Using more than one plume to make GCM convective tendencies participate in large scale phenomena better

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trying to be CAM-useful
with much help from

Rich Neale, Sungsu Park, Chris Bretherton, Julio Bacmeister

Basis: well mixed steady plumes

- Updraft mass flux is drawn from the mean PBL
  - » + perturbations ?
- Lateral mixing occurs instantly with the mean environment
  - » + perturbations ?
- Buoyancy determines how much mass starts & mixes, & where mixtures end up
- Tendencies built from vertical mass flux, microphysical processes, & any contingent downdrafts.

Key claim to physical validity

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Key uncertainty

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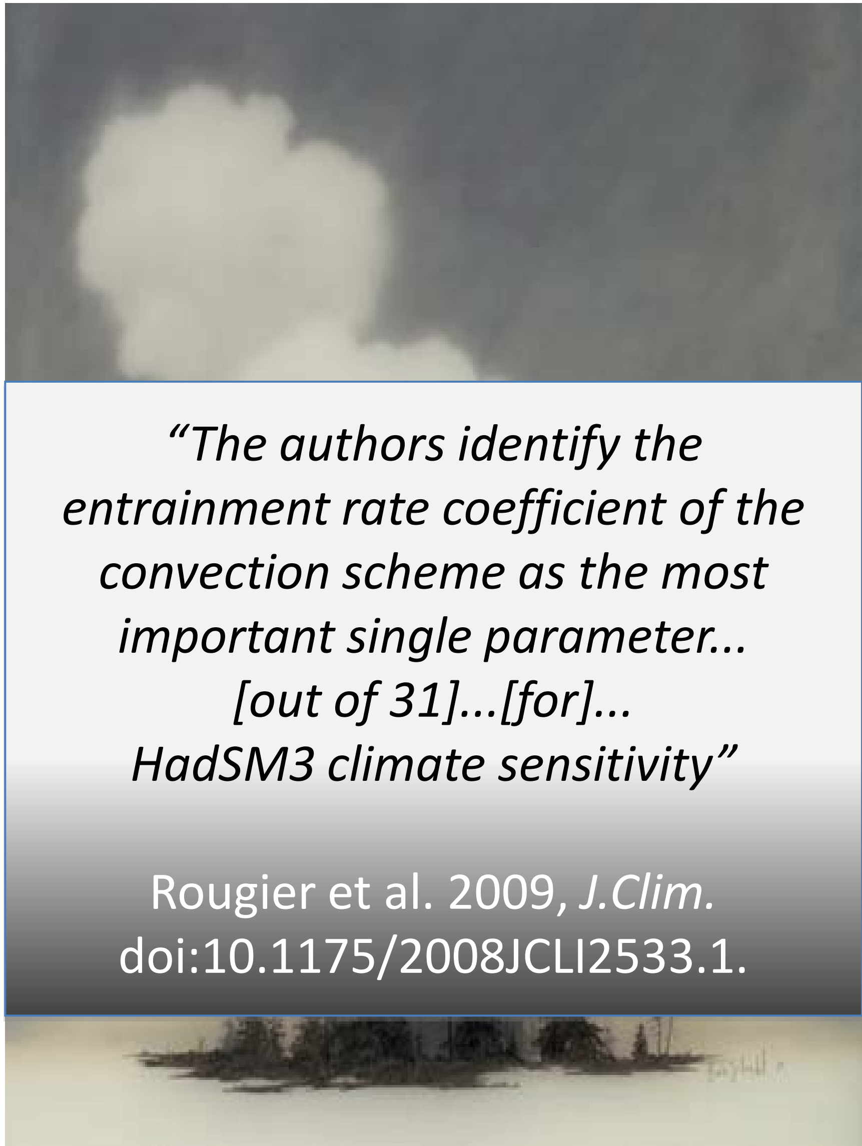

"The authors identify the entrainment rate coefficient of the convection scheme as the most important single parameter... [out of 31]...[for]... HadSM3 climate sensitivity"

Rougier et al. 2009, *J.Clim.* doi:10.1175/2008JCLI2533.1.

Another big uncertainty: closure

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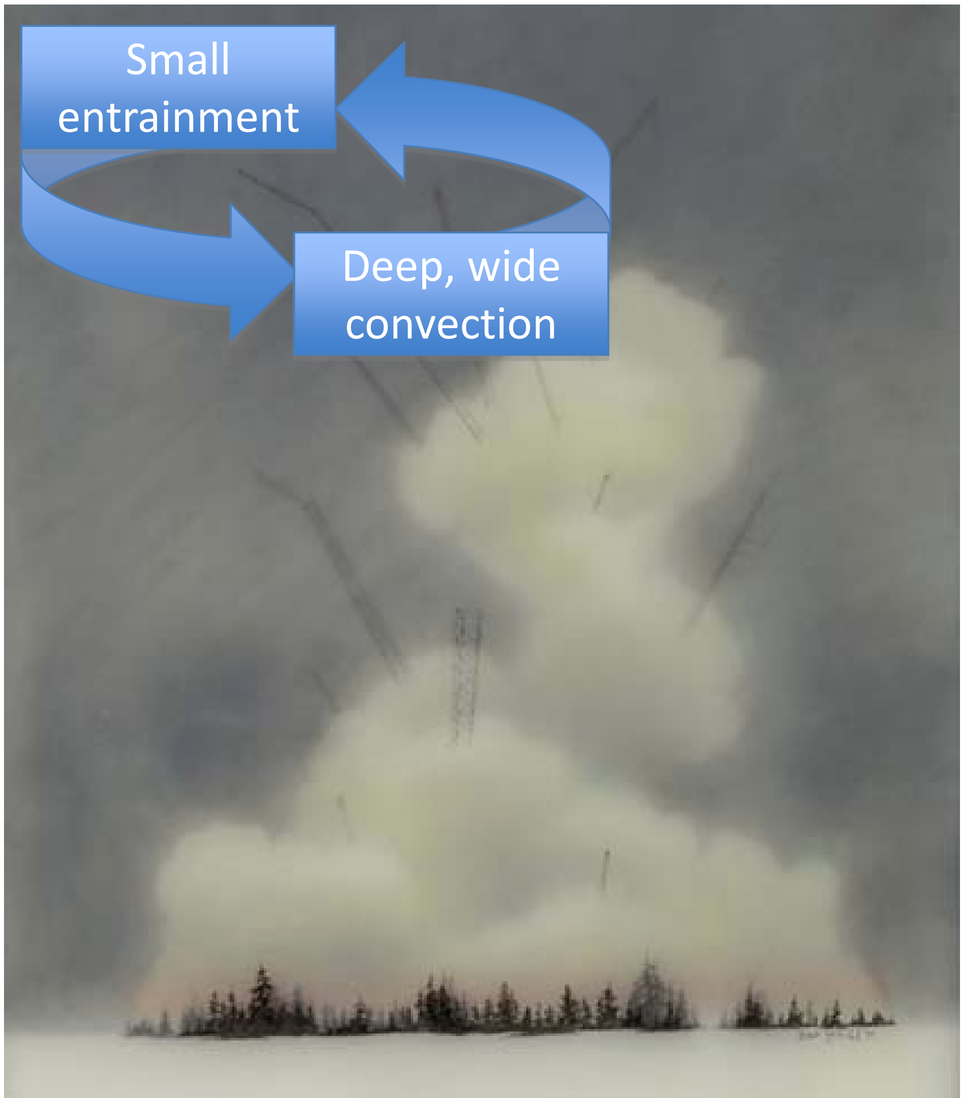
1 plume type not enough?

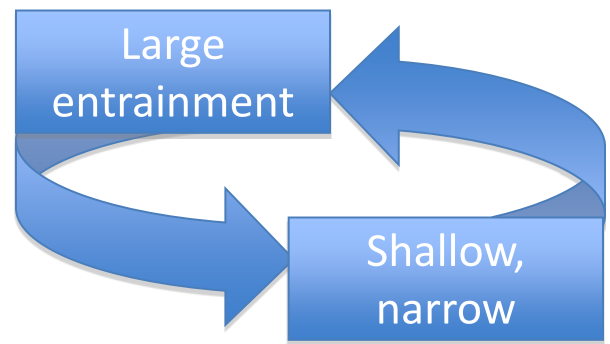
Brooks Salzwedel **Plume #1 2009** 12" x 8” Mixed Media

Plume #2 2009 12" x 8”

Choice is self-fulfilling



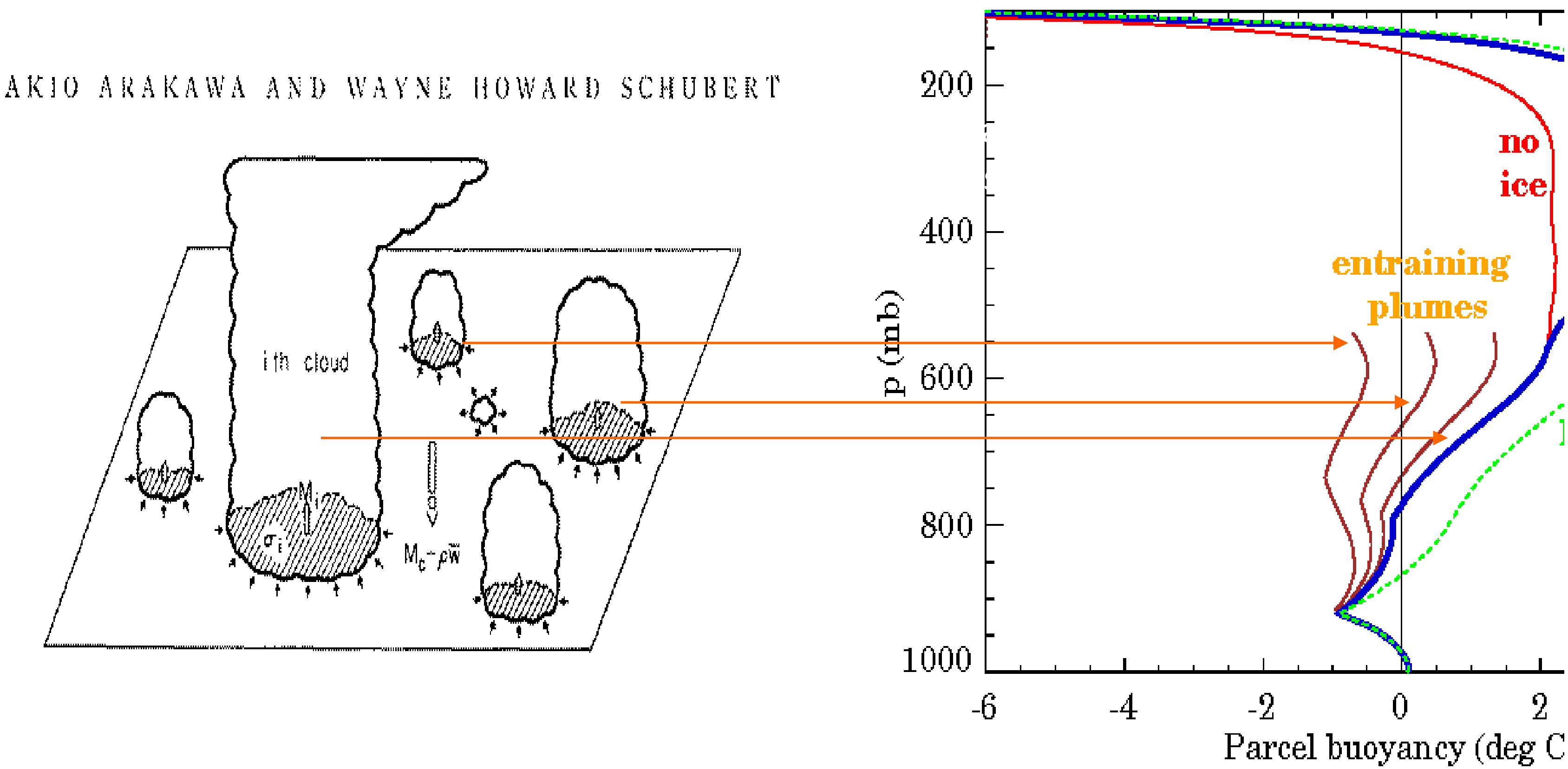
Brooks Salzwedel **Plume #1 2009** 12" x 8” Mixed Media



Plume #2 2009 12" x 8”

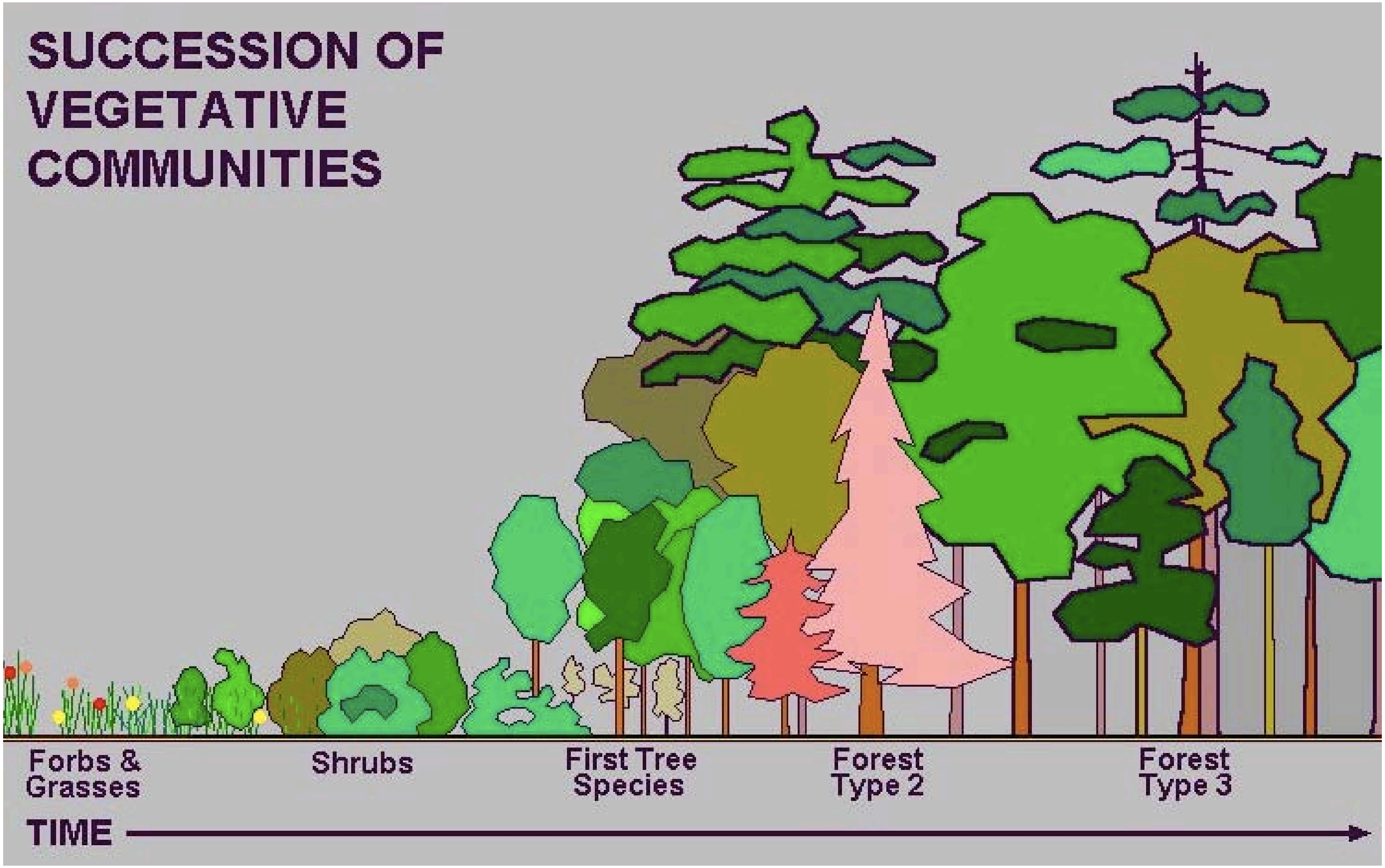
Can’t we have both?

competing? favors the large

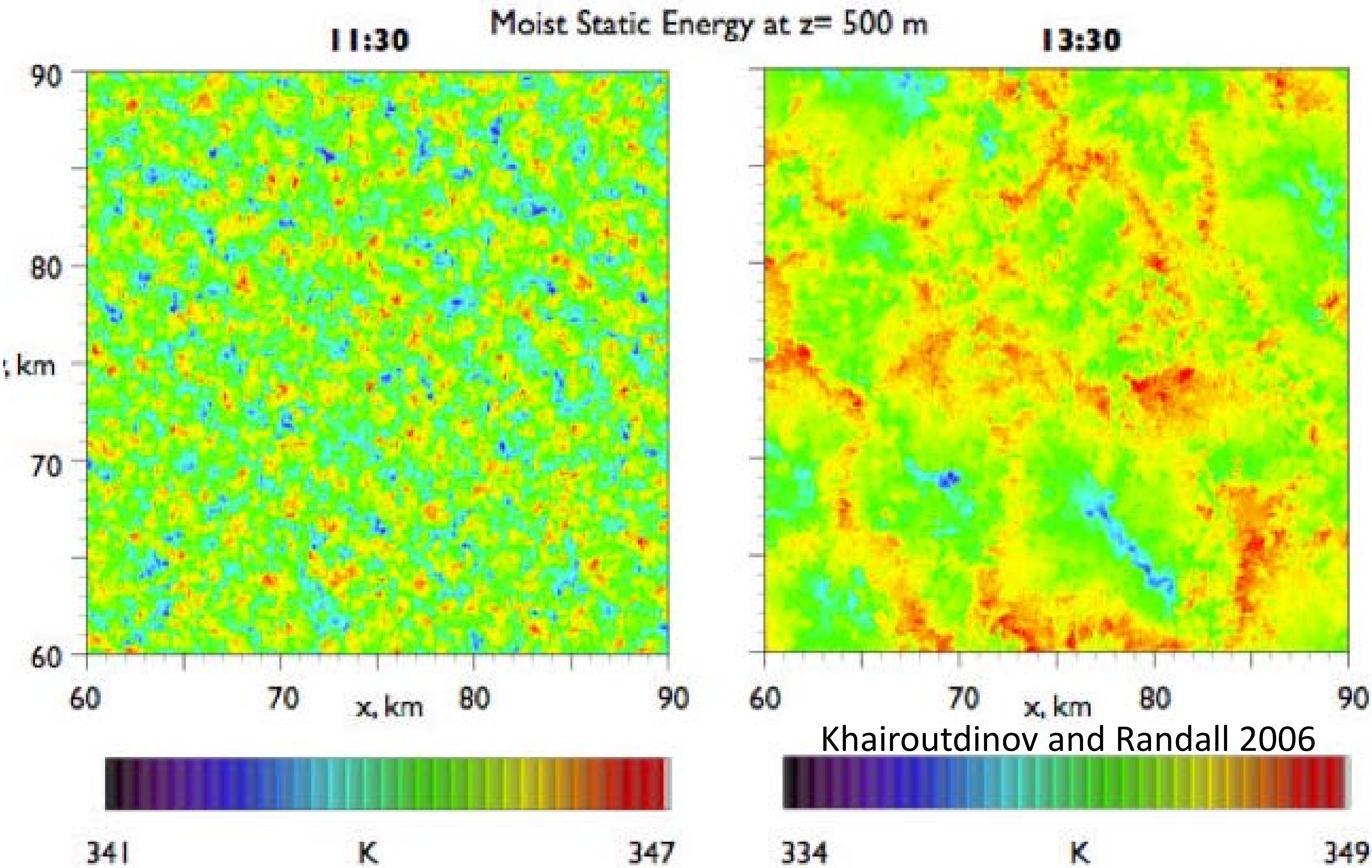


requiring elaborate handicapping schemes

more like a *succession?*



precip organizes & enlarges plume bases



Khairoutdinov and Randall 2006

?Time? well mixed steady plumes

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Performance problem targets

1. Entrainment dilemma (CCM2-CCM3, rehashed)
   – more mixing gives too-dilute convection
      » unstable (e.g. cold aloft) climate biases
   – less mixing gives too-undilute convection
      • weak q sensitivity
         » too little variability, bland rainrate PDF, ...
   – there is no "just right" in terms of constant ent. rate
2. Closure issues (if separated from above)
   – variability, land/sea, SST/thermo/dyn sensitivities,...
3. Too instant response to instability
   • systematic: diurnal cycle over land
   • other variability surely affected

What's lacking?

lack = (nature) – (model)

=

(convection's subgrid variations in all fields and all systematic relationships among them)

-

(independent mixing plumes rising from PBL in uniform env.)

Holistic parameterization

- Take the biggest possible bite of what's missing, for minimum cost & arbitrariness
- Relationships, not just another subgrid thing
- Involves tails & 'unlikely' overlaps, cultivated by natural selection (penetrative buoyant ascent), not just slabs of gross macrophysics PDFs.

Problems in knob space

1. plume base conditions and mixing effects are too situation-independent
2. Lack of finite-timescale development process

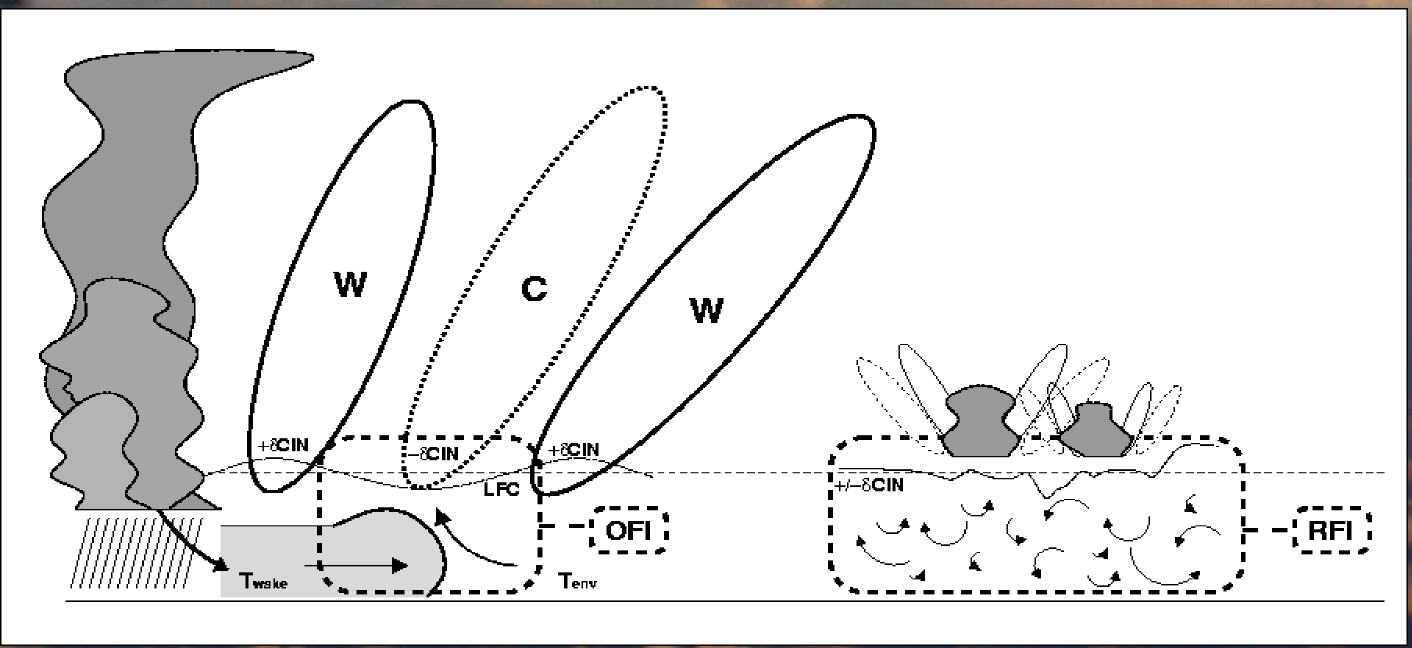
Solutions in knob space

1. plume base conditions and mixing effects are too situation-independent
2. Lack of finite-timescale development process

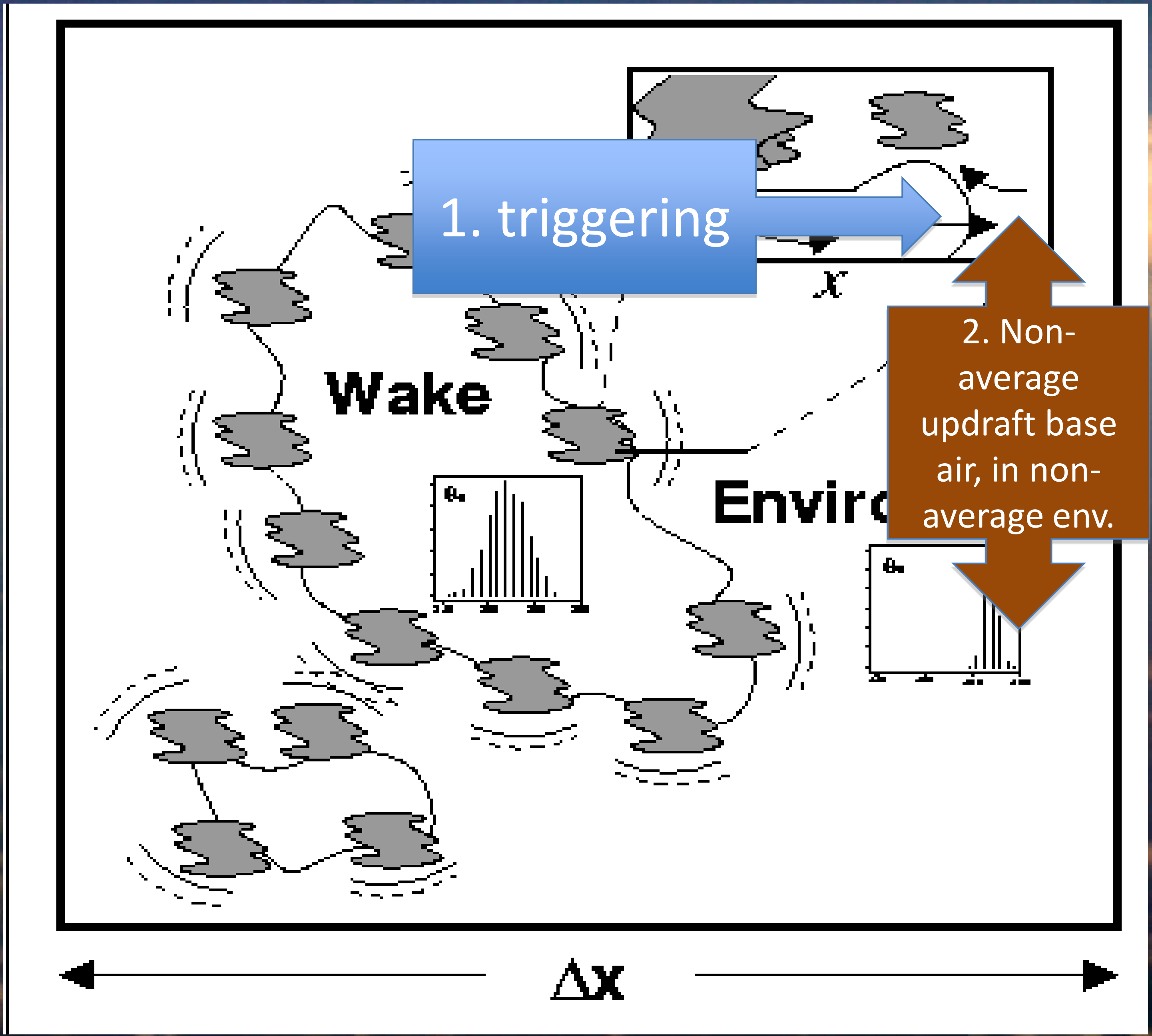
suggests need for some prognostic measure of subgrid convection "situation" to key off of

‘Organization’

very much



very little


1. triggering
2. Non-average updraft base air, in non-average env.
Wake
Envir
Δx

very much

tests in 2 knob spaces (CAM, toy)

A single prognostic variable: org(t)

Connected to convection apparatus by adjustable coefficients, so absolute value is meaningless.

forced,
τ–damped
org(t)

τ is a *cloud system or cloud field* timescale.

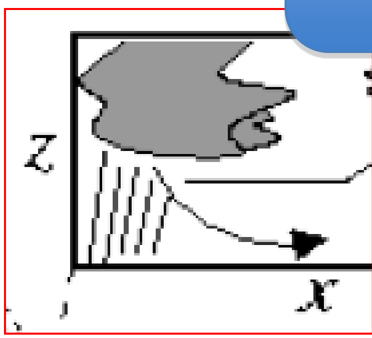
τ

A sum of N bubble-ascent time(s) $\Sigma(H_i/w_i)$?

Maybe someday – for now just 3h.

Full org treatment

deeper, more rain



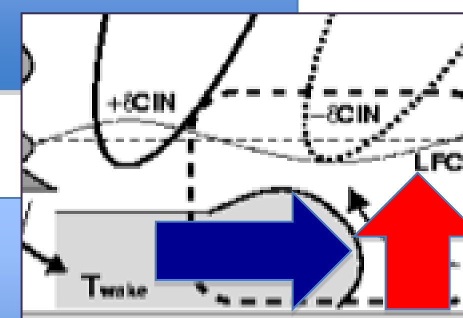
forced, τ–damped

org(t)

local env

M_b closure, R

T_b



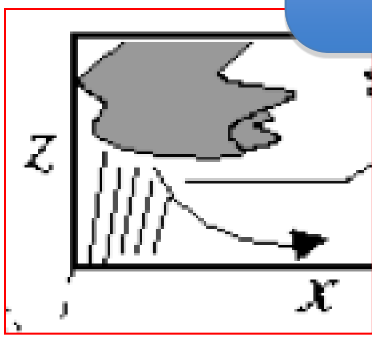
>Tmean + T'turb

subgrid geog.

shear, rolls, deformation (*directional?*)

First CAM 3.5 expts (2007)

ZM closure
CAPE+

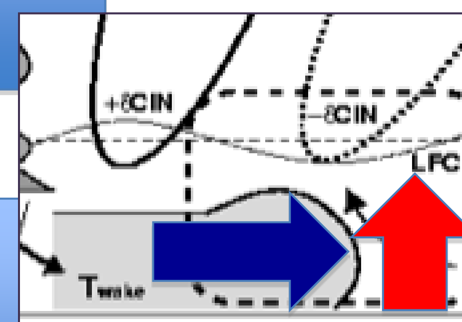


forced,
3-hour damped
org(t)

local
env

M_b trig,
big R

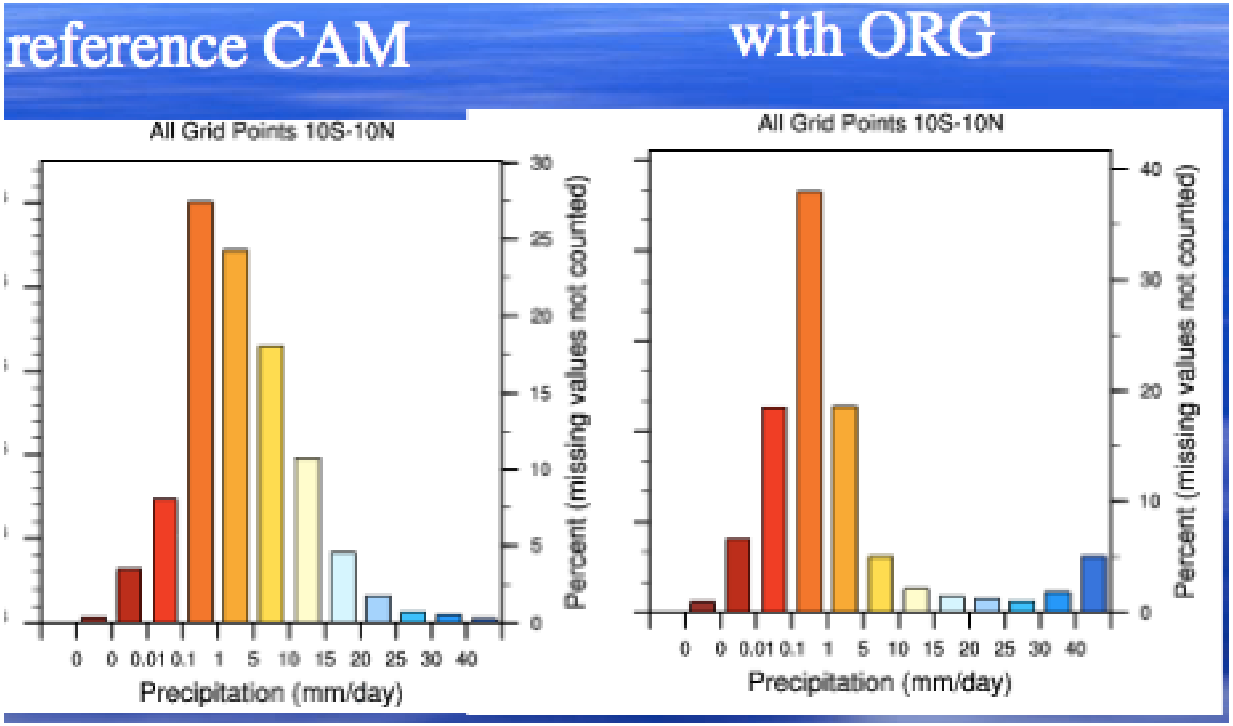
T_b



>Tmean + T'turb

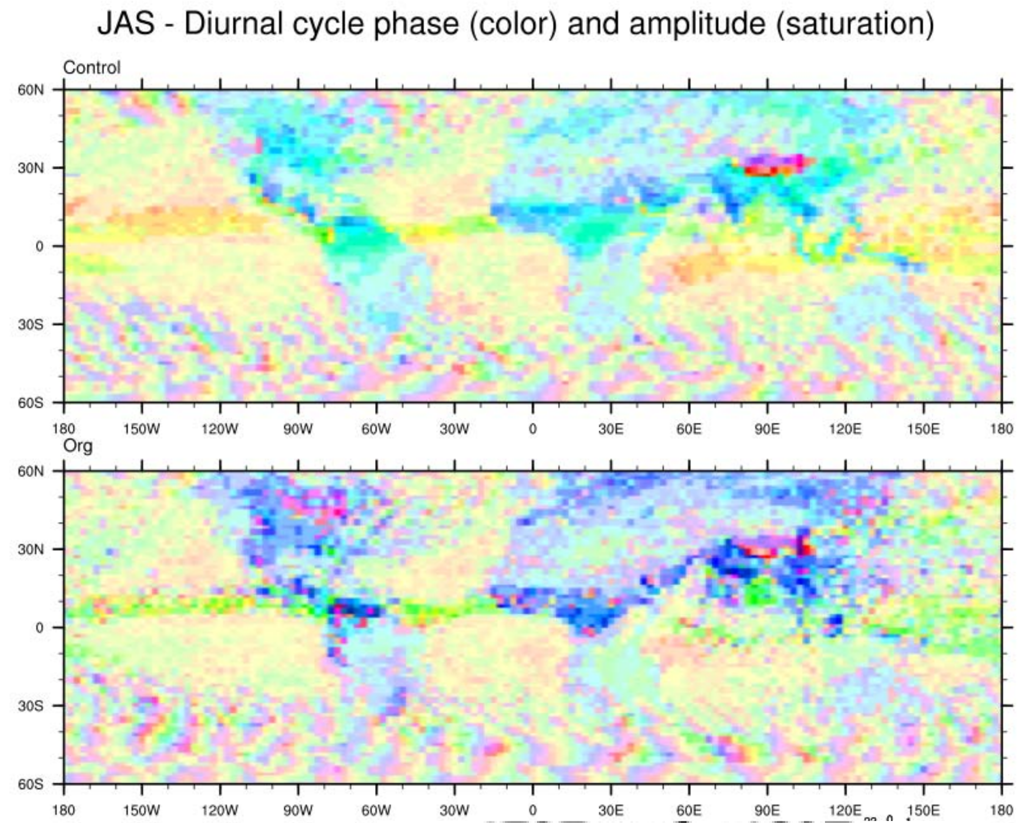
org effects 1

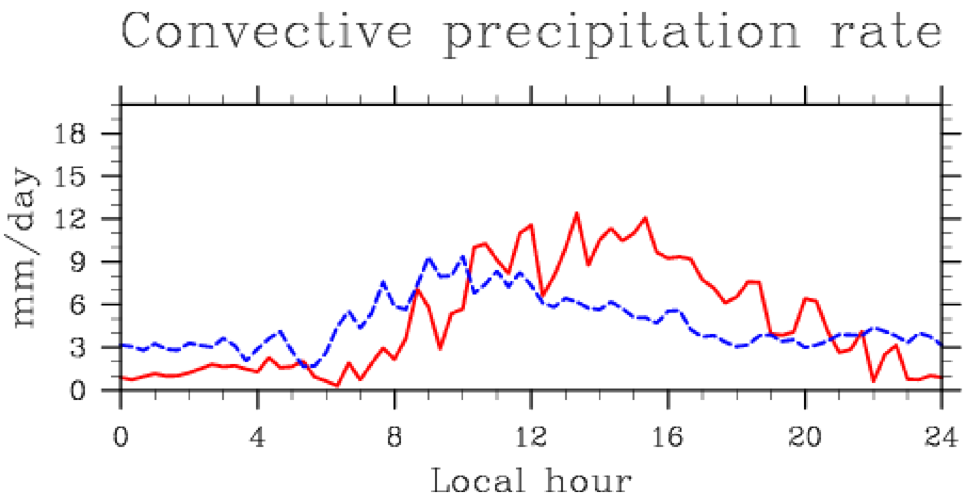
- When it rains, it pours
  - rest of atm (mean) more stable



org effects 2

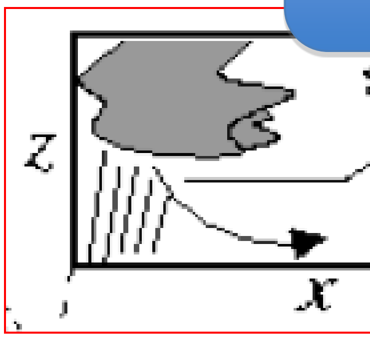
- Delayed diurnal cycle





(Offline) multi-Park/Breth plumes

deeper, more rain



forced, **3-hour damped** org(t)

local env

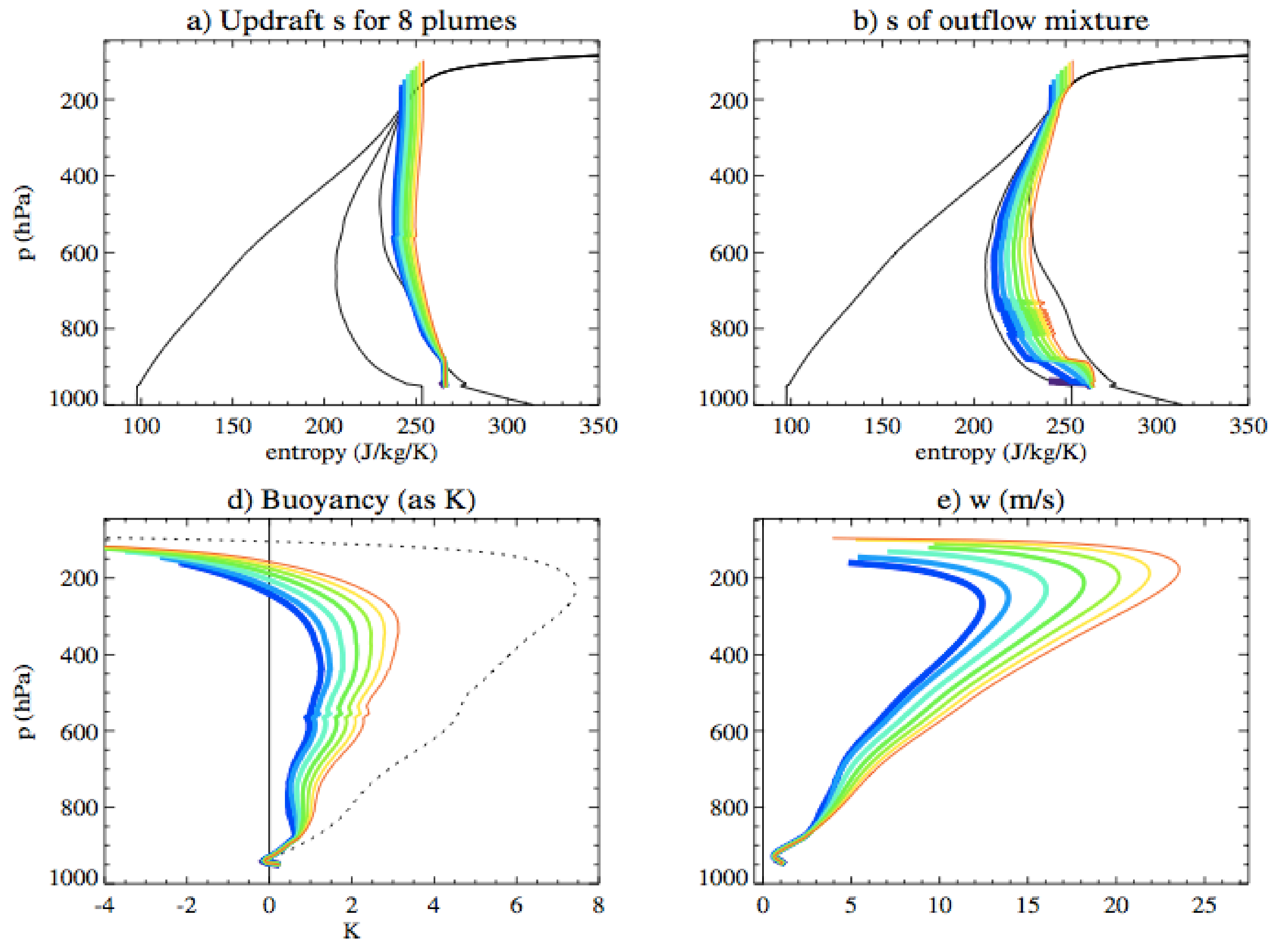
M_b trig, big R

Evading entrainment dilemma?

- deeper plumes will have moisture sensitivity indirectly, through their succession contingency on shallower ones

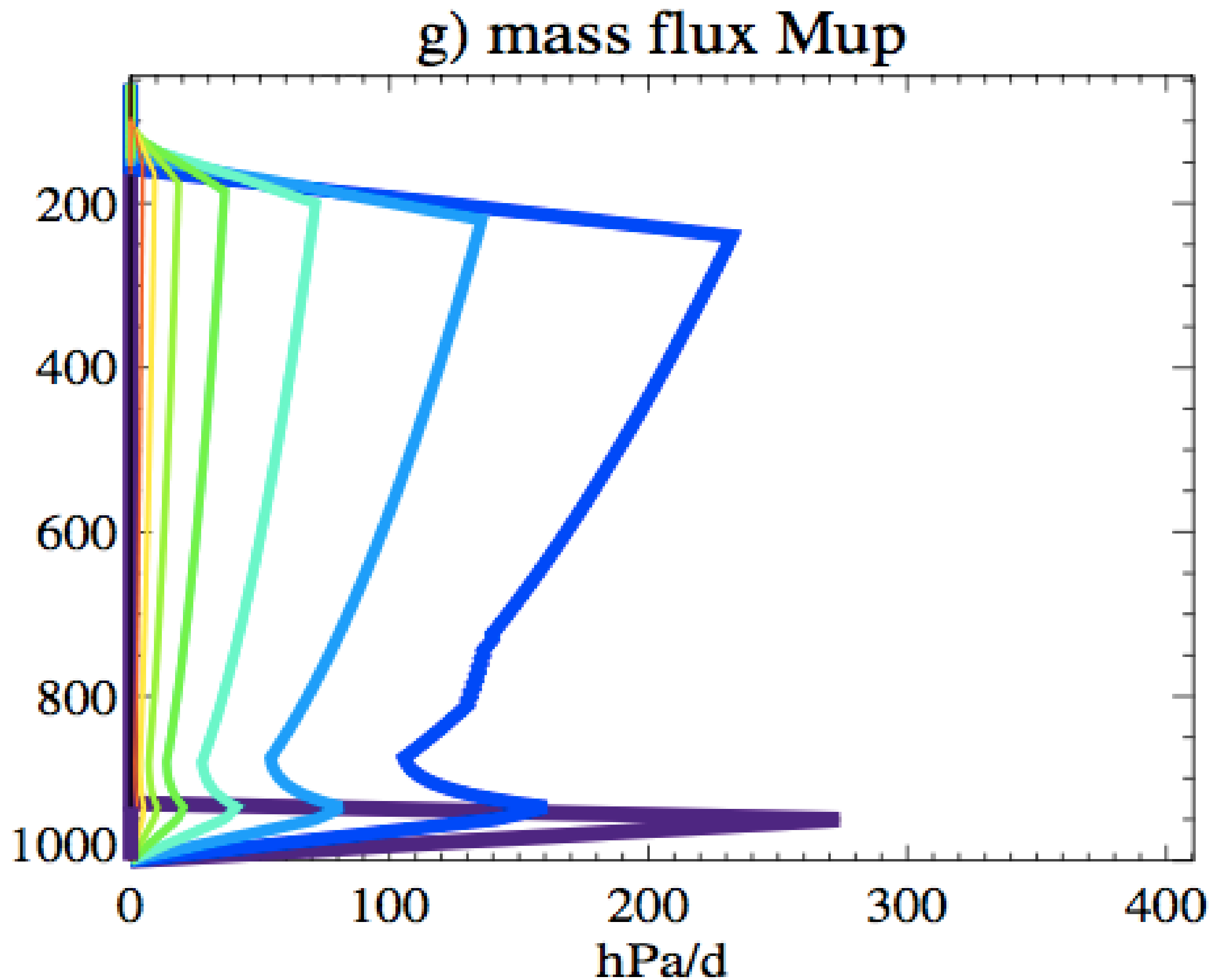
- without being too diluted

Example: in COARE mean sounding, I get 8 plumes of increasing depth



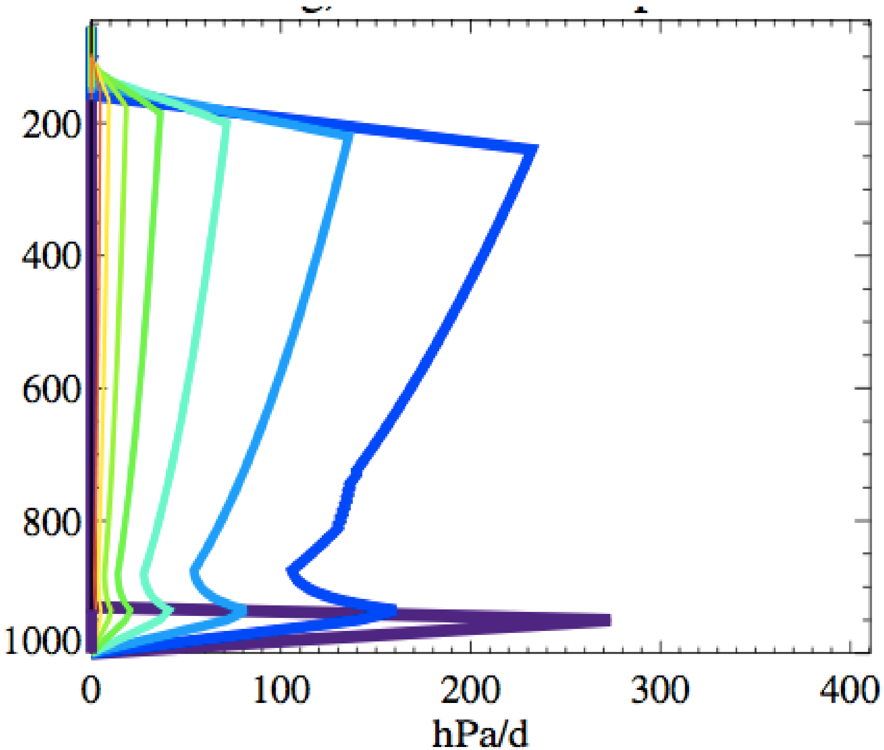
...but decreasing mass flux

Each contingent on the last for its gains

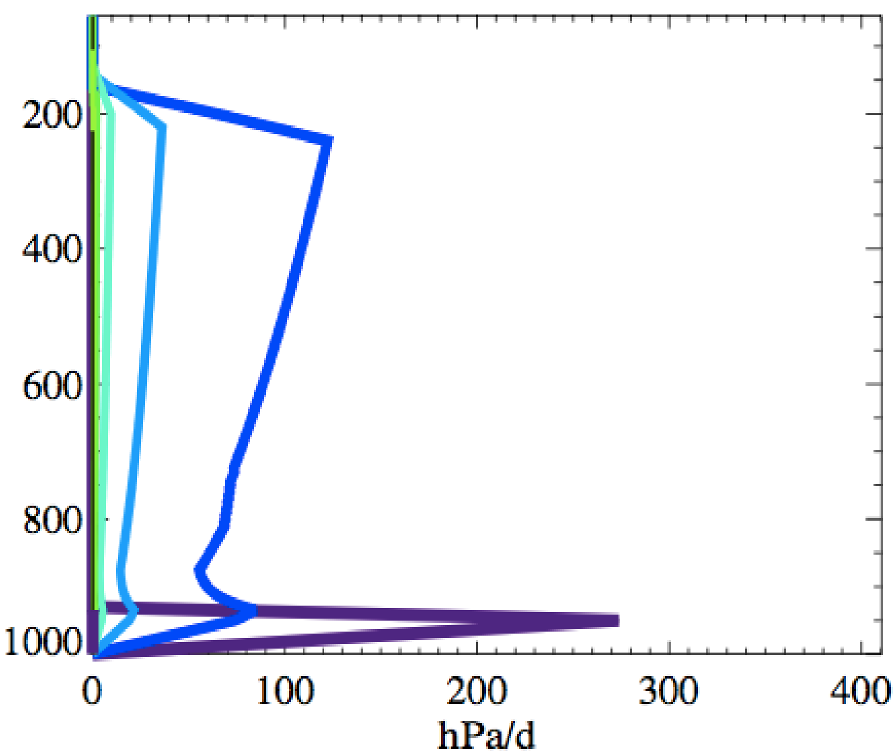


Depends on org
(a slider of plume overlap probability between random (0) and maximum (1)

org = 0.5



org = 0.2



Org effects

- Again: when it rains, it pours
- Mean state more stable, as convection occurs preferentially in org-enhanced microclimates
    - stronger effect than latent heat of freezing on/off
- Delay time

Plans for CAM

- Real Park-Bretherton plumes in real CAM
- Flexible implementation allowing various effects to be switched on/off
  - learn our way around knob space
    - » Biggy – plume radius/ ent. rate – appears still unavoidable
- Better diagnostics
  - falsifiable with CRM/LES data
    - » (not same as DERIVABLE FROM them!)