Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2020-82-AC1, 2020

Atmospheric Measurement Techniques Discussions

Interactive comment on "Detecting turbulent structures on single Doppler lidar large datasets: an automated classification method for horizontal scans" *by* Ioannis Cheliotis et al.

Ioannis Cheliotis et al.

ioannis.cheliotis@etu.univ-littoral.fr

Received and published: 21 July 2020

Thank you very much for your comments and for your thorough review. We addressed all of your comments and hopefully we will communicate better our methodology and the overall concept of our study.

Referee Comment: 1. In the manuscript a cosine fit is applied to wind lidar data acquired during VAD scans in order to estimate the mean wind speed and direction. Such a data analysis method requires the assumption of horizontal homogeneity of the wind vector, as also stated by the authors. However, I am wondering to which extent this homogeneity is expected over the urban landscape of Paris. I think that a discussion

Printer-friendly version

Discussion paper

on the terrain heterogeneity is missing from the article. In this direction, I think that it would be constructive to add an elevation map of the area over which the scanning wind lidar was acquiring measurements. This would provide an insight to which extent the observed spatial variations of the wind are related to temporal fluctuations of the wind and/or due to changes of the terrain elevation.

Authors' Response: 1. The lidar scans were covering the urban area of Paris as it can be seen in Figure 1b of the manuscript. In Paris there is a height limit for the buildings. Please see Figure 1 of the supplementary materials with the height limits of the buildings in Paris from the official Planning Department of the city of Paris, 2006. The Jussieu site is highlighted by the green text symbol. The buildings in the centre of Paris range between 25 and 37 m and rarely reach or exceed 50 m. So despite being an urban area, it is rather homogeneous. We will add the elevation map of the area. Please see Figure 2 of the supplementary materials. We also included the map with the altitude of the beam, see Figure 3 of the supplementary materials.

RC: In this context and regarding the data analysis: a. A statistical parameter is required to specify the representativeness of the fit used in the VAD scan. In the manuscript it is stated that the RMSE values of the estimated fit have been calculated but they are not stated in the document. b. Did the authors perform a quality check of the acquired data? Do they apply any SNR filtering to the acquired radial wind speed prior the application of the data analysis?

AR: a. The RMSE and similar statistical parameters for the fit quality evaluation incorporate in their values the difference between the radial wind speed and the fitted function which is the parameter we are interested in. Therefore, it is complicated to use such a parameter to characterize the quality of the fit. What we did instead, it was to select the bad cases based on the symmetry of the radial wind field. An example of a bad case is showcased in Figure 3a of the manuscript, where the radial wind field is not symmetric and as a result the radial wind speed shows a more chaotic behaviour when plotted against the azimuth angle (Figure 3, manuscript). On the contrary the good

cases were selected for symmetric radial wind fields as the one presented in Figure 2 of the manuscript. b. We forgot to include this information. We considered only the radial wind speed values for which the carrier-to-noise ratio (CNR) is higher than -27 dB. The values where CNR< -27 dB were filtered out since the radial wind speed had anomalously high values, 2 times or higher compared to the rest of the radial wind observations. In P4 Line 124 the following sentence will be added "The radial wind speed values for which the carrier-to-noise ratio is lower than -27dB (CNR<-27dB) were disregarded from the study since they were anomalously high, exceeding the values of the rest of the radial wind speed values by two times or higher.".

RC: 2. The subtraction of the mean wind speed from the radial wind speeds does not compensate the fact that the individual measurements along the scanning pattern are the result of the projection of the instantaneous wind vector to the line-of-sight of the wind lidar. Therefore, the term turbulent wind field could lead to a misinterpretation. The authors should clearly state that they measure the high frequency fluctuations of the radial wind speed.

AR: 2. It is true that using the word turbulent can be misleading since we do not observe the small scales. We will make clear in the manuscript that what we observe are medium-to-large fluctuations and coherent structures (mlf-cs). However, we will state that these are associated to a turbulent atmosphere.

RC: Specific Comments: P2 Line 28. The reference of Roth 2007 is a review of the atmospheric turbulence studies over urban landscapes and it doesn't directly discuss how the pollution concentration in urban environment is dependent on the weather and on the turbulence. A reformulation of this sentence is suggested for a clarification.

AR: The first paragraph will be removed along with the references. We will instead emphasize the effect of the turbulent structures in the pollutants' dispersion. In P1 L31-35 the following text will be added: "Several studies have been carried out to examine the effect of the coherent turbulent structures in the dispersion of pollutants by utilizing

boundary layer simulations. The results of these studies indicate that the turbulent structures can play a significant role in the pollutants' concentrations (Aouizerats et al., 2011; Soldati, 2005). Furthermore, Sandeepan et al., (2013) have demonstrated via simulations that the pollutants' concentrations can alternate from low to high during coherent turbulent structures events. It is therefore important to be able to identify turbulent structures in the atmosphere and observe them in an efficient and consistent way.".

RC: P3 Line74. Why is it relevant if the campaigns are short-term or long-term? And what is the time scale of these two types of campaigns that it is relevant for the topic of this study?

AR: We used an example of a short term study to show that so far lidars have been used to observe coherent structures for short periods since the analysis of a large dataset is very time-consuming. On the other hand, the example of a long-term study is mentioned to show that it provides us only point measurements instead of the whole wind filed over an area. Thus we wanted to highlight the benefits of our study. In order to clarify the limitations of the long-term study, we will add the following sentence after P3 line 77 "However, their study is limited to point measurements instead of the larger wind field we observe via lidars."

RC: P3 Line95. I am not sure that the two references of Kumer 2014 and Veselovskii et al. 2016 are the appropriate to be used here. In none of them there is an analytical explanation of the wind lidar instrument as it is stated. I suggest replacing them with more relevant references. An example could be the work of: Cariou, J. P., R. Parmentier, M. Valla, L. Sauvage, I. Antoniou, and M. Courtney. "An innovative and autonomous 1.5 μm Coherent lidar for PBL wind profiling." In Proceedings of 14th Coherent Laser Radar Conference. 2007.

AR: Thank you very much for this correction. After going through the references again we agree that Cariou et al, 2007 is the appropriate reference here, hence we replaced

the other two references by it.

RC: P3 Line 101. It is stated that “The duration of each scan was 3 minutes which is sufficiently short for the observation of structures”. Could the authors elaborate more on this statement?

AR: In P3 line 101 the word “fast” will replace the initial “short”. Furthermore, the sentence “The duration of each scan was 3 minutes which is sufficiently short for the observation of structures” will be rephrased to “The duration of each scan was 3 minutes which is sufficiently fast for the observation of coherent structures, as their lifespan is several minutes.”

RC: P4 Line 102. The authors state that the maximum range of the scans reached 5 km. However, in none of the figures that they have included in the manuscript the range ever reaches 5 km. The most common range in their data is between 2 – 2.5 km. Can the authors explain why is this happening?

AR: We have used the CNR < -27dB filtering. Please see also the reply 1b.

RC: P4 Line111. Table 2. A list of scanning patterns is included here that are not used in this study. In addition, the purpose of each scanning pattern is included without explaining the reasoning for their selection. I would suggest to either remove this table. If the authors wish to keep it then I suggest that they should elaborate more in the text about it.

AR: We acknowledge that the presentation of the entire scanning sequence can be confusing for the reader, therefore the Table 2 will be modified to include only the information for the PPI and the DBS scans. We have also removed the 90° elevation angle from the table as it was not part of the DBS scanning method. The latter scanning method is also important for this study as the DBS scans revealed the high wind shear cases during night. We will also change parts of the text. The sentence “Table 2 showcases the implemented scanning methods during the VEGILOT campaign that

are important for the current study" will replace the initial "Table 2 showcases the scanning sequence as it was implemented during the VEGILOT campaign.". Additionally, a brief description of the DBS scan will be added to the text. In particular, the following sentence will be added in P4 line 103-106: "It was also important for this study to retrieve observations regarding the vertical wind shear. For this purpose, the Doppler beam swinging (DBS) scanning method was implemented. This method was consisted of four line of sight beams at azimuth angles of 0°, 90°, 180° and 270° with an elevation angle of 75° and it was applied twice. The duration of the four direction beams emission was approximately 15 seconds.".

RC: P4 Line120. The "offset" refers to the vertical wind speed component? What does it mean that α is much smaller than b? Is this a common observation over the whole scanning plan? And what kind of α values does the application of the model result in?

AR: The offset is indeed associated to the vertical wind speed. The radial wind speed analysed in its' wind components for a line of sight beam with azimuth angle theta and elevation angle phi will be: Vr=u*cos(theta)*sin(phi)+v*sin(theta)*sin(phi)+w*cos(phi), where u is the longitudinal, v is the transverse and w is the vertical wind component respectively. The offset is associated to the parameter w*cos(phi) (Thubois et al. 2018, Study of the configurations and scanning strategies of Doppler Lidars for providing wind and aerosol/cloud profiles). Since the elevation angle of the PPI scans was 1° and not 0° we included this parameter in the fit function. However, it is much smaller than the b component which is associated to the horizontal wind. So the horizontal wind is still dominant. This is a common observation over the whole scanning plan. The value of the offset is around 10 times smaller than the amplitude and ranges according to the value of the amplitude from 0.05 to 0.5 m/s.

RC: P6. Line156-157. It is not clear how the unaligned thermals are dependent on the increased solar radiation measurements.

AR: The increased solar radiation measurements result in surface heating which we

typically observe during fair weather cumuli conditions.

RC: P6. Line 163. How do the authors estimate the value of the wind shear? Also, shouldn't the units of the wind shear be seconds to the power of -1?

AR: The DBS observations provided us the zonal u and meridional v winds. The horizontal wind was computed from these components from the formula: V_hor=$\sqrt{}$(uˆ2+vˆ2). The wind shear was estimated from the vertical profile of V_hor by subtracting the local minima from the local maxima above it, near the surface. Thank you for this correction, the units have been corrected to s-1.

RC: P6. Line 166. The authors in P5. Line 133 state that the VAD method could not be applied in the data acquired during the night, especially at those occasions where the mean wind speed was less than 2 m/s. Does this mean that only cases with mean wind speed higher than 2 m/s were selected?

AR: The VAD method can be applied regardless of the mean wind speed values as long as the radial wind speed field is symmetric. It is true however that when the mean wind speed is lower than 2 m/s then the radial wind field has the risk to not be symmetric. For the training ensemble, regarding streaks, rolls and thermals only cases with moderate winds were selected (5-8 m/s) whereas for the category others, cases with weak winds below 2 m/s were included. We are currently preparing a separate study with the physics of the structures based on the whole classification from this methodology. The results show that we observe winds below 2 m/s mostly during the others category. More particularly the results are: 7 out of the 1145 streaks cases, 0 out of 420 rolls cases, 67 out of the 900 thermals cases and 670 out of the 2112 others cases.

RC: P6. Line 167. How well was the mean direction and speed estimated through the VAD method in the selected cases? I suggest adding a statistical parameter that describes the representativeness of the applied fit (equation 1) to the measured data (e.g. RMSE).

AR: As we previously stated statistical parameters as the RMSE are not appropriate for the evaluation of the fit since the interesting parameter for us is the difference between the observation and the fit. We instead selected the training ensemble based on how well symmetric or not was the radial wind field and by plotting random rings for each scan to confirm good fits as displayed in Figure 2 or a bad fit as in Figure 3 of the manuscript.

RC: P7. Line 170. It is difficult to understand the scale of the Modis colour images. Would it be possible to either add a scale or mark on the images the scanning area?

AR: In P7 line 170 the scanning area will be added to the MODIS images. See Figure 5 of the supplementary materials.

RC: P7. Line 176. I recommend describing very shortly the texture analysis especially in the context of remote sensing. It would be useful to add any references in the introduction regarding the previous applications of this type of analysis to remote sensing data.

AR: We will add the following brief description: “Texture analysis is an effective way to evaluate the distribution of the values within an image (Castellano et al. 2004). It is widely used in various scientific fields in order to classify images, covering meteorology (Alparone et al., 1990), medical studies (Holli et al., 2010) and forestry (Kayitakire et al. 2006).”. If showing that the variety of the texture analysis in science is not appropriate, we can focus only on the remote sensing studies e.g. Alparone et al. (1990) and more.

RC: P8. Line 181-182. What is the logic behind the selection of this particular values for defining the contrast?

AR: We wanted to enhance the contrast of the structures. For this reason, we had to select the bins in such a way that the difference between positive and negative values will be more apparent. We have tried more configurations. The selection of only 2 bins (one positive, one negative), led to a less successful classification of the different

types of structures as the 2 bins give a 2 by 2 co-occurrence matrix. The size of the co-occurrence matrix is important in this case, since from the Equations 2, 3 and 4 of the manuscript, it is evident that the texture analysis parameters also depend on the distance between the bins i,j. The classification error in this case was around 18%. The selection of the 4 bins (one bin including all the negative values below −0.5 m/s, one bin between −0.5 m/s and 0, one bin between 0 and +0.5 m/s and one bin including all the positive values above +0.5 m/s) did not really improve the results with the error remaining around 18%. The selection of 8 bins reduced the error significantly. The selection of one bin including all the negative values below −0.5 m/s, six bins equally distributed between −0.5 m/s and +0.5 m/s and one bin including all the positive values above +0.5 m/s allows us to enhance the difference between the positive and negative values while keeping the distance between the bins i,j. We selected the values 0.5 as the limit in order to well separate the positive and negative values while having some information near 0. We also tested the limit with 1 and -1 m/s and the classification error was above 14%. We did not try to select more than 8 bins because we believe that it will not be useful to increase the number of bins near 0. It is in our future plans however to automatize this part as well. We would like to include an algorithm in our method in order to find the optimal selection of bins that minimizes the classification error.

RC: P10. Line 243. The authors state that 60 cases of “other” patterns are used during the supervised machine learning step. They argue that this is necessary because “it is expected to be the dominant category in the classification”. I am not sure that I understand what it is meant with this statement. I suggest having this part a bit more explained. Furthermore, how is the mean wind speed and direction estimated in these cases? As it is stated the VAD was not successfully applied to this data.

AR: When we were analysing the results, we observed that the chaotic type of patterns (see Figure 4 of the supplementary materials) was the most common type. The algorithm can be sensitive to an unbalanced training ensemble. It is preferable to select

a training ensemble based on the expected results (Kubat, 2017 p.194). Even for the bad cases, the VAD method was selected for the estimation of the mean wind speed and wind direction. In Figure_vi of the supplementary material, a fitted function for a non-symmetric field is displayed. We can still obtain the mean wind direction from this figure, but the patterns will have the chaotic look as in Figure 4 of the supplementary materials.

RC: P10. Line 225. How do the authors explain the change in the slope of the homogeneity curve that is observed for absolute azimuth angles larger than 45 degrees?

AR: The angle represents also the distance between two grid point. For 45° angles or above, the distance between two grid points are n rows away whereas below 45° they are n-1, n-2 etc. We have prepared an illustration of an ideal case, Figure 7 of the supplementary materials. We hope that it is clear. Keep in mind the Figure 6 of the manuscript refers to the third neighbour which is equivalent to 150 m distance between the grid points.

RC: P10. Line 240. Could the authors add a reference to the literature describing the "supervised machine learning methodology"?

AR: The following references will be added: "Bonamente, M. Statistics and analysis of scientific data, Springer, 2017, 318 p., DOI:10.1007/978-1-4939-6572-4; Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer Texts in Statistics, 2013, 426 p, DOI: 10.1007/978-1-4614-7138-7 Kubat M. An Introduction to Machine Learning, Springer, 2017, https://doi.org/10.1007/978-3-319-63913-0"

RC: P11. Line 265. How do the authors physically explain this result? A low RMSE in the cosine fit, couldn't also mean that the mean wind speed and direction are not estimated correctly?

AR: This result show that according to the algorithm, the different shapes of the pat-

terns in the radial turbulent wind field are more significant for the classification of the structures than the physical parameters. The wind values range from 1 m/s to 14 m/s. Therefore, a higher RMSE does not necessarily mean a worse fit, but it may be caused due to this scale difference.

RC: P12. Line 291. It is stated that "there were scarcely any rolls cases observed at night". However, in the sentence 288 it is written that for the classification of this study the authors "consider only thermals and rolls during daytime". To my understanding there is an inconsistency between the two statements. Can this be explained better?

AR: For the training ensemble only thermals and rolls during daytime were selected. However, the classification of all the data was made based on the five texture analysis parameters displayed in Figure 7 of the manuscript. As time is not included in the classifiers, the algorithm can classify the patterns at any time of the day but still few cases of rolls and thermals were classified during the night. This result is an indication that the classification is working as intended.

RC: P13. Line 312. In the conclusions the author state that time, wind speed and the cosine fit RMSE of the VAD method were not selected by the algorithm for the classification. However, in the results presented in figure 9 there is a time dependency in the detection of certain patterns (e.g. thermals and rolls). Could the authors comment why the inclusion of the time as a classification parameter would not improve further their results?

AR: The algorithm finds the best combination of parameters that minimize the classification error and time was not one of the five parameters as it can be seen in Figure 7 of the manuscript. By including the time as a parameter the classification error will not be reduced.

RC: P13. Line 318. Given the fact that one PPI scan lasts for 3 minutes and occurs every 18 means, can the authors explain how does the acquired data set contribute to the comprehension of the development of coherent structures?

AR: The lifespan of streaks can be several tens of minutes and for rolls it can be hours. Even with this time gap between the observations we believe that it is still interesting to study the transitions between the different types of structures. For example, we have vertical lidar observations between the PPI scans and we can study the development of the atmospheric boundary layer height with regards to the type of the structures.

RC: Technical Corrections: General: There is a small inconsistency on the way that figures are referred to. Sometimes they are used parenthesis after the number of the Figure to denote a subfigure and sometimes are not.

AR: All the subfigures will be corrected in order to keep consistent naming. The number of the subfigure will be followed by the corresponding letter e.g. “Figure 1a”.

RC: P2 Line 34. I think that the statement “Futhermore, ...” is a self-evident. I would suggest removing it. Also, I would suggest to add the reference of (Hussain, 1983) at the end of the previous sentence.

AR: In P2 line 34 the sentence ”Furthermore ..... time-averaged statistics calculations.” will be removed. The reference of (Hussain, 1983) will now follow the sentence “The principal aspect that determines a coherent structure is the maintenance of the phase-averaged vorticity of the turbulent fluid mass over the spatial extend of the flow structure.”.

RC: P2 Line 37. “and the lower”

AR: In P2 line 3 “and the lower” will replace “and lower”.

RC: P3 Line 72. I suggest reformulating this sentence. It is not clear to the reader how is the two-dimensional autocorrelation function was used. Also, I suggest changing the sentence “the observation of the scans by eye” to “visual observation of the scans”.

AR: In P3 line 72 the sentence “They combined quantitative characteristics of the coherence such as the integral scales and the anisotropy coefficients, obtained by a two-dimensional autocorrelation algorithm, with the visual observation of the scans.”

will replace the initial “They combined a two-dimensional autocorrelation function with the observation of the scans by eye”.

RC: P3 Line76. Change “month” to “months”

AR: In P3 line 76 “months” will replace “month”.

RC: P3 Line83. The “Section 0” should change to “Section 3”

AR: In P3 line 83 “Section 3” will replace “Section 0”.

RC: P3 Line86. The word “two” is used as a noun modifier and therefore the word month should be in singular form.

AR: In P3 line 86 the phrase “A two-month measurement campaign” will replace the initial “A two-months campaign”.

RC: P3 Line96. I suggest to change the text “The lidar is sensitive only to the” to “A wind lidar is measuring the”

AR: In P3 line 96 the phrase “A wind lidar is measuring the” will replace the initial “The lidar is sensitive only to the”.

RC: P3 Line100. Change the “for a” to “with a”.

AR: In P3 line 100 “with a” will replace the initial “for a”.

RC: P4 Line103. I think that it is more grammatically correct to either use the past tense or the passive form of the “rise” verb.

AR: In P4 line 103 “the beam rise” will be rephrased to “the beam was risen”.

RC: P5 Line132. The authors state that due to the surface heterogeneity the VAD method can be applied in some cases. A surface heterogeneity will introduce an error in the VAD method regardless the wind speed.

AR: We have probably phrased this in a wrong way. As it can be seen in Figure 2 in the

supplementary material, there are some hills in the limits of the scanning range but with low elevation. We have not study what could be the orographic effect in the wind speed as this would require model simulations. However, there have been relevant studies for the area. Troude et al. (2002) in their study "Relative influence of urban and orographic effects for low wind conditions in the Paris area" and Lemonsu and Masson (2002) in their study "Simulation of a summer urban breeze over Paris" examined the orographic effect of the nearby hills as well as the urban heat island effect in the synoptic wind speed over Paris. The results show that during low wind conditions these effects can be the main driving forces for the local wind speed. We did not include these references in our study because they refer to spring-time and summer-time conditions respectively and only for case studies. We are not aware of a longer term or an autumn study.

RC: P5 Line132. I suggest that the "Jussie site" is changed to "The Jussie site".

AR: In P5 line 132 "The Jussieu site" will replace "Jussie site".

RC: P5 Line138. Figure 3 caption. Change the "a case" to "A case", also a add a tab space between (a) and "Radial".

AR: In P5 line 138 "A case" will replace "a case" and a tab space will be inserted between (a) and "Radial" in the caption of Figure 3 of the manuscript.

RC: P6. Line149. "Sec" should be replaced by "Section".

AR: In P6 line 149 "Section" will replace "Sec".

RC: P6. Line 164. I suggest to re-write the sentence "For many cases, the wind shear was accompanied by turbulent streaks pattern" and specify for which particular wind shear values were streaks detected. RC: P6. Line165. The part of the sentence "so or the training ensemble" should be rewritten.

AR: In P6 line 164 the sentence "Therefore for the training ensemble, only night cases when streaks patterns (Figure 4c, manuscript) were accompanied by wind shear higher than 2 m/s near the surface, were selected." will replace the initial "For many cases,

the wind shear was accompanied by turbulent streaks patterns (Figure 4c, manuscript) so or the training ensemble, only night cases of streaks were selected to ensure that wind shear was the primary factor for the generation of turbulence.".

RC: P10. Line 230. "fore" should be changed to "for".

AR: In P10 line 230 the word "for" will replace the initial "fore".

RC: P11. Line251 – 253. The authors state the higher number of dimensions relative to the number of patterns lead to the "curse of the dimensionality problem". I suggest to re-write it by using appropriate scientific statements.

AR: The "curse of the dimensionality problem" is a scientific term, which is common in statistics/data science domain. We think that it is relevant here.

RC: P11. Line 259. Correct the "Section 0".

AR: In P11 line 259 "Section 3" will replace "Section 0".

RC: P12. Table 5 caption: I suggest changing the "eye-made" to "visual".

AR: In P12 the word "visual" will replace the initial "eye-made" in the caption of Table 5.

RC: P12. Line 290. The coherent structures don't have a preference. They are formed under favourable atmospheric conditions. I suggest commenting the result of Figure 9 on that basis.

AR: This was undoubtedly a bad way to phrase it. We will make the following change in the text: "It is evident that despite time was not one of the selected classifiers, the number of occurrences of the structures show a distribution that can be associated to the atmospheric conditions. More particularly, rolls and thermals were mainly classified during day. This result is noteworthy as these structures are linked to a well-developed atmospheric boundary layer during the day. On the contrary there were scarcely any rolls cases observed at night, and a few unaligned thermals were classified at night." will replace the initial "It is evident that despite time was a much less significant classi-

fier compared to the curves parameters, the structures show a time preference. There were scarcely any rolls cases observed at night, though a few unaligned thermals were classified at night."

RC: P15. Line 386. "Lemone" should be changed to "LeMone". Also, necessary information of the article (e.g. journal) is missing.

AR: In P15 line 386 the name will be corrected and the missing information will be added. The complete reference now is: "LeMone, M., 1972. The structure and dynamics of the horizontal roll vortices in the planetary boundary layer. J. Atmos. Sci. 30, 1077–1091. https://doi.org/10.1175/1520-0469(1973)030<1077:tsadoh>2.0.co;2"

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-82, 2020.

Printer-friendly version

Discussion paper

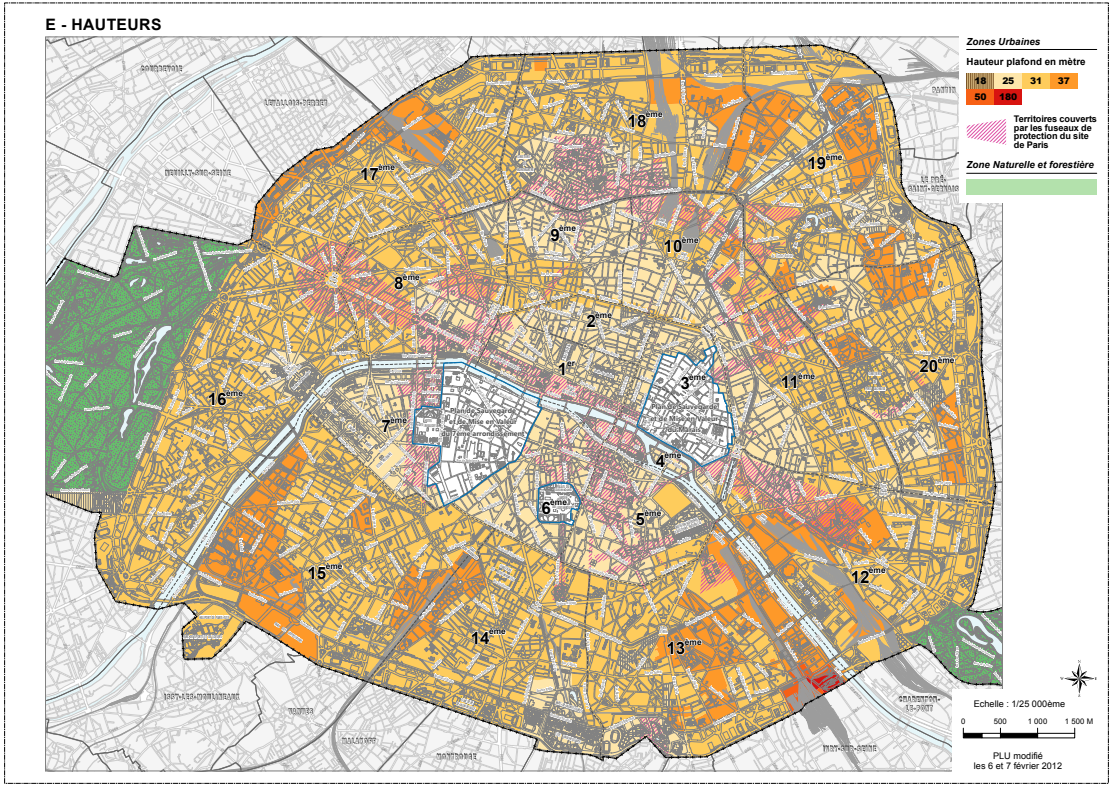
E - HAUTEURS
Zones Urbaines
Hauteur plafond en mètre
18
25
31
37
50
180
Territoires couverts par les fuseaux de protection du site de Paris
Zone Naturelle et forestière
Echelle : 1/25 000ème
0
500
1 000
1 500 M
PLU modifié
les 6 et 7 février 2012

Fig. 1.

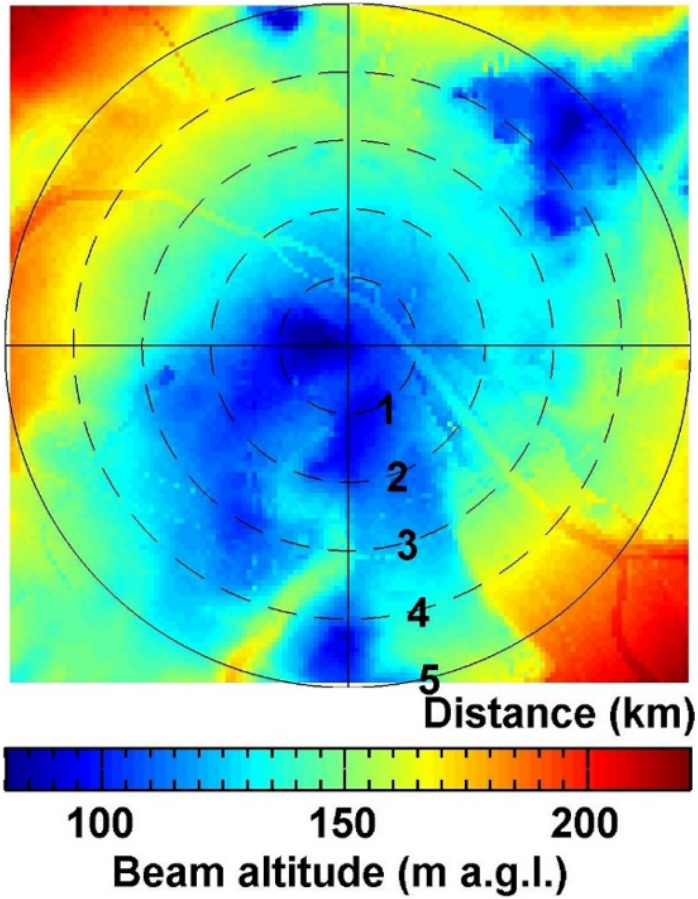

Fig. 2.

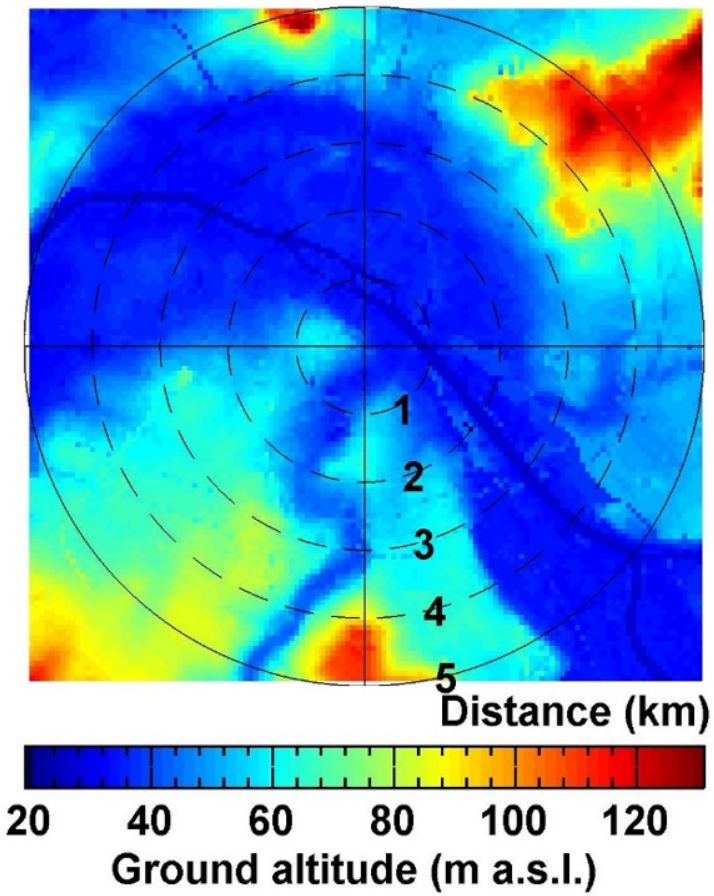

Fig. 3.

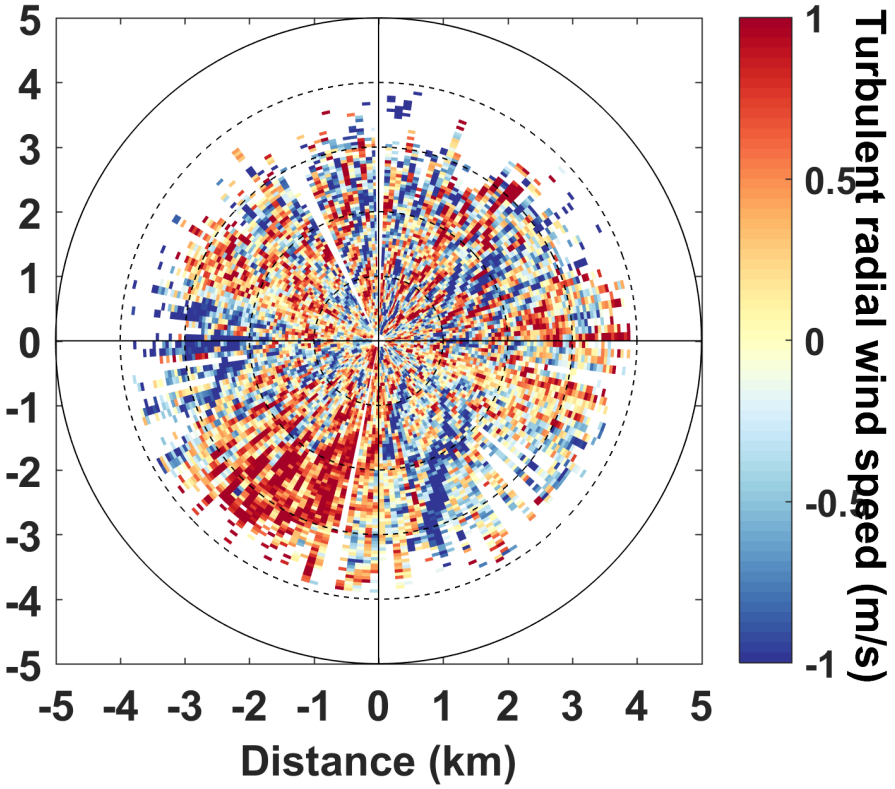

Fig. 4.

Printer-friendly version

Discussion paper

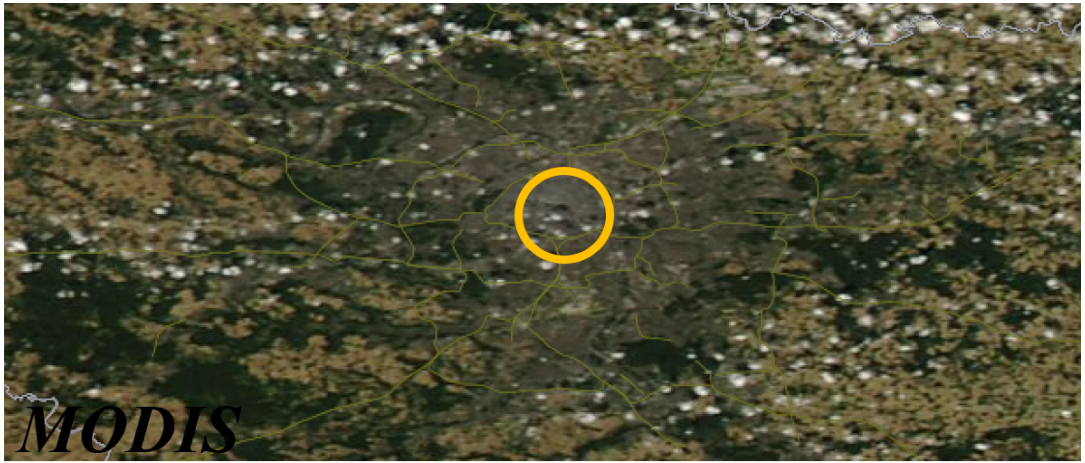

Fig. 5.

Printer-friendly version

Discussion paper

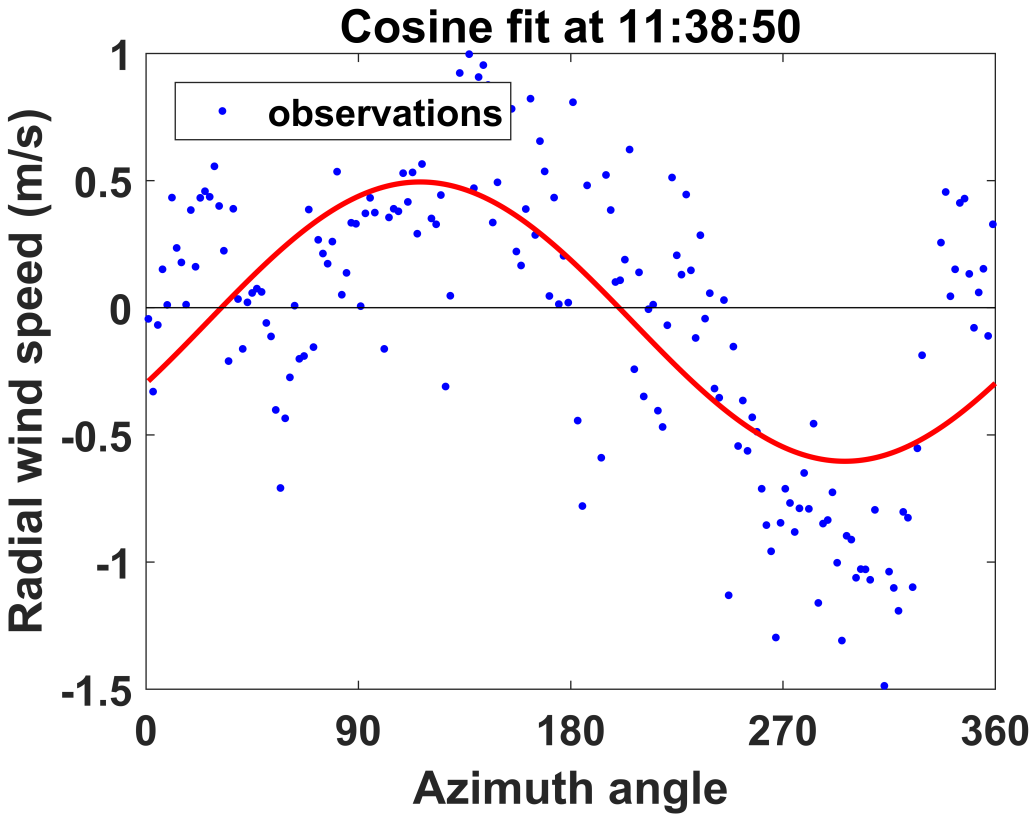

Fig. 6.

Printer-friendly version

Discussion paper

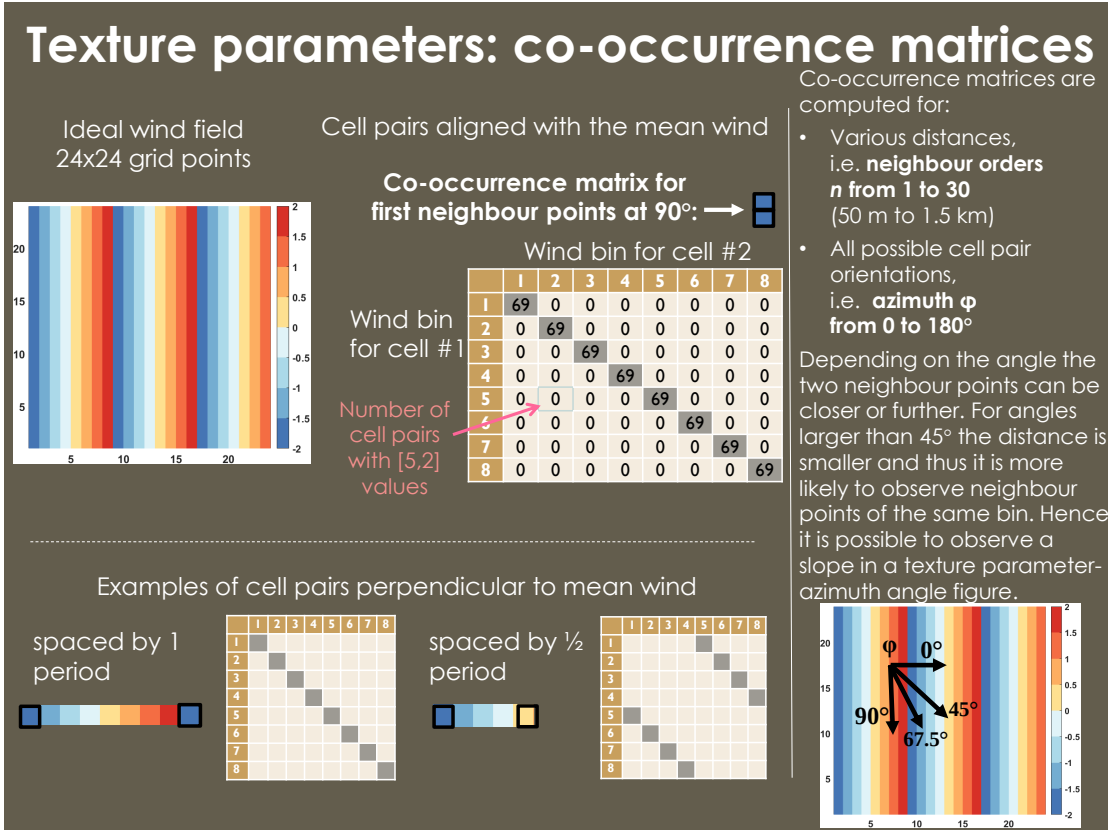

Fig. 7.

Printer-friendly version

Discussion paper