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Millennial-scale variations in East Asian summer monsoon during the last glacial period in the northern East China Sea

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Long-term rainfall records are particularly important for regions impacted by the Asian monsoon, because prediction of changes in future precipitation pattern in that area is controversial. Previous studies of the East Asian summer monsoon [EASM] based on oxygen isotope [$d^{18}O$] of speleothems claimed that millennial-scale variations in the EASM has been associated with abrupt climate changes in the high-latitude North Atlantic region called the Dansgaard-Oeschger [D-O] events and Heinrich events during the last glacial period. However, interpretation of speleothem $d^{18}O$ is difficult and suffered from uncertainties such as effect of temperature, local evaporation, $d^{18}O$ of source, and transport distance from source. Thus, past changes in regional precipitation pattern and intensity have not fully understood yet.

Today, interannual variability of sea surface salinity [SSS] in the northern East China Sea [ECS] during summer is influenced strongly by the discharge from the Yangtze River. Thus, in the northern ECS, variation in $d^{18}O$ of seawater [$d^{18}O$]{sw}], a function of salinity, reflects variation in regional summer rainfall over the Yangtze River catchment, which occupies large part of South China. In this study, we aim to reveal large-scale changes in regional EASM precipitation and consequent changes in the discharge from the Yangtze River by reconstructing the summer sea surface temperature [SST] and sea surface salinity [SSS] in the northern East China during MIS 3 and 2.

The marine sediment core, KR07-12-01recovered from the northern ECS was used in this study to reconstruct SST and SSS. An age model of KR07-12-01 was constructed based on fifteen 14C-dating points and ash layers Kikai-Akahoya (7.3 ka) and Aira-Tanzawa (29 ka). The base of the core reached 42 ka and the sediment accumulated continuously without any interruption except for the two ash layers.

Mg/Ca records revealed that lower SST events are observed at 39-40, ˜33, ˜29 ka in the studied core, which coincide with D-O stadials #9, #6, and #5, respectively, suggesting teleconnection between high-latitude North Atlantic and mid-latitude EASM regions. Positive shifts of $d^{18}O_{sw}$ by ˜0.4permil were observed at ˜39, ˜33, ˜35.5, ˜32, and ˜30 ka in the northern ECS, which seems to coincide with Heinrich event #4, D-O stadial #6, #7, and Heinrich event #3, respectively. These higher $d^{18}O_{sw}$ events in the ECS also coincide with maxima of stalagmites' $d^{18}O$ in South China. These results suggest that the EASM precipitation decreased in South China during colder periods in MIS 3 and 2 in the North Atlantic region.

On the other hand, previous studies in the ECS revealed that the $d^{18}O_{sw}$ in the northern ECS has not changed significantly associated with Younger Dryas[YD] cold event during the last deglaciation. This is in contrast with stalagmites records from eastern China, which show significant changes in association with YD. Whereas, the terrestrial records from lakes and peats in the South China suggest that the EASM precipitation has not decreased in association with YD event in that region during the last deglaciation.

The decreases in discharge from the Yangtze River during the cold periods of MIS 3 and 2 are consistent with stalagmite records. However, the discrepancy occurs between ECS $d^{18}O_{sw}$ of stalagmites and $d^{18}O$ during the deglaciation. The discrepancy could be due to the difference in global boundary condition such as the presence or absence of large ice sheets on Eurasian and North American continents. At present, the limit of EASM reaches northern China. On the other hand, the limit of the EASM likely shifted southward within South China during the last glacial period. Due to the southward shift of the EASM limit, the southern China was more easily affected by millennial scale variations in the EASM limit position during the last glacial period. Thus the decreases in EASM precipitation in southern China were associated with the abrupt changes in North Atlantic.

Keywords: Last glacial period, Dansgaard-Oeschger event, Heinrich event, East Asian summer monsoon, Mg/Ca ratio, East China Sea