

East Asian winter monsoon records for the last 140 kyr based on the diatom valve flux from Lake Biwa, Japan

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To reconstruct the pattern of past climate change in central Japan during the last 140 kyr, total planktonic diatom valve concentration (valves g⁻¹) and flux (valves cm⁻² yr⁻¹) of total planktonic diatoms and individual species were examined using a 140 m core taken from Lake Biwa, Shiga Prefecture. Sample resolution in most of the records was between ~150 and 300 years. Based on the characteristics of past and modern diatom responses to possible climate variables, we interpret changes in flux of *Aulacoseira nipponica* (AVF), those in winter lake vertical mixing induced by those in winter temperature and snowfall levels, in other words, strength of East Asian winter monsoon. During the 140–101 ka interval, disappearance of *A. nipponica* during the same period indicates weaker vertical mixing, possibly caused by increased temperature and decreased snowfall levels in winter. It suggests weak winter monsoon during this period.

During the 101–70 ka interval, AVF record shows levels near to, or above those observed at the present level, indicating that winter water temperature keeps an optimal range allowing *A. nipponica* to prosper. It suggests winter monsoon activity similar to present. Generally low AVF value during the 70–7 ka interval indicates weak winter vertical mixing and cold winter, suggesting strengthened winter monsoon. Especially, during the 55 to 12 ka interval, comparison of *Aulacoseira nipponica* flux record with the ice core record shows that the number of peaks and troughs and relative amplitudes are very similar in both profiles. Close link between decreased *Aulacoseira nipponica* flux events and ice core cold events during the last glacial and the deglacial period suggests that strengthened winter monsoons are associated with decreased temperature events over the Northern hemisphere. Between 7 and 0 ka, records of AVF show levels near to or above those at present, suggesting that winter temperature was values favorable for growth of *A. nipponica*, and snowfall during this period were probably similar to or above those at present. It suggests winter monsoon activity similar to or stronger than present.

Comparison between AVF record and GRIP ice core record suggests that there is a close link between East Asian winter monsoon and North Atlantic temperature is found only during the cool interval; both records show a approximately 4500 cycle. In contrast, during part of warm periods (mid to late Holocene and MIS 5a–5c), both records showed no close link, and millennial fluctuations found in *A. nipponica* record are not clearly found in the ice core record. These observations suggest existence of particular dynamics of East Asian winter monsoon during the warm periods, that is, the dynamics appears to be independent of North Atlantic climatic dynamics. But further consideration is required to determine it.