Modeling of subtropical stratocumulus to cumulus transition with EULAG

Marcin J. Kurowski[1], Dorota Jarecka[2], Hanna Pawlowska[2], Wojciech W. Grabowski[3]

[1)]Institute of Meteorology and Water Management – National Research Institute, Warsaw, Poland
[2)]University of Warsaw, Faculty of Physics, Institute of Geophysics, Warsaw, Poland
[3)]National Center for Atmospheric Research, Boulder, Colorado, USA

email: mkuro@igf.fuw.edu.pl

The vast fields of subtropical marine stratocumulus (Sc) are the climatically important component of global energy budget as they strongly affect the Earth's albedo. They are persistent and extend over relatively cold oceanic regions off the eastern coast of the continents. A strong inversion capping stratocumulus-topped boundary layer is provided by subtropical atmospheric circulation where subsidence of dry and warm air is associated with long-lived high pressure systems. The life cycle of stratocumulus usually ends up when a solid cloud deck dissipates and transforms into the broken Sc or cumulus (Cu) field. The process is greatly demanding for reconstruction in large-eddy simulation (LES) since numerous feedbacks, that can easily change the decay rate of the cloud and thus the dynamic equilibrium, are involved in.

The anelastic nonhydrostatic model EULAG in one of the models that takes part in the EUCLIPSE project. The project is mainly focused on reconstruction of stratocumulus to cumulus transition in the subtropics. The proposed numerical setup is based on the data collected during the ASTEX Lagrangian campaign and includes a multi-day evolution of the environment.

In this study, we present the results of LES modeling of Sc to Cu transition carried out by EULAG. The model was adopted to a time-dependent quasi-realistic environment in order to provide physically sound solution for long-lasting simulations. The boundary conditions such as heat and moisture surface fluxes or radiative forcings depend on time and dynamics. The initially thick and uniform stratocumulus cloud deck undergoes systematic changes in response to a gradual increase of the sea surface temperature, a decrease of the large-scale subsidence, and the diurnal cycle of radiative forcing, with the dominant role of the cloud-top longwave radiative cooling. Combined with a quasi-steady entrainment of warm dry air from above the inversion, these processes lead to a systematic increase of the boundary layer depth until the transition to broken cumulus regime takes place. We analyze sensitivity of the boundary-layer evolution to the representation of cloud microphysical parameterizations. Representation of cloud microphysics affects the entrainment rate, drizzle formation, and to some extent radiative transfer, and consequently has a significant impact on the evolution of mean boundary-layer characteristics.