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North Atlantic sea-level variability during the last millennium

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Climate modelling studies have demonstrated that spatial and temporal sea-level variability observed in North Atlantic tide-gauge records is controlled by a complex array of processes, including ice-ocean mass exchange, freshwater forcing, steric changes, changes in wind fields, and variations in the speed of the Gulf Stream. Longer records of sea-level change, also covering the pre-industrial period, are important as a 'natural' and long-term baseline against which to test model performance and to place recent and future sea-level changes and ice-sheet change into a long-term context. Such records can only be reliably and continuously reconstructed from proxy methods. Salt marshes are capable of recording decimetre-scale sea-level variations with high precision and accuracy. In this paper we present four new high-resolution proxy records of (sub-) decadal sea-level variability reconstructed from salt-marsh sediments in Iceland, Nova Scotia, Maine and Connecticut that span the past 400 to 900 years. Our records, based on more than 100 new radiocarbon analyses, Pb-210 and Cs-137 measurements as well as other biological and geochemical age markers, together with hundreds of new microfossil observations from contemporary and fossil salt marshes, capture not only the rapid 20th century sea-level rise, but also small-scale (decimetre, multi-decadal) sea-level fluctuations during preceding centuries. We show that in Iceland three periods of rapid sea-level rise are synchronous with the three largest positive shifts of the reconstructed North Atlantic Oscillation (NAO) index. Along the North American east coast we compare our data with salt-marsh records from New Jersey, North Carolina and Florida and observe a trend of increased pre-industrial sea-level variability from south to north (Florida to Nova Scotia). Mass changes and freshwater forcing cannot explain this pattern. Based on comparisons with instrumental sea-level data and modelling studies we hypothesise that multi-decadal to centennial changes in wind and air pressure are more important than mass flux from land-based ice as drivers of North Atlantic sea-level variability during the last millennium.