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紊流統計特徵分析方法應用於杜鵑颱風侵台期間紊流風況之適用性分析
Applicability of statistical turbulence characterization to typhoon wind turbulence exemplifying typhoon Dujuan off the west coast of Taiwan

Jonna Wagner[1]、Christian Behnken[1]、Joachim Peinke[1]、呂宗行 [2*]、苗君易 [2]

[1] ForWind Research Center, University of Oldenburg, Germany
[2] 國立成功大學航空太空工程學系

Jonna Wagner[1], Christian Behnken[1], Joachim Peinke [1], Tzong-Shyng Leu[2*], Jiun-Jih Miau[2]

[1] ForWind Research Center, University of Oldenburg, Germany
[2] Department of Aeronautics and Astronautics, National Cheng Kung University
*tsleu@mail.ncku.edu.tw

摘要

由於熱帶氣旋使風機面對嚴峻的挑戰，因此探討颱風風況與正常風況的紊流特性差異很重要。 本研究以台灣杜鵑颱風風況為例，使用紊流統計特徵方法分析颱風紊流。這項方法本著大氣紊流是理想紊流子集的疊加，刻劃已知子集的模型。方法重點關於風速增量的分析。突然變大的速度增值對風力發電機傷害很大。極端增量的概率比常態分佈大的特徵稱為間歇性 (intermittency)。在這項研究中發現，颱風大尺度紊流的間歇性有部分會比正常風況的紊流小。不過颱風小尺度紊流的特性和正常風況的紊流之間具有相似性。此結果說明已知的紊流統計模型能夠形容颱風小尺度紊流。為了解釋大尺度紊流的為何有差別需要分析更多颱風數據。本研究透過紊流統計方法分析從歐洲到台灣的風況數據，進而找出全球風場最佳紊流特徵模型，此研究成果將有助於優化風力發電機材料疲勞的預防。

關鍵詞：紊流，紊流統計特徵分析方法，陣風，杜鵑颱風。

Abstract

The challenges of tropical cyclones for the use of wind energy raise the question of differences between typhoon and normal wind condition turbulence. Using the example of typhoon Dujuan, the applicability of a framework to statistically characterize wind turbulence is evaluated. As wind generated loads affecting a wind turbine are built up typically in a few seconds, we concentrate on wind fluctuations in this time range. The framework is based on the division of wind turbulence characteristics into subsets that may be described by existing turbulence models. It focuses on the analysis of wind speed increments (characterizing wind fluctuations in the range of seconds), which can be extremely damaging for wind turbines when occurring suddenly. A higher than Gaussian potential for extreme velocity increments is called intermittency. This work shows how typhoon turbulence can be divided into different packages, which often resemble the famous lognormal turbulence of Kolmogorov. With this approach it is possible to quantify differences between typhoon and non-typhoon turbulence. Indications are found that typhoon turbulence has a partially lower intermittency at larger scales or higher time lags. The characteristics of turbulence at smaller scales or time lags, however, do not differ substantially from normal wind condition turbulence. This promises an applicability of existing turbulence models to typhoon turbulence at smaller time scales. Further typhoon data is needed to explain the discrepancy in turbulence at larger time lags as well as to characterize periods of low wind speeds associated with the typhoon eye. By applying the current statistical framework originating from Europe to Taiwanese data, a stepping stone is added to the search for optimal global wind turbulence characterization, which aims at enhancing fatigue control of wind turbine systems.

Keywords: wind turbulence; statistical characterization; gusts; typhoon Dujuan