

Capacity Building on the Use of High-Resolution Climate Change Projections for Impact Studies over Southeast Asia

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Climate change;
Automatic weather stations;
Climate records;
In situ atmospheric observations;
Climate models;
Regional models

What is ARCDAP-4?

What: This 4-day in-person workshop was coordinated by the Association of Southeast Asian Nations (ASEAN) Specialized Meteorological Centre (ASMC) and delivered by the Centre for Climate Research Singapore (CCRS). This Fourth Workshop on ASEAN Regional Climate Data, Analysis and Projections (ARCDAP-4) brought together more than 40 attendees from Southeast Asia (SEA) National Meteorological and Hydrological Services (NMHSs), the research community, and practitioners to share knowledge on the latest progress on regional climate projections and their application in regional impact studies.

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1. Motivation

The Association of Southeast Asian Nations (ASEAN) Regional Climate Data, Analysis and Projections (ARCDAP) workshop series is an ASEAN Specialized Meteorological Centre (ASMC)-led initiative delivered by the Centre for Climate Research Singapore (CCRS) within the Meteorological Service Singapore (MSS). It was first held in 2018, in response to a proposal from the World Meteorological Organization (WMO) Regional Association (RA) V Working Group on Climate Services (WG-CLS) for the ASEAN region to enhance synergies in generating regional/national climate change projections. The previous ARCDAP-3 (ASMC and MSS 2021) was held virtually from 15 to 18 March 2021, during the COVID-19 pandemic, and covered the application of the Coupled Model Intercomparison Project phase 6 (CMIP6) datasets, model evaluation, and a framework for understanding key regional processes across Southeast Asia (SEA) using a wide range of climate models.

For ARCDAP-3, National Meteorological and Hydrological Services (NMHSs), related national agencies, and other academic groups came together (virtually) and, through presentations and discussions, updated their knowledge of the regional climate model (RCM) projection datasets, experimental design, and current data availability, as well as the latest evaluation tools/online resources.

Following this, and recognizing the COVID-19-induced longer time gap since ARCDAP-3, ARCDAP-4 was designed to (i) update the community on the status of the CMIP6-based regional climate change projections and (ii) build a bridge from there to the climate impacts community within ASEAN countries. With this, the workshop also aimed to enhance the understanding of available validation datasets (both nationally and regionally). As with all, ARCDAP's consensus was reached around a set of recommendations covering these topics.

Regarding the regional projections, the workshop aimed to present both CCRS's Third National Climate Change Study (V3), which provides CMIP6-based projections at 8-km resolution (MSS 2024) and several Coordinated Regional Climate Downscaling Experiment for SEA (CORDEX-SEA) efforts across Southeast Asia (Nguyen et al. 2026).

2. Workshop organization

ARCDAP-4 took place from 21 to 24 April 2025 in Singapore with support from the WMO. This in-person workshop brought together 40 participants from ASEAN NMHSs, international climate experts, sectoral specialists on climate change impacts, and representatives from regional research institutions (Fig. 1). The overarching theme was “Applications of high-resolution regional climate change projections for Southeast Asia climate impact studies.”

The 4-day event featured country-specific presentations, hands-on sessions, and group exercises, structured around scientific capacity building in the use of regional observational



Fig. 1. ARCDAP-4 participants' group photo taken on day 1.

datasets, national climate projections, climate impacts, and regional coordination to draft recommendations for applying high-resolution regional climate projections to sectoral climate change impact studies.

3. Objectives

The ARCDAP-4 workshop aimed to

- consolidate knowledge on the status of high-resolution regional climate projections for SEA (e.g., CORDEX-SEA, V3);
- support climate change impact studies for SEA by improving the understanding and application of climate projection data;
- enhance the understanding of the application of climate change impact metrics;
- strengthen regional collaboration and capacity building around observational datasets, climate projections, and impact studies;
- provide hands-on training on CCRS's V3 Data Visualization Portal (DVP) and V3 Data Sharing Portal (DSP);
- draft a set of recommendations for the use of high-resolution climate projections in sectoral climate change impact studies.

4. Key themes and sessions

The 4-day ARCDAP-4 workshop covered the following themes.

a. Sharing on regional climate model projections, CORDEX-SEA, V3, and others. Participants presented the status of national and regional climate model projections, including results from Singapore's V3. Experts from CORDEX-SEA shared insights on current regional modeling efforts and the status quo. Faye Cruz (Manila Observatory, Philippines) presented an extensive update on CORDEX-SEA phase 3, which involves downscaling 13 CMIP6 GCMs

using five RCMs at 25-km resolution. She also introduced the “Climatic hazard Assessment to enhance Resilience against climate Extremes for Southeast Asian megacities (CARE for SEA megacities)” initiative, which targets city-level projections for extreme heat and rainfall for five SEA cities (Bangkok, Hanoi, Jakarta, Kuala Lumpur, and Manila).

Sandeep Sahany (CCRS, Singapore) presented on Singapore’s V3, which, at 8 km, is currently the highest spatial resolution climate change dataset available for the Southeast Asia region. He also provided insights from the extreme analysis of V3 data, including a continued rise in daily maximum temperatures and an increase in dry spells.

All representatives from SEA NMHSs presented their country-specific approaches to construct their national climate projections. For example, Brunei Darussalam presented on how they integrate CCRS’s V3 projections (8 km) into their National Climate Vulnerability Assessment. In contrast, the Vietnam Institute of Meteorology, Hydrology and Climate Change (IMHEN) and the Vietnam Meteorological and Hydrological Administration (VNMHA) maintain ongoing collaborations with the Met Office, using its 12-km downscaling, including validation against Vietnam’s national station network. For countries that lack local resources for conducting their own national climate projections, such as Lao People's Democratic Republic (Lao PDR) and Cambodia, they use Lao Climate Service for Agriculture (LaCSA) and World Bank data products, respectively.

During the Q&A sessions, participants posted questions on Padlet (see Fig. 2) that also suggested a whole-region approach to produce ASEAN-wide projections using a single ASEAN-developed RCM for all countries. The concern was how to address the significant capacity imbalance in producing national climate change information across ASEAN. Other questions were more technical and specific, such as threshold choices for dry spell studies and whether the values will differ; whether it is annual or monthly; as well as seasonal datasets

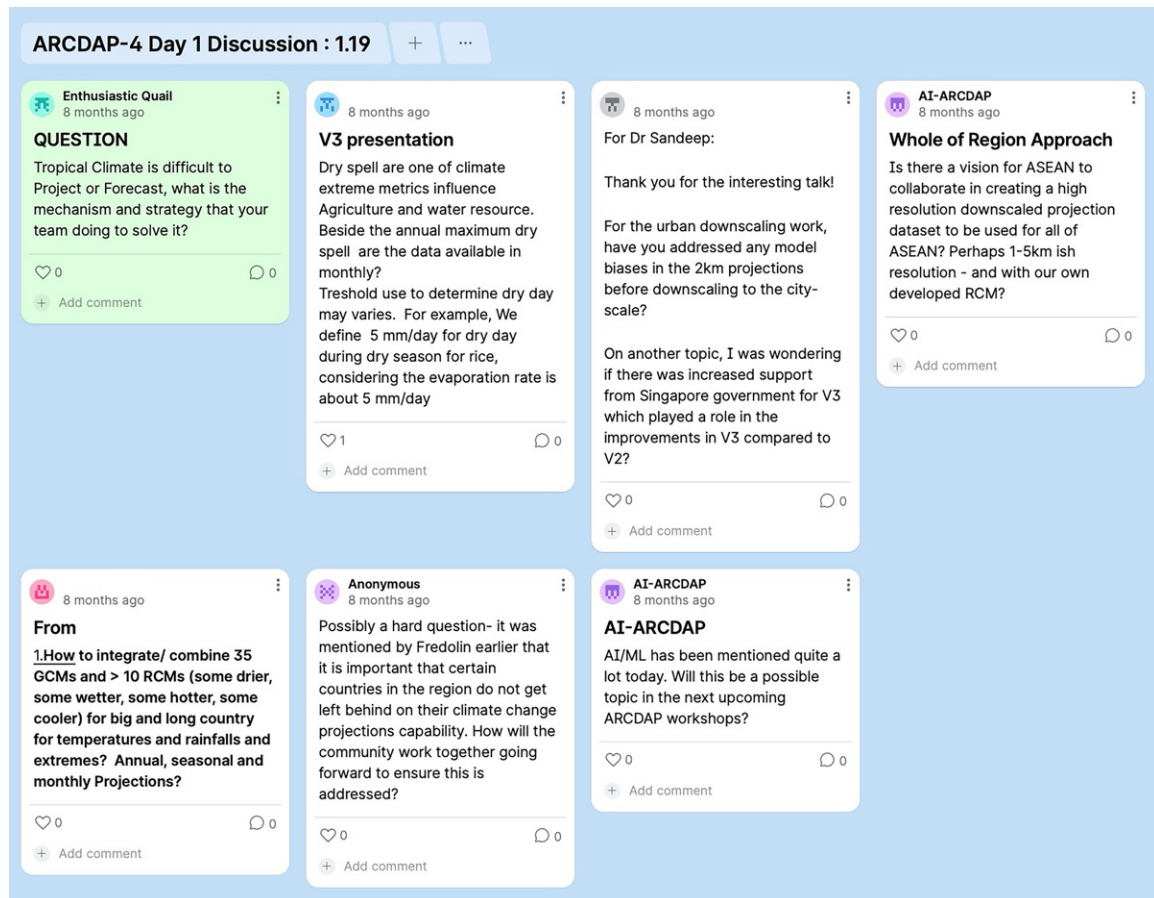


FIG. 2. Questions posed by workshop participants for the discussion session 1.19 on day 1.

and how the biases have been dealt with in CCRS's Singapore domain (2 km) V3 simulations before urban modeling was carried out.

b. Observational datasets for climate evaluation and climate change impact studies. Day 2 of the workshop focused on the observational datasets, with all participants sharing their nationally available gridded/observational datasets. All participants expressed a desire for reliable observational datasets and hoped to make all datasets available for the region to share. Discussions highlighted the importance of observational datasets for model evaluation and bias correction. Muhammad Eeqmal Hassim (CCRS, Singapore) gave an overview of the observational datasets for the region, including a daily gridded surface temperature and precipitation dataset for Southeast Asia [SA observed (SA-OBS); van den Besselaar et al. 2017], Multisource Weighted-Ensemble Precipitation (MSWEP; Beck et al. 2019), and Integrated Multi-satellitE Retrievals for Global Precipitation Measurement (IMERG; Huffman et al. 2020). He also explained the biases, temporal coverage, and best use cases for each dataset.

For the Philippines, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) has developed high-resolution observation-based gridded subdaily climate data for the Philippines (ClimGridPh) v2.0, which is a 1-km dataset derived from NASA's Global Precipitation Measurement (GPM; Hou et al. 2014) rainfall with bias-corrected station data and validated with cross validation and Taylor diagrams. These datasets are also publicly available through the Climate Information Map (CliMap) v2.0 portal. MetMalaysia produced a 10-km blended rainfall product using Global Satellite Mapping of Precipitation (GSMaP; Kubota et al. 2020) and Barnes successive correction method combined with gauge observations. Cambodia maintains 100 precipitation stations with gridded datasets for near-real-time (10-min) radar data.

c. Launch V3 DSP and hands-on session with V3 DVP. Muhammad Eeqmal Hassim (CCRS, Singapore) gave a presentation on the V3 DVP (<https://www.mss-int.sg/v3-climate-projections/explore>) and also a walk-through of the V3 DSP¹ (<https://v3-climate-projections-uat.mss-int.sg>) that was launched as a part of his presentation (see Fig. 3). He announced the launch of the V3 DSP, offering free access under the Singapore Open Data License. Participants then used the V3 DVP to extract country-specific information and explored key climate variables through interactive visual tools.

¹ The V3 Data Sharing Portal is currently in beta release and is only available in some geographical regions for now. Please email NEA_CCRS_Data@nea.gov.sg if the portal is not yet available at your location and you wish to request access.

All the participants were very delighted with the open access to the portal and registered accounts to test out data requests and download from the portal with the aid of the on-site technical support team. The V3 DSP offers each user a 50-GB monthly quota with a limit of 10 GB per individual data request. At the time of writing, around 4 TB have been shared through this portal.

d. Climate impact studies in Southeast Asia. Day 3 of the workshop focused on regional climate change impact studies. Experts and country representatives showcased the application of climate projections in impact assessments across sectors, including agriculture, disaster risk reduction, and water resources.

Leanne Webb [Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia] introduced climate impact methodologies and coproduction frameworks from the Vanuatu Klaemet Infomesen blong Redy, Adapt mo Protekt (Van-KIRAP) and Pacific next generation (NextGen) programs, showing how sectoral case studies [e.g., Cook Islands pearling, Papua New Guinea (PNG) coffee, Tuvalu coastal hazards] transformed projections into actionable adaptation plans. Elyssa Kaur Ludher [Yusof Ishak Institute (ISEAS)] highlighted food



FIG. 3. Launch of V3 DSP.

security risks, including projected 30%–50% reductions in coffee yield and rice productivity in Vietnam and Thailand by 2050. She advocated for crop diversification and investments in resilience. As for heat health, Lydia Law [Global Heat Health Information Network (GHHIN) SEA Hub/Heat Resilience and Performance Centre (HRPC)] discussed heat-health impacts, emphasizing that humid-heat exposure already causes multibillion-dollar productivity losses. She presented Singapore's wet-bulb globe temperature (WBGT)-based framework for occupational safety and urged adoption of region-specific heat stress thresholds.

Asif Uddin Bin Noor [Regional Integrated Multi-Hazard Early Warning System (RIMES)] presented case studies on floods and droughts, including the 2022 Pakistan flood attribution analysis and Cambodia's hydropower drought crisis, and demonstrated the Regional Resilience Data and Analytics Service (RDAS), an open platform integrating climate, hazard, and socioeconomic data.

The panel discussion, moderated by Aurel Moise, addressed uncertainty communication, physiological adaptation to chronic heat, and data gaps in small island research. Cross-sector collaboration between health, agriculture, and disaster agencies was strongly encouraged.

e. Drafting regional guidelines on climate impact studies recommendations. Participants collaborated to develop a draft guideline for selecting and applying metrics relevant to climate extremes and their impacts on various sectors. Aurel Moise first provided an in-depth overview of climate metrics and their applications in sectoral climate change impact studies. Participants expressed the need to establish and maintain a set of standard selected metrics for the region. Sectors such as agriculture, water resources, and health were mentioned several times by both the presenter and participants for their importance and relevance in a world of global warming and climate change. The last section on day 3 was group work on drafting the regional guidelines—best practice on using projections for impact studies. All participants were asked to work in group settings, split into tables, using provided materials/questions to draft the guidelines (see Fig. 4). The participants were asked to write recommendations on national climate change projections, observational



FIG. 4. Workshop participants from table 3 working on drafting the regional guidelines.

datasets, and climate impact indicators and identify key climate impact sectors and which indicators should be applied to these. In section 1, provide context and background on the guidelines. Some participants raised the concerns that “Uneven capacity in the region in terms of how to use climate projection data and how to use it for risk assessment.” Regarding recommendations on climate projection outputs, some participants noted they need “simple and easy access to data” and asked whether to use all CMIP6 models or subselect the best ones for SEA.

For the recommendations on observation datasets, some participants suggested ranking the different datasets, station, gridded, satellite-based, and reanalysis data, and providing a list of pros and cons for each of them. There were in total six groups (tables), and the consolidated recommendations and guidelines are listed in section 5.

f. Exploring regional synergies and collaborations. On day 4, the final session identified shared interests and potential regional partnerships for advancing climate projections and their applications. The panel discussion session titled “CORDEX-SEA and SEA-wide collaborations” was conducted with panel members Faye Cruz (Manila Observatory), Fredolin Tangang (Universiti Brunei Darussalam), and Lawrence Dimailig [ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre)]. Participants expressed the need to establish an ASEAN climate impact data and analysis platform/network for sharing national datasets and impact studies. Participants from different NMHSs identified common areas for collaboration, such as climate impacts for floods and the heat-health nexus. There was also a strong desire to host the CCRS-CORDEX-SEA V3 roadshows in each of the ASEAN countries.

5. Outcomes and recommendations

According to the postworkshop survey, all participants ranked the workshop organization from very good to excellent. The same is true for the following question: “How relevant was the workshop content to your professional work in climate science, services, or policy?” All participants indicated either relevant (38.5%) or very relevant (61.5%). Overall, the participants

are satisfied with the workshop format, content, presentations, and various themed sessions and group activities.

ARCDAP-4 provided an update on the status of regional observational data and high-resolution country projections. During the workshop, various events took place, including the Launch of the Climate Change Country Brief and V3 DSP. The workshop established a SEA regional guideline for sectoral impact metrics, strengthened cross-border collaboration on observational datasets, high-resolution climate projections, and climate change impact studies and promoted ongoing knowledge exchange and capacity building through the ARCDAP series. The consolidated recommendations and guidelines on the Best Practice for the Use of Climate Projections in Climate Impact Studies in Southeast Asia are listed below.

Recommendation 1: Climate change risk assessment for the Southeast Asia region is best supported by datasets that have a degree of confidence attached to them, preferably through multiple lines of evidence. This refers to both Southeast Asia regional climate change projections and observational datasets used to evaluate and bias correct the model simulations. Multiple lines of evidence include (i) high-resolution observational datasets (preferably gridded and long term), (ii) downscaling of a subselection of skillful global models based on extensive evaluation for SEA region, (iii) ensemble of future downscaled simulations for multiple scenarios, and (iv) an assessment of future climate variability as well as climate change.

Recommendation 2: It is recommended to engage in key national stakeholder/sectorial discussions before, during, and after conducting climate change projections studies and inquire about their needs on (i) data format, (ii) which variables/parameters, (iii) domain coverage, (iv) historical and future time periods, (v) temporal frequency of data, (vi) need for bias correction, and (vii) how to visualize and share data/information.

Recommendation 3: It is recommended to (i) produce SEA region national gridded dataset (if station record allows) for a longer time period (at least 20 years) using standard approach including for homogenization and quality assurance (QA)/quality control (QC), (ii) find a consensus across this community on which SEA regional datasets should be used for model evaluation and bias adjustment of climate simulations (for key variables), and (iii) establish a framework for SEA regional dataset creation and dissemination (including sharing platform where these datasets are being updated and maintained).

Recommendation 4: It is recommended to establish a consensus for SEA on bias correction methods applied to climate simulation outputs. Current internationally accepted standards include (i) the “delta” method, (ii) bias-variance correction, (iii) trend-preserving methods, and (iv) quantile mapping methods (empirical, detrended, or quantile delta). All these methods are captured within the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) framework.

Recommendation 5: It is recommended to consider establishing a sharing platform for regional impact analysis; sharing of national and regional climate change impact study results for the following sectors: water resources, food security, energy, infrastructure, forestry/biodiversity, fisheries, transport, and health. Build a network of experts from these different sectors.

Recommendation 6: For the evaluation of the impacts of climate change in SEA, it is recommended to initially use sectoral climate change impact indicators (CCIIs) from the Expert Team on Sector-specific Climate Indices (ET-SCI). Especially mentioned were cumulative 10-day rainfall, consecutive dry day (CDD)/consecutive wet day (CDD/CWD),

and maximum and minimum daily temperatures and heat wave–related and heat stress–related indicators such as excess heat factor (EHF) and WBGT/heat index (HI).
Recommendation 7: It is recommended to set some standard thresholds for climatic impact driver (CIDs) and develop software tools to facilitate the consistent application of the same methodology for generating CCIIs related to these CIDs.

Recommendation 8: It is recommended that funding opportunities be explored by CCRS, WMO, and ASMC in collaboration with the ASEAN NMHSs to continue the ARCDAP workshop series.

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