EUROCS in retrospect

Jean-Luc Redelsperger
&
Françoise Guichard

Centre National de Recherche en Météorologie
CNRS & Météo-France
Toulouse, France

EUROCS: EUROPEAN PROJECT on CLOUD SYSTEMS IN NWP/CLIMATE MODELS

http://www.cnrm.meteo.fr/gcss/

- Major European Component of GCSS (GEWEX cloud system studies) concentrating on basic problems of cloud representation in NWP & climate models
- Funded on 3 years (2000-2003) by EC and National Institutions
- 10 European groups

CNRM/GAME (France) (Coordinator)
ECMWF European Centre for Medium-range Weather Forecasts
INM Instituto Nacional de Meteorologia (Spain)
LMD Laboratoire de Météorologie Dynamique (France)
MPI Max-Planck-Institut fuer Meteorologie (Germany)
MO Meteorological Office (UK)
KNMI Royal Netherlands Meteorological Institute (Netherlands)
SMHI Swedish Meteorological and Hydrological Institute (Sweden)
University of Lisbon (Portugal)
University of Utrecht/IMAU (Netherlands)

- Special QJRMS Issue (Summer 2004)

EUROCS Outlines

- A strategy based on model hierarchy & observations
- A consortium linking the cloud modelling European community
- Issues chosen by European GCM groups

  (*versus* choices issued from the LES/CRM community)

  - Boundary layer clouds *(2 cases; Leaders: Duynkerke & , De Roode, Siebesma & Lenderink)*
  - Precipitating Deep convective Clouds

    (2 cases; Leaders: Derbyshire, Guichard & Petch)
  - Pacific case *(Leaders: Siebesma & Jakob)*

EUROCS: BASIC CLOUD PROBLEMS

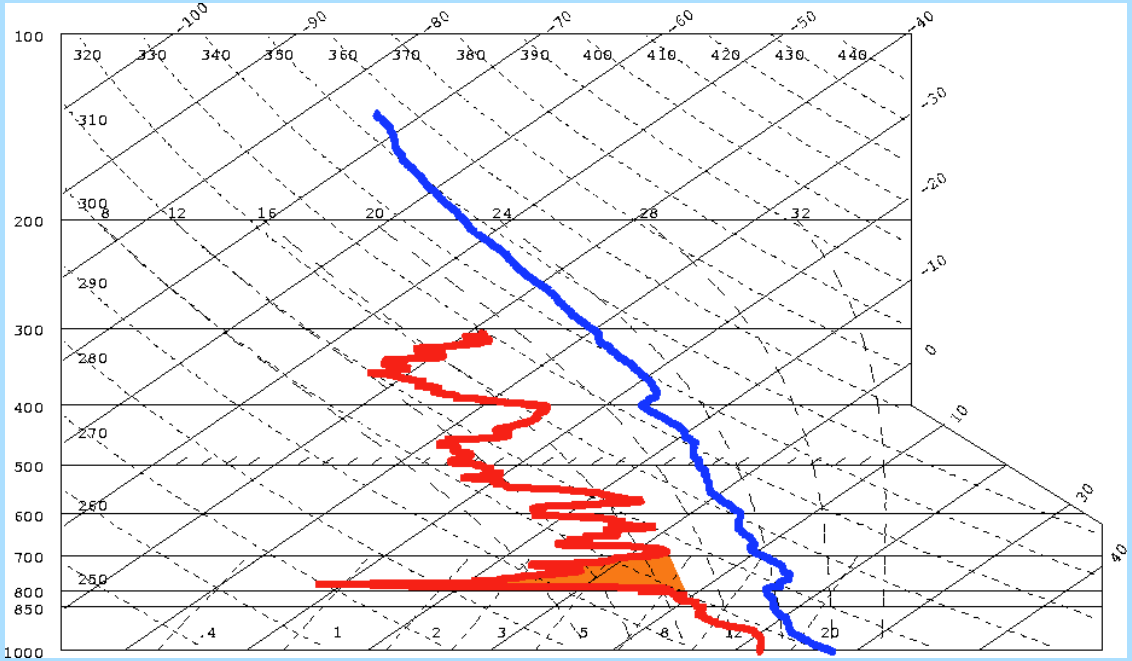
PRECIPITATING DEEP CONVECTIVE CLOUDS

sensitivity of cloud development and transports to mid-tropo. humidity

dry layers often observed in the tropical mid-troposphere
advection from deserts, Stratospheric air intrusions, … :
TOGA-COARE, CEPEX, INDOEX, JET2000…

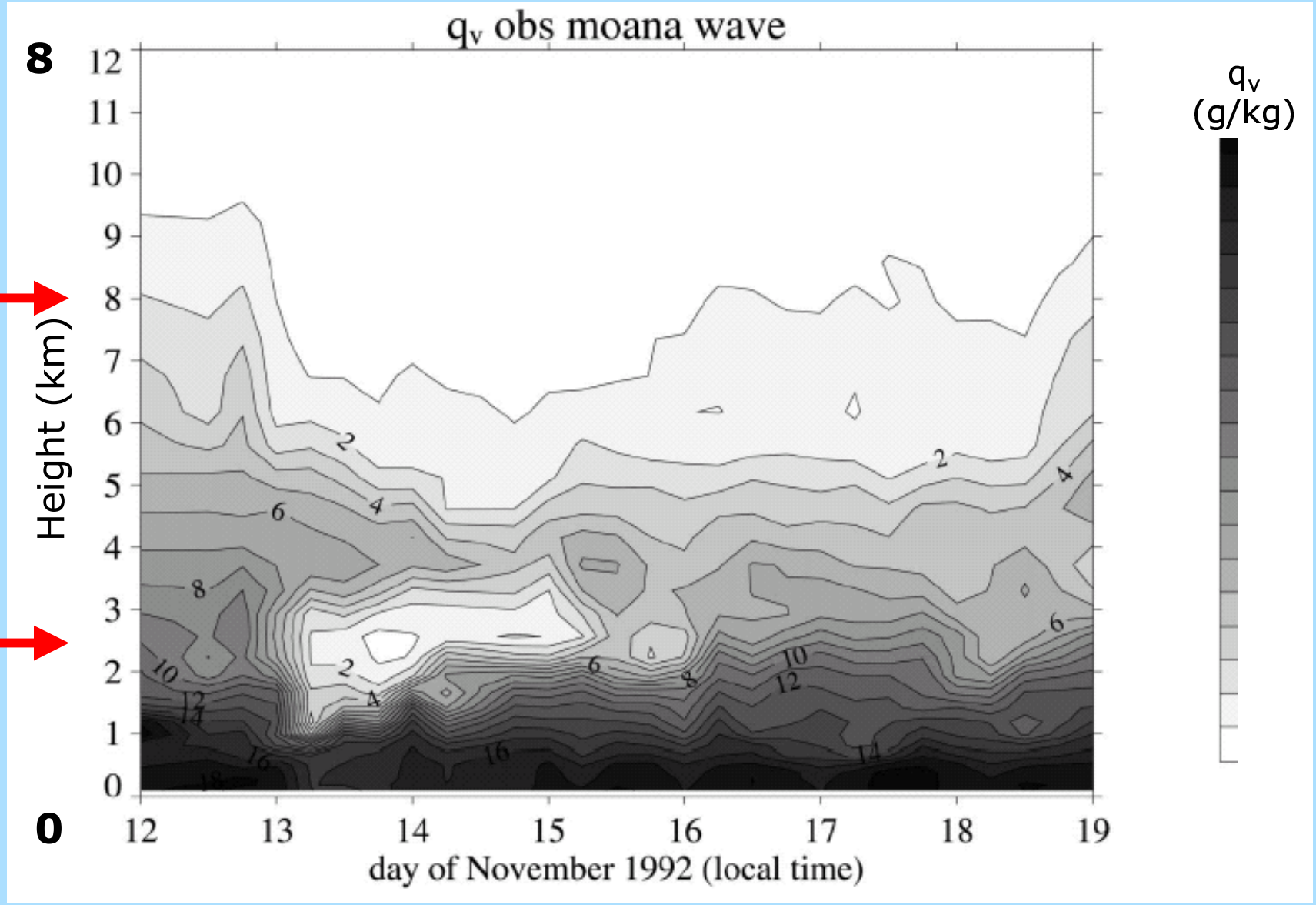
Importance:

- suppressed or reduced convective periods (link to MJO),
- precipitating shallow convection mostly present over Warm Pool,
- downdraft intensity, …



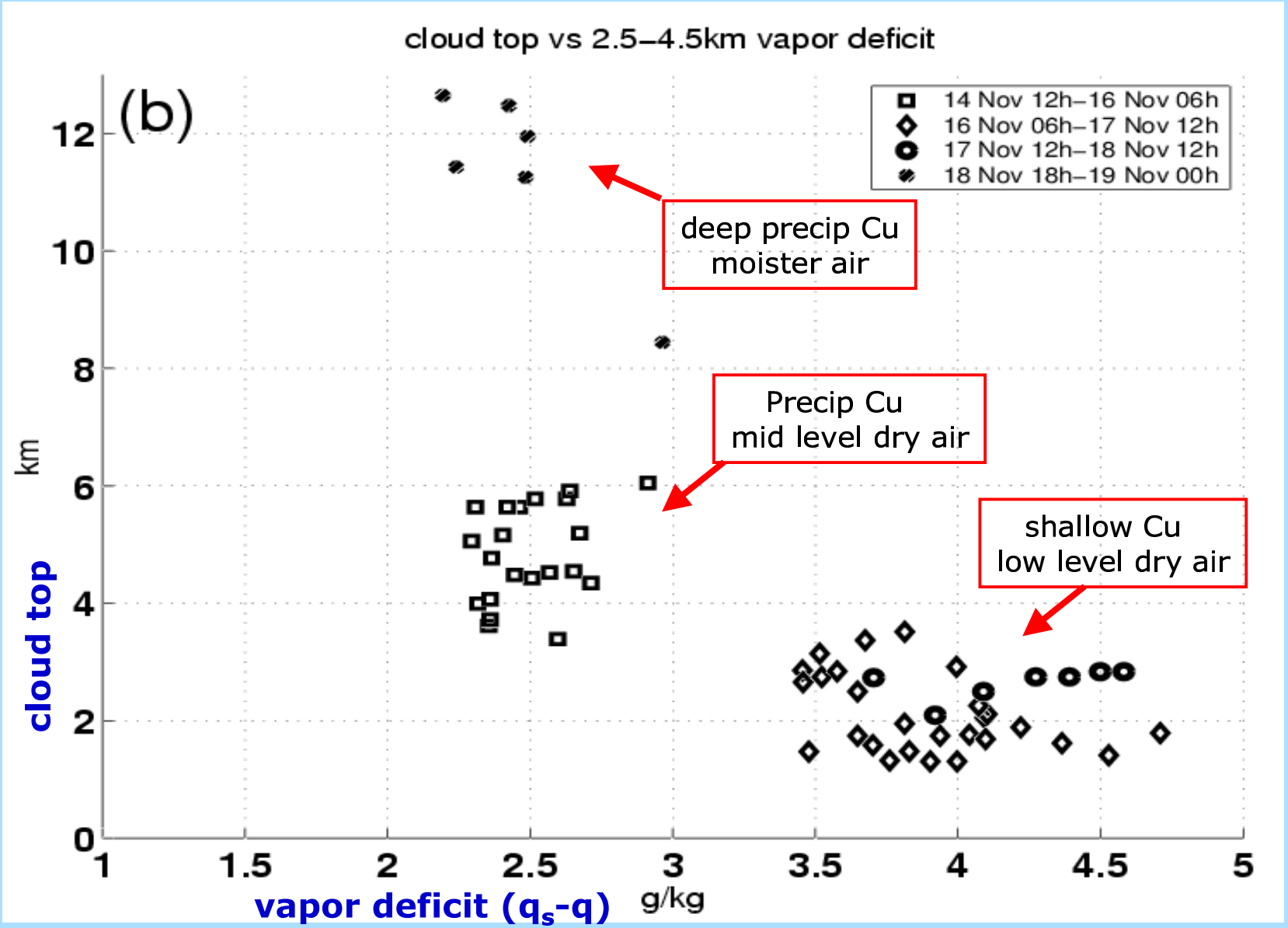
Redelsperger JL, F. Guichard
GTP NCAR Workshop

dry air intrusions observed over the warm pool



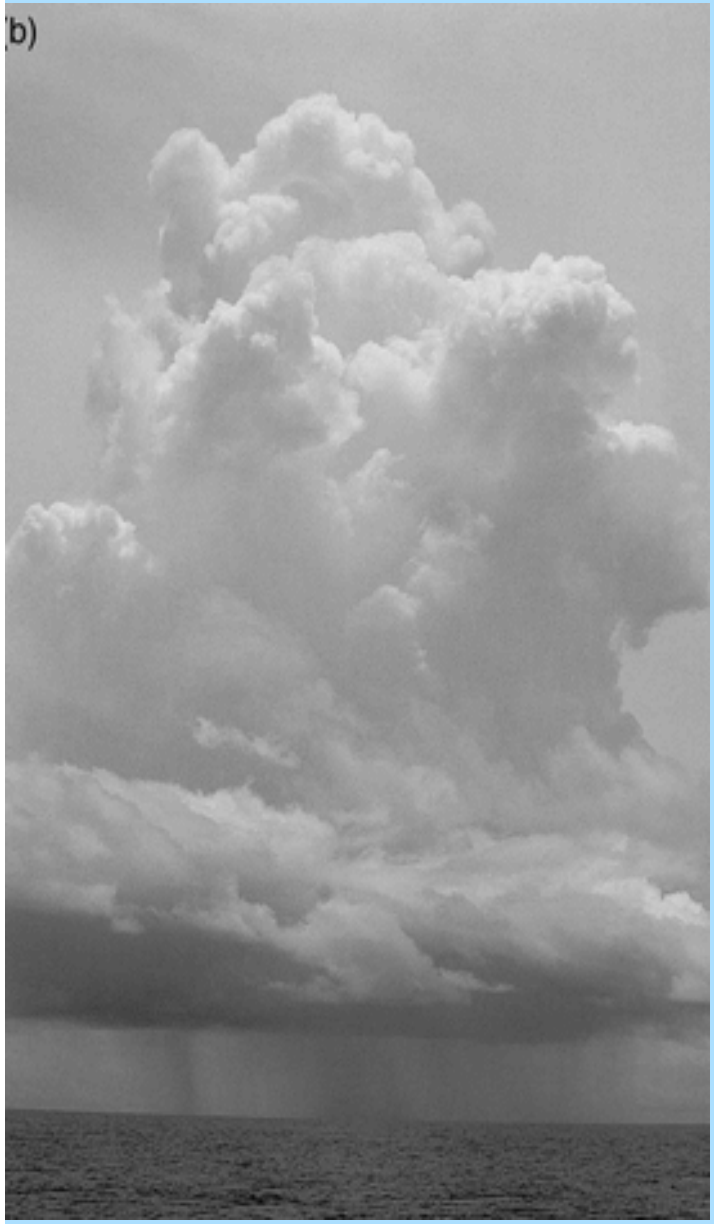
Redelsperger, Parsons, Guichard (JAS 2002)

Relationship between dry air & cloud top (TOGA-COARE)

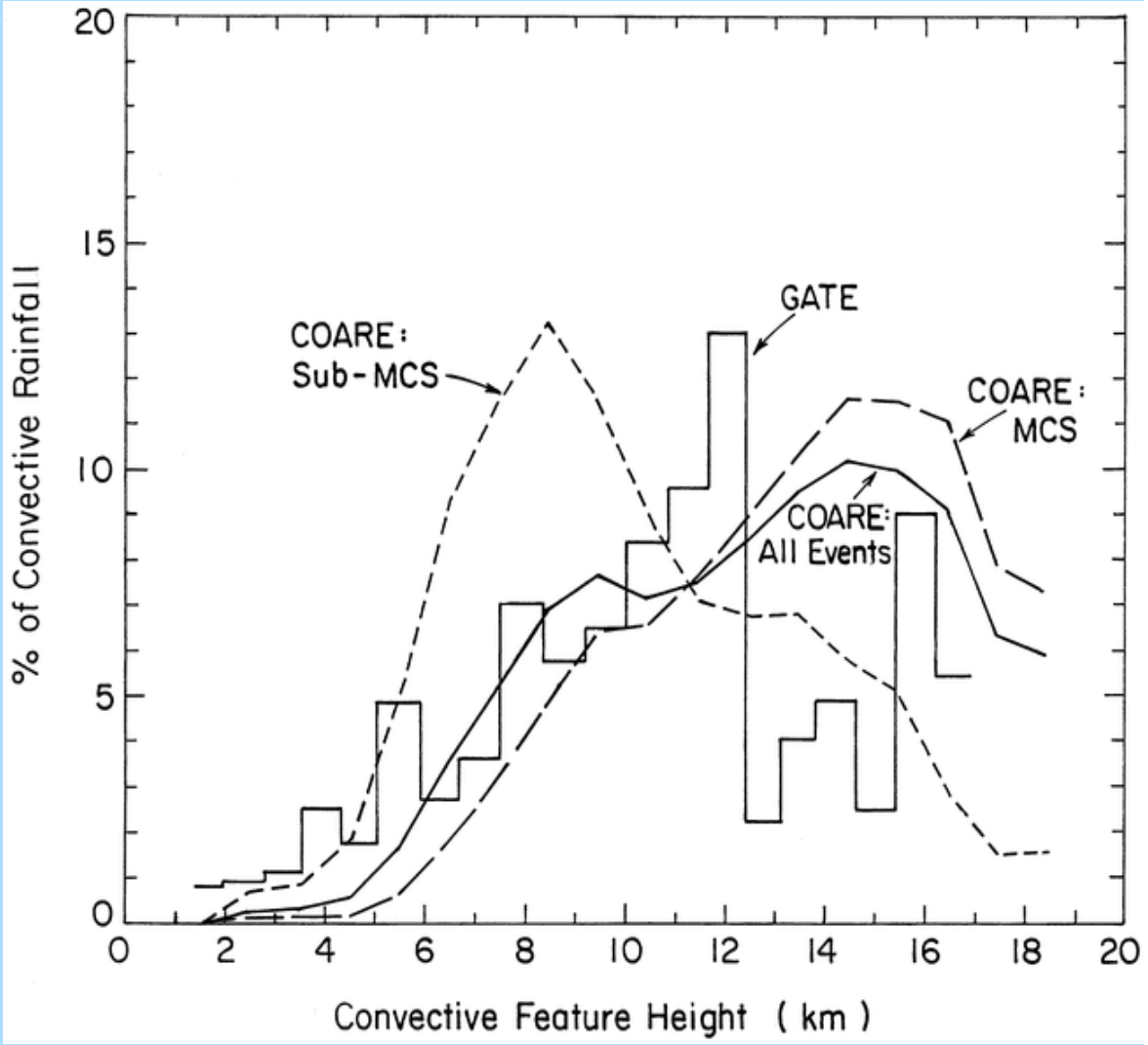


Redelsperger, Parsons, Guichard (JAS 2002)

TOGA-COARE: dominance of precipitating Cu Congestus



(Johnson et al 1999)



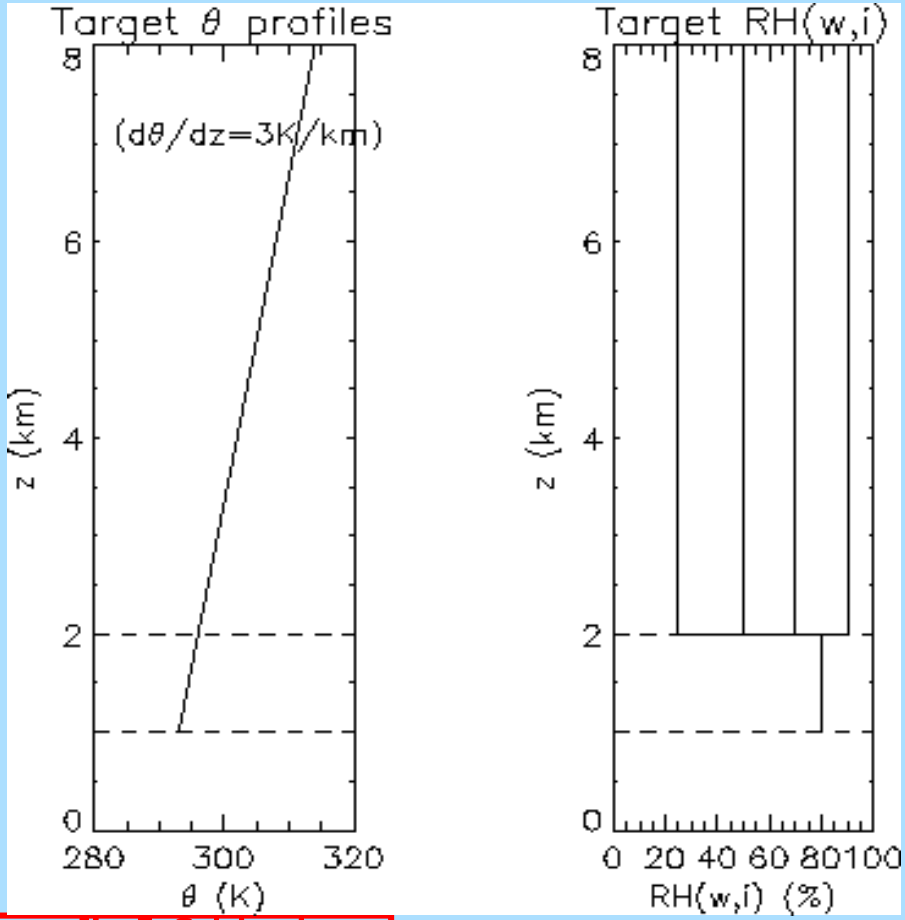
EUROCS: BASIC CLOUD PROBLEMS

PRECIPITATING DEEP CONVECTIVE CLOUDS

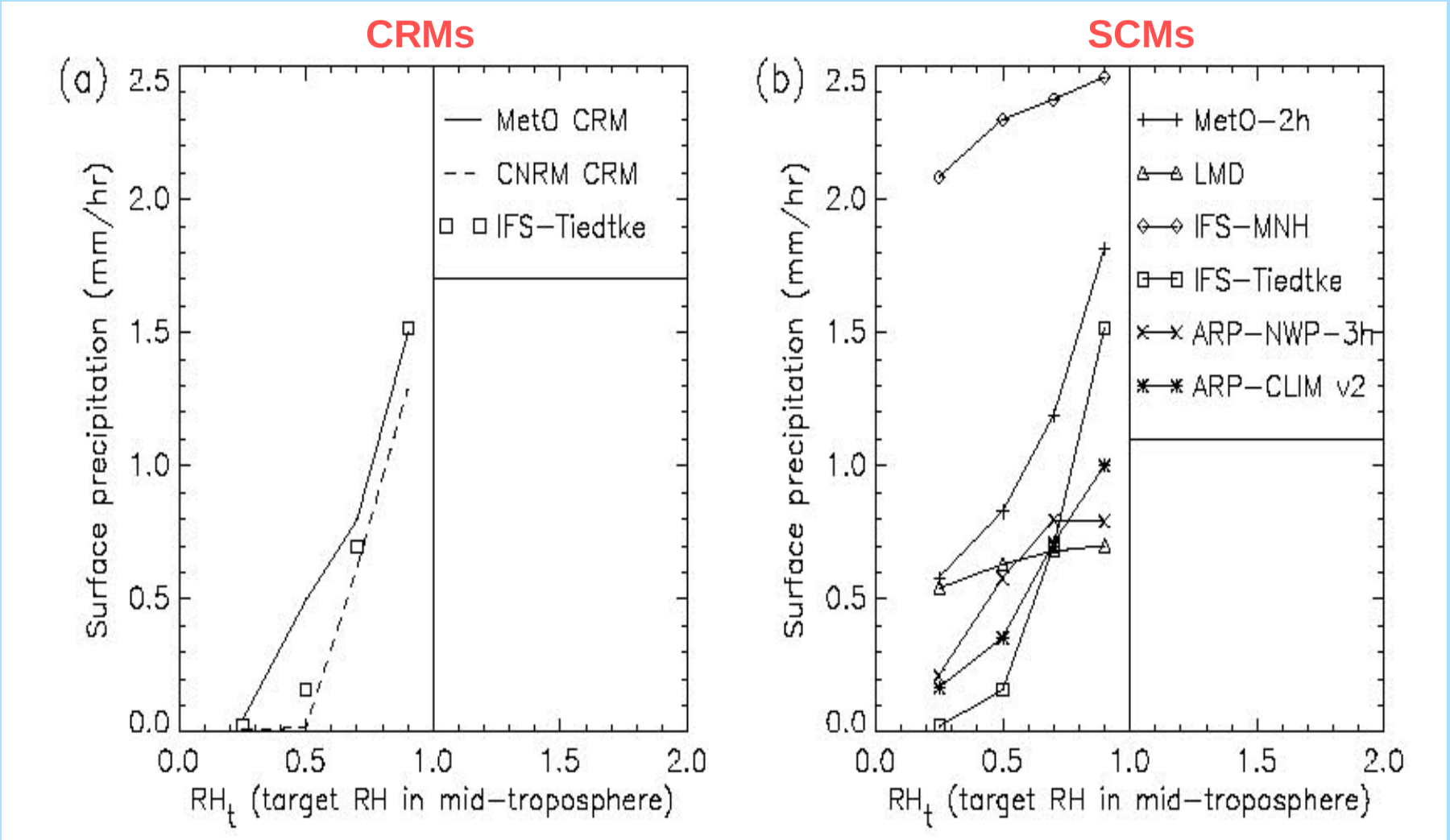
- sensitivity humidity of cloud development and transports to mid-troposphere

Case Leader: S. Derbyshire

simple idealized case analysis of quasi-steady responses to different background profiles of RH



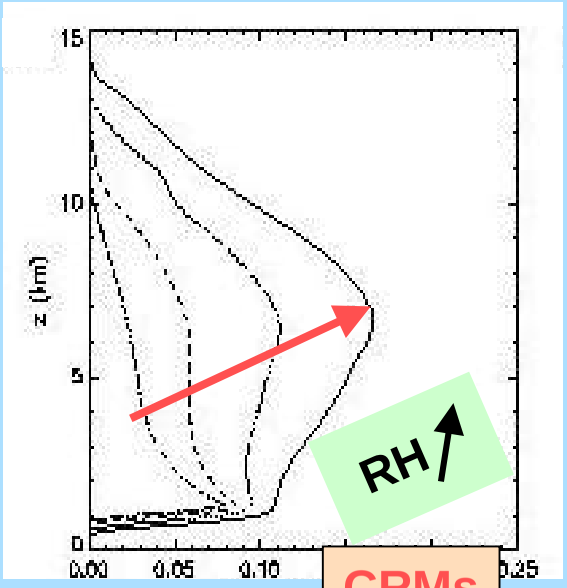
Surface precipitation rates as function of RH



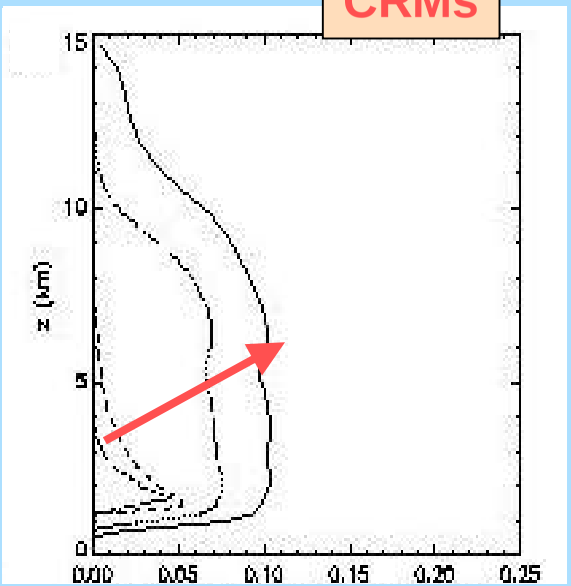
Derbyshire et al.

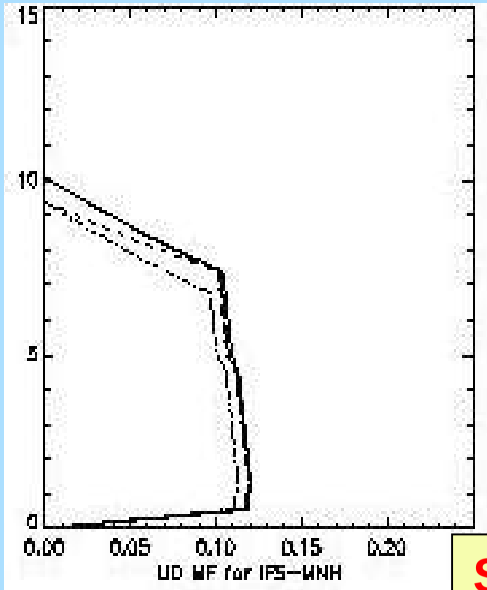
(EUROCS QJ 2004)

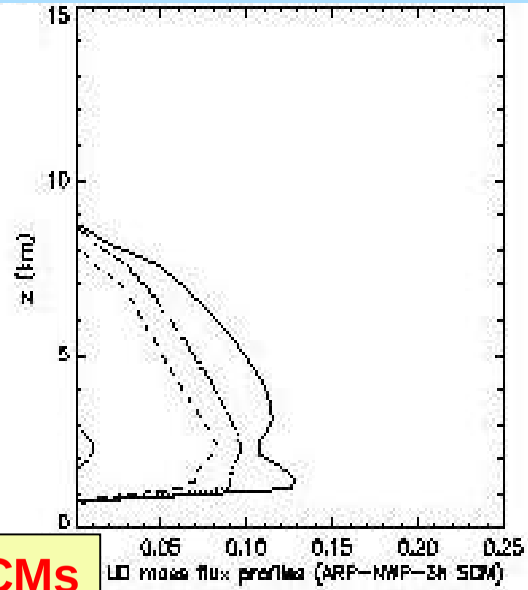
Upward convective mass flux



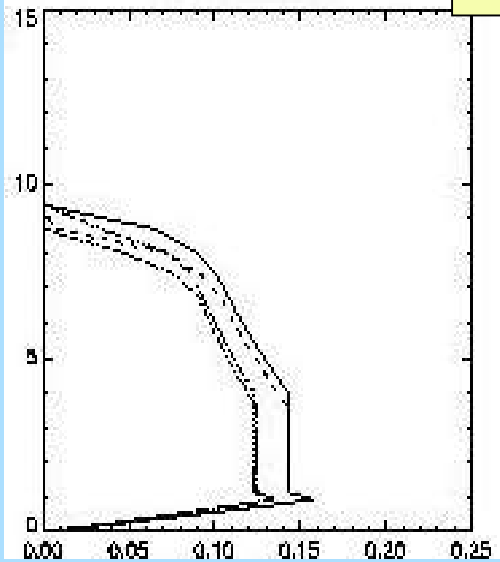
CRMs

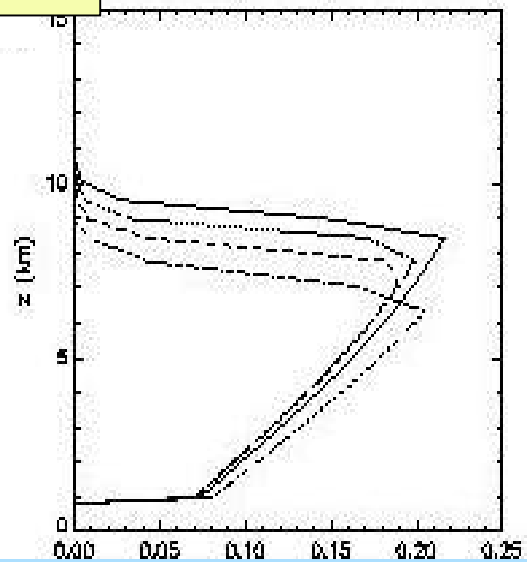






SCMs

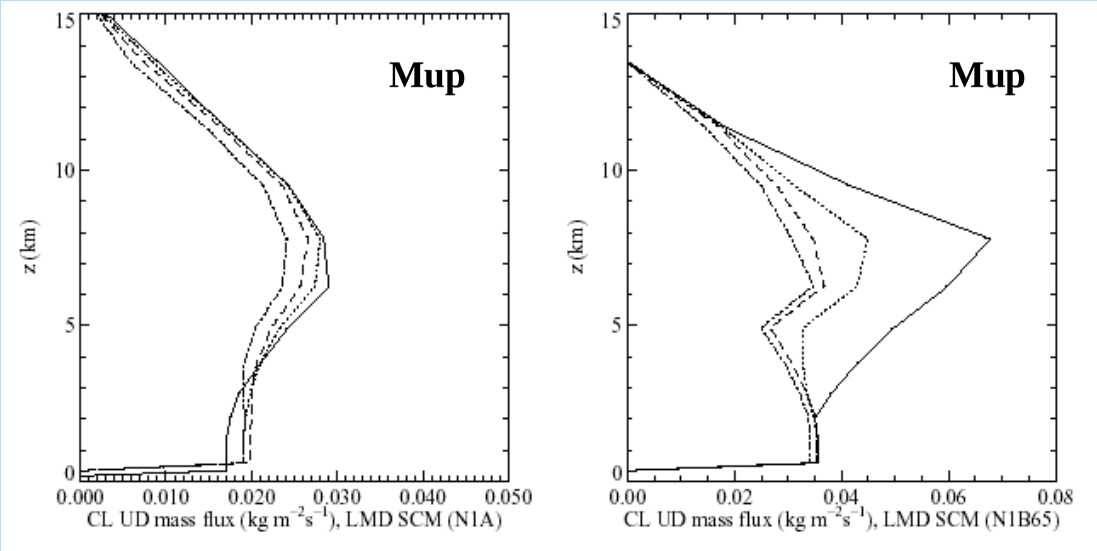




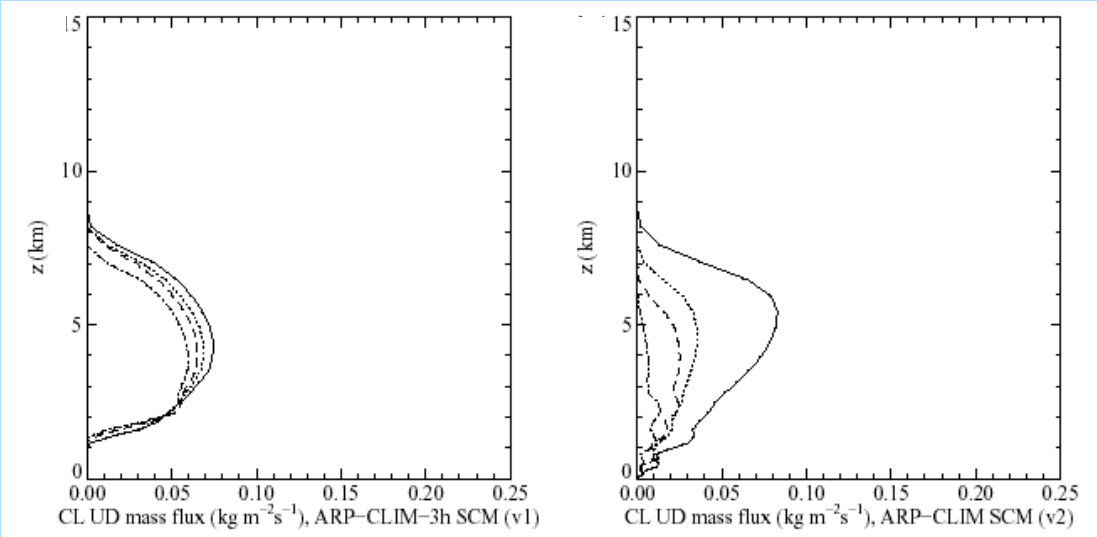
Derbyshire et al. (EUROCS QJ 2004)

Exemple of improvement: PDF for mixing fraction in Emanuel scheme LMD version

Grandpeix et al. (EUROCS QJ 2004)



New convection scheme in ARPEGE GCM Gueremy-Grenier



EUROCS: BASIC CLOUD PROBLEMS

PRECIPITATING DEEP CONVECTIVE CLOUDS

sensitivity of cloud development & transports to mid-tropo. humidity

- Current convective schemes exhibit dependency on humidity for rainfall but not for vertical redistribution (mass fluxes)

- Works currently carried out in SCM/GCMs (UKMO, LMD, ECMWF, CNRM) impacts on tropical circulation, e.g. improved African monsoon in LMD model (jump of monsoon)

- One week TOGA-COARE case study (dry intrusion) also ready to be run by SCMs

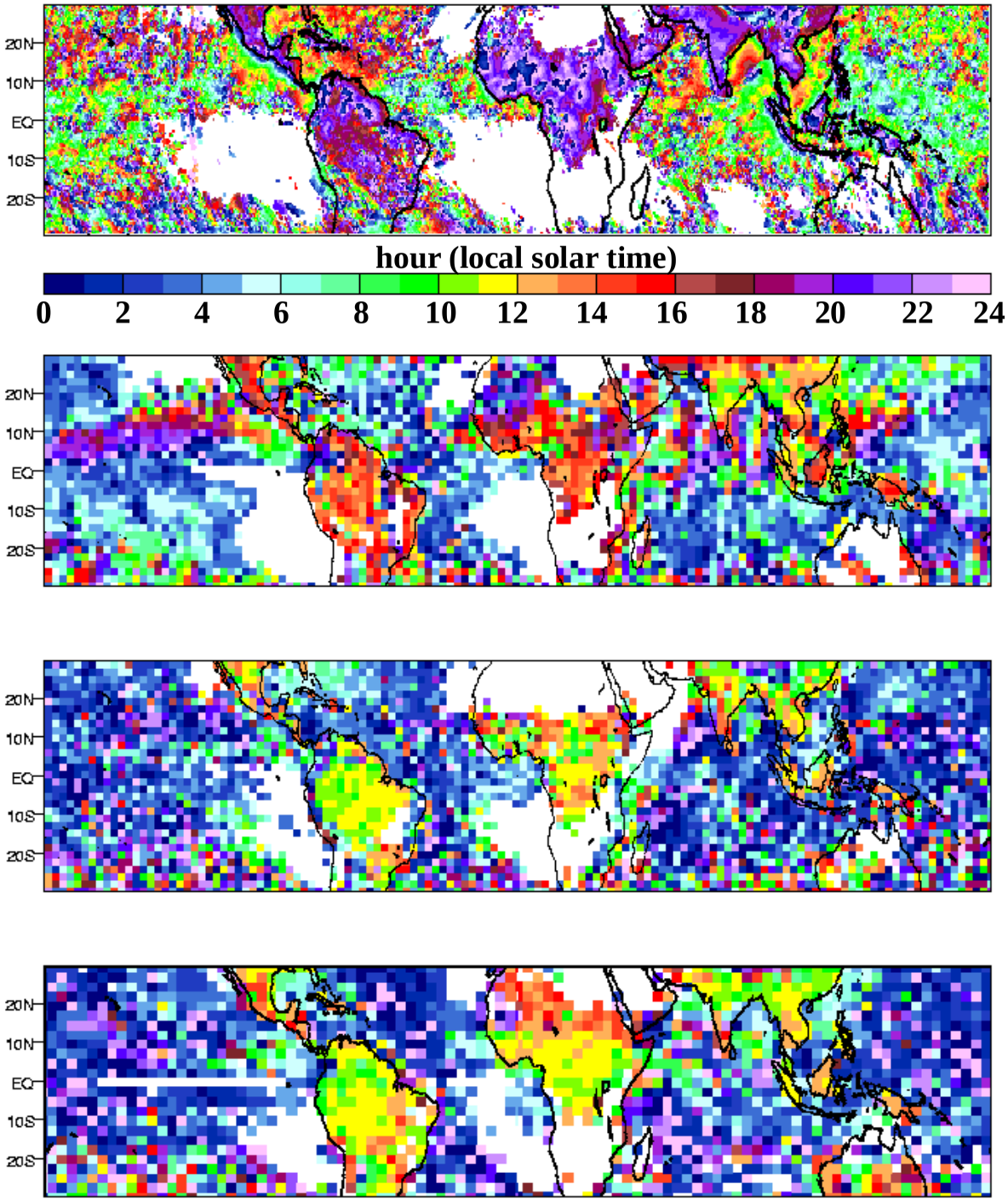
EUROCS: BASIC CLOUD PROBLEMS

PRECIPITATING DEEP CONVECTIVE CLOUDS

- diurnal cycle of precipitating convection over land
  poor representation in GCMs

Importance:

- Radiative budget at top of atmosphere and surface
- Surface T & q bias
- Precip forecasts
- ...



PHASE OF THE DIURNAL HARMONIC IN 3 GCMs
thanks to J.-M. Pirou

OBSERVATIONS
Yang & Slingo (MWR, 2001)

ARPEGE NWP model
Piriou (2002)

IFS NWP model
Beljaars (2002)

UNIFIED CLIMATE model
Yang & Slingo (MWR, 2001)

Ø GCMs wrong in the « same way »

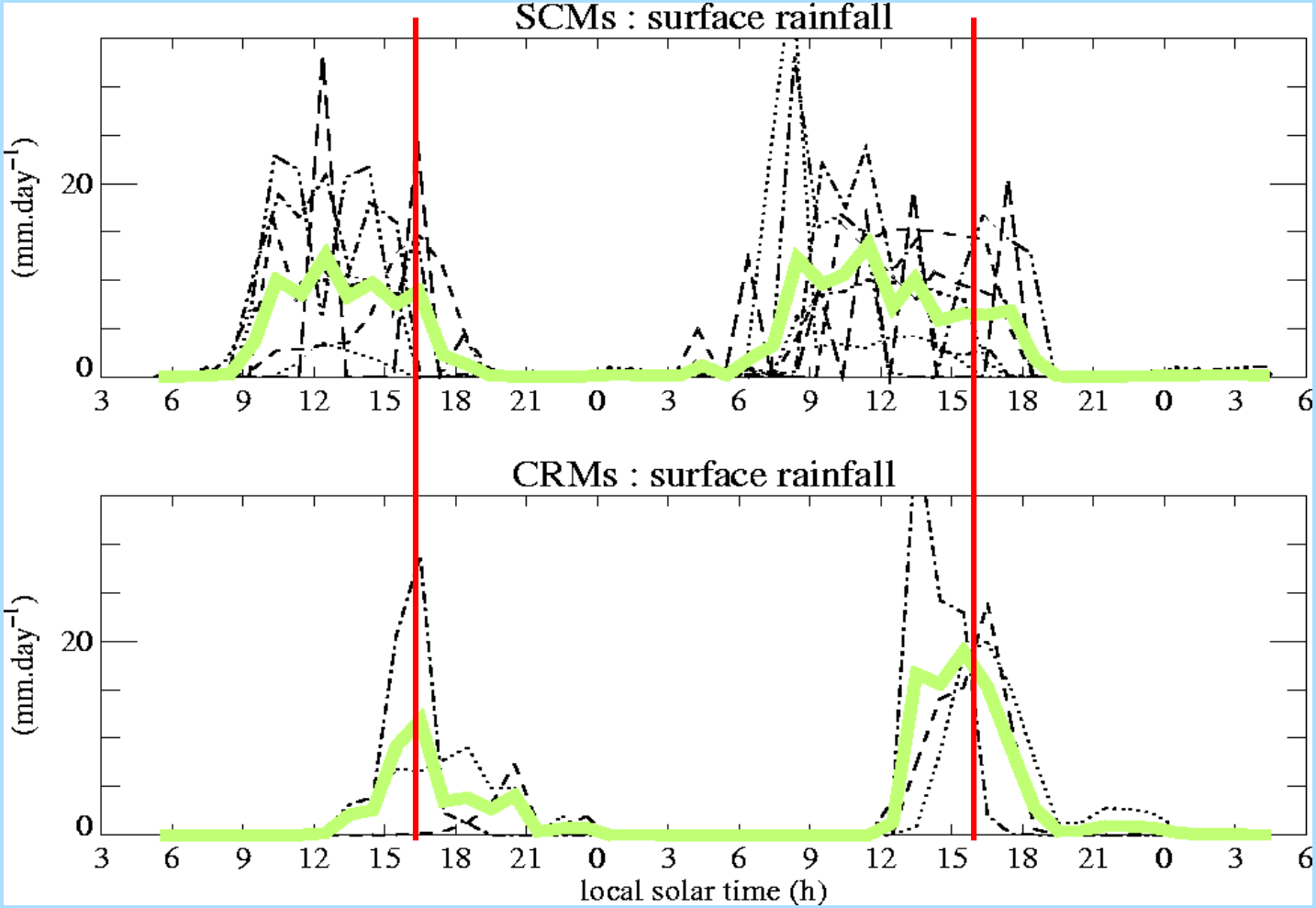
EUROCS: BASIC CLOUD PROBLEMS

Diurnal cycle of precipitating convection over land

Leaders: F. Guichard & J. Petch

Idealized case of local development of convection:

- *weak LS forcings*
- *prescribed diurnal cycle of surface fluxes*
- *2-day runs*



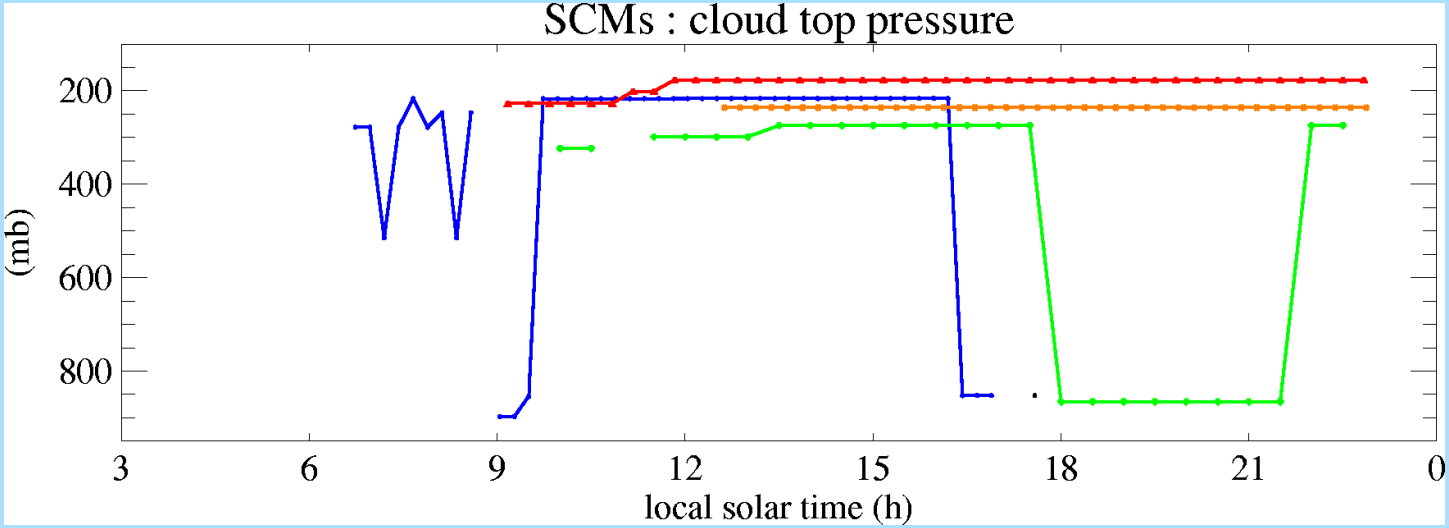
Ø Large spread in the amount of predicted rainfall but…
the phase error found in GCMs is reproduced

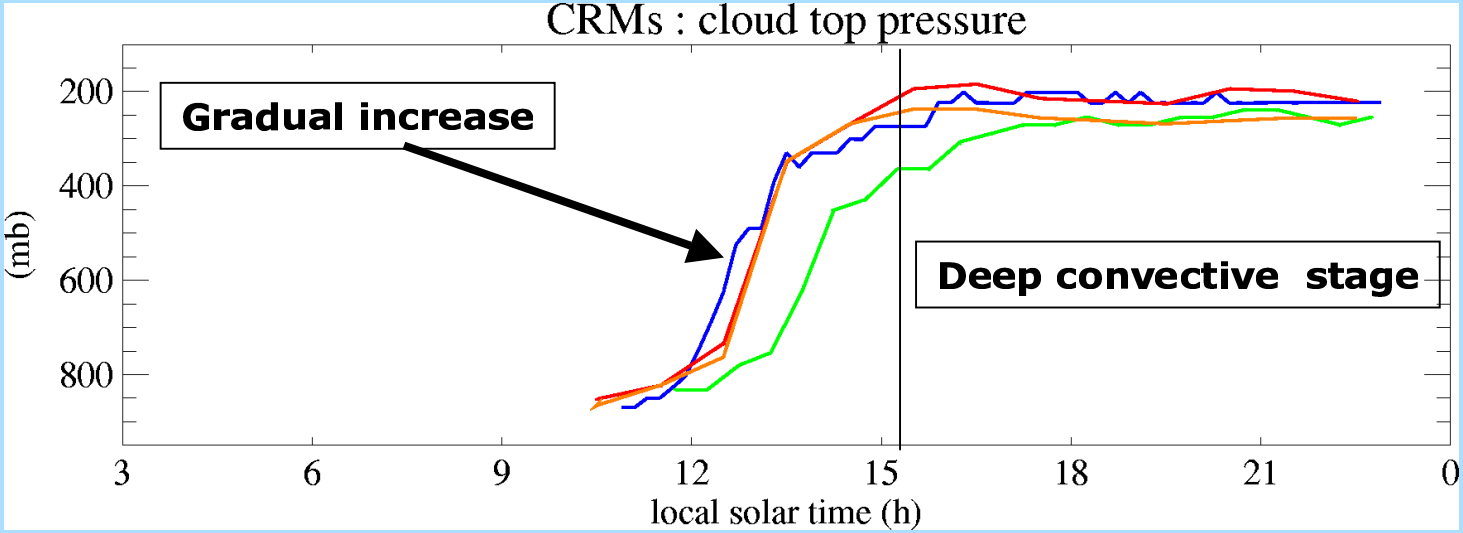
Ø Deep convection starts later in CRMs

Guichard et al.

(EUROCS QJ 2004)

Cloud tops





Guichard et al.

(EUROCS QJ 2004)

Further analysis of CRM results

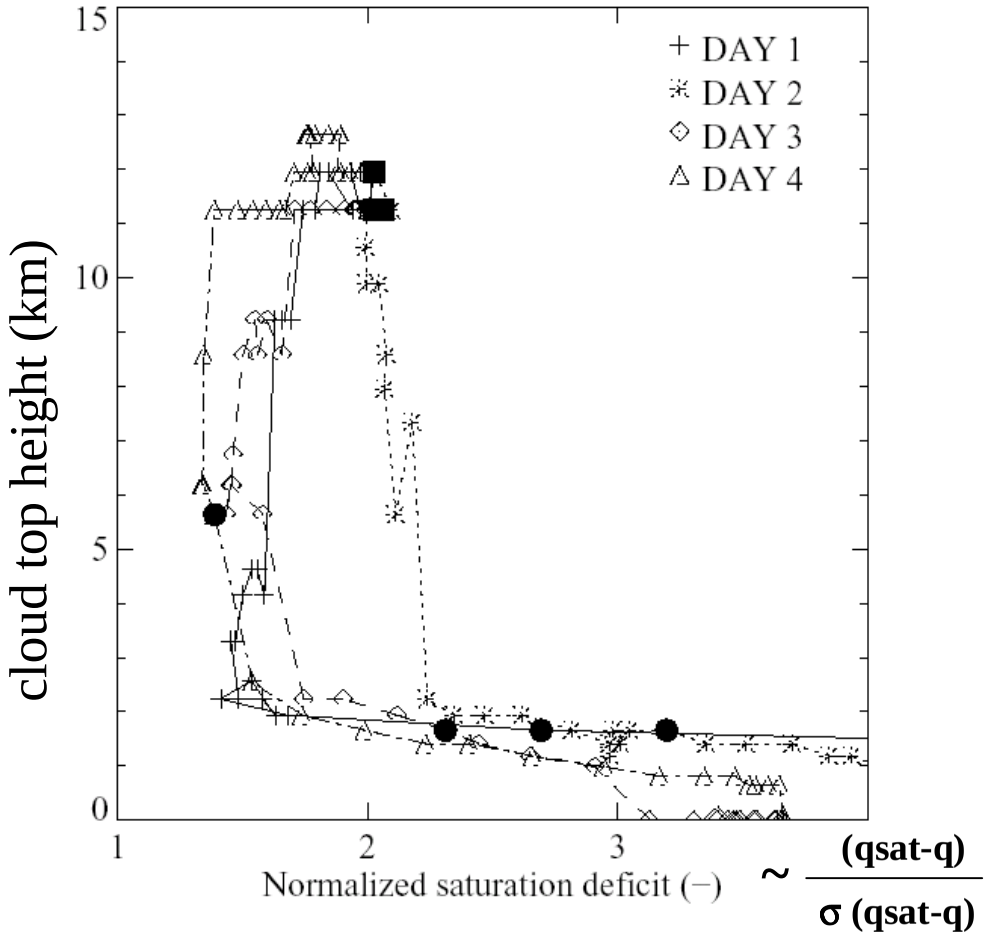


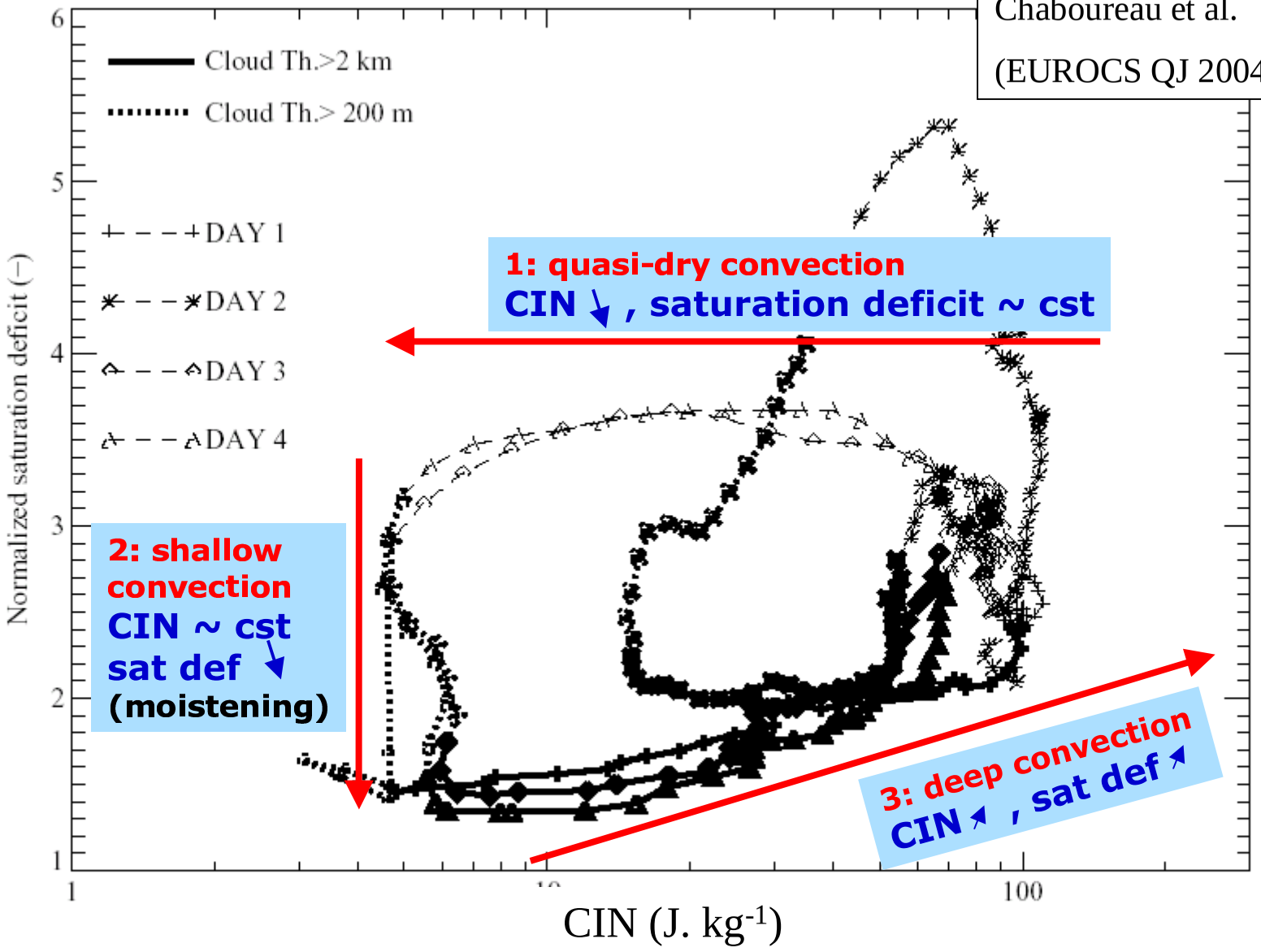
Figure 6. Cloud top height as function of the normalized saturation deficit averaged between the PBL top and the LFC. Points are every 12 min from 9 to 17 h. Points at 12 h and 17 h are indicated by large dots and squares, respectively.

Chaboureau et al.

(EUROCS QJ 2004)

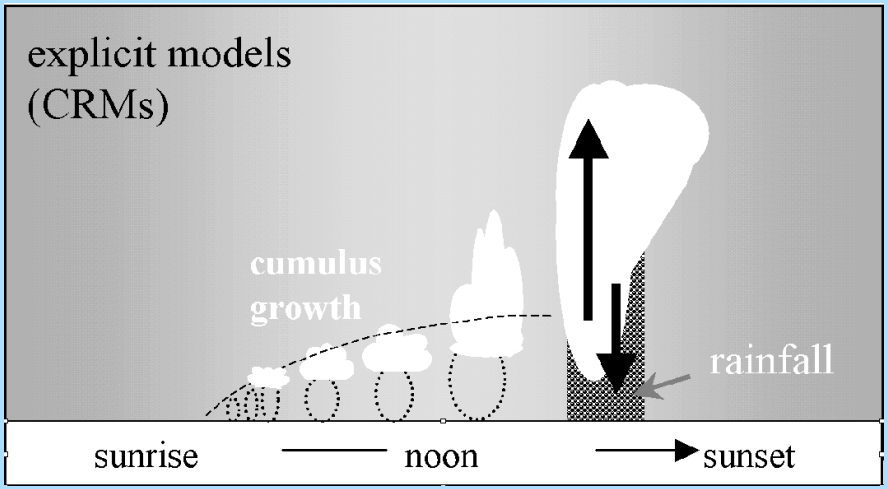
Chaboureau et al.

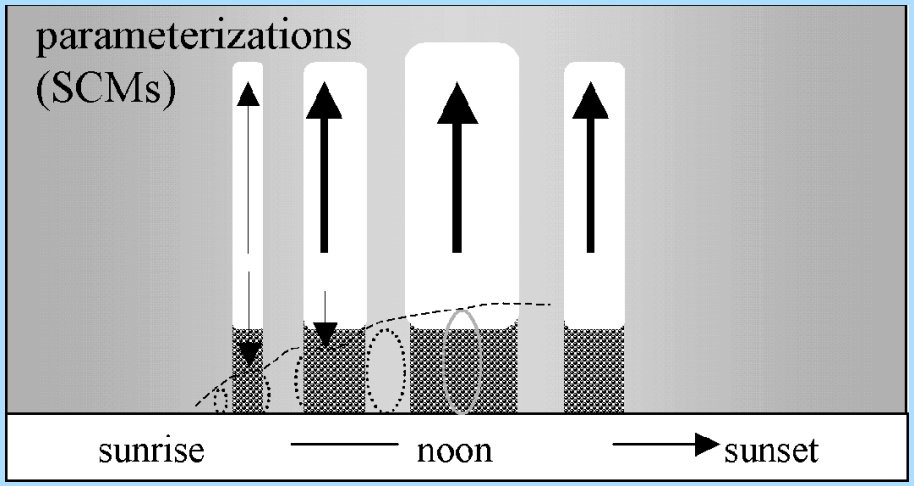
(EUROCS QJ 2004)



the challenge for SCM & GCM: PBL + shallow & deep convection

EUROCS: BASIC CLOUD PROBLEMS





Conclusions

- ü Three regimes during daytime: dry, shallow and deep
- ü Case allows to reproduce GCM defaults and to sort out issues:
  - §To increase the sensitivity to moisture of convective schemes
  - §To represent clearly the Cu-Cb gradual transition regime
  - §To improve the triggering function: taking better in account PBL convection
  - §To improve the representation of convective downdraughts
- ü Need observations documenting the diurnal cycle of tropical convection, in particular the growing phase of convection (field experiment in AMMA?)
- ü Works carried out in GCMs (LMD, ECMWF, CNRM, …)

CONCLUSIONS ON WATER VAPOUR

- Convective cases of EUROCS confirm the key importance of the saturation deficit
  - Support by recent observations

  (Jensen & Del Genio 2003 ARM/NAURU; Sobel et al 2004 KWAJEX)
  - Need also to take in account its subgrid variance in GCM

- Moistening of the free troposphere by cumulus congestus acts to precondition the atmosphere for deep convection and so to change its timing:
  - Diurnal cycle
  - Intraseasonal variability: MJO (Slingo et al; Grabowski), African convective systems (Roca et al)

- Most of conceptual models of tropical convection are based on shallow Cu (trade-wind type) and deep convection: Transition stage needs to be represented (Precip Congestus)
  - Saturation deficit
  - Temperature inversions also important (radiative effects due to sharp vapor vertical gradient; melting layer)