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Interactive comment on "Recent accumulation rates of an alpine glacier derived from firn cores and repeated helicopter-borne GPR" *by* L. Sold et al.

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Sold et al (2014) provide a new approach using GPR to assess accumulation distribution. The key advance in this airborne system is that it can observe multiple accumulation layers over a region assessing the retained accumulation of previous years. The system is validated using just two firn cores. The snowpits are of little value since the most recent years accumulation is not assessed. The approach is sound and the results interesting. The main issue is better illustrating the spatial distribution of accumulation and the poor validation. Better spatial validation is needed going forward, but cannot be expected of the current study.

1. 4433-5: The statement of limited accumulation zone measurements versus ablation stakes is sometimes the reverse and cannot be categorically made. For example on Storglaciaren, Sweden, Brewster Glacier, New Zealand, Columbia Glacier, Easton Glacier, Rainbow Glacier and Sholes Glacier, United States probing densities of accumulation are much higher than ablation measurement (WGMS, 2011; Pelto and Brown, 2012)

Changed to: "For many study sites, the main drawback is a lack of accumulation measurements that typically involve the time-consuming excavation of snow pits (Ostrem and Brugman, 1991). If measurements of accumulation are under-represented the spatial variability is often not resolved correctly"

2. 4436-2: The GPR was flown in April and May and is focused on assessment of firn from previous melt seasons not the most recent accumulation season that is just ending. This point should be emphasized here.

Added: "Thus, the uppermost firn layer is covered by the recent winter accumulation layer."

3. 4445-20: A citation that arrives at a similar finding of the percent of retained firn being from refrozen meltwater on a temperate glacier is: Miller and Pelto (1999) who found on Lemon Creek Glacier 10% refrozen meltwater. "To determine how much meltwater is retained in diagenetic ice, the walls of each test-pit have been continually surveyed. In our records from the two field seasons of 1982 and 1984, an average of 10% of the firn stratigraphy comprised this secondary ice at a density of 0.90."

Added sentence and reference: "This is in line e.g. with Miller and Pelto (1999), who found 10% of the firn stratigraphy made up by refrozen meltwater on a temperate glacier in Alaska."

4. 4444-25: Wadham et al (2006) in Svalbard found a higher ratio of retained meltwater, but did note that this thick layer did represent the annual layer. The higher percent is expected in a more polar setting. The key item is that it was the annual layer where the main refrozen layer formed.

Revised paragraph in the Introduction P4434, L9: "To extract past annual accumulation rates from the GPR signal, the IRH must correspond to previous summer surfaces. In polar and sub-polar regions this is confirmed by several studies (e.g., Wadham et al., 2006; Van Pelt et al., 2014). For mid-latitude glaciers with a complex firn stratigraphy it can be difficult to establish this link (Kohler et al., 1997), although the large number of melt–refreeze cycles suggests the generation of a high-density or ice layer at the snow surface during summer. Thus, this precondition must be verified by independent layer dating information."

5. 4447-4 or 4449-10: Detailed mass balance can provide more than a plausibility check, it is the best means of validation on this particular glacier. Going forward a simple means of better spatial validation would be to utilize an extensive network of probing at the end of the balance year. That could be contrasted the next spring to the GPR mapping of the second annual layer down. On Storglaciaren the network allows this. On Lemon Creek Glacier we used over 300 probing measurements in 1998 and 2014 to validate our snowpits (Miller and Pelto, 1999). This could be done to validate GPR too.

On Findelengletscher we do not conduct snow probings at the end of the balance year because the determination of the last summer surface is often ambiguous while probing. Accumulation measurements are obtained from two snow pits down to a marked horizon at the sites indicated in Fig. 1. They are inter- or extrapolated using the calibrated mass balance model. This mass balance dataset is already used for a comparison (Fig. 5 and 7). However, in the revised manuscript we provide a validation of our approach using the annual mass balance data.

6. Figure 6: An additional figure of the distribution of accumulation from a single year is needed, to better see the details of spatial variation.

Figure 6 shows four maps of the annual layer water equivalents derived along the GPR profiles. In order to better demonstrate the spatial variability the point values were interpolated to a grid. However, we are convinced that a larger map does not provide a better visualization of the variability of accumulation because the spatial resolution of the measurements is already clearly visible and the small-scale differences are given by interpolation.

Interactive comment on The Cryosphere Discuss., 8, 4431, 2014.