

Strengthening Hydrological Modeling Curricula in CA Universities

Lessons Learned & Recommendations
from two Years of Cooperation

Meeting of the Network of Academic Society,
3rd Dushanbe Water Action Decade Conference

Dr. Tobias Siegfried, hydrosolutions GmbH
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Schweizerische Eidgenossenschaft
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**Swiss Agency for Development
and Cooperation SDC**

Blue
Peace
Central Asia



Background

Blue Peace CA (BPCA)

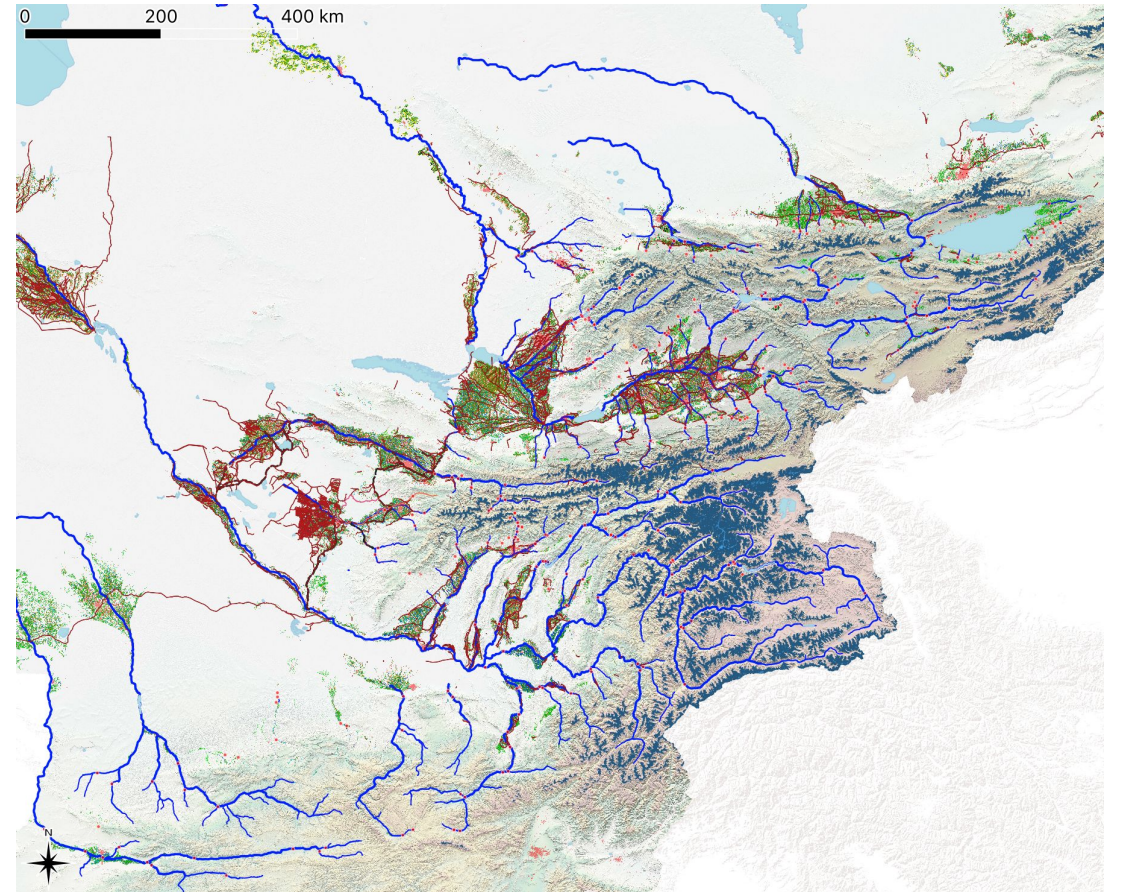
- Launched in 2010 by the Swiss Agency for Development and Cooperation
- BPCA Phase 1 (2017 – 2021) built on three pillars
 - Water diplomacy
 - Supporting action on the ground
 - Contribute to Educating future water leaders

Educational BPCA Pillar

- Support for the development of three tailored educational programs at the Masters level
 - WASH
 - **Applied Hydrological Modeling**
 - Hydrodiplomacy

MSc Course “Applied Modeling of Hydrological Systems in Central Asia”

- Educate on hydrological modeling specific to Central Asia, focusing on local hydrology and water challenges.
- Practical examples, covering fundamentals, data sources, and modeling approaches, focusing on hands-on learning.
- Open-source software and data with real-world examples encourage experimentation, replication, and adaptation to different local contexts.



Challenge: Wide Application Arena in Hydrological Modeling

Simulation of past/present conditions

- Filling of data gaps
- Resource management with elaboration of tradeoffs
- Basin planning
- Structure design

Forecasting

- Early warning (minutes/hourly time scales)
- Operational forecasting for sectors (daily/monthly/seasonal time scales)
- **Impact studies (decadal/centennial time scales)**



MSc Course Elements

- Hydrology and hydrological modeling primers
- Hydrological modeling scenarios and strategies for application
- Useful sources of relevant data and their access
- Data preparation and basin characterization
- Model implementation, calibration, and validation
- Analysis of results



MSc Course Elements

Effort

70%

20%

10%

- Hydrology and hydrological modeling primers
- Hydrological modeling scenarios and strategies for application
- Useful sources of relevant data and their access
- Data preparation and basin characterization
- Model implementation, calibration, and validation
- Analysis of results



Required Knowledge & Skill Set

- Water balance analysis and understanding of key fluxes in specific contexts
- Elements of numerical modeling
- Programming
- GIS
- Writing and presentation skills



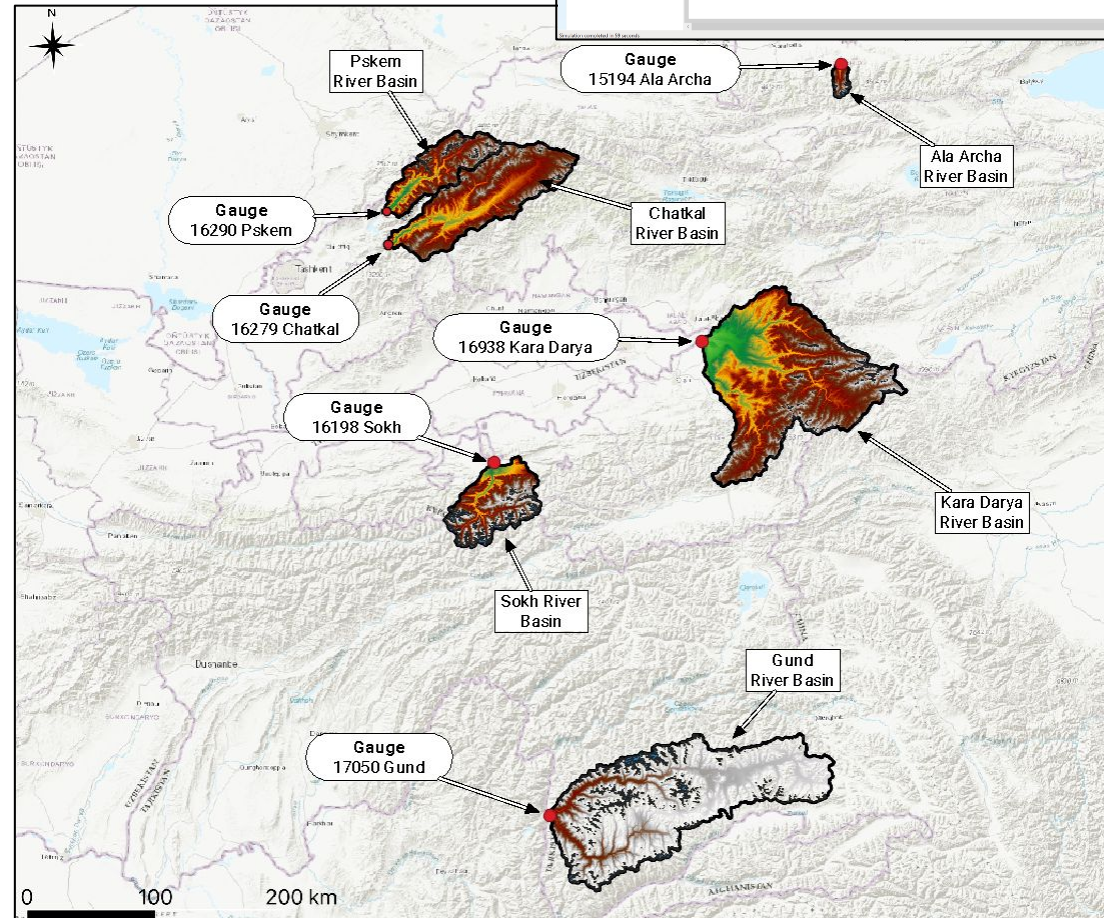
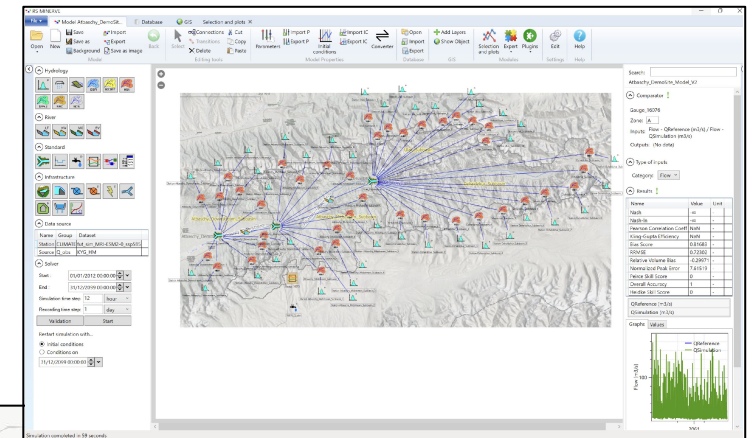
Open Access Data & Free Software

Data

- Geospatial data
- Climate and climate projections
- In-situ discharge data (where available)
- Cryosphere data

Software

- QGIS, R, RS Minerve
- R Package riversCentralAsia, hosted on GitHub



Online Coursebook, YouTube Channel

- [Online](#), free, up-to-date with frequent improvements by hydrosolutions GmbH
- Easy online translation into local languages
- Accompanying [YouTube channel](#) Ru/En videos

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Modeling of Hydrological Systems in Semi-Arid Central Asia

Q

About This Book

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 - A Software

Part I: Hydrology of Semi-Arid Central Asia > 1 Hydrological Systems in Semi-Arid Central Asia

1 Hydrological Systems in Semi-Arid Central Asia

Here, we provide a tour d'horizon of key hydrological systems in Central Asia and highlight important aspects of this complex, yet fascinating domain which is shown in [Figure 1.1](#). Note that from the hydrological perspective the region is defined to comprise the former Soviet Central Asia together with Afghanistan. Source: ZoI Environment Network.

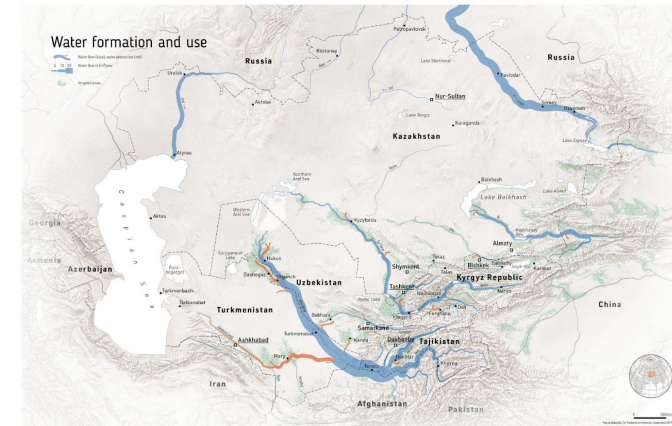


Figure 1.1: The Figure shows the entire Central Asia Region with the key rivers highlighted in blue color.

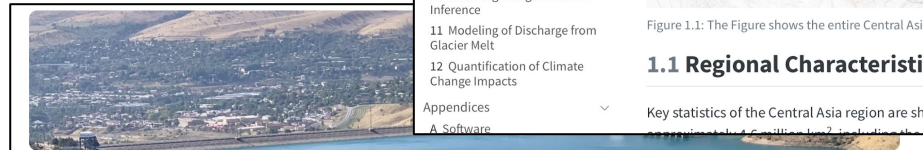
1.1 Regional Characteristics

Key statistics of the Central Asia region are shown in [Table 1.1](#). Central Asia is spreading over approximately 4.5 million km² including the territories of Kazakhstan, Kyrgyzstan, Tajikistan,

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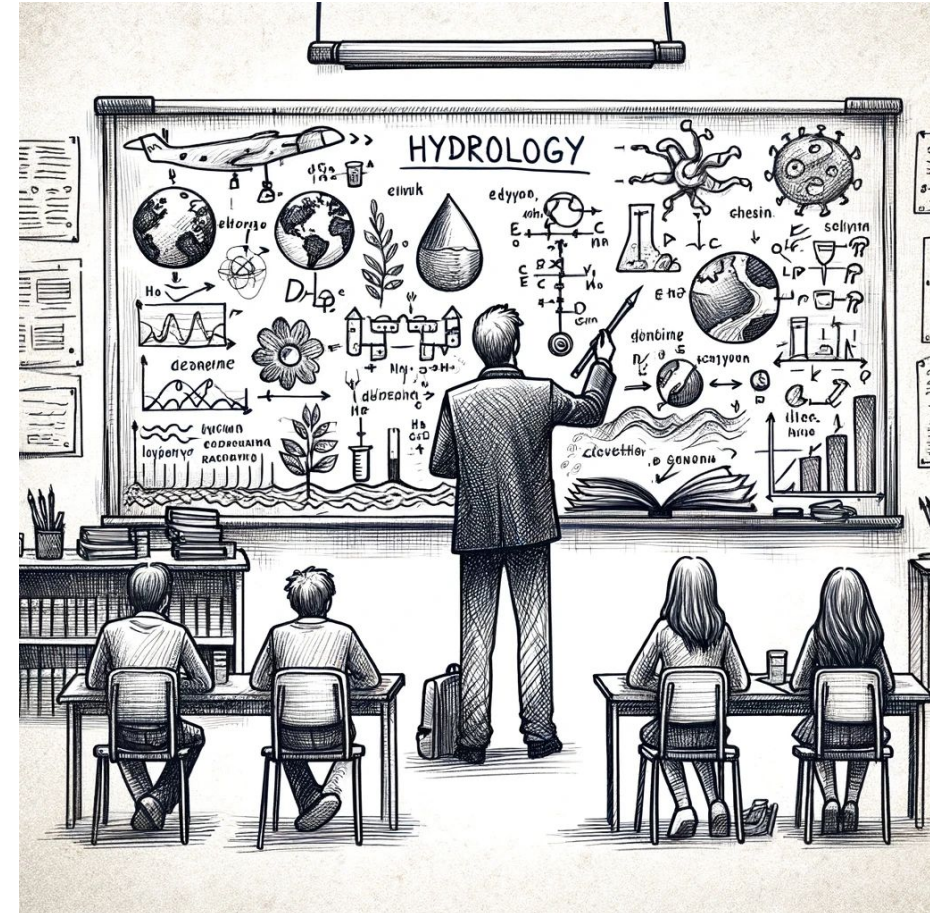
Гидрологические системы в засушливой Центральной Азии

предназначен для современного изучения гидрологии и математического анализа гидрологических систем в полусухой Центральной Азии. Он написан на студентах и преподавателях, которые хотели бы узнать об этих темах в образном. Книга использует философию открытого образования и предоставляет использование открытых данных и бесплатного программного обеспечения.

Мы предлагаем экскурсию по ключевым гидрологическим системам в Центральной Азии, с особым вниманием к этой сложной, но увлекательной области, которая как включавший в себя бывшую Советскую Центральную Азию с Исламским ниستانом. Источник: ZoI Environment Network.

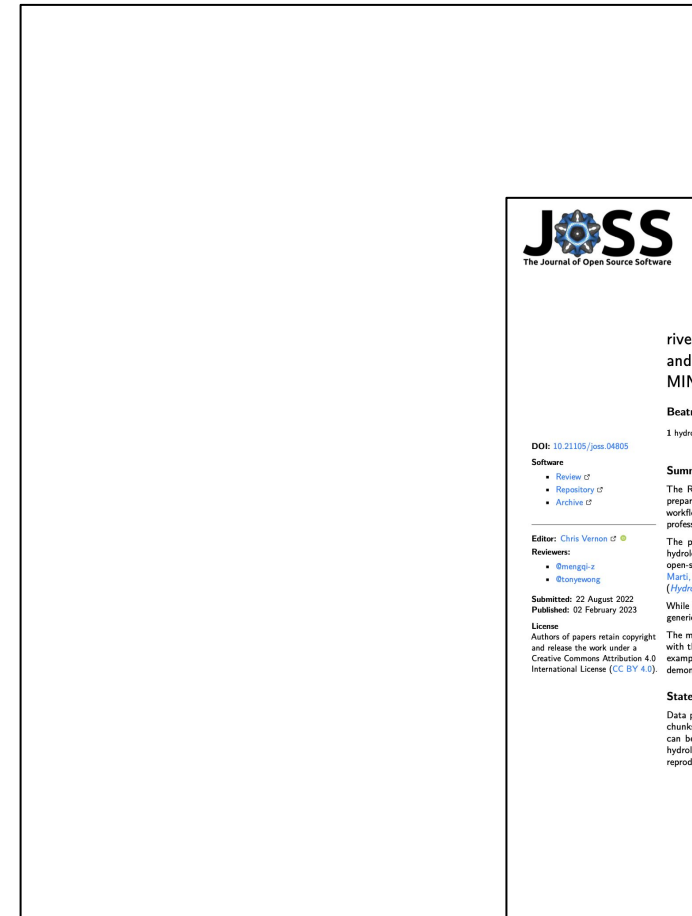
Execution


- Course integrated into German Kazakh University (DKU) Integrated Water Resources Management MSc program
- Two-week block courses at DKU 2021 – 2022 (extended to 2023) for 20 IWRM MSc students
- Two one-week training of trainers seminars in 2022. 25 teachers from 20 Universities attended
- Due to COVID-19 restrictions, all courses were held online only
- Following a subtopic-focused (modeling for climate impact), student-centered, inquiry-based collaborative learning approach



Results

- Training of 20 students and 25 professors and colleagues and friends gained
- DKU course continued for one more year despite a lack of funding
- Development of coursebook website, continued maintenance by hydrosolutions GmbH
- 2 peer-reviewed publications in international journals
- 1 scientific paper under review (MDPI Hydrology)
- 6-month visiting professor from KAZ in Zurich (additional financial support by [ETH4D](#))
- Update of coursebook content at ETH Zurich ([ETHZ](#)) and Technical University Munich ([TUM](#))





JOSS
The Journal of Open Source Software

riversCentralAsia: An R package to support data pre- and postprocessing for hydrological modelling with RS MINERVE

Beatrice Marti ¹* and Tobias Siegfried ¹*

¹ hydrosolutions GmbH, Zurich, Switzerland * These authors contributed equally.

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Summary

The R package *riversCentralAsia* includes a set of tools to facilitate and automate data preparation for hydrological modelling. It thus contributes to more reproducible modelling workflows and makes hydrological modelling more accessible to students and to interested professional modellers.

The package has been developed within the frame of a master level course on applied hydrological modelling in Central Asia (B. S. Marti et al., 2023) and is extensively used in the open-source book "Modelling of Hydrological Systems in Semi-Arid Central Asia" (Siegfried & Marti, 2022). The workflows are further validated within the Horizon 2020 project HYDRO4U (Hydro4U Project Web Site, 2022).

While the package has been developed for the Central Asia region, most of the functions are generic and can be used for modelling projects anywhere in the world.

The most important functionalities of the package as well as the data that can be processed with the package are described in the articles of the [project documentation site](#) but the examples in the course book "Modelling of Hydrological Systems in Semi-Arid Central Asia" demonstrate the full range of functions available and how to use them in a workflow.

Statement of need

Data preparation comes before hydrological modelling and is actually one of the biggest work chunks in the modelling process. This package includes a number of helper functions that can be connected to efficient workflows that automatize the data preparation process for hydrological modelling, as shown in the figure below. The package thereby supports a more reproducible modelling workflow and improves the scalability of hydrological modelling.

Marti, & Siegfried. (2023). *riversCentralAsia*: An R package to support data pre- and postprocessing for hydrological modelling with RS MINERVE. 1. Journal of Open Source Software, 4(82). 4850. <https://doi.org/10.21105/joss.04805>.

Modeling of Hydrological Systems in Semi-Arid Central Asia ^{CF} ^{CF}

2024 Q1 Edition hydrosolutions GmbH

AUTHOR: Tobias Siegfried, Beatrice Marti, Adrian Weber, and Akbar Zhumabev

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About This Book

This handbook is designed to serve as a comprehensive guide for early- or in-career water professionals engaged in the hydrological modelling of river basins within Central Asia. It addresses the intricacies of the natural and anthropogenically influenced hydrological systems characteristic of this region. The text underscores the dual nature of the challenges faced by these professionals. On the one hand, contemporary hydrological modelling must navigate the multifaceted acknowledgment of property and the long-term water balance modelling. On the other hand, the region's historical context is essential for understanding the challenges of climate change from the El Niño event.

Part I: Hydrological Modelling & Applications

- 1. Hydrological Systems in Semi-Arid Central Asia
- 2. Case Study: River Basins
- Part II: Data Sources, Assessment and Preparation
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Appendices

- A. Software
- B. R Package *riversCentralAsia*
- C. Quick Start
- D. Example Solutions



Learnings

Students

- Content delivery via a two-week block course format is not optimal (the topic is broad, and the required skill set is too wide-ranging).
- Learning via video lectures on YouTube is the most popular knowledge delivery format. Reading materials are rarely consulted.

Trainers

- Often unaware of opportunities for integrating open-source software and open data archives into teaching.
- Adapting existing courses requires extra work and commitment, which is critical with limited time and resources.

Recommendations

- **Embedding** Develop course in conjunction with dedicated GIS and programming courses
- **Timing** Recommendation to teach material over one semester-long course
- **Linking** Better link CA Universities with peers from Europe/US
- **Funding** Development of a local research funding stream, e.g., for research on transboundary water resources issues
- **Perspective** Donors should take a more long-term perspective when supporting education in the region (opportunity for SDC BPCA Phase 2)



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Contact

Dr. Tobias Siegfried
hydrosolutions GmbH
Venusstrasse 29
CH-8050 Zurich
Switzerland

+41 43 535 05 80

email: siegfried@hydrosolutions.ch

web: <http://www.hydrosolutions.ch>