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Large eddy simulations of low-level turbulence caused by tree lines in the vicinity of an airfield

Stefan Fluck and Julien G. Anet
Zurich University of Applied Sciences, Center for Aviation, School of Engineering, Winterthur, Switzerland (fluf@zhaw.ch)

Obstacles in the vicinity of an airfield are sources of low-level turbulence that can adversely affect air traffic in critical flight phases close to the ground. The airfield in Yverdon in western Switzerland is surrounded by tall tree lines and is notorious for turbulence during take-offs and landings. This situation is even more pronounced when a strong northwesterly local wind, the Joran, prevails. Some parts of the tree lines to the north and to the west of the airfield were removed around 2017. To analyze the effect of the tree lines before and after their removal with respect to low-level turbulence, large eddy simulation tools can be applied to gain valuable insights.

In this study, the flow patterns in the vicinity of the airfield in Yverdon were analyzed by means of high-resolution large-eddy simulations with the PALM model system. This was conducted for different wind scenarios, as well as for two different tree line configurations. In PALM, a nested simulation approach was chosen, where the smallest domain was configured to a resolution of four meters and the larger domain to a resolution of 32 meters. The simulations were forced by COSMO-1 model reanalysis fields, in order to factor in the synoptic weather conditions of the respective days. We validated the model results by comparing the simulated fields with measurement data that were recorded by a sonic anemometer close to the airfield in July 2019, during which period one Joran event was captured.

The results of the simulations show in general good coherence with the measurement data at the mast position. The onset of the Joran event was also well captured in amplitude as well as in time. For each scenario, wind speed, wind direction and turbulence intensity were analyzed with the aim to investigate the effect of the removal of parts of the existing tree lines. The simulations show that the removal of the tree lines change the characteristics of the winds experienced by air traffic significantly. During the simulated Joran case, over the runway, the turbulence intensity is reduced by 0.12 (-27 %), while the mean wind speed increases by 1.78 m/s (+62 %). Furthermore, the lack of wind breaking from the tree lines introduces large crosswind components that were not present before. Similar effects were identified for the other analyzed wind directions.

These results show that the placement of obstacles in the vicinity of an airfield matters to aviation safety and large eddy simulation tools like PALM can produce very helpful insights into how they do so. This is an especially encouraging message regarding future airport infrastructure projects, as costly mistakes can be effectively avoided already during planning phases.