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Atlantic Cold Anomalies: Causes and Consequences for European Climate

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The causes of ocean temperature anomalies in the mid-high latitude North Atlantic on timescales from interannual to centennial will be considered together with their impacts on European climate. Most notably, a large region of persistently low surface temperatures, accompanied by a sharp reduction in ocean heat content, was evident in the subpolar gyre from winter 2013-14 to 2016. The presence of this feature at a time of pervasive warming elsewhere has stimulated considerable debate. Here, we review the role of air-sea interaction and ocean processes in generating this cold anomaly and place it in a longer-term context. Potential impacts of surface temperature anomalies for the atmosphere, including the North Atlantic Oscillation and European heat waves are also discussed. In particular, a high-resolution coupled ocean atmosphere model is used to study the effects of seasonal re-emergence of North Atlantic subsurface ocean temperature anomalies on northern hemisphere winter climate. A 50-member control simulation is integrated from September 1 2007 to 28 February 2008 and compared with a similar ensemble with perturbed ocean initial conditions. The perturbation consists of a density-compensated subsurface (deeper than 180m) temperature anomaly corresponding to the observed subsurface temperature anomaly for September 2010, which is known to have re-emerged at the ocean surface in subsequent months. The perturbation is confined to the North Atlantic Ocean between 23º S and 65º North. The model has 1/4 degree horizontal resolution in the ocean and the experiment is repeated for two atmosphere horizontal resolutions ($\sim$60km and $\sim$25km) in order to determine whether the sensitivity of the atmosphere to re-emerging temperature anomalies is dependent on resolution. The experiment ensembles display a wide range of re-emergence behaviour, in some cases re-emergence occurs by November, in others it is delayed or does not occur at all. In response to re-emergence (negative SST anomalies), there is reduced latent heat loss, colder surface air temperature and positive low level pressure anomalies downstream. The results highlight a potentially important process whereby ocean memory of conditions up to a year earlier can have a significant impact on the atmosphere and European climate.