SaWaM - Seasonal Water Resources Management, Regionalized Global Data and Transfer to Practice

Kickoff meeting, 21. – 22.06.2018, Khartoum, Sudan

Introduction

It is expected that until 2025 approximately 1.8 billion people will suffer from absolute water scarcity. In order to deal with this projected development, scientists and decision makers rely their planning more and more on global hydrometeorological data sets, remote-sensing products or global model systems, as the number of in situ gauges is significantly decreasing. The major task of SaWaM is therefore the development of methods and tools for the practice transfer of regionalized global data for water resources management. The performance of the developed products will be evaluated over selected semi-arid regions. Special focus is on the *seasonal prediction* of water availability, the state of the eco-system, and the modelling of sediment flow. This will be achieved through an integrative approach between climate-, hydrological-, and ecosystem sciences together with remote-sensing based methods and data. The practice application of the developed products will be analyzed within a consortium of seven universities and research institutes, two international German business partners as well as a variety of regional decision makers. The full model- and information chain will be analyzed for dedicated regions, including the basins of the Atbara and the Blue Nile. In the end, the superordinate product from SaWaM will be an industry mature online prototype, which allows to examine and apply all developed products – from the methods and data to the seasonal predictions for water resources management.

Venue

Paradise Hotel, Ozone Park SQ, Khartoum, Sudan (http://paradisehotels-sd.com)

Workshop material

All workshop material (presentations, protocols, etc.) will be made available through the SaWaM-Team-Site www.team-extern.kit.edu/sites/sawam. For registration, send an Email to Christof.Lorenz@kit.edu.

Objectives of the meeting

1. Introduction to the SaWaM-Project: Objectives, team, scientific approaches, time-schedule

2. Coming together of Sudanese and German partners for elaborating joint research on the seasonal water management in Sudan

3. Introduction of methods and scientific approaches:
    a. Global hydrometeorological datasets for regional applications: Can seasonal predictions support the regional water management?
    b. Modeling of the Hydro- and Ecosystem: Availability of water resources, sediment transport, ecosystem-services and functionality
    c. Dynamical and statistical downscaling of past, present, and expected future hydrometeorology
    d. Near-real-time estimation of satellite-based precipitation, lake levels, and river runoff

4. Expert introduction to the Atbara basin: Current water management practice and challenges, overview of ongoing research for the basin, interplay with stakeholders

5. Identification of joint research topics: possibility of SaWaM to support research and water management in Sudan

6. Planning of joint research in the next two years: exchange of methods and data, opportunities for joint PhD-supervision, opportunities for additional funding

Further Information

Project homepage: http://grow-sawam.org
Twitter: https://twitter.com/GROW_SaWaM

Contact

Prof. Dr. Harald Kunstmann (Project lead, KIT, Harald.Kunstmann@kit.edu)
Dr. Christof Lorenz (Project coordination, KIT, Christof.Lorenz@kit.edu)
Dipl. Ing. Berhon Dibrani (Lahmeyer International, Berhon.Dibrani@de.lahmeyer.com)
Eng. Abdelrahman Saghayroon (DIU, hydro.diu@gmail.com)

Agenda

Day 1		
8:30	**Welcome**	DIU, H. Kunstmann
9:00	**Introduction to the SaWaM Project**	H. Kunstmann
9:20	**Short introduction of the German participants (max. 8 minutes)**	
	• **Karlsruhe Institute of Technology**	H. Kunstmann
	• **University of Potsdam**	A. Müller
	• **University of Stuttgart**	S. Behnia
	• **University of Marburg**	N. Turini
	• **TU Berlin**	E. Paton
	• **UFZ**	P. Shrestha
	• **GFZ**	A. Smetatnova
	• **Lahmeyer International**	B. Dibrani
	• **GAF AG**	T. Kukuk
	• **TH Cologne**	N. Elagib
10:30	**Coffee break**	
10:45	**Short introduction of the Sudanese participants (max. 10 minutes)**	
	• **Dams Implementation Unit**	K. ElSeed
	• **Nile Water Directorate**	S. Hamid
	• **Upper Atbara Dams Complex Project**	M. Suliman
	• **Hydraulic Research Center**	Y. Mohamed
	• **University of Khartoum, Water Research Center**	G. Abdo
	• **Sudan Meteorological Authority - Seasonal Predictions to Support Water Resources Management in Sudan**	A. Abdelkarim
	• **National Water Research Center**	A. El Tayeb
12:30	**Lunch**	
13:30	**Introduction to the SaWaM-Work-Packages (max. 10 minutes)**	
	• **Modeling Systems, Regionalization (downscaling), and Satellite-based Techniques**	C. Lorenz
	• **Characterization of Ecosystem State and Functionality**	A. Smetanova
	• **Regional Modelling of Hydrosystems and Water Resources Management**	E. Paton

	• **User dialogue and development of a user-friendly online prototype for seasonal forecast in the frame of water management**	T. Kukuk / B. Dibrani
14:30	**Introduction to the Upper Atbara basin**	B. Dibrani
15:00	**Coffee break**	
15:15	**Discussion: Modeling and remote sensing approaches**	
17:00	**Closing remarks – day 1**	H. Kunstmann
17:15	**Workshop: Land degradation hot spots in Atbara**	A. Smetanova
17:15	**Workshop: Hydrological modelling in the Atbara**	P. Shrestha

Day 2		
8:30	**Discussion: Exchange of data and information**	
10:00	**Coffee break**	
10:15	**Discussion: Joint activities in the Atbara basin**	
11:45	**Closing remarks – day 2 and Farewell**	DIU, H. Kunstmann
12:00	**Break for Prayer**	
13:00	**Lunch**	
14:00	**Optional discussion: Focus groups, open questions, next steps, etc. (until 17:00)**	

SaWaM – Who is who[1]

Affiliation	Name	Work focus
Karlsruhe Institute of Technology	**Prof. Dr. Harald Kunstmann** Prof. Dr. Almut Arneth Dr. Patrick Laux Dr. Anita Bayer **Dr. Christof Lorenz** M. Sc. Tanja Portele **Maurus Borne**	Dynamical and statistical downscaling of seasonal forecasts, ecosystem modeling, bias correction
University of Potsdam	Prof. Dr. Axel Bronstert Dr. Gerd Bürger **M. Sc. Anne Müller**	Hydrosystem modeling, modeling of sediments, statistical downscaling

[1] Participating SaWaM-partners are marked in bold

University of Stuttgart	Prof. Dr. Nico Sneeuw M. Sc. Peyman Saemian **M. Sc. Sajedeh Behnia**	Remote-sensing-based discharge and water storage changes, data assimilation
University of Marburg	Prof. Dr. Jörg Bendix Dr. Boris Thies M. Sc. Nazli Turini	Satellite-based precipitation in near-real-time
Technical University of Berlin	**Prof. Dr. Eva Paton** **Dr. Anna Smetanova**	Impact assessment of droughts and floods, mitigation of land degradation
Centre for Environmental Research (UFZ) Leipzig	Dr. Luis Samaniego **M. Sc. Pallav Kumar Shrestha**	Hydrological modeling
German Research Centre for Geosciences (GFZ) Potsdam	Dr. Sigrid Roessner Dr. Saskia Förster Dr. Robert Behling	Remote sensing of geohazards, erosion and flood risk management
Lahmeyer International	**M. Sc. Berhon Dibrani**	Planning and management of water construction projects
GAF AG Munich	**Dipl.-Geogr. Thomas Kukuk**	Data visualization, development of decision support systems
TH Cologne	**Dr. Nadir Elagib**	Management of renewable energy and water resources

Affiliation	Name	Work focus
Dams Implementation Unit (DIU) – Ministry of Water Resources, Irrigation and Electricity (MoWRIE)	Eng. Khidir Gasm ElSeed Eng. Musab Mukhtar Dr. Mohamed Ali Ahmed Eltoum Eng. Mustafa Hussein Eng. Ammar Ali Mohammed Eng. Abdelrahman Saghayroon Eng. Hussein Musa Adam Eng. Mohammed Adil Hassan Eng. Mayson Ali Ahmed	Utilization of water resources across Sudan, development of irrigation systems

Nile Water Directorate - MoWRIE	Dr. Salih Hamad Hamid Dr. Iqbal Salah	Operation of hydrological stations, flow forecasting, optimization of water utilization
Upper Atbara Dams Complex Project (UADCP) - MoWRIE	Eng. Mohamed Suleiman Eng. Aymen Ahmed Yousif	
Hydraulics Research Center (HRC) - MoWRIE	Prof. Dr. Yasir A. Mohamed Eng. Yasir Hageltom Khaled Elnour Islam Saleh Abu Obieda Babiker Ahmed Dr. Younis A. Gismalla	Applied research for supporting the decision making of water management in Sudan
University of Khartoum, Water Research Center (WRC)	Prof. Dr. Gamal Murtada Abdo Prof. Dr. Mohammed Akode Osman Prof. Dr. Esadig Sharifi Prof. Dr. Babiker Barsi Eng. Abubaker Abdalla	Water resources and environmental management including hydrology, climate change, transboundary water management, etc.
Sudan Meteorological Authority (SMA)	Dr. Ahmed Mohamed Abdelkarim M.Sc. Abulegasim Ibrahim Idriss Musa M.Sc. Ammar Mokhtar Gomaha Gaber	Seasonal Forecast, Dynamical and Statistical Downscaling
National Water Research Center (NWRC)	Dr. Ahmed El Tayeb	
Regional Center for Research and Capacity Development on Water Harvesting (RCWH)	Eng. Hatim Ali Elbadri	Research, capacity development, and knowledge transfer on water harvesting

Work Groups

During the meeting, it is aimed to establish joint Sudanese-German working groups (WGs). These groups should help to simplify and optimize the project activities in Sudan and serve as a platform for exchanging expert knowledge, data, and information. As there are already similar groups for the study regions Rio São Francisco (Brazil) and Karun (Iran), we would like to use the opportunity to establish international expert groups on the different aspects of the water management of semi-arid regions.

The topics and their German representatives are:

- **WG1: Meteorology and atmospheric modeling** (P. Laux, KIT, p.p. C. Lorenz, KIT) – Dynamical downscaling using the Weather Research and Forecast (WRF) model, statistical downscaling, seasonal predictions

- **WG2: Hydrology and hydrological modeling** (L. Samaniego, UFZ, p.p. Pallav Kumar Shresta, UFZ) – Hydrological modeling of extremes, drought and drought monitoring, remote-sensing-based monitoring of hydrological quantities

- **WG3: Ecosystems and ecosystem modeling (A. Smetanova, TU Berlin) –** Land degradation trends under and effect of climate extremes (drought, storms) on ecosystems and sediment dynamics.

- **WG4: Sediments** (A. Bronstert, University of Potsdam, p.p. Anne Mueller, University of Potsdam) – Water management, modeling of sediment transport and –entry

- **WG5: End-users** (B. Dibrani, Lahmeyer International, T. Kukuk, GAF AG) – Online-visualization, management and decision support tools, mobile applications

- **WG6: Data** (C. Lorenz, KIT) – Data conventions, data server, data transfer, restrictions

If you are an expert in one of these fields, please feel free

to join the respective group by sending a mail to Christof.Lorenz@kit.edu

Short summary of the SaWaM-Work Packages (WPs)

WP1: Global and regional hydrometeorology: Modeling systems, regionalization (downscaling), and satellite-based techniques

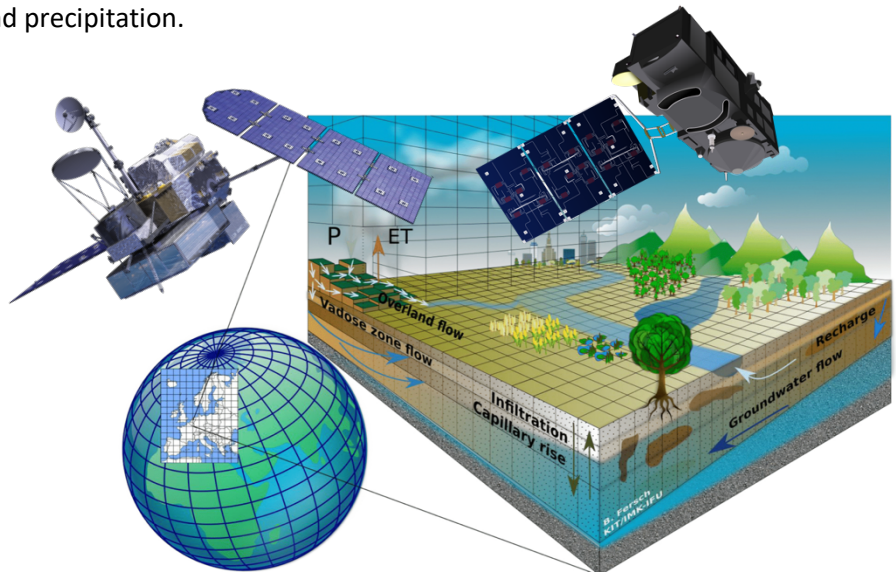
KIT-RKH, Uni Potsdam, Uni Marburg, Uni Stuttgart

Motivation and objective

Particularly in water-scarce areas, ecosystem functions, agricultural productivity and thus food security strongly depend on the spatiotemporal variability of hydrometeorological variables. Under weak technical infrastructure in developing and emerging economies, the quantification of available water resources remains a challenging task. There, usually very limited observation data is available. The overall goal of this WP is the analysis of the performance of both global- and regional-scale hydrometeorological datasets for their praxis-orient applicability in water resources management, and the provision of suitable tools for such analyses. The focus of this WP is on seasonal predictions with lead times of (up to) 6 months.

Methods in WP1

Global precipitation datasets such as GPCC, MSWEP, TRMM/GPM, and CRU are used and validated with local in-situ observation data of the different research regions. Reanalyses (ERA-Interim) and operational forecasts of ECMWF IFS's latest seasonal prediction system 5 (SEAS5) are dynamically downscaled following a nested approach with the use of the mesoscale numerical Weather Research and Forecasting/Advanced Research (WRF-ARW) Model. In addition, statistical refinement and (multivariate) bias-correction approaches are developed to further regionalize the global seasonal forecasts. An improved quantification of potentially available water resources including an estimation of uncertainty ranges will be done based on statistical assimilation techniques (e. g., Ensemble-Kalman-Filter). For this purpose, special focus is laid on the usage of remote-sensing products (e. g., SMAP, GRACE/GRACE-FO, MODIS). The development of operational approaches for the combination of historical discharge measurements with data from satellite altimetry (Jason 2 & 3, SARAL/AltiKa, Sentinel 3), and precipitation products (GPM, TRMM) will allow for improved real-time estimations of discharge and precipitation.



Schematic overview of WP1's earth observation and modeling system

Work tasks in WP1

T1.1 – Performance analysis of global data for regional applications (KIT)

T1.2 – Performance analysis of seasonal predictions (KIT)

T1.3 – Probabilistic predictions of hydrological extremes (Uni P)

T1.4 – Combination of global data products (KIT)

T1.5 – Precipitation from satellite data in near real-time (Uni M)

T1.6 – Runoff from satellite altimetry and water storage changes from GRACE (Uni S)

Provision of

- Downscaled and corrected seasonal predictions
- Downscaled retrospective hydrometeorological data
- Satellite-derived precipitation and river discharge
- Uncertainty ranges of the derived products

WP1 provides forcing data for hydro- and ecosystem modeling as well as data recommendations. The scientific goal is to understand the benefits and possibilities as well as the limits of global hydrometeorological datasets for the regional water management.

Data exchange and output:

Input: global hydrometeorological data, seasonal forecasts, remote-sensing based information for precipitation, satellite-borne altimetry and gravity field data

Output: regionalized precipitation and temperature from retrospectives and seasonal forecasts, discharge and water storage change in near real-time

Data needs: in-situ data for major hydrometeorological variables for calibration/validation

Contact to SaWaM team in WP1

Karlsruhe Institute of Technology (KIT): Dr. Christof Lorenz (christof.lorenz@kit.edu).

University of Potsdam (Uni P): Prof. Dr. Axel Bronstert (axelbron@uni-potsdam.de).

Phillips-University of Marburg (Uni M): Prof. Dr. Jörg Bendix (bendix@staff.uni-marburg.de).

University of Stuttgart (Uni S): Prof. Dr. Nico Sneeuw (sneeuw@gis.uni-stuttgart.de).

WP2: Global and regional modeling: Characterization of ecosystem state and functionality

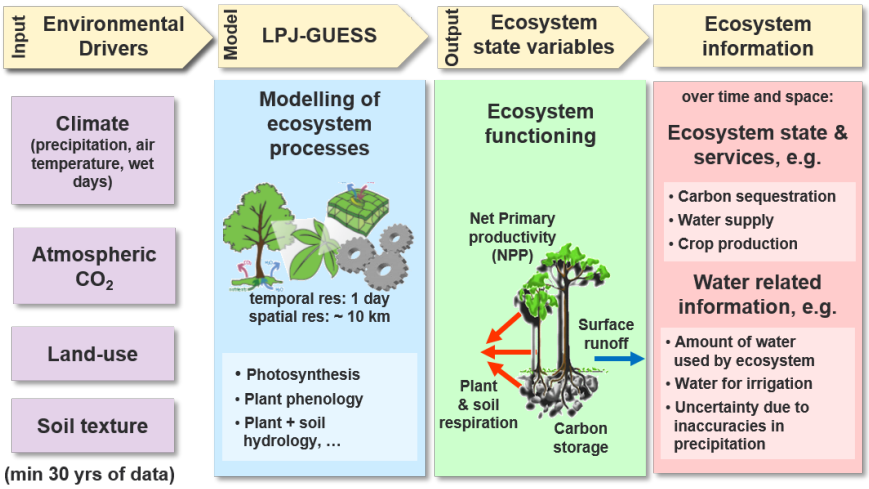
KIT-ÖAI, TU Berlin, GFZ

Motivation and objective

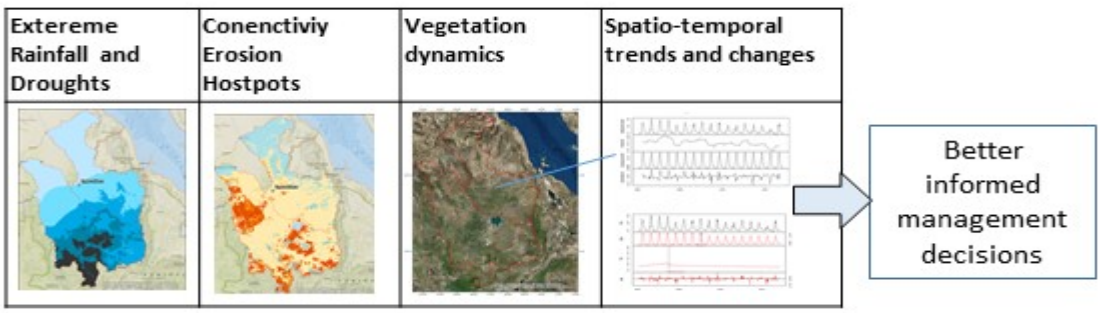
Semiarid regions show a small total rainfall amount and besides this a large variability in precipitation determining a water deficit for flora and fauna. The effects of inaccurate rainfall on vegetation dynamics are large. The objective of WP2 is to characterize state and function of semi-natural and managed ecosystems due to changes in water availability. Using a combination of dynamic vegetation and sediment modelling and satellite earth observation we derive land surface information (land cover, crop yields, erosion hotspots, …) and identify seasonal and long-term trends in the vegetation.

Methods in WP2

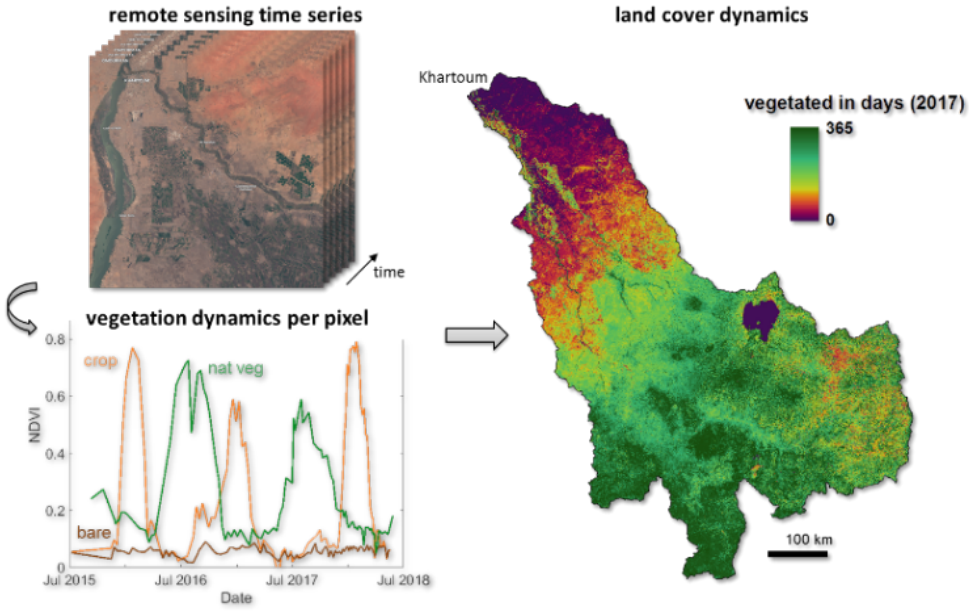
Large-scale vegetation modelling (KIT-ÖAI). The global dynamic vegetation model LPJ-GUESS is applied on regional scale to quantify ecosystem function and indicators for ecosystem services based on input consisting of gridded time series of most importantly land use and climate. Model simulations will identify how uncertainties in the amount of precipitation and its temporal and spatial distribution are reflected in, for example, crop yields, carbon sinks and ecosystem water balance (e.g. precipitation water vs. water used by the ecosystem vs. water used for irrigation vs. excess water).



Ecohydrological modelling and land degradation hostspots (TUB). Land degradation hotspots are identified to support sediment management decisions. Spatio-temporal trends ecohydrological trends of water-soil-plant interactions are analysed in order to understand sediment flows from large catchments in response to projected states of the vegetation.



Satellite earth observation (GFZ). Long-term medium resolution (MODIS, Landsat) and newly available high spatio-temporal resolution satellite data (Sentinel) will be used to quantify the seasonal and long-term dynamics of vegetation status (e.g. LAI), land use and land cover for model assimilation. Thereby derived information will also be used to analyze the relationship between land cover and water availability for characterizing the carrying capacity.



Remote sensing time series data for large-scale analysis of vegetation dynamics

Work tasks in WP2

T2.1 - Modification of vegetation model for regional application.

T2.2 - Quantification of ecosystem state and services in response to water availability. Evaluation of uncertainties due to inaccuracies in precipitation input data.

T2.3 - Development of a processing chain for multi-sensor satellite data.

T2.4 - Regional changes in vegetation dynamics. Multi-methods comparison of parameters for seasonal and long-term vegetation dynamics in response to water management (regional, high-resolution vs. larger scale), Identification of seasonal and long-term trends (different temporal and spatial scales).

T2.5 - Seasonal prediction of water used by plants and sediment transport. Erosion and sediment transport and hotspot mapping.

Data exchange and output:

Input: regionalized climate data from WP1, various external data, as many regional data as possible.

Output: vegetation dynamics and their parameters (NPP, LAI, etc.), trends in vegetation (seasonal and long-term), water budgets, erosion hotspots, inaccuracies in parameters due to variance in input data, etc.

Data needs: spatio-temporal data of land cover/land use classes, crop types and management (irrigation, fertilization), vegetation and soil parameters (phenology, plant height, soil layer thickness), dam and river network.

Contact to SaWaM team in WP2

Karlsruhe Institute of Technology (KIT): Dr. Almut Arneth (almut.arneth@kit.edu), Dr. Anita Bayer (anita.bayer@kit.edu).

TU Berlin (TUB): Prof. Dr. Eva Paton (eva.paton@tu-berlin.de), Dr. Anna Smetanova (anna.smetanova@tu-berlin.de).

German Research Centre for Geosciences (GFZ): Dr. Saskia Förster (foerster@gfz-potsdam.de), Dr. Sigrid Roessner (roessner@gfz-potsdam.de), Dr. Robert Behling (behling@gfz-potsdam.de).

WP3: Regional Modelling of Hydrosystems and Water Resources Management

Uni Potsdam, Uni Stuttgart, Helmholtz Centre for Environmental Research, TU Berlin

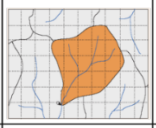
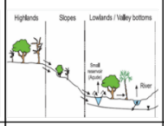
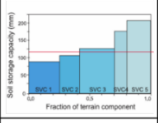
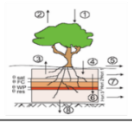
Motivation and objective

The evaluation of different options for water management in dryland regions requires profound knowledge of hydrological processes as well as the mechanisms and effects of the water management. Dryland areas particularly dependent on the storage of water in reservoirs to bridge periods of low or zero discharge and to secure water supply throughout the year. However, erosion of over-exploited land surfaces and sediment input into reservoirs greatly reduce the safety of the water supply. The aim of WP3 is the transfer of the seasonal meteorological forecasts (WP1) to the key variables in regional water management in semi-arid areas: discharge, reservoir capacity, soil moisture and sedimentation in rivers and reservoirs.

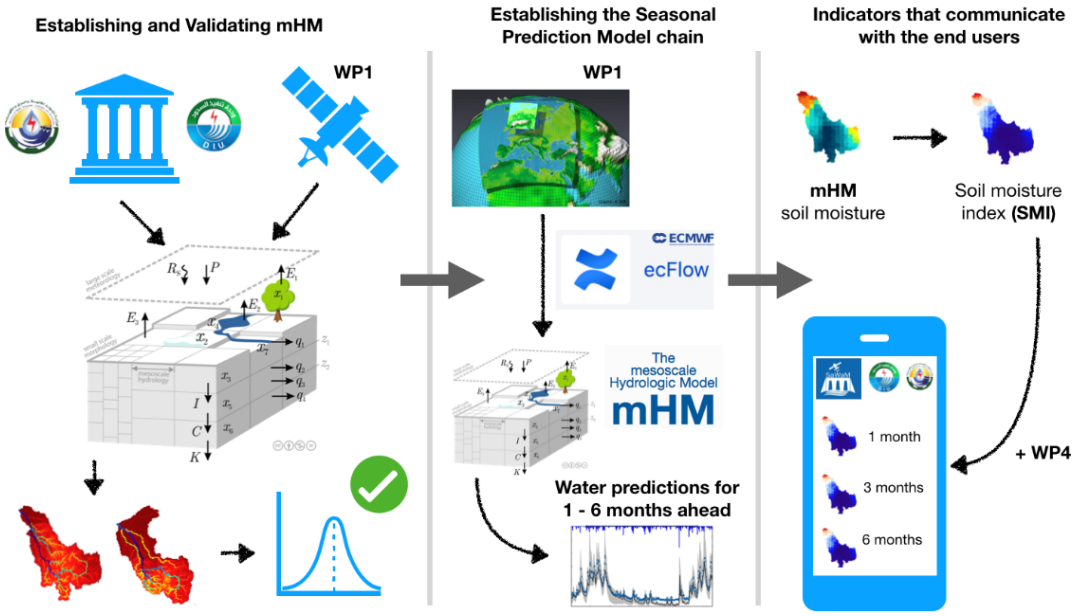
Methods in WP3

End-to-end seasonal monitoring and prediction model chain (UFZ): The meso-scale Hydrological Model (mHM) is applied on the project regions to quantify the water balance and availability in the river basins. A seasonal forecasting model chain is setup based on the ecFlow framework, wherein the seasonal meteorological forecasts are forced into mHM (input from WP1), batch mHM runs are made, quality of prediction quantified and the output ensemble hydrological forecast for various lead time (1 to 6 months) are obtained. All results of the seasonal model chains are provided for visualization in almost real-time in the netCDF file format (input for WP4).

Analysis of hydrological and sedimentological processes with the WASA-SED model (UP, TUB): To specify and further analyze this information, the regional water distribution and sediment transports are assessed and predicted with the model system WASA-SED for semi-arid conditions. Approaches for the above-mentioned water management schemes will be implemented to obtain results relevant for water management and ecosystem issues. The quantification of sediment transport in rivers and the sedimentation in reservoirs (remote sensing-based and model-based) provide a basis for both, the anticipatory seasonal reservoir management as well as a medium to long -term assessment of ways to achieve a sustainable reservoir use.

Scale	Sub-Basin	Landscape Unit	Terrain Component	Soil-Vegetation Component	Profile
Scheme					
Major processes	Climate input and reservoirs	Fluß-Routing, (including sediments)	Lateral surface and subsurface runoff (incl. sediment)	Soil moisture	Interaction with soil, vegetation and Atmosphere

Satellite-based information on water levels (US): The utilization of the hydrological modelling system is based on innovative and globally available data-sets for model parameterization and validation, such as satellite-based information on water levels of major rivers and reservoirs (WP1: Jason 2&3, SARAL/ALTIKA, Sentinel3), soil moisture (ESA CCA, SMAP, SMOS), as well as anomalies of the total water storage for very large areas (GRACE).



Work tasks in WP3:

T3.1 Water balance simulations and seasonal forecast using global Information (Lead: UFZ)

T3.2 Adaptation of hydro-sedimentological approaches for the upper meso-scale and implementation of water management approaches (Lead: Uni P)

T3.3 Hydro-sedimentological simulation in the upper meso-scale (Lead: Uni P)

T3.4 Validation of large-scale water budget (rivers & reservoirs) by remote sensing (Lead: Uni S)

Data exchange and output:

Input: regionalized climate data from WP1, various regional data

Output: Predictions of river runoff, reservoir water level and water availability will be made available for 1 to 6 months lead-time

Data needs: daily climate data (rainfall, temperature), reservoir outflow and bathymetric surveys, soil and land cover information

Contact to SaWaM team in WP3

TU Berlin (TUB): Prof. Dr. Eva Paton (eva.paton@tu-berlin.de), Dr. Anna Smetanova (anna.smetanova@tu-berlin.de).

University of Potsdam (Uni P): Prof. Dr. Axel Bronstert (axel.bronstert@uni-potsdam.de), Anne Müller (anne.mueller.V@uni-potsdam.de)

University of Stuttgart (Uni S): Prof. N. Sneeuw (nico.sneeuw@gis.uni-stuttgart.de), P. Saemian (peyman.saemian@gis.uni-stuttgart.de)

Centre for Environmental Research (UFZ): Dr. L. Samaniego (luis.samaniego@ufz.de), Pallav Kumar Shrestha (pallav-kumar.shrestha@ufz.de)

WP4: User dialogue and development of a user-friendly Online Prototype for seasonal forecast in the frame of water management

German partners: Lahmeyer, GAF

Motivation and objective

WP-4 represents the synthesis of the main results obtained by the other WPs (1-3). This work package will collect requirements in close cooperation with local decision makers and collate user-oriented and scientific information with the goal of contributing to specific decision support in the projct regions. For this purpose the scientific feasibility will be analyzed and new information will be synthesized and simplified for the purpose of practical application, whereas comprehensible communication of the scientific information is of central importance. The main goal of WP 4 consists of the development of an industry-ready Online Prototype facilitating access and use of the outcomes of the project in form of methods and data including a seasonal forecast of water resources management. Moreover, the transferability of results and findings obtained for the development regions to the perspective regions will be investigated.

Methods in WP4

Stakeholder workshops for assessing user-oriented needs, supervision of continuous user dialogue at the interface of application, science and economy; Web-GIS (Geographical Information Systems) and database programming for archiving and visualization of results; WMS/WMS-T integration of time-series including pixel- and vector-based layers with accuracy and uncertainty information; overlay, intersection and special visualization tools for evaluation and support of decision making taking into account uncertainties; web-based methods using existing basic software tools (e. g., GeoServer, GAFmap); training for correct online prototype / software use.

Workshops have been held in Brazilia, Brazil (ANA) and Ahvaz, Iran (KWPA).

Work tasks in WP4

T4.1-T4.4 - Dialogue between science, partners and stakeholders, data acquisition and processing, check of user-oriented methodology and tools, transfer of methods and products to practice.

T4.5-T4.10 - Development of online prototype: concept and mock-up, user requests and workshops, analysis of input data (interfaces and data standards), consolidation and requirements, concept, system architecture and concept for visualization, implementation.

T4.11 - Final online prototype.

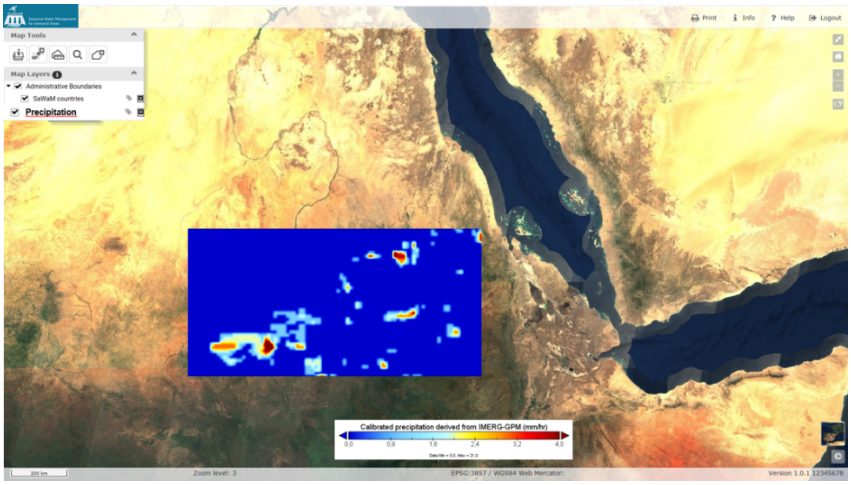


Figure 1 SaWaM Online Prototype Mock-up (precipitation)

Data exchange and products from WP4:

Input: Data and methods from WPs 1-3.

Output: Tool(s) for visualizing results, decision support, optimization of water resources management (irrigation strategies, seasonal reservoir management, planning of additional reservoirs, reduction of sedimentation) taking into account economic constraints, sustainable preservation of ecosystem functions and user conflicts; online prototype for seasonal forecast and for near-real-time monitoring of water resources management for promising project regions.

Contact to SaWaM team in WP4

Lahmeyer International GmbH: Berhorn Dibrani (Berhon.Dibrani@de.lahmeyer.com).

Gesellschaft für Angewandte Fernerkundung AG (GAF): Thomas Kukuk (thomas.kukuk@gaf.de)

Short summary of the participants

Karlsruhe Institute of Technology - Institute of Meteorology and Climate Research - Division for Regional Climate and Hydrology

The department *Regional Climate Systems* and the working group *Regional Climate and Hydrology* (KIT-RKH), under the leadership of Prof. Dr. Harald Kunstmann, investigates the impact of climate variability and climate change on the water cycle. For this, regional atmospheric (WRF, CCLM), hydrological (WaSiM, GEOtop, NDHMS) and, in particular, fully-coupled atmosphere-hydrology models (WRF-Hydro, WRF-HMS) are being developed, and further regionally adapted and optimized. Another working focus is on the analysis of small-scale variability of precipitation, multivariate bias correction and on regionalization of meteorological fields. Moreover, we innovatively use directional radio signals of commercial mobile networks to quantify precipitation. We further set up and operate hydrometeorological observatories (HGF-TERENO, HGF-ACROSS, BMBF-WASCAL). The regional focus is on climate- and water-sensitive regions: like the Alpine region, West and East Africa, the Middle East. Our department has long-standing experience in international projects in data-sparse regions with, in part, difficult political conditions (West Africa, Syria, Palestine). In the WASCAL project, the KIT-RKH together with the University of Augsburg are the German main partners in the field of climate modeling, in the setup of an observational network and in hydrometeorological analyses.

In the SaWaM project, the group of the KIT-RKH is responsible for the analysis, the provision and further processing of global and large-scale datasets. This also includes the regionalization and the derivation of uncertainty ranges for hydrological variables that are relevant for the regional water management. Moreover, making use of the appropriate methods, we dynamically downscale seasonal forecasts for the target regions. The regionalized fields serve as decision support both for project internal business partner and for local stakeholders. The data are further improved with appropriate correction methods, and shall therefore significantly contribute to the decision support for the regional water management in the target regions. Finally, the KIT-RKH is the national and international coordinator and organizer of the SaWaM project and is the primary contact partner of the consortium.

Contact: Prof. Dr. Harald Kunstmann (Harald.Kunstmann@kit.edu), Dr. Christof Lorenz (Christof.Lorenz@kit.edu), Dr. Patrick Laux (Patrick.Laux@kit.edu), M. Sc. Tanja Portele (Tanja.Portele@kit.edu), Mr. Maurus Borne (Maurus.Borne@kit.edu)

Karlsruhe Institute of Technology - Institute of Meteorology and Climate Research - Division for Ecosystem - Atmosphere Interactions

Within Karlsruhe Institute of Technology, the division ecosystem-atmosphere interactions, lead by Prof. Dr. Almut Arneth, is interested in the interplay between terrestrial ecosystems, climate change and land-use change, focussing on regional-global scale questions and applications. With a special interest in gas and matter fluxes between the land surface and the atmosphere, we combine measurements on various scales with process-based models in a multi-disciplinary approach. We use advanced dynamic ecosystem modelling frameworks (e.g., LPJ-GUESS) coupled to Earth system models (e.g., EC-Earth) and models of land-use change. With a number of research initiatives on the topics ecosystem services, land use change, and model development, the division contributes to BMBF and EU FP7 funded projects (CliFF, OPERAs, LUC4C, SaWaM) and international activities (Global Carbon Project, ISI-MIP, etc.).

Within the SaWaM project, we will use the LPJ-GUESS ecosystem model to assess ecosystem state and functionality and the services that are provided by the ecosystem for humans (e.g., carbon uptake

potential, crop yields etc.) in response to water availability. This includes and estimation of the amounts of water that are used by the semi-natural vegetation, rainfed and irrigated agriculture and run off as excess water. We will also quantify the effects of regionalized precipitation estimates and their uncertainties on vegetation growth and functionality in the semi-arid landscapes of the five SaWaM regions.

Contact: Prof. Dr. Almut Arneth (Almut.Arneth@kit.edu), Dr. Anita Bayer (Anita.Bayer@kit.edu)

University of Potsdam - Institute of Earth and Environmental Science

Statistical climate downscaling (from global to regional information), focussing on droughts: The same principle applies to seasonal or decadal "climate predictions" as to climate downscaling: The ocean-atmosphere system is dynamically described by models, while regional information in turn are dynamically or statistically derived therefrom. Yet, there is a decisive difference to climate simulations. Since climate downscaling consists of real forecasts (unlike scenarios), the whole system is understood as probabilistic and is realised using ensemble simulations. Thus, climatological regionalized information derived therefrom are probalistic, too. The method of statistical downscaling developed at UP is particularly suitable for hydrological extremes, while for seasonal forecasts especially droughts are of interest. This method shall be further developed for the aforementioned seasonal climate prediction module and, thus, shall provide prerequisites for "proactive" regional water management under conditions of water scarcity.

Hydrological processes and water management under semi-arid conditions: The assessment of different water management options demands knowledge of regionally relevant hydrological processes (e. g., preconditions for surface runoff, wetland dynamics, hydrological connectivity or drainage conditions, characteristics of evapotranspiration), as well as knowledge of mechanisms and effects of water management (e. g., water retention in reservoirs of different size classes, water demand of irrigation systems, efficiency of water transfer, "multi-purpose systems" such as water power and irrigation provision). Specifically for semi-arid regions, these aspects shall be developed and adapted within a modelling system and realised in an application oriented manner.

As basis serves the modelling system WASA-SED (developed at UP) and the therein already implemented process-oriented approaches for hydrological processes under semi-arid conditions. These approaches will be further developed, inter alia, to integrate recently available global information (e. g., from remote sensing and data analysis techniques) with regard to regional applicability of hydrological information and resulting processes, such as erosion, sediment transport or water absorption by ecosystems.

In addition, new approaches are implemented for the above mentioned measures of water management, in order to derive information relevant for practical application for both water management and ecosystem services.Within SaWaM, the chair of Hydrology and Climatology of the University of Potsdam (UP) focuses on the following main research topics:

1. Empirical-statistical downscaling of meteorological-climatological information, especially regarding droughts as meteorological-hydrological extreme events.
2. Further development of the hydro-sedimentological model WASA-SED with respect to water management processes and measures.

The aim is a comprehensive, area-wide simulation of hydrological processes, soil erosion, and sedimentation of reservoirs for large-scale areas within semi-arid regions of the Earth – using modelling systems especially developed for these demands, as well as novel, globally available data.

This combination of specific simulation systems and data analysis methods shall enable both efficient and sustainable utilisation of scarce water resources within these regions. For this purpose, an innovative instrument is the generation of regionally valid seasonal forecasts of climatological conditions and resulting water availability.

These methods are developed and applied in 5 regions of the Earth (Brazil, Ecuador, Iran, Sudan, West-Africa), while research at the University of Potsdam focuses on river basins in Brazil (Sao Francisco River Basin) and Iran (Karun River Basin), where long standing and intense scientific collaborations exist.

Contact: Prof. Dr. Axel Bronstert (axelbron@uni-potsdam.de), Dr. Gerd Bürger (gbuerger@uni-potsdam.de), M. Sc. Anne Müller (Anne.Mueller.V@uni-potsdam.de)

Philipps-University of Marburg - Faculty of Geography - Laboratory for Climatology and Remote Sensing

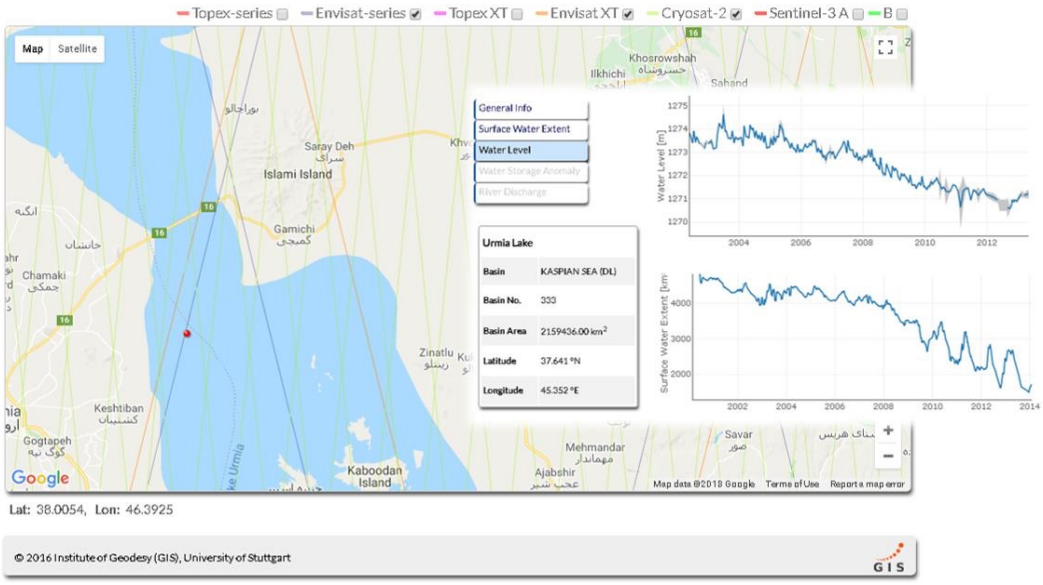
The LCRS is a working group within the Faculty of Geography at the University of Marburg. Research is done in the fields of climatology, remote sensing and numerical modelling, with a focus on atmospheric and boundary layer climatology, climate-ecology and climate change impact assessment.
One major goal of the LCRS is the development of rainfall retrieval and fog detection techniques based on satellite data, For this purpose we use state of the art models together with data from various sensors (NOAA-AVHRR, MSG-SEVERI, TERRA/AQUA, MODIS, METOP, GOES). Our modelling cluster provides the sophisticated hardware essential for this task.

Within the framework of SaWaM, the LCRS is responsible to derive and develop high spatio-temporal resolution of precipitation in near real time using satellite data. The new precipitation retrieval is based on the newest generation of geostationary (GEO) satellite systems and the data from Global Precipitation Measurement Mission, which is generated by NASA. In addition to the precipitation information, uncertainty ranges of the derived data will be provided.

Contact: Dr. Boris Thies (boris.thies@geo.uni-marburg.de), M.Sc. Nazli Turini (turini@staff.uni-marburg.de)

University of Stuttgart - Institute of Geodesy

Research at GIS is mainly focused on geodesy and its applications in close disciplines such as geophysics, oceanography, and hydrology. In the frame of different projects, our scientists employ observations from spaceborne geodetic sensors to investigate hydro-geodetic phenomena (e.g. variations in hydrological water cycle caused by extreme events, characterizing storage-based drought, and influence of Arctic river runoff variations on Arctic sea level, sea ice and circulation). Toward the same objectives, we also conduct data processing and data analysis studies (e.g. ocean tide aliasing in spaceborne gravimetry, data mining for GRACE monthly solutions, and satellite altimetry waveform retracking) to better understand and interpret space geodetic observations. All publications and products from the hydro-geodesy group at GIS are accessible on HydroSat (http://hydrosat.gis.uni-stuttgart.de/php/index.php , Figure 1).



Water Level and Surface Water Extend at Lake Urmia, provided by HydroSat

The project SaWaM aims to come up with a framework for water resource management in semi- arid regions. It is, therefore, crucial that the team is provided with reliable records of hydrologic observations. Given the significant lack of in situ stations, our main contribution to the SaWaM project is to offer the alternative sources of information using geodetic spaceborne technologies. We will use satellite altimetry to derive water level time series over rivers, lakes, and reservoirs. In order to deal with the poor spatial and temporal data coverage which makes it difficult to conduct time series analysis, particularly along narrow rivers, we consider using multi-mission satellite altimetry. The next step would be to provide discharge time series based on the previously developed satellite-based runoff determination approaches at our institute.

Contact: Prof. Dr. Nico Sneeuw (sneeuw@gis.uni-stuttgart.de), M.Sc. Sajedeh Behnia (sajedeh.behnia@gis.uni-stuttgart.de)

TU Berlin - Institute for Ecology - FG Ecohydrology and Landscape Evaluation

Research at the Chair of Ecohydrology focuses on water availability, drought and flood assessment, sustainable land use management and land degradation mitigation measures in dryland regions. Regional foci are semi-arid regions in West and East Africa, the Mediterranean regions of Europe and dryland regions in Brazil. Using various modelling schemes, the research team at Berlin has international experience in the simulation of water fluxes, erosion and sedimentation of reservoirs as well as plant water availability to calculate agricultural yield under different stress scenarios. Special emphasis of their research lies on the analysis of ecohydrological feedback processes by linking analysis methods of ecohydrological modelling and monitoring (including remote sensing data). They employ and develop transdisciplinary approaches to transfer sustainable land-use methods into society. Further research activities of the research group comprise urban ecohydrology assessments, soil hydrology, and analysis of different disturbance regimes in heavily modified systems due to high-intensity storms, overgrazing, erosion and drought.

Prof. E. N. Paton (née Mueller) was in charge of the development of the hydro-sedimentological model WASA-SED (*Water Availability in Semi-arid Areas with SEdimentDynamics)*, which is being employed

as part of the water management assessment in the SaWaM project. Her research interest lays in the development of cropland adaptation scenarios for seasonal forecasts, which takes into account the current state of vegetation (degradation) and vulnerability of the land surface to excessive soil erosion. Within the framework of the SaWam project, Dr. Anna Smetanova coordinates the activities of the Berlin sub-project in SaWaM working on the identification of erosion hotspot dynamics at the lower macro-scale, identification of ecosystem degradation and analysis of terrestrial ecohydrological dynamics for land degradation neutrality in semi-arid data-scarce areas.

Contact: Prof. Dr. Eva Paton (eva.paton@tu-berlin.de), Dr. Anna Smetanova (anna.smetanova@tu-berlin.de)

German Research Centre for Geosciences (GFZ) Potsdam - Section for Remote Sensing

The Remote Sensing section at GFZ Potsdam is concerned with the development and use of remote sensing techniques for the monitoring of land surfaces using optical as well as radar data. The main research lines comprise (i) methodological developments for remote sensing data analysis and definition of future satellite missions, and (ii) application-oriented research for the monitoring of bio- and geophysical parameters of interest to a wide range of scientific disciplines, including soil and land degradation studies, geological exploration, precision agriculture and global vegetation functioning, natural and man-made hazards, and land-atmosphere interactions.

Within the framework of SaWaM, the remote sensing section at GFZ Potsdam is responsible for the large-scale analysis of seasonal and long-term vegetation dynamics which will be derived from satellite time series data. The resulting land use specific information on vegetation dynamics will be used to validate regional vegetation modeling. In addition, the globally available optical satellite time series data, in particular the new Sentinel-2 satellite mission of the Copernicus Earth observation program, will be evaluated in their suitability for modeling of ecosystems, vegetation states and erosion/sedimentation processes.

Contact: Dr. Sigrid Roessner (sigrid.roessner@gfz-potsdam.de), Dr. Saskia Förster (saskia.foerster@gfz-potsdam.de), Dr. Robert Behling (behling@gfz-potsdam.de)

Helmholtz-Centre for Environmental Research (UFZ) - Department of Computational Hydrosystems

The Helmholtz Centre for Environmental Research – UFZ is one of the world's leading research centers in the field of environmental research. Scientists at UFZ investigate the complex interactions between mankind and nature under the influence of global change and develop system solutions to improve the management of complex environmental systems and to tackle environmental issues. The Department of Computational Hydrosystems (CHS) at UFZ works as a "computational laboratory" devoted to the development, validation and integration of hydrologic models on multiple scales of the water cycle and their interrelationships with terrestrial ecosystems. Our final aim is the development of management, forecasting, and optimization tools based on fully integrated, parameter-efficient simulation models to find robust strategies for water resources management and to provide improved forecasting skills with longer lead times on regional scales. The **meso-scale Hydrologic Model (mHM)** (http://www.ufz.de/index.php?en=40114) is a spatially explicit distributed hydrologic model that was developed by the Land Surface Hydrology group of Dr. Luis Samaniego in CHS. Since its first release in

2010, the mHM development team has been actively working on refining the model, making new releases twice a year with added functionalities and improved processes.

mHM has been extensively tested in more than 800 river basins in Germany and Europe, large river basins in USA as well as catchments worldwide. The model is parallelized i.e. model calculations can run on several CPUs simultaneously, and shows a fast runtime (approximately 1 millisecond simulation time per cell per year). Moreover, mHM has reached the technological readiness level 7 i.e. it has been applied for system prototype demonstration in operational environment. With these requirements, mHM is particularly suitable for use as an operational model and in real-time forecasting systems as in the case with the WP3 of the SaWaM project. Furthermore, mHM has been applied in extremely relevant studies in recent past. In End-to-end Demonstrator for improved decision-making in the water sector in Europe (EDgE) project (2017, visualization portal - http://edge.climate.copernicus.eu/Apps/ - seasonal) mHM was applied to determine the longest drought periods based on the daily soil moisture content over the last 60 years across Europe. Another example is the German Drought Monitor (GDM) (2016, visualization portal - https://www.ufz.de/index.php?en=37937) which provides up-to-date high-resolution drought information for Germany based on the simulations performed with the operationalized mHM. In addition, mHM has been used to study the prediction of a seasonal, hydrological prediction system for soil moisture index in Europe (figure below).

Contact: Dr. Luis Samaniego (luis.samaniego@ufz.de), M.Sc. Pallav Kumar Shrestha (pallav-kumar.shrestha@ufz.de)

Lahmeyer International GmbH (LI)

Lahmeyer International offers a wide range of planning and consultancy services, primarily for complex infrastructure projects in the fields of energy, hydropower and water resources, water supply and wastewater management as well as building and transportation. With our original origins dating back to 1890, Lahmeyer International has developed in 50 years since its establishment in 1966 into one of the leading international engineering companies with project experience in 165 countries around the globe. Since December 2014, Lahmeyer belongs to Tractebel Engineering S.A., Belgium. Our new parent company is part of the ENGIE Group (formerly GDF SUEZ). The Tractebel Group employs 4,400 people in 33 countries and in 2017 achieved a turnover of 605 million Euros.

Lahmeyer International is one of the few companies world-wide that can offer the whole spectrum of technical services with all associated disciplines by drawing on the expertise of our in-house professional personnel. This ability is based on decades of experience in the design, planning and realisation of technical projects in Germany and especially abroad. This experience allows offering clients technically and economically optimal solutions and to guarantee successful project execution from the design and planning phases, through to planning approval, construction and commissioning.

Contact: Dipl.-Ing. Berhon Dibrani (Berhon.Dibrani@de.lahmeyer.com)

GAF AG

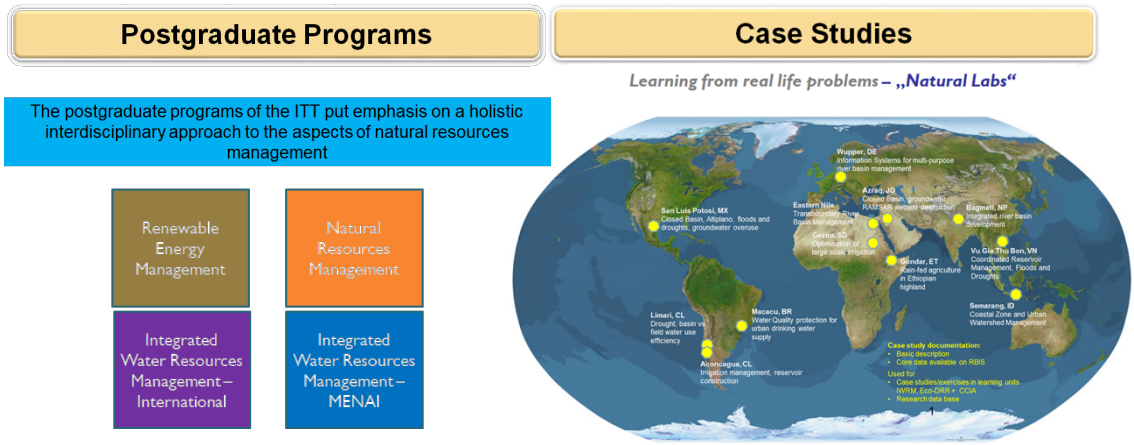
GAF AG is a service provider in the satellite earth observation (EO) and geo-information (GI) domain. GAF started operations in 1985 and has since grown to over 230 staff specialised in satellite image processing, data provision on all levels from reception to full service and system provision. Additionally GAF provided tailored management and technical consulting for geo-information and EO-applications

for management and decision support systems. Up to 50 GAF experts are working on system and software development in the geo-information, image processing and data exploitation domain using i.a. SW- and System Development. In 2002 GAF was transformed into a stock company (AG) subsequently taken over by Telespazio S.p.A.. Since 2008 GAF is 100% owned by e-GEOS S.p.A. a Telespazio S.p.A./ASI company. GAF is involved in the provision of a number of Copernicus Services (EMS, Land etc.) – the European EO-Programme - and provides a large number of clients and end users in Europe, Africa and worldwide with EO based geo-information services, and environmental information and consulting. GAF is working continuously in Sudan since 2010.

Contact: Dipl.-Geogr. Thomas Kukuk (thomas.kukuk@gaf.de)

TH Cologne - Institute for Technology and Resources Management in the Tropics and Subtropics (ITT)

New demographic, economic and climate pressures on the availability of safe and sustainable supplies of food, water and energy require new strategies to manage our precious natural resources. In order to face this global challenge, the demand for experts who can analyse complex human-environmental system and develop suitable solutions is growing. Tropical and subtropical regions represent a special case as they often have additional challenges and exhibit highly unstable environment. The Institute for Technology and Resources Management in the Tropics and Subtropics (ITT) at the TH Köln (University of Applied Sciences) aims to enable people of various technical and cultural backgrounds to better solve the complex issues related to environmental problems with an interdisciplinary and intercultural approach at the graduate and postgraduate level. We cooperate with key regional, national and international organizations within the fields of resources management, development co-operation and higher education in addition to providing teaching, research and capacity development worldwide.



Contact: Dr. Nadir Elagib (elagib@hotmail.com)

Dams Implementation Unit (DIU)

The DIU belongs to the Ministry of Water Resources Irrigation and Electricity and was established by a Presidential decree in 2005 to enhance and develop the role played by “Merowe Dam Implementation Unit”. The new body inherited all assets and staff. Dams Implementation Unit was established to develop and utilize water resources across Sudan according to international measures and standards. Dams Implementation Unit also works to develop irrigation systems to increase agricultural lands.

Contact: Abdelrahman Saghayroon Elzein (hydro.diu@gmail.com)

Hydraulics Research Centre Sudan

The Hydraulics Research Centre HRC-Sudan (http://www.hrc-sudan.sd/), is one directorate of the Ministry of Water Resources Irrigation and Electricity, Sudan. It is located in Wad Medani, Gezira State. It has been established in late 1970's, with the main mission as "to support decision making for water resources management in Sudan through solution-oriented research and capacity building programs". By now, the HRC is the largest research centre in Sudan working on water related issues, with more than 100 staff members, of which 42 are researchers (BSc, MSc, PhD).

The HRC has successfully completed many research and capacity building projects in Sudan. These include research projects on water management in irrigation schemes (Gezira, Rahad, and others); Research projects on the hydrology of the Nile and non-Nilotic streams (e.g., Wadi hydrology and water harvesting); Research projects on reservoir operation (and reservoir sedimentation) of existing and planned reservoirs across the Nile; Research projects on wetlands and environmental issues (e.g., Sudd wetlands); Research projects on river morphology and training works along the Nile and tributaries (e.g., bank erosion and protection along the Main Nile).; research projects on flood forecasting. Research projects on irrigation water management, e.g., calibration of hydraulic structures, Smart ICT for irrigated agriculture among many others. More details about research projects and capacity building programs are available at http://www.hrc-sudan.sd/

Similarly, the centre has successfully completed a number of consultancy assignments requested by different clients, mainly from Sudan, but also from outside, e.g., from ENTRO-NBI, Ethiopia, IWMI, Sri Lanka, among others.

The HRC is well equipped with facilities to carry out applied research and consultancy work, including an experimental hall for physical models, soil laboratory, and good computer facilities for numerical computations. The institute also has a good equipment (and experience) of conducting field measurements (bathymetric surveys, hydrometry, filed surveys, etc.).

Contact: Prof. Dr. Yasir A. Mohamed (y.mohamed@un-ihe.org), Eng. Yasir Hageltom (y.eltom@hrc-sudan.sd)

National Water Research Center (NWRC)

Contact: Dr. Ahmed El Tayeb (ahmed_eltayeb2000@yahoo.com)

Nile Water Directorate

The Nile Water Directorate is one of the departments of the General Directorate for Nile Water and Reservoirs. It is concerned with the accounting of surface water resources in Sudan and calculating its consumption of Nile water. It works as an executive arm of the Joint Technical Commission for Nile water. It provides hydrological data for Nile and its tributaries.

Tasks and Terms of Reference

- Construction and operation of Nile hydrological stations to monitor Nile Levels, flows and sampling and analyzing sediment.
- Nile Water balance and accounting
- Nile River flow forecasting

- Identification of projects to increase the yield of the Nile River and its tributaries
- Identify storage projects for irrigation and energy generation and determine the optimum methods for water utilization
- Cooperation with international and regional organizations for the purpose of developing and modernizing monitoring methods, increasing Nile yield and minimizing losses

Contact: Dr. Salih Hamad Hamid (shhomer@gmail.com)

Regional Center for Research and Capacity Development on Water Harvesting (RCWH)

The Regional Center for Capacity Development and Research on Water Harvesting (RCWH) was established in 2013 through the agreement between the government of Sudan and the United Nations Educational Scientific and Cultural Organization (UNESCO) as a category 2 centre under the auspices of UNESCO for Water Harvesting in East Africa and Arab States.

Its core mandate is to act as the principal regional center on water harvesting in the countries of East Africa and Arab States, as a platform for research, capacity development, and knowledge transfer on water harvesting in the region in order to:

- promote and support the development of the water harvesting sector
- contribute to better quality of life
- facilitate/ ensure natural resources conservation and utilization; and
- alleviate poverty.

The RCWH's main functions are to:

- conduct specialized training programmes and other capacity development activities as well as raising awareness and knowledge on water harvesting through training sessions that target stakeholders at both the national and regional levels;
- promote scientific research and undertake effective capacity development activities at the institutional and professional levels;
- create and reinforce networks among institutions and individuals for the exchange of scientific, technical and policy information;
- develop and coordinate cooperative research activities, taking particular advantage of the scientific and professional capacity of the IHP networks and the relevant programmes of non-governmental organizations, international institutions and networks;
- organize knowledge and information transfer activities, including nationaRegional and international symposia or workshops, and engage in appropriate awareness-raising activities targeting various audiences, including the public;
- develop a strong programme of information and communication technology, as well as a database on water harvesting;
- produce technical publications and other media items related to the activities of the Centre, with the opportunity of producing joint publications with UNESCO, observing the quality assurance of their publications; and,
- provide technical consulting services on water harvesting.

The RCWH pursues the above objectives and performs the abovementioned functions in close coordination with UNESCO-IHP.

Contact: Eng. Hatim Ali Elbadri (hatim26@hotmail.com)

Sudan Meteorological Authority (SMA)

Sudan Meteorological Authority focusing on developing reliable and robust products to support decision makers as well as the various community sectors to achieve their objectives and fulfill their aims regarding the sustainable development goals.

For this end, SMA doing extensive research in Rainfall Seasonal Prediction to improve the forecast quality by applying the suitable methods and techniques that suite the country. This have been carried out since 1999, with a collaboration with IGAD Climate Predictions and Applications Center (ICPAC). In the same regards, SMA collaborated with Finish Meteorological Institute (FMI) to develop the short-range weather forecast for aviation and other sectors. This under modernization and rehabilitation of SMA project.
Some research focused on the impact of Haboob on the air traffic operations, which concern with source identification and potential forecast methods to eliminate the potential risks.

Regarding Agriculture and Food Security, the impact of climate change is the main research topic. SMA start a collaboration with Tottori University to assist in this area.

Proposal research topic are:

1. Data assimilation to improve the weather forecast.
2. Characteristics of inter-Tropical Conversion Zone (ITCZ) over Sudan to improve weather forecast.
3. Identifying suitable climate services dissemination methods for Sudan.
4. The influence of Indian monsoon low pressure on Sudan's rainfall.
5. Statistical and dynamical Downscaling of local climate .

Contact: Dr. Ahmed Mohamed Abdelkarim (ahmed@ersad.gov.sd), M. Sc. Abulegasim Ibrahim Idriss Musa (gasim@ersad.gov.sd), M. Sc. Ammar Mokhtar Gomaha Gaber (ammar@ersad.gov.sd)

Upper Atbara Dams Complex Project (UADCP)

Contact: Eng. Mohamed Suleiman (mohdtyba@gmail.com)

Water Research Centre, University of Khartoum

The Water Research Centre, University of Khartoum is a multidisciplinary research and capacity building centre established by the University of Khartoum in 2009 within the Faculty of Engineering. It aims at cconducting multi-disciplinary research and development studies addressing the needs related to water and the environment, promoting capacity building through continued training of water resources professionals , providing technical, strategic and policy advice to policy makers and stakeholders and enhance the role of the university in community development and its involvement and leadership in regional and international water activities. In 2014 the Centre has been promoted to a Centre of Excellence in Water Research by the Ministry of Higher Education and scientific Research. In 2017 the Centre has been selected as one of the AU/NEPAD Centers of Excellence in water science and technology, and its currently hosting the Secretariat of the AU/NEPAD Centers of Excellence in water science and technology in Central and eastern Africa.

The centre has seven departments specialized in various aspects of water resources and environmental management and conducting research in areas relevant to the needs of Sudan and the Region. Research areas include arid Zone or dry land hydrology, flash flood and drought management, water

conservation, watershed modeling and management, river morphology and sediment transport, climate change studies, irrigation management and water use efficiency, water supply and sanitation, water quality management, water accounting, water diplomacy and transboundary water management and water-energy-food security nexus on the river Nile. The centre has scientific collaboration with many universities, research institutions, specialized networks and programs nationally, regionally and internationally. These include UNESCO International Hydrological Program (IHP), Global G-Wadi (Water and Development Information), African G-Wadi, Arab G-Wadi, International Flood Initiative (IFI), International Sediment Initiative (ISI), World Bank- Nile Basin Initiative NBI/, Eastern Nile Technical Regional Office (ENTRO), UNESCO-IHE, Delft the Netherlands , ITT, Cologne University of Science and Technology, Germany, Imperial College of Science and Technology, London, UK, Oxford University, Oxford, UK as well as many Regional Universities including Addis Ababa University, Nairobi University., Kenyatta University, Dar el Salam Univ., Cairo University., and Ain Shams University.

Contact: Prof. Dr. Gamal Murtada Abdo (gabdo2000@yahoo.com), Prof. Dr. Mohammed Akode Osman (mohdakode@yahoo.com)