IPID4all Doctorate Research Exchange with Portland State University

Feedback report

Dominik Traphan, Dipl. Phys.
AG TWiSt, University of Oldenburg, ForWind
Professor Dr. Joachim Peinke
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Rotor blade aerodynamics of wind turbines

Portland State University
Thermal & Fluid Science Group, Portland, USA
Professor Raúl Cal

Introduction

The thermal and fluid science group at Portland State University (PSU) has a strong focus on optical measurement techniques applied to turbulent flows about wind turbines in a wind park configuration. While ForWind has so far extensively investigated rotor blade aerodynamics in laminar inflow, rotor blades exposed to turbulent inflow have been optically captured within the scope of my PhD work for the first time. Since turbulent flows require tailored analysis techniques, experiences on turbulent flow analysis available at PSU are of high interest for the experimental wind energy group of ForWind at the University of Oldenburg. Additionally, knowledge about these techniques is crucial for successfully progressing in this part of my PhD work.

Research Undertaken

The challenge of turbulent flows is that essential details are often obscured by the chaotic interaction of vortical structures that form in a broad range of sizes. In order to uncover cause-effect relationships, a variety of methods is necessary that respectively focus on a specific kind of flow structure. Discussions with Professor Cal and two PhD students yielded a selection of promising methods that cover different aspects of the available flow data about an airfoil. On the one hand, we selected two global filtering techniques, POD and DMD. In principle, these techniques are able to emphasize large coherent structures that have strong but more or less deterministic impact on the aerodynamic response of the airfoil. On the other hand, we selected two local filtering techniques, flow field correlation and vortex identification, that were intended to pinpoint small flow structures. Interesting about such allegedly small structures is that they can induce nonlinear aerodynamic response, which can result in extreme lift events characterized by large stochasticity. This is of importance for wind turbines because these events mainly contribute to the components' fatigue.

After three weeks of successfully adapting and implementing these methods into our algorithms, it turned out that particularly two methods are useful for our purposes: POD and vortex identification. First results suggested a strong connection between (i) POD coefficients and global lift as well as (ii) vortices emerging in the wake region of the airfoil and single lift events. Since such

connection has never been shown before, we decided for continuing collaboration past the time I spent in Portland and aiming for a joint publication. This publication will be a central part of my future research.

Personal Experience

Personally, I enjoyed the time in Portland a lot. People living in Portland seem to be different from most parts of the US: they value sustainability in its diverse aspects and still are relaxed in following this. The food culture is very pronounced and popular, meaning that a lot of small restaurants, bars and cafes are available all over the city, which offer delicious and affordable food and drinks. Besides, the city provides an excellent cycling infrastructure. These aspects all together make Portland livable. Fortunately, my coworkers in Portland valued all these aspects, too. I thus had a time in Portland I gladly remember: sharing cultural experiences, enjoying food and efficiently working on my research field at the same time.

Conclusions

In summary, the stay was a great personal and professional success. I extended the portfolio of methods to analyze flow data, which will be beneficial for my own research as well as future activities of ForWind. After my research stay, there are already plans to continue exchange with two master's students visiting Oldenburg. I recommend Professor Cal's group, Portland and the exchange program, IPID4all, without any reservations.

Outlook

Results from this exchange will be further discussed in weekly conference calls in order to summarize them in a paper.

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