

MONITORING CRYOSPHERE DYNAMIC OVER HIGH MOUNTAIN ASIA WITH INTEGRATED EARTH OBSERVATIONS AND EVALUATING ITS HYDROLOGICAL IMPACTS AT UPSTREAM RIVER BASIN

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List of Principal Investigators (PIs)

Topic Nr.	PIs	Title
32388_1	Prof. Andrew Hooper, Prof. Liming Jiang	Monitoring Decadal Glacier and Frozen Ground Dynamic over High Mountain Asia Region with Integrated Earth Observations
32388_2	Prof. Liqiu Meng, Prof. Lan Cuo	Impacts of Cryospheric Component Changes on Hydrological Process in Typical Watersheds at High Mountain Asia Region
32388_3	Prof. Nico Sneeuw, Prof. Jiancheng Li	Monitoring Lake Level Variations over the Qinghai-Tibet Plateau by Consistent Multi-Satellite Altimetry (QTibMSA)

EXECUTIVE SUMMARY

This project has a two-fold objective. First, we will monitor plateau lake and cryosphere dynamics in the High Mountain Asia (HMA) by synergistic use of multi-mission remote sensing data and insitu observations, second, we will establish physically based distributed cryo-hydrological models in order to analyze impacts of different cryospheric component changes on hydrological processes including lakes of endorheic region and upper stream of great rivers. Cryosphere over HMA is the largest component outside polar region; its dynamic and its impacts on regional hydrological process are essential to earth system. HMA is also termed as Asia Water Tower because several great rivers rise from this region; its water supply safety is essential to billions of people. In last few decades, glaciers over HMA generally suffered from quick and heterogeneous degradation in different sub-regions, thus substantially contributed to sea level risings. Water volumes of endorheic lakes and surface runoffs experienced rapid changes. All these indicate the importance of monitoring lake height changes, cryosphere status and dynamic over HMA and analyzing its impacts on surface hydrology. In this project multimissions of archived and planned satellite altimetry and gravimetry will be employed for monitoring water volume changes of several typical lakes over HMA. For the cryospheric part, the status and dynamics of glacier and frozen ground in each sub-region of HMA will be monitored with integrated earth observations including optical and microwave remote sensing as well as insitu observations. Several new algorithms will be designed for new satellite datasets for deriving cryospheric features. In sub-topic of hydrological modeling part, these results will be imported for modeling and calibration. We will employ or modify one or two physically based models to simulate glacier or frozen ground status and calibrate with remote sensing or in-situ observation data. Then these models will be established and coupled with glacier and frozen ground observation and model to several typical watersheds over HMA. After calibrating the cryohydrological model with cryosphere, meteorological, lake volume and discharge observation in baseline period, we will apply the General Circulation Models (GCMs) on different scenarios of emission or Radio Control Protocols (RCPs) to project the fate of cryosphere over HMA and evaluate its impacts on hydrological process including exdoheic surface runoffs and endorheic lake variation in future. Furthermore, the contribution rates of seasonal snow melting, glacier ablation and frozen ground degradation to endorheic lakes and exdoheic surface runoffs will be quantified and projected in each chosen basin in past, present and future. Water supply safety in important irrigation systems such as Indus and Yarlung Zangbo River will be analyzed. Being Principal Investigator supported by an Open Virtual Geographic Environment (OVGE) system, the relationship of the plateau environmental condition and global climate change, interaction between cryosphere and hydrosphere can be studied and interpreted, which helps to reveal climate and environmental changes impacts over HMA. The primary goals for this project will be: (1) A synergistic analysis and interpretation of multisource data including altimetry, gravimetry, optical and SAR images for monitoring different features of hydrosphere and cryosphere over HMA. (2) To derive typical lake water budget decadal glacier and frozen ground dynamic pattern in each of sub-regions over HMA. (3) To establish physically based distributed cryo-hydrological models for typical endorheic basin and upper stream for the analysis of possible impacts of cryosphere changes on surface hydrology. (4) To simulate cryosphere fate over HMA and analyze its impacts on endorheic lakes and surface runoffs with different scenarios of RCPs. (5) To integrate earth observations, multi-sphere modeling and result analysis in an OVGE system.

ABSTRACT 32388_1: “Monitoring Decadal Glacier and Frozen Ground Dynamic over High Mountain Asia Region with Integrated Earth Observations”	
European Principal Investigator Prof. Andrew Hooper (Leeds University,UK)	Chinese Principal Investigator Prof. Liming Jiang (Institute of Geodesy and Geophysics, Chinese Academy of Sciences, The Chinese Academy of Sciences, CHINA)
<p>The objective of this project will be concentrated on the cryosphere dynamics in the High Mountain Asia (HMA) by the synergistic use of microwave and optical earth remote sensing as well as in-situ observations. As the largest component of cryosphere outside Arctic and Antarctic, cryosphere at HMA is an essential indicator of global and regional climate changes. In recent years, frozen ground and glacier over HMA experienced drastically and heterogeneous degradation suggested by different methods of observations. Generally monsoon dominate region suffered from quick degradation while westerlies dominate region kept stable or shows positive mass balance. However, glacier mass balance at different sub-region over remains on debates with different monitoring methods and equilibrium line uplifting remain blank at most regions. For frozen ground, most in-situ study concentrated on regions along Qinghai-Tibet Railway while most of other region remains unclear. All these imply the importance of sustained monitoring cryosphere and exploring new methods to limit observations bias and errors and achieve to a higher precision. In this project, status of glacier and frozen ground in each sub-region of High Mountain Asia will be monitored with integrated earth observations including optical and microwave remote sensing and in-situ observations. Topographic differencing method will be employed for deriving glacier height and mass balance; single and dual polarized SAR images will be applied for identify summer end snow lines (equilibrium line) on glaciers, multi-temporal SAR interferometry will be performed to evaluate frozen ground deformation, lost rates of ice-rich layer and net ice balance. By the supporting of Open Virtual Geographic Environment (OVGE) system, the relationship of the plateau environmental condition, regional climate and global climate change will be further studied to exploit reasons for heterogeneous cryosphere degradation rates over HMA region, supporting researches of cryospheric impact of surface hydrology, and also in supporting the regional sustainable development, e.g. water supply safety estimation and engineering structures safety operation.</p> <p>The primary goals will be: (1) A synergistic analyzing and interpretation of multi-source of optical and SAR images for the purposes of monitoring glacier outlines, summer end snowlines, flow velocities, and height changes in multi-temporal scale. (2) Applying multi-mission SAR images to monitor seasonal and decadal frozen ground changing associate with ground observations. (3) Exploring pattern of changing glaciers and frozen ground over HMA, and try to explain different behavior among different sub-regions. (4) An integrated VGE platform for multi-dimensional visualization, geospatial analysis, dynamical modeling and decision-making for geological and environmental process.</p> <p>Under the funding support from National Basic Research Program of China (973) and European FUTUREVOLC, this project will be implemented based on the planned schedule. The potential deliverables will include new developed methodologies and an integrated VGE analysis prototype.</p>	

ABSTRACT 32388_2: "Impacts of Cryospheric Component Changes on Hydrological Process in Typical Watersheds at High Mountain Asia Region"

European Principal Investigator

Prof. Liqiu Meng
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Chinese Principal Investigator

Prof. Lan Cuo
 (Institute of Tibetan Plateau Research, The Chinese Academy of Sciences, CHINA)

The objective of this project will be concentrated on analyzing the cryosphere dynamics affections on hydrological process at the High Mountain Asia (HMA) by integrated earth observation, in-situ observation and also cryo-hydrological model at multi-temporal scale. In recent decade, due to temperate increasing and precipitation changes at HMA, glacier and frozen ground suffered from significant degradation. As solid water reservoir, glacier and permafrost play essential roles in cryo-hydrological process and their impacts to need to be explored in large domains. Due to lacking of long-term in-situ observations, physically based cryo-hydrological modeling can reveal historical trends and can project future trends of hydrological variables for large river basins given reasonable forcings as an alternative. In this project, Five typical watersheds in both endorheic and exorheic regions and with different impacts of westerlies and monsoons over HMA are selected. We will establish several physical based and/or empirical models for simulating glacier mass balance and frozen ground status. Physical models and/or empirical methods will be constructed or refined to simulate glacier mass balance and frozen ground status. For each watershed, a physical distributed cryo-hydrological model will be established such as modified VIC model. Then GCMs and different radiative forcings are used to simulate the fates of future glacier and frozen ground, and estimate their impact on hydrological processes in different scenarios. The project is dedicated to visual analysis of the cryospheric dynamics (historical trends and future trends) and its impacts on hydrological processes in High Mountains in Asia (HMA). Data sources provided by earth observations of satellite missions from China and ESA, in-situ observations and cryo-hydrological models will be integrated at multi-temporal scales, shared, analyzed and visualized in an Open Virtual Geographic Environment (OVGE).

The primary goals will be: (1) establishing empirical or physical based models for simulating glaciers dynamic and frozen ground freezing-thawing cycle over typical watersheds in HMA region; (2) evaluating past and recent glacier melting and frozen ground melting contributions to surface runoff change and endorheic lake volume changes at different sub-regions in HMA; (3) predicting glacier and frozen ground melting rates and their contribution in future 100 years at five typical watersheds at different sub-regions over HMA; (4) making water resources management reports for HMA region.

ABSTRACT 32388_3: "Monitoring Lake Level Variations over the Qinghai-Tibet Plateau by Consistent Multi-Satellite Altimetry (QTibMSA)"

European Principal Investigator

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Designated as the "Roof of the World" or the "Third Pole", the Qinghai-Tibet Plateau is a vast elevated plateau in Central Asia and East Asia. It stretches approximately 1000 km north to south and 2500 km east to west. With an average elevation exceeding 4500 m, the Qinghai-Tibet Plateau accommodates the headwaters of the drainage basins of most of the major rivers in east and south Asia. With tens of thousands of glaciers, hundreds of lakes, and other geographical and ecological features the plateau serves as a "water tower" storing water and maintaining flow. The impact of global warming on the Qinghai-Tibet Plateau is consequently a topic of intense scientific interest. The lakes over the Qinghai-Tibet Plateau, with an area of 36900 km², are the largest group of lakes in China. Lake level fluctuation is an important indicator of global change, e.g. from climate change, plateau uplift, glacial ablation and other environmental changes. However, the observational record with in situ gauges is notoriously poor. Satellite altimetry, primarily designed for ocean monitoring, is an efficient tool for near real-time and continuous monitoring of inland lake levels, albeit with reduced accuracy. The heritage of the Topex-Jason family and the ERS-Envisat family of altimeters will be continued with Sentinel-3 and Sentinel-6. A consistent data processing of multi-satellite altimetry in terms of intersatellite biases, spatio-temporal sampling and data quality is one of the key technical challenges in this project.

This proposal is rooted in the theme "Hydrology & Cryosphere" but crosses theme boundaries, particularly towards "Climate", "Ecosystems" and "Solid Earth". It is a continuation, though with sharper focus, of the Dragon-3 project "Current and Future Geodetic Satellite Missions for Global Change Monitoring" between the University of Stuttgart and Wuhan University.

The main objectives of this joint project are:

- Training of young researchers and scientists.
- Consistent data processing of multi-satellite altimetry in terms of intersatellite biases, of spatio-temporal sampling and of data quality.
- Investigation of water budgets not only by satellite altimetry, but also by satellite gravimetry and other relevant data.
- Quantification of the relationship between lake level changes over the Qinghai-Tibet Plateau and global climate change.

Method: We will select a wide variety of lakes over Qinghai-Tibetan Plateau for our case studies, based on size, altitude, ground-track geometry, availability of auxiliary data and so on. Their levels will be observed by multi-satellite altimetry, whereas the height change of glaciers surrounding the study cases will be also observed either by radar or laser altimetry. Lake level changes and glacial melting are combined to analyze the water budgets at regional or scale, as relevant to climate change. We will use the ground water estimates from satellite gravity measurements and hydrological model to support our analysis and to improve our understanding of the climate and environmental changes over the Qinghai-Tibet Plateau.

Deliverables: The deliverables will be scientific outputs in terms of peer reviewed journal publications, PhD theses, and analysis results (consistent time series) of the lake level/water budgets over Qinghai-Tibet Plateau.

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