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The Little Ice Age revisited

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The 'Little Ice Age' concept has for nearly three decades defined a recent period in our climate history that was characterized as cool enough to promote glacier growth in the Northern Hemisphere (NH) in the time from around 1300-1850 AD. A stunning number of proxy records have been published during the last 30 years documenting the effect of this brief climate epoch and it has been suggested that the LIA perhaps was not just confined to the NH, but that it in fact was a true global event. Although a well of proxy archives seems to reconstruct the LIA (though it usually differs in both timing and spatial distribution), the glaciers were always pivotal in spurring the hypothesis further – that a cooling would cause the glaciers to expand seemed almost self-explanatory. Because the LIA seem to fall within the Spöerer (1450-1550 AD), the Maunder (1645-1715 AD) and the Dalton (1790-1820 AD) Minimum the favored forcing mechanism has commonly been a decrease in solar irradiance, usually taken in combination with a relatively strong volcanic forcing (Shindell et al., 2003). A cooler climate is also recorded in most of the major temperature reconstructions covering the NH, even though the cooling is limited to 1 ˚C or so. But in terms of climate dynamics the question still remains: What exactly was the LIA? And can the global, but scattered proxy data, be reconciled in both time and space or are they simply recording local changes?

Here we present a glacier record that allows us to revisit the LIA hypothesis and offer a coherent explanation for its wide geographical extension, as well as a more exact timing of the epoch. A high-resolution lake sediment archive, retrieved from a site located on the western coast of Arctic Norway (66˚N), has enabled a detailed reconstruction of a semi-maritime glacier (Okstindan) through the last 2000 years. Because of the glaciers unique location, situated at the southern margin of the Arctic region, it is particularly sensitive to shifts in the variability of large-scale atmospheric patterns such as the Northern Hemisphere Annular Mode (NAM), which typically exhibits largest variance in the north Atlantic sector (Thompson et al., 2001). During periods of low-polarity index the NAM forces the winter climate towards a cooler and drier state with more northerly winds, causing unfavorable conditions for the maritime glaciers, which consequently are likely to retreat. The reversed situation (high-polarity), with southerly/westerly winds bringing in more precipitation and relatively mild winters, causing favorable conditions, which would promote glacier growth. This relationship can be exploited when assessing the dynamical mechanisms forcing the evolvement of the glacier record through time.

The sedimentary record shows how the glacier reached a maximum stand just prior to 1400 AD, whereupon it retreated rapidly. It stayed in a minimum position for ca 300 years before it started growing again and it reached a new maximum position just prior to 1800 AD. We suggest that the period of smaller glaciers was due to a prevailing low-polarity index of the NAM and that the time span (1400 to 1800 AD) should be used as the reference period for the LIA. A low-polarity situation for the LIA is supported by an atmospheric reconstruction based on the relative concentration of nssK and ssNa showing a lasting situation with low pressures over Iceland (Meeker and Mayewski, 2002).

The enhanced atmospheric circulation over the NH probably caused the Intertropical Convergence Zone (ITCZ) to migrate southwards (cf. Haug et al., 2001). This is in conjunction with Lund et al. (2006), which demonstrate a 10% reduction in the northward transport of warm saline water during the LIA due to a major shift in the ITCZ that weakens the northward advection of water masses from the sub-tropical gyre. We suggest here that the mechanism behind the LIA anomaly was a large-scale shift in the NAM (low-polarity index) that propagated downward changes in other atmospheric systems further south such as the ITCZ, and hence explain the diverse regional impact recorded in the various proxy records.