2011 International Conference on Climate Change, Howard Civil Service International House, Taipei, Taiwan (2011/12/07)

Climate change impact assessment on Japanese extreme hazards and a basic proposal heading to adaptation

Eiichi Nakakita
Disaster Prevention Research Institute, Kyoto University
(中北英一、京都大学防災研究所)

KAKUSHIN

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 worst case scenario into consideration

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 worst case scenario into consideration.

KAKUSHIN

Innovative Program of Climate Change Projection for the 21st Century
(KAKUSHIN Program)

by

Ministry of Education, Culture, Sports, Science and Technology (MEXT)

Secretariat of the Outreach Committee of the Program

Frontier Research Center for Global Change

Japan Agency for Marine-Earth Science and Technology

KAKUSHIN

Participating groups and their studies

- ***Long-term global environmental projection***

  with an earth system model

  − Frontier Research Center for Global Change (**FRCGC**) et al.

- ***Near-term climate prediction***

  with a high-resolution coupled ocean-atmosphere GCM

  - Center for Climate System Research (**CCSR**) of the University of Tokyo et al.

- ***Projection of changes in extremes in the future***

  with super-high resolution atmospheric models

  - Meteorological Research Institute (**MRI**) et al.

  - Disaster Prevention Research Institute (DPRI), Kyoto University

  - International Centre for Water Hazard and Risk Management (ICHARM), Public Work Research Institute (PWRI)

Program structure

Advancing Climate Modeling and Projection

Coordination

Comprehensive Impact Assessment Projects by *Ministry of Environment* (MOE)

Close linkage

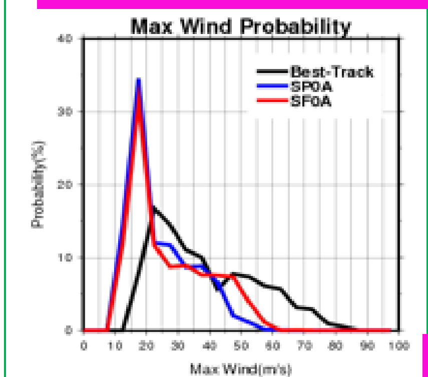
Impact assessment on natural disasters

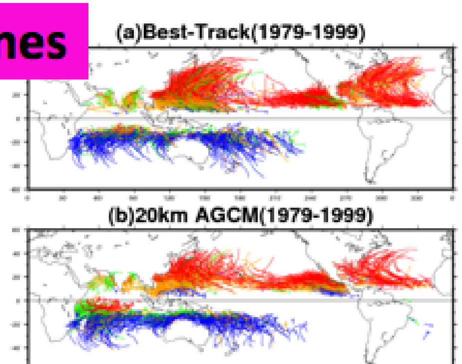
Quantification and Reduction of Uncertainty

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

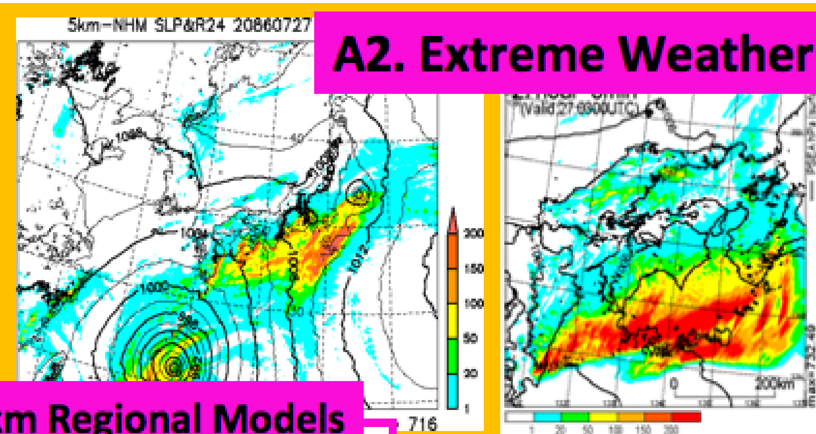
Akio Kitoh (MRI/JMA), **Shoji Kusunoki** (MRI/JMA), **Eiichi Nakakita** (DPRI/Kyoto-Univ.),
Kuniyoshi Takeuchi (ICHARM/PWRI)

A1. Tropical Cyclones

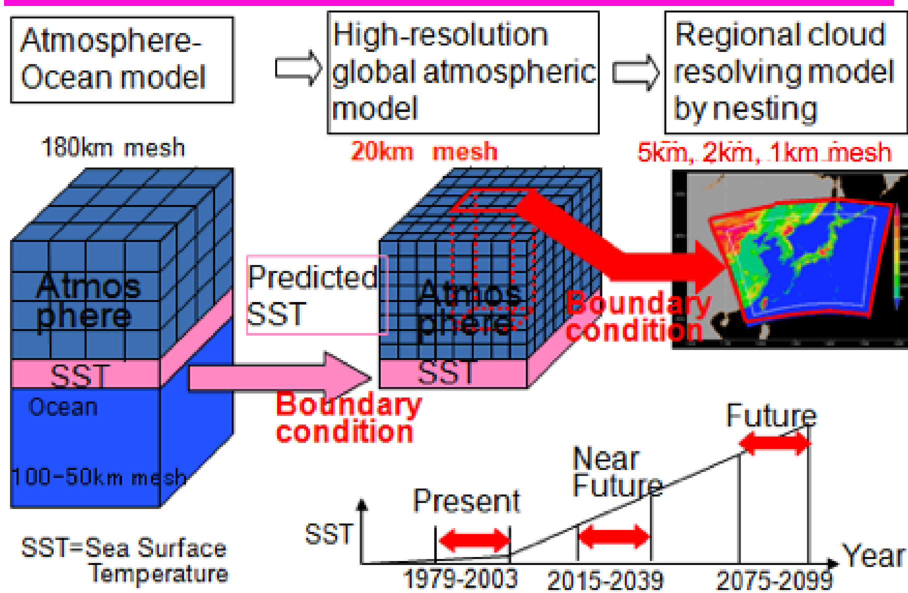




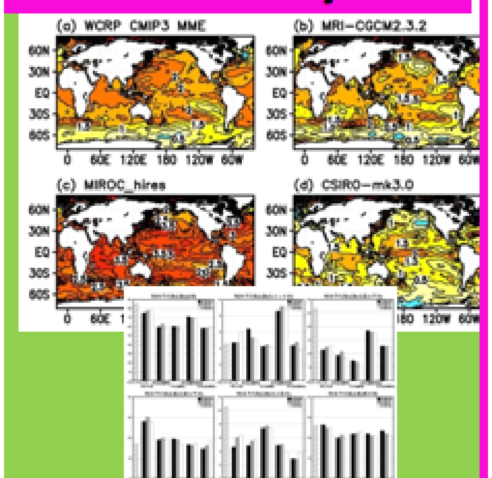
A2. Extreme Weather



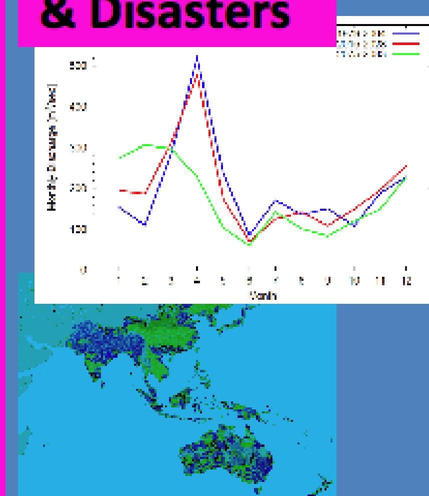
20km Global and 1-, 2- & 5-km Regional Models



B. Uncertainty



C. Flood & Disasters

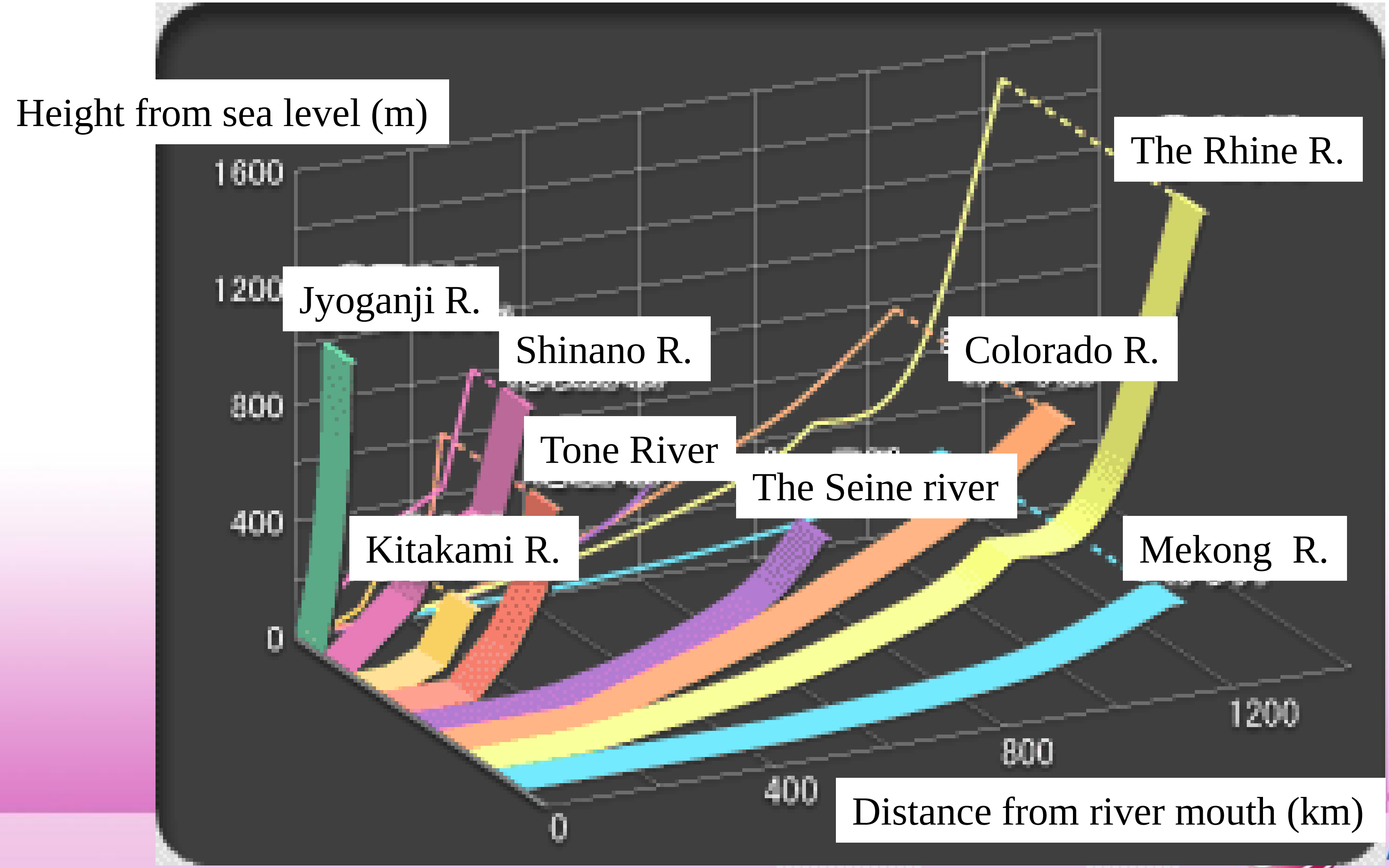


Points in climate change assessment on Japanese hazard

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

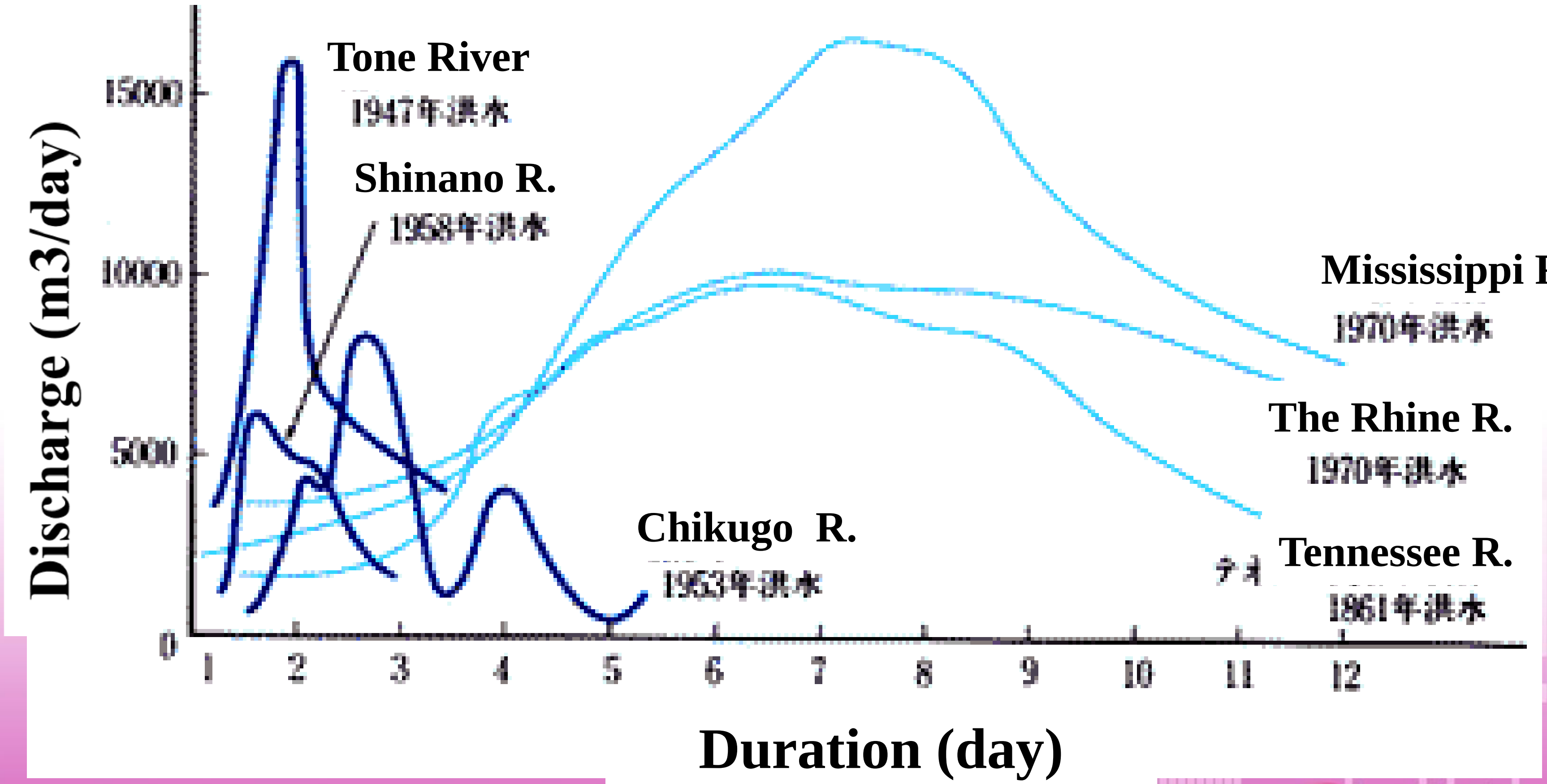
Features of Japanese River(1)

- Short length and steep slope.



Features of Japanese River(2)

- Large peak discharge, short duration

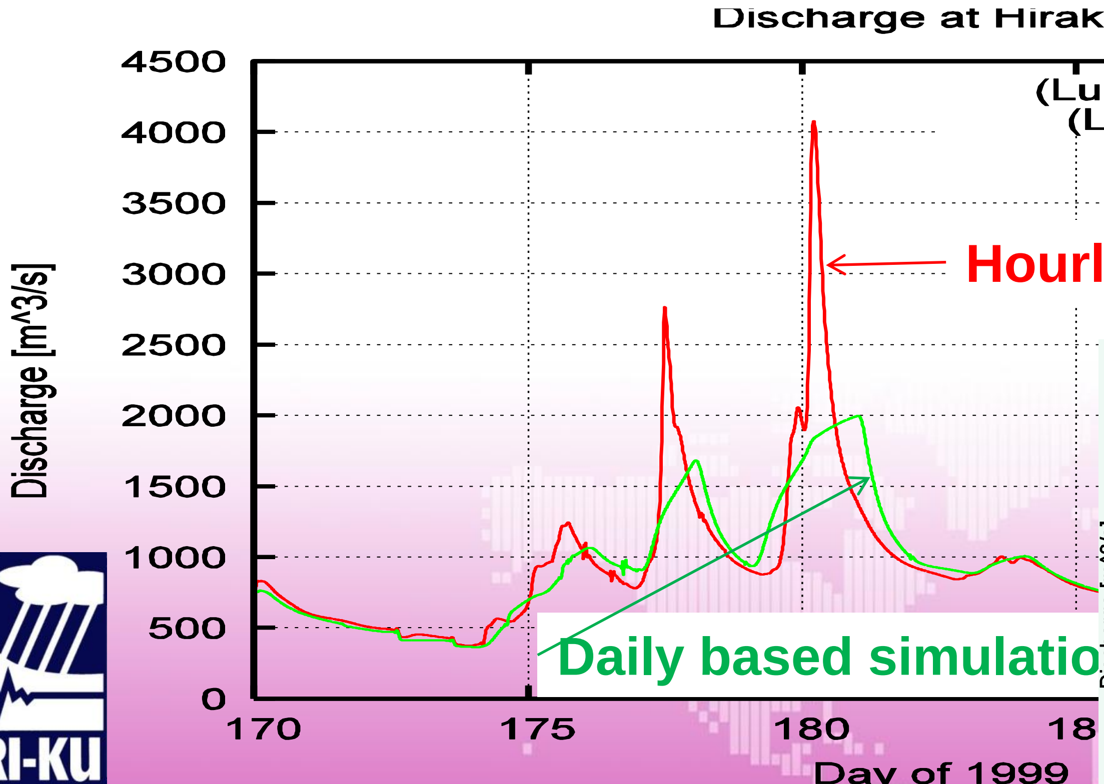


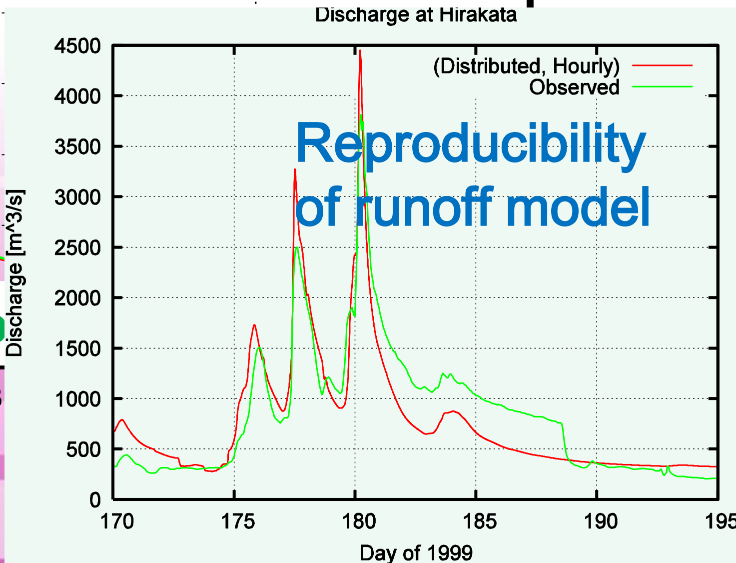
Importance of temporal resolution of rainfall data in calculating river discharge

- Comparison of simulation results for hourly and daily rainfall data in rainfall runoff model
- Yodo river basin（Hirakata water stage stn.：7,281km^2）

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

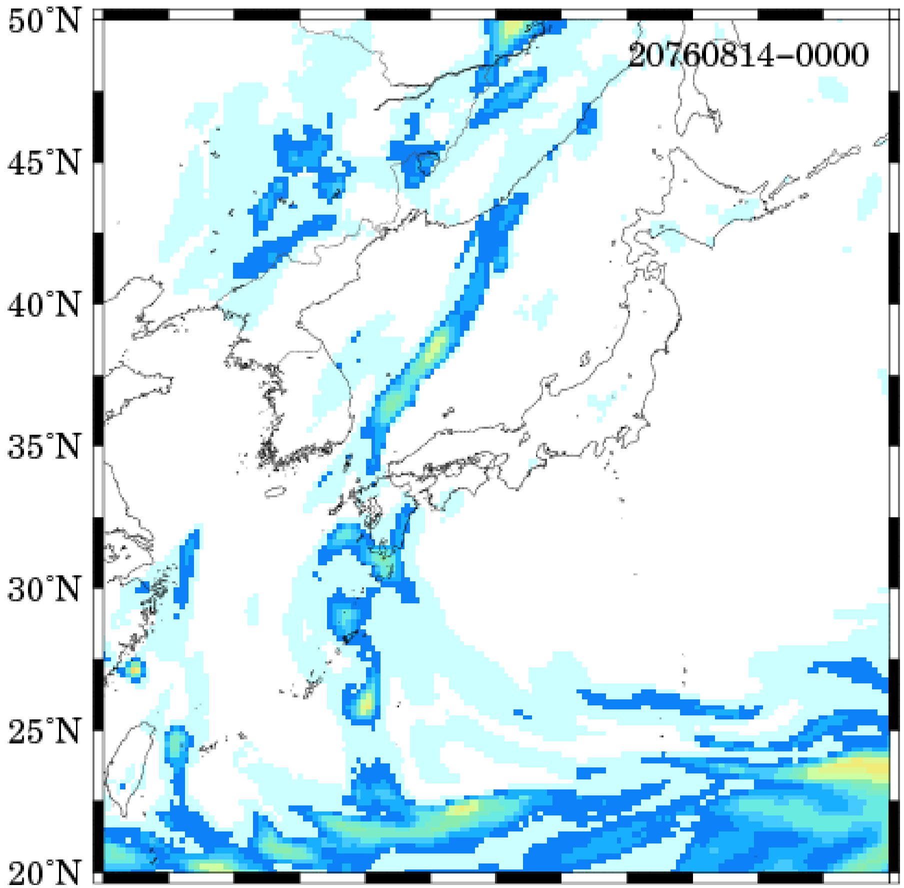
⇒ WE HAVE TO CALCULATE RIVER DISCHARGE USING HOURLY RAINFALL DATA.





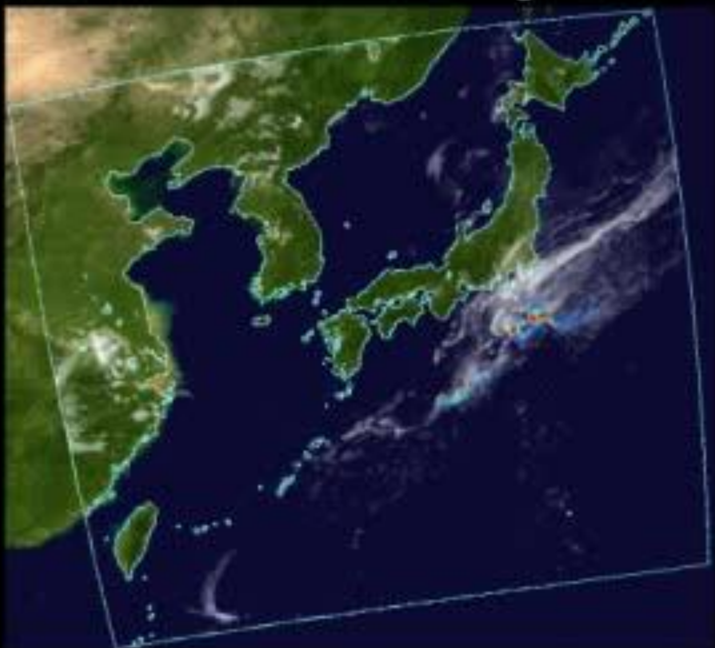
By Masuda, Tachikawa et al. (2006)

Projected typhoon by GCM20



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

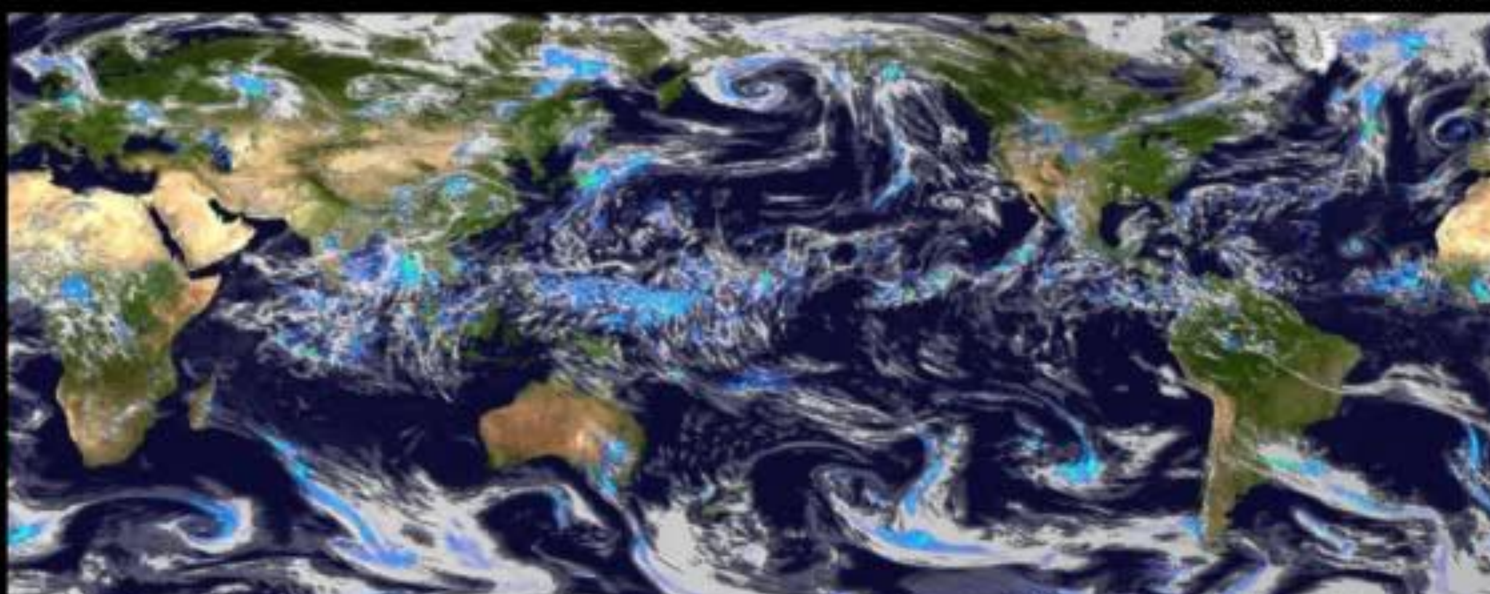
5km Regional Model



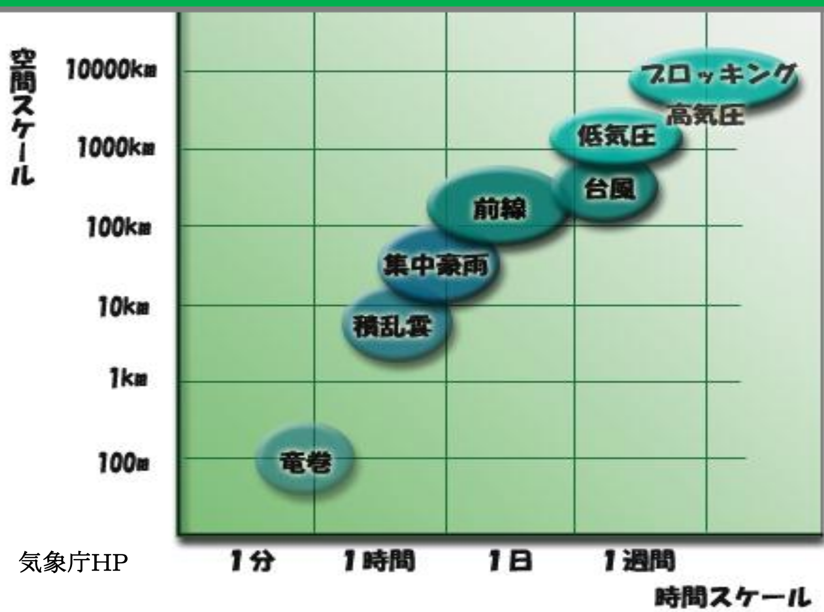
2km Regional Model

20 km Global Model

05 Sep
208X
00 UTC



Spacio-tempral scale

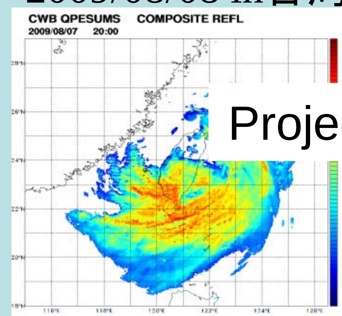


気象庁HP

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



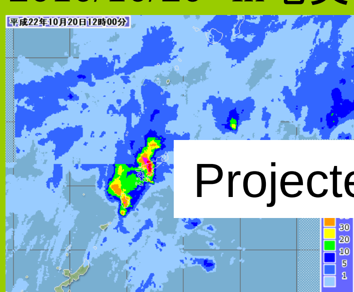
Projected by AGCM20

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

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 worst case scenario into consideration.

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)

Interpreta-tion 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

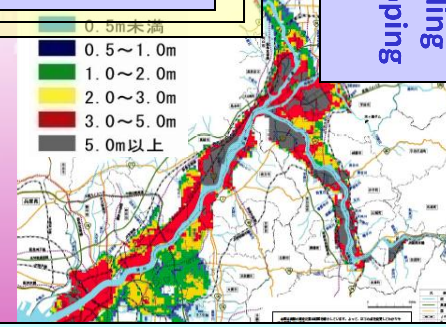
Rainfall runoff

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

Minimum Target of DPRI

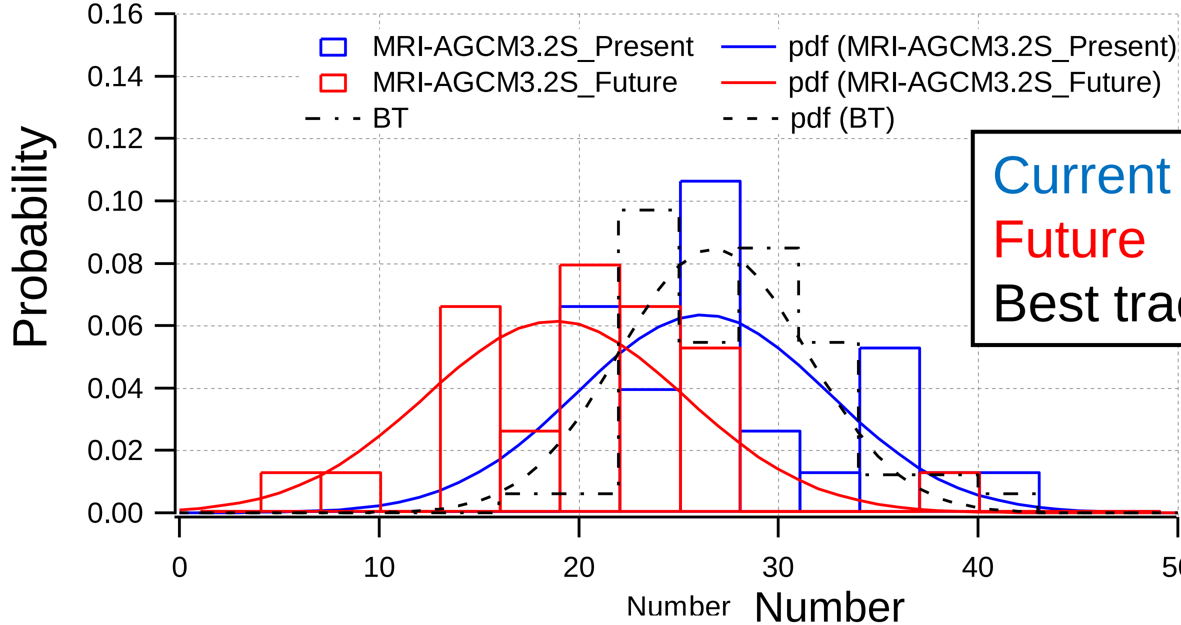
- Interpletation of GCM output
- Precipitation
- Land slide and Debris flow
  Mainly western Japan
- River discharge
  Japanese major large river basins (with fine resolution)
  All Japanese river basins (with medium resolution)
- Storm surge and wave
  Tokyo, Ise (Nagaya) and Osaka Bays, Global
- Damage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

DPRI-KU

KAKUSHIN

Characteristic of projected typhoon

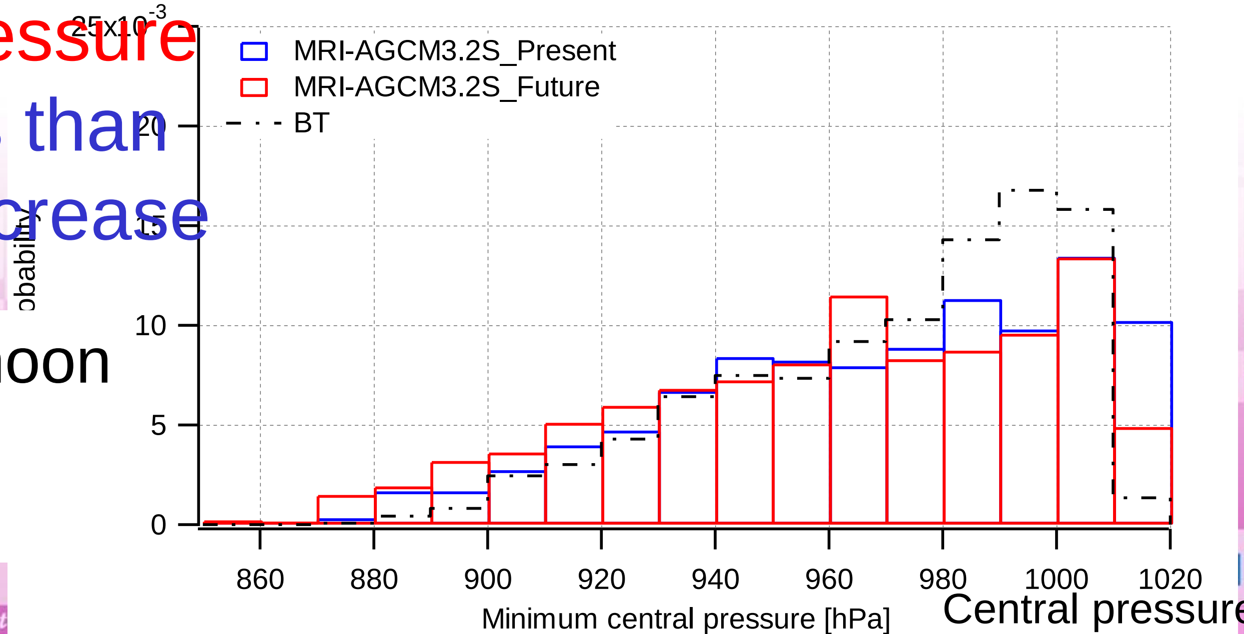
cyclogenesis number
decrease



Current
Future
Best track

Number

Lowest center pressure
frequency less than
930hPa will increase

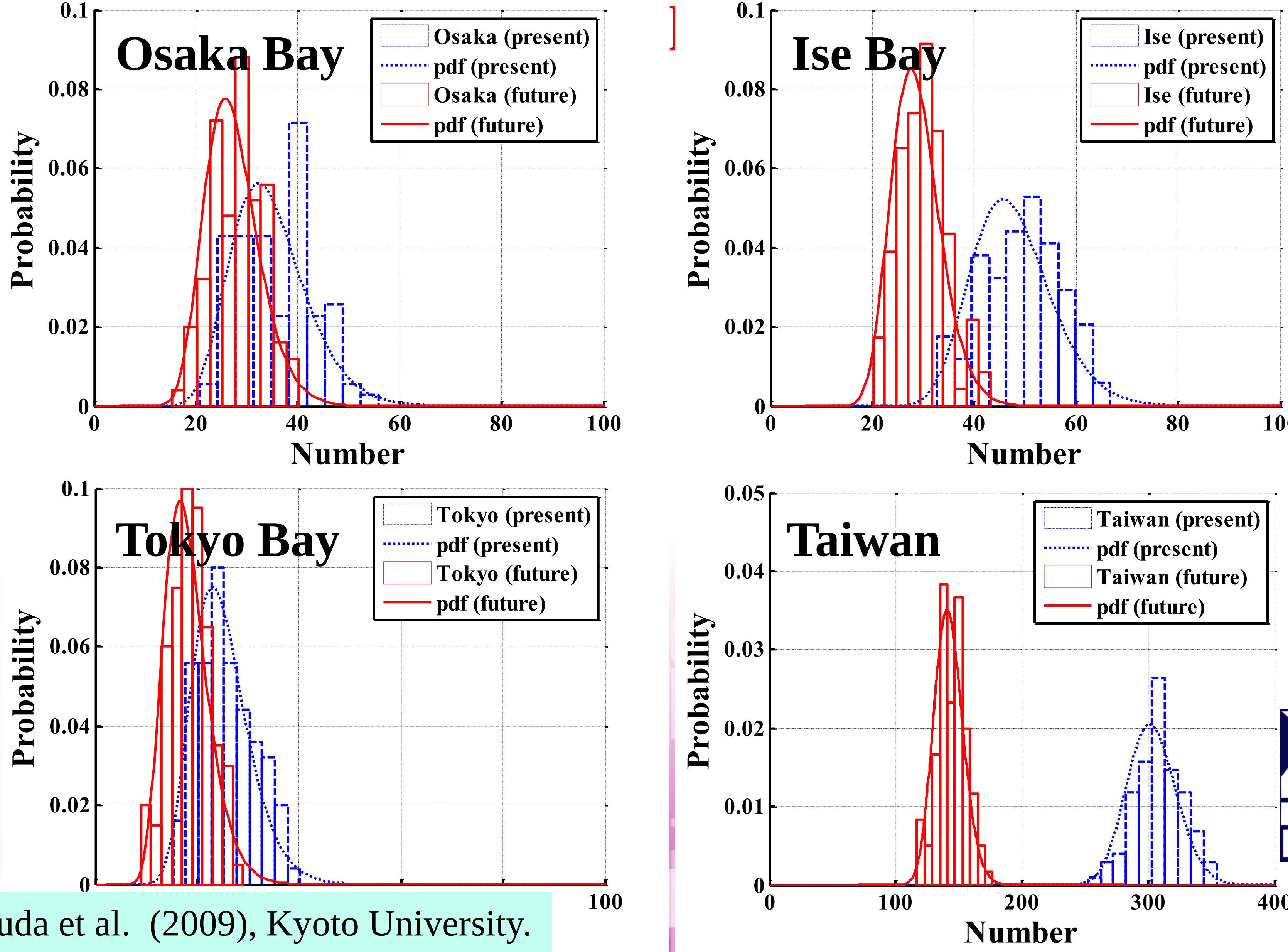


Central pressure

The strongest typhoon
current：865.9 hPa
future：845.4 hPa

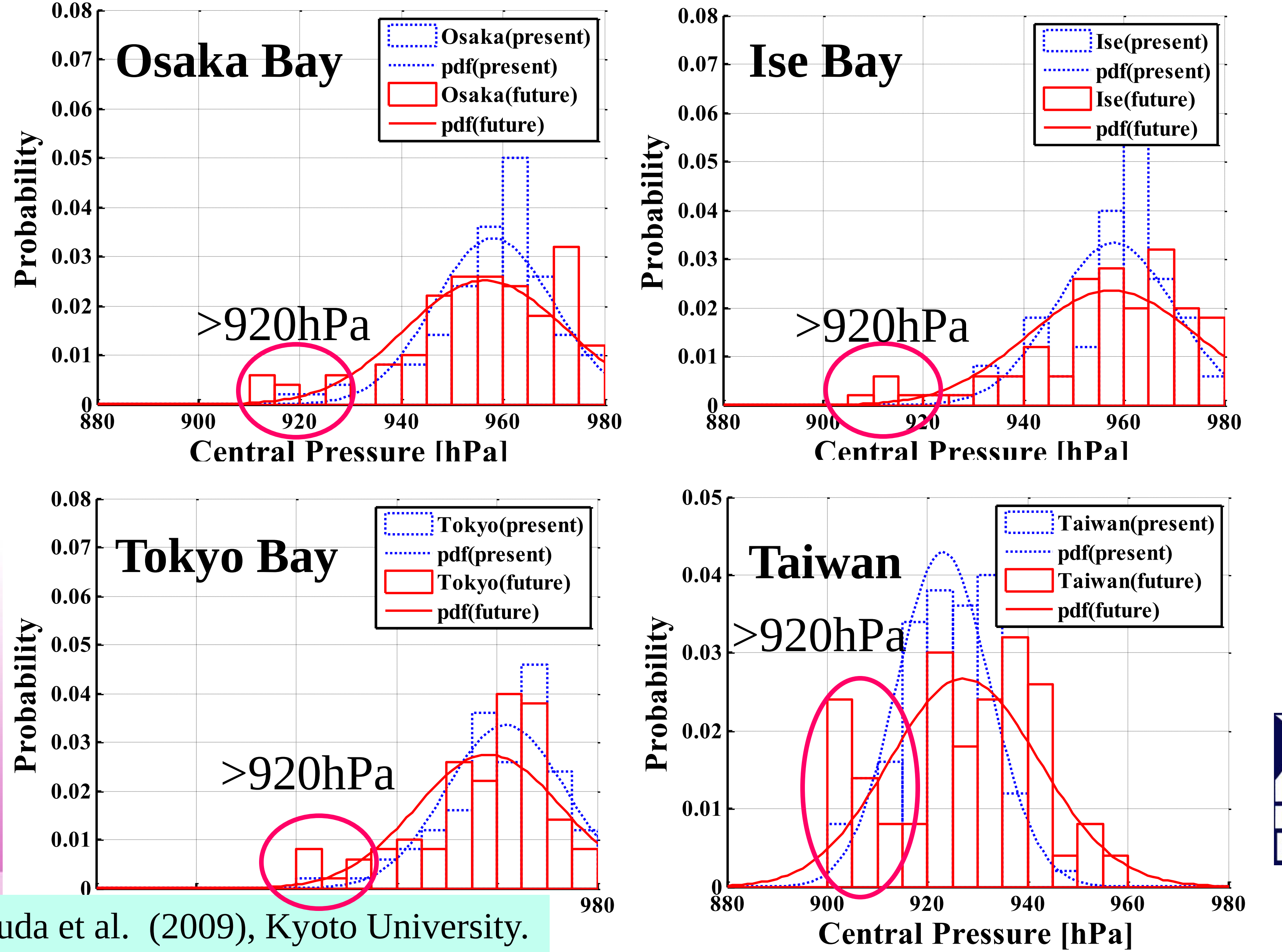
Mase et al (2011)

Probability of typhoon attack for 100yrs



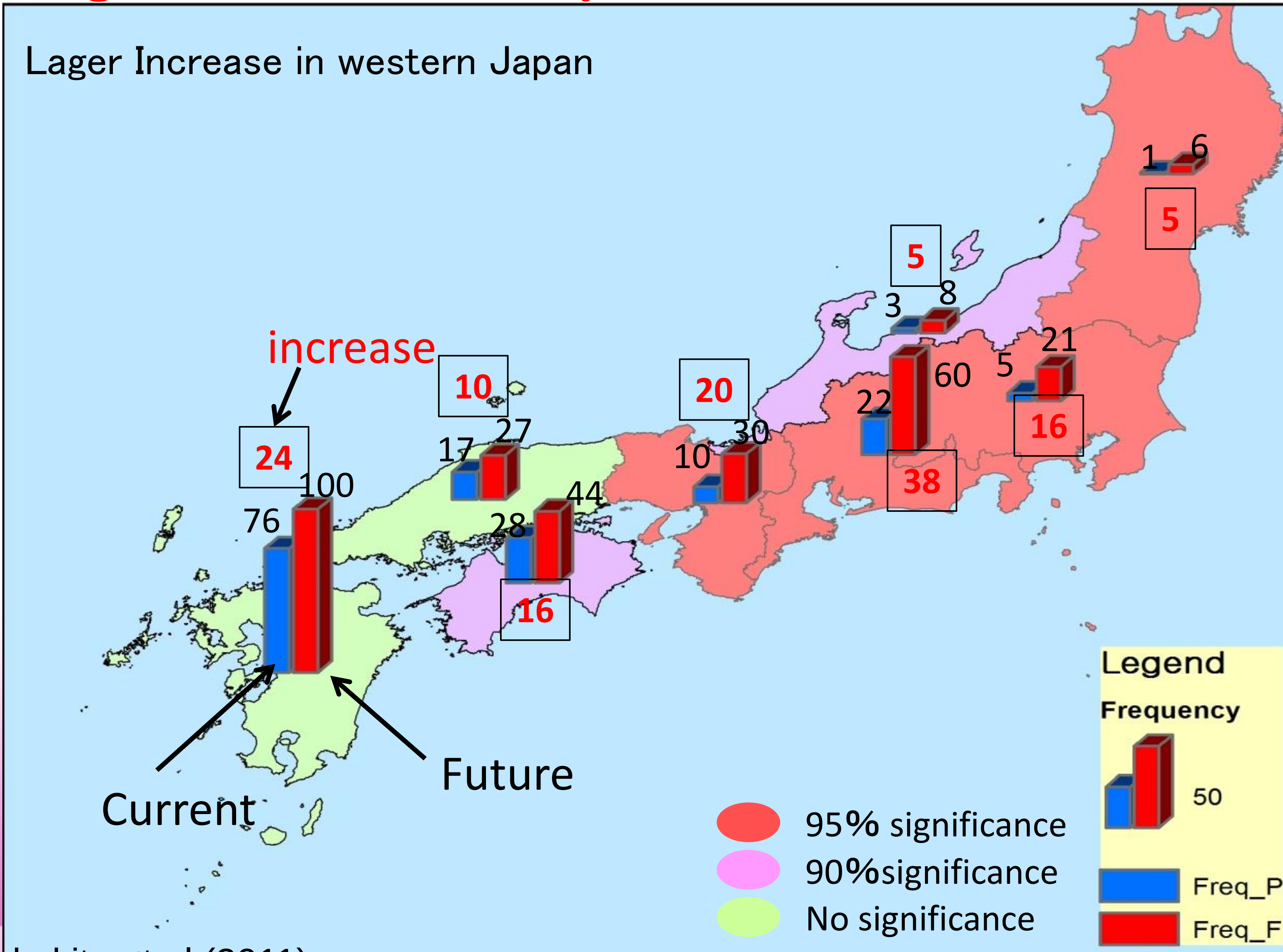
Yasuda et al. (2009), Kyoto University.

Probability of center pressure for 100yrs

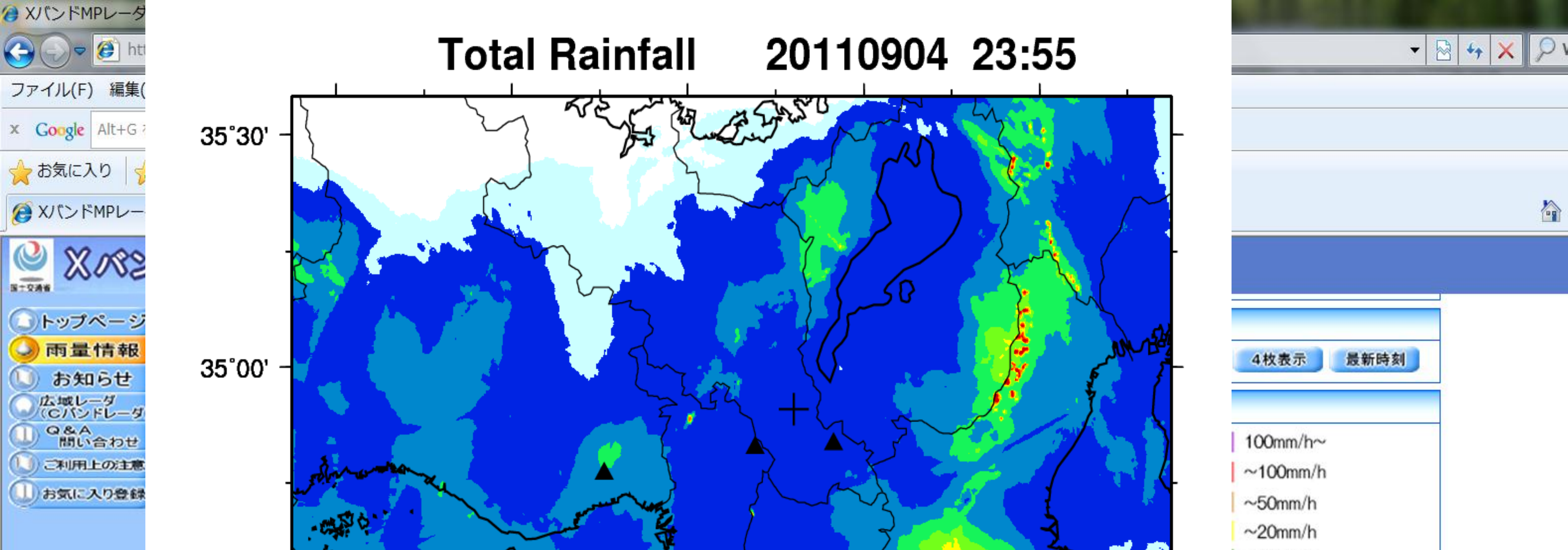
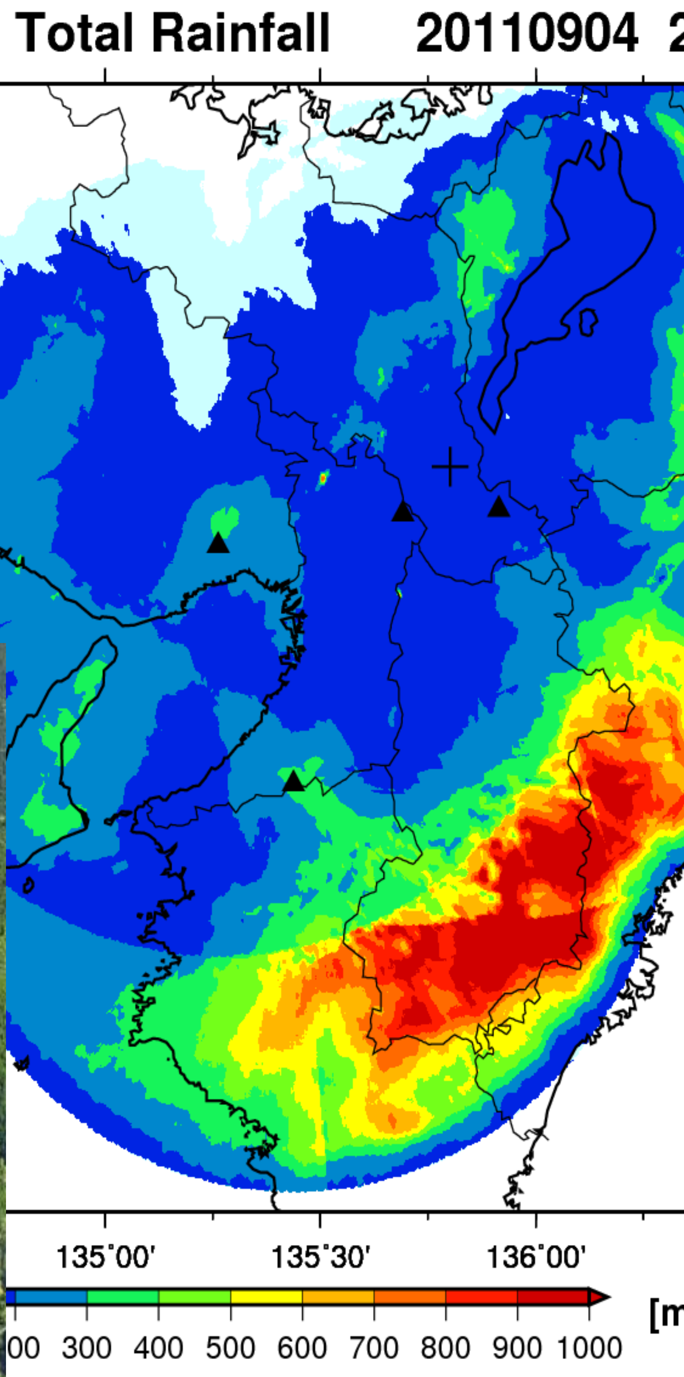


Yasuda et al. (2009), Kyoto University.

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



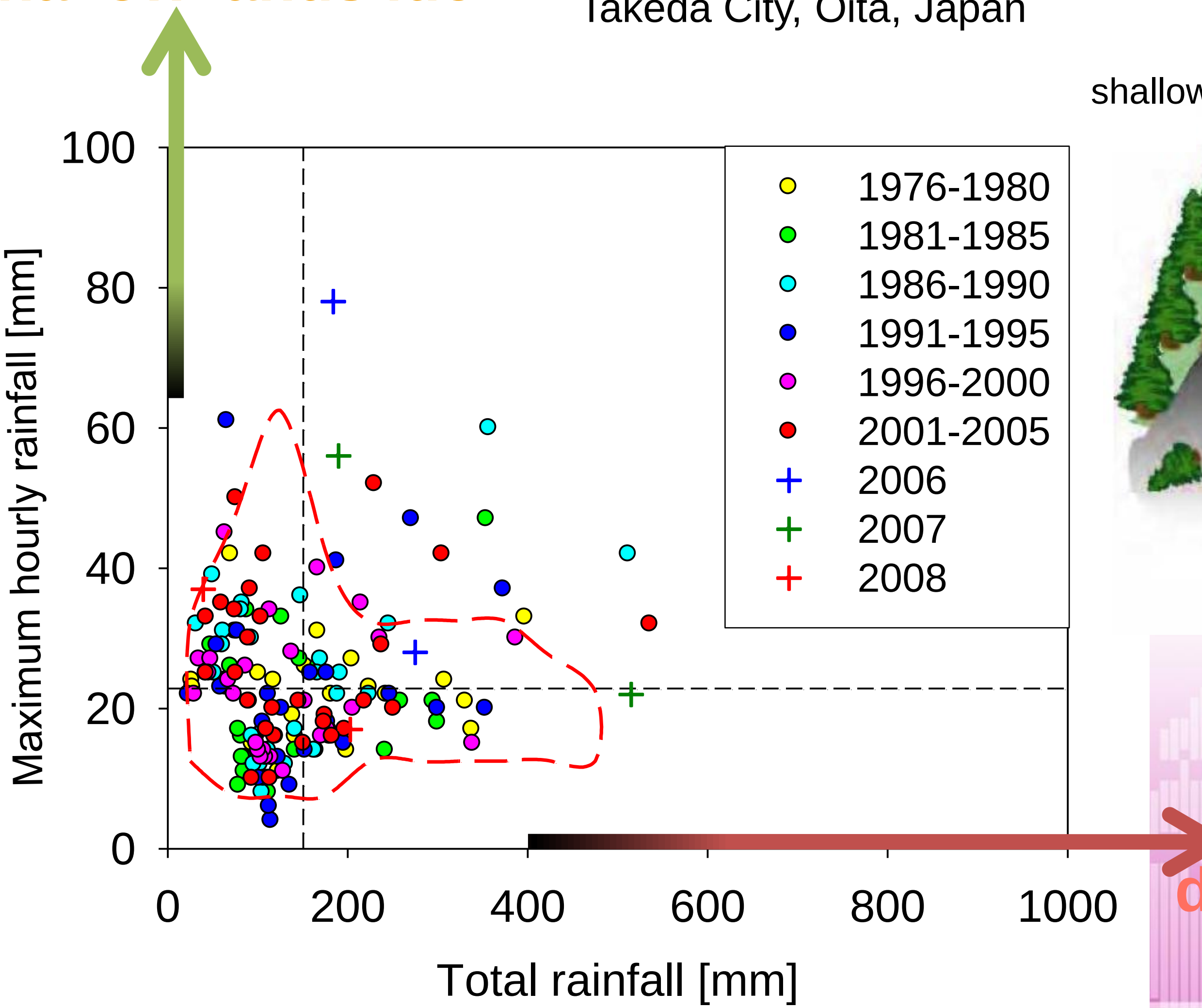
Nakakita et al (2011)


XバンドMPレーダ
ファイル(F)
編集(
Google
Alt+G
お気に入り
XバンドMPレー
トップページ
雨量情報
お知らせ
広域レーダ
(Cバンドレーダ
Q & A
問い合わせ
ご利用上の注意
お気に入り登録
4枚表示
最新時刻
100mm/h~
~100mm/h
~50mm/h
~20mm/h

Total Rainfall 20110904 23:55
35˚30'
35˚00'
135˚00'
135˚30'
136˚00'
00 300 400 500 600 700 800 900 1000
[m

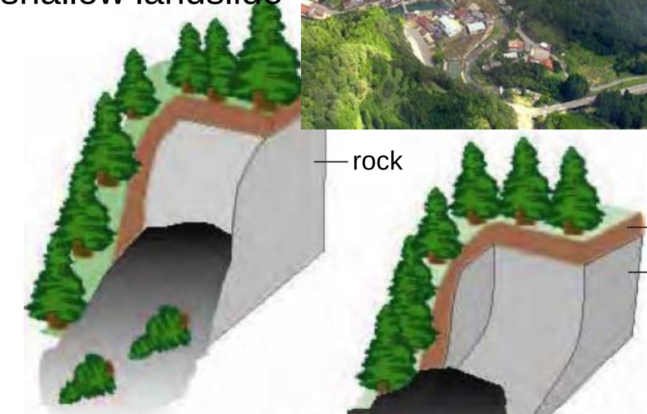
Total rainfall versus maximum hourly

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

risk of shallow landslide

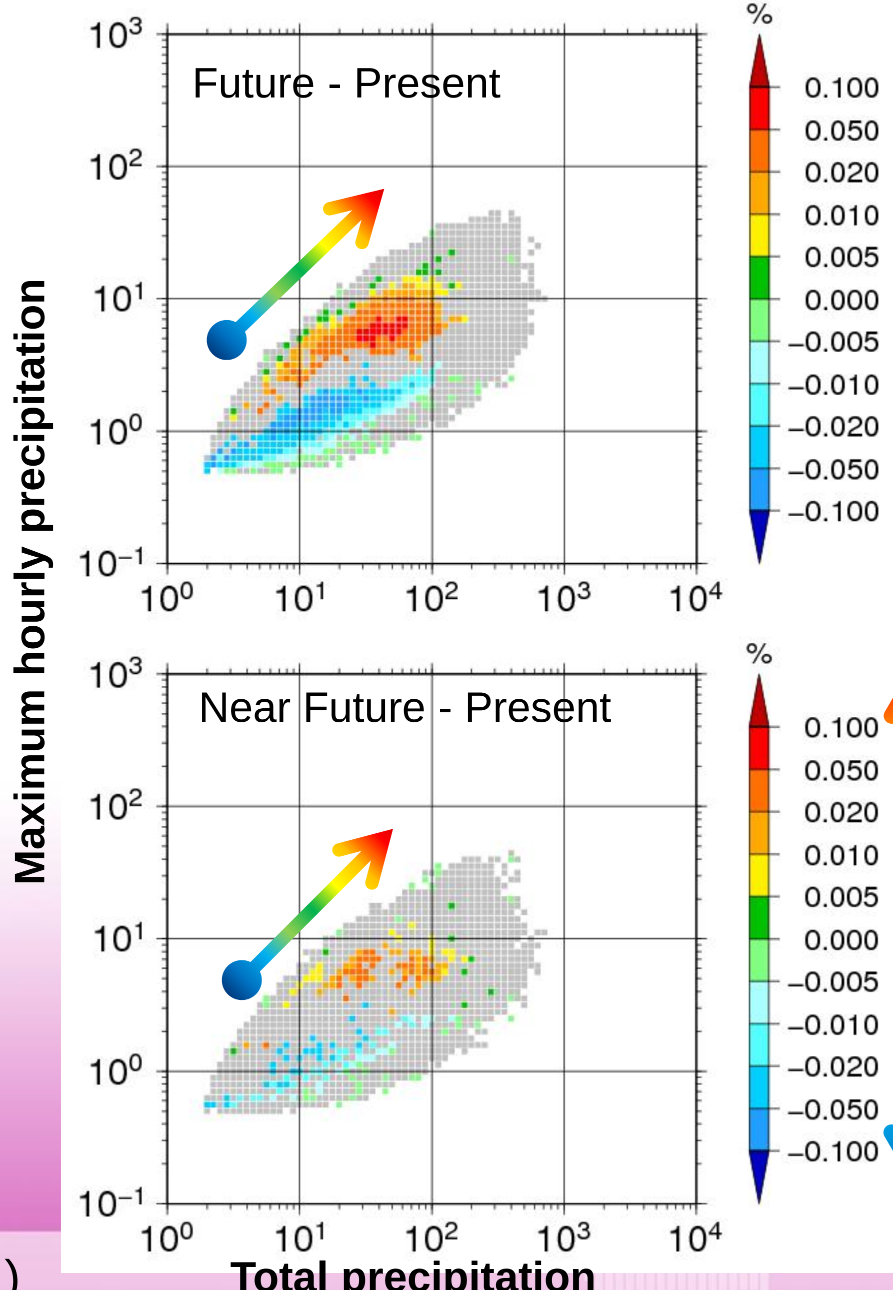


shallow landslide



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

increase

frequency

decrease

Oku et al (2011)

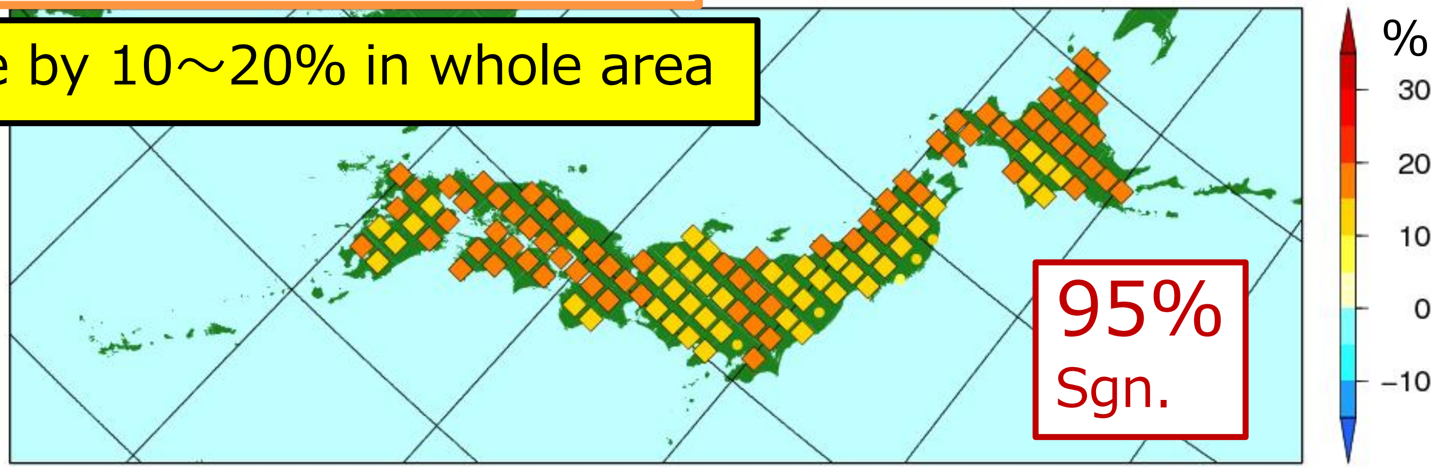
KAKUSHIN

Increase in land slide risk

Fut. – Pres.

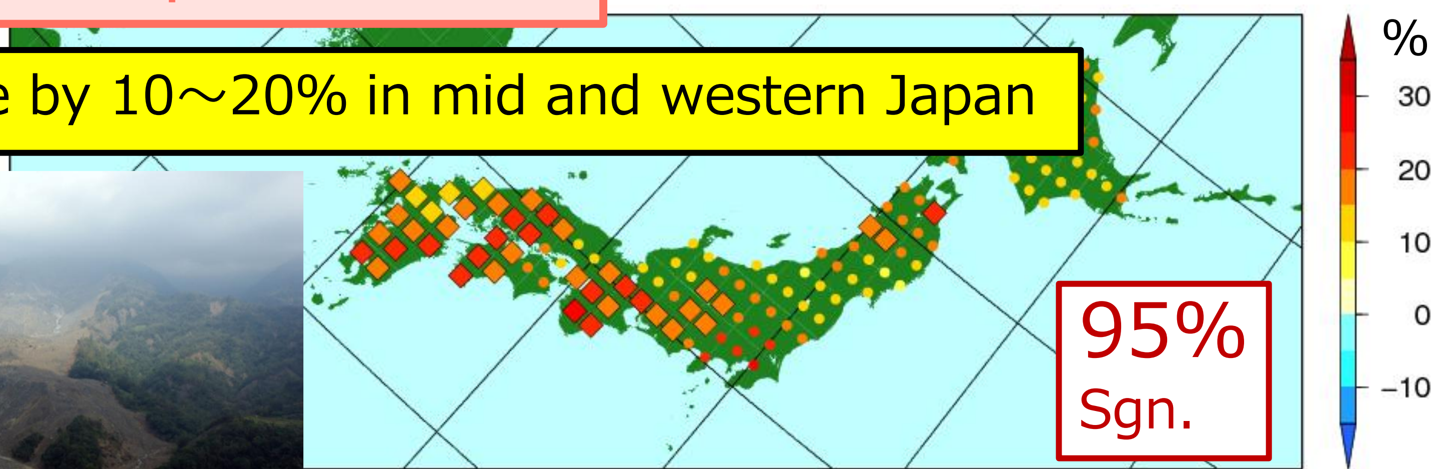
Risk of shallow land slide

Increase by 10～20% in whole area



Risk of deep land slide

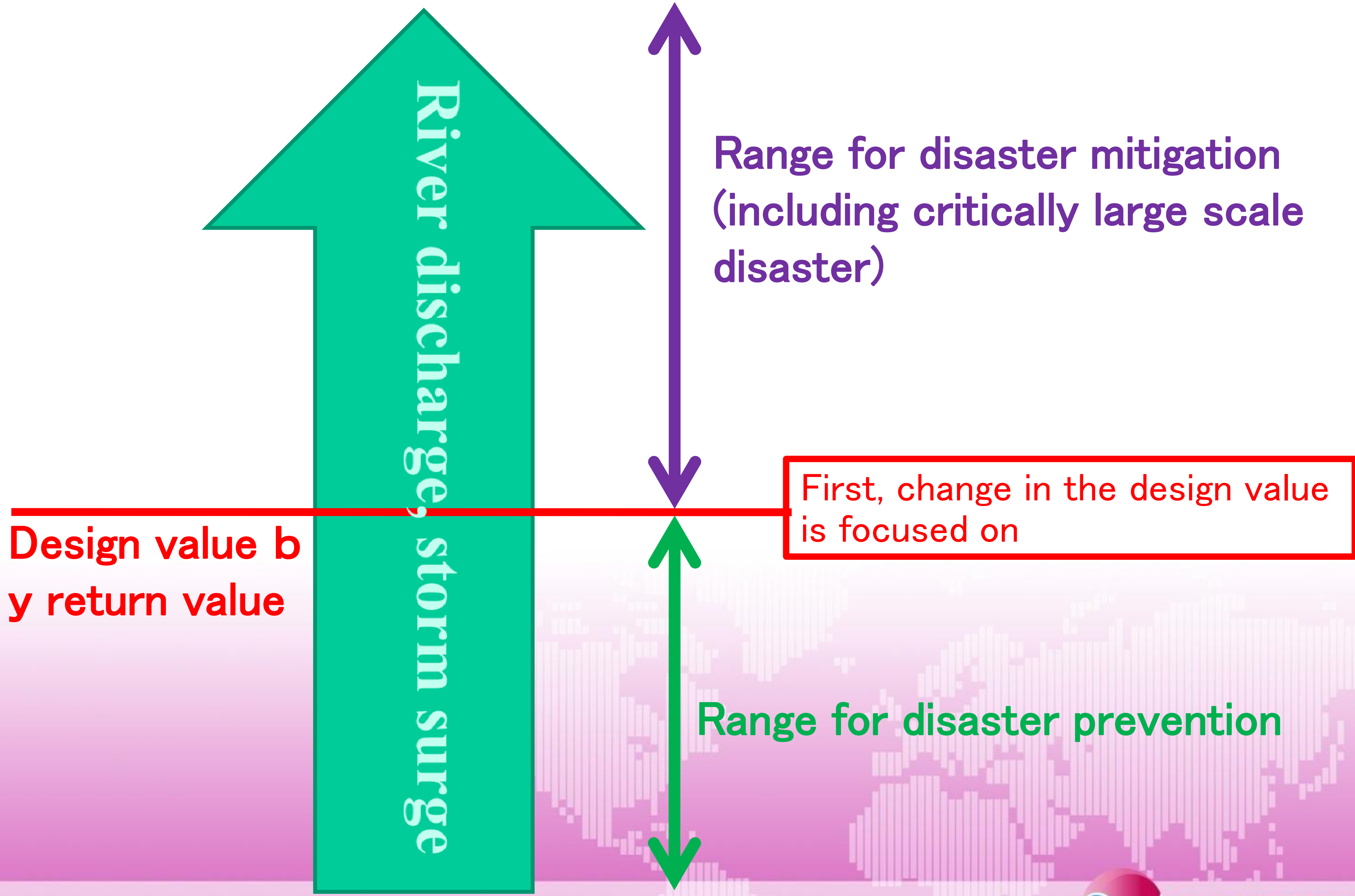
Increase by 10～20% in mid and western Japan



Oku et al (2011)

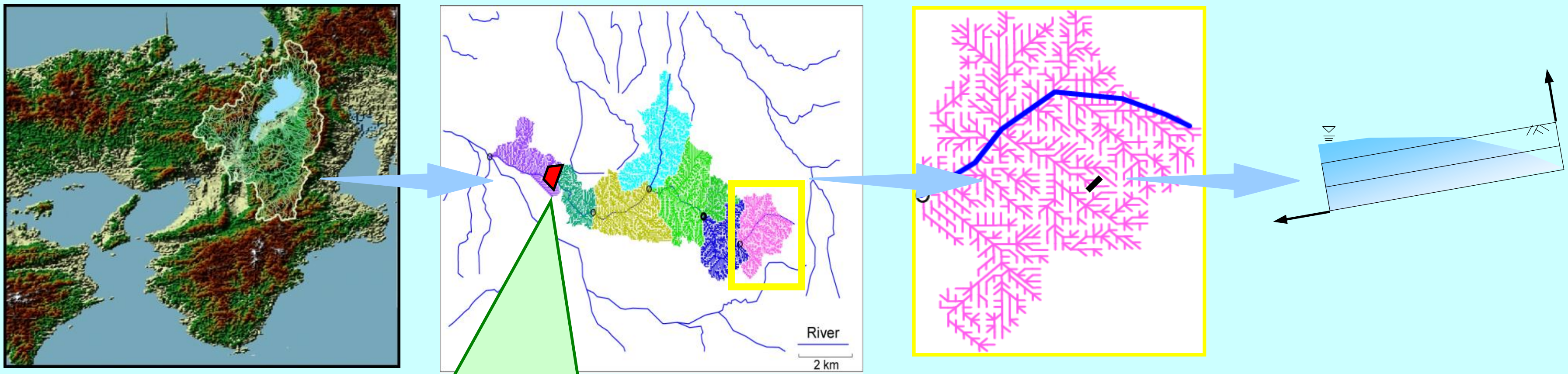
KAKUSHIN

Design value for river discharge and storm surge

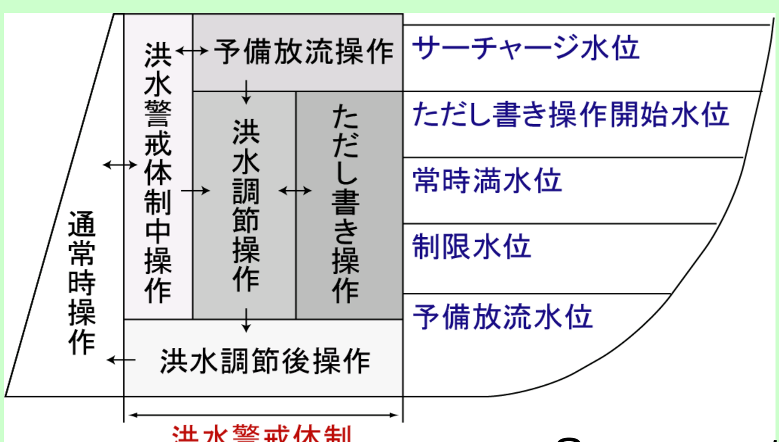


Introducing reservoir operation models into distributed runoff model

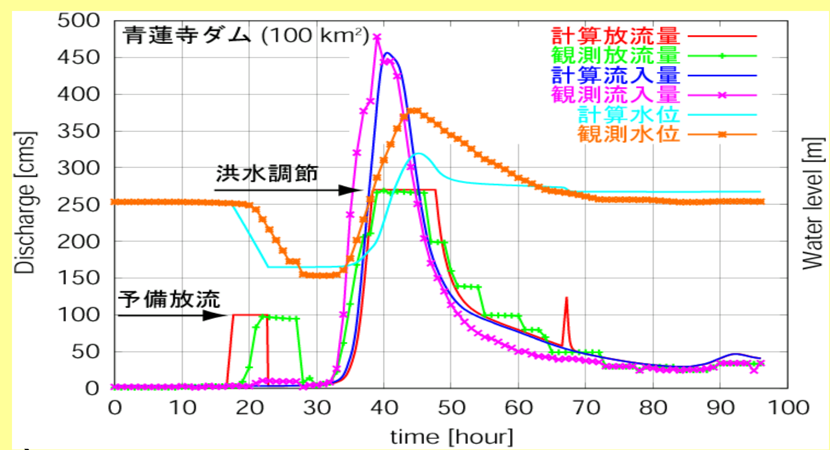
System of distributed runoff model



Reservoir operation model



Example of combined computation

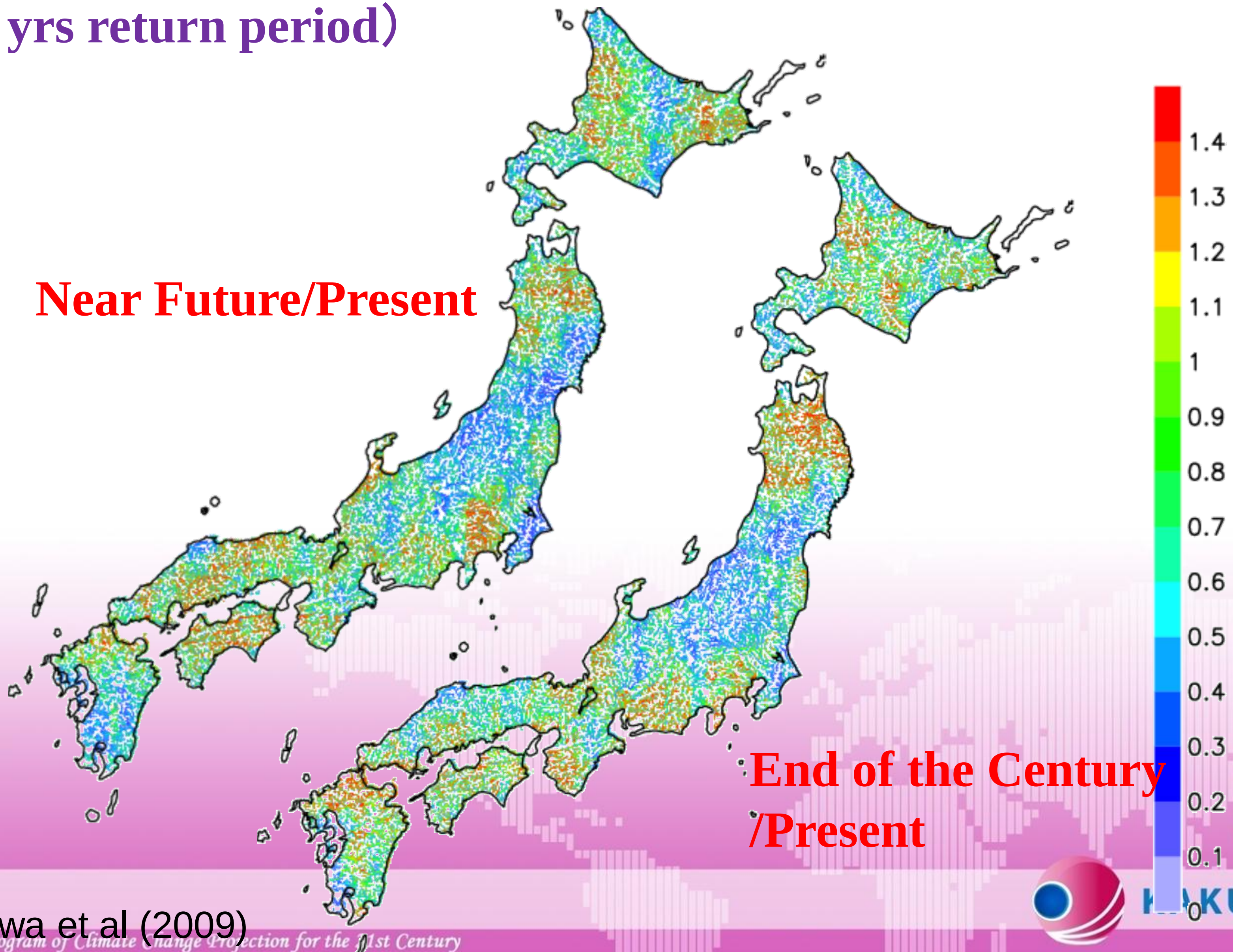


Sayama et al (2008)

Impact Assessment on River Regime（Flood）

Annual Max. Discharge
（100 yrs return period）

Near Future/Present



End of the Century /Present

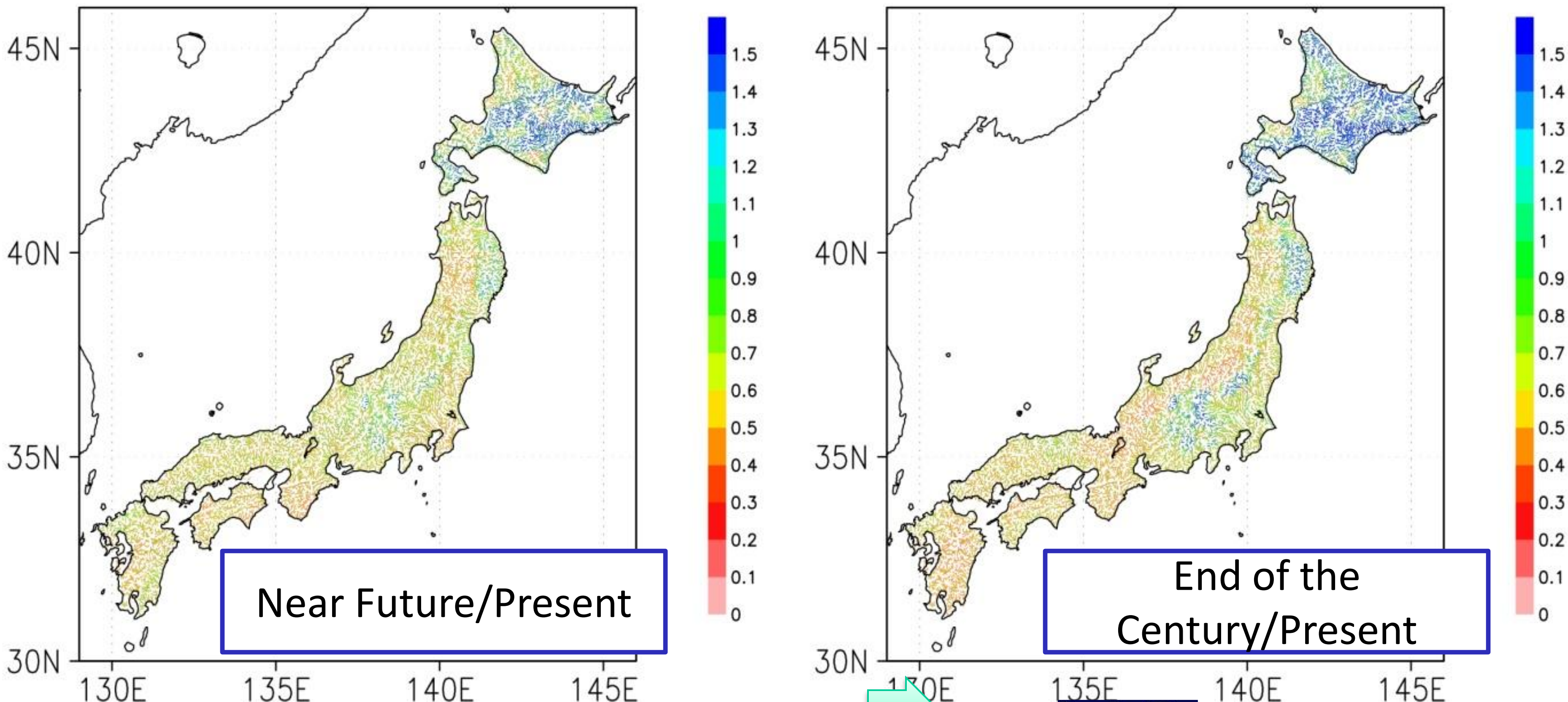
DPRI-KU

KAKUSHIN

Tachikawa et al (2009)

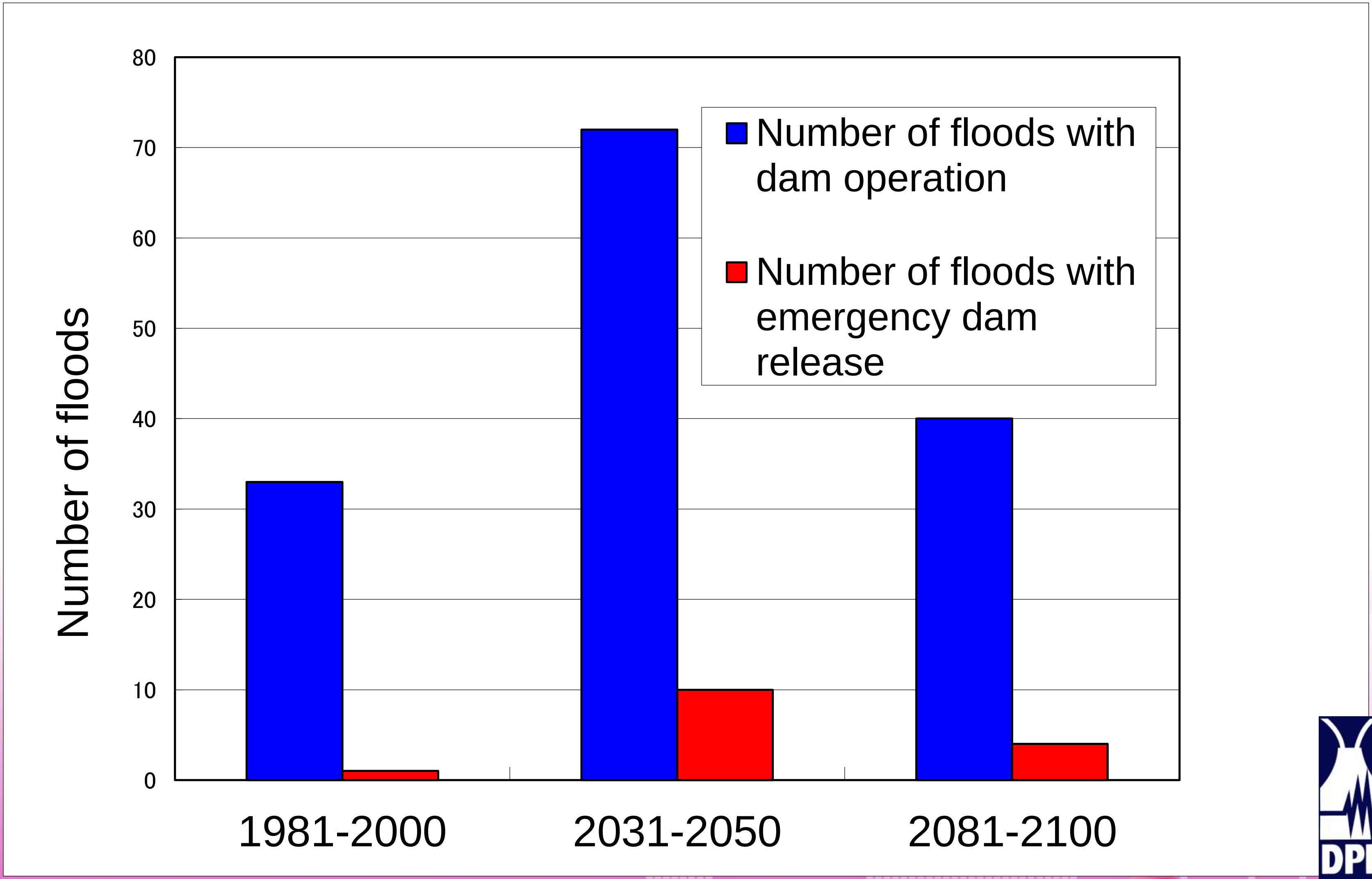
Impact Assessment on River Regime（Drought）

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



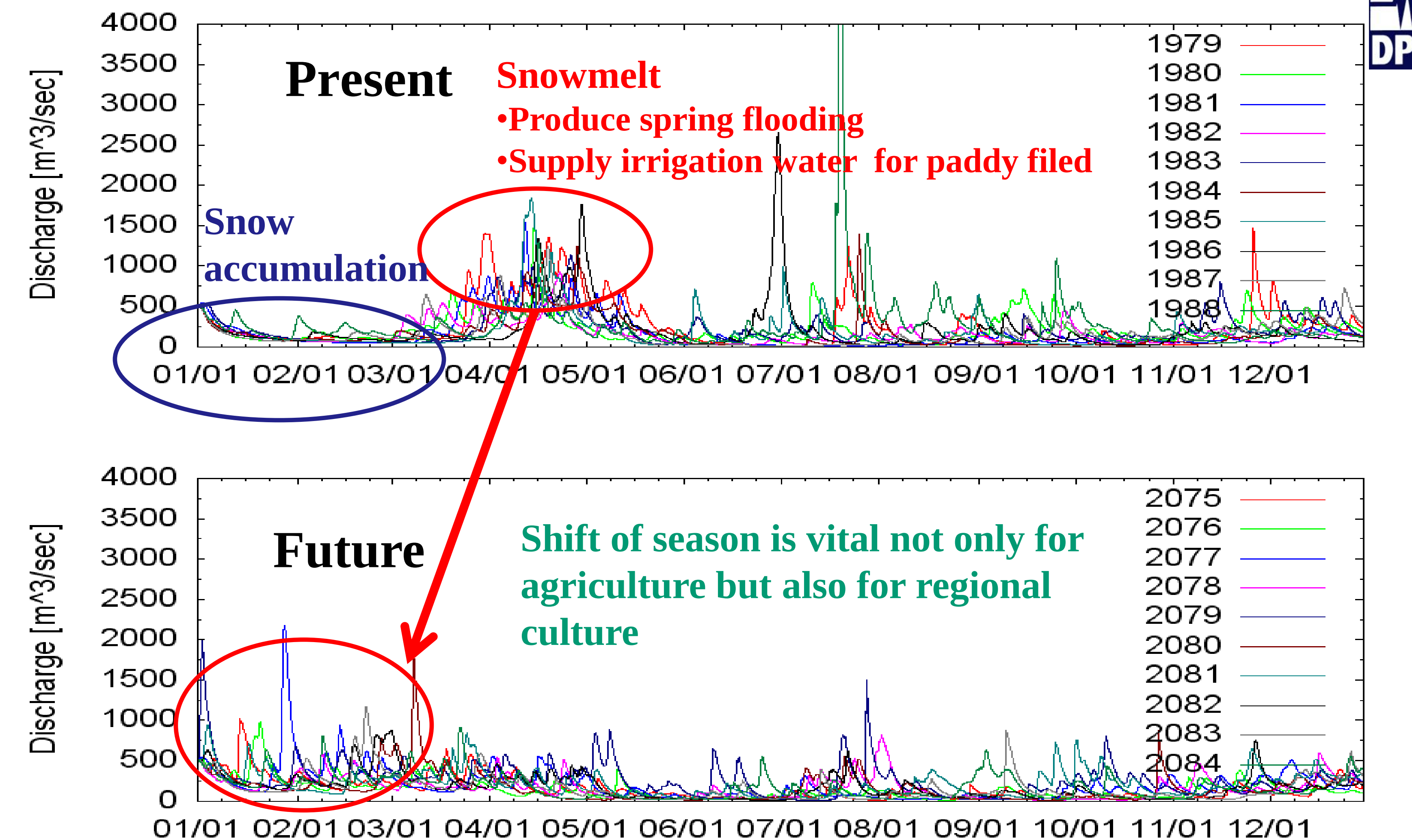
Tachikawa et al (2009)

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



Sayama et al. (2008), Kyoto University.

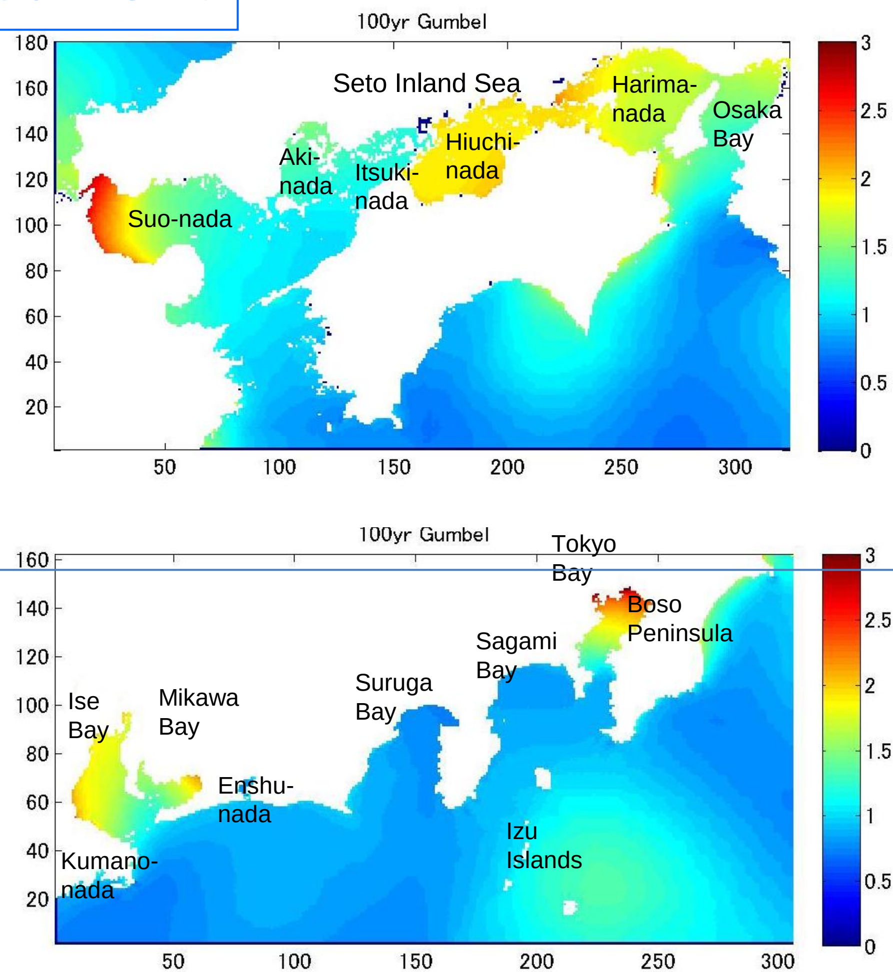
Influence of changing in snowfall and snow melt (Mogami River: Japan seaside in Tohoku)



Tachikawa et al., 2008, Kyoto University

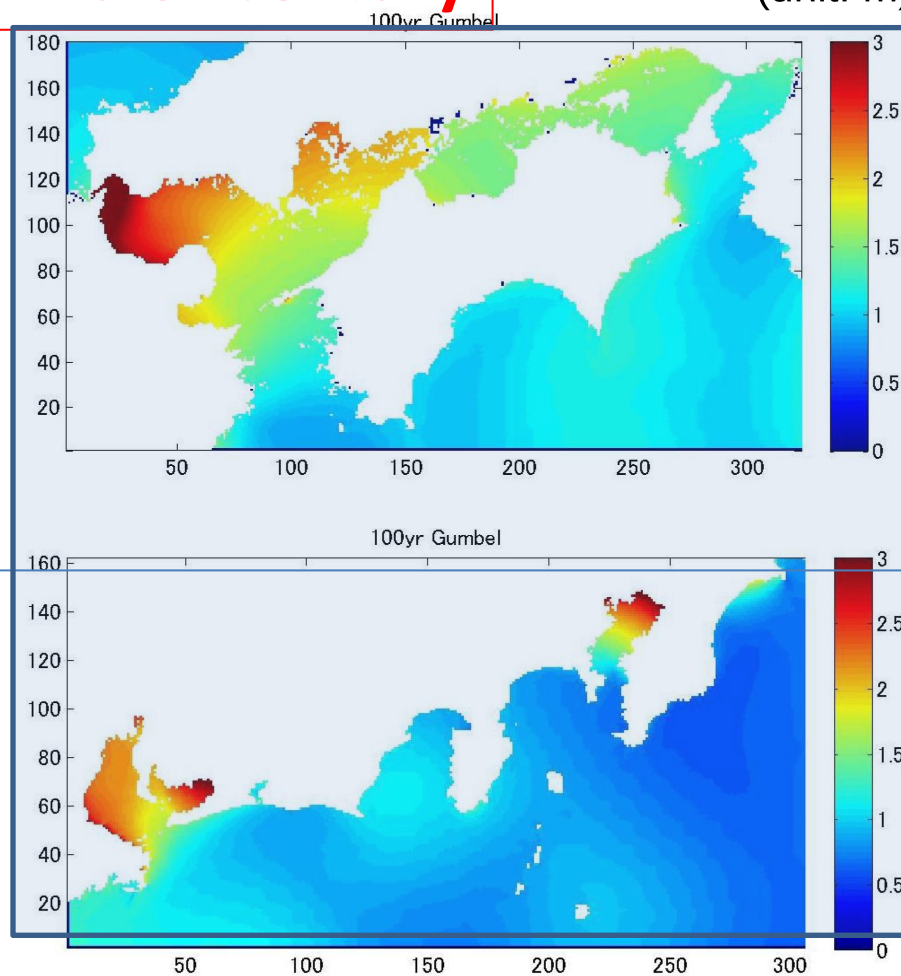
100-years return values of Storm surge (deviation from the average year value)

Current



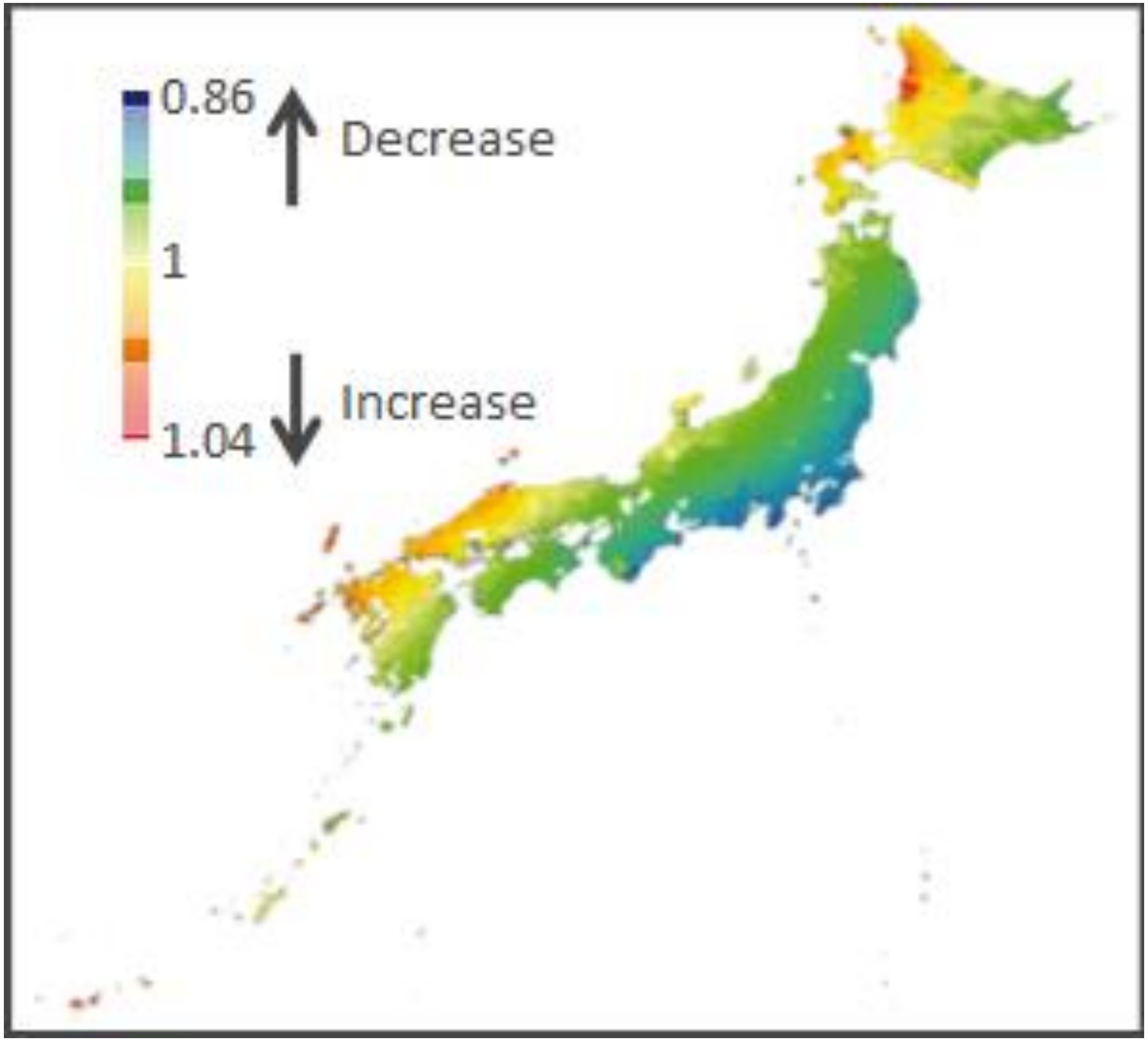
End of Century

(unit: m)



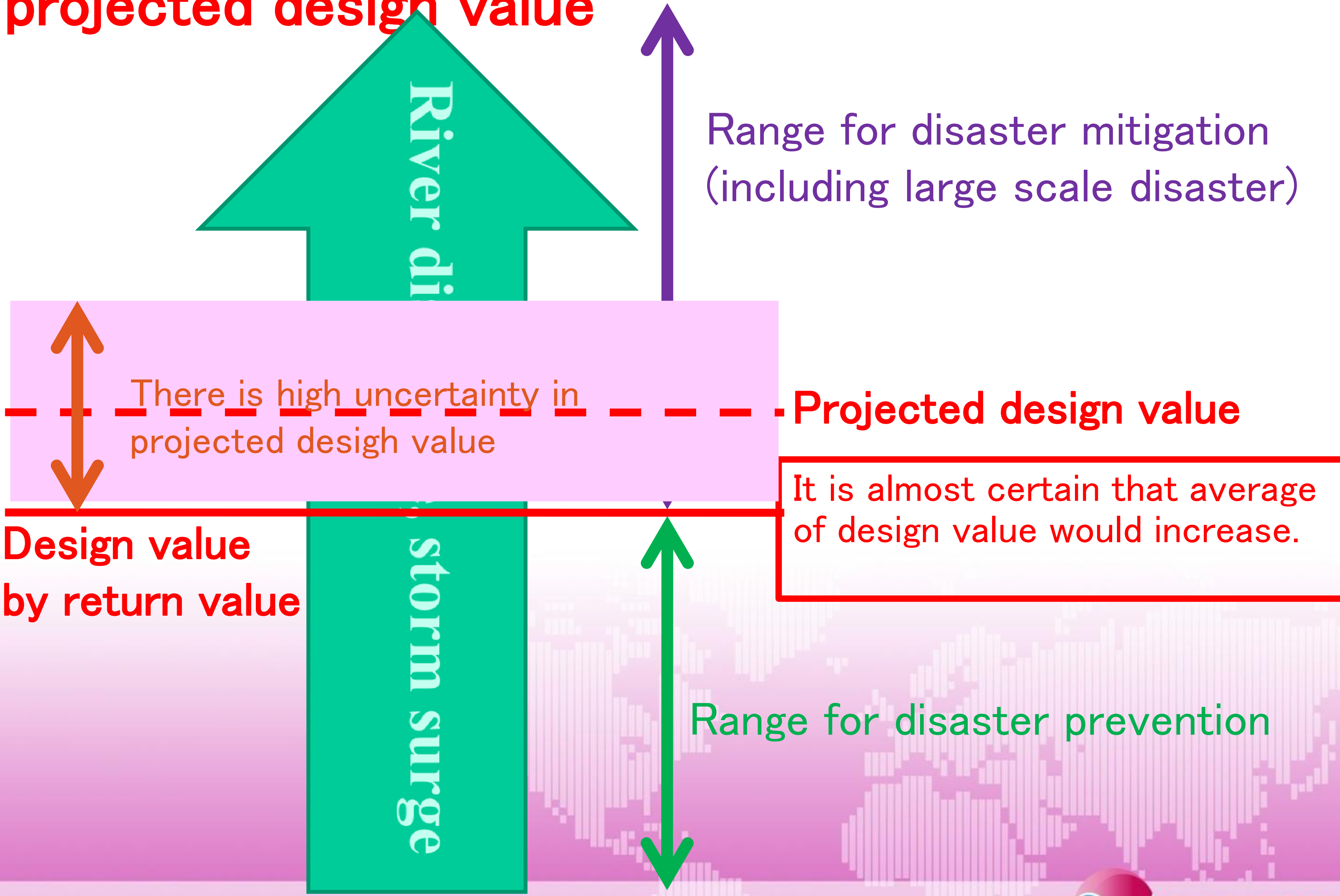
Mase et al (2011)

Change in building risks by wind

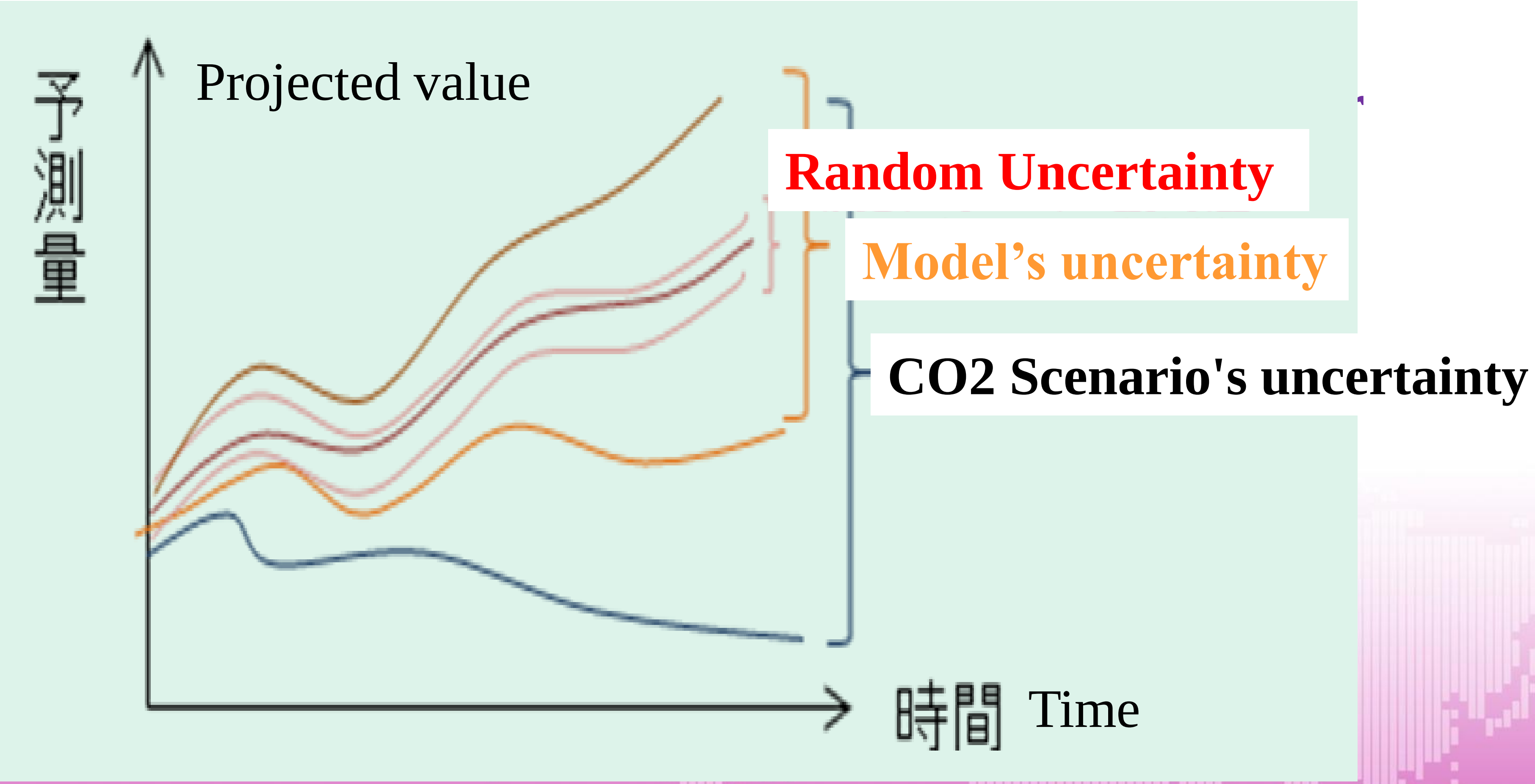


Maruyama et al (2011)

There is high uncertainty in projected design value



Uncertainty inherent to GCM projection

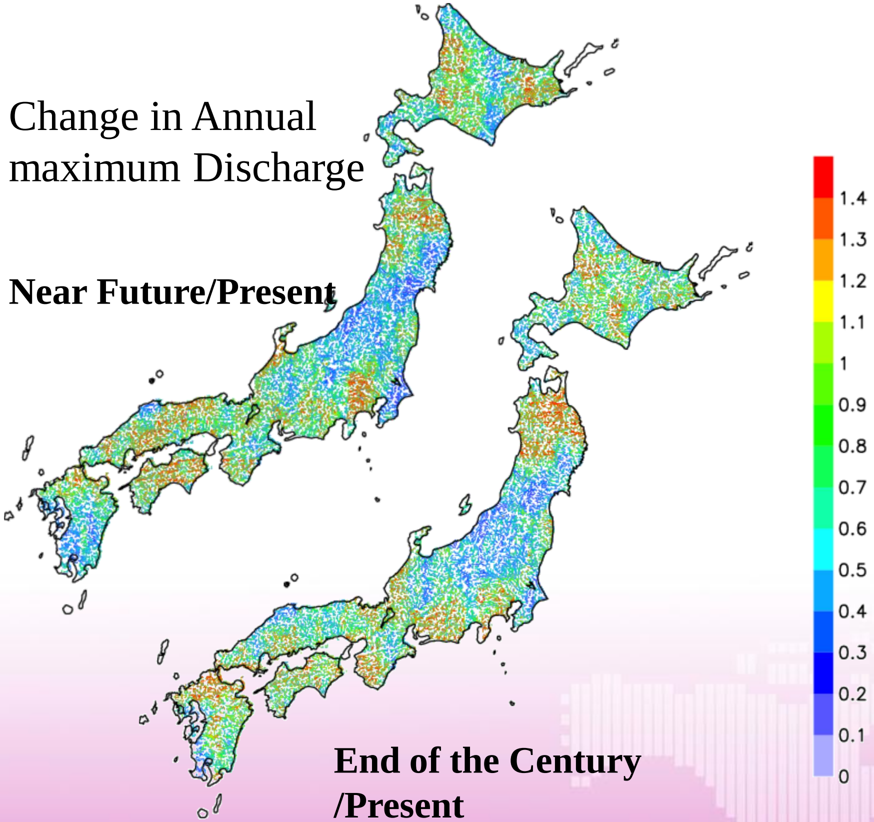


Accuracy of estimated annual max. discharge

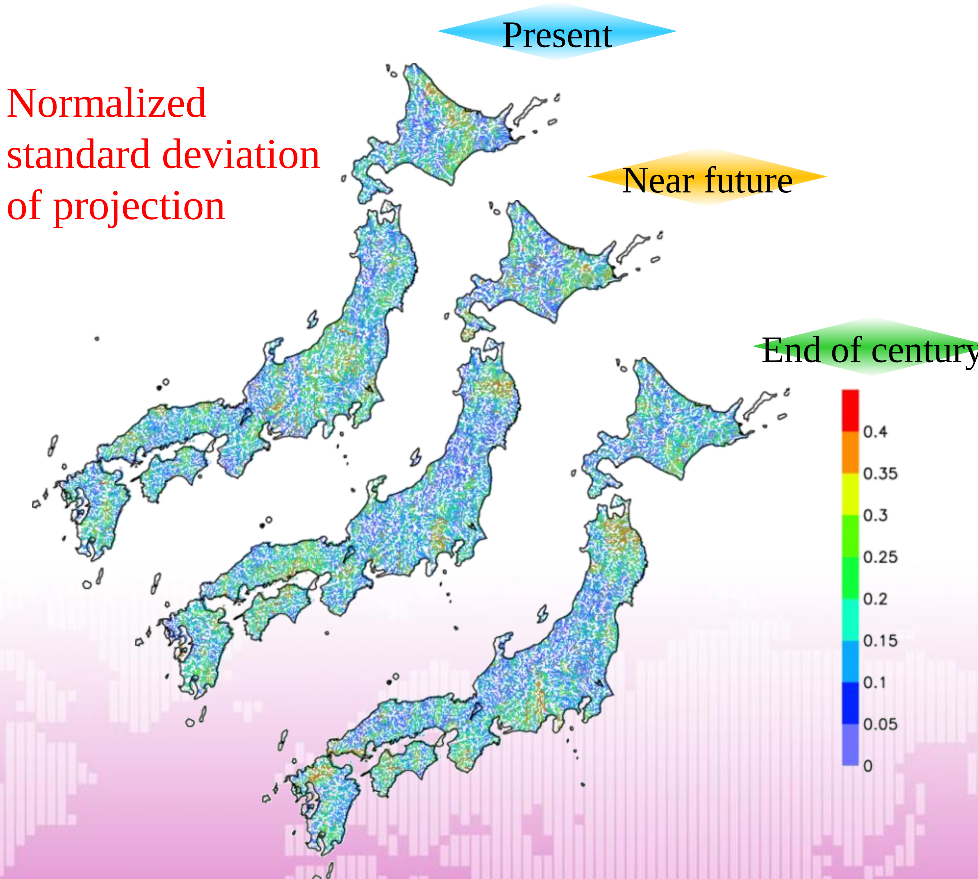
Accuracy of 100 years return value (Jackknife method)

With 25-years single time series

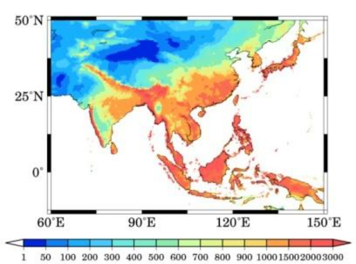
Change in Annual maximum Discharge



Normalized standard deviation of projection



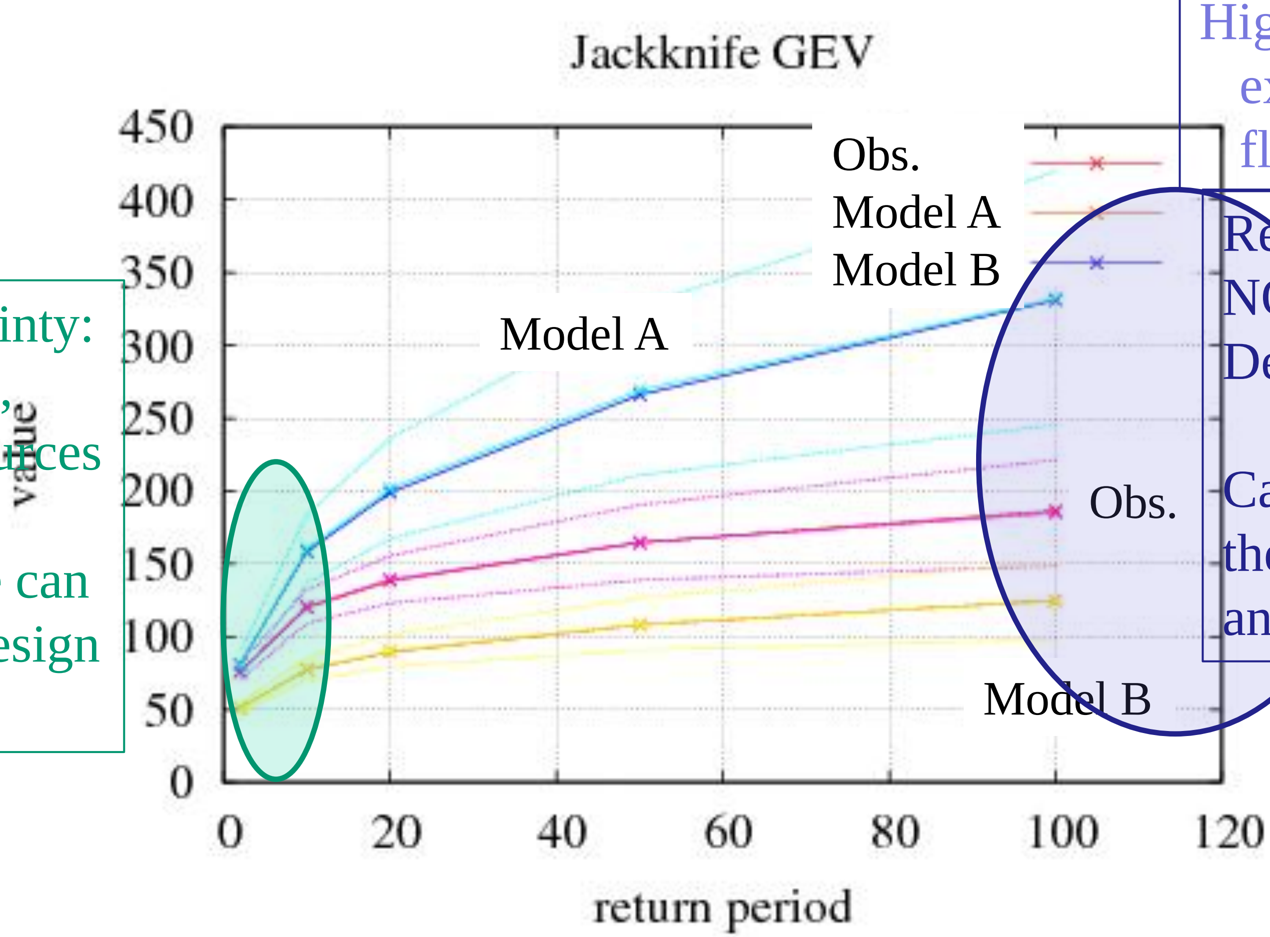
The larger the projected value is, the larger the standard deviation is.



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)

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 worst case scenario into consideration

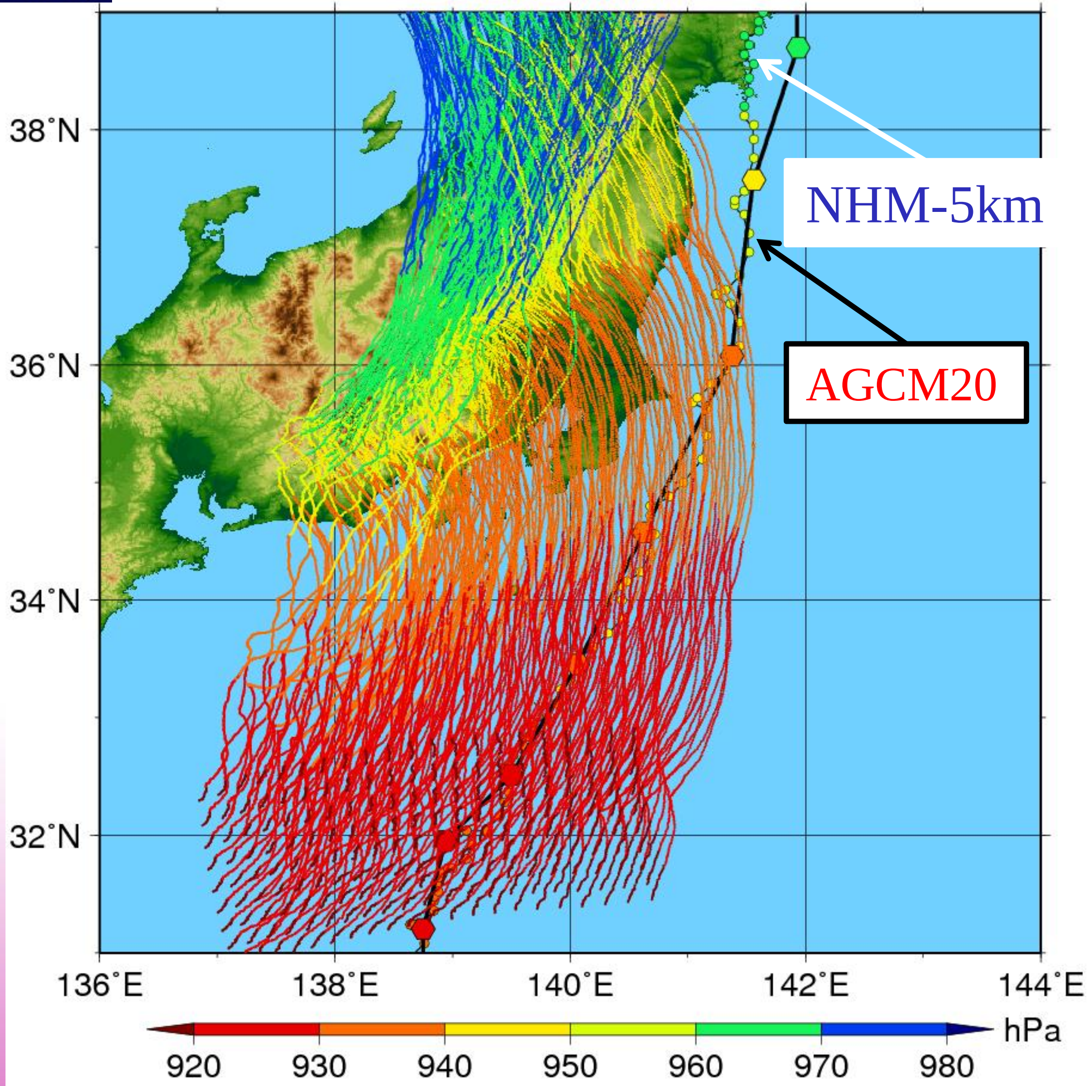
KAKUSHIN

There is high uncertainty in projected design value

- We are almost sure that average of design value would increase.
- However, projected increase in design value is merely rough estimation,
- because 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 worst case typhoon would pass through, even though we cannot estimate return period.

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



Virtual Shifting of typhoons initial position by keeping potential vorticity same

(a vorgas method)

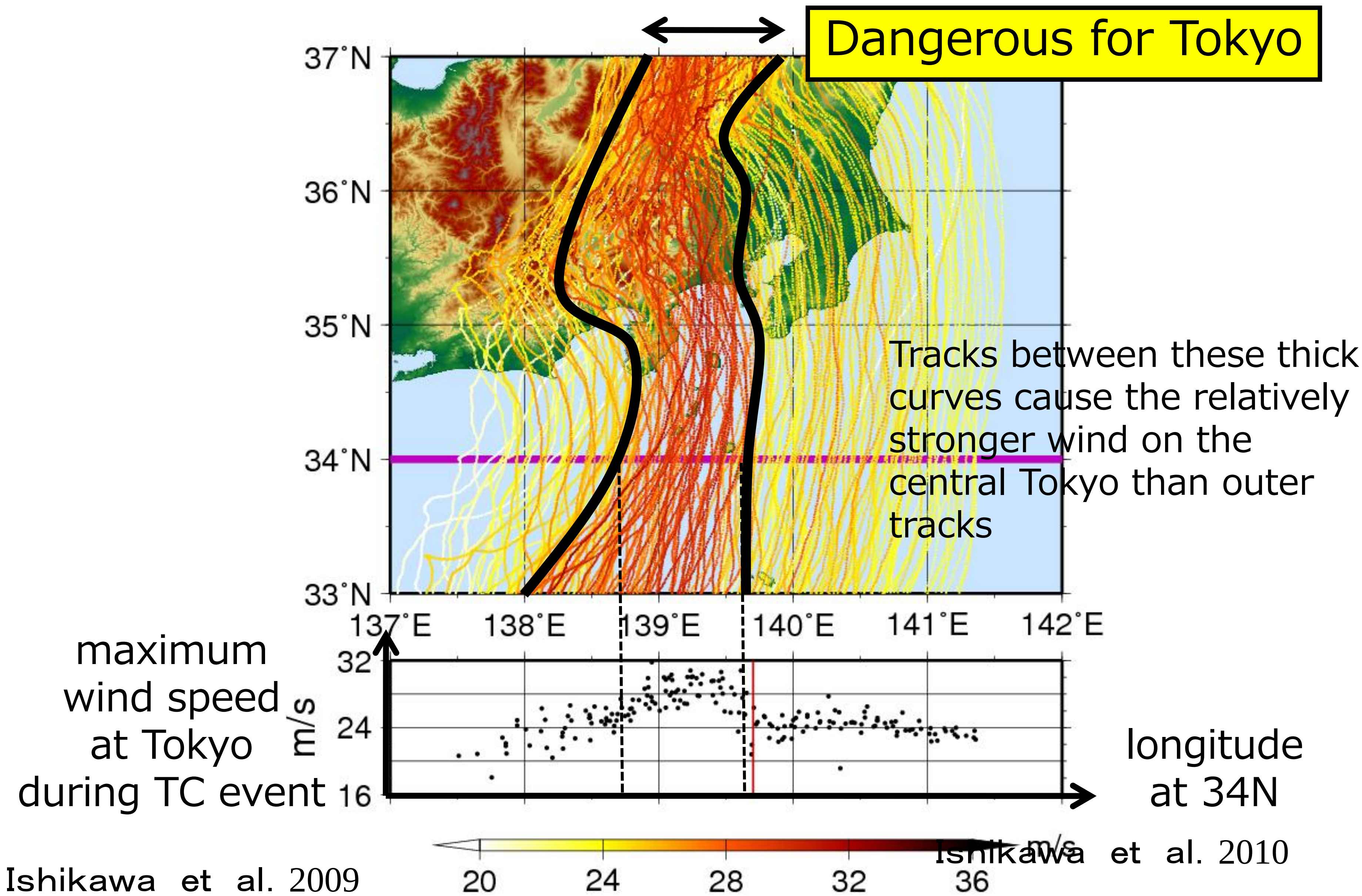
Dynamic downscale by RCM

Worst case impact assessment on

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

Ishikawa et al (2009)

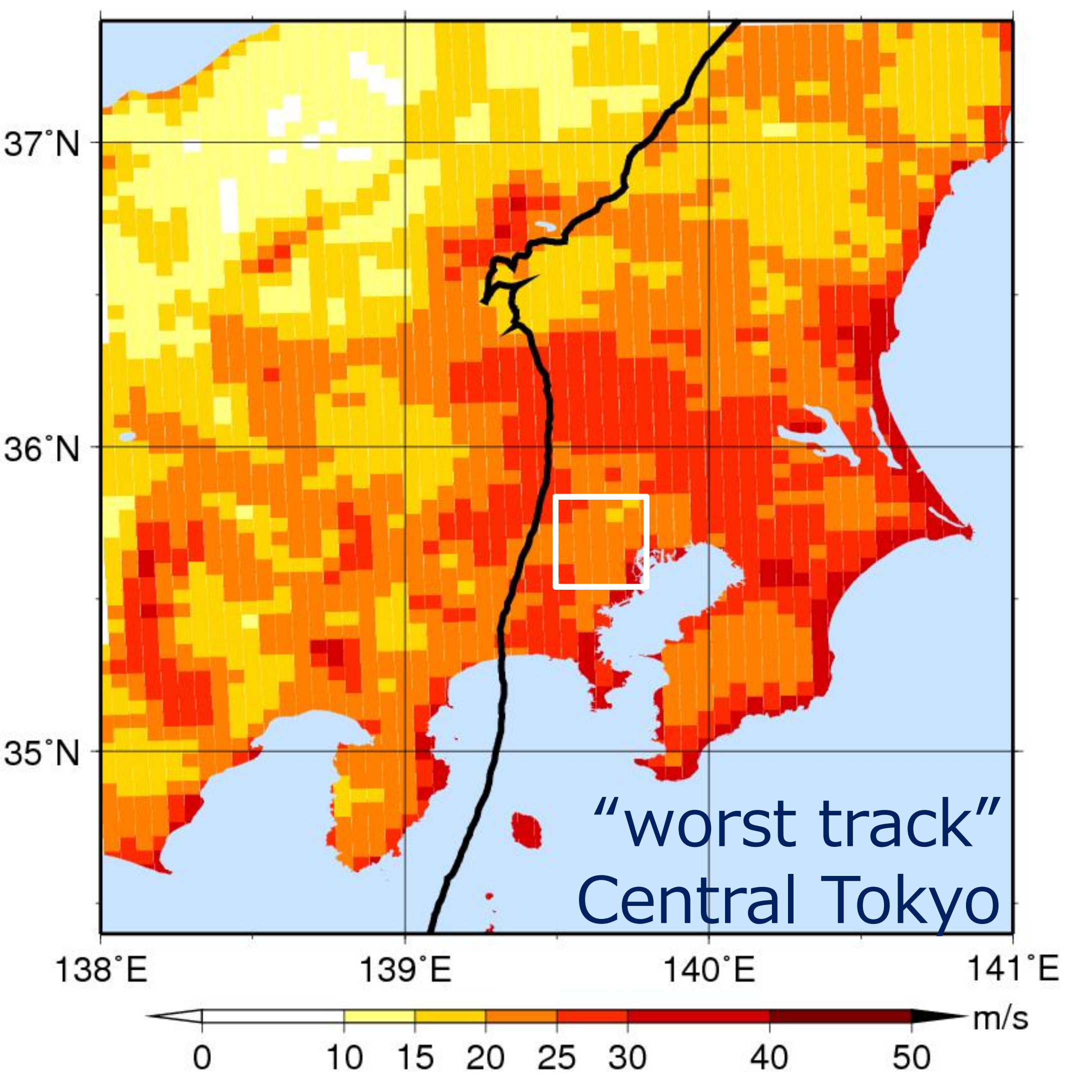
Track and wind speed

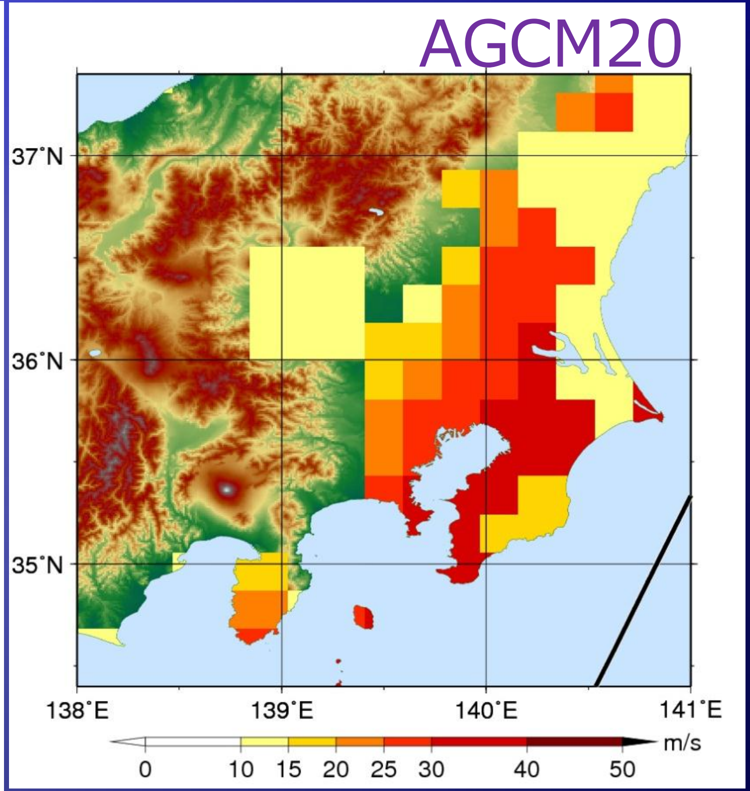


Ishikawa et al. 2010

Ishikawa et al. 2009

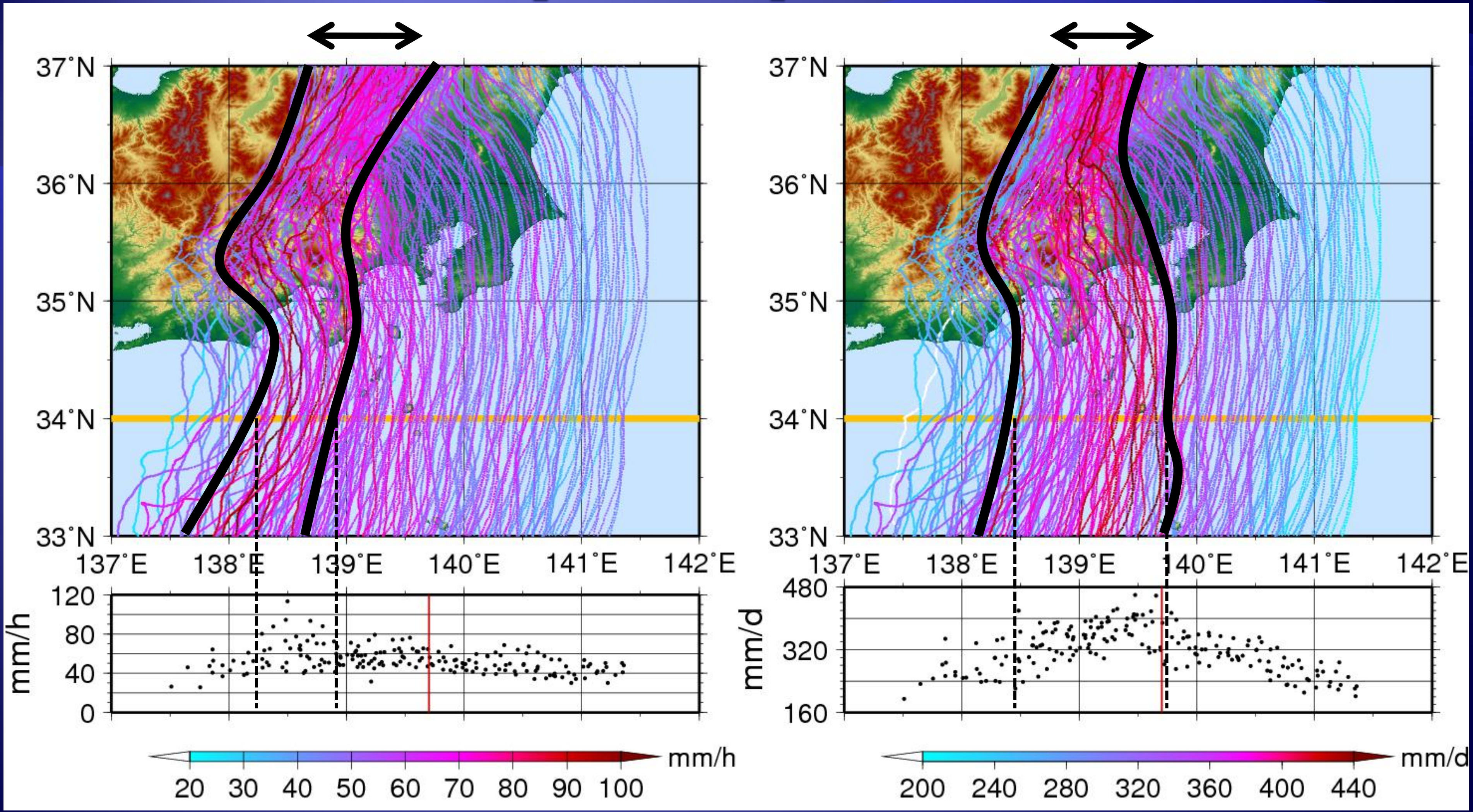
Probable maximum Wind speed





Ishikawa et al. 2009

Track and precipitation

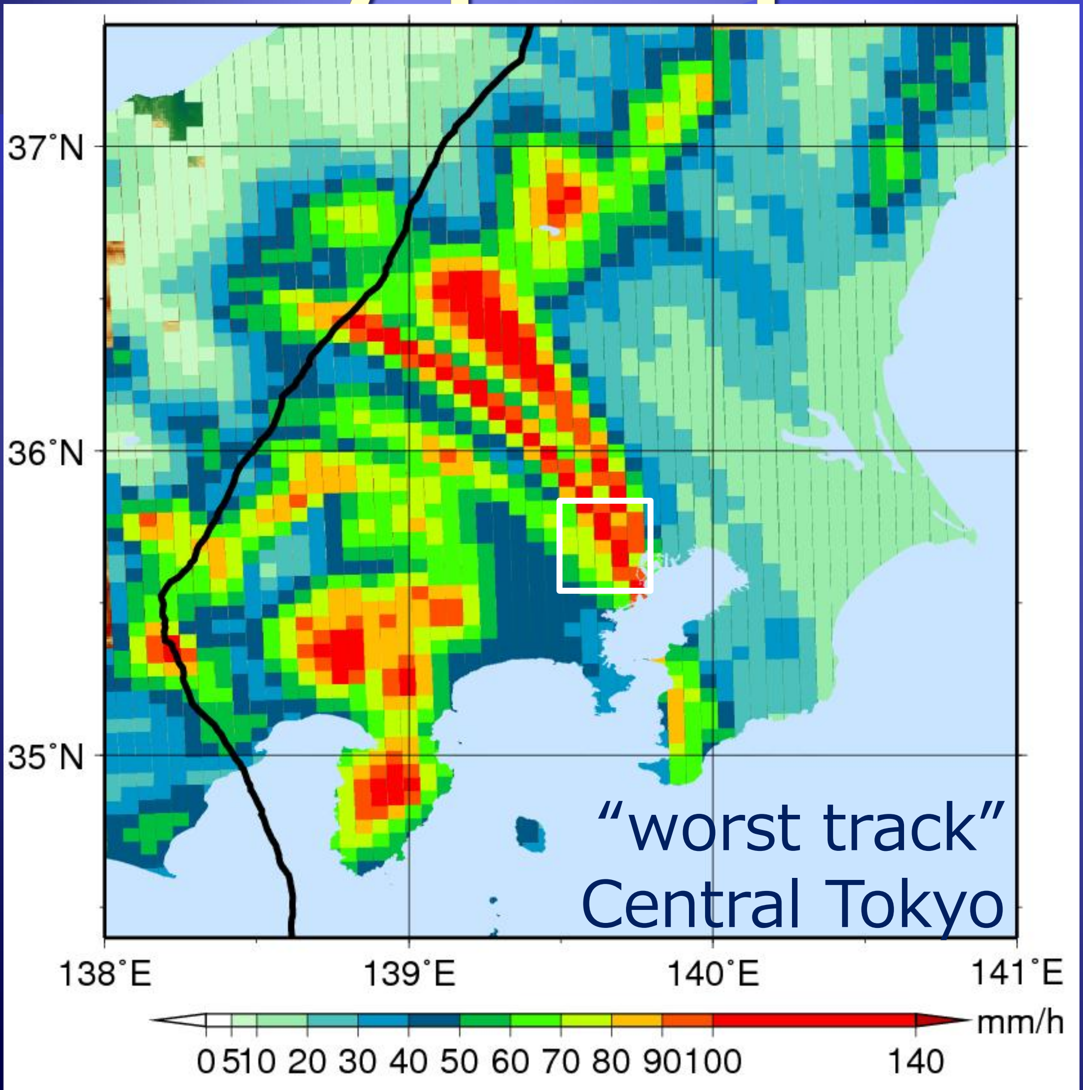


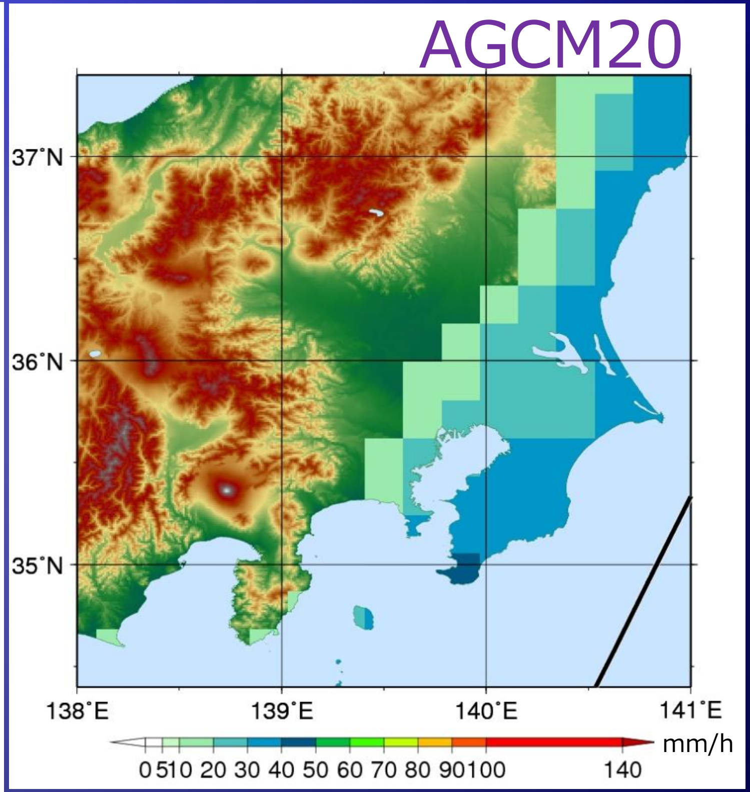
hourly precipitation

daily precipitation

Ishikawa et al. 2009

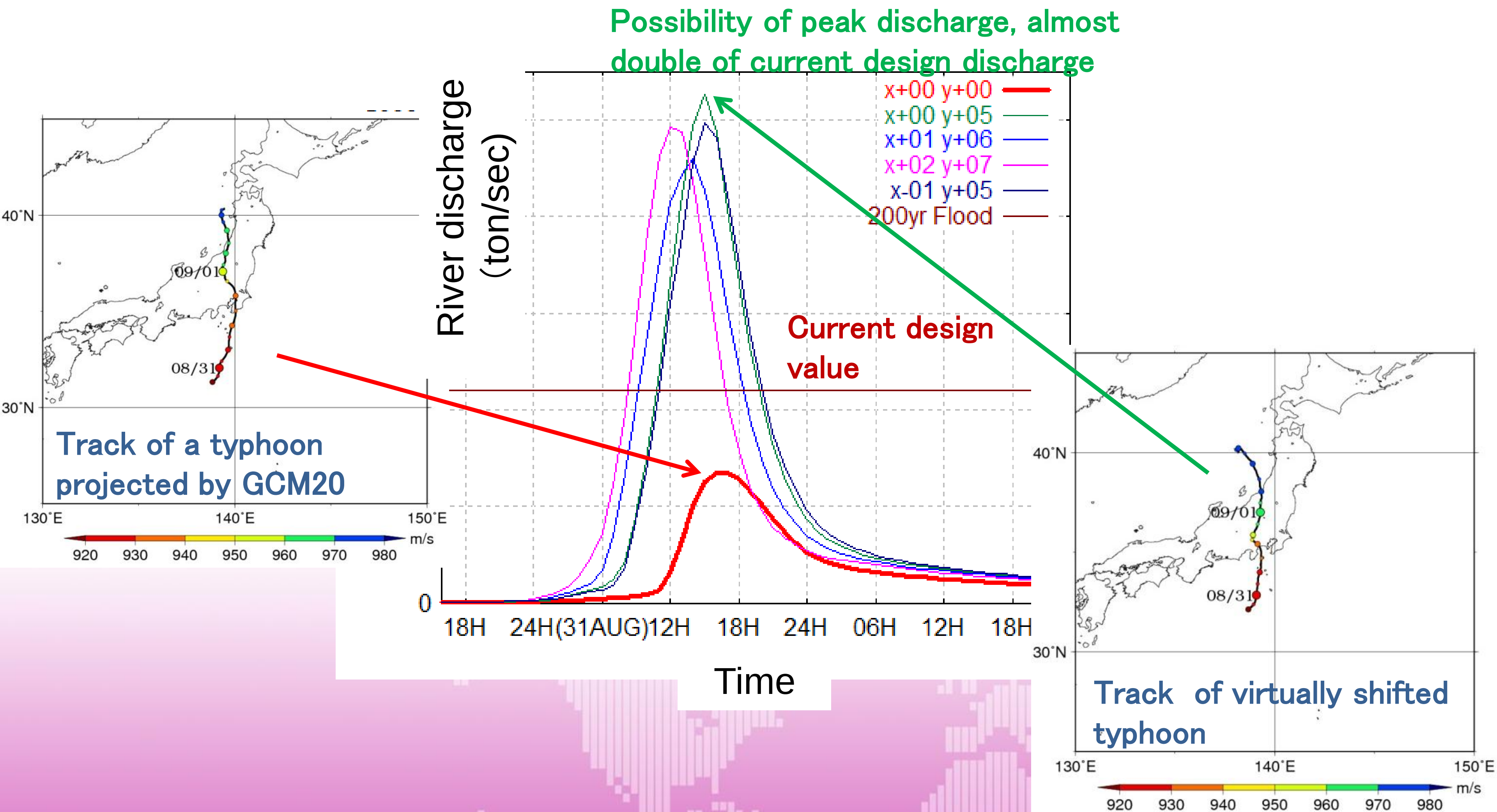
Probable maximum hourly precipitation





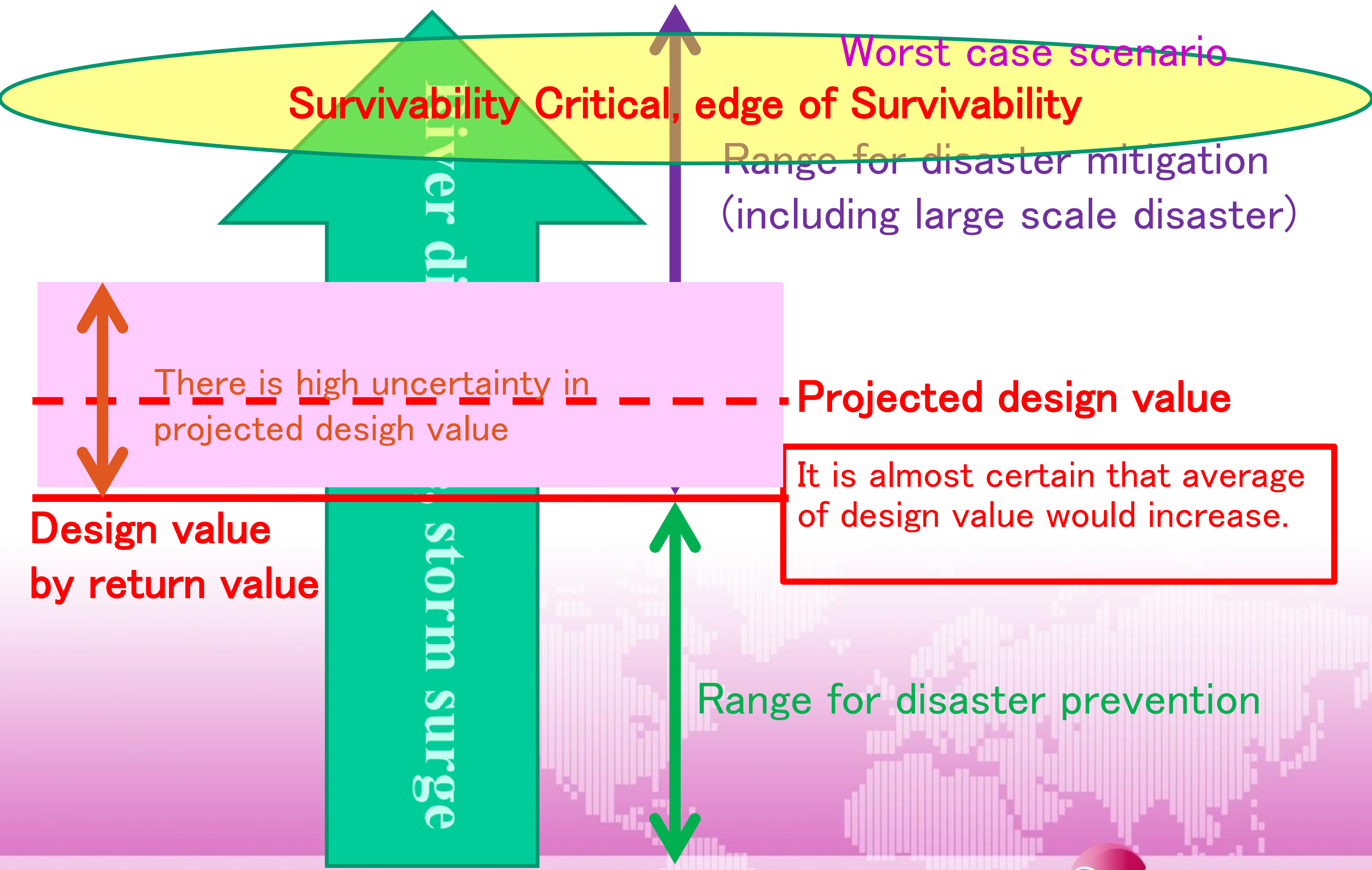
Ishikawa et al. 2009

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



Oku et al (2009)

Heading to adaptation



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 period of extreme events.
4. However, there is a risk that the return period does not have enough accuracy. Also, there is no guarantee that quite extreme events could be properly projected within the limited number of ensembles as GCM output. 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 the worst case scenario as a one of the forcing for risk management on climate change.

6. 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.

Rainfall output from GCM and RCM

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