Importance of thinking worst case senario in the climate impact assessment on disaster environment

Eiichi Nakakita and DPRI's Kakushin Group
Disaster Prevention Research Institute, Kyoto University

Outline

- Impact of AGCM20 on extreme events climate impact assessment in Japan
- Typical climate change assessment on disaster environment in Japan – projection of change in design value
- Heading to adaptation :importance of taking a worst case scenario into consideration

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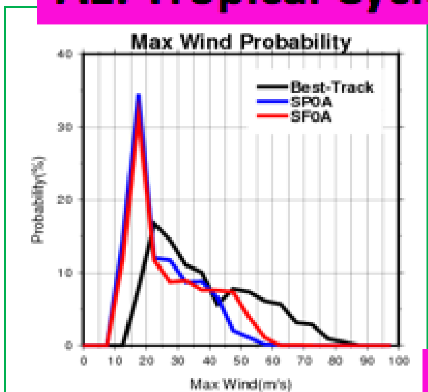
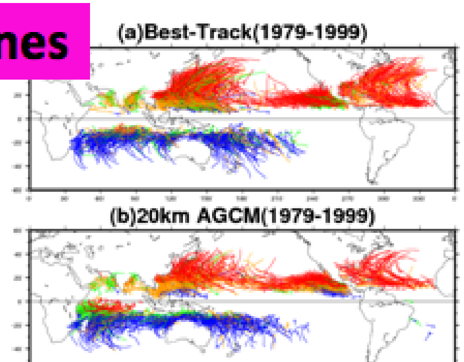
Projection of the Change in Weather Extremes Using Super-High-Resolution Atmospheric Models in the KAKUSHIN Program

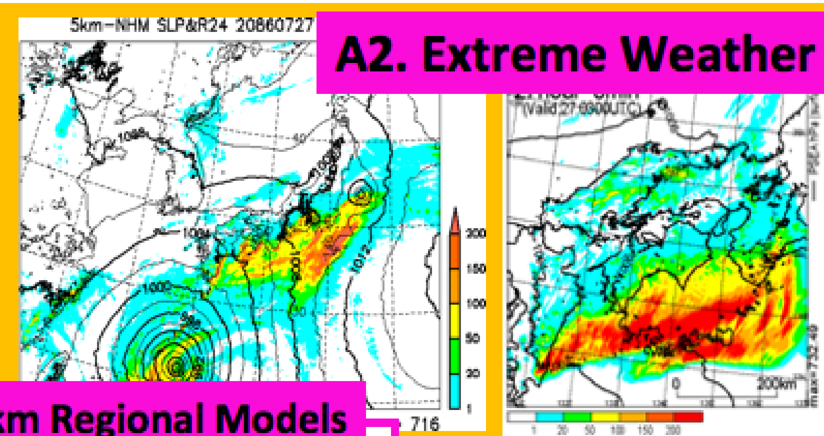
Akio Kitoh (MRI/JMA), **Shoji Kusunoki** (MRI/JMA), **Eiichi Nakakita** (DPRI/Kyoto-Univ.), **Kuniyoshi Takeuchi** (ICHARM/PWRI)

A1. Tropical Cyclones

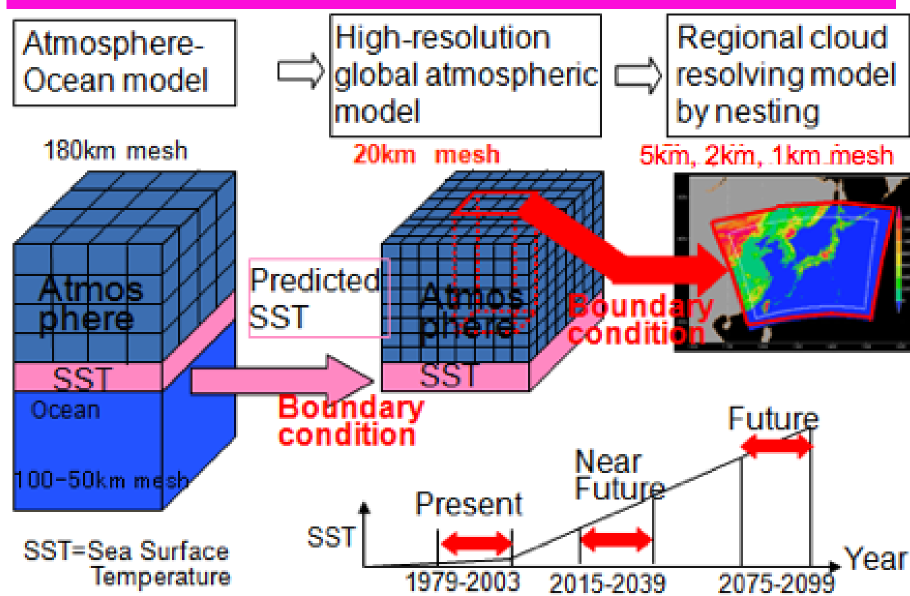




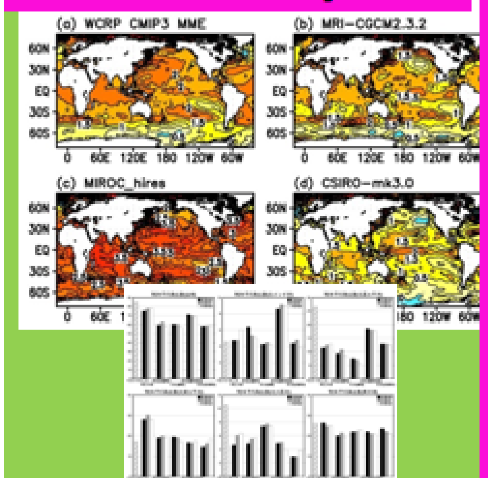
A2. Extreme Weather



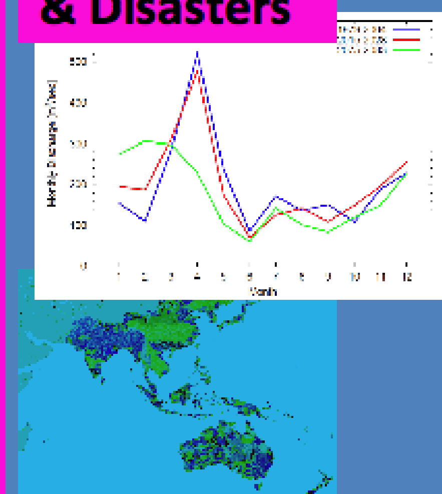
20km Global and 1-, 2- & 5-km Regional Models



B. Uncertainty



C. Flood & Disasters



Points in climate change assessment on Japanese hazard

- There are various types of hazards that bring disasters.
- Spacio-temporal information with high resolution is required for representing reasonable extreme river discharge in Japan.

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Minimum Target of DPRI

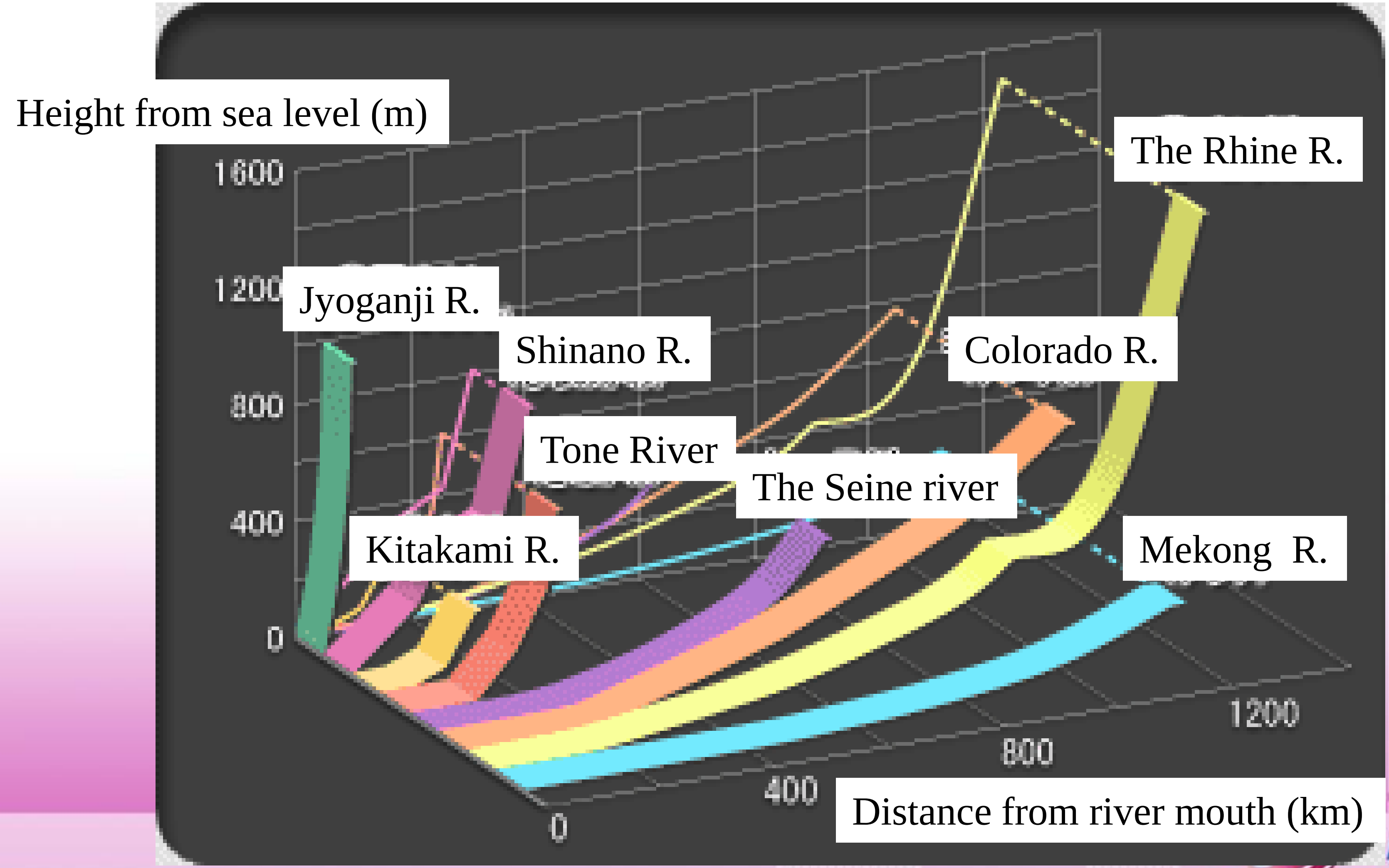
- Precipitation (Monsoon Asia)
- Land slide and Debris flow
  Mainly western Japan
- River discharge
  Japanese major large river basins (with fine resolution)
  All Japanese river basins (with medium resolution)
- Storm surge and wave
  Tokyo, Ise (Nagaya) and Osaka Bays, Global
- Damage by strong wind
  Whole Japanese archipelago
- Inundation
  Some major cities

Points in climate change assessment on Japanese hazard

- There are various types of hazards that bring disasters.
- Spacio-temporal information with high resolution is required for representing reasonable extreme river discharge in Japan.

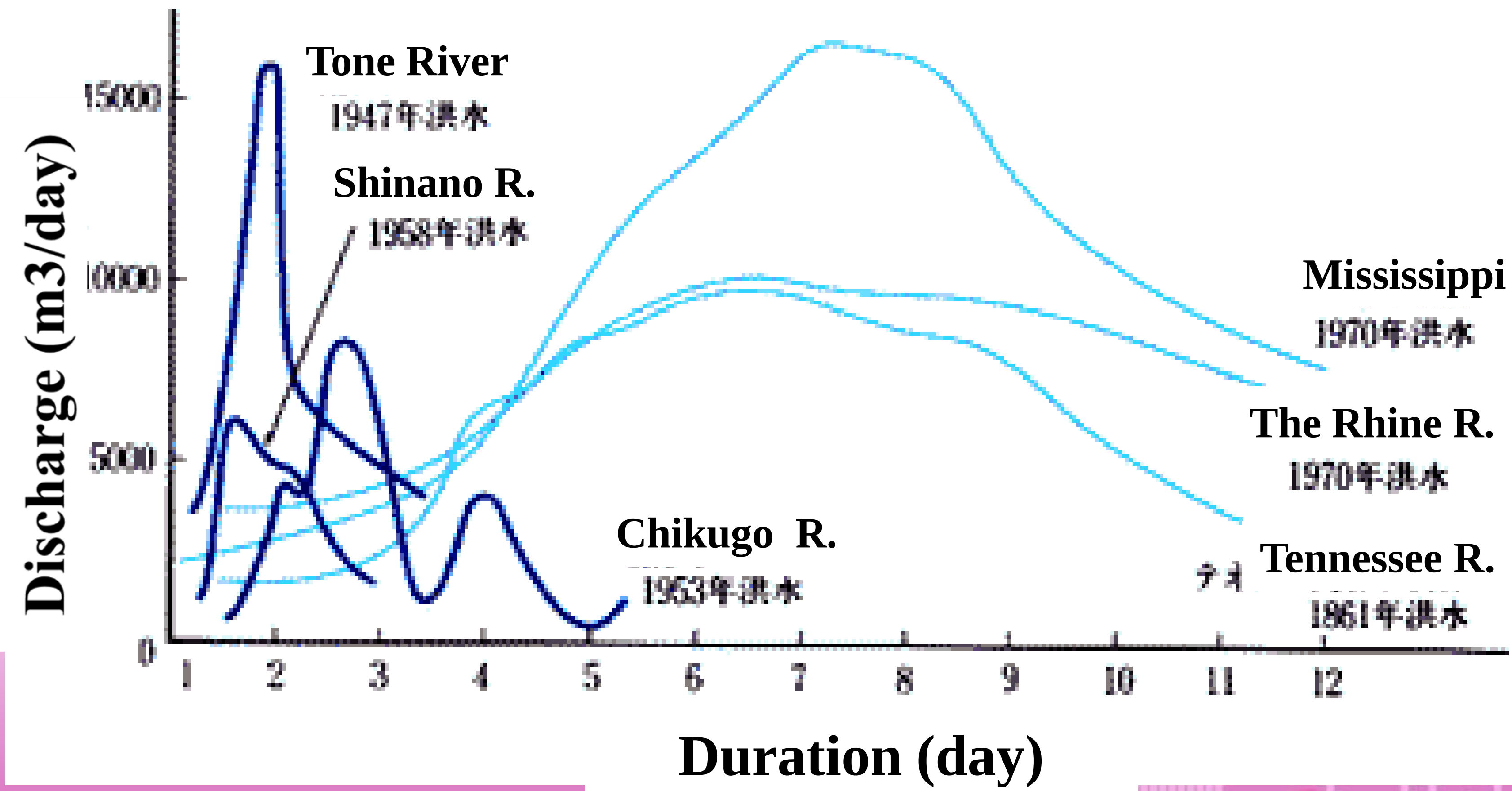
Features of Japanese River(1)

- Short length and steep slope.

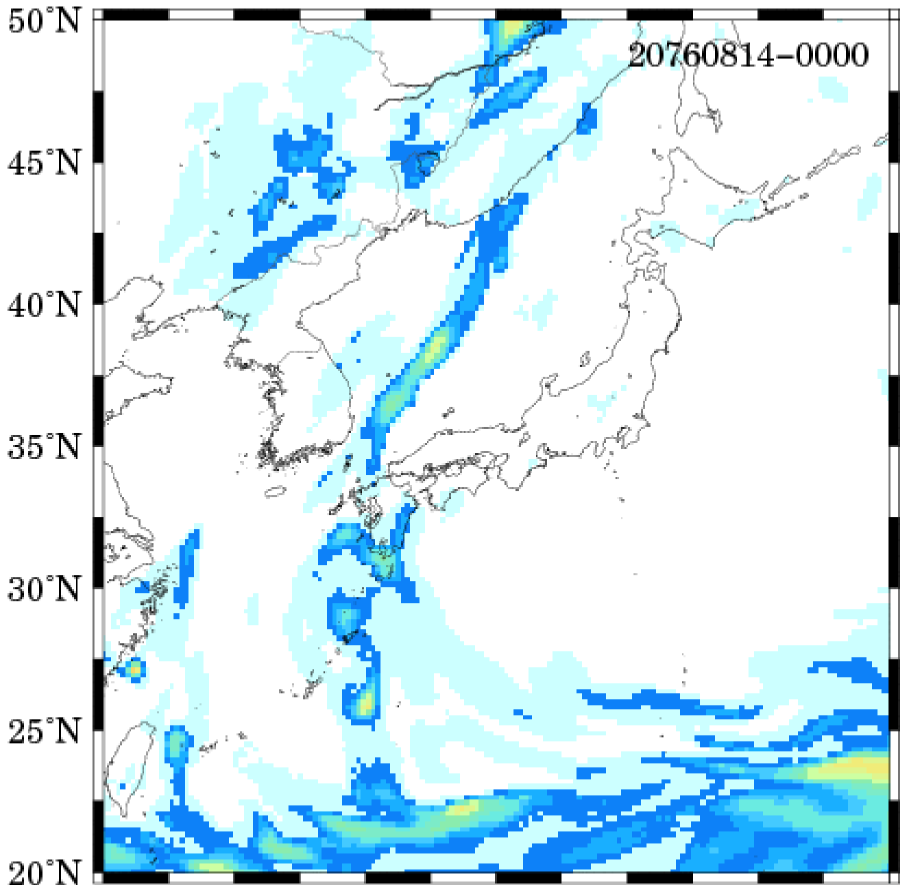


Features of Japanese River(2)

- Large peak discharge, short duration

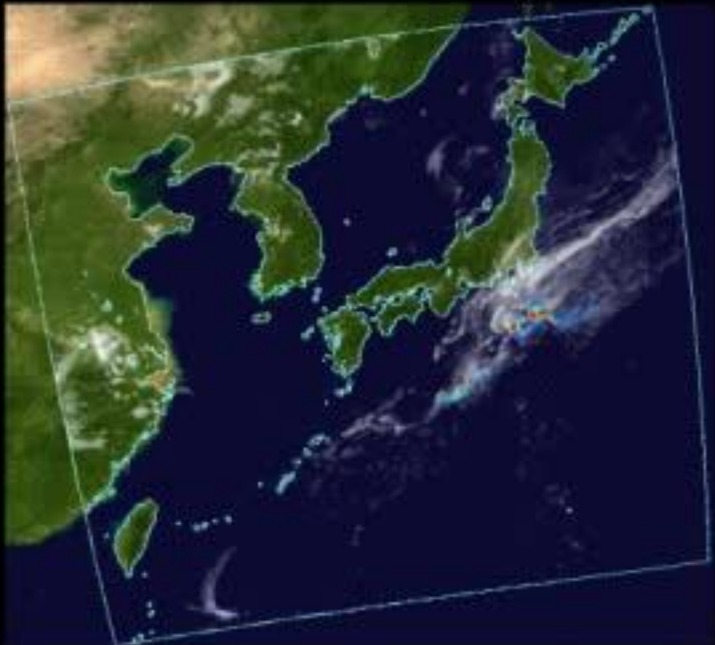


Projected typhoon by GCM20



It is the typhoon resolving output from GCM20 that has realized the impact assessment on Japanese river regime

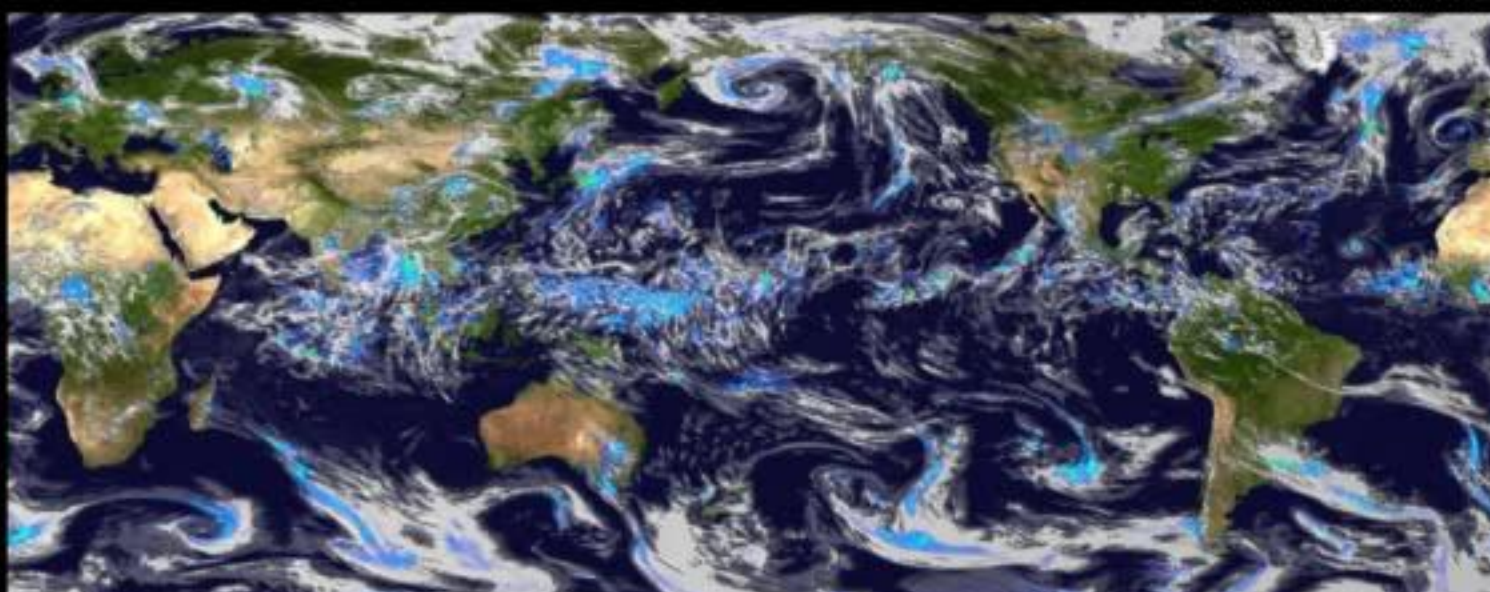
5km Regional Model



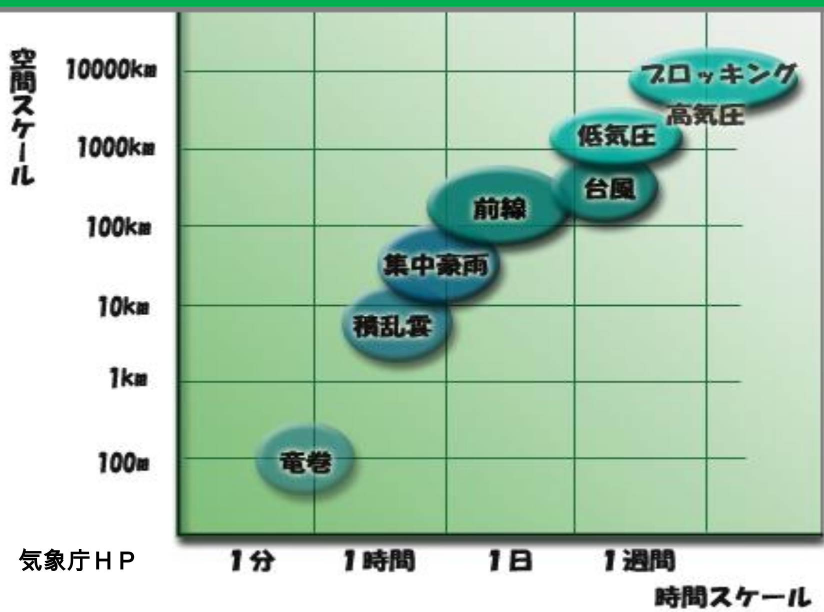
2km Regional Model

20 km Global Model

05 Sep
208X
00 UTC



Spacio-temporal scale

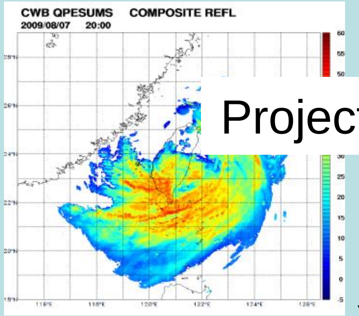


気象庁ＨＰ

Typhoon

Range：1000km
Duration： 1 day to a few days

大河川での洪水、大規模水害、土砂災害
2009/08/08 in台湾



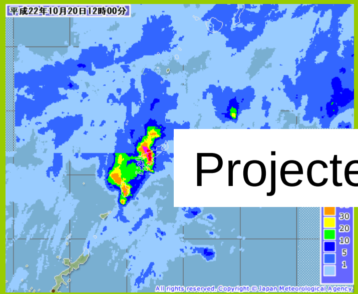
Projected by AGCM20

台湾中央気象局、台湾国家災害防救科技中心

Localized heavy rainfall (Baiu season)

Range：100km
Duration：6 hours to half a day

中・小河川での洪水、内水氾濫、土砂災害
2010/10/20　in奄美



Projected by RCM

南日本新聞　OFFICIAL SITE

Shower

Range：10 km
Duration：about half an hour

小河川や下水道内での鉄砲水、都市内水氾濫
2008/07/28 at都賀川　　2008/08/05 at雑司ヶ谷

Impossible?

都賀川モニタリング映像

共同通信

Prediction and evaluation of disaster environment in Japan

DPRI / Kyoto-Univ.

Slope | Mountains | River | Habitable Area | Coastal Area

Output from GCM and RCM

Hourly precipitation, temperature, water vapor, wind velocity, radiation and air pressure
(25-years time series (20km) and ensemble predictions (60km) for current, near future and century end)

Regional climate model (RCM_5km, RCM_2km, RCM_1km)

Interpretation of output

Surface hydrological model

Stochastic typhoon model

Probability density function of extreme value (depending on spacio-temporal scales)
Stochastic precipitation model (time series depending on spacio-temporal scales)

Various Models (with long-term run)

Soil production

Reservoir operation

Soil runoff

Sedimentation and transportation of soil

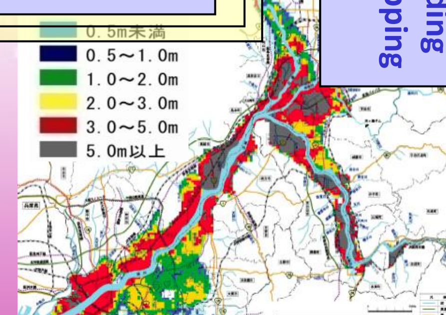
Rainfall runoff

River channel flow

Inundation including underground shopping mole

Building damage by strong wind

Storm surge



Evaluation

Decreasing of safety against landslide, debris flow, flood, draught, storm surge and strong wind .
Assessment of current protection system and proposal of alternatives

DPRI-KU

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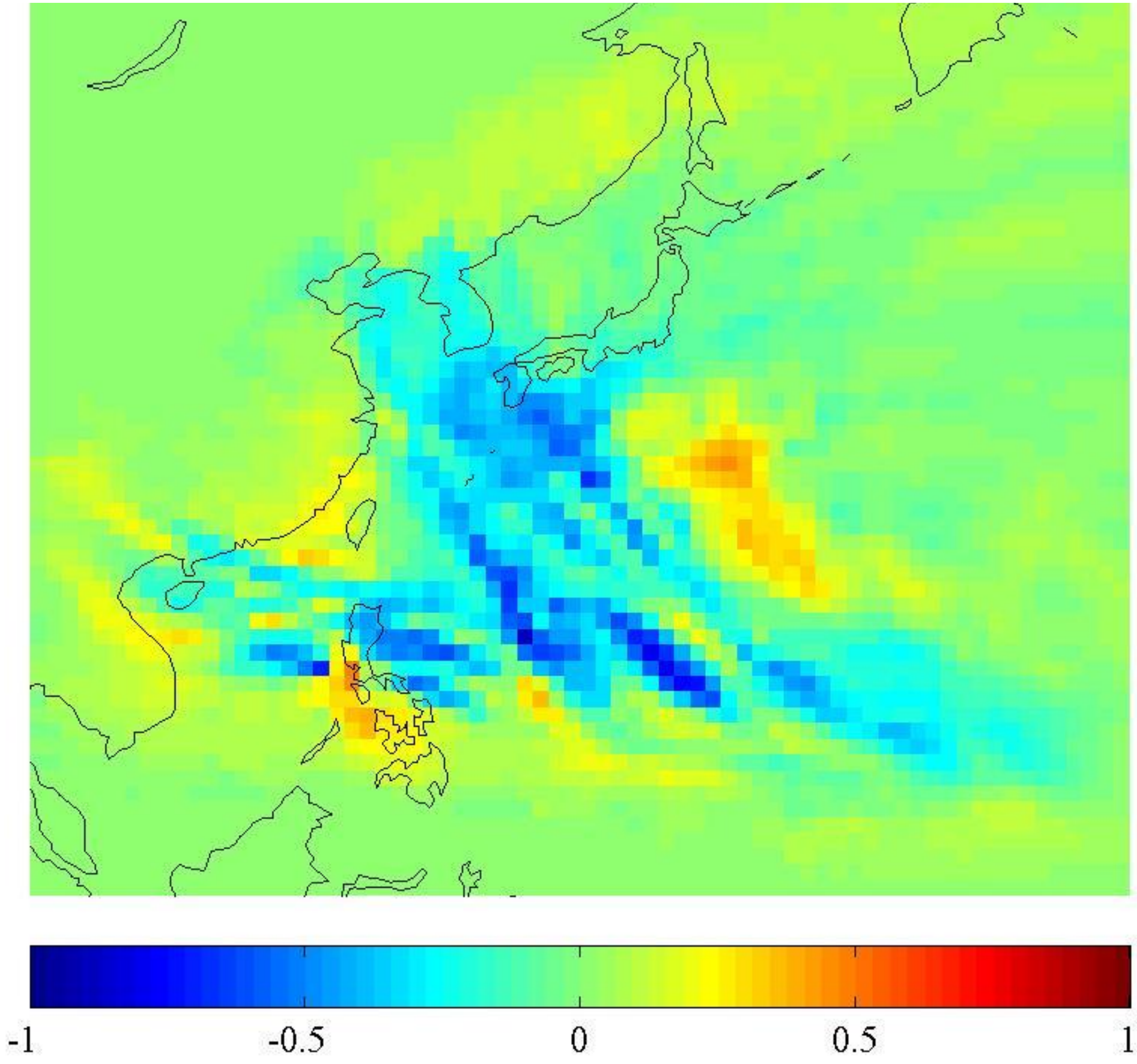
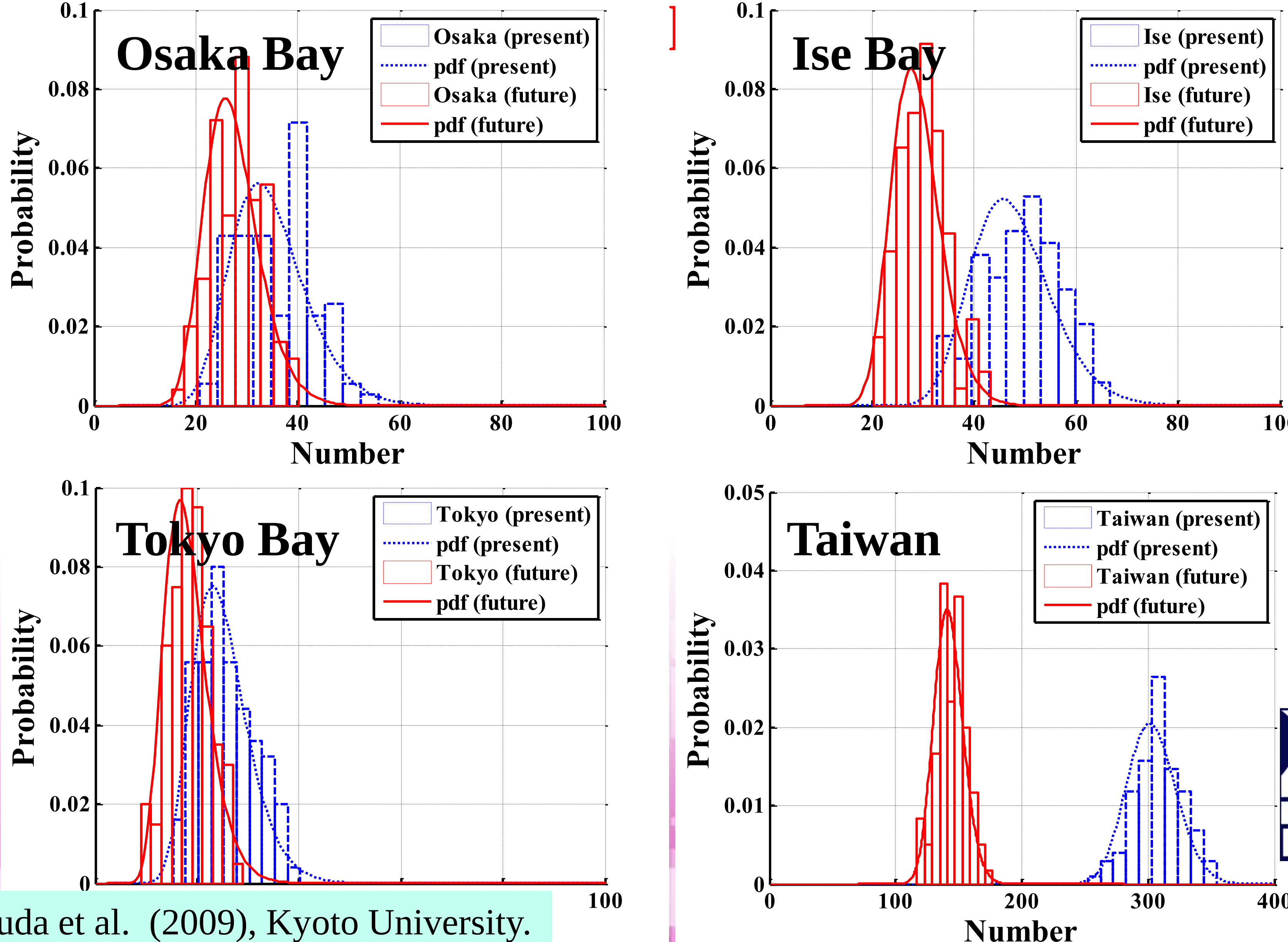
Stochastic typhoon model



Typhoon Numbers/yr: Present - Future

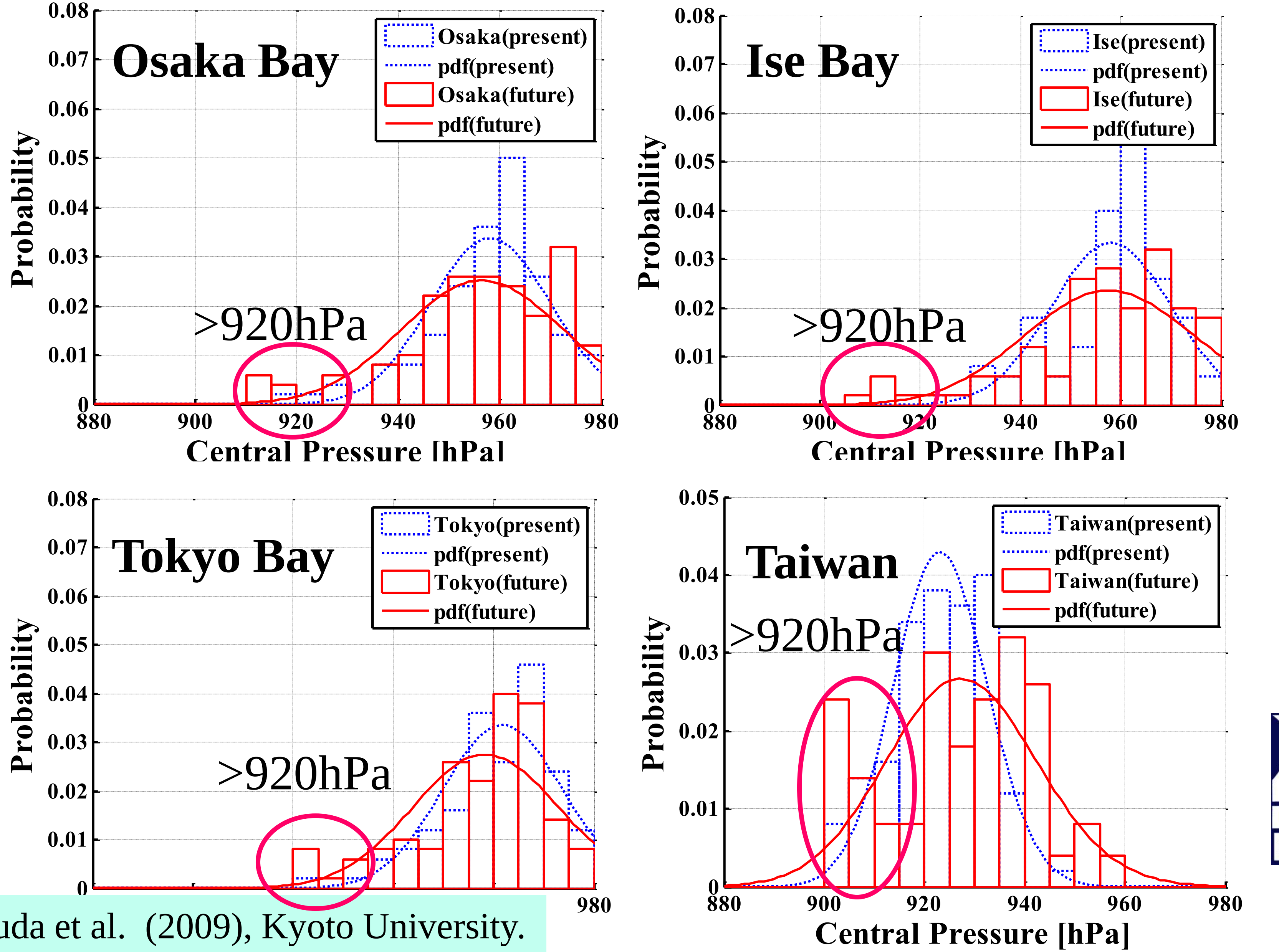
Yasuda et al (2009)

Probability of typhoon attack for 100yrs



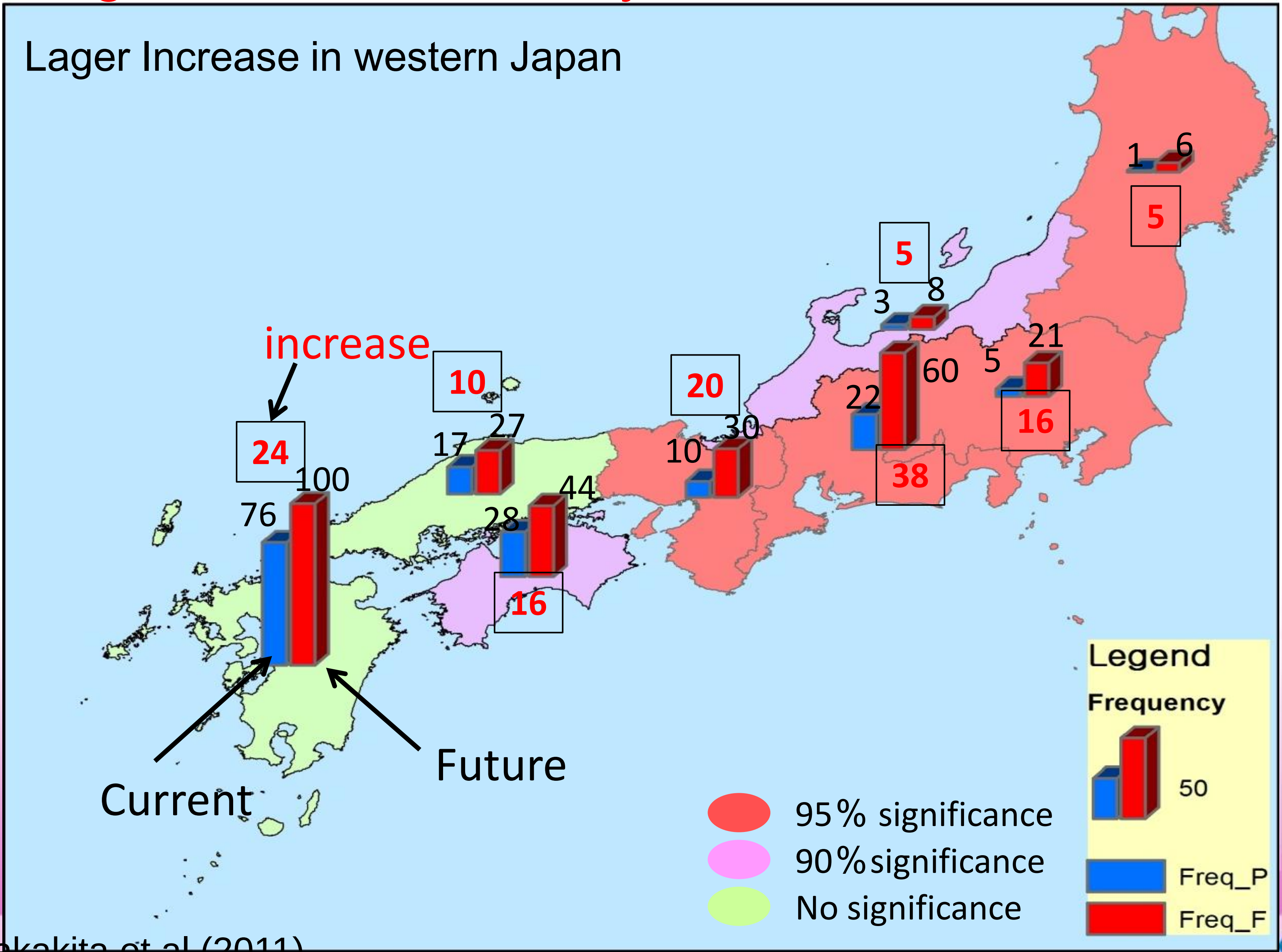
Yasuda et al. (2009), Kyoto University.

Probability of center pressure for 100yrs



Yasuda et al. (2009), Kyoto University.

Increase in Number of localized heavy rainfall during Baiu season in 25 years



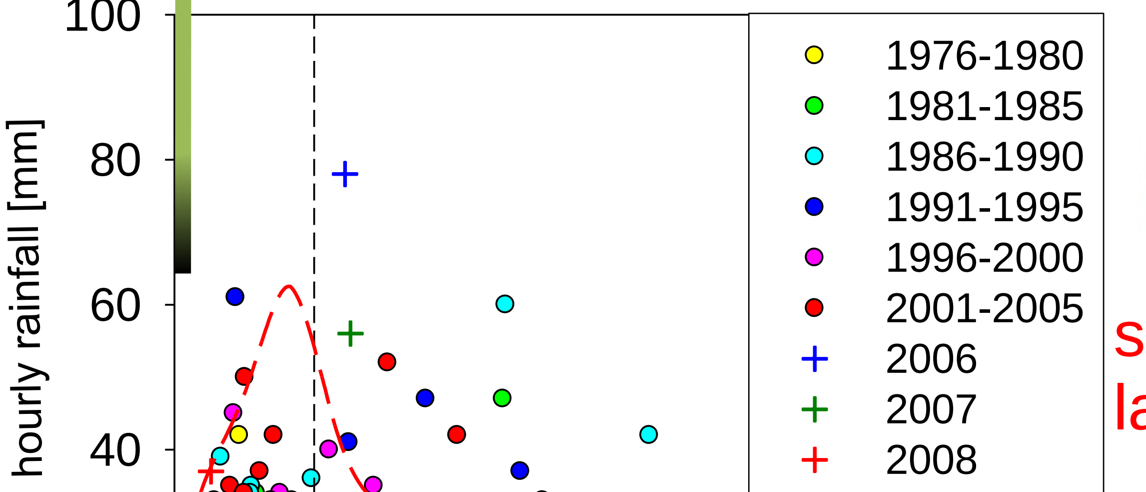
Nakakita et al (2011)

Impact Assessment on Land slides

-Total rainfall versus maximum hourly rainfall-

risk of
shallow landslide

Top 20 data of total rainfall and maximum hourly rainfall from Takeda City, Oita, Japan



shallow landslide

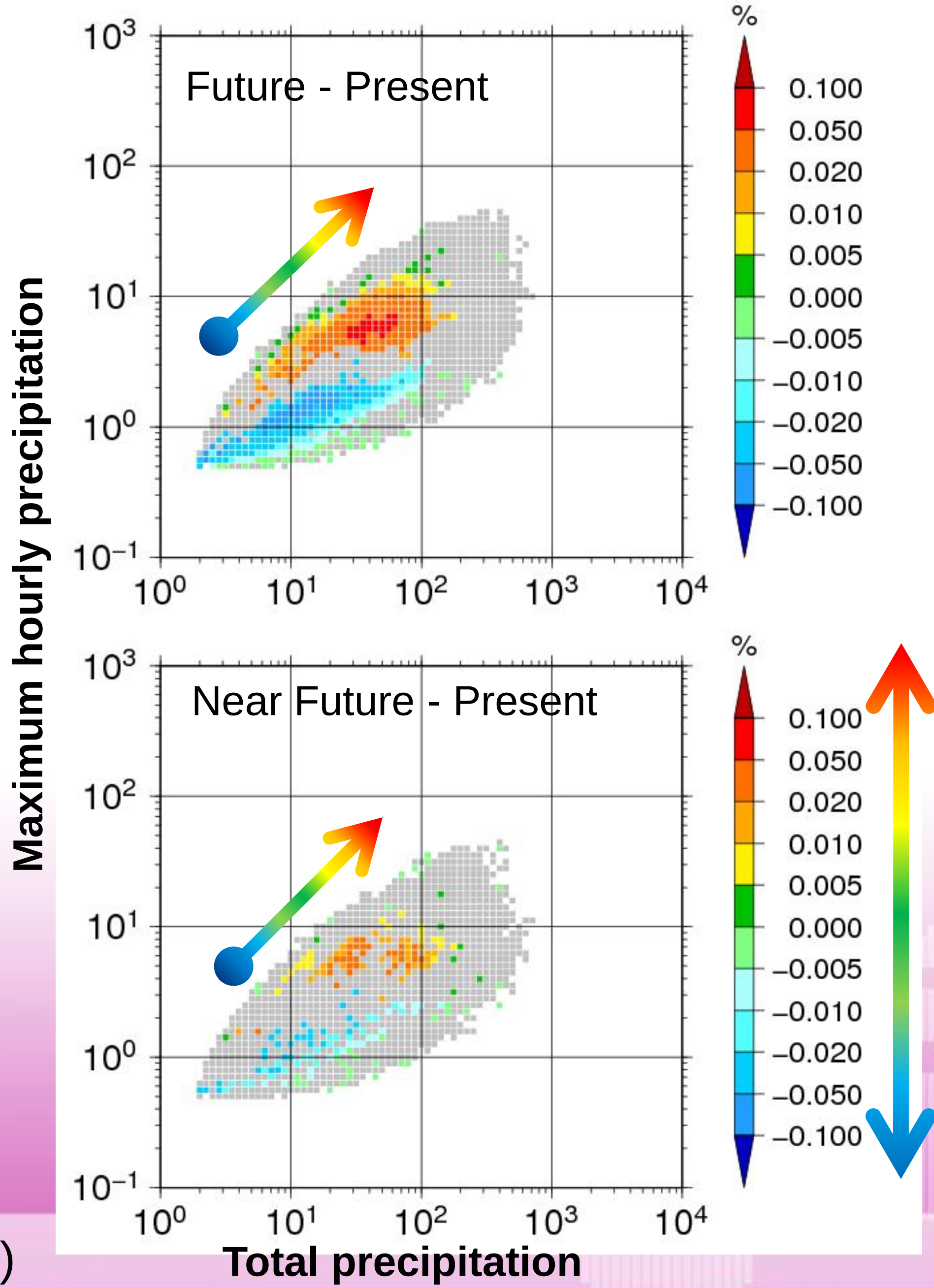
deep landslide

Schematic from PWRI Report No.4129 (2009)

risk of
deep landslide

Oku et al (2011)

Projected changes in total and maximum hourly rainfall in Japan



Color: 95% significance based on 60-km model ensemble experiments

Increase of strong and large rainfall

↓

Increase of both the shallow and deep landslide risk

Oku et al (2011)

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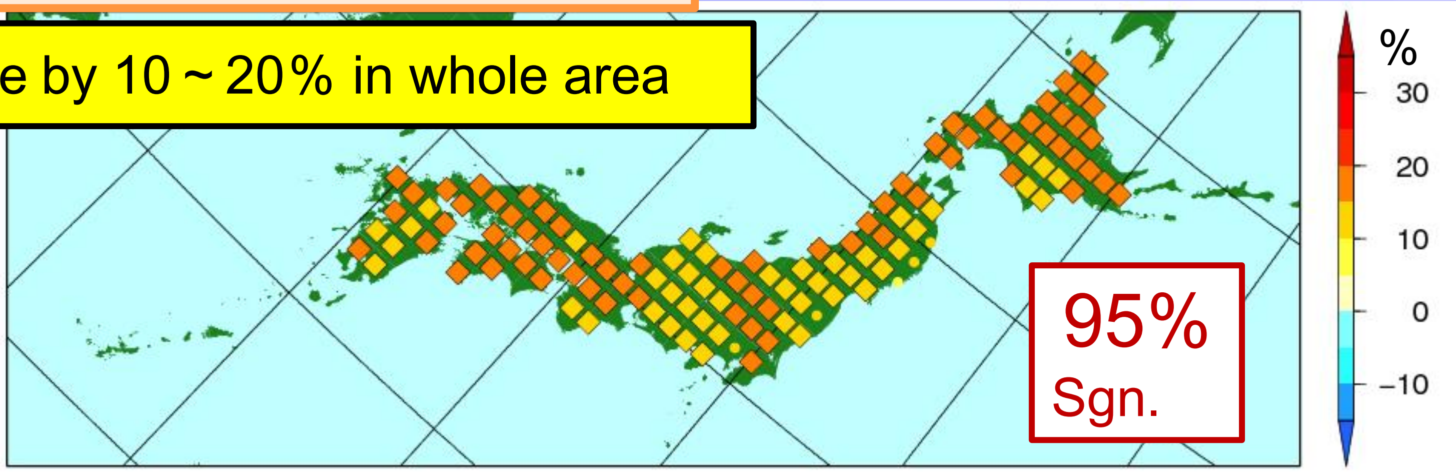
Increase in land slide risk

Fut. - Pres.

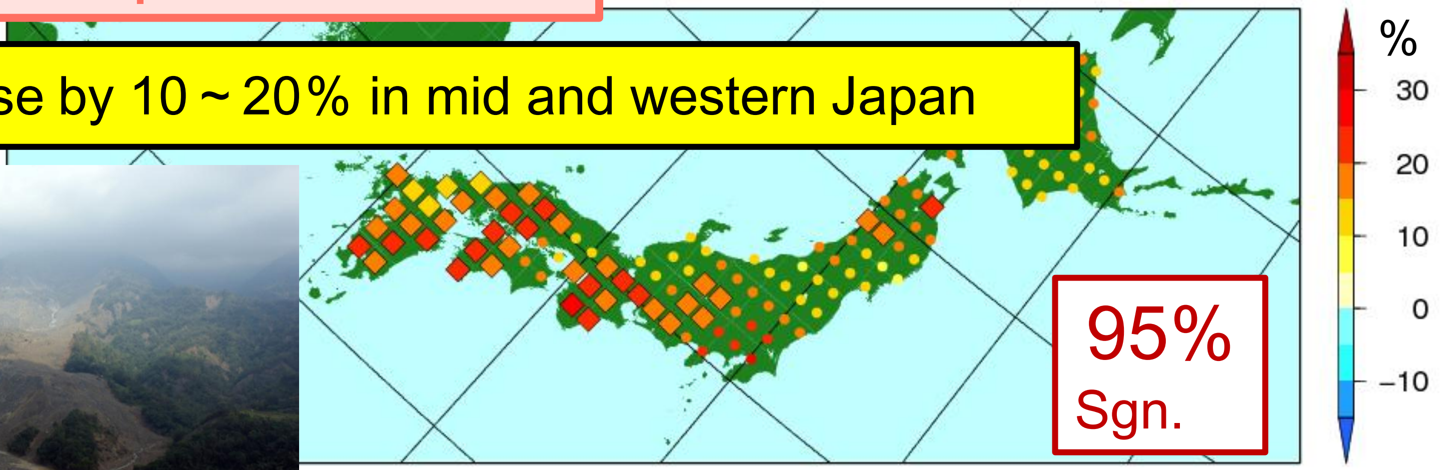
Risk of shallow land slide

Increase by 10～20% in whole area



Risk of deep land slide

Increase by 10～20% in mid and western Japan



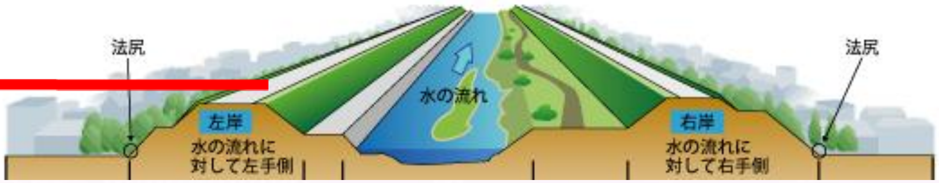
Oku et al (2011)

Design value

River discharge
Storm surge

Design value
(Return period)

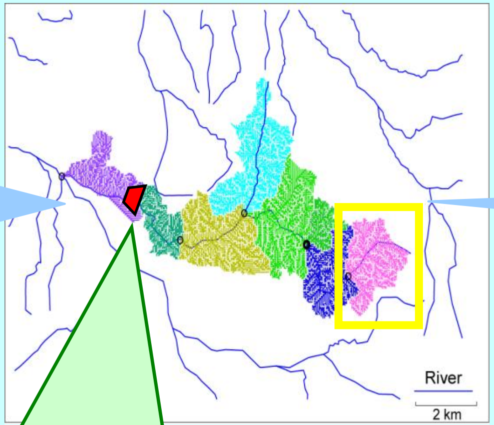
Range for disaster <u>Mitigation</u>

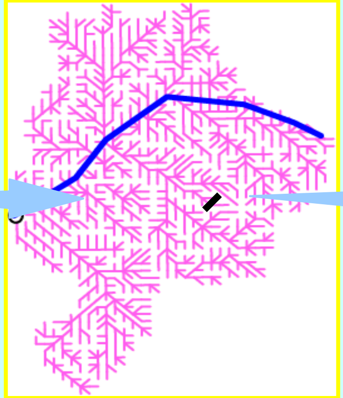


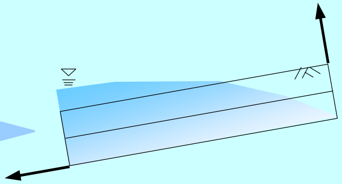
Range for disaster <u>Prevention</u>

Introducing reservoir operation models into distributed runoff model

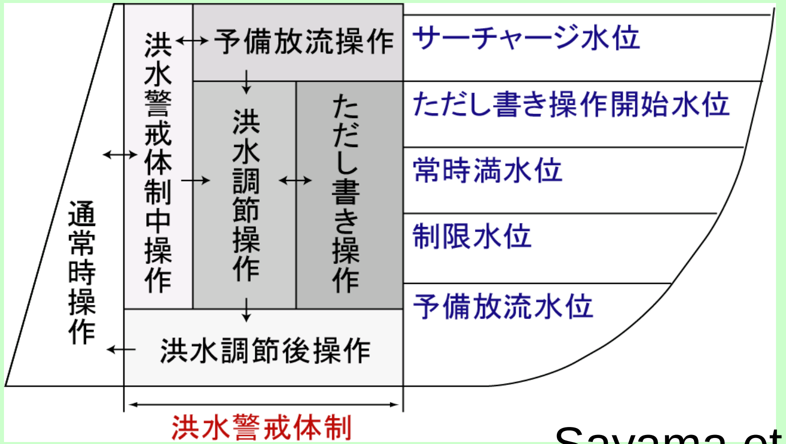
System of distributed runoff model



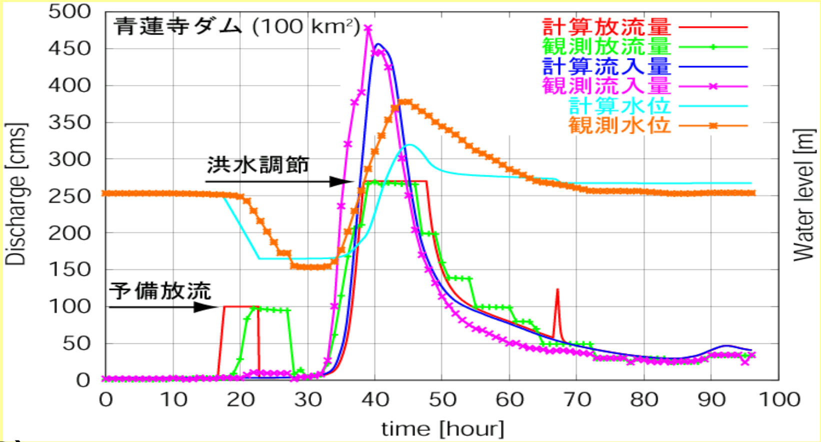




Reservoir operation model



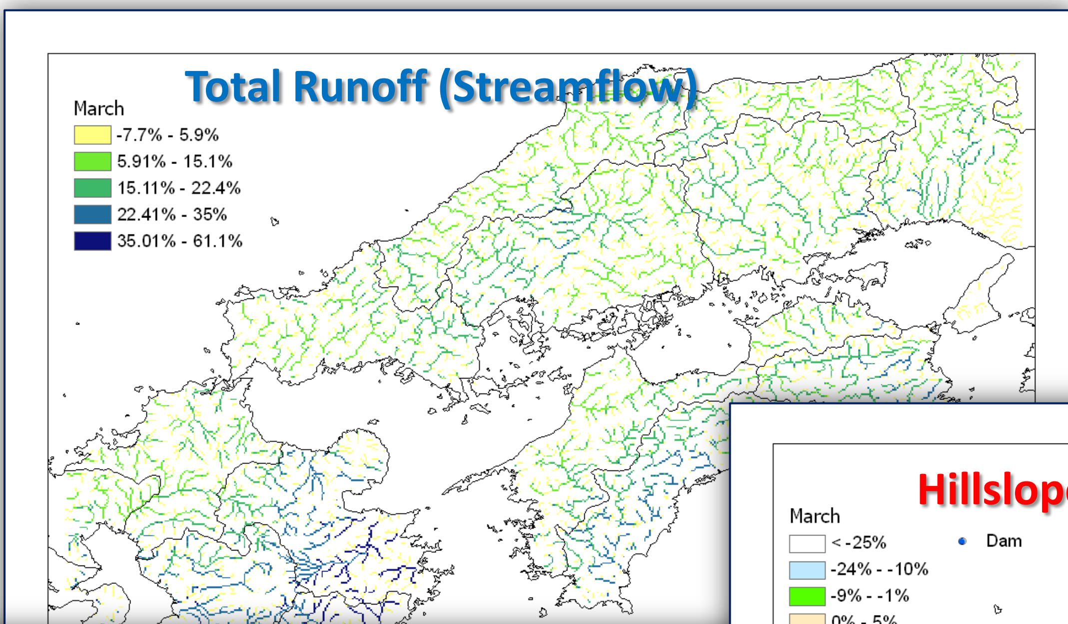
Example of combined computation

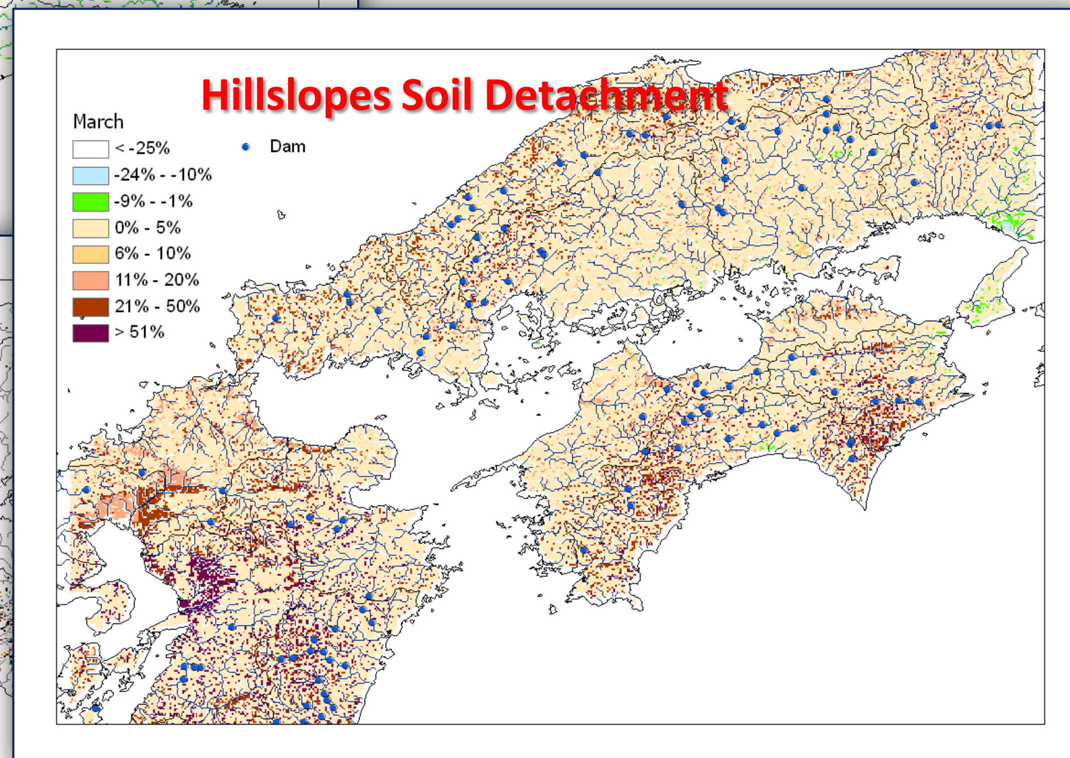


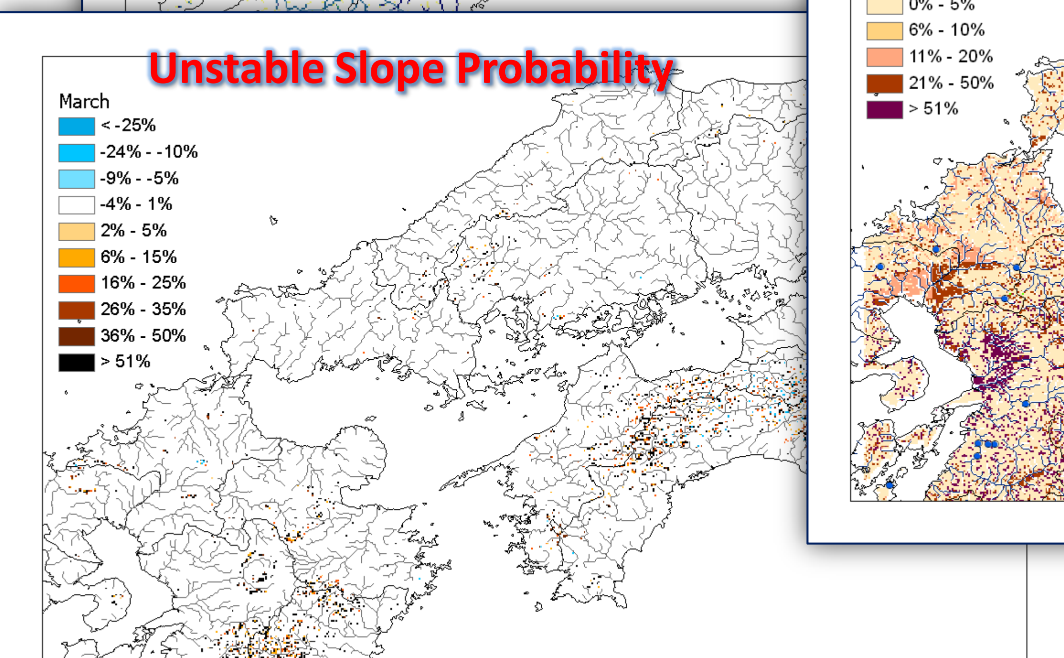
Sayama et al (2008)

Change of the Percentage Difference of the Mean Monthly Streamflow Discharge, Soil Detachment and Unstable Slope Probability in the Future Climate Condition with Respect to the Present Climate Condition

(March-October, in animation)



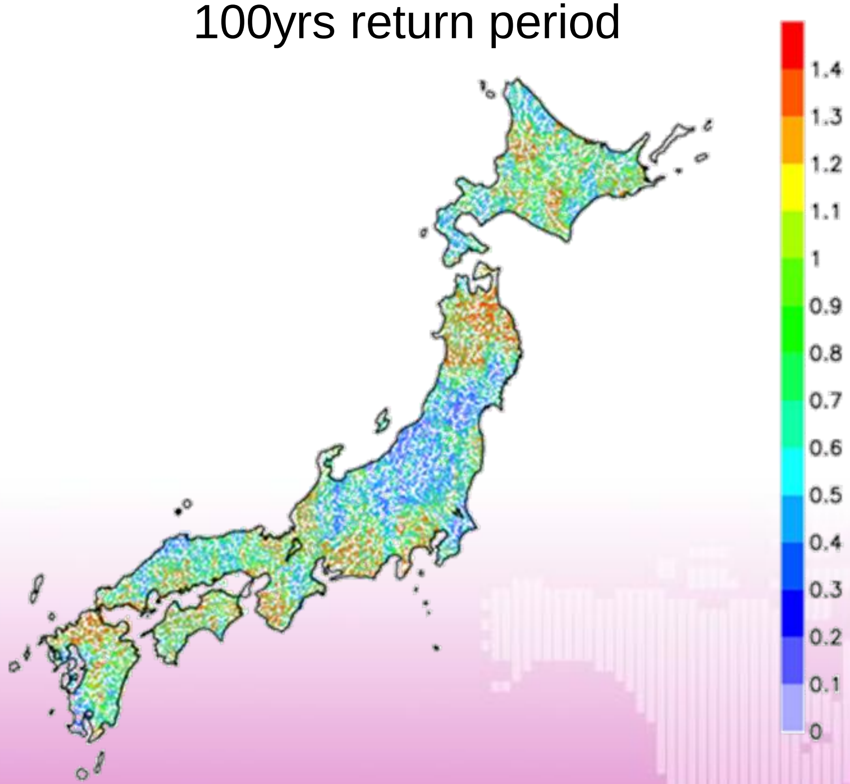




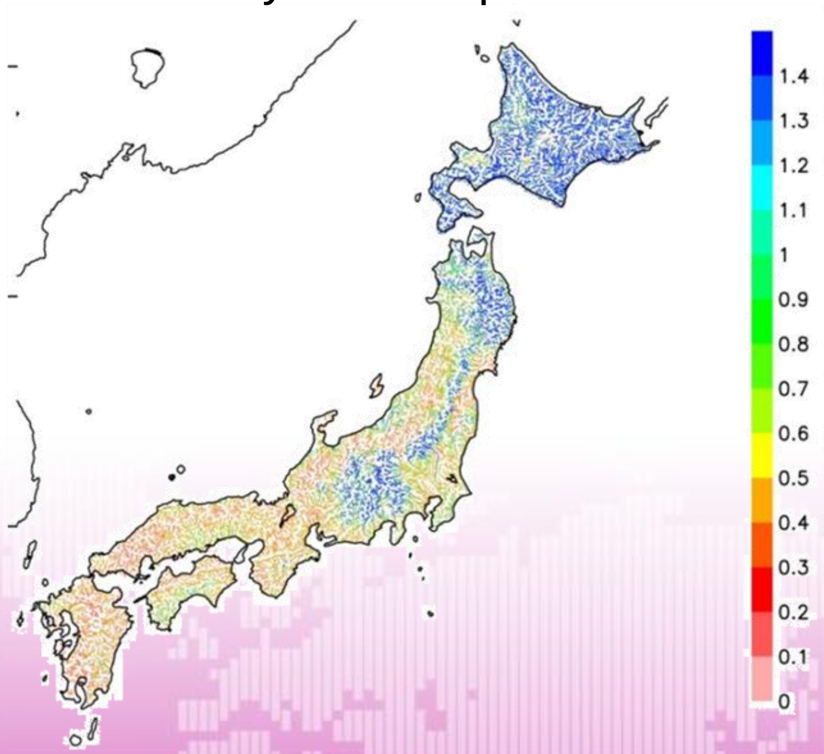
A p i p et al (20

River discharge

Flood flow change
(Q_1: Annual Maximum discharge)
100yrs return period

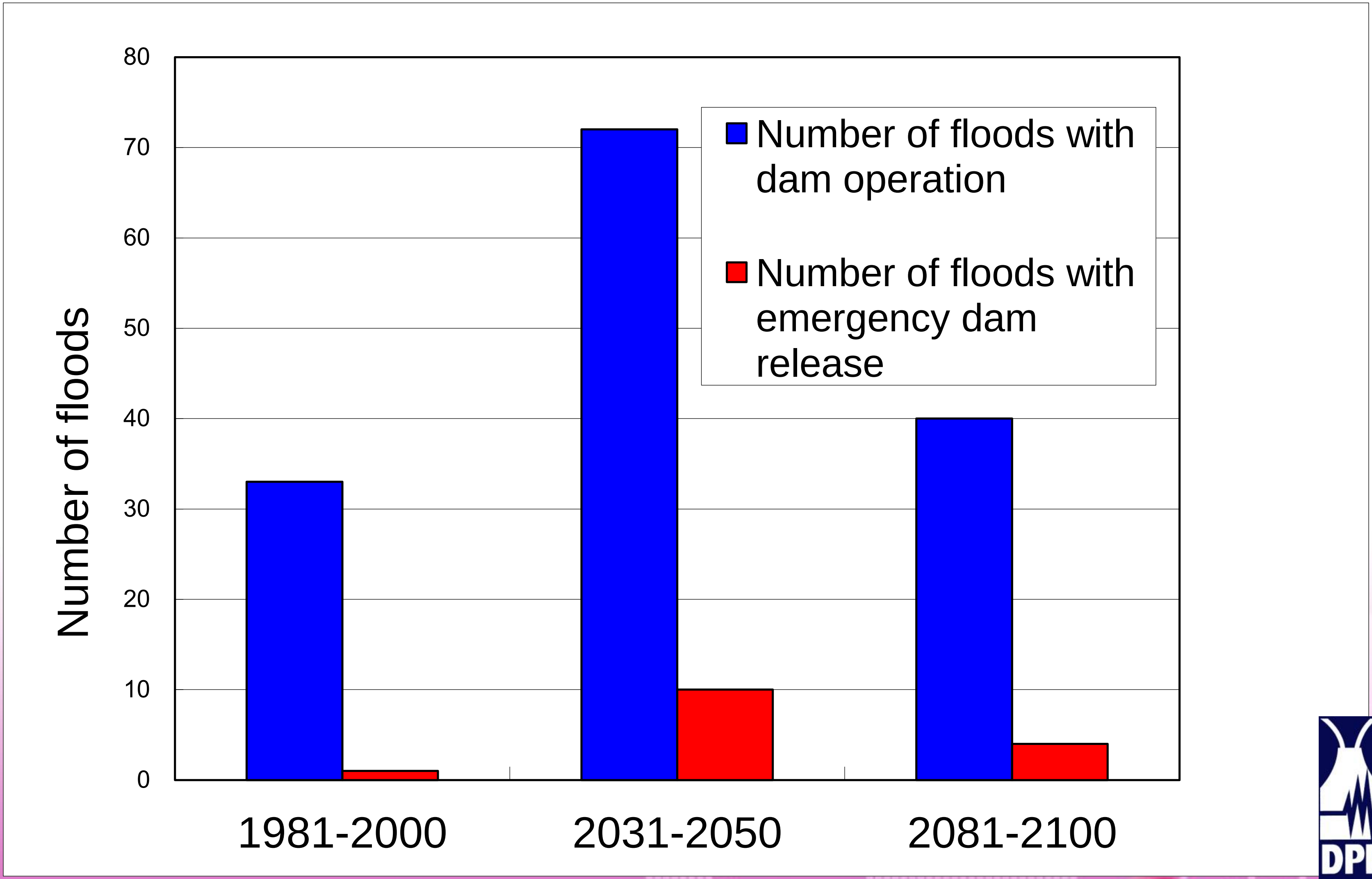


Draught flow change
(Q_{355} discharge)
10yrs return period



Tachikawa et al (2009)

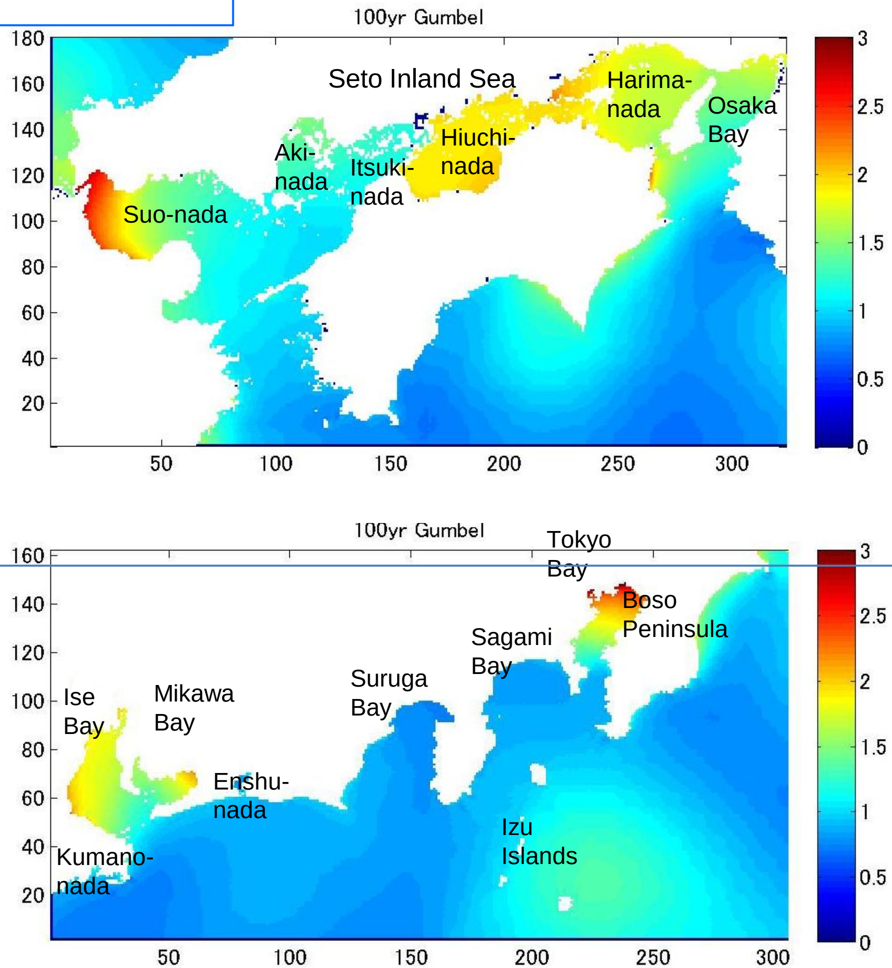
Possible changes in the number of floods requiring dam operation and emergency dam release (Yodo River)



Sayama et al. (2008), Kyoto University.

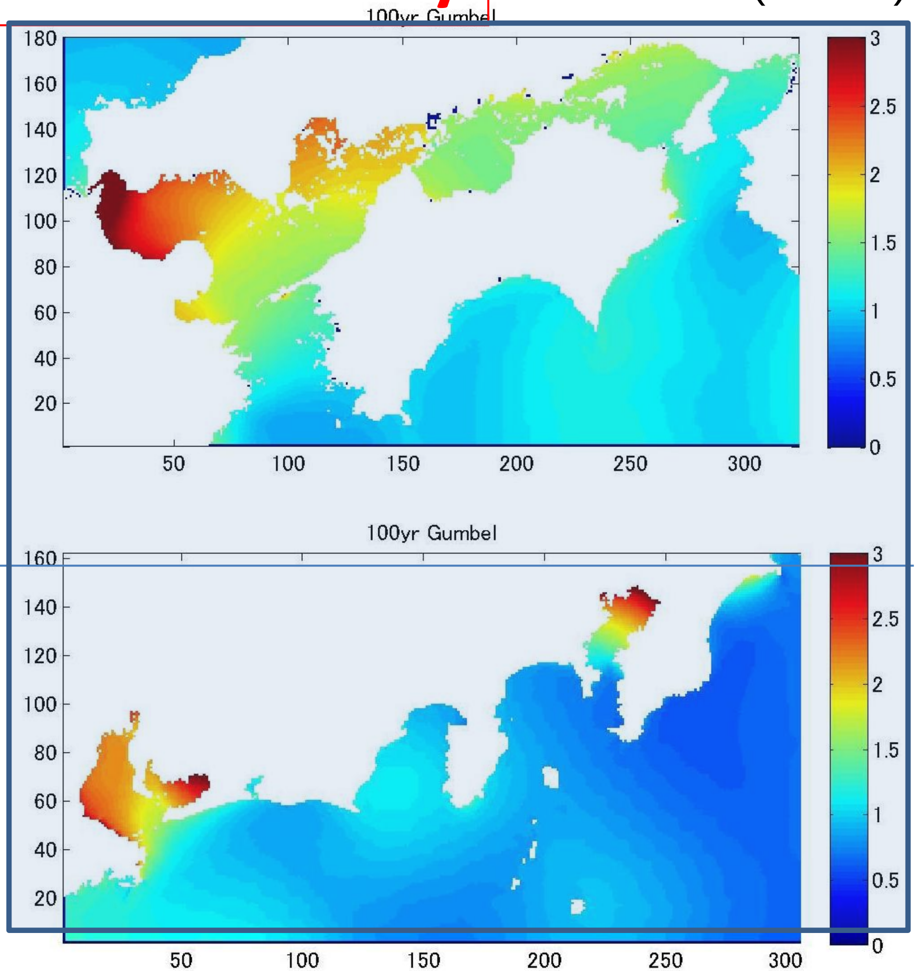
100-years return values of Storm surge (deviation from the average year value)

Current



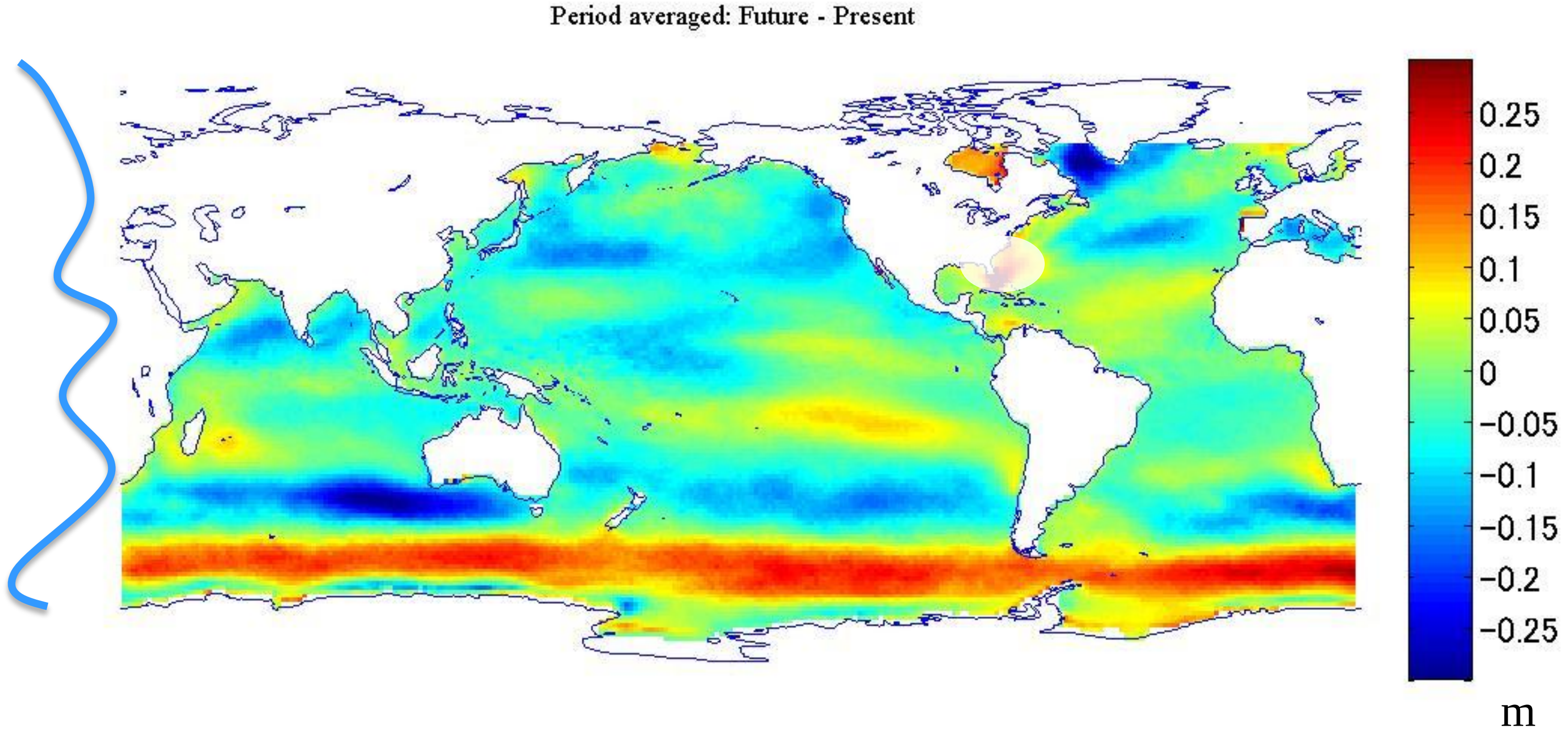
End of Century

(unit: m)



Mase et al (2011)

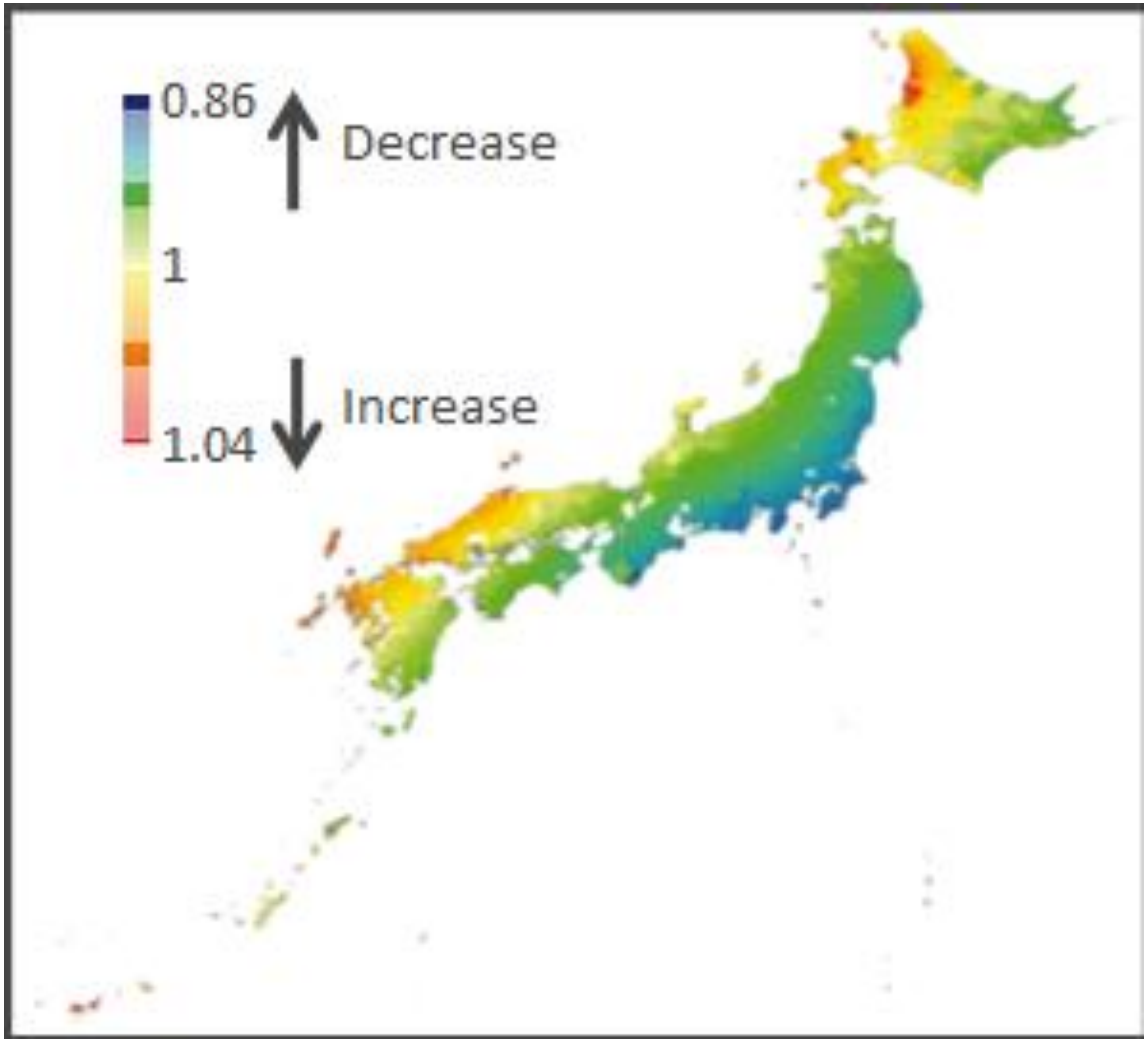
Change in wave height



Averaged *Hs*: Future-Present

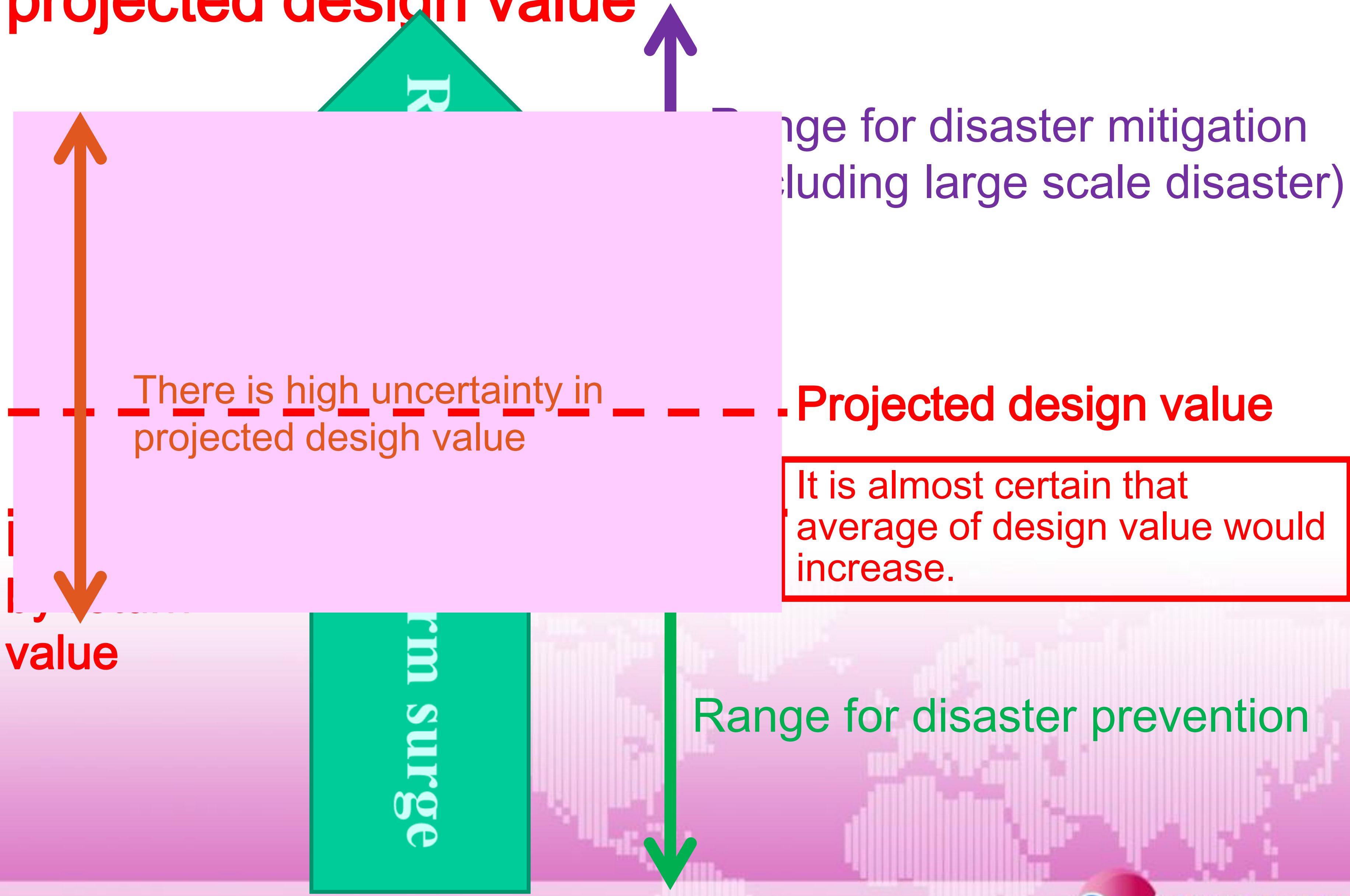
Mori et al (2010)

Change in building risks by severe wind

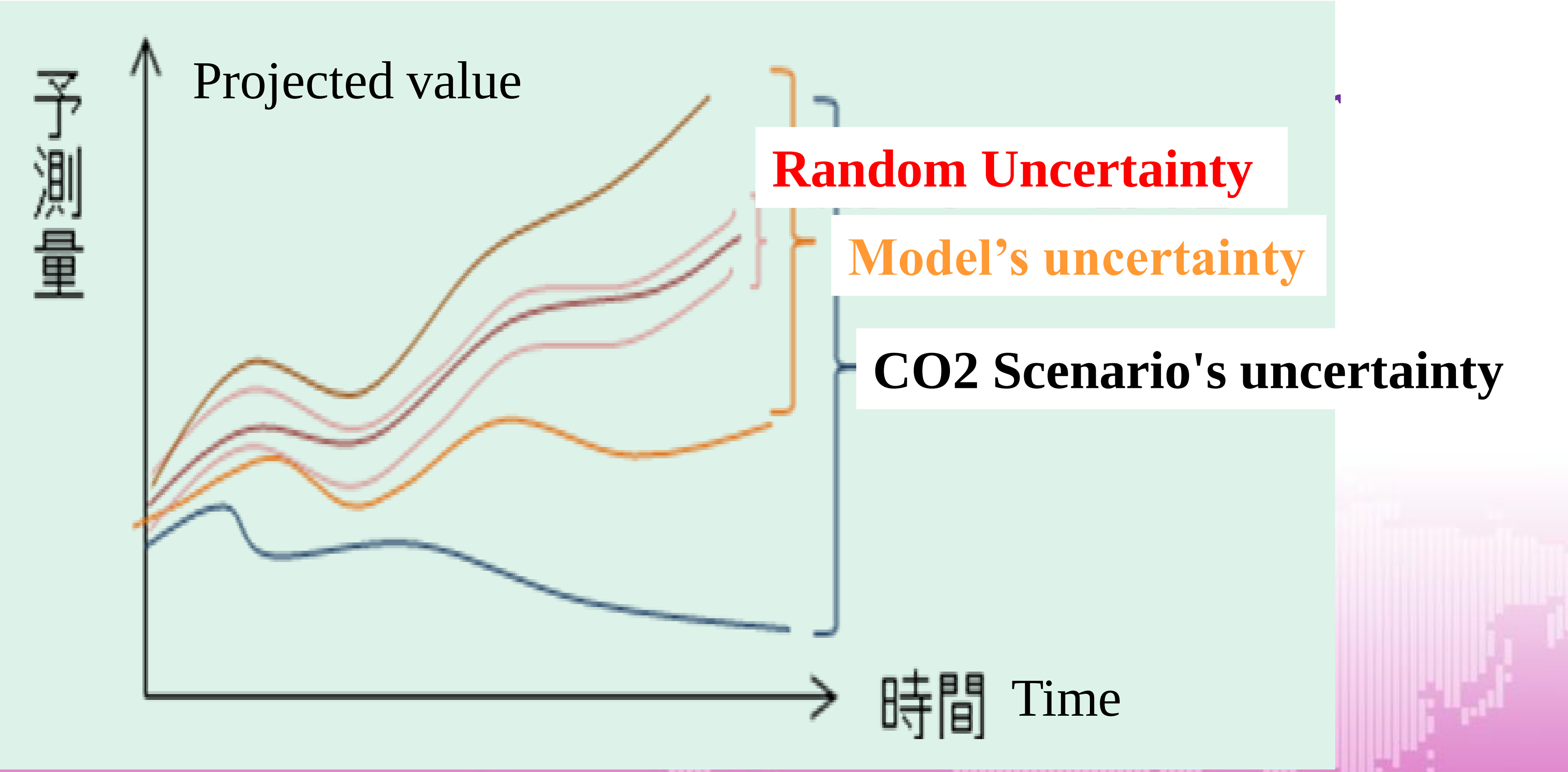


Maruyama et al (2011)

There is high uncertainty in projected design value



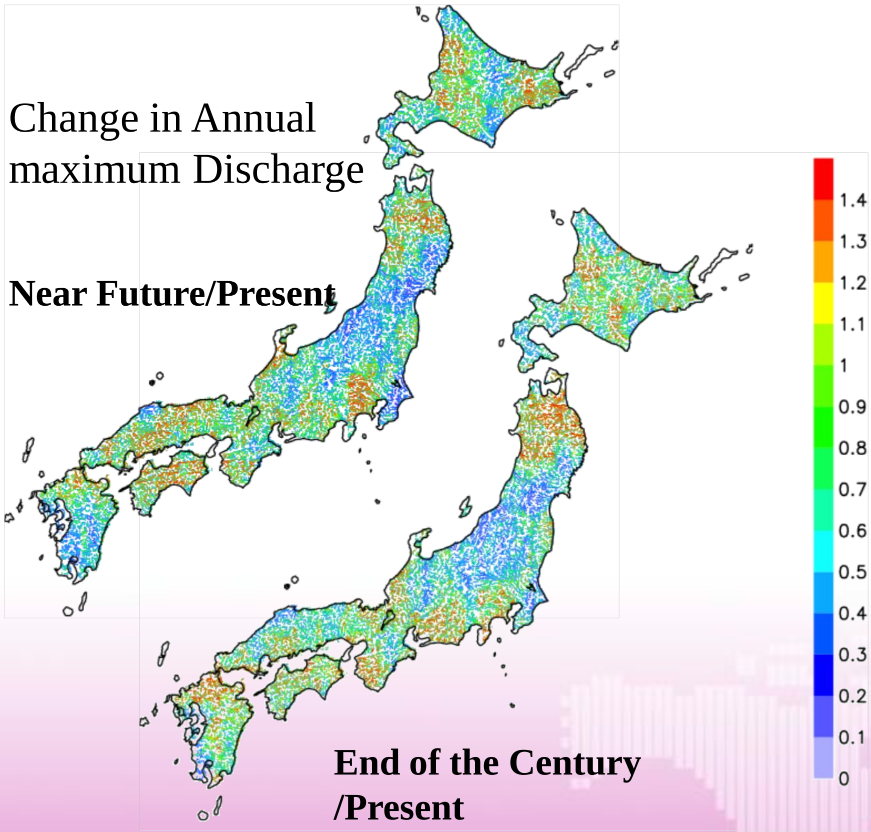
Uncertainty inherent to GCM projection

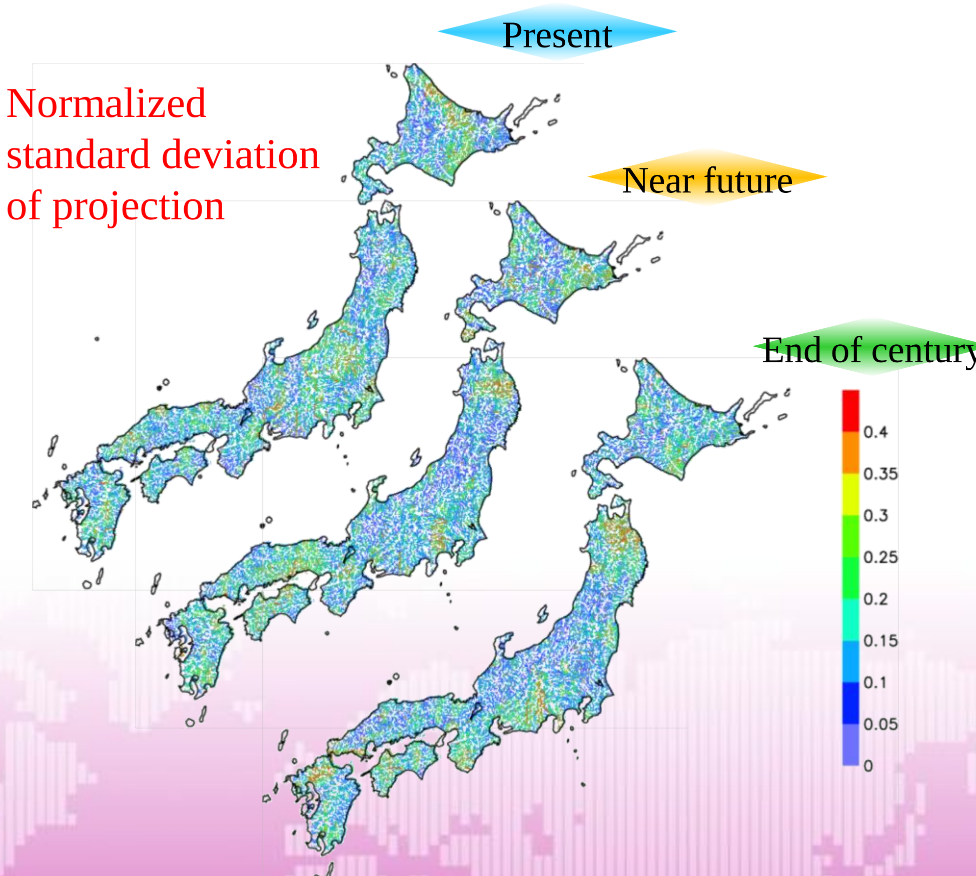


Accuracy of estimated annual max. discharge

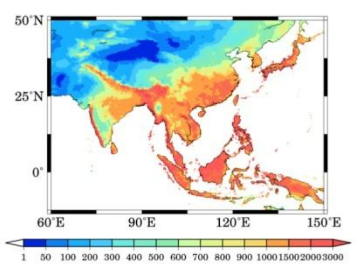
Accuracy of 100 years return value (Jackknife method)

With 25-years single time series





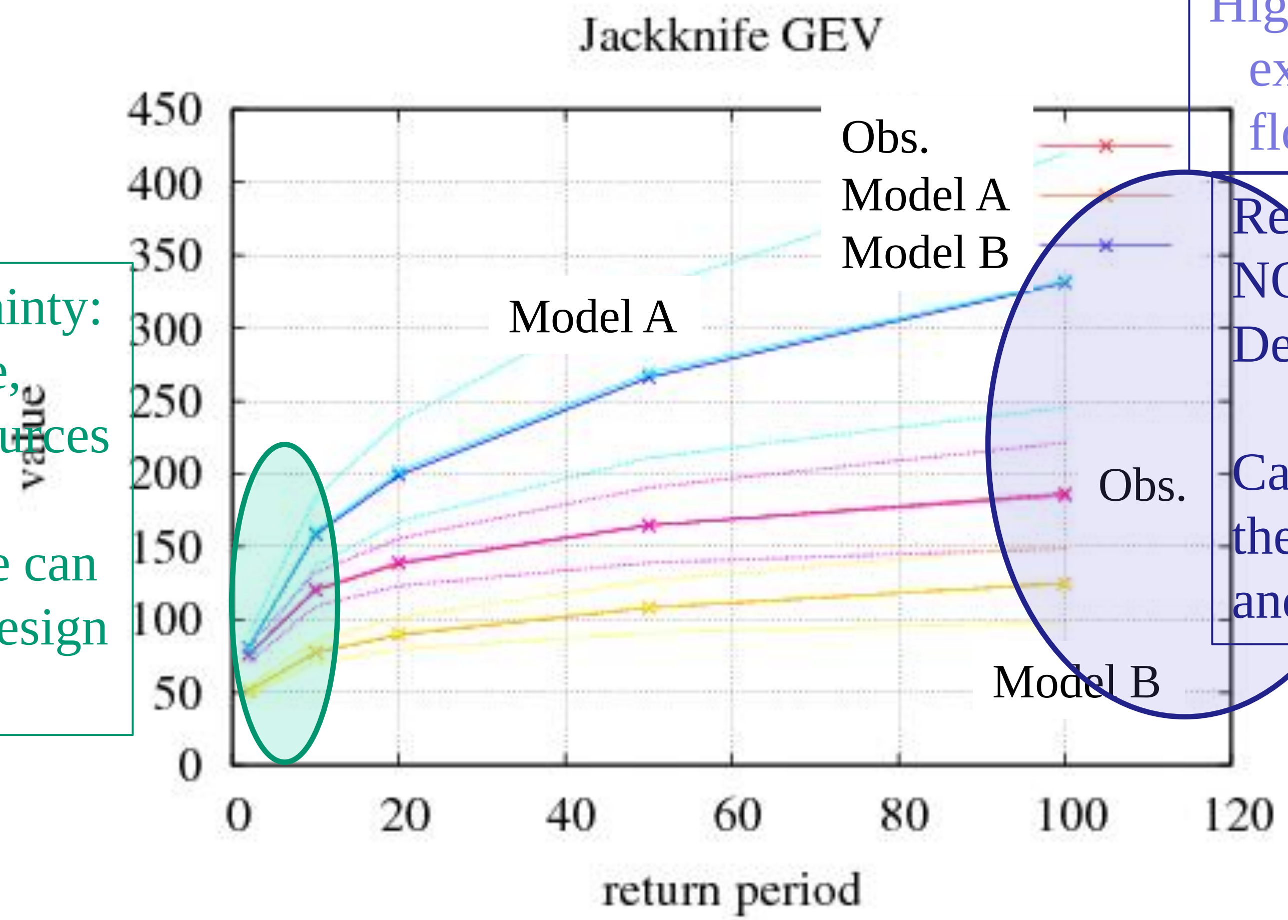
The larger the projected value is, the larger the standard deviation is.



Schematic of return value's uncertainty

AMS

High uncertainty:
extreme events,
flood, land slide



Low uncertainty:
agriculture,
water resources

Return value can be used as design level

Return value can NOT be used as Design level

Can RCM reduce the uncertainty and bias?

With 25-years single time series

Konoshima and Nakakita (2010)

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There is high uncertainty in projected design value

- We may be almost sure that average of extreme design value would increase.
- However, projected increase in the design value is merely rough estimation,
- because, for example, the worst case typhoon for a specific river basin may not be realized (computed) in a single projected time series.
- Therefore, it is very important to estimate river discharge when a worst case typhoon would pass through, even though we cannot estimate return period.

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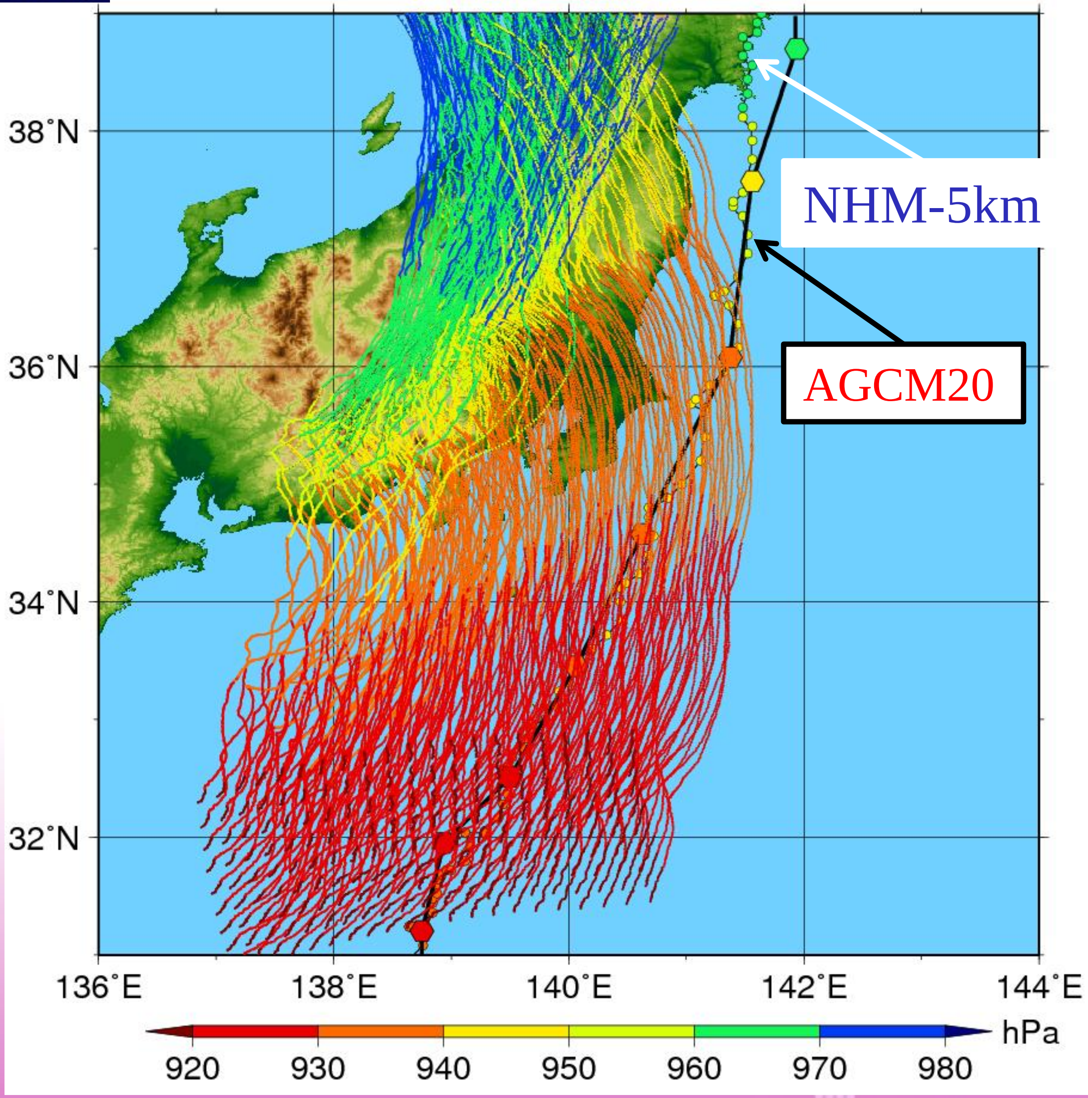
Virtual Shifting of typhoon's initial position
- for making a worst scenario -



Virtual Shifting of typhoons initial position by keeping potential vorticity same

(a vorgas method)

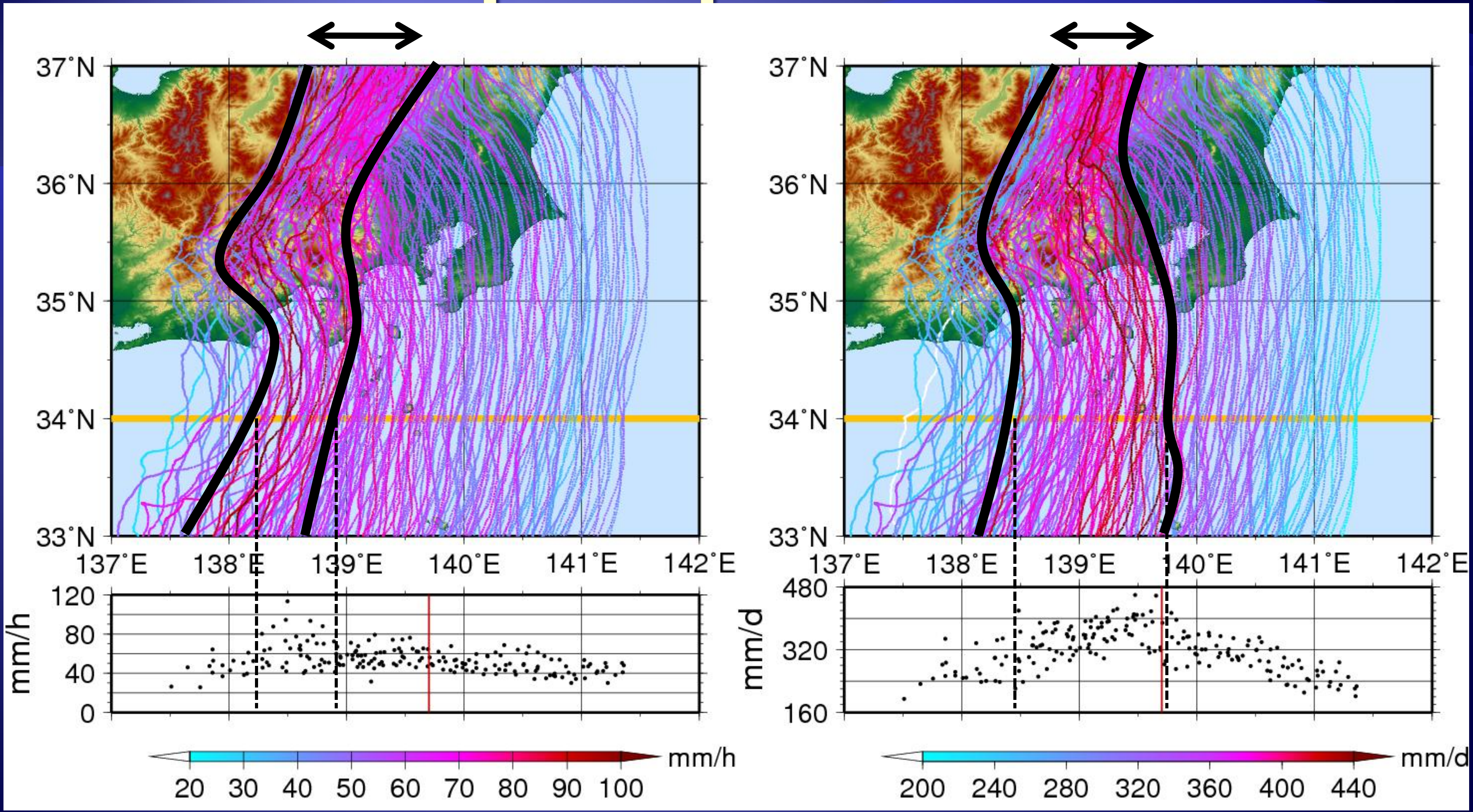
Dynamic downscale by RCM

Worst case impact assessment on

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

Ishikawa et al (2009)

Track and precipitation

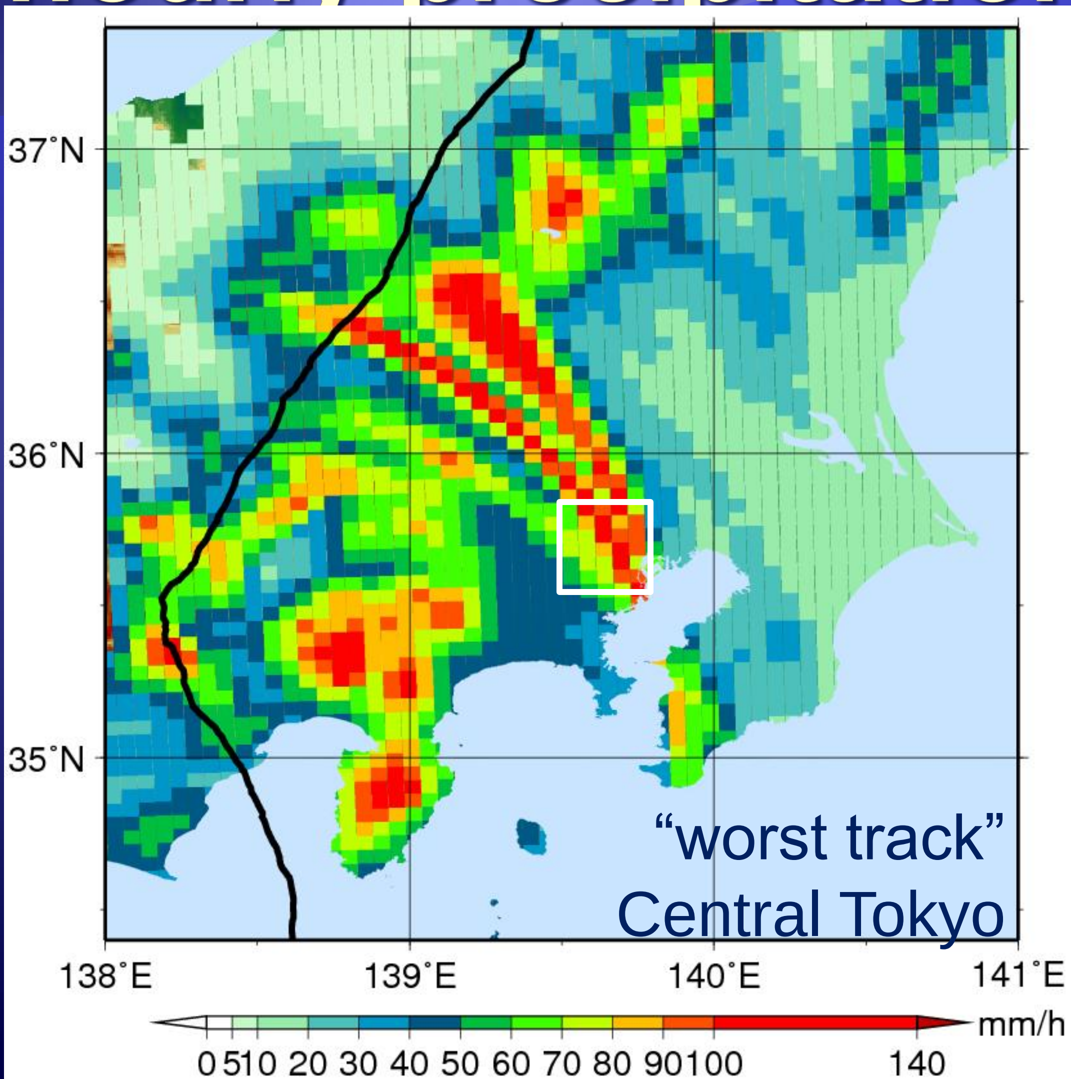


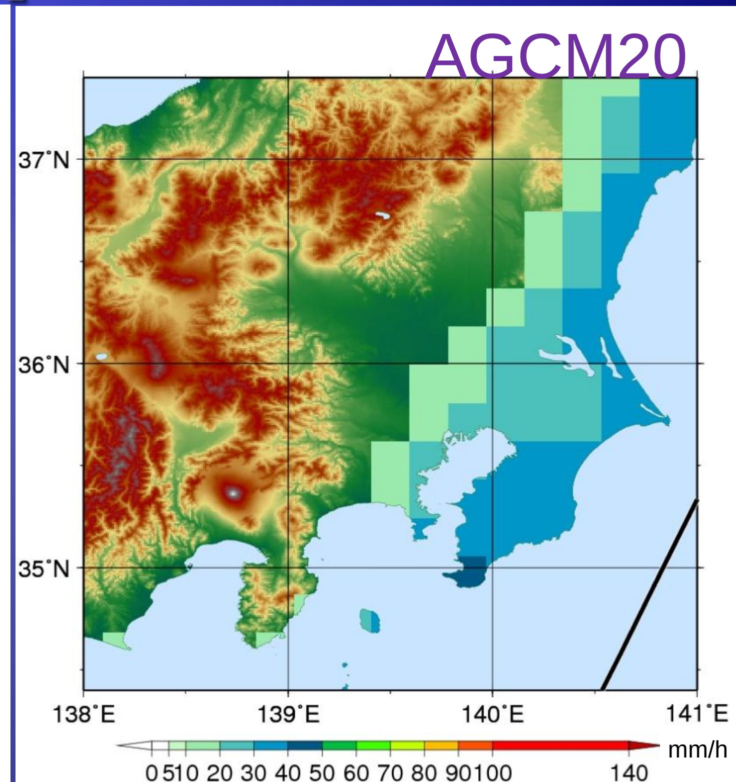
hourly precipitation

daily precipitation

I s h i k a w a e t

Probable maximum hourly precipitation





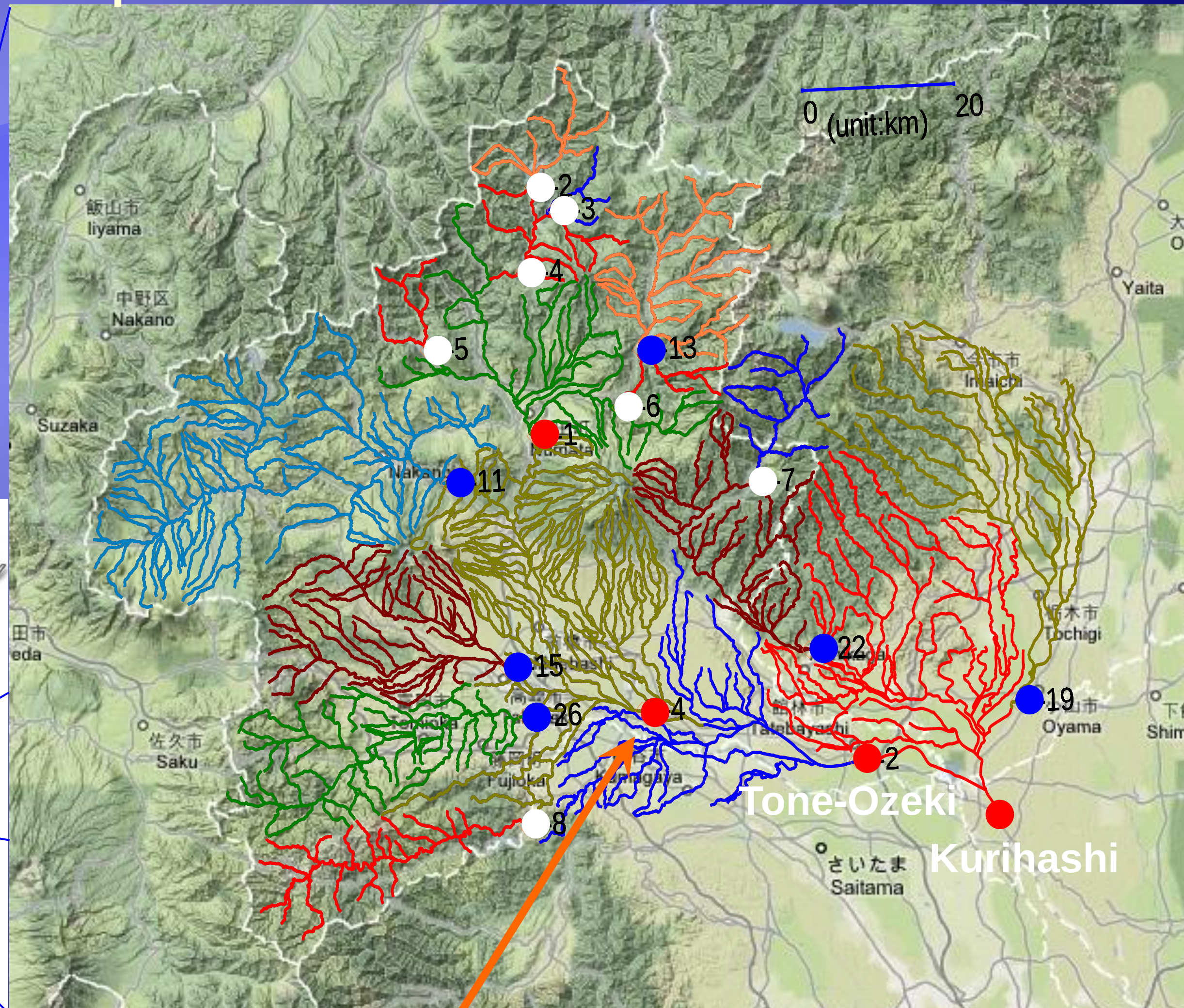
Ishikawa et

Simulation of River Discharge using Precipitation Output （Tone River Basin）

Main Points
- Yakatahara (1677.5 km²)
- Yattajima (5133.6 km²)
- Tone-Ozeki (6058.8 km²)
- Kurihashi (8772.2 km²)

Dam Points
- Yagisawa Dam
- Naramata Dam
- Fujiwara Dam
- Aimata Dam
- Sonohara Dam
- K
- S

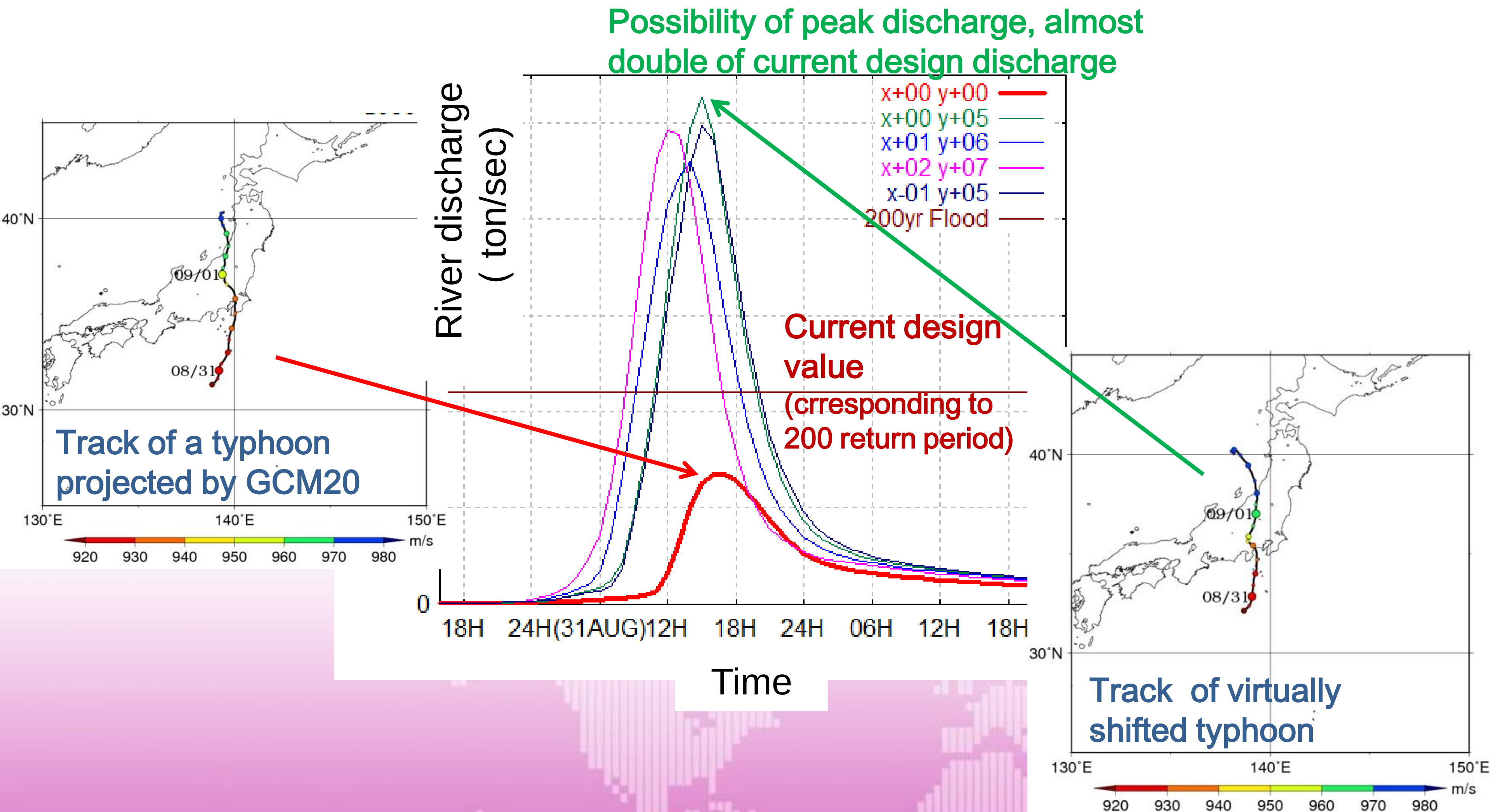
(I



Yattajima （八斗島）
Design Flow Rate：22,000 m³/s （200years）

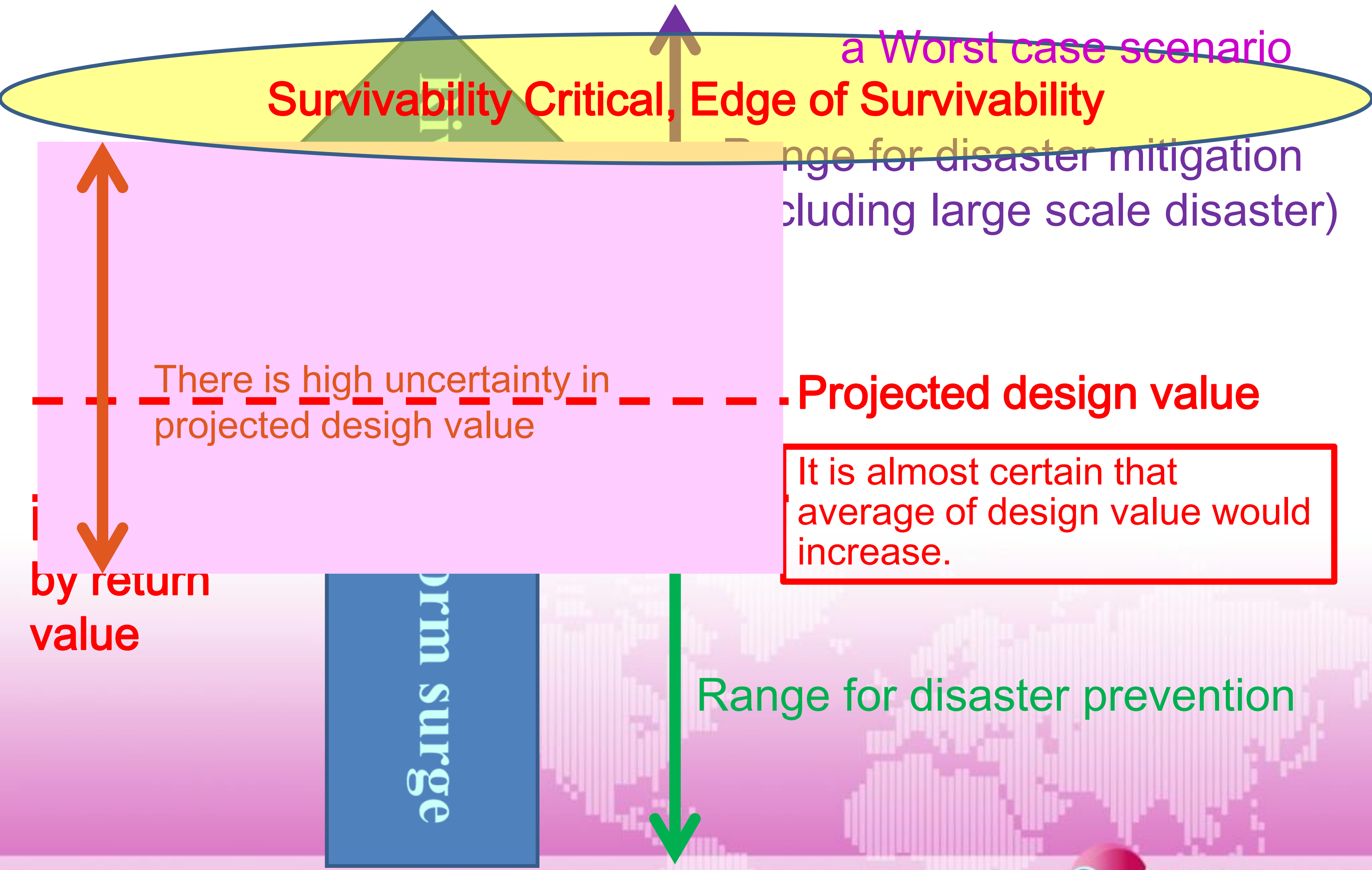
Oku et al (2009)

River Discharge by the virtual shifting of typhoon which was projected by GCM



Oku et al (2009)

Heading to adaptation



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Summary (1)

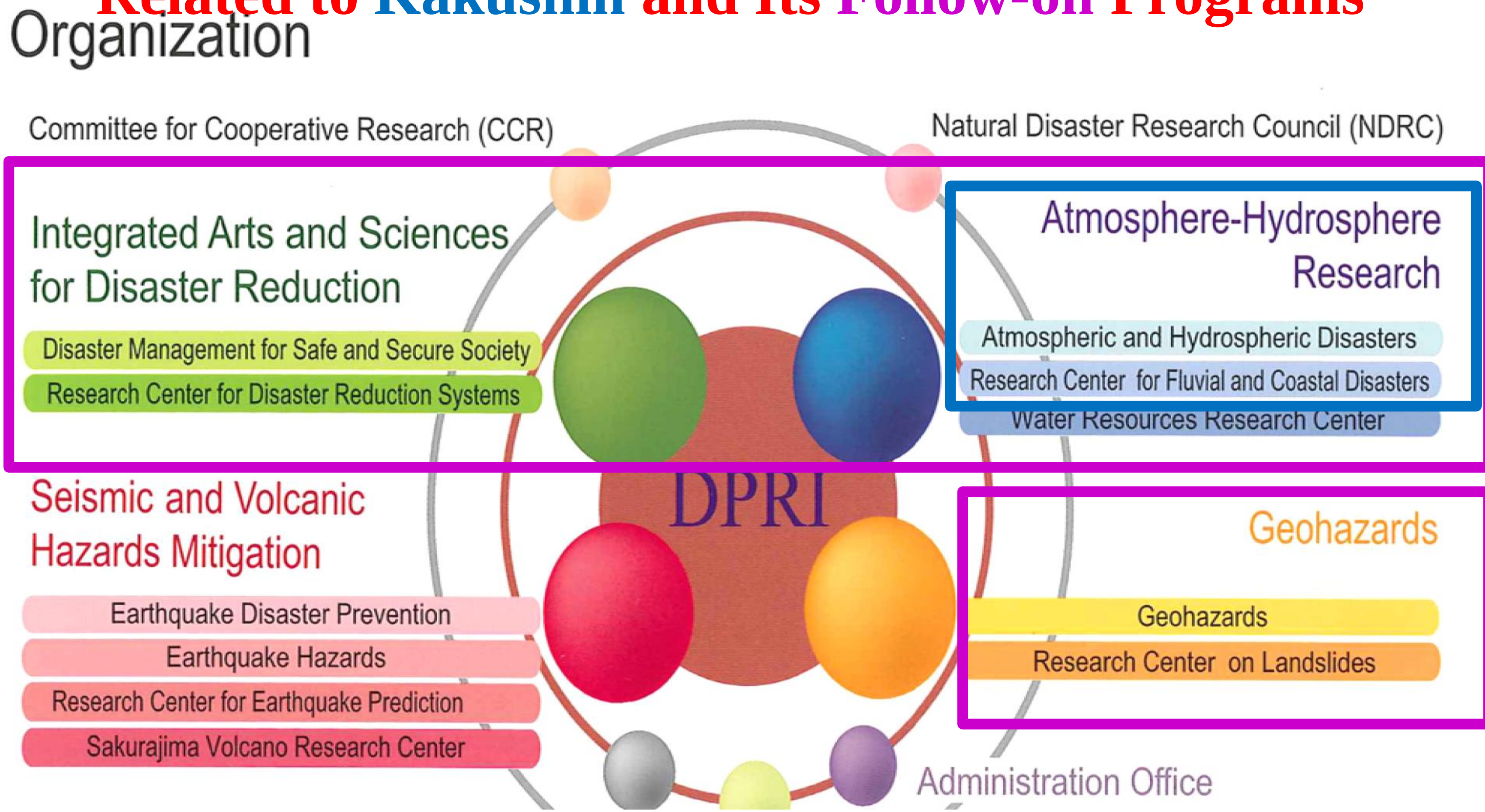
1. The AGCM and RCM with super-high spatio-temporal resolutions (20 km-1 hour) made it possible to evaluate extreme hazard (ex. Max. discharge).
2. However, this does not mean that we can evaluate the changes in such a high spatial resolution.
3. We can get approximate projection on changes of return values of extreme events.
4. However, there is a risk that the return period does not have enough accuracy because there is no guarantee that quite extreme events could be properly projected within the limited number of ensembles. (Single time series output from the AGCM20 and RCM)
5. In this sense, it may be difficult to project correct design hazard for water management and flood control so on.

Summary (2)

5. 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 a worst case scenario as one of the forcing hazard for disaster risk management under climate change.
6. Taking into consideration above items, I think, it is very important for climate change adaptation to discriminate more between planning with an uncertain design level and risk management with a worst case scenario.
7. Of cause, making the number of ensembles increase is essential for the Kakushin follow-up program.

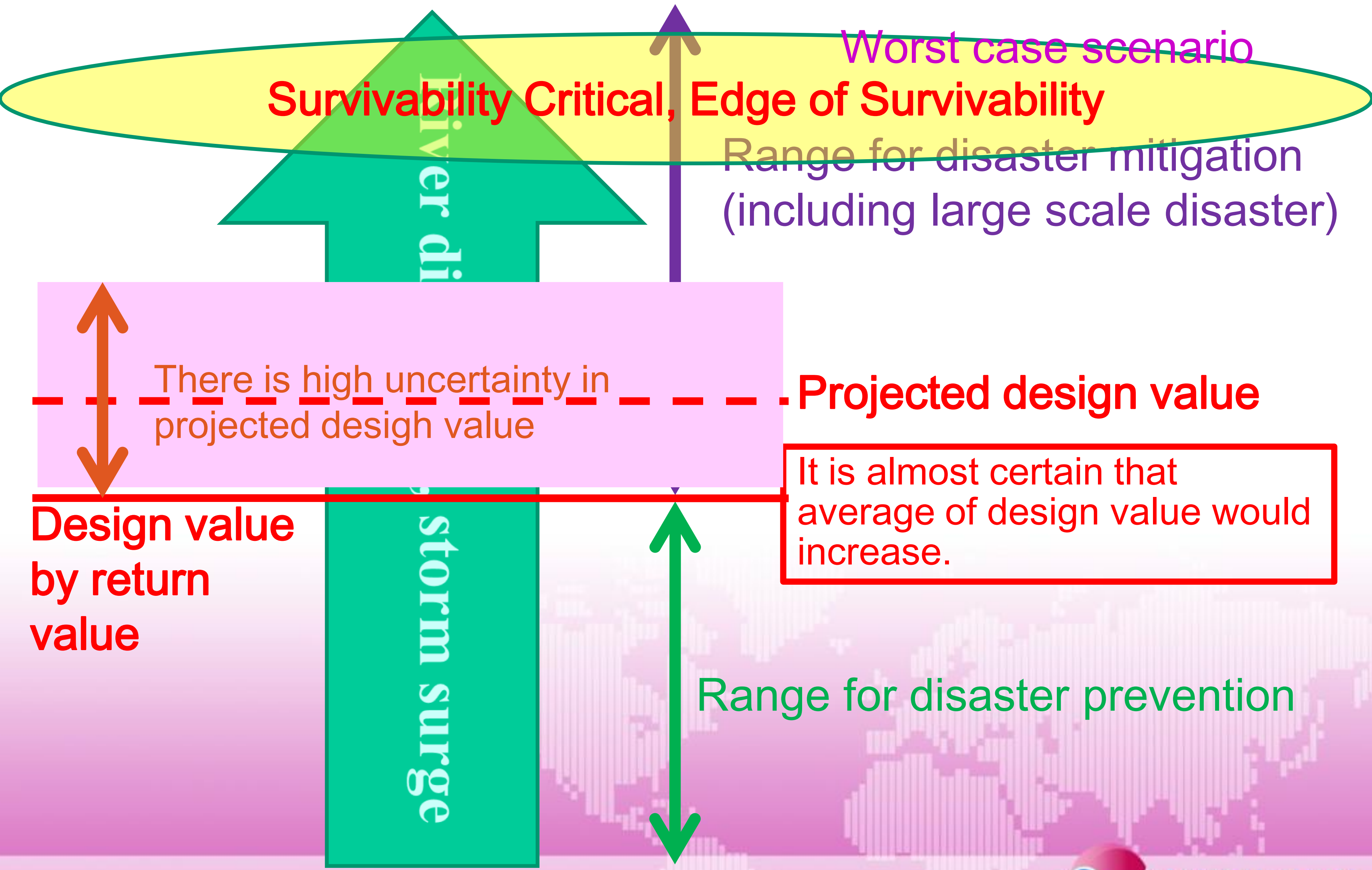
Research division and center

Related to Kakushin and Its Follow-on Programs



Thank you for your kind attention!

Heading to adaptation



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
Design rainfall, Design typhoon

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

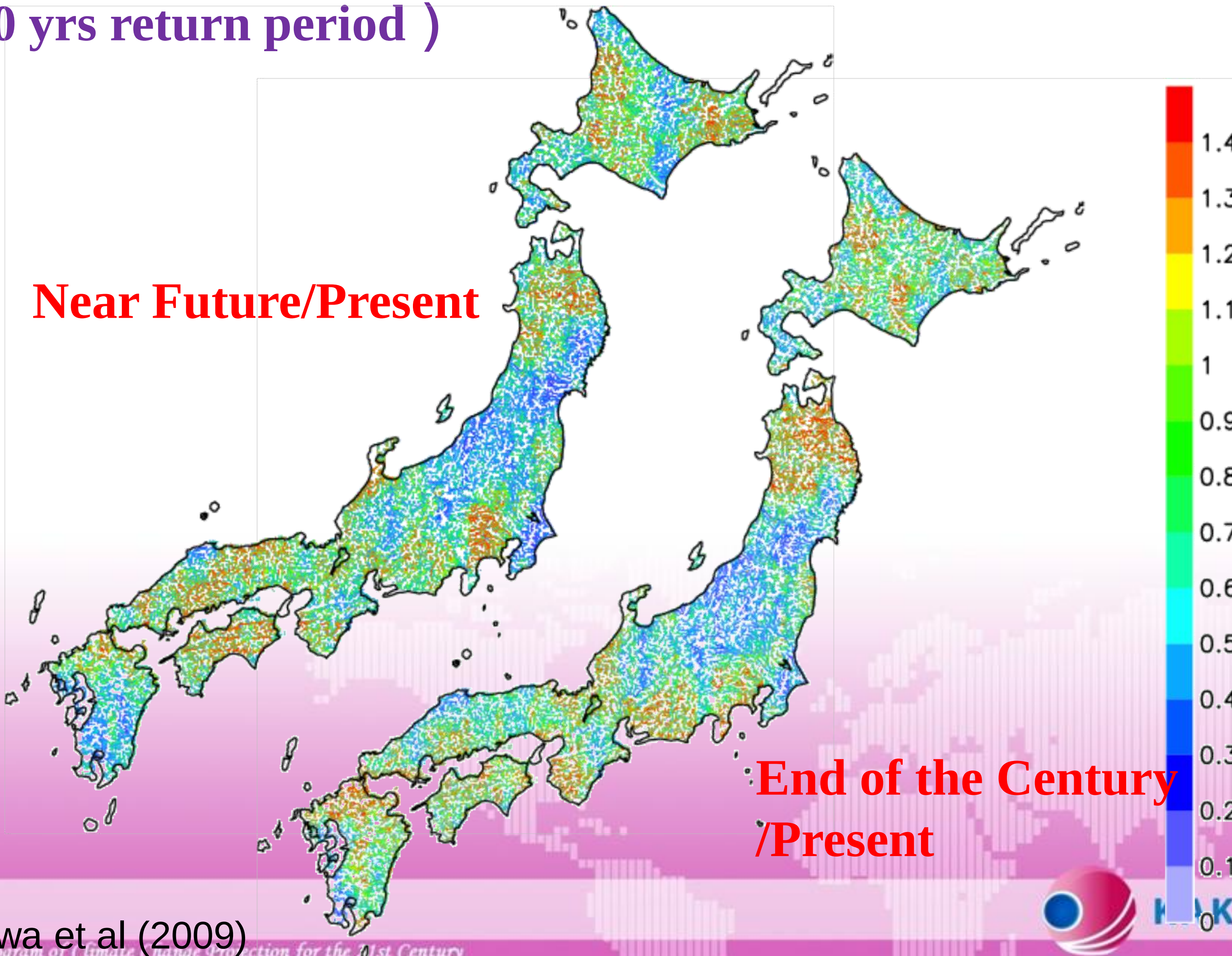
Evaluation of changes in hazards

Evaluation of Changes in Disaster Risks

Proposal of Adaptation Measures

Impact Assessment on River Regime （Flood）

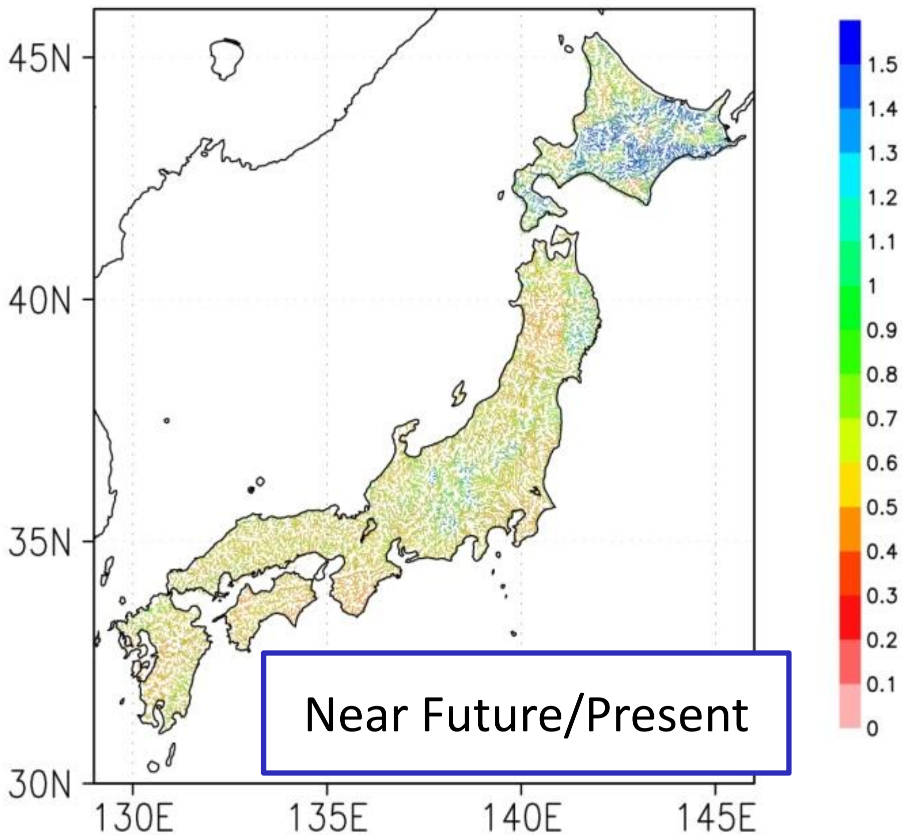
Increasing Ratio of Annual Max. Discharge （100 yrs return period）

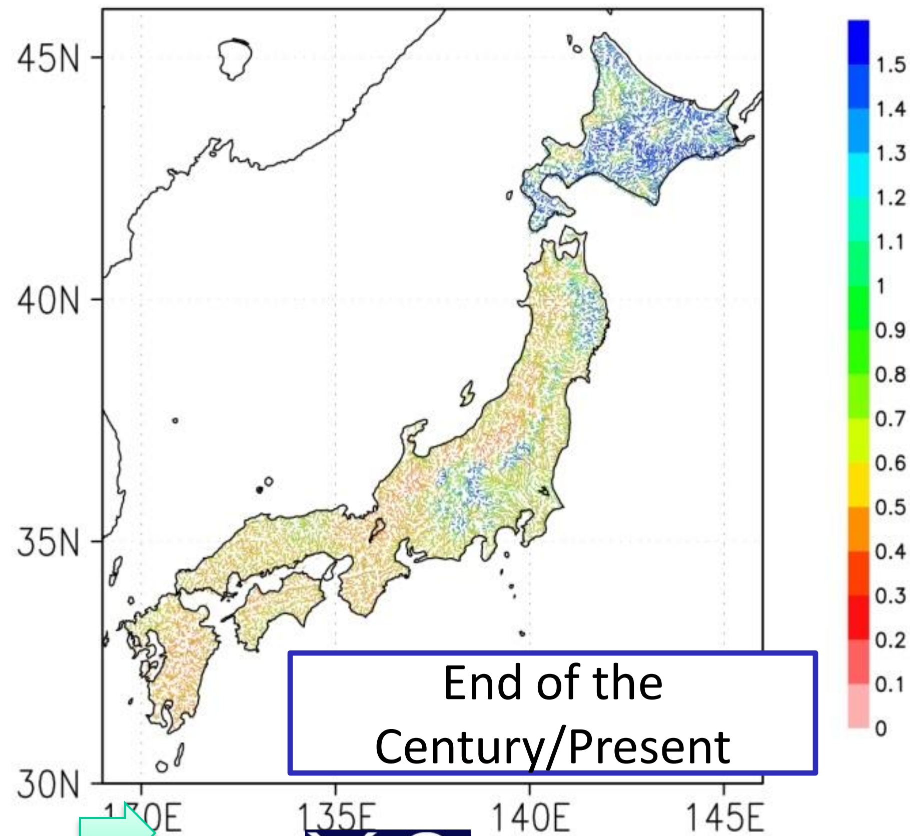


Tachikawa et al (2009)

Impact Assessment on River Regime （Drought）

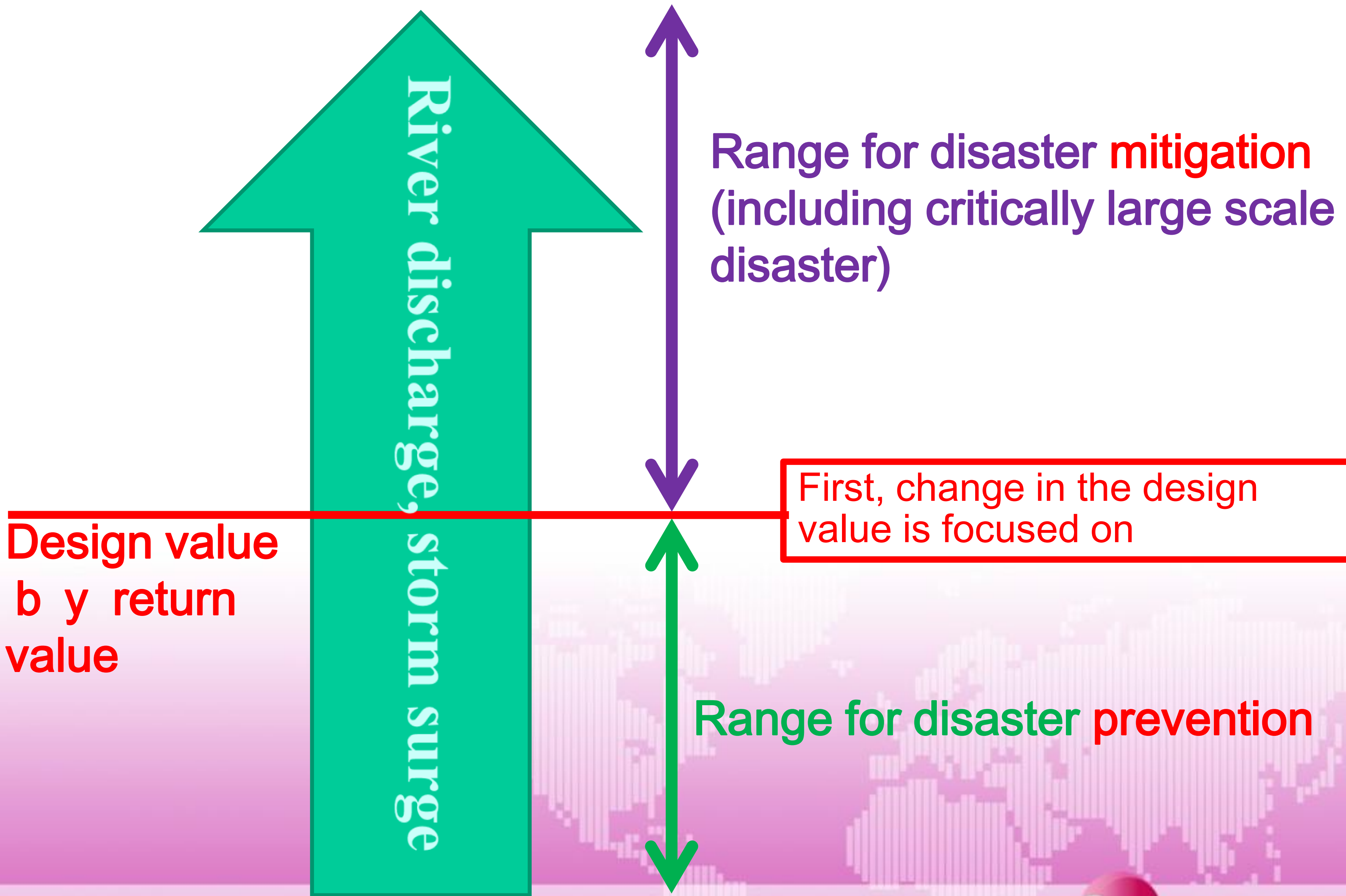
Drought Discharge: The 355th largest daily discharge in a year.





Tachikawa et al (2009)

Design value for river discharge and storm surge



KAKUSHIN