

## Manuscript: On the Sufficiency of Low-Order Spatial Descriptors for Fatigue Load and Power Prediction from Aggregated Rotor-Plane Flow Fields in Offshore Wind Farms

In this work, it is investigated what spatial information on wind speeds and turbulences across the rotor disk is required when calculating fatigue loads and energy yield of offshore wind turbines in a wind farm. A classical approach is to train surrogate models for the prediction using full spatial (and temporally aggregated) information. This work proposes using not only temporally aggregated but also spatially aggregated information, e.g., mean values, shear gradients, wake center, etc., to train the surrogate model.

The topic of this paper is not of major relevance, as current high-fidelity aeroelastic wind farm simulations provide the full spatial information anyway. Nonetheless, the proposed aggregation could be beneficial, as it, for example, reduces computational cost during surrogate training and inference and simplifies data storage. All these benefits are not essential for most applications, as the computation cost etc. is determined by the high-fidelity aeroelastic wind farm simulation anyway. Despite this moderate relevance, the paper might be interesting for readers of WES. However, before being suitable for publication in WES, several shortcomings must be addressed.

- 1) Although you use available/published data for training (input: wind speed and turbulence; output: DELs and energy yield), a short description of how DELs and energy yield have been calculated is necessary (or at least a clearer statement where the descriptions can be found in the original publication). This is especially important as some results of your work are not intuitive (see comment 8)
- 2) In Section 2, additional explanations are required, e.g.,
  - a. A figure showing the “load positions” of Table 1 (including a coordinate system)
  - b. Eq. (3): What value has  $\epsilon$ ? (same in Eq. (26))
  - c. Eq. (8) and (9): How exactly are the gradients calculated (you only mention Sobel operators)?
  - d. Eq. (13): Why did you choose  $\alpha = 0.1$
  - e. L. 130/131: Some more explanations on the left-right and top-bottom mean differences are required.
  - f. Section 3.5: A figure showing which grid points are included for  $r = 1$  and  $r = 2$  would help.
  - g. Section 3.8: A list/an overview of all 31 spatial descriptors would help.
- 3) You use two different surrogates for DELs and energy yield. This makes your findings unclear. The relevance of spatial information for the energy yield could be just due to the different surrogate. Use the same surrogate for both and explain why you used it. For DEL approximation, according to the state of the art, GPR are more frequently used so far. Hence, you must justify your choice.
- 4) Section numbering is wrong in Section 4, e.g., Section 4.0.1.
- 5) For your surrogates, why did you choose the settings/values you chose (Figure 1 and Table 2)? Any justification/preliminary study?
- 6) Figure 1 should be referenced in the text.
- 7) Section 4.1: Normally, we talk about training, validation (for hyperparameter tuning etc.) and test data (for surrogate evaluation) in the context of surrogates/machine learning. You only mention training and validation data. Please, clarify this.
- 8) Section 5: For me, the results are not very intuitive. Normally, the energy yield should be less influenced by spatial variation (see for example Liew et al., 2023b “While this parameterisation is often adequate for predicting power output, more spatial information is required to predict fatigue loads.”), as the energy yield depends on the rotor speed (only). In contrast, most fatigue loads are influenced by spatial effects, e.g., partial wake. Moreover, the blade edgewise moment – also mainly influenced by the rotor speed (at least when the blades are not pitched) – should behave similar to the energy yield. Hence, I assume that the differences are due to the different surrogate models. This must be investigated in detail.
- 9) I think that the conclusion should be more concise. Currently, there are many repetitions.