


UrbaWind

Study cases - Validation File

					
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INTRODUCTION

In order to validate **UrbaWind**'s results, different study cases based on practical uses proposed by the *Architectural Institute of Japan* (<http://www.aij.or.jp>) have been set up. The three selected cases have an ascending complexity, from the simple block to the complete rebuilding of a quarter of the Japanese city of **Niigata**. These published cases allowed to compare the computations results of **UrbaWind** with the measurements of the *AIJ*.

Therefore, the sites have been recreated in a file format that can be used by **UrbaWind** and the conditions taken for the CFD computations are as near as possible of the experiments conditions. The values obtained by the computations are then compared with the measured values.

At first a graphical comparison is done by placing the points on a graph with the computed values in ordinate and the measured values in abscise (regression line).

Statistical indicators of the results accuracy are proposed as followed:

- The error, calculated by the formula:

$$Err = \frac{\sum_n |y - x|}{n}$$

- The determination coefficient R^2 , which corresponds to the square of the Pearson product-moment correlation coefficient :

$$R^2 = \frac{(\sum(x - \bar{x})(y - \bar{y}))^2}{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}$$

This last value is nothing but the square of the covariance of the reduced centered variables. Its value is between 0 and 1. 0 means a total independence between both variables.

In these equations as well as in the whole document, y corresponds to the computed values and x to the measured values, both normalized.

In every case, results are considered for all points in a first time and only for consistent points in a second time. For the consistent points, we exclude all the very low speed points, which lead to the biggest error and for which a great accuracy is not required when considering the installation of wind turbines.

1. FIRST CASE: SIMPLE BLOCK

1.1 DESCRIPTION

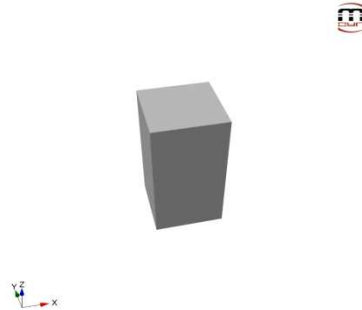


Figure 1: First case, simple bloc

The first study has been done on a square tower of 20 m high with a base of 10 m by 10 m (figure 1). A wind with a direction of 270° (blue arrow) is applied and the computations are done on the result points spread in two plans: a vertical plan located on $x=0$, which cut a tower on its middle (figure 2).

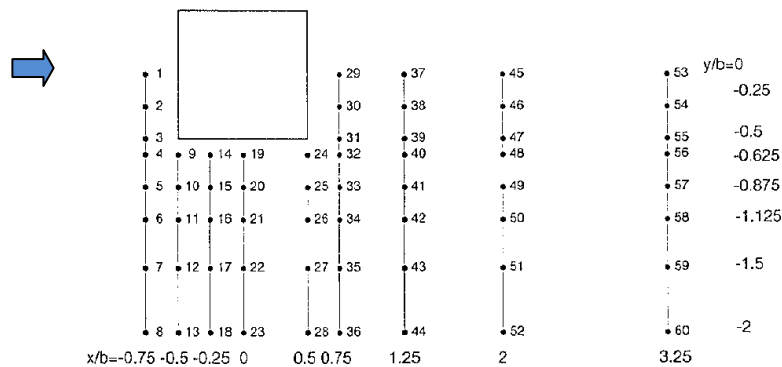
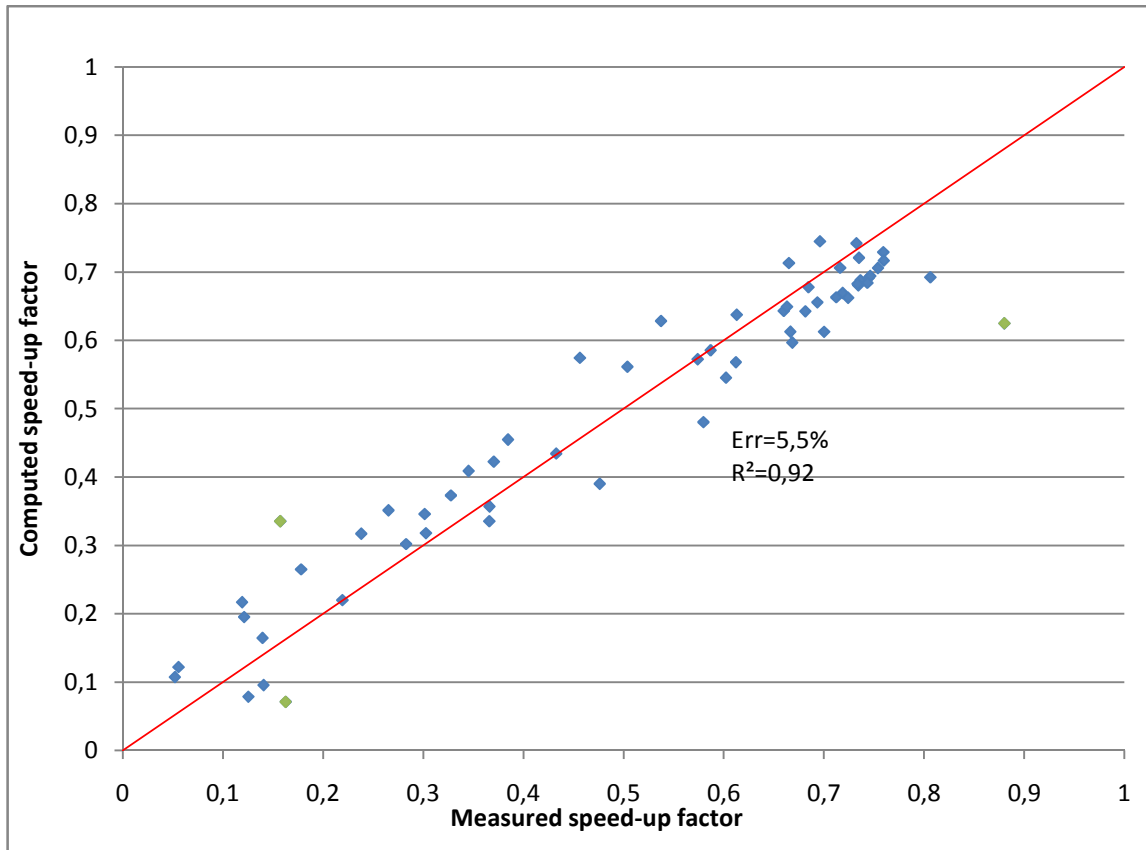


Figure 2: Results points in a horizontal plan at $z=1.25m$

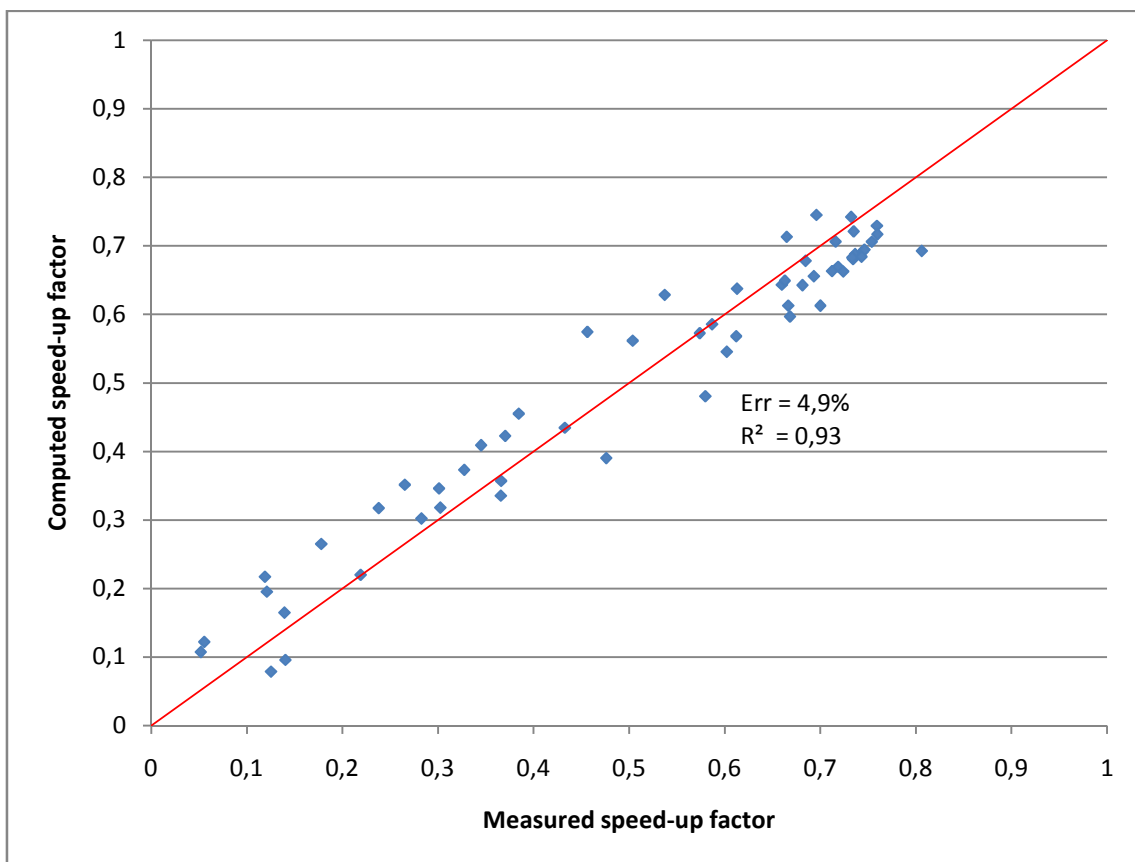
1.2 RESULTS

1.2.1 Mean accelerations

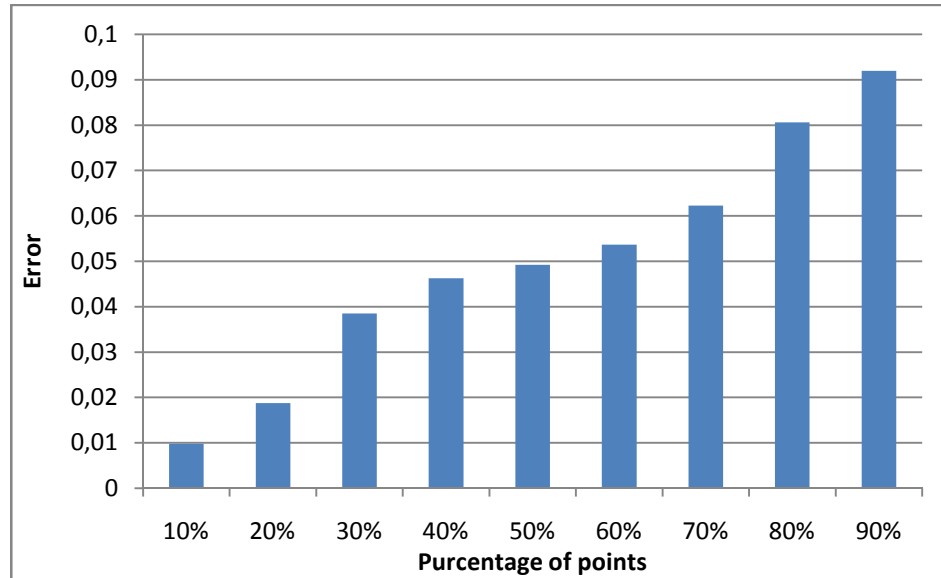
The speed-up coefficients of the computation have been compared to the coefficients obtained by the experimental measurements. On the following graph, we have represented the computed values functions of the measured values. Moreover the furthest points of the bisecting line (equation line $y=x$) have been represented in green.



Graph 1: First case, horizontal at z=1,25m, all points



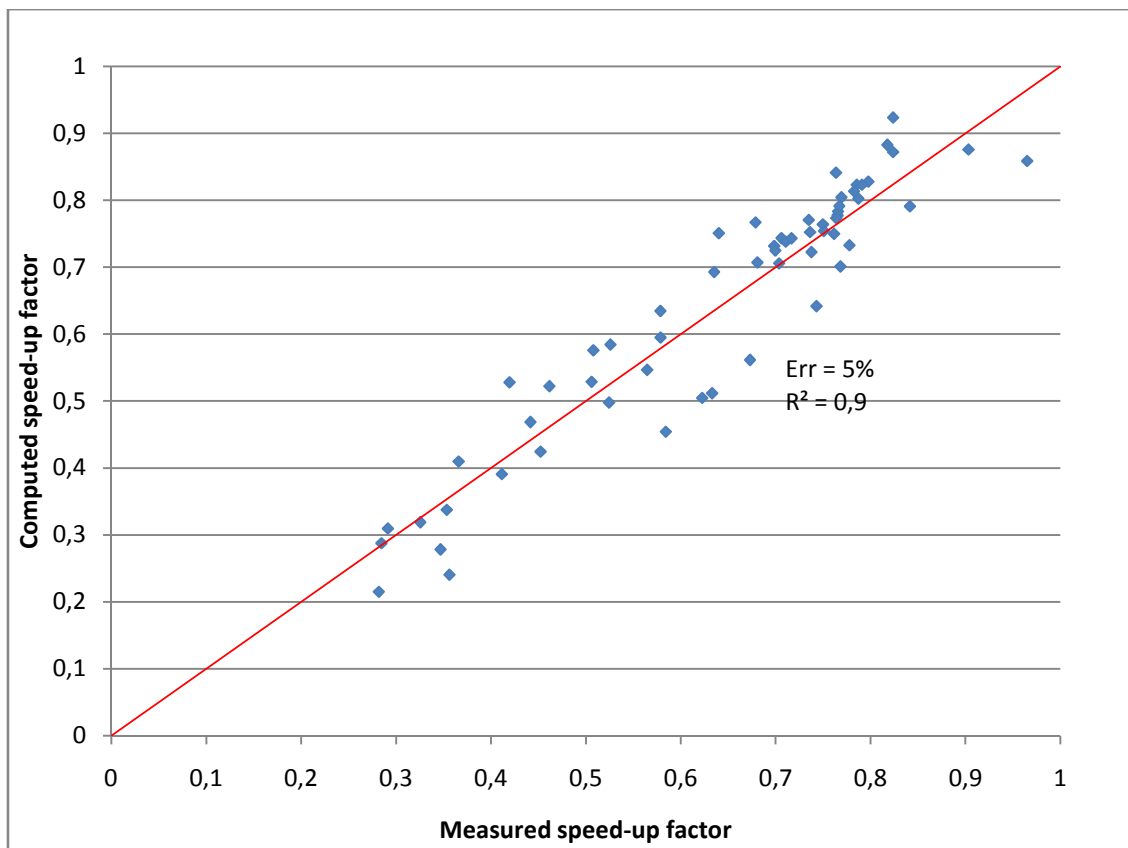
Graph 2: First case, horizontal at z=1,25m, consistent points



Graph 3: First case, proportion of the error

1.2.2 Gust

For this first case, measurements of the gust have been done as well and can be compared to **UrbaWind**'s results. These values are calculated by adding the standard deviation to mean wind speed divided by the reference wind. The resulting graph is as following:



Graph 4: First case, horizontal at z=1.25m, gust

1.3 INTERPRETATION

We have represented thanks *UrbaWind* the furthest points of the straight line (green points in the graph 1), as well as the mean acceleration values on the surface around the bloc (figure 4).

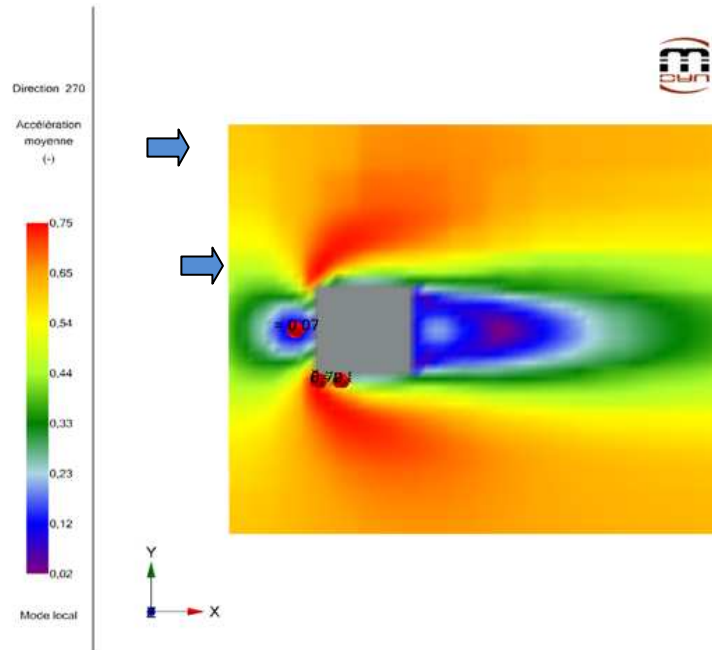


Figure 3: First case, horizontal at $z=1,25m$, visualization

The error (5.5% in average for all points and 4.9% when selecting only the consistent points) and the determination coefficient allow to confirm the accuracy of *UrbaWind*'s results for this first case.

We can observe that the results provided by the software *UrbaWind* are very good for most of the points. Only a few points are far from the linear regression curve. These differences have several explanations.

At first most of the points correspond to low wind speeds. The differences of values are thus proportionally bigger than for higher wind speeds.

Furthermore, by visualizing these points, we can notice that these points are in general near the walls in areas where de big speed difference can exist between points which are very near. This explains that the computation results can be different without necessarily casting doubt on the general aspect of the simulation.

2. SECOND CASE: GROUP OF BLOCKS

2.1 DESCRIPTION

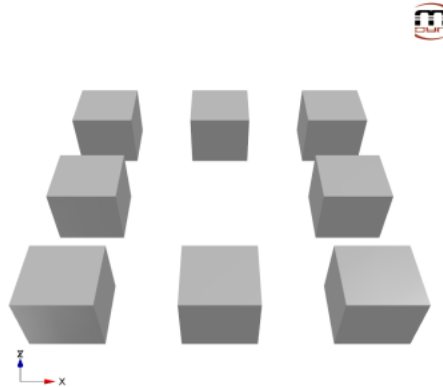


Figure 4: Second case

The second studied site is built up of 8 blocks of 20 m of edge and an empty space in the center (figure 5). The computations are done with a wind coming from the West (blue arrow) and the result points are located around the central empty space at two meters high, like shown in the figure 6.

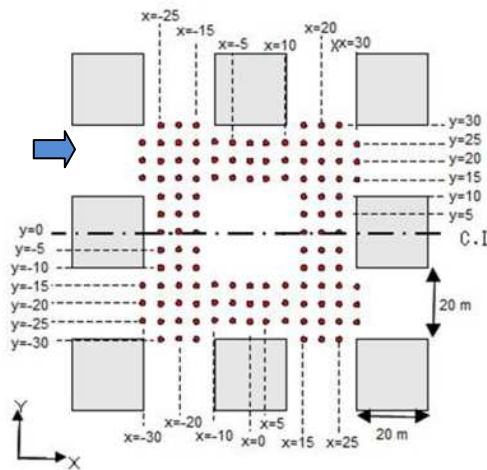
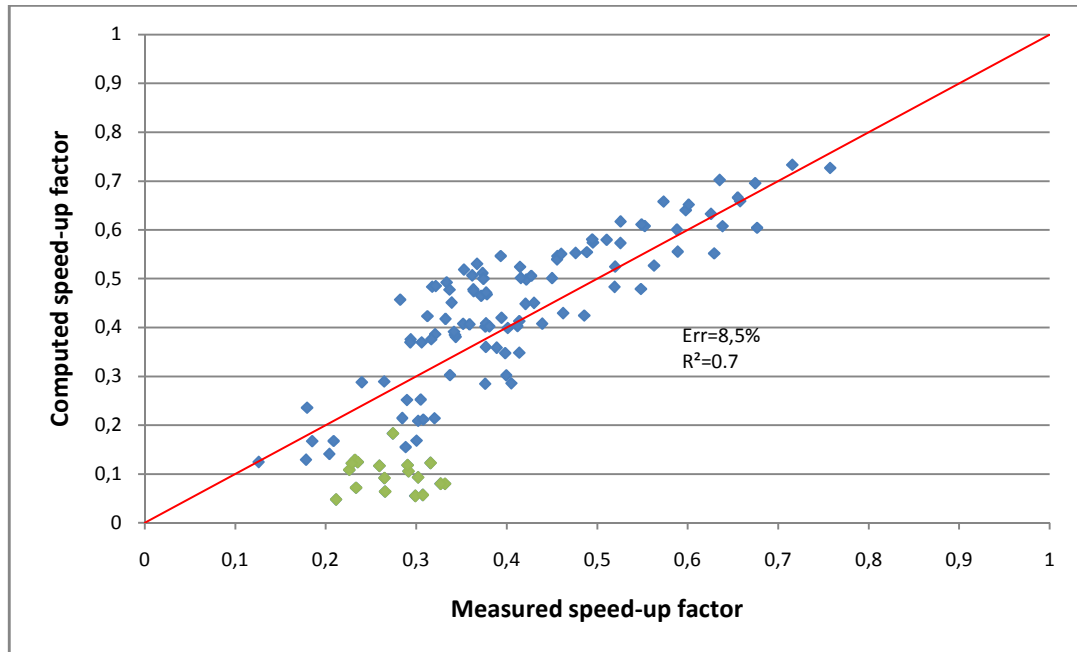


Figure 5: Results points, z=2m

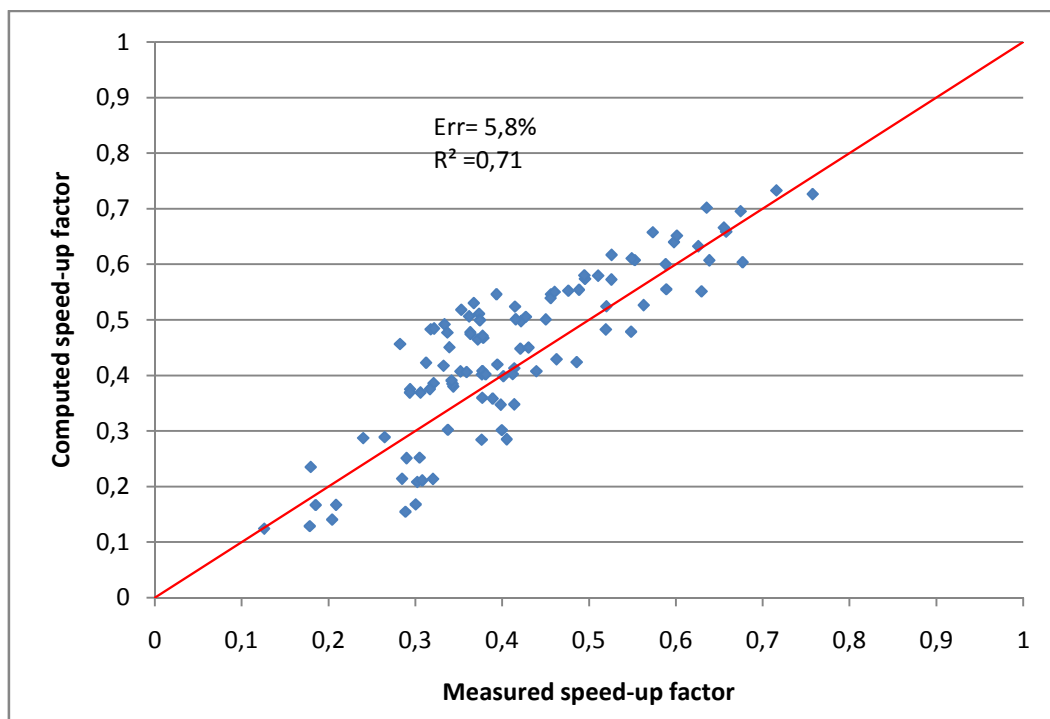
2.2 RESULTS

The speed-up factors of the computation have been compared with the speed-up factors obtained by the experimental measures. In the following graph, we have represented the computed values functions of measured values.

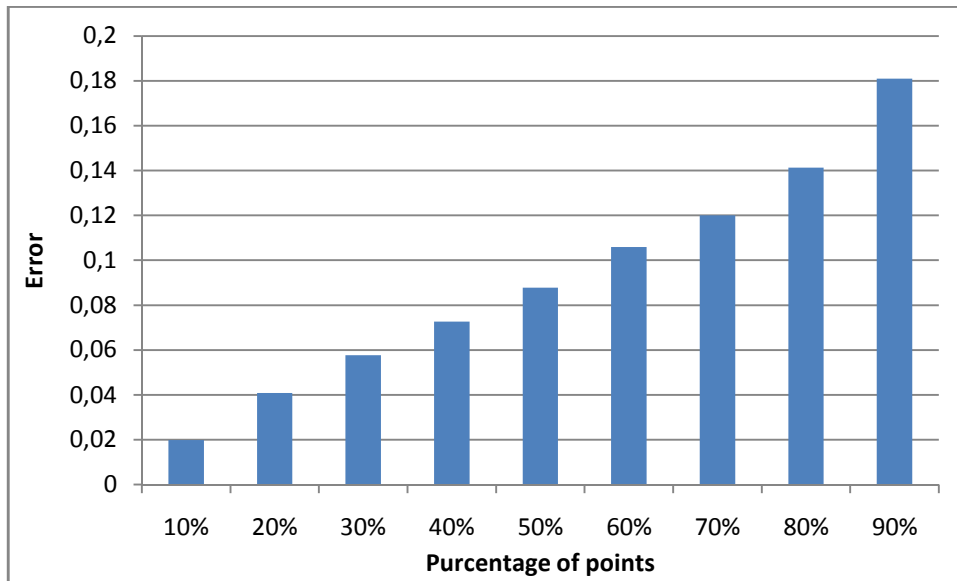
Like in the first case, several points far from the bisecting line have been represented in green.



Graph 5: Second case, group of blocks, all points



Graph 6: Second case, group of blocks, consistent points



Graph 7: Second case, proportion of the error

2.3 INTERPRETATION

Like in the first case, we have represented the mean acceleration around the structure as well as the worst points.

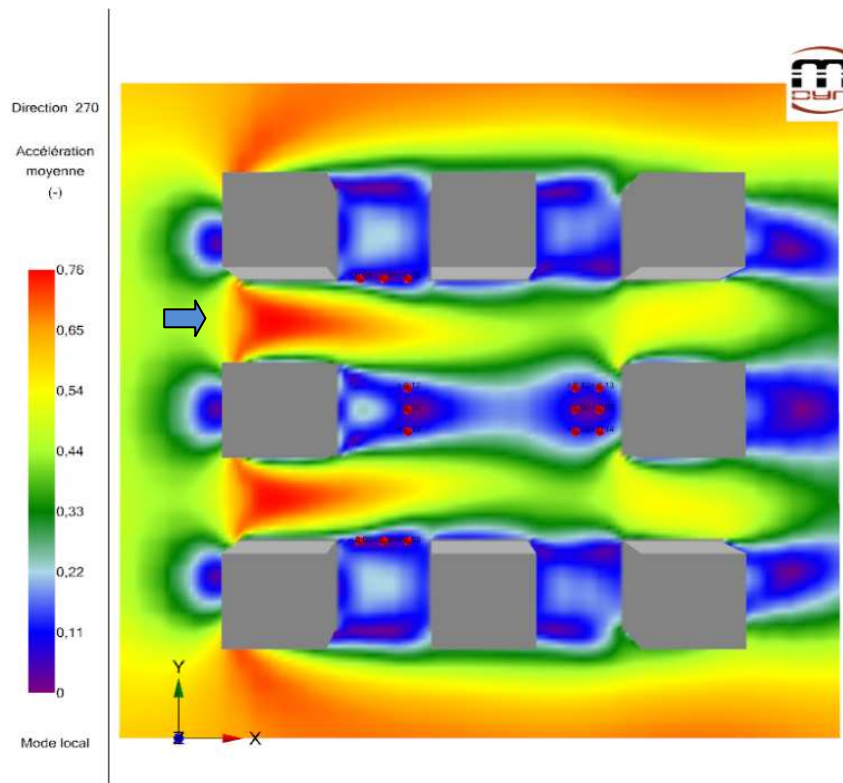


Figure 6: Second case, visualization

We can notice that the less consistent points are the points located in the areas where the mean acceleration is near zero. As all the CFD models, this is near the joining distance that the results are the most difficult to reproduce.

Thus, like in the first case, the underestimation of these low values does not cast doubt on the relevance of the computation.

Moreover we observe a value of the error which is equal to 8.5% and 5.8% when selecting only the consistent points, which validates partly the results provided by **UrbaWind** in this case.

3. THIRD CASE: QUARTER OF NIIGATA (JAPAN)

3.1 DESCRIPTION



Figure 7: Third case, quarter of Niigata

The last study has been done in the quarter of the Japanese city of Niigata. The wind is coming in the direction of 225° (blue arrow) and results points are placed in different locations as indicated in the figure 9, at two meters high.

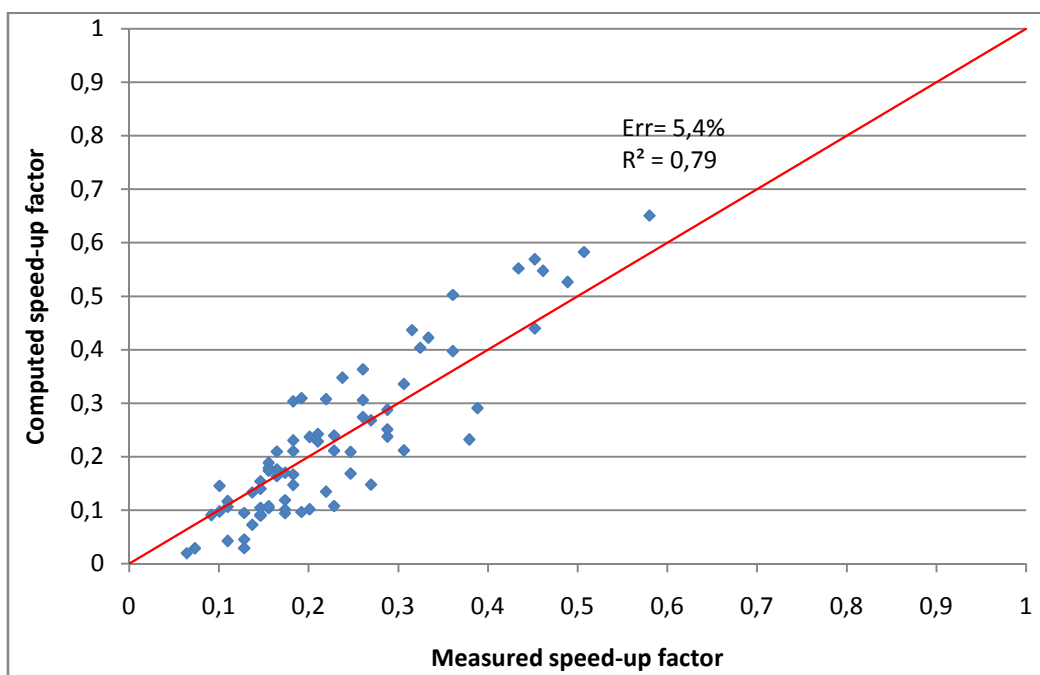
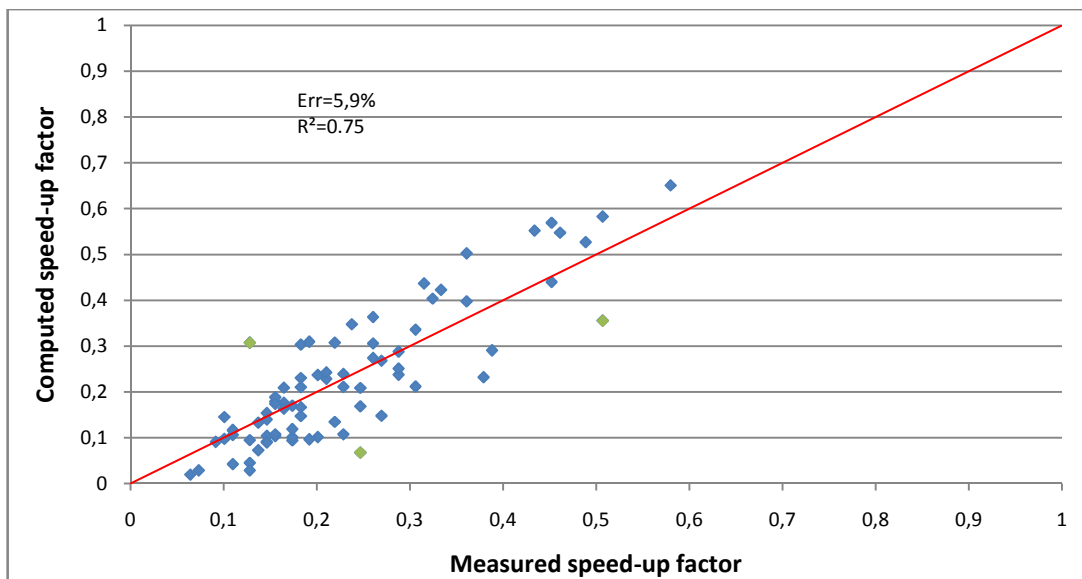


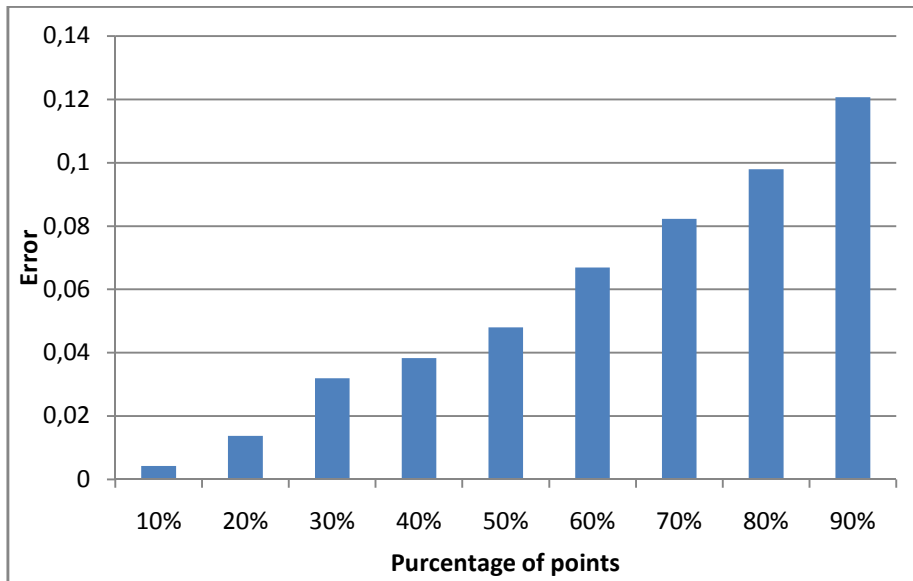
Figure 8: Third case, result points, z=2m

3.2 RESULTS

The speed-up factors of the computation have been compared to the speed-up factors obtained by the experimental measurements. In the following graphs, we have represented the computed values functions of the measured values.

The green points represent, as well as in the previous cases, the points of which the computed value of the speed-up factor is too far from the measured value.





Graph10: Proportion of the error

3.3 INTERPRETATIONS

Like in the previous cases, the points where the computed value of the speed-up factor is far from the measured value are represented thanks the software *UrbaWind*.

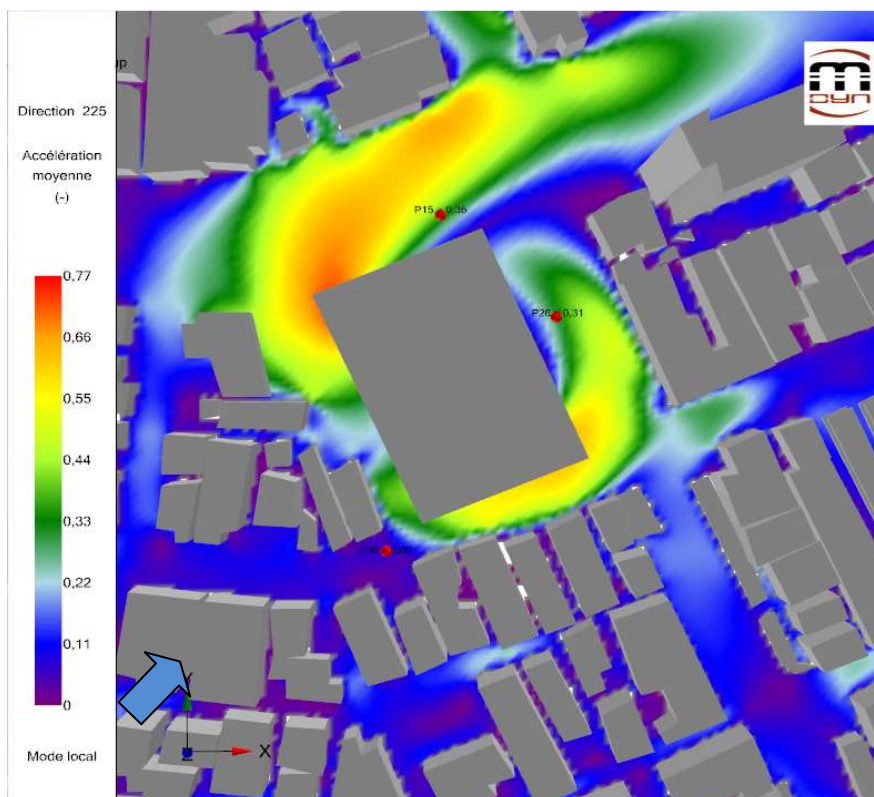


Figure 9: Third case, quarter of Niigata, visualization

We are in the same situation than the cases 1 and 2. Indeed, we can observe in the figure 10 that the worst points correspond either to low-speed areas, or to areas where a small change of location can lead to an important speed variation.

Moreover, the error and the determination coefficient allow again validating the results of **UrbaWind**. Indeed 90% of the points have an error value lower than 12% and the mean error is lower than 5.9% for all points and 5.4% when selecting only the consistent points.

SUMMARIZATION AND CONCLUSION

Finally, the table 1 shows that the results provided by **UrbaWind** are much closed to the results of the experimental measurements of the *Architectural Institute of Japan*. Indeed the typical error of the computations when considering all points is at most 8.5% and even decrease to 5.5% in the first case.

	Error for all points	Error for the consistent points	R ²
First case, mean accelerations	5.5%	4.9%	0.92
First case, gust	5%	-	0.9
Second case	8.5%	5.8%	0.7
Third case	5.9%	5.4%	0.75

Table 1: Summarization of the results

To conclude, this study allows validating the software **UrbaWind** as well for theoretical cases (first and second cases) as for real cases (quarter of Niigata) by offering a minor error margin. In several precise cases of particular interest areas (top of a building, backside of a building) and for low speeds, METEODYN recommends the use of a given LES (Large Eddy Simulation) model on which our company have a recognized expertise.