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Evaluation of the precipitation input for hydrological modeling of a mountainous catchment in Kyrgyzstan

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Introduction

- In mountainous catchments the generation of suitable precipitation input fields is a challenge, as the number of stations is low and at the same time the spatial variability is high due to the complex terrain.
- In such catchments downscaled reanalysis data may be a better input for hydrological models than interpolated stations data.
- With respect to the Karadarya catchment in Central Asia this study investigates the following questions:
  - What is the performance of dynamically downscaled reanalysis data compared to station data?
  - What is the quality of different precipitation data sets if judged by the performance of a hydrological model? - Does downscaled reanalysis data sometimes better represent catchment precipitation than interpolated station data?

The Karadarya catchment

- Area c. 12000 km².
- Average annual precipitation: between < 400 mm in the lowlands and intramountainous valleys to >1000 mm in the northwest.

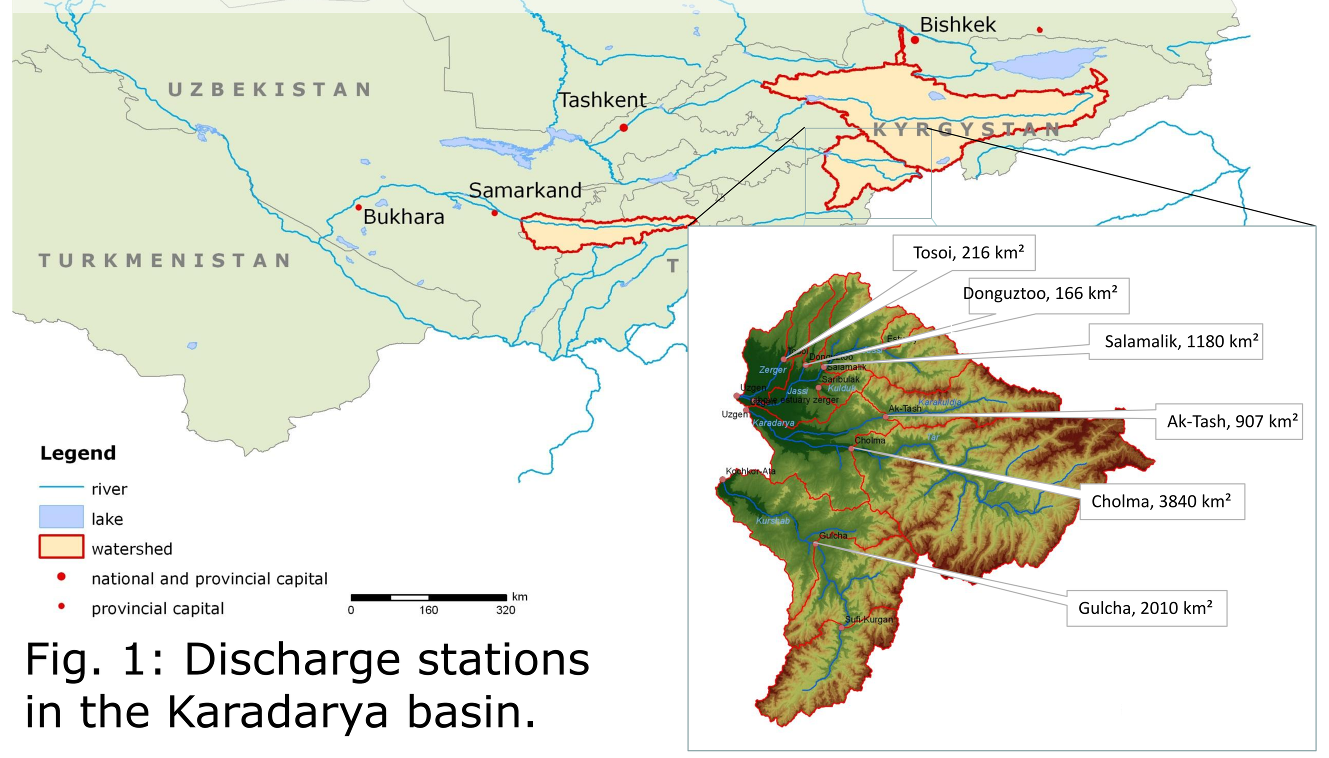

Fig. 1: Discharge stations in the Karadarya basin.

The hydrological model WASA

- Semi-distributed
- Extensions for high mountain areas: introduction of elevation zones, a snow melt module and a glacier mass balance module.

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Precipitation input data sets

1: Multi-linear regression of station data

Step1 - Monthly precipitation maps:

- Multi-linear regression by elevation, longitude and latitude.

Step2 - Daily precipitation fields:

- Calculate scaling factor at station locations and interpolate this scaling factor (IDW). Multiply the scaling factor map with the monthly map from multi-linear regression.

2: Downscaled reanalysis data (ERA-40)

- Regional climate model: WRF
- Spatial resolution 12 km

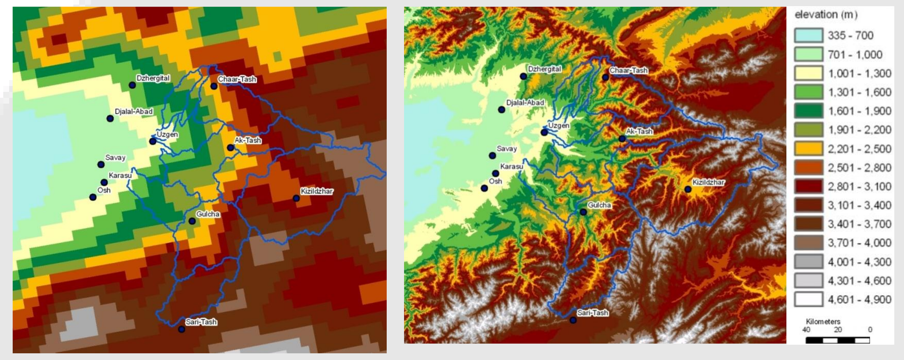


Fig. 2: Topography as in the WRF model (left) and real topography (SRTM, right).

3: Station data interpolated using monthly WRF maps

Step1 - Monthly precipitation maps from WRF.

Step2 - Daily precipitation fields:

- Calculate scaling factor at station locations and interpolate this scaling factor (IDW). Generate daily precipitation maps by multiplying the scaling factor map with the monthly map from WRF.

Evaluation of the precipitation data sets based on the performance of the hydrological model

- The hydrological model is automatically calibrated against observed discharge using the different precipitation data sets:
  - 10 parameters, including a precipitation correction factor
  - Automatic calibration using DDS for six subcatchments
  - 4 year calibration (1982-1985) and validation period (1986-1989), objective function 0.5·(NSE+log NSE)
- The performance is evaluated based on:
  - The average objective function value over the calibration and validation period.
  - The value of the precipitation correction factor, which should be close to one.

Results

Resulting precipitation maps from WRF and multi-linear regression

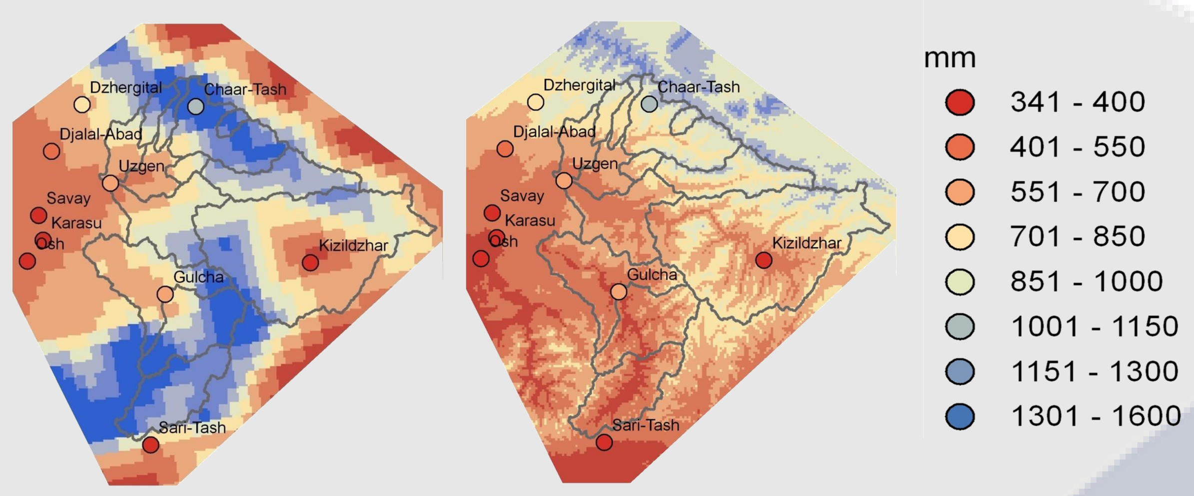


Fig. 3: Annual average precipitation sums over 1981-1990 from WRF (left) generally show a higher precipitation than from multi-linear regression (right).

Performance of the regional climate model compared to station data

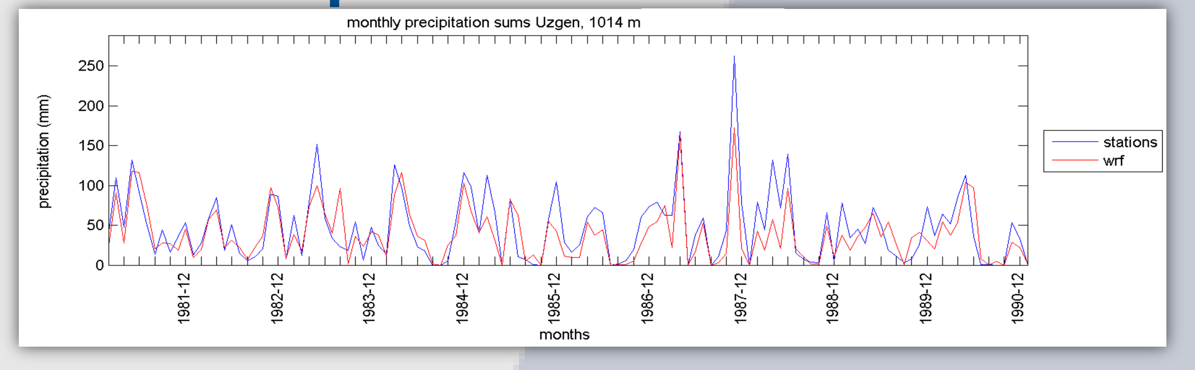


Fig. 4: Time series of monthly precipitation from WRF compared to station data over the period 1981-1990 for the station Uzgen.

Table 1: The comparison of monthly time series of WRF data to station data over the period 1960-2001 generally shows a good performance, with an average r^2 of 0.72 and a slight overestimation of 17%.

	Station	Elevation (m)	R^2	Bias (%)
1	Sari-Tash	3155	0.55	89
2	Kizildzhar	2230	0.67	27
3	Chaar-Tash	2748	0.66	34
4	Gulcha	1542	0.83	11
5	Uzgen	1014	0.74	-24
6	Dzhergital	1198	0.79	-19
7	Djalal-Abad	971	0.74	-8
8	Savay	753	0.72	6
9	Karasu	866	0.74	13
10	Osh	887	0.74	41

Evaluation of the precipitation data set based on the performance of the hydrological model

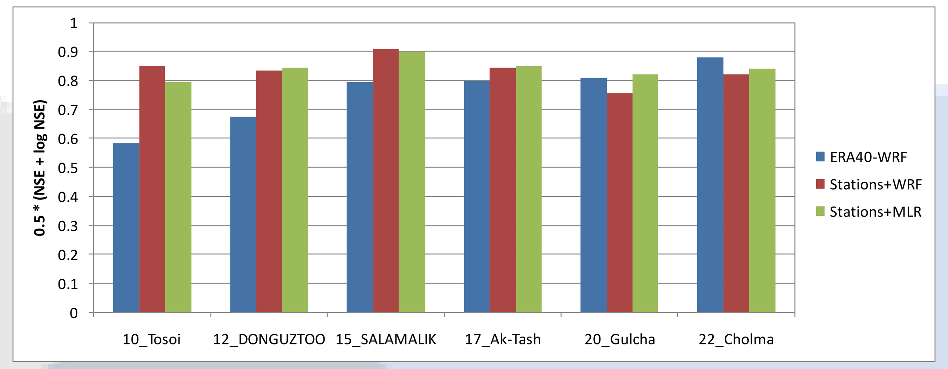


Fig.5: Average objective function values over the calibration and validation period for the three different precipitation input data sets and six subcatchments.

In one subcatchment higher obj. function values are achieved using WRF input, in all other subcatchments the performance of the hydrological model with precipitation input based on station data is superior.

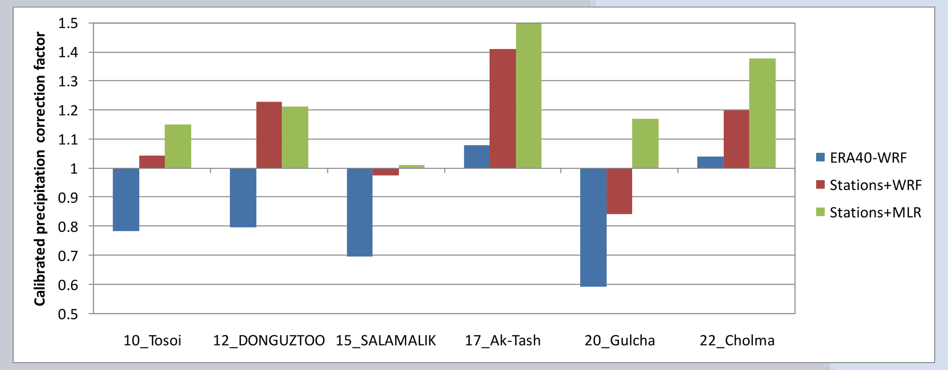
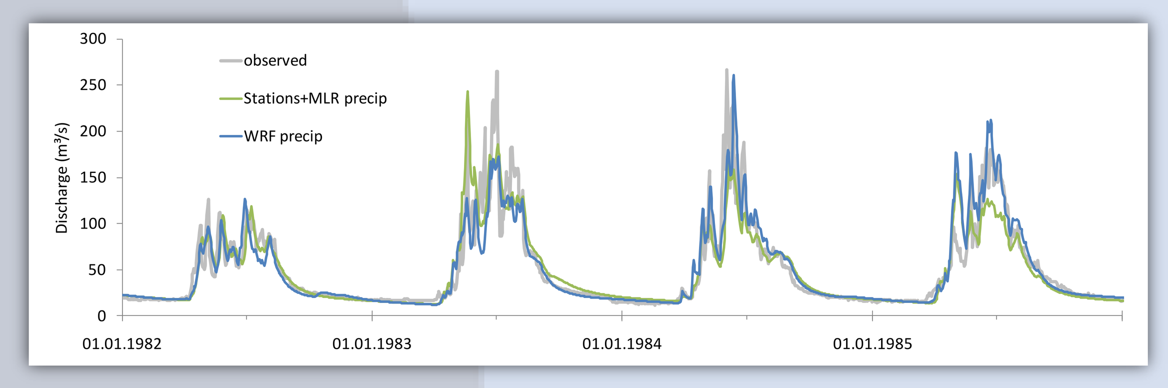


Fig. 6: Value of the calibrated precipitation correction factor for the three different precipitation input data sets and six subcatchments.

In most catchments the calibrated precipitation correction factor with WRF is less than one, and it is usually greater than one for the precipitation data sets based on station data. In Cholma where WRF outperformed the precipitation data based on station data, the precipitation correction factor is also close to one.

Fig. 7: Observed and simulated discharge with two different precipitation data sets for the subbasin Cholma.



Conclusions

- With respect to the achieved objective function value the hydrological model performed similarly well with the two data sets based on station data. The value of the calibrated precipitation correction factor however signifies differences between the two data sets and for example indicates that there are difficulties in Ak-Tash where the calibrated precipitation correction factor seems very large.
- Precipitation from the regional climate model correlates well with monthly measured station data, but both the comparison to station data and the calibrated correction factors in the hydrological model show an overestimation by WRF.
- Nevertheless in all subcatchments except one better objective function values are achieved using precipitation input based on station data.

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