MONASH Weather and Climate

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The relationship of large and small scales in a convecting atmosphere

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Motivation

* Task of any parametrization is to **relate large and small scales** to each other
* When early convection parametrizations were built, data on both scales was sparse
* Yet, almost all existing convection parametrizations are still based on ideas formulated then
* It is **timely to revisit** convection parametrizations **with 21st century data**

Starting point

* Need **many samples of concurrent large and small scale observations**
* **ASR/ARM data** provides a **perfect background** to do this
* Use **three years** of **Darwin** data **6-hourly** to
    * build a **large-scale** data set using the **variational analysis**
    * build a **small-scale** data set using **C-band radar** data

Some questions

* Which variables show the **strongest** large to small scale **relationships**?
  * Is **mass-flux** a good variable for convection schemes?
* **How stochastic** is the problem?
  * Do we need fully stochastic convection schemes?
* How much **memory** is in the large-scale alone?
  * Do we need fully prognostic convection schemes?

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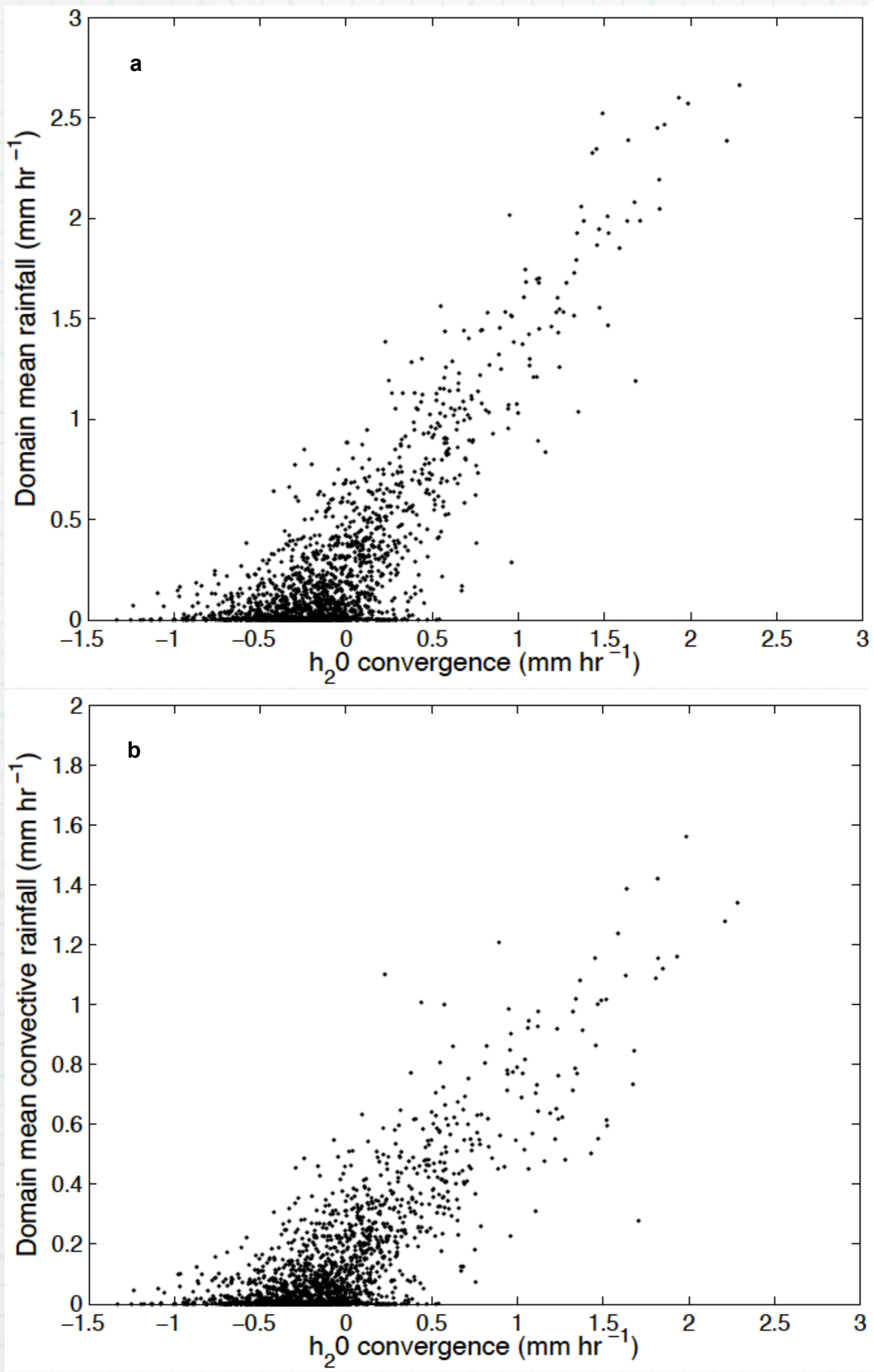
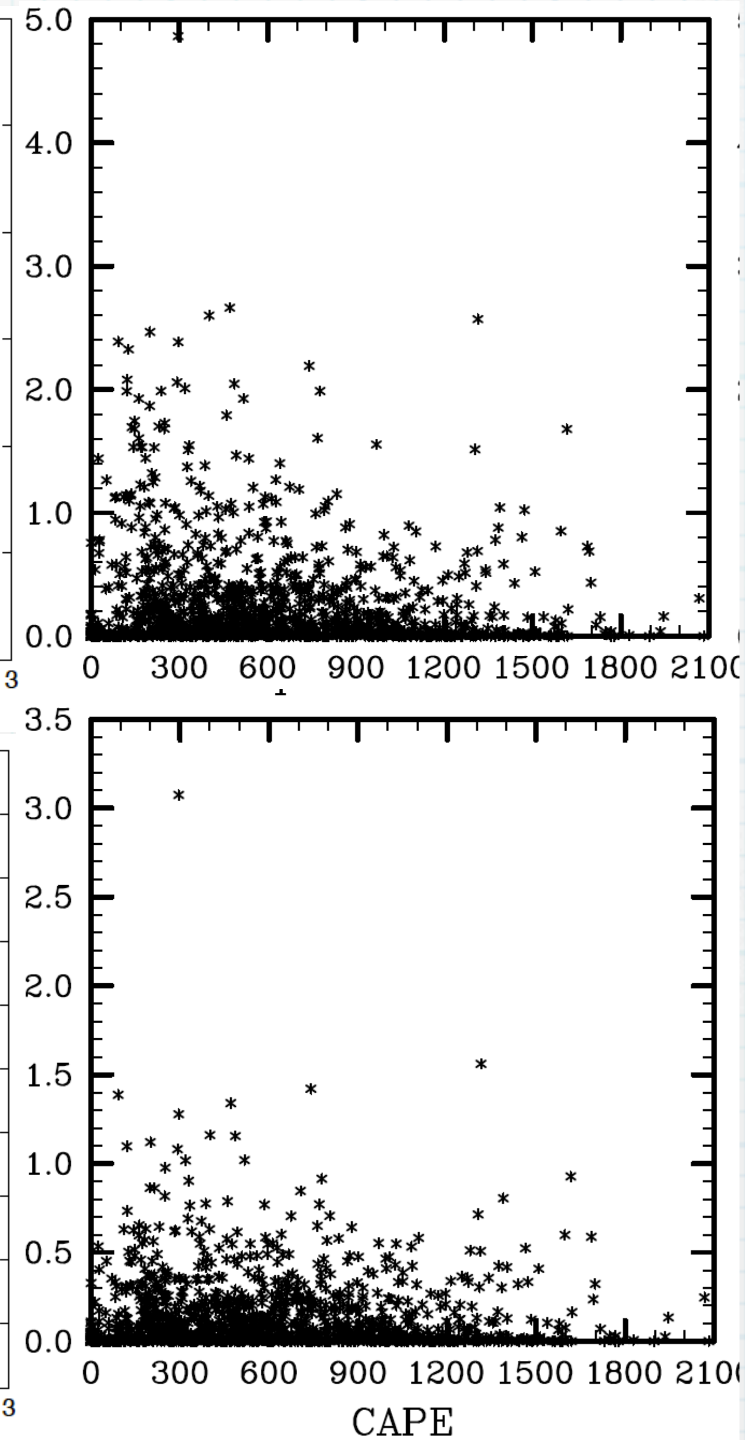
Some basic relationships

Total rainfall

Convective rainfall



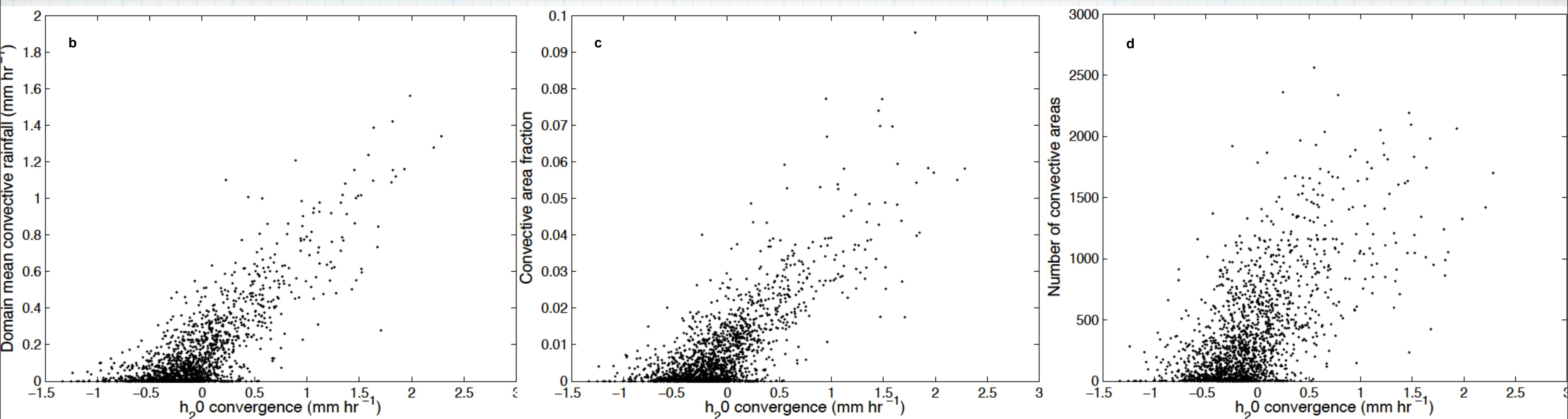


Large-scale q convergence

CAPE

Some basic relationships

Relationship to large-scale q convergence

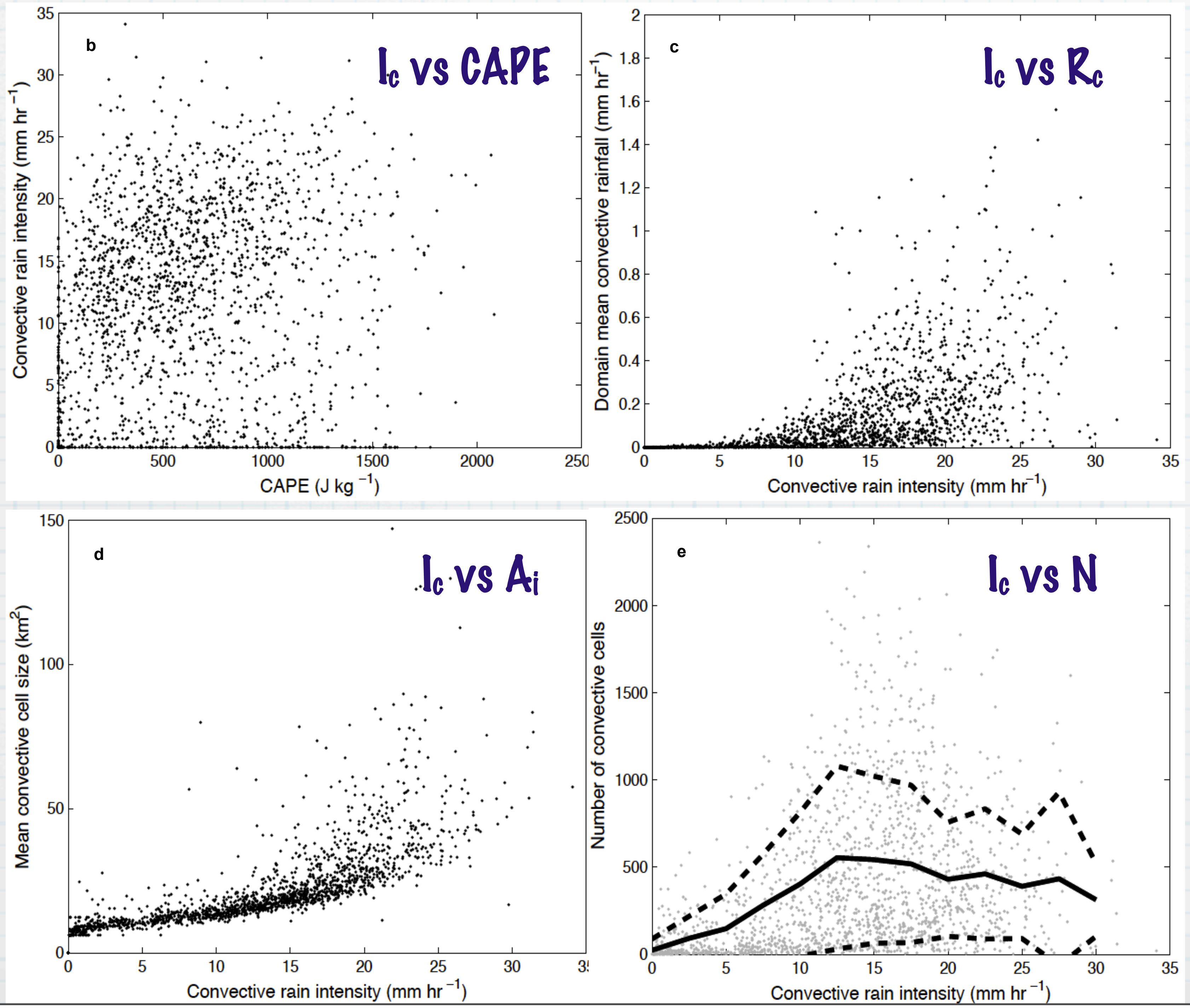


Domain-mean convective rainfall

Convective area fraction

Number of convective cells

Learning more about intensity



$$I_c = \frac{\overline{R_c}}{f_c} = \frac{\overline{R_c}}{N\overline{A_i}} \times A_0$$

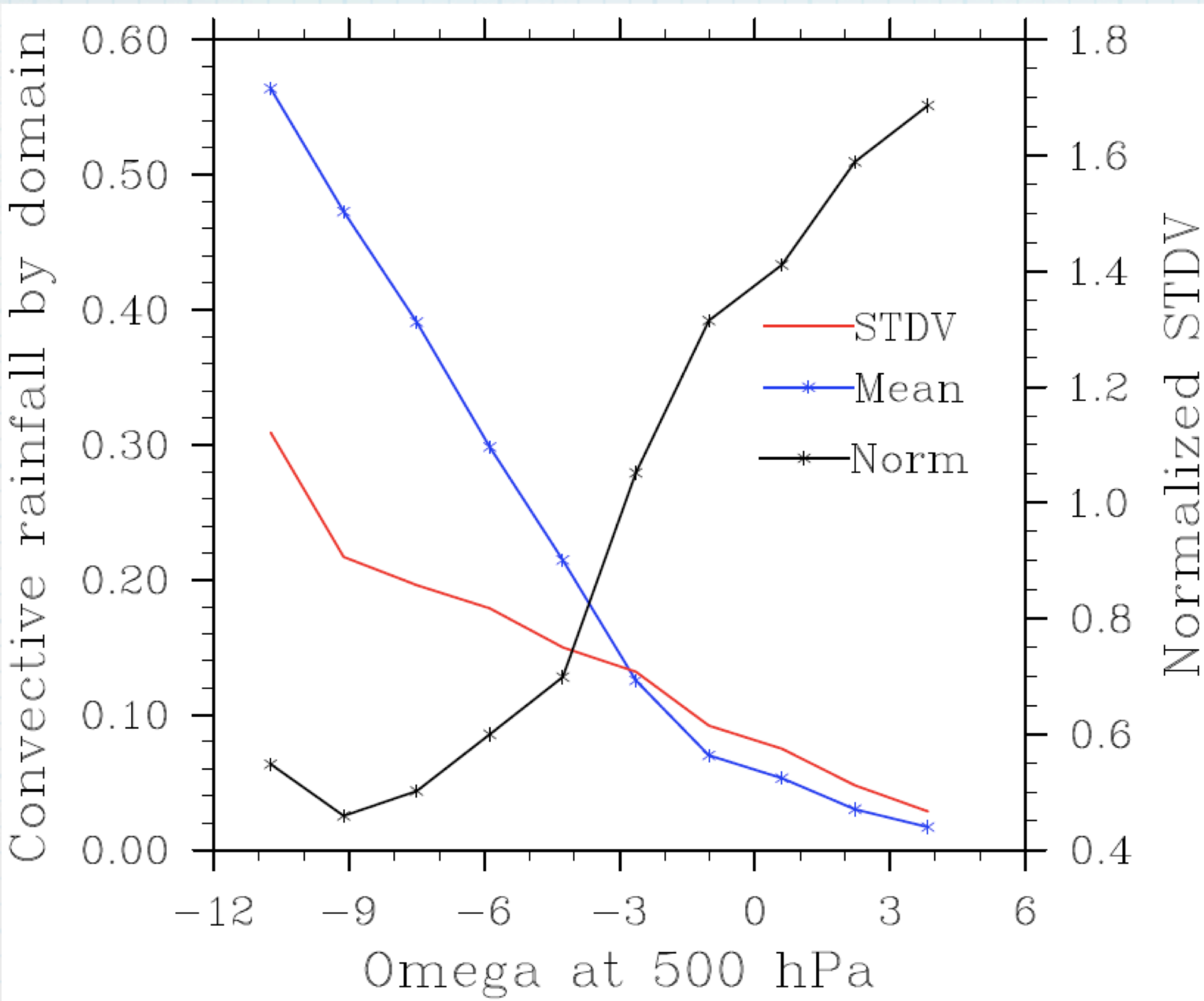
R_c - domain mean convective rainfall

f_c - convective area fraction

A_i - mean convective cell size

N - Number of convective cells

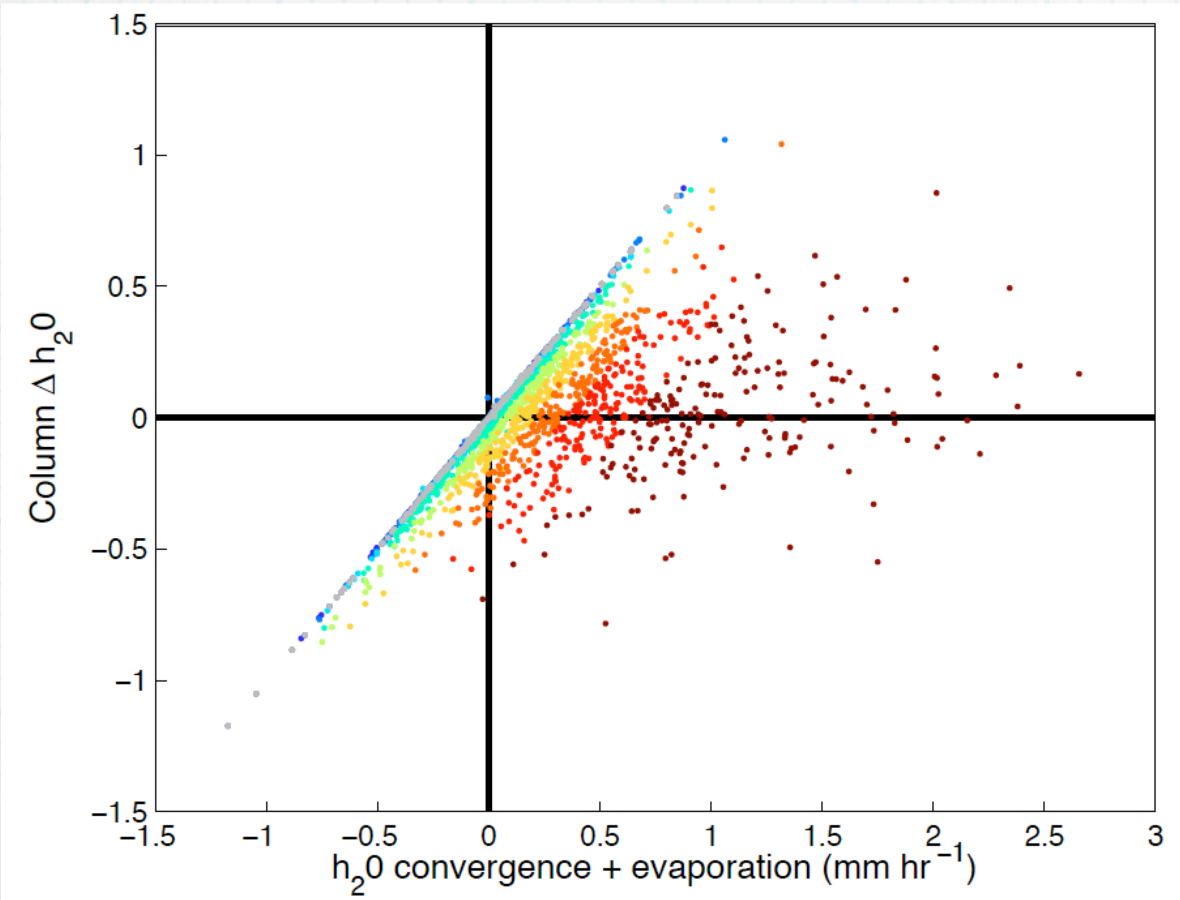
How stochastic is convection?

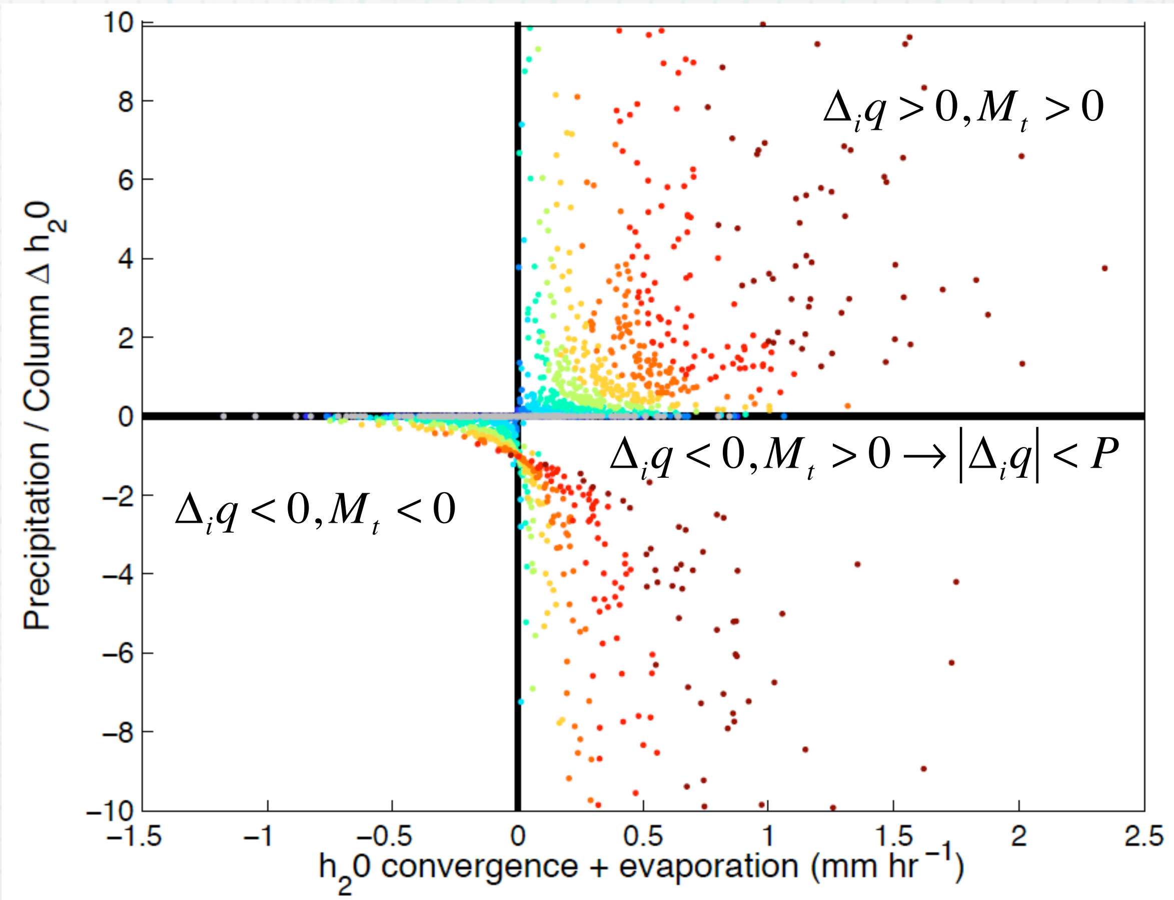


- Both mean and standard deviation increase with large-scale "forcing".
- However, the signal to noise ratio decreases.
- Hence, overall convective behaviour becomes more "predictable" as the "forcing" increases.
- This is contrary to some implementations of "stochastic" convection.

Back to 1974 - The convective moisture budget

How is moisture supply distributed among rainfall and moistening of the grid-box?





Column Moistening ($\Delta_i q$) vs Moisture input (M_t)

Prec/$\Delta_i q$ vs M_t

Colours indicate mean rainfall (grey=0; red=large)

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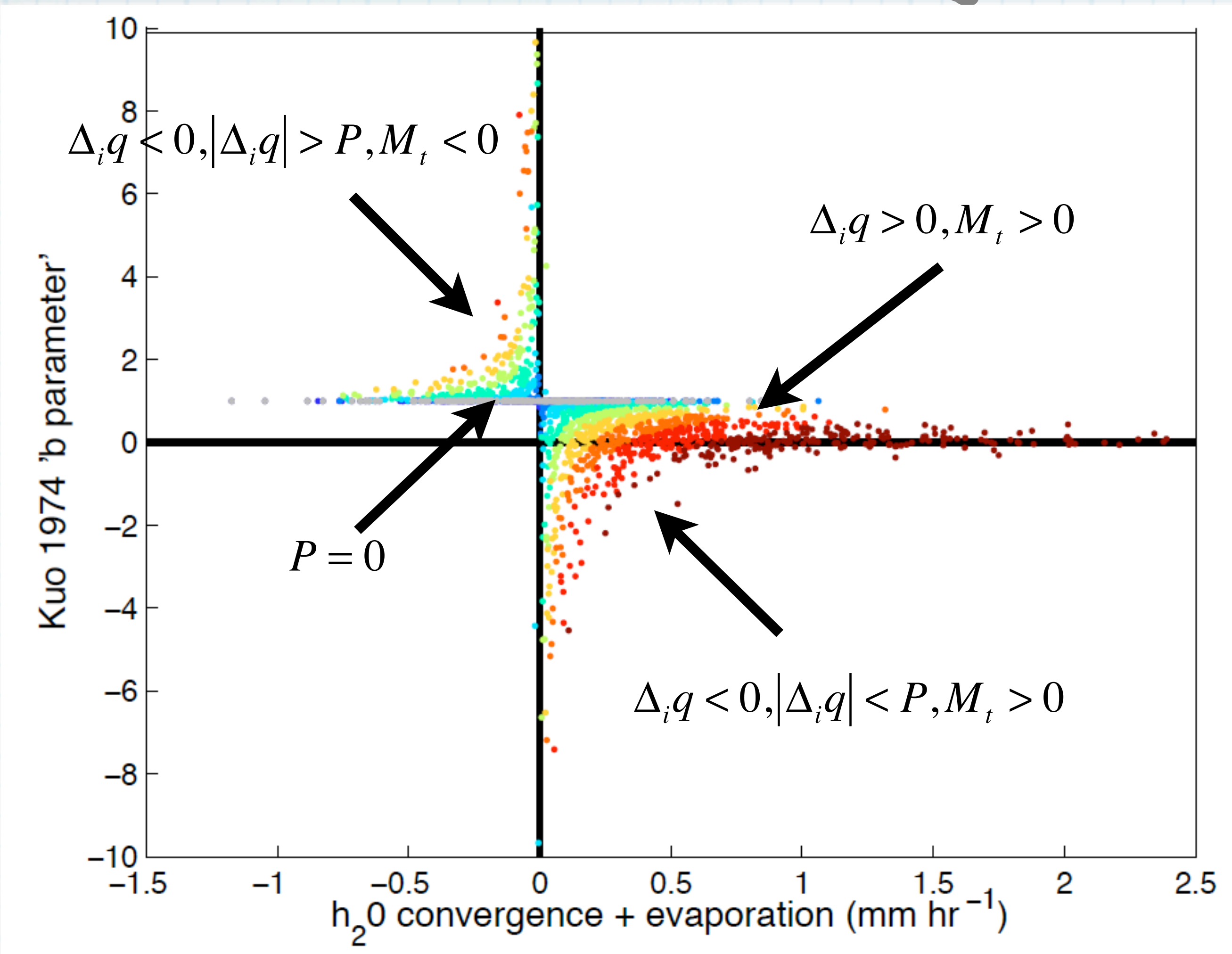

Kuo parameter b vs M_t

Colours indicate mean rainfall (grey=0; red=large)

$$P = (1 - b) M_t$$

$$\frac{1}{g}\int_0^{p_0} \frac{\partial q}{\partial t} dp = \Delta_i q = b M_t$$

$$M_t = -\frac{1}{g}\int_0^{p_0} \nabla \cdot \vec{v} q \cdot dp + E_S$$

$$b = \frac{\Delta_i q}{\Delta_i q + P}$$

Conclusions and next steps

* ASR/ARM data provides a **great opportunity** to **revisit key ideas** in convection parametrization
* More observational analysis is required - add **another location**
* Run **"forced" CRM** for three years and compare the results with the observations
* Run **large-domain "free" CRM** and compare results with the observations
* Define key variables and relationships as **design specs for a new parametrization**

Thank you!