Melt layer statistic of two firn cores recently drilled at Dye3 and South Dome in the dry snow zone of Southern Greenland

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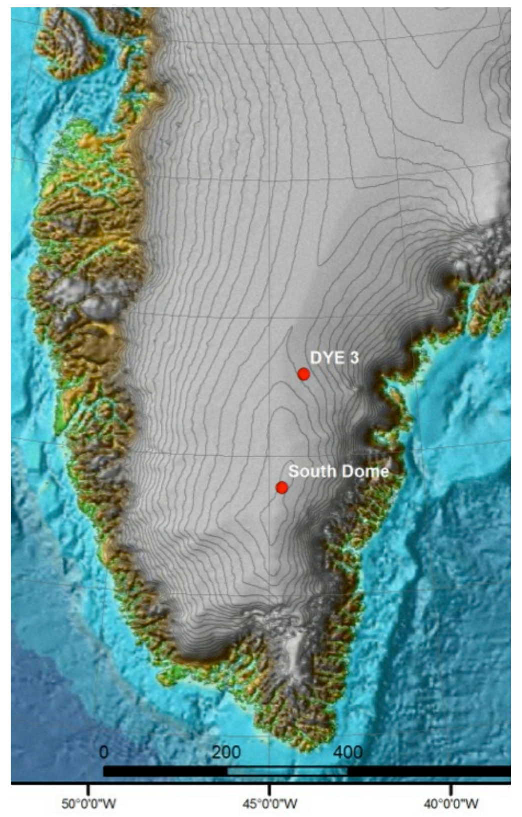
What happened with the snow in Southern Greenland during the last 30 years?



In the last couple of years remote sensing data have shown large areas of wet snow in the Southern part of the Greenland ice sheet. These melt features are attributed to the overall warming trend. Persistent warming implies changes in the firn layer as well. Even in areas of the dry snow zone one can observe sporadically a few ice lenses within the firn column indicating refrozen meltwater from warm events in the past. In our contribution we want to close the gap between investigations of firn cores drilled in the 70's and the observational record of remote sensing data over the last decade in South Greenland.

The focus lies on firn of the dry snow zone which is sensitive against changes in a warming atmosphere and cold enough to prevent a longway percolation path of meltwater to several firn layers. To this end we had drilled two 45m-long firn cores at the former drilling sites of DYE3 (65°11'N, 43°49'W) and South Dome (SD) (63°32'N, 44°34'W) during a aircraft-supported field campaign 2012.

Methods

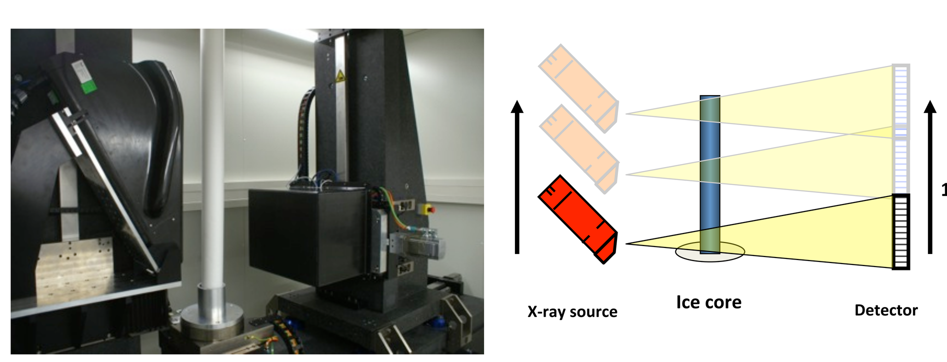


Figure 2: Setup of the AWI ICE-XCT (Freitag et al 2013)

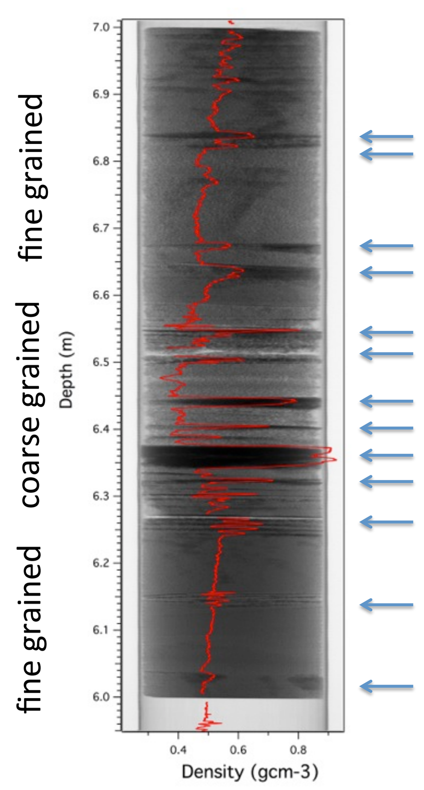
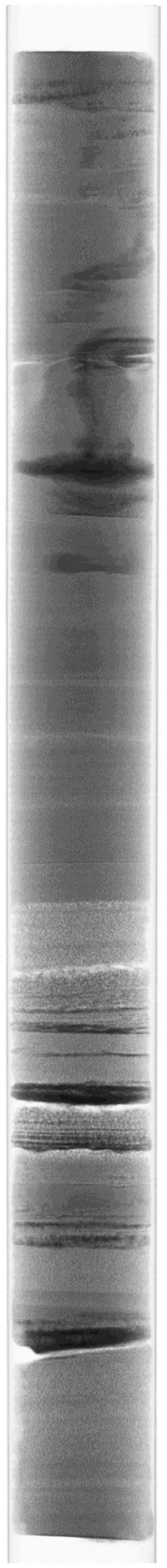
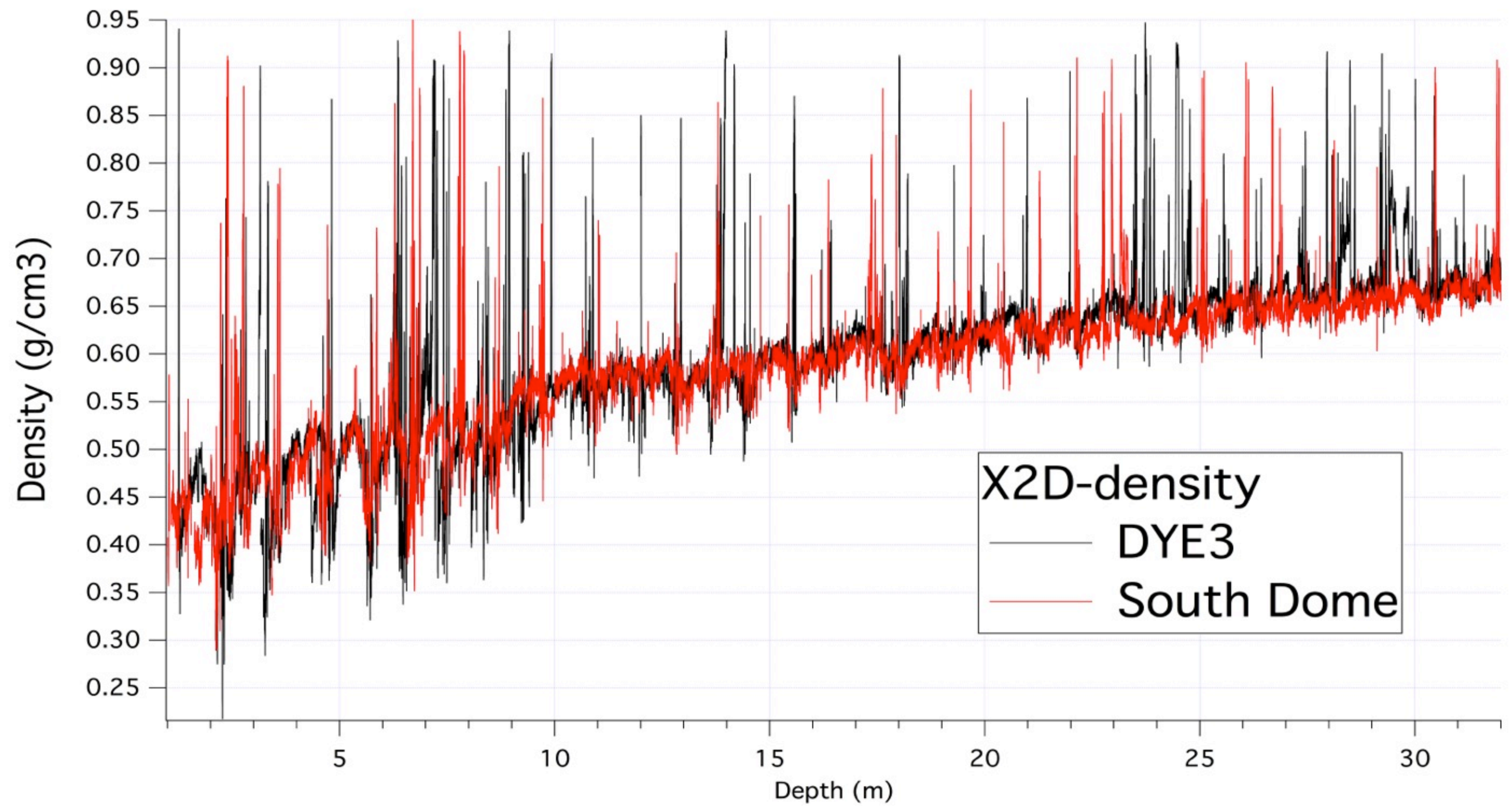


Figure 3,4 (right): Manually identified meltlayers (blue arrows) on a X2d-image (Dye3 6-7m) overlayed with the calculated density.



The retrieved 3inch-firn core segments of 1m length are measured by a X-ray-scanning routine with the means of the core-scale AWI-ICE-XCT (Fig. 2). The density profiles are derived from the absorption images with a vertical resolution of 0.1mm (Fig. 3). Melt features are identified visually by image inspection and density (Fig. 4). The annual melt percentage is calculated as the ratio of the ice layers to the total volume in running intervals of 0.5m w.eq.. In addition to density the oxygen-isotope ratios are measured on discrete samples with a vertical resolution of 25mm with the means of a standard Picarro. Depth-scales are converted to time-scales by using constant accumulation rates (which are cross checked by counting d18O cycles (in case of DYE3) and by counting the alternating grain size variations (in case of DYE3 and SD).

Density profiles



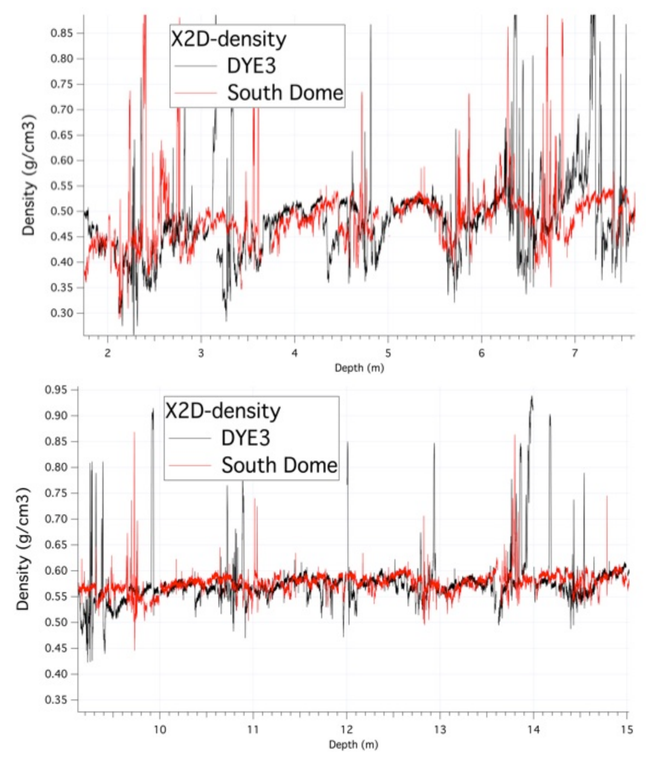


Figure 5: Measured density profiles of Dye3 (black line) and South Dome (red line) . The density shows a seansonal cycle with low density during the summer period. The upward peaks are meltlayers, the downward peaks are associated with depth hoar or coarse grained layers. Both profiles show an unexpected similarity even in seasonal cycles (examples are shown in the blow-ups on the right)

Annual melt percentage AMP

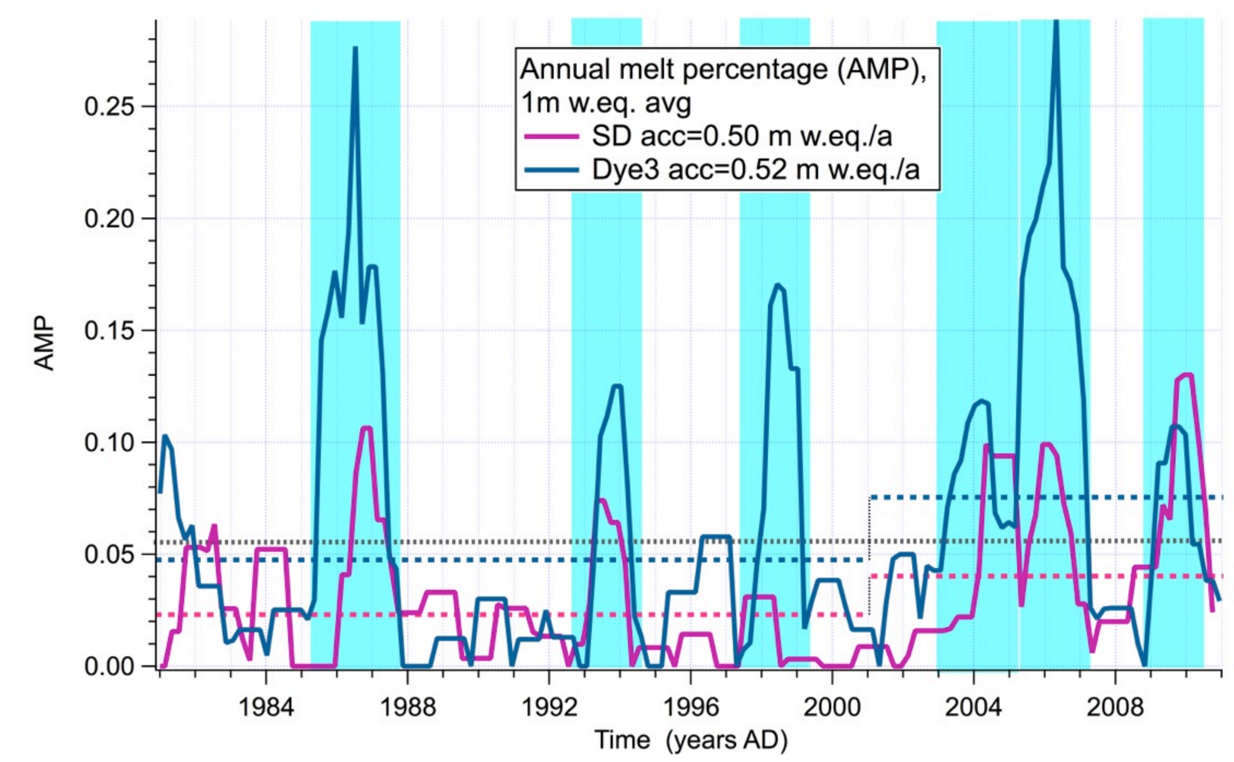


Figure 7: Annual melt percentage (AMP) over the last 30 yr period for Dye3 (blue, solid and dashed lines) and South Dome (pink, solid and dashed lines). Periods of enhanced melt are highlighted. In spite of 200km distance the AMP profiles of both cores show a remarkable similarity in detecting periods of low and high melt. The AMP of both cores increase by more than 50% in the last decade compared to the 20-yr period before (dashed blue and pink lines, DYE3: 4.9% to 8.5%, SD: .2.3% to 4.1%). The gray dashed line indicates the mean AMP in the period BC 300 - AD 1980 at DYE3 (5.6%) derived by Herron et al. (1981), Fig. 8.

Site characteristics

Dye 3 : 2480 m asl; A=0.52m w.eq./a (1900-1979 average), Tsite=-21°C
South dome: 2854m asl; A=0.5m w.eq./a (1900-1979 average); Tsite=-22°C, 200km distance to Dye3
(Ref. Burchardt et al., 2012)

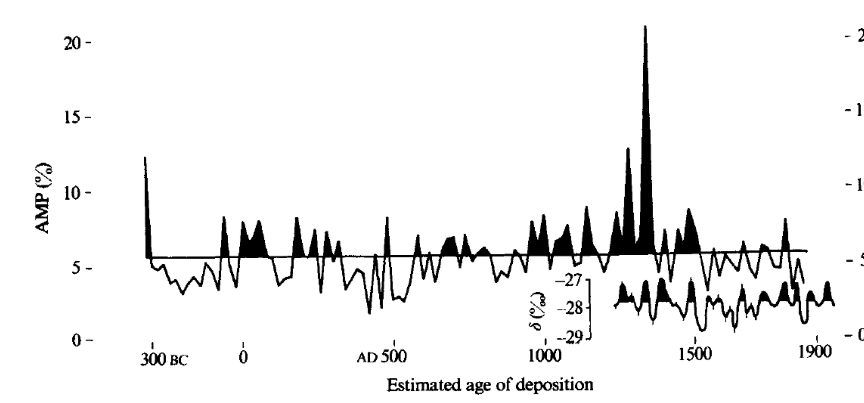


Figure 8: AMP versus age from a former study by Herron et al. (1981, Fig. 2 therein) on the deep DYE3 ice core drilled 1979-1980. The AMP is a 20-yr mean. Above average values are shaded. Relatively warm periods identified were AD 700-800 (AMP: ~7%), AD 950-1520 (AMP: ~8-20% (AD 1325))

d18O profiles

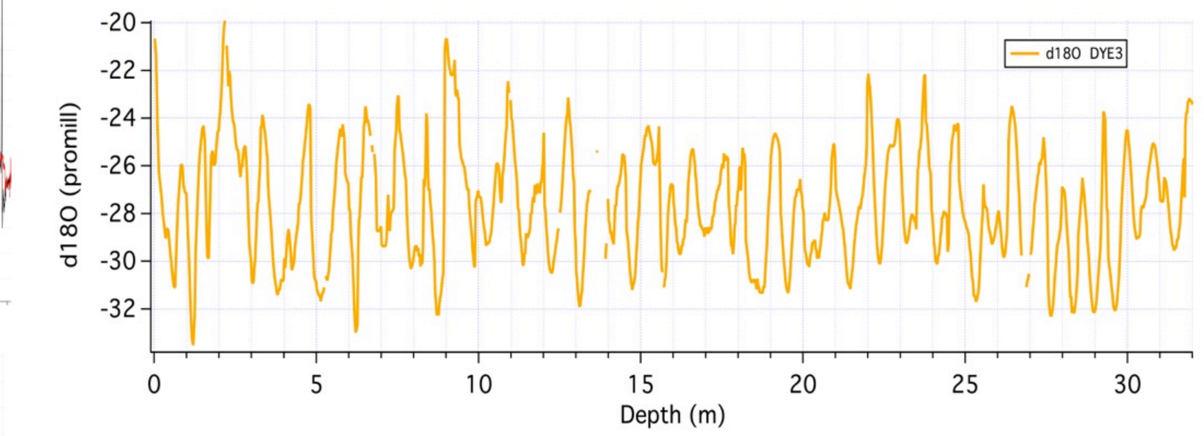


Figure 5: Measured isotope profile of Dye3. d18O follows a clear seasonal cylce covering a time period from summer 2012 (0m) to about 1975 (32m on the right side). There is no significant trend in mean d18O during the last 30 years to isotopic heavier ratios (meaning less negative, associated with warmer temperatures) .

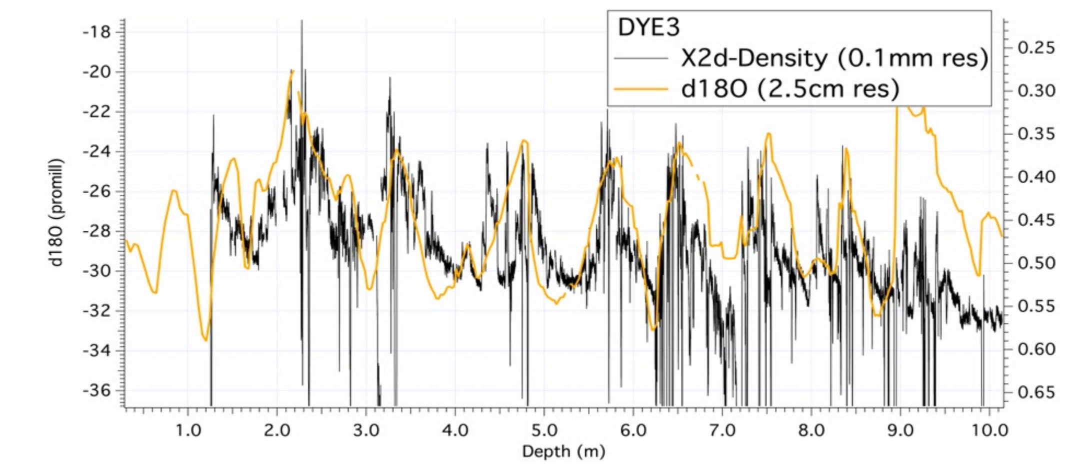


Figure 6: d18O (yellow) and density (black line, note the reverse oriented axis). Low density corresponds to less negative d18O (summer season). The d18O signal shows strong gradients at meltlayer boundaries. Meltlayers have no particular d18O signature.

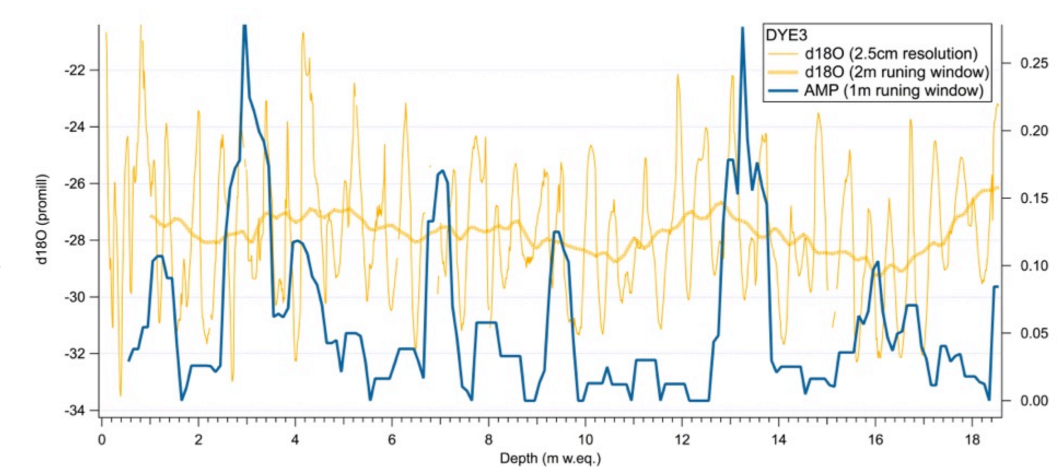


Figure 9: d18O (yellow lines) and AMP (blue line) versus depth in m w.eq. with surface at the left (2012) and bottom part at the right (1978). AMP and d18O show no correlation, even peaks with enhanced melt have no counterpart in d18O.

Conclusions

- **AMP-profiles at DYE3 and SouthDome indicate an increase of melt in the last decade. Years of enhanced melt are 2010, 2005-2007, 1998, (1994), 1986-1987.**
- **There is no trend in d18O over the last 30 years at DYE3 (where is the imprint of warming?)**
- **Firn columns at DYE3 and SouthDome (200 km distance) show unexpected similarities in density even on the seasonal scale. It points to an higher impact of large scale climate conditions than of local conditions (wind, deposition)**

References

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