Projection of River Discharge in Japan and Thailand under Climate Change and its Impact on Water Resources

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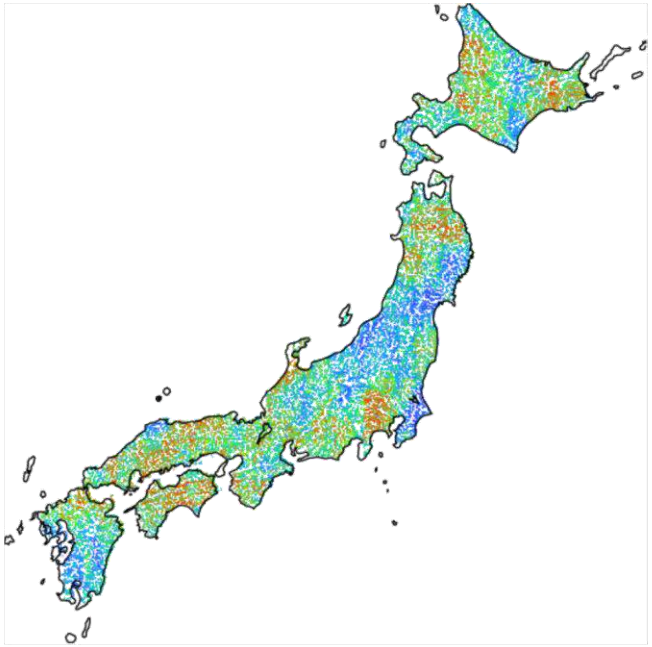
Motivations

- How will river discharge change under climate change?
- Are there some catchments where projected discharge show a large change?
- A river discharge change will have an influence on what?

Method of Analysis

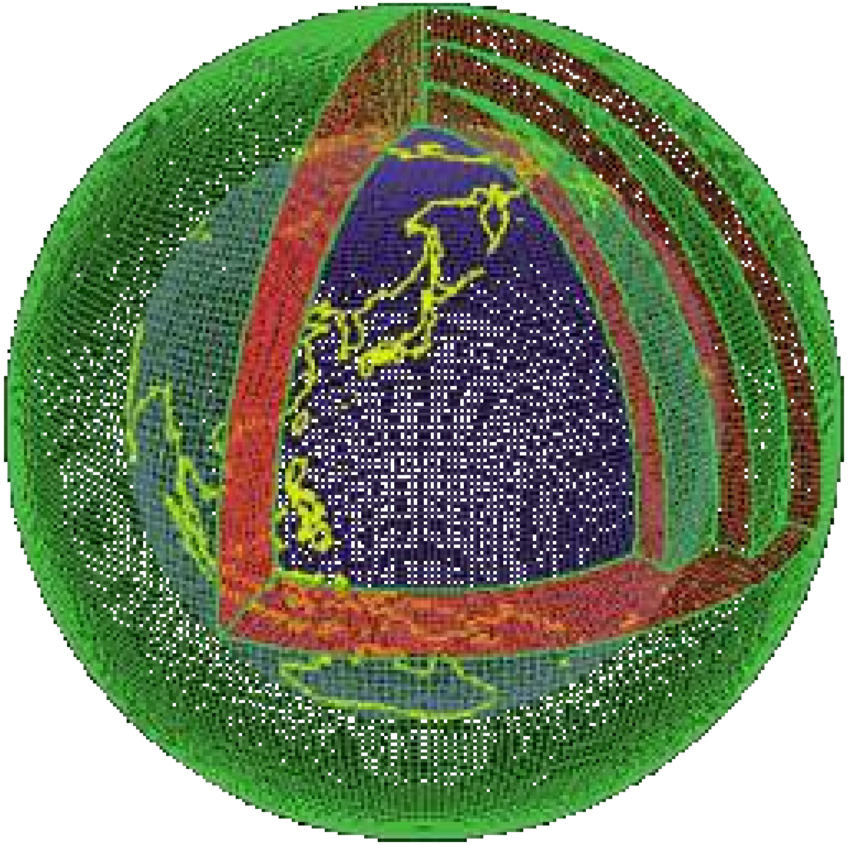
20km resolution GCM output provided through KAKUSHIN Project

1km resolution distributed hydrologic model at Japanese catchments and Thai catchment for 75 years runoff simulations



Examine changes of flood risks, drought risks, and the change of water resources.

Future climate projection 20km data
MRI-GCM3.1S developed by MRI, Japan

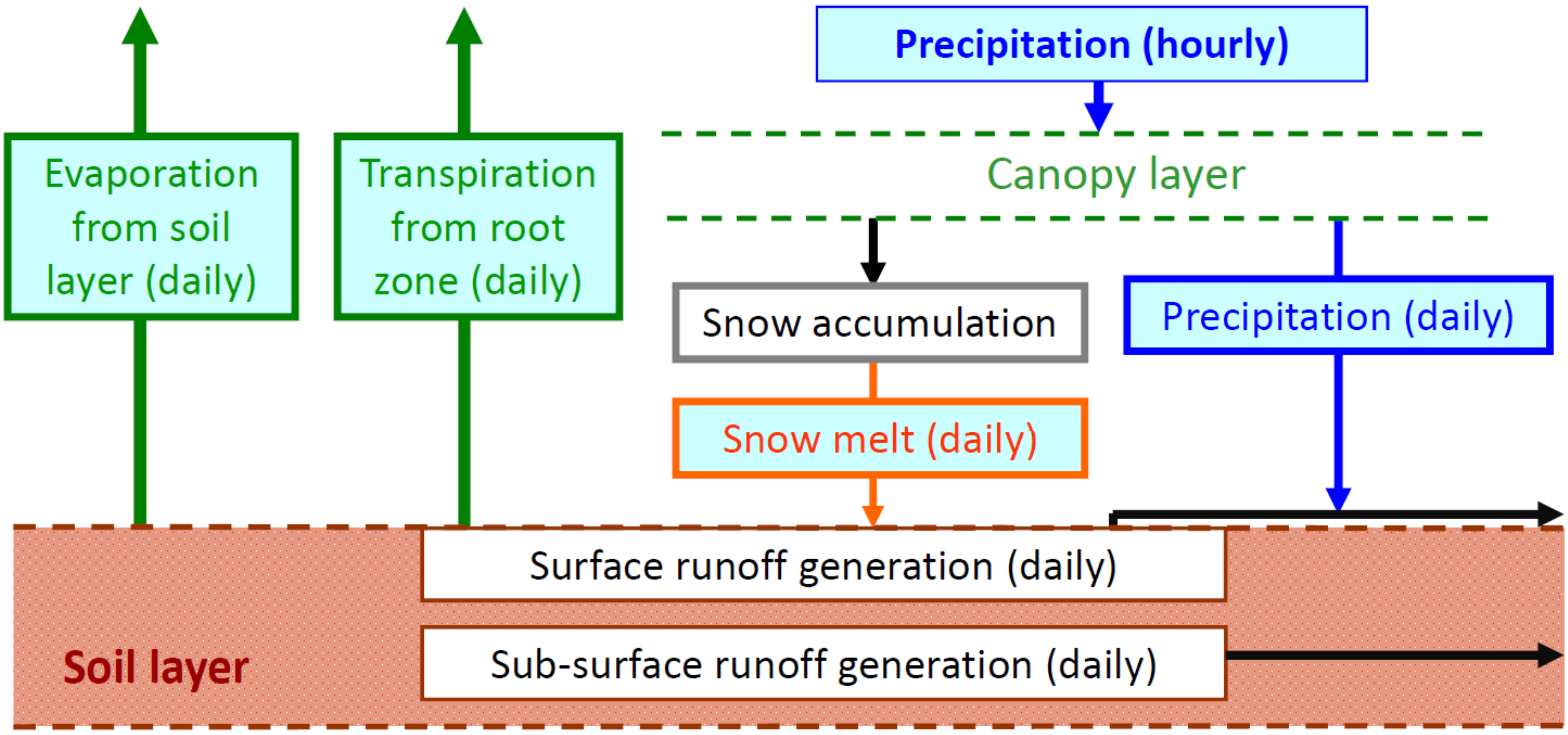


Current climate
experiment: 1979-2004

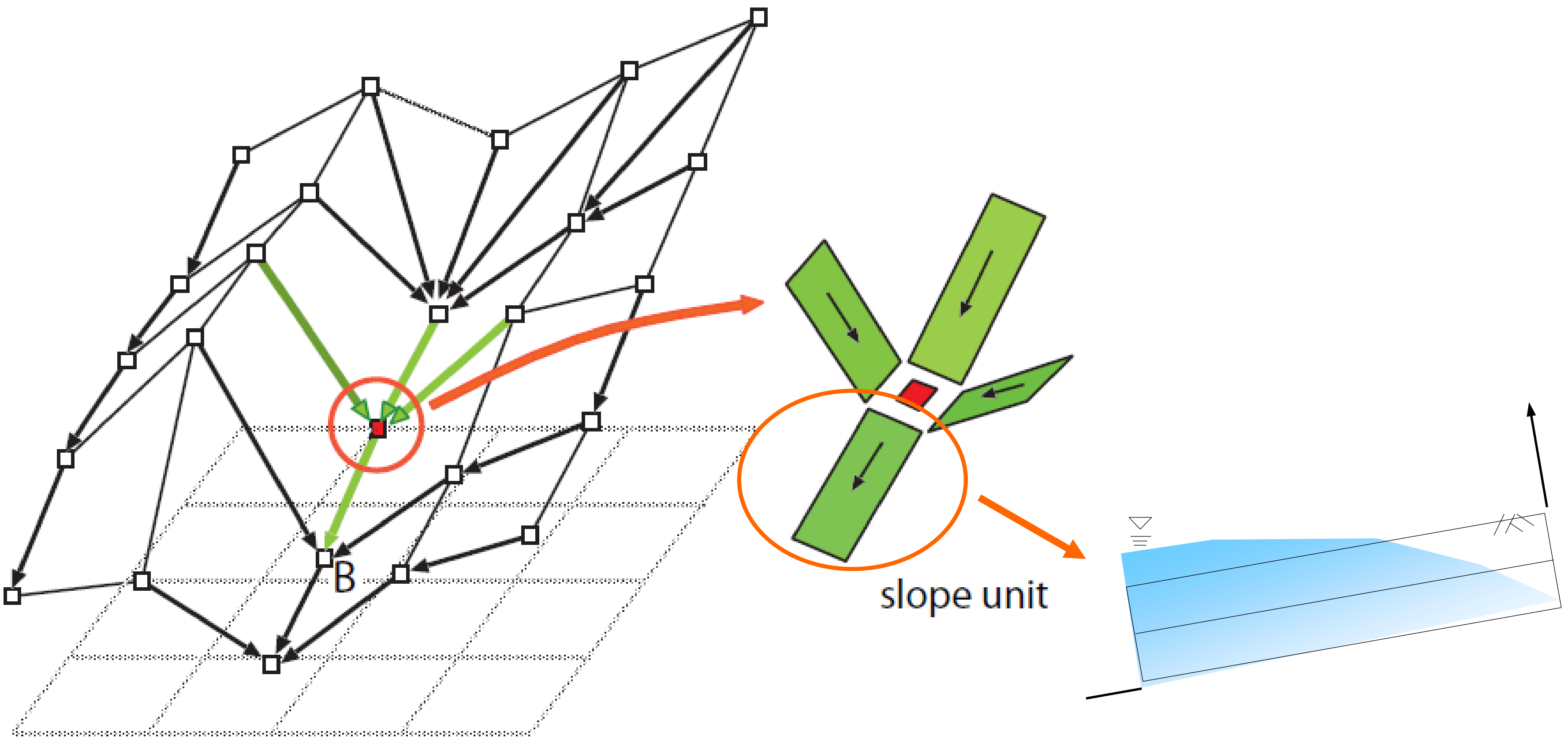
Near future climate
experiment: 2015-2039

Future climate
experiment: 2075-2099

GCM Projection data for runoff simulation

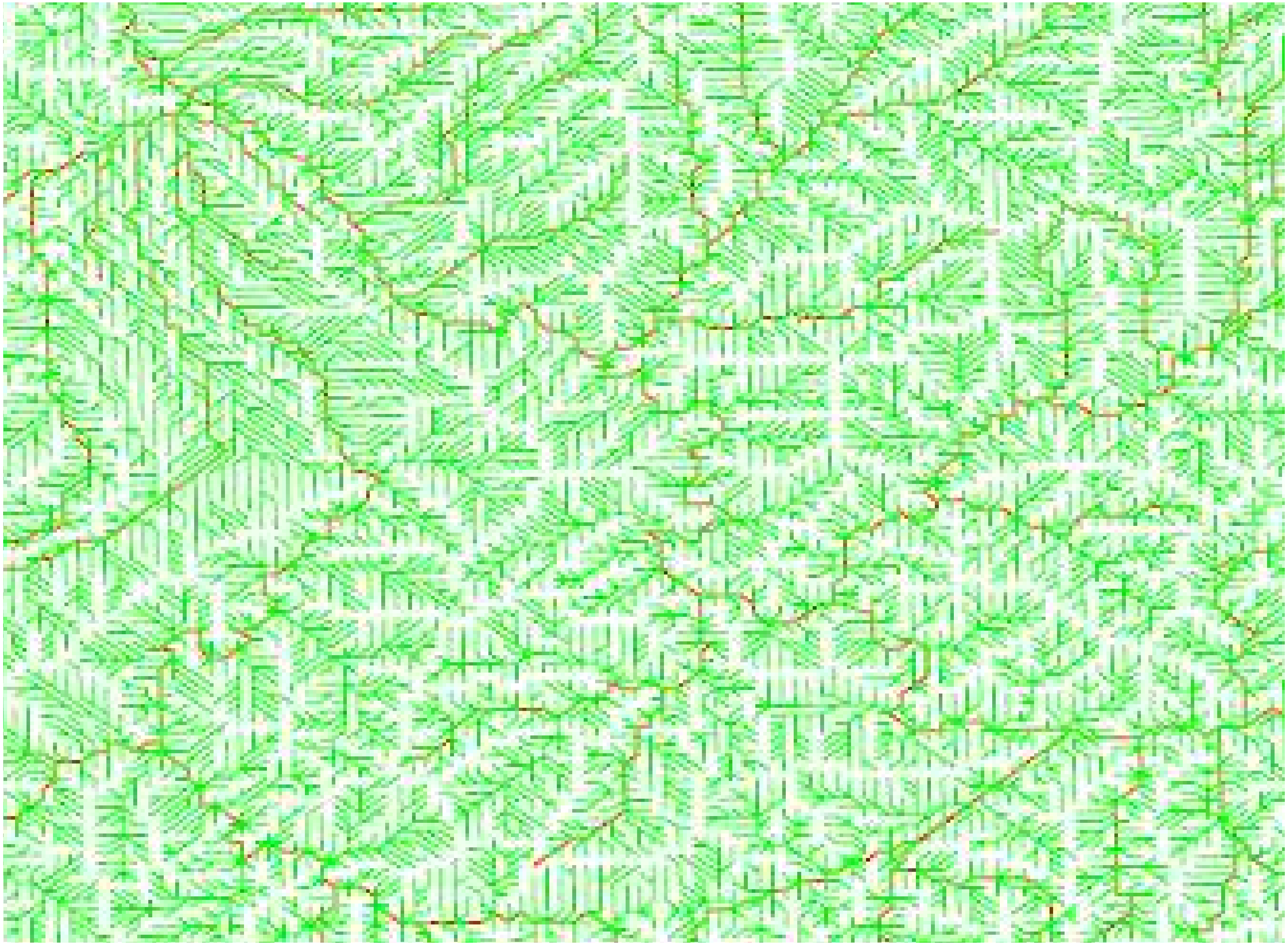


Hydrologic Flow Modeling

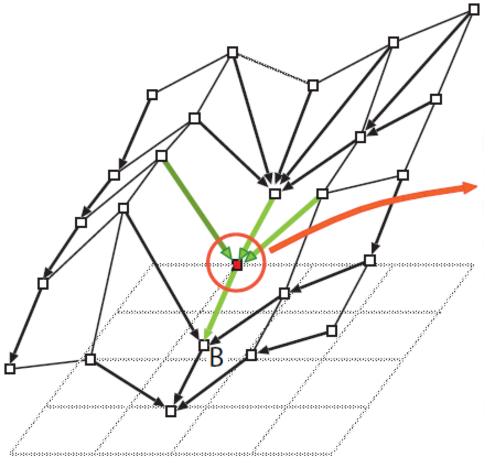


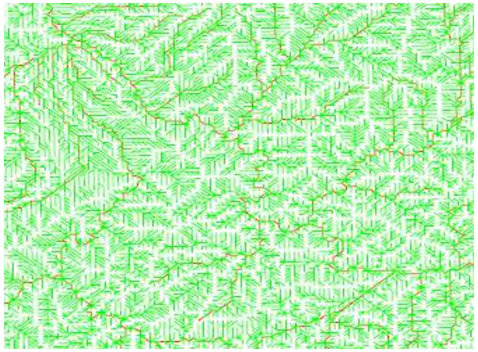
A flow direction map with 1 km spatial resolution is developed. Then, runoff is routed according to the flow direction map using one dimensional kinematic wave flow model .

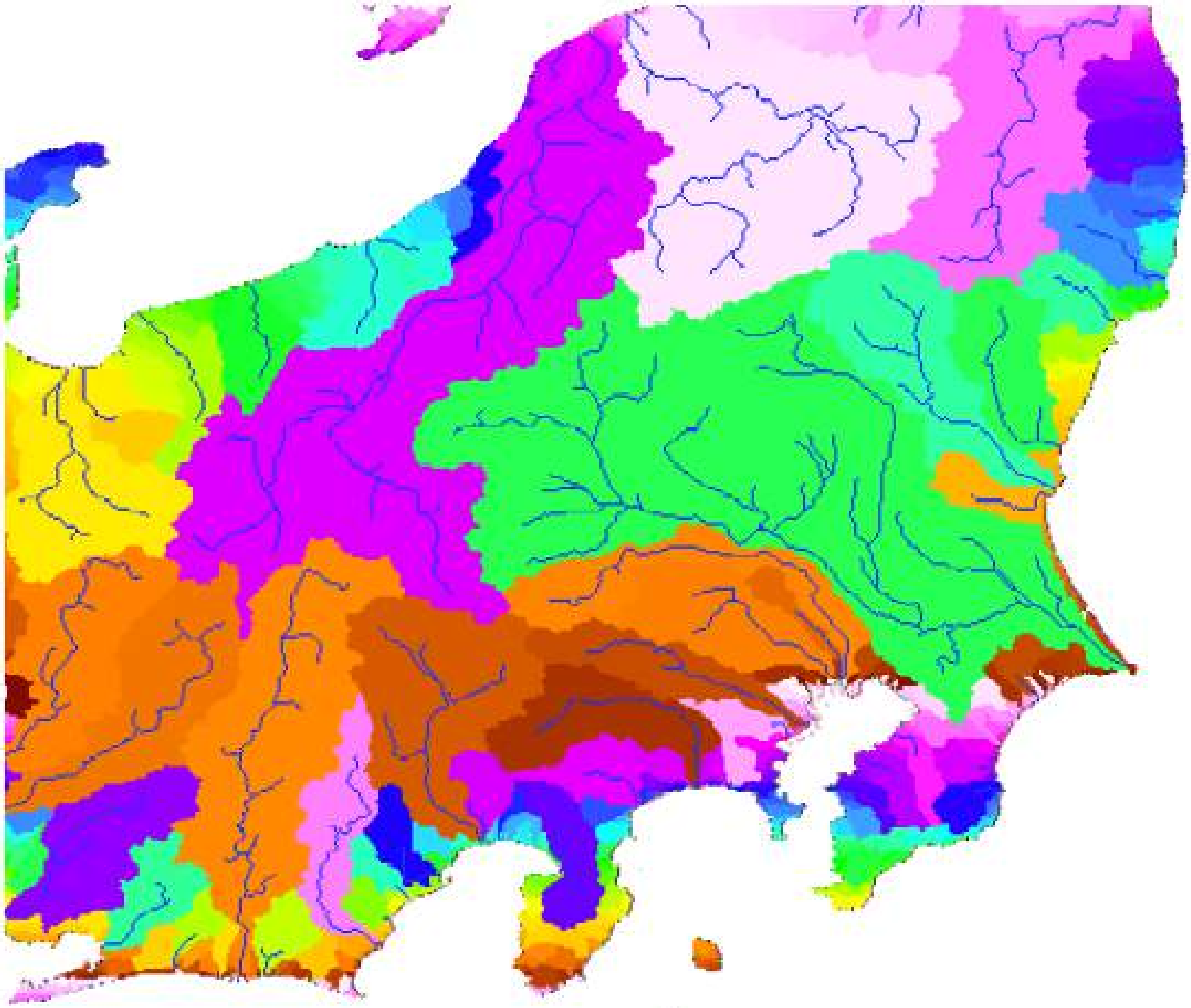
1 km flow direction map using GTOPO 30



Flow direction modeling in Kanto region

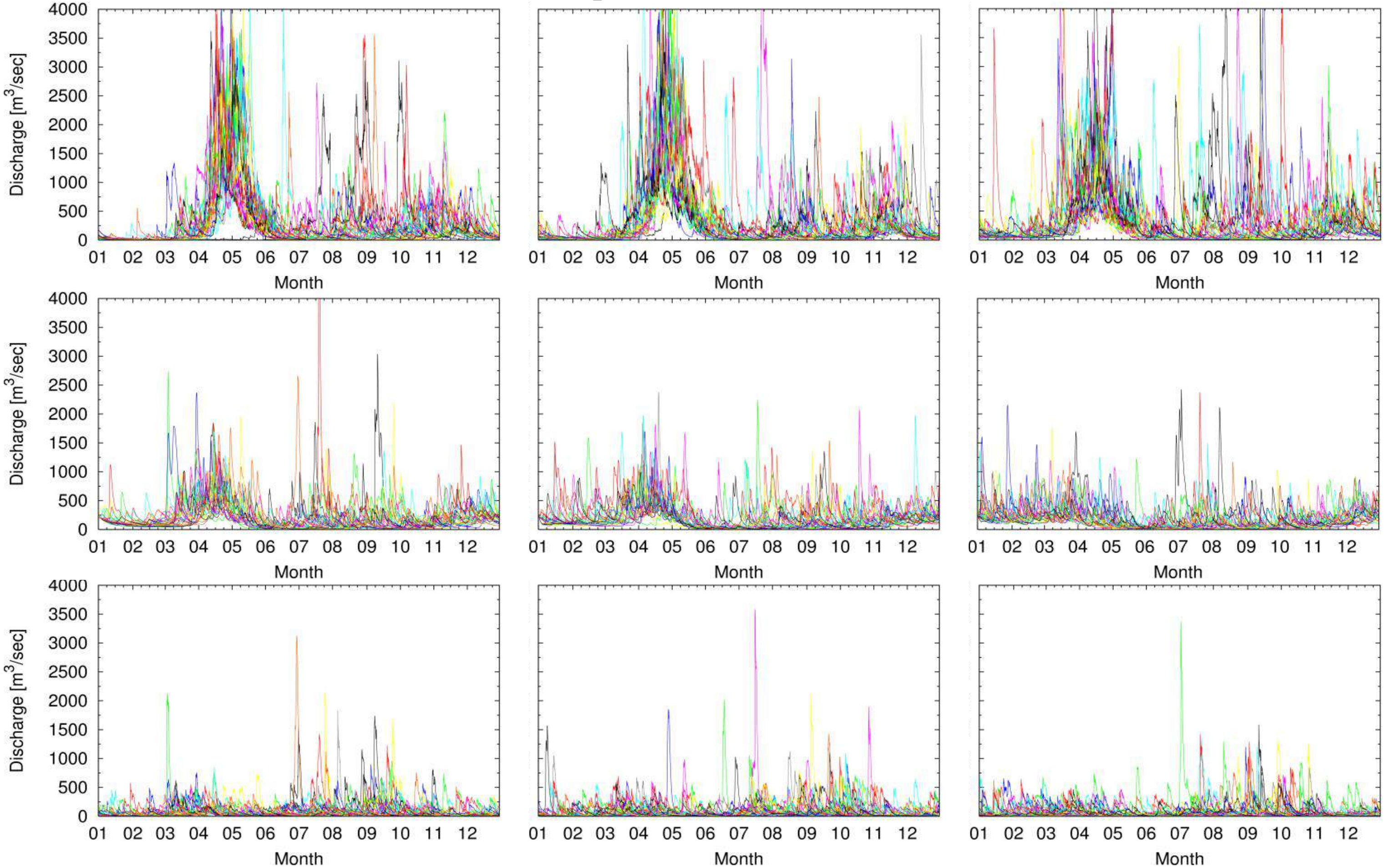






Runoff projections using MRI-GCM3.1S

	Current climate experiment 1979-2003	Near future climate experiment 2015-2039	Future climate experiment 2075-2099
Ishikari River Hokkaido region			
Mogami River Northern Japan			
Abukuma River Northern Japan			

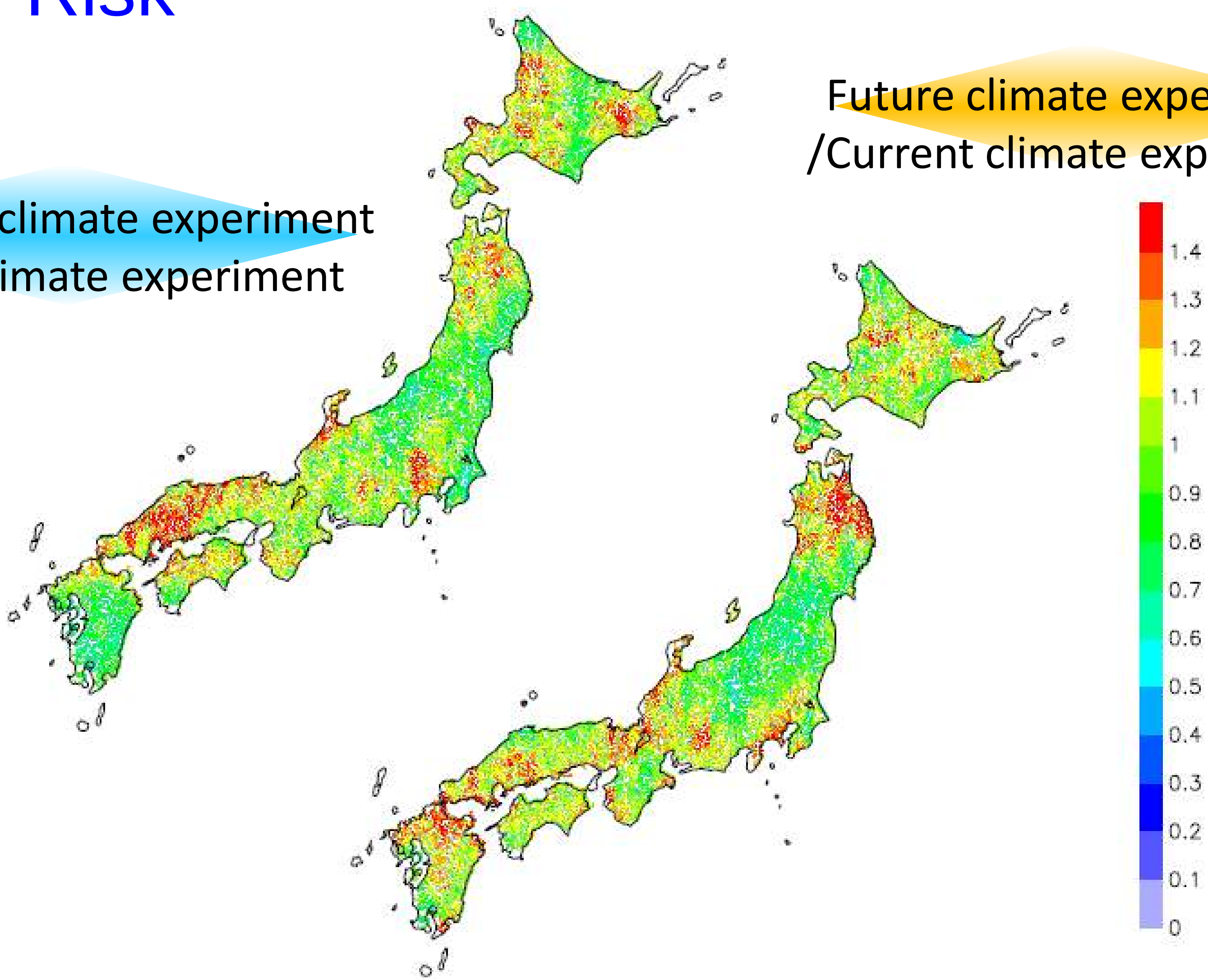


Change of mean annual maximum hourly discharge

Flood Risk

Near future climate experiment
/Current climate experiment

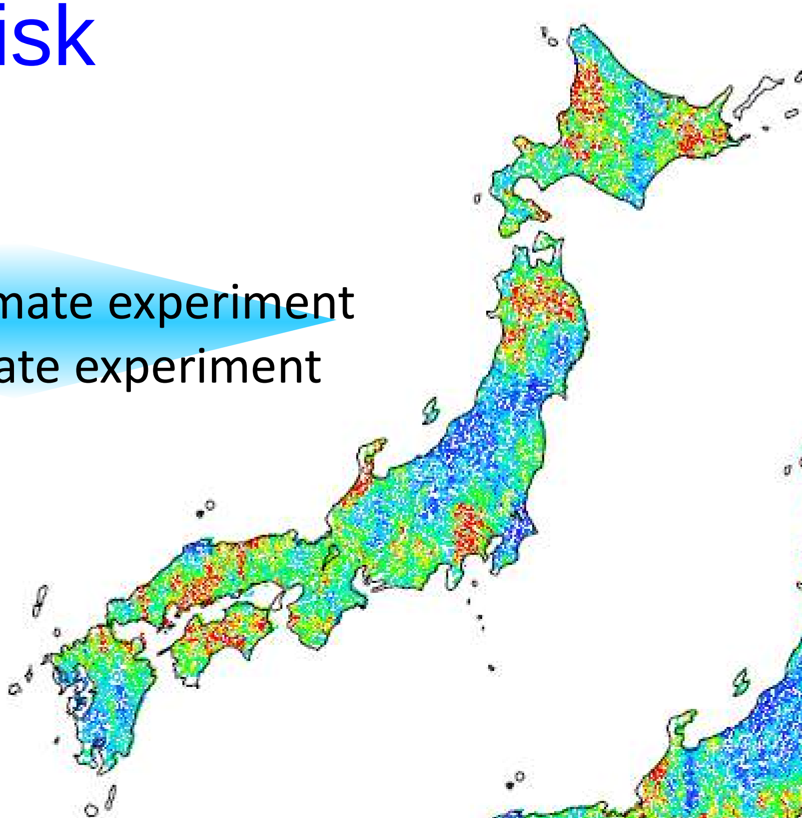
Future climate experiment
/Current climate experiment



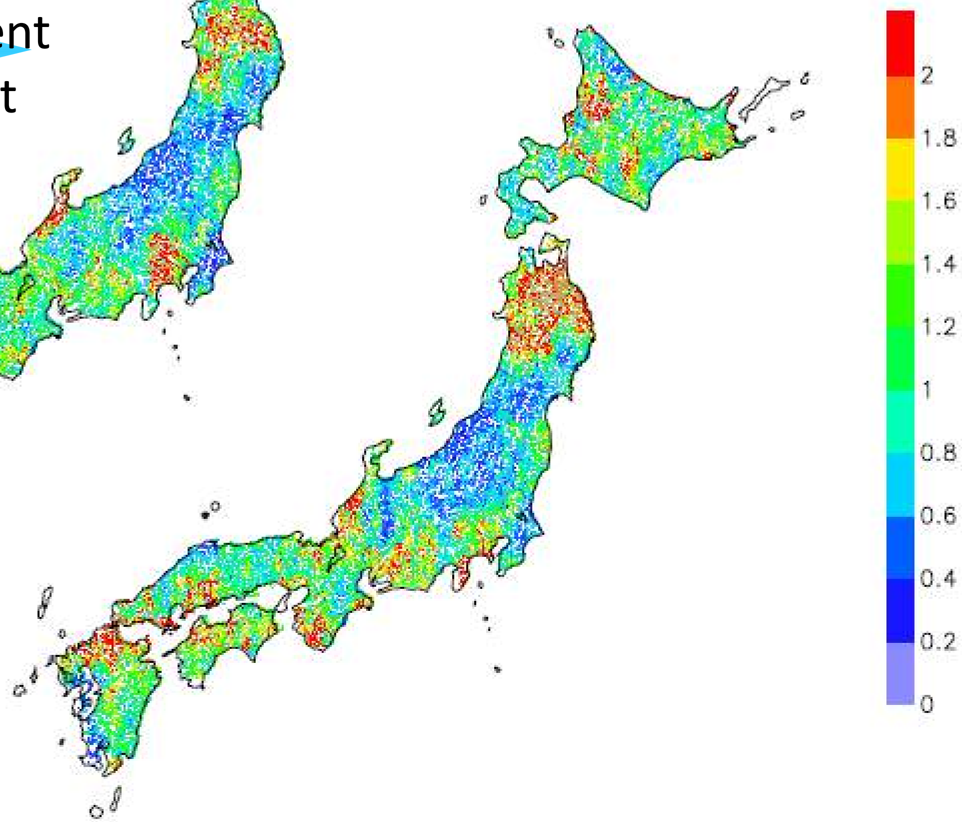
Change of standard deviation of annual maximum hourly discharge

Flood Risk

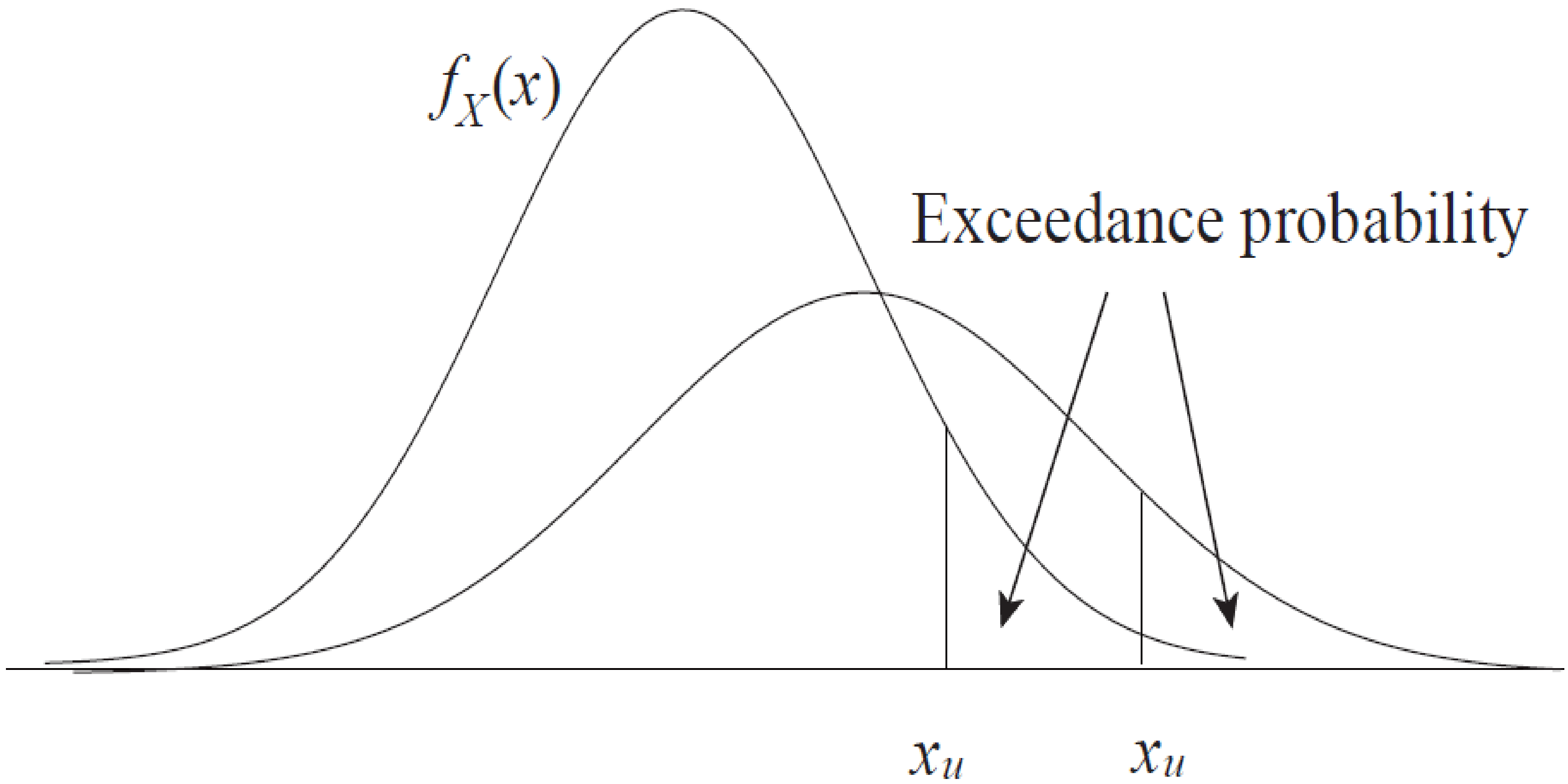
Near future climate experiment
/Current climate experiment



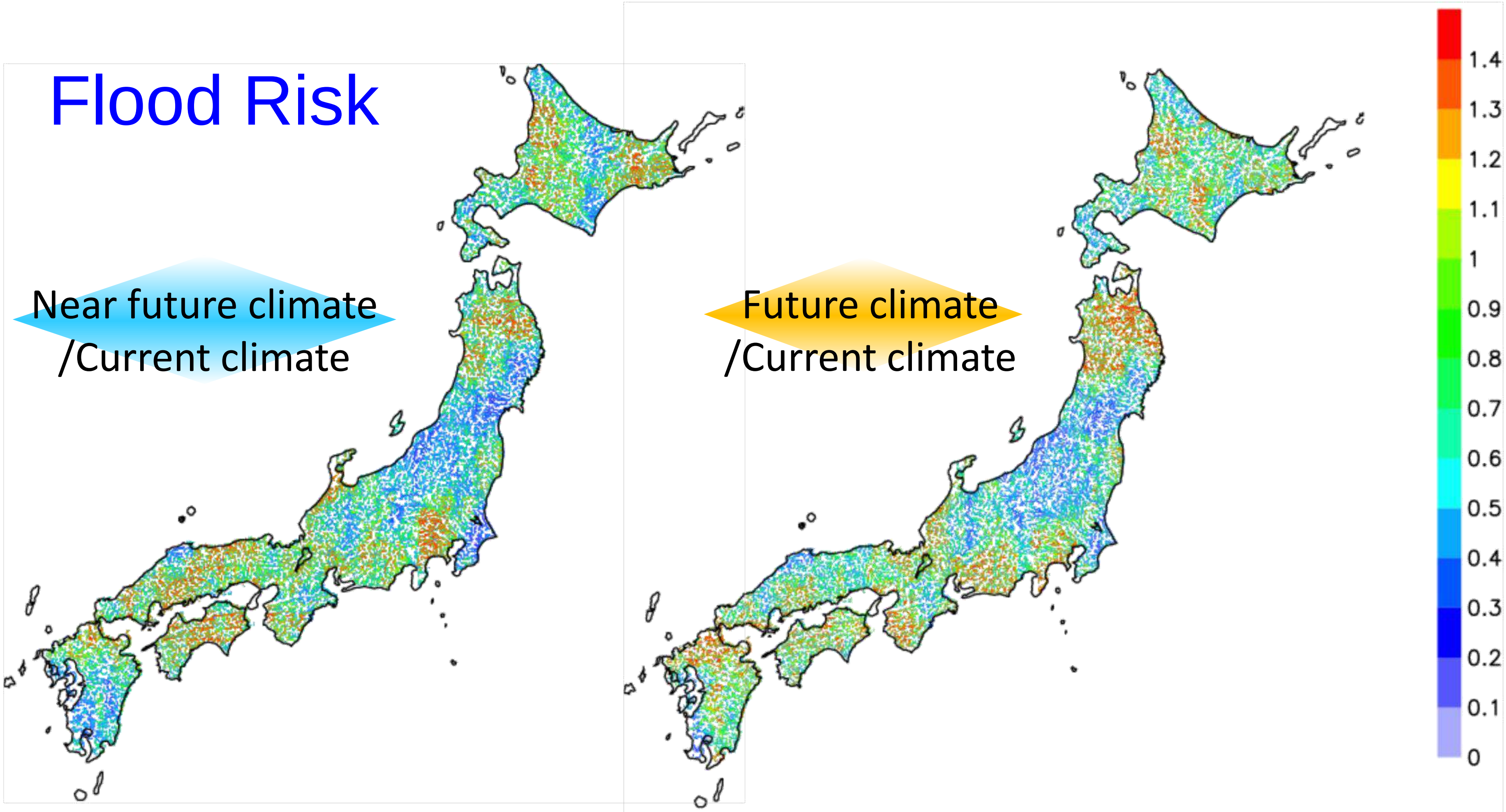
Future climate experiment
/Current climate experiment



Change of frequency distribution?



Change of 100-year annual maximum hourly discharge



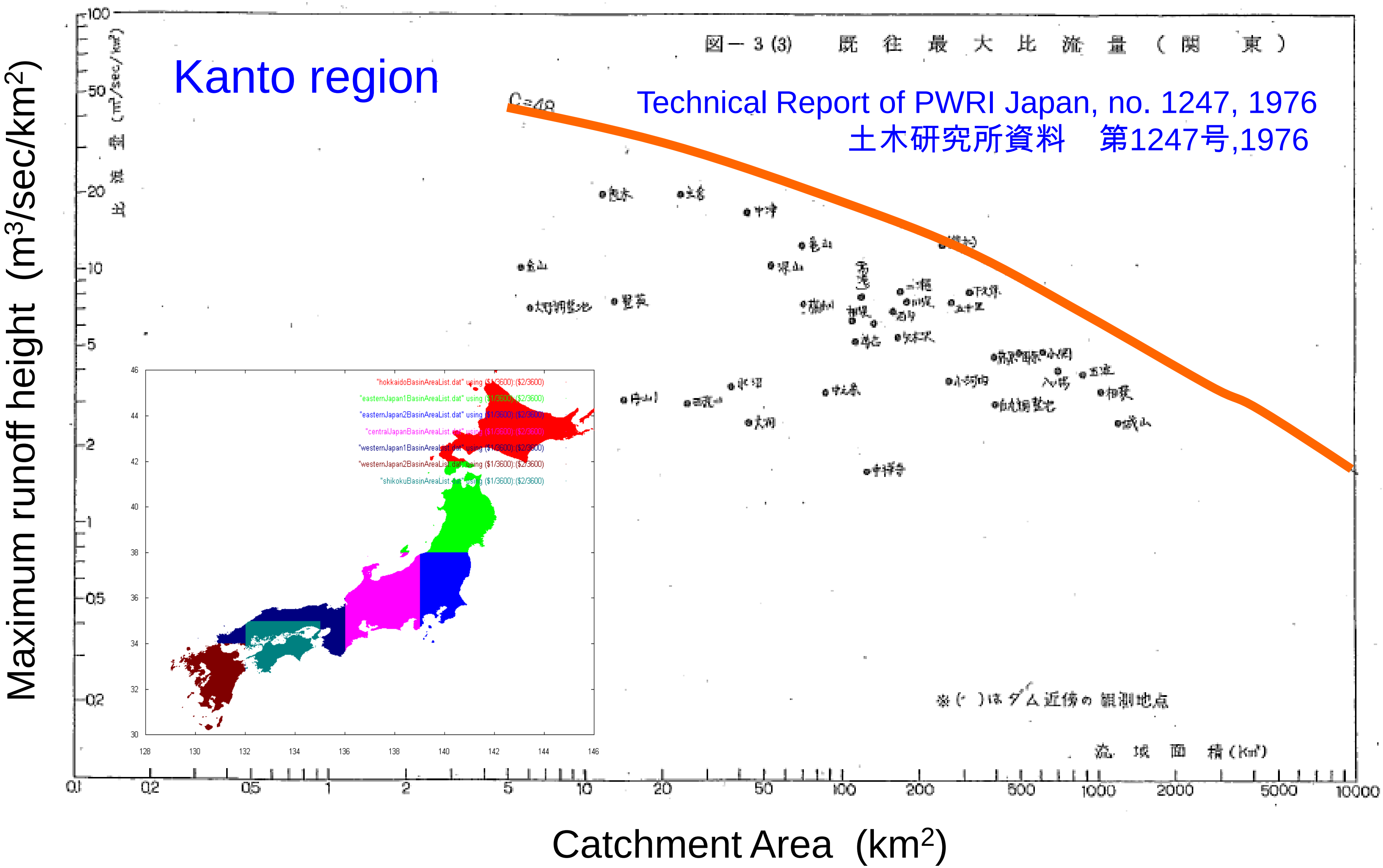
Quintiles of river discharge with 100-year return period estimated using GEV distribution.

Design flood discharge for dam reservoir construction

Maximum discharge which flows through spillway

Kuzuryu Dam in Japan

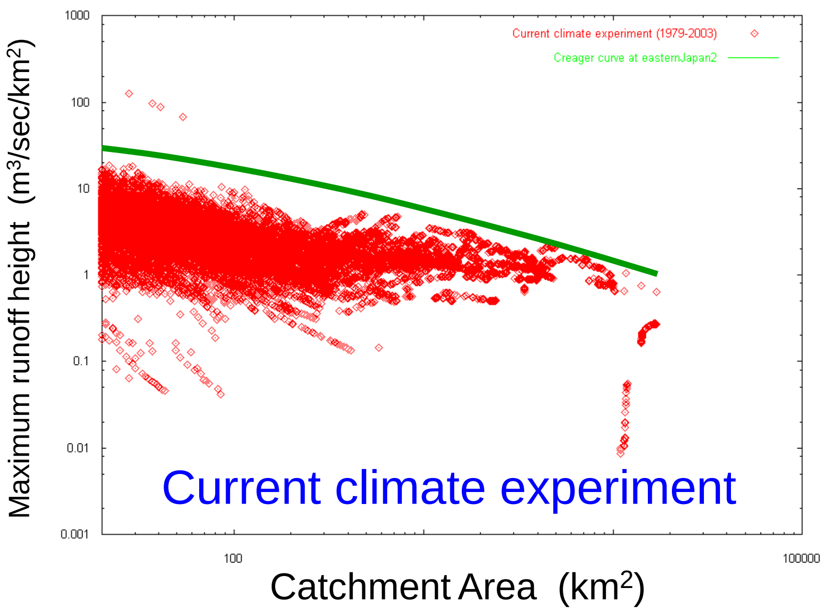
Design flood discharge for dam reservoir construction

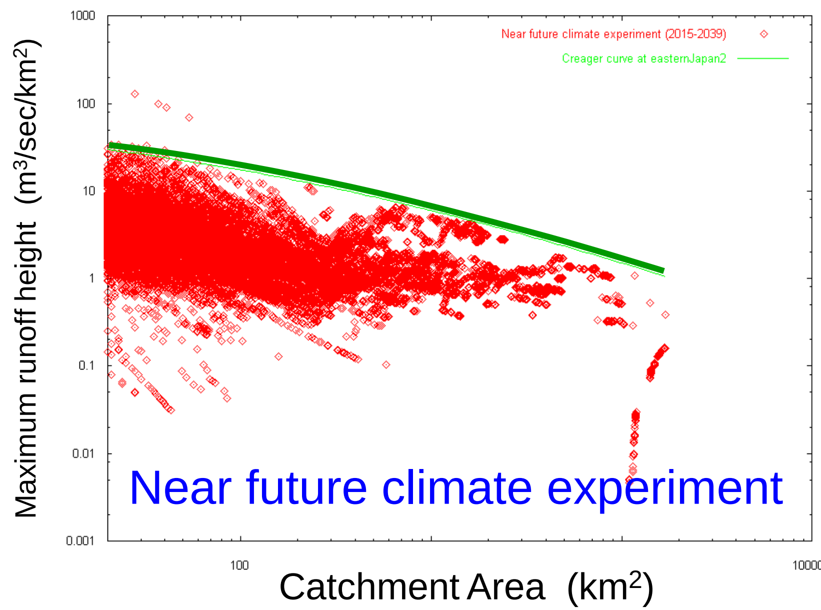


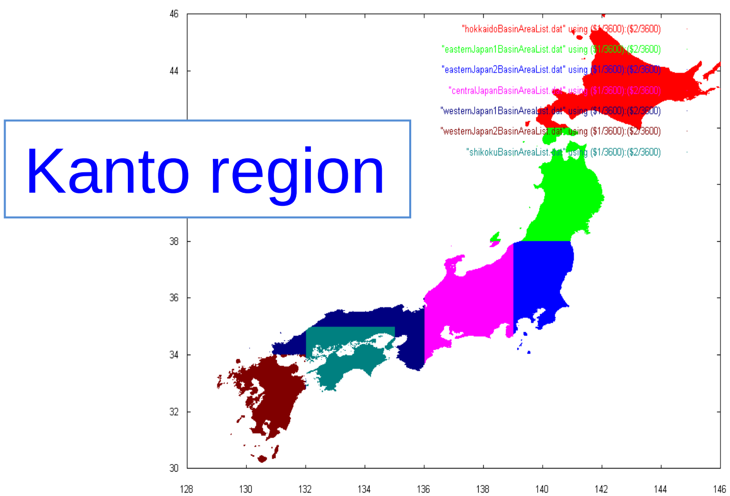
Design flood discharge for dam reservoir construction

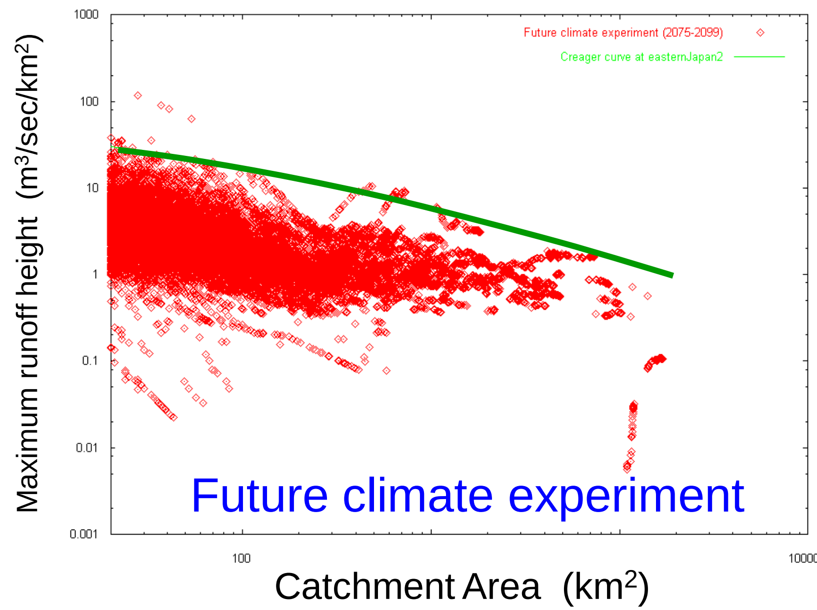
Maximum discharge flowing through spillway

Maximum flood discharge at Kanto region



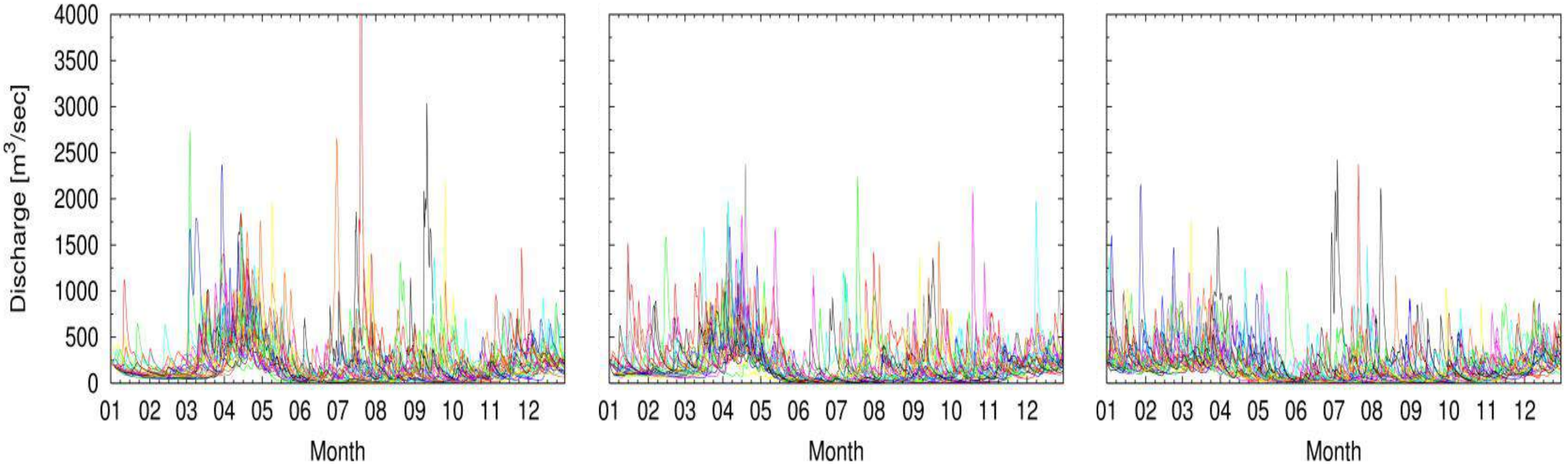






Change of water resources

Runoff simulations at Mogami River, Northern Japan

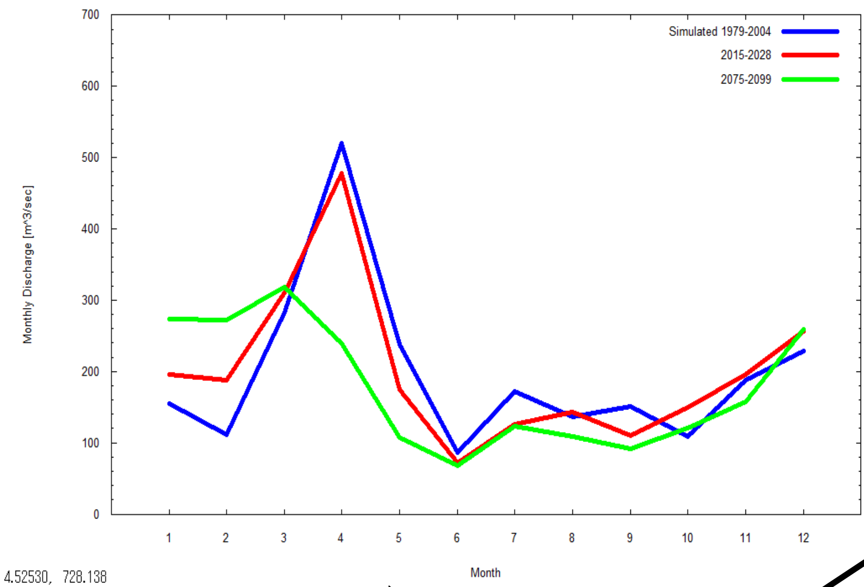


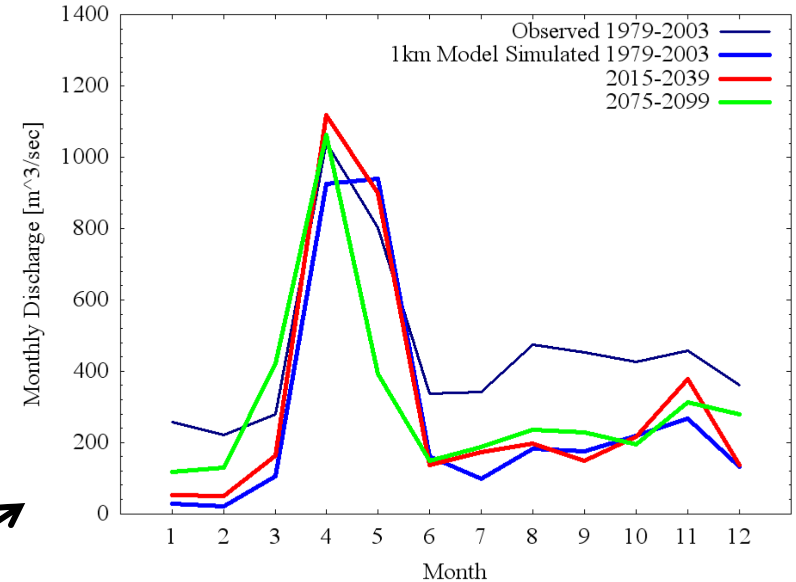
Current climate experiment 1979-2004

Near future climate experiment 2015-2039

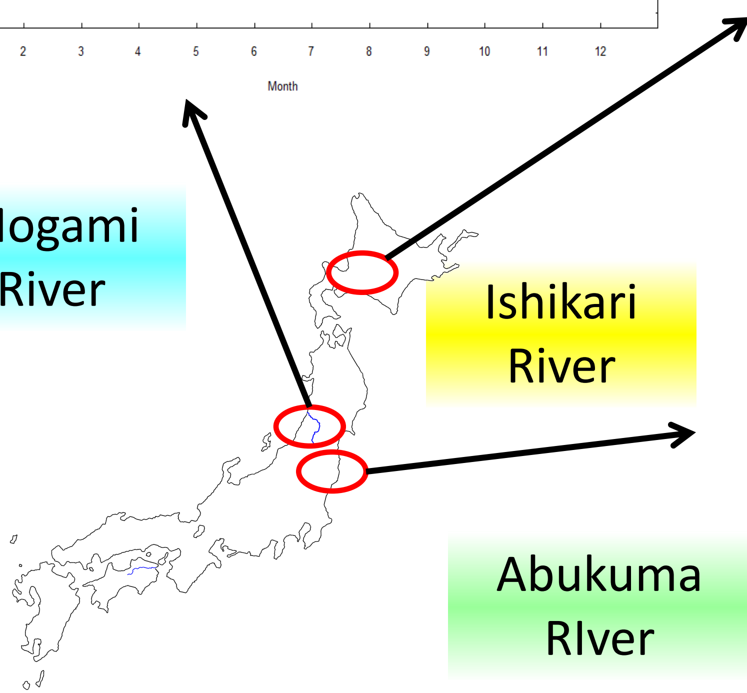
Future climate experiment 2075-2099

Change of monthly discharge in snow melting season

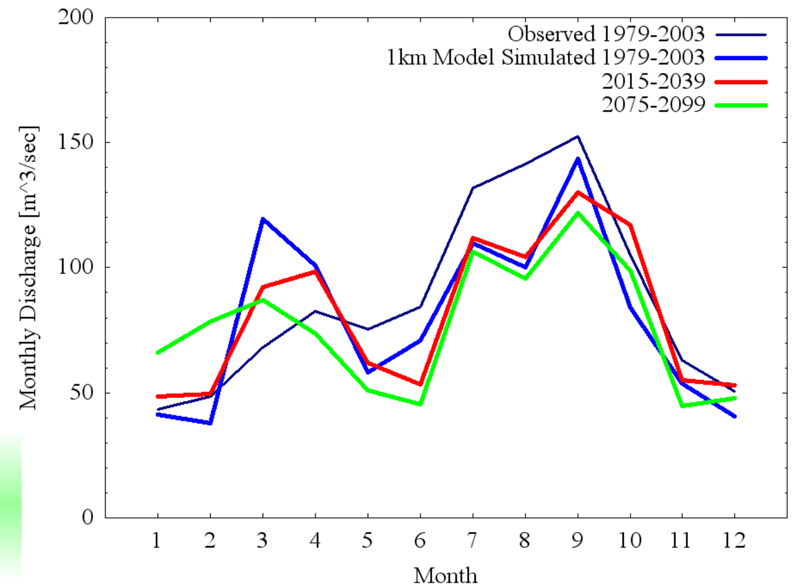




Mogami River

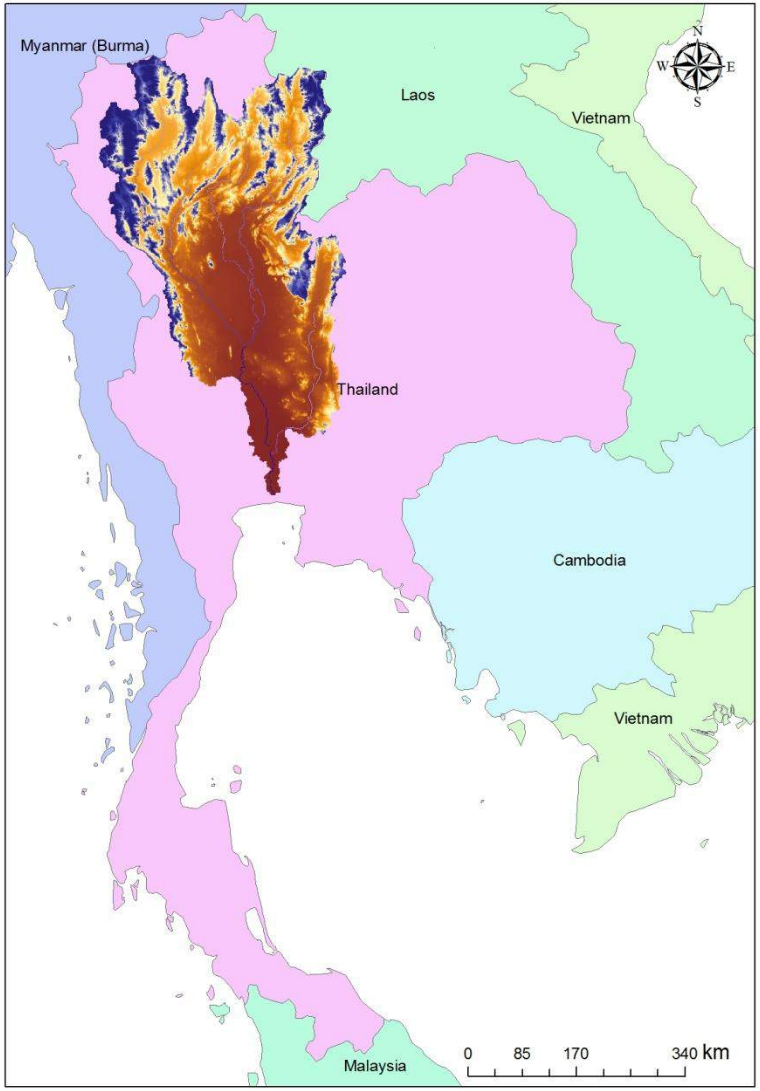


Ishikari River



Abukuma RIver

Chao Phraya River in Thailand



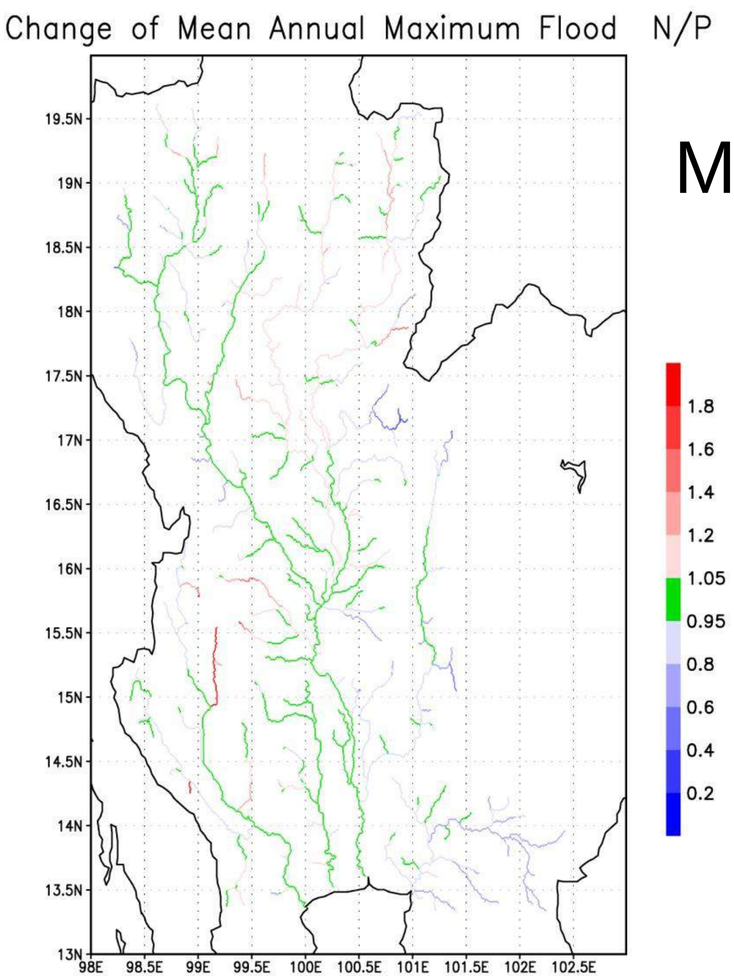
Chao Phraya Basin, Thailand

- Largest River Basin
- Area is about 160,400 km^2
- This area has a wet monsoon climate,
  - with over 1,400 mm annual rainfall
  - temperatures ranging from 33°C to 24°C in

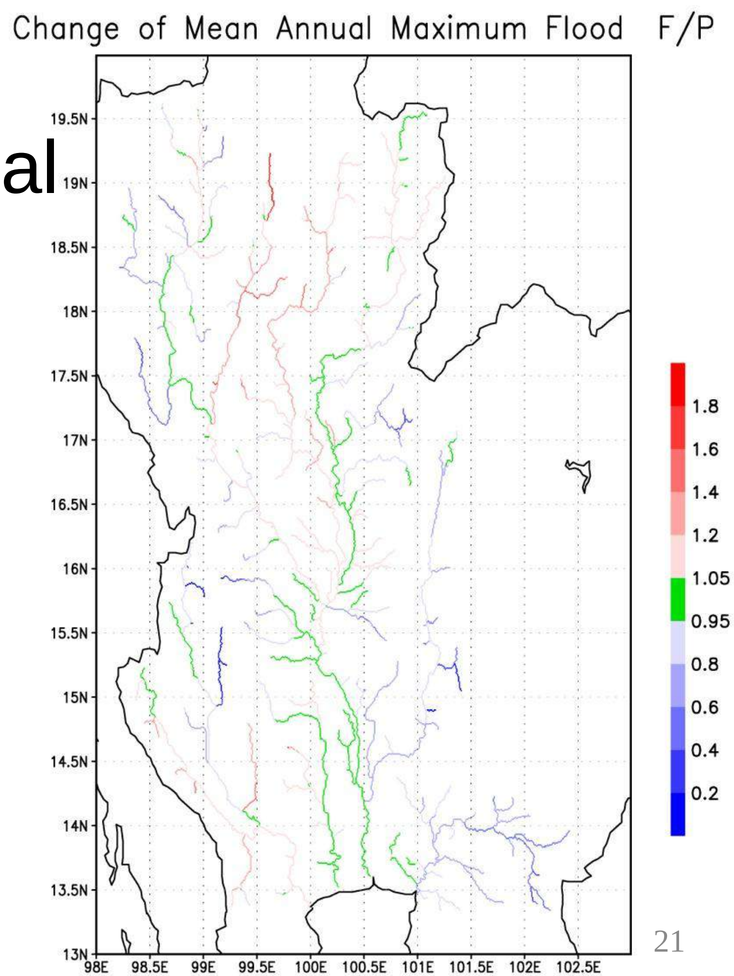
Results ; Flood…

$NearFuture \big/ Present$

$Future \big/ Present$

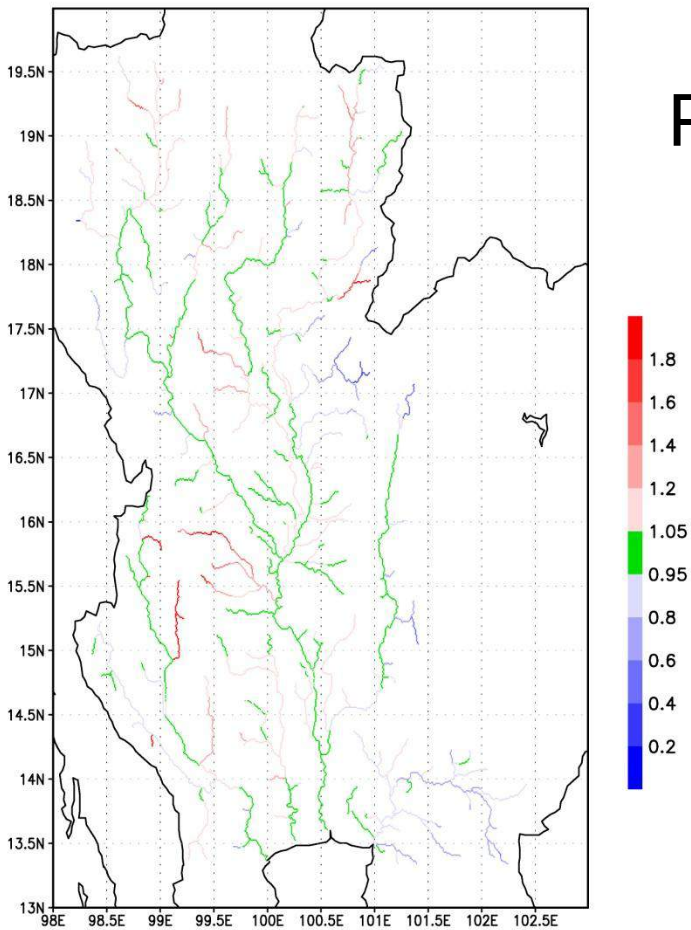


Mean Annual Maximum Flood



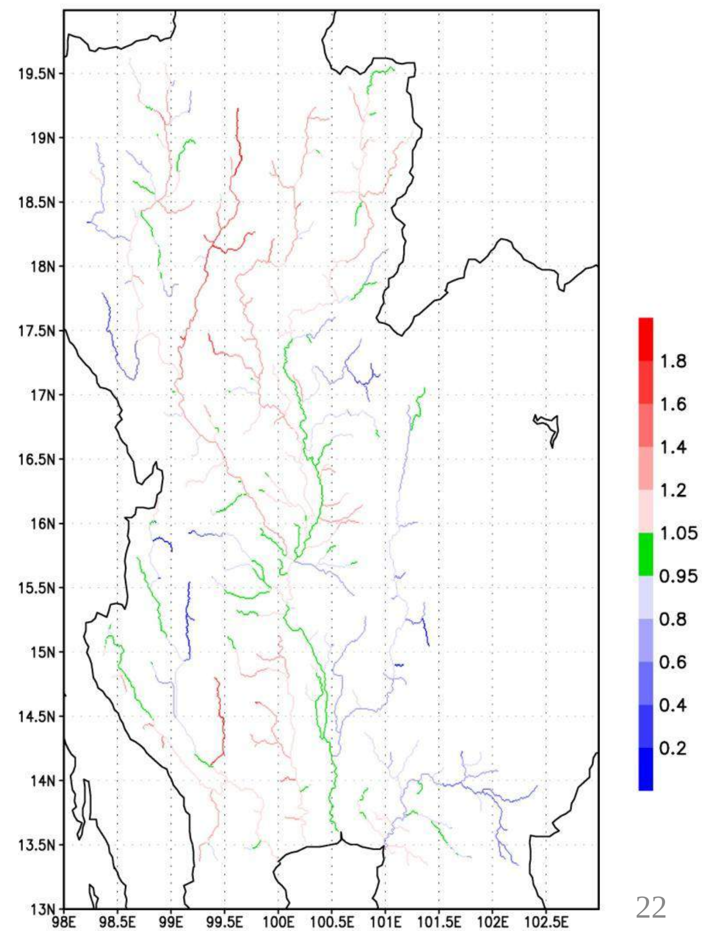
Results ; Flood…

$\mathit{NearFuture}\big/\mathrm{Pr}\,\mathit{esent}$

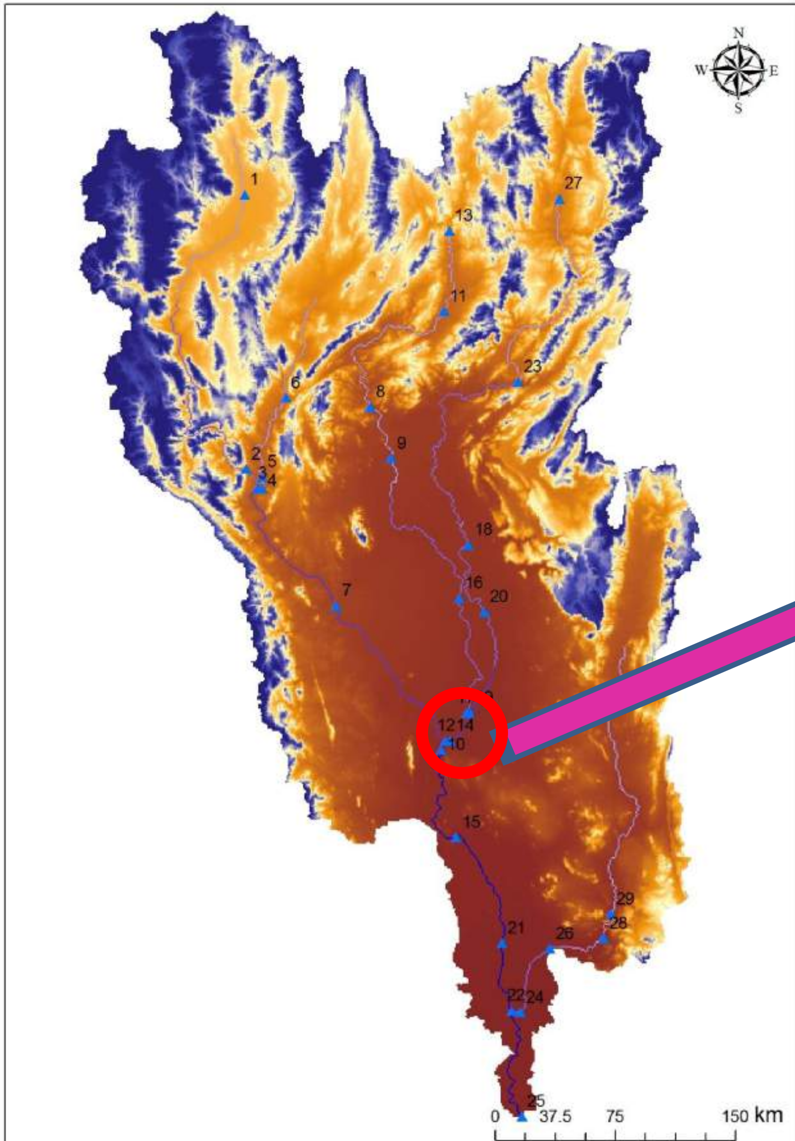


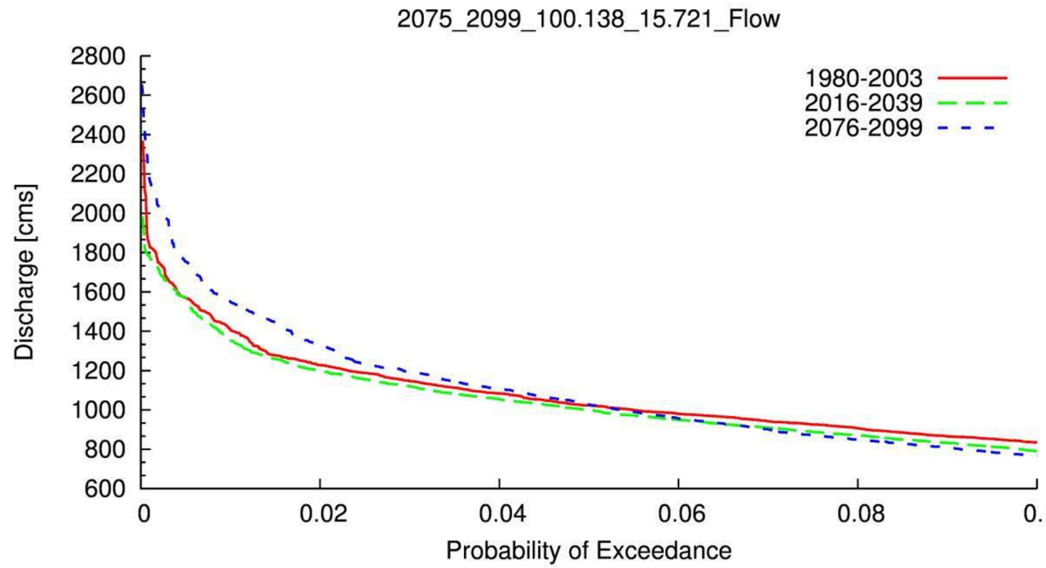
Flood with 10-years Return Period

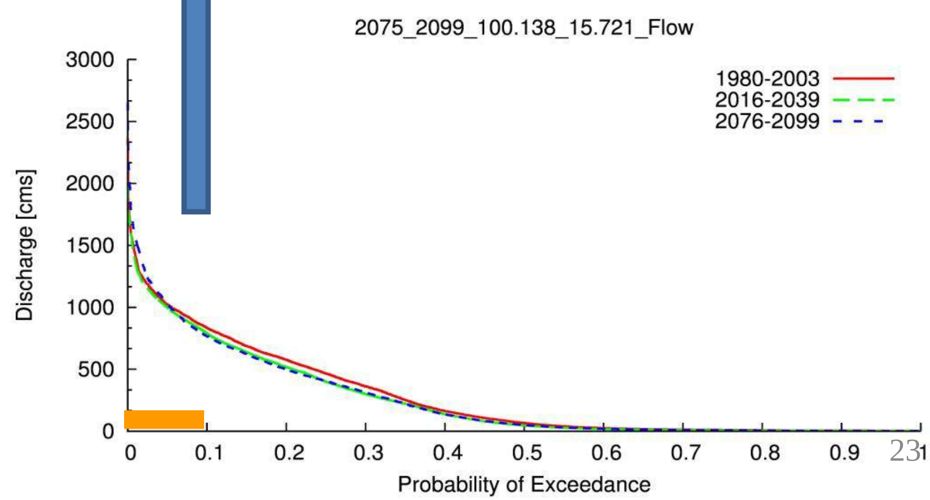
$\mathit{Future}\big/\mathrm{Pr}\,\mathit{esent}$



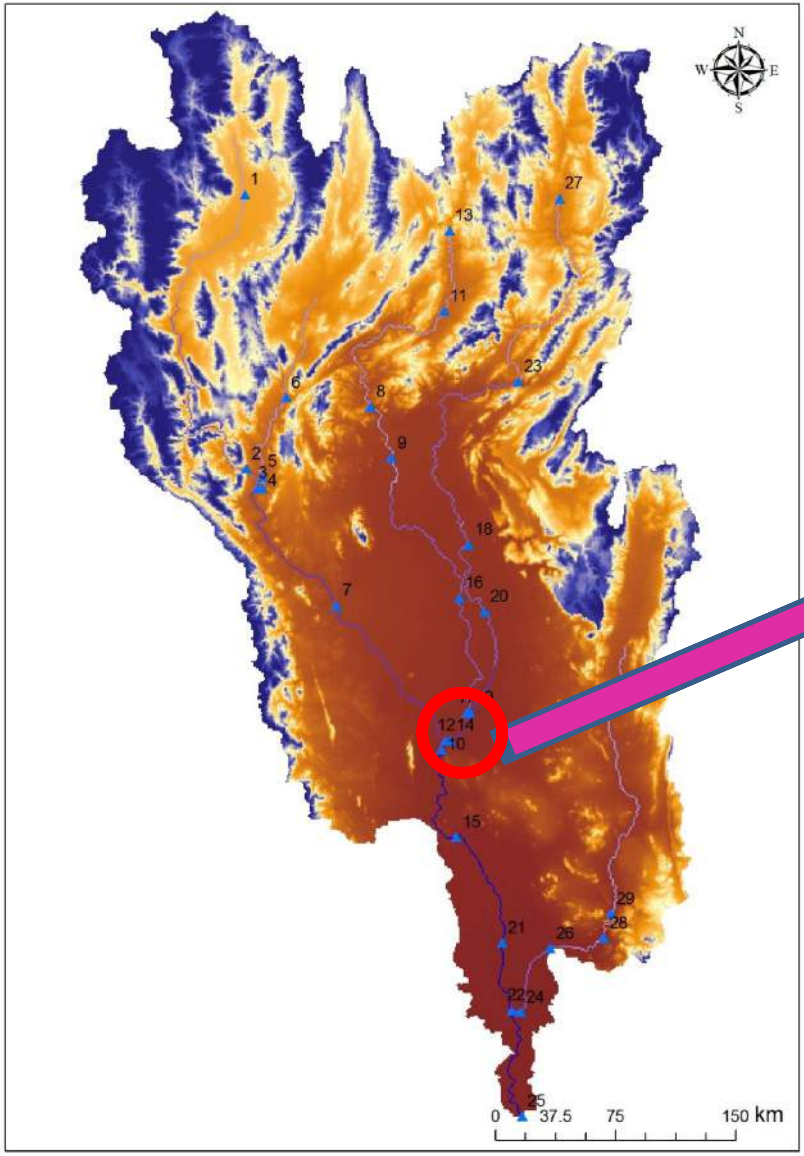
Results ; Flood…

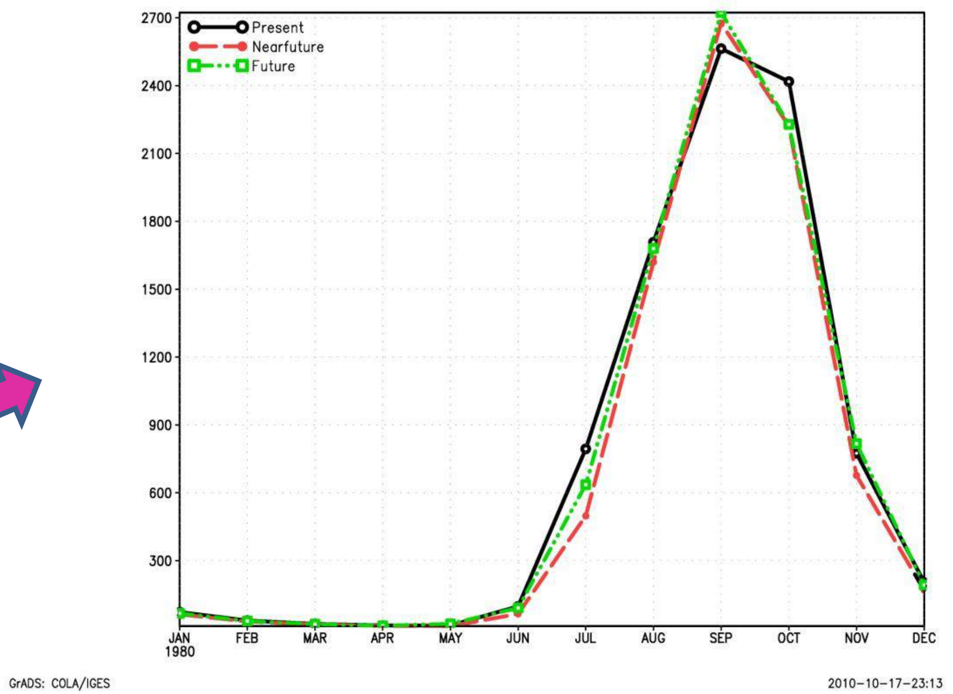




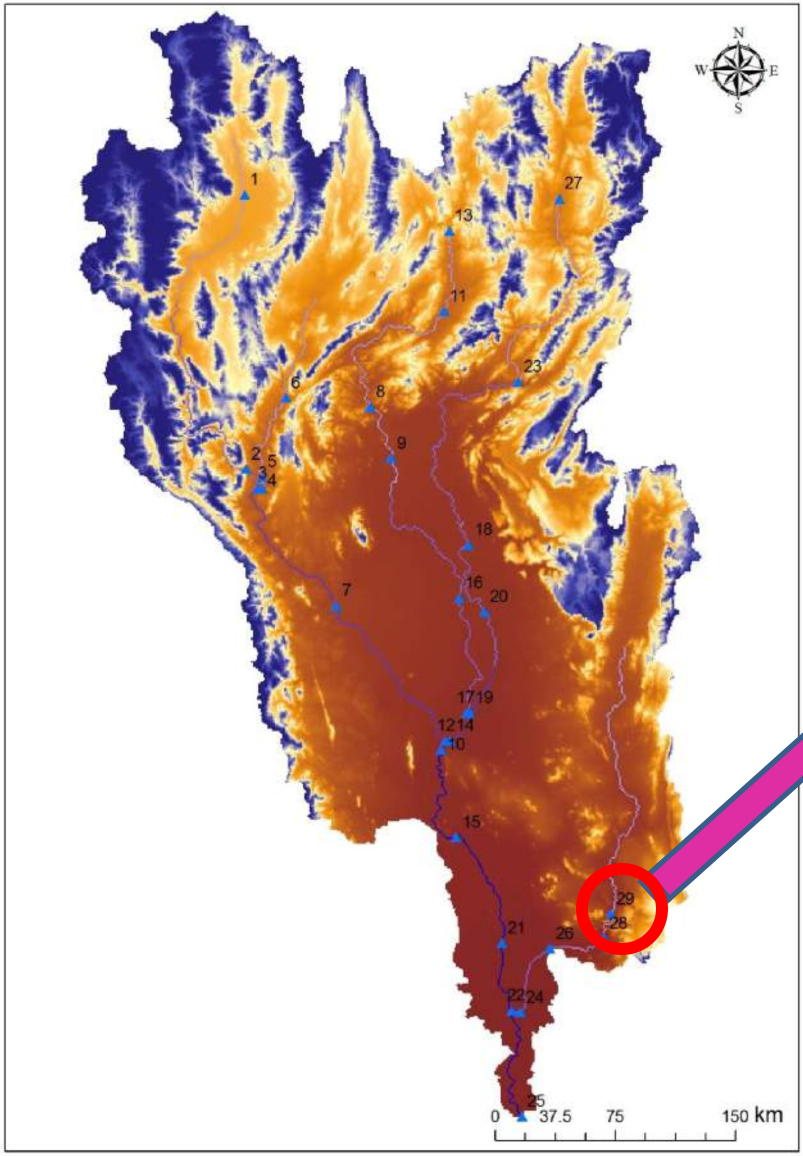


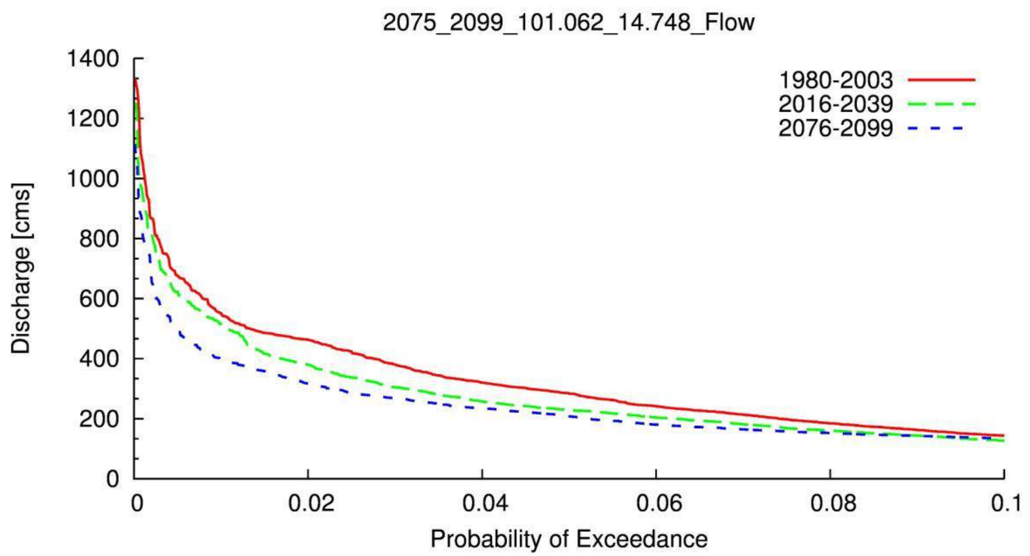
Results ; Water Resources

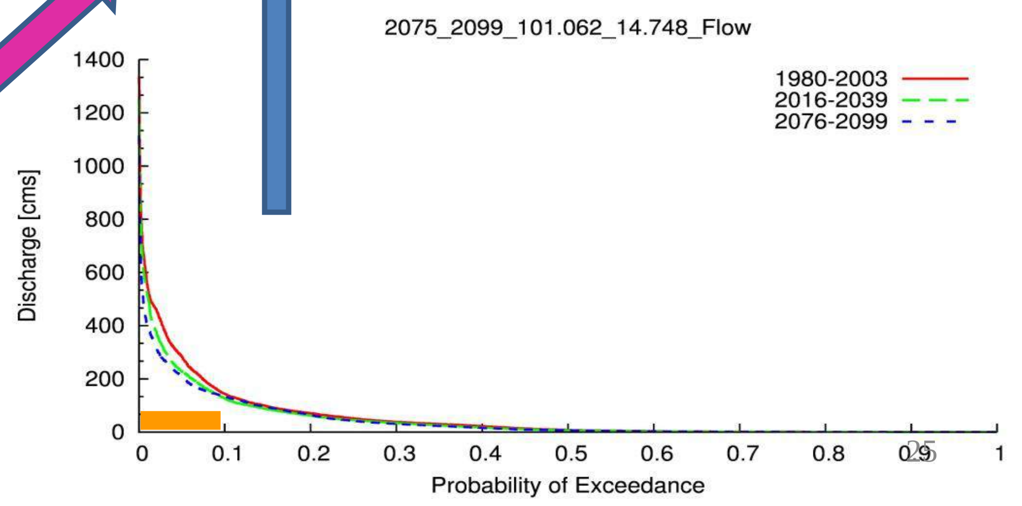




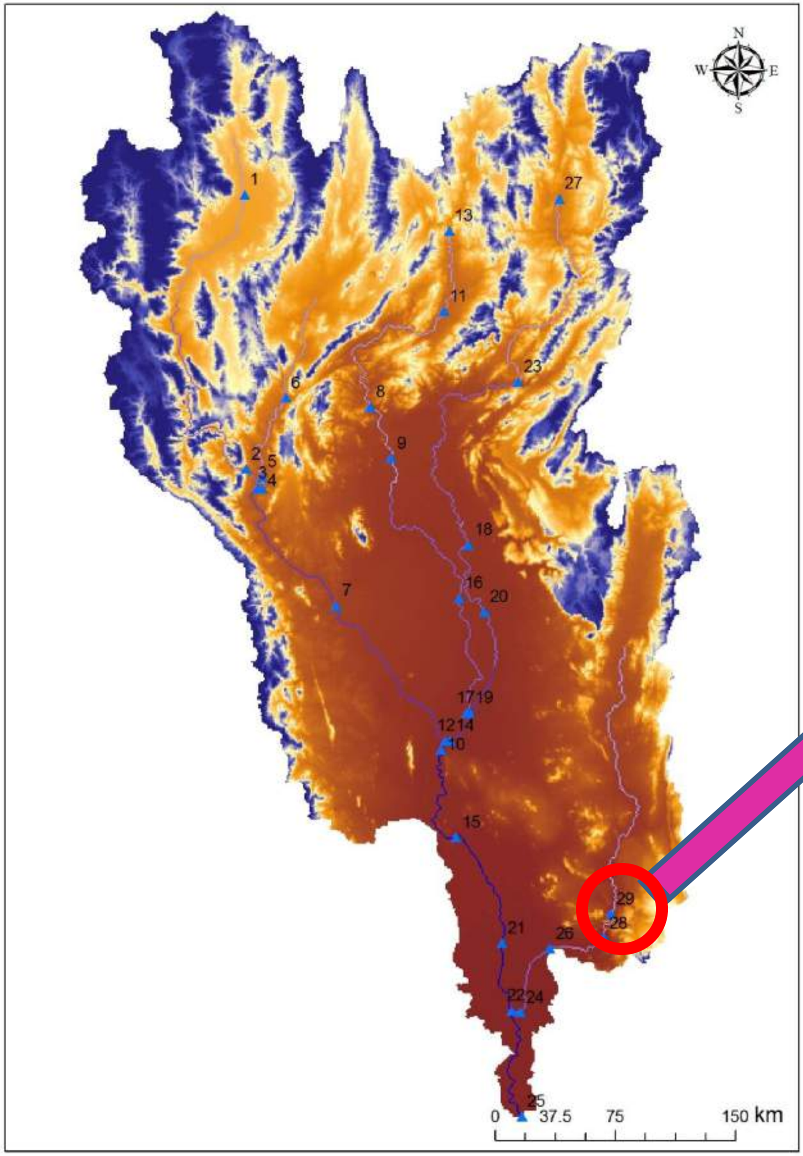
Results ; Flood…

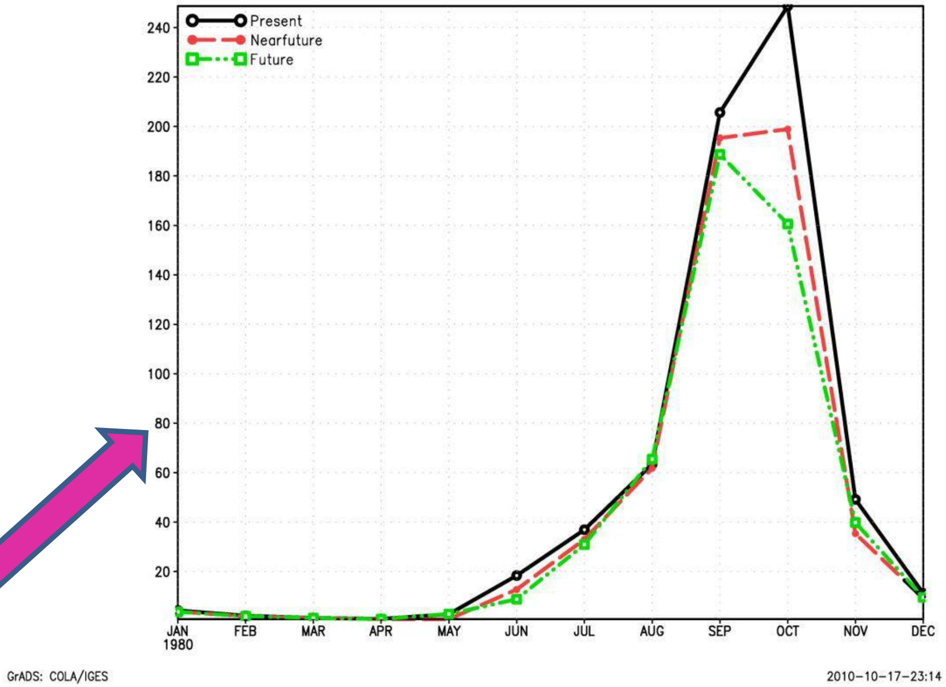






Results ; Water Resources

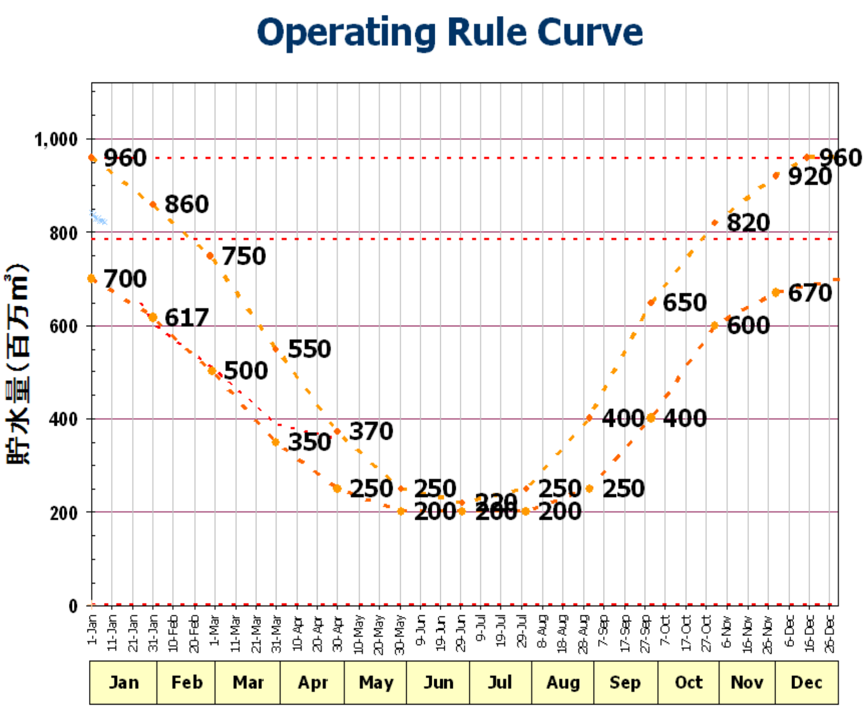


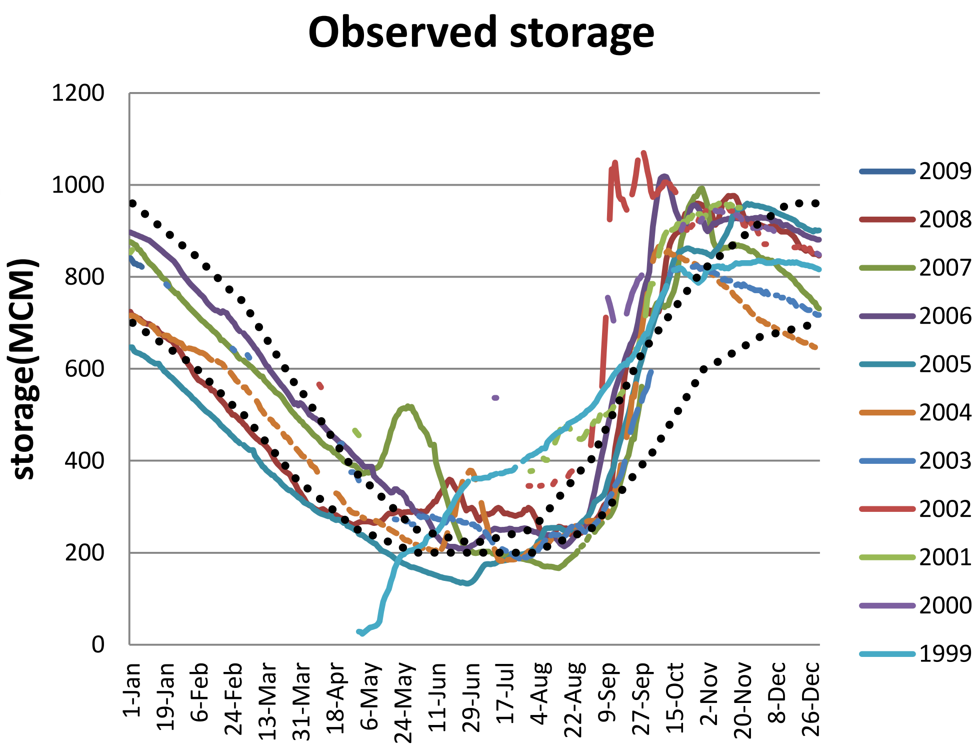


Pasak Jolasit Dam basin (14,520km^2)

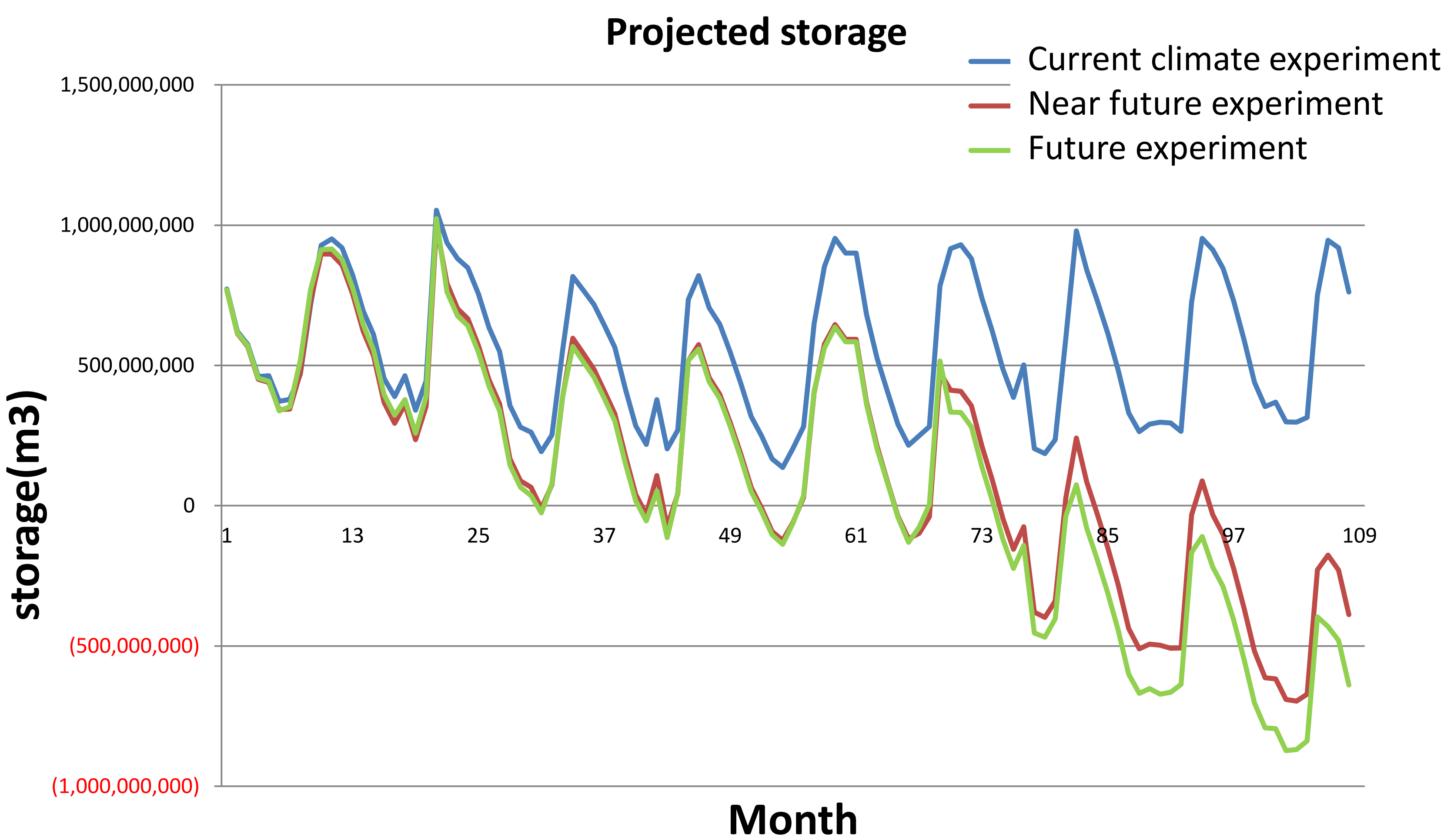
Change of the Pasak Dam storage

Does the dam storage change within the rule curve?





Projected Pasak Dam storage



Findings

1. Clear changes of hourly flood peak discharge, daily drought discharge (last 10th discharge) and monthly discharge were detected;
2. For each discharge, the degree of the changes differs according to location; and
3. The changes appear in the near future climate experiment, which become clearer in the future climate experiment.

Acknowledgement: The GCM projection data was provided by MRI, Japan Metrological Agency through KAKUSHIN project. The research is conducted cooperatively with DPRI, KU and MRI.

1-K DHM – Windows Internet Explorer

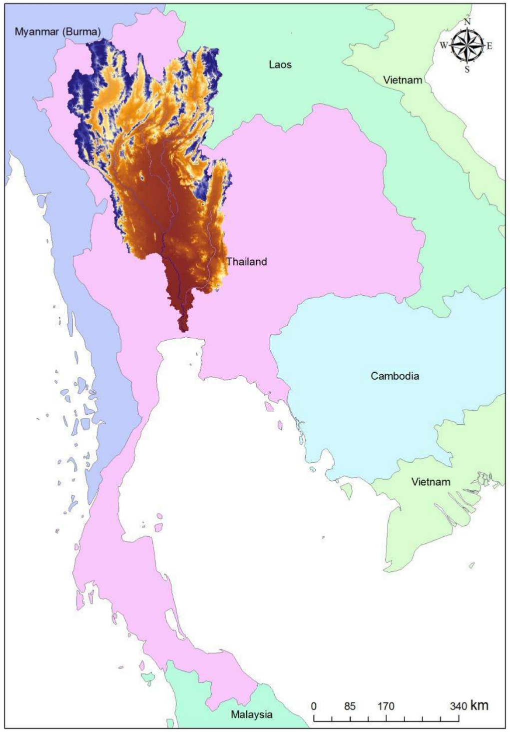
1K-FRM/DHM

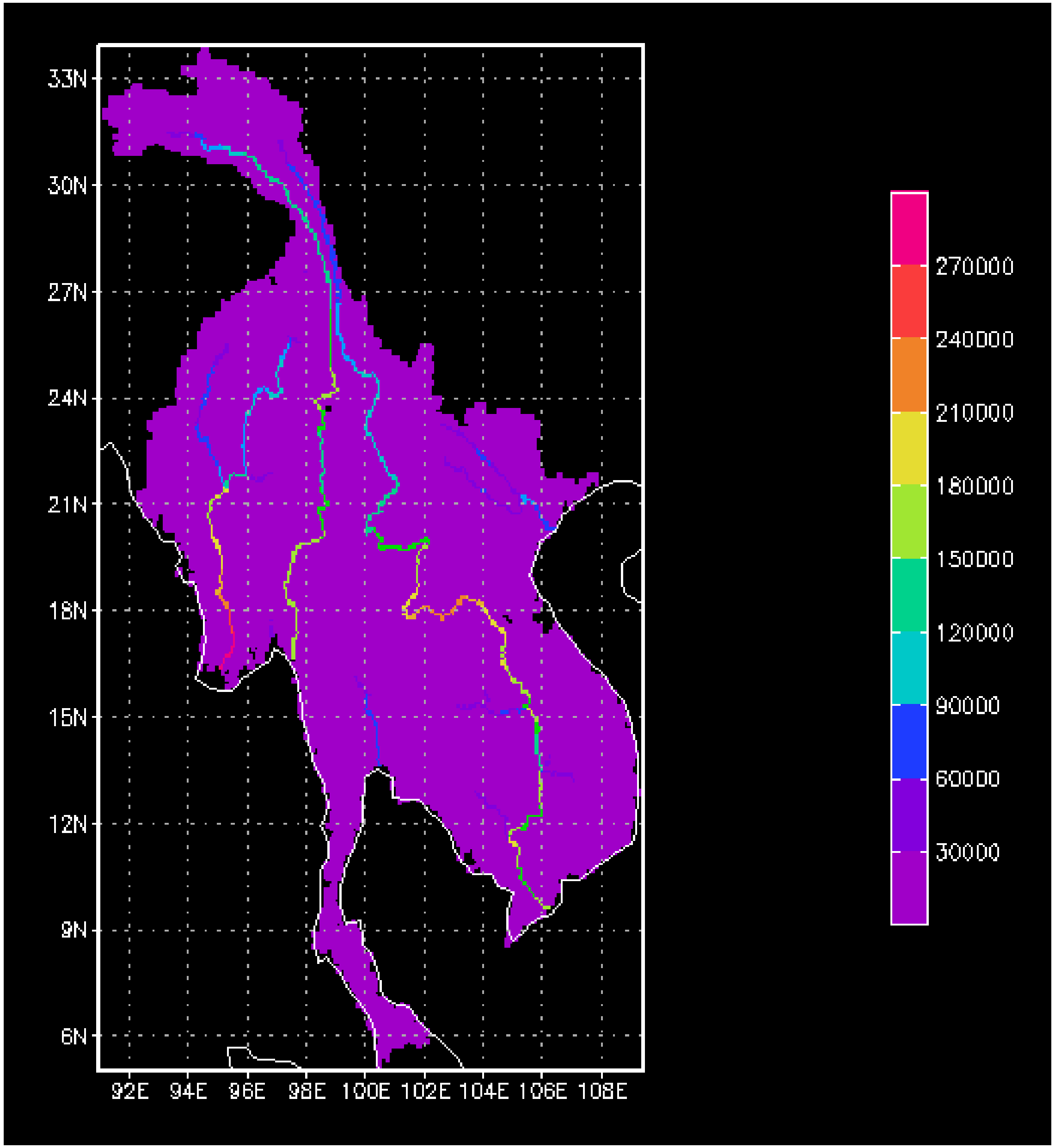
A distributed river discharge simulation model based on kinematic wave theory using HydroSHED topography data

May 9, 2012, YT

- 1K-FRM ver. 1.32 (C++ source code and sample input data)
  - A distributed flow routing model for river discharge simulation. Input of the model is monthly sorted hourly lateral flow to slope and river, which is supposed to be generated by the MRI 20km GCM output for analysing the change of future river dishcharge under climate change scenario.
  - [IMPORTANT] Topography data must be generated by hydroshed2topo ver. 1.30 or higher.
  - User manual ver. 1.32 (PDF file)
- 1K-FRM-event ver. 1.32 (C++ source code and sample input data)
  - A distributed flow routing model for river discharge simulation. The model structure is the same as 1K-FRM, but Input data to 1K-FRM-event is an event based hourly data.
  - [IMPORTANT] Topography data must be generated by hydroshed2topo ver. 1.30 or higher.
  - User manual ver. 1.30 (PDF file)
- 1K-DHM
  - A distributed rainfall-runoff model for river discharge simulation.
- 1K-DHM-event
  - A distributed rainfall-runoff model for river discharge simulation.
- hydroshed2topo ver. 1.30 (1MB zip file including C++ source code)
  - a topography data processing program for 1K-FRM, 1K-DHM, 1K-FRM-event, and 1K-DHM-event.
  - [IMPORTANT] Topography data generated by ver. 1.30 is applicable for 1K-FRM and 1K-FRM-event ver. 1.30 or higher.
  - Input data ver. 1.00 for hydroshed2topo (90MB zip file including sample data of elevation and flow direction for Asia, which was generated from HydroSHED)
- Tools
  - A program to extract forcing data from MRI-GCM
  - pointdata-event: A program to extract time series data from output discharge file
  - makeppm-event: A program to generate PPM image files from output discharge file
- Sample topography data for 1K-FRM and 1K-FRM-event above ver. 1.30
  - Japanese basins (Hokkaido, Tohoku, East Japan, Central Japan, West Japan, Shikoku, Kyusyu)
  - Chaophraya River basin
- History of development

Next Step


Myanmar (Burma)
Laos
Vietnam
Thailand
Cambodia
Vietnam
Malaysia
0 85 170 340 km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Summary

Through the 75 years runoff simulations for Japanese catchments, the findings are summarized as follows:

1)A clear change of temporal and spatial discharge patterns appears;

2)The degree of the change differs according to location;

3)In northern Japan, river discharge for the future climate is smoothened because of the decrease of snow melting;

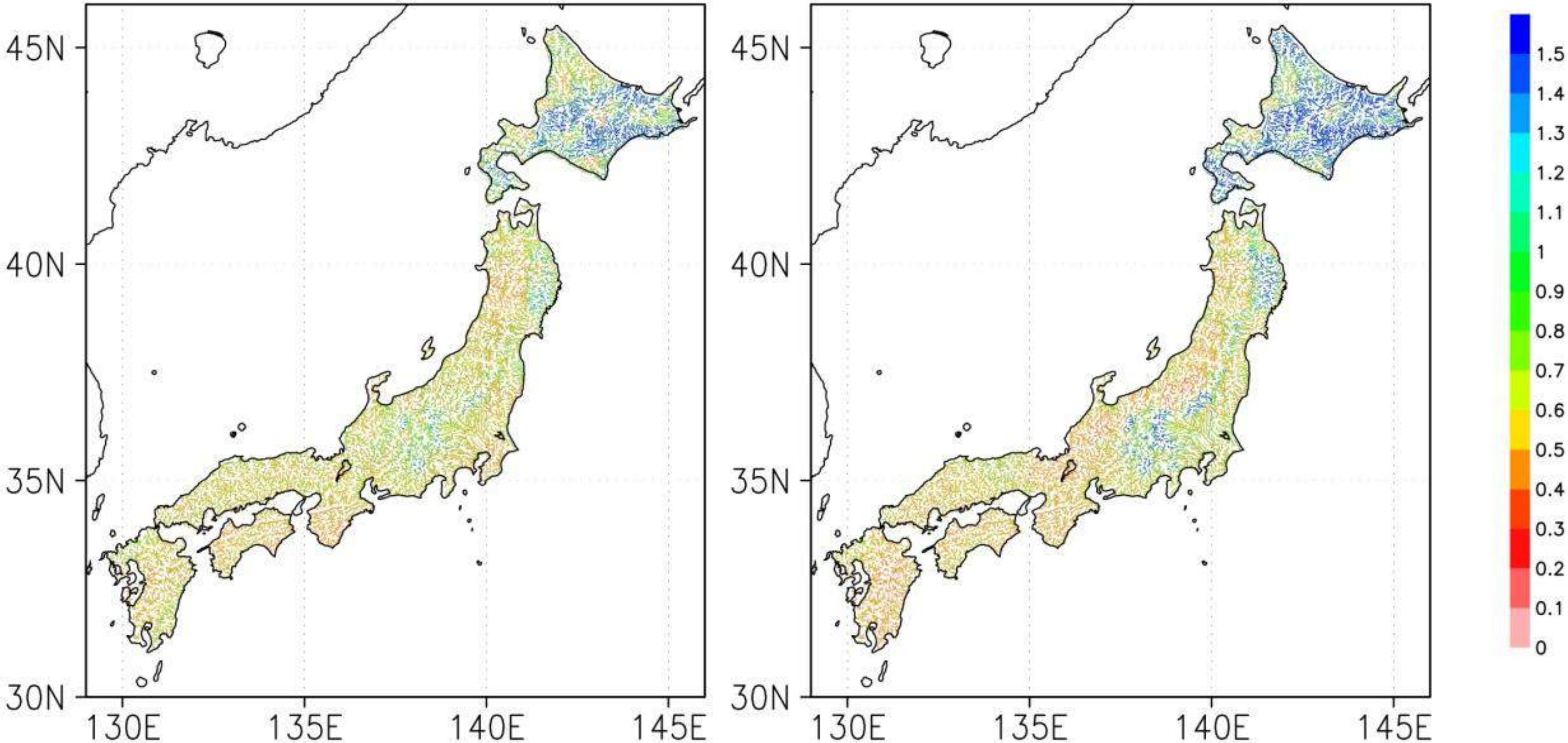
4)In southern Japan, the flood peak discharge increases because of higher short term precipitation , which leads to the increase of flood risk;

5)In southern Japan, the 355th daily discharge in descending order in a year decreases, which leads to the increase of drought risk;

6)The discharge change appears in the near future climate experiment.

Appendix

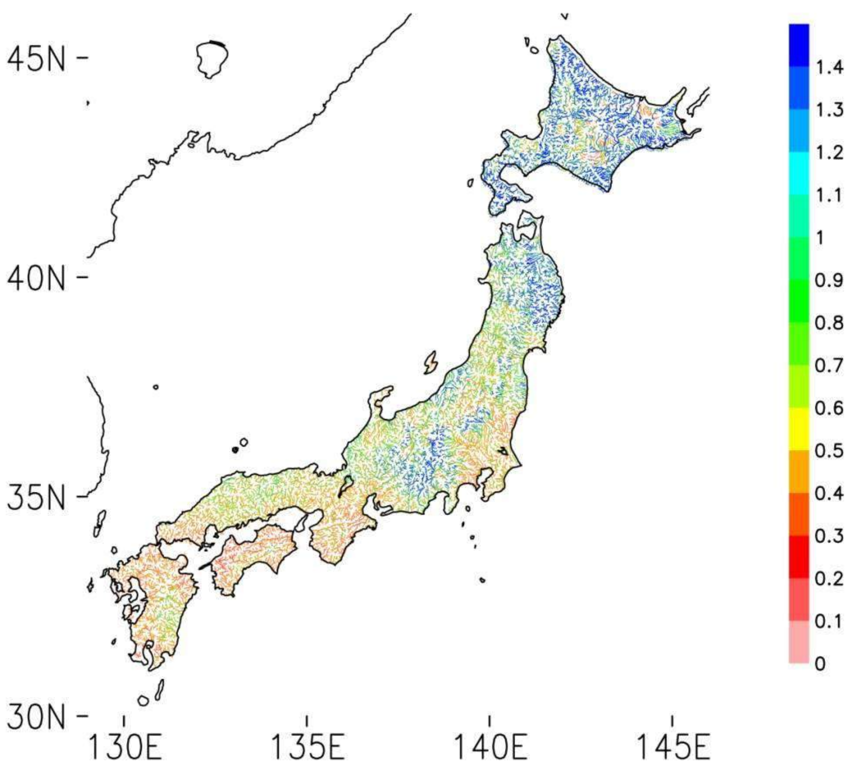
Change of the mean of the 10th daily discharge in ascending order in a year



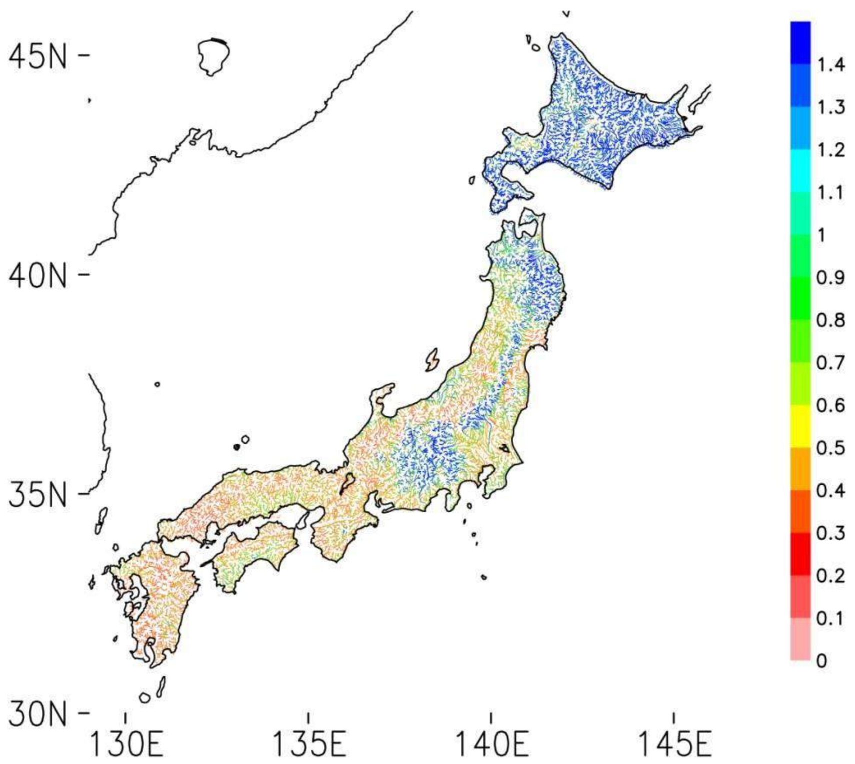
Near future climate
/Current climate

Future climate
/Current climate

Change of the 10-year 10th daily discharge in ascending order in a year using W e i b u l l distribution



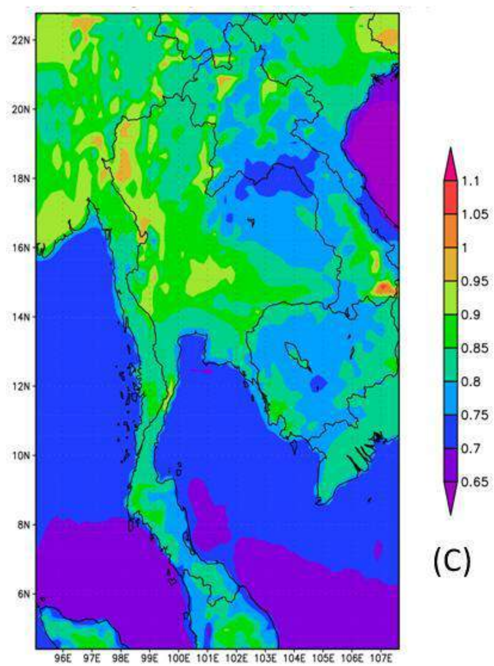
Near future climate
/Current climate



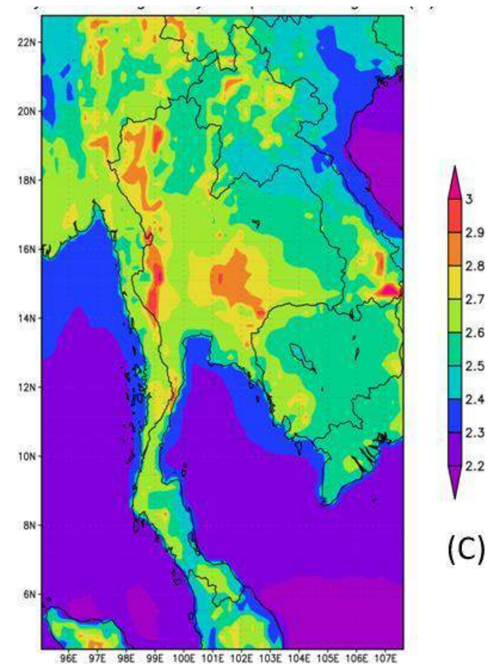
Future climate
/Current climate

Changes ; Basic meteorological parameters (a)Temperature …

difference of the average annual daily temperature in near future and future climate with respect to the present climate



a) Near Future

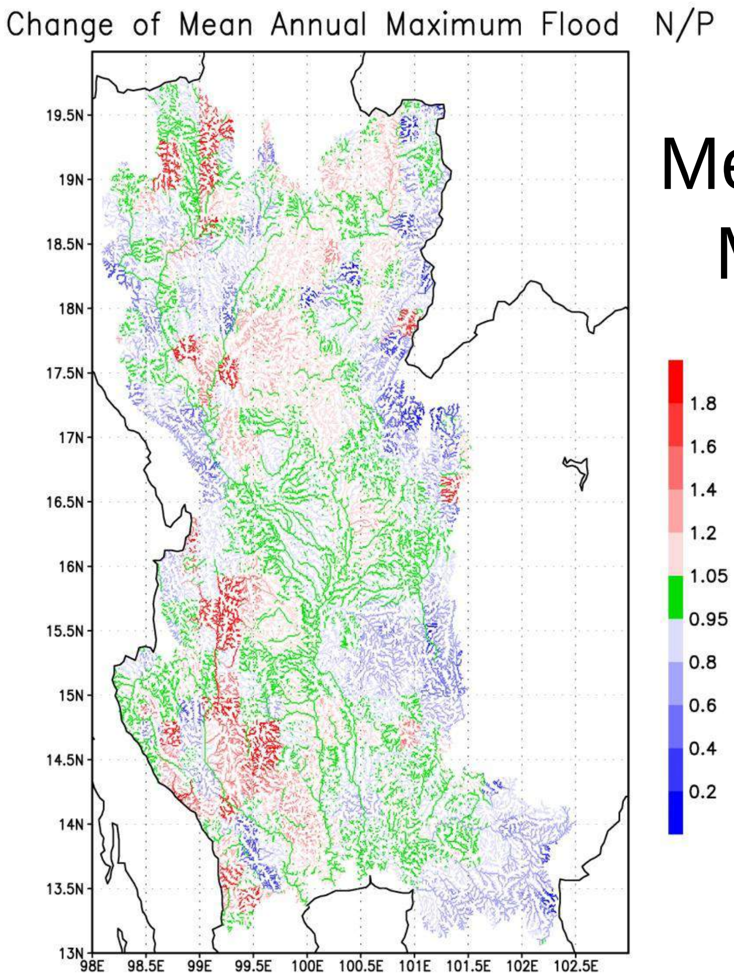


b) Future

According to the GCM20 projection data for near future climate, the surface temperature found to be increase roughly by 0.5 to 1 degree from the present temperature whereas the temperature increased by about 2.5 to 3 degrees in the future climate.

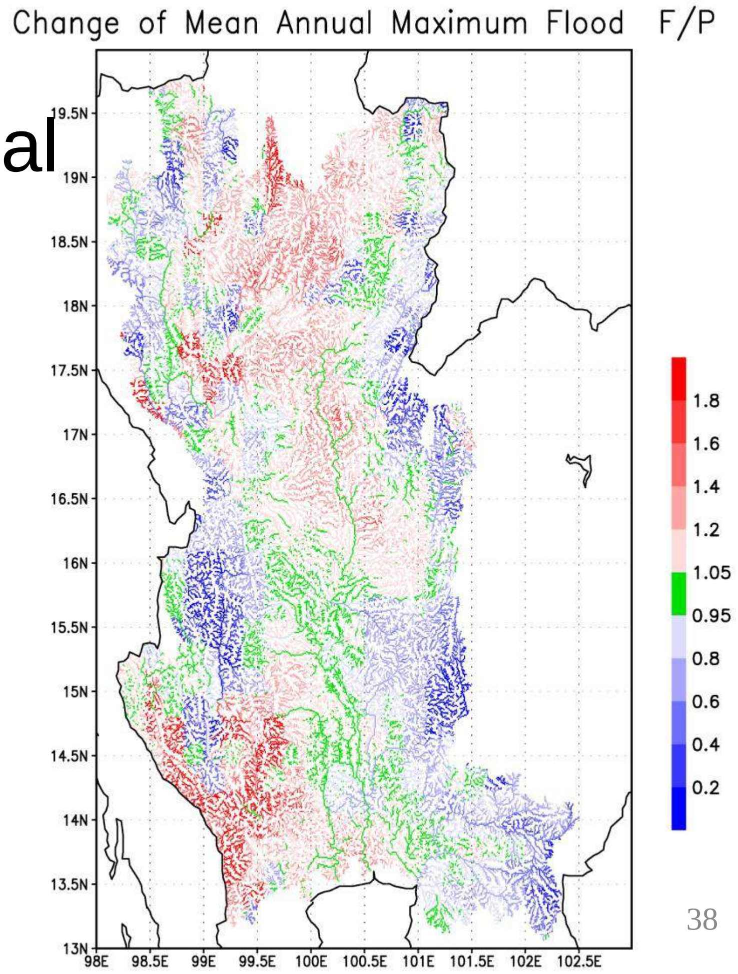
Results ; Flood...

$NearFuture / Present$



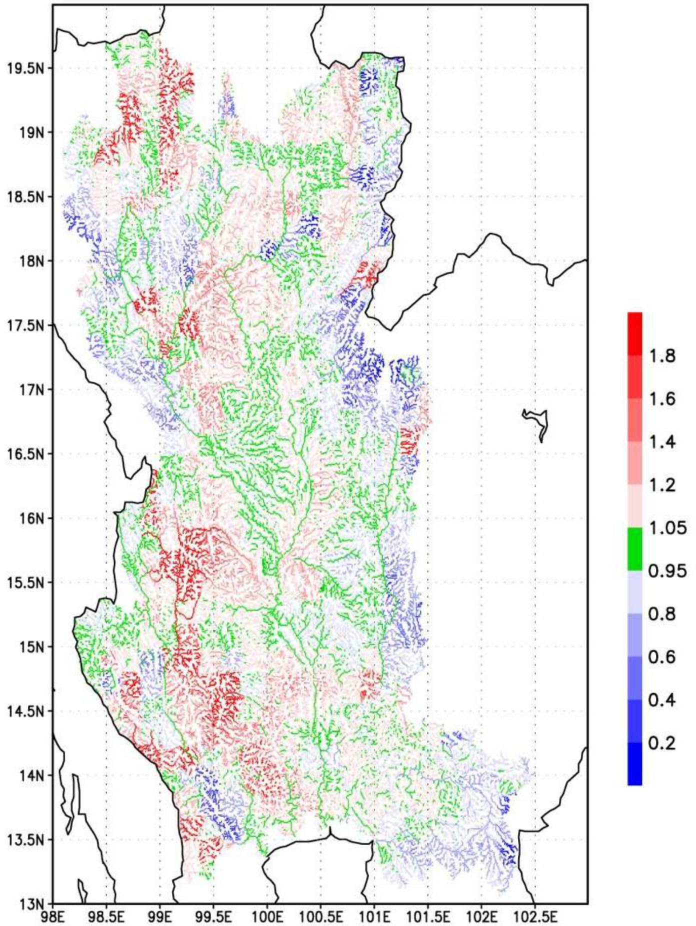
Mean Annual Maximum Flood

$Future / Present$



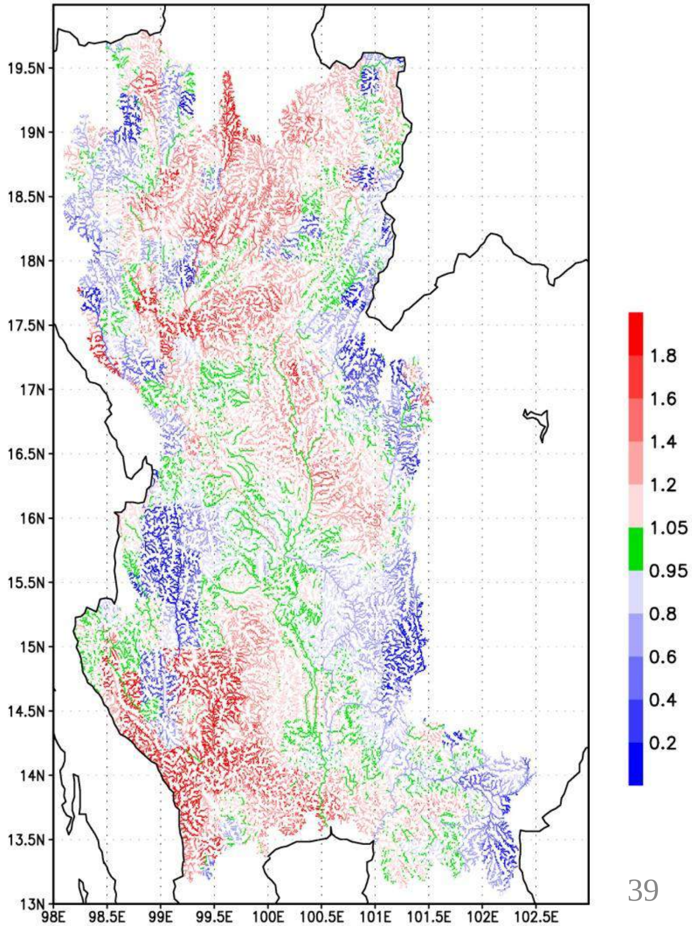
Results ; Flood…

$NearFuture / Present$



Flood with 10-years Return Period

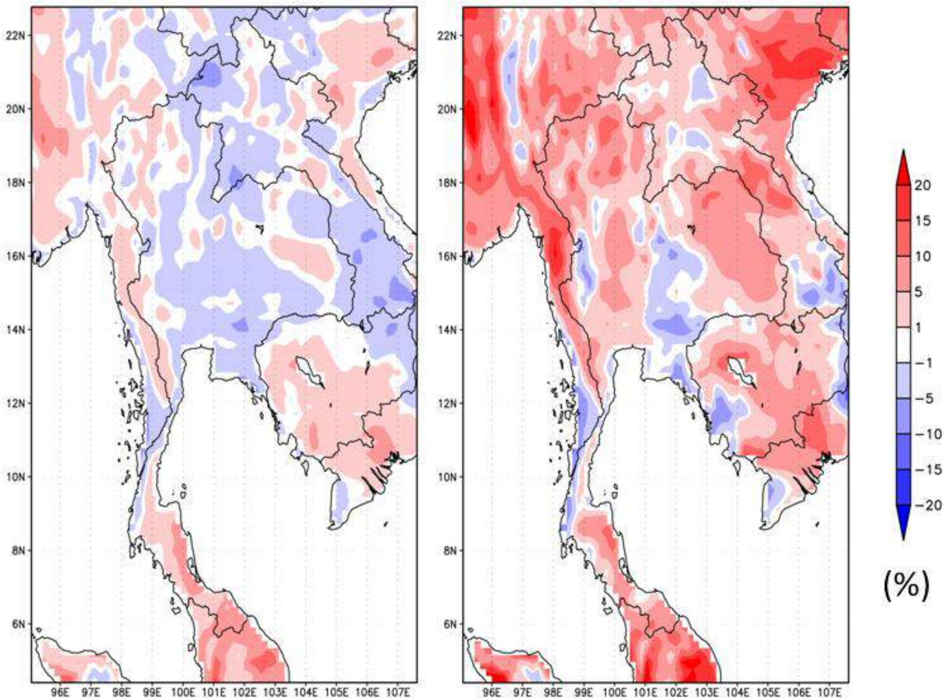
$Future / Present$



Changes ; Basic meteorological parameters (a)Rainfall …

Percentage difference of the average annual rainfall with respect to present climate

% Percentage Difference = 100*(Near future-Present)/Present



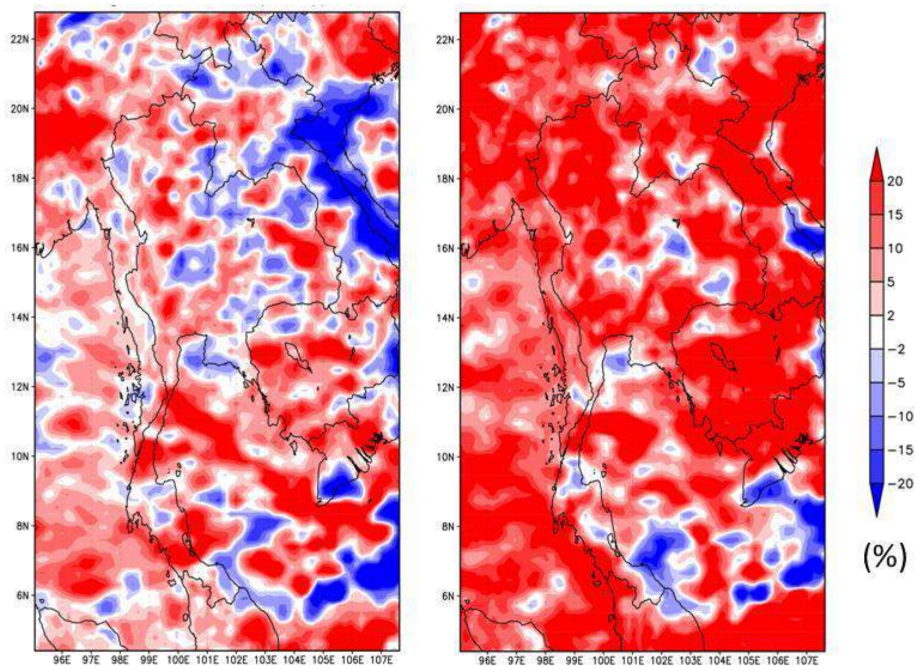
a) Near Future b) Future

1% to 5% decreases of annual precipitation can be observed in the central region of Thailand and 1% to 10% of increase in annual precipitation can be observed in southern region in the near future climate (2015-2039).

Future climate conditions, it is expected to have 1% to 10% of increase in annual precipitation in north mountainous region and 5% to 10% increase in northeast region.

Changes ; Basic meteorological parameters (a)Rainfall …

Percentage difference of the average annual maximum hourly rainfall intensity with respect to present climate

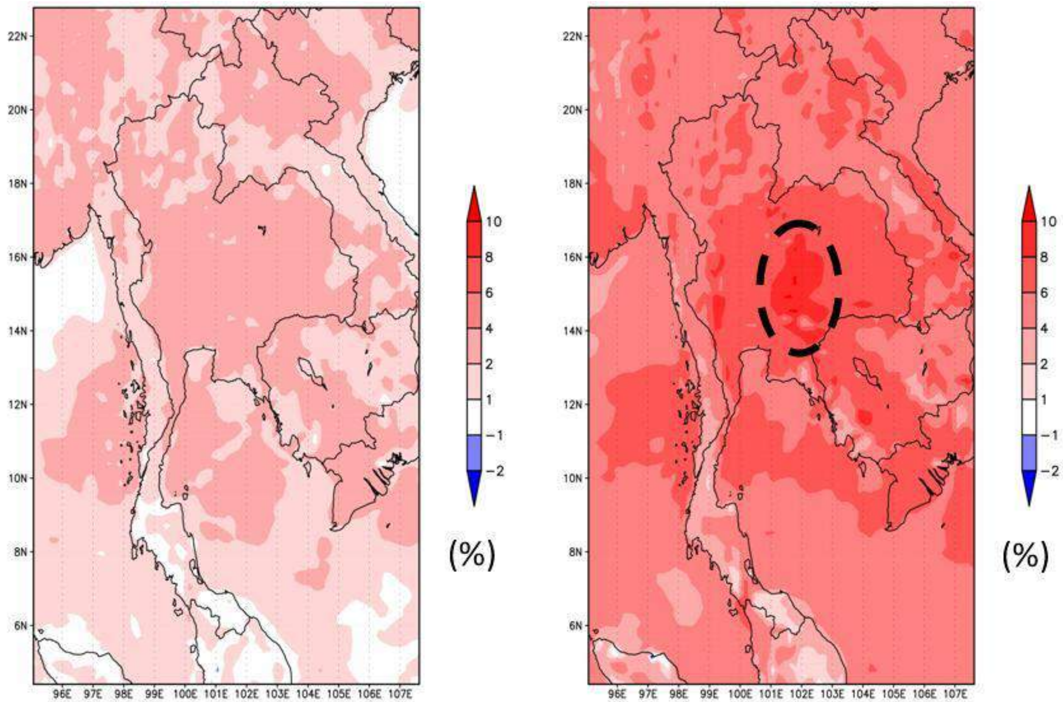


a) Near Future b) Future

we can observe a clear increasing trend of the annual maximum hourly rainfall intensity over Thailand for both time periods. Notably, in future climate we can observe about 20% of increase of annual maximum hourly rainfall intensity in many parts of the country

Changes ; Basic meteorological parameters (a) Potential evaporation

Percentage difference of the average annual daily potential evapotranspiration in near future and future climate with respect to the present climate

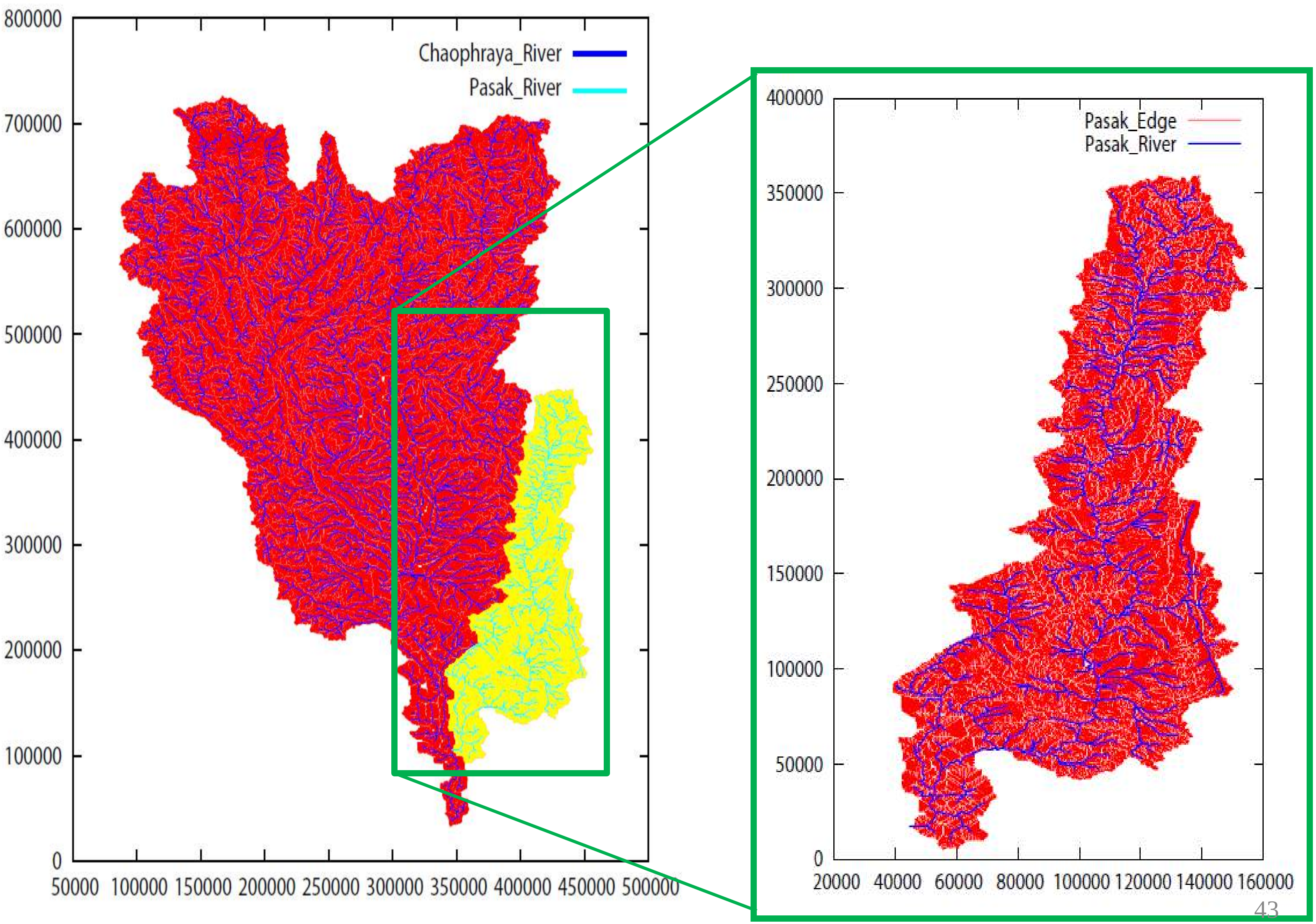


a) Near Future

b) Future

It can be clearly noticed that the potential evappotranspiration will increase by 4% to 6% in near future climate and 4% to 10% in future climate.

Detailed distributed hydrologic model for Pasak River Basin



手法1.GCM各気候間の流入量比率を用いて、観測流入量をもとに将来の流入量を作成する方法

- この方法では、GCM現在気候に対する近未来･将来の月ごとの変化比率を、観測された流入量に乗じることで、観測データを基に近未来･将来の流入量を作成する。

$$r_{near,i} = \frac{\overline{Inflow_{near,i}}}{\overline{Inflow_{present,i}}}, \quad r_{future,i} = \frac{\overline{Inflow_{future,i}}}{\overline{Inflow_{present,i}}} \quad (i = 1 \sim 12)$$

$$Inflow'_{present,j,i} = Inflow_{obs,j,i}$$

$$Inflow'_{near,j,i} = r_{near,i} \times Inflow_{obs,j,i}$$

$$Inflow'_{future,j,i} = r_{future,i} \times Inflow_{obs,j,i}$$

j ：観測データが存在する年(2000年～2009年)

- 上記の要領で得られた流入量から実際に月ごとに観測された放流量と損失を引くことで貯水量を計算し、「将来流入量が変化した場合、現在必要とされる放流量を放流するとルールカーブを満たせるか否か」を分析する。