Running Tropical Convection through the Radar Gauntlet

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Running the gauntlet
Punishments or tests consisting of consecutive blows or tasks endured sequentially; an onslaught or attack from all sides.
Radars of choice

TRMM Precipitation Radar (PR)
- 2.2 cm ($K_u$ band)
- 4.3 km footprint at nadir, 250 m vertical resolution
- 215 km swath width
- $\sim 17$ dBZ sensitivity

C-POL in Darwin
- 5 cm (C band)
- 2 km horizontal resolution, 500 m vertical resolution
- 10 minute volume scans
- $\sim 0$ dBZ sensitivity
Tropical cloud population

Many cloud types contribute to tropical rainfall. Also, cm-wavelength radars only sense the precipitation in clouds.
Shallow to moderate convection

TRMM PR: 30 Jun 2004

C-POL: 26 Jan 2006
Deep convection

TRMM PR: 14 Jun 2004

C-POL: 10 Feb 2006
Stratiform rain

TRMM PR: 19 May 2004

C-POL: 23 Jan 2006
Stratiform rain can also form in weak shear situations.
Anvil

TRMM PR: 14 June 2004 Orbit 37514

C-POL: 23 Jan 2006
TRMM PR rainfall (1998-2000)

Schumacher and Houze (2003)
Conditions that appear conducive to stratiform rain production:
- More maritime BL (sustainability of convection)
- Weaker upper level shear (hydrometeor availability)
- Moister mid levels (less sublimation and evaporation)
GCMs generally either don’t “get” stratiform rain or have a different definition (likely a combination of both).
Chen et al. (2007) shows that GISS GCM has opposite change in stratiform rain during El Niño => causes weaker remote response.
Shallow and deep convection

TRMM PR: echo tops < 3 km

Short and Nakamura (2000)

TRMM PR: maximum height of 40 dBZ

Zipser et al. (2006)

Stratiform

Convective

Anvil

Shallow, isolated

Reflectivity (dBZ)

Height (km)

~0 dB/km

~1 dB/km

~2 dB/km

East Atlantic  West Africa  WA-EA

Reflectivity (dBZ)

Height (km)

Reflectivity (dBZ)

Difference (dB)

Stratiform

Convective

Schumacher and Houze (2006)
West African MCSs evolve from more convective to more stratiform while East Atlantic systems are more constant.
Idealized latent heating profiles

Schumacher et al. (2007)
Kwajalein Experiment (KWAJEX)
24 July - 15 September 1999
Convective cloud $Q_1$ during KWAJEX

Fair-wx cumulus: 22%, < 1 mm/d
Cumulus congestus: 31%, 3 mm/d
Cumulonimbus: 39%, 8 mm/d
MCS: 7%, 28 mm/d

Schumacher et al. (in press), photos from Rangno and Hobbs (2005)
Total latent heating profiles for 10 mm d$^{-1}$ of rain
C-POL derived latent heating during TWP-ICE
19 January - 11 February 2006

Stronger and longer-lived systems during active monsoon, weaker and more shallow systems during dry monsoon.
PR annually-averaged latent heating at 10°N

A horizontally varying stratiform rain fraction dictates the geographical distribution of the height of maximum latent heating, which has implications for the large-scale circulation.

Schumacher et al. (2004)
Weather radar observations provide a somewhat untapped source of metrics for model validation.

Radar shows that convective systems over land have less shallow convection, more intense deep convection, lower percentages of stratiform rain, and more thick anvil than systems over the ocean.

GCMs (or models in general) don’t necessarily capture the observed distribution of tropical stratiform rain, which is important to the large-scale circulation (e.g., during El Nino).

4-D latent heating can be estimated using the temporal and geographical distribution of convective cloud components observed by radar.