Convection regimes during TWP-ICE and in the GISS SCM

Jingbo Wu (Columbia U.), Anthony D. Del Genio (NASA/GISS), and Audrey B. Wolf (Columbia U.)

Summary: Soundings acquired during the TWP-ICE IOP at Darwin show stronger buoyancies/CAPE for the “break” period late in the IOP than for the early “active” monsoon period. Convective response to the stronger large-scale forcing neutralizes the moist stability during the “active” period; for the “break” period, sporadic moist convection under moderate forcing keeps the mid-troposphere relatively cool, and combined with the low-level heating from surface turbulent fluxes, leads to a steeper lapse rate, which generates more intense convection. The GISS SCM is able to simulate more intense deep convection for the “break” period than for the “active” period.

1. Introduction

The TWP-ICE IOP included an early “active monsoon” period with an apparent maritime style of convection, and a late “break” period with occasional intense continental convection. This IOP thus offers the opportunity to understand physical processes that cause differences in convective intensity and the ability of GCM cumulus parameterizations to simulate these differences, which are hypothesized to influence detrainment into radiatively important anvil clouds.

2. Observations

- **Figure 1:** Overview of the TWP-ICE array (J. Beringer: TWP-ICE surface flux stations data)
- **Figure 2:** Evolution of integrated diabatic heating $Q_1$, stratification, vertical large-scale forcing, and CAPE

  - “Active” (1/21-1/22):
    - heavy precipitation;
    - strong large-scale forcing;
    - near-neutral stratification;
    - low-value CAPE

  - “Break” (2/8 – 2/12):
    - moderate precipitation;
    - moderate large-scale forcing;
    - destabilized stratification;
    - high-value CAPE

- **Figure 3:** Buoyancy profiles for “active” (solid) and “break” (dashed) periods

- **Figure 4:** Circulation reverses from onshore (“active”) to offshore (“break”) during the IOP (data provided by BOM,AU)

Large-scale adiabatic cooling and moistening balances diabatic heating and drying (primarily through convection events) during both periods.

For the “active” monsoon period, the magnitudes of moistening/drying and cooling/heating are much larger due to the stronger vertical large-scale forcing. The convective response to the strong vertical forcing results in a near-neutral moist stability.

For the “break” period, the magnitudes of moistening/drying and cooling/heating are small relative to the strong large-scale forcing. The relatively steeper lapse rate results in larger buoyancies/CAPE.

3. SCM Results

- **Figure 5:** Water vapor mixing ratio (upper panels) and dry static energy (low panels) budgets for “active” and “break” periods

- **Figure 6:** Heating rate from surface fluxes for “active” and “break” periods

- **Figure 7:** Pressure-time cross-sections of cumulus updraft speed for a) “active”, b) “break” period; evolution of precipitation for c) “active”, d) “break” period (red = observed, 3-hr total; blue/green = SCM convective/stratiform, 30-min timestep)

In general, the SCM shows some difference in updraft speed between “active” and “break” periods but not for all events; magnitude may be affected by an overestimate of the SCM forcing driving the model.

The SCM is able to capture the stronger intensity of deep convection during the “break” period; timing is poor when the large-scale forcing is weak.

Considerable stratiform anvil rainfall is simulated (50% or more of total – probably too much).