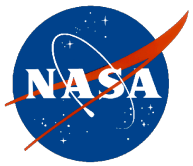

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The Eddy-Diffusivity/Mass-Flux (EDMF) CPT: Recent Developments

J. Teixeira (1, 2), J. Bacmeister (3), L. Donner (4), R. Fu (1), G. Matheou (5), M. Witte (1, 6), Y.-H. Chen (4), A. Herrington (3), M. Kurowski (2), O. Lamaakel (5), R. Storer (1), K. Suselj (2), M. Chinita (1) and R. Venters (5)

(1) University of California Los Angeles, California
(2) JPL, California Institute of Technology, Pasadena, California
(3) NCAR, Boulder, Colorado
(4) GFDL, Princeton, New Jersey
(5) University of Connecticut, Storrs, Connecticut
6) Naval Postgraduate School, Monterey, California

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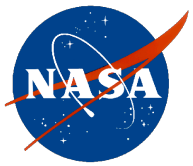

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EDMF CPT (funded by NSF, NOAA)

Goal: to reduce key biases related to PBL clouds and deep convection in the NCAR and GFDL climate models.

Implementing and evaluating unified PBL and convection multi-plume Eddy-Diffusivity/Mass-Flux (**EDMF**) parameterization.

Focused on **PBL and transition to deep convection**:

(i) Spatial transition over ocean from stratocumulus to cumulus and to deep convection;

(ii) Temporal transition (diurnal cycle) over land from dry convection, to shallow convection and to deep convection.

Lead PI: J. Teixeira (UCLA/JPL)
PIs: J. Bacmeister (NCAR), L. Donner (GFDL), R. Fu (UCLA), G. Matheou (U. Conn.), M. Witte (UCLA, NPS).

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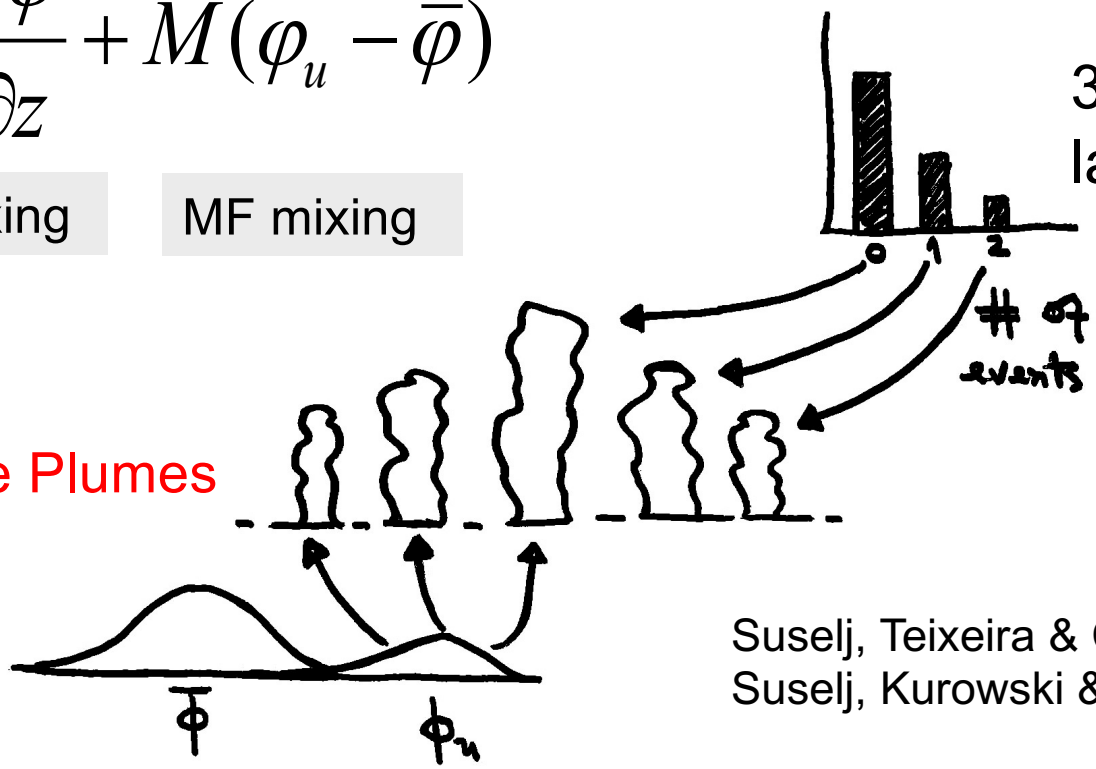
EDMF and moist convection: multiple plumes and stochastic entrainment

$$\overline{w'\varphi'} = -k\frac{\partial\bar{\varphi}}{\partial z} + M(\varphi_u - \bar{\varphi})$$

ED mixing

MF mixing



3) Stochastic lateral entrainment

Partly inspired by Romps & Kuang, JAS, 2010

Suselj, Teixeira & Chung, JAS, 2013
Suselj, Kurowski & Teixeira, JAS 2019a, b

1) Parameterization of PDF of surface layer thermodynamics
2) Monte Carlo sampling of PDF to produce multiple plumes

- Different types of convection coexist in the same model grid-box
- Total updraft area is just the sum of individual updraft areas

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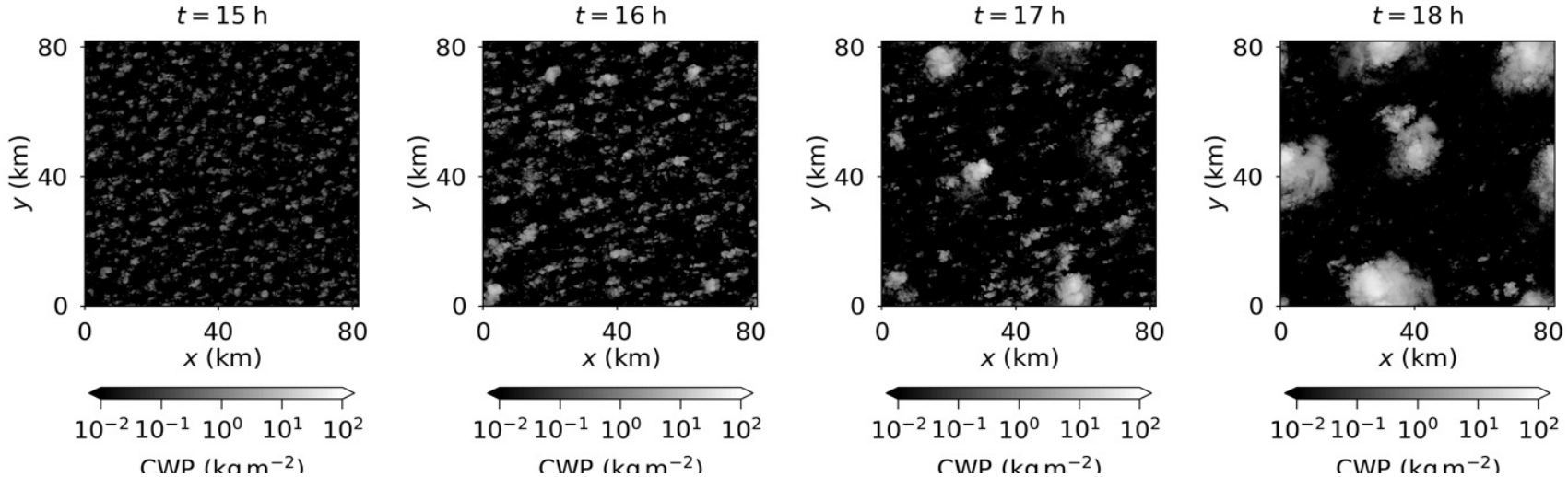
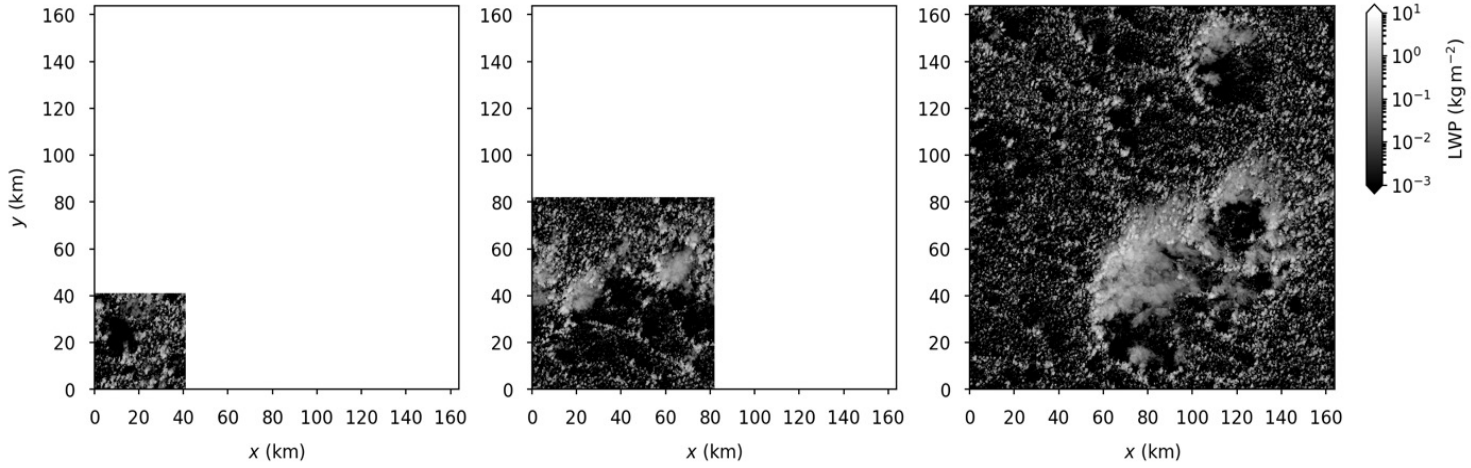
Large Eddy Simulation (LES)



Development of the cloud field as convection transitions from shallow to deep in the last four hours of the **UConn LES** of the AMMA case



Convection organization depends on LES domain size:
potential significant impact on parameterization

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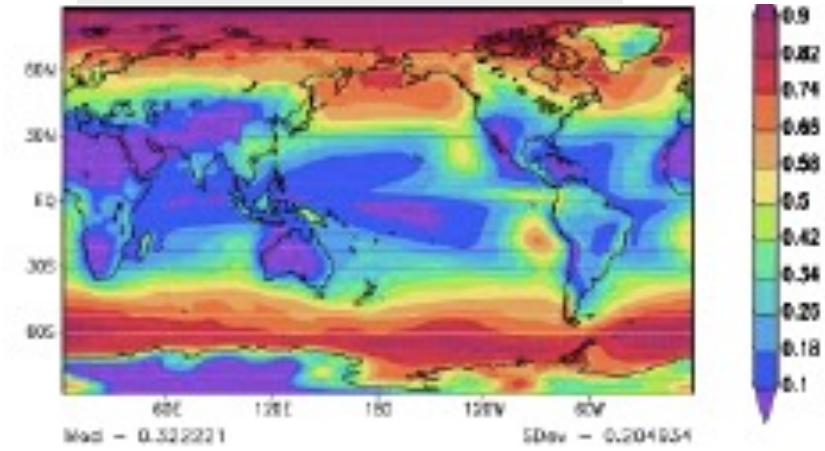
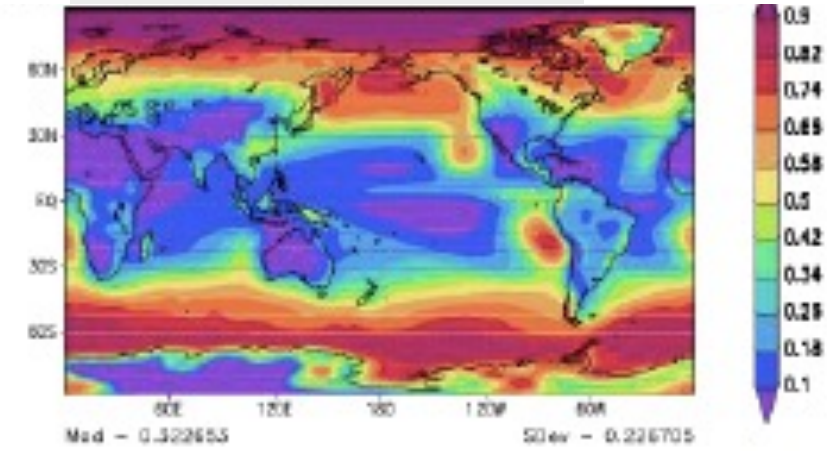
Implementation of ED TKE in GFDL

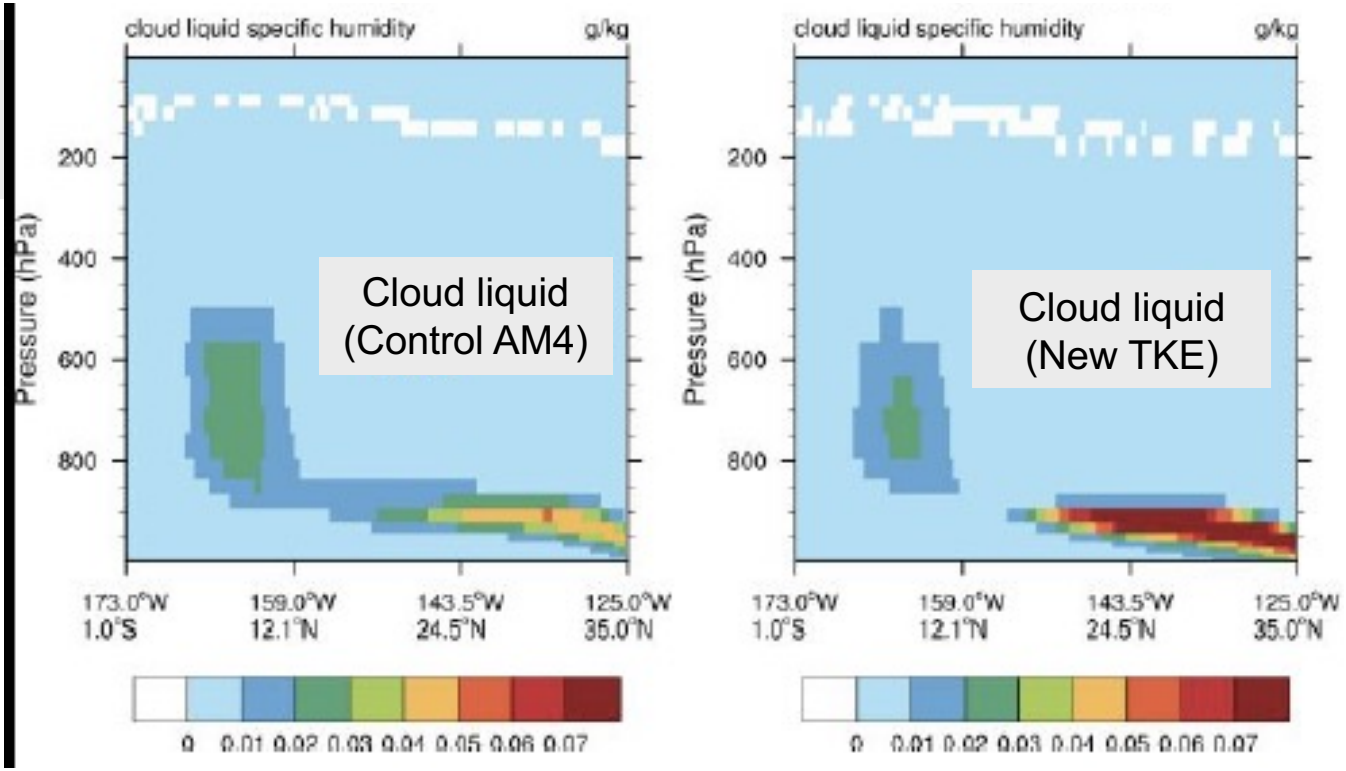
LCC GFDL control



LCC GFDL TKE



GPCI Pacific crossection



New GFDL TKE version produces more realistic PBL, clouds and net TOA radiation

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Merging Higher-Order Closure with Mass-Flux: CLUBB + MF in SCAM

- CLUBB represents double-gaussian mixing while MF plumes represent additional discrete skewness of the sub-grid PDF

- MF plumes are coupled to CLUBB via 5-diagonal prognostic solver for mean fields and turbulent fluxes (solved simultaneously):

$$\frac{\bar{\varphi}^{t+\Delta t}}{\Delta t} + \frac{1}{\rho_s}\frac{\partial}{\partial z}\rho_s \overline{w'\varphi'}^{t+\Delta t}_{CLUBB}$$
$$= \frac{\bar{\varphi}^{t}}{\Delta t} - \frac{1}{\rho_s}\frac{\partial}{\partial z}\left(\rho_s \sum a_i w_i \varphi_i'\right)^{t}_{MF} + \left.\frac{\partial \bar{\varphi}}{\partial t}\right|_{forcing}$$

- Plume cloud macrophysics is calculated but not yet coupled to other processes (e.g. radiation, microphysics)

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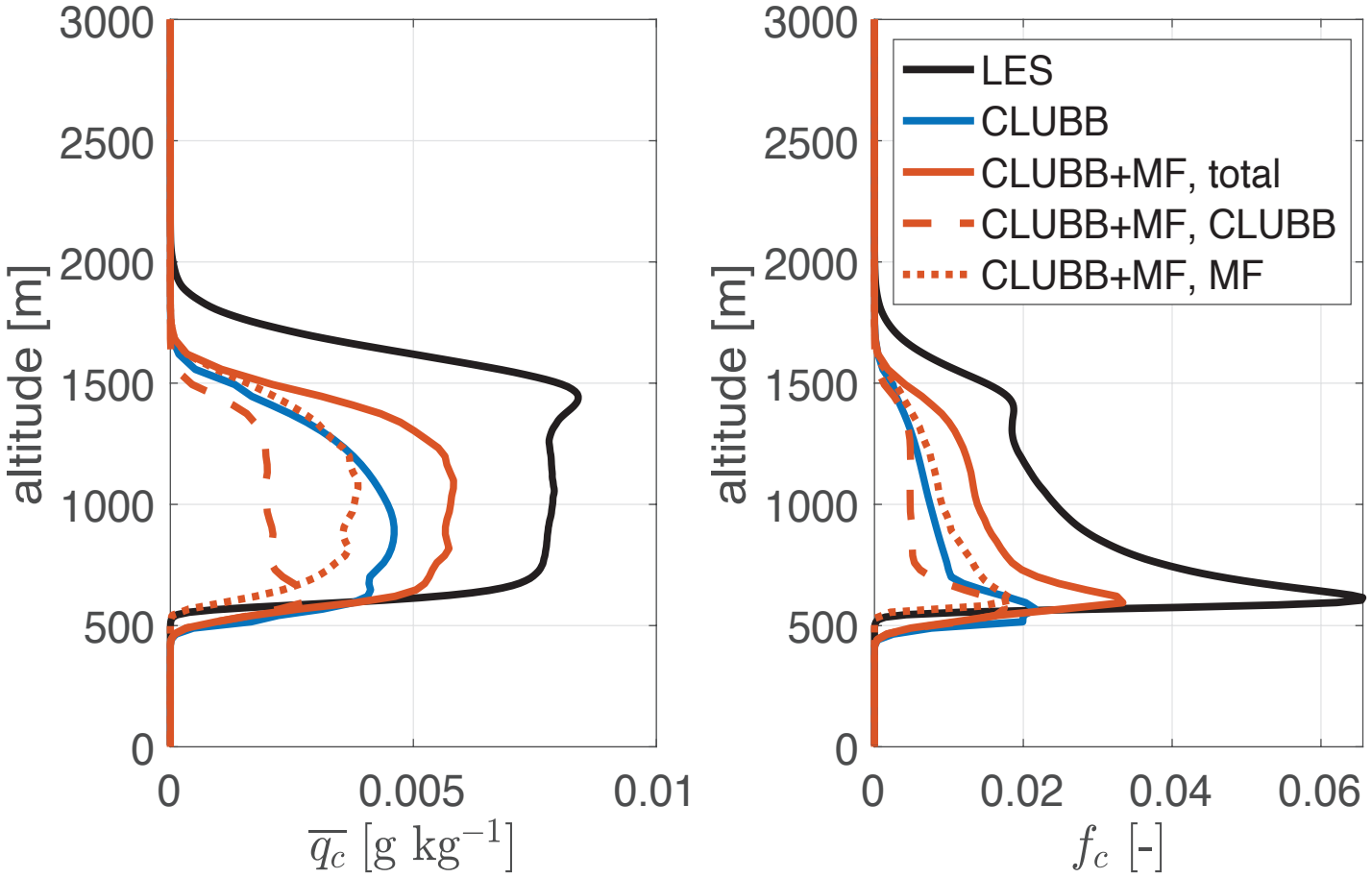
CLUBB+MF: Shallow Convection

BOMEX Case



MF plumes provide additional vertical mixing to CLUBB

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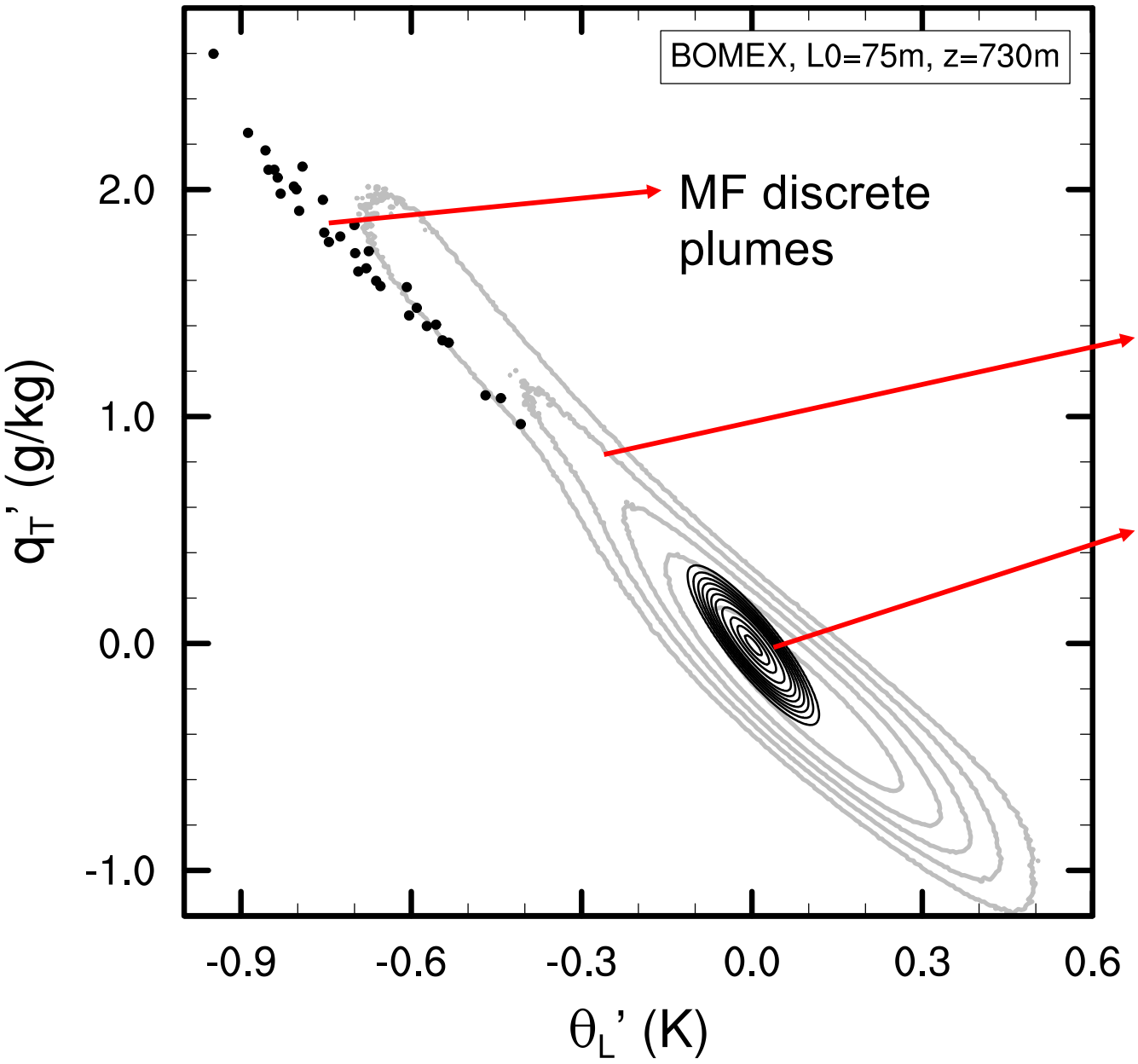
PDFs for LES, CLUBB and MF: the BOMEX Shallow Convection Case



MF plumes populate skewed part of PDF to produce more efficient mixing

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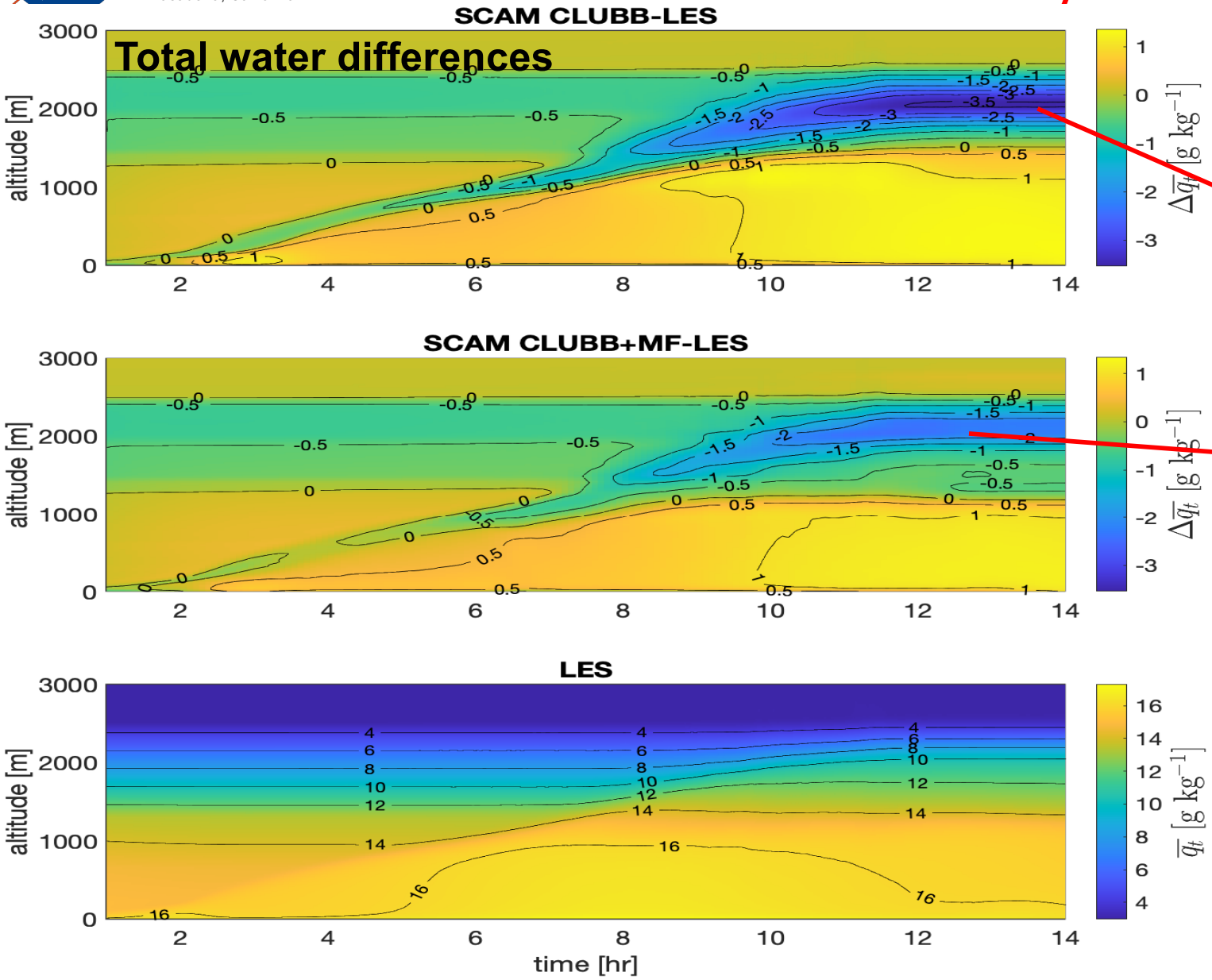
CLUBB+MF: ARM Shallow Convection Diurnal Cycle



CLUBB bias almost twice as large as CLUBB+MF

ARM diurnal cycle case shows more efficient mixing with MF

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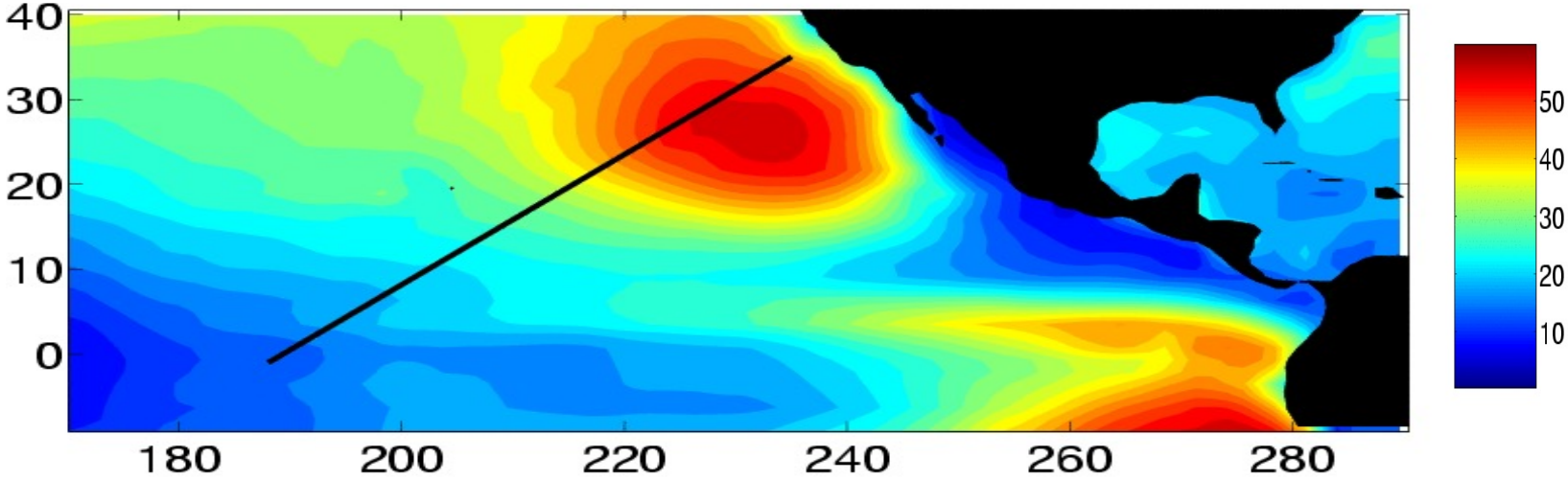
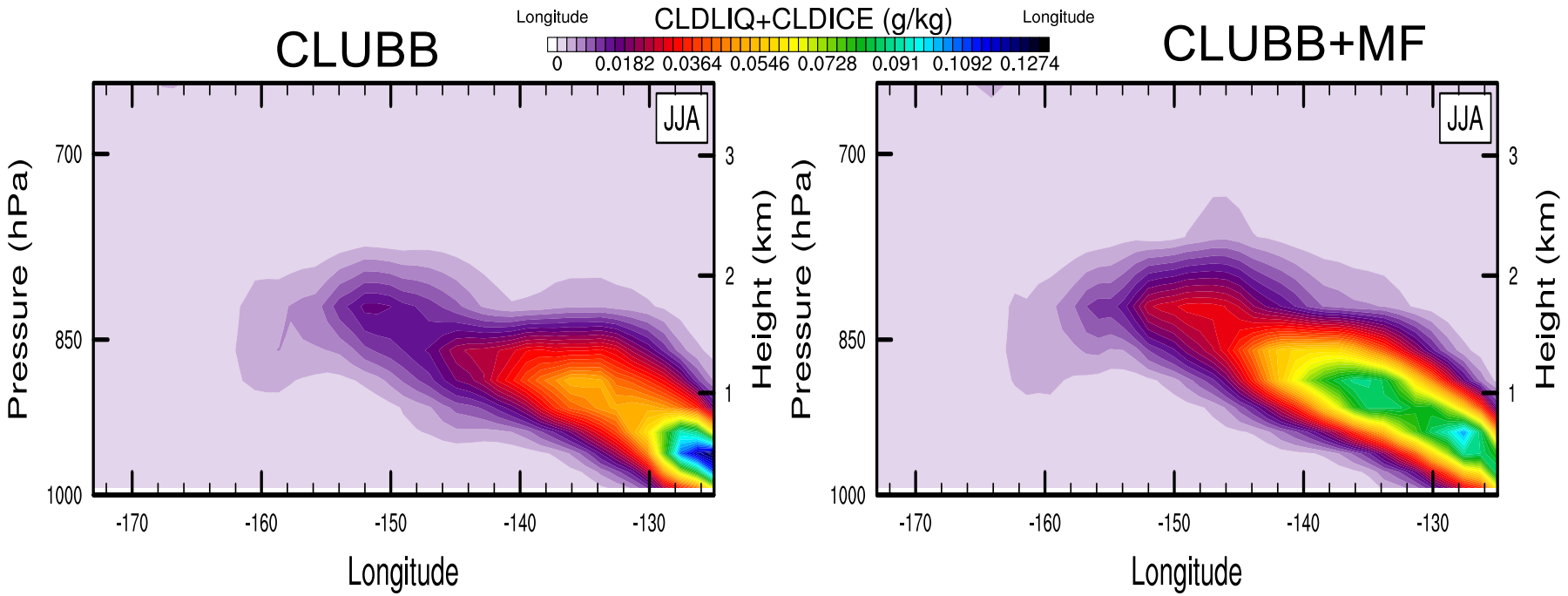
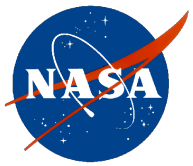
Dry MF in CESM: impact on PBL clouds

GPCI Pacific crossection





CLUBB + dry MF produces much more realistic stratocumulus



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Summary

EDMF combines ED and MF to represent in a unified way turbulence and convection in atmospheric models

EDMF has been implemented operationally at ECMWF, NCEP, US Navy, Meteo-France

EDMF CPT project:

- More sophisticated LES setups and case-studies (e.g., impact of convection organization)
- Dry EDMF version at GFDL improves low clouds
- New ED TKE scheme at GFDL improves, clouds, TOA radiation
- CLUBB+MF leads to more realistic shallow convection in CAM
- Dry CLUBB+MF improves PBL cloud AMIP simulations

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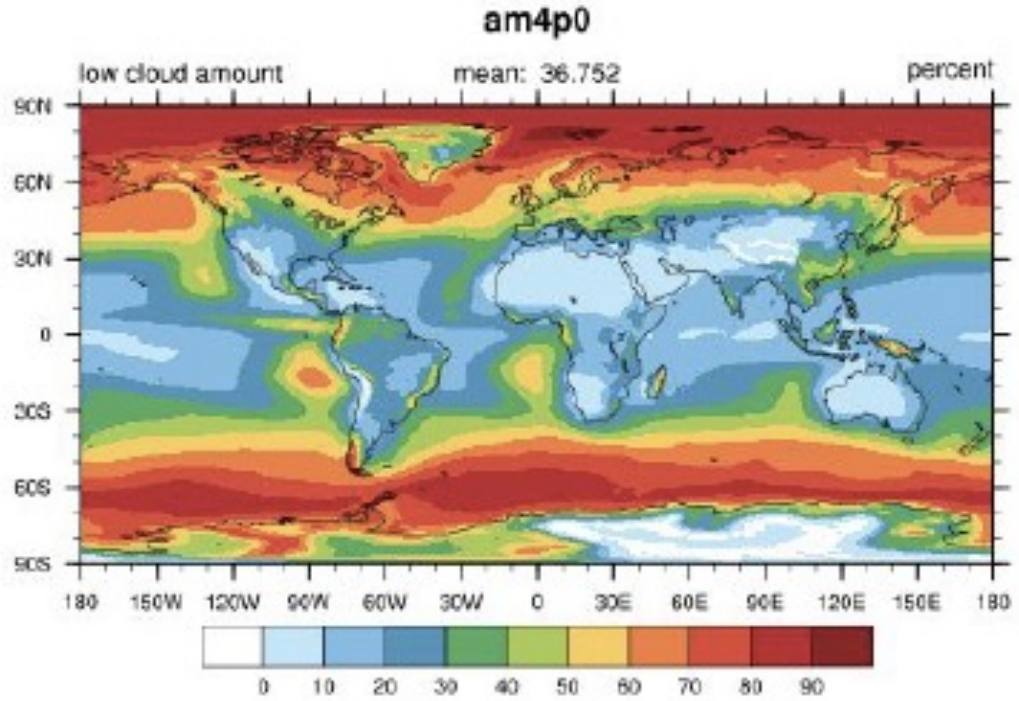
GFDL Dry EDMF simulations

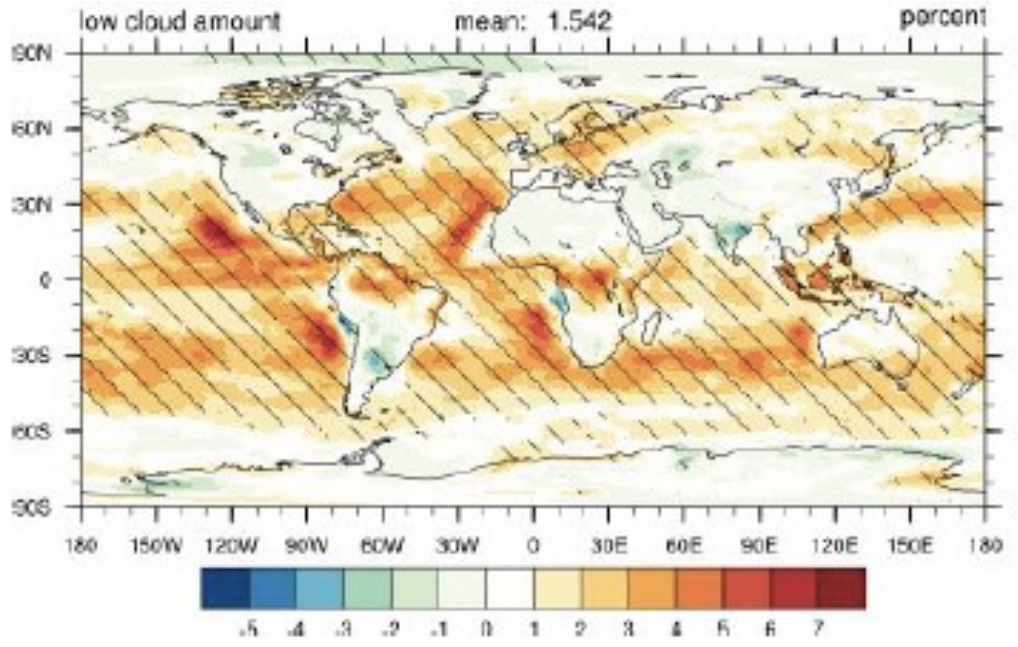
AM4 ED + Dry MF plumes (no condensation)

Low cloud amount (AM4 control)

25-year AMIP

Low cloud amount (EDMF -control)





Dry EDMF improves GFDL simulation of low clouds because of more efficient mixing in sub-cloud layer