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)*

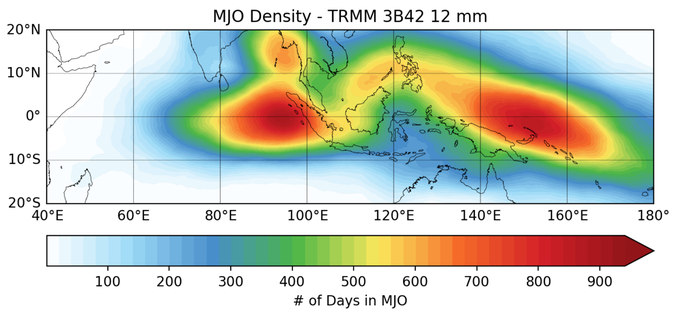

Fig. 1: Density of MJO events identified by LPT tracking in 20 years of TRMM-GPM 3B42 data.

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

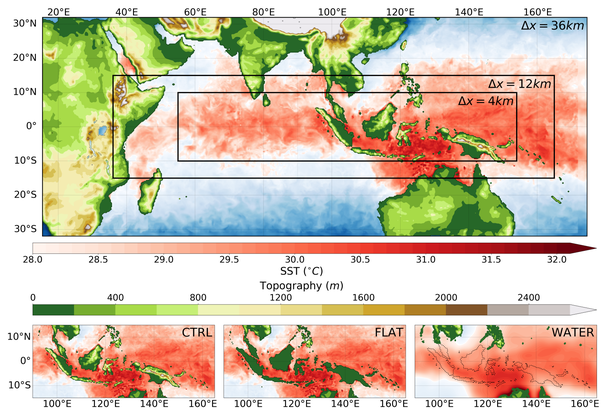

Fig. 2: UWIN-CM model domains and terrain height in model experiments.

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

Model Experiments

- 15 day simulations starting on November 22, 2011.

CTRL	FLAT	WATER
real land-sea distribution and topography	MC terrain leveled to 10 m, landuse is 100% rainforest	MC land replaced with water, SST evolves with surrounding seas

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.

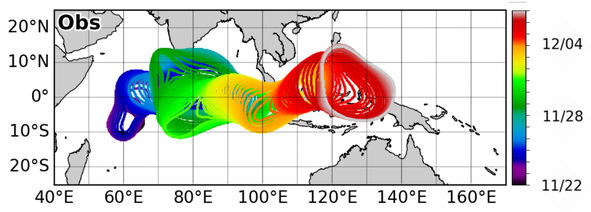

Fig. 3: LPT track of the observed MJO event starting on November 22, 2011. Contours outline the area of 3-daily 15 mm rain accumulation, colors represent time.

DC Analysis

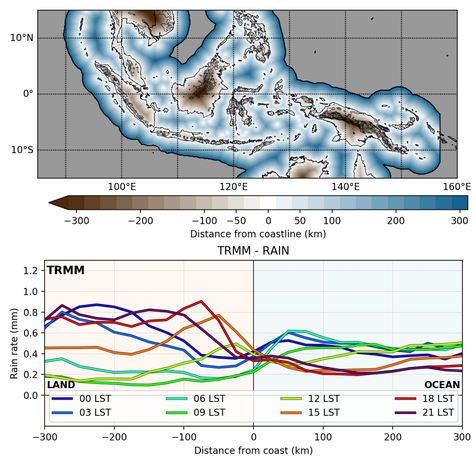

Fig. 4: Distance from coastline over the MC (top), and the 15-day composite of DC of precipitation in TRMM 3B42 (bottom).

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 2-m temperature over land at 9 AM seems to contribute to unrealistically strong on-shore winds and enhanced morning rainfall in UWIN-CM and ERA5.

Acknowledgements

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We thank Brandon W Kerns for providing the TRMM-GPM LPT tracking data.

Reference: Kerns, B. W. and S. S. Chen, 2016: Large-scale precipitation tracking and the MJO over the Maritime Continent and Indo-Pacific warm pool. *JGR Atmos., 121, 8755-8776.*

Results

MJO Tracking and the DC of Precipitation

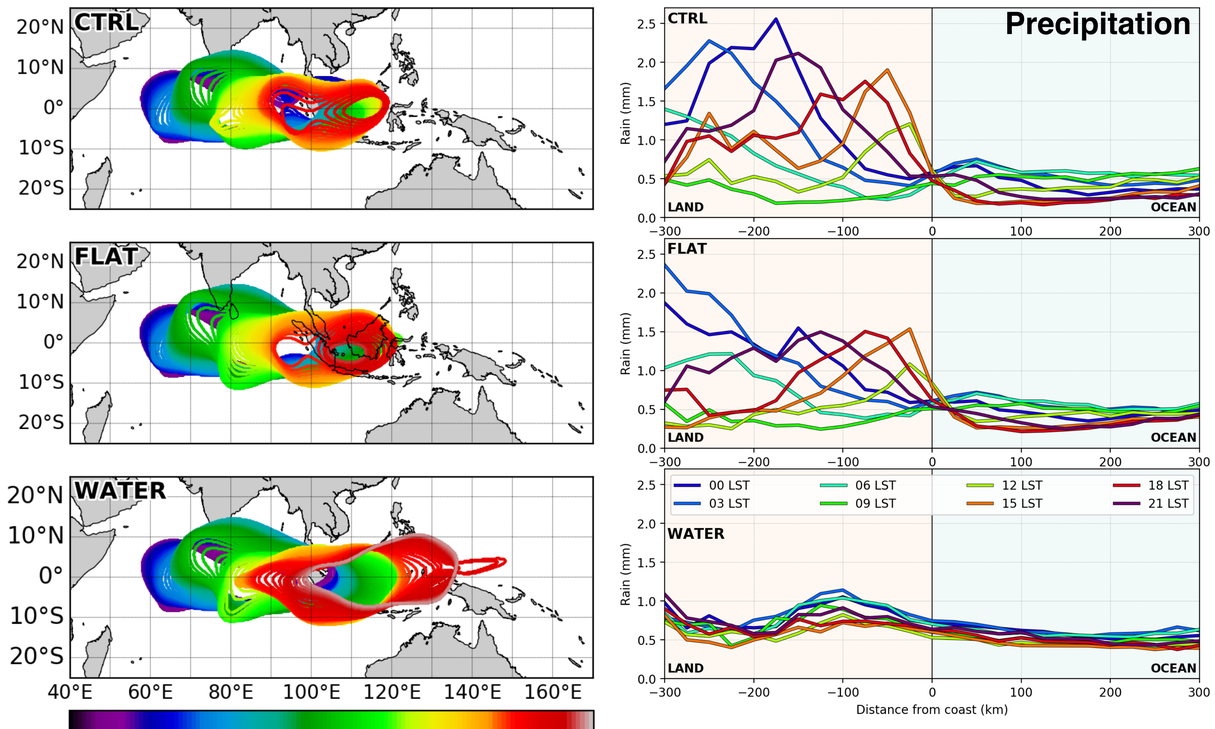


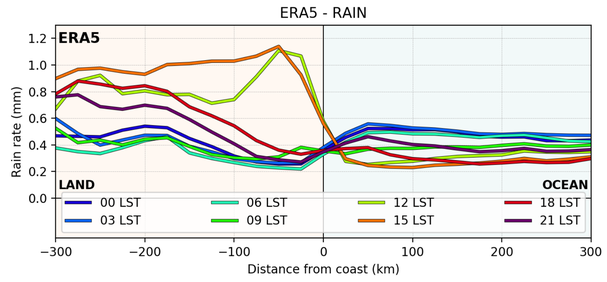
Fig. 5: LPT MJO tracks (left) and rainfall DC (right) in the CTRL (top), FLAT (middle), and WATER (bottom) experiments.

- 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

Fig. 6: 15-day DC composites of onshore surface wind (left) and 2 m temperature (right) anomalies with distance from coastline. Shown from top to bottom are: CCMP observations, ERA5 reanalysis, and CTRL, FLAT, and WATER experiments.

- 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.



Future Work

- Analysis of changes in the DC of winds, temperature, moisture in MJO and non-MJO conditions using global analysis fields, satellite observations, and coupled model experiments.