



## Reconstructing sea ice extent in the Arctic over the past ~900 years using a multi-proxy approach

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Arctic sea ice extent and concentration have declined significantly over the last few decades, with thick multi-year ice being replaced by thinner first year ice. While the 2009 minimum summer sea-ice extent ( $\sim 5.4$  million sq km) was greater than that of the record low of 2007, it remained well below the 1979-2000 mean value of 7 million sq km. In order to properly identify the various mechanisms that drive sea-variability on inter-annual to centennial time scales, there is a need to document past sea-ice cover variations in the Arctic region.

Here we present circum-Arctic and regional-scale reconstructions of sea-ice (summer) cover variations over the past ~900 years developed from a multi-proxy network of paleo-environmental data. These data include glacial ice cores, lake sediments, tree rings, and historical and/or documentary evidence. We adopt well-established multivariate statistical techniques to apportion the spatio-temporal variance in the multi-proxy network between temperature and other forcings. A stepwise multiple linear regression procedure is used to construct annually-resolved time-series of total and regional summer sea ice extent for the circum-Arctic. The resulting reconstructions are compared with known atmospheric circulation patterns (e.g., NAO) and key climatic variables in order to identify dominant processes responsible for the observed variability in the past millennium.

The most striking feature of our pan-Arctic sea-ice cover reconstruction is the abrupt and sustained decrease in summer ice extent observed during the second half of the 20th century, which is apparently unprecedented in the previous ~9 centuries. Our results suggest that as of 1985, Arctic summer sea ice cover extent dropped below the lower bound of the reconstructed minimum for the Medieval Warm Optimum (ca AD 1150). These findings support the contention that human influence on Arctic sea ice became detectable after the early 1990s.