IPID4all Doctorate Research Exchange with the University of Colorado Boulder
Feedback report

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Influence of the atmospheric boundary layer on wind farm control

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Introduction

With the challenge to increase the overall power output of wind farms on limited space, wind farm control, that is based on cooperative control of individual turbines during operation, is a much discussed subject of recent wind energy research. In this context my thesis topic focuses on the influence of different atmospheric conditions on the application of wind farm control.

The technical approach for my studies are large-eddy-simulations (LES), that are capable of representing both the turbulence of the atmosphere and the impact of the energy conversion of a wind turbine on the flow. While numeric simulations allow testing control in well-known boundary conditions, they lack in significance if not validated by free field measurements.

The Department of Atmospheric and Oceanic Sciences (ATOC) of the University of Colorado has built up a reputation for executing measurement campaigns of wake flow of onshore wind turbines. One focal point of the campaigns has always been to support the wake measurements by extensive meteorological instrumentation which enables to approximate the measured atmospheric conditions, such as atmospheric stability, in numerical models.

The exchange presented a promising opportunity to compare the approaches to validate models with measurements, developed at ForWind, with the approaches of the ATOC.

Research Undertaken

During my two months in Boulder I mostly worked with the CWEX-11 lidar data set, recorded at an operating wind farm in Iowa, USA during 2011. The data set consists of two vertical profiling lidars aligned along the main wind direction upwind and downwind of a multi-megawatt turbine. The lidar measurements have the interesting aspect, that they display the vertical wake profile as well as inflow and wake flow at the same time.

In cooperation with the doctoral student J. Lee we worked on a simulation chain to incorporate model data produced by Lee into the LES models of my work. During the exchange I held one talk at the ATOC and another at the nearby National Renewable Energy Lab (NREL).

Personal Experience

After struggling a little with the different climate at a height of 1 mile above sea level during the first days, I had a great experience in Boulder. Boulder is one of the most liberal and open-minded places in the US and people were very open and helpful everywhere. The nature with the Rocky Mountains

National Park is breath-taking. The downside of this popular place is that it is quite expensive and even though Boulder has quite a good public transportation system it was sometimes troubling to get along without car, especially because the deep snow made biking impossible.

The staff at the institute was very friendly and I experienced a great support in the first days. Even though the institute had just moved in a new building that was not completely equipped yet it was no problem to organize a working place with computer. I had a lot of fruitful discussions with Prof. Lundquist and her doctoral students.

Conclusions

The exchange visit was a great personal and professional experience for me.
By having the opportunity to discuss my work in another environment than my group in Oldenburg I gained a lot of additional inside into the topic. I want to the thank the DAAD for the financial support, because without it a stay at Boulder would not have been affordable.

Outlook

The study conducted by J. Lee and me and supervised by Prof. Lundquist will be orally presented at the Wake Conference 2017 in Visby, Sweden. The talk will be accompanied by a proceedings paper with the title “A wind turbine wake in changing atmospheric conditions: Comparison of LES and lidar measurements”. From my talk at the NREL cooperation developed in the context of a task of the Wind Energy programme of the International Energy Agency (IEA, Task 32).

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