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The influence of small scale heterogeneities on the near surface turbulence structure and the energy balance closure

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Inhomogeneities due to differences in the surface structure may trigger secondary circulations in the convective boundary layer. They reach the top of the boundary layer if the wavelength of the heterogeneity is in the order or larger than the boundary layer height. Turbulence measurements with the eddy-covariance method are not able to detect these fluxes because of their stationarity. These circulations are thus suspected to be partly responsible for the non-closure of the energy balance in a height of 2 m (height of energy balance stations).

Previous studies have shown that the mentioned circulations can influence tower measurements but that they have nearly no influence in a height of 2 m. Therefore heterogeneities with diameters of a few hundred meters are suspected to be responsible for the observed non-closure. As the fluxes cannot be measured in field experiments, sinusoidal heat flux heterogeneities with a wavelength of up to 500 m are simulated with the parallelized LES model PALM and the developing circulations are analyzed.

The wavelength of the heterogeneity has a big influence on the strength of the circulation. With growing wavelength the circulation gets stronger and reaches larger heights. However, the generated circulations are clearly weaker than circulations induced by heterogeneities with wavelengths in the order of the boundary layer height. Increasing the background wind from 1 m s^{-1} to 6 m s^{-1} decreases the strength of the circulation for each wavelength.

The energy imbalance is determined and investigations are made concerning the influence of the wavelength on the spatially averaged imbalance and of the position within a heat flux wave on the local imbalance. Increasing the wavelength of the heterogeneity leads to just a small rise in the imbalance. The position within the wave has a greater influence on the imbalance as there is nearly no imbalance in the part of the wave where the vertical velocity of the circulation is zero and the imbalance increases when the vertical velocity increases. The results of this study suggest that small scale heterogeneities cannot be responsible for the non-closure of the energy balance because the circulations are only in small parts of the heat flux wave producing an imbalance of over 10 %, which is observed in field experiments.