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Quantitative reconstruction of paleoproductivity changes in the Arctic by regionally constrained dinocyst transfer functions

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The Arctic is experiencing a greater-than-average response to anthropogenically induced climate change. Arctic marine ecosystems are known to react quickly to changing environmental conditions and the ongoing climate change will likely affect the Arctic marine carbon cycle. A possible approach to predict future changes in the Arctic marine carbon cycle is by investigating its past variability. However, quantification of the reaction of the individual components of the marine carbon cycle to global change in the past is hampered by the difficulty to separate the bioproductivity signal in marine sediments from diagenetic processes as well as the difficulty to reconstruct past primary productivity independent of other environmental forcings. Here we make use of the observations that the composition of marine plankton communities reflects the trophic regime under which they grew and that this information is transferred into the sediment by their fossils and that organic-walled dinoflagellate cysts (dinocysts) are in general not, like calcareous and siliceous remains, susceptible to dissolution at high latitudes.

Our specific aim is to advance the quantification of primary productivity reconstruction for the Arctic and Subarctic Baffin Bay region by calibrating regional transfer functions evaluated by a rigorous statistical analysis of the relationship between assemblage data and multiple candidate controlling parameters. The choice to calibrate regionally is guided by the hypothesis that such calibration will minimise the effect of nuisance variables and complex ecological relationships observed in a global calibration. We begin by carrying out an objective variable selection guided by canonical ordination, revealing that the regional dinocyst dataset contains multiple mutually independent environmental gradients, including productivity. We then use the dataset to design regional transfer functions and test their ability to interpret assemblage changes recorded in Holocene sediments by their applications on four records covering a north-south transect throughout the Baffin Bay. We specifically focus on Holocene sections, assuming that the magnitude of environmental change in the Holocene was small and the regional calibration is sufficient to capture the range of past environments recorded in the cores. To estimate the significance of the reconstructions we evaluate if the reconstructed primary productivity explains more of the variation in the fossil data than random environmental variables assigned to the same fossil data.

This analysis indicates that in each of the cores the environmental change to which the dinocysts reacted correspond to changes in different oceanographic parameters and that the statistical significance of the reconstructions depends on the calibration techniques used. These results imply that the existence of multiple environmental factors independently affecting the dinocyst assemblage composition requires a rigorous test of which of these parameters were likely changing in the past, before the transfer functions can be interpreted.