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Silicic acid leakage during Last Glacial Maximum and glacial termination

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Changes in the marine biological carbon pump during glacial times have been supposed to contribute to the glacial CO_2 drawdown. One particular hypothesis that received attention during last two decades is the Silicic Acid Leakage Hypothesis (SALH), which proposed the Si leakage during glacial times from the Southern Ocean (SO) was transported towards lower latitudes and then contributed to enhanced biological productivity there and thus to global cooling by lowering atmospheric pCO_2.

Thanks to the flexible stoichiometry (C:N:Si:Chl ratios) implemented in the biogeochemistry model REcoM (used with AWIESM2), we are able to study Si leakage based on changes in diatom physiology and its effect on nutrient supply to low-latitude surface waters. Our simulations show a significant increase of Si:N ratios in surface seawater in the SO and southern-sourced mode waters at Last Glacial Maximum (LGM) when compared to pre-industrial, confirming the first part of SALH. However, due to stronger stratification and weaker upwelling during LGM, these Si-enriched waters cannot be transported to the low-latitude surface to induce higher diatom growth, arguing against the second part of SALH but in agreement with reconstructions of marine opal accumulation rates. Instead, the simulation of the beginning of the glacial termination reveals that Si leakage during deglaciation drives a low-latitude productivity increase, supporting the more recent Silicic Acid Ventilation Hypothesis (SAVH). The effect of increased biological carbon uptake is more than compensated by intense CO_2 outgassing through stronger ventilation, resulting in a rapid CO_2 rise during deglaciation.