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Stability of Antarctic Bottom Water formation to freshwater fluxes and implications for global climate

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The stability of Antarctic Bottom Water (AABW) to freshwater perturbations is investigated in a coupled climate model of intermediate complexity. It is found that AABW is stable to surface freshwater (FW) fluxes greater in volume and rate to those that permanently 'shutdown' North Atlantic Deep Water (NADW). Although AABW weakens during FW forcing, it fully recovers within 50 years of termination of FW input. This is due in part to a concurrent deep warming during AABW suppression that acts to eventually destabilise the water column. In addition, the prevailing upwelling of Circumpolar Deep Water (CDW) and northward Ekman transport across the ACC, regulated by the subpolar westerly winds, limits the accumulation of FW at high latitudes and provides a mechanism for re-salinifying the surface after the FW forcing has ceased. Enhanced sea-ice production in the cooler AABW suppressed state also aids in the re-salinification of the surface after FW forcing is stopped. Convection then restarts, with AABW properties only slightly colder and fresher compared to the unperturbed control climate state. Further experiments with larger FW perturbations, and with application rates slow enough (0.2 Sv/1000 years) for the system to be considered in a quasi-equilibriated state, confirm the lack of multiple steady states of AABW in the model. This contrasts the North Atlantic, wherein classical hysteresis behaviour is obtained with similar forcing. The climate response to reduced AABW production is also investigated. During peak FW forcing, Antarctic surface sea and air temperatures decrease by a maximum of $2.5^{\circ}\ C$ and $2.2^{\circ}\ C$ respectively. This is of a similar magnitude to the corresponding response in the North Atlantic, although in the final steady-state, the AABW experiment returns to the original control climate,

whereas the North Atlantic case transitions to a different steady-state characterised by substantial regional cooling (up to $6.0°C$ surface air temperature).