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Reduction of future Greenland mass loss from ocean circulation weakening

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The Greenland ice sheet (GrIS) is currently losing mass, and is expected to become a major contributor to sea level rise in the coming centuries. Several positive feedbacks have been identified for future Greenland deglaciation, as the albedo-melt and elevation-melt feedbacks. On the other hand, climate models project a future substantial weakening of the North Atlantic Meridional Overturning Circulation (NAMOC), which has the potential to reduce Greenland melt rates as a result of reduced ocean heat transport to the Greenland area, however this effect has not been yet quantified. On the other side of this ice-climate interaction, numerous studies have separately addressed the potential of enhanced GrIS freshwater fluxes to weaken the NAMOC. In this study we explore the relationship between GrIS melt and NAMOC changes by means of a bi-directionally coupled climate and ice sheet model. For an idealized extreme scenario of 1% increase of carbon dioxide until quadrupled pre-industrial levels, we attribute a $\sim$24% reduction of future Greenland mass loss to NAMOC weakening after a century of stabilized greenhouse gas concentrations, or by simulation year 250. This reduction is due to lower melt rates only partially compensated by reduced snowfall accumulation. A moderate further NAMOC reduction to complete collapse reduces the mass loss with an extra $\sim$8%. Our results highlight a negative feedback for the potential of increased GrIS melt to weaken or collapse the NAMOC. In our specific model and in a 250-year time-scale, this reduction is secondary as compared to the direct ice sheet mass loss from global atmospheric warming. In addition, we found a strong dependency of the melt response to NAMOC change with the background climate conditions and duration of forcing, with higher melt reduction for sustained warmer climates due to amplifying albedo feedback and higher accumulation to ablation area ratio.

Keywords: Greenland ice sheet, AMOC, coupled ice-sheet/climate model, sea level change, climate change, surface mass balance, ice-climate feedbacks