Diurnal Cycle of Convection and Air-Sea-Land Interaction Associated with MJO over the Maritime Continent

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Motivation

- Madden-Julian Oscillation (MJO) convection initiates primarily over the Indian Ocean and propagates eastward to the Pacific over the Maritime Continent (MC).
- The Maritime Continent acts as a barrier to the MJO: 50-60% of MJOs do not cross the MC, and ones that do get weakened in the process. (Fig. 1)
- Large-scale precipitation tracking (LPT) can be used to track MJO events in time and space using accumulated precipitation. (Fig. 3)

Objectives

- Understanding the barrier effect of the MC on the MJO.
- Characterizing the interaction of the MJO with the diurnal cycle (DC) of precipitation over the MC.

Methodology

Unified Wave Interface - Coupled Model (UWIN-CM)

- Weather Research and Forecasting model (WRF v3.6.1)
- Initial and lateral BCs: ECMWF analysis
- YSU PBL, WSM5 microphysics, Tiedtke cumulus param. in 36-, 12-km grids
- Hybrid Coordinate Ocean Model (HYCOM v2.2.98)
- 0.08° resolution, 32 vertical levels
- Initial and lateral BCs: HYCOM analysis

Data

- TRMM 3B42 precipitation(0.25°, 6-hourly), CCMP surface winds (0.25°, 6-hourly), ERA5 (31-km, hourly).

Model Experiments

- 15 day simulations starting on November 22, 2011.

MJO Identification

Large-scale precipitation tracking (LPT) tracks features that:
- accumulate precipitation over 3 days using a spatial filter & 15 mm threshold.
- move eastward and persist for 7+ days.

Results

MJO Tracking and the DC of Precipitation

- UWIN-CM reproduces the phase of the precipitation DC and its pattern of variability, but strongly exaggerates the amount of land precipitation.
- The MJO in CTRL and FLAT experiments dissipates over the western MC, while the MJO in the WATER experiment does not weaken and propagates farther east.

Across-Shore Surface Flow and 2m Temperature

- Observed surface flow follows the land-sea breeze pattern: onshore flow in the afternoon, and offshore flow at night.
- In ERA5 and model experiments, the land-sea wind shift is present, but the strongest winds are colocated with strongest temperature gradients (at the coastline), and highest precipitation totals.

Summary

- Land-locked DC of convection is disruptive to the MJO and its eastward propagation (i.e. the MC barrier effect), with mountains affecting local organization of convection, but play a minor role overall.
- The strong on-shore flow in the morning (9 AM) and rainfall peak around noon over land in UWIN-CM and ERA-5 are absent in CCMP and TRMM data.
- Increase in 2m temperature over land at 9 AM seems to contribute to unrealistically strong on-shore winds and enhanced morning rainfall in UWIN-CM and ERA5.

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