LANCANG-MEKONG NEWSLETTER

December 2021, No. 7

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

Principal Investigator:
Deliang CHEN, University of Gothenburg, Sweden
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!

This past year 2021 has presented unprecedented challenges, as we are still in the middle of a raging pandemic. This year has been difficult for everybody. No continent, no country, no sector has been spared. Despite the difficulties and challenges we faced, our project team has made remarkable achievements in scientific research in 2021. We greatly appreciate your support, cooperation and efforts for the project.

New Year is just around the corner, ushering in the year 2022 of hope and expectation. We wish you good health, happiness and prosperity in 2022! 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

News

10 September

Professor Junguo LIU received the Paul A. Witherspoon Lecturer

The American Geophysical Union (AGU) announced its list of AGU awards/honors for renowned experts in various fields in 2021. 78 scientists from all over the world received accolades, including 30 awards for named lectureships to recognize distinguished scientists with proven leadership in their fields of science.

Junguo LIU, Chair Professor of the School of Environmental Sciences and Engineering at the Southern University of Science and Technology (SUSTech) and a member of the European Academy of Sciences, received the Paul A. Witherspoon Lecture in the Hydrology Section. He is the first Asian scholar to receive the award since its formation.

The Paul A. Witherspoon Lecture is presented annually. It recognizes significant and innovative contributions by mid-career scientists to the hydrologic sciences through research aimed at socially important problems and through mentoring of young scientists.

28 September

Professor Yan ZHENG selected as Fellow of American Geophysical Union

On September 28, 2021, the American Geophysical Union (AGU) announced the 2021 Class of Fellows. Amongst them included Chair Professor Yan ZHENG of the School of Environmental Science and Engineering at the Southern University of Science and Technology (SUSTech).

She became the 22nd scientist from China (including Hong Kong, Macao, and Taiwan) to receive this honor. Worldwide, 59 scientists in the field of Earth and space sciences became AGU fellows in 2021.

Yan ZHENG received her Ph.D. degree from the Department of Earth and Environmental Sciences at Columbia University in 1999 and was elected as a Fellow of the Geological Society of America in 2010.

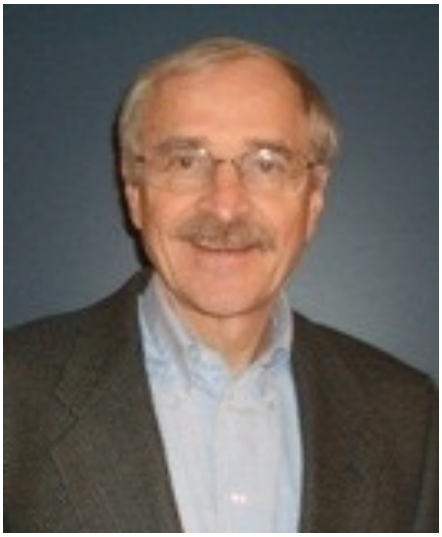
02 November

Obituary

In Memory of Professor Eric F. Wood

It is with great sadness that we marks the death of Eric F. Wood, who served as a member of our project Advisory Board. We remembers Eric F. Wood as one of the greatest hydrologist in our time. He was well-known for his work in hydrology, remote sensing, climate, and meteorology.

Eric F. Wood was the Susan Dod Brown Professor of Civil and Environmental Engineering. He was born in Vancouver, Canada in 1947. He joined Princeton's faculty in 1976. He transferred to emeritus status in 2019.



Prof. Wood led the Terrestrial Hydrology Research Group, which investigated land-atmosphere interactions for climate models and for water resource management. Eric Wood will always be known for the enormous impact he had on the field of hydrology through his professional service to the global scientific community and through his mentoring of graduate students, who have gone on to have successful careers in academia, research and engineering practice.

Research

Global terrestrial water storage and drought severity under climate change

Terrestrial water storage (TWS) modulates the hydrological cycle and is a key determinant of water availability and an indicator of drought. **Prof. Junguo LIU** from the Southern University of Science and Technology (SUSTech) joined an international research team including scientists from Michigan State University (the USA) demonstrated that climate change could reduce TWS in many regions, especially those in the Southern Hemisphere using ensemble hydrological simulations. Strong inter-ensemble agreement indicates high confidence in the projected changes that are driven primarily by climate forcing rather than land and water management activities.

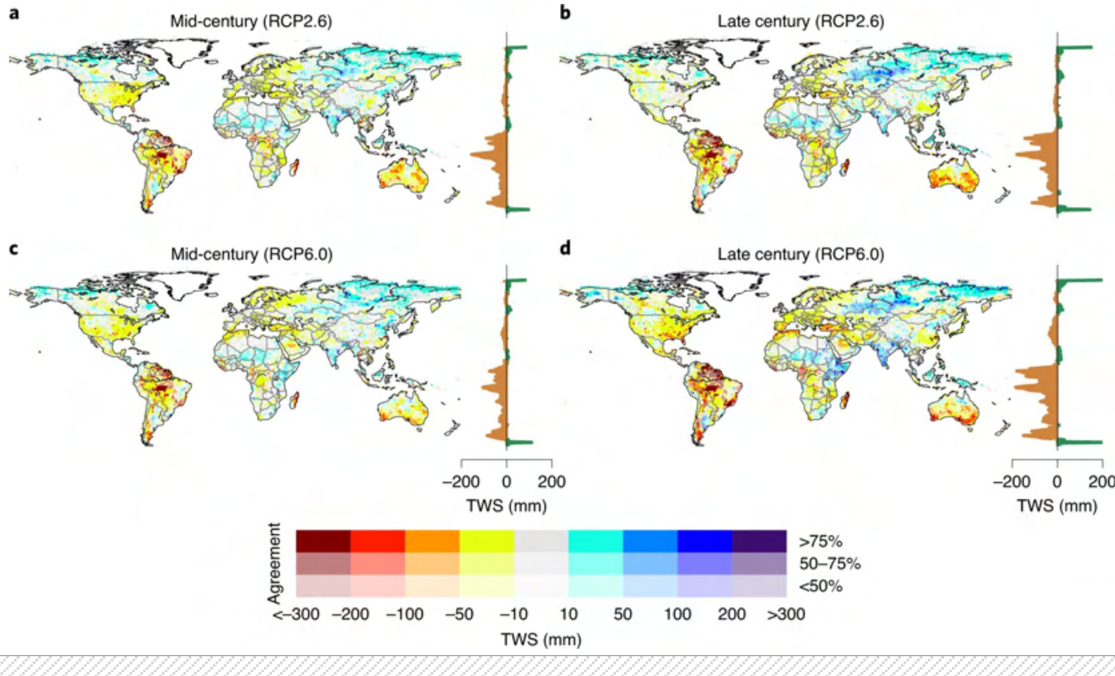


Figure 1: The changes (multi-model weighted mean) in TWS, averaged for the mid- (2030–2059; a,c) and the late (2070–2099; b,d) twenty-first century under RCP2.6 (a,b) and RCP6.0 (c,d) relative to the average for the historical baseline period (1976–2005).

Declines in TWS translate to increases in future droughts. By the late twenty-first century, the global land area and population in extreme-to-exceptional TWS drought could more than double, each increasing from 3% during 1976–2005 to 7% and 8%, respectively. This study provides a comprehensive assessment of climate impacts on future TWS and related droughts. Given large uncertainties and medium confidence in drought projections using traditional drought indices, these results provide information to better predict future droughts and understand water resource and vegetation growth impacts.

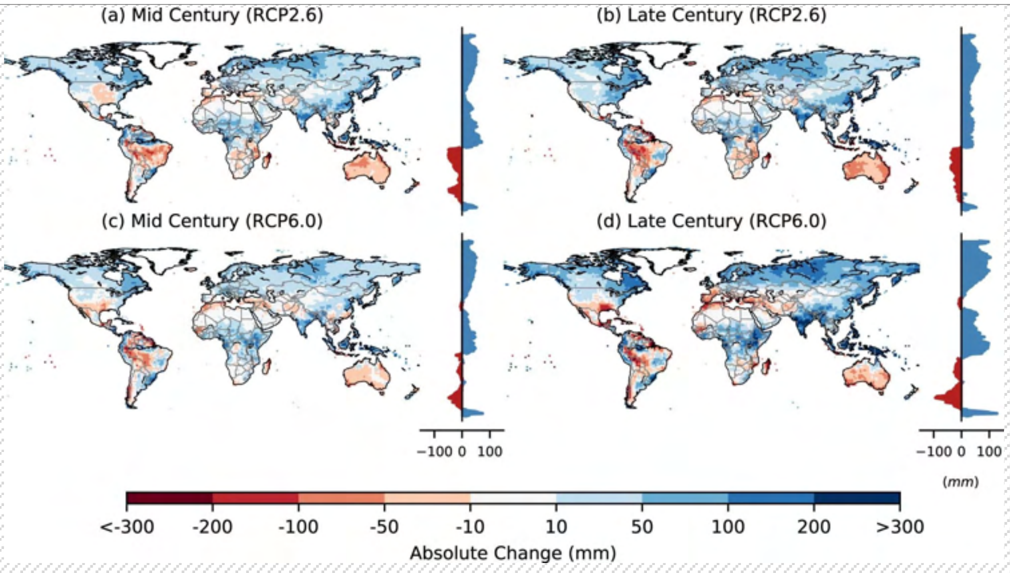


Figure 2: The absolute differences in the 30-year mean (mm/year) between the two future periods and historical baseline period of 1976–2005, calculated as the mean of the results from four Global Climate Models (GCMs) used to drive the hydrological models: HadGEM2-ES, GFDL-ESM2M, IPSL-CM5A-LR, and MIROC5.

The results were published in ***Nature Climate Change***

Full article link: https://doi.org/10.1038/s41558-020-00972-w

High-resolution river networks of Lancang-Mekong River

Recognizing that Sentinel-2 satellite can detect surface water up to a 10-m resolution over large scales, **Prof. Junguo LIU**'s group proposed a new method named Remote Sensing Stream Burning (RSSB) to integrate high-resolution observational flow location with coarse topography to improve the extraction of drainage network.

In RSSB, satellite-derived input is integrated in a spatially continuous manner, producing a quasi-bathymetry map where relative relief is enforced, enabling a fine-grained, accurate, and multitemporal extraction of drainage network. RSSB was applied to the Lancang-Mekong River basin to derive a 10-m resolution drainage network, with a significant reduction in location errors as validated by the river centerline measurements (Figure 1).

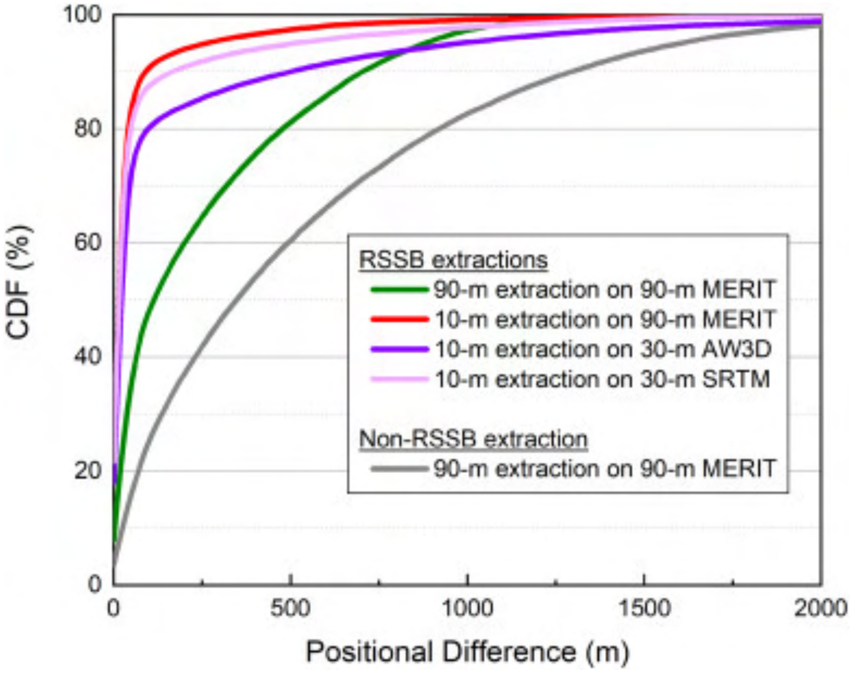


Figure 1: Location errors of river networks generated by RSSB method and conventional method (non-RSSB). The closer CDF curve near top left, the better.

The high-resolution extraction resulted in a realistic representation of meanders and detailed network connections. RSSB also enabled a multitemporal extraction of river networks during wet/dry seasons and before/after the formation of new channels.

The RSSB method provides a basis for the accurate representation of drainage networks of Lancang-Mekong River basin, and could enable a greater understanding of complex but active exchange between inland water and other related Earth system components in the basin.

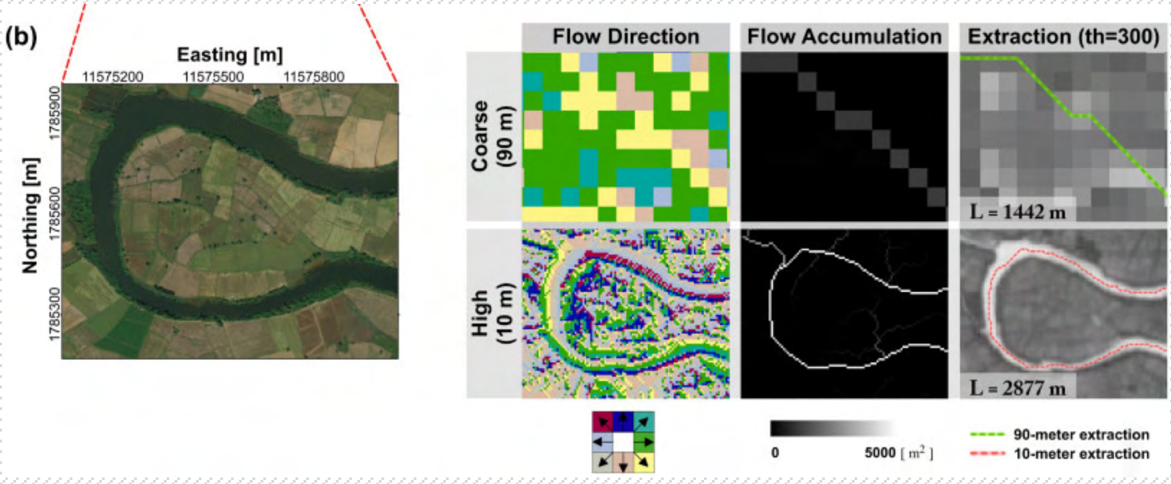


Figure 2: Comparisons of 90-m and 10-m drainage networks, including flow direction, flow accumulation and extracted river vector.

The work was led by **a PhD candidate Zifeng Wang**, and the method details of RSSB were published in ***Remote Sensing of Environment*** (https://doi.org/10.1016/j.rse.2020.112281). River networks dataset can be downloaded from National Tibetan Plateau Data Center (https://data.tpdc.ac.cn/en/data/512bb48e-d3c7-4964-9578-a4da92af62ad/).

Modeling Daily Floods in the Lancang-Mekong River Basin Using an Improved Hydrological-Hydrodynamic Model

Lancang-Mekong River is a flood-prone zone with the world highest flood-induced mortalities. In the past few decades, this basin has experienced climate change, sea level rise, and intensified anthropogenic activities. These threats will continuously challenge this basin, which can potentially lead to more frequent floods and thus greater flood risk in the future. It is therefore crucial to better understand the changing flood dynamics of the basin. However, few studies have investigated the model capacity to simulate floods over the entire basin, especially through an integrated hydrological hydrodynamic model.

Recently, **Prof. Qiuhong TANG**'s group used an improved hydrological-hydrodynamic model (VIC and CaMa-Flood) considering regional parameterization to simulate the flood dynamics over the basin from 1967 to 2015.

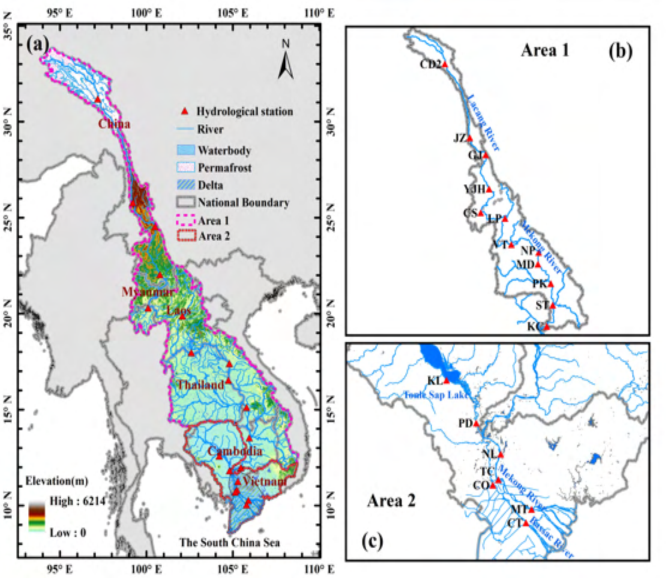


Figure 1: Overview of the basin and hydrological stations distribution.

Research

The results show that the daily discharge and water level are both well simulated at selected stations with relative error (RE) less than 10%. The peak time and flood volume are well reproduced while both peak discharge and water level are slightly underestimated. The results tend to worsen when the characteristics of flood events are extended to annual extremes. These extremes are generally underestimated but RE is still within 20%. The simulated rainy season inundation area generally agrees with observations from remote sensing, with about 86.8% inundation occurrence frequency captured within the model capacity. Ignoring the regional parameterization and reservoir regulation can both deteriorate flood simulation performance at the local scale, resulting in lower Nash-Sutcliffe efficiency coefficient.

The results were published in ***Water Resources Research***
Full article link: **https://doi.org/10.1029/2021WR029734**

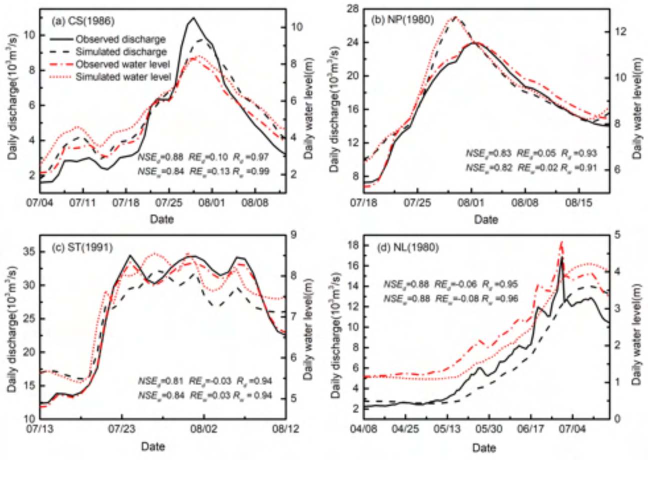


Figure 2: Observed and simulated discharge and water level hydrographs for the selected flood events

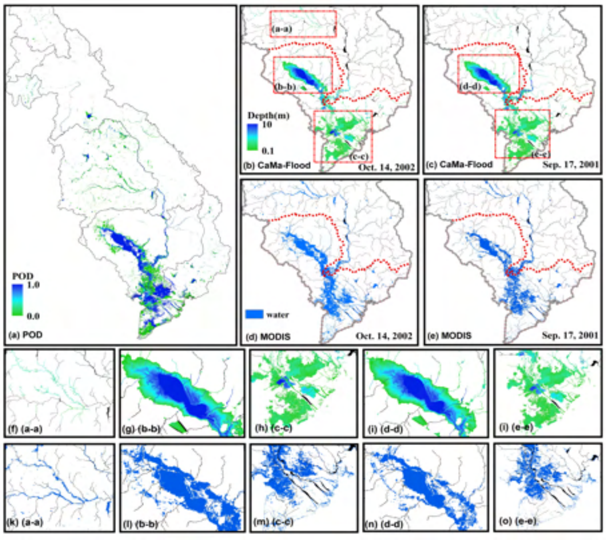


Figure 3:Spatial distribution of the probability of detection (POD) for rainy season inundation (a), two spatial inundation maps, and their corresponding enlarged views (f-o)

Observed changes of Köppen climate zones based on high-resolution data sets in the Qinghai-Tibet Plateau

Climate classification is a crucial step to understanding the climate itself and its ecological impacts. Emerging and disappearing climate zones are frequently used to diagnose and project climate change. However, little attempt has been made to quantify shifts of climate zones in Qinghai-Tibet Plateau (QTP) based on the high-resolution data sets. Recently, **Prof. Junguo LIU's** group used the Köppen–Geiger classification to diagnose regional climate zones shifted from past to present in QTP. Results show that highland climate was decreased substantially during 1961–2011 and was mainly replaced by boreal climate. Furthermore, they also found that the mean elevation of boreal and highland climate continues to rise, with obvious longitudinal geographical characteristics.

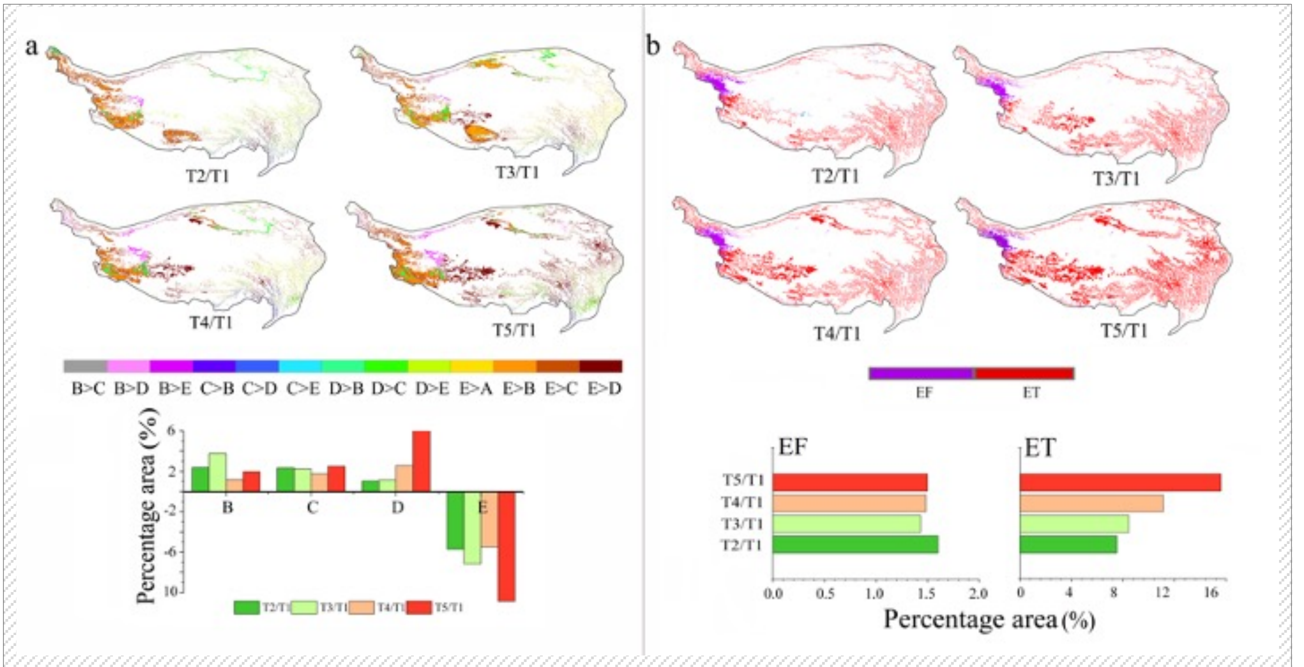


Figure 1: (a) The spatial shifts of major Köppen climate zones and (b) disappearing frost (EF) and tundra (ET) climates in QTP for 1971-1980 (T2), 1981-1990 (T3), 1991-2000 (T4) and 2001-2010 (T5) relative to 1961-1970 (T1). B–E represents arid, temperate, boreal, and highland climate types, respectively.

More importantly, they found that the climate spaces of both boreal and highland climate types tend to be warm and humid ones, which may provide more suitable climate conditions for species to maintain and promote diversity. Characterization of changes in QTP climate types deepens our understanding of regional climate and its biological impacts.

The work was led by a postdoc **Dr. Yanlong GUAN** and the results were published in ***Geophysical Research Letters***
Full article link: https://doi.org/10.1029/2021GL096159

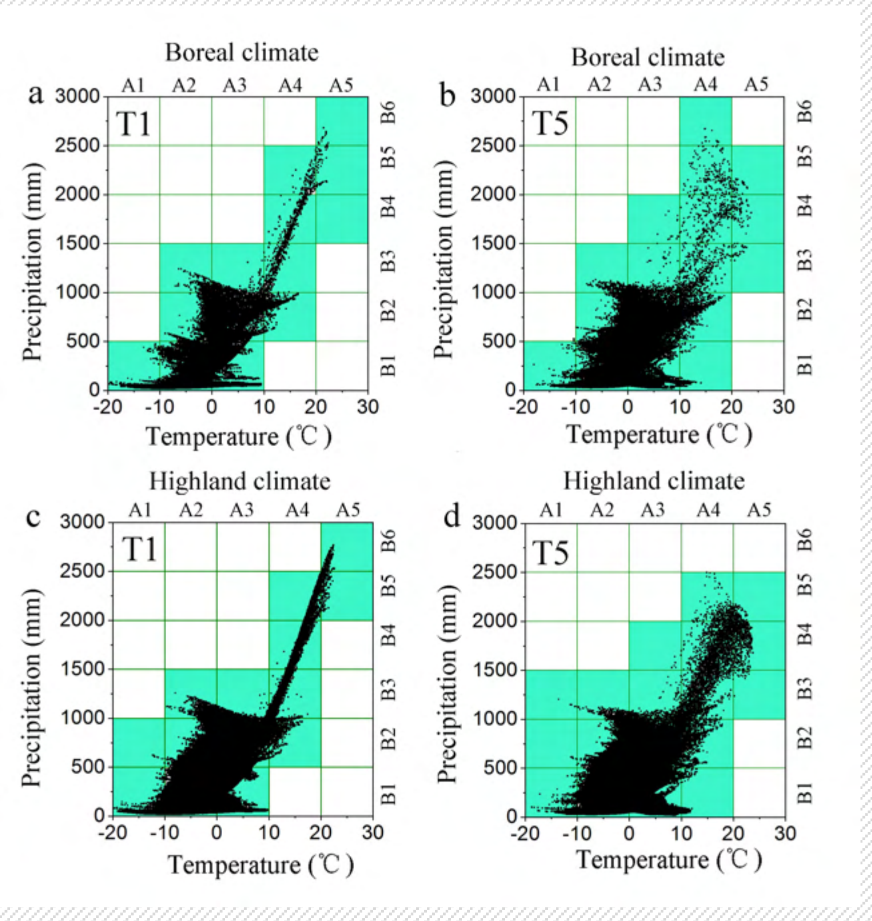


Figure 2: The climate spaces of boreal (a-b) and highland (c-d) climate types between T1 and T5. Each box represents a climate space (10 °C*500 mm). Cyan box refers to the climate space involved in the climate volume which composed by temperature and precipitation.

Links between global terrestrial water storage and large-scale modes of climatic variability

Large-scale states of ocean and atmosphere control the quantity and routine of vapor transported into land and the land water storage pattern. However, the contributions of leading climatic modes, or teleconnections (TCs), to global terrestrial water storage (TWS) variations are poorly understood. Led by **Prof. Lanlan GUO's** group from Beijing Normal University, conducted a study on the 14 main TC controls on river basins and continental and global water storage patterns. Variations in terrestrial water storage anomaly (TWSA) in>93% of the LANCANG-MEKONG land surface are significantly correlated with at least 1 studied climatic mode. The ENSO, PDO and AMO is identified as the dominate climate mode.

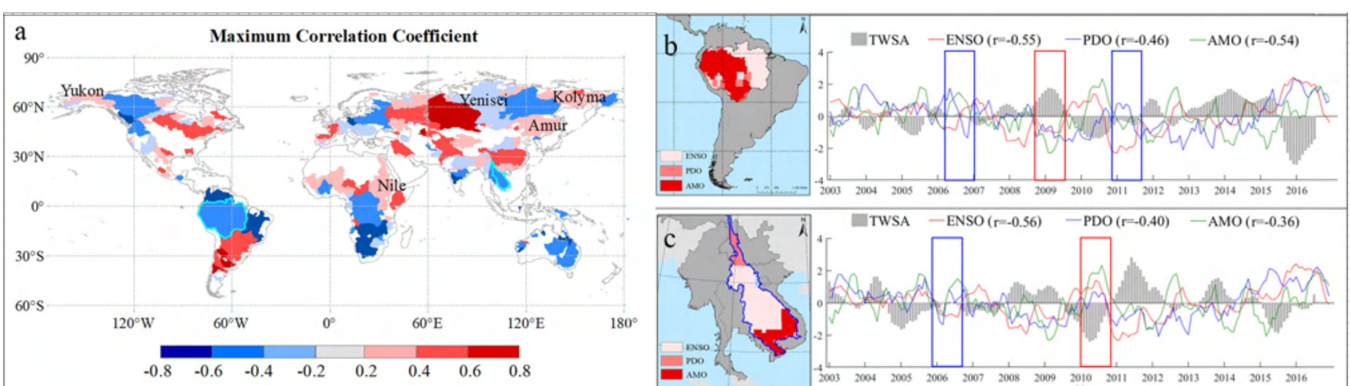


Figure 1: The response of TWSA to multiple TCs within investigated water catchments. (a) Maps of the investigated water catchments color-coded based on the value of the maximum correlation coefficient found between TWSA and TCs. (b) Time series of TWSA and correlated TCs in the Amazon basin (top) and Mekong River basin (bottom). Red boxes plot the phase synchronization cases of three TCs, and blue boxes plot the non-synchronization cases.

Research

The TWSA in the LANGCANG-MEKONG Basin is most sensitive to the synchronous fluctuations of ENSO, PDO and AMO. The synchronous negative phase of PDO, ENSO and AMO usually leads to a stronger positive TWSA, and vice versa. TC modes regulate the terrestrial water cycle by mediating precipitation (P), evapotranspiration (ET), runoff (R) and glacial melting in the cryosphere. The results show that the TWSAs of LANGCANG-MEKONG river basins are predominantly driven by ET (contribution > 80%). PDO and AMO are the dominant TCs driving ET fluctuations in the area.

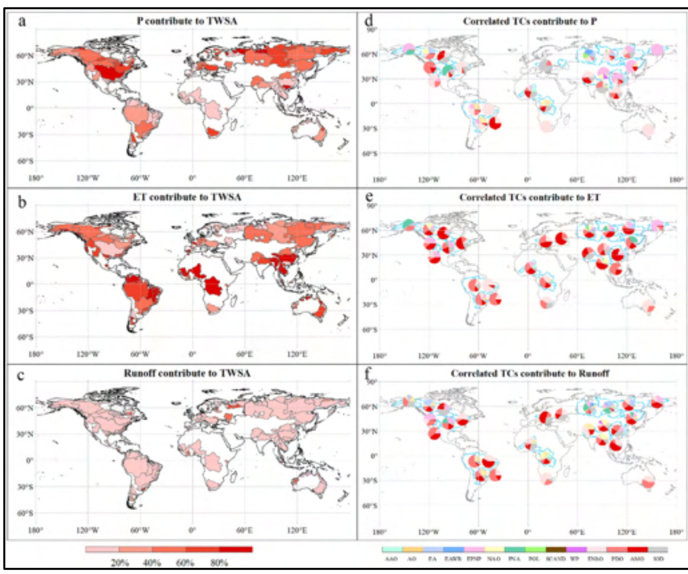


Figure 2: Maps of variations in TWSA contributed from (a) precipitation (P), (b) evapotranspiration (ET) and (c) runoff (R) and spatial patterns of variations in (d) precipitation (P), (e) evapotranspiration (ET) and (f) runoff (R) contributed from multiple TCs (color-coded) of the investigated river basins.

The results were published in **Journal of Hydrology**

Full article link: https://doi.org/10.1016/j.jhydrol.2021.126419

Assessment of climate change impacts on the streamflow for the Mun River in the Mekong Basin, Southeast Asia: Using SWAT model

Serious water problems exist in the typical warm-wet Southeast Asia. However, it is seldomly known how the future streamflow will change with altered future climate change. **PhD student Chaoyue LI** and **Prof. Haiyan FANG** from the Institute of Geographic Sciences and Natural Resources Research gave a study on this issue by coupling the Soil and Water Assessment Tool (SWAT), downscaling method (Delta) and global circulation models (GCMs) under three Representative Concentration Pathways (RCPs) in the Mun River Basin, Thailand (Figure 1).

Results showed that future monthly minimum and maximum temperature would rise under RCP2.6, RCP4.5, and RCP8.5, which is more significant in dry season than that in wet season. The average annual precipitation would decrease in the 2030s, while increase by 8.9, 12.8, and 13.9% for three climate scenarios in the 2060s. The marked increase in precipitation was detected from June to September in wet season.

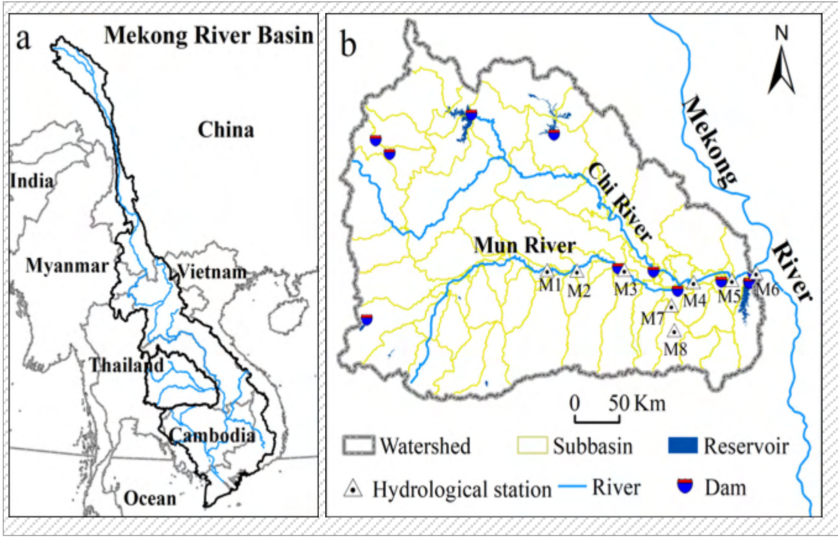


Figure 1: Location of the study area and river monitoring network.

Research

The future streamflow under three scenarios during 2020-2093 would increase by 10.5, 20.1, and 23.2%, respectively (Figure 2). Monthly average streamflow would increase from June to September and decrease from February to May. These changes in flow were closely related to climate changes. This study highlights the impact of future climate changes on streamflow in the Southeast Asia regions at different time scales, deeps current researches on the climate change impacts on the tropical regions, and thus can provide scientific basis for adaptive management for this and similar regions in the world.

The results were published in ***Catena***.
Full article link: https://doi.org/10.1016/j.catena.2021.105199

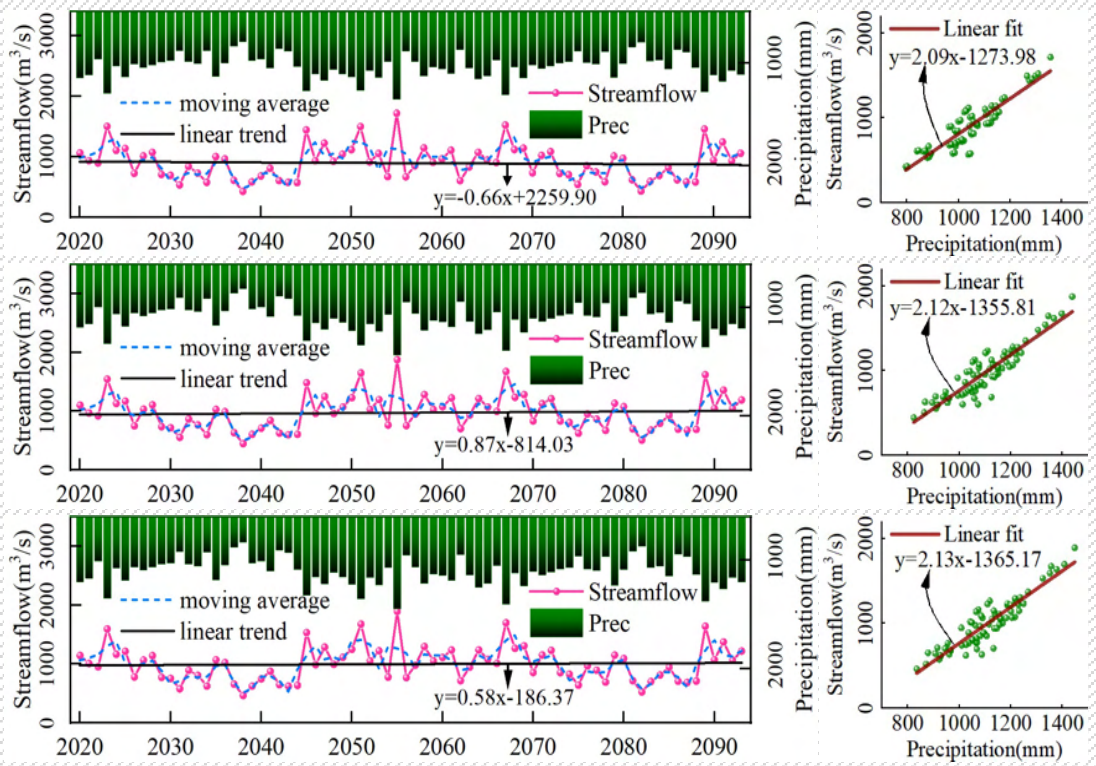


Figure 2: The annual streamflow simulated by the calibrated SWAT model and the relations between precipitation and streamflow during the future periods under RCP2.6 (upper), RCP4.5 (middle), and RCP8.5 (lower) scenarios.

Summer afternoon precipitation associated with wind convergence near the Himalayan glacier fronts

The effects of glacier-air interactions on the Himalayan glacier mass balance is important for a reliable projection of the future changes. Led by **Dr. Changgui LIN**, **Prof. Deliang CHEN**'s group from the Department of Earth Sciences at University of Gothenburg, Sweden, conducted a study describing the drying effect of the katabatic winds on the up-valley summer monsoon flows by creating favorable conditions for local convergence-induced precipitation to occur near the glacier fronts. The analyses are based on the exclusive data recorded in the Khumbu valley and the Langtang valley in the Nepalese Himalayas.

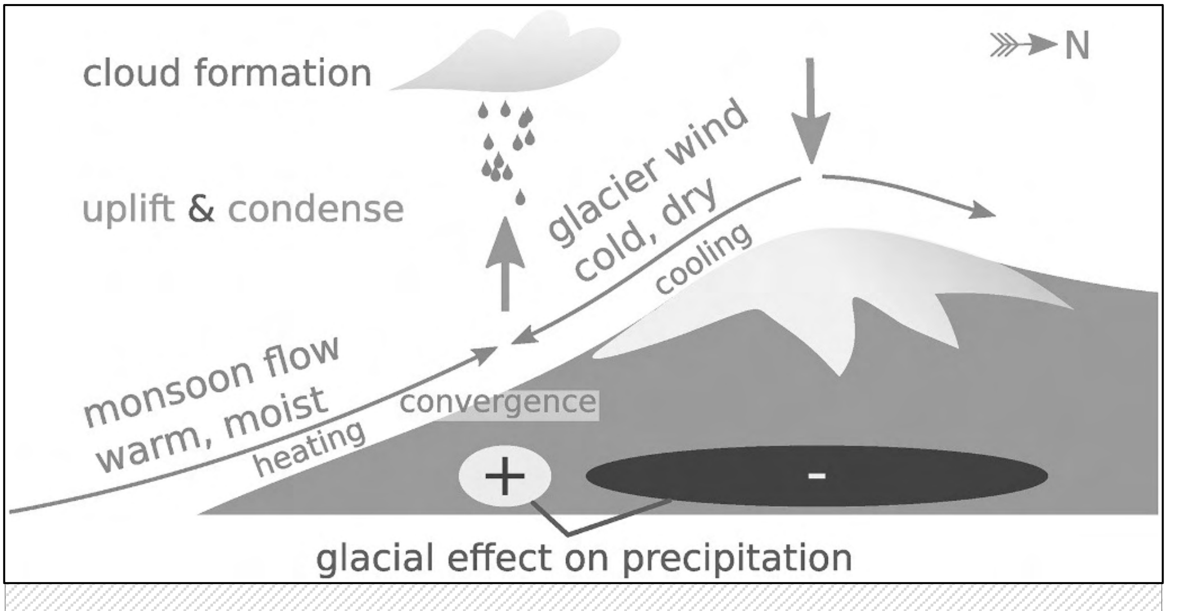


Figure 1: Hypothesized effect of glacier-air interactions on local precipitation. Arrows show the motion of air masses; plus and minus signs indicate the promotion or suppression of precipitation, respectively.

Research

These data revealed higher afternoon precipitation in summer associated with surface wind convergence near the glacier fronts and a sharp decrease in the temperature lapse rate over the glacier surfaces. The principle of the observed phenomena was proven by our high-resolution modeling sensitive experiment, which involved two simulations, one with the present glaciers and the other without. This numerical experiment also supports the proposed negative feedback. Furthermore, we report a low deuterium excess near the glacier fronts, indicating below-cloud re-evaporation facilitated by the local convergence induced by the dry katabatic winds. The study suggests that current models may overestimate the retreat of Himalayan glaciers because they have completely ignored the glacier-air interactions.

The results were published in ***Atmospheric Research***.
Full article link: https://doi.org/10.1016/j.atmosres.2021.105658

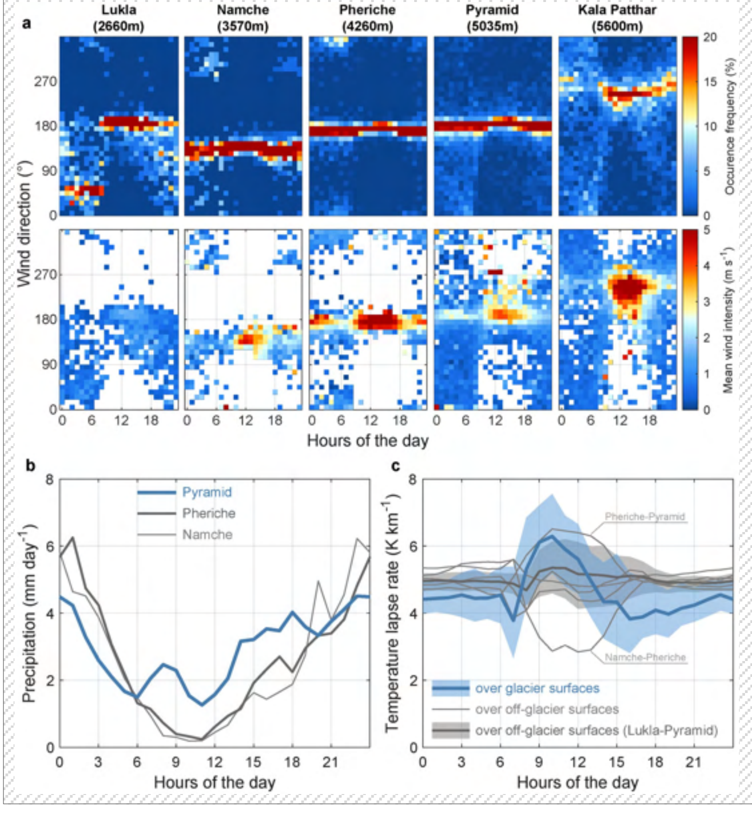


Figure 2: Diurnal cycle of the three parameters measured in the Khumbu valley in summer (June–August) during 2007–2010: (a) occurrence frequency and mean intensity of near-surface wind; (b) precipitation; and (c) lapse rate of surface air temperature between any combination of two stations.

Multidecadal variability of the Tonle Sap Lake flood pulse regime

Tonle Sap Lake (TSL) flood pulse and its long-term dynamics under the Mekong River basin's (MRB) fast socio-economic development and climate change need to be identified and understood. Led by **Dr. Aifang CHEN**, **Prof. Junguo LIU** and an international research team, conducted a study on systematically analysing the changes in multiple key flood pulse parameters of the TSL. The analyses are based on using observed WL data for 1960–2019 accompanied with several parameters derived from a Digital Bathymetry Model. Results show significant declines of water level and inundation area from the late 1990s in the dry season and for the whole year, on top of increased subdecadal variability.

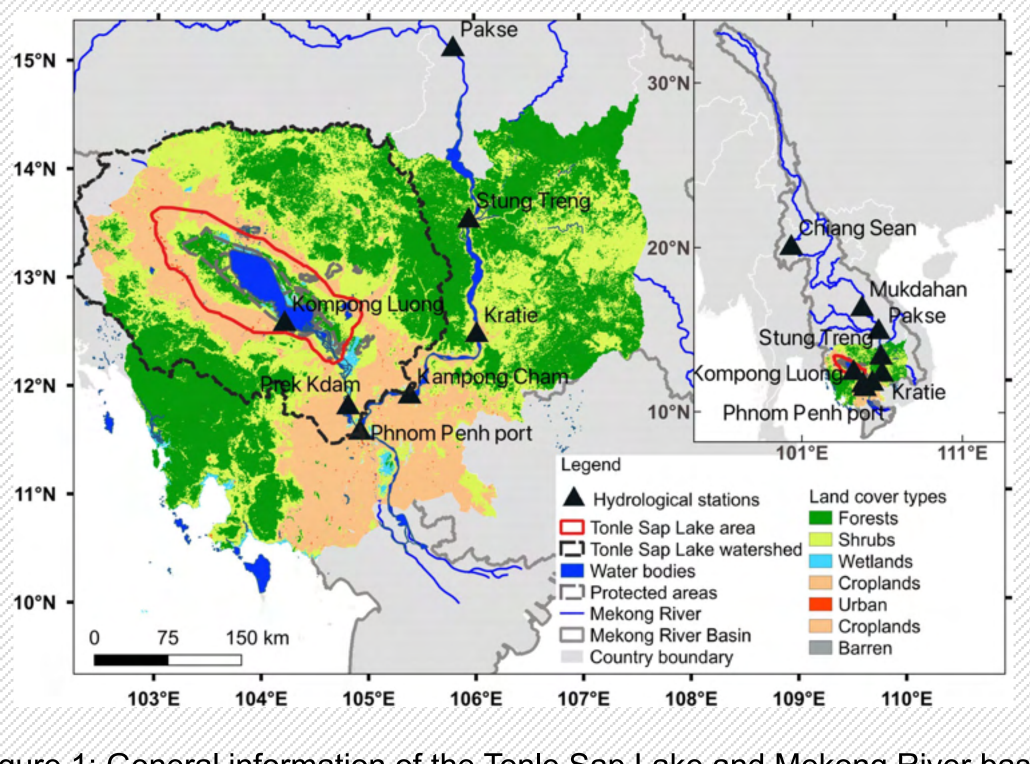


Figure 1: General information of the Tonle Sap Lake and Mekong River basin

Decreasing (increasing) probabilities of high (low) inundation area for 2000–2019 have been found, in comparison to the return period of inundation area for 1986–2000 (1960–1986). The mean seasonal cycle of daily WL in dry (wet) season for 2000–2019, compared to that for 1986–2000, has shifted by 10 (5) days. Significant correlations and coherence changes between the WL and large-scale circulations (i.e., El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO) and Indian Ocean Dipole (IOD)), indicate that the atmospheric circulations could have influenced the flood pulse in different time scales. Also, the changes in discharge at the Mekong mainstream suggest that anthropogenic drivers may have impacted the high water levels in the lake. Overall, our results indicate a declining flood pulse since the late 1990s.

The results were published in ***Hydrological Processes***.
Full article link: https://doi.org/10.1002/hyp.14327

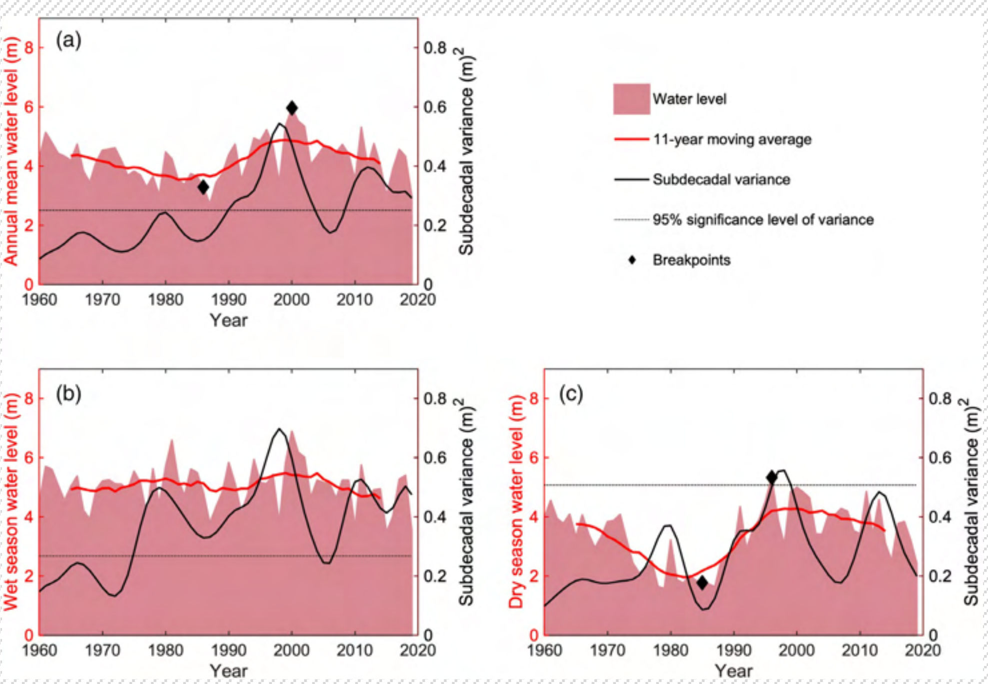


Figure 2: Time series of water level of the Tonle Sap Lake for 1960–2019: Mean water level: (a) annual, (b) wet season (May–October) and (c) dry season (November–April).

Publications

Selected Publications Since September 2021

- Liu, J., D. Chen, G. Mao, M. Irannezhad, and Y. Pokhrel. Past and Future Changes in Climate and Water Resources in the Lancang–Mekong River Basin: Current Understanding and Future Research Directions. *Engineering*, 2021. https://doi.org/10.1016/j.eng.2021.06.026.

- Huang, Z., X. Liu, S. Sun, Y. Tang, X. Yuan, and Q. Tang. Global Assessment of Future Sectoral Water Scarcity under Adaptive Inner-Basin Water Allocation Measures. *Science of the Total Environment*, 2021, 783: 146973. https://doi.org/10.1016/j.scitotenv.2021.146973

- He, B., C. Chen, S. Lin, W. Yuan, H. W. Chen, D. Chen, Y. Zhang, L. Guo, X. Zhao, X. Liu, S. Piao, Z. Zhong, R. Wang, and R. Tang. “Worldwide Impacts of Atmospheric Vapor Pressure Deficit on the Interannual Variability of Terrestrial Carbon Sinks.” *National Science Review*, 2021. http://dx.doi.org/10.1093/nsr/nwab150.

- Liu, X., Q. Tang, S.-M. Hosseini-Moghari, X. Shi, M.-H. Lo, and B. Scanlon. "Grace Satellites Enable Long-Lead Forecasts of Mountain Contributions to Streamflow in the Low-Flow Season." *Remote Sensing*, 2021, 13 (10). http://dx.doi.org/10.3390/rs13101993.

- 陈德亮, 赖慧文. IPCC AR6 WGI报告的背景、架构和方法[J]. *气候变化研究进展*, 2021, 17(6): 636-643.

Publications

Selected Publications Since September 2021

- Wang, K., J. Liu, J. Xia, Z. Wang, Y. Meng, H. Chen, G. Mao, and B. Ye. Understanding the Impacts of Climate Change and Socio-Economic Development through Food-Energy-Water Nexus: A Case Study of Mekong River Delta. *Resources, Conservation and Recycling*, 2021, 167 : 105390. https://doi.org/10.1016/j.resconrec.2020.105390.

- Pi, X., L. Feng, W. Li, J. Liu, X. Kuang, K. Shi, W. Qi, D. Chen, and J. Tang. "Chlorophyll-a Concentrations in 82 Large Alpine Lakes on the Tibetan Plateau During 2003–2017: Temporal–Spatial Variations and Influencing Factors." *International Journal of Digital Earth, 2021,* 14(6): 714-35. http://dx.doi.org/10.1080/17538947.2021.1872722.

- Liu, Y., C. Zhang, Q. Tang, S.-M. Hosseini-Moghari, G. G. Haile, L. Li, W. Li, K. Yang, R. J. van der Ent, and D. Chen. Moisture Source Variations for Summer Rainfall in Different Intensity Classes over Huaihe River Valley, China. *Climate Dynamics*, 2021. http://dx.doi.org/10.1007/s00382-021-05762-4.

- Tian, W., X. Liu, K. Wang, P. Bai, K. Liang, and C. Liu. "Evaluation of Six Precipitation Products in the Mekong River Basin." *Atmospheric Research*, 2021, 255: 105539. http://dx.doi.org/https://doi.org/10.1016/j.atmosres.2021.105539.

Contact Us

The Contact Information:

Address:
School of Environmental Science and Engineering, Southern University of Science and Technology, Shenzhen, P.R. China

Phone: 0755-88018012

Email: liujg@sustech.edu.cn

Web: http://www.lancang-mekong.net