Comparing a simple stochastic cloud model to observations

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CoE theme "Tropical Convection"

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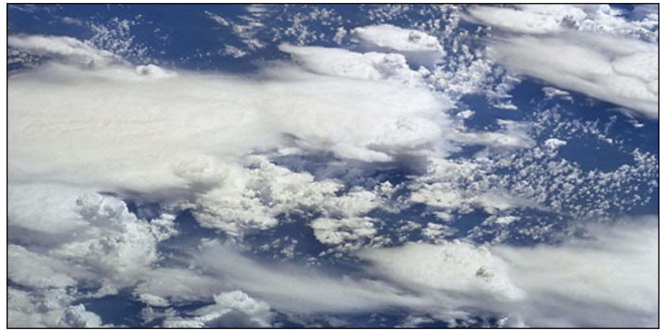
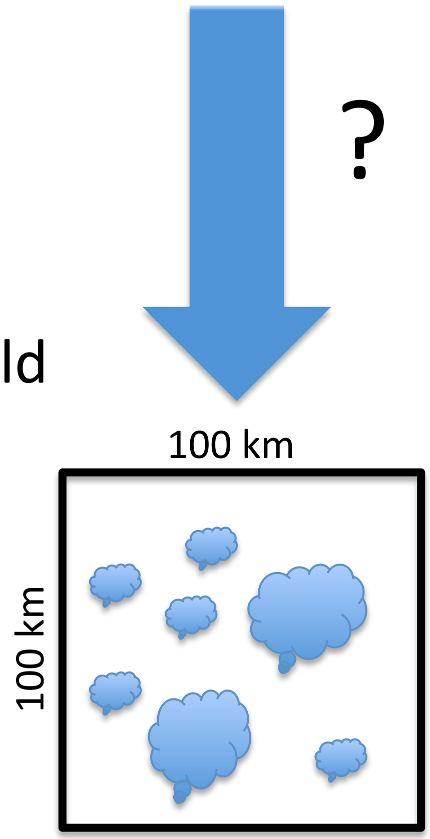
what ?

design a convection parameterisation closure to



- represent the **stochastic** nature of convection
- represent the **sub-grid scale variability** of convection
- yield estimates of convective **area fractions**



why ?

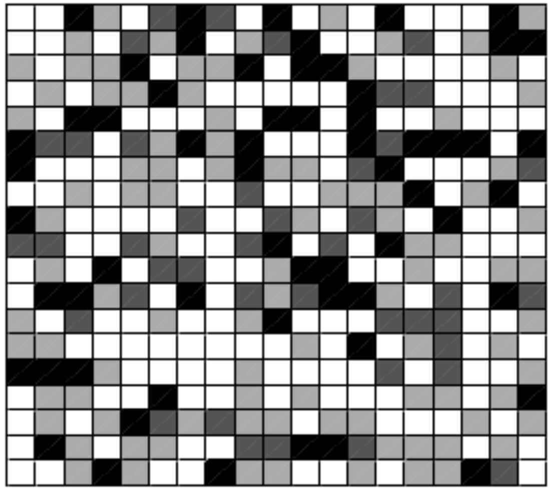
current GCM-simulated convective processes yield

- cloud cover issues (low, mid, high ?)
- issues with hydrological cycle
- a lack of sub-grid scale variability
- …

Approach (rough outline)

Employ the concept of the **S**tochastic **M**ulti-**C**loud **M**odel (SMCM)
(Khouider et al (2010))

- divides a large-scale domain into n x n **independent** sub-domains (e.g. 20x20)
- predicts an ensemble of three cloud types (congestus, deep, stratiform)
  - ➢ cloud formation/transition/decay determined by **stochastic** Markov-Chain process
- driven by a set of 2 large-scale parameters
  - ➢ C as "convection"
  - ➢ D as "dryness"



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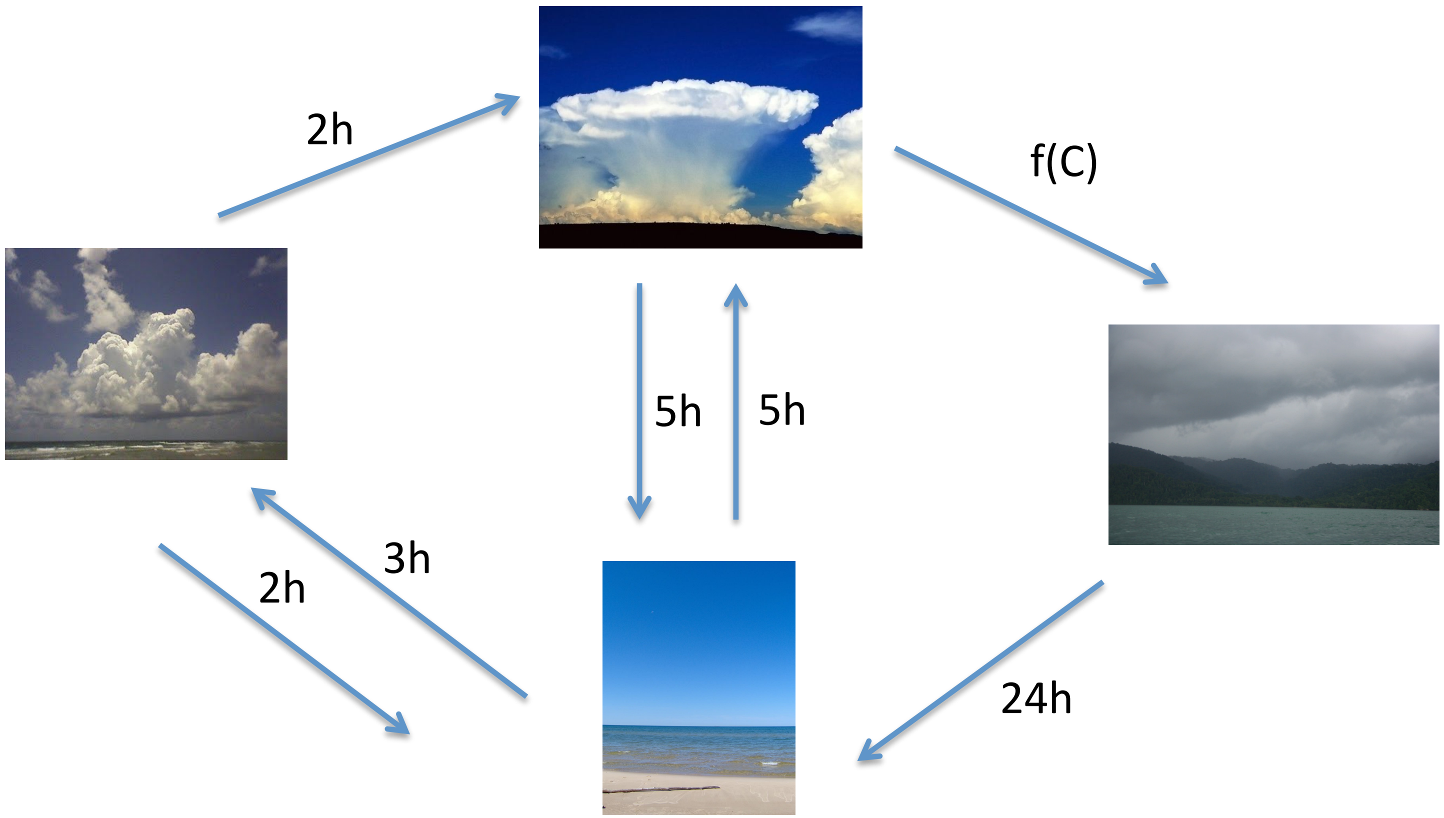

Strategy

Evaluate the SMCM with observations.

If needed, modify the model setup to simulate observed state.

Implement into GCM environment (ACCESS)

Evaluate performance in single-column mode, then full GCM.

Powerful convective parameterisation closure

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Observations

Large-scale atmospheric state over tropical locations

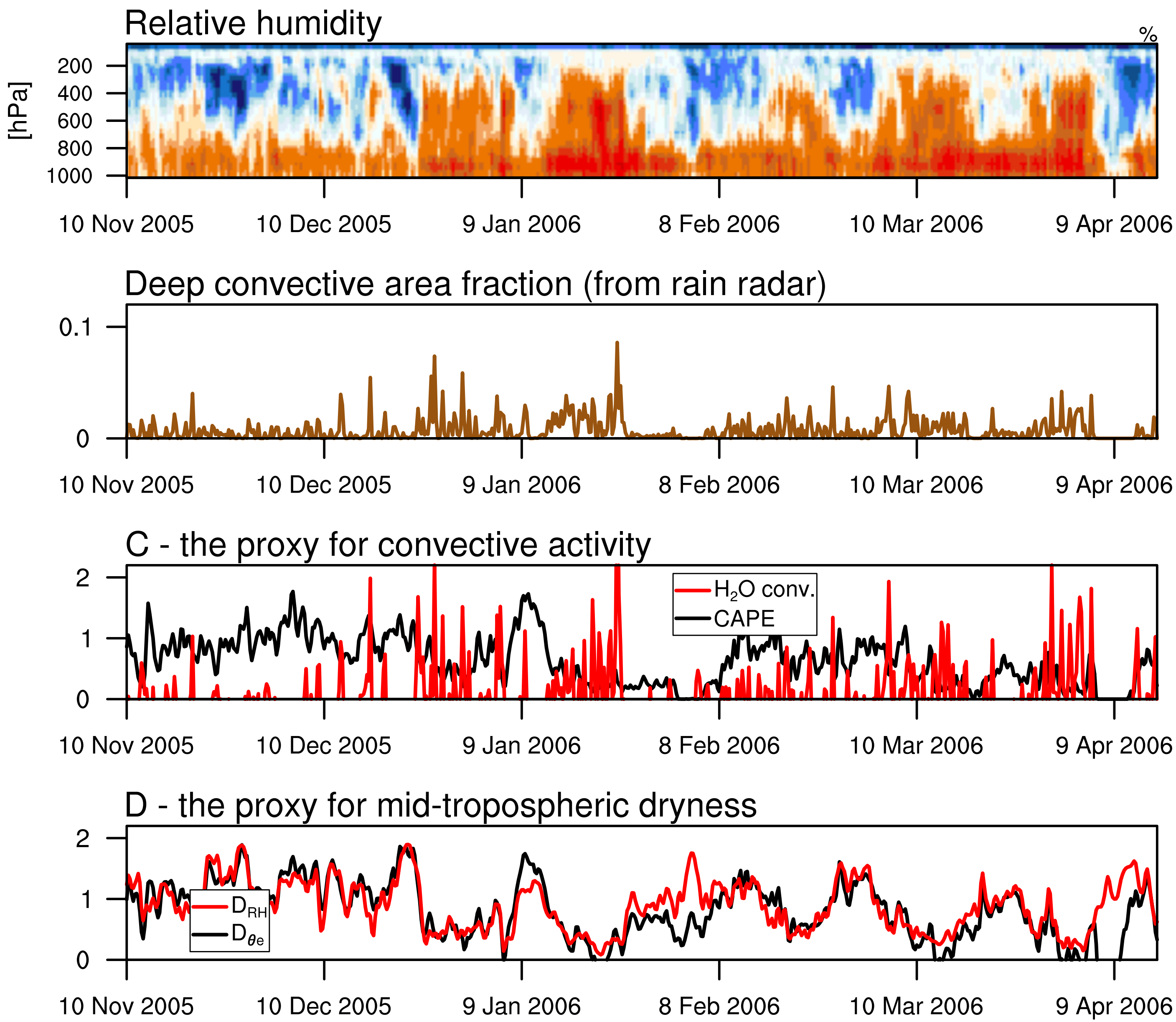
Three wet seasons @Darwin

+

One wet season @Kwajalein

C and D can be derived from observations (scaled to vary between 0 and 2)

Darwin example



Deep convective area fractions (Darwin site)*

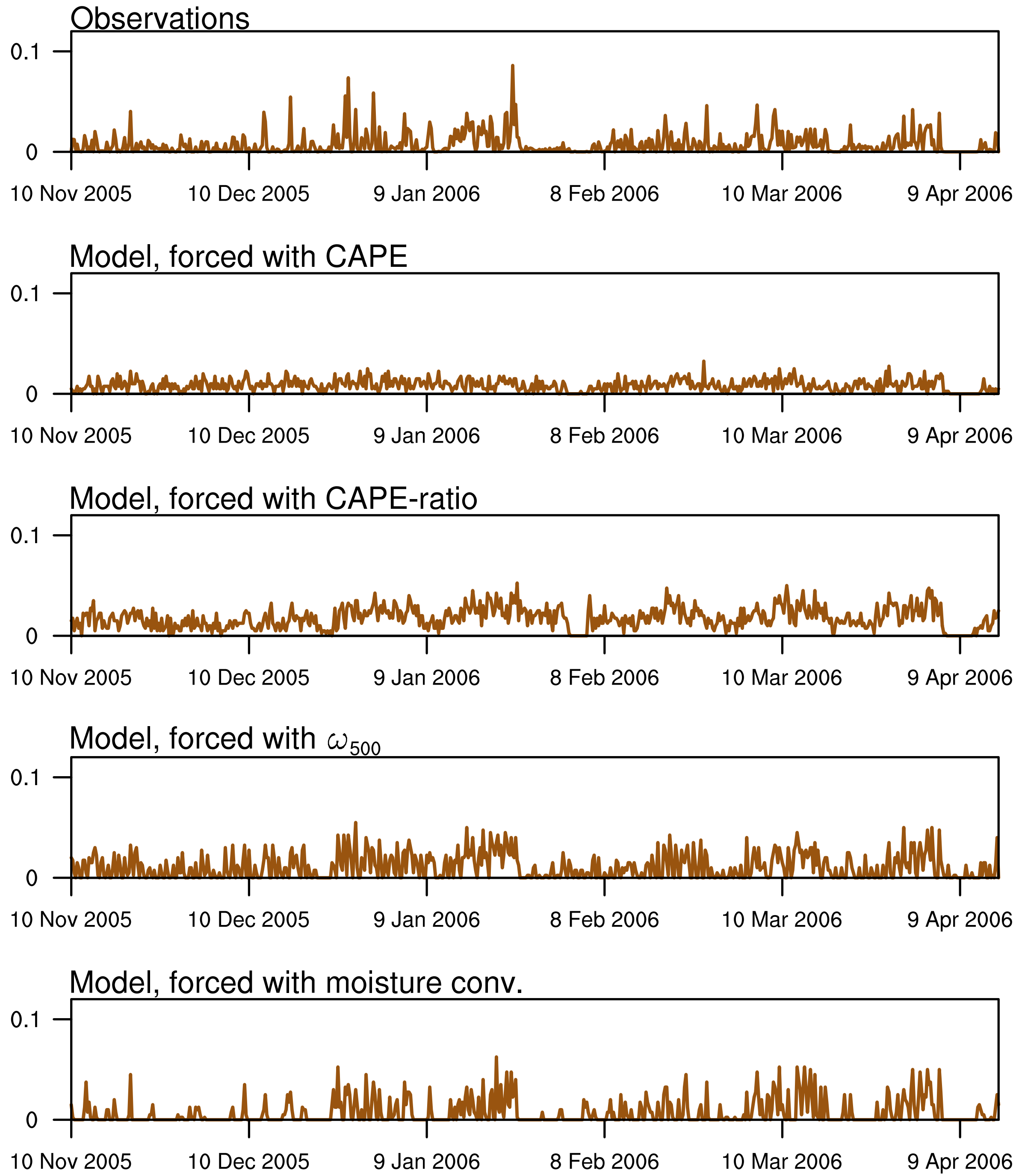
As expected, moisture convergence and vertical velocity @500hPa work best, extreme values too low

Problems with the cause and effect relationship

Ratio of LCAPE to CAPE also seems somewhat reasonable, but also problems with cause and effect.

Forcing with CAPE does not show any sensible results.

*tuned using equil. distributions from Kwaj & Darwin, tuning via timescales



To do (in terms of model evaluation/modification/implementation)

- role of congestus clouds (over-emphasised in the model ?)
- test sensitivity towards increasing number of sub-domains, i.e. attach a sensible spatial scale to the processes
- ACCESS implementation…

Images:

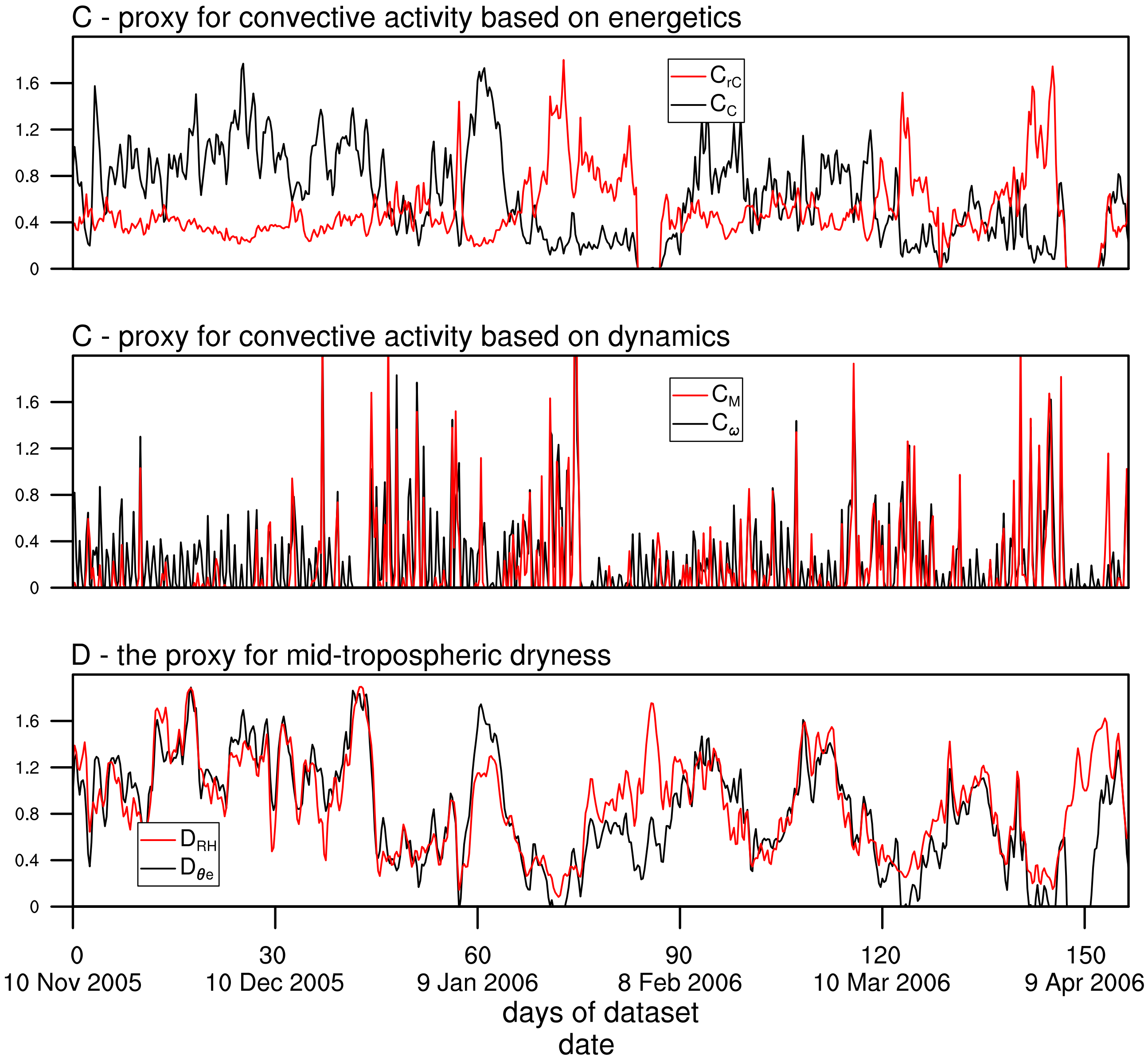
Slide 2: http://earthobservatory.nasa.gov/Features/ArbitersOfEnergy/

Slide 3: Khouider et al (2010)

Slide 4:

http://bukagambar.com/gambar/clear+blue+sky+beach.aspx
http://regulus-starnotes.blogspot.com.au/2009/08/back-from-south-florida-much-to-say-but.html
http://science.nationalgeographic.com/science/photos/clouds/

Forcing parameters extended



Timescales used for model simulations

Process	convection proxy C_C	C_{rC}	C_ω	C_M
formation of congestus (τ_{01})	2	1	1	0.9
decay of congestus (τ_{10})	1	1.2	1.2	1.2
conversion of congestus to deep (τ_{12})	3	1.2	1.2	0.9
formation of deep (τ_{02})	4	2.2	2.2	2
conversion of deep to stratiform (τ_{23})	0.13	0.16	0.16	0.16
decay of deep (τ_{20})	5	2.2	2.4	2.4
decay of stratiform (τ_{30})	5	4	4	4

Table 1: Transition timescales in [hours] leading to the modeled equilibrium cloud fractions in left columns of Figs. 7 – 10.