Comparing a simple stochastic cloud model to observations

Karsten Peters, Christian Jakob, Laura Davies  
Monash University  
CoE theme “Tropical Convection”

1st annual CoE Workshop, Hobart, Tasmania  
25 Sep 2012
**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 **Stochastic Multi-Cloud Model (SMCM)**
(Khouider et al (2010))

- divides a large-scale domain into \( n \times n \) 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”
Approach (rough outline)

Employ the idea of a **Stochastic Multi-Cloud Model (SMCM)** (Khouider et al (2010))

2h → f(C) → 5h → 5h → 24h → 2h → 3h → 2h
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)
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

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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 4:
http://bukagambar.com/gambar/clear+blue+sky+beach.aspx
http://science.nationalgeographic.com/science/photos/clouds/
Forcing parameters extended

C - proxy for convective activity based on energetics

C - proxy for convective activity based on dynamics

D - the proxy for mid-tropospheric dryness
## Timescales used for model simulations

<table>
<thead>
<tr>
<th>Process</th>
<th>convection proxy</th>
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</thead>
<tbody>
<tr>
<td>formation of congestus ($\tau_{01}$)</td>
<td>$C_C \quad C_{rC}$</td>
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<tr>
<td>decay of congestus ($\tau_{10}$)</td>
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<tr>
<td>conversion of congestus to deep ($\tau_{12}$)</td>
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<tr>
<td>formation of deep ($\tau_{02}$)</td>
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<td>conversion of deep to stratiform ($\tau_{23}$)</td>
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<tr>
<td>decay of deep ($\tau_{20}$)</td>
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<tr>
<td>decay of stratiform ($\tau_{30}$)</td>
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<td>5</td>
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</table>

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