LES Simulations of Entrainment and mixing on the Stratocumulus Top

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We discuss here results of LES simulation of entrainment and mixing near the STBL top. Setup of the numerical experiment is based on research flight RF-01 in DYCOMS-II field campaign (geometry 96x96x301, dx=dy=35m, dz=5m). The focal point is the Entrainment Interface Layer (EIL), a few- to a few-tens of meters deep mixing zone that separates the cloudy and cold (in the potential temperature sense) boundary layer air from the dry and warm free-tropospheric air aloft. We investigate stability of the flow in the cloud-top region using the local gradient Richardson number calculated at the surface of maximum static stability near the STBL top and at the material top of STBL, the latter defined using a threshold value of the total water content.

Boundary-layer updrafts, spanning entire depth of the STBL, impinge upon the inversion and produce diverging horizontal flows just below the layer of maximum stability. Ensuing strong vertical shear results in the local gradient Richardson number smaller than one typically associated with onset of flow instabilities. Turbulence, characterized by large local values of enstrophy, causes mixing responsible for the formation of the EIL and for the entrainment of free-tropospheric air into the STBL.

Entrainment processes are further analyzed using a passive scalar introduced after three hours of the simulation above the layer of maximum stability. Mixing fraction of this scalar within the STBL, an indicator of the fraction of entrained free-tropospheric air, falls within the range corresponding to the buoyancy reversal at the cloud top.

Large-eddy simulations of Sc cloud strongly depend on a grid resolution as well as subgrid processes. Switching off the turbulence (an inviscid case) leads to unstable conditions, where liquid water path systematically grows up to unrealistic values - subgrid scheme is necessary to produce credible characteristics of STBL. Finer vertical grid size (with subgrid mixing) suppresses the role of subgrid parameterization and produces more thick cloud. It points a question about the role of subgrid mixing within LES simulations. Another question considers the problem of the numerical estimate of the Critical Richardson number at the top of STBL.