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ASEAN SPECIALISED METEOROLOGICAL CENTRE

Fourth Workshop on ASEAN Regional Climate Data, Analysis and Projections (ARCDAP-4)

21 - 24 April 2025

Meeting Report



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List of Abbreviations

AHA Centre	ASEAN Coordinating Centre for Humanitarian Assistance on disaster Management
APHRODITE	Asian Precipitation – Highly-Resolved Observational Data Integration Towards Evaluation
ARCDAP-4	Fourth Workshop on ASEAN Regional Climate Data, Analysis and Projections
ASEAN	Association of Southeast Asian Nations
ASMC	ASEAN Specialised Meteorological Centre
BDMD	Brunei Darussalam Meteorological Department
BCCO	Brunei Climate Change Office
CCRS	Centre for Climate Research Singapore
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CMIP	Coupled Model Intercomparison Project
CORDEX	Coordinated Regional Climate Downscaling Experiment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DMH	Department of Meteorology and Hydrology, Myanmar
DOM	Department of Meteorology, Cambodia
DMRS	Disaster Monitoring and Response System
ENSO	El Niño–Southern Oscillation
ERA	ECMWF Re-Analysis
ET-SCI	The Expert Team on Sector-specific Climate Indices (ET-SCI)
GCM	Global Climate Model / General Circulation Model
IMHEN	Viet Nam Institute of Meteorology, Hydrology and Climate change
IPCC	Intergovernmental Panel on Climate Change
IOD	Indian Ocean Dipole
KNMI	Royal Netherlands Meteorological Institute
METMalaysia	Malaysian Meteorological Department
MJO	Madden-Julian Oscillation
MSWEP	Multi-Satellite Weighted Ensemble of Precipitation
MSS	Meteorological Service Singapore
NAHRIM	National Water Research Institute of Malaysia
NMHS	National Meteorological and Hydrological Services
PAGASA	Philippine Atmospheric, Geophysical, and Astronomical Services Administration
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
RIMES	Regional Integrated Multi-Hazard Early Warning System (RIMES)
SSP	Shared Socioeconomic Pathway

SST	Sea-surface Temperature
TMD	Thai Meteorological Department
UKM	National University of Malaysia
UKMO	Meteorological Office (United Kingdom)
V2	Singapore's Second National Climate Change Study
V3	Singapore's Third National Climate Change Study
VNMHA	Viet Nam Meteorological and Hydrological Administration
WCRP	World Climate Research Programme
WMO	World Meteorological Organisation
WMO RAP	WMO Regional Office for Asia and the South-West Pacific

Introduction

The Fourth Workshop on ASEAN Regional Climate Data, Analysis and Projections (ARCDAP-4) was held in Singapore from 21st to 24th of April 2025. ARCDAP-4 was co-organised by the ASEAN Specialised Meteorological Centre (ASMC) and Meteorological Service Singapore (MSS) in consultation with the World Meteorological Organisation (WMO).

The ARCDAP workshop series was conceived in 2017 following a proposal from the WMO Regional Association (RA) V working group on climate services to consolidate the various national and regional-level climate projection studies that had been conducted in ASEAN and work towards formulating a set of best practices in generating climate change scenarios.

During the first workshop ARCDAP-1 (originally named Best Practice Workshop on Climate Change Projections and their Applications in ASEAN Countries) held in Singapore in March 2018, representatives from ASEAN National Meteorological and Hydrological Services (NMHSs) and end-user sectors, together with climate science experts, proposed a set of recommendations regarding the generation of climate change projections. A number of these called for enhancing the region's collective understanding behind the science and methodology behind climate change projections, e.g. compiling technical guidelines on existing methodologies such as downscaling, bias-correction and spatial resolution; advancing the understanding of key physical processes over the region and their reproduction in climate models; continuing the use of multiple scenarios to highlight not just the most impactful climate change signals but also the benefits of mitigation. It was also recommended that a follow-on workshop should develop strategies to incorporate the anticipated set of global climate model (GCM) simulations from Phase 6 of the Coupled Model Intercomparison Project (CMIP6) into existing and future work.

ARCDAP-2, which was held in March 2019 in Singapore, built on recommendations from ARCDAP-1 around observational data and the need for sector-relevant extreme indices by involving extensive hands-on sessions on the ClimPACT software led by international experts from the Expert Team on Sector-specific Climate Indices (ET-SCI). With much accomplished in the area of observational data at ARCDAP-2, it was recommended that ARCDAP-3 turn its focus to the newly available and growing CMIP6 database. Representatives and experts agreed that the need for ASEAN climate change practitioners to upgrade their knowledge of the latest global climate model database was important. With the most recent regional studies driven by output from preceding global databases, CMIP3 and CMIP5, studies would eventually need to move to the latest available database as well as future scenario standards (i.e. the use of RCPs in CMIP5 to SSPs in CMIP6).

ARCDAP-3 served as the ideal platform to support ASEAN NMHSs, related national agencies, and other academics in their next phase of national climate projection work. Encouraging the uptake and understanding of the latest ensemble of CMIP6 simulations helped provide a segue into discussions on evaluating regional climate processes, variability and change. The workshop provided opportunities to further develop on recommendations from ARCDAP-1 and work towards refining a set of best practices in terms of data, climate scenario use, key processes, etc. for regional climate science, climate change information and related services. In continuing the ARCDAP workshop series, ARCDAP-3 maintained this effort to encourage regional collaboration and information sharing within the ASEAN as well as the international community.

ARCDAP-4 built on the momentum of previous workshops by serving as a regional platform for ASEAN NMHSs, national and international agencies, and the academic community to exchange the latest information on the availability and use of observational, reanalysis, and climate projection datasets for the ASEAN region. The workshop strengthened the interface between climate science and impact assessment by fostering targeted discussions on how these datasets can be applied to climate change impact studies across key sectors. In line with the objectives of the ARCDAP series, ARCDAP-4 reinforced its role in promoting regional collaboration, enhancing technical capacity, and facilitating open information sharing within ASEAN and with the wider international climate community.

In light of the above-mentioned needs highlighted by both the regional and international community, the objectives of ARCDAP-4 were as follows:

- 1) Apprise each other on the current status of ASEAN regional RCM projection output, CORDEX-SEA, V3, and others
- 2) Apprise each other on the current status of ASEAN observational data sets for both climate evaluation and climate change impacts studies
- 3) Conduct hands-on session on V3 DVP
- 4) Showcase the application of projections for climate impact studies across Southeast Asia
- 5) Draft a regional guideline for usage of metrics for sectoral climate impact studies
- 6) Discuss regional synergies and potential collaborations: Future directions in producing and using observational and climate projections dataset across the ASEAN region

Workshop Recommendations

A. Confidence in datasets for climate risk assessment

ARCDAP-4 highlighted that credible climate risk assessments depend on datasets with clear confidence measures. Singapore's V3 projections (8 km rainfall, 12-min resolution) and CORDEX-SEA's downscaled CMIP6 runs were cited as benchmarks, combining high resolution with multi-scenario ensembles. Brunei's integration of V3 into its National Climate Vulnerability Assessment shows the value of detailed, bias-corrected data for hazard mapping. Viet Nam's use of 0.1° gridded station datasets to validate the UK Met Office downscaling further illustrates that robust observational baselines strengthen model trust. Participants agreed that confidence increases when datasets are high-resolution, gridded, and scenario-diverse, and when variability is assessed alongside long-term change. Embedding these standards in ASEAN practice will ensure that projections can reliably guide adaptation measures for sectors ranging from coastal defence to agriculture.

Recommendation-1: Climate change risk assessment for the Southeast Asia region is best supported by data sets 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, as well as Southeast Asian countries' national observational datasets used to evaluate and bias-correct the model simulations. Multiple lines of evidence include: (a) high-resolution observational datasets (preferably gridded and long term) (b) downscaling of a sub-selection of skilful global models based on extensive evaluation for SEA region (c) ensemble of future downscaled simulations for multiple scenarios; (d) an assessment of future climate variability as well as climate change.

B. Stakeholder engagement on climate projections

Examples from PAGASA's V3-based country brief and CSIRO's Pacific NextGen program demonstrated that early and continuous stakeholder engagement ensures projections match operational needs. The Philippines tailored variables for flood modelling and heat-health studies, while NextGen worked directly with farmers and infrastructure agencies to define relevant domains, periods, and formats. Cambodia's omission of heat extremes in water resource modelling showed the cost of limited engagement. ARCDAP-4 participants agreed that consultations before, during, and after simulations should define dataset resolution, update frequency, and variables of interest. Such engagement not only improves uptake but also ensures that projections are transformed into actionable policies and investments, reducing the risk of producing technically sound but unused outputs.

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 (a) data format; (b) which variables/parameters; (c) domain coverage; (d) historical and future time periods; (e) temporal frequency of data; (f) need for bias correction; (g) how to visualize and share data/information.

C. Use of reliable observational datasets

Validation and bias correction rely on high-quality observational baselines. PAGASA's ClimGridPh blends 1 km GPM rainfall with station data; METMalaysia's 10 km blended product merges GSMaP with gauge observations; Viet Nam's 186-station 0.1° dataset underpins UK Met Office downscaling. Brunei supplements sparse AWS coverage with CHIRPS, GSMaP, and IMERG, while Lao PDR's LaCSA produces 5 km gridded data from mixed networks. ARCDAP-4 discussions stressed that combining dense, quality-controlled station data with calibrated satellite and reanalysis products yields robust baselines. This is critical for credible bias correction, cross-country comparisons, and ensuring projections are grounded in empirical evidence. Countries without dense coverage should prioritise national gridded datasets to close spatial gaps.

Recommendation-3: It is recommended to (a) Produce SEA region national gridded observational data set (if station record allows) for a longer time period (at least 20 years) using standard approach including for homogenisation and QA/QC; (b) 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). (c) Establish a framework for SEA regional dataset creation and dissemination (including sharing platform where these data sets are being updated and maintained).

D. International standards for bias correction

CCRS's V3 bias correction, aligned with ISIMIP3, showcased the benefits of using globally recognised methods-Delta, Bias-Variance, and empirical/detrended Quantile Mapping-applied to base variables. This preserved physical consistency (e.g., $T_{max} \geq T_{min}$) and improved extremes representation. Thailand and Malaysia noted that uncorrected datasets can distort hazard models. ARCDAP-4 participants called for standardised workflows across ASEAN to harmonise outputs and enable cross-country comparability. Documenting methods, sharing scripts, and training NMHSs in these standards would enhance transparency, reproducibility, and trust in projections.

Recommendation-4: It is recommended to establish a consensus for SEA on bias corrections methods applied to climate simulation outputs. Current internationally accepted standards include: (a) the “Delta” method; (b) Bias-Variance Correction; (c) trend-preserving methods; and (d) Quantile Mapping Methods (empirical, detrended, or quantile delta). All these methods are captured within the ISIMIP framework.

E. Key sectoral climate impact studies

ARCDAP-4 case studies demonstrated climate change’s diverse sectoral impacts. Indonesia linked rainfall thresholds to rice yields, RIMES modelled floods and droughts, ISEAS projected losses in coffee and rice production, Cambodia experienced energy disruptions from droughts, and GHHIN addressed heat-health impacts. Singapore’s V3 informed urban flood and heat planning; Viet Nam integrated projections into mandated adaptation plans. These examples show the need for sector-specific modelling, validated by local data, to ensure relevance. Embedding such studies into planning cycles strengthens climate resilience and supports investment in targeted adaptation measures.

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.

F. On application of impact indicators

Sessions on climate metrics stressed that ET-SCI’s standardised indicators-cumulative 10-day rainfall, consecutive dry/wet days, excess heat factor, Tmax/Tmin-are vital for translating projections into sector-relevant impacts. Dry-day counts inform drought alerts; heat indices guide work-rest safety; rainfall totals support crop planning. Countries like Singapore operationalise WBGT, the Philippines applies rainfall thresholds for flood risk, and Indonesia links rainfall totals to yield models. Adopting ET-SCI indicators across ASEAN would improve comparability, streamline communication, and ensure adaptation planning is built on measurable climate risks.

Recommendation-6: For the evaluation of the impacts of climate change in SEA, it is recommended to initially use sectoral climate change impact indicators (CCII) from the Expert Team on Sector-specific Climate Indices (ET-SCI). Especially mentioned were cumulative 10-day rainfall, consecutive dry/wet days (CDD/CWD), and maximum and minimum daily temperatures. Additionally, heat wave and heat stress-related indicators such as EHF and WBGT/HI.

G. Standard thresholds for CIDs and CCII tools

ARCDAP-4 discussions revealed inconsistent definitions for climate impact-drivers (e.g., “heatwave,” “heavy rainfall”) across ASEAN. Singapore’s WBGT-based work-safety limits contrast with ad hoc thresholds elsewhere. Participants proposed regional standards embedded in shared toolkits to automate CCII generation. PAGASA’s ClimGridPh and CCRS’s V3 portal demonstrate how user-friendly interfaces can integrate computation and dissemination. Standardising thresholds and tools would make CID-based analyses comparable, reproducible, and regionally actionable.

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 CCII related to these CIDs.

H. Continuation of the ARCDAP workshop series

Since ARCDAP-1 (2018), the series has delivered tangible outputs - V3 country briefs, CORDEX-SEA projections, bias-correction guidance-while fostering trust and cooperation. ARCDAP-4 participants, including WMO, ASMC, and ASEAN NMHSs, warned that discontinuing the series risks fragmentation and duplication. Continued funding would enable thematic deep-dives (e.g., urban climate, climate-health), dataset interoperability, and expanded capacity building. Sustaining ARCDAP secures its role as ASEAN’s primary platform for turning climate science into coordinated adaptation action.

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

1 Day 1: 21 April 2025

Welcome and Introduction

1.1 Registration. The in-person Workshop on ASEAN Regional Climate Data, Analysis and Projections (ARCDAP-4) was held in Singapore, from 21st to 24th April 2025.

1.2 Prof Dale Barker, Director of CCRS, Singapore, welcome address, Prof Dale Barker delivered the opening address at ARCDAP-4, extending his gratitude to delegates from ASEAN countries for their participation. He emphasized that the primary aim of ARCDAP-4 is to foster the exchange of knowledge and experiences related to regional climate projections, the availability and use of relevant datasets, and the understanding of climate change impacts across Southeast Asia.

1.3 Mr Jochen Luther, WMO regional Office for Asia and the South-West Pacific, Singapore, opening address, Mr Jochen Luther outlined the primary objective of the ARCDAP-4 workshop as a collaborative effort to enhance regional climate projections and deepen the understanding of climate impacts among participants. He reviewed outcomes from the ASMC Regional Forum held in September 2024, which focused on advancing climate projection capabilities and supporting the “Early Warning for All” initiative. Mr Luther noted that 2024 was the hottest year on record, with global temperatures surpassing the 1.5°C threshold set by the Paris Agreement. He also highlighted that 2024 was marked by exceptionally dry conditions, significantly disrupting the hydrological cycle. Emphasizing Southeast Asia’s high vulnerability to climate change, he underscored the critical role of ARCDAP-4 in building regional capacity to respond to these growing challenges.

1.4 Ms Fei Luo, CCRS, Singapore, admin brief and group photo. Ms Fei Luo provided an administrative brief and guidelines for presenters and participants to follow for the workshop. This was followed by the first group photo that was taken.



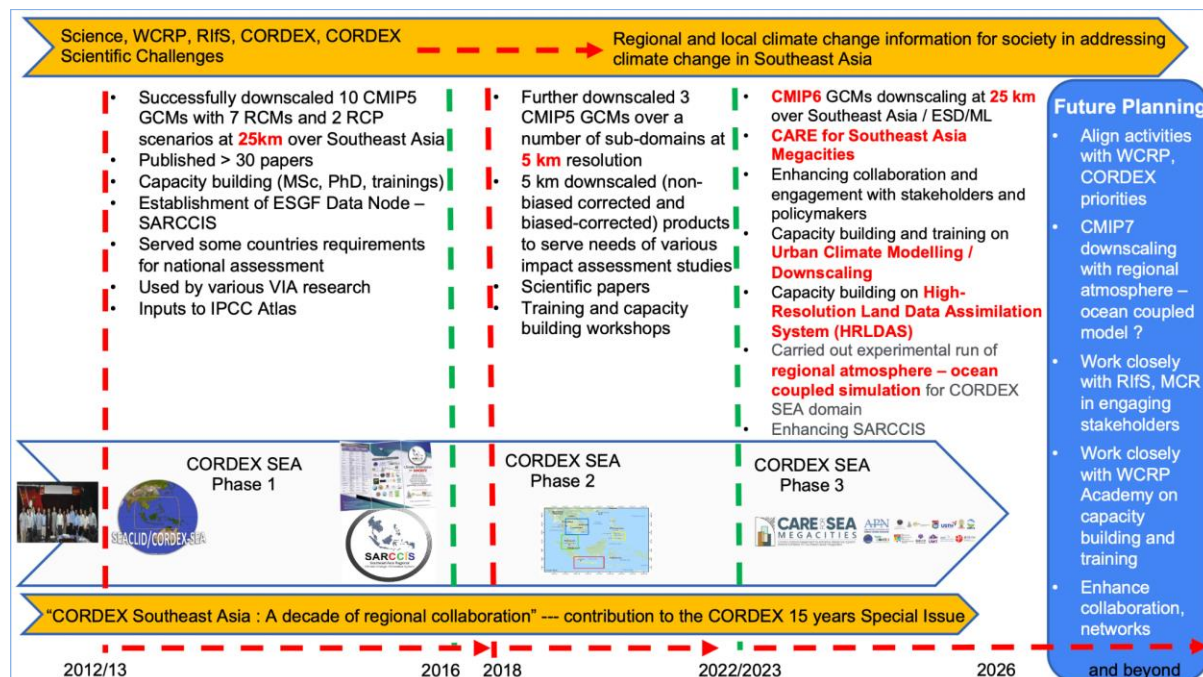
ARCDAP-4 participants group photo taken on Day 1.

1.5 Dr Aurel Moise, CCRS, Singapore, workshop overview. Dr Aurel Moise provided a comprehensive overview of the objectives and key achievements of the first three ARCDAP workshops - ARCDAP-1 in 2018, which introduced Singapore's Second National Climate Change study (V2); ARCDAP-2 in 2019, which focused on climate extremes and indices derived primarily from station-based datasets; and ARCDAP-3, held online in 2021, which explored the CMIP6 database, model sub-selection process, key regional climate processes over Southeast Asia, and statistical evaluation techniques. He emphasized that a major outcome of each workshop has been the development of recommendation documents, which serve as important deliverables. Dr Moise also presented the ARCDAP-4 programme, highlighting sessions dedicated to knowledge sharing on national climate change study efforts, observational datasets in use, the launch of the V3 data-sharing platform, country briefs such as that of the Philippines based on V3 data, the integration of climate projections with impact studies, and the drafting of regional guidelines for best practices in impact assessment.

Presentation on CORDEX-SEA

1.6 Dr Faye Cruz, Manila Observatory (MO), Philippines, provided an update on the CORDEX-SEA initiative, outlining its planning for future phases, including preparation for CMIP7 and the integration of machine learning techniques. She reviewed the achievements of CORDEX-SEA Phase 1, which included downscaling 10 GCMs with 7 RCMs under RCP4.5 and RCP8.5, leading to the publication of over 40 scientific papers - mainly on model validation and rainfall projections. The resulting datasets have supported major platforms such as the

IPCC Interactive Atlas, the Southeast Asia Regional Climate Change Information System (SARCCIS), and national assessments like those for



Overview diagram of the past decade's effort in CORDEX-SEA activities.

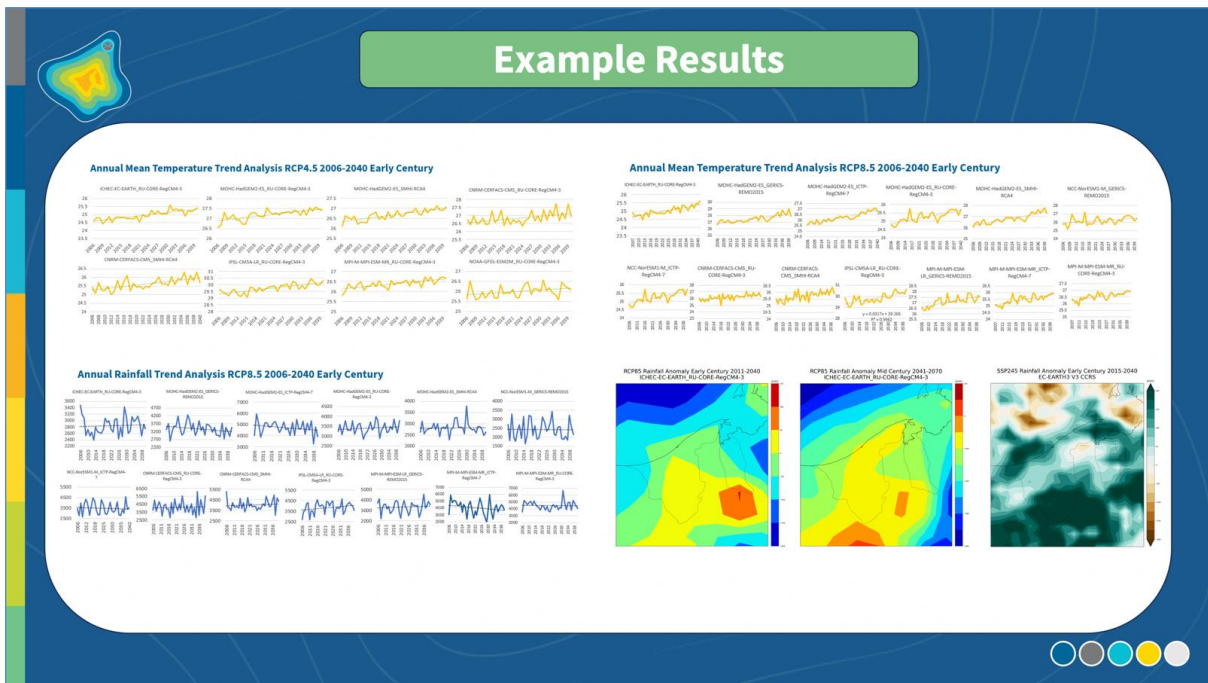
the Philippines. Capacity building has been a key component, with 13 workshops conducted to date. CORDEX-SEA Phase 2 downscaled 3 CMIP5 GCMs over a number of subdomains at 5 km resolution. There were both non-biased corrected and biased-corrected products based on the 5 km products that later served needs of impact assessment studies as well as training and capacity building workshops. Currently, CORDEX-SEA Phase 3 is underway, focusing on downscaling 13 CMIP6 GCMs with 5 RCMs and contributing to 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. CARE incorporates both dynamical and statistical downscaling approaches and seeks alignment with WCRP initiatives such as My Climate Risk. Three of the five planned workshops for Phase 3 were completed in 2023, including showcases in Malaysia and Viet Nam, with the next workshop scheduled for August 2025 in Jakarta.

Dr. Faye emphasized the importance of engaging policymakers and regularly updating stakeholders on progress. In response to questions, she explained that flagship pilot studies (FPS) on regional coupled atmospheric-ocean modelling are evaluated by a science advisory team. While the intention is to promote multinational collaboration, single-country efforts are also accepted. Prof Tangang added that while these FPS projects are not funded directly, they are valuable platforms for addressing scientific gaps and leveraging support. Regarding manuscript training, Dr. Faye shared that workshops focused on identifying and presenting research topics collaboratively, enhancing scientific output across participants. When asked

about the regional analysis project at HKUST and its link with CORDEX-SEA, she noted that this topic had not yet been discussed.

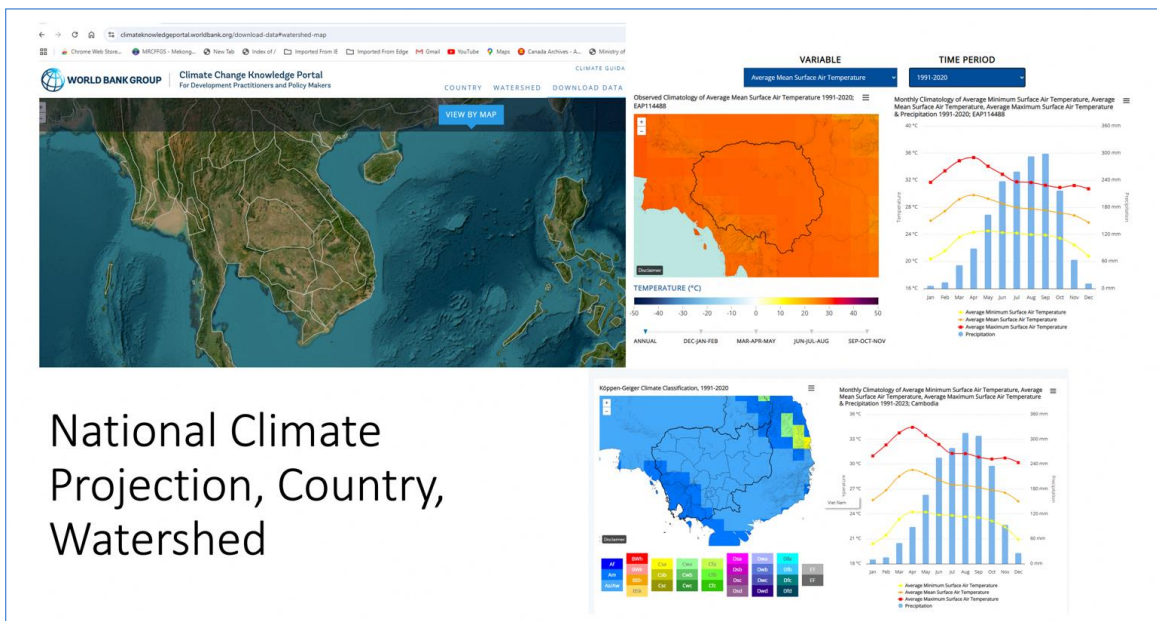
Presentations by ASEAN representatives on National Climate Projections

1.7 Mr. Arifin Yussof, Brunei Darussalam Meteorological Department, and Mr. Zainul Jamil, Brunei Climate Change Office, Prime Minister's Office, Brunei Darussalam, Mr. Arifin Yussof presented Brunei's national climate change study, highlighting the use of multiple climate datasets, including GCMs at 50-100 km resolution and RCMs from CORDEX-SEA and Singapore's V3 dataset at 25 km and 8 km resolution, respectively. Brunei was acknowledged as the first country to receive and examine the V3 projections, with thanks extended to CCRS for their support. They mentioned that temperature and rainfall were the primary climate variables of concern, with CMIP5-based projections indicating a modest warming trend of 0.38°C per decade and no significant change in rainfall patterns. Mr. Zainul Jamil, Brunei Climate Change Office (BCCO), Brunei Darussalam, presented on Brunei National Climate Vulnerability Assessment (NCVA), which plans to integrate V3 projections, which will support future iterations of Brunei Darussalam's National Adaptation Plan (NAP), aimed at prioritizing and identifying key adaptation projects for Brunei. The 2025 focus is to establish a vulnerability index through stakeholder engagement across six priority sectors, followed by assessing climate hazards and exposure to identify national risk hotspots. In the Q&A session, Mr. Zainul Jamil explained that sectoral vulnerability will be ranked through consultations with stakeholders. In response to questions on model performance, Mr. Arifin noted discrepancies between GCM historical simulations and station observations, particularly for rainfall, while emphasizing that the assessments focus on seasonal changes and shifts in the monsoon cycle. The spatial resolution for the vulnerability index maps is still under consideration.



Example results for Annual Temperature and Rainfall Trend analysis for Brunei climate projection under RCP4.5 and 8.5 for the period of 2006 to 2040.

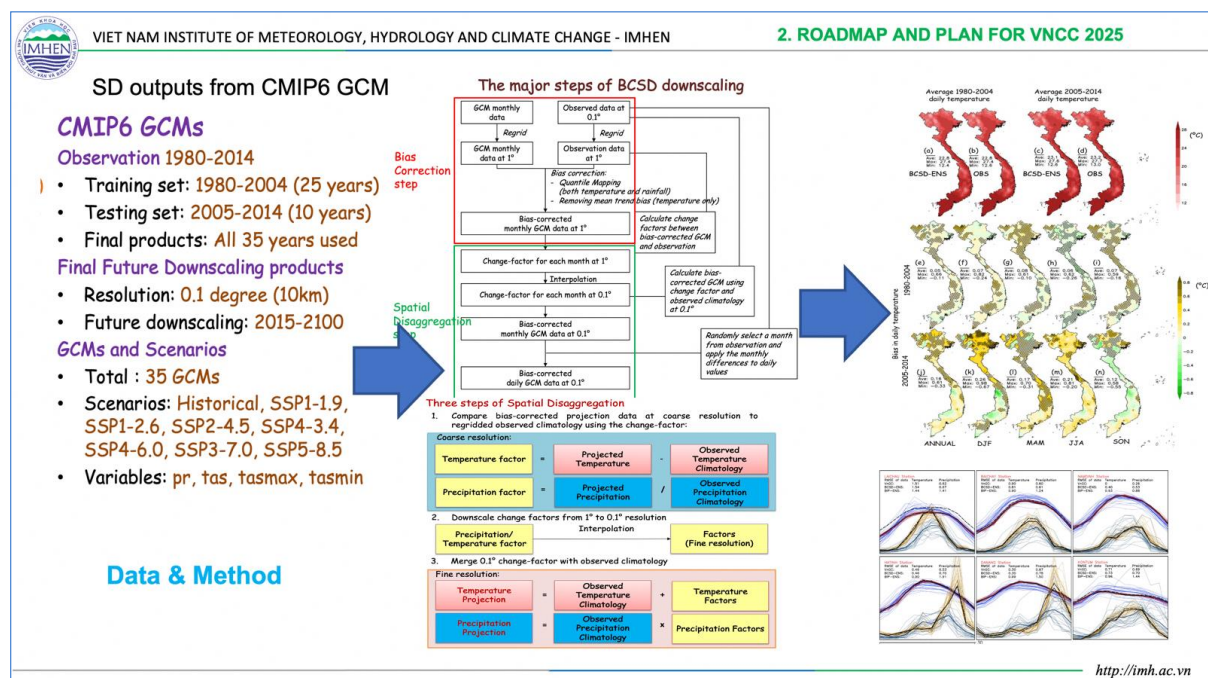
1.8 Mr. Soim Monichoth, Department of Meteorology, Ministry of Water Resources and Meteorology, Cambodia, presented Cambodia’s national climate change study, highlighting the use of climate projection datasets provided by the World Bank to support hydrological modeling, primarily for applications in water resource management and agriculture. A key case study in the Stung Chinit River Basin involved using the World Bank precipitation data to drive the SWAT hydrological model, with simulations conducted at daily resolution and results analyzed at the monthly scale to assess future changes in water availability.



Climate Change Knowledge Portal by World Bank Group.

Additional case studies in the Kbalhong and Kanghort Basins revealed increased dry-season (November-April) flow under most scenarios, although March - April flows are projected to decrease under SSP5-8.5. In response to a question from Prof Tangang, Mr. Soim noted that the driving precipitation data is assumed to be based on a multi-model mean from the World Bank dataset. Dr. Truong Ba Kien of Viet Nam added that his team is planning a water resources assessment for the lower Mekong Delta and welcomed collaborative contributions from Cambodia, offering to share results. When asked by Dr. Aurel Moise about consideration of heat extremes, Mr. Soim acknowledged that such assessments have not yet been undertaken.

1.9 Dr. Truong Ba Kien, Deputy Director, Center for Meteorology and Climatology (IMHEN), Viet Nam, presented an overview of Viet Nam’s National Climate Change Study (VNCC), which is conducted every five years, with previous iterations completed in 2009, 2012, 2016, and 2020. All government agencies are mandated to develop adaptation plans that incorporate the latest climate projections. The most recent study, supported by the Weather and Climate Information Services (WISER) Programme, is currently in draft phase and is expected to be released by late 2025 or early 2026. Based on the 2020 VNCC, mean temperatures in Viet Nam are projected to increase by 1.7-2.3°C under RCP4.5 and up to 3.0°C under RCP8.5. Downscaling to 12 km resolution using three model members was conducted by the UK Met Office under the WISER program, with validation performed using a 0.1° gridded observational dataset derived from 186 meteorological stations from Viet Nam. The study places particular emphasis on the monsoon system and has benefited from regional insights on climate drivers from Singapore’s V3 study and typhoon knowledge shared by Philippines colleagues. Dr. Kien acknowledged the UK Met Office for its data support and training programs.

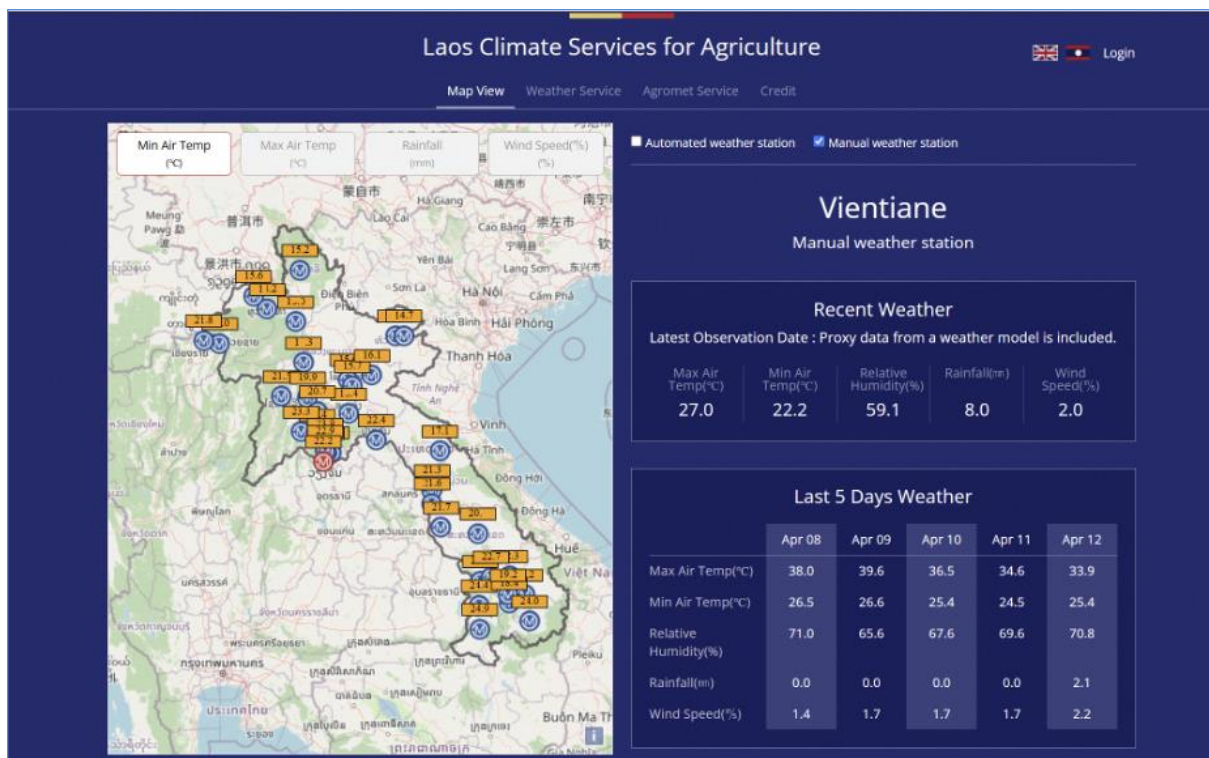


Roadmap and plan for the Viet Nam National Climate Change study 2025.

In the Q&A session, Dr. Kien initially stated there were 14 tidal stations in Viet Nam but later clarified, based on Dr. Tran Quang Nang's input, that there may be 28, pending confirmation. When asked by Prof. Tangang about stakeholder engagement in climate risk assessments, Dr. Kien explained that Viet Nam's national climate adaptation program is government-funded and centrally coordinated by the ministry, requiring agencies to integrate the latest climate projections into their planning and reporting processes.

1.10 Ms. Maninoud Phonsena, Department of Meteorology and Hydrology, Lao PDR, presented the current status of climate change study and services in Laos, noting the absence of national climate projections and the lack of Numerical Weather Prediction (NWP) model implementation for forecasting and early warning systems. Weather and climate forecasts are provided at short-range (3 hours), medium-range (7 days), and long-range (3 to 6 months) intervals, with regular weekly and monthly updates featured in the Agromet Bulletin. A key initiative is the Lao Climate Service for Agriculture (LaCSA), launched in May 2019 with support from the Global Environment Facility and developed in collaboration with the Ministry of Agriculture and Forestry.

LaCSA aims to enhance climate monitoring and information dissemination, offering seasonal forecasts and agricultural advisories via web platforms and mobile apps. Its agrometeorological database integrates historical data from manual and automatic stations, producing 5 km gridded datasets for temperature and rainfall. Forecast services include drought, heavy rainfall, heat stress, and cold stress alerts at national to district levels. However, Laos currently lacks in-country modeling systems, climate downscaling capacity, and the technical expertise required for advanced climate modeling, underscoring a pressing need for capacity building and external collaboration.



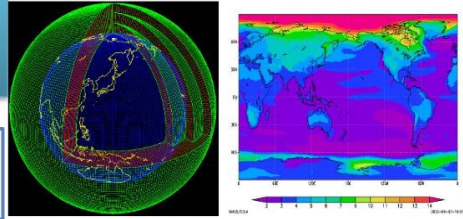
The Website Interface of Laos Climate Services for Agriculture (LaCSA).

1.11 Mr. Terencio Moniz, National Directorate of Meteorology and Geophysics, Timor-Leste, presented the national climate change study for Timor-Leste, emphasizing the country's diverse climate conditions influenced by key drivers such as the monsoon, ENSO, IOD, MJO, and tropical cyclones. Timor-Leste experiences two distinct seasons: a rainy season marked by flooding and cyclones, especially along the northern and southern coasts, and a dry season associated with water scarcity and heightened forest fire risks. Climate data plays a crucial role in understanding and issuing alerts for these hazards during extreme events. With support from the Australian government, Timor-Leste employs both statistical and dynamical downscaling techniques using CMIP3 and CMIP6 models to project future scenarios for rainfall, temperature, and sea level rise.

Mr. Moniz highlighted the ongoing need for enhanced methodologies and expressed interest in collaborating with CCRS to improve climate projections and data application. In response to a question from Dr. Aurel Moise, he confirmed that Timor-Leste has completed a national framework for climate services, which has been submitted to the Ministry of Transport and Communication for approval: an important step toward strengthening the country's climate information infrastructure.

XI. CMIP6 PROJECTIONS

(1) Using projection data,
Analyze and visualize data with GrADS



12 results found for CMIP6

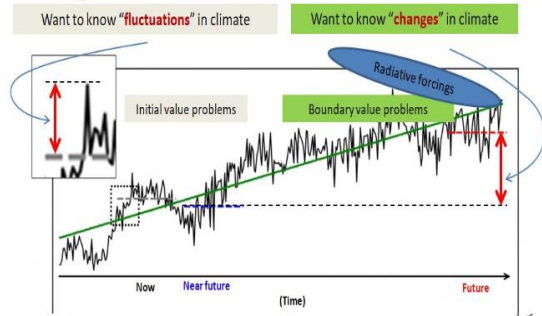
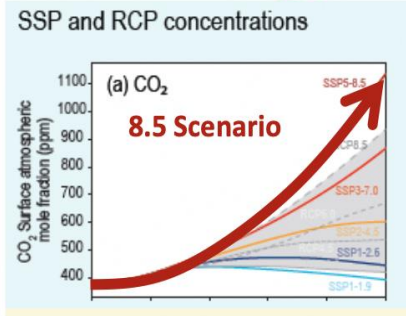
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Earth System Grid Federation (ESGF)

(2) MRI-AGCM projection data

Folder Name	File Name	Content	datetime
temp	TAS_AMON_MRI_AGCM3_2_5_HIGH_F1_NC	AGCM temperature (monthly, future)	2071.1 - 2099.12
	TAS_AMON_MRI_AGCM3_2_5_HIGH_F2_NC	AGCM temperature (monthly, future)	2099.1 - 2099.12
	TAS_AMON_MRI_AGCM3_2_5_HIGH_P1_NC	AGCM temperature (monthly, present)	1990.1 - 2009.12
	TAS_AMON_MRI_AGCM3_2_5_HIGH_P2_NC	AGCM temperature (monthly, present)	2010.1 - 2014.12
rain	PR_AMON_MRI_AGCM3_2_5_HIGH_F1_NC	AGCM precipitation (monthly, future)	2071.1 - 2099.12
	PR_AMON_MRI_AGCM3_2_5_HIGH_F2_NC	AGCM precipitation (monthly, future)	2099.1 - 2099.12
	PR_AMON_MRI_AGCM3_2_5_HIGH_P1_NC	AGCM precipitation (monthly, present)	1990.1 - 2009.12
	PR_AMON_MRI_AGCM3_2_5_HIGH_P2_NC	AGCM precipitation (monthly, present)	2010.1 - 2014.12
fix	SFTLF_FX_MRI_AGCM3_2_5_HIGH_F1_NC	Land Area Fraction, Surface Altitude (future)	-
	OROG_FX_MRI_AGCM3_2_5_HIGH_F1_NC	Land Area Fraction, Surface Altitude (future)	-
	SFTLF_FX_MRI_AGCM3_2_5_HIGH_P1_NC	Land Area Fraction, Surface Altitude (present)	-
	OROG_FX_MRI_AGCM3_2_5_HIGH_P1_NC	Land Area Fraction, Surface Altitude (present)	-



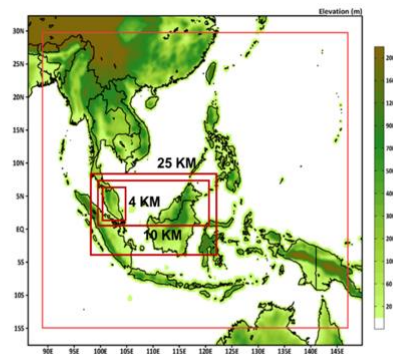
The CMIP6 Projection datasets used for Timo-Leste's National Climate Change Study.

1.12 Ms. Tan Yin San, Malaysian Meteorological Department, Malaysia, presented Malaysia's national climate change study, detailing its contribution under CORDEX-SEA to downscale three CMIP6 models using the WRF model, producing high-resolution outputs at 4 km covering Peninsular Malaysia under SSP2-4.5 and SSP3-7.0 scenarios.

The current focus of the METMalaysia team is on the operational provision of climate data to other agencies rather than running climate models themselves. Ms. Tan noted that verification of the downscaled models is ongoing, which presents challenges for the public release and communication of results. She explained that verification efforts will use gridded observational data derived from Malaysian meteorological stations. Dr. Aurel Moise sought clarification on which entity (METMalaysia or NAHRIM [National Water Research Institute of Malaysia]) is running the models and emphasized the importance of transparent model verification, which Ms. Tan confirmed is being addressed collaboratively.

Latest High-Resolution Regional Climate Projections

- 1 Resolution**
Final resolution of the downscaled simulations: 4km
- 2 IPCC Scenarios**
The simulations consider SSP 245 & SSP 370
- 3 Time Periods**
Baseline data: 1979 – 2014
Projections: 2015 - 2100



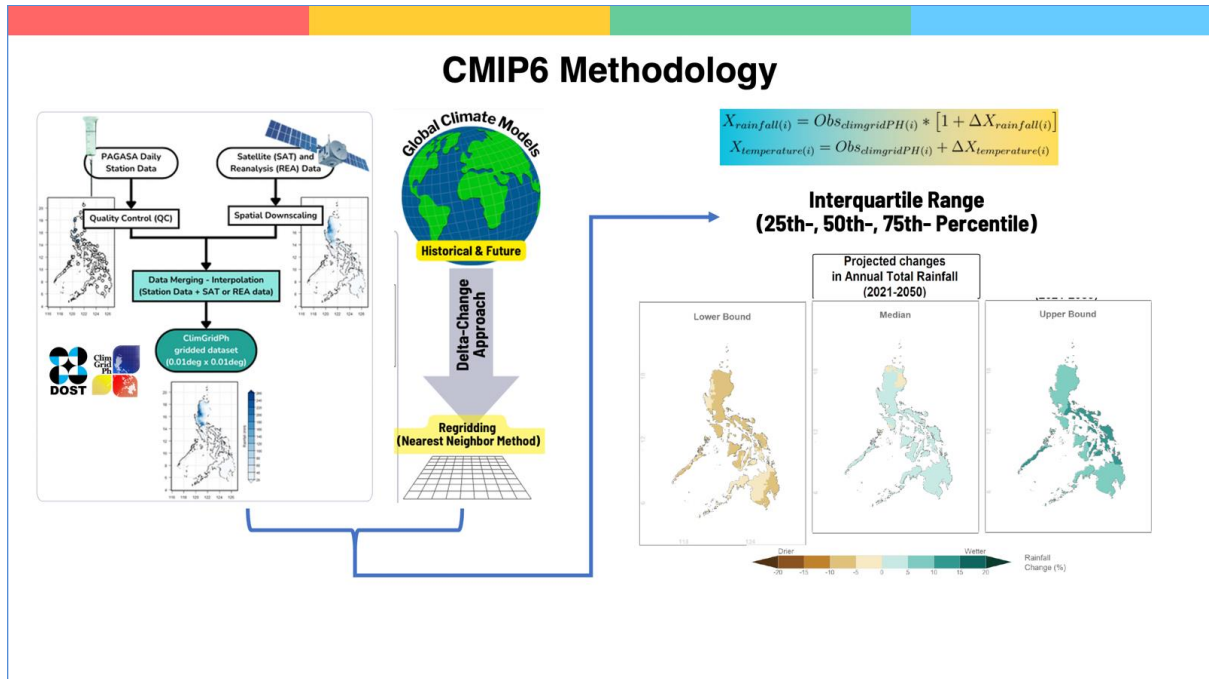
[Malaysia's latest national climate change study.](#)

1.13 Dr. Tin Mar Htay / Ms. Chaw Su Hlaing, Department of Meteorology and Hydrology, Myanmar (absence) Colleagues from Myanmar were unable to attend because of the earthquake earlier this year.

1.14 Mr. Wilmer Agustin, PAGASA, the Philippines, presented the Philippines' national climate change study, outlining the country's evolving climate projection efforts, including the adoption of various models and downscaling methodologies to improve the localization and resolution of projections. He highlighted the transition from CMIP5 to CMIP6 datasets, which offer improved accuracy, and noted that to address the limited number of observation stations the team has generated high-resolution observational datasets at approximately 1 km grid resolution using national station data.

A key focus of the study is supporting local government units in planning and risk assessments, emphasizing the importance of collaboration with research institutions and inter-agency coordination. Mr. Agustin also discussed ongoing challenges in translating climate projections into actionable plans, underscoring the need for continuous stakeholder engagement. In the Q&A session, Dr. Kien inquired about ensemble methods and uncertainty representation; Mr. Agustin explained that equal model weights are used, with uncertainty conveyed through the 25th and 75th percentiles of projected values. He also acknowledged CCRS support in

providing V3 data, which the Philippines plans to use moving forward. Prof. Tangang praised the comprehensive work and asked about community engagement, to which Mr. Agustin responded that increasing collaboration between PAGASA and local research institutions particularly in flood modeling and health impact studies is underway.

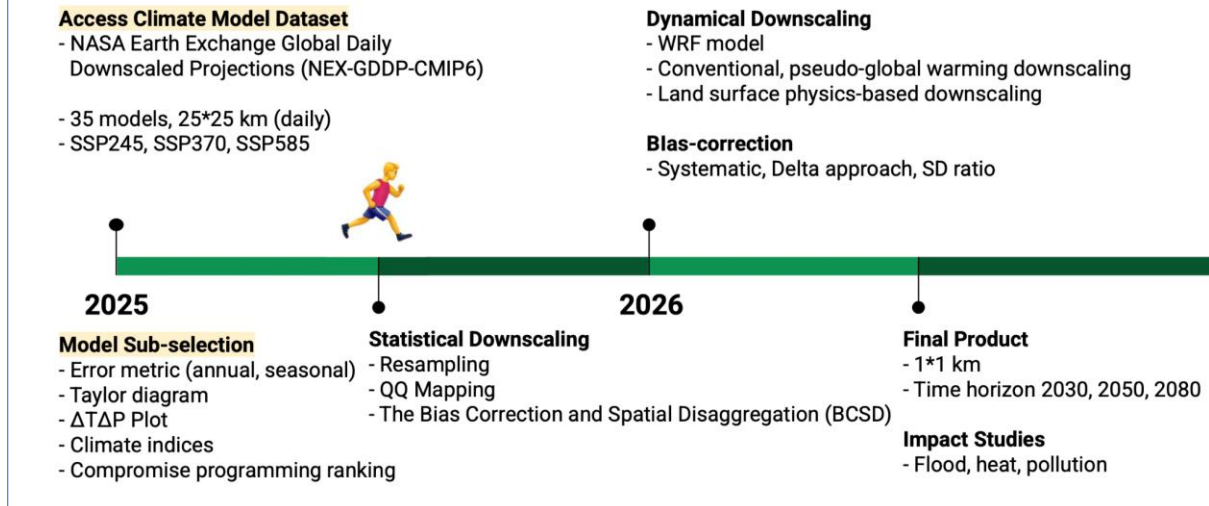


CMIP6 methodology applied to national climate change projections in the Philippines.

1.15 Mr. Chaowat Siwapornchai, Thai Meteorological Department, Thailand, presented Thailand’s national climate projection initiative, which aims to enhance long-term climate planning through a structured and collaborative approach. The current phase involves selecting a subset of climate models to generate projections for three time horizons, 2030, 2050, and 2080, drawing data from major sources including the World Climate Research Programme, Copernicus, and NASA’s Earth Exchange program, selected for its robust datasets. To improve the accuracy and applicability of projections, both statistical and dynamical downscaling methods will be employed, alongside bias correction techniques to support impact modeling focused on flooding, heat, and air pollution.

Collaboration with research groups and agencies is central to the project, ensuring outputs are reliable and actionable for national adaptation planning. During the Q&A session, participants raised concerns about ensuring model independence and the need for diversity in model selection to capture a full range of climate futures, as well as the importance of carefully defined boundary conditions. Mr. Siwapornchai acknowledged these issues and emphasized the importance of methodological rigor, data handling, and ongoing collaboration to strengthen the relevance and usability of Thailand’s national climate projections.

Thailand National Climate Projection Timeline

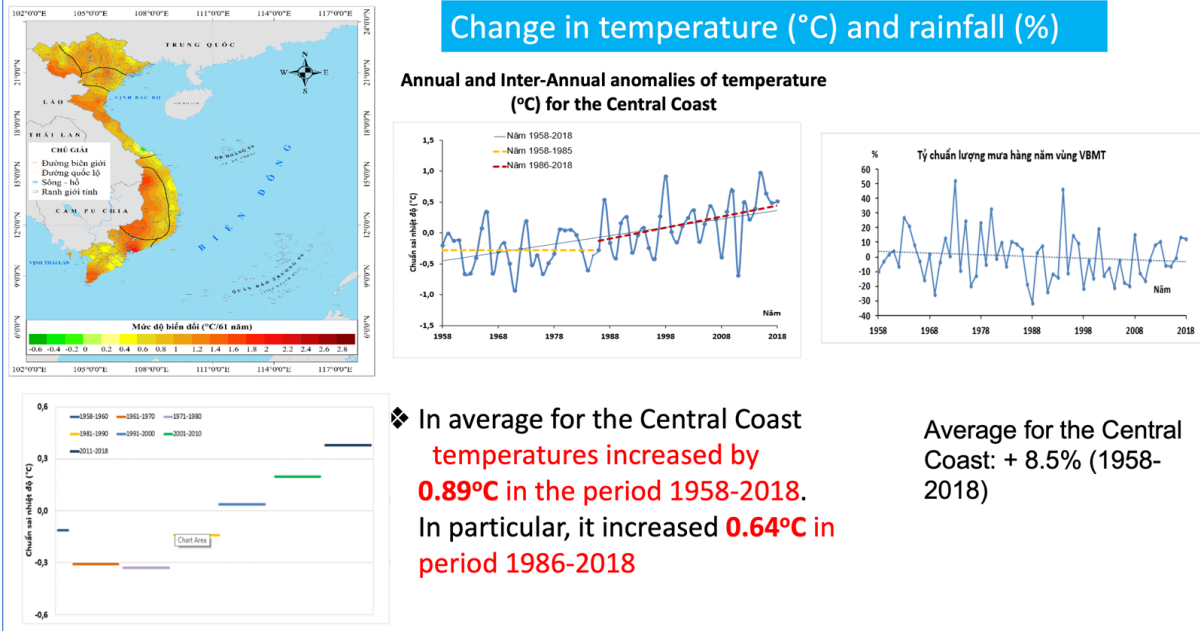


National climate projection timeline for Thailand.

1.16 Mr. Tran Quang Nang and Mr. Hoang Trong Thang, Viet Nam Meteorological and Hydrological Administration (IMHEN), Viet Nam, presented Viet Nam's national climate projections, emphasizing the strong legal and institutional frameworks supporting climate monitoring and scenario development. They outlined the roles of key agencies, including the Department of Climate Change and IMHEN, in implementing regular climate assessments and integrating projections into national and regional strategies. Since 2009, Viet Nam has produced updated climate change scenarios every five years, incorporating diverse climate zones and variables such as sea level rise, temperature, and rainfall. Recent analyses indicate a 0.89°C rise in temperature over the past 61 years and shifting rainfall patterns, alongside observed changes in tropical cyclone behavior and updated sea level projections.

3. VNCC 2020

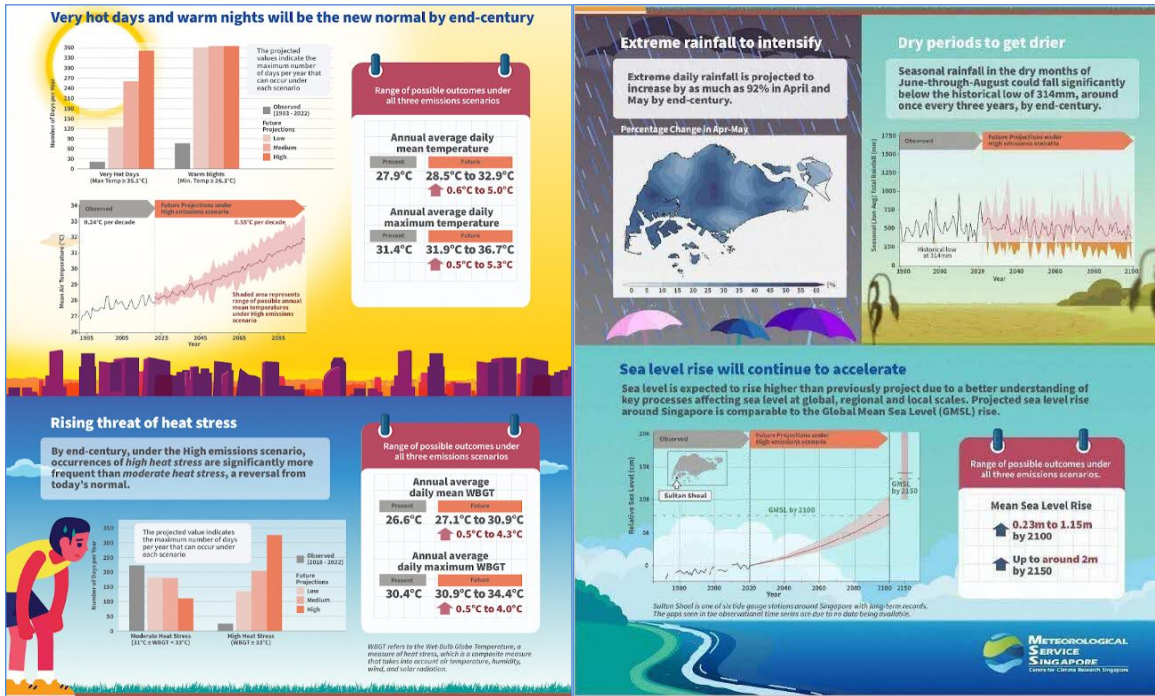
Change in temperature (°C) and rainfall (%)



Viet Nam National Climate Change Study 2020.

Projections for the 21st century suggest continued increases in temperature and precipitation, with significant risks from sea level rise to low-lying coastal areas. During the Q&A session, participants asked about the number and reliability of tide gauge stations, the integration of vertical land motion data, and the need to include more comprehensive heat stress metrics, such as humidity and wind. Dr. Kien emphasized Viet Nam’s commitment to enhancing data coverage, refining climate change projection methods, and producing actionable projections to inform policy and adaptation planning. Overall, the session highlighted Viet Nam’s proactive, scientifically grounded approach to addressing climate change through coordinated governance, robust data systems, and ongoing stakeholder engagement.

1.17 Dr Sandeep Sahany, CCRS, Singapore, presented an overview and key findings from Singapore’s Third National Climate Change Study (V3), a major effort that extends beyond national borders to cover Southeast Asia. Leveraging advanced global climate models and high-resolution downscaling techniques, V3 produced detailed climate projections with 8 km spatial and 12-minute temporal resolution for rainfall, an unprecedented level of granularity. The study highlights anticipated increases in extreme rainfall, dry spells, and sea-level rise, with profound implications for urban planning and adaptation strategies, particularly in vulnerable cities like Bangkok and Manila where land subsidence compounds the risks. V3 also projects a continued rise in daily maximum temperatures, likely intensified by urban heat island effects. Collaboration with government agencies and stakeholders is a key feature of the study, ensuring the data is policy-relevant and accessible, offered via concise summaries and a user-friendly online portal.



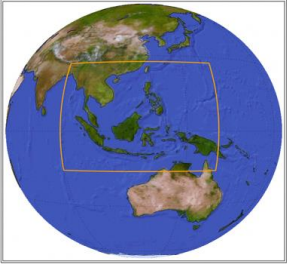
Key climate change projections for Singapore.

During the Q&A session, Prof. Tangang called attention to the interplay between long-term climate trends and variability, such as future El Niño events; Dr. Aurel Moise advocated for the use of AI to expand ensemble sizes and better capture variability; and Dr. Truong Ba Kien emphasized stakeholder communication and questioned data source consistency between V2 and V3. Dr. Sahany acknowledged these challenges, reaffirmed the need for methodological rigor, and introduced a forthcoming data-sharing platform to support effective planning and decision-making. Dr Moise also mentioned about the usefulness of the storylines approach in communicating climate change projections to stakeholders. The session ultimately underscored the importance of precision, transparency, and collaboration in national and regional climate change projection efforts.


1.18 Prof. Fredolin Tangang, Universiti Brunei Darussalam, Brunei Darussalam, presented on ASEAN climate projection datasets, emphasizing the urgent threats posed by climate change and the critical importance of regional collaboration in advancing both scientific understanding and policy responses. Citing alarming findings from the IPCC, such as the global 1.5°C temperature rise and accelerated climate system shifts, he underscored the wide-ranging risks to human health, ecosystems, and future generations. He identified anthropogenic activities as the dominant drivers of these changes, resulting in more extreme weather events and ecological disruptions, and cautioned that without significant emissions reductions, Earth's climate could resemble conditions last seen millions of years ago, unsustainable for current life forms. While expressing skepticism about the feasibility of achieving global emissions targets in time, he emphasized the growing need for adaptation strategies alongside mitigation. Prof. Tangang also discussed the technical and scientific

challenges of climate modeling, advocating for high-resolution models, better simulation of extremes, and the integration of socio-economic dimensions. He highlighted the progress achieved through regional collaboration in Southeast Asia, which has already led to more refined projections, and noted the promising role of machine learning and AI in enhancing predictive capabilities.


Progress / Achievements Made



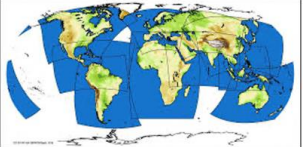
CORDEX Southeast Asia, one of CORDEX domains which community can participate and contribute in a coordinated manner.



With involvement of scientists from various institutions



CMIP5 Downscaling: 25 km x 25 km (completed)
[11 GCMs, 7 RCMs]
CMIP5 Further Downscaling: 5 km on smaller sub-domains (Completed)
CMIP6 Downscaling: Ongoing
CARE for SEA Megacities: Ongoing



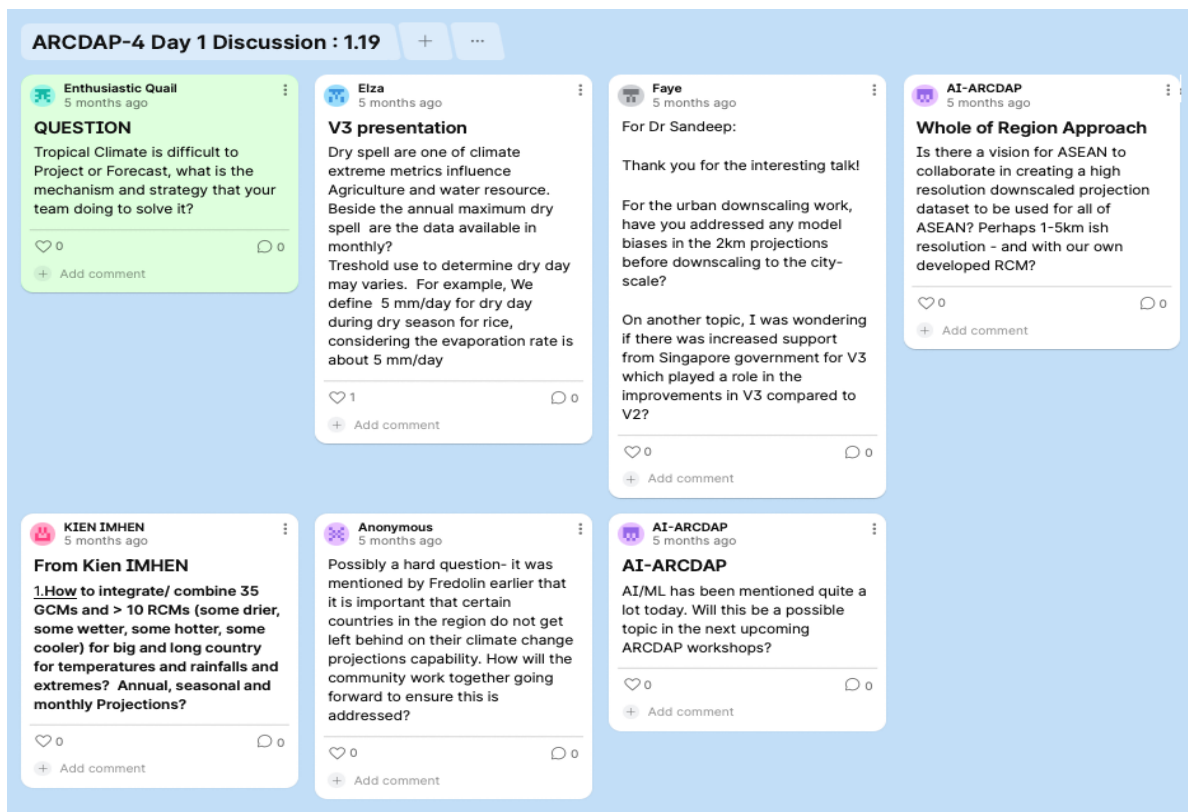
The CORDEX-CORE Initiative
[3 CMIP5 GCMs and 2 RCMs]

- Scientific understanding of regional climate change (published > 40 papers),
- Regional and global network,
- Capacity building / development (produced MSc, PhD graduates),
- Climate change data portal (SARCCIS, an ESGF node)
- VIA studies and used in National Assessments
- CORDEX-SEA data used in IPCC Atlas for Southeast Asia in AR6

Overview of progress and achievements made by CORDEX-SEA.

Additionally, he stressed the importance of attribution science in linking specific extreme events to climate change and raised sustainability concerns regarding the high computational demands of climate modeling. Ultimately, his talk called for a balanced, interdisciplinary, and cooperative approach to climate science, one that combines mitigation, adaptation, and regional knowledge-sharing to address the complex and escalating challenges facing ASEAN countries.

1.19 Dr Aurel Moise (Moderator), CCRS, Discussion Session. During the discussion session moderated by Dr. Aurel Moise (CCRS), participants raised a range of questions on improving tropical climate projections, including the availability of monthly dry spell data with flexible thresholds for agriculture (e.g., 5 mm/day), strategies for addressing biases in urban-scale downscaling, and the influence of governmental support on the success of Singapore’s V3 climate projections. Questions also addressed the feasibility of developing a high-resolution (1-5 km) ASEAN-wide regional projection dataset using a regionally developed RCM, and the methodological integration of outputs from 35 GCMs and 10+ RCMs across diverse climatic regimes and temporal scales. Concerns were voiced about ensuring equitable capacity development among ASEAN countries, particularly those with limited technical infrastructure.



Questions posted by workshop participants for Day 1 on the Padlet.

Participants also expressed a strong interest in incorporating AI and machine learning into future ARCDAP workshops. In response, Dr. Moise clarified the distinction between short-term forecasting and long-term climate projections, emphasizing the importance of model resolution, parameterization, and flexible thresholds. He affirmed the availability of high-frequency datasets that can be aggregated as needed and reiterated that bias correction is critical before applying projections at the urban scale. He acknowledged that Singapore’s enhanced V3 projections were significantly aided by governmental investment. On regional collaboration, he encouraged a multi-model ensemble approach to better capture uncertainty. He advocated for broader ASEAN cooperation, emphasizing that capacity building through training and data sharing must be prioritized to prevent any country from being left behind. He concluded by confirming that AI/ML applications will be incorporated into future ARCDAP workshops, recognizing their growing role in advancing climate science and applications.

2 Day 2: 22 April 2025

Sharing by ASEAN NMHS/Agency representatives on observations datasets

2.1 Dr Aurel Moise, CCRS, Singapore, recap of Day1 and overview for Day2, opened Day 2 with a recap of Day 1, highlighting Dr Faye Cruz's overview of CORDEX and its future directions, including ocean downscaling, coupled RCMs, urban climate modeling, and AI applications. He summarized country presentations, noting that Viet Nam, Malaysia, Thailand, the Philippines, and Singapore are engaging in CMIP6-based downscaling, while others rely on existing datasets like V3 or World Bank products. Dr Sahany introduced the V3 project and its data access options, including a visualization portal and upcoming ASEAN country briefs. Prof Tangang emphasized the need to consider both climate variability and long-term change. Dr Moise previewed Day 2's focus on observational datasets, bias correction, and the launch of the V3 data sharing portal and the Philippines Country Brief. Clarifications were made by a Viet Nam representative regarding their 2025 projection timeline.

2.2 Dr Chen Chen, CCRS, Singapore, Bias Correction in V3 Study, presented the bias correction methodology adopted in V3, emphasizing its role in enhancing the reliability of climate projections while preserving physical consistency. Acknowledging the inevitability of model biases in means, variances, and distributions, she outlined the use of parametric quantile mapping for correcting daily-scale variables such as precipitation, temperature, humidity, and wind, guided by gridded observational datasets. For future projections, a pseudo-reference preserving climate change trends was constructed to maintain model variability post-adjustment.

Notably, daily temperature range and skew were corrected instead of directly adjusting maximum and minimum temperatures to ensure bounded, physically consistent results. The methodology aligns with the ISIMIP3 framework and prioritizes correcting base variables to derive indices like RX1day and TXX, rather than adjusting the indices directly. Discussions highlighted challenges in explaining changes in the direction of trends post-bias correction and the limitations posed by observational data availability. Dr. Chen emphasized that while bias correction improves variable ranges for impact studies (e.g., flood risk), its application should be guided by specific research needs. The session also addressed stakeholder communication, the implications of altered change signals, and the utility of brochures for conveying technical nuances.

BA historical - Quantile Mapping (QM)

It starts from the distribution of the daily variable.

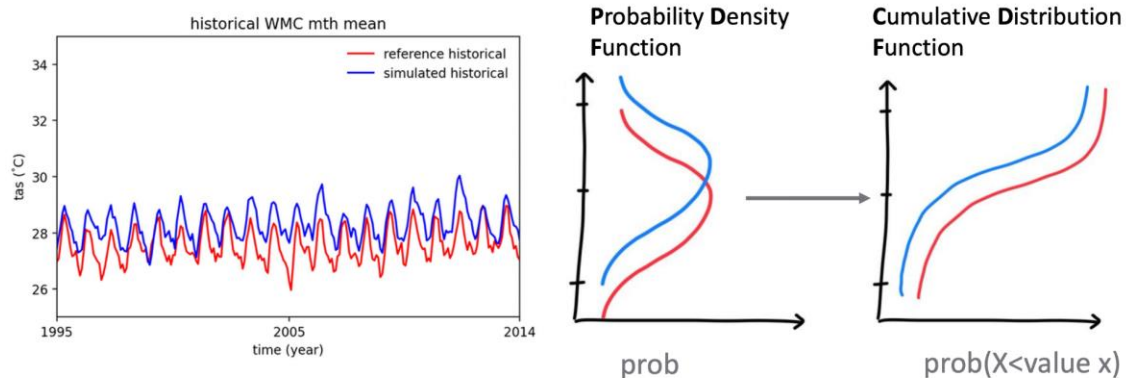


Illustration of bias correction method quantile mapping.

2.3 Dr Muhammad Hassim, CCRS, Singapore, SEA Observational datasets, delivered a presentation on the availability and characteristics of observational datasets for Southeast Asia, highlighting their critical role in climate monitoring, early warning systems, and sectoral applications such as agriculture, water resource management, and urban resilience. He discussed the three main data types - station-based, satellite-based, and reanalysis, and emphasized the importance of understanding limitations such as station relocation, data discontinuities, record heterogeneity, and spatial coverage gaps. For station-based datasets, he noted their high accuracy over land areas with dense networks but pointed out the need for careful homogenization and quality control. Satellite datasets, while offering broad spatial coverage, require calibration with ground-based observations.

He introduced key datasets used in the region, including the Multi-Source Weighted-Ensemble Precipitation (MSWEP), and presented evaluation studies on rainfall products in Southeast Asia. Additionally, Dr. Muhammad highlighted that gridded precipitation datasets are available for countries like the Philippines, Singapore, and Viet Nam, underscoring ongoing regional efforts in dataset development and validation.



Dataset	Period	Res. (spatial/temp)	Strengths	Limitations
TRMM 3B42	1998–2015	0.25° / 3-hourly	Good tropics performance	Replaced by GPM
GPM IMERG	1998–present	0.1° / 30-min	High resolution, global	Early runs not bias-corrected
CHIRPS	1981–present	0.05° / daily	Long record, gauge + satellite	Land only, less accurate over islands
CMORPH	1998–present	0.25° / 30-min	High frequency	May miss orographic rainfall
PERSIANN-CDR	1983–present	0.25° / daily	Long-term climate analysis	Coarse, some bias in tropics
GSMaP (JAXA)	2000–present	0.1° / hourly	Designed for Asia-Pacific	Satellite-only in near-real-time

Comparisons of familiar satellite-based datasets.



MSWEP V2 GLOBAL 3-HOURLY 0.1° PRECIPITATION

Methodology and Quantitative Assessment

HYLKE E. BECK, ERIC F. WOOD, MING PAN, COLBY K. FISHER, DIEGO G. MIRALLES, ALBERT I. J. M. VAN DIJK, TIM R. MCVICAR, AND ROBERT F. ADLER

MSWEP V2 is the first fully global precipitation dataset with a 0.1° resolution derived by optimally merging a range of gauge, satellite, and reanalysis estimates.

Precipitation P drives the terrestrial hydrological cycle (Oki and Kanae 2006; Trenberth et al. 2007). It is also among the most difficult meteorological variables to estimate because of its high spatiotemporal heterogeneity (Daly et al. 1994; Adler et al. 2001; Roe 2005; Stephens et al. 2010; Herold

et al. 2016; Prein and Gobiet 2017). A plethora of regional, quasi-global, and fully global gridded P datasets have been developed over the past decades (for an overview, see Maggioni et al. 2016; Beck et al. 2017c; Levizzani et al. 2018; Sun et al. 2018; <http://ipwg.isac.cnr.it>; <http://reanalysis.org>). These datasets differ in terms of design objective (instantaneous

<https://doi.org/10.1175/BAMS-D-17-0138.1>

<https://www.gloh2o.org/mswep/>



Overview

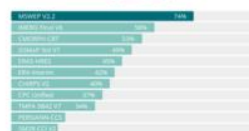
MSWEP is a global precipitation product with a 3-hourly 0.1° resolution available from 1979 to ~3 hours from real-time. The product is unique in that it merges gauge, satellite, and reanalysis data to obtain the highest quality precipitation estimates at every location.

MSWEP incorporates daily gauge observations and accounts for gauge-reporting times to reduce temporal mismatches between satellite-reanalysis estimates and gauge observations. Near real-time estimates are available with a latency of ~3 hours. MSWEP is compatible with GloH2O's operational Multi-Source Weather (MSWX) forecasts can thus be used to extend MSWEP into the future. MSWEP tends to exhibit better performance than other precipitation products in both densely gauged and ungauged regions (see the Performance section on this page, Beck et al., 2017, and Beck et al., 2018).

Performance

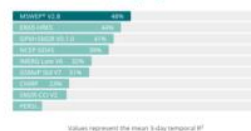
Mean temporal correlation (R^2) against two references for MSWEP and other widely used precipitation products, demonstrating the higher overall accuracy of MSWEP in densely gauged and ungauged regions, respectively.

Reference: Stage-IV gauge-radar data



Values represent the mean daily temporal R^2 over the US. Adapted from Beck et al. (2017c).

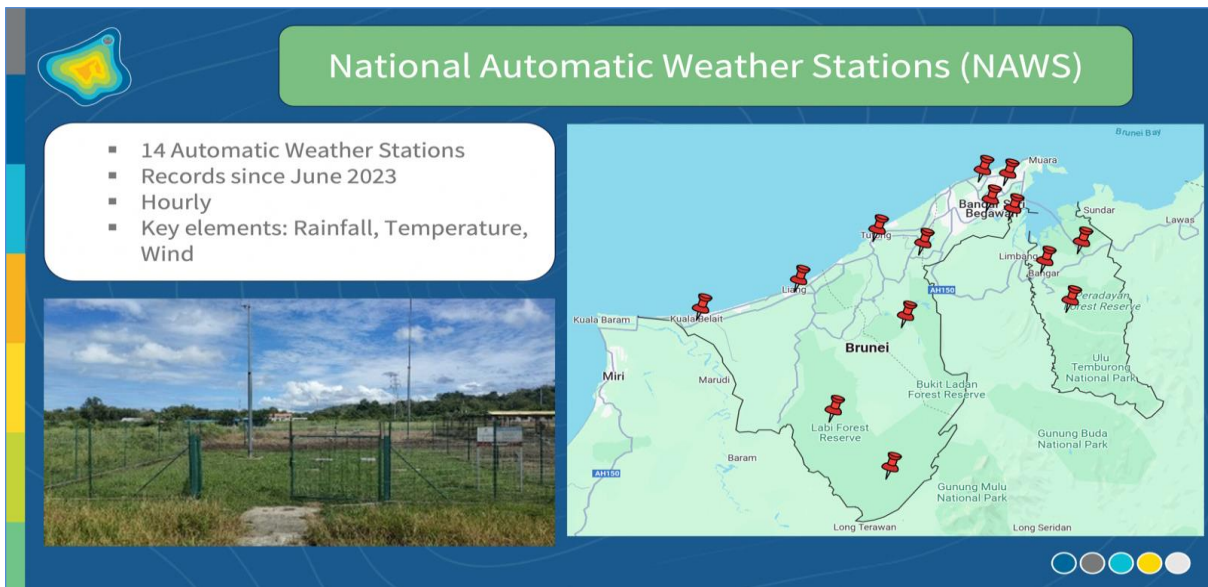
Reference: 75,540 gauges worldwide



Values represent the mean 3-day temporal R^2 over the US. Publication in preparation.

Overview of MSWEP Global 3-Hourly precipitation dataset.

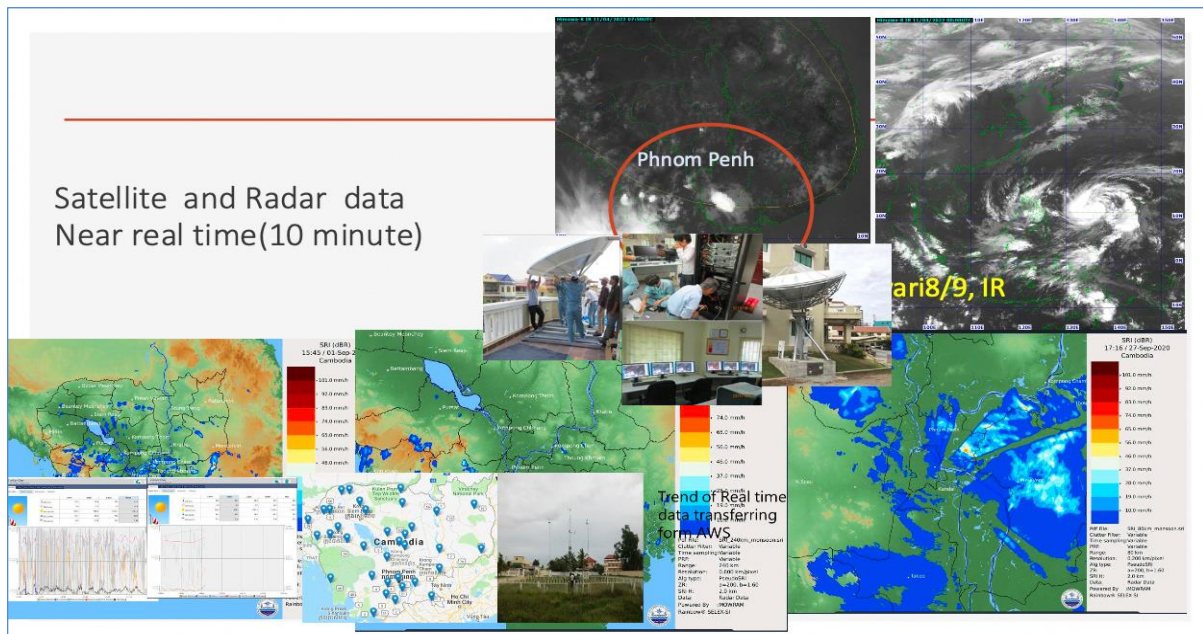
2.4 Mr. Arifin Yusoff, Brunei Darussalam Meteorological Department, Brunei Darussalam, presented an overview of Brunei's national observational datasets, focusing on key infrastructure, including the long-running Brunei International Airport station (since 1961), 14 operational automatic weather stations (AWS) as of June 2023, and the Doppler radar system initiated in April 2023. The AWS network provides hourly data on temperature, rainfall, and wind, though some inland stations experience data gaps due to wildlife interference.



Map of national automatic weather stations in Brunei Darussalam.

Mr. Yussof highlighted the use of various satellite-based datasets such as the Climate Hazards InfraRed Precipitation with Station data (CHIRPS), that from the Tropical Rainfall Measuring Mission (TRMM), the Asian Precipitation—Highly Resolved Observational Data Integration Towards Evaluation of Water Resources (APHRODITE), the Global Satellite Mapping of Precipitation (GSMaP), and the Integrated Multi-satellitE Retrievals for the Global Precipitation Measurement (IMERG) to supplement ground observations. In response to queries, he explained that station placement was guided by a consultancy study proposing around 50 sites, with the current network viewed as a foundational phase. He acknowledged that other government departments may collect meteorological data without adhering to WMO standards, with their efforts often being project-based. On heat monitoring, he noted that while Brunei currently measures only ambient temperature, there are ongoing discussions to adopt indices like the Wet-Bulb Globe Temperature (WBGT), drawing inspiration from Singapore’s practices.

2.5 Mr. Soim Monichoth, Department of Meteorology, Ministry of Water Resources and Meteorology, Cambodia, presented an overview of Cambodia’s national observational datasets, which include daily measurements of rainfall, minimum and maximum temperatures, pressure, and humidity. He noted that satellite and radar data are available in near real-time. In response to questions, Mr. Monichoth reported that Cambodia operates nearly 100 precipitation stations. While a gridded dataset exists for radar data, he emphasized that time series observations are of greater importance to stakeholders.



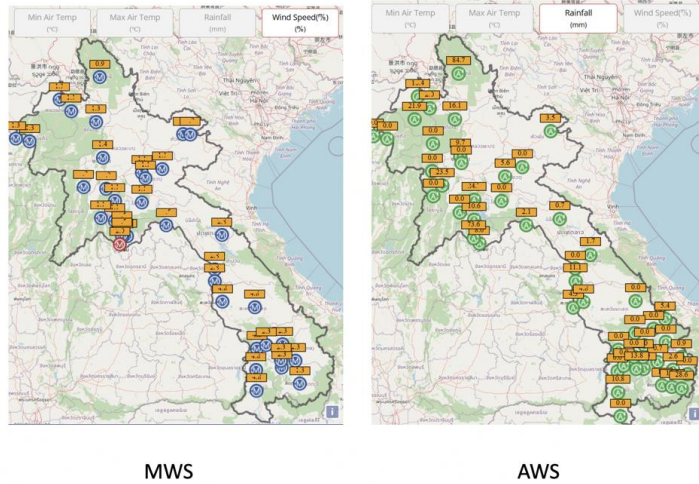
Map of weather stations and satellite/radar data in Cambodia.

Dr. Sahany highlighted the necessity of gridded datasets for bias correction in climate impact studies using products like V3 and inquired whether the World Bank datasets used in Cambodia required bias correction. Mr. Monichoth responded that the relevant procedures are publicly available on the World Bank’s website.

2.6 Ms. Maninoud Phonsena, Ministry of Agriculture and Environment, Lao PDR, presented an overview of Lao PDR’s national observational datasets, managed by the Climate, Agro-meteorology and Remote Sensing Division. The country operates 64 stations in total, comprising 19 synoptic, 30 climatic, and 15 automatic weather stations, with historical records dating back to 1971. Manual station data are first documented in logbooks before digital compilation, while additional data from 38 manual and 51 automated weather stations are integrated into the LaCSA (Laos Climate Services for Agriculture) system, which supports agricultural planning and is updated via WhatsApp.

Weather Stations in LaCSA

- 38 manual weather stations: 19 Synoptic and 19 climate stations;
- 51 automated weather stations;
- The average spatial density of all weather stations is approximately 52 km (89 stations/236,800 Km²)



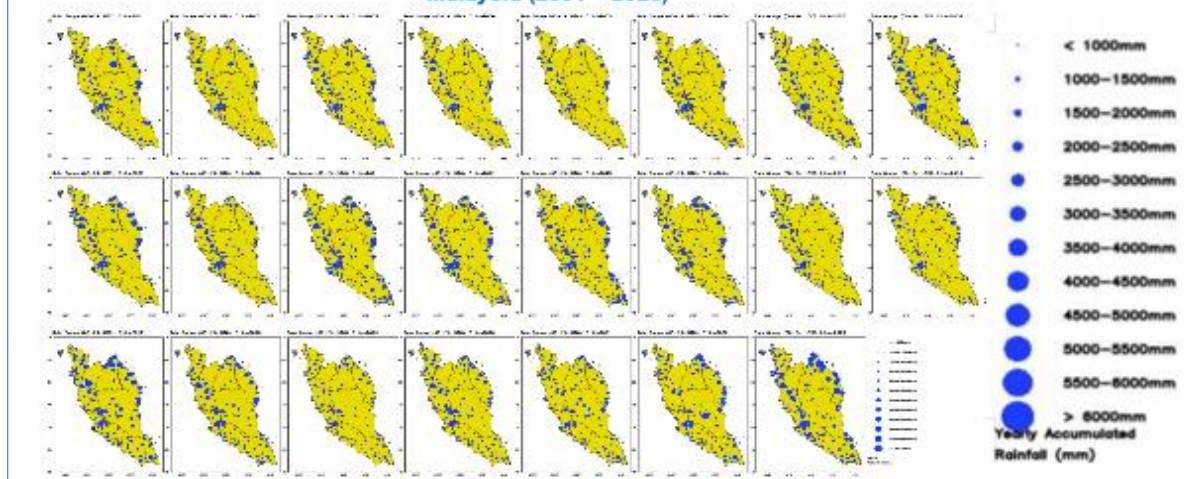
Map of both manual and automated weather stations in the Lao PDR.

Despite data collection challenges, including equipment maintenance and validation, these datasets are used to generate 5 km gridded temperature and rainfall data for downscaling and bias correction purposes. In response to Dr. Moise's inquiry, Ms. Phonsena confirmed that the gridded dataset had already been produced, but was uncertain about the exact number of stations contributing to it.

2.7 Ms. Noor Syafini Ramli, METMalaysia, Malaysia, presented an overview of Malaysia's national observational datasets, highlighting the central role of METMalaysia alongside other agencies such as the Department of Environment (DOE), Department of Irrigation and Drainage (DID), and the Malaysian Space Agency (MYSA). METMalaysia maintains 42 principal stations, 256 automatic weather stations, and 122 conventional stations, with historical records extending back to 1951. The National Climate Centre manages the climatological and hydrological data, with hourly observations across various variables supporting trend and extreme event analyses. While no consistent rainfall trends have been detected across Peninsular and East Malaysia, temperature extremes have generally increased.

Climate Monitoring

Annual rain-gauge observations over Peninsular Malaysia (2001 – 2023)



Map of rain-gauge observations over Peninsular Malaysia (2001-2023).

A gridded dataset at 10 km resolution has been developed using the Barnes successive-correction method to blend GSMaP satellite data with gauge observations. Plans are underway to strengthen MetMalaysia's capabilities in seasonal and sub-seasonal climate forecasting. In response to queries, Ms. Ramli clarified that Malaysia lacks an official heavy rainfall threshold and that tide gauge operations and vertical land movement assessments fall outside MetMalaysia's scope. Encouragingly, she noted that the agency's new leadership is open to sharing the blended dataset for broader use.

2.8 Dr. Tin Mar Htay / Ms. Chaw Su Hlaing, Department of Meteorology and Hydrology, Myanmar (absence)

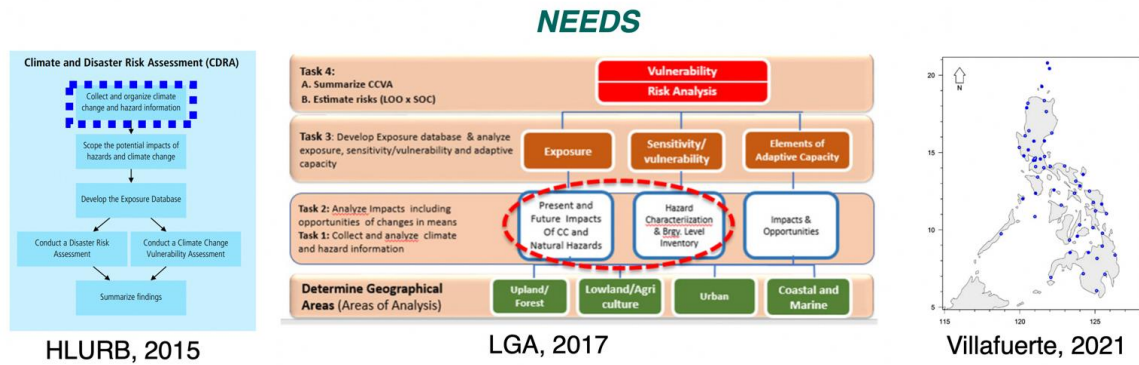
Colleagues from Myanmar were unable to attend because of the earthquake earlier this year.

2.9 Ms. Cyrill Hope Depasucat, PAGASA, the Philippines, focused on surface synoptic (SYNOP) and agrometeorological (AGROMET) stations, which provide meteorological and agriculturally relevant data, respectively. Through the Scaling Up Climate Information and Services for Societal Benefits (CLIM'UP) program, PAGASA developed high-resolution gridded datasets by spatially downscaling GPM satellite rainfall data to 0.01° (~ 1 km), followed by bias correction using station observations. Interpolation techniques including kriging, inverse distance weighting, and Cressman were employed, with performance evaluated via leave-one-out cross-validation and Taylor diagrams. The resulting datasets covering 20 years for rainfall and 30 years for temperature, pressure, and humidity are quality controlled, include sub-daily data, and are publicly available through the CliMap v2.0 portal.

ClimGridPh

Project: Development of High-Resolution Observation-based Sub-daily Gridded Climate Data for the Philippines

Program: Scaling Up Climate Information and Services for Societal Benefits (CLIM'UP)



Overview of ClimGridPh climate data for the Philippines.

Future updates are planned, including broader variable access. Remote sensing inputs include ERA5 and JRA for temperature and humidity. The initiative emphasizes data accessibility for local researchers and stakeholders, with user download activity monitored monthly to assess engagement. Prof. Tangang encouraged formal publication to enhance credibility, and Dr. Moise inquired about broader public data access, highlighting the importance of open science communication.

2.10 Mr. Chaowat Siwapornchai, Thai Meteorological Department, Thailand, presented Thailand’s national observational datasets, emphasizing their application in developing climate projections. He highlighted the availability of monthly precipitation, maximum and minimum temperature data from 75 TMD stations spanning 1981 to 2024.

The station data undergoes interpolation to address missing values and to generate spatially continuous datasets. Additionally, climate indices derived from reanalysis data are shared with stakeholders for broader use. In the discussion, Dr. Moise queried whether Thailand intended to match or surpass the 9 km resolution of ERA5-Land, to which Mr. Siwapornchai affirmed interest. In response to Dr. Prasanna’s inquiry on data homogeneity testing, Mr. Siwapornchai noted that such efforts were still at an experimental stage.

Observational Dataset Preparation



TMD observational data

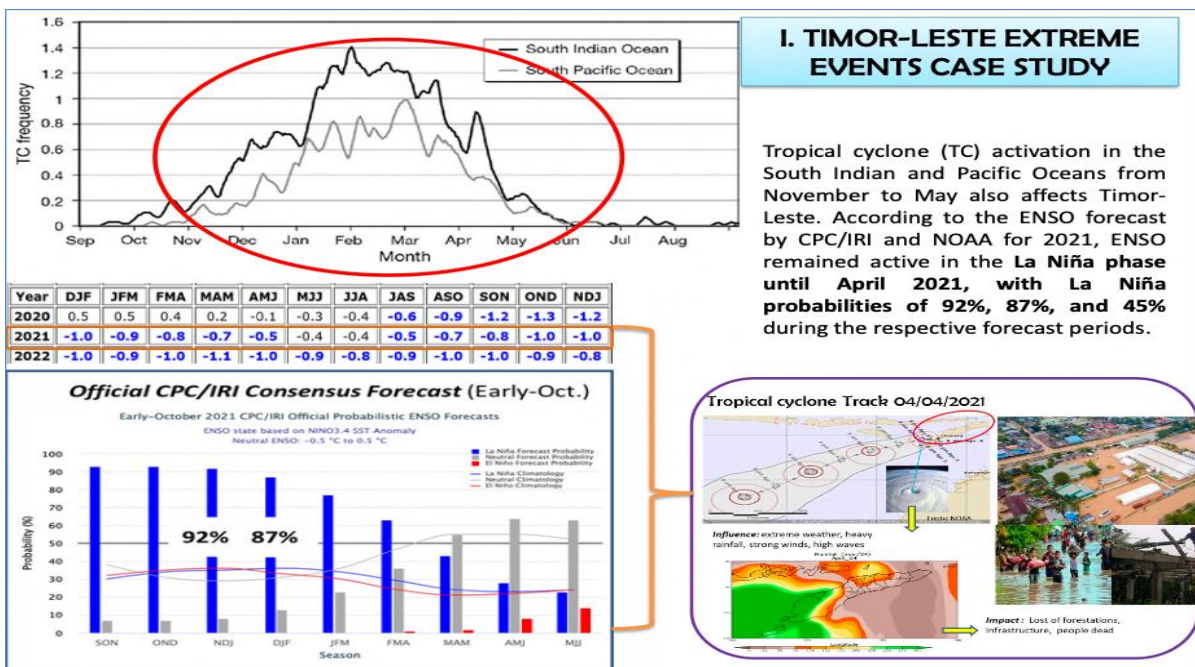
- 75 stations
- Monthly, 1981 - 2024
- Prec, Tmax, Tmin

Interpolate to gridded data

- Inverse Distance Weighting (IDW)
- Co-Kriging

Overview of workflow for observational dataset preparation in Thailand.

2.11 Ms. Angelina Baptista Freitas, National Directorate of Meteorology and Geophysics, Timor-Leste, presented the country's observational datasets, contextualizing them with impactful events such as the tropical cyclone on 4 April 2021 and emphasizing the influence of ENSO on national climate patterns. She noted that data is now managed within a centralized system, though it is not yet publicly accessible.



A case study for tropical cyclone on 4 April 2021 in Timor-Leste.

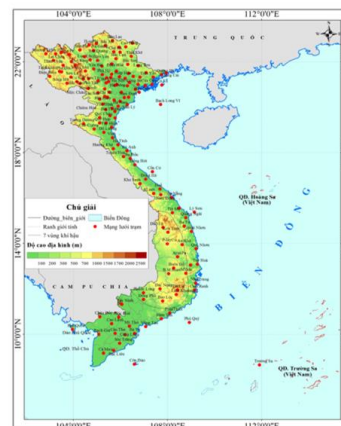
Timor-Leste experiences peak rainfall during boreal winter and a pronounced dry season in boreal summer. A major limitation is the presence of only two operational stations, both located along the coast, prompting interest in spatial interpolation techniques to better

capture the climatic variability across the country's mountainous interior. Dr. Moise highlighted the need for gridded datasets to account for the complex topography, where over 60% of the land is on steep slopes.

2.12 Mr. Tran Quang Nang, Viet Nam Meteorological and Hydrological Administration, Viet Nam, presented an overview of Viet Nam's extensive observational network, which underpins the Viet Nam National Climate Change Scenarios 2020. Some stations hold over a century of climate records. The national hydro-meteorological system comprises more than 1800 stations, including around 1700 equipped with tipping bucket rain gauges that transmit data at 10-minute or hourly intervals. Wave observations are still conducted visually using binoculars.

1. Observational data set used for the development of the Vietnam National Climate Change Scenarios (VNCC) 2020

- **Meteorological Data for Climate Change Assessment (as of 2020)**
- **Using 187 surface meteorological stations nationwide by 2020.**
- Only stations with **at least 30 years of data** starting from **1986 or later** were selected.
- After quality control and statistical testing, **150 stations** with reliable temperature and rainfall data were used to:
 - Assess climate change trends
 - Update Vietnam's climate change scenarios

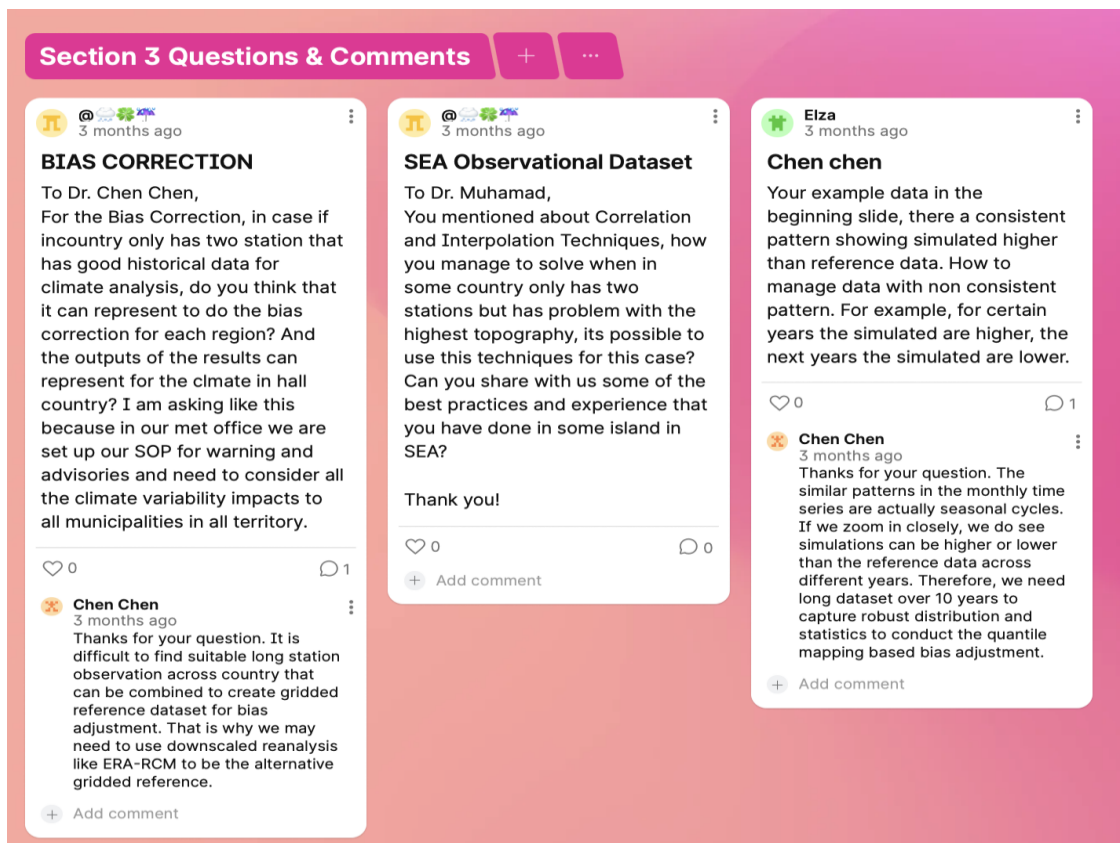


Map of national surface meteorological stations in Viet Nam.

Plans are underway to expand and modernize the network by 2030. Mr. Tran also mentioned ongoing collaboration with Japan to develop a 1 km gridded dataset, available on their website. While observational data, including for locations like Hanoi, exists, data sharing remains limited and subject to quality control challenges. Prof. Tangang praised the high station density, and Dr. Moise and other participants emphasized the importance of continued development and accessibility of gridded datasets for research and applications.

Discussion based on survey results, presentations, and Q&A

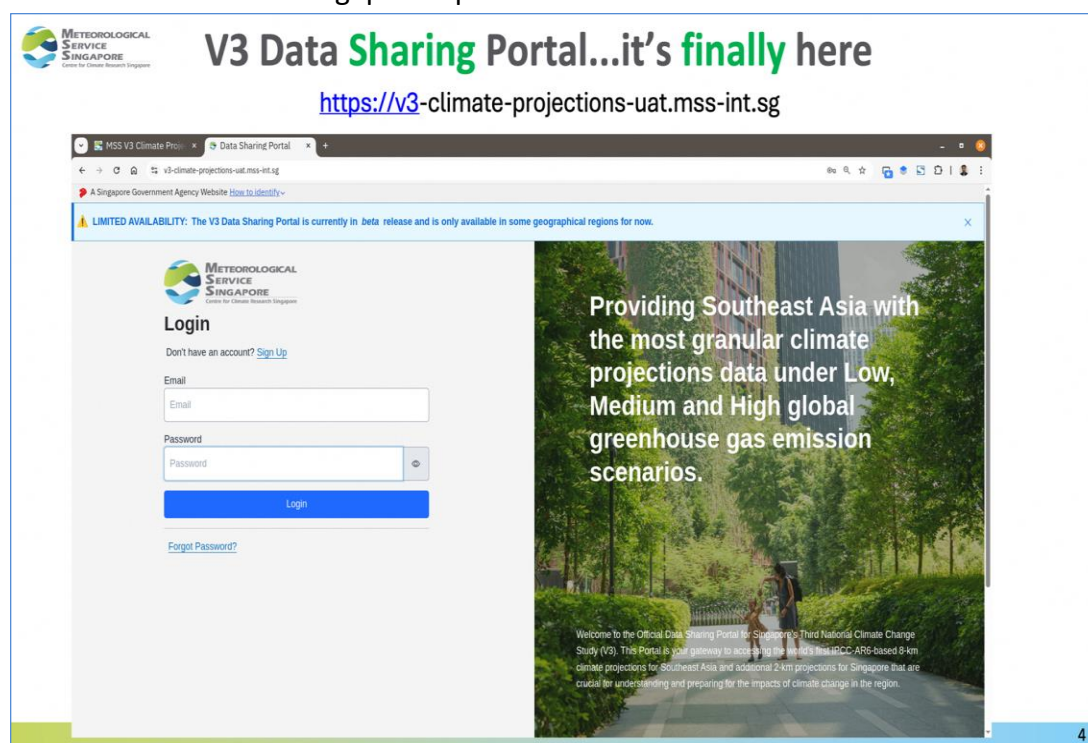
2.13 Dr Aurel Moise facilitated a discussion on the use and treatment of observational datasets across Southeast Asia, emphasizing the importance of data sharing for bias correction and model evaluation. Drawing on the pre-workshop survey, he highlighted disparities in data accessibility and invited perspectives on collaborative data platforms. Prof. Tangang proposed a regional gridded dataset akin to SA-OBS, suggesting a 1 km resolution blended with satellite data, and noted that existing regional reanalysis efforts could inform this. Mr. Noor from RIMES introduced a WMO-supported data exchange platform and expressed readiness to lead dataset integration efforts, contingent on quality control protocols and country-level buy-in. Discussions addressed challenges in high-topography regions like Timor-Leste and the use of correlation distances in kriging, with Dr. Muhammad offering methodological suggestions. Dr. Cruz proposed sharing derived indices as an alternative where raw data sharing is restricted. Participants agreed on cataloguing available datasets and access conditions, with suggestions to host these under institutions such as RIMES, the ASEAN Centre for Climate Change, or the Regional Climate Centre awaiting WMO approval. The AHA Centre also expressed interest in receiving actionable climate impact data. Overall, the discussion reflected strong regional interest in collaborative dataset development and emphasized institutional mechanisms to support long-term data governance and accessibility.



Questions posted by workshop participants for Day 2 on the Padlet.

Launch of CCRS V3 Data Sharing Portal

2.14 Dr Muhammad Eeqmal Hassim, CCRS, Singapore, gave a presentation on the V3 Data Visualization Portal (DVP) and also a walk-through of the V3 Data Sharing Portal (DSP) that was launched as a part of his presentation. He announced the launch of the V3 DSP, offering free access under the Singapore Open Data License.



The website interface for V3 data sharing portal.

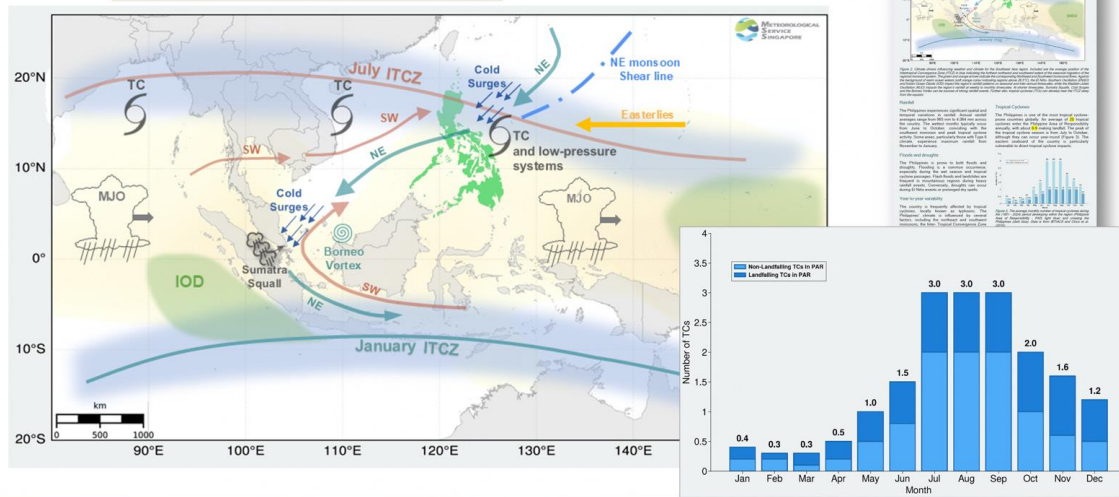
He shared that the portal provides daily and monthly mean climate data, including near-surface variables and atmospheric pressure levels (monthly only). He further shared that users can customize geographic regions and time periods for data extraction, with each user having a 50 GB monthly quota, and a limit of 10 GB per individual data request. It was well received by the participants, and there was a registration session with technical help on-site.

Launch of the Philippines Country Brief and Group Exercise

2.15 Dr. Aurel Moise, Dr. Faye Cruz, Ms Cyrill Hope Depasucat and Mr. Wilmer Agustin (PAGASA, Philippines) showcased the climate change country brief initiative led by CCRS that utilized V3 data, focusing on co-developing country-specific climate briefs with local stakeholders, using the Philippines as a pilot. The brief integrates domestic data and local expertise to reflect climate variability and change of key climate processes/indices/impact indicators, such as monsoons, tropical cyclones, ENSO, and sea level rise, identified through adaptation planning documents.

Example: Country Brief for the Philippines

Historical climate information



5

The showcase of the country brief for the Philippines.

It includes historical trends (e.g., rainfall and temperature extremes), IPCC-based projections for future climate scenarios (e.g., sea level rise exceeding 3 m by 2150), and changing patterns in tropical cyclone intensity. Designed as an accessible, policy-relevant communication tool, the brief emphasizes co-production, clarity, and consistency across Southeast Asia while being tailored to national contexts. Other countries were invited to participate in similar assessments and they were keen to do so.

2.16 Discussion and Group Work on Country Briefs. Followed by the launch of the Philippines Country brief, Dr Aurel Moise moderated a group exercise that country representatives carried out to come up with a draft country brief for each country using local observation data and images from the V3 DVP for the respective countries. Each country was then invited to present draft country briefs. This formed the foundation for tailoring country-

specific assessments and ensured alignment with national needs and contexts.



What is the Country Brief?

1. An climate change assessment focussed on ONE country, for example: “Current and Future Climate of The Philippines”
2. Co-designed and co-developed with the country
3. Based on the countries domestic data (for historic information) and mostly V3 projections at 8km (for future information)
4. Tailored for each country
5. Broad target Audience; not a science paper
6. CCRS provides resources to finalise



2

The explanation of the content covered by the Country Brief.

The session marked a very good start toward integrating robust observational evidence with future projections for effective climate planning.

3 Day 3: 23 April 2025

Regional climate change impact studies

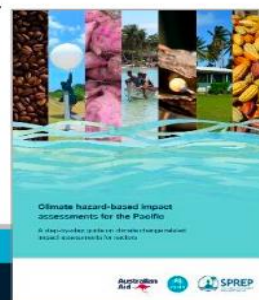
3.1 Dr Aurel Moise, recap of Day2 and overview for Day3, opened Day 3 with a recap of Day 2, highlighting the V3 Data Sharing Portal that offers free access to high-resolution (8 km) daily and monthly data under Singapore’s Open Data License. Additionally, the Philippines’ climate change assessment (“Current and Future Climate of the Philippines”) was showcased as a co-developed country brief. A group session followed to identify key observational needs and climate drivers for each country, marking a strong starting point for tailored national climate assessments across ASEAN. He also emphasized the use and treatment of observational datasets across Southeast Asia, stressing the importance of data sharing for bias correction and model evaluation. Drawing on the pre-workshop survey, he highlighted disparities in data accessibility and invited perspectives on collaborative data platforms.

3.2 Dr Leanne Webb, CSIRO, Australia, Introduction to Climate Impact Studies, delivered a comprehensive presentation on climate impact studies and stakeholder engagement in the Pacific Islands, emphasizing co-production as key to successfully using climate projections information to inform adaptation planning. Drawing on the Van-KIRAP (Climate Information Services for Resilient Development in Vanuatu) and the NextGen Pacific case studies, she showcased how climate projections can be translated into actionable information across sectors such as agriculture, fisheries, tourism, and infrastructure. CSIRO has produced multiple detailed reports for different sectors and countries in the Pacific Islands, including case studies, describing climate change impacts on Cook Islands’ pearl farming and Papua New Guinea’s coffee production, climate summaries, and mapping tools tailored to local needs. More recently, integrated climate hazards, vulnerability, and risk assessments have been led by CSIRO to inform National Adaptation Plans (NAPs) for countries including Tuvalu and Nauru.

NextGen case studies



- Six case studies
 - Ag, fisheries, health
 - 4 PICs
 - Detailed technical reports
 - ~30 pages long
- Fact sheets
 - 4 page summaries
- Guidance material:
 - How to undertake an impact assessment

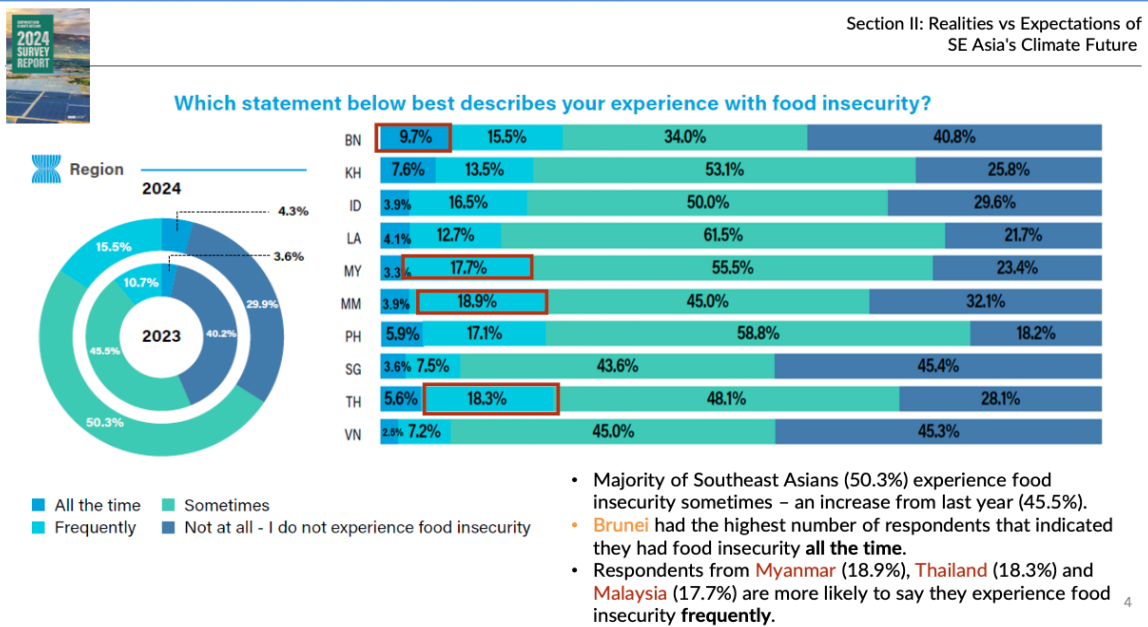


<https://www.rccap.org/>

The overview for NextGen case studies for Pacific island states by CSIRO.

Dr. Webb explained the importance of working closely with local communities and government agencies to ensure the relevance and uptake of climate information. She advised that successful implementation in Southeast Asia would require similar interdisciplinary collaboration and iterative engagement with sectoral stakeholders. In response to questions, she highlighted the strategic use of relevant climate variables in sectoral analysis and encouraged use of existing guidance materials to replicate these methodologies in other regions.

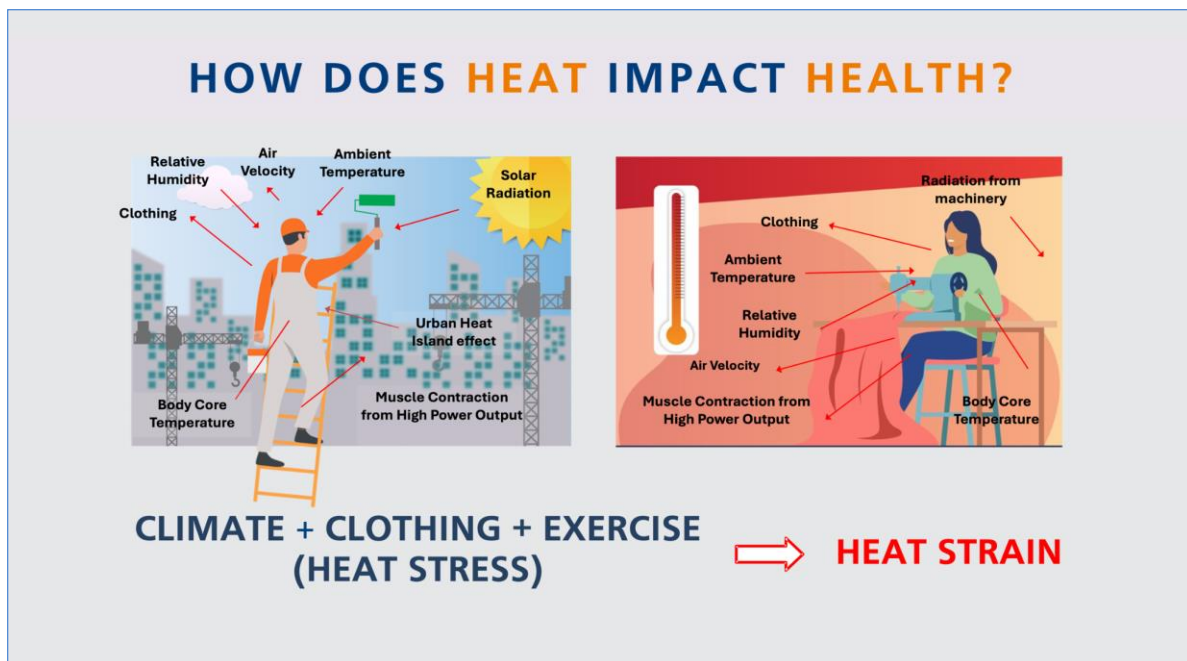
3.3 Ms. Elyssa Kaur Ludher, ISEAS – Yusof Ishak Institute, Singapore, Food Security, delivered a presentation on climate impacts on food security in Southeast Asia, highlighting both socio-economic and environmental vulnerabilities. She discussed the complex interplay between aging farming populations, geopolitical instability, and climate change, with a focus on food availability and affordability. Survey data revealed growing public concern, with a significant number of respondents in Thailand and Viet Nam opting to grow their own food.



Survey results from Southeast Asian respondents on their experience with food insecurity.

She detailed how climate extremes, such as heatwaves and drought, impact crops, livestock, and food systems, citing projections such as a potential 50% decline in Viet Nam’s coffee production by 2050 and substantial rice yield losses in Thailand, Indonesia, and Viet Nam due to sustained high temperatures. Ocean acidification was noted as a serious threat to fisheries and protein security. Ms. Ludher emphasized the critical role of climate modelling in informing long-term food policy and advocated for investment in climate-resilient agriculture, such as heat- and salinity-tolerant crops. She also identified overdependence on rice as a regional vulnerability, proposing diversification through alternative crops, such as millet and sorghum. Despite data gaps, her findings suggest growing recognition of climate risks among older stakeholders and a pressing need to raise awareness among younger populations and policymakers.

3.4 Ms. Lydia Law, Heat Resilience & Performance Centre (HRPC) and Global Heat Health Information Network (GHHIN) Southeast Asia Hub, Heat and Health, presented an overview of the health impacts of heat in Southeast Asia, highlighting the region’s unique vulnerability due to the combination of high temperatures, humidity, and chronic exposure. She emphasized that extreme heat is the leading cause of weather-related mortality and noted the critical role of warm nights in impairing human recovery.

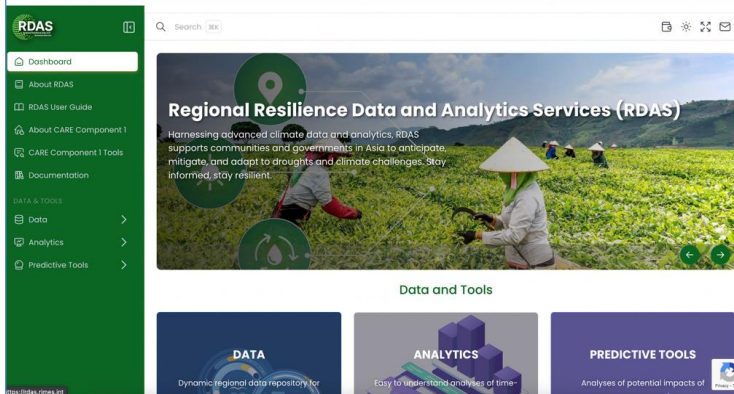


Infographic on how health is impacted by heat.

Her talk detailed the physiological responses to heat stress and its wide-ranging effects on physical and mental health, productivity, sleep, diet, fertility and productivity, where she cited estimates of \$2 billion in productivity loss due to heat. She also stressed that heatstroke deaths are preventable with appropriate measures such as hydration, fitness, and work-rest guidelines. Ms Law went on to introduce the Global Heat Health Information Network Southeast Asia Hub and called for greater collaboration with climate experts. She underscored the need to move beyond mortality and consider broader heat-related outcomes, while advocating for region-specific heat stress thresholds and personalized metrics. The session concluded with expressions of interest in cross-sectoral collaboration, particularly with the disaster management and climate science communities, to inform effective responses to rising heat risks in a warming climate.

3.5 Mr Asif Uddin Bin Noor, RIMES, Thailand, Floods and Droughts, delivered a presentation on climate impact case studies focusing on floods and droughts in South and Southeast Asia. He emphasized the increasing frequency and intensity of extreme precipitation events and the growing prominence of flash droughts based on several attribution studies, citing scientific evidence and case studies such as the 2022 Pakistan floods. He noted the intensifying impact of climate extremes on vulnerable communities and key sectors, such as the link between drought-induced low river flow and power blackouts in Cambodia. Mr Noor advocated for improved climate information services, highlighting the value of multi-hazard and multi-timescale impact forecast products . He introduced RIMES' Regional Resilience Data and Analytics Service (RDAS), a publicly accessible platform that integrates climate, sectoral, and socioeconomic data to support adaptation planning and investment.

Use Case of DSS : Regional Resilience Data and Analytics Services (RDAS)



The key pillars of RDAS are

- Climate and Sectoral Data
- Analytics
- Predictive Tools

<https://rdas.rimes.int>

The Regional Resilience Data and Analytics Services (RDAS) is a data and analytics platform in the public domain that is designed for resilient planning and investments in South Asia.

Regional Integrated Multi-Hazard Early Warning System for Africa and Asia

The website interface of Regional Resilience Data and Analytics Services (RDAS).

He also demonstrated a climate-adaptive planning tool developed for Pakistan e.g. to support in formulation national adaptation plans for specific sectors. In the discussion, Mr Noor explained RIMES' collaborative role in harmonizing regional capabilities, especially among less developed members, and responded to queries on drought typologies and the use of subsurface soil moisture anomalies derived from NASA data.

Discussion and Q&A Session

3.6 Dr Aurel Moise moderated this session. The discussion session following the morning presentations centered on physiological adaptation, heat health frameworks, uncertainty in impact assessments, and challenges in small island climate impact research. A question was raised on which population segment has the highest mortality due to heat. Ms Lydia Law emphasized the need for more data, especially in the Southeast Asian context. In response to a question by Dr Cruz on physiological adaptation to chronic heat, Ms Law highlighted that at least in Singapore, individuals are behaviorally acclimatized in that they will avoid the heat as much as possible and hence cannot be assumed to be heat acclimatized. Dr Yu referenced A/Prof Jason Lee's (Chair of the GHHIN SEA Hub) suggestion for our youth to actually go outdoors more (for sensible durations of time) as there are benefits to be gained from sun exposure.

Mr Augustin shared concerns from his experience in implementing heat indices in coordination with the Department of Health. He described challenges arising from threshold-

based class suspensions set by the Department of Education that lack scientific backing. Dr Moise responded by describing Singapore's multi-agency process, involving ministries such as Health and Defence. He detailed the infrastructure used, such as 15-minute and 5-minute data from different networks, and shared that Singapore is now working on a comprehensive heat health framework.

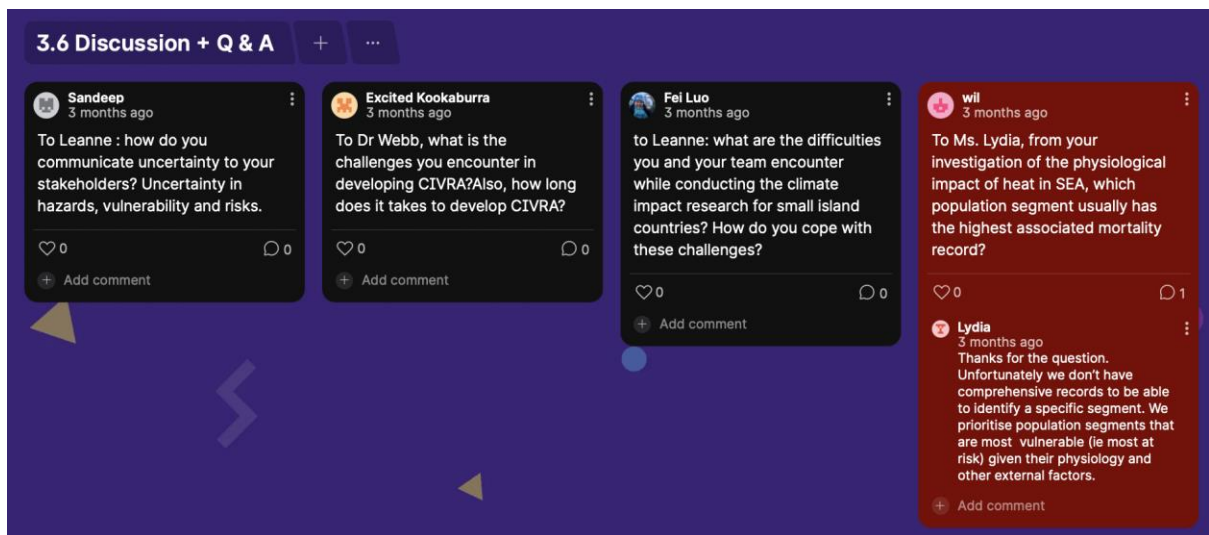
Prof Tangang asked about the humid heat problem, which Dr Moise and Dr Yu indicated would be discussed in more detail in the afternoon session, with some preliminary results already shared. Dr Sahany asked Dr Leanne Webb how uncertainty is communicated in stakeholder-facing products. Dr Webb shared that climate projections are presented as a range using different emissions pathways and models (e.g., least vs most warming). She highlighted the need to explain model limitations clearly, and that community and census data contribute to the risk and vulnerability aspects.

When asked anonymously about challenges and time required to produce the Climate Impacts, Vulnerability and Risk Assessments (CIVRA), Dr Webb cited difficulties in accessing consistent observational data, though noting that data availability is improving. She emphasized the importance of cross-sectoral engagement and estimated that the core team of ~10 people could complete a CIVRA in under a year, excluding ongoing stakeholder communication.

Ms Luo asked about conducting impact studies for small island countries. Dr Webb explained that until recently, the Pacific islands were not part of the CORDEX domain, but now it is included in a new project. Previously, statistical downscaling was used; now, dynamical downscaling at 20 km and finer resolutions (1–4 km) will be developed for specific areas.


Dr Moise expressed interest in how this would be modelled, given the Pacific's many small islands. Ms Luo highlighted work by KNMI on Dutch Caribbean islands that might offer relevant methodological insights. Dr Webb mentioned her awareness of the Caribbean-focused work and its inclusion in the IPCC Small Islands chapter.

Dr Cruz concluded by emphasizing that CORDEX is increasingly covering both the Pacific and Caribbean islands, and is working with what is available to enhance regional relevance.



Questions posted by workshop participants for Day 3 on the Padlet.

3.7 Dr Aurel Moise, Sectoral Impact Studies Metrics, provided an in-depth overview of climate metrics and their critical role in assessing the impacts of climate change across sectors. He began by outlining the purposes of these metrics, including risk assessment, policy formulation, investment planning, and stakeholder communication, and emphasized the importance of using relevant climate variables such as temperature, precipitation, sea level rise, and extreme events. The talk explored diverse categories of metrics, including climate impact indicators, radiative forcing, and global warming potentials tailored to sectors like agriculture, water resources, and health. A key focus was the World Meteorological Organization’s 55 Essential Climate Variables (ECVs) and sector-specific indicators for drought, evaporation, and heat stress. Metrics such as the Wet Bulb Globe Temperature (WBGT), Heat Index, and Universal Thermal Climate Index (UTCI) were highlighted, with a detailed discussion of their thresholds and implications for public health.



CCIIs – Climate Change Impact Indicators

Variable	Units	Definition
Essential climate variables (12)		
Monthly mean precipitation	$m s^{-1}$	Monthly mean (of the daily mean) precipitation. To compute the total precipitation sum over the aggregation period, a conversion factor should be applied of $3600 \times 24 \times 1000 \times 30.4$ (average number of days per month).
Annual mean daily precipitation	$m s^{-1}$	Annual mean (of the daily mean) precipitation. To compute the total precipitation sum over the aggregation period, a conversion factor should be applied of $3600 \times 24 \times 1000 \times 365$ (average number of days per year).
Annual maximum daily precipitation	$m s^{-1}$	Annual maximum of daily precipitation. To compute the total precipitation sum over the aggregation period, a conversion factor should be applied of $3600 \times 24 \times 1000 \times 365$ (average number of days per year).
Annual maximum 2m temperature	K	Annual maximum (of the daily maximum) temperature at 2 m above surface.
Annual minimum 2m temperature	K	Annual minimum (of the daily minimum) temperature at 2 m above surface.
Monthly mean and annual mean 2m temperature	K	Monthly/annual mean of the daily mean temperature at 2 m above surface.
Monthly mean daily maximum 2m temperature	K	Monthly mean of the daily maximum temperature at 2 m above surface.

Essential Climate Variables

Monthly mean daily minimum 2m temperature	K	Monthly mean of the daily minimum temperature at 2 m above surface.
Annual mean daily maximum 2m temperature	K	Annual mean of the daily maximum temperature.
Annual mean daily maximum 2m temperature	K	Annual mean of the daily minimum temperature.
Monthly and annual water vapour pressure	Pa	Monthly and annual mean of the contribution to the total atmospheric pressure provided by the water vapour over the period 00:24h local time per unit of time.
Monthly and annual cloud cover	-	Monthly and annual mean of the cloud cover fraction.

COPERNICUS CDS: [Global bioclimatic indicators from 1950 to 2100 derived from climate projections](#)

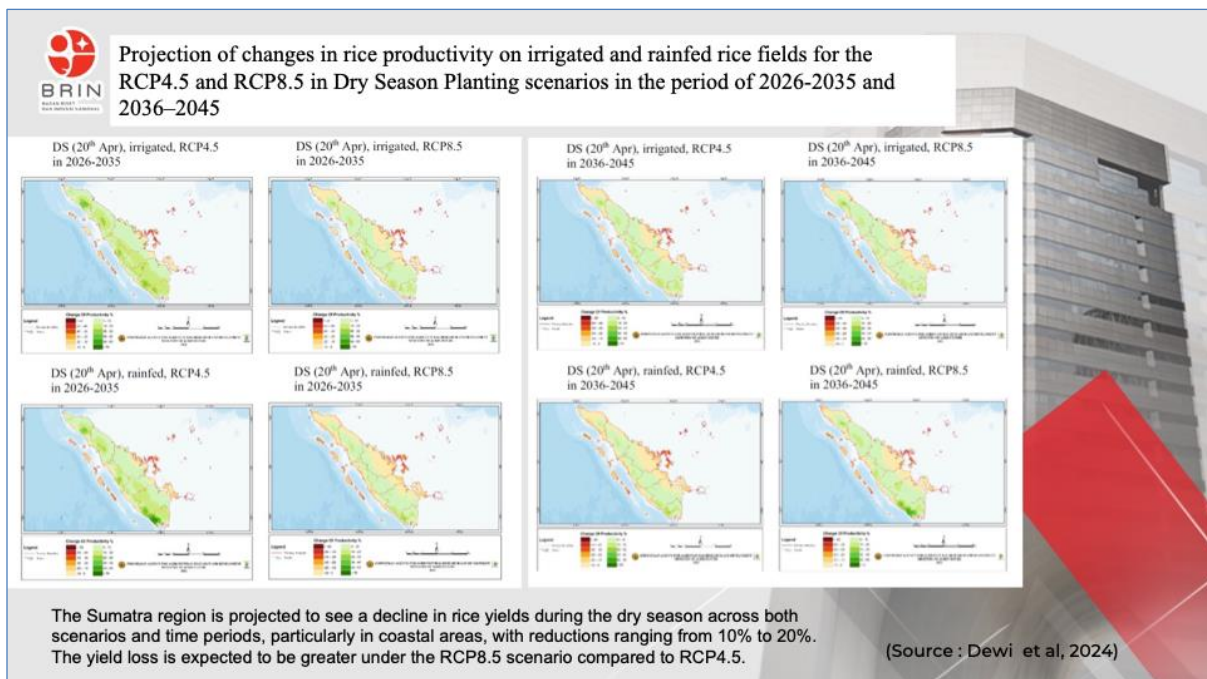
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Some examples of Climate Change Impact Indicators (CCIIs).

The ETCCDI's 27 standardized indices for detecting climate extremes were also covered. Dr. Moise noted the challenges in standardizing metrics due to regional and sectoral variability and stressed the importance of collaborative efforts in developing and sharing climate indicators. He highlighted Singapore's operational use of WBGT for heat assessments and called for greater guidance and stakeholder engagement in selecting context-relevant metrics. Tools such as Python packages and the Climate Data Operator (CDO) were mentioned as accessible resources for calculating these indices. Overall, the presentation underscored the complexity, utility, and growing necessity of robust climate metrics in informing adaptation and resilience strategies.

3.8 Dr Elza Surmaini, PRIMA/BRIN, Indonesia, discussed the impacts of climate change on Indonesia's agricultural sector, focusing on temperature and rainfall trends and their implications for crop production, particularly rice. Indonesia has experienced a 1.0°C rise in surface air temperature since 1850 and notable changes in rainfall patterns, with increased annual totals and daily intensities in some regions, alongside sea level rise of 4.6 ± 0.4 mm per year (1990–2020). Although the national average temperature change remains below the global average, urban areas like Jakarta are warming faster. Climate projections show a steady temperature increase, especially during the dry season, and greater rainfall in the wet season, raising flood risks and creating dry-season water stress.

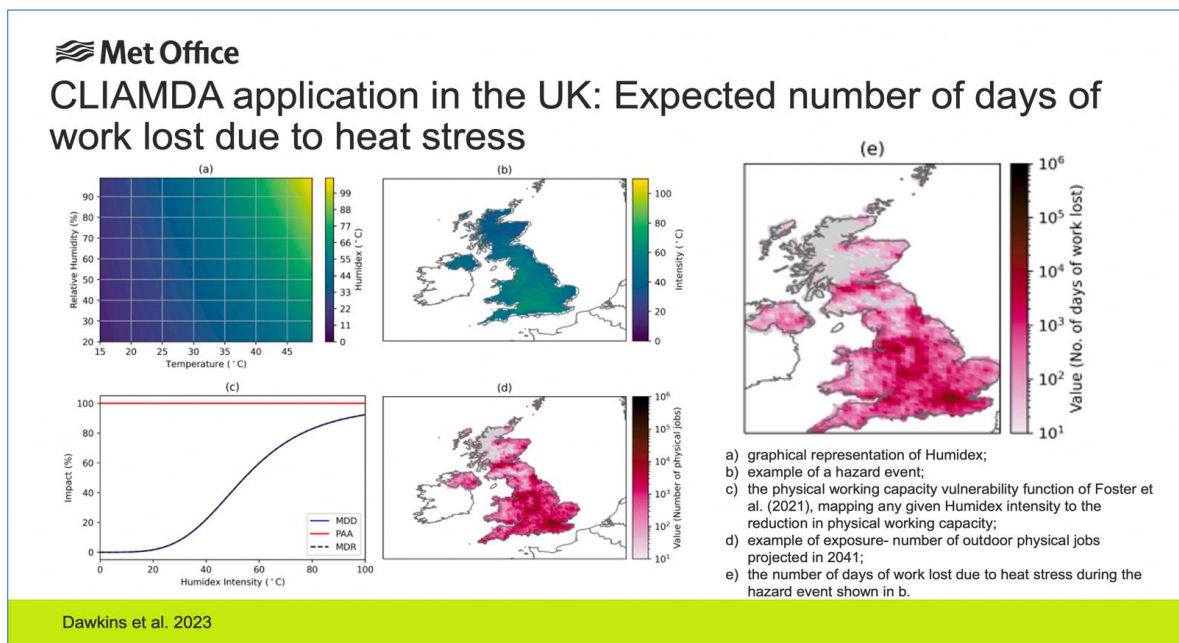
Regional studies project that Central and East Java may face 10-20 % rainfall declines, with >20% losses expanding under RCP8.5. In Sumatra, wet-season rice yields may improve, but dry-season productivity could drop 10–20% under high emissions, especially in coastal areas.



Case study of projected changes in rice yield in Sumatra based on CORDEX-SEA RCP 4.5 and RCP 8.5.

Projection of climate suitability for crops like Robusta coffee in Aceh and pest distribution shifts, such as those of the Brown Plant Hopper in Indonesia, were also assessed. A method using CORDEX data linked optimal rice yield to rainfall thresholds (~800 mm), with projections pointing to yield declines by 2040 in some scenarios. The talk emphasized the urgent need for localized, crop-specific adaptation strategies and improved data access, including bias-corrected projections and field model validation. Collaborative efforts with Indonesia's Ministry of Agriculture and Ministry of Environment aim to enhance national agricultural resilience and communication in the face of ongoing climate variability and change.

3.9 Dr Rebecca Sawyer, WISER, UK Met Office, UK, highlighted the application of the CLIMADA climate risk assessment tool to model humid-heat-related health risks in Southeast Asia. Developed by ETH Zürich and the UNDP, CLIMADA is a free, open-source platform designed to integrate hazard, exposure, and vulnerability data for probabilistic climate risk assessment, with the goal of improving resilience in vulnerable populations. The study focused on humid heat events, defined as periods of three or more days with apparent temperatures above the 95th percentile, and applied a high-resolution 4 km convection-permitting model over Viet Nam, Cambodia, and Laos, driven by UKESM1-0-LL CORDEX SEA data. Population exposure was modeled using 1 km-grid projections from 2020 to 2100 under different SSPs, combined with World Bank mortality data. Vulnerability was assessed through a temperature-mortality function that estimated heat-related deaths based on apparent temperature, population, and baseline mortality rates. This integrated approach offers a novel, granular view of climate risk in the region, valuable for adaptation planning.



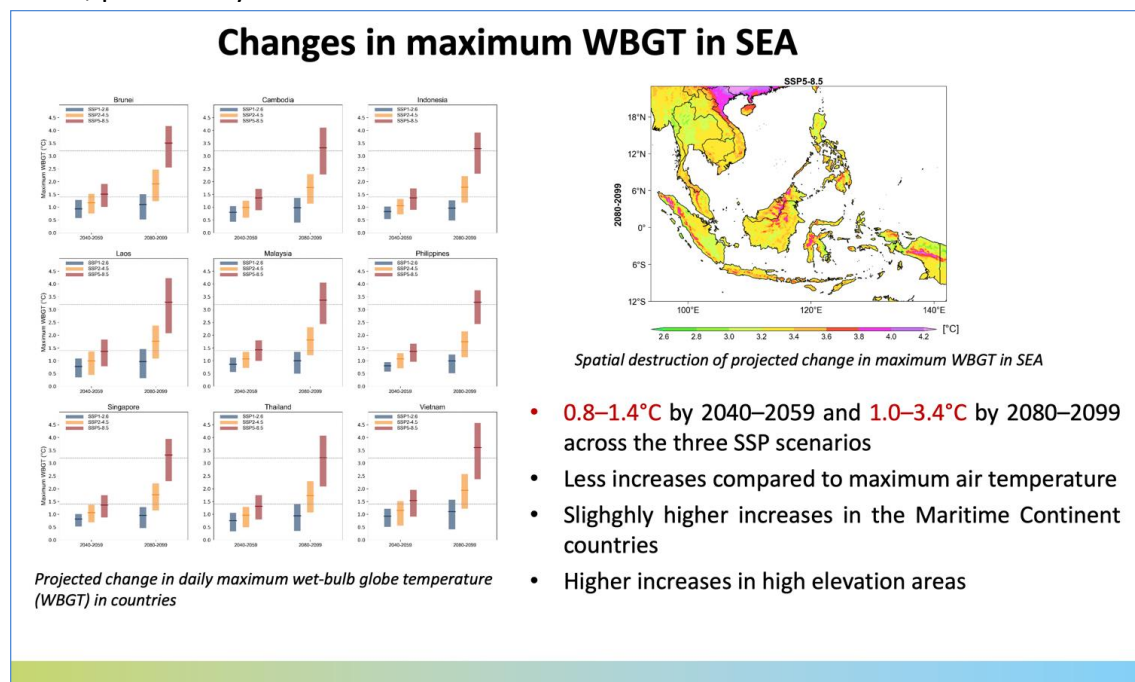
One CLIMADA application case study for the UK.

Dr. Sawyer noted several challenges, including limited and inconsistent mortality data, difficulties in selecting appropriate vulnerability functions, and the need for robust validation.

Importantly, CLIMADA’s flexible, user-adaptable structure enables stakeholders to input local data and explore tailored adaptation strategies. The talk underscored both the promise and complexity of using advanced modeling tools for climate-health risk assessments in developing countries.

3.10 Dr Jianjun Yu, CCRS, Singapore, highlighted key case studies from the Climate Change Impacts Branch (CCIB), focusing on the multifaceted impacts of climate change in Southeast Asia, particularly extreme heat, food security, vector-borne diseases, and sea level rise.

The talk began with an overview of CCIB’s mission and research scope, followed by a depiction of regional warming trends using “warming stripes,” showing that Southeast Asia is heating rapidly. Climate model projections indicate temperature increases of 1.1 to 4.0°C and Wet Bulb Globe Temperature (WBGT) increase of 1.0 to 3.4°C by 2080–2099, especially under the high-emissions scenario, with significant implications for public health due to heightened heat stress, particularly in urban areas.



Projected changes in maximum WBGT in Southeast Asia.

The impact on food security was illustrated through case studies over Thailand and Viet Nam, where rising temperatures are expected to render certain regions less suitable for rice cultivation, posing serious risks for a region dependent on rice and for import-reliant countries like Singapore. Sea-level rise was assessed through localized projections, highlighting that vulnerability varies across Southeast Asian cities, with places like Bangkok and Manila particularly at risk due to compounding factors such as land subsidence.

Dr. Yu emphasized the importance of robust climate projections in guiding adaptation strategies, and noted CCIB’s ongoing collaborations with governmental and academic

stakeholders to enhance climate resilience through targeted, data-informed policymaking. Overall, the presentation underscored the urgent need for coordinated adaptation efforts across sectors and borders in response to the accelerating impacts of climate change in the region.

Group work on drafting the regional guideline on Best practice on using projections for impact studies

3.11 Dr Aurel Moise moderated the session. The session focused on drafting regional guidelines for best practices in using climate change projections for impact studies in Southeast Asia, grounded in survey results from organizations working across sectors such as agriculture, water, health, energy, and tourism. The session began by reviewing survey findings which informed key recommendations for the guideline document, including the importance of reviewing existing datasets, incorporating case studies, aligning projections with stakeholder needs, and providing methodological guidance on topics such as bias correction, model selection, and computation of impact indicators.


A strong emphasis was placed on producing practical, user-oriented guidance with accessible tools such as Python/R functions and a web-based script-sharing hub to facilitate automated impact analyses. Working Group 1-style themes were explored, addressing issues like data visualization, uncertainty analysis, and effective communication of projections. The session also recognized the value of combining dynamical and statistical downscaling techniques to enhance the applicability of projections in regional contexts. Participants engaged in collaborative brainstorming to shape the document, with consensus-building and methodological rigor identified as priorities for future refinement. Overall, the session underscored the necessity of collaboration, accessibility, and sector-specific relevance in developing actionable climate guidance for Southeast Asia.

4 Day 4: 24 April 2025

Discussions on collaborations and recommendations

4.1 Dr Aurel Moise opened Day 4 with a recap of Day 3, highlighting the presentations by experts on regional climate impact studies. He started with Dr. Webb and CSIRO Asia-Pacific Team’s work on stakeholder engagement from initial stages of projections to sectoral case studies, and climate risk assessments. He then moved on to Ms. Ludher’s talk on climate impacts on food security in Southeast Asia and Ms. Law’s presentation on heat health and the activities at GHHIN. He then emphasized the panel discussion happening later in session 4.3 for future collaborations and the final session for the regional guideline on best practices on using regional climate projections for climate change impact studies.

4.2 Dr Sandeep Sahany presented ongoing and potential ASEAN collaborative projects, highlighting CCRS’s current initiatives and areas of interest. A key proposal includes developing Country Briefs for each ASEAN nation, co-designed to reflect local climate drivers and needs. Common themes across the proposed projects include urban climate projections, as well as climate impact studies focusing on floods and heat-health, emphasizing the importance of regional relevance and impact-driven research.

 **Malaysia**

Potential

1. Country Brief
2. Urban projections (Dr Ahmad Fairudz, MMD)
3. V3-CORDEX-SEA Roadshow (Dr Ju Neng, Prof Fredolin, Dr Faye Cruz)
4. Climate Impacts – Floods
5. Climate Impacts – Heat health

4

One example of future collaborations on climate change studies for Malaysia.

4.3 CORDEX-SEA and SEA wide collaborations, presentations and panel discussions led by Dr Faye Cruz, Prof Fredolin Tangang, and Mr Lawrence Dimailig

The panel, led by Faye Cruz, Fredolin Tangang, and Lawrence Dimailig, discussed ongoing and proposed initiatives under the CORDEX-SEA framework and broader regional collaborations.

Faye Cruz outlined CORDEX-SEA's strategic directions, including CMIP6-based climate projection analysis, empirical-statistical downscaling development, and coupled ocean-atmosphere modelling. Key projects include urban climate research under CARE for SEA Megacities, workshops in Jakarta (Aug 2025) and Vietnam (Nov 2025), and further development of SARCCIS to support data users. She emphasized linking existing SEA datasets (e.g., V3, SEA4C) and enhancing stakeholder engagement across the region.

Priorities of CORDEX-SEA

- Analysis of CMIP6 CORDEX-SEA climate projections
- Develop urban climate research (CARE for SEA Megacities)
 - Next workshop in Jakarta in August 2025
- Develop empirical statistical downscaling
- Develop coupled regional ocean – atmosphere for regional downscaling
 - Planned training workshop in Vietnam in November 2025
- Continue capacity building
- Further develop SARCCIS to provide tools for data users
 - Linking SEA data products (e.g. V3, HKUST SEA4C dataset, etc)
- Strengthen collaboration with stakeholders and policymakers
 - Planned Asia Strategic Workshop in 2025

The priority list for CORDEX-SEA's activities.

Fredolin Tangang presented a proposal by the University of Brunei Darussalam for high-resolution regional downscaling across Brunei and the wider Borneo region, intending to form a dedicated Climate Modelling Group. He highlighted the V3 dataset as a regional milestone, especially for urban-scale projections, and invited collaboration with CORDEX-SEA and other research institutes, including those exploring AI-based climate emulation.

Lawrence Dimailig focused on the integration of climate data into disaster preparedness and early warning systems. He introduced the Disaster Monitoring and Response System (DMRS) portal (<https://dmrs.ahacentre.org/dmrs/>) and proposed embedding V3 data into it for impact relevance. He stressed the importance of maintaining momentum in climate-disaster collaboration, positioning AHA Centre as a key facilitator for coordination with ASEAN institutions, policy alignment, and the development/hosting of climate insights with a disaster risk lens.

The session emphasized the critical need for interoperability of regional datasets, capacity building, and cross-sectoral integration to ensure regional preparedness and resilience in a changing climate.

4.4-4.5 Dr Aurel Moise moderated a group work on drafting a regional guideline on best practices on using climate change projections for impact studies. It was recommended that the statement of recommendations be clearly and precisely worded, with a suggestion to develop concise country-by-country fact sheet summaries for ASEAN member states. These summaries would outline each country's status in key areas such as producing and understanding climate change projections, the use and availability of gridded observational datasets (i.e., a regional stocktake), translating projections into climate risk and impact assessments, and effectively communicating projections, uncertainties, and impacts to stakeholders. This approach aims to identify gaps, support targeted capacity-building, and facilitate coordinated regional action.

4.6 Dr Aurel Moise (Moderator) – Discussion on the outline/next steps for collaborations. There was a suggestion for ARCDAP5 to build on the discussions initiated in ARCDAP4, potentially with a more focused or thematic structure to deepen engagement on specific topics such as urban projections, climate impacts, or sectoral applications, thereby fostering continuity and more targeted regional collaboration.

4.7 Dr Aurel Moise - Closing Remarks. Dr Moise gave closing remarks for the ARCDAP-4 workshop, following which all the participants were asked to fill in feedback for the workshop form provided by CCRS. Responses from the workshop feedback have been summarised in Annex C.

Annex A: List of Participants

TITLE	NAME	ORGANISATION	CONTACT
Ms	Analiya MJ	Regional Integrated Multi-Hazard Erly Warning System (RIMES)	analiya@rimes.int
Ms	Angelina Baptista Freitas	National Directorate of Meteorology and Geophysics (NDMG), Timor-Leste	angelina.ubr.freitas@gmail.com
Dr	Anupam Kumar	Centre for Climate Research Singapore (CCRS)	Anupam_KUMAR@nea.gov.sg
Mr	Arifin Hj Awg Yussof	Brunei Darussalam Meteorological Department (BDMD), Brunei Darussalam	arifin.yussof@met.gov.bn
Mr	Asif Uddin Bin Noor	Regional Integrated Multi-Hazard Erly Warning System (RIMES)	asif@rimes.int
Dr	Aurel Moise	Centre for Climate Research Singapore (CCRS)	Aurel_MOISE@nea.gov.sg
Ms	Noor Syafini Binti Ramli	Malaysian Meteorological Department (MMD; MetMalaysia)	noorsyafini@met.gov.my
Mr	Chaowat Siwapornchai	Thai Meteorological Department (TMD)	chaowats.tmd@gmail.com
Dr	Chen Chen	Centre for Climate Research Singapore (CCRS)	CHEN_Chen@nea.gov.sg
Ms	Cyrill Hope Depasucat	Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), Philippines	cyrillhope.depasucat@gmail.com
Prof	Dale Barker	Centre for Climate Research Singapore (CCRS)	Dale_BARKER@nea.gov.sg
Ms	Elyssa Kaur Ludher	ISEAS - Yusof Ishak Institute	elyssa_ludher@iseas.edu.sg

Ms	Elza Surmaini	Research Center for Climate and Atmosphere (PRIMA), National Research and Innovation Agency, Republic of Indonesia (BRIN)	elzasurmaini@gmail.com
Dr	Faye Cruz	Manila Observatory (MO), Philippines	fcruz@observatory.ph
Dr	Fei Luo	Centre for Climate Research Singapore (CCRS)	Fei_LUO@nea.gov.sg
Prof	Fredolin Tangang	Universiti Brunei Darussalam (UBD), Brunei Darussalam	ftangang@gmail.com
Mr	Hoang Trong Thang	Viet Nam National Meteorological and Hydrological Administration (VNMHA), Viet Nam	htthang.ht@gmail.com
Dr	Jianjun Yu	Centre for Climate Research Singapore (CCRS)	YU_Jianjun@nea.gov.sg
Dr	Jochen Luther	WMO RAP	JLuther@wmo.int
Dr	Kien Ba Troung	Viet Nam Institute of Meteorology, Hydrology and Climate Change (IMHEN), Viet Nam	kien.cbg@gmail.com
Mr	Lawrence Anthony Dimailig	ASEAN Co-ordinating Centre for Humanitarian Assistance on disaster management (AHA Centre)	lawrence.dimailig@ahacentre.org
Dr	Leanne Webb	Commonwealth Science and Industry Research Organisation	Leanne.Webb@csiro.au
Mr	Lonh Nrak	Department of Meteorology (DOM), Cambodia	lonhnrak.cs@gmail.com
Ms	Lydia Law	National University Singapore (NUS) Heat Resilience & Performance Centre (HRPC) and WMO-WHO Global Heat Health Information Network (GHHIN) SEA Hub	lydialaw@nus.edu.sg

Ms	Maninoud Phonsena	Department of Meteorology and Hydrology (DMH), Lao PDR	maninoud.phonsena@gmail.com
Dr	Muhammad Eeqmal Hassim	Centre for Climate Research Singapore (CCRS)	Muhammad Eeqmal HASSIM@nea.gov.sg
Ms	Nichanun Trachow	Thai Meteorological Department (TMD)	nichanun.tr@gmail.com
Mr	Phousavanh Siyavong	Department of Meteorology and Hydrology (DMH), Lao PDR	phousavanh.syv@gmail.com
Dr	Prasanna	Centre for Climate Research Singapore (CCRS)	Venkatraman PRASANNA@nea.gov.sg
Dr	Rebecca Sawyer	UK Met Office, United Kingdom	rebecca.sawyer@metoffice.gov.uk
Dr	Sandeep Sahany	Centre for Climate Research Singapore (CCRS)	Sandeep SAHANY@nea.gov.sg
Mr	Soim Monichoth	Department of Meteorology (DOM), Cambodia	monichoth@gmail.com
Mr	Terencio Moniz	National Directorate of Meteorology and Geophysics (NDMG), Timor-Leste	tfmoniz.moniz@gmail.com
Mr	Tran Quang Nang	Viet Nam National Meteorological and Hydrological Administration (VNMHA), Viet Nam	tqnang@mae.gov.vn , trannang030984@gmail.com
Mr	Wilmer Agustin	Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), Philippines	wil.ags12@gmail.com
Dr	Xin Rong Chua	Centre for Climate Research Singapore (CCRS)	CHUA Xin Rong@nea.gov.sg
Ms	Yin San Tan	Malaysian Meteorological Department (MMD; MetMalaysia)	ystan@met.gov.my
Mr	Zainul Farhan Bin Haji Awang Jamil	Brunei Climate Change Office (BCCO), Brunei Darussalam	zainul.jamil@jpm.gov.bn

Annex B: Workshop Programme

Day 1: Monday, 21st of April 2025 (All timings given in local time GMT +8)			
Welcome and Introduction			
Chair: Fei Luo Notetaker: Dr Jianjun Yu			
08:00 - 08:30	1.1	Registration	
08:30 - 08:40	1.2	Welcome Address - Director, CCRS	Prof Dale Barker (<i>Centre for Climate Research Singapore - CCRS</i>)
08:40 - 08:50	1.3	Opening Address - WMO-Regional Office for Asia and the South-West Pacific (RAP)	Mr Jochen Luther (<i>World Meteorological Organisation - WMO</i>)
08:50 - 08:55	1.4	Admin Brief + Group Photo 1	Fei Luo (<i>CCRS</i>)
08:55 - 09:15	1.5	Workshop Overview and Objectives including talk on continuation of ARCDAP series	Dr Aurel Moise (<i>CCRS</i>)
Presentation on CORDEX			
Chair: Fei Luo Notetaker: Dr Jianjun Yu			
09:15 - 09:45	1.6	CORDEX-SEA Overview	Dr. Faye Cruz (<i>CORDEX-SEA Co-Chair; Head of the Regional Climate Systems Laboratory, Manila Observatory</i>)
ASEAN NMHS/Agency representatives on National Climate Projections			
Chair: Dr Sandeep Sahany Notetaker: Dr Chen Chen			
09:45 - 10:05	1.7	National Climate Projections in Brunei	Mr. Arifin Yussof (<i>Brunei Darussalam Meteorological Department</i>) Mr. Zainul Jamil (<i>Brunei Climate Change Office</i>)
10:05 - 10:25	1.8	National Climate Projections in Cambodia	Mr. Soim Monichoth & Mr. Lonh Nrak (<i>Department of Meteorology, Cambodia</i>)
10:25 - 10:45	1.9	Climate projections in Viet Nam (WISER)	Dr. Truong Ba Kien (<i>Deputy Director, Center for Meteorology and Climatology (CMETC)</i>)
10:45 - 11:00	Morning Tea Break		
11:00 - 11:20	1.10	National Climate Projections in Lao PDR	Ms. Maninoud Phonsena & Mr. Phousavanh Siyavong (<i>Department of Meteorology and Hydrology, Ministry of Natural Resources and Environment</i>)
11:20 - 11:40	1.11	National Climate Projections in Timor-Leste	Mr. Terencio Moniz & Ms. Angelina Baptista Freitas (<i>National Directorate of Meteorology and Geophysics</i>)

11:40 - 12:00	1.12	National Climate Projections in Malaysia	Ms. Tan Yin San & Ms. Noor Syafini Ramli (<i>METMalaysia</i>)
12:00 - 12:20	1.13	National Climate Projections in Myanmar	Dr. Tin Mar Htay & Ms. Chaw Su Hlaing (<i>Department of Meteorology and Hydrology, Ministry of Transport and Communications</i>)
12:20 - 12:40	1.14	National Climate Projections in the Philippines	Ms. Cyrill Hope Depasucat & Mr. Wilmer Agustin (<i>PAGASA</i>)
12:40 - 13:40	Lunch		
13:40 - 14:00	1.15	National Climate Projections in Thailand	Ms. Nichanun Trachow & Mr. Chaowat Siwapornchai (<i>Thai Meteorological Department</i>)
14:00 - 14:20	1.16	National Climate Projections in Viet Nam	Mr. Tran Quang Nang / Mr. Hoang Trong Thang (<i>Viet Nam Meteorological and Hydrological Administration</i>)
14:20 - 15:20	1.17	V3 presentation & data sharing	Dr Sandeep Sahany (<i>CCRS</i>)
15:20 - 15:40	Afternoon Tea Break		
15:40 - 16:40	1.18	Presentation on ASEAN projection datasets	Prof. Fredolin Tangang (<i>Universiti Brunei Darussalam</i>)
16:40 - 17:30	1.19	Discussions	Dr Aurel Moise (Moderator) (<i>CCRS</i>)
17:30	End of Day 1		

Day 2: Tuesday, 22nd of April 2025			
Sharing by ASEAN NMHS/Agency representatives on observations datasets			
		Chair: Dr Jianjun Yu Notetaker: Dr Xin Rong Chua	
08:30 - 08:40	2.1	Recap of Day1 and overview for Day2	Dr Aurel Moise (<i>CCRS</i>)
08:40 - 09:10	2.2	Bias Correction in V3 Study	Dr Chen Chen (<i>CCRS</i>)
09:10 - 09:40	2.3	General presentation for SEA observational datasets	Dr Muhammad Hassim (<i>CCRS</i>)
09:40 - 09:50	2.4	National Observational datasets in Brunei	Mr. Arifin Yussof (<i>Brunei Darussalam Meteorological Department</i>)
			Mr. Zainul Jamil (<i>Brunei Climate Change Office</i>)
09:50 - 10:00	2.5	National Observational datasets in Cambodia	Mr. Soim Monichoth & Mr. Lonh Nrak (<i>Department of Meteorology, Ministry of Water Resouces and Meteorology, Cambodia</i>)

10:00 - 10:10	2.6	National Observational datasets in Lao PDR	Ms. Maninoud Phonsena & Mr. Phousavanh Siyavong (<i>Department of Meteorology and Hydrology</i>)
10:10 - 10:20	2.7	National Observational datasets in Malaysia	Ms. Tan Yin San & Ms. Noor Syafini Ramli (<i>METMalaysia</i>)
10:20 - 10:45	Morning Tea Break		
10:45 - 10:55	2.8	National Observational datasets in Myanmar	Dr. Tin Mar Htay / Ms. Chaw Su Hlaing (<i>Department of Meteorology and Hydrology</i>)
10:55 - 11:05	2.9	National Observational datasets in Philippines	Ms. Cyrill Hope Depasucat & Mr. Wilmer Agustin (<i>PAGASA</i>)
11:05 - 11:15	2.10	National Observational datasets in Thailand	Ms. Nichanun Trachow & Mr. Chaowat Siwapornchai (<i>Thai Meteorological Department</i>)
11:15 - 11:25	2.11	National Observational datasets in Timor-Leste	Mr. Terencio Moniz & Ms. Angelina Baptista Freitas (<i>National Directorate of Meteorology and Geophysics</i>)
11:25 - 11:35	2.12	National Observational datasets in Viet Nam	Mr. Tran Quang Nang & Mr. Hoang Trong Thang (<i>Viet Nam Meteorological and Hydrological Administration</i>)
11:35 - 12:30	2.13	Discussion based on survey results + presentations + Q&A	Dr Aurel Moise (Moderator) (<i>CCRS</i>)
12:30 - 13:30	Lunch		
V3 DVP & DSP Lunch Country Climate Brief Launch			
Chair: Dr Sandeep Sahany Notetaker: Dr Prasanna Venkatraman			
13:30 - 15:00	2.14	Presentation of V3 Data Visualisation Portal and LAUNCH of Data Sharing Portal	Dr Muhammad Eeqmal Hassim (<i>CCRS</i>)
15:00 - 15:20	Afternoon Tea Break		
15:20 - 16:00	2.15	LAUNCH of Philippines country brief (<i>CCRS + PAGASA + MO</i>)	Dr. Aurel Moise, Dr. Faye Cruz, Ms. Cyrill Hope Depasucat and Mr. Wilmer Agustin
16:00 - 17:30	2.16	Discussion and Group Work on country briefs	Dr Aurel Moise (Moderator) (<i>CCRS</i>)
17:30	End of Day 2		

Day 3: Wednesday, 23rd of April 2025			
Regional Climate Impact studies			
Chair: Dr Jianjun Yu Notetaker: Dr Chua Xin Rong			
08:30 - 08:45	3.1	Recap of Day2 and overview for Day3	Dr Aurel Moise (<i>CCRS</i>)

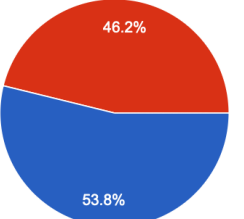
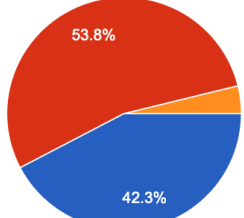
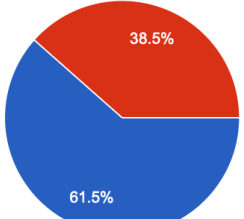
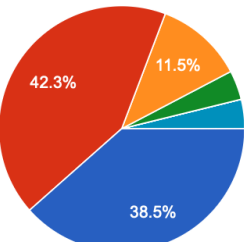
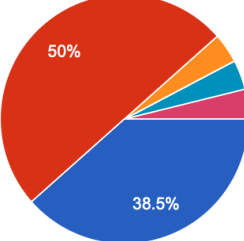
08:45 - 09:30	3.2	General introduction to climate impact studies	Dr Leanne Webb (<i>Commonwealth Science Industry Research Organisation</i>)
09:30 - 10:15	3.3	Climate Impact Case studies on Food Security	Ms. Elyssa Kaur Ludher (<i>ISEAS – Yusof Ishak Institute</i>)
10:15 - 10:30	Morning Tea Break		
10:30 - 11:15	3.4	Climate Impact Case studies on Heat and Health	Ms. Lydia Law (<i>NUS Heat Resilience & Performance Centre; GHHIN SEA Hub</i>)
11:15 - 12:00	3.5	Climate Impact Case studies on Floods and Droughts	Mr Asif Uddin Bin Noor (<i>RIMES</i>)
12:00 - 12:30	3.6	Discussion + Q&A	Dr Aurel Moise (Moderator) (<i>CCRS</i>)
12:30 - 13:30	Lunch		
Draft a regional guideline for sectoral impact studies			
Chair: Dr Sandeep Sahany Notetaker: Dr Anupam Kumar			
13:30 - 14:00	3.7	Overview of current metrics for sectoral impact studies	Dr Aurel Moise (<i>CCRS</i>)
14:00 - 14:30	3.8	Selected country impact study presentation: PRIMA/BRIN	Ms Elza Surmaini (<i>PRIMA/BRIN</i>)
14:30 - 15:00	3.9	Selected country impact study presentation: WISER on Humid-heat health risk modelling in SEA	Dr Rebecca Sawyer (<i>WISER, UK MetOffice</i>)
15:00 - 15:15	Afternoon Tea Break		
15:15 - 15:45	3.10	Showcase from CCRS Climate Change Impacts Branch Case Studies	Dr Jianjun Yu (<i>CCRS</i>)
15:45 - 17:30	3.11	Group work on drafting the regional guidelines – <i>Best practice on using projections for impact studies</i>	Dr Aurel Moise (Moderator) (<i>CCRS</i>)
17:30	End of Day 3		

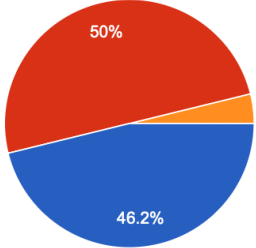
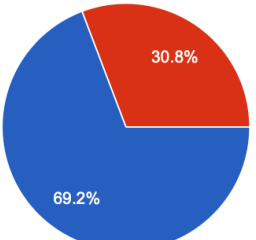
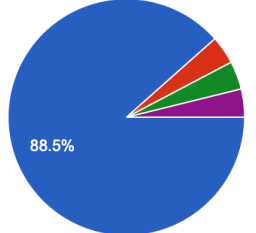
Day 4: Thursday, 24th of April 2025			
Discussions on collaborations			
Chair: Dr Aurel Moise Notetaker: Dr Muhammad Eqmal Hassim			
08:30 - 08:45	4.1	Recap of Day3 and overview for Day4	Dr Aurel Moise (<i>CCRS</i>)
08:45 - 09:15	4.2	Overview of ongoing/potential ASEAN projects	Dr Sandeep Sahany (<i>CCRS</i>)

09:15 - 09:45	4.3	CORDEX-SEA and SEA wide collaborations – presentations and Panel discussion	Dr Faye Cruz / Prof Fredolin Tangang / Mr Lawrence Dimailig (<i>Manila Observatory/ Universiti Brunei Darussalam/ AHA Centre</i>)
09:45 - 10:30	4.4	Drafting Guidelines on Regional climate impact studies (continued)	Dr Aurel Moise / Dr Jianjun Yu (Moderators) (<i>CCRS</i>)
10:30 - 10:45	Morning Tea Break		
10:45 - 11:30	4.5	Drafting Guidelines on Regional climate impact studies (continued)	Dr Aurel Moise / Dr Jianjun Yu (Moderators) (<i>CCRS</i>)
11:30 - 12:15	4.6	Discussions on the outline/next steps for collaborations	Dr Aurel Moise (Moderator) (<i>CCRS</i>)
12:15 - 12:30	4.7	Closing Remarks	Dr Aurel Moise (<i>CCRS</i>)
12:30 - 13:30	Lunch		
13:30	End of Day 4 and overall ARCDAP-4 Workshop		

Annex C: Workshop Feedback

Rating scale-based questions

Question	score	legend
How would you rate the overall organization of the ARCDAP-4 workshop?		<ul style="list-style-type: none"> ● 5 - Excellent ● 4 - Very good ● 3 - Good ● 2 - Satisfactory ● 1 - Needs improvement
How would you rate the overall quality of the content of the ARCDAP-4 workshop?		<ul style="list-style-type: none"> ● 5 - Excellent ● 4 - Very good ● 3 - Good ● 2 - Satisfactory ● 1 - Needs improvement
How relevant was the workshop content to your professional work in climate science, services, or policy?		<ul style="list-style-type: none"> ● 5 - Very relevant ● 4 - Relevant ● 3 - Neutral ● 2 - Somewhat relevant ● 1 - Not relevant
To what extent did the workshop enhance your understanding of climate data analysis and regional climate projections?		<ul style="list-style-type: none"> ● 5 - Very Strong ● 4 - Strong ● 3 - Medium ● 2 - Neutral ● 1 - Little ● The vision on what are the next priorities is very important
How would you rate the usefulness of the tools, methods, or case studies presented during the workshop (e.g., CORDEX-SEA data, V3 data portal, bias correction, climate change indices etc)?		<ul style="list-style-type: none"> ● 5 - Very Strong ● 4 - Strong ● 3 - Medium ● 2 - Neutral ● 1 - Little ● V3 data portal not able to access from Malaysia ● NA

<p>Were the sessions effectively tailored to the needs and context of the ASEAN region?</p>		<ul style="list-style-type: none"> ● 5 - Strongly agree ● 4 - Agree ● 3 - Somewhat agree ● 2 - Neutral ● 1 - Little agreement
<p>Did the workshop facilitate meaningful regional collaboration or networking opportunities?</p>		<ul style="list-style-type: none"> ● 5 - Yes, definitely ● 4 - Yes ● 3 - To some extent ● 2 - Neutral ● 1 - Not really
<p>Would you be interested in participating in future ARCDAPs or related activities (e.g., technical training, working groups, collaborative projects)?</p>		<ul style="list-style-type: none"> ● Yes ● Maybe ● No ● Depends on approval of boss ● For certain sessions yes

Selected responses to short answer questions:

1. What key insights did you learn during this workshop?
 - *Where ASEAN is at in regards to climate modelling- that we have a ways to go and there's potential for mutual assistance*
 - *Learning from examples of Climate Impact Studies made around the region as well as from other places such as the Pacific Islands.*
 - *I got the idea how can implement the Climate Projections in my Country.*
 - *The projections was insightful for me because I am a disaster management practitioner and the impacts presentations were really knowledge enhancing.*

2. Do you have any suggestions for improving the ARCDAP workshop?
 - *Very well organised. Thank you for the invitation.*
 - *Include and invite also Disaster management for sharing their experience in ASEAN member countries.*
 - *In the spirit of expanding work on climate impact assessment, increase thematic sectoral involvement, and design the sessions based on their needs.*
 - *Next workshops could be more thematic, that is, centered on certain sectoral impacts (e.g., disaster management), to allow for a more focused and deeper discussion.*

3. Which session or component of the workshop did you find most valuable?
- *This first session to explain each country's capabilities in climate modelling*
 - *The "V3 Study Presentation and Data Visualisation Portal" session (Day 2, Session 2.15) was most valuable. Seeing firsthand how the high-resolution V3 ensemble products are visualized and shared via the online portal provided concrete insights into making regional climate projections accessible for operational use.*
 - *V3 data, availability, visualization , report/method on sub-selection bias correction, and impact study cases*
 - *Day 2: Agency presentatives on observations datasets*
 - *It was helpful to learn about the current situation in different SEA countries, as well as the talks on climate impacts.*
4. What topic(s) would you like to see covered in a future ARCDAP-5?
- *Machine Learning/AI. Advanced post processing techniques of climate projection data. Advanced visualisation of datasets. Workshop on Bias Correction?*
 - *Methods of Integration from climate projection outputs to early warning systems/ operational systems for stakeholders understanding*
 - *A session on best practice delivering the climate projections to policymaker*
 - *Country application of climate modelling on sector impacts*