A CPT for Cloud Parameterization and Aerosol Indirect Effects

Supported by

Update for CMMAP January 2011

Dynamics-PDF Cloud Parameterization: Review from CMMAP August 2010

- Based on Golaz et al. (2002, *J. Atmos. Sci.*): "CLUBB" (Cumulus Layers Unified by Bi-Normals)
- Joint PDFs for vertical velocity, liquid potential temperature, and total water mixing ratio
- Single-column model tests for BOMEX and DYCOMS-II field programs

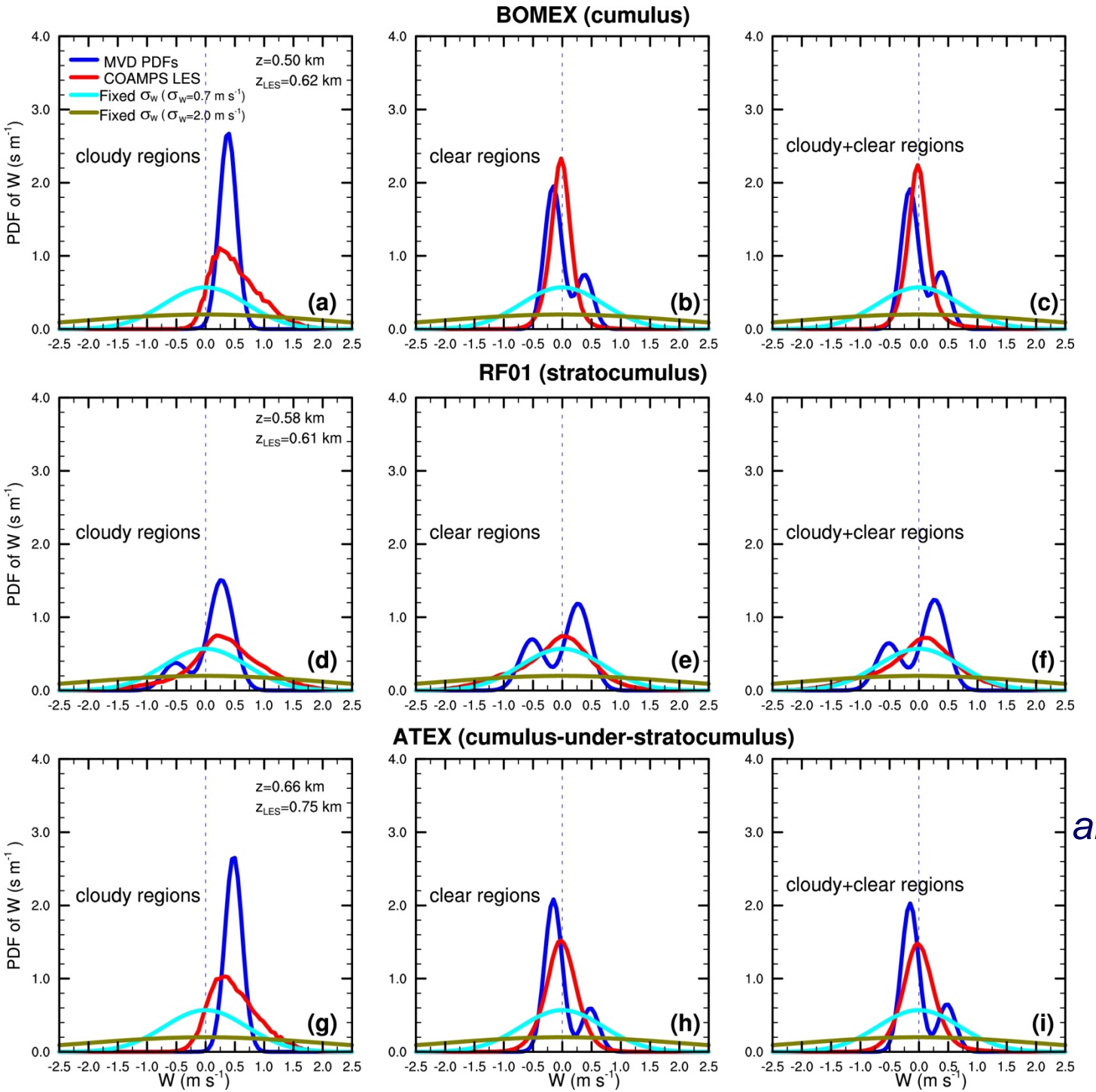
Dynamics PDF Parameterization for Stratiform Clouds and Turbulence

- Fit liquid potential temperature, total water, vertical velocity PDFs for range of Cu and Sc PBLs to LES simulations
- LES evaluated using GCSS WG 1 cases (ARM, ATEX, BOMEX, DYCOMS-II RF01 & RF02, FIRE, RICO)
- Prognostic equations for higher-order moments
- Select PDFs based on evolution of higher-order moments
- Extract cloud macrophysics (fraction, liquid content, etc.) from PDFs

Overview: Progress Since August 2010 CMMAP

- Using multi-variate probability density functions with dynamics to parameterize boundary layers and clouds
- PDFs of vertical velocity and cloud drop number for Sc, shallow Cu GCSS cases
- Cloud macrophysics for Sc, shallow Cu
- Aerosol indirect effects for Sc, shallow Cu

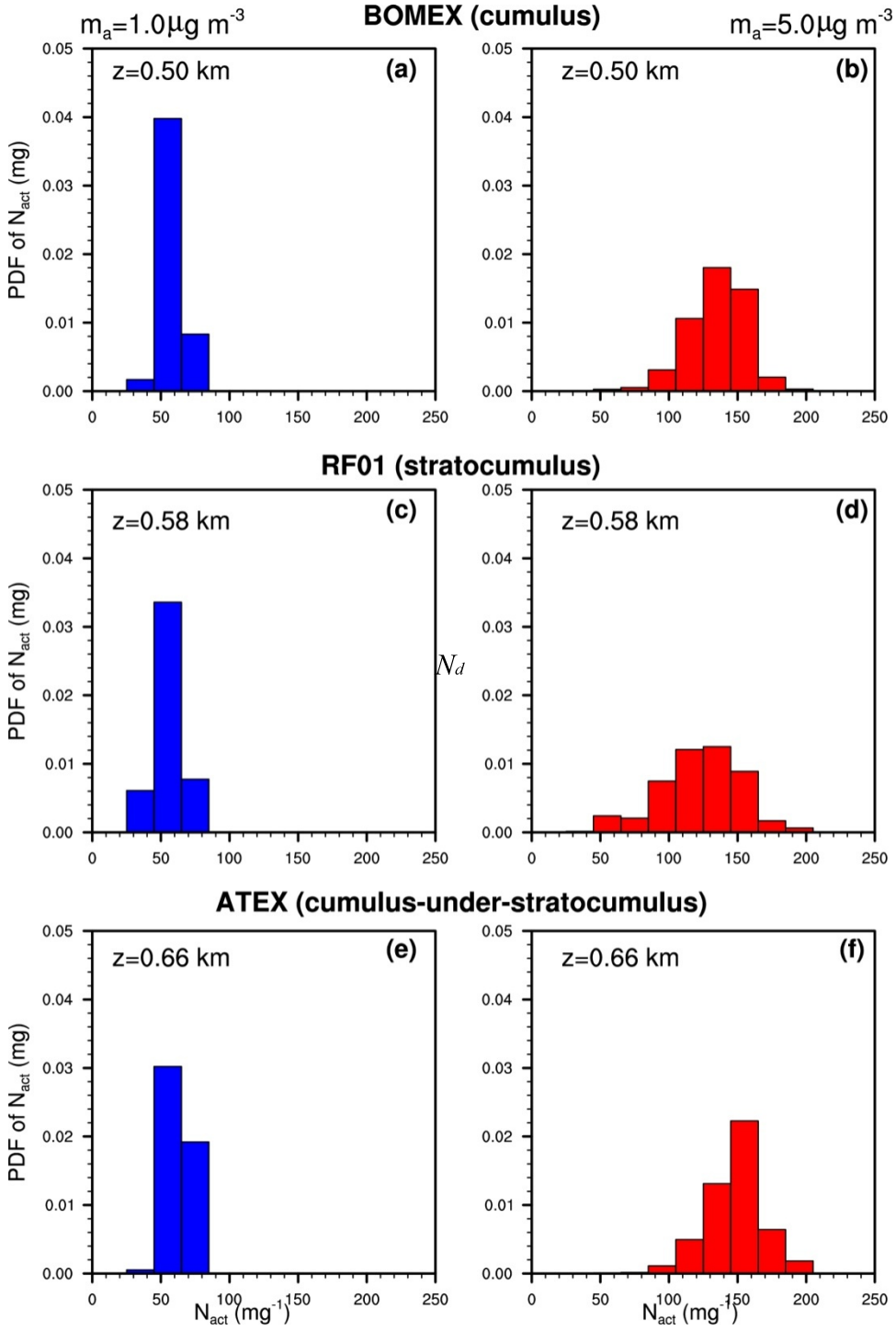
W PDF



from Guo *et al.* (2010, *GMD)*

N_d

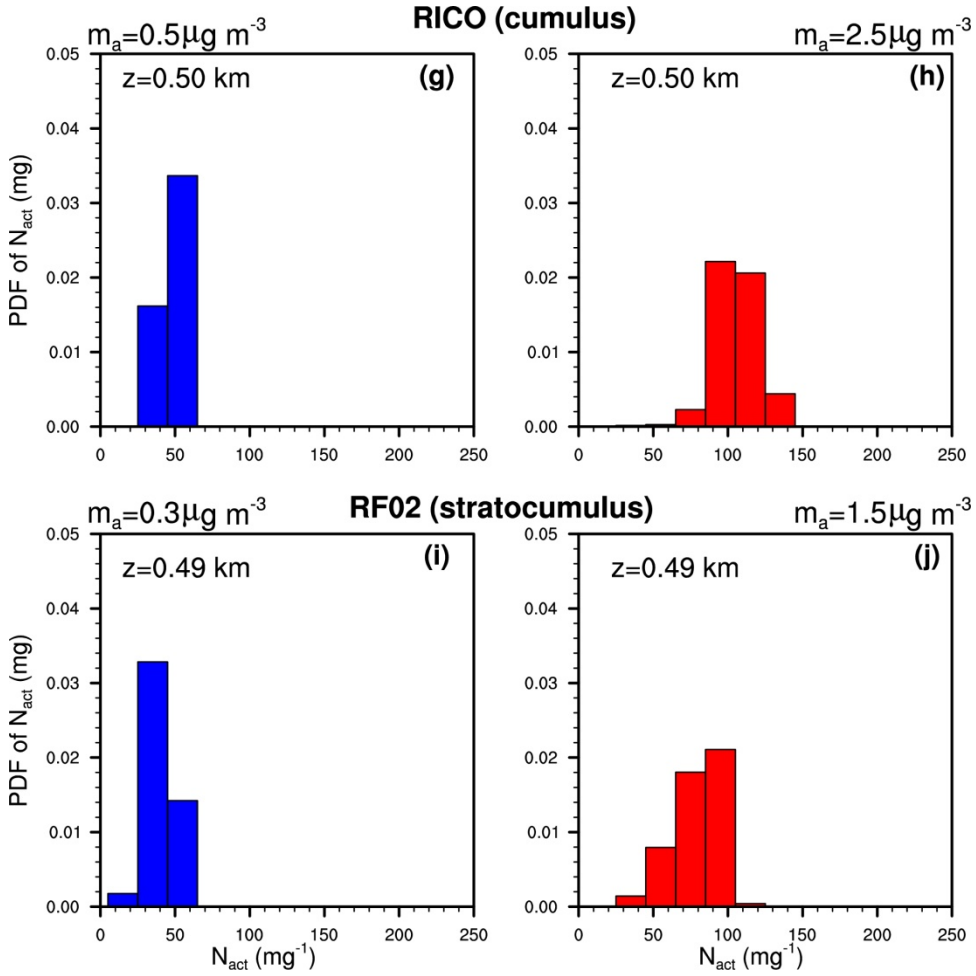
PDF



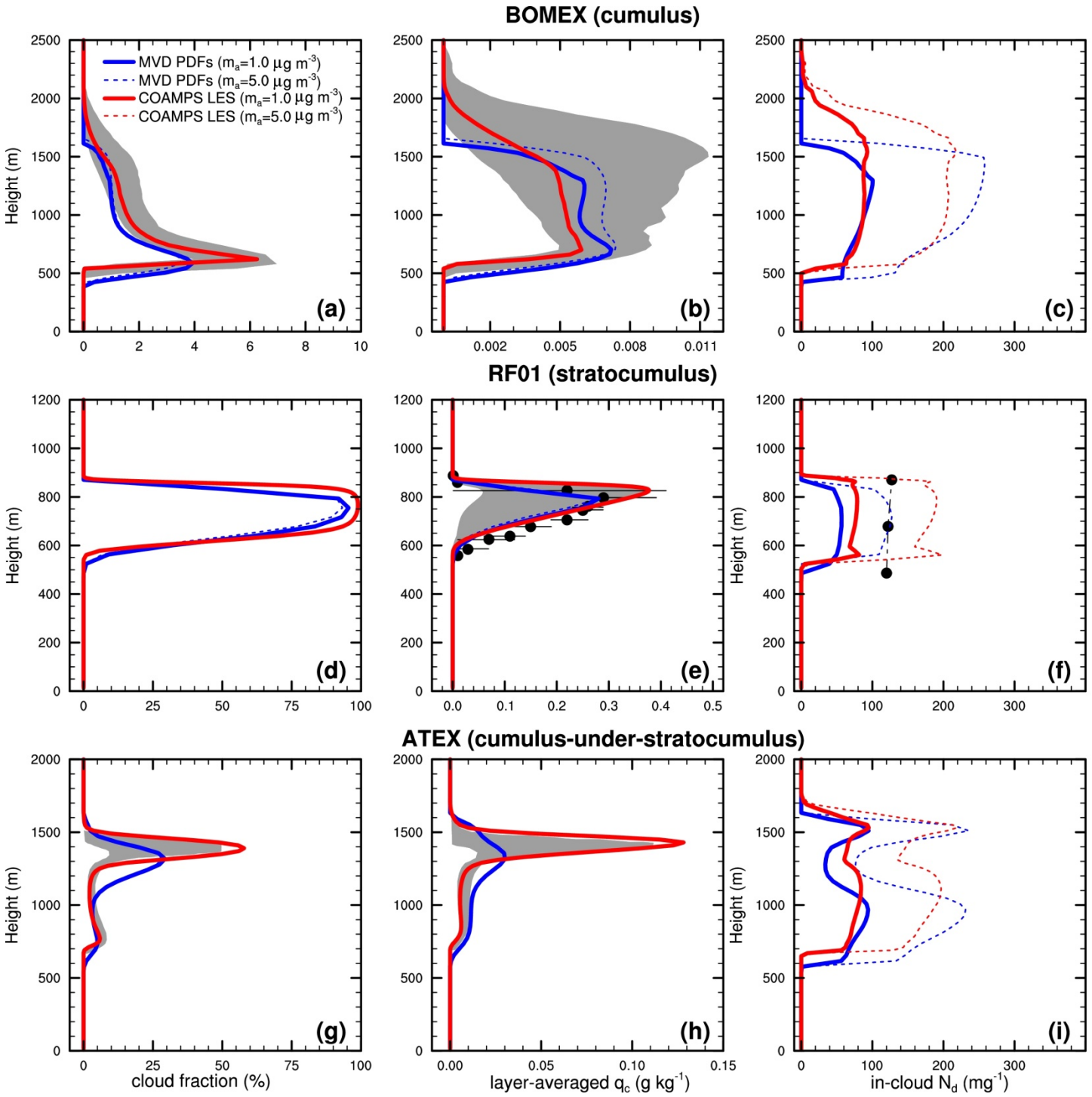
from Guo *et al.* (2010, *GMD*)

N_d

PDF

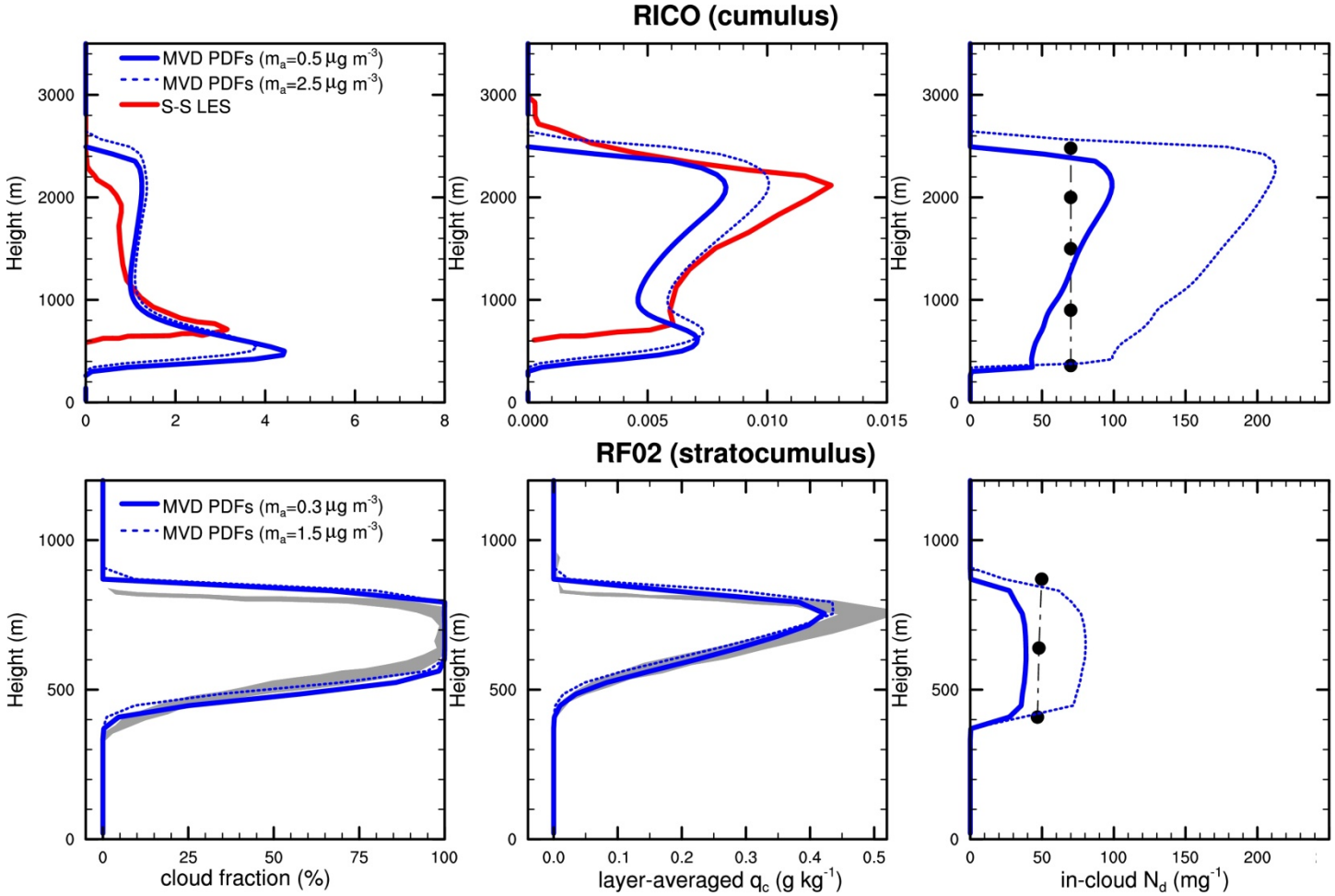


from Guo *et al.* (2010, *GMD*)



Gray shade: LES range
Dots: Observation

from Guo *et al.* (2010, Geosci. *Mod. Dev.)*

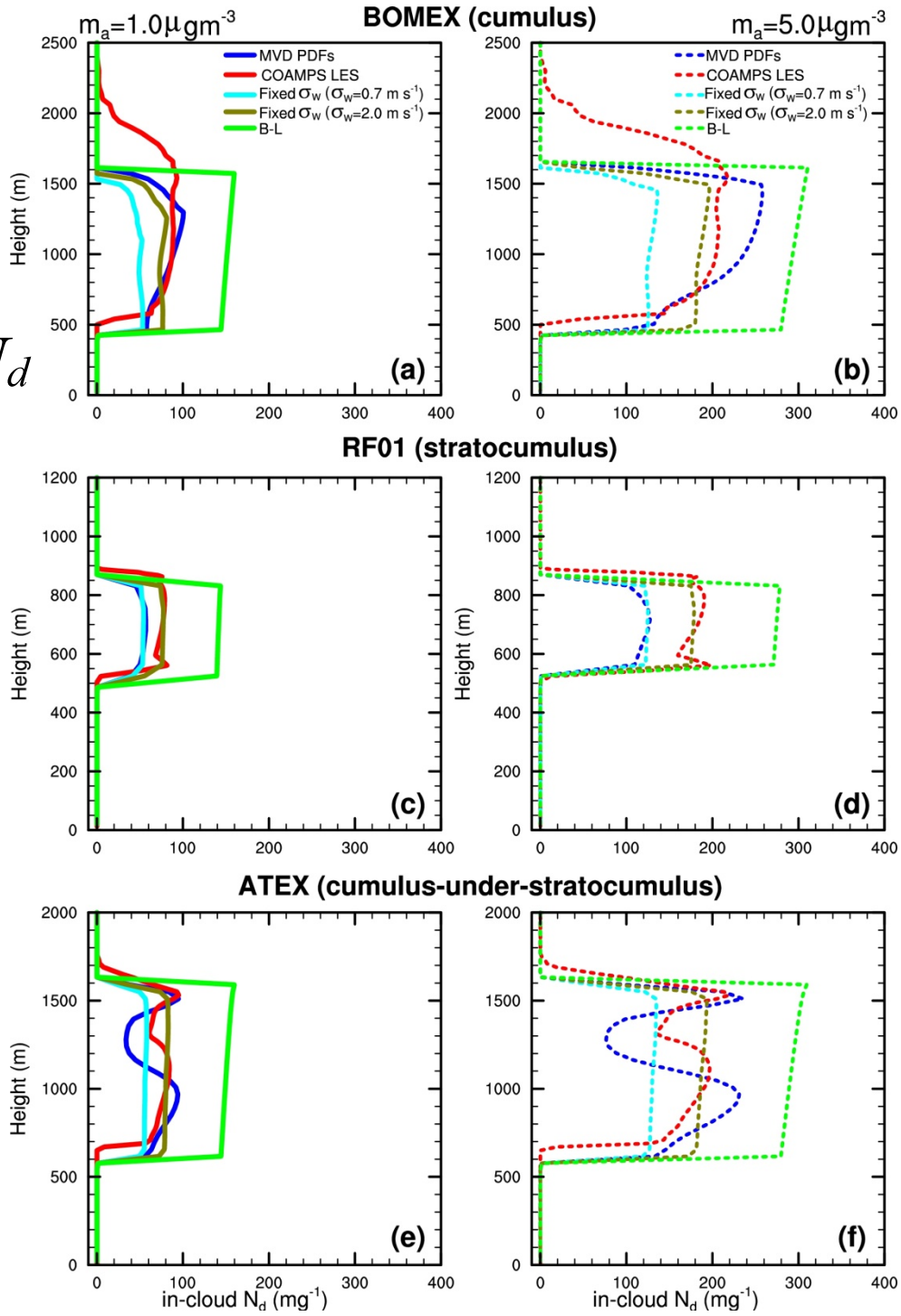


Gray shade: LES range
Dots: Observations

From Guo *et al.* (2010, *Geosci. Mod. Dev.*)

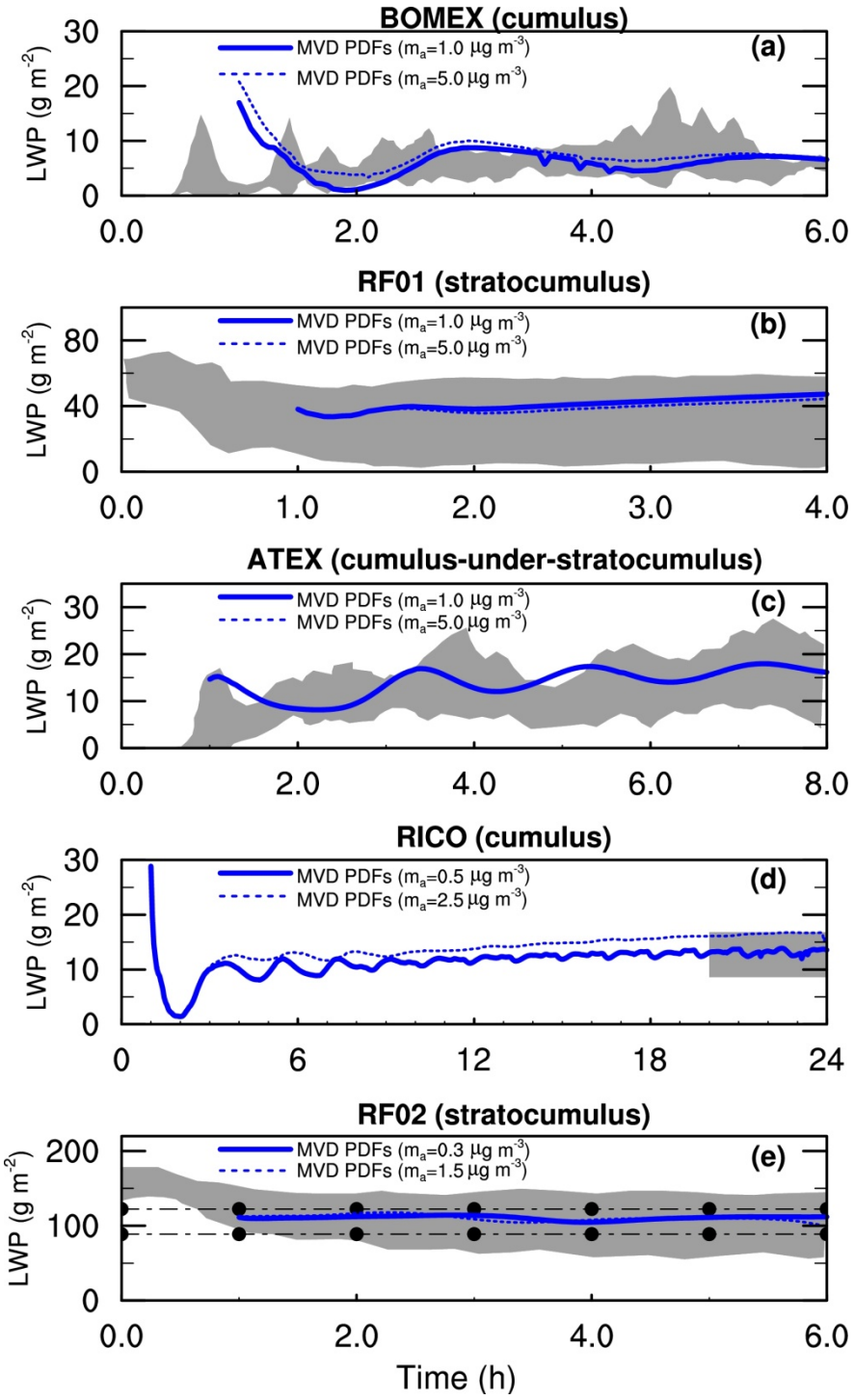
In-Cloud N_d

From MVD PDFs, LES, Gaussian with specified variance, and diagnostic aerosol/ drop number relationship (Boucher and Lohmann, 1995, *Tellus*)



From Guo *et al.* (2010, *Geosci. Mod. Dev.*)

AM3 Single Column Model using Multi-Variate Probability Density Function with Dynamics, Aerosol Activation, and Double-Moment Microphysics



from *Guo et al.* (2010, *Geosci. Model Dev.*)

Next Steps

- Mixed-phase clouds
- Deep and shallow cumulus together
- Working with process modelers and field experimentalists on CPT to develop test cases with aerosols

Summary

- MVD PDFs successfully simulate cloud fraction, water path, and droplet numbers for Sc and shallow Cu GCSS cases
- MVD PDFs indicate both positive and negative indirect effects on LWP
- Critical to evaluate MVD PDF methods against LES and observations with aerosols