Representation of Nocturnal Marine Stratocumulus Cloud by Means of a Mesoscale Model (MM5)

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ABSTRACT

The fifth-generation Pennsylvania State University-National Center for Atmospheric Research Mesoscale model (MM5) is used to model a marine nocturnal stratocumulus deck, which was observed on June 13, 1992 during the Atlantic Stratocumulus Transition Experiment (ASTEX). The model was originally initialized using the ECMWF data. Various boundary layer schemes and microphysical schemes were tested by doing different experiments and compared these results with observations.

MM5 is unable to represent the main characteristics of the observed stratocumulus deck using the initial and boundary conditions of ECMWF. In addition, sensitivity analysis was made with SST to determine the influence of this variable on the representation of stratocumulus. However, the results revealed that increasing the SST did not reproduce the main characteristics of stratocumulus rather it shows a signal of transition of stratocumulus deck to shallow cumulus.

By proposing new initial and boundary conditions for temperature and relative humidity vertical profiles, MM5 is able to reproduce stratocumulus deck with almost the correct amount of LWP and the buoyancy flux compared to the available observations. These new initial profiles are based on the profiles of observations. However, the model represents poorly the profiles of conserved variables such as the liquid water potential temperature and total liquid water content at the cloud top cooling region. These results suggested that MRF boundary layer scheme is unable to reproduce enough turbulent mixing if the cooling is relatively strong. Besides, the model underestimates the cloud base and top height by 50 m.

Furthermore, we briefly study the relevance of horizontal wind advection in the development of stratocumulus deck. Removing or decreasing horizontal wind advection resulted in increasing the LWP, cloud top height and the cloud depth. As a result, the stratocumulus deck starts to transit to convective clouds under this simulation.