The Terminations 1 and 2 as Revealed by the Record of Stable Isotopes from the EDML Ice Core

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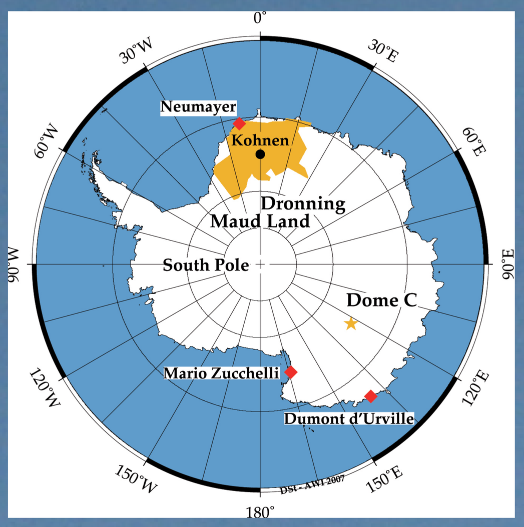
Figure 1



The data

Within the European Project for Ice Coring in Antarctica (EPICA) two deep ice cores had been recovered, at Dome C and Kohnen Station, respectively **(Figure 1)**. The second core was drilled in Dronning Maud Land (DML), in the Atlantic sector of Antarctica, at Kohnen Station (0.0684° E, 75.0025° S, 2892 m WGS84) [1, 2, 3, 4] It was labelled EDML. In total, the recovered core is 2774 m long. The annual accumulation rate at the drill site amounts 64 kg m^{-2} a^{-1}. The horizontal flow velocity is 0.74 m/a [2]. The EDML core is well dated down to the depth of 2416 m with an age of 150 kyrs BP [4].

Stable isotopes (18-O, D) have been measured with a depth resolution of 0.5 m and 0.05 m, respecively **(Figure 2)**. Deuterium excess values were calculated at least for all 0.5m samples [5]. Corrections to the 18-O and D values had to be added to account for changing 18-O or D content, respectively, of the sea water in the past and surface elevation changes at the location of original snow deposition [3].
In the EDML Community paper [3] a gradient of -0.94 ‰/100m was used. In January 2006, further snow samples had been collected along the ice flow line upstream of the drilling site. The sampled snow pits covered at least the accumulation of the last 10 years [6]. With this new data set a gradient of -0.63 ‰/100m was calculated. Using all avaliable data from the region, at the time being, a mean gradient of -0.756 ‰/100m results.

Figure 2

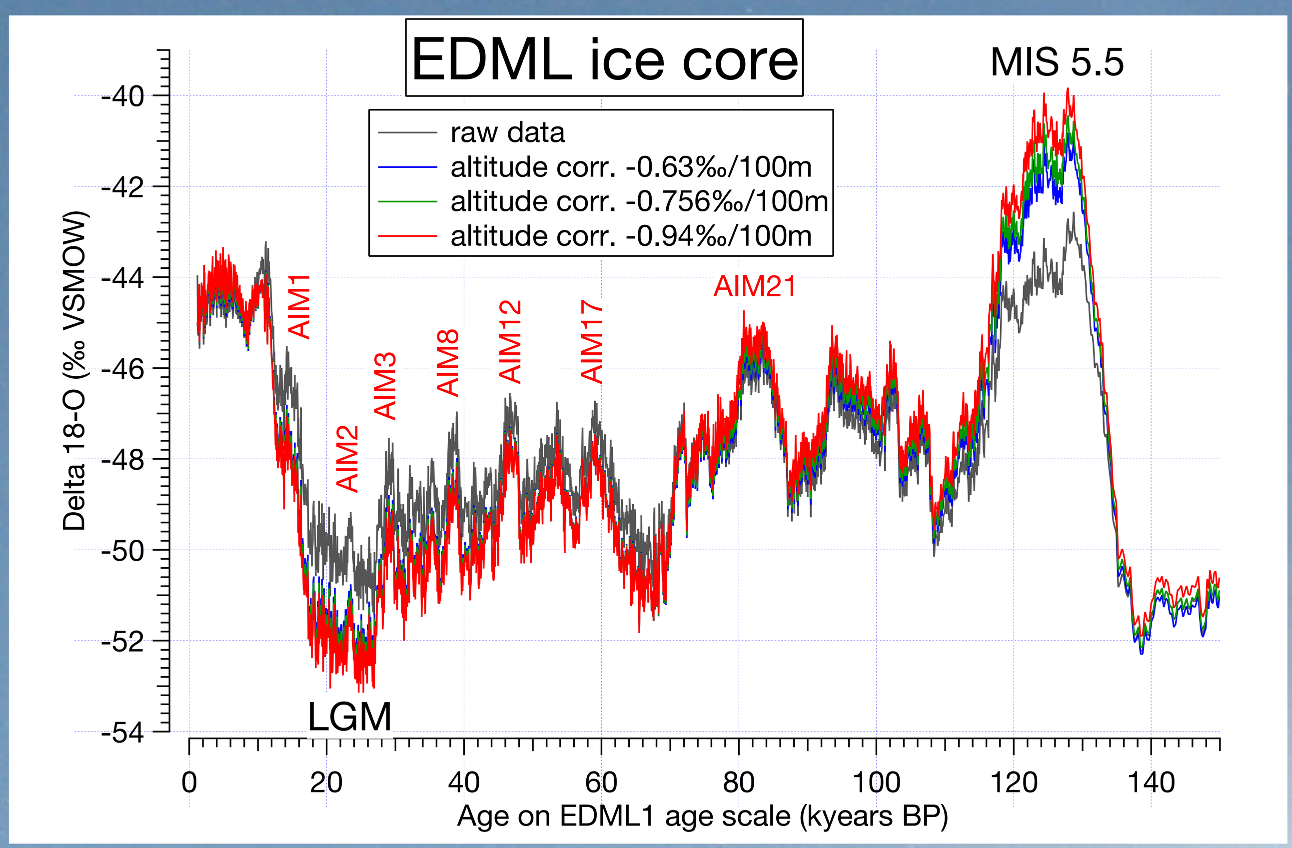
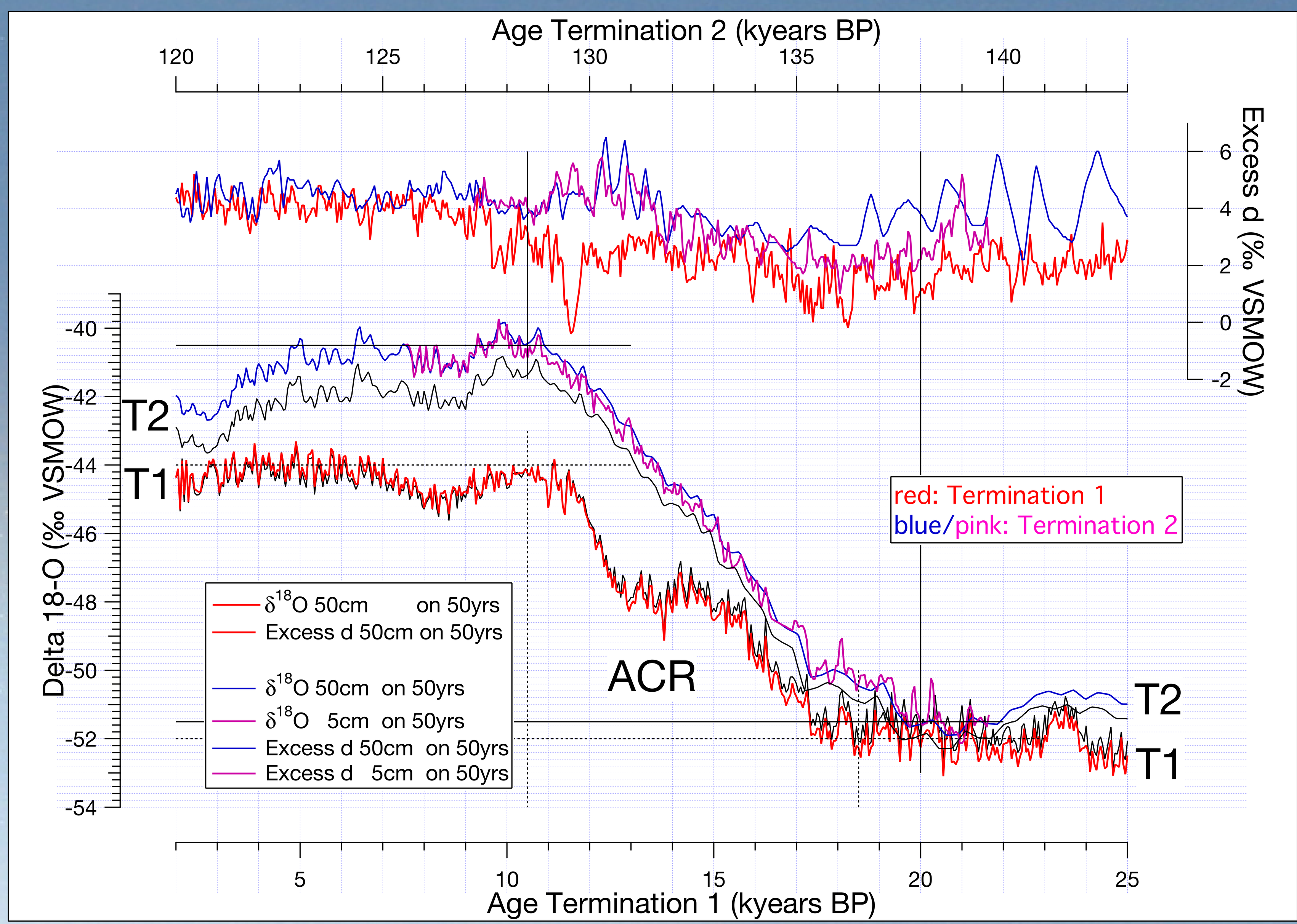


Figure 2 shows the 18-O values as measured on 0.5 m samples and resampled on 50 year time steps (grey colour) [8]. The corrected values are shown in red, green, and blue colours using the different gradients of -0.94, -0.756, and -0.63 ‰/100m, respectively. The strongest influence of the altitude correction is visible during the time of the Last Glacial Maximum (LGM) and the Marine Isotope Stage (MIS) 5.5 (in the North called Eem).

Figure 3



The stable isotope records for the periods of terminations 1 and 2 (T1, T2) were resampled on a common time step of 50 years [8]. The record for Termination 1, red colour in in **Figure 3**, is only based on 0.5 m samples. The record for Termination 2 is plotted with the 0.5m samples (blue colour) and the 0.05 m samples (pink colour), as far as data are availble, to get a similar time resolution for both terminations. The shown data correspond to the published data with the gradient -0.94 ‰/100m [3]. In addition, a thinner black line shows the 0.5m samples corrected with the smallest gradient of -0.63 ‰/100m to indicate the uncertainty due to different spatial gradients.

Discussion

The most prominent difference between T1 and T2 is the fact that the Antarctic Cold Reversal (ACR) of T1 has no analogue in T2. This is a common feature with the EDC ice core [7]. With the elevation correction of -94‰/100m used in [3| T2 shows a steady increase from -51.5 ‰ to -40.5 ‰ over a time span of 9.5 kyrs, whereas T1 displays an increase from -52 ‰ to -44 ‰ over 8 kyrs. At the beginning of the Terminations the gradient of the increasing 18-O content is almost similar for 3 kyears, until the ACR within T1.
The influence of a smaller elevation gradient than used in [3] does not strongly affect T1. For T2, however, a smaller gradient would lower the 18-O values, and thus make the difference between T1 and T2 as well as between the Holocene and MIS 5.5 smaller. The deuterium excess shows differences towards the end of the terminations, with remarkable lower values in and after the ACR during T1. The main driver of these differences lies in the conditions prevailing in the evaporative source areas and of the subsequent transport of the moisture providing snow at the site. We infer that the atmospheric transport and the source area of precipitation or the source temperature were different for T1 and T2.

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References:
[1] Oerter, H. et al. (2009): Kohnen Station - the Drilling Camp for the EPICA Deep Ice Core in Dronning Maud Land. Polarforschung 78 (1-2), 1-23. **[2]** Wesche, C. et al. (2007): Surface topography and ice flow in the vicinity of the EDML deep-drilling site, Antarctica. J. Glaciology, 53(182), 442-448. **[3]** EPICA community members (2006): One-to-one coupling of glacial climate variability in Greenland and Antarctica. Nature 444, 195-198. **[4]** Ruth et al. (2007): "EDML1": A chronology for the EPICA deep ice core from Dronning Maud Land, Antarctica, over the last 150 000 years, Climate of the Past, 3, 475-484. {www.clim-past.net/3/475/2007/}. **[5]** Stenni et al. The deuterium excess records of EPICA Dome C and Dronning Maud Land ice cores (East Antarctica. Quatern. Sci. Rev., Special issue, subm. **[6]** Oerter et al. (2008): Spatial variability of delta 18-O upstream and around the EDML drilling site. Quaternary Climate: from Pole to Pole, EPICA Open Science Conference, Venice, Italy, November 10-13 (Poster). **[7]** Jouzel et al. (2007): Orbital and Millennial Antarctic Climate variability over the Past 800,000 Years. Science 317, 793-797. **[8]** Paillard, D. et al. (1996): Macintosh program performs time-series analysis. EOS Trans. AGU, 77, 379 (release AnalySeries2.0, May 2005).

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