Integrated assessment of climate change impacts on watersheds in a disaster environment under Kakushin Program

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1. Introduction

2. Structure of DPRI’s impact assessment

3. Impact assessment related to the topics which will be presented from DPRI in this workshop

4. Impact assessment directly related adaptation

5. Spatial scale in which AGCM20 output can reproduce river regime

6. Spatial scale in which the Climate Change becomes statistically significant

7. Can RCM improve reproducibility river regime in smaller basin?

8. Expectation for RCM

9. Heading to adaptation

10. Summary

1. INTRODUCTION

Projection of changes in extremes in the future with very-high resolution atmospheric models

A. Projection

Extreme event projection by very high resolution atmospheric models

Meteorological Research Institute (MRI)
Japan Meteorological Agency (JMA)
Advanced Earth Science & Technology Org. (AESTO)

uncertain information

data

B. Uncertainty

Evaluation and reduction of uncertainty in global warming projection

Meteorological Research Institute (MRI)
Japan Meteorological Agency (JMA)
Advanced Earth Science & Technology Org. (AESTO)

Requirement of types of output
Significance of GCM and RCM output for disaster environment

uncertain information

C. Risk assessment

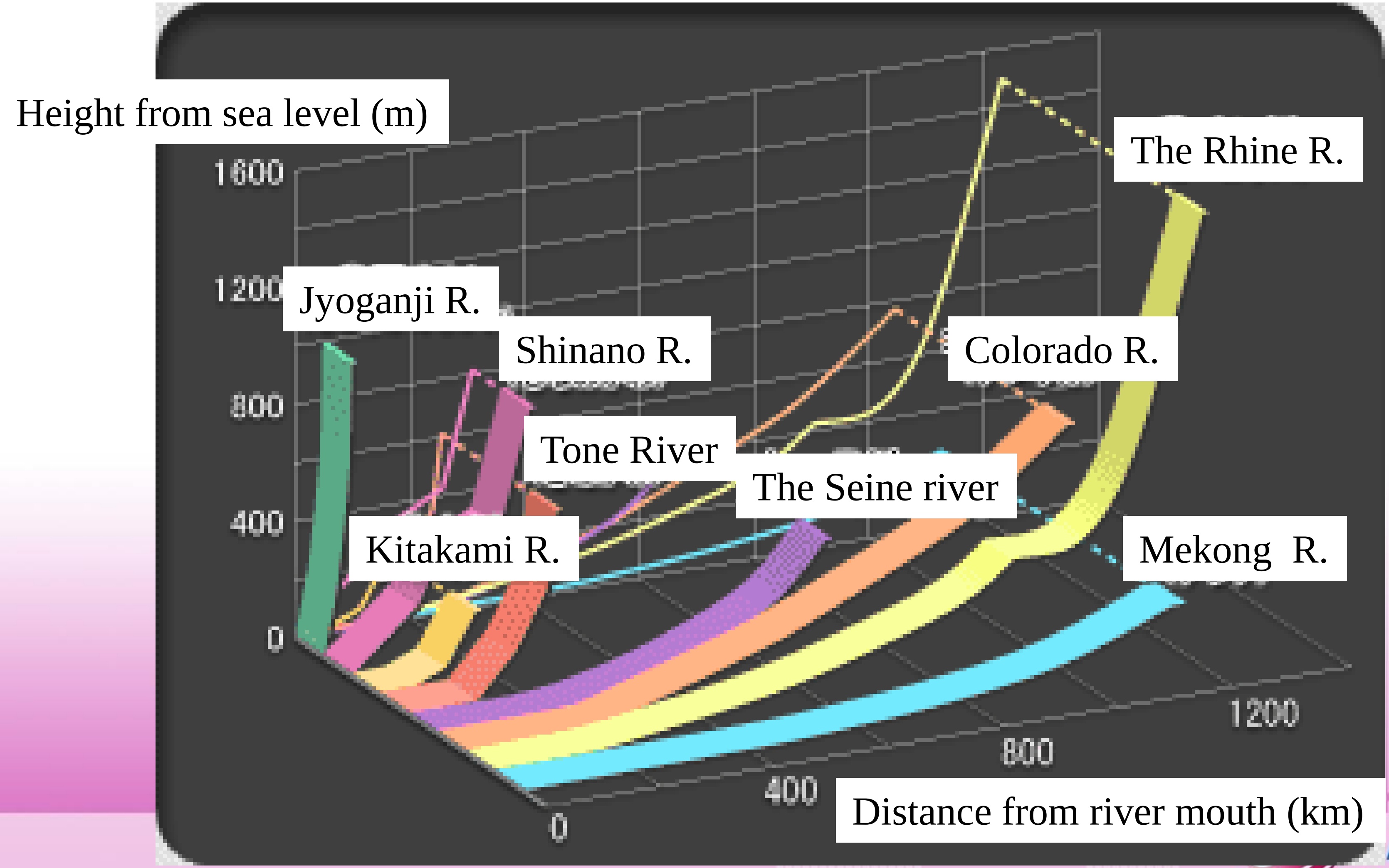
- **Prediction and evaluation of disaster environment**
  Disaster Prevention Research Institute (DPRI), Kyoto University
- **Assessment of climate-change impacts on flood risk and its reduction measures on global and local scales**
  International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute

Basic background

- Policy on disaster prevention
  - Policy strategy: A certain level to prevent from disaster
    - e.g.) design level for hydrologic structure.
  - The design levels have been decided from a concept of statistical technique.
  - However, if a certain disaster exceeds the level under climate change condition, 'Risk Management' is also important.
- Current state-of-the-art AGCM20 output
  - Output from AGCM20 has realized computing reasonable peak discharge and flood level of Japanese rivers.
  - WE CAN CHECK EXTREME PEAK DISCHARGE/FLOOD LEVEL of Japanese river in the current climate condition.
  - IN OTHER WORD, WE MAY FIND THEIR OVERALL TREND NOW!

Features of Japanese River(1)

- **Short length and steep slope**



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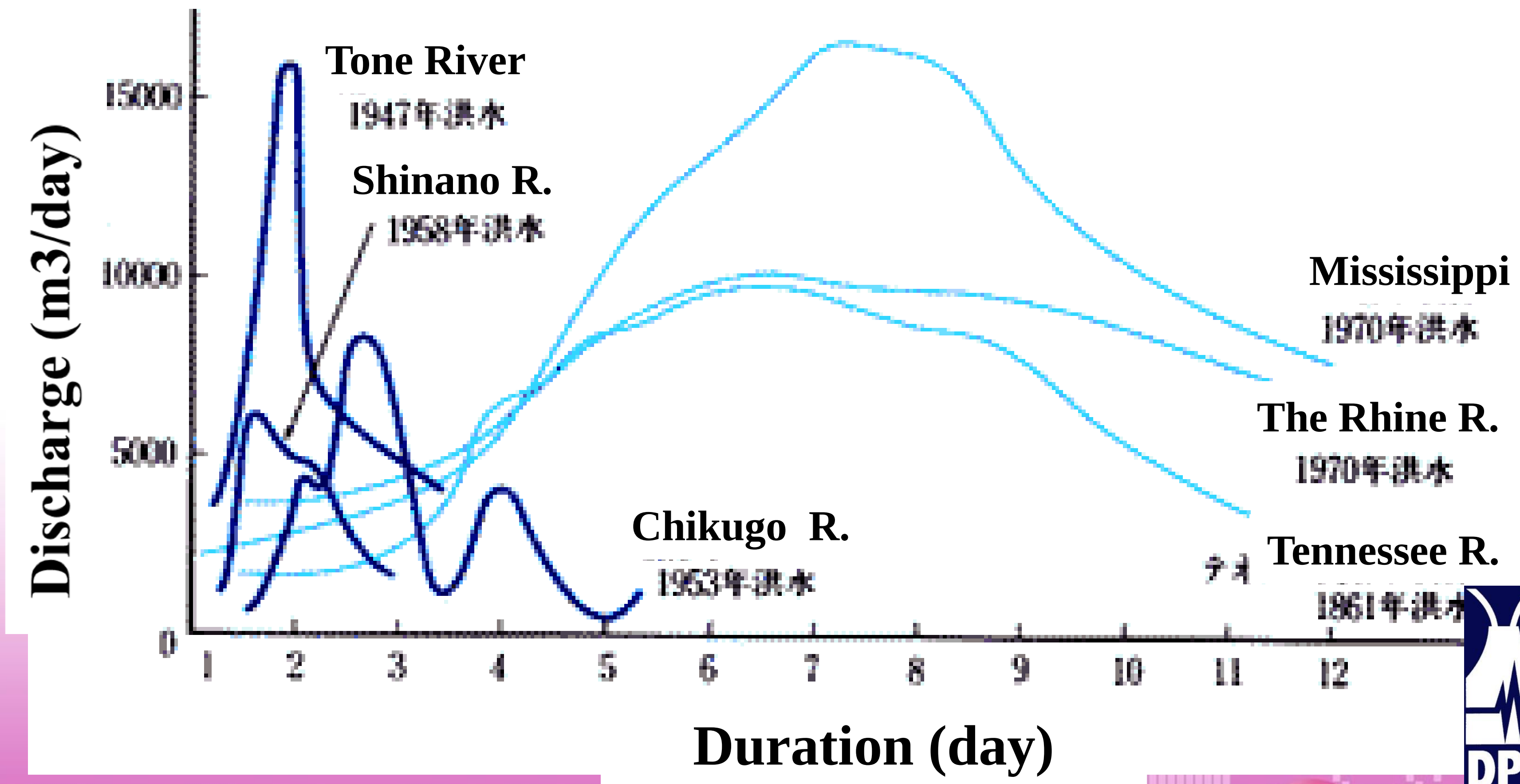
Features of Japanese River(2)

- **Large peak discharge, short duration**

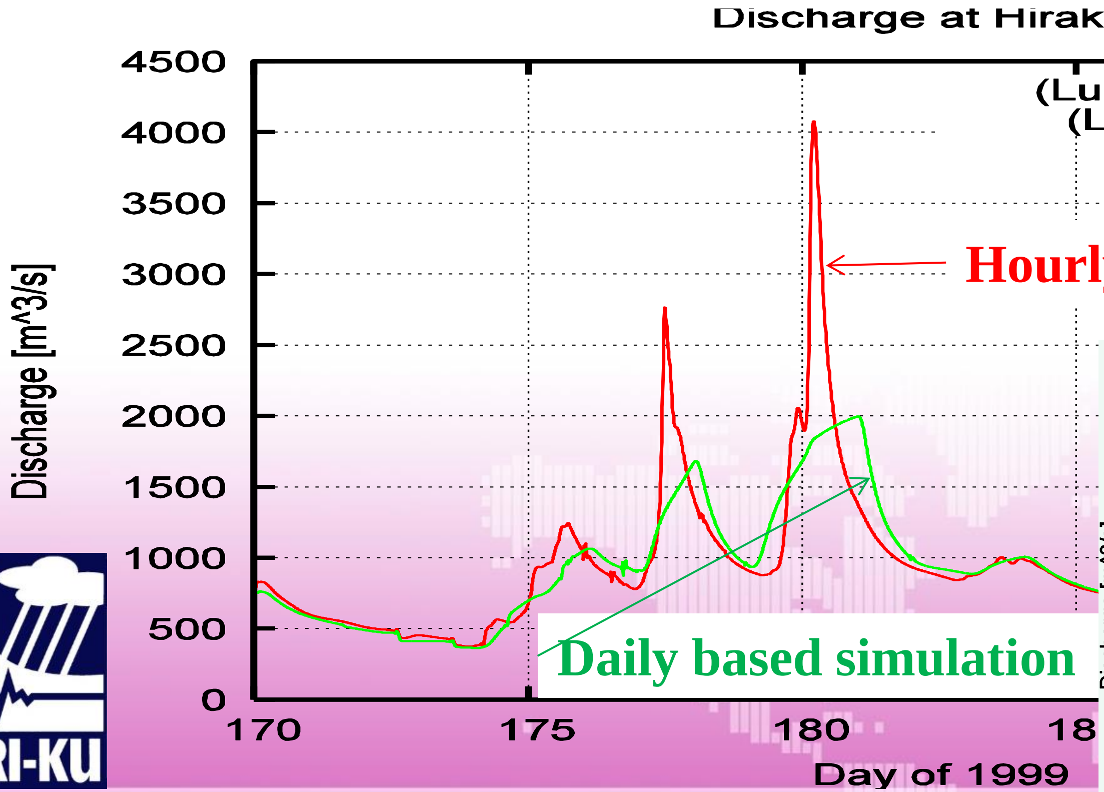


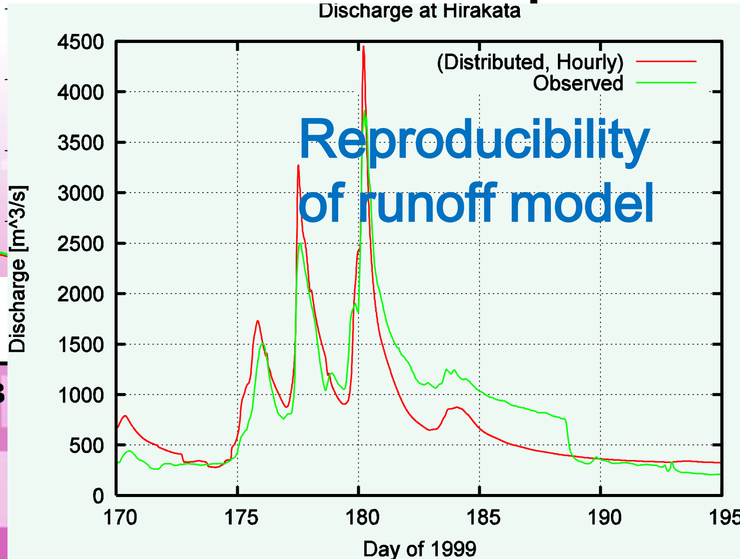
Importance of temporal resolution of rainfall data in calculating river discharge

- Comparison of simulation results for hourly and daily rainfall data in rainfall runoff model
- Yodo river basin（Hirakata water stage stn.：7,281km²）

⇒ Under-estimation of peak flow up to 50% when we use daily data.

⇒ WE HAVE TO CALCULATE RIVER DISCHARGE USING HOURLY RAINFALL DATA.





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By Masuda, Tachikawa et al. (2006)

East Asia

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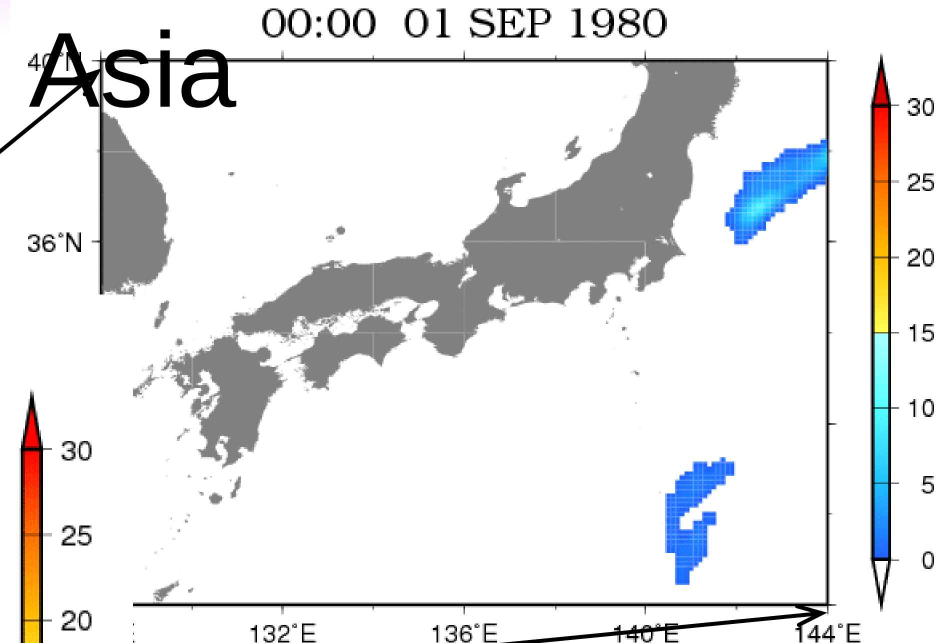
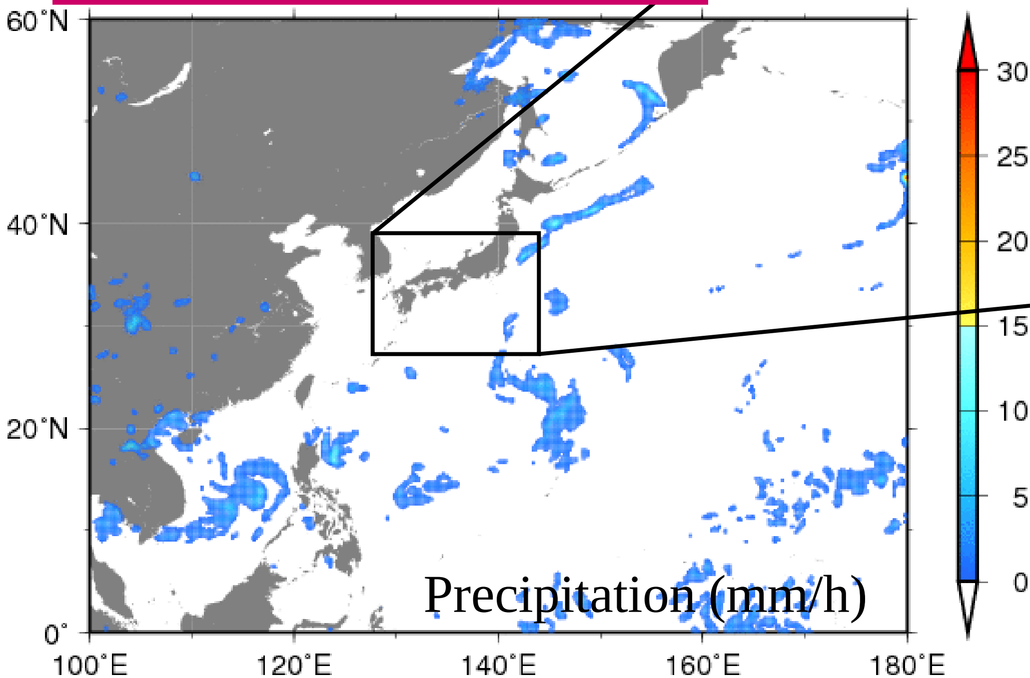
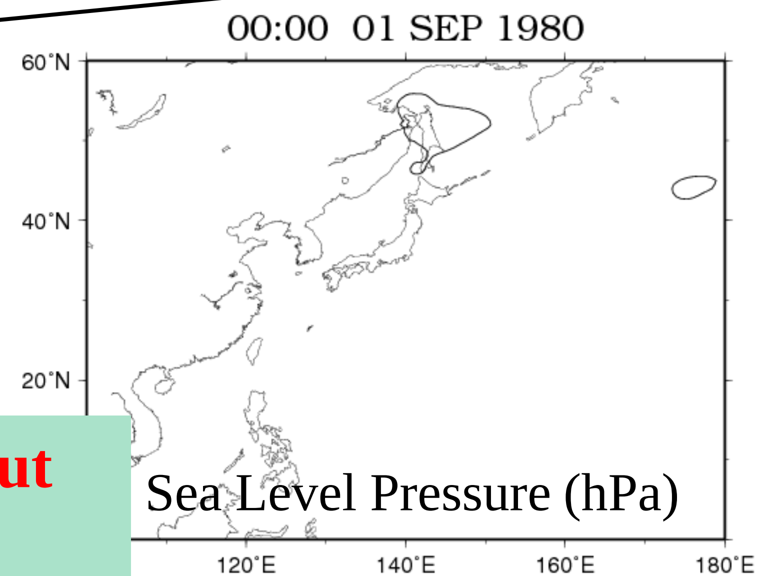
MRI-AGCM20,
hourly outoput







It is the typhoon resolving output that has realized the impact assessment of Japanese disasters

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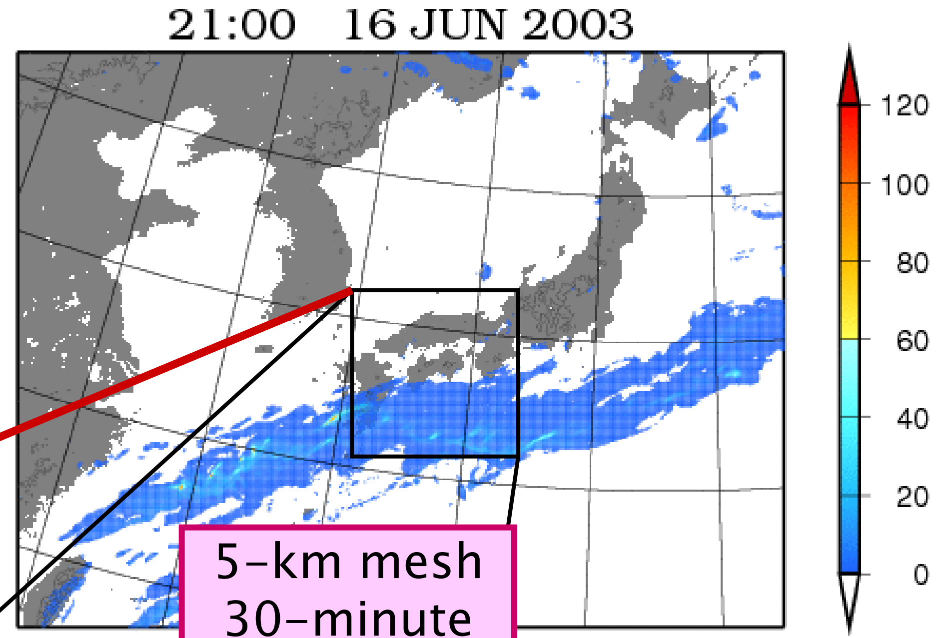
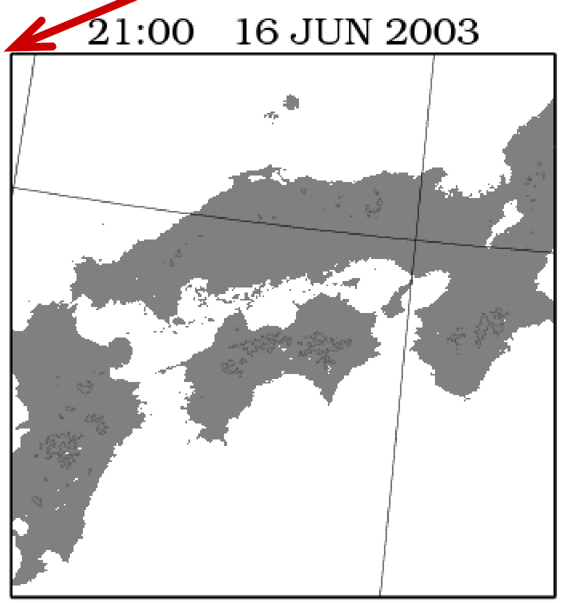
MRI-RCM output

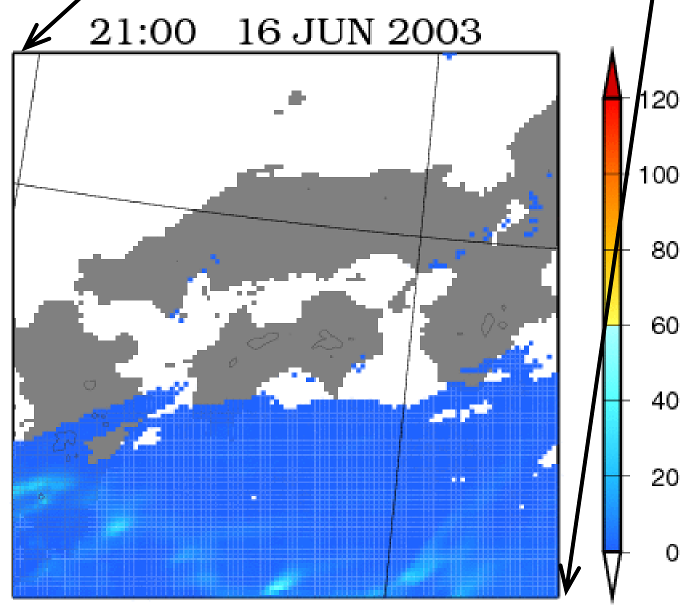
Very important for assess initiation of land slide and debris flow

NESTING



1-km mesh
10-minute





Precipitation (mm/h)

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2. STRUCTURE OF DPRI'S IMPACT ASSESSMENT

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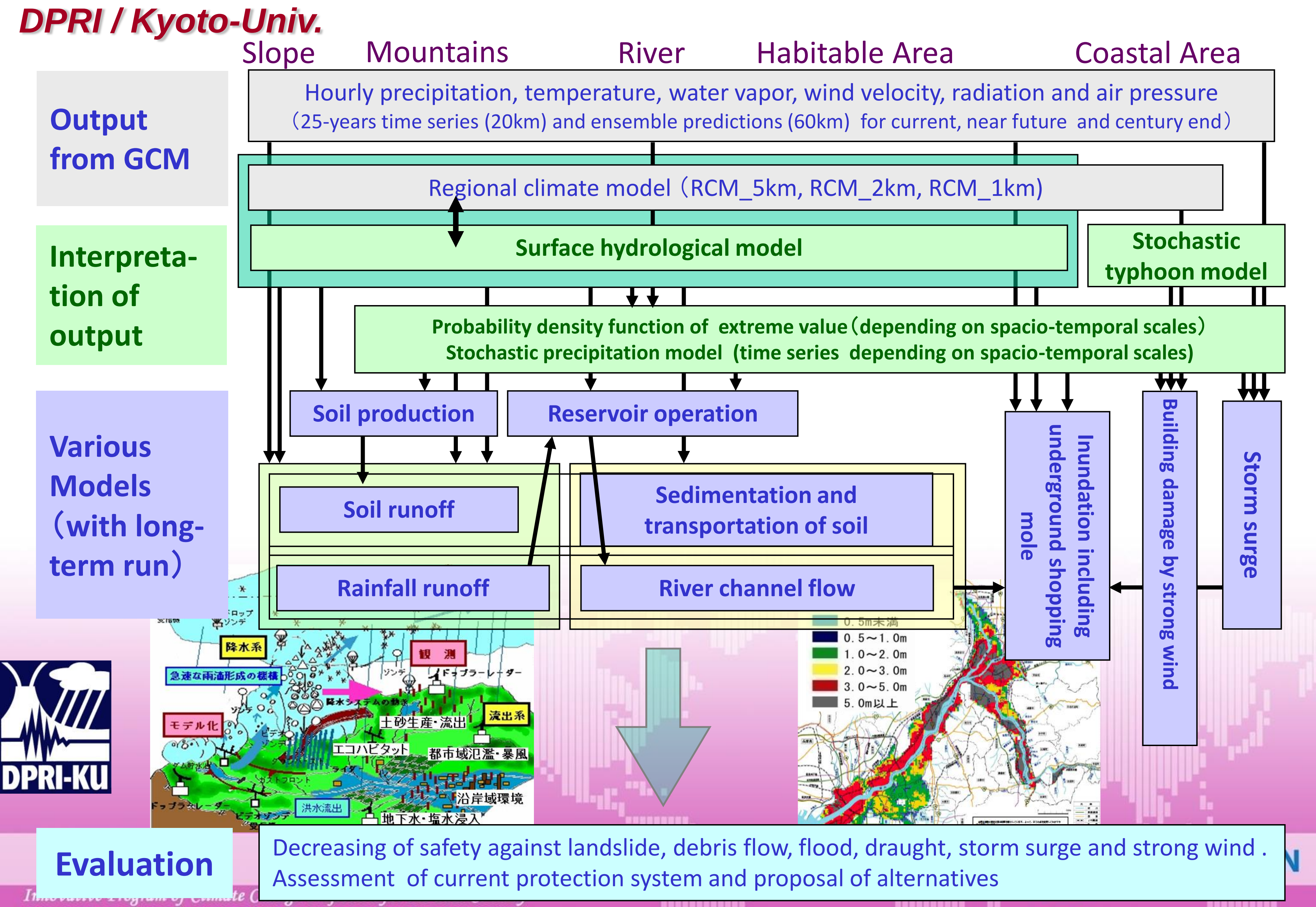
Prediction and evaluation of disaster environment in Japan



Minimum Target of DPRI

- Interpletation of GCM output
- Precipitation: Global
- Land slide and Debris flow: mainly western Japan
- River discharge:
  Japanese major river basins (with fine resolution)
  All Japanese river basins (with medium resolution)
- Storm surge: Tokyo, Ise (Nagaya) and Osaka Bays
- Damage by strong wind: entire Japanese archipelago
- Inundation: Tokyo, Nagoya, Osaka and Fukuoka

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Rainfall output from GCM and RCM

- **GCM20 (Hourly, Globe)**
  - Rainfall, storm surge and ocean wave in the world
  - Discharge from major and all Japanese rivers basins
- **RCM5 and RCM2 (30 and 20 minutes, Around Japanese Archipelago)**
  - Inundation in major metropolitan areas
  - Land slide, debris flow
  - Major Japanese river basins
- **RCM1 (10 minutes, Piecewise sections in Japanese Archipelago)**
  - Inundation in major metropolitan arears
  - Land slide and debris flow
  - Strong wind hazard

Methods of Impact assessment

Output from GCM and/or RCM

■Hydrological Regime, Ocean wave
Direct and continual utilization of time-series of GCM/RCM outputs

Hazard models
- Run-off Model
- Ocean Wave Model

Evaluation of changes in hazards

Evaluation of Changes in Disaster Risks

■Strom Surge, Land Slides, Inundation
Statistical evaluation of extreme forcing such as design rainfall, design typhoon

Hazard models
- Storm Surge Model
- Land slide Model, Inundation Model

Evaluation of changes in hazards

Evaluation of Changes in Disaster Risks

Proposal of Adaptation Strategy

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3. IMPACT ASSESSMENT RELATED TO THE TOPICS WHICH WILL BE PRESENTED FROM DPRI IN THIS WORKSHOP

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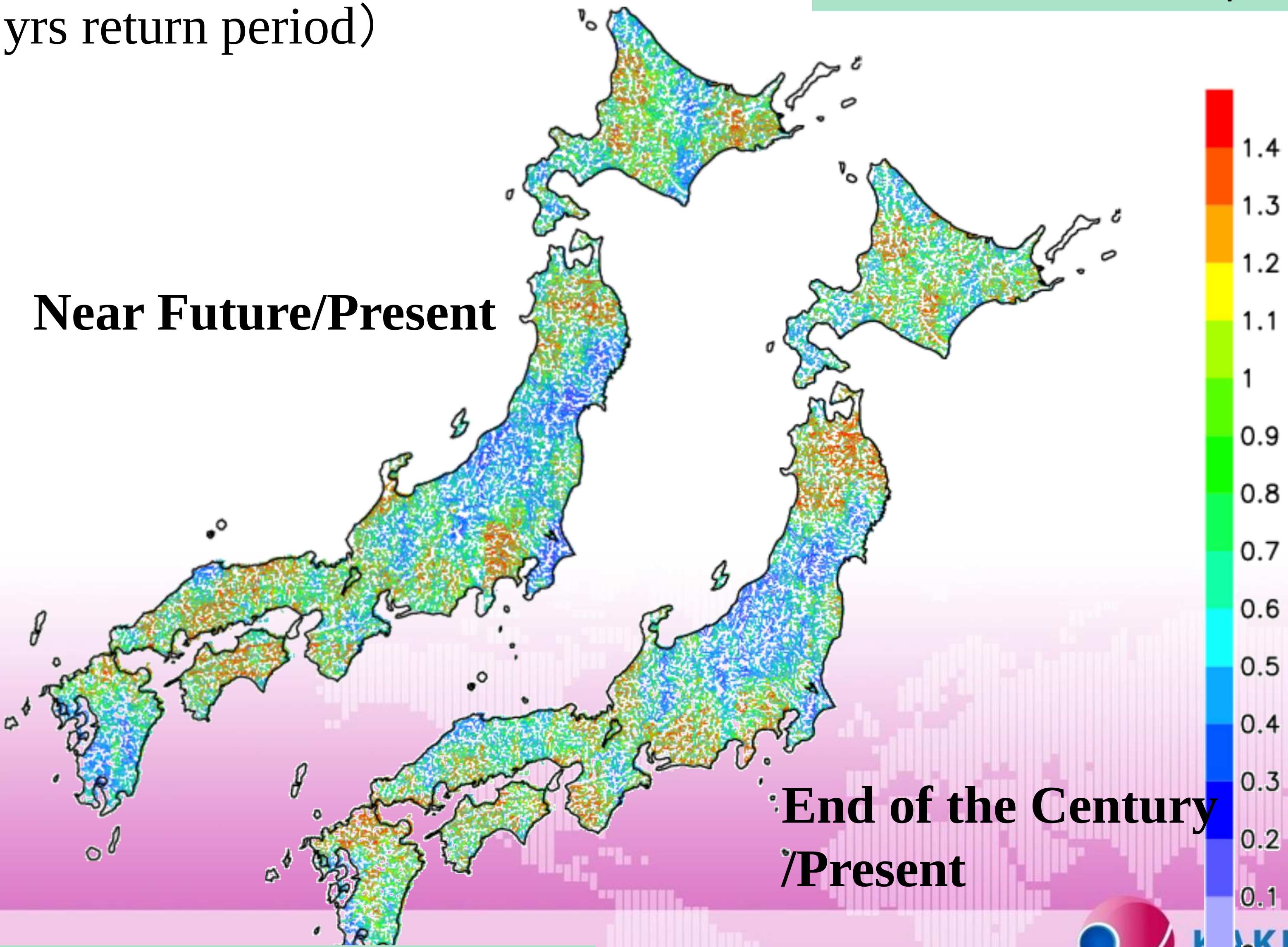
Impact Assessment on River Regime（Flood）

Annual Max. Discharge
（100 yrs return period）

Prof. Tachikawa will present.



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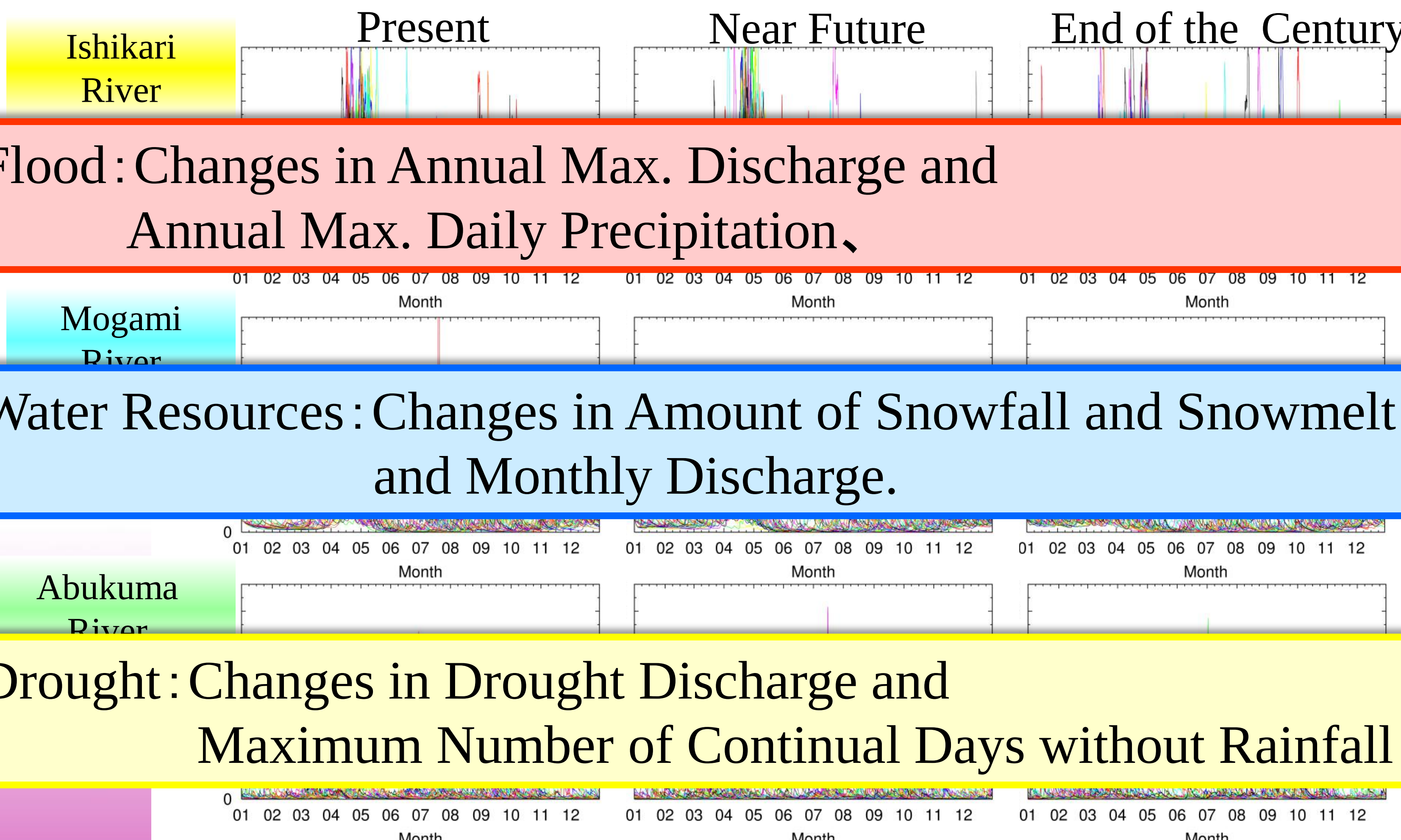
Tachikawa et al., 2010, Kyoto University

Impact assessment on river regime

Prof. Tachikawa will present.



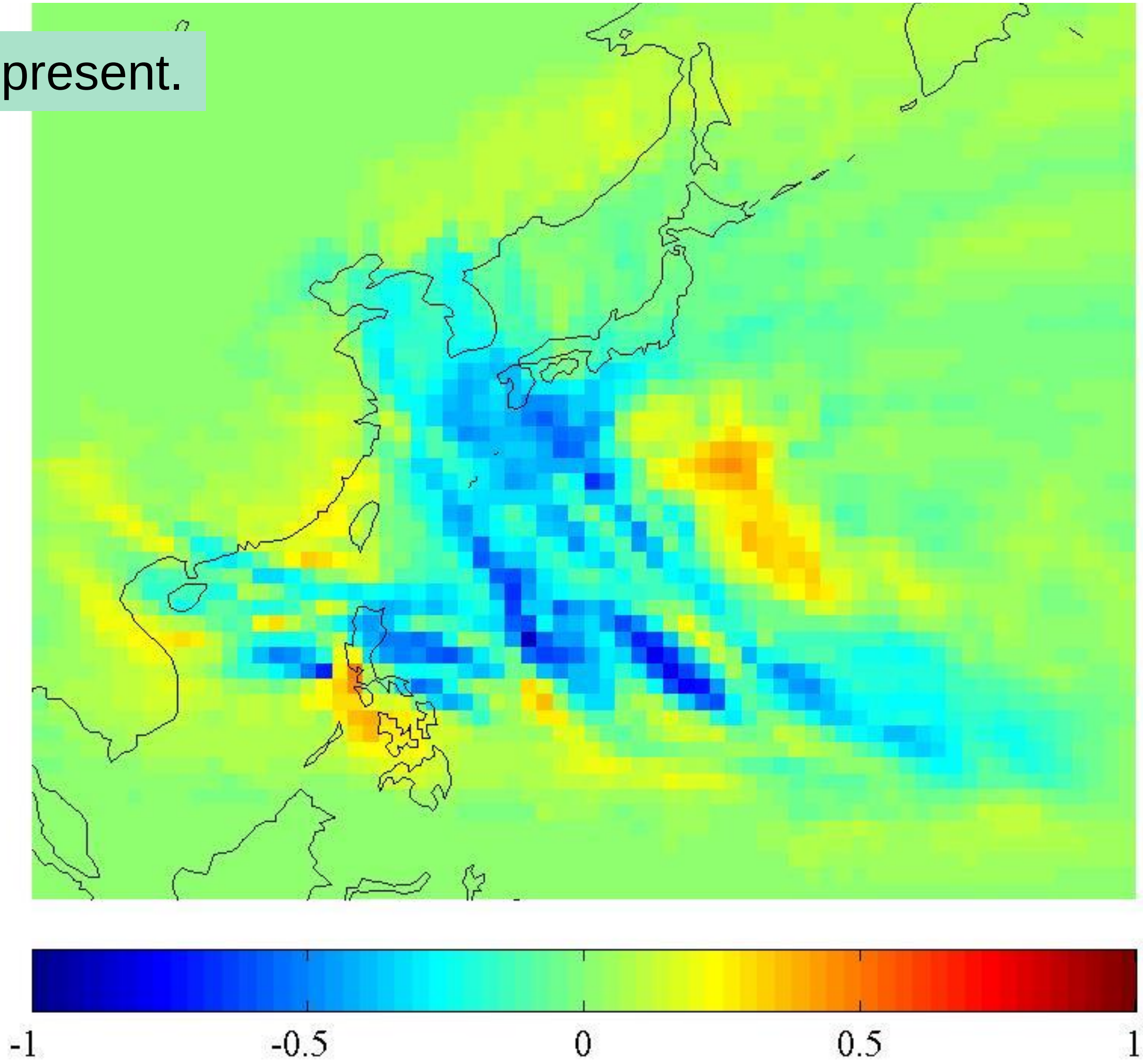
Flood：Changes in Annual Max. Discharge and
Annual Max. Daily Precipitation、

Water Resources：Changes in Amount of Snowfall and Snowmelt
and Monthly Discharge.

Drought：Changes in Drought Discharge and
Maximum Number of Continual Days without Rainfall

Stochastic typhoon model

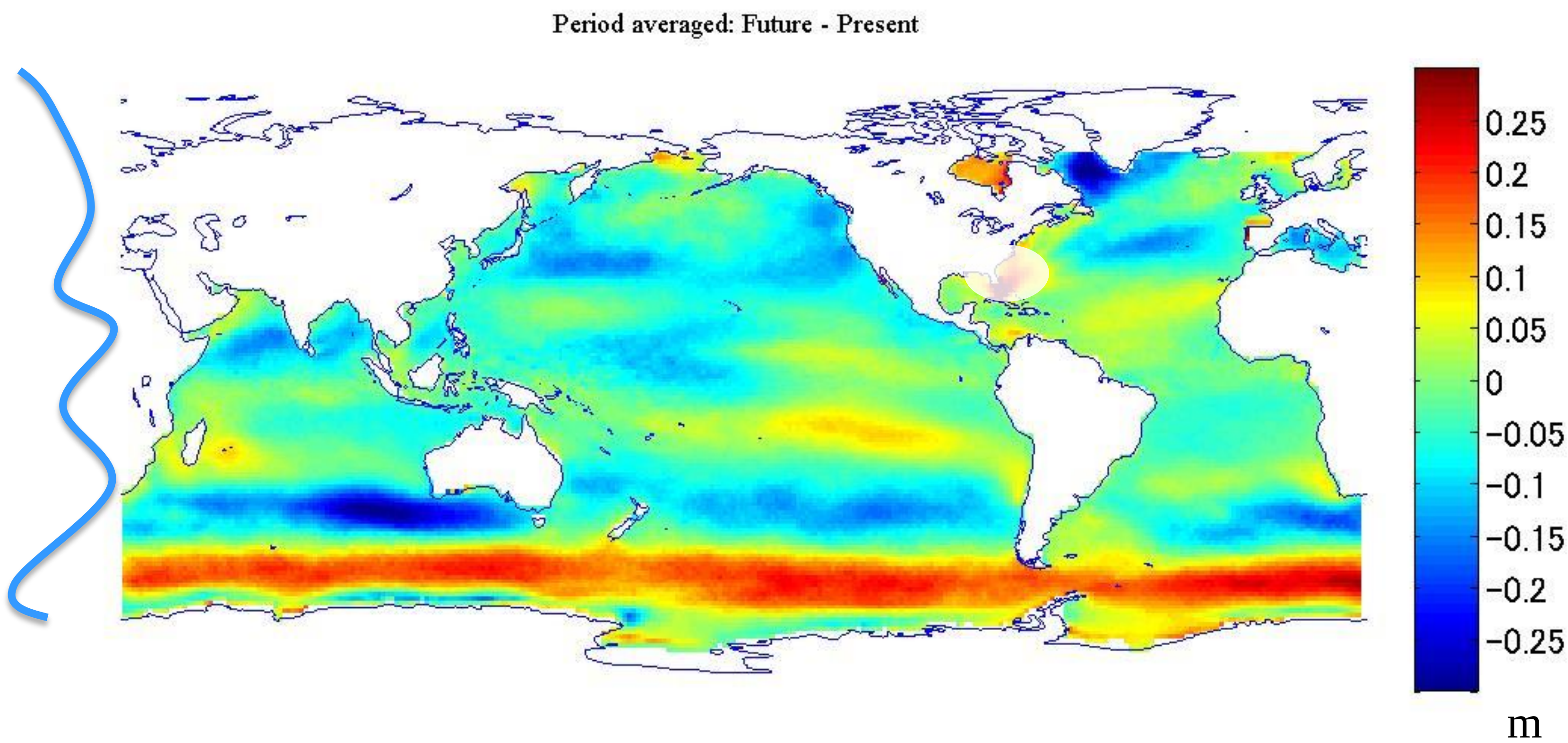
Prof. Mori will present.



Typhoon Numbers/yr: Present - Future

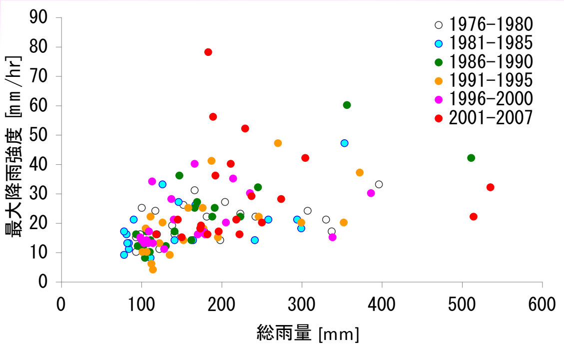
Change in wave height

Prof. Mori will present.

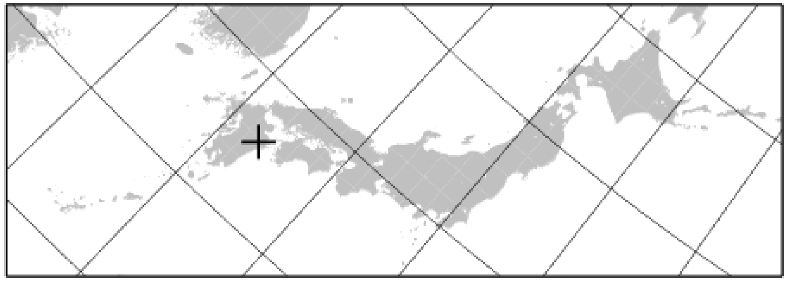


Averaged *Hs*: Future-Present

Rainfall evaluation for land slide (Total rainfall .VS. Max. hourly Rainfall)

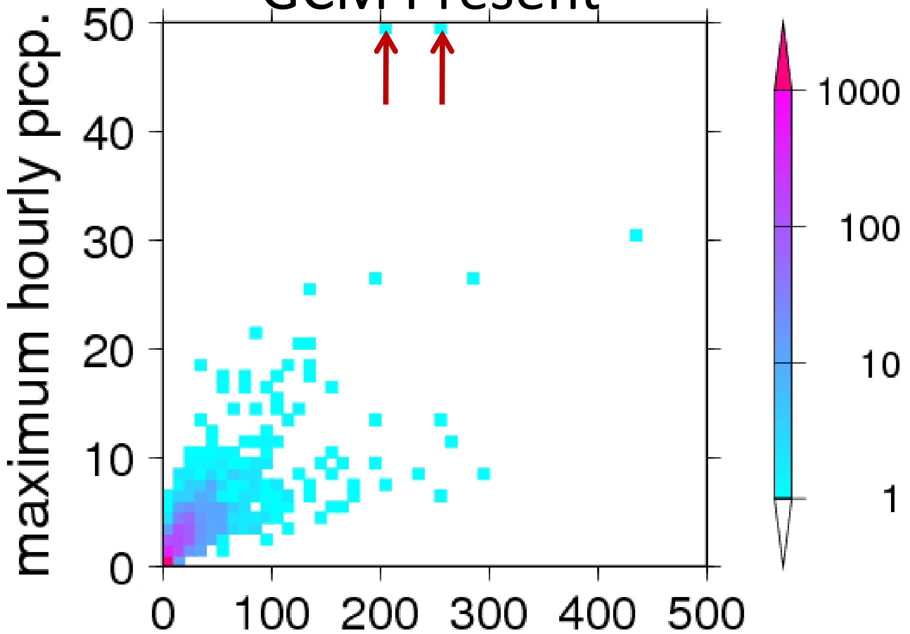


Observed relation

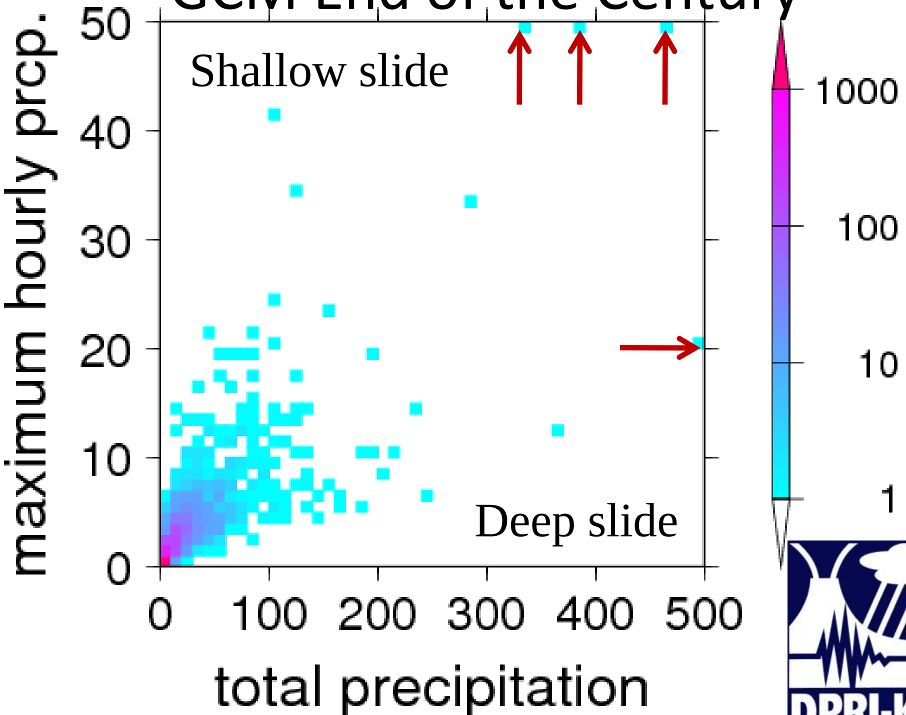


Related to Prof. Tsutsumi's presentation

GCM Present



GCM End of the Century



Oku et al., 2009, Kyoto Univesity

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4. IMPACT ASSESSMENT DIRECTLY RELATED ADAPTATION

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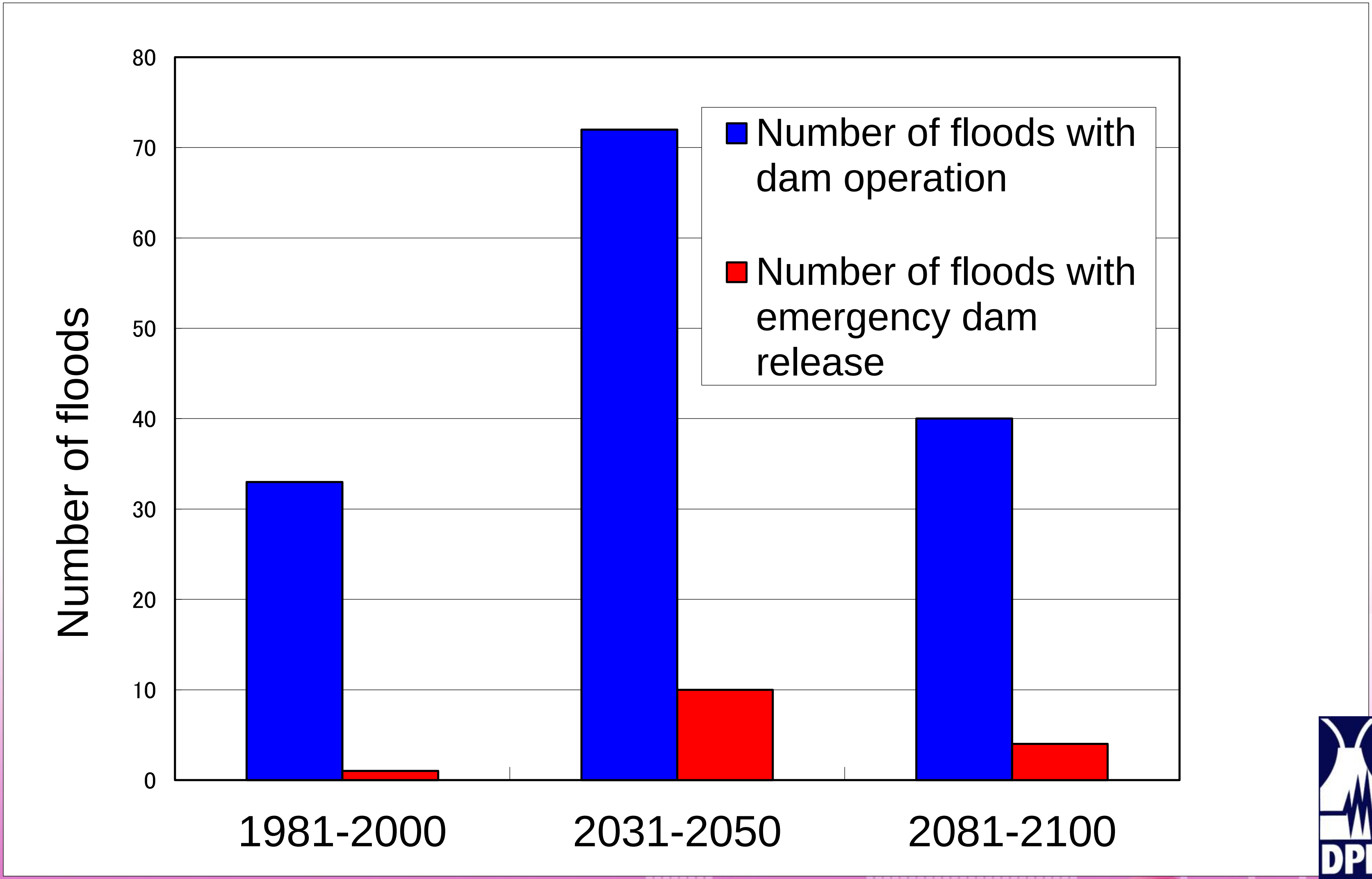
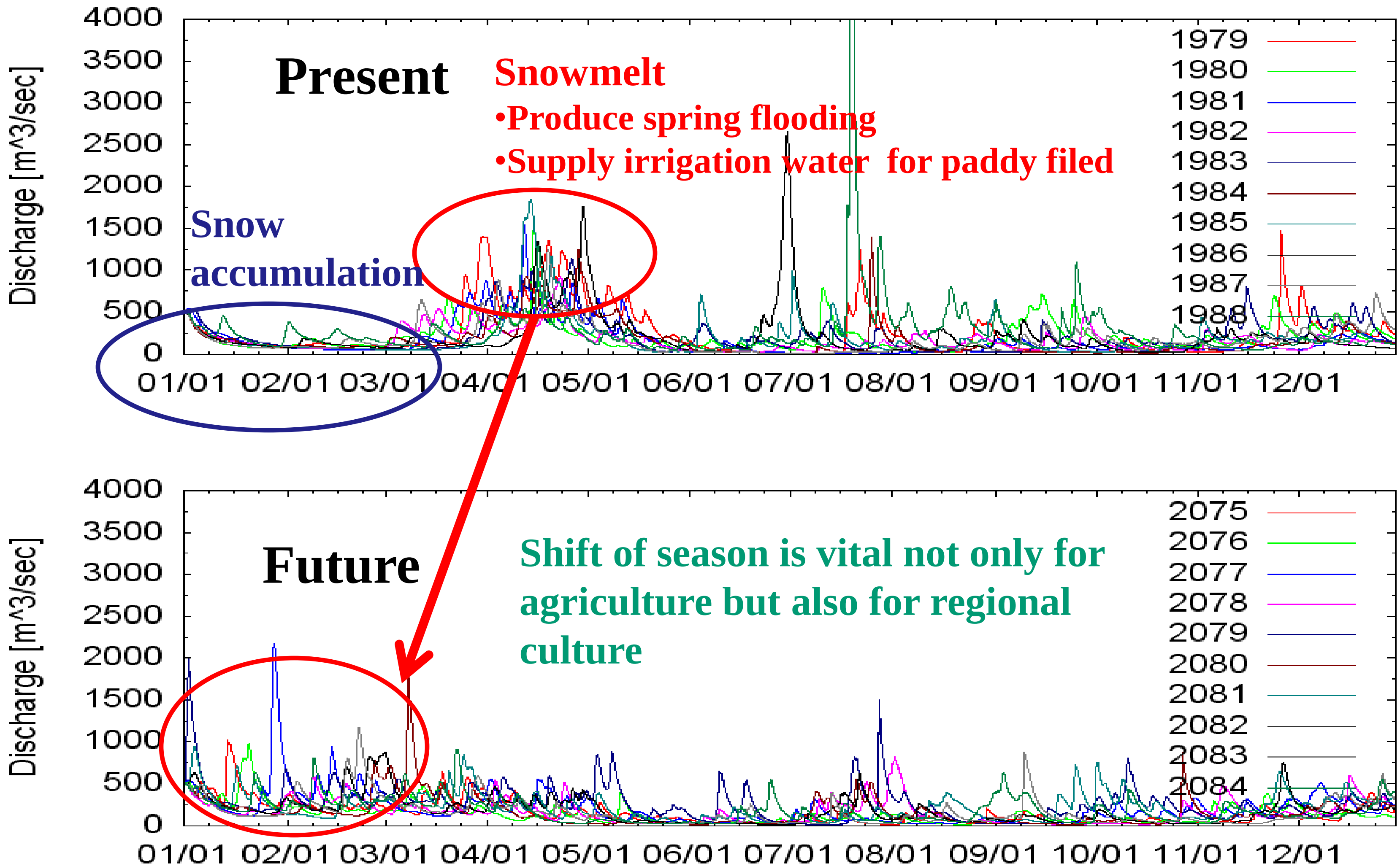
Possible changes in the number of floods requiring dam operation and emergency dam release (Yodo River)



Sayama et al. (2008), Kyoto University.

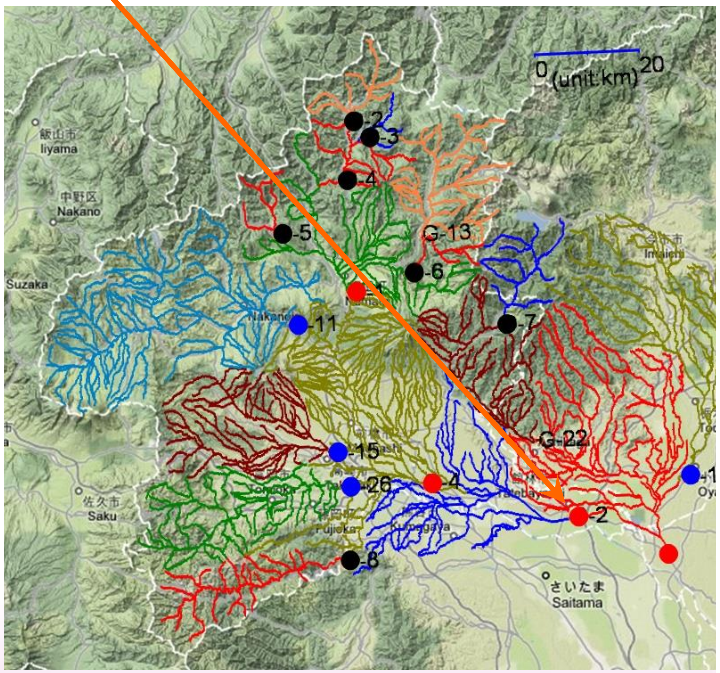
Influence of changing in snowfall and snow melt (Mogami River: Japan seaside in Tohoku)

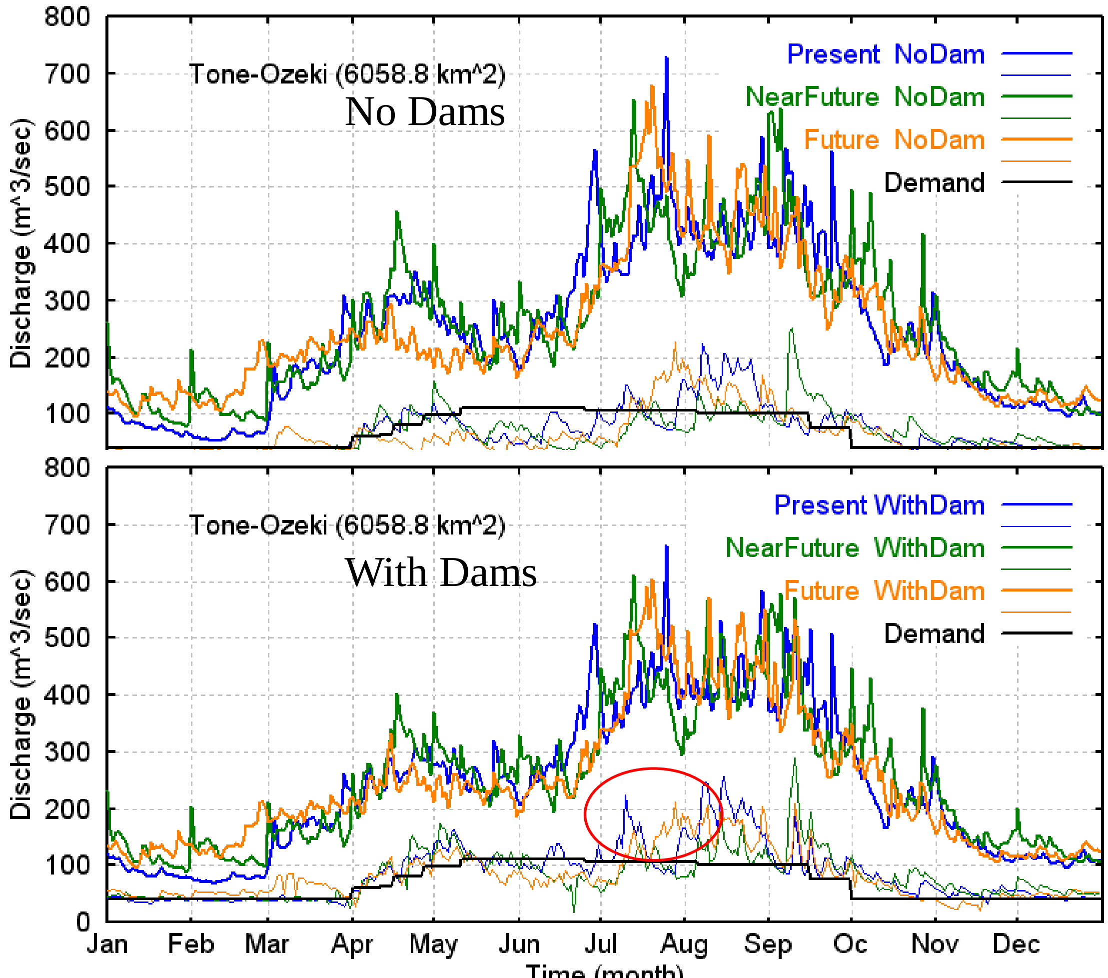


Tachikawa et al., 2080, Kyoto University

Will dam's network work in future?

Water Resources at Tone-Ozeki (6058.8 km2)





Water Demand

- Living water: 37.43 m^3/s
- Industrial water: 2.08 m^3/s
- Agricultural water:
  Apr~May 39.51 ~ 60.99 m^3/s
  May~Sep 111.62~186.71 m^3/s

Kim et al., 2010, Kyoto University

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5. SPATIAL SCALE IN WHICH AGCM20 OUTPUT CAN REPRODUCE RIVER REGIME

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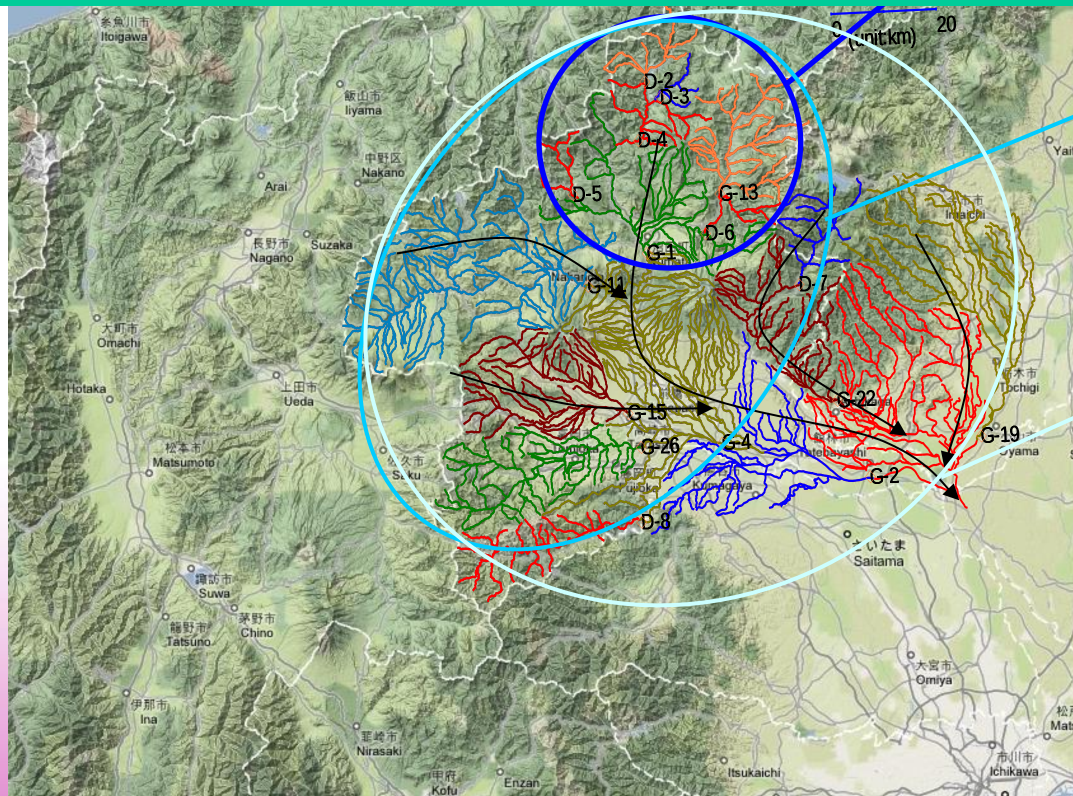
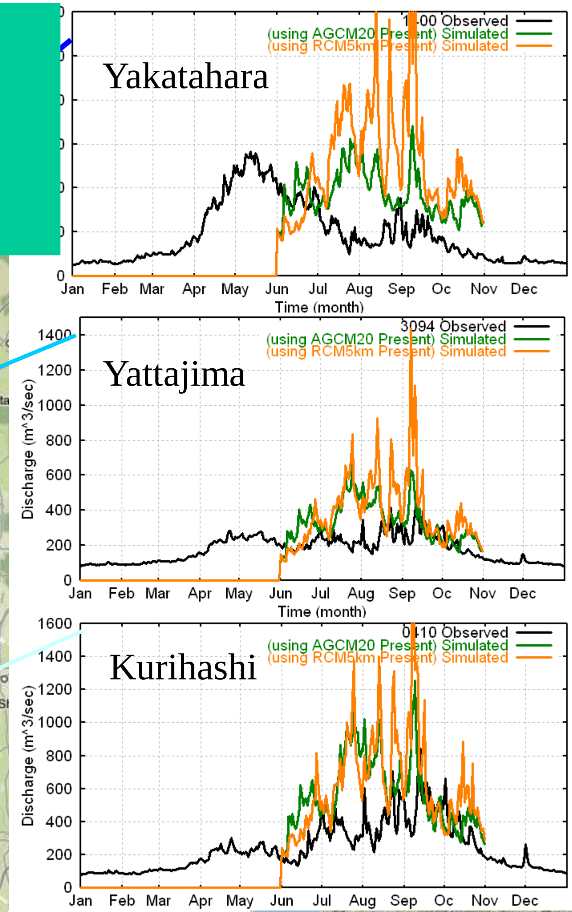
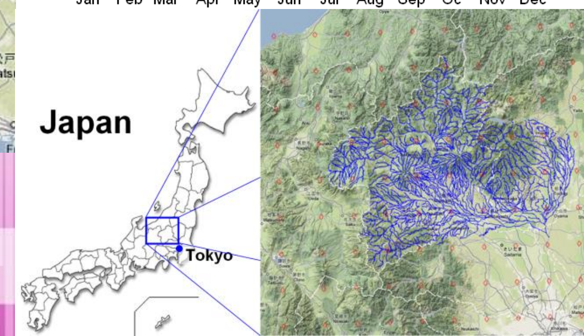
Rainfall-Runoff Simulation Results using AGCM20 (25 years average in current climate)

Reproducibility of 25 years-averaged discharge computed with AGCM20 approaches to observed one as basin scale becomes larger.







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Kim and Nakakita (2009), Kyoto University.

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6. SPATIAL SCALE IN WHICH THE CLIMATE CHANGE BECOMES STATISTICALLY SIGNIFICANT

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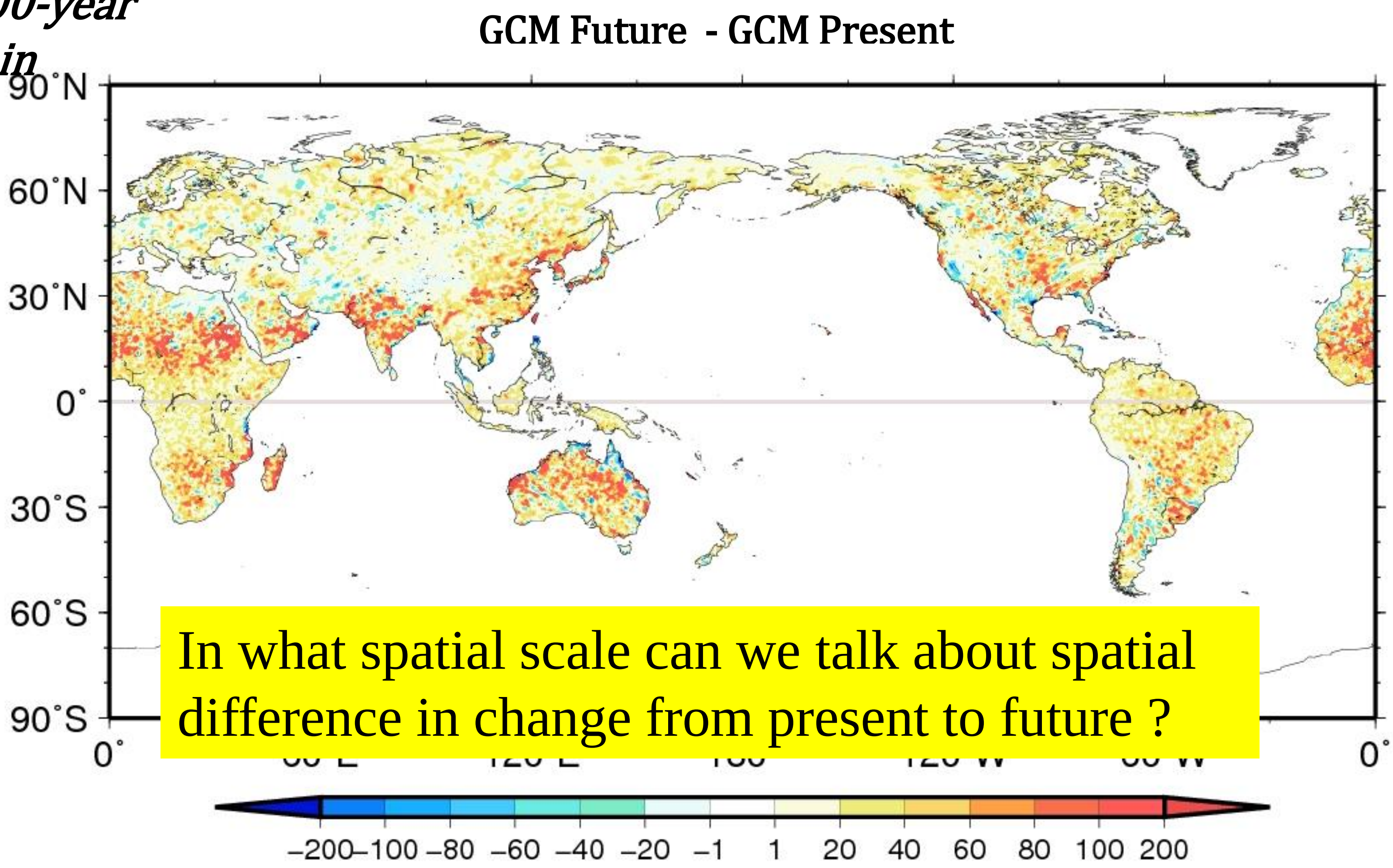
20km mesh → 100km scale

Future changes in 100-year annual max daily 20km averaged rainfall.

100-year rain



In what spatial scale can we talk about spatial difference in change from present to future ?

Konoshima and Nakakita (2009), Kyoto University.

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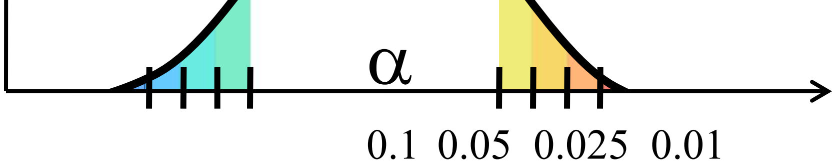
Statistical test on changes in max. value. (Future – Present)

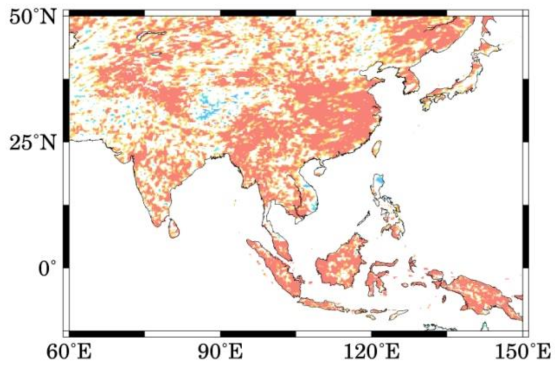


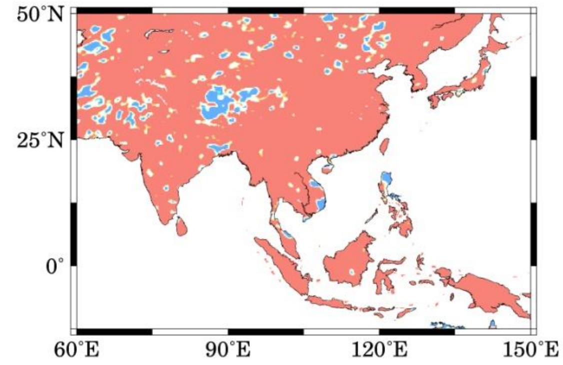
20km

100km

Flash Floods

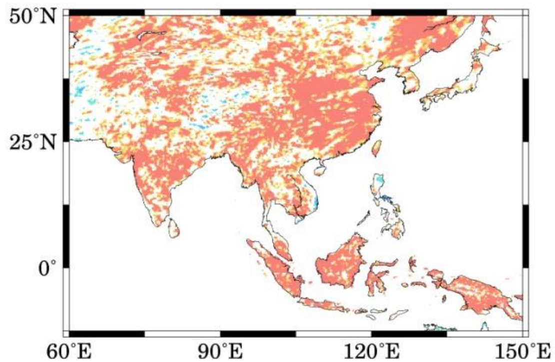
3 hours

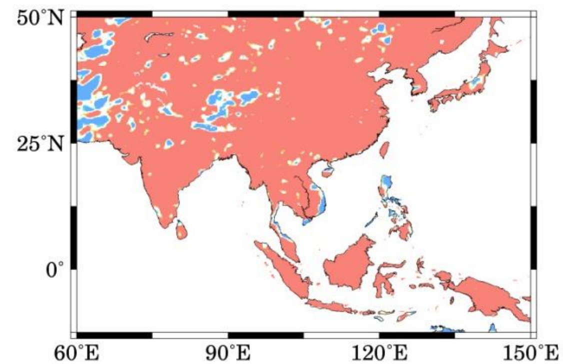




Short- rain Floods

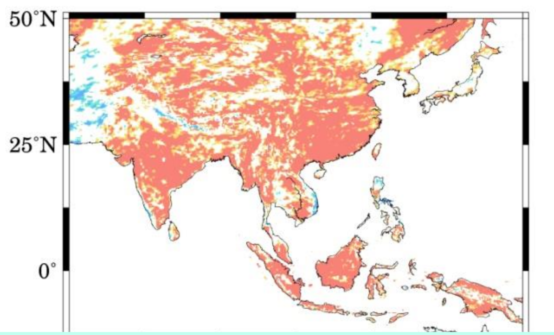
1 day

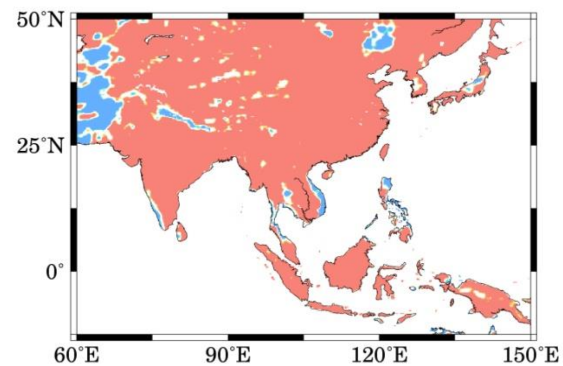




Long- rain Floods

15 days





Konoshima and Nakakita (2009), Kyoto University.

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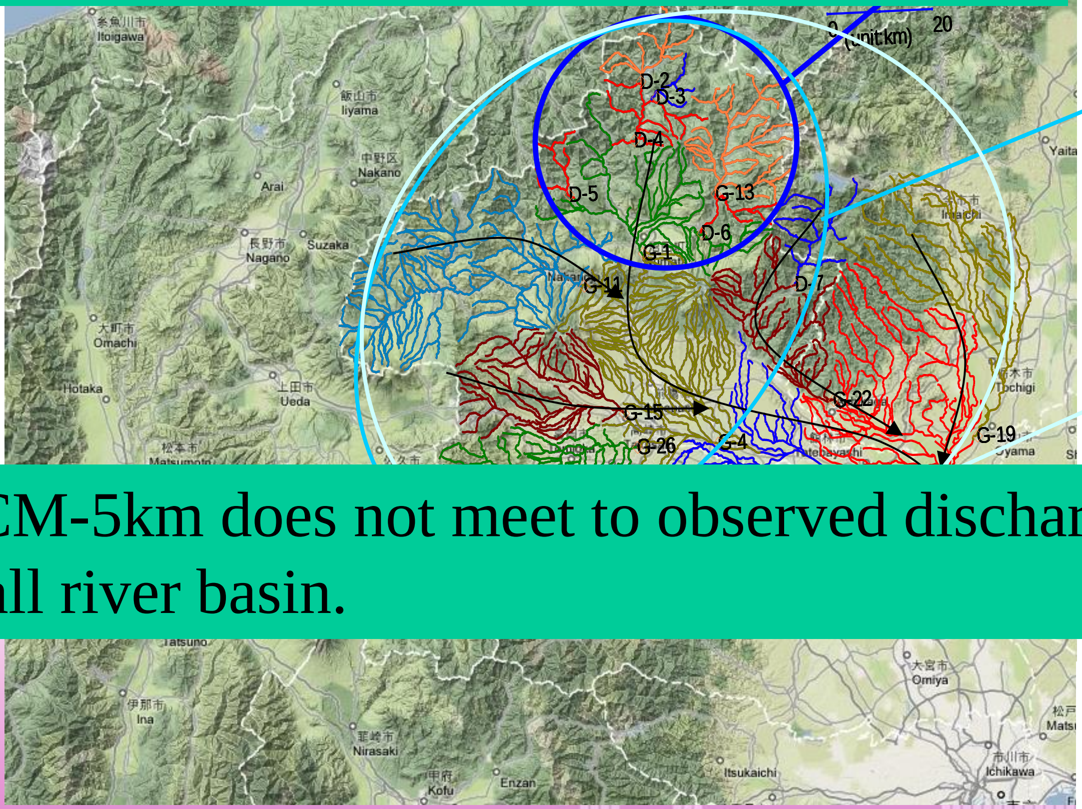
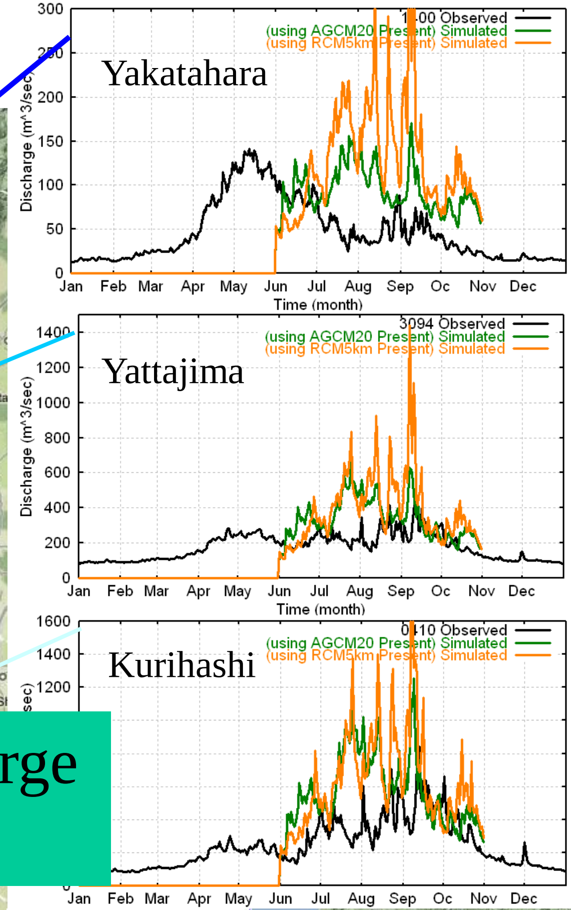
7. CAN RCM IMPROVE REPRODUCIBILITY RIVER REGIME IN SMALLER BASIN

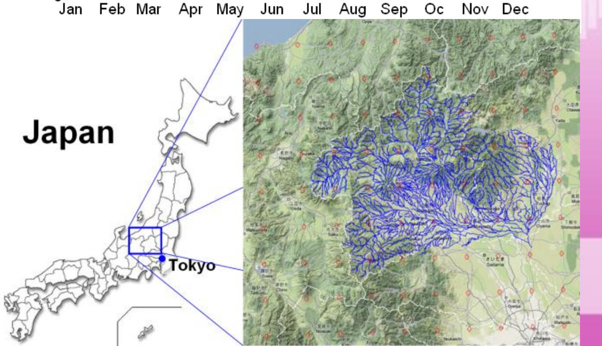
Rainfall-Runoff Simulation Results using AGCM20 vs. RCM-5km Output (25 years average in current climate)

Reproducibility of 25 years-averaged discharge computed with AGCM20 approaches to observed one as basin scale becomes larger.





Even RCM-5km does not meet to observed discharge in a small river basin.



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Kim and Nakakita (2009), Kyoto University.

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8. EXPECTATION FOR RCM

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Expectation for RCM (1)

- Expectation for RCM (1)
  - Current GCM20 outputs enable us to assess,
    - Drought due to rainfall deficit
    - Flooding due to typhoon and large-scale low pressure.
    - Change of in timing and position of Baiu/Meiyu front
  - With regard to flooding, the assessment may be limited to those of 'national river scale' including large-scale inundation.
  - Small-scale catchment, landslide, inland inundation may be affected more easily by localized storm under Baiu/Maiu front. Is it possible to evaluate them with RCM?

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Expectation for RCM (2)

- Expectation for RCM (2)
  - Computation of more extreme event
    - by sharper vortex and convergence of wind
    - by orographic enhancement
  - Identification of climatic division by large-scale but narrow mountainous terrain
    - Difference of monthly or annual rainfall between both sides of the narrow chain of mountains
    - Regionalization of snowfall area and non-snowfall area due to winter monsoon
    - These are very important in water resources management.
  - Can RCM enable us to find the change of future with higher resolution?

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9. HEADING TO ADAPTATION

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Heading to building up adaptation scenario

- Planning with design level and risk management
  - Basic planning of river improvement has been based on the design level (return value).
  - The probability rainfall of climate change induced condition may involves uncertainty.
    - We cannot predict the change of statistical properties exactly.
  - Risk management will has more important meaning.
    - However, single simulated time series for 25-30 years may not include the extreme hazard corresponding to risk management.

Super Typhoon by Dynamic DS

Will super typhoon come more frequently?

Heading to building up adaptation scenario

1. Increasing of ensemble number
   - Random ensemble with single model .VS. Multi-model?
   - Random ensemble with single model
     - to improve the worst scenario
     - to improve the accuracy of return value
   - Multi-model ensemble
     - to improve worst scenario
     - to improve the accuracy of return value (?)
2. The most extreme scenario by the pseudo global warming (PGW) experiment with RCM
3. The most Extreme scenario by bogus [Typhoon]

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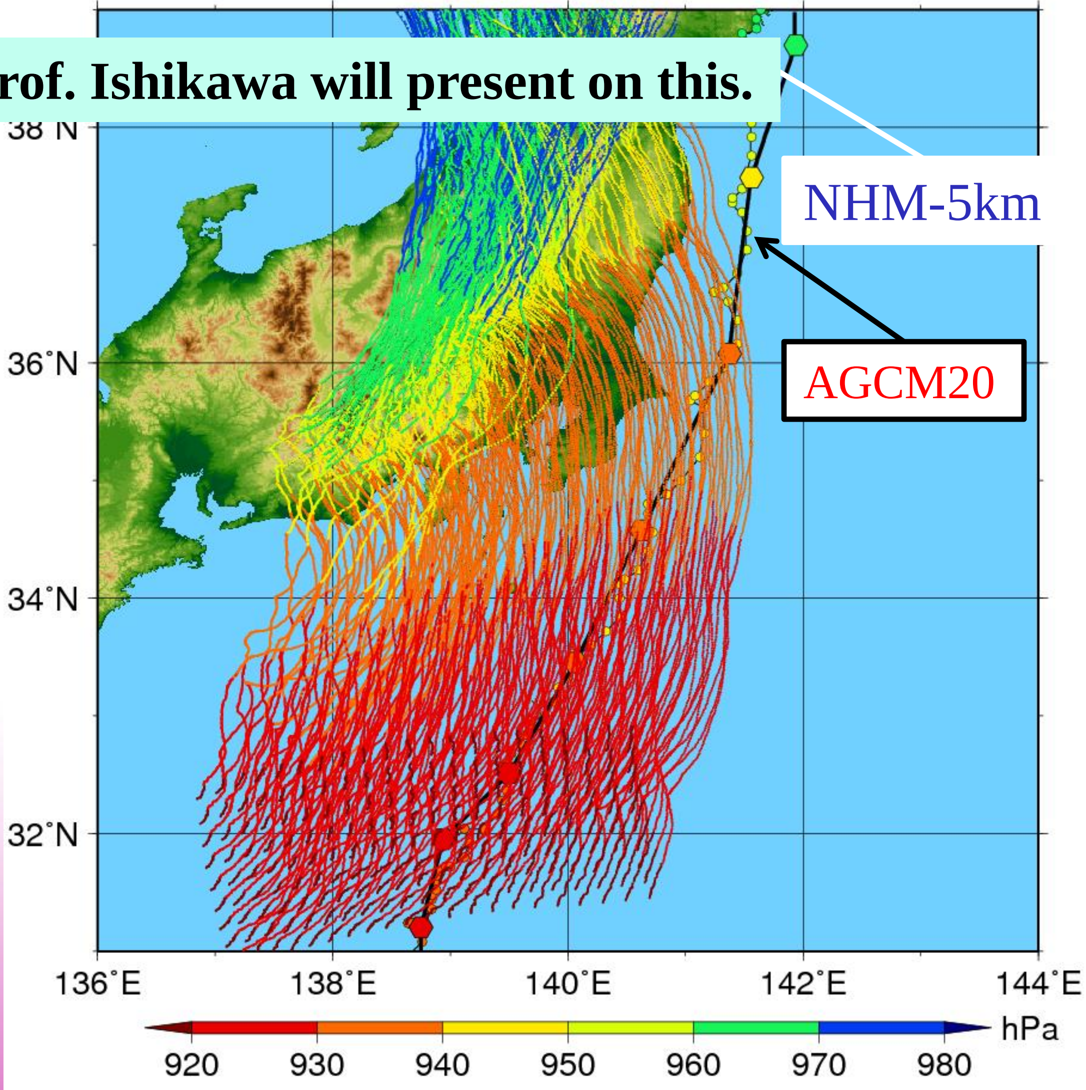
Virtual Shifting of typhoon's initial position - for making the worst scenario -

Prof. Ishikawa will present on this.



Virtual Shifting of typhoons initial position by keeping potential vorticity same

(a vorgas method)

Dynamic downscale by RCM

Worst case impact assessment on

- Land : extreme wind and rainfall
- Ocean : storm surge and wave height

Ishikawa et. al, 2009, Kyoto University

10. SUMMARY

Summary (1)

1. GCM and RCM with the super-high spatio-temporal resolutions (20 km-1 hour) makes it possible to evaluate extreme hazard (ex. Max. discharge).

2. However, this does not mean that we can evaluate the changes in such a high spatial resolution.

3. We can get approximate projection on changes in return value of extreme events. However, there is a risk that the return period does not have enough accuracy.

Summary (2)

4. On the other hand, the risk management deal with phenomena beyond design hazards. In this sense, it is very important to take into account the result from the worst case scenario as a one of the forcing for risk management on climate change.

5. Taking into consideration above items, I think, it is very important for climate change adaptation to discriminate more between planning with uncertain design level and risk management with the worst case scenario.