Geophysical Research Abstracts
Vol. 21, EGU2019-10643, 2019
EGU General Assembly 2019

The North Atlantic's response to Greenland melting: Role of atmospheric feedbacks

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Enhanced melting of the Greenland ice sheet is considered one of the most likely causes for rapid climate change to occur under current global warming. This is because of the potential for the meltwater to directly enhance oceanic stratification in the subpolar North Atlantic and thus impede deep water formation. The latter could then lead to a slowdown of the Atlantic Meridional Overturning circulation (AMOC). Running climate model experiments with and without interactive atmosphere, to which we apply realistically enhanced runoff around Greenland, we find the impact on the AMOC significantly dampened in the fully coupled system.

We conducted a systematic set of enhanced Greenland runoff (EGR) experiments using the Flexible Ocean and Climate Infrastructure (FOCI) at GEOMAR, Kiel. In contrast to past hosing experiments, our EGR forcing is based on observational estimates of the freshwater flux (FWF) from Greenland (Bamber et al., 2012, GRL), thus maintaining the actual spatial heterogeneity and the observed annual cycle while being scaled up to 0.05 Sv and 0.1 Sv annually, respectively, for different sensitivity experiments. While 0.1 Sv matches the magnitude of most hosing experiments, 0.05 Sv is a gentler and more realistic disturbance as this magnitude will be reached toward the end of the 21st century (extrapolated linear trend over 1995-2010, Bamber et al. (2012) FWF data). The experiments presented include century-long coupled climate model simulations and ocean/sea-ice-only hindcasts (1948-2009) being forced with EGR over 100 and 62 years respectively.

In our simulations, AMOC strength is significantly reduced by 3-4 Sv after about 40 years with both models when 0.1 Sv of freshwater are applied. However, for the 0.05 Sv scenario the reduction is only found in the ocean-only configuration, whereas in the fully coupled model AMOC strength is practically unchanged. The total freshwater content (FWC) of the subpolar North Atlantic, i.e. the background state to which the disturbance is added, differs only by 20% between the control runs of the two configurations, which is little compared to the tripling of the FWC by the strong EGR forcing. In contrast, mean state surface heat and freshwater fluxes of the two configurations differ at about the magnitude of the configuration's individual response to the EGR forcing (50% and 20%) in the subpolar North Atlantic. A detailed analysis will be provided in the presentation. These first results, however, suggest that interaction between ocean and atmosphere matter for projecting the impact of future Greenland melting.