Modelling the impact of land use change on the water balance in the Xiangxi Catchment (Three Gorges Region, China) using SWAT

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YANGTZE PROJECT

Department of Hydrology and Water Resources Management

Federal Ministry of Education and Research

Outline

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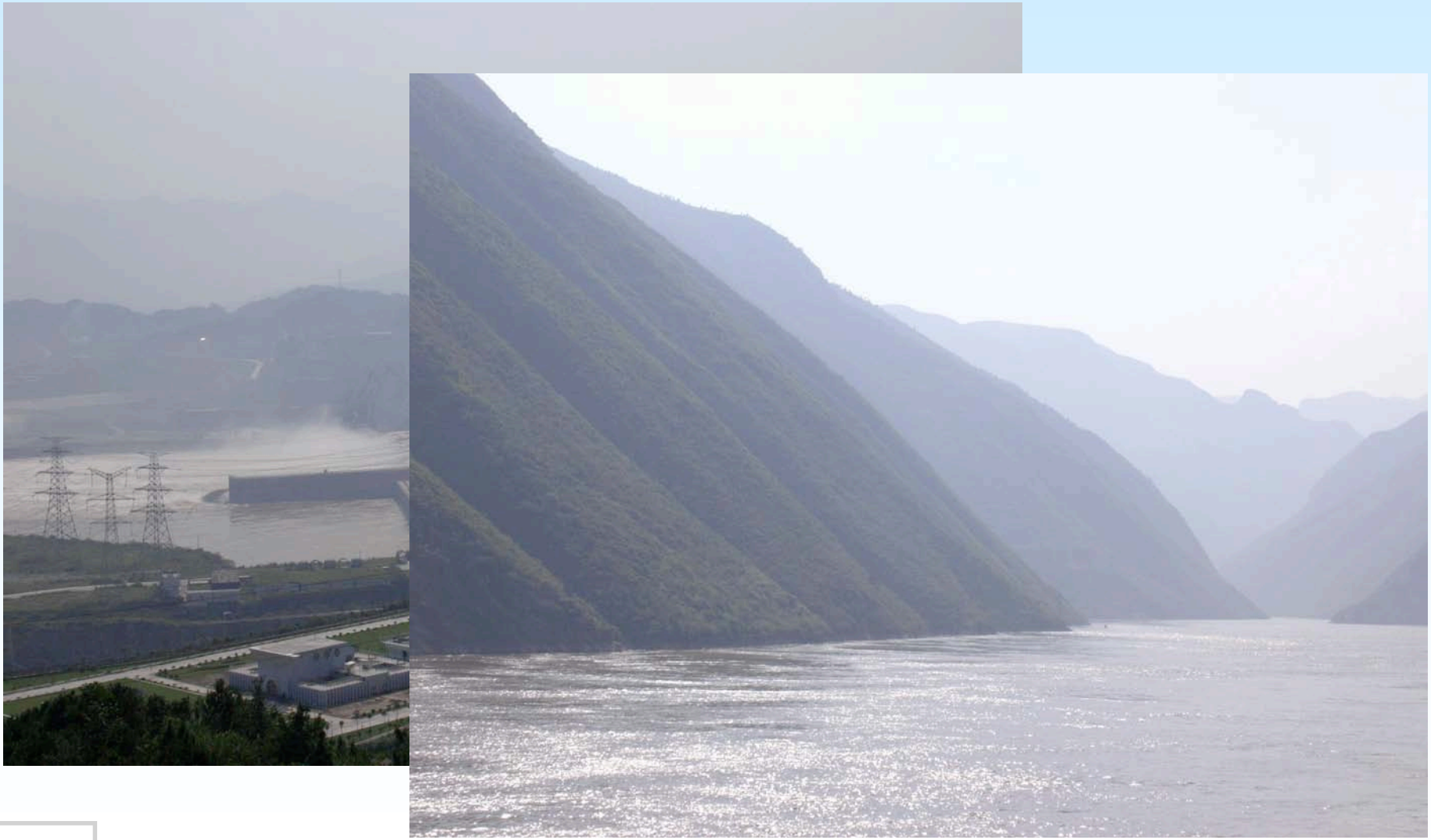
1. Introduction

Three Gorges Dam



Land use change

- Uphill shift of agricultural areas
- Resettlement
- Construction of infrastructure

Impact on water balance and quality

- Alteration of runoff and evaporation processes
- Risk of increasing diffuse inputs to rivers because of increase in erosion and landslides
- Higher potential of eutrophication due to limited exchange of water in Three Gorges Reservoir


Picture: X. Jiang 2007


Picture: X. Jiang 2007

2010

2. YANGTZE-Project

Federal Ministry of Education and Research

Project collaboration

YANGTZE PROJECT

YANGTZE-Project: land use change, erosion, mass movement, diffuse inputs

Coordination: Research Centre Jülich

Remote Sensing Potsdam	Land use change Giessen	Erosion Tübingen	Landslides Erlangen	Diffuse sediment and P inputs Kiel
Assessment of mass move-ments using remote sensing techniques	Classification of land use and assessment of vulnerability	Assessment and analysis of soil erosion	Assessment and analysis of landslides	Analysis of sediment and phosphorus inputs to rivers using SWAT

Aim:
Analysis of land use change and vulnerability, risk assessment of mass movements, soil erosion and diffuse inputs to rivers

Objectives

- Assessment of the impact of land use change on water quantity and quality in the Xiangxi Catchment
  - How has the changing land use in the last 20 years influenced the water balance and diffuse inputs?
  - How will possible future land use patterns affect these factors?

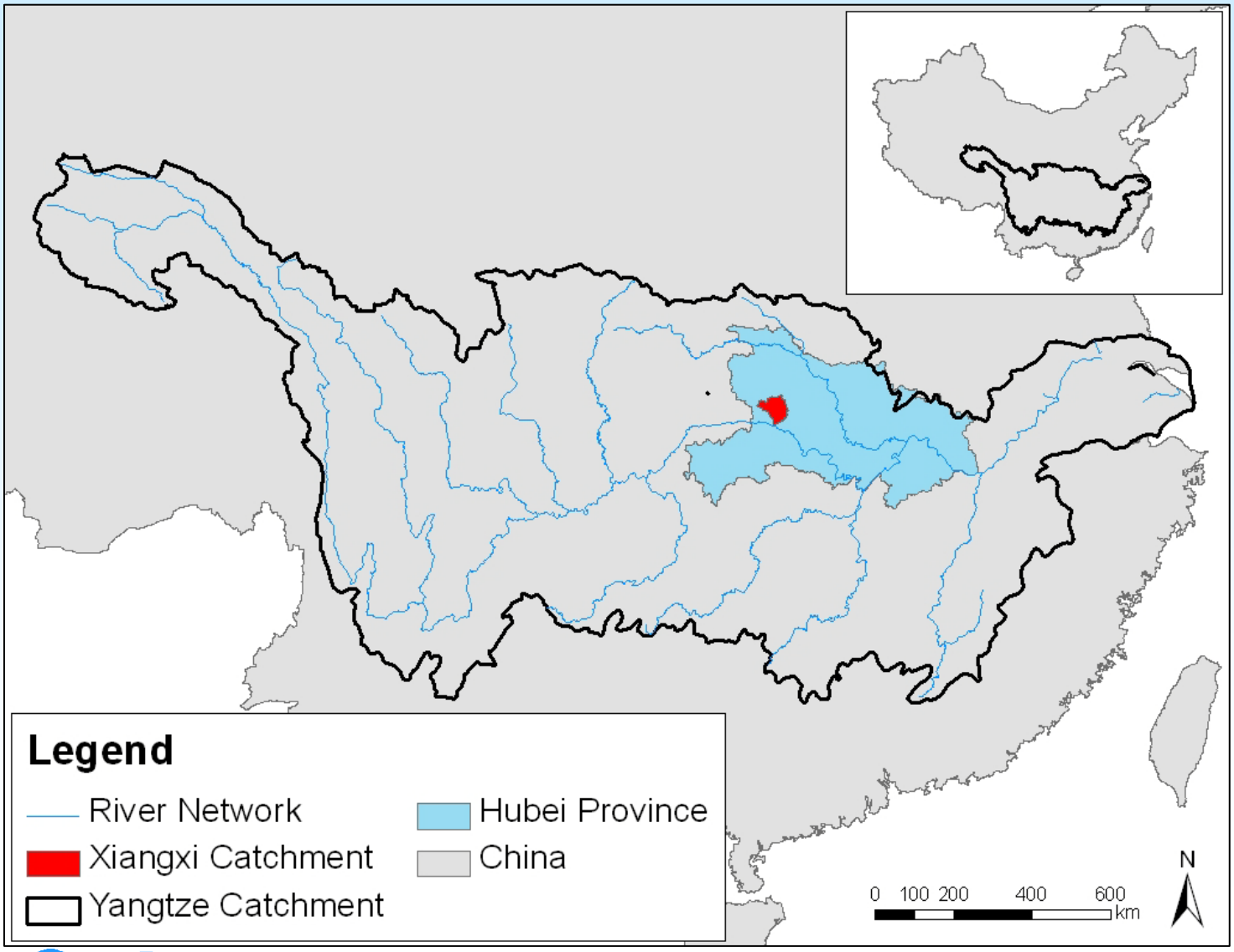
- Development of sustainable land use options for the Three Gorges Region

Methods

- SWAT2009
- Water balance, sediment, phosphorus
- Past and present land use (1987-2007)
- Land use scenarios
- Study area: Xiangxi Catchment
  - Example for a catchment impacted by a large dam project
  - Methods and results to be transferable to similar regions

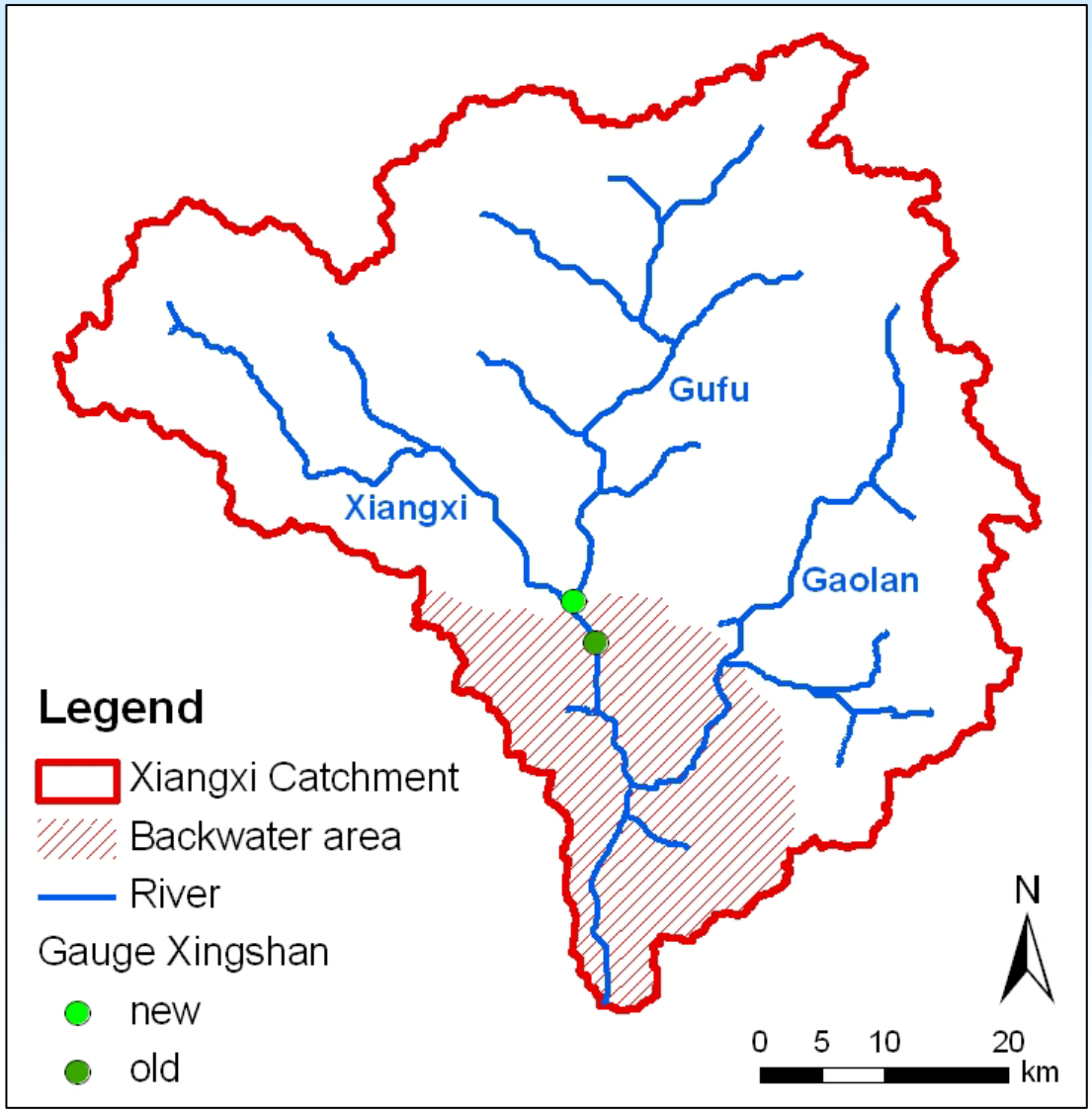
3. Study area

Location of study area



Xiangxi River

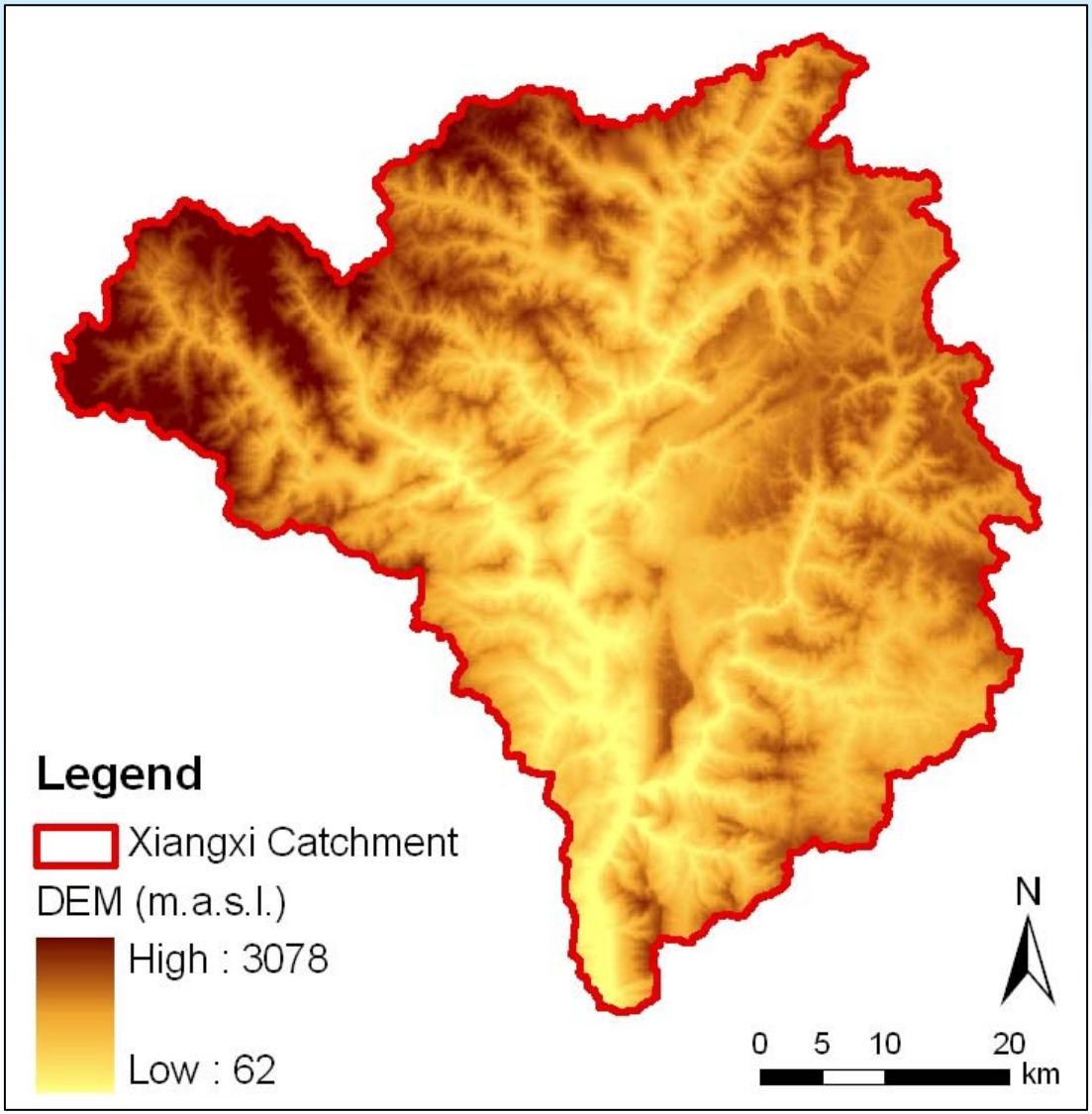
- Length of river:
  94 km
- Catchment area:
  3099 km^2
- Mean annual discharge
  (Gauge Xingshan):
  65.5 m^3/s
- Mean annual temperature/
  precipitation:
  16.9 ° C/1000 mm
- Xiangxi Bay:
  Influence of Three Gorges
  Reservoir impoundment



4. SWAT model application

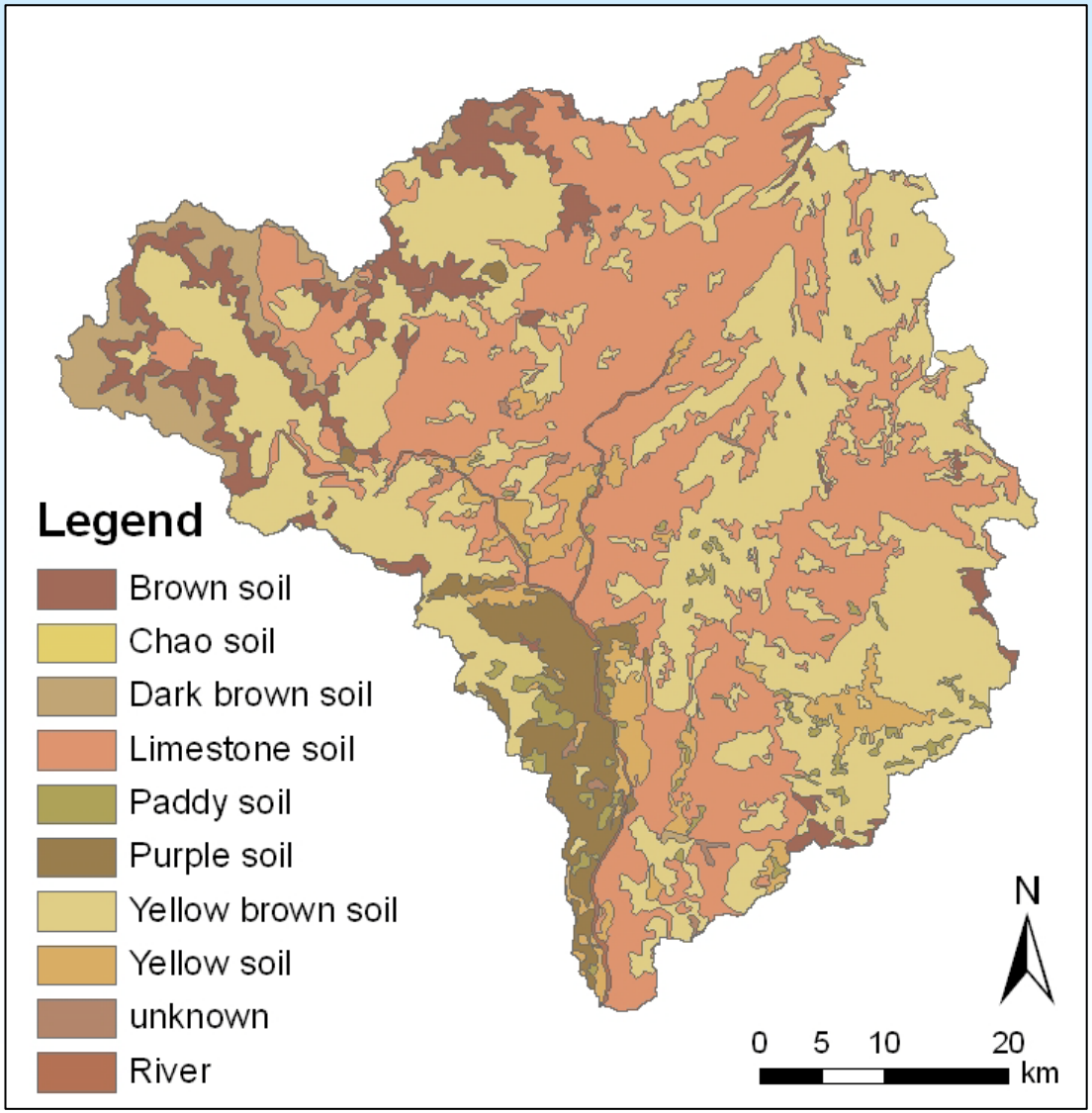
Spatial input data I: DEM

- SRTM 3, Version 4 (CGIAR-CSI): resolution 90 m, resampled to 45 m
- Large differences in elevation (>3000 m)
- Steep slopes
  - Mean 24° (46%)
  - Maximum 76° (414%)

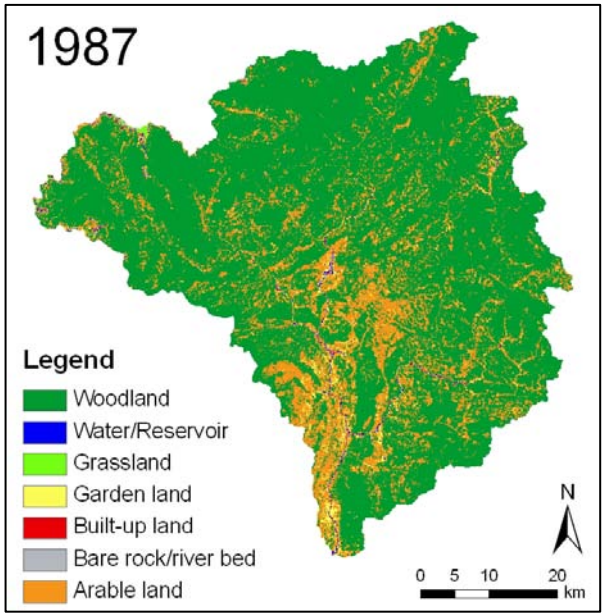


Spatial input data II: soil map

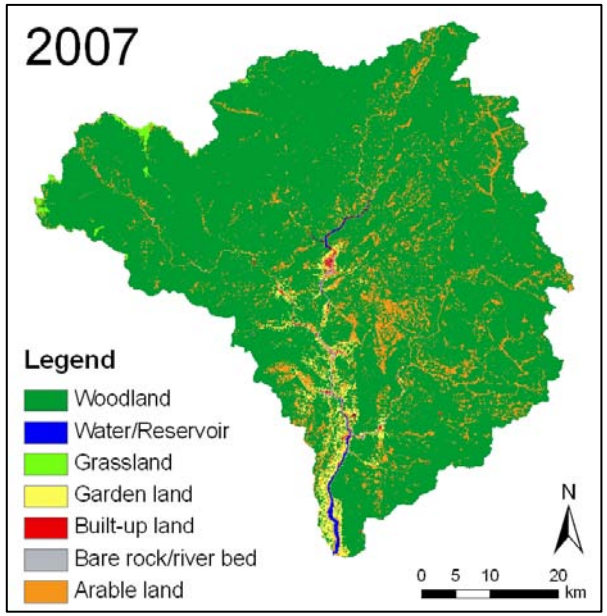
- Digitized from analogue soil maps of the counties Shennongjia, Xingshan and Zigui (1:160000 and 1:180000) (Schönbrodt & Scholten 2009)
- Dominating soils: Limestone soil and Yellow brown soil
- Attributes taken from Chinese Soil Database (www.soil.csdb.cn)



Spatial input data III: land use maps



Land use class	Change (km^2)	Change (%)
Woodland	+99.0	+3.68
Arable land	-119.0	-28.07
Orchard	+15.6	+27.86
Grassland	-7.0	-36.84
Built-up area	+0.3	+4.30
Bare rock	+3.3	+33.00
Reservoir	+9.4	---



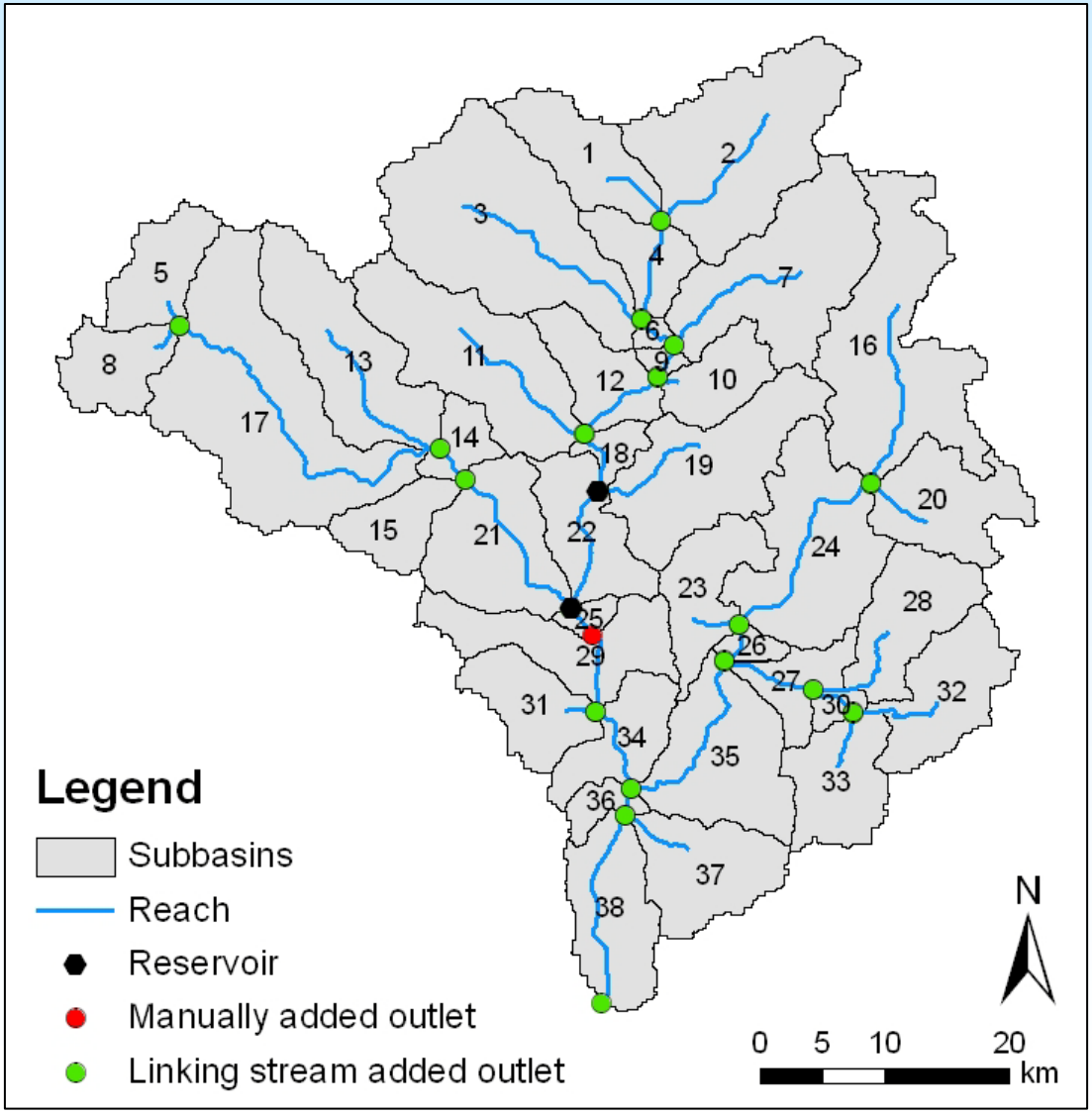
Major changes especially close to Xiangxi Bay, rivers and roads!

- Land use maps for 1987 and 2007 classified from Landsat-TM images (Seeber et al. 2010)

Classification of further scenes planned

Model setup I: watershed delineation

- Threshold: 4500 ha
  ⟶ 37 subbasins
- 1 subbasin outlet added manually at Gauge Xingshan
  ⟶ 38 subbasins
- 1 point source added to each subbasin
- Reservoirs in subbasins 18 and 22



Model setup II: HRU definition

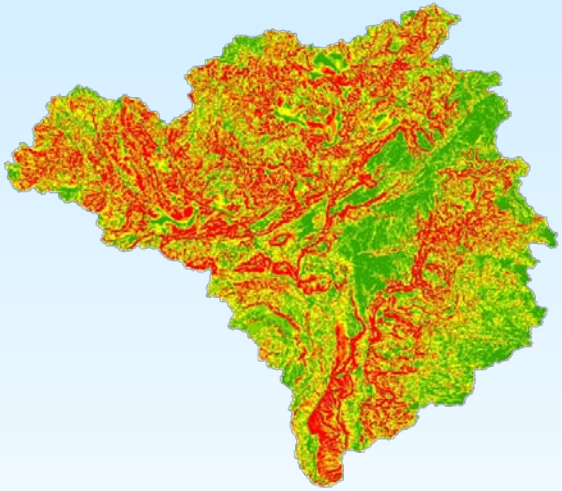
Soil
(Schönbrodt & Scholten 2009)

Threshold: 0%

Land use
(Seeber et al. 2010)

Threshold: 10%

Slope
(SRTM)

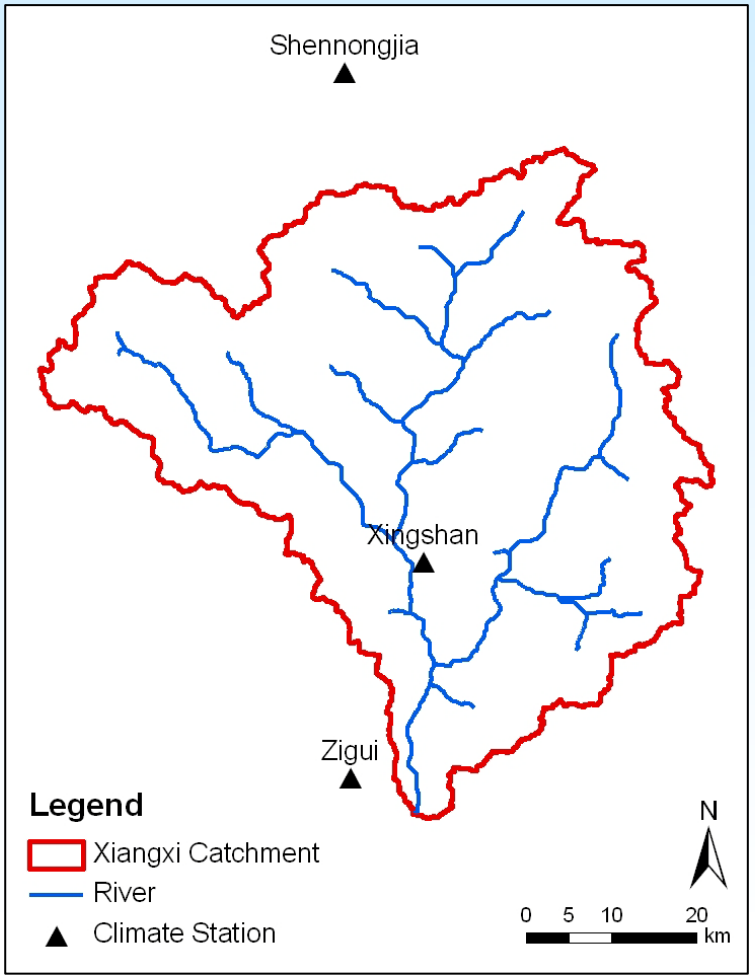


Threshold: 10%
5 slope classes:
26, 39, 50, 65, 9999

1597 Hydrologic Response Units

Model setup III: Climate data

- 3 climate stations: Xingshan, Zigui, Shennongjia
  - Precipitation
  - Temperature
  - Wind speed
  - Humidity
  - Solar radiation (calculated from sunshine duration)
- Weather generator: climate station Xingshan (1958-2007)



Model setup IV: Simulation

- Discharge data (Gauge Xingshan): 1970-2005
- Warm-up: 1980-1987
- Calibration: 1988-1996
- Validation: 1997-2005
- Model evaluation statistics:
  - NSE
  - R^2
  - PBIAS
  - RMSE

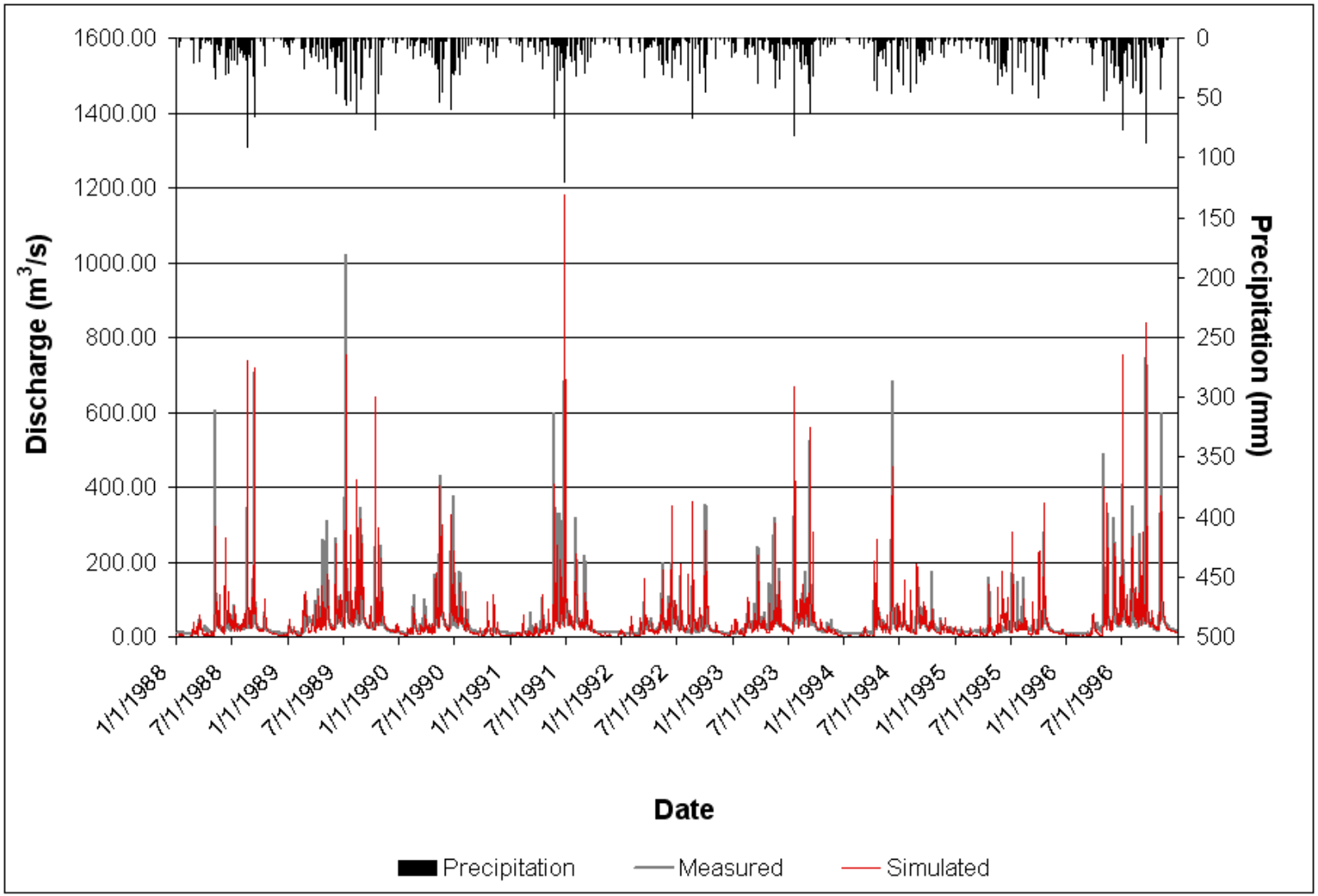
Uncalibrated simulation: discharge

NSE:
-0.25

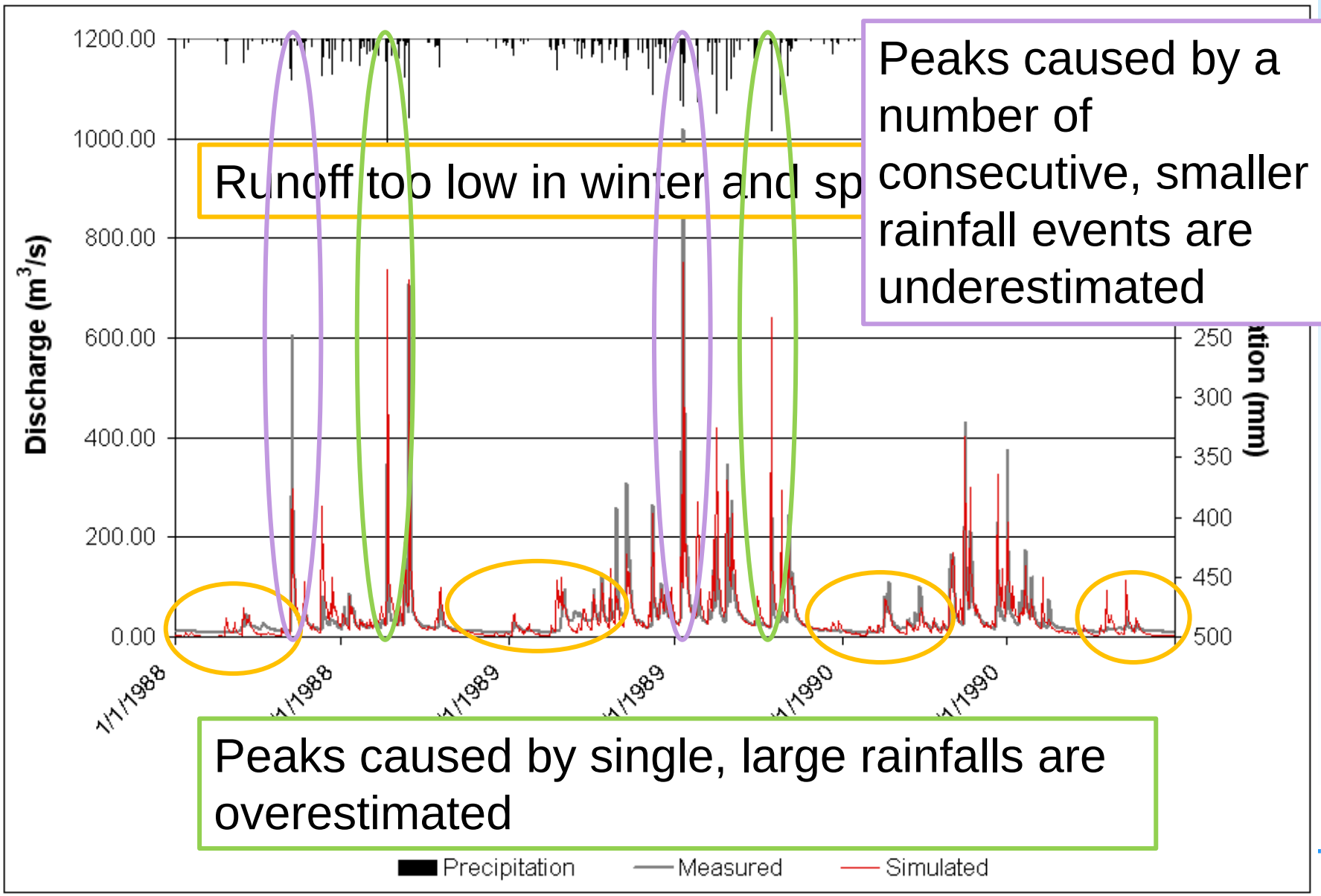
R^2:
0.62

PBIAS:
42.93

RMSE:
23.38



Analysis of weak points



Specific characteristics of the catchment

- Steep slopes
- Terraces
- Reservoirs
- Hydropower stations

5. Outlook

Outlook

- Sediment and phosphorus

  ⟶ sediment dredging, phosphorus company


Thanks for your interest
and attention!
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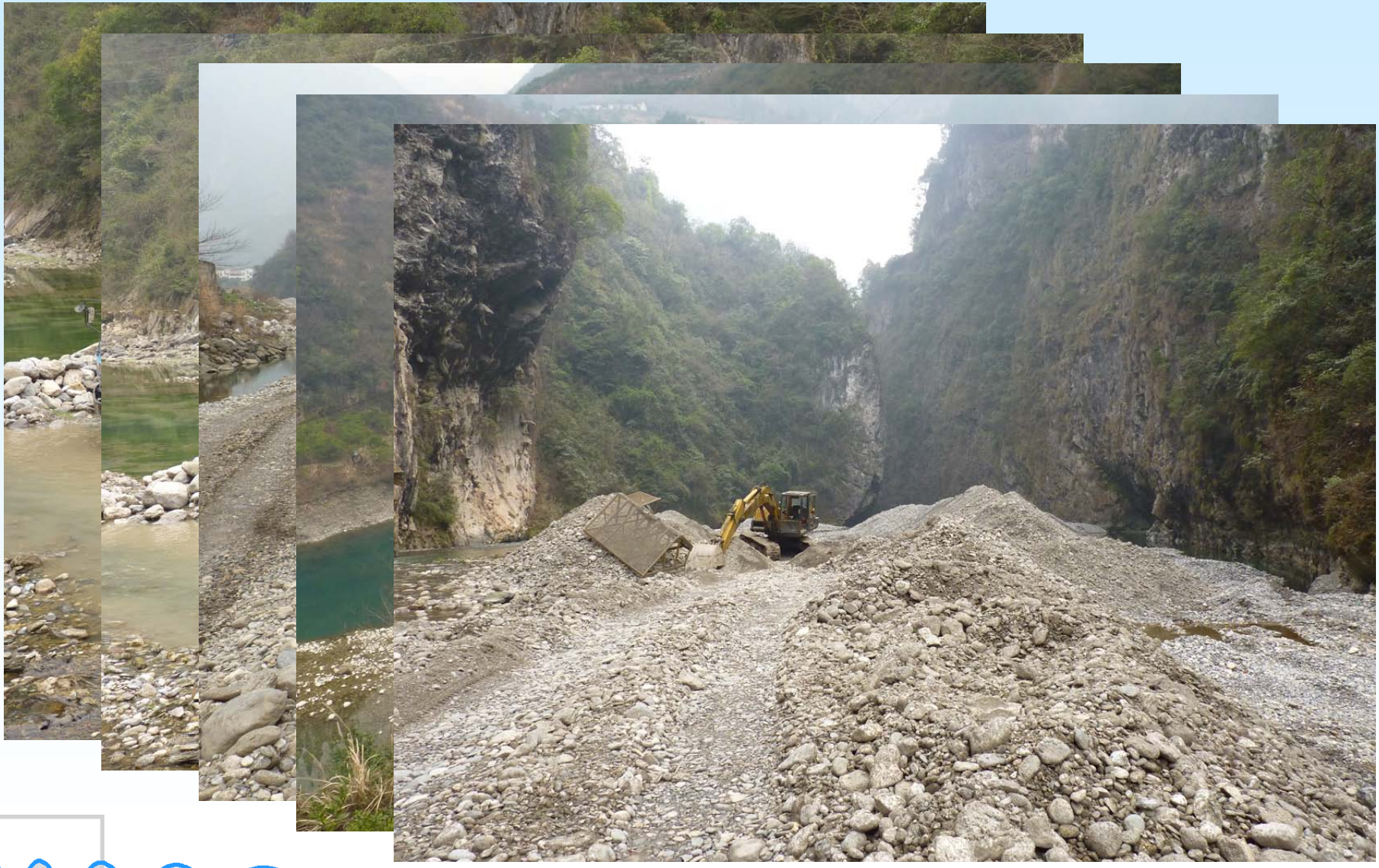
Hydropower stations

Sediment dredging



Sediment transport