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Assessing the role of internal ocean dynamics and external forcings on the decadal-scale predictability in the North Atlantic: a large ensemble analysis

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Understanding processes and mechanisms which contribute to decadal climate variability is a crucial step in the development of a reliable prediction system, and as such it constitutes an important segment of the activities carried forward by the EU-funded Horizon 2020 EUCP project.

Sea surface temperature (SST) variability in the North Atlantic is known to be a key source of decadal predictability for the Euro-Atlantic sector. However, the nature of the observed variability is at the core of a long-standing debate.

In this work, we investigate the origins of North Atlantic SST variability, focusing on a specific event: the mid-20th century (1940-1975) “warm-to-cold” transition. This event is particularly interesting as it represents a well documented decadal-scale fluctuation of the observed climate record and can be used as a suitable test-bed to evaluate the relative skill of initialized versus non-initialized (historical) climate simulations.

Several mechanisms and processes have been taken into account to explain the cooling in the middle of 20th century, ranging from a slowdown of the Atlantic Meridional Overturning Circulation (AMOC) to an increase in anthropogenic aerosol. Here the 1940-1975 transition is examined firstly in the NCAR Large Ensemble (NCAR-LENS), aiming to further explore the role of the possible drivers. Despite the lack of a realistic model state initialization, the NCAR-LENS shows some skill in capturing the North Atlantic SST transition, suggesting a non-negligible influence of the external forcing. Some lag between observations and model results is found, with the ensemble mean SST leading the onset of the observed transition by about ten years. This is consistent with previous studies, where some evidence was found of the driving role of anthropogenic aerosol and greenhouse gas forcing. In contrast, the simultaneous ocean dynamic response (AMOC) exhibits a large intra-member spread. This finding corroborates the hypothesis of a non-oceanic driver for the decadal-scale SST fluctuation. The same episode is then analysed in the NCAR Decadal Prediction Large Ensemble (NCAR-DPLE), which shares the same model code, configuration details, component resolutions, and external forcing datasets as for the non-initialized LENS ensemble. This allows a rigorous attribution of the relative roles of initialization, (mainly constraining the ocean-driven internal variability) and external forcing conditions on the

overall skill in reproducing the Atlantic decadal variability, with clear implications for decadal predictability and predictions.