The use of CPOL data for validating GCM simulations of tropical convection

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1. Motivation

Evaluate the DOE Energy Exascale Earth System Model (E3SM) convective parameterizations over the Maritime Continent with 10-25 km resolution

Convection in E3SM parameterized → convection triggers based on available CAPE. Limits interactions with seabreezes and cold pools generated by surrounding convection.

The link between large scale forcing (i.e. MJO phase) + rainfall rates, cloud top heights convection in Darwin not well understood.

2. Darwin rainfall

Nov. to May, Northern Australian Monsoon [1] + Madden-Julian Oscillation (MJO) [2] important + not well resolved in GCMs

- 19 years of continuous data from CPOL in Darwin:
- Examine cloud top heights in different/ phases of monsoon and MJO
- Provide statistics for E3SM evaluation

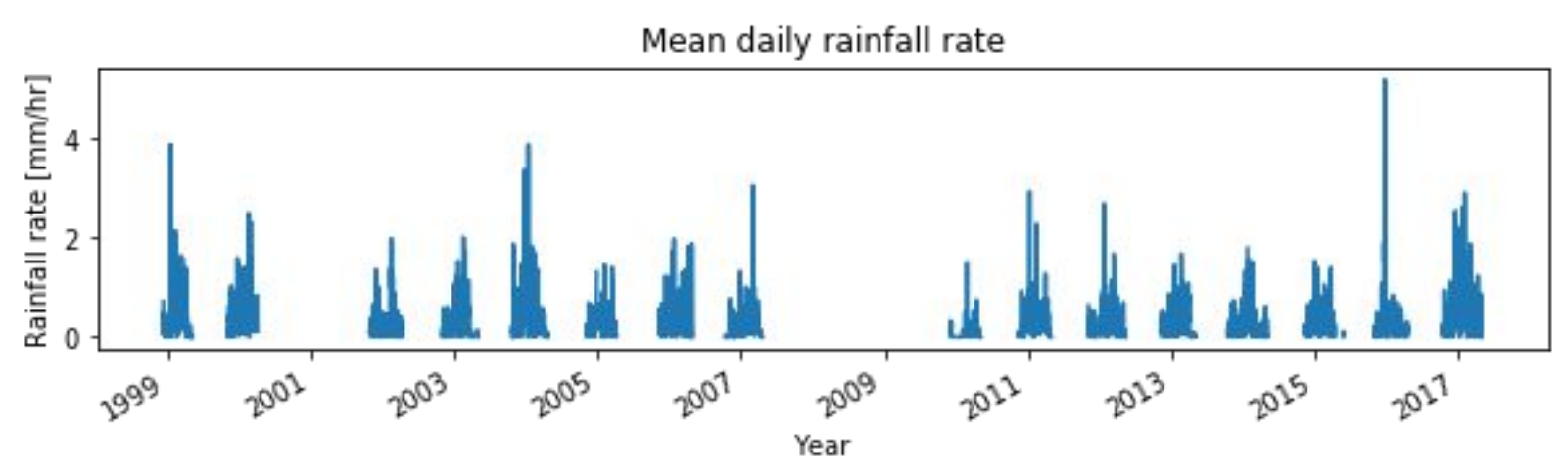
3. Instrumentation

CPOL: C-band POLarization radar, PPI scans @ 18 elevations every 10 min. from 1998-2017

Python ARM Radar Toolkit (Py-ART) [3] used to process/grid data

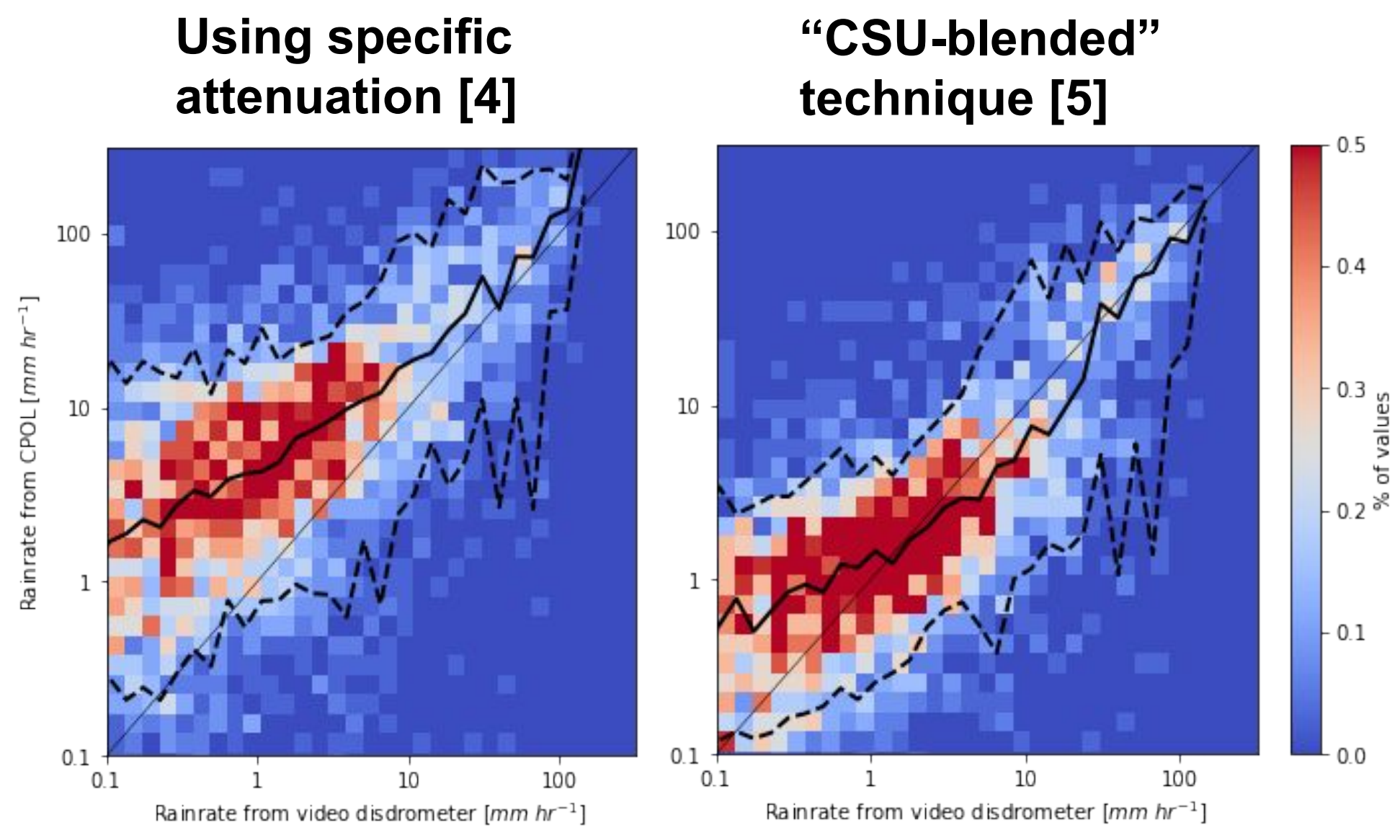
4/day rawinsondes: Monsoon/Break [1]

Multidecadal dataset provides observational targets for GCM simulations of tropical convection



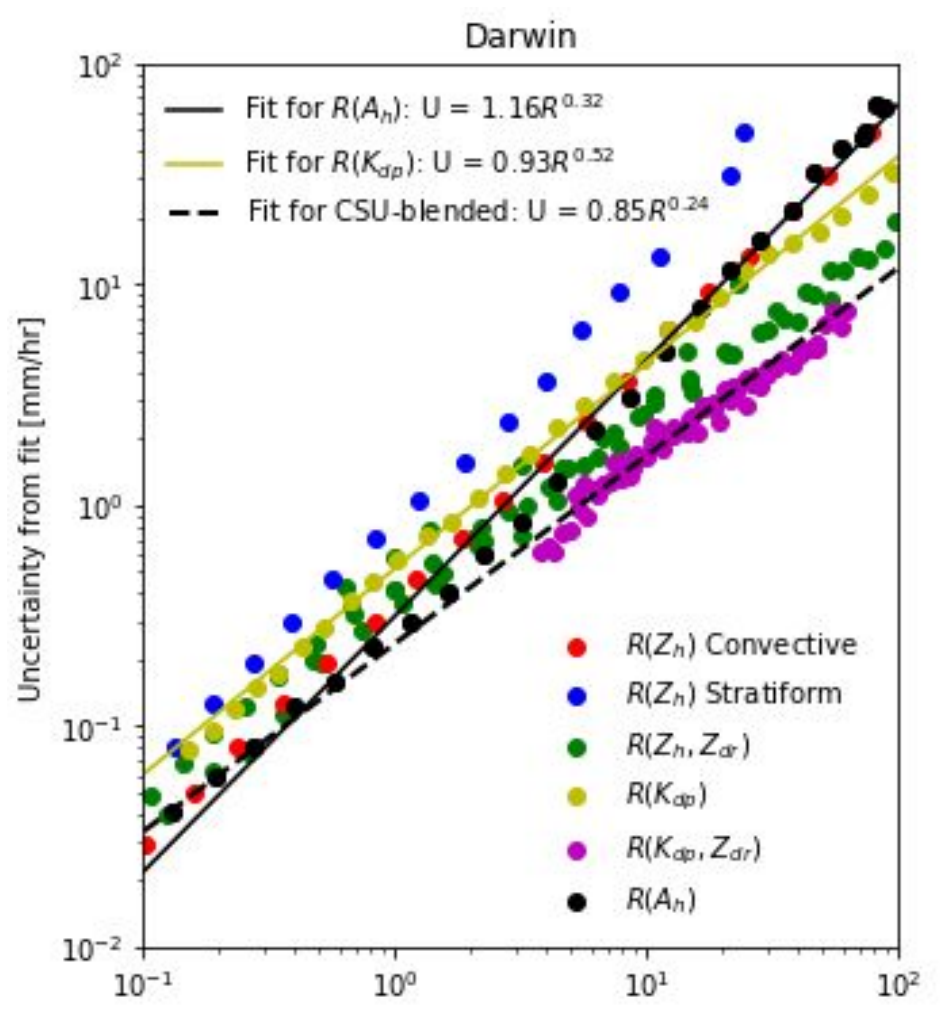
4. Rainfall uncertainty analysis

2D histogram of radar estimated vs. disdrometer observed rain rates


Using specific attenuation [4]

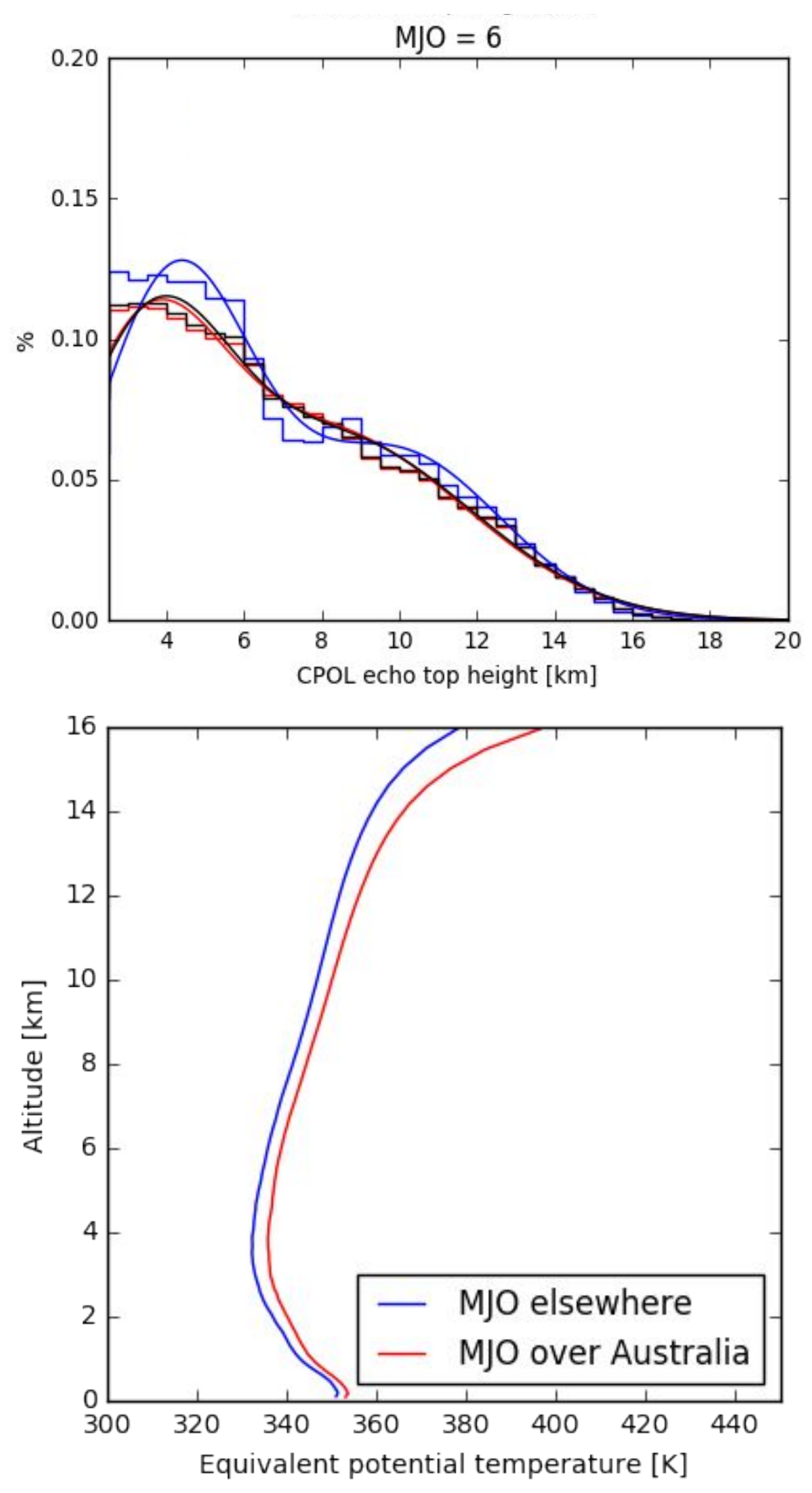
"CSU-blended" technique [5]

Statistical uncertainty [6]

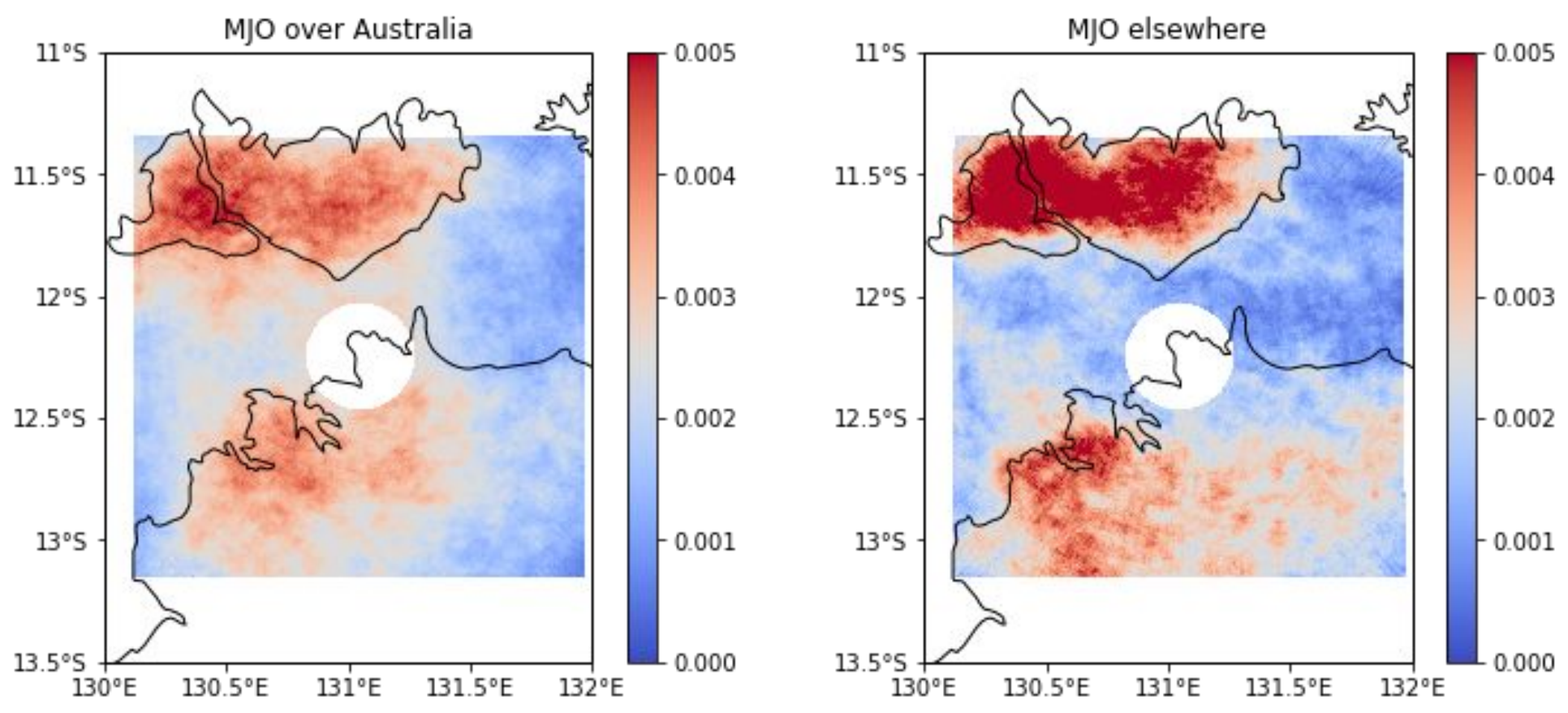


Using the tropical ocean "CSU-blended" technique [5] minimizes the difference in derived rainfall rates from disdrometer data + statistical uncertainty of retrieval.

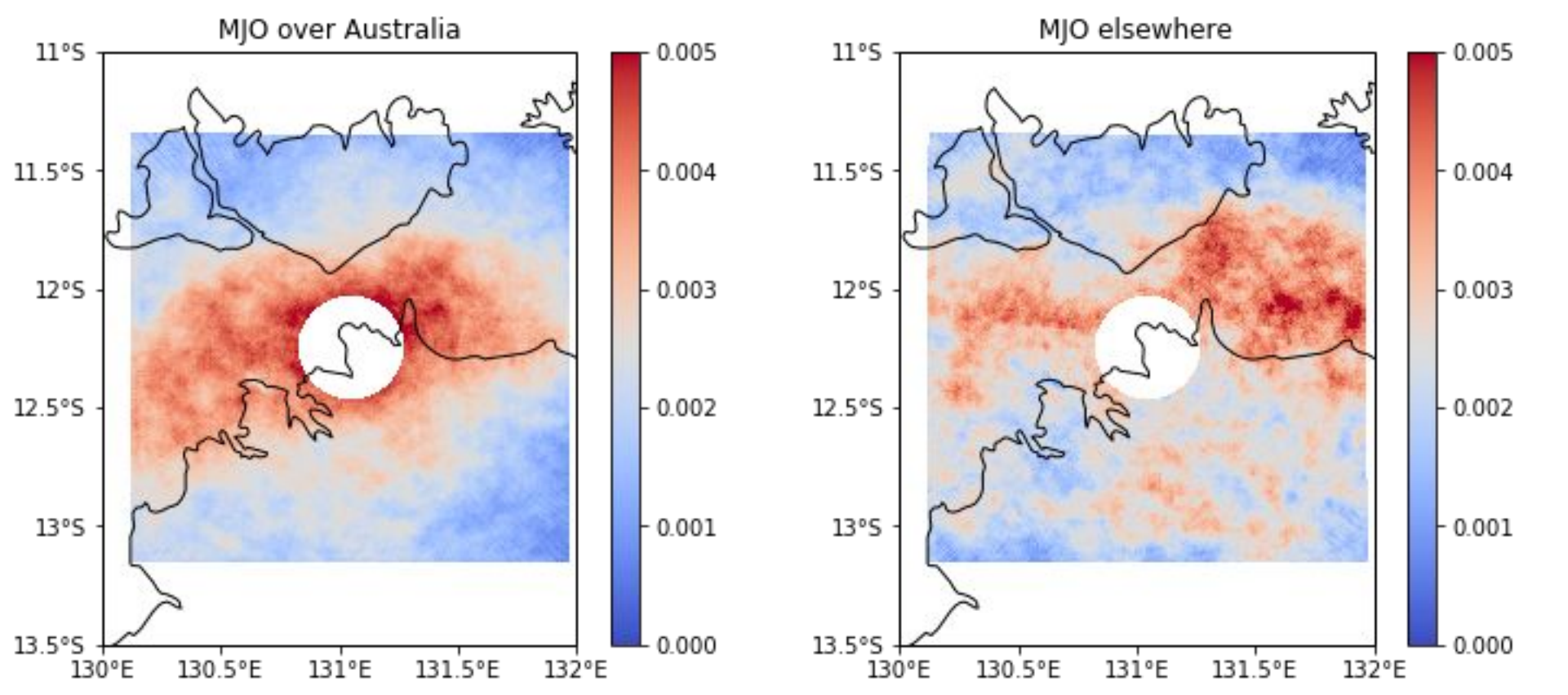
5. Echo top heights



ETH > 7 km occurrence peaks in daytime break conditions. Hector & seabreeze convection is prevalent. More occurrences over ocean in active MJO.

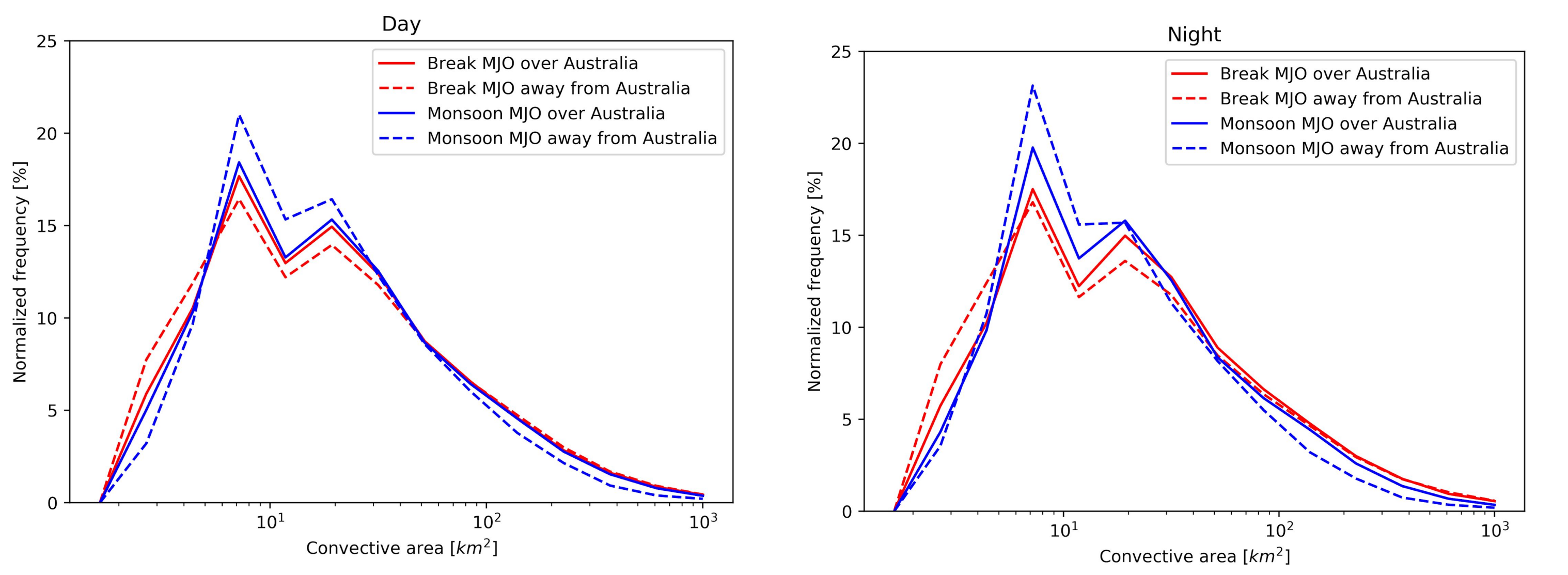


@ night, convection confined more to oceans



Bimodal ETH distributions observed → stable layer inhibiting more moderate convection

6. Convective areas



- **Lower convective cell areas during active monsoon….but only if MJO is inactive (phases 1-3, 8). No difference if MJO is active (phases 4-7).**
- **Convective area is proxy for updraft strength. This suggests updrafts are only stronger in break conditions compared to monsoon when MJO is inactive over Australia. Therefore both phenomena must be considered!**

References

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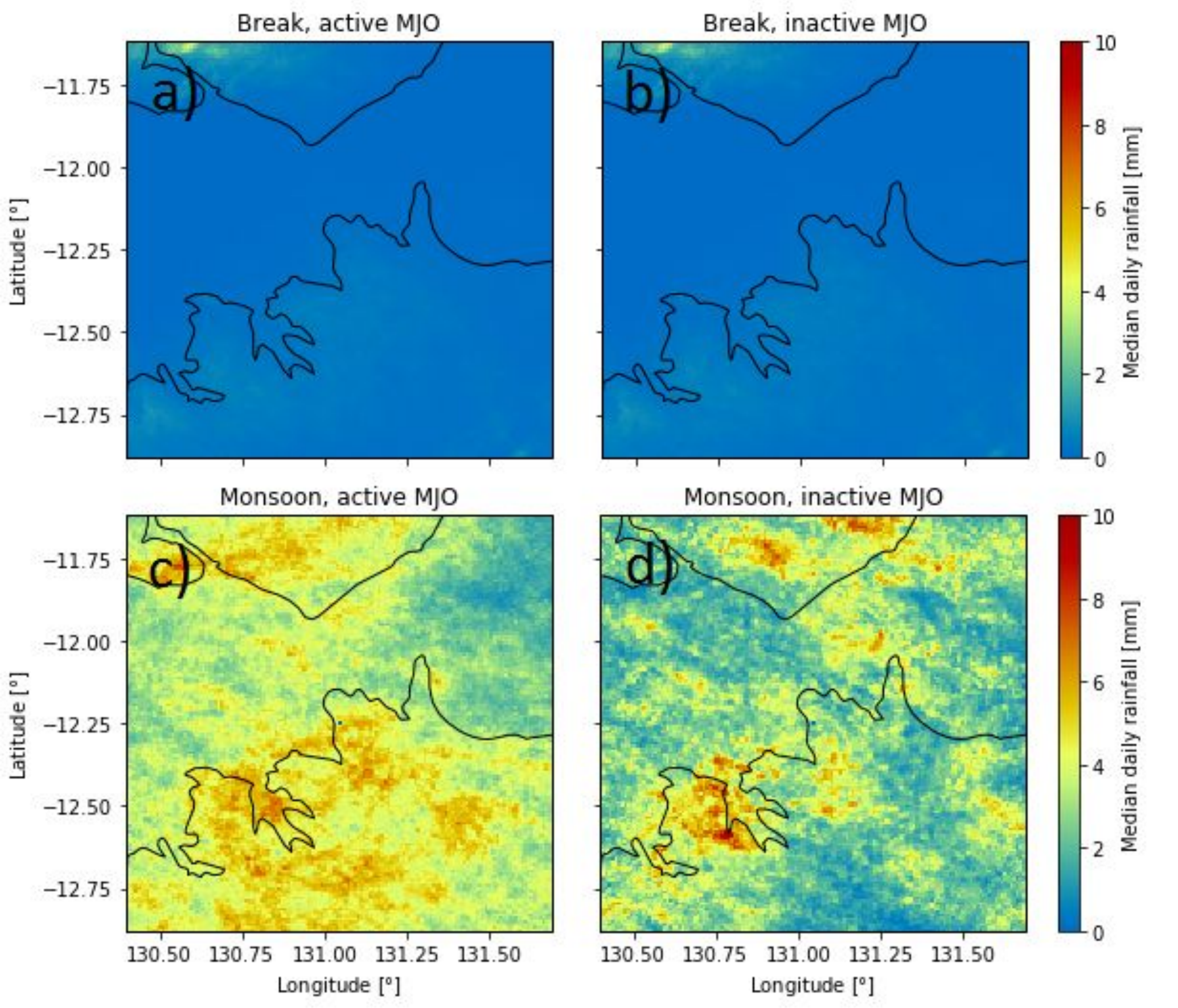
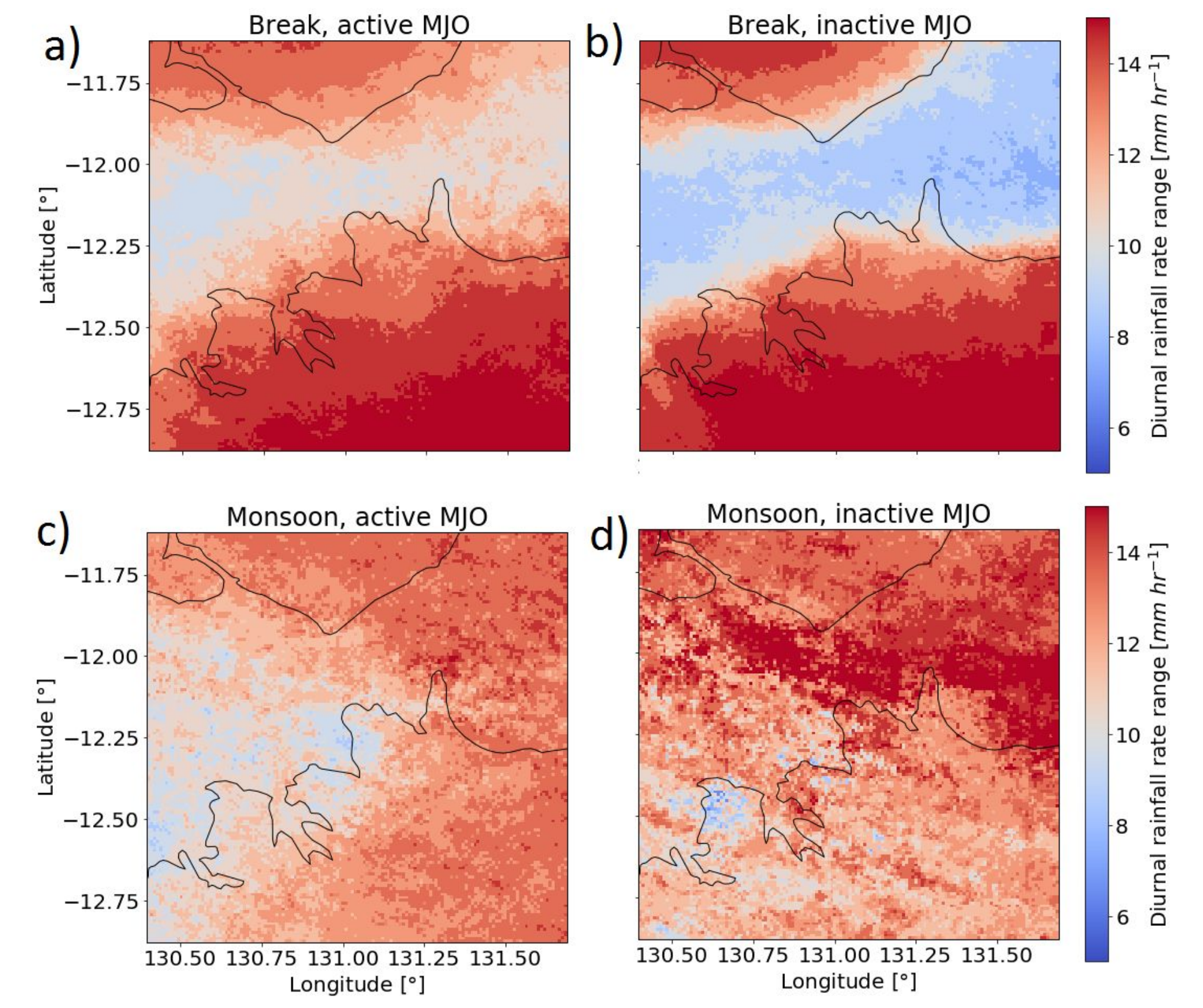
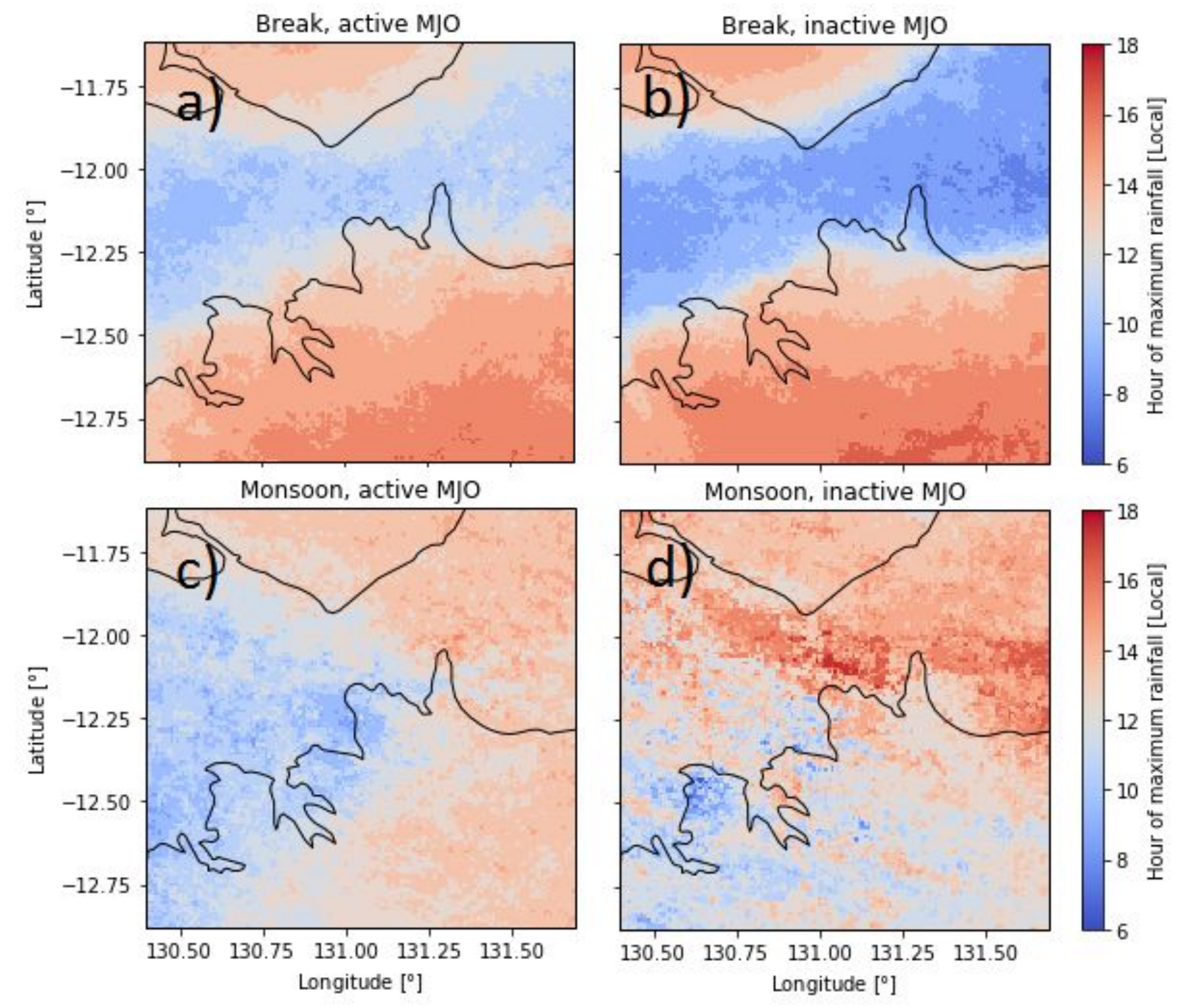
7. Rainfall rates

Median daily rainfall much higher in monsoon conditions.







- **Strong afternoon diurnal cycle over land in break → diurnal heating.**
- **Early morning peak over ocean stronger w/ active MJO, also observed in Indonesia [7], potentially due to convergence from differential radiative cooling.**

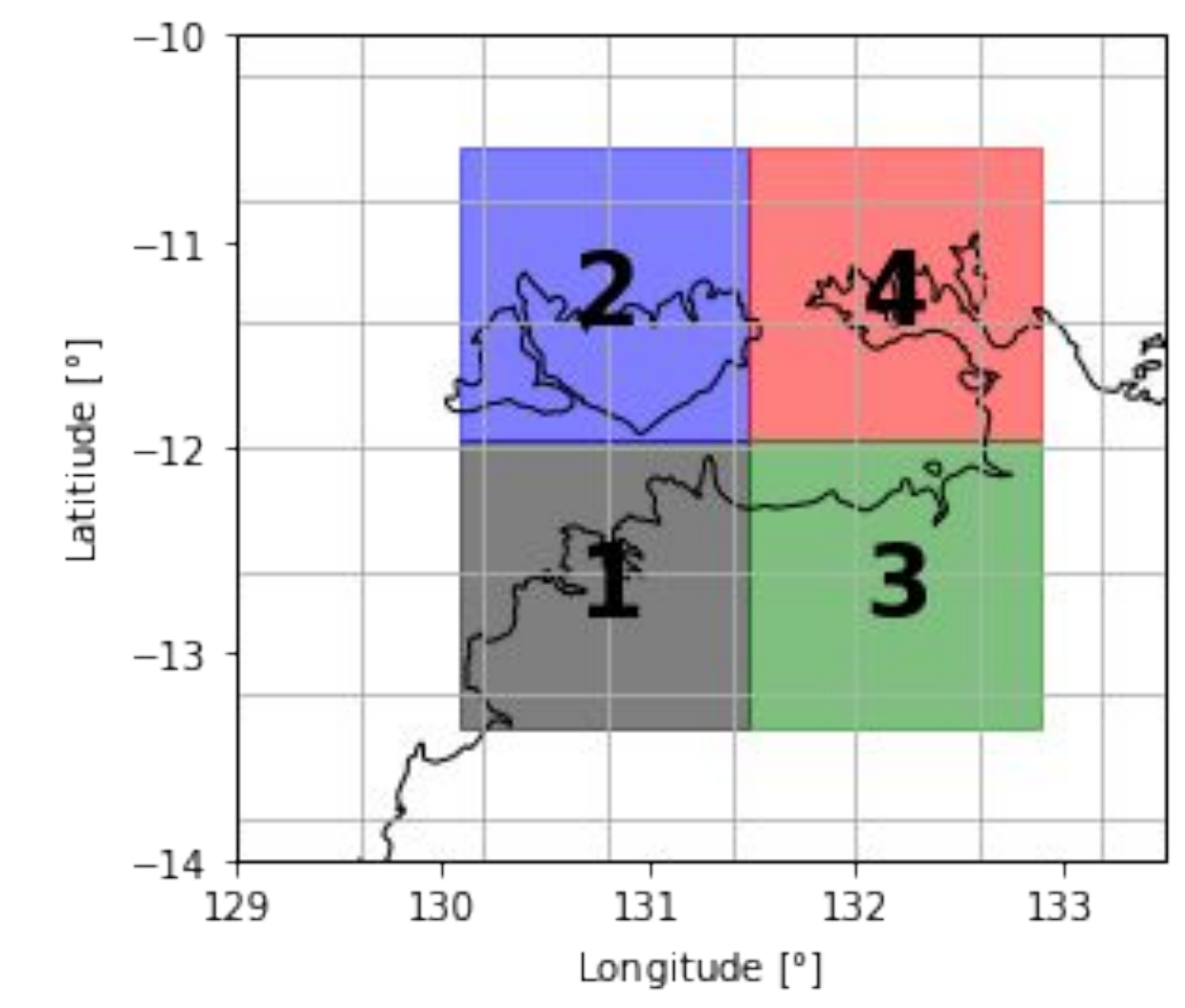
8. Diurnal cycle evaluation of E3SM

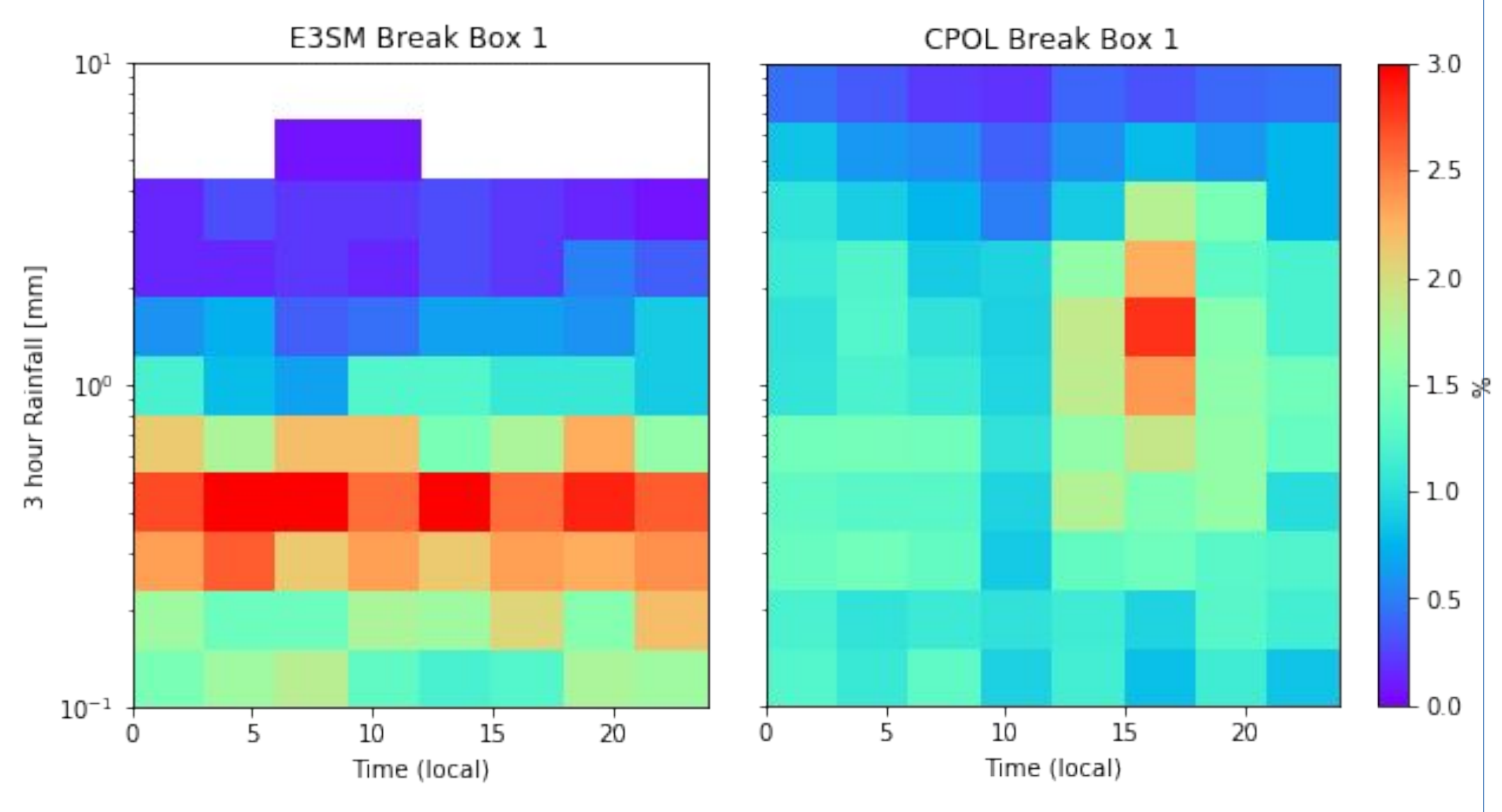
Global run of E3SM using:

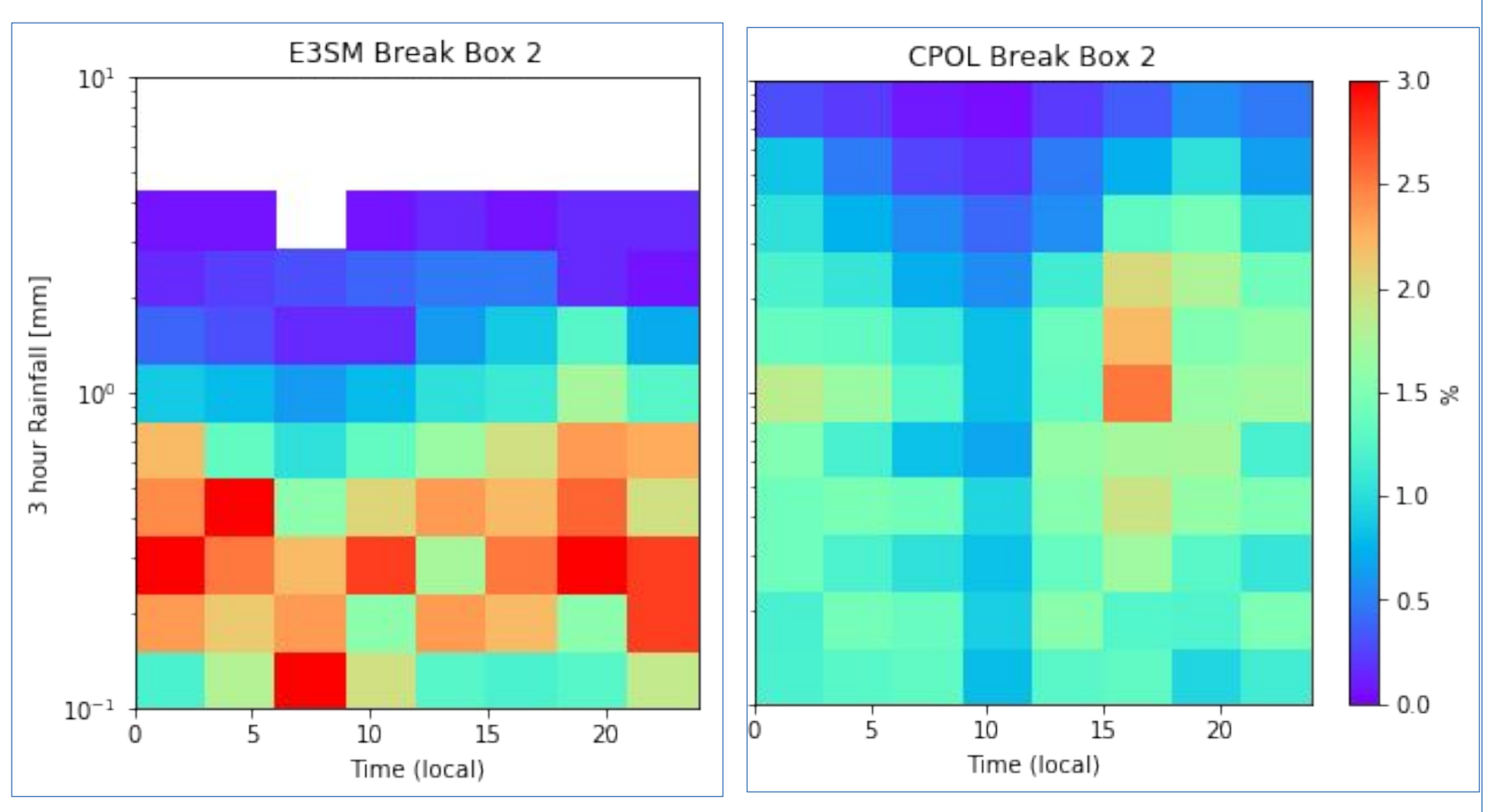
- November 2009 to April 2011
- IPCC AR5 scenario
- Temperature, humidity, winds nudged to ERA-Interim forcing.
- 1 degree spatial resolution

Compute: 3 hour rain accumulation in 4 grid cells below, same metric compared in both CPOL and E3SM data

Area coverage of grid boxes used in comparison:







- **E3SM run fails to resolve phase and magnitude of diurnal cycle of rain. Likely due to inability of E3SM to resolve seabreezes.**
- **Future runs with improved resolution/machine learning based convective trigger to see if improvements result**

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