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Two distinct phases in the North Atlantic gyre circulation changes under global warming

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The North Atlantic Ocean gyres play a crucial role in distributing heat, salinity and nutrients throughout the ocean basin. An important question is: how could these gyre circulations evolve under global warming? Using the Max Planck Institute Grand Ensemble (MPI-GE) simulations, we investigate the mechanisms behind the changes in the mean state of the gyre circulations in the North Atlantic under increased greenhouse gas forcing. We find two distinct phases in the changes of the gyre circulation. In the first phase of 2 K warming in the global mean surface temperature (GMST) from the pre-industrial values, the sub-polar gyre (SPG) intensifies. The intensification starts from the eastern side of the SPG and is controlled by the density difference between the east and the centre of the SPG. In contrast, in the next phase of further warming beyond 2 K, the SPG keeps constant in strength except the southern part. Moreover, a northward shift of the zonal winds leads to a northward shift of the sub-tropical gyre (STG). The latter causes warmer conditions in the inter-gyre region and a weakening of the southern part of the SPG. These changes in the mean state of the gyre circulations have associated signatures in the basin wide ocean heat transports and on the North Atlantic Ocean surface temperatures.