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Revealing mechanisms of change in the Atlantic Meridional Overturning Circulation under global heating

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The North Atlantic ocean is key to climate through its role in heat transport and storage, but the response of the circulation's drivers to a changing climate is poorly constrained. The transparent machine learning method Tracking global Heating with Ocean Regimes (THOR) identifies drivers of circulation with minimal input: depth, dynamic sea level and wind stress. Beyond a black box approach, THOR's predictive skill is transparent. A dataset is created with features engineered and labeled by an explicitly interpretable equation transform and k-means application. A multilayer perceptron is then trained, explaining its skill using relevance maps and theory. THOR reveals a weakened circulation with abrupt CO₂ quadrupling, due to a shift in deep water formation areas and locations of the Gulf Stream and Trans Atlantic Current transporting heat northward. If CO₂ is increased 1% yearly, similar but transient patterns emerge. THOR could accelerate model analysis and facilitate process oriented intercomparisons.