Representation of precipitation and clouds associated with deep convection in the LMDZ GCM

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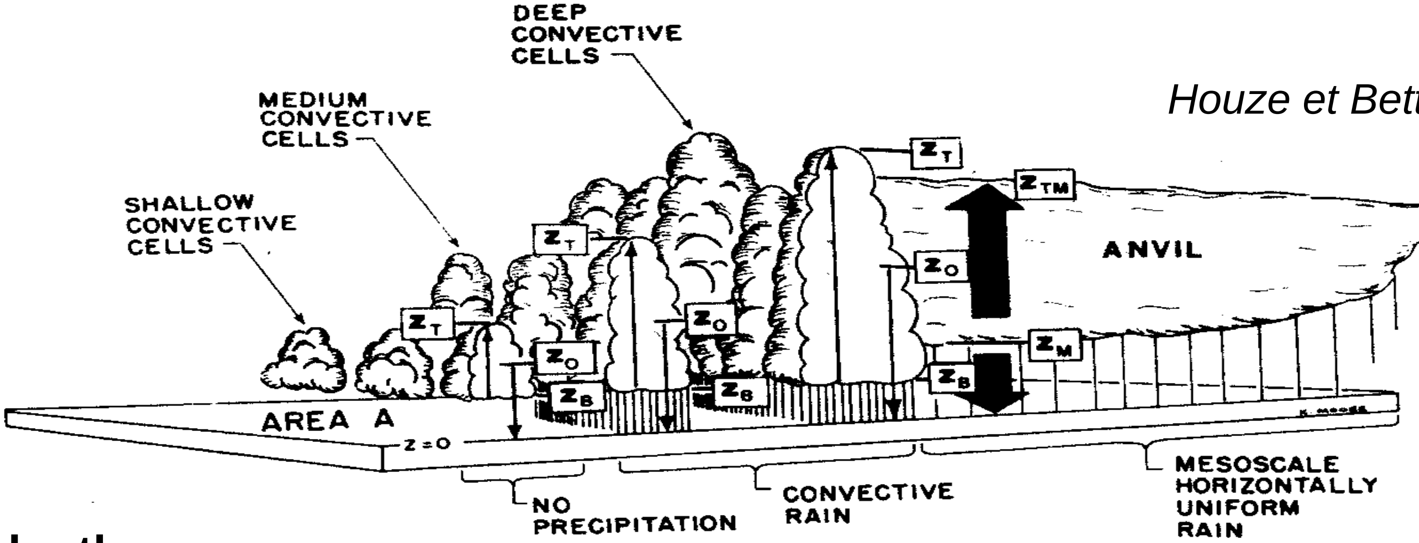
Parameterization of convective systems in LMDZ

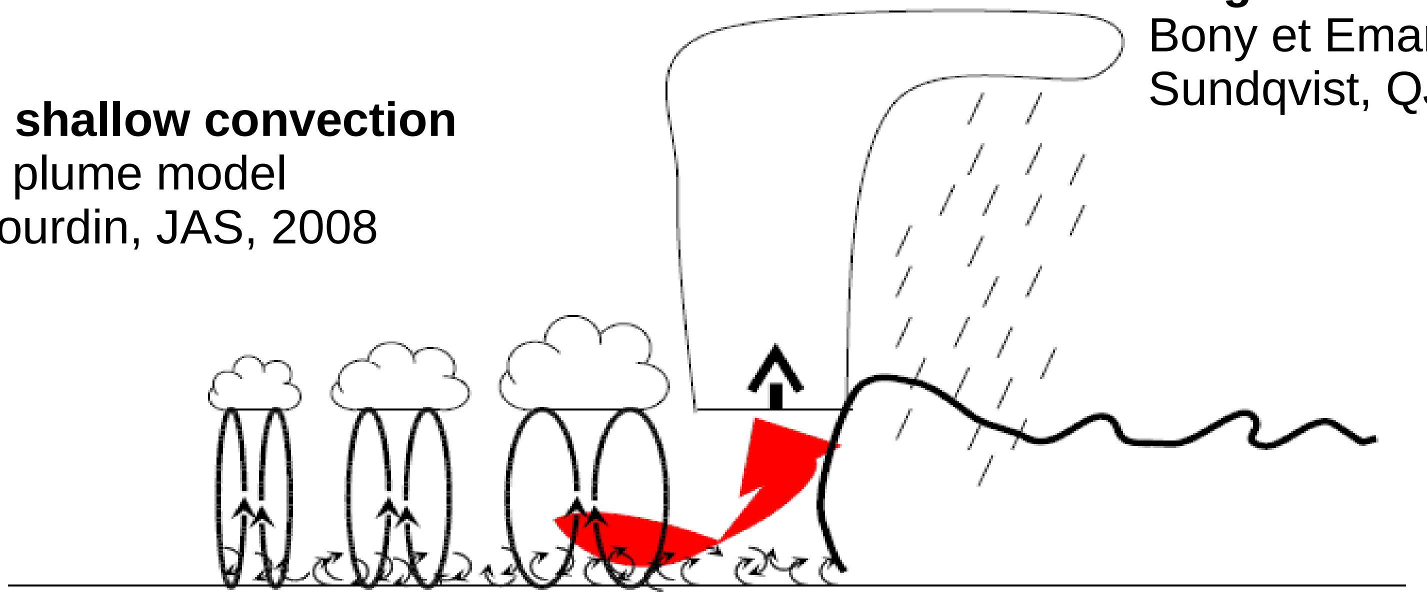


Houze et Betts, RGSP, 1981

Handled by three different parameterizations

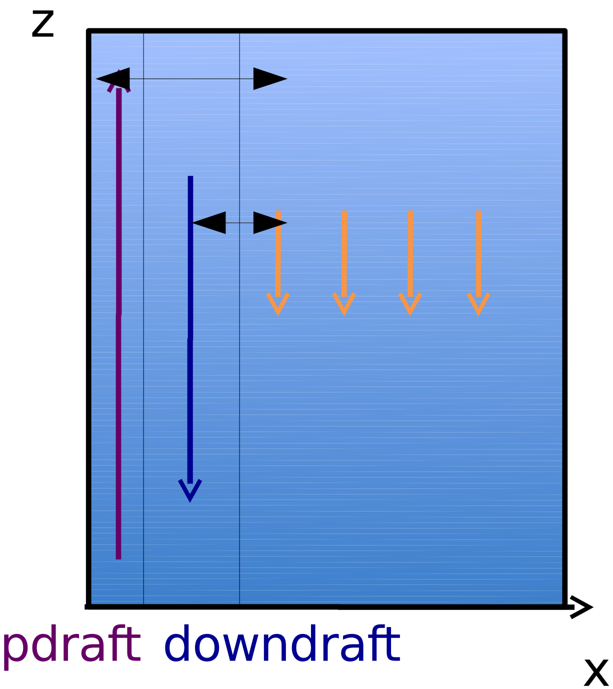
Large-scale condensation
Bony et Emanuel, JAS, 2001
Sundqvist, QJRMS, 1978

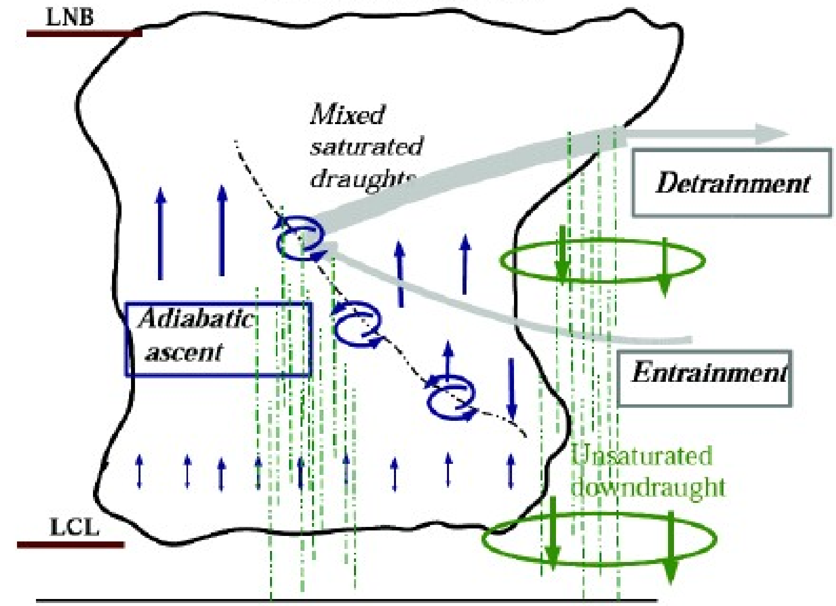
Dry and shallow convection
Thermal plume model
Rio et Hourdin, JAS, 2008



Deep convection and associated cold pools
Emanuel, JAS, 1991 revisited by
Grandpeix et Lafore, JAS, 2010

Parameterization of deep convection in LMDZ





Emanuel, 1991

- **Triggering** function of the deep convection scheme:
Criteria on the convective inhibition

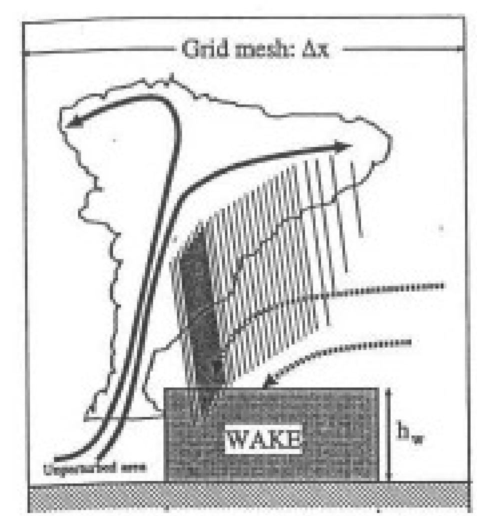
- Convection **intensity** (“closure”):
Convective intensity related to mean environmental properties (LMDZ5A)
Convective intensity related to sub-cloud processes (LMDZ5B)

- **Precipitation efficiency**: fraction of condensate that precipitates instead of being detrained

- Updrafts and downdrafts properties: **vertical velocity, buoyancy and fractional coverage**

- **Mixing rates** between clouds and environment

Parameterization of cold pools (LMDZ5B)



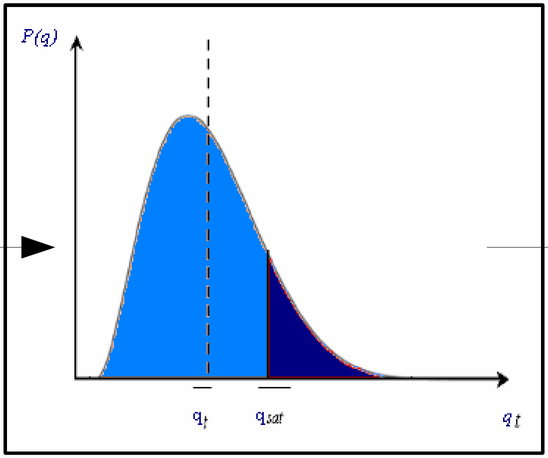
Grandpeix & Lafore, JAS, 2010

Parameterization of clouds associated with deep convection in LMDZ

Log-normal distribution of total water qt

Grid cell
mean state → qt, qsat

Convection scheme → qc

→ 

→ σ, cf

Bony & Emanuel, JAS, 2001

Uncertain parameters:

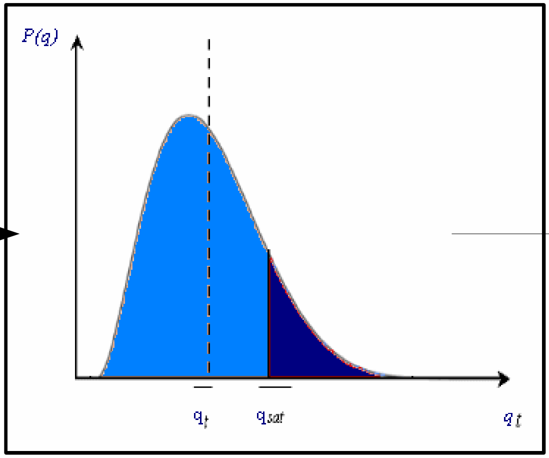
- **Shape** of the pdf of qt?
- **Width** of the distribution?

Parameterization of large-scale clouds in LMDZ

Log-normal distribution of total water qt (Bony & Emanuel, JAS, 2001)

Grid-cell mean state → q, qsat

σ/q imposed



$$\alpha_c = \int_{q_{sat}}^{\infty} P(q)dq$$

$$q_c = \int_{q_{sat}}^{\infty} (q - q_{sat})P(q)dq$$

The profile of σ/qt is defined crudely as increasing linearly
from the surface (0) to 600hPa (0.005)
from 600hPa to 300hPa (0.25)

Microphysics and precipitation:
See Jean-Baptiste's talk for more details

The particular case of convective anvils

Which scheme should handle convective anvils?

- The deep convection scheme
Importance of mesoscale updrafts and downdrafts
However, in mass-flux schemes
$\alpha << 1$

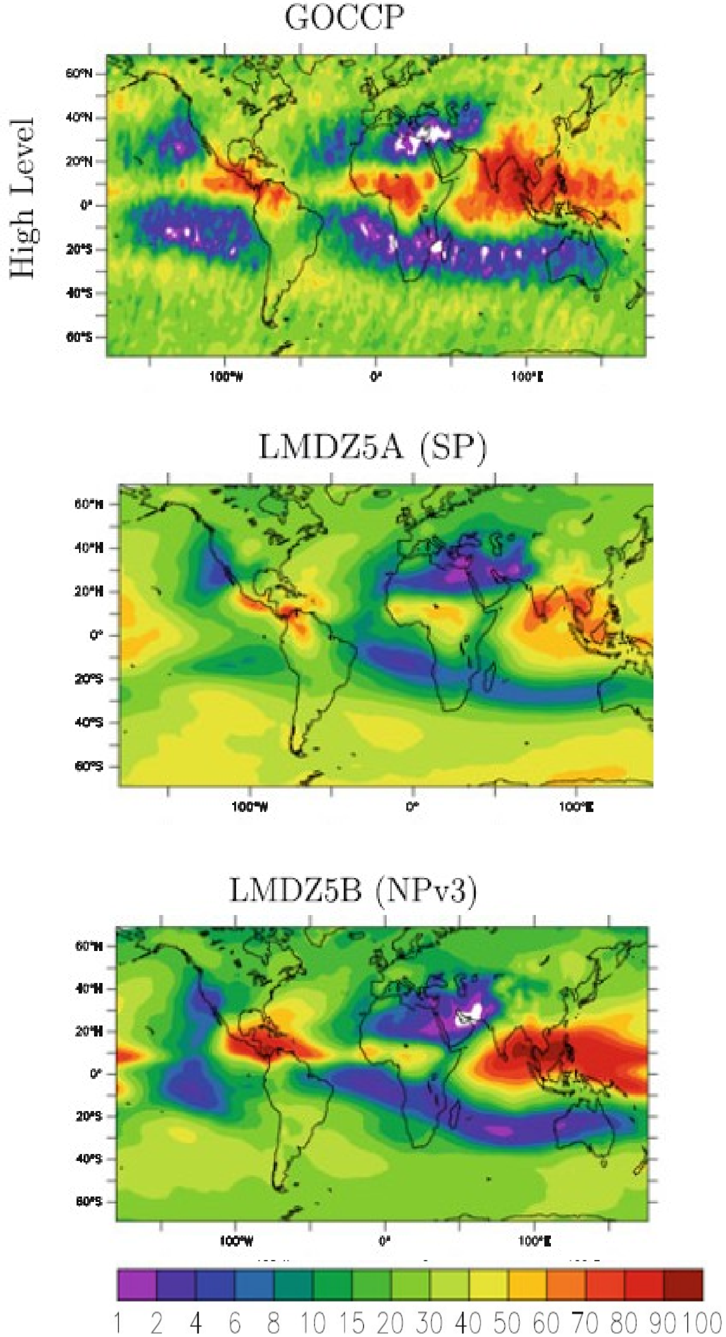
- The large-scale scheme
Importance of radiative impact of clouds
How to control the large-scale scheme more directly from convective activity?
For example, via the width of the distribution used in the large-scale scheme

- An additional scheme?
To allow the co-existence of convective-scale and mesoscale updrafts and downdrafts

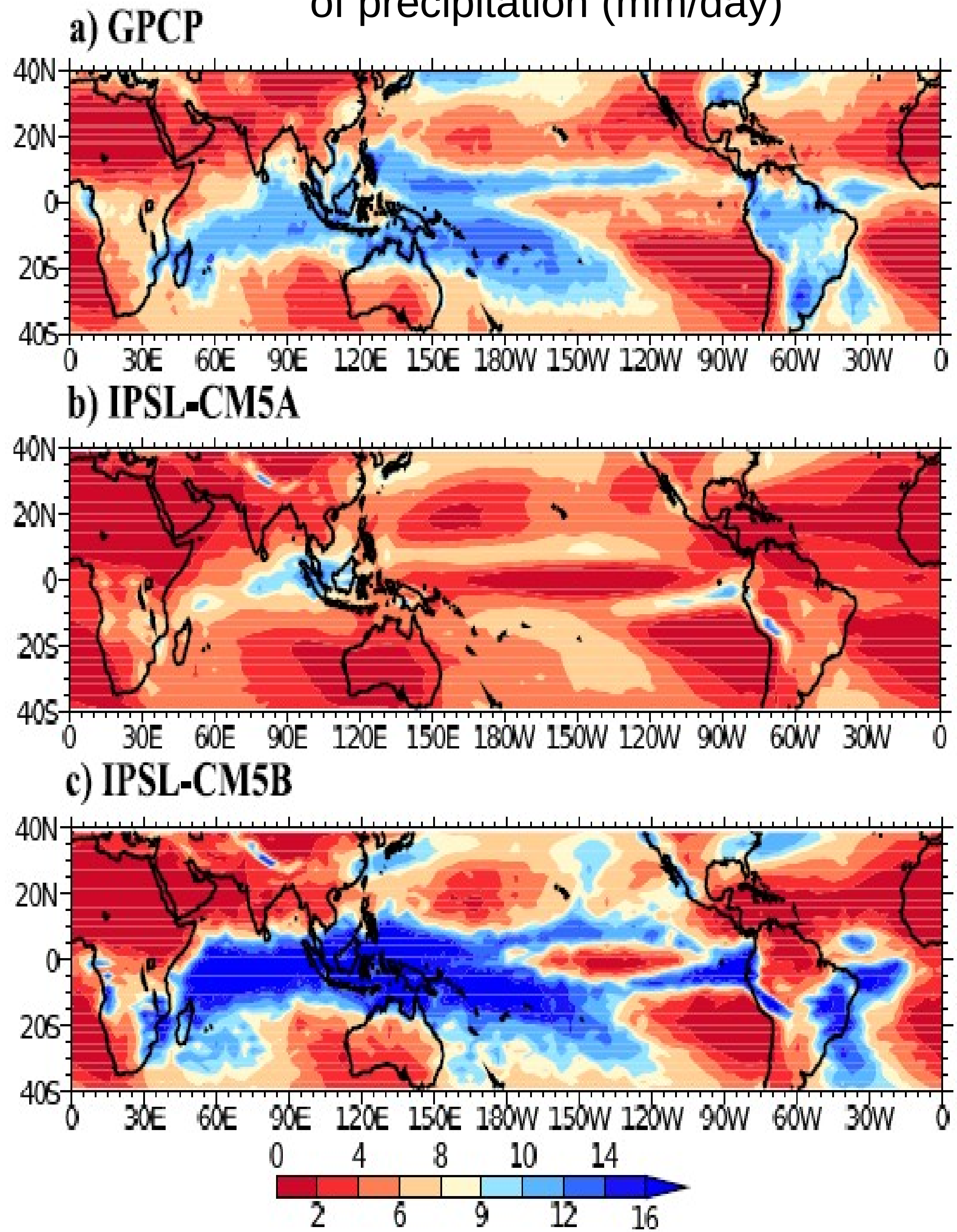
In any case: question of the relative size of the GCM grid-box and the anvil
Need for scale-aware parameterizations

High clouds and precipitation variability in LMDZ

High cloud fraction (%)
Annual mean



Intraseasonal variability
of precipitation (mm/day)



Conclusions

Contribution of observations for parameterization development of convection and associated clouds:

1. Evaluation of the hypothesis at the basis of parameterizations
   - Triggering criteria
   - Environmental conditions and convective intensity
   - pdf of qt

2. Contribution to conceptual models of important processes
   - life-cycle of cold pools
   - life-cycle of anvils

3. Model evalutaion
   - Cloud cover, liquid/ice content, precipitation efficiency
   - Radiative fluxes
   - Heating rates Q1, Q2, QR

4. From single case-studies to 3D modeling
   - MCS composites in various environments
   - ocean vs continent contrasts
   - Sahel vs Amazonie contrasts