Potsdam Institute for Climate Impact Research

Hydrological modelling of the principle Tarim tributary, NW China

The influence of glacial lake outburst floods

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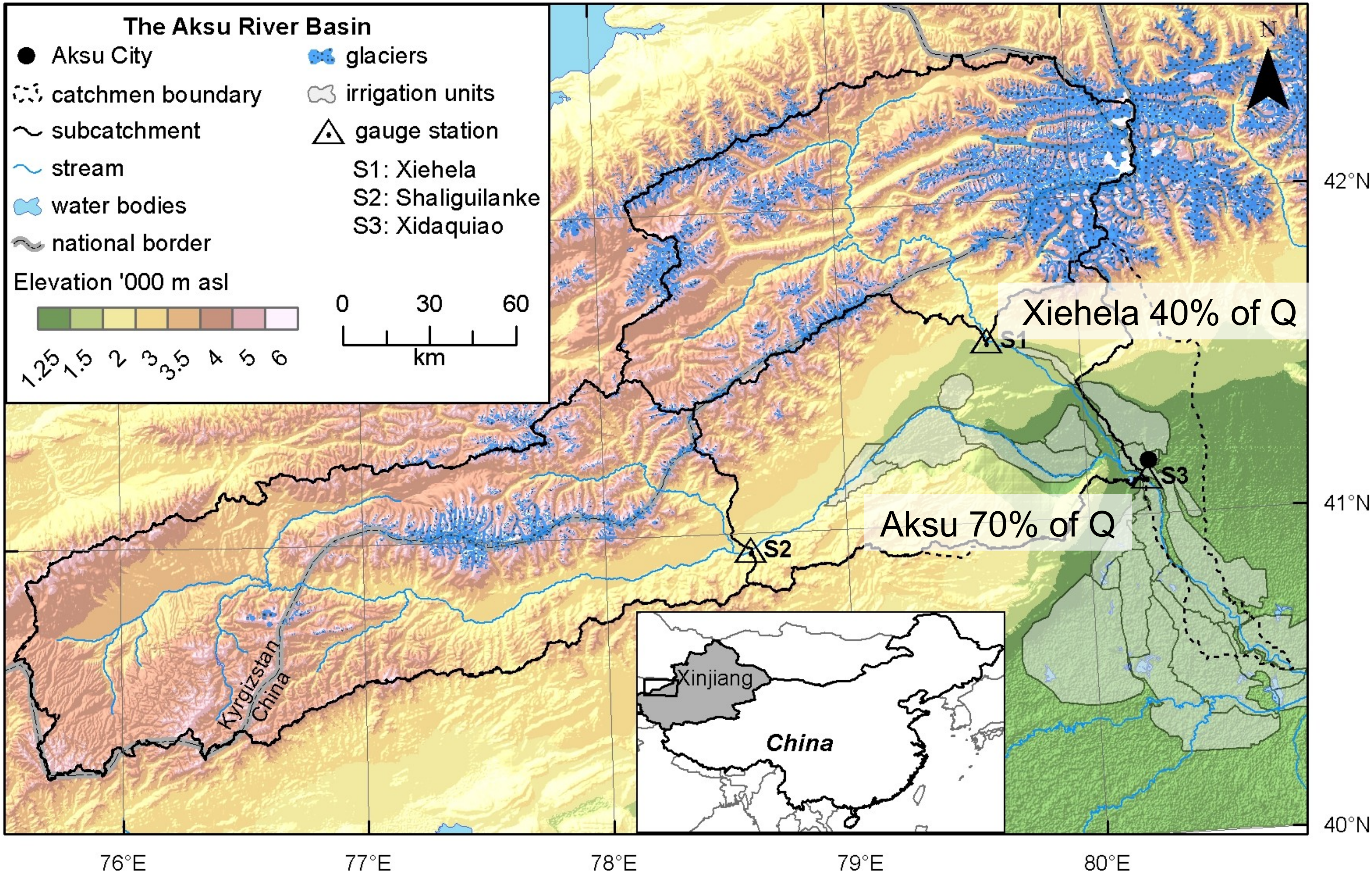
RD2 Climate Impacts & Vulnerability



The Aksu River Basin
Aksu City
catchmen boundary
subcatchment
stream
water bodies
national border
glaciers
irrigation units
gauge station
S1: Xiehela
S2: Shaliguilanke
S3: Xidaquiao
Elevation '000 m asl
1.25
1.5
2
3
3.5
4
5
6
0
30
60
km
N
Xiehela 40% of Q
Aksu 70% of Q
S1
S2
S3
Kyrgizstan
China
Xinjiang
China
42°N
41°N
40°N
76°E
77°E
78°E
79°E
80°E

Climate change in the Aksu-Tarim Basin

- Severe water scarcity (50-300 mm of P p.a.)
- Glacier and snow melt generate discharge for downstream hyperarid desert environment
- Extensive irrigation agriculture along the river courses (river oases)
- While discharge has been increasing, so has the area under irrigation
- What are the changes under a warmer climate?

(Wang et al., 2008; Tao et al., 2009; Thevs, 2011)

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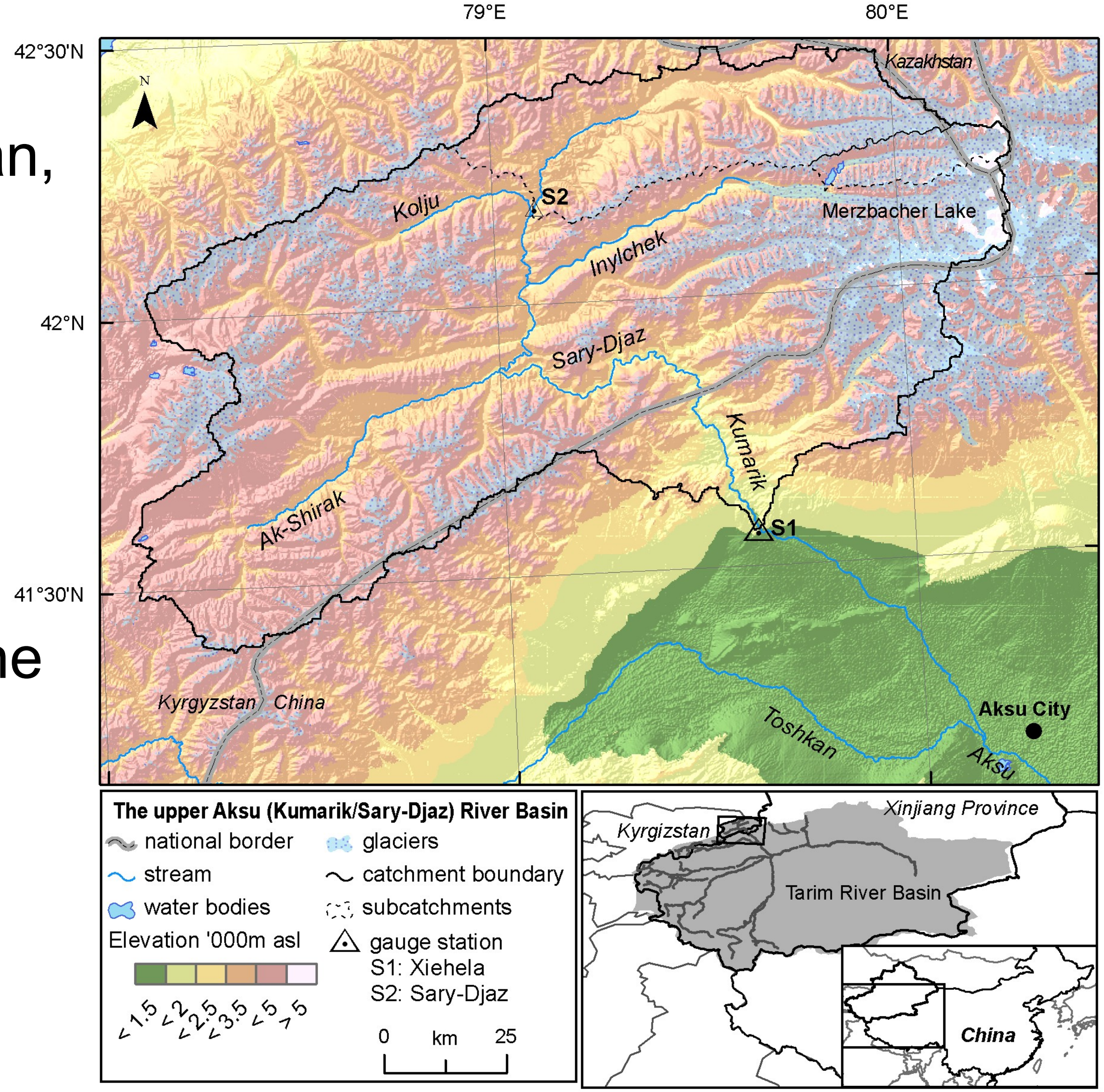
The upper Aksu/Kumarik catchment

- Source in Kyrgyzstan, flowing into China
- 1400 – 7400 m asl
- 30% glacier cover
- 200 – 300 mm of precipitation
- generates 40% of the Tarim R. discharge



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M.W. Aug 2012


M.W. Aug 2012


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Hydrologcial modelling of the Kumarik catchment

- Complex environment and extreme data scarcity
- Synthesis of various national and global datasets
- Implemented the Soil and Water Integrated Model (SWIM), based on SWAT
- Manual and automatic calibration using PEST

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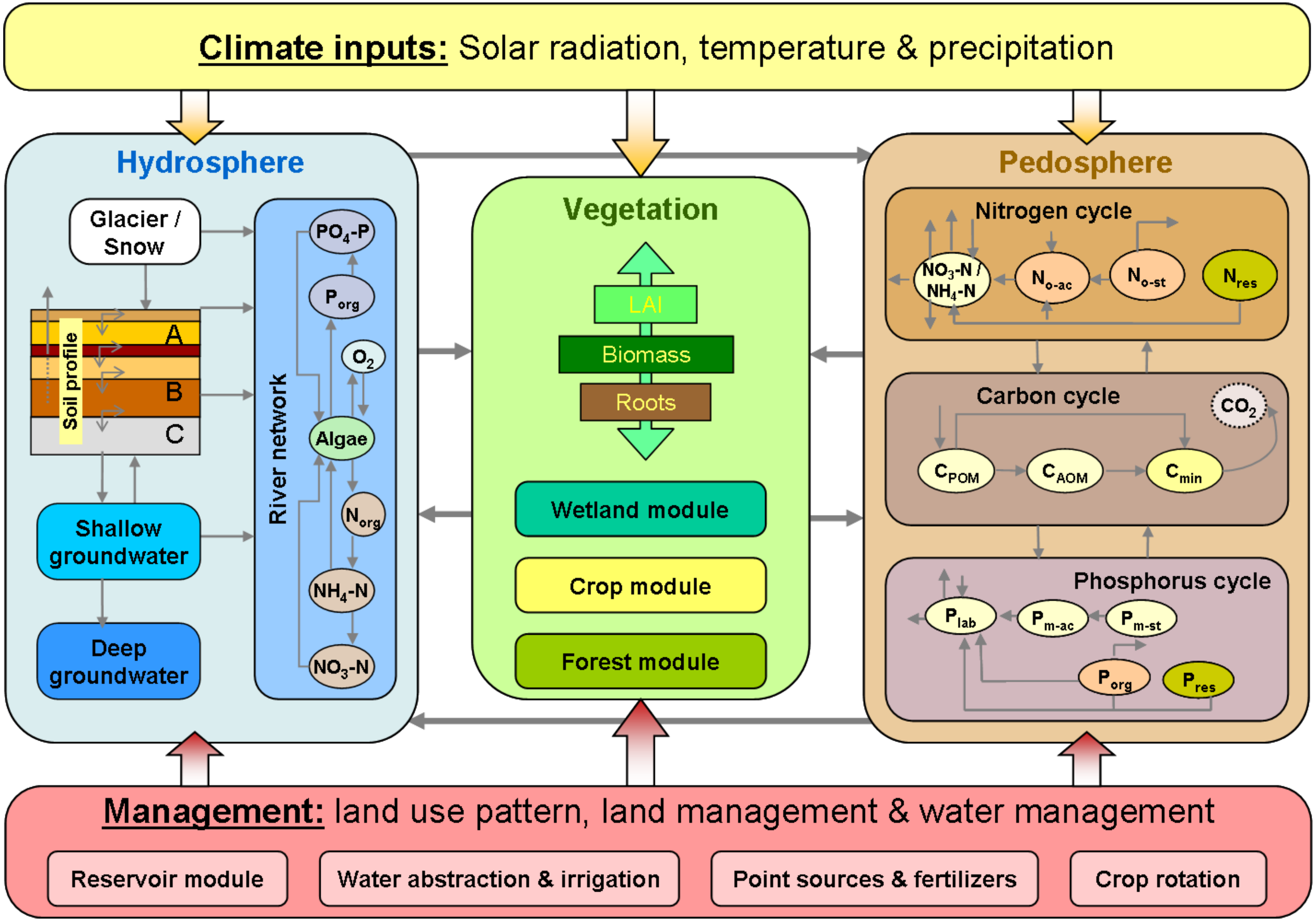

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Data sources

Spatial:

- Topography: SRTM 90 m digital elevation model (DEM)
- Land use: CMA land cover for China, MODIS land cover for Kyrgyzstan
- Soil map: Harmonised World Soil Database (HWSD) (Chinese part based on 1:10^6 soil map of China)

Glaciers: enhanced GLIMS (Bolch et al.)

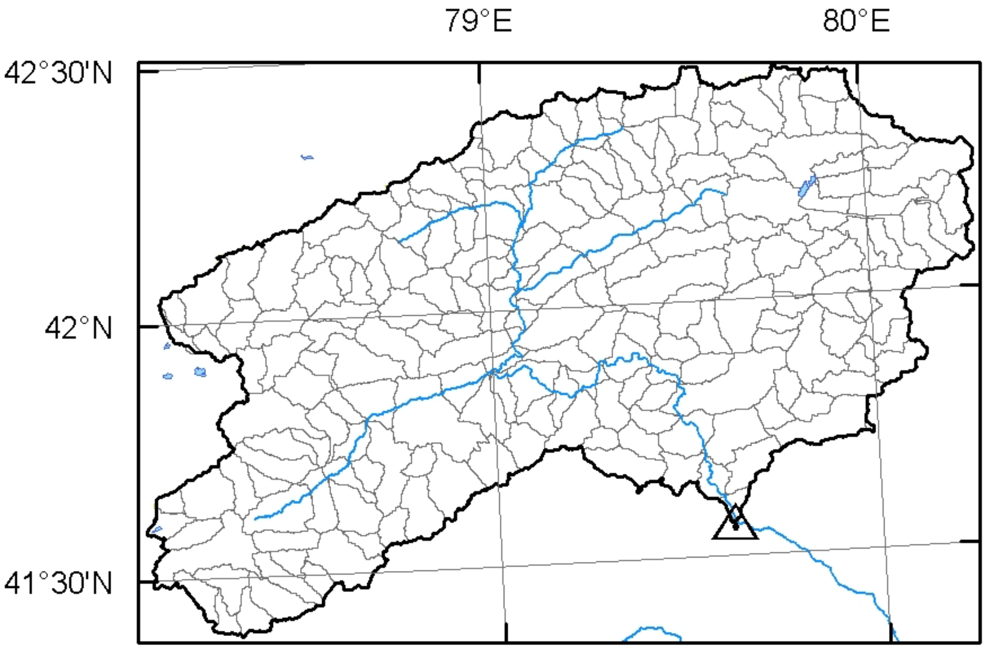
Climate:

- Precipitation and Temperature (max, min, mean) from the NCC at ¼ degree grid for China
- Precipitation, Temperature, Humidity and Solar radiation from WATCH at ½ d.

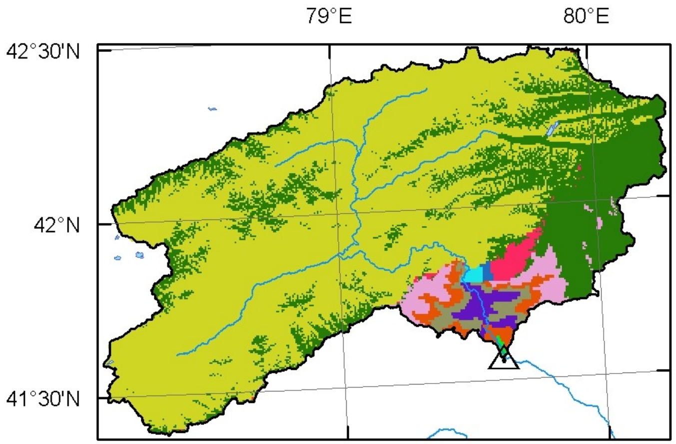
Validation: Daily discharge at the Xiehela outlet station and one Kyrgyz internal station for the period 1964 – 1987

Spatial structure

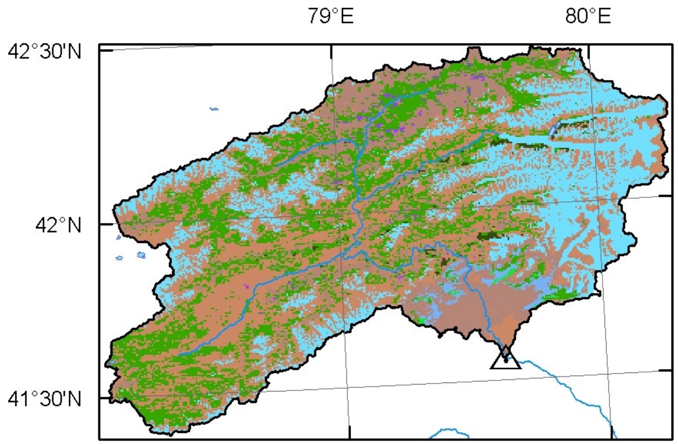
Subbasins



Soils

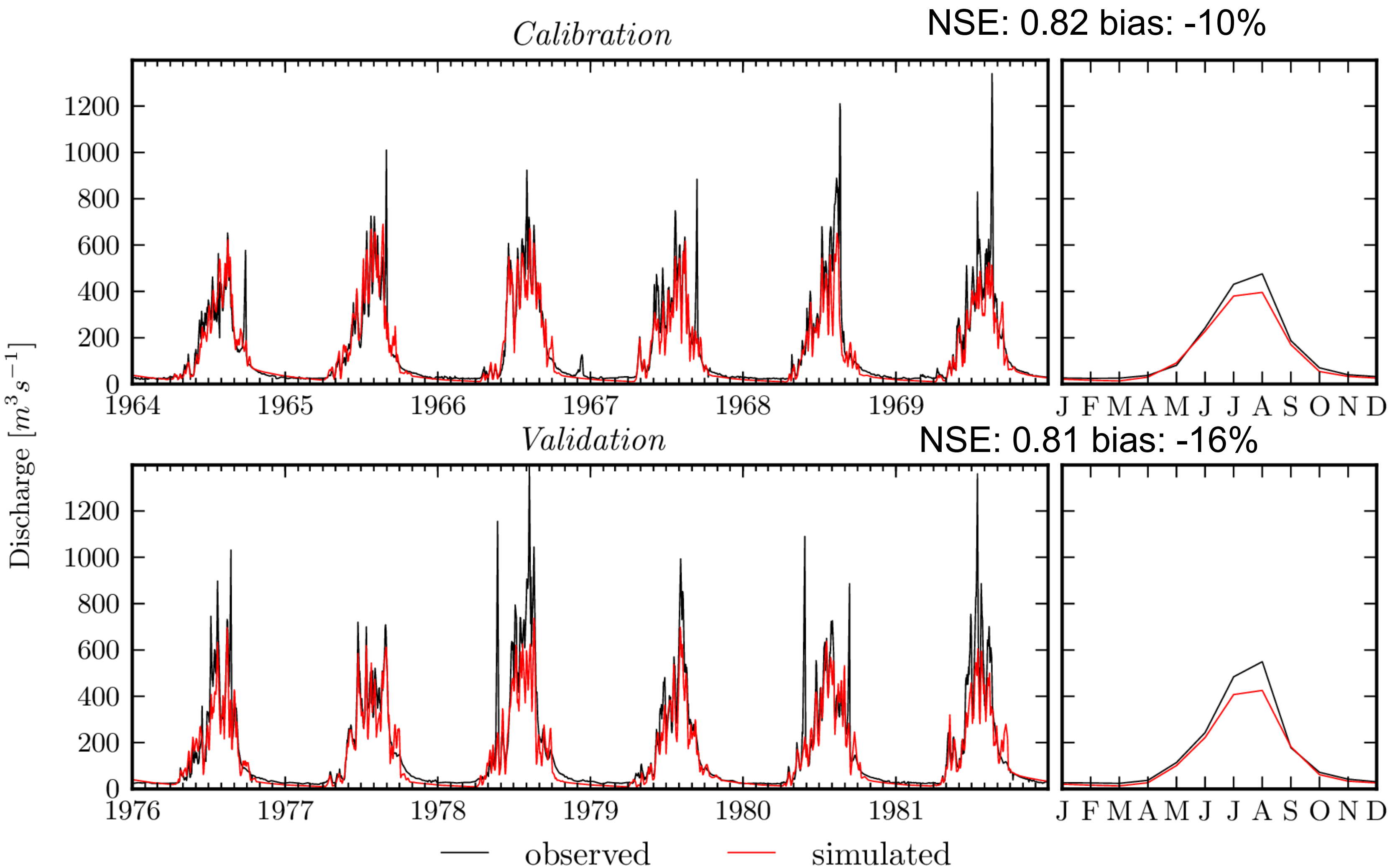


Landcover



➔ Unique combinations make up hydrotopes / HRUs

Simulated vs observed discharge at Xiehela



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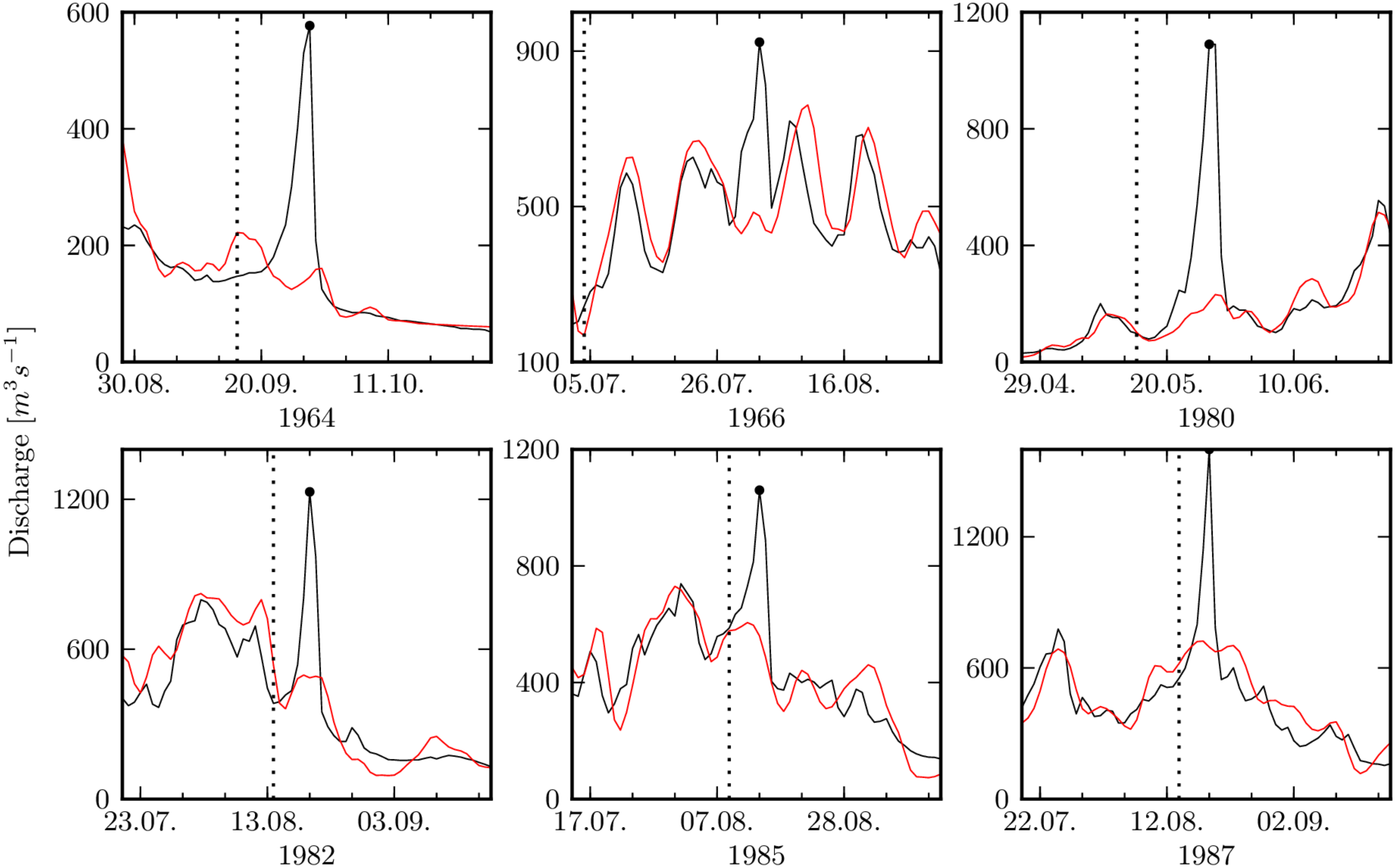
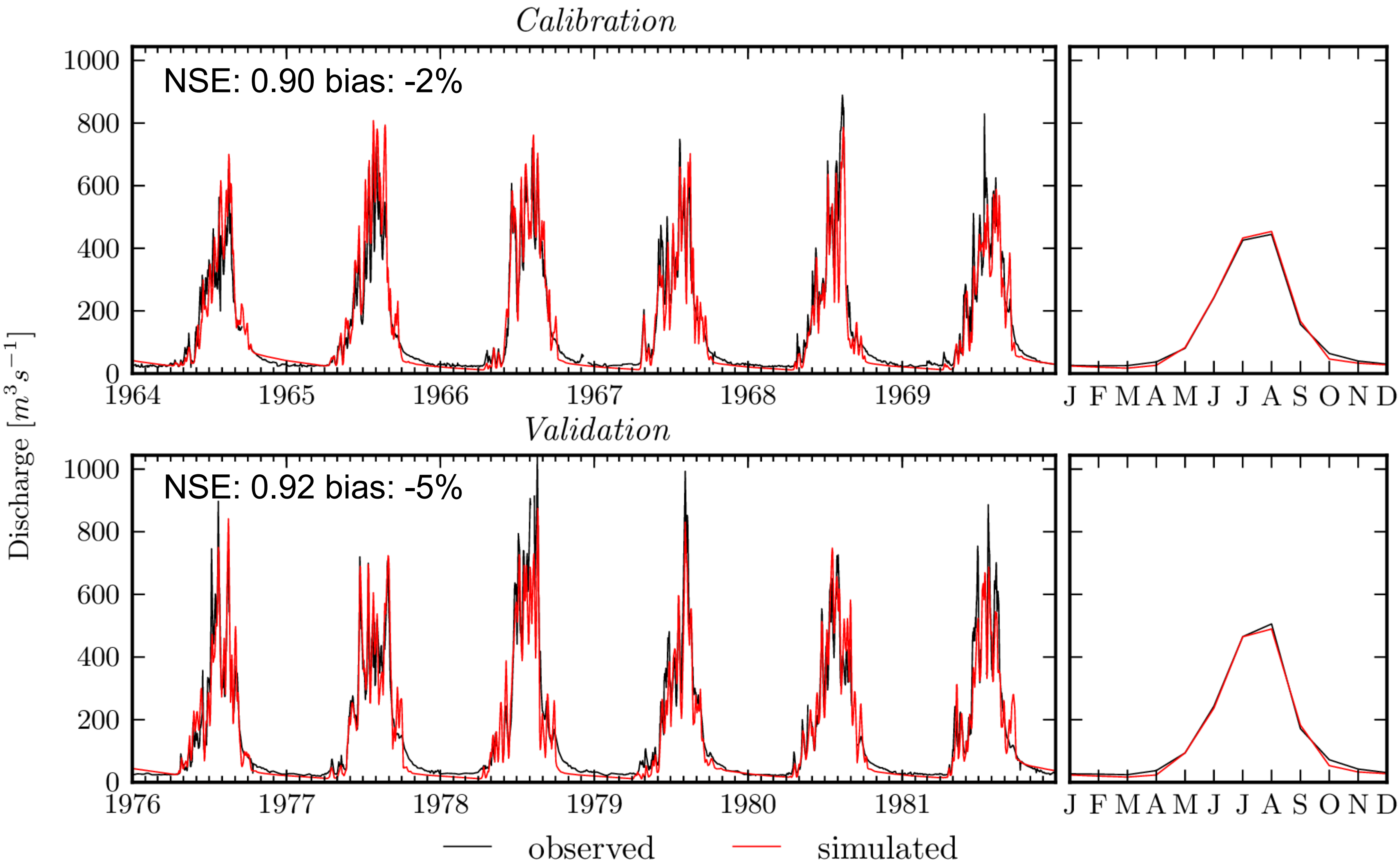
Unrepresented summer peaks (GLOFs)



(Glazirin, 2010)

Calibration results without GLOFs in observations



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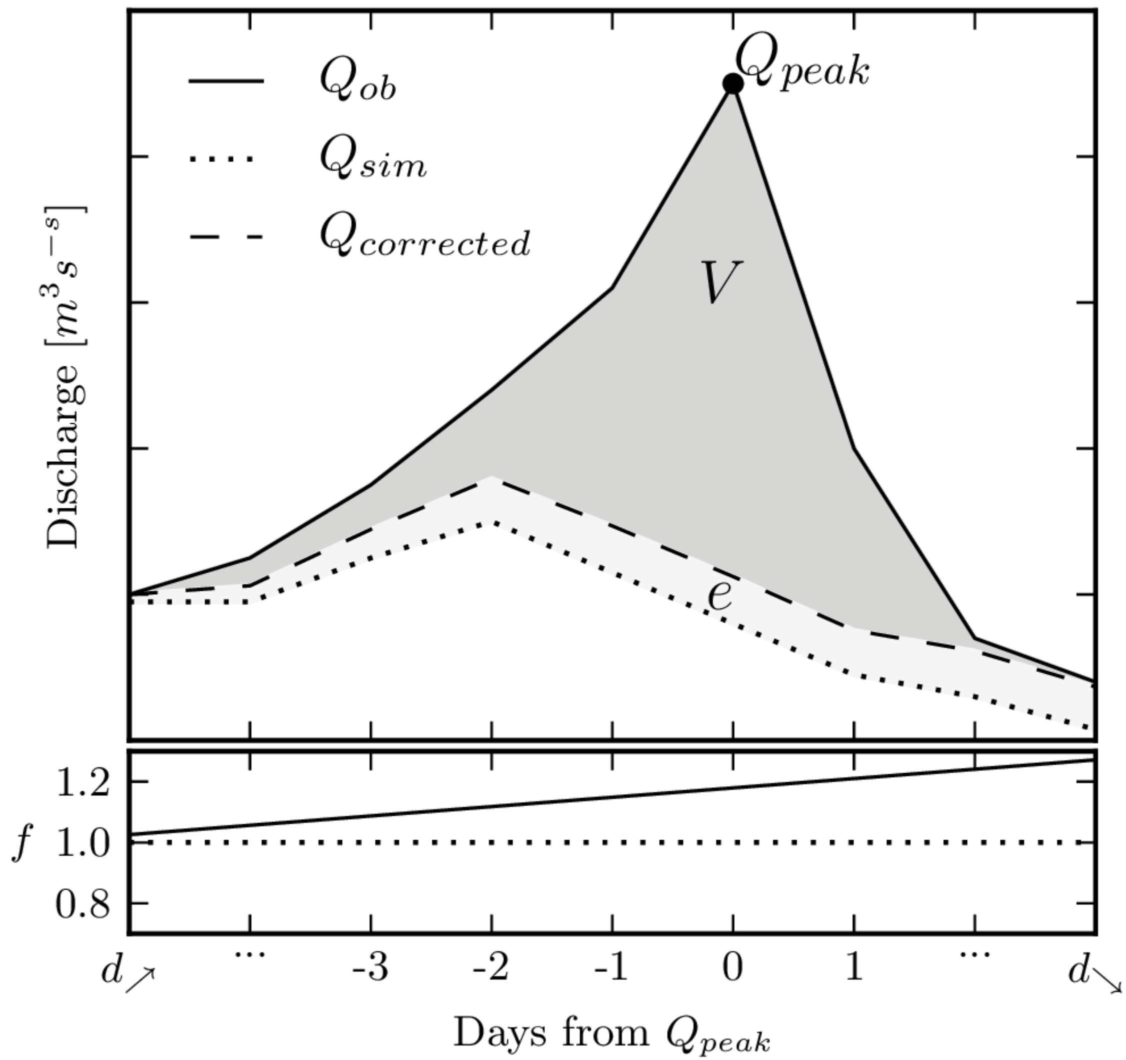
GLOF volume estimation

- Flood hydrograph separation
- Using 'normal' catchment discharge as baseflow



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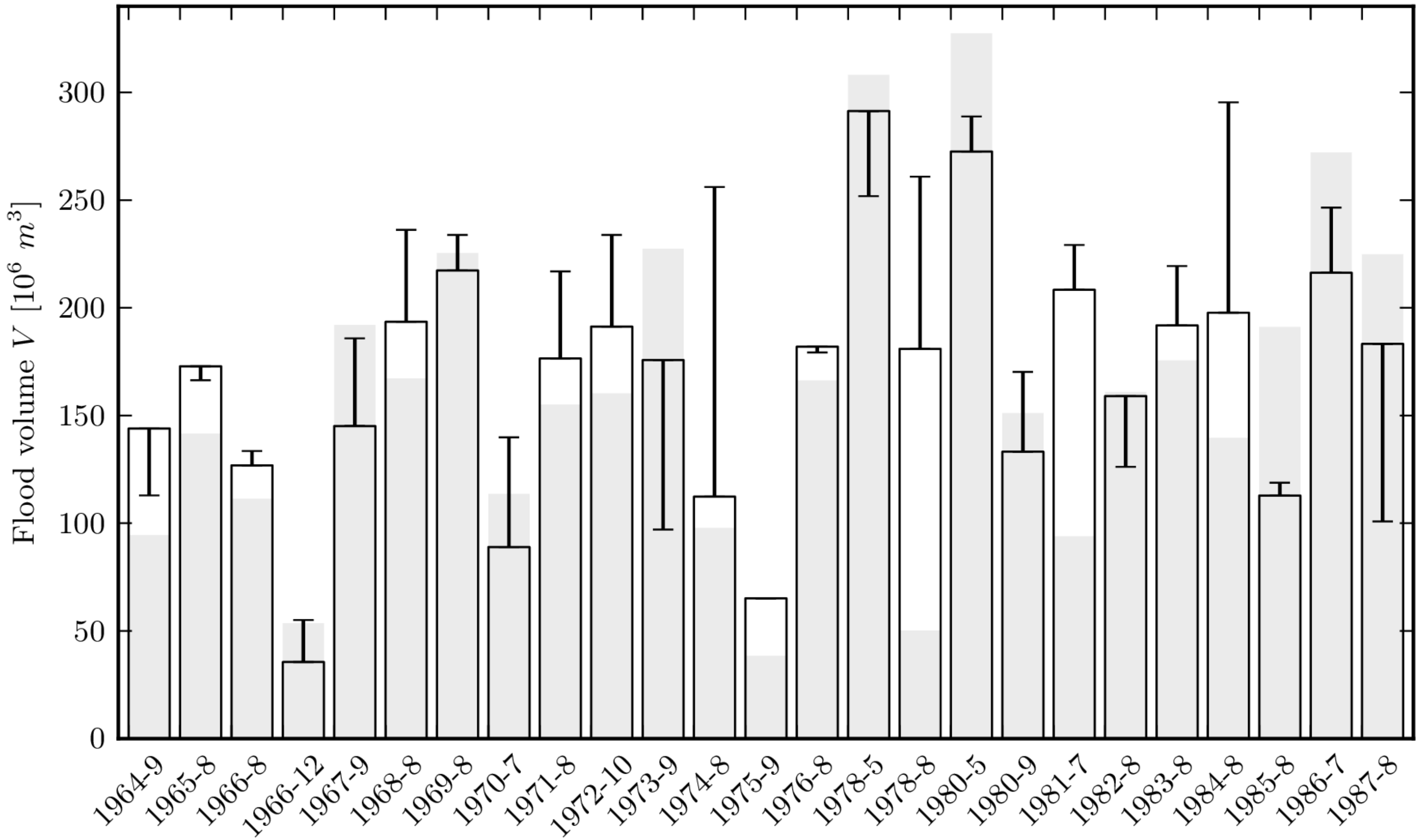
GLOF Volume estimation



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Conclusions

- SWIM was implemented and achieved good calibration and validation results considering the data scarcity and uncertainty
- GLOFs represent a hydrological threat and make hydrological modelling more complex
- Excluding the GLOF events from observations improves the model calibration results, and produces the ‘normal’ catchment discharge
- SWIM can be used to detect/confirm GLOFs in a hydrological record and as a tool to estimate GLOF volumes
- However, climate impact assessment in the region represents a challenge, as GLOFs cannot be modelled yet

Future work

- Expanding the model to the other Tarim headwaters
- Looking for an approach to represent GLOFs in future scenarios
- Climate change impact assessment: driving the model with future climate scenarios from Regional Climate Models (RCMs):
  - downscaling of General Circulation Model (GCM) outputs
  - STARS: statistical model producing prescribed T trend
  - CCLM: physically-based, driven by IPCC emission scenarios

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Get in touch! Michel Wortmann

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Our papers:

Wortmann, M., Krysanova, V., Su, B., Li, X., Kundzewicz, Z.W. 2013 (submitted) The influence of glacial lake outburst floods on the discharge of the upper Aksu River, northwest China: an assessment using the hydrological model SWIM.

Krysanova, V., Wortmann, M., Bolch, T., Merz, B., Duethmann, D., Walter, J., Huang, S., Jiang, T., Su, B., Kundzewicz, Z.W. et al. 2013 (submitted). Analysis of current trends in climate parameters, river discharge, glaciers and land cover in the Aksu River basin (Central Asia). Regional Environmental Change.

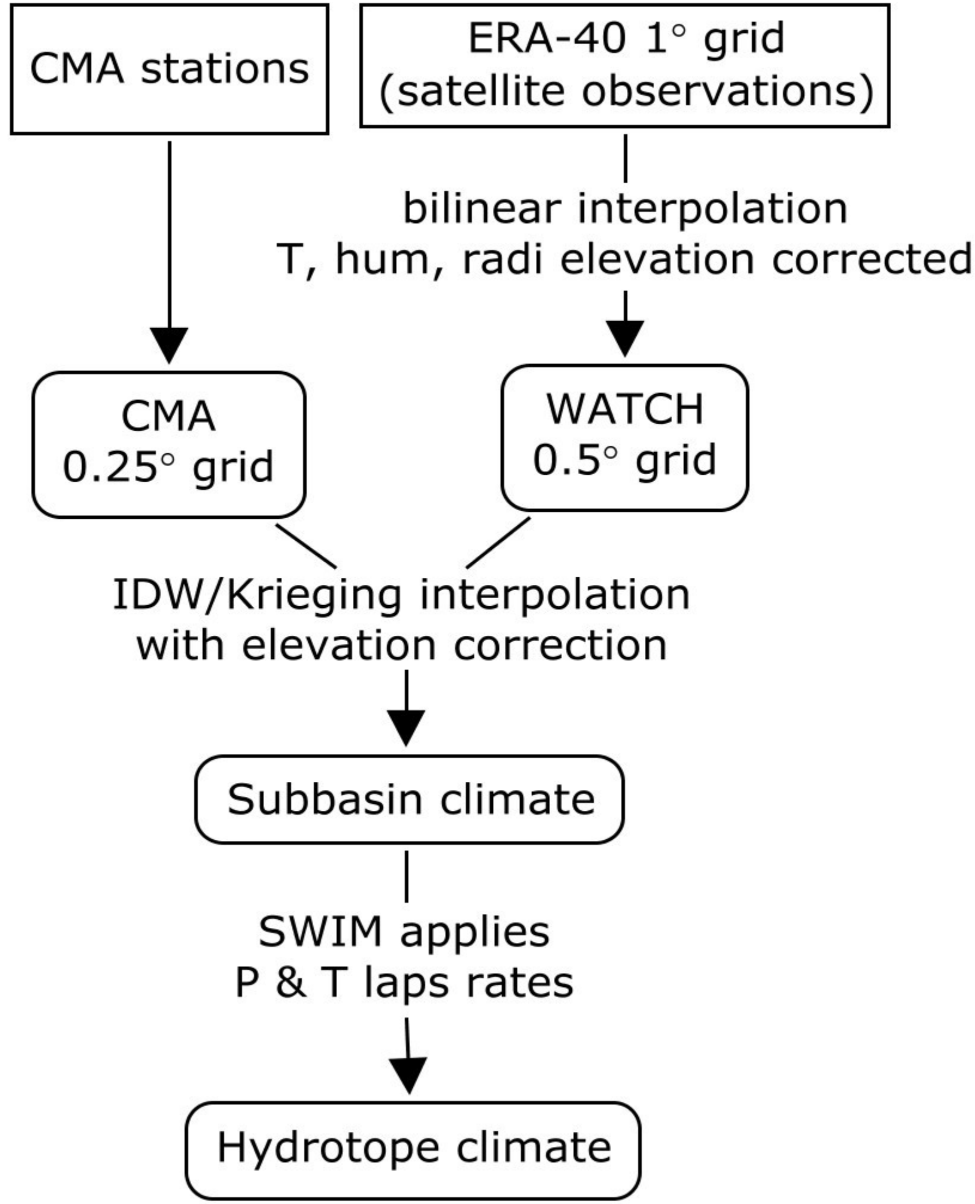
References:

Glazirin, G.E., 2010. A century of investigations on outbursts of the ice-dammed Lake Merzbacher (Central Tien Shan). Austrian Journal of Earth Sciences 103, 171–179.

Thevs, N., 2011. Water Scarcity and Allocation in the Tarim Basin: Decision Structures and Adaptations on the Local Level. Journal of Current Chinese Affairs 113, 137.

Wang, G., Shen, Y., Su, H., Wang, J., Mao, W., Gao, Q., Wang, S., 2008. Runoff Changes in Aksu River Basin during 1956-2006 and Their Impacts on Water Availability for Tarim River. Journal of Glaciology and Geocryology 30, 562–568.

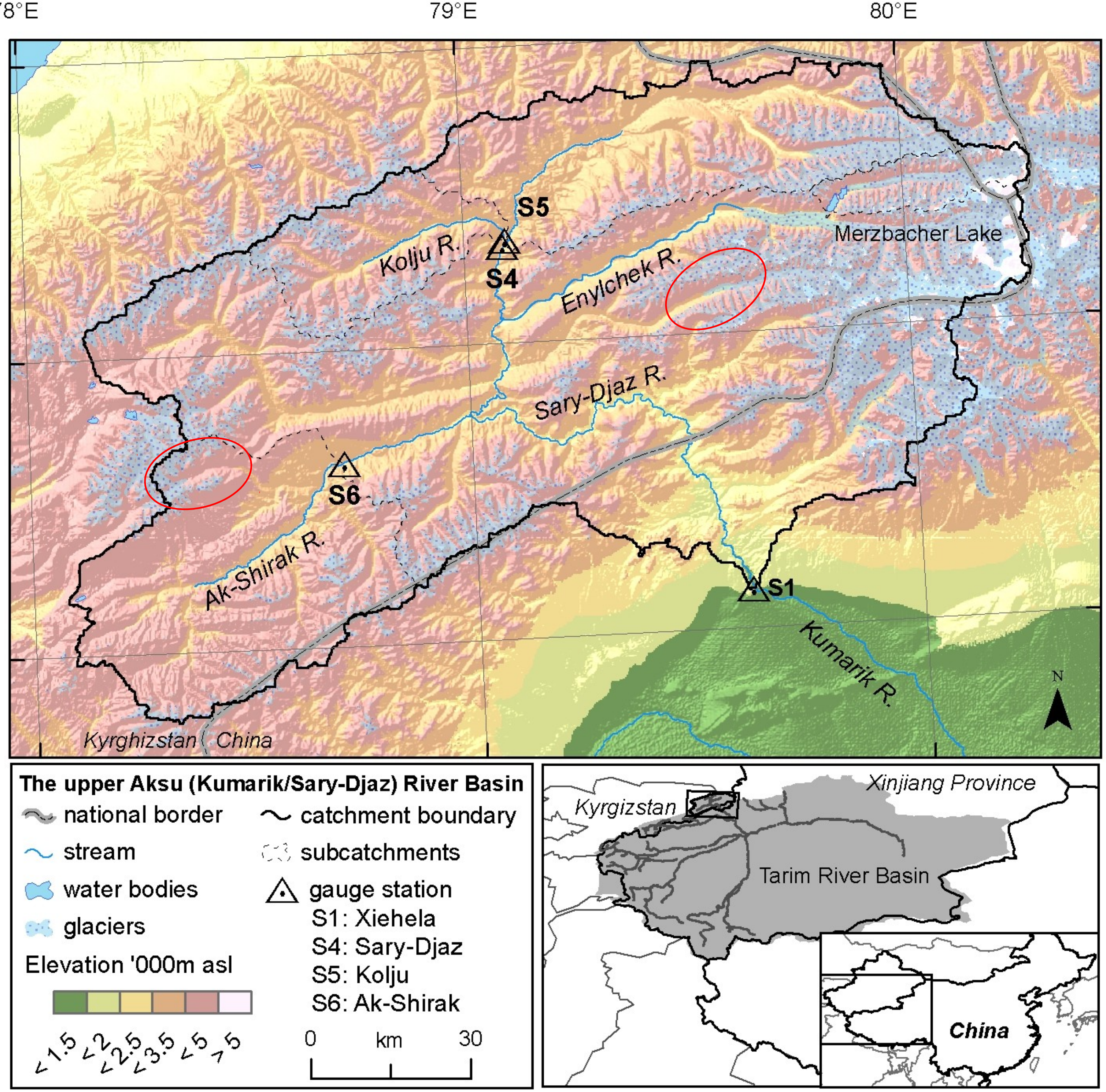
Climate data preprocessing



Field trip August 2012

Kaindy glacier

Ak-Shirak massif



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