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Interannual, Decadal and Centennial Variability in the North Atlantic Sector

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Nearly 50 years ago Bjerknes suggested that the character of large-scale air-sea interaction over the mid-latitude North Atlantic Ocean depends on timescale: the atmosphere drives most short-term (seasonal to interannual) sea surface temperature (SST) variability, while the ocean significantly contributes to longer-term changes. The conjecture for short timescales is well accepted. However, understanding decadal to centennial variability remains a challenge. Analysis of SST, atmospheric circulation characteristics, and results from numerical models provide some evidence that the ocean indeed drives the atmosphere at these timescales. A new (more than a century long) heat flux dataset supports this, revealing that at timescales longer than 10 years, surface turbulent heat fluxes are driven by SST Furthermore, there is some consensus from models that the Atlantic Meridional Overturning Circulation (AMOC) is a main driver of the long-term SST fluctuations. The mechanisms that drive AMOC, however, are highly uncertain. Can the variability be described by a first-order (red-noise) or higher-order stochastic model (oscillatory)? What is the role of processes in the subpolar North Atlantic relative to those in the tropical Atlantic? What are the relative roles of the heat and freshwater fluxes? What is the role of the wind stress? How important are coupled feedbacks? And what is the role of external forcing?

While the variability up to timescales of several decades seems to originate within the North Atlantic itself, at the longer centennial timescales, remote forcing, specifically from the Southern Ocean, may become important in driving variability in the North Atlantic Sector. This is supported by the very limited SST observations and by a multi-millennial control integration of a (coarse-resolution) global climate model. The latter suggests that variations in Weddell Sea convection drive AMOC on these timescales, leading not only to significant SST changes in the North Atlantic but also globally. In this model, the Weddell Sea convection is driven by the competing roles of heat accumulation by the AMOC at mid–depth and salinity changes at the surface on the stability of the water column.