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Measurements and modelling of turbulence statistics and CO_2 fluxes above a land –water mosaic area in Denmark

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The measurement of turbulence statistics and chemistry compounds in the lower atmosphere using towers of approximately 100 m height is becoming increasingly common. A general problem for such towers is the proper interpretation of signals measured by instruments when the underlying surface is non-uniform. The 125m tall tower at Risø (Denmark) was recently renovated and re-instrumented including an eddy-covariance flux measurement at the top of the tower. The area surrounding the Risø tower at the Roskilde fjord is mosaic of water and uneven land covered by agriculture and forest. These heterogeneities are clearly reflected in the tower-based observations of the turbulence statistics using a profile of six sonic anemometers. To analyse and quantify how the different surface types influence the eddy-covariance measurement, we apply the atmospheric boundary layer (ABL) model SCADIS based on a two-equation closure scheme capable to simulate flow in complex forested terrain (Sogachev et al., Boundary layer meteorol. 2012). We compare the modelled flow statistics (wind speed and turbulent kinetic energy) derived at different heights at mast position under varied wind direction with that measured by the sonic anemometers. The comparison shows the ability of the model to qualitatively reproduce effect of upwind conditions at flow regime. Using the 2D mode of the model, we then estimate the scalar flux footprints of the eddy-covariance measurement for different wind directions. The footprint methodology based on ABL flow model (Sogachev and Lloyd, Boundary layer meteorol. 2004) have been used successfully for many years. Using values of cross-integrated footprints for each simulated wind direction, we estimate the effect of the underlying surface on CO_2 fluxes registered at the mast position. The minimal variation in CO_2 fluxes was found in the direction having the longest fetch above the water. Wind direction for which water surface was a minor part in upwind fetch demonstrate large diurnal flux variations that directly connect to forest growing upwind.