Met Office and UK University contribution to YMC

Ground instrumentation and modelling

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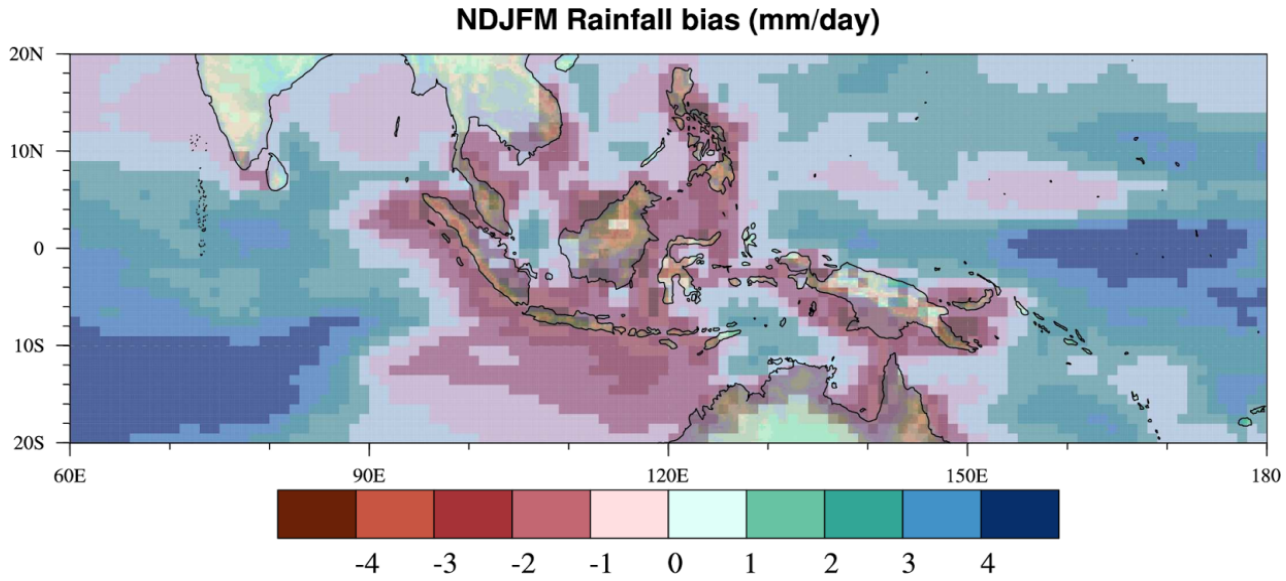
Motivation



Bias of November-March mean rainfall in atmosphere-only Met Office Unified Model GA6.0 (AMIP-type simulation)

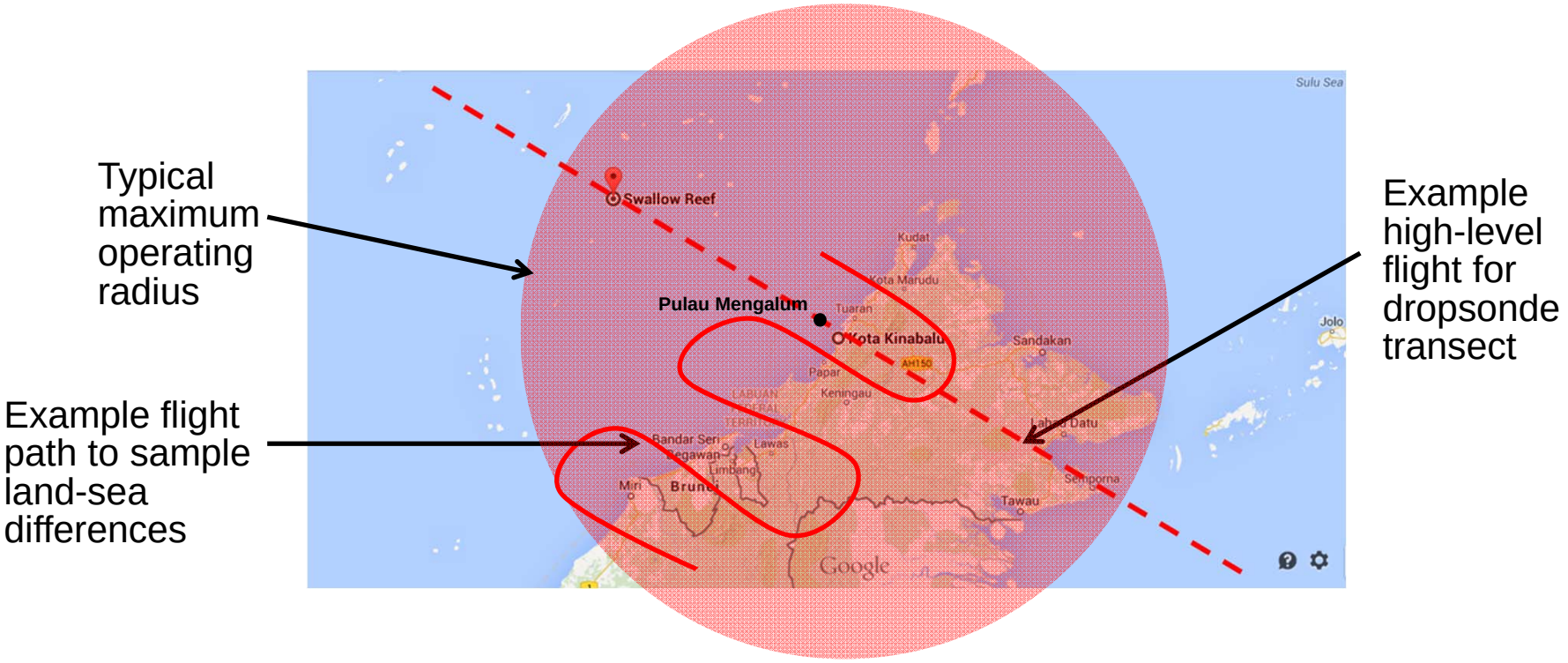
- Met Office priority is to reduce the dry bias over Maritime Continent
- Understand convective processes
- Reduce remote biases

Science aims

- To understand the diurnal evolution of the boundary layer, convection initiation, and the dynamics of storm development and their offshore propagation.
  - How is land convection triggered (sea breezes, topography)?
  - How does convection develop and interact with land-sea breezes and gravity waves?
  - How do the land and ocean surface evolve during the day and how does this influence convection?
  - How do changes in the large-scale flow influence the evolution of the diurnal cycle?
  - Definitive evaluation of convective processes in models across scales
  - Understand how process errors in models lead to errors on the larger-scale

- Met Office can provide access to FAAM Bae146 aircraft (see Paul Barrett's talk)
- Aerosol/air-quality is not a priority but basic observations will be achievable
- The UK Universities intend to submit a grant proposal to fund additional research aircraft hours, ground instrumentation, modelling and analysis time (pre-proposal 10th March 2015, full proposal Nov 2015)
- Dates and location currently flexible

Example field campaign



- Highly dependant on local sites and permissions
- Aircraft based at Kota Kinabalu Airport in Malaysia (previous experience here)
- 3-hourly radiosonde launches from Swallow Reef or Pulau Mengalum and mainland
- Possibility of deploying UK mobile Doppler radar (several months)
- Longer-term (~1 year) deployment of ground instrumentation
- Ideally co-locate with other YMC observations e.g. a ship could reduce need for an island

Ground instrumentation

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mobile X-Band Radar

Doppler and dual-polarisation capability

Radiosonde system

Flux towers and automatic weather stations

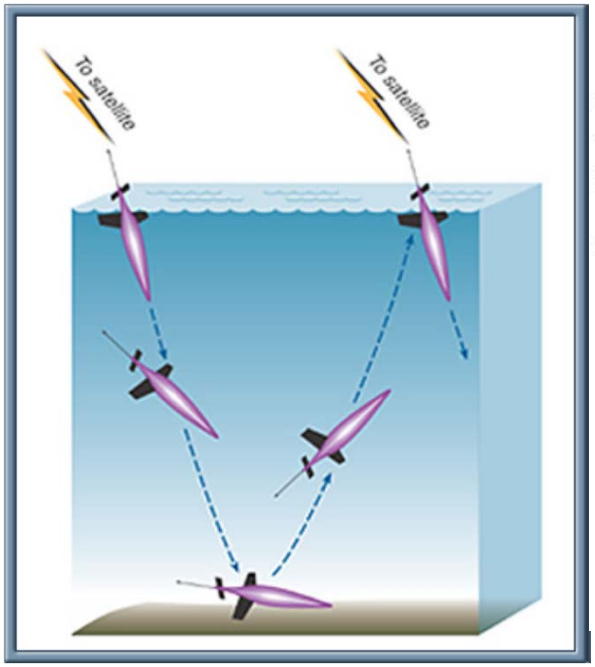
Boundary layer wind profiler

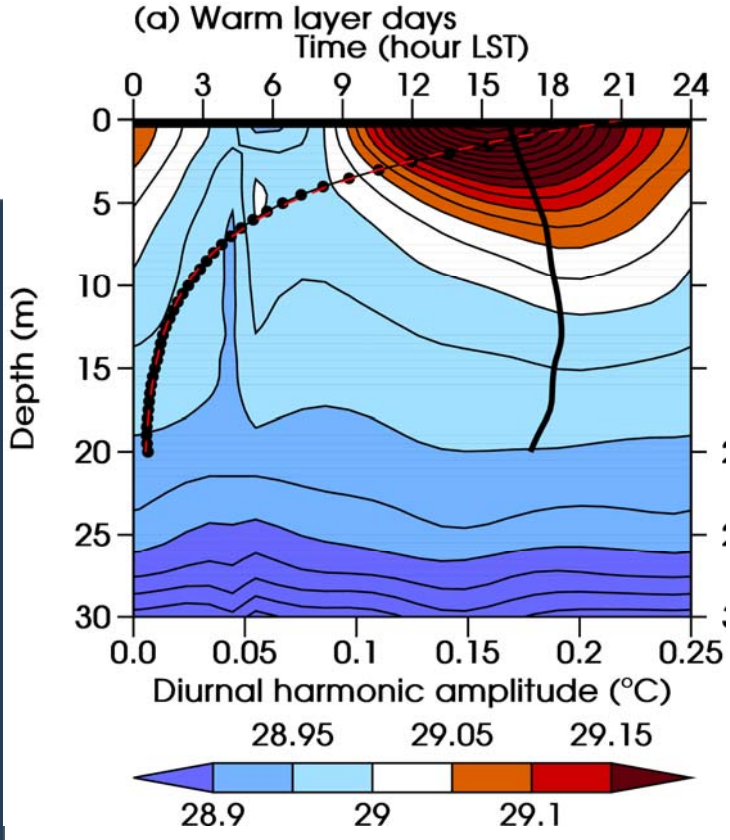
Doppler aerosol LiDAR

Radiometer

University of East Anglia

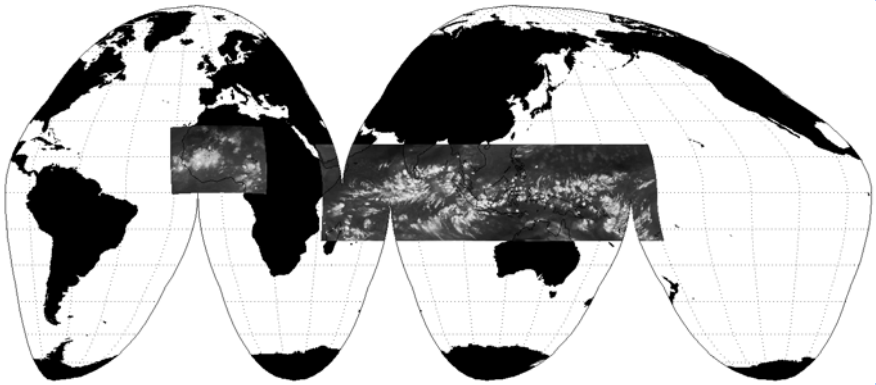
Seagliders





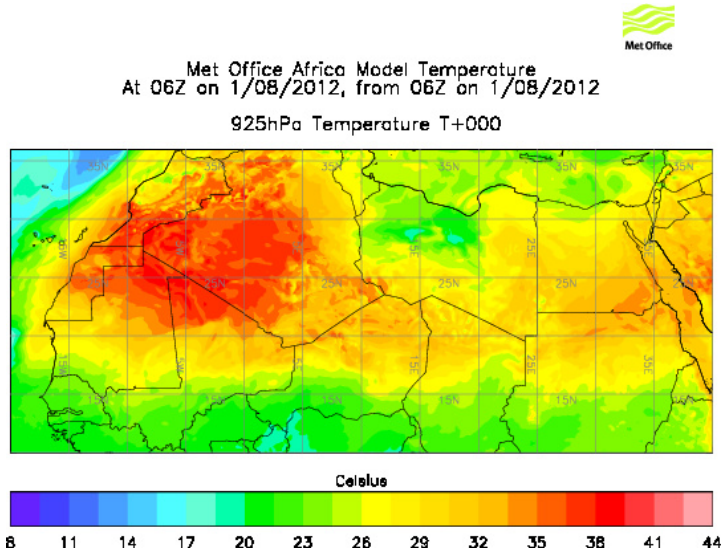
- Possibility of deploying one or more Seagliders to measure upper ocean structure (T, salinity, chlorophyll, dissolved oxygen)
- Seagliders dive every 2 hours to depths of ~1km – diurnal cycle
- Operate automatically for up to 4-5 months, data communicated via satellite
- It is possible to deploy sea gliders from Swallow Reef, the coast of some of the main islands or a ship

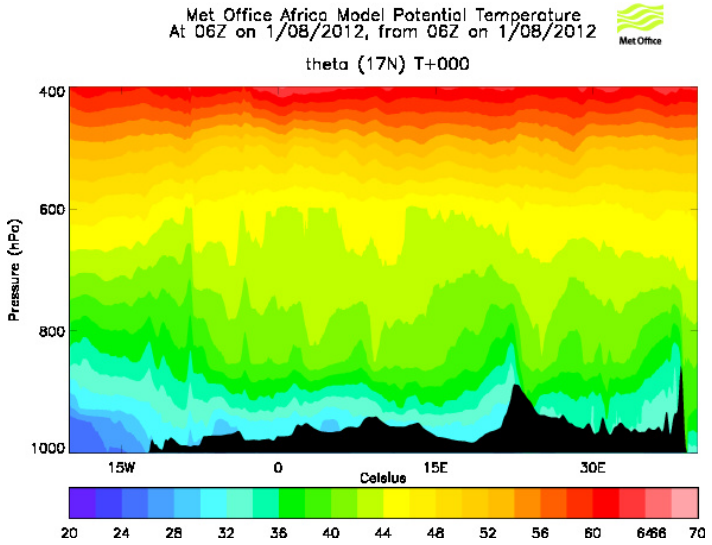
Proposed modelling for YMC

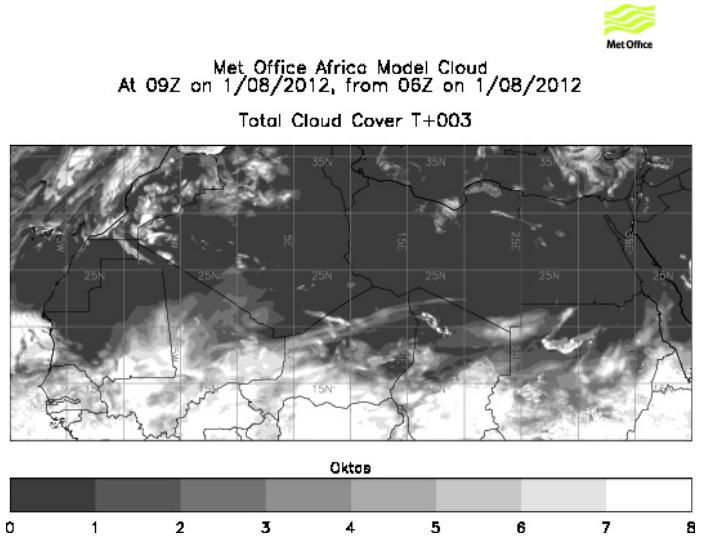


- Previous experience through ‘Cascade’ project, including Love et al 2011
- Very high resolution model simulations (100-200m) to capture specific storm case studies
- Run Cascade-style simulations for several months
- Domains of ~3500x2500 grid points will be possible for several months (domain above at 1km)
- Use simulations plus observations to understand convective processes and evaluate coarser models

Forecast products for YMC campaign







Met Office can provide forecasts for the field campaign.

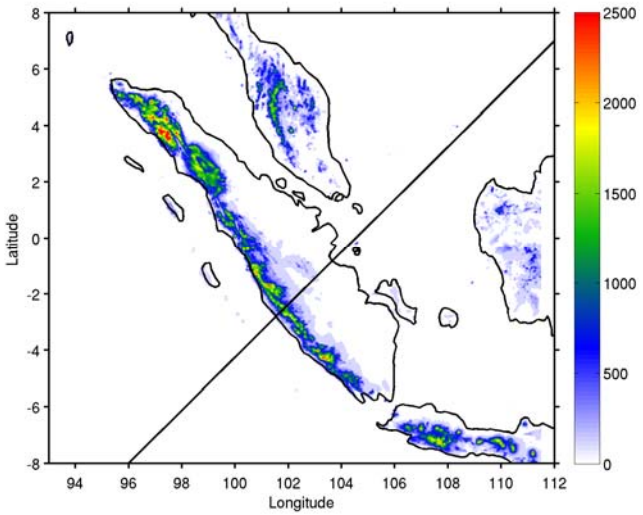
- Twice daily global NWP forecasts (~17km)
- Convective scale model forecasts (4km or less)
- Any model diagnostic could be plotted on lat-lon maps or vertical sections
- Made available via ftp
- Coordination with MSS?

Conclusions

- Joint MetOffice–UK University science objective is to understand the diurnal evolution of the boundary layer, convection initiation and the dynamics of storm development and their offshore propagation
- FAAM Bae146 aircraft (~1 month), longer term deployment of ground instrumentation (~1+ year)
- Highly dependant on local sites and permissions (and grant success)
- Currently dates and location are flexible – extremely keen to co-locate with other groups
- Plans for high-resolution modelling studies
- Met Office are able to provide model forecast products for YMC

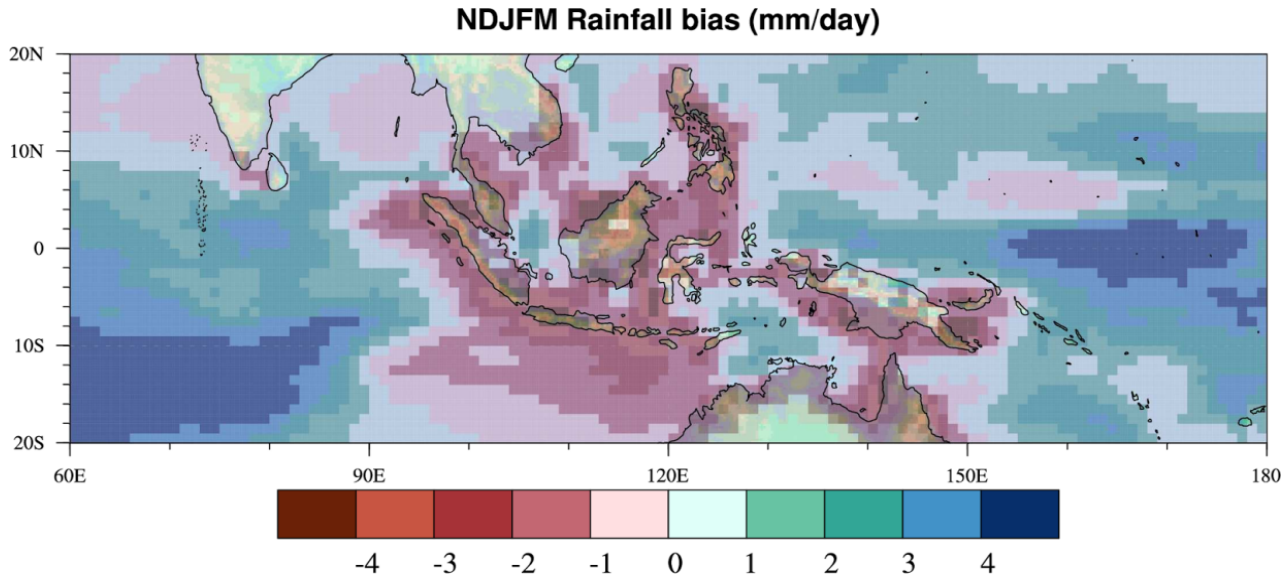
Thank you

Proposed modelling for YMC



- Previous experience through ‘Cascade’ project
- Very high resolution model simulations (100-200m) to capture specific storm case studies
- Run Cascade-style simulations for several months
- Right-hand domain (3300x2000 grid points) will be possible at 1km for several months

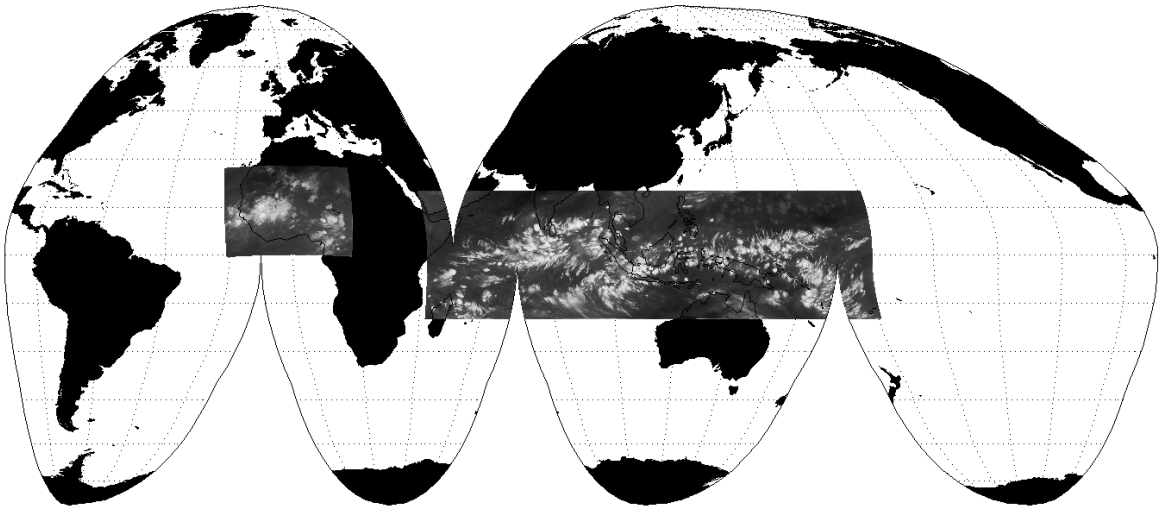
Motivation



Bias of November-March mean rainfall in atmosphere-only Met Office Unified Model GA6.0 (AMIP-type simulation)

- Bias develops in the first few days of a forecast, suggesting that it is related to fast-physical processes such as convection (Martin et al 2006)
- Models fail to represent the diurnal cycle and propagation of storms
- Significant influence on remote model biases
- Need to better understand rainfall-producing mechanisms to improve models

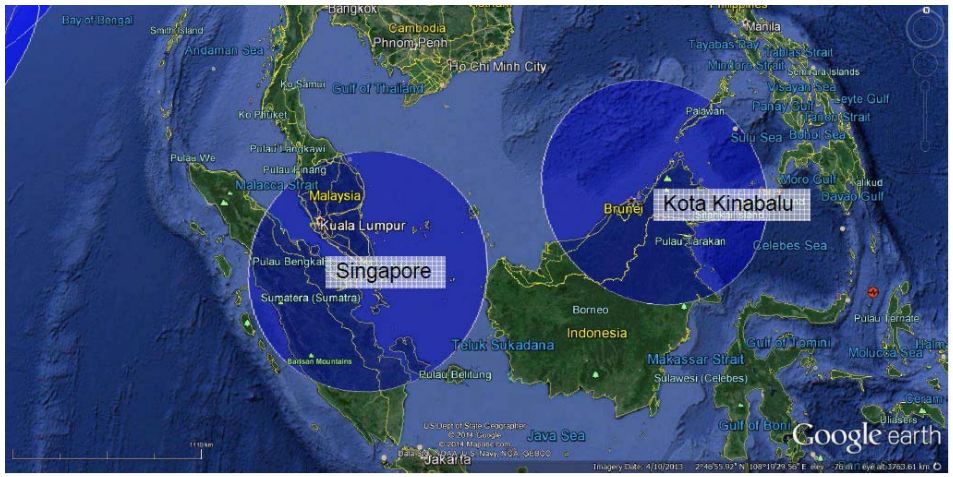
Previous modelling experience



- UK high-resolution modelling project: Cascade
- Two domains over West Africa and the MJO region
- Large-domain, month-long simulations with grid-spacings at 1.5, 4, 12, and 40 km with and without convective parameterisation
- Allows statistical analysis of realistic modelled convective processes for the first time e.g. African water cycle, MJO, storm propagation off Sumatra, analysis of cold pools
- 16+ publications to date

- https://www.ncas.ac.uk/index.php/en/the-facility-amf/mobile-instruments

Field campaign



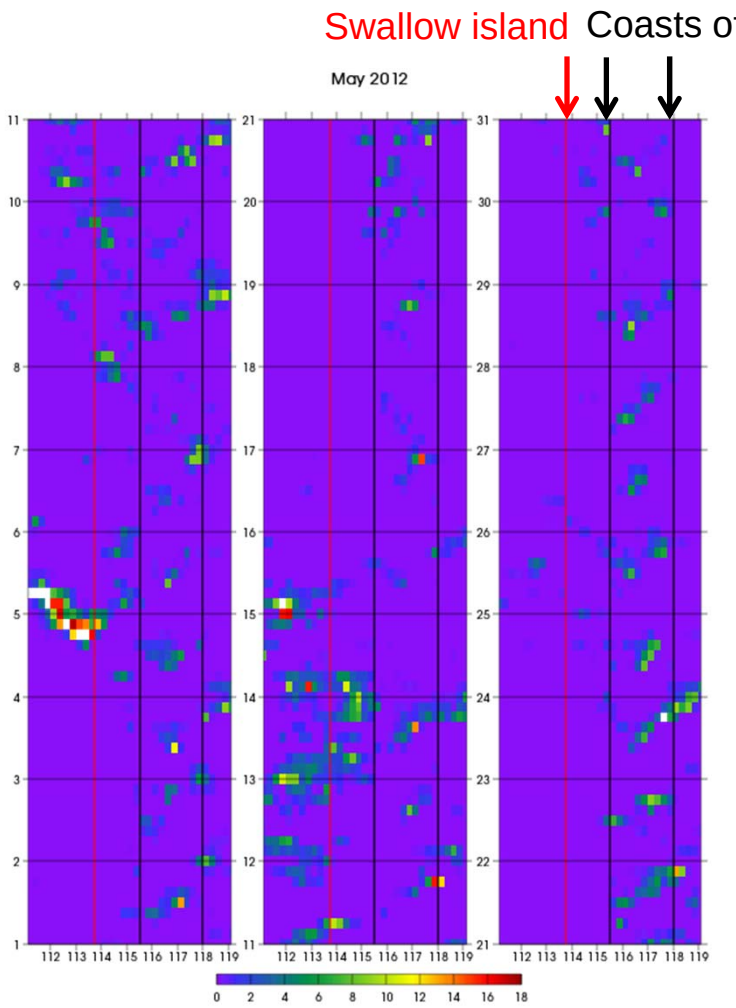
Typical maximum operating radius for a single flight

e.g. fly an hour's transit, do 2 hours of measurement and return

Suggested aircraft locations:

- Singapore, where there are a number of regional airports. Could be convenient due to established links with Met Office-Singapore links
- West coast of mainland Malaysia (Penang Airport 5.3N, 100.2E)
- Research station called on the East coast of Malaysia in Bachok (6N, 102.4E), with a nearby local airport where they release radiosondes
- Kota Kinabalu in Malaysia, where a field campaign involving the British research aircraft took place a few years ago.

Example field campaign



Hovmoller plot of May 2012 TRMM rainfall along flight dropsonde transect

- Swallow Reef is only open Apr-Aug
- Hovmollers of rainfall along dropsonde transect for an example year (2012)
- Aug 2012 had little rainfall, but other months better (e.g. May shown on left).
- Clear diurnal offshore propagation visible
- Sporadic
- Recommend at least 1 month of observations to capture reasonable sample, possibly more
- D. Parker and J. Marsham have had experience flight planning and leading previous aircraft field campaigns over Africa and Northern Europe

Cascade over Maritime Continent

Quarterly Journal of the Royal Meteorological Society Q. J. R. Meteorol. Soc. 137: 934–947, April 2011 B

RMetS
Royal Meteorological Society

The diurnal cycle of precipitation over the Maritime Continent in a high-resolution atmospheric model

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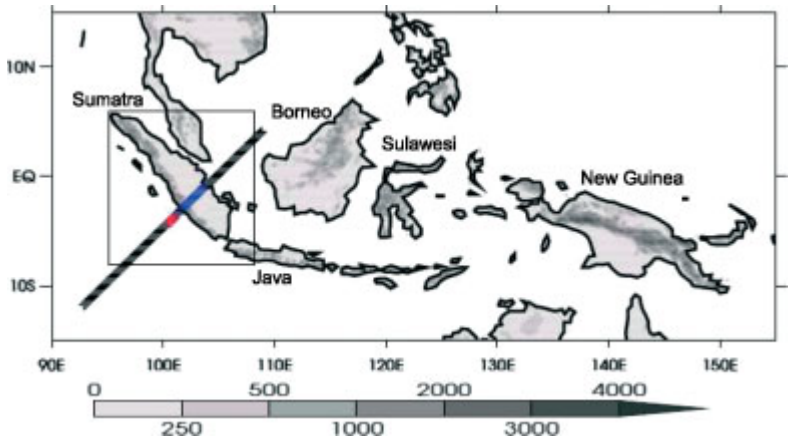
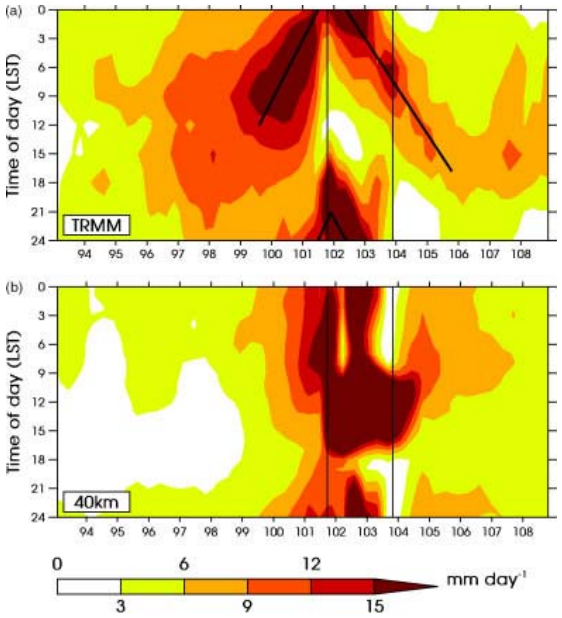
Climate models can exhibit systematic errors in their mean precipitation over the Maritime Continent of the Indonesian archipelago at the heart of the tropical warm



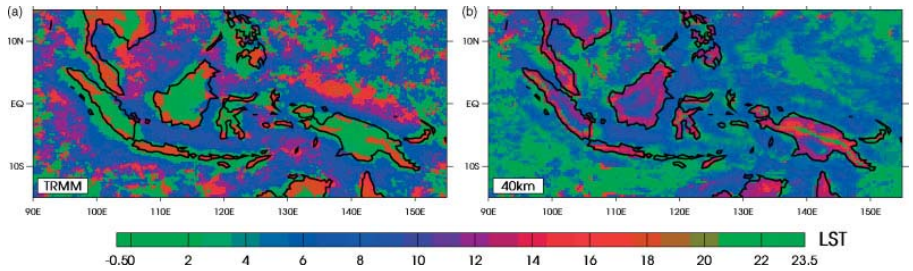
- Oct-Apr 2008-2009
- 180 days over large domain with 40 and 12km grid-spacing
- 60 days over small (Sumatran) domain with 4km grid-spacing

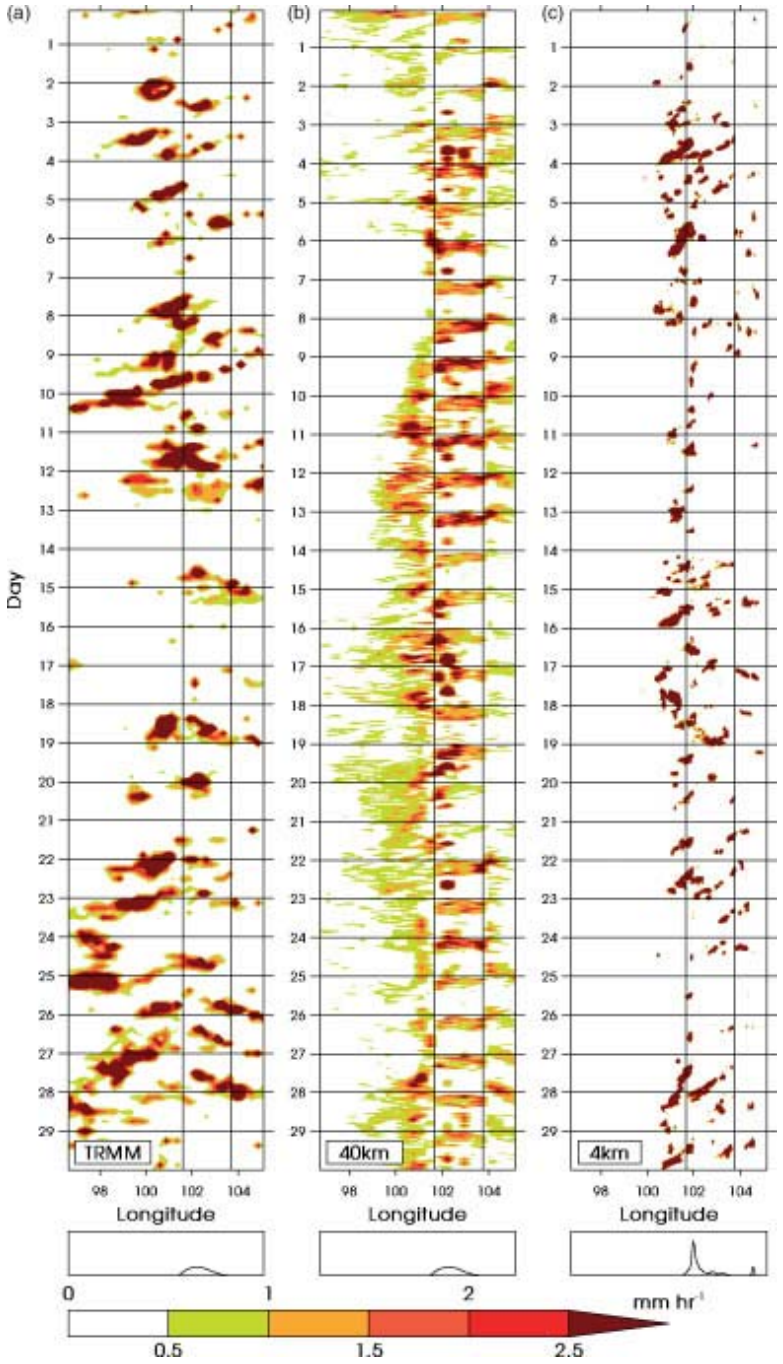
Met Office



Diurnal cycle and propagation of storms are improved when convective parameterisation switched off

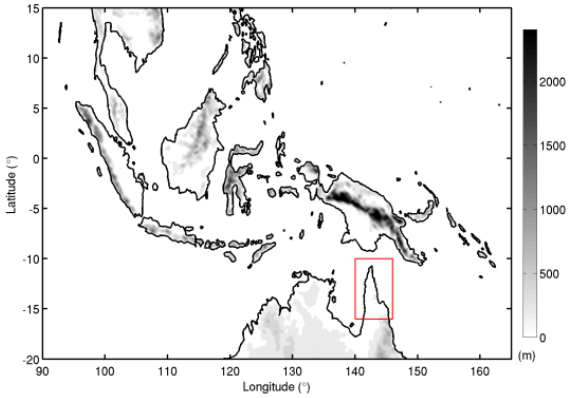
Love et al. 2011 QJRMS

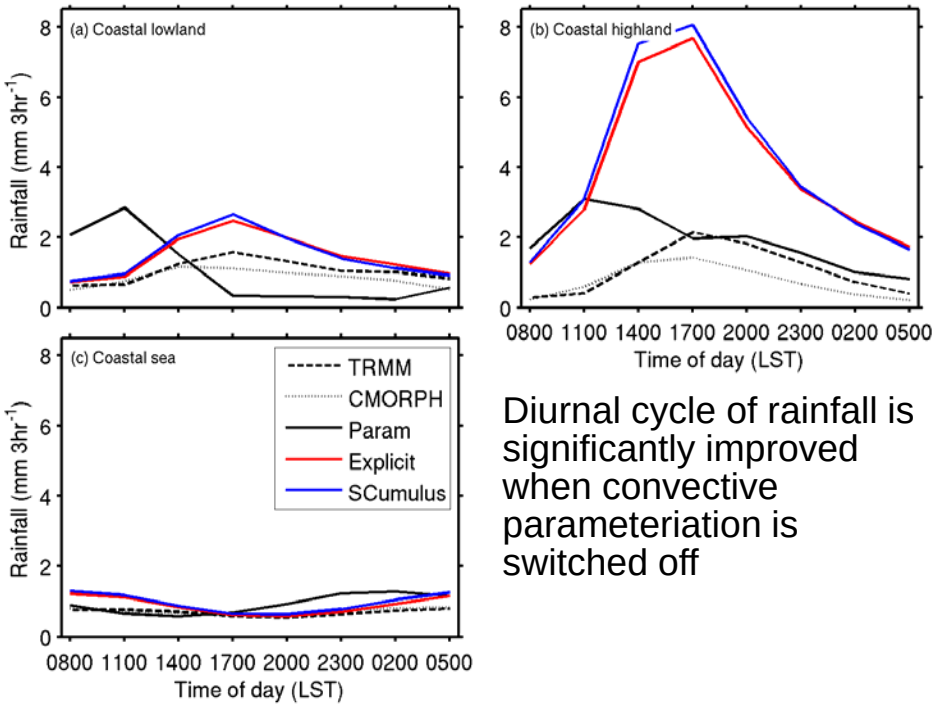




Global convection-permitting simulations

Averaging domain



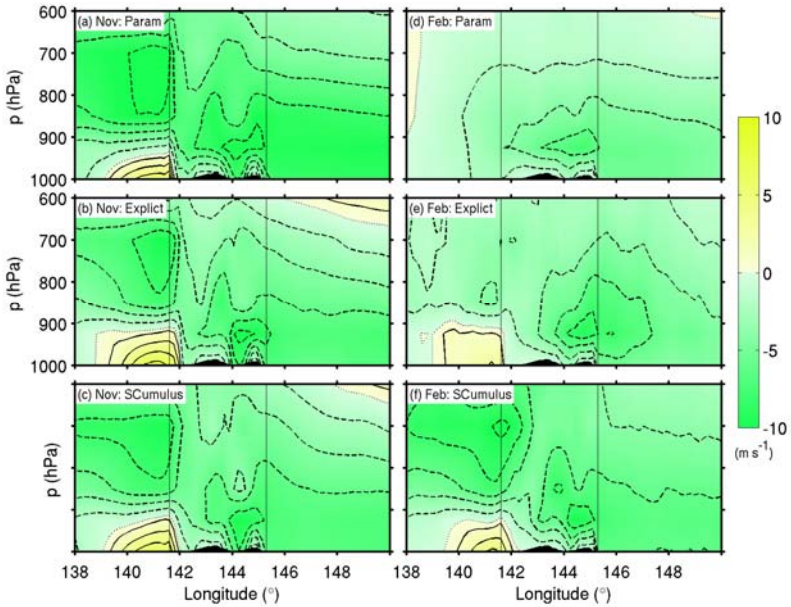


Diurnal cycle of rainfall is significantly improved when convective parameteriation is switched off

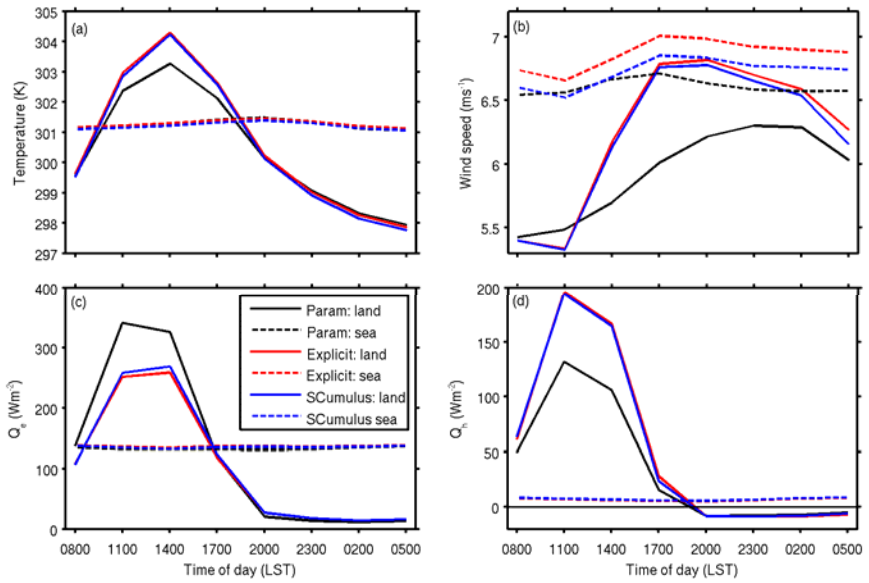
- Three global climate simulations at 12km horizontal resolution
- Standard convective parameterisation (Param), explicit convection (Explicit), shallow-cumulus parameterised + deep convection explicit (SCumulus)

Birch et al. 2014, J. Climate submitted

Global convection-permitting simulations



Sea breeze strength is similar in the simulations in November (dry season) but the sea breezes are weaker in Param in February (wet season)



Convective parameterisation causes rain too early in the day, cools and wets boundary layer, reduces land-sea temperature contrast and weakens the sea breeze

- GCM's with 17km grid-spacing are able to reproduce sea breezes, a major convection forming mechanism in the Maritime Continent
- The convective parameterisation does not respond to this trigger realistically

Birch et al. 2014, QJRMS submitted