Eddy-diffusivity/Mass-flux parameterization for boundary layer in the global NASA GEOS5 model

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New boundary layer parameterization

- Improve parameterization of boundary layer processes and shallow convection
- Unified parameterization for turbulence and shallow convection
- Improve representation of low-level clouds
- New parameterization can be extended to include deep convection within the same framework (future work)

Key properties of the new parameterization

- Represents surface-forced convective thermals which can condense and become core of convective clouds
- Thermals modeled with as steady state multiple plume equations
- Surface plume conditions assumed to represent tail of joint distribution of vertical velocity, virtual potential temperature and total water mixing ratio (following Cheinet 2003). Monin-Obukhov like scaling for near surface conditions
- Stochastic entrainment rate (drawn from assumed Poisson distribution for each plume and each vertical level; see Sušelj et al., 2013)

Turbulent fluxes in the EDMF framework for prognostic variables:

$$\overline{w'\varphi'} = -K\frac{\partial\overline{\varphi}}{\partial z} + \sum_i a_i w_i(\varphi_i - \overline{\varphi})$$

Eddy-diffusivity coefficient (based on Louis, 1982 parameterization)

Property of the *i*-th plume

Equation for properties of the *i*-th plume:

$$\frac{\partial\varphi_i}{\partial z} = \varepsilon_i(\overline{\varphi} - \varphi_i) \qquad \frac{1}{2}\frac{\partial w_i^2}{\partial z} = B_i - 1.5\varepsilon_i w^2$$

Entrainment rate for the *i*-th plume

Buoyancy of the *i*-th plume

Control parameterization (current official GEOS5):

- Eddy-diffusivity model
- Louis (1982) model for stable boundary layer
- Lock et al., (2002) model for convective boundary layer

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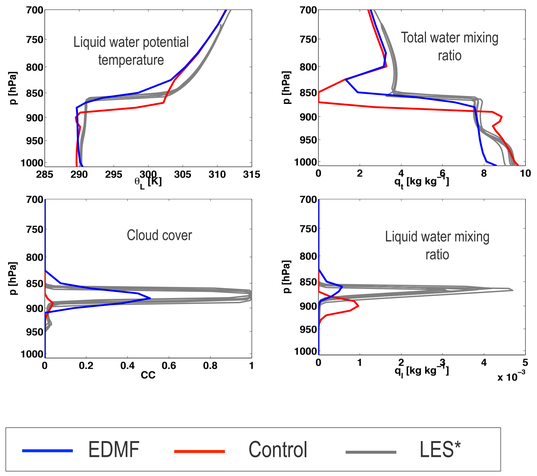
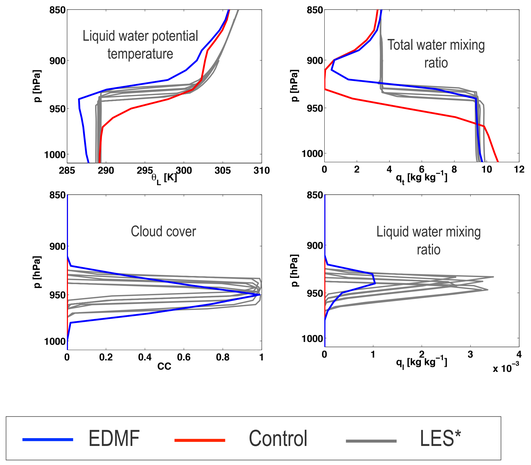
Single Column Model results: CGILS cases

- Stratocumulus CGILS cases – Blossey et al., 2013
- Similar model setup as in the 3D simulations
  - 72 vertical levels
  - Δt=900 s
- 5 day long runs

Profiles from CGILS11 case (cumulus under stratocumulus)



Profiles from CGILS12 case (stratocumulus)



* We thank Peter Blossey for providing LES results

3D simulations

Low resolution simulation (2.5°×2.5°)
1 year of simulation (April 2007 – March 2008)

3D simulations - impact of new parameterization

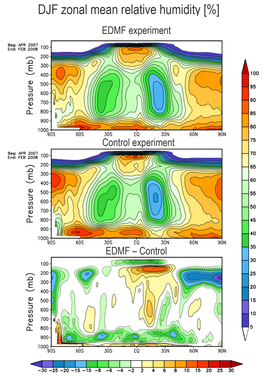
EDMF simulations compared to Control

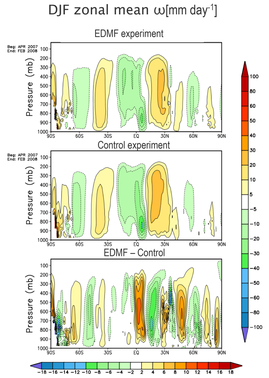
Tropics:

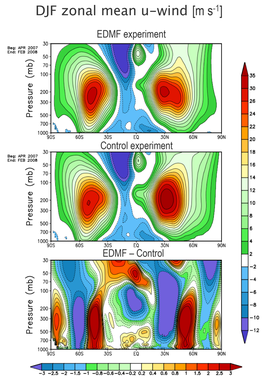
- Weaker vertical transport in the boundary layer
- Convection less vigorous – reduction of convective precipitation, vertical velocity in the ITCZ, more moist and colder tropical mid-troposphere

Mid-latitudes:

- Weaker westerlies, frontal system moved polewards, less frontal precipitation



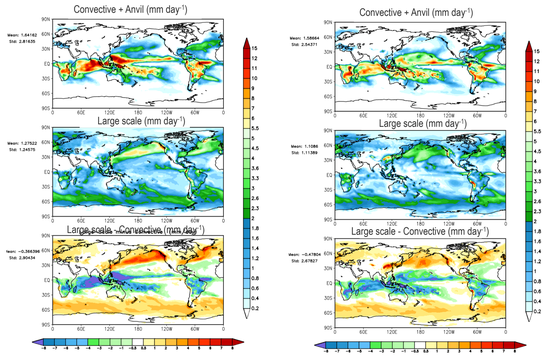




DJF Precipitation

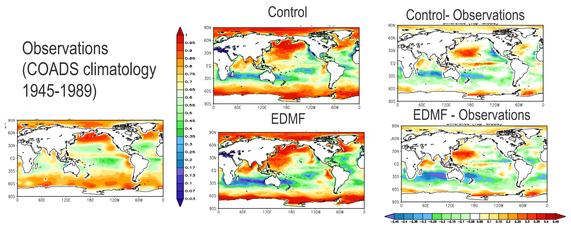
Control experiment

EDMF experiment

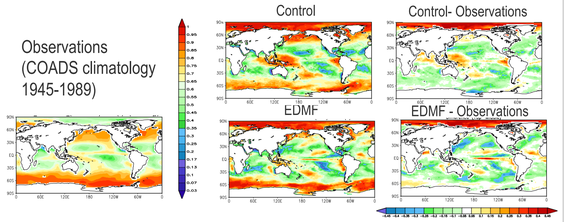


3D simulations - Low Level Clouds and Precipitation

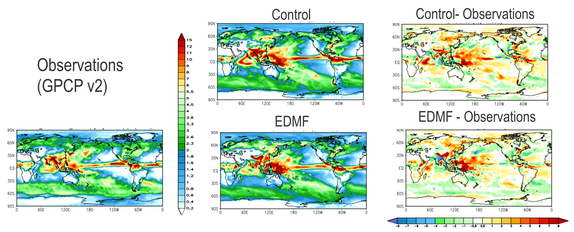
JJA Low Cloud Cover (%)



DJF Low Cloud Cover (%)



JJA Precipitation (mm day⁻¹)



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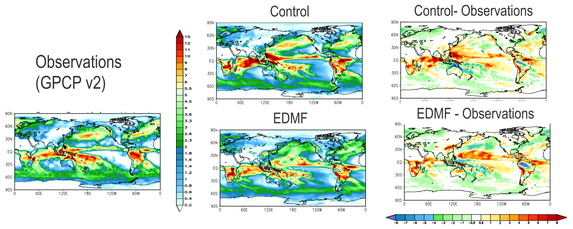

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