Drizzle-induced Change in the Organization of Stratocumulus

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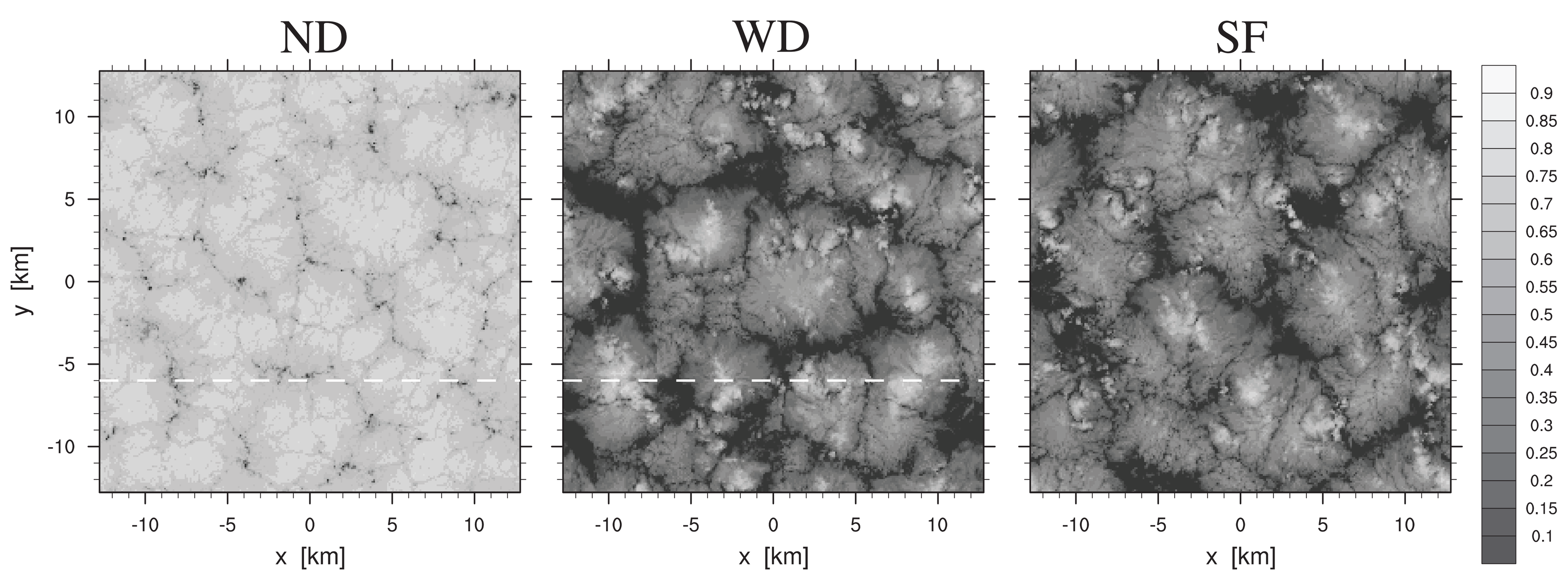
Introduction

Drizzle is not an exception in the STBL, but a common place. However, a question of its effect on the cloud organization and the structure of the STBL is not fully resolved yet.

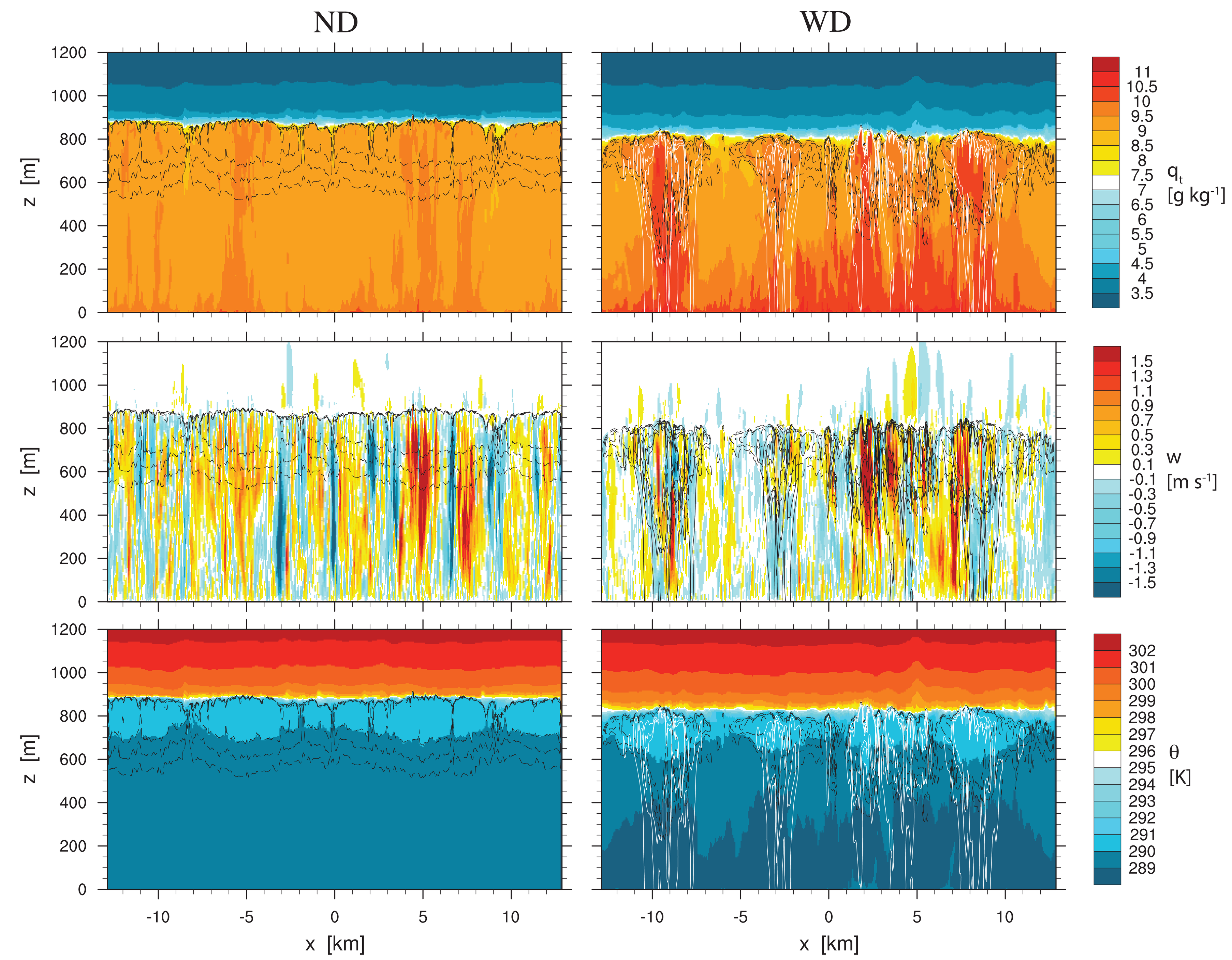
In this study, we simulate the STBL with and without presence of drizzle to explore the changes in the cloud and boundary layer structures introduced by drizzle. We also evaluate the importance of drizzle interaction with the surface for the cloud organization. We run UCLA LES with bulk microphysical parameterization (Seifert and Beheng, 2001) on a horizontal domain of 25.55^2 km^2. For simplicity of the presentation, we name the simulations: ND (without drizzle), WD (with drizzle) and SF (drizzle interacting with surface).

Planar View



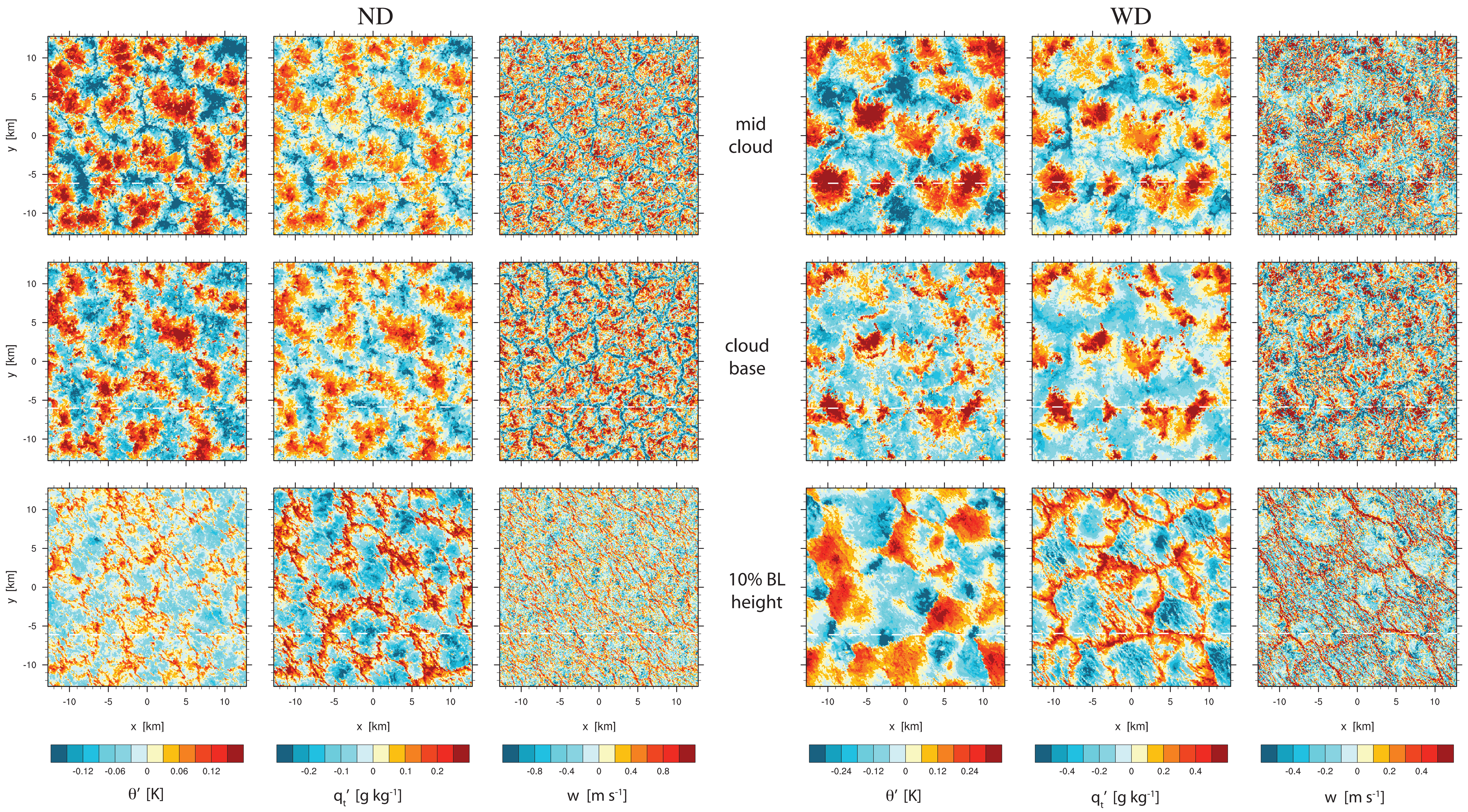
To visualize the change in cloud organization we present the planar view of pseudo albedo, which resembles the satellite visual imagery. In the absence of drizzle, the cloud albedo adopts a closed cell planform structure with mean value of 72 %. With drizzle active, mean albedo reduces to 33.6 % and seem to keep the closed cell structure. However, there are visible brighter spots that indicate deeper and more narrow clouds - Cu rising into Sc. The organization of these Cu clouds, however, has the appearance of open cells that are not a simple negative of the closed cells, but actually emerge from them. As there is no qualitative difference in the cloud structure between the simulation where drizzle interacts with surface and where the surface fluxes are prescribed, we conclude that the interaction of surface and drizzle does not have a dominant effect and focus our attention on drizzle interaction with the interior of BL.

Vertical Cross Section



Fields of cloud-water (black. dashed contours) and precipitating-water (white, solid contours) mixing ratios are superimposed over total-water mixing ratio, vertical velocity and potential temperature fields to illustrate the changes in vertical structure of clouds and BL introduced by drizzle. The most striking change is breaking of the layered cloud structure and formation of locally deeper clouds with more cellular structure. The core of these cells is collocated with drizzle showers that can reach the surface. The signals of decoupling are also present in thermodynamic fields of WD. Reduction in variability of vertical velocity, which is even m ore clear in representation, indicates less favorable conditions for horizontal mixing and therefore higher variability in TD fields. In addition, there is an absence of strong downdrafts, which is especially noticeable in the areas where cloud tops are lowering.

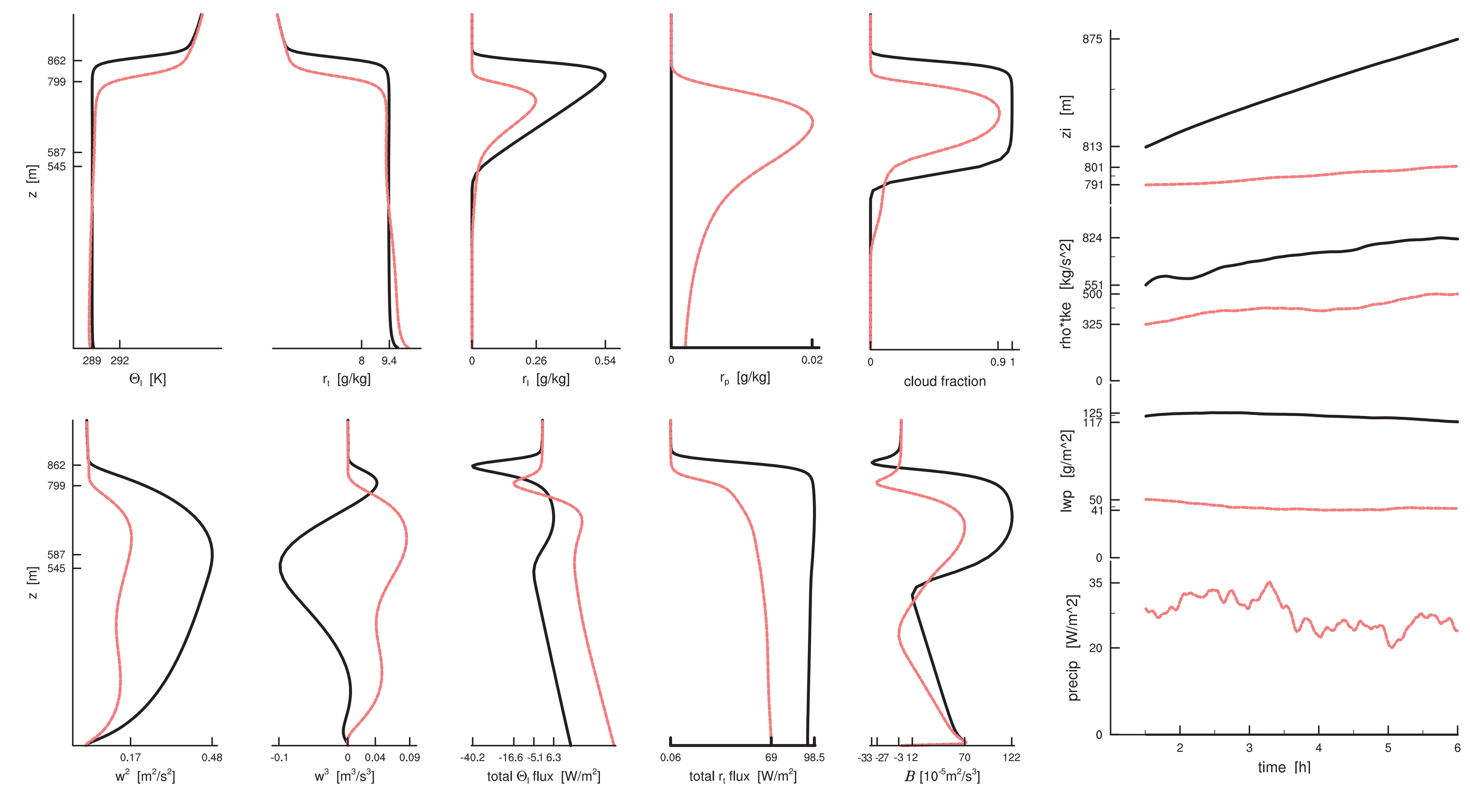
Horizontal Cross Sections



Planar view of vertical velocity and perturbations of potential temperature and total-water mixing ratio visualizes the horizontal variability in thermodynamic and momentum fields. One change introduced by drizzle is an amplification of variability in thermodynamic fields and reduction of variability in momentum through the depth of BL. Drizzle also increases the spatial scale of variability, which is most noticeable in temperature field close to the surface.

Statistics

Mean vertical profiles summarize the view of drizzling Sc-topped BL as we developed it from analysis of horizontal and vertical cross sections. Drizzle induces development of a two-layer structural BL, with reduced cloud water and mixing. It also affects the type of circulation, resulting in dominance of updrafts. Although the total fluxes of heat and moisture are strongly affected by the presence of drizzle, the total buoyancy flux still does not develop the negative region just under the cloud base. This indicates that the drizzle does not result in the development of fully decoupled BL



Time series illustrate that drizzle reduces the growth of BL by restricting the TKE production and therefore entrainment. Additionally, even though the mean cloud depth (or its proxy LWP presented here) is reduced, drizzle stays present and even has a stationary behavior.

Conclusions

Large-domain LES of Sc-topped BL with and without presence of drizzle revealed that drizzle induces change in the cloud organization, from Sc to Cu rising to Sc. It also increases variability in thermodynamic fields and decreases variability in vertical velocity. Moreover, there is an increase in the spatial scale on which the variation occurs. Although there are indications of development of sub layers within the BL, there is no evidence of the full decoupling. The circulation changes toward the dominance of the updrafts.