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LARGE-EDDY SIMULATIONS FOR ATMOSPHERIC BOUNDARY LAYER FLOWS OVER COMPLEX TERRAINS WITH APPLICATIONS IN WIND ENERGY

Ashvinkumar Chaudhari[1], Ville Vuorinen[2], Oxana Agafonova[1], Antti Hellsten[3] and Jari Hämäläinen[*,1]

[1]Lappeenranta University of Technology (LUT), P.O.Box 20, FI-53851 Lappeenranta, Finland
Ashvinkumar.Chaudhari@lut.fi, Oxana.Agafonova@lut.fi,
*Presenting author. Jari.Hamalainen@lut.fi and http://www.lut.fi
[2]Aalto University, P.O. Box 14300, FI-00076 Aalto, Finland. Ville.Vuorinen@aalto.fi
[3]Finnish Meteorological Institute (FMI), P.O. Box 503, FI-00101 Helsinki, Finland
Antti.Hellsten@fmi.fi and http://www.fmi.fi

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Substantial increase of wind energy production has made modeling of Atmospheric Boundary Layer (ABL) flows over wind farms an important research topic. The Bolund experiment performed in 2007-2008 provides a new validation data for atmospheric flow models that resolve the flow on scales relevant for wind-turbine siting [2, 3]. In the present work, Large Eddy Simulations (LES) are carried out to investigate the turbulent boundary layer flows over an isolated two-dimensional ($2D$) RUSHIL wind-tunnel hill and the LES model is successively applied for the Bolund hill, which represents a real complex terrain. In order to validate our LES methodology presented here, the results are compared against the wind-tunnel [1] and the Bolund field measurements [2, 3].

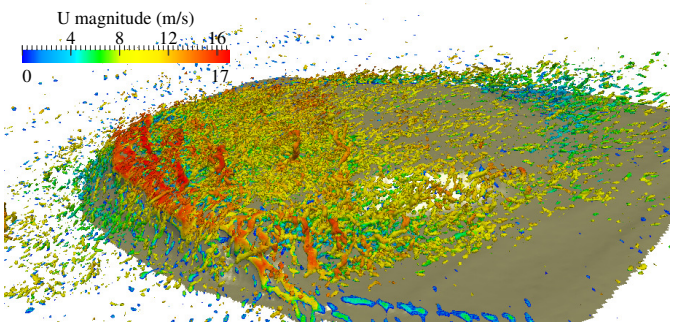

Figure 1: Iso-surfaces of the second invariant of the velocity gradient tensor Q colored with the velocity magnitude around the Bolund hill.

Figure 1 depicts the instantaneous iso-surfaces of the second invariant of the velocity gradient tensor Q colored with instantaneous velocity magnitude in order to show the resolved small-scale turbulent motions over the Bolund hill. Figure 2(a) compares the mean wind-wise velocity profiles with the wind-tunnel measurements [1] for flow over an isolated hill, whereas Figure 2(b) shows the ratio of the LES results to the Bolund experimental data [3] for the velocity magnitude at different heights and locations over the Bolund hill. In $2D$ hill case, LES captures the flow separation accurately on the

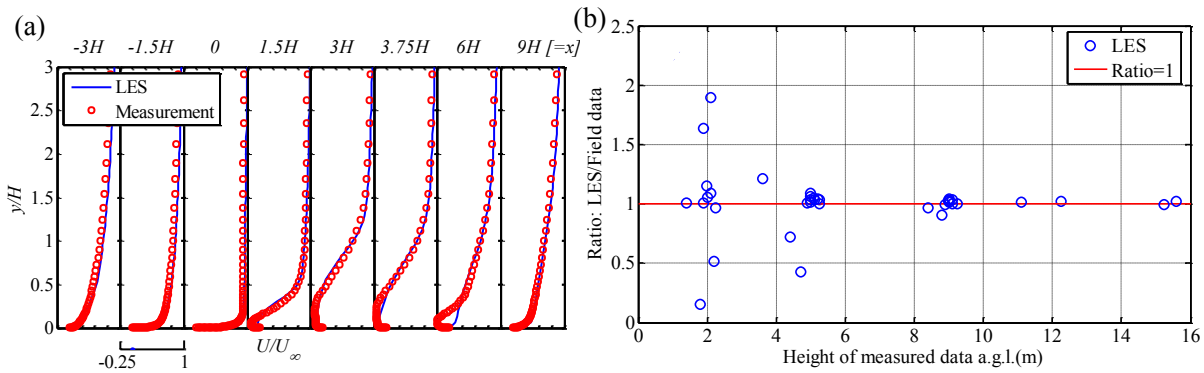

Figure 2: (a) Vertical profiles of mean wind-wise velocity compared with the measurements for flow over isolated hill at some longitudinal locations. (b) Ratio of LES results to field data for velocity magnitudes at different heights over the Bolund hill

lee-side of the hill and the results are in very good agreement with the wind-tunnel data (Figure 2(a)). For the Bolund hill case, the ratio shows slightly immature prediction only for few mast locations which are near the ground surface (at 2 m height), afterwards the results are in better agreement and give accurate matching with the field data above the height = 5 m. Thus, it can be observed that present LES can reproduce complex turbulent wind structures over complicated terrains such as the Bolund hill. The LES methodology validated here is further employed to simulate wind structures over a real wind-farm topography located in South-East Finland, and the preliminary results from this test case will be shown at the conference.

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