Water and disaster in terms of dynamics

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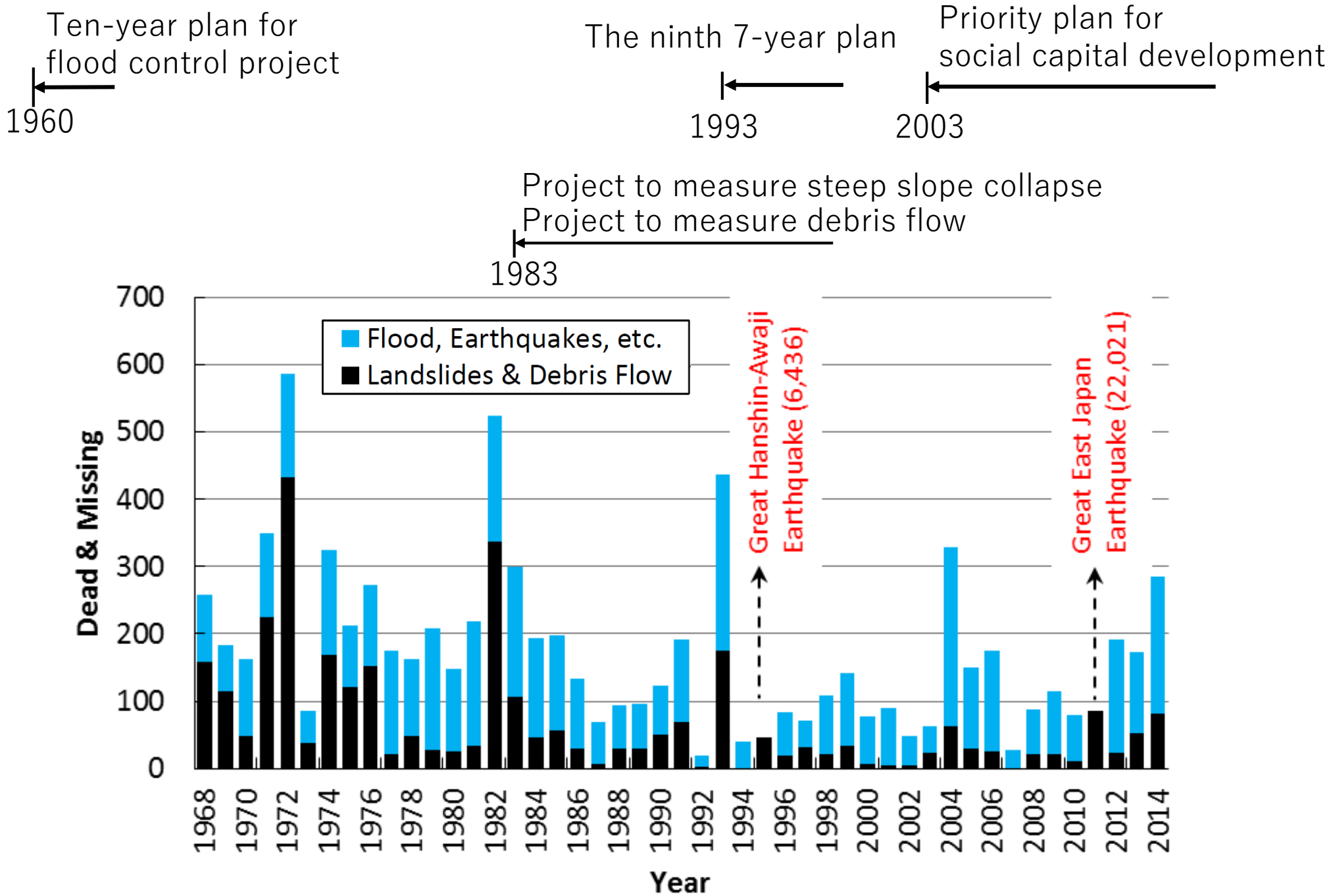
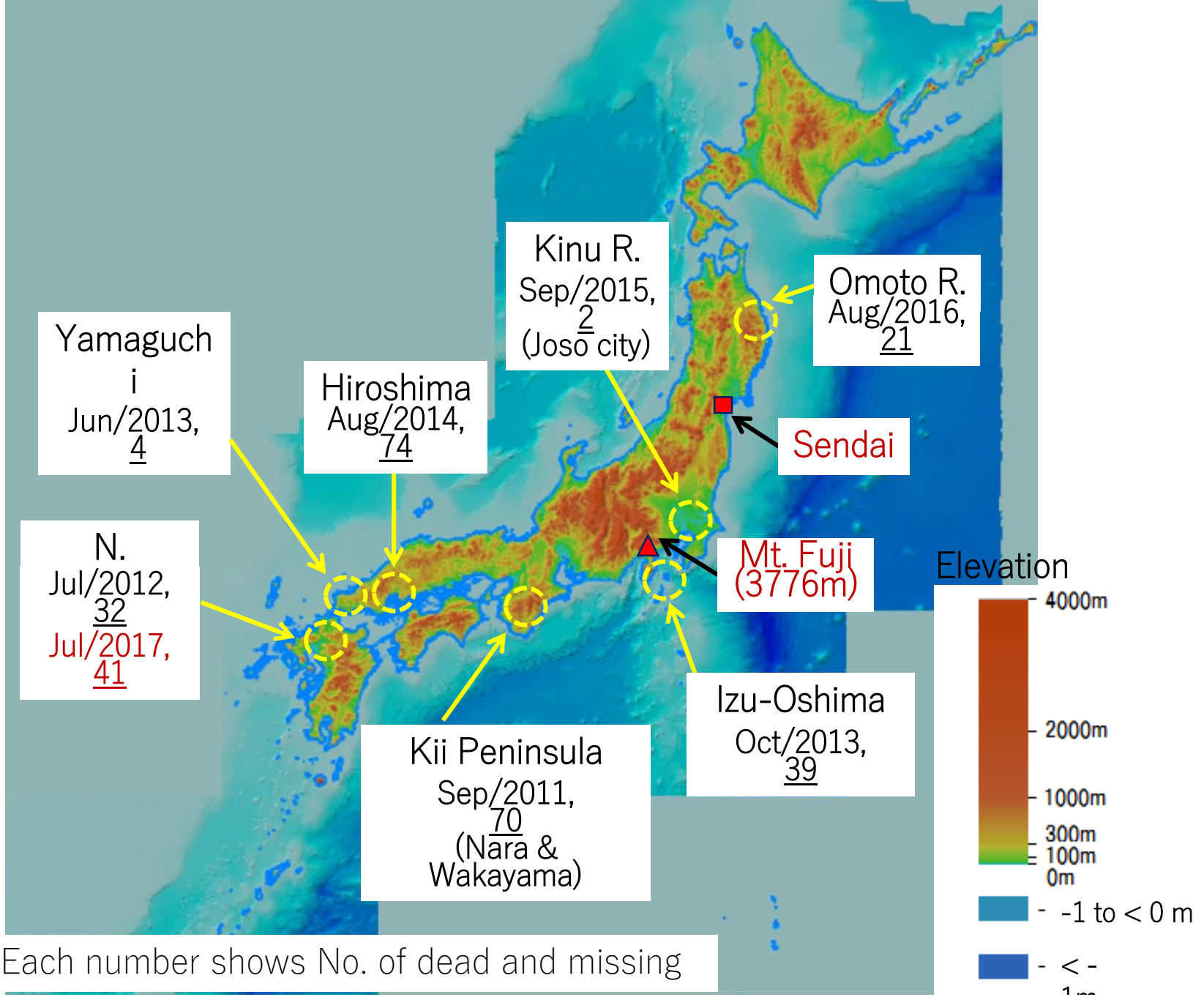
Casualties resulted from landslides, debris flow , flood, etc.

Governing equations to describe behaviors of flood flow, landslides and debris flow

Some numerical results

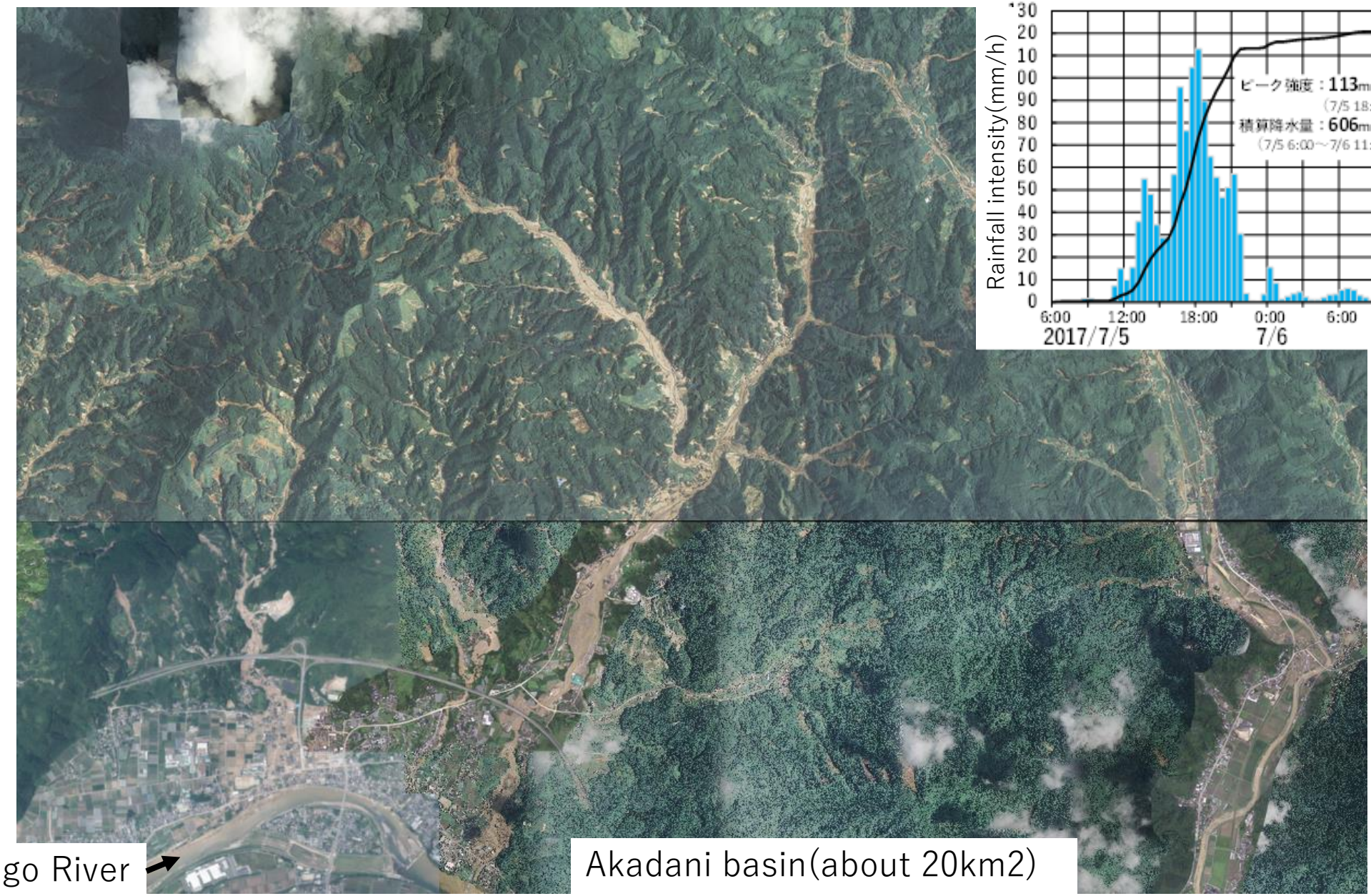


Casualties resulted from natural disasters in Japan



✓ Each number shows No. of dead and missing

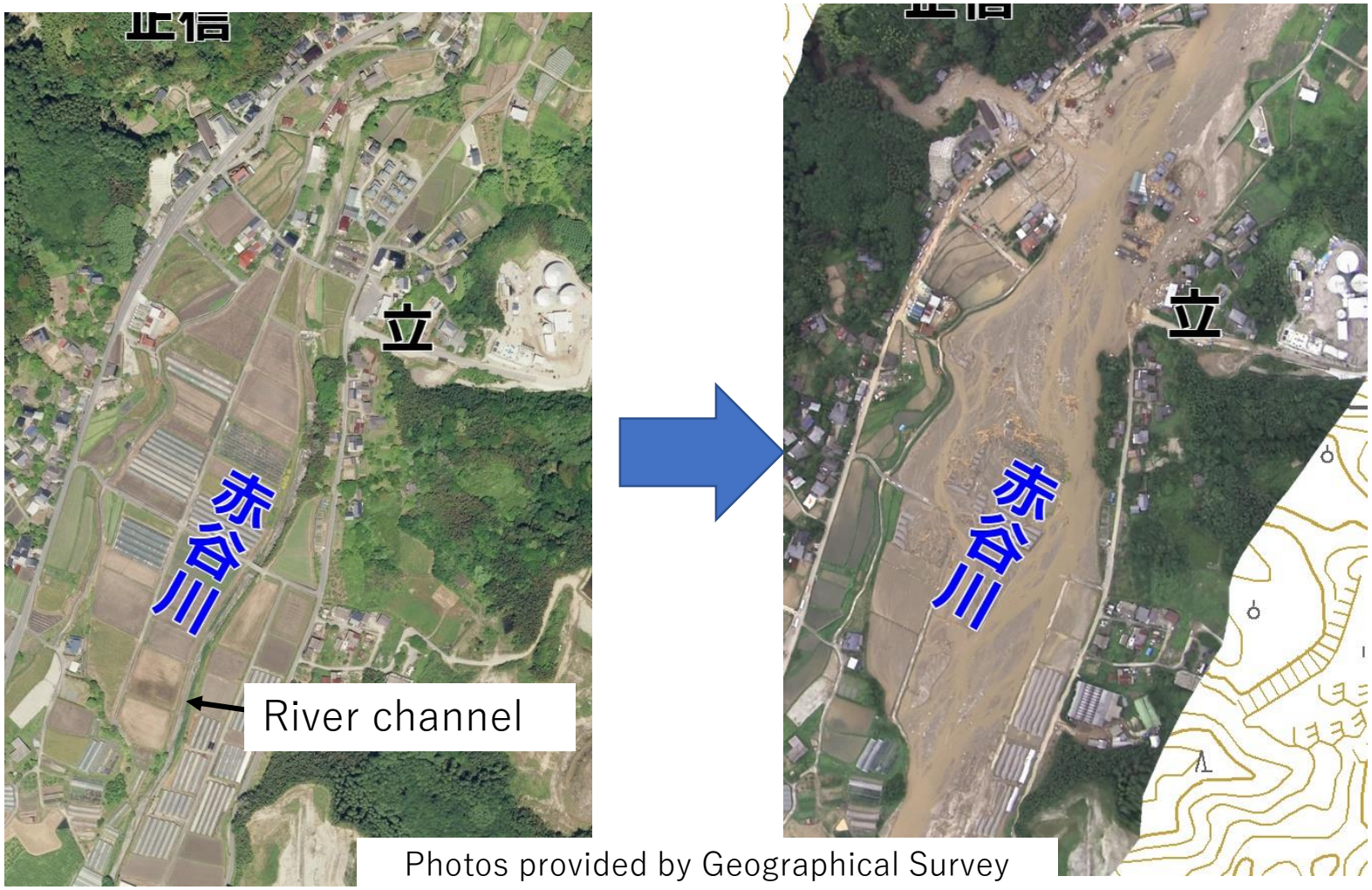
Flood and sediment disasters in the last 5 years, Japan



Flood and sediment disaster resulted from severe rainfall at northern Kyushu in July, 2017

Debris flow deposition in the upstream of Akadani basin

Damaged houses due to debris flow



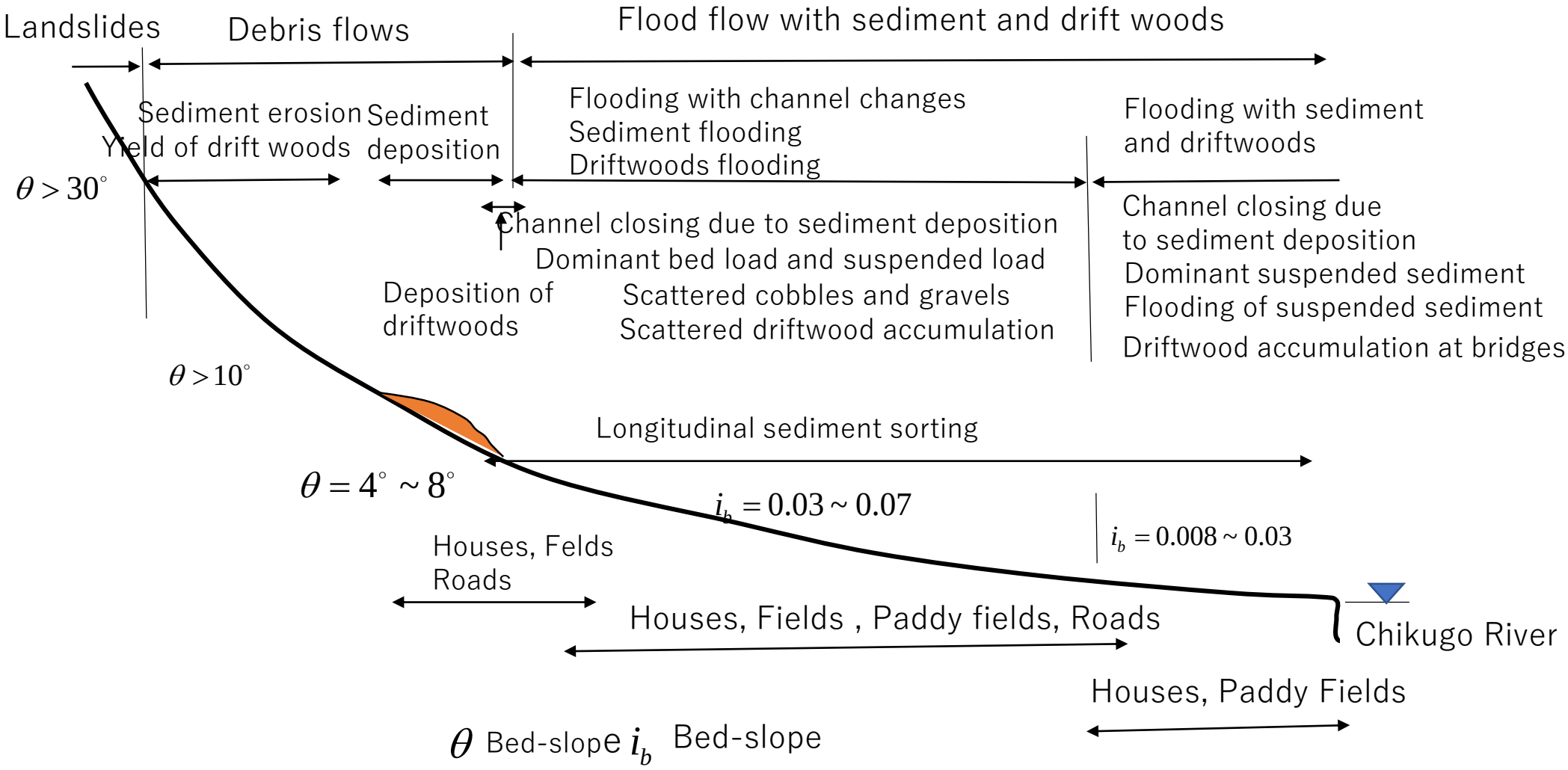
Photos provided by Geographical Survey Institute

Before the flood

Immediately after the flood

Channel change in the middle reach of Akadani

A huge amount of sediment deposited in the downstream reach of Akadani

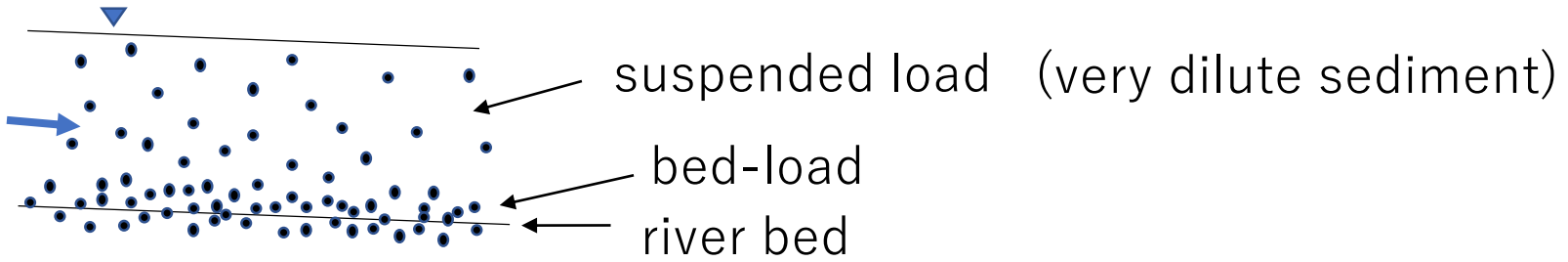


Characteristics of hazards resulted from the rain fall event at northern Kyusyu in July 2017

Governing equations for **flood flow** with sediment transportation and drift wood

- Mass conservation equation for water
- Momentum conservation for water

- Mass conservation equation for sediment in flow body (very dilute sediment)
- Mass conservation equation for bed sediment
- Bed load formula, Erosion/deposition rate for suspended sediment
  (instead of momentum conservation equation)
- Mass conservation equations for drift wood in flow body as well as in bed sediment



Governing equations for **debris flow** and **soil mass** released by landslides

- Mass conservation equation for water-sediment mixture

$$\frac{\partial h}{\partial t}+\frac{\partial uh}{\partial x}+\frac{\partial vh}{\partial y}=\frac{E}{c_*}$$

for mixture

$$\frac{\partial \bar{c} h}{\partial t}+\frac{\partial \gamma \bar{c} uh}{\partial x}+\frac{\partial \gamma \bar{c} vh}{\partial y}=E$$

for sediment only

for coarse sediment

for fine sediment

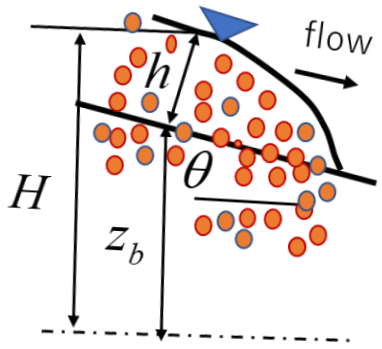
- Momentum conservation for water-sediment mixture

$$\frac{\partial uh}{\partial t}+\frac{\partial uuh}{\partial x}+\frac{\partial vuh}{\partial y}=-gh\frac{\partial H}{\partial x}-\frac{\tau_{bx}}{\rho_m}$$

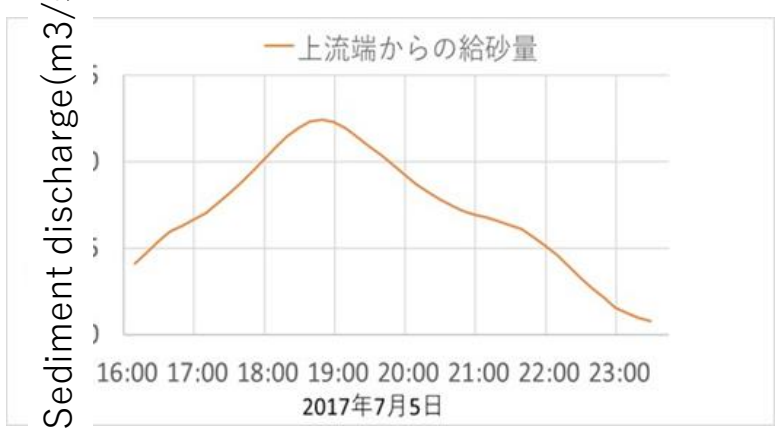
$$\frac{\partial vh}{\partial t}+\frac{\partial uvh}{\partial x}+\frac{\partial vvh}{\partial y}=-gh\frac{\partial H}{\partial y}-\frac{\tau_{by}}{\rho_m}$$

- Mass conservation equation of bed sediment

$$\frac{\partial z_b}{\partial t}=-\frac{E}{c_*\cos\theta}$$

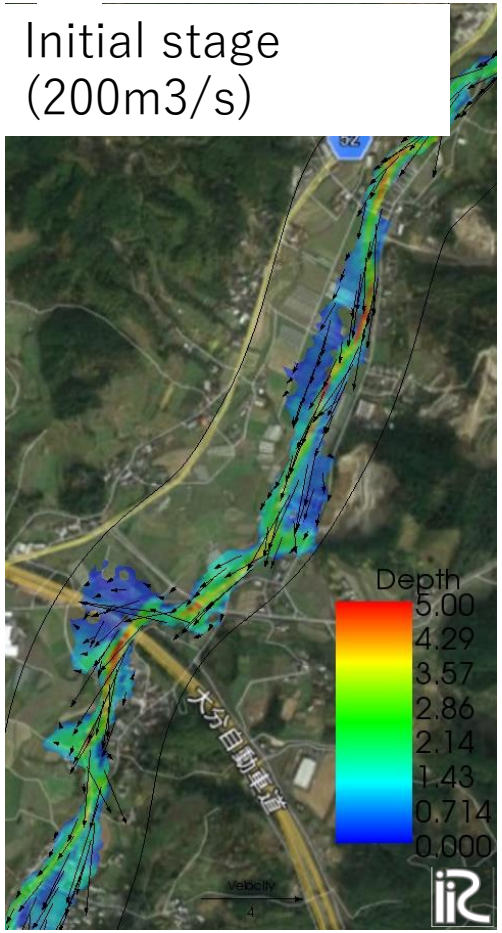


h	Flow depth
u, v	Flow velocity
c	Sediment concentration in flow body
c_*	Sediment concentration in bed sediment
E	Erosion/deposition rate
H	Free surface elevation
z_b	Bed surface elevation
τ_{bx}, τ_{by}	Bed shear stress

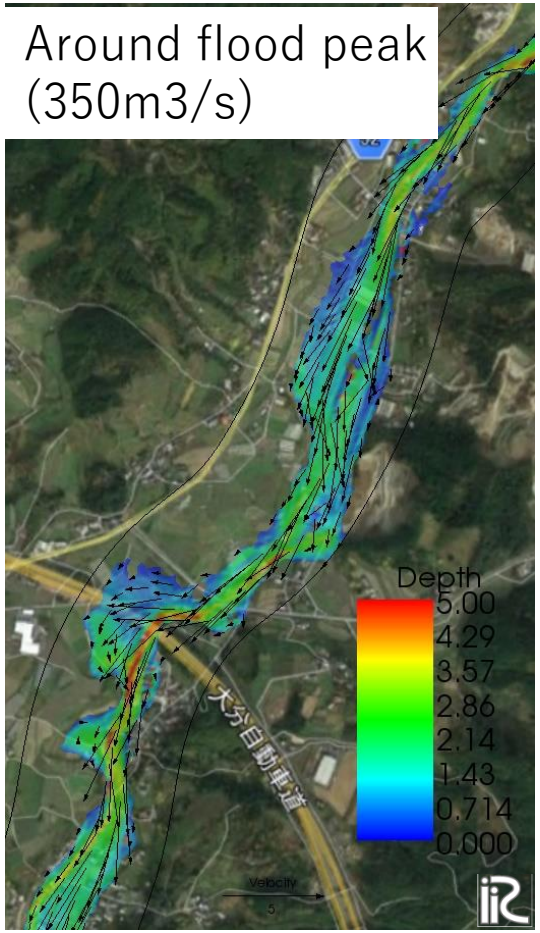


Increase of flood area with increase of flow discharge and sediment deposition

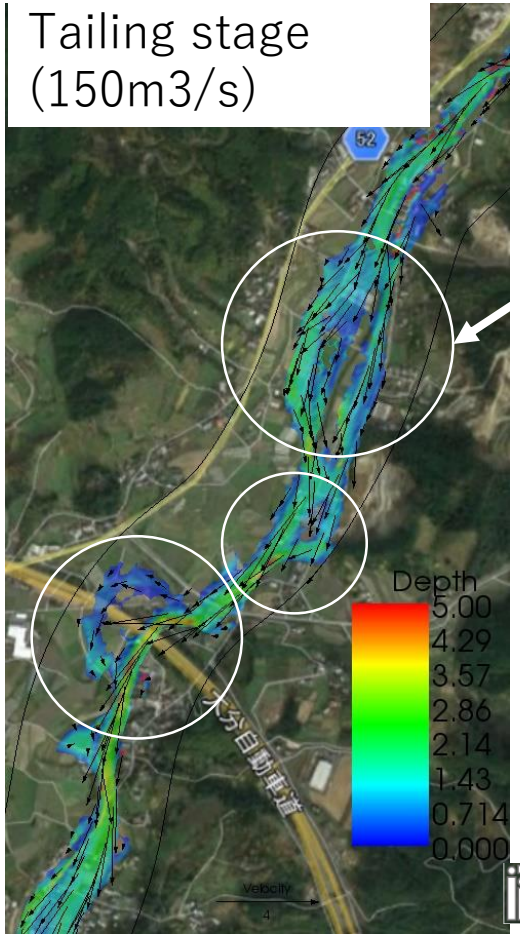
Initial stage (200m3/s)



Around flood peak (350m3/s)



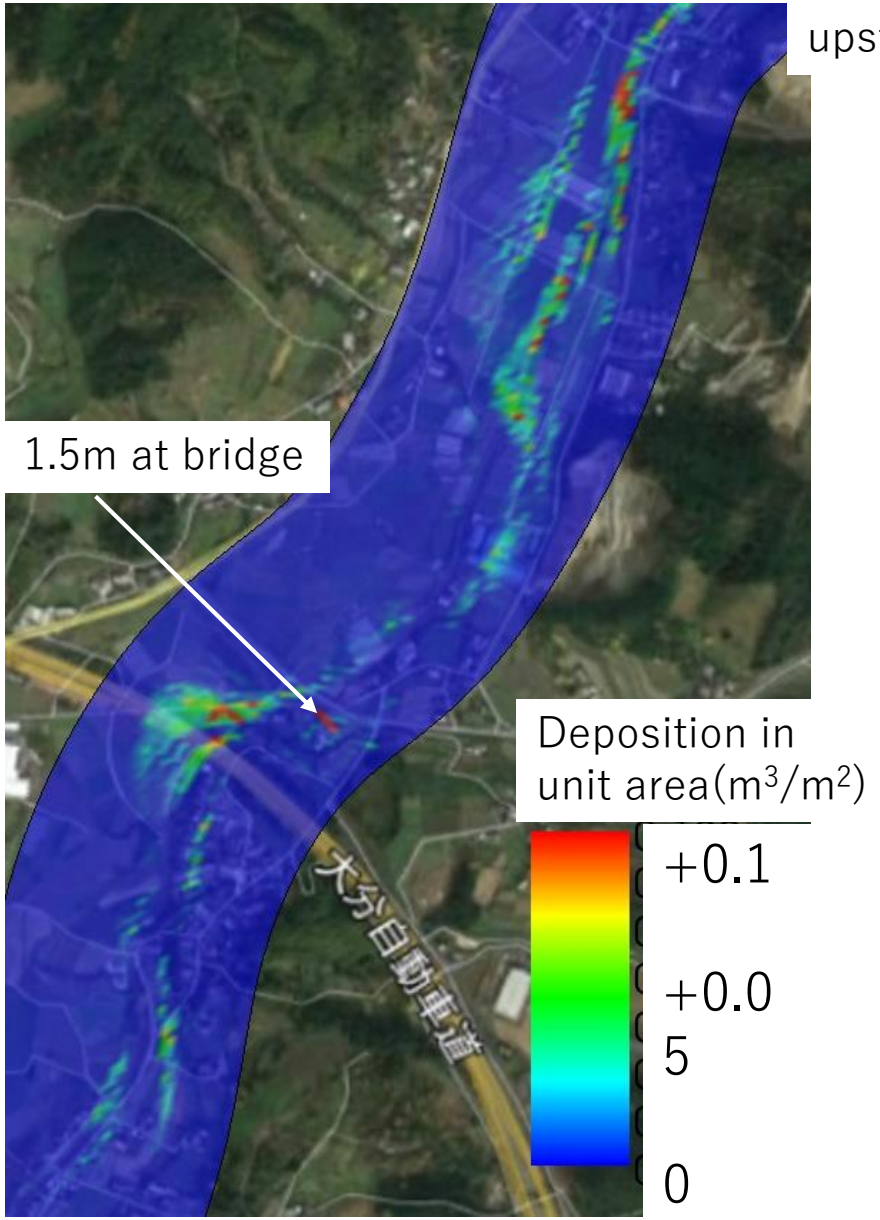
Tailing stage (150m3/s)



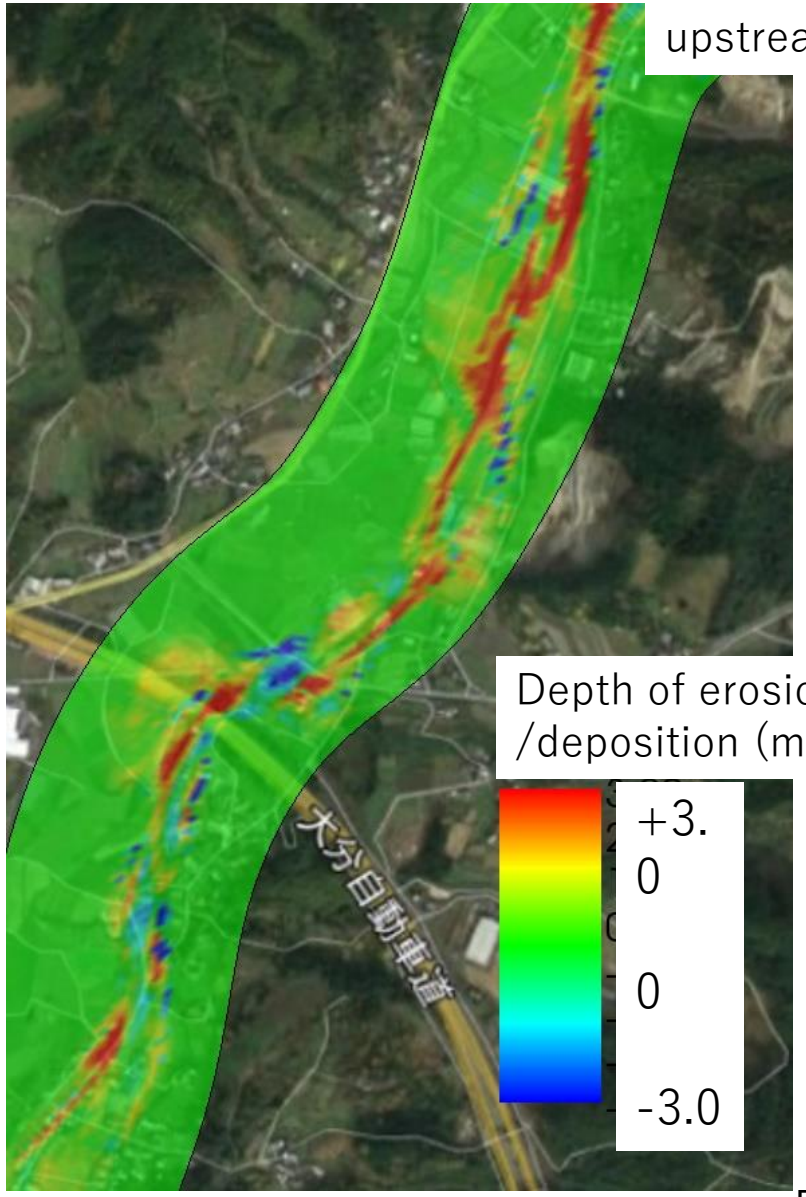
Stream bifurcation due to sedimentation

Computed flow patterns

provided by Harada et.al. (Nov. 2017)

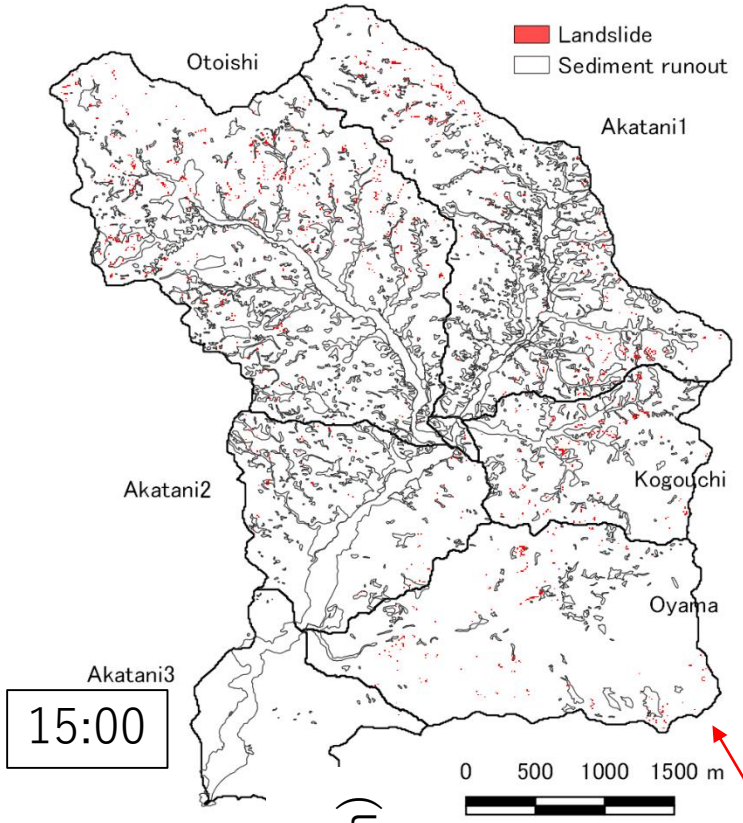


Deposition of drift wood



Change of bed elevation

Provided by Harada et.al. (Nov. 2017)



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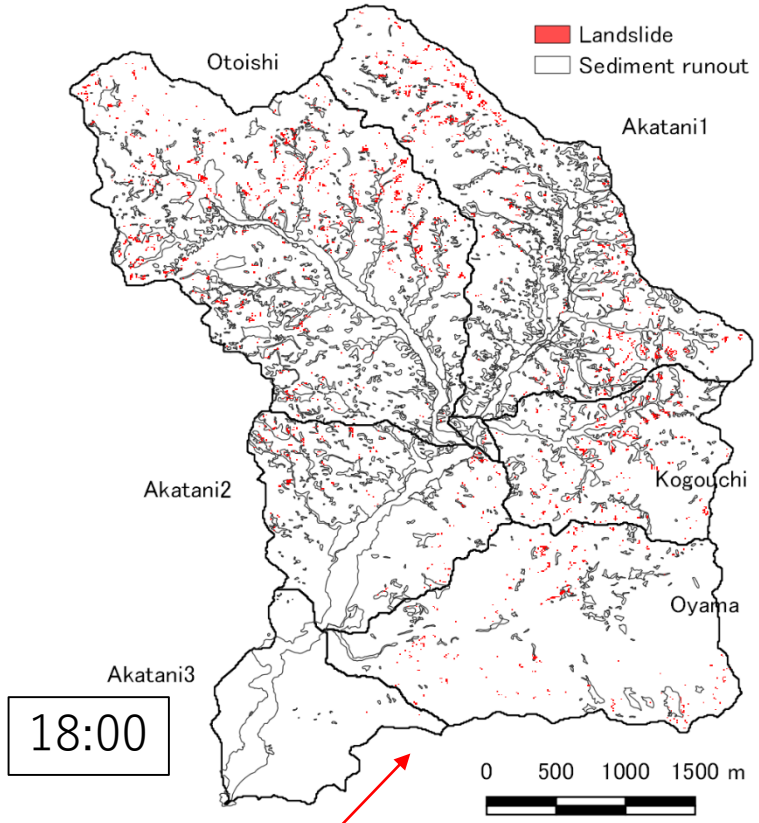

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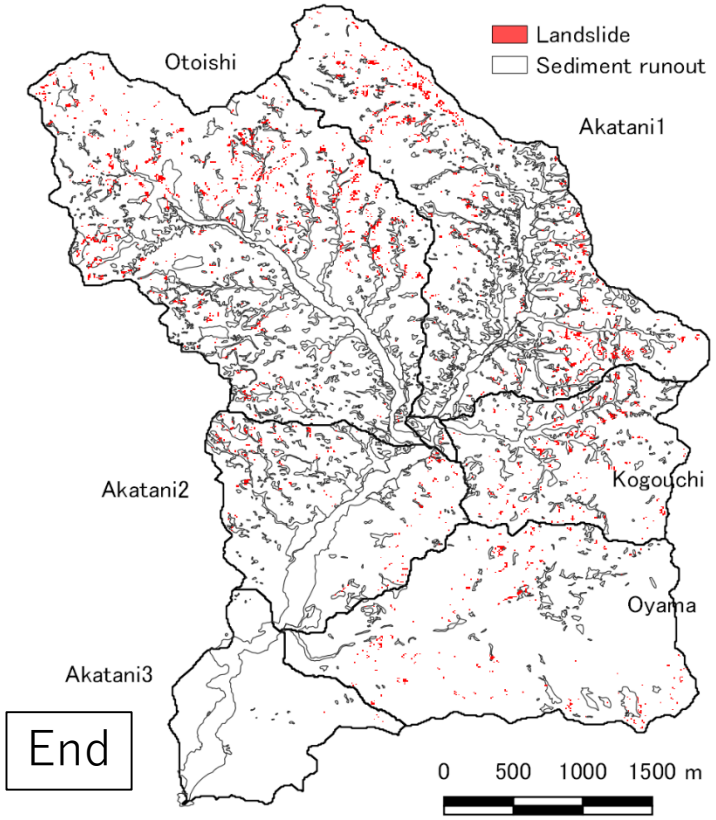
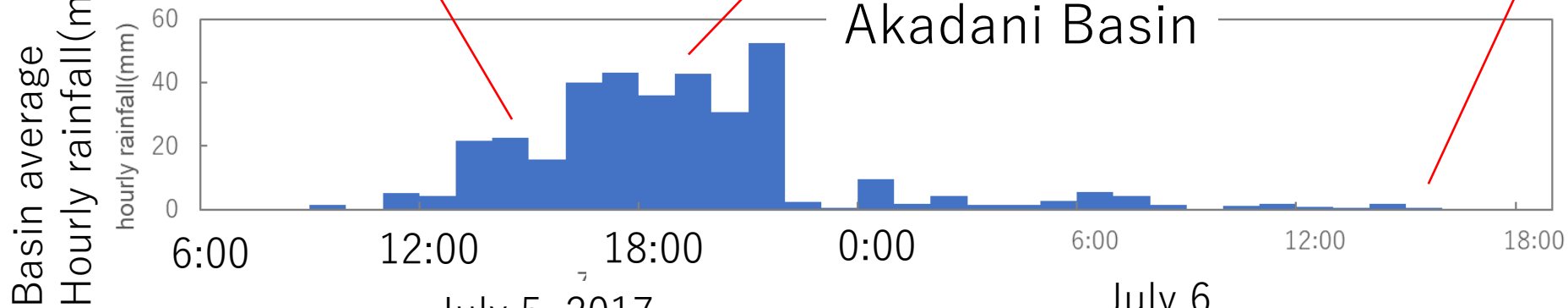
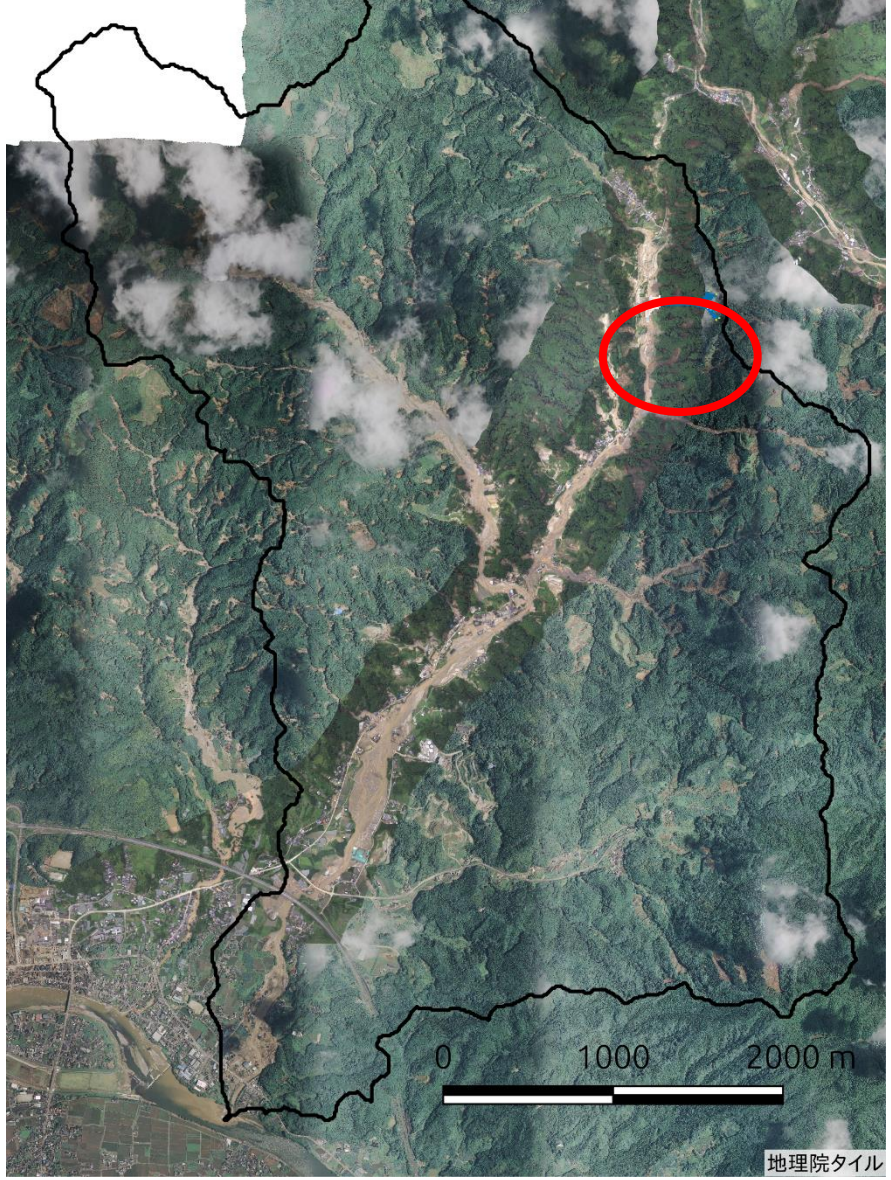


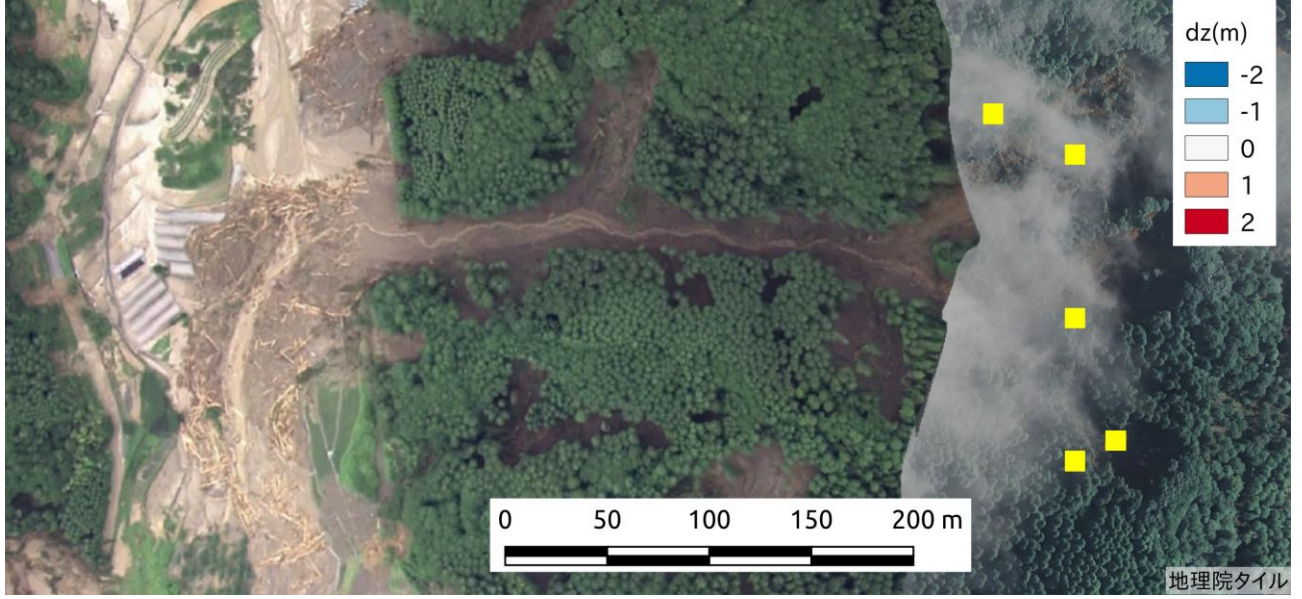
End

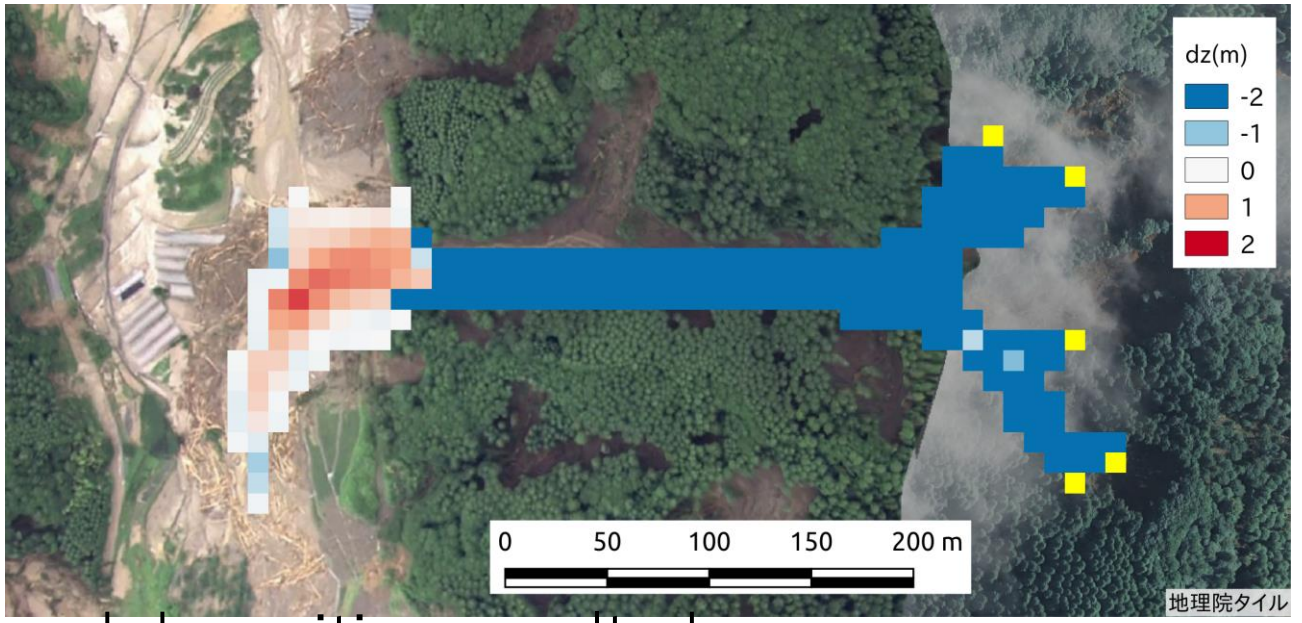


Temporal changes in the number of unstable cells

Provided by Yamazaki et.al. (Nov. 2017)

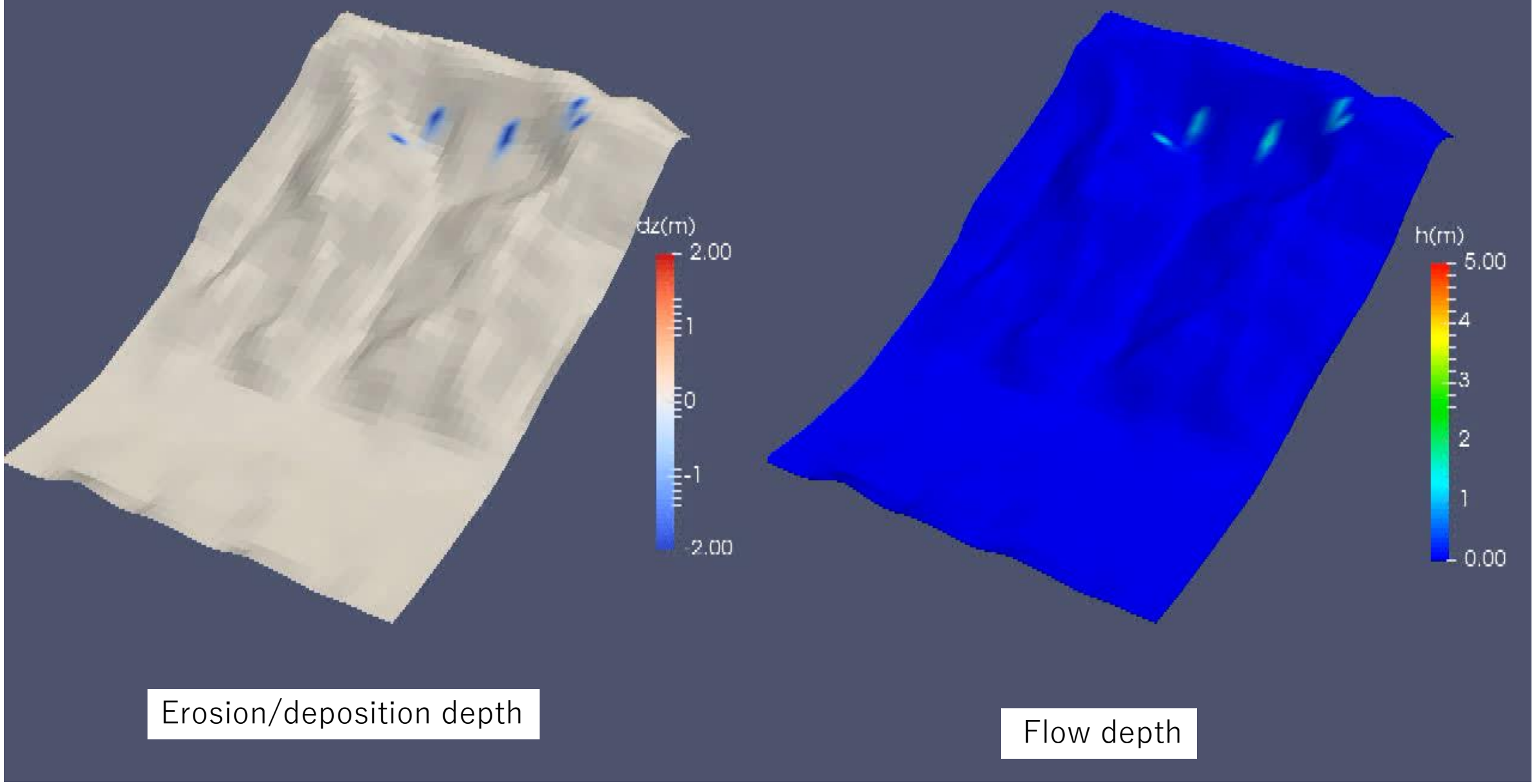






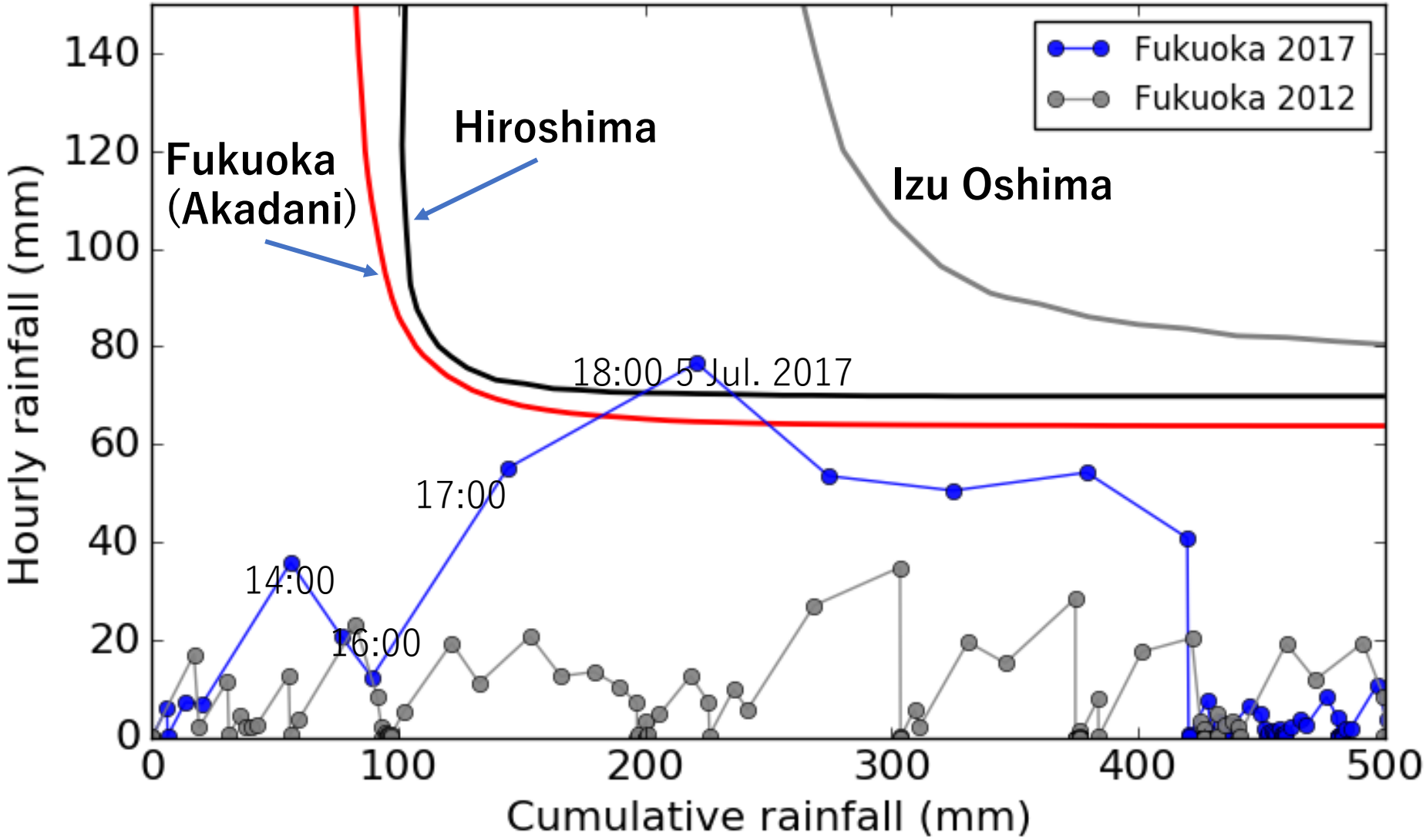
Spatial distribution for erosion and deposition resulted from debris flow

Provided by Yamazaki et.al. (Nov. 2017)



Debris flow resulted from landslides

Provided by Yamazaki et.al.
(Nov. 2017)



Rainfall
(C-BAND JMA)

Critical rainfall conditions to cause severe sediment disasters in different regions

Provided by Yamazaki et.al.
(Nov. 2017)

Concluding remarks

A specific closed world?

Governing equations, Numerical models and results

on flood flow (inundation processes) with sediment transportation and drift wood as well as on landslides and debris flow

(Researchers and practitioners)

Evaluation & decision

Information necessary for modification & development

Countermeasures

Structural measures:
- river channel design,
- debris control dam,
- whole town's structures, etc.

Non-structural measures:
- hazards maps, early warning,
- evacuations etc.

Education tools:

Administrators, beneficiaries (people living in hazardous areas)

Plat form enables to provide tools and information for researchers, engineers, administrators and others who are interested in flood and sediment hazards.