EMS Annual Meeting Abstracts,
Vol. 6, EMS2009-218, 2009
9th EMS / 9th ECAM

9th EMS Annual Meeting
9th European Conference on Applications of Meteorology
High resolution meteorology
- applications and services

Resolved versus parametrized boundary-layer plumes

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The aim of this study is to present a new methodology to compare LES resolved and large-scale parametrized thermals. A conditional sampling based on the combination of a passive tracer emitted at the surface and thermodynamic variables is proposed to qualify the organized structures in cloud-free and cloudy boundary layers. The sampling is validated against more traditional samplings of clouds or dry thermals. It enables to characterize convective updrafts from the surface to the top of the boundary layer (or the top of cumulus clouds) describing in particular the transition from the sub-cloud to the cloud layer. It retrieves plume characteristics, entrainment and detrainment rates, variances and fluxes. With this sampling, the contribution of boundary-layer thermals to fluxes and variances is analyzed in the subcloud and cloud layer.

The new sampling, by providing thermal characteristics, is then used to extensively evaluate and improve boundary-layer mass-flux parametrizations. In particular, a new formulation of fractional entrainment and detrainment rates is derived from theoretical considerations, validated using LES thanks to the conditional sampling, and tested in the thermal plume model, a mass-flux scheme for the dry and cloudy convective boundary layer. The new formulation takes into account the impact of acceleration and deceleration inside the plume on mixing and has the advantage of being continuous from the surface to the top of clouds.