A NEW APPROACH FOR ESTIMATING ENTRAINMENT RATE IN CUMULUS AND PARAMETERIZATION IN MODELS

Chunsong Lu¹, ², Yangang Liu¹, Seong Soo Yum³, Shengjie Niu², and Satoshi Endo¹

1 Atmospheric Sciences Division, Brookhaven National Laboratory (BNL), NY 11973
2 School of Atmospheric Physics, Nanjing University of Information Science and Technology (NUIST), Jiangsu, China 210044
3 Department of Atmospheric Sciences, Yonsei University, Seoul, Korea 120-749

For presentation at the
2011 IYC O³ Symposium on Stratospheric Ozone and Climate Change,
Washington, DC
Nov. 7-10, 2011

Environmental Sciences Department/Atmospheric Sciences Division
Brookhaven National Laboratory
U.S. Department of Energy
Office of Science

ABSTRACT

Entrainment of dry air into clouds is essential to many cloud processes, affecting cloud microphysical properties, cloud radiative properties, and evaluation of aerosol indirect effects, but it is still poorly understood and represented in atmospheric models. In an effort of the FASTER project to integrate aircraft measurements into model evaluation and parameterization development, here we present a new approach for estimating fractional entrainment rate in cumulus clouds from aircraft observations. This approach is based on the definition of fractional entrainment rate and the mass ratio of the adiabatic cloudy air to the dry air entrained during the ascent from cloud base to aircraft observation level. The essence of this approach is that the mass ratio is not calculated directly from the air masses, but is determined indirectly from the microphysics and thermodynamics along the observation level. This approach is applied to one flight of the RICO (Rain in Cumulus over the Ocean) where entrainment rate was calculated in a previous study with a traditional approach. Comparison between the results from these two approaches shows substantial consistency in terms of the vertical trend of entrainment rate. The average entrainment rate of all observation levels from this approach is comparable to the results in other previous studies. This approach has a potential to straightforwardly connect the studies of entrainment rate and microphysical effect of entrainment-mixing process (homogeneous/inhomogeneous entrainment-mixing mechanisms), improving the parameterization of entrainment-mixing process in models.

NOTICE: This manuscript has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Department of Energy. The publisher by accepting the manuscript for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government purposes.