Flow over complex terrain. The secrets of Bolund

Since the Bolund field campaign in 2007, the Bolund peninsula in the Roskilde Fjord in Denmark is a well-known reference case for numerical and physical modelling for wind modelling and wind turbine siting. Its well-described characteristics and boundary conditions makes it ideal for the analysis and the understanding of flow over complex terrain. The work presented in this thesis contains two diverse approaches to help understand the flow behavior over a complex terrain site, in this case the Bolund peninsula. The first approach investigates the wake and recirculation zone downstream of the Bolund escarpment with the help of a continuous-wave Doppler lidar (light detection and ranging). The instrument measures the line-of-sight windspeed 390 times per second in highly resolved 7-m tall profiles by rapidly changing the focus distance and beam direction. The profiles reveal a detailed and rapidly changing structure of the recirculation zone induced by the Bolund escarpment. This wake grows with distance from the escarpment, with the wake height depending strongly on the wind direction, such that the minimum height appears when the flow is perpendicular to the escarpment.

Although the presented full-scale experiments around the Bolund escarpment has been performed with great success, experiments in controlled environments such as wind tunnels provide the opportunity to study problems systematically in greater detail. Such a controlled experiment was realized at the WindEEE Dome, a windtunnel facility of the Western University, London, Ontario, Canada and presents the second approach of this thesis. This large-scale wind laboratory investigation of the flow field over a large-scale model of the Bolund peninsula shows that the mean wind, wind shear and turbulence level are extremely sensitive to the exact details of the terrain. A modification of the escarpment of the Bolund model to give a sharper edge has dramatic consequences for a wind turbine positioned close to the edge. Additionally the windtunnel investigations show only a modest Reynolds number dependence of the flow, while it is more sensitive to the details of the inflow wind profile.