Organised convection and scale interactions in the tropical atmosphere

- Cloud-system resolving simulations over large tropical domains
- Real case studies and idealised equatorial waves
- UK NERC funded consortium, 2008-2012

Aims

- Advance understanding of convective organisation and scale interactions
- Inform the development of new approaches to convective parameterization
- Create a new framework for process modelling
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Case Studies

West Africa
- African Easterly Waves
- Diurnal Cycle

Warm Pool
- MJO
- Maritime Continent
- Diurnal Cycle

Idealised
- Warm Pool Convection
- Equatorial Waves

Model Evaluation against Observations
- CloudSat/CALIPSO: vertical cloud properties
- GERB/SEVIRI/MTSAT: horizontal and time

Synthesis
- Analysis of scale interactions
- Insight into physical processes
- Compare with climate / NWP resolution
- Conclusions for parameterization
Cascade

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• Cascade PIs

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• Cascade Post-docs

  Grenville Lister, Chris Holloway, Barney Love, Nick Dixon, Thorwald Stein, Kevin Pearson, Guiying Yang

• Met Office Involvement

  Numerous people in Atmospheric Process and Parametrization and the Joint Centre for Mesoscale Modelling, led by Paul Field

http://ncas-climate.nerc.ac.uk/Cascade
Cascade

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Model

• Met Office UM at 40, 12, 4, 1.5km resolution
  • All used operationally at MO
  • Operational configuration starting point for testing
• 40, 12km
  • 38 levels
  • Convection scheme
  • Diagnostic cloud scheme
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Model

- 4km
- 70 levels
- Convection scheme on with closure timescale function of CAPE
  - High CAPE $\Rightarrow$ long timescale $\Rightarrow$ resolved dynamics does strong convection, convection scheme does weak convection
- 3 component cloud microphysics (prognostic liquid, ice, rain)
- Horizontal mixing by 2D Smagorinsky type scheme
Model

- 1.5km
  - 70 levels
  - Testing with and without convection scheme (configured similar to 4km)
  - Testing 3 (liquid, ice, rain) and 5 (liquid, 2 ice, rain, graupel) component microphysics
  - Horizontal mixing by 2D Smagorinsky type scheme
  - Stability dependent vertical mixing throughout depth
West Africa Case Studies

• Chosen from AMMA so not strictly YoTC but hopefully results still useful
  • Domain 20W-20E, 5S-28N
  • Forced by ECMWF analysis at boundaries

Case 1: 26-28 July 2006 – Significant but “unusual” AEW with a range of significant scales

Case 2: 31 July – 5 Aug 2006 – Weak AEW activity but several strong storms, good examples of diurnal cycle, secondary initiation etc

Case 3: around 10 September 2006 – A “textbook” AEW subsequently initiating a hurricane

• 40,12 km simulations of Case 1 & 2 completed
• 4km simulation of Case 1 & 2 running
Indian Ocean West Pacific Warm Pool

• Coincide with YoTC
• Domain 40E-183E, 22S-22N
• Forced with ECMWF analysis
• 7 months of integration starting 11 Oct, reinitialized every 30 days at 40km, 12km to look at diurnal cycle and MJOs
• 2 MJO events at 4km resolution (for about 20 days)
  • 11 October 2008
  • 5 April 2009
• 1 of above MJO events at 1.5km resolution (TBD based on analysis of 4km runs)
• 3 months of 40km and 1 month of 12km runs complete
• 4km run for October being setup
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Idealized Experiments

• ~8000x4000km domain
• 4km resolution
• ~50 day integrations
• $f=0$ plane
  • Examine the organization of convection in the absence of equatorial wave dynamics.
  • Assess the sensitivity of the results of Bretherton et al. (2005) and Stephens et al. (2008) to dimensionality and domain size.
• Full rotational effects
  • Organization of convection by equatorial waves
  • Impact of convection on equatorial waves
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Analysis

• Comparison with observations
  • CloudSat/Calipso to look at vertical structure and assess model representation of microphysics
  • Geostationary satellites to assess horizontal structures and temporal evolution

• Convective Organization and scale interactions
  • Analysis of spatial scales – spectral, clusters etc
  • Energy and PV budgets
  • Processes based studies, e.g. role of cold pools, gravity waves, tropospheric humidity…
  • Dependence of heating, moisture transports etc on mesoscale organization
  • Role of diurnal cycle