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Holocene seasonal environmental trends at Tokyo Bay, Japan, reconstructed from bivalve mollusk shells—implications for changes in the East Asian monsoon and latitudinal shifts of the Polar Front

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Abstract

During the last 7400 years central Japan was exposed to large swings in monsoon-related precipitation, temperature and food availability. This is supported by intra-annual growth patterns and the oxygen isotope ratios of the intertidal bivalve mollusk *Phacosoma japonicum* (Reeve, 1850) from Tokyo Bay. Results of the analysis indicate that a warm and wet period occurred around 6120–5590 cal yr BP, i.e. during the so-called 'Holocene Climate Optimum'. Summer temperatures were about 3°C higher than today, monsoon precipitation rates were near present, but the food availability was much lower than at present. However, during the periods 7390–6770 cal yr BP and 3860–3420 cal yr BP summer temperatures were about 1–2°C colder than at present and the influence of the monsoon was barely noticeable. Changes in the strength of the East Asian monsoon are mainly attributed to variations of orbital forcing of the climate. We suggest concurrent latitudinal displacements of the Polar Front, which caused significant changes in the seasonal food levels.

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1. Introduction

Today, billions of people's lives depend on the East Asian monsoon. Its failure can lead to severe droughts, and its strengthening may result in devastating floods over Asia and India. Prediction of future climate trends in these areas has thus become a focus of climate research. Understanding the natural variability of the East Asian monsoon during the Holocene, in particular during the Holocene Climatic Optimum (HCO; around 6500–5500 yr BP), the analog for expected future climate changes (An et al., 2000), provides an excellent basis for modeling anthropogenic climate changes. The Asian monsoon system is also teleconnected with the global climate system (e.g. Walker, 1924; Yasunari and Yuji, 1992; Lau and Weng, 2000). So, changes in the Asian monsoon system affect the global climate (Gupta et al., 2003). Finally, changes in the East Asian monsoon can also help to interpret cultural developments (Sandweiss et al., 1999). Changes in precipitation rates, for example, might have caused population migrations or mixing, and thus cultural and economic exchange.

Monsoon refers to seasonally shifting meridional winds, i.e. southward blowing winds during winter and northward blowing winds during summer, within the low to mid-latitudes of the northern hemisphere. Our focus is on the summer monsoon. Due to increasing insolation over the Asian continent after winter and a strong northward shift of the intertopical convergence (ITC), the thermal contrast between the warm Asian landmasses and the colder Pacific Ocean intensifies. The resulting pressure contrast drives the East Asian summer monsoon northward. Heavy rain occurs along the monsoonal front as the warm, moist, northward-flowing

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