CORDEX-SEA: Providing Regional Climate Information for Enabling Adaptations in Southeast Asia

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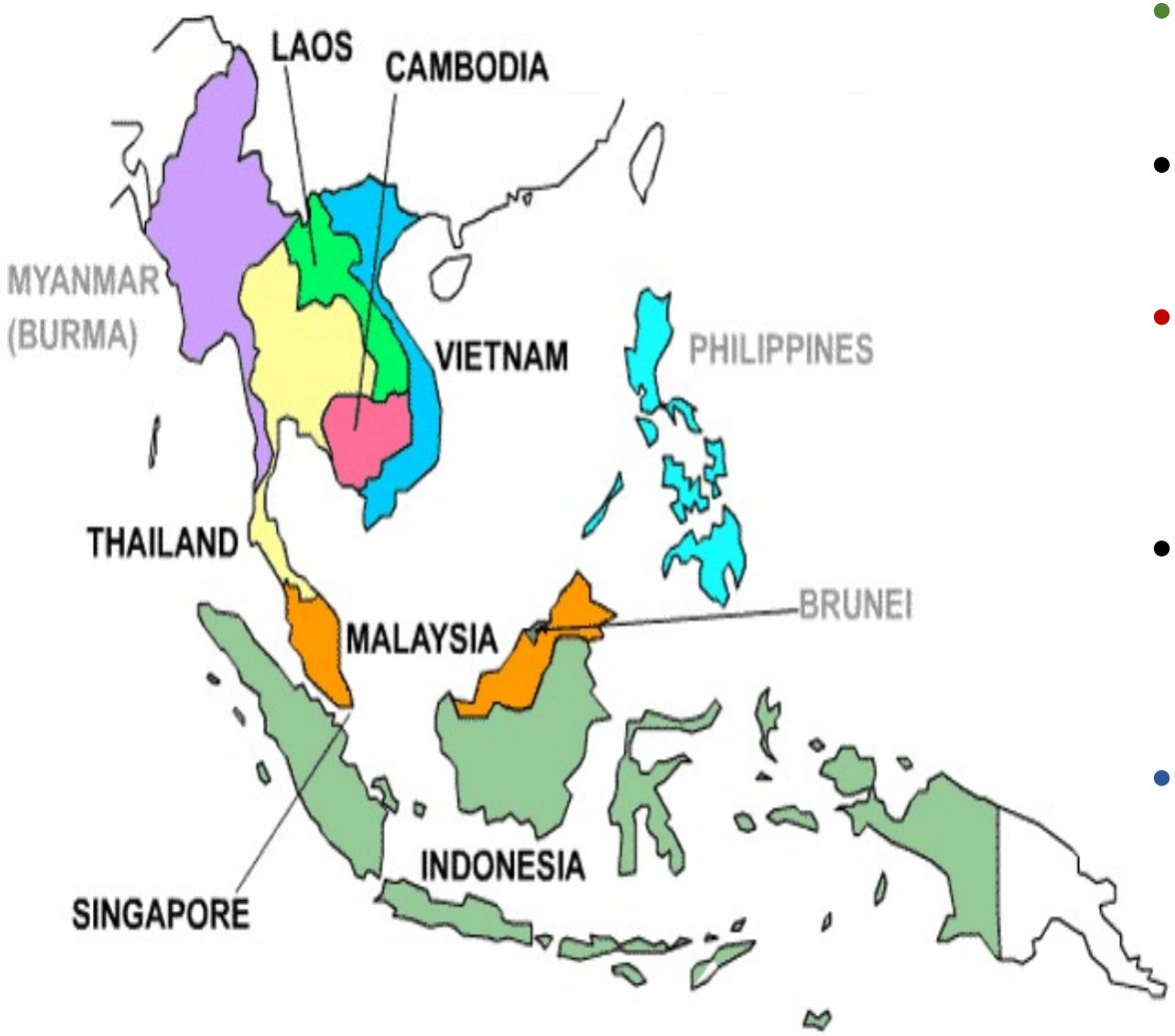
Outline

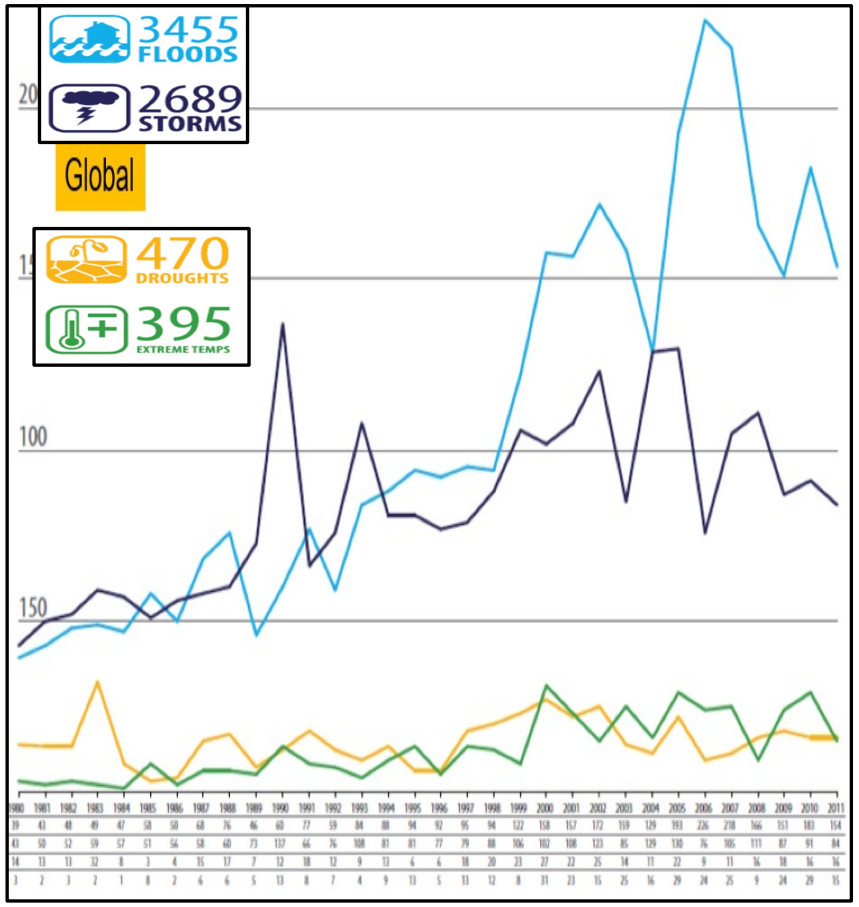
- Southeast Asia: Exposure, vulnerability and knowledge gaps in enabling adaptation
- CORDEX-SEA: A step towards enabling adaptation
- Future research priorities

Southeast Asia



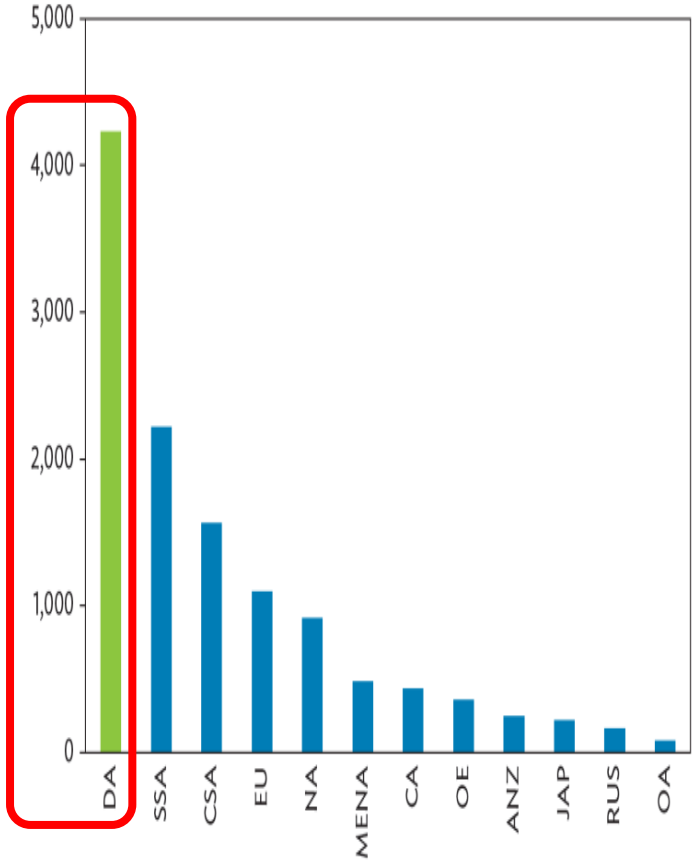
- Home to > 0.65 billion people & growing
- High exposure and vulnerability to climate extremes: floods, droughts, typhoons, SLR
- Various key sectors could be severely impacted
- Need to adapt and minimize impacts; need robust policy for adaptation, increase climate resilience and implement NAP
- Large knowledge gaps on how climate change impacting critical sectors (IPCC AR5 WGII, 2014)
- Inter-country variations in knowledge availability and capability in generating climate change information

Climate related disaster 1980-2011



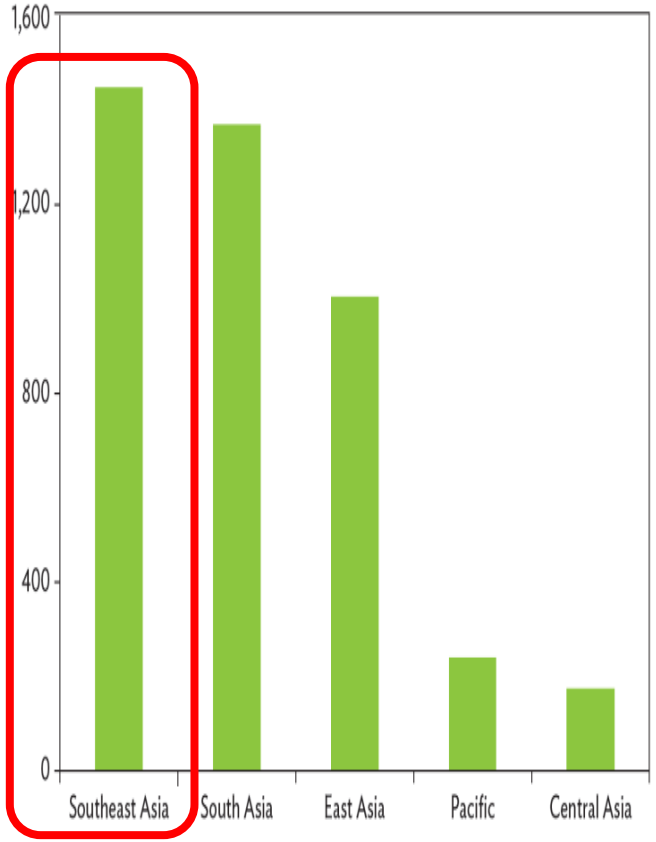
EM-DAT
The International Disaster Database
Centre for Research on the Epidemiology of Disasters - CRED

Figure 1: Total Number of Disasters, 1980–2017



ANZ = Australia and New Zealand, CA = Caribbean, CSA = Central and South America, DA = developing Asia, EU = European Union, JAP = Japan, MENA = Middle East and North Africa, NA = North America, OA = other Asia, OE = other Europe, RUS = Russian Federation, SSA = sub-Saharan Africa.
Source: Authors, based on Centre for Research on the Epidemiology of Disasters. Emergency Events Database. https://www.emdat.be (accessed 1 August 2018).

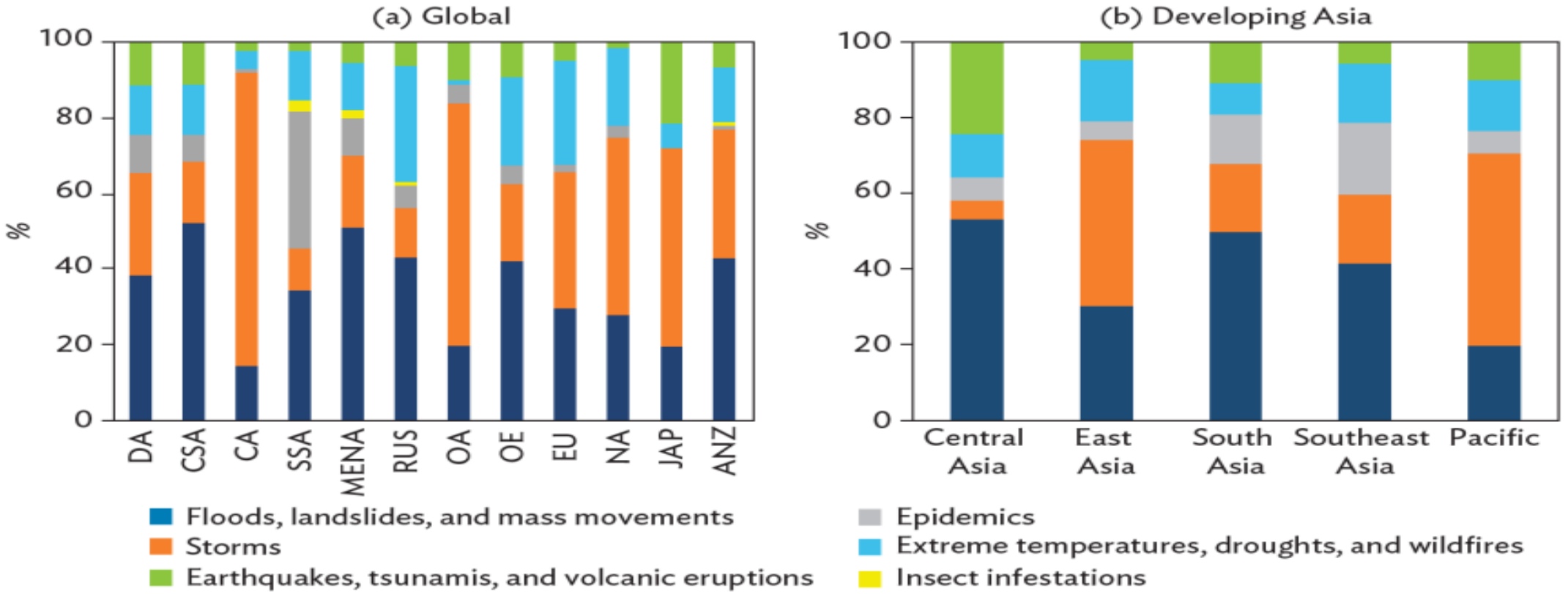
Figure 2: Total Number of Disasters in Developing Asia Subregions, 1980–2017



Source: Authors, based on Centre for Research on the Epidemiology of Disasters. Emergency Events Database. https://www.emdat.be (accessed 1 August 2018).

Dagli & Ferrarini 2019 (The Growth Impact of Disasters in Developing Asia, ADB Economic Working Paper Series)

Figure 3: Disaster Types, 1980–2017



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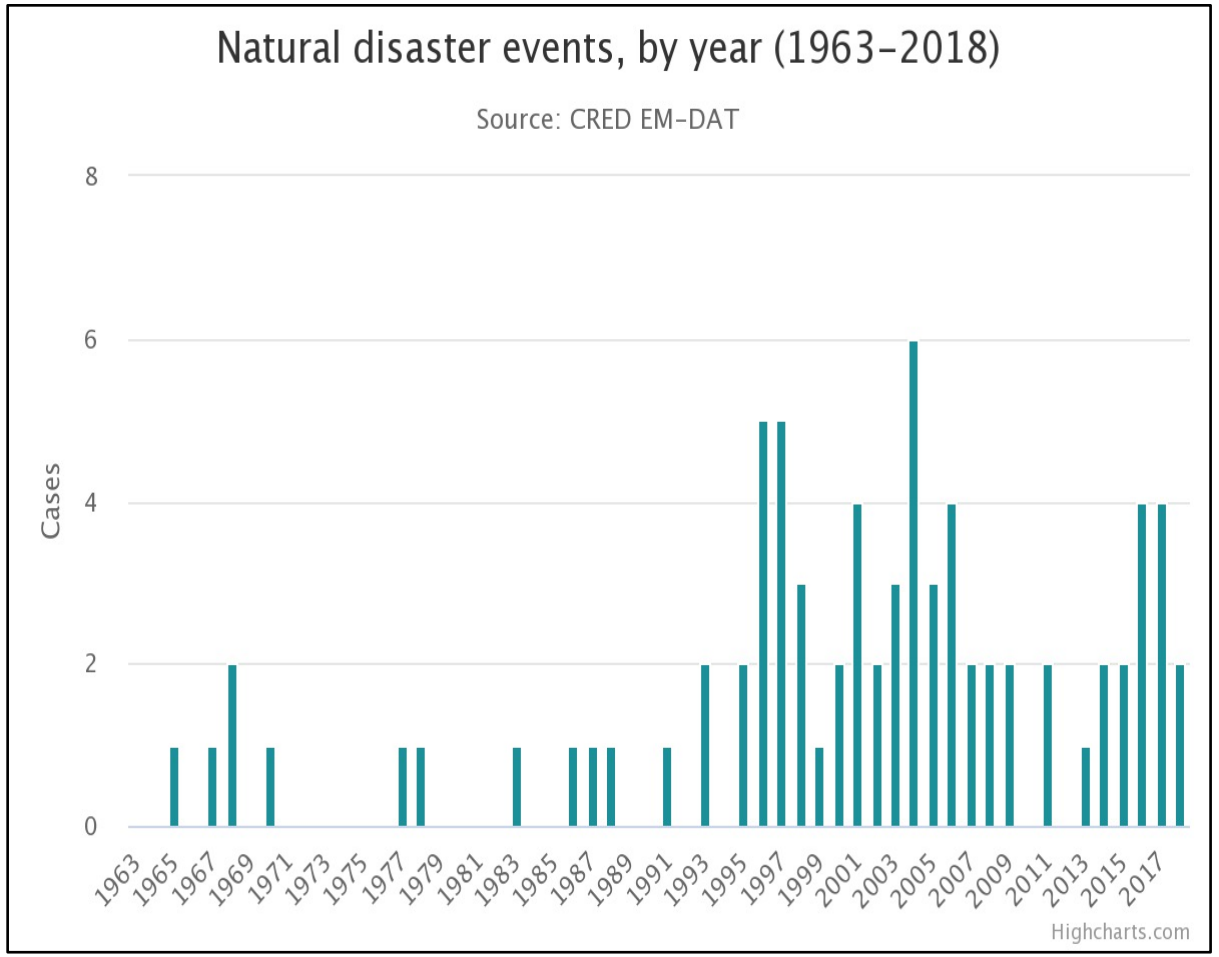

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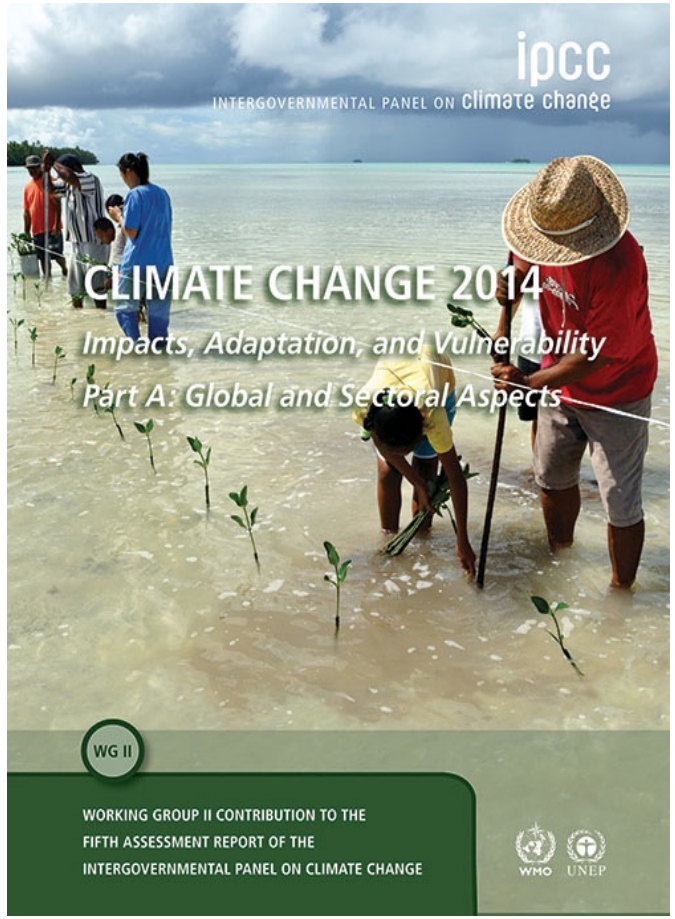
MALAYSIA: Natural disasters 1963-2018, 75% Flood events

The amount of information supporting conclusion regarding observed and projected impacts (Table24.2 IPCC AR5 WGII)

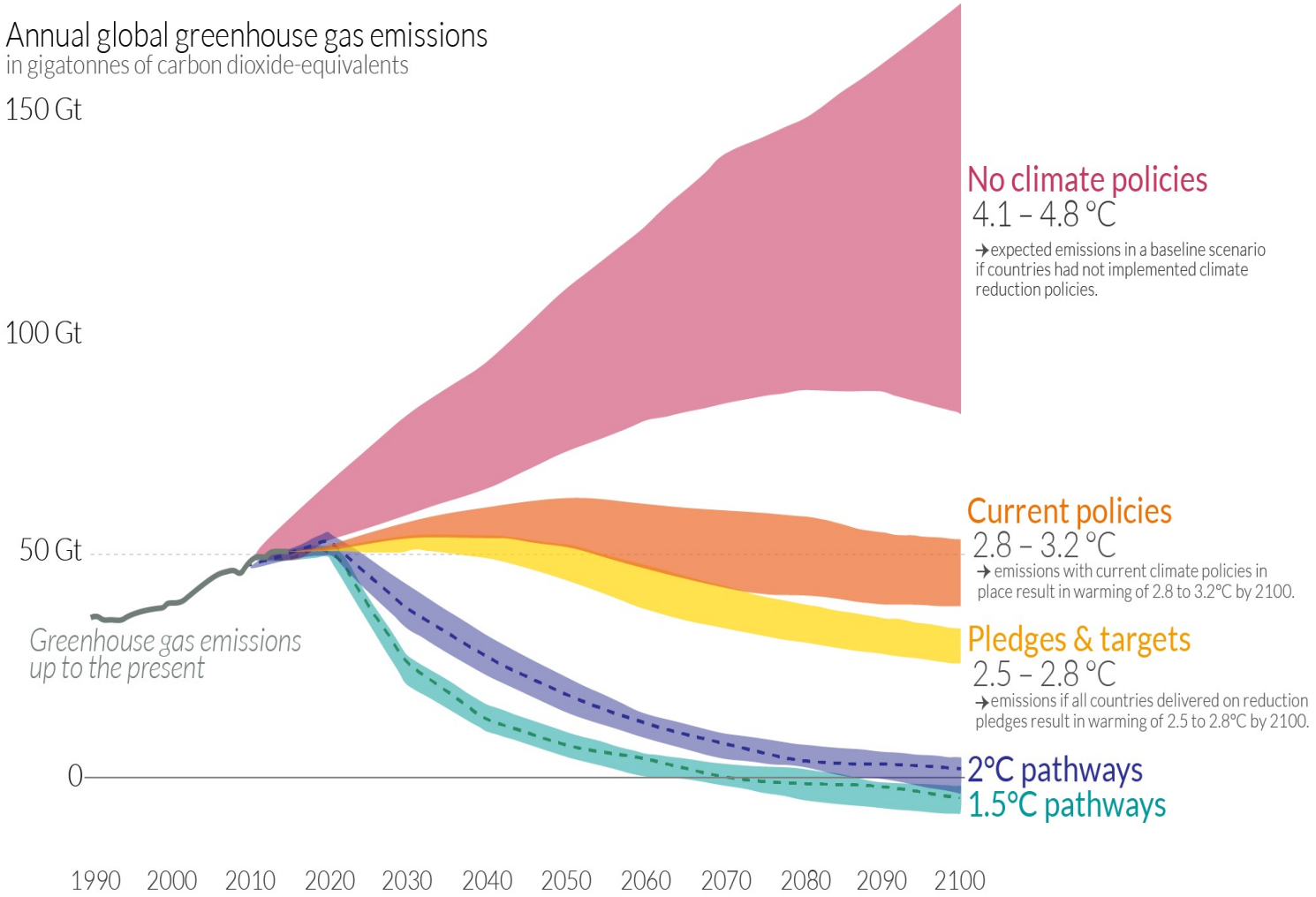


Sector	Topics/issues	North Asia		East Asia		Southeast Asia		South Asia		Central Asia		West Asia	
	O = Observed impacts, P = Projected Impacts	O	P	O	P	O	P	O	P	O	P	O	P
Freshwater resources	Major river runoff	/	x	/	/	/	/	/	x	x	x	x	x
	Water supply	x	x	x	x	x	x	x	x	x	x	x	x
Terrestrial and inland water systems	Phenology and growth rates	/	/	/	/	x	x	x	x	x	x	x	x
	Distributions of species and biomes	/	/	/	/	x	x	x	/	x	x	x	x
	Permafrost	/	/	/	/	/	x	/	/	/	/	/	x
	Inland waters	x	x	/	x	x	x	x	x	x	x	x	x
Coastal systems and low-lying areas	Coral reefs	NR	NR	/	/	/	/	/	/	NR	NR	/	/
	Other coastal ecosystems	x	x	/	/	x	x	x	x	NR	NR	x	x
	Arctic coast erosion	/	/	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Food production systems and food security	Rice yield	x	x	/	/	x	/	x	/	x	x	X	/
	Wheat yield	x	x	x	x	x	x	x	/	x	x	/	/
	Corn yield	x	x	x	/	x	x	x	x	x	x	x	x
	Other crops (e.g., barley, potato)	x	x	/	/	x	x	x	x	x	X	/	/
	Vegetables	x	x	/	x	x	x	x	x	x	x	x	x
	Fruits	x	x	/	x	x	x	x	x	x	x	x	x
	Livestock	x	x	/	x	x	x	x	x	x	x	x	x
	Fisheries and aquaculture production	x	/	x	/	x	/	x	x	x	x	x	x
	Farming area	x	/	x	/	x	x	x	/	x	/	x	x
	Water demand for irrigation	x	/	x	/	x	x	x	/	x	x	x	x
	Pest and disease occurrence	x	x	x	x	x	x	x	/	x	x	x	x
Human settlements, industry, and infrastructure	Floodplains	x	x	/	/	/	/	/	/	x	x	x	x
	Coastal areas	x	x	/	/	/	/	/	/	NR	NR	x	x
	Population and assets	x	x	/	/	/	/	/	/	x	x	x	x
	Industry and infrastructure	x	x	/	/	/	/	/	/	x	x	x	x
Human health, security, livelihoods, and poverty	Health effects of floods	x	x	x	x	x	x	/	x	x	x	x	x
	Health effects of heat	x	x	/	x	x	x	x	x	x	x	x	x
	Health effects of drought	x	x	x	x	x	x	x	x	x	x	x	x
	Water-borne diseases	x	x	x	x	/	x	/	x	x	x	x	x
	Vector-borne diseases	x	x	x	x	/	x	/	x	x	x	x	x
	Livelihoods and poverty	x	x	/	x	x	x	/	x	x	x	x	x
	Economic valuation	x	x	x	x	/	/	/	/	x	x	x	x

Global greenhouse gas emissions and warming scenarios

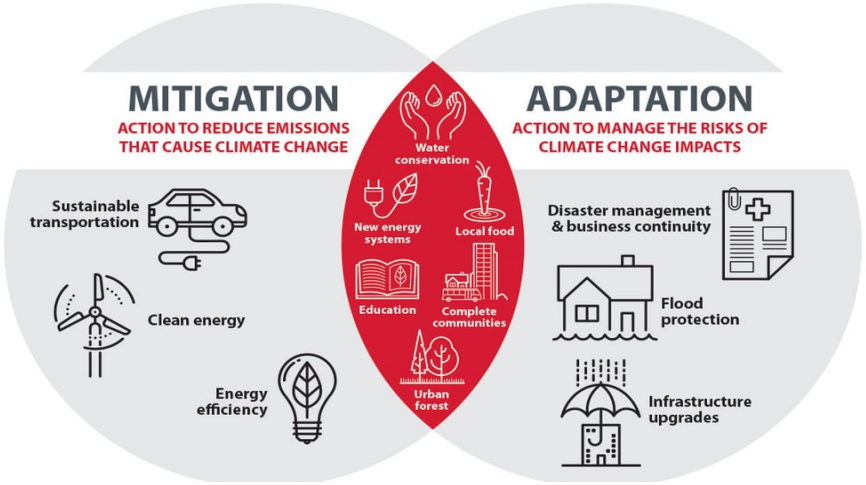
– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

Our World in Data



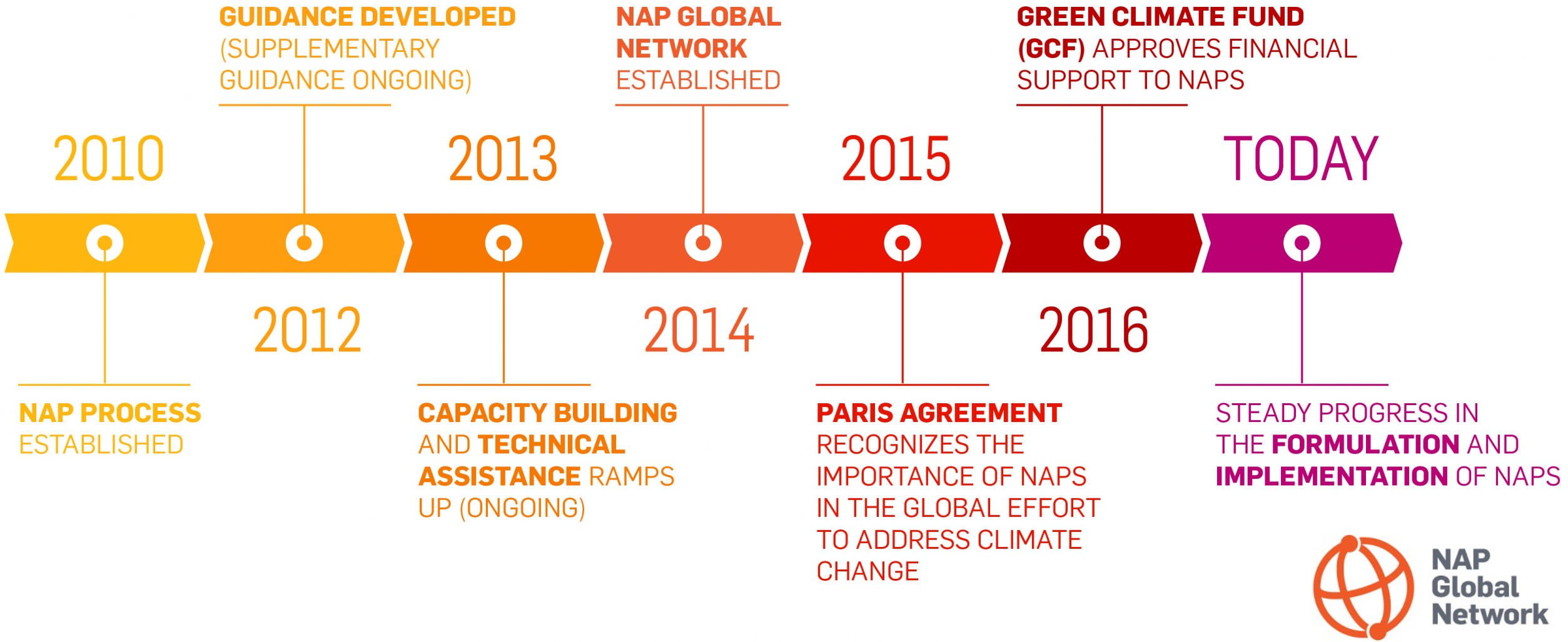
Data source: Climate Action Tracker (based on national policies and pledges as of December 2019).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Building Climate Resilience



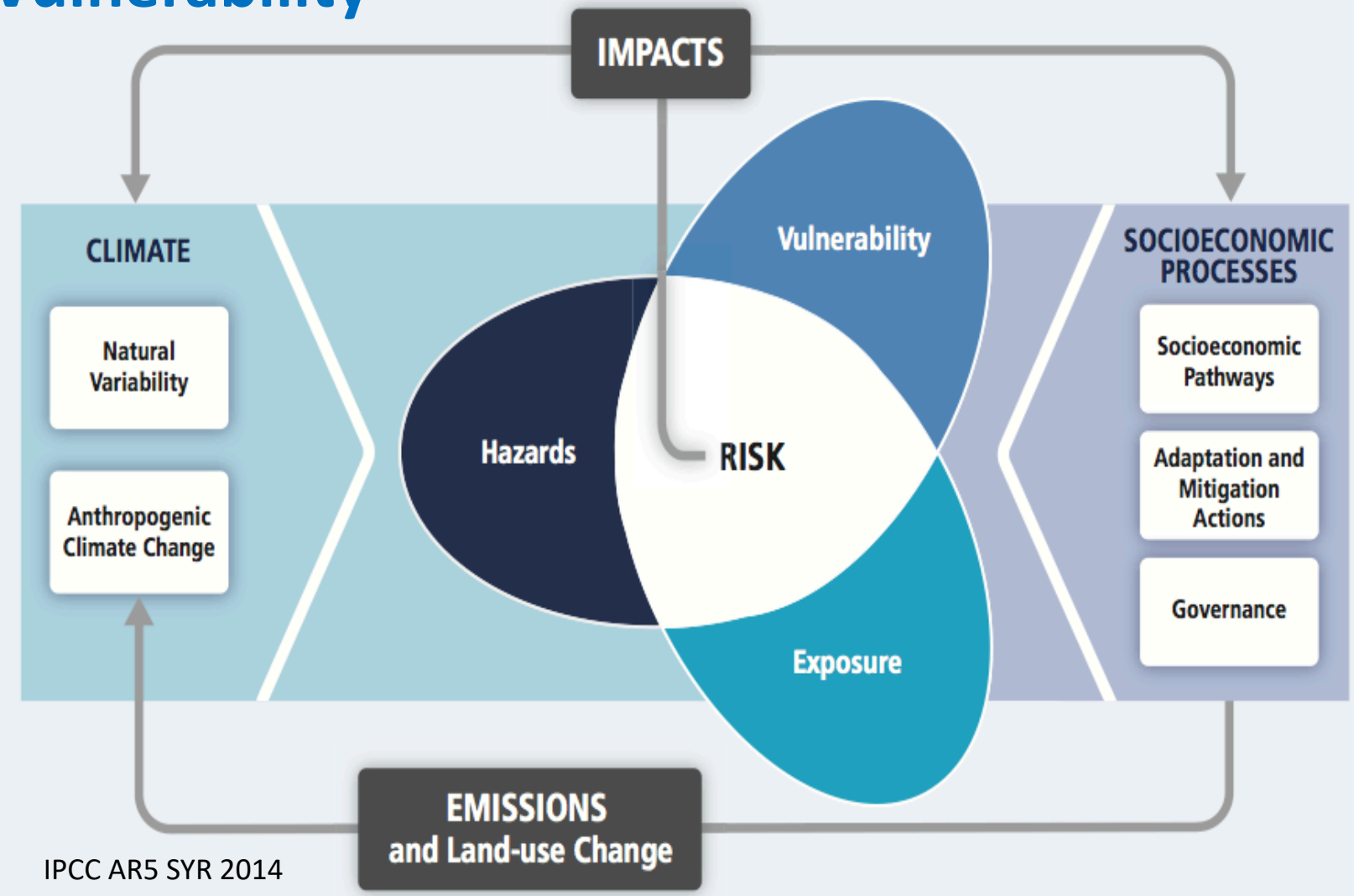
https://www.calgary.ca/UEP/ESM

National Adaptation Plan



NAP Global Network

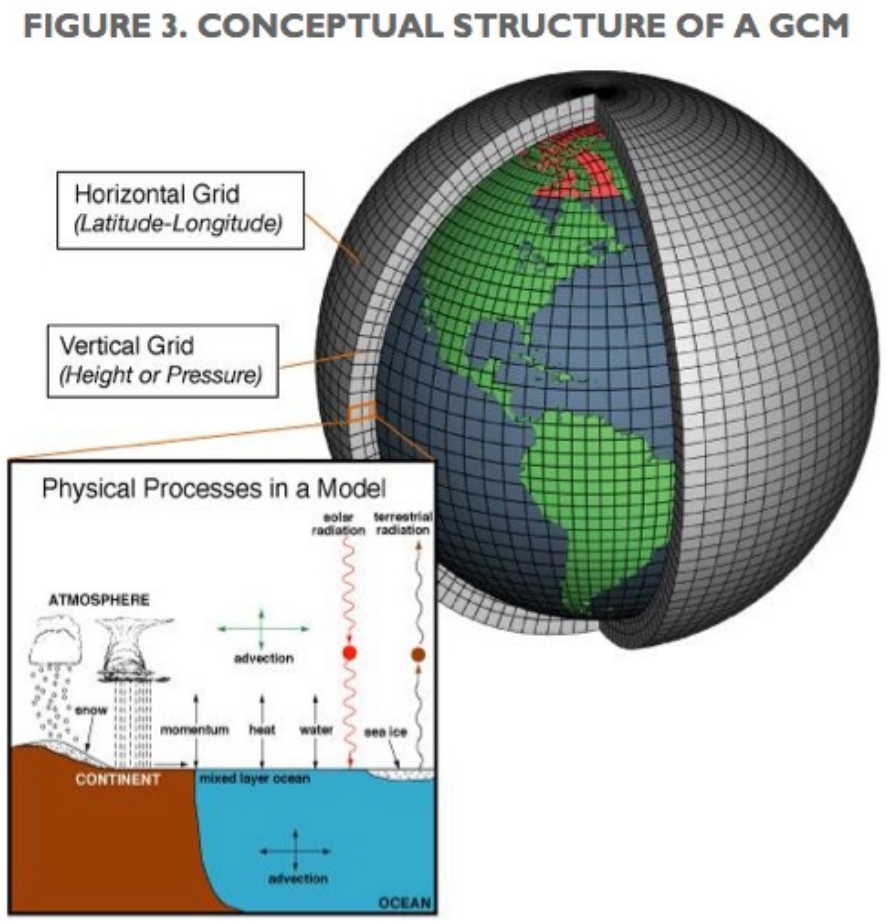
Risk of Impacts as functions of Climate Hazards, Exposure and Vulnerability



IPCC AR5 SYR 2014

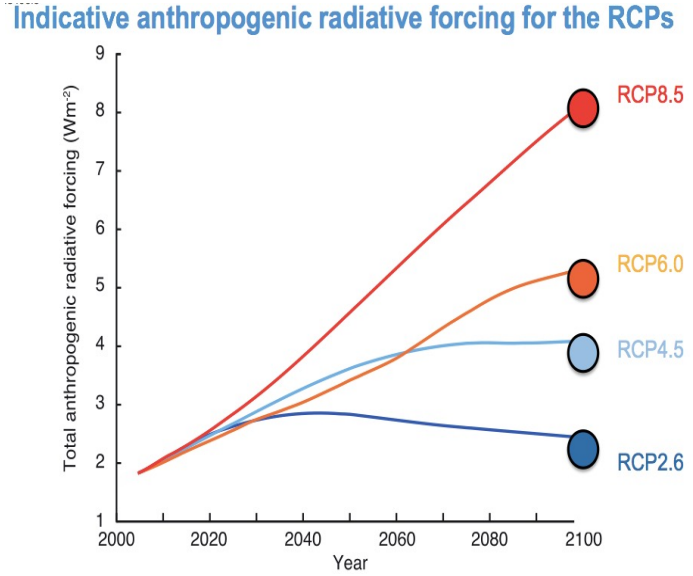
- Climate information (past, present and future) is at local scales is vital in risk assessment of climate impacts
- Future climate information must be based on robust projections (multi-models, multi-scenarios, high-resolutions) to become the basis for NAP

Modelling Future Climate Using Global Climate Model (GCM)

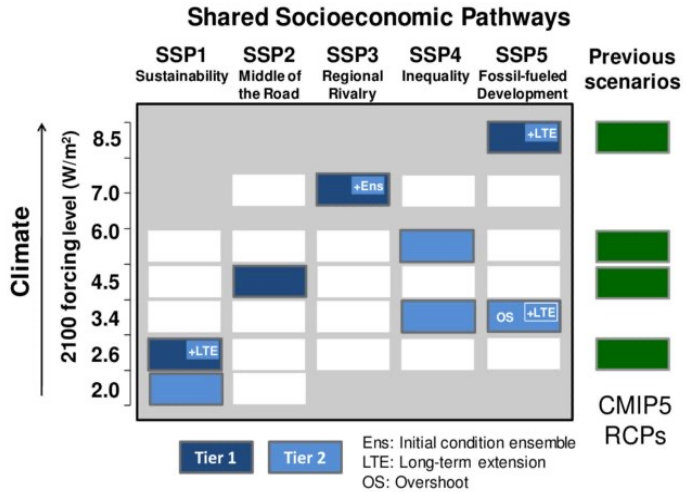


Source: National Oceanic and Atmospheric Administration (NOAA), 2012

Resolution 100 - 300 km



CMIP5



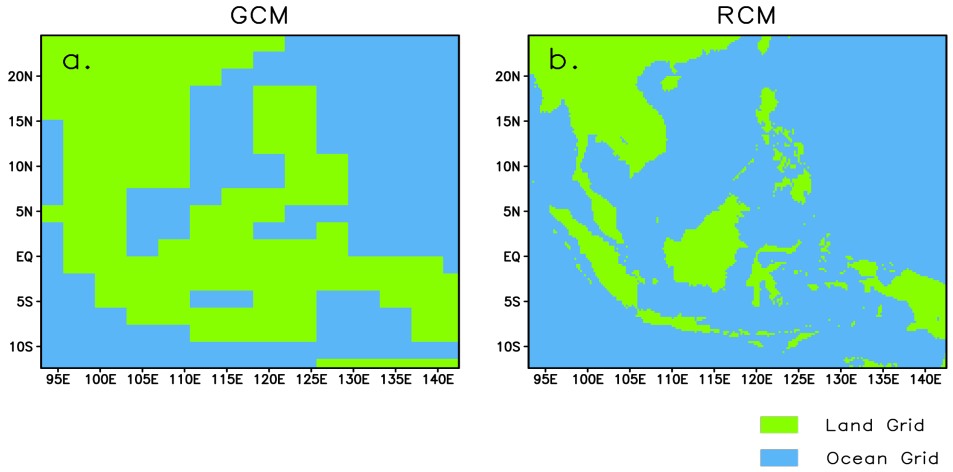
CMIP6

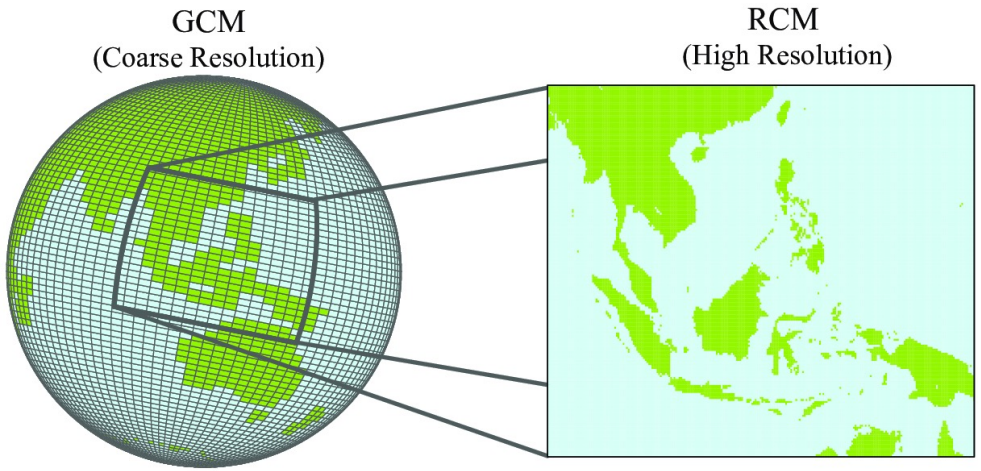
(Eyring et al. 2016)

GCM vs. RCM

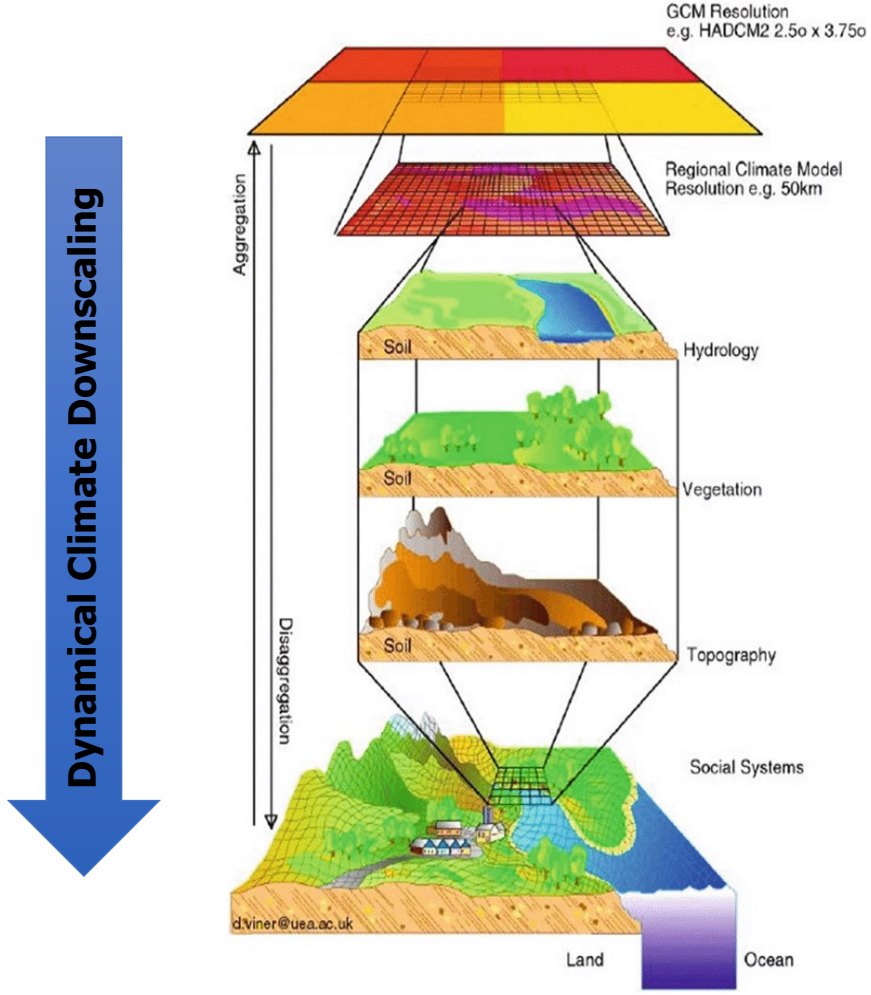
Regional Climate Downscaling (RCD)

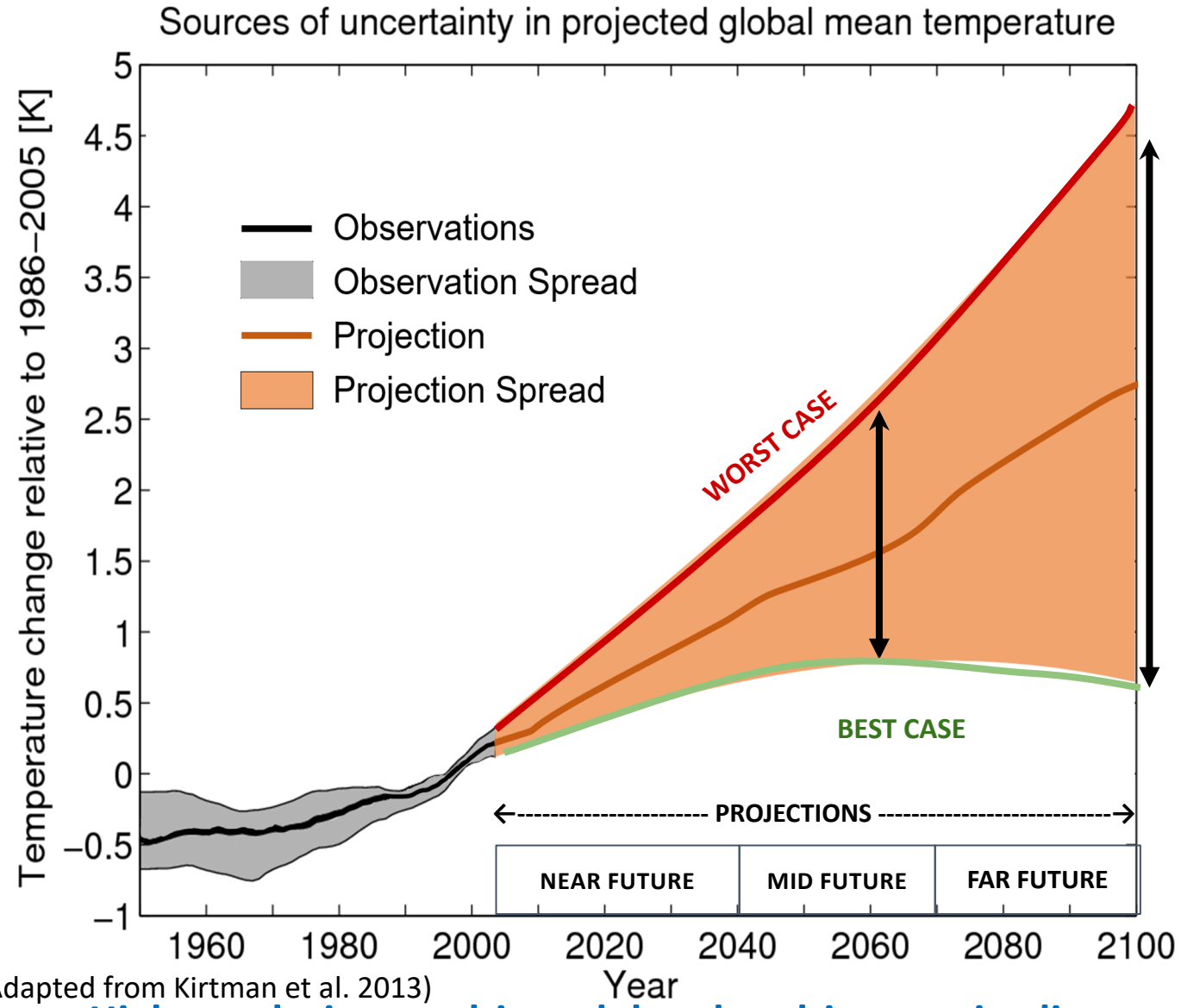
Landmasses in GCM and RCM





Tangang et al. (2021)





(Adapted from Kirtman et al. 2013)

RCM outputs

- **Model ensemble**
  combination of several models

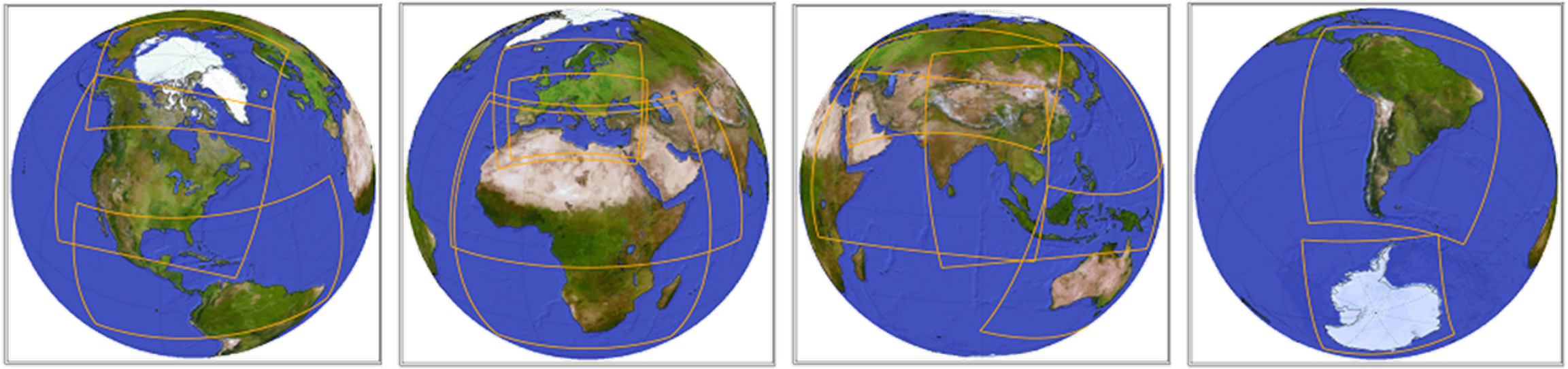
- **Confidence & Robustness**
  More models can give **more confidence** to model output & robustness in the projection

- **Model spread**

High-resolution, multi-model and multi-scenario climate downscaling can be very expensive and time consuming to implement!!

Coordinated Regional Climate Downscaling Experiment (CORDEX)

Coordinated Regional Climate Downscaling Experiment



- Arctic CORDEX
- North America CORDEX
- Central America CORDEX
- EURO-CORDEX
- MED-CORDEX
- CORDEX Africa
- MENA-CORDEX
- Central Asia CORDEX
- South Asia CORDEX
- East Asia CORDEX
- South East Asia CORDEX
- Australasia CORDEX
- South America CORDEX
- CORDEX Antarctica

Initial Workshop convened by Fredolin Tangang and hosted by VNU Hanoi University of Science, Vietnam, 2-3 Aug 2012

SEACLID/CORDEX-SEA

APN ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

WCRP CORDEX Coordinated Regional Climate Downscaling Experiment

With involvement of scientists from various institutions

14th Domain of CORDEX

Led to the formation of the Southeast Asia Regional Climate Downscaling (SEACLID) (a Project funded by APN), which later streamlined into CORDEX and became the 14th domain of CORDEX and now better known as CORDEX Southeast Asia or CORDEX-SEA.

SEACLID/CORDEX SEA MODELS: 11 GCMs and 7 RCMs

Table 1 The list of simulations carried out in CORDEX-SEA

Ensemble member	GCM	RCM	Projection Periods of 21st Century		
			Early (2011–2040)	Mid (2041–2070)	End (2071–2099)
1	CNRM-CM5 (CNRM, France)	RegCM4 (ICTP, Italy)	x	x	x
2	HadGEM2-ES (Hadley Centre, UK)	RegCM4 (ICTP, Italy)	x	x	x
3	MPI-ESM-MR (MPI-M, Germany)	RegCM4 (ICTP, Italy)	x	x	x
4	EC-Earth (EC-Earth consortium)	RegCM4 (ICTP, Italy)	x	x	x
5	CSIRO MK3.6 (CSIRO, Australia)	RegCM4 (ICTP, Italy)	x	x	x
6	CNRM-CM5 (CNRM, France)	RCA4 (SMHI, Sweden)	x	x	x
7	MPI-ESM-LR(MPI, Germany)	ROM(GERICS-AWI, Germany)[b]	x	x	x
8	HadGEM2-ES (Hadley Centre, UK)	RCA4 (SMHI, Sweden)	x	x	x
9	ACCESS1.0 (CSIRO, Australia)	CCAM (CSIRO, Australia)[a]		x	
10	MRI-AGCM (MRI, Japan)	NHRCM (MRI, Japan)[c]			x
11	HadGEM2-AO (Hadley Centre, UK)	WRF (NCAR USA)	x	x	x
12	HadGEM2-ES (Hadley Centre, UK)	PRECIS (Hadley Centre, UK)[a]	x	x	x
13	CCSM4 (NCAR, USA)	CCAM (CSIRO, Australia)[a]		x	
14	CNRM-CM5 (CNRM, France)	CCAM (CSIRO, Australia)[a]		x	

[a]Only RCP8.5

[b]50 km × 50 km resolution with larger domain size to cover warm pool of western Pacific Ocean

[c]Baseline period (1981–2000), end of 21st period (2080–2099)

Tangang et al. (2020, Clim Dyn)

List of published papers on CORDEX SEA

- Juneng et al. 2016. Sensitivity of Southeast Asia rainfall simulations to cumulus and air-sea flux parameterizations in RegCM4. *Climate Research*, 69(1):59–77.
- Ngo-Duc et al. 2017. Performance evaluation of RegCM4 in simulating extreme rainfall and temperature indices over the CORDEX-Southeast Asia region: Performance evaluation of RegCM4 over the CORDEX-Southeast Asia Region. *International Journal of Climatology*, 37: 1634–1647
- Cruz et al. 2017. Sensitivity of temperature to physical parameterization schemes of RegCM4 over the CORDEX-Southeast Asia region. *International Journal of Climatology*, 37: 5139–5153; DOI:10.1002/joc.5151
- Chung et al. 2018. Performances of BATS and CLM land-surface schemes in RegCM4 in simulating precipitation over CORDEX Southeast Asia domain. *International Journal of Climatology,* 38: 794–810; DOI: 10.1002/joc.5032
- Tangang et al. 2018. Future changes in annual precipitation extremes over Southeast Asia under global warming of 2° C. *APN Science Bulletin, 8*(1). doi:10.30852/sb.2018.436
- Tan et al (2019), Future hydro-meteorological drought of the Johor River Basin, Malaysia, based on CORDEX-SEA Projections, *Hydrological Sciences Journal*, DOI:10.1080/02626667.2019.1612901
- Tangang et al. 2019. Projected future changes in mean precipitation over Thailand based on multi-model regional simulations of CORDEX Southeast Asia. *Int J Climatol.* 1-24. https://doi.org/10.1002/joc.6163
- Trinh-Tuan et al. 2019. Application of Quantile Mapping Bias Correction for Mid-Future Precipitation Projections over Vietnam, SOLA, 15, 1-6
- Tangang et al. 2020. Projected Future Changes in Rainfall in Southeast Asia based on CORDEX – SEA Multi-model Simulations. *Climate Dynamics,* https://doi.org/10.1007/s00382-020-05322-2
- Supari et al. 2020. Multi-model projections of precipitation extremes in Southeast Asia based on CORDEX-Southeast Asia simulations, Environmental Research, Environmental Research 184, 109350
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- Tan et al. 2020. SouthEast Asia HydrO-meteorological droughT (SEA-HOT) framework: A case study in the Kelantan River Basin, Malaysia, Atmospheric Research, 246, 105155
- Nguyen-Thuy et al. 2020. Time of emergence of climate signals over Vietnam detected from the CORDEX-SEA experiments. https://doi.org/10.1002/joc.6897
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- Tibay et al. 2021. Climatological characterization of tropical cyclones detected in the regional climate simulations over the CORDEX-SEA domain. International Journal of Climatology. https://doi.org/10.1002/joc.7070
- Nguyen-Ngoc-Bich et al. 2021. Projected evolution of drought characteristics in Vietnam based on CORDEX-SEA downscaled CMIP5 data, International Journal of Climatology, https://doi.org/10.1002/joc.7150
- Tangang F & Chung JX. 2021. The relevance of CORDEX Southeast Asia Regional Climate Projection: Malaysia's perspectives. In "Making SGDs matter: Leaving No One Behind", Mahadi A & Zhafri N (Eds), Konrad Adenauer Stiftung & Institute of Strategic and International Studies, Malaysia
- Tangang et al. (2021), Progress in Climate Change Downscaling Simulations in Southeast Asia In "Climate Resilience and Environmental Sustainability Approaches-Global Lessons and Local Challenges" (Eds. Anubha Kaushik, C.P.Kaushik, S.D.Attri)., Springer (*in press*)

Climate Dynamics (2020) 55:1247–1267
https://doi.org/10.1007/s00382-020-05322-2

Projected future changes in rainfall in Southeast Asia based on CORDEX–SEA multi-model simulations

Fredolin Tangang[1,2] · Jing Xiang Chung[1,3] · Liew Juneng[1] · Supari[1,4] · Ester Salimun[1] · Sheau Tieh Ngai[1] · Ahmad Fairudz Jamaluddin[1,5] · Mohd Syazwan Faisal Mohd[6] · Faye Cruz[7] · Gemma Narisma[7,8] · Jerasorn Santisirisomboon[2] · Thanh Ngo-Duc[9] · Phan Van Tan[10] · Patama Singhruck[11] · Dodo Gunawan[4] · Edvin Aldrian[12] · Ardhasena Sopaheluwakan[13] · Nikulin Grigory[14] · Armelle Reca C. Remedio[15] · Dmitry V. Sein[16,17] · David Hein-Griggs[18,19] · John L. McGregor[20] · Hongwei Yang[21,22] · Hidetaka Sasaki[23] · Pankaj Kumar[24]

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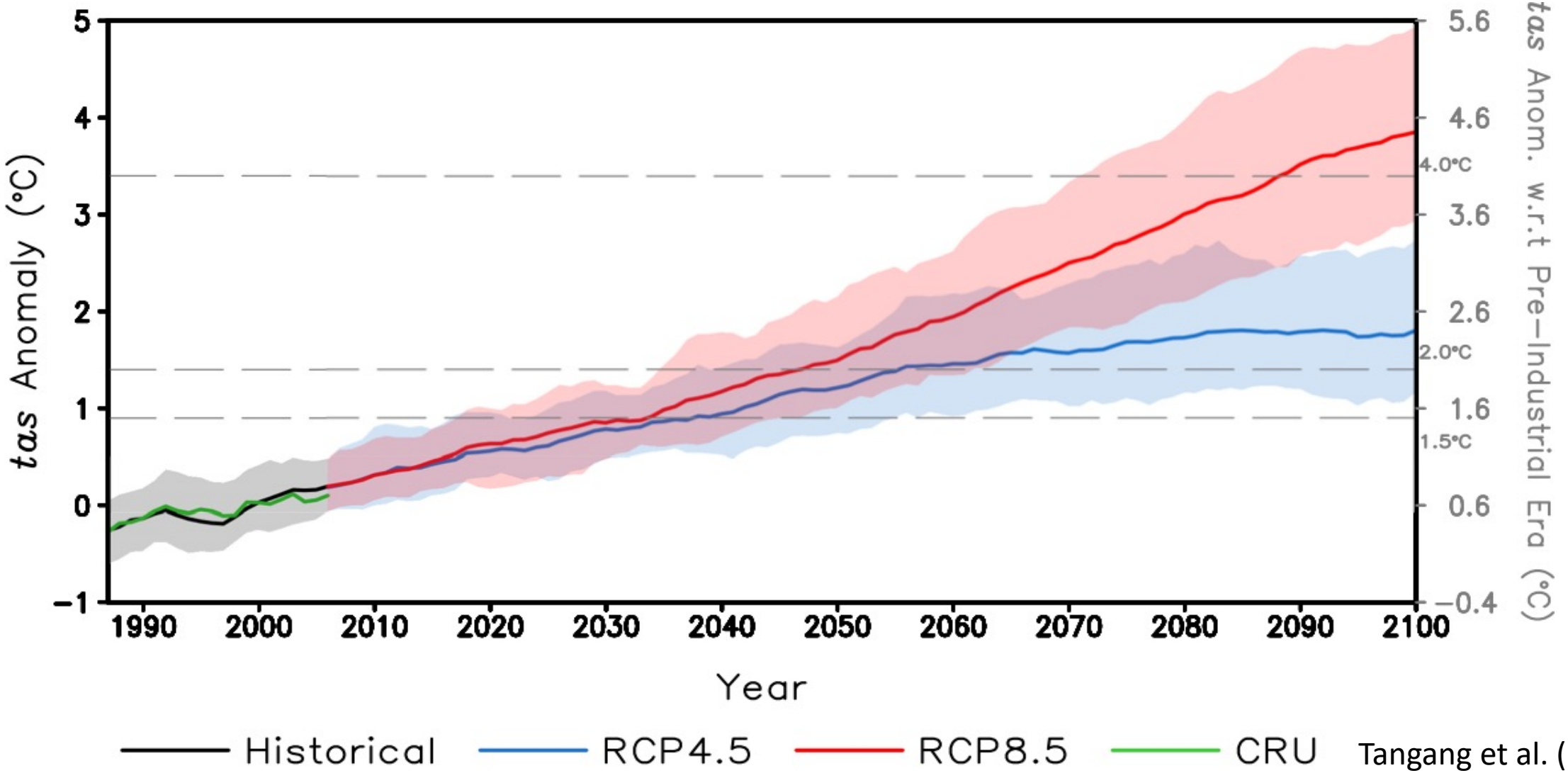
Multi-model projections of precipitation extremes in Southeast Asia based on CORDEX-Southeast Asia simulations

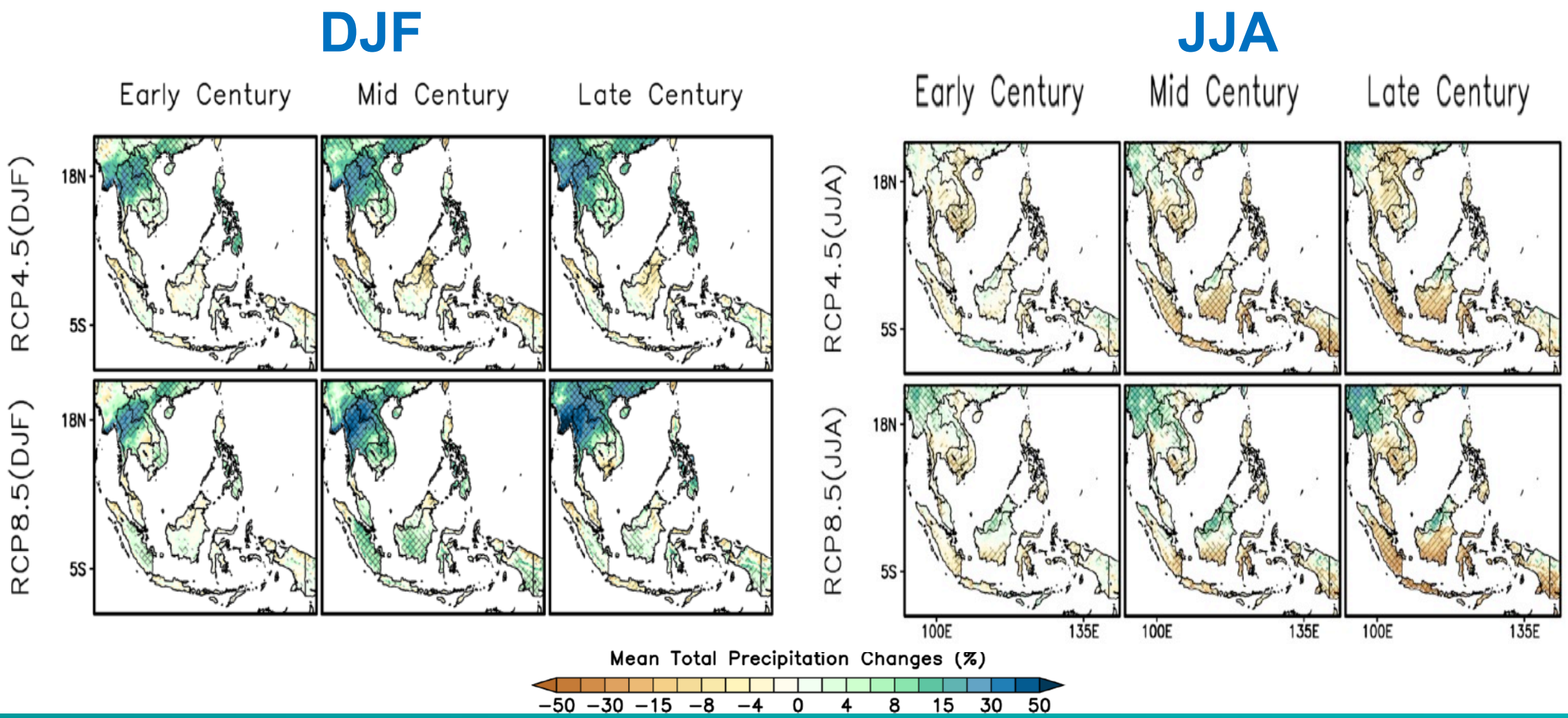
Supari[a,b], Fredolin Tangang[a,c,*], Liew Juneng[a], Faye Cruz[c], Jing Xiang Chung[a,l], Sheau Tieh Ngai[a], Ester Salimun[a], Mohd Syazwan Faisal Mohd[d], Jerasorn Santisirisomboon[e], Patama Singhruck[f], Tan PhanVan[g], Thanh Ngo-Duc[h], Gemma Narisma[c,i], Edvin Aldrian[j], Dodo Gunawan[b], Ardhasena Sopaheluwakan[k]

Projected Mean Temperature Increases over Southeast Asia

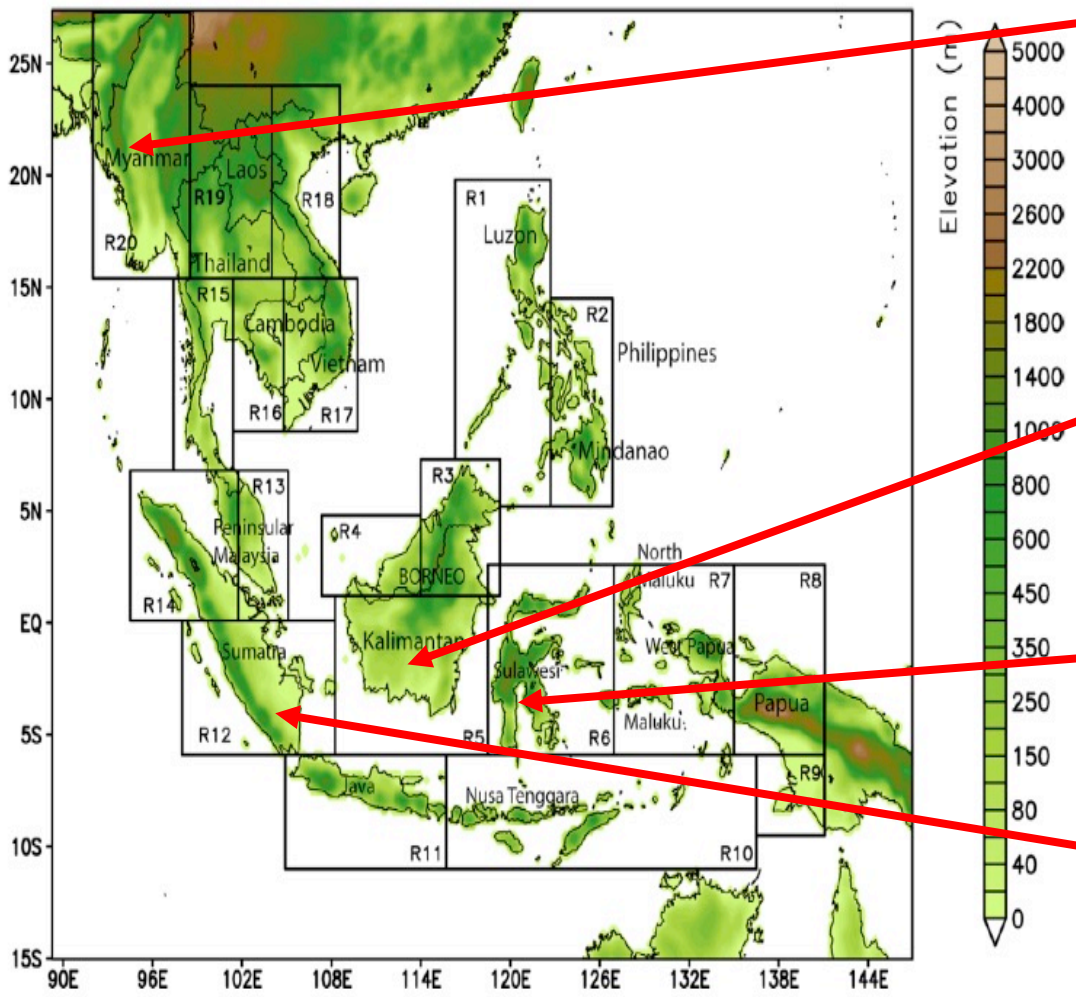


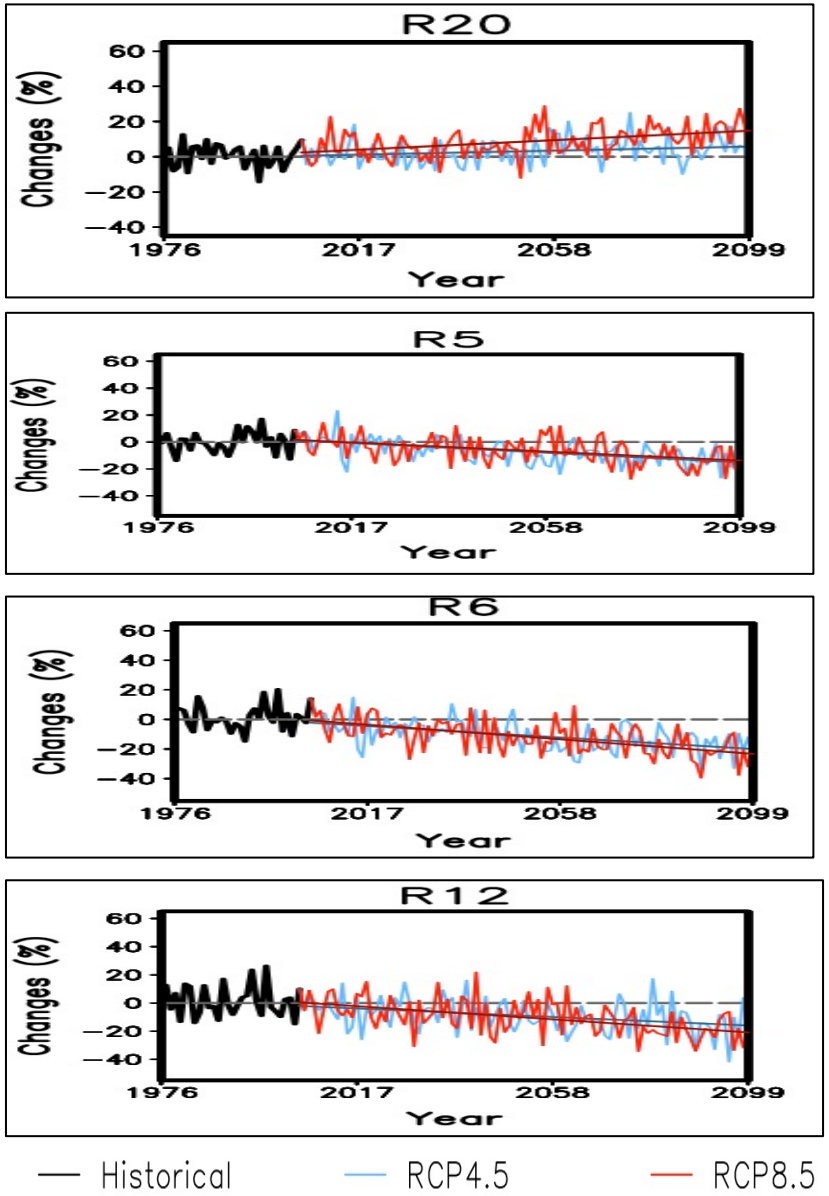
Tangang et al. (2018)

Projected Changes in Seasonal Mean Rainfall



Gradual and long-term changes of annual mean rainfall under RCP4.5 and 8.5



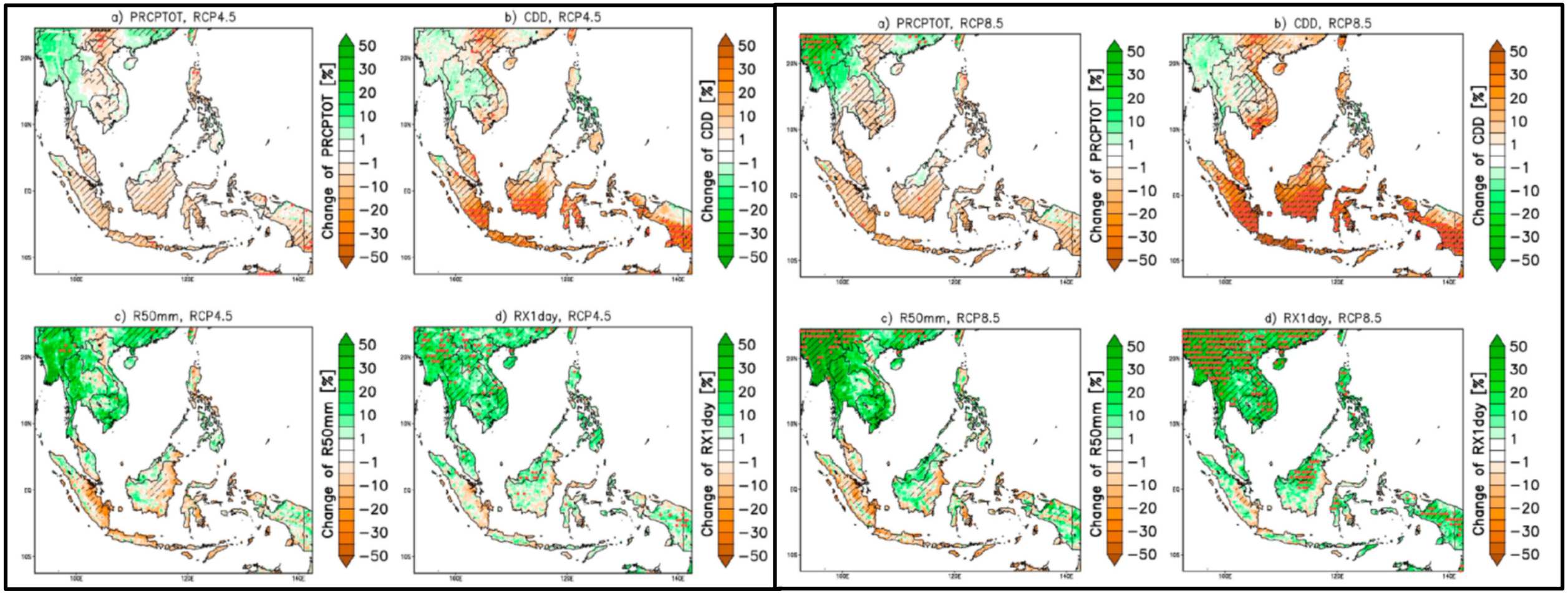


Tangang et al. (2020, Clim Dyn)

Projected Changes of Annual Extreme Indices by the end of the 21st century

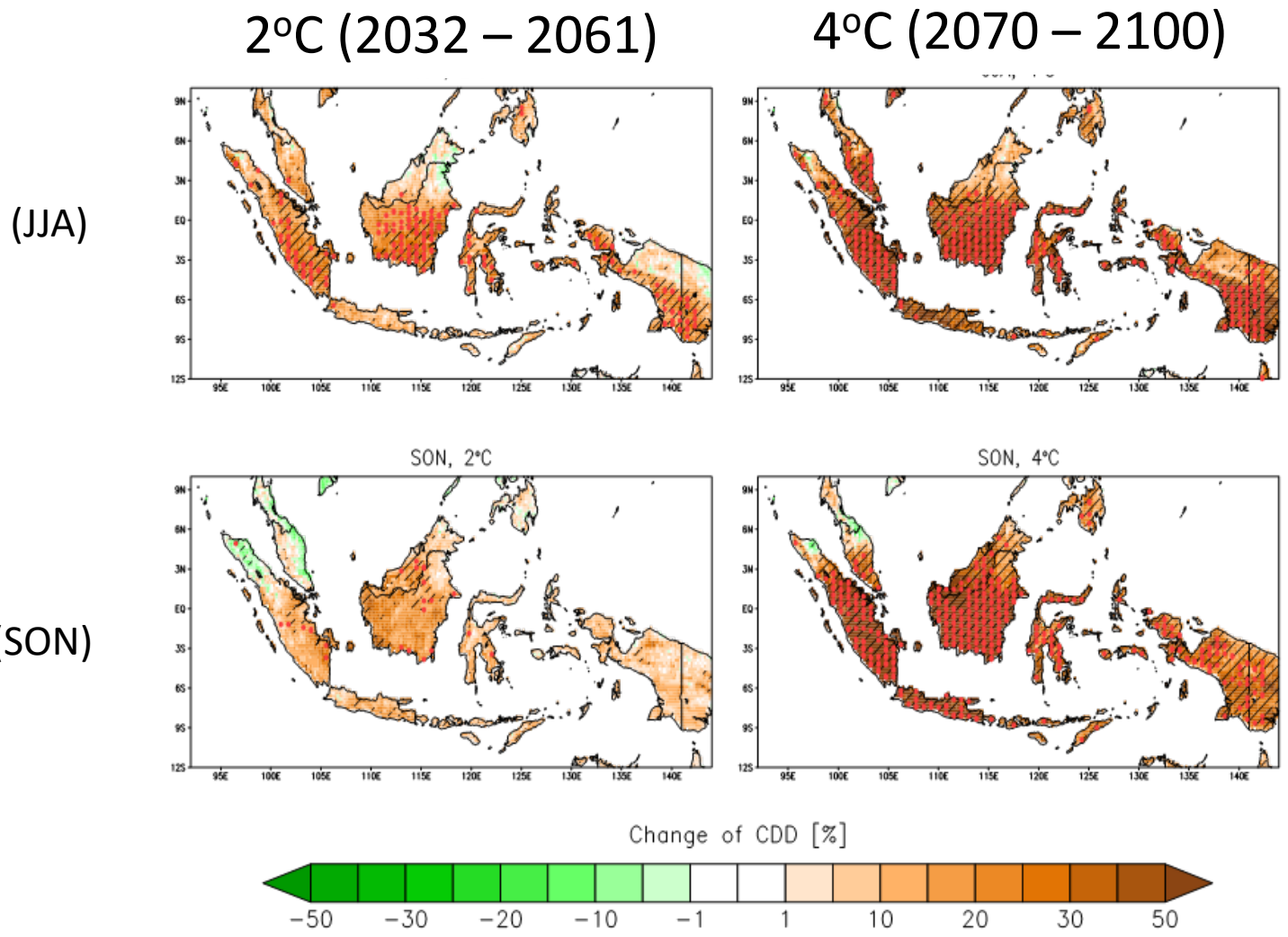
RCP4.5

RCP8.5



Supari, Tangang et al. (2020, Env Res)

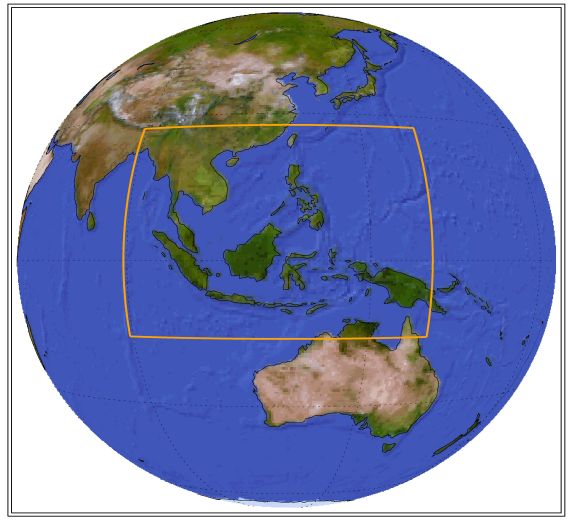
Projected Changes in Seasonal Consecutive Dry Days (CDD) for Worst Case Scenario (RCP8.5) under Global Warming 2°C and 4°C



- Drying tendency for Maritime Continent, especially Indonesian region for months of June to November
- This is equivalent to the amplitude of drying experienced during El Nino in current climate
- This implies in future warmer periods, **drier condition (comparable to those associated with El Nino) is projected to be occurring annually**

Supari, Tangang et al. (2020, Env Res)

Research Priorities in regional modelling & CORDEX SEA Future Plan



CORDEX Southeast Asia

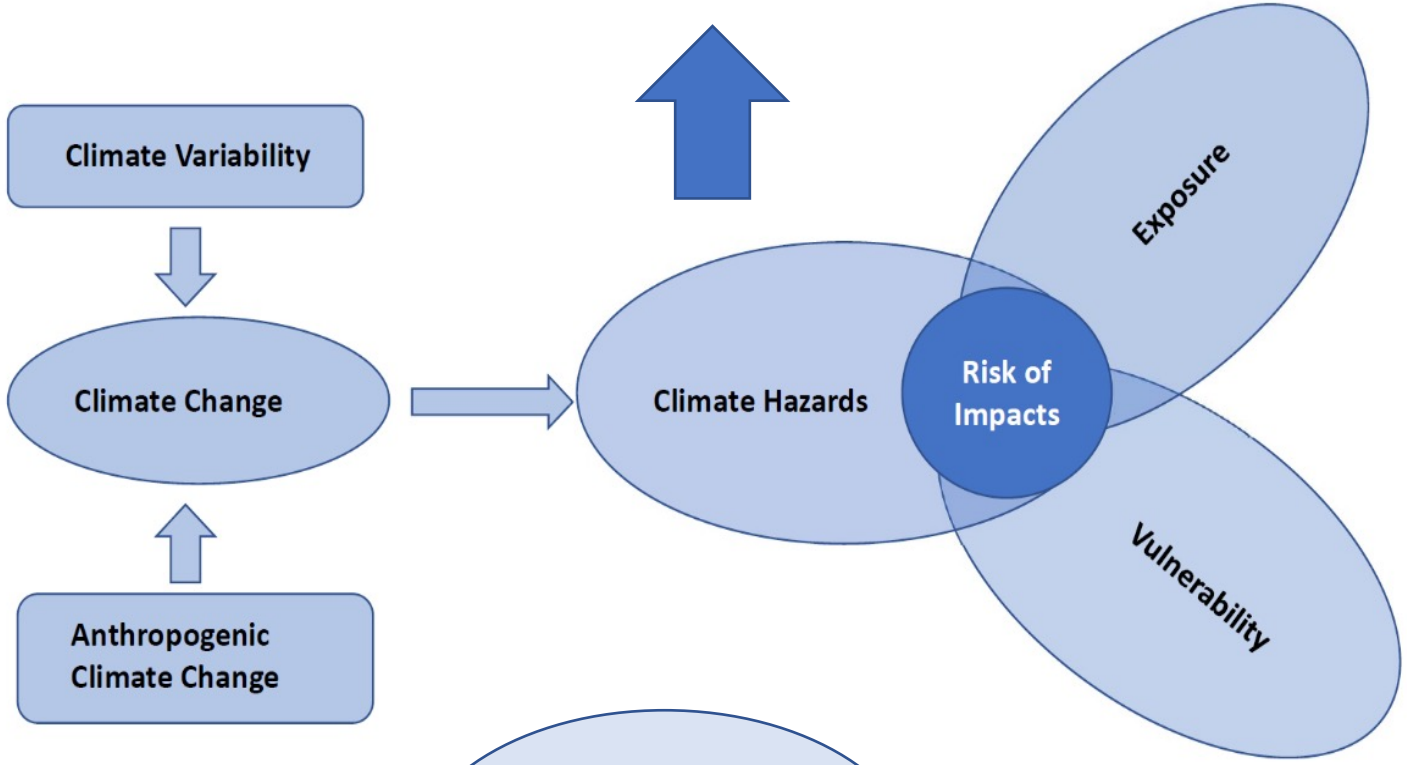
- Downscaling CMIP6 GCMs with more ensemble members and reduce uncertainties
- Further model tuning through physical processes parameterisation
- Ultra-high resolution < 5km
- Convective permitting modelling
- Regional Atmosphere – Ocean Coupled Model

WCRP CORDEX FLAGSHIP PILOT STUDIES

Robust Policy & Actions Towards Climate Resilience, Enabling Adaptations and Minimizing Impacts of Climate Change

Global Climate Modelling,

Regional Climate Modelling Communities



Climate Change Vulnerability, Impact and Adaptation (VIA) Communities

WCRP CORDEX

Coordinated Regional Climate Downscaling Experiment

CORDEX – MAIRS-FE Joint Programme

MAIRS fe

Monsoon Asia Integrated Research for Sustainability- Future Earth

Sectors likely to be impacted by Climate Change

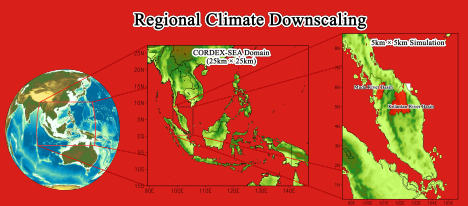
Agriculture, food security
Health
Air Quality, Forest Fires, Haze
Water resources
Environment
Forestry
Marine ecosystem
Socio-economic impacts
People Livelihoods
Marginalised communities
Mega cities

- **Countries need to narrow knowledge gaps in some of these critical sectors & carry out assessments of risk and impacts of future climate change**
- **CORDEX SEA data can be used for assessments in these sectors**
- **Robust assessments can lead to robust policy and enabling NAP**

MINISTRY OF HIGHER EDUCATION

LRGS Programme (led by Prof. Fredolin Tangang) in Assessing Impacts of Climate Extremes on Water Balance, Health and Socio-Economics under GW 1.5 and 2.0°C

Challenges & solving it with robust sciences



CMIP5, CMIP6

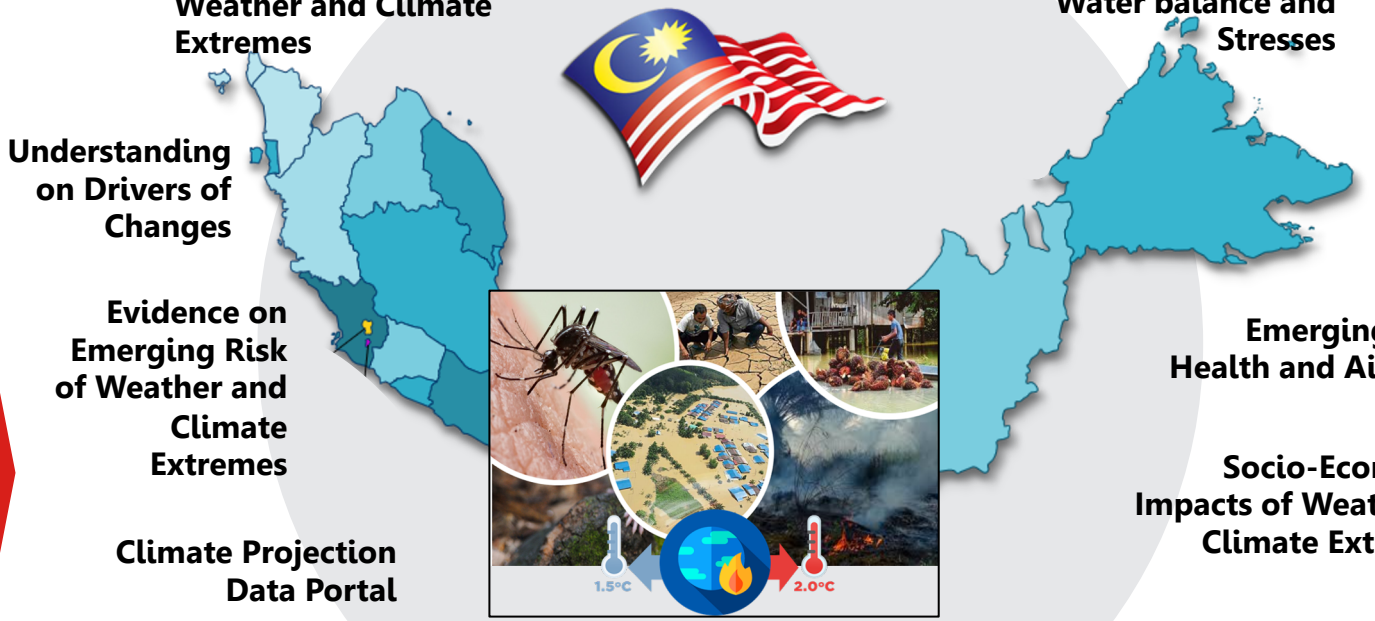
Evidence on Changes of Weather and Climate Extremes

Understanding on Drivers of Changes

Evidence on Emerging Risk of Weather and Climate Extremes

Climate Projection Data Portal

IR-Early Warning System



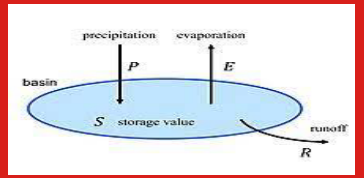
Emerging Risk on Water balance and Stresses

Emerging Risk on Health and Air Quality

Socio-Economic Impacts of Weather & Climate Extremes

Evidence - based inputs for Climate Change Policy

Impacts on Critical Sectors & Livelihood



Water Balance

Public Health

Socio-economic & Livelihood

BUILDING RESEARCH CONSORTIA & PARTNERSHIPS AMONG UNIVERSITIES - GOV INST, NGO, BETWEEN LOCAL & INTERNATIONAL INSTITUTIONS

Universiti Kebangsaan Malaysia National University of Malaysia · UPM Universiti Putra Malaysia · USM Universiti Sains Malaysia

Universiti Malaysia Kelantan · unisel Universiti Selangor · University of Malaya · UMT · UTM Universiti Teknologi Malaysia · Ministry of Health Malaysia · NAHRIM · Jabatan Pengairan dan Saliran Malaysia · MARDI · MySEE · BMKG · CSIRO · WCRP CORDEX

Universiti Kebangsaan Malaysia National University of Malaysia · UPM Universiti Putra Malaysia · USM Universiti Sains Malaysia

The Southeast Asia Regional Climate Change Information System (SARCCIS), CORDEX-SEA Data Portal

List of GCMs and RCMs used in SEACLID/CORDEX Southeast Asia Simulations

Contribution by country	General Circulation Model (GCM)	Representative Concentration Pathway (RCP)	Regional Climate Model (RCM)
Vietnam	CNRM-CM5 (CNRM, France)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
Philippines	HadGEM2 (Hadley Centre, UK)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
Thailand	MPI-ESM-MR (MPI-M, Germany)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
Thailand	EC-Earth (EC-Earth consortium)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
Indonesia	CSIRO MK3.6 (CSIRO, Australia)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
Malaysia*	CanESM2 (CCCMA, Canada)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
Malaysia	IPSL-CM5A-LR (IPSL, France)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
Malaysia	GFDL-ESM2M (GFDL, USA)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
South Korea	HadGEM2-AO (Hadley Centre, UK)	RCP8.5, 4.5	WRF (NCAR USA)
Sweden	CNRM-CM5 (CNRM, France)	RCP8.5, 4.5	RCA4 (SMHI, Sweden)
Sweden	HadGEM2-ES (Hadley Centre, UK)	RCP8.5, 4.5	RCA4 (SMHI, Sweden)
Australia**	CNRM-CM5 (CNRM, France)	RCP8.5	CCAM (CSIRO, Australia)
Australia**	CCSM4 (NCAR, USA)	RCP8.5	CCAM (CSIRO, Australia)
Australia**	ACCESS1.3 (CSIRO, Australia)	RCP8.5	CCAM (CSIRO, Australia)
Hong Kong SAR***	ESM2M (GFDL, USA)	RCP8.5, 4.5	RegCM4 (ICTP, Italy)
United Kingdom	HadGEM2-ES (Hadley Centre, UK)	RCP8.5	PRECIS (Hadley Centre, UK)
Germany***	MPI-ESM-LR (MPI-M, Germany)	RCP8.5, 4.5	ROM (MPI-M Germany)
Japan**	MRI-AGCM3.2 (MRI, Japan)	RCP8.5, 4.5	NHRCM (MRI, Japan)

[Note: * yet to be completed, ** time-slice runs, *** 50 km x 50 km and slightly different domains to cover Western Pacific warm pool]

For more information about this project :
- http://www.ukm.edu.my/seaclid-cordex/
- http://www.rucore.ru.ac.th
- http://www.cordex.org
- http://www.apn-gcr.org/resources/items/show/1886
- http://www.apn-gcr.org/resources/items/show/2048

Institutions of Scientists/Funding Agencies

SARCCIS
Southeast Asia Regional
Climate Change Information System

Climate Information for SOCIETY

ข้อมูลภูมิอากาศเพื่อสังคม
Maklumat Iklim untuk masyarakat
Informasi iklim untuk masyarakat
Impormasyon sa klima para sa lipunan
Thông tin Khí hậu phục vụ Xã hội
ຂໍ້ມູນພູມອາກາດເພື່ອສັງຄົມ
လူမှုကွန်ယက်အသင်းအဖွဲများအတွက် ရာသီဥတုဆိုင်ရာသတင်းအချက်အလက်

Jointly Managed and Operated by

http://www.rucore.ru.ac.th/SARCCIS

*The SARCCIS logo was designed and graciously donated by Assoc. Professor Viwat Udompitisup, VR Digital Company Limited, Thailand

http://www.rucore.ru.ac.th/SARCCIS

ESGF
Earth System Grid Federation

Launched in May 7, 2018 jointly by the President of Ramkhamhaeng University, Bangkok, Thailand and UKM Deputy Vice Chancellor at UKM, Malaysia

SARCCIS
Southeast Asia Regional Climate Change Information System

ESGF
Earth System Grid Federation

SARCCIS is jointly managed and operated by

Ramkhamhaeng University

RU-CORE
Ramkhamhaeng University
Center of Regional Climate Change and Renewable Energy

Universiti Kebangsaan Malaysia
The National University of Malaysia

http://www.rucore.ru.ac.th/SARCCIS

- Accessed by Scientists for studies in assessing impact of climate change in Southeast Asia
- Used by countries for National Assessment: Philippines, Indonesia, Vietnam (more in future)
- Currently used by IPCC for Regional Atlas in Sixth Assessment Report


Thank
you