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Sensitivity of the Atlantic ocean circulation to a hydraulic overflow parameterisation in a coarse resolution model: Response of the subpolar gyre

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We investigate the sensitivity of a coarse resolution coupled climate model to the representation of the overflows over the Greenland-Scotland ridge. This class of models suffers from a poor representation of the water mass exchange between the Nordic Seas and the North Atlantic, a crucial part of the large-scale oceanic circulation. We revisit the explicit representation of the overflows using a parameterisation by hydraulic constraints and compare it with the enhancement of the overflow transport by artificially deepened passages over the Greenland-Scotland ridge, a common practice in coarse resolution models. Both configurations increase deep water formation in the Nordic Seas and represent the large-scale dynamics of the Atlantic realistically in contrast to a third model version with realistic sill depths but without the explicit overflow transport. The comparison of the hydrography suggests that for the unperturbed equilibrium the Nordic Seas are better represented with the parameterised overflows. As in previous studies, we do not find a stabilising effect of the overflow parameterisation on the Atlantic meridional overturning circulation but merely on the overflow transport. As a consequence the surface air temperature in the Nordic Seas is less sensitive to anomalous surface fresh water forcing.

Special attention is paid to changes in the subpolar gyre circulation. We find it sensitive to the overflow transport and the density of these water masses through baroclinic adjustments. The analysis of the governing equations confirms the presence of positive feedbacks inherent to the subpolar gyre and allows us to isolate the influence of the overflows on its dynamics.