# Recent progress of Japan's regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD)

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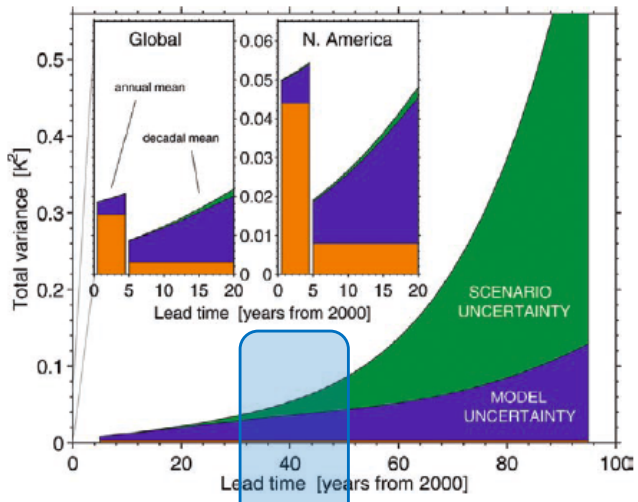
# Backgrounds of developing regional climate scenarios

- ✓ The Asia-Pacific region are increasingly threatened by large scale natural disasters. Growing concerns that loss and damages of natural disasters are projected to further exacerbate by climate change and socio-economic change.
- ✓ The **Paris Agreement** dealing with greenhouse gas emissions mitigation and adaptation entered into force in 2016. **Sustainable Development Goals(SGDs)** set targets of 17 goals (include climate action) to be achieved over the next 15 years in 2015. **The Climate Change Adaptation Act will come into effect in Dec 2018** in Japan.
- ✓ **Fundamental regional climate information** is indispensable for understanding changing climate and making decisions on **when and how to act.**
- ✓ Spatio-temporal comprehensive and consistent information is necessary and useful for decision making.

# Sources of variance of climate scenarios




Mean Surface Temperature
CMIP3 15GCMs
SRES A1b, A2,B1
2000-2100

Global

Regional (e.g., England)

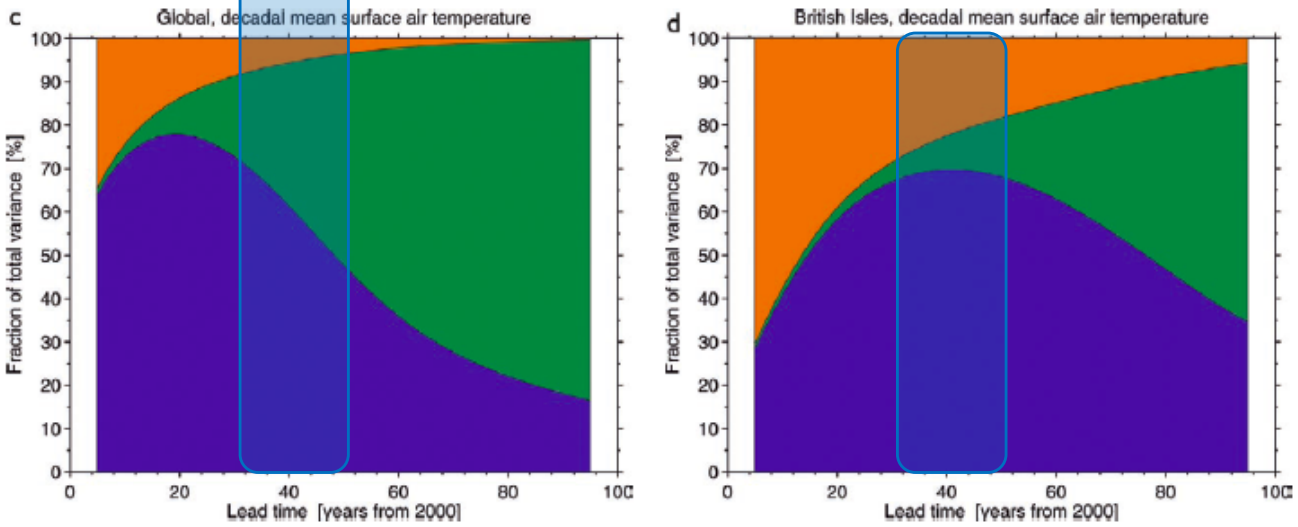



FIG. 4. The relative importance of each source of uncertainty in decadal mean surface temperature projections is shown by the fractional uncertainty (the 90% confidence level divided by the mean prediction) for (a)

Major sources of uncertainty

- Natural variability (Internal variability) (orange)
- Structural differences of climate models (blue)
- Socio-economic scenarios (green)

→ Internal variability grows relative importance for regional/local scale.

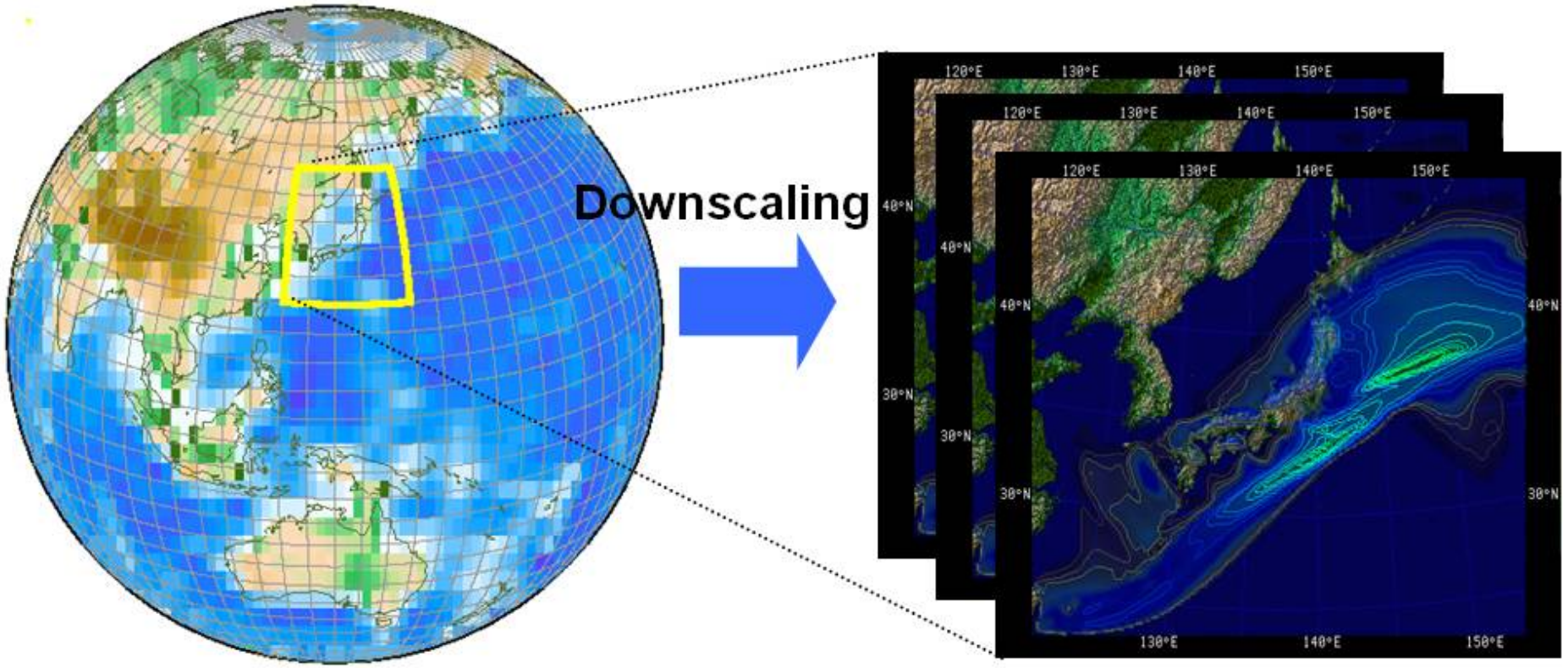
→ Model uncertainty is important for near term.

→ Socio-economic scenarios becomes important in multi-decadal timescale.

Hawkins and Sutton, BAMS, 2009

# Multi-model ensemble experiment

- Ensemble downscaling experiment by multi-regional climate models to investigate the range of structural uncertainty



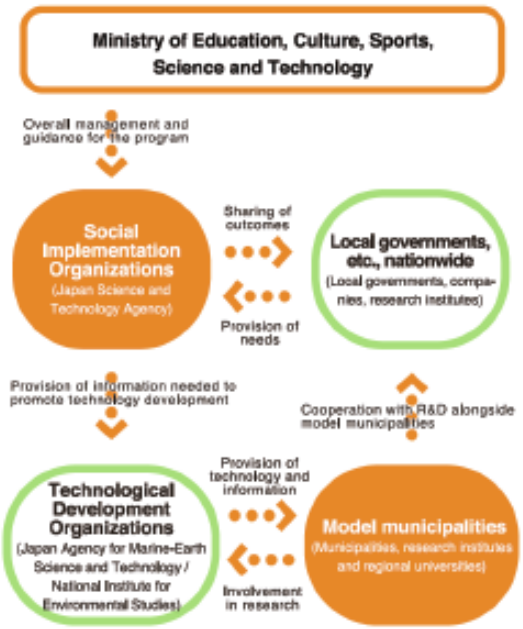

e.g., Iizumi et al., JGR 2011, Ishizaki et al., JMSJ, 2012, 2012b, Iizuka, Dairaku et al., JMSJ, 2012, Iizumi et al., JGR, 2012, Sasaki et al., JMSJ, 2012, Tsunematsu et al., JGR, 2013; Nayak, Dairaku, HRL, 2017; Nayak, Dairaku et al., Clim. Dyn. 2017.

CORDEX-EA(RMIP): Tang et al., Int. J. Clim., 2016; Li et al., Int. J. Clim., 2016, Niu et al., Int. J. Clim., 2017.

# SI-CAT

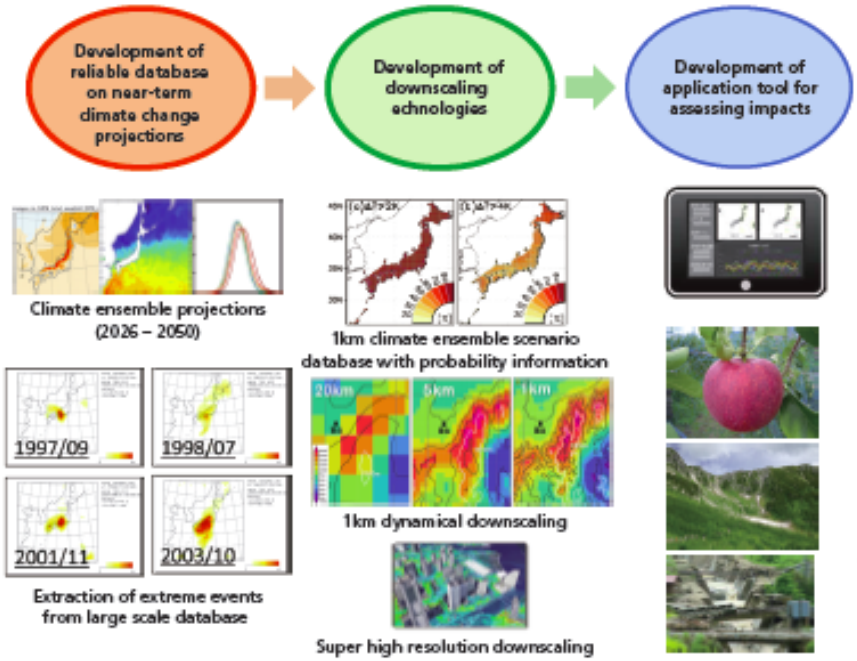
(Dec2015-Mar2020)

## SI-CAT Framework




- Develops reliable technologies for near-term climate change projections for climate change adaptation by matching seeds of technologies with the needs of local governments.
- Develop multi-model ensemble near-term regional climate scenarios with 1km horizontal grid-spacing over Japan by **dynamical and statistical downscaling methods** to support various regional adaptation measures

## SI-CAT Technology Development Organizations





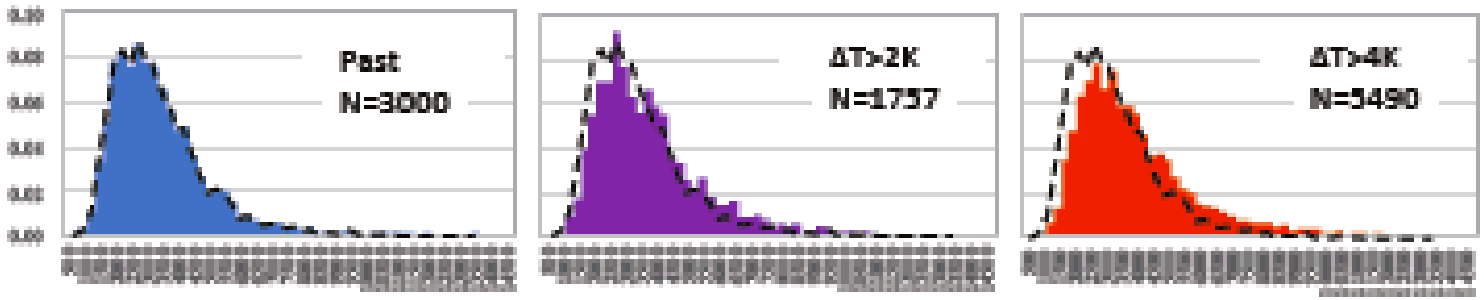

Data

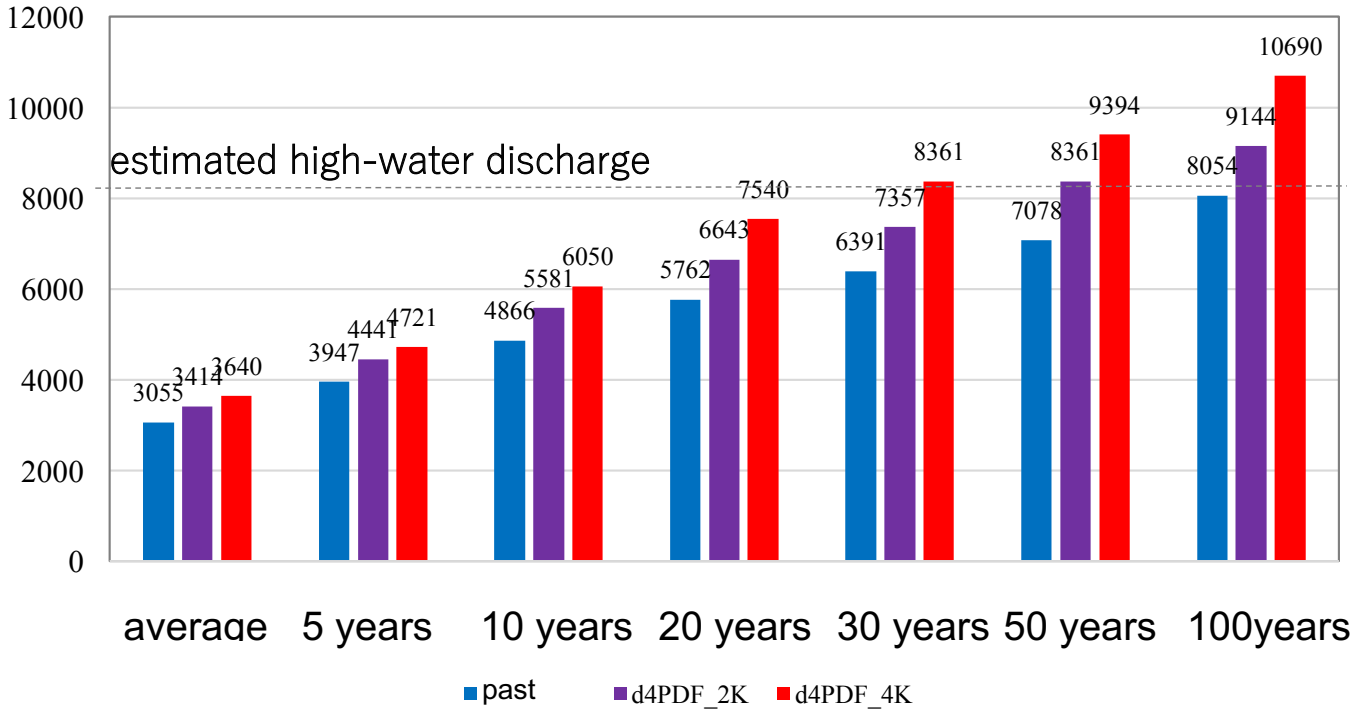
Cooperation

- National Plan for Adaptation to the Impacts of Climate Change
- Climate Change Adaptation Bill
- Ministry of Environment
  Climate change Adaptation Regional Consortium
- Ministry of Ministry of Agriculture, Forestry and Fisheries of Japan
- Ministry of Land, Infrastructure, Transport and Tourism
  (Hokkaido Regional Development Bureau)
- Integrated Research Program for Advancing Climate Models (TOUGOU) TOUGOU
- Data Integration and Analysis System Program (DIAS) DIAS

# A Case study (GIFU) of model municipalities

## Examples of prediction of flood probability in Nagara basin



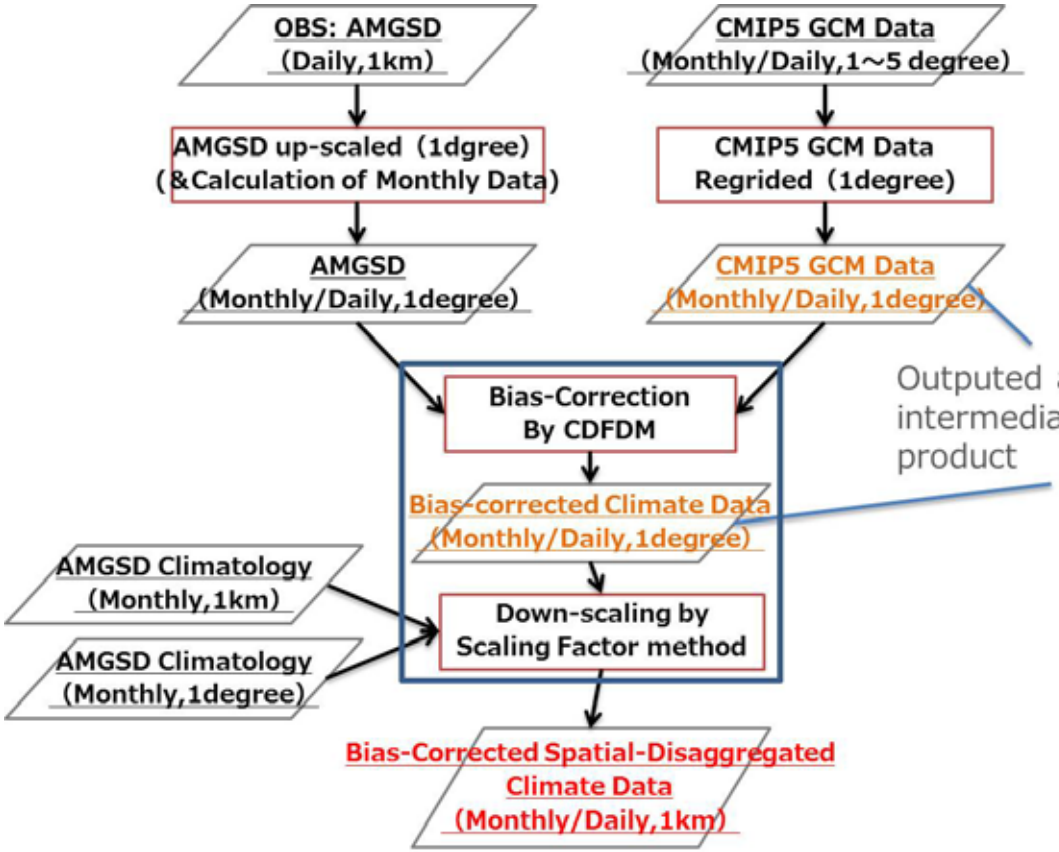

Based on more than 3,000 years/each large ensemble simulations
(by using only one hi-res GCM with 20km grid spacing)

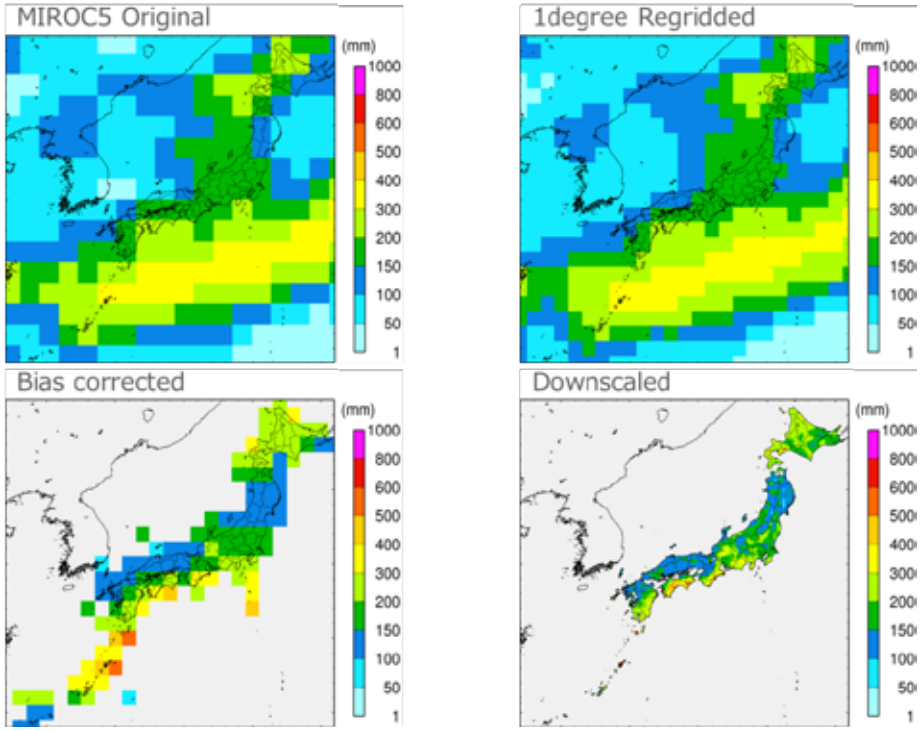
- Quantitative flood assessment in Nagara river basin under climate change.
- 100-year floods are projected to be 50-year floods in 2030, and be 30year-floods in 4K (Late 21st Century) climate change scenarios.

Harada et al.(2018)

# Methodology and ESD Output Sample

(BCSD, Wood et al. 2002, Wood et al. 2004, Maurer et al. 2008)

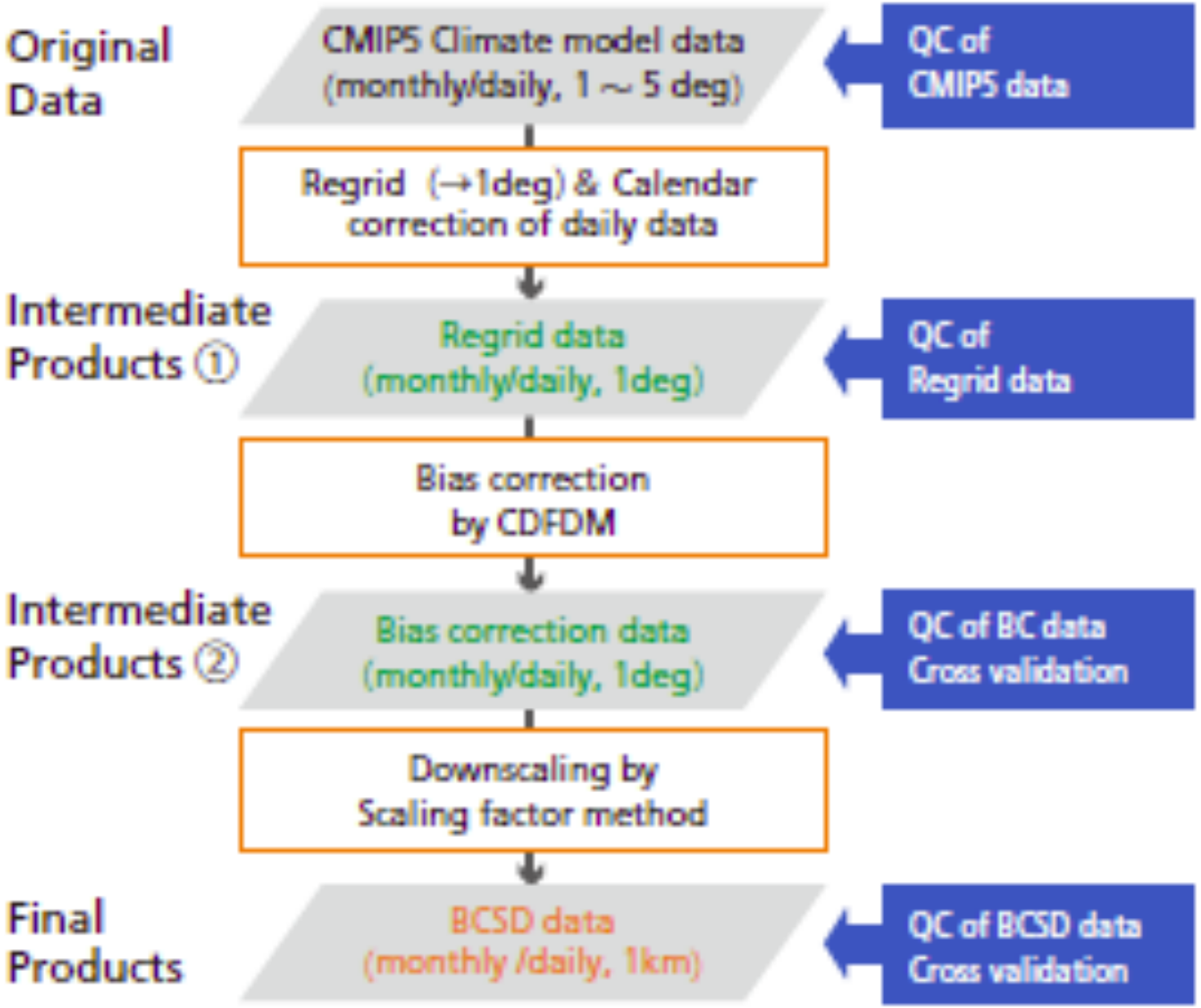



Climate information with 1km horizontal grid spacing over Japan

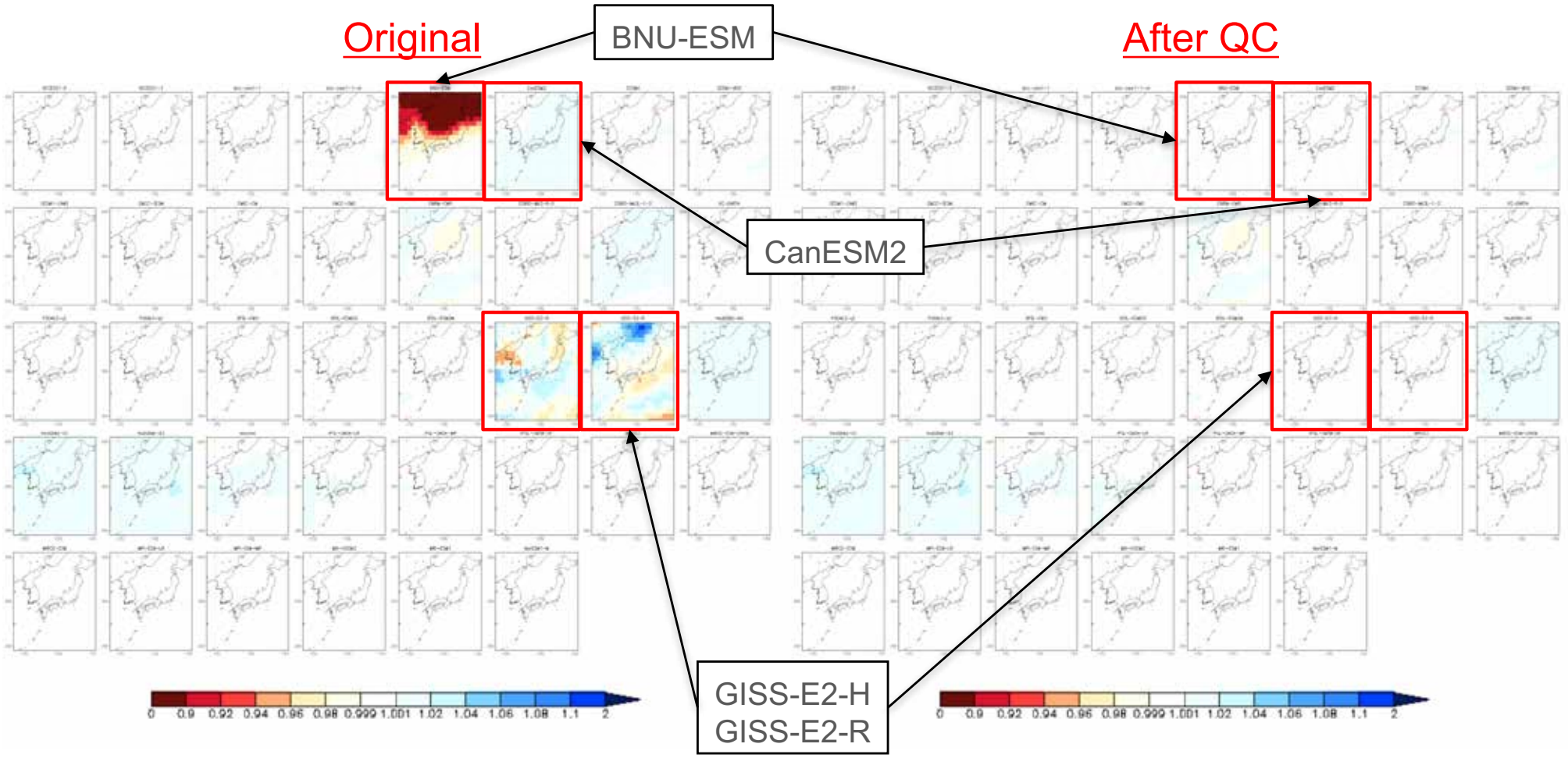
For spatio-temporally comprehensive and consistent investigation of the range of climate model's structural uncertainty.

# Data quality check of multi-ensemble ESD



# QC of Regrid data（Pr, Historical 1950-2005）

Ratio of Monthly Pr to Daily Pr




BNU-ESM: double counting of snowfall in monthly Pr

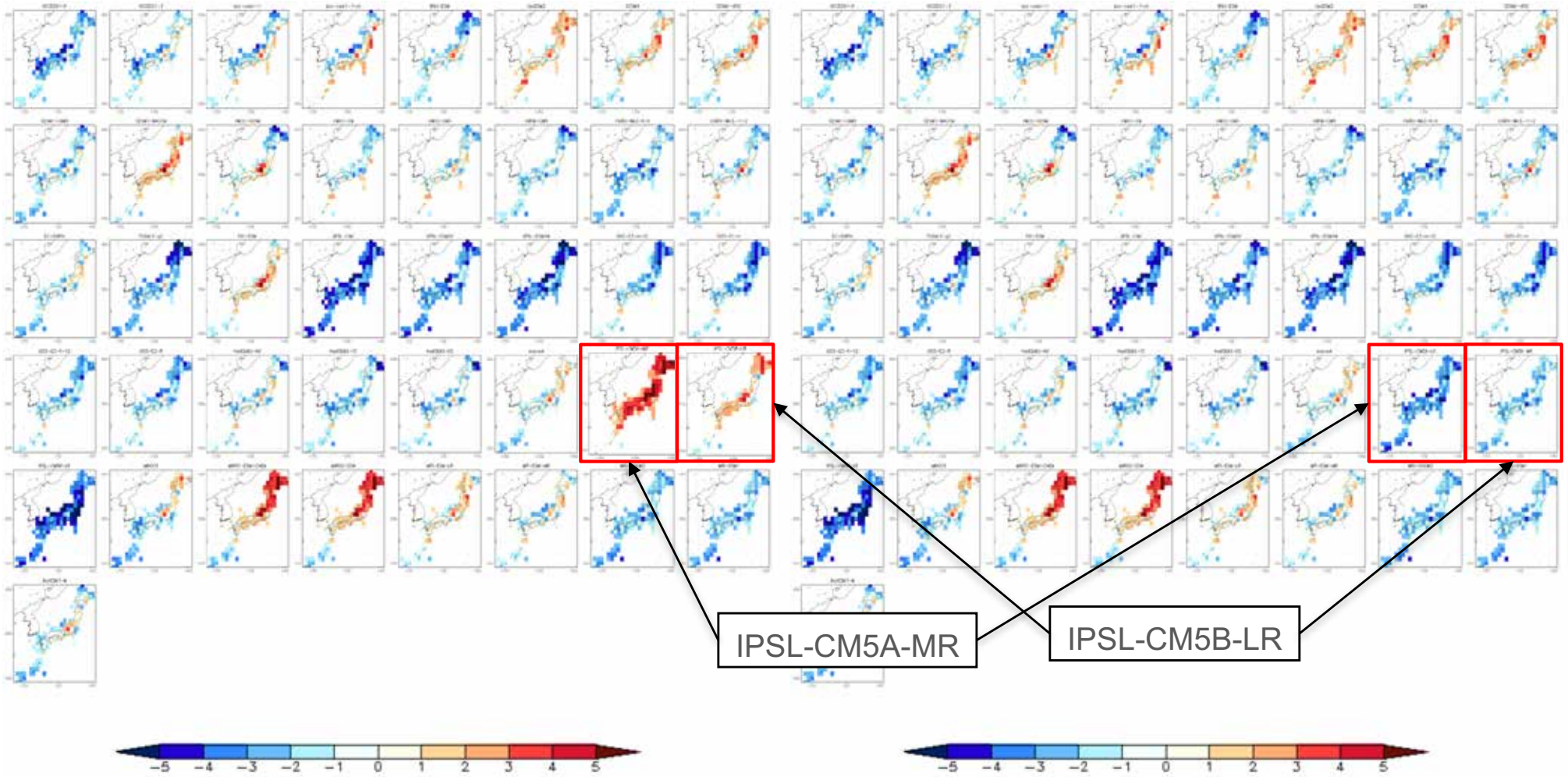
CanESM2: slight different -> recalculate monthly Pr.

GISS-ES: different ensemble member

# Bias-correction（tasmax, Historical 1950～2005）

Annual mean of bias-corrected values of monthly tasmax
(daily maximum temperature)

Original　　After BC

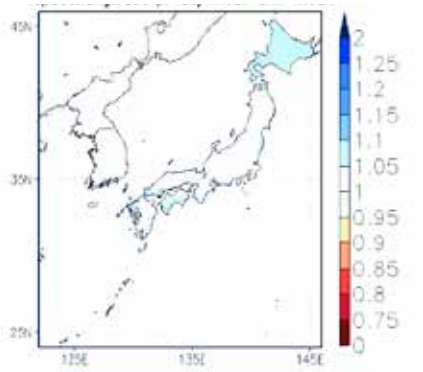



**Bias-corrected values are applied to future scenarios!**

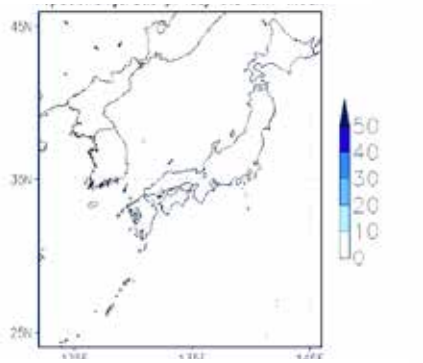
※IPSL-CM5A-MR・IPSL-CM5B-LR: tasmax was monthly (**not daily**) maximum temperature

# Projected future change of annual precipitation （pr, Daily）

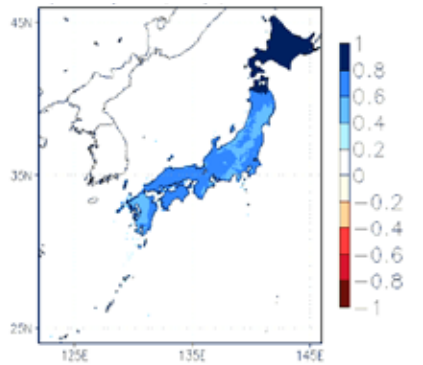
Ensemble average



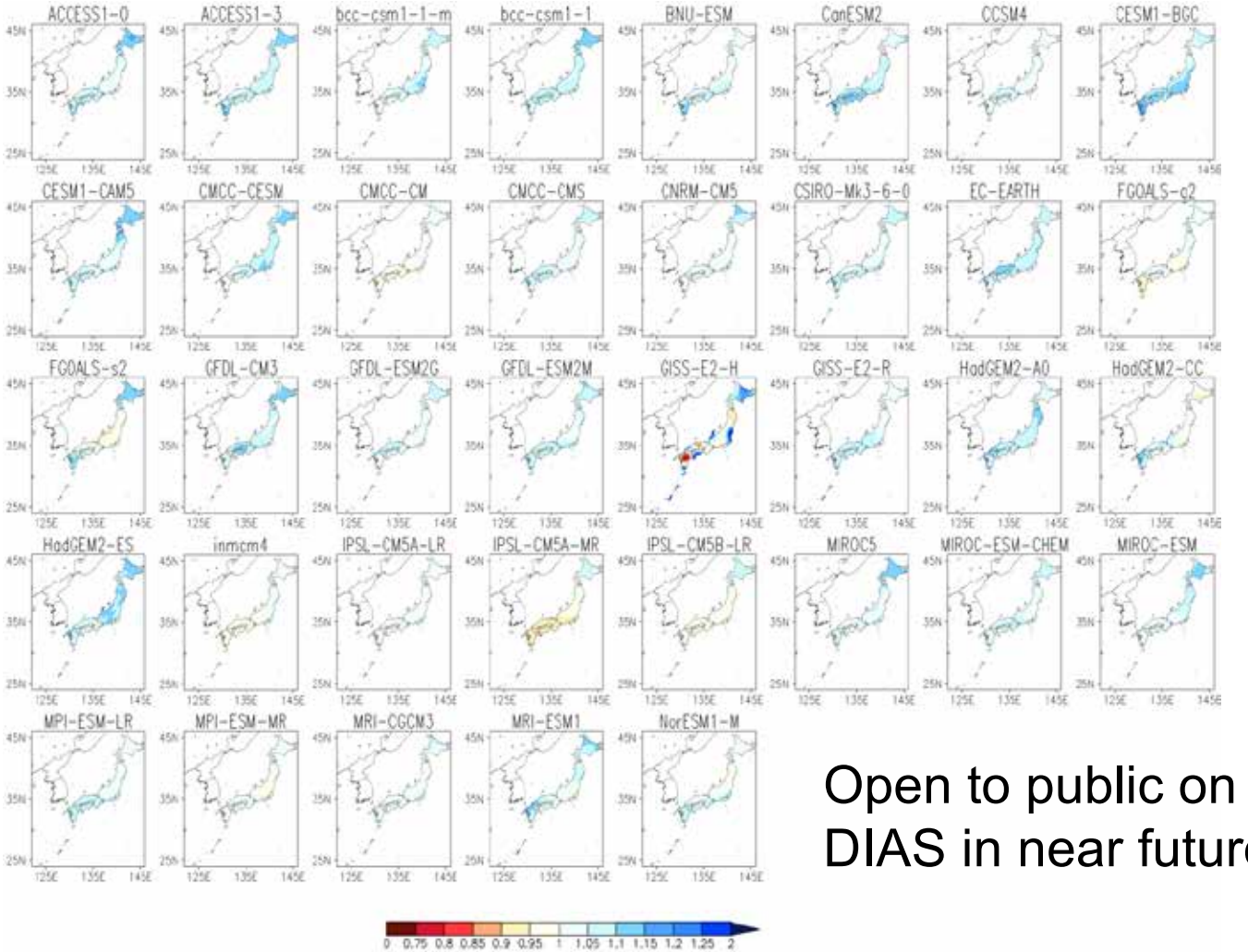
Standard Deviation



Ratio of models of increase/decrease change



37 models (CMIP5, RCP8.5, 2026-2050)




Open to public on DIAS in near future

- ✓ Each model projected different responses because of structural differences.
- ✓ The most models show increase of precipitation (qualitative consistentency) .
- ✓ Working on multi-methods ensemble

Dairaku, to be submitted.

# Expanding to CORDEX Asia

Preliminary development of ESD regional climate scenarios (BCSD) in Asia

5 Models（CSIRO-Mk3-6-0, GFDL-CM3, HadGEM2-ES, MIROC5, MRI-CGCM3）

Will contribute to inter-comparisons of multi-RCMs and multi-ESD methods as a common benchmark for investigating uncertainty of regional climate scenarios and **added values of downscaling**.

# CORDEX Asia Empirical-Statistical downscaling (ESD) group

Current Members of CORDEX Asia-ESD group

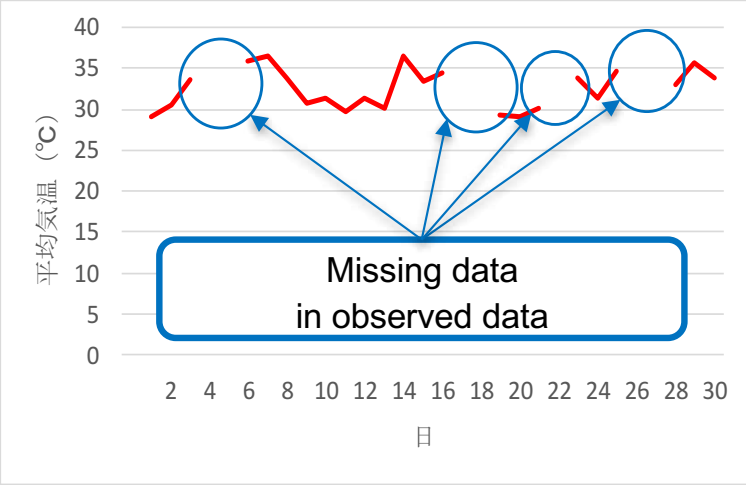
Group Leader: **Koji Dairaku** (NIED, JAPAN)
China: Ailikun (Co-chair: ITP/CAS), Lianhua Zhu (NUIST), Lijun Fan (IAP/CAS)
India: Ashwini Kulkarni (IITM)
Indonesia: Ardhasena Sopaheluwakan (BMKG), Muhammad Ridho Syahputra (ITB)
Japan: M. Nishimori (NIAES), N. Endo (NIAES), A. Yatagai (**APHRODITE-2**, Hirosaki Univ.)
Korea: Hyunhan Kwon (Chonbuk Nati. Univ.)
Malaysia: Liew Juneng (Malaysia National Univ.), Ester Salimun (Univ. of Malaysia)
Pakistan: Nuzba Shaheen, Shaukat Ali (GCISC)
Philippines: Francia B. Avila (Ateneo de Davao Univ.)
Singapore: Bertrand Timbal (CCRS)
Sweden: Iréne Lake (SMHI)
Taiwan: Cheng-Ta Chen (NTNU), Chao-Tzuen Cheng, (NCDR)
Thailand: Jerasorn Santisirisomboon (Ramkhamhaeng Univ.), Chakrit Chotamonsak (Chiang Mai Univ.)
Vietnam: Quang Dinh (VNCWE)

- Integrating the science and application of downscaling activities in Asia (EA,SEA,SA etc.) to provide regional climate information and service for risk assessment and IPCC AR6.
- **Case studies of inter-comparison of multi-ESD methods in small domain and a common benchmark** for investigating uncertainty of regional climate scenarios.

# CORDEX Asia

- Missing data processing based on APHRODITE (0.25 degree)

Daily data of monthly mean temperature

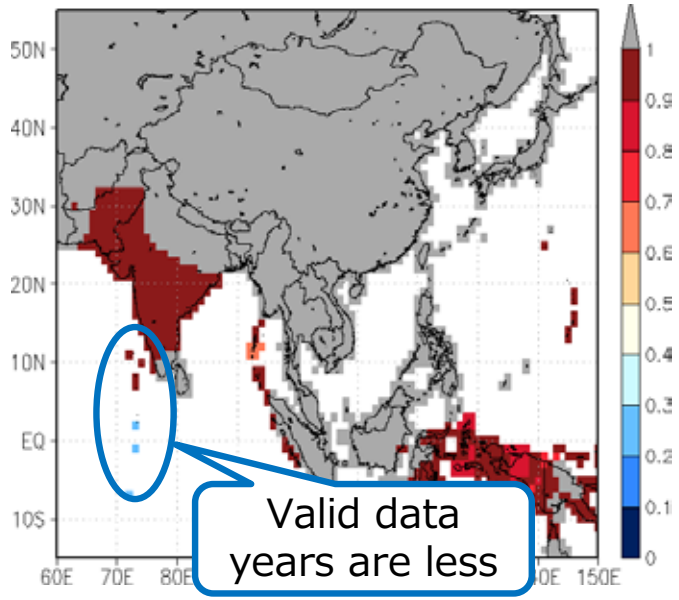



| 日 | 気温 | 日 | 気温 | 日 | 気温 |
|---|---|---|---|---|---|
| 1 | 29.2 | 11 | 29.7 | 21 | 30.1 |
| 2 | 30.5 | 12 | 31.3 | 22 | － |
| 3 | 33.7 | 13 | 30.1 | 23 | 33.8 |
| 4 | － | 14 | 36.4 | 24 | 31.4 |
| 5 | － | 15 | 33.5 | 25 | 34.6 |
| 6 | 35.9 | 16 | 34.4 | 26 | － |
| 7 | 36.5 | 17 | － | 27 | － |
| 8 | 33.9 | 18 | － | 28 | 32.9 |
| 9 | 30.6 | 19 | 29.3 | 29 | 35.7 |
| 10 | 31.3 | 20 | 29.1 | 30 | 33.8 |

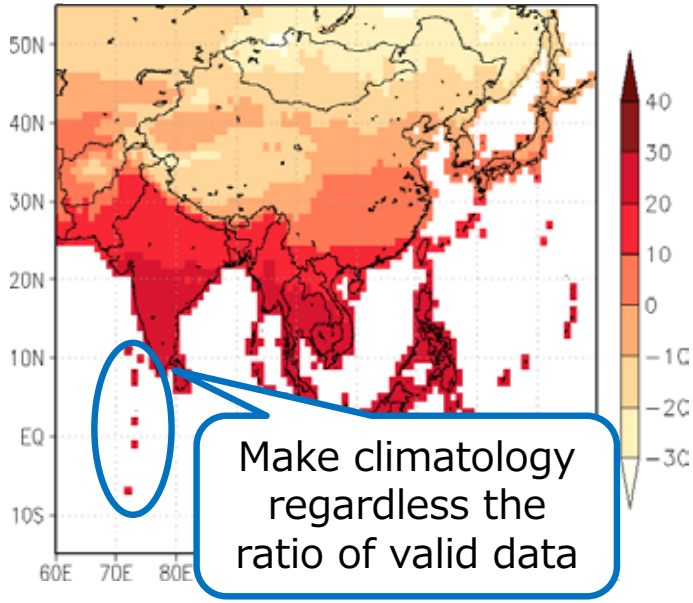
- ✓ If data is missing in a month more than 20%, the monthly data is missing data.
- ✓ If the missing data is less than 20%, the precipitation is accumulated and the temperature is monthly averaged.

- ✓ Make climatology and data for bias correction from valid data
- ✓ Make information on the percentage of valid data as reference for analysis

Valid data ratio of monthly T

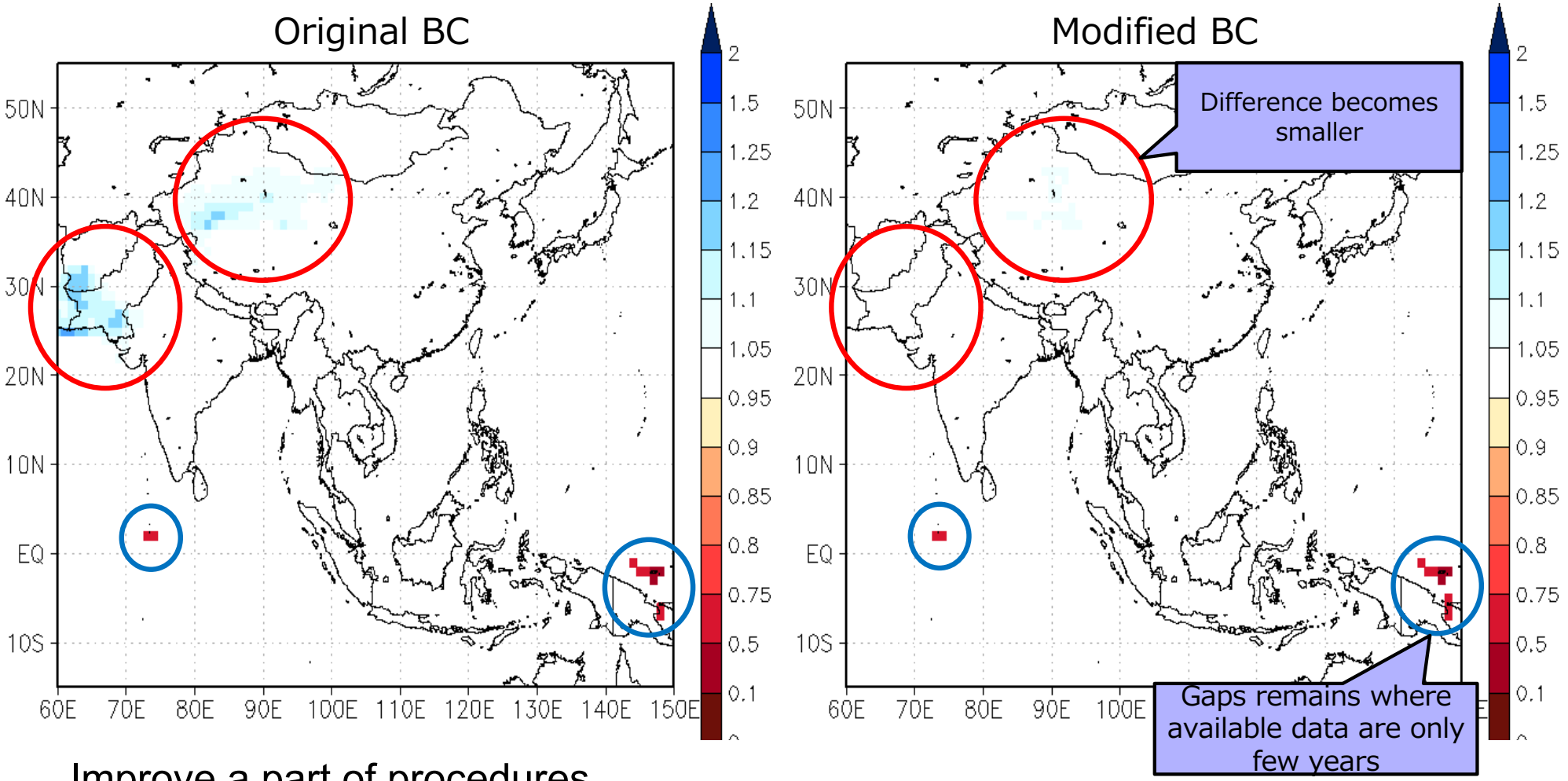



Climatology of average T



# Improvement of bias-correction method

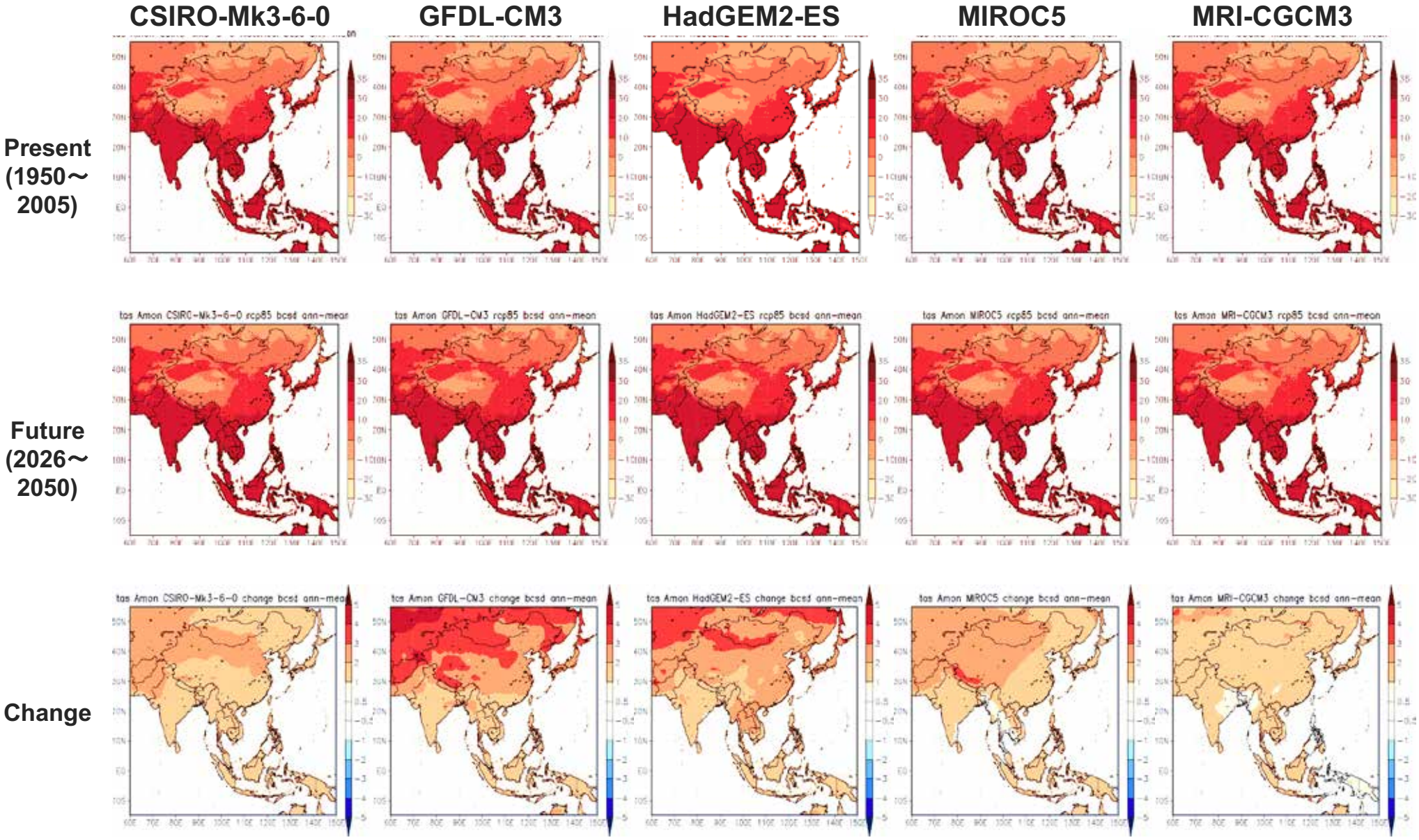
We found differences between bias-corrected Monthly and Daily values in less precipitation areas where monthly precipitation may be 0 mm. **Add pre-process** to match the precipitation months with the observation.



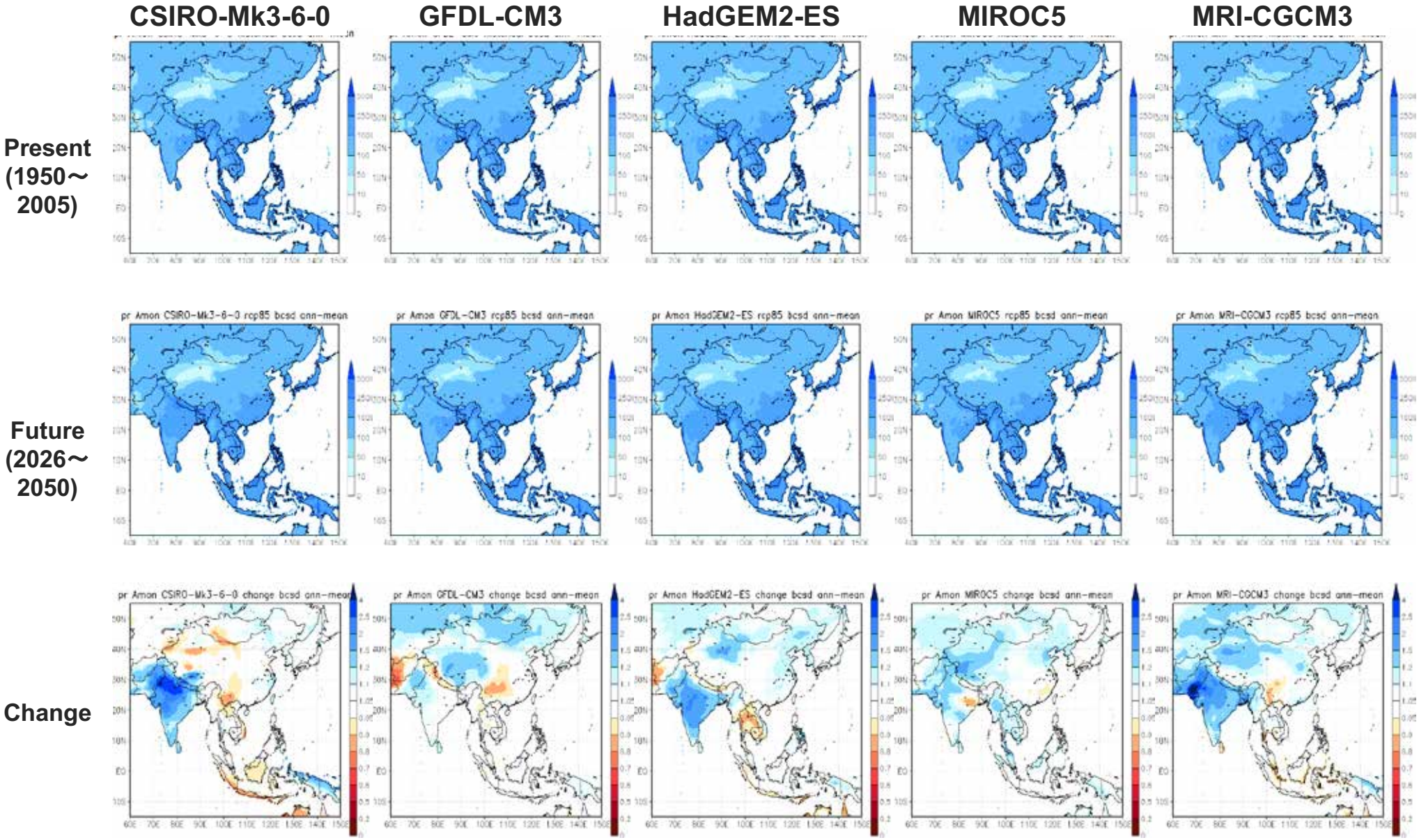

Improve a part of procedures.

→ **Improve generality and robustness of the method.**

# Projected future change of annual 2m air temperature （tas, near future: 2026-2050, RCP8.5）



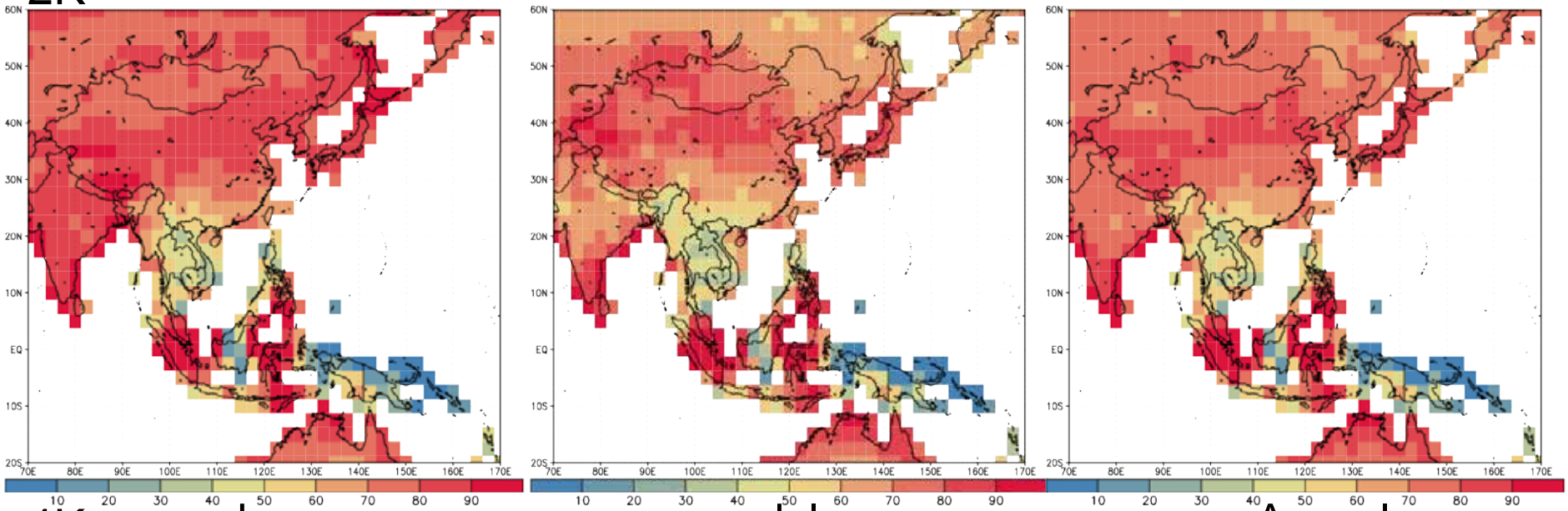
# Projected future change of annual precipitation
# （pr, near future: 2026-2050, RCP8.5）



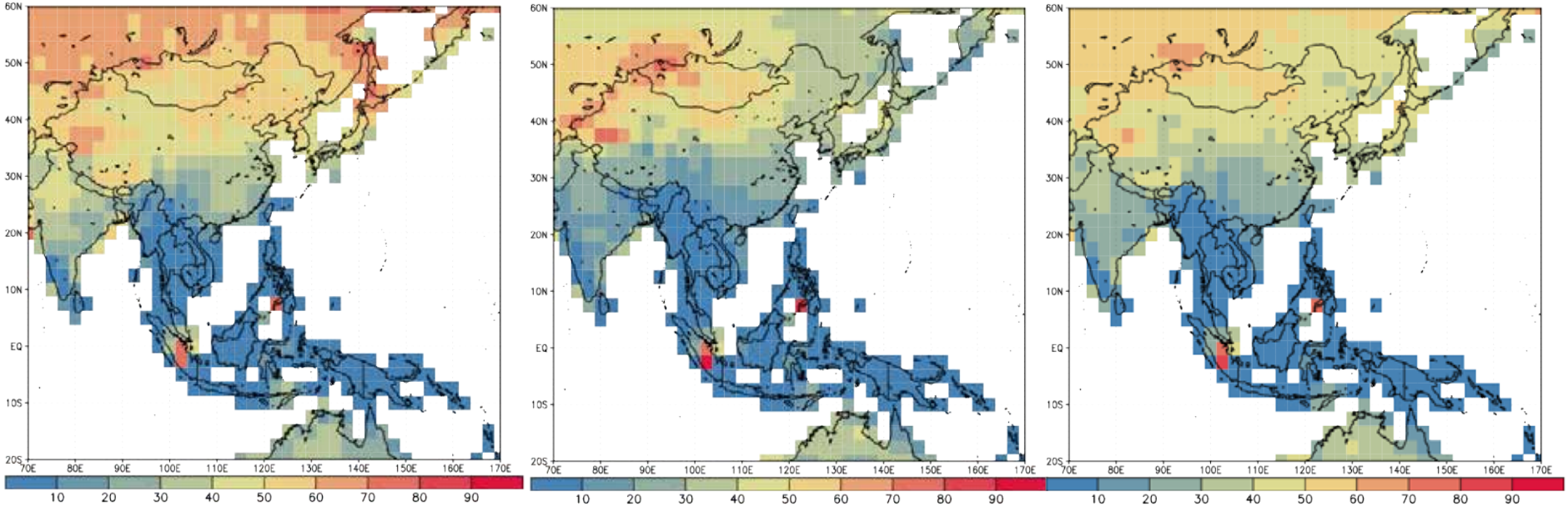
Future(A1b)-Present

# Probability map of 2m Temperature (2069-2098)-(1969-1998)

ΔT>2K




ΔT>4K




**Contributed to the report by the Ministry of Foreign Affairs in Japan for G7 Working Group on Climate Change and Fragility** (Sep 6th 2017 press release) (Based on Ishizaki, Dairaku, Ueno, HRL, 2017)

# Summary and Issues

◆**Bottom-up process and risk-based approach(SI-CAT)**

Include more regional stakeholders to develop regional climate scenarios for policy-relevance (national/regional climate adaptation).

◆Develop Hi-resolution **large ensemble** dynamical/statistical downscaling for **probabilistic regional climate information** in Japan and CORDEX-Asia.

**Already provided to many stakeholders. Open to public on DIAS (ESGS regional node in Japan)** in very near future. Uncertainty in climate scenario ensemble experiments, Added values, Extreme events.

◆**CORDEX Asia**.

・Develop preliminary product for **a common benchmark and stocktake** for a rich diversity of multi-model/method ensembles and for investigating uncertainty of climate scenarios and climate risks.

・Improvement of reliability/skill (added values) of regional climate scenarios by cooperation with observational research.