Water resources impact on climate change in Japan

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Water resources impacts

- **Snow** water resource decline
- Higher **flood** risk
- Higher **slope** failure risk
- Worse water **quality**

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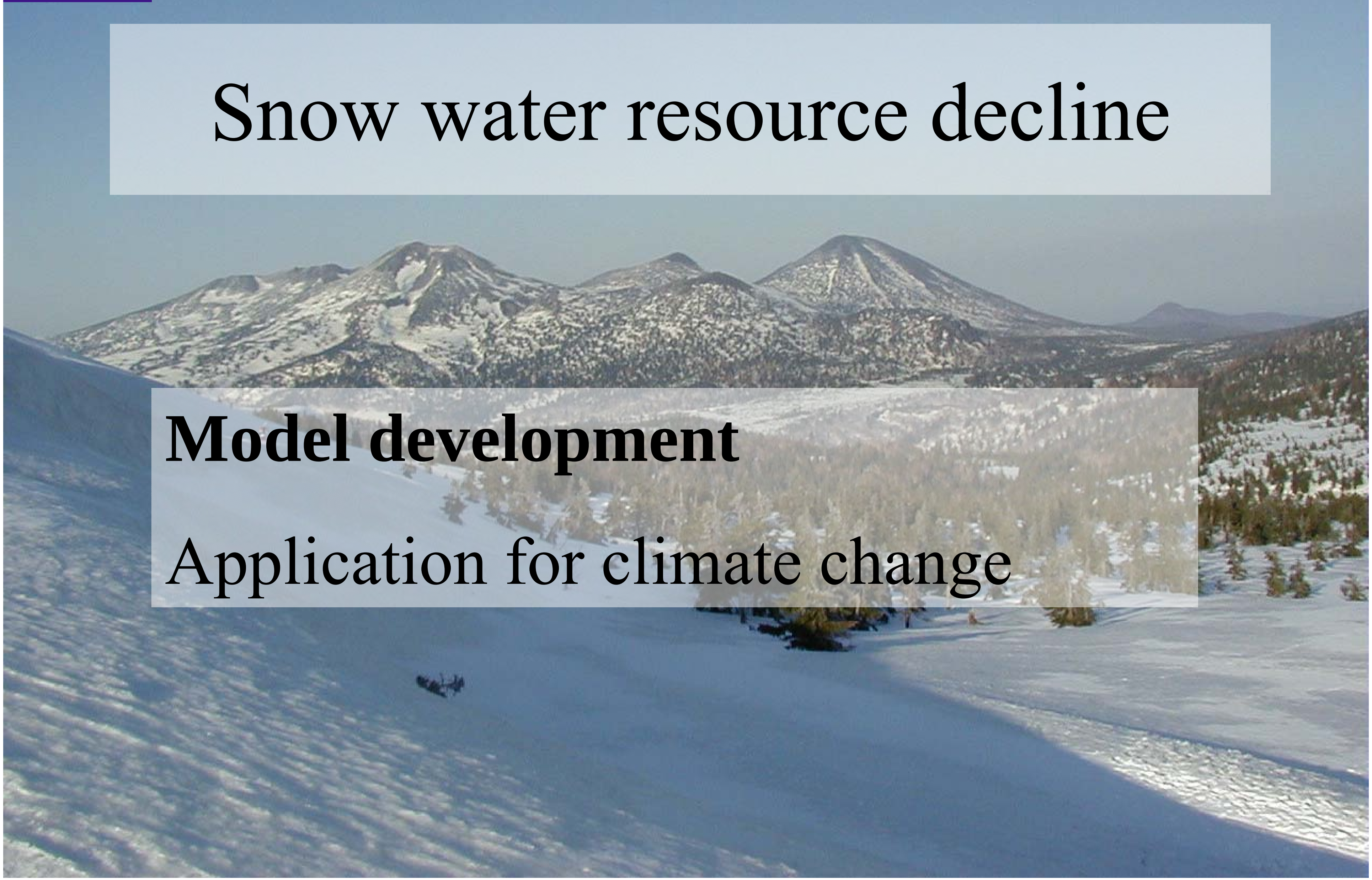
snow

Snow water resource decline



Model development

Application for climate change

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Model Flow

AMeDAS data
D. M. Tem(℃)

DEM

Elevation

Tem. Dis.

AMeDAS data
D.Precip.(mm)

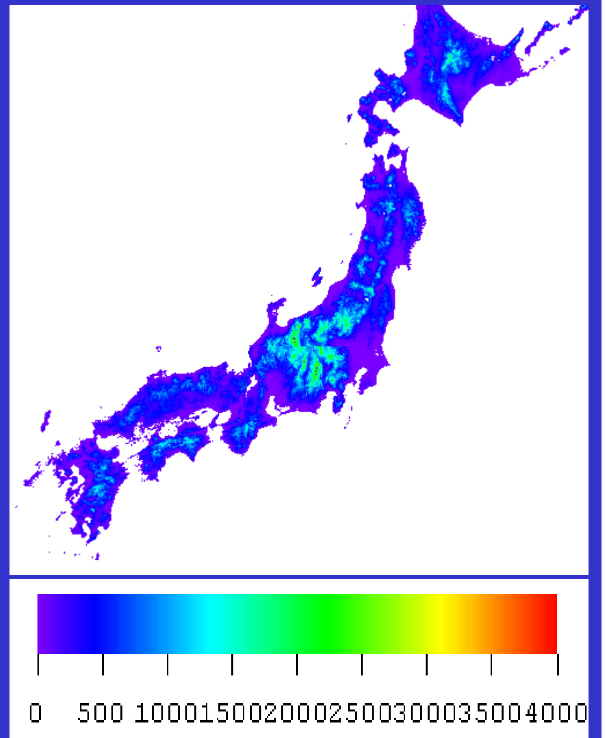
SF Dis.

SM Dis.

SWE Dis.

Density Dis.

Depth Dis.



(1480×1520) (m)

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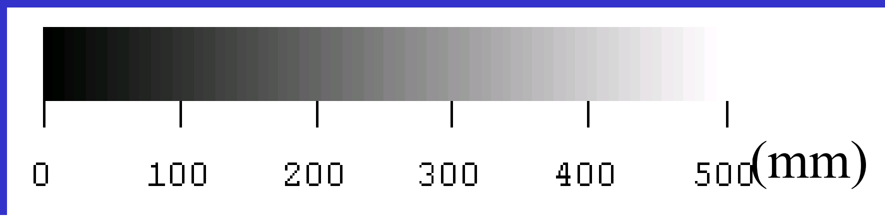
SWE Dis.

1998.12～1999.4

Simulation

(1480×1520)



Vulnerability of Snow Water Resources

$$\text{Dif of SWE} = \mathbf{SWE_i} - \mathbf{SWE_j}$$

1993－1999（less－Ave），2000－1999（Heavy－Ave）
2005－1999（Ave－Ave），2000－1993（Heavy－less）

Comparing 4 cases of SWE distribution

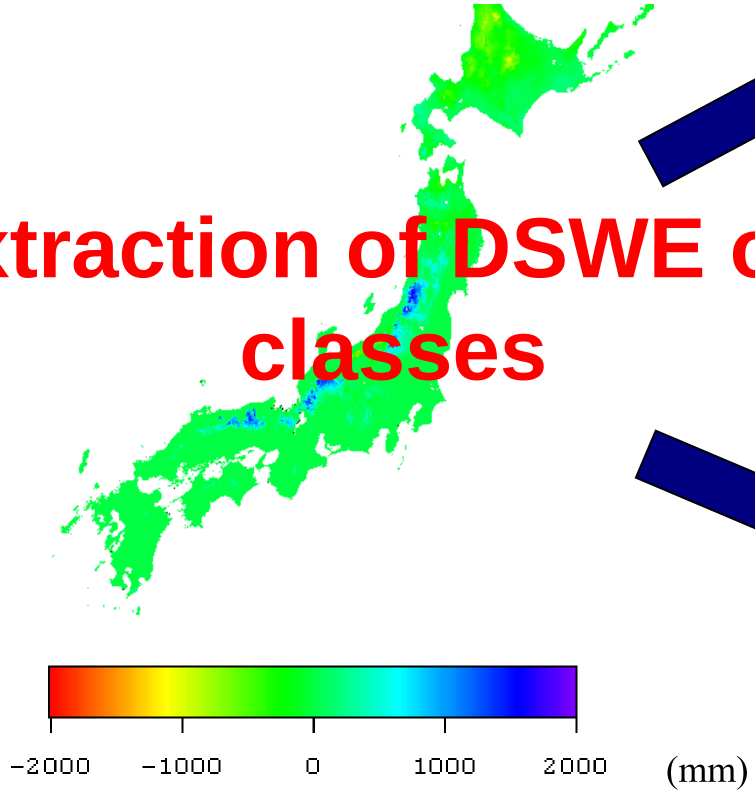
5 classes of DSWE
(Difference of SWE)

Focus on class **1** and **2**

Class**1**	1000mm～
Class**2**	500～1000mm
Class**3**	100～500mm
Class**4**	0～100mm
class**5**	～0mm

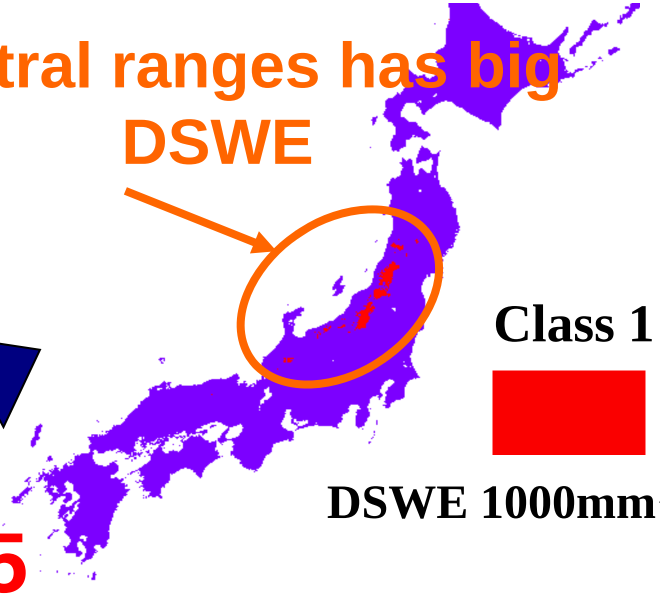
Vulnerability of snow water resources

2000－1993（15 March）



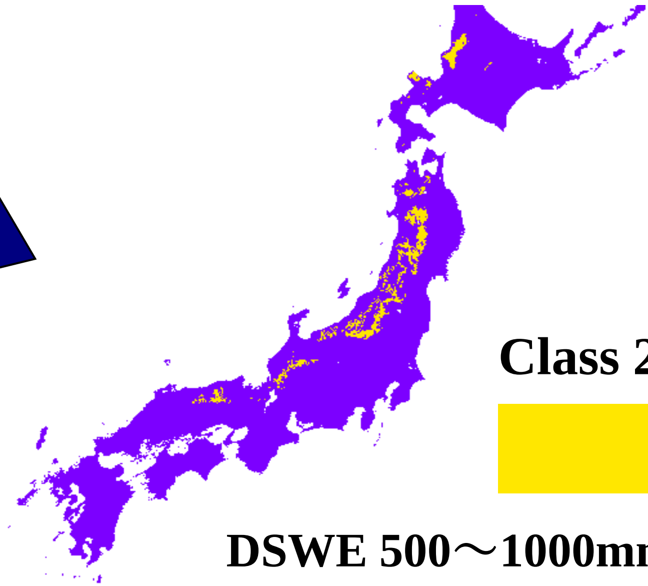
Extraction of DSWE of 5 classes

Central ranges has big DSWE



Class 1

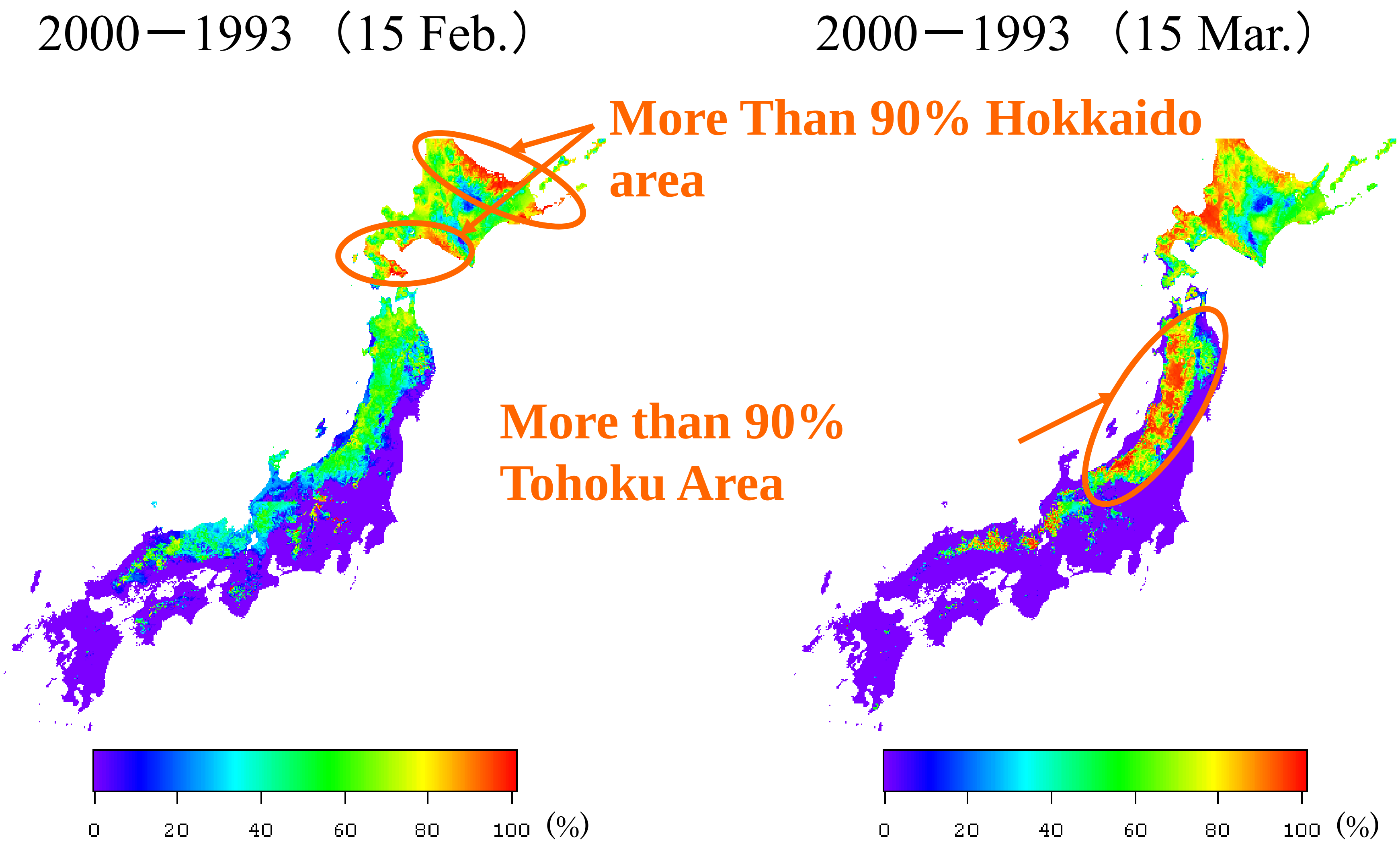
DSWE 1000mm～



Class 2

DSWE 500～1000mm

Ratio of DSWE to Maximum SWE



Kazama et al., 2008. *Hydrological Processes*

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Ratio of SWE to Irrigation in spring

		SWE(m3)	Rice area (km2)	SWE/Ra (m3/m2)	SWE/Water demand for irrigation
Mogami River	less	8.83×10^8	717	1.23	0.82
	more	32.0×10^8	Yamagata	4.46	2.97
Kitakami River	less	0.96×10^8	795	0.12	0.08
	more	4.05×10^8	Miyagi	0.51	0.33
Shinano River	less	32.1×10^8	1210	2.65	1.76
	more	78.5×10^8	Niigata	6.49	4.32

CONCLUSION
Some paddy fields will face to water restriction.

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Higher flood risk

Model development

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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）

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

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Objectives

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

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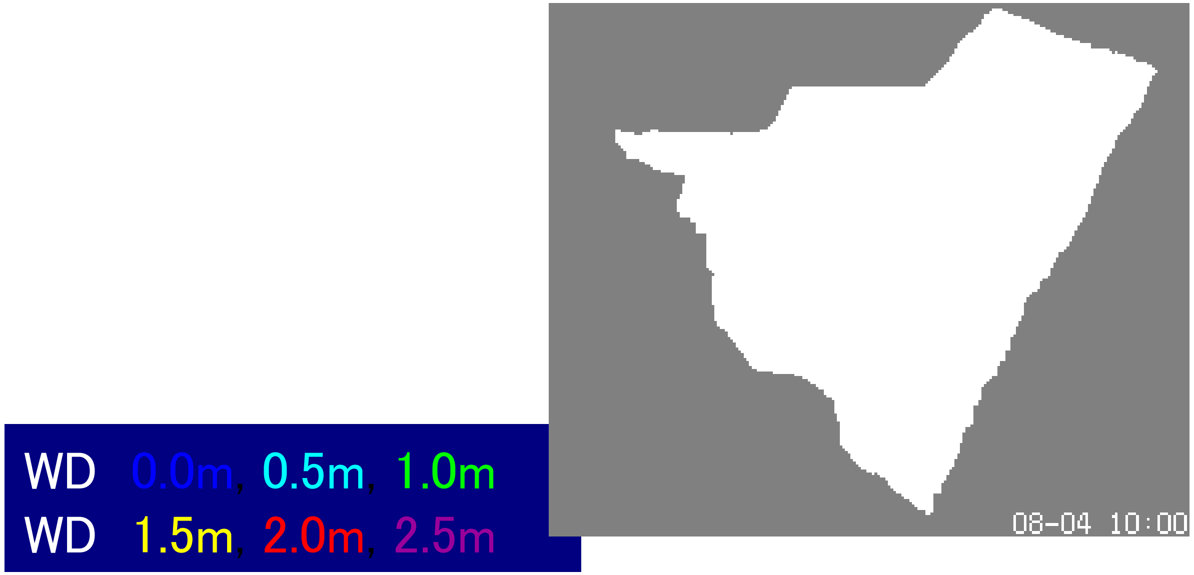
Quantifying the adaptation cost using the increase of damage cost from current flood control.

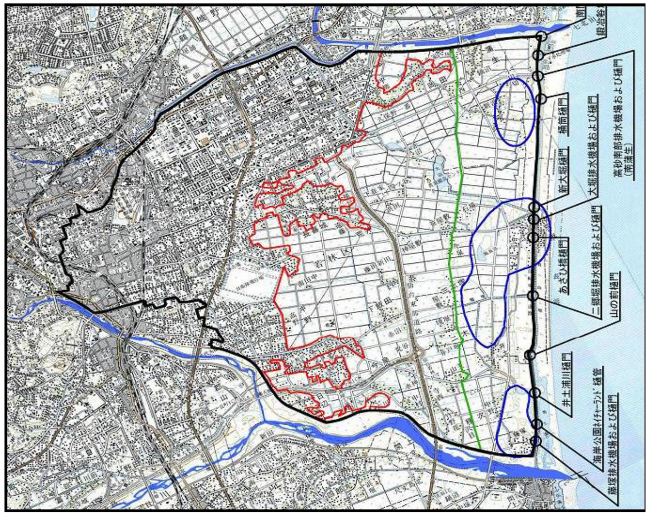
17.7.2004, MLIT

Model Verification

- Flood simulation

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





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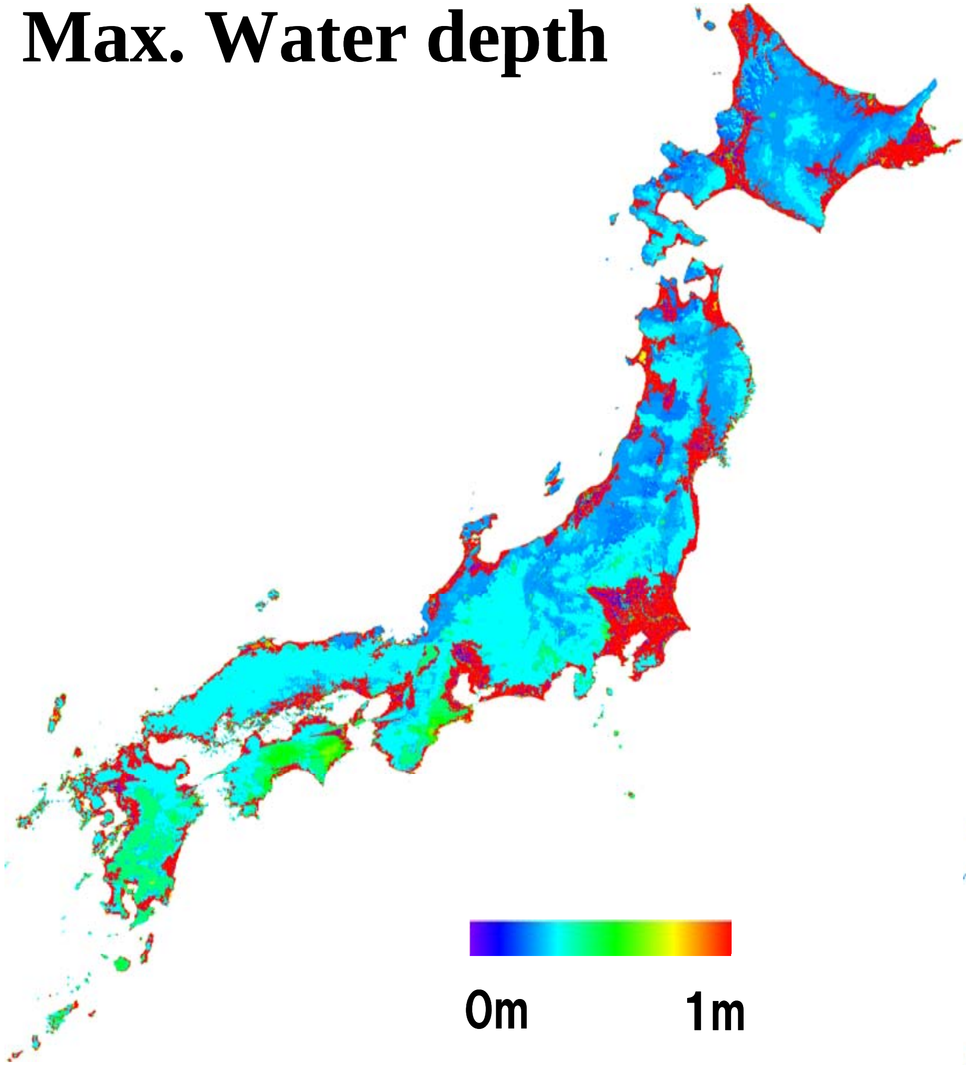
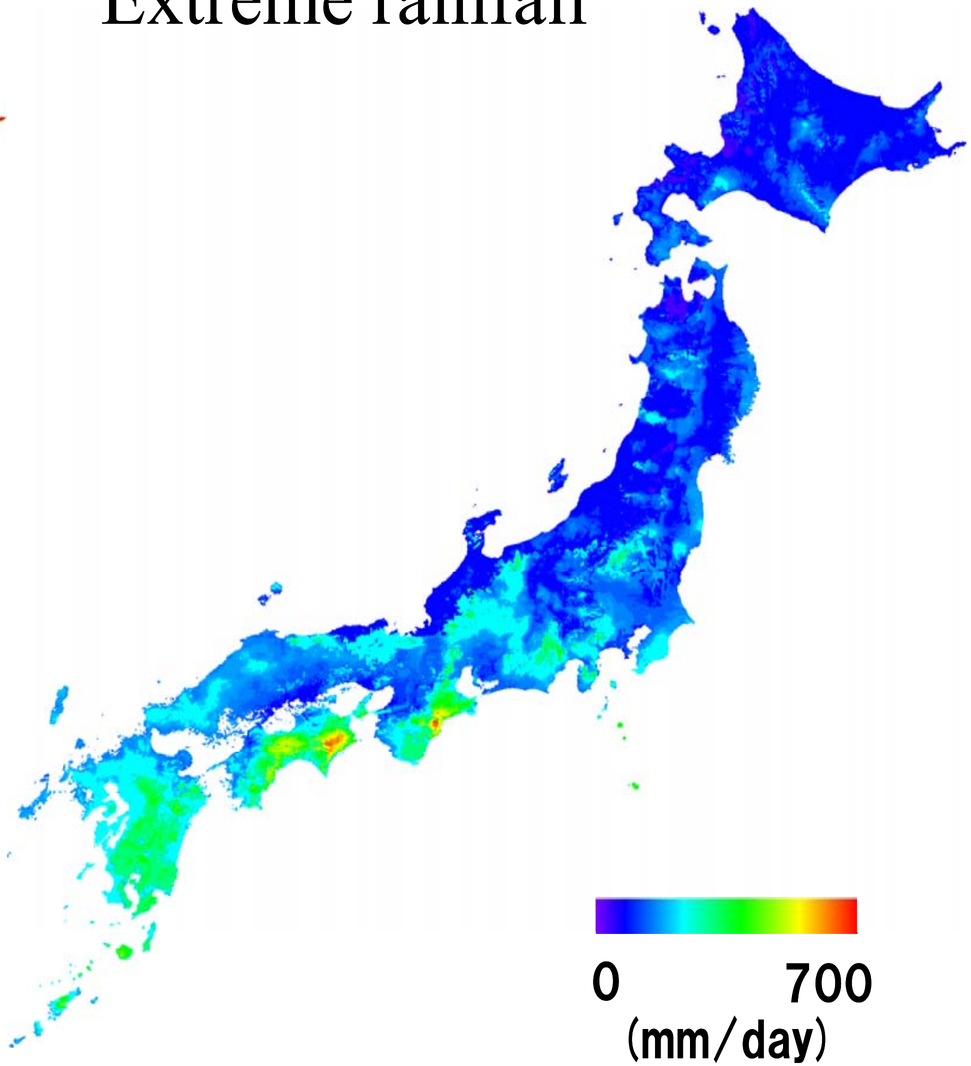
Results（case : 100yrs RTN）

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

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Estimation of adaptation cost

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

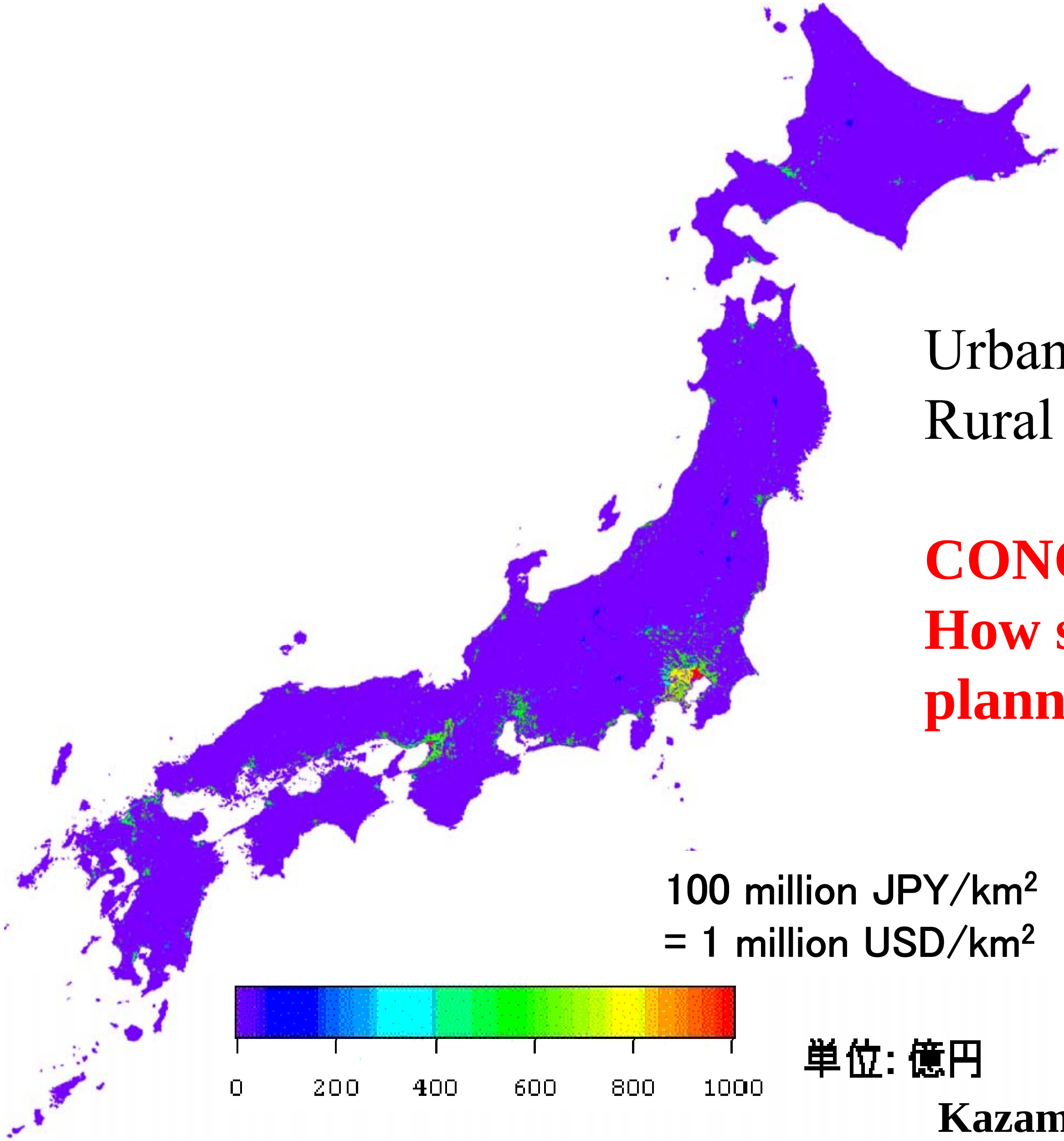
Billion USD

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.

CONCLUSION
How should we consider land planning?

Kazama et al., 2009. *Sustainability Science*

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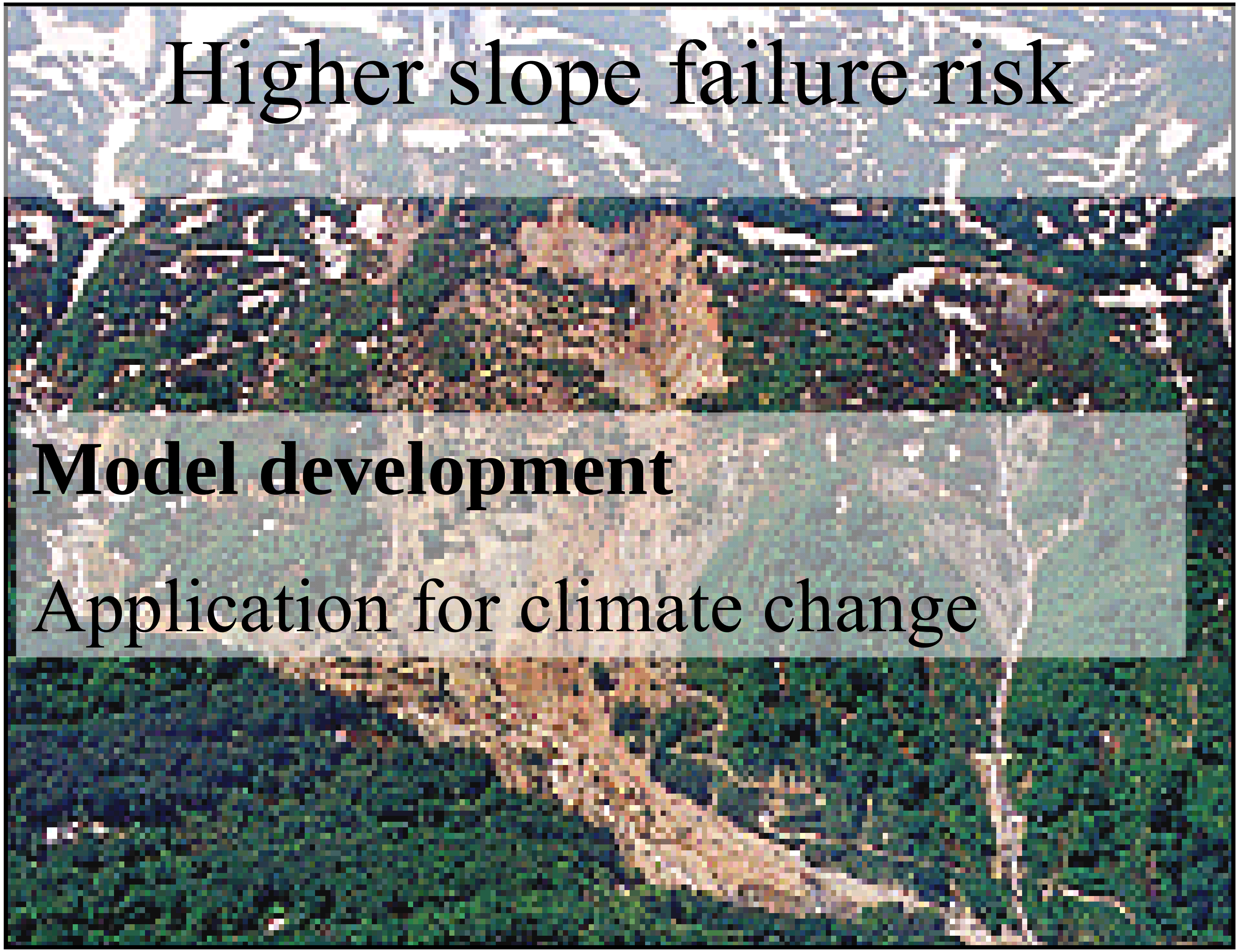

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Past hazard results

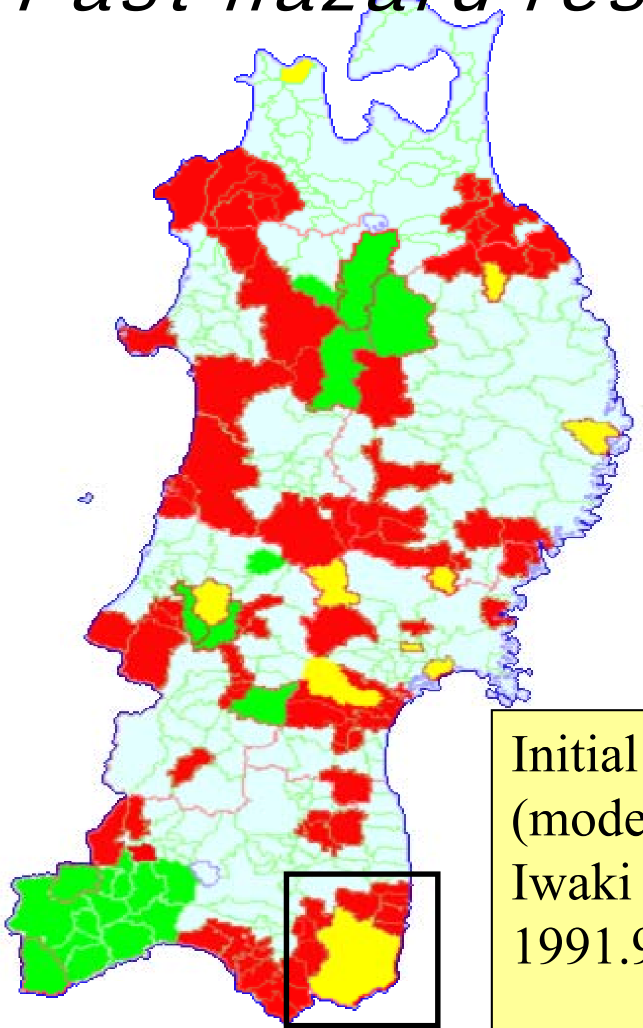

Fig. Slope hazard map by literature

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

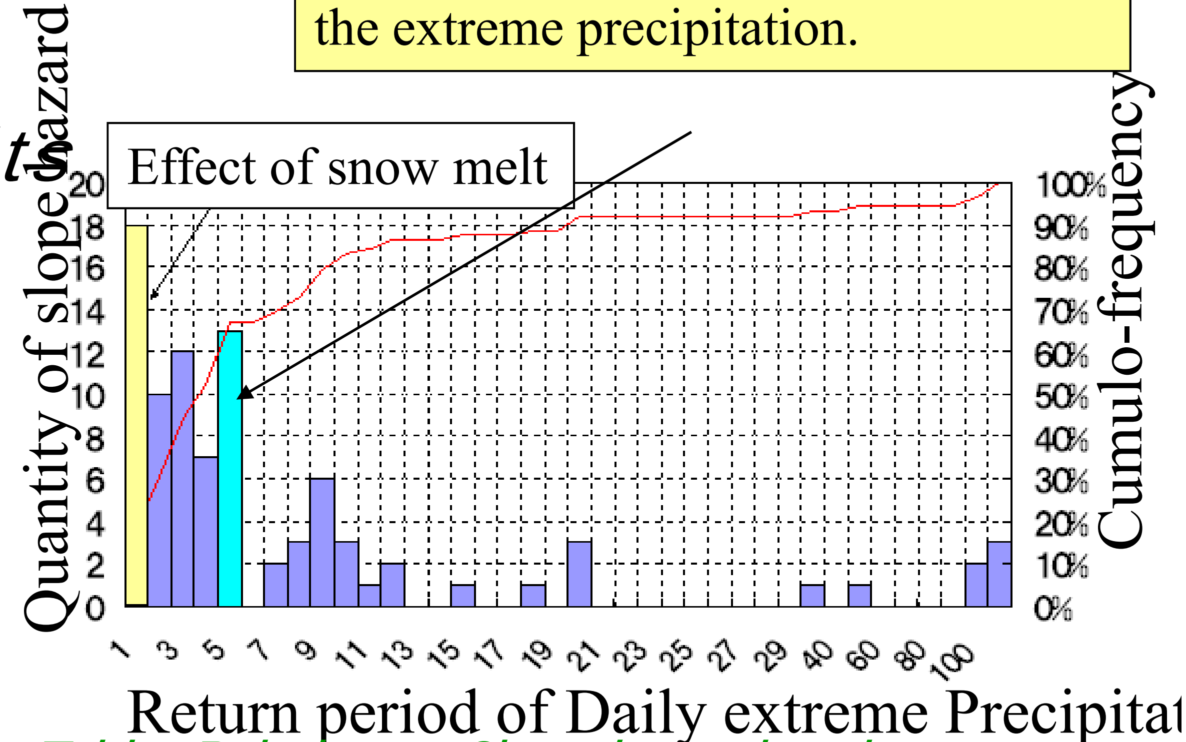

Table. Relation to Slope hazard and return period on extreme precipitation

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

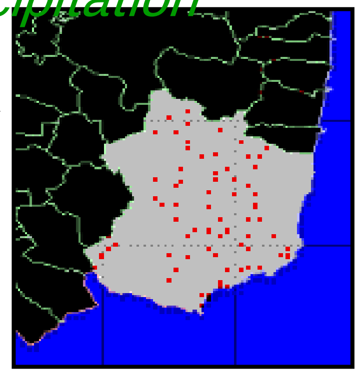

Fig. Hazards map in Iwaki

Probability model equation

slope

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

Where P is **probability**,β_0 *is intercept*,β_h*:is coefficient of hydraulic gradient,*

β_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

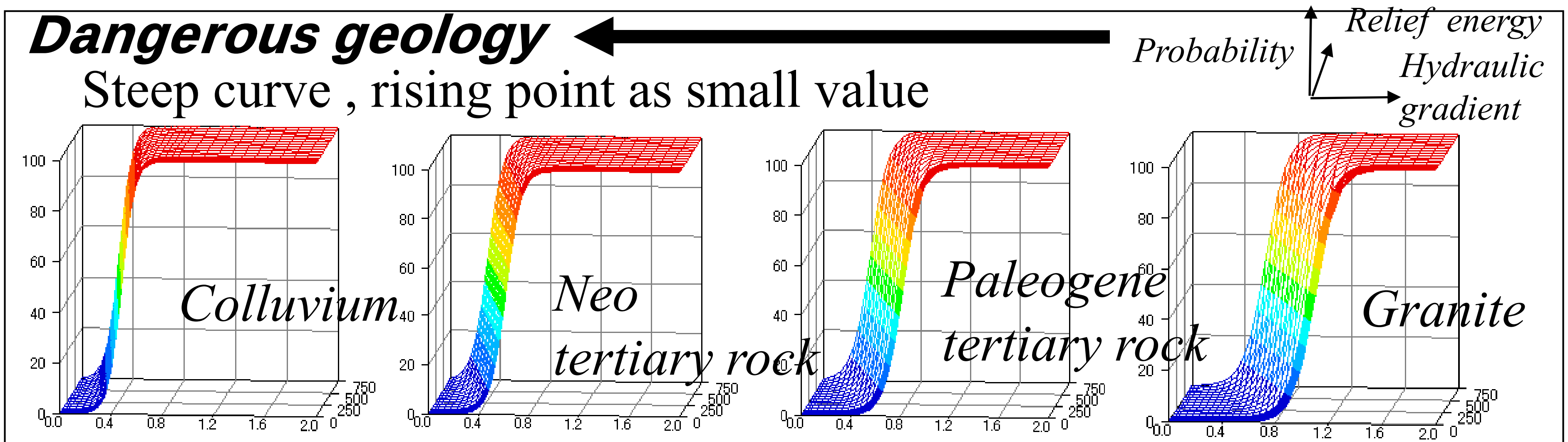

Fig. Logistic curve of each geological features

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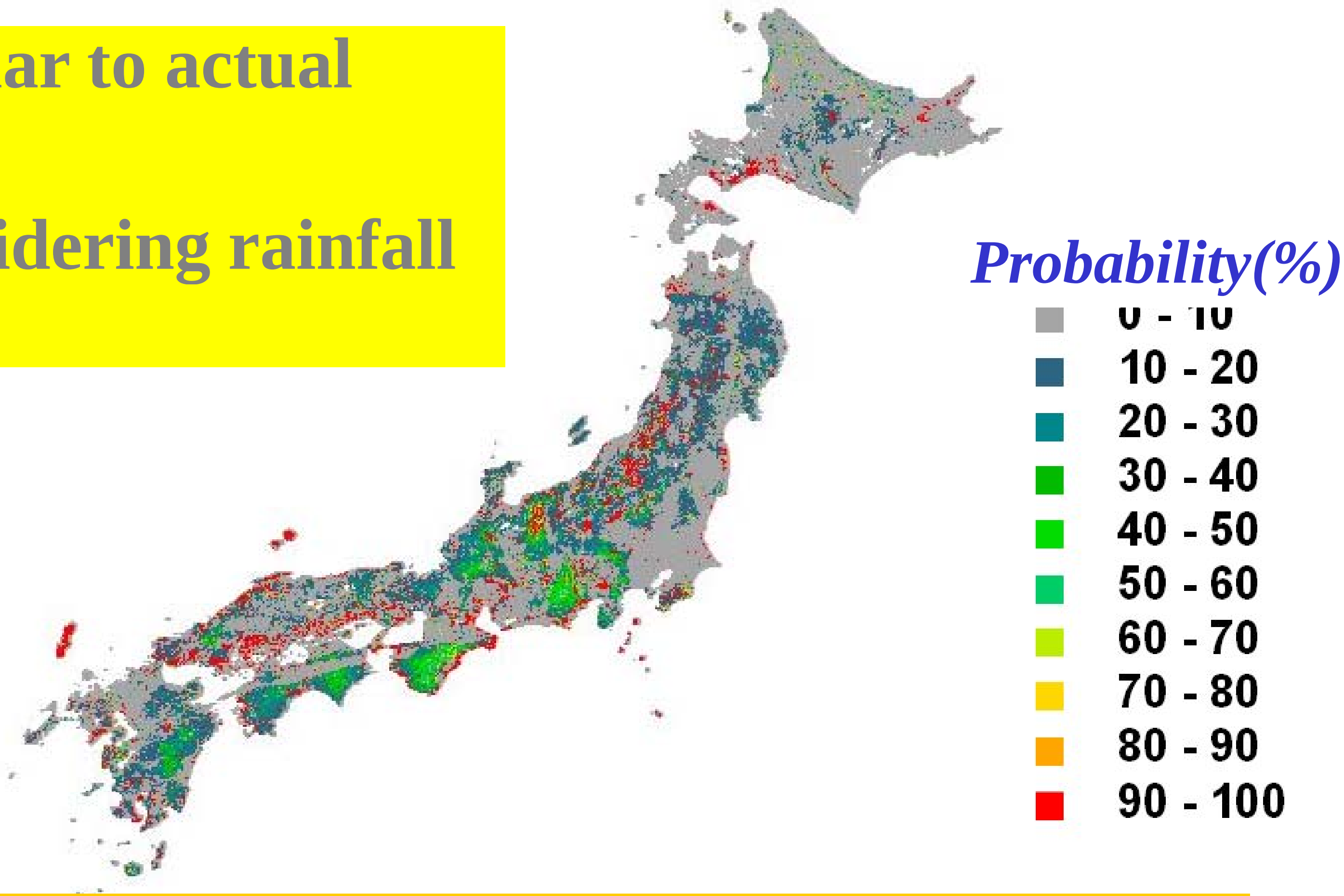
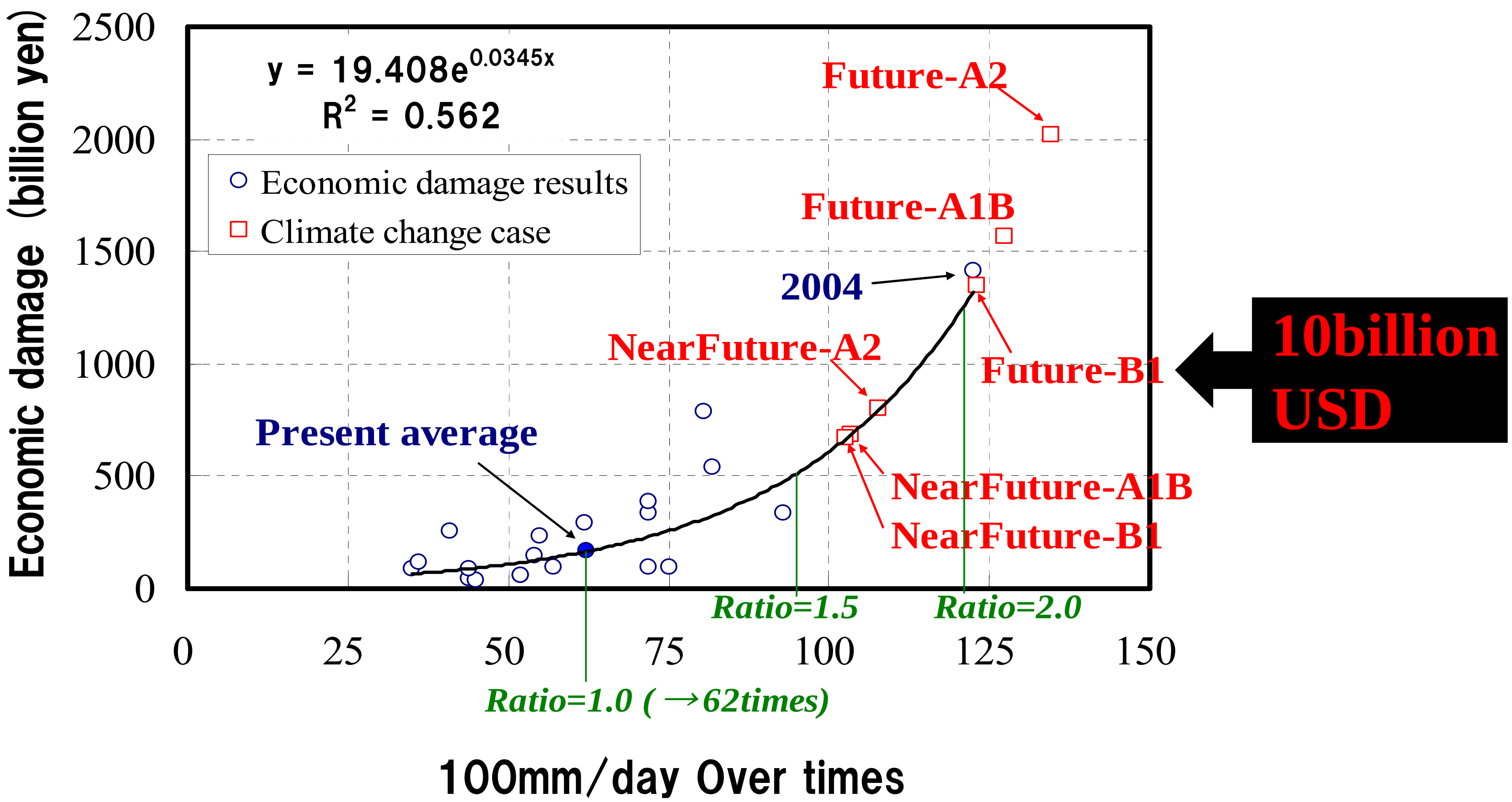
Sediment hazard map

These are similar to actual events.

These are considering rainfall effects.



Slope failure probability on 30 years return period downpour.



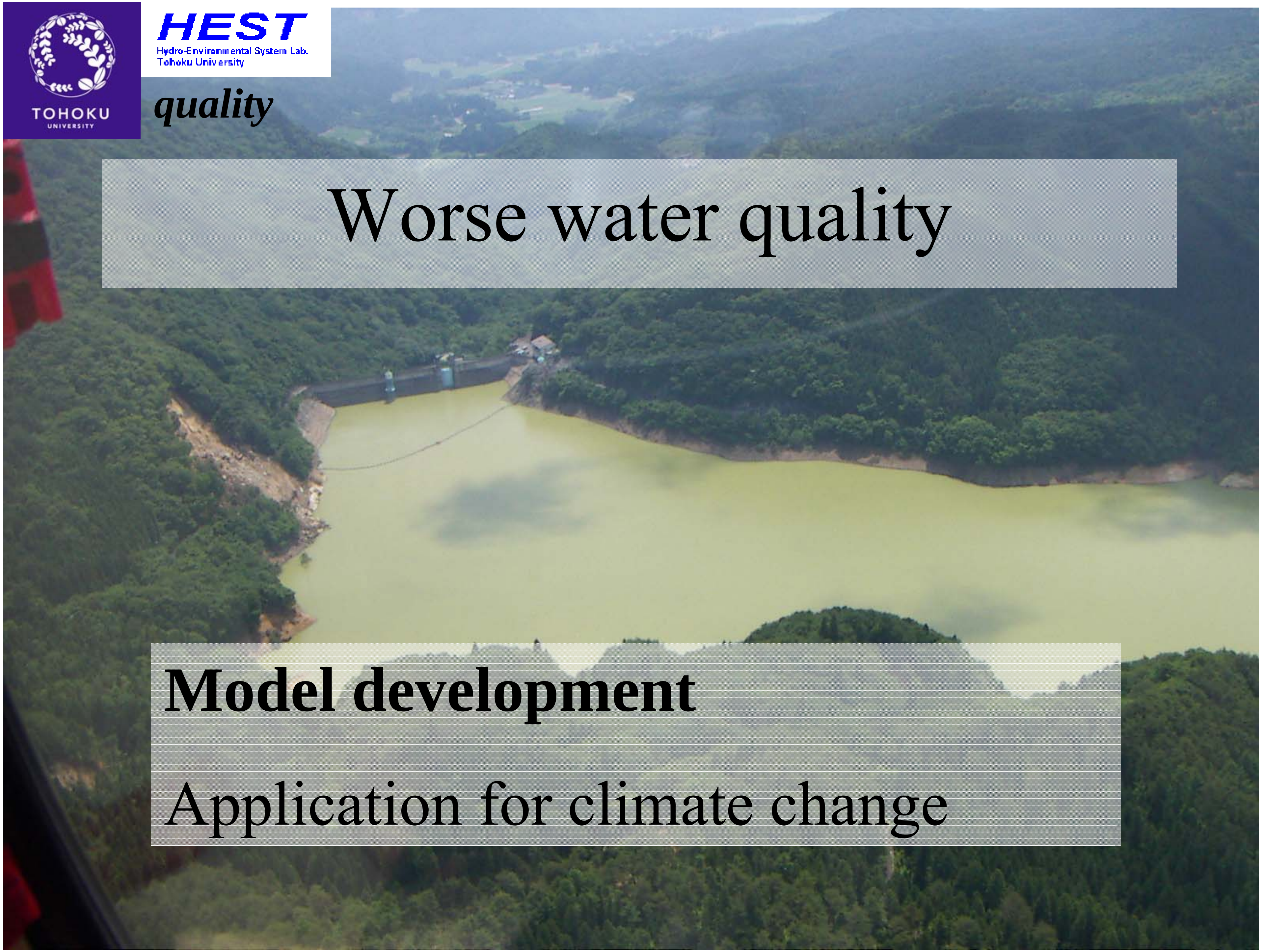
Relationship between days of over 100mm/d and damage costs

CONCLUSION

Huge water disasters increase rapidly caused by climate change.

quality

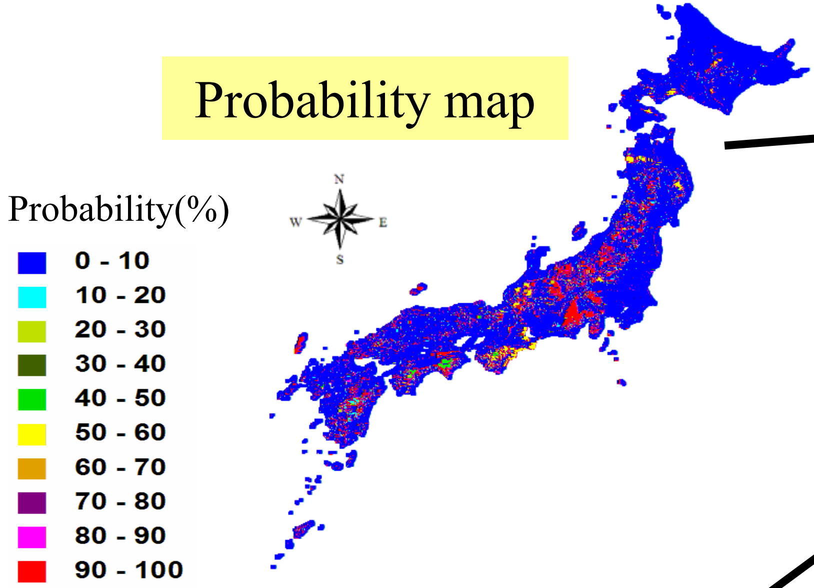
Worse water quality



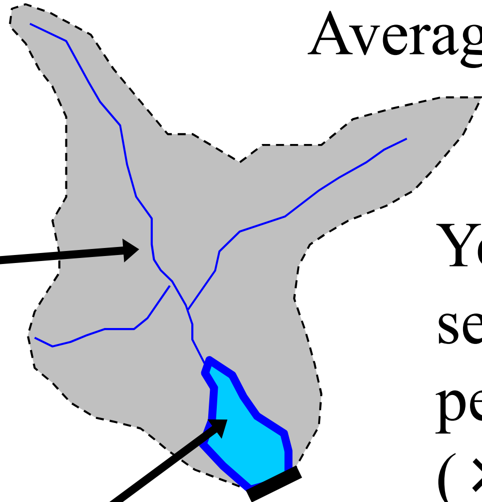
Model development

Application for climate change

quality



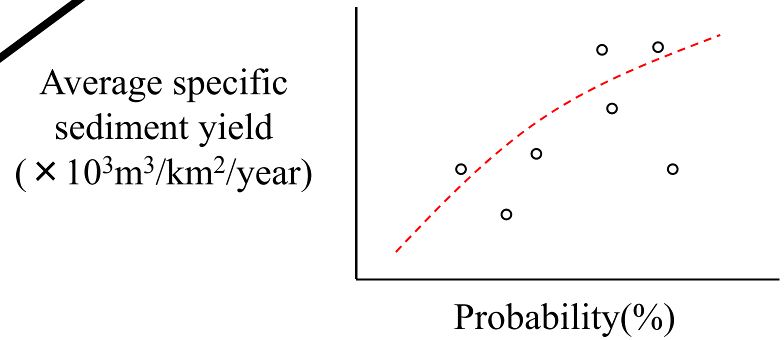
Dam basins

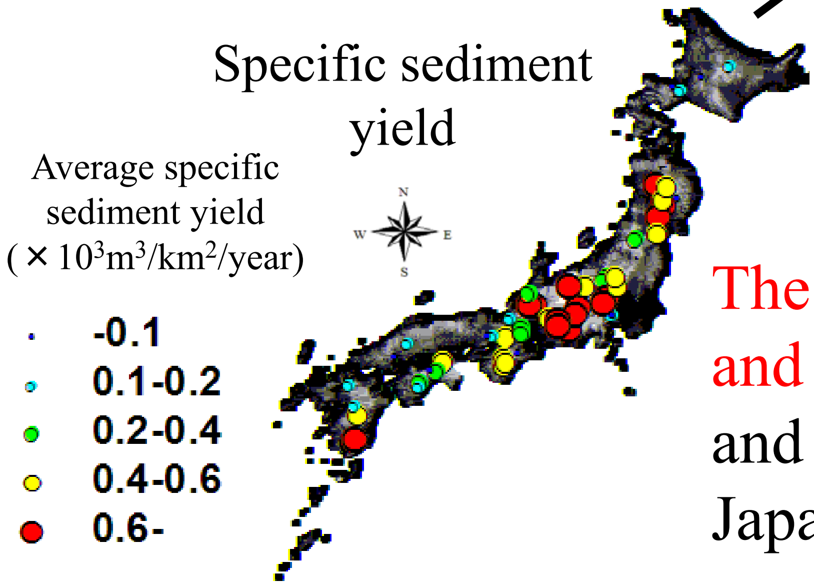


Average probability(%)

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

comparative verification





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

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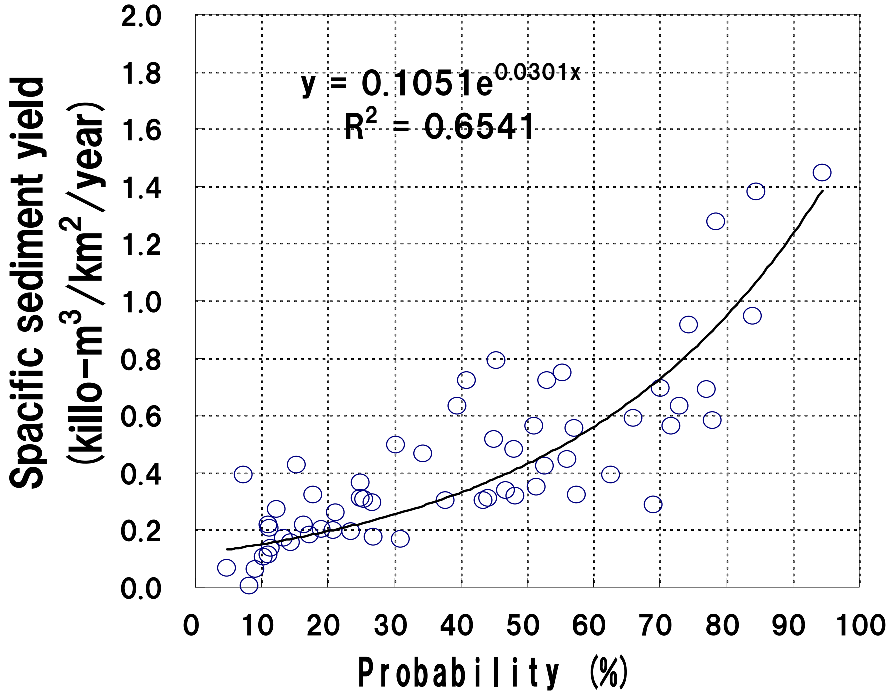
Probability model reproduces sediment hazard



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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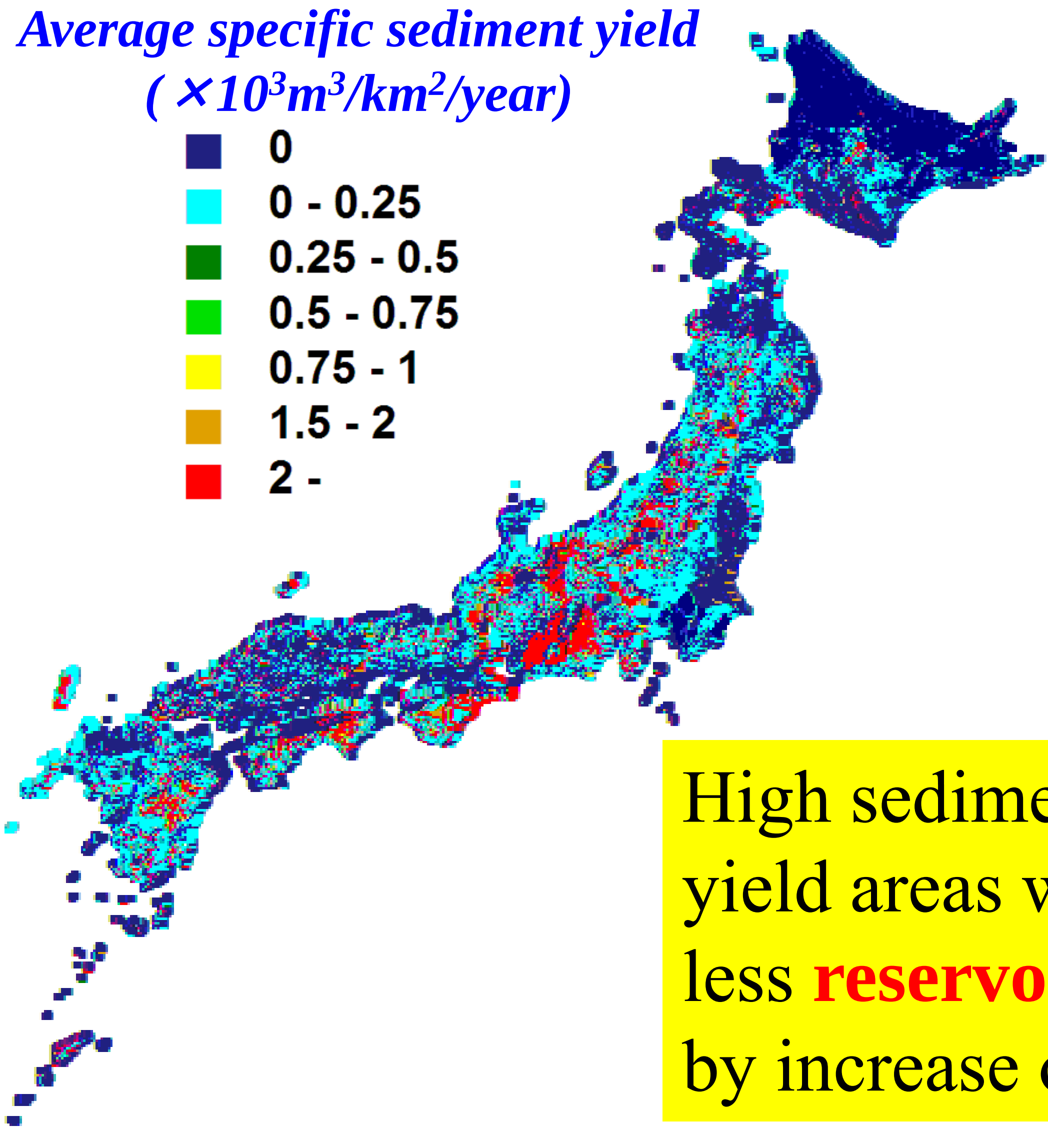
Sedimentation yield map



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

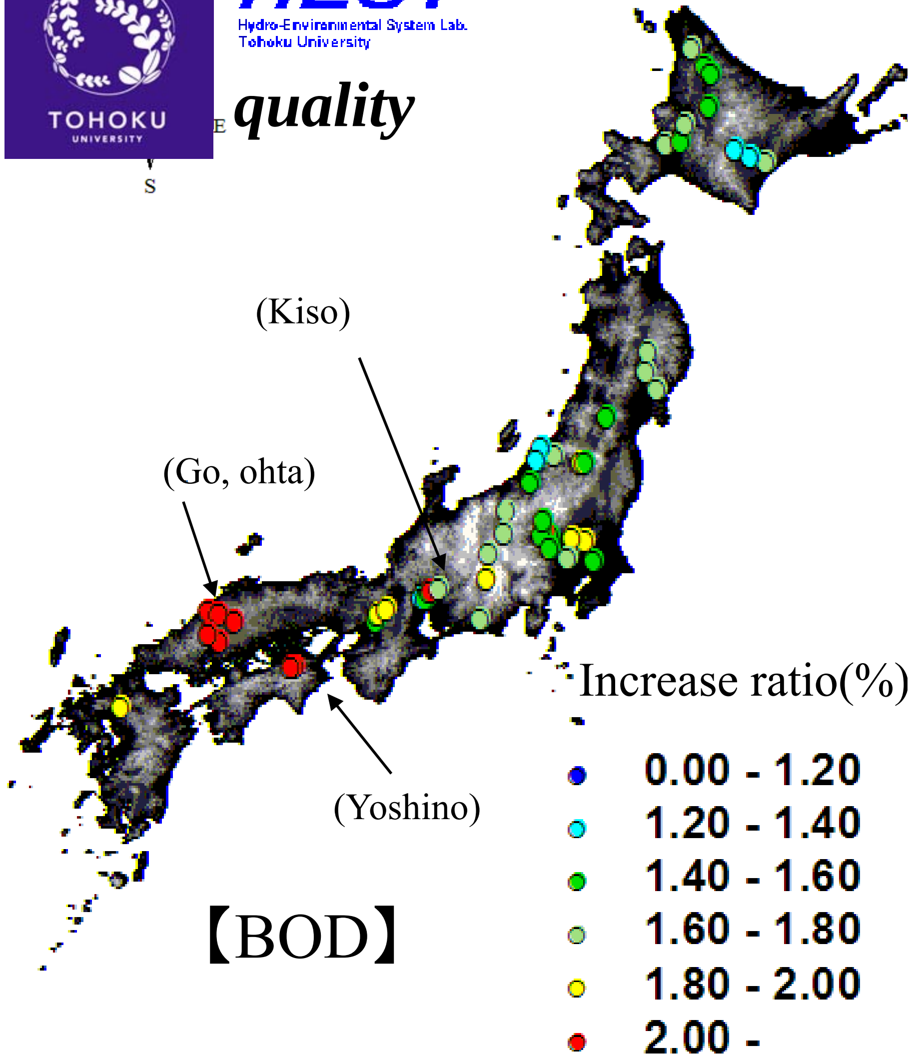
Water quality problems

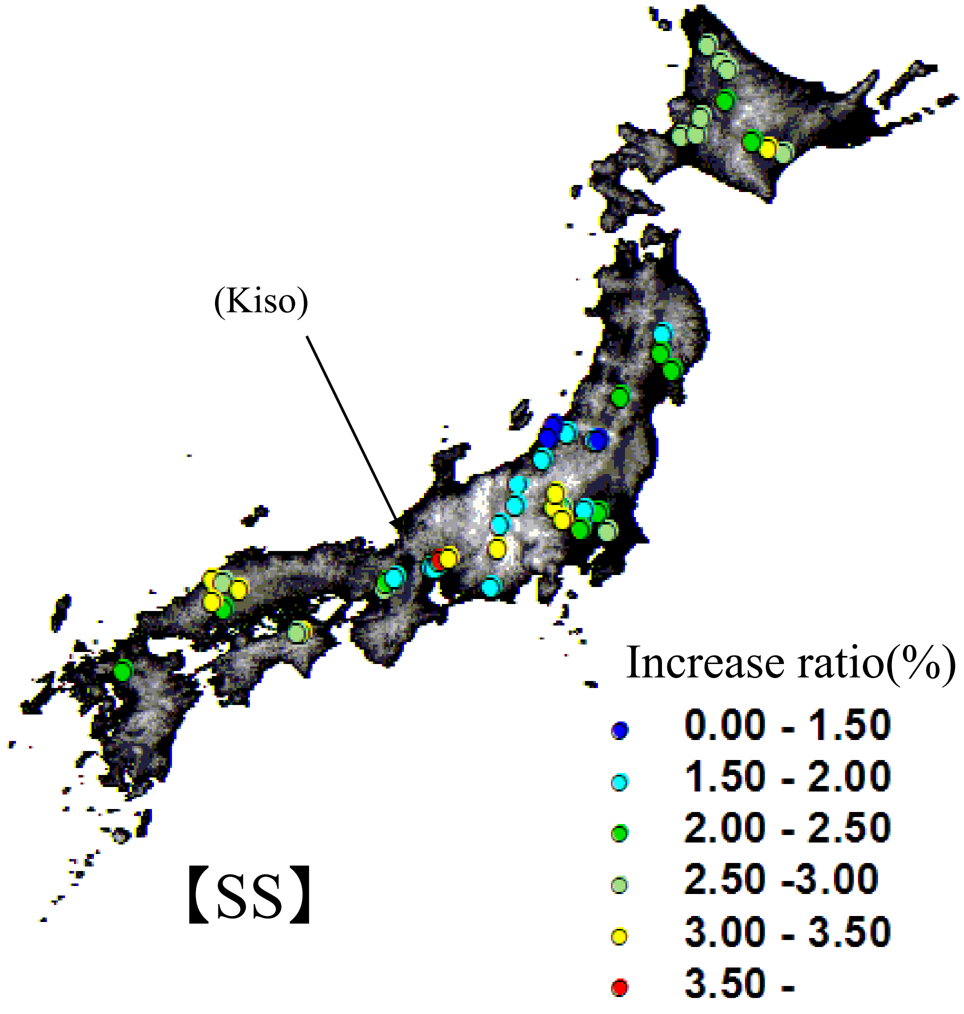
- □ **Influence of downpour**
  - ･Use of L-Q formula
  - ･Extreme rainfall input to L-Q formula for BOD and SS
- □ **Influence of drought period**
  - ･Use of turbidity deposit function
  - ･Input of drought period to a deposit function for BOD and SS

⇩

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

quality





Downpour affects WQ (RTN 50 years / 10years)

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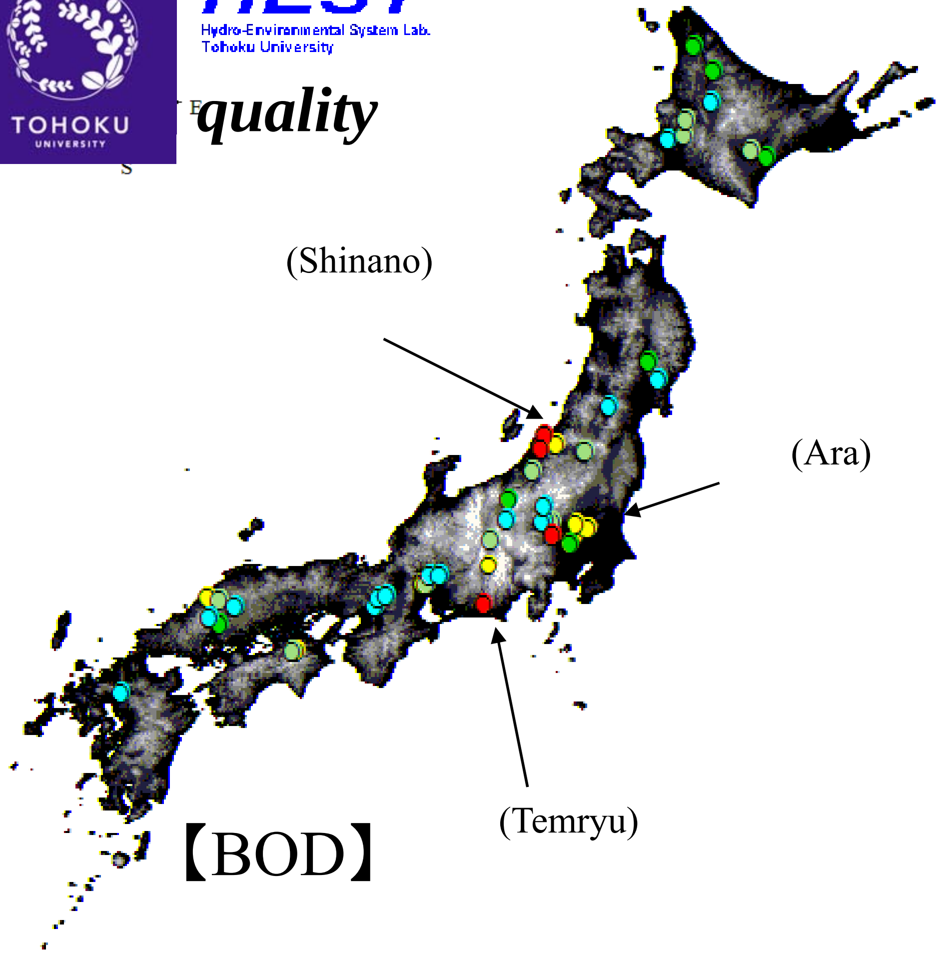

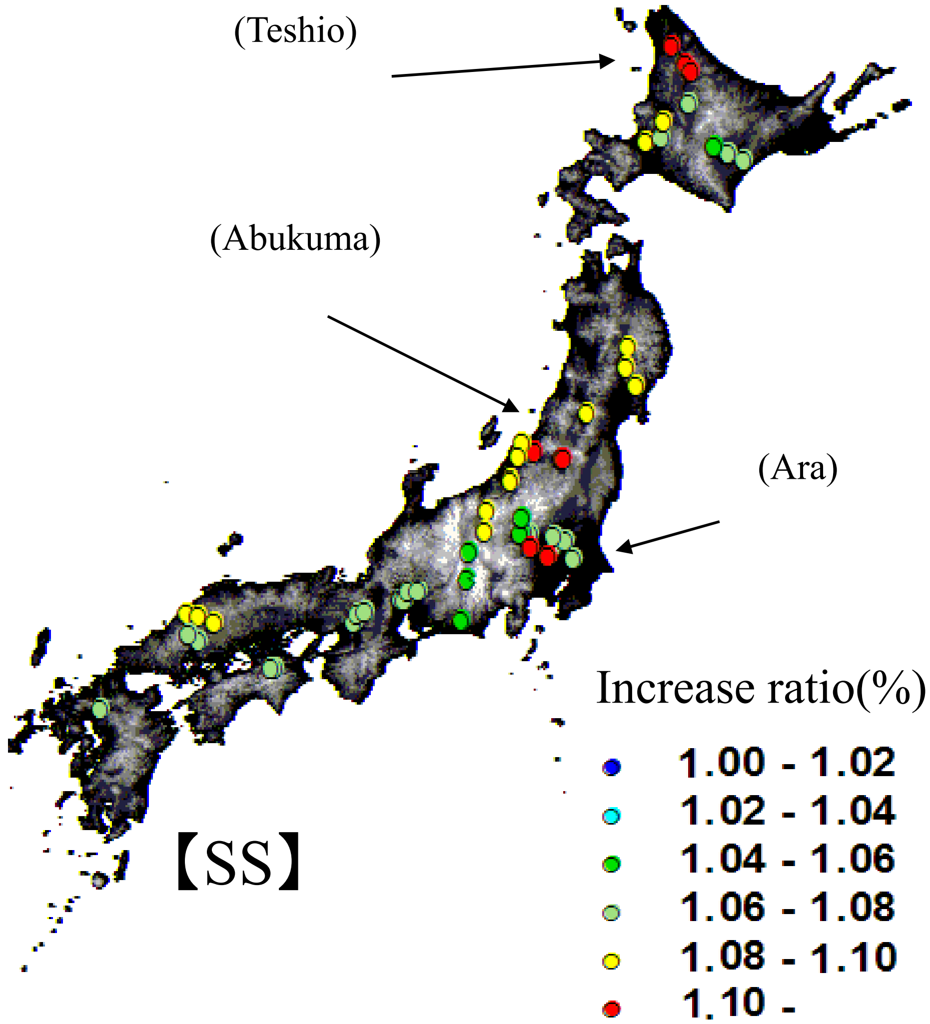

Drought affects WQ change (RTN50uyears/RTN10years)

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.