Ocean-atmosphere dynamical coupling fundamental to the Atlantic Multidecadal Oscillation

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The North Atlantic has shown large multidecadal temperature shifts during the 20th century. Periods of warmer than average temperatures are associated with Arctic sea-ice loss, drought in the United States, drought relief in the Sahel, and a higher frequency of landfalling Atlantic hurricanes. There is ongoing debate about whether this variability arises from atmospheric variability alone, from changes in ocean circulation, or from anthropogenic aerosol forcing. Here we isolate the mechanisms driving Atlantic temperature variability on multidecadal timescales by using low-frequency component analysis to separate out the influences of high-frequency variability and long-term global warming, objectively identifying the North Atlantic subpolar gyre as the dominant region of Atlantic multidecadal variability. Using climate models, we show that warm subpolar temperatures are associated with a strengthened Atlantic Meridional Overturning Circulation, strengthened North Atlantic subpolar gyre, and local heat fluxes from the ocean into the atmosphere. Atmospheric variability plays a role in the intensification and subsequent weakening of ocean overturning and helps to communicate warming into the tropical Atlantic. These findings suggest that dynamical coupling between atmospheric and oceanic circulations is fundamental to the Atlantic Multidecadal Oscillation and motivate approaching decadal prediction with a focus on ocean circulations. We find that ocean circulation and sea level anomalies peak 2-3 years before the maximum North Atlantic warming, suggesting sea level as a predictor of decadal sea-surface temperature variability.