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Large eddy simulation of plume dispersion and concentration fluctuations in a neutral boundary layer

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The PALM Large Eddy Simulation (LES) code has been used to perform a set of numerical experiments investigating the statistical characteristics of the scalar field dispersing from a small-localized continuous source in a neutrally stratified boundary layer resembling that generated in a wind tunnel. The computational domain extended for about five times the boundary layer thickness in the along-wind direction, and for the boundary layer thickness in the vertical and crosswind directions. The effects of numerical schemes and grid resolution on high order concentration statistics have been investigated. In particular, the effect of grid resolution on the concentration fluctuations has been thoroughly examined by varying the grid resolution in a range from 64x64x256 up to 512x512x2048, respectively in the vertical, crosswind and along-wind directions. Adequate averaging times have been used to ensure the convergence of the high concentration moments up to the fourth order, which have a much slower convergence rate compared to the mean concentration. The higher order statistical moments of the scalar field show a significant dependence on the grid resolution. This dependence has been investigated using the transport equation of the concentration variance and the spectrum of the scalar concentration in several positions. The turbulent velocity and scalar concentration statistics have been compared with several wind tunnel experimental measurements available in the literature. Regarding the scalar field the comparison included the mean concentration, the higher moments up to the fourth order and the concentration probability density function (pdf) at several downwind positions. The comparison shows that LES is a reliable method to estimate the higher order moments of the concentration and the concentration pdf if the first and second concentration moments are correctly predicted