Funded by JST, CREST
独立行政法人 科学技術振興機構
Japan Science and Technology Agency

Effects of ground vegetation cover on scaling effects of overland flow generation in forested headwater catchments draining Japanese cypress forest

Field monitoring and modeling approaches

Takashi Gomi, Shusuke Miyata, Roy C. Sidle, Ken'ichirou Kosugi, Marino Hiraoka, Yuichi Onda

Tokyo University of Agriculture and Technolo
Appalachian State University
Kyoto University
University of Tsukuba

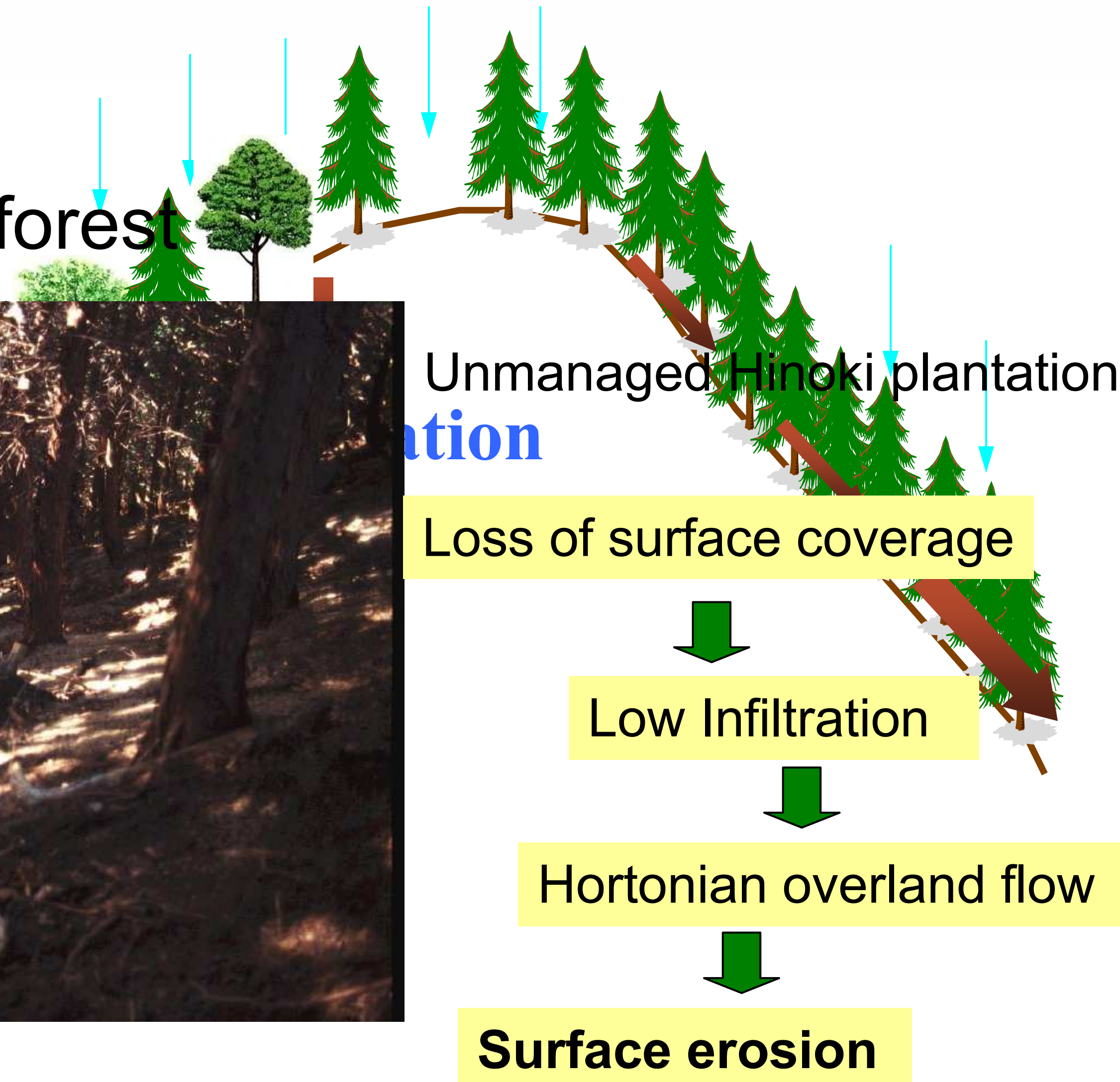
40% Japanese forest is monoculture plantation such as Japanese cypress and cedar

Forest management (e.g., thinning) have NOT been conducted, because of the low timber prices and high labor cost.

Understory vegetation sparse because of low light conditions in Japanese cypress(Hinoki) plantations with dense stem density.

In addition, litter of JPN cypress is susceptible to move down slope and mineral soil is typically exposed.

Potential flow path of unmanaged Japanese cypress (Hinoki) plantation

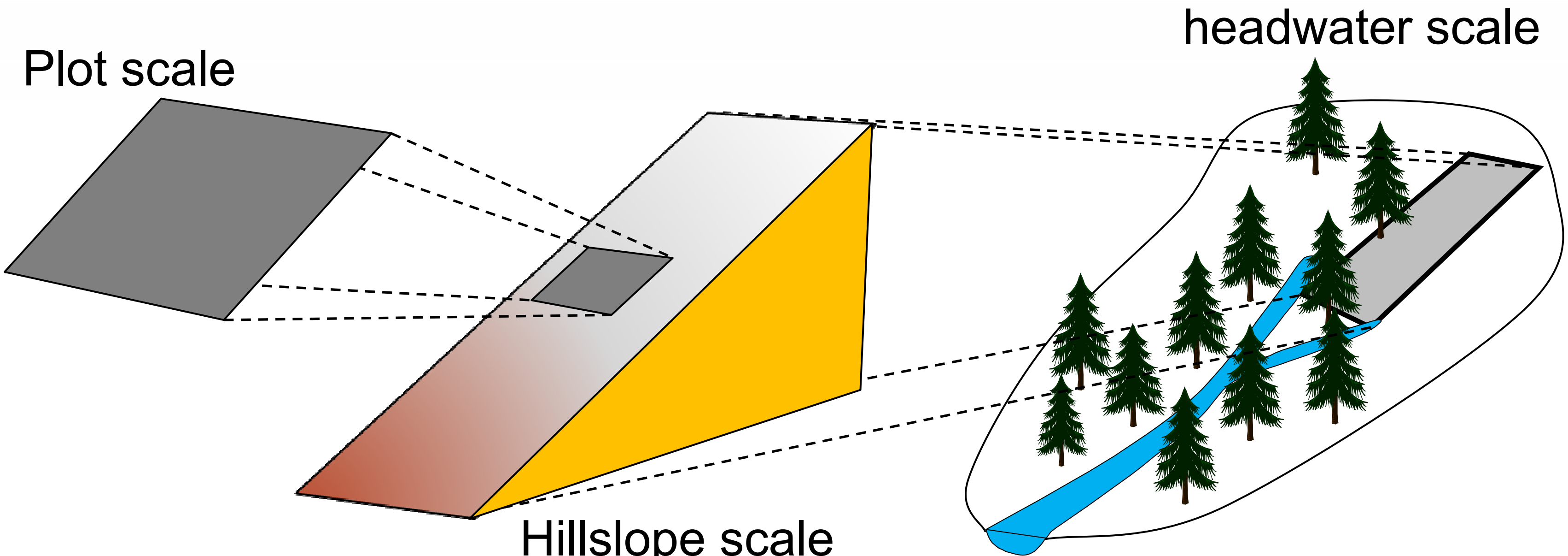


Background

- Hortonian overland flow and related soil erosion is one of the major concerns in the forest management of headwater catchments in Japan

(Miyata et al., 2007 *HP*; Gomi et al., 2008 *WRR*; Gomi et al., 2008 *JoH*; Onda et al., 2009 *HP*; Fukuyama et al., 2009 *HP*; Miyata et al., 2009 *WRR*).

Scaling effects of hydrologic system



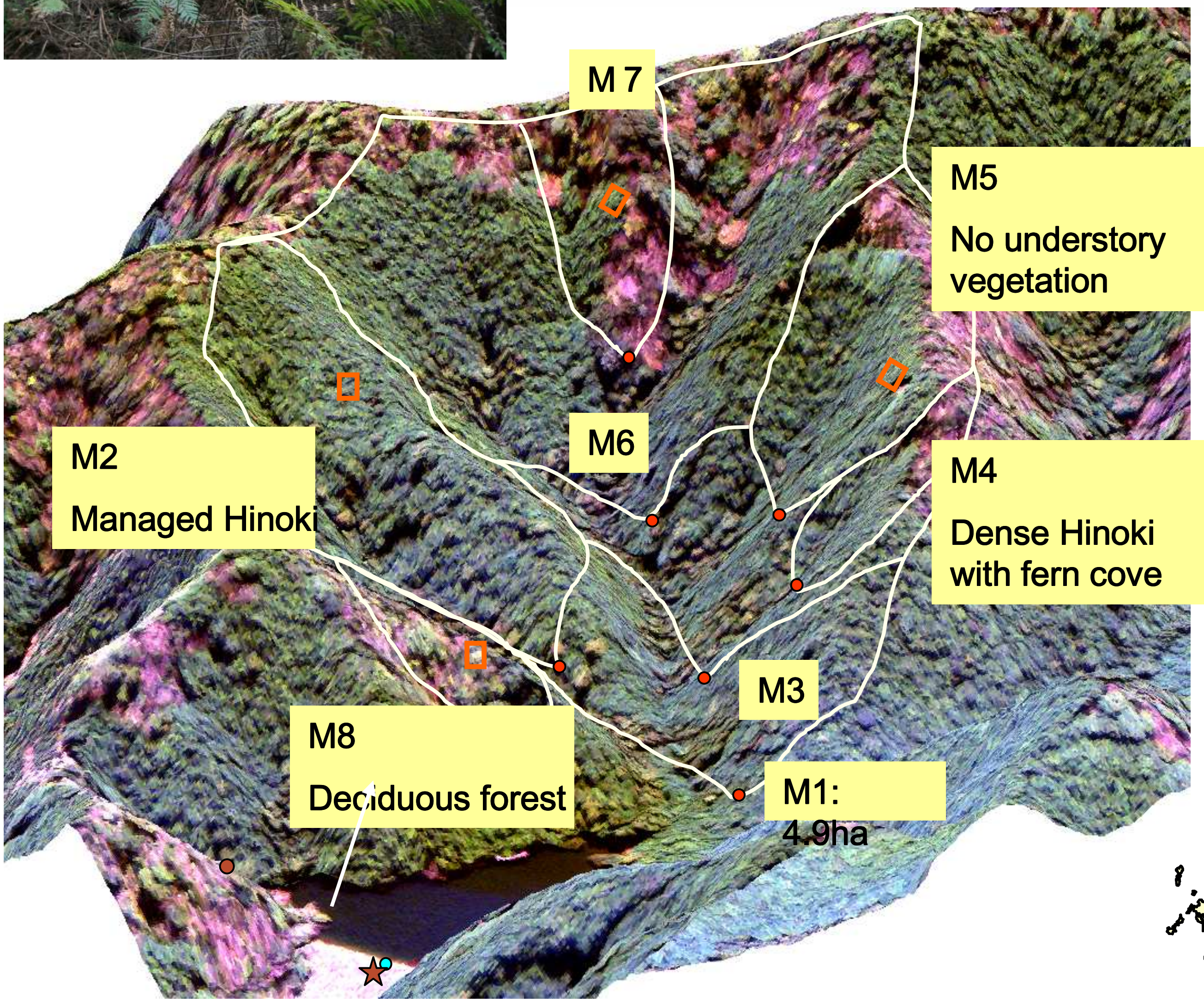
Objectives

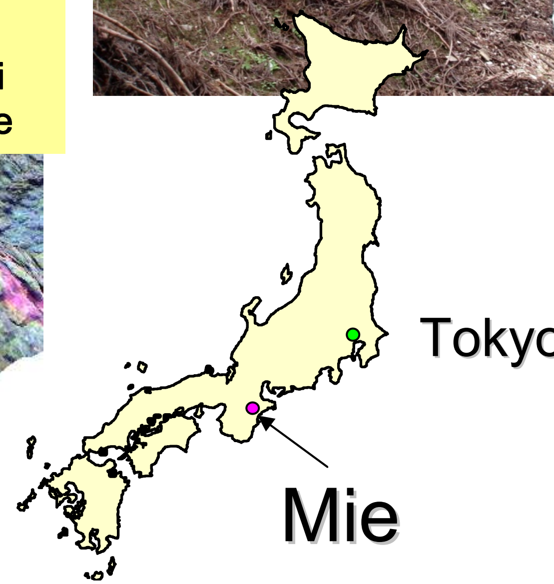
(1) Monitoring the occurrence of overland flow at various scales.

(2) Evaluating the scaling effects of overland flow generation and transfer from hillslopes to stream channels.

(3) Examining vegetation effect on runoff from hillslopes and channels in forested headwaters using a model.

Outline of Mie Site





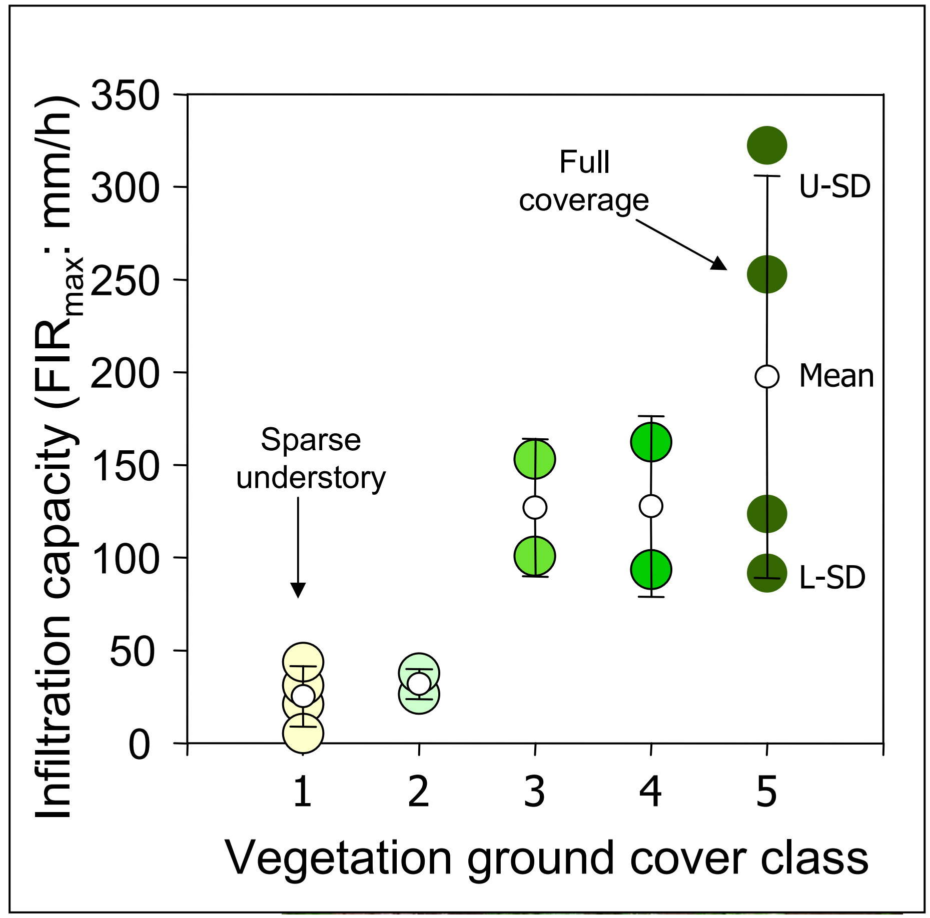
Monitoring Hortonian Overland Flow in Multiple Scales

Infiltration measurement
1 x 1 m plot scale

Small plot
0.5 x 2.0 m plot scale

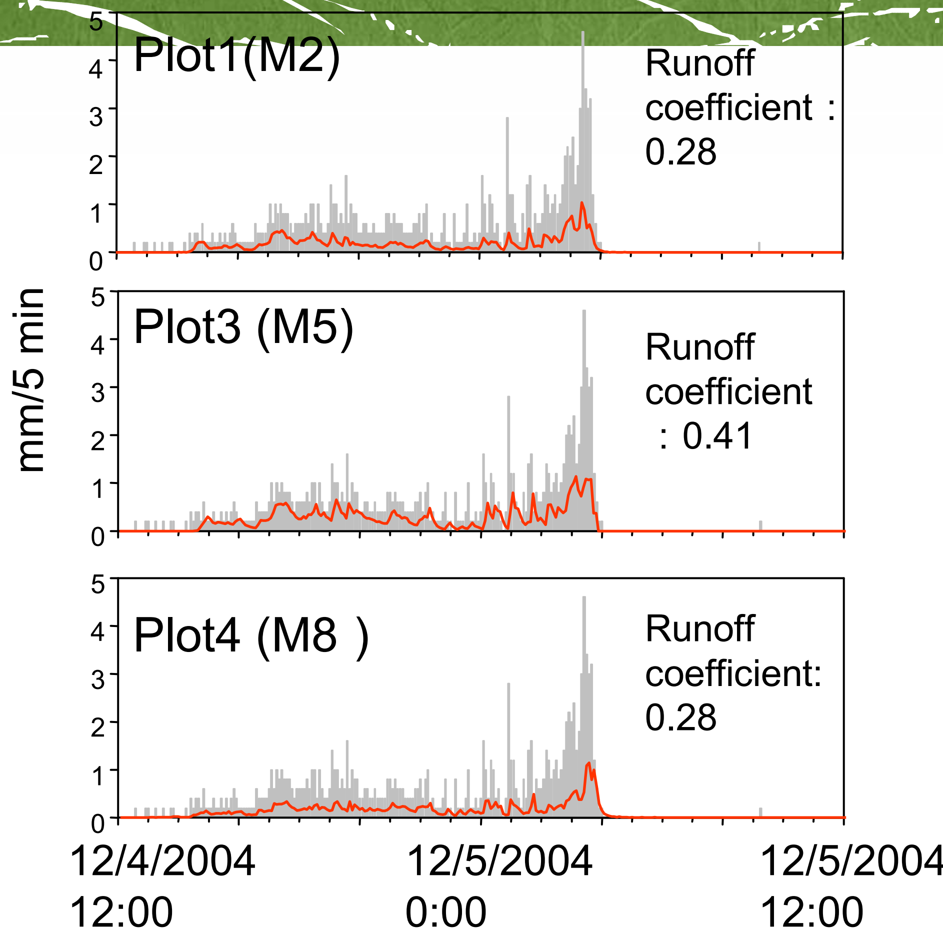
8 x 25 m hillslope scale

Field Infiltration Measurement and Infiltration Capacities



Hiraoka et al., *in review*

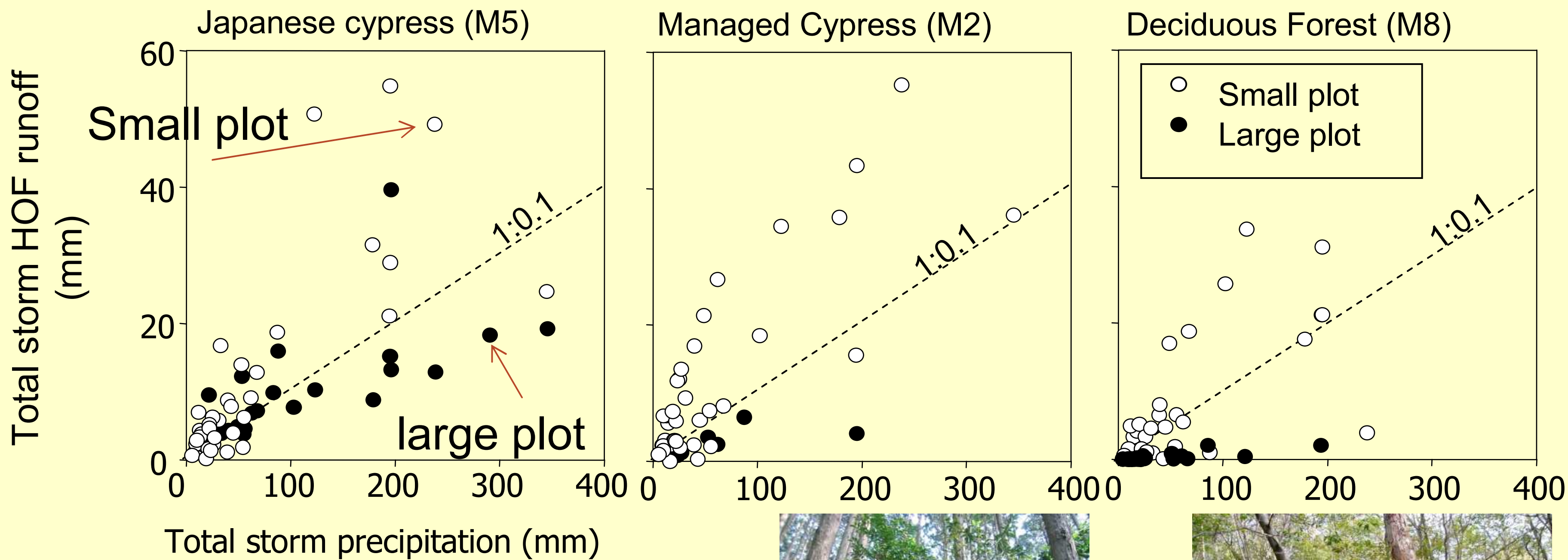
Observed overland flow in the small plots



Gomi et al., 2008 *JoH*

- Significant overland flow occurred from the beginning of the storm event.
- Japanese cypress forest without understory vegetation had more runoff.

Scaling Effects of Overland Flow (comparing small and large plots)

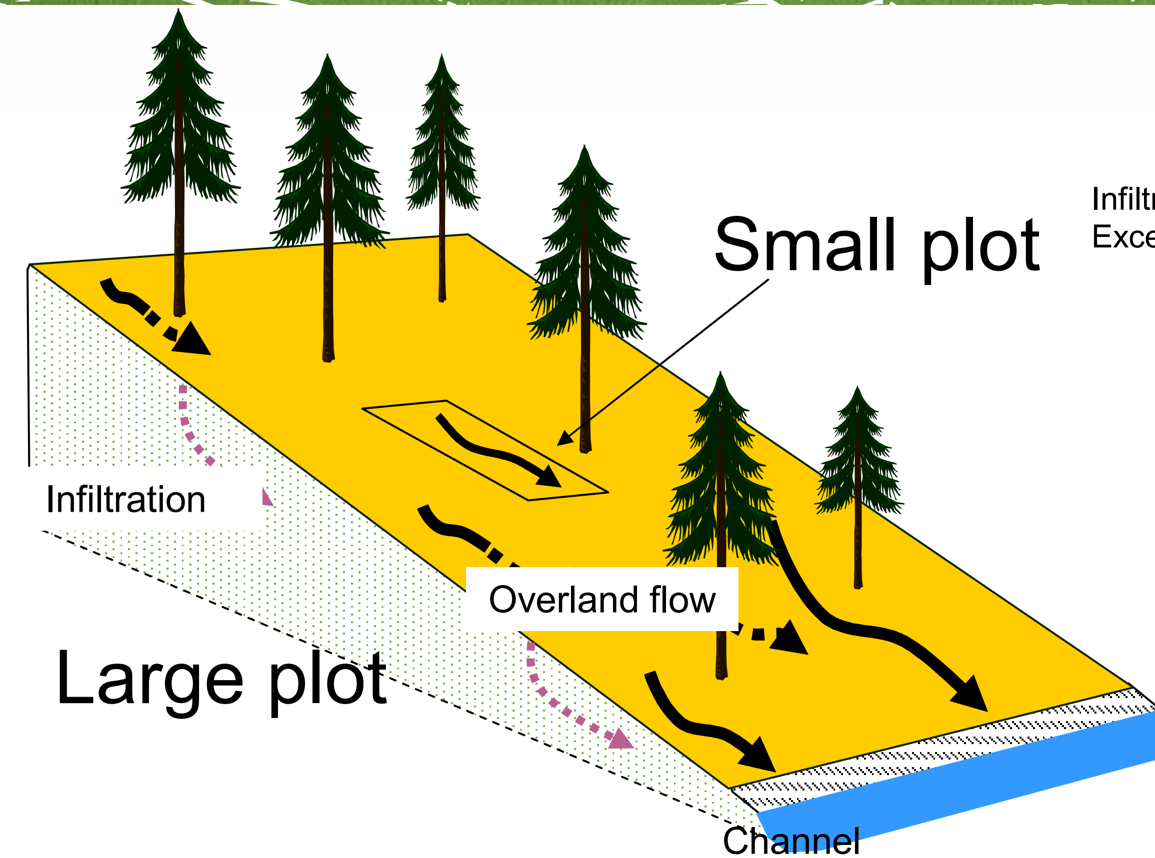


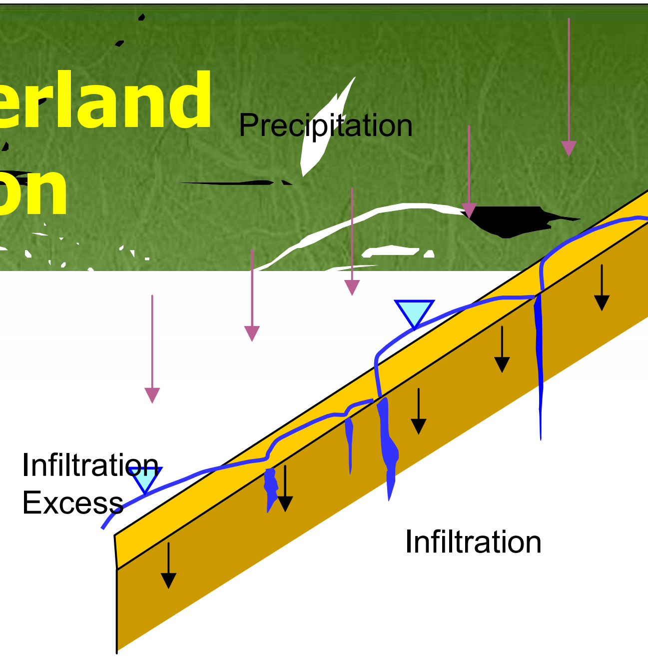
Gomi et al., 2008 *WRR*

•Large plots had smaller runoffs than small plots.

•Differences between large and small plots was more pronounced at Japanese cypress forest WITH understory vegetation cover.

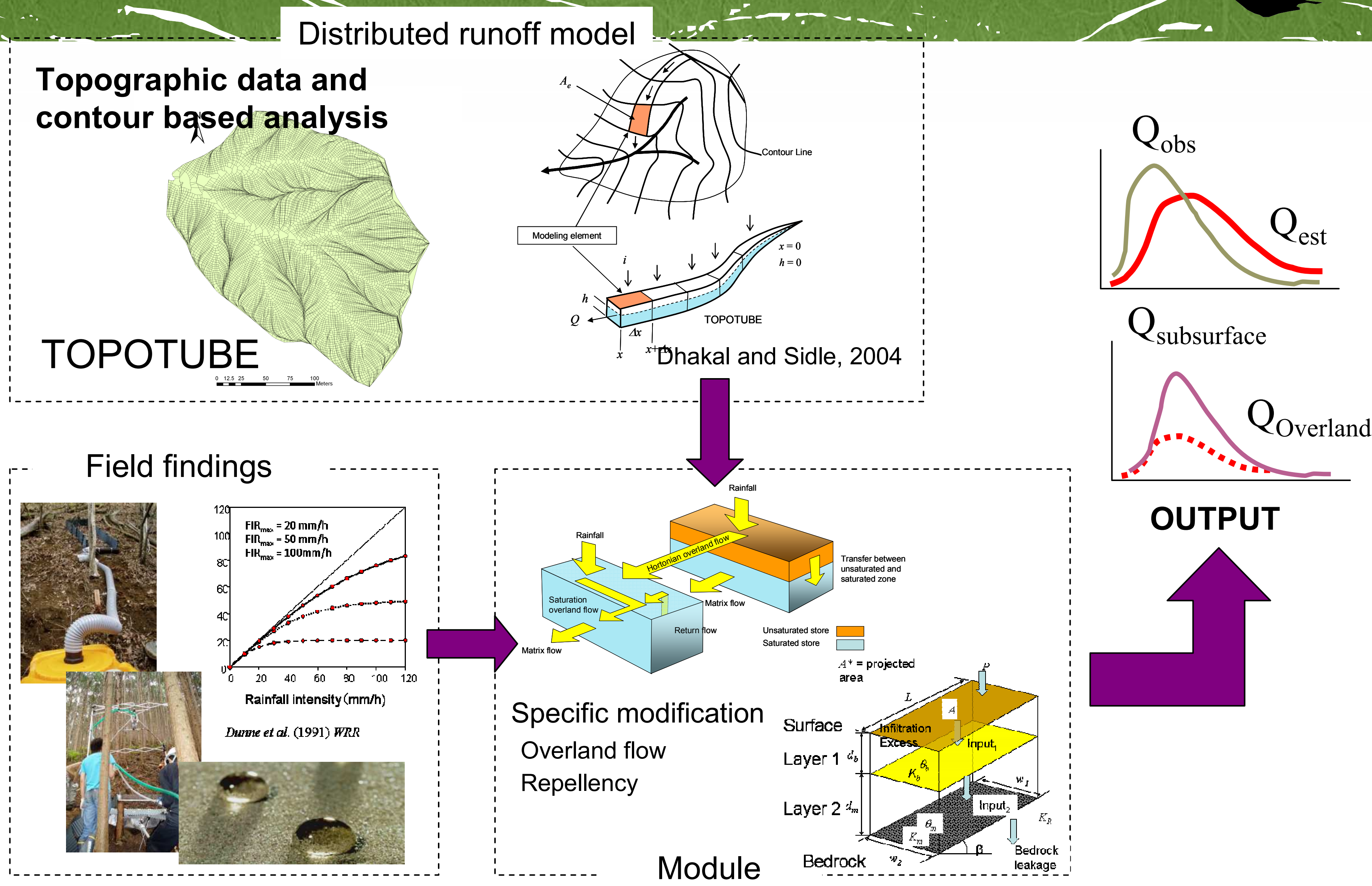
Conceptual Framework for Overland Flow Generation and Infiltration





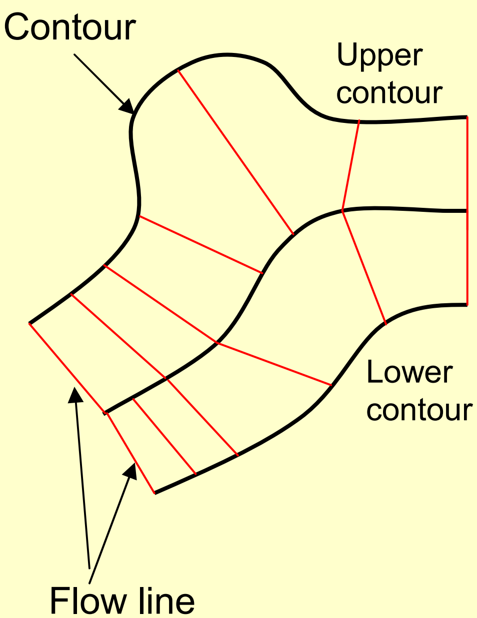
In sparse understory vegetation, overland flow is continuously flown on the hillslope.

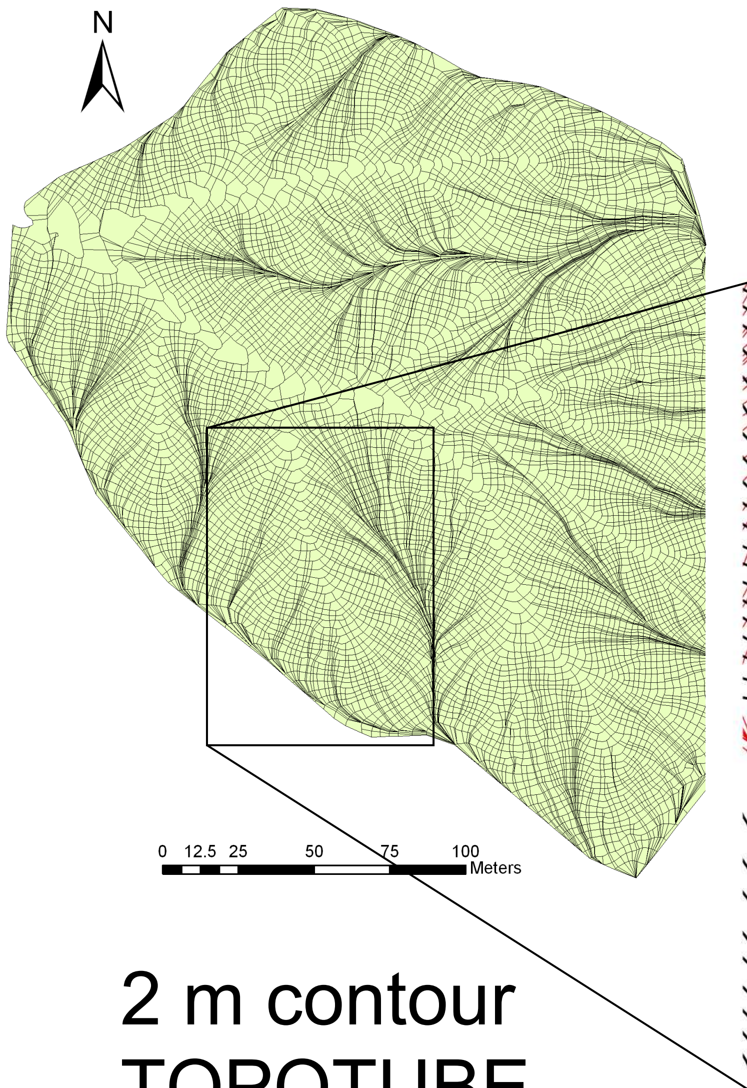
Distributed Runoff Model



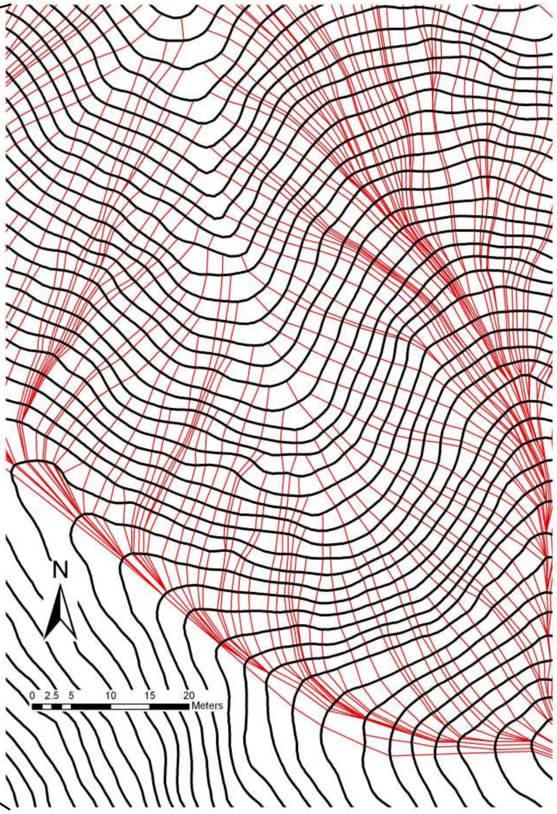
Topographic Analysis of the Model (TOPOTUBE; or TAPES-C)

A set of elements formed by contours and flow lines



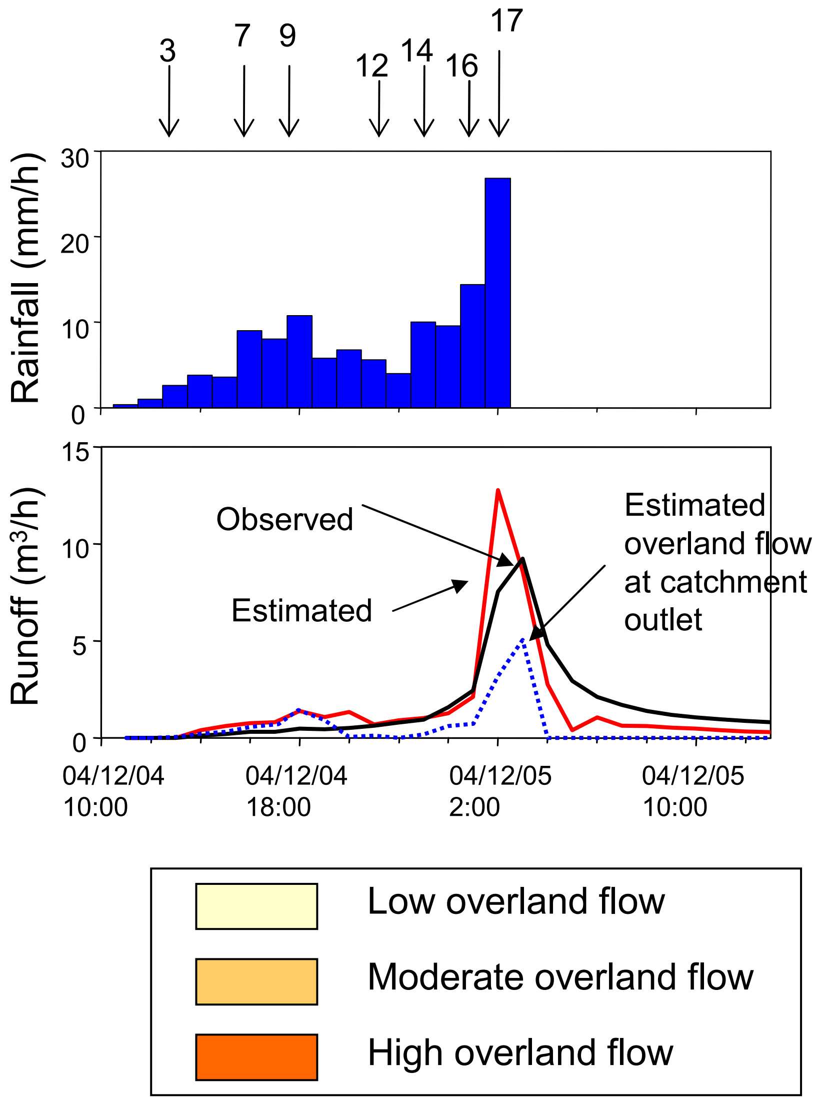


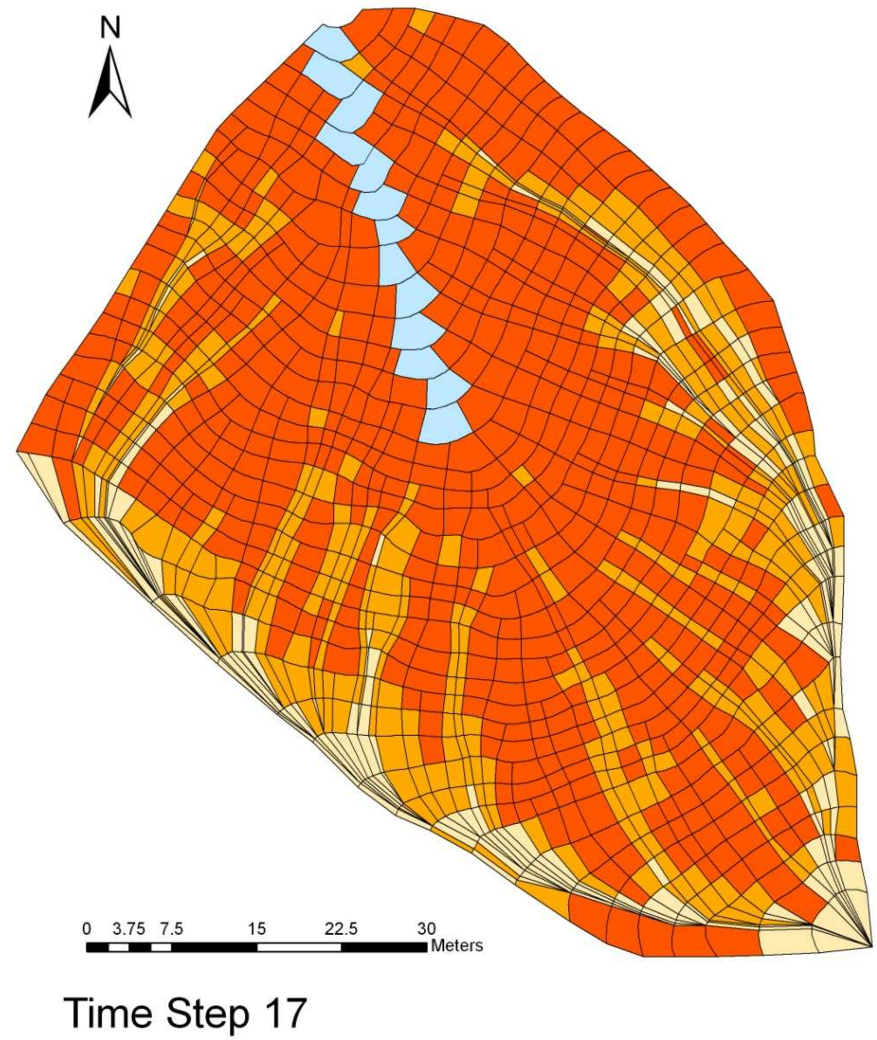
2 m contour TOPOTUBE



0.3 ha catchment

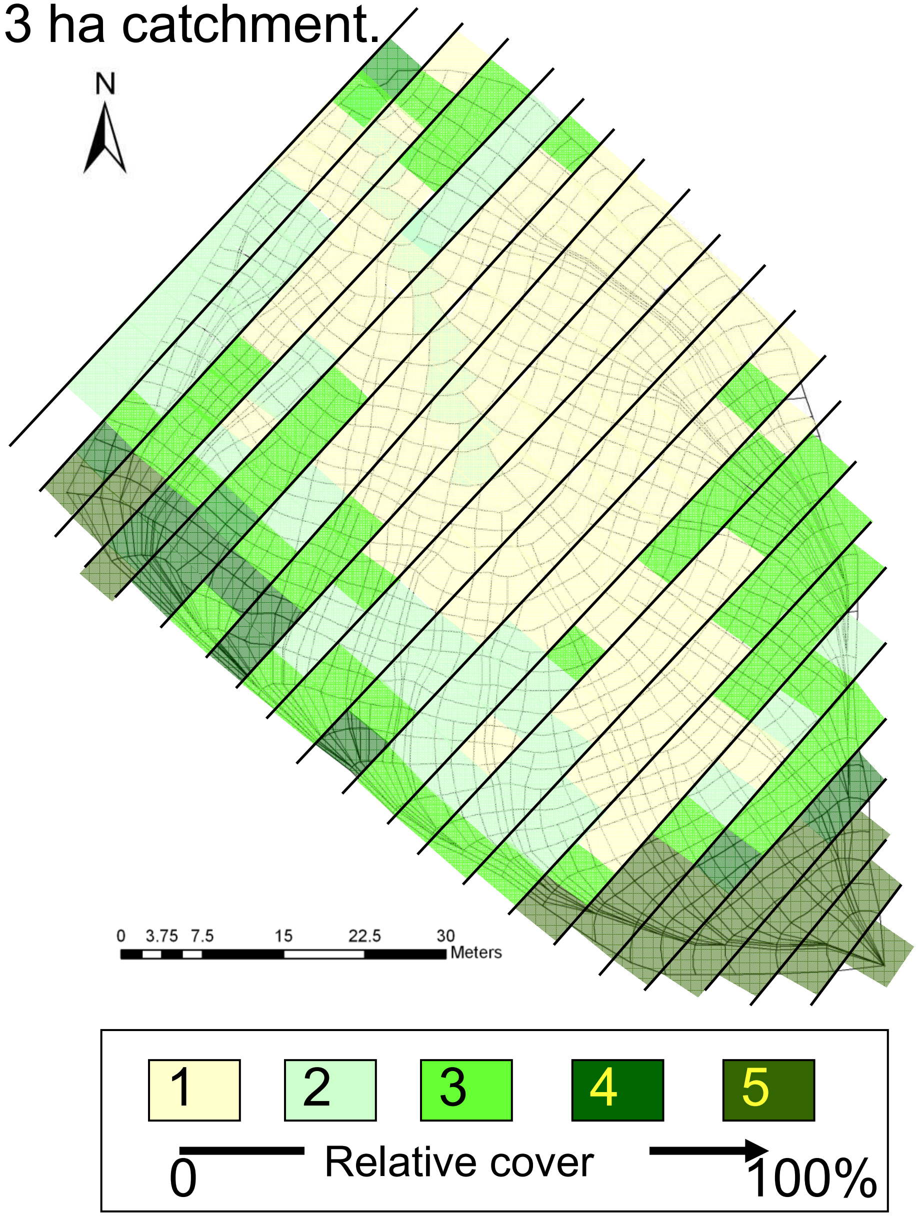
Runoff at catchment outlet and distribution of overland flow



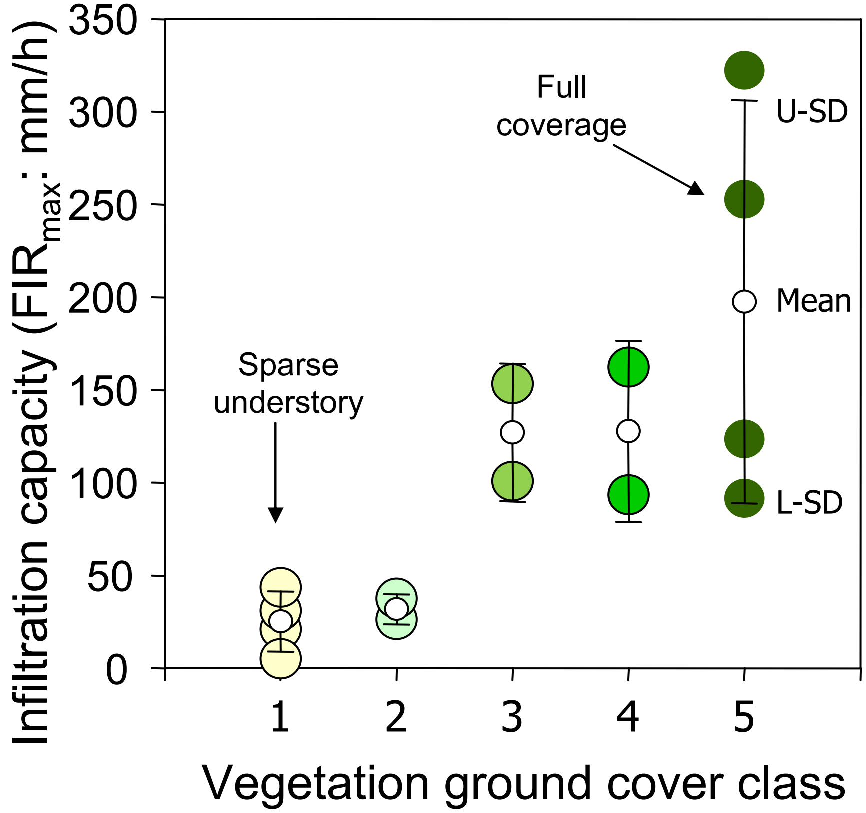


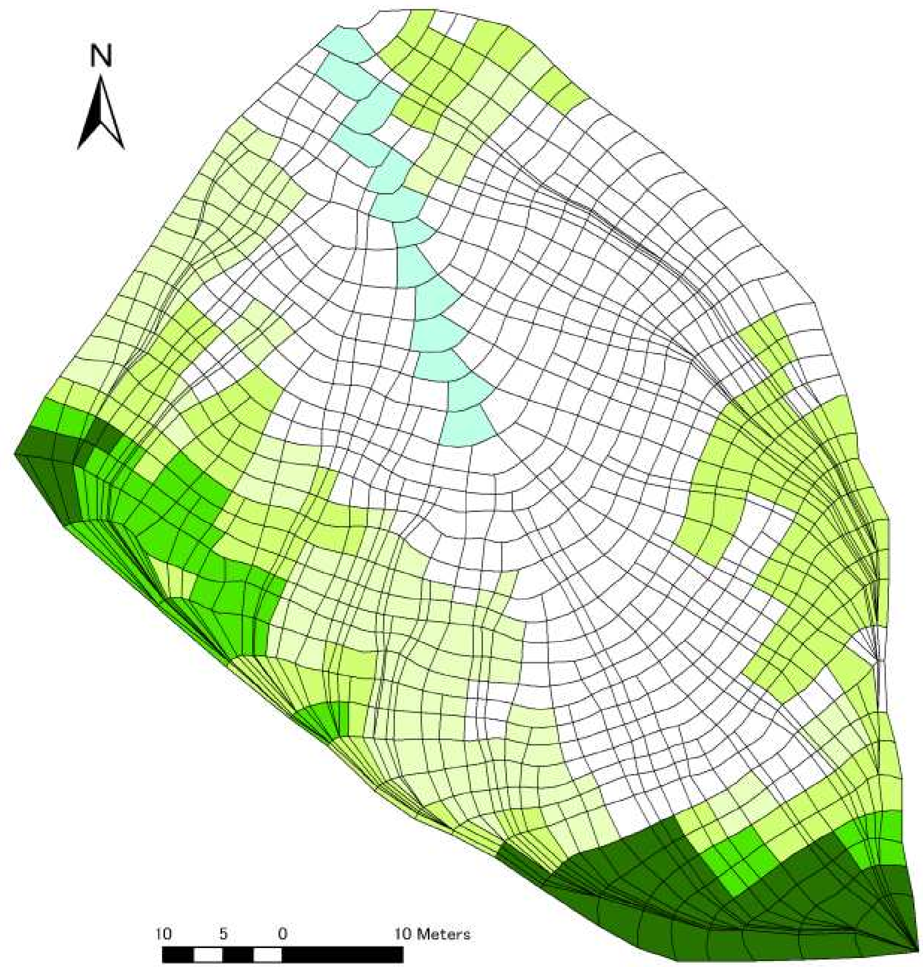
Distribution of soil ground cover

Soil ground cover was estimated based on 5 x 5 m grid of 0.3 ha catchment.



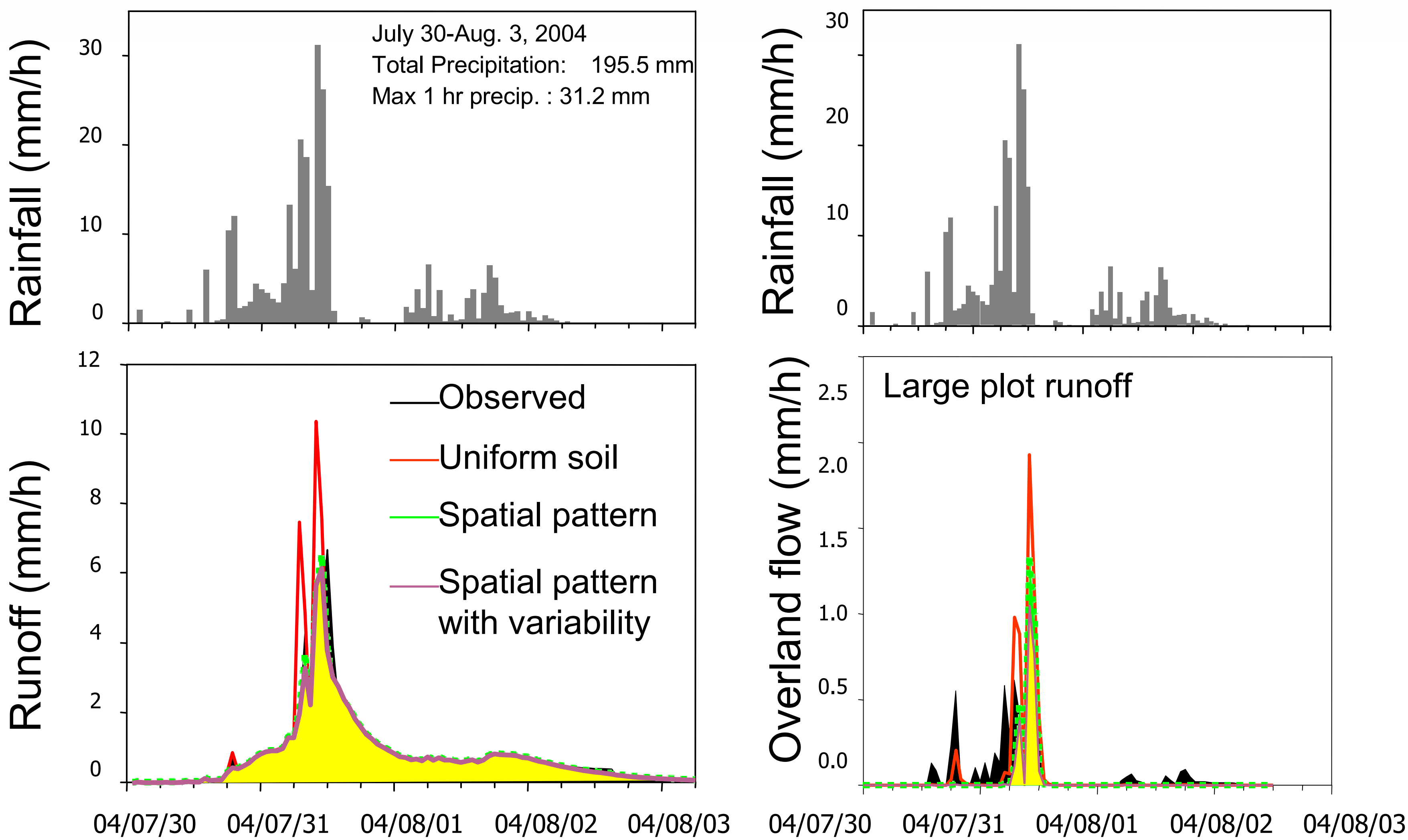
Distribution of estimated infiltration





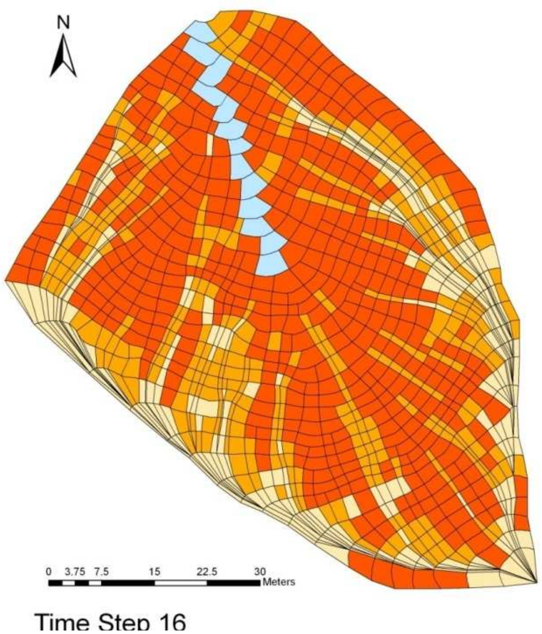
1. Uniform infiltration
2. Spatial patterns of infiltration
3. Further spatial variability of infiltration class (based on Standard Deviation)

Catchment runoff and overland flow

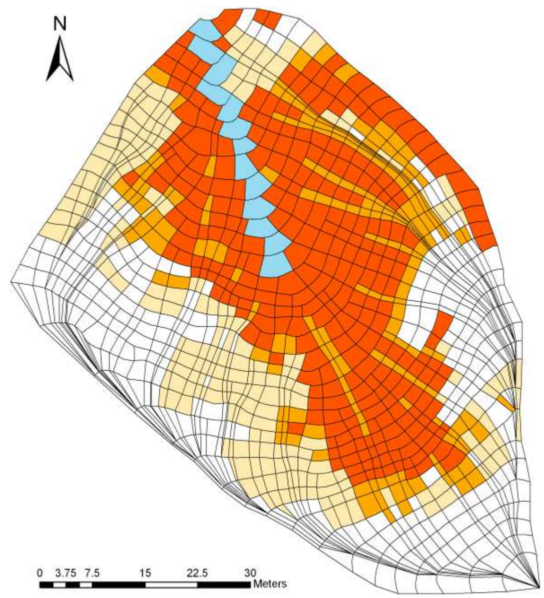


Scenario of spatial variability

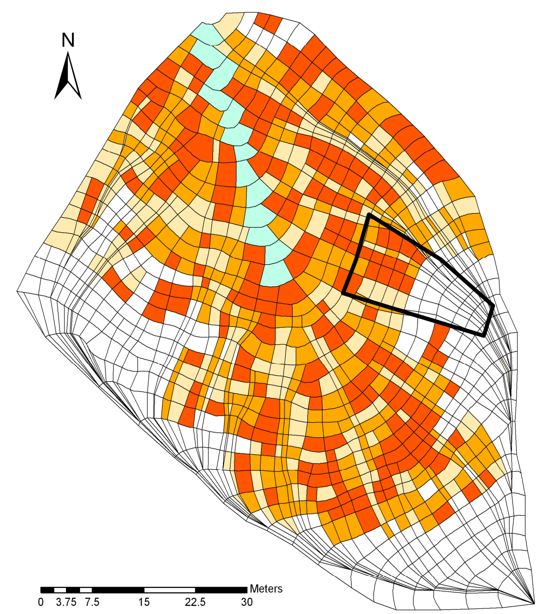
Uniform infiltration



Spatial pattern of infiltration



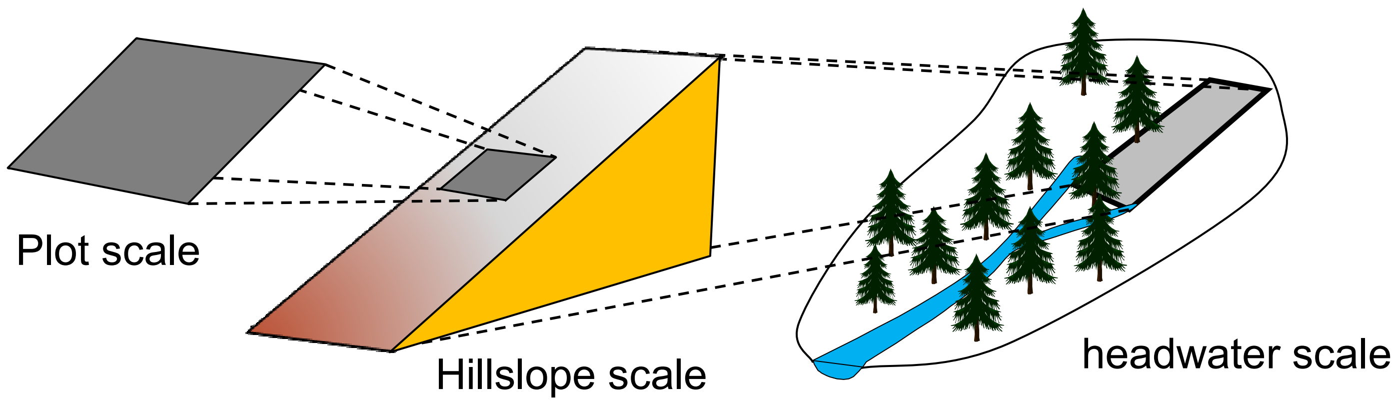
Spatial pattern of infiltration with variability



Increase in spatial variability

Summary and conclusion

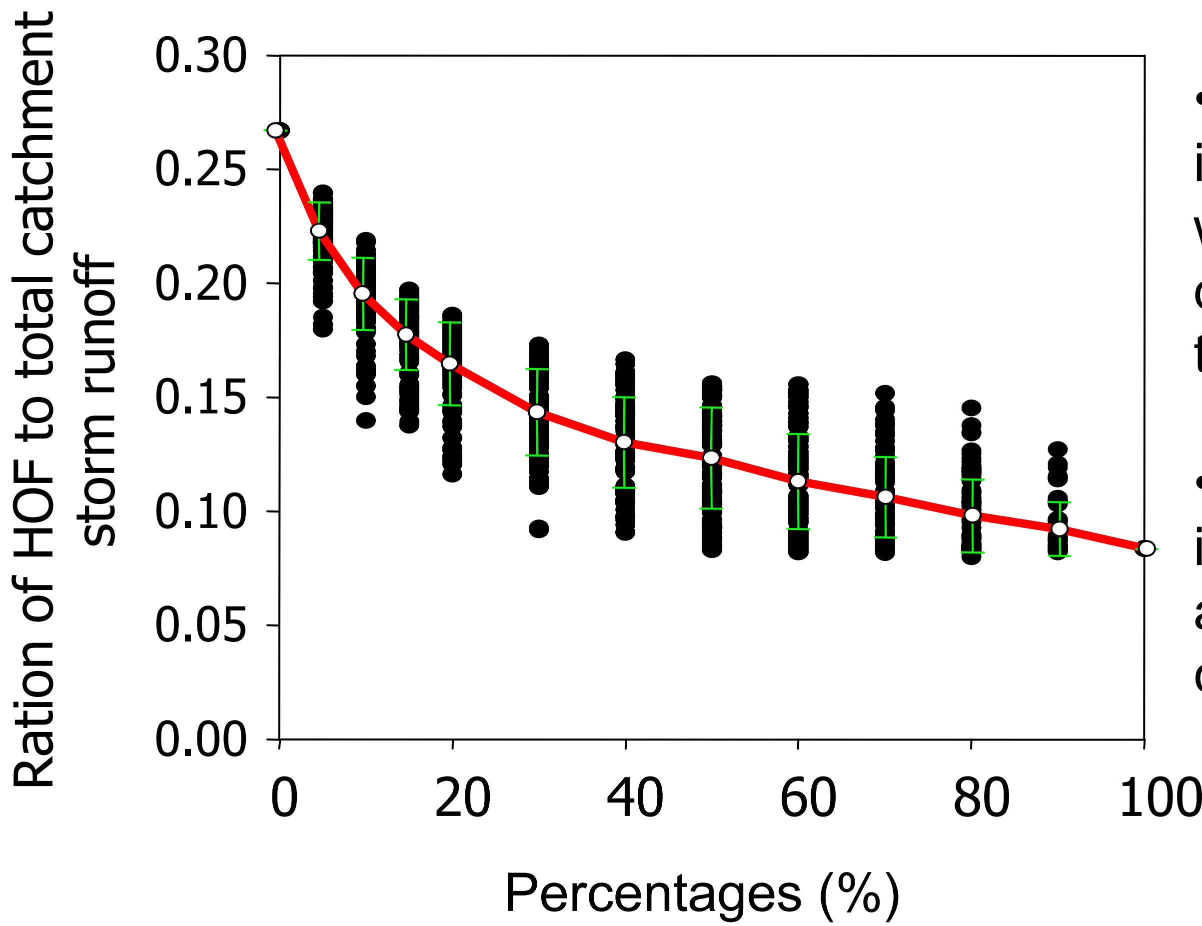
- Because of the scaling effects, transfer of overland flow on hillslope scale depending on the vegetation ground cover.



- If we include the spatial variability of infiltration capacity associated with soil groundcover, model provided appropriate patterns of overland flow in headwater scales.
- Contribution of overland flow at the catchment scale can be validated using geochemical and isotopic hydrograph separations (Gomi et al., 2009 *HP in press*)

Percentages of high infiltration and HOF generation

Simulating 100 patterns of randomness with specific percentages of high infiltration



- Increases in high infiltration (associated with vegetation cover) decreases in HOF transfer to catchment.
- Availability of high infiltration significantly affect up to 40% of catchment