Supplementary Information

Field sampling methods. We sampled primarily granitic or gneissic glacial erratic boulders that were greater than 1 m in diameter and rested on stable geomorphic surfaces with minimal till cover or directly on bedrock. Each sampling site was spaced ~100 km from the next site (Figure S1), and boulder samples at each site were sampled within an ~1 km^2 area, with the ages on the boulder population from each site reflecting the time of deglaciation from that site. Erratics sampled in southern Sweden and Finland were under forested canopy, while sites in northern Finland and Sweden were sampled amongst sparse vegetation. Samples were collected with a hammer and chisel from the tops of the boulders, making sure to not sample along any sides. We also avoided sampling heavily weathered surfaces exhibiting pitting and spallation. Because many of the sampled boulders had glacial polish, we assume post-depositional erosion was minimal, and that no correction for erosion was necessary. Geographic location and elevation were recorded using a handheld GPS. Because of the low relief of our sampling sites, corrections for topographic shielding were not necessary. Sites in northern Sweden, where the relief was greatest, were sampled in low-lying valleys far from surrounding topography that would otherwise provide some shielding to the boulders.

Sample processing. Rock samples were crushed and sieved to isolate the 250-710 µm fraction. Mafic grains were removed using a Frantz magnetic separator. Samples were then leached in dilute solutions of HCl and a combination of HNO_3 and HF repeatedly until sufficient quartz purity was reached, as determined by ICP-OES measurements at the University of Colorado, Boulder. Anion exchange, cation exchange, and pH adjustment steps were performed to isolate the beryllium (Kohl and Nishiizumi, 1992). A reference ^{9}Be spike was added to each sample (Marcott, 2011). Developed at Oregon State University, this spike has a ^{9}Be concentration of 358 ppm and has an average blank ratio of 1.1±0.5 x 10^{-15} (n=11) (Table S1). During each sample batch (typically nine samples), a procedural blank was processed to assess background levels of contamination in the cosmogenic lab. ^{10}Be/^{9}Be ratios were measured by accelerator mass spectrometry at PRIME Laboratory at Purdue University.

^{10}Be production rate and age calculation. ^{10}Be ages were calculated using the CRONUS-Earth online calculator (v2.2) (Balco et al., 2008) using our uplift-corrected production rate (see text). Inputs needed to calculate ages are given in Table S4. Samples were not corrected for snow cover, vegetation, or erosion. All previously published ^{10}Be chronologies used in our compilation (Anjar et al., 2014; Briner et al., 2014; Heine et al., 2009; Johnsen et al., 2009; Larsen et al., 2012; Linge et al., 2007; Mangerud et al., 2013; Rinterknecht et al., 2014; Rinterknecht et al., 2008; Rinterknecht et al., 2006; Rinterknecht et al., 2004; Rinterknecht et al., 2005; Rinterknecht et al., 2007; Stroeven et al., 2011; Stroeven et al., 2015; Svendsen et al., 2015) are recalculated using our revised western Norway production rate (Table S2).

Comparison to existing age control. Along transect 1 in southern Sweden (Fig. 1), we first compare previously published recalculated mean ^{10}Be ages used in our study with the constraints on deglaciation derived from varve chronologies and ^{14}C ages synthesized by Lundqvist and Wohlfarth (herein the L&W chronology) (Lundqvist and Wohlfarth, 2001). We note that the mean ^{10}Be ages directly date the time of deglaciation, whereas the varve and ^{14}C ages provide minimum limiting ages for deglaciation. In several cases, the mean ^{10}Be ages from this region are slightly older than the L&W chronology, consistent with the latter being minimum-limiting ages, but all of the ages are in agreement within the uncertainties of the ^{10}Be ages (Anjar et al., 2014; Johnsen et al., 2009; Larsen et al., 2012).

The mean ^{10}Be age on the Halland Coastal Moraines in southwestern Sweden is 16.3±0.9

ka (Larsen et al., 2012), in agreement with the age of the moraines suggested by the L&W chronology (16-18 ka). The mean ^{10}Be age from the Skåne region of southernmost Sweden is 15.2±0.7 ka (Anjar et al., 2014), while the L&W chronology places deglaciation of this region at >14.95 ka. Just to the north, a mean ^{10}Be age of 15.1±0.6 ka (Anjar et al., 2014) is in an area where the L&W chronology suggests minimum deglacial ages of 14.5-14.7 ka and an age of 14.5-15.4 ka for the Göteburg moraine immediately to the west. Next to the north, the Vimmerby Moraine has a mean ^{10}Be age of 14.7±0.7 ka (Johnsen et al., 2009) in the area where the L&W chronology suggests a minimum deglacial age of 13.9-14.0 ka. In addition, the L&W chronology suggests that the Trollhättan Moraine to the west, dated to >14.2 ka, is correlative to the Vimmerby Moraine. The mean ^{10}Be age for the Levene moraine is 14.4±0.9 ka (Larsen et al., 2012) while the L&W chronology suggests the age of the moraine is >13.4 ka. The mean ^{10}Be age from the Kättebo area in northern Småland on the east side of Lake Vättem is 14.5±0.6 ka (Anjar et al., 2014), which agrees well with the age of the Levene Moraine directly to the west of the lake.

The Middle Swedish End Moraines (MSEMs) record the next well-defined ice-marginal position just to the north of the Levene moraine (Lundqvist and Wohlfarth, 2001). Our first two sites on transect 1 (Swe-1 and Swe-2) are north of the MSEMs. The mean ^{10}Be ages from these sites, which are in stratigraphic order with mean ^{10}Be ages to the south and north, suggest that ice had retreated from the MSEMs before 13.1±0.6 ka. However, this conflicts with the age of the MSEMs according to the standard deglaciation model of Sweden, which suggests that they formed earlier during the Younger Dryas period (Björck, 1995; Lundqvist, 1986; Lundqvist and Wohlfarth, 2001; Wohlfarth et al., 2008).

The MSWMs are not directly dated, but their age is suggested by the need for the ice margin to be at the northern tip of Mount Billingen immediately west of Lake Vättem to dam the Baltic Ice Lake until its rapid drainage at the end of the Younger Dryas (Björck, 1995; Wohlfarth et al., 2008). The timing of this lake drainage associated with retreat from the MSEMs at Mount Billingen is based on multiple lines of evidence. Perhaps the most robust constraint on the timing of lake drainage comes from the isolation of lakes along the Swedish east coast, where there is evidence for a rapid change in deposition from varved clays to sediments indicating isolation from a much larger water body Björck, 1995; Svensson, 1991). Multiple lakes that were sampled across an elevation transect suggest that this isolation event occurred due to a 20-25 m drop in the level of the Baltic Ice Lake. Pollen stratigraphy places this sudden isolation just before the Younger Dryas/Preboral palynostratigraphic boundary, which is a regional signal that is well dated in other pollen stratigraphic records in southern Sweden (Björck et al., 1996). Although there are no age constraints, there is independent geomorphic evidence for a comparable lake-level drop within the basin (Jakobsson et al., 2007; Svensson, 1991), and the inferred drop of 20-25 m is consistent with the lake level on the eastern side of Mount Billingen (150 m) and the elevation of the contemporaneous sea level on the western side (125 m), to which the lake level would have lowered following drainage (Björck and Digerfeldt, 1986). Additional evidence is suggested by marine records off the Swedish west coast that show a freshwater signal at the end of the Younger Dryas that has been attributed to the drainage of the Baltic Ice Lake (Bodén et al., 1997).

We conclude that there is a considerable difference in deglaciation age (on the order of 1000 years) for this region of southern Sweden based on our mean ^{10}Be ages from sites Swe-1 and Swe-2 when compared to the Younger Dryas age for the MSEMs to the south of our sites that is suggested for the Baltic Ice Lake history. On the other hand, there are other lines of evidence suggesting that the ice margin was at the northern tip of Mount Billingen during the Younger Dryas up until the drop of the Baltic Ice Lake immediately before the end of the Younger Dryas.

Until further age control becomes available involving dating the MSEMs directly or obtaining additional ages to the north of the MSEMs near our sites Swe-1 and Swe-2, we propose that both scenarios are equally viable. The first scenario, based on our mean ^{10}Be ages from sites Swe-1 and Swe-2, suggests a more gradual retreat from the MSEMs, as suggested by the mean ^{10}Be age of the Levene Moraine immediately to the south of the MSEMs (14.4±0.9 ka) (Larsen et al., 2012) and the mean ^{10}Be age for site Swe-1 (13.1±0.6 ka). In contrast, a Younger Dryas age for the MSEMs suggests that our mean ^{10}Be ages from sites Swe-1 and Swe-2 are too old. In this case, retreat from the MSEMs at the end of the Younger Dryas (~11.7 ka) to site Swe-3 further north on transect 1 (11.1±0.7 ka) (Fig. 1) implies a more rapid rate of retreat at the end of the Younger Dryas.

We next discuss several cases where existing age constraints of ice retreat in northern Norway, Sweden and Finland are consistent with our new ages from this region. Transect 3 begins at site Fin-5 within an inferred Younger Dryas moraine complex (Johansson et al., 2011), which is confirmed by our mean ^{10}Be age for this site (11.7±0.6 ka). Our mean ^{10}Be age from site Fin-6 (11.6±0.8 ka) is in agreement with the mean ^{10}Be age from an adjacent site (11.4±0.5 ka) (Stroeven et al., 2011) that occurs near the same isochrone (Fig. 1). Calibrated radiocarbon ages on macrofossils from sediments cores near Aareavaara, northern Sweden (67°25’N, 23°31’E) provide a minimum age for deglaciation of 10.5-10.7 ka (Möller et al., 2012). This site occurs on an isochrone whose age is constrained by mean ^{10}Be ages from two of our sites: Fin-8

(10.8±0.5 ka) and Swe-5 (11.1±0.5 ka) (Fig. 1). Calibrated ^{14}C ages of 10.6±0.2 ka and 10.7±0.3 ka provide minimum-limiting ages on deglaciation from Norrbotten northern Sweden (~65°30'N, 20°45'E) (Linden et al., 2006). This site occurs on the same isochrone as the ages from Aareavaara, and thus provides further agreement for the age of regional deglaciation suggested by our mean ^{10}Be ages from sites Fin-8 and Swe-5.

A mean ^{10}Be age of 10.2±0.5 ka from northern Norway (Linge et al., 2007) lies on an isochrone whose age is bracketed by mean ^{10}Be ages from two of our sites: Swe-5 (11.1±0.5 ka) and Swe-6 (10.0±0.5 ka) (Fig. 1). A mean ^{10}Be age of 9.2±0.6 ka from northern Sweden (Stroeven et al., 2011) is in agreement with our mean ^{10}Be age of 9.0±0.6 ka for final deglaciation of the SIS.

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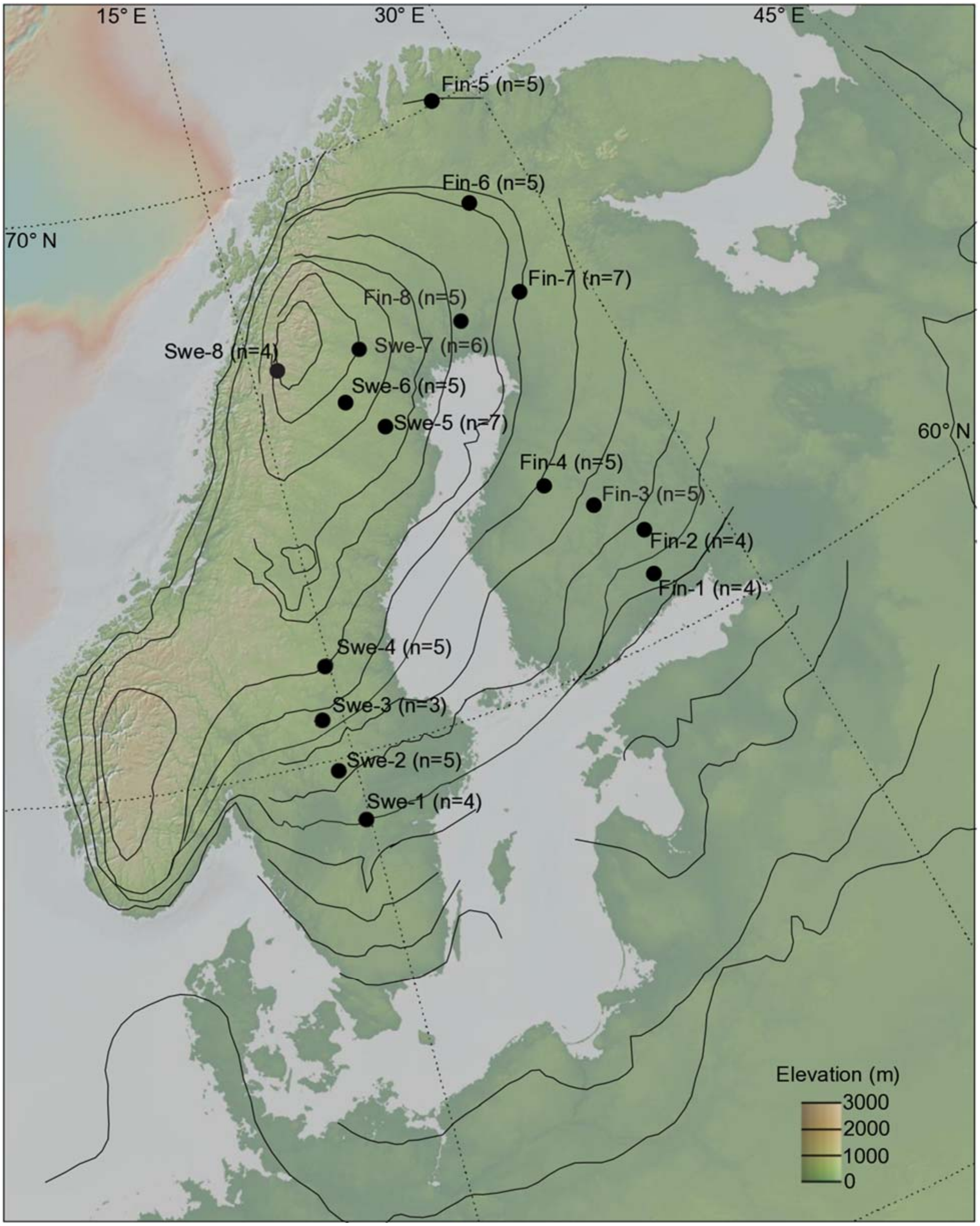

Figure S1. Location of our sampled sites along mapped ice-retreat contours (Boulton et al., 2001; Johansson et al., 2011; Lundqvist, 1986), with the number of ^{10}Be ages from each site.

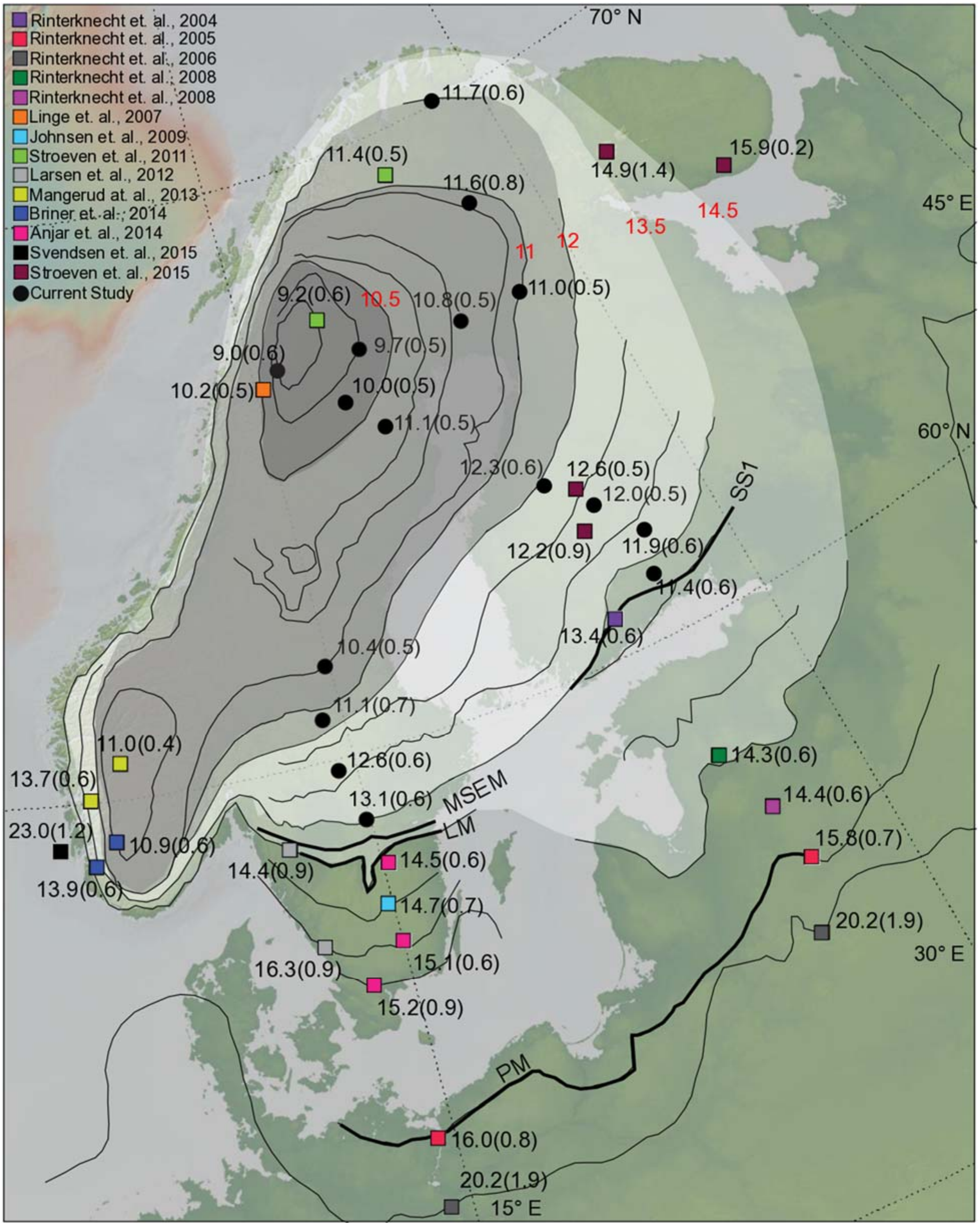

Figure S2. Areas (shaded) drawn at discrete time intervals (associated ages shown in red), which are used for the calculations of the SIS volume and estimated sea level contribution. Sites with ages for present study are shown as black circles; sites with recalculated ages are shown as colored squares (Anjar et al., 2014; Briner et al., 2014; Heine et al., 2009; Johnsen et al., 2009; Larsen et al., 2012; Linge et al., 2007; Mangerud et al., 2013; Rinterknecht et al., 2014; Rinterknecht et al., 2008; Rinterknecht et al., 2006; Rinterknecht et al., 2004; Rinterknecht et al., 2005; Rinterknecht et al., 2007; Stroeven et al., 2011; Svendsen et al., 2015).

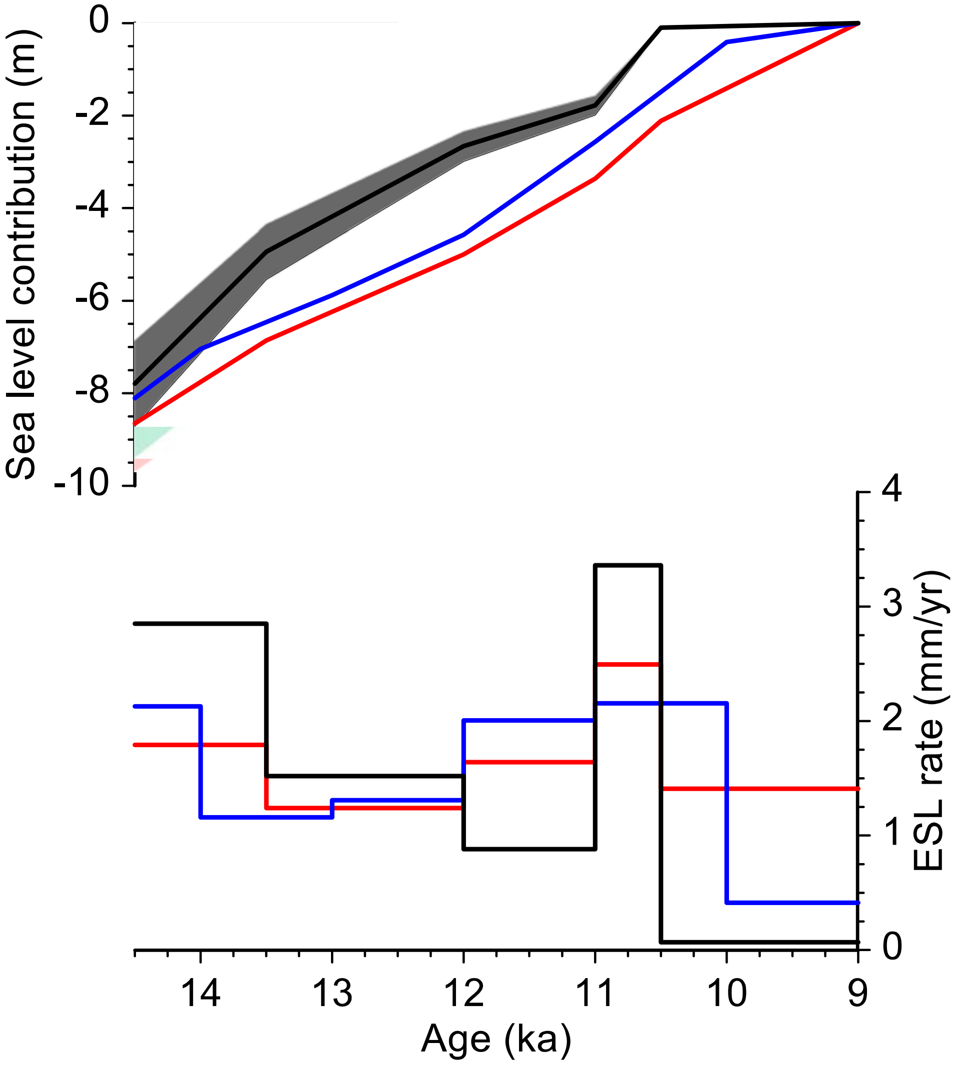

Figure S3. Upper - Reconstructed sea-level histories for the Scandinavian Ice Sheet based on our study (black), the DATED study (blue) (Hughes et al., 2015), and from Stroeven et al. (2015) (red), as derived using our methodology (see text). Lower – Rates of sea-level rise based on reconstructed sea-level histories.

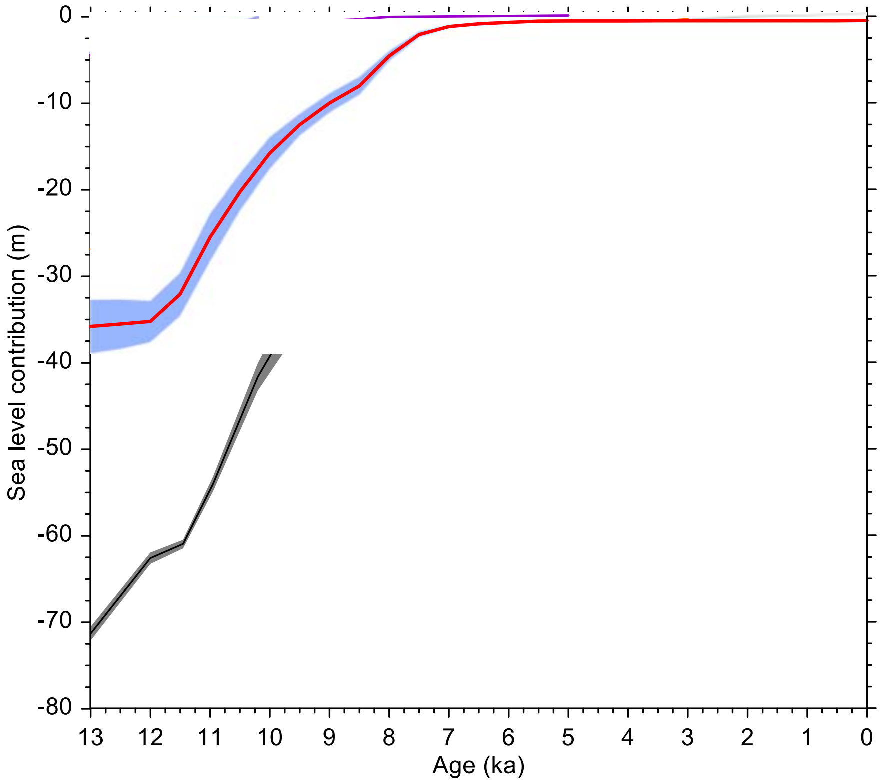

Figure S4. Estimated sea-level contributions over the last 13 kyr. **A.** Sea-level contribution from the Scandinavian Ice Sheet (blue) (current study), Laurentide Ice Sheet (red) (Tarasov et al., 2012), and Greenland Ice Sheet (magenta) (Lecavalier et al., 2014). The residual (orange) is the difference between the sum of the Northern Hemisphere ice sheets and global mean sea level (black) (Lambeck et al., 2014).