Rainfall-Runoff-Inundation Simulation for Basin-wide Flood Hazard Mapping at the Batanghari River in Sumatra, Indonesia

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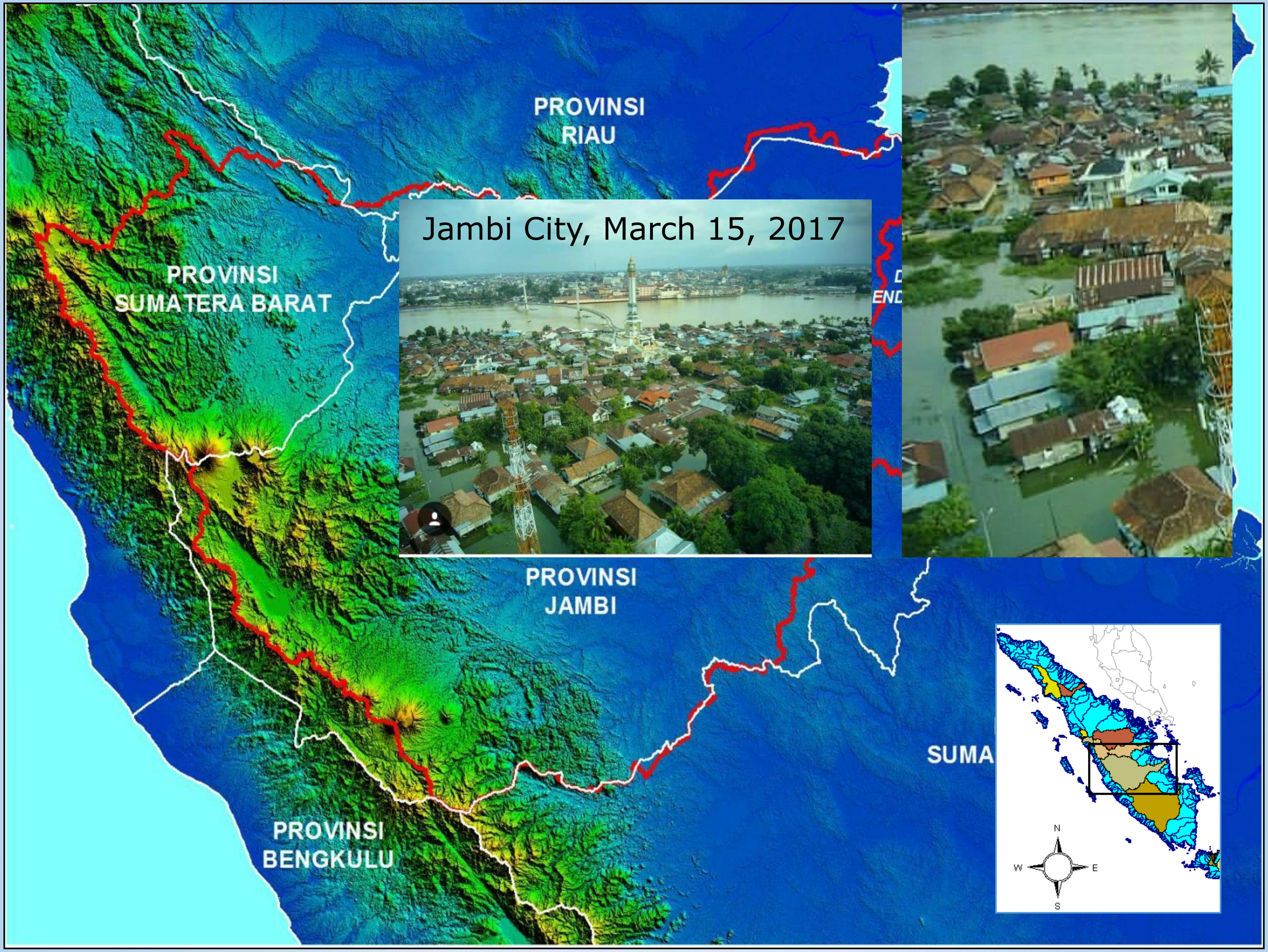
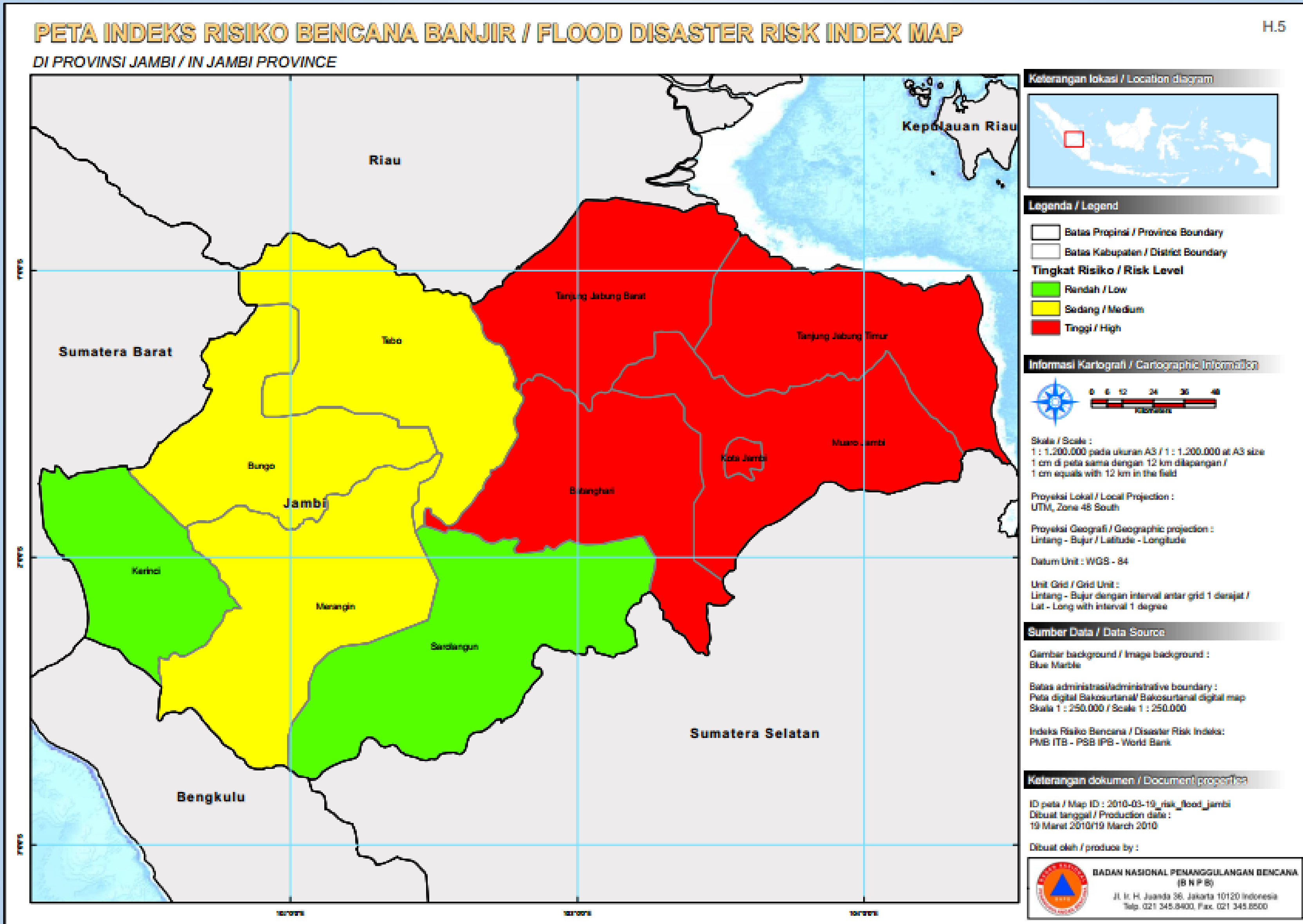
The Batanghari River Basin



The Batanghari River Basin (42,960 km^2)

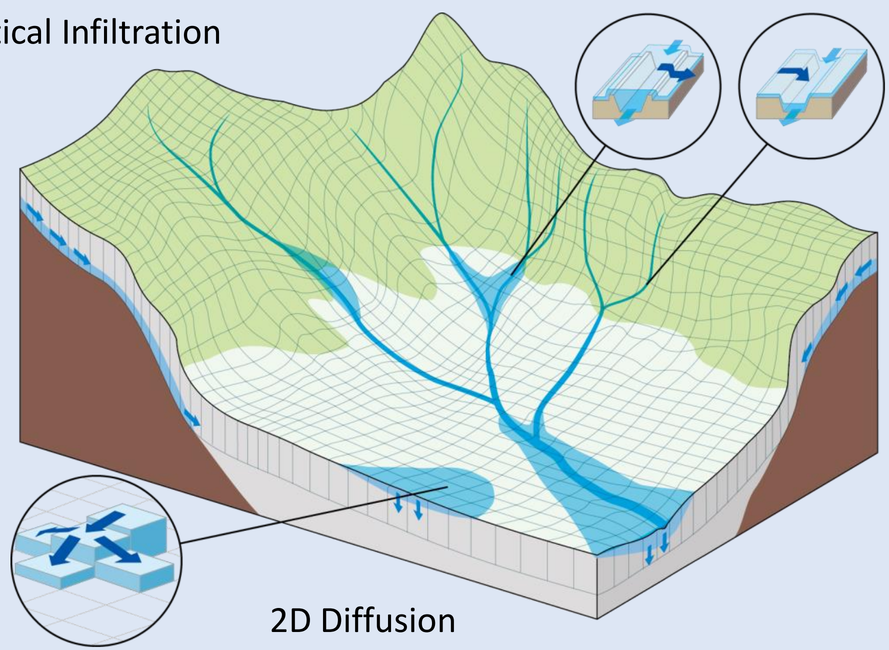
A Regional Flood Hazard Map



Rainfall-Runoff-Inundation (RRI) Model

Input

- Rainfall
- DEM
- Land Cover
- Cross Sec.



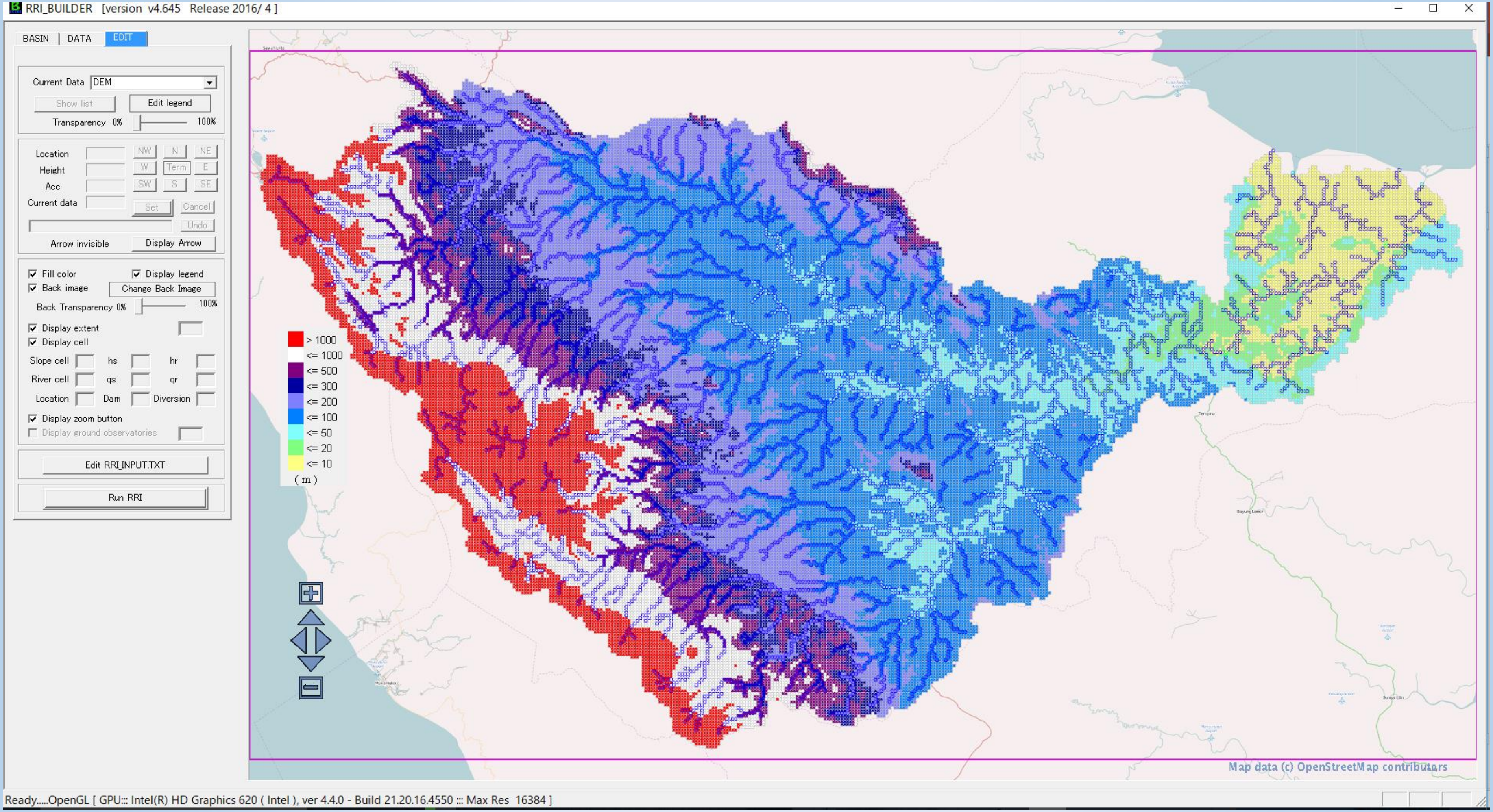
Output

- Discharge
- W. Level
- Inundation

Sayama, T. et al. *Hydrological Sciences Journal*, 2012.

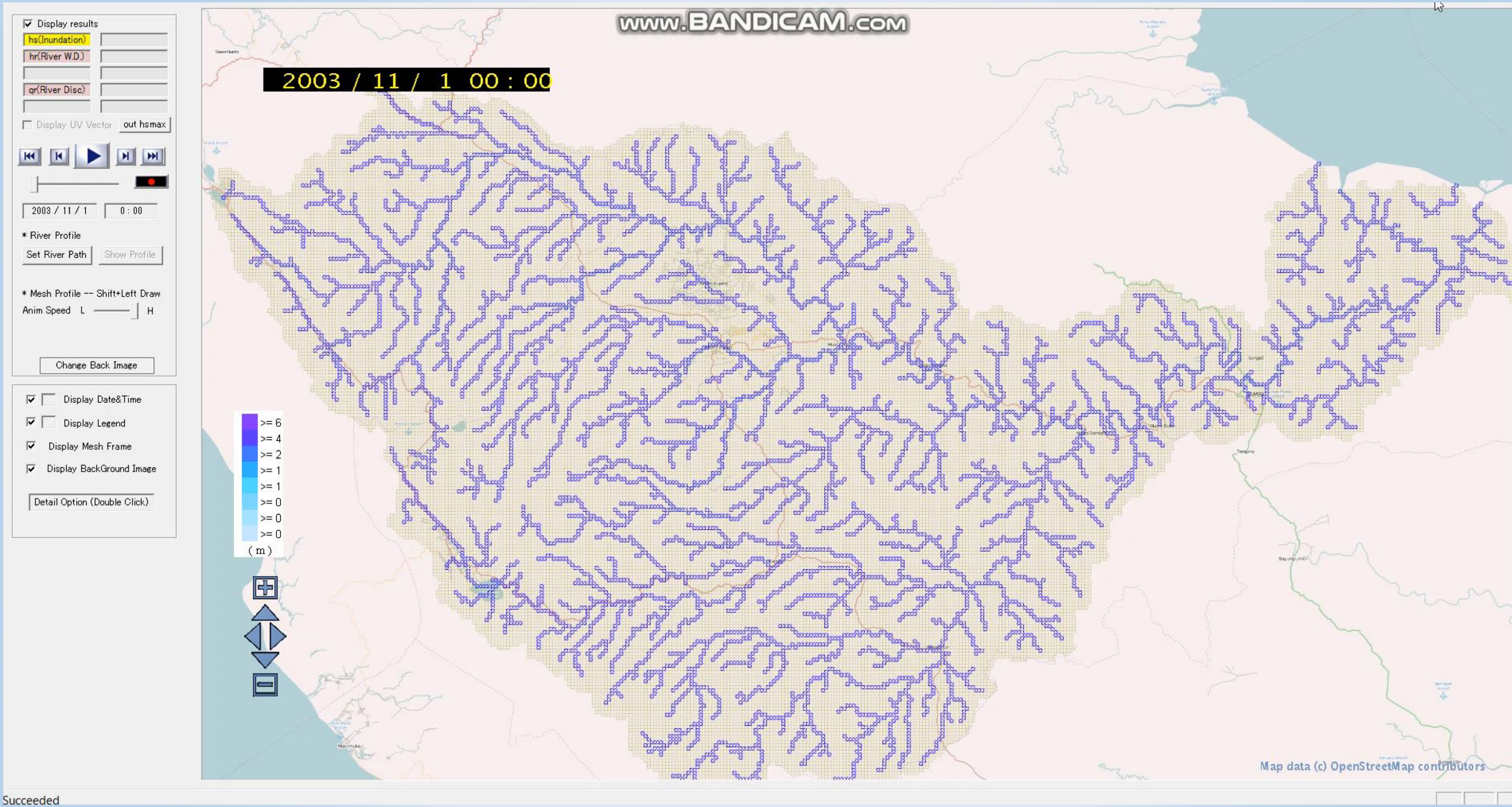
RRI Model is freely available from ICHARM webpage.

RRI Model Builder



RRI Model is freely available from ICHARM webpage.

RRI Model Viewer



RRI Model is freely available from ICHARM webpage.

Landscapes in the Batanghari RB

Peatland Area in the Downstream

Land Cover and Hydrologic Cycle

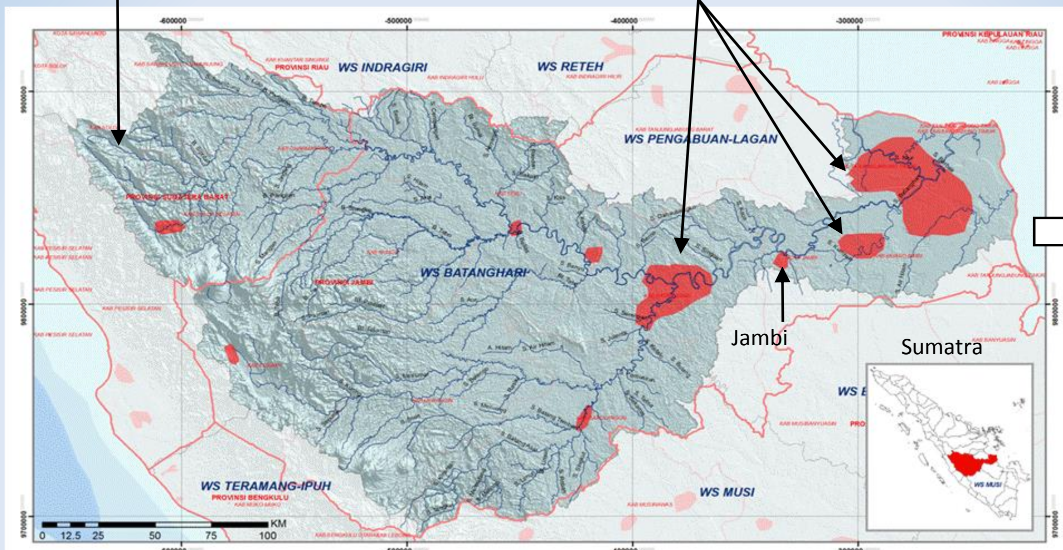
Batanghari River Basin (42,960 km^2), Sumatra, Indonesia

Upstream

Downstream

Frequent flooding areas, Wetland

Natural Forest

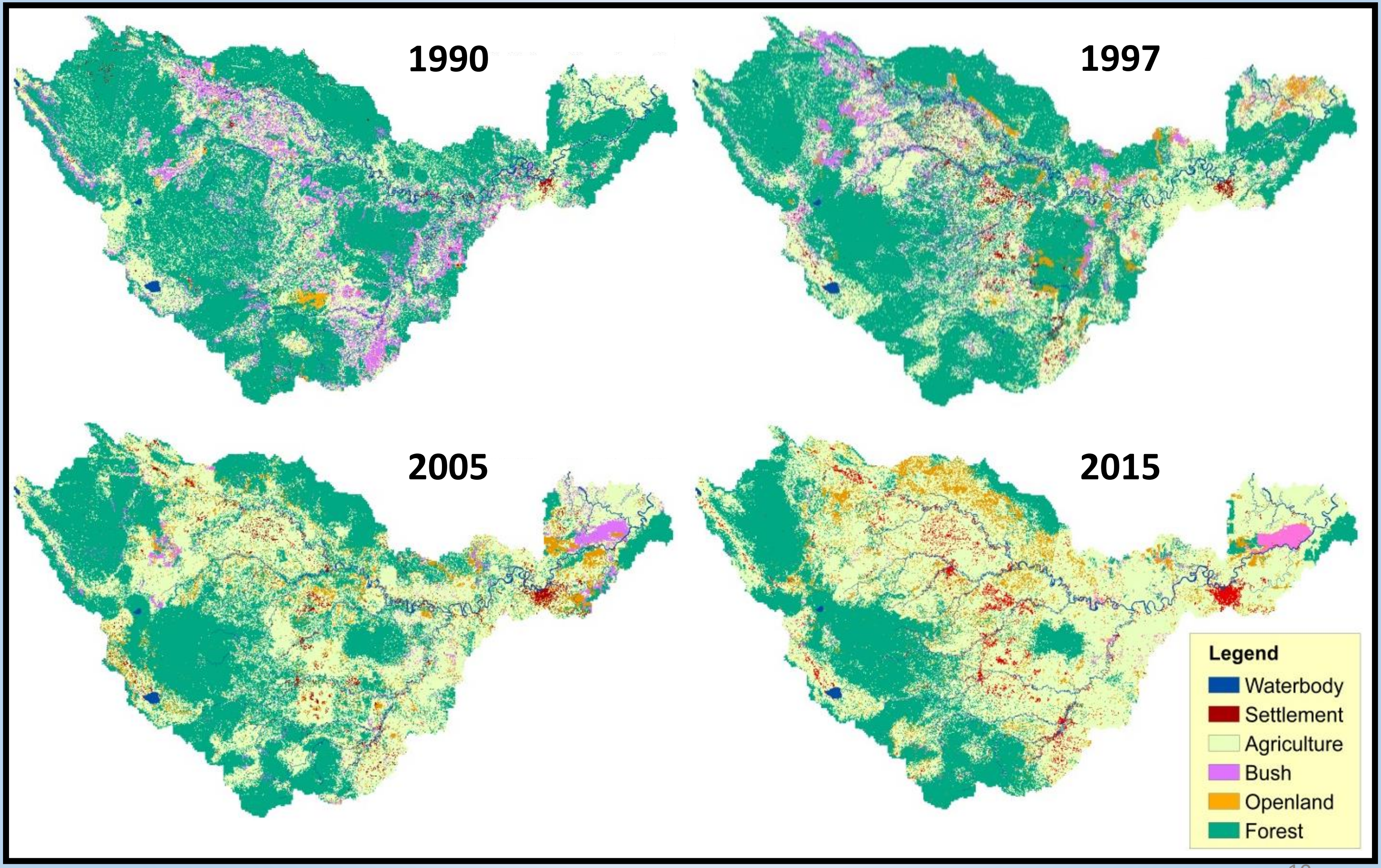


Peatland Area

Drying wetland
Peatland fire

1. In Sumatra, **50 % of primary forest has been deforested** in the last 25 years (1985-2009)
2. The deforestation has impacted to the increase of CO_2 emission and **change in the hydrologic cycle**, causing flood and drought disasters, soil erosion and drying lands.
3. In the downstream part of the river basin, where large **peatland** exists, the change in river flow regime as well as artificial drainage system for creating new farmland has dried the area, leading to frequent fire in the peatland area and haze issue.

Land-cover land-use Change (LC)



Courtesy by Dr Apip

Impact of Land Cover Change on Flooding

DPRI-KU

- Based on BNPB data, during the period of 1995 until 2014, the frequency of flooding in Jambi province had increased steadily. The most probable reason was forest cover change and the expansion of plantation crops (Tarigan, 2016).

- Deforestation increases the frequency of flooding.

- **Scientific Questions**

  - What are actual changes in hydrologic processes induced by the land cover changes?
  - In humid tropical rainforest / plantation croplands, what is a dominant runoff process during storm events? (overland flow / quick subsurface flow?)
  - How to assess the impact with hydrologic models?

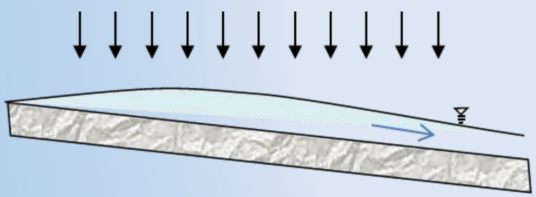
Three Conditions of Surface / Subsurface Flow in RRI

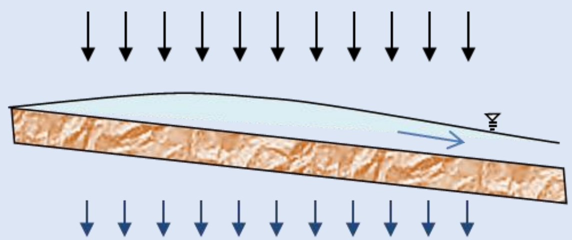
Surface / subsurface flow conditions

(A) Only overland flow (no infiltration loss, no subsurface flow)

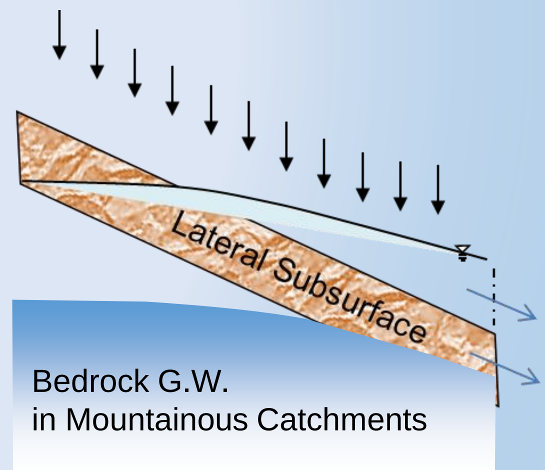
(B) Vertical infiltration + Infiltration excess overland flow

(C) Saturated subsurface + Saturation excess overland flow

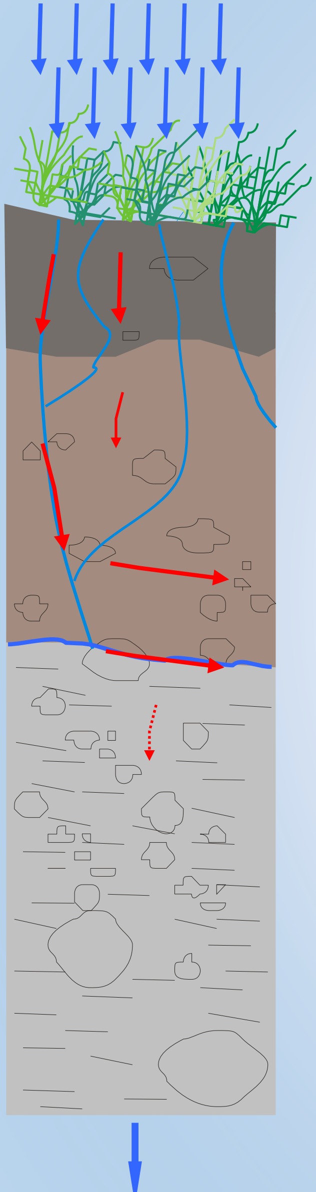




Infiltration : Green Ampt Model

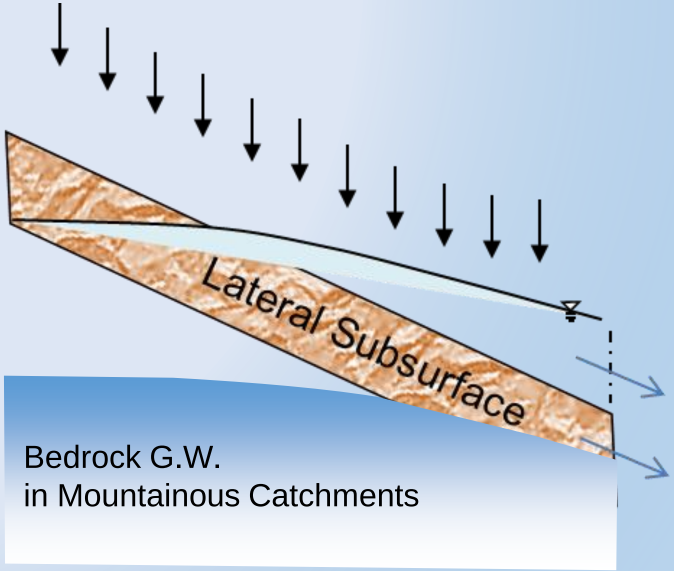


In case of Japanese Forest



Peter Kienzler, ETH Zurich

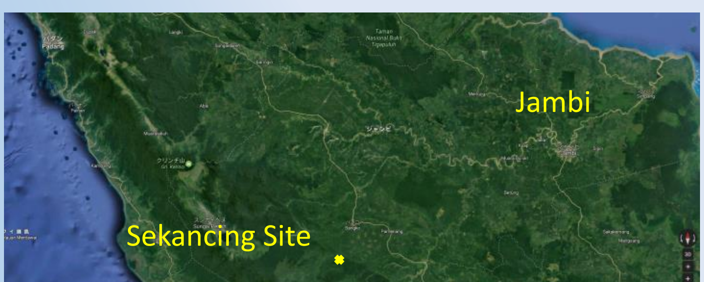
Soil depths: 60 – 100 cm
Underlain by granite bedrock
(Kiryu Experimental Watershed)



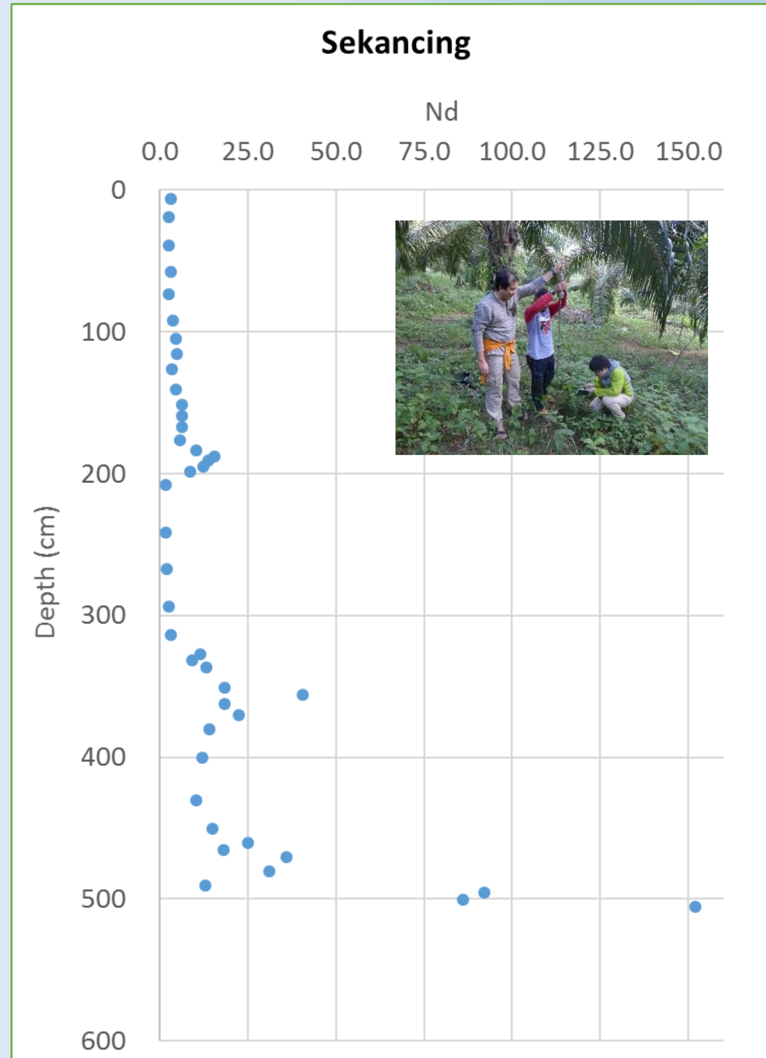

Chris Graham PhD thesis

Thick Soil Depths in Tropical Climate

Forest mountainous hillslope

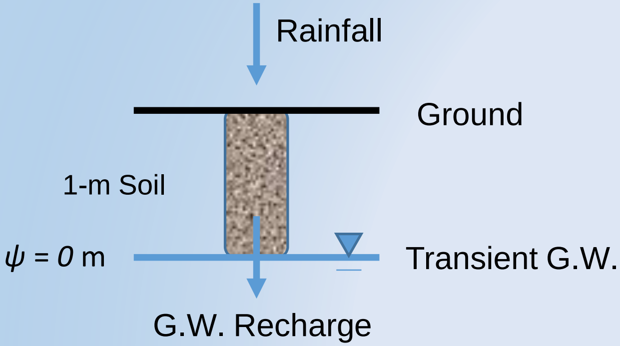


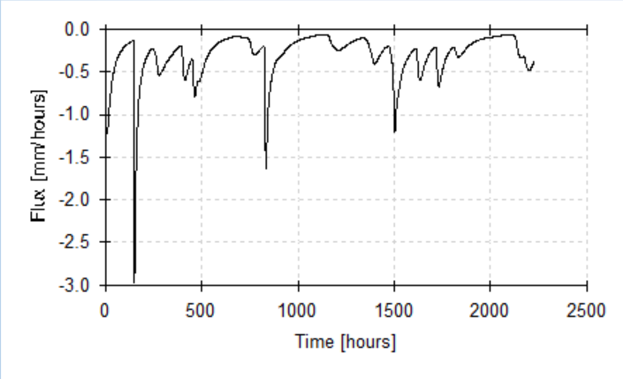
Soil depths = 5 m

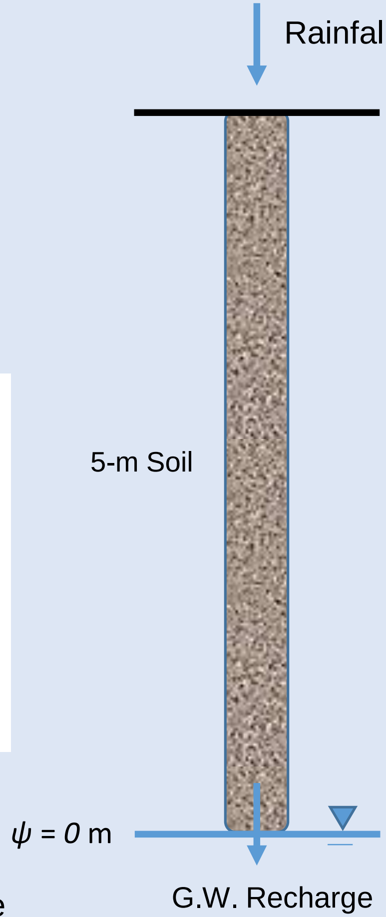


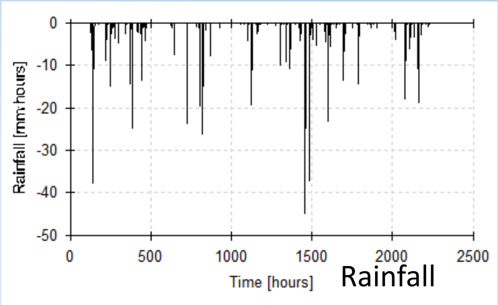
Effects of Soil Depths on G.W. Recharge

- Use HYDRUS-1D: 1D Richards Equation Solver
- Soil Type: Sandy Clay Loam
- Upper Boundary: Atmospheric, Lower Boundary: $\psi = 0$ m

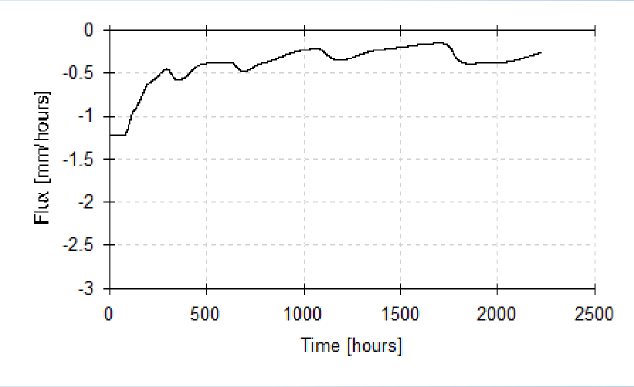








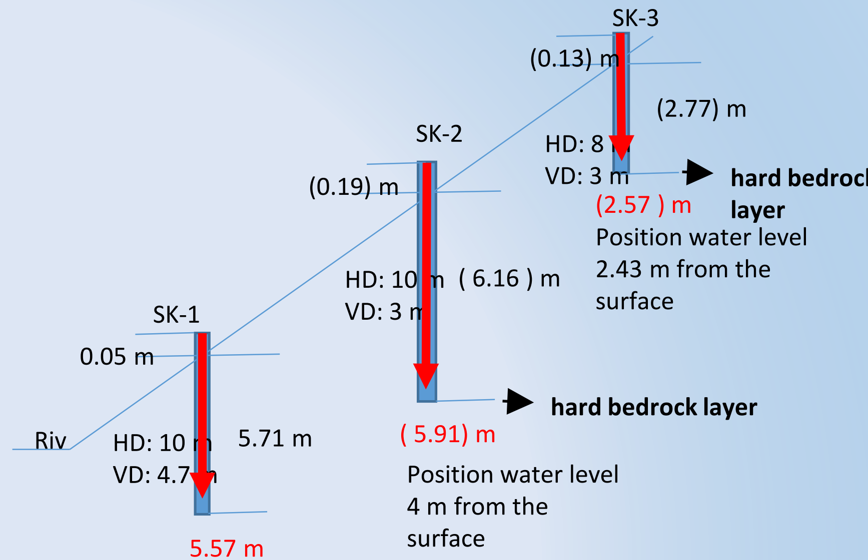
3 Months



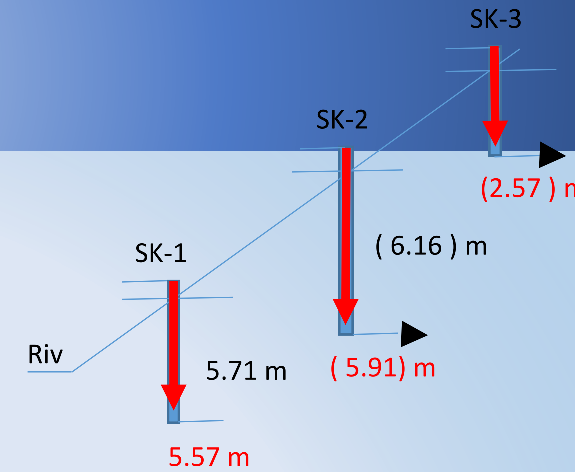
In case of 1-m Soil:
- High temporal variability in the G.W. recharge
- With impermeable inclined bedrock, the recharged water becomes subsurface storm flow

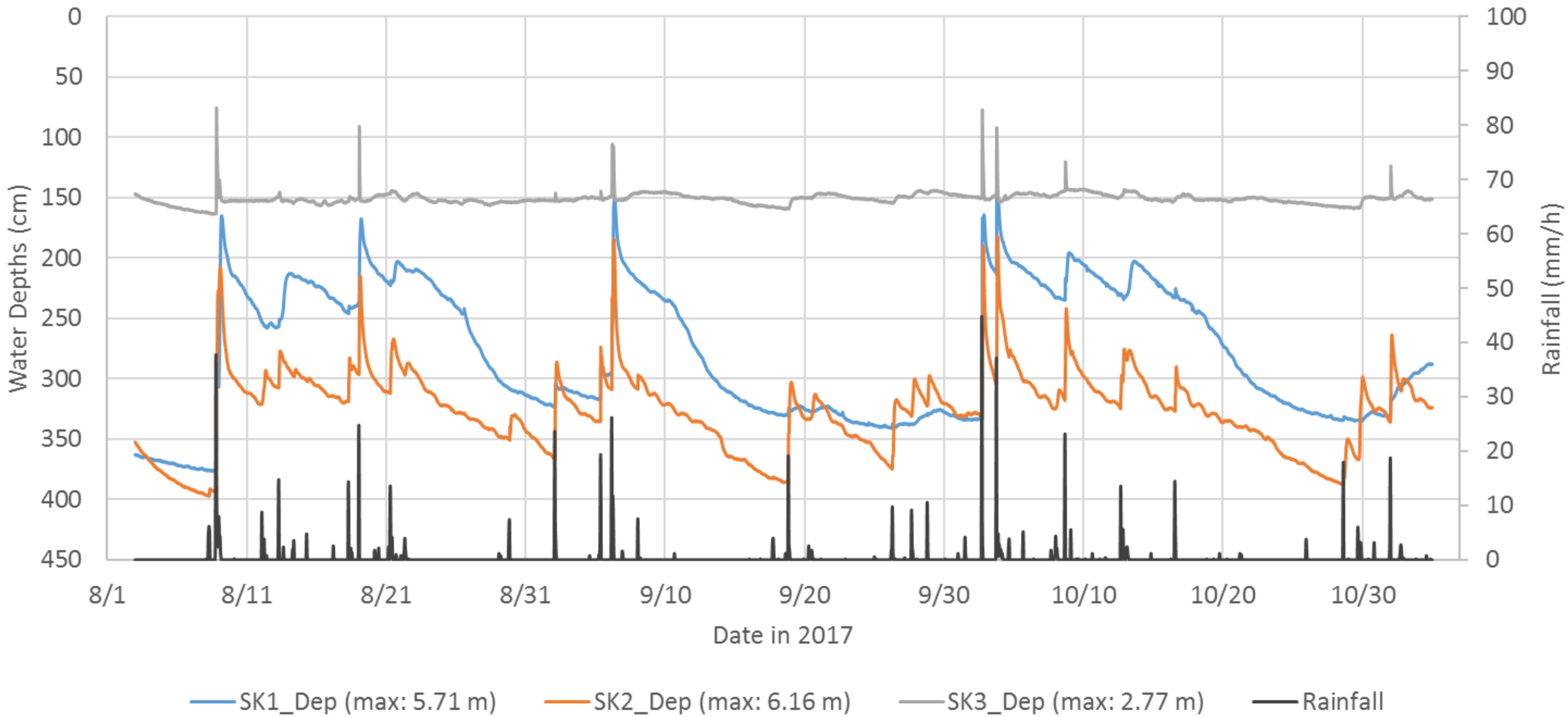
In case of 5-m Soil:
- Low temporal variability in the G.W. recharge
- Hypothesis: no significant fluctuation in the groundwater table

Well drilling and GW Monitoring

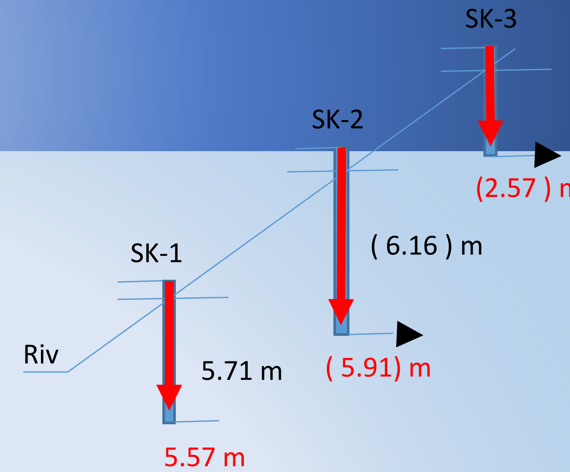


Monitored G.W. Depths

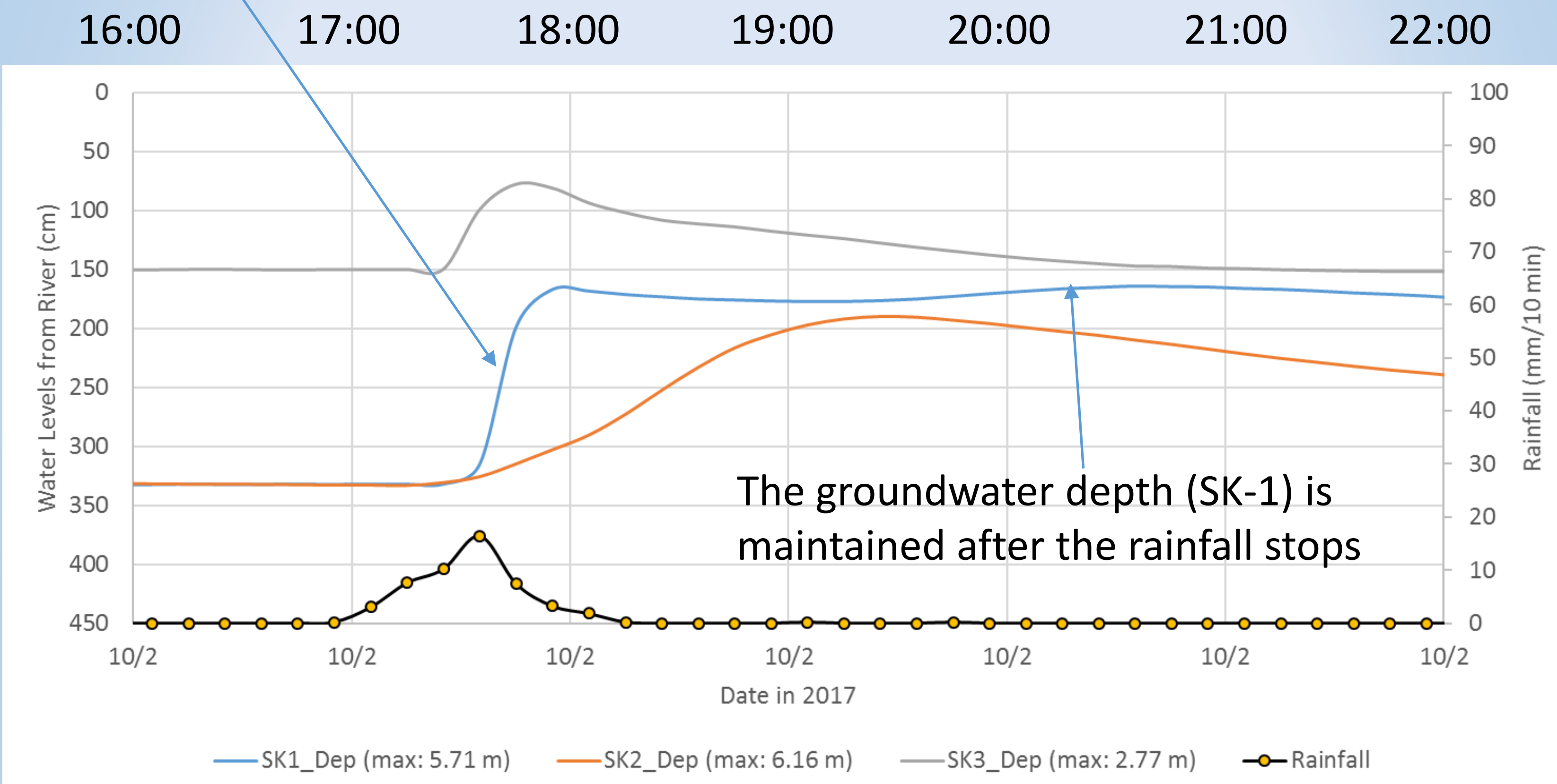




Monitored G.W. Depths



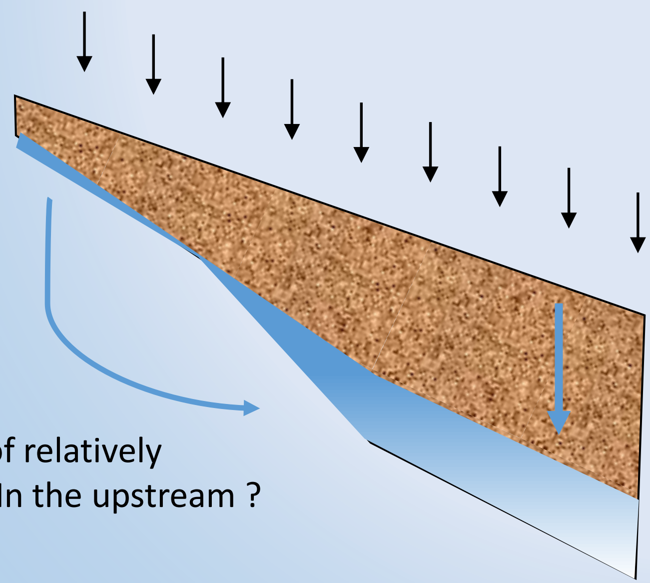
The groundwater depth (SK-1) increases by
1.5 m within 10 minutes after the peak of rainfall



Summary

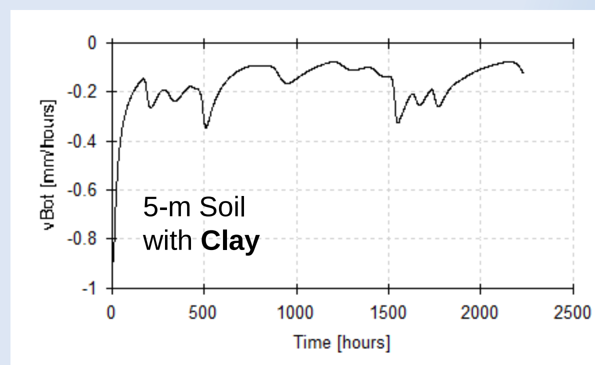
- Clear understanding of rainfall-runoff processes in humid tropical forest mountains is required for assessing the impact of land cover change on flooding.
- In our experimental hillslope, the soil depth at the slope foot was about 5 m and the mountainous groundwater exist in the depths of 3 to 4 m.
- The groundwater table increase by about 1.5 m during some storm events and then decrease gradually.
- Further studies are needed. Hope to develop a physically-sound element model incorporated into the Rainfall-Runoff-Inundation (RRI) model.

New Hypothesis?

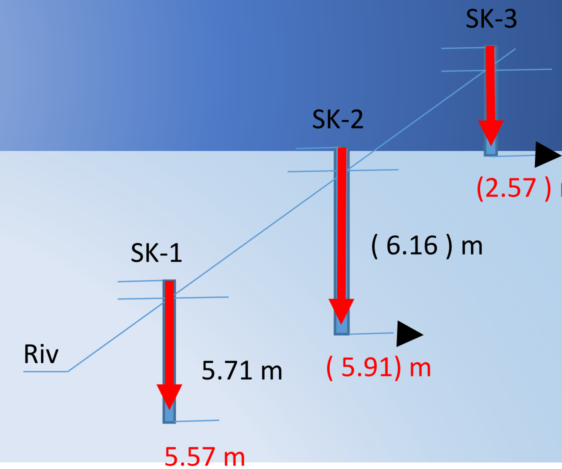


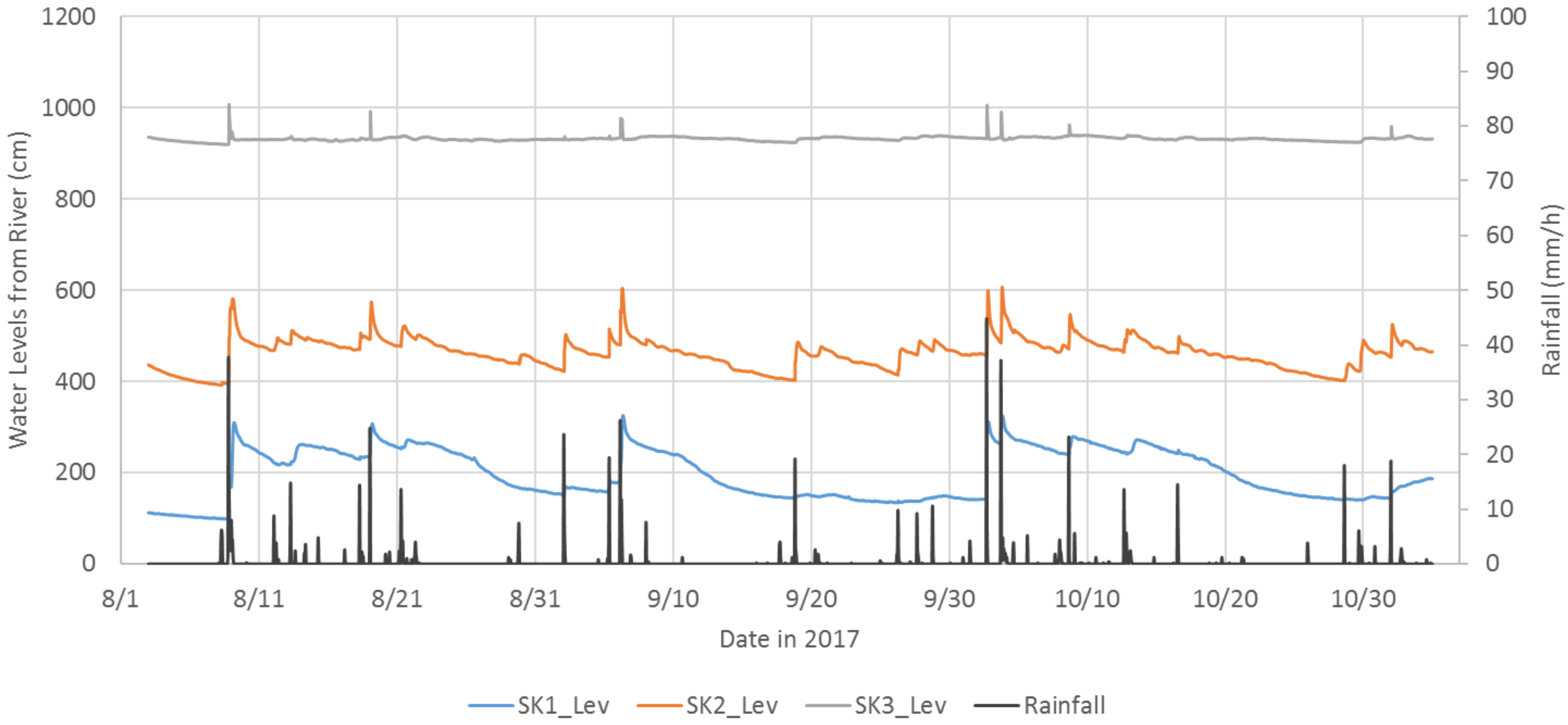
a) Controls of relatively shallow soil In the upstream ?

b) If the soil is characterized by clay, the G.W. recharge may have high temporal variabilities



Monitored G.W. Levels





Research Projects

- The Japan-ASEAN Science, Technology and Innovation Platform (JASTIP) funded by Japan Science and Technology (JST)
  - Since FY2015
  - WP4: Disaster Research Group
  - Collaborative Research between DPRI, KU and Research Center for Limnology, LIPI

- MEXT KAKENHI (B)
  - Since FY2016
  - "Assessing the Impact of Deforestation in Tropical Forest in Sumatra, Indonesia, on Hydrologic Cycle at the River Basin Scale including Lower Wetland Area" (PI: T. Sayama)

- TOUGOU Project: Integrated Research Program for Advancing Climate Models
  - Since FY2017
  - Area Theme D: Integrated Hazard Prediction (PI: Prof. Nakakita, KU)
  - Hazard Assessment in Asian and Pacific Countries and International Cooperation