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Stratosphere boosts wintertime atmospheric response to Atlantic decadal variability

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The atmosphere and ocean circulation in the North Atlantic Sector exhibit pronounced multi-decadal fluctuations with major socio-economic impacts, affecting storminess, hurricanes, ecosystems, climate of surrounding continents, and Northern Hemisphere surface temperature. The atmospheric fluctuations are dominated by the boreal winter North Atlantic Oscillation (NAO. The oceanic ones are reflected in annual basin wide sea surface temperature (SST) anomalies and coined Atlantic Multi-decadal variability (AMV). While winter NAO changes drive a significant portion of AMV, whether the multi-decadal NAO changes result from ocean-atmosphere interaction or other processes - internal or external - to the atmosphere is controversial. And state-of-the-art climate models have difficulty explaining the observed atmospheric changes. Here we show, through observational analysis and atmospheric model experiments, that warming associated with AMV drives precursory changes in the stratosphere that propagate downward, causing a negative NAO in late winter. The mechanism involves wave-induced stratosphere/troposphere dynamical coupling, and can only be simulated with a stratospheric resolving model. Whereas tropical and extra-tropical SST contribute almost equally to the tropospheric response, the stratospheric changes come primarily from the extra-tropical SST. The potential stratospheric role in multi-decadal NAO fluctuations was previously recognized, but primarily in association with externally driven climate change; our results emphasise the importance of ocean variability. The influence of the stratosphere is a new aspect for understanding extra-tropical atmosphere/ocean interaction and climate variability. These findings suggest that the use of stratospheric-resolving models should improve the simulation, prediction, and projection of extra-tropical climate, and lead to better understanding of natural and anthropogenic climate change.