Understanding Barrier Effects of the Maritime Continent on MJO Prediction

Ajda Savarin and Shuyi Chen

University of Washington, Seattle, Washington, USA

Are the barrier effects of the MC on MJO propagation physical or dynamical?

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EGU General Assembly 2022 - May 27 2022 - Vienna, Austria

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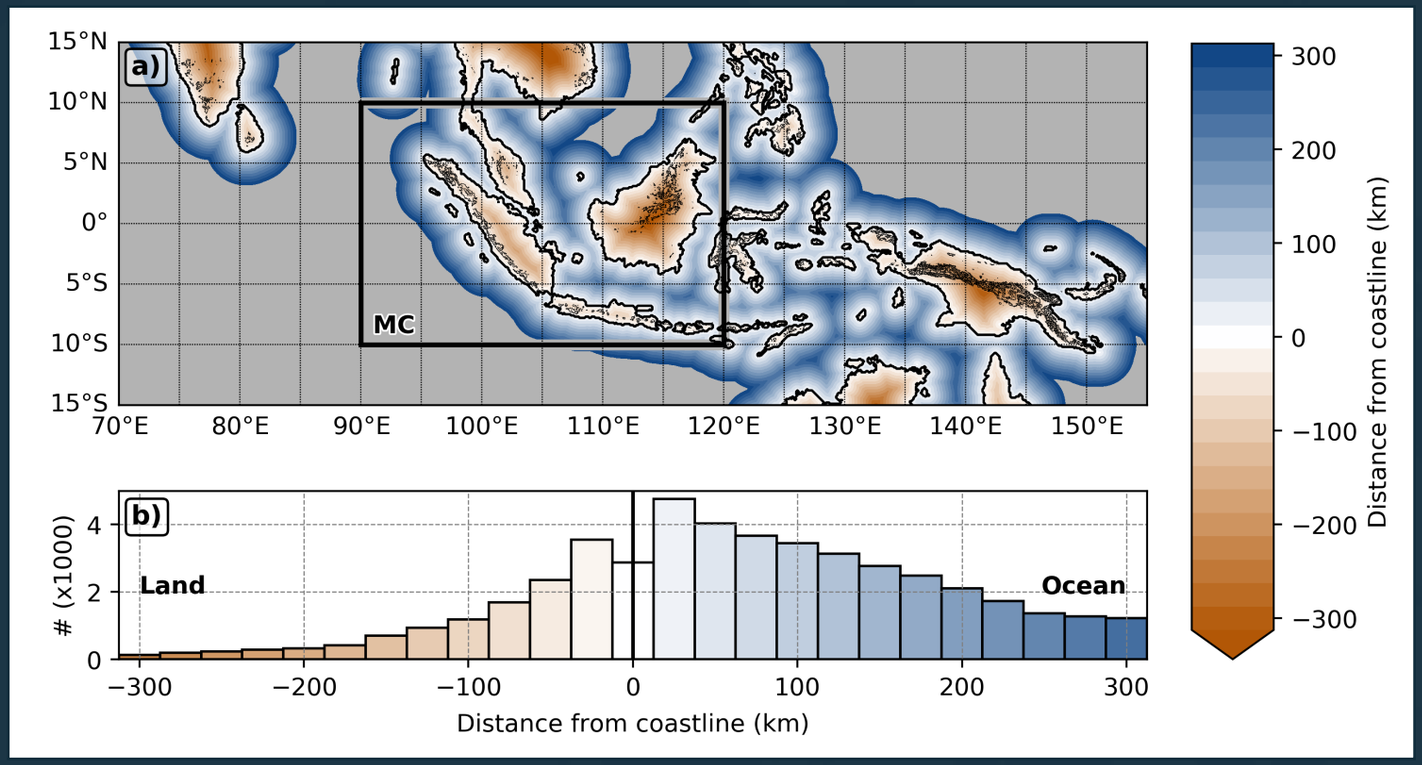
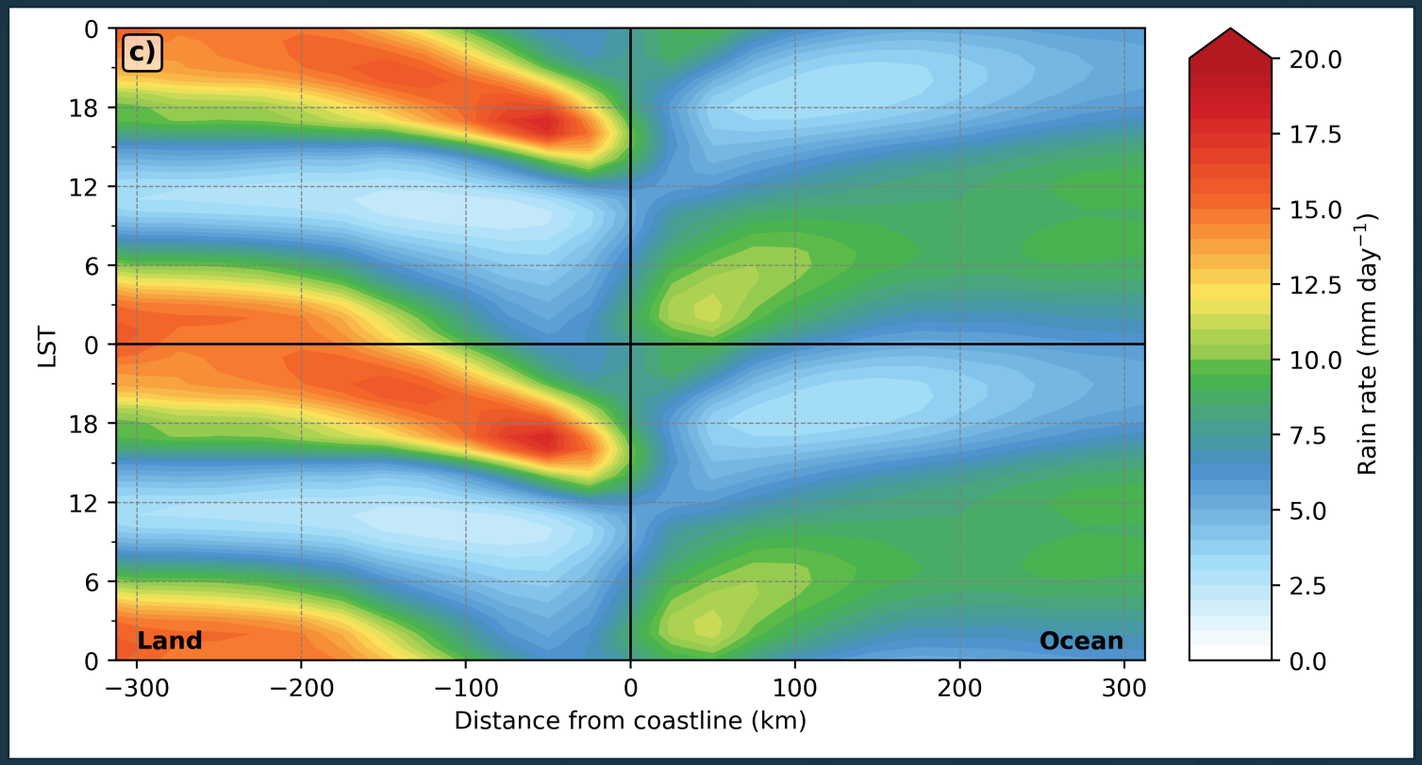
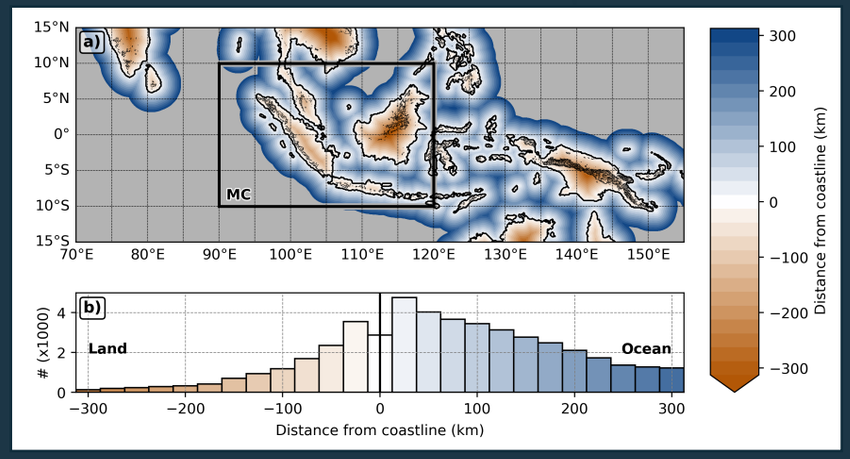
Coastline-Relative Framework



- ETOPO1 global relief - 1 arc-minute resolution.
- Negative distances are over **land**, positive distances over **water**.

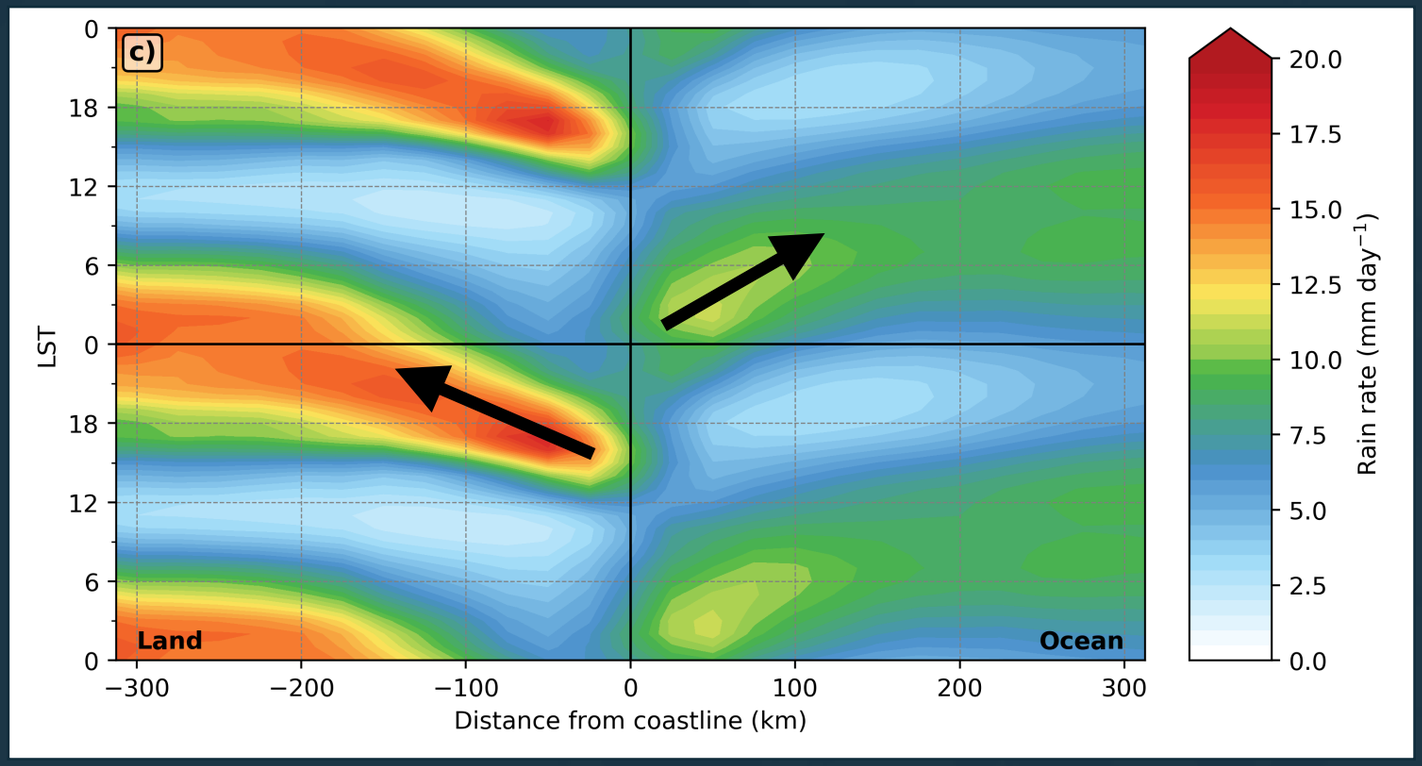
Coastline-Relative Framework

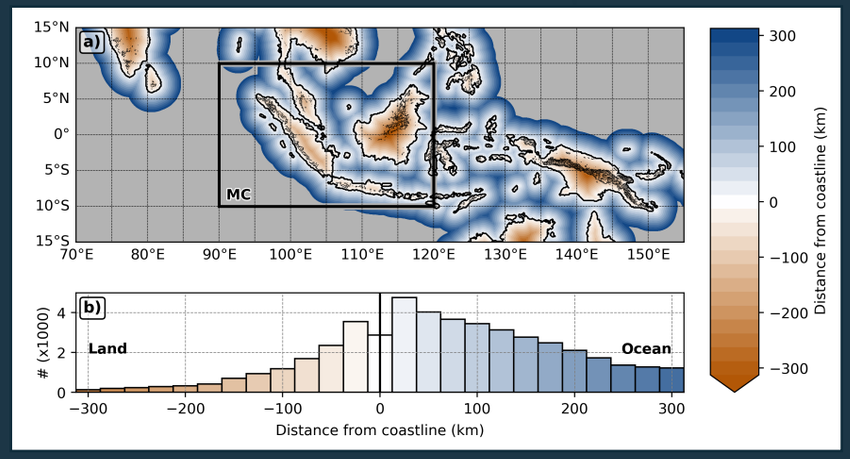




- Diurnal cycle (DC) of IMERG precipitation.

Coastline-Relative Framework





- Diurnal cycle (DC) of IMERG precipitation: **land-sea breeze** pattern over MC.

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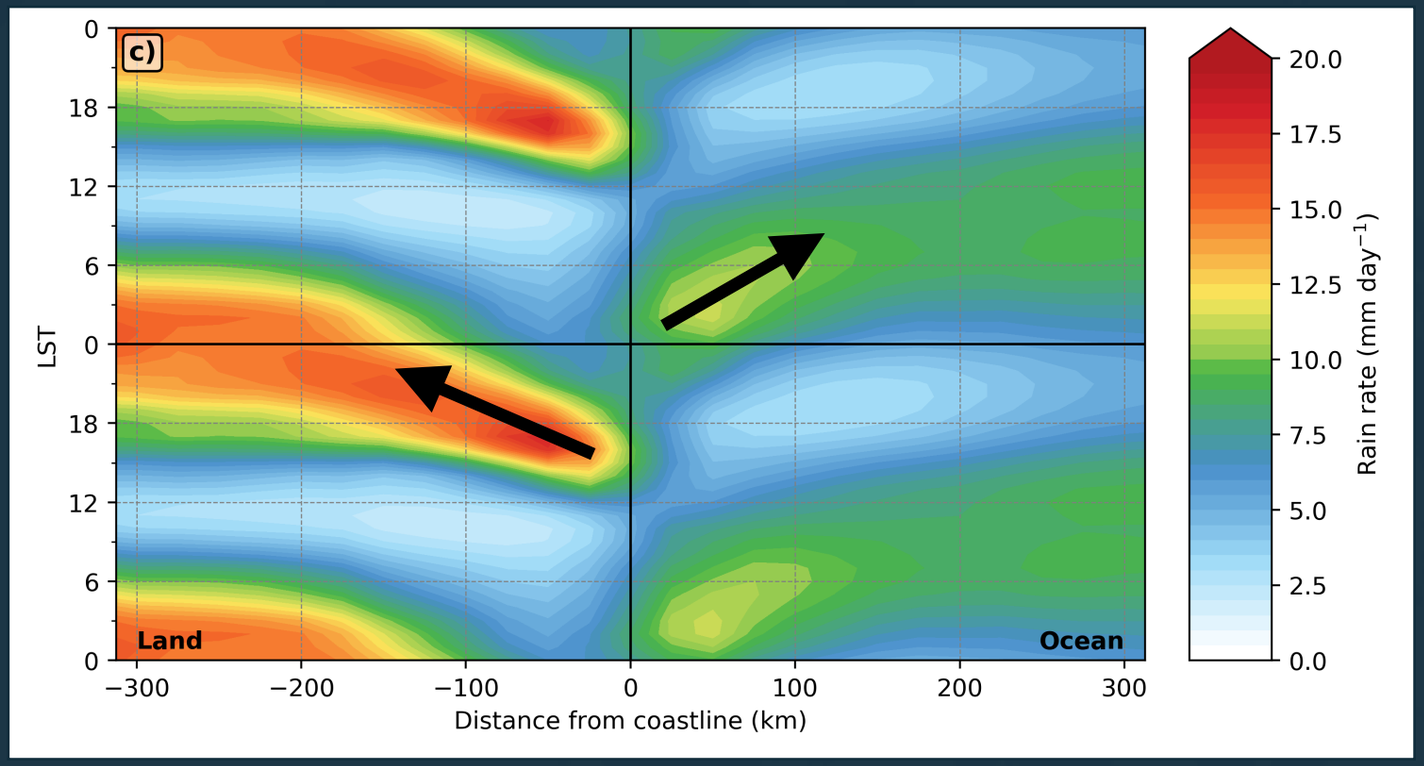

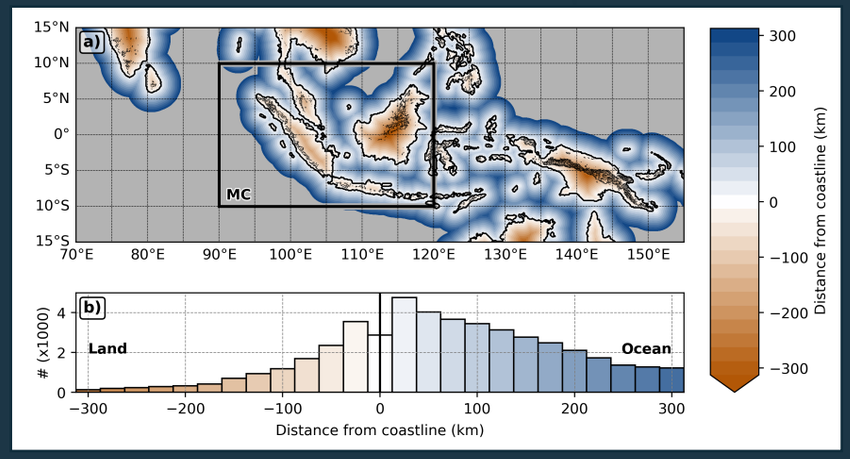

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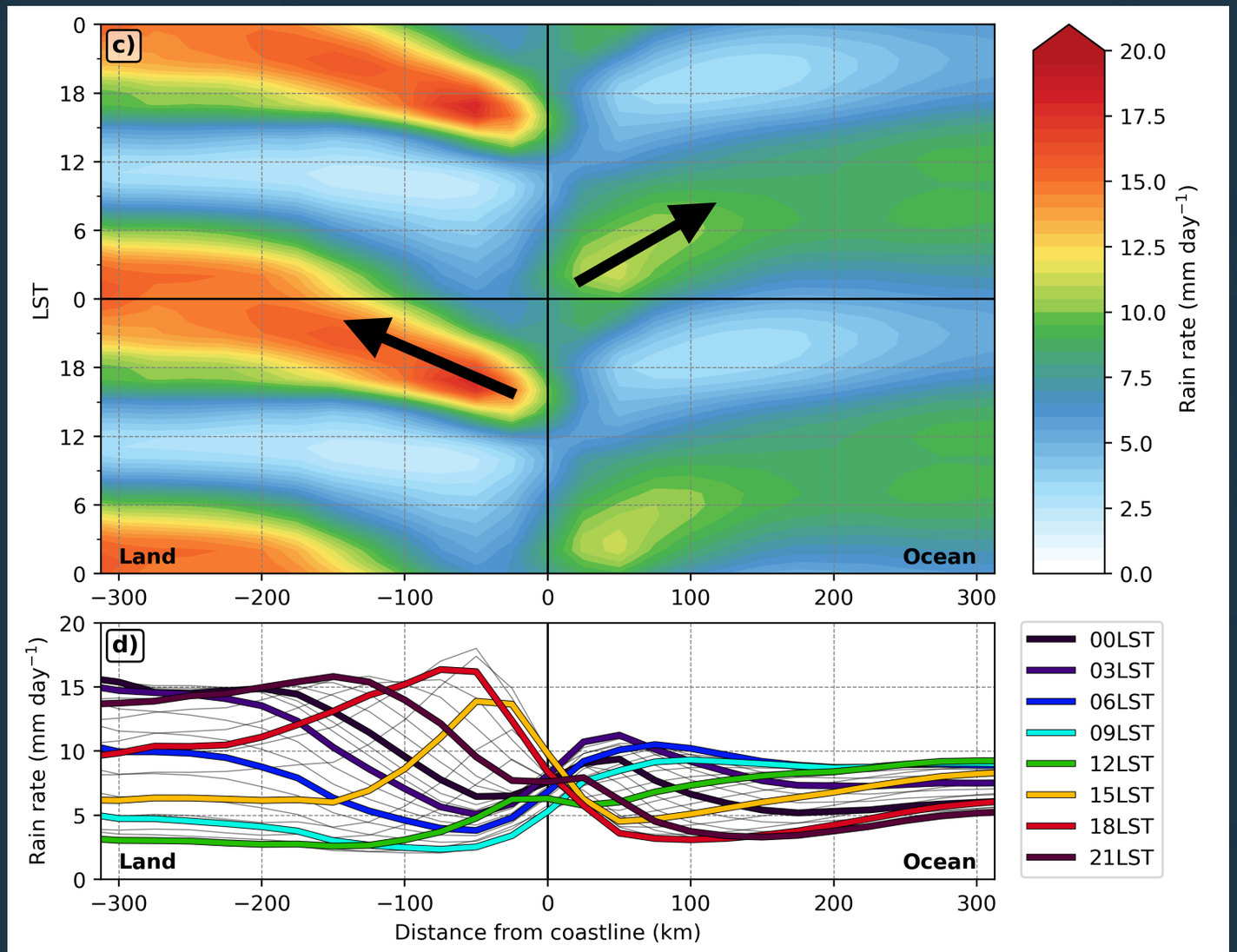
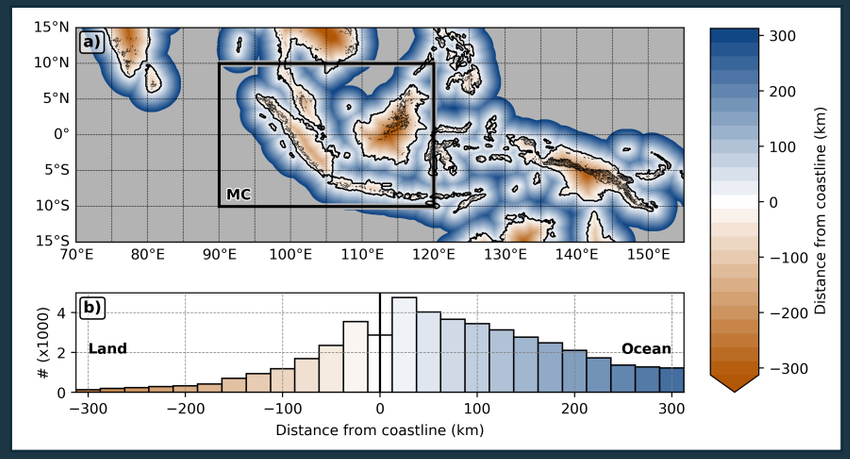
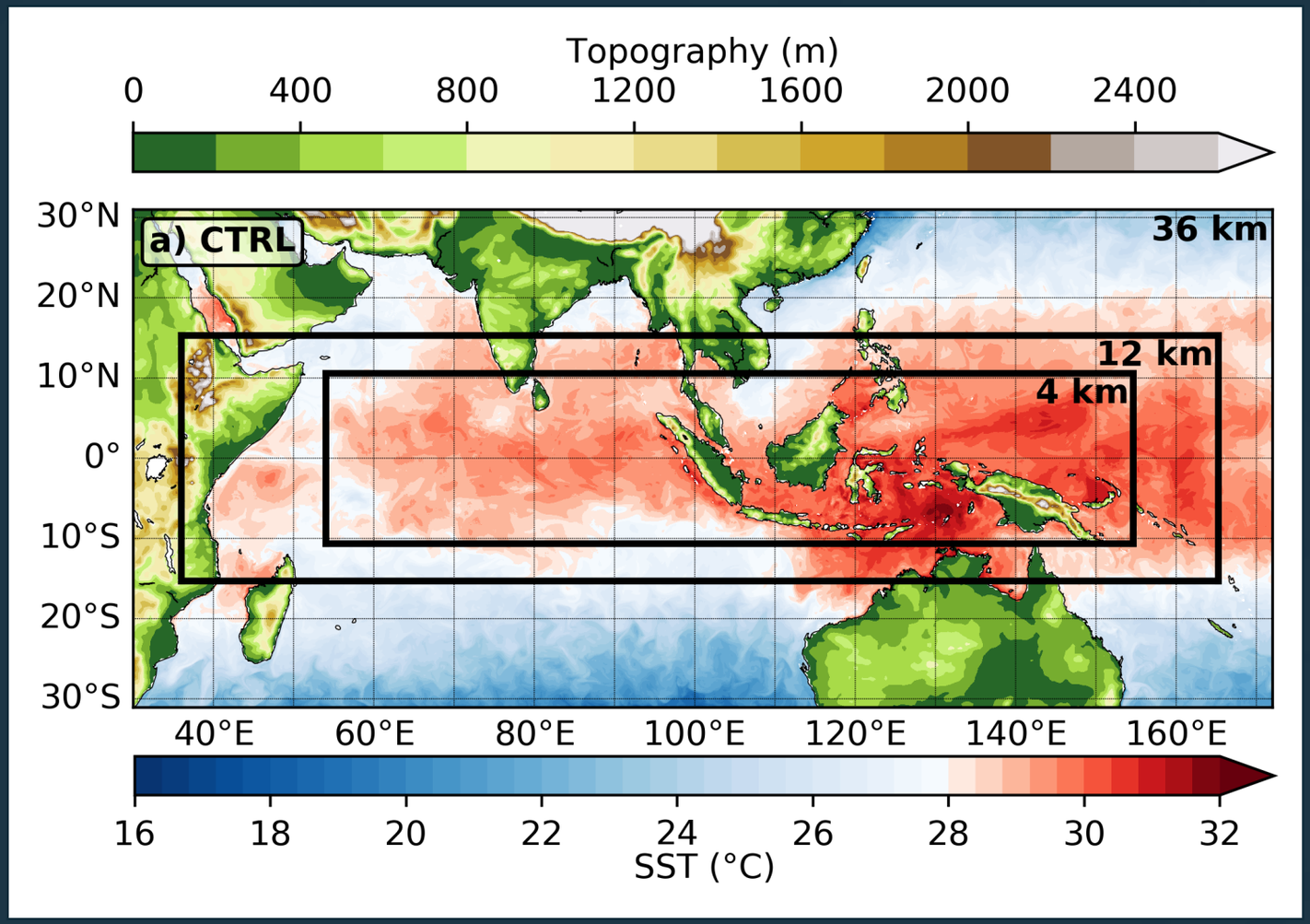




- Diurnal cycle (DC) of IMERG precipitation: **land-sea breeze** pattern over MC.

- Convection in late afternoon/early morning is **land-locked**.
  - Precipitation over land is more intense than over ocean.

Model Configuration



- Atmosphere-ocean **coupled** (WRF v.3.6.1, HYCOM v2.2.99).
- **Convection-permitting** (4km), 44 vertical levels.
- ECMWF analysis, HYCOM analysis initial and boundary conditions.
- 22 Nov 2011 - 6 Dec 2011

CTRL

Real topography and bathymetry.

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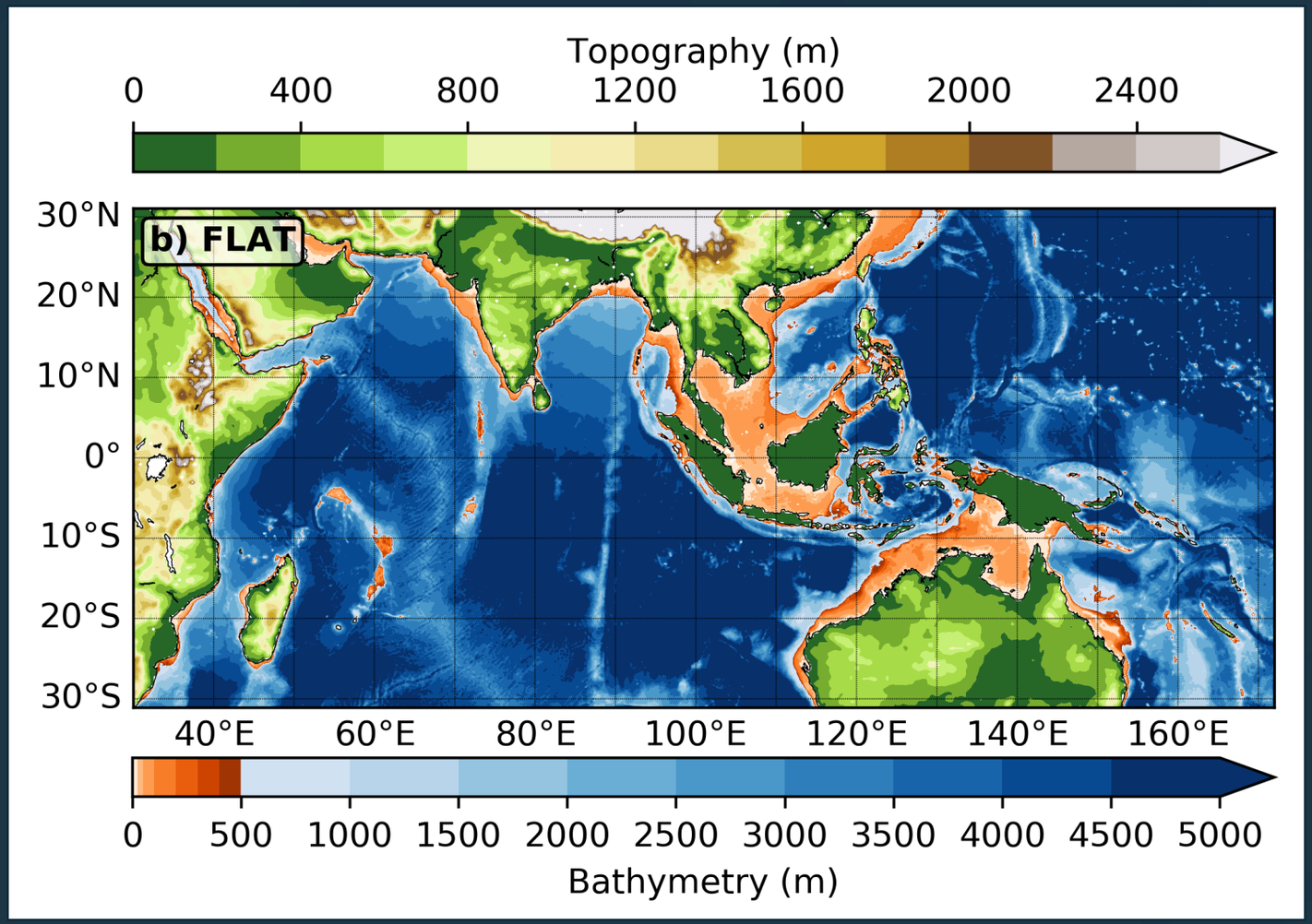

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MC terrain flattened to 0 m, land use set to evergreen rainforest.

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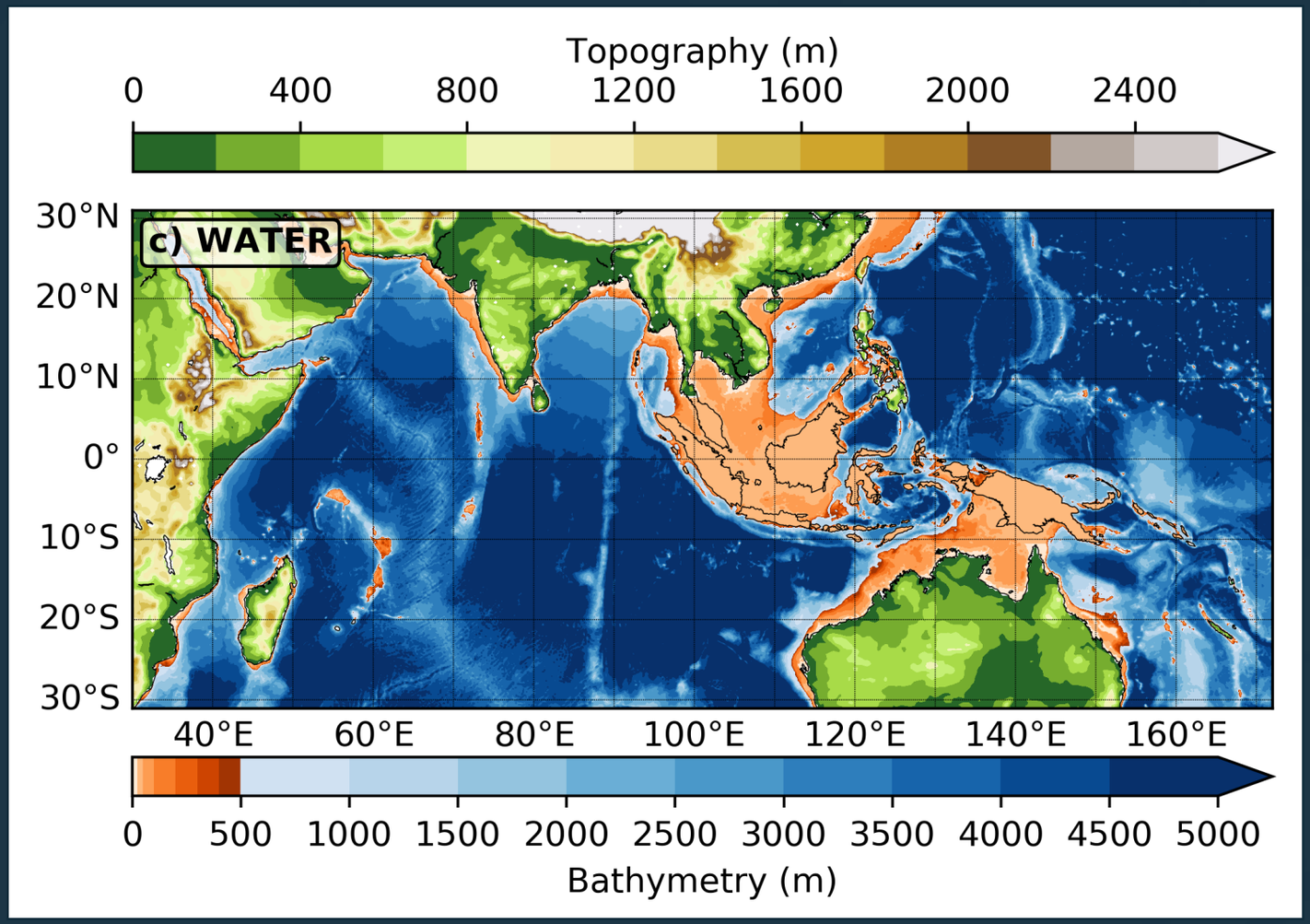

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Real topography and bathymetry.

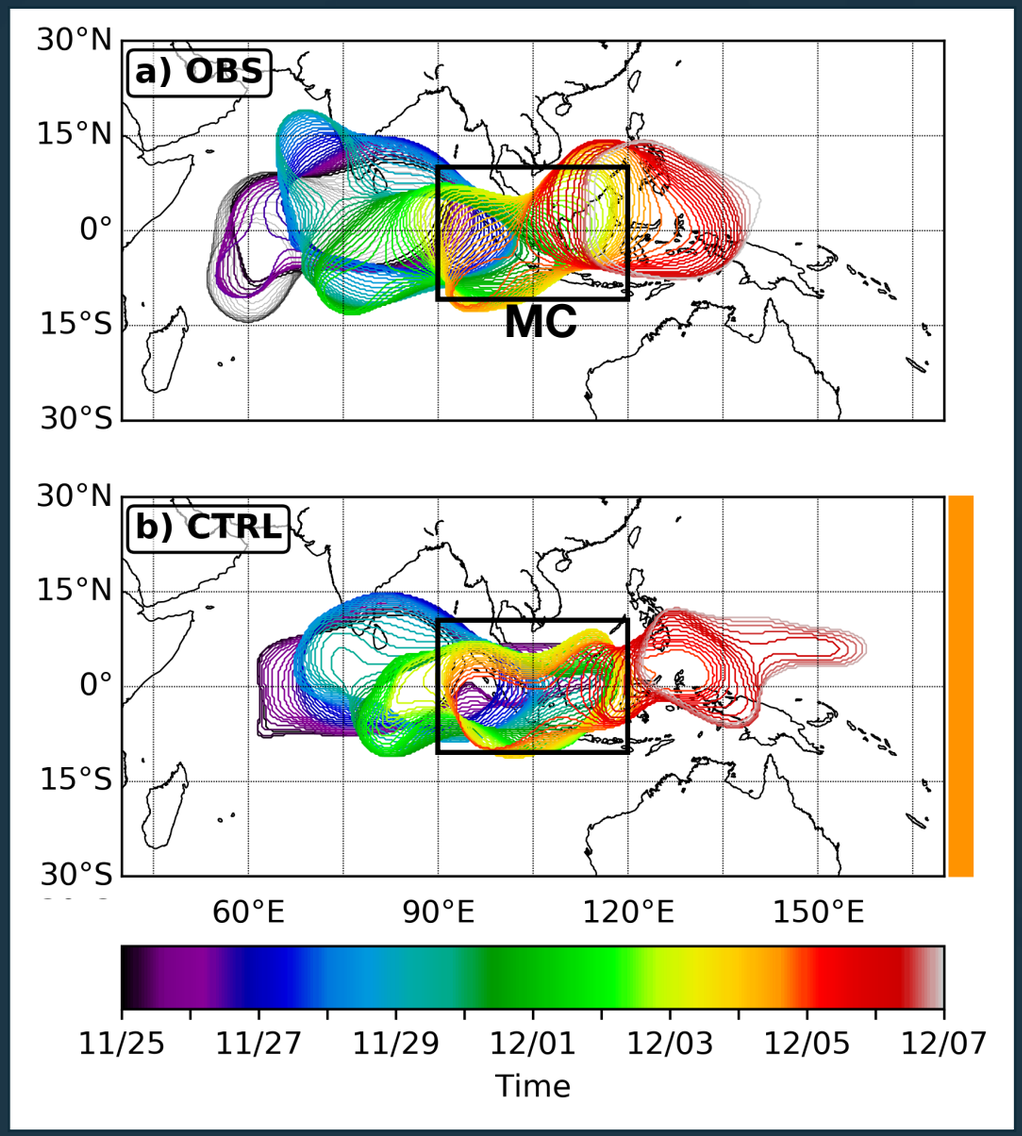
FLAT

MC terrain flattened to 0 m, land use set to evergreen rainforest.

WATER

MC terrain replaced with 50-m ocean

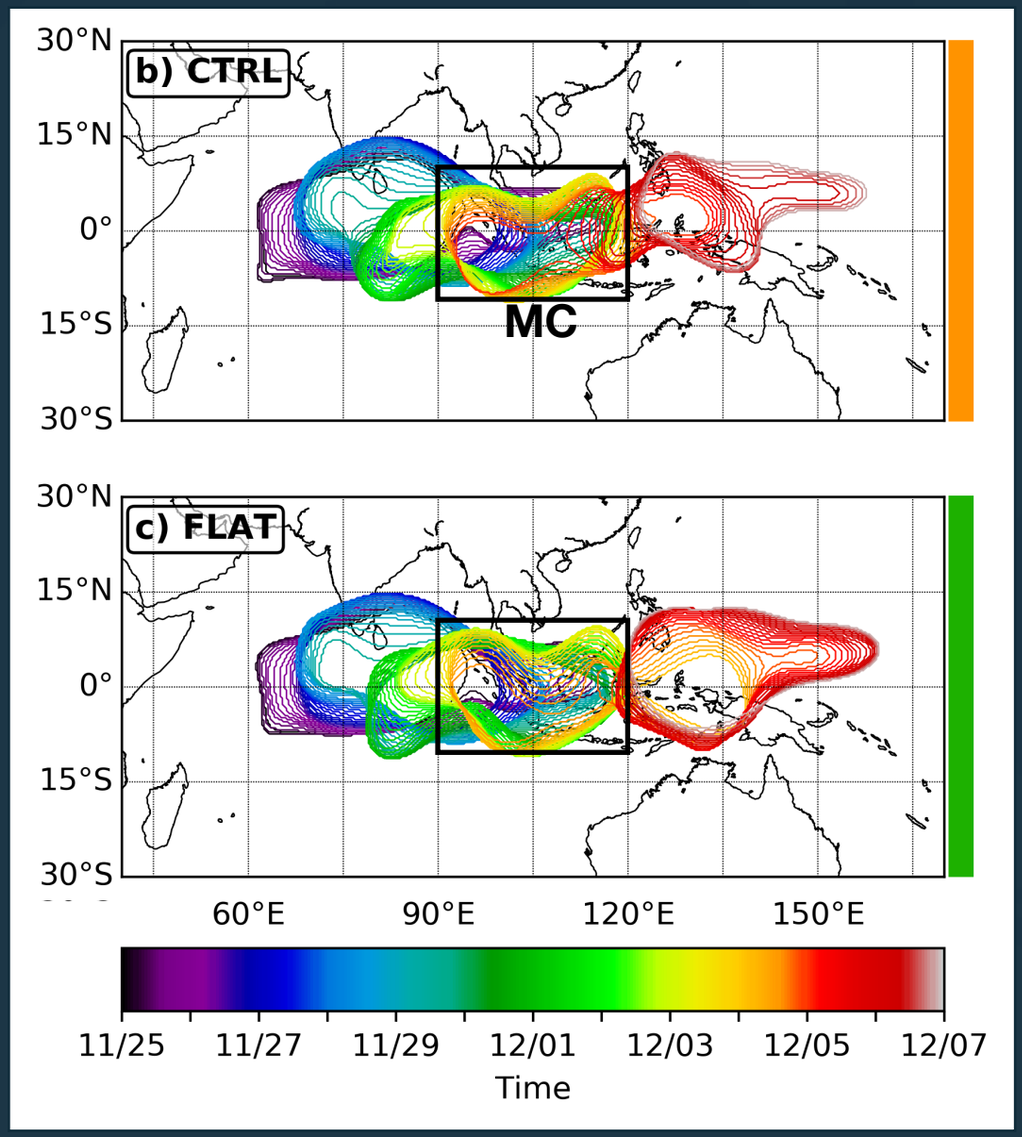
MJO in Model Simulations



- Large-scale precipitation tracking **(LPT)** tracks areas that accumulate a significant amount of precipitation.
  (Kerns & Chen 2016, 2020)
- Tracks the MJO convective envelope in space and time.
- **CTRL** simulation does a good job representing the observed MJO.

  For more details, see:
  - Savarin and Chen 2022: Pathways to Better Prediction of the MJO - Part II: Impacts of Atmosphere-Ocean Coupling on the Upper Ocean and MJO Propagation. *JAMES - in press*.

MJO in Model Simulations



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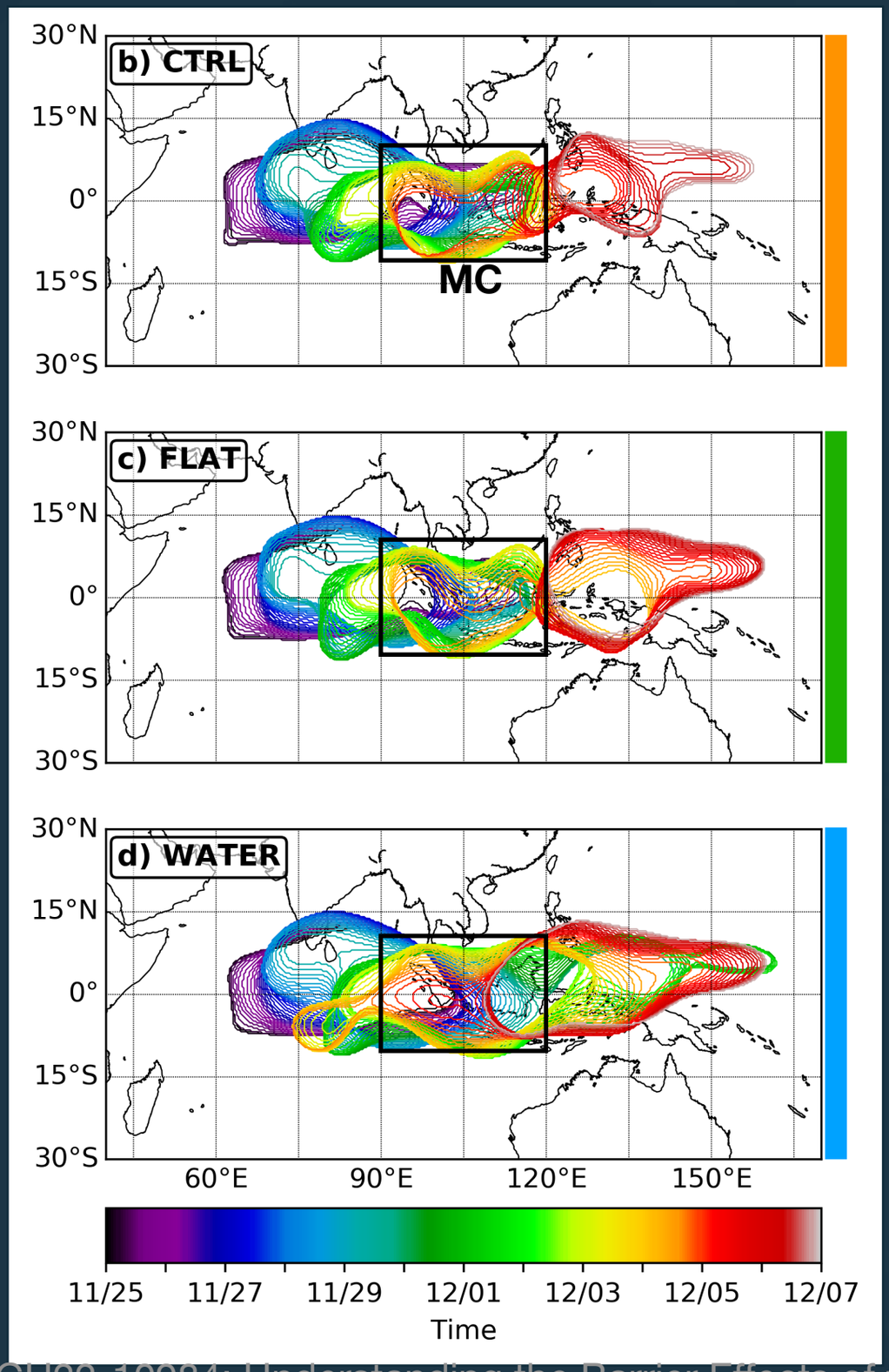
  (Savarin & Chen 2022)

- Flattening terrain leads to small difference in MJO propagation - more disjointed over the MC. (**CTRL** v. **FLAT**)

MJO in Model Simulations



- **CTRL** simulation does a good job representing the observed MJO.
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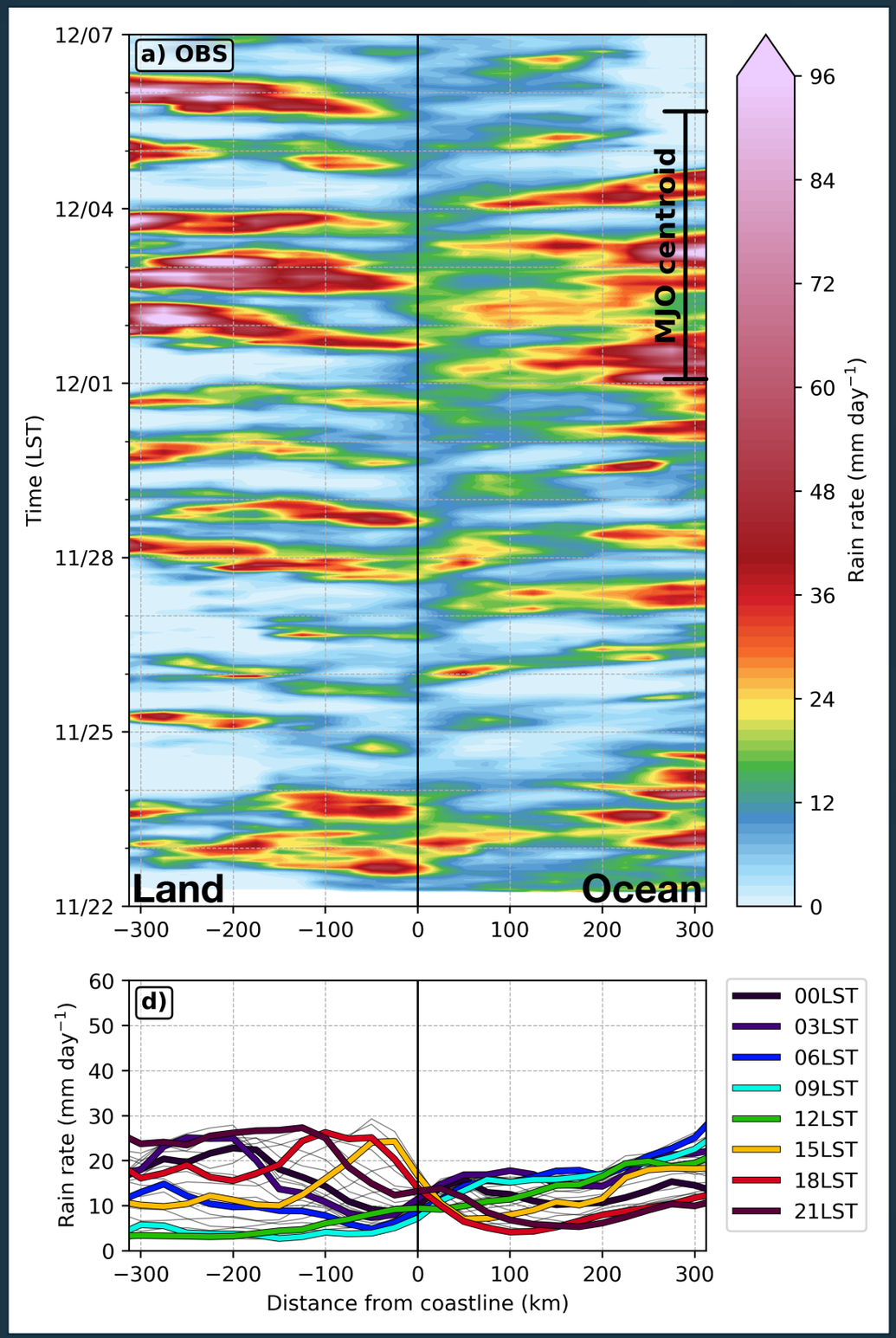
- Flattening terrain leads to small difference in MJO propagation - more disjointed over the MC. (**CTRL** v. **FLAT**)

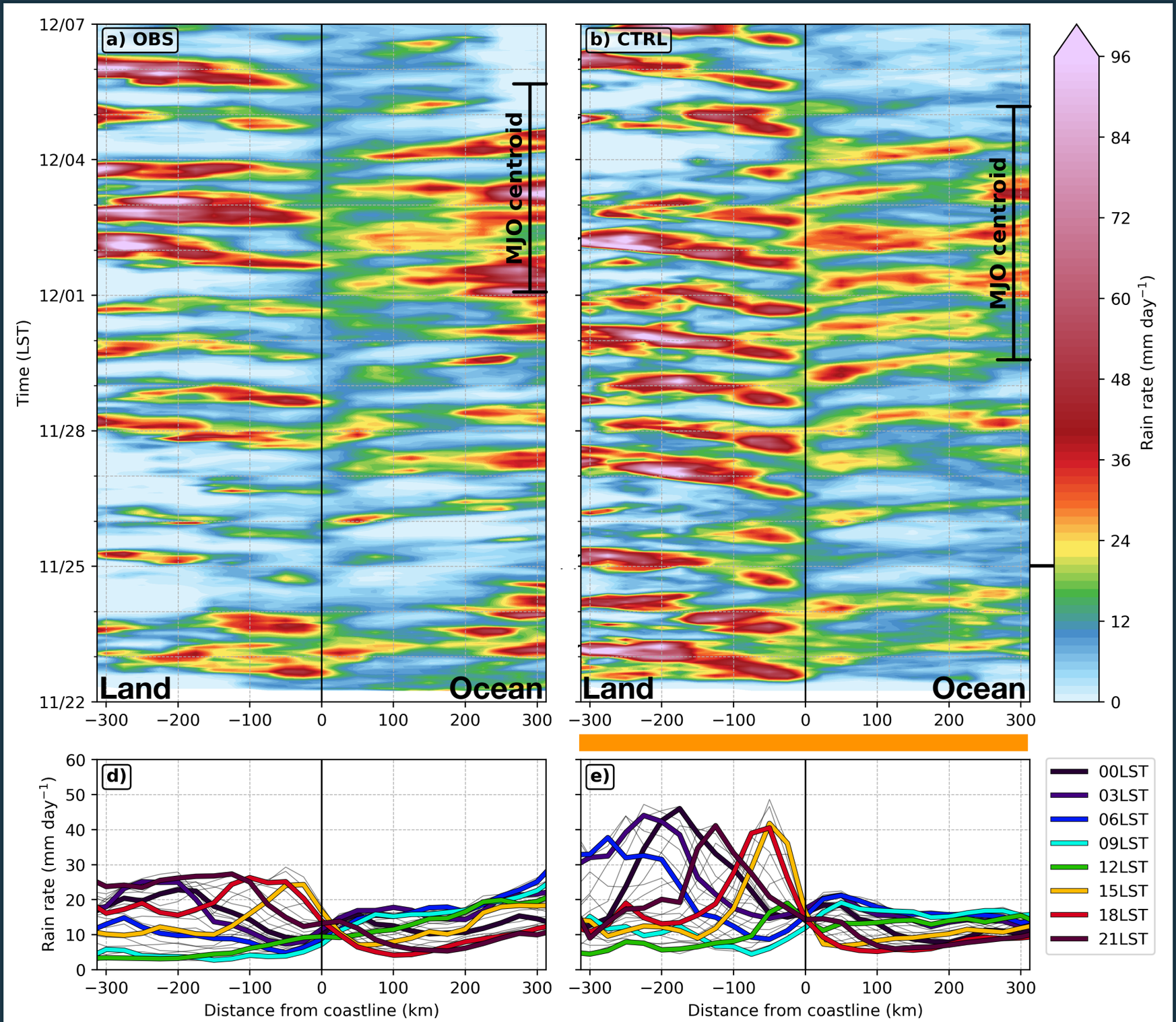
- Replacing land with water leads to a larger, smoother-propagating MJO.
  (**WATER** v. **CTRL**, **FLAT**)

Land-Locked Convection and the MJO



- MJO enhances all MC precipitation:
  - especially **over ocean**, at night.
  - follows sea-breeze timing over land.

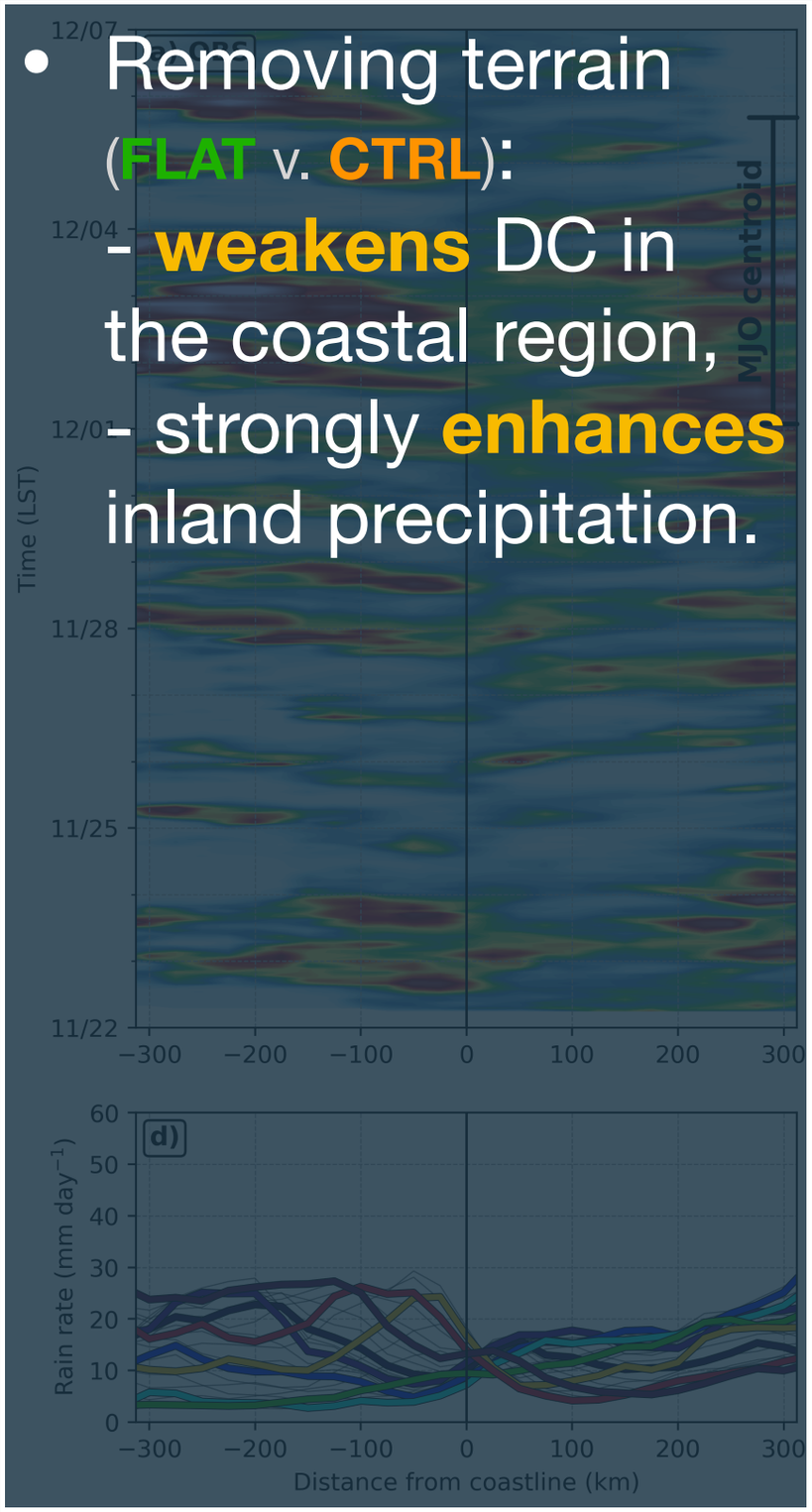
Land-Locked Convection and the MJO

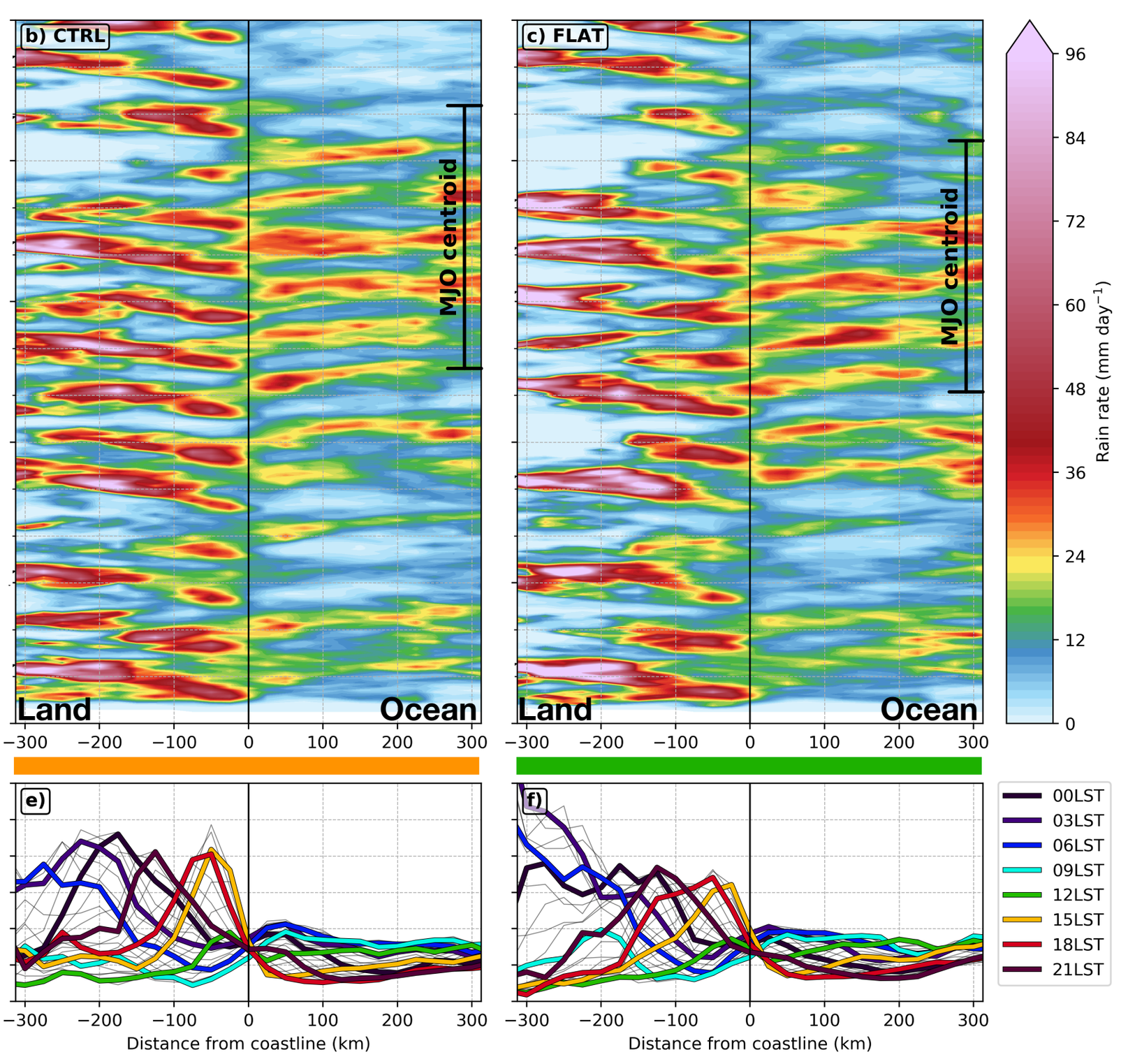


- In **CTRL**:
  - precipitation is more **land-dominated** than in observations,
  - DC is much more **regular**.

Land-Locked Convection and the MJO

- Removing terrain (**FLAT** v. **CTRL**):
  - **weakens** DC in the coastal region,
  - strongly **enhances** inland precipitation.





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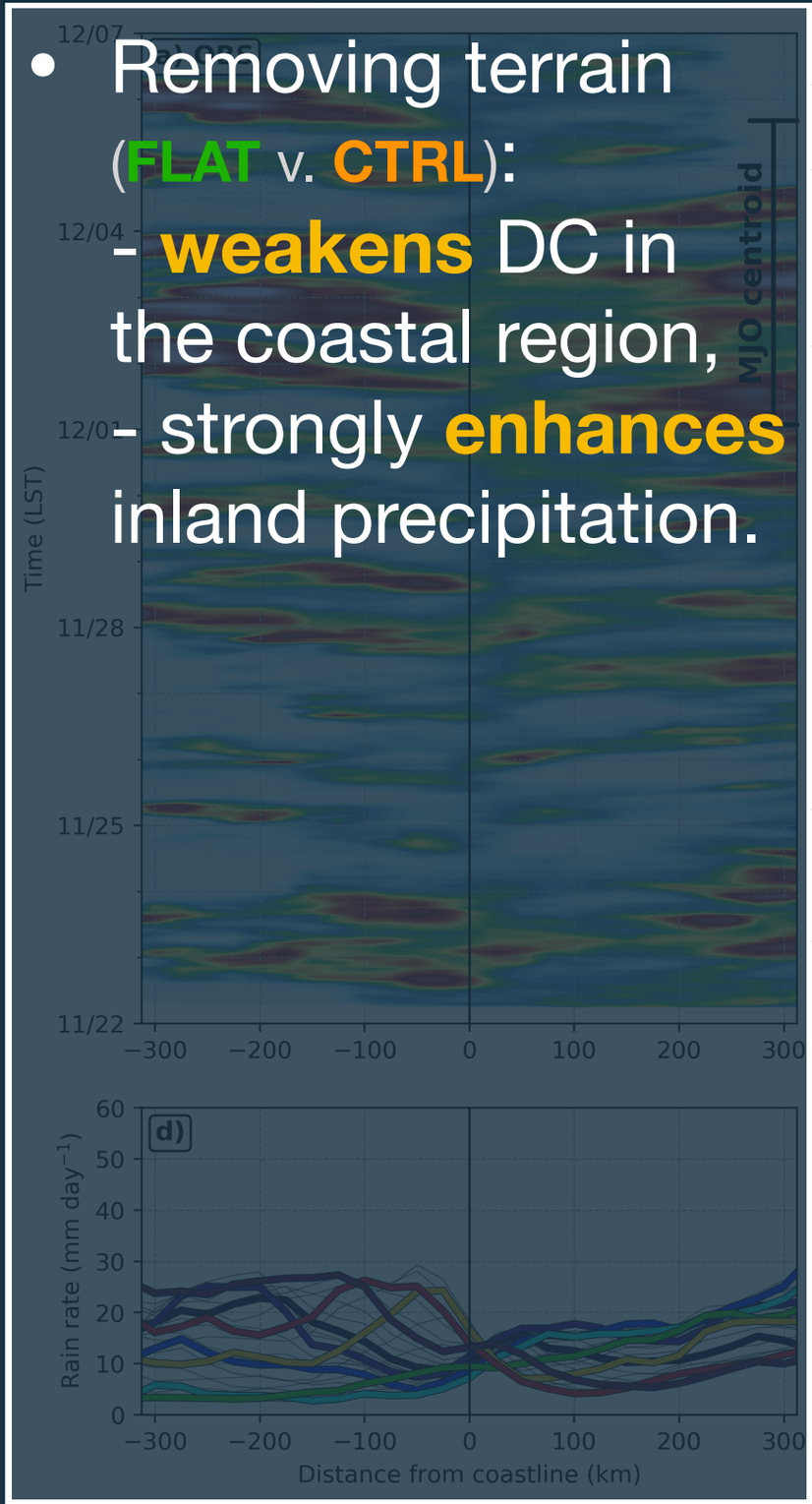
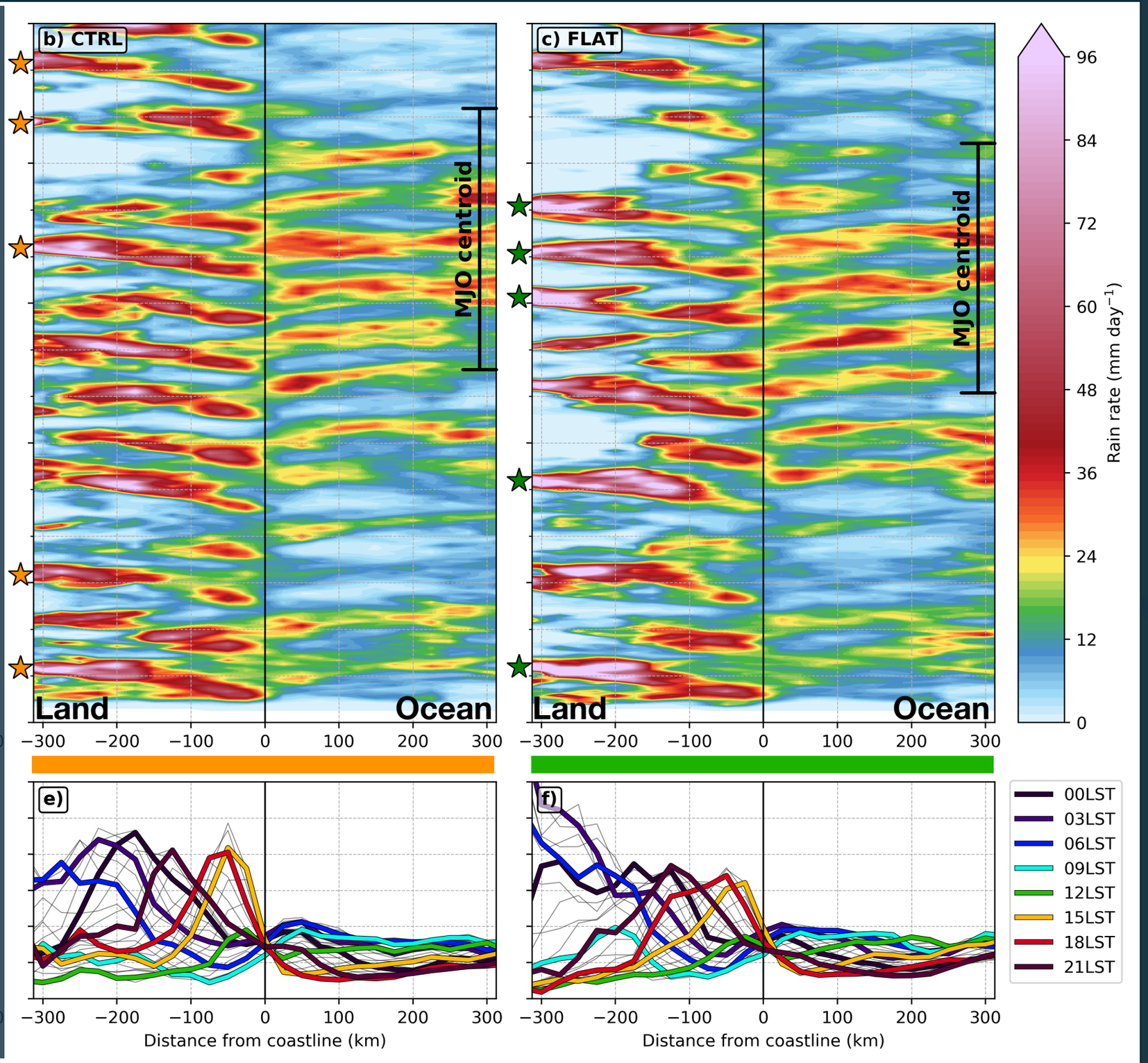
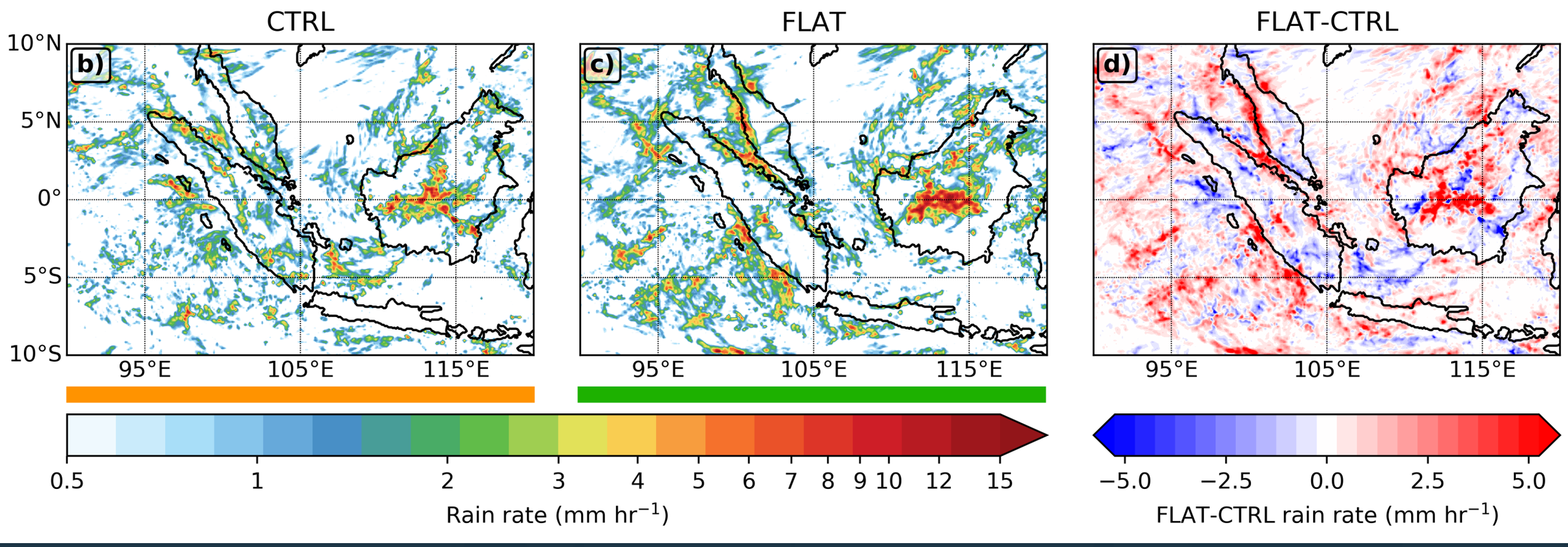




Land-Locked Convection and the MJO



- Converging sea breezes in the **FLAT** simulation result in **larger and more intense** convective systems over land.

- Terrain in the **CTRL** simulation disrupts sea breeze convergence; convective systems are organized on smaller scales and are **less disruptive to MJO propagation**.

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Summary & Conclusions

- Replacing MC land with ocean results in a smooth-propagating MJO event without weakening. **(WATER)**

- Presence of MC islands results in a strong diurnal cycle and intense land-locked convection associated with the afternoon sea breeze circulation. **(CTRL, FLAT)**

- Mountains **(CTRL)** are less disruptive to the MJO than the large and intense convective systems that form over land when mountains are removed **(FLAT)**.

If models don't represent MC terrain, this can exaggerate the MC barrier effect.

References:
- Kerns and Chen 2016: Large-Scale Precipitation Tracing and the MJO over the Indo-Pacific Warm Pool. *J. Geophys. Res. - Atmospheres*, **121**. DOI: https://doi.org/10.1002/2015JD024661
- Kerns and Chen 2020: A 20-Year Climatology of Madden-Julian Oscillation Convection: Large-Scale Precipitation Tracking from TRMM-GPM Rainfall. *J. Geophys. Res. - Atmospheres*, **125**, DOI: https://doi.org/10.1029/2019JD032142
- Savarin and Chen 2022: Pathways to Better Prediction of the MJO - Part II: Impacts of Atmosphere-Ocean Coupling on the Upper Ocean and MJO Propagation. *JAMES - in press*.