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Advances in high-resolution paleoclimate reconstructions using growth experiments, age modelling and clumped isotope analyses

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Geochemical records from incremental carbonate archives, such as fossil mollusk shells, contain information on climate and environmental change at the resolution of days to decades (e.g. Schöne and Gillikin, 2013; Ivany, 2012). These high-resolution paleoclimate data, providing snapshots of past climate change on a human scale, complement more conventional reconstructions on a geological timescale of thousands to millions of years. Recent innovations in geochemical techniques such as high-resolution trace element and clumped isotope analyses provide the unique potential to improve the accuracy and resolution of these high-resolution climate reconstructions in the near future (see e.g. de Winter et al., 2020a; b; Caldarescu et al., 2021). However, to be able to make the most out of these new techniques requires a more detailed understanding of the timing and mechanisms of mollusk shell growth as well as the relationship between environment and shell chemistry on daily to weekly timescales.

The UNBIAS (UNravelling BIvAlve Shell chemistry) project combines investigations on lab-grown modern bivalve shells with reconstructions based on fossil shell material from past greenhouse periods in an attempt to improve our understanding of short-term temperature variability in warm climates. Samples from cultured shells labeled with a novel trace element spiking method are used to calibrate accurate temperature reconstructions from bivalve shells using the state-of-the-art clumped isotope method. As a result, we present a temperature calibration of clumped isotope measurements on aragonitic shell carbonates. New statistical routines are developed to accurately date microsamples within shells relative to the seasonal cycle (ShellChron; de Winter, 2020) and to strategically combine these microsamples for seasonal reconstructions of temperature and salinity from fossil shells (seasonalclumped, de Winter et al., 2020c; de Winter, 2021). We present the first results of this integrated seasonal reconstruction approach on fossil bivalve shells from the Pliocene Warm Period and Late Cretaceous greenhouse of northwestern Europe as well as an outlook on future plans within the UNBIAS project.

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