

## ***Interactive comment on “Surrogate models for unsteady aerodynamics using non-intrusive Polynomial Chaos Expansions” by Rad Haghi and Curran Crawford***

### **Anonymous Referee #2**

Received and published: 16 June 2020

The paper presents an application of polynomial chaos expansions for uncertainty propagation through models of unsteady aerodynamics for wind energy purposes. In my opinion, this scientific topic is worth of being studied and be subject to publications, and the authors have made a fair effort in building a sound technical implementation of an uncertainty propagation algorithm. However, the current manuscript has several issues:

- Quality of descriptions and discussions. In a revised version of the paper, the presentation needs to be made much more thorough, with formal definitions of the variables, the steps in the analysis, model inputs and outputs, etc.

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- Likewise, there are no quantitative results shown, and there is little discussion of the key findings of the paper, and how the results could be used further.
- The aerodynamic model is represented by a very simple one-step-memory autoregressive process, which is not necessarily capable of taking more complex dynamic effects into account (e.g. when using the one-step memory the process autocorrelation function is limited to an exponential decay function, hence harmonics and other dynamics due to structure motion can't be represented). This limits the usability of the conclusions such as e.g. the statements regarding using many short simulations rather than few longer ones. Some specific ideas of what could be improved are listed below. Given the amount of necessary changes, it would be most appropriate to resubmit the paper as a new manuscript rather than a revision of the current one.

### **General comments**

- 1) The introduction lacks a proper description of what is considered an “aerodynamic model” (e.g. inputs, outputs, functionality) and what is its purpose. This is important in order to understand the motivation for the present study and define what the requirements for the surrogate model are.
- 2) I think you need to explain thoroughly what are the time and space dimensions used in the paper. We see a definition that the aerodynamic forces are a function of time and the incoming wind, but in the wind itself can be assumed both as a random process (in 1D), or as a random field with a certain coherence structure (in 3D), whereas the turbulence generation process normally makes use of the frozen turbulence hypothesis and a quasi-static wind field is generated, which is then advected with a predefined mean wind speed. Currently it is not clear which of these dimensions and properties are used and how are they included in the models.

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- 3) Define clearly what is a “simulation” and what is a “wind time series”
- 4) Define the “surrogate model”. What are the inputs and what are the outputs? How is time taken into account?
- 5) I would add a table with some comparison of the results for the different cases that have been run. Right now, Figures 7-10 show some qualitative results but there is no quantitative evidence and no clear recommendations as to what is the appropriate/recommended surrogate modelling approach for this problem.
- 6) What are the properties of the Veers model used? The wind field has autocorrelation which may influence the convergence of the simulation distributions.
- 7) The authors claim that “building a few accurate surrogate models for a small length of time would suffice for our purpose. Therefore, to build an accurate surrogate model, we can reduce the simulation length significantly while increasing the number of simulations”. This is based on the experience from a one-step autoregressive model but how valid would this be in general?
- 8) What are the key findings of this paper? Please outline this clearly in the conclusions.

**Specific comments:**

- 9) Abstract: six seeds per condition is just a recommendation (a minimum requirement) from IEC61400-1, and not necessarily a common industrial practice.
- 10) Abstract: the description of the motivation for the present work is good, but the description of the present study and even more so, the outcomes of the study, are only vaguely defined. Please improve the abstract with more concrete descriptions of work done and results.

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- 11) Page 1, lines 17-18: What is used is not exactly a Monte Carlo method (sampling from a specific distribution), it is more a sort of stratified sampling or importance sampling, since the simulations are done at predefined fixed wind speeds with numbers that do not correspond to a wind speed distribution.
- 12) Page 5, line 107: Isn't an autoregressive model with one-step memory also called a Markov chain?
- 13) Figure 6: what's the purpose of this figure? I think it can be left out without any loss of information.

**Technical comments:**

- 14) Abstract: typo – Balded written instead of Bladed

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Interactive comment on Wind Energ. Sci. Discuss., <https://doi.org/10.5194/wes-2020-24>, 2020.

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