Numerical Experiment of Change in Flooded Area Using Gridded Rainfall Data During 1981-2017 in The Mun and The Chi Rivers Basin, Thailand

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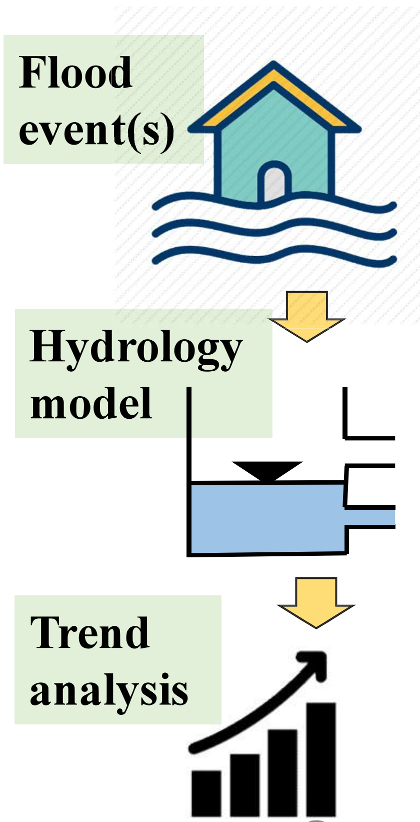
Introduction

- **The large flood of 2011** in Thailand caused serious damage.
- **Northeastern Thailand,** which famous for agriculture industry therefore particularly **susceptible to damage severe flooding.**
- **As the population increases along the Mekong River**, there is a **high risk** that flooding damage will also **increase**



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Literature review

Intergovernmental Panel on Climate Change (IPCC), 2013	the frequency and intensity of heavy rainfall over all land areas **may increase with future climate change**
Mekong River ... Commission (MRC-b), 2017	economic and human life costs are expected to rise following flooding disasters, **unless** ... expected to **reach 38% and 28% for floods occurring once every 2 and 5 years**

Need to prevent further chronic flood damage!!

Etc.,

Floods have already caused major damage to the **manufacturing**, **agriculture**, and **tourism** industries in Thailand.

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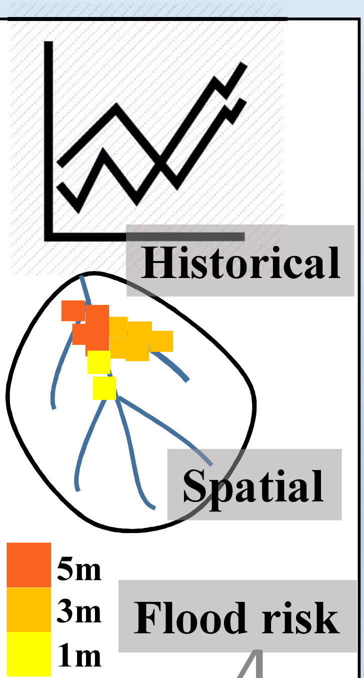
Objective

We have to understand the historical spatial features of the flooding.

3 main objectives of this study

- **To clarify the historical change** in flooded area in a river basin using **numerical simulation** during 1981-2017.
- **To capture the spatial features of flooding** by **analyzing the flooded areas** in a river basin from 1981 to 2017.
- **Find out where the flood risk** is **high**.



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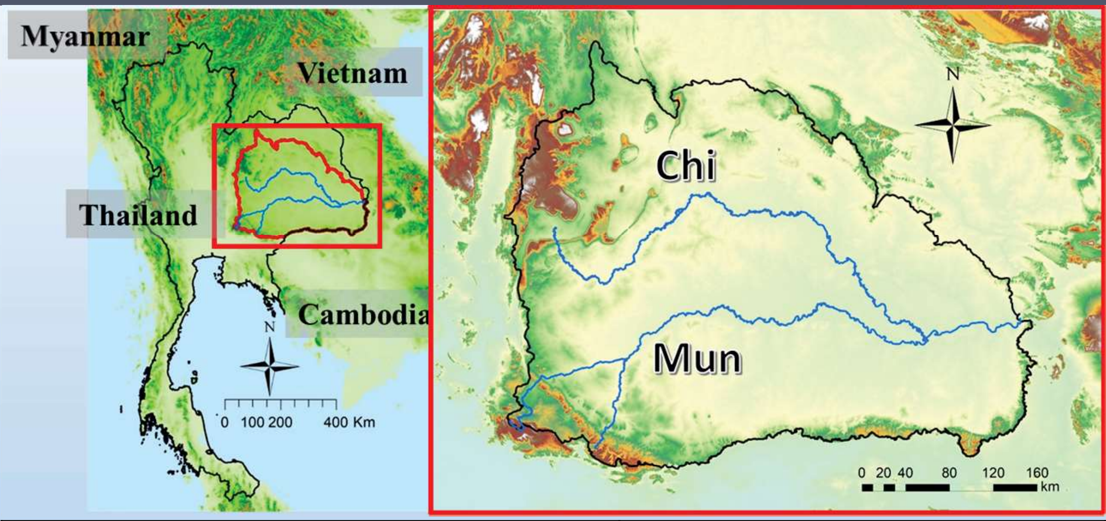
Study Area



Area		**119,200km²**
Population		**15.8million**
Landuse(agricultural land)		**55%(66,000km²)**
River slope	**Whole**	**1/7000－1/50000**
	Middle stream	**1/10000-1/15000**

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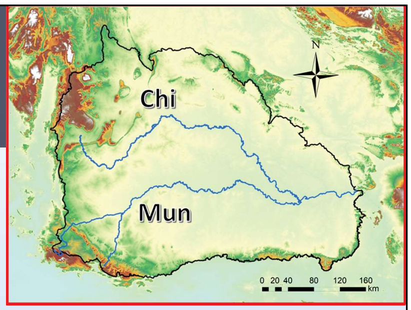
Study Area



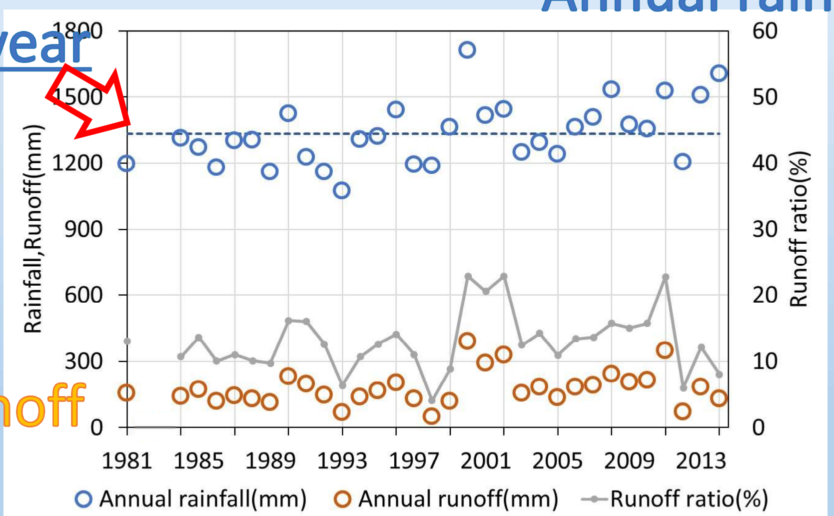
Features of rainfall

Annual evaporation: 1500 mm/year

Annual rainfall
1380 mm/year

Annual rainfall

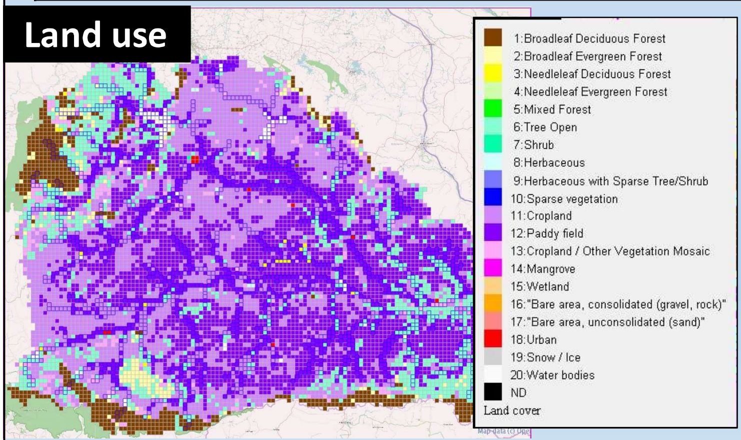
Annual runoff



- Since much of the precipitation is evaporating, only about 10% of annual precipitation runoff as river flow.

Data Preparation

Content	Source
Digital elevation model(DEM)	HydroSHEDS(120s)
Land use	HydroSHEDS(120s)
Rainfall	TMD/ADAP-T Dataset RainGridDataVer1.0 1981-2017
River shape	Following formula



River width:W

$$W = C_W A^{S_W}$$

River depth:D

$$D = C_D A^{S_D}$$

A: Accumulation area(km^2)

C_W, S_W, C_D, S_D: Geometry parameter

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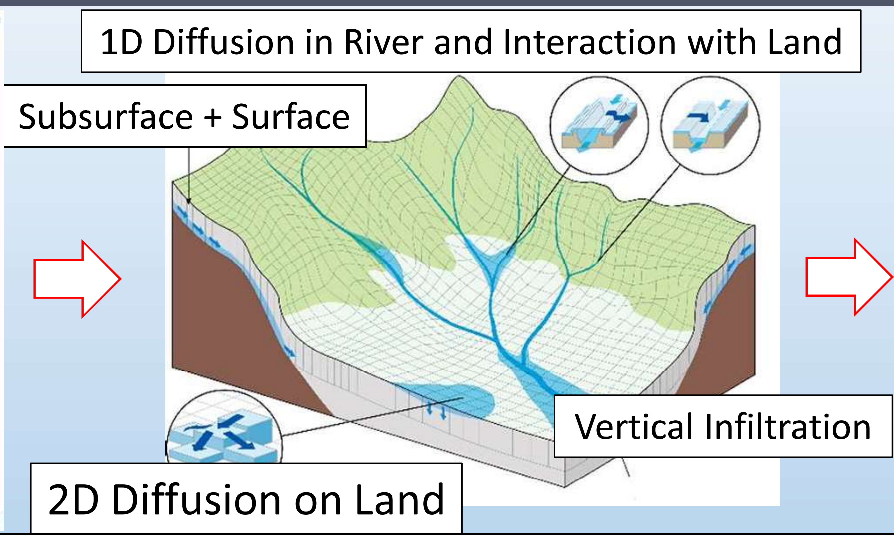
Modeling

Developed by Prof. Sayama

(Rainfall-Runoff-Inundation (RRI) model)

Input
- Rainfall
- Dem
- Land use
- River



output
- Discharge
- W.L.
- Inundation

- ☐ Two-dimensional model capable of simulating rainfall-runoff and flood inundation simultaneously
- ☐ The model deals with slopes and river channels separately
- ☐ The flow in slope grid cells was calculated using a two-dimensional (2D) diffusive-wave model, and channel flow was calculated using a one-dimensional (1D) diffusive-wave model.

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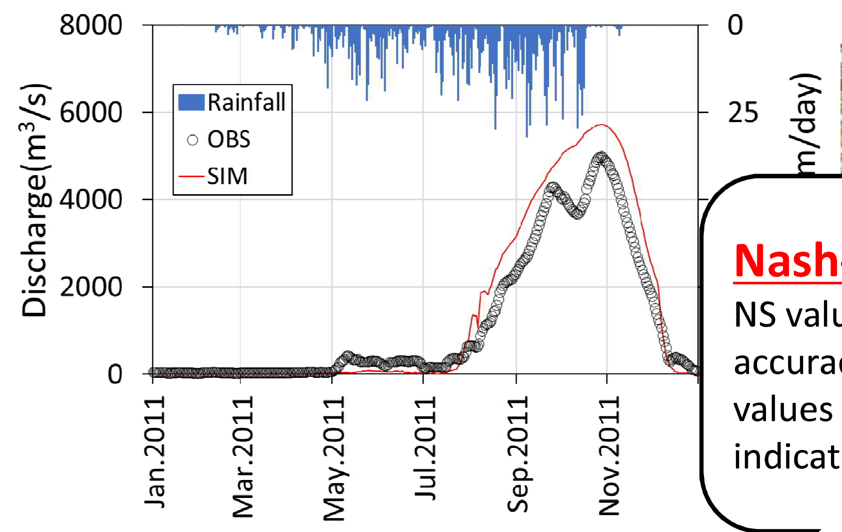
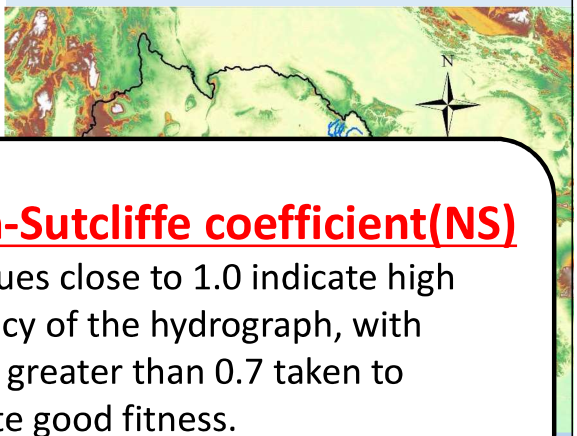
Reproduction of flood in 2011

Model parameters had been tuned by the flood event in 2011, the calibration period from Janualy 2011 to December 2011.





Nash-Sutcliffe coefficient(NS)

NS values close to 1.0 indicate high accuracy of the hydrograph, with values greater than 0.7 taken to indicate good fitness.

Calibration accuracy

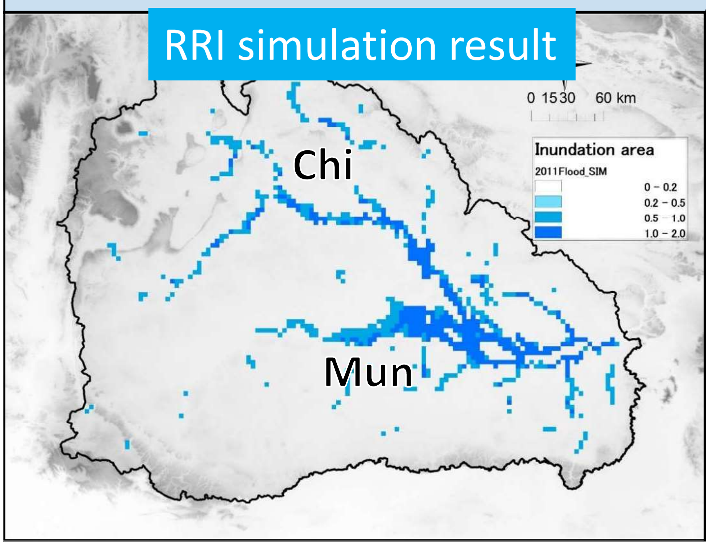
Index	NS	R^2
Value	0.85	0.99

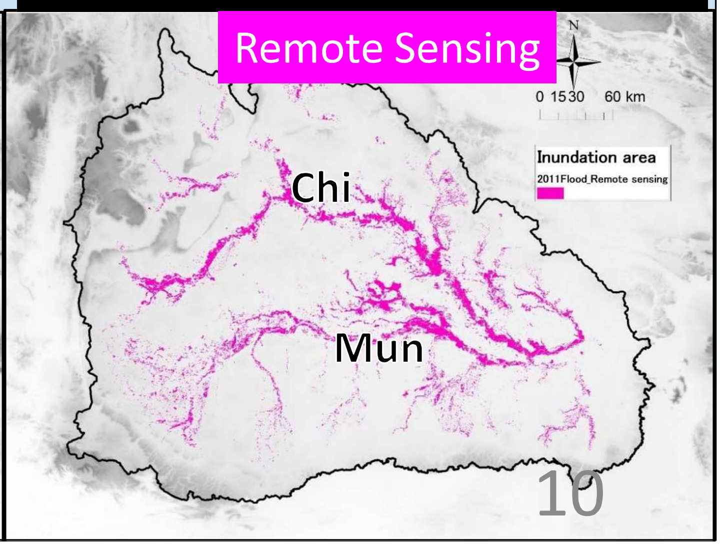
Reproduction of flood in 2011

To evaluate the reproducibility of the inundation area data, we compared simulated inundation areas with those shown by the Remote Sensing(RS) images. The left figure is described as RRI simulation result and the right side define as the actual data from RS.

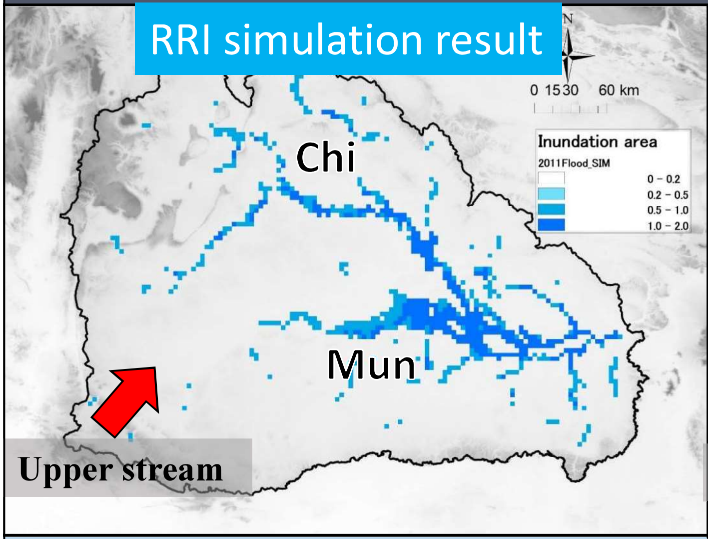
Thailand Flood Monitoring System

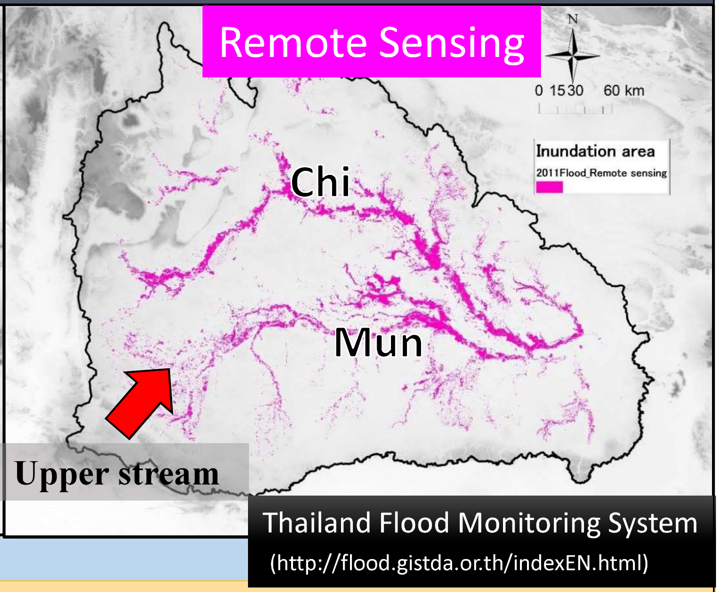
(http://flood.gistda.or.th/indexEN.html)





Reproduction of flood in 2011





- The upper reaches of the Mun River contain innumerable small rivers that could not be reproduced at the coarse spatial resolution used in this study, such that the inundation area was underestimated by our simulation.
- However, the inundation area near the confluence point of the Mun and Chi Rivers was **highly reproducible.**

Simulation of flooding (1981 to 2017)

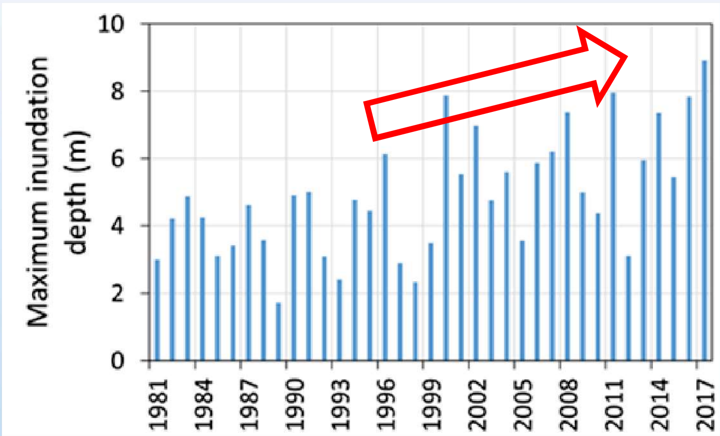


Fig. Annual change in maximum flooding depth from 1981 to 2017.

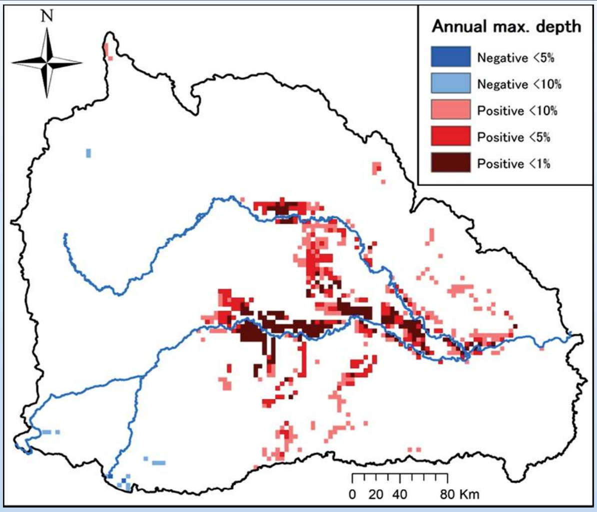
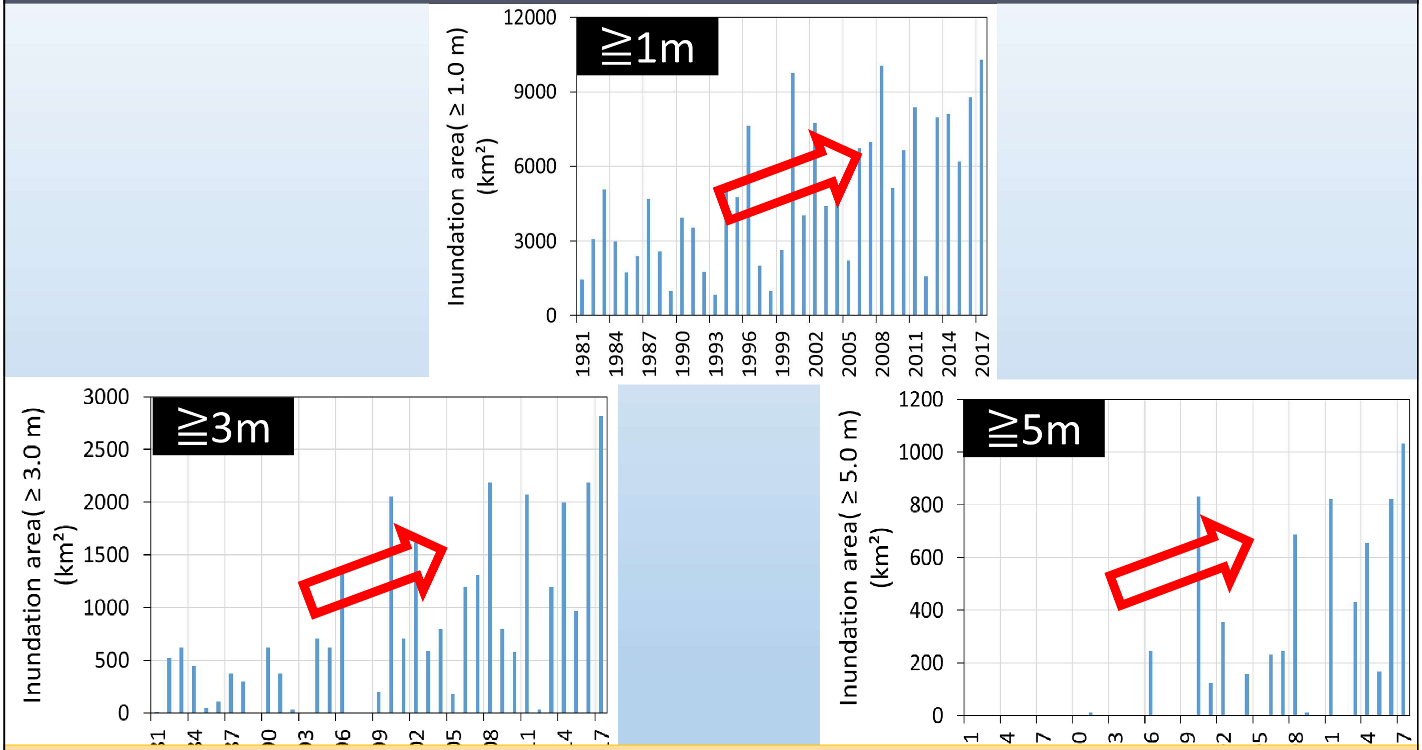


Fig. Trend of maximum flooding depth variation

- It was found that the maximum flooded depth **tend to increased** year by year.
- Statistical analysis of the trend of maximum flooding depth variation for each mesh showed **a significant increase** trend in **the area along the river.**

Simulation of flooding (1981 to 2017)



- For each of inundation area showed an increasing trend over time. three classes of inundation depth (≥ 1 m, ≥ 3 m, and ≥ 5 m)

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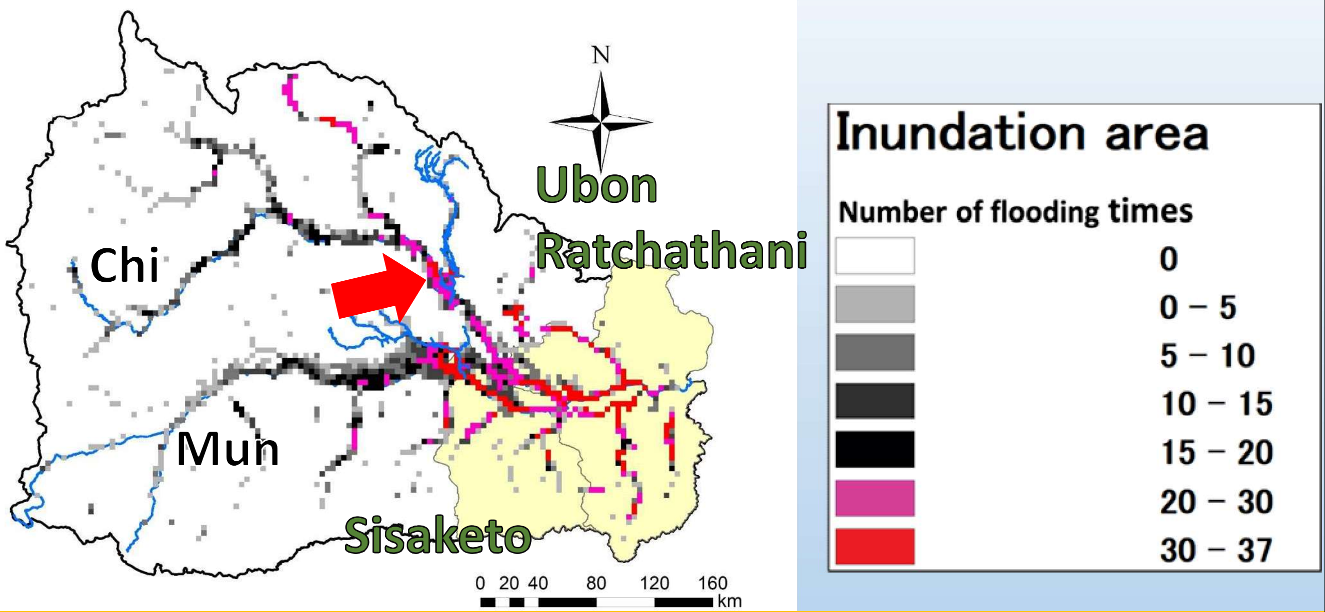
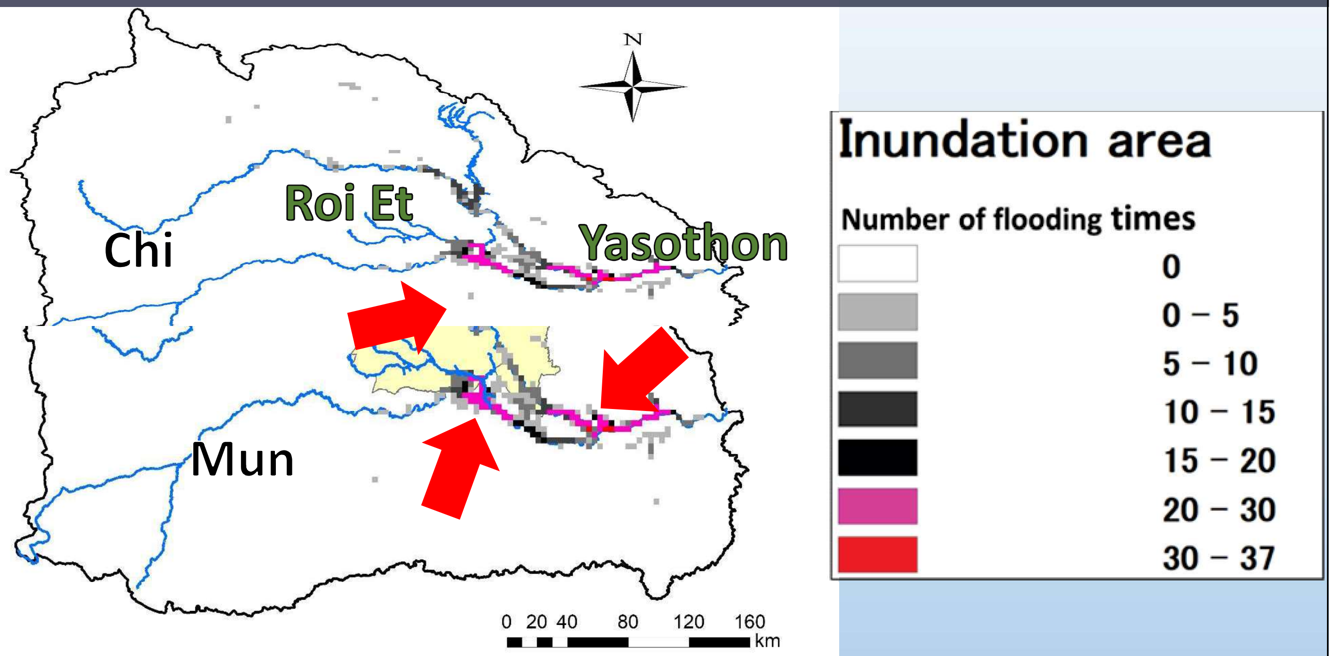
Simulation of flooding (1981 to 2017)



- Floods exceeding 1 m in depth occurred **extensively both upstream and downstream of the confluence of Mun and Chi rivers.**
- Red areas, where flooding was most frequent, are clearly most abundant in Ubon Ratchathani Province and Sisaket Province, where the **Mun and Chi Rivers join**, and in Yasorton Province where **smaller tributaries join the Chi River.**

Simulation of flooding (1981 to 2017)



- The first area is at the point where **the Mun and Chi Rivers join.**
- The second area is where **the small tributaries joins the Mun River** in Sisaket Province
- The third area is at the provincial border between Roi Et Province and Yasothon Province, where **the small river joins the Chi River.**

Conclusion

- We simulated flooding in the Mun-Chi river basin during the 37-year period from 1981 to 2017 to calculate yearly maximum inundation area and depth, with the objective of capturing the spatial characteristics of flooding in this basin.
- We found that both maximum inundation depth and area are **generally increasing over time.**
- Relatively small floods of ≥ 1 m occurred along the Mun and Chi Rivers every year, and large flooding events occurred frequently at **confluence points between tributaries.**

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Thank you for your attention

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Simulation parameters

ne_river	$m^{-1/3}/s$	0.03	
River thresh	-	20	
width_para_Wc	-	0.0415	
width_para_Ws	-	0.745	
depth_para_Dc	-	2.48	
depth_para_Ds	-	0.12	
height_para	-	0	
height_limit_para	-	20	
ns_slppe	$m^{-1/3}/s$	0.3	
soil depth	m	1.5	
gamma a	-	0.3	
Ksv	m/s	3d-5	5d-6
sf	m	0.1101	0.3163
Ka	m/s	0	
gamma m	-	0.2	0.1
beta	-	4	

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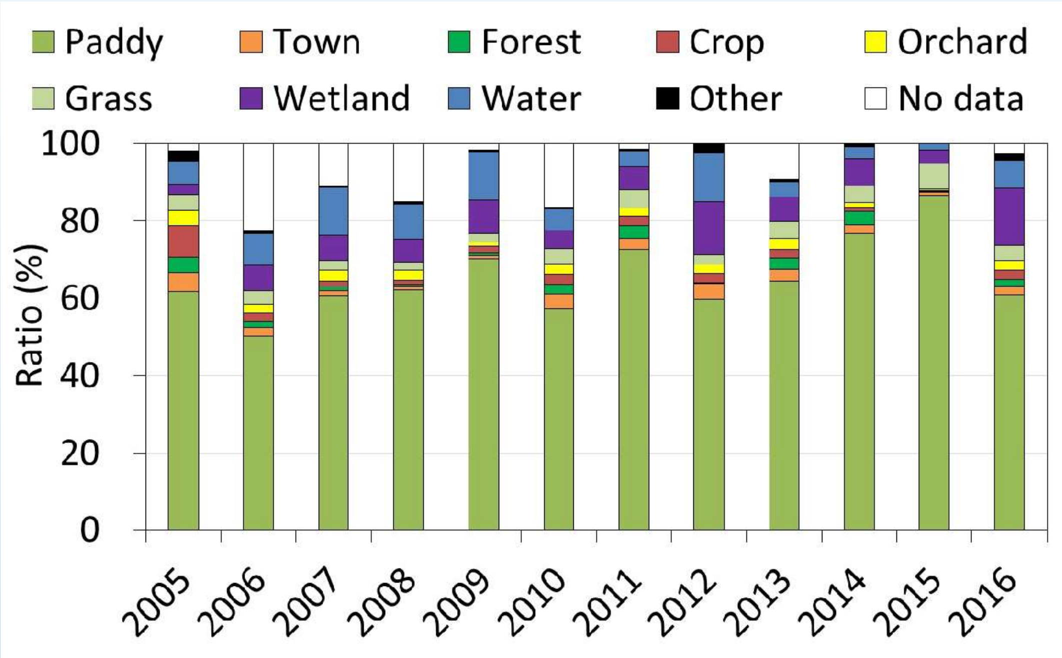
Land use



Breakdown of land use in flood area

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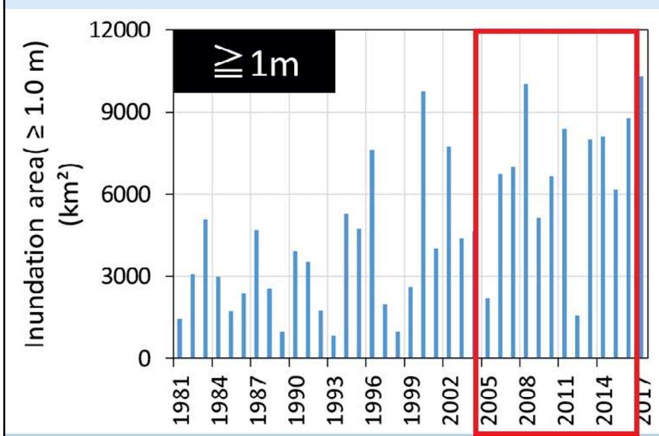
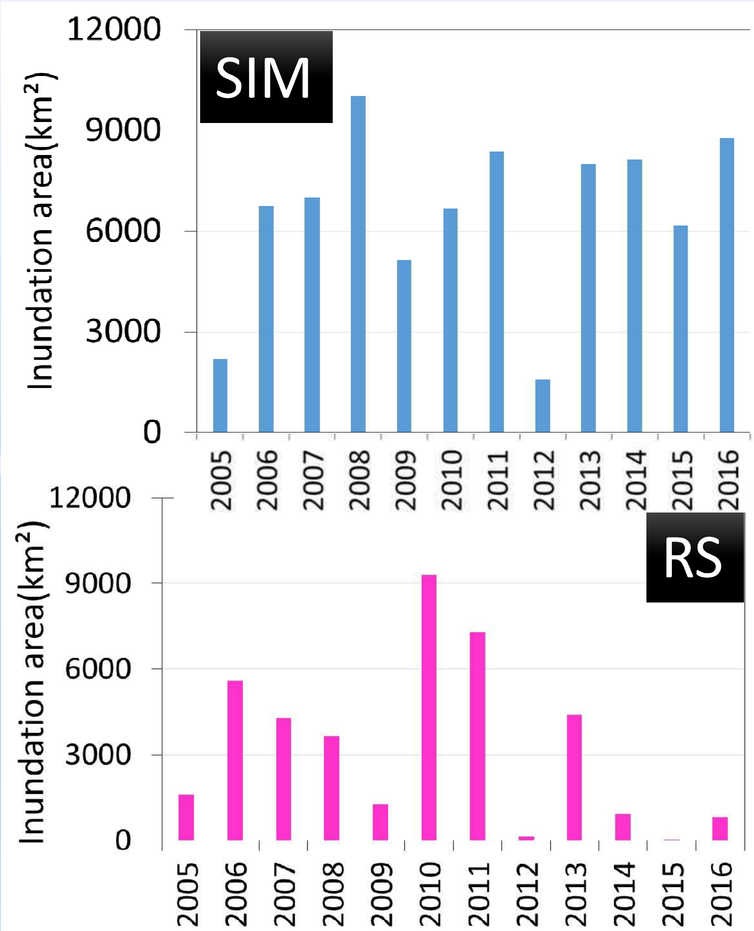
Comparison SIM and RS(2005 to 2016)

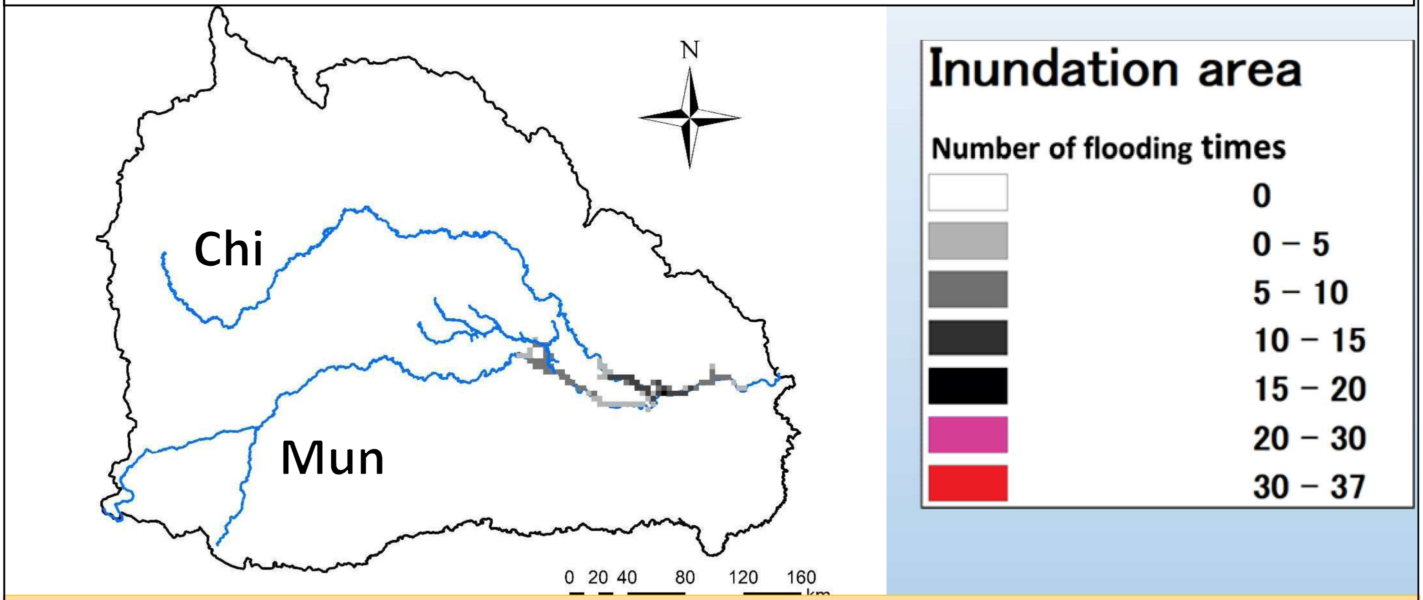


We can obtained RS images only 12 years.



Simulation of flooding (1981 to 2017)

The number of inundation with **5 m or more** in the map based on the simulation.



- Inundation frequency did not exceed 20 in this region.
- However, multiple inundations occurred where **the Mun and Chi Rivers join**, and at the **meeting point of the Mun and small tributaries.**

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