

Water Resources Assessment of the Mountainous Upper Syr Darya Catchment

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Study Area

Water is a strategic and highly contested resource in Central Asia. In this study we evaluate the water resources of the headwaters of the Syr Darya River. The Syr Darya is one of the two tributaries of the Aral Sea. The headwaters investigated in this study include the Naryn and Karadarya Rivers, which originate in the mountainous regions of Kyrgyzstan and flow into the Ferghana Valley. The water resources of the region are highly susceptible to climate change.

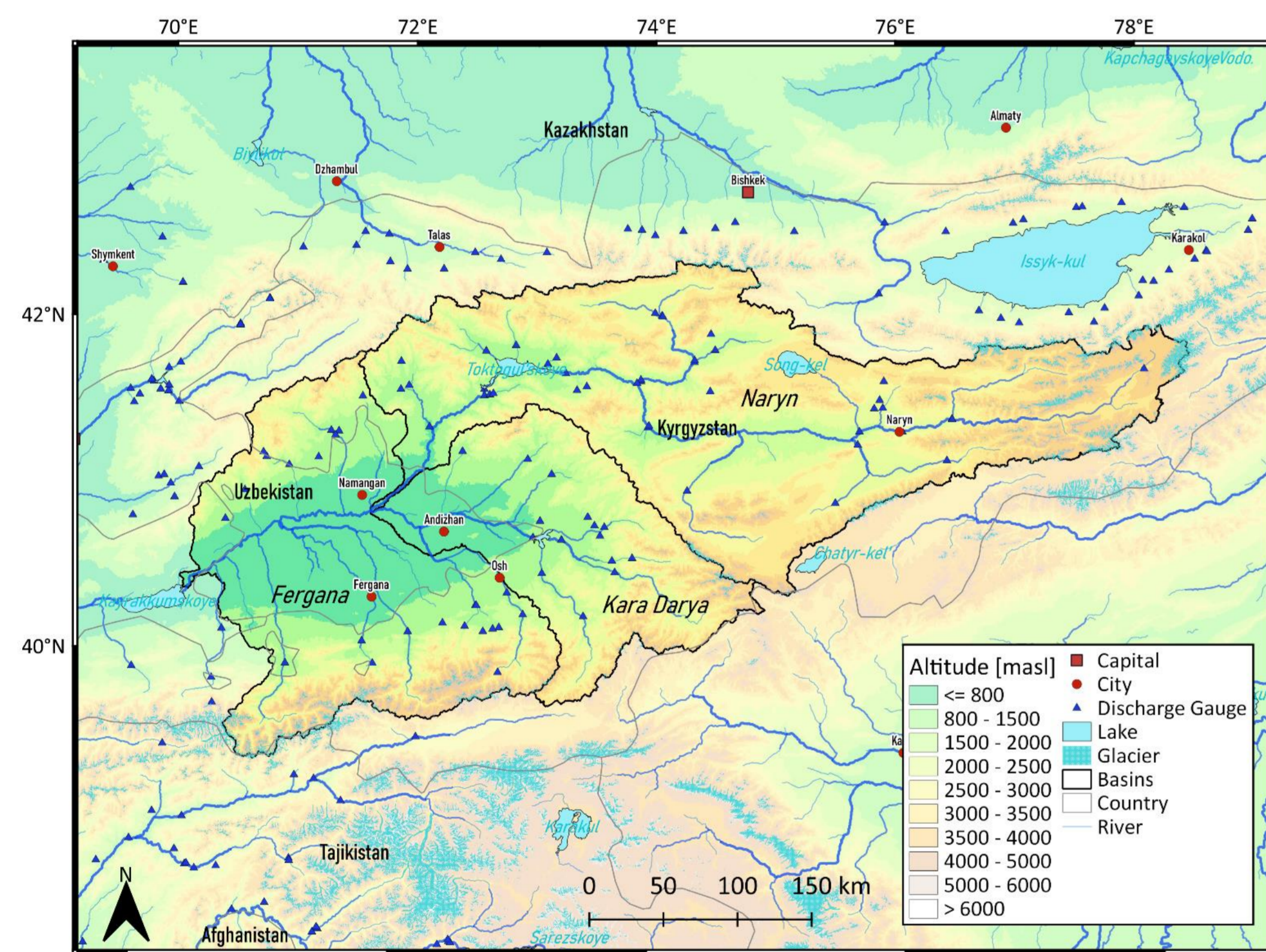




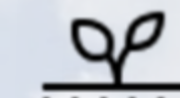
Figure 1. Overview of the Study area including the Naryn and Karadarya catchments.

References

- [1] Bieger, K., Arnold, J.G., Rathjens, H., White, M.J., Bosch, D.D., Allen, P.M., Volk, M., Srinivasan, R., 2017. Introduction to SWAT +, A Completely Restructured Version of the Soil and Water Assessment Tool. *J American Water Resour Assoc* 53, 115–130. <https://doi.org/10.1111/1752-1688.12482>
- [2] Stefan Lange, Matthias Mengel, Simon Treu, Matthias Büchner (2023): ISIMIP3a atmospheric climate input data (v1.2). ISIMIP Repository. <https://doi.org/10.48364/ISIMIP.982724.2>
- [3] Stefan Lange, Matthias Büchner (2020): ISIMIP2a atmospheric climate input data (v1.0). ISIMIP Repository. <https://doi.org/10.48364/ISIMIP.886955>
- [4] Houska, T., Kraft, P., Chamorro-Chavez, A., Breuer, L., 2015. SPOTting Model Parameters Using a Ready-Made Python Package. *PLOS ONE* 10, e0145180. <https://doi.org/10.1371/journal.pone.0145180>
- [5] Schaffhauser, T., Lange, S., Tuo, Y., Disse, M., 2023. Shifted discharge and drier soils: Hydrological projections for a Central Asian catchment. *Journal of Hydrology: Regional Studies* 46, 101338.

Methodology

In-depth trend analysis was performed for observation data using Mann-Kendall test and Theil-Sen slope. Furthermore, the widely used SWAT+ model [1] was used to represent the hydrological cycle of the Naryn and Karadarya catchments in two separate models.

- Input data:
 - GSWP-W5E5 (ISIMIP3; calibration) [2]
 - GSWP-EWEMBI (ISIMIP2) [3]
- Optimizer:
 - Shuffled Complex Evolution (spotpy [4])
- Variables:
 - Streamflow 
 - Evapotranspiration 
 - Soil moisture (validation) 

Comparison of driving datasets

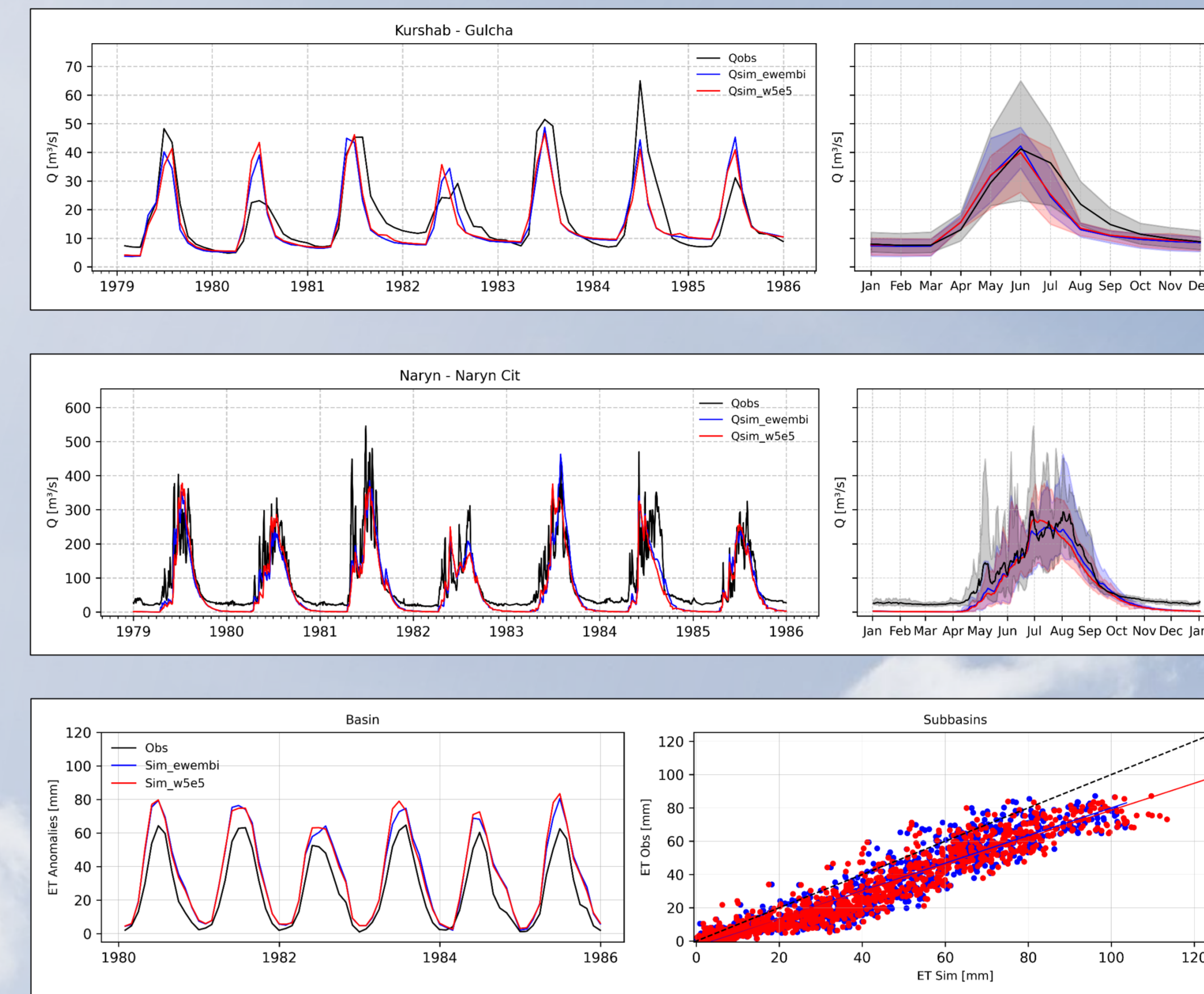


Figure 4. Comparison of the results of discharge (top two) and evaporation (Karadarya) of the SWAT+ model driven with gswp-ewembi and gswp-w5e5 data, respectively.

- EWEMBI & W5E5 very similar statistics.
- Slight differences in temperature and timing of precipitation.
- Goodness of fit criteria not strongly affected.

	GSWP-W5E5	GSWP-EWEMBI
Gauge Gulcha	NSE: 0.7 KGE: 0.76	NSE: 0.7 KGE: 0.77
Gauge Naryn	NSE: 0.7 KGE: 0.71	NSE: 0.74 KGE: 0.74
ET Karadarya	R: 0.98 R ² : 0.97	R: 0.98 R ² : 0.96

Goal was to find robust parameter sets for subsequent climate impact assessments. The results are an indication for such parameter sets!

Trends

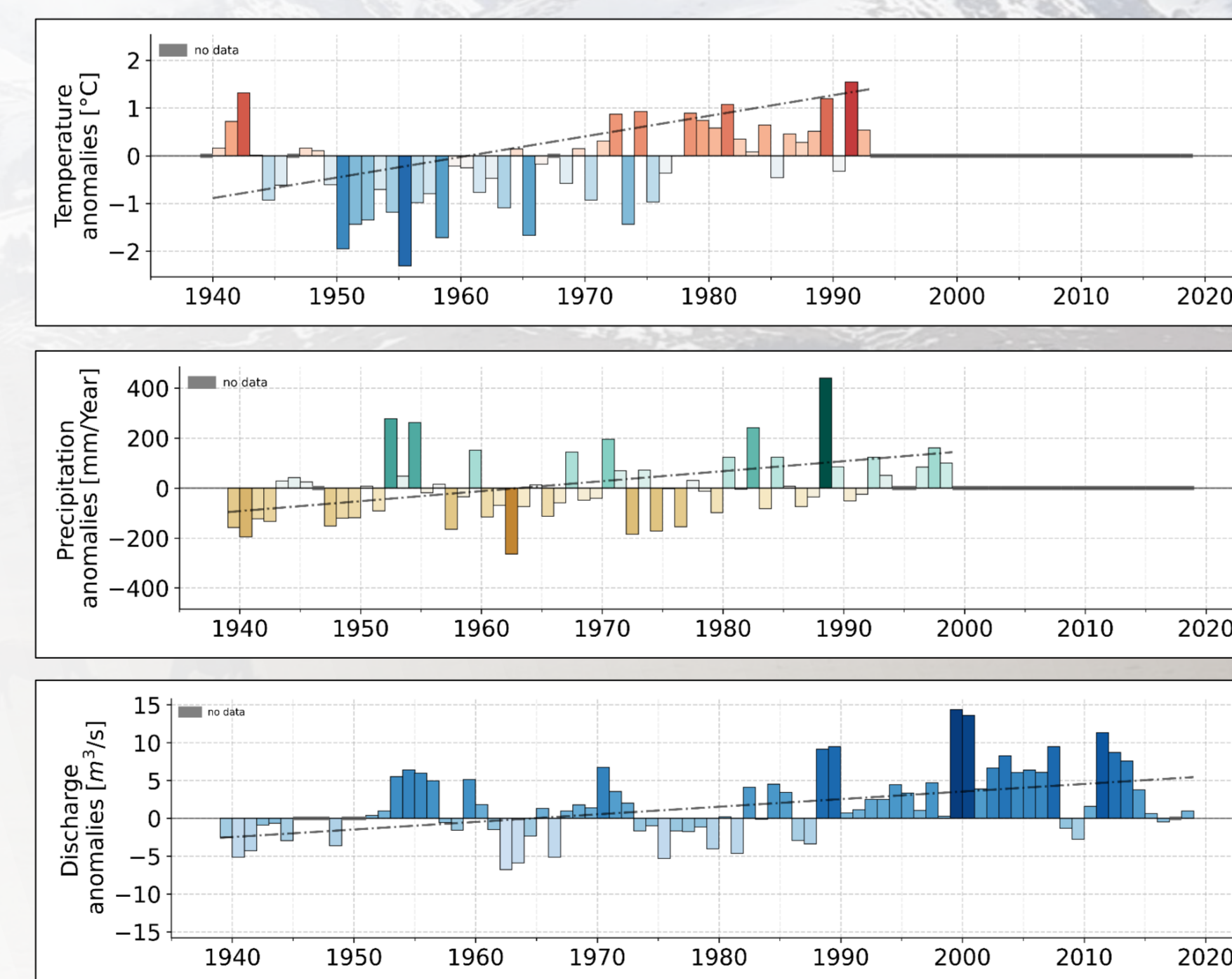


Figure 2. Anomalies of annual average temperature (top) precipitation sums (middle) and average discharge and respective trends for weather station and gauge in Gulcha.

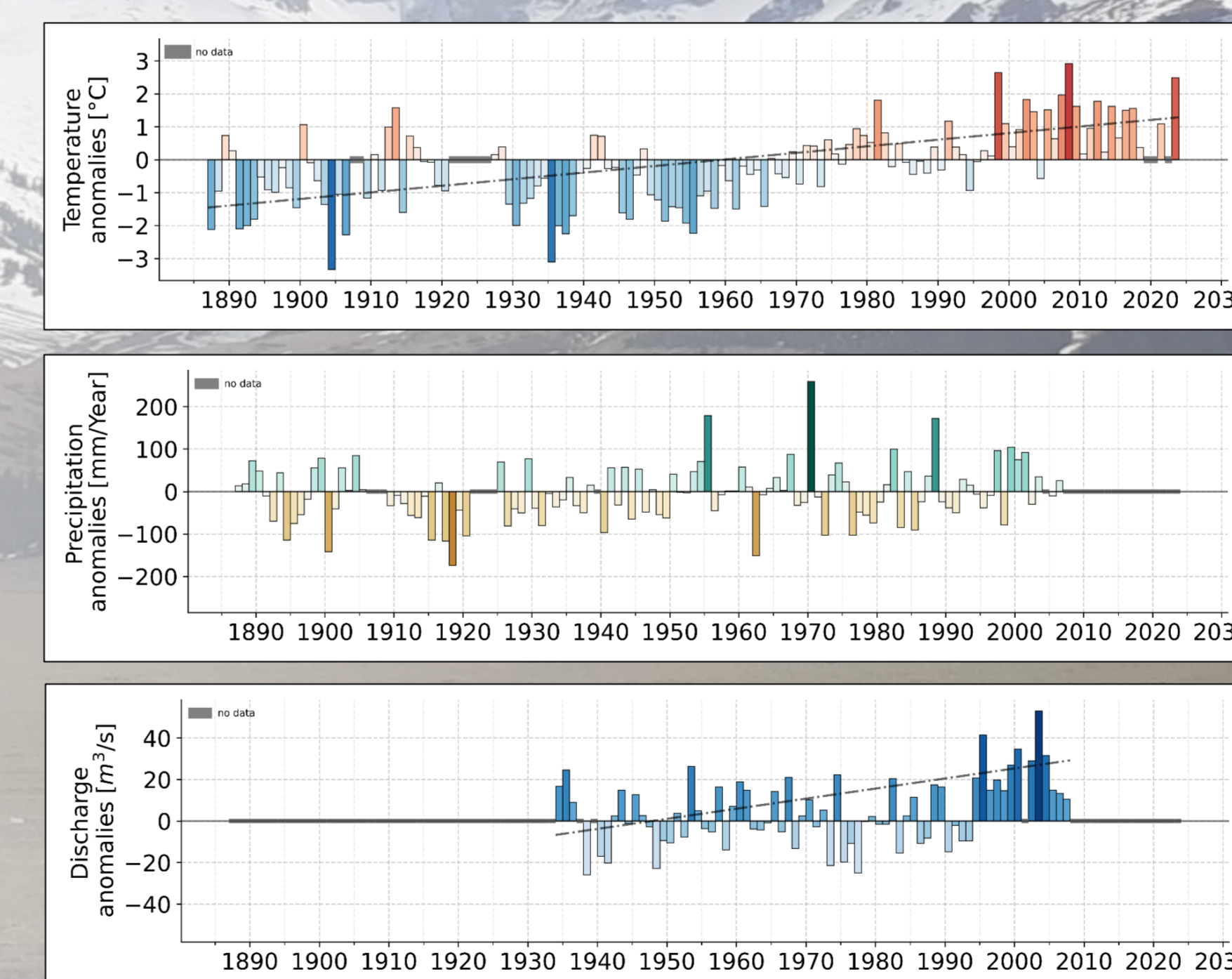


Figure 3. Same as figure 2 for weather station and gauge in Naryn.

A clear increase of temperature is visible. This is in accordance with other stations. Lower increases were observed for stations within the Ferghana Valley (e.g. Namangan) larger increases for high-elevated stations (e.g. Tian Shan). Precipitation was observed to shift regionally, but no overall trend could be identified. Streamflow increased in several subcatchments, likely due to (a) locally increased precipitation and or (b) increased snow and glacial melt.

Summary & Outlook

- Temperature & partially discharge increasing in headwaters of Syr Darya.
- Models robustly represent hydrological cycle.
- Regions high susceptibility to climate change calls for climate impact study. Expanding existing impact assessments (e.g.: Schaffhauser et al. 2023 [5]).
- Large anthropogenic influence on water resources stipulates an investigation into land-use change scenarios.