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Supplementary Method section

All presented experiments were started from the same pre-industrial (1850 AD) quasi-equilibrium climate. In the stochastic oscillation experiments (Figure 1) a continuous freshwater flux of respectively 5, 7.5 and 10 mSv was divided over 9 grid cells in the Labrador Sea. To prevent artificial drift in the model, the freshwater forcing was globally compensated. In the periodically forced experiment (Figure 2) the forcing was varied between 5 mSv and 10 mSv with a 500 year period. This forcing is of the same order of magnitude as the yearly precipitation over that area [Schulz, et al., 2007] and it is consistent with low-end estimates of ice sheet run-off in a shrinking Greenland ice sheet scenario [Gregory and Huybrechts, 2006]. The maximum values of the annual mean of the meridional overturning stream function north of 30 degrees N and below 500 meters were taken as indicators of the Atlantic meridional overturning circulation.

In all presented runs, this overturning circulation undergoes state-transitions between a weak and a strong mode. The absolute timing of a state switch was defined as the model-year in which the 73-year running mean of the yearly maximum of the meridional overturning stream-function crossed the 25 Sv line. The relative timing of each off-switch was defined as the phase difference (360 degrees/500 years) with respect to the nearest forcing-maximum. Likewise the relative timing of each on-switch equals the phase difference with the nearest forcing-minimum, as illustrated in Figure 2 (insets). The choice of zero phase lag coinciding with the extreme is arbitrary and does not affect the significance of the phase locking. In the control run (Figures 1 b and 3 (bottom)) the forcing was constant (at 7.5 mSv), but the same definition of relative timing in terms of phase difference with a 500 yr periodicity has been used.

To show that the timing of the switches is phase-locked with the forcing we have to reject the null-hypothesis that the timing is random. Under the null-hypothesis the events would have a random phase lag, and the vectors in Figure 3 would be expected to be drawn from a von Mises distribution with resultant vector tending to zero when the number of data points approaches infinity. By comparing the length of the resultant vector of the events to a critical value derived from such a von Mises distribution for the appropriate sample size, we can reject the null hypothesis at a certain significance level. Effectively this is a Rayleigh test for directional data, which is in general considered suitable for small sample sizes ($n>4$) [Davis, 1986].

The number of observed switches n is practically limited by the computational expensiveness of the climate model. We note that these sample sizes are too small for significance testing of binned data (histograms).

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