Geophysical Research Abstracts
Vol. 17, EGU2015-5688, 2015
EGU General Assembly 2015

North Atlantic westerlies during the last millennium

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Understanding North Atlantic decadal-scale climate variability is crucial in order to make projections of future climate change and to assess anthropogenic impacts on climate. However, reconstructing past changes in atmospheric circulation patterns from proxy data is particularly challenging, and different proxy reconstructions often show conflicting results. Winter accumulation dominates the annual mass-balance of glaciers along the west coast of Norway, and because the winter accumulation is highly sensitive to changes in the strength of wintertime westerly winds, these glaciers are potentially valuable recorders of past atmospheric circulation. Here we present a 1200-year long spatiotemporal reconstruction of Nordfonna, a maritime plateau glacier in western Norway, based on an integrated study of terrestrial moraine sequences, sub-glacial topography, and multi-proxy records from two distal glacier-fed lakes located at the opposite sides of the glacier in a west-east transect. We use temporal changes in the west-to-east tilt of the Equilibrium-Line-Altitude (ELA) across the ice cap to infer the strength of North-Atlantic westerly winds over the past 1200 years, and validate our high-resolution (5-yr) record against instrumental data. While multidecadal fluctuations in the regional ELA can be explained largely by changes in North Atlantic sea surface temperatures (i.e. the AMO), our data suggests that the local 'Little Ice Age' maximum glacier expansion (AD 1700-1750) was caused mainly by strengthened wintertime westerlies. The wintertime westerlies over southern Norway are closely linked to the leading mode of atmospheric variability in the North Atlantic, known as the North Atlantic Oscillation (NAO), and our record therefore represents a unique proxy of past changes in the NAO.