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Increased multidecadal hydroclimate variability over northern France during the past 500 years, and its relation to large-scale atmospheric circulation

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We examine secular changes and multidecadal climate variability on a seasonal scale in northern France over the last 500 years and examine the extent to which they are driven by large-scale atmospheric variability. Multiscale trend analysis and segmentation procedures show statistically significant increases of winter and spring precipitation amounts in Paris since the end of the 19th century. This changes the seasonal precipitation distribution from one with a pronounced summer peak at the end of the Little Ice Age to an almost uniform distribution in the 20th century. This switch is linked to an early warming trend in winter temperature. Changes in spring precipitation are also correlated with winter precipitation for time scales greater than 50 years, which suggests a seasonal persistence. Hydrological modelling results show similar rising trends in river flow for the Seine at Paris. However, such secular trends in the seasonal climatic conditions over northern France are substantially modulated by irregular multidecadal (50–80 years) fluctuations. Furthermore, since the end of the 19th century, we find an increasing variance in multidecadal hydroclimatic winter and spring, and this coincides with an increase in the multidecadal North Atlantic Oscillation (NAO) variability, suggesting a significant influence of large-scale atmospheric circulation patterns. However, multidecadal NAO variability has decreased in summer. Using Empirical Orthogonal Function analysis, we detect multidecadal North Atlantic sea-level pressure anomalies, which are significantly linked to the NAO during the Modern period. In particular, a south-eastward (south-westward) shift of the Icelandic Low (Azores High) drives substantial multidecadal changes in spring. Wetter springs are likely to be driven by potential changes in moisture advection from the Atlantic, in response to northward shifts of North Atlantic storm tracks over European regions, linked to periods of positive NAO. Similar, but smaller, changes in rainfall are observed in winter.