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Wind turbine wake deflection in different atmospheric stratifications

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Measurements have shown that the atmospheric stratification has a strong influence on wind turbine wakes. Increasing computing capacities make it now possible to study these effects in high detail by the means of Large Eddy Simulation (LES) models. The repowering of existent onshore wind farms with favorable wind conditions enhances the power losses of downstream turbines caused by wakes. With the challenge to increase overall power output of wind farms on limited space, wind farm control strategies that aim on influencing wakes become more relevant. We set up LES models of convective, neutral and stable boundary layers to investigate wind turbine - flow interaction and its impact on wind farm control methods. A new solver that couples the LES code PALM (IMUK) with the aeroelastic wind turbine simulation tool FAST (NREL) was developed to allow for the reaction of the wind turbine to changing flow properties and the implementation of various control strategies. We investigated the strategy of the active control of the yaw angle of wind turbines to deflect the wake and potentially increase the power output of downstream turbines. Previous studies showed that this strategy can improve the power output of a two turbine array by around 5% for certain wind directions. We find that the efficiency of this strategy is strongly depending on the atmospheric stratification. Wake properties and turbine loadings were studied in the LES set-ups with regard to atmospheric stratification parameters for different turbine yaw angles. The control strategy was further evaluated by monitoring total power output and loadings of turbine arrays with the upstream turbines intentionally yawed.