Investigating the relationship between large-scale and convective states in the tropics

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..the aim of this proposal to apply a combination of long-term observations taken by ARM (ASR) and BOM in the tropics and simulations using CRMs to comprehensively explore the relationships between the large-scale and convective scales and to use the findings to guide improvements of the representation of convection in NWP.
Project components

- Long term LARGE-scale data set
  - Define the observed large-scale state of the atmosphere.
  - Use a combination of re-analysis, observations and constrained variational analysis.

- Long term SMALL-scale data set
  - Define the observed convective state.
  - Use radar data to derive properties of deep convection and convective cells
  - (and non-precipitating ice clouds)

- Cloud-resolving modelling (CRM)
  - Force a CRM with the large-scale state.
  - Derive an additional small-scale state from model data.
  - THEN, perform a ‘limited’ number of large domain radiative-convective equilibrium simulations.
  - Derive a new set of large-scale states and small-scale states from the model data.
Large-scale state

- Long term large-scale data set
  - Derived using ECMWF re-analysis in place of radiosonde data but constrained with observations.

All observations

ECMWF analysis constrained with variational analysis

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Using the large-scale state

- What can we do with the large-scale state alone?

Find behaviour at Darwin found in similar studies, e.g. Holloway and Neelin JAS 2009

Attribute possible sources of moisture, e.g. vertical advection?
Advertising the large-scale data set

- Long term large-scale data set now from ASR PI site
  - Best estimate and ensemble product.
  - One of the deliverable targets in year 1 of ASR project.

- 3 wet seasons: 2004-2005, 2005-2006 (which includes TWP-ICE) and 2006-2007

- Data only available when sufficient precipitation data, hence data available in sub-periods.

- Data in netcdf files of the exact same format of standard ARM best estimate forcing data products (except cloud data is missing).

- Ensemble product based on techniques and errors used in forcing data for ensemble TWP-ICE intercomparison.
Defining small-scale state

- What we have...
  - Rain rate,
  - Rain intensity,
  - Area fraction,
  - Classified rainfall data – convective/stratiform,
  - Classified rain rate,
  - Classified intensities,
  - Classified area fractions,

- Wish list...
  - Vertical velocities,
  - Cell characteristics including number, size and height.
  - Anything else...?!
Small-scale state

Rain rate

Rain intensity

Rain area fraction
Small-scale vs large-scale

- Relationship between small-scale and large-scale 700 mb omega

Rain rate

Rain intensity

Strong relationship with rain rate (expected) but not with rain intensity
Small-scale vs large-scale

- Why isn’t there a relationship with intensity?

Strong relationship with convective fraction but rain intensity not related to CAPE.
Summary

- We have created a long term large-scale data set for Darwin, Australia.
  - It's available to download on the ASR PI website.
  - It's as easy to use as the standard forcing data sets and comes with a 100 member ensemble.

- We are defining a long term small-scale data set.
  - At the moment we are using classified rainfall data but shortly we will have other radar derived characteristics of the convective state.
  - In time this too will be available as an ASR PI data product.

- We've started to investigate relationships between the large scale and the convective scale.
  - We've found relationships we were expecting like between rain rate and vertical velocity...
  - ... and new relationships like between convective area and vertical velocity.
  - We have not found strong relationships we might have expected, nothing so far is strongly related to CAPE.
Out standing questions
(some of them)

- What does control intensity?
- How indicative is this study of the tropics in general?
- What is the role of stratiform rain? How would a parameterisation relate convective rain to large-scale stratiform rain?
- Can we use better methods to find relationships? e.g. using multiple regression or clustering techniques.