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Interactive comment on "Polynomial chaos to efficiently compute the annual energy production in wind farm layout optimization" *by* Andrés Santiago Padrón et al.

Anonymous Referee #2

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The article concerns application of polynomial chaos to estimating average energy production (AEP) of a wind-farm, subject to uncertain wind-speed and direction (2 parameter UQ). This PC estimate is used in optimisation under uncertainty, to maximize AEP subject to farm-layout.

The setup and application of both the wind-farm model, and the UQ is competent and clear. Discussion is concise and unambiguously presented, conclusions are well founded based on results, and the presentation is professional.

My main concern is that this work may not be innovative enough. Certainly from a UQ perspective, the methods applied are perhaps the *default* UQ methods, applied in the

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standard way, and they in fact seem not very well suited to this particular problem. The problem has many features that make it a challenging and unique UQ problem: dependent input uncertainties, non-smooth distributions and responses, periodic parameters, significant noise, need for smoothness in the turbine-position space (to aid optimization). None of which are adequately addressed in the choice of numerical methods or the discussion.

The authors mention that the rectangle rule is standard in wind-energy, and PC is largely unknown. I would say this is article not a great advert for PC because of the mediocre results - but on the other hand if this is one of the first applications of modern UQ to this problem, I could see the value. I recommend major revisions:

Major comments:

- PC is interpolating/regressing figure 5, the power as a function of wind-speed (y) and direction (x), which shows a highly irregular pattern in the x. I suggest polynomials may be quite a poor choice for approximating this function. This could be verified by the authors if they plotted the implied response surfaces of PC-R and PC-Q and compared with this reference - oscillations may be present, as well as high sensitivity to the sample locations (hence perhaps their 10 runs with varying samples). In contrast the rectangle rule is just "pixellating" Fig 5. Given the periodicity of and shape of x, I would use combination of a Fourier series in x, and a polynomial in y. An equivalent integral approximation can be built, and since the underlying representation better matches the response, the AEP should be better.

- The fact that PC is perhaps not a good choice here, is additionally suggested by that fact that it performs only very slightly better than the rectangle rule (I don't agree with the authors interpretation of significant improvements in Figures 6-8). Rectangle should be 2nd-order while PC should be spectral. I suggest the lower variance of PC-R in Fig 9 is most likely the effect of PC-R filtering noise with regression. PC is likely not significantly improving the representation of Fig 5, compared to the under-sampling of

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the rectangle rule.

- The authors should not underestimate the effect non-independence of wind-speed and direction may have on the AEP. In my experience (in unrelated problems) dependence relationships in inputs are significantly more important than non-Gaussianity (skewness, kurtosis, etc.) of 1d-marginals. This makes the careful choice of Weibull potentially irrelevant for the purposes of comparing layouts. Please plot the 2d distribution in Fig 3, so we can see how strong the dependence is. Mention how PC could be generalized to allow for this (there is some literature on the subject). Computing the effect of this on the AEP would also be a very nice addition.

- Justify why wind-speed is fit with a distribution, but direction not.

- Justify why computing time of this problem is relevant. This is a one-off optimization for a farm that might last 20 years.

- Given your results it seems that the layout problem could have a very large subspace of close-to-optimal designs - all essentially equivalent. Do you agree? Please comment.

Minor comments:

- I have a personal interest in wake-deflection, which is mentioned in connection with FLORIS. Could the authors comment on how the layout problem would change if optimal wake deflection were allowed?

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