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Sub-decadal- to decadal-scale climate variability during the Holsteinian interglacial (MIS 11) evidenced in varves from northern Germany

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The Holsteinian is generally considered to be equivalent to Marine Isotope Stage 11, which with regard to orbital forcing represents one of the closest analogues for the present interglacial. Hence, in order to gain further insights into the natural (i.e., non-anthropogenic) climate variability during an interglacial, we have examined a ∼6-meter-long, annually laminated sequence from the Dethlingen palaeolake (Lüneburger Heide, northern Germany). Micro-facies analyses, varve counting, and measuring of varve thickness have been carried out on thin sections of epoxy-impregnated sediment. The finely laminated sediments from Dethlingen comprise biogenic (diatomaceous) varves consisting of two discrete layers. The light layers are predominantly controlled by the spring and summer diatom blooms, mainly of the genera *Stephanodiscus, Ulnaria*, and *Aulacoseira*. The dark layers are composed predominantly of amorphous organic matter with fragments of diatom frustules; reworked periphytic diatoms, plant remains, and freshwater sponge spicules from the littoral zone are also common. These dark layers are formed by reworking of littoral material due to wind and wave activity, and surface runoff during autumn and winter.

Time-series analysis supports the existence of signals exceeding the 99% confidence level with time scales similar to those observed in modern instrumental data and in Holocene palaeoclimatic records. Spectral peaks at periods of 90, 25, and 10.5 years may be associated with the 88-yr Gleissberg solar cycle, the 22-yr Hale solar cycle, and the 11-yr sunspot cycle, respectively. In addition, statistically significant variability occurs within the conventional 3-to-6-year El Niño-Southern Oscillation (ENSO) bandwidth, whereas significant peaks at 5.8 and 2.6-2.7 year periods may be associated with the North Atlantic Oscillation (NAO). The power and wavelet spectra of the light and dark layers reveal pronounced differences. In particular, the ENSO/NAO-like variability is more significantly expressed in the dark layers, whereas the solar variability is more pronounced in the light layers. In addition, the wavelet spectrum of the light layers is characterized by intervals of reduced variability that have no equivalent in the dark layers. These observations reflect the processes controlling the seasonal sedimentation, which can be attributed to different responses to climate forcing and/or variations in the palaeolake's physical properties. Our results suggest that central European climate was strongly influenced by sub-decadal to decadal variability during the Holsteinian interglacial, possibly forced by solar activity and ENSO/NAO-like variability similar to the present interglacial.