LANCANG-MEKONG NEWSLETTER

December 2020, No. 5

Project Title:
Climate Change and Water Resources in Great Rivers Region in Southeast and South Asia

Principal Investigator:

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Junguo LIU, Southern University of Science and Technology, China

Participating Institutions:

Southern University of Science and Technology
Institute of Tibetan Plateau Research, CAS
Institute of Atmospheric Physics, CAS
Institute of Geographic Sciences and Natural Resources Research, CAS
Beijing Normal University
University of Gothenburg

Project Period:

March 2018 – February 2023

"Climate Change and Water Resources in Great Rivers Region in Southeast and South Asia"

Project Office

Happy New Year and Best Wishes!

The year 2020 has been a difficult and different year with the spread of the COVID-19: a threat to all human beings. Despite of challenges, our project team has made great progress in scientific research in this year. We greatly appreciate your support and cooperation for the success of our project in the hard time.

The bell of the New Year is about to ring. We wish you good health, happiness and prosperity in 2021! We look forward to our more exciting collaborations soon.

Deliang Chen
Junguo Liu

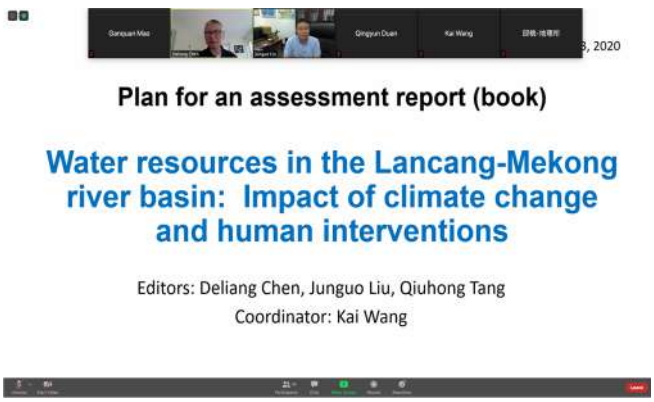
"Climate Change and Water Resources in Great Rivers Region in Southeast and South Asia"

Project Office

13 October

Water Resources Assessment Report Launch Meeting

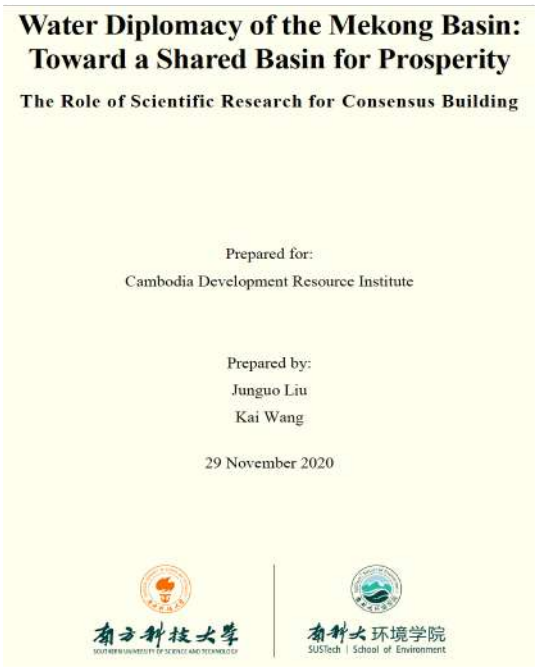
The launch meeting of the project for an assessment report of "*Water resources in the Lancang-Mekong river basin: Impact of climate change and human interventions*" was held online on October 13, 2020. The report editors are Prof. Deliang CHEN, Junguo LIU, and Qiuhong TANG with the coordinator of Dr. Kai WANG and coordinating contributors mostly from the project members. Report chapter outlines were structured, while the writing process and preliminary timelines were also discussed. The current report information is available on the project website: http://www.lancang-mekong.net/AboutUs.aspx?aid=562



29 November

Water Diplomacy of the Mekong Basin: Toward a Shared Basin for Prosperity

A research report, "*Water Diplomacy of the Mekong Basin: Toward a Shared Basin for Prosperity with focus on The Role of Scientific Research for Consensus Building*", written by Prof. Junguo LIU and Dr. Kai WANG was issued on November 29, 2020. This report is one of the research results of the project of "Water Diplomacy of the Mekong Basin: Toward a Shared Basin for Prosperity" funded by Cambodia Development Resource Institute (CDRI). This report found that scientific research can be an effective way to improve the understanding of the root causes of conflicts by providing scientific evidence and further contribute to consensus building, and thus can be an important tool for the water diplomacy in the Lancang-Mekong River Basin.



30 July

Professor Junguo LIU elected as a Member of Academia Europaea

Chair Professor Junguo LIU at SUSTech, one co-PI of of the project, were recently elected as a Member of Academia Europaea. In 2020, a total of 361 international scholars were invited to accept new membership. The Academia Europaea (formed in 1988) is the pan-European academy of science, humanities, and letters. Current membership stands at around 4,000. Amongst them, there are 74 Nobel Laureates, several of whom were elected to the Academia before they received the prize.

ACADEMIA EUROPAEA } *The Academy of Europe*

Junguo Liu

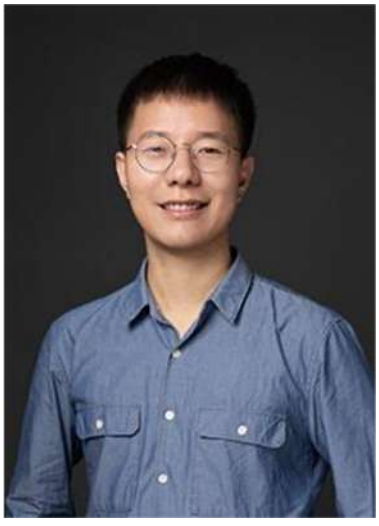
Membership Number:	5288
Membership type:	FOREIGN
Main Country of Residence:	CHINA
Section:	EARTH & COSMIC SCIENCES
Elected:	2020
ORCID:	0000-0002-5745-6311
Homepage:	http://faculty.sustech.edu.cn/liujg/en

28 October

Professor Zhenzhong ZENG won Qiu Shi Outstanding Young Scholar Award

Recently, Qiu Shi Science & Technology Foundation announced the ” Outstanding Young Scholar Award” winner list in 2020, with 12 scholars winning the prize. Prof. Zhenzhong ZENG, one of the core member in the project, won the Qiu Shi Outstanding Young Scholar Award.

Qiu Shi Outstanding Young Scholar Award was set up in 1995 at the initiative of five leading scientists, namely Xingshen CHEN, Zhenning YANG, Guangzhao ZHOU, Yuanzhe LI, and Yuewei JIAN. It awards outstanding young researchers engaged in basic research in the mainland of China.



In 2013, Qiu Shi Foundation launched the “Qiu Shi Outstanding Young Scholar Award” as a new program to support domestic universities in attracting top talents worldwide and assist young scientists. It aims to cultivate future leaders for China’s science and technology development in the next two decades.

04 December

Professor Junguo LIU receives TWAS Awards

On 4 December 2020, The World Academy of Science (TWAS) announced the winners of the TWAS Awards. This year, there are 13 award winners. Chair Professor Junguo LIU at SUSTech, one of the project PIs, received the award for his fundamental contribution to policy relevant studies on water resources, climate change mitigation, and environmental management in China and other developing countries.

TWAS was founded in 1983 by a distinguished group of scientists from the developing world, under the leadership of Abdus Salam, the Pakistani physicist and Nobel laureate. They shared a belief that developing nations, by building strength in science and engineering, could build the knowledge and skill to address such challenges as hunger, disease, and poverty. TWAS was given to talents who make an outstanding contribution in nine fields of sciences.

Research

Abrupt shift to hotter and drier climate over inner East Asia beyond the tipping point

Unprecedented heatwave-drought concurrences in the past two decades have been reported over inner East Asia. Tree-ring–based reconstructions of heatwaves and soil moisture for the past 260 years reveal an abrupt shift to hotter and drier climate over this region. Enhanced land-atmosphere coupling, associated with persistent soil moisture deficit, appears to intensify surface warming and anticyclonic circulation anomalies, fueling heatwaves that exacerbate soil drying.

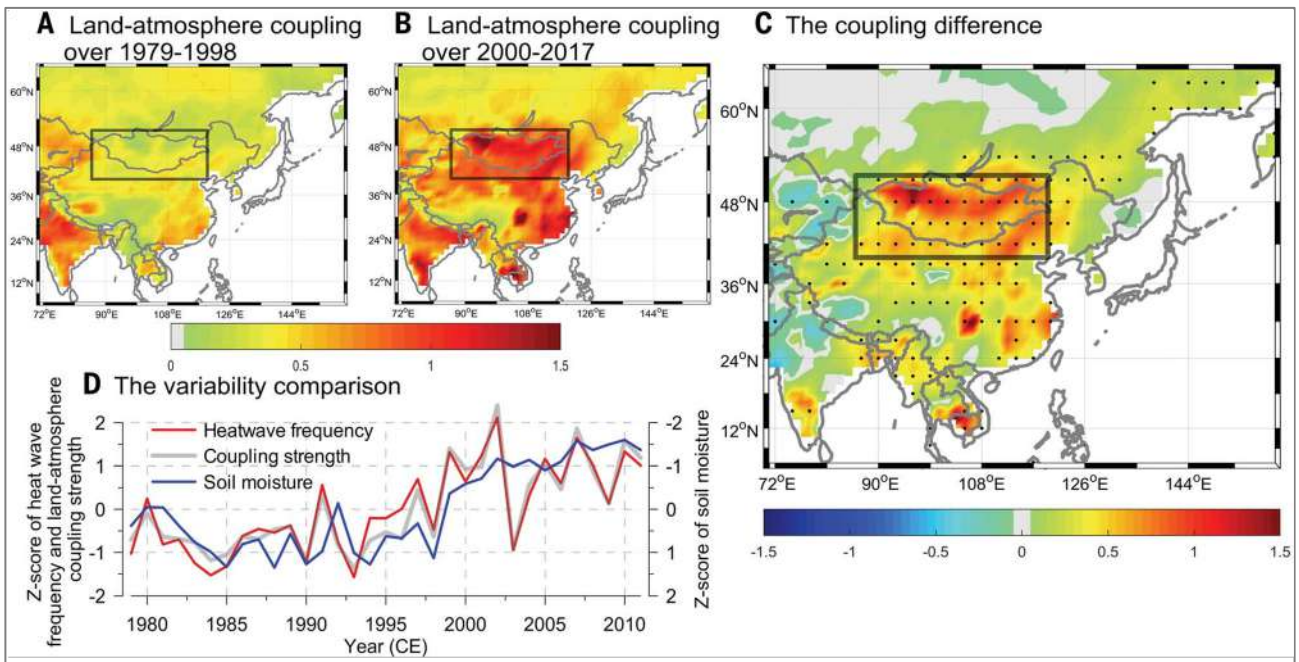


Figure 1: Land-atmosphere coupling strength. (A to C) July-August land-atmosphere coupling strength over the period 1979–1998 (A) and 2000–2017 (B) and their differences [(B) minus (A)] (C) and comparison with soil moisture and heatwave frequency variabilities. Black dots mark the grids where differences are significant at the $P < 0.05$ level. The coupling strength is calculated based on the ERA interim daily dataset with 1.5° x 1.5° spatial resolution. (D) Interannual variability of the coupling strength (gray), hot extreme frequency (red), and soil moisture (blue, reversed value in y-axis) over the domain.

Research

A recent study by Prof. Deliang CHEN's group demonstrates that the magnitude of the warm and dry anomalies compounding in the recent two decades is unprecedented over the quarter of a millennium, and this trend clearly exceeds the natural variability range. The "hockey stick"–like change warns that the warming and drying concurrence is potentially irreversible beyond a tipping point in the East Asian climate system.

The work was led by Dr. Peng Zhang and the results were published in *Science*.

Full article link: https://science.sciencemag.org/content/370/6520/1095

Research

Influential teleconnections for precipitation variability in the Lancang-Mekong River Basin

The Lancang-Mekong River Basin (LMRB) is home to ~70 million people, mostly living in poverty and typically working in primary freshwater-related sectors, particularly agriculture and fishery. Understanding the mechanisms of the historical variability in precipitation (as the crucial water source) plays a key role in regional sustainable development in the LMRB.

Recently, Prof. Junguo LIU's group cooperated with Prof. Deliang CHEN studied the spatiotemporal variability of precipitation over the LMRB using the Global Precipitation Climatology Centre (GPCC) data for the period 1952-2015. The empirical orthogonal function (EOF) and wavelet transform coherence (WTC) methods were utilized to investigate the relationships of such historical variations in annual (water year: Nov–Oct), dry season (Nov–May), and wet season (Jun-Oct) precipitation with 13 different teleconnections. The following major conclusions were drawn:

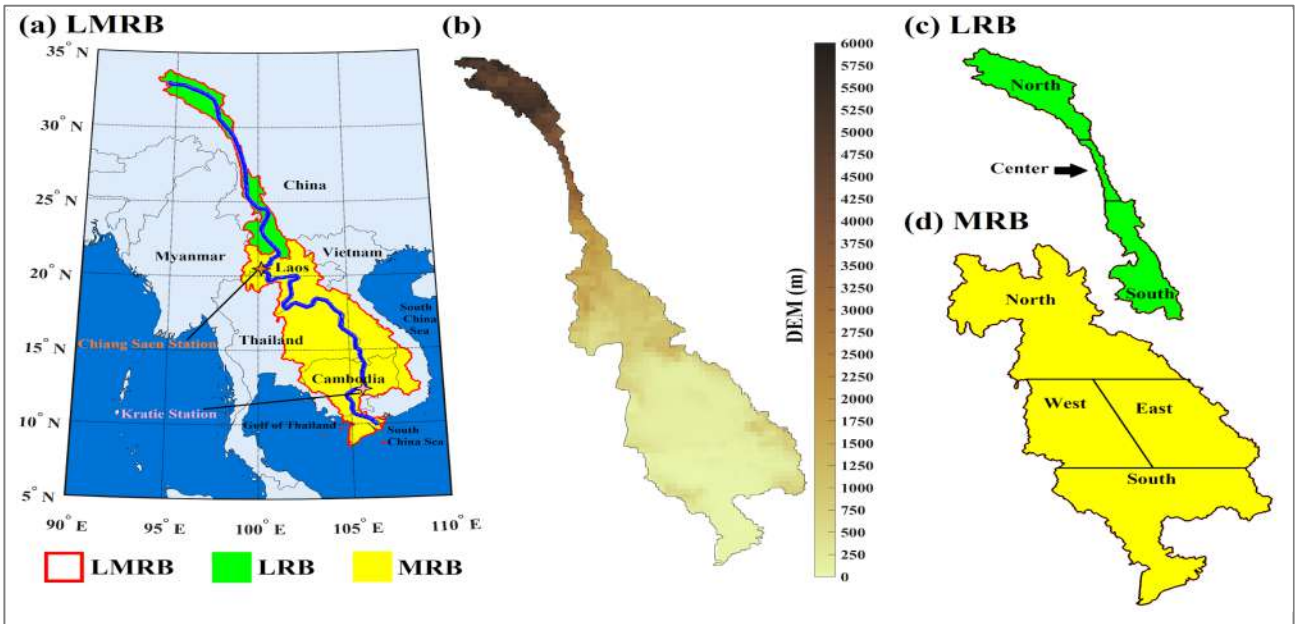


Figure 1: The Lancang-Mekong River Basin (LMRB)

1) On the basin scale, only a significant ($p<0.05$) wetting trend (0.34 mm/year) in dry season precipitation during 1952-2015 was uncovered.
2) Significant wetting (drying) trends in annual precipitation detected over the northeastern (most western) parts of the Mekong River Basin during the water years 1952–2015, largely contributed by the substantial increases (decreases) in historical wet season precipitation.
3) The most important precipitation pattern (EOF1) was identified as a strong (relatively weak) positive center in the eastern (southwestern) MRB accompanying by a significantly high (relatively low) positive value for the first EOF mode of the DSP (WSP).
4) Precipitation variability in the LMRB during 1951-2015 was significantly associated with the South Asian Summer Monsoon Index, Southern Oscillation Index, and Indian Summer Monsoon Index.

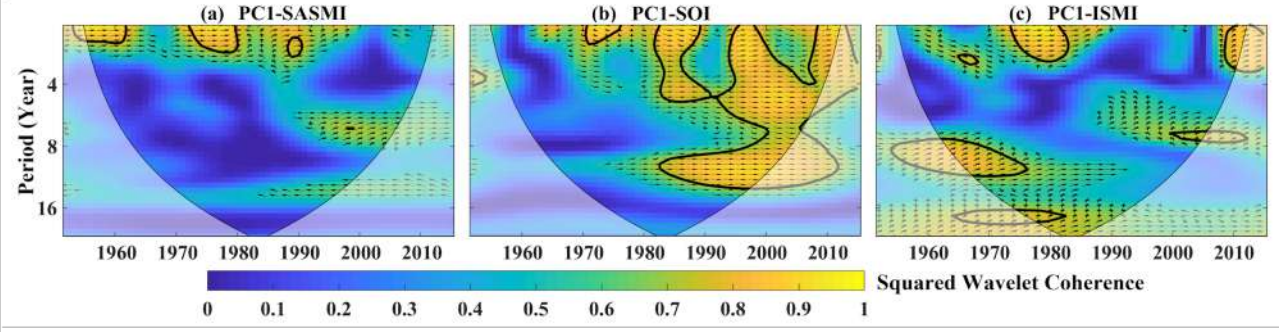


Figure 2: WTC for the most significant teleconnections and the EOF1s of (a) annual, (b) dry and (c) wet seasons precipitation in the LMRB during 1952-2015.

The work was led by Dr. Masoud Irannezhad and the results were published in *Journal of Geophysical Research: Atmospheres*.

Full article link: https://doi.org/10.1029/2020JD033331

Research

How climate and reservoir alter the flow and flood in the Lancang-Mekong River basin

The streamflow and flood in the Lancang-Mekong River Basin (LMRB), one of the most important transboundary river basins in Asia, are subject to both climate change and reservoir operations. To quantitatively assess this combined impact on flow and flood, Prof. Qiuhong TANG's group incorporated a reservoir module into the Variable Infiltration Capacity (VIC) model to simulate the streamflow susceptible to the reservoirs. It was found that the reservoirs had a substantial influence on the streamflow during 2008–2016, when many reservoirs were constructed in the LMRB.

Compared with the baseline period of 1985–2007, the reservoir operation dramatically affected streamflow at the midstream stations with higher dry season streamflow (+15% to +37%), but lower wet season streamflow was less affected (−2% to −24%) in 2008–2016.

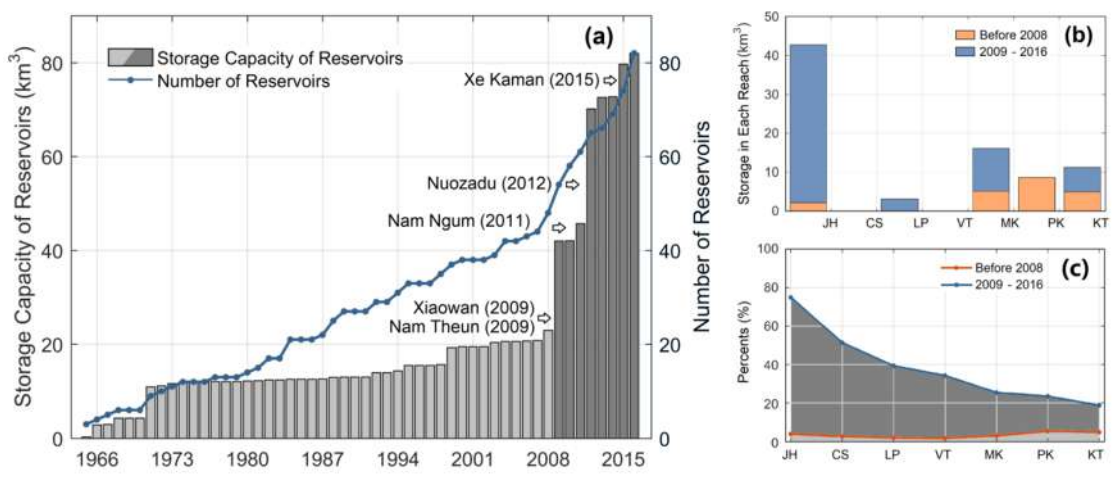


Figure 1: Reservoirs in the LMRB: (a) Changes in the number and total storage capacity of reservoirs during 1965–2016. Different color bars are used to distinguish the periods of rapid increasing storage capacity. (b) Storage capacity of reservoirs in different reaches partitioned by seven gauging stations by 2008 and 2016. (c). Proportion of the total reservoir storage capacity in 2008 and 2016 to the mean annual streamflow.

Research

The impact from upstream reservoirs was felt much less at stations downstream than at midstream stations. The reservoirs across the Lancang River (the upper Mekong River located in China) reduced the annual average streamflow by 5% at Chiang Sean station (northern Thailand) in 2008–2016, whereas their influence became undetectable downstream of Vientiane station (northern Laos). Meanwhile, reservoirs are mitigating climate change in the area. Climate change increased the magnitude and frequency of the flood by up to 14% and 45%, respectively, whereas the reservoir operation reduced them by 16% and 36%, respectively.

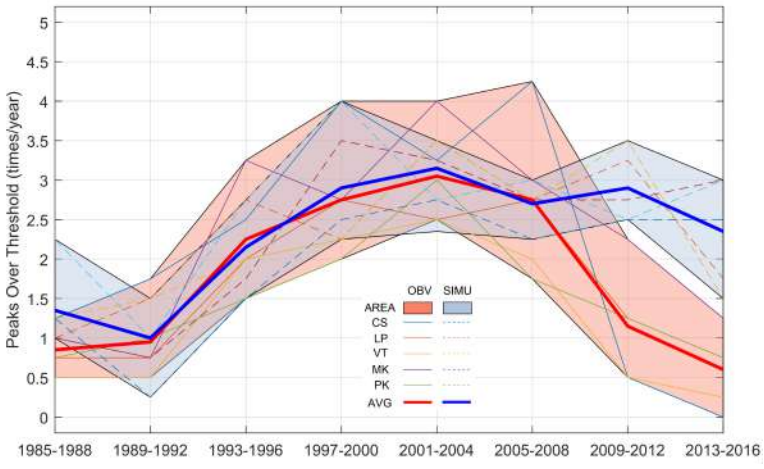


Figure 2: Variation in the observed flood frequency (red line and shading) and simulated natural floods frequency (blue line and shading) at the five selected stations during 1985–2016. Here, OBV represents observations and SIMU represents simulation. The time interval of flood frequency calculation was 4 years.

The results were published in *Journal of Hydrology*.
Full article link:
https://www.sciencedirect.com/science/article/pii/S002216942030932X

Research

Let rivers stay connected: A new graph theory-based method and tool for representing river networks

River networks are presumedly dendritic, often acting as the most recognizable binary-tree pattern on the Earth's surface. However, the widespread braided rivers that form multiple flow routes between two locations cannot be represented by the conventional dendritic model of river networks. Inspired by the well-known problem of the Seven Bridges of Königsberg, Prof. Junguo LIU's group devised a new method to represent complex river morphology (including braided rivers) based on graph theory. This new method, *GrabRiver*, is developed on remote sensing imagery. To take full advantage of remote sensed datasets, river width, the fundamental morphodynamical variable, is simultaneously measured and combined with the graph theory-based representation of river networks.

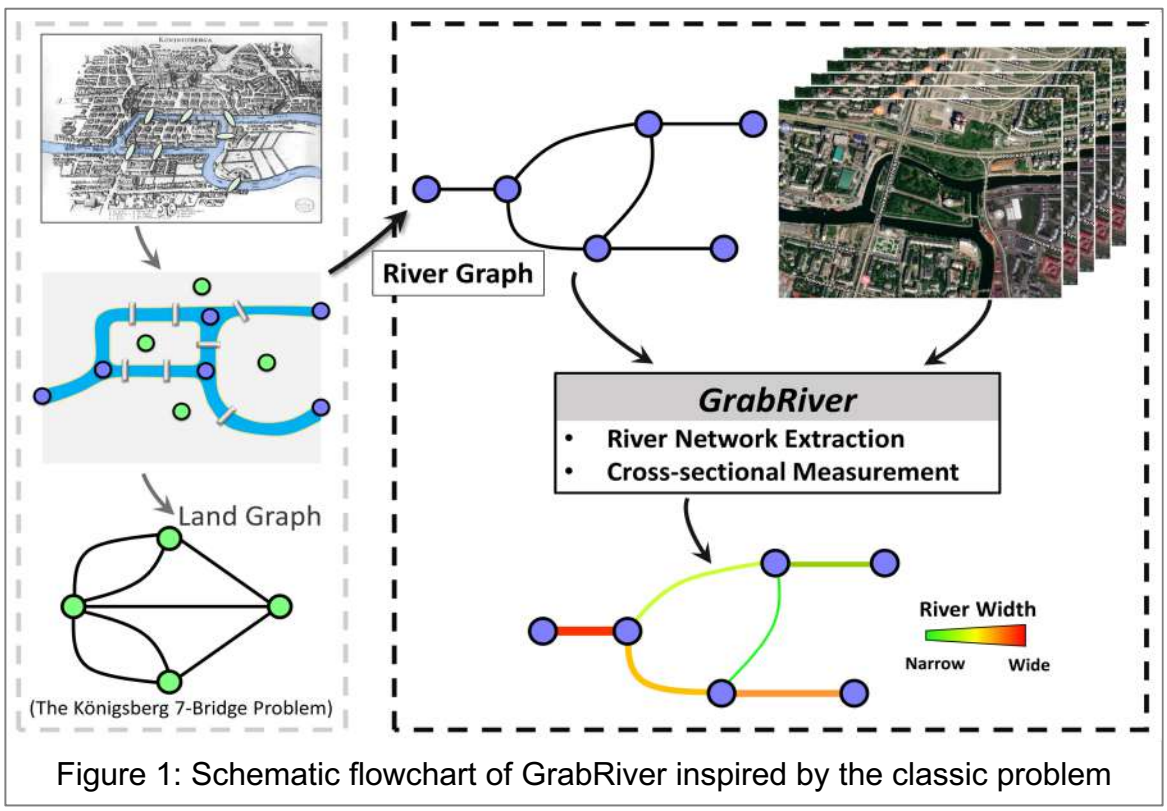


Figure 1: Schematic flowchart of GrabRiver inspired by the classic problem

Research

GrabRiver implements whole-process automation from image preparation to river width calculation. Three major steps are proposed: 1) Mapping and connecting rivers. The Multi-spectral Water Index (MuWI) is used to produce high-accuracy water maps from imagery, whereby specialized algorithms are used to reduce impacts from non-river water (lakes, reservoirs, wetlands) and on-channel objects (bridges, dams, ships) and to enforce river connectivity. 2) Constructing the river graph. A connected river map is skeletonized into the graph while maintaining geo-references as properties of edges and nodes in the river graph, and it is followed by river graph pruning to remove false and redundant river tributaries in the topologic structure. 3) Measuring river widths. The cross-sectional measure is conducted on the river-reach (graph edge) basis, where orthogonals to centerlines are determined by the bounding geometry.

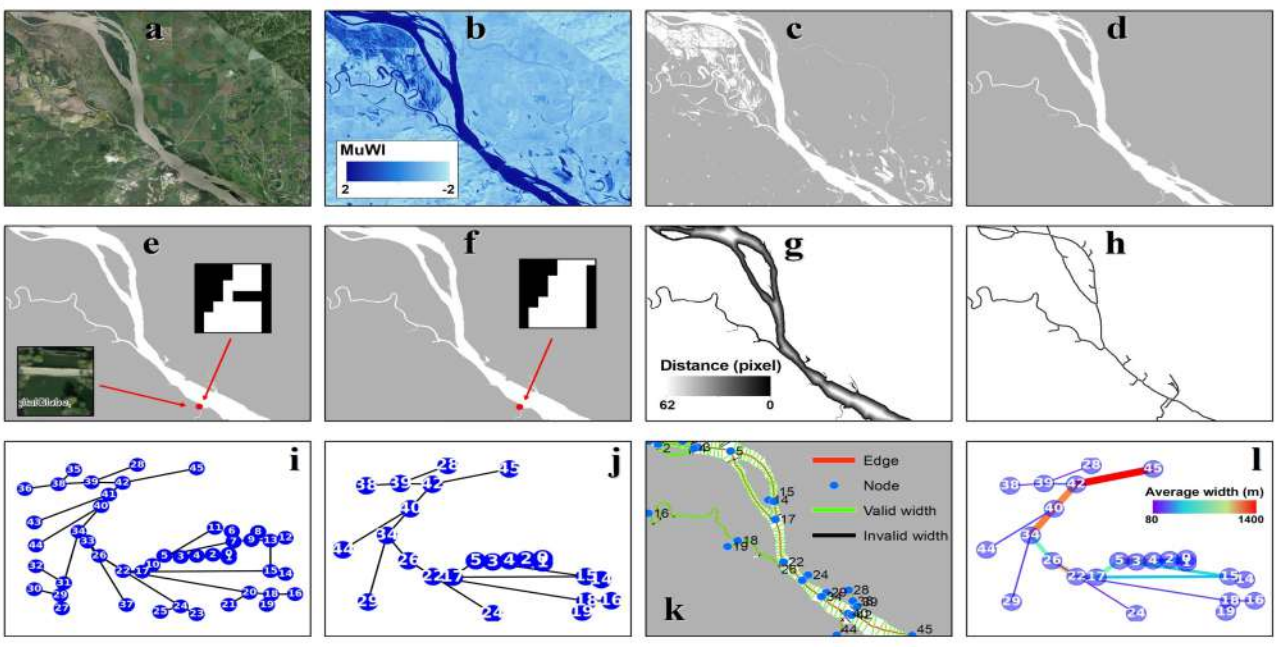


Figure 2: Stepwise illustrations of GrabRiver method

Furthermore, we applied the *GrabRiver* method and validate the river width measurements across the Mekong River from headwater to downstream. Generally, *GrabRiver* can successfully deal with the complex morphology of river networks and produces width measurements of satisfactory accuracy (R^2=0.98), which demonstrates the high efficiency and potential of this new method. The integrative design not only facilitates high accuracy river width extraction through a high level of process automation from image preparation to the final calculation, but also allows further investigation of morphodynamics in a complex river system.

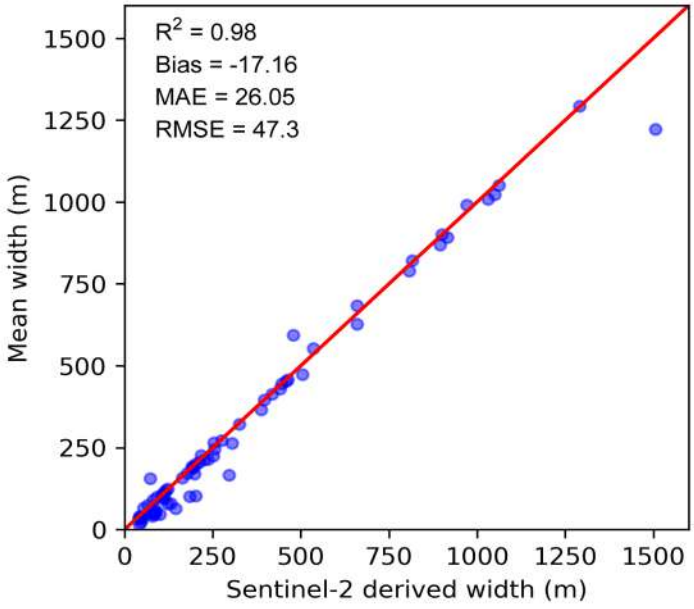


Figure 3: Validation of width extractions in the Mekong River basin

The work was led by by PhD student Zifeng Wang, and the results were published in *IEEE Geoscience and Remote Sensing Letters*.
Full article link:
https://ieeexplore.ieee.org/document/9203861

Research

Temporal and spatial variations of convection, clouds and precipitation over the Tibetan Plateau from recent satellite observations.

Prof. Deliang CHEN's group has examined spatial patterns of seasonal and diurnal variations of precipitation based on the Global Precipitation Measurement Mission (GPM) and three additional satellite products. The results show a spatial dipole pattern of two distinct seasonalities: The central TP is marked by strong July peaks and exhibits rainfall contributions of the monsoon season (May–September) of more than 70%, whereas northwestern and southern regions of the plateau exhibit significantly smaller amplitudes in the annual cycle. In some southern regions which are characterized by very high summer mean precipitation and more extreme rain rates, winter months (October–April) contribute significantly to the total annual mean precipitation.

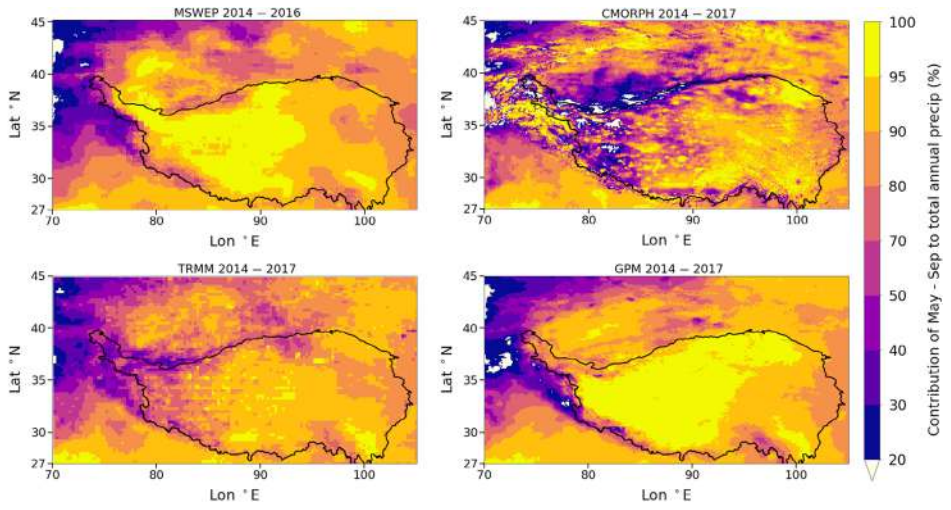


Figure 1: Contributions of summer precipitation to total annual mean precipitation for MSWEP, CMORPH, TRMM and GPM.

These show also a seasonal dependence and are characterized by a stronger afternoon to early evening peak (17:00 LST time, 11:00 UTC) and weaker nighttime peak (23:00 LST, 17:00 UTC) during the monsoon season and over the plateau compared to its surroundings. Furthermore, it was shown that convective precipitation during the monsoon season contribute only up to 30% to the total precipitation, whereas more than 70% is produced by the 90th percentile of daily rain rates. An important characteristic of summer precipitation is hence that a significant part of the extreme precipitation is non-convective. This paper reveals new features of spatial patterns in seasonal and diurnal precipitation and highlights the importance of non-monsoonal components for seasonal precipitation variations.

The work was led by PhD student Julia Kukulies and the results were published in *International Journal of Climatology*.
Full article link: https://doi.org/10.1002/joc.6493

Simulation of summer precipitation diurnal cycles over the Tibetan Plateau at the gray-zone grid spacing for cumulus parameterization

The Tibetan Plateau (TP) is often referred to as the “water tower of Asia” or the “Third Pole”. It remains a challenge for most global and regional models to realistically simulate precipitation, especially its diurnal cycles, over the TP. Recently, Prof. Deliang CHEN’s team evaluated the summer (June–August) precipitation diurnal cycles over the TP simulated by the Weather Research and Forecasting (WRF) model. The horizontal resolution used in this study is 9 km, which is within the gray-zone grid spacing that a cumulus parameterization scheme (CU) may or may not be used.

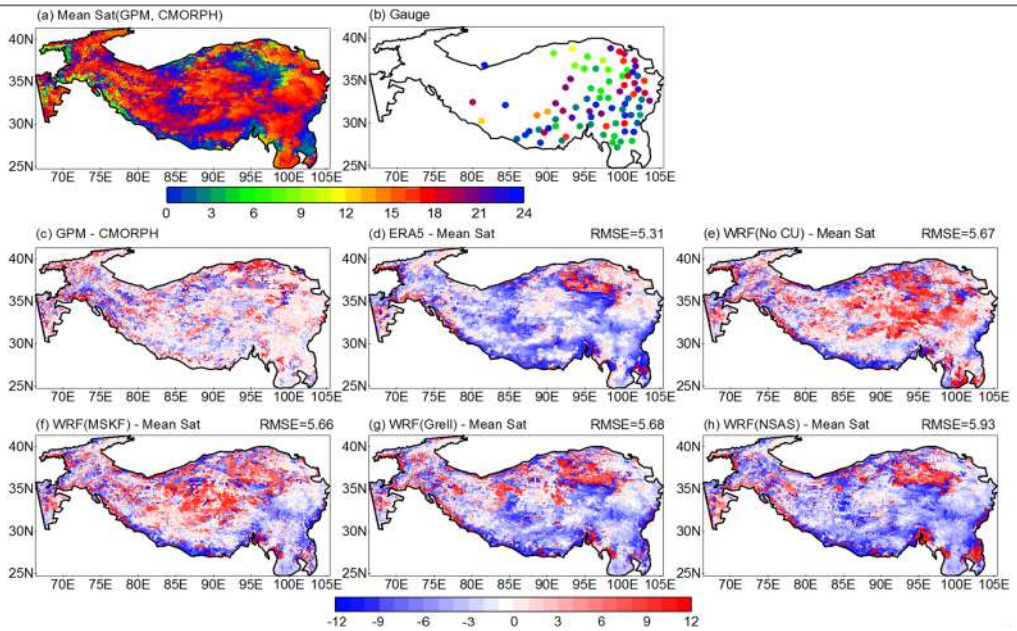


Figure 1: Spatial distributions of diurnal peak time of summer total precipitation amount, shown as GPM/CMORPH (a); the in-situ observations (b); the difference between GPM and CMORPH (c); and the difference between GPM/CMORPH and the global reanalysis ERA5 (d), and the difference between GPM/ CMORPH and the four WRF simulations driven by the ERA5 (e WRF(no CU), f WRF(MSKF), g WRF(Grell), and h WRF(NSAS)). RMSEs for the ERA5 and four WRF simulations relative to part (a) are shown in the upper-right of the related panels.

Research

We conducted WRF simulations with different cumulus schemes (CU experiments) and a simulation without CU (No_CU experiment). The selected CUs include the Grell-3D Ensemble (Grell), New Simplified Arakawa-Schubert (NSAS), and Multiscale Kain-Fritsch (MSKF). These simulations are compared with both the in-situ observations and satellite products. Results show that the scale-aware MSKF outperforms the other CUs in simulating precipitation in terms of both the mean intensity and diurnal cycles. In addition, the peak time of precipitation intensity is better captured by all the CU experiments than by the No_CU experiment. However, all the CU experiments tend to overestimate the mean precipitation and simulate an earlier peak of precipitation frequency when compared to observations. The frequencies and initiation timings for short-duration (1–3 h) and long-duration (> 6 h) precipitation events are well captured by the No_CU experiment, while these features are poorly reproduced by the CU experiments. The results demonstrate simulation without a CU outperforms those with a CU at the gray-zone spatial resolution in regard to the precipitation diurnal cycles.

The work was led by Dr. Tinghai Ou and the results were published in *Climate Dynamics*.
Full article link: https://doi.org/10.1007/s00382-020-05181-x

Research

Climate change may threaten the water resource cooperation in the Lancang-Mekong River basin

As one of the most important transboundary river basins in Asia, changes in upstream the Lancang-Mekong River Basin (LMRB) will propagate through river streamflow, affecting the downstream water resource security. When upstream or downstream the LMRB encounter extreme drought and humid events, they can be dealt with through the deployment and cooperation of cross-border water resources. However, this measure will temporarily invalid when the LMRB encounters a basin-wide concurrent extreme events, which is not conducive to water resource cooperation between upstream and downstream within the basin.

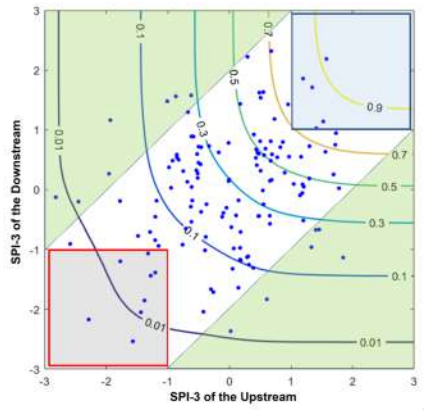


Figure 1: Level curve of the joint probability distribution of the SPI-3 in upstream and downstream from 1982 to 2016 in the LMRB (The red frame area indicates the concurrent drought (SPI-3 ≤ -1), the blue frame area indicates the concurrent wet (SPI-3 ≥ 1), the green area indicates the uneven water resource period)

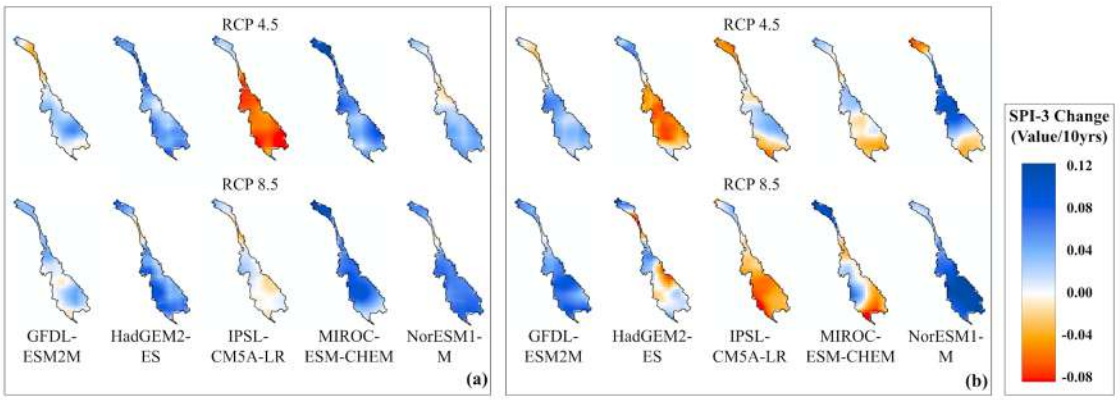


Figure 2: Distribution of SPI-3 change rate in the LMRB based on GCMs, (a) is the near future periods (2021-2055) change, (b) is the far future periods (2056-2090) change.

Research

Based on the Princeton precipitation dataset and global climate model data, Prof. Qiuhong TANG's group used the standardized precipitation index (SPI-3) and Copula function to investigate the impacts of climate change on concurrent drought, concurrent wet and concurrence of different dry and wet conditions during the historical period (1982–2016) and future period (2021-2090) in the upstream and downstream of the Lancang-Mekong River Basin. The results showed that compared with the historical period, the Lancang-Mekong River Basin shows the similar change trend under the scenarios of RCP4.5 and RCP8.5 in the future period: the probability of concurrent wet will gradually increase (maximum + 199.5%), and the probability of concurrent drought will gradually decrease (minimum -35.9%), and the probability of uneven water resource situation will greatly reduce in all periods (-42.5% ~ -53.1%). The results indicate that water resources cooperation between the upstream and the downstream of the Lancang-Mekong River Basin may be adversely affected by climate change, and there is an urgent need for adaptation strategy to address water resources cooperation in the Lancang-Mekong river basin.

The results were published in *Climate Change Research*.
Full article link: http://www.climatechange.cn/CN/10.12006/j.issn.1673-1719.2020.008

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