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A multi-proxy model-tested NAO reconstruction for the last millennium

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In this study, we propose a new last millennium reconstruction of the winter North Atlantic Oscillation (NAO), the dominant mode of atmospheric variability in the North Atlantic. For this purpose, we use a selection of 60 annually to decadally resolved proxy records from different archives (ice cores, tree rings, speleothems, and lake and ocean sediments), which are distributed around the Atlantic Ocean and continental boundaries. These records are selected for showing a significant correlation with the longest instrumental NAO time series. The reconstruction is based on a Principal Component Regression (PCR) technique using a subset of the initial predictors. Two pseudo-proxy studies based on the Twentieth Century Reanalysis (20CR) and the last millennium PMIP3 simulations are performed to validate the choice of proxies and therefore produce a model and reanalysis-consistent NAO. This is a novel approach in which proxy and model worlds are combined with the aim of improving the reliability of the reconstruction. An ensemble of reconstructions is additionally generated to explore the potential uncertainties inherent to the reconstruction method (i.e. calibration period, number of PCs retained, level of significance imposed, and data smoothing). Thus, we provide a robust benchmark that enables us to test recent hypotheses. For example, no persistent positive NAO phase is observed during medieval times, in clear contrast with the bi-proxy NAO reconstruction by Trouet et al (2009). Furthermore, no significant link between the winter NAO and the external forcings is identified, thus opposed to previous results with climate models. Finally, our millennial reconstruction depicts a remarkable shift around 1450 AD, characterised by a fast negative-to-positive NAO transition lying within the range of recent winter NAO excursions. This result supports that 20th century NAO variability is not unprecedent in the context of the last millennium, in line with the IPCC AR5.