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Climate signatures on decadal to interdecadal time scales as obtained from mollusk shells (*Arctica islandica*) from Iceland

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ABSTRACT

Pronounced decadal climate oscillations are detected in a multi-centennial record based on shell growth rates of the marine bivalve mollusk, *Arctica islandica*, from Iceland. The corresponding analysis of patterns in sea level pressure and temperature exhibit large-scale teleconnections with North Atlantic climate quantities. We find that the record projects onto blocking situations in the northern North Atlantic. The associated circulation shows a low-pressure signature over Greenland and the Labrador Sea and a high-pressure system over Western Europe associated with northeasterly flow towards Iceland and weakening in the westerly zonal flow over Europe. It can be speculated that such circulation affects food availability controlling shell growth. On multidecadal time scales, the record shows a pronounced variability linked to North Atlantic temperature. In our record, we find enhanced variability of the shell growth rates on multidecadal time scales, and it appears that this oscillation has high amplitudes in the 16th to 18th century also consistent with marine alkenone data. It is conceivable that these climate oscillations, also linked to sea ice export and enhanced blocking, are a more pronounced feature during times when the climate was relatively cold.

1. Introduction

In order to attribute recent environmental changes to human influence knowledge of the background variability is required, particularly for the latest Holocene (Jansen et al., 2007). Instrumental and proxy data indicate that the climate over the North Atlantic sector varies largely on quasi-decadal to multi-decadal time scales (Deser and Blackmon, 1993; Hurrell, 1995; Enfield and Mayer, 1997; Sutton and Allen, 1997; Dima and Lohmann, 2007). Decadal variability in the North Atlantic is characterized by a tripole pattern in sea surface temperature (SST) anomalies and is linked to atmosphere–ocean interactions (Bjerknes, 1964; Deser and Blackmon, 1993; Kushnir, 1994; Dima and Lohmann, 2004). Part of its signature resembles the North Atlantic Oscillation (NAO) (Hurrell and van Loon, 1997) pattern. Teleconnection patterns are large-scale patterns associated to atmosphere–ocean dynamics (for a review: Barnston and Livezey, 1987). A primary objective of paleoclimate research is the reconstruction and characterization of natural climate variability. Based on the relationships between atmospheric teleconnection patterns and different proxy data during the observational period, valuable information related to the NAO and its associated climate anomalies during the pre-instrumental period has been obtained (e.g. Appenzeller et al., 1998; Trouet et al., 2009; Rimbu and Lohmann, 2011). Teleconnection patterns, in particular the NAO and other modes in the North Atlantic are related to the frequency, intensity and spatial distribution of synoptic scale atmospheric phenomena, including atmospheric blocking (e.g., Shabbar et al., 2001). Therefore, decadal variations of atmospheric teleconnection pattern indices give information about decadal variations in the properties of synoptic-scale phenomena.

There is evidence that the global climate system contains modes of climatic variability operating on multidecadal time scales involving temperature and circulation (Mann et al., 1995; Delworth and Mann, 2000). The signature of multidecadal variability has been detected in observed sea surface temperature (SST) data showing a monopolar SST signature in the North Atlantic (Deser and Blackmon, 1993; Kushnir, 1994). The Atlantic Multidecadal Oscillation (AMO) was firstly detected from the instrumental data (Schlesinger and Ramankutty, 1994) and later on demonstrated to exist in both proxies (Mann et al., 1995; Lohmann et al., 2004; Grosfeld et al., 2007; Hetzinger et al., 2008; Poore et al., 2009; Knudsen et al., 2011) and climate models (Timmermann et al., 1998; Delworth and Mann, 2000; Latif et al., 2004; Knight et al., 2005). In control experiments of long-term simulations, the AMO has been considered as an internal mode of variability linked to reorganizations of the ocean meridional overturning circulation (e.g. Delworth and Mann, 2000; Wei et al., 2012). However, the temperature in the North Atlantic is additionally affected by external forcing through greenhouse gases, solar irradiance and volcanoes. It is worth noting that AMO also affects structures like NAO and blocking (Eden and Jung, 2001; Grosfeld et al., 2007; Häkkinen et al., 2011).

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