Spatial variability of delta 18-O upstream and around the EDML drilling site

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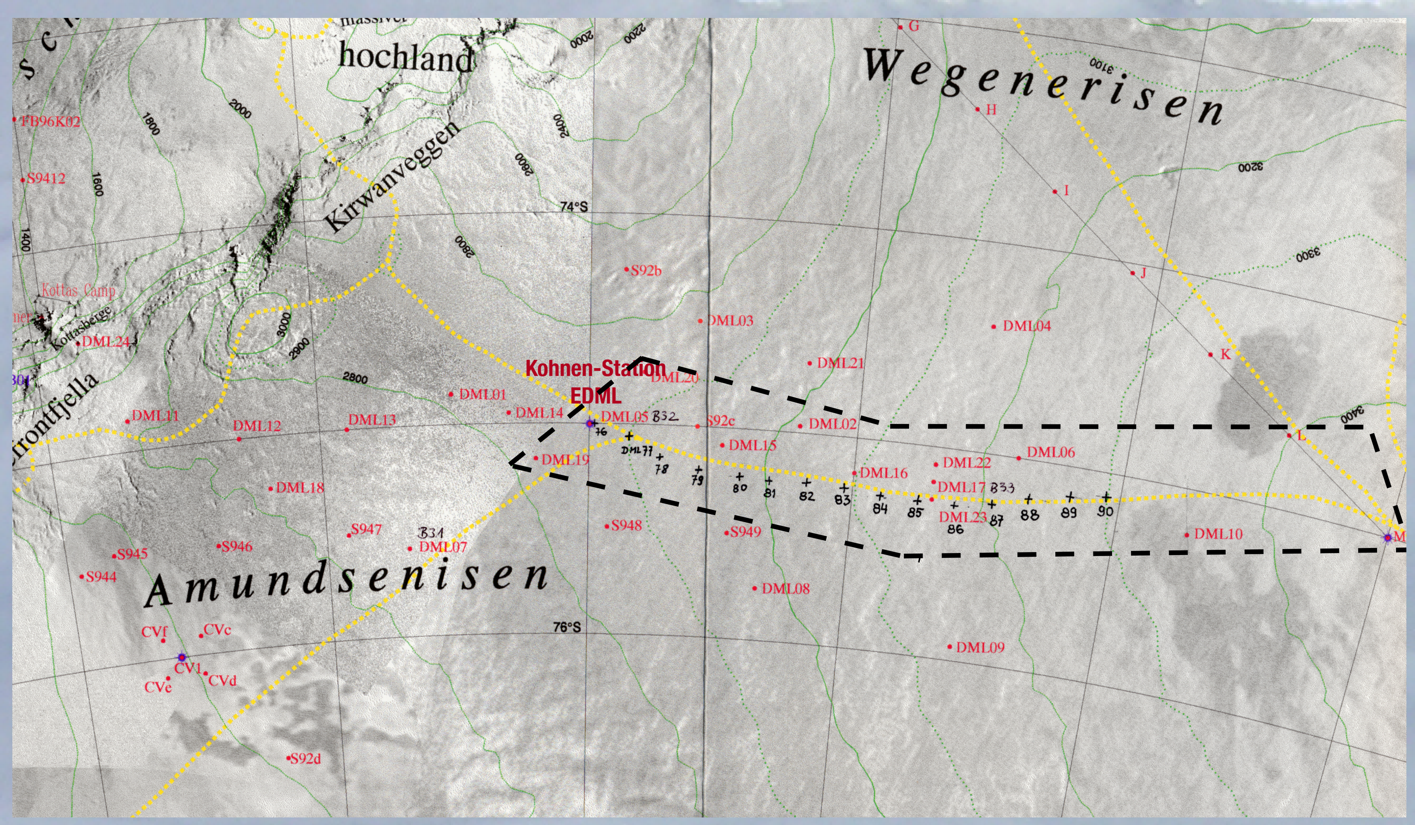

Figure 1: Map of Dronning Maud Land (detail). Shown are in yellow the ice divides (smoothed), in red locations for shallow ice-core drillings, with black + the sampling sites (DML76-90) of the 2005/06 „EDML upstream traverse", and in green contour lines (100m). The black dotted line circumscribes the area from which isotope data was used to calculate spatial gradients.

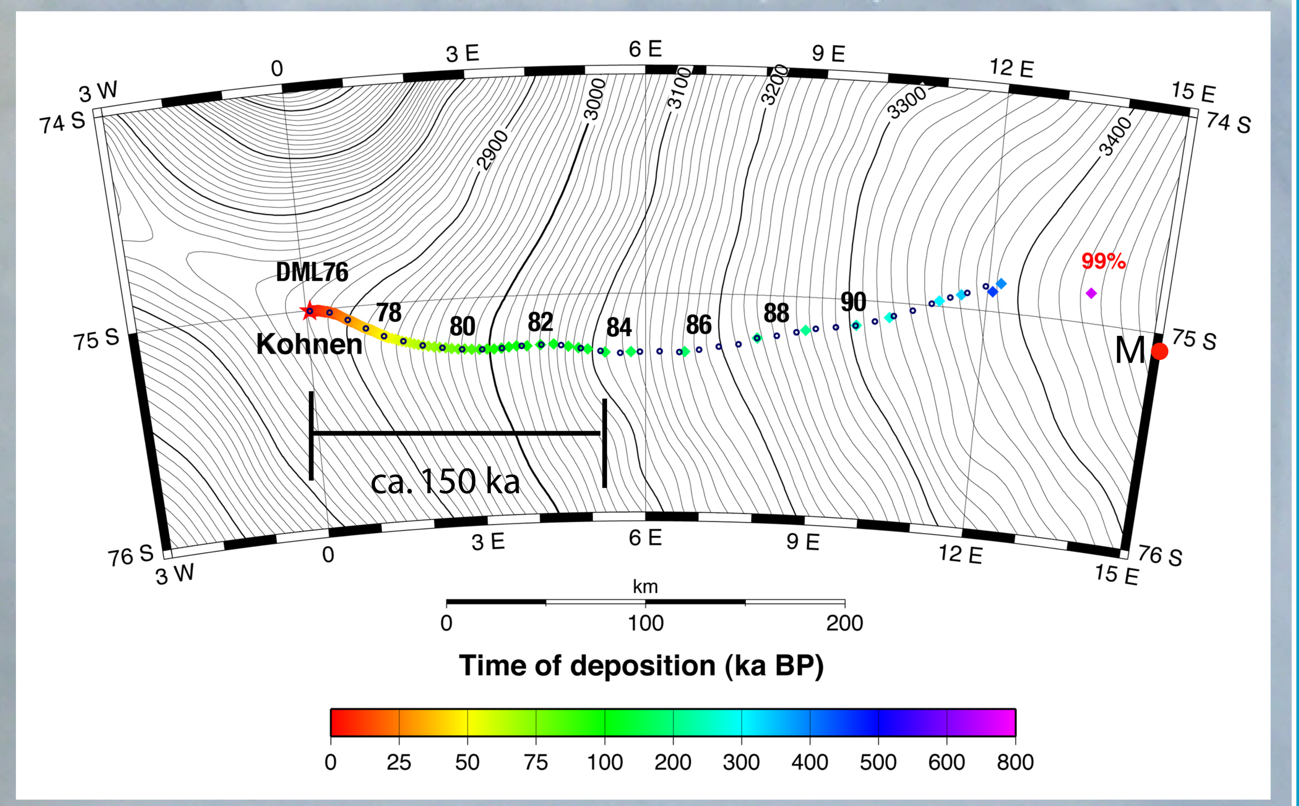

Figure 2: Flow line to the drilling site of EDML after Huybrechts et al. (2007). The colour code gives the age when the snow was originally deposited at the respective site. The ice in the EDML ice core down to a depth of 2400 m, coinciding with an ice age of 150 ka, was deposited in the area between EDML (DML76) and DML83/84.

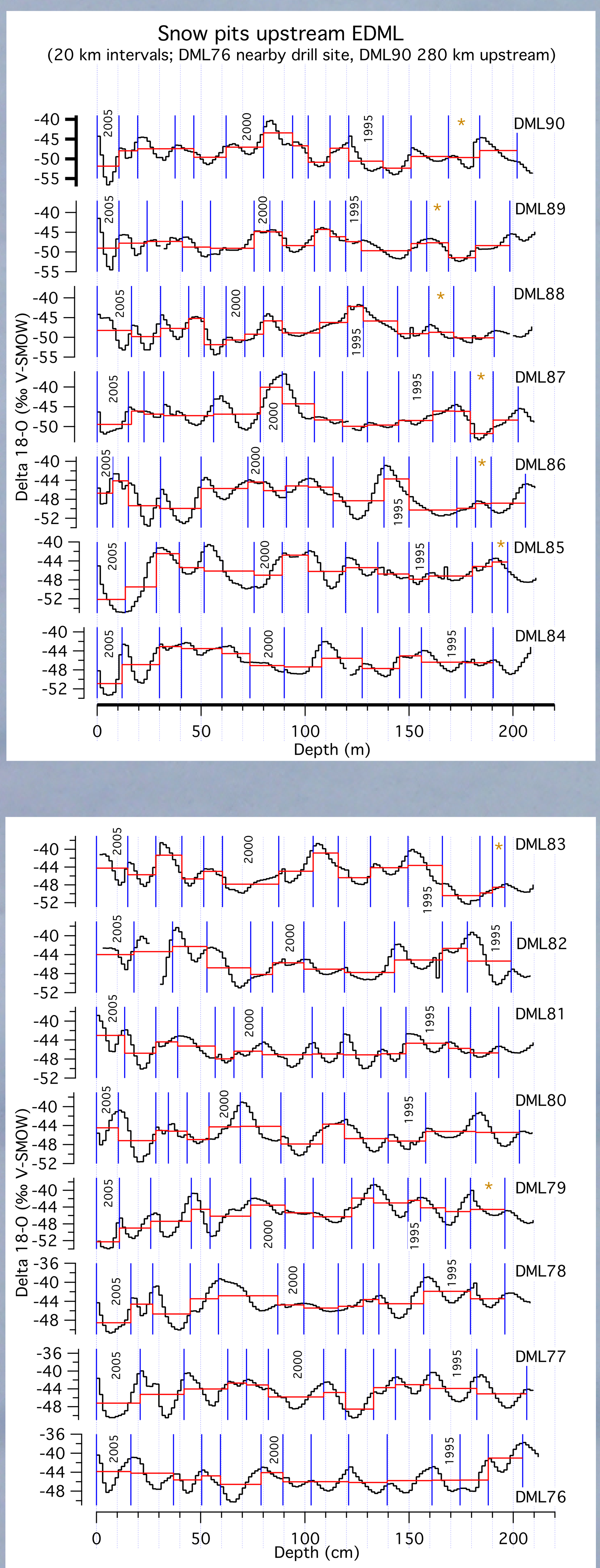

Figure 3: $\delta^{18}O$ depth profiles (black) for the snow pits DML76-DML90 (see. Fig.1). The boundaries between the annual layers (appr. Dec./Jan.) are marked by the vertical blue lines. They are based on the maxima in the $\delta^{18}O$ records supplemented by information from major-ion content. The red curves show the annual means of $\delta^{18}O$. The yellow stars mark the 1992 layers identified by elevated sulfate concentrations due to the eruption of Mt. Pinatubo and Cerro Hudson in June/July 2001.

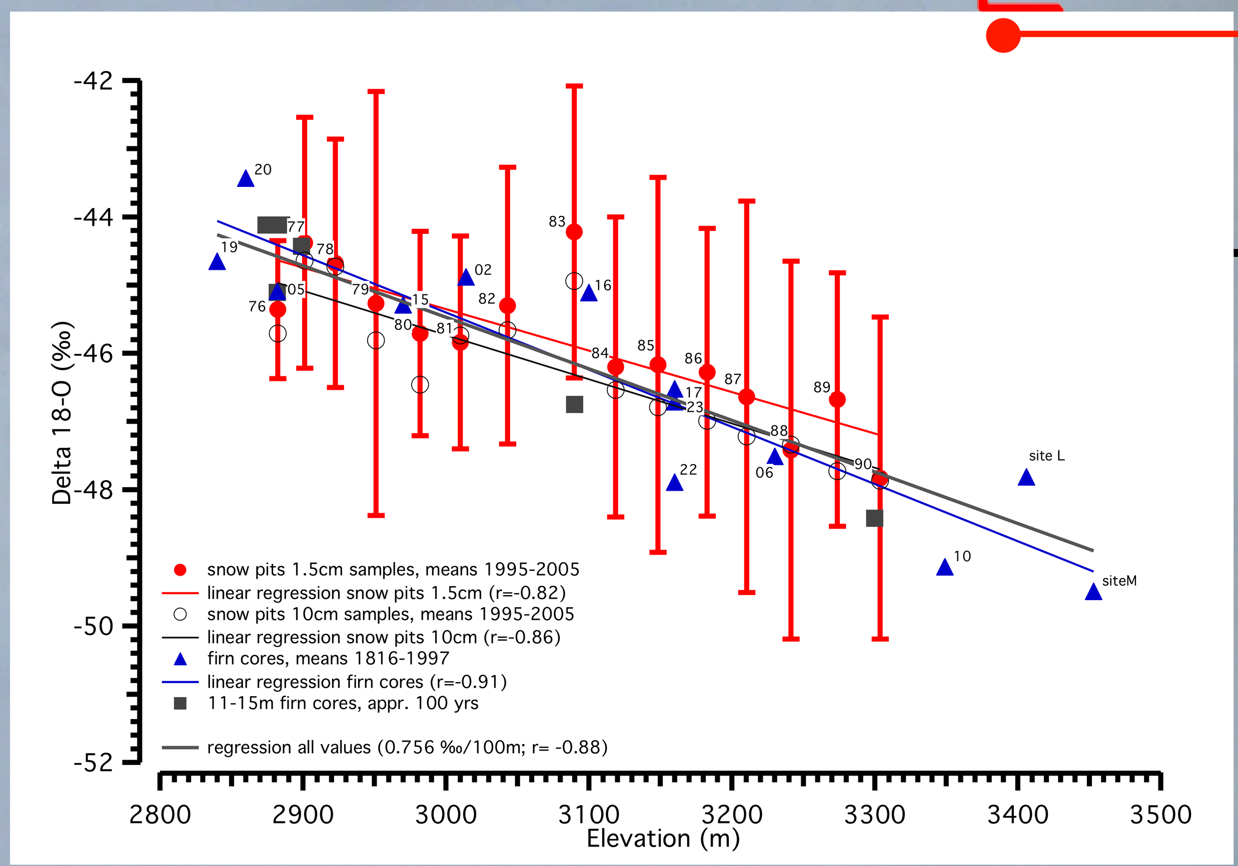

Figure 4: $\delta^{18}O$ content against elevation. The figure contains four different data sets. For location of numbered DML sites see Figure 1. Linear regression lines were calculated seperately for the four data sets and for all data together.

Red filled circles: snow pits from January 2006, sampled with 1.5 cm depth resolution. Plotted are the means for the period 1995-2005. Gradient: -0.61 ± 0.12 ‰/100m

Black open circles: snow pits from January 2006, sampled with 10 cm depth resolution. Plotted are the means for the same depth interval as for the 1.5cm samples. Distance between both sample sets appr. 1-2 m. Gradient: -0.65 ± 0.11 ‰/100m

Blue triangles: Firn cores covering the period 1816-1997 including sites L and M of the Norwegian/Dutch expeditions. (Masson et al., 2008) Gradient: -0.84 ± 0.11 ‰/100m

Grey squares: 10-15m firn cores drilled in the 1999/2000 and 2005/06 Antarctic seasons, covering approximately the accumulation of one century (not finally dated). Gradient: -0.95 ± 0.12 ‰/100m

The linear regression for all data points together (thick grey line) yields a gradient of -0.76 ± 0.06 ‰/100m. By introducing weights for the data sets according to the length of the covered period (11, ca. 100 or ca. 200 years) the gradient would be reduced to -0.63 ± 0.13 ‰/100m.

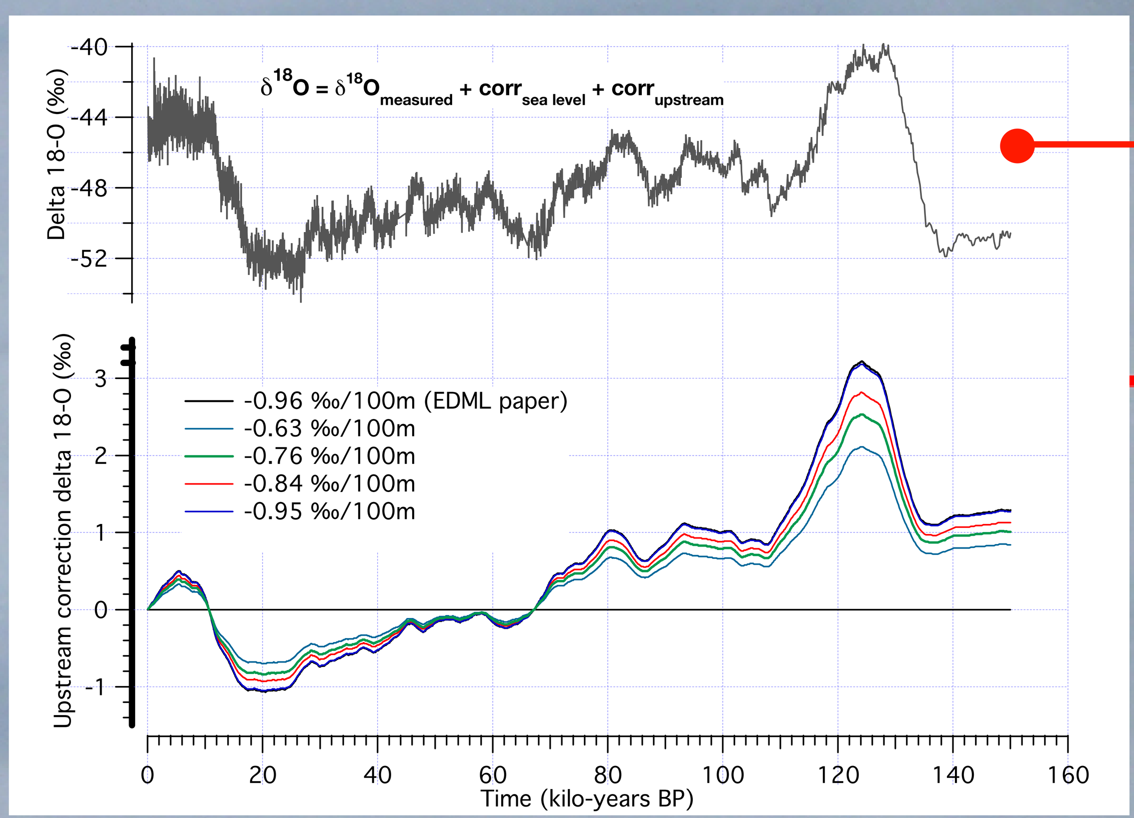

Figure 5: Upstream corrections for $\delta^{18}O$ values due to changing surface elevation (spatial & temporal) in the catchment of the EDML core. The upper panel shows the published $\delta^{18}O$ record, including corrections for sea level and elevation change (EPICA community members 2006) In the lower panel the calculated elevation correction is plotted for different spatial gradiens (see Figure 4). The differences are biggest for the last interglacial. This underlines the uncertainty which we have to consider when temperatures are calculated for the past.

1 °C change corresponds to 0.82 ‰ change in $\delta^{18}O$.

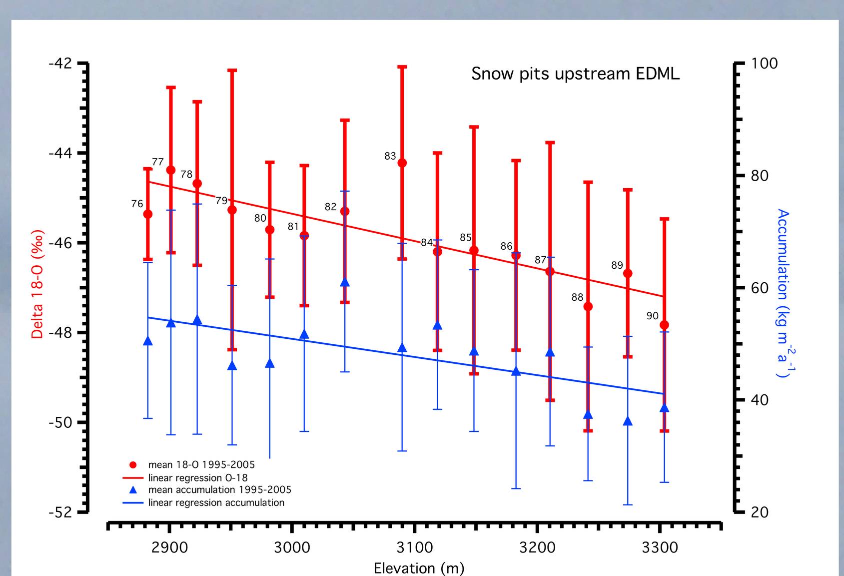

Figure 6: Mean values (1995-2005) of $\delta^{18}O$ (1.5cm samples) and accumulation rates for each site plotted against the elevation.

Furthermore, correlating $\delta^{18}O$ and accumulation with each other shows that they are correlated for multi-year mean values (0.106±0.03 ‰/(kg m^{-2}a^{-1}); r=0.69).

However, they are not correlated using single annual means from one pit. Obviously, redistribution of snow within one annual layer disturbs the correlation of $\delta^{18}O$ and accumulation. The annual layer thickness does not represent the real amount of annual precipitation at that site.

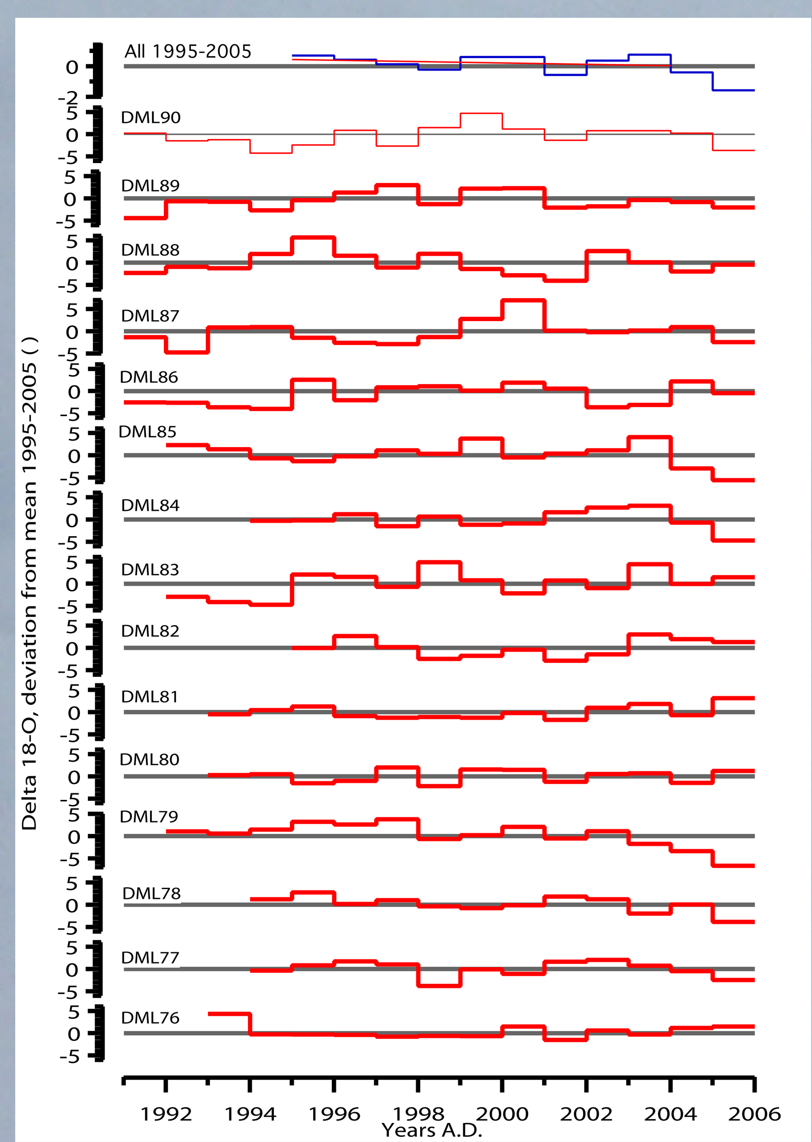

Figure 7: Deviation of the annual mean values of $\delta^{18}O$ from the 1995-2005 average. Plotted are the records of the 15 pits and a stacked record, averaged for each year over all pits.

The slightly negative trend of decreasing $\delta^{18}O$ values (-0.12 ± 0.06 ‰/a) is caused by the low values of the 2005 layers, the first year of accumulation sampled in the pits.

Without the 2005 layer no trend is provable.

Background snow pit DML82

References:

Huybrechts, P., Rybak, O., Pattyn, F., Ruth, U., Steinhage, D. (2007). Ice thinning, upstream advection, and non-climatic biases for the upper 89% of the EDML ice core from a nested model of the Antarctic ice sheet, *Climate of the Past*, 3, 577-589.
Masson, V. and others (2008): A review of Antarctic surface snow isotopic composition: observations, atmospheric circulation and isotopic modeling. *Journal of Climate*, 21(13), 3359-3387.
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