Authors' reply to Referee #1

Dear Referee #1,

Many thanks for the feedback about our manuscript. Your comments are really appreciated to improve the quality and clarity of the paper. Please find below our point-by-point responses to your suggestions and concerns, and the corresponding changes in the reviewed manuscript, where necessary. The original comments are written in **blue** below, and the corresponding answer by authors in black.

RC1: Overall, the manuscript describes the rationale used to analyse data extracted from a commercial wind farm. However, the description of the methodology remains too brief.

Answer: We fully acknowledge that the methodology section is presented too briefly in its current form. Upon reviewing your observation, we recognise that we may not have adequately conveyed the complete methodological workflow within a single subsection. To address this issue, we will reorganise the structure of the manuscript to provide a more comprehensive, detailed, and coherent description of the methodological procedures.

RC1: Important information, such as the characteristics and accuracy of the instruments used to collect the data (only briefly mentioned in lines 65–70), is missing. As a result, it is difficult to assess the reliability of the measurements and the validity of the analysis presented in Section 4.

Answer: We appreciate the referee's comment. As indicated in lines 65 to 70 of the article, the instrumentation located in the measurement tower consists of Thies First Class cup anemometers at six levels (30 m, 50 m, 70 m, 78 m and 82.3 m, two anemometers at this last level), Thies First Class wind vanes at three levels (50 m, 70 m and 77.5 m), 2 Galltec KP termohigrometer sensors (5 and 76.5 m), 1 air pressure sensor Ammonit AB 60 (5 m), 1 rain gauge Thies IR 5.4103.20.741 (10 m).

The instrumental set-up is compliant with IEC 61400-12-1 (International Electrotechnical Commission, 2005)[1] and with MEASNET cup anemometer calibration (Measnet, 2009)[2].

In the rain gauge, precipitation is detected opto-electronically via a measuring area of approx. 25 cm².

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[1] International Electrotechnical Commission. (2005). *IEC61400-12-1 ed1., Wind turbines-Part 12-1: Power performance measurements of electricity producing wind turbines*.

[2] Measnet. (2009). ANEMOMETER CALIBRATION Version 2 October 2009. *Measurement*, *October*.

For the sake of the manuscript's completeness, all this information will be included in the reviewed article.

RC1: Furthermore, the discussion of the underlying physical mechanisms is very limited, and the manuscript mainly presents a data-processing procedure without sufficient interpretation in terms of flow physics and turbine–rain interaction.

Answer: As the referee states, the methodology is mostly focused on the data-processing perspective. Nevertheless, and to complement it, a description of the interaction between precipitation and air flow will also be included in the introduction in the reviewed article.

RC1: The simulations mentioned in the manuscript are not properly introduced or discussed. Their purpose, assumptions, and main characteristics remain unclear. I recommend adding a dedicated numerical methods section describing the simulation approach and its role within the study.

Answer: Although the manuscript already contains information about the type of models and parameters used and the type of cases simulated (line 226 – default wake parameters and 'Gauss' velocity deficit model and calibration process section 4.4.5), the authors will highlight better in the reviewed paper the purpose and underlying assumptions for the wind farm model, by following the referee's suggestion.

RC1: While the manuscript distinguishes between rainy and non-rainy conditions, the characterisation of precipitation events is insufficient. Additional information on rain properties, such as intensity, drop size, and measurement methodology, should be provided. At present, it is unclear what specific rain parameters are available and how they influence the analysis.

Answer: The available instrumentation in the wind farm under study characterises rainfall based on its intensity. Although it was initially proposed to carry out the analysis based on rain intensity, by categorising different situations, the amount of data available in each set was very limited in the available measurement period, so it was decided to approach the study case by analysing only the behaviour in rainy situations versus non-rainy situations. This decision will be clarified further in the article review.

As a side remark, it should also be noted that the available instrumentation in commercial wind farms typically lacks the characterisation of rain drop size. For the sake of wider applicability to a relevant number of conditions and wind farms, the data-driven methodology has been defined on the basis of sensing systems commonly used. Authors recognise the interest in delving into the effect of rain characteristics. However, and as a first step, the manuscript aims to raise awareness of the potential impact of rain on the wind farm performance. Indeed, this will help to justify further investment required to advance in subsequent future work.

Accordingly, the objectives and limitations of the study will be clarified in the reviewed manuscript.

RC1: The Introduction is too brief for such a complex topic. In particular, it lacks a proper review of previous experimental and numerical studies on the effects of rainfall on wind turbine performance and wakes, both in field conditions and wind-tunnel experiments. The discussion of previous LES studies is also too limited and should be expanded.

Answer: Authors fully agree that this is a complex topic. In the revision of the article, we will expand the introduction, attempting to provide a greater number of references related to the subject of study and a more comprehensive perspective.

RC1: The analysis presented in Figure 4 appears incomplete and requires further clarification.

Answer: Figure 4 summarises the analysis carried out, in which, for the measurement period analysed, periods of rainfall have been identified in contrast to periods without rainfall. This resulted in the definition of three data sets: the total period set, the set of events in which rainfall was recorded, and the set of data in which there was no rainfall. For each data set, a series of characteristics related to the characterisation of wind flow have been analysed.

A more detailed explanation of this figure will be provided in the review of the article.

RC1: The axis labels in Figures 9 and 10 are incomplete and should be corrected.

Answer: Due to confidentiality restrictions on the commercial wind farm, we are not permitted to disclose the actual absolute values of the variables; therefore, both axes had been intentionally decontextualised. In the revised manuscript, however, we will provide normalised values and variable units for each of the concerned figures for the sake of completeness.

RC1: Line 195 refers to the IEC 61400-12 Annex M procedure without providing any description or explanation. This should be clarified for readers unfamiliar with this standard.

Answer: The authors opted to summarise the general approach (power curve normalisation to reference TI) in the manuscript and explicitly reference the corresponding standard, where the procedure is described in full detail. Our intention was to maintain clarity and readability while avoiding unnecessary repetition of content that is already formally established and accessible through the cited standard. Nevertheless, we will revise the manuscript to slightly expand the description.

RC1: Finally, the conclusions remain too general and do not sufficiently highlight the main physical findings, limitations of the study, and implications for wind energy applications.

Answer: The authors appreciate the comment. In the article review, the conclusions section will be expanded with the aim of better highlighting the objectives and findings achieved, limitations of the study, and implications for wind energy applications.