

The Effects of Convection-permitting Downscaling on Sub-daily Precipitation Characteristics Over the Western Maritime Continent

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Introduction

- ❖ High resolution climate change projections using the SINGV-RCM (Prasanna et al. 2024) conducted as a part of Singapore's Third National Climate Change Study (V3) is widely used in many of Singapore's climate change adaptation efforts.
- ❖ As part of assessing our confidence in the model simulations, it is important to evaluate if the model realistically simulates the physical processes underlying the simulated weather and climate using process-oriented diagnostics.
- ❖ One such set of diagnostics is the Analysing Scales of Precipitation (ASoP), which were created to compare spatial and temporal scales of precipitation to inform model evaluation and development (Klingaman et al. 2017, Martin et al. 2017), which provides an elegant way to summarize precipitation frequency and intensity information.
- ❖ Here, we make use of ASoP to:
 - Identify added value because of downscaling
 - Assess future changes (SSP scenarios) in the precipitation distribution.

One Dimensional ASoP

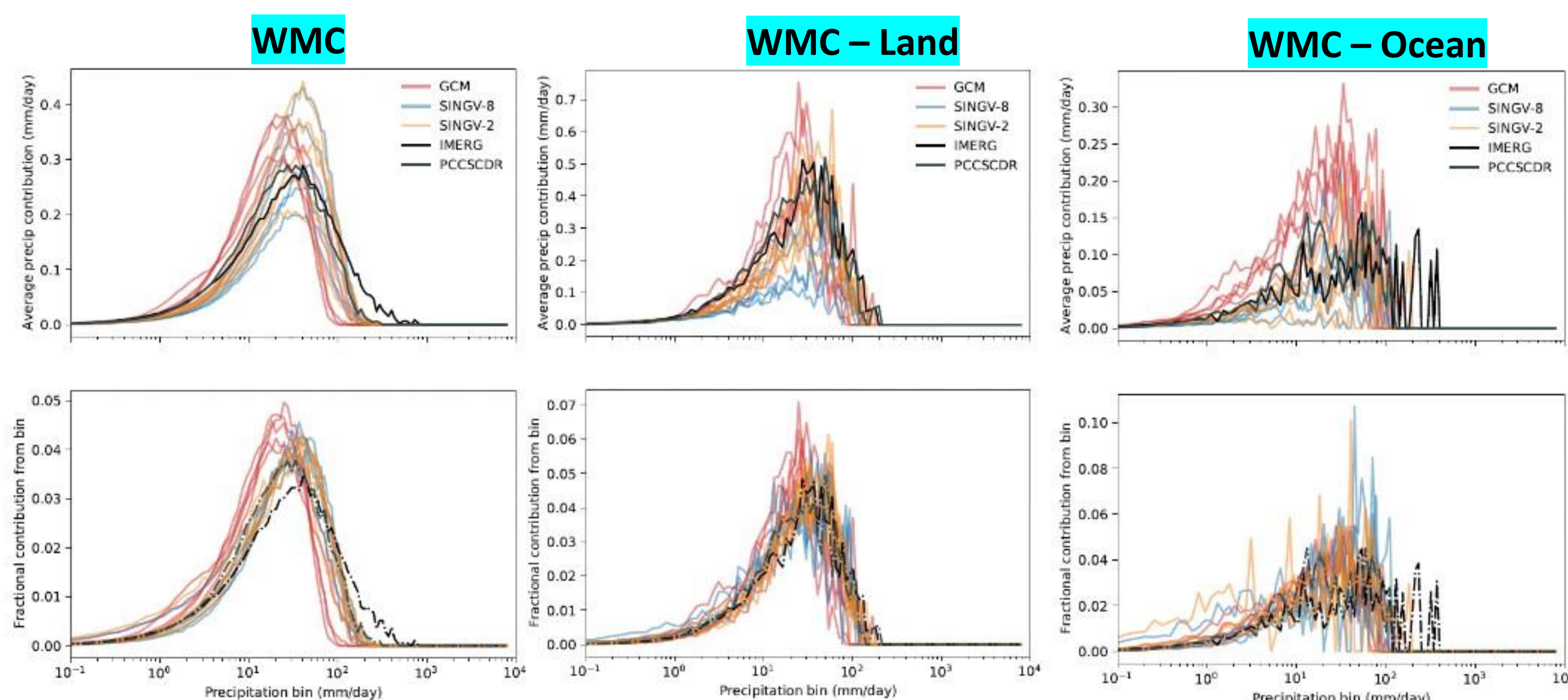
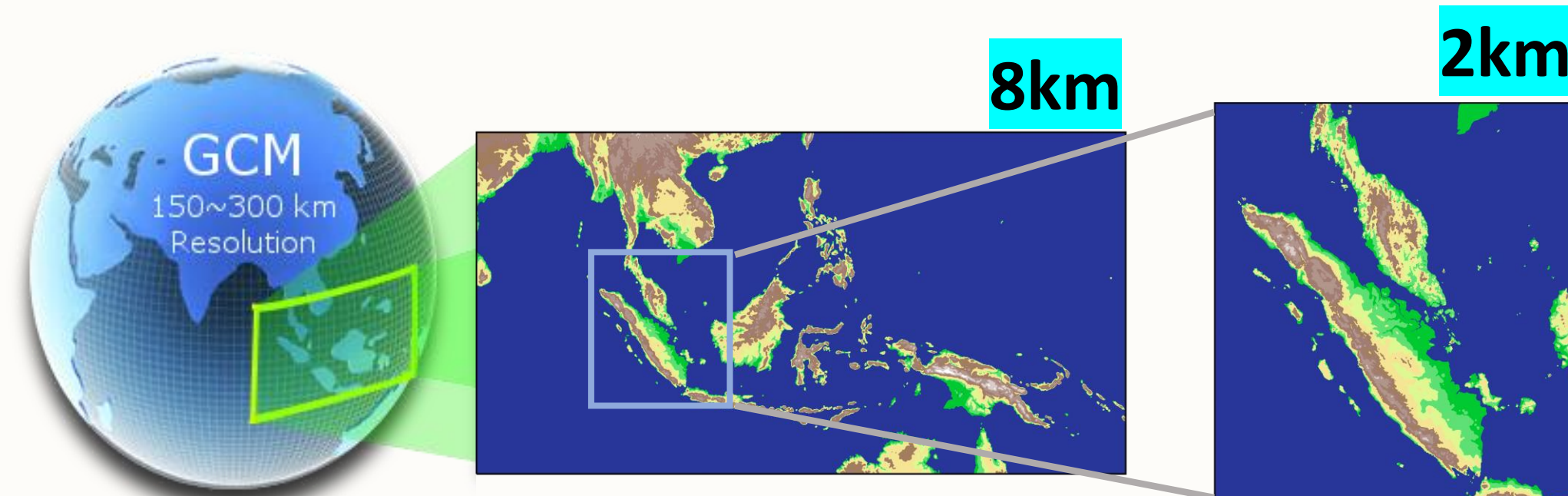


Figure 1: Top row shows average contribution (mm/day) of the different precipitation bins to mean precipitation over the WMC in DJF from IMERG (black), PCCSCDR (gray), the 5 GCMs (red), downscaled simulations at 8km (blue) and 2km (orange). Bottom row used, top, but for the fractional contribution of precipitation bins to mean precipitation. Three-hourly frequency is used, and data is coarsened to 2 degrees by 2 degrees. Middle panel similar to left, but for a WMC land point (103E-105E, 4S-2S). Right panel similar to left, but for a WMC ocean point (105E-107E, 4N-6N).

- ❖ Over WMC, SINGV-RCM intensity distribution closer to observations
- ❖ 2km improvement over GCM, better than 8km

Methods



Dynamical downscaling details:

- ❖ UM v11.1
- ❖ RA1T Physics
- ❖ 8km domain - 1120 x 560 (timestep=240s)
- ❖ 2km domain - 960 x 960 (timestep=120s)
- ❖ Convection-permitting for both 8km and 2km
- ❖ Prescribed SSTs (updated every 3 hours)
- ❖ 1-year spin-up

Data used in analysis:

- ❖ Models: 5 CMIP6 GCMs, and corresponding 8km and 2km dynamically downscaled simulations using SINGV-RCM
- ❖ Domain: Western Maritime Continent
- ❖ Observations: IMERG, 0.1°, PERSIANN-CCS-CDR, 0.04°
- ❖ Temporal resolution: 3-hourly
- ❖ Time: 2001 to 2005

ASoP diagnostic:

- ❖ Contribution to average rainfall in grid box over data sample by events in bin = (no. of events in bin x avg. pr rate in bin) / (no. of intervals in sample) → points sum to mean rainfall
- ❖ Fractional contribution from bin = contribution from bin / average rain in grid box → points sum to unity
- ❖ Distribution calculated for each point, then the area mean is taken
- ❖ Bin edges in mm/day defined using the equation in Klingaman et al. (2017):

$$b_i = e \left\{ \ln(0.005) + \left[i \cdot \frac{(\ln(120) - \ln(0.005))^2}{59} \right]^{\frac{1}{2}} \right\}$$

Two Dimensional ASoP

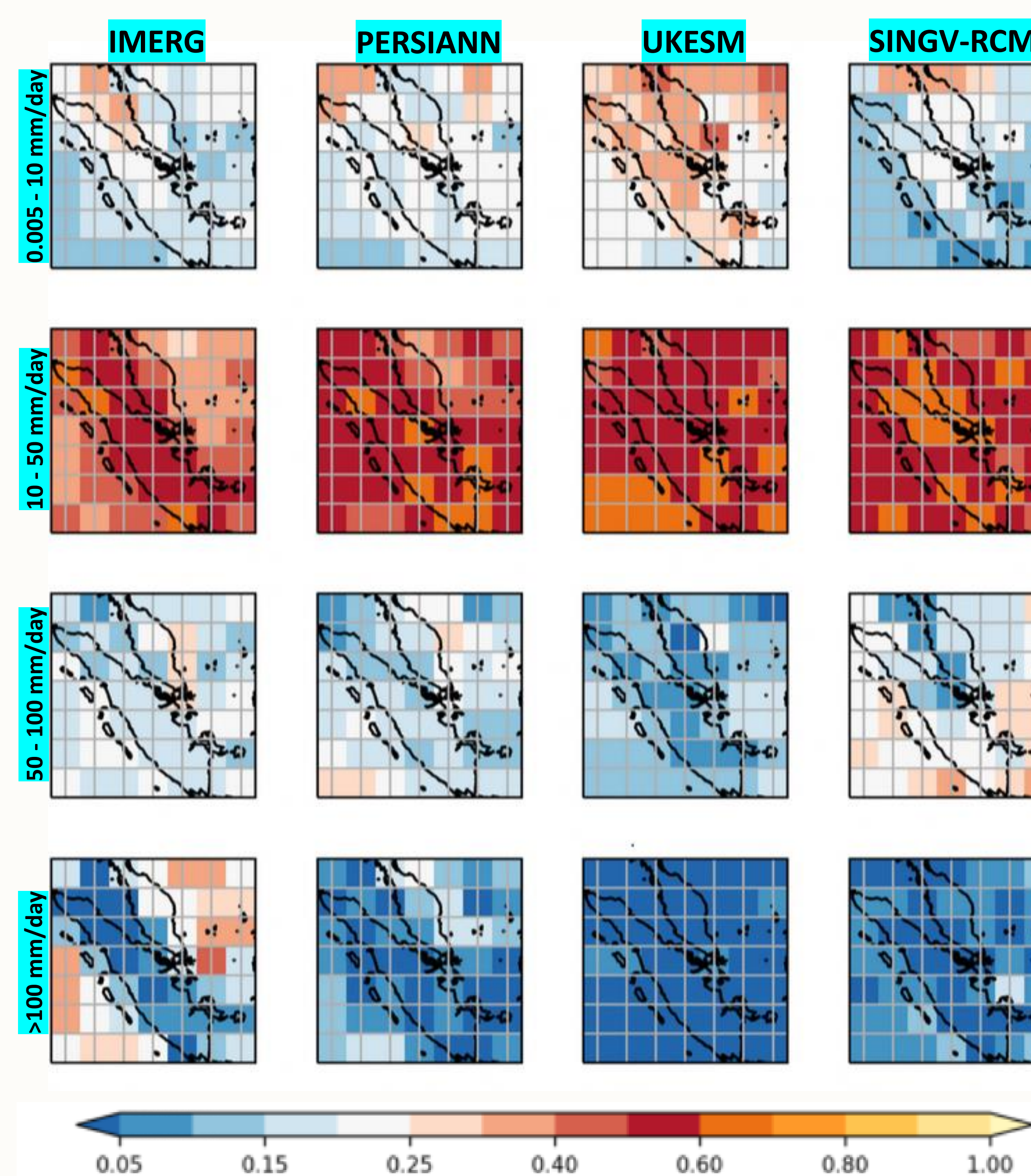


Figure 2: Fractional contribution of light (0.005 to 10 mm/day) precipitation to total precipitation over each 2° grid point in UKESM, during DJF, using 3-hourly data: (column 1) IMERG, (column 2) PERSIANN, (column 3) UKESM, and (column 4) UKESM downsampled to 8km using SINGV-RCM. Rows 2-4, similar to row 1, but for medium (10 to 50 mm/day), heavy (50 to 100 mm/day), and very heavy (exceeding 100 mm/day) precipitation, respectively.

- ❖ IMERG and PCCSCDR are broadly in agreement, except for larger fraction of precipitation coming from the > 100 mm/day category in sea regions.
- ❖ In UKESM, a land-sea contrast is notable in the first and third rows. In comparison to the observations, UKESM has too much rainfall in the light rainfall category and too little rainfall in the very heavy category.
- ❖ These deficiencies are alleviated upon downscaling to 8 km, although there are some areas where heavy precipitation is overestimated (e.g., in the southeast corner of the domain).

Conclusions

- ❖ Over WMC, SINGV-RCM intensity distribution closer to observations
- ❖ 2km improvement over GCM, better than 8km
- ❖ UKESM has too much rainfall in the light rainfall category and too little rainfall in the very heavy category
- ❖ These deficiencies are largely alleviated upon downscaling to 8 km, although there are some areas where heavy precipitation is overestimated, and need further improvements in the SINGV-RCM, downscaling method, etc.

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FURTHER INFORMATION

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