Object-based Evaluation of Tropical Precipitation Systems in DYAMOND Simulations over the Maritime Continent

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1. Su, C. Y., Wu, C. M., **Chen, W. T.**, & Chen, J. H. (2021). Implementation of the Unified Representation of Deep Moist Convection in the CWBGFS. *Monthly Weather Review*, *149*(10), 3525-3539.
2. Su, C. Y., **Chen, W. T.**, Wu, C. M., & Ma, H. Y. (2022). Object-Based Evaluation of Tropical Precipitation Systems in DYAMOND Simulations over the Maritime Continent. *Journal of the Meteorological Society of Japan. Ser. II.*

Abstract

This study evaluates whether the global convection-permitting models can reproduce the relationship between the precipitation features and the horizontal scale of convective systems in high-resolution satellite rainfall products. The result shows that the models with convection parameterization perform better in some of the evaluation metrics, and the models with a finer native resolution are not superior to the others. The difference in the variability of tropical convection between a GCRM (NICAM) and a model with parameterized convection (CWBGFS) suggests that the upscale processes of tropical convection systems in the global models require further investigation.

DYAMOND

- ARPNH, ICON, and NICAM explicitly resolve moist convection.
- UM, FV3, and IFS-4km parameterize the effects of shallow convection.
- IFS-9km parameterizes both the effects of shallow and deep convection.
- MPAS uses a scale-aware cumulus parameterization.
- CWBGFS uses the unified representation of deep convection (Su et al. 2021).
- All the models were integrated for 40 days starting from August 1st, 2016.
- Grid points precipitation rate stronger than 1 mm h^{-1} are identified as an object-based precipitation system (OPS) representing an organized convective system.
- The object detection was carried out after the data interpolation (15 km, hourly).

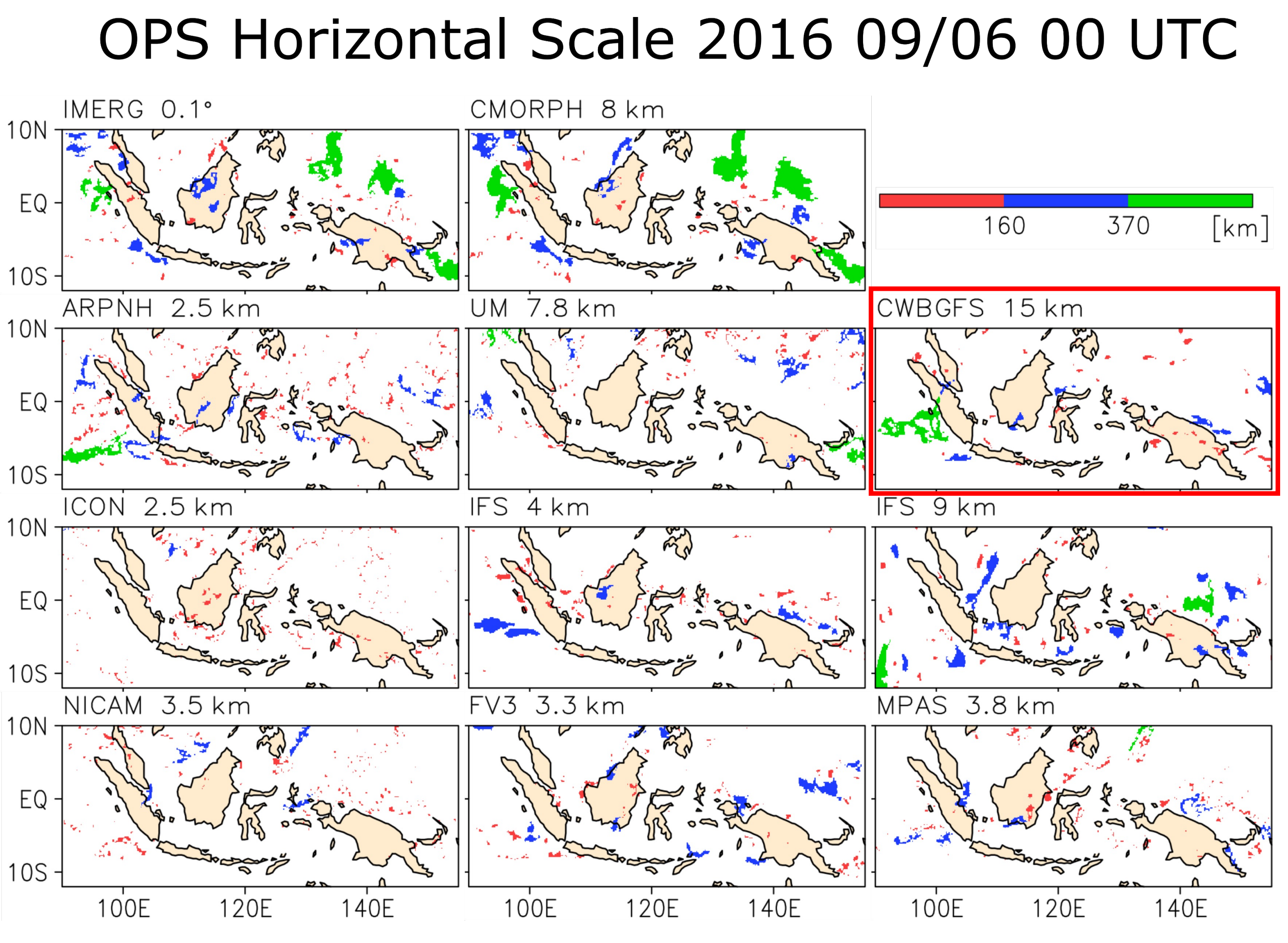
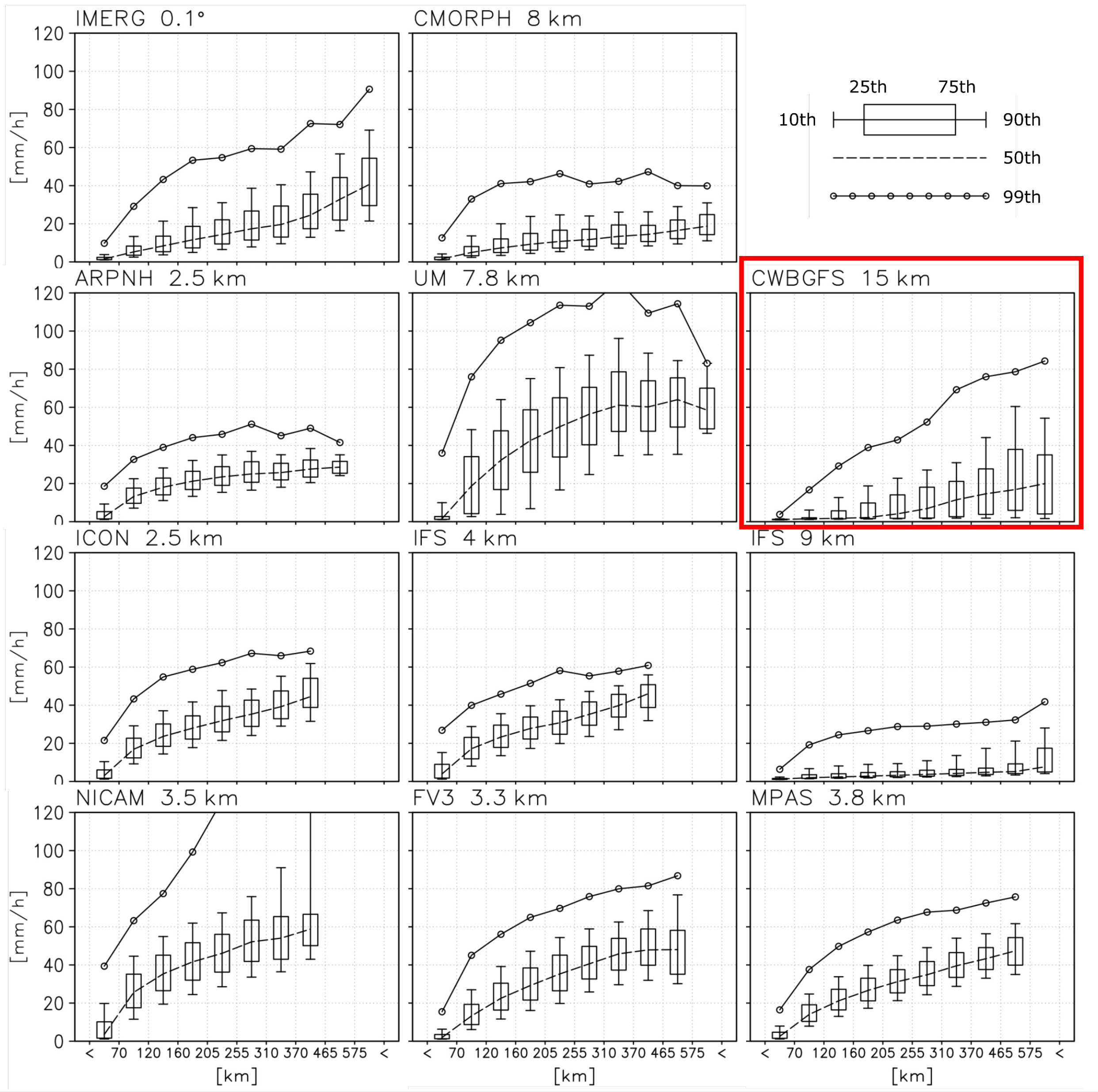


Figure 1 A snapshot of OPS horizontal scale of each dataset. The horizontal scale is determined by the square root of the OPS area. The OPSs are classified into: small (red), mid-size (blue) and large (green). The native resolution of each dataset is also shown in this figure.

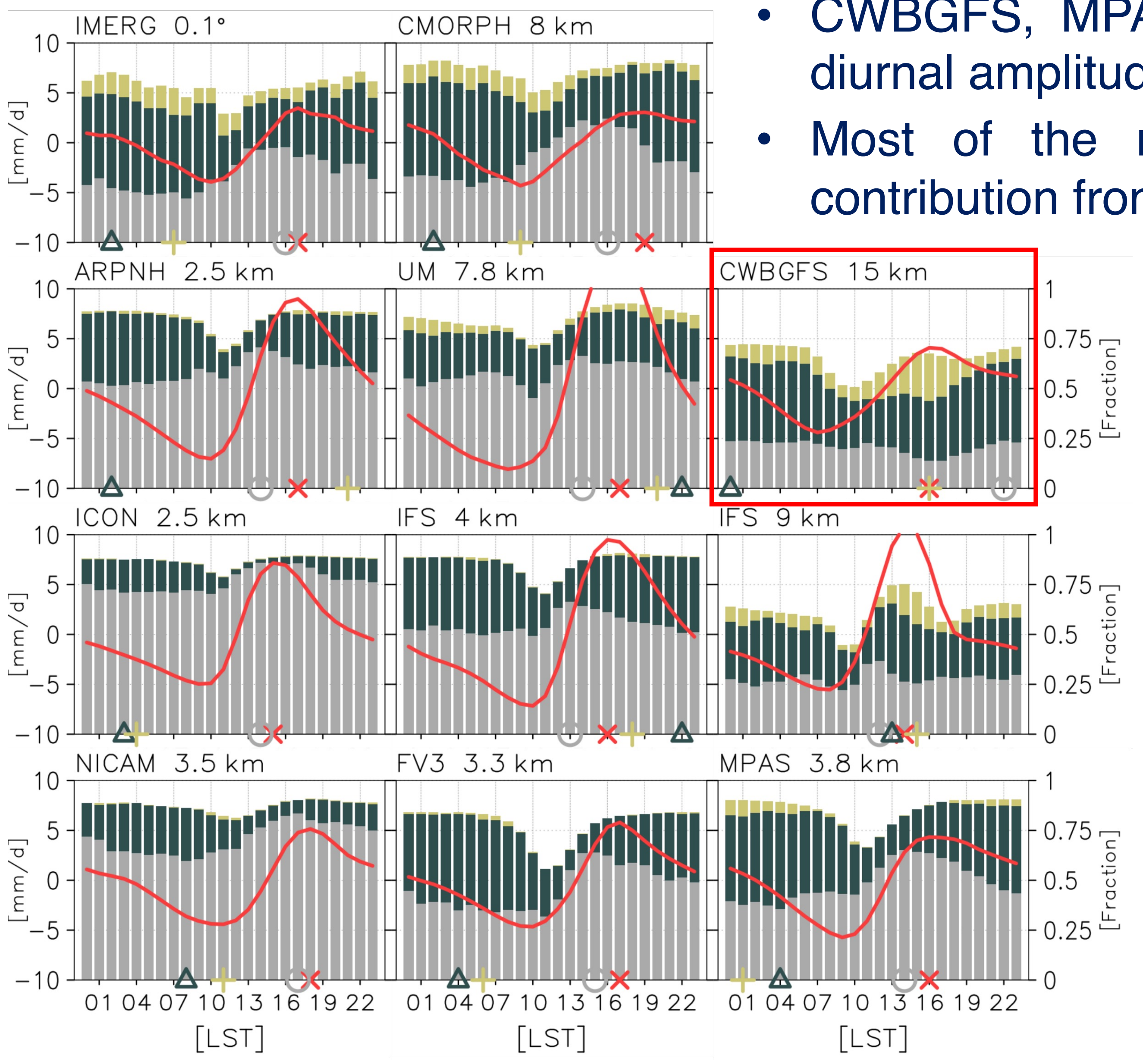
Object based precipitation extremes



- The observations show increasing 50th and 99th percentiles along with the increasing OPS scale.
- The CMORPH exhibits weaker precipitation extremes in large convective systems compared to the IMERG.
- Some of the models overestimate the sensitivity with the OPS scale for the variability of precipitation extremes (i.e., NICAM and UM).
- A few models underestimate the sensitivity (i.e., ARPNH and IFS-9km).
- The rest of the models generally fall within the observational difference for this sensitivity.

Figure 2 The spectrum of precipitation extremes (y-axis) for different horizontal scales (x-axis) of OPS. The x-axis is binned to assure a nearly equal fractional contribution to total rainfall in each bin based on the IMERG data. The error bars, box, dashed line, and circle represents the 10th, 25th, 50th, 75th, 90th, and 99th percentiles of the maximum precipitation intensity of OPS in each size bin.

Diurnal cycle over land



- CWBGFS, MPAS, FV3, and NICAM reproduce observed diurnal amplitude
- Most of the models underestimate (overestimate) the contribution from large (small) OPSs
- Only the models with convection parameterization (i.e., CWBGFS, IFS-9km, MPAS) can represent the diurnal evolution of fractional contribution from different OPSs.

Figure 3 The diurnal variation of average precipitation intensity (left y-axis, red line) and the fractional contribution to total rainfall of different scale categories of OPS (right y-axis, grey: small; dark green: mid-size; yellow: large) over the land area in the Maritime Continent. The diurnal peak time of each component is plotted as colored symbols along with the x-axis (red cross: average precipitation intensity; grey circle: small OPS fractional contribution; dark grey triangle: mid-size OPS fractional contribution; yellow plus sign: large OPS fractional contribution).

- In CWBGFS, the large convection variability mostly occurs over the ascending regions of the large-scale circulation.
- The convection variability with 0.25° mesh is still significant over the descending regions in NICAM.
- Both the extreme updrafts and downdrafts in NICAM over the ascending regions are twice stronger than those in CWBGFS.

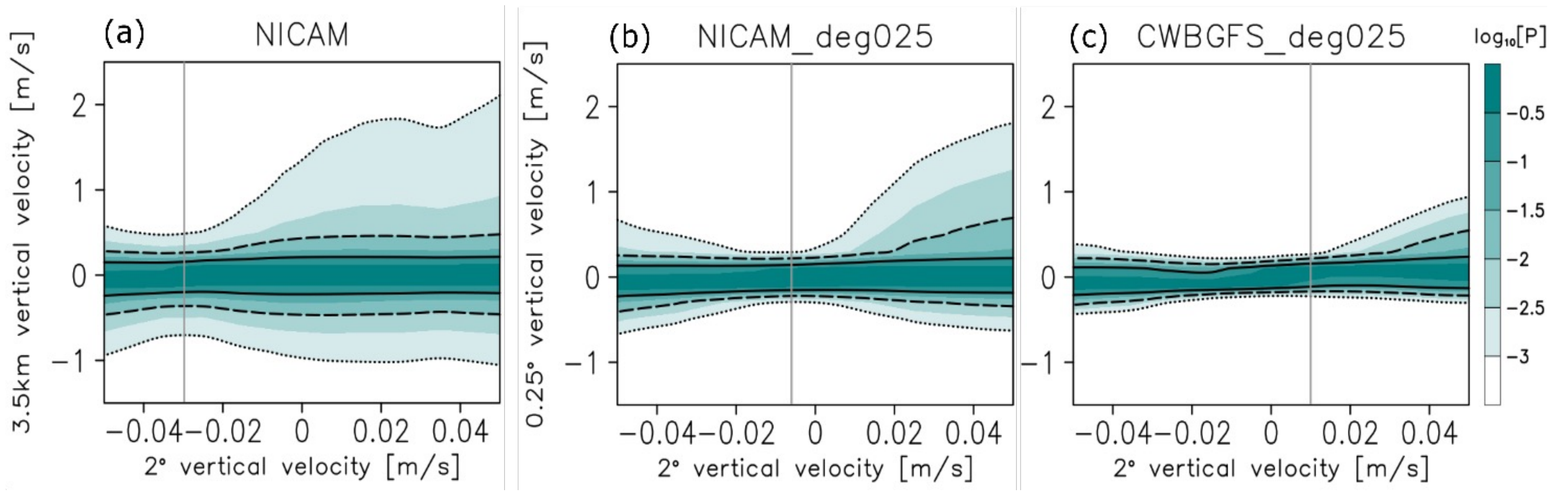


Figure 4 (a) The change in the probability distribution of the vertical velocity (shading) at the 3.5-km horizontal resolution at 5 km altitude (y-axis) along with the change in the vertical velocity averaged over a 2° mesh that represents the large-scale vertical motions at the same height over the tropical ocean (-15°S~15°N) in NICAM. (b) and (c) show the probability distribution of the vertical velocity averaged over a 0.25° mesh in NICAM and CWBGFS.