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Adaptation for water problems for climate change

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WATER. Key Issue on climate change

- Climate change affects water (Hydrologic) cycle.
- Water influences wide field.
- Flood and drought problems are the biggest impact for human life.
- Water environmental problems threat our life for long time.

Higher flood risk

Model development

Application for climate change

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Flood impact

Extreme rainfall increase (IPCC, 2007)

Heavy rainfall produces frequent flooding.

Rainfall with 100yrs return period increase 20% from now in 2100.（JMA　RCM results）

It is necessary to evaluate economic damage in 2100 for the adaptation.

Objectives

Calculation of economic damage by flooding after climate change in a whole Japan using extreme rainfall data.

Quantifying the adaptation cost using the increase of damage cost from current flood control.

17.7.2004, MLIT

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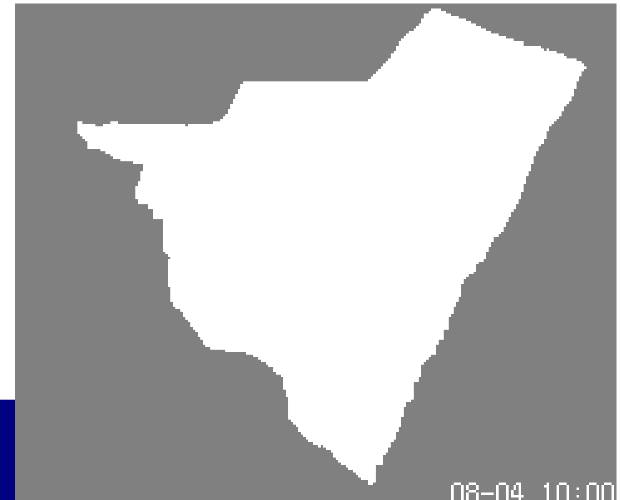
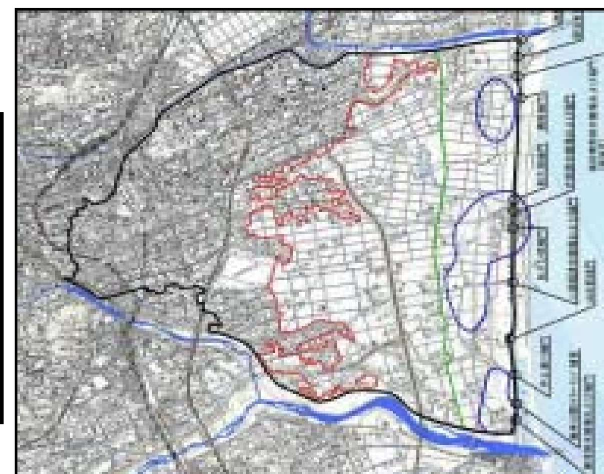
Model Verification

- Flood simulation

landuse	*n*
Agri.&Forest	0.060
Traffic area	0.047
Others	0.050
Urbaned	0.050
Waterbody &Beach	0.020

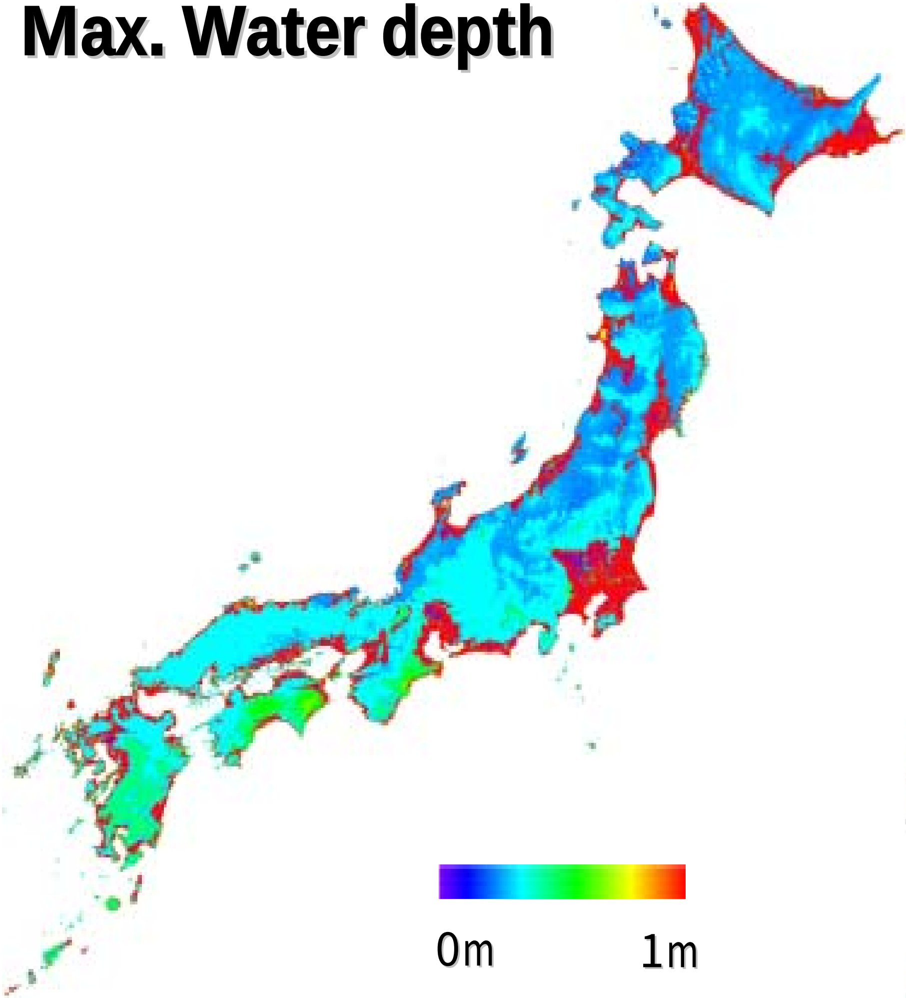


WD 0.0m, 0.5m, 1.0m
WD 1.5m, 2.0m, 2.5m

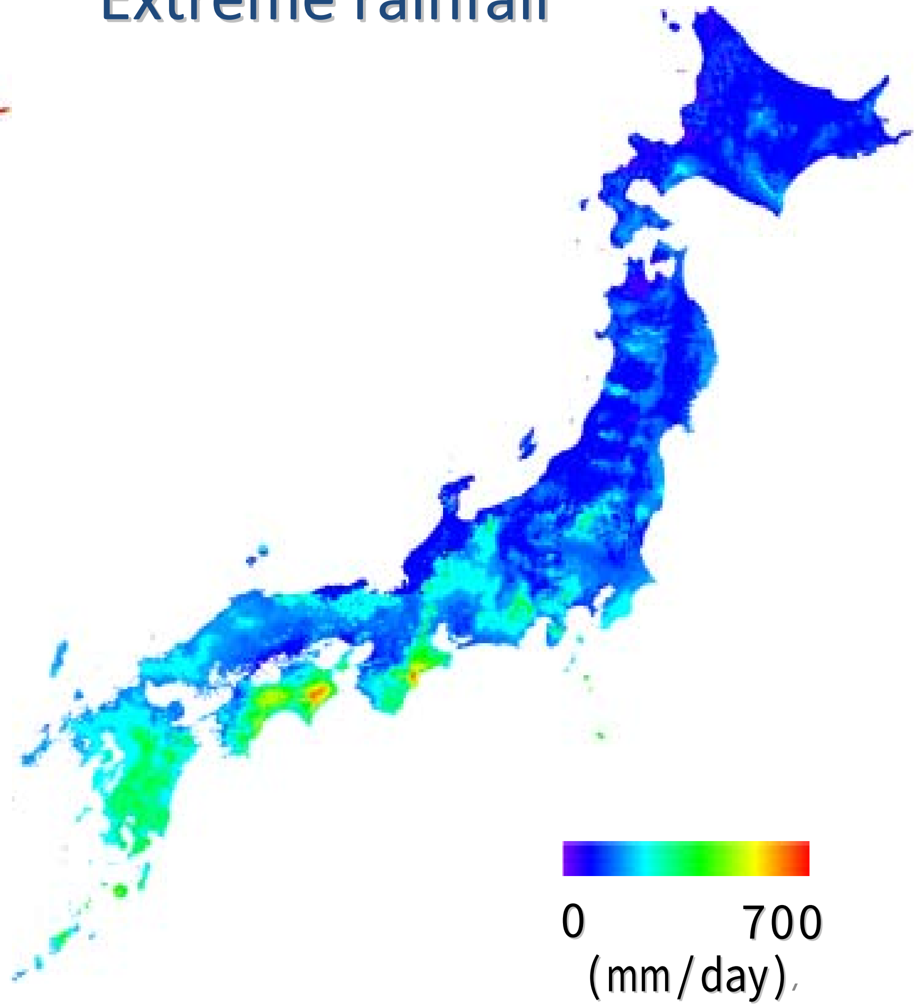


Results (case : 100yrs RTN)

Max. Water depth



Extreme rainfall



Estimation of damage cost

1） Paddy field

D.C.＝rice production/area×rice price×inundated area

×damage rate to water depth

2） Crops field

D.C.=crops production/area×average crops price×inundated area

×damage rate to water depth

3） Buildings （ 4）Golf links）

D.C.of houses=damaged floor area to water depth×price/m^2

×damage rate to water depth

D.C.of house articles=house number to water depth

×house article value/house×damage rate to water depth

D.C.of asset of office=worker number×

(amortized asset value/person×coefficient to water depth＋

stock asset value/person×damage rate to water depth)

5） Public facilities

D.C.=general damaged asset value×1.694

Estimation of adaptation cost

Annual expected damage → Annual adaptation cost (B/C=2.3)

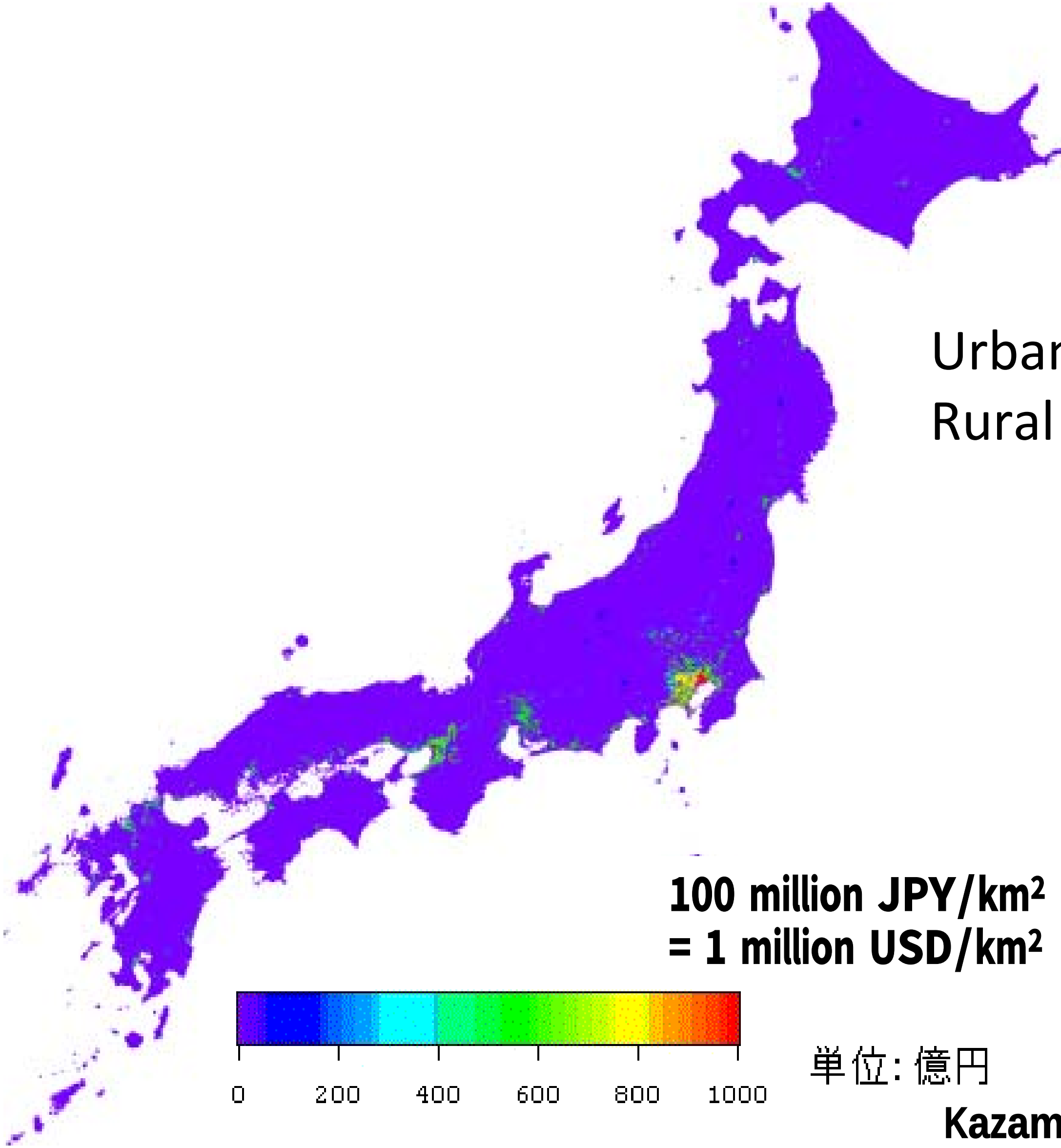
Billion USD

RTN **Period**	Annual extreme P.	Damage Cost	Interval Av. Damage	Interval probability	Av. Annual expected damage cost
5	0.20	380			
10	0.10	550	470	0.1	**47**
30	0.03	770	660	0.067	**44**
50	0.02	910	840	0.013	**11**
100	0.01	1,120	1,020	0.010	**10**

This amount is similar to annual expense of flood control in Japan.

Adaptation cost is 4.6bilion USD

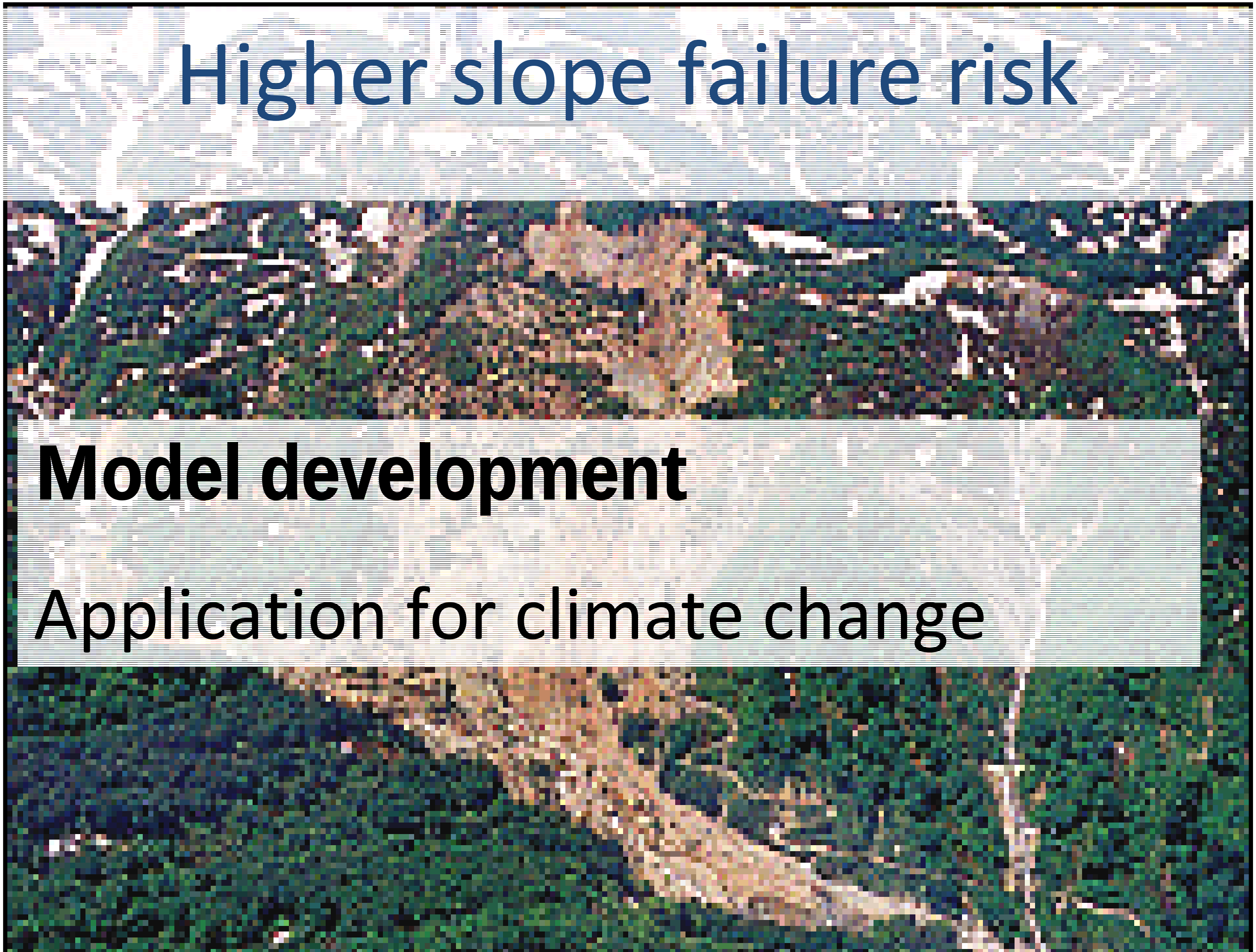
Annual Expected Damage Cost



Urban Areas have huge damage.
Rural areas have less damages.

Kazama et al., 2009. *Sustainability Science*

slope



Higher slope failure risk

Model development

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There are a lot of slope hazards by the extreme precipitation.

Past hazard results

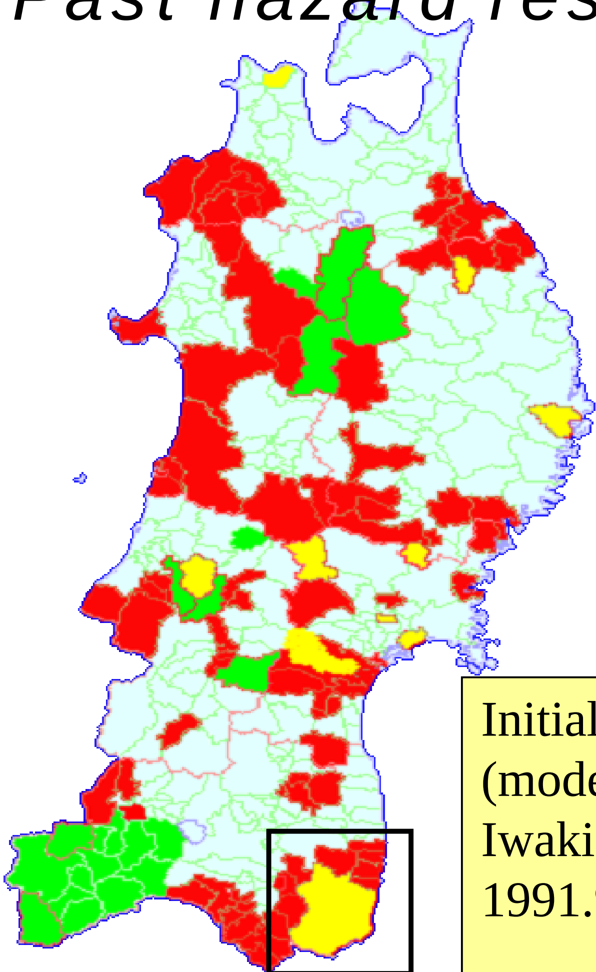


Fig. Slope hazard map by literature

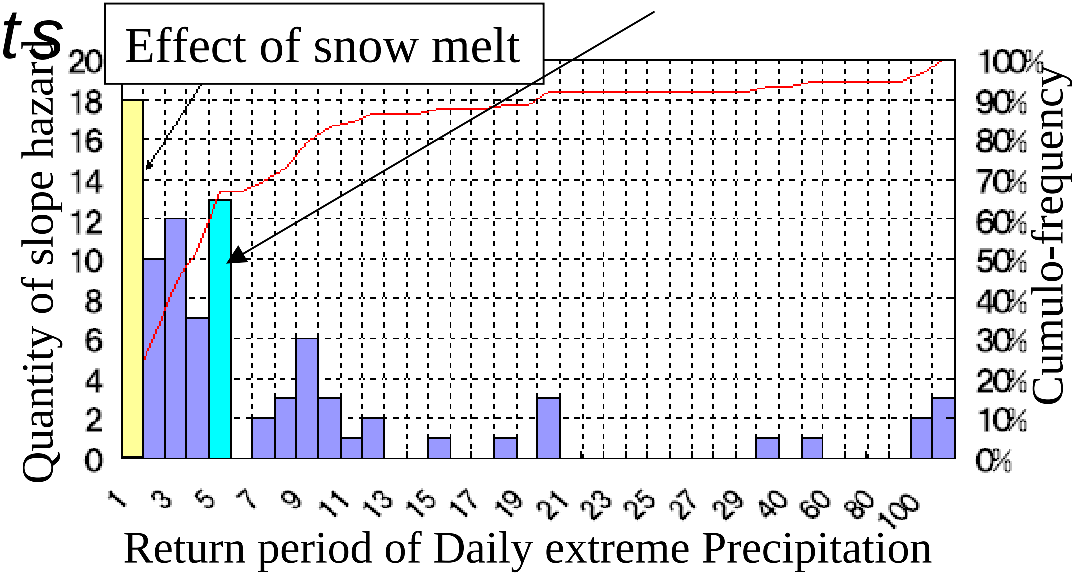


Table. Relation to Slope hazard and return period on extreme precipitation

Initial slope hazard condition;
(model sample of Tohoku region)
Iwaki city, Fukushima prefecture
1991.9.19

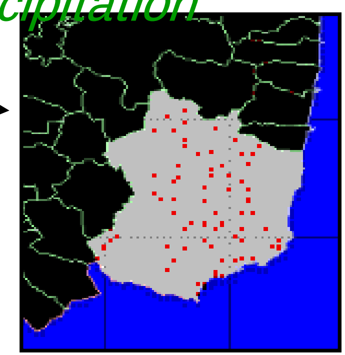


Fig. Hazards map in Iwaki

slope

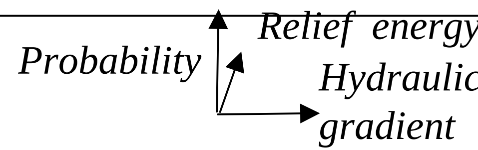
Probability model equation

$$P = \frac{1}{1 + \exp\left[-\left(\beta_0 + \beta_h hydY_h + \beta_r reliefY_r\right)\right]}$$

Where P is ***probability****,* $\boldsymbol{\beta}_0$ *is intercept,* $\boldsymbol{\beta}_h$*:is coefficient of hydraulic gradient,* $\boldsymbol{\beta}_r$ *is coefficient of hydraulic gradient,,*$hydY_h$ *is* ***hydraulic gradient****,* *reliif* Y_r*is* ***relief energy***

Dangerous geology

Steep curve , rising point as small value



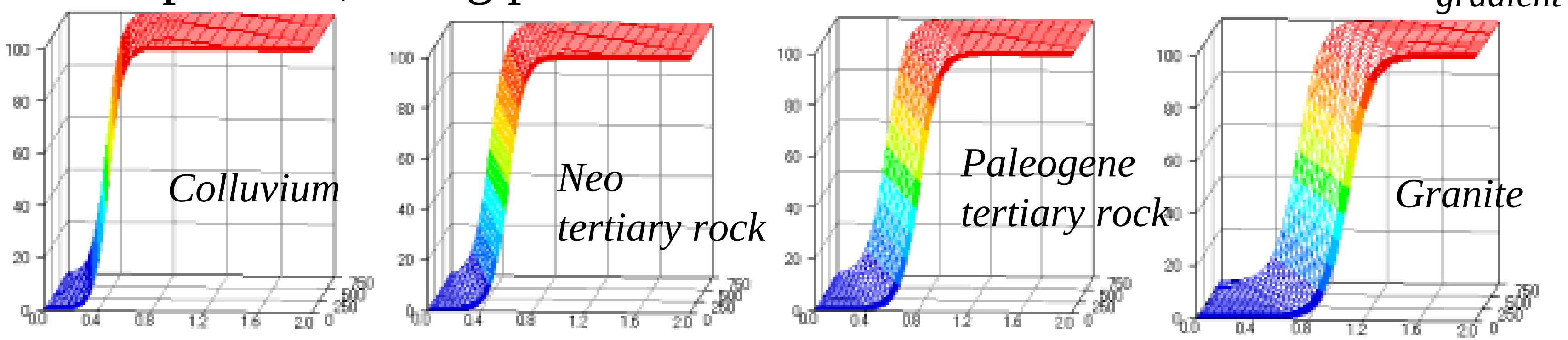


Fig. Logistic curve of each geological features

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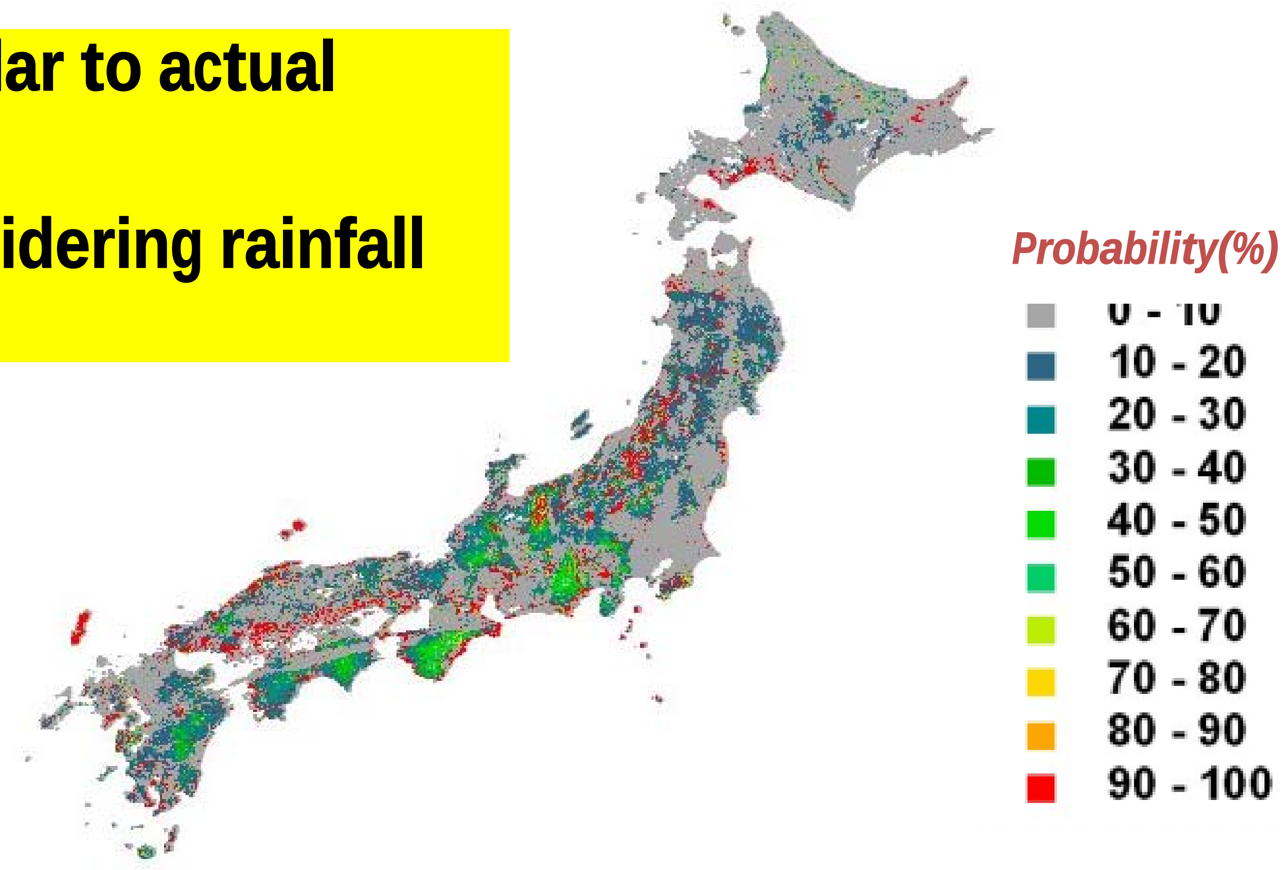
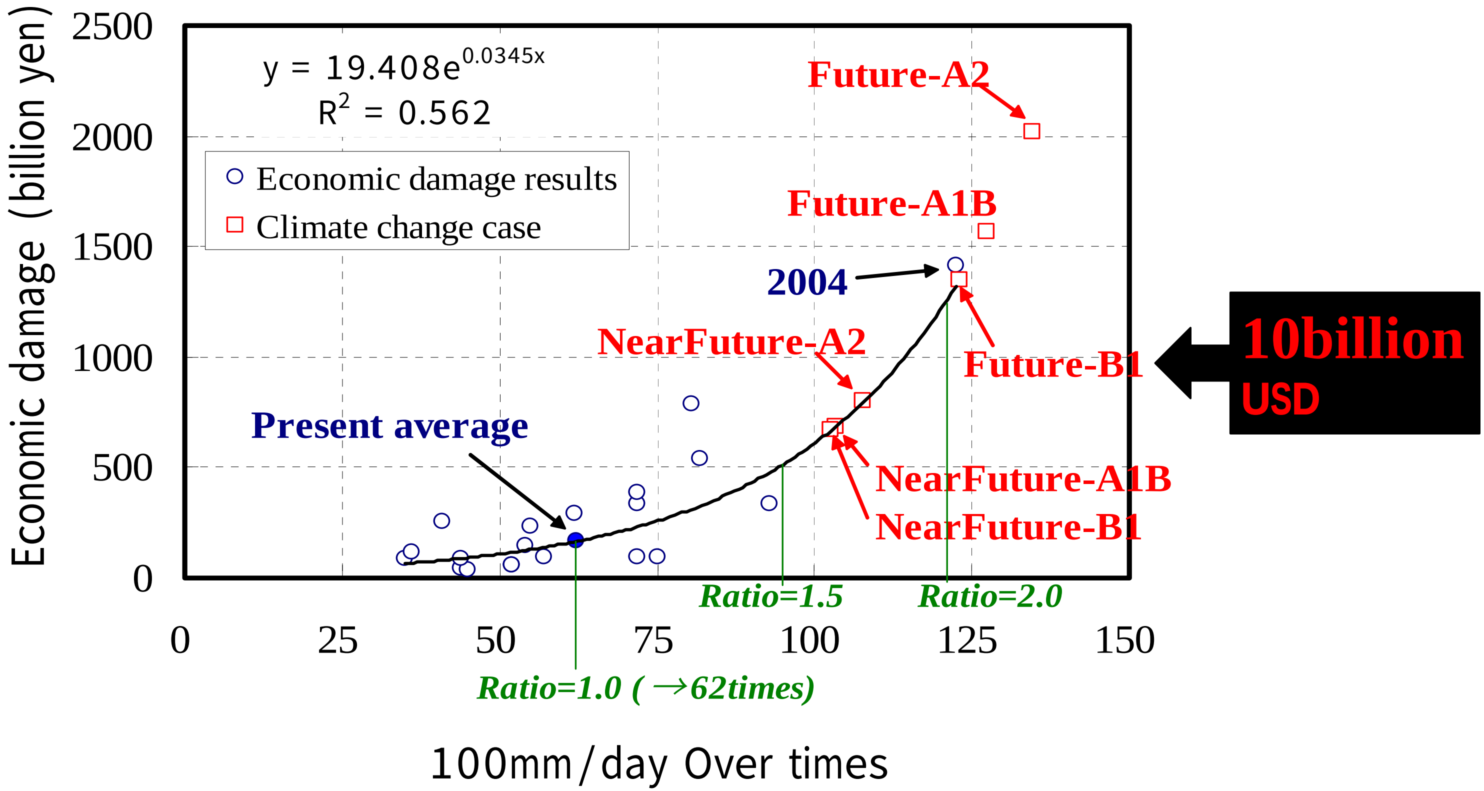
Sediment hazard map

These are similar to actual events.

These are considering rainfall effects.



Slope failure probability on 30 years return period downpour.



Relationship between days of over 100mm/d and damage costs

CONCLUSION

Huge water disasters increase rapidly caused by climate change.

Kawagoe et al., 2010. Hydrology and Earth System *Science (submitted)*

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Worse water quality

Model development

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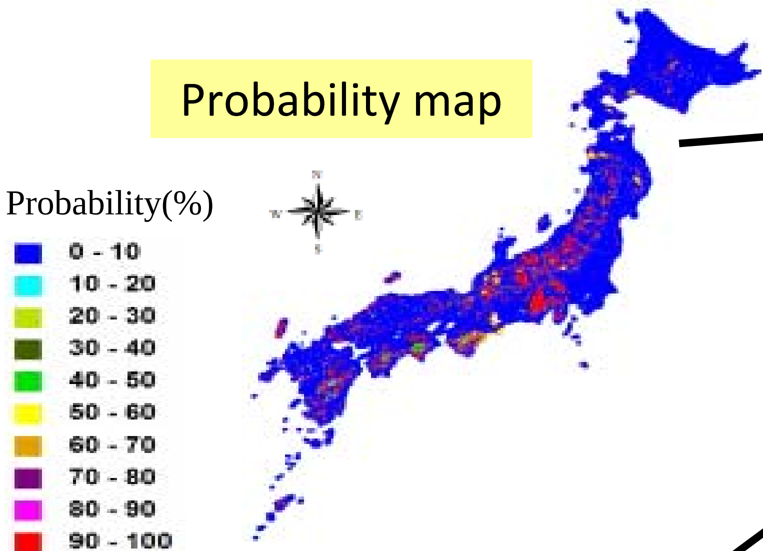
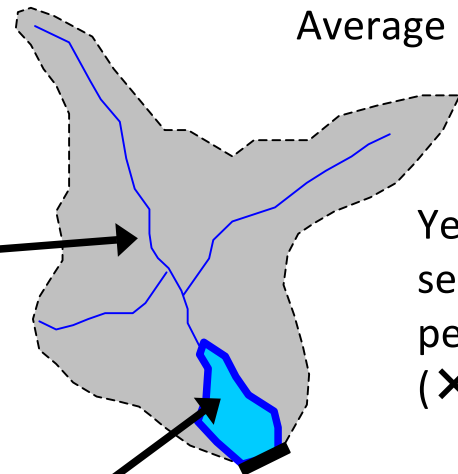
Probability map



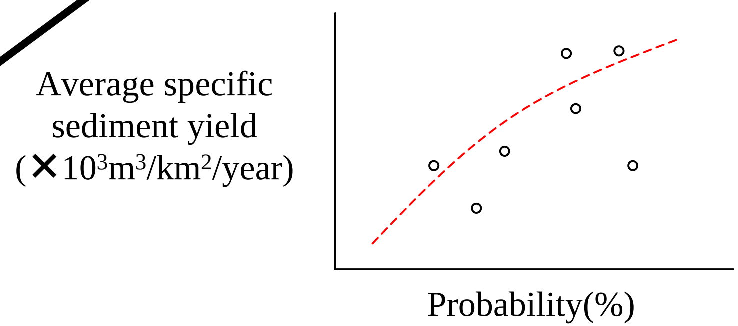
Dam basins



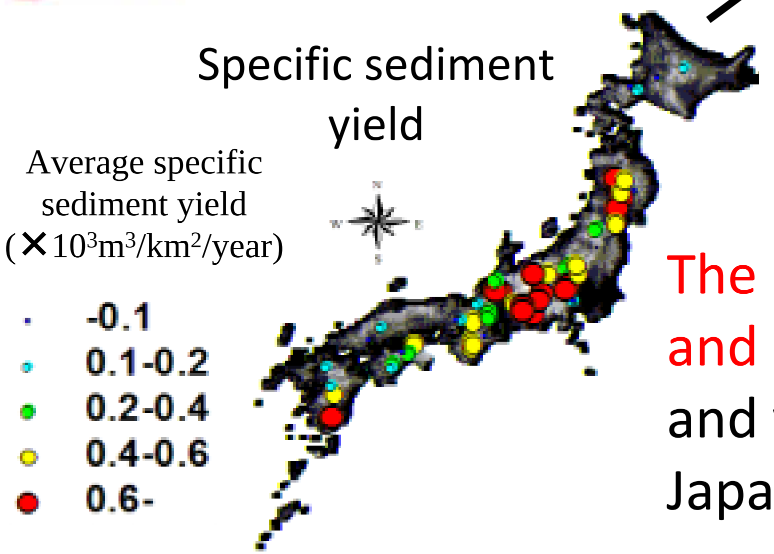
Average probability(%)

Year average sediment yield per unite area (✕$10^3 m^3/km^2/year$)

comparative verification



Specific sediment yield



The relationship between probability and specific sediment yield was obtained and verified about 59 dam areas in the Japanese Islands.

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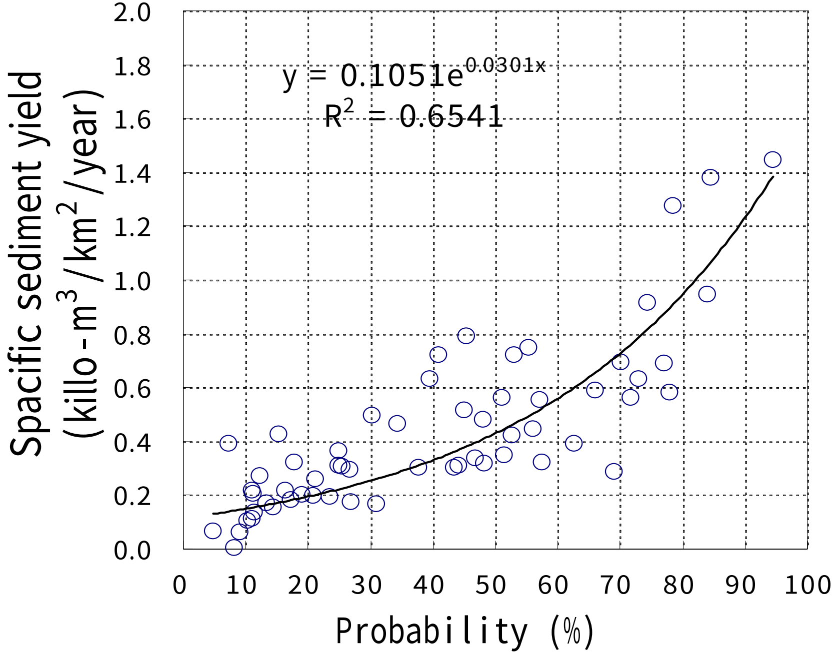
Probability model reproduces sediment hazard



Relationship between probability with return period of 5years and specific sediment yield

An exponential equation shows the relationship.
→ sediment production model

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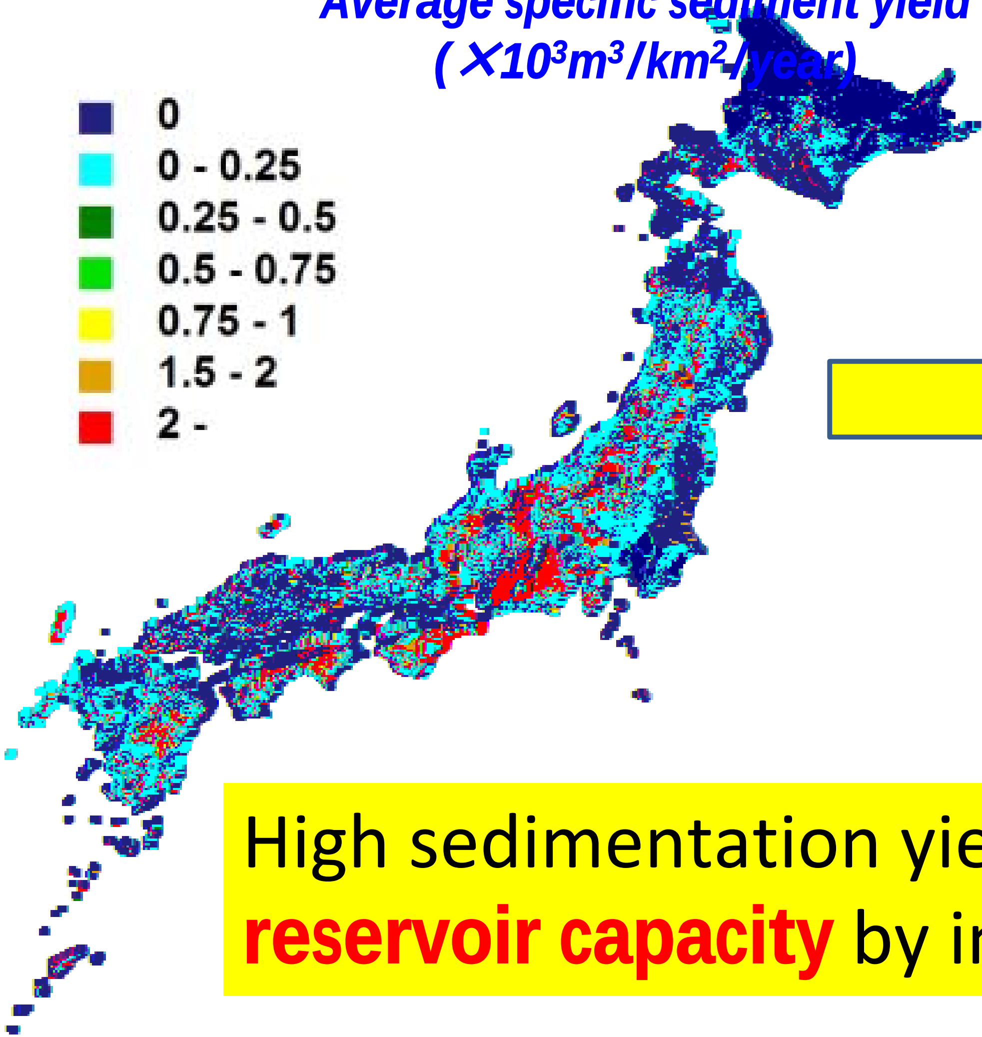
Sedimentation yield map

Average specific sediment yield
($\times 10^3 m^3/km^2/year$)



High sedimentation yield areas will have less **reservoir capacity** by increase of downpour.

Water quality problems

☐ **Influence of downpour**

- Use of L-Q formula
- Extreme rainfall input to L-Q formula for BOD and SS

☐ **Influence of drought period**

- Use of turbidity deposit function
- Input of drought period to a deposit function for BOD and SS

⇩

Show relationship between extreme period (return period) and BOD and SS.

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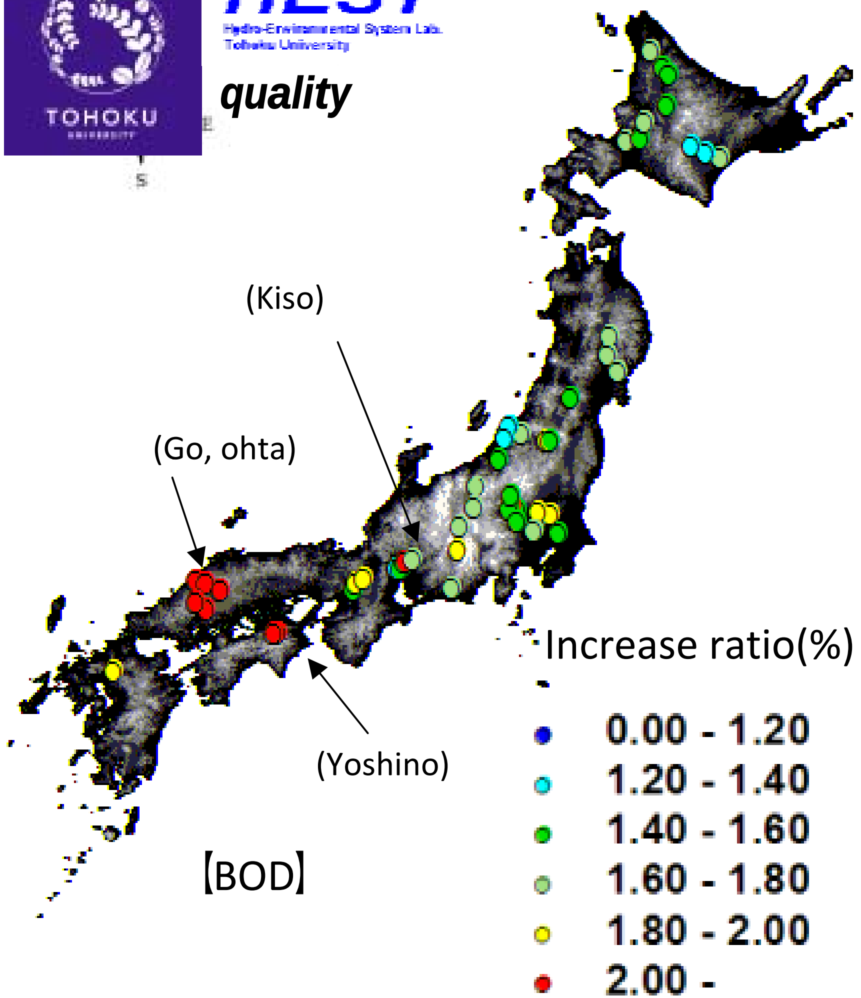

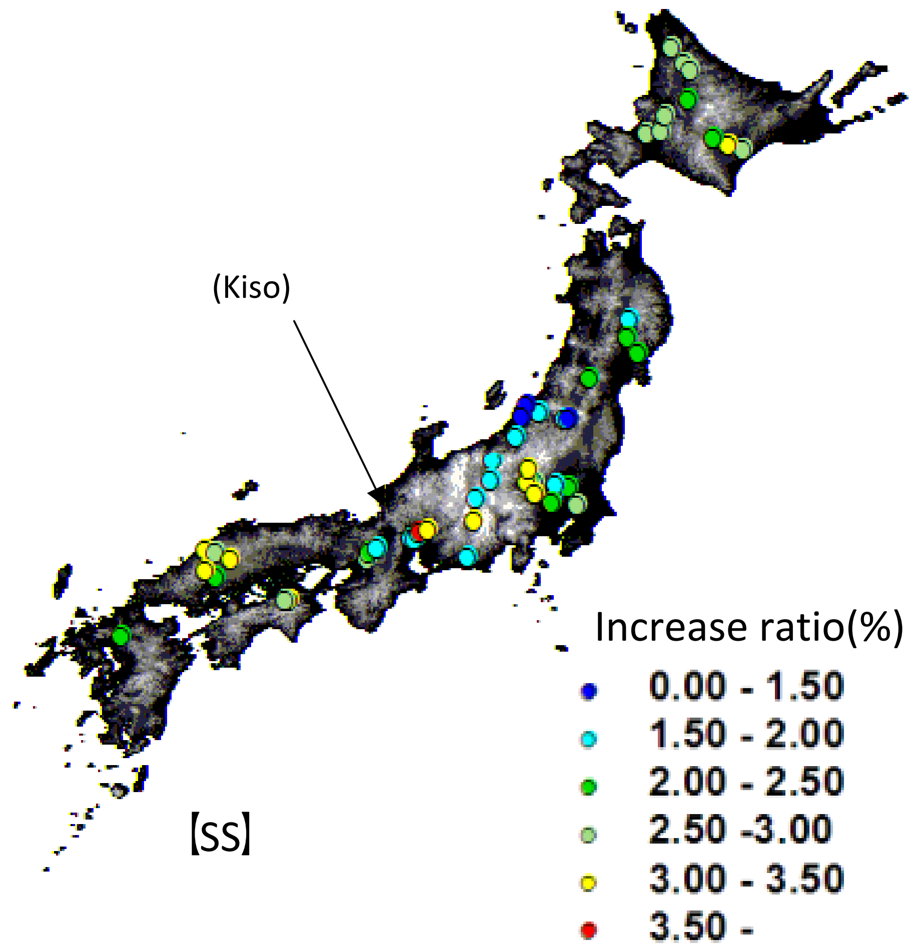

Downpour affects WQ (RTN 50 years / 10years)

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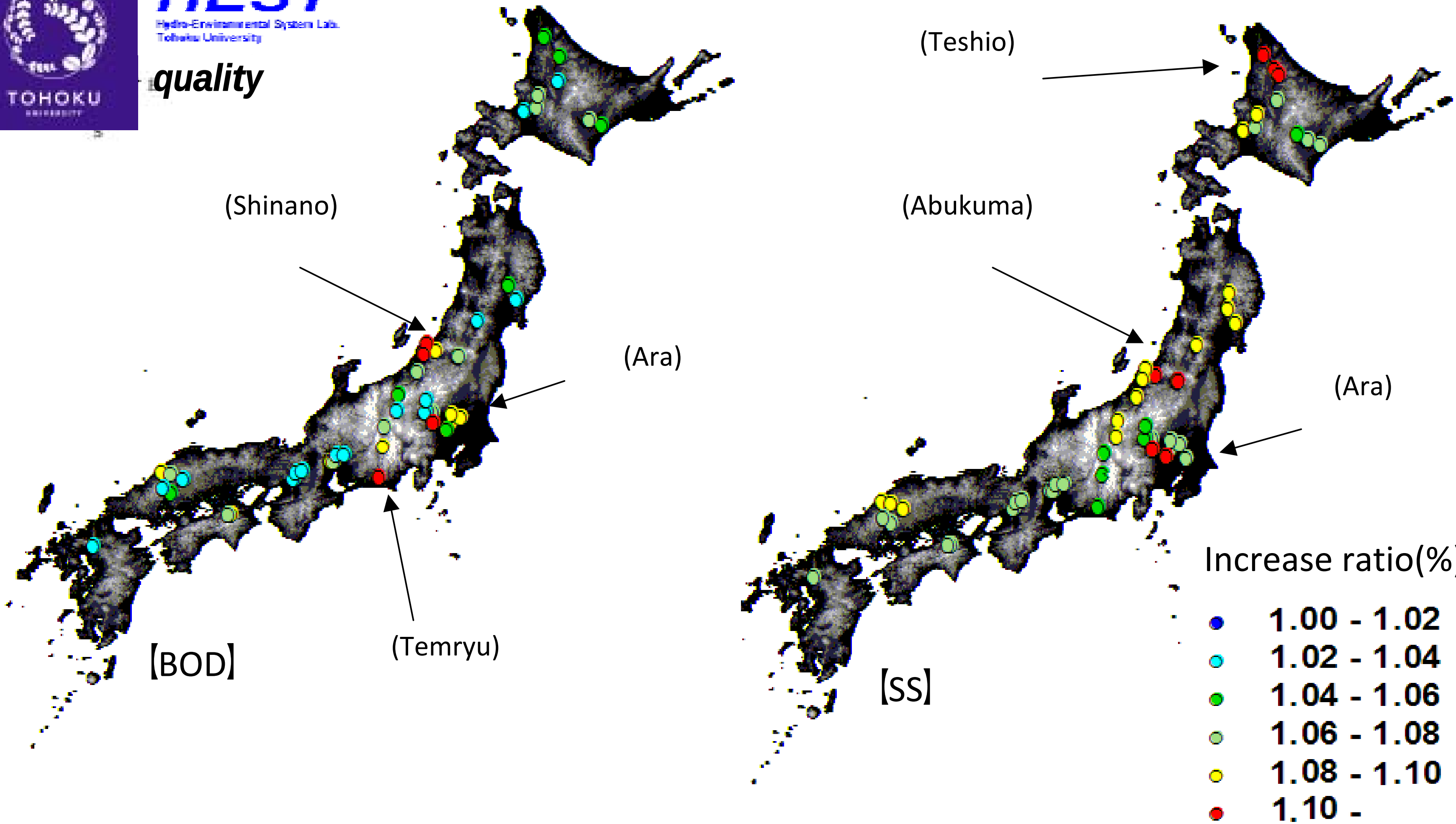

Drought affects WQ change (RTN50uyears/RTN10years)

Kawagoe et al., 2008. Journal of Environmental Engineering

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Water quality of closed lakes

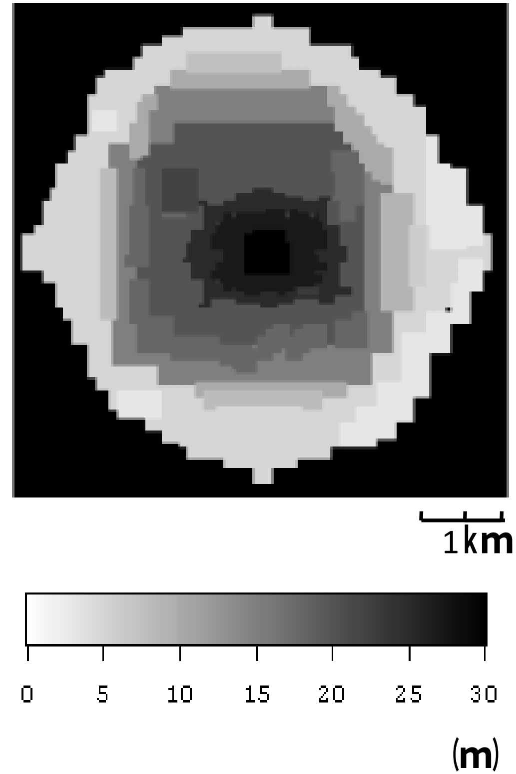
Ideal closed water body (Max depth 30m)

+

Meteorological conditions in different climate zones (Temperature, Precipitation)

⇩

Simulation of water temperature change



Analysis of response temperature
Comparison of different climate zones

Same calculation conditions

Study Area	4000✕4000 m
Surface Ares	2.8×10^6 m^2
Max. Depth	30m
Max. Depth Position	**Center**

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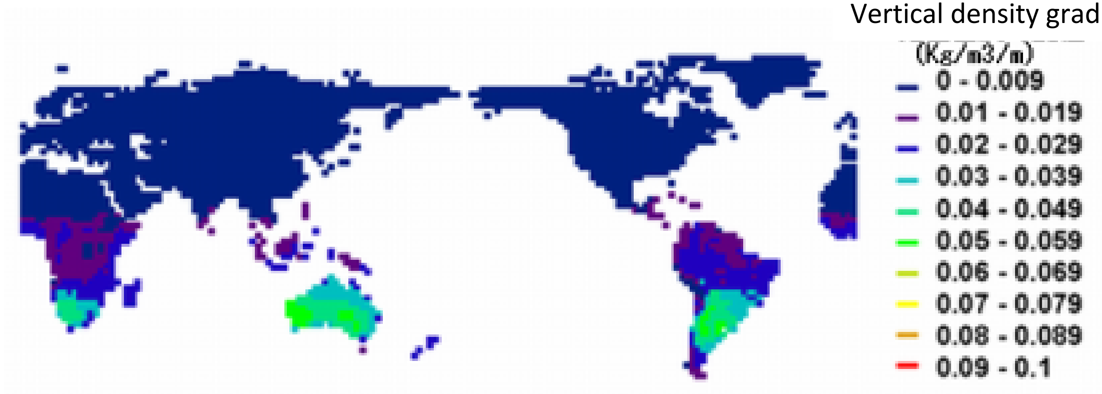
GCM Use

Results of present climate condition Vertical density gradient in summer(2005)

South sphere

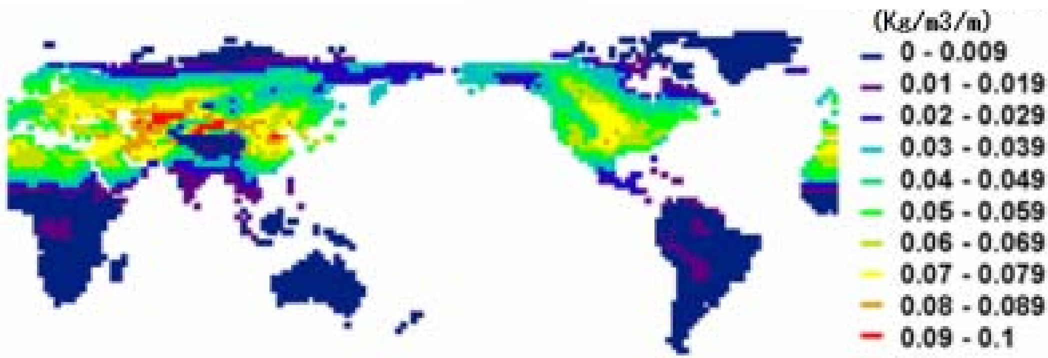
Vertical density gradient



31 Jan. 2005

North sphere

Vertical density gradient



31 July, 2005

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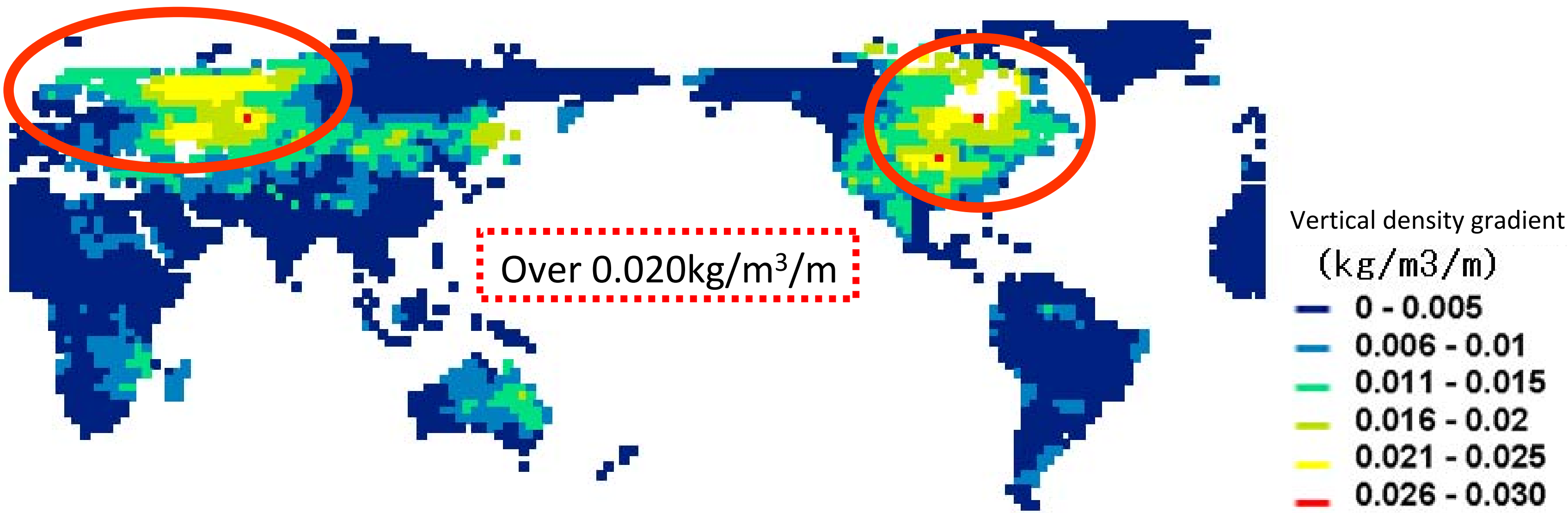
GCM Use

Influences of climate change for temperature in closed lakes
Change of density gradient in the future (2005 - 2050)



Large impact areas (Gradient more than 0.020kg/m^3/m)
North Sphere : North America, Eastern Europe, Northeastern Africa

Shida et al., 2008. Journal of Global Environmental Engineering

Conclusions

1) The probability according to extreme precipitation could show **the spatio-temporal distribution** of water disaster hazard.
2) The rainfall pattern change affects **water quality** and resources management.
3) The high influence areas were specified through the distribution **map** according to return period.
4) This algorithm will be applied using multi-GCM models.