# Direct numerical simulation of climate relevant cloud mixing processes

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Work to be performed by Dr.-Ing. Juan Pedro Mellado within the DFG SPP 1276 Metström program (`http://metstroem.mi.fu-berlin.de`), project *"Ein hybrides Frontverfolgungs-Verfahren für Stratocumulus Wolken unter Berücksichtigung instationärer Entrainment-Prozesse"*, principal investigators Dr.-Ing. Heiko Schmidt (speaker), Prof. Norbert Peters, Prof. Bjorn Stevens.

**Description of the project**

Our understanding of stratocumulus, and hence our ability to model them in the climate system, is limited in important ways by our poor understanding of cloud mixing processes. Particularly in stratocumulus, the cloud-regime with the largest cloud radiative forcing of the climate system, cloud-top mixing has been shown to play a crucial role in determining cloud amount and planform structure [Stevens, 2002]. Turbulent mixing occurring at cloud boundaries, such as at the top of stratocumulus clouds, is a complicated geophysical problem that compounds the difficulty of turbulent entrainment [Fernando, 1991, Dimotakis, 2005] with cloud microphysical processes [Shaw, 2003].

This has been the motivation for the aforementioned project funded by the German Research Foundation within the Metström program, now in the beginning of its second phase. One particular contribution of this sub-project consists in using direct numerical simulation (DNS) of idealized flow configurations to gain more insight into the details of cloud-top mixing processes, so as to calibrate parameterizations designed for modern climate models. The role of latent heat and the possible buoyancy reversal due to evaporative cooling is the first phenomenon that has been considered. Part of the work on this particular question has been already finished [Mellado et al., 2009a,b], and the next step is to conclude that work by performing the direct numerical simulation of the cloud-top mixing layer there described. That is the purpose of the computational time here requested.

The cloud-top mixing layer is a small-domain horizontally homogeneous two-layer system defined to investigate the turbulent mixing between the moist and cold cloud region below and the warm and dry subsiding clear-air current above (see Fig. 1

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from preliminary work). It represents the top of the cloud in the stratocumulus-topped boundary layer. The length scale of the system is of the order of meters, i.e. the scales that need to be modeled in larger scale analysis of atmospheric flows. **Our objective is to perform a direct numerical simulation of the cloud-top mixing layer and to study the details of turbulent moist convection entrainment**.

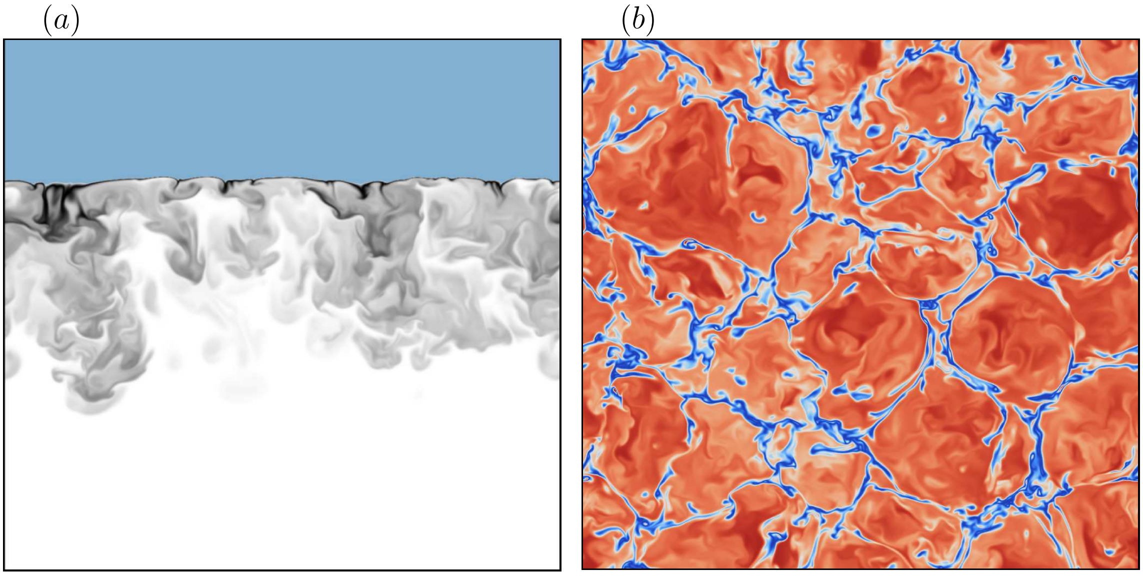


**Figure 1:** DNS of the top of a stratocumulus cloud. The vertical plane (a) represents the cloud in the lower layer in white color, the free sky on the top in blue color, and the gray mixtures correspond to cool and heavier parcels of fluid falling down and promoting a turbulent state in the lower cloudy layer. The horizontal cut (b) shows the cell structure at the inversion by representing in red the ascending (towards the reader) currents, and in blue the downdrafts of the relatively cool mixtures.

# References


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