METEOROLOGICAL SERVICE SINGAPORE
Centre for Climate Research Singapore

High-resolution AR6-based climate projections for the Southeast Asia / Maritime Continent region

Xin Rong CHUA

Climate Projections & Extremes | Department of Climate Research

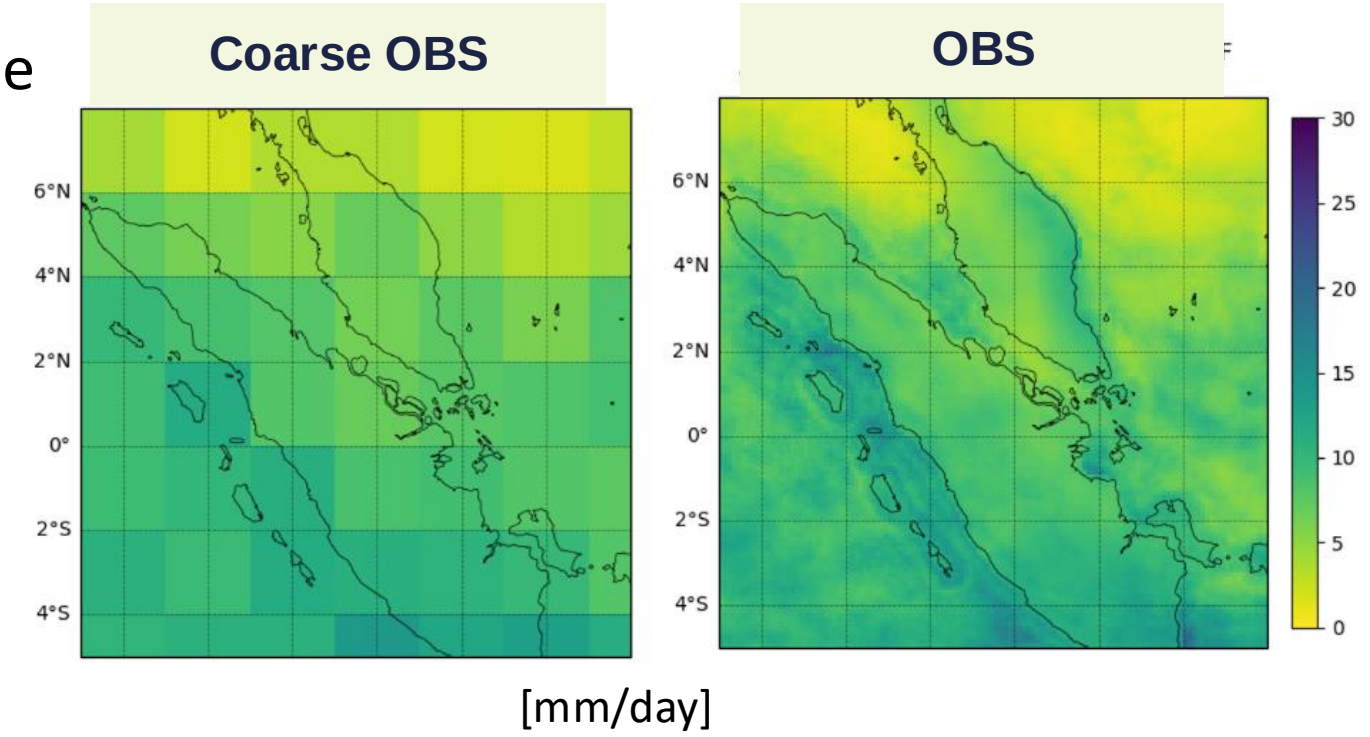
V3 core team members: Aurel Moise, Sandeep Sahany, Prasanna Venkatraman, Muhammad Eeqmal Hassim, Chen Chen, Pavan Harika Raavi, Fei Luo, Jianjun Yu, Trina Ng, Nidheesh Ganghadharan
UKMO contributors: Gill Martin, Nicholas Savage

BoM R&D Workshop and Convective Scale Workshop

11 September 2024

Motivation: What does downscaling do to GCMs?

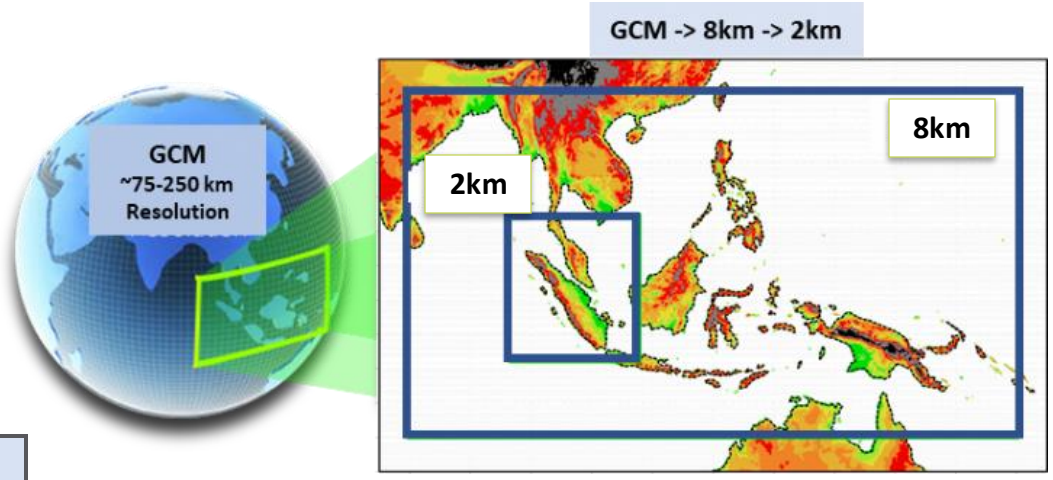
- Background on the Third National Climate Change Study and downscaling simulations
- Do downscaled simulations resemble their parents versus showing precipitation characteristics of the RCM?
  - Climatology maps
  - Diurnal cycle
  - Analysing Scales of Precipitation (ASoP) spectral and coherence statistics



V3: From Start to Finish

Stakeholder engagement

BCA · STRATEGY GROUP, PRIME MINISTER'S OFFICE, SINGAPORE · MND SINGAPORE · PUB, Water for All: Conserve, Value, Enjoy · SLA, Singapore Land Authority · Singapore Food Agency · MAS · National Parks, Let's Make Singapore Our City in Nature · Land Transport Authority, We Keep Your World Moving · MINISTRY OF HEALTH SINGAPORE · MPA SINGAPORE · Energy Market Authority, Smart Energy, Sustainable Future · jtc · HOUSING & DEVELOPMENT BOARD · URBAN REDEVELOPMENT AUTHORITY, To make Singapore a great city to live, work and play



Sub-selection of global climate models

RCM 8km downscaling

RCM 2km downscaling

Temperature, rainfall, winds, humidity, etc.

Sea-level projections

Based on IPCC methodology using long-term sea level records at individual stations

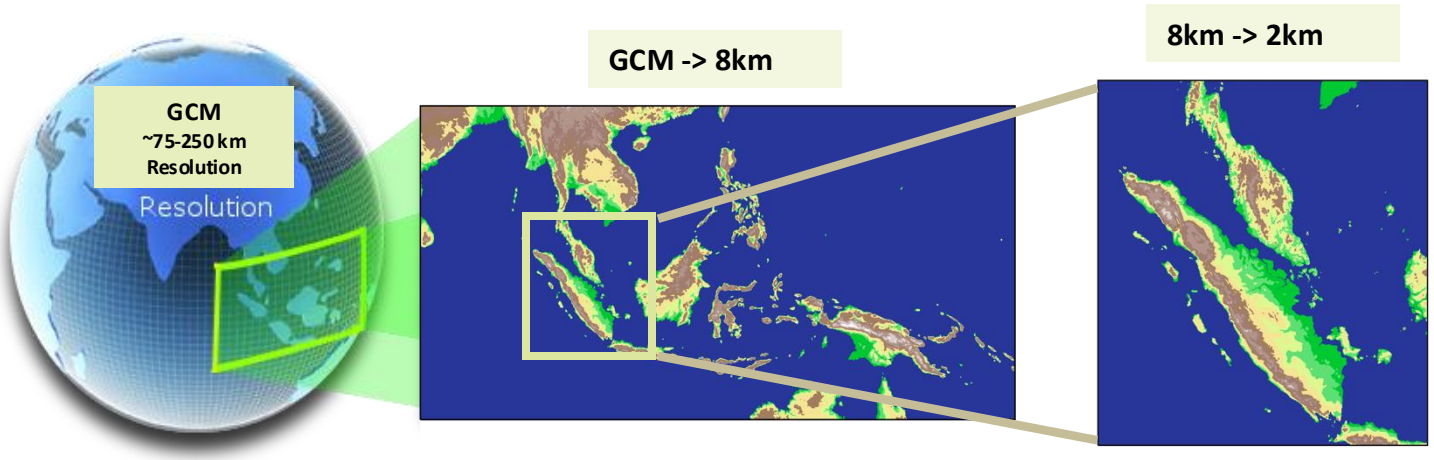
Sea Level

V3 Data Visualisation Portal

SINGV-Regional Climate Model (SINGV-RCM)

SINGV-RCM was adapted from SINGV-NWP to run in climate mode

Uses Climate Change Initiative (CCI) land use and land cover data (more realistic urban fraction for Singapore and Kuala Lumpur)



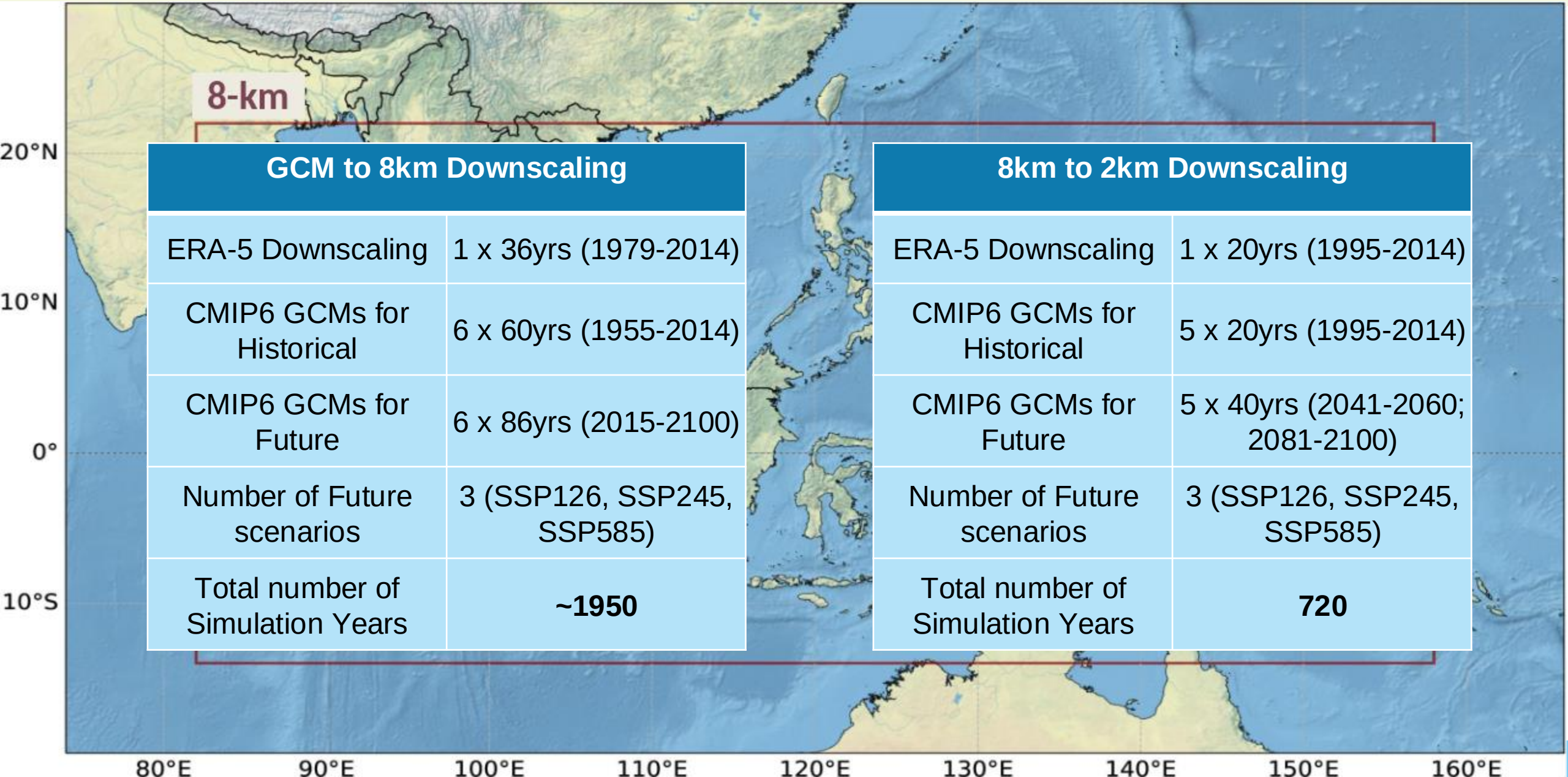
Model Configuration (SINGV-RCM)

- 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
- 8km domain – 1 year simulation takes ~12 days, with 400 CPUs (Cray XC40)
- 2km domain – 1 year simulation takes ~25 days, with 320 CPUs (Cray XC40)

8-km downscaling of two GCMs was also carried out by our University collaborators using WRF to assess dynamical downscaling uncertainty

For more info: Prasanna, V., Dipankar, A., Liu, J., Lim, G., Moise, A., Chua, X.R., Sanchez, C., Chen, C., Yu, J., Raavi, H.P. and Luo, F., 2024. SINGV-RCM: the convection-permitting regional climate model for Singapore. *Climate Dynamics*, pp.1-13, ERA5 evaluation by Prasanna et al., submitted to IJOC.

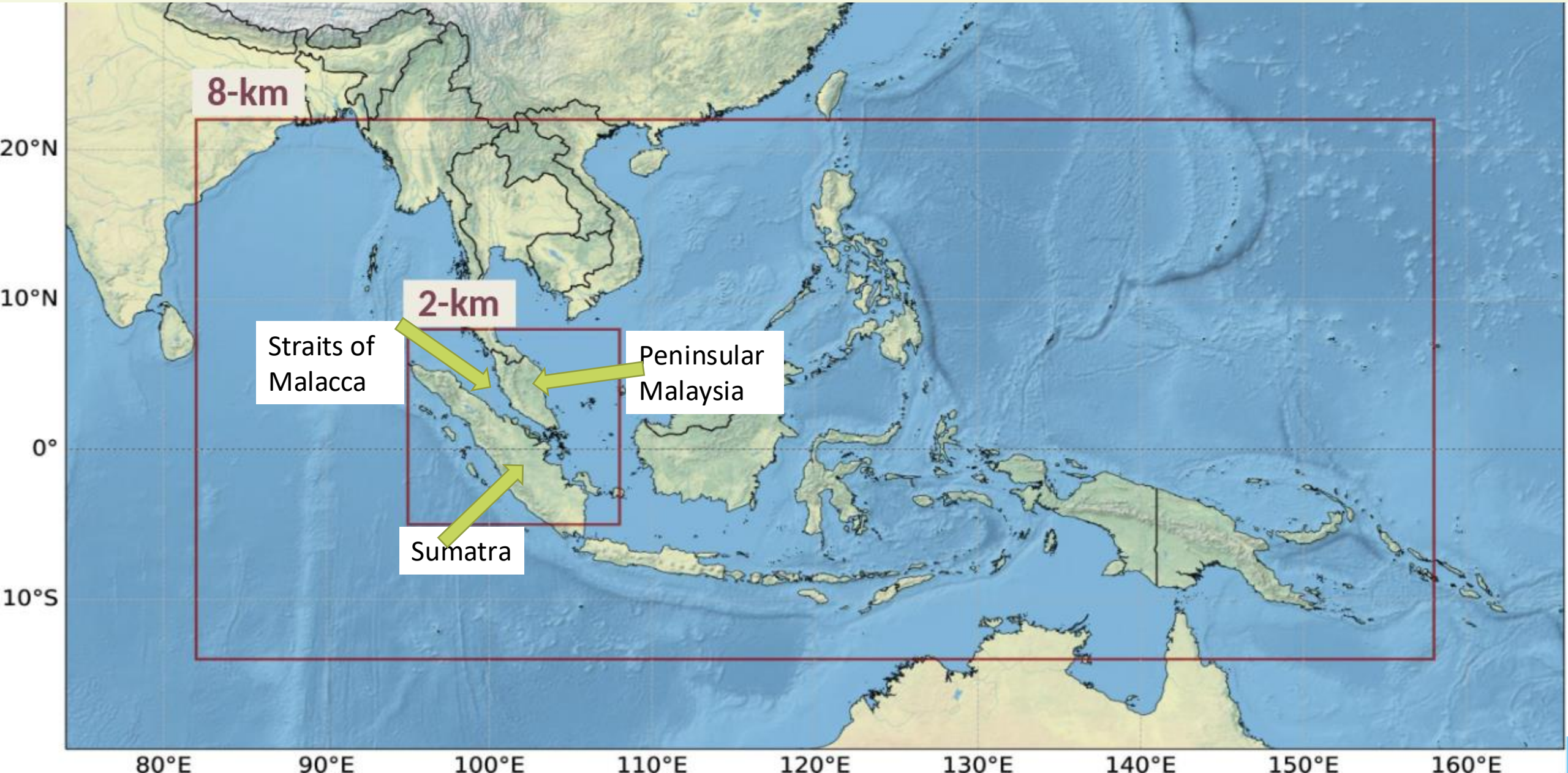
V3 8-km and 2-km downscaling domains



GCM to 8km Downscaling	
ERA-5 Downscaling	1 x 36yrs (1979-2014)
CMIP6 GCMs for Historical	6 x 60yrs (1955-2014)
CMIP6 GCMs for Future	6 x 86yrs (2015-2100)
Number of Future scenarios	3 (SSP126, SSP245, SSP585)
Total number of Simulation Years	**~1950**

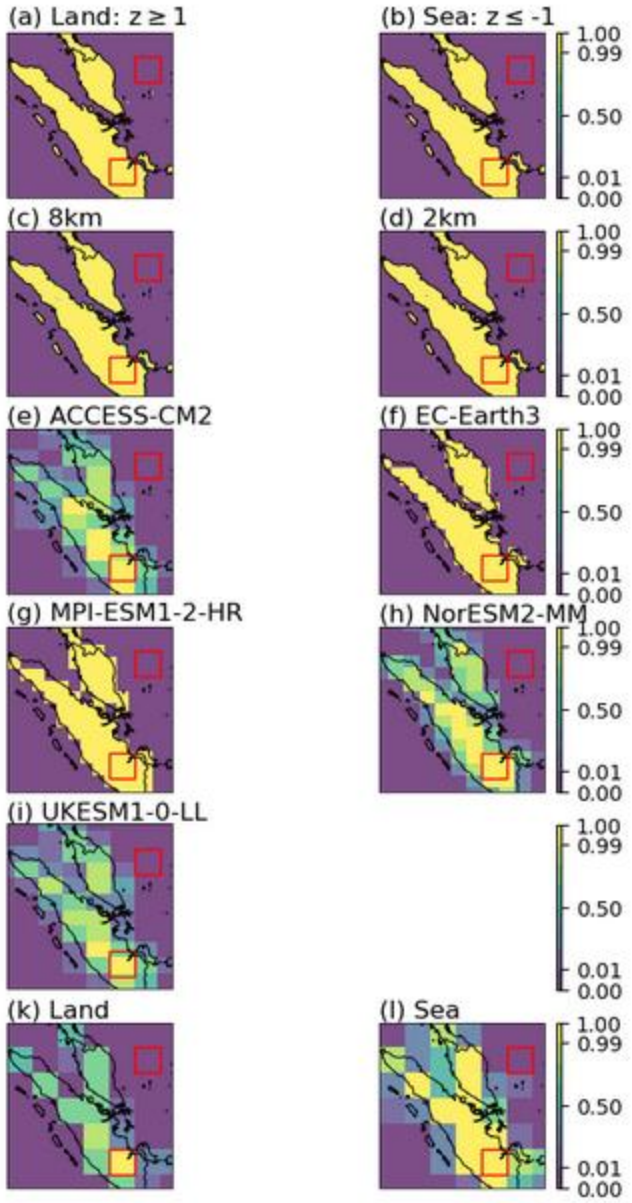
8km to 2km Downscaling	
ERA-5 Downscaling	1 x 20yrs (1995-2014)
CMIP6 GCMs for Historical	5 x 20yrs (1995-2014)
CMIP6 GCMs for Future	5 x 40yrs (2041-2060; 2081-2100)
Number of Future scenarios	3 (SSP126, SSP245, SSP585)
Total number of Simulation Years	**720**

V3 8-km and 2-km downscaling domains



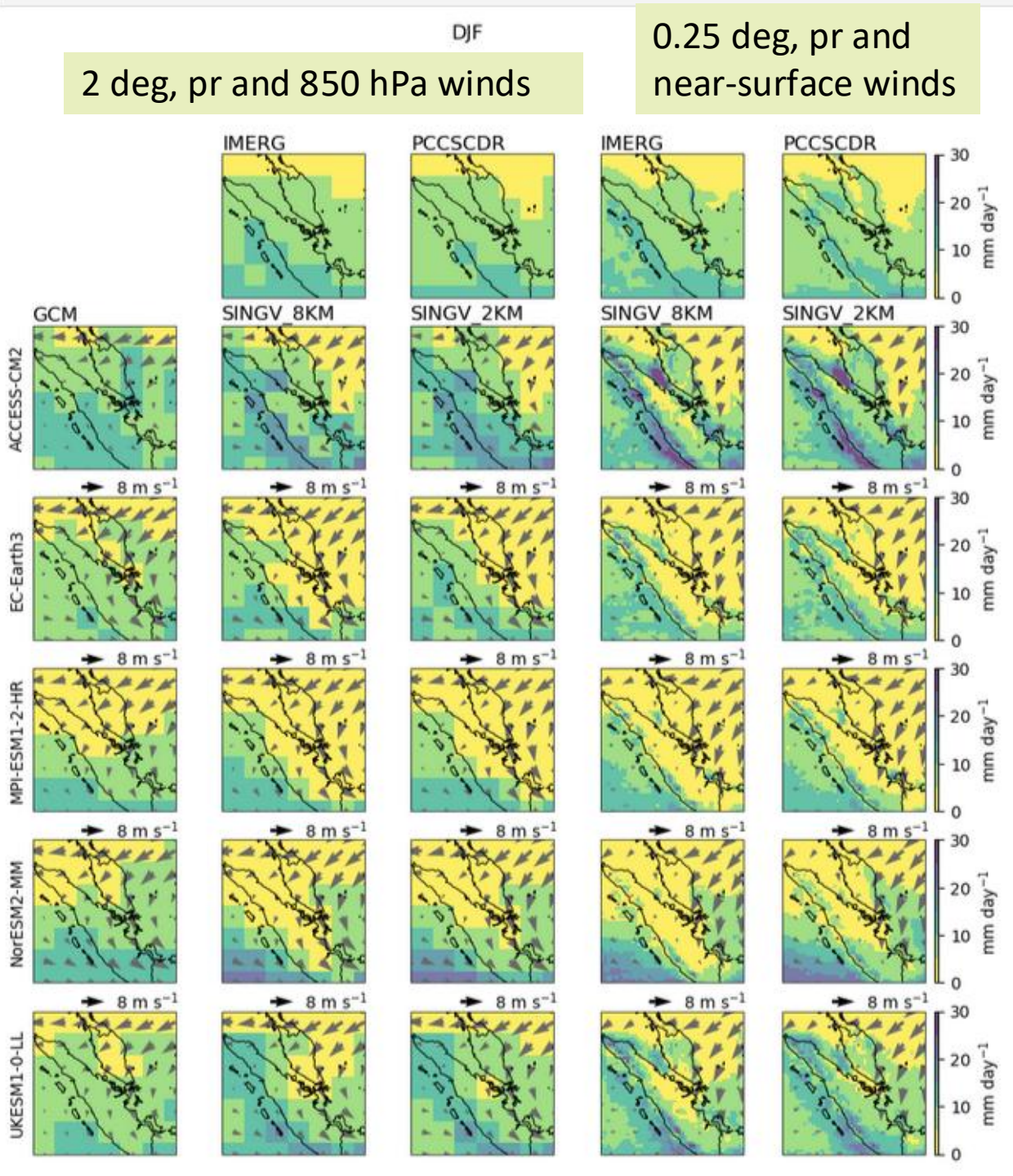
Land sea representation

- In this study: 2001-2005 DJF (this presentation) and JJA.
- The land-sea mask of the WMC is generally well captured in the 8km and 2km grids, as well as the higher resolution EC and MPI grids.
- In contrast, large fractions of land masses within the region are classified as a mixture of land-sea in the other three GCMs.
- The Straits of Malacca and the area off the southwest coast are considered as considering land in some GCMs.
- Nearest-neighbor mapping was used to obtain SST forcings in the RCM.



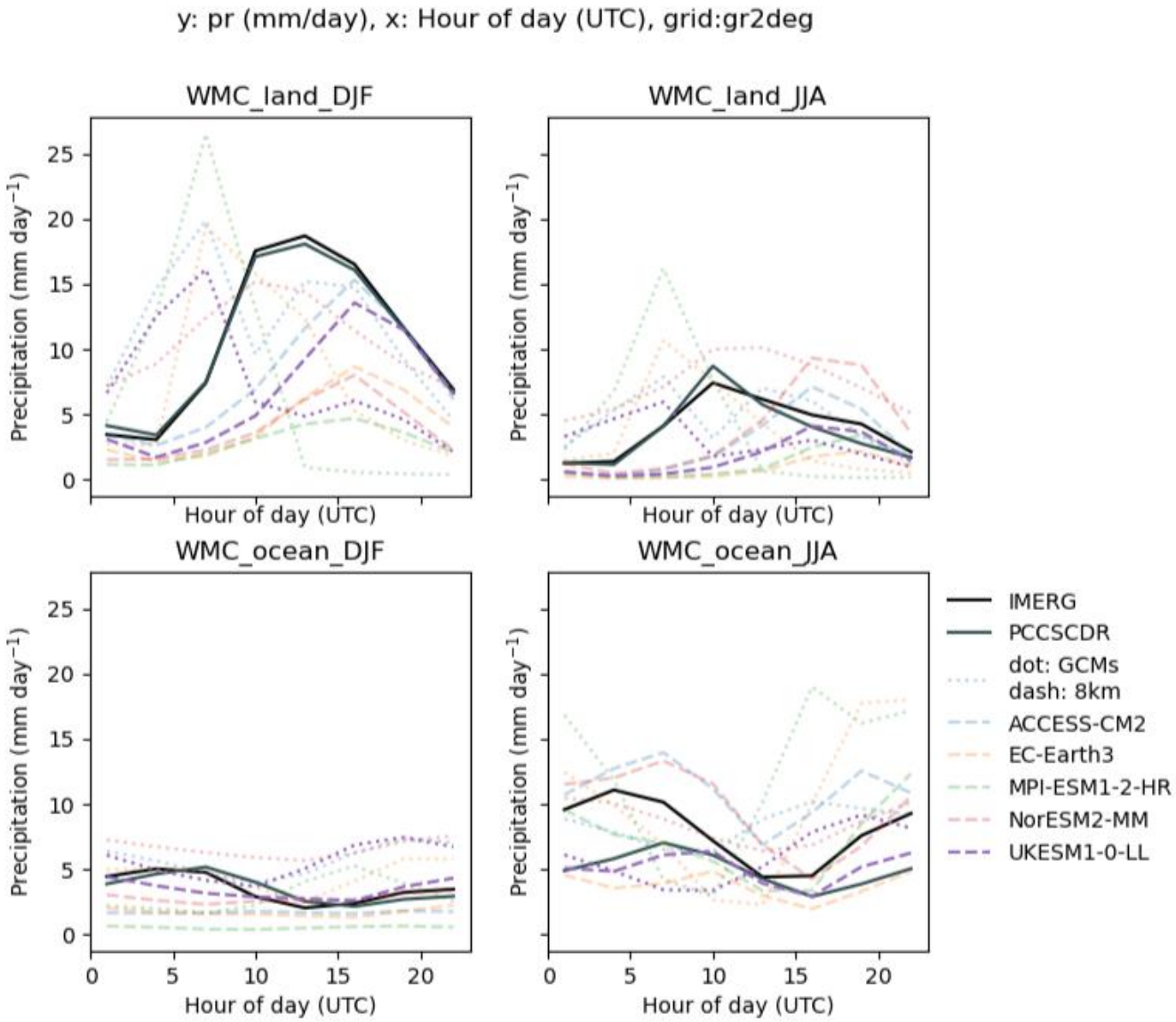
GCM vs RCM

- RCMs carry characteristics of their parents
- Enhancement of precipitation can occur over ocean or coastal areas, possibly together with drying of land
- Possible reasons: (partial) land GCM points as RCM SST forcings, stronger latent heat fluxes in RCM vs GCM



Diurnal rainfall for land and ocean

- SINGV-RCM shows improvements for rainfall later in the day
- Peaks are more aligned in RCM simulations than in their parents

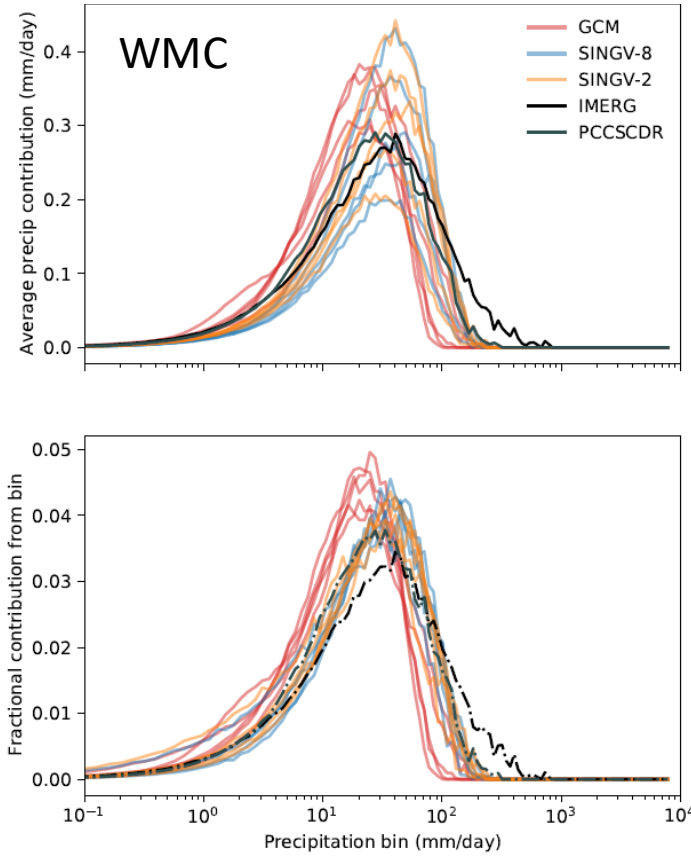


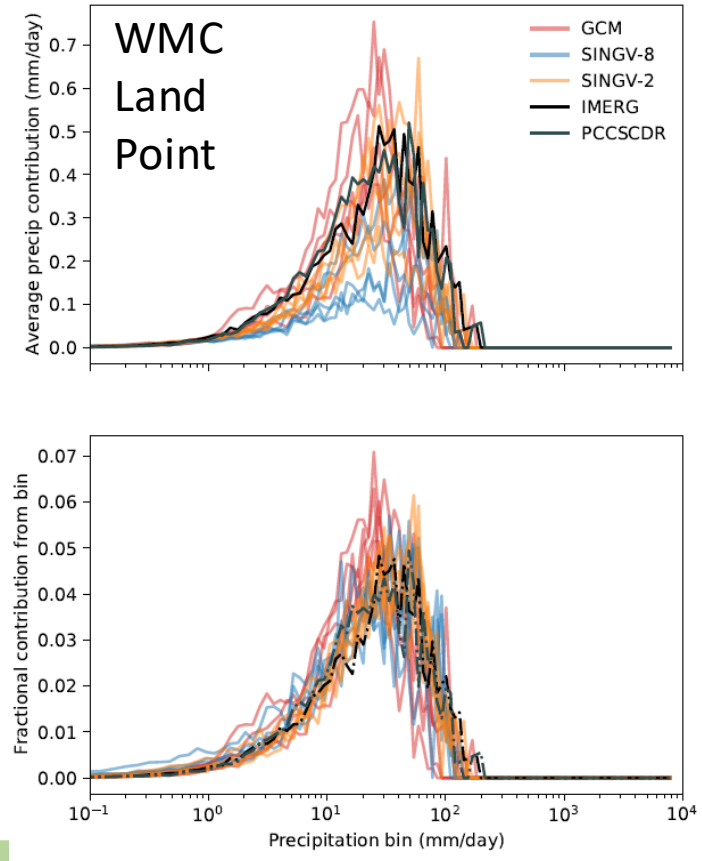
ASoP methodology

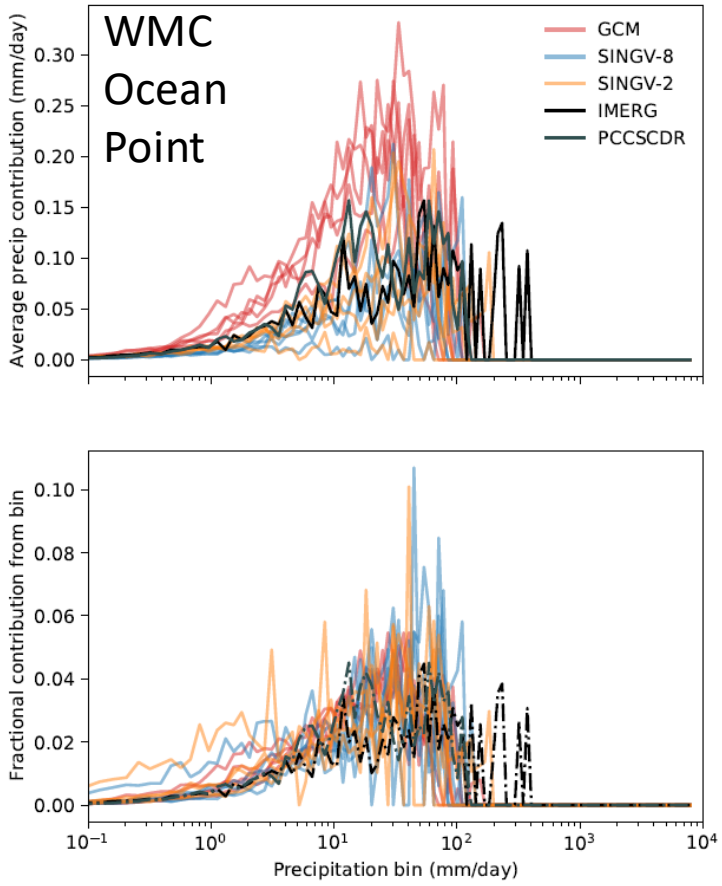
- Diagnostics applicable to different timesteps/resolution to inform model evaluation and development (Klingaman et al. 2017, Martin et al. 2017).
- Incorporates precipitation frequency and intensity information with temporal and spatial dimensions.
- Originally used to diagnose GCMs (e.g. GC5), now applying to downscaling.

Intensity distribution over WMC improved by downscaling

- 2 degrees, 3 hr frequency, DJF
- Over WMC, SINGV-RCM intensity distribution closer to observations
- 2km improvement over GCM, comparable/ better than 8km

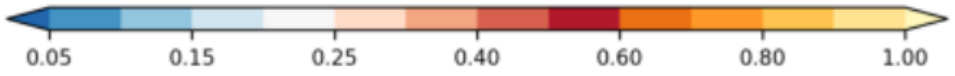


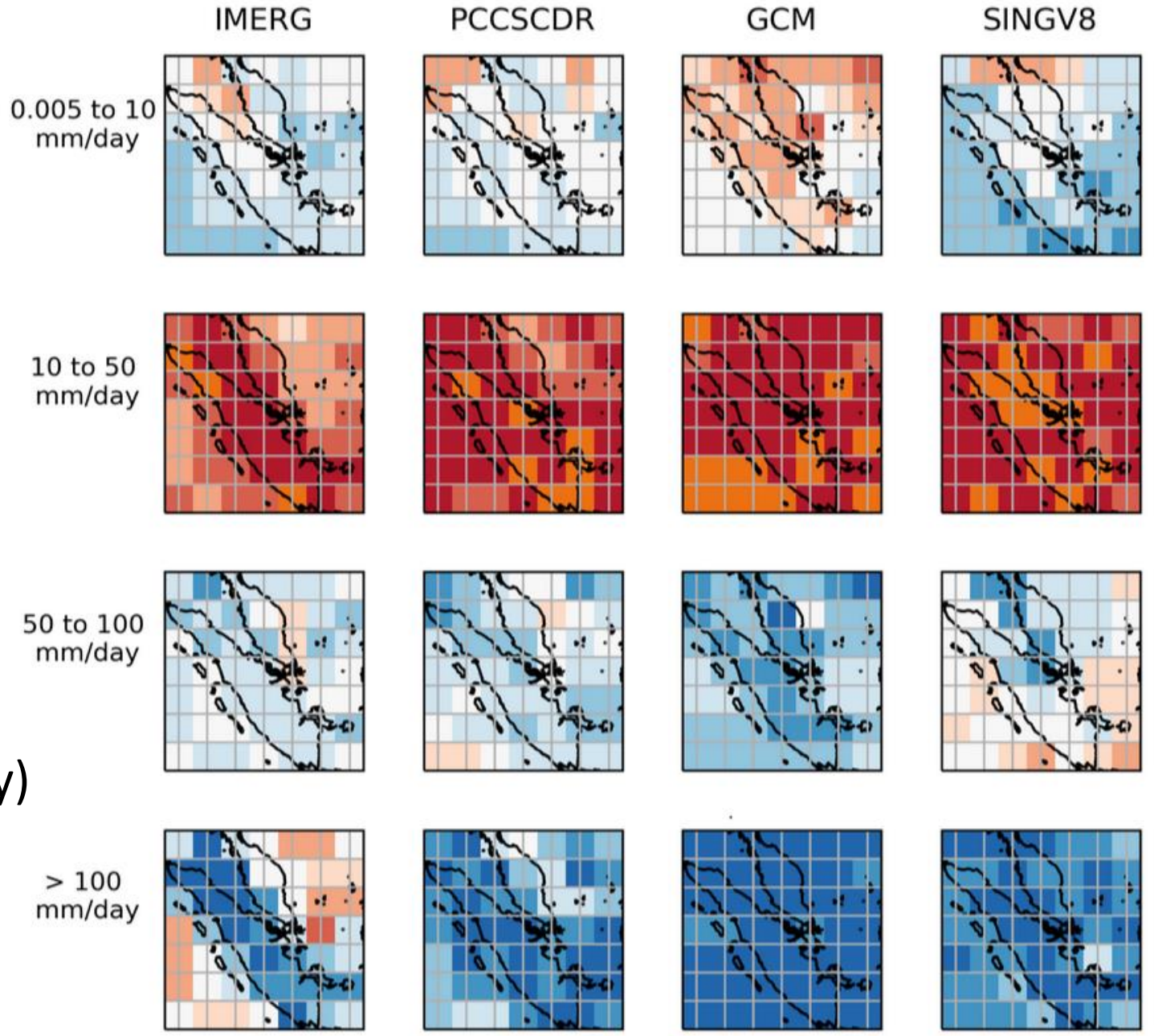




Spatial distribution of fractional intensity contributions

- Some differences in extreme rainfall between IMERG and PCCSCDR
- Improvements in intensity distribution over Peninsular Malaysia across intensities in SINGV-RCM, ocean west of Sumatra
- Possibly too much rainfall over parts of Sumatra (10-50 mm/day)



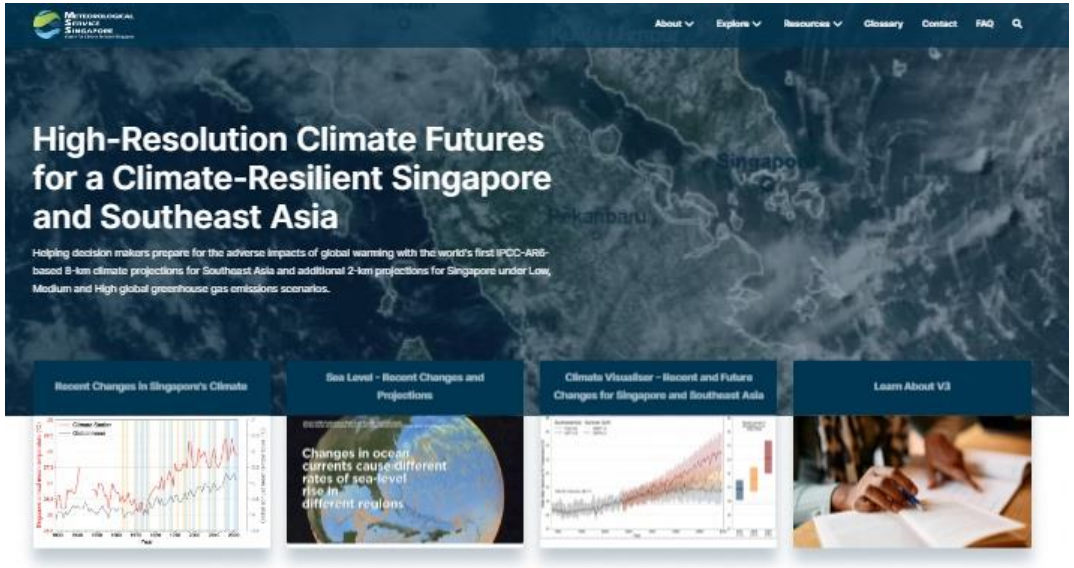


Conclusions

- Maritime Continent requires careful consideration of choosing SST due to the complex land-sea contrast
- Climatological features of downscaled simulations recognizable from parent GCMs
- RCM shifts the diurnal peak and the intensity distribution

Future plans/resources

- Future: O(100)m downscaling for Singapore, data sharing of 8km data with CORDEX-SEA



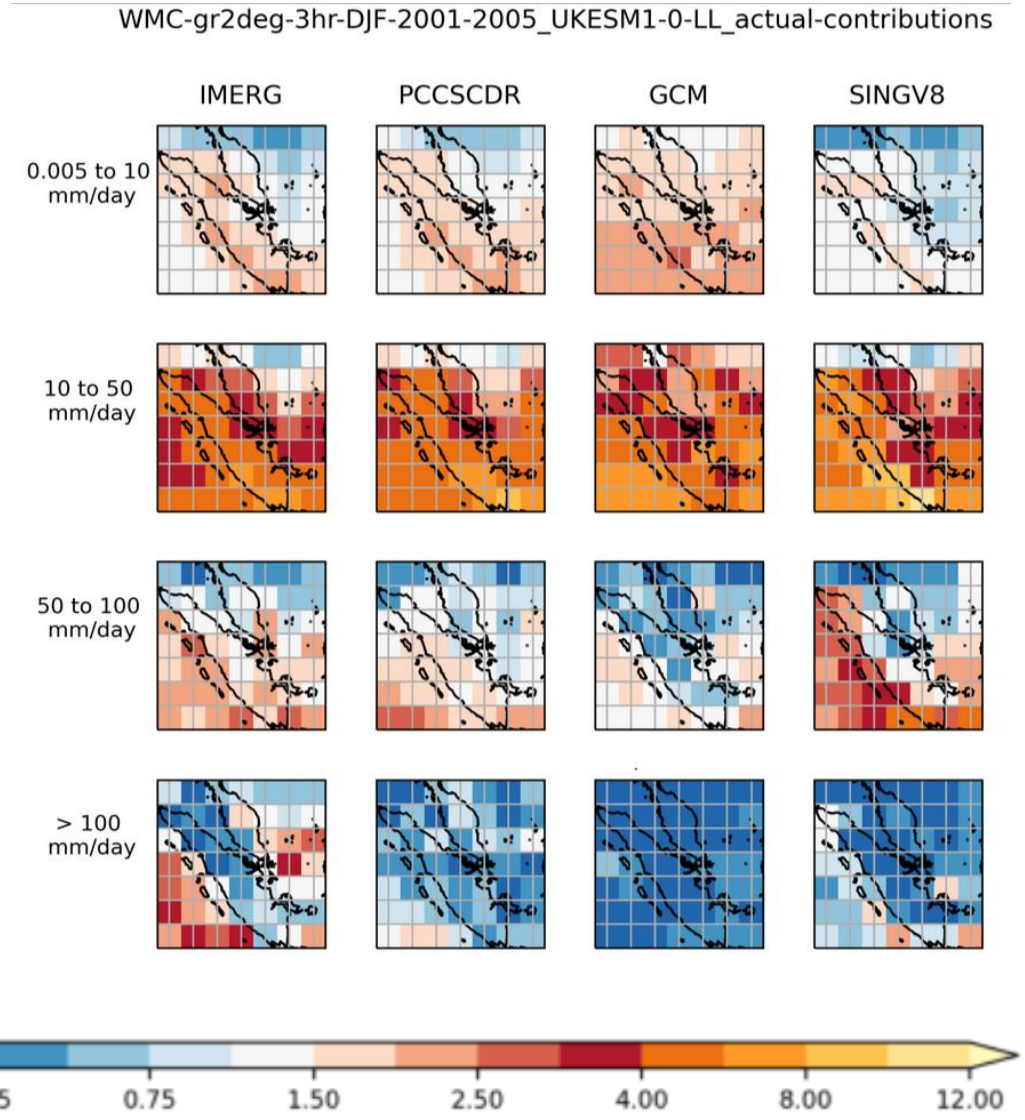
V3 Portal

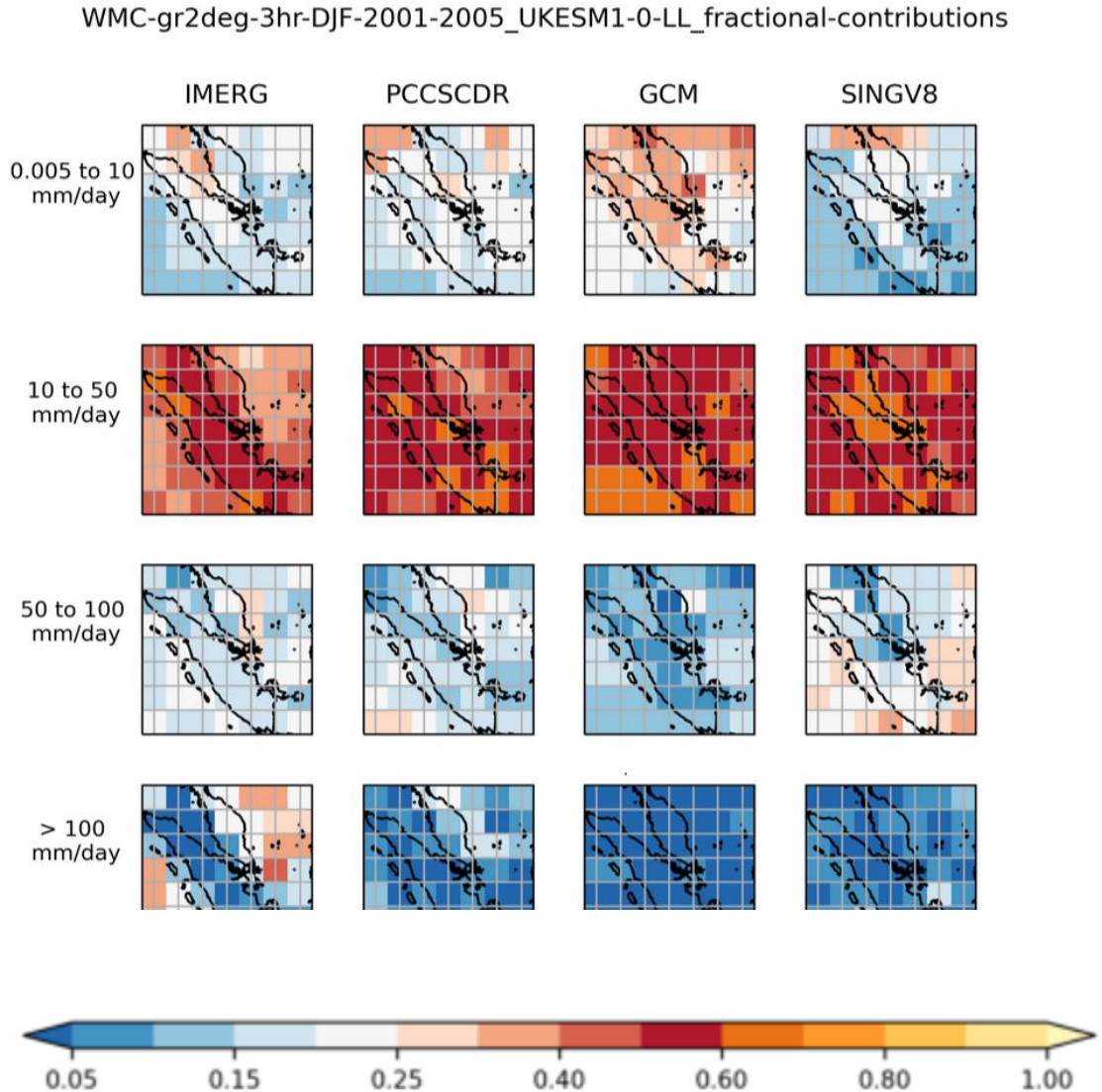
CCRS LinkedIn

MSS Youtube

Additional slides

Actual contributions vs fractional contributions





UKESM (left), MPI (right)