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Atlantic subsurface temperatures: response to a shut-down of the overturning circulation and consequences for its recovery

J. Mignot (1,2), **A. Ganopolski** (1) and A. Levermann (1)

(1) Potsdam Institute for Climate Impact Research, Potsdam, Germany, (2) LOCEAN, Paris, France

Using the coupled climate model CLIMBER-3α, we investigate changes in the vertical thermal structure associated with a shut-down of the Atlantic meridional overturning circulation (AMOC) induced by anomalous freshwater forcing. When Atlantic deep water formation is inhibited by this forcing, intermediate depth ventilation can still remain active and cool the subsurface water masses. If this ventilation is completely suppressed, relatively warm water masses penetrate into the high latitudes of the North Atlantic beneath the halocline and induce a strong vertical temperature inversion between the surface and intermediate depth. The resulting temperature anomalies can be detected already within the first decade after the begining of the perturbation and have strong implications for the recovery rate of the AMOC once the anomalous freshwater forcing is removed. While the AMOC recovery occurs on centennial timescales when intermediate ventilation is still active, it is much more rapid (decadal timescales) when all ventilation is suppressed. This is explained by different mechanisms of deep convection resumption in the North Atlantic in the case of positive and negative subsurface temperature anomalies. An additonal suite of sensitivity experiments with varying strength and duration of the freshwater perturbation and a larger value of background vertical diffusivity demonstrate that this feature is robust in our model. We finally discuss implications of simulated subsurface temperature response to the shutdown of the AMOC for future climate and abrupt climate changes of the past.