Climate Change Impacts on the Flood Hazard and Economic Risk In a Japanese River Catchment using GCM Precipitations Under the A1B Scenario

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Motivation

Tokai heavy rainfall（Shinkawa）: Nagoya URL

Sayo Town, heavy rainfall (2009）: Kuzaki district

Recently flood disasters due to heavy rainfall often happens in Japan.

1999 June: Fukuoka flood disaster

2000 Sep.: Tokai heavy rainfall

2004 July.: Niigata/Fukushima heavy rainfall, Fukui heavy rainfall

2004 Oct.: Yuragawa river, Kyoto and Maruyamagawa river, Hyogo flood disasters by Typhoon No. 23.

2008. Aug.: Okazaki-city, Aichi, flood disasters

2009. July: Yamaguchi heavy rainfall

2009. Aug.: Sayo-town, Hyogo by Typhoon No. 9

- At Tokai heavy rainfall, it was characteristic that 96.4 % of the total property damage was public asset damage（house and household article 43.6%, business office asset 42.4%, business suspension 9.6%, agriculture, forestry and fishery 0.8%）
- Ministry of Construction (currently MLIT) estimated that approx. 850 billion JPY damage was brought only in Aichi Prefecture at the Tokai heavy rainfall

Development of a framework for the flood hazard and economic risk assessment

The vector-type data is useful when we assess the property damage and the economic loss due to flooding in the region.

Rainfall-runoff simulation

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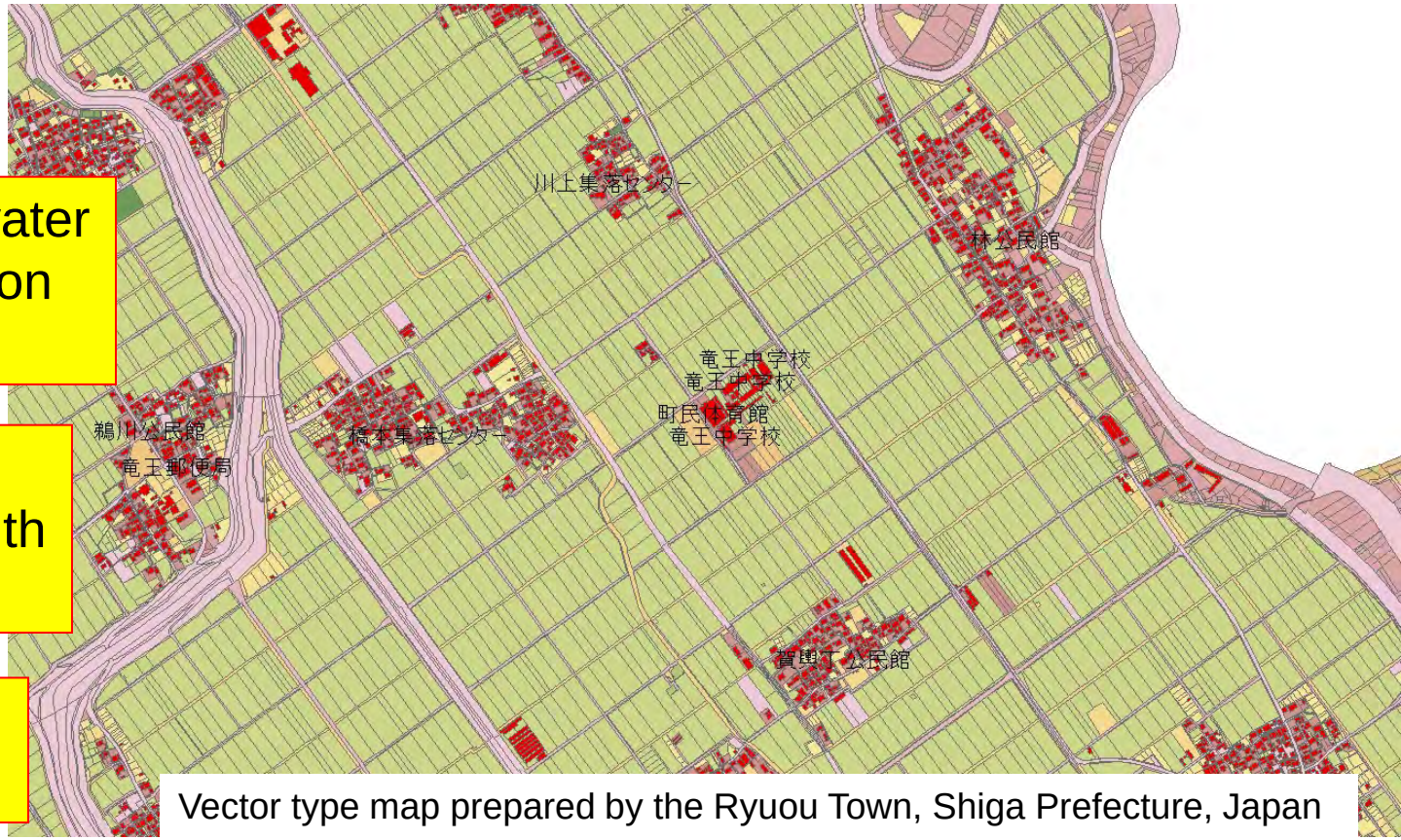
Flood and inland water inundation simulation (with drainage)

↓

Integration of the simulation result with the vector map

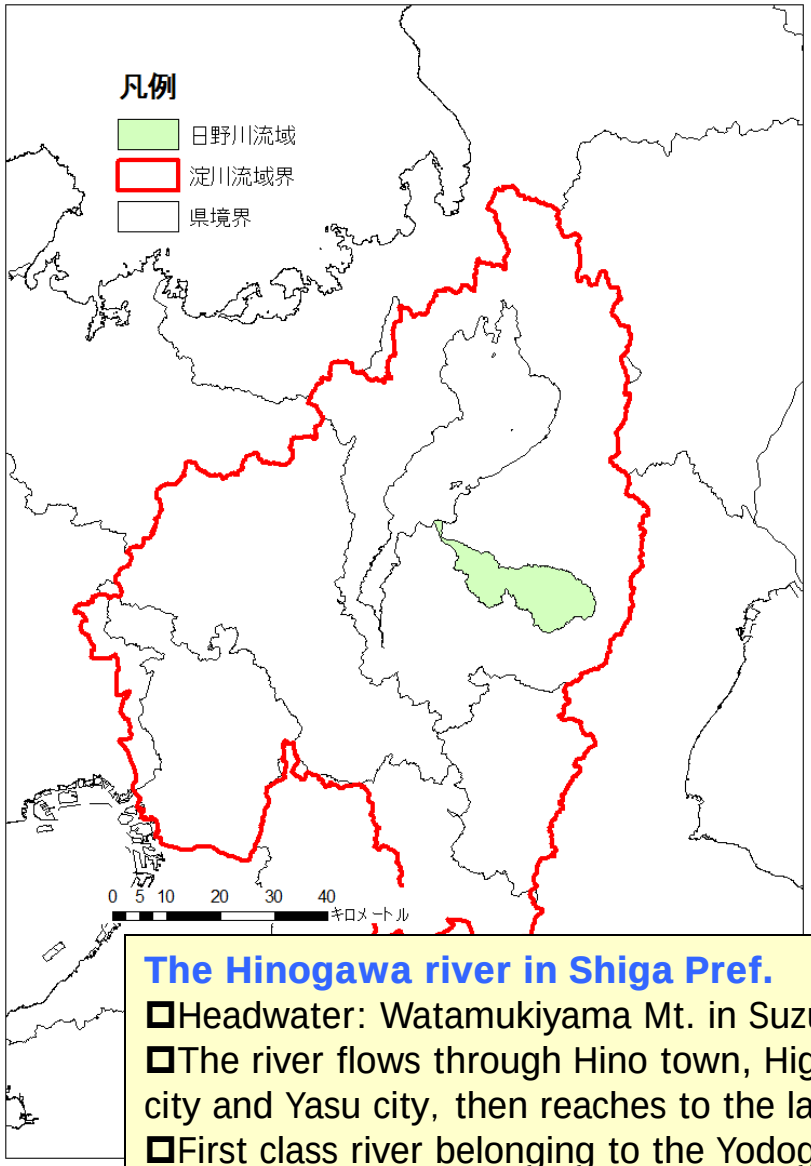
↓

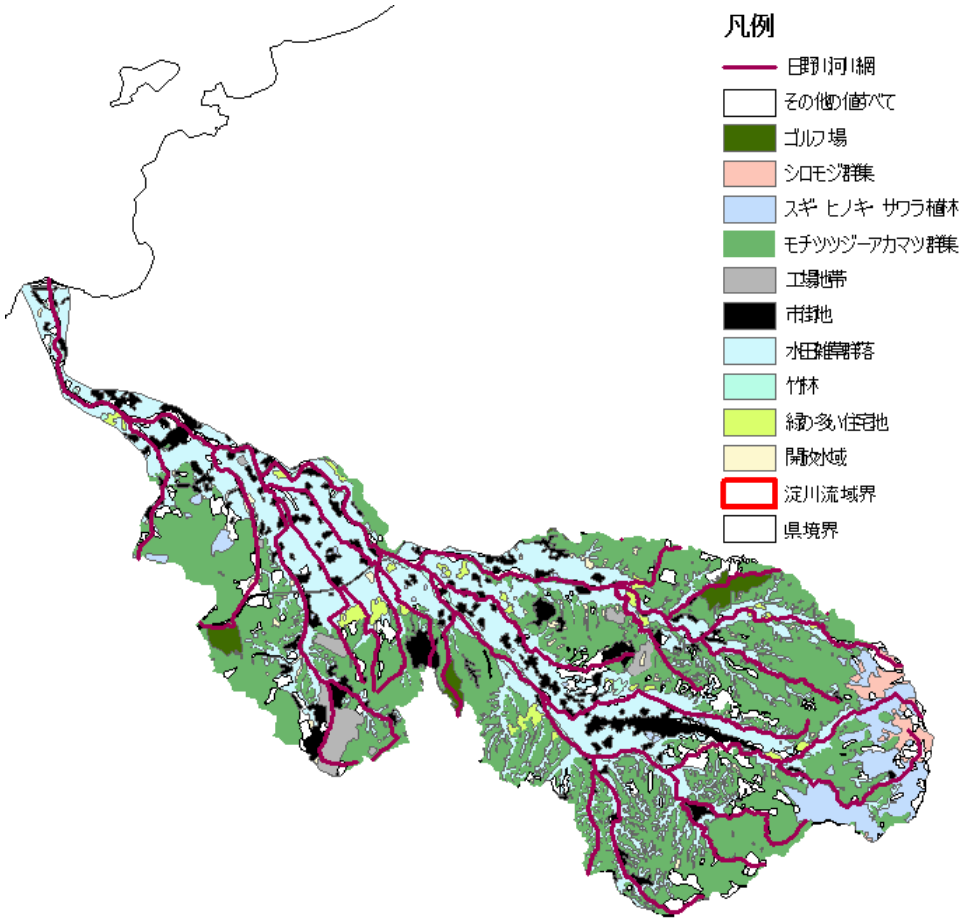
House/crop damage estimation



Vector type map prepared by the Ryuou Town, Shiga Prefecture, Japan

The Hinogawa river catchment

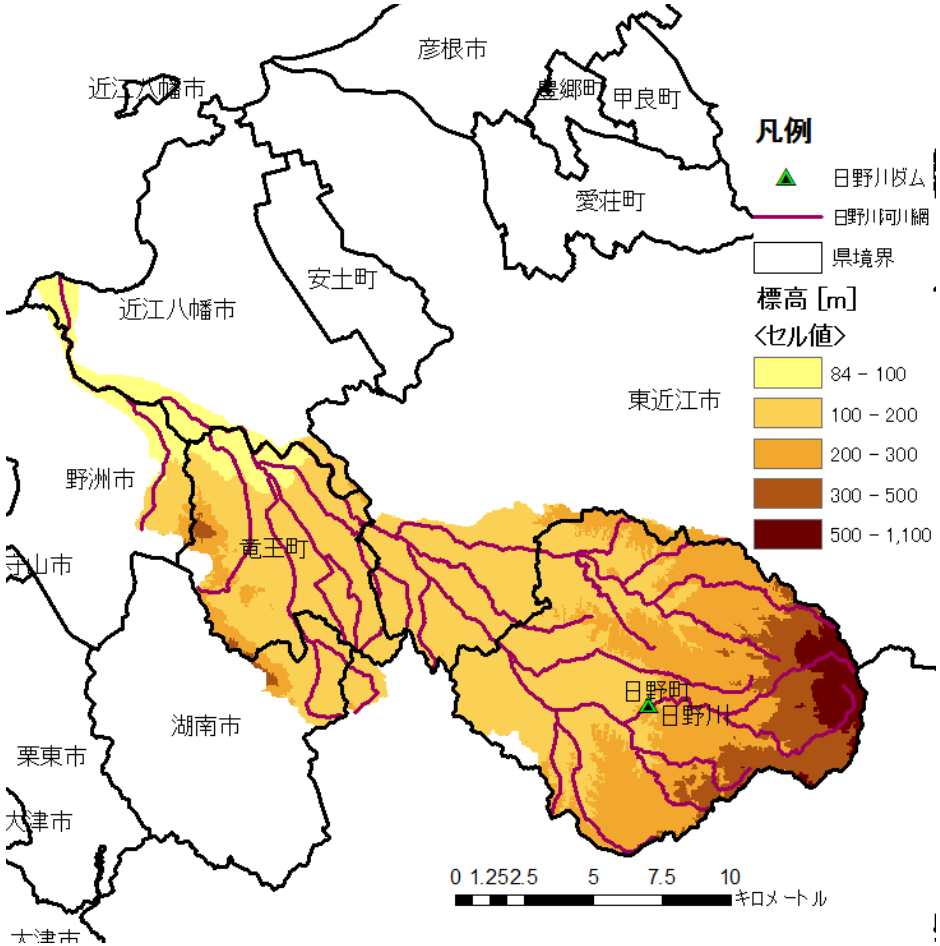


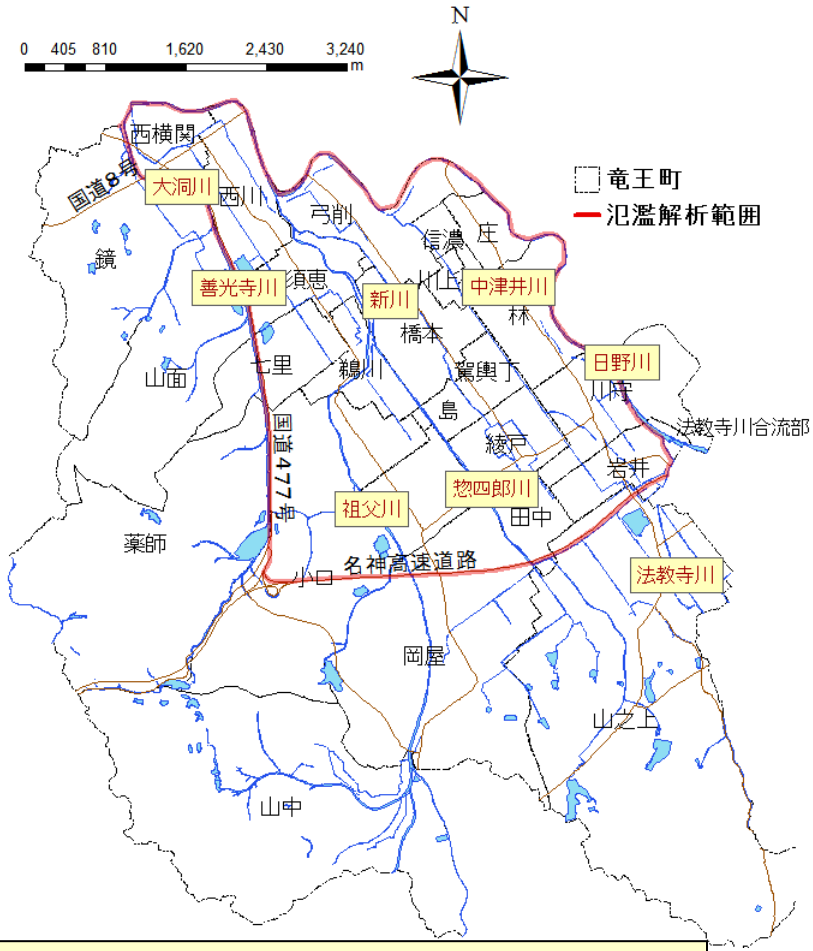


The Hinogawa river in Shiga Pref.

- Headwater: Watamukiyama Mt. in Suzuka range（elevation 1100m）
- The river flows through Hino town, Higashi-Omi city, Ryuou town, Omi-Hachiman city, Konan city and Yasu city, then reaches to the lake Biwa.
- First class river belonging to the Yodogawa river system (Catchment Area 207.1 km^2, channel length 42.2km）.

Ryuou Town





Ryuou Town

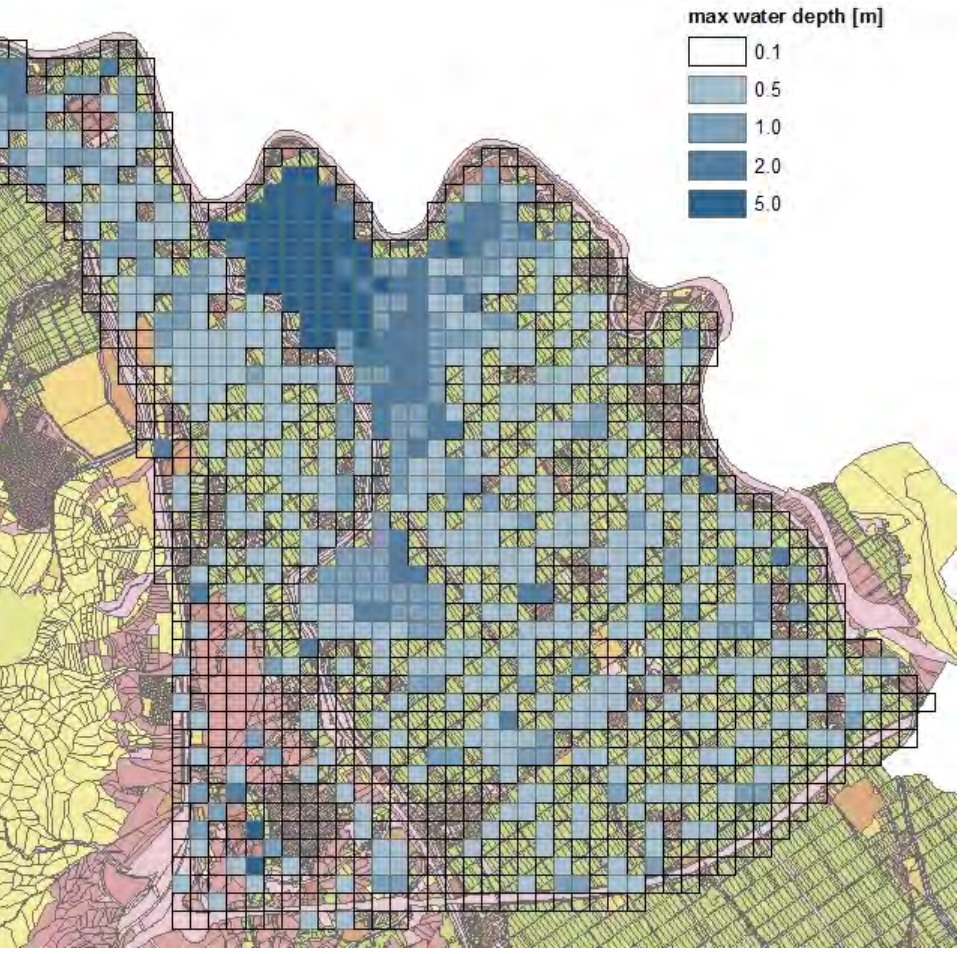
- Located in the middle to downstream region of the Hinogawa river
- Large part of the town is surrounded by Yukinoyma in the east, Kagamiyama in the west, hilly terrain in the south and the Hinogawa river in the north
- Town area: 44.52km^2, population:13674（male:7529, female: 6145）, 5045 households（as of March 1, 2008)

Flood Inundation simulation

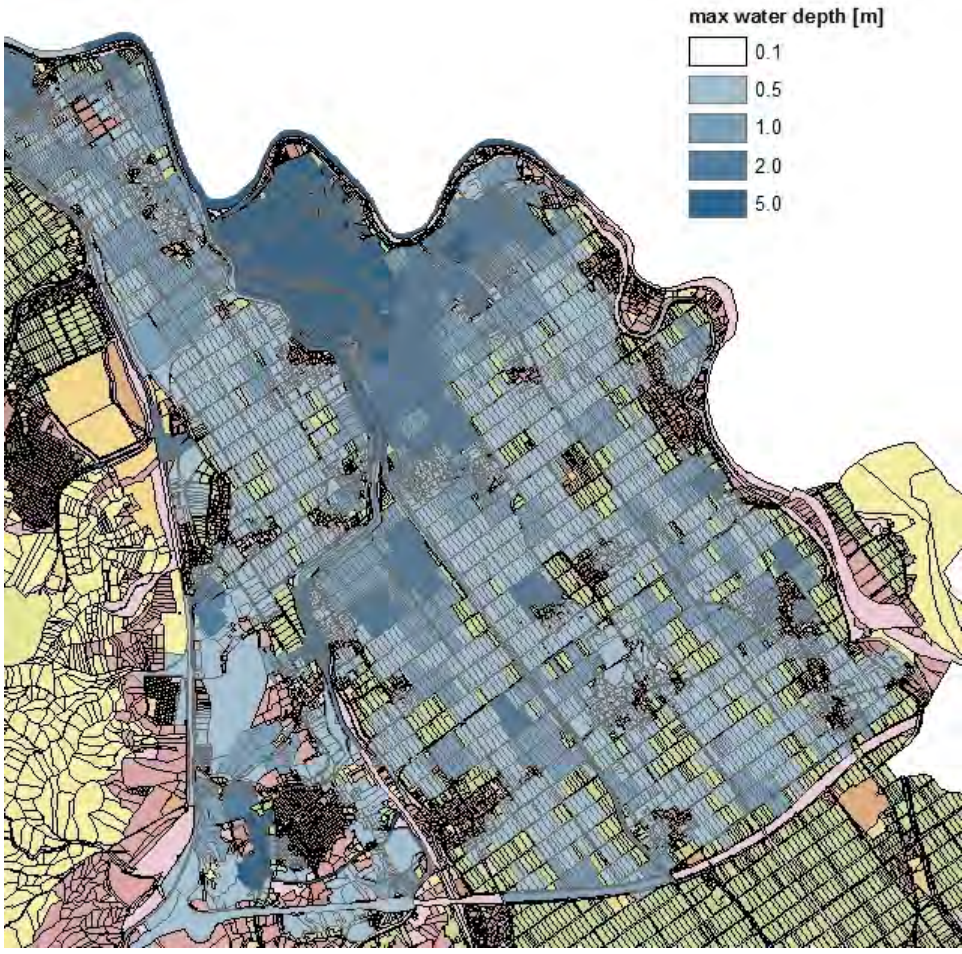
Interpolation

Integration of the grid cell inundation depth to the vector type house and paddy field map

Raster type water depth overlaid on the vector map



Integrated result



The relation between the house damage ratio and the inundation depth

Inundation depth [m] / Ground slope [-]	< 0.45	<0.5	≧0.5 < 1.0	≧1.0 < 2.0	≧2.0 < 3.0	≧3.0
<1/1000	3.2 [%]	9.2	11.9	26.6	58.0	83.4
1/1000 - 1/500	4.4	12.6	17.6	34.3	64.7	87.0
≧1/500	5	14.4	20.5	38.2	68.1	88.8

Flood control economic risk assessment manual
=Chisui Keizai Chousa Manual (2005 version)

The relationship between the crop damage ratio and the inundation depth + duration

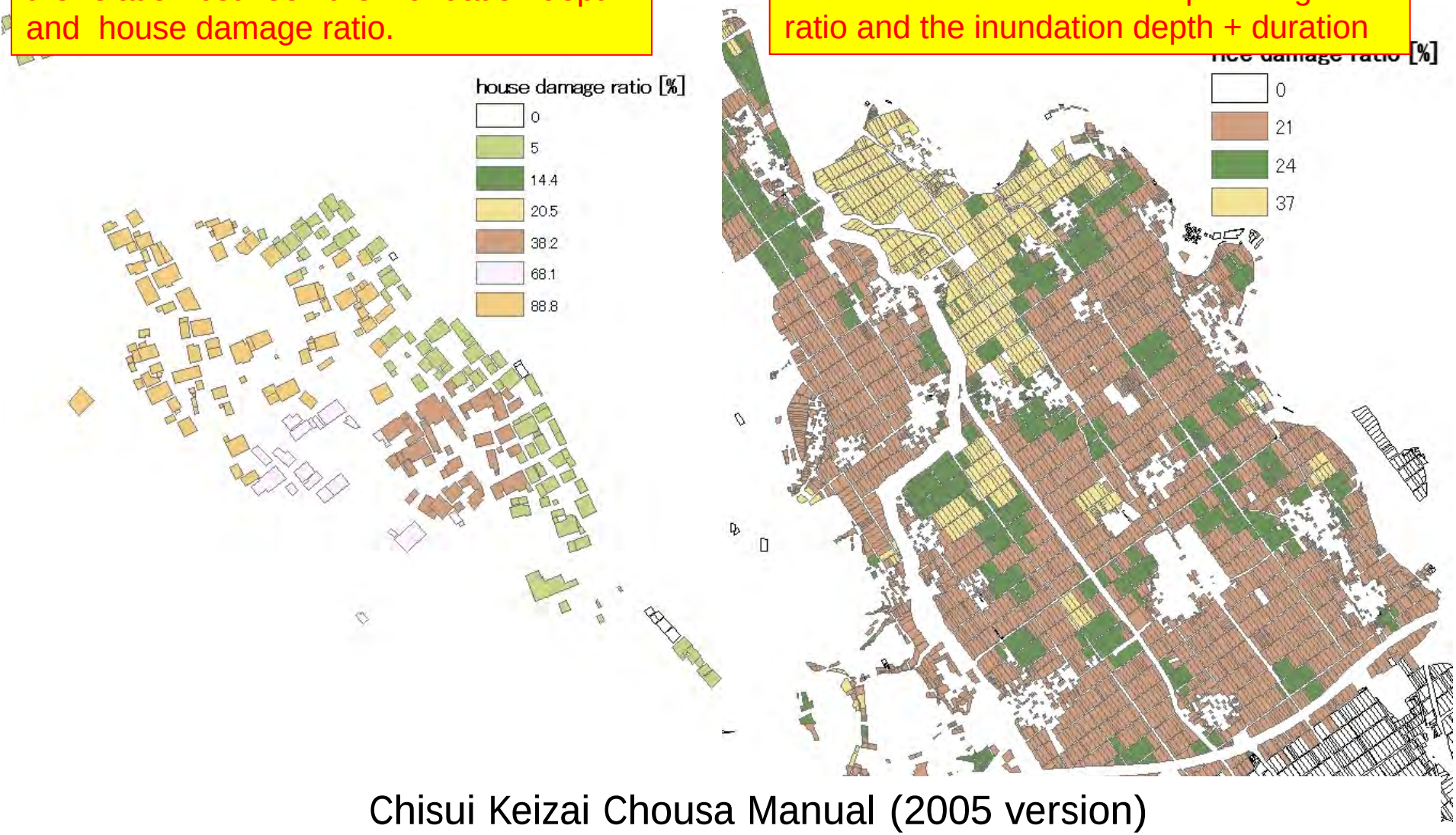
Inundation depth [m]	< 0.5				≧0.5 < 1.0				≧1.0			
Inundation duration [day]	1-2	3-4	5-6	7	1-2	3-4	5-6	7	1-2	3-4	5-6	7
rice (paddy) [%]	21	30	36	50	24	44	50	71	37	54	64	74
crop average [%]	27	42	54	67	35	48	67	74	51	67	81	91

Flood control economic risk assessment manual
=Chisui Keizai Chousa Manual (2005 version)

The house and crop damage ratios are estimated using the statistics of the Chisui Keizai Chosa Manunal

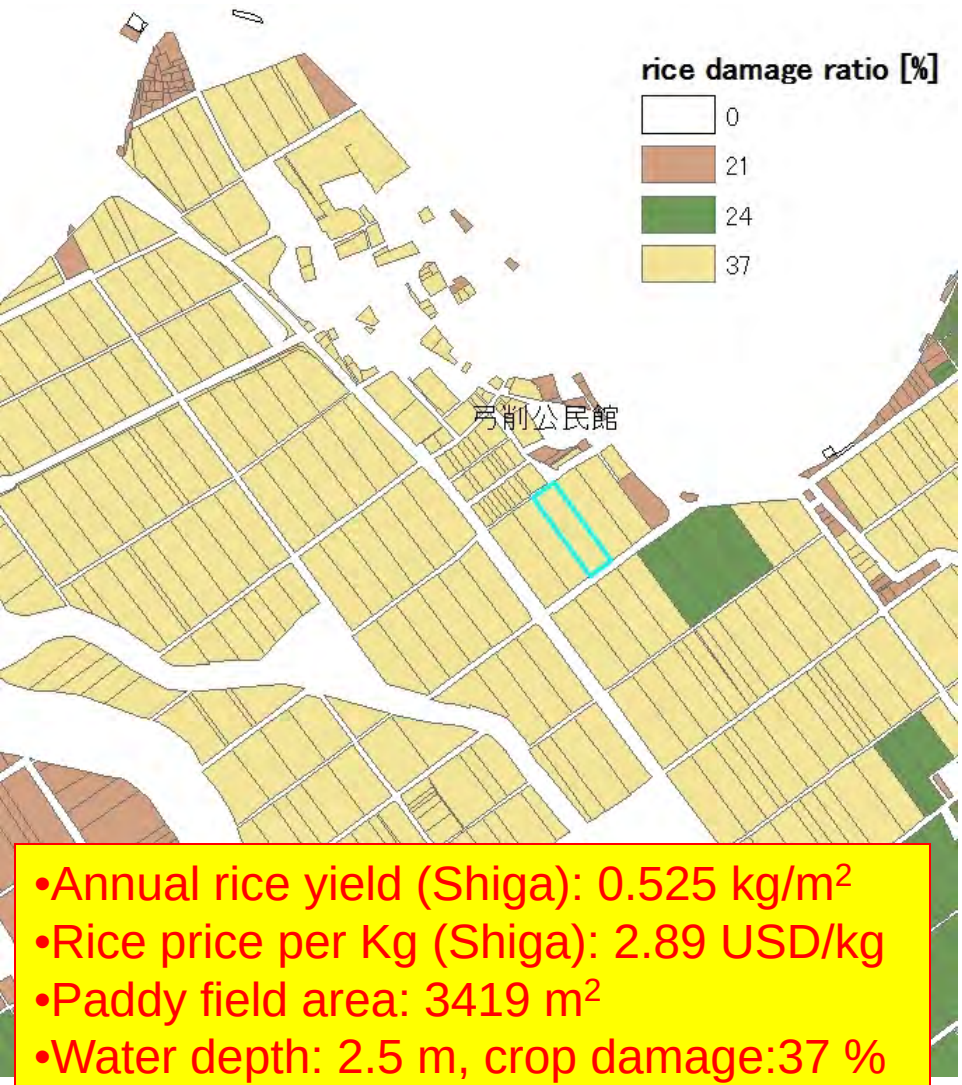
The house damage ratio is estimated with the relation between the inundation depth and house damage ratio.

The crop damage ratio is estimated with the relation between the crop damage ratio and the inundation depth + duration



Chisui Keizai Chousa Manual (2005 version)

Economic loss



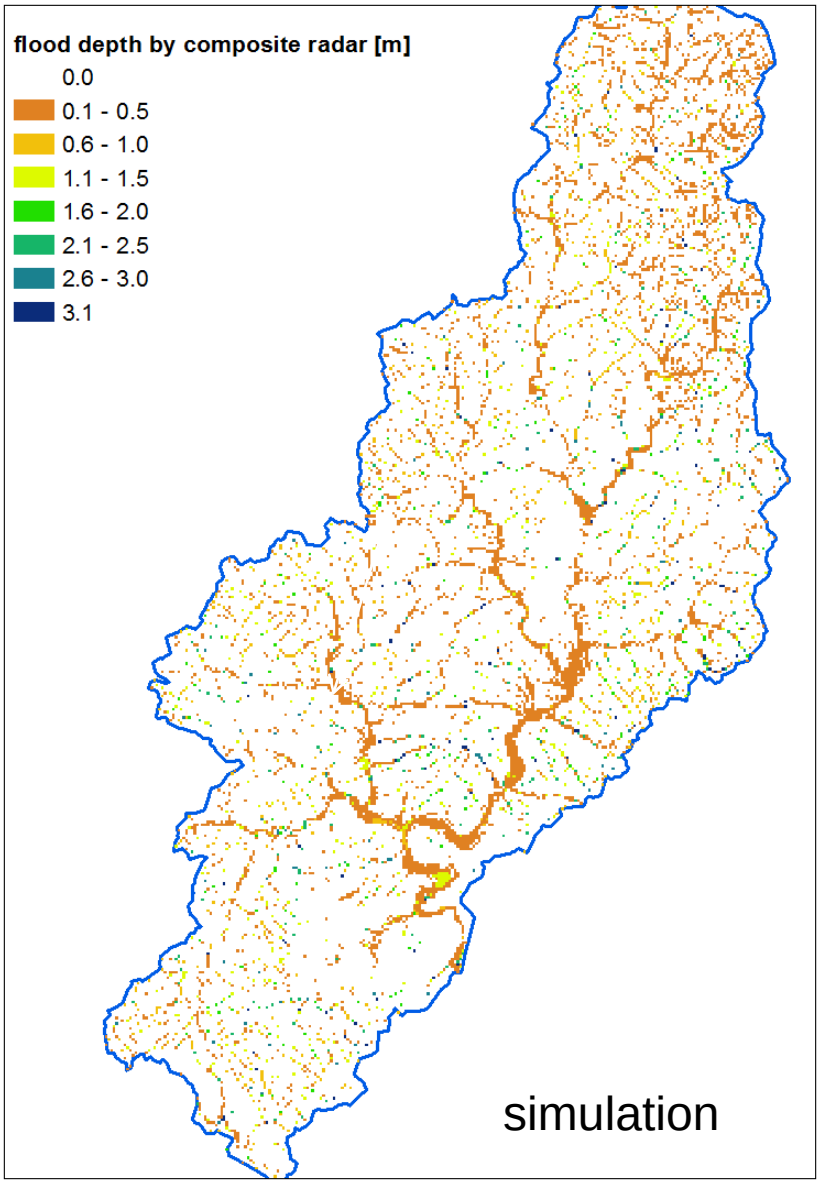
- Annual rice yield (Shiga): 0.525 kg/m^2
- Rice price per Kg (Shiga): 2.89 USD/kg
- Paddy field area: 3419 m^2
- Water depth: 2.5 m, crop damage:37 %

Economic loss of the crop:
$3419 \times 0.525 \times 2.89 \times 0.37 = 1920$ USD
Following: Chisui Keizai Chousa Manual (2005 version)

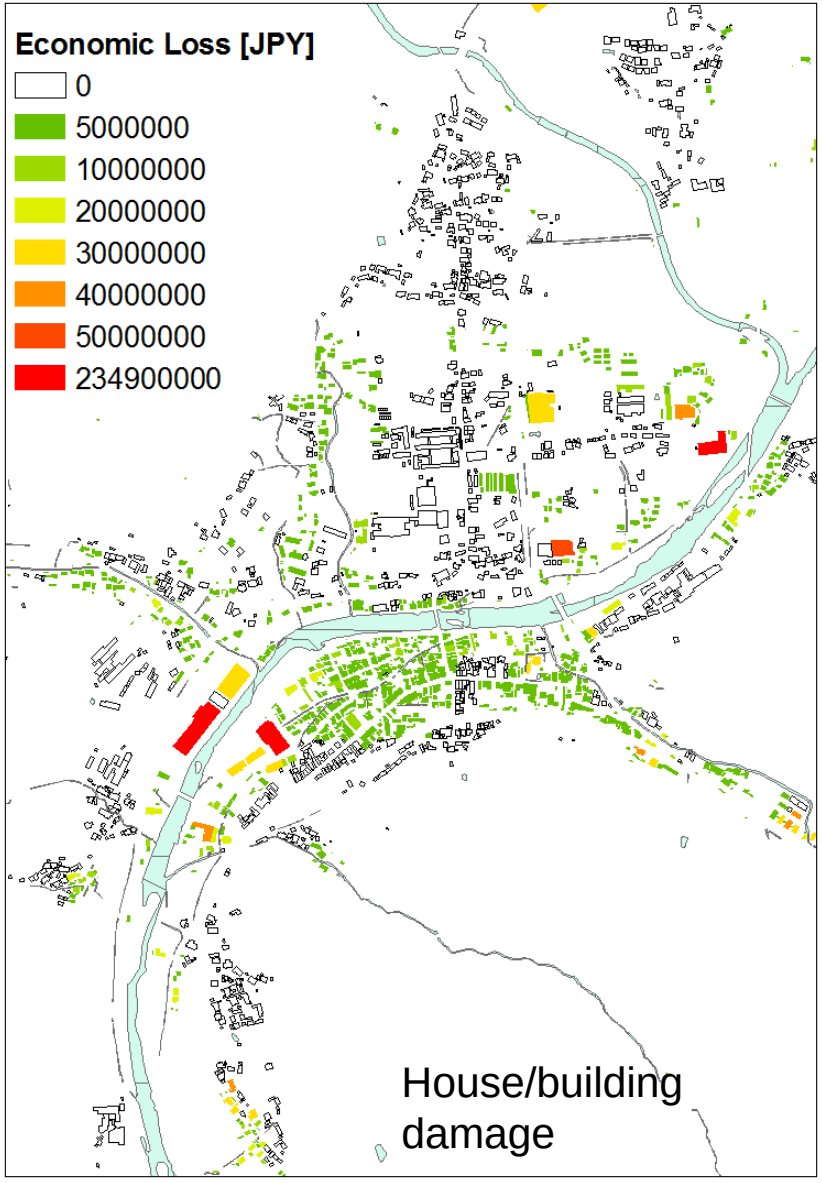
- House value (Shiga) :1519 USD/m^2
- House area (Ryuou post office): 376 m^2
- Water depth: 0.71 m, House damage ratio:20.5 %

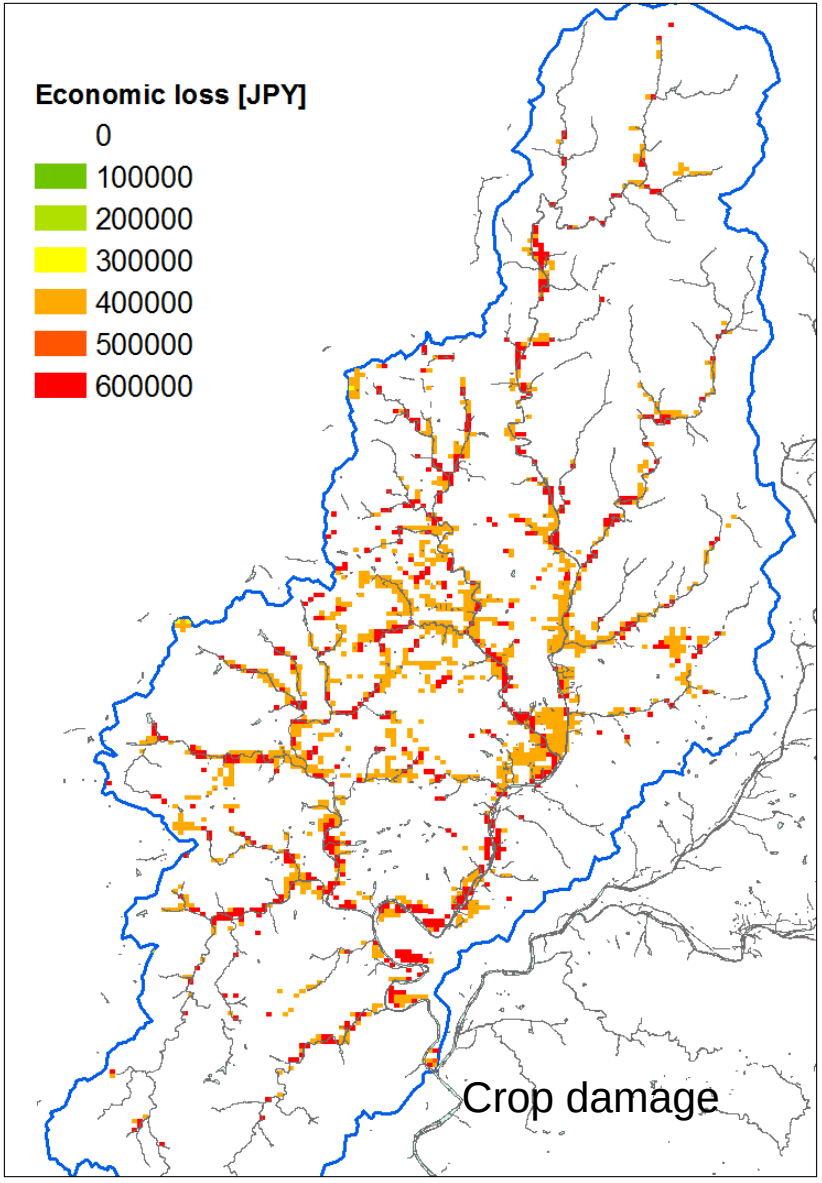
Economic loss of the building:
$376 \times 1519 \times 0.205 = 117084$ USD
Following: Chisui Keizai Chousa Manual (2005 version)

Other example of the same procedure at the place where recently experienced the flood hazard



The result of economic loss estimation





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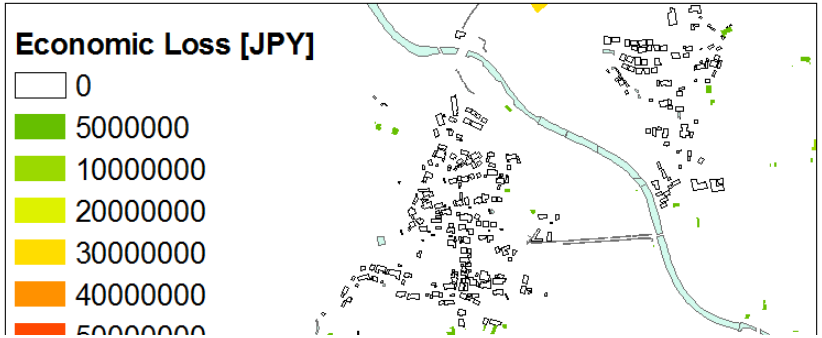
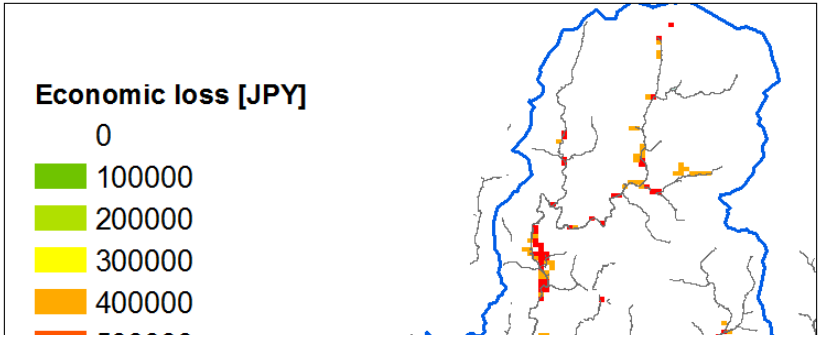




Estimated amount by Hyogo Prefecture（Dec. 1 2009）:

House/buildings:

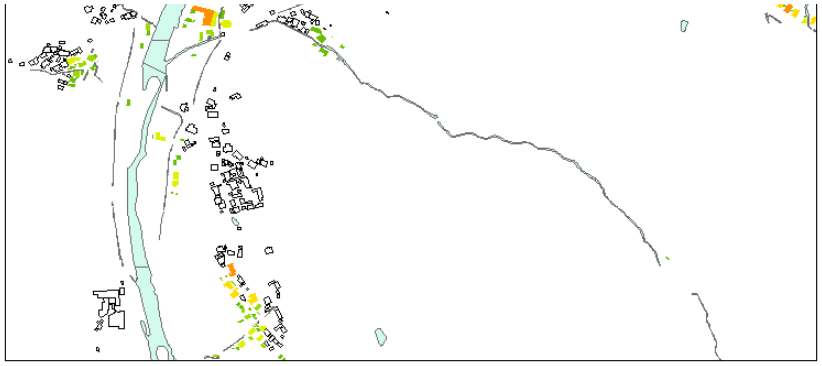
Reported:18.5 billion JPY =185 million USD (100 JPY approx. 1 Dollar)

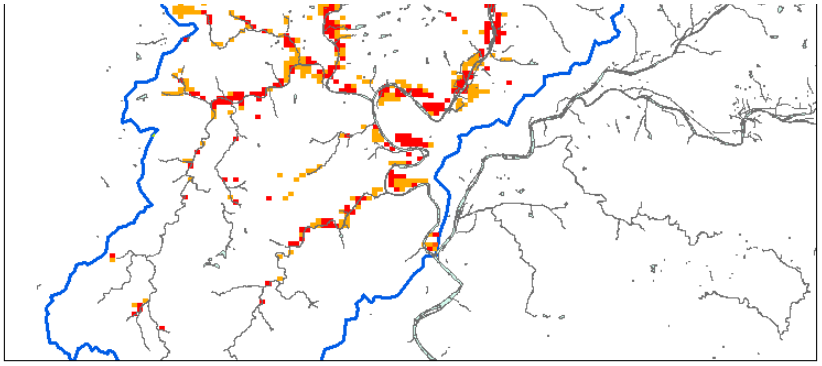
Estimated by the model：16.1 billion JPY = 161 million USD (to be calibrated more）

Crop：

Reported:0.245 billion JPY = 2.45 million USD

Estimated by the model：0.76 billion JPY = 7.6 million USD





KAKUSHIN Program, Japan

Source: KAKUSHIN official website

- The Ministry of Education, Culture, Sports, Science, and Technology (MEXT) has launched a 5-year (FY2007 - 2011) initiative called the Innovative Program of Climate Change Projection for the 21st Century (KAKUSHIN Program) using the Earth Simulator (ES).

The KAKUSHIN Program is targeting three major themes:

- **Advancing climate modeling and projection** for better simulation of physical and biogeochemical processes by sufficient reflection of feedbacks;
- **Quantification and reduction of uncertainty** for more reliable projections of climate change using model comparisons and other methodologies;
- **Application of regional projections to natural disasters** for better assessments of natural disasters caused by extreme events using sufficiently high-resolution regional projection.

Slide form the KAKUSHIN Program

Extreme event projection by very high resolution atmospheric models

MRI / JMA / AESTO

A1B scenario

Atmosphere-Ocean model

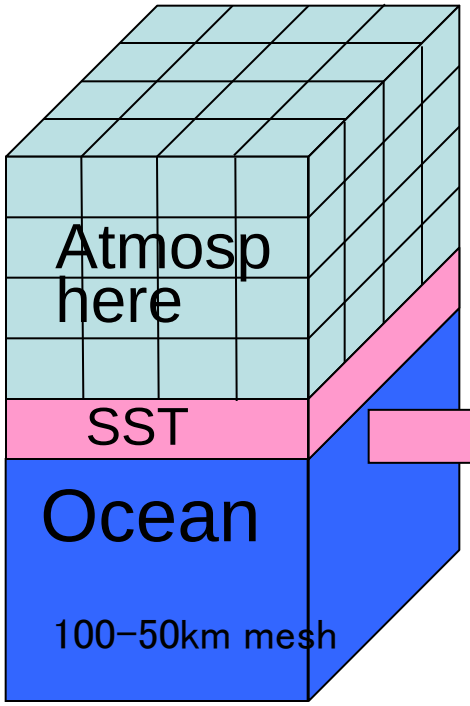
High-resolution global atmospheric model

Regional cloud resolving model by nesting

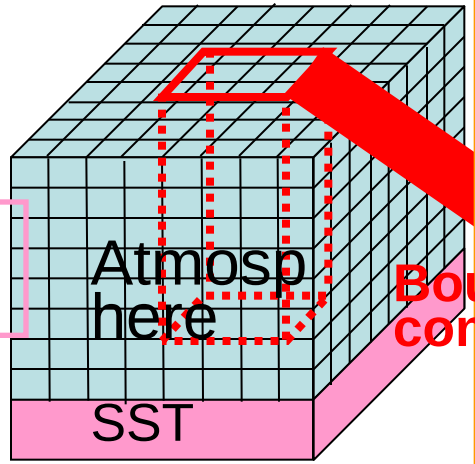
180km mesh

20km mesh

5km, 1km mesh

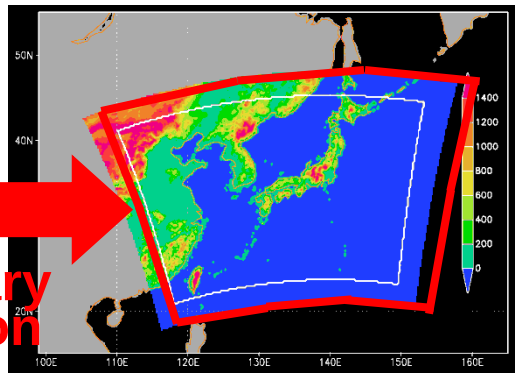


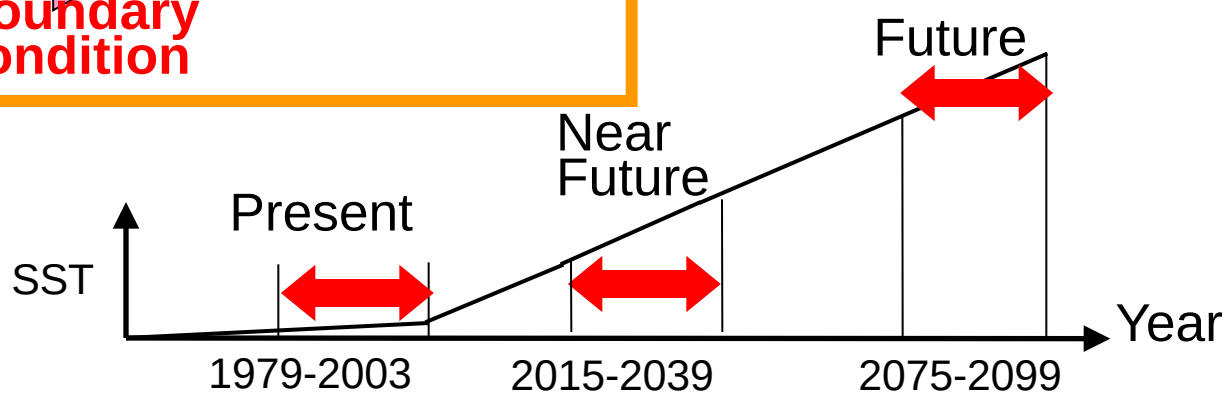
Predicted SST



Boundary condition

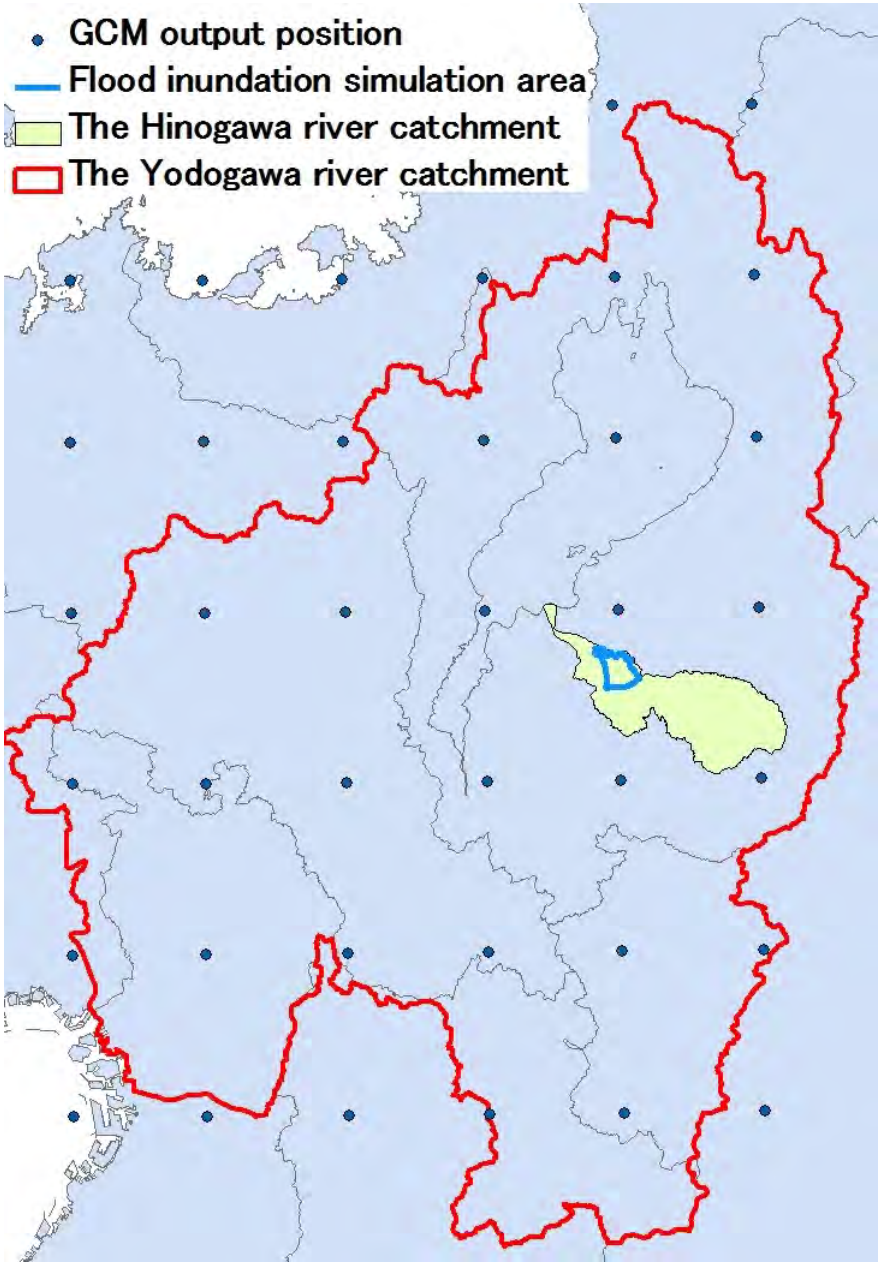
Boundary condition

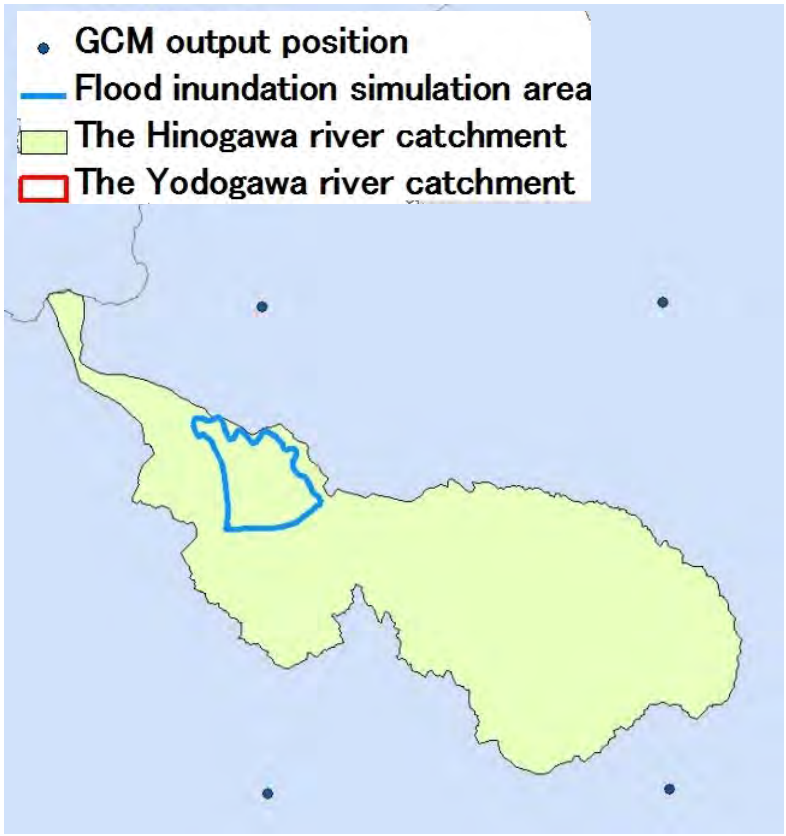




SST=Sea Surface Temperature

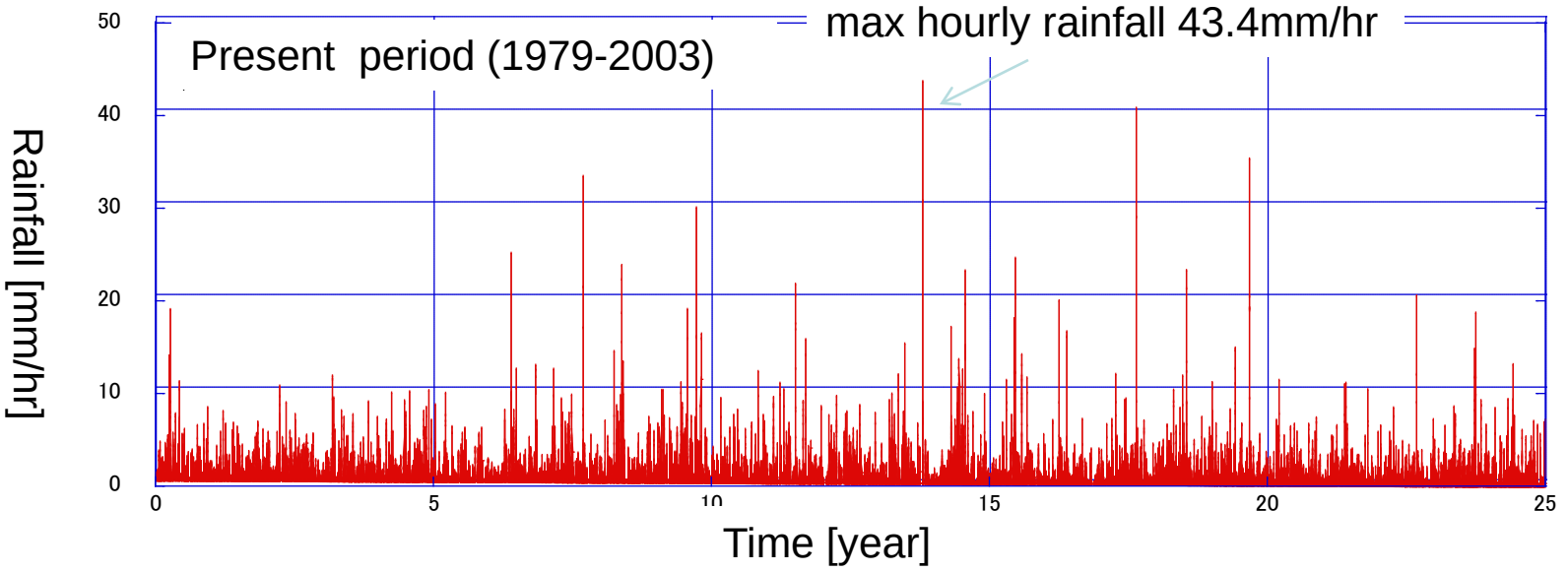
GCM output position and the Hinogawa river catchment

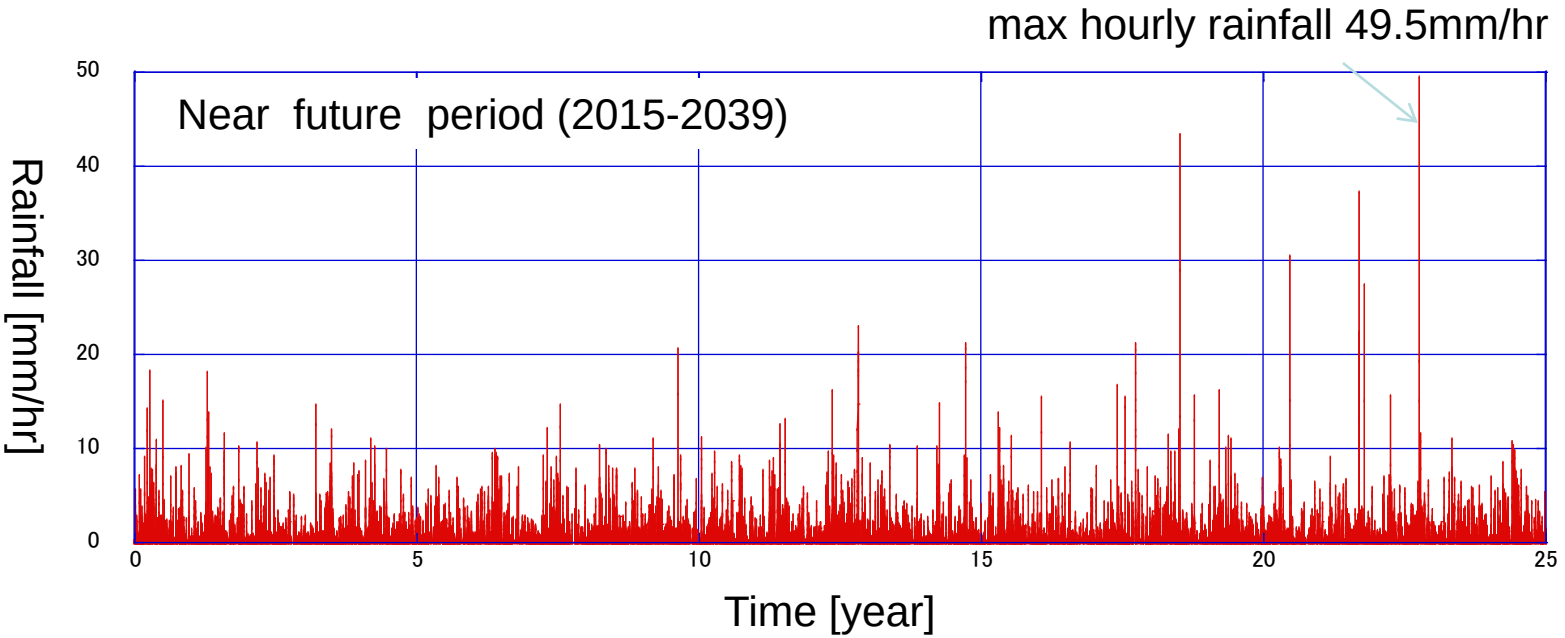




The Hinogawa river is divided into 4 division if we apply the GCM precipitations.

The catchment average hourly rainfall of the Hinogawa river by GCM

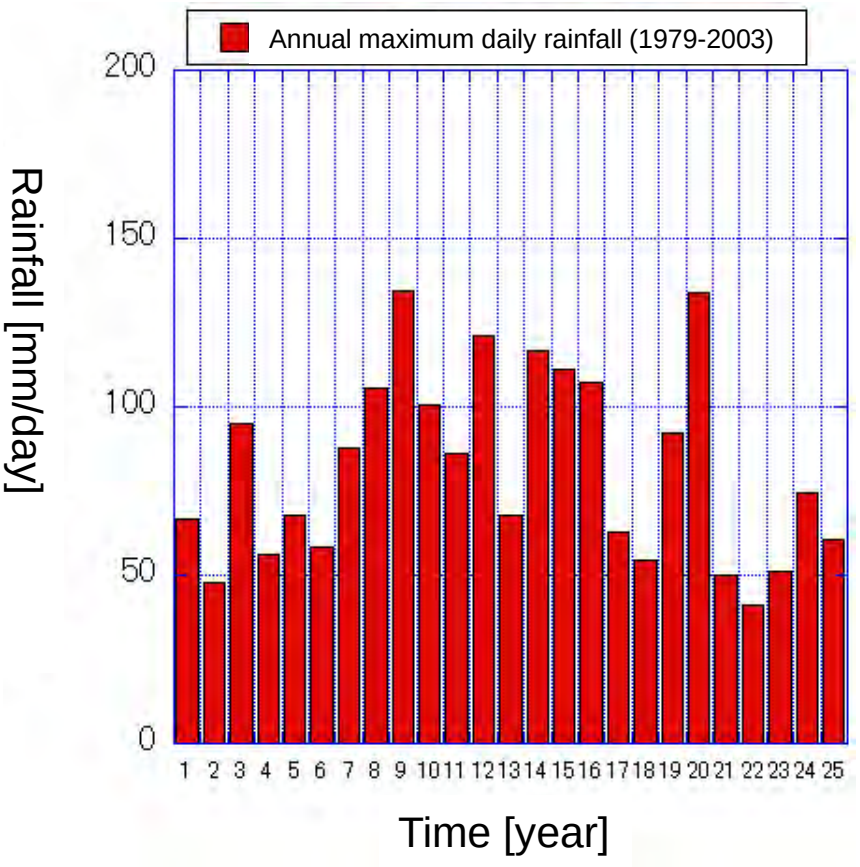


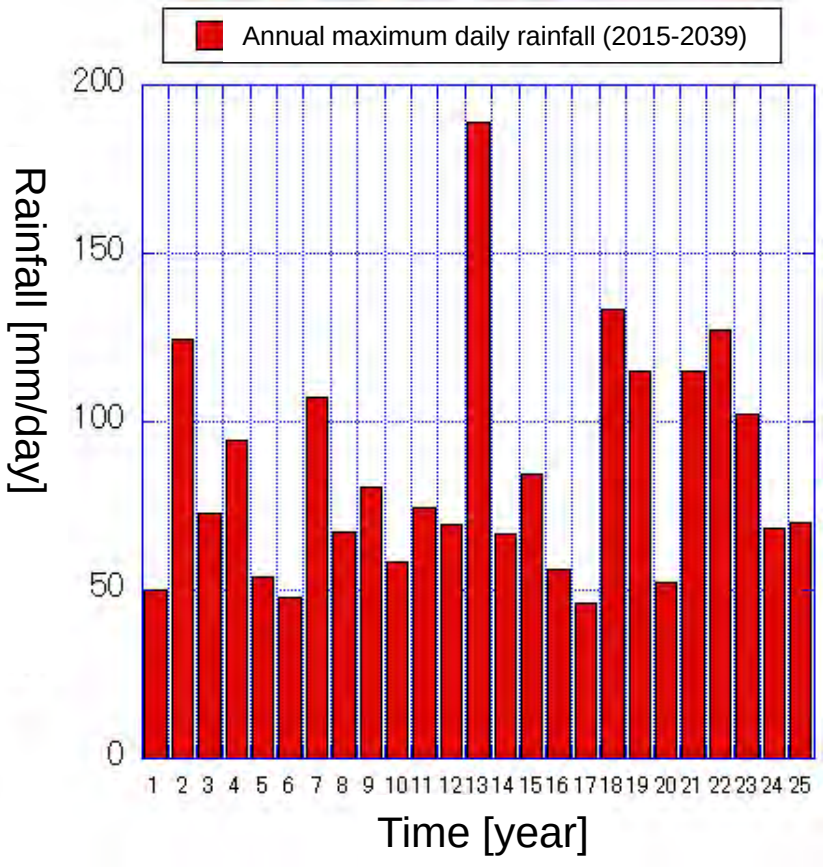


Changes of the annual daily maximum rainfall of the Hinogawa river catchment

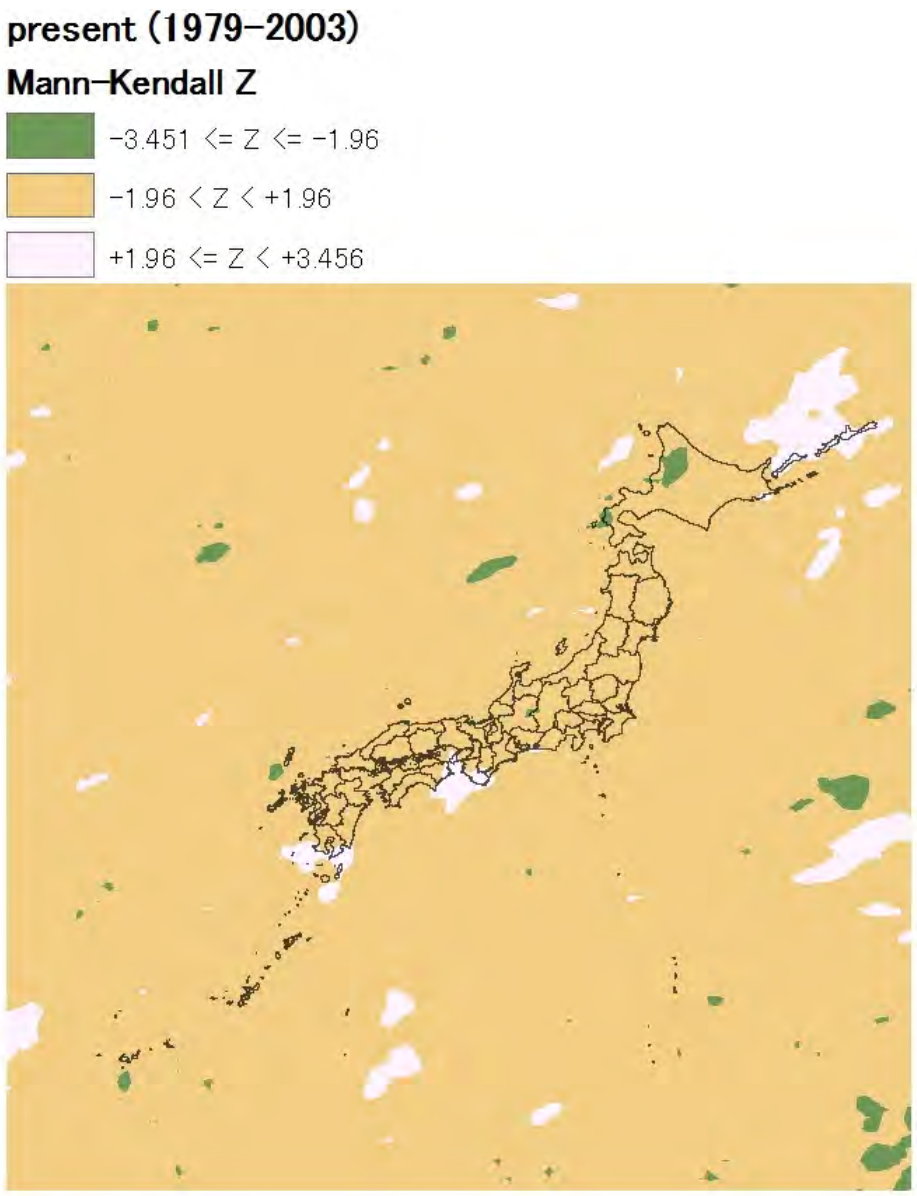
The 100-year rainfalls of the present and near future period estimated using these two annual maximum daily rainfall time series and GEV distribution .

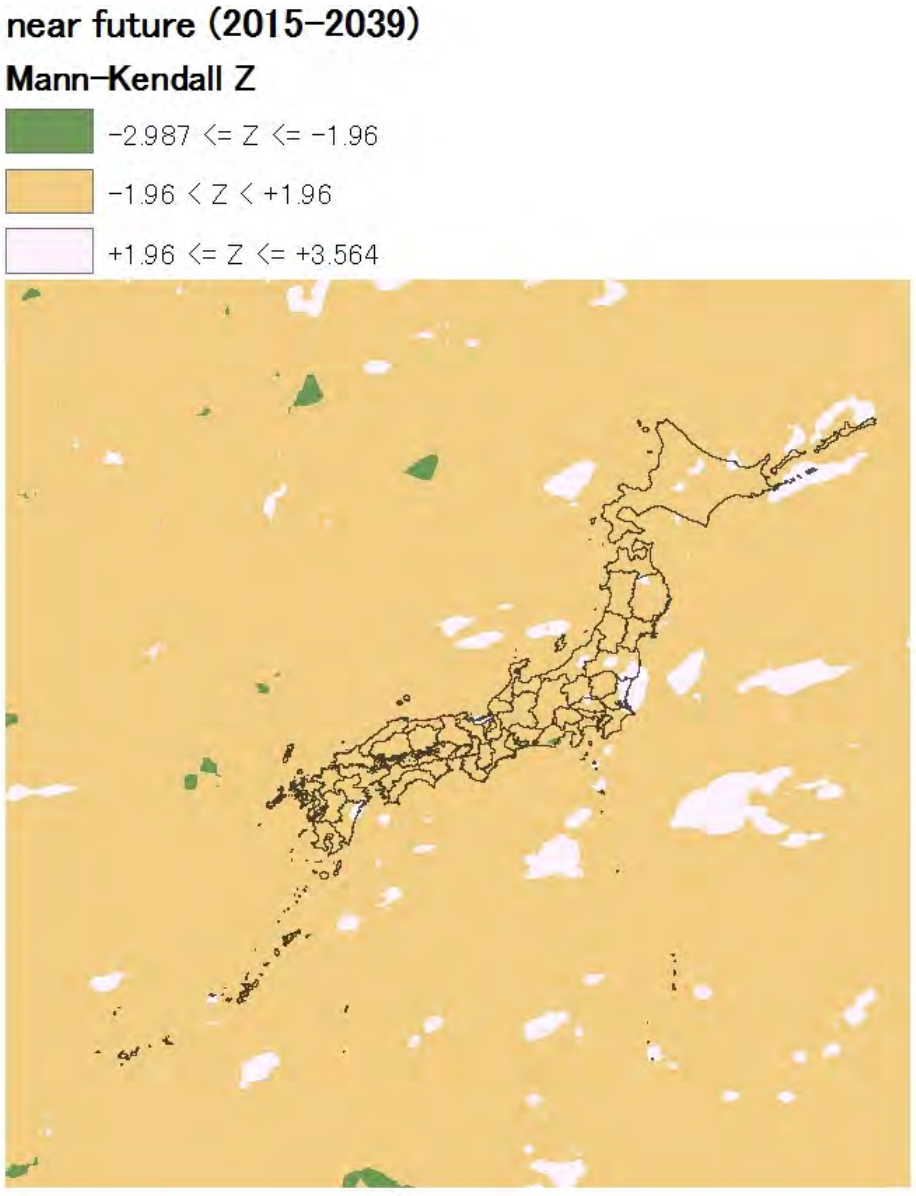
Present: 187mm/day, Near future: 224mm/day



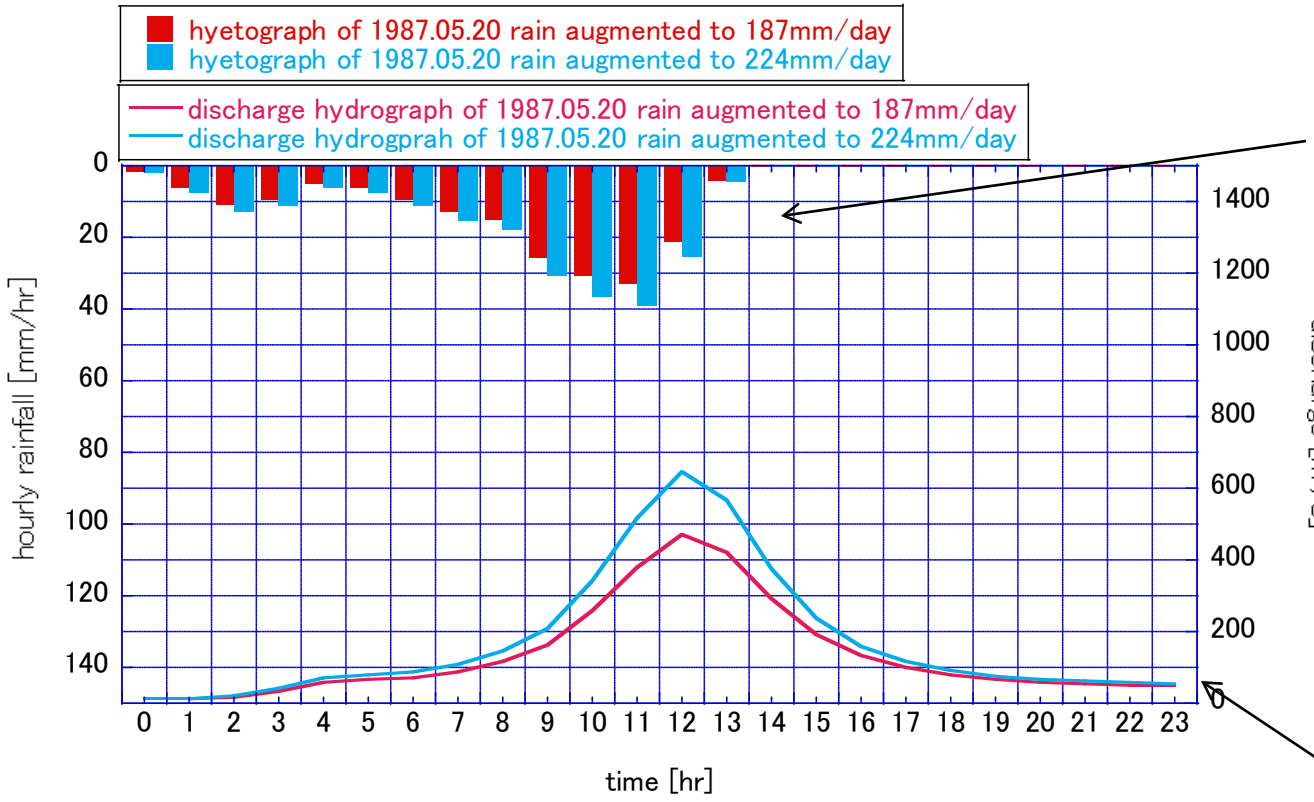


Mann-Kendall trend test (26082 points）for stationality check



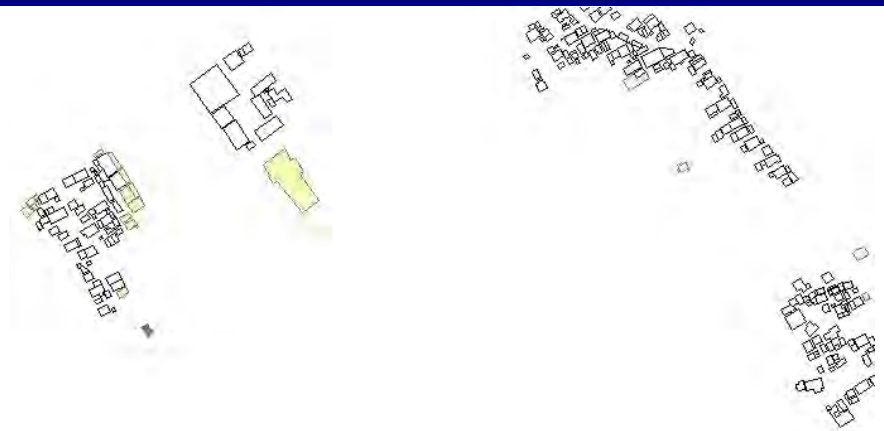


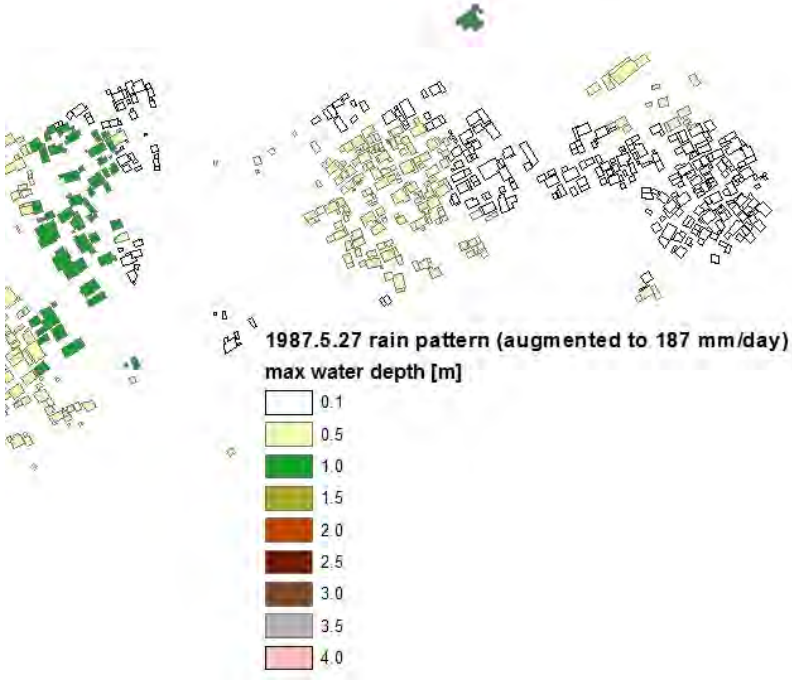
Augmentation of the rainfall and the rainfall-runoff simulation

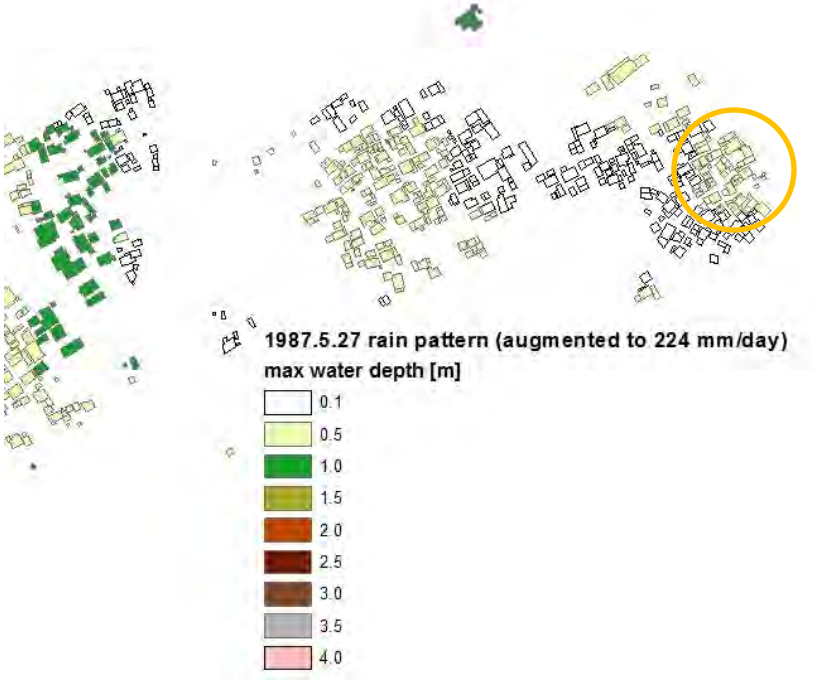


The peak discharges after the augmentation are 33mm/hr and 39 mm/hr respectively.

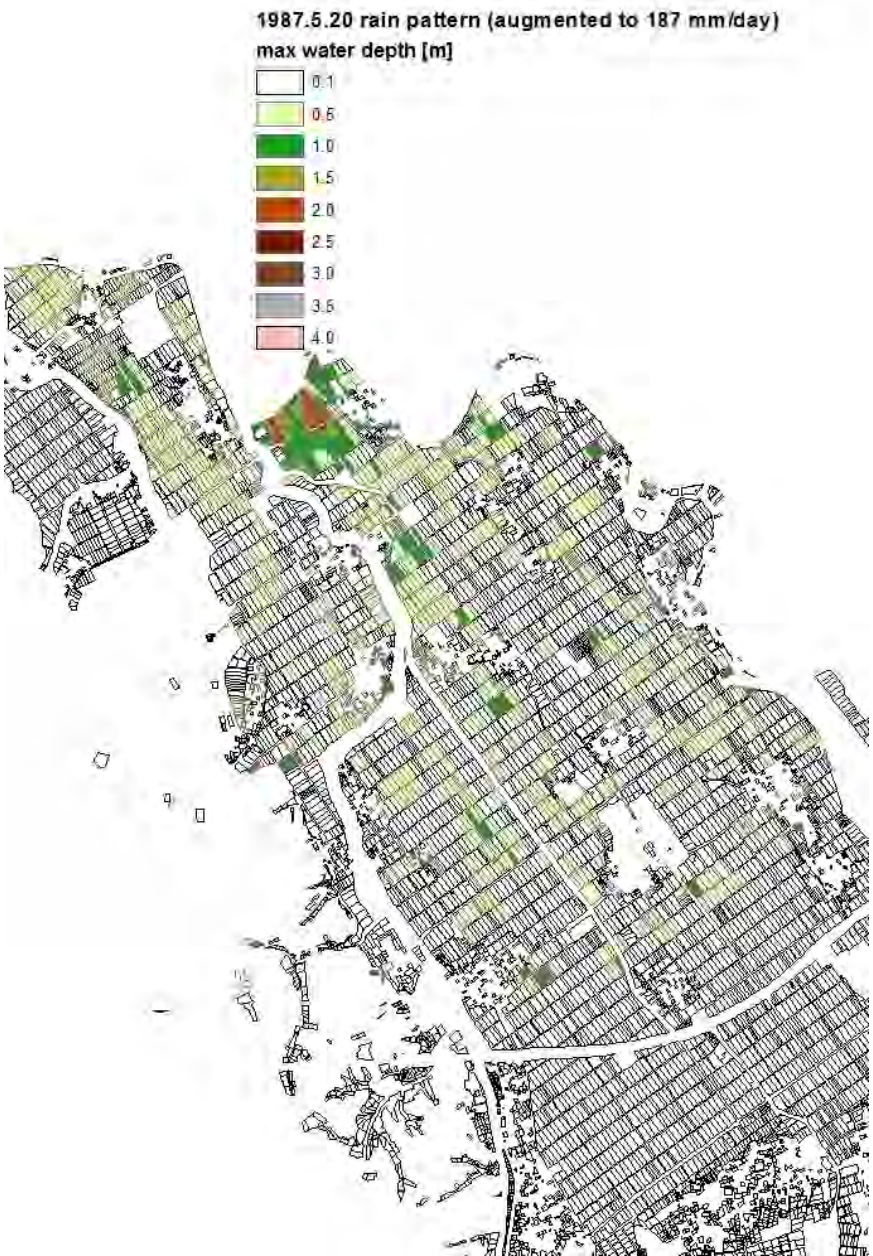
Inundated water depth of the Houses







Inundated water depth of the crop field



The number of houses and paddy fields classified according to the inundation depth

Houses

Rainfall pattern	Maximum water depth [m]				
	0.5-1m	1-2m	2-3m	Over 3m	Over 50cm
1987.05.20 rainfall pattern (augmented to 187mm/day)	449	50	2	0	501
1987.05.20 rainfall pattern (augmented to 224mm/day)	498	84	37	0	619

Paddy field

Rainfall pattern	Maximum water depth [m]				
	0.5-1m	1-2m	2-3m	Over 3m	Over 50cm
1987.05.20 rainfall pattern (augmented to 187mm/day)	313	52	0	0	365
1987.05.20 rainfall pattern (augmented to 224mm/day)	326	123	22	0	471

Changes of the house and economic damage (JPY)

rainfall	House economic damage (USD)	Paddy field economic damage (USD)
1987.05.20 rainfall pattern (augmented to 187mm/day)	48.2 million	1.6988 million
1987.05.20 rainfall pattern (augmented to 224mm/day)	53.7 million	1.7210 million

5.5 million increase

0.0222million increase

Concluding remarks

- A framework for the flood hazard and economic risk assessment is proposed.

- An example of a climate change impact assessment following a conventional Japanese flood control planning is shown using AGCM (by Meteorological Research Institute) and the framework.