# 湖泊流域动态

## 本期导读

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- 湖泊水位记录支持中国北方全新世中期降水达到最高值

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# 新文速递

## Imbalance of global nutrient cycles exacerbated by the greater retention of phosphorus over nitrogen in lakes

Wu, Zhen; Li, Jincheng; Sun, Yanxin;等

Lakes preferentially retain phosphorous over nitrogen, amplifying the imbalance of nutrient cycles caused by anthropogenic inputs, according to analyses of more than 5,000 lakes globally. Imbalanced anthropogenic inputs of nitrogen (N) and phosphorus (P) have significantly increased the ratio between N and P globally, degrading ecosystem productivity and environmental quality. Lakes represent a large global nutrient sink, modifying the flow of N and P in the environment. It remains unknown, however, the relative retention of these two nutrients in global lakes and their role in the imbalance of the nutrient cycles. Here we compare the ratio between P and N in inflows and outflows of more than 5,000 lakes globally using a combination of nutrient budget model and generalized linear model. We show that over 80% of global lakes positively retain both N and P, and almost 90% of the lakes show preferential retention of P. The greater retention of P over N leads to a strong elevation in the ratios between N and P in the lake outflow, exacerbating the imbalance of N and P cycles unexpectedly and potentially leading to biodiversity losses within lakes and algal blooms in downstream N-limited coastal zones. The management of N or P in controlling lake eutrophication has long been debated. Our results suggest that eutrophication management that prioritizes the reduction of P in lakes-which causes a further decrease in P in outflows-may unintentionally aggravate N/P imbalances in global ecosystems. Our results also highlight the importance of nutrient retention stoichiometry in global lake management to benefit watershed and regional biogeochemical cycles.

（来源：Nature Geoscience 出版年: 2022, **DOI:** 10.1038/s41561-022-00958-7）

## Managing nitrogen legacies to accelerate water quality improvement

Basu, Nandita B.; Van Meter, Kimberly J.; Byrnes, Danyka K.;等

Increasing incidences of eutrophication and groundwater quality impairment from agricultural nitrogen pollution are threatening humans and ecosystem health. Minimal improvements in water quality have been achieved despite billions of dollars invested in conservation measures worldwide. Such apparent failures can be attributed in part to legacy nitrogen that has accumulated over decades of agricultural intensification and that can lead to time lags in water quality improvement. Here, we identify the key knowledge gaps related to landscape nitrogen legacies and propose approaches to manage and improve water quality, given the presence of these legacies. Agricultural nitrogen legacies are delaying improvements to water quality. Comprehensive management strategies that address legacy issues are needed to ensure better environmental outcomes.

（来源：Nature Geoscience 出版年: 2022, **DOI:** 10.1038/s41561-021-00889-9）

## Observationally constrained projection of Afro-Asian monsoon precipitation

Chen, Ziming; Zhou, Tianjun; Chen, Xiaolong;等

A new study shows the latest climate models tend to overestimate future Afro-Asian monsoon rainfall and runoff due to present-day biases of warming patterns. By constraining biases, the rainfall increase is 70% of the raw projection. The Afro-Asian summer monsoon (AfroASM) sustains billions of people living in many developing countries covering West Africa and Asia, vulnerable to climate change. Future increase in AfroASM precipitation has been projected by current state-of-the-art climate models, but large inter-model spread exists. Here we show that the projection spread is related to present-day interhemispheric thermal contrast (ITC). Based on 30 models from the Coupled Model Intercomparison Project Phase 6, we find models with a larger ITC trend during 1981-2014 tend to project a greater precipitation increase. Since most models overestimate present-day ITC trends, emergent constraint indicates precipitation increase in constrained projection is reduced to 70% of the raw projection, with the largest reduction in West Africa (49%). The land area experiencing significant increases of precipitation (runoff) is 57% (66%) of the raw projection. Smaller increases of precipitation will likely reduce flooding risk, while posing a challenge to future water resources management.

（来源：Nature Communications 卷:13 期: 1 出版年: 2022, **DOI:** 10.1038/s41467-022-30106-z）

## The importance of hydrology in routing terrestrial carbon to the atmosphere via global streams and rivers

Liu, Shaoda; Kuhn, Catherine; Amatulli, Giuseppe;等

The magnitude of stream and river carbon dioxide (CO2) emission is affected by seasonal changes in watershed biogeochemistry and hydrology. Global estimates of this flux are, however, uncertain, relying on calculated values for CO2 and lacking spatial accuracy or seasonal variations critical for understanding macroecosystem controls of the flux. Here, we compiled 5,910 direct measurements of fluvial CO2 partial pressure and modeled them against watershed properties to resolve reach-scale monthly variations of the flux. The direct measurements were then combined with seasonally resolved gas transfer velocity and river surface area estimates from a recent global hydrography dataset to constrain the flux at the monthly scale. Globally, fluvial CO2 emission varies between 112 and 209 Tg of carbon per month. The monthly flux varies much more in Arctic and northern temperate rivers than in tropical and southern temperate rivers (coefficient of variation: 46 to 95 vs. 6 to 12%). Annual fluvial CO2 emission to terrestrial gross primary production (GPP) ratio is highly variable across regions, ranging from negligible (<0.2%) to 18%. Nonlinear regressions suggest a saturating increase in GPP and a nonsaturating, steeper increase in fluvial CO2 emission with discharge across regions, which leads to higher percentages of GPP being shunted into rivers for evasion in wetter regions. This highlights the importance of hydrology, in particular water throughput, in routing terrestrial carbon to the atmosphere via the global drainage networks. Our results suggest the need to account for the differential hydrological responses of terrestrial-atmospheric vs. fluvial-atmospheric carbon exchanges in plumbing the terrestrial carbon budget.

（来源：PNAS 卷:119 期: 11 出版年: 2022, **DOI:** 10.1073/pnas.2106322119）

## Current water quality guidelines across North America and Europe do not protect lakes from salinization

Hintz, William D.; Arnott, Shelley E.; Symons, Celia C.;等

Human-induced salinization caused by the use of road deicing salts, agricultural practices, mining operations, and climate change is a major threat to the biodiversity and functioning of freshwater ecosystems. Yet, it is unclear if freshwater ecosystems are protected from salinization by current water quality guidelines. Leveraging an experimental network of land-based and in-lake mesocosms across North America and Europe, we tested how salinization-indicated as elevated chloride (C-) concentration-will affect lake food webs and if two of the lowest Cl- thresholds found globally are sufficient to protect these food webs. Our results indicated that salinization will cause substantial zooplankton mortality at the lowest Cl- thresholds established in Canada (120 mg Cl-/L) and the United States (230 mg Cl-/L) and throughout Europe where Cl- thresholds are generally higher. For instance, at 73% of our study sites, Cl- concentrations that caused a >= 50% reduction in cladoceran abundance were at or below Cl thresholds in Canada, in the United States, and throughout Europe. Similar trends occurred for copepod and rotifer zooplankton. The loss of zooplankton triggered a cascading effect causing an increase in phytoplankton biomass at 47% of study sites. Such changes in lake food webs could alter nutrient cycling and water clarity and trigger declines in fish production. Current Cl- thresholds across North America and Europe clearly do not adequately protect lake food webs. Water quality guidelines should be developed where they do not exist, and there is an urgent need to reassess existing guidelines to protect lake ecosystems from human-induced salinization.

（来源：PNAS 卷:119 期:9 出版年: 2022, **DOI:** 10.1073/pnas.2115033119）

## Monitoring global carbon emissions in 2021

Liu, Zhu; Deng, Zhu; Davis, Steven J.;等.

Following record-level declines in 2020, near-real-time data indicate that global CO2 emissions rebounded by 4.8% in 2021, reaching 34.9 GtCO(2). These 2021 emissions consumed 8.7% of the remaining carbon budget for limiting anthropogenic warming to 1.5 degrees C, which if current trajectories continue, might be used up in 9.5 years at 67% likelihood.

（来源：Nature Reviews Earth & Environment 出版年: 2022, **DOI:** 10.1038/s43017-022-00285-w）

## Threshold constraints on the size, shape and stability of alluvial rivers

Phillips, Colin B.; Masteller, Claire C.; Slater, Louise J.; 等等.

The size and shape of alluvial river channels control and adjust to the flow of water and sediment, with consequences for flooding and ecological habitat. This Perspective examines how the sediment entrainment threshold constrains the size, shape and dynamics of alluvial rivers. The geometry of alluvial river channels both controls and adjusts to the flow of water and sediment within them. This feedback between flow and form modulates flood risk, and the impacts of climate and land-use change. Considering widely varying hydro-climates, sediment supply, geology and vegetation, it is surprising that rivers follow remarkably consistent hydraulic geometry scaling relations. In this Perspective, we explore the factors governing river channel geometry, specifically how the threshold of sediment motion constrains the size and shape of channels. We highlight the utility of the near-threshold channel model as a suitable framework to explain the average size and stability of river channels, and show how deviations

relate to complex higher-order behaviours. Further characterization of the sediment transport threshold and channel adjustment timescales, coupled with probabilistic descriptions of river geometry, promise the development of future models capable of capturing rivers' natural complexity.

（来源：Nature Reviews Earth & Environment 出版年: 2022, **DOI:** 10.1038/s43017-022-00282-z）

## Towards a unified understanding of human-nature interactions

Soga, Masashi; Gaston, Kevin J.

Interest in the direct interactions between individual people and nature has grown rapidly. This attention encompasses multiple academic disciplines and practical perspectives. A central challenge thus lies in creating a rich cross-disciplinary understanding of these interactions, rather than one that might become characterized by little conceptual, terminological and methodological unity. Here, to facilitate the former outcome, we bring together concepts and theories about direct human-nature interactions drawn from diverse disciplines within a unified conceptual framework. Using this framework, we discuss the linkages among key concepts and theories, identify important knowledge gaps and suggest directions for future research. Understanding interactions between people and nature is increasingly vital. This Perspective argues that synthesizing concepts and theories from diverse disciplines is crucial, and suggests a conceptual framework for unifying this effort and science.

（来源：Nature Sustainability 出版年: 2022, **DOI:** 10.1038/s41893-021-00818-z）

## Assessing placement bias of the global river gauge network

Krabbenhoft, Corey A.; Allen, George H.; Lin, Peirong; 等

Hydrologic data collected from river gauges inform critical decisions for allocating water resources, conserving ecosystems and predicting the occurrence of droughts and floods. The current global river gauge network is biased towards large, perennial rivers, and strategic adaptations are needed to capture the full scope of rivers on Earth. Knowing where and when rivers flow is paramount to managing freshwater ecosystems. Yet stream gauging stations are distributed sparsely across rivers globally and may not capture the diversity of fluvial network properties and anthropogenic influences. Here we evaluate the placement bias of a global stream gauge dataset on its representation of socioecological, hydrologic, climatic and physiographic diversity of rivers. We find that gauges are located disproportionally in large, perennial rivers draining more human-occupied watersheds. Gauges are sparsely distributed in protected areas and rivers characterized by non-perennial flow regimes, both of which are critical to freshwater conservation and water security concerns. Disparities between the geography of the global gauging network and the broad diversity of streams and rivers weakens our ability to understand critical hydrologic processes and make informed water-management and policy decisions. Our findings underscore the need to address current gauge placement biases by investing in and prioritizing the installation of new gauging stations, embracing alternative water-monitoring strategies, advancing innovation in hydrologic modelling, and increasing accessibility of local and regional gauging data to support human responses to water challenges, both today and in the future.

（来源：Nature Sustainability 出版年: 2022, **DOI:** 10.1038/s41893-022-00873-0）

## Extreme rainstorms drive exceptional organic carbon export from forested humid-tropical rivers in Puerto Rico

Clark, K. E.; Stallard, R. F.; Murphy, S. F.; 等

Extreme rainfall in Puerto Rico leads to some of the highest particulate organic carbon yields. Here the authors find that global estimates of carbon export may be underestimated by up to 9% because of a lack of studies in the tropics. Extreme rainfall events in the humid-tropical Luquillo Mountains, Puerto Rico export the bulk of suspended sediment and particulate organic carbon. Using 25 years of river carbon and suspended sediment data, which targeted hurricanes and other large rainstorms, we estimated biogenic particulate organic carbon yields of 65 +/- 16 tC km(-2) yr(-1) for the Icacos and 17.7 +/- 5.1 tC km(-2) yr(-1) for the Mameyes rivers. These granitic and volcaniclastic catchments function as substantial atmospheric carbon-dioxide sinks, largely through export of river biogenic particulate organic carbon during extreme rainstorms. Compared to other regions, these high biogenic particulate organic carbon yields are accompanied by lower suspended sediment yields. Accordingly, particulate organic carbon export from these catchments is underpredicted by previous yield relationships, which are derived mainly from catchments with easily erodible sedimentary rocks. Therefore, rivers that drain petrogenic-carbon-poor bedrock require separate accounting to estimate their contributions to the geological carbon cycle.

（来源：Nature Communications 出版年: 2022, **DOI:** 10.1038/s41467-022-29618-5）

## Shifts in regional water availability due to global tree restoration

van Dijke, Anne J. Hoek; Herold, Martin; Mallick, Kaniska; 等

Global tree restoration could cause substantial and regionally variable changes in water availability, according to an ensemble of Budyko models and moisture recycling data. Tree restoration is an effective way to store atmospheric carbon and mitigate climate change. However, large-scale tree-cover expansion has long been known to increase evaporation, leading to reduced local water availability and streamflow. More recent studies suggest that increased precipitation, through enhanced atmospheric moisture recycling, can offset this effect. Here we calculate how 900 million hectares of global tree restoration would impact evaporation and precipitation using an ensemble of data-driven Budyko models and the UTrack moisture recycling dataset. We show that the combined effects of directly enhanced evaporation and indirectly enhanced precipitation create complex patterns of shifting water availability. Large-scale tree-cover expansion can increase water availability by up to 6% in some regions, while decreasing it by up to 38% in others. There is a divergent impact on large river basins: some rivers could lose 6% of their streamflow due to enhanced evaporation, while for other rivers, the greater evaporation is counterbalanced by more moisture recycling. Several so-called hot spots for forest restoration could lose water, including regions that are already facing water scarcity today. Tree restoration significantly shifts terrestrial water fluxes, and we emphasize that future tree-restoration strategies should consider these hydrological effects.

（来源：Nature Geoscience 出版年: 2022, **DOI:** 10.1038/s41561-022-00935-0）

## Identifying biases in the global placement of river gauges

Krabbenhoft, Corey A.; Allen, George H.

A global analysis of stream gauges reveals that they are predominantly installed on large, perennially flowing and human-impacted rivers. The current placement of stream gauges does not provide observations that represent the wide variety of global rivers, resulting in a biased dataset, which has broad implications for ecology, hydrology, and freshwater management.

（来源：Nature Sustainability 出版年: 2022, **DOI:** 10.1038/s41893-022-00878-9）

# 摘要精选

## Whither Winter: The Altered Role of Winter for Freshwaters as the Climate Changes

Cotner, James B.; Powers, Stephen M.; Sadro, Steven;等

Our changing climate is having effects on freshwater ecosystems in all seasons, especially winter. High latitude lakes, wetlands, and rivers are experiencing shorter periods of ice cover, and lower latitudes systems that used to freeze are experiencing open water conditions throughout the winter. A 2019 AGU Chapman conference convened aquatic scientists to examine these changes and address the implications of changing winters to aquatic life, chemistry, and physics. Several studies demonstrate decreased ice cover duration than in the past. The removal of an ice lid from lakes and rivers impacts the exchange of gases with the atmosphere and the predominant types of metabolism occurring in the waters below, with the potential for more photosynthesis and an increase in oxic versus anoxic metabolism when the lid is removed. Multiple studies indicated an increase in the interannual variability of winters, especially in terms of ice-cover duration and ice quality. Increased variability may simply be an outcome of a more variable winter climate or small differences in environmental conditions such as temperature that can have strong effects on gas exchange, light transmission, and turbulence when ice forms. A question that merits further consideration is whether and how winters of shorter duration and severity will change the dynamics of freshwater systems. Are there memory or legacy effects that carry over to the next season or year? There is much work to be done to understand how changing winters will impact the biogeochemical behavior of lakes and rivers in the coming decades. Plain Language Summary Winters at mid-high latitudes are changing rapidly with important implications for freshwater ecosystems. An AGU Chapman conference, convened in 2019, brought together scientists to outline what we know about the changes that are occurring and what questions need further study. This special issue is a collection of the papers that developed from that workshop. These studies demonstrate that lakes and rivers at mid-high latitudes are experiencing less ice cover duration and greater variability in year-to-year ice cover. Changing ice and snow cover impacts processes occurring under ice in winter by altering the light regime, mixing, biota present, and the availability of oxygen. There are many important research questions regarding winter dynamics that still need to be addressed but one of the most important ones has to do with how changing winters might influence the biota in other seasons.

（来源：JOURNAL OF GEOPHYSICAL RESEARCH-BIOGEOSCIENCES 出版年：2022, **DOI:** 10.1029/2021JG006761）

## Distinctive Microbial Processes and Controlling Factors Related to Indirect $N_2O$ Emission from Agricultural and Urban Rivers in Taihu Watershed

Song, Kang; Senbati, Yeerken; Li, Lu;等

As Inland rivers are hotspots of anthropogenic indirect nitrous oxide ($N_2O$) emissions, but the underlying microbial processes remain poorly understood. This study measured $N_2O$ fluxes from agricultural and urban rivers in Taihu watershed and investigated the microbial processes driving $N_2O$ production and consumption. The $N_2O$ fluxes were significantly higher in agricultural rivers (140.1 +/- 89.1 mu mol m-2 d-1) than in urban rivers (25.1 +/- 27.0 mu mol m-2 d-1) ($p < 0.001$). All wind-based models significantly underestimated $N_2O$ flux in urban rivers ($p < 0.05$) when using the Intergovernmental Panel on Climate

Change method because they underestimated the $N_2O$ emission factor (EF5r). Wind speed and nitrate were the key factors affecting $N_2O$ fluxes in agricultural and urban rivers, respectively. NirK-type denitrifiers produced $N_2O$ in urban river water, while nirS-type denitrifiers consumed $N_2O$ in the sediments of all rivers. Co-occurrence network analysis indicated organics from Microcystis served as electron donors for denitrifiers (dominated by Flavobacterium) in water, while direct interspecies electron transfer between Thiobacillus and methanogens and between Dechloromonas and sulfate-reducing bacteria enhanced $N_2O$ reduction in sediments. This study advances our knowledge on the distinctive microbial processes that determine $N_2O$ emissions in inland rivers and illustrates the need to revise EF5r for $N_2O$ estimation in urban rivers.

（来源：ENVIRONMENTAL SCIENCE & TECHNOLOGY 出版年: 2022, **DOI:** 10.1021/acs.est.1c07980）

## The Scaling Relationship for the Length of Tributaries to Lakes

Seekell, D.; Cael, B.; Bystrom, P.等

Globally, the length of tributaries to lakes varies from 0 to more than 15,000 km, but scaling relationships describing this aspect of lake-river connectivity are lacking. In this study, we describe a simple theoretical scaling relationship for tributary length based on the principle of line intercepts of topographic features, and test this theory using data from Scandinavia. Tributary length increases by 73% for each doubling of lake area. This pattern reflects the relationship between catchment and lake area, and is modified by inlet frequency, junction angle, and lake shape-factors related to specific geologic and hydrologic processes. The theory is precise (r(2) = 0.74), with low bias (mean error is 14% of mean tributary length) when the characteristic junction angle (similar to 76 degrees) is estimated statistically. Our study bridges the gap between geomorphic and large-scale statistical relationships to provide simple rules for understanding complex patterns of lake-river connectivity.

（来源：GEOPHYSICAL RESEARCH LETTERS 出版年: 2022, **DOI:** 10.1029/2022GL098183）

## Can top-down effects of planktivorous fish removal be used to mitigate cyanobacterial blooms in large subtropical highland lakes?

Yin, Chengjie; He, Wanchao; Guo, Longgen;等

Removal of planktivorous fish is used extensively in northern temperate lakes to reduce phytoplankton abundance via enhanced zooplankton grazing. However, whether this method would work also in large subtropical highland lakes to alleviate cyanobacterial blooms is unknown. We conducted a one-year pilot in situ experiment where we removed a substantial biomass of fish in a fenced-in area, followed by a 3-year whole-lake experiment where the dominant fish species (Japanese smelt) was removed in Lake Erhai in southwest China. The fencing experiments showed that between July and November, when the biomass of the removed stock reached 4 g/m(2), the zooplankton biomass inside the fence increased significantly compared to a control fence. In the full-lake experiment, we found that sustained removal of Japanese smelt led to an increase in the biomass of cladocerans (Daphnia spp. but especially of Bosmina spp.) and a significant decrease in the biomass of Cyanobacteria and Chlorophyta. Additionally, a marked increase in the ratio of zooplankton to phytoplankton biomass, as well as an increase in the body size of cladocerans, emphasising the importance of enhanced top-down control for mitigating cyanobacterial blooms following extensive fish removal. Our results reveal that removal of small fish (here Japanese smelt) can lead to a reduction of the phytoplankton and cyanobacteria biomass through a trophic cascade in highland deep subtropical lakes. Thus fish removal may be a feasible additional

restoration tool to external nutrient loading reduction in such lakes.

（来源：WATER RESEARCH 卷:218 出版年: 2022, **DOI:** 10.1016/j.watres.2022.118483）

## Molecular-level composition of dissolved organic matter in distinct trophic states in Chinese lakes: Implications for eutrophic lake management and the global carbon cycle

Liu, Shasha; Hou, Junwen; Suo, Chengyu;等

Dissolved organic matter (DOM) is an abundant and mobile part of the aquatic environment and plays important roles in aquatic biogeochemical cycles and the global carbon cycle. Recently, eutrophication has become an important environmental issue in global lakes, but how eutrophication drives changes in the molecular composition of DOM along trophic gradients remains poorly understood. We thus characterized 67 DOM isolates from 11 lakes along a trophic gradient in China by using a combined approach including absorption spectroscopy, excitation-emission matrix fluorescence and Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS). Our results indicated that dissolved organic carbon and absorption coefficients at 350 nm increased with increasing trophic status index. The ultraviolet absorbance at 254 nm and fluorescence intensity of all fluorescent components were higher in eutrophic lakes than in oligotrophic lakes. DOM in high trophic state lakes tended to be dominated by higher molecular weight, unsaturation degree, greater abundance of S -containing compounds, and condensed or polycyclic aromatic compounds than oligotrophic lakes. Additionally, autochthonous DOM characterized by more aliphatic compounds increased with the increasing trophic state. We concluded that nutrient input along with allochthonous DOM favors the lake eutrophication and subsequently increases the release and accumulation of autochthonous DOM. Consequently, eutrophication modifies the structure of the organic matter into more complex materials with increased input of allochthonous DOM and increased release of autochthonous DOM, which could accelerate global carbon cycle processes. Our results here have potential to contribute significantly to future studies of DOM dynamics in eutrophic lakes.

（来源：WATER RESEARCH 卷:217 出版年: 2022, **DOI:** 10.1016/j.watres.2022.118438）

## Dissimilatory nitrate reduction in urban lake ecosystems: A comparison study between closed and open lakes in Chengdu, China

Yang, Zhanbiao; Lu, Lan; Cheng, Zhang;等

Urban lake ecosystems play important roles in nitrogen cycling, yet the occurrence, contribution and mechanism of nitrate reduction in urban closed and open lakes (UCL and UOL) remain unclear. On November - December of 2020, the potential rates of denitrification (DEN), anammox (ANA), and dissimilatory nitrate reduction to ammonium (DNRA) were quantified using slurries incubations in six urban lakes of Chengdu, China. The environmental variables, genes abundance (nirS, hzsB and nrfA), bacterial 16S rRNA gene were also measured. UOL had higher water ammonium ($NH_4$ (+)), nitrate ($NO_3$(-)) and nitrite ($NO_2$(-)), and sediment $NH_4$(+), $NO_3$ (-), total organic carbon (TOC) and ferrous iron ($Fe_2$ (+)) content than UCL. The potential rates of DEN and anammox in UOL were & nbsp; 2.16- and 3.45-times more than in UCL, respectively. Conversely, the DNRA rate in UCL was 1.20-fold higher than UOL. Higher nirS and hzsB abundance were found in UOL, while higher nrfA abundance occurred in UCL. High-throughput sequencing analysis showed that the relative abundance of DEN bacteria was higher in UOL (2.59-12.30%) than in UCL (1.96-6.70%) at the genus level, while the relative abundance of DNRA

bacteria was higher in UCL (2.02-4.19%) than in UOL (1.14-2.31%). The difference in the relative abundance of anammox bacteria at the genus level was not significant. Multiple linear regression showed that the physico-chemical properties and nitrate reduction bacteria together control the potential nitrate reduction rates. Since a higher nitrogen retention capability appears in UCL, according to the nitrogen retention index (NRI), further management should be focused on urban closed lakes to avoid the potential for eutrophication.

（来源：WATER RESEARCH 卷:214 出版年: 2022, **DOI:** 10.1016/j.watres.2022.118218）

## Interactions between dissolved organic matter and perfluoroalkyl acids in natural rivers and lakes: A case study of the northwest of Taihu Lake Basin, China

Li, Xiao-qing; Hua, Zu-lin; Zhang, Jian-yun;等

Understanding the interactions between dissolved organic matter (DOM) and perfluoroalkyl acids (PFAAs) is essential for predicting the distribution, transport, and fate of PFAAs in aquatic environments. Based on field investigations in the northwest of Taihu Lake Basin combined with laboratory experiments, we obtained DOM and PFAA concentrations as well as compositions and investigated key factors of DOM affecting PFAA variability and capture of PFAAs by DOM. Results indicated that the total concentrations of PFAAs were 73.4-689 ng/L in surface water and that PFAAs were dominated by C3-7 perfluoroalkyl carboxylic acids and perfluorooctane sulfonic acid. The main components of DOM included tyrosine-, fulvic-, and tryptophan-like substances. The Mantel test revealed a significant positive correlation between DOM and PFAAs (P = 0.0001). Fulvic-like substances were identified as the most crucial factors affecting PFAA variability. The laboratory experiments revealed that DOM can spontaneously aggregate into a microgel. Furthermore, 19.1-50.9% of PFAAs, DOM characteristic peaks, and several metals (Ca, Mg, Cu, and Fe) can be removed during aggregation, indicating the capacity of DOM binding organic/inorganic substances. The fulvic-like substances were more effectively removed than the protein-like substances. The distribution coefficients of all PFAAs except perfluorohexanoic acid significantly correlated with their perfluorinated carbon numbers ($r = 0.975$, $p<0.001$). Our results provided insights into the interactions between DOM and PFAAs, improving the understanding of the distribution, transport, and fate of PFAAs in aquatic environments.

（来源：WATER RESEARCH 卷:216 出版年: 2022, **DOI:** 10.1016/j.watres.2022.118324）

## Buffering effect of suspended particulate matter on phosphorus cycling during transport from rivers to lakes

Ji, Ningning; Liu, Yong; Wang, Shengrui;等

How to maintain harmful algal blooms under phosphate-limitation is still an open question in mesotrophic/eutrophic lakes. Little evidence for the importance of suspended particulate matter (SPM) in mediating phosphorus cycling and contributing to eutrophication has been generated for aquatic ecosystems, especially in coupled river-lake systems. In this study, we examined phosphorus transport and redistribution in a river-lake system in the Lake Erhai basin by establishing the relations between phosphorus distribution and phosphorus sorption behavior on SPM, and predicted how changes in the quality and quantity of SPM might influence phosphorus cycling by laboratory experiments and modeling. During the wet seasons, TP pool shifted from being dominated by total dissolved phosphorus (TDP) in the Miju River and estuary regions (73 +/- 5%) to being dominated by total particulate phosphorus (TPP)

(74 +/- 11%) in Lake Erhai. The detritus-SPM in the Miju River as a P-sink and phytoplankton-SPM in Lake Erhai as a P-source buffered TDP levels during the wet seasons, which attributed to P activity and phytoplankton-POC of SPM. Increasing SPM concentrations could enhance the P-buffering. When C-0 & nbsp;<=& nbsp;5 mu mol/L and phytoplankton-SPM >= 16 mg/L, P release increased by 50%-300%; when C-0 >= 5 mu mol/L and detritus-SPM > 16 mg/L, P removal could exceed 30%. This study highlights two distinctive roles of SPM in regulating P cycling during transport from rivers to lakes. Especially the phytoplankton-SPM to buffer phosphate-limitation during algal blooms should not be ignored, which could provide theoretical references for the mechanism of continued algal blooms in mesotrophic lakes.

（来源：WATER RESEARCH 卷:216 出版年: 2022, **DOI:** 10.1016/j.watres.2022.118350）

## Development of remote sensing algorithm for total phosphorus concentration in eutrophic lakes: Conventional or machine learning?

Xiong, Junfeng; Lin, Chen; Cao, Zhigang;等

Phosphorus is a limiting nutrient in freshwater ecosystems. Therefore, the estimation of total phosphorus (TP) concentration in eutrophic water using remote sensing technology is of great significance for lake environmental management. However, there is no TP remote sensing model for lake groups, and thus far, specific models have been used for specific lakes. To address this issue, this study proposes a framework for TP estimation. First, three algorithm development frameworks were compared and applied to the development of an algorithm for Lake Taihu, which has complex water environment characteristics and is a representative of eutrophic lakes. An Extremely Gradient Boosting (BST) machine learning framework was proposed for developing the Taihu TP algorithm. The machine learning algorithm could mine the relationship between FAI and TP in Lake Taihu, where the optical properties of the water body are dominated by phytoplankton. The algorithm exhibited robust performance with an R-2 value of 0.6 (RMSE = 0.07 mg/L, MRE = 43.33%). Then, a general TP algorithm (R-2 = 0.64, RMSE = 0.06 mg/L, MRE = 34.13%) was developed using the proposed framework and tested in seven other lakes using synchronous image data. The algorithm accuracy was found to be affected by aquatic vegetation and enclosure aquaculture. Third, compared with field investigations in other studies on Lake Taihu, the Taihu TP algorithm showed good performance for long-term TP estimation. Therefore, the machine learning framework developed in this study has application potential in large-scale spatio-temporal TP estimation in eutrophic lakes.

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## Extracting phosphorus and other elements from lake water: Chemical processes in a hypolimnetic withdrawal and treatment system

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Hypolimnetic withdrawal provides a way to remove phosphorus (P) from eutrophic lakes, but the method is still rarely combined with water treatment for capturing this P. Thus, little is known about the chemical interactions of P and other elements upon the treatment of hypolimnetic lake water. We investigated these chemical processes in a hypolimnetic withdrawal and treatment system (HWTS) in which hypolimnetic water is first led into a treatment unit for dissolved P (dP) precipitation and subsequently filtered before being circulated back into the lake. We studied three different field-scale treatment unit setups and water treatments (aeration only, aeration + calcium hydroxide (Ca(OH)(2)), aeration +

biopolymer) to compare their effectiveness for dP removal and the geochemical properties of the resulting precipitate. In the aeration only treatment, most of the dissolved iron (dFe) (91-95%) and dP (71-91%) were removed when sand filters were used. The addition of Ca (OH)(2) and biopolymer enhanced Fe flocculation, leading to more effective removal of dFe (d99-100%) and dP (88-95%) from the water. Regardless of the water treatment method, dP was always precipitated by amorphous Fe oxides formed in the hypolimnetic water upon aeration. The P content of the resulting precipitates was somewhat lower than expected (2 439-4 145 mg kg(-1)), which may be linked to chemical interactions between Fe and other components in the hypolimnetic water, such as organic matter. The precipitates also contained some heavy metals such as copper and zinc. We conclude that all the tested water treatments were effective in removing dP from hypolimnetic water, but the enhanced precipitation by the addition of treatment chemicals is beneficial when a mesh or other rapid filtration method is used, or when there is only negligible accumulation of dFe in the hypolimnion of the treated lake. Depending on the water treatment method and the water chemistry of the treated lake, the precipitate may have potential for nutrient recycling, although it may sometimes require preliminary processing to enhance bioavailability for plants and to reduce the concentration of heavy metals.

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## Occurrence, partitioning, and bioaccumulation of an emerging class of PBT substances (polychlorinated diphenyl sulfides) in Chaohu Lake, Southeast China

Nian, Kainan; Yang, Wenhui; Zhang, Xuesheng;等

Polychlorinated diphenyl sulfides (PCDPSs) represent an emerging group of constituents that are persistent, bioaccumulative and toxic (PBT) substances of great concern in terms of human health and ecological integrity. However, little is known about the occurrence, environmental behaviour and ecological risks of PCDPSs in lake environments. In this study, the concentrations of 21 PCDPSs were determined in surface water, suspended particulate matter (SPM), sediments, and 8 fish species from Chaohu Lake, China. Eighteen PCDPS congeners were prevalently detected in the samples, with concentrations ranging from 0.272-1.69 ng/L (water), 0.477-2.03 ng/g d.w. (SPM), 0.719-4.07 ng/g d.w. (sediment) and 0-0.131 ng/g w.w. (fish), respectively. Medium- and high-chlorinated PCDPSs in SPM and sediment were significantly higher than those in water samples. Increased PCDPS concentrations were found in higher trophic level fishes and those with a demersal habitat preference, indicating their bioaccumulation and biomagnification potential. The logBCFs, BSSAFs, and BSAFs of PCDPS congeners in fishes were determined to be 3.91-5.18, 0.0500-2.33, and 0.0360-4.94 L/kg, respectively. The organic carbon normalized partition coefficients (logKoc) of PCDPSs in surface water-SPM (4.61-5.54 L/g) and surface water-sediment (4.38-5.69 L/g) systems were determined, and it was found that highly chlorinated PCDPSs were more prone to migrate from water to sediment and SPM. The toxic equivalent (TEQ) values of PCDPSs in the samples (lower than 10-1 pg/g or pg/L) and daily intake via fish consumption (0.180-0.340 mu g/kg/day) were estimated for humans, and cumulative risk quotients (RQs) after correction at ten sampling sites (0.065-0.66) were calculated for green algae. The findings elucidated the environmental behaviour of PCDPSs in Chaohu Lake.

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## Water clarity mapping of global lakes using a novel hybrid deep-learning-based recurrent model with Landsat OLI images

He, Yuan; Lu, Zheng; Wang, Weijia;等

Information regarding water clarity at large spatiotemporal scales is critical for understanding comprehensive changes in the water quality and status of ecosystems. Previous studies have suggested that satellite observation is an effective means of obtaining such information. However, a reliable model for accurately mapping the water clarity of global lakes (reservoirs) is still lacking due to the high optical complexity of lake waters. In this study, by using gated recurrent units (GRU) layers instead of full-connected layers from Artificial Neural Networks (ANNs) to capture the efficient sequence information of in-situ datasets, we propose a novel and transferrable hybrid deep-learning-based recurrent model (DGRN) to map the water clarity of global lakes with Landsat 8 Operational Land Imager (OLI) images. We trained and further validated the model using 1260 pairs of in-situ measured water clarity and surface reflectance of Landsat 8 OLI images with Google Earth Engine. The model was subsequently utilized to construct the global pattern of temporal and spatial changes in water clarity (lake area > 10 km(2)) from 2014 to 2020. The results show that the model can estimate water clarity with good per-formance (R-2 = 0.84, MAE = 0.55, RMSE = 0.83, MAPE = 45.13%). The multi-year average of water clarity for global lakes (16,475 lakes) ranged from 0.0004 to 9.51 m, with an average value of 1.88 +/- 1.24 m. Compared to the lake area, elevation, discharge, residence time, and the ratio of area to depth, water depth was the most important factor that determined the global spatial distribution pattern of water clarity. Water clarity of 15,840 global lakes between 2014 and 2020 remained stable (P >= 0.05); while there was a significant increase in 243 lakes (P < 0.05) and a decrease in 392 lakes (P < 0.05). However, water clarity in 2020 (COVID-19 period) showed a significant increase in most global lakes, especially in China and Canada, suggesting that the worldwide lockdown strategy due to COVID-19 might have improved water quality, espically water clarity, dueto the apparent reduction of anthropogenic activities.

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## Particle size-related vertical redistribution of phosphorus (P)-inactivating materials induced by resuspension shaped P immobilization in lake sediment profile

Wang, Changhui; Wei, Zhao; Shen, Xinyi;等

Lake geoengineering with phosphorus (P)-inactivating materials to reduce sediment P loading is often used for eutrophication control. The redistribution of materials in sediment, especially those induced by resuspension, is reportedly a common phenomenon during practical applications, which may interfere with the pollution control. Notably, a recent study by the authors initially found that the heterogeneous properties of materials and sedi-ments varied the P immobilization in different sized sediments which exhibited diverse movement characteris-tics. Therefore, this study hypothesizes a particle size-related vertical redistribution of materials in the sediment profile induced by resuspension, which shapes sediment P immobilization at different depths. Based on two differently sized materials, lanthanum (La)-modified bentonite clay (Phoslock) and drinking water treatment residue (DWTR), this study found a weakened reduction of mobile P and bioavailable P pool by both DWTR and Phoslock in surface sediment after resuspension. As the depth decreased from 8 mu m fraction), which tended to become enriched in surface sediment after resuspension, while relatively large materials (e.g., 63 mu m fraction)

regulated their redistributions and were more likely to be buried at the bottom of the sediments. Accordingly, to design appropriate strategies for lake geoengineering, relatively small materials (e.g., <8 mu m) targeting to immobilize both mobile and bioavailable P are typically recommended to be developed for restoration of lakes with frequent sediment resuspension.

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## Impacts of nutrient reduction on temporal beta-diversity of rotifers: A 19-year limnology case study on Lake Wuli, China

Li, Yun; Shen, Ruijie; Liu, Xia;等

There have been many studies on the effects of eutrophication on beta diversity (8-diversity) of species assemblages. However, few studies have focused on the effects of nutrient reduction on 8-diversity and community structure, and long-time series analyses are particularly scarce. We conducted a 19-year case study on the impacts of management intervention on the temporal 8-diversity of aquatic grazers in a lake at the Yangtze River Basin. In our study, we compared the changes in temporal 8-diversity as well as its two components, nestedness and turnover, and the synchrony of the rotifer community after management intervention. Our results showed that while the abundance of some sensitive species increased, there was no trend in species richness. Moreover, both the seasonality and interannual stabilities of rotifer assemblages increased. The species synchrony decreased in both spring and summer after management intervention. We also found that management intervention significantly reduced nutrient concentrations but not water clarity and phytoplankton abundance. The total nitrogen (TN): total phosphorous (TP) ratio was reduced after management intervention, causing an increase in the abundance of cyanobacteria that may contribute to the increase of rotifer synchrony in autumn. Our results imply that stable environmental fluctuations after management intervention may increase temporal 8-diversity and stability of herbivorous assemblages. However, imbalanced changes in TN and TP after management intervention may weaken the top-down control of zooplankton on phytoplankton and slow down water clarity improvement.

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## Reducing nutrient increases diatom biomass in a subtropical eutrophic lake, China-Do the ammonium concentration and nitrate to ammonium ratio play a role?

Liu, Xia; Li, Yun; Shen, Ruijie;等

Response of aquatic organisms to eutrophication have been well reported, while less studies are available for the recovery of eutrophic lakes following a reduction in the external loading, especially for systems where nitrogen is reduced but the phosphorus concentration is maintained high due to internal loading. Diatoms are nitrate ($NO_3$-N) opportunists but can also use ammonium ($NH_4$-N). They may, therefore, be more sensitive to nitrogen reduction than other algae that typically prefer $NH_4$-N. We document the variations of nutrients and diatoms in subtropical, eutrophic Lake Taihu over 28 yr during which a reduction of the external loading resulted from lake management. According to the results of change point analysis, data on environmental variables were divided into two periods (P1: 1992-2006; P2: 2007-2019) with two different seasons (WS: Winter-Spring; SA: Summer Autumn), respectively. Compared with P1-WS, the concentration of $NH_4$-N decreased significantly whereas $NO_3$-N showed no

significant change in P2-WS. In contrast, $NH_4$-N concentrations were low and showed no significant changes in P1-SA and P2-SA and $NO_3$-N decreased significantly in the latter period. Accordingly, $NO_3$-N: $NH_4$-N mass ratios in P1-SA and P2-WS were all significantly higher than those in P2-SA and P1-WS, respectively. The biomass of WS diatom increased significantly and the timing of the peak biomass shifted from P1-SA to P2-WS since 2007. The SEM analysis showed that $NO_3$-N was retained as a statistically significant predictor for diatom biomass in P1-SA and significant effects of windspeed, zooplankton and $NH_4$-N on diatom biomass in P2-WS. Windspeed and zooplankton have further changed the biomass of diatoms in the case of declining inorganic nitrogen. We conclude that the magnitude of vernal suppression or stimulation of diatom assemblages has increased, concomitant with the variations of $NH_4$-N and $NO_3$-N: $NH_4$-N mass ratios. Diatoms response to $NH_4$-N or $NO_3$-N is apparently changing in response to water temperature in this eutrophic shallow lake. Thus, parallel reductions in external nitrogen loading, along with variations in dominant inorganic nitrogen, will stimulate the growth of diatom and therefore increase the total biomass of phytoplankton in still high internal phosphorus loading, which is should be regarded as a good sign of restoration measures.

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## Production and transformation of organic matter driven by algal blooms in a shallow lake: Role of sediments

Du, YingXun; An, ShiLin; He, Hu;等

The generation of organic matter (OM) occurs synchronously with phytoplankton growth. Characterization of the generated particulate and dissolved OM during algal blooms in eutrophic lakes is crucial for better understanding the carbon cycle but remains limited. We speculate that sediments play a critical role in the biogeochemical transformation of OM derived from algal blooms in shallow lakes. In this study, changes in OM quantity and quality and the concentrations of biogenic elements (nutrients and metals) during algal blooms, were studied in situ in a shallow eutrophic lake (Lake Chaohu, China). Two enclosure treatments in the presence and absence of sediments were compared, and the cause-effect relationships among sediment, nutrients, metals, phytoplankton, particulate OM (POM), and dissolved OM (DOM) were revealed by a partial least square-path model (PLS-PM). The results showed that the changes in nutrients and metals concentrations over time were consistent with that of chlorophyll a (Chl a), and at the end of the treatment, the concentrations of Chl a, nutrients, and metals in Treatment S (with sediments) were approximately 3-5 times of those in Treatment N (without sediments). The high concentration of Chl a in Treatment S resulted in a high quantity of POM, which showed low molecular weight, low humification, and was enriched in protein-like components (~ 70%). For DOM, the quantity increased after the decrease in POM, and DOM quality showed a significantly higher abundance of humic-like components and a higher molecular weight than POM did. The PLS-PM results showed that the significant positive effects of sediment on nutrients, metals, phytoplankton, POM, and DOM were 0.28, 0.37, 0.28, 0.25, and 0.25, respectively, suggesting that sediment had an important role in the biogeochemical cycles of these substances. The significant negative relationship between POM and DOM (-0.62) and the distinct difference in POM and DOM quality implied the efficient transformation of the freshly generated OM to those with a higher molecular weight, higher humification, and potentially refractory. Our results depicted the quick biogeochemical transformation of nutrients, metals, and the potential formation of refractory organic carbon in water column, as driven by the couple of the algae pump with the microbial carbon pump.

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## Multiscale effects of wind-induced hydrodynamics on lake plankton distribution

Sprules, William Gary; Cyr, Helene; Menza, Charles W.

In this study, we used a combination of high-intensity sampling technologies, and a 3D hydrodynamic model of a medium-sized lake in southern Ontario, Canada to investigate physical-biological relationships at spatial scales from 100 m to 6 km and temporal scales from hours to months. At the scale of the whole study basin, we predicted that stronger winds would lead to higher zooplankton biomass downwind relative to upwind. The hydrodynamic model suggests rapid downwind displacement of progressively deeper surface mixed layers with increasing winds, and we found a statistically higher downwind biomass of small-bodied zooplankton on windy days, but not large zooplankton. At a fine spatial scale (hundreds of meters), we predicted that zooplankton patchiness would decrease with increasing wind mixing of the upper water column and confirmed this for small-bodied but not large-bodied zooplankton. At this fine-scale cross-correlations of zooplankton biomass with water temperature and chlorophyll fluorescence suggested that zooplankton are not simply moved passively by water masses. We also found a clear change in the cross-correlation between large- and small-bodied zooplankton biomass, with out-of-phase spatial distributions during calm periods becoming in-phase with increasing winds. Overall these results indicate that the response of zooplankton to wind-driven physical forces is strongly dependent on an interaction between their body size, which determines their swimming speed and capacity to position themselves vertically in the water column, and the spatial scale and intensity of the wind-generated physical forces. We discuss the implications for food web interactions.

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## Long-term change in metabolism phenology in north temperate lakes

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The phenology of dissolved oxygen (DO) dynamics and metabolism in north temperate lakes offers a basis for comparing metabolic cycles over multi-year time scales. Although proximal control over lake DO can be attributed to metabolism and physical processes, how those processes evolve over decades largely remains unexplored. Metabolism phenology may reveal the importance of coherence among lakes and facilitate general conclusions about the controls on lake metabolism at regional scales. We developed a Bayesian modeling framework to estimate DO concentrations and metabolism in eight lakes in contrasting landscapes in Wisconsin, USA. We identify the DO and metabolism phenologies for each lake, and use those to compare how decadal patterns relate to trophic state and landscape setting. We show that lakes can be categorized by their hypolimnetic oxygen consumption dynamics, with oligotrophic lakes having a diverse set of patterns and eutrophic lakes having uniform trends of increased oxygen consumption over the last decade. Metabolism phenology is likewise diverse for oligotrophic lakes, whereas eutrophic lakes in southern Wisconsin share consistent long-term patterns of metabolic trends and seasonal DO consumption highlighting the importance of trophic state driving metabolism. Eutrophic lakes had higher magnitudes and more seasonal variation in net ecosystem production in contrast to oligotrophic lakes. Generally, long-term metabolic trends of north temperate lakes suggest a limited influence of climate on lake metabolism and that temporal coherence of long-term metabolism

change is driven primarily by the landscape setting.

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## Quantification of microcystin production and biodegradation rates in the western basin of Lake Erie

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Cyanobacterial biomass forecasts currently cannot predict the concentrations of microcystin, one of the most ubiquitous cyanotoxins that threaten human and wildlife health globally. Mechanistic insights into how microcystin production and biodegradation by heterotrophic bacteria change spatially and throughout the bloom season can aid in toxin concentration forecasts. We quantified microcystin production and biodegradation during two growth seasons in two western Lake Erie sites with different physicochemical properties commonly plagued by summer Microcystis blooms. Microcystin production rates were greater with elevated nutrients than under ambient conditions and were highest nearshore during the initial phases of the bloom, and production rates were lower in later bloom phases. We examined biodegradation rates of the most common and toxic microcystin by adding extracellular stable isotope-labeled microcystin-LR (1 mu g L-1), which remained stable in the abiotic treatment (without bacteria) with minimal adsorption onto sediment, but strongly decreased in all unaltered biotic treatments, suggesting biodegradation. Greatest biodegradation rates (highest of -8.76 d(-1), equivalent to the removal of 99.98% in 18 h) were observed during peak bloom conditions, while lower rates were observed with lower cyanobacteria biomass. Cell-specific nitrogen incorporation from microcystin-LR by nanoscale imaging mass spectrometry showed that a small percentage of the heterotrophic bacterial community actively degraded microcystin-LR. Microcystin production and biodegradation rates, combined with the microcystin incorporation by single cells, suggest that microcystin predictive models could be improved by incorporating toxin production and biodegradation rates, which are influenced by cyanobacterial bloom stage (early vs. late bloom), nutrient availability, and bacterial community composition.

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## A review of spatial structure of freshwater food webs: Issues and opportunities modeling within-lake meta-ecosystems

Borrelli, Jonathan J.; Relyea, Rick A.

Lakes are currently facing multiple anthropogenic stressors impacting their ecological communities. The best way to understand how these systems will be affected by the changing environment is by modeling community dynamics. Models of lake food webs have tended to focus on pelagic organisms and treat lakes as if they contain single, uniform communities. However, heterogeneity in environmental conditions and resource availability generates within-lake compartmentalization in food web structure. Turnover among species and their interactions resulting from differences in depth and substrate type creates unique food webs in different regions of lakes. Food webs within lakes can therefore be represented as a three-dimensional meta-ecosystem, where food web compartments are connected by flows of nutrients, materials, and consumers with variable degrees of mobility within the lake. We review how food webs are spatially structured within lakes and the processes that connect different parts of the ecosystem. We then discuss how current modeling approaches address the spatial heterogeneity of lake communities,

highlighting key methods and some of the constraints preventing more spatially explicit representation of food webs. Finally, we recommend the use of allometric trophic networks to make spatially explicit food web modeling easier. By capitalizing on empirically described allometric relationships to parameterize trophically complex food webs, we can balance generalizable model approaches with system-specific needs. Given the spatially explicit nature of many current threats to freshwater lakes, building an understanding of how space structures the community is imperative to create better approaches for freshwater management and conservation.

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## Natural and anthropogenic controls on lake water-level decline and evaporation-to-inflow ratio in the conterminous United States

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Lake water levels are integral to lake function, but hydrologic changes from land and water management may alter lake fluctuations beyond natural ranges. We constructed a conceptual model of multifaceted drivers of lake water levels and evaporation-to-inflow ratio (Evap : Inflow). Using a structural equation modeling framework, we tested our model on (1) a national subset of lakes in the conterminous United States with minimal water management to describe natural drivers of lake hydrology and (2) five ecoregional subsets of lakes to explore regional variation in water management effects. Our model fits the national and ecoregional datasets and explained up to 47% of variation in Evap : Inflow, 38% of vertical water level decline, and 79% of horizontal water level decline (littoral exposure). For lakes with minimal water management, Evap : Inflow was related to lake depth (beta = -0.31) and surface inflow (beta = -0.44); vertical decline was related to annual climate (e.g., precipitation beta = -0.18) and water management (beta = -0.21); and horizontal decline was largely related to vertical decline (beta = 0.73) and lake morphometry (e.g., depth beta = -0.18). Anthropogenic effects varied by ecoregion and likely reflect differences in regional water management and climate. In the West, water management indicators were related to greater vertical decline (beta = 0.38), whereas in the Midwest, these indicators were related to more stable and full lake levels (beta = -0.22) even during drought conditions. National analyses show how human water use interacts with regional climate resulting in contrasting impacts to lake hydrologic variation in the United States.

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## Seasonal dynamics of anaerobic oxidation of ammonium and denitrification in a dimictic lake during the stratified spring-summer period

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In aquatic ecosystems, nitrogen (N) loading is mitigated in redox transition zones principally through the processes of denitrification and anaerobic oxidation of ammonium (anammox). Here, we investigate the N cycling processes in the water column of a seasonal stratified lake influenced by benthic processes in Southern Germany (Fohnsee) during the development of the vertical redox stratification between April and September. Concentration profiles and stable isotope compositions of NO3- and NH4+ together with numerical modeling and quantification of the hydrazine synthase gene (hzsB) and nitrite reductase (nirK and nirS) genes were used to identify the predominant nitrogen-transformation processes at lake

Fohnsee throughout the spring and summer periods. Water chemistry data, quantitative polymerase chain reaction analysis and increases of delta N-15 and delta O-18 values of nitrate from 7.0 parts per thousand to 41.0 parts per thousand and 2.0 parts per thousand to 28.0 parts per thousand, respectively, showed that nitrate reduction to nitrite and NO occurs in an upward moving zone of the water column from June to September following the displacement of the oxycline caused by thermal stratification. We also observed an increase in delta N-15 of ammonium from 15 parts per thousand to 28 parts per thousand in the anoxic water column. Modeling results suggest that this shift in delta N-15-NH4+ is predominantly controlled by mixing between ammonium stemming from the oxic water column with delta N-15 values of 25 parts per thousand and ammonium that is likely formed in the lake sediments by oxidation of organic matter with delta N-15 values of 11 parts per thousand. Observed gene abundances (hzsB, nirK, and nirS) in lake water samples collected in June and July indicated the co-occurrence of nitrate reduction and low rates of anammox, while the presence of sulfide in August and September may have inhibited the activity of anammox bacteria near the sulfate-reduction zone at the lake bottom. This study revealed temporal and spatial (e.g., depth dependent) variations in the dominant N-transformation processes in the investigated lake.

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## Periphyton as a key diet source of essential fatty acids for macroinvertebrates across a nutrient and dissolved organic carbon gradient in boreal lakes

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We studied how physiologically important long-chain polyunsaturated fatty acids (PUFA) in benthic macroinvertebrates (Asellus aquaticus, Chironomidae, and Oligochaeta) were related to those in periphyton and terrestrial organic matter (tree leaves), collected from littoral areas of 17 boreal lakes that differed in their dissolved organic carbon (DOC) and nutrient (phosphorus and nitrogen) concentrations. We also analyzed fatty acid (FA)-specific stable carbon isotopes (delta C-13(FA)) to investigate the dietary origin (periphyton vs. terrestrial organic matter) of PUFA in the consumers. In contrast to periphyton, terrestrial organic matter was deprived of long-chain PUFA, such as eicosapentaenoic acid (EPA), but rich in short-chain PUFA. The FA composition of macroinvertebrates was primarily taxon-specific despite the large differences in DOC and nutrient concentrations of the lakes. An increase in DOC concentration had a negative impact on the EPA content of Asellus, chironomids, and oligochaetes as well as the total FA content of chironomids and oligochaetes. However, the FA content of macroinvertebrates was not related to lake total phosphorus concentrations, although the total FA and EPA content of periphyton increased with the trophic status of the study lakes. The delta C-13(PUFA) values of macroinvertebrates were positively related with the delta C-13(PUFA) of periphyton and weakly with delta C-13(PUFA) of terrestrial leaf material. The results indicate that EPA in the studied macroinvertebrate taxa was mainly derived from an algal-based diet and not via biosynthesis from allochthonous precursor FA. Thus, macroinvertebrate production in lakes may be limited by the available algae-based food sources.

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## Potential role of submerged macrophytes for oxic methane production in aquatic ecosystems

Hilt, Sabine; Grossart, Hans-Peter; McGinnis, Daniel F.;等

Methane ($CH_4$) from aquatic ecosystems contributes to about half of total global $CH_4$ emissions to the atmosphere. Until recently, aquatic biogenic $CH_4$ production was exclusively attributed to methanogenic archaea living under anoxic or suboxic conditions in sediments, bottom waters, and wetlands. However, evidence for oxic $CH_4$ production (OMP) in freshwater, brackish, and marine habitats is increasing. Possible sources were found to be driven by various planktonic organisms supporting different OMP mechanisms. Surprisingly, submerged macrophytes have been fully ignored in studies on OMP, yet they are key components of littoral zones of ponds, lakes, and coastal systems. High $CH_4$ concentrations in these zones have been attributed to organic substrate production promoting classic methanogenesis in the absence of oxygen. Here, we review existing studies and argue that, similar to terrestrial plants and phytoplankton, macroalgae and submerged macrophytes may directly or indirectly contribute to $CH_4$ formation in oxic waters. We propose several potential direct and indirect mechanisms: (1) direct production of $CH_4$; (2) production of $CH_4$ precursors and facilitation of their bacterial breakdown or chemical conversion; (3) facilitation of classic methanogenesis; and (4) facilitation of $CH_4$ ebullition. As submerged macrophytes occur in many freshwater and marine habitats, they are important in global carbon budgets and can strongly vary in their abundance due to seasonal and boom-bust dynamics. Knowledge on their contribution to OMP is therefore essential to gain a better understanding of spatial and temporal dynamics of $CH_4$ emissions and thus to substantially reduce current uncertainties when estimating global $CH_4$ emissions from aquatic ecosystems.

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## Lake microbiome and trophy fluctuations of the ancient hemp rettery

Iwanska, Olga; Latoch, Przemyslaw; Suchora, Magdalena;等

Lake sediments not only store the long-term ecological information including pollen and microfossils but are also a source of sedimentary DNA (sedDNA). Here, by the combination of traditional multi-proxy paleolimnological methods with the whole-metagenome shotgun-sequencing of sedDNA we were able to paint a comprehensive picture of the fluctuations in trophy and bacterial diversity and metabolism of a small temperate lake in response to hemp retting, across the past 2000 years. Hemp retting (HR), a key step in hemp fibre production, was historically carried out in freshwater reservoirs and had a negative impact on the lake ecosystems. In Lake Slone, we identified two HR events, during the late stage of the Roman and Early Medieval periods and correlated these to the increased trophy and imbalanced lake microbiome. The metagenomic analyses showed a higher abundance of Chloroflexi, Planctomycetes and Bacteroidetes and a functional shift towards anaerobic metabolism, including degradation of complex biopolymers such as pectin and cellulose, during HR episodes. The lake eutrophication during HR was linked to the allochthonous, rather than autochthonous carbon supply-hemp straws. We also showed that the identification of HR based on the palynological analysis of hemp pollen may be inconclusive and we suggest the employment of the fibre count analysis as an additional and independent proxy.

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## System dynamics modeling of lake water management under climate change

Bozorg-Haddad, Omid; Dehghan, Paniz; Zolghadr-Asli, Babak;等

Lake Urmia, the twentieth largest lake in the world, is the most valuable aquatic ecosystem in Iran. The lake water level has decreased in recent years due to human activities and climate change. Several studies have highlighted the significant roles of climatic and anthropogenic factors on the shrinkage of the lake. Management policies for water resources harvesting must be adopted to adapt to climate change and avoid the consequent problems stemming from the drought affecting Lake Urmia, and rationing must be applied to the upstream water demands. This study analyzes strategies and evaluates their effectiveness in overcoming the Urmia Lake crisis. Specifically, system dynamics analysis was performed for simulating the water volume of Lake Urmia, and the Hadley Centre coupled model was applied to project surface temperature and precipitation for two future periods: 2021-2050 and 2051-2080. Six management scenarios were considered for decreasing the allocation of agricultural water demand corresponding to two options: (1) one-reservoir option (Bukan reservoir only), and (2) six-reservoir option. The net inflow of Urmia Lake was simulated for the two future periods with the IHACRES model and with artificial neural network models under the six management scenarios. The annual average volumes of Lake Urmia would be 30 x 10(9) and 12 x 10(9) m(3) over the first and second future periods, respectively, without considering the management scenarios. The lake volumes would rise by about 50% and 75% for the first and second periods, respectively under the management scenarios that involve strict protective measures and elimination of the effect of all dams and their reservoirs. Implementing strict measures would increase the annual average lake volume to 21 x 10(9) m(3) in the second period; yet, this volume would be less than the long-term average and strategic volume. The human water use would be completely eliminated under Scenario 6. Nevertheless, Lake Urmia would experience a considerable loss of storage because of drought.

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## Paleoreconstructions of ciliate communities reveal long-term ecological changes in temperate lakes

Barouillet, Cecilia; Vasselon, Valentin; Keck, Francois;等

Ciliates are unicellular heterotrophic organisms that play a key role in aquatic planktonic and benthic food webs. Advances in sedimentary DNA (sed-DNA) analysis offer the possibility to integrate these bioindicators in paleoenvironmental reconstructions. In this study, we used the top-bottom paleolimnological approach and metabarcoding techniques applied to sed-DNA to compare the recent and past (i.e. prior to major anthropogenic impacts) ciliate communities of 48 lakes located along an elevation gradient. Our results show an overall decline in the beta-diversity in recent time, especially in lowland lakes, which are more strongly exposed to local human pressures. Analyses of the functional groups indicate important restructuration of the food web, including the recent increase in mixotrophs. Moreover, changes in the benthic ciliates were consistent with the widespread increase in deep water anoxia. Our results provided evidence that sed-DNA can uncover information about past ciliate communities on a wide variety of lakes. Overall, our study demonstrates the potential of using ciliates as new paleoindicators, integrating information from the pelagic to the benthic zones, and providing valuable insights into ecosystem functioning through a trait-based functional community approach. As

paleoindicator, they thus offer a more holistic view on the long-term changes of aquatic ecosystems.

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## Spatial distribution and source identification for heavy metals in surface sediments of East Dongting Lake, China

Yuan, Yi; Liu, Baolin; Liu, Hao

Dongting Lake is one of the most important inland freshwater lakes in China. To investigate the spatial distribution and seasonal variation characteristics of heavy metals (Cr, Co, Cu, Zn, Cd, and Pb) in the lake, 53 surface sediment samples were collected in the East Dongting Lake (ED Lake) in the wet and dry seasons. Results show Cr, Co, Cu, Zn, Cd, and Pb contents were 1.7 (1.9), 1.8 (2.0), 2.9 (3.0), 1.9 (1.9), 11.7 (13.1), and 2.0 (2.2)-fold of their geochemical soil background values of Hunan province (China) in the wet (dry) season. Spatial and seasonal heterogeneity could be found in the distribution of Cr, Co, Cu, Zn, and Pb in the surface sediments. The enrichment factor (EF) suggested that Cd has reached severe enrichment in the sediment. The result of the geo-accumulation index (I-geo) indicated that Cr, Co, Cu, Zn, and Pb were at levels corresponding to low contamination, and moderately to highly polluted with Cd. Multivariate statistical analysis including pearson correlation analysis and principal component analysis was used for the identification of potential sources of the heavy metals in the sediments. The results showed that Cu, Zn, and Pb from the sediments of the East Dongting Lake in the wet and dry seasons were possibly anthropogenic sources, such as emissions from mining and smelting while Al, Fe, and Cr are attributed for natural sources. Cd enrichment in the sediments is influenced by both natural factors, and human activities in local areas.

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## Diversity, distribution and ecology of fungal communities present in Antarctic lake sediments uncovered by DNA metabarcoding

Drumond de Souza, Lauren Machado; Lirio, Juan Manuel; Coria, Silvia Herminda;等

We assessed fungal diversity in sediments obtained from four lakes in the South Shetland Islands and James Ross Island, Antarctica, using DNA metabarcoding. We detected 218 amplicon sequence variants (ASVs) dominated by the phyla Ascomycota, Basidiomycota, Mortierellomycota, Mucoromycota and Chytridiomycota. In addition, the rare phyla Aphelidiomycota, Basidiobolomycota, Blastocladiomycota, Monoblepharomycota, Rozellomycota and Zoopagomycota as well as fungal-like Straminopila belonging to the phyla Bacillariophyta and Oomycota were detected. The fungal assemblages were dominated by unknown fungal taxa (Fungal sp. 1 and Fungal sp. 2), followed by Talaromyces rubicundus and Dactylonectria anthuriicola. In general, they displayed high diversity, richness and moderate dominance. Sequences representing saprophytic, pathogenic and symbiotic fungi were detected, including the phytopathogenic fungus D. anthuriicola that was abundant, in the relatively young Soto Lake on Deception Island. The lake sediments studied contained the DNA of rich, diverse and complex fungal communities, including both fungi commonly reported in Antarctica and other taxa considered to be rare. However, as the study was based on the use of environmental DNA, which does not unequivocally confirm the presence of active or viable organisms, further studies using other approaches such as shotgun sequencing are required to elucidate the ecology of fungi in these Antarctic lake sediments.

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## TELEMAC modelling of the influence of the Poyang Lake Hydraulic Project on the habitat of Vallisneria natans

Xiao, Yang; Wang, Zixuan; Zhang, Taotao;等

The Poyang Lake Hydraulic Project (PLHP) has been proposed to address the water resource shortage and hydro-environment deterioration in Poyang Lake. This proposal has raised concerns over the possible changes to the habitat of aquatic organisms. Vallisneria natans is a main food source for the Siberian Crane, an indicator species for migratory birds in Poyang Lake. In this study, the influence of the PLHP on the habitat suitability of Vallisneria natans is predicted based on a hydrodynamic model and the growth characteristics of Vallisneria natans. The results show that the effect of the PLHP varies greatly in different typical years. The mean monthly habitat area of Vallisneria natans can increase by up to 191% in a low-water-level year, 145% in a medium-water-level year, yet only 18% in a high-water-level year. The habitat area can reach more than 1000 km(2) during most of September and October, nearly 1/3 of the total area of the lake region. It indicates that Vallisneria natans will gain large areas of land suitable for its growth, and provide abundant food sources for Siberian Crane during winter. These findings can be helpful to evaluate the ecological benefits of the regulatory schemes of the PLHP.

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## Quantifying the contribution of direct runoff and baseflow to nitrogen loading in the Western Lake Erie Basins

Song, Jung-Hun; Her, Younggu; Guo, Tian 等

Soluble nitrogen is highly mobile in soil and susceptible to leaching. It is important to identify nitrogen transport pathways so that the sources can be efficiently targeted in environment management. This study quantified the contribution of direct runoff and baseflow to nitrate + nitrite loading by separating flow and nitrate + nitrite concentration measurements into two periods depending on whether only baseflow was present or not using baseflow separation methods. When both direct runoff and baseflow were present in streamflow, their nitrate + nitrite concentrations were assumed based on the hydrological reasoning that baseflow does not change rapidly, and streamflow mostly consists of direct runoff within a rainfall event. For this study, we obtained and investigated daily flow and nitrate + nitrite concentration observations made at the outlets of 22 watersheds located in the Western Lake Erie area. Results showed that baseflow was responsible for 26 to 77% of the nitrate + nitrite loads. The relative nitrate + nitrite load contributions of direct runoff and baseflow substantially varied with the sizes of drainage areas and agricultural land uses. Increases in drainage areas tend to prolong the travel time of surface runoff and thus help its reinfiltration into soil, which then could increase the baseflow contribution. In addition, the artificial drainage networks common in the agricultural fields of the study areas would promote the drainage of nutrient-laden excess water from soils. Such findings suggest the need for environmental management customized considering nitrogen transport pathways.

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## Coupling reconstruction of atmospheric hydrological profile and dry-up risk prediction in a typical lake basin in arid area of China

Wang, Jie; Liu, Dongwei; Tian, Songni;等

Arid area is very sensitive to global warming and are extremely vulnerable to climate change. Moreover, the water resources system in the arid area is fragile and will undergo tremendous changes with climate change. Therefore, the interaction of climate and hydrology in arid area has an important impact on the formation of regional microclimate and hydrological changes. Daihai Lake is a typical closed inland lake in arid area of China, and a key area for ecological protection in North China. In this paper, WRF-Hydro model is used to simulate the climate hydrological coupling situation of Daihai Basin from 1980 to 2020, and the coupling results are verified and calibrated by meteorological statistics, runoff calculation and remote sensing analysis. Based on the synopsis of climate and hydrology in the past 40 years, the causes and future trends of the hydrological elements in Daihai Basin are analyzed. Through the analysis, it is found that the interannual variation of precipitation in Daihai Basin is sharp, with 401.75 mm as the average from 1980 to 1994; and drastic fluctuations from 1995 to 2011, with a difference of nearly 400 mm between the interannual maximum and minimum; From 2012 to 2020, the fluctuation is small. Although the interannual variation of evaporation fluctuated, it showed an upward trend with a slope of 8.855 mm/year. The annual average temperature showed an obvious upward trend with a slope of 0.040 degrees C/year. From 1980 to 2020, the inflow of Daihai Lake shows a downward trend; Since 2013, the runoff into the lake has tended to be flat. Climate change and human activities are the decisive factors leading to the change of water quantity in Daihai, among which human activities play a greater role. Cultivated land irrigation and industrial water use are highly correlated with the lake discharge, and these two factors have a great influence on the lake discharge. If the current agricultural and industrial water consumption does not increase, Daihai still has a lifespan of nearly 120 years. If human activities do not change and any protective measures are not taken in time, under the background of global climate change, the flow of the Daihai Lake into the lake will be reduced to zero in 2025, and the Daihai Lake will completely dry up in 2031-2033. The study of climate hydrological coupling of long time series in Daihai Basin can not only make up for the lack of runoff data, but also provide the basis for water resources management, disaster prevention and mitigation.

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## Lake Chemodiversity Driven by Natural and Anthropogenic Factors

Luo, Jiwei; Zhou, Qixing; Hu, Xiangang;等

As extremely active sites processing terrestrially derived dissolved organic matter (DOM), lakes deserve sufficientattention. Because of high-complexity interactions between DOMand the surrounding environment, the natural and anthropogenicdrivers controlling the composition and chemodiversity of DOMmolecules in lakes remain unclear. Here, 13,952 DOM moleculeswere identified and assessed in 45 lakes across China via ultrahigh-resolution mass spectrometry. Furthermore, the effects of bothnatural and anthropogenic factors on the DOM composition,DOM chemodiversity, and greenhouse gas emissions wereinvestigated. The majority of the variations in DOM chemicalcomposition could be attributed to the differences in the hydrologyand nutrient concentrations of the lakes, and human activities alsoplayed a role, mainly through atmospheric pollution. Environmental factors mainly influenced DOM chemodiversity in the form ofS-containing compounds. N-containing compounds exhibited a positive correlation with $CO_2$ emissions, while N- and S-freecompounds exhibited a positive

correlation with $N_2O$ emissions. These results facilitate a comprehensive understanding of theinteractions between lake DOM and the surrounding environment, thereby providing a reference for the formulation of strategiesaimed at the harmonious development of human and natural environments.

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## Nontargeted Identification and Temporal Trends of Per- and Polyfluoroalkyl Substances in a Fluorochemical Industrial Zone and Adjacent Taihu Lake

Yao, Jingzhi; Sheng, Nan; Guo, Yong;等

Various per- and polyfluoroalkyl substances (PFASs) remain undiscovered and unexplored in the environment. The goals of this study were to discover new species of PFASs in effluent and surface waters from a fluorochemical industrial zone, and to assess their concentration, distribution, and temporal trends in the adjacent natural environment. In total, 83 emerging PFASs from 14 classes were identified, 22 of which were reported for the first time. Authentic standards were synthesized for 13 per- and polyfluoroalkyl ether carboxylic acids (PFECAs), thereby greatly expanding the scope of PFAS-targeted monitoring. The newly identified compounds accounted for 27%-95% of the total PFAS concentrations. Of note, a novel diether carboxylic acid, 2-[2(trifluoromethoxy) hexafluoropropoxy] tetrafluoropropanoic acid (C7 HFPO-TA) was detected at an extremely high concentration in the fluorochemical zone effluent (447 000 ng/L) and at a median concentration in the fluorochemical zone surface water (670 ng/L), with detectable levels also found in the natural environment, that is, Wangyu River (23 ng/L) and Taihu Lake (5.6 ng/L). The distinct geographic distribution of C7 HFPO-TA suggests transport from the industrial point source to Taihu Lake via the Wangyu River. The concentration of C7 HFPO-TA in Taihu Lake, along with that of many other emerging PFASs, continued to grow in three sampling campaigns from 2016 to 2021. Considering the environmental persistence and toxicity of structurally similar PFECAs (e.g., HFPO-DA), studies on C7 HFPO-TA are urgently needed.

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## Mercury Isotope Variations in Lake Sediment Cores in Response to Direct Mercury Emissions from Non-Ferrous Metal Smelters and Legacy Mercury Remobilization

Sun, Ruoyu; Hintelmann, Holger; Wiklund, Johan A.;等

Nature archives record atmospheric mercury (Hg) depositions from directly emitted Hg and re-emitted legacy Hg. Tracing the legacy versus newly deposited Hg is still, however, challenging. Here, we measured Hg isotope compositions in three dated sediment cores at different distances from the Flin Flon smelter, the largest Canadian Hg sources to the atmosphere during the 1930s-2000s. During the smelter's operative period, Hg isotope compositions showed limited variations in the near-field lake (<10 km) sediments but were rather variable in middle- (20-75 km) and far-field lake (similar to 800 kin) sediments. Only the post-2000 sediments in middle/far-field lakes showed significantly negative Hg isotope shifts, while sediments from the 1970s-1990s had Hg isotope values resembling those of near-field lake post- 1930 sediments. We suggest that the smelter's peak Hg emissions during the 1970s-1990s, which coincided with the deployment of a super stack in the mid-1970s, largely increased the long-range dispersion of smelter plumes. For the top post-2000 sediments, the fugitive dust from ore tailings and terrestrial legacy Hg re-emissions dominated Hg deposition in near-field lakes and

middle/far-field lakes, respectively. Our study demonstrates that legacy Hg remobilization now exports substantial amounts of Hg to ecosystems, highlighting the need for aggressive remediation measures of Hg-contaminated sites.

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## Evolution of geodetic mass balance over the largest lake-terminating glacier in the Tibetan Plateau with a revised radar penetration depth based on multi-source high-resolution satellite data

Zhou, Yushan; Li, Xin; Zheng, Donghai;等

The southeast Tibetan Plateau has become the region with the fastest rate of mass loss within High Mountain Asia (HMA), and the mass loss from lake-terminating glaciers in the region is the most significant. However, the evolution of the mass change of lake-terminating glaciers is still unclear, and accurate penetration depth estimates of C-band and X-band radar in glacierized areas are unknown, which greatly hinders the monitoring and understanding of the glacier evolution. Hence, in this study, taking the largest lake-terminating glacier in HMA (the Yanong Glacier) as the study object, we first evaluated the X-band penetration depth using Ple ' iades and TanDEM-X data, and further combined the penetration depth difference between the C-band and X-band radar (1.14 +/- 0.14 m) to estimate the C-band penetration depth based on a newly proposed area-weighted strategy, according to surface categories. The results indicate a region-wide average penetration depth of 1.84 +/- 0.59 m and 2.98 +/- 0.61 m for the X-band and C-band radar, respectively, demonstrating either an underestimation of 60% or an overestimation of 202% for the previous C-band penetration corrections. On this basis, we determined the multi-temporal glacier mass balance for the Yanong Glacier, using KH-9, SRTM DEM, SPOT-7, and multi-orbit TanDEM-X data. The results show that the Yanong Glacier has been in a state of serious mass loss (at a rate of -0.73 +/- 0.13 m w.e./a) during 1974-2015, and the rate of mass loss has doubled since 2000 (i.e., -0.48 +/- 0.20 (1974-2000), -0.95 +/- 0.20 (2000-2012), and - 1.02 +/- 0.53 m w.e./a (2012-2015)). Moreover, the interannual mass change has shown a highly volatile and accelerating trend during 2012-2015 (i.e., -0.47 +/- 0.85 (2011-2012), -0.87 +/- 0.66 (2012-2013), -1.26 +/- 0.72 (2013-2014), and - 1.58 +/- 0.44 m w.e./a (2014-2015)). By further analyzing the ERA5 reanalysis data and the changes in the proglacial lake and glacier dynamics, we can conclude that, qualitatively: 1) the long-term acceleration of mass loss at the Yanong Glacier has mainly been controlled by climate change, but has also been affected by the glacier dynamics to a limited extent; and 2) the inter-annual acceleration of mass loss has, to some extent, been affected by subglacial/englacial melting. The findings of this study will not only provide an accurate penetration depth correction for future relevant studies, but will also significantly improve the understanding of the evolution of lake-terminating glaciers in HMA and other high mountain areas of the world.

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## Tracking the source direction of surface mass loads using vertical and horizontal displacements from satellite geodesy: A case study of the inter-annual fluctuations in the water level in the Great Lakes

Wang, Linsong; Bevis, Michael; Peng, Zhenran;等

Climate oscillations with seasonal and longer periods drive surface water cycles and quasi-cycles at regional and global scales. Changes in terrestrial water storage produce responses in the Earth's

gravitational field and crustal deformation. Here, we use techniques from the Global Positioning System (GPS) and the Gravity Recovery and Climate Experiment (GRACE) to reveal a normal pattern of inter-annual fluctuations in the water level in the North American Great Lakes (GL). The GRACE-estimated time series was in good agreement with in situ water level measurements from 2002 to 2018, especially in terms of phases. The amplitude of 3-4 inter-annual signals in water thickness was 4-6 cm, which is equivalent to a 50-75 km(3) oscillation in surface water volume within the entire GL. The slightly larger annual and inter-annual fluctuation amplitudes estimated using GRACE data indicate that the aquifer system of the GL and its surroundings also contributes to seasonal mass changes. After 2013, water levels in the GL region rose abruptly, and the water mass increased by nearly 270 km(3) until the end of 2018. We also used GPS-and GRACE-derived three-component displacements (vertical, northward, and eastward) to identify load patterns. GPS-and GRACE-estimated maximum probability source directions based on multi-channel singular spectrum analysis showed that most of the selected GPS sites point to the GL region, although the direction deviations of GPS results at a few sites are mainly caused by the combined effect of the local load and superposition of the distant GL. Our findings indicate that inter-annual displacement changes at different frequencies (1-to 8-year cycle) are primarily due to water volume fluctuations in the GL. The amplitudes estimated by GPS are greater than the GRACE-based and GL-modeled results at most stations, which reflects sensitivity differences between these geodetic solutions to the surface load, as hydrological processes in the local area around a station are difficult to identify using GRACE data with a resolution of similar to 300 km.

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## Long-term trends and seasonal variation in host density, temperature, and nutrients differentially affect chytrid fungi parasitising lake phytoplankton

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Parasites are generally considered the most commonly occurring type of consumers, yet their biomass and population dynamics are rarely quantified at community level. Here, we used 12 years of weekly or fortnightly monitoring data (518 time points) to determine the occurrence of chytrids, fungal parasites of phytoplankton, to assess their seasonality and long-term (seasonally-detrended) dynamics in the pelagic plankton community of a temperate, eutrophic, and polymictic lake. Chytrid infections were observed in c. 75% of all samples with recurrent infections in multiple host taxa. Infection prevalence was highest in spring, but infections occurred throughout the entire year with an average of 2.3 host taxa infected per time point (ranging from 0 to 10 host taxa) and an average infection prevalence of 2.78% (ranging from 0% to 47.35%). Infected host biomass equalled that of the carnivorous zooplankton and decreased over time, while infection prevalence remained unchanged. Seasonal infection prevalence increased with phytoplankton biomass, but decreased with increasing temperature and phosphorus concentrations, reflecting that peak prevalence occurred in spring when temperature and phosphorus concentrations were relatively low. In contrast, seasonally-detrended prevalence increased with temperature, but decreased with increasing phosphorus concentrations. Chytrids are a common component of the pelagic plankton community with sizeable biomass and removing an-at times-substantial proportion of the primary production, challenging the long-standing underrepresentation of parasites in ecological studies. Chytrids responded differentially to seasonal variation and long-term trends in host density, water temperature and nutrient availability, highlighting the need to disentangle seasonal signals from long-term changes.

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## Biomass, community composition and N:P recycling ratios of zooplankton in northern high-latitude lakes with contrasting levels of N deposition and dissolved organic carbon

Bergstrom, Ann-Kristin; Lau, Danny C. P.; Isles, Peter D. F.;等

Global changes are causing decreases in inorganic nitrogen (N) concentrations, increases in coloured dissolved organic carbon (DOC) concentrations, and decreases in dissolved inorganic N to total phosphorus ratios (DIN:TP) in northern lakes. The effects of these changes on phytoplankton and zooplankton biomass and the N:P recycling ratio of zooplankton remain unresolved. In 33 Swedish headwater lakes across subarctic-to-boreal gradients with different levels of N deposition (low N in the north [Vasterbotten, boreal; Abisko, subarctic] vs. high N in the south [Varmland, boreal; Jamtland, subarctic]), we measured water chemistry, phytoplankton biomass (chlorophyll-a [Chl-a], Chl-a:TP), seston mineral quality (C:P, N:P), as well as zooplankton biomass, community composition, and C:N:P stoichiometry. We estimated nutrient imbalances and the N:P recycling ratios of zooplankton using ecological stoichiometry models. There was a large-scale gradient from low lake DIN and DIN:TP in the north to high DIN and DIN:TP in the south, with lower DIN:TP in lakes coinciding with higher DOC within each region. Lower lake DIN was associated with lower phytoplankton biomass (lower Chl-a:TP). Lower lake DIN:TP was associated with richer seston mineral quality (lower seston C:P and N:P) and higher zooplankton biomass. Zooplankton community composition differed in the north vs. south, with a dominance of N-requiring calanoid copepods with high N:P in the north and P-requiring cladocerans with low N:P in the south. Also, greater differences in zooplankton community composition were found between subarctic regions (with lower DOC) than between boreal regions (with higher DOC), suggesting that increases in lake DOC and associated declines in lake DIN:TP reduce differences in zooplankton community composition. The combination of lower lake DIN, higher lake DOC, and lower lake DIN:TP led to reduced zooplankton N:P recycling ratios, possibly by reducing seston N:P and/or by enhancing calanoid copepod dominance in the zooplankton community. Our findings suggest that the combination of declining N deposition and increasing lake browning in northern high-latitude lakes will reduce phytoplankton biomass, but will concurrently enhance seston mineral quality and probably also zooplankton biomass and their recycling efficiency of P relative to N.

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## Estimation of the Thermally Reactive Layer in Lakes Based on Surface Water Temperature

Toffolon, Marco; Yousefi, Azadeh; Piccolroaz, Sebastiano

How fast does lake surface water temperature (LSWT) react to climate warming or cooling? The thermal response of lakes varies with the season and, typically, day-to-day fluctuations are larger in summer. The reason is that lakes are stratified systems where the thermally reactive volume is smaller in summer and, hence, its heat capacity (thermal inertia) is reduced. We define the dimensionless parameter delta as the ratio between the surface volume reacting to the net heat flux through the air-water interface and the volume of the whole lake. By referring to a fully controlled case study obtained by means of a one-dimensional physically based model (Simstrat), we investigate the variability of delta throughout the year and its dependence on LSWT. Then, we compare the results with the parameterization adopted in

the hybrid data-driven model air2water. Our analysis confirms that delta follows an exponential decay with increasing LSWT (i.e., a thinner surface layer in summer), and shows that this functional dependence varies between the warming and the cooling periods. These findings contribute to the understanding of the effect of a warming climate on water bodies and ecosystems by providing a simple tool to estimate the rate of change in lakes' water temperature.

（来源：WATER RESOURCES RESEARCH 卷: 58 期: 6 出版年: 2022, **DOI:** 10.1029/2021WR031755）

## Estimating the Total Economic Costs of Nutrient Emission Reduction Policies to Halt Eutrophication in the Great Lakes

Garcia-Hernandez, Jorge A.; Brouwer, Roy; Pinto, Rute

The Great Lakes (GL) in North America are among the largest freshwater resources on the planet facing serious eutrophication problems as a result of excessive nutrient loadings due to population and economic growth. More than a third of Canada's GDP is generated in and around the GL. Hence, the economic interests affected by pollution and pollution control are high. New policies to reduce pollution are often insufficiently informed due to the lack of integrated models and methods that provide decision-makers insight into the direct and indirect economic impacts of their policies. This study fills this knowledge gap and estimates the impacts of different total phosphorus (TP) restriction policy scenarios across the GL. A first of its kind multi-regional hydro-economic model is built for the Canadian GL, extended to include TP emissions from point and non-point sources. This optimization model is furthermore extended with a pollution abatement cost function that allows sectors to also take technical measures to meet the imposed pollution reduction targets. The latter is a promising new avenue for extending existing hydro-economic input-output modeling frameworks. The results show decision-makers the least cost-way to achieve different TP emission reduction targets. The estimated cost to reduce TP emissions by 40% in all GL amounts to a total annual cost of 3 billion Canadian dollars or 0.15% of Canada's GDP. The cost structure changes substantially as policy targets become more stringent, increasing the share of indirect costs and affecting not only the economic activities around the GL, but the economy of Canada as a whole due to the tightly interwoven economic structure.

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## Model Estimates of China's Terrestrial Water Storage Variation Due To Reservoir Operation

Dong, Ningpeng; Wei, Jianhui; Yang, Mingxiang;等

Understanding the role of reservoirs in the terrestrial water cycle is critical to support the sustainable management of water resources especially for China where reservoirs have been extensively built nationwide. However, this has been a scientific challenge due to the limited availability of continuous, long-term reservoir operation records at large scales, and a process-based modeling tool to accurately depict reservoirs as part of the terrestrial water cycle is still lacking. Here, we develop a continental-scale land surface-hydrologic model over the mainland China by explicitly representing 3,547 reservoirs in the model with a calibration-free conceptual operation scheme for ungauged reservoirs and a hydrodynamically based two-way coupled scheme. The model is spatially calibrated and then extensively validated against streamflow observations, reservoir storage observations and GRACE-based terrestrial water storage anomalies. A 30-year simulation is then performed to quantify the seasonal dynamics of China's reservoir water storage (RWS) and its role in China's terrestrial water storage (TWS) over recent

decades. We estimate that, over a seasonal cycle, China's RWS variation is 15%, 16%, and 25% of TWS variation during 1981-1990, 1991-2000, and 2001-2010, respectively, and one-fifth of China's reservoir capacity are effectively used annually. In most regions, reservoirs play a growing role in modulating the water cycle over time. Despite that, an estimated 80 million people have faced increasing water resources challenges in the past decades due to the significantly weakened reservoir regulation of the water cycle. Our approaches and findings could help the government better address the water security challenges under environmental changes.

（来源：WATER RESOURCES RESEARCH 卷: 58 期: 6 出版年: 2022, **DOI:** 10.1029/2021WR031787）

## Estimation of global reservoir evaporation losses

Tian, Wei; Liu, Xiaomang; Wang, Kaiwen;等

Estimating global reservoir evaporation losses is essential for reservoir regulation, operation, and associated water resources management. Estimating globe-scale reservoir evaporation losses remains a gap due to limited accessibility of global long-term continuous reservoir geographic information. Two new datasets, the Global Reservoir Surface Area Dataset and the Global Reservoir and Dam Database, try to address inaccessibility and provide an opportunity to bridge the gap. Here, we used the two datasets to estimate the monthly reservoir evaporation volume of global 7242 large reservoirs from 1985 to 2016. Around 339.8 km(3) of water is estimated to evaporate from these large reservoirs annually during 1985-2016, and the loss amount is near ~& nbsp;73% of the municipal water withdrawal in 2010. From 1985 to 2016, the global reservoir evaporation volume increases significantly at a rate of ~& nbsp;2.0 km(3)/a, and 80% of the increment is contributed by middle-income countries. A surge in reservoir construction in middle-income countries after 1985 triggers the increment. The results can benefit the regulation and operation of reservoirs and realize their role in global water conservation and management.

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## Human-Induced water loss from closed inland Lakes: Hydrological simulations in China's Daihai lake

Wang, Shuhang; Xu, Chi; Zhang, Wanchang;等.

In recent decades, water levels in many closed inland lakes over north-western China experienced severe declines, among which the Daihai Lake in Inner Mongolia, China was particularly significant. Remotely sensed investigations indicated that the Daihai Lake had shrunk approximately 64% in an area with the dramatic decline of water level approximately 9 m from the 1980 s to 2010 s, which has caused serious concern on the sustainable development of the surrounding region. Consequently, several previous studies have concentrated on the possible causes of lake shrinkage. However, predicting climate variability and anthropogenic activities' relative contributions to lake water decline is challenging due to the lack of direct water consumption upstream and watershed-scale natural runoff observations. In this paper, a hydrological modeling approach was presented to quantitatively evaluate and separate the relative contributions of climate variations and intensifying anthropogenic activities. The simulation accuracy was evaluated through comparisons with observed data and cross validation with previous studies. Based on a baseline period, the natural streamflow draining into the lake was reconstructed using the model. The results revealed that the water loss of the Daihai Lake was caused predominately by human activities rather than climate variability. Specifically, for wet conditions, the climate factors

posed a negative effect on the water level decline of the lake and delayed the shrinking process of the lake area. The anthropogenic factors took a dominant role (roughly 58%) of lake shrinkage at the annual average scale for normal and dry conditions, while the climate factors accounted for approximately 42%. Hence, the rational policy for water resource management, ecological restoration, and dam and reservoir constructions/ operations should be the essential precautions for sustainable development of the Daihai Lake and its surroundings. Additionally, the hydrological modeling approach adopted in this investigation serves as a useful example of the quantitative assessment of climate variations and human activities, especially for the ungauged catchments.

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## Evaluation of gridded precipitation datasets over international basins and large lakes

Hong, Yi; Do, Hong Xuan; Kessler, James;等

Reliable precipitation estimates are a crucial component for hydrologic modeling and hydro-climate applica-tions. However, watersheds that extend across international boundaries or those that contain large bodies of water pose particular challenges to the acquisition of consistent and accurate precipitation estimates. The North American Great Lakes basin is characterized by both of these features, which has led to long-standing challenges to water budget analysis and hydrologic prediction. In order to provide optimal conditions for hydrologic model calibration, retrospective analyses, and real-time forecasting, this study comprehensively evaluates four gridded datasets over the Great Lakes basin, including the Analysis of Record for Calibration (AORC), Canadian Pre-cipitation Analysis (CaPA), Multi-sensor Precipitation Estimate (MPE), and a merged CaPA-MPE. These products are analyzed at multiple spatial (overland, overlake, sub-basin, country) and temporal (daily, monthly, annual) scales using station observations and a statistical water balance model. In comparison with gauge observations from the Global Historical Climatology Network Daily (GHCN-D), gridded datasets generally agree with ground observations, however the international border clearly delineates a decrease in gridded precipitation accuracy over the Canadian portion of the basin. Analysis reveals that rank in gridded precipitation accuracy differs for overland and overlake regions, and between colder and warmer months. Overall, the AORC has the lowest variance compared to gauge observations and has greater performance over temporal and spatial scales. While CaPA and AORC may better capture atmospheric dynamics between land and lake regions, comparison with a statistical water balance model suggests that AORC and MPE provide the best estimates of monthly overlake precipitation.

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## Characteristics and driving factors of lake level variations by climatic factors and groundwater level

Wu, Chu; Wu, Xiong; Lu, Chuiyu;等.

Hongjiannao Lake (HL), the largest desert freshwater lake in China, has been undergoing quickly evolution of lake area during the past 30 years. The causes and driving mechanism of such changes, however, are still not well understood. The evolution process can be divided into three phases: the stationary phase, the shrinking phase, and the rising phase, which were affected by climate change and human activities, such as unreasonable utili-zation and water diversion. Here, wavelet coherence was used to analyze the relationship between the groundwater level and the lake level, and the results shown

that groundwater levels in the lakeshore region were positively correlated to lake level within a short lag period of approximately 30 days. Then a gradient boosting decision tree-based regression model was applied to analyze the relative importance of climatic factors (model 1) and both of climatic factors and groundwater level (model 2) to the lake level. In model 1, the most important factor was the evaporation to the HL level, while in model 2, it was the groundwater level and the evaporation, which also achieved better prediction performance. Finally, using the 2021 meteorological data and groundwater level, model 2 was utilized to dynamically predict the daily water level of the HL, showing that the lake level fluctuated upward.

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## Spatiotemporal characteristics, influencing factors and evolution laws of water exchange capacity of Poyang Lake

Huang, Aiping; Liu, Xiaobo; Peng, Wenqi;等

As an important indicator of pollutant transport and dispersion conditions in lakes, the water exchange capacity of large shallow lakes has always been a focus in research on lake hydrodynamic and water environment. Poyang Lake is a large shallow lake and also the largest freshwater lake in China, which is being given prominent environmental and ecological status. Poyang Lake's hydrological situation fluctuates dramatically and the spatial and temporal characteristics and influencing factors of its water exchange capacity are complicated. In this paper, water age was selected to describe the water exchange capacity of Poyang Lake, and a water age model of Poyang Lake was established. With the water age model, the spatial and temporal characteristics and influencing factors of water age of Poyang Lake were studied and the law of response of the water age to the evolution of River-Lake relationship between Yangtze River and Poyang Lake and the proposed Poyang Lake Water Conservancy Hub was analyzed. The results showed that: (1) The water age of Poyang Lake demonstrates significant spatial and temporal heterogeneity, that is, the water age in summer and autumn is obviously higher than that in winter and spring and the water age in the disc-shaped lake and lake bay area is obviously higher than that in the main river channel and beach; (2) The water stage at Hukou and catchment inflow are the main factors affecting the water age of Poyang Lake and the influence of the water stage at Hukou on the water age of Poyang Lake is greater than that of the catchment inflow, and the higher water stage at Hukou, the higher the water age of Poyang Lake, while the higher the catchment inflow, the lower the water age of Poyang Lake; (3) After 2003, the water age of Poyang Lake decreases with the evolution of River-Lake relationship and the most significant decrease happens in autumn; (4) The proposed Poyang Lake Water Conservancy Hub may increase the water age of Poyang Lake to some extent while it alleviates the problem of low water in Poyang Lake. This study can provide a scientific base for the water environment management of Poyang Lake and provide a reference for research on water exchange capacity of other large shallow lakes.

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## A modelling framework to track phosphorus sources of the drinking water intakes in a large eutrophic lake

Qian, Rui; Wang, Xuesong; Gao, Junfeng;等

Excess phosphorus (P) in freshwater lakes is a global challenge due to its potential cause of harmful algal blooms threating drinking water safety. However, quantifying the P sources for a specific site in a

large lake is extremely challenging due to the complex interaction between internal and external P loading to surface water. To address this challenge, this study developed a modelling framework to track P sources of two drinking water intakes in a large shallow lake (Lake Taihu) in China. The framework proposed a new-developed index (PSCI, P source contribution index) to quantify the contributions of various P sources for the drinking water intakes. PSCI was derived by a three-dimensional hydrodynamic and water quality model that describes the complex processes of P sources, sinks and transportation in both horizontal and vertical directions within the lake. Application of the framework to these two drinking water intakes (Jinshu and Shangshan) achieved a surprising finding that in-ternal P loading from sediment was a significant P source with a contribution as high as 47.1% and 30.4%, respectively. Central Lake Taihu had a large contribution of 49.5% and 68.3% for Jinshu and Shangshan, and inflow river (Wangyu River) had a contribution of < 5%. The high contribution of internal P loading was mainly due to the sediment P accumulation for years and large external P loading. Our study highlighted the important role of internal P loading affecting the P concentration of drinking water intake in a large eutrophic lake, and demonstrated the high value of the modelling framework in quantifying the P sources for a specific site (e.g., drinking water intake) in a lake.

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## Variations in lake water storage over Inner Mongolia during recent three decades based on multi-mission satellites

Xu, Yuyue; Gun, Zhao; Zhao, Jianwei;等

Lake shrinkage is a frequent water resource problem in arid and semi-arid regions that can affect the hydrological cycle and damage the local aquatic environment. Since the 1990 s, many lakes in Inner Mongolia have shrunk significantly. However, the causes of the shrinkage and long-term storage trends of lakes in Inner Mongolia are still poorly understood. Using observations from multi-mission satellites, we analyzed water storage changes in six major lakes in Inner Mongolia over the past 30 years and explored the underlying causes. The results reveal divergent changes between the two lake categories. For each of the tectonic lakes (including Lake Hulun, Lake Dalinuoer, Lake Daihai, and Lake Hongjiannao), the water storage has continuously decreased with annual rates of 0.067 km(3)/yr, 0.012 km(3)/yr, 0.021 km(3)/yr, and 0.01 km(3)/yr, respectively. In contrast, for oxbow lakes (including Lake Hasuhai and Lake Wuliangsuhai), the storage trends were insignificant (0.001 km3/yr for both). Human activities were the most significant driving factors, especially coal mining, agricultural irrigation, and grazing, which explained more than 70% of the storage changes in Lake Hulun, Lake Dalinuoer, and Lake Hasuhai. Among the natural factors, evapotranspiration and runoff were secondary influences on these lake storage changes. This study provides a systematic analysis and attribution of water storage changes for major lakes in Inner Mongolia and provides scientific guidance for local water resource management and planning. Our method provides a useful example of using multi-mission satellite data for estimating water storage changes.

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## Mapping the trophic state index of eastern lakes in China using an empirical model and Sentinel-2 imagery data

Li, Sijia; Chen, Fangfang; Song, Kaishan;等

Lake eutrophication has become a critical environmental issue due to the global effects of anthropogenic

activities and climate change, and has been comprehensively studied for many years. A series of models and indicators have been proposed to assess the trophic state of lakes. The trophic state index (TSI) is a synthetic index that integrates chlorophyll-a, water clarity, and total phosphorus and is widely used to evaluate the trophic state of aquatic environments. In this study, we collected in situ lake samples (N = 431) from typical lakes to match Sentinel-2 MultiSpectral Instrument (MSI) imagery data using the Case 2 Regional Coast Color processor. Then we developed a new empirical model, TSI = -34.04 x (band 4/band 5) - 1.114 x (band 1/band 4) + 97.376). This model is valid for all of China, with good performance and few errors (RMSE = 7.36; MAE = 6.25) for the validation dataset. Recognizing that over 94% of the Chinese population located along eastern watersheds and large lakes have competing water uses, and given the TSI model on the seasonal scales, we further estimated the mean TSI and trophic state in eastern Chinese lakes (> 100 km(2)) from 2019 to 2020. The results revealed that more lakes were eutrophic in autumn (94.28%) than in spring (> 77.14%), indicating a serious eutrophication of eastern lakes. Although the eastern lakes have been studied in more detail, this study found that eutrophication still has markedly negative impacts on lake ecosystems. In addition, no significant improvement was observed in spring, most likely due to the months of curfew/lockdown from January 2020 onwards due to COVID-19. This may be due to the enrichment of nutrients deposited in sediment or watershed soil, which can be characterized as autochthonous sources of lake eutrophication, over decades with high rates of economic development. This study demonstrates the applicability of Sentinel-2 MSI data to monitor lake eutrophication as well as the feasibility of blue/red and red/red edge combinations. The framework and TSI model used bands available on MSI sensors to develop a novel approach for generating historical eutrophication data for large-scale evaluation of and decision-making related aquatic environmental changes, even in poorly studied areas.

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## Groundwater discharge tracing for a large Ice-Covered lake in the Tibetan Plateau: Integrated satellite remote sensing data, chemical components and isotopes (D, O-18, and Rn-222)

Liao, Fu; Wang, Guangcai; Yang, Nuan;等

It has been known that groundwater-lake water interaction plays an important role in mass exchange between land and lakes. However, most of the lakes in the world freeze during the winter, and few studies of groundwater and surface water interaction (groundwater discharge tracing) focus on ice-covered lakes. This study investigated groundwater discharge into a large ice-covered lake, Xiao Qaidam Lake in the Tibetan Plateau (TP), using sat-ellite remote sensing and chemical and isotopic tracing. Analysis of chemical components, stable isotopes (D, O-18) and Rn-222 revealed that groundwater discharge occurred in the western and southern portions of Xiao Qaidam Lake. Remote sensing data (the distribution of and variation in lake surface temperature, LST) revealed these locations of groundwater discharge and indicated additional groundwater discharge in areas of springs. Based on the regression model between LST and Rn-222 activity in lake water and 222Rn mass balance model, the groundwater discharge into Xiao Qaidam Lake was estimated to be (2.77 +/- 0.26) x 10(5) m(3)/d, which is slightly higher than river water input at summer. In addition, this study also suggests that ice melting process should be considered when tracing groundwater discharge into an ice-covered lake, and that the LST distribution during the icing period is better than the LST variation for tracing groundwater discharge because the ice eliminated noise from wind and surface water. The study provides insight into the tracing

of groundwater discharge into large ice-covered lakes in the TP and elsewhere.

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## A computational method for rapid orthographic photography of lake sediment cores

Ankor, Martin James; Tyler, Jonathan James

Photographs of sediment cores are an important dataset, often containing visual evidence for environmental change via sediment composition and structure. These photographs may be used to stratigraphically correlate adjacent cores or for automated image analysis, and can facilitate collaboration amongst researchers through sharing and annotation of the image files. Here we describe the use of computational photogrammetry (also known as Structure from Motion-Multi-View Stereo) to generate orthographic imagery of sediment cores. Computational photogrammetry is a rapid and economical technique, typically requiring only a few minutes for each metre of core, using consumer-grade digital camera equipment. The photogrammetric methodology corrects for topographic distortion caused by sediment surfaces that are not perfectly flat, and can also record features of the scene surrounding the core, such as notes, colour reference cards and measurement tapes or rulers. As the photogrammetric process also generates a three-dimensional reconstruction of the sediment core, spatial-based analysis can be used to identify damaged or non-representative sections of the core that are to be avoided during image analysis. Using an intermittently laminated sediment core from Lake Surprise, Australia, we tested 22 scenarios using control points in a variety of configurations, as well as calibrated and uncalibrated cameras, to identify techniques that can reconstruct the core accurately and generate orthophotos. Multiple techniques were able to achieve suitable accuracy. In particular, targets placed on the table alongside the core, combined with a calibrated camera, achieved high accuracy and enabled a simple, rapid, and repeatable method for generating high-quality sediment core images.

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## Effects of climate change and nutrient concentrations on carbon sources for zooplankton in a Tibetan Plateau lake over the past millennium

Su, Yaling; Li, Kuanyi; Zhang, Yongdong;等

Autochthonous and allochthonous organic carbon (OC) are important carbon sources for zoo-plankton in lakes, and changes in the abundance and proportions of those sources may affect zooplankton community composition and lake ecosystem function. Nevertheless, long-term changes in assimilation of autochthonous and allochthonous carbon by zoo-plankton and associated climate- and environment-related forcing mechanisms have rarely been studied. We used a sediment record of cladoceran remains and geochemical variables from Lake Jirentso on the Tibetan Plateau to track long-term changes in sources of carbon for cladocera over the past similar to 950 years. High cladoceran:diatom accumulation rate ratios during the cold Little Ice Age indicated that cladocerans assimilated more allochthonous OC that was released from glaciers and frozen soils to replenish their food supply, a consequence of low primary production in the lake. In contrast, low cladoceran:diatom accumulation rate ratios during the Current Warm Period indicated that cladocerans utilized more autochthonous OC. Less autochthonous OC was available for clad-ocerans during the Medieval Warm Period than during the Current Warm Period. The total accumulation rate of cladocerans was significantly

correlated with the annual mean air temperature, total phosphorus, and the organic carbon to nitrogen ratio in the sediment core. Recent warming and sharply increased nutrient inputs affected the cladoceran and diatom assemblages, further inducing a shift in the diet of zooplankton towards more recently produced OC. The sediment record from Lake Jirentso, which represents the last similar to 950 years of deposition, spanned an ideal time window for assessing historical changes related to the impacts of climate and nutrients on zooplankton carbon sources.

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## Fish consumption and advisory awareness in the Great Lakes basin

He, Xiaofei; Raymond, Michelle; LaHue, Nathaniel;等

Background: Fish is a dietary staple in the United States. Risk of exposure to persistent contaminants through fish consumption is a significant health concern. Great Lakes basin states, along with the US Environmental Protection Agency and the Great Lakes Consortium for Fish Consumption Advisories, have developed and continuously updated fish consumption advisories specifically for the Great Lakes basin residents. Objectives: To characterize Great Lakes basin residents' fish consumption and advisory awareness, we conducted a point-in-time survey to describe fish consumption habits and awareness of state and EPA/FDA fish advisories. Methods: We used a randomized, address-based sampling approach to recruit respondents from the eight Great Lakes basin states. Weighted survey analysis procedures were used to estimate population prevalence of fish consumption habits, state and EPA/FDA advisory awareness, and demographic and background characteristics. Logistic regression models were used to assess the associations between demographic and background factors and fish consumption and awareness of advisories, respectively. Results: About 92% of respondents, representing an estimated 61 million adults, reported eating fish in the last 12 months. About 64% of respondents only consumed commercial fish, and an estimated 5 million fish consumers exceeded the EPA/FDA recommended limit for fish meals. Minorities were more likely to exceed the EPA/FDA recommended limit. About half of the respondents were aware of state or EPA/FDA advisories; however, minorities and women were less aware of the EPA/FDA advisory. After adjusting for demographic characteristics, sportfish consumption was significantly associated with state advisory awareness; commercial fish consumption was significantly associated with EPA/FDA awareness. Discussion: Most respondents only consumed commercial fish, but an estimated 18.6 million adults consumed sportfish. While half of the fish consumers were aware of state or EPA/FDA advisories, minorities and women continue to be less aware of fish advisories. Improved outreach strategies are needed to inform them about safe fish-consumption guidelines.

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## Response of cyanobacterial bloom risk to nitrogen and phosphorus concentrations in large shallow lakes determined through geographical detector: A case study of Taihu Lake, China

Li, Shan; Liu, Chang; Sun, Ping;等

Understanding the sensitivity of the response of chlorophyll (Chla) to nutrients (e.g., nitrogen and phosphorus) concentrations is important for predicting cyanobacterial bloom risk. However, the processes by which nutrients in lake that affect cyanobacterial growth and outbreaks are nonlinear, gradual and spatially and temporally heterogeneous, and the single response thresholds of

concentrations between nutrients and the Chla proposed in current studies maybe hardly reflect these characteristics. Due to three decades of rapid regional socio-economic development, the eutrophication in Taihu Lake of China is serious and there are cyanobacterial blooms every year. In this study, we quantified the interaction effects of different forms of nitrogen and phosphorus on Chla concentrations in lake water and sediment pore water. Anda refined response threshold range with continuous variation was proposed to characterize the relationship between the Chla concentration and the NH4-N, total nitrogen (TN) and total phosphorus (TP) concentrations. The results showed that TP was the dominant factor influencing the spatial variation of cyanobacteria blooms in most areas of Taihu Lake, followed by TN. TP should therefore be the highest priority for future pollution load reduction in Taihu Lake. The effects of the inter-actions between the pollution factors were greater than the sum of them individually. NH4-N and dissolved inorganic phosphorus (DIP) are likely to be preferentially consumed by algae for growth and should be the focus of nutrient control efforts in Taihu Lake. For cyanobacterial risk prediction, prevention and control, NH4-N, TN and TP concentrations of 0.06 mg/L, 2.89 mg/L and 0.06 mg/L, respectively, can be used to indicate the beginning of cyanobacterial blooms in Taihu Lake, and concentrations of 0.34 mg/L, 4.67 mg/L and 0.11 mg/L, respectively, can be used as reference thresholds to indicate serious cyanobacterial blooms.

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## Bioaccumulation of polyfluoroalkyl substances in the Lake Huron aquatic food web

Ren, Junda; Point, Adam D.; Baygi, Sadjad Fakouri;等

Polyfluoroalkyl substances (PFAS) are a group of fluorinated organic chemicals that have been produced for industrial and commercial application since the 1950s. PFAS are highly persistent and ubiquitous in water, sediment, and biota. Toxic effects of PFAS on humans and the ecosystem have increased scientific and public concern. To better understand the distribution of PFAS in the Laurentian Great Lakes, carbon (C-12 and C-13) and nitrogen (N-14 and N-15) stable isotope enrichment, fatty acid profiles, and PFAS were measured in the Lake Huron (LH) aquatic food web. The trophic level of the organisms was estimated using delta N-15 and found to be a determinant of PFAS biomagnification. The delta C-13 and fatty acid profiles were used to assess the carbon/energy flow pathway and predator-prey relationships, respectively. The delta C-13, delta N-15, and fatty acids were used to elucidate the trophodynamics and understand the PFAS trophic transfer in the LH aquatic food web. Perfluorooctanesulfonic acid (PFOS) was the dominant PFAS observed, followed by C9 -C11 perfluorinated carboxylic acids (PFCA). The highest PFOS concentrations (45 +/- 11 ng/g, wet weight (wwt)) were detected in lake trout (Salvelinus namaycush), while the highest total PFCA concentrations (sum of C4 - C16 PFCAs) were detected in deepwater sculpin (Myoxocephalus thompsonii). With the exception of perfluorooctanoic acid (PFOA), C8-C14 PFAS biomagnification factors (BMFs) were found to be generally greater than 1, suggesting PFAS biomagnification from prey to predator. Trophic magnification factors (TMFs) of C8-C14 PFCA were found to be independent of compound hydrophobicity.

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## Evidence for multiple potential drivers of increased phosphorus in high-elevation lakes

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Total phosphorus (TP) concentrations have increased in many remote mountain waterbodies across the western United States, and reports of algal blooms in these systems have increased in frequency. Explanations for observed TP increases are uncertain, and typical landscape drivers, such as agricultural/urban runoff, are implausible. We investigated multiple atmospheric and terrestrial-P loading mechanisms to explain the observed decadal increase in TP, including a novel hypothesis that warming soils may lead to elevated P fluxes to receiving water bodies. Using northern Utah mountains ranges as a case study, we measured prospective inputs of total and bioavailable P via dust deposition. Terrestrial loading was evaluated through soil leaching experiments designed to simulate soil acidification and recovery, as well as observed decadal increases in soil temperatures and extended growing season. In the Uinta Mountains, dust-P flux appears to be one of the most plausible mechanisms for P increases where we estimated bioavailable dust-P loading ranged from 1.6 to 23.1 mg Pm-2 yr(-1). However, our results revealed that an increase of soil pH by 0.5 units could lead to a rise in leached P, ranging from 4.7 to 65 mg P m(-2). Rising temperatures also showed the potential to increase soil P leaching; Observed average historical (similar to +3 degrees C) and future (+2 degrees C) increases in temperature led to a prospective increase in leached P from 2 to 264 mg SRP m(-2). While we found that pH shifts can mobilize significant amounts of P in some locations, we found no evidence of pH changes through time in the Uinta Mountains. However, summer soil temperatures increased at most locations. The mechanisms evaluated in this study can help explain the widespread observed increases in P across Western US lakes, but the mechanisms that dominate in any given region are likely to vary based on local to regional factors.

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## The relationship between land cover and microbial community composition in European lakes

Sperlea, Theodor; Schenk, Jan Philip; Dressler, Hagen;等

Microbes are essential for element cycling and ecosystem functioning. However, many questions central to understanding the role of microbes in ecology are still open. Here, we analyze the relationship between lake microbiomes and the lakes' land cover. By applying machine learning methods, we quantify the covariance between land cover categories and the microbial community composition recorded in the largest amplicon sequencing dataset of European lakes available to date. Our results show that the aggregation of environmental features or microbial taxa before analysis can obscure ecologically relevant patterns. We observe a comparatively high covariation of the lakes' microbial community with herbaceous and open spaces surrounding the lake; nevertheless, the microbial covariation with land cover categories is generally lower than the covariation with physico-chemical parameters. Combining land cover and physico-chemical bioindicators identified from the same amplicon sequencing dataset, we develop analytical data structures that facilitate insights into the ecology of the lake microbiome. Among these, a list of the environmental parameters sorted by the number of microbial bioindicators we have identified for them points towards apparent environmental drivers of the lake microbial community composition, such as the altitude, conductivity, and area covered herbaceous vegetation surrounding the lake. Furthermore, the response map, a similarity matrix calculated from the Jaccard similarity of the environmental parameters' lists of bioindicators, allows us to study the ecosystem's structure from the standpoint of the microbiome. More specifically, we identify multiple clusters of highly similar and possibly functionally linked ecological parameters, including one that highlights the importance of the calcium-bicarbonate equilibrium for lake ecology. Taken together, we demonstrate the use of machine

learning approaches in studying the interplay between microbial diversity and environmental factors and introduce novel approaches to integrate environmental molecular diversity into monitoring and water quality assessments.

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## Estimating nutrient thresholds for eutrophication management: Novel insights from understudied lake types

Poikane, Sandra; Kelly, Martyn G.; Varbiro, Gabor;等

Nutrient targets based on pressure-response models arc essential for defining ambitions and managing cutrophication. However, the scale of biogeographical variation in these pressure-response relationships is poorly understood, which may hinder cutrophication management in regions where lake ecology is less intensively studied. In this study, we derive ecology-based nutrient targets for five major ecoregions of Europe: Northern, Central-Baltic, Alpine, Mediterranean and Eastern Continental. As a first step, we developed regressions between nutrient concentrations and ecological quality ratios (EQR) based on phytoplankton and macrophyte communities. Significant relationships were established for 13 major lake types; in most cases, these relationships were stronger for phosphorus than for nitrogen, and stronger for phytoplankton than for macrophytes. Using these regressions, we estimated the total phosphorus (TP) and total nitrogen (TN) concentrations at which lakes of different types are likely to achieve good ecological status. However, in the very shallow lakes of the Eastern Continental region, relations between nutrient and biological communities were weak or non-significant. This can be attributed to high nutrient concentrations (in the asymptotic zone of phosphorus-phytoplankton models) suggesting other factors (light, grazing) limit primary production. However, we also show that fish stocking is a major pressure on Eastern Continental lakes, negatively affecting ecological status: lakes with low fish stocking show low chlorophyll-a concentrations and good ecological status despite high nutrient levels, while the lakes with high fish stocking show high chlorophyll-a and low ecological status. This study highlights the need to better understand lakes in biogeographic regions that have been, for historical reasons, less studied. This, in turn, helps reveal factors that challenge the dominant paradigms of lake assessment and management.

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## Exploring watershed effects on nutrient concentrations in shallow lakes through stable isotope analysis

Langer, Thomas A.; Zimmer, Kyle D.; Herwig, Brian R.;等

Biogeochemistry patterns in shallow lakes are influenced by both in-lake factors such as ecosystem state as well as watershed-level factors such as land use, but the relative importance of in-lake versus watershed factors is poorly known. This knowledge gap makes it difficult for lake mangers to prioritize efforts on watershed versus in-lake strategies for stabilizing the clear-water state. We studied 48 shallow lakes in Minnesota, USA to assess the relative influence of lake size, land use in watersheds, and ecosystem state (turbid versus clear) on water column total nitrogen (TN) and total phosphorus (TP), as well as delta N-15 and delta C-13 in three species of fish. Our land use categories included natural areas, row crop agriculture, and all agriculture (row crops plus alfalfa). A model selection approach revealed different control mechanisms on the behavior of stable isotopes and nutrients. delta C-13 ratios in fish were most strongly influenced by lake size, while delta N-15 ratios were influenced by all agriculture in

watersheds. In contrast, water column TN and TP concentrations were influenced by the in-lake factor of ecosystem state, with both nutrients lower in the clear state. We detected no effects of land use on TN or TP concentrations, likely due to strong effects of ecosystem state masking watershed effects. However, the strong relationship between agriculture and d15N in fish indicated that watersheds did influence nutrient processing in shallow lakes, and that effects are not a legacy from past watershed events. Collectively, these observations indicate that lake managers should minimize agricultural intensity in shallow lake watersheds to facilitate the clear-water state, which will, in turn reduce water-column TN and TP relative to the turbid state.

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## Divergent change patterns observed in hydrological fluxes entering China's two largest lakes

Li, Tong; Liao, Qiang; Wang, Shuai;等

Large lakes are key components of hydrological processes and have critical ecological and economic functions. Streamflow and riverine sediment loads exported from tributary rivers to lakes provide inputs of water and nutrients and greatly impact the health of lacustrine ecosystems. Understanding the spatiotemporal patterns of water and sediment transport dynamics within the basins of large lakes is therefore required for informed management of their resources. In particular, the hydrological processes of large lake basins in western China were not fully explored yet. This study investigated changes in runoff and sediment fluxes entering the two largest lakes in China (Qinghai Lake and Poyang Lake) over the past half century. Our results showed that the regional trends of the two lake basins have changed in divergent way. The patterns of change of streamflow and sediment transport-including the trends, periodicity, and transition points as well as the relationship between streamflow and sediment flux-were quite different. The results obtained by a Sediment Identity method revealed that increases of the precipitation and runoff coefficient controlled the observed increase of streamflow and sediment flux within the Qinghai Lake basin, whereas the decrease of the sediment flux entering Poyang Lake was caused mainly by a reduction in sediment concentration. Climate change was the dominant driver influencing the recent increases in surface water resources and sediment load in the Qinghai Lake basin as well as the long-term fluctuations of streamflow within the Poyang Lake basin. In contrast, the observed abrupt reduction in total sediment flux entering Poyang Lake was due mainly to declining sediment discharge from the Gan River; this decrease is attributed primarily to human activities, especially reservoir construction and soil conservation practices. Overall, this study discovers the divergent change patterns when investigating hydrological processes, and highlights the importance of developing policies for managing soil and water resources within large lake basins to the northwest and southeast of the Hu Line. Management policies should consider the tremendous differences in geography, climate, and population across China.

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## Metal ratio mixing models clarify metal contamination sources to lake sediments in Yunnan, China

Bain, Daniel J.; Hillman, Aubrey L.; Abbott, Mark B.;等

Contaminated legacy sediments contribute to modern pollution loadings, particularly trace metals. These contributions are challenging to quantify as metal histories reconstructed from sediment records cannot

be easily divided into legacy and concurrent contamination. In particular, the contribution from re-mobilization and delivery of legacy metals stored in catchment soil, colluvial, and fluvial environments are rarely considered or quantified when interpreting sediment records. Here, extended records of metals accumulation for a set of three lakes in Yunnan, China are compared with endmember chemistries using Monte Carlo-Markov Chain mixing models to help identify source contributions to the sediments. This approach allows attribution of metals transported by atmospheric and fluvial mechanisms in a region with a history of mining and metallurgy spanning millennia. These analyses reveal distinct source mixtures and demonstrate the sensitivity of lake records to basin sediment dynamics. In particular, substantial proportions of elevated metal concentrations in these lake systems seem to arise from soil contributions more than from atmospheric deposition of smelting emissions. The largest soil contributions seem to be in Erhai, a lake with erosion prone soils closely connected to the lake. Moreover, these invesigations illustrate the potential for mixing approaches to accommodate and clarify uncertainties in metal source and extraction as differences in extraction efficiency can be incorporated into source uncertainty estimates. Ultimately, these approaches emphasize the need to account for fluvial metal transport in interpretation of sediment histories.

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## Insight into microbial degradation of hexabromocyclododecane (HBCD) in lake sediments under different hydrodynamic conditions

Hu, Yu; Chen, Juan; Wang, Chao;等

Hexabromocyclododecane (HBCD), an emerging persistent organic pollutant, has been widely detected in aquatic ecosystems with various hydrodynamic conditions, however, the effects of hydrodynamic changes on microbial degradation of HBCD in aquatic sediment remains unclear. Here, we conducted an annular flume experiment to characterize variation in HBCD removal from contaminated sediment under three hydrodynamic conditions with different flow velocities, as well as clarify the underlying microbial mechanisms. We detected significant HBCD removal and bromine ion generation in all contaminated sediments, and microbial reduction debromination was an important process for HBCD removal. At the end of the 49-day experiment, both HBCD removal percentage and the bromine ion concentration were significantly lower under dynamic water condition with higher sediment redox potential, compared with static water conditions. The dynamic water conditions resulted a relatively high sediment redox potential and decreased the iron reduction rate and the abundance of organohalide-respiring bacteria (OHRB) in the genera Geobatcer, Dehalogenimonas, Dehalobacter, and Dehalococcoide, which reduced the microbial degradation of HBCD in contaminated sediments. The community composition of both total bacteria and OHRB also differed significantly among hydrodynamic conditions. Some bacterial groups with HBCD degradation abilities such as Pseudomonas and Sulfuricurvum were less abundant under dynamic water conditions, and the HBCD degradation efficiencies were lower. These findings enhance our understanding of the bioremediation potential of HBCD-contaminated sediments in different hydrodynamic areas.

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## Human activities affect the multidecadal microplastic deposition records in a subtropical urban lake, China

Li, Bo; Wan, Hang; Cai, Yanpeng;等

Microplastic deposition in subtropical lakes and the influences of human activities remain to be deeply and fully understood. Owing to the intensification of urban construction and population growth, urban lakes serving as significant freshwater resources for sustainable development of the regional economy are becoming degraded, especially due to microplastic pollution. To understand the deposition characteristics of microplastics in lake sediments from the China's subtropical city, six sediment core samples were collected from Xinghu Lake of Guangdong Province. Here, we analyzed the morphological characteristics of microplastics from the perspective of microstructure, and investigated the temporal and spatial distribution patterns of microplastics on the macroscopic scale. The deposition characteristics of microplastics in the past 64 years and the influence of socio-economic factors on the accumulation of microplastics were further clarified through the isotope composition of cesium-137 and lead-210 in the subtropical urban area with intense human activities. The results showed that the microplastic concentration of sediment cores in Xinghu Lake was 523 +/- 140 particles/kg. The average sizes of microplastics in the five sub-lakes (i.e., Bohai, Zhongxin, Li, Qinglian, and Xiannu Lakes) of Xinghu Lake were 668, 642, 727, 708 and 646 mu m, respectively. There were 25 polymers in sediment cores of Xinghu Lake. Rayon, polypropylene, polyethylene terephthalate and polypropylene-polyethylene copolymer were the main types, and the microplastics have the aging phenomenon or mechanical abrasion. The average deposition rates of sediment and microplastics were 0.6 cm/a and 106 particles/(kg center dot a) in Xinghu Lake, respectively. Meanwhile, the urban expansion and economic growth, as indicated by the increase in the urban area, population and gross domestic product, all played an essential role in the accelerated accumulation of microplastics in sediment cores of Xinghu Lake.

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## Anthropogenic impacts on the biodiversity and anti-interference ability of microbial communities in lakes

Luo, Jiwei; Zeng, Hui; Zhou, Qixing;等

Lakes are critical for biogeochemical and ecological processes and are sensitive and vulnerable to anthropogenic disturbances, but how and to what extent human activities disturb the biodiversity in lakes remain unknown. Here, we showed the microbial diversity in 46 lakes and assessed the influence of 27 anthropogenic factors. We found that the economic level (e.g., per capita gross domestic product) was strongly negatively correlated (r = -0.97) with bacterial diversity but positively correlated (r = 0.17) with fungal diversity in lakes. The composition of the microbial community significantly changed with increasing economic level. Bacteria are more sensitive than fungi to anthropogenic impacts. Expanding the population size and increasing the economic level may promote the development of fungal diversity but inhibit bacterial diversity. Air quality, urbanization and ozone were negatively correlated with bacterial diversity, and fisheries had a negative correlation with fungal diversity. The anti-interference ability of lake microorganisms in the middle economic level zones (45,000-90,000 yuan/person) was stronger than that in high-level (> 90,000 yuan/person) and low-level (> 45,000 yuan/person) economic zones. Overall, our investigation provides national-scale evidence that changes in the microbial diversity in lakes were related to economic levels.

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## Scaling relations reveal global and regional differences in morphometry of reservoirs and natural lakes

Sjoberg, Ylva; Dessirier, Benoit; Ghajarnia, Navid;等

Water bodies provide essential ecosystem services linked to morphometric features that might differ between natural lakes and reservoirs. We use the HydroLAKES global dataset to quantitatively compare large (area > 1 km(2)) reservoirs and natural lakes in terms of scaling exponents between morphometric measures (volume, area, shore length). These exponents are further compared to those expected from geometrical assumptions and constraints. Lakes cover a larger range of volumes for the same range of surface areas than reservoirs, and have a larger volume-area scaling exponent. The volume-area scaling exponent for reservoirs (but not natural lakes) and the area-shore length exponent for all water bodies follow the predictions for self-affine surfaces. Land cover and terrain influence the scaling relations more for lakes than for reservoirs. These morphometric differences may be used to model the impact of reservoirs and lakes on hydrological processes and associated ecosystem services at regional to global scales.

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## Nitrate as a predictor of cyanobacteria biomass in eutrophic lakes in a climate change context

Cremona, Fabien; Oglu, Burak; McCarthy, Mark J.;等

We aimed to predict cyanobacteria biomass and nitrate ($NO_3$-) concentrations in Lake Vortsjarv, a large, shallow, and eutrophic lake in Estonia. We used a model chain based on the succession of a mechanistic (INCA-N) model and an empirical, generalized linear model. INCA-N model calibration and validation was performed with long term climate and catchment parameters. We constructed twelve scenarios as combinations of climate forcing from the Intergovernmental Panel on Climate Change (IPCC, 3 scenarios), land conversion (forest to agriculture, 2 scenarios), and fertilizer use (2 scenarios). Models predicted 46% of the variance of cyanobacteria biomass and 65% of that of $NO_3$- concentrations. The model chain simulated that scenarios comprising both forest conversion to agricultural lands and a greater use of fertilizer per surface area unit would cause increases in lacustrine $NO_3$- (up to twice the historical mean) and cyanobacteria biomass (up to a four-fold increase compared to the historical mean). The changes in $NO_3$- concentrations and cyanobacteria biomass were more pronounced in low and moderate warming scenarios than in high warming scenarios because of increased denitrification rates in a warmer climate. Our findings show the importance of reducing anthropogenic pressures on lake catchments in order to reduce harmful pollutant and microalgae proliferation, and highlight the counterintuitive effects of multiple stressor interactions on lake functioning.

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## Wildfires trigger multi-decadal increases in sedimentation rate and metal loading to subarctic montane lakes

Pelletier, Nicolas; Chetelat, John; Sinon, Sarah;等

We evaluated how two large wildfires affected the sedimentation rate and accumulation of lead (Pb), mercury (Hg), and cadmium (Cd) in sediment of four subarctic montane lakes in the Yukon, Canada. The wildfires occurred 60 and 20 years (1958, 1998) before sediment collection in 2018. Site-specific fire exposure was inferred from the charcoal accumulation histories in the lake sediments and the burned

catchment area was determined from historical fire maps. The two major wildfires caused a two to five-fold increase in sedimentation rates and a two to eight-fold increase in sediment metal accumulation rates in Little Fox Lake. The mass accumulation rates of metals in Little Fox Lake sediment increased by a maximum of 2.7-4.7 mg Pb m(-2) yr(-1), 19-29 mu g Hg m(-2) yr(-1) and 37-114 mu g Cd m(-2) yr(-1) following wildfires. Modelling using elemental ratios of lithogenic sources suggested a large proportion of the Pb and Hg accumulating in post-fire sediment was from remobilized legacy anthropogenic pollution. In contrast, Cd fluxes were consistent with variation in catchment weathering. Impacts of wildfires were visible but more muted in the sediment of Little Braeburn Lake, whereas Fox Lake and Grayling Lake sediments showed little to no wildfire impact and served as a reference for external (long-range) metal deposition. Major changes to lake sediment geochemistry in Little Fox Lake were caused by the lack of vegetation and soil recovery in the catchment following the severe 1998 fire. Wildfire impacts were persistent in the lake more than 20 years after the last fire, with no sign of a return to pre-fire Pb, Hg, and Cd accumulation rates. This study shows that wildfires in northern montane catchments can significantly increase the rate of metal accumulation in affected lakes, thereby impeding recovery from reductions in anthropogenic air emissions of these metals.

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## Investigating the climatology of North China's urban inland lake based on six years of observations

Yang, Ting; Li, Hongyi; Cao, Jie;等

There are unclear characteristics of the effect of lake breeze in small urban inland lakes due to little research on lake breezes. In this work, six-year observations were performed to study the comprehensive climatologic characteristics of lake breezes on North China's urban inland lake, Lake Hengshui (75 km2). By removing background winds calculated by ERA5 data and successfully recording the lake-land breeze cycle, we devised a succinct and effective approach for distinguishing lake-land breezes. Lake-land breeze had a high annual occurrence frequency of 13.4%-24.7% and a yearly mean lake-breeze speed of 1.6 m/s and yearly mean lake-breeze duration of 4.8 h; spring has the highest frequency and summer has the lowest frequency because of the greater thermal differences between lake and land in spring. The lake breeze mostly started at 06:00-07:00 and 10:00-13:00 (LST), showing a double-peak pattern, and ended at 17:00-19:00 (LST). On the other hand, the land breezes mainly started at 00:00-01:00 (LST) and ended at 05:00-06:00. The distance between each station and the lake has a negative correlation to the frequency and duration of the lake-land breeze, showing the higher frequency and duration at the near stations and the lower frequency and duration at the stations far from the lake. The land breeze has similar spatial characteristics. Winter has relatively lower

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## Spatial and temporal patterns of heavy metals and potential human impacts in Central Yangtze lakes, China

Wang, Rui; Xia, Wentong; Eggleton, Michael A.;等

Lakes in the central Yangtze River basin have experienced increasing levels of human disturbance during the past several decades, yet large-scale environmental patterns in these lakes and their driving factors remain unclear. Herein we examined spatial and temporal patterns of copper (Cu), zinc (Zn), lead (Pb), arsenic (As), and seven other heavy metals from 16 lakes experiencing a gradient of human

disturbance. These lakes were divided among six groups: suburban reservoirs (SR), suburban high-aquaculture lakes (SH), suburban low-aquaculture lakes (SL), suburban noaquaculture lakes (SN), urban aquaculture lakes (UA) and urban no-aquaculture lakes (UN). Spatially, water-column concentrations of Cd, Ni, Co, Mn, Fe, and Al, and sediment concentrations of Ni were significantly lower in SR compared to other lake groups. Except for Al, heavy metal concentrations did not differ between SN and SL lakes in the water-column or sediments. SH lakes exhibited significantly greater concentrations of Cu, Co, Cr, Mn, and Al in the water-column and Zn in sediments compared to SN lakes. UA lakes contained significantly lower concentrations of Zn, Cd, and Al in sediment compared to UN lakes, though no significant differences were detected within water column samples. Temporally, with all lake groups combined, summer water-column concentrations of Cd, Pb, Co, Mn, and Al were lower compared to spring and autumn. Additionally, summer sediment concentrations of Zn, As, Co, Fe also were lower compared to autumn. Further results indicated that low-density fish stockings without external feed inputs appeared to have little impact on heavy metals in both suburban and urban lakes. However, high-density fish stockings with external feed inputs were associated with increased heavy-metal concentrations across all lakes. Overall, urbanization has great potential to increase sediment heavy-metal ecological risks. These findings are crucial for developing heavy-metal pollution control and management strategies for freshwater lakes.

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## Late Holocene vegetation, climate, and lake changes in northern China: Varved evidence from western Loess Plateau

Guo, Chao; Ma, Yuzhen; Meng, Hongwei

High-resolution archives deepen the understanding of past climate variability. We report new sedimentological and paleoecological data from Chaona Lake in northern China. The record represents the annually laminated (i.e., varved) archive from the western Loess Plateau spanning the Late Holocene, allowing insights into critical time intervals of decadal to centennial-scale climate instability. After developing a robust, continuously chronology supported by radioisotope dating and varve chronology, we used high-resolution palynological and sedimentological data to decipher the specific climate and ecosystem evolution over the last 2800 years. Our results show a general forest decline and climate deterioration intercalated with a series of oscillations during the Late Holocene, which may have profoundly influenced the eco-social development of northern China. In addition, lake development changes that mainly reflect the transformation from deep to shallow lake conditions generally match the regional vegetation, which is probably driven by climate-related processes. However, fluctuations in well or poor and the absence of varved sediment indicate variations in the water circulation in the lake catchment. Periods of predominantly well-varved sediments are considered to reflect reduced lake circulation and more anoxic conditions, coinciding with warmer and more stable climate intervals, such as the Roman Warm Period and the Medieval Warm Period. Conversely, periods of poor or even non-varved preservation indicate strengthened lake circulation, which may be influenced by strong winds (e.g., 2800-2000 cal yr BP) and cold/drought conditions (e.g., the Little Ice Age). Integration of our data with those of published climatic reconstructions in northern and eastern monsoon China suggests that this variability in climate can be explained by shifts in solar insolation and large-scale ocean-atmospheric coupling dynamics that affect the Loess Plateau (e.g., the East Asia Summer Monsoon and El Nino-Southern Oscillation).

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## New permafrost is forming on the exposed bottom of Zonag Lake on the Qinghai-Tibet Plateau

Zhang, Yuxin; Xie, Changwei; Wu, Tonghua;等

Most lakes on the Qinghai-Tibet Plateau have expanded in recent years. Zonag lake, a critical habitat for Tibetan antelopes in the continuous permafrost zone, burst and overflowed after several years of expansion, resulting in a reduction of approximately 100 km(2) in the lake area. Observations have revealed new permafrost is forming on the exposed bottom, accompanied by various periglacial landscapes. The permafrost aggradation on the exposed bottom is rapid, and the permafrost base reached 4.9 m, 5.4 m, and 5.7 m in the first three years, respectively. In this study, the future changes and influencing factors of recently formed permafrost are simulated using a one-dimensional finite element model of heat flow. The simulated results indicate that the permafrost on the exposed bottom is likely to continue to develop, appearing first quick back slow trend. Besides the surface temperature, the annual amplitude is also an important factor in affecting the aggradation of permafrost. The unidirectional permafrost aggradation in the study area is different from the bidirectional permafrost aggradation on the closed taliks around the Arctic. Additionally, snow cover and vegetation are two important factors influencing the future development of permafrost on the exposed lake bottom.

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## The spatiotemporal characteristics of water quality and phytoplankton community in a shallow eutrophic lake: Implications for submerged vegetation restoration

Chao, Chuanxin; Lv, Tian; Wang, Ligong;等

One of the most serious consequences of eutrophication in shallow lakes is deterioration of water quality, proliferation of phytoplankton and disappearance of submerged macrophytes. After removing herbivorous and plankti-benthivorous fish, submerged macrophyte restoration was utilized at the entire lake (82.7 km(2)) to combat eutrophication and improve water quality in the shallow subtropical aquaculture of Lake Datong. We conducted two years of monitoring, from March 2018 to February 2020. During the first year of restoration, 80% of the area of Lake Datong (approximately 60 km(2)) was successfully recovered by submerged vegetation, and the water quality was improved. For example, the phosphorous (P) content (including total P (TP), dissolved reactive P (DRP) and total dissolved P (TDP)) and turbidity decreased, and the Secchi depth (SD) increased. However, the submerged vegetation disappeared from autumn 2019 in the intermittent recovery area (MN), while the continuous recovery area (DX) continued to recover with an abundance of submerged vegetation. During the second year, the water quality continued to improve significantly in the DX area, with high biomass and coverage of submerged vegetation. In the MN area, although turbidity and ammonia nitrogen (NH4+-N) increased significantly and SD decreased significantly, the P content (TP, TDP, and DRP) still continued to decrease. The restoration of submerged macrophytes could significantly decrease the density of phytoplankton. Over time, there was a regime shift in Lake Datong. The structural equation model (SEM) results illustrated that the water level and submerged plant coverage were the primary drivers that triggered changes in the state of the lake ecosystem. Our results highlight the potential of restoring submerged vegetation to control water eutrophication at the whole-lake scale. However, the water level in spring was

the primary driver that triggered changes in the state of the lake ecosystem. Water level management should be emphasized during the early stages of recovery of submerged plants.

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## Evaluating spatio-temporal soil erosion dynamics in the Winam Gulf catchment, Kenya for enhanced decision making in the land-lake interface

Humphrey, Olivier S.; Osano, Odipo; Aura, Christopher M.;等

Soil erosion accelerated by poor agricultural practices, land degradation, deprived infrastructure development and other anthropogenic activities has important implications for nutrient cycling, land and lake productivity, loss of livelihoods and ecosystem services, as well as socioeconomic disruption. Enhanced knowledge of dynamic factors influencing soil erosion is critical for policymakers engaged in land use decision-making. This study presents the first spatio-temporal assessment of soil erasion risk modelling in the Winam Gulf, Kenya using the Revised Universal Soil Loss Equation (RUSLE) within a geospatial framework at a monthly resolution between January 2017 and June 2020. Dynamic rainfall emsivity and land cover management factors were derived from existing datasets to determine their effect on average monthly soil kiss by water erosion. By assessing soil erasion rates with enhanced temporal resolution, it is possible to provide greater knowledge regarding months that are particularly susceptible to soil erosion and can better inform future strategies for targeted mitigation measures. Whilst the pseudo monthly average soil loss was calculated (0.80 t ha(-1) month(-1)), the application of this value would lead to misrepresentation of monthly soil loss throughout the year. Our results indicate that the highest erosion rates occur between February and April (average 0.95 t ha(-1) month(-1)). In contrast, between May and August, there is a significantly reduced risk (average 0.72 t ha(-1) month(-1)) due to the low rainfall erosivity and increased vegetation cover as a result of the long rainy season. The mean annual gross soil loss by water erosion in the Winam Gulf catchment amounts to 10.71 Mt year with a mean soil loss rate of 9.63 t ha(-1) year(-1). These findings highlight the need to consider dynamic factors within the RUSLE model and can prove vital for identifying areas of high erosion risk for future targeted investigation and conservation action.

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## Spatially non-stationary relationships between urbanization and the characteristics and storage-regulation capacities of river systems in the Tai Lake Plain, China

Lei, Chaogui; Wang, Qiang; Wang, Yuefeng;等

Given environmental or hydrological functions influenced by changing river networks in the development of rapid urbanization, a clear understanding of the relationships between comprehensive urbanization (CUB) and river network characteristics (RNC), storage capacity (RSC), and regulation capacity (RRC) is urgently needed. In the rapidly urbanized Tai Lake Plain (TLP), China, various methods and multisource data were integrated to estimate the dynamics of RNC, RSC, and RRC as well as their interactions with urbanization. The bivariate Moran's I methods were applied to detect and visualize the spatial dependency of RNC, RSC, or RRC on urbanization. Geographically weighted regression (GWR) model was set up to characterize spatial heterogeneity of urbanization influences on RNC, RSC and RRC. Our results indicated that RNC, RSC and RRC variables each showed an overall decreasing trend across

space from 1960s to 2010s, particularly in those of tributary rivers. RNC, RSC, or RRC had globally negative correlations with CUB, respectively, but looking at local scale the spatial correlations between each pair were categorized as four types: high-high, high-low, low-low, and low-high. GWR was identified to accurately predict the response of most RNC, RSC, or RRC variables to CUB (R-2: 0.6-0.8). The predictive ability of GWR was spatially non-stationary. The obtained relationships presented different directions and strength in space. All variables except for the water surface ratio (Wp) were more positively affected by CUB in the middle eastern parts of TLP. Drainage density, RSC and RRC variables were more negatively influenced by CUB in the northeast compared to other parts. The quantitative results of spatial relationships between urbanization and RNC, RSC or RRC can provide location-specific guidance for river environment protection and regional flood risk management.

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## Significance of different n-alkane biomarker distributions in four same-age peat sequences around the edges of a small maar lake in China

Zhang, Yan; Gao, Chuanyu; Zhang, Shaoqing;等

A decade-resolution study of peat cores from four different locations around Yuanchi Lake, a small shallow maar lake in the Changbai Mountains of northeastern China, has established that peat deposition around this lake amplified at ca. 1800 CE with accumulation rates that differ among the four closely spaced sites. Comparisons of the n-alkane distributions of typical plants and the distributions in the peat cores indicate that the differences in the n-alkane contents at the four sites around the lake are consequences of differences in the peat-forming plant communities that have developed on the lake edges. These floral differences likely resulted from different littoral water depths from small but significant variations in bottom topography around the lake, compounded by progressive infilling of the edges at different rates as peat accumulated. Moreover, several n-alkane-inferred variations in peat accumulation rates from 1800 to 1950 CE are common to the four sites and appear to reflect local cold and dry periods. We infer that these periods are associated with nearby volcanic eruptions in the Changbai Mountains and possibly to distal eruptions in the tropical Pacific. Since 1950 CE, decreases in peat accumulations around the lake may result from enhanced peat decomposition as the water table declined in response to a warm and dry climate and to anthropogenic impacts on the lake catchment.

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## Seasonal diatom community responses to development and climate change in Lake George, an oligotrophic lake in the Adirondack Mountains

Ruka, Adam T.; Johansen, Jeffrey R.; Leps, Jan;等

Lake George is a highly monitored, oligotrophic lake that experiences widespread tourism in the summer months. The southern basin has more shoreline development than the northern basin, resulting in a south to north gradient of anthropogenic impairment. This study aimed to assess differences in nearshore diatom communities regarding gradients of water chemistry and watershed development throughout the lake. Using redundancy analyses, water chemistry explained more variation within diatom assemblages than watershed variables. Seasonal comparisons of watershed types, based on development, revealed SPC values to be significantly higher in the southern basin in all three seasons

(spring, summer, and autumn). Among the three seasons, summer demonstrated the best potential for further monitoring of diatom communities with the north and south basins demonstrating differences in Shannon-Weiner (H ') diversity index values and proportions of Asterionella formosa, Fragilaria crotonensis, and Lindavia lemanensis. Dominant diatoms from previous studies in the lake were compared to present populations and showed a concomitant reduction in Stephanodicus spp. and Melosira spp. while smaller centric species continue to increase. Given the differences between the two basins, climate change is likely to manifest differently in the southern, more productive basin than the northern basin.

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## Physical characteristics of northern forested lakes predict sensitivity to climate change

Edlund, Mark B.; Ramstack Hobbs, Joy M.; Heathcote, Adam J.;等

Evidence suggests that boreal-lake ecosystems are changing rapidly, but with variable ecological responses, due to climate warming. Paleolimnological analysis of 27 undeveloped northern forested lakes showed significant and potentially climate-mediated shifts in diatom communities and increased carbon and biogenic silica burial. We hypothesize the sensitivity of northern forested lakes to climate change will vary along two physical gradients: one reflecting direct, in-lake climate effects (propensity to thermally stratify), the other reflecting indirect watershed effects (watershed to lake-surface area ratio). We focus on the historical response of algal communities to test our two-dimensional sensitivity framework. Historical algal response was summarized by measures of diatom community turnover, changes in species and diagnostic species groups, and measures of siliceous algal and overall primary production (biogenic silica, carbon burial). Measures of algal production increased across all lake types, with carbon burial proportionately higher in polymictic lakes. Greater diatom community change occurred in deep, stratified lakes with smaller watersheds, whereas diatom species groups showed variable responses along our two-dimensional sensitivity framework. Physical characteristics of lakes and watersheds could serve as predictors of sensitivity to climate change based on paleo-indicators that are mechanistically linked to direct and indirect limnological effects of climate change.

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## Unravelling chironomid biodiversity response to climate change in subarctic lakes across temporal and spatial scales

Belle, Simon; Klaus, Frederika; Gonzalez Sagrario, Maria de los angeles;等

We combined paleolimnological reconstructions and space-for-time substitutions to unravel chironomid biodiversity responses to climate change in subarctic mountains across temporal and spatial scales. Using sediment records, we found that long-term temporal changes in chironomid taxonomic diversity were mainly induced by the temperature tolerance/optimum of species, while little changes in functional diversity were found due to the replacement of similar functional-type taxa within the community. Overall, paleolimnological reconstructions suggested the selection of larger chironomid species by long-term climate cooling and little changes in trophic guilds. Space-for-time substitutions showed, however that low-elevation lakes with forested have more sediment-feeding taxa and larger larvae than high-elevation lakes, thus, suggesting the selection of large chironomid morphotypes with a sediment-feeding mode under warmer climate. Space-for-time substitutions and paleolimnological reconstructions, therefore,

gave contrasting results for the link between climate and functional diversity of chironomid communities, likely because space-for-time substitutions failed to match the extent of both spatial and temporal climatic gradients. We suggest that future studies must address biodiversity issues across both temporal and spatial scales as an improved understanding of biodiversity responses to climate change may help us to understand how biodiversity will be affected by ongoing and future change.

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## Prolonged drought increases environmental heterogeneity and plankton dissimilarity between and within two semiarid shallow lakes over time

Lima Cardoso, Maria Marcolina; Sousa, Wanessa; Brasil, Jandeson;等

Extreme weather events are likely to become more frequent in the future due to climate change, and how they will affect communities is a major challenge to ecologists. In this study, we assessed the effects of a prolonged drought on environmental heterogeneity (EH) components and phytoplankton and zooplankton alpha, beta and gamma diversities between and within two tropical semiarid shallow lakes. We hypothesize that prolonged droughts decrease phyto- and zooplankton alpha and gamma diversities, increase between-lake and within-lake EH and accordingly increase plankton species replacement over time. To test this, we performed generalized least squares and general linear regressions to relate the effects of time and EH on the diversity components of phyto- and zooplankton assemblages and separately by their size groups (nano, micro- and mesoplankton). In agreement with our hypothesis, our results showed that between-lake (alpha) over bar and gamma diversities from phytoplankton and zooplankton (and their respective size classes) were generally negatively related to EH, whereas the plankton beta diversity showed an opposite pattern at both within-lake and between-lake scales. In a dry future, actions to improve water quality and water use will be needed to reduce the risk of biodiversity loss and water deterioration within and across lakes over time.

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## Does bait type and bait container configuration influence the performance of remote underwater video systems in temperate freshwater lakes for assessing fish community structure?

Glassman, D. M.; Chhor, A.; Vermaire, J. C.;等

Methods for the use of baited remote underwater video stations (BRUVS) have been tested and refined such that they are now widely used in marine research for assessing fish community structure. There is comparatively less known about the effectiveness of different bait types or bait containers for use with BRUVS in freshwater temperate environments. We conducted a field-based experiment in Lake Opinicon, located in southeastern Ontario, Canada to compare the effectiveness of three baits and two styles of bait container to unbaited systems. Species richness per deployment and the probability of detecting each species were used as measures of effectiveness. BRUVS were deployed in weedy habitats in the littoral zone of the lake (1-3 m depth) with corn, cat food, sardines, or no bait, in an accessible mesh bag, or an inaccessible perforated PVC container. The mean species richness detected was uniform across bait type and container. For Micropterus salmoides, Cyprinidae spp., and Esox lucius, there were associations between bait type and proportion of detections. BRUVS appear to be effective in observing species richness in a shallow, low-visibility freshwater environment; however, there is little evidence that

use of bait improves effectiveness relative to unbaited RUVS.

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## Historical genetic connectivity of lake sturgeon in a dammed Great Lakes tributary

Wilson, Chris C.; Haxton, Tim; Wozney, Kristyne M.;

Lake sturgeon (Acipenser fulvescens) populations are the focus of rehabilitation efforts across the Great Lakes. Although historical fisheries were a major cause of population collapses, habitat fragmentation and/or loss and reduced access to spawning and juvenile habitat impose contemporary challenges for population recovery. The loss of connectivity between habitat types required by different life stages may particularly limit recruitment rates, inhibiting population increase towards recovery targets. We used microsatellite DNA genotyping to assess population structure, diversity, and historical connectivity of lake sturgeon in the Black Sturgeon River watershed, a major tributary of Black Bay, Lake Superior with both historical and contemporary dams. Genotype data from lake sturgeon sampled above and below an existing major barrier, as well as from lakes in the upper watershed, showed evidence of historical connectivity throughout the watershed. Despite the existing barrier fragmenting the river and preventing upstream migration, lake sturgeon from the Black Sturgeon watershed showed clear membership to a single ancestral gene pool. Estimates of genetic effective population size (N-e) for the above-and below-barrier population segments were reduced compared to the larger (watershed level) gene pool. Although the longevity of lake sturgeon has largely enabled the retention of historical genetic diversity for the population in the watershed, the reduced productive capacity of this significant tributary may have implications for recovery rates for the regional Lake Superior metapopulation. Restoring connectivity among habitats would benefit the long-term conservation and management of this species throughout this river system, and potentially the regional metapopulation.

（来源：JOURNAL OF GREAT LAKES RESEARCH 出版年：2022, **DOI:** 10.1016/j.jglr.2022.03.0070380-1330）

## A simple water clarity-turbidity index for the Great Lakes

Zheng, Guangming; DiGiacomo, Paul M.等

There are a multitude of satellite-derived water clarity and turbidity indicators to support the decision making of environmental managers and policy makers. However, water quality dynamic ranges addressed by these indicators can differ significantly, subjecting non-expert users to potential pitfalls. Here we propose a satellite water clarity-turbidity index (CTI) as a simplified way to capture major changes in water clarity/turbidity across all water types in the Great Lakes. The CTI is defined to merge key information from three prerequisite variables derived from Visible Infrared Imaging Radiometer Suite (VIIRS) measurements, namely, the Secchi disk depth, the particulate backscattering coefficient, and the nephelometric turbidity, which are suitable for clear, intermediate, and turbid waters, respectively. Application to the Great Lakes shows that with one parameter, the CTI can illustrate major spatial and temporal patterns that are not entirely visible with each of the three original indicators alone. Using the CTI, we identified significant decrease in water turbidity in Lakes Michigan and Huron from 2000 to 2005, during which daily variability of CTI in August initially spiked and then gradually decreased most likely owing to diminishing whiting events. The CTI is a convenient and holistic assessment tool for water quality management.

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## Rip currents near coastal structures in Lake Michigan: Characterization and assessment for warnings

Liu, Yuli; Wu, Chin H.

Rip currents near coastal structures commonly occur in Lake Michigan in the Great Lakes region of the United States. Lack of timely warning due to undocumented characteristics of rip currents and no assessment tool can contribute to tragic drownings incidents. In this paper, we characterized rip current occurrences near breakwater structures and developed an assessment tool for providing timely rip current warnings to beachgoers at the study site, City of Port Washington, WI. Characteristics of rip currents near the structure were observed from field measurements or visual images. Deflection rip currents had speeds of ti 0.2 m/s and lasted for several hours. The rip current occurrences were associated with environmental proxies. It was found that rip currents can occur even when the water appears calm near the structure. A Structure Rip Checklist and Assessment Matrix (SRiCAM) with a four-tiered risk was developed and validated using observations. Furthermore, the SRiCAM was integrated into cyberinfrastructure with a data contingency plan to provide real-time warnings to the public. The applicability of the SRiCAM to other locations across Lake Michigan was further tested and results are promising. Overall, the SRiCAM has the potential to be widely extended to foster recreational water safety and resilience to rip current hazards in the Great Lakes.

（来源：JOURNAL OF GREAT LAKES RESEARCH 出版年：2022, **DOI:** 10.1016/j.jglr.2022.03.0010380-1330）

## A comparison of methods for estimating euphotic depths in the Great Lakes from satellite observations

Lesht, Barry M.; Barbiero, Richard P.; Marshall, Kathleen;等

Because it defines the vertical extent of the zone of active photosynthesis, an estimate of the euphotic depth (Z(eu)), the depth in the water column at which the intensity of photosynthetically available radiation (PAR) is reduced to 1% of the intensity just below the surface, is a critical component of both depth resolved and vertically integrated numerical models of aquatic primary production. In recent years these models have become more detailed in both space and time and it is necessary to make estimates of Z(eu) at the same spatial and temporal scales. In large bodies of water such as the Great Lakes, satellite remote sensing is the only practical method available to provide such estimates at the needed resolution, but the algorithms used for estimating Z(eu) from satellite observations have not been rigorously tested in the Great Lakes. To assess these methods we used measurements of the vertical profile of PAR collected as part of the U.S. EPA's, Great Lakes National Program Office (GLNPO) annual monitoring program to estimate Z(eu). We compared the field measurements to satellite-derived estimates of Z(eu) obtained from a variety of algorithms ranging from simple empirical relationships to more complicated methods based on the inherent optical properties of the water. We found that an algorithm based on a quasi-analytic determination of absorption and backscatter coefficients that also incorporates a depth-dependent attenuation coefficient performed best.

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## Comparison of catch in multifilament and monofilament gill nets in a long-term survey on Lake Michigan

Smith, Jason B.; Jonas, Jory L.; Hayes, Daniel B.;等

Long-term fishery independent surveys provide metrics of relative abundance and contribute biological

information critical to effective fisheries management. Improvements in technology and manufacturing processes have had profound effects on gear efficiency. In Lake Michigan, a standardized multi-agency fish community survey was adopted in 1998 which used multifilament nets to survey nearshore fish communities. Contemporary commercial gill netting operations largely utilize monofilament nets because they're less expensive, more durable and thought to be less visible and therefore more efficient. As such, interest in converting long-term agency surveys to monofilament nets has grown. To compare catch rates and the size of fish collected, we set similarly configured nets of both mesh materials on the same day at standard survey locations. The most common species captured in the survey were lake trout (52%), yellow perch (19%), lake whitefish (15%), longnose sucker (8%), white sucker (4%) and burbot (1%). Monofilament nets were more efficient in capturing lake whitefish and longnose sucker and equally efficient in capturing other species. On average, nearly three times (2.85) as many lake whitefish were captured in monofilaments nets, and two times as many longnose suckers (2.13). Larger lake whitefish and yellow perch were captured in monofilament nets, whereas lake trout were slightly smaller. For other fish species, similar sizes were captured in each net material. This evaluation incorporated broad replication (298 paired nets) and representation from diverse locations and depth strata in Lake Michigan to inform gear conversion efforts and allow for adjustments as needed in gear conversion efforts.

（来源：JOURNAL OF GREAT LAKES RESEARCH 出版年: 2022, **DOI:** 10.1016/j.jglr.2022.01.004）

## Benthos of Green Bay, Lake Michigan revisited after 40 years: A temporal update and assessment of environmental associations

Olson, Cadie R.; Schmude, Kurt L.; Dimick, Jeffrey J.;等

Benthos of southern Green Bay, Lake Michigan have not been comprehensively examined since 1978. Since then, invasive species appeared, urbanization intensified, and restoration efforts were implemented, which likely altered the benthic macroinvertebrate community. Further, current benthos are subjected to dynamic factors including eutrophication, sedimentation, and periodic hypoxia. Understanding community responses to these anthropogenic stressors and natural habitat gradients is imperative to preserving biological integrity within Green Bay. Therefore, the objectives of this project were to describe the current macroinvertebrate community, examine changes since 1978, and assess the roles of productivity, substrate type, water depth, and hypoxia in structuring macroinvertebrate communities. Benthos were sampled at 197 stations, including 97 also sampled in 1978 by Markert (1982) and 100 that were added to increase spatial resolution. We collected 93 macroinvertebrate taxa in southern Green Bay with the community dominated by Chironomus and immature tubificid worms. Nonmetric multidimensional scaling (NMDS) ordination distinguished present and historical communities. Although oligochaete worms and chironomids remained dominant over time, Chironomus abundance increased and characterized the present community, whereas benthos were historically more diverse. The magnitude of temporal change varied spatially among zones of Green Bay, with larger differences concentrated in the Middle Bay and the Inner Bay remaining comparable to 1978. Present-day assemblages were most associated with the trophic gradient driven by Green Bay's southernmost tributary, the Fox River, but also differed with substrate type and had similar structures in areas subjected to frequent hypoxia. Routine monitoring should continue to track changes while accounting for spatial effects.

（来源：JOURNAL OF GREAT LAKES RESEARCH 出版年: 2022, **DOI:** 10.1016/j.jglr.2022.01.001）

## Diet differences between wild and stocked age-0 to age-3 lake trout indicate influence of early rearing environments

Marsden, J. Ellen; Schumacher, Madeline N.; Wilkins, Pascal D.;

Wild lake trout recently began to appear in abundance in Lake Champlain after over 40 years of stocking, providing an opportunity to compare the seasonal diet of wild and stocked juveniles. We sampled 2,349 age-0 to age-3 lake trout collected in bottom trawls from April to November 2015-2018, and examined the relationship between diet and spatial heterogeneity in abundance of wild and stocked juveniles. Stocked fish were, on average, the size of wild fish one year older. Wild juveniles had fewer empty stomachs and more items per stomach than stocked fish at each age. Mysis diluviana dominated the diet of age0 and age-1 wild lake trout until they began to consume fish in fall at age-1. In contrast, the diet of newlystocked fish (age-1) comprised rainbow smelt (Osmerus mordax), slimy sculpin (Cottus cognatus), alewife (Alosa pseudoharengus), with Mysis only abundant in summer and fall. Number and composition of diet items varied among geographic areas of the lake but did not explain differences in abundance of wild or stocked fish by area. Diet overlap was high between wild and stocked fish for each age class at each season, except in fall at age-0. Differences in the diet of wild and stocked juveniles likely reflect effects of early rearing experience. Recruitment of wild lake trout depends on availability and abundance of Mysis, but our diet data do not provide insight to explain why recruitment is finally occurring after a protracted delay.

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## The effect of different coverage of aquatic plants on the phytoplankton and zooplankton community structures: a study based on a shallow macrophytic lake

Zeng, Qinghui; Wei, Zhengling; Yi, Chai;等

Understanding the effect of different coverage of aquatic plants on the characteristics of the phytoplankton community structure is beneficial for management of lakes and protection of the aquatic ecosystems. In the present study, the effect of aquatic plants coverage on plankton community structure in a shallow macrophytic lake located in the middle reaches of the Yangtze River was investigated by dividing the lake into low, median, and high coverage habitats. Furthermore, the characteristics of phytoplankton and zooplankton community structures, and physicochemical indexes of lake water in the three habitats were analyzed. The results showed that an increase in aquatic plant coverage effectively reduced total phosphorus and total nitrogen in water and reduce the risks posed by phytoplankton blooms. Phytoplankton populations fluctuated slightly, and cyanobacteria density decreased in the medium coverage habitat when compared to those in the low coverage habitat. The phytoplankton species and quantity increased, and the lake water stability was enhanced in low coverage habitat when compared to those in the high coverage habitat. Zooplankton density, biodiversity index, and Pielou's evenness index of the medium coverage habitat were higher than those of the low and high coverage habitats. Our results suggest that to improve the stability of shallow lake water environment, the coverage of aquatic plants should be maintained at 26.7-33.1% based on the physicochemical properties of water bodies and variations in phytoplankton community structure.

（来源：AQUATIC ECOLOGY 出版年：2022, **DOI:** 10.1007/s10452-022-09970-w）

## Is the littoral zone taxonomically and functionally more diverse? Investigating the rotifer community of a tropical shallow lake

Coelho, Paula Nunes; Henry, Raoul

We investigated the taxonomic and functional diversity of rotifers in the littoral, intermediate, and pelagic zones of a tropical lake. Rotifers were collected at 10 sampling stations located in the three distinct zones. Taxonomic diversity was determined by species richness, abundance, and Shannon-Wiener diversity, while functional diversity was calculated using functional richness (FRic), functional evenness (FEve), and the community-weighted mean of functional traits (CWM). Redundancy analysis (RDA) were applied to ordinate the taxonomic and functional composition between the zones of the lake. The taxonomic diversity, represented by the abundance of organisms, was higher in the ecotone (i.e., intermediate zone). The RDA showed a difference between the three zones, with the occurrence of epiphytic rotifers in the littoral zone and semi-planktonic and planktonic species in the intermediate and pelagic zones. Regarding functional diversity, values of FRic and FEve did not differ between the zones. In contrast, CWM showed a distinct response between the zones of the lake. Illoricate species with raptorial characteristics, virgate trophi, and corona of the Asplanchna-type dominated in the littoral zone. In turn, microphagous rotifers, loricate species with spines, malleate trophi, and corona of the Brachionus/Euchlanis-type occurred in the intermediate and pelagic zones of the lake. The ecotone (intermediate zone) was taxonomically more diverse for the abundance of organisms compared to other two zones of the lake. For functional diversity, the three zones of the lake presented distinct functional traits.

（来源：LIMNOLOGY 出版年：2022, **DOI:** 10.1007/s10201-022-00697-z）

## Effect of alternative regional urban growth scenarios on a major urban lake

Costadone, Laura; Sytsma, Mark D.

Land use management decisions developed at the regional scale that are intended to optimize environmental quality could have negative results at a local scale. We downscaled 3 regional urban growth scenarios (low, medium, and high land conversion) to a watershed scale and assessed how different regional land-use scenarios can impact important ecosystem services provided by a major urban lake. The scenario that depicted a low land conversion and concentrated future urban growth within an urban growth boundary at the regional scale resulted in a high-density development in the area surrounding the lake at the watershed scale. This type of development resulted in an increase of more than 30% in external phosphorus input to the lake compared to current conditions. Higher external phosphorus input will likely lead to water quality deterioration, with detrimental consequences for the ecosystem services provided by the lake. Our model forecasted a reduction of 3 to 4 m in lake water transparency, which will diminish recreational benefits provided by the lake and degrade wildlife habitat. In the next decades, population growth and land conversion will likely cause the resurgence of serious eutrophication symptoms. The reinforcement of nutrient management practices in the lake watershed will be necessary to offset the negative impact of urbanization from regional scale planning. Land-use policies developed at regional scales should consider trade-offs that impact highly valued local sources of ecosystem services.

（来源：LAKE AND RESERVOIR MANAGEMENT 出版年：2022, **DOI:** 10.1080/10402381.2022.2076634）

## Testing the effect of the submerged macrophyte Ceratophyllum demersum (L.) on heterotrophic bacterioplankton densities under different levels of nitrogen and phosphorus concentrations in shallow lake mesocosms

Cun, Deshou; Dai, Yanran; Fan, Yaocheng;等

To investigate the effect of submerged macrophytes on heterotrophic bacterioplankton communities in response to nutrient enrichment, we simulated mesocosms to test two factors, namely, the presence of Ceratophyllum demersum (L.) and the level of nutrients (slight and medium nutrient enrichment) under four possible system combinations for a duration of more than 3 months. The results show that C. demersum can affect the temporal dynamics of heterotrophic bacterioplankton density (HBD) and cause it to decrease. However, the effect of C. demersum on HBD was more pronounced under medium nutrient enrichment. The mean values of HBD in the treatment and control systems under slight nutrient enrichment were 1.30 x 10(5) cells mL(-1) and 1.34 x 10(5) cells mL(-1), respectively; whereas for medium nutrient enrichment, they were 1.78 x 10(5) cells mL(-1) and 2.65 x 10(5) cells mL(-1), respectively. The total nitrogen (TN) and total phosphorus (TP) concentrations were maintained throughout the experiment, and no significant differences were observed in the pH value, chlorophyll a (Chl. a) concentrations or dissolved organic carbon (DOC) levels between the systems with and without macrophytes, regardless of the nutrient level. Furthermore, linear mixed models revealed that environmental variables had a limited impact on HBD and that C. demersum had no significant direct effect on the environmental variables in the systems. A likely explanation is higher predation on bacterioplankton in the mesocosms, although allelopathic effects exerted by C. demersum cannot be excluded.

（来源：JOURNAL OF FRESHWATER ECOLOGY 出版年：2022, **DOI:** 10.1080/02705060.2022.2083709）

## Drivers of fish trophic guild composition in lakes of the Upper Parana River floodplain

Lopes, Taise Miranda; Muniz, Carolina Mendes; Schmitz, Marcelo Henrique;等

In freshwater ecosystems, flood pulses, the degree of connectivity between environments, and the vegetation mosaic are among the main variables affecting environmental structure at the landscape scale. At a finer scale, local limnological conditions seem to be more important for structuring river fish assemblages. However, rather than exerting isolated effects, these limnological characteristics can have combined impacts on the environment. We evaluated the main drivers of the spatial structuring of fish trophic guilds in the littoral zone of lakes in the Upper Parana River floodplain (UPRF) and determined the relative importance of limnological conditions, spatial distance, and riparian vegetation. We sampled fish and limnological variables in June, September, and December of 2011, and classified the fish species into trophic guilds. We used variation partitioning analysis to assess the influence of the three sets of predictors and distance-based redundancy analysis to visualize the position of samples, as described by the composition of trophic guilds in multivariate space. The distribution of trophic guilds was mainly influenced by limnological variables, i.e., conductivity, chlorophyll a, and pH, in periods of low water. Spatial and riparian vegetation predictors, despite being low, also influenced the distribution because limnological variables and riparian vegetation of the UPRF have a well-defined spatial structure due to differences between rivers. The lakes with Class III riparian vegetation (dominated by tree species) supported most of the trophic guilds, including insectivores. This indicates that allochthonous materials,

even when they occur in smaller proportions, contribute to the structuring of fish communities in periods of low water.

（来源：AQUATIC SCIENCES 出版年：2022, **DOI:** 10.1007/s00027-022-00860-9）

## Phytoplankton taxonomic and functional diversity in two shallow alluvial lakes with contrasting river connectivity

Frau, Diego; Pineda, Alfonso; Mayora, Gisela;等

The mechanisms behind phytoplankton diversity patterns in natural ecosystems still remain elusive. In two shallow lakes with contrasting river connectivity, we first explored how diversity within each sampling (alfa diversity, alpha), among samplings (beta diversity, beta 1), and among hydrological seasons (beta 2) contributed to the diversity registered throughout the whole year (gamma diversity, gamma). Then we estimated the importance of several environmental and temporal factors as structuring factors of these diversity patterns. To do this, we sampled the two lakes-one laterally isolated and other laterally connected lake with the Parana River System-during a complete hydrological year. For the analyses, we considered both the species and the functional group level. At the species level, temporal variation (beta 1 + beta 2) made the main contribution for gamma diversity at the connected lake, possibly related to the constant species input from the river system. For the isolated lake, however, alpha was the main contributor. Regarding functional groups, alpha was the most important for both lakes, although no element of gamma diversity was different from the null model. Environmental factors like conductivity, turbidity, nutrient availability, and flood phases appeared as more relevant for the connected lake. Temporal processes (e.g., succession, ecological drift) were critical for the observed diversity patterns in both lakes. These results were consistent particularly considering the taxonomical approach. Our main findings are that the environment influences phytoplankton diversity patterns; however, other dynamics occurring on temporal scales may be more relevant for the phytoplankton community.

（来源：AQUATIC SCIENCES 出版年：2022, **DOI:** 10.1007/s00027-022-00857-4）

## Air2water model with nine parameters for lake surface temperature assessment

Piotrowski, Adam P.; Zhu, Senlin; Napiorkowski, Jaroslaw J.

The air2water model is a physically-based model in which major physical processes are parameterized. It allows to predict the surface lake temperature based solely on the time series of the air temperature. Due to its simplicity and very limited data requirements, it has found numerous applications around the globe. The air2water model defines the normalized depth of the well-mixed surface layer using a fixed parameter. This parameter is a threshold value that is set to 4 degrees C - the temperature of water with maximum density - for dimictic lakes, and to the minimum or to the maximum water temperature for warm or cold monomictic lakes, respectively. In this paper we propose to calibrate the threshold value as the ninth parameter of the model, instead of setting it fixed. We test the proposed approach on a set of 30-years long daily data from 22 lakes located in the lowland part of Poland and 25-years long daily data from the two Great Lakes - Huron and Eire. The proposed modification is very simple and improves the performance of the model, especially for winter-spring season, for the vast majority of lakes not only for the calibration, but also for the independent 8-10 years long validation data.

（来源：LIMNOLOGICA 出版年：2022, **DOI:** 10.1016/j.limno.2022.125967）

## New insights into identifying sediment phosphorus sources in river-lake coupled system: A framework for optimizing microbial community fingerprints

Sun, Chenyue; Xiong, Wei; Zhang, Wenlong;等

Identifying sediment phosphorus sources in river-lake coupled system is a question in developing preferential control strategies for phosphorus. As sediments adsorbed phosphorus and microbes would be transported with changing hydrodynamic, the phosphorus source-specific microbial community fingerprints shed light on determining the major sediment phosphorus sources. However, the identification of microbial community fingerprints is a challenge because both microbial succession and hydrological characteristics of river-lake systems would affect the stability of fingerprints. Therefore, this study provided a framework for optimizing phosphorus source-specific microbial community fingerprints, and attempted to identify the major sources of sediment phosphorus in river-lake coupled ecosystem. Meiliang Lake is one of the highly eutrophic area in Taihu Lake, where the sediments, bacterial communities, and phosphorus had a close relationship. Through analyzing the connectivity of microbes along water continuum, a microbial fingerprints candidate database was constructed. The phosphorus-related bacterial communities were screened and optimized by comparing the difference of predicted results between upstream and downstream, forming the stable microbial community fingerprints which consisted of Bacteroidia, Bacilli, Clostridia, and other species at the class level. SourceTracker results that based on the optimized phosphorus source-specific microbial community fingerprints indicated that the major sediment phosphorus sources to Meiliang Lake were Liangxi River, Wujingang River, and Donghuandi River, with the relative standard deviations ranging from 2.59% to 27.56%. The accuracy of phosphorus source apportionments was further confirmed based on the composite pollution index and hydrodynamic condition. This study put forward suggestions on how to improve the stability of microbial community fingerprints, and would help to improve the understanding of applying microbial source tracking method to identify the sources of abiotic pollution like sediment phosphorus.

（来源：ENVIRONMENTAL RESEARCH 出版年：2022, **DOI:** 10.1016/j.envres.2022.112854）

## Dissolved organic carbon concentration and biodegradability across the global rivers: A meta-analysis

Liu, Futing; Wang, Dong

Riverine dissolved organic carbon (DOC) exerts a vital role in the global carbon cycle. Although substantial studies have explored DOC dynamics in aquatic ecosystems, it remains unknown about the patterns and drivers of riverine DOC concentration and biodegradability at the global scale. Here, by synthesizing 396 data points from 42 published literatures worldwide, we explored the spatial variations and controls of riverine DOC concentration and biodegradability. Our results revealed that the DOC concentration varied largely across the global rivers, with an average concentration of 10.4 mg L-1. The variations of DOC concentration were influenced by mean annual precipitation, vegetation type, soil type, permafrost degradation and river order. Furthermore, our results illustrated that the riverine DOC also had high biodegradability, showing an average of 16.4% loss within less than 90 days. The biodegradability of DOC was dominantly regulated by inorganic nutrients and DOC composition, but the controlling factors exhibited significant differences between small streams and large rivers. For small streams, DOC composition was the primary driver influencing DOC biodegradability, while for large rivers,

nitrogen availability became the dominant factor affecting DOC biodegradability. This study highlights the high concentration and biodegradability of riverine DOC, which could exert an important role in the feedbacks between the global carbon cycle and climate warming.

（来源：SCIENCE OF THE TOTAL ENVIRONMENT 卷:818 出版年: 2022, **DOI:** 10.1016/j.scitotenv.2021.151828）

## Contributions of moisture sources to precipitation in the major drainage basins in the Tibetan Plateau

Li, Ying; Su, Fengge; Tang, Qiuhong; 等

Tracking and quantifying the moisture sources of precipitation in different drainage basins in the Tibetan Plateau (TP) help to reveal basin-scale hydrological cycle characteristics under the interactions between the westerlies and Indian summer monsoon (ISM) systems and to improve our understanding on the mechanisms of water resource changes in the 'Asian Water Tower' under climate changes. Based on a Eulerian moisture tracking model (WAM-2) and three atmospheric reanalysis products (ERA-I, MERRA-2, and JRA-55), the contributions of moisture sources to the precipitation in six major sub-basins in the TP were tracked during an approximately 35-year period (1979/1980-2015). The results showed that in the upper Indus (UI), upper Tarim River (UT), and Qaidam Basin (QB), the moisture sources mainly extended westward along the mid-latitude westerlies to the western part of the Eurasian continent. In contrast, in the Brahmaputra (BR), inner TP (ITP), and the source area of three eastern rivers (TER, including the Nujiang River, Lancang River, and Yangtze River), the moisture sources extended both westward and southward, but mainly southward along the ISM. In winter and spring, all of the sub-basins were dominated by western moisture sources. In summer, the western sources migrated northward with the zonal movement of the westerlies, and simultaneously the southern sources of the BR, ITP, and TER expanded largely toward the Indian Ocean along the ISM. In autumn, the moisture sources of the UI, UT, and QB shrank to the western sources, and the moisture sources of the BR, ITP, and TER shrank to the central-southern TP and the Indian subcontinent. By quantifying the moisture contributions from multiple sources, we found that the terrestrial moisture dominated in all of the sub-basins, particularly in the UT and QB (62-73%). The oceanic contributions were relatively high in the UI (38-42 degrees%) and BR (38-41%). In winter, evaporation from the large western water bodies (such as the Mediterranean, Red Sea, and Persian Gulf) was significantly higher than that from the continental areas. This contributed to the peak (valley) values of the oceanic (terrestrial) moisture contributions to all of the sub-basins. In summer, the terrestrial moisture contributions to the UI, UT, and QB reached their annual maximum, but the abundant oceanic moisture transported by the ISM restrained the appearance of land source contribution peaks in the BR, ITP, and TER, resulting in almost equal moisture contributions in the BR from the ocean and land.

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## Projected changes in terrestrial water storage and associated flood potential across the Yangtze River basin

Xiong, Jinghua; Guo, Shenglian; Yin, Jiabo; 等

Terrestrial water storage is a crucial component in water cycle and plays an important role in flood formations process, particularly in a changing environment. In this study, we aim to examine the future variation of terrestrial water storage anomaly (TWSA) and associated flood potential in one of the most flood-prone regions, the Yangtze River basin in China. Using the Gravity Recovery and Climate

Experiment (GRACE) data, we perform bias correction for seven general circulation models (GCMs) from the Coupled Model Intercomparison Project Phase 6 under three Shared Socio-economic Pathway (SSP) scenarios: SSP126, SSP245, and SSP585. The spatiotemporal characteristics of changes in future Flood Potential Index are projected and compared between the near (2031-2060) and far (2071-2100) future with reference to the historical period (1985-2014). The results show that GCMs-simulated TWSA generally agrees well with the GRACE results after downscaling and bias correction with the average correlation coefficient of 0.86, Nash-Sutcliffe efficiency of 0.73 and the root mean square error of 21.68 mm. We found that the total variance of projected TWSA is mainly sourced from the internal variability and model uncertainties, while the uncertainties in scenarios contribute relatively less. Moreover, the flood potential is projected to decline during the near future under various scenarios and even lower during the far future under SSP585 scenario. Our findings provide implications for flood control and management under climate change over high flood risk regions worldwide.

（来源：SCIENCE OF THE TOTAL ENVIRONMENT 卷:817 出版年: 2022, **DOI:** 10.1016/j.scitotenv.2022.152998）

## Increasing global urban exposure to flooding: An analysis of long-term annual dynamics

Cao, Wenting; Zhou, Yuyu; Guneralp, Burak; 等

An improved understanding of global Urban Exposure to Flooding (UEF) is essential for developing risk-reduction strategies for sustainable urban development. This study is the first to assess the long-term historical global UEF at a fine spatial resolution (i.e., 30 m) and annual temporal frequency, with consideration of smaller urban areas in the exposure assessment compared to those using coarse resolution data. We assessed the UEF by investigating the spatially explicit urban expansion in the 100-year floodplain extents. The global UEF increased more than four-fold from 16,443 km(2) in 1985 to 92,233 km(2) in 2018 with accelerated temporal trends. The most notable growth in UEF occurred in Asia (74.1%), followed by Europe (11.6%), Northern America (8.7%), Africa (2.9%), Southern America (2.2%), and Australia (0.5%). Notably, China and US were the two countries with the largest UEF, accounting for about 61.5% of global growth in UEF. In addition, only 1.2% of global floodplains were occupied by urban expansion by 2018, whereas this percentage reached 20% in the basins of Western Europe, Eastern Asia, and Northeastern US. Moreover, although the floodplains only accounted for 5.5% of the global land areas, 12.6% of the urban expansion occurred in the floodplains from 1985 to 2018, with the most rapid increases in the basins in Southeastern and Eastern China. Our findings highlight that the trends of accelerated increasing urban exposure to flooding have been occurring for at least the past three decades.

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## Why wastewater treatment fails to protect stream ecosystems in Europe

Buettner, Olaf; Jawitz, James W.; Birk, Sebastian; 等

There is significant debate about why less than half of European rivers and streams are in good ecological status, despite decades of intense regulatory efforts. Of the multiple stressors that are recognized as potential contributors to stream degradation, we focus on discharge from 26,500 European wastewater treatment plants (WWTPs). We tested the hypothesis that stream ecological status

degradation across Europe is related to the local intensity of wastewater discharge, with an expected stream-order (omega) dependence based on the scaling laws that govern receiving stream networks. We found that ecological status in streams (omega & LE;3) declined consistently with increasing urban wastewater discharge fraction of stream flow (UDF) across river types and basins. In contrast, ecological status in larger rivers (omega & GE;4) was not related to UDF. From a continental-scale logistic regression model (accuracy 86%) we identified an ecologically critical threshold UDF = 6.5% +/- 0.5. This is exceeded by more than one third of WWTPs in Europe, mostly discharging into smaller streams. Our results suggest that new receiving water-specific strategies for wastewater management are needed to achieve good ecological status in smaller streams.

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## Dam construction attenuates trace metal contamination in water through increased sedimentation in the Three Gorges Reservoir

Bing, Haijian; Liu, Ye; Huang, Jiacong; 等

Dam construction has a far-reaching impact on trace metal accumulation and the metal-induced quality of the aquatic environment. However, the long-term impacts of dam construction and impoundments on the spatial distribution of trace metals and water quality remain poorly understood. Here, we found that the concentrations of trace metals in the mainstream water of the world's largest reservoir, Three Gorges Reservoir (TGR), decreased after impoundment, while their concentrations and contamination in the sediments of the water-level fluctuation zone increased significantly, especially for anthropogenic sources of metals such as cadmium, lead, and zinc. The spatial and temporal variations of anthropogenic metals in the sediments revealed increased anthropogenic dominance in their distribution under current hydrological management, especially for the urban area of the upper TGR. Sediment fluxes, particle composition, and extreme climate modulated the distribution of trace metals in the sediments. The results demonstrate that human activities have increasingly determined the distribution and contamination state of trace metals in the mainstream TGR. However, in contrast to our previously thought, the anthropogenic discharge of trace metals did not adversely affect water quality. Our results indicate that dam construction in riverine systems attenuates trace metal contamination in water through sediment sorting and deposition.

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## Damming alters the particulate organic carbon sources, burial, export and estuarine biogeochemistry of rivers

Wang, Hao; Ran, Xiangbin; Bouwman, Alexander F.; 等

The long-term changes in composition and export of particulate organic carbon (POC) by rivers due to dam construction are poorly known. Based on observations, incubation experiments and modelling, this study analyzed the sources, spatial and temporal distribution and annual export of POC in the Changjiang River during recent decades to explore the POC changes due to dam construction. Changes in POC composition resulted from both increasing POC sequestration and carbon fixation in the river basin. The allochthonous POC (from terrestrial input) export by the Changjiang River to its estuary decreased by ~90% between 1956 and 2002 and 2013-2019. We estimated that 2.3 & nbsp;+/- 0.5 Mt C/yr allochthonous POC has been sequestered in the Changjiang watershed since 2013. The

autochthonous (entirely from in-stream riverine primary production) contribution increased from 1% to 55% of total POC export during the same period due to improved light transparency caused by decreased sediment discharge. Global POC trapping in nine large rivers strongly impacted by dams is 12% of the global riverine POC export. The reduced POC export and increase in labile autochthonous POC strongly impact the estuarine carbon cycle. Therefore, with continued dam construction in the future, important changes in the riverine and estuarine carbon cycle can be expected.

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## Advancing prediction of emerging contaminants in a tropical reservoir with general water quality indicators based on a hybrid process and data-driven approach

Tong, Xuneng; You, Luhua; Zhang, Jingjie; 等

Monitoring and predicting the occurrence and dynamic distributions of emerging contaminants (ECs) in the aquatic environment has always been a great challenge. This study aims to explore the potential of fully utilizing the advantages of combining traditional process-based models (PBMs) and data-driven models (DDMs) with general water quality indicators in terms of improving the accuracy and efficiency of predicting ECs in aquatic ecosystems. Two representative ECs, namely Bisphenol A (BPA) and N, N-diethyltoluamide (DEET), in a tropical reservoir were chosen for this study. A total of 36 DDMs based on different input datasets using Artificial Neural Networks (ANN) and Random Forests (RF) were examined in three case studies. The models were applied in prognosis validation based on easily accessible data on water quality indicators. Our results revealed that all the models yielded good fits when compared to the observed data. These new insights into the advantages using the combination of traditional PBMs and DDMs with general water quality datasets help to overcome the constraints in terms of model accuracy and efficiency as well as technical and budget limitations due to monitoring surveys and laboratory experiments in the study of fate and transport of ECs in aquatic environments.

（来源：JOURNAL OF HAZARDOUS MATERIALS 卷:430 出版年: 2022, **DOI:** 10.1016/j.jhazmat.2022.128492）

## Long-term riverine nitrogen dynamics reveal the efficacy of water pollution control strategies

Wu, Kaibin; Hu, Minpeng; Zhang, Yufu; 等

Identification of long-term water quality trends in response to watershed anthropogenic interventions is crucial for developing and adapting water pollution control strategies. This study represents the first use of the Weighted Regressions on Time, Discharge, and Season (WRTDS) model to evaluate trends and sources of riverine nitrogen (N) levels over the 1980-2019 period in the Yongan River watershed of eastern China. The WRTDS model showed satisfactory accuracies for predicting daily riverine total N (TN), $NH_4$+ and $NO_3$- concentrations/loads (R2 > 0.55, n = 366). Modeled flow-normalized riverine $NH_4$+ concentration increased by 789% from 1980 to 2009 and then decreased by 63% in 2010-2019. This changing trend for riverine $NH_4$+ concentration was mainly attributed to a 43% decrease of wastewater $NH_4$+ discharge load in 2010-2019 due to establishment of three new WWTPs in urban areas and enhanced rural domestic sewage collection/treatment. Although chemical N fertilizer use decreased by 49% and domestic animal numbers decreased by 73% in 2000-2019, flow-normalized riverine TN and $NO_3$- concentrations progressively increased by 161% and 232% in 1980-2019, respectively. The

paradox between decreasing N inputs and increasing riverine TN/ $NO_3$- concentrations is attributed to inputs of legacy N from soil and groundwater. This is supported by the 3.8-fold increase of riverine $NO_3$- concentration in 1980-2019 (86% increase in 2000-2019) following 10-days with no-precipitation (representing groundwater contributions to baseflow) and a 4.1-fold increase of riverine $NO_3$- concentration in 1980-2019 (91% increase in 2000-2019) following the first rainstorm after 10-days of no-precipitation (representing soil flushing). These results document that point-source pollution control efforts were effective, whereas benefits from nonpointsource pollution control were masked by inputs from legacy N pollution. The WRTDS model was demonstrated to be a useful tool for assessing long-term riverine N pollution dynamics and sources, thereby providing decision-makers with critical information to guide watershed N pollution control strategies.

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## Temporal and spatial hydrological variations of the Yellow River in the past 60 years

Xu, Mengzhen; Wang, Guanghui; Wang, Zijing; 等

Understanding water and sediment variations of the Yellow River is significant for future management of the river from perspectives of water resources utilization and ecology protection. The study characterized the temporal and spatial variations in its flow and sediment load based on the daily datasets of the past 60 years from all main-stem hydrological gauge stations, and proposed a new five-segment river reach division scheme instead of the traditional three- or four-segment division. Furthermore, we distinguished the key factors and their contributions that caused the flow and sediment variations, offering reference for the river management stra-tegies as per the local conditions. A significant decreasing trend in annual flow and sediment load was observed in the river basin, except for certain reaches in Segment 1 (upstream of Tangnaihai). The maximum flood-event duration decreased significantly in Segment 2 (from Tangnaihai to Shizuishan). The flood volume and sediment load during the maximum flood event also showed significant downward trend in Segments 2-5 (downstream of Tangnaihai). Operation of cascade reservoirs, especially in Segment 2, has smoothed the annual flow process in the upstream. Sediment trapping in the reservoirs had little effect on the change in sediment load, but reservoir regulation of flow greatly influenced siltation in the upstream river channel. Water abstraction has also played a significant role in flow variation. Consequently, the ratio of flood sediment load to annual sediment load decreased significantly in the upper reach, but increased significantly in the lower reach. Temporally, the recorded period was divided into three periods using change point detection: pre- 1987, 1987-1999, and post 1999. The ratio of flood volume to annual flow decreased significantly in the first two periods, and generally increased post 1999, with the impact of aforementioned anthropogenic activities.

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## A global synthesis of human impacts on the multifunctionality of streams and rivers

Brauns, Mario; Allen, Daniel C.; Boechat, Iola G.; 等

Human impacts, particularly nutrient pollution and land-use change, have caused significant declines in the quality and quantity of freshwater resources. Most global assessments have concentrated on species diversity and composition, but effects on the multifunctionality of streams and rivers remain unclear. Here,

we analyse the most comprehensive compilation of stream ecosystem functions to date to provide an overview of the responses of nutrient uptake, leaf litter decomposition, ecosystem productivity, and food web complexity to six globally pervasive human stressors. We show that human stressors inhibited ecosystem functioning for most stressor-function pairs. Nitrate uptake efficiency was most affected and was inhibited by 347% due to agriculture. However, concomitant negative and positive effects were common even within a given stressor-function pair. Some part of this variability in effect direction could be explained by the structural heterogeneity of the landscape and latitudinal position of the streams. Ranking human stressors by their absolute effects on ecosystem multifunctionality revealed significant effects for all studied stressors, with wastewater effluents (194%), agriculture (148%), and urban land use (137%) having the strongest effects. Our results demonstrate that we are at risk of losing the functional backbone of streams and rivers if human stressors persist in contemporary intensity, and that freshwaters are losing critical ecosystem services that humans rely on. We advocate for more studies on the effects of multiple stressors on ecosystem multifunctionality to improve the functional understanding of human impacts. Finally, freshwater management must shift its focus toward an ecological function-based approach and needs to develop strategies for maintaining or restoring ecosystem functioning of streams and rivers.

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## Global methane and nitrous oxide emissions from inland waters and estuaries

Zheng, Yajing; Wu, Shuang; Xiao, Shuqi; 等

Inland waters (rivers, reservoirs, lakes, ponds, streams) and estuaries are significant emitters of methane ($CH_4$) and nitrous oxide ($N_2O$) to the atmosphere, while global estimates of these emissions have been hampered due to the lack of a worldwide comprehensive data set of $CH_4$ and $N_2O$ flux components. Here, we synthesize 2997 in-situ flux or concentration measurements of $CH_4$ and $N_2O$ from 277 peer-reviewed publications to estimate global $CH_4$ and $N_2O$ emissions from inland waters and estuaries. Inland waters including rivers, reservoirs, lakes, and streams together release 95.18 Tg $CH_4$ year(-1) (ebullition plus diffusion) and 1.48 Tg $N_2O$ year(-1) (diffusion) to the atmosphere, yielding an overall $CO_2$-equivalent emission total of 3.06 Pg $CO_2$ year(-1). The estimate of $CH_4$ and $N_2O$ emissions represents roughly 60% of $CO_2$ emissions (5.13 Pg $CO_2$ year(-1)) from these four inland aquatic systems, among which lakes act as the largest emitter for both $CH_4$ and $N_2O$. Ebullition showed as a dominant flux component of $CH_4$, contributing up to 62%-84% of total $CH_4$ fluxes across all inland waters. Chamber-derived $CH_4$ emission rates are significantly greater than those determined by diffusion model-based methods for commonly capturing of both diffusive and ebullitive fluxes. Water dissolved oxygen (DO) showed as a dominant factor among all variables to influence both $CH_4$ (diffusive and ebullitive) and $N_2O$ fluxes from inland waters. Our study reveals a major oversight in regional and global $CH_4$ budgets from inland waters, caused by neglecting the dominant role of ebullition pathways in those emissions. The estimated indirect $N_2O$ EF5 values suggest that a downward refinement is required in current IPCC default EF5 values for inland waters and estuaries. Our findings further indicate that a comprehensive understanding of the magnitude and patterns of $CH_4$ and $N_2O$ emissions from inland waters and estuaries is essential in defining the way of how these aquatic systems will shape our climate.

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## Anoxia decreases the magnitude of the carbon, nitrogen, and phosphorus sink in freshwaters

Carey, Cayelan C.; Hanson, Paul C.; Thomas, R. Quinn; 等

Oxygen availability is decreasing in many lakes and reservoirs worldwide, raising the urgency for understanding how anoxia (low oxygen) affects coupled biogeochemical cycling, which has major implications for water quality, food webs, and ecosystem functioning. Although the increasing magnitude and prevalence of anoxia has been documented in freshwaters globally, the challenges of disentangling oxygen and temperature responses have hindered assessment of the effects of anoxia on carbon, nitrogen, and phosphorus concentrations, stoichiometry (chemical ratios), and retention in freshwaters. The consequences of anoxia are likely severe and may be irreversible, necessitating ecosystem-scale experimental investigation of decreasing freshwater oxygen availability. To address this gap, we devised and conducted REDOX (the Reservoir Ecosystem Dynamic Oxygenation eXperiment), an unprecedented, 7-year experiment in which we manipulated and modeled bottom-water (hypolimnetic) oxygen availability at the whole-ecosystem scale in a eutrophic reservoir. Seven years of data reveal that anoxia significantly increased hypolimnetic carbon, nitrogen, and phosphorus concentrations and altered elemental stoichiometry by factors of 2-5x relative to oxic periods. Importantly, prolonged summer anoxia increased nitrogen export from the reservoir by six-fold and changed the reservoir from a net sink to a net source of phosphorus and organic carbon downstream. While low oxygen in freshwaters is thought of as a response to land use and climate change, results from REDOX demonstrate that low oxygen can also be a driver of major changes to freshwater biogeochemical cycling, which may serve as an intensifying feedback that increases anoxia in downstream waterbodies. Consequently, as climate and land use change continue to increase the prevalence of anoxia in lakes and reservoirs globally, it is likely that anoxia will have major effects on freshwater carbon, nitrogen, and phosphorus budgets as well as water quality and ecosystem functioning.

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## Glacier shrinkage will accelerate downstream decomposition of organic matter and alters microbiome structure and function

Kohler, Tyler J.; Fodelianakis, Stilianos; Michoud, Gregoire; 等

The shrinking of glaciers is among the most iconic consequences of climate change. Despite this, the downstream consequences for ecosystem processes and related microbiome structure and function remain poorly understood. Here, using a space-for-time substitution approach across 101 glacier-fed streams (GFSs) from six major regions worldwide, we investigated how glacier shrinkage is likely to impact the organic matter (OM) decomposition rates of benthic biofilms. To do this, we measured the activities of five common extracellular enzymes and estimated decomposition rates by using enzyme allocation equations based on stoichiometry. We found decomposition rates to average 0.0129 (% d(-1)), and that decreases in glacier influence (estimated by percent glacier catchment coverage, turbidity, and a glacier index) accelerates decomposition rates. To explore mechanisms behind these relationships, we further compared decomposition rates with biofilm and stream water characteristics. We found that chlorophyll-a, temperature, and stream water N:P together explained 61% of the variability in decomposition. Algal biomass, which is also increasing with glacier shrinkage, showed a particularly strong relationship with decomposition, likely indicating their importance in contributing labile organic

compounds to these carbon-poor habitats. We also found high relative abundances of chytrid fungi in GFS sediments, which putatively parasitize these algae, promoting decomposition through a fungal shunt. Exploring the biofilm microbiome, we then sought to identify bacterial phylogenetic clades significantly associated with decomposition, and found numerous positively (e.g., Saprospiraceae) and negatively (e.g., Nitrospira) related clades. Lastly, using metagenomics, we found evidence of different bacterial classes possessing different proportions of EEA-encoding genes, potentially informing some of the microbial associations with decomposition rates. Our results, therefore, present new mechanistic insights into OM decomposition in GFSs by demonstrating that an algal-based green food web is likely to increase in importance in the future and will promote important biogeochemical shifts in these streams as glaciers vanish.

（来源：GLOBAL CHANGE BIOLOGY 出版年: 2022, **DOI:** 10.1111/gcb.16169）

## 湖泊水位记录支持中国北方全新世中期降水达到最高值

曹建涛，饶志国，石福习 等

20 世纪 60 年代，东亚夏季风北边界的湖泊水位记录所指示的区域全新世夏季风演化历史备受争议。文章以中国北方一个封闭湖泊过去 15000 年来甘油二烷基甘油四醚(GDGTs)的记录来探讨此问题。湖泊表层和岩芯沉积物数据结果显示，GDGT-0 和 brGDGTs 均来源于湖泊内部自生。从湖岸到湖中心，表层沉积物中 GDGT-0 和 brGDGTs 含量随着水深增加而逐渐增加，且由 brGDGTs 得出的温度数值逐渐减小。这是由于生产这些 GDGTs 的厌氧微生物偏向于在缺氧的底层湖水环境中生存。相应地，基于 brGDGTs 的温度与 pH 指标应该反映的是湖泊底层水的状态，而底层水状态很大程度上受控于湖泊水位或水深的变化。岩芯沉积物中 GDGTs 记录结果显示，末次冰消期到早全新世，湖泊水位逐渐增加； 9.5～5ka BP 期间水位保持高值，5ka BP 之后水位逐渐降低。本文得出的独立可靠的湖泊水位变化记录大致与该区域的孢粉记录一致，均支持全新世中期区域降水达到最高值。

（来源：中国科学:地球科学 2022,52(01):113-132）

## 青藏高原降水再循环率与水汽来源辨析

阳坤，汤秋鸿，卢麾

降水再循环率(即蒸发-降水反馈强度)和水汽来源是区域水循环的两个关键环节，它们的量化对于理解水循环过程及其变化至关重要。关于青藏高原降水再循环率和水汽源的已有研究结果存在很大争议。文章厘清了理解水循环的不同视角，指出蒸发与降水之比主要取决于气候模态，而降水再循环率还与区域大小密切相关，水汽源区则取决于追踪时段(降水时段或非降水时段)和追踪程度。在同一理论框架下，关于青藏高原水循环的不同研究结果之间不存在根本冲突。

（来源：中国科学:地球科学 2022,52(03):574-578）

## 中国陆地生态系统碳汇估算:方法、进展、展望

朴世龙，何悦，王旭辉 等

2020 年 9 月，中国向世界宣示力争 2030 年前实现碳达峰、2060 年前实现碳中和的目标。这一背景下，中国陆地生态系统碳汇潜力受到空前关注，成为各国政府、学术界、公众共同关心的热点议题。文章聚焦中国陆地生态系统碳汇估算，梳理不同估算方法的原理、优点和不足，对比不同研究和方法得到的中国陆地生态系统碳汇大小，评述目前的研究进展及存在的问题，并对未来研究思路提出建议，以期为准确估算中国陆地生态系统碳汇提供方法论参考，为中国制定实现碳中和的减排政策提供科学支撑。

（来源：中国科学:地球科学　2022,52(06):1010-1020）

## 青藏高原东缘地热活动对河流水、碳输送影响

钟君，李思亮，李铮等

造山带地区显著的地热活动对地表过程产生显著且深远的影响，而地热活动对河流水、碳输送的影响仍鲜有报道。据此，本研究对青藏高原东缘温泉和河流水进行了采集，并对其化学组成、溶解无机碳（DIC）的稳定及放射性碳同位素组成(δ13CDIC 和Δ14CDIC)进行了分析。结果表明，温泉样品离子浓度变化范围较大，其中碱度主要来自于高温硅酸岩的溶解。地表水混入导致温泉水化学及Δ14CDIC 发生明显的改变。基于Δ14CDIC 实测值与变质成因Δ14CDIC 理论值（－1000‰）之间的差异，通过同位素平衡方程，定量计算了地表水对温泉水的贡献。对地热流体中离子浓度进行校正后，通过 Ge/Si 比值的化学平衡，利用蒙特卡罗算法计算了变质流体对地表水的贡献。结果表，青藏高原东缘大河中变质流体对地表水的贡献变化范围为 0.17%（黄河）～0.52%（金沙江，而部分位于断裂带的支流，深部水的贡献明显较高；变质碳对青藏高原东缘大河溶解无机碳的贡献变化范围为 0.87～3.96%，而变质碳脱气作用造成的二氧化碳排放通量则更高。本研究对于深部流体贡献的估算值明显低于前人对喜马拉雅小流域的估算结果，并证明前人可能高估了青藏高原变质碳通量。本研究重点阐明构造活动区河流中变质碳的贡献比例，弱化了造山运动加速化学风化的结果，这一初步结果表明，在未来的研究中应开展更加系统性的工作以更加精确地评估青藏高原变质碳的通量。

（来源：中国科学:地球科学　2022,52(05):932-941）

## 黄河流域地质地表过程与重大灾害效应研究与展望

兰恒星，彭建兵，祝艳波等

黄河流域地质构造活跃、地貌演化迅速、气候区域分异显著，流域重大灾害类型多、分布广、突发性强，且灾害往往链生成链、致灾后果严重，破坏黄河流域生态环境，影响流域地质与生态安全。目前，大江大河流域地质地表过程与重大灾害效应是地球科学研究的国际前沿与热点。为此，文章详细梳理了与黄河流域地质地表过程、重大灾害效应、风险防范有关的国内外研究现状与发展动态，探讨了研究趋势和面临的挑战，分析了亟需突破的关键科学问题，并基于地球系统科学思想提出了研究展望。黄河流域地质地表过程与重大灾害效应研究的主要方向有：黄河流域地质、地表和气候过程及其联动孕灾机制，黄河流域上游巨型

滑坡形成机理及灾害链演化，黄河流域中游黄土地区水土灾害机制与灾害链生效应，黄河流域下游巨型洪灾发生规律及链生放大效应，黄河流域重大灾害风险防范。亟待突破的关键科学问题为：如何揭示地质、地表与气候过程耦合联动孕育重大灾害机制，如何阐明重大灾害与生态互馈效应，如何构建基于人地协调的流域重大灾害风险综合防控体系。研究展望包括：以地球系统科学理论为指导，突出学科交叉融合，从“重建历史-聚焦现代-展望未来”的时间轴尺度揭示黄河流域地质、地表与气候联动孕灾机制；创新理论体系，从“地-域-河”的空间轴尺度阐明黄河流域重大灾害区域模式、动力学机制、灾害链生与生态互馈效应；突破技术瓶颈，从"人地协调观"角度建立黄河流域综合风险评估模型与防控理论，形成“全流域覆盖、分区分带管控”应用示范格局，保障流域生态地质安全，为黄河流域生态保护和高质量发展提供科学参考。

（来源：中国科学:地球科学 2022,52(02):199-221）

## 多尺度多要素水文变化与极移的关系

邓珊珊，刘苏峡，莫兴国 等

地球系统的要素变化息息相关，寻找与水文变化联动的关键因子对深入剖析水文变化具有重要意义。文章选取地球运动因子之一——地极移动(极移)作为关键因子，探求其与多尺度水文要素的关系特征和作用机制。首先，通过趋势、突变、相关等分析方法研究极移和多水文要素(降水、蒸散、径流、陆地水储量)变化在流域至全球、年内至年际尺度上统计关系的时空特征。其次基于激发机制量化水文变化对极移的推动作用，基于平衡潮理论和大气动力学方程探索极移对水文变化的反馈作用，以此研究两者相互作用的途径和量级。结果显示，两者存在显著相关关系和共同突变点。一方面，区域至全球尺度的水文变化对极移的激发作用显著。2002 年 4 月至 2020 年 6 月期间全球陆地水储量显著减少(速率约为-4.68mm a-1)，显著驱动地极朝格林尼治子午线方向漂移(速率约为 4.32mas a-1)；同时区域水储量变化对 2005 和 2012 年左右长期极移的方向转折贡献显著。另一方面，基于极移扰动地球离心力场产生平衡潮，计算了极移变化引起的海平面气压、风场和水汽传输的变化的空间分布，发现在浅海附近的流域，如长江流域和珠江流域，极移引起的相关水汽变化与流域观测降水或水储量变化在去除趋势后相关关系仍显著，前者比后者提前约 4～14 个月。研究结果进一步展示了极移与水文变化的关系，有助于认识长期水文变化的关联因子。

（来源：中国科学:地球科学 2022,52(06):1021-1037）

## 中国北方沙尘暴变化与人类世探讨:东亚夏季风-人类活动-沙尘暴-湖泊生态相互作用动态变化

刘建宝，陈杰，陈圣乾等

如何确立人类世的地层标志物，是当前人类世研究的关键科学问题。亚洲内陆干旱半干旱区是世界第二大粉尘源区，其产生的粉尘对全球气候变化、陆地和海洋生物地球化学循环产生深远影响。特别是过去两千年人类活动已经超过了自然气候成为控制中国北方沙尘暴的

主导因素，探讨人为亚洲粉尘能否作为人类世标志物及其湖泊生态效应可以为深入理解人类世提供重要的视角和信息。文章基于中国北方公海湖泊过去两千年叶绿素 a 的测定，对比分析了同钻孔重建的沙尘暴历史和其他气候环境指标，根据亚洲粉尘的广布性、全球影响性、包含的人类活动信号以及可以在各种地质载体中长期稳定保存，首先提出了人为粉尘可以作为人类世地层潜在标志物之一；其次，基于中国北方人类活动导致地层记录的过去两千年的亚洲粉尘信号显著不同于全新世的结果，提出在区域尺度上中国北方人类活动超过自然营力至少开始于两千年前，人类世起始时间可能存在时空差异性，呈现穿时性的特征；最后，基于过去两千年(除现代)中国北方公海湖泊叶绿素 a 与沙尘暴频率的正相关关系，发现人类活动超过东亚夏季风控制的亚洲沙尘暴是过去两千年中国北方高山湖泊生产力的主要驱动因素，并提出过去两千年来东亚夏季风、人类活动、沙尘暴和湖泊生态相互作用动态模式发生了从“人类活动超过东亚夏季风影响地表系统”模式(20 世纪 50 年代之前)到“人类活动全面影响东亚夏季风和地表系统”模式(20 世纪 50 年代至今)的转变，未来可能迈向“人与环境可持续发展”模式。在理解人-气候-环境多元互动过程的前提下，未来人类世研究应当注重区域差异、穿时性、加速期的研究。

（来源：中国科学:地球科学　2022,52(06):1065-1077）

## 科学视点

# 新研究揭示亚非季风区夏季降水增幅“缩水”三成

近日，中国科学院大气物理研究大气科学和地球流体力学数值模拟国家重点实验室(LASG)科研团队研究发现国际上现行的最新气候模式过高预估了未来亚非季风区的夏季降水和总径流量的增幅，他们研发设计出一种基于观测数据的、物理意义清晰的“萌现约束”方法，利用该方法对国际上最新的气候模式预估结果进行约束校正后，亚非季风区的区域平均降水增幅只有原始结果的约 70%。相关研究成果发表在《自然—通讯》。

适应和减缓气候变化需要利用气候模式进行未来变化预估。基于“一人一票”的“模式民主”原则进行多模式集合(MME)，是包括 IPCC 科学评估报告在内的科学界常用的方法。但是，这种方法在应用于最新的、以 CMIP6 为代表的气候模式时面临挑战，原因是受气候系统复杂过程的参数化中存在的不确定性因素影响，最新的气候模式许多存在“对温室气体的敏感度过高”、“模拟的温度变化过热”等问题，这会造成对未来气候变化影响风险的高估。

为解决这些问题，IPCC 第六次评估报告针对全球平均温度等的预估提出了基于观测证据对 CMIP6 结果进行约束的技术。不过，如何在区域尺度上解决 CMIP6 模式气候敏感度过高所造成的预估偏差问题，科学界尚没有统一的、行之有效的方法。LASG 科研团队研发设计的“萌现约束”方法，有望为解决季风区的预估偏差问题提供一种重要途径和参考。

“萌现约束是国际气候变化研究领域近年来提出来的一种修正模式偏差对气候预估影响的的思想，基本原理是把大样本的多个气候模式对未来气候变化预估的偏差和它们对历史气候模拟的性能表现结合起来，寻找二者间的联系规律，并且这种联系需要有清晰的物理内涵；随后，通过把模式的历史气候性能表现与观测数据对比来寻找最佳契合点，利用最佳点对应的统计关系对预估结果进行订正。”论文通讯作者、中科院大气物理研究所研究员周天军表示。

据介绍，亚非季风系统是全球季风系统的重要组成部分，包括东亚、南亚和西非季风。亚非季风区数十亿人口的水资源来自夏季风降水。亚非季风的未来变化，将会对水资源和粮食产量造成显著影响。因此，准确预估亚非季风区的降水变化，对于开展气候变化影响和适应评估、制定减缓策略等至关重要。

该研究发现，在 SSP5-8.5 和 SSP2-4.5 情景下，CMIP6 模式对亚非季风区夏季降水中长期（2050-2099）变化的预估不确定性，主要与历史升温空间分布的模拟偏

差有关：气候敏感度越高的模式，其历史气候模拟中北半球的升温幅度比南半球越强，对应的亚非季风环流的变化也越强，预估的未来季风降水变化的增幅也越大。基于观测数据，通过半球间热力差这一指标来对夏季降水预估结果进行约束校正，发现原始的 CMIP6 模式显著高估了亚非季风区夏季降水的增幅，而采用约束校正后，预估的亚非季风区平均降水未来（2050-2099）较之参考态（1965-2014）的增幅仅是 CMIP6 模式原始结果的 70%，减少最大的是西非季风区，约为原始值的 49%。

降水变化还影响到径流量的变化，基于降水和总径流量之间的联系，研究利用约束后的降水预估数据来估算总径流量的变化，发现未来总径流量显著增多的区域面积占比仅为原始结果的 66%，其中受影响最大的是西非季风区。

周天军表示，预估的降水和径流少于原始估算、新的结果“缩水”三成，这个结果的利弊需要综合评判，特别是对生态系统等的影响还需要评估。从应对气候变化的角度，预估的降水增加不似原始结果那么强，这有利于减轻气候变化适应方面的压力，但与此同时，对于观测中最近几十年降水呈减少态势的非洲季风区、南亚季风区来说，这对水资源的管理有提出了新的议题。

审稿人认为，在气候变化科学领域，大家其实早已经开始重视这个问题。这项工作重点关注季风区，提出了一种有效的约束校正方法，减少了模式预估的不确定性范围，这对于季风区应对气候变化具有重要参考价值。

（来源：科学网，https://news.sciencenet.cn/htmlnews/2022/5/480087.shtm,根据相关资料编译）

## 科学家首次系统阐述亚洲水塔失衡问题

以青藏高原为核心的第三极地区，储存着世界上仅次于南北极的固态水。它是亚洲十多条大江大河和数以千计的大小湖泊的源头，地球上近 20 亿人赖以生存，也被称为“亚洲水塔”。近日，从事第二次青藏科考和第三极环境研究的科学家们系统阐述了亚洲水塔失衡问题，在《自然-地球与环境论评》发表了最新研究成果。该研究的主要作者、第二次青藏科考队长、第三极环境（TPE）国际计划联合主席姚檀栋院士 7 日表示，亚洲水塔失衡是第三极环境发生重大变化的一个标志，这项最新研究成果对该地区的水资源管理和水安全战略有重要科学意义和现实意义。

研究发现，亚洲水塔失衡的主要特征是：固态水正在快速融化、液态水呈增加趋势；从空间上看，液态水增加主要在北部内流区，南部外流区一些流域的液态水呈减少趋势。

研究者详细分析了亚洲水塔失衡的原因，认为第三极气候快速变暖改变了亚洲水塔冰川等固态水和湖泊及河流等液态水的库存比例，同时第三极地区大气环流的变化也改变了其库存水体的空间格局。该研究的共同作者、中国科学院青藏高原研

究所研究员高晶说，西风的加强和印度季风的减弱导致北部内流区降水增多、南部外流区降水减少。

这项研究进一步揭示了亚洲水塔失衡和下游区水供应和水需求之间的不平衡问题。目前，亚洲水塔南部外流区的水供应呈减少趋势，但南部外流区下游区需水量急剧增加。该研究共同作者、北京大学教授、中科院院士朴世龙说，快速增加的水需求和有限的水供给之间的矛盾是南亚和东南亚地区水资源面临的严重问题，这个地区非常需要可持续的水资源管理政策和高效的水资源利用技术。

科学家们提出，从观测、模拟、特殊过程、适应战略四个方面进一步深入研究，获取更多的信息帮助公众和社会应对亚洲水塔变化。该研究的共同作者、TPE 联合主席、美国俄亥俄州立大学教授朗尼·汤普森说，需要在加强观测的基础上对未来的水供应进行更准确的预测，以帮助该地区调整水资源管理的适应战略。该研究的共同作者、TPE 联合主席、瑞典哥德堡大学陈德亮教授说，未来的优化预测需要在数据稀缺的地区建立系统的监测站点，也需要发展先进的大气-冰冻圈-水文耦合模型。

（来源：科学网， https://news.sciencenet.cn/htmlnews/2022/6/480535.shtm,根据相关资料编译）

## 揭开 Li 同位素示踪水文与大陆风化的秘密

晚新生代以来全球气候变冷到底是“气候反馈”还是“构造抬升”的结果？一直是地球科学研究的前沿热点之一，存在着不同观点和激烈争论。到底是什么机制主导着大气 $CO_2$ 浓度的变化是争论的根源。作为调控长时间尺度大气 $CO_2$ 变化的核心机制，硅酸盐岩风化又是争论根源的焦点，而如何有效示踪硅酸盐岩风化又是焦点中的焦点。那么，河水和海水的 $\delta^7$Li 是否能有效示踪大陆硅酸盐岩风化呢？其主导的控制因素到底是什么？

中国科学院地球环境研究所副研究员张飞和研究员金章东，联合来自英国杜伦大学、牛津大学、澳大利亚国立大学等单位的科学家形成的国际团队，开展了现代季节性到深时尺度的全球河流和海洋 Li 同位素大数据组网研究。他们从青海湖流域两个毗邻的、不同岩性的布哈河和沙柳河的季节性 Li 同位素变化出发，发现季节性河水 $\delta^7$Li 明显受控于径流，表现为低 $\delta^7$Li 值对应于雨季的高径流量，$\delta^7$Li 值与径流呈现显著负相关。随后，他们又进一步测试并汇总了全球其他河流的季节性 $\delta^7$Li 及流量数据。其结果发现，从高纬度到赤道均一致展示了河流 $\delta^7$Li 对水文变化的敏感响应，即：气候变干，河水 $\delta^7$Li 升高；气候变湿，河水 $\delta^7$Li 降低。

由此，他们提出，这些全球一致的 $\delta^7$Li 变化反映了水岩反应时间的变化：旱季高的 $\delta^7$Li 值归因于长的水岩反应时间，形成了更多的二次矿物，导致更高比例的 6Li

被黏土吸附，更多的 7Li 进入到河水。该重要发现也得到了室内玄武岩和黄土溶解实验结果的证实。

他们通过进一步空间大尺度对比研究也显示同样结果：中高纬平坦低地河流具有普遍低的径流及高的 $\delta^7$Li 值，而热带低地及活跃造山带河流具有高的径流及低的 $\delta^7$Li 值。

张飞和金章东等认为：在不同时间尺度上，河水和海水 $\delta^7$Li 也受水文主导，从冰期-间冰期石笋记录，到新生代 MMCO、EECO、PETM 等关键时段，乃至深时尺度的海洋无氧事件（OAE1a、OAE2）以及更古老的晚奥陶纪冰河期的雪球地球事件（~4.45 亿年前）。在已有研究文献中，将形成 1700~1500 万年期间的温暖期称为中中新世气候适宜期（Middle Miocene climatic optimum, 简称 MMCO）；而在 5200~5000 万年，全球温度达到最高值，称为早始新世气候适宜期（EECO）；在古新世与始新世界线(P/E)时期的短时间内发生了一件全球性增温（变暖）事件，称为古新世-始新世极热 (PETM)事件，是发生在早新生代的一次极端碳循环扰动和全球变暖事件，主要表现为大气 CO2 浓度快速增加和全球增温，地表温度增加了 5～6℃，高低纬度间温度梯度减小，同时伴随有水循环加快及大规模生物灭绝、演替和迁徙现象。白垩纪大洋缺氧事件(OAEs)则记录了显著的气候变化，代表了温室气候下全球性的碳循环扰动，而阿普第期(Aptian)早期记录的大洋缺氧事件(OAE 1a)是中生代最重要的环境变化事件之一，大洋缺氧事 2(OAE2)是白垩纪中期(~12000-9000 万年)温室气候状态下出现的一次短暂而影响深远的全球性重大古海洋与古气候事件，对全球大洋沉积,海洋生物演替，以及全球碳循环等地球化学过程等产生了严重扰动，被认为是研究地球系统在温室状态下受扰动而发生快速气候变化的一个范例。

“需要特别指出的是，PETM、OAE1a、OAE2 等短期极端事件仅仅持续了< 100 万年时间，而海水 $\delta^7$Li 变化幅度竟可以高达 13‰。”金章东强调说。为此，他们提出，单独的气候驱动的水文变化在短时间尺度上足以产生显著的 $\delta^7$Li 变化。进一步地表明，晚新生代以来逐渐减弱的陆地径流（通过增加水岩反应时间）及模型预测均可以解释海水 $\delta^7$Li 值 9‰的上升。

“最为关键的是 5000 万年以来海水 $\delta^7$Li 上升完美匹配了欧亚板块大西洋和太平洋两侧降雨量的减弱。” 张飞说。

那么，减弱的水文循环如何调节晚新生代以来大陆硅酸盐岩风化和碳循环呢？作者在文章中阐述表明：在从全球活跃造山带和平坦低地的 64 条河流数据来看，径流与硅酸盐岩风化速率呈现良好的正相关。这意味着晚新生代全球减弱的水文循环将降低大陆风化通量。该结果得到现代过程的有力支持，即全球径流减少 1%会降低 0.4-0.7%的大陆河流溶质通量。这也和喜马拉雅山周边记录显示的 1600 万年以来减

少的风化速率一致。因此，上述研究结果也对“构造-风化-气候”经典假说提出了新的质疑。

相关研究领域的专家认为，水文对不同时间尺度 Li 同位素控制观点的提出，将为利用 Li 同位素重建地球历史时期水文变化提供巨大潜力，并激发有关不同时间尺度全球水文变化如何影响大陆风化和碳循环的科学探索。相关研究成果发表于在线出版的《自然—通讯》（Nature Communications）。

（来源：科学网， https://news.sciencenet.cn/htmlnews/2022/6/481027.shtm,根据相关资料编译）

## 青藏高原可可西里高寒串联湖泊变化机理研究获进展

在气候变化背景下，第三极地区湖泊整体呈扩张趋势，特别是青藏铁路沿线，与铁路存在潜在汇流关系的 42 个大型湖泊（>100km2）中，有四分之三高寒湖泊（自上世纪 90 年代中期以来）面积呈现明显增加趋势（图 1b）。

2011 年 9 月，可可西里卓乃湖发生溃决，可可西里地区的四个主要高寒湖泊（卓乃湖、库塞湖、海丁诺尔湖和盐湖）形成了串联湖泊群，导致最下游的盐湖水量急剧扩张，对青藏铁路造成了直接威胁（图 1c）。然而由于该高寒无人区实测资料稀缺，高寒区串联湖泊过程复杂，目前仍缺乏对该高寒串联湖泊形成机理及未来变化的定量解析。

为此，中国科学院青藏高原研究所环境变化与多圈层过程团队与合作者以可可西里地区的高寒串联湖泊流域为研究对象，利用基于物理过程的分布式冰冻圈-水文-湖泊-调度模型，定量解析了高寒串联湖泊形成的驱动机制，并基于多模式气候预估结果和冰冻圈-水文-湖泊-调度模型定量预测了下游盐湖未来几年的水量水位变化。结果表明，降水（+84 mmdecade-1）和冰雪融水的增加（+8.8% decade-1）是导致卓乃湖溃决前水量增加的主要原因。自 2012 年起，入湖径流急剧增加（1999-2010：0.25 km3 year-1；2012-2018：0.76 km3year-1）使得盐湖迅速扩张（图 2）；冻土变化对卓乃湖和盐湖水量增加的贡献较小，但会降低湖泊湖岸和湖盆的不稳定性。

该研究定量解析了由于冰湖溃决事件形成的高寒区串联湖泊的变化机理及其未来变化趋势。随着区域气候持续变暖，该研究可为第三极地区因气候变化而引起的新型冰冻圈灾害事件研究提供模型工具和科学依据。

相关研究成果以 Domino effect of a natural cascade alpine lake system on the Third Pole 为题，发表在 PNAS-Nexus 上。

（来源：中国科学院院网， https://www.cas.cn/syky/202205/t20220517_4834913.shtml,根据相关资料编译）

## 雅鲁藏布江流域多圈层水文监测网建成

中国科学院青藏高原研究所环境变化与多圈层过程团队与合作者通过加强系统监测，结合该流域及周边现有监测站，建立了雅鲁藏布江流域多圈层水文监测网，生成了 1981-2019 年（38 年来）雅鲁藏布江流域高时空分辨率降水数据，为该流域综合水资源管理、生态环境保护提供科技支撑。相关成果日前发表于国际水文气象学著名期刊《美国气象学会通报》。

雅鲁藏布江是中国最长的高原河流，全长 2070 公里，流域面积 24 万平方公里，其水文过程受冰冻圈和地表环境变化的影响十分显著。由于环境条件、观测资料和模型的限制，无法准确评估气候变化对该流域降水、冰川、冻土和植被、径流的影响。

自 2017 年，研究团队逐步构建了包括大气圈、水圈、冰冻圈、土壤圈和生物圈的大尺度多圈层水文监测网络，覆盖雅鲁藏布江流域地面水文、气象、冰川、冻土、植被和土壤等的系统监测，为定量解析雅鲁藏布江流域冰川-冻土-植被变化的协同关系及其径流效应提供观测数据。

论文第一作者和通讯作者、中科院青藏高原所研究员王磊介绍，雅鲁藏布江流域多圈层水文监测网包括：12 个站点的降水和温度梯度监测、5 个站点的水位和径流监测、9 个站点 10 厘米至 120 厘米不同土壤层的土壤和植被监测、34 个站点海拔 4500-5200 米的冻土地表温度监测、2 个站点 9 层冻土水热传递过程监测。

依托监测网络和其他多源数据，研究团队生成了 1981-2019 年雅鲁藏布江流域高时空分辨率降水数据，通过对比、综合主流冰冻圈水文模型的径流组分模拟，得出该流域奴下水文站以上新的降雨、融雪、冰川融化和地下水补给分别占总径流的 66%、21%、9%和 4%。

研究成果有效提升了雅鲁藏布江流域综合监测和模拟能力，增强了对流域水文物理机制的理解，为该流域综合水资源管理、生态环境保护提供科技支撑。

（来源：科学网， https://news.sciencenet.cn/htmlnews/2022/4/477916.shtm,根据相关资料编译）

## 树轮证据显示：喜马拉雅 Karnali 流域极端气候事件发生频率增加

极端降水（EP）中国科学院西双版纳热带植物园 18 日发布消息称，该园科研人员联合德国、尼泊尔等国学术机构，在尼泊尔西部 Karnali 流域进行大范围树木年轮取样，并分析树轮宽度年表与 Karnali 流域气候和水文因子的相关性。结果表明：Karnali 流域极端气候事件发生的频率在过去一个多世纪呈现增加的趋势。

喜马拉雅山是世界上最高大最雄伟的山脉，从西到东绵延 2400 多公里，是冰川发育的中心，蕴藏着巨大的水力资源，与青藏高原一起被誉为“亚洲水塔”。Karnali 河位于尼泊尔西部，是恒河流域的上游，提供了重要的流域生态服务功能，为该地区数百万人口的生产生活提供了重要的水资源。由于气候变暖，喜马拉雅山中部的大多数冰川正在迅速退缩，人们对气候变化如何影响该地区的水资源和水文气候仍然知之甚少。

西双版纳植物园树木年轮与环境演变组博士后 Narayan Gaire 和 Zaw Zaw，在范泽鑫研究员的指导下，与德国埃尔朗根-纽伦堡大学、尼泊尔特里布文大学和尼泊尔科学院合作，在尼泊尔西部 Karnali 流域进行了大范围树木年轮取样，收集和研制了 5 个针叶树种共 11 个样点的树轮宽度年表序列(共计 354 个树轮样芯)，分析了树轮宽度年表与 Karnali 流域气候和水文因子(河流径流量)的相关性，旨在高精度重建该流域河流径流量变化历史。

该项研究的结果表明：样点和区域树轮宽度年表与春季-夏季(3 月-7 月)降水量和干旱指数正相关，与同期温度呈负相关，表明该区域树木生长主要受水分可利用性的限制；采用区域年表高精度地重建了该流域 1628 年以来河流径流量的变化历史，重建结果与喜马拉雅中西部地区及周边地区的干旱指数和降水量重建结果具有较好的一致性；Karnali 流域径流量重建显示，喜马拉雅中西部地区极端低流量(干旱)和高流量(洪涝)事件发生的频率在过去一个多世纪呈现增加的趋势；Karnali 流域径流量变化与厄尔尼诺-南方涛动(ENSO)年际变率和太平洋十年涛动(PDO)有关。

该研究首次高精度重建了喜马拉雅中西部的区域水文变化历史，可为当前和未来气候变化背景下流域水资源的科学管理和利用提供参考依据。相关研究成果于日前发表在国际期刊 Journal of Hydrology 上。

（来源：科学网， https://news.sciencenet.cn/htmlnews/2022/4/477481.shtm,根据相关资料编译）

## 全球变化背景下溶解有机碳和微生物的生态网络关系研究

溶解性有机碳是水生生态系统中最大的碳库之一，其分子构成和周转动态受到微生物的调控。具体表现为，微生物通过降解和生成作用影响着有机碳分子的多样性，在此过程中形成了有机碳分子性状，包括分子量和生物可利用性等，这些性状决定着有机碳的归驱。同时，有机碳作为微生物新陈代谢的能量和碳源，也影响着微生物群落的组成、多样性和功能。相关的科学问题包括：如何量化自然界中有机碳和微生物之间的耦联关系，以及这一关系如何受到气候变化和人类活动等全球环境变化的独立和交互影响。

为了解决上述科学问题，中国科学院南京地理与湖泊研究所王建军研究员与湖南农业大学胡盎副教授构建了“能量-多样性-性状”（EDTiA）的理论框架，即：运用了生态网络等模型，建立了量化溶解性有机碳分子构成与细菌物种之间耦联关系的特异性指数，提出了气候变化和人类活动通过能量、多样性和有机碳分子性状直接或间接影响有机碳-微生物耦联关系。进一步，将此框架应用于大空间尺度的山地水体微宇宙实验，定量了温度变化和营养富集对这一耦联关系的独立和交互影响。

研究结果表明，特异性指数在不同气候带均对温度和营养富集存在着显著的响应，具体表现为，营养富集促进了有机碳生成的特异性，但降低了有机碳分解的特异性；后者的响应在亚热带山区更显著，表明营养富集将促进亚热带地区有机碳被更多的细菌分解。进一步通过结构方程模型等统计方法，量化了温度和营养盐主要通过“能量-多样性-性状”间接驱动着两者的耦联关系，从而揭示了全球变化背景下山地水体微生物介导碳循环过程的环境响应机理。本研究阐释了有机碳和微生物的耦联关系受到全球环境变化的影响，对湖泊有机碳库的动态变化具有重要指导意义，也对人类活动如何影响未来环境变化下的有机碳动态提供了科学参考。 相关研究成果以研究论文的形式，发表在综合性期刊 Nature Communications。

（来源： http://www.niglas.ac.cn/xwdt_1_1/yjjz/202207/t20220702_6470567.html,根据相关资料编译）

## 浅水湖泊更易富营养化，并非偶然

从湖泊外源氮磷负荷来看，浅水湖泊（特别是大型浅水湖泊）一般分布于平原和低地地区，这些区域土壤肥沃、农业发达、人口众多和城市环绕，一定程度上决定了该区域湖泊外源氮磷负荷高；相反，深水湖泊主要分布于高原和山地地区，这些地区土壤贫瘠、人口稀少，流域土地主要以自然状态为主，导致深水湖泊氮磷外源负荷往往较低，不易富营养化。同时，与深水湖泊相比，浅水湖泊的容积（蓄水量）较小，环境容量较小且对外源输入营养盐的稀释能力较弱，导致对人为活动更为敏感。此外，在浅水湖泊中，水-沉积物相互作用更为普遍，沉积物中营养盐和生物可以悬浮和释放，从而有助于提高湖泊生产力。总体而言，浅水湖泊易富营养化且难治理不是偶然，富营养化浅水湖泊的治理往往比我们预想的要困难。

富营养化和有害藻类水华是现在和未来一段时间全球湖库面临的主要环境问题。尽管已投入了大量资源用于控制湖库富营养化和水华，但许多大型湖库藻类水华并没有得到有效控制，如太湖、巢湖和美国的奥基乔比湖和伊利湖；甚至一些已修复的湖泊又重新出现藻类水华。值得深思，为什么富营养化基本发生在浅水湖泊或湖湾且难于治理？目前国际湖沼学主要是基于深水湖泊的认知，而关于浅水湖泊湖沼学的发展较之仍然有限。湖泊水深特征作为湖泊重要的基础条件对湖泊流域氮磷负荷（土地利用类型、人口、经济等）和湖泊内氮磷循环过程具有关键影响。尽管关

于湖泊富营养化已有大量的研究，而大部分研究主要集中在人类活动、内源和水文气象条件等单独对湖泊富营养化和水华的影响，忽视了湖泊地理特征与上述因子之间的内在联系及其分异机制，使得对湖泊富营养化缺乏科学全面的认知。

中国科学院南京地理与湖泊研究所科研团队收集整理了美国和欧洲 1151 个湖泊的地理形态特征、营养状态、流域土地利用类型和生态区等相关数据，研究发现湖泊水深特征与人类活动强度和富营养化之间存在内在关系。根据湖泊起源和流域地形，浅水湖泊往往位于受人类活动影响强烈（农业和城市）的平原和低地地区，大量的氮磷等污染物排放，使得湖泊外源负荷高，易富营养化和暴发藻类水华。然而，深水湖泊一般位于以自然土地利用类型（如森林和草地等）为主的山地和高原，人类活动影响较弱，湖泊外源氮磷输入较少。同时，与浅水湖泊相比，深水湖泊通常容积更大，其环境容量更大，能更好的缓冲、稀释和沉降输入的氮磷营养盐。此外，浅水湖泊的内源营养盐（特别是磷）可以在水动力作用下悬浮和释放到水柱中，而在深水湖泊中氮磷很难被再次利用，往往沉积在湖底。

湖泊作为人类经济社会活动的组成部分，它们是一个有机整体。不同水深特征湖泊所面临的富营养化风险不同，浅水湖泊的地理特征一定程度上决定了其面临更高的外在和内在的富营养化风险。因此，浅水湖泊易富营养化且难治理不是偶然，富营养化治理和保护应该重点关注浅水湖泊，且富营养化浅水湖泊的治理往往比我们预想的要困难。

本研究有助于澄清为什么富营养化湖泊治理成功案例大部分都发生在深水湖泊（Schindler et al., EST, 2016）?为什么投入了大量的资源用于一些重点大型浅水富营养化湖泊（如太湖、巢湖、奥基乔比湖和伊利湖等）的治理却并未取得预期的效果，甚至一些湖泊的水质反而有所下降。本研究有助于调整大家对于浅水富营养化湖泊治理和保护的预期，认识到尽管富营养化浅水湖泊的恢复速度较慢，但持续的投入和治理是其恢复的基本保障。

（来源：http://www.niglas.ac.cn/xwdt_1_1/yjjz/202206/t20220620_6463410.html,根据相关资料编译）

## 我国西南晚第四纪湖泊—湿地沉积的释光年代学及区域水文气候变化

我国西南地区的湖泊沉积是研究印度季风动态及重建古水文气候的重要地质载体。年代学框架是开展上述研究的必要依据和时间标尺。以往研究工作主要依据 14C 定年方法，建立的年代序列相对较短，冰期—间冰期尺度上的西南湖泊沉积与区域水文气候变化的地质记录缺少绝对测年研究。

鉴于此，中国科学院南京地理与湖泊研究所隆浩研究员课题组高磊博士与肖霞云研究员等学者合作，选取云南腾冲北海湿地 13.4m 长岩芯沉积物为材料，利用石英释光和混合矿物红外释光测年技术，结合岩芯的 AMS 14C 定年结果，厘定了云南腾冲北海湿地沉积地层过去~5,3000 年以来的年代框架；通过湖泊—湿地沉积序列交替变化重建了地质历史时期湖泊水位升降变化过程。在此基础上，集成了西南地区多个湖泊钻孔沉积速率变化历史，推断不同时期的湖泊—湿地系统沉积演化过程与印度季风影响下的水文气候变化过程密切相关。相关研究成果发表在国际第四纪领域著名期刊 Palaeogeography 上。

（来源：http://www.niglas.ac.cn/xwdt_1_1/yjjz/202205/t20220516_6448918.html,根据相关资料编译）

## 湖泊水环境优先污染物筛选识别及清单构建方法取得进展

人类生产生活伴随着大量化学品的生产和使用，《全球化学品展望》(II)报告显示，2020 年末 CAS 登记在册的化学品数量已超过 1.7 亿，从 2013 年起，年增长速度为 25%，其中有毒有害化学品占比达 62%。大量有毒有害化学品经工农业和生活污废水排放、城市地表径流和干湿沉降等最终进入地表水环境，湖泊成为流域有毒有害化学品的重要蓄积库，严重威胁其生态系统服务功能和流域可持续发展。由于有毒有害化学品种类繁多、环境浓度低，无法实现全面监测和风险评估，如何从众多的化合物中筛选识别出优先污染物，建立水环境优先污染物清单，是开展湖泊水环境有毒有害化学品污染精准防控和削减治理的关键。

然而，国际上尚未建立统一的地表水环境优先污染物清单构建方法。基于此，中国科学院南京地理与湖泊研究所赵中华等研究人员从保护受纳水环境生态安全和人群健康的角度出发，围绕有毒有害化学品，构建了囊括环境实测暴露水平(Occurrence, O)、化合物持久性(Persistence, P)、生物累积性(Bioaccumulation, B)、生态风险(Ecological risk, Eco-T)和人体健康风险(Human health risk, Hum-T)评价参数在内的多指标综合评分法，以环境实测浓度替代模型预测浓度、以概率生态风险评价替代阈值法风险排序，综合考虑区域人群暴露途径和健康风险，筛选识别优先污染物，建立湖泊水环境优先污染物清单。

在科技部基础性工作专项、科技部常规科技援助项目、中国科学院中-非联合研究中心重点部署项目等资助下，团队建立了包括重金属、挥发性有机污染物 VOCs、持久性有机污染物 POPs、环境内分泌干扰物 EDCs、抗生素等新污染物在内的 150 余种化合物调查评估基础数据库，应用多指标综合评分法建立了我国东部典型湖泊和东非坦桑尼亚内陆湖泊水环境优先污染物清单，可为不同区域湖泊有毒有害化学品污染问题识别、风险评估、流域管控提供重要的方法学支撑。相关成果发表在国

内外学术期刊 Water Research、Science of the Total Environment 以及《环境科学》《湖泊科学》杂志上。

（来源： http://www.niglas.ac.cn/xwdt_1_1/yjjz/202205/t20220507_6444975.html,根据相关资料编译）

## 湿润平原区耕地冬季撂荒对水文过程的影响

我国农村受劳动力析出和产业结构调整滞后影响，部分地区耕地撂荒现象日益明显，且以季节性撂荒为主。耕地撂荒通过改变下垫面性质，引起地表蒸散、土壤水分和降水径流等关键过程变化，造成能量循环和水分情势改变，深刻影响到区域水文过程和水资源的时空分配。

长江中下游农村耕地冬季撂荒面积达 20 万 $km^2$，占总耕地面积 40%以上，尤其是地处中下游平原区的江苏、湖北、湖南等省份，占区域耕地撂荒总面积约一半。研究长江中下游湿润平原区冬季耕地撂荒的生态水文与水资源水环境效应，对于明确水资源时空分布规律具有重要意义，将为耕地保水保湿和区域水资源高效利用、区域农业水资源规划与管理、水利工程建设面对耕种新形势下的适应性调整等提供科学依据。

中国科学院南京地理与湖泊研究所高俊峰研究员课题组闫人华博士，针对湿润平原区耕地冬季撂荒的水文效应，以太湖流域典型试验区长期监测实验数据为基础，量化了冬季耕地撂荒的生态水文效应，取得了一系列成果：1）揭示了水田在夏稻+冬油轮作、夏稻+冬闲（撂荒）模式下蒸散发的日内、季节变化规律及驱动机制，明确了蒸散发过程及各分量的变化特征，识别了主导环境因子及多因子间的结构关系。2）构建了针对夏季水稻、冬季油菜和冬闲地等不同作物模式下的蒸散发估算模型，确定了一套适合湿润平原区耕地不同作物的蒸散发模型关键参数值。提出区分冬季撂荒与年际辐射、水分差异对蒸散变化作用的单样点植被演替监测+情景模拟方法，相比以往多样点同期观测法，显著降低了试验成本，避免了因地形、土壤、微气候等空间异质带来的结果不确定性。3）定量评估了冬季撂荒引起的蒸散发变化对水文过程的影响，发现相比原种植冬油菜，冬季撂荒使湿润耕地表层直接接受辐射能量，导致蒸散发增加 0.13±0.11 mm/d，使年平均土壤含水量减少 12%，地下水位下降 5%，径流量减少 20%，且撂荒的时间累积效应明显。研究成果在线发表在水文水资源领域著名期刊 Water Resources Research 上。

（来源： http://www.niglas.ac.cn/xwdt_1_1/yjjz/202204/t20220418_6428380.html,根据相关资料编译）

## 湖库是保障饮用水安全的重要基石，但也面临脆弱性增加的风险

清洁空气、洁净饮用水和安全食品是保障人民生命健康的底线。湖库含全世界近 90%的液态地表淡水，是全球最重要的饮用水源地之一。湖库、河流和地下水是

我国城市集中式饮用水源地“三驾马车”，其中湖库饮用水源地贡献最大，水源地数量占 40.6%，服务了 47.2%的人口。近期，中科院南京地理与湖泊研究所张运林研究员团队在国家自然科学基金重大项目等联合资助下，在国家自然科学基金委员会主办的综合性学术期刊《Fundamental Research》上发文，论述湖库在保障我国饮用水安全中的重要性和脆弱性。

通过对全国 340 个地级市（包括香港和澳门）和 55 个 100 万人口以上县级市的 1093 个市县级集中式饮用水源地类型和服务人口进行分析，发现湖库型、河流型和地下水型水源地数量占比分别为 40.6%、30.8%和 28.6%，胡焕庸线以东地区三者占比分别为 46.7%、34.1%和 19.2%，表现为湖库型水源地占比最高，北京、上海、深圳等 10 个重点城市湖库型水源地占比高达 65.4%。就服务人口而言，湖库型、河流型和地下水型水源地服务的人口占比分别为 47.2%、36.8%和 16.0%，胡焕庸线以东人口聚集分布区，湖库型水源地服务的人口比例达 51%，北京、上海、深圳等 10 个重点城市湖库型水源地服务的人口比例更是高达 72.9%。

另外，相比于河流和地下水，湖库型水源更稳定，水质更优质，如 2016-2020 年山东省市县级集中式饮用水源地逐月监测显示，达到或优于Ⅱ类水标准的水源地中，湖库型、河流型和地下水型分别占 75.6%、14.1%和 10.3%。由此可见，湖库已成为我国最主要的集中式饮用水源，特别是保障了我国东部经济发达地区众多人口的饮用水安全和经济社会发展。

随着南水北调等一系列重大调水工程的实施，源源不断将优质的湖库水输送到地表水资源贫乏的北京、天津、河南、河北和山东，满足其城市集中式供水。如南水北调中线工程 2019 年调水 86.22 亿立方米，自 2014 年来累计调水 340.53 亿立方米，惠及沿线 24 个大中城市及 130 多个县，直接受益人口超过 6700 万人。此外，未来引汉济渭工程从黄金峡水库引水满足西安、咸阳、宝鸡和渭南等重点城市饮用水供水，千岛湖配供水工程保障杭州和嘉兴等城市供水安全，其服务人口都在千万以上。因此，湖库型集中式饮用水源地在保障城市供水安全，改善和提升区域饮用水质量方面将发挥越来越大的作用。

但近 30 年来，富营养化及其所引发的藻类水华和水体异味等已经逐渐威胁到我国湖库水生态系统健康和饮用水供水安全。如 2007 年 5 月底太湖暴发严重蓝藻水华灾害引发大规模饮用水危机事件，让无锡数百万居民的自来水供应中断一星期；2007 年 6 月河北秦皇岛洋河水库蓝藻水华暴发危及北戴河安全供水；2016 年 8 月发生在浙江富春江水库的蓝藻水华曾一度威胁到 G20 杭州峰会的水环境质量保障和周边城市饮用水安全；2019 年 4 月湖北安陆市集中式饮用水源地解放山水库暴发裸藻水华，造成自来水出现异味影响 50 万居民饮用水供应。上述典型事件出现后，各地开展了大规模综合治理，水环境质量呈现稳中向好态势，但由于全球气候变暖和极端气候

事件会加重藻类水华暴发，其引发的异常水体和异味物质风险加大，增加湖库饮用水源地脆弱性。

（来源：http://www.niglas.ac.cn/xwdt_1_1/yjjz/202204/t20220412_6425104.html,根据相关资料编译）

## 人类活动对长江中下游湖泊生态系统的影响

长江中下游湖泊是人类活动干扰较为严重的区域，主要包括富营养化、水产养殖和受损湖泊的人工修复等。这些活动究竟如何影响湖泊生态系统，分别影响了哪些生态过程，是认识和管理湖泊亟需回答的难题。

敏感属种和α-多样性变化通常用于评价湖泊生态系统的变化，然而这些指标缺乏对生态系统变化内在过程的解析。面对外在的环境压力，生物首先通过调整其群落结构适应环境的变化，当无法承受环境压力时生态系统才会发生转变。网络结构和β-多样性可以反映生物之间的相互作用模式，并可以对群落结构的内在变化规律进行分解分析，因此可以作为生态系统转变的早期预警信号。

浮游动物作为初级消费者，在湖泊生态系统中起着“承上启下”的作用，且其对环境变化十分敏感，能快速对人类活动引起的水质、食物组成和捕食压力的变化作出响应，因此从浮游动物的群落结构入手有助于认识湖泊生态系统的变化。近期，中科院南京地理与湖泊研究所陈非洲研究员团队基于长江中下游湖泊调查和五里湖长时间序列监测的浮游动物数据，深入分析了浮游动物群落结构对湖泊富营养化、鱼类养殖和水体修复的响应过程。

对长江中下游湖泊浮游动物的研究显示，营养盐和鱼类的捕食对浮游动物多样性和生态网络有协同影响。α-多样性主要受营养条件的限制，营养盐升高抑制了α-多样性；而β-多样性同时受营养盐和滤食性鱼类的影响，滤食性鱼类对β-多样性的影响呈单峰模式。浮游动物多样性的变化主要原因在于群落结构的变化，因为群落结构的调整过程发生在多样性变化之前，浮游动物网络偏度与 TN 正相关与滤食性鱼类密度负相关。当滤食性鱼类密度高于 200kg/ha 后，浮游动物网络结构负偏。研究结果显示下行效应对浮游动物群落的影响强于上行效应，鱼类捕食诱导了浮游动物群落的结构调整，意味着广布种优势度增加，进而削弱了空间上的β-多样性。

那么浮游动物多样性的变化究竟如何影响生态系统功能呢？在此研究基础上，进一步调查了 40 个渔业管理加强后的长江中下游湖泊。结果表明，人类活动导致的土地利用变化与湖泊营养状态指数紧密相关，随着营养状态指数的升高，原核藻类、真核藻类和浮游动物的异质性均下降，这种变化不仅与营养水平升高紧密相关，也与环境异质性下降紧密相关。营养水平升高和环境异质性下降可以通过影响藻类的组成和多样性间接影响浮游动物多样性，进而削弱其下行控藻功能。

浮游动物下行控藻功能的减弱会导致富营养水体蓝藻增长不受控制，生态修复是受损生态系统恢复的重要措施，但如何评价富营养湖泊的修复效果需要深入的探索。通过对无锡五里湖 19 年的跟踪研究，对修复前后轮虫的多样性进行比较，结果表明湖泊修复后轮虫敏感属种密度增加、轮虫群落的季节性 β -多样性加大、年际间的 β -多样性下降，但是物种丰富度没有增加。湖泊修复后尽管营养水平显著下降，但是修复后氮磷比下降导致蓝藻生物量增加，对轮虫产生了不利影响。研究表明修复后营养盐比例的控制仍需引起重视。尽管 α -多样性的变化不明显，但是时间序列的 β -多样性显示轮虫群落的稳定性增强了，说明 β -多样性的变化比 α -多样性更为敏感，在今后的研究中应加强对浮游动物群落结构的监测和长时间序列 β -多样性变化的分析，有助于认识湖泊修复的效果。

上述研究表明，（1）流域土地利用的改变、外源营养负荷的控制和鱼类调控在长江中下游湖泊的管理中有着重要的作用；（2）湖泊修复后内源负荷的影响需要进一步关注；（3）如何对湖泊进行有效的生态评估，需要更广泛研究并运用新的生态评价方法。该系列研究有望对长江中下游湖泊评估和管理提供科学参考。研究成果分别发表在国际知名期刊 Limnology and Oceanography、Water Research 和 Science of the Total Environment 上。

（来源：http://www.niglas.ac.cn/xwdt_1_1/yjjz/202204/t20220407_6419938.html,根据相关资料编译）

## 湿润平原河网区蒸散发互补关系

蒸散发是地表水循环和碳循环的关键过程，深刻影响到地表物理、化学和生物过程，与水资源利用和时空分配密切相关。湿润河网地区由于植被茂密、河网湖荡密集、人类活动影响巨大，蒸散发在不同单元和地表类型上差异巨大，机制和过程尤其复杂，准确估算和预测蒸散发量成为水文、水环境、水生态、水安全等领域的核心和焦点问题。

近年来通过不断发展，蒸发互补理论（认为实际蒸散与潜在蒸散间存在定量互补关系）及其模型为仅需常规气象数据估算区域尺度蒸散提供了有力方法，然而蒸发互补理论和方法研究目前主要集中在国内外干旱区和半干旱区，在具有复杂下垫面性质的南方湿润平原河网区缺少全面评价，限制了该区域大尺度蒸散过程的研究进展。

中国科学院南京地理与湖泊研究所高俊峰研究员团队的闫人华博士，选择太湖流域常州实验区域，在长期蒸散发监测实验与过程模拟工作的基础上，取得了一系列成果：

1）验证了蒸散发互补理论在该区域的适用性，阐明在地表差异性和平流影响下，稻季蒸散发互补关系呈非对称性的机制；

2）通过与不同区域的对比分析，明确了湿润平原河网区相对蒸散Φ与干燥力 D 分布关系，相对蒸散Φ集中在 0.8 以上，D 主要分布在 0.3-0.5 之间，分布曲线与干旱区截然不同；

3)通过对平流-干旱 AA 模型（Brutsaert, 1979）、GG 模型（Granger and Gray, 1989）、广义非线性平流-干旱 B2015 模型（Brutsaert, 2015）、S 型广义互补函数 H2018 模型（Han and Tian, 2018）和广义互补 C2018 模型（Crago and Qualls, 2018）等 5 个代表性蒸散发互补模型的适用性与预测精度对比分析，发现 S 型广义互补函数（H2018）模型具有最好模拟效果，确定了一套适合湿润河网区不同时间尺度的稻季蒸散发模型关键参数值，并阐释了其数值的合理性，认为受夏季东南季风带来的太平洋和太湖冷水汽影响，且地处水网密集区，水分充足，导致模型参数 α 较默认值 1.26 偏小。

该研究对湿润平原河网区的蒸散发互补理论和模型研究有示范和推广意义，为南方平原河网区水文过程精细化模拟、水资源规划与管理提供了科学和技术支撑。研究成果发表在国际农林科学领域著名期刊 Agricultural and Forest Meteorology。

（来源：http://www.niglas.ac.cn/xwdt_1_1/yjjz/202204/t20220401_6417413.html,根据相关资料编译）

# 业界动态

## 水利部出台 19 项举措 推动水利项目加快建设

日前，水利部出台 19 项具体工作举措，推动水利项目加快建设。

水利部相关负责人介绍，19 项具体工作举措涉及：扩大水利建设融资渠道、全力推进 55 项重大水利工程、加快推进灌区建设和改造、加快推进病险水库除险加固等重点内容。

在扩大水利建设融资渠道方面，5 月底之前，水利部已从银行贷款、信托基金、社会资本等多方面，加强对水利建设投融资的政策支持。今年国家部署推进的 55 项重大水利工程，目前已开工 12 项，6 月底前将再开工 6 项。

**水利部规划计划司副司长 乔建华：**包括南水北调中线引江补汉工程、安徽省包浍河治理工程、长江芜湖河段整治工程、福建闽江干流防洪提升工程、湖南大兴寨水库工程、黄河下游引黄涵闸改建工程，预计上半年累计开工项目将达到 18 项。

在加快推进灌区建设和改造方面，今年将重点推进国务院明确的 6 项新建大型灌区项目，目前江西大坳和广西大藤峡 2 项灌区工程已开工建设，其余江西梅江灌区、海南牛路岭灌区、广西龙云灌区、安徽怀洪新河灌区也将确保能开早开、年内全部开工。今年，中央下达投资 67 亿元用于 76 处大型灌区改造。截至 5 月底，有 58 处批复了初步设计。各地落实中央水利发展资金 70 亿元，对 405 处中型灌区开展节水改造建设。截至 5 月底，已经完成中央投资 27.32 亿元，完成进度为 39%。

在病险水库除险加固方面，水利部将加快推进已到安全鉴定期限水库的安全鉴定工作，确保如期完成年度计划任务。

**水利部建设司一级巡视员 赵卫：**今年中央预算内投资计划安排实施 102 座大中型病险水库除险加固项目，其中第一批下达中央预算内投资安排了 81 座，目前已经开工 61 座；第二批将下达中央预算内投资安排 21 座。

截至今年 5 月底，农村供水工程已开工建设 6474 处。此外，今年以来，我国全力推进农村供水工程开工建设进度。切实提高农村供水保障水平。

今年以来，我国通过财政资金、地方政府专项债券、银行贷款、社会资本等多渠道落实资金，加快农村供水工程建设进度。截至 5 月底，各地已落实农村供水工程建设资金 516 亿元，已开工建设 6474 处。

**水利部农村水利水电司副司长 许德志：**两项数据比去年同期增长都在 50%以上，已完工 2419 处，提升了 932 万农村人口的供水保障水平。

水利部相关负责人表示，今年，水利部以县为单元，建立分省农村供水工程开工建设情况工作台账，专人盯办，逐省督办，督促各地农村供水工程应开工尽开工。各地也结合实际，多措并举，继续加快农村供水工程建设进度。

云南省开展农村供水保障 3 年专项行动，提高农村供水规模化程度。江西省开展城乡供水一体化先行县建设行动。市场和政府两手发力，吸引多家大型水务企业作为实施主体参与建设。

安徽省实施“皖北地区群众喝上引调水工程”，皖北 6 市 25 个县（区）今年计划新建工程 35 处。截至 5 月底，已开工 15 处。

（来源：科学网，https://news.sciencenet.cn/htmlnews/2022/6/480494.shtm ，根据相关资料编译）

## 七大流域水旱灾害防御部署完成

目前，按照水利部的部署，长江、黄河、淮河、海河、珠江、松花江、太湖七大流域防总已全部召开 2022 年工作视频会议，七大流域水旱灾害防御部署全面完成。

据预测，今年汛期涝旱并重，北部和南部将发生洪涝，北部重于南部，中部将出现干旱。北方黄河中下游、海河流域大部水系、松花江、嫩江、黑龙江、辽河、淮河等可能发生较大洪水，南方长江、太湖等流域等可能发生区域性暴雨洪水。华中南部、西南东部、华南北部、西北西部北部等地可能出现夏旱。水利部门分析研判流域防汛抗旱形势，对流域水旱灾害防御各项工作进行全面动员、督促落实，全面做好防大汛抗大旱抢大险各项准备。

此外，近日水利部全面启动全国水库安全度汛电话抽查。电话抽查内容主要包括大坝安全责任人和小型水库防汛的行政责任人、技术责任人、巡查责任人落实情况、病险水库的控制运用措施落实情况、影响水库度汛安全的隐患治理情况及原则上病险水库主汛期一律空库运行的执行情况等。水库电话抽查覆盖全国大中小型水库，抽查工作计划持续至汛期结束。对于水库电话抽查中发现的问题，水利部将及时反馈各省级水行政主管部门以及水库管理单位，督促各单位落实好整改措施，确保水库安全度汛。

（来源：人民网，http://cpc.people.com.cn/n1/2022/0519/c64387-32424851.html，根据相关资料编译）

## 聚焦高原湖泊生物治理 拯救濒危土著鱼种

云南素有“动物王国”的美誉，其鱼类种类数量一直稳居全国前列。近年来，受水生态环境变化等因素影响，云南特有鱼类资源逐渐枯竭，鱼类种质资源保护工作已刻不容缓。

昆明市水产科学研究所密切关注水生生物资源与水环境问题，致力于高原湖泊及水库环境生物治理研究，依托宜良县生态渔业相关项目，首次在柴石滩水库实施“以鱼治水、以鱼控藻”，获得了昆明市科学技术奖三等奖。此外，昆明市水产科学研究所近年来持续开展土著鱼类保护工作，加大对土著鱼类尤其是濒危物种的搜集，为保护和修复滇池土著鱼类生物多样性奠定了基础。

银白鱼是滇池特有的土著鱼种，随着滇池水环境改变，银白鱼的生存繁殖也受到影响，种群几近消失。2017 年，昆明市水产科学研究所成立了以“滇池土著鱼保护”为研究课题的科技创新团队，在全国率先人工繁育出银白鱼；2019 年开始向滇池试验性增殖放流；2021 年向滇池放流银白鱼 10 万余尾，目前已掌握规模化人工繁育银白鱼的技术，有效扭转了滇池银白鱼濒危的状态。

同时，昆明市水产科学研究所分别在晋宁区和寻甸回族彝族自治县建立了两个土著鱼繁育基地，经过不断努力，已培育储备了包括银白鱼、滇池高背鲫、中臀拟鲿等多个土著鱼品种，并根据其不同的生活、繁殖习性，开展人工驯养、繁殖研究，设法克服珍稀濒危鱼类对环境要求高、人工驯养难、受精率和孵化率低等技术难题。

目前，昆明市水产科学研究所已建设成为集水生生物资源监测、土著鱼类人工繁殖、水生态修复等为一体的科研机构，先后承担多个水生态保护与修复项目，并连续多年对滇池鱼类及水生生物开展跟踪调查，鱼类资源数据为滇池实施封湖禁渔、开湖捕捞、增殖放流提供科学依据，为滇池流域鱼类种质资源保护、多样性恢复作出贡献。

下一步，昆明市水产科学研究所将持续发挥专业技术优势，围绕滇池、阳宗海水生生物资源保护、水环境修复等基础研究，开展云南省珍稀濒危鱼类拯救、保护和人工繁育等科研工作，在推动云南省生物资源可持续利用、滇池水生态环境修复、渔业健康发展、生物多样性恢复方面贡献科技力量。

（来源：新华网，http://yn.news.cn/hot/2022-05/07/c_1310586477.htm，根据相关资料编译）

## 青藏高原所建成雅鲁藏布江流域多圈层水文监测网

中国科学院青藏高原研究所环境变化与多圈层过程团队和合作者通过加强系统监测，结合雅鲁藏布江流域周边现有监测站，已建成雅鲁藏布江流域多圈层水文监测网，将为该流域综合水资源管理、生态环境保护提供科技支撑。

研究团队基于雅鲁藏布江流域多圈层水文监测网，已顺利生成 1981-2019 年雅鲁藏布江流域高时空分辨率降水数据，相关研究成果论文近日在国际水文气象学专业期刊《美国气象学会通报》(BAMS)发表，可有效提升雅鲁藏布江流域综合监测和模拟能力，增强对流域水文物理机制的理解。

论文第一作者和通讯作者、中科院青藏高原所王磊研究员介绍说，雅鲁藏布江流域多圈层水文监测网主要包括：12 个站点的降水和温度梯度监测、5 个站点的水位和径流监测、9 个站点 10 厘米至 120 厘米不同土壤层的土壤和植被监测、34 个站点海拔 4500-5200 米的冻土地表温度监测、2 个站点 9 层冻土水热传递过程监测。

王磊表示，依托监测网络和其他多源数据，研究团队生成了 1981-2019 年这 38 年内雅鲁藏布江流域高时空分辨率降水数据，在此基础上进一步通过对比、综合主流冰冻圈水文模型的径流组分模拟，研究得出的结果显示，雅鲁藏布江流域(奴下水文站以上)新的降雨、融雪、冰川融化和地下水补给分别占总径流的 66%、21%、9%和 4%。

中科院青藏高原所称，雅鲁藏布江是中国最长的高原河，全长 2070 公里，流域面积 24 万平方公里，其水文过程受冰冻圈和地表环境变化的影响十分显著。不过，由于环境条件、观测资料和模型的限制，此前无法准确评估气候变化对该流域降水、冰川、冻土、植被和径流的影响。

针对这一难题，中科院青藏高原所环境变化与多圈层过程团队自 2017 年起，逐步构建起包括大气圈、水圈、冰冻圈、土壤圈和生物圈的大尺度多圈层水文监测网络，对覆盖雅鲁藏布江流域地面水文、气象、冰川、冻土、植被和土壤等进行系统监测，为定量解析雅鲁藏布江流域冰川-冻土-植被变化的协同关系及其径流效应提供观测数据，为青藏高原雅鲁藏布江流域相关科学研究奠定重要基础。

（来源，中国新闻网，https://www.cas.cn/cm/202204/t20220426_4832822.shtml，根据相关资料编译）

## 江苏：强化湖泊保护与修复 为高质量发展添动力

加强湖泊保护，有利于改善水质，提高湖泊行水蓄水能力。近年来，江苏通过立法、退渔还湖、生态修复等方式，全面提升湖泊保护水平，为高质量发展增添绿色动力。

走进淮安白马湖旅游度假区，清澈的湖水波光粼粼，成群的候鸟游弋嬉戏。很难想像，几年前这里还是大家眼中的黑臭湖。那时由于缺乏管理，相当长一段时间，无序的水产养殖，让湖体水质总磷严重超标，生态环境遭到严重破坏。接到中央生态环境保护督察交办件后，当地立即梳理出 36 项具体整改任务，投资 36 亿元，在做好围网搬迁、渔民上岸工作的同时，积极开展截污清淤、增加生态涵养林。如今，湖泊生态安全水平稳步提升，由劣Ⅴ类变成总体稳定在Ⅲ类水标准。

淮安市白马湖规划建设管理办公室湖区（湿地）管理处处长胡鑫说：“经过这几年的治理，我们白马湖湿地已经有 175 种鸟类。其中，国家二级保护鸟类是 16 种，省级保护是 82 种。”

为了做好湖泊保护与修复工作，江苏将全省湖泊保护个数由 137 个增加到 154 个，同时出台了针对太湖水污染防治、洪泽湖保护的省级地方性法规。按照因地制宜的原则，各地也纷纷行动：骆马湖恢复自由水面 4.5 万亩；太湖近 4.5 万亩围网养殖设施全部拆除的同时，还在生态修复区成功放流河蟹蟹苗进行天然增殖、生态育肥；位于苏皖交界的石臼湖，以河长制为依托探索跨省长效管理新机制……如今，湖长制覆盖全省，84%的主要河湖生态状况达到优良、太湖连续 14 年实现“两个确保”，全省湖泊环境容量不断加大、蓄水防洪能力不断提高。

（来源：人民网，http://js.people.com.cn/n2/2022/0406/c360302-35209322.html，根据相关资料编译）

## 中国最大湖泊青海湖正式创建国家公园

青海湖景区保护利用管理局在青海湖国家公园创建新闻媒体座谈会上向外发布，青海湖国家公园正式进入创建阶段，并力争早日完成青海湖国家公园设立工作。

青海湖位于青藏高原东北部，总面积 4625.6 平方公里，是中国最大的湖泊，青海省因青海湖而得名。青海湖流域是维护青藏高原东北部生态安全和中国西北部大环境生态平衡的重要水体；是控制西部荒漠化向东蔓延、保障东部农业区生态安全的天然屏障；是高原生物基因库，国际候鸟迁徙通道重要节点；是中国内流区完整水循环水生态过程的典型区域，形成了特有的“草—河—湖—鱼—鸟”共生生态链，极具国家代表性。创建青海湖国家公园，对中国生态安全屏障和青藏高原生态文明意义重大。

近年来，青海启动以国家公园为主体的自然保护地体系示范省建设，在中国率先完成自然保护地整合优化，圆满完成三江源和祁连山两个国家公园体制试点任务。三江源国家公园正式设园，成为中国首批、排在首位、面积最大的国家公园。经过五年多的不断努力，青海湖蓄水量增加，流域水质保持稳定，草原综合植被盖度提升，生物多样性资源恢复加快，环境质量显著提高，为青海湖国家公园创建工作打下良好的基础。

五年来，青海湖湿地指示性物种(水鸟)种类由 2017 年的 92 种增加到 2021 年的 97 种，栖息水鸟数量较 2017 年的 33.6 万余只增加 69.9%，达到 57.1 万只，青海湖成为中国候鸟繁殖数量最多、种群最为集中的繁殖地。同时，通过先后 5 次实施封湖育鱼，青海湖裸鲤资源量逐步恢复，2021 年，青海湖裸鲤资源蕴藏量较 2017 年增加 33.6%，达到 10.85 万吨；普氏原羚数量较 2017 年增加 120.8%，达到 2800 余只；草地综合植被盖度达 59.7%，草原植物多样性丰富稳定；湿地保护率达 69%，流域生物多样性和物种丰富度明显提升。

（来源：科学网，https://news.sciencenet.cn/htmlnews/2022/6/480528.shtm,根据相关资料编译）

## 湖北首次开展湖泊群生态价值核算 为湿地碳汇纳入交易提供支撑

国家发展改革委受武汉市测绘研究院委托，经过近一年的监测评估，湖北省地质调查院日前发布结果，武汉市汉阳湖泊群生态系统生产总值（GEP）为 7.547 亿元。

湖北省地质调查院基础地质调查中心主任李朋说，本次调查的汉阳湖泊群由墨水湖、龙阳湖、南太子湖、北太子湖、月湖、三角湖等 6 个湖泊组成，这是武汉四大水网之一。2021 年以来，湖北省地质调查院从湖泊的供给服务、调节服务、支持服务、文化服务等四个方面，对汉阳湖泊群生态系统生产总值进行精准核算，确定其 GEP 为 7.547 亿元。

本次调查是湖北省首次对湖泊群生态价值进行核算。数据显示，汉阳湖泊群以水文调节、净化环境、气候调节、水源涵养等为主的调节服务价值最大，达 6.379 亿元，占 84.52%；以水资源供给为主的供给服务价值为 0.489 亿元；以生物多样性维持功能为主的支持服务价值为 0.384 亿元；以休闲娱乐和科普教育功能为主的文化服务价值为 0.295 亿元。

同时，湖北省地质调查院还通过对龙阳湖和墨水湖的湖泊水体、沉积物及植被等介质进行研究，估算出两个湖泊的碳汇功能价值分别为 0.113 亿元、0.179 亿元。其中，湖泊沉积物比水体、植被在碳汇功能方面的贡献更大。

生态系统生产总值（Gross Ecosystem Product），简称“GEP”，是与国内生产总值（GDP）相对应、衡量生态价值统计与核算的体系，也被称为“绿色 GDP”。

李朋表示，本次调查对湖北省湖泊 GEP 核算、摸清全省湖泊生态家底、提升生态价值具有样本意义。下一步，湖北省地质调查院将继续推进武汉市主要湖泊湿地 GEP 统计与考核，探索通过生态补偿、碳交易等方式，破解生态产品“难度量、难抵押、难交易、难变现”等问题。湖北省地质调查院还将通过积累数据样本，制定科学精准的定量评价方法，定量掌握不同介质对湿地碳汇的影响，为湿地碳汇纳入碳交易市场提供科学支撑。

（来源：新华网，http://m.news.cn/2022-04/15/c_1128564632.htm，根据相关资料编译）

## 云南设立九大高原湖泊财政考核奖补专项资金

“十三五”以来，云南省财政厅通过安排省级一般公共预算和发行政府专项债券，累计落实九大高原湖泊保护治理财政资金195亿元，为支持打好九大高原湖泊保护治理攻坚战提供了财力支撑。

为落实省委、省政府关于实施“湖泊革命”攻坚战的决策部署，按照保障

与激励并重、监督与考核并举的原则，近日，省财政厅会同省河长制办公室、省生态环境厅联合印发了《云南省九大高原湖泊省级财政奖补资金考核管理办法》（以下简称《办法》）。《办法》以落实九大高原湖泊“退、减、调、治、管”工作任务，推动九大高原湖泊流域生态环境质量改善为政策目标，明确设立九大高原湖泊保护治理省级财政考核奖补专项资金。

专项资金实行考核奖补，主要依据“年度工作目标考核”和“项目资金绩效考核”两个考核指标体系。其中，工作目标考核围绕省委、省政府治湖五字方针：“退、减、调、治、管”，细化为16项具体考核指标，由省河长办牵头实施年度考评并提出评分建议；资金绩效目标考核围绕决策、过程、产出、效益、满意度5个方面，细化为7项二级指标和15项三级指标，由省财政厅牵头负责年度考评并提出评分建议。

通过差异化考核奖补，激励引导各地加大工作力度。资金将优先用于支持九湖保护治理“十四五”规划和“一湖一策”方案确定项目。将列出资金使用负面清单以强化监督检查；开展绩效目标、运行监控、绩效评估评价等全过程绩效管理，考核评价结果与奖补资金分配挂钩。

《办法》实施期限暂定至2025年，期满后根据法律、法规和省委、省政府有关规定及湖泊保护治理工作形势，有关部门将再行评估政策期限。

（来源：新华网，http://yn.news.cn/newscenter/2022-05/29/c_1310607353.htm，根据相关资料编译）

## 洞庭湖流域双碳研究中心签约挂牌

5 月 16 日，由中国科学院亚热带农业生态研究所与湖南师范大学共建的洞庭湖流域双碳研究中心在中科院洞庭湖湿地生态系统观测研究站签约挂牌。

签约仪式上，洞庭湖站站长谢永宏介绍了洞庭湖站的发展历程及研究方向。湖南师范大学教授彭长辉介绍了团队研究方向及最新研究进展。双方就洞庭湖流域碳循环与全球变化未来发展方向、如何服务国家双碳战略等方面进行了深入交流，并在项目合作、研究生联合培养、成果产出等方面达成一致意见。

经过近七年的持续建设，洞庭湖站碳通量观测平台已初具规模，观测对象覆盖了水域、苔草和芦苇等湿地类型。依托该平台，科研人员开展了洞庭湖湿地碳源汇格局、甲烷排放途径及环境影响、凋落物分解与土壤碳收支等方面的研究工作。

（来源：中国科学院院网，https://www.cas.cn/yx/202205/t20220517_4834920.shtml，根据相关资料编译）