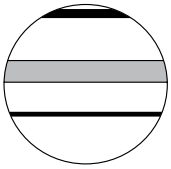

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The seasonal water temperature cycle in the Arctic Dicksonfjord (Svalbard) during the Holocene Climate Optimum derived from subfossil *Arctica islandica* shells

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Abstract

Future climate change will have significant effects on ecosystems worldwide and on polar regions in particular. Hence, palaeo-environmental studies focussing on the last warmer-than-today phase (i.e. the early Holocene) in higher latitudes are of particular importance to understand climate development and its potential impact in polar systems. Molluscan bivalve shells constitute suitable bio-archives for high-resolution palaeo-environmental reconstructions. Here, we present a first reconstruction of early Holocene seasonal water temperature cycle in an Arctic fjord based on stable oxygen isotope ($\delta^{18}O_{shell}$) profiles in shells of *Arctica islandica* (Bivalvia) from raised beach deposits in Dicksonfjorden, Svalbard, dated at 9954–9782 cal. yr BP. Reconstructed maximum and minimum bottom water temperatures for the assumed shell growth period between April and August of 15.2°C and 2.8°C imply a seasonality of about 12.4°C for the early Holocene. In comparison to modern temperatures, this indicates that average temperature declined by 6°C and seasonality narrowed by 50%. This first palaeo-environmental description of a fjord setting during the Holocene Climate Optimum at Spitsbergen exceeds most previous global estimates (+1–3°C) but confirms studies indicating an amplified effect (+4–6°C) at high northern latitudes.

Keywords

Arctica islandica, Holocene Climate Optimum, palaeo-temperature, polar amplification, sclerochronology, seasonality, Svalbard

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Introduction

Environmental and ecological consequences of future climate change will be most pronounced at high latitudes, as the ice covered polar systems are particularly sensitive to a rise in temperature (IPCC, 2013). A statistically significant warming trend of 0.09°C per decade has already been observed in mean surface temperature over the last century in the Arctic polar region (ACIA, 2004). Temperature and sea level rise across the Arctic Ocean are expected to be considerably higher (ACIA, 2004; IPCC, 2013; Spielhagen et al., 2011) than global average rise of up to 3.7°C and 0.63 m (IPCC, 2013) predicted by global circulation models (GCMs) for the year 2100.

The Holocene Climate Optimum (HCO), approximately 10,500–8200 yr BP in the Arctic region, was the warmest interval of the Holocene interglacial, followed by a general cooling trend into the modern (Ebbesen et al., 2007; Hald et al., 2004; Rasmussen et al., 2012). It was associated with an 8% higher maximum insolation anomaly (Berger and Loutre, 1991), 1–3°C warmer temperatures and an increased seasonality compared with modern (e.g. ACIA, 2004; Koc et al., 1993; Kutzbach and Guetter, 1986; Rasmussen et al., 2012; Salvigsen et al., 1992; Sarnthein et al., 2003). The similarities between the climate of the HCO and predictions for the forthcoming centuries therefore make this a particularly important interval for predicting and understanding the mechanisms and impacts of future global warming.

The archipelago of Svalbard is located north of the Arctic Circle at 74–84°N (Figure 1). The West Spitsbergen Current (WSC), the northernmost extension of the Norwegian Atlantic Current (NAC; e.g. MacLachlan et al., 2007), transports relatively warm and salty Atlantic water (AW) polewards along the western coasts of Svalbard and produces the distinct hydrography of the coastal and fjord waters. In addition, modern fjord hydrography is seasonally influenced by cold Arctic surface waters of the East Spitsbergen Current (ESC) and glacial meltwater input (e.g. Saloranta and Svendsen, 2001; Tverberg and Nøst, 2009). This general pattern (Figure 1) is presumed to have existed during the entire Holocene (Salvigsen, 2002; Slubowska-Woldengen et al., 2007). However, the early Holocene is associated with reduced (or even completely absent) glacial conditions at Svalbard, a reduced expansion of sea-ice from the north and an enhanced WSC (Hald et al., 2004; Salvigsen, 2002; Sarnthein et al., 2003; Svendsen and Mangerud, 1997). This setting is considered to resemble future conditions

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