Dynamical Downscaling of Climate Projection Data

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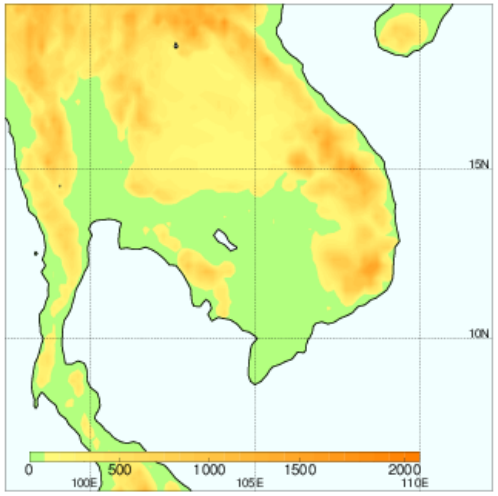
SENTAN
advanced studies of climate change projection
気候変動予測先端研究プログラム

Webinar Series on Climate Change Projection for Disaster Risk Reduction in Asia-Pacific Region

What is downscaling?

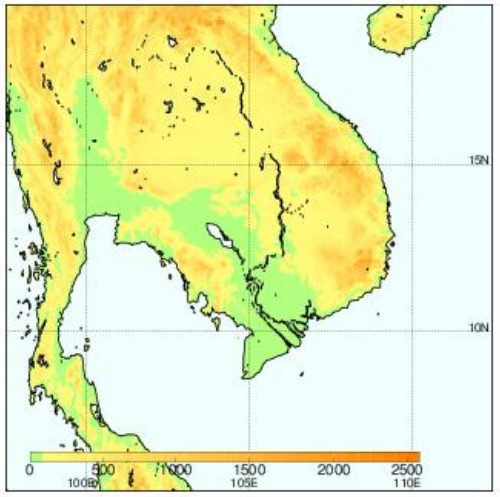
- Purpose
  - To project future climate on regional and local scales

20-km resolution



x 10

2-km resolution

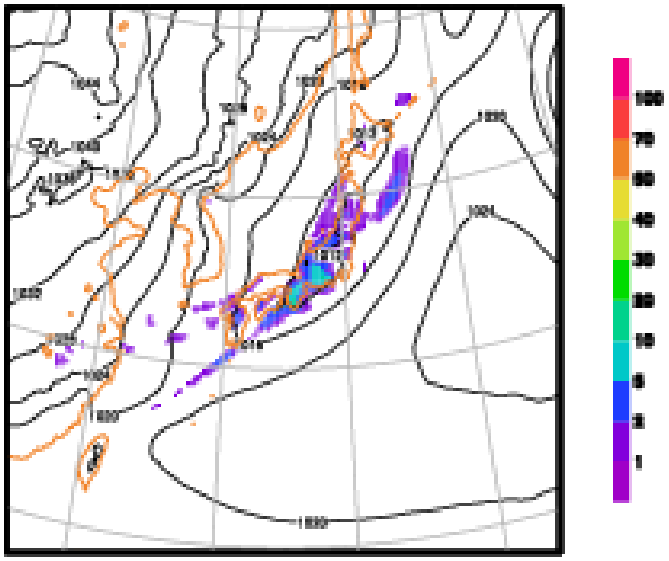


- Two types
  - Dynamical downscaling: Based on numerical simulations
  - Statistical downscaling: Based on statistical knowledge

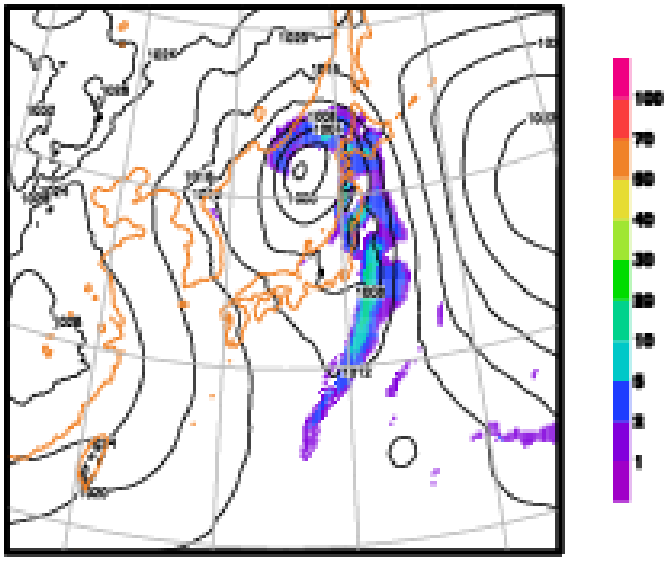
Regional Climate Model (RCM)

- Similar to numerical prediction model for weather forecast
- But for regional- and local-scale climate (not weather)

Present-day climate



Future climate (e.g., the end of 21C)



Experimental design

Numerical Model:

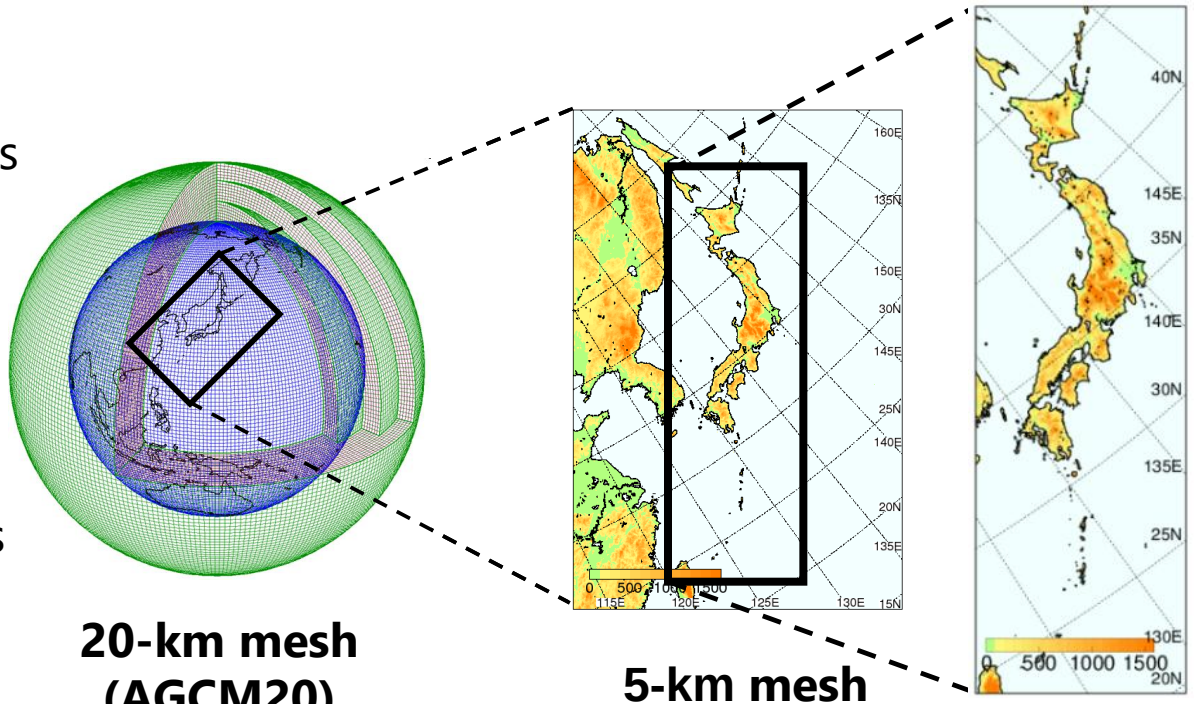
NonHydrostatic Regional Climate Model (NHRCM; Sasaki et al. 2008),
based on Japan Meteorological Agency NonHydrostatic Model (JMA-NHM; Saito et al. 2006)

Present climate

Integration period: 20 years
Sep 1980 – Aug 2000
(1-year time slice:
Sep – next Aug)

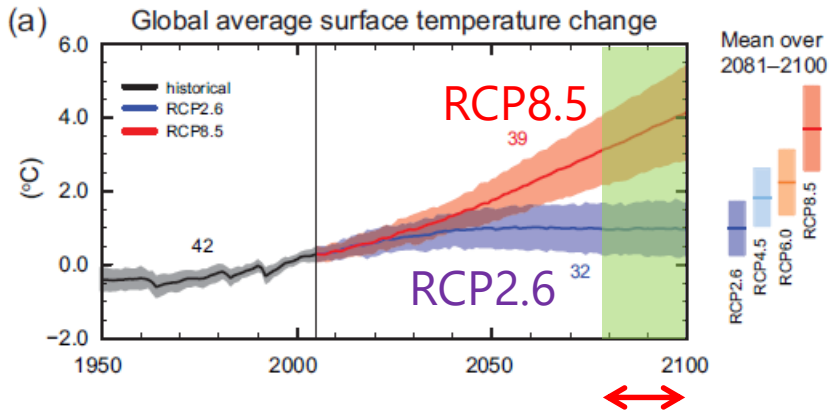
Future climate

Integration period: 20 years
Sep 2076 – Aug 2096
(1-year time slice:
Sep – next Aug)
Scenario: RCP8.5
SST: Change + Trend + Variability
Ensemble of boundary conditions (4 members)



Downscaling methods

- Scenario in terms of greenhouse gases
  - Shared Socioeconomic Pathways (SSP)
  - Representative Concentration Pathways (RCP)
- Time sliced
  - e.g., Around the end of this century: 2080-2100
- Using high-speed supercomputer
  - e.g., Earth Simulator



IPCC (2013)

Time sliced

Earth Simulator

http://www.jamstec.go.jp/es/jp/output/gallery/images/es3/org/002.jpg

Dynamical downscaling over Southeast Asian countries

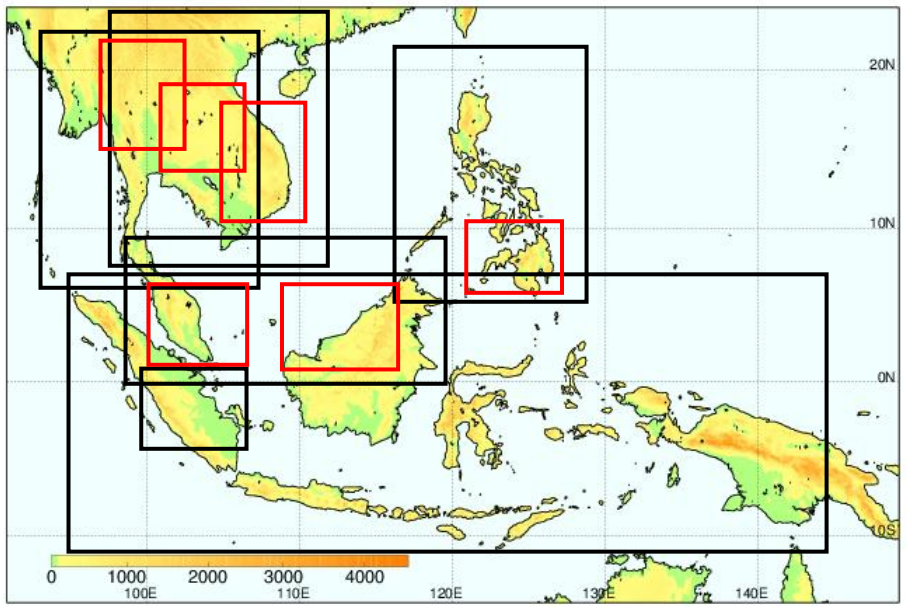
- High-resolution RCM simulations have been performed for CORDEX-SEA using RCM called NHRCM

Schedules for invited researches

2. Research collaboration

The MRI has invited researchers from the collaborating countries to the MRI in Tsukuba, Japan, for two months to implement custom downscaling technology with a super computer for each region and to adjust the NHRCM program (source code) to improve reproductivity of local climate conditions. Thus far, meteorology/climatology or environment researchers with knowledge of LINUX, Fortran, and meteorological/climatological dynamics have participated in the joint study. This research collaboration has been supported by the Ministry of Land Infrastructure Transport and Tourism (MILT), Japan Society for the Promotion Science (JSPS), Program for Risk Information on Climate Change, and Integrated Research Program for Advancing Climate Models operated by the Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT). A schedule of joint study is indicated in Figure 3, and relevant organizations are shown in Figure 4.

Model domains



Studies for each country

- Arpornrat, T., S. Ratjiranukool, P. Ratjiranukool, and H. Sasaki, 2018: Evaluation of southwest monsoon change over Thailand by high-resolution regional climate model under high RCP emission scenario, J. Phys.: Conf. Ser., 1144, 012112.
- Cruz, F. T., H. Sasaki, and G. T. Narisma, 2016: Assessing the sensitivity of the Non-Hydrostatic Regional Climate Model to boundary conditions and convective schemes over the Philippines. J. Meteor. Soc. Japan, 94, 165–179.
- Cruz, F. T, and H. Sasaki, 2017: Simulation of present climate over Southeast Asia using the Non-Hydrostatic Regional Climate Model. SOLA, 13, 13–18.
- Jamaluddin, A. F., F. Tangang, J. X. Chung, L. Juneng, H. Sasaki, and I. Takayabu, 2018: Investigating the mechanisms of diurnal rainfall variability over Peninsular Malaysia using the non-hydrostatic regional climate model. Meteor. Atmos. Phys., 130, 6, 611–633.
- Kieu-Thi, X., H. V. U.-Thanh, T. Nguyen-Minh, D. Le, L. Nguyen-Minh, I. Takayabu, H.Sasaki, and A. Kitoh, 2016: Rainfall and tropical cyclone activity over Vietnam simulated and projected by the Non-Hydrostatic Regional Climate Model – NHRCM. J. Meteor. Soc. Japan, 94A, 135–150.
- Ngai, S. T., H. Sasaki, A. Murata, M. Nosaka, J. X. Chung, L. Juneng, Supari, E. Salimun, and F. Tangang, 2020: Extreme rainfall projections for Malaysia at the end of 21st century using the high resolution non-hydrostatic regional climate model (NHRCM), SOLA, 16, 132–139.
- Mau, N. D., N. M. Truong, H. Sasaki, and I. Takayabu, 2017: Rainfall projection for seasonal rainfall over Vietnam by the end of 21st century under RCP8.5 scenario by the NHRCM model. Vietnam Journal of Hydrometeorology, pp 7–13.
- Mau, N. D., H. Sasaki, and I. Takayabu, 2018: A study of seasonal rainfall in Vietnam at the end of 21st century according to the Non-Hydrostatic Regional Climate Model, Vietnam Journal of Science, Technology and Engineering, 60, 3, 89–96.

An example: Projections of future changes in extreme precipitation over Malaysia

Ngai et al. (2020)

136 SOLA, 2020, Vol. 16, 132−139, doi:10.2151/sola.2020-023

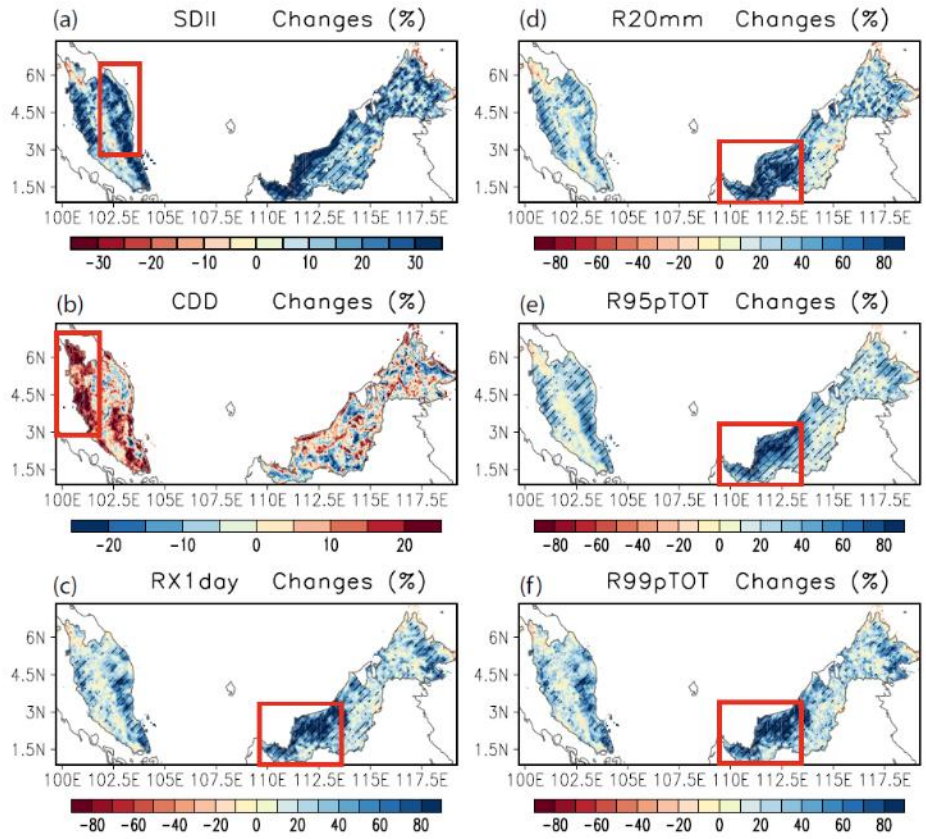


Fig. 5. Future changes (%) in extreme rainfall indices: (a) SDII, (b) CDD, (c) RX1day, (d) R20mm, (e) R95pTOT, and (f) R99pTOT. Hatching area indicated that changes are significant at 90% confidence level. The boxes indicated selected hotspots for the PDFs in Figure 6.

Future changes in extreme rainfall indices

Table 1. List of extreme rainfall indices together with respective definitions.

No.	Indices	Definition	Units
1	SDII	Simple daily intensity index, seasonal total/number of wet days ≥ 1 mm/day	mm/day
2	CDD	Maximum number of consecutive dry days (dry days < 1 mm/day)	days
3	RX1day	Highest one day rainfall amount per time period / Seasonal maximum 1-day rainfall amount	mm
4	R20mm	Number of days with rainfall amount ≥ 20 mm/day	days
5	R95pTOT	Total rainfall amount when daily rainfall amount > 95th percentile of rainfall on wet days in the time period	mm
6	R99pTOT	Total rainfall amount when daily rainfall amount > 99th percentile of rainfall on wet days in the time period	mm

- Overall, all indices are projected to increase
- There are some hotspots
  - Eastern Malaysia (Southern Sarawak)
  - East coast of Peninsula Malaysia

Data for Malaysia

- Present climate: 1980-2000
- Future climate: 2080-2100 (RCP8.5 scenario)

- 5km –mesh: The whole area of Malaysia
- 2km-mesh: Peninsula Malaysia
- 2km-mesh: East Malaysia

- If you are interested in these datasets, just contact me: amurata at mri-jma.go.jp

Summary

- Overview of dynamical downscaling
- Research program: SENTAN
  - Dynamical downscaling for their countries using a non-hydrostatic RCM, called NHRCM, has been conducted
  - High-speed computer system, called the Earth Simulator, can be used

https://www.jamstec.go.jp/sentan/eng/

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