MULTI - SOURCE HYDROLOGICAL DATA PRODUCTS TO MONITOR HIGH ASIAN RIVER BASINS AND REGIONAL WATER SECURITY (MUSYCADHARB)

European Leader Investigator	***Chinese Leader Investigator***
Prof. Massimo Menenti Delft University of Technology, NETHERLANDS	Prof. Li Xin Cold and Arid Regions Environmental and Engineering Research Institute, CHINA

List of Principal Investigators (PIs)

Topic Nr.	PIs	Title
32439_1	*Prof. Massimo Menenti,* *Prof. Li Jia*	***Satellite data products on each component of the terrestrial water cycle at the land – atmosphere interface (SADTALE)***
32439_2	*Dr. Francesca Pellicciotti,* *Prof. Kun Yang*	***Observation and modeling of high elevation hydrological processes, including accumulation and ablation in glaciers***
32439_3	*Prof. Marco Mancini,* *Prof. Xin Li*	***Forcing, calibration, validation and data assimilation in basin scale hydrological models using satellite data products***
32439_4	*Dr. Maria Jose Escorihuela,* *Prof. Jiancheng Shi*	***Monitoring Water resources in Red River Basin using Microwave Remote Sensing***

EXECUTIVE SUMMARY

Problem statement. Fully integrated use of satellite, ground observations and hydrological distributed models is necessary to support water resources management in S and E Asia and to clarify the roles of the interactions between the land surface and the atmosphere over the Tibetan Plateau in the Asian monsoon system.Objectives -This project is part of an integrated response to the Call Theme Hydrology & Cryosphere with the projects "Earth Observation to investigate the characteristics and changes of the cryosphere in High Mountain Asia(EOCRYOHMA, led by T.Yao and T.Bolch) and Earth Observations tools for Water resource and quality monitoring in Yangtze wetlands" (EOWAQYWET, led by Y. Wang and H. Yesou). -Hydrological data products will be generated taking advantage of the synergies of European and Chinese data assets and space-borne observation systems, taking advantage of the improved accessibility and standardization of Chinese data products; -Develop an energy-budget-based glacier mass balance model driven by satellite observations and linked with a distributed river basin model to describe glacier-melt contribution to river flow; -Use satellite hydrological data products for forcing, calibration, validation and data assimilation in basin scale hydrological models;Methods. We plan to exploit specific synergies of ESA and Chinese satellites, such as the combination of ESA S1 SAR data with Chinese microwave radiometers or the high spatial and spectral resolution of Sentinel 2 with the thermal data acquired by CBERS-4/ IRS and HJ-1B. Such multi-source remote sensing data, from visible to thermal infrared and microwave, will be used for forcing, calibration, validation and data assimilation of/into basin scale hydrological models. Besides hydrological data products on gains and losses of water at the land - atmosphere interface, other land surface properties will be retrieved to meet model data requirements. The latter includes: vegetation fractional cover, LAI, land surface albedo and temperature, snow cover, soil water content, surface soil freeze-thaw status, lakes extent and water level. Some of these data products will be used to update state variables of hydrological models. As regards high elevation hydrological processes, the project combines in-situ, satellite observations with modeling that includes accumulation and ablation. An energy-budget-based glacier mass balance model is to be developed and key model parameters will be tuned with high-resolution satellite products on albedo and surface temperature. The glacier mass balance model is coupled with a distributed hydrological model, and the coupled model is then used to quantify the contribution of glacier melt to river discharge. Deliverables: see Management section. Funding sources. NSFC- Grant no. 91425303); 973 Grant no. 2015CB953702); 1000 Talent Plan for High-level Foreign Experts (M.Menenti, Grant no. WQ20141100224); H2020/ MOSES (Grant no. 642258). H2020/ MOSES (Grant no. 642258); H2020 JPI/ Waterworks ; Innovation Grant / SEGUICI; NSFC Land-atmosphere Interactions in the Tibetan Plateau and its global climate impact (Grant No. 91537210); CAS Priority Research Grant No. XDB03030300); NSFC - Integrated modeling and prediction of the water-ecosystem- economy in the Heihe River Basin-(Grant number: 91425303); CAS Interdisciplinary Innovation Team; NSFC - Spatial distribution of glacier mass balance on the southeast Tibetan Plateau and its mechanism (4) MOST National Special Basic Research Project "Glacier melting investigations on the Tibetan Plateau" (2013FY111400-2); Swiss National Science Foundation (SNSF) project UNCOMUN (UNderstanding COntrasts in high MoUNtain hydrology in Asia).

ABSTRACT 32439_1: "Satellite data products on each component of the terrestrial water cycle at the land – atmosphere interface (SADTALE)"

European Principal Investigator	***Chinese Principal Investigator***
Prof. Massimo Menenti	Prof. Li Jia
(Delft University of Technology,NETHERLANDS)	(Institute of Remote Sensing and Digital Earth,CHINA)

Problem statement
The last decade has seen an increasing interest for cryospheric and hydrologic processes in cold, high elevation regions. This is due to a two- fold relevance:
a) The cryosphere in high elevation regions is a very sensitive indicator of climate change;
b) Meltwater from glaciers, permafrost and snow is a significant fraction, and a critical one at times, of fresh water resources in many parts of the world, particularly in China and in the Countries receiving waters from the Qinghai – Tibet Plateau.
An analysis of recent literature shows that Cryosphere and Hydrology questions should be linked towards better science for a better understanding of the terrestrial water cycle across a range of spatial and temporal scales. This leads to the need of connecting regional and global analyses of water resources.
The grand challenge of cryosphere and hydrosphere science in high elevation regions is the scarcity and sparseness of data on the multiple variables and processes of relevance and the difficulty of carrying out experiments at the appropriate spatial and temporal scales.
Observations from space have the potential of providing observations of several key – variables on the terrestrial water cycle with the required temporal sampling and over extended periods of time.
Objective
The objective is to generate products on the water fluxes determining the water balance over land. By taking advantage of the synergies of European and Chinese satellite data to monitor river basins. To strengthen the synergies under the theme Hydrology and Cryosphere, we will generate hydrological data products useful to characterize hydrological processes in high elevation and cold regions (see Proposal "Earth Observation to investigate the characteristics and changes of the cryosphere in High Mountain Asia (EOCRYOHMA)"), wetlands (see Project on Wetlands and ecology) and more broadly to support modeling large and complex river basins (see Sub-Topic 3). We plan to exploit specific synergies of ESA and Chinese satellites, such the combination of ESA S1 SAR data with Chinese microwave radiometers or the high spatial and spectral resolution of Sentinel 2 with the thermal data acquired by CBERS-4/ IRS and HJ-1B.
Method
The retrieval methods are described in the Detailed Proposal for each variable. Most methods generate data products by combining data acquired by different satellites and sensors. In some cases, e.g. ET, it is necessary to combine measurements of different surface properties in different spectral ranges. In some other cases data acquired by similar sensors on different satellites are combined to improve temporal sampling. Examples of sensor synergies include retrieval of snow water equivalent by combining measurements by microwave radiometers with multispectral imagers to retrieve snow cover. Retrieval of liquid and solid precipitation is of particular relevance and we plan to further develop an approach based on the assimilation of active and passive microwave measurements in atmospheric models. From a Chinese perspective such approach would be applicable to the measurements to be collected by the Water Cycle Observation Mission (WCOM)..
The water losses variables include the evapotranspiration and its components like plant transpiration, soil evaporation, open water evaporation, rainfall interception, snow and ice sublimation. To retrieve these variables, a physical process based model using remote sensing observations, ETMonitor, will be improved and applied with a suite of surface biophysical and hydrological variables as input, including the land cover, land surface temperature, leaf area index, albedo. ETMonitor makes use of multispectral data from the visible to microwave.
Funding
National Natural Science Foundation of China (NSFC) (Grant no. 91425303), the National Key Basic Research Program of China (Grant no. 2015CB953702) and the 1000 Talent Plan for High-level Foreign Experts (LI M.Menenti, Grant no. WQ20141100224); H2020 MOSES (Grant no. 642258); H2020/ JPI WaterWorks.

ABSTRACT 32439_2: "Observation and modeling of high elevation hydrological processes, including accumulation and ablation in glaciers"

European Principal Investigator	*Chinese Principal Investigator*
Dr. Francesca Pellicciotti	Prof. Kun Yang
(ETH Zurich,Switzerland)	(CAS ITP,CHINA)

This project seizes the opportunity offered by ESA and NRSCC to access high resolution satellite observations of the cryosphere and earth surface to investigate the hydrological cycle, water fluxes, and snow and glacier changes in four representative high elevation catchments across the Tibetan Plateau. Its main aim is to unravel the hydrological functioning of those high elevation catchments and identify the causes for different glacier retreat and contribution to basin runoff in individual climate regimes. To achieve this goal, we will use an integrated approach based on ground data from field programmes, satellite observations from ESA and NRSCC and numerical models of glacier mass balance and catchment hydrology. The high resolution data sets will guide model developments and support model calibration and validation in a systematic manner that ensures that results are comparable across case studies, providing one of the first truly inter-comparative studies of glacier response to climate change in the Tibetan Plateau. The four glaciers investigated are Parlung No.4 Glacier and Glacier 24K (maritime glaciers, the latter covered by debris) in the southeast Tibetan Plateau, Zhadang glacier (continental glacier) in the central Tibetan Plateau, and Rongbuk Glacier (partially debris-covered), in the southern Plateau bordering the Himalaya, where measurements of glacier melt, mass balance and meteorological variables are available.

Comparison of results from debris-covered and debris-free glaciers will allow studying the so-called debris cover anomaly, by which debris covered glaciers in High Mountain Asia (HMA) are losing mass at rates similar to non-debris covered glaciers despite the assumed insulating effect of the debris.

The integrated modelling approach is afforded by the combined expertise of the Chinese and European partners, existence of previous models and availability of novel datasets. Our young, multidisciplinary team of European and Chinese scientists will thus collaborate to: i) provide an advanced characterisation of the climatic drivers in high elevation catchments of the Tibetan Plateau; ii) collect data sets for processes under-represented in HMA and still poorly understood, including snow processes and the dynamics of debris covered glaciers; iii) develop a physically-based energy balance model of glacier changes based on work undertaken by both PIs; and iv) include knowledge of physical processes in a distributed hydrological model which better represents the complexity of catchment response with an enhanced physical basis for greater robustness and transferability. The distributed hydrological model will be used to quantify the spatial distribution, seasonality and interannual variability of snow and glacier contributions to runoff.

Input data will be provided by ground data and satellite observations combined to provide a high resolution time series of hourly gridded forcing, including the elevation dependence of precipitation. The glacier mass balance model will be enhanced with in situ data for inclusion of snow transport and redistribution and debris surface features such as supra-glacial lakes and cliffs. Model parameters will be estimated with high-resolution satellite albedo, surface temperature and snow water equivalent.

The work proposed will be supported by the following projects (1) A key project of NSFC Program "Land-atmosphere Interactions in the Tibetan Plateau and its global climate impact" (Grant No. 91537210); (2) CAS Strategic Priority Research Program (B) (Grant No. XDB03030300); (3) the NSFC project "Spatial distribution of glacier mass balance on the southeast Tibetan Plateau and its mechanism"; (4) National Special Basic Research Project of the Ministry of Science and Technology "Glacier melting investigations on the Tibetan Plateau" (2013FY111400-2); and (5) the Swiss National Science Foundation (SNSF) project UNCOMUN (UNderstanding COntrasts in high MoUNtain hydrology in Asia).

ABSTRACT 32439_3: "Forcing, calibration, validation and data assimilation in basin scale hydrological models using satellite data products"

European Principal Investigator	***Chinese Principal Investigator***
Prof. Marco Mancini (Politecnico di Milano,ITALY)	Prof. Xin Li (Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI), Chinese Academy of Sciences (CAS),CHINA)

Problem statement: Accurate spatio-temporal monitoring of hydrological processes is essential to improve the capability to quantify the hydrological cycle process for water resource management in a parsimonious and sustainable way and for forecasting extreme events such as floods and droughts.
Objectives: The main objective is to improve the estimate of water balance under natural and human pressures in the Heihe river basin in China and in the Po river basin in Italy, using in a synergic and innovative way remote sensing (EO) data from NRSCC, ESA and NASA and distributed hydrological models.
This will be achieved through the following sub-objectives:
• Retrieval of EO products at different temporal and spatial scales (WP1)
• Identification of dynamically and statistically downscaling algorithm for high resolution meteorological forcings from satellite data (WP2)
• Definition of a database of meteorological and hydrological data (WP2)
• Calibration/validation of hydrological models using EO data of land surface temperature (LST), soil moisture (SM), snow cover (WP3)
• Hydrological model state variables updating by assimilating EO data (WP3)
• Retrieval of hydrological cycle components through the combined use of EO data and hydrological models (WP4).
Method: The different components of the hydrological cycle (evapotranspiration (ET), SM, LST, discharge, glacier melt, snow water equivalent (SWE) and groundwater dynamic) will be retrieved from the combined use of distributed hydrological models and EO data at different spatial and temporal scales. In particular Chinese SHAW-DBHM and HeiFLOW and Italian FEST-EWB models will be applied and compared.
EO data, from visible to thermal infrared and microwave, will be used to retrieve vegetation parameters, snow coverage, SWE, glacier melt, LST and SM, lakes extent and water level height, meteorological forcings. These data will be used for forcing, calibration, validation of basin scale distributed hydrological models.
FEST-EWB model coupled with EO data will also be run in the Yangtze river basin exploiting the work done during the Dragon 3 and for its connection with the Dragon 4 project on "Wetlands and ecology monitoring". The innovative way of writing the soil water balance in the FEST-EWB, based on the system of energy-water balances equations as function of the LST, allow that modelled LST can be directly compared with LST from EO for model calibration and validation improving the actual calibration generally performed with discharges.
SHAW-DBHM and HeiFLOW will be used for the upstream and mid-downstream areas considering the significant differences in hydrologic and thermal processes of the two areas of Heihe basin. The SHAW-DBHM is a couple model which is based on one-dimensional simultaneous heat and water model (SHAW) and the geomorphologically based distributed hydrological model (GBHM). HeiFLOW is an eco-hydrologic model which can address a complicated irrigation system with both surface water division and groundwater pumping.
Deliverables:
• LST, SM, snow area cover, water storage change, vegetation parameters from EO (WP1)
• Meteorological forcings from merged ground and EO data (WP2)
• Calibration/validation procedures for distributed hydrological models (WP3)
• Datasets of ET, SM, ET deficit, SWE, snow area coverage, from the hydrological model merging ground and EO data: (WP4);
• Flow duration curves for different river cross sections (WP4).
Source of funding:
• SIM: SMART IRRIGATION FROM SOIL MOISTURE FORECAST USING SATELLITE AND HYDRO –METEOROLOGICAL MODELLING, funded project by ERA-NET Cofund initiative WaterWorks2014
• SEGUICI, Smart technologies for water resources management for irrigation and civil uses, funded by Lombardia Region (Italy)
• A key project of NSFC Program "Integrated modeling and prediction of the water-ecosystem- economy in the Heihe River Basin" (Grant number: 91425303).
The CAS Interdisciplinary Innovation Team of the Chinese Academy of Sciences.

ABSTRACT 32439_4: "Monitoring Water resources in Red River Basin using Microwave Remote Sensing"	
European Principal Investigator Dr. Maria Jose Escorihuela (isardSAT, Spain)	***Chinese Principal Investigator*** Prof. Jiancheng Shi (Institute of Remote Sensing and Digital Earth (RADI),CHINA)
The project will focus on the Red River basin. The Red River, also known as the Yuan River in Chinese, is a transboundary river basin with its total area of 169,000km2 shared by Vietnam(51%), China (48%) and Laos (1%). The Red River basin has a tropical o	