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Role of ocean memory in driving decadal thermal variability in the subpolar North Atlantic Ocean

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Decadal variability in subpolar North Atlantic Ocean heat content is strongly influenced by the atmosphere. Seasonal and annual atmospheric disturbances leave a lasting impact on the ocean for several years due to the ocean's substantial thermal inertia. These atmospheric perturbations first generate anomalous air-sea heat fluxes and wind patterns, rapidly modifying upper ocean temperatures (a short-term, local response). Subsequently, these modifications can alter meridional heat transport rates, leading to persistent anomalous heat convergence (long-term, far-field response) in the subpolar ocean (Khatri et al., 2022, Geophys Res Lett).

We propose a novel approach that incorporates both short-term and long-term ocean responses to evaluate ocean memory and its role in driving decadal ocean variability. This approach combines heat budget analysis with linear response theory to investigate how the North Atlantic Oscillation (NAO) influences the decadal variability of upper ocean temperatures and quantifies the associated ocean memory. Using CMIP6 climate model outputs and observations, we find that ocean memory in the subpolar North Atlantic ranges from 10 to 20 years. Furthermore, we find that the NAO significantly influences long-term ocean variability, explaining 20%-30% of subpolar ocean heat content variability on decadal timescales. This implies that the impact of seasonal atmospheric events on the ocean persists for over a decade through a combination of local and far-field ocean responses.

The proposed framework, built upon the concept of ocean memory, integrates local and far-field ocean effects into a single metric. This framework can be used to analyse how relatively short-lived atmospheric variations drive changes in the ocean state over decadal timescales.

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