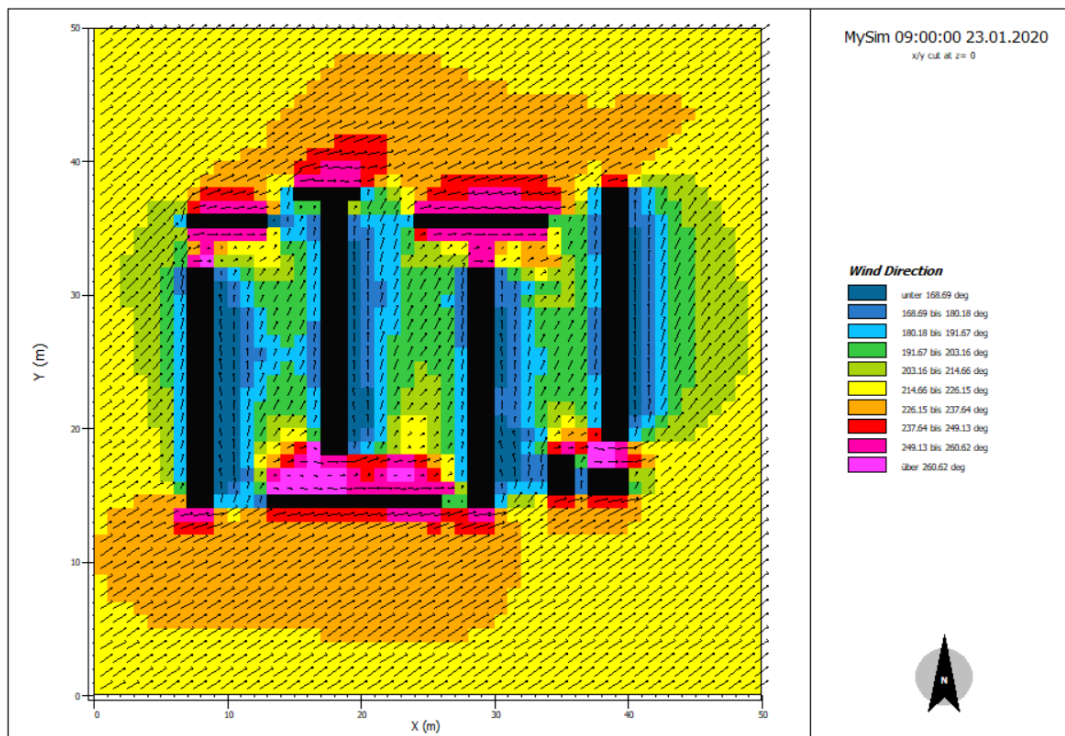((a)) Wind speed at 23:00 pm for a wind at 90 degrees (default mode)
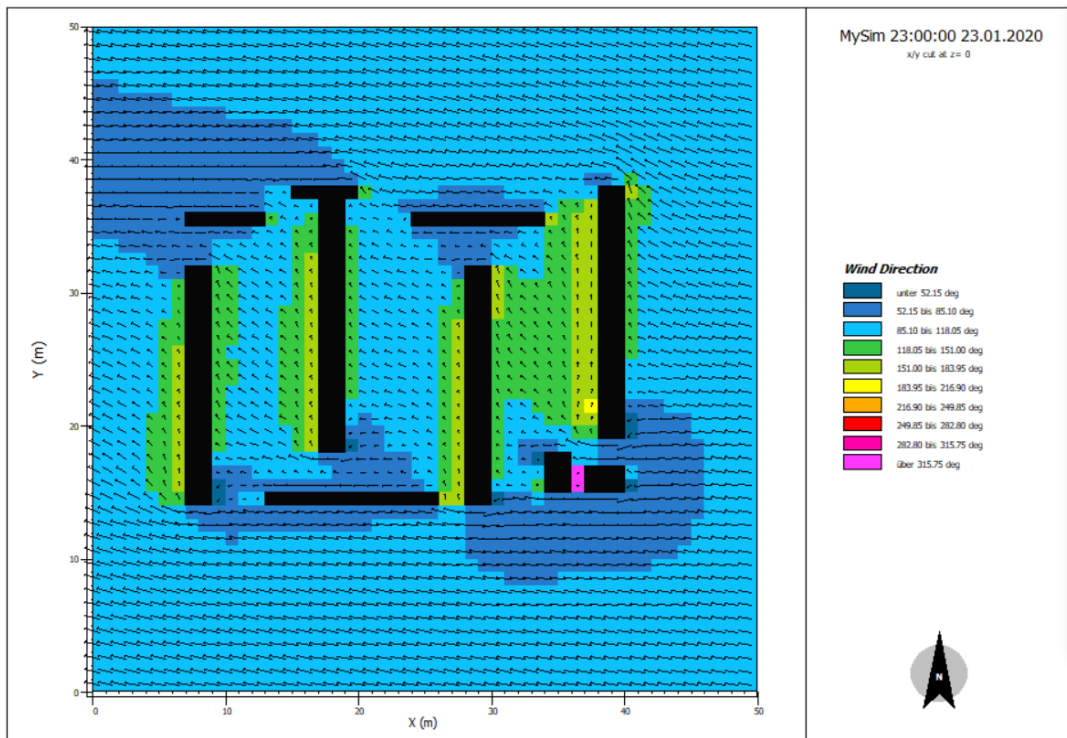
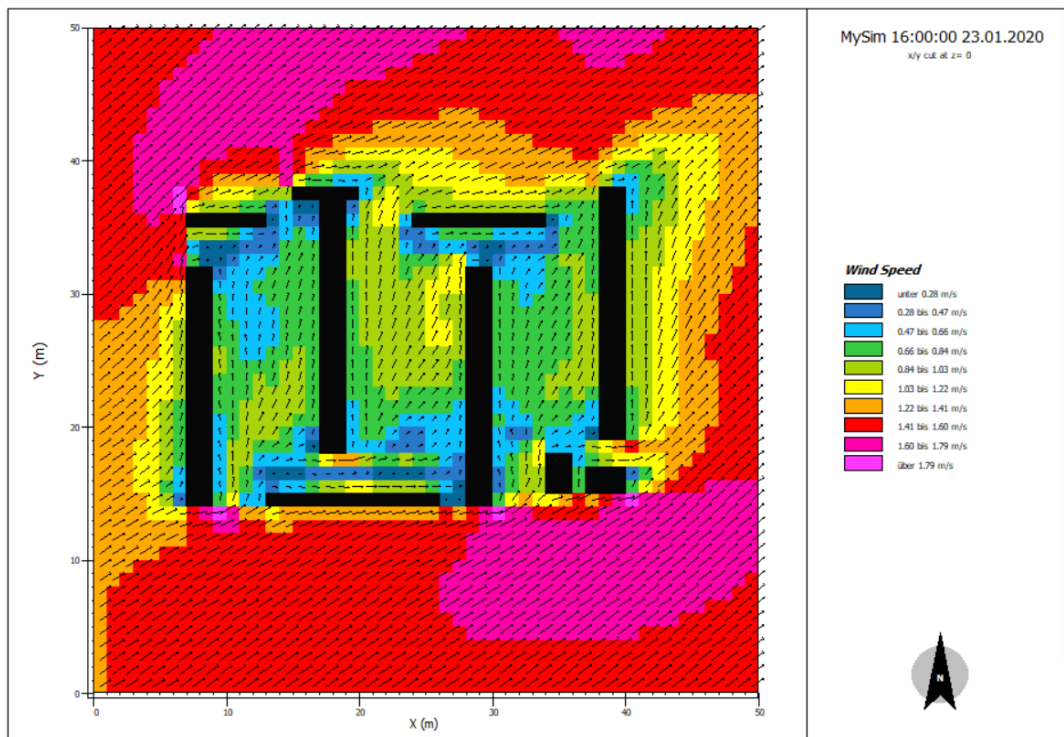((b)) Wind degrees distribution at 23:00 pm for an incoming wind at 90 degrees

Figure 9
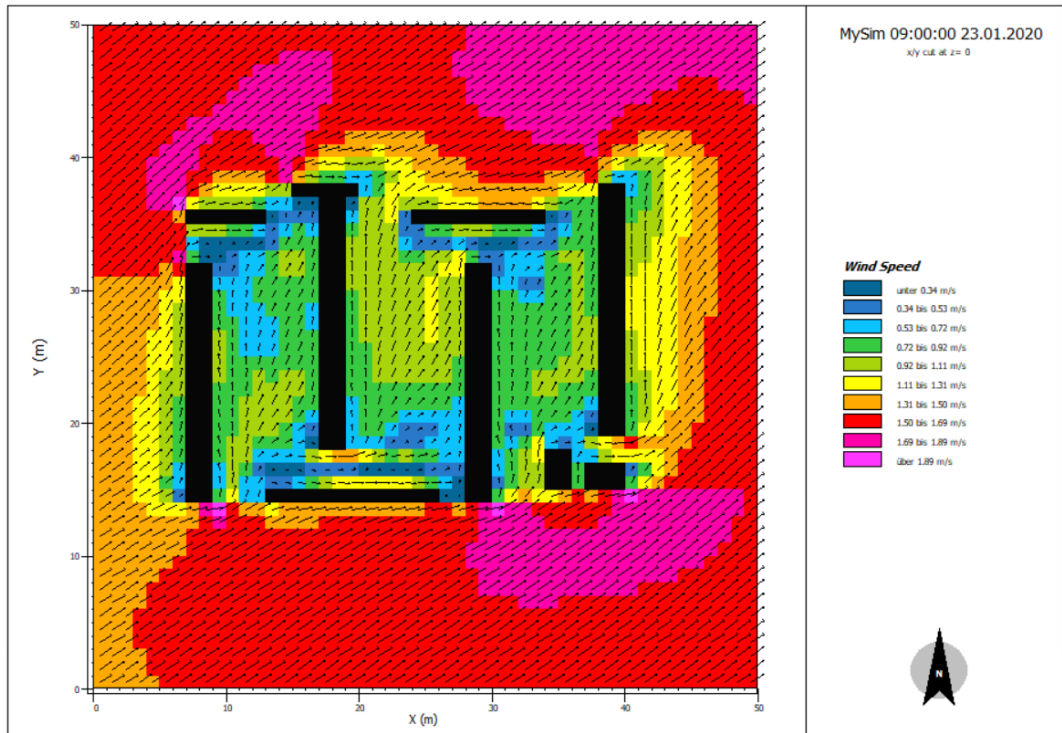
((a)) Wind speed at 9:00 am for a wind at 225 degrees , a perfect south-western wind
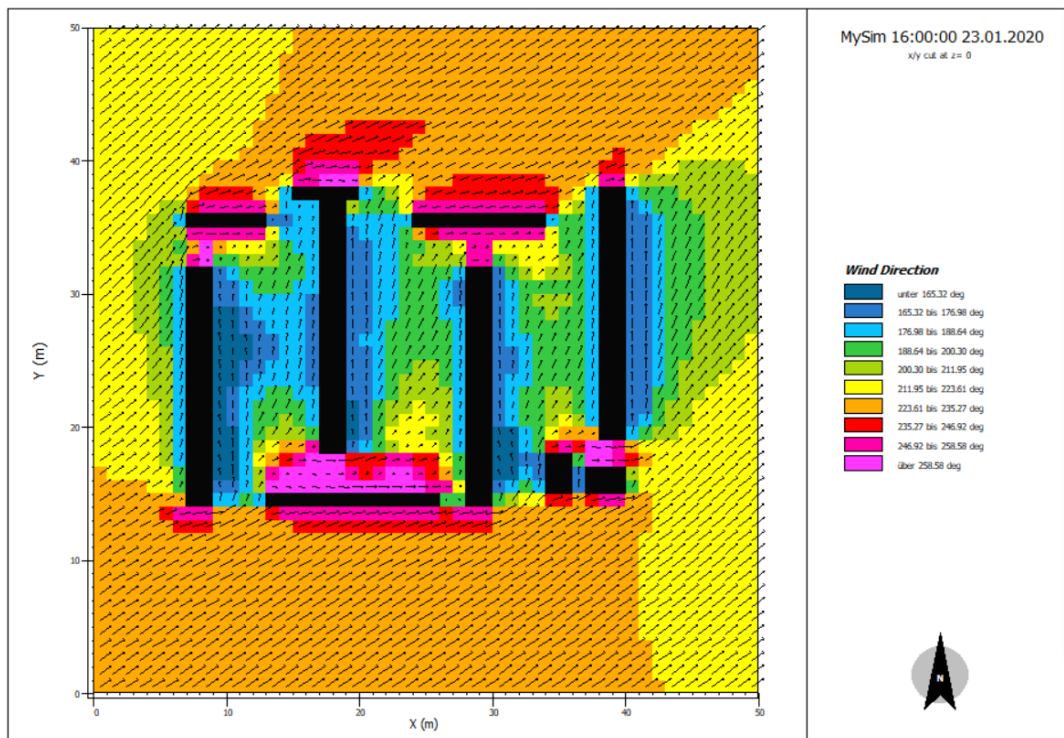

((b)) Wind degrees distribution at 9:00 am for an incoming wind at 225 degrees , a perfect south-western wind
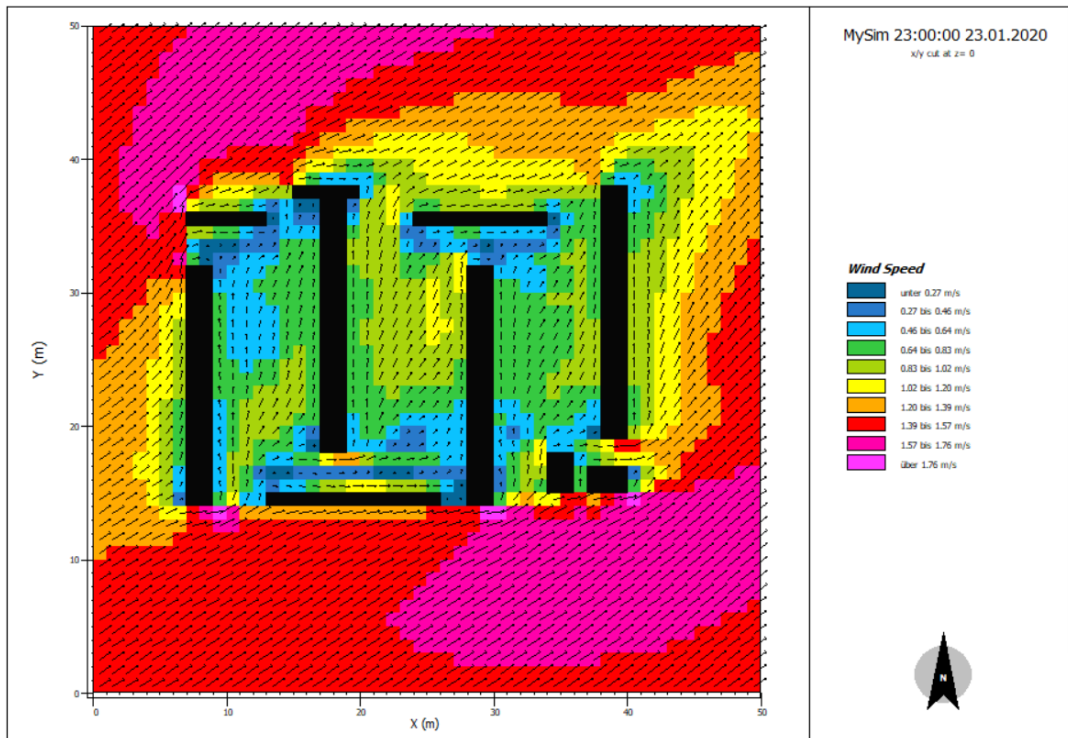
Figure 10

((a)) Wind speed at 16:00 pm for a wind at 225 degrees , a perfect south-western wind
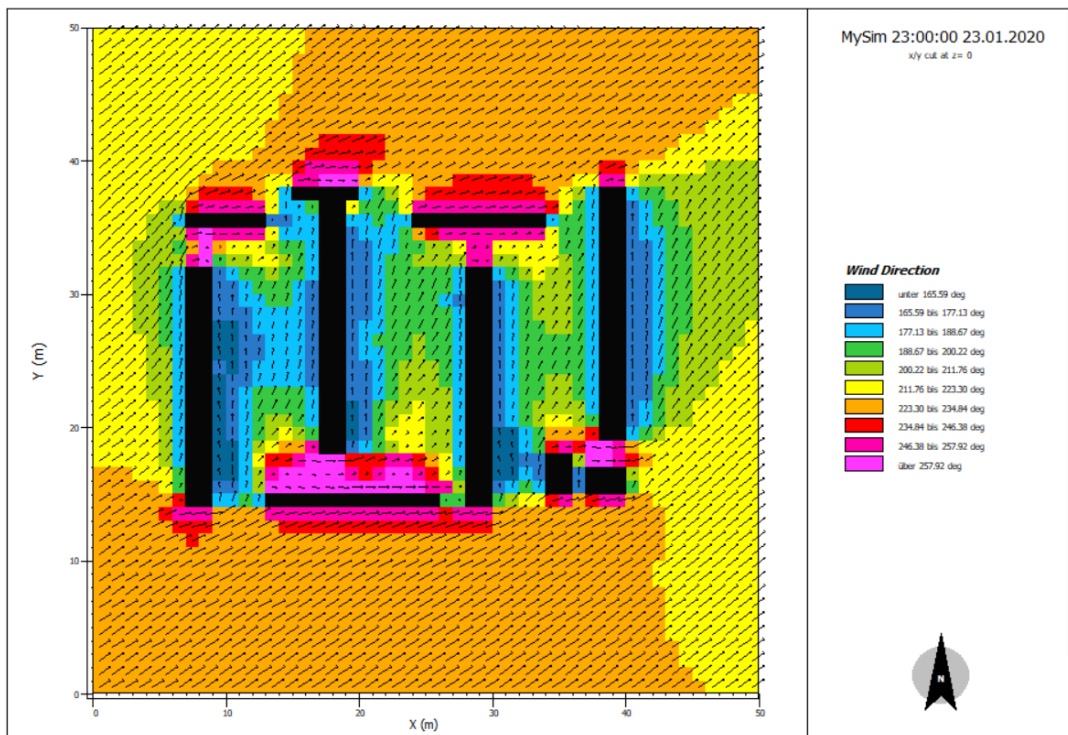

((b)) Wind degrees distribution at 16:00 pm for an incoming wind at 225 degrees , a perfect south-western wind

Figure 11

((a)) Wind speed at 23:00 pm for a wind at 225 degrees , a perfect south-western wind

((b)) Wind degrees distribution at 23:00 pm for an incoming wind at 225 degrees , a perfect south-western wind

Figure 12