Cryosphere matters – attribution of observed streamflow changes in headwater catchments of the Tarim River

Doris Düthmann, Tobias Bolch [*°], Tino Pieczonka [*], Daniel Farinotti, David Kriegel, Sergiy Vorogushyn, Bruno Merz, Tong Jiang [+], Buda Su [+], Andreas Güntner

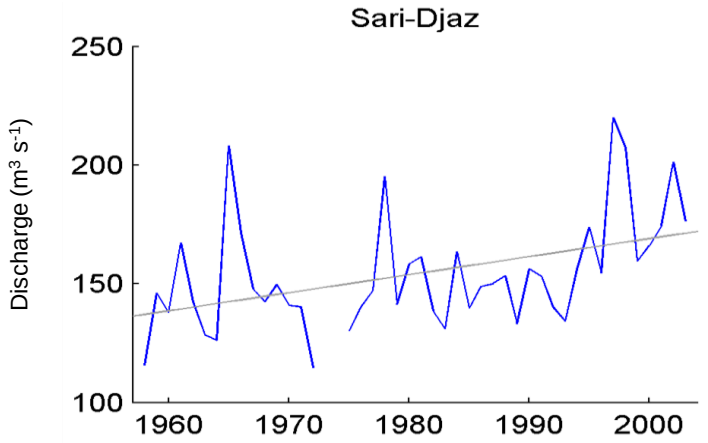
GFZ German Research Centre For Geosciences

[*]TU Dresden Germany, [°]University of Zurich Switzerland, [+]National Climate Centre, China

2015-12-11

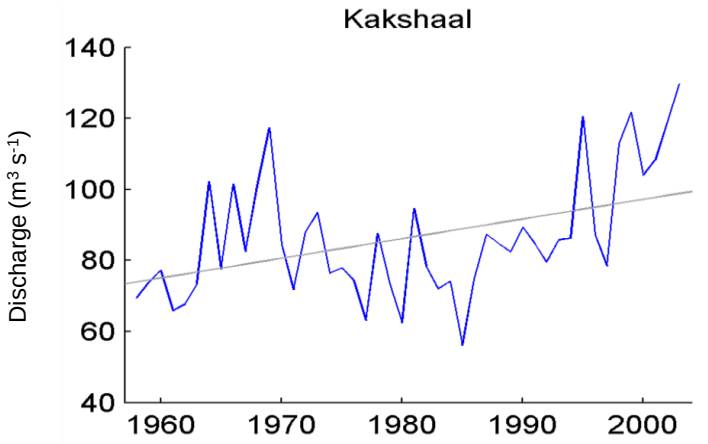
Drivers of changes in hydrology of glacierized headwater catchments?

To what extent can runoff increase be explained by the changes in temperature and precipitation?

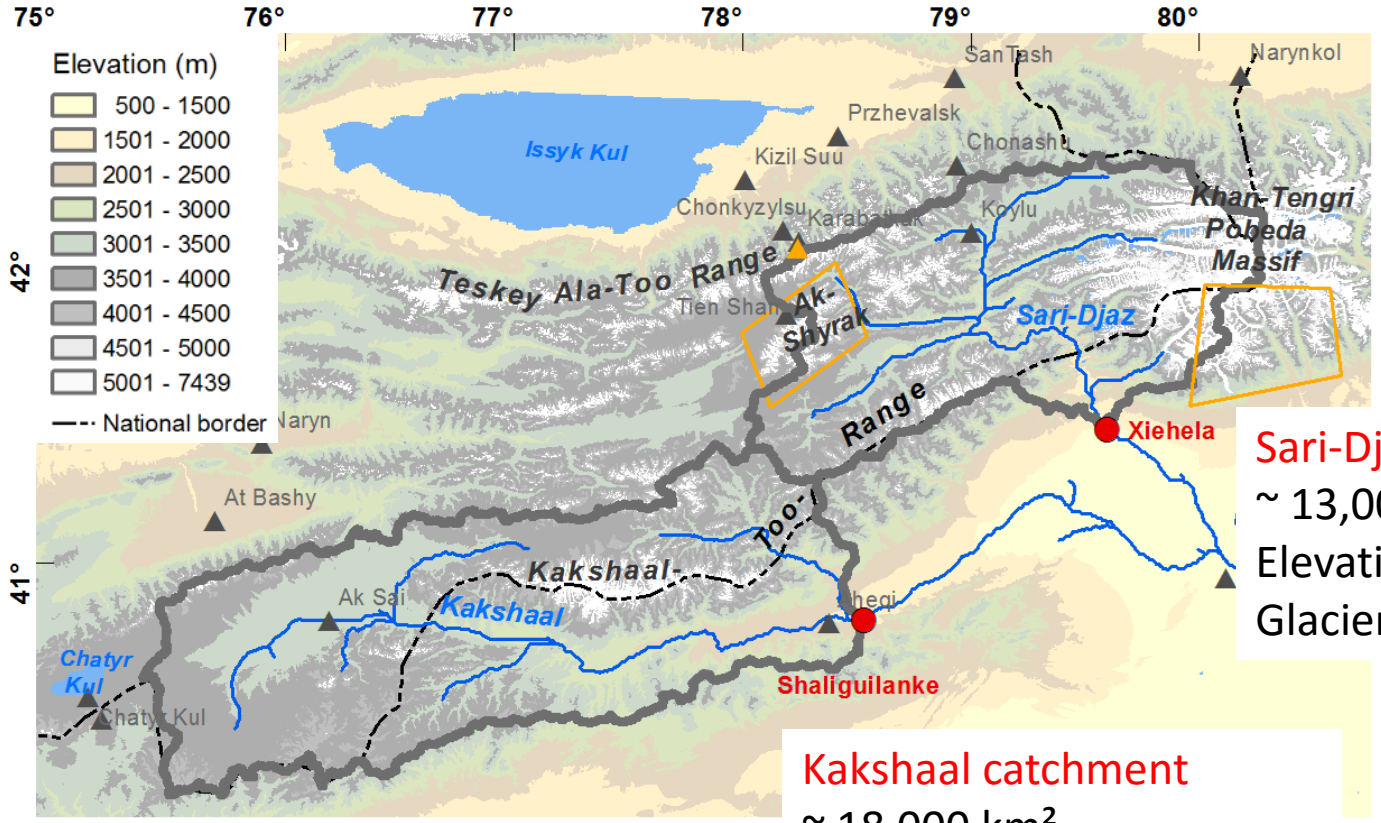


Application of two approaches

- Data-based using multilinear regression
- Simulation-based using a hydrological model



The study region



Sari-Djaz catchment
~ 13,000 km²
Elevation: 1,500-7,100 m
Glacier cover: 21%

Kakshaal catchment
~ 18,000 km²
Elevation: 1,900-5,900 m
Glacier cover: 4.4%

Data-based approach: multilinear regression

Performed at seasonal time scale

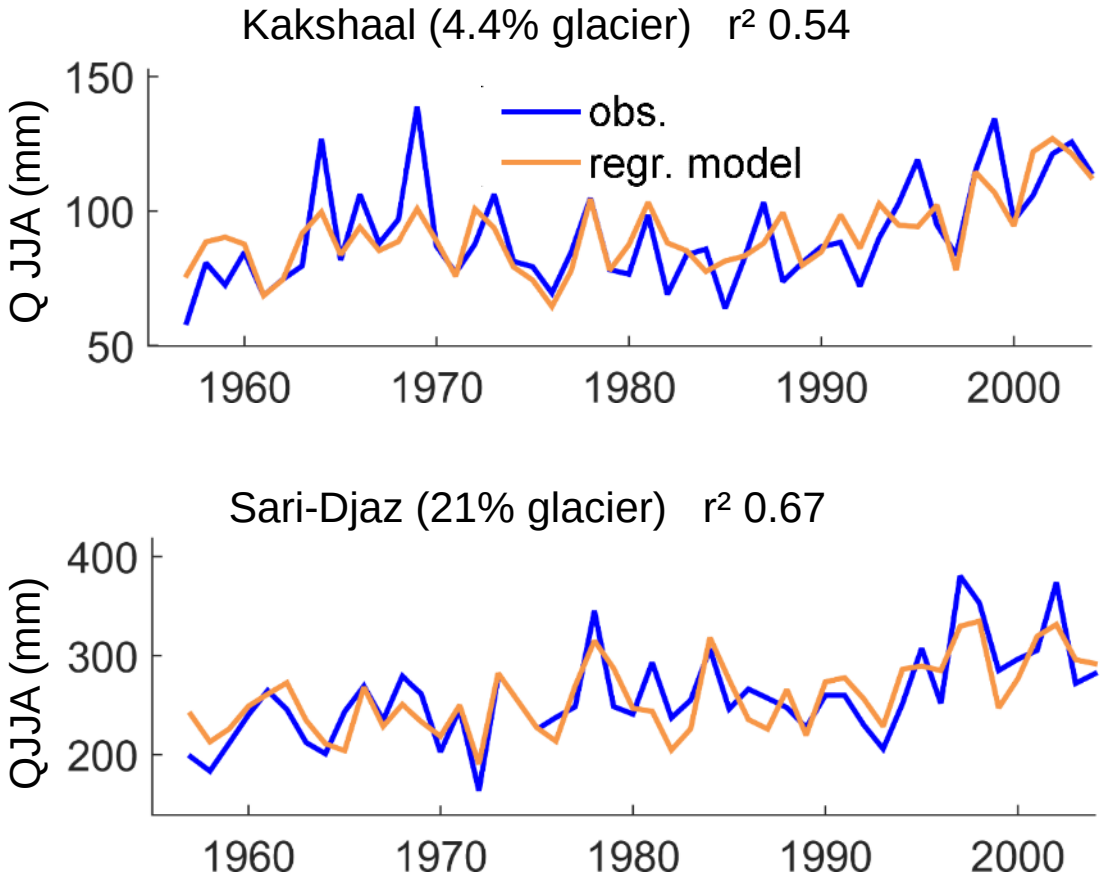
Dependent variable: annual time series of seasonal runoff

Predictors:

- Temperature and precipitation of the investigated season
- Accumulated precipitation over previous months
- Temperature during the last summer, and during the summer before last summer

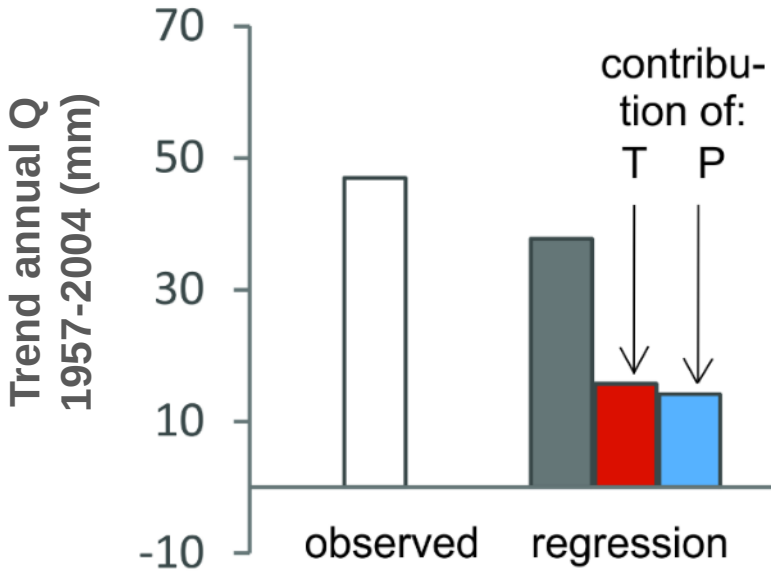
Selection of best set of predictors using Bayesian information criterion

Observed series of summer runoff and summer runoff by the regression approach

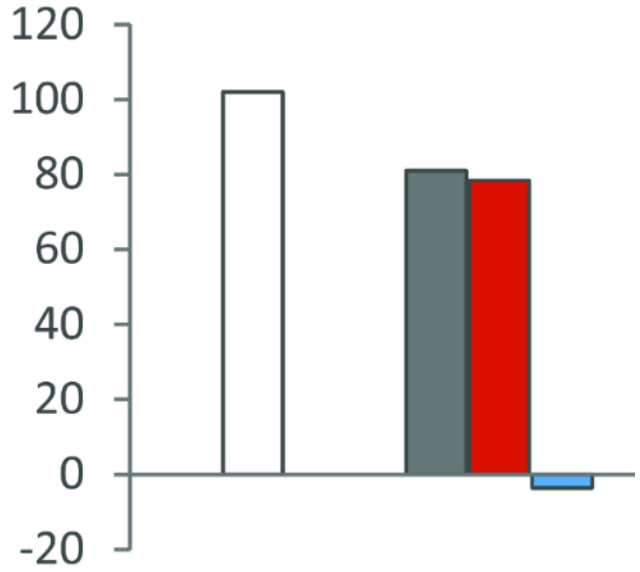


Contribution of temperature and precipitation changes to annual runoff trend

Kakshaal (4% glacier)



Sari-Djaz (21% glacier)



Simulation-based approach: hydrological modeling

Hydrological model WASA:

- Semidistributed, process-oriented and conceptual approaches
- Previous applications in other catchments in Central Asia

  Duethmann et al. (2014) *WRR*, *50*(3);
  Duethmann et al. (2013), *HESS*, *17*(7)

Glacier geometry changes

- Area changes: derived from two glacier inventories
- Elevation changes: Δh-approach

  Huss et al. (2010), *HESS*, *14*(5).

Multiobjective calibration

Discharge

- Daily discharge variations
- Interannual variations of seasonal flow

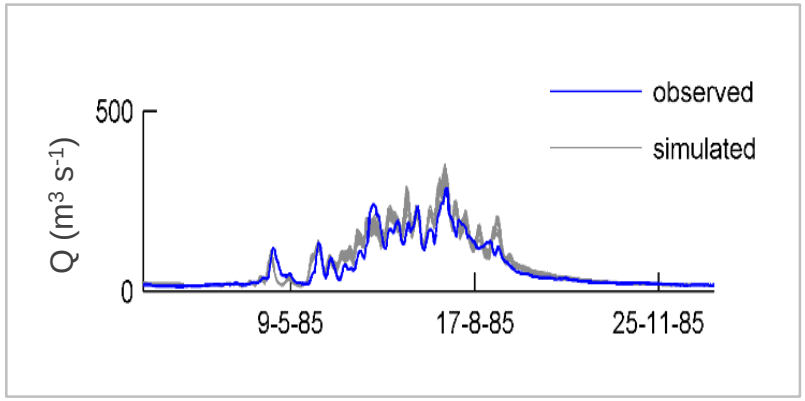
Glacier mass balance

- Cumulative glacier mass change: geodetic mass balance estimates
- Interannual variation of the simulated glacier MB: correlation to a measured glacier MB time series

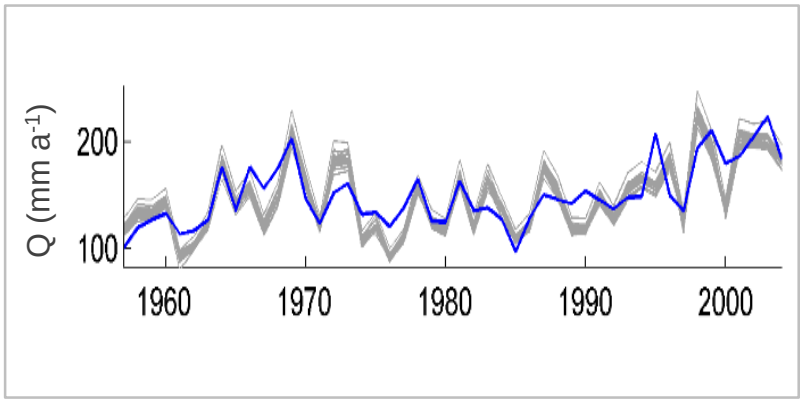
Automatic calibration using a multiobjective optimization algorithm

Simulation-based approach: model performance

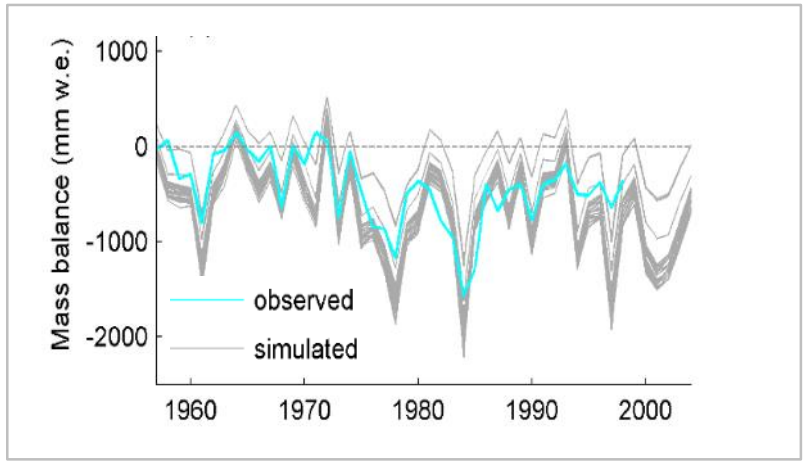
Daily discharge variations



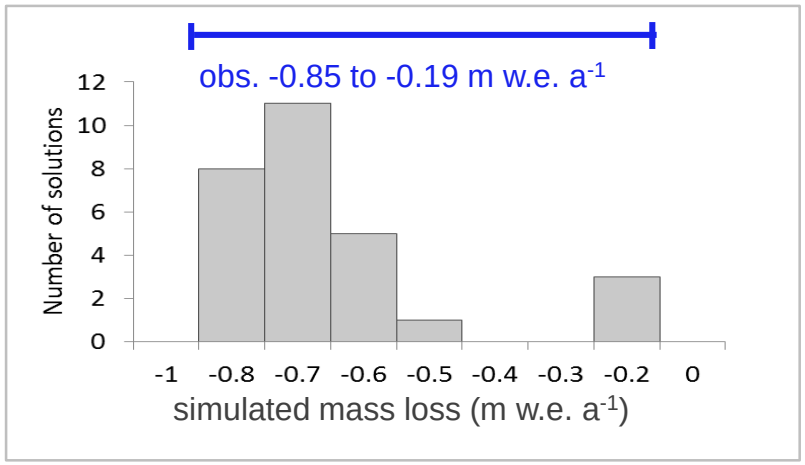
Interannual discharge variations



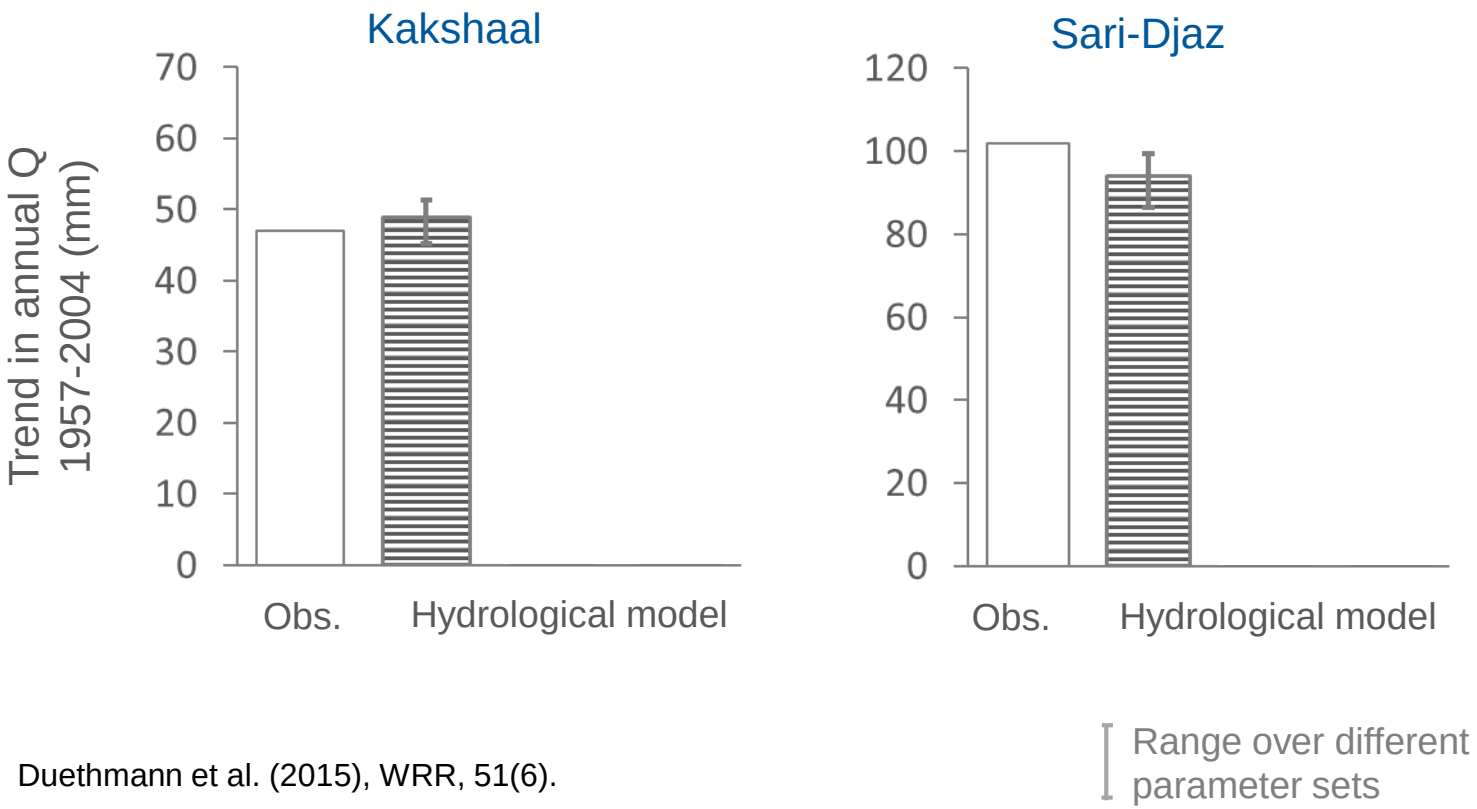
Interannual variation of glacier MB



Cumulative glacier mass loss 1976-99



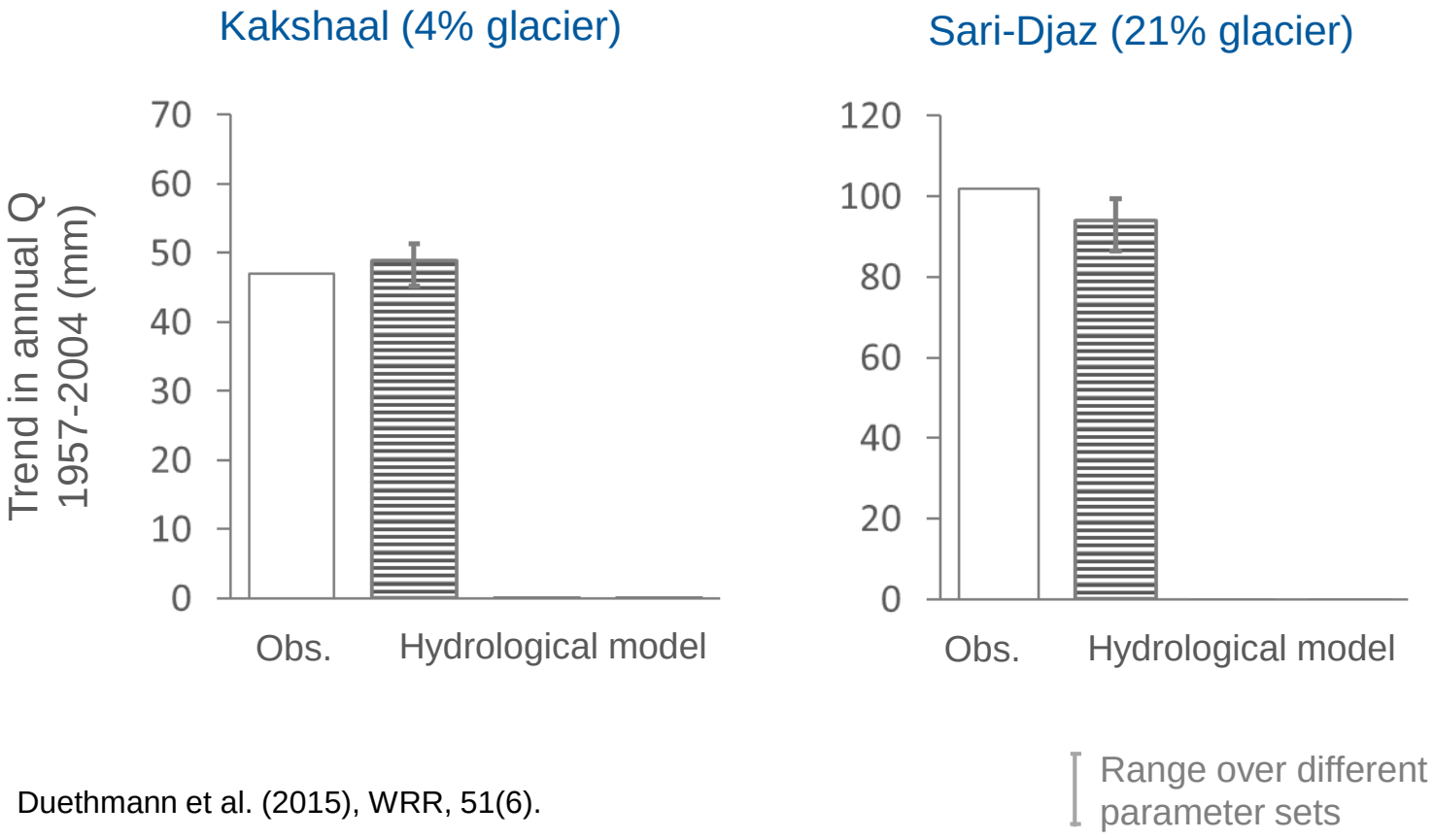
Observed and simulated discharge trend



Duethmann et al. (2015), WRR, 51(6).

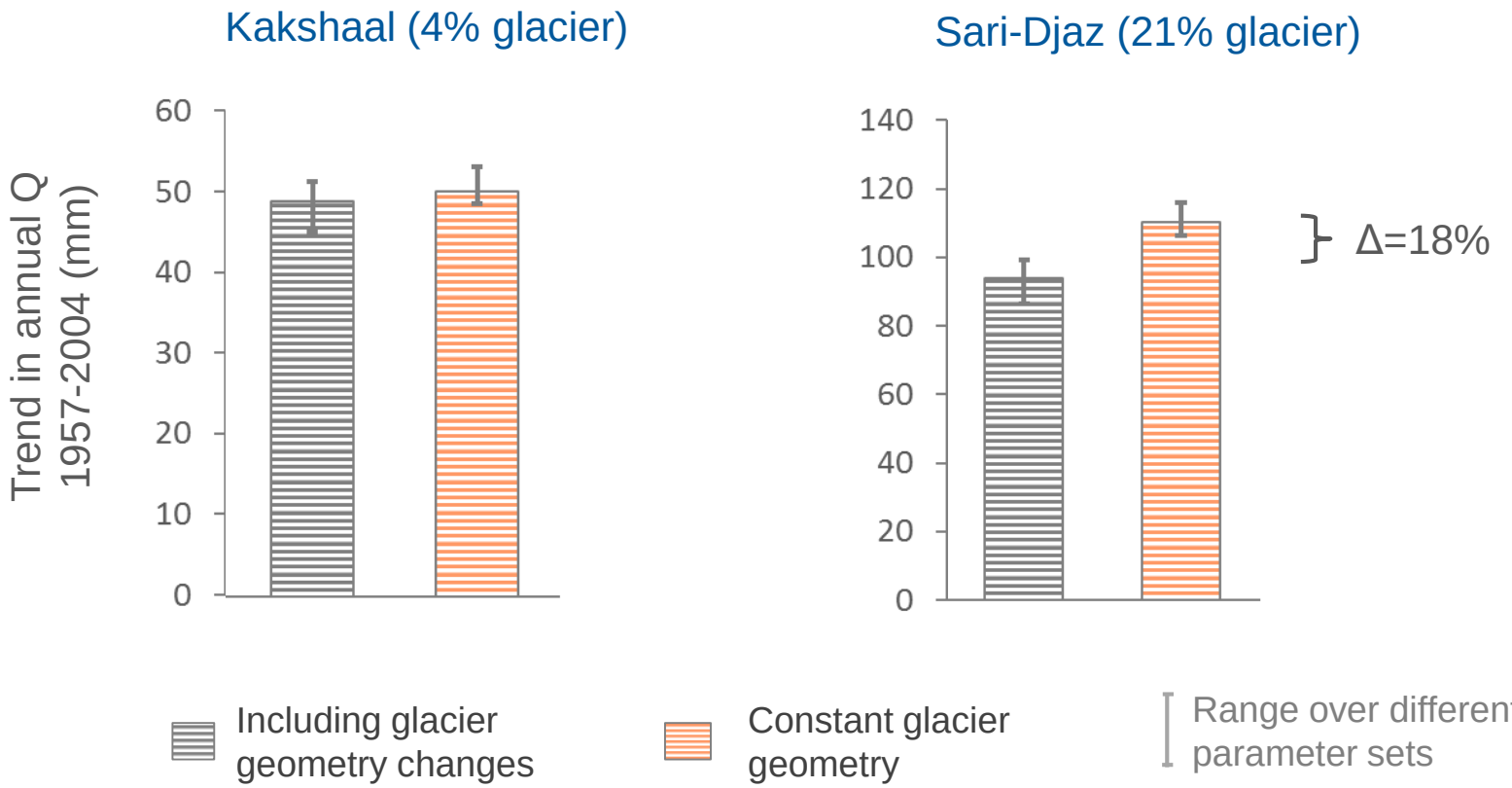
Effects of precipitation and temperature changes

Additional simulations with detrended temperature and precipitation series



Duethmann et al. (2015), WRR, 51(6).

Effect of changes in glacier geometry



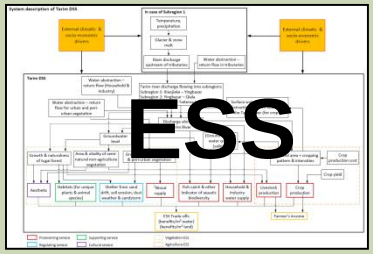
Conclusions

Increases in temperature / glacier melt play larger role for observed discharge changes in Aksu headwater catchments than previously assumed.

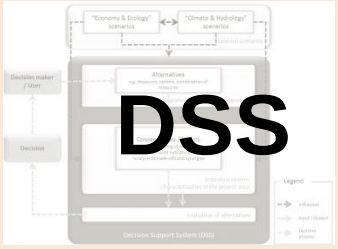
Additional runoff to large extent from glacier mass loss
→ trend likely to get reversed in future.

Hydrological model could not only represent daily discharge variations, but also observations for glacier mass loss and long term discharge trends
→ Increases confidence in the model for climate impact analyses

Research contribution to Ecosystem Services (ESS) in the Tarim Basin and the contribution to the SuMaRiO-Decision Support System (DSS)



Provision of surface water



Climate change impact on surface water availability in headwater catchments of the Tarim River Basin

Thank you for your attention!

References

Duethmann et al. (2015): **Attribution of streamflow trends in snow- and glacier melt dominated catchments of the Tarim River, Central Asia**. *WRR*, *51*(6).

Duethmann et al. (2014): **The value of satellite-derived snow cover images for calibrating a hydrological model in snow-dominated catchments in Central Asia**. *WRR, 50*(3): 2002-2021.

Duethmann et al. (2013): **Evaluation of areal precipitation estimates based on downscaled reanalysis and station data by hydrological modelling**. *HESS, 17*(7): 2415-2434.

Huss et al. (2010): **Future high-mountain hydrology: a new parameterization of glacier retreat**, *HESS, 14,* 815-829.

Trends in temperature and precipitation