A new multi-plume stochastic EDMF model: A step towards unified turbulence and convection parameterization

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The Future of Cumulus Parameterization

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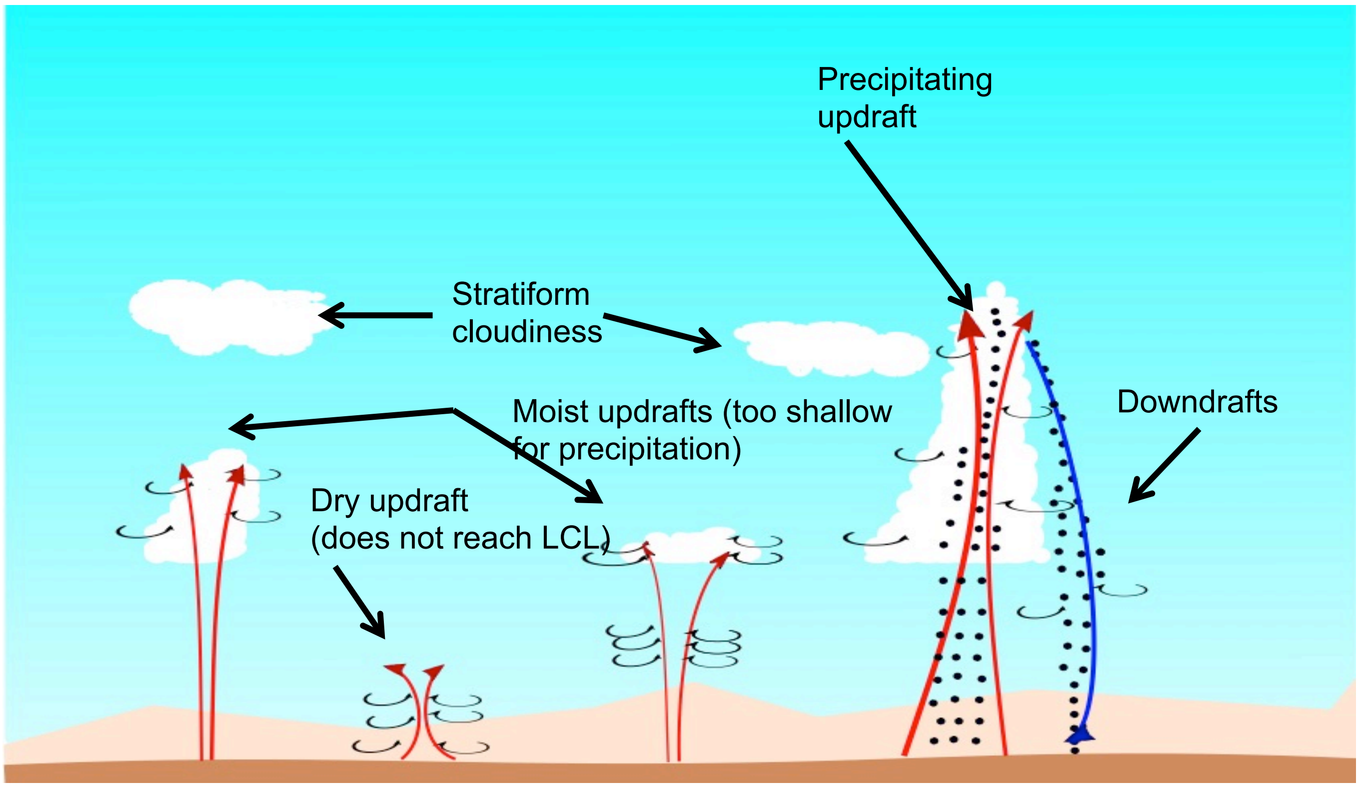
EDMF parameterization



Decomposition of model grid-box into:

- *Multiple* convective thermals (updrafts and downdrafts)
- Non convective environment

First-order moments:

$$\overline{\varphi} = a_e \varphi_e + \sum_i a_i \varphi_i$$

i	Convective thermals
e	Environment
a_e,a_i	Fractional areas

Second-order moments (e.g. turbulent fluxes):

$$\overline{\varphi'\psi'} = a_e \overline{\varphi'\psi'}|_e + a_e(\varphi_e - \overline{\varphi})(\psi_e - \overline{\psi}) + \cancel{\sum_i a_i \overline{\varphi'\psi'}_i} + \sum_i a_i(\varphi_i - \overline{\varphi})(\psi_i - \overline{\psi})$$

EDMF model – key ideas

Convective updrafts:

- **Steady state surface-forced laterally-entraining plumes**
- **Stochastic entrainment rate**
- **Surface properties represent tail of assumed normal distribution**

$$\frac{\partial \varphi_i}{\partial z} = \epsilon_i(\overline{\varphi} - \varphi_i) + \frac{S_i^{\varphi}}{w_i}$$

$$\frac{1}{2}\frac{\partial w_i^2}{\partial z} = aB_i - b\epsilon_i w_i^2$$

$$RRi(z) = \int_z^{\infty} \rho S_i^{q_t}(1-f)dz$$

Convective downdrafts:

- **Steady state plumes**
- **Driven by evaporation of rain**

S_i^{φ}	Microphysical source terms (Kessler-type autoconversion)
$\epsilon_i = \epsilon_i(w_*, w_{dn})$	Entrainment rate
w_{dn}	Downdraft velocity scale
f	Fraction of rain forming downdrafts

Turbulence in the environment:

$$\overline{w'\varphi'}|_e = -K\frac{\partial \overline{\varphi}}{\partial z} \qquad K = l\sqrt{tke_e}$$

Large scale (stratiform) cloudiness:

- **Statistical scheme with assumed normal distribution of moist conserved variables**
- **Second order moments consistent with the EDMF model**

EDMF parameterization

Advantages of the new parameterization:

- **All parameterized processes based on consistent assumptions**
- **Coexistence of different types of convection in the same vertical column of the model**
- **No need for convective trigger functions and explicit CAPE/CIN closures**

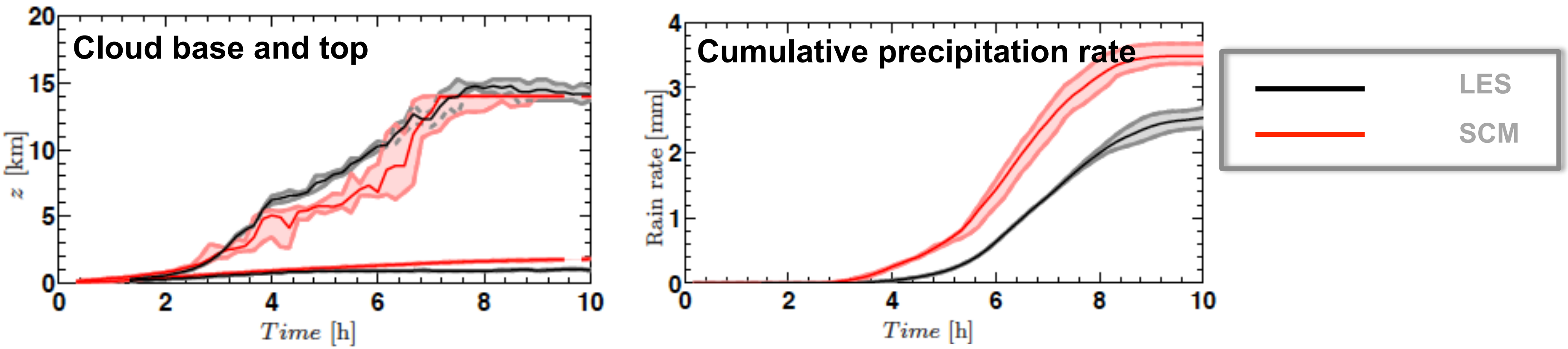
Development and validation:

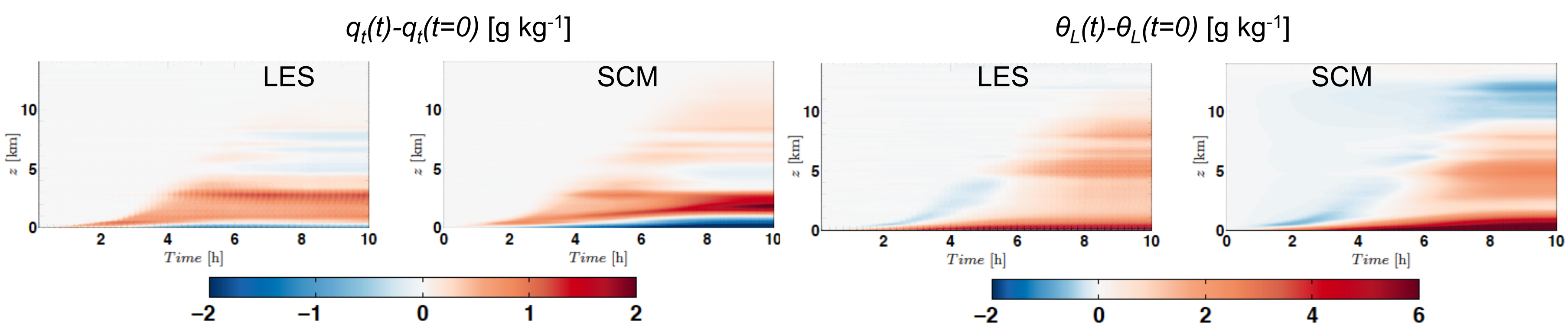
- **Idealized experiments in the single-column-model (SCM) framework and comparison with LESs/CRMs (e.g. GEWEX-GCSS cases)**
- **Impacts of parameterization in fully 3D models**
- **Statistical comparison against observational data(work in progress)**

Comparison of the EDMF against LES

LBA case:

- **Diurnal cycle of continental convection**
- **Dry boundary layer ➔ non-precipitating moist convection ➔ shallow precipitating ➔ deep convection**





Role of the EDMF in GCMs

US Navy Global Environmental Model (NAVGEM)

- **EDMF implemented in operational NAVGEM in 2013**
- **Significant improvement of thermodynamic state of the atmosphere and circulation**

Zonal mean temperature bias at t=120 h