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Further characteristics of the atmospheric turbulent wind: Periods of constant wind speed and waiting times between gusts

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The loads affecting an operating wind turbine are estimated using numerical simulations that aim to reproduce the real interactions between the turbine and the incoming wind. Then, accurate descriptions of both, the physical turbine and the atmospheric wind, to be included in the numerical estimations are essential in the design, manufacturing and operation processes of a wind turbine. Particularly, the characterization of the atmospheric turbulent wind is currently performed based on the standard guideline proposed by the International Electrotechnical Commission (IEC 61400-1). Although this guideline accounts for essential descriptions of the atmospheric wind, some further statistical characteristics have been poorly addressed. As a result, operating wind turbines might react unpredictably to such structures that have not been properly identified and parametrized from atmospheric data and later included within the numerical models. In this work, we introduce and parametrize two additional features from the atmospheric turbulent wind that have not been considered by the current IEC guideline: the periods of constant wind speed (T_c) and waiting times between wind gusts (T_g). We hypothesize that certain conditions of these events on the wind might induce unexpected dynamic responses in the turbine. Therefore, we focus on the statistical description of those features on the wind in terms of their magnitude, probability of occurrence and possible extreme events.

The probability distributions $p(T_c)$ and $p(T_g)$ exhibit a power-law decay. From an engineering perspective, very long periods of constant wind speed T_c might be undesirable for an operating wind turbine. As an example, if a such long event is located on a specific area of the rotor plane, it may lead to unexpected periodic loads resulting from the blade passing through the constant speed structure at the given location on the plane. On the other hand, the time between two consecutive large increments might be of high relevance for the dynamic response of the wind turbine. Specific times T_g that coincide with the characteristic frequencies of the turbine, might either intensify or diminish oscillations of the structure. Consequently, in combination with the characterization of features such as T_c and T_g, it is essential to investigate the impact of those structures carried by the wind on the response of the wind turbine.

Results from a preliminary study on the effect of the magnitude of T_g on numerically simulated loads showed that the variation in the waiting time for the second gust to reach the turbine induces a different load on the tower of the turbine. Therefore, future work has to be devoted to a deeper understanding of the characteristics of events such as T_c and T_g on the atmospheric wind, their dependence on the parameters for their definitions and their relation to a purely turbulent flow. Additionally, evaluating the response of a wind turbine under different scenarios involving these structures might be beneficial, firstly as an insight into the source of unpredicted measured loads on an operating wind turbine or secondly, as improvements to current control practices.

Category

Meteorology / Atmospheric Physics

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