the 140th HyARC seminar
Date: September 22 (Thu) 15:00-
Room: HyARC lecture room (3F)
Title: Cooling of Entrained Parcels in a Large-Eddy Simulation
Speaker: Dr. Takanobu Yamaguchi
(Cooperative Institute for Research in Environmental Science, University of Colorado, and NOAA Earth System Research Laboratory, Boulder Colorado)

Abstract:
The relative importance, for cloud-top entrainment, of the cooling rates due to longwave radiation, evaporation, and mixing was assessed through analysis of the results produced by a Lagrangian parcel tracking model (LPTM) incorporated into a large-eddy simulation model. The LPTM predicts each parcel's trajectory over time, using the resolved velocity simulated by the host model. An LPTM makes it possible to identify entrained parcels; this is almost impossible to do in an observational study.

A nocturnal stratocumulus cloud was simulated over four hours using a 5 m horizontal grid spacing and a 2.5 m vertical grid spacing. At the start of the last hour of the simulation, over 40 million parcels were placed near the top of the inversion layer, then tracked. Parcel histories were analyzed to identify entrained parcels.

Entrainment occurs in cloud holes, which occur in dry regions of sinking air. Entrainment into the mixed layer is regulated by buoyancy, which requires parcels to be pre-cooled in the inversion layer, prior to entrainment. A mixing fraction analysis was used to separate the cooling due to longwave radiation, evaporation, and mixing. Results show that radiative and evaporative cooling are of comparable importance, but that mixing is by far the dominant cooling mechanism. The radiative cooling rate is strongly inhomogeneous, and only weak radiative cooling is found in regions of entrainment. Therefore, the entrained parcels experience less than the horizontal-mean radiative cooling. Although radiative cooling maintains the boundary layer turbulence, its direct effects on buoyancy of entrained parcels are modest.