湖泊科学动态

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热点文章

Mapping the World's Free-Flowing Rivers

G. Grill, B. Lehner, M. Thieme; et al.

Free-flowing rivers (FFRs) support diverse, complex and dynamic ecosystems globally, providing important societal and economic services. Infrastructure development threatens the ecosystem processes, biodiversity and services that these rivers support. Here we assess the connectivity status of 12 million kilometres of rivers globally and identify those that remain free-flowing in their entire length. Only 37 per cent of rivers longer than 1,000 kilometres remain free-flowing over their entire length and 23 per cent flow uninterrupted to the ocean. Very long FFRs are largely restricted to remote regions of the Arctic and of the Amazon and Congo basins. In densely populated areas only few very long rivers remain free-flowing, such as the Irrawaddy and Salween. Dams and reservoirs and their up- and downstream propagation of fragmentation and flow regulation are the leading contributors to the loss of river connectivity. By applying a new method to quantify riverine connectivity and map FFRs, we provide a foundation for concerted global and national strategies to maintain or restore them.

（来源：Nature，2019，DOI:10.1038/s41586-019-1111-9 ）

中文点评：

全球大河仅三分之一可自由奔流

《自然》杂志 5 月 9 日发表文章指出，世界上较长的 246 条河流中，目前仅有三分之一还能保持全程自由流动，越来越多的水坝和水库正在减少健康河流为全人类提供的多种利益。这是科学家有史以来第一次对地球上河流自由流动的状况进行评估。来自世界自然基金会（WWF）等机构的 34 名研究人员组成的国际团队，利用卫星图像和其他数据，对世界范围内总流程达 1200 万公里的河流的连通状况进行了分析。他们发现，在全世界长度超过 1000 公里的 246 条河流中，仅有 37%的河流还能不受阻碍地自由流动；在 91 条长度超过 1000 公里的入海河流中，只有 21 条还能保持从源头到海洋的贯通。这些尚能自由流动的河流主要流经北极圈、亚马逊和刚果盆地等偏远地区；而在人口密集地区，只有伊洛瓦底江、萨尔温江等少数大河还能自由流动。

研究人员指出，全球河流形成了一个错综复杂的网络，与土地、地下水和大气有着重要联系。自由流动的河流对人类和环境都很重要，不仅支撑淡水鱼的繁衍，为数亿人提供粮食安全保障，还能提供足够多的沉积物，防止耕地流失，并维系丰富的生物多样性。扰乱这些河流的连通性，往往会减少甚至消除其带给人类和自然的各种好处。

该研究还指出，水坝和水库是全球河流连通性丧失的主要原因。目前全世界已建成的大型水坝有近 6 万座，正在规划或建造的大坝则超过 3700 座，这些人为设施让许多江河无法自由奔流。此外，气候变化也威胁着全球河流的健康，温度上升已经影响到河流的流动模式、水质和生物多样性。新研究提供了跟踪自由流动河流状况的数据和方法，有助于各国协调战略，维护或恢复河流连通性。

（来源：根据世界自然基金会网站发布资料整理 2019-05-10）

摘要精选

Methane Sources in the Waters of Lake Michigan and Lake Superior as Revealed by Natural Radiocarbon Measurements

DongJoo Joung, Mihai Leonte, John D. Kessler.

The methane dynamics in the waters of Lakes Michigan and Superior, components of the North American Great Lake system, were investigated using measurements of methane concentration and natural radiocarbon (^{14}C - CH_4) dissolved in these lake waters. All ^{14}C - CH_4 measurements were above modern levels regardless of location and depth with a range of 117 - 145% modern carbon (pMC). Methane concentrations in the deep basin of both lakes were low, ranging from 3.3 to 4.3 nM, with minimal vertical variation. However, the concentrations of CH4 increased toward coastal areas in both lakes, possibly due to higher groundwater inputs and aerobic methanogenesis associated with primary productivity. Except for one site, ^{14}C - CH_4 dissolved in the waters of Lake Michigan was greater than in Lake Superior by ~12 pMC, a difference that was likely due to inputs of excess $^{14}CH_4$ from nuclear power plants along the coast of Lake Michigan.

（来源：Geophys. Res. Lett., 2019,46(10):5436-5444）

Hydrological and Ecological Controls on Autochthonous Carbonate Deposition in Lake Systems: A Case Study From Lake Wuliangsu and the Global Perspective

Dayang Sun, Yuxin He, Jinglu Wu; et al.

Based on ~150-year of sedimentary records, we identify that autochthonous carbonate deposition in Lake Wuliangsu, in the upper reaches of the Yellow River, was independent of both hydrological and ecological variations before 1965, influenced by hydrological changes due to agricultural activities during 1965-1990, and slightly impacted by higher productivity under the eutrophication process after 1990. By comparing with data from lakes across the globe, we find that lake size and lake stratification control the contribution of recycled organic carbon to autochthonous carbonate deposition. Continuous mixing and aeration in shallow lakes facilitate the transformation of organic carbon into 29-45% of sedimentary carbonate, different from large and deep lakes (2-25%). Organic carbon recycling in lakes remains generally stable or decreases under the pressure of lake eutrophication, requiring further investigations on whether more organic carbon will be buried in the carbonate form.

（来源：Geophys. Res. Lett., 2019, https://doi.org/10.1029/2019GL082224）

NIRS quantification of lake sediment composition by multiple regression using end-member spectra

Russell, Fiona E.; Boyle, John F.; Chiverrell, Richard C.

Here we develop a novel method for quantifying sediment components, e.g. biogenic silica, organic or mineral matter, from near infrared (NIR) spectra based on fitting by multiple regression of measured spectra for end-member materials. We show that with suitable end-members our new open-source multiple regression routine gives excellent simultaneous quantification of the major components of a

sediment, the concentrations comparing well with independent methods of quantification. Widely used partial least squares regression approaches rely on large environmental training data sets; our method produces comparable results, but with the advantages of negating the need for a training dataset and with greater simplicity and theoretical robustness. We demonstrate that component NIR spectra are additive, a prerequisite for use of multiple regression to un-mix the compound spectra, and show that a number of environmental materials make suitable end-members for this analysis. We show that spectral mixing is not conservative with respect to mass proportion, but rather to the relative chromatic intensity of contributing sediment components. Concentrations can be calculated using the measured spectra by correction using a chromatic intensity factor, the value of which can be measured independently. We have applied our approach to a postglacial sediment sequence from Loch Grannoch (SW Scotland) and reveal a down-core pattern of varying dominance by biogenic silica, organic and mineral content from the late glacial to present. With isolation and measurement of appropriate end-members this multivariate regression approach to interrogating NIR spectra has utility across a wide range of sedimentary environments and potentially for other spectral analytical methods.

（来源：JOURNAL OF PALEOLIMNOLOGY, 2019, 62(1):73-88）

Historical Black Carbon Reconstruction from the Lake Sediments of the Himalayan-Tibetan Plateau

Neupane, Bigyan; Kang, Shichang; Chen, Pengfei; et al.

Black carbon (BC) is one of the major drivers of climate change, and its measurement in different environment is crucial for the better understanding of long-term trends in the Himalayan-Tibetan Plateau (HTP) as climate warming has intensified in the region. We present the measurement of BC concentration from six lake sediments in the HTP to reconstruct historical BC deposition since the pre-industrial era. Our results show an increasing trend of BC concurrent with increased anthropogenic emission patterns after the commencement of the industrialization era during the 1950s. Also, sedimentation rates and glacier melt strengthening influenced the total input of BC into the lake. Source identification, based on the char and soot composition of BC, suggests biomass-burning emissions as a major contributor to BC, which is further corroborated by open-fire occurrence events in the region. The increasing BC trend continues to recent years, indicating increasing BC emissions, mainly from South Asia.

（来源：ENVIRONMENTAL SCIENCE & TECHNOLOGY, 2019, 53(10):5641-5651）

Triple oxygen isotope signatures of evaporation in lake waters and carbonates: A case study from the western United States

Benjamin H. Passey, Haoyuan Ji.

Evaporation can increase the $\delta^{18}O$ values of lake waters and carbonates by several per mil. If not accounted for in geological studies, this can lead to substantial misinterpretation of $\delta^{18}O$ values in terms of paleoclimate and paleoelevation. Evaporation also leads to a lowering in residual waters of $\Delta^{17}O$, a measure of the departure of $\delta'^{17}O$ from a characteristic relationship with $\delta'^{18}O$. We present new triple oxygen isotope data from waters and carbonates from lakes and their source rivers in the western United States (Bear Lake, Great Salt Lake, Lake Tahoe, Mono Lake, and Pyramid Lake). Consistent with

predictions from steady-state isotopic mass balance models, the data illustrate marked lowering of $\Delta^{17}O$ n closed basin lakes and freshwater lakes relative to their source rivers. The evaporation slope in triple oxygen isotope space (λ_{lake}) is similar for these lakes, averaging 0.5229 and ranging between 0.5219 and 0.5239. Moreover, models and data both show that the evaporation slope correlates with $\Delta^{17}O$, meaning that the slope can be estimated on the basis of the measured $\Delta^{17}O$ value of the carbonate. We show how triple oxygen isotopes in lake waters and carbonates and 'clumped isotopes' (Δ_{47}) in carbonates can be combined to reconstruct the $\delta^{18}O$ values of primary (unevaporated) catchment precipitation ($\delta^{18}O_{rucp}$). We use our lacustrine carbonate data as a test case for this approach, and find that $\delta^{18}O_{rucp}$ values closely approximate independently-measured $\delta^{18}O$ values of catchment precipitation. However, the $\delta^{18}O_{rucp}$ values are consistently higher than $\delta^{18}O$ of catchment precipitation by ~2‰, which may reflect present incomplete understanding of a number of triple oxygen isotope parameters used in the calculation, such as the fractionation exponent for carbonate-water equilibrium, the evaporation slope λ_{lake}, and the $\Delta^{17}O$ values of unevaporated meteoric waters. In conclusion, triple oxygen isotope analysis of lake waters and lacustrine carbonates is a promising new method for studying evaporation in fossil lake systems, but will benefit from additional research into triple oxygen isotope systematics relevant to meteoric waters, lake systems, and carbonate-water fractionation.

（来源：Earth and Planetary Science Letters, 2019, 518:1-12）

Variable responses of dissolved organic carbon to precipitation events in boreal drinking water lakes

Warner, Kate A.; Saros, Jasmine E.

In boreal regions, increased concentrations of dissolved organic carbon (DOC) have been linked to extreme wet years; however, less is known about the extent to which precipitation events are altering DOC concentration and quality. We assessed the effects of rain events on a suite of six lakes in Maine, U.S.A., to better understand how events alter DOC quantity and quality. DOC concentrations and DOC quality (measured as DOC-specific absorption coefficients (Specific Ultraviolet Absorbance (SUVA(254) (also a(254)*). a(320)*, and a(380)*)) were quantified 24 h before, and at three time points (24-48 h, 5-7 days, and 3 weeks) after five different precipitation events. Our results revealed three types of responses across the lakes: (1) an initial spike in DOC concentrations of 30-133% and in the three quality metrics of 20-86% compared to pre-storm levels, followed by return to pre-storm concentrations; (2) a sustained increase in DOC concentrations (by 4-23%) and an increase in the three DOC quality metrics (by 1-43%) through the second post-storm sampling, with concentrations falling by the third post-storm sampling compared to pre-storm levels; and (3) no change during all sampling periods. Lake residence time was a key driver of changes in DOC concentration and DOC quality in response to storm events. Our research provides evidence that precipitation events contribute to short-term abrupt changes in DOC quantity and quality that are largely driven by key landscape and lake characteristics. These changes in DOC may have important implications for management of water utilities, including alteration or implementation of treatment strategies.

（来源：WATER RESEARCH, 2019, 156:315-326）

Contrasting arsenic cycling in strongly and weakly stratified contaminated lakes: Evidence for temperature control on sediment-water arsenic fluxes

Barrett, P. M.; Hull, E. A.; Burkart, K.; et al.

Arsenic contamination of lakebed sediments is widespread due to a range of human activities, including herbicide application, waste disposal, mining, and smelter operations. The threat to aquatic ecosystems and human health is dependent on the degree of mobilization from sediments into overlying water columns and exposure of aquatic organisms. We undertook a mechanistic investigation of arsenic cycling in two impacted lakes within the Puget Sound region, a shallow weakly stratified lake and a deep seasonally stratified lake, with similar levels of lakebed arsenic contamination. We found that the processes that cycle arsenic between sediments and the water column differed greatly in shallow and deep lakes. In the shallow lake, seasonal temperature increases at the lakebed surface resulted in high porewater arsenic concentrations that drove larger diffusive fluxes of arsenic across the sediment-water interface compared to the deep, stratified lake where the lakebed remained similar to 10 degrees C cooler. Plankton in the shallow lake accumulated up to an order of magnitude more arsenic than plankton in the deep lake due to elevated aqueous arsenic concentrations in oxygenated waters and low phosphate : arsenate ratios in the shallow lake. As a result, strong arsenic mobilization from sediments in the shallow lake was countered by large arsenic sedimentation rates out of the water column driven by plankton settling.

（来源：LIMNOLOGY AND OCEANOGRAPHY, 2019, 64(3):1333-1346）

Total phosphorus-precipitation and Chlorophyll a-phosphorus relationships of lakes and reservoirs mediated by soil iron at regional scale

Tang, Quehui; Peng, Liang; Yang, Yang.

Phosphorus is a critical element determining trophic status and Chlorophyll a (Chl a) level in natural lakes and reservoirs, and total phosphorus (TP) concentrations can be predicted from data on phosphorus loading, hydraulic flushing rate and sedimentation. Due to their interactions with phosphorus, iron (hydr) oxides in suspended particles, originally derived from watershed soil, can strongly influence the phosphorus sedimentation and phosphorus bioavailability in water columns. Thus, the TP-precipitation relationship and the response of Chl a to TP are likely associated with watersheds soil iron. To test this assumption, we built hierarchical linear models for summer observation of natural lakes and reservoirs across a large geographic gradient. The intercepts and slopes of TP-precipitation relationships are higher in natural lakes than those in reservoirs, and these model coefficients exhibit latitudinal variations that are explained by the natural soil iron gradient. Soil iron, operating at a regional level, significantly mediates the effect of precipitation on TP concentration in both natural lakes and reservoirs, and drives the latitudinal variation in the Chl a-TP relationships for reservoirs. Our results imply that the increase in extreme precipitation events anticipated under future climate conditions may substantially mitigate eutrophication in tropical and subtropical reservoirs, but may worsen conditions in temperate lakes.

（来源：WATER RESEARCH, 2019, 154:136-143）

Effects of trophic status, water level, and temperature on shallow lake metabolism and metabolic balance: A standardized pan-European mesocosm experiment

Scharfenberger, Ulrike; Jeppesen, Erik; Beklioglu, Meryem; et al.

Important drivers of gross primary production (GPP) and ecosystem respiration (ER) in lakes are temperature, nutrients, and light availability, which are predicted to be affected by climate change. Little is known about how these three factors jointly influence shallow lakes metabolism and metabolic status as net heterotrophic or autotrophic. We conducted a pan-European standardized mesocosm experiment covering a temperature gradient from Sweden to Greece to test the differential temperature sensitivity of GPP and ER at two nutrient levels (mesotrophic or eutrophic) crossed with two water levels (1 m and 2 m) to simulate different light regimes. The findings from our experiment were compared with predictions made according the metabolic theory of ecology (MTE). GPP and ER were significantly higher in eutrophic mesocosms than in mesotrophic ones, and in shallow mesocosms compared to deep ones, while nutrient status and depth did not interact. The estimated temperature gains for ER of similar to 0.62 eV were comparable with those predicted by MTE. Temperature sensitivity for GPP was slightly higher than expected similar to 0.54 eV, but when corrected for daylight length, it was more consistent with predictions from MTE similar to 0.31 eV. The threshold temperature for the switch from autotrophy to heterotrophy was lower under mesotrophic (similar to 11 degrees C) than eutrophic conditions (similar to 20 degrees C). Therefore, despite a lack of significant temperature-treatment interactions in driving metabolism, the mesocosm's nutrient level proved to be crucial for how much warming a system can tolerate before it switches from net autotrophy to net heterotrophy.

（来源：LIMNOLOGY AND OCEANOGRAPHY, 2019, 64(2):616-631）

Sediment nutrients, ecological status and restoration of lakes

Horppila, Jukka.

Phosphorus (P) is the main nutrient that causes eutrophication in fresh waters. The majority of P in lake ecosystems is usually stored in the bottom sediment, hence P cycling from the sediment into the water column can significantly and negatively impact water quality. However, sediment nutrients are not taken into account, for instance, in the ecological status assessment determined by the European Water Framework Directive. This encourages lake managers to improve the water quality at the expense of the sediment; for example, chemical inactivation of P has been applied to the sediment in numerous lakes for rapid water quality improvement. While this may generate immediate results, inactivation of sediment P may in fact delay the long-term recovery of lake ecosystems and inhibit the re-use of nutrients. In some specific cases, these rapid restoration efforts that compromise sediment quality are justified. Nevertheless, we should aim for a general strategy that can promote permanent recovery of lake ecosystems - including their sediments. The support for such restoration activities may be difficult to find, since the tangible outcome is realized only after long periods of time.

（来源：WATER RESEARCH, 2019, 160: 206-208）

The wind-driven formation of cross-shelf sediment plumes in a large lake

McKinney, Paul; Austin, Jay; Fai, Gills; et al.

Wind-driven turbidity plumes frequently occur in the western arm of Lake Superior and may represent a significant cross-shelf transport mechanism for sediment, nutrient, and biota. Here, we characterize a plume that formed in late April 2016 using observations from in situ sensors and remote sensing imagery, and estimate the volume of cross-shelf transport using both the observations and an idealized analytical model of plume formation. The steady-state, barotropic model is used to determine a relationship between the intensity and duration of a wind event and the volume of water transported from nearshore to offshore during the event. The model transport is the result of nearshore flow in the direction of the wind and a pressure-gradient-driven counter flow in the deeper offshore waters, consistent with observations. The volume of offshore transport associated with the 2016 plume is estimated by both methods to have been on the order of 10(10) m(3). Analysis of similar events from 2008 to 2016 shows a strong relationship between specific wind impulse and plume volume. Differences in the intensity and duration of individual events as well as ice cover, which prevents plume formation, lead to interannual variability of offshore transport ranging over an order of magnitude and illustrates how wind-driven processes may contribute to interannual variability of ecosystem functioning.

（来源：LIMNOLOGY AND OCEANOGRAPHY, 2019, 64(3):1309-1322）

Potential anthropogenic regime shifts in three freshwater lakes in Tropical East Asia

Bannister, Wayne; McGowan, Suzanne; Santos-Borja, Adelina C.; et al.

Regime shifts in ecology are characterised by major, often abrupt changes in ecosystem structure and functioning in response to one or more driving variables, or pressures. Changes in the provision of ecosystem services are a potential outcome. Despite the current combination of rapidly increasing pressures on what are often highly important socio-ecological systems, the resilience of lakes in the warm tropics to human perturbation is far less well understood than those at higher latitudes. This paper focuses on evidence of aquatic ecosystem change from a cluster of three deep, freshwater, volcanic crater lakes (Yambo, Mohicap, and Sampaloc) at low altitude on the island of Luzon, Philippines. The lakes support different intensities of aquaculture, an important livelihood but also a driver of poor water quality throughout tropical Asia. Measured and monitored climate and water quality data, in addition to sedimentary evidence from sediment cores collected from the three study lakes, were used to determine the magnitude and trajectory of changes in lake water quality. Sediment cores were radiometrically dated and analysed for organic matter, spheroidal carbonaceous particles, and diatom remains. Diatom data were zoned numerically using cluster analysis. Diatom remains were also used to infer past variations in pH and possible relationships between potential driving climatic variables (temperature and rainfall). Diatom data sets were explored using detrended component analysis and principle component analysis. Despite differences in intensity of aquaculture, a common trajectory and timing of a potential regime shift, characterised by a replacement of benthic with planktonic diatoms and an increase in diatom accumulation rates from the early to mid-1980s, is evident, and attests a low threshold for disturbance effects. A predominantly planktonic diatom flora has persisted even after recent improvements in environmental quality. The potential new regime may be less resilient and more susceptible to harmful

algal blooms, abrupt expansions of anoxic conditions, and periodic mass fish kills when compared with its former state. The research further highlights the sensitivity of freshwater ecosystems in the warm tropics to disturbance pressures, and the risks to livelihoods, ecosystem services, and sustainable development.

（来源：FRESHWATER BIOLOGY, 2019, 64(4):708-722）

Mountain lakes: Eyes on global environmental change

Moser, K.A., Baron, J.S., Brahney, J.; et al.

Mountain lakes are often situated in protected natural areas, a feature that leads to their role as sentinels of global environmental change. Despite variations in latitude, mountain lakes share many features, including their location in catchments with steep topographic gradients, cold temperatures, high incident solar and ultraviolet radiation (UVR), and prolonged ice and snow cover. These characteristics, in turn, affect mountain lake ecosystem structure, diversity, and productivity. The lakes themselves are mostly small, and up until recently, have been characterized as oligotrophic. This paper provides a review and update of the growing body of research that shows that sediments in remote mountain lakes archive regional and global environmental changes, including those linked to climate change, altered biogeochemical cycles, and changes in dust composition and deposition, atmospheric fertilization, and biological manipulations. These archives provide an important record of global environmental change that pre-dates typical monitoring windows. Paleolimnological research at strategically selected lakes has increased our knowledge of interactions among multiple stressors and their synergistic effects on lake systems. Lakes from transects across steep climate (i.e., temperature and effective moisture) gradients in mountain regions show how environmental change alters lakes in close proximity, but at differing climate starting points. Such research in particular highlights the impacts of melting glaciers on mountain lakes. The addition of new proxies, including DNA-based techniques and advanced stable isotopic analyses, provides a gateway to addressing novel research questions about global environmental change. Recent advances in remote sensing and continuous, high-frequency, limnological measurements will improve spatial and temporal resolution and help to add records to spatial gaps including tropical and southern latitudes. Mountain lake records provide a unique opportunity for global scale assessments that provide knowledge necessary to protect the Earth system.

（来源：Global and Planetary Change, 2019, 178:77-95）

Spatio-temporal impacts of meteorological and geographic factors on the availability of nitrogen and phosphorus to algae in Chinese lakes

Huo, Shouliang; He, Zhuoshi; Ma, Chunzi; et al.

Designing effective management strategies for lake ecosystems requires an understanding of regional differences, interannual variability, and other drivers affecting the availability of nutrients to algae. In this study, generalized additive models (GAMs) based on meteorological factors and geographic location were developed to quantitatively estimate the availability of nutrients to algae (as represented by the ratio of Chlorophyll a (Chl a) to total phosphorus (TP) or total nitrogen (TN)) across 167 Chinese freshwater lakes and reservoirs. This model was then used to produce the first spatial and temporal estimates of Chl a/TP and Chl a/TN within mainland China from 1987 to 2016. The results revealed high spatial variability

driven primarily by geographic location, which explained 58.86% of the observed variability in Chl a/TP (41.98% in Chl a/TN). In addition, high interannual variability was driven by annual average temperature for both Chl a/TP and Chl a/TN. These results point to a fundamental challenge in managing regions with high nutrient levels, because these regions also tend to exhibit the strongest interannual variability, such that the impact of changes in management practices will be modulated by meteorological variability. In addition, this study provides regionalization indicators that serve as a quantitative foundation for formulating nutrient ecoregions to better administer lakes and reservoirs in China. It is therefore imperative that models combining meteorological factors with geographic location are further developed to improve the simulation of spatio-temporal variability in the availability of nutrients to algae.

（来源：JOURNAL OF HYDROLOGY, 2019, 572:380-387）

Extreme Lake Level Changes on the Tibetan Plateau Associated With the 2015/2016 El Niño

Yanbin Lei, Yali Zhu, Bin Wang; et al.

Although the impact of El Niño–Southern Oscillation on the Tibetan Plateau (TP) is reflected through stable isotopes of precipitation and ice cores, the hydroclimate response of TP lakes to El Niño–Southern Oscillation is seldom investigated. Here we show that significant lake water deficit occurred on the central TP (CTP) due to a dramatic decrease in precipitation 2016 El Ni/2016 El Niño event, followed by extreme lake water surplus in 2016 and 2017 over most of the TP (except the eastern CTP). Similar but weaker lake shrinkage and afterward expansion can also be found during historical El Niño events. Further exploration reveals that the CTP dry anomaly during El Niño events tends to bridge the dry anomalies over India and northern China, thereby forming a dry zone along the northwestern edge of the Asian monsoon domain. This study may shed light on the prediction of lake level changes on the TP.

（来源：Geophys. Res. Lett., 2019, 46(11): 5889-5898）

Winter Precipitation and Summer Temperature Predict Lake water Quality at Macroscales

Collins, S. M.; Yuan, S.; Tan, P. N.; et al.

Climate change can have strong effects on aquatic ecosystems, including disrupting nutrient cycling and mediating processes that affect primary production. Past studies have been conducted mostly on individual or small groups of ecosystems, making it challenging to predict how future climate change will affect water quality at broad scales. We used a subcontinental-scale database to address three objectives: (1) identify which climate metrics best predict lake water quality, (2) examine whether climate influences different nutrient and productivity measures similarly, and (3) quantify the potential effects of a changing climate on lakes. We used climate data to predict lake water quality in similar to 11,000 north temperate lakes across 17 U.S. states. We developed a novel machine learning method that jointly models different measures of water quality using 48 climate metrics and accounts for properties inherent in macroscale data (e.g., spatial autocorrelation). Our results suggest that climate metrics related to winter precipitation and summer temperature were strong predictors of lake nutrients and productivity. However, we found variation in the magnitude and direction of the relationship between climate and water quality. We predict that a likely future climate change scenario of warmer summer temperatures

will lead to increased nutrient concentrations and algal biomass across lakes (median similar to 3%-9% increase), whereas increased winter precipitation will have highly variable effects. Our results emphasize the importance of heterogeneity in the response of individual ecosystems to climate and are a caution to extrapolating relationships across space.

（来源：WATER RESOURCES RESEARCH, 2019, 55(4):2708-2721）

Extracting aquaculture ponds from natural water surfaces around inland lakes on medium resolution multispectral images

Zhe Zeng, Di Wang, Wenxia Tan; et al.

A considerable portion of the natural inland lakes has been gradually transformed into aquaculture ponds to meet the enormous demand for aquaculture products. The changes in ponds area can be used to measure the impact of human activities on inland lakes. However, aquaculture ponds and inland lakes are often intermingled with each other especially in the areas close to the lake shore, posing great difficulties for the extraction of aquaculture ponds from medium resolution (15–30 m) multispectral imagery, such as Landsat TM, OLI, and Geofen-1 WFV images. This study proposes a contour-based regularity measurement for water segments, which evaluates the zero-curvature portions of the boundaries, to distinguish aquaculture ponds from natural water. Water surfaces are firstly extracted from satellite images, and then boundary trace of each water segment is carried out to evaluate the geometrical feature of its contour, including perimeter, curvature and the proposed contour-based regularity. Eventually, SVM classification based on these geometrical features separates the aquaculture ponds from inland lakes. Experiments on Landsat TM, OLI, and Geofen-1 WFV images showed that the combination of perimeter, area and proposed contour-based regularity outperforms other feature combinations and produced the most accurate classification. Therefore, the proposed method can be used to extract all aquaculture ponds from all historic Landsat images to monitor the changes in inland aquaculture.

（来源：International Journal of Applied Earth Observation and Geoinformation, 2019, 80:13-25）

Sediment residence time reveals Holocene shift from climatic to vegetation control on catchment erosion in the Balkans

Alexander Francke, Anthony Dosseto, Konstantinos Panagiotopoulos; et al.

Understanding the evolution of soil systems on geological time scales has become fundamentally important to predict future landscape development in light of rapid global warming and intensifying anthropogenic impact. Here, we use an innovative uranium isotope-based technique combined with organic carbon isotopes and elemental ratios of sediments from Lake Ohrid (North Macedonia/Albania) to reconstruct soil system evolution in the lake's catchment during the last ~16,000 cal yr BP. Uranium isotopes are used to estimated the paleo-sediment residence time, defined as the time elapsed between formation of silt and clay sized detrital matter and final deposition. The chronology is based on new cryptotephra layers identified in the sediment sequence. The isotope and elemental data are compared to sedimentary properties and pollen from the same sample material to provide a better understanding of past catchment erosion and landscape evolution in the light of climate forcing, vegetation development, and anthropogenic land use.

During the Late Glacial and the Early Holocene, when wide parts of the catchment were covered by open vegetation, wetter climates promoted the mobilisation of detrital matter with a short paleo-sediment residence time. This is explained by erosion of deeper parts of the weathering horizon from thin soils. Detrital matter with a longer paleo-sediment residence time, illustrating shallow erosion of thicker soils is deposited in drier climates. The coupling between climatic variations and soil erosion terminates at the Early to Mid-Holocene transition as evidenced by a pronounced shift in uranium isotope ratios indicating that catchment erosion is dominated by shallow erosion of thick soils only. This shift suggests a threshold is crossed in hillslope erosion, possibly as a result of a major change in vegetation cover preventing deep erosion of thin soils at higher elevation. The threshold in catchment erosion is not mirrored by soil development over time, which gradually increases in response to Late Glacial to Holocene warming until human land use during the Late Holocene promotes reduced soil development and soil degradation. Overall, we observe that soil system evolution is progressively controlled by climatic, vegetation, and eventually by human land use over the last ~16,000 years.

（来源：Global and Planetary Change, 2019, 177:186-200）

Worldwide alteration of lake mixing regimes in response to climate change

R. Iestyn Woolway, Christopher J. Merchant.

Lakes hold much of Earth's accessible liquid freshwater, support biodiversity and provide key ecosystem services to people around the world. However, they are vulnerable to climate change, for example through shorter durations of ice cover, or through rising lake surface temperatures. Here we use a one-dimensional numerical lake model to assess climate change impacts on mixing regimes in 635 lakes worldwide. We run the lake model with input data from four state-of-the-art model projections of twenty-first-century climate under two emissions scenarios. Under the scenario with higher emissions (Representative Concentration Pathway 6.0), many lakes are projected to have reduced ice cover; about one-quarter of seasonally ice-covered lakes are projected to be permanently ice-free by 2080–2100. Surface waters are projected to warm, with a median warming across lakes of about 2.5 °C, and the most extreme warming about 5.5 °C. Our simulations suggest that around 100 of the studied lakes are projected to undergo changes in their mixing regimes. About one-quarter of these 100 lakes are currently classified as monomictic—undergoing one mixing event in most years— and will become permanently stratified systems. About one-sixth of these are currently dimictic—mixing twice per year—and will become monomictic. We conclude that many lakes will mix less frequently in response to climate change.

（来源：Nature Geoscience, 2019, 12:271-276）

Sea-level change as the driver for lake formation in the Yangtze Plain – A review

Yantian Xu, Zhongping Lai, Chang'an Li.

The Yangtze Plain (floodplains in the middle and lower reaches of the Yangtze River) is a region with numerous lakes, including the three largest freshwater lakes in China, i.e. Poyang Lake (PYL), Dongting Lake (DTL), and Taihu Lake (THL). The formation mechanism of these lakes offers insights into the

ongoing debate concerning the interaction between tectonic activity, climate, sea-level, human impact, and Earth-surface processes. Previous studies have usually focused on individual lakes, so there remains no over-arching and consistent framework for lake formation in the region as a whole. Here we review published sedimentary and chronological records on the above three lakes and propose that sea-level change has determined their formation. During the last glacial maximum (LGM; ca 30–20 ka), with a sea-level >120 m lower than present, a landscape of incised valleys and interfluves prevailed over the entire Yangtze Plain, including the DTL area, which is >1400 km upstream from the modern river mouth, and there was no large lake on the plain. The lakes emerged in the Holocene, although more precise ages await further investigations. The glacial sea-level lowstand, with concomitant headward incision, was responsible for the extensive deeply incised landscape of the LGM, whereas the Holocene high sea-level, with resultant infilling of the incised valleys, accounted for the formation of lakes. This sea-level forcing hypothesis suggests a more far-reaching influence of sea-level change on the Yangtze Plain, and a closer relationship between Earth-surface processes and glacial–interglacial cycles (global climate) than is commonly believed. According to our newly hypothesized climate-controlled geomorphological (CCG) model, it is very likely that similar lake-forming processes could have occurred multiple times during earlier glacial–interglacial cycles, and that this pattern might also have occurred in many other river systems in the eastern coastal areas of China, as well as in other similar river plains worldwide, thus having an important role in shaping modern coastal-plain landscapes. Further work is required to test this CCG model.

（来源：Global and Planetary Change, 2019, 181:102980）

A data set of inland lake catchment boundaries for the Qiangtang Plateau

J. S. Bowling, S. J. Livingstone, A. J. Sole; et al.

Few subglacial lakes have been identified beneath the Greenland Ice Sheet (GrIS) despite extensive documentation in Antarctica, where periodic release of water can impact ice flow. Here we present an ice-sheet-wide survey of Greenland subglacial lakes, identifying 54 candidates from airborne radio-echo sounding, and 2 lakes from ice-surface elevation changes. These range from 0.2–5.9 km in length, and are mostly distributed away from ice divides, beneath relatively slow-moving ice. Based on our results and previous observations, we suggest three zones of formation: stable lakes in northern and eastern regions above the Equilibrium Line Altitude (ELA) but away from the interior; hydrologically-active lakes near the ELA recharged by surface meltwater and; small, seasonally-active lakes below the ELA, which form over winter and drain during the melt season. These observations provide important constraints on the GrIS's basal thermal regime and help refine our understanding of the subglacial hydrological system.

（来源：Scientific Data, 2019, 10, doi.org/10.1038/s41467-019-10821-w）

Evaluating Operational Hydrodynamic Models for Real - time Simulation of Evaporation From Large Lakes

A. D. Gronewold, E. J. Anderson, J. Smit.

Methods for simulating evaporative water loss from Earth's large lakes have lagged behind advances in hydrodynamic modeling. Here we explore use of oceanographic models to simulate lake evaporation

from a long‐term water balance perspective. More specifically, we compare long‐term monthly simulations of latent heat flux from two configurations of a current operational hydrodynamic forecasting system (based on the Finite Volume Community Ocean Model, or FVCOM) for the Laurentian Great Lakes. We then compare these simulations to comparable simulations from a legacy conventional lake thermodynamics model, and from a recently developed statistical water balance model. We find that one of the FVCOM configurations that is currently used in operations for short‐term hydrodynamic forecast guidance is also suitable for real‐time simulation of evaporation from very large lakes. The operational versions of FVCOM should therefore be considered a readily available tool for supporting regional water supply management and, pending further research, extended water supply forecasting.

（来源：Geophys. Res. Lett., 2019, 46(6):3263-3269）

Unchanged frequency of moraine-dammed glacial lake outburst floods in the Himalaya

Georg Veh, Oliver Korup, Sebastian von Specht; et al.

Shrinking glaciers in the Hindu Kush–Karakoram–Himalaya–Nyainqentanglha (HKKHN) region have formed several thousand moraine-dammed glacial lakes1,2,3, some of these having grown rapidly in past decades3,4. This growth may promote more frequent and potentially destructive glacial lake outburst floods (GLOFs)5,6,7. Testing this hypothesis, however, is confounded by incomplete databases of the few reliable, though selective, case studies. Here we present a consistent Himalayan GLOF inventory derived automatically from all available Landsat imagery since the late 1980s. We more than double the known GLOF count and identify the southern Himalayas as a hotspot region, compared to the more rarely affected Hindu Kush–Karakoram ranges. Nevertheless, the average annual frequency of 1.3 GLOFs has no credible posterior trend despite reported increases in glacial lake areas in most of the HKKHN3,8, so that GLOF activity per unit lake area has decreased since the late 1980s. We conclude that learning more about the frequency and magnitude of outburst triggers, rather than focusing solely on rapidly growing glacial lakes, might improve the appraisal of GLOF hazards.

（来源：Nature Climate Change, 2019, 9:379-383）

Flood occurrence change-point analysis in the paleoflood record from Lake Mondsee (NE Alps)

Hansjörg Albrecher, Martin Bladt, Dominik Kortschak; et al.

Knowledge about changes of flood occurrence patterns is important for risk estimation of the future. Robust and well-calibrated paleoflood records, derived e.g. from lake sediments, are excellent natural archives to investigate flood variability of the past and to use the data for further modelling. In this paper, we analyse a 7100 year summer flood record recovered from Lake Mondsee (NE Alps), using a statistical approach. We identify a point process of renewal type, with a significant change-point of the occurrence pattern around 350 CE, switching from the overlay of two mechanisms of event recurrences of 5 and 50 years before to 2 and 17 years after this change-point. This change-point approach enables a comparison to other flood records, and possibly to relate event frequencies to climatic conditions. We also highlight how lower temporal resolution of flood records can hamper the analysis of relations to climatic signals. Hence high-resolution records with robust chronologies and flood information (e.g.

seasonality and event characteristics) are essential to improve the understanding of the interplay between climatic signals and flood occurrences, which is an important ingredient for proper risk estimation and risk management.

（来源：Global and Planetary Change, 2019, 178:65-76）

Lake Water Depth Controlling Archaeal Tetraether Distributions in Midlatitude Asia: Implications for Paleo Lake‐Level Reconstruction

H. Wang, Y. He, W. Liu; et al.

Lake-level reconstructions, related to terrestrial hydrological changes, are important for our understanding of past and future climates. Currently, however, reliable lake-level proxies are still limited. Here we report distributions of archaeal tetraether lipids in 70 surface sediment samples collected from 55 lakes in midlatitude Asia. We have found that among various lake physico-chemical characteristics, the relative abundances of crenarchaeol and Hydroxylated isoprenoid glycerol dialkyl glycerol tetraethers (%cren and %OH-GDGTs) are best correlated with lake water depth, due to a preference of Thaumarchaeota, the producer of these biomarkers, for a niche in subsurface lake water. This supports the recent hypothesis based on single-lake investigations that %cren and %OH-GDGTs are potentially novel lake-level proxies. Our results also suggest that %OH-GDGTs is less affected by soil input than %cren. Nevertheless, other confounding factors should be well constrained and local/site-specific calibrations are needed before the two molecular proxies are used quantitatively in down-core applications.

（来源：Geophys. Res. Lett. , 2019, 46(10): 5274-5283）

Middle to Late Miocene Eccentricity Forcing on Lake Expansion in NE Tibet

Zhixiang Wang, Chunju Huang, Alexis Licht; et al.

The East Asian summer monsoon (EASM) variability on orbital time scale has been extensively investigated in Quaternary loess and speleothems. However, EASM variability during pre-Quaternary time remains poorly understood. Here we report a continuous upper Miocene cyclostratigraphic record from lake deposits of the Tianshui basin, Northeast Tibet, to reconstruct past variations of the regional hydrological cycle. Our results, combined with previously published cyclostratigraphic records from Northeast Tibet, show that regional lake expansion cycles have been consistently dominated by ~100-kyr eccentricity forcing over most of the middle to late Miocene. These ~100 kyr cycles corroborate a significant forcing of the East Asian hydrological cycle by Antarctic ice sheet variations at that time. It is, however, unclear if this forcing affected EASM intensity or westerly derived moisture supply to the far east. Regardless of the nature of the main source of precipitation in Northeast Tibet during the Miocene, these results emphasize the existence of a strong teleconnection between Antarctic ice sheet modulations and the continental climate of Asia.

（来源：Geophys. Res. Lett., 2019, https://doi.org/10.1029/2019GL082283）

A long-term dataset of lake surface water temperature over the Tibetan Plateau derived from AVHRR 1981-2015

Baojian Liu, Wei Wan, Hongjie Xie; et al.

Lake surface water temperature (LSWT) is of vital importance for hydrological and meteorological studies. The LSWT ground measurements in the Tibetan Plateau (TP) were quite scarce because of its harsh environment. Thermal infrared remote sensing is a reliable way to calculate historical LSWT. In this study, we present the first and longest 35-year (1981–2015) daytime lake-averaged LSWT data of 97 large lakes (>80 km2 each) in the TP using the 4-km Advanced Very High Resolution Radiometer (AVHRR) Global Area Coverage (GAC) data. The LSWT dataset, taking advantage of observations from NOAA's afternoon satellites, includes three time scales, i.e., daily, 8-day-averaged, and monthly-averaged. The AVHRR-derived LSWT has a similar accuracy (RMSE = 1.7 °C) to that from other data products such as MODIS (RMSE = 1.7 °C) and ARC-Lake (RMSE = 2.0 °C). An inter-comparison of different sensors indicates that for studies such as those considering long-term climate change, the relative bias of different AVHRR sensors cannot be ignored. The proposed dataset should be, to some extent, a valuable asset for better understanding the hydrologic/climatic property and its changes over the TP.

（来源：Scientific Data, 2019, 6, doi.org/10.1038/s41597-019-0040-7）

Resolving biogeochemical processes in lakes using remote sensing

Nouchi, Vincent; Kutser, Tiit; Wuest, Alfred; et al.

Remote sensing helps foster our understanding of inland water processes allowing a synoptic view of water quality parameters. In the context of global monitoring of inland waters, we demonstrate the benefit of combining in-situ water analysis, hydrodynamic modelling and remote sensing for investigating biogeochemical processes. This methodology has the potential to be used at global scales. We take the example of four Landsat-8 scenes acquired by the OLI sensor and MODIS-Aqua imagery over Lake Geneva (FranceSwitzerland) from spring to early summer 2014. Remotely sensed data suggest a strong temporal and spatial variability during this period. We show that combining the complementary spatial, spectral and temporal resolutions of these sensors allows for a comprehensive characterization of estuarine, littoral and pelagic near-surface features. Moreover, by combining in-situ measurements, biogeochemical analysis and hydrodynamic modelling with remote sensing data, we can link these features to river intrusion and calcite precipitation processes, which regularly occur in late spring or early summer. In this context, we propose a procedure that can be used to monitor whiting events in temperate lakes worldwide.

（来源：AQUATIC SCIENCES, 2019, 81(2): UNSP 27）

Nutrient enrichment homogenizes taxonomic and functional diversity of benthic macroinvertebrate assemblages in shallow lakes

Zhang, You; Cheng, Long; Li, Kuanyi; et al.

Eutrophication alters the trophic dynamics in lakes and may result in biotic homogenization. How nutrient enrichment drives patterns of taxonomic and functional (i.e., trait-based) homogenization of macroinvertebrate assemblages at within-lake (local) and among-lake (regional) scales is, however, not

well understood. Taxonomic and functional compositions of macroinvertebrate assemblages in 41 lakes of the middle and lower reaches of the Yangtze River and Huaihe River were analyzed at within-lake and among-lake scales. Our results indicated that there was a significant difference in macroinvertebrate assemblages among lakes under different trophic status, and that total phosphorus was the major environmental factor that regulated both taxonomic and functional beta diversity of macroinvertebrate assemblages. That the abundances of pollution-tolerant species (e.g., Limnodrilus hoffmeisteri and Microchironomus tabarui) increased with trophic state contributed the most to among-lake dissimilarity. Functional beta diversity was significantly positively correlated with taxonomic beta diversity, while functional beta diversity was on average lower than taxonomic beta diversity. A combination of univariate and multivariate techniques revealed that nutrient enrichment homogenized taxonomic and functional diversity of benthic macroinvertebrate assemblages in shallow lakes at within-lake and among-lake scales, and that there was an overall trend toward taxonomic homogenization that exceeded the trend of functional homogenization. Thus, taxonomic and functional compositions should be considered simultaneously to improve understanding of the response of aquatic communities to anthropogenic disturbance, as the loss and gain of species may be influenced by species-specific features, and functional composition may exhibit a relatively high correspondence with changes in environmental conditions.

（来源：LIMNOLOGY AND OCEANOGRAPHY, 2019, 64(3):1047-1058）

Drainage network position and historical connectivity explain global patterns in freshwater fishes' range size

Juan Carvajal-Quintero, Fabricio Villalobos, Thierry Oberdorff; et al.

Identifying the drivers and processes that determine globally the geographic range size of species is crucial to understanding the geographic distribution of biodiversity and further predicting the response of species to current global changes. However, these drivers and processes are still poorly understood, and no ecological explanation has emerged yet as preponderant in explaining the extent of species' geographical range. Here, we identify the main drivers of the geographic range size variation in freshwater fishes at global and biogeographic scales and determine how these drivers affect range size both directly and indirectly. We tested the main hypotheses already proposed to explain range size variation, using geographic ranges of 8,147 strictly freshwater fish species (i.e., 63% of all known species). We found that, contrary to terrestrial organisms, for which climate and topography seem preponderant in determining species' range size, the geographic range sizes of freshwater fishes are mostly explained by the species' position within the river network, and by the historical connection among river basins during Quaternary low-sea-level periods. Large-ranged fish species inhabit preferentially lowland areas of river basins, where hydrological connectivity is the highest, and also are found in river basins that were historically connected. The disproportionately high explanatory power of these two drivers suggests that connectivity is the key component of riverine fish geographic range sizes, independent of any other potential driver, and indicates that the accelerated rates in river fragmentation might strongly affect fish species distribution and freshwater biodiversity.

（来源：PNAS, 2019, https://doi.org/10.1073/pnas.1902484116）

Hydrologic and anthropogenic influences on aquatic macrophyte development in a large, shallow lake in China

Zhang, Qinghui; Dong, Xuhui; Yang, Xiangdong; et al.

Macrophyte composition and abundance affect the overall ecological structure and function of lakes, and information on the nature and timing of changes in macrophyte assemblages is therefore crucial for understanding their impact on the lake ecosystem. We examined plant macrofossils, diatoms, cladocerans, and physical and geochemical proxies in two sediment cores from Lake Liangzi, a large shallow lake located on the Yangtze floodplain in south-east China, in order to assess recent and historical trajectories of ecological and environmental change. We also used archival records of environmental changes (i.e. hydrological, climatic, fishery, and social factors) in the lake and its catchment. Lake Liangzi is of particular interest as it, unlike most other lakes in the region, has maintained a macrophyte-dominated state. The results revealed a shift in the lake during the past ca. 160 years from a clear water, low-growing submerged macrophyte community (e.g. Najas minor, charophyte species), dominated by planktonic diatoms and planktonic cladocerans, towards a more pollutant-resistant, tall-growing macrophyte community (Potamogeton spp., Ceratophyllum demersum and Myriophyllum spicatum) and dominance by benthic and epiphytic diatoms and littoral cladocerans. However, a pronounced increase in the abundance of planktonic Bosmina spp. at the expense of true littoral cladoceran species and a decline in plant macrofossil assemblages in the surface samples suggest that the lake recently entered into a new unprecedented state. Redundancy analysis indicated major changes in hydrology and moderate inputs of anthropogenic pollutants as well as climate warming as the main drivers of ecological and environmental changes in the lake. Our study demonstrated that plant macrofossils from radionuclide-dated short sediment cores provide reliable information on the nature and timing of changes in the macrophyte community in Lake Liangzi. Furthermore, our study provided information on the composition of the plant community before recent strong perturbations and also showed the trajectories and suggested the drivers of ecological and environmental change, thereby offering valuable information for lake managers in the Yangtze region and elsewhere. Our study identifies a relatively resistant community of submerged macrophytes, which may be an initial restoration target for managers when restoring the many lakes in the region where submerged vegetation coverage has declined during the last few decades.

（来源：FRESHWATER BIOLOGY，2019，64(4):799-812）

The relative importance of weather and nutrients determining phytoplankton assemblages differs between seasons in large Lake Taihu, China

Deng, Jianming; Salmaso, Nico; Jeppesen, Erik; et al.

Climate change affects seasonal weather patterns, but little is known about the consequent effects on phytoplankton assemblage variation. We studied the changes in phytoplankton assemblages, expressed as morpho-functional groups, during four seasons over the past two decades in large shallow eutrophic Lake Taihu, China. During this period, both climate and nutrient levels changed in the lake. Wind speed declined significantly from 1997 to 2016 in all seasons, while global radiation increased significantly in spring and winter. Phosphorus and chlorophyll a concentrations showed a significant increasing trend in

all seasons, especially in summer and autumn. Diatoms, mainly Aulacoseira and Asterionella, increased during late winter and early spring. Multiple stepwise regression analysis and non-metric multidimensional scaling indicated that climatic variables (i.e., decreasing wind speed and increasing global radiation) were the main drivers of phytoplankton assemblage variance in winter and early spring. An increase in the dominance of cyanobacteria (mainly Microcystis spp.) in summer and autumn was mainly related to changes in phosphorus. Our results indicate that both nutrients and climatic variables were major drivers of the observed changes in phytoplankton assemblages, differing in importance between seasons. The differential response of phytoplankton community variation to future environmental change in the different seasons needs to be taken into account when evaluating the long-term changes in phytoplankton.

（来源：AQUATIC SCIENCES, 2019, 81(3): UNSP 48）

科技热点

格陵兰冰原下新发现 50 多个湖泊

格陵兰冰盖面积约为英国的七倍，面积超过三公里，目前在全球海平面上升方面发挥着重要作用。冰下湖泊是冰体下形成的水体。融水来自厚厚的上覆冰的压力，冰流产生的热量，保留在地球中的地热，或者流到床上的冰表面上的水。这些水可能被困在凹陷中或由于冰厚度的变化。

对这些新湖泊的了解有助于形成更加全面的图片，了解水的位置以及水在冰盖下的排水方式，这将影响冰盖如何动态响应温度上升。

近日在Nature Communications上发表的论文“格陵兰冰下湖泊的分布和动态”提供了格陵兰冰盖下第一个冰盖层的冰盖湖库存。

通过分析超过500,000公里的机载无线电回波探测数据，提供格陵兰冰盖床的图像，兰卡斯特大学，谢菲尔德大学和斯坦福大学的研究人员确定了54个冰下湖泊，以及另外两个使用冰面的湖泊海拔变化。

研究人员对南极冰下湖泊有很好的了解，这些湖泊可以填充和排出，并使覆盖的冰层更快地流动。但是，到目前为止，人们对格陵兰冰盖下的冰下湖泊分布和行为知之甚少。

“这项研究首次让我们开始建立格陵兰冰盖下湖泊形成的图片。这对于确定它们对更广泛的冰下水文系统和冰流动力学的影响以及提高我们的认识非常重要。”谢菲尔德大学自然地理高级讲师Stephen J. Livingstone博士说。

新发现的湖泊长度为0.2-5.9公里，大部分位于相对缓慢移动的冰层之下，远离冰盖内部大部分冰冻的河床，似乎相对稳定。然而，在未来随着气候变暖，地表融水将在冰盖表面的较高海拔处形成湖泊和溪流，并且将这些水排放到河床可能导致这些冰下湖泊流失并因此变得活跃。研究人员已经看到了湖泊活动的一些证据，观察到两个新的冰下湖泊被排水然后重新填充。

“这些湖泊可以为直接勘探提供重要目标，以寻找极端生命的证据，并对沉积在湖中的沉积物进行采样，以保存环境变化记录。”Stephen J. Livingstone博士说

（来源：根据http://www.sohu.com/a/323318381_100158206相关资料整理 2019-06-27）

气候变化正在改变全球渔业的生产力

鱼类为世界上一半以上的人口提供了重要的蛋白质来源，超过5600万人依赖或从事渔业生产活动。但气候变化正开始破坏支撑这一主要食物来源的复杂而相互关联的系统。由加州大学圣巴巴拉分校布伦环境科学与管理学院领导的一个科学家小

组发表了一份关于海洋变暖的水域如何影响渔业生产力的调查。该研究结果已发表在《科学》杂志上。

该研究调查了38个地区124个物种的历史丰度数据，约占报告全球捕鱼量的三分之一。研究人员将这些数据与海洋温度记录进行了比较，发现8%的种群明显受到气候变暖的负面影响，而4%的种群则受到了积极的影响。不过，总体来说，损失大于收益。研究表明，这些地区对鱼类响应温度上升的影响最大，同一地区的物种往往以类似的方式作出反应。同一科的鱼对变化的反应也有相似之处。研究人员推断，相关物种具有相似的特征和生命周期，赋予它们相似的优势和弱点。

在研究从1930年到2010年鱼类食用供应情况如何变化时，研究人员发现日本海、北海、伊比利亚海岸、黑潮海流和凯尔特-比斯开大陆架生态区生产力损失最大。另一方面，最大的收益发生在拉布拉多-纽芬兰地区、波罗的海、印度洋和美国东北部。尽管到目前为止渔业生产力的变化很小，但存在着巨大的区域差异。例如，变暖导致人口增长最快的东亚地区渔业生产力下降了15％至35％。

这些调查结果强调了考虑气候变化对渔业管理影响的重要性。这意味着要提出评估鱼类种群规模的新工具，制定适应不断变化的渔业生产力的捕捞限制新战略，以及在损失和收益地区之间共享捕鱼量的新协议。

防止过度捕捞将是应对气候变化对世界渔业构成威胁的一个关键部分。它使鱼类种群更容易受到气候变暖的影响，而气候变暖则阻碍了过度捕捞种群的恢复。但海洋变暖只是影响海洋生物和依赖海洋生物产业的众多过程之一。海洋酸化，氧气水平下降和栖息地丧失也都是重要的影响因素。未来需要更多的研究来了解气候变化影响鱼类种群以及依赖它们的人们的生计问题。

原文来源： https://www.universityofcalifornia.edu/news/warm-seas-scatter-fish

（来源：新华网 2019-03-04）

科学家首次研究西伯利亚北极地区湖泊对全球变暖的影响

塔斯社2019年4月23日消息，俄罗斯托木斯克国立大学、瑞典于默奥大学和法国南比利牛斯天文台的科学家首次对西伯利亚北极地区的湖泊进行全面研究，以确定它们对北极气候的影响。

在西伯利亚北极地区存在大量热熔湖，其向大气中排放大量温室气体。世界各国科学家，特别是预测全球气候变化的学者对这些湖泊非常感兴趣。当前气候预测数据仅来自5-10个湖泊的信息，没有充分考虑到西伯利亚北极地区水体的复杂性，并没有全面反映温室效应的变化。

科学家在春、夏、秋分分别对76个湖泊进行了三次取样。其间，测量了湖水中的溶解碳浓度、二氧化碳排放量以及水体表面甲烷的排放量。三国科学家成功确定了影响排放活动的因素：湖水深度、水和空气的温度、大气压力、气流等，并据此评估出温室气体排放强度。

根据科学家的研究成果，温室气体的最大排放发生在春季，当春季湖水开化后，积累了一冬天的二氧化碳气体大量排放。当秋季长时间降雨期到来之际，土地浸水面积显著增加，排放量从南向北增加并在连片永久冻土带地域达到最大值，北部的排放量比南部多1-4倍。三国科学家的相关研究结果发表在《Nature Communications》杂志上，未来将用于针对北极地区更加准确的气候预测。

（来源：科技部网站 2019-06-06）

尼泊尔的地震隐患

尼泊尔位于亚欧板块与印度板块交界地带，地壳不稳定，容易发生地震。但是在该国的西部，自1505年以来就已经没有再发生任何重大的地震的记载，如此“地震间隙”也许是一个坏消息，因为如果该地区的断层不经常释放它们挤压的能量，一个或者多个巨大且具备灾难性的地震就会发生。

为了确定这样的地震间隙是否真的存在，Ghazoui以及相关研究人员冒险进入尼泊尔喜马拉雅山脉西部的拉拉湖，从底部取回沉积层的核心。他们怀疑地核里面可能记录着过去任何一次地震所发生的时间，因为地震会导致地下水雪崩，留下了被研究人员称为的“无组织”的沉积物质。该研究小组发现了自1505年以来至少8次雪崩的证据，相当于中到大型的地震。“我们希望找到1505年地震的痕迹，但发现另一个由地震引发的雪崩纯属惊喜。这样意味着该地区的断层也许并没有想象中那样存储那么多的能量，但是也同样也突出了该地区在地震灾害总体上面对的一个“几乎永恒的风险”。科罗拉多大学博尔德分校（University of Colorado Boulder）的地震学家罗杰•比勒姆（Roger Bilham）表示，虽然他没有参与这项研究，但这是研究人员第一次利用湖泊沉积物记录来研究喜马拉雅山的地震，为研究该地区的地震历史提供了新的手段。

（来源：根据https://www.nature.com/articles/s41467-019-10093-4相关资料编译）

土卫六上的部分液态甲烷湖泊消失

4月15日发表在《自然天文学》(Nature Astronomy)杂志上的一项新研究指出，根据研究人员对卡西尼号探测器的土卫六观测数据分析显示，土卫六北极存在的数

个液态甲烷湖随季节和时间更替消失，并不具备存在生命的基本条件。

来自约翰·霍普金斯应用物理实验室和NASA喷气推进实验室的一组研究人员研究了卡西尼号2006年飞越土卫六时的图像，他们注意到土卫六的北半球存在着不少暗斑，分析显示这些都是液态甲烷湖。土卫六绕太阳一周大约需要30年的时间，所以其季节更替要比地球长得多。

2013年，当研究小组再次对同一地区进行研究时，土卫六已经从冬季进入了春季。三个表面有液体的特殊黑色斑块已经不再可见。所谓的“幽灵湖”已经消失了。研究小组认为，这些幽灵湖可能是只有几英寸深的池塘，这一现象在某种程度上印证了土卫六所经历的季节周期以及它绕太阳运行时的气候变化。尽管土卫六一直被认为是一个可能存在生命的潜在地方，但是根据这篇论文的说法，这些短命的湖泊“缺乏营养”。对于外星人来说，这不会是一个可以称之为家的好地方。当然，最新一期的《自然天文学》杂志也在当日刊登了另一篇论文，其通过卡西尼号探测器的数据描述了土卫六上存在非同寻常的甲烷湖，他们发现其深度可以超过100米。

NASA的卡西尼号探测器于1997年发射，2004年抵达土星，前后历时13年对土星及其卫星进行观测。观测了这颗环状行星及其卫星。卡西尼号探测器于2017年9月15日坠入土星大气层燃烧殆尽。NASA目前正在考虑一项新提议，派遣一架名为Dragonfly的无人航天器，对土卫六进行更详细的研究。

（根据https://www.nature.com/articles/s41550-019-0714-2相关资料编译）

月壤 8 厘米之下均匀分布着水

月球水的来源一直都是争论不休的问题。据英国《自然·地球科学》杂志15日在线发表的一篇最新论文，美国国家航空航天局（NASA）团队报告称，月球下层土里均匀分布着水。这些水源自月球形成早期，而小型陨石的撞击会释放这些月球上的水。这一发现为人类未来研究这些水的演变及更好地利用月球水奠定了基础。

10年前，研究人员在月球表面发现了微量的水，表明月球的水并非像之前认为的仅存在于极地冰储中。科学家认为，这些水源自太阳风和陨石。但是时至今日，这些微量水的来源和分布范围仍存在争议。

在位于美国马里兰州的NASA戈达德太空飞行中心内，科学家梅迪·班纳及同事决定对月球水来源进行深入分析。他们表示，NASA的月球大气与粉尘环境探测器（LADEE）搭载的一个仪器，在月球大气中检测到了偶发却含量异常高的水分，LADEE探测器在2013年10月至2014年4月之间一直绕月运行。

研究团队发现，检测到的水释放时间点，大部分都与研究期间发生的29次陨石群撞击时间重合。通过研究不同规模的陨石群所释放的水量，团队确定月壤最上层的8厘米不含水。在此之下的月壤中，则均匀分布着水，含水量最高达0.05%左右。

根据研究人员的估算，陨石撞击导致月球每年损失多达200吨的水。他们分析认为，被释放出来的地下水源自月球形成初期。

鉴于月球将会作为人类未来太空远征的“补给站”，对其水源水量的发现不但有助于日后进一步了解月球水演化，还将为人类合理利用这些水铺平道路。

（来源：科技日报 2019-04-06）

业界动态

《国家节水行动方案》印发

近日，国家发展改革委、水利部联合印发了《国家节水行动方案》（以下简称《方案》），这是贯彻落实习近平新时代中国特色社会主义思想的重要实践，是党的十九大的战略部署，是今后一段时间我国节水工作开展的主要依据。《方案》牢牢把握习近平总书记“节水优先、空间均衡、系统治理、两手发力”新时期治水方针，把水资源节约贯穿到经济社会发展全过程和各领域，为建设生态文明、推动绿色高质量发展、实现“两个一百年”奋斗目标奠定坚实基础。

目前，我国人多水少，水资源供需矛盾突出，全国正常年份缺水量达 500 亿立方米，水安全已全面亮起红灯。全社会节水意识不强、用水粗放、浪费严重，水资源利用效率与国际先进水平存在较大差距。2017 年，我国农田灌溉水有效利用系数仅为 0.54，与发达国家 0.7 至 0.8 的系数差距很大；万元工业增加值用水量为 45.6 立方米，是世界先进水平的 2 倍；万美元 GDP 用水量约为 500 立方米，而发达国家基本在 300 立方米以下。水资源短缺已经成为生态文明建设和经济社会可持续发展的瓶颈制约，迫切需要从国家层面统筹推动节水工作。

为逐步提高各领域、各行业用水效率，提升全民节水意识，基于我国国情水情和地区差异，《方案》明确提出近远期有机衔接的总体控制目标，即到 2020 年，节水政策法规、市场机制、标准体系趋于完善，万元国内生产总值用水量、万元工业增加值用水量较 2015 年分别降低 23%和 20%，节水效果初步显现；到 2022 年，用水总量控制在“十三五”末的 6700 亿立方米以内，节水型生产和生活方式初步建立；到 2035 年，全国用水总量严格控制在 7000 亿立方米以内，水资源节约和循环利用达到世界先进水平。

《方案》提出六大重点行动和深化机制体制改革两方面举措，确定了 29 项具体任务。提出“总量强度双控”“农业节水增效”“工业节水减排”“城镇节水降损”“重点地区节水开源”和“科技创新引领”六大重点行动，旨在抓大头、抓重点地区、抓关键环节，提高各领域、各行业用水效率，提升全民节水意识。强调机制体制改革，突出政策制度推动和市场机制创新两手发力，深化水价、水权水市场改革，结合用水计量监管，激发内生动力；推行水效标识、节水认证和水效领跑工作，推动合同节水管理，力求取得实效。

《方案》在保障民生和经济社会发展的基础上，坚持政策引领、市场主导、创新驱动的原则，培育竞争有序的节水服务市场。强调完善激励政策，引导社会投资，扶持节水服务企业，推动节水产业发展。推行合同节水管理模式，提供节水整体解决方案，使节水服务产业成为拉动地方就业的新途径，推动绿色发展的新支点，促

进经济社会发展的新动能。

《方案》强调，加强党对节水工作的领导，各方面协同统筹实施。推动法治建设，完善财税政策，充分发挥税收促进节水的作用。拓展融资模式，鼓励金融和社会资本进入节水领域。加大宣传力度，树立绿色节水观念，倡导简约、适度消费模式，让节水理念不断深入人心，使爱护水、节约水成为全社会的良好风尚和自觉行动。

（来源：发展改革委网站 2019-04-19）

全球约三分之一人口无安全饮用水

联合国儿童基金会和世界卫生组织6月18日联合发布的一份新报告显示，全世界约有22亿人没有安全管理的饮用水服务，42亿人没有安全管理的卫生服务，30亿人缺乏基本的洗手设施。

报告对2000年至2017年全世界在饮用水、环境卫生和个人卫生方面的进展进行了评估，并对不平等现象给予了特别关注。报告发现，虽然在实现普遍获得基本用水、环境卫生和个人卫生方面取得了重大进展，但在提供的服务质量方面还存在巨大缺口。

儿基会负责水、环境卫生和个人卫生问题的副主任纳勒尔表示，仅仅做到“提供”还不够。如果水不干净不能安全饮用，或是距离很远，如厕的路上不安全或厕所有限，那么就不算是为世界儿童提供了这些基本服务。

自2000年以来，已有18亿人获得基本的饮用水服务，但这些服务的可及性、可用性和质量存在巨大的不平等。据估计，十分之一的人口，即7.85亿人仍然缺乏基本饮用水服务，其中1.44亿人仍在饮用未经处理的地表水。数据显示，生活在农村地区的10人中有8人无法获得这些服务；在四分之一的国家中，根据对不同财富群体的估计，最富裕人群的基本服务覆盖率至少是最贫困人口的两倍。

世卫组织负责公共卫生、环境和社会决定因素问题的主任内拉表示，各国必须加倍努力，否则无法在2030年前实现普及饮用水、环境卫生和个人卫生的目标。她说：“如果各国未能加强环境卫生、安全用水和个人卫生方面的努力，我们将继续面对很久以前就已被列入历史书籍的疾病。投资于水、环境卫生和个人卫生在很多方面都具有成本效益，并且对社会有益，同时也是身体健康的重要基础。”

纳勒尔强调，在水、环境卫生和个人卫生的可及性、质量和可用性方面弥合不平等差距，应该是各国政府投资和规划战略的核心。减少这方面的投资将以牺牲后代的利益为代价，并使数十年来所取得的进展受到破坏。

原文来源： http://www.cas.cn/kj/201904/t20190416_4688946.shtml

（来源：中国科学院 2019-04-16）

数说全球水资源变化

一直以来，地球上存在的淡水绝对量并未发生大的变化。但水的分布空间和时间不平均，不能满足人类的需要。目前全世界近 20%的人口生活在远离河川等水源地的地方，甚至不得不依靠海水淡化维持生存。

近年来，随着人口的增加和城市化进程的加快，用水压力进一步加重。世界上平均每年增加 8000 万人口，意味着每年增加 640 亿立方米的用水量。同时由于人们收入增加，生活水平提高，生活方式和消费方式也发生了变化，给水资源带来巨大压力。

此外，经济活动也带来用水类型的变化。1900 年至 1995 年，全世界范围内，农业虽仍是用水大户，但已从 90%减少到不到 70%；而工业生产用水量却增加了 17 倍，从 8%增加到 20%；生活用水量也扩大了 16 倍。

中国同样是缺水国家，我国水环境面临污染威胁，生态用水缺乏，水环境恶化加剧。特别是城市化之后，处理好与人们生活、生产息息相关的水资源显得更加重要。

（来源：科技日报 2019-04-23）

生态环境部发布全国城市水环境质量排名

生态环境部于 5 月 7 日发布了 2019 年 1-3 月全国地表水环境质量状况。雅安、来宾、云浮等 30 个城市国家地表水考核断面水环境质量相对较好，吕梁、营口、邢台等 30 个城市水环境质量相对较差。

生态环境部有关负责人说，从今年一季度起，将每季度开展地级及以上城市国家地表水考核断面水环境质量状况及变化情况排名。排名城市范围为设置有国家地表水考核断面的所有地级及以上城市，参加排名的断面为 2050 个国家地表水考核断面（其中 1940 个为国家地表水评价断面，110 个为入海控制断面），主要分布在长江、黄河、珠江、松花江、淮河、海河、辽河等七大流域和西北诸河、西南诸河和浙闽片等三大片区的主要河流和重点湖库。排名不涉及城市地下水、黑臭水体，以及未设置国家地表水考核断面的较小河流、湖泊或水库。

通报还指出，2019 年 1-3 月，1940 个国家地表水评价断面中，水质优良断面比例为 74.3%，同比上升 8 个百分点；劣Ⅴ类断面比例为 6%，同比下降 3.6 个百分点。主要污染指标为氨氮、总磷和化学需氧量。而西北、西南诸河和浙闽片河流水质为优，长江和珠江流域水质良好，松花江、黄河、淮河和海河流域为轻度污染，辽河流域为中度污染。

（来源：科技日报 2019-05-08）

联合国呼吁加强全球采砂治理

近日联合国环境署的一份报告显示，过去 20 年间，消费模式的转变、人口的增长、城市化和基础设施的发展使对砂石的需求增加了 3 倍。除此之外，筑坝和开采减少了从河流到许多沿海地区的沉积物输送，导致河流三角洲沉积物减少和海滩侵蚀加速。

报告显示，沙砾资源是仅次于水的第二大开采和交易资源，国际砂石贸易正在增长，随着城市化和基础设施建设的快速发展，预计国际砂石贸易每年将增长 5.5%。由于世界各地对采砂的监管不同，拥有生物多样性和生态系统的重要区域因当地执行法规的挑战而变得更加脆弱。海洋、沿海和淡水生态系统中不可持续和非法开采的趋势日益增长，构成一种可持续性挑战。这不仅会影响环境，还会产生深远的社会影响。

该报告进一步警告说，为了在不损害环境的情况下满足世界上 100 亿人口的需求，需要有效的政策、规划、监管和管理。为了遏制不负责任和非法开采，报告建议根据国情制定标准和最佳做法。报告还呼吁投资于砂石生产和消费衡量、监测和规划，并进一步建议：在透明和问责的基础上，在砂石价值链的关键参与者和利益攸关方之间展开对话。

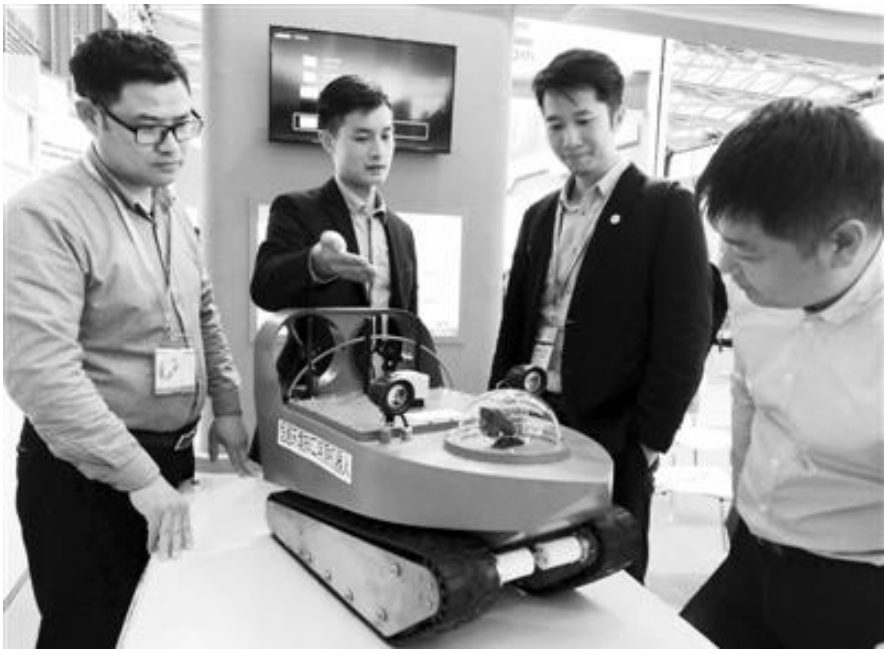
（来源：科技日报 2019-05-09）

恒通环境机器人“挂帅”治污水

4月15日至17日，第20届中国环博会在上海举行，来自全球25个国家和地区的2000多家环保企业全方位展示了环保领域中固废、水、大气、土壤等方面的最新治理技术和创新科研产品。

图为恒通环境推出的首款“排口溯源机器人”。它集成了声呐、气体检测等模块，采用无线与有线相结合的控制系统，能够在排水管网、城市暗河中检查监控雨污混接、偷排漏排等，破解黑臭水体治理难题。

4月15-17日，中国第20届环博会在上海新国际博览中心盛大举行，北京恒通国盛环境有限公司（简称：恒通环境）携最新研发的排口溯源机器人、第四代箱涵清淤机器人、圆管清淤机器人及独特的底泥原位生态修复工艺参展，收获了环保、市政领域同行及国际友人、媒体的热情关注。



（来源：科技日报 2019-04-18）

中捷企业签订污水处理合作协议

近日于克罗地亚杜布罗夫尼克举行的第八次中国—中东欧国家领导人会晤期间，中广核环保产业有限公司与捷克Environment Commerce CZ s.r.o.签订了中捷污水处理项目合作协议。

根据协议，双方将在污水处理厂设计、建设、小型一体化污水处理装置以及多项成熟先进技术的引进等方面进行深度合作，首个合作项目确定落地湖北襄阳市高新区污水处理厂，日处理污水能力为3万吨。

襄阳市高新区污水处理厂将引入由EC公司设计并开发的一体化集成污水处理方式，与传统工艺相比，可减少占地达2/3，且施工周期短，运行成本显著降低，具有“节地、节能、高标、共享”等优势，填补了国内技术空白。值得一提的是，使用该工艺后，出水水质稳定达到地表四类水或更高标准，可直接用于中水回用，解决国内新建污水处理设施或提标改造过程中的水质难达标问题。此外，无嗅厂区、封闭式的景观设计，能够达到生态共享的良好效果。

后续，双方还将在江西省抚州市等地开展深入合作，携手打造一批效果良好、外观精美、环境友好、经济适用的污水处理示范标杆项目。

（来源：科技日报 2019-04-17）

日本开发水处理陶瓷膜过滤系统

水是维持生命必需的资源，也是粮食生产、工业、资源、环境和卫生等各个领域不可或缺的资源，是建设可持续型社会不可或缺的要素。

目前，世界大部分地区都面临水资源短缺和水质污染问题，也都在进行水资源的有效管理和水处理工作。

针对水处理问题，科技日报记者近日采访了日本美得华水务株式会社海外营业部长寒川博之。

日本水处理系统运维形势严峻

日本的上下水基础设施多建于高度经济增长时期，目前设备和设施处于严重老化状态。此外，人口减少、收入下降和技术人员短缺等因素，也导致了上下水道建设和运营出现困难。在大地震和大暴雨等形势较为严峻的情况下，防灾对策成为大的课题。

据了解，美得华水务株式会社是日本第一家水和环境领域的综合工程企业集团，其融合机械技术、电气技术、信息和通信技术、维护管理等专有技术，业务范围涵盖国内外上下水道以及资源环境领域。

用先进技术方案解决现实难题

在水处理技术中，臭氧发生器具有将异味气体成分氧化分解为无臭气体成分，对病毒、细菌等进行杀毒和灭活；分解、漂白染料，分解腐殖质等有色成分；有效分解有机及有害物质等效果。

利用长年积累的经验和技术，美得华水务独有的先进水处理臭氧发生器，成功地降低了臭氧发生器的放电间隙，并且保持均衡的间隙界面，实现了高效生产臭氧。臭氧发生器的接地电极采用不锈钢内衬玻璃特殊结构，通过流经玻璃介质外侧的不锈钢管内的冷却水直接冷却，提高了臭氧的产生效率。

此外，陶瓷膜过滤系统通过可靠技术提供安全稳定用水。

据介绍，美得华水务使用的0.1微米孔径的陶瓷膜，能去除水中几乎所有杂质、微生物和有害细菌；即使原水浊度突然增加，该系统仍可持续稳定运行；水回收率高，由于是终端过滤，且反冲洗频率低，原水处理回收率高达98%以上；陶瓷膜机械强度高，化学稳定性好，运营维护简便；陶瓷膜能源利用率更高，使用寿命更长，显著降低了运营成本。

凭借其开发的多种独特先进水处理技术，美得华水务在日本国内运行、管理着数十处水处理设施，在国外也参与建设了很多水处理项目。

（来源：科技日报 2019-04-23）

生态优先使水库变“金库”

近年来，江苏省泗洪县魏营镇围绕“特色发展，生态优先”的理念，在先锋水库水面、滩涂引进装机容量 15 兆瓦的光伏发电项目，同时发展珍珠养殖 2000 余亩，尝试光伏发电和渔业养殖的立体生产，使水库滩涂变成脱贫攻坚、乡村振兴的“金库”。图为近日，在江苏泗洪魏营镇先锋水库，珍珠养殖人员在投放珍珠蚌（张连华/摄）。

（来源：新华社网站 2019-04-16）

智能养殖让鱼儿四季畅游

近日，一座智能化循环水养殖系统车间在浙江湖州吴兴区八里店镇一家生态农业公司正式投入使用。该车间占地约 1500 平方米，分为上下两层，共 36 个鱼池。整个系统包括水质监控系统、增氧系统、用水处理系统、尾水循环利用处理系统、自动投饵系统等模块，通过对溶氧、水质、水温、室温、光照等鱼类生长环境的调节控制，使鱼类一年四季都处在一个适宜的生长环境中。图为 4 月 13 日，技术人员在智能化循环水养殖车间监控运行情况（新华社记者黄宗治摄）。

（来源：科技日报 2019-04-16）