EUROCS DEEP CONVECTIVE CLOUDS

DIURNAL CYCLE
of
DEEP CONVECTION OVER LAND

CNRM, ECMWF, LMD, Met Office, NCAR & SMHI
(Europe, France, Sweden, UK & US)

Guichard & Petch

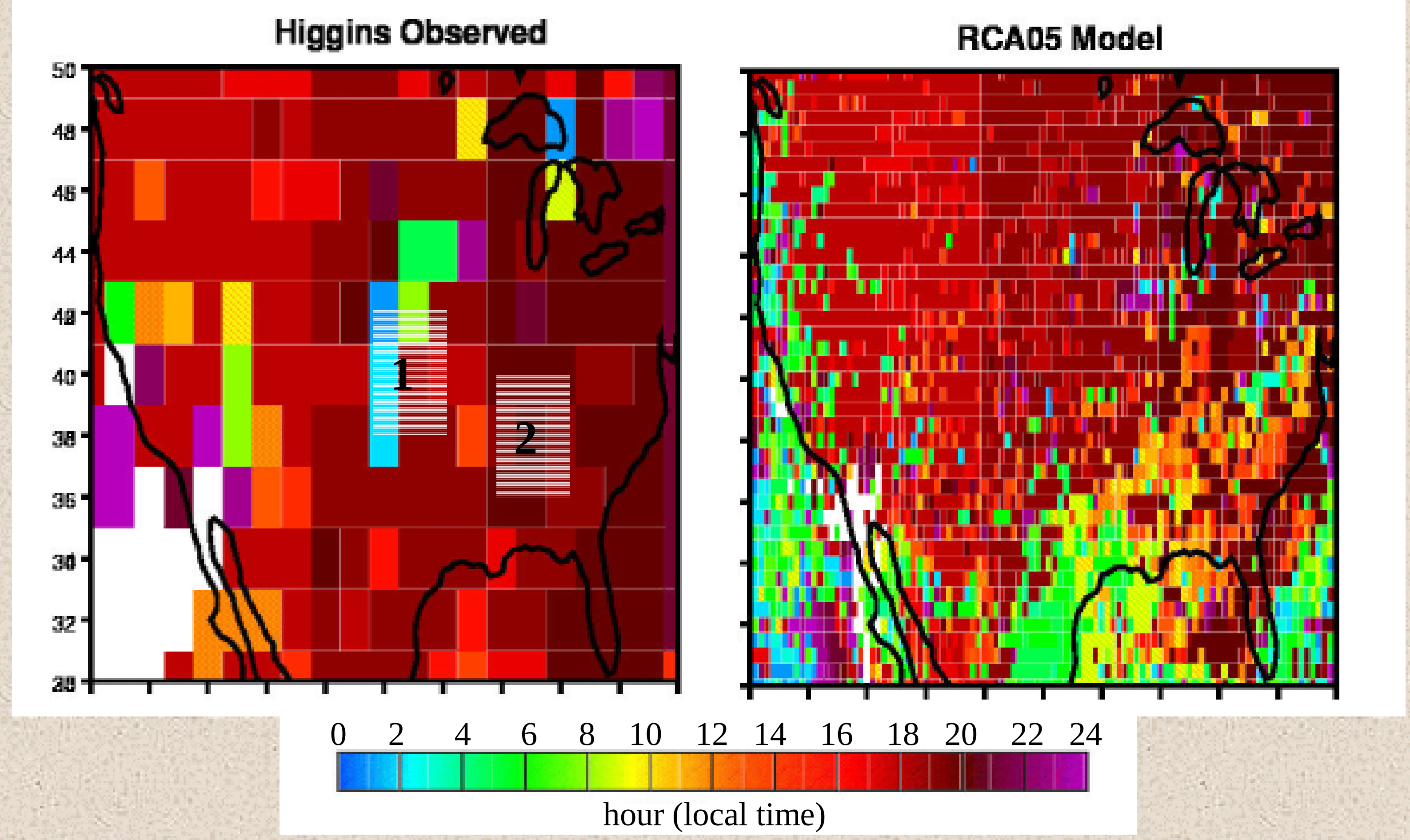
Beau, Beljaars, Chaboureau, Cheinet, Grabowski, Grandpeix, Grenier, Jakob, Jones, Koehler, Lafore, Piriou, Redelsperger, Royer, Stirling, Tailleux, Tomasini

EUROCS, 16 December 2002, Madr

OBJECTIVES

- ✓ to document performances of GCMs
- ✓ to design a framework to address the problem (a simple ***case study*** for CRMs & SCMs)
- ✓ to analyse the case, findings, conclusions
- ✓ to improve parameterisations & GCMs

most frequently occuring time of max precipitation in a diurnal cycle
(June 10-July 31 1993, from hourly accumulations)



- ✓ *the model captures the broad early-late evening max of rainfall*
- ✓ *errors is in the SE, could be related to the proximity of model boundaries*

COMMON CRMs/SCMs CASE STUDY

1 : an « observed case » to assess our models over land

Southern Great Plains (US)

GCSS WG4 Case3a

✓4-day runs with deep convection

✓forcings prescribed from observations

(large scale advection, surface fluxes)

2 : building an « idealized case » to address the diurnal cycle of deep convection over land and its representation in models

✓ because most events of the « observed case » not linked to our aims

(not designed for this purpose)

✓ motivated by Betts & Jakob (2002)

error in the diurnal cycle of deep convectio
shared by short & long- term GCM runs
reproduced in SCM runs

THE SIMULATIONS : 6 SCMs & 4 CRMs

model type	lab *(model name)*	participants
SCM	CNRM *(ARPEGE, Clim & WF)*	Beau, Grenier, Piriou
SCM	ECMWF *(IFS)*	Chaboureau, Jakob, Koehler, Bechtold
SCM	LMD *(LMDz)*	Tailleux
SCM	Met Office *(UM)*	Petch
SCM	SMHI *(close to HIRLAM)*	Jones
CRM	CNRM *(mésoNH)*	Chaboureau & Tomasini
CRM	CNRM *(comeNH)*	Guichard
CRM	Met Office *(UM)*	Petch
CRM	NCAR *(UM)*	Grabowski

In practice

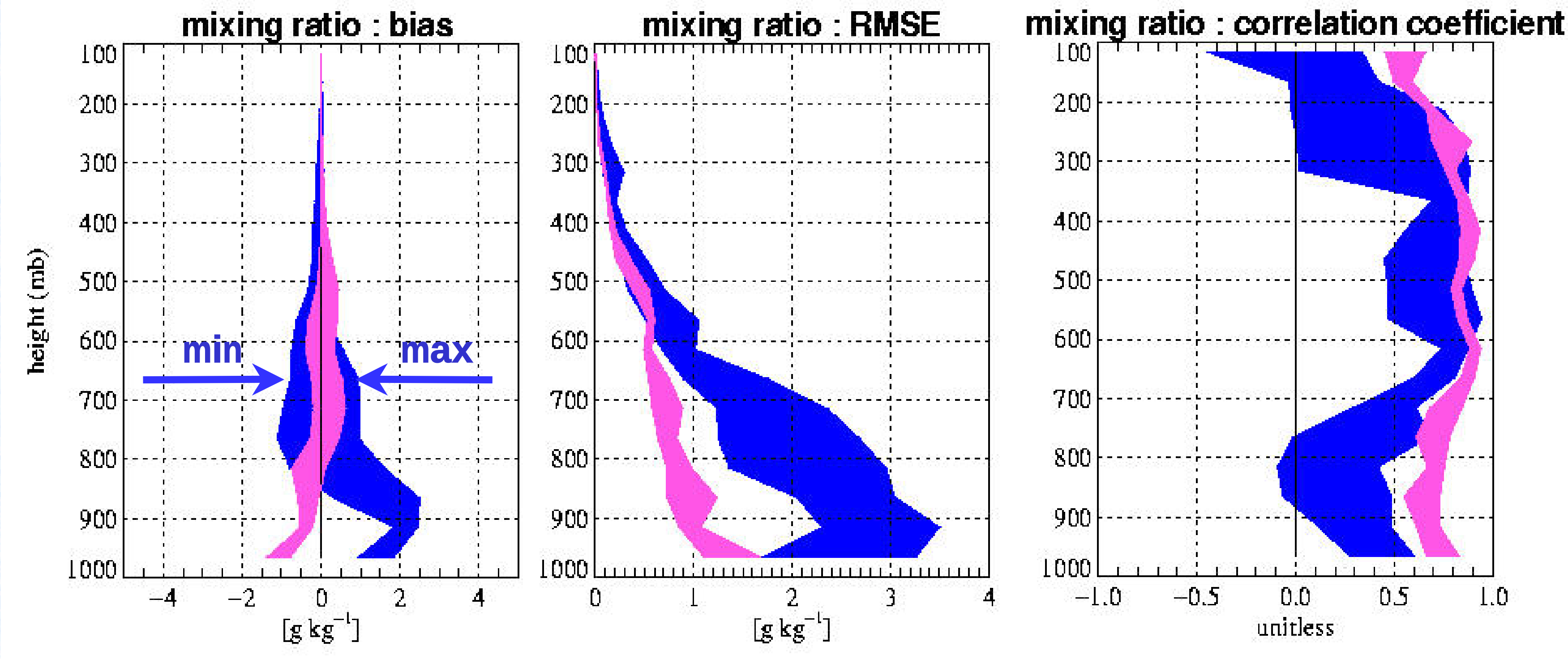
- ✓ Preparation of the case
- ✓ Definition of a «base lists» of relevant diagnostics
  - times series & time-height series of selected fields
  - mean profiles, convective fluxes, subgrid-scale moments, Q1, Q2,
  - radiative heating rates, cloud fraction, cloud water…
- ✓ CRMs : Lx ~ 500 km Dx ~ 250m to 2km
  - Dz ~ stretched 70-700m or less
- ✓ SCMs : operational version
- ✓Closer lab-lab CRM-SCM direct collaborations, e.g. CNRM-ECMWF
- ✓ Sharing the work, e.g. for CRMs, sensitivity studies:
  - UK Met Office: spatial resolution
  - CNRM: sub-grid scale representation

SIMULATION OF DEEP CONVECTION OVER LAND
THE OBSERVED CASE

✓ broad conclusions consistent with Xu *et al.* (2002) & Xie *et al.* (2002)

(new test for more than 50% of models)

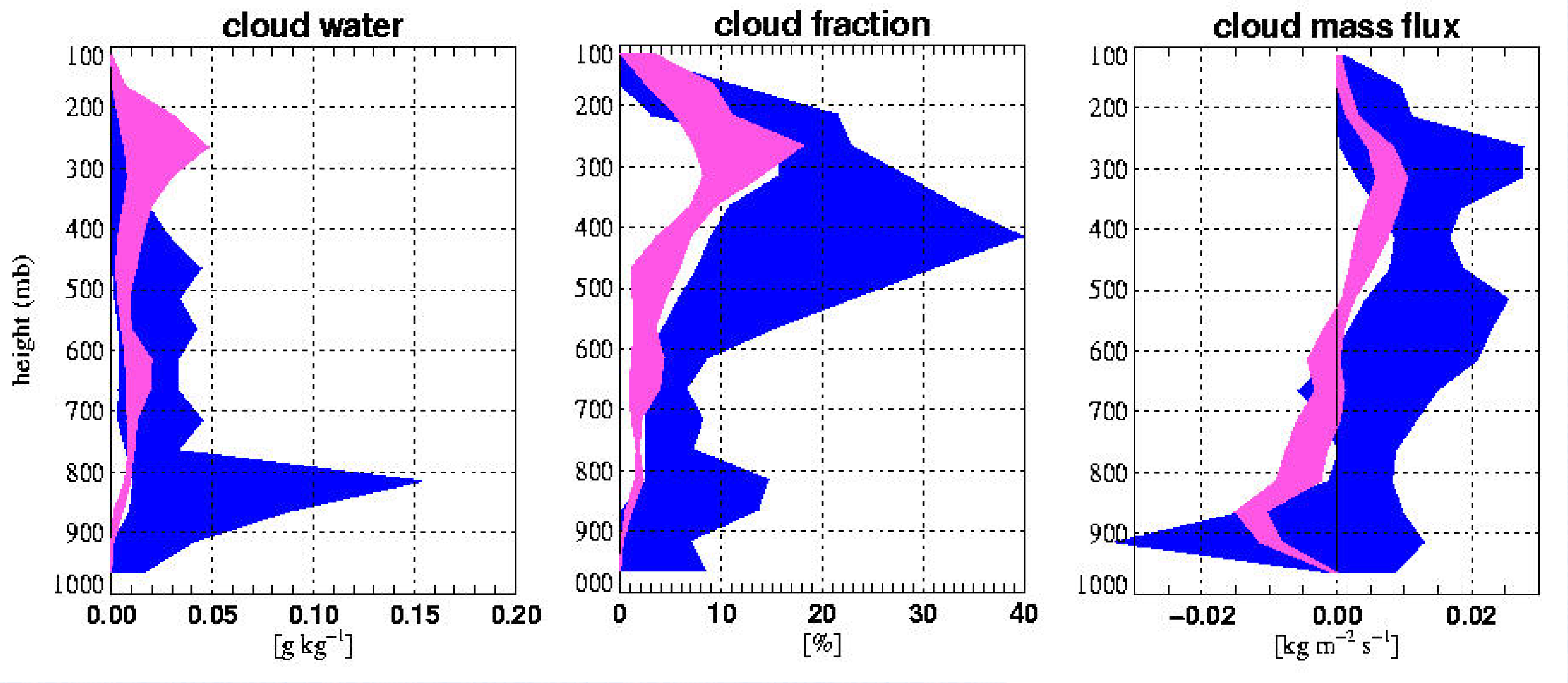
an example : comparison with obs, min-max envelope for **CRMs** & **SCMs**



➢ *better agreement & less scatter among CRM results that SCM ones*

comparison CRMs & SCMs

(parameters for which direct observations are not available)



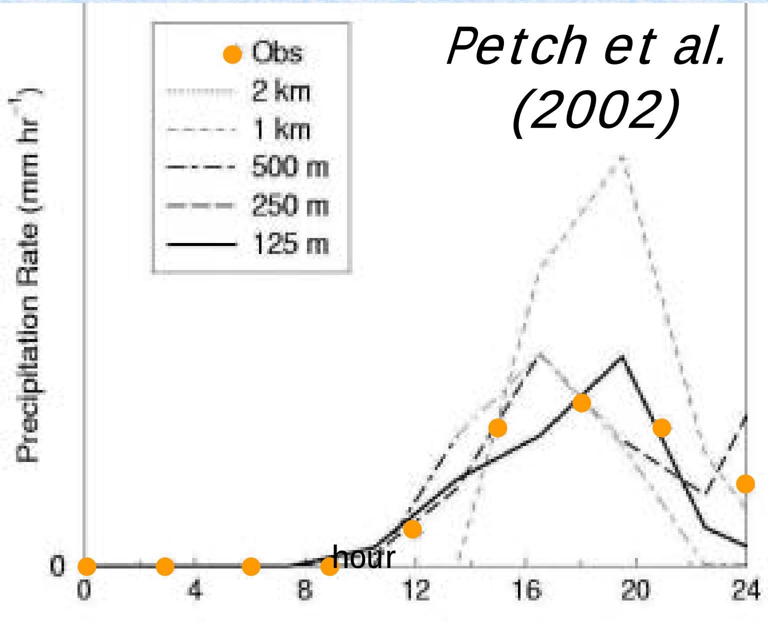
- *obviously room for CRMs improvements (« cold » microphysics)*
- *however much more consistency among CRMs than SCMs*
- *very weak convective downdraughts in several SCMs*

comments

for CRMs

importance of the resolution and of the representation of subgrid-scale processes

➢ ***because the good representation of boundary layer processes is essential for this issue***



SCMs & GCMs issues

complex interactions among parameterisations involved

➢ ***why convection occurs or not ? and how ?***

➢ ***identifying the major weaknesses to correct them in priority***

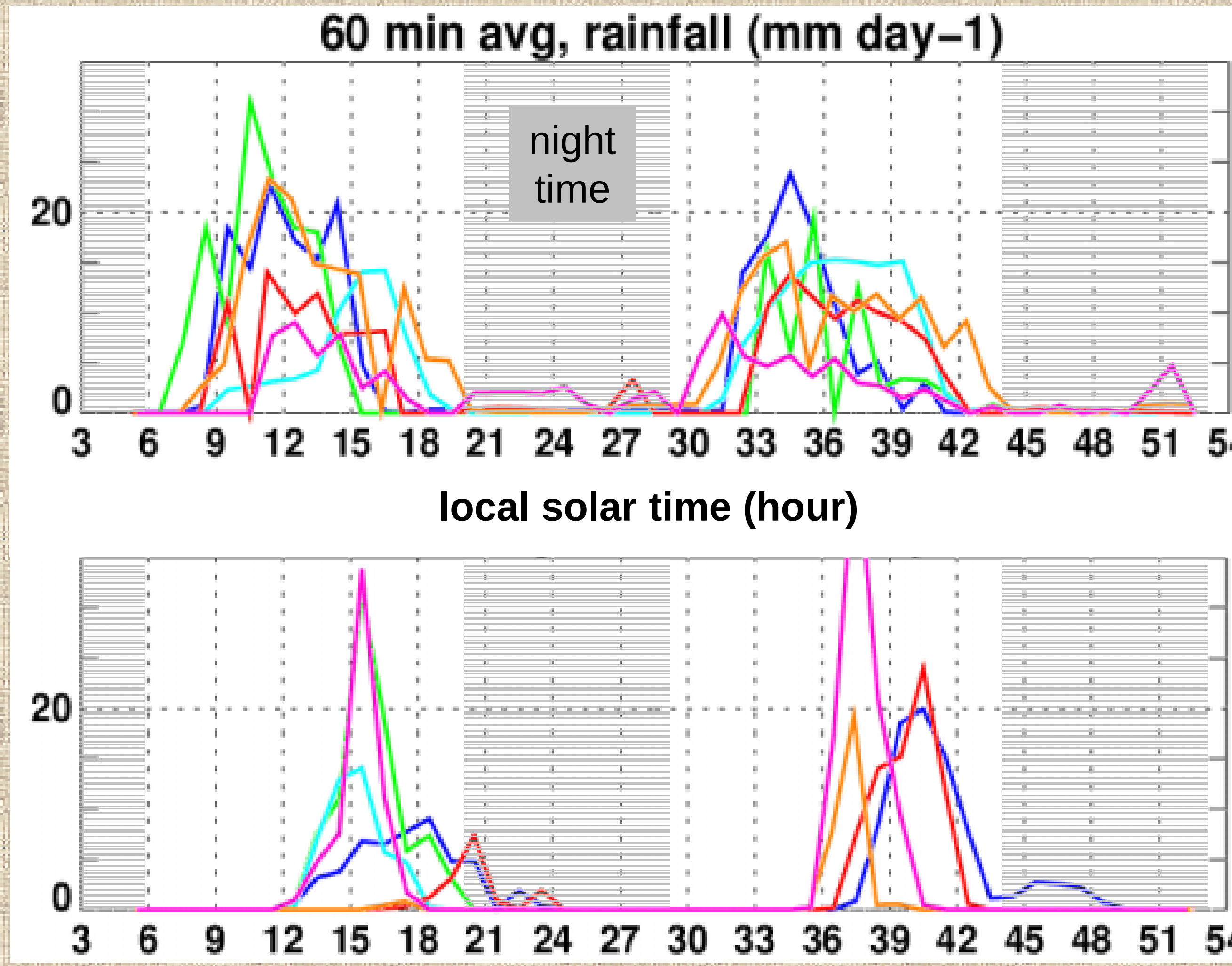
THE IDEALIZED CASE

similar type of framework as the 1st one:

✓ 27 Mai 1997 of GCSS case 3a repeated twice
(prescribed large-scale adv. & surface heat fluxes)

✓ starting in the morning instead of the evening

rainfall events tend to occurs earlier in SCMs than in CRMs

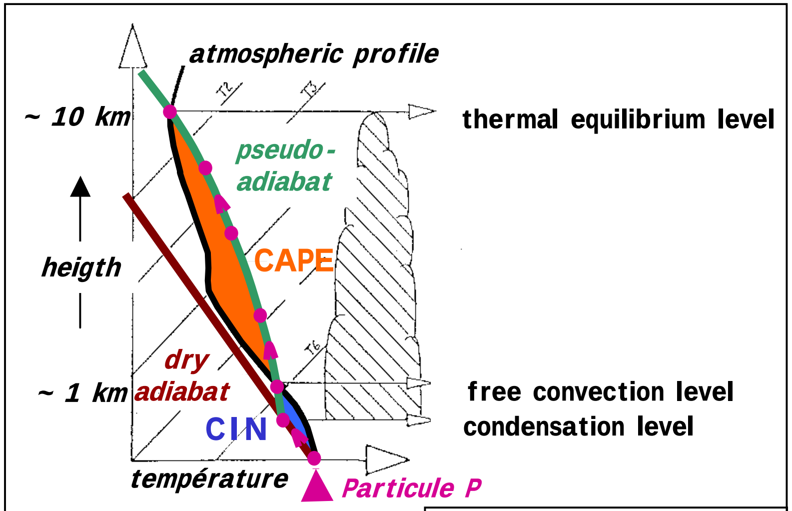


What are the main reasons accounting for these differences ? *(beginning)*

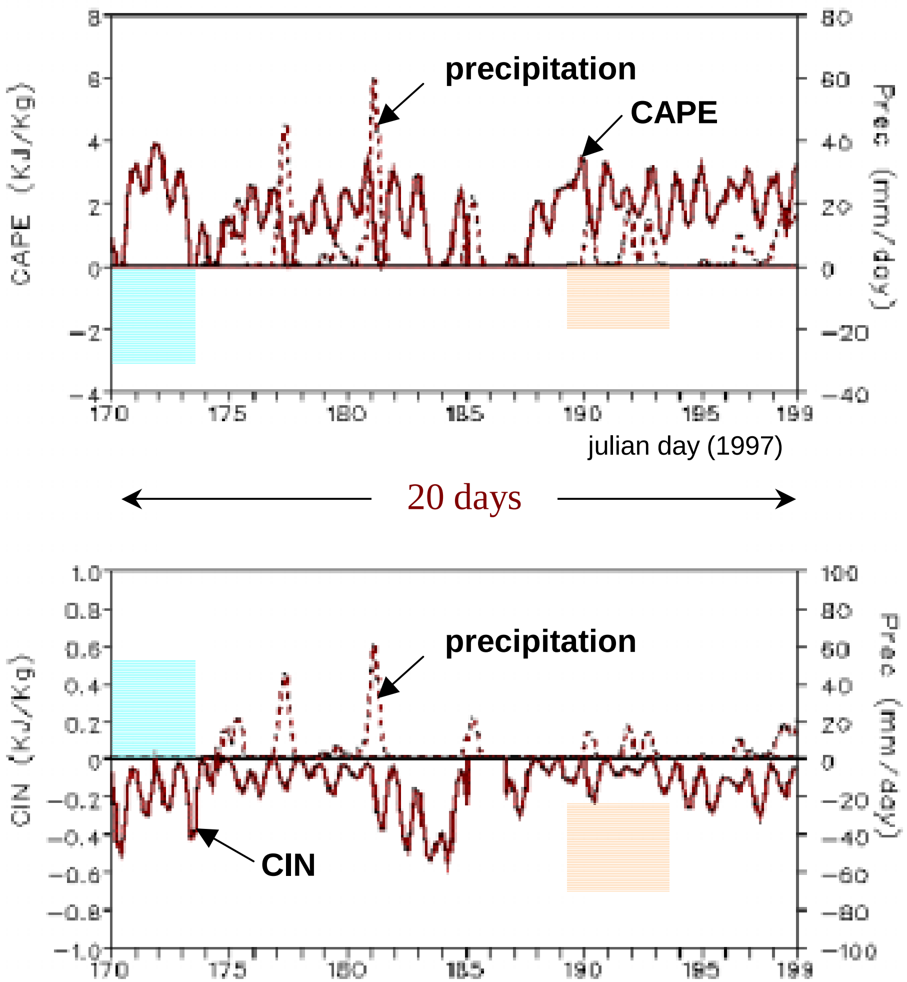
development of large CAPE
during daytime associated
with boundary layer evolution

by design, strong link with CAPE
in many parameterizations
(CAPE closure)

Not much account of CIN
in existing formulations



adapted from Roux (1991)

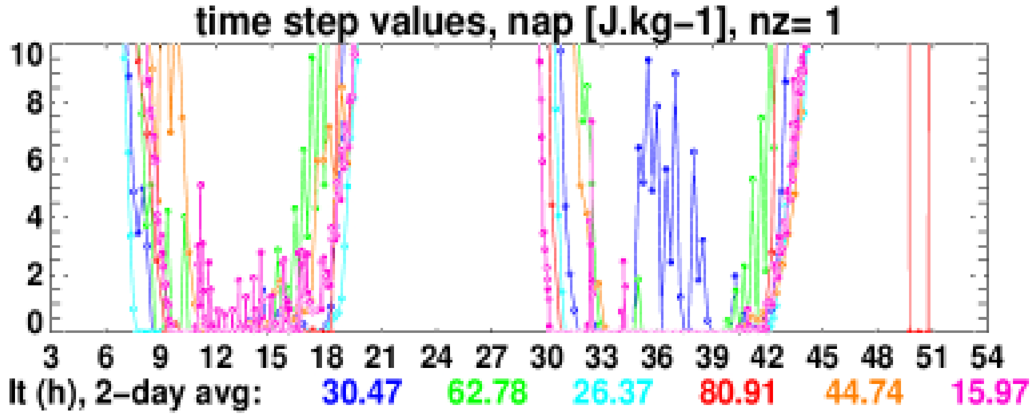


values derived from observations
(Xie et al. 2001)

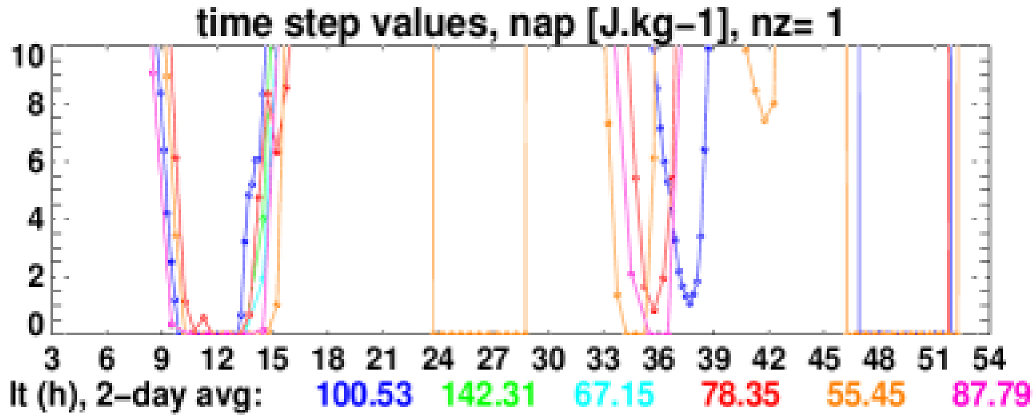
Convective Inhibition (CIN)

large fluctuations linked to the surface but

in SCMs



in CRMs

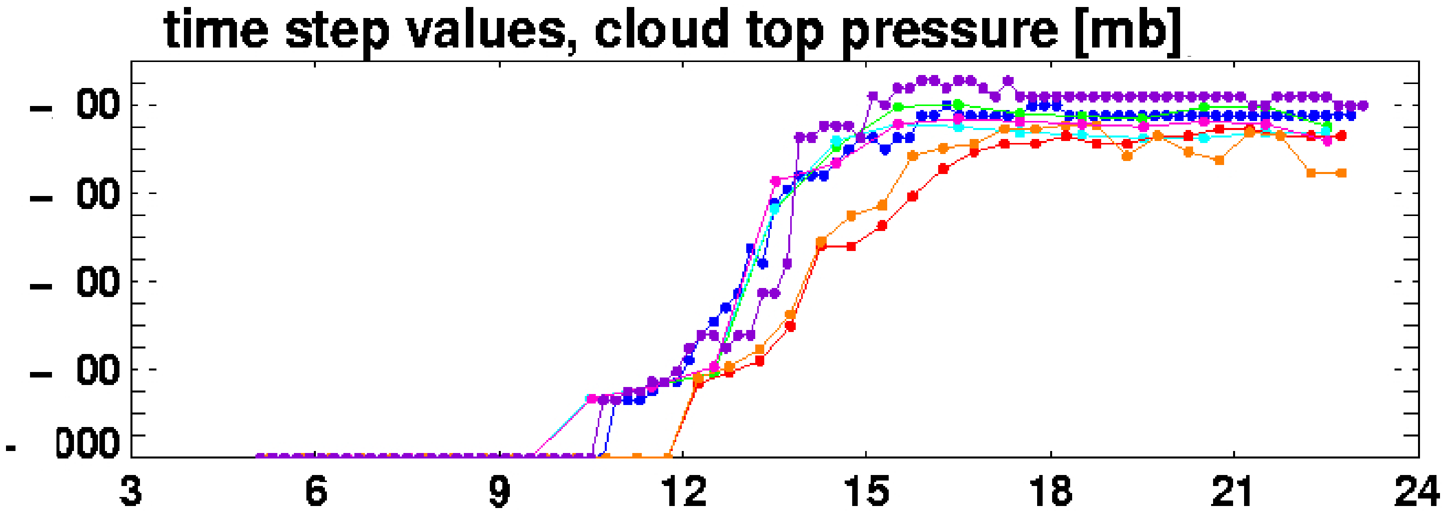


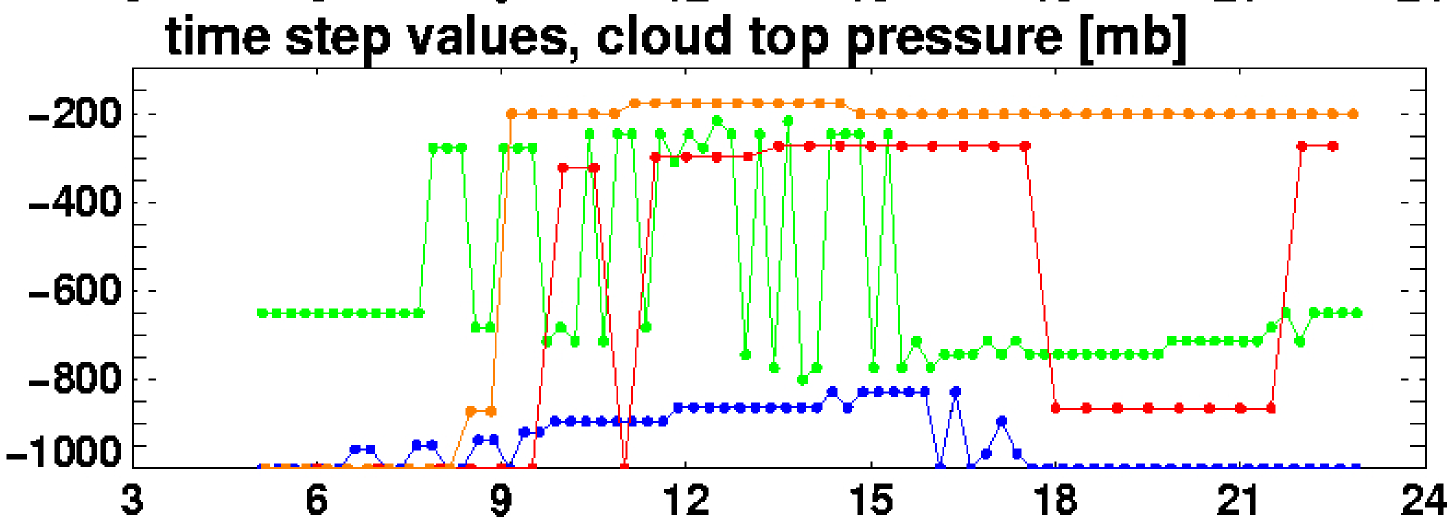
In CRMs, significant increase of CIN associated with deep convection

in SCMs, more largely controlled by the diurnal cycle of the surface
the impact of convection on CIN is too weak

What are the main reasons accounting for these differences ?

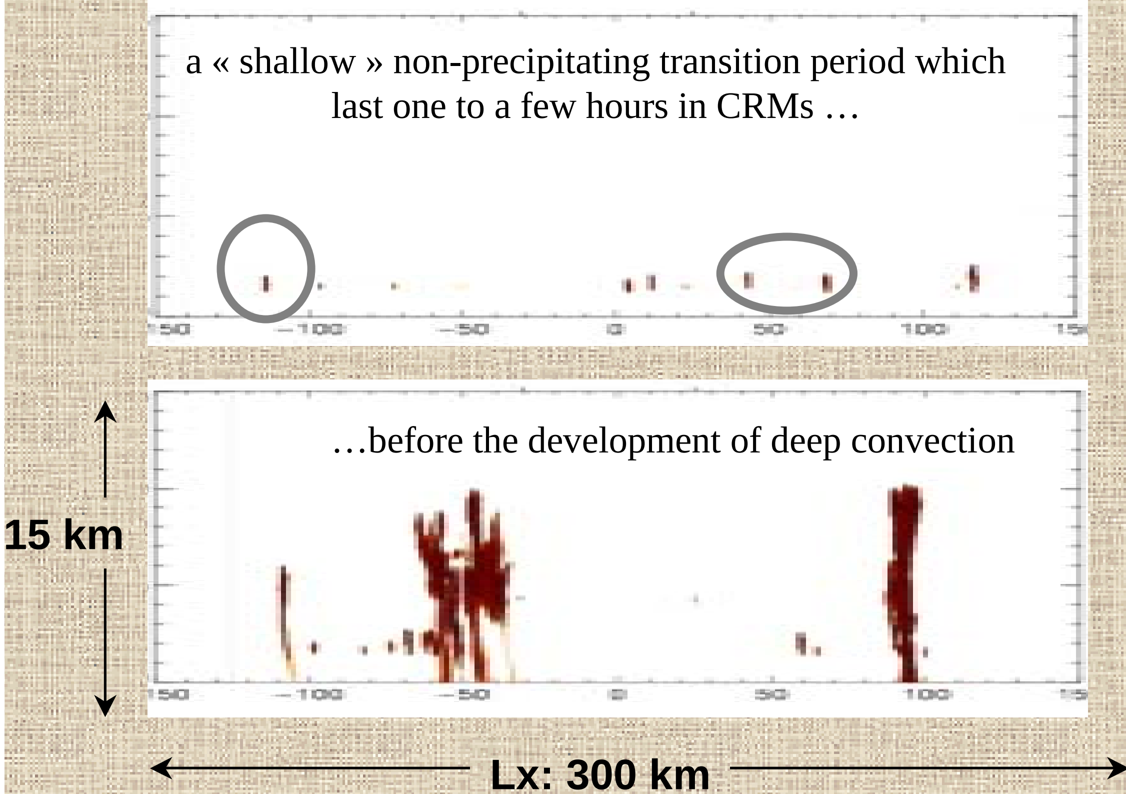
(continue)





What are the main reasons accounting for these differences ? *(continue)*

snapshots of cloud + rain water content in CRM run (UK UM CRM, Petch)



transition regime in CRMs, corresponding to the build up of convection: a feature « broadly coherent » with several previous observed studies

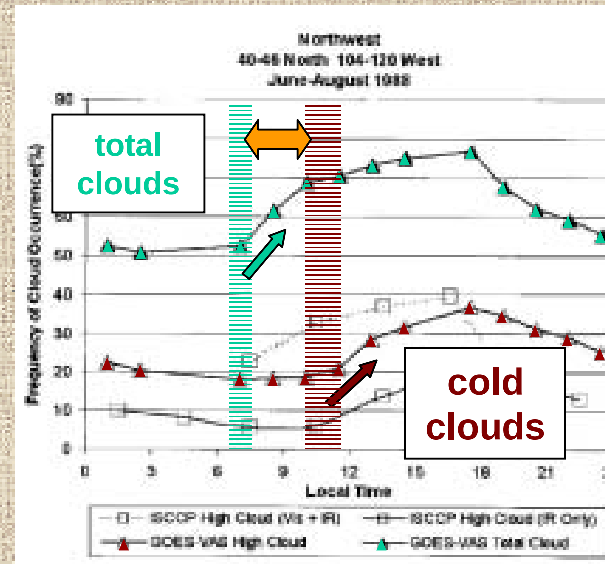


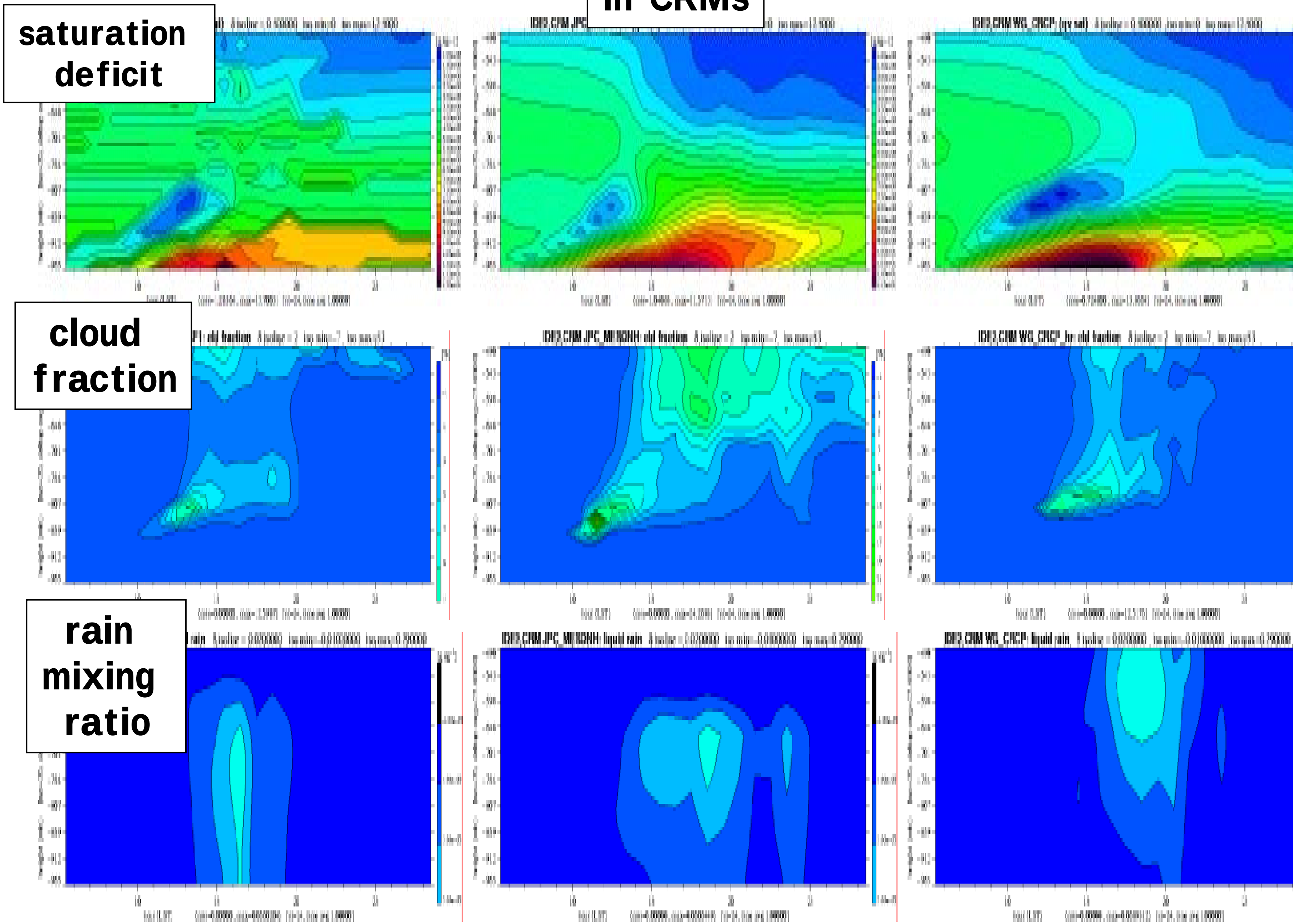
Fig. 4. The frequency of clouds in the northwestern United Stat during Jun–Aug 1988.

Wylie & Woolf (2002)

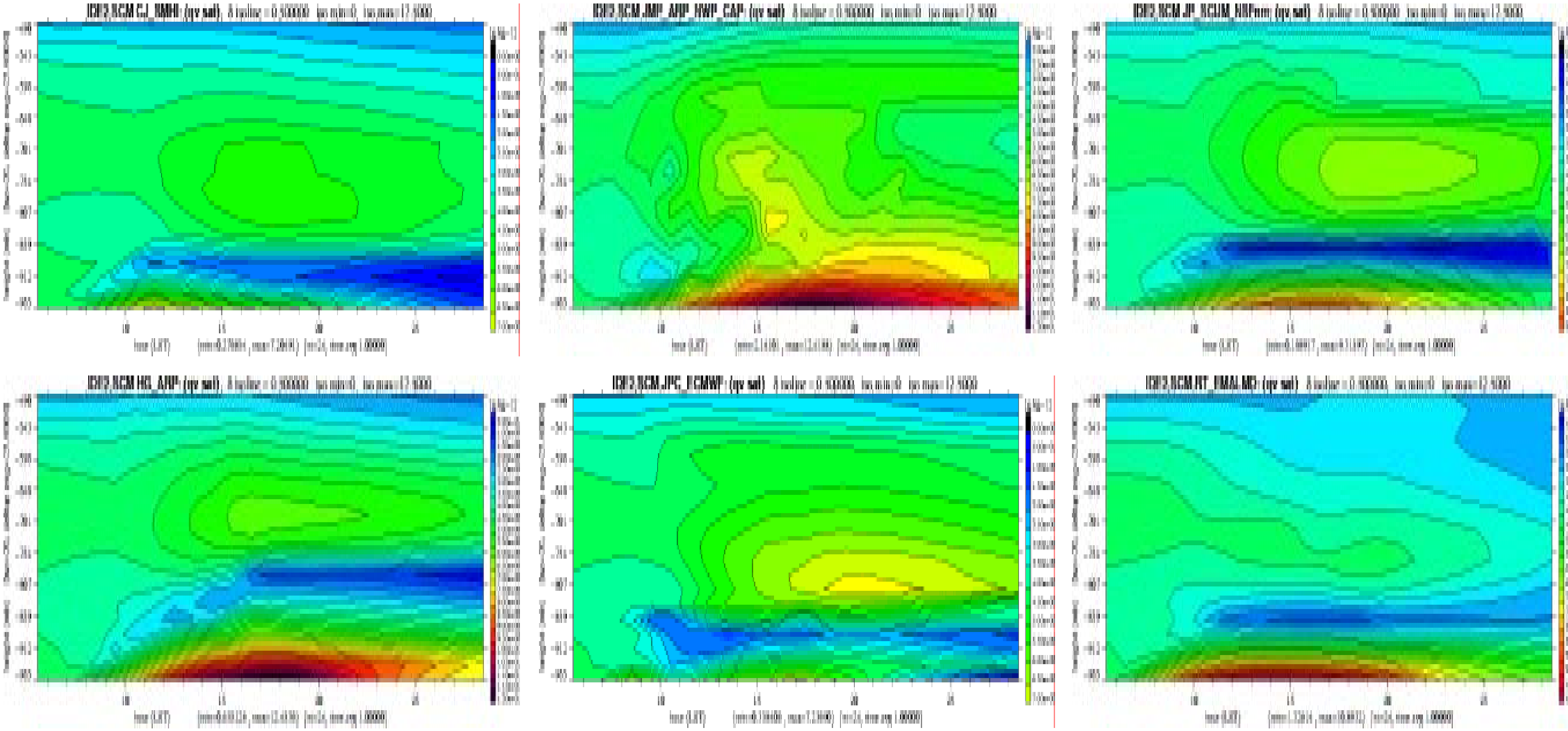
which factors control the lenght of this phase?

role of buoyancy, wind shear, moisture…

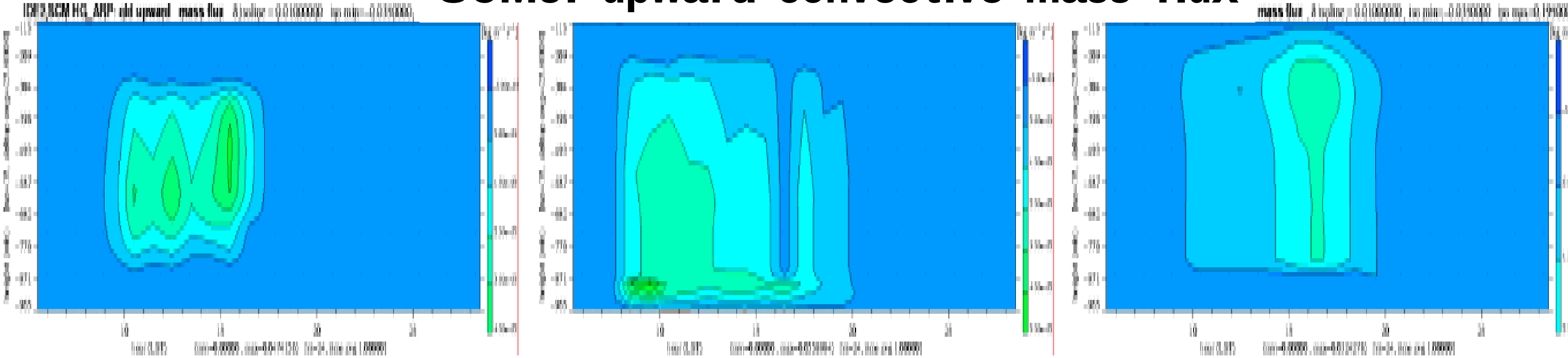
in CRMs



SCMs: saturation deficit



SCMs: upward convective mass flux



Chaboureau, Bechtold,
Köhler, Beljaars, *et al.*

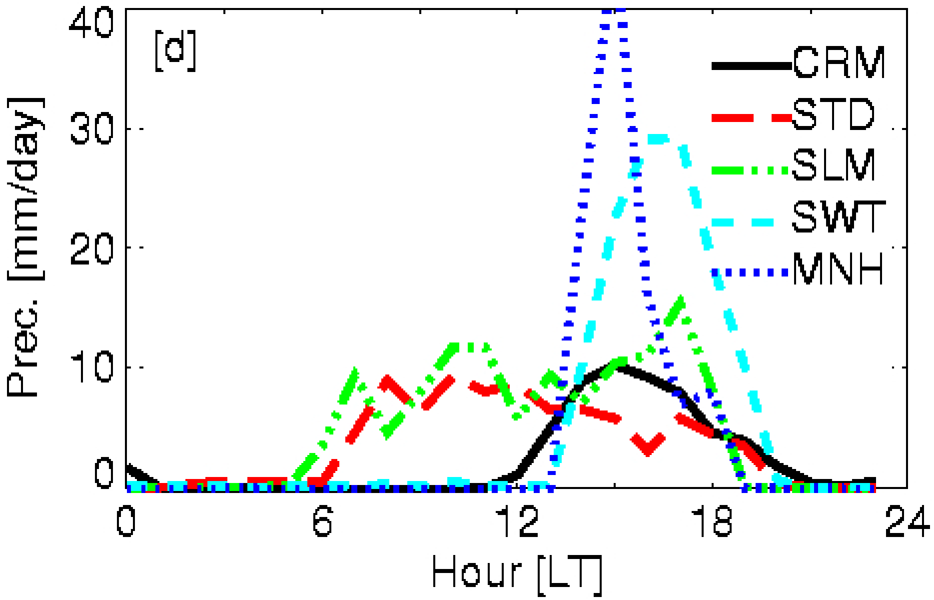
ECMWF GCM

formulation of the **trigger function**
adding a representation of local subgrid-scale forcing

(correct representation of shallow convection required)

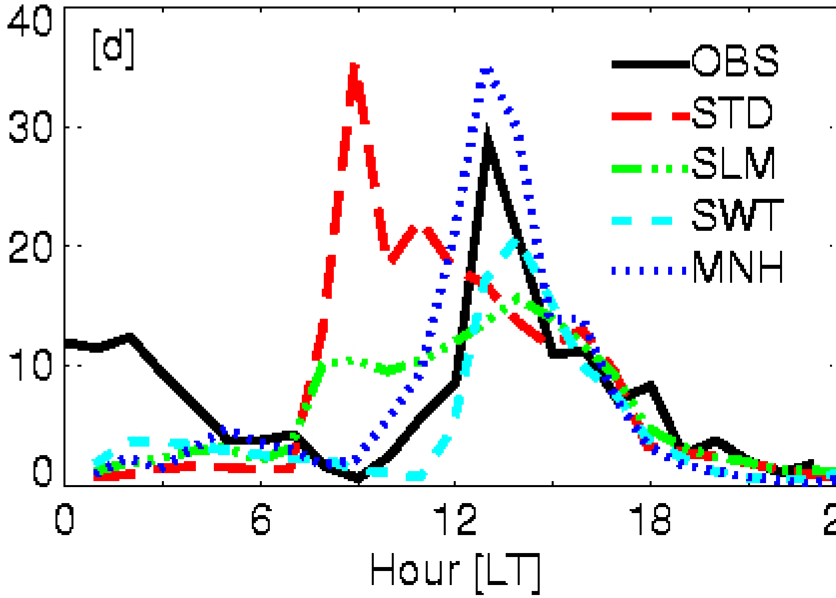
1D column mode

idealized EUROCS case
(4-day composite)



3D mode (i.e.; full GCM)

Rhodonia, Amazonia
(1-month composite)



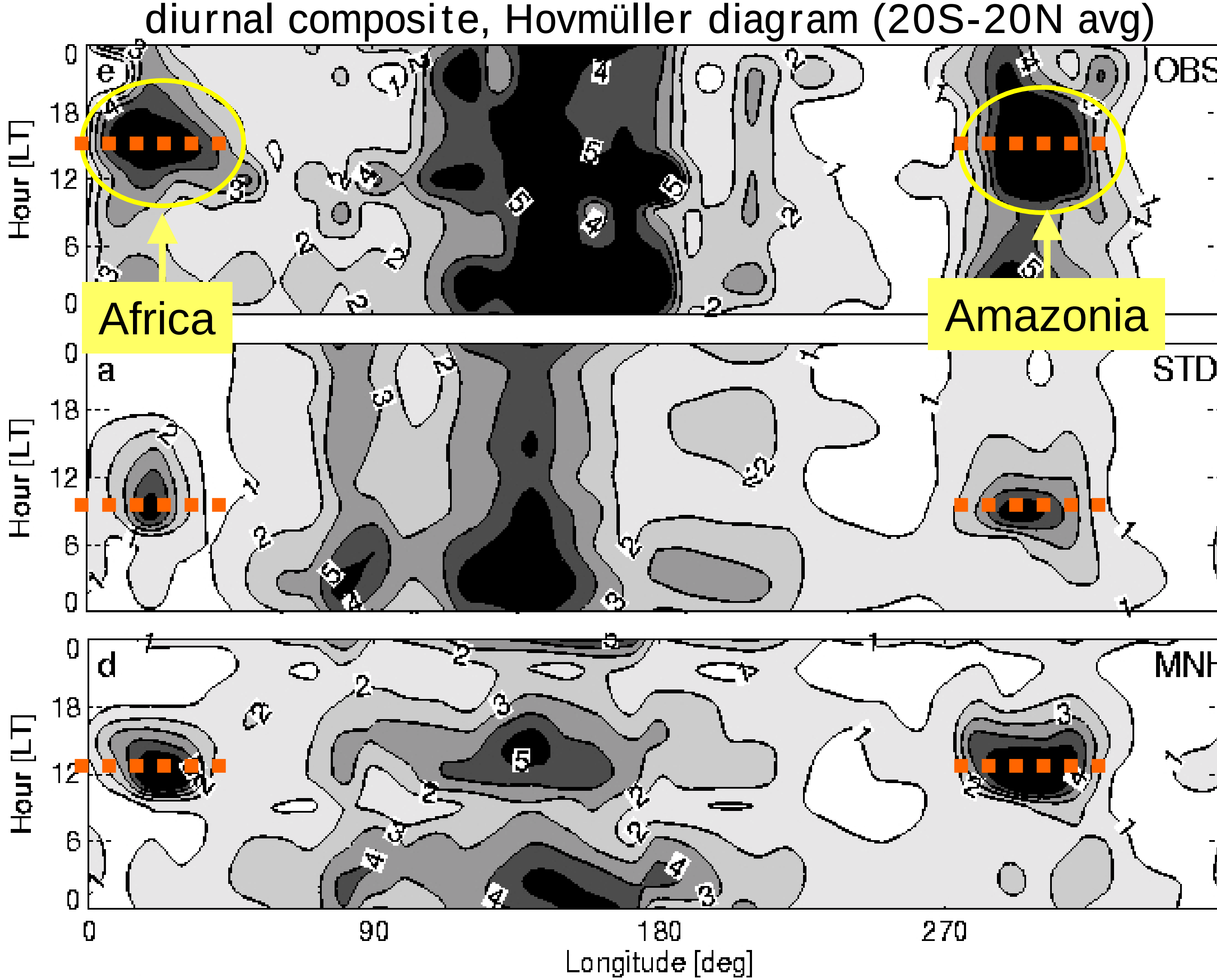
Chaboureau, Bechtold, Köhler, Beljaars *et al.*

diurnal cycle of rainfall in the Tropics

OBS Feb 1999 (TRMM data)

ECMWF GCM Standard Feb 1999

ECMWF GCM Modified Feb 1999



CONCLUSION, PERSPECTIVES

✓documentation of GCMs & RCMs weaknesses/diurnal cycle of deep convection

✓assess CRMs/SCMs over land with GCSS/ARM case

✓design an idealized case to address the problem

and it worked! i.e., deep convection occurs earlier than observed in many SCMs runs (consistent with results of GCMs)

✓better results/consistency among CRMs than SCMs

(T & q, cloud parameters: agreement with previous studies)

✓CRM runs : the treatment of the BL is crucial

increased horizontal resolution &/or subgrid-scale processes raising issues concerning the gap between shallow and deep convection (numerical investigation)

✓SCM runs: identifying the major weknesses & testing modifications

- no succession of dry-shallow-deep regimes in SCMs, dry to deep directly
- sensitivity to the triggering criteria
- distinct diurnal cycle of stability in CRMs & SCMs (weak param. downdrafts)

✓ improvement of GCMs

- first results quite successfull, ongoing activity & more need to be done