The Interaction between Cumulus Convection and Its Environment over the Indian Ocean during the CINDY2011/DYNAMO Period as Revealed by 100-m-mesh Convection Resolving Simulations

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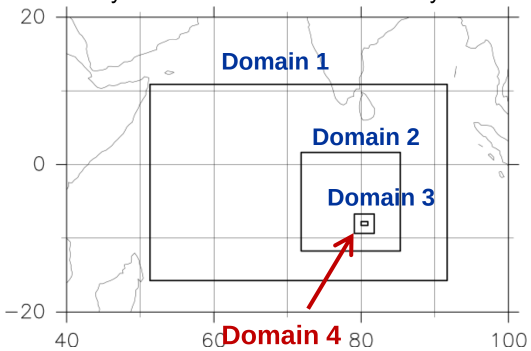
Introduction

The large-scale variability of moisture content in space and time strongly controls the development, evolution, and morphology of tropical oceanic cumulus convection, while the cumulus activity affects large-scale environments by transporting moisture. Mixing between cumulus and the environment is a key to understand dynamics and interactions of tropical convection across scales. This study investigates the cumulus-environment interaction by conducting convection-resolving simulations at 100-m grid. The simulated period extends two months during CINDY2011/DYNAMO.

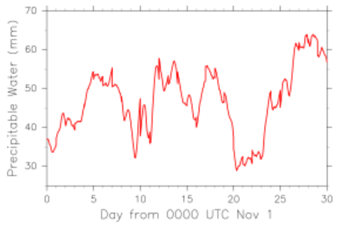
Model and Experimental Design

- Model: WRF/ARW Version 3.3.1
  - One-way, four nested domains
  - Microphysics: Single-moment, 6 class scheme (WSM6)
  - Cumulus: Tiedtke (only for Domain 1)
  - Turbulence: non-local PBL (YSU) for Domains 1-3; Deardorff TKE for Domain 4
- Domain and resolution:
  - Top: 21 km, 61 vertical levels
  - Domain 1: 4250 x 3000 km@12.5 km
  - Domain 2: 1500 x 1500 km@2.5 km, covers sounding array
  - Domain 3: 300 x 300 km@500 m, centered at R/V Mirai
  - Domain 4: 100 x 60 km@100 m, centered at R/V Mirai
- Initial and boundary conditions: JMA Global Analysis



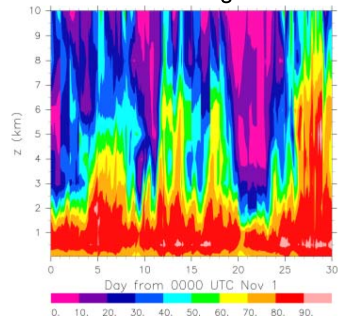
Results: Domain 3, Nov 2011

Domain-averaged precipitable water content

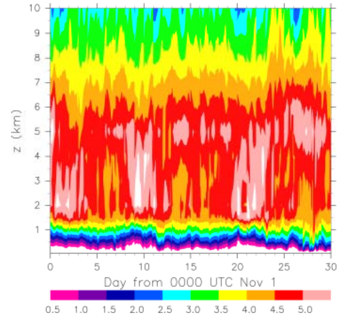


The simulation well reproduced moisture variation.

Domain-averaged RH



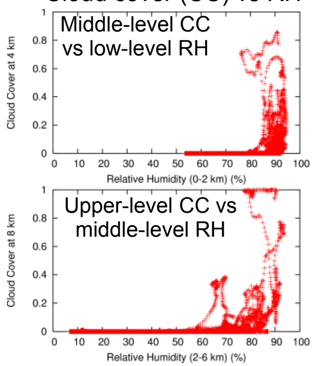
Domain-averaged $\frac{d\theta_v}{dz}$



The levels in the lower layer of the dry air corresponds to the layer with higher stability.

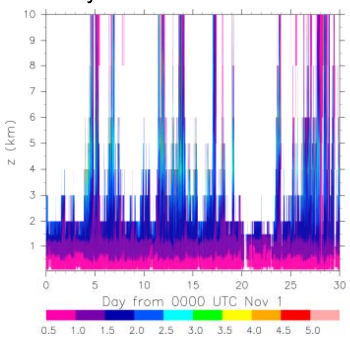
Results: Domain 4, Nov 2011

Cloud cover (CC) vs RH

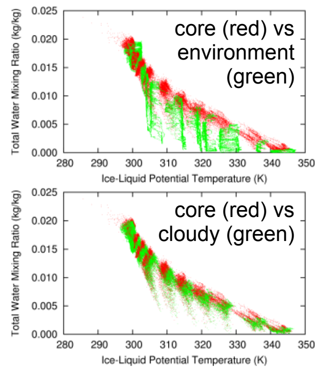


A higher CC at a certain level is related to higher RH below.

Domain-averaged vertical velocity within convective core



Paluch diagram



Strong updrafts at middle/upper levels within cores (qw>0.05 g/kg, w>0.5 m/s) are less diluted with the environment.

Summary

- Moisture variation is closely linked to the vertical development of convection.
- Convective cores with stronger updrafts are less diluted with the environment.
- Convective clouds affects the moisture field at a larger-scale.