Innovations for Water Management in the Global Drylands

Presentation of Selected Work

Zurich, Switzerland, August 2019

hydrosolutions ltd.

Spinoff ETHzürich

Team of Experts

Dr. Tobias Siegfried   Dr. Haijing Wang   Dr. Beatrice Marti   Dr. Silvan Ragettli

More than 20 years of extensive experience in water and related fields and as practitioners on the ground in China, Africa, the Middle East, India, Central Asia and Europe, including Switzerland.

Advisory board

Prof. Dr. W. Kinzelbach   Prof. Dr. T. Bernauer   Dr. Lucas Beck

Selected Project Partners

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

**Swiss Agency for Development
And Cooperation (SDC)**
&
**Swiss Federal Office for the
Environment (FOEN)**

WSL   THE WORLD BANK   IFPRI INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE   IWMI International Water Management Institute   FAO FIAT PANIS   World Meteorological Organization Weather · Climate · Water

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hydrosolutions ltd. – Competences

Water Resources Management & Water Information Systems

Water Resources Management supported by Satellite Remote Sensing

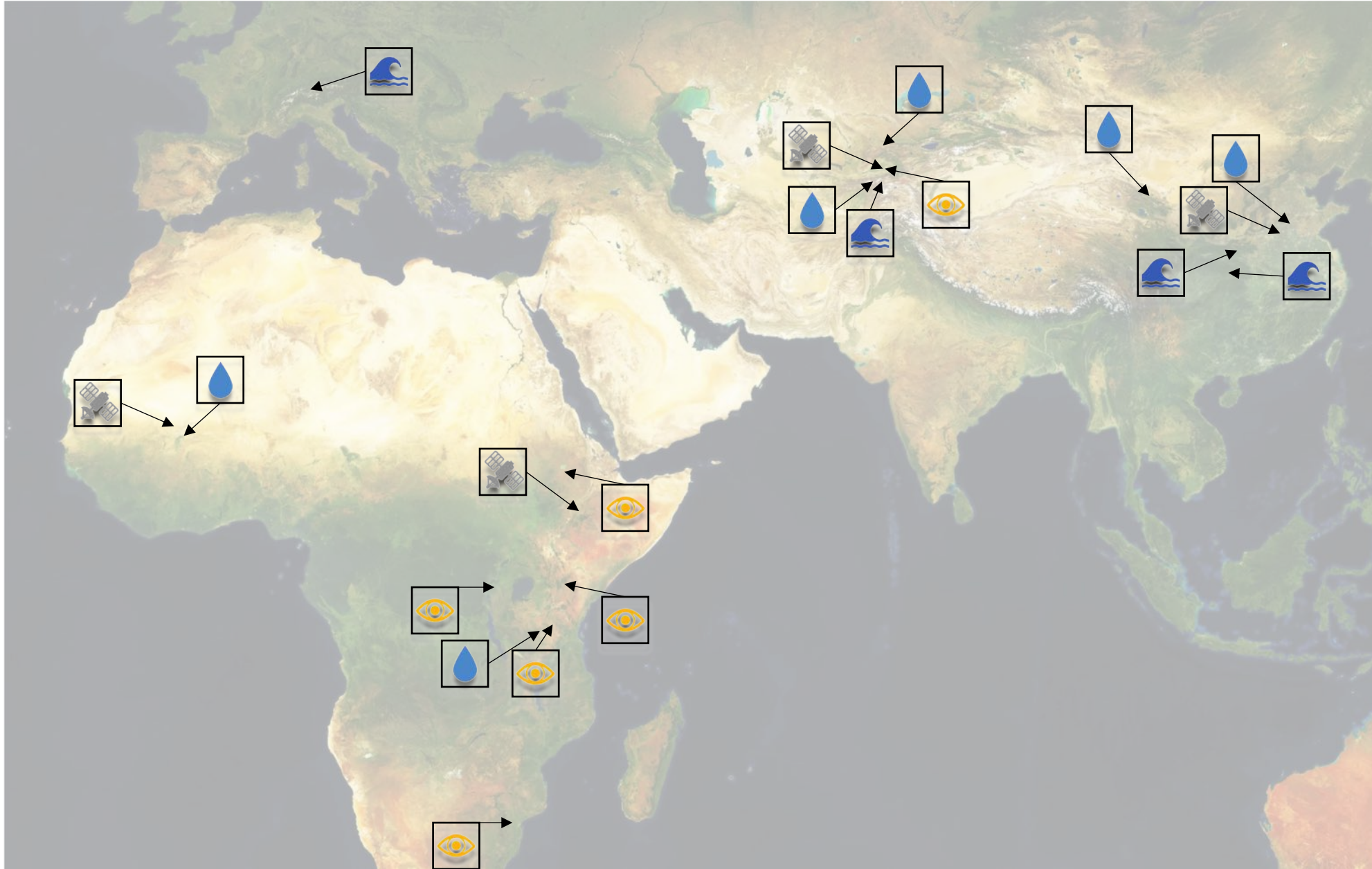Non-Traditional Water Monitoring Through Local Involvement

Flood-risk Management

hydrosolutions ltd., a Swiss-based consulting company, develops and deploys innovative technologies for multi-scale water resources management. These range from the collection of non-traditional data through local involvement to planetary-scale remote sensing and state-of-the-art water balance modeling, including forecasting, for accounting and accountability and the definition of best management strategies and tradeoffs under a changing climate and increasing population pressure.

hydrosolutions ltd. has a global focus with a large footprint in semi-arid and arid regions where the company has extensive experience in agricultural irrigation water management, among other things. Their solutions are modular, custom-tailored (co-designed with local stakeholders) and based on inter-operable web and mobile communication technologies, thus providing essential building blocks for modern Water Information Systems. This greatly help stakeholders in effective and sustainable resources management and planning with the goal to turn complex development challenges into opportunities for sustained growth.

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hydrosolutions ltd. – Project Locations

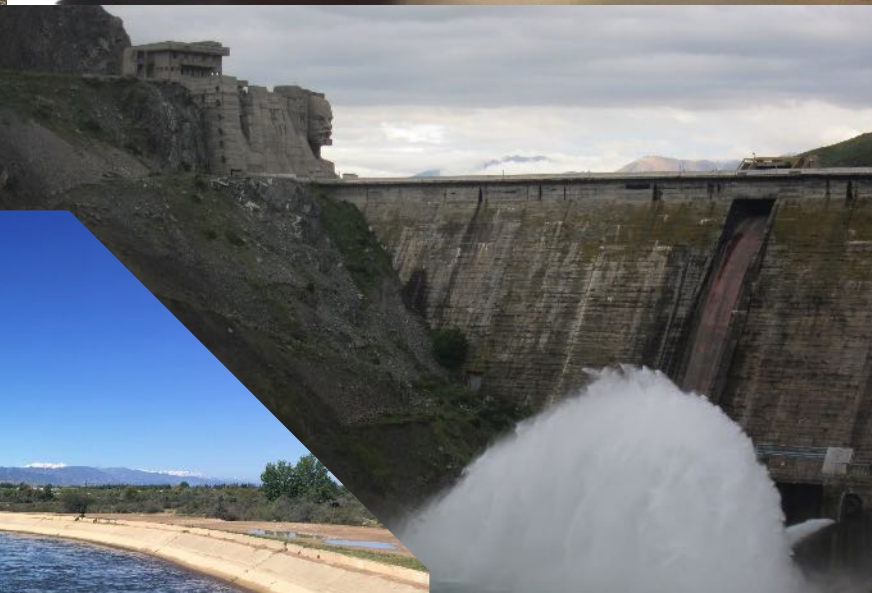Water Resources Management & Water Information Systems

Water Resources Management supported by Satellite Remote Sensing

Non-Traditional Water Monitoring Through Local Involvement
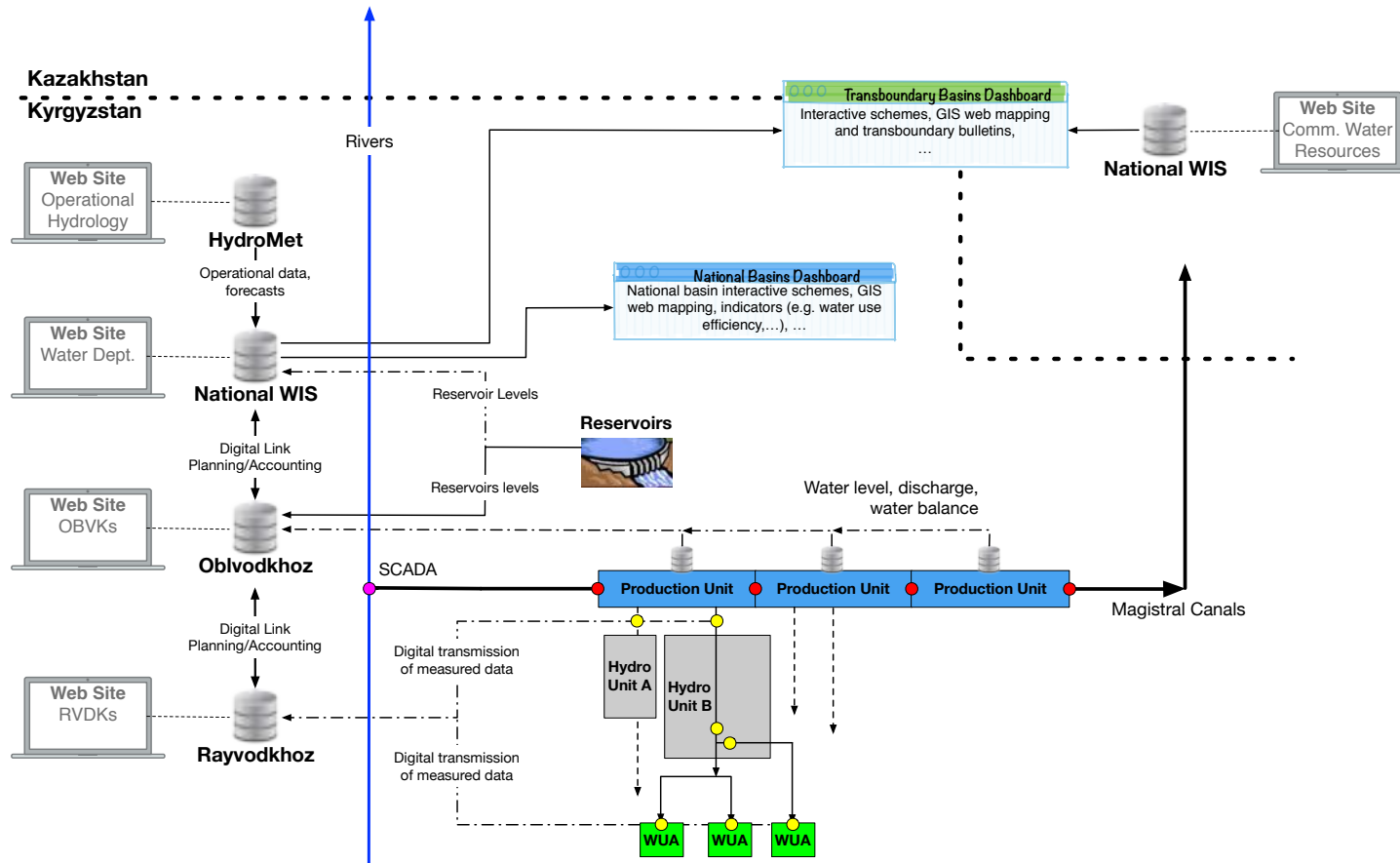
Flood-risk Management

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Project Region: Central Asia

Project Region: China

Project
Region:
Africa

hydrosolutions ltd. – Projects

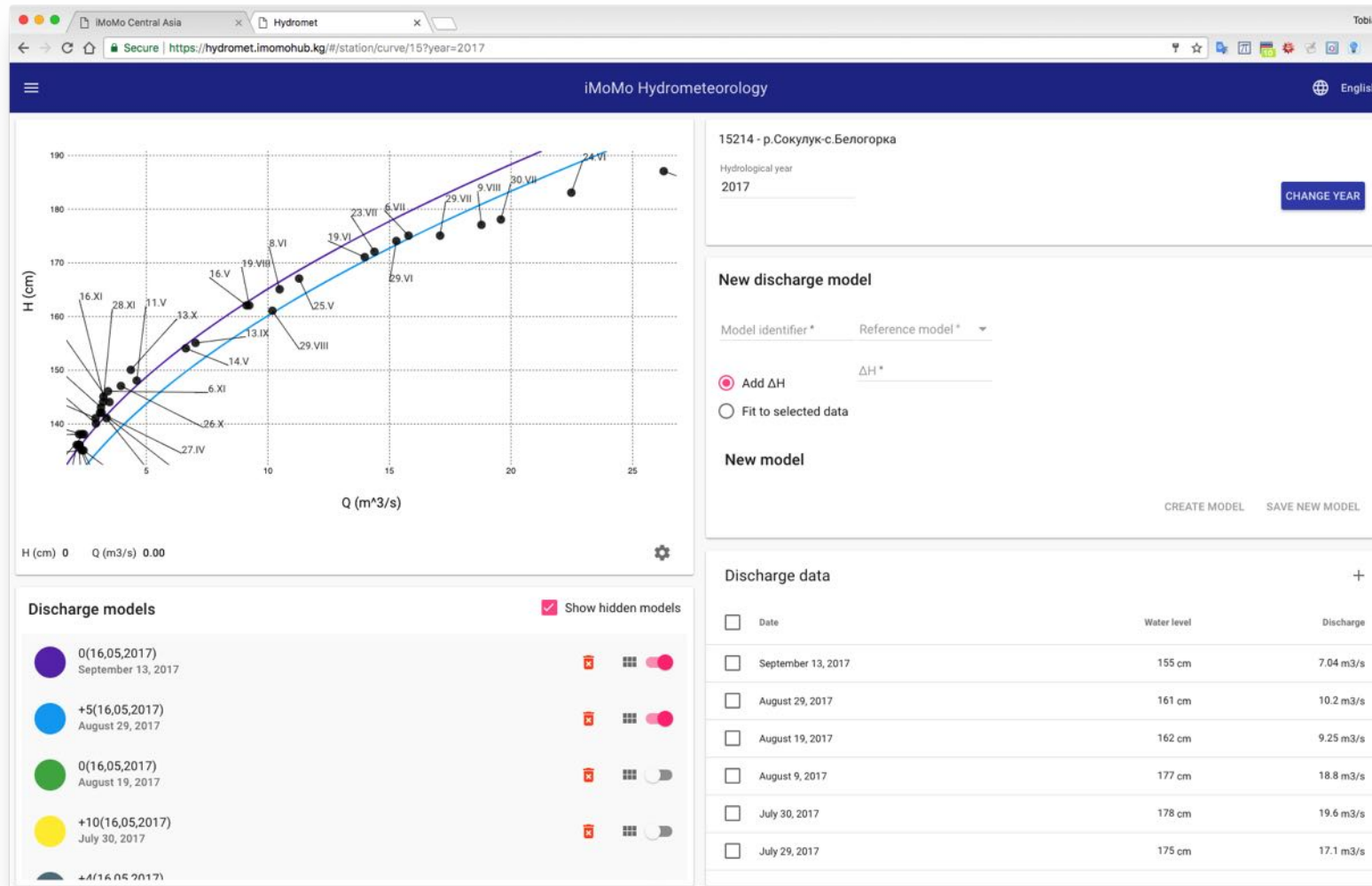Water Resources Management & Water Information Systems

Project Title: Water Accountability in Transboundary Chu Talas River Basins

Focus Region: Transboundary Chu-Talas River Basins, Kyrgyzstan and Kazakhstan

Partner Institution: Various Kyrgyz and Kazakh Water Stakeholders

- Modernization of pathway from observation to decision-support
- Modern data acquisition, including through local involvement and by remote sensing
- Improving analytical capacity for management and planning
- **Facts-based Accounting = Foundation for 'Blue Peace'**

Project Title: Modern Operational Hydrology in Central Asian Hydromets

Focus Region: Central Asian Republics

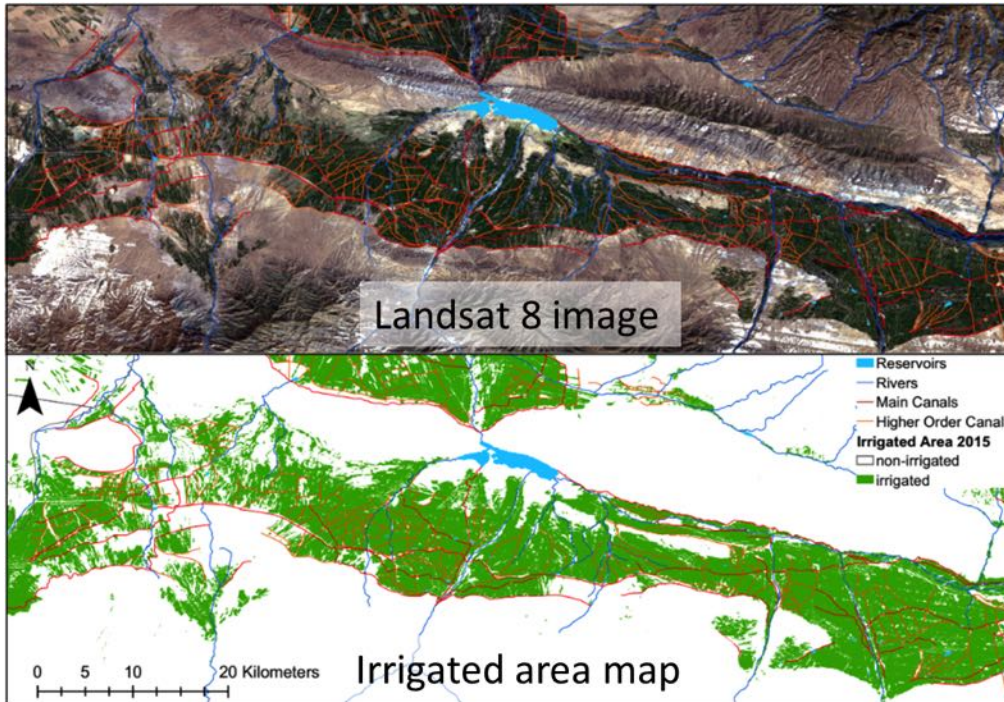**Partner Institution**: Central Asian Hydrometeorological Agencies

Implementation of fully digitized workflows, including for the

- Management and exchange of digital runoff data
- Maintenance of rating curves for an arbitrary number of stations
- Generation of operational journals and hydrological bulletins
- Forecasting river discharge through machine learning

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Mapping irrigated areas

Landsat 8 image

Reservoirs
Rivers
Main Canals
Higher Order Canals
Irrigated Area 2015
non-irrigated
irrigated

0   5   10   20 Kilometers

Irrigated area map

*Remote Sensing* **2018**, *10*(11), 1823; https://doi.org/10.3390/rs10111823

Project Title: Water Accountability in Transboundary Chu Talas River Basins

Focus Region: Transboundary Chu-Talas River Basins, Kyrgyzstan and Kazakhstan

Partner Institution: Department of Water and Land Melioration, Kyrgyzstan

Irrigation is the largest consumer of water. In semi-arid to arid places, the monitoring of irrigated area and its development in space and over time is important to account for precisely for this reason. We use state-of-the-art algorithm for global scale mapping that can deliver high-precision inputs for decision-making in the irrigation sector.

- Operational production of high-resolution irrigation maps to assess water use and productivity.
- Execution of performance diagnoses and impact assessments.
- Strategic planning, ease operations, control water rights.
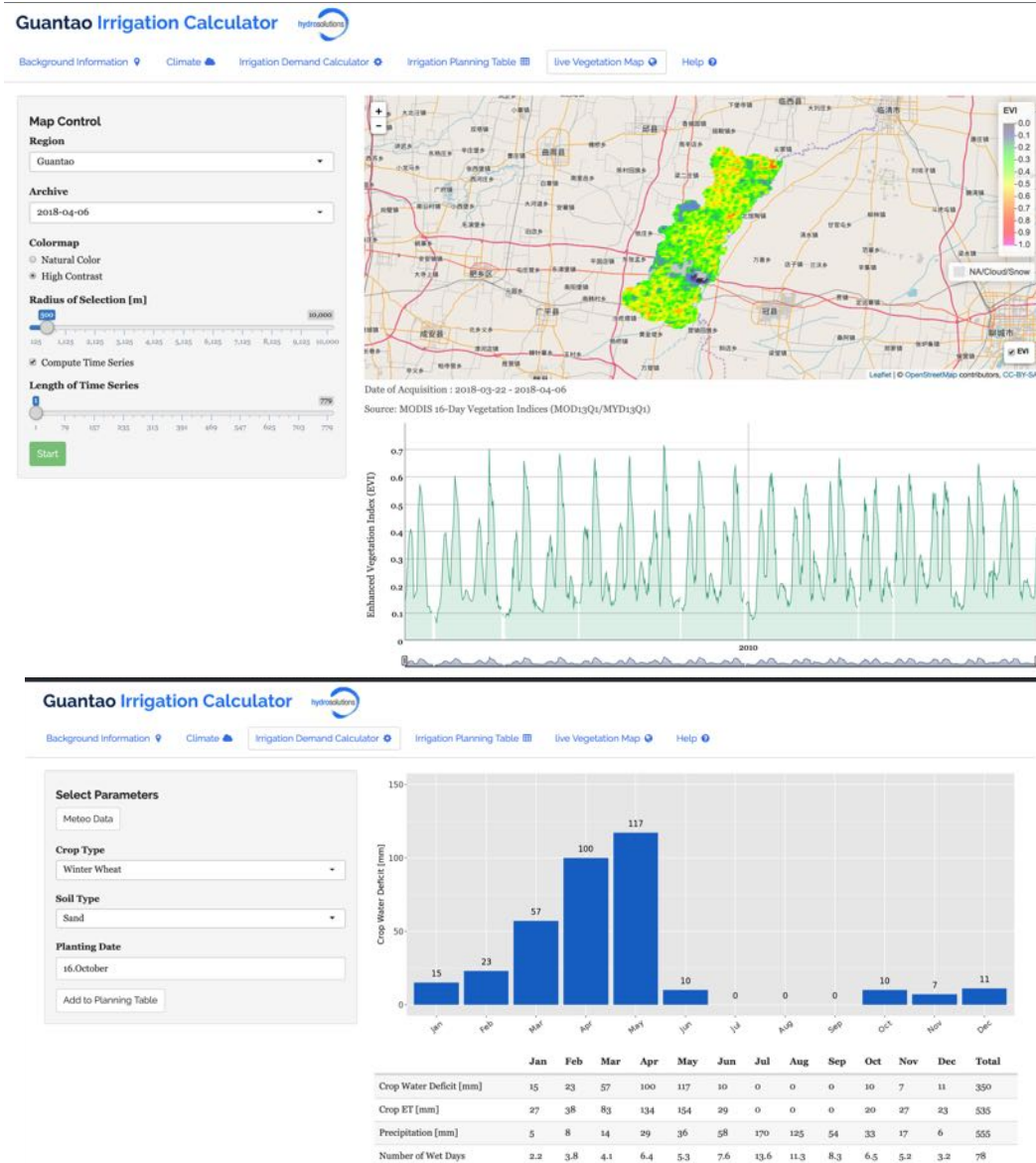
hydrosolutions ltd. – Projects

Computation of irrigation norms

Project Title: Rehabilitation and Management Strategy for Over-Pumped Aquifers under a Changing Climate

Focus Region: Handan Prefecture, Hebei Province, China

Partner Institutions: ETH Zurich, Design Institute of the Chinese Ministry of Water Resources; Local Departments of Water Resources

- Irrigation norms determine crop water needs for optimal growth conditions as a function of soil melioration conditions, climate and crop type.
- The are required for water and crop planning and water scheduling in irrigation systems.
- Our irrigation calculator is an online tool to
  - estimate crop water deficits
  - determine optimal crop water application
  - monitor regional cropping activity
- The method is based on FAOs Aquacrop model. The irrigation calculator is available online and can be easily tailored to specific circumstances.

hydrosolutions ltd. – Projects
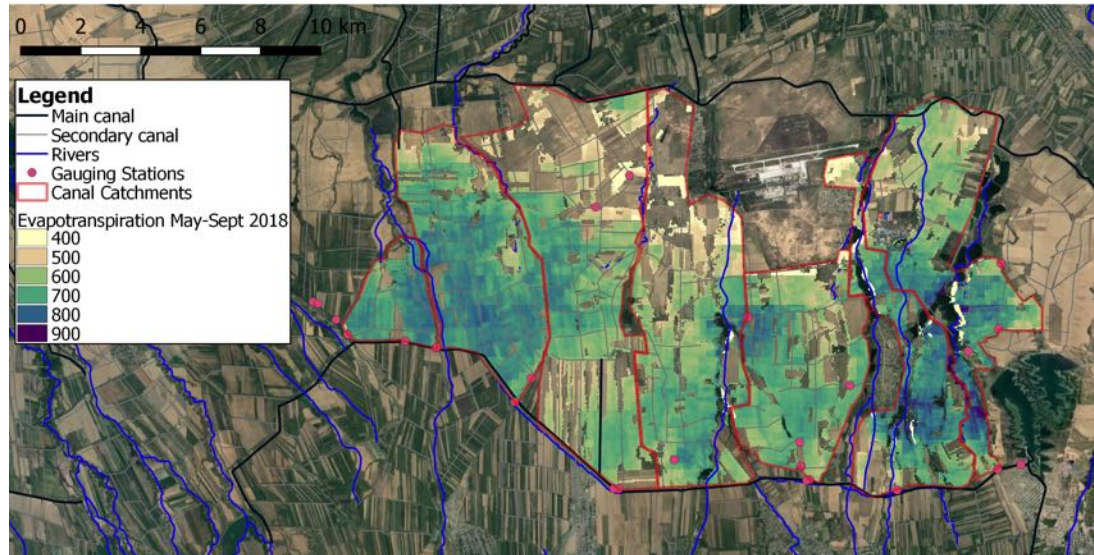
Irrigation Efficiency – Sovhoznyi Scheme, Year 2018 Evapotranspiration*

Water Balance:
$$Losses = Q_{net} + P - ET$$

Losses in % Irrigation Water:
$$Losses[\%] = 100 \cdot \frac{Q_{net} + P - ET}{Q_{net}}$$

LOSSES: Losses to soil and discharge canals
ET: Evapotranspiration (computed using remote sensing data)
Q_{net}:   Irrigation Water (data from water authorities)
P: In-season precipitation (station or reanalysis data)

*: Computed using METRIC – Algorithm (see also https://en.wikipedia.org/wiki/METRIC)

Project Title: Water Accountability in Transboundary Chu Talas River Basins
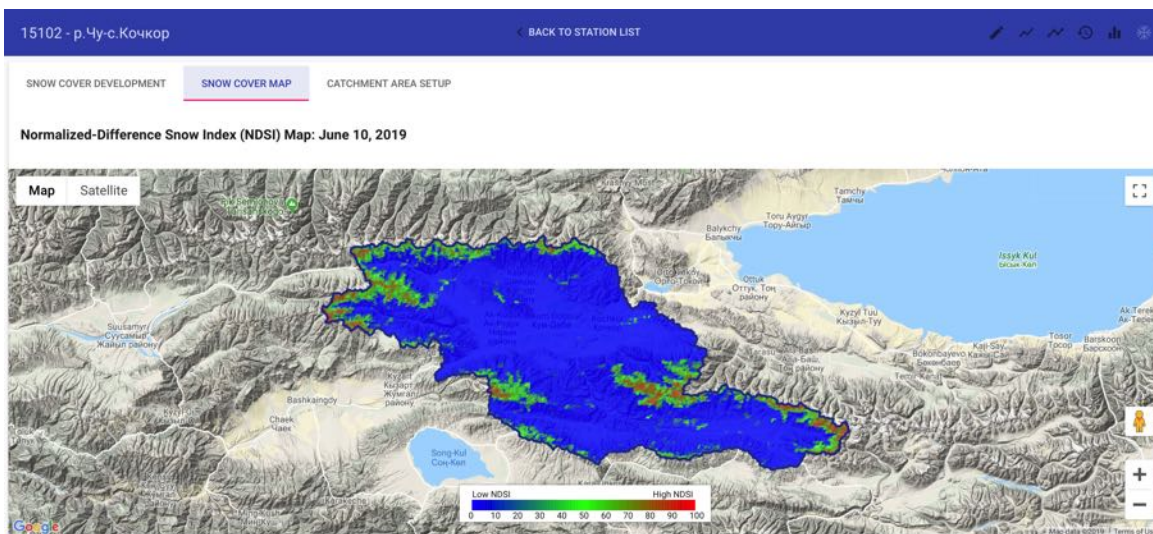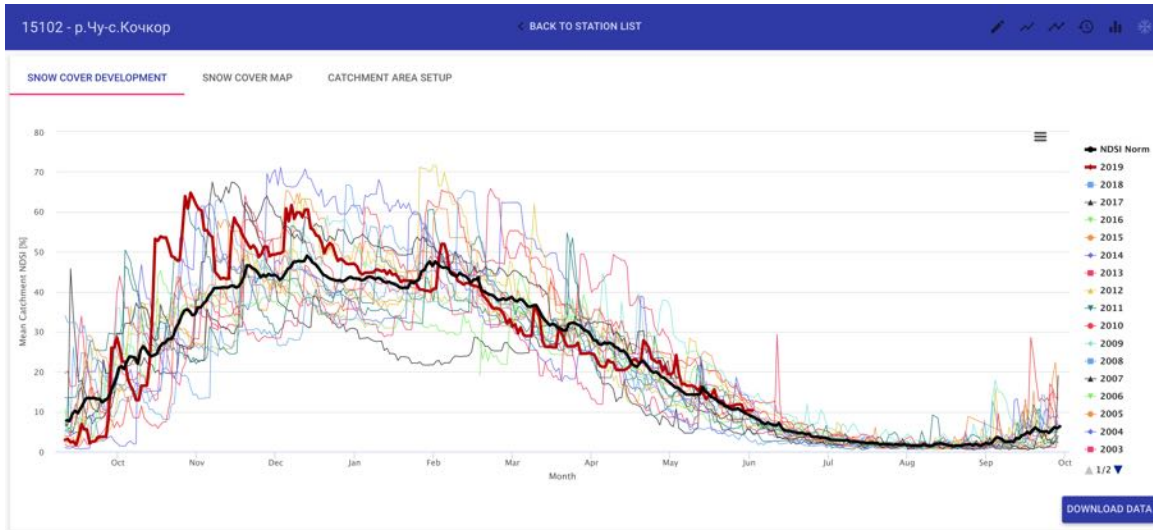**Focus Region**: Transboundary Chu-Talas River Basins, Kyrgyzstan and Kazakhstan
Partner Institution: Department of Water and Land Melioration, Kyrgyzstan

The minimization of unproductive losses of water deliveries is key where water is scarce. The methods that we have developed for tracking irrigation efficiency allows for the cost-effective and scalable mapping of this performance indicator, from the canal up to the scheme- and oasis-level. The information is vital for scheme managers who must prioritize rehabilitation measures under budget constraints.

- Quantification of all relevant water balance components.
- Obtain the irrigation efficiency by relating water losses to the total amount of irrigation water.
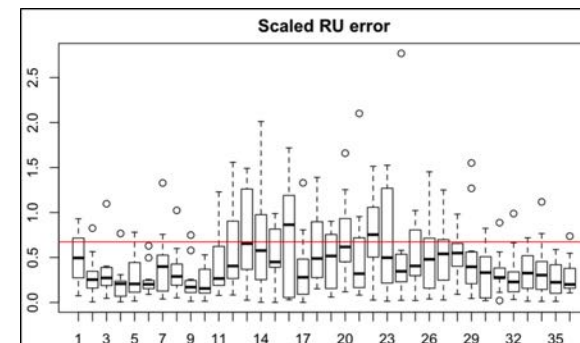
Water balance & irrigation efficiency

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hydrosolutions ltd. – Projects

Snow cover information for improved forecasts

Project Title: Modern Operational Hydrology in Central Asian Hydromets

Focus Region: Central Asian Republics

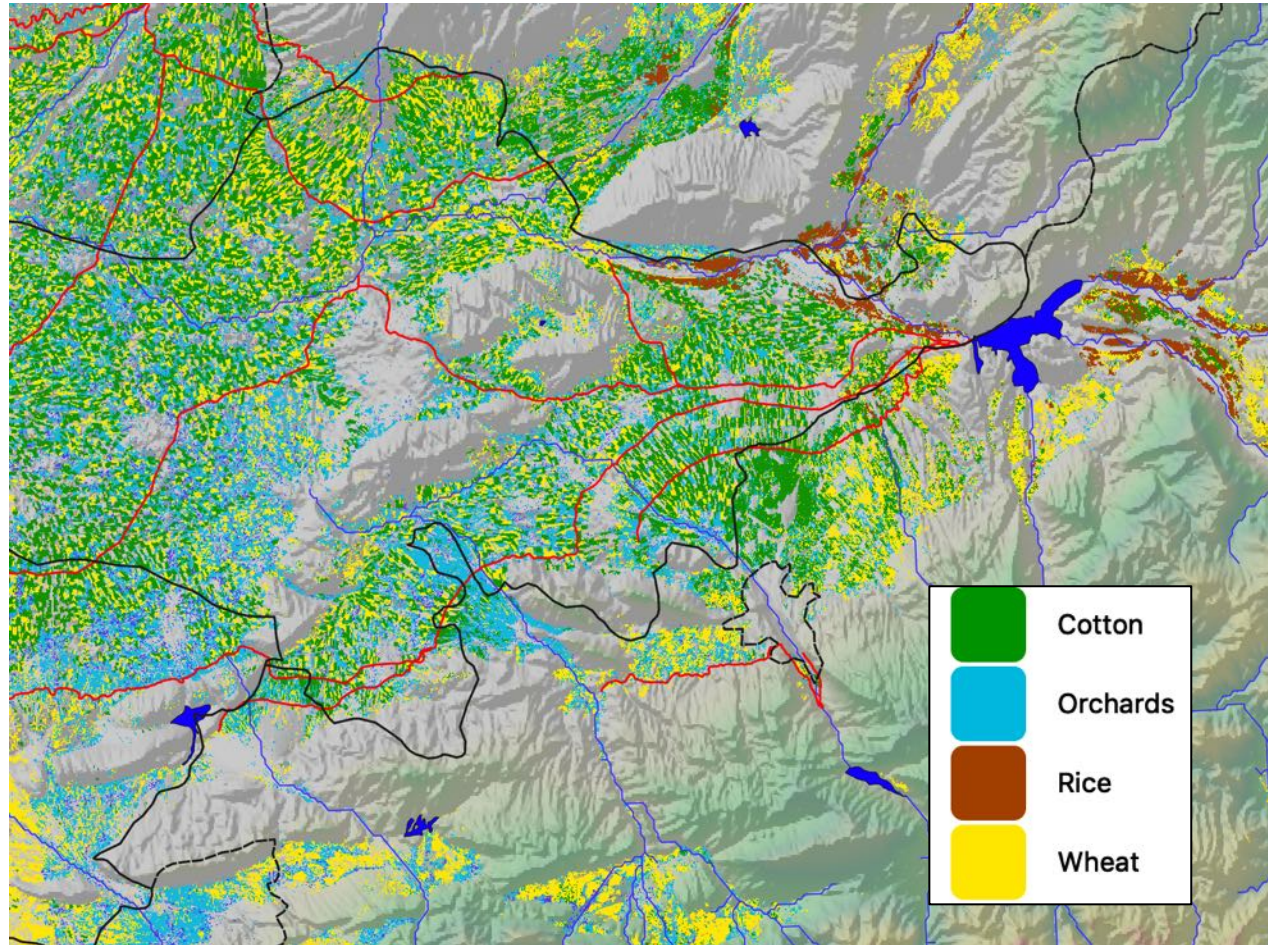**Partner Institution**: Central Asian Hydrometeorological Agencies

Hydrological forecasts in regions where summer flows are snow-melt dominated benefit from a precise knowledge of the mountainous snow cover and its development over time in catchments of interest.

The tool that we have developed in close collaboration with the Central Asia Hydromets automatically tracks snow cover over time and the resulting data can be used in powerful machine learning prediction routines to forecast discharge at different lead times.

Mapping crop types

Eastern Fergana Valley, mapped crop types during the July-September 2018 period.

Legend:
- Cotton (green)
- Orchards (light blue)
- Rice (brown)
- Wheat (yellow)

Project Title: Improving Rural Water Supply in Uzbekistan

Focus Region: Fergana Valley, Central Asia
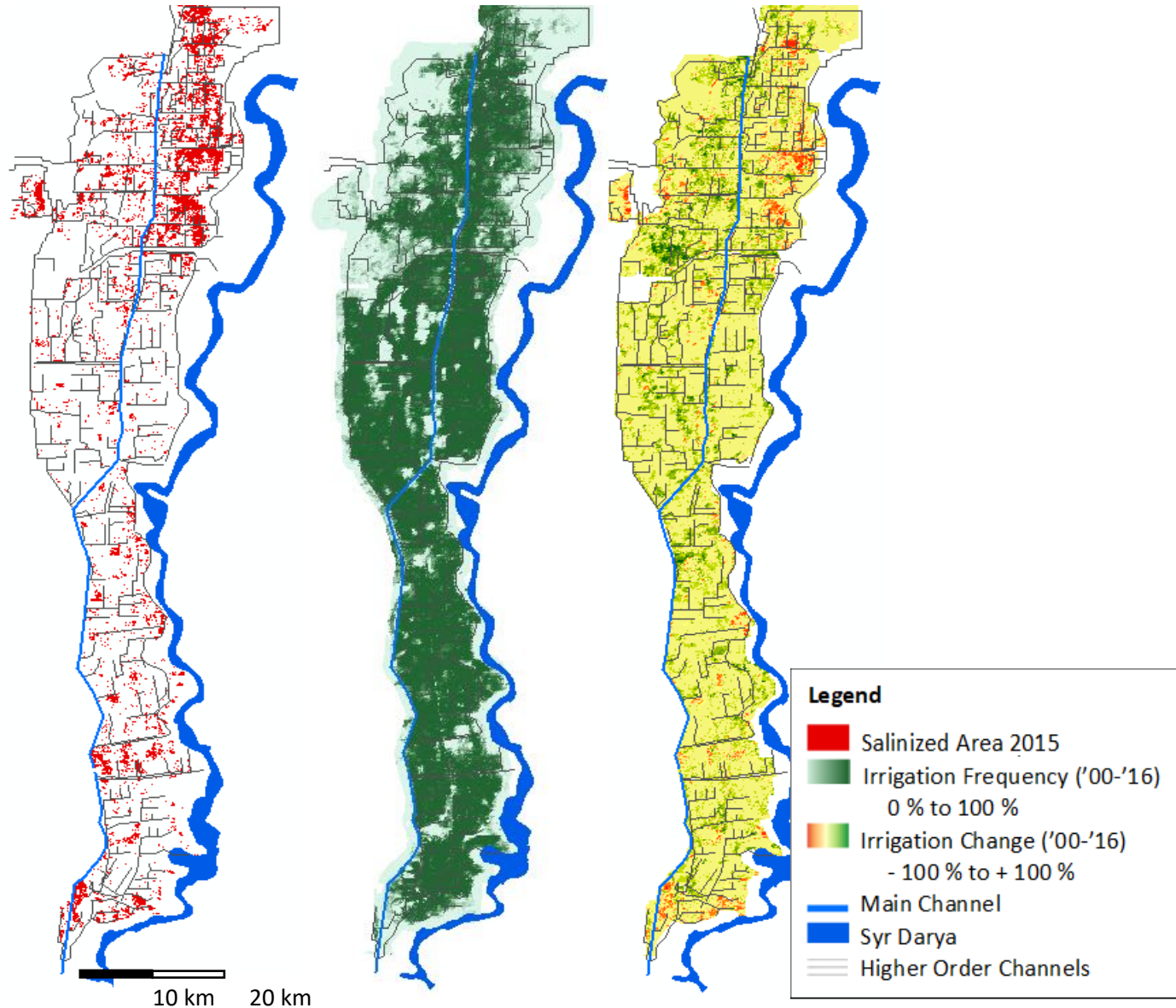
Partner Institution: IWMI Central Asia

In the global drylands, modern remote-sensing can greatly help to accurately track irrigated areas, including the types of crops planted.

Our methods for doing so rely on minimal amounts of in-situ information as they are based on unsupervised learning. The information obtained can be used for water planning / scheduling by authorities but also for tracking illegal water use.

- Crop types are identified based on a cluster analysis of radar backscatter data and optical remote sensing data.
- Crop evapotranspiration obtained from remote sensing data is related to crop types and vegetative stages.
- Large regions can bee analyzed for benchmarking of irrigation consumption by type of culture.

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Mapping melioration conditions

Legend

- 🟥 Salinized Area 2015
- Irrigation Frequency ('00-'16) 0 % to 100 %
- Irrigation Change ('00-'16) - 100 % to + 100 %
- ▬ Main Channel
- ▬ Syr Darya
- ▬ Higher Order Channels

10 km   20 km

Project Title: Water Balance Study of the Kyzylkum Irrigation Scheme in South Kazakhstan

Focus Region: South Kazakhstan, Kyzylkum Irrigation Massive

Partner Institution: South Kazakhstan Hydro-Geological-Meliorative Expedition, The World Bank

- More than one third of the world's irrigated land is affected by water logging & salinization
- To prevent salinization of soils, groundwater levels must be maintained at permissible levels below which no significant adverse effects on soil properties and salinity levels are expected.
- The remotely-sensed information can be combined with computational models to better constrain water balances and thus help to provide and improved understanding of the key mechanisms at play.

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Irrigation policy compliance monitoring

Fallow Area 2017
Wheat, fallow in 2016
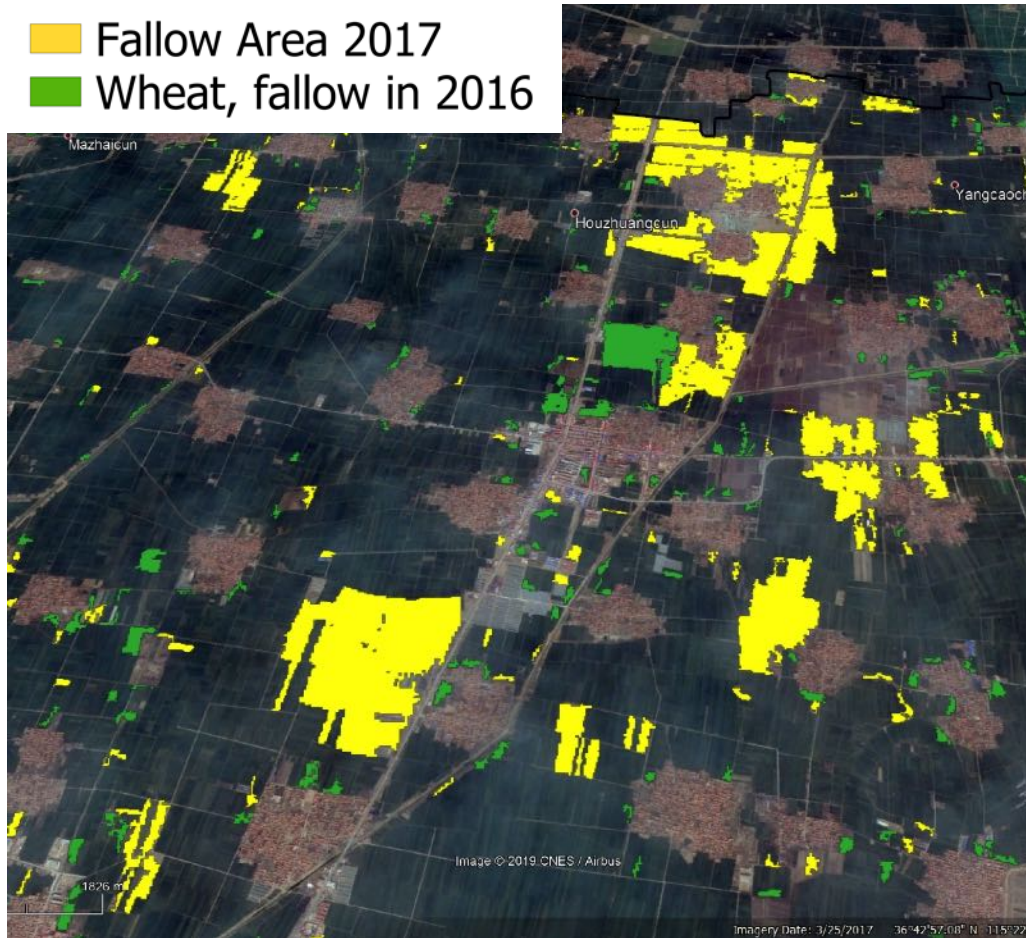
Project Title: Rehabilitation and Management Strategy for Over-Pumped Aquifers under a Changing Climate

Focus Region: Handan Prefecture, Hebei Province, China

Partner Institutions: ETH Zurich, Design Institute of the Chinese Ministry of Water Resources; Local Departments of Water Resources

- Irrigated double crop causes groundwater overuse which leads to falling aquifer tables.
- Farmers get compensated by the state for not planting wheat in the winter season.
- Effective compliance monitoring is required for policy to be enforceable.
- Our remote-sensing expertise helps to track compliance and eligibility of farmers for compensation.

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Created On
2017-07-20 08:10

Level
26.0 cm

Velocity
49.3 cm/s

Discharge
103.0 L/s
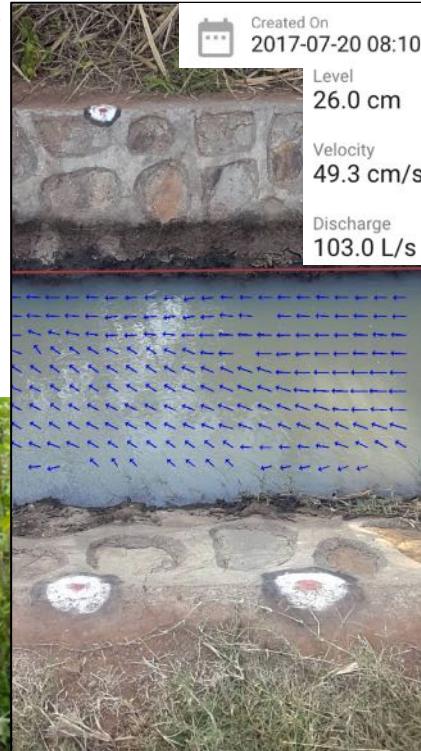
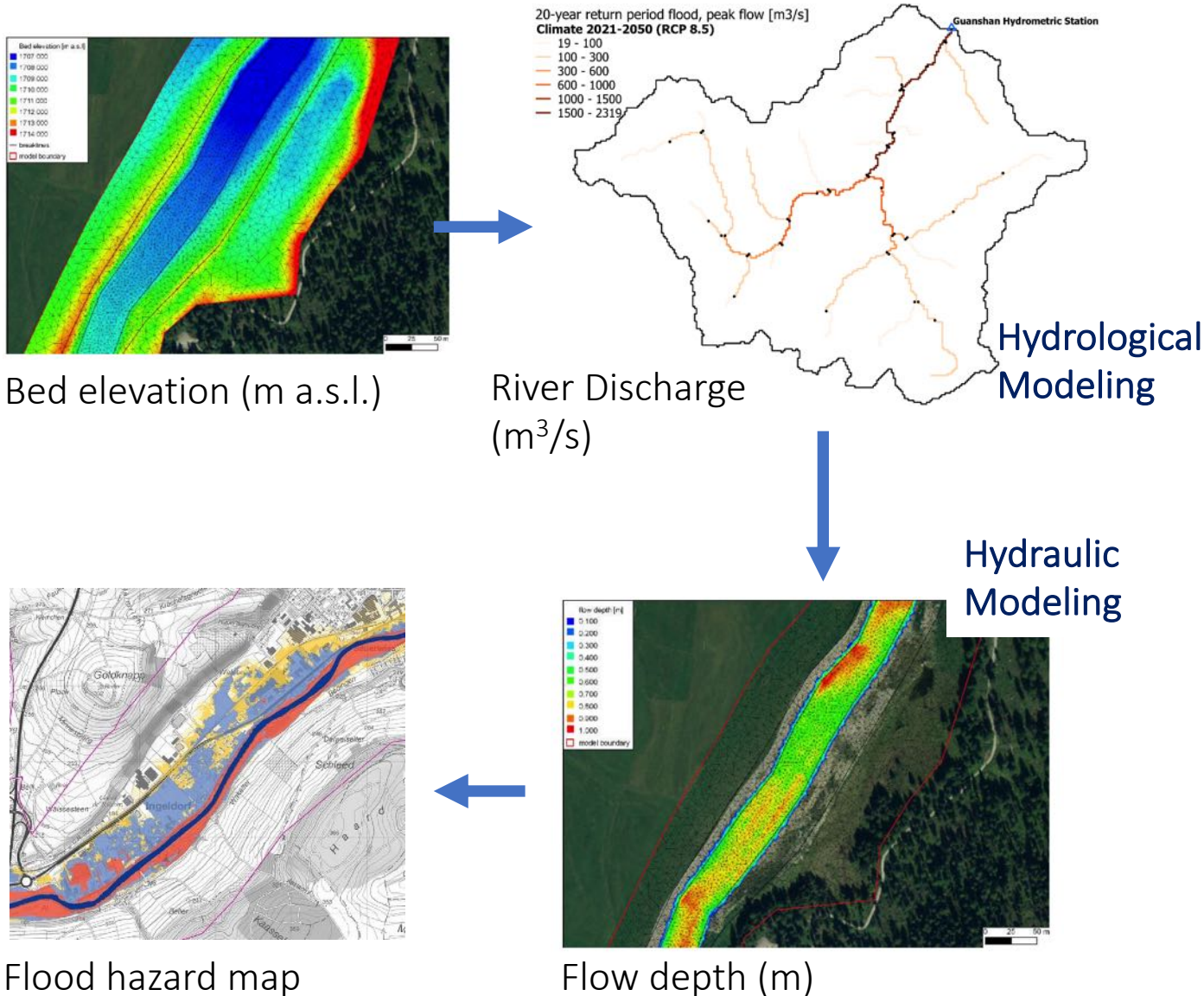**Project Title**: iMoMo - Innovation Technologies for Monitoring, Modeling and Managing Water Resources

Focus Region: Tanzania, Mozambique, Uganda, Kenya, Ethiopia, Kyrgyzstan and Kazakhstan

Partner Institution: Var. national water resources departments and Ministries, IFPRI and World Bank

Recent developments in environmental sensing, mobile communication technologies as well as web-based accounting enable the application and deployment of affordable and scalable high-tech solutions for better water management at different scales, from local up to transboundary levels.

Jointly with many partner organizations in numerous places, we have designed, deployed and carried out non-traditional monitoring campaigns, including for
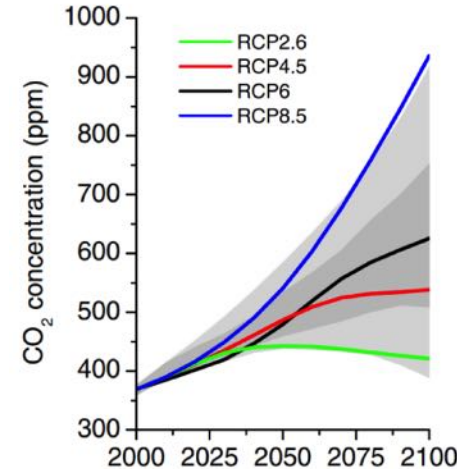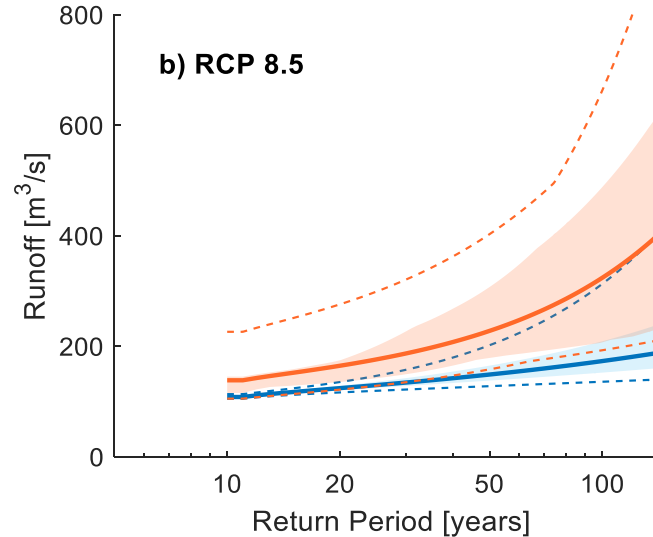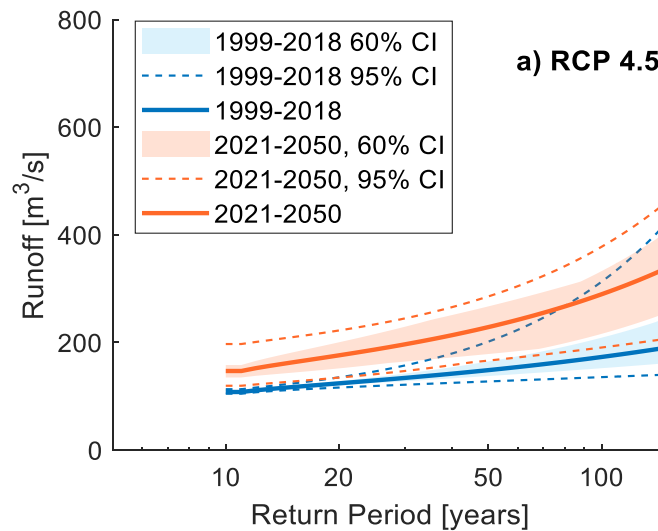
- measuring discharge with a Smartphone
- measuring water-levels with a "Smart-Stick"
- web-based water accounting, WUA-level

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Flood Risk Mapping

Bed elevation (m a.s.l.)

River Discharge (m³/s)

Hydrological Modeling

Hydraulic Modeling

Flood hazard map

Flow depth (m)

Project Title: Sino-Swiss Pilot Project on Mountain Torrent Disaster Prevention

Focus Region: Guanshan catchment, Hubei Province, China

Partner Institution: Yangtze River Commission, China; Geotest, Switzerland; Swiss Federal Institute for Forest, Snow and Landscape Research WSL

- Detailed flood hazard assessments are required for flood mitigation purposes.
- Flood hazard maps are obtained by combining high-resolution digital elevation models, hydrological and hydraulic models.
- The pilot study about the Guanshan catchment in China shows that such assessments can be carried out also in relatively data scarce mountain catchments.

Climate Change Projections & Hydrological Modeling

Climate Change Impact on Floods

a) RCP 4.5

Legend:
- 1999-2018 60% CI
- 1999-2018 95% CI
- 1999-2018
- 2021-2050, 60% CI
- 2021-2050, 95% CI
- 2021-2050

b) RCP 8.5

Climate change impacts on summer flood frequencies in two mountainous catchments in China and Switzerland

S. Ragettli[1], X. Tong[2], G. Zhang[2], H. Wang[1], P. Zhang[2], M. Stähli[3]

[1]{Hydrosolutions Ltd., Zurich, Switzerland}

[2]{Changjiang River Scientific Research Institute, Wuhan City, China}

[3]{Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland}

Hydrology Research **2019**, *under review*

Project Title: Climate Change Impacts on Summer Flood Frequencies in Mountain Areas

Focus Region: Alptal catchment, Switzerland; Guanshan catchment, China

Partner Institution: Changjiang River Scientific Research Institute, China; Swiss Federal Institute for Forest, Snow and Landscape Research WSL

We use a hydrological model coupled with a stochastic weather generator to simulate the summer flood regime in two mountainous catchments. To assess the climate change impacts on flood frequencies we re-calibrate the weather generator with the climate statistics for 2021-2050 obtained from ensembles of bias-corrected regional climate models. Across all assessed return periods (10-100 years) and two emission scenarios, nearly all model chains indicate an intensification of future flood extremes.

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Ungauged Catchments
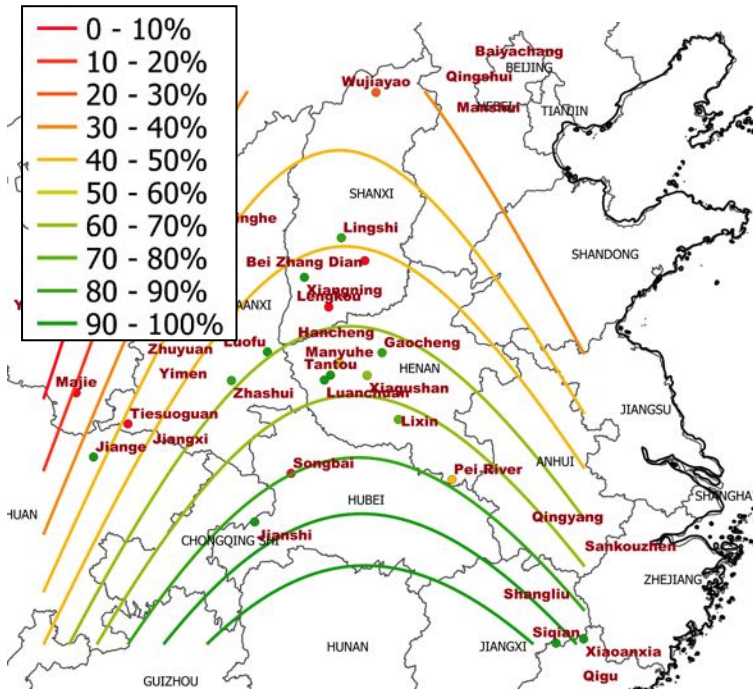
Probability of detection of a 10-year event

Journal of Hydrology

Research papers

Modeling flash floods in ungauged mountain catchments of China: A decision tree learning approach for parameter regionalization

S. Ragettli[a,*], J. Zhou[b], H. Wang[a], C. Liu[c,d], L. Guo[c,d]

[a] Hydrosolutions ltd, Zurich, Switzerland
[b] Northwest Institute of Eco-Environment and Resources, CAS, Lanzhou, Gansu, PR China
[c] China Institute of Water Resources and Hydropower Research, Beijing, PR China
[d] Research Center on Flood & Drought Disaster Reduction of the Ministry of Water Resources, Beijing, PR China

Journal of Hydrology **2017**, *555 (330-346)*;
https://doi.org/10.1016/j.jhydrol.2017.10.031
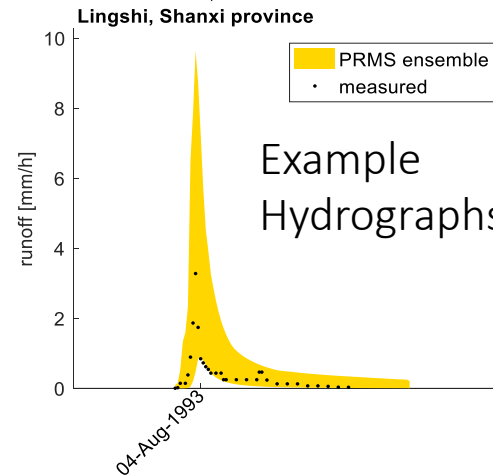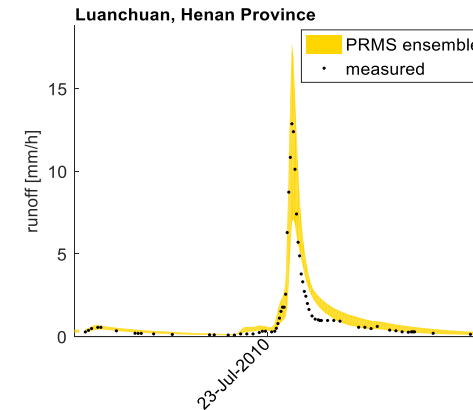
Example Hydrographs

Project Title: Flood prediction modeling for small mountain river catchments in China

Focus Region: 35 mountain catchments in 10 provinces of China

Partner Institution: Chinese Academy of Science Lanzhou; China Institute of Water Resources and Hydropower Research

Flash floods in small mountain catchments are one of the most frequent causes of loss of life and property from natural hazards in China. Hydrological models can be a useful tool for the anticipation of these events and the issuing of timely warnings. One of the main challenges of setting up such a system is finding appropriate model parameter values for ungauged catchments. For this study we established decision trees for the selection of model parameters for ungauged catchments based on a machine learning approach.

Contact and Location

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