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Supporting Information for

Growth increments of coralline red alga *Clathromorphum compactum* capture sea-ice variability links to Atlantic Multidecadal and Arctic Oscillations (1805 – 2015)]

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Introduction

The contents of this supplement relate to our study which showed a sea-ice response to Atlantic Multidecadal Oscillation (AMO) and Arctic Oscillation (AO) in Lancaster Sound located in the Canadian Arctic Archipelago. These findings were based on growth increment-based timeseries from coralline red algae, *Clathromorphum compactum*, stated in the study as the coralline-algal-sea-ice-proxy (CASIP) record. The supplement provides comprehensive spectral analysis results (extracted the kSpectra software: methods and techniques described in Ghil et al., 2002) including comprehensive explanation of both multi-taper and single spectrum analysis (**Text S1**) and visual representation of multi-taper results (**Figure S1**) showing shared signal frequencies between CASIP and AMO/AO. Periods of time investigated relate to those of relevance to either the availability of reliable instrumental datasets (i.e., AO), the length of the entire CASIP record (1805-2015), or may be cut-off at 2000 due to documented loss of correlation between AO and sea ice cover. To specify, spectral analysis on AO was only conducted on summer index values (average of May to October).

Text S1.

Multi-taper spectral analysis identifies oscillation signals in the algal and instrumental chronologies by maximizing signal resolutions through a number of tapers, with statistical significance being independent of signal amplitude (Ghil et al., 2002). Multi-taper results showed a highly significant (99% level) 60-77-year signal in the algal chronology (ASIP: 1805–2015) (Figure S1d), comparable to the posited periodicity of AMO (60–80 years) (Kerr, 2000; Schlesinger & Ramankutty, 1994). Significant (95% level) signals at 2.3 and 3 years were also found (Figure SId), closely matching AO (Figure S1a) signatures also previously shown to affect sea ice circulation in the Baltic Sea (Jevrejeva et al., 2003).

A previous study on instrumental AO periodicity found an 8–10-year signal present since 1960s through wavelet power spectrum analysis (Ramos da Silva & Avissar, 2005). Multi-taper spectral analysis of the algal timeseries since 1960, however, only showed a significant multi-taper signal of 2–2.7-year in the ASIP record (1960-2015 and 1960-2000) and a 2.9-year signal in the AO_{SUMMER} record (1960-2015) (Figures S1a, S1b and S1c). This shared signal of approximately 2–3 years in algal and AO_{SUMMER} timeseries supports their AO and ASIP co-variability, however, surprisingly did not show the 8–10 year signal of the AO as previously reported (Ramos da Silva & Avissar, 2005).

Unlike multi-taper spectral analysis that reduces the variance of spectral estimates, singular spectrum analysis calculates total variance and estimates the amount of co-variability of signals through lagging techniques, and was specifically designed for short and noisy timeseries (Ghil et al., 2002). Accordingly, singular spectrum analysis of the shortened ASIP record (1960-2000) identified at the 95% confidence level a 10.3-year signal responsible for 34.9% variance, a 7.6-year signal for 27.8%, a 3.4-year signal for 19.1%, and 2.6-year for 18.3%. This suggests that 7.6 – 10.3-year signals were responsible for more than 60% of ASIP variance. In the AO_{SUMMER} record (1960-2000), most of the variability is captured in signals of 5.1-years, 3.4-years and 2.5-years (responsible for 22.8%, 28.2% and 32.1% variance, respectively), with a 10.6-year signal responsible for only 16.9% of total variance. In addition, results of singular spectrum analysis for the 1805–2015 period pointed to a 33-55-year signal in the algal record responsible for 29.3 % of variance, a 3–6-year signal for 13.1 % of variance and 10–17-year signal for 17.2 % of variance, quite similar to sea ice-AO responses in the Baltic Sea (2.2–3.5, 5.7–7.8, and 12–20-year signals: Jevrejeva et al., 2003) (Figure S1d). Multi-taper and singular spectral analyses did not fully identify the 8 – 10-year AO signals previously identified through wavelet power spectrum analysis (Ramos da Silva & Avissar, 2005). This further suggests that the shared variability at the approximately 2–3-year periodicity level is what sea ice-AO and sea ice-ASIP are recording.

Figure S1. Multi-taper spectral analysis for the Beechey Island algal growth increment timeseries (CASIP) and AO_{SUMMER} for time periods discussed in text. Red lines indicate 99% and 95% level of significance.