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TITLE: The Sensitivity of Subsurface Microbes to Ocean Warming Accentuates Future Declines in Particulate Carbon Export

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ABSTRACT:

Under future warming Earth System Models (ESMs) project a decrease in the magnitude of downward particulate organic carbon (POC) export, suggesting the potential for carbon storage in the deep ocean will be reduced. Projections of POC export can also be quantified using an alternative physiologically-based approach, the Metabolic Theory of Ecology (MTE). MTE employs an activation energy (Ea) describing organismal metabolic sensitivity to temperature change, but does not consider changes in ocean chemistry or physics. Many ESMs incorporate temperature dependent functions, where rates (e.g. respiration) scale with temperature. Temperature sensitivity describes how temperature dependence varies across metabolic rates or species. ESMs acknowledge temperature sensitivity between rates (e.g. between heterotrophic and autotropic processes), but due to a lack of empirical data cannot parameterise for variation within rates, such as differences within species or biogeochemical provinces. Here we investigate how varying temperature sensitivity affects heterotrophic microbial respiration and hence future POC export. Using satellite-derived data and ESM temperature projections we applied microbial MTE, with varying temperature sensitivity, to estimates of global POC export. In line with observations from polar regions and the deep ocean we imposed an elevated temperature sensitivity (Ea = 1.0 eV) to cooler regions; firstly to the Southern Ocean (south of 40 ?S) and secondly where temperature at 100 m depth < 13 ?C. Elsewhere in both these scenarios Ea was set to 0.7 eV (moderate sensitivity/classic MTE). Imposing high temperature sensitivity in cool regions resulted in projected declines in export of 17 ? 1 % (< 40 ?S) and 23 ? 1 % (< 13 ?C) by 2100 relative to the present day. Hence varying microbial temperature sensitivity resulted in at least twofold greater declines in POC export than suggested by classic MTE derived in this study (12 ? 1 %, Ea = 0.7 eV globally) or ESMs (1-12 %). The sparse observational data currently available suggests metabolic temperature sensitivity of organisms likely differs depending on the oceanic province they reside in. We advocate temperature sensitivity to be incorporated in biogeochemical models to improve projections of future carbon export, which could be currently underestimating future POC export.

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