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Comparison of Entrainment Rates from a Tank Experiment with Results Using the One-Dimensional-Turbulence Model

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Abstract

Recent work suggests that cloud effects remain one of the largest sources of uncertainty in model-based estimates of climate sensitivity. In particular, the entrainment rate in stratocumulus-topped mixed layers needs better models. More than thirty years ago a clever laboratory experiment was conducted by McEwan and Paltridge to examine an analog of the entrainment process at the top of stratiform clouds. Sayler and Breidenthal extended this pioneering work and determined the effect of the Richardson number on the dimensionless entrainment rate. The experiments gave hints that the interaction between molecular effects and the *one-sided* turbulence seems to be crucial for understanding entrainment.

From the numerical point of view large-eddy simulation (LES) does not allow explicitly resolving all the fine scale processes at the entrainment interface. Direct numerical simulation (DNS) is limited due to the Reynolds number and is not the tool of choice for parameter studies. Therefore it is useful to investigate new modeling strategies, such as stochastic turbulence models which allow sufficient resolution at least in one dimension while having acceptable run times.

We will present results of the One-Dimensional Turbulence stochastic simulation model applied to the experimental setup of Sayler and Breidenthal. The results on radiatively induced entrainment follow quite well the scaling of the entrainment rate with the Richardson number that was experimentally found for a set of trials. Moreover, we investigate the influence of molecular effects, the fluids optical properties, and the artifact of parasitic turbulence experimentally observed in the laminar layer. In the simulations the parameters are varied systematically for even larger ranges than in the experiment. Based on the obtained results a more complex parameterization of the entrainment rate than currently discussed in the literature seems to be necessary.

References

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