# Assessing climate change impact on flood peak discharges of all the class-a rivers in Japan

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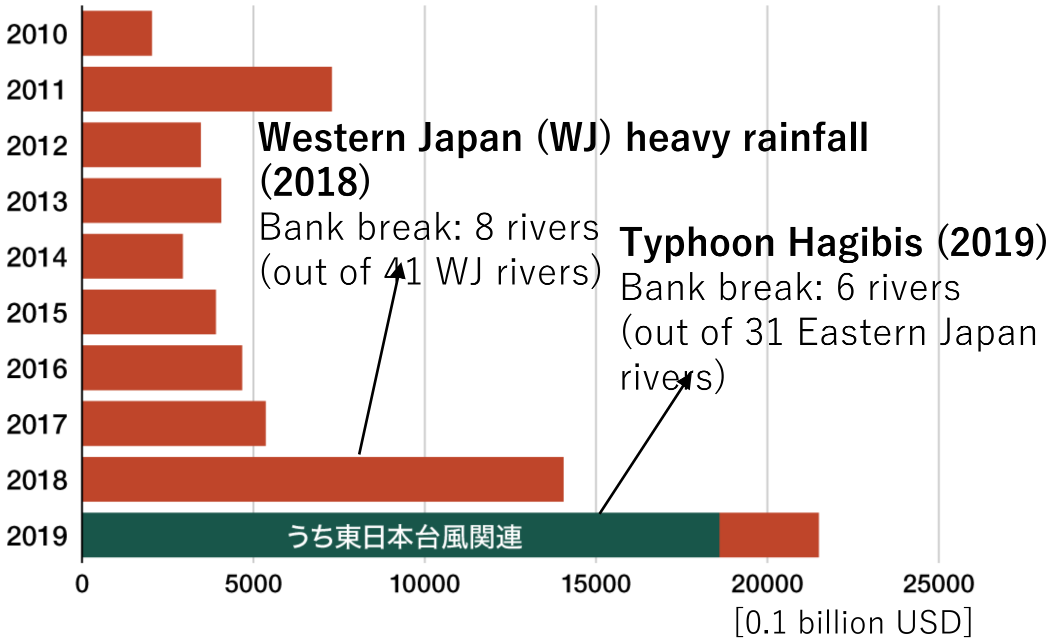
# Increasing impact of flood disaster in Japan

January 17, 2022

# Recent flood disaster in Japan

- Increasing amount of economic loss due to water-related disasters
- Heavy rainfall over a wide range caused simultaneous flood damage in recent two years (2018, 2019)
- Nation-scale impact assessment is urgent

Water-related disaster damage (without Tsunami)




MLIT, Japan

nippon.com

https://www.nippon.com/ja/japan-data/h00812/

Translated/Edited by Tanaka T.

# database for(4) Policy Decision makers for Future climate change (d4PDF)

# → Large ensemble for robust trend detection

IPCC AR5 WG1 Fig. SPM7 edited based on d4PDF website by Tanaka

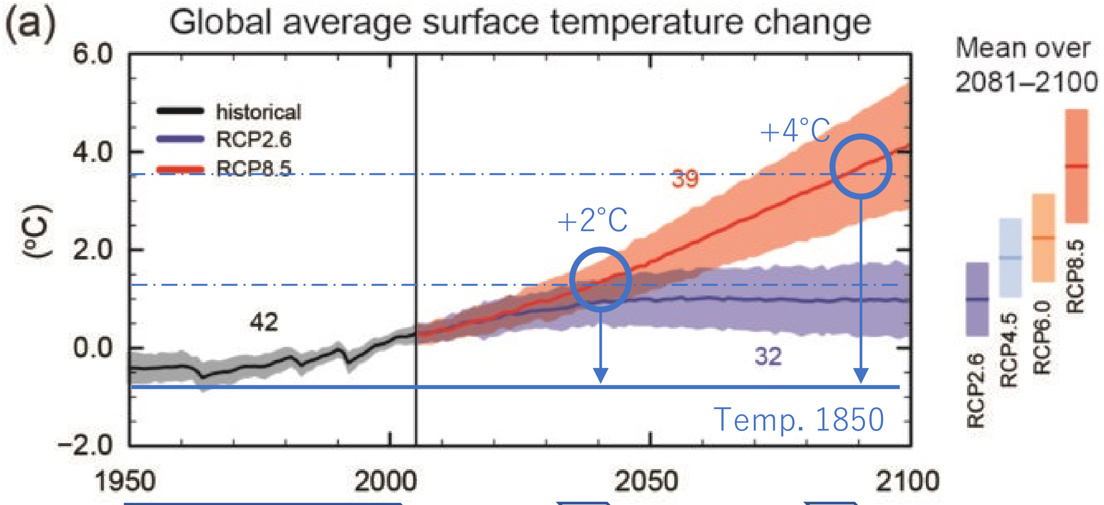
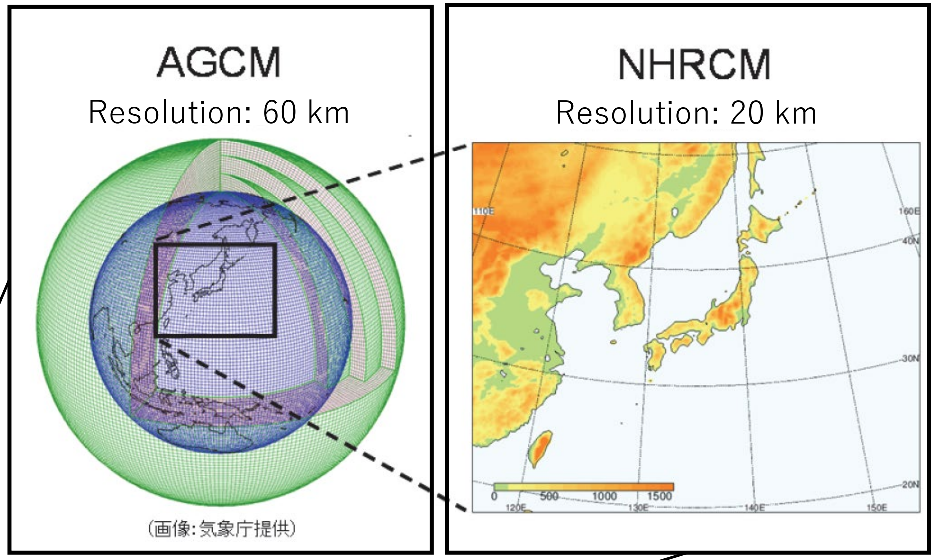



Image cited from d4PDF website and edited by Tanaka




100 ens. → 90 ens. GCM (Global)

Dynamical downscaling

Historical experiment: 50 ens. → 90 ens. RCM (Regional)

4-deg rise experiment

This study used…

- Present climate (Historical)
- Future climate (4-deg rise)

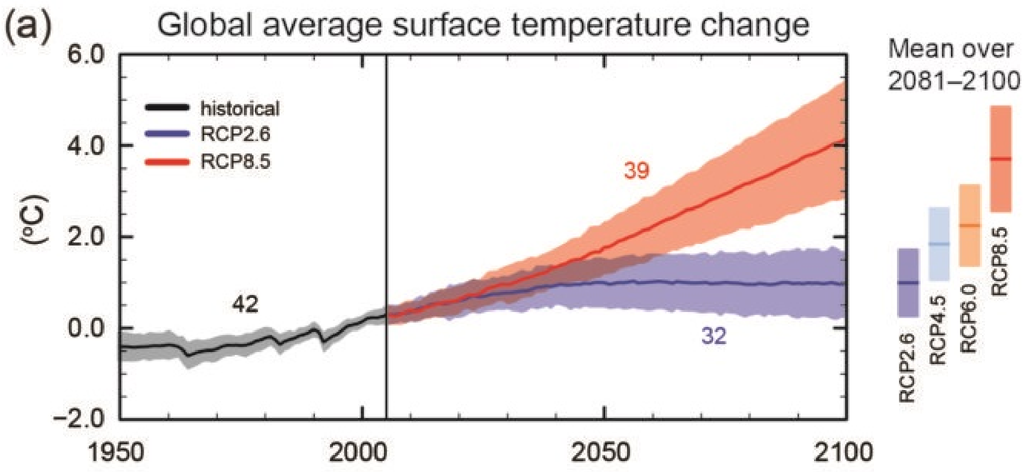
# Purposes

- To make a full use of the state-of-the-art large ensemble climate simulation data d4PDF to detect future flood risk all over Japan
    - Bias correction of large ensemble data with observation data
    - All-Japan rainfall-runoff modelling
    - River discharge/Simultaneous flood assessment

# Data and Study area

<u>d4PDF</u>

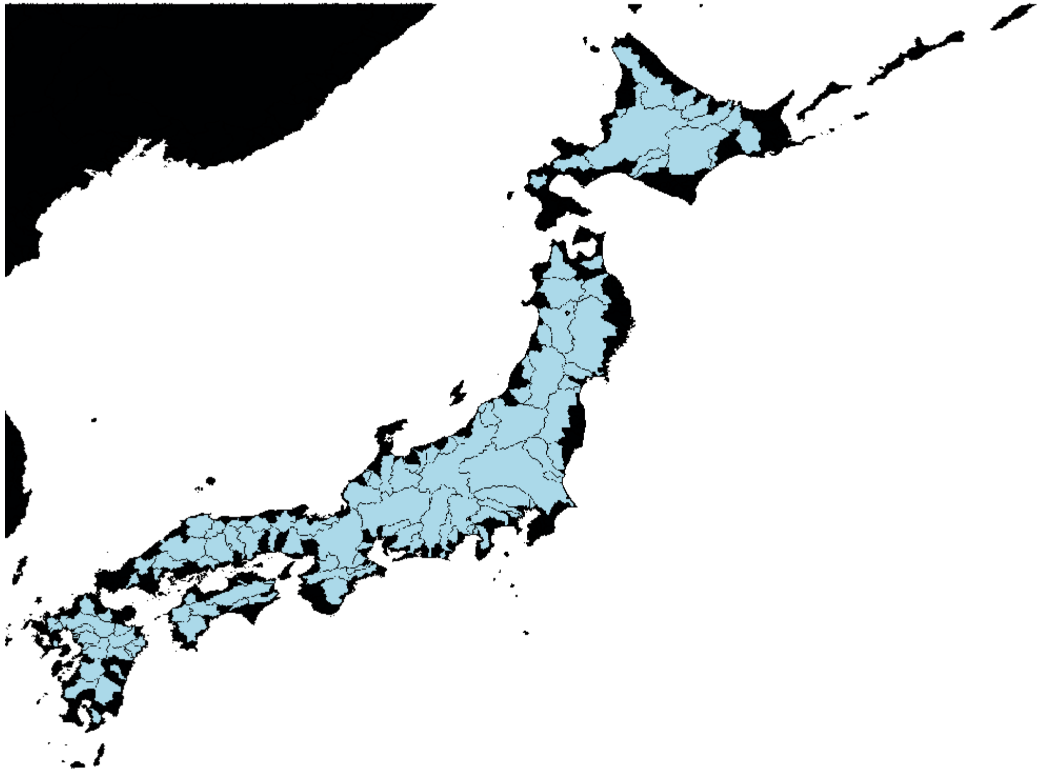
Large ensemble climate data




IPCC AR5 WG1 Fig. SPM7

<u>All (109) class-A rivers in Japan</u>

Nation-wide analysis



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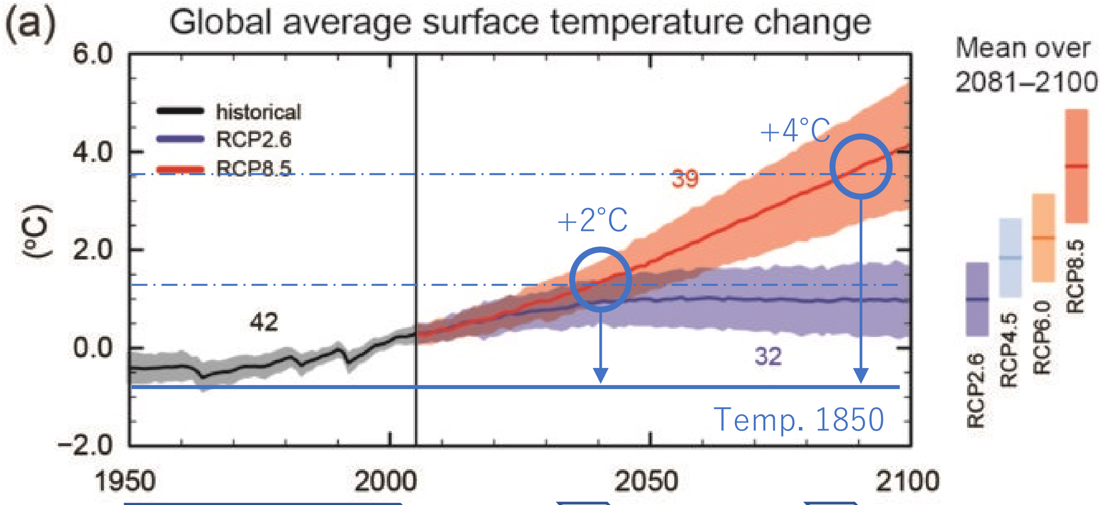
IPCC AR5 WG1 Fig. SPM7 edited based on d4PDF website by Tanaka

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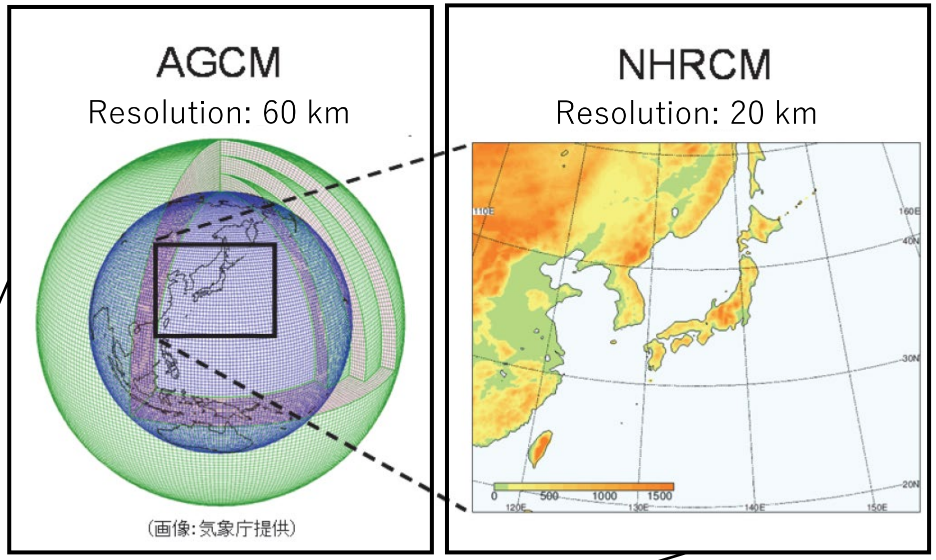


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4-deg rise experiment

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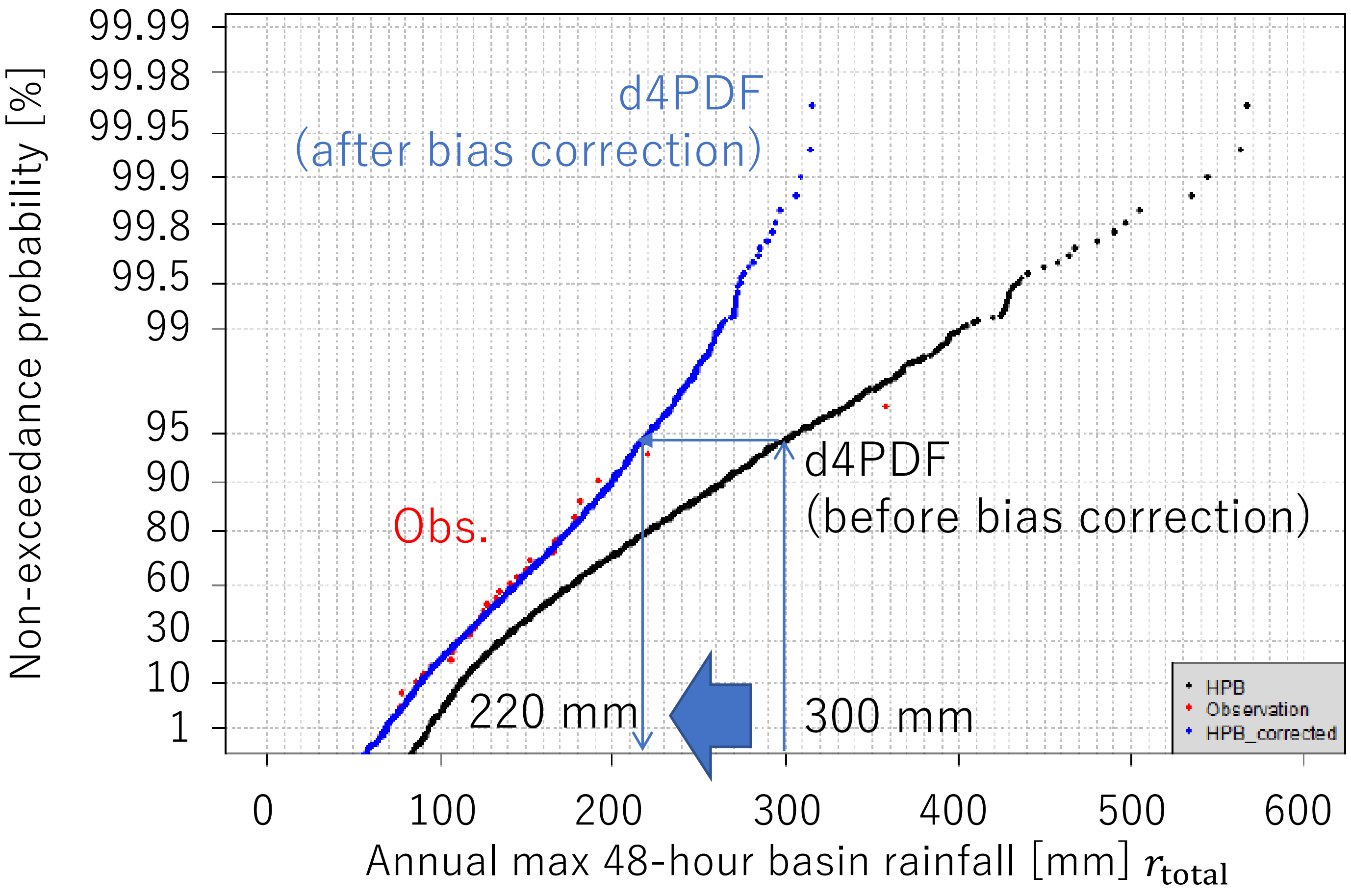
# Bias correction for extreme rainfall

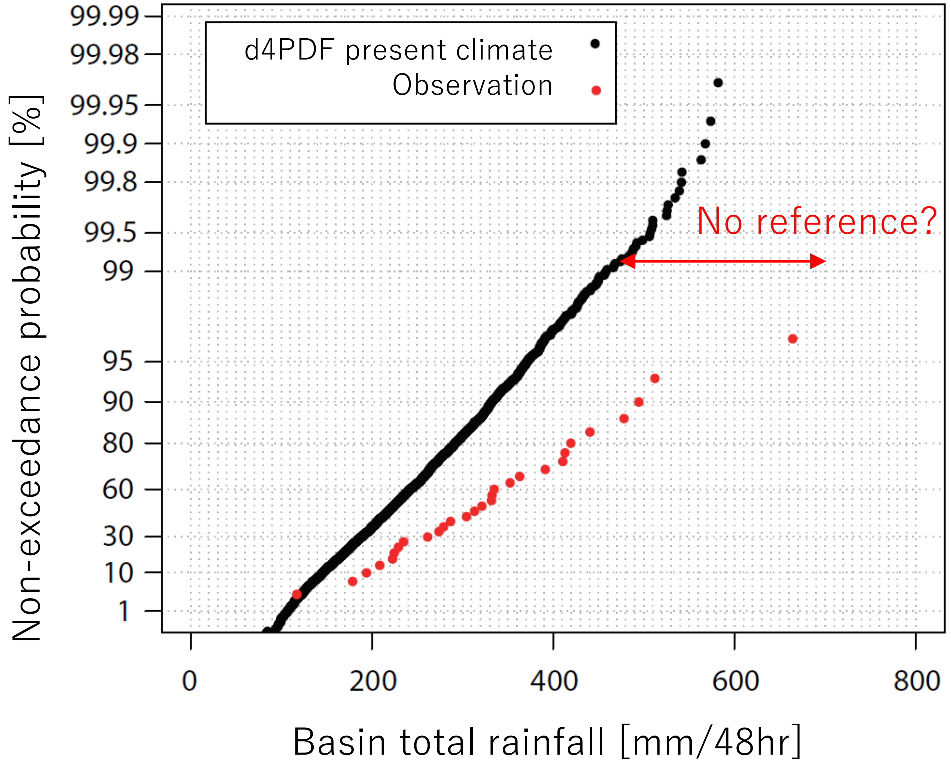
1. Fit Gumbel/GEV distribution to observation data
2. Calculate correction factor $\alpha$ to for each rainfall level $\alpha = \alpha(r_{\mathrm{total}})$ (Piani et al., 2010)
3. Apply the factor to rainfall intensities of annual max storm events in d4PDF 4-deg rise rainfall $r_{\mathrm{Cor}}(t) = \alpha\big(r_{\mathrm{Raw}}(t)\big)r_{\mathrm{Raw}}(t)$



# Bias correction of large ensemble?

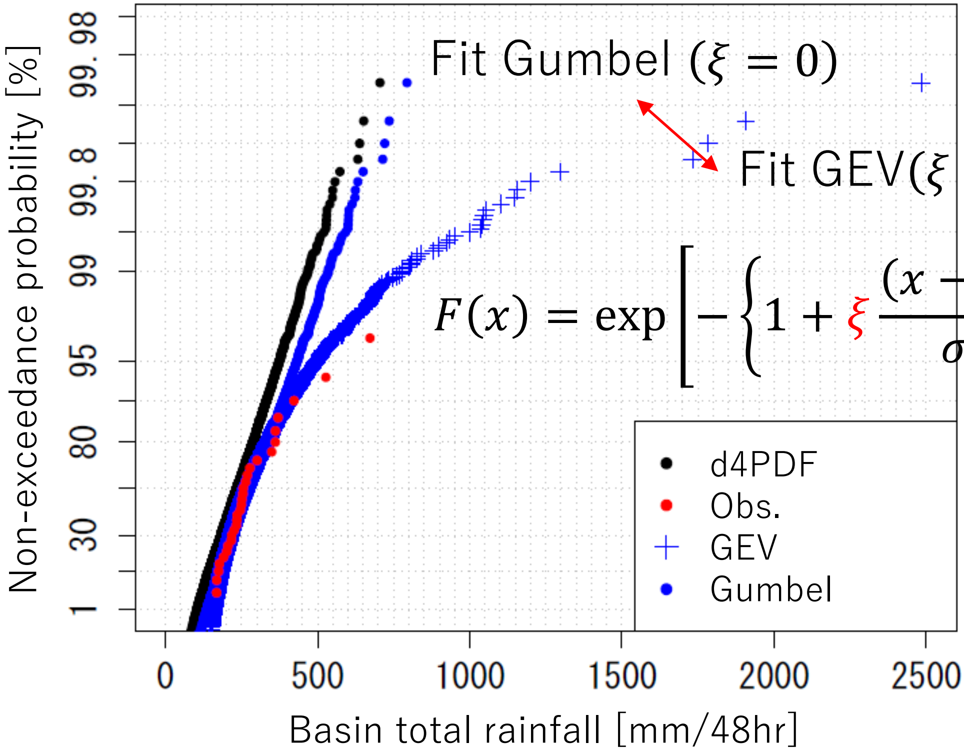
No reference is available for higher data in d4PDF

→ Fit extreme value distributions




Allowing a free parameter $\xi$ (GEV) potentially overfits

→ Examine a reasonable range of the shape parameter

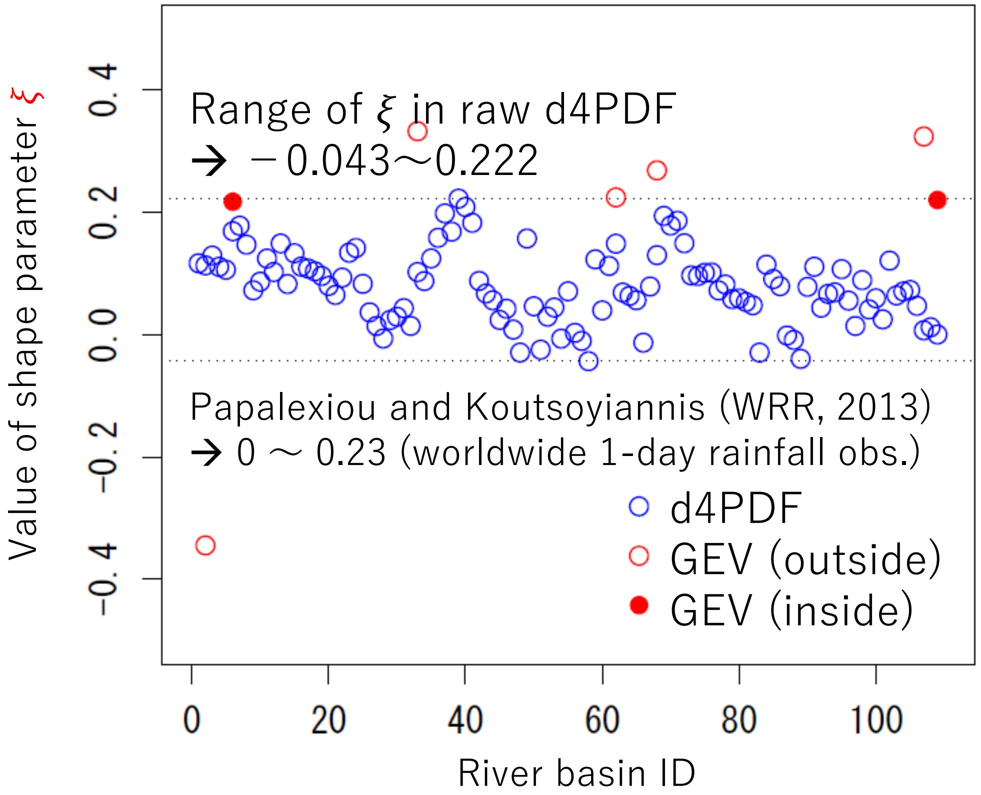



$$F(x) = \exp\left[-\left\{1 + \xi \frac{(x-\mu)}{\sigma}\right\}^{-1/\xi}\right]$$

# Bias correction of large ensemble?

Assuming that "bias is mainly for location/scale",
its reasonable range is referred from raw d4PDF

→ Well corresponded to the literature

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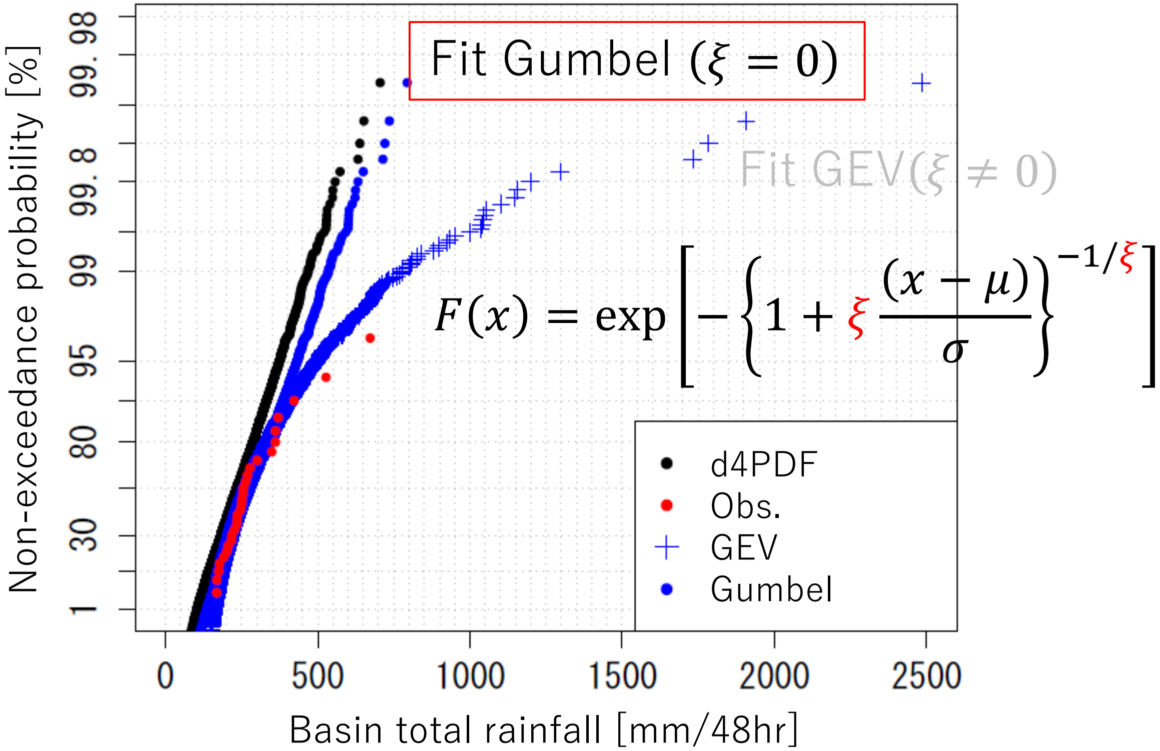
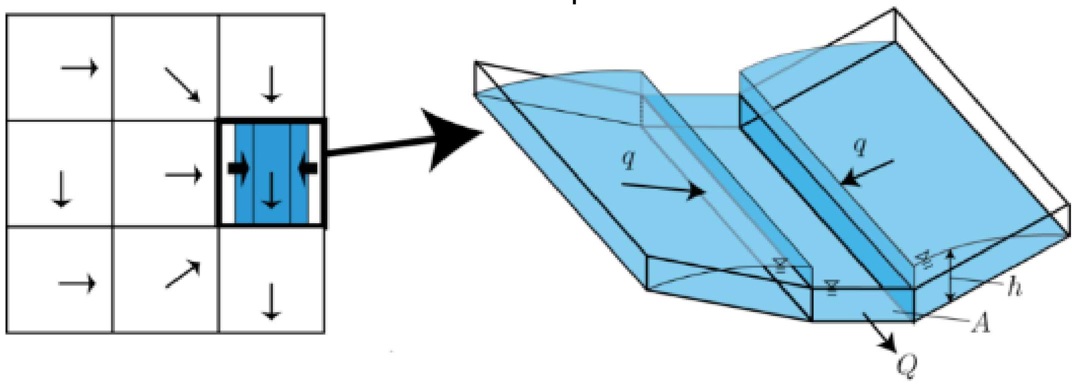


# Rainfall-runoff model: 1K-DHM

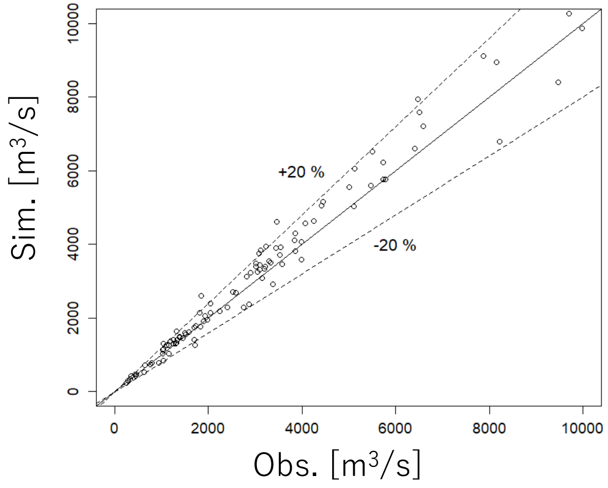
- Model: 1 Km Distributed Hydrological Model (1K-DHM)
- Scheme: kinematic wave model with surface and sub-surface flow components
- Soil parameter:
  - Soil depths
  - Hydraulic conductivity
  - Exponential coefficient of saturation for hydraulic conductivity
  - Manning's roughness coefficient
- Dam: operational cut-off rule
- Optimization: SCE-UA
- Target event: largest flood

Flow direction

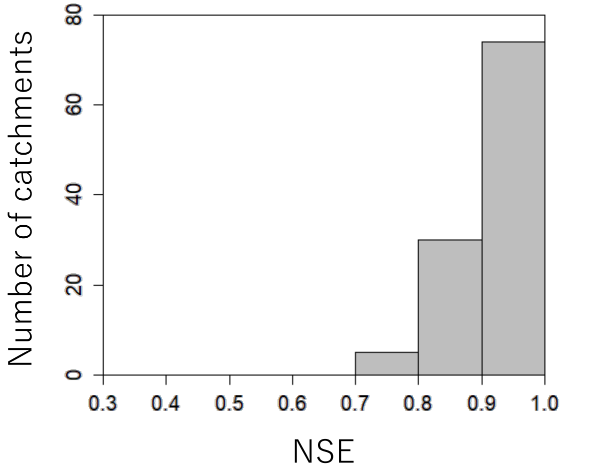
Slope-river element




Peak flow

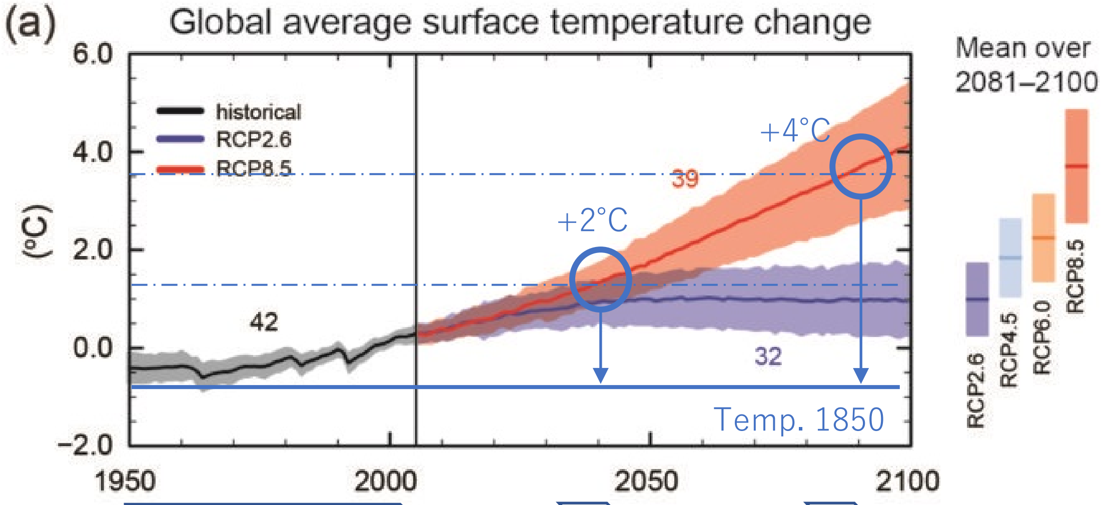



Nash-Sutcliffe Coefficient



# Ensemble description in d4PDF

IPCC AR5 WG1 Fig. SPM7 edited based on d4PDF website by Tanaka




100 ens. → 90 ens. — GCM (Global)

Dynamical downscaling

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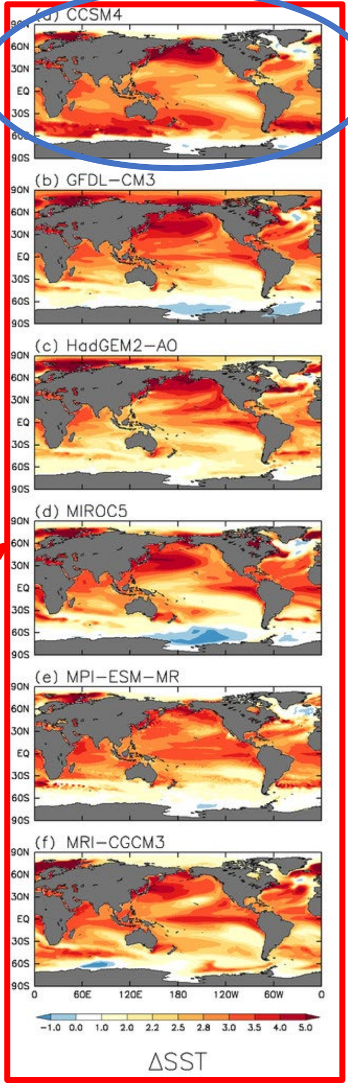
Historical experiment

4-deg rise experiment

6 SST projections (boundary condition)



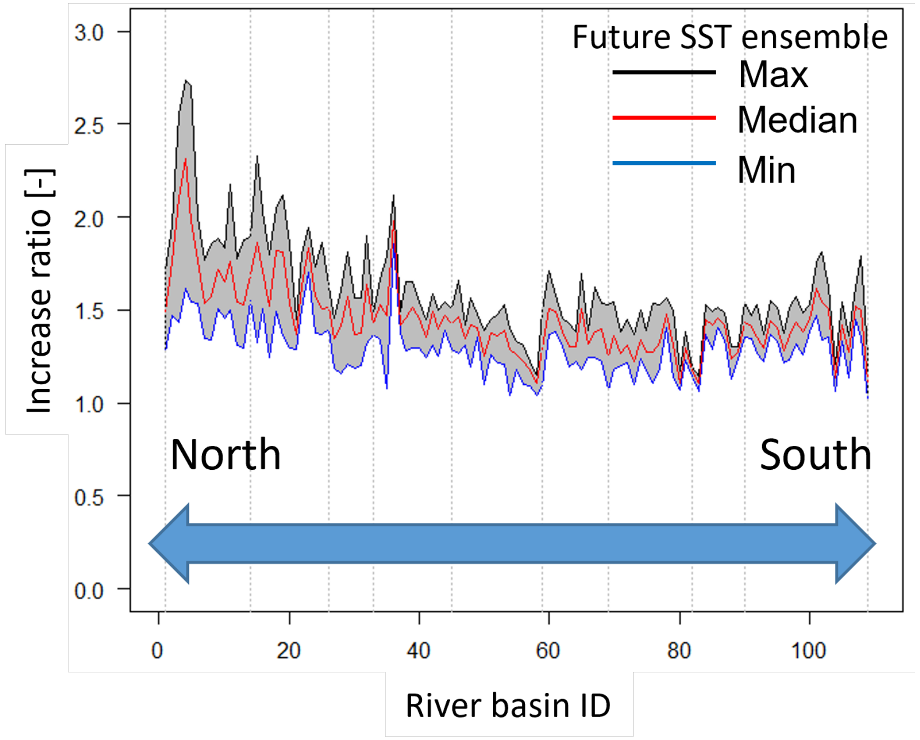

Mizuta et al. (2017) Fig. 2 (a)-(f)

60-year simulation times 15 small perturbation patterns
→ 900-year simulation

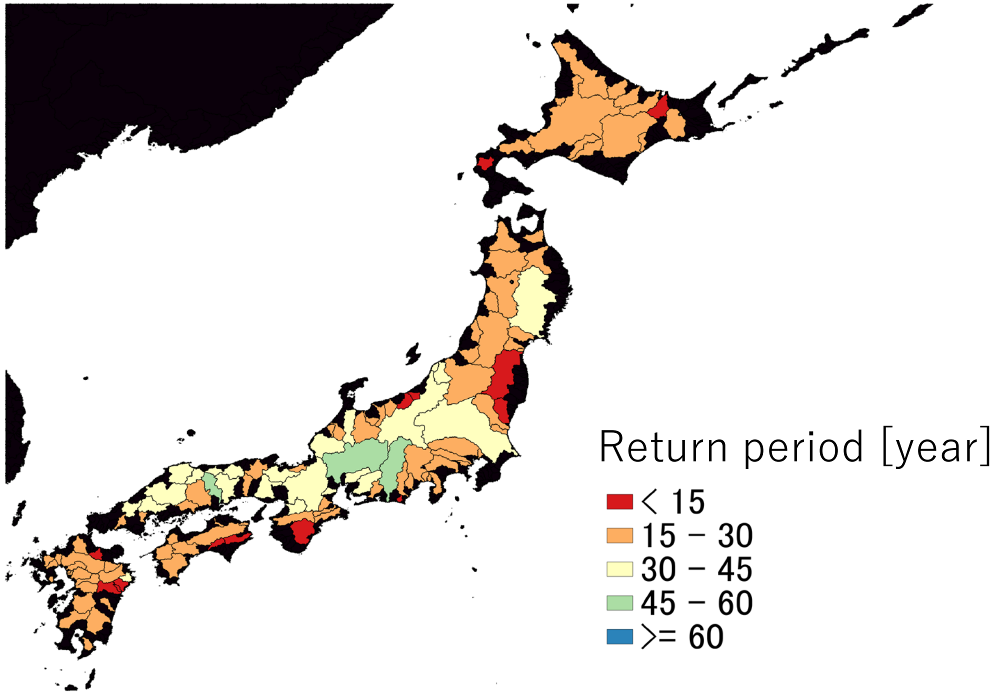
For 4-degree rise experiment, 900-year data is treated as one large dataset and 6 SST projections are shown as ensemble spread

# All-Japan impact assessment

Higher increase ratio in northern Japan, closer to the Arctic ocean

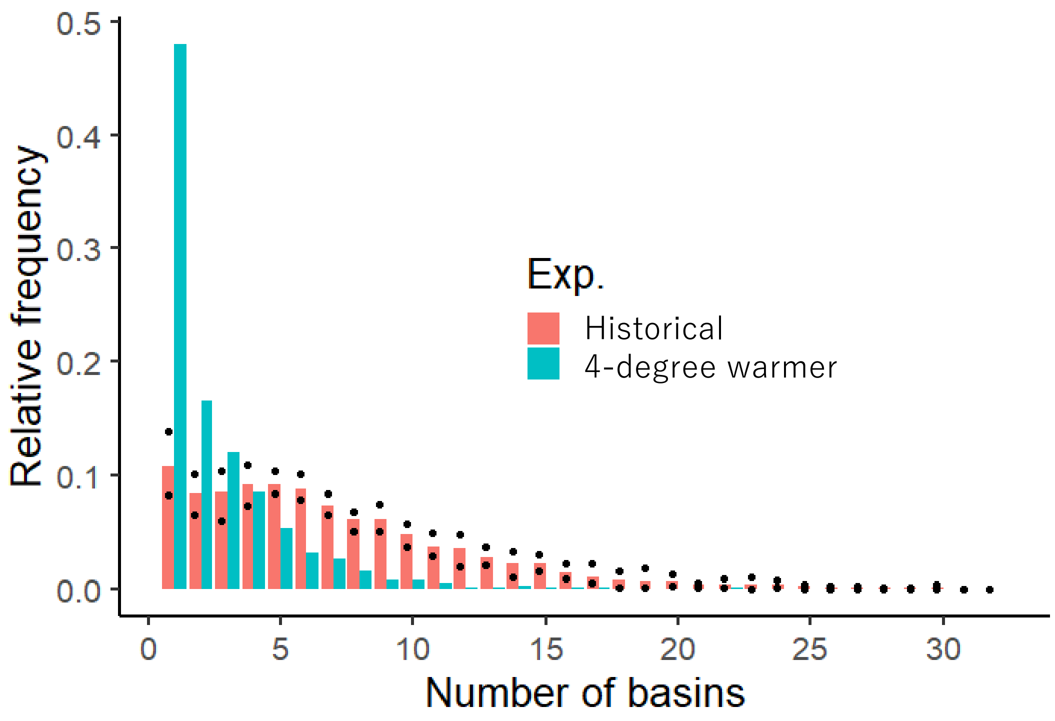



Design level (100 to 200 years in Japan) will decrease to 15 to 60 years in the 4 degree rise climate

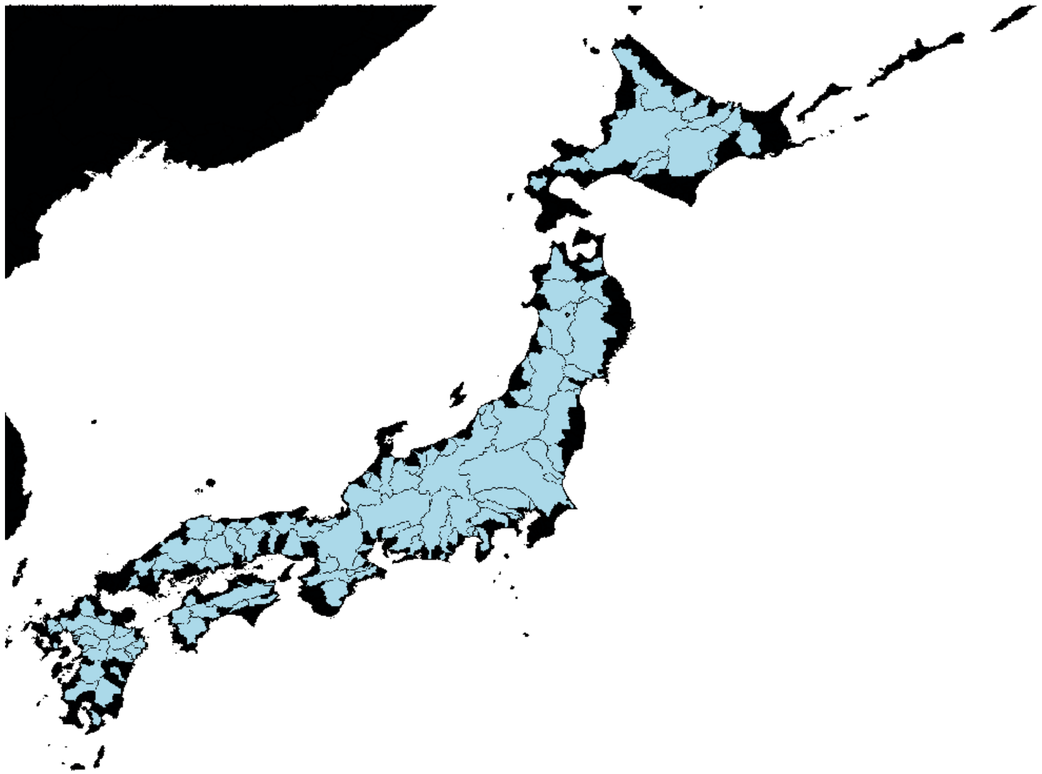


# Simultaneous flood probability
## (1) All Japan

Higher frequency of same-year flood far beyond ensemble spread (black)



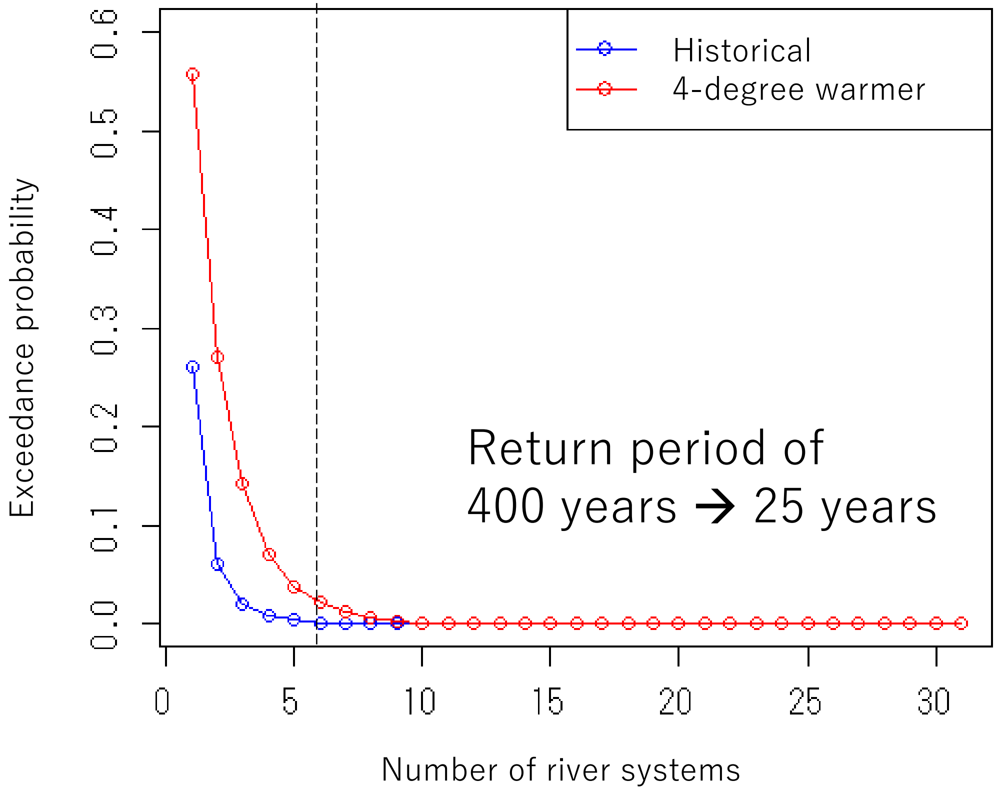

Number of simultaneous flood rivers
→ Exceed design flow in the same year in d4PDF

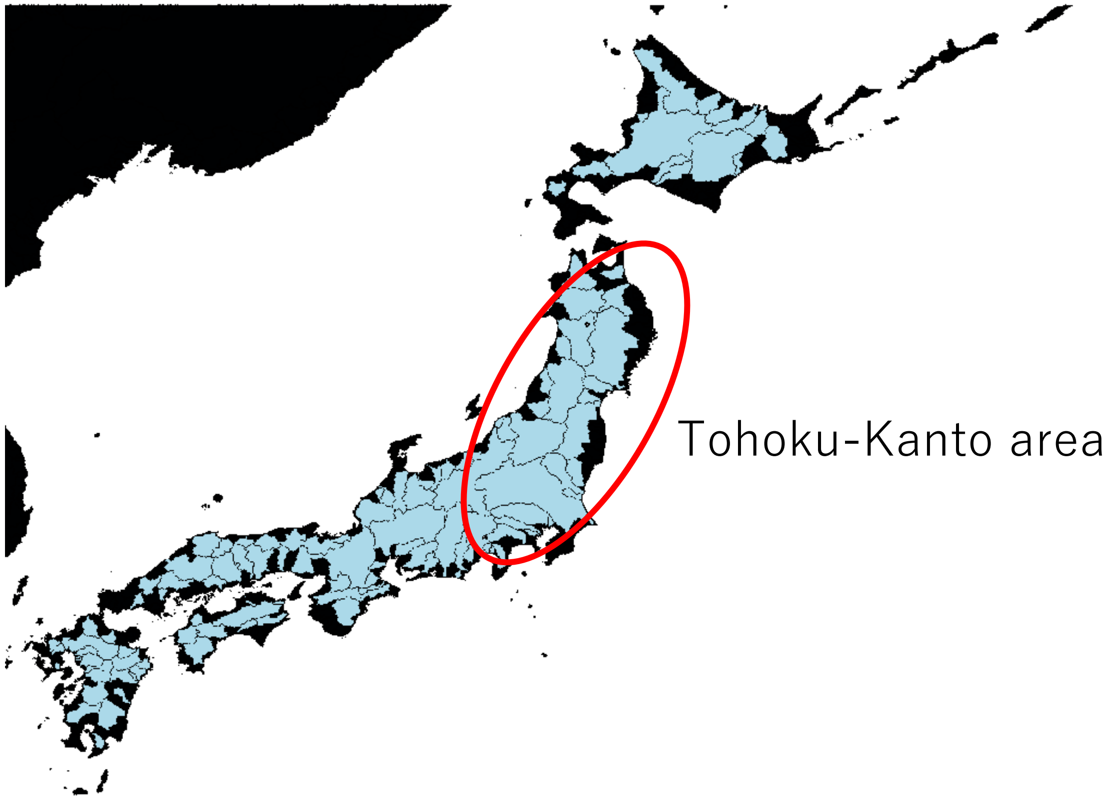


# Simultaneous flood probability

## (2) Tohoku-Kanto area damaged by Tyhoon Hagibis, 2019

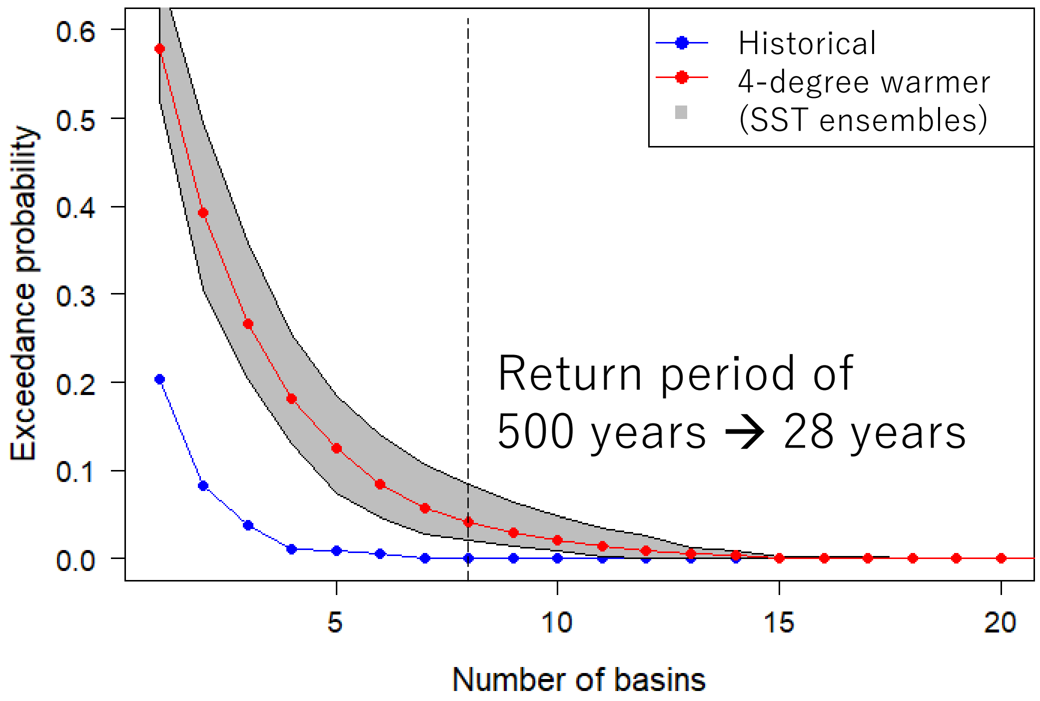
Heavy rainfall in 2018
→ 6 rivers were flooded

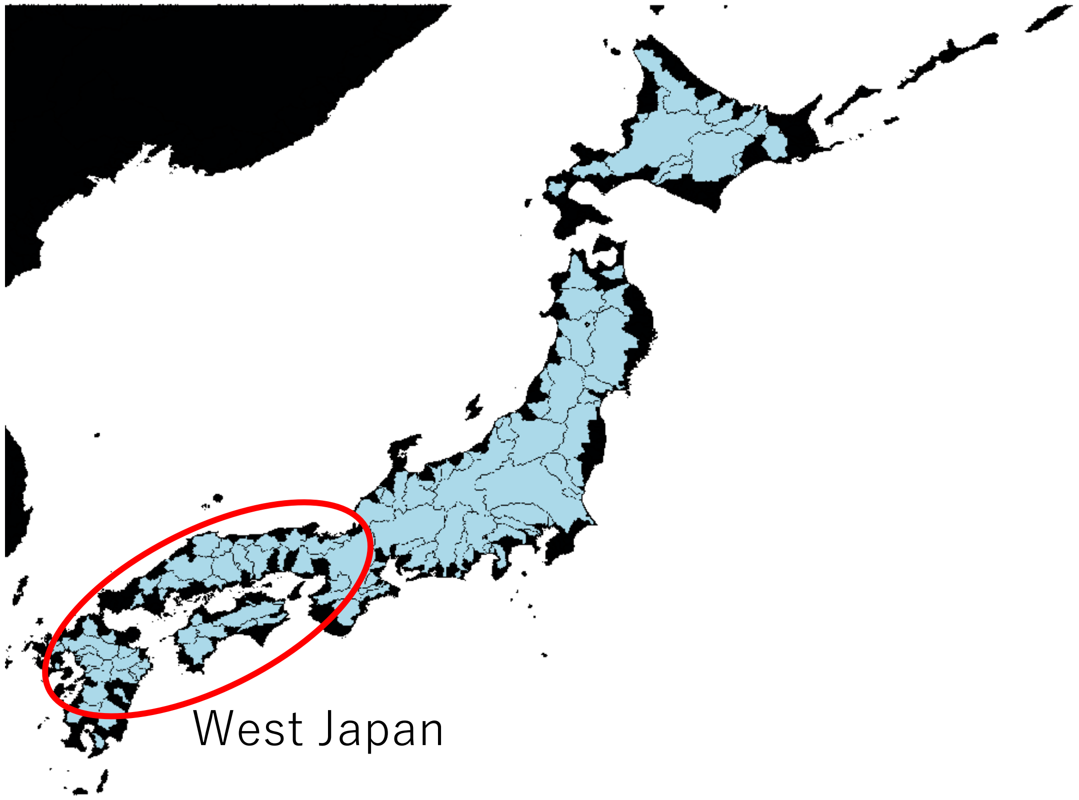


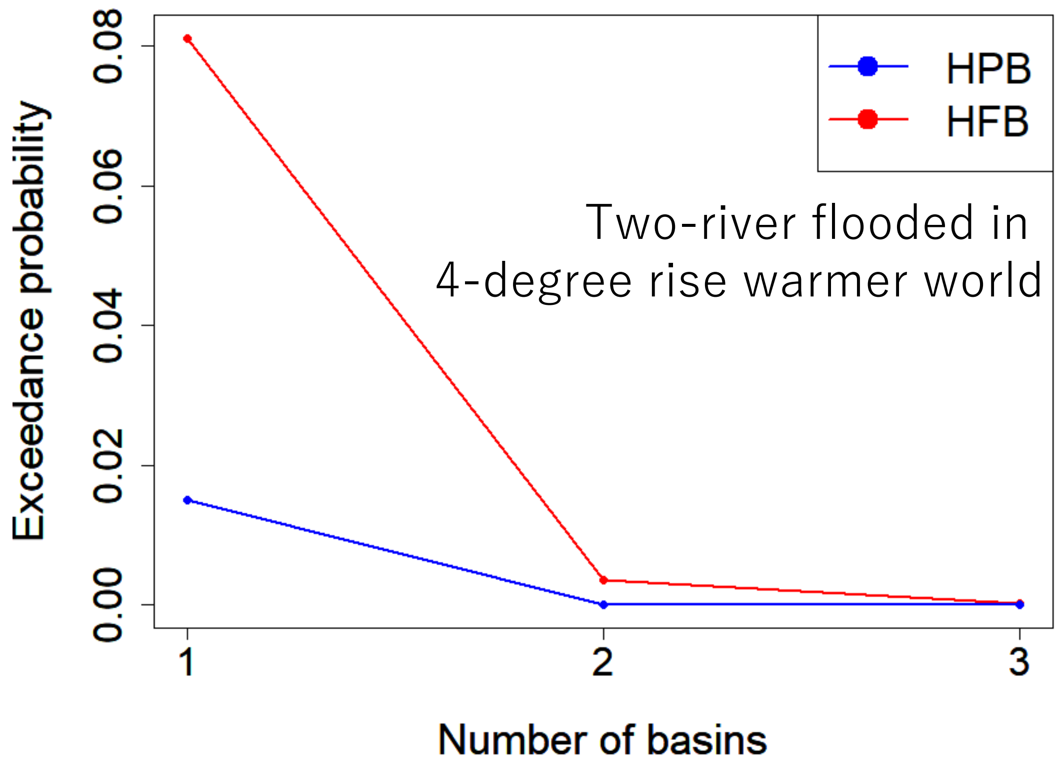
# Simultaneous flood probability
## (3) West Japan area damaged by heavy rainfall 2018

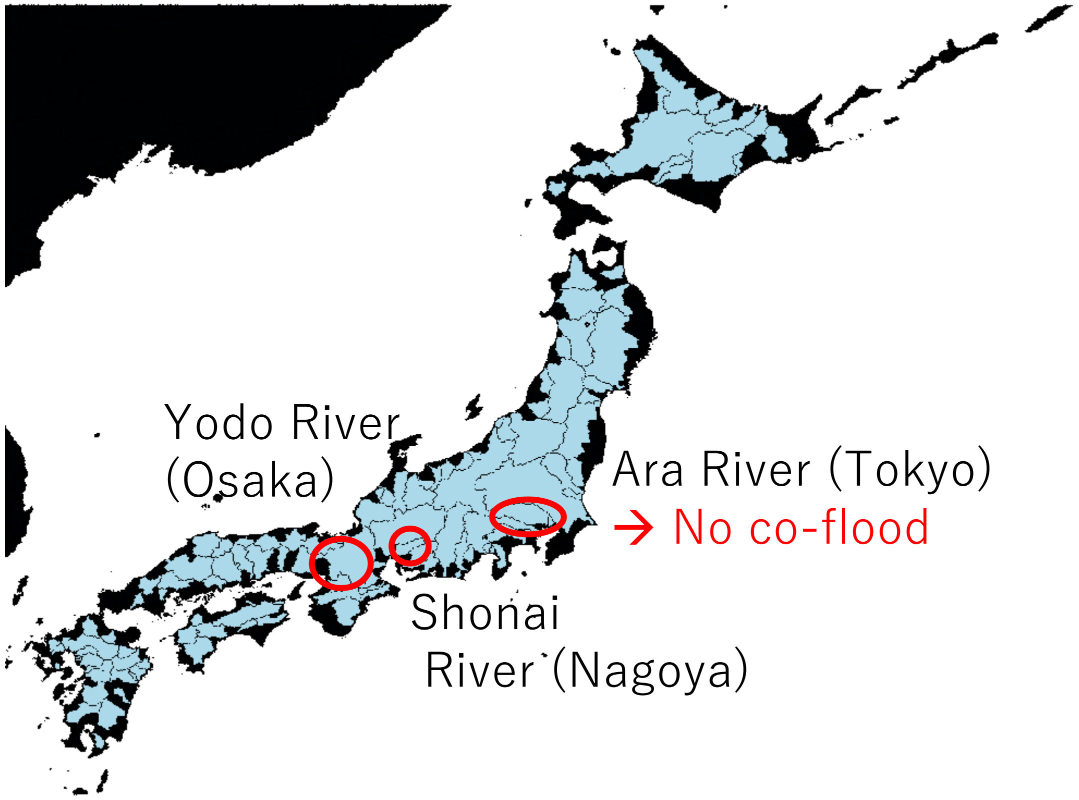
Heavy rainfall in 2018
→ 8 rivers were flooded



# Simultaneous flood probability
## (4) Tokyo-Nagoya-Osaka metropolises



# Conclusions

- All-Japan impact assessment on flood flows was achieved by the combination of:
  1. Basin-scale rainfall-runoff modelling over all 109 class-A rivers
  2. Large ensemble extreme rainfalls by d4PDF (with its robust bias correction in line with extreme value theory)
- In the 4-degree warmer climate,
  - Clearly higher impact on floods is seen in northern Japan (~ 1.5-2.0 times of annual max flow)
  - Design floods (100-200 years) will occur at 15- to 60-year return period
  - Simultaneous flood frequency will significantly increase even considering the ensemble spread of future SST projections

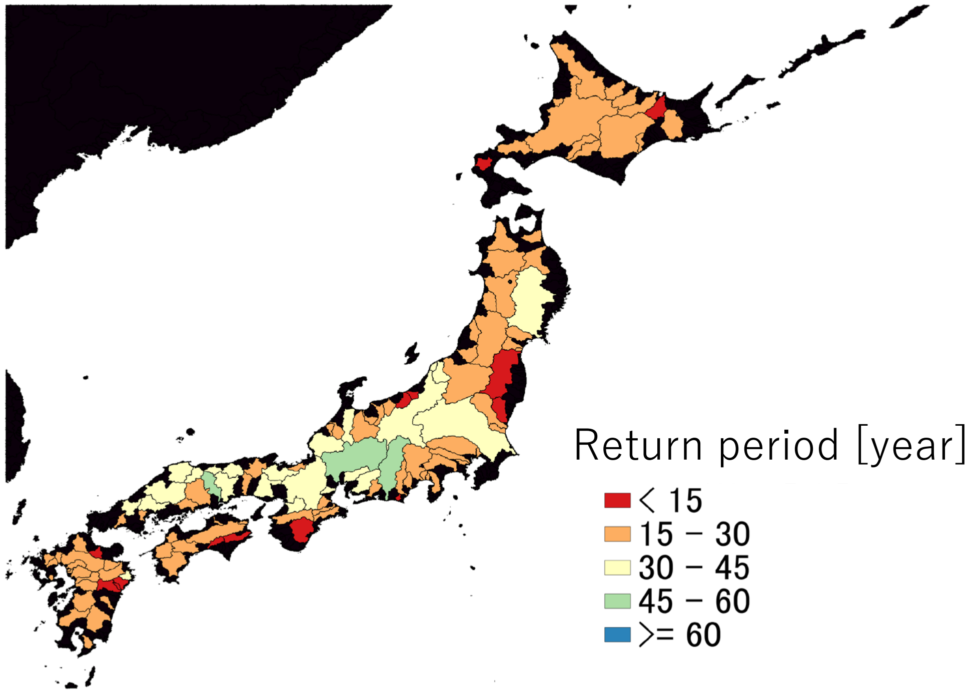
**In addition to higher river basin management, large-scale flood risk management (including the national master plan) is essential**

# Research continues…

Future extreme floods were projected

What about dam effect and capacity?

How/Why will they change in region to region?




Jan. 27 Room 6 at 15:00-15:20
Presented by Keiichiro Kitaguchi

TA-123L
Future changes of flood control effects of dams in class-A rivers in Japan using d4PDF

# Thank you very much for your kind attention!

Paper list:


1. Kobayashi, K., Tanaka, T., Shinohara, M. and Tachikawa Y. 2020. Analyzing future changes of extreme river discharge in Japan using d4PDF, Journal of Japan Society of Civil Engineers, Ser. B1 (Hydraulic Engineering), 76(1), 140-152.
2. Tanaka, T., Kobayashi, K. and Tachikawa, Y. 2020. Analyzing return period of number of flooded rivers by typhoon Hagibis and its future change, Journal of Japan Society of Civil Engineers, Ser. B1 (Hydraulic Engineering), 76(1), 159-165.
3. Tanaka, T., Kobayashi, K. and Tachikawa, Y. 2021. Simultaneous flood risk analysis and its future change among all the 109 class-A river basins in Japan using a large ensemble climate simulation database d4PDF, Environmental Research Letters, 16, 074059.



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