Article, Published Version

Wang, Guangqian; Wie, Jiahua; Huang, Yuefei; Fu, Xudong; Zhong, Deyu

The Sky River Project

Hydrolink

THE SKY RIVER PROJECT

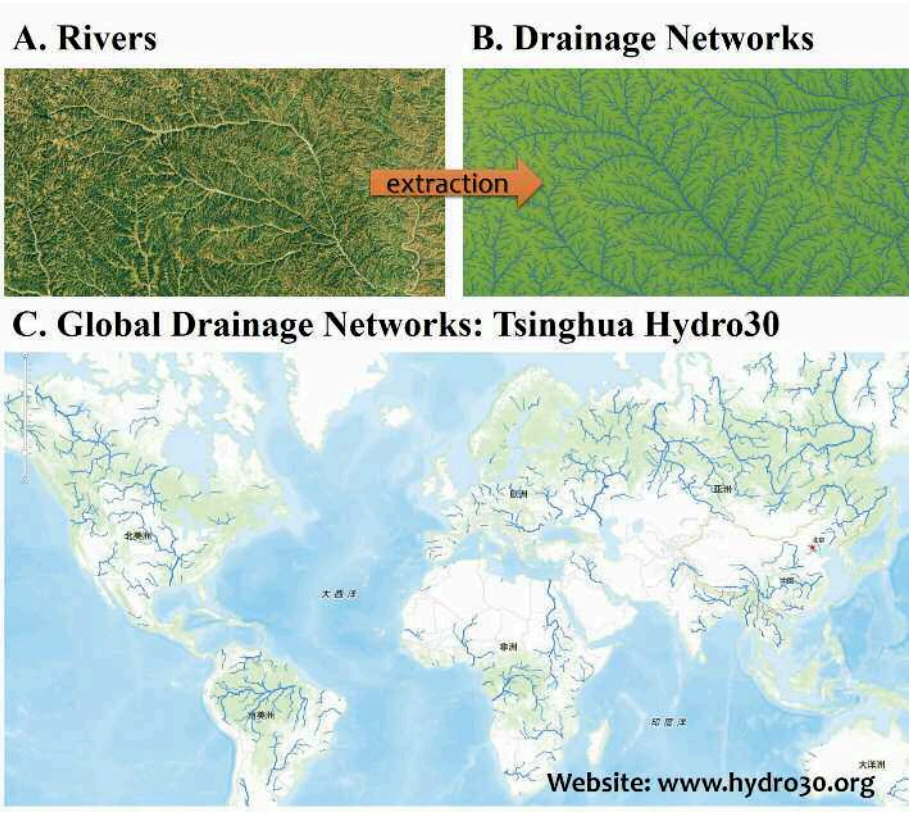
BY GUANGQIAN WANG, JIAHUA WEI, YUEFEI HUANG, XUDONG FU & DEYU ZHONG

The "Sky River Project" is a comprehensive research project initiated by Professor WANG Guangqian, member of Chinese Academy of Sciences (CAS). The project aims at solving the water shortage crisis in West China by exploiting cloud water resources. Sky River dynamics provides the theoretical basis for exploiting atmospheric water resources. Integrated utilization of water resources of both sky rivers and earth surface rivers is proposed. Combinations of traditional and modern artificial weather modification techniques have been tested. Effects of the different techniques are evaluated through the monitoring system. Temporal and spatial impacts of utilization of atmospheric water resources on the earth surface rivers will be investigated in various spatial regions.

Global Drainage Network Hydro30

The global digital drainage network Tsinghua Hydro30, produced by our team, describes important spatial information used in hydraulic research and public services. Besides the intrinsic characteristics of space and topology, the digital drainage network contains information useful for hydraulic engineering, environmental, ecological and other studies. Extraction, storage, and management of the high resolution digital drainage network, however, faces difficulties which limit its use. While current software for extracting the drainage network mainly works with Digital Elevation Model (DEM) data with the amount of data points (pixels) at the million level, our team has adapted a highly scalable and efficient algorithm which can deal with DEMs with the amount of pixels at the ten billion level, to make the extraction and coding of large-scale drainage networks possible. Combined with auto-detection of channel headwaters based on geomorphological features, the accuracy of the extraction is also improved significantly. By coding and storing the drainage networks, and developing a hierarchical retrieval algorithm for large-scale networks, the dataset for the main river basins in the world, which consists of features such as the vector drainage network, its characteristics, and precipitation data from remote sensing, is established. The results of this research can offer convenient data support for wide use of the digital drainage network in fields like fluvial geomorphology, water resource management, hydraulic engineering, environmental studies, and GIS.

Figure 1. Tsinghua Hydro30: A global digital drainage network



Digital River Basin Integrated Model

The Digital River basin Integrated Model (DiRIM) focuses on the simulation of runoff and sediment processes at the river basin scale. With the high-resolution structural digital drainage network obtained from Hydro30, integrating sub-models of different sub-processes of the yield and concentration of runoff, and the yield and transport of sediment in each hillslope-channel unit, it provides a complete system for hydrologic and sediment transport simulations in river basins. The DiRIM model efficiently solves several problems in the interaction between datasets and models at different scales, and it increases the efficiency of computation of large-scale river basins by using a binary-tree based coding algorithm for the drainage network and the technology of parallel computing in computer clusters. The DiRIM model has been applied in the Yellow River, especially in the coarse sediment source region on the loess plateau, and other river basins including the Yarlung Zangbo River, the drainage basin of the Tangjiashang Barrier Lake, and etc.

The Sky River Concept and the Project

Based on meteorological reanalysis data, we found that highly structured water vapor

conveyance systems exist in the troposphere of the atmosphere. The water vapor conveyance systems have higher vertically integrated transport flux than their immediate environments, consisting of dominant channels for atmospheric water vapor transfer ranging from local scale to global scale.

The water vapor transfer systems in the troposphere providing high water (vapor) conveyance are similar to land surface rivers and thus can be referred to as "Rivers in the Sky", or simply "Sky Rivers". Studies on Sky Rivers will help us have a new appreciation of global atmospheric water vapor transfer and a better understanding of the global water cycle.

Figure 2. Digital River Basin Integrated Model and its methodology

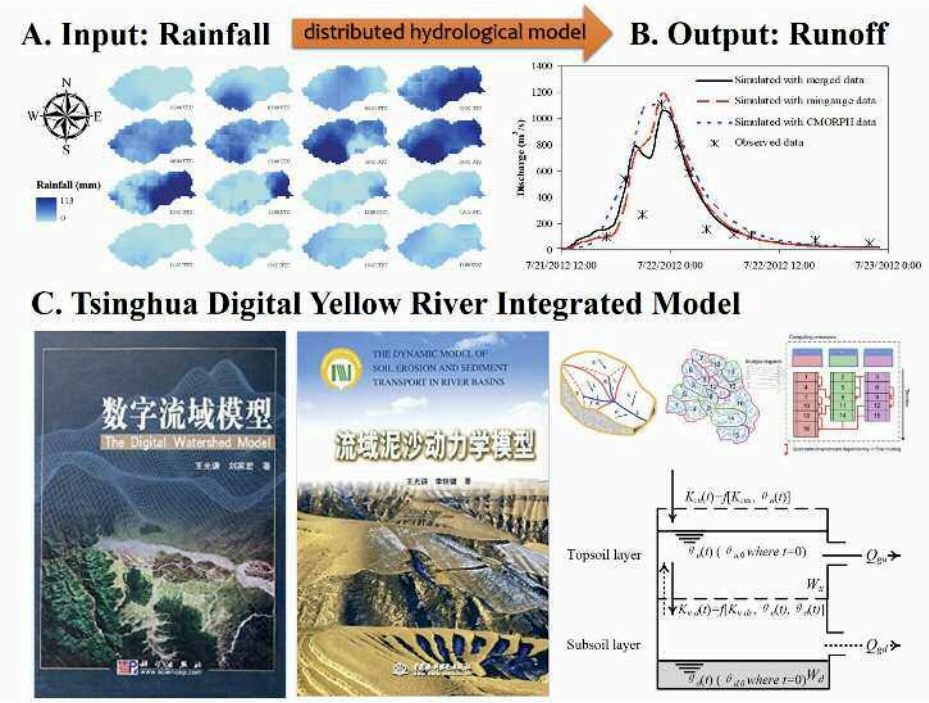
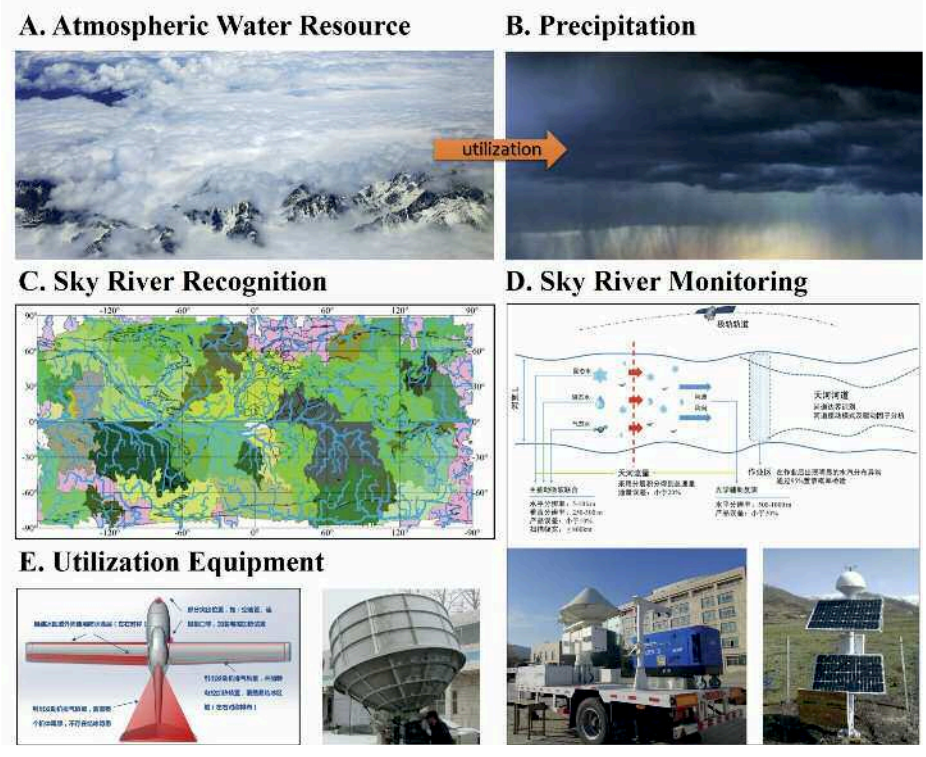


Figure 3. The sky river theory and the project



Guangqian Wang, born in 1962 in Nanyang, Henan Province, China. Professor of Tsinghua University, President of Qinghai University, member of the Chinese Academy of Sciences, director of the National Natural Science Foundation Division of Materials Science and Engineering. He is Leader of the Sky River Project.

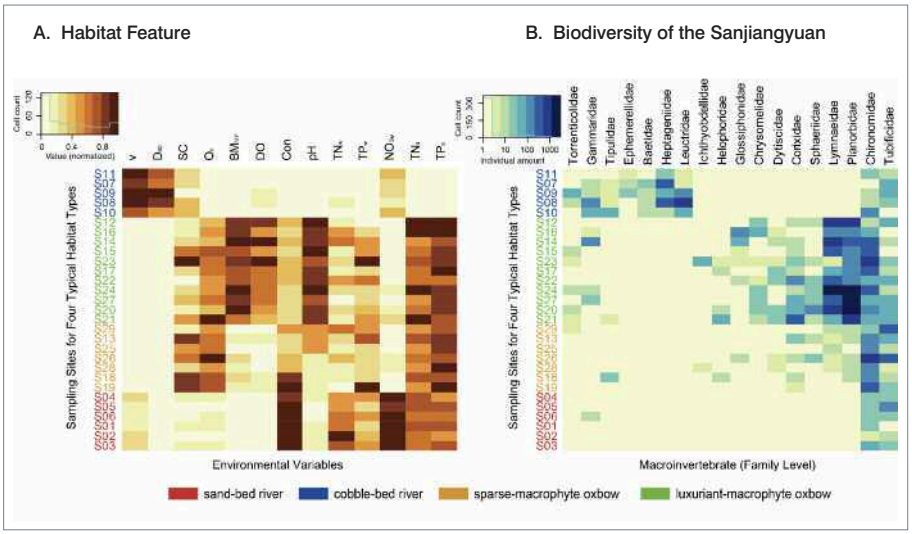
Jiahua Wei, professor of Tsinghua University (2004~NOW), distinguished professor of the Changjiang Scholars of the Ministry of Education (2014), executive vice-president of the School of Hydraulic and Electric Power Engineering of Qinghai University, chief scientist of the State Key Laboratory of Plateau Ecology and Agriculture (Hydrology and Water Resources). He is Chief of Technology of Sky River Project.

Yuefei Huang, professor of Tsinghua University. His research interests include the multidisciplinary field of ecological response of the hydrology-energy-carbon cycling processes, predicting model for non-point pollution and substance transportation, the theory and methods of risk management in water resources and environment adaptability. He is Chief of Remote Sensing monitoring of Sky River Project.

Xudong Fu, professor and Vice Dean of School of Civil Engineering at Tsinghua University. He serves as a council member of Chinese Society of Soil and Water Conservation (CSSWC) and Vice Chair of CSSWC Landslide and Debris Flow Committee. His research focuses on fluvial processes and watershed sediment dynamics. He was awarded the NSFC Fund for Distinguished Young Scholars in 2015. He is Chief of Digital River Basin Modelling of the Sky River Project.

Deyu Zhong, professor of Tsinghua University, distinguished professor of the Changjiang Scholars of the Ministry of Education. His research interests include sediment mechanics, fluvial processes, flood control. He has improved the sediment dynamic theoretical system by applying two-phase flow theory to the river management, protection and exploitation. He is Chief of Theoretical Research of the Sky River Project.

Based on this concept and on related research results in recent years, the Sky River research group further proposed the concept of the "Sky River Project". The aim of the "Sky River Project" is the joint and coupled utilization of atmospheric and surface water resources in different regions. Specific regions can be selected when the atmospheric water vapor distribution and transport patterns are fully understood. A new ground-based weather modification technology is being developed and tested for long-term operation at fixed sites. The vision of the project is to achieve its aim -- the coupled utilization of water resources in the sky and on the earth surface in the future, by combining the Sky River theory and techniques with the Tsinghua Hydro30 and the DiRIM as its supports.



Responses of high plateau wetland ecosystem to the artificial weather interventions

High plateau wetlands provide important natural habitats in the Sanjiangyuan area with adequate food resources, as well as comfortable refuge for wildlife species listed in the National Key Protected Wildlife Species in China, IUCN red data book and CITES Appendices. In the context of global climate change, alterations in regional hydrological conditions have directly and/or indirectly influenced the physical environmental conditions of these wetland ecosystems, which have changed the trophic basis of the food web, and affected every consumption unit within these systems.

Aimed at comprehensively understanding the current ecological status of the high plateau wetlands, team members from the Sky River Project have been conducting extensive and systematic field investigations on the physio-chemical environmental conditions and food availability (mainly macroinvertebrates) through continuous monitoring and sampling. On the basis of the collected data, we have distinguished four different sorts of patch-scale habitats in the Sanjiangyuan wetlands according to their environmental conditions, biotic assemblage structures, and trophic characteristics. With the help of ecological statistical methods, we have established an interconnected model of relationships among the regional hydrology, the physio-chemical environments, the biotic assemblages, and the trophic supply. This statistical model can provide reliable evaluations of the ecological health and food resources of the current high plateau wetland systems. It can also be used to predict patterns of ecological conditions and changes in this area under potential human weather interventions. This environment-biota model can be regarded as a specific expansion of the digital watershed model in which the ecological influences of the sky river project will be evaluated based on the responses from terrestrial and aquatic systems. ■