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Editorial: Integration of records and simulations in paleoclimatology

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Editorial on the Research Topic
Integration of records and simulations in paleoclimatology

The past is the key to the future. Derived from natural records and model simulations, paleoclimate evidence extends instrument-based observations of Earth's climate changes on inner-annual to glacial-interglacial time scales. This provides the long-term context and unique perspective to understand natural climate variability and future climate change. Though great progress has been made in paleoclimate reconstruction and simulation, contradictions between records and models still abound. This issue of Frontiers in Earth Science is dedicated to improving our understanding of past climate changes through both paleoclimate records and simulations at multiple temporal-spatial scales.

Temperature is one of the most important climatic factors in paleoclimate research, given we are facing unprecedented global warming. For the past decades, the temperature history of the Holocene has been intensely debated, with the best-known one being the "Holocene temperature conundrum." Rao et al. present a review of pollen-based and pollen-dominated temperature records, emphasizing the significant effects of human activities on the natural vegetation in monsoonal humid China, North America, Europe, and elsewhere. After further consideration of the evidence of forcing by global ice volume and sea level, atmospheric greenhouse gases, and insolation, this research questions the reliability of the long-term cooling trends in late Holocene. They propose that pollen may be a poor indicator of temperature change in this same epoch, mainly as a result of the impacts of intensified human activities on terrestrial vegetation. This provides a new plausible reason for the "Holocene temperature conundrum" besides the sensitivity of the climate models and the seasonality of the proxy reconstructions.

Precipitation is another important climatic factor in paleoclimate research. However, this is more locally constrained than temperature, and therefore precipitation reconstruction on large spatial scales is more challenging. Ye et al. offer a comprehensive assessment of global monsoon precipitation over the past 12,000 years based on modern observations, paleoclimate simulations, and paleoclimate records. They

reconstruct global monsoon precipitation at intervals of 10 latitudinal degrees to emphasize the effect of precipitation in sub-monsoon regions. Their results show that middle-latitude monsoon precipitation is in line with the evolution of insolation and that low-latitude monsoon precipitation shows no significant trend over the past 12,000 years. They also find that monsoon precipitation response lags approximately 2,000 years behind the onset of North Atlantic warming, providing important insights into monsoon precipitation dynamics.

As the most typical monsoon system, the Asian summer monsoon (ASM) includes two subsystems, Indian summer monsoon (ISM) and East Asian summer monsoon (EASM). The relationship between ISM and EASM on different timescales is of great significance but still unclear. Based on a stalagmite $\delta^{18}O$ record from the Didonghe (DDH) Cave in central China, Chen et al. reconstruct ASM changes during the last glacial period. It is found that DDH stalagmite $\delta^{18}O$ is controlled by low latitude summer insolation changes on orbital timescale and responds to millennial climate changes from the northern high latitudes. After comparison with stalagmite $\delta^{18}O$ from other ASM regions, they argued that the stalagmites $\delta^{18}O$ in Central China is a mixed signal of the ISM and EASM, which indicates a change of the water vapor source as an important influence on the Chinese stalagmite $\delta^{18}O$ record.

Lake sediments are one of the most used terrestrial archives in paleoclimate reconstruction. On the subject of the "Asian Water Tower," Shen C. et al. provide a Holocene environmental record from Xuguo Co, a large lake in the central Tibetan Plateau. Its pollen and loss-on-ignition analyses reveal an early Holocene climate optimum, witnessing summer temperature, monsoonal rainfall, and lake-level maxima, as well as several winter and spring aeolian activities and frequent wildfires; and modern climatic and environmental conditions were established after 4,100 cal yr BP. In the drylands of northern China, Shen Z. et al. collected fresh plant leaves, basin surface soils, lake surface sediments, and a short sediment core in the Daihai Lake basin to analyze the paleoclimate implications of n-alkanes. They found that the average chain length of long-chain n-alkanes (ACL_{27-35}) and total long-chain n-alkane concentration ($\sum alk_{long\text{-}chain}$) has the potential to reconstruct regional summer temperature and summer precipitation, respectively. Moreover, human activity can greatly influence $\sum alk_{long\text{-}chain}$ and has little effect on ACL_{27-35}. Their findings have broad significance for the paleoclimate reconstruction of other hydrologically closed lakes.

Author contributions

YL organized the Research Topic.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note