Support of integrated water resources management by hydrological modelling and remote sensing of arid and semi-arid ecosystems in the Tarim basin (phase 2) 'Tarim Water Management' (ARCHIMOD -phase 2) - BL/01/C55- BL/67/C56

(Geographic) study area (country/region): China, Xinjiang Province

Data used: Meteorological and hydrological datasets Tarim river basin; GCM simulation results IPCC AR4 archive, LANDSAT TM/ETM+, CORONA Satellite imagery

Context and objectives

The project delivered a significant contribution to the water management problem solving in the Tarim river basin of the Xinjiang Province of the P.R. China. The Tarim river and basin forms one of the world's largest closed hydrological drainage systems, forms ideal land for agriculture (e.g., cotton production), but suffers from reduced water availability. Since the 1950's, excessive land reclamation, over-grazing, unreasonable utilization of water resources in the upper reaches of the basin in combination with temperature increase due to climate change, have intensified environmental deterioration. Since the 1970's a strong dry-out of the lower region has been observed. This dry-out seriously deteriorated the basin's downstream ecosystems, with an expanding desertification along the lower reaches of the river. In order to meet these problems, there is a strong need for integrated and sustainable water management planning in the region.

During Phase 1 of the project, a prototype decision support system has been set up based on linked river catchment hydrological and river hydrodynamic models. The 2nd phase of the project demonstrated that the prototype decision-support system can be applied for scenario-analysis in water management. Also training on the use of the system has been given to the local experts. The following set of scenarios were developed, implemented in the system, and the effects investigated on the Tarim river hydrology: climate change (global warming) till the 2050s and till about 2100, land use trends (historical since 1950 and projected till 2030), and upstream snow and glacier melting scenarios.

Methodology

In order to meet the objectives, the project has:

- analysed future trends (by global warming) in precipitation, temperature and potential evapotranspiration by statistically processing and downscaling of climate model simulation results (GCM runs of the IPCC AR4 archive);
- analysed the effects of these climate change trends in precipitation, temperature and potential evapotranspiration on the hydrology of the Tarim basin: on rainfall-runoff and river flow and stages, during high and low flow periods (floods and droughts), and on groundwater levels;
- analysed long-term changes in land cover over the Tarim basin by means of available remotely sensed data (LANDSAT TM/ETM+ and CORONA), and investigated the impact of these historical land use changes on the hydrology of the basin;
- developed future land use change scenarios based on the Moland CA model, and investigated the impact of these projected land use changes on the hydrology of the basin;
- analysed the effects of upstream snow and glacier melting scenarios on the hydrology of the basin.

The impact investigations on the Tarim basin hydrology were based on the combined hydrological – hydrodynamic models developed for the lower Tarim river and the Kaidu subbasins. In order to enable impact analysis of glacier melting, additional models were developed for the Hetian subbasin.

Results

- Global and regional climate model simulation results for the Tarim basin statistically analyzed and downscaled to be used as input for hydrological impact investigation (future climate projections till 2045-2065 and 2075-2095).
- Long-term changes in land cover over the Tarim basin for the historical period 1964-2005.
- Future land-use change scenarios developed till 2030.
- Climate scenarios and land use trends simulated in the regional surface water model, and coupled river-groundwater model for the downstream Tarim region and the Kaidu and Hetian subbasins.
- Impact assessments of climate scenarios on snow and glacier melting, high and low runoff flows, soil moisture and groundwater levels for the study region.
- Training and dissemination of earth observation products, remote sensing data processing techniques and hydrologic-hydraulic modelling tools to the local partners.

Products and services

Remote sensing products:

- bio-geophysical 2D fields of land surface temperature and soil moisture
- land cover maps derived from LANDSAT TM/ETM+ and CORONA imagery, for selected period 1964 - 2005

Developed scenarios:

- regional climate change scenarios for precipitation, temperature and potential evapotranspiration till 2045-2065 and 2075-2095
- land use change patterns till 2030

Hydrological/hydraulic impact results:

- impacts of climate change (global warming)
- impacts of historical and future land use trends
- impacts of upstream snow and glacier melting scenarios

Peer-reviewed international journal publications:

- Huang Y., Chen X., Bao A., Liu T., Feng X-W. (2009), 'Daily flow modeling in arid ungauged basin', Advances in Water Science, 20(3), 332-336
- Huang Y., Chen X., Li Y.P., Willems P., Liu T. (2010), 'Integrated modeling system for water resources management of Tarim River Basin', Environmental Engineering Science, 27(3), 255-269
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- Liu, T., Willems, P., Feng, X.W., Bao, Anm., Chen, Xi, Veroustraete, F., Dong, Q.H. (2011), 'On the usefulness of remote sensing input data for spatially distributed hydrological modelling: case of the Tarim River basin in China', Hydrological Processes, 25, 10.1002/hyp.8129, [In Press]
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- Liu T., Fang, H., Willems P., Bao A., Chen X., Veroustraete F., Dong Q.H. (2011), 'Historical landuse analysis for the lower Tarim river region in China', Hydrological Processes [Submitted]
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- Li Q., Veroustraete F., Chen X., Verstraeten W., Li J., Liu T., Dong Q., Willems P., (2011). 'The AMSL LST algorithm validated for the Xinjiang province in China', International Journal of Remote Sensing, [In Press]
- Veroustraete F., Li Q., Verstraeten W.W., Chen X., Bao A., Qinghan D., Liu T., Willems P. (2011), 'Soil Moisture Content Retrieval based on Apparent Thermal Inertia for the Chinese province of Xinjiang', International Journal of Remote Sensing, [In Press]
- Veroustraete F., Fang H., Xi C., Bao A-M., Dong Q-H., Liu T.and Willems P., (2011). Diachronic Mapping of LUCC in the Northwest of China over the last half Century. Conversion of CORONA Panchromatic reflectance into LANDSAT NDVI Imagery. Sensors, [Submitted]

International conference proceedings publications:

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- Huang Y., Chen X., Feng X-W., Liu T., Willems P. (2009), 'Incorporating remote sensing and geography information system in hydrological modeling of Kaidu Basin, northwest China', 2009 World Congress on Computer Science and Information Engineering (CSIE 2009), Los Angeles, USA, 31 March - 2 April 2009, vol.4, p.137-142; ISSN 1001-6791/ISBN 978-0-7695-3507-4
- Liu T., Willems P., Feng X.W., Li, Q., Huang, Y., Bao, An.M., Chen, X., Veroustraete F., Qinghan D. (2009), 'Hydrological modelling in support of emergency water allocation studies in the Xinjiang Province in China', In: Hydrology and Ecology: Ecosystems Interfacing with Groundwater and Surface Water (ed. by J. Bruthans, K. Kovar & P. Nachtnebel), Proc. HydroEco2009 Conf. (20-23 April 2009, Vienna, Austria). Published by Universität für Bodenkultur (BOKU), Vienna, p.107-110. ISBN 978-3-900962-80-7
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- Basher Md. A., Liu T., Kabir Md. A., Ntegeka V., Willems P. (2010), 'Climate change impact on the hydrological extremes in the Kaidu river basin, China', USSD (United States Society on Dams) 30th Annual Conference on "Collaborative Management of Integrated Watersheds", 12-16 April 2010, Sacramento, California, 637-651; U.S. Society on Dams, Denver, ISBN 978-1-884575-51-8
- Li Q., Xi C., Veroustraete F., Verstraeten W. W., Bao A-M., Dong Q-H. and Wang, (2009) Soil Moisture Content Retrieval based on Thermal Inertia in the Arid to Semi-Arid Xinjiang province in China. Proceedings, Integrated Water Resources Management in theory and practice (IWRM), Brussels, pp.1-24
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- Feng X-W., Huang Y. Chen X., Veroustraete F., Qinghan D., Willems P. (2006), 'Support of integrated water resources management by hydrological modelling and remote sensing of arid and semi-arid ecosystems in the Tarim basin – 1st Phase I Report', Hydraulics Division K.U.Leuven, VITO - Center of Expertise of Remote Sensing and Earth Observation Processes and XIEG-Urumqi, Report for Belgian Science Policy Office, May 2006, 37 p.
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- Liu T., Willems P., Veroustraete F., Qinghan D., Huang Y. & Qin L. (2007), 'Support of integrated water resources management by hydrological modelling and remote sensing of arid and semi-arid ecosystems in the Tarim basin – 3rd Phase I Report', Hydraulics Division K.U.Leuven, VITO - Center of Expertise of Remote Sensing and Earth Observation Processes and XIEG-Urumqi, Report for Belgian Science Policy Office, May 2007, 99 p.
- Liu T., Willems P., Veroustraete F., Qinghan D., Feng X-W., Chen X. & Bao A. (2007), 'Support of integrated water resources management by hydrological modelling and remote sensing of arid and semi-arid ecosystems in the Tarim basin – 4th Phase I Report: Distributed hydrological modelling for the downstream basin of Tarim River and advanced remote sensing processing activities', Hydraulics Division K.U.Leuven, VITO - Center of Expertise of Remote Sensing and Earth Observation Processes and XIEG-Urumqi, Report for Belgian Science Policy Office, December 2007, 156 p.
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- Liu T., Willems P., Qinghan D., Veroustraete F., Hui Fang, Yan Dou (2010), 'Support of integrated water resources management by hydrological modelling and remote sensing of arid and semi-arid ecosystems in the Tarim basin – 3rd Phase II Report', Hydraulics Division K.U.Leuven, VITO - Centers of Expertise TAP and RMA and XIEG-Urumqi, Report for Belgian Science Policy Office, January 2010, 135 p.
- Liu T., Willems P., Qinghan D., Veroustraete F., Hui Fang, Yan Dou (2010), 'Support of integrated water resources management by hydrological modelling and remote sensing of arid and semi-arid ecosystems in the Tarim basin – 4th Phase II Report', Hydraulics Division K.U.Leuven, VITO - Centers of Expertise TAP and RMA and XIEG-Urumqi, Report for Belgian Science Policy Office, June 2010, 156 p.
- Liu T., Willems P., Qinghan D., Veroustraete F., Hui Fang, Chen X., Bao A. (2011), 'Support of integrated water resources management by hydrological modelling and remote sensing of arid and semi-arid ecosystems in the Tarim basin – 5th Phase II Report', Hydraulics Division K.U.Leuven, VITO - Centers of Expertise TAP and RMA and XIEG-Urumqi, Report for Belgian Science Policy Office, January 2011, 103 p.
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PhD dissertation:
Tie Liu: 'CLIMATE AND LANDUSE CHANGE IMPACT ANALYSIS ON THE WATER RESOURCES OF THE TARIM BASIN IN CHINA, INTEGRATING HYDROLOGICAL MODELING AND REMOTELY SENSED DATA', K.U.Leuven – Faculty of Engineering, 22 August 2011

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Execution

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Discipline

Hydrology & freshwater resources
General Earth observation
Hardware & software