11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

NUMERICAL MODELING AND VALIDATION OF THE WIND FLOW OVER THE LAKE WANNSEE

Oliver Krüger[1*], Christina Schrödinger[1], Antonio Lengwinat[2], and Christian Oliver Paschereit[1]

[1] Chair of Fluid Dynamics – Hermann-Föttinger-Institut – TU-Berlin, Müller-Breslau Str. 8, D-10623 Berlin, o.krueger@tu-berlin.de, www.fd.tu-berlin.de
[2] Entwurf und Betrieb Maritimer Systeme, TU-Berlin, Salzufer 17-19, D-10623 Berlin, lengwinat@tu-berlin.de, www.marsys.tu-berlin.de

Key words: *Atmospheric Flows, Tree Canopy, Complex Terrain.*

Predicting air flows over complex terrain is of high interest for a broad variety of applications. Determining the wind loads on wind turbines and the optimization of the deployment within a candidate wind farm location to maximize the power output are probably the most prominent applications in wind engineering. Other applications are the prediction of dispersion of pollutants or the forecast of wind flow patterns in urban areas. Due to the fact that the atmospheric boundary layer (ABL) is the lowest part of the atmosphere it's flow pattern is mainly influenced by the ground topology.

There is extensive literature concerning computational fluid dynamics (CFD) simulations of wind flows over complex terrain. Most studies use a finite volume code based on solving the incompressible Reynolds-averaged Navier-Stokes equations (RANS) together with a two-equation turbulence model ($k-\varepsilon$ or $k-\omega$). Even though RANS methods only provide information on the mean wind and level of turbulent kinetic energy, they are not seriously challenged by large eddy simulations (LES) due to their robustness and low computational costs [1].

The most comprehensive ABL flow measurement stem from the Askervein Hill project [2]. However, the Askervein Hill is a smooth hill without obstacles. Therefore, the present study is dedicated to the evaluation of the wind flow over the lake Wannsee in Berlin, Germany (N52°25′ 39″ E13°10′ 23″). The simulations were carried out with the free open source toolkit OpenFOAM (Ver 2.1) using the SST turbulence closure. The simulations were validated with measurements, conducted on a sailing yacht (8m OneDesign) equipped with wind sensors (cup anemometer and wind vane from *tacktick*) and a positioning system.

*Address all correspondence to this author: *o.krueger@tu-berlin.de*

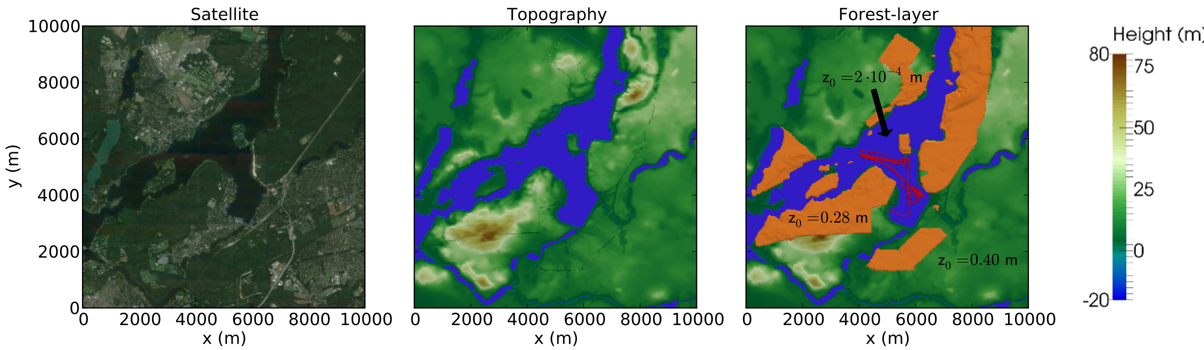

Figure 1: Overview of the computational domain showing a satellite image (left), the discretized topography (middle), and the displaced forest-layer (right). The right image also shows the course of the sailing yacht used for the measurements (red curve).

The computational domain was derived from satellite data. In most cases digital terrain models (DTM) computed from satellite data usually represents the bare ground surface lacking objects like plants and buildings. If individual roughness elements of a specific size are packed closely together, they act as a displacement surface. The computational domain was derived from satellite data, which indicates that the lake surrounded by deciduous forests. The forest area was elevated by 80% of the average tree size (≈ 14 m) normal to the surface, as shown in orange in the right image in Figure 1.

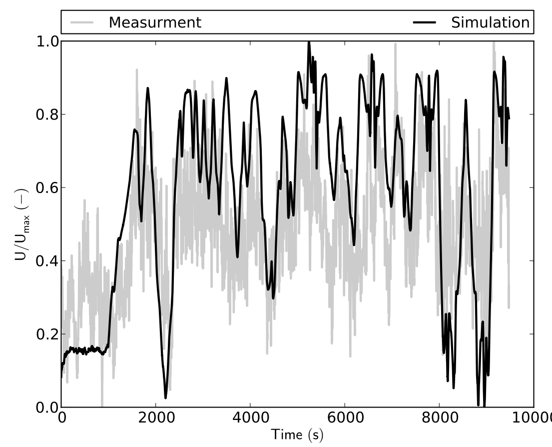

Figure 2: Velocity profile as a function of the sailing time. The time corresponds to a position on the sailing course.

Figure 2 shows the results of the computed wind velocity as a function of the sailing time, which corresponds to a position on the sailing course. The simulation exhibits the same flow characteristics as the measurements. The noise of the measurement signal, however, cannot be reproduced by the computation. This can be attributed to high wind gusts and measurement errors.

REFERENCES

[1] Kemal Hanjalić and Saša Kenjereš. Some developments in turbulence modeling for wind and environmental engineering. *Journal of Wind Engineering and Industrial Aerodynamics*, 96(10-11):1537–1570, October 2008.

[2] P. A. Taylor and H. W. Teunissen. Askervein '82: Report on the September / October 1982 Experiment to Study Boundary Layer Flow over Askervein, South Uist. Technical report, Atmospheric Environment Service, Ontario, 1982.