Hydrological modelling for selected catchments in Central Asia

Doris Düthmann, Abror Gafurov, David Kriegel, Stefan Seeger, Sergiy Vorogushyn

The study aims at applying a semi-distributed hydrological model to selected catchments in Central Asia (Naryn, Karadarya, Zerafshan and Ala Archa). In this region water is used intensively for irrigation and the generation of hydropower. Together with the output of a regional climate model (REMO, University of Würzburg), the hydrological model will be used to investigate possible impacts of climate change on water resources.

The Karadarya catchment

- Second largest tributary to the Syr Darya River and an important water source for the Fergana valley.
- Area c. 12000 km².
- Average annual precipitation: between < 400 mm in the lowlands and intramountainous valleys to >1000 mm in the northwest.
- The seasonal precipitation distribution shows maxima in spring and autumn, but due to snowmelt maximum discharge values are observed during late spring and summer.

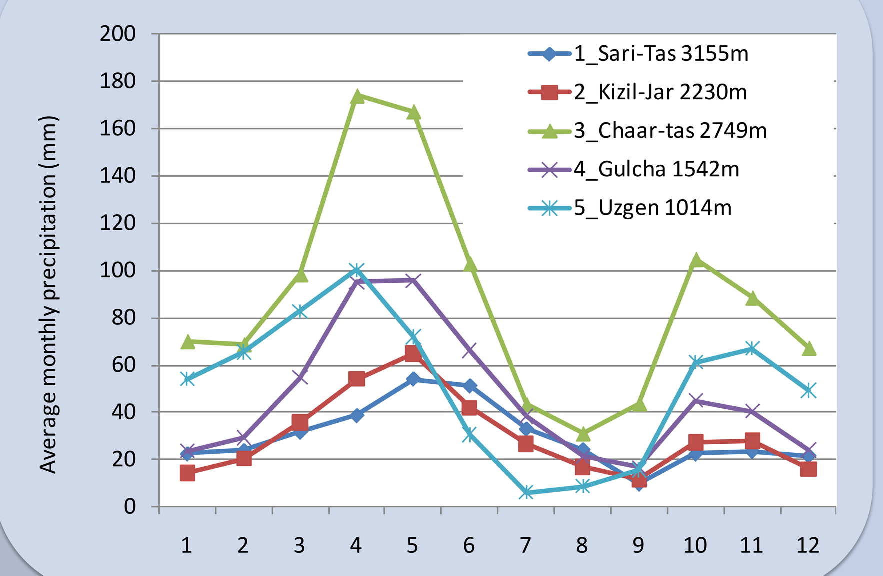

Fig. 1: Average monthly precipitation (1977-1991) for selected stations in the Karadarya basin (left), and topography and discharge stations in the Karadarya basin (right).

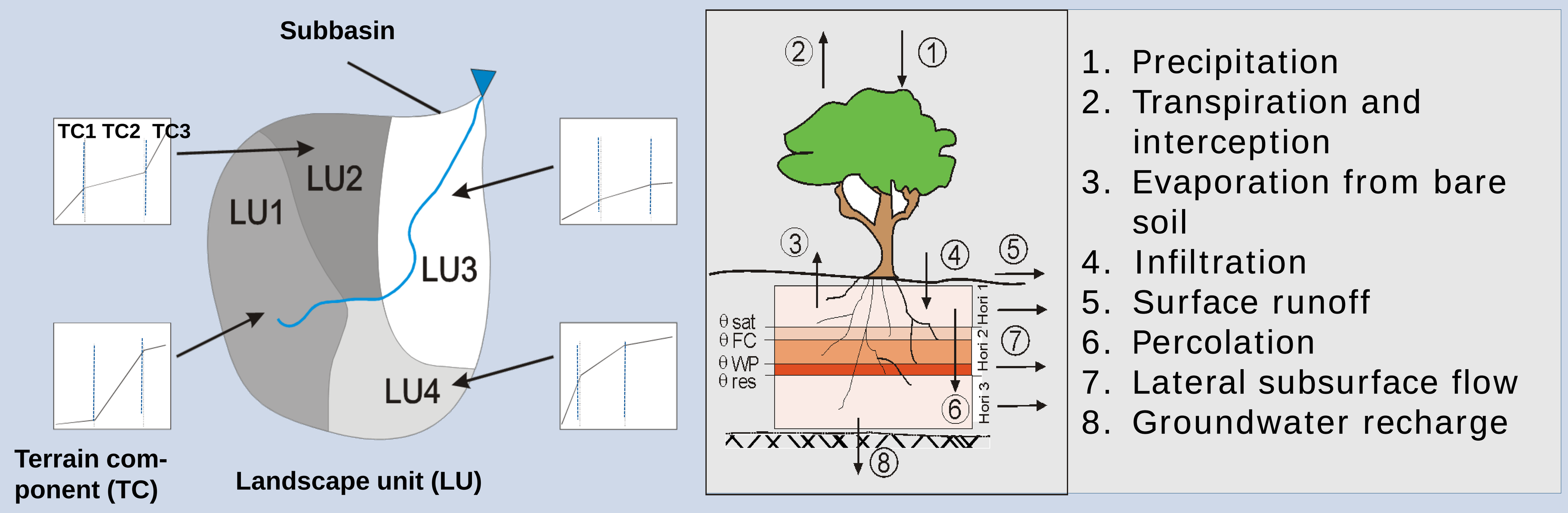

Fig. 2: Spatial discretisation and processes represented by the WASA model.

The hydrological model WASA

- Semi-distributed, spatial discretization based on representative hillslope profiles.
- Successfull applications to semi-arid catchments in Brazil and Spain.
- Extensions for high mountain areas: introduction of elevation zones, a snow melt module and a glacier mass balance module.

Integration of LAI from satellite data

- Advantages of using LAI (leaf area index) from satellite data
  - LAI values are specific for this region.
  - Variation of LAI with elevation zone and variability between years can usually not be covered with literature values, but may be significant in semi-arid areas with high elevation differences.
- For each subcatchment, average monthly LAI values are calculated by landcover class, elevation zone and aspect from MODIS data for 2001-2008.
- Multilinear regression model: in order to extrapolate to years where MODIS data are not available, these average monthly LAI values are related to meteorological parameters (cumulative precipitation and degree days).
- Next: impact of using this more detailed LAI representation on the simulated water balance elements.

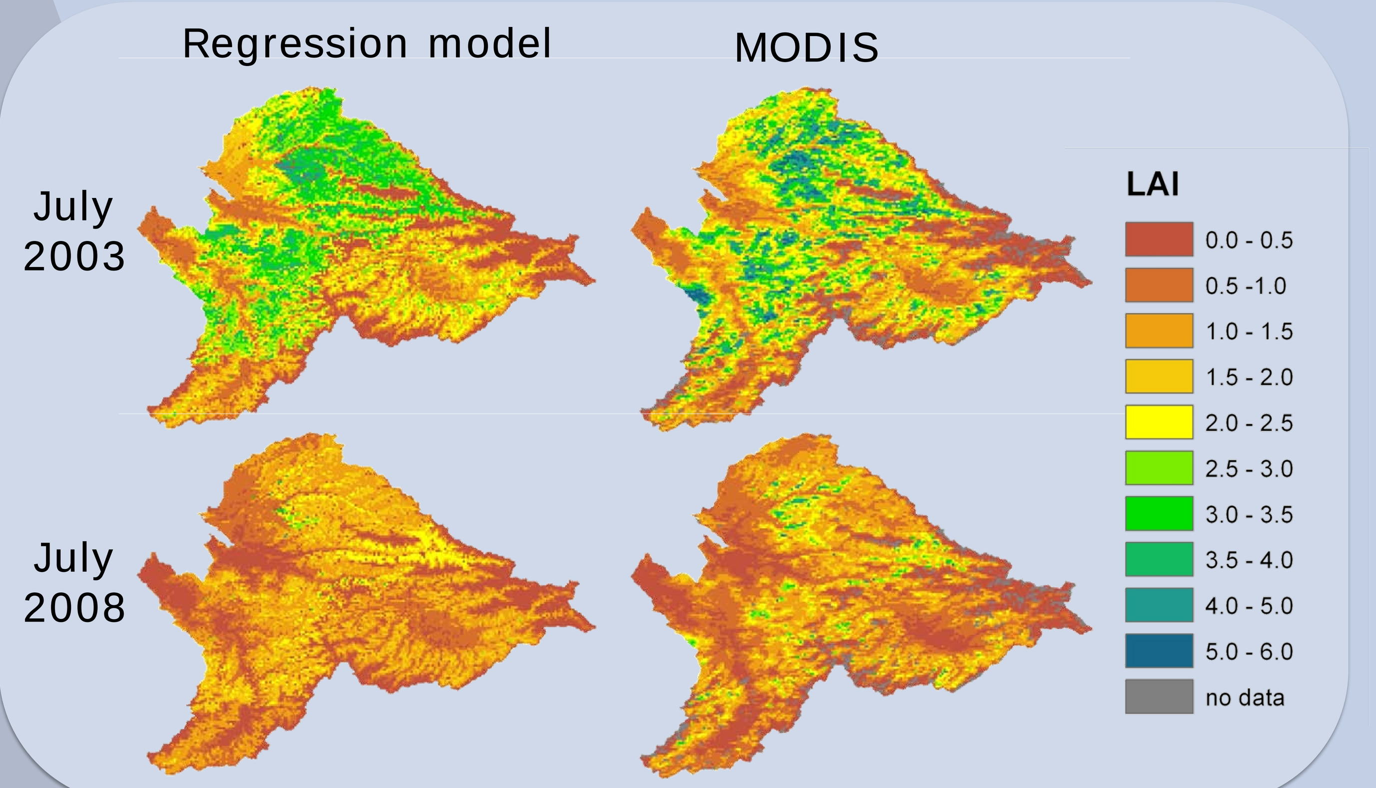

Fig. 3: LAI distribution for the Karadarya catchment directly from MODIS data and as represented by the regression model.

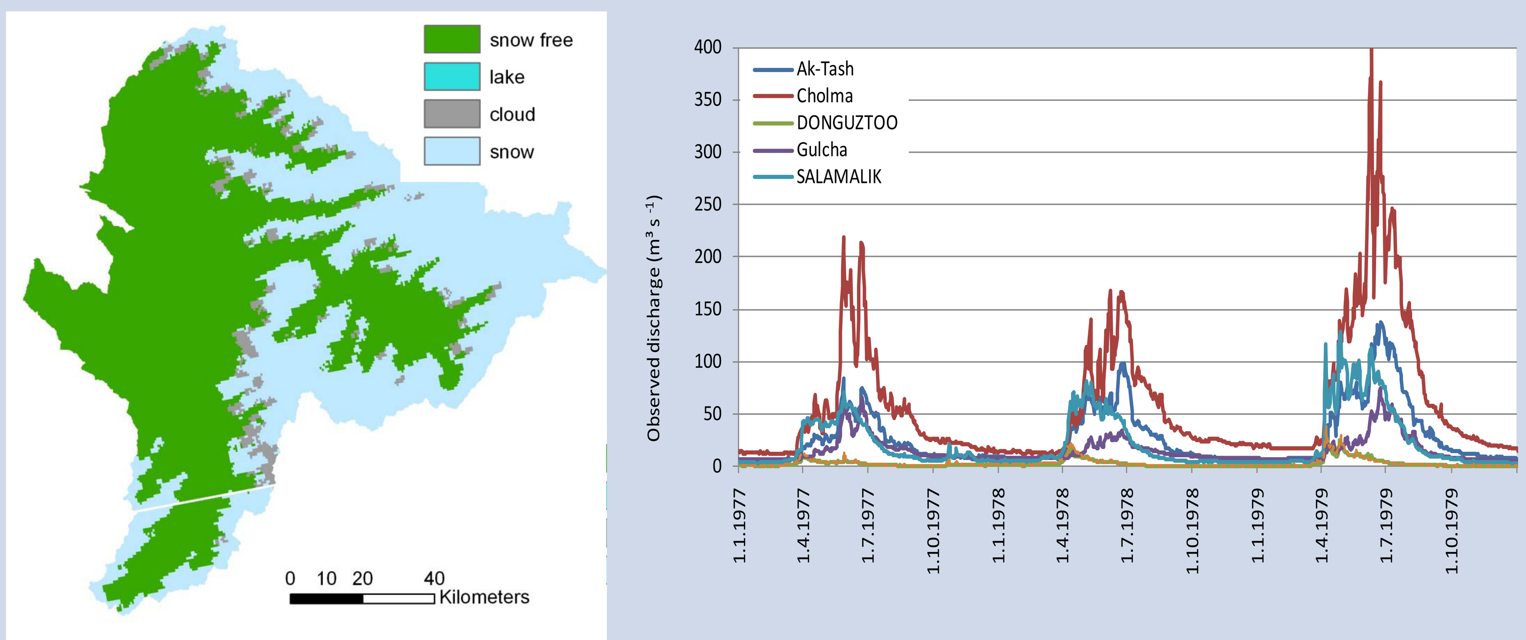

Fig. 4: Examples of MODIS snow cover map (29.4.2003) and discharge timeseries (1977-79) for the Karadarya basin.

Multi-objective calibration using discharge timeseries and satellite snow data

- Advantages of using satellite snow data for model calibration:
  - Snowmelt is the most important process for runoff generation in this catchment.
  - Spatial data, like satellite images, are very well suited for calibrating a spatially distributed model instead of calibrating the model to discharge data alone.
  - For the investigation of climate change impacts it is important that internal variables are simulated correctly.
- Daily snow maps: AVHRR: 1km resolution, from 1986
  MODIS: 500m resolution, from 2002
- Evaluation of match/mismatch of simulated snow water above a certain threshold vs. observed snowcover in the satellite image at terrain component level.

www.gfz-potsdam.de