1 Report 1

- 1. My main criticism is the structure of the paper. The main point of the paper is summarized in line 130 f. on page 6. This must necessarily be stated already in both abstract and introduction. In the current state of the paper the reader is left with a number of unprecise claims about the new method for almost 6 pages, before this point is finally made. The current structure is therefore misleading because the reader is left without information about the nature of the novelty of the paper until page 6, which is quite confusing.

  Action1: the motivation of the paper in the abstract has been updated.
  L7 - The motivation for this paper is to develop an algorithm able to synthesize high fidelity homogeneous and isotropic wind speed datasets within an arbitrary model domain geometry without the need for optimizing weighting parameters. This is achieved by eliminating the band-pass effect of the discrete Fourier transform inherent to the typically used algorithm.

  Action2: in the introduction the claim of the algorithm is presented.
  L30 - The here proposed method builds on the RPM and the Fourier integral method (FIM) developed by Pardo-Iguzquiza and Chica-Olmo [1993], and solves the optimization issues needed for different spatial domains, allowing one to obtain a high fidelity 1-D, 2-D, or 3-D dataset on a wide range of spatial domains, and for any regular grid shape (e.g., square, rectangular, cuboid). This is achieved using the relation between the correlation function and the PSD, eliminating the band-pass effect of the discrete Fourier transform (DFT) arising while using the RPM.

- 2. A second major point is the relevance of the scientific progress made by the paper. In which context is it relevant to match a given correlation tensor better by several orders of magnitude, given the vast spread of local flow conditions in the field? The typical statistical uncertainty of field-measured wind conditions is quite large. The precision of current and newly proposed methods should be compared to this.

  Reply: the authors focused their effort in developing an *exact in principle* synthesization method, thinking that decreasing as much as possible the errors arising from the synthesization methods would allow to investigate with greater accuracy real measured data from the field, not increasing the statistical uncertainty of the synthesized wind field due to the algorithm. Indeed, the objective of this paper is not to propose a synthesizing method generating a high fidelity wind field w.r.t. real datasets, but w.r.t. theoretical structure functions. The authors are working to expand the use of the proposed method to investigate the synthesization of wind field using real data measured using anemometers or five-hole probes, from high resolution Large Eddy Simulation (LES) results, or by considering a non-stationary wind using the method presented in Wilson [1997], however these topics are not part of this publication.

Action: the authors tried to explain this concept in the conclusions:
L227 - For spatial domains greater than $2.5L_0$*, the CB-RPM can be declared as exact in principle. This refers to the computational errors, not to how close the synthesized wind field is to reality. Indeed, the reason in developing the CB-RPM has been to decrease the errors of the synthesized wind field w.r.t the theoretical structure function, not real data.*

II. Detailed criticsm

These points are given in the sequence of appearance, rather than in the order of priority.

- 1. Naming of methods: The two classes of methods discussed in the paper are the "random phase methd" (RPM) and the "correlation-based method" (CBM). It appears confusing that all of the methods mentioned and discussed in the paper, without exception, are using a random phase approach for the Fourier back-transformation and are heavily based on the correlation tensor, in one or the other way. Unfortunately I do not immediately have a more precise suggestion for the two classes.

  Action: the authors understand the confusion. They propose to define the proposed method as *correlation-based random phase method* (CB-RPM).

- 2. The abstract claims that the method is able to "synthesize ... wind speed datasets within an arbitrary model domain geometry". This seems to be quite exaggerated and should be made more precise. What about non-rectangular domains, such like cylindrical or spherical ones, or even more complex? What about non-equidistant grid points in space and, especially interesting, in time? The latter two are of very high relevance and should be commented on.

  Action: thanks for pointing out that this is not clear. The sentences have been updated:

  - in the abstract: *L5 - Moreover, being a generic method, it can be used to simulate other Gaussian phenomena (e.g., temperature or index of refraction fluctuations) on various spatial domains with uniformly spaced rectangular grid shapes.*
  - in the introduction: *L32 - ...allowing one to obtain a high fidelity 1-D, 2-D, or 3-D dataset on a wide range of uniform spaced spatial domains having rectangular grid shapes.*

For the other interesting cases pointed by the reviewer, the authors are investigating if it is possible to use the same method for other grid shapes (e.g., spherical) with non-equidistant grid points using non uniform fast Fourier transform algorithms (NUFFT). However this is still at an early stage of the research and it is not investigated in this publication.

- 3. In eq. (5), one of the well-known mathematical and numerical challenges is the square root. It is not unique, i.e., it leaves the choice of several different results, and is also numerically challenging to compute. This should be discussed along with eq. (5).

  Action: thanks for pointing this out. The sentence describing how $\sqrt{\Phi_{pq}(\boldsymbol{k})}$ can be computed has been updated:
  L65 - The $\sqrt{\Phi_{pq}(\boldsymbol{k})}$ *term is computed using matrix decomposition techniques, such as the Cholesky [1910] decomposition, or the dimension-dependent factorizations suggested in Mann [1998]. The result is not unique, differing accordingly to the implemented technique, and it can be numerically challenging to compute.*
  The authors taught not to explain in more details how this is done, being already well described in Mann [1998].

- 4. In eq. (16), f(r) and g(r) appear without comments. They should be liked to eq. (13) and it should be explained that both are specific to the given domain.

  Action: the comments of Eq.(16) have been updated:
  L148 - ...where δ_{pq} *is the Dirac delta function, and* $f(\boldsymbol{r})$ *and* $g(\boldsymbol{r})$ *are the longitudinal and lateral correlation functions. In the case of a 2-D domain and assuming a VK spectrum, they are expressed by Eq.(14) and Eq.(15) respectively.*

- 5. On line 156, the difference between CBM and FIM approaches is stressed. However, the FIM has not been discussed before in the paper besides a citation in the introduction. Again, all mentioned methods are based on Fourier integrals. Hence, what is the characteristic feature of the FIM in the context of the paper? And where exactly is the CBM different from that?

  Action: the authors added more information regarding the FIM and the differences with the proposed method:

  - L141: *Another proposed method, the FIM [Pardo-Iguzquiza and Chica-Olmo, 1993], is very similar to the here proposed CB-RPM, computing the PSD from the correlation function. However, no arrangements of the Fourier coefficients on the wavenumber domain before computing the dataset are needed in the latter one.*

  - L161: *The novelty of the CB-RPM w.r.t. the FIM lies in this last step. Indeed the CB-RPM does not need to divide the wavenumber domain in different regions where the amplitude spectrum's coefficients (i.e., the square root of the PSD) are computed, as it's needed in the FIM, but the PSD* $\Phi_{\text{CB-RPM}}$ *is directly used in the computation, resulting in a faster computation having one step less than the FIM.*

  The authors think that the FIM method shall not be described in more details in this publication.

- 6. On line 170, and again on line 197, it is stated that structure functions have been calculated "from 0.01 L_0 up to 10 L_0". Looking at fig. 5, this does not seem to be correct. Is this sentence meant differently? How?

  Reply: the maximum error of the structure functions w.r.t. the theoretical ones, described in Eq.(24), has been effectively computed in that range of spatial domains. This is shown in the x-axis of Fig.(5), where the label expresses the ratio between the grid size and the outer scale, assumed in the paper to be $L_0 = 756\,\text{m}$.

- 7. The last paragraph of sec. 7 "Comparing the RPM and CBM methods" draws already conclusions from the given results. It should therefore be shifted to the conclusions.

  Action: The paragraph has been moved to the conclusions.

III. Minor points

- 1. Citation format: please make use of the *citet* and *citep* commands of the natbib latex package in order to make the text more readable.

  Action: the citations have been updated trying to make the text more readable, substituting *citep* with *citet* in different citations.

- 2. Figures and subfigures All figures containing two subfigures have both subfigures stacked vertically. This could be much improved by setting them side-byside, saving a lot of space.

  Action: all the figures containing subfigures have been updated according to the suggestion.

2 Report 2

- line 105 – *...its expected structure function are represented* As I read this - structure functions in plural (data and based on equ (13)) is better, please make also clear that expected refers to dataset's expected and theoretical to equ (13).

Action: substituted with:
L108 - The generated wind field, its structure function, and the expected one, computed substituting Eq.(13) in Eq.(9), are represented in Fig.(1).

- Fig.2 (outer scale – commonly denoted as integral length scale should be added)

  Action: in the caption it has been added:
  Fig.2 - ..., and the black line represents the turbulence outer scale - also referred as integral length scale.

- citation of Kolmogorv 1991 - better 1941 in the Russian journal Doklady Akademii Nauk SSSR.

  Action: Updated.

References

E. Pardo-Iguzquiza and M. Chica-Olmo. The fourier integral method: An efficient spectral method for simulation of random fields. *Mathematical Geology.*, 25:177–217, 1993.

D. K. Wilson. Three-dimensional correlation and spectral functions for turbulent velocities in homogeneous and surface-blocked boundary layers. *Army Research Laboratory: Adelphi, MD, USA*, 7 1997.

A. L. Cholesky. Sur la résolution numérique des systèmes d'équations linéaires. *Bulletin de la Sabix.*, 1910. doi: 10.4000/sabix.529.

Jakob. Mann. Wind field simulation. *Probabilistic Engineering Mechanics*, 13 (4):269–282, 10 1998. ISSN 0266-8920. doi: 10.1016/S0266-8920(97)00036-2.