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The Cryosphere Discussions

Interactive comment on "Comparison of airborne radar altimeter and ground-based Ku-band radar measurements on the ice cap Austfonna, Svalbard" *by* O. Brandt et al.

O. Brandt et al.

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I partly totally agree with you Olaf. One of the still remaining great challenges with radar altimetry is to actually precisely pin-point the surface in the data. The choice of retracker and method is often not very well justified. We have considered including the laser data, but believe the manuscript will be too long - but most of all - lose focus.

From my point of view, the hypothesis (and focus) I had in mind while doing this work was to "test the frequently used assumption that ground-based radar measurements are a valuable tool for direct validation of the received waveforms from air- or space-borne radars." p780 line 11 (the end of the introduction). The focus has therefore been to compare waveforms and try to better understand the relation between the

snow/firn/ice makeup and the received signals - rather than finding the optimal retracker.

To find an optimal retracker, working over various surfaces and ground properties (changing over time) I think is a very difficult task, and should be the next step after fully learning and being able to understand the waveforms received. The main challenge with finding the optimal retracker is the variability of the recived signals to ground makeup, which in many regions change severely with season. Thus, our "one time" measurement is not suitable for that (as exemplified by Scott et al. 2006a). Instead I believe a time series of measurements with along-side ground truth or laser data are mandatory for that purpose. This now partly do exist over Austfonna - but I do think we need to take one step at a time, and first learn what is actually causing the received signals. What are the physical properties that are "picked up" by the radar and mostly influence the return? After we have learnt that, then it is time to sit down, take up our "list" of what is causing the response and pick out when and where major response changes can be expected and how to take that into account when retracking. Without following these steps I don't think you will be able to design a robust retracker which physically makes sense, not breaking down or tracking differently just because the snow/firn/ice layer composition is different at the time of tracking.

Naturally, in this manuscript, to compare the ground and airborne signals, they both need to be somehow lined up against each other, with a common "time-zero" point. To use laser would partly help to pinpoint the airborne data but doesn't help with the ground based. The use of corner reflectors (1.5-2 m above the surface) to determine the surface position seems to me more being an office dream and don't work well in practice. We have only used the reflectors to make 100 % sure we have measured at the same position. Nevertheless, we therefore still have a potential offset in time between the radar waveforms. Anyway, based on what some people might call a crude time-zero lineup (see the discussion p793), the signals do resemble each other well - something to my knowledge not previously shown in this context - but something very

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often assumed. To me that is an important finding and confirmation that long has been lacking.

You will therefore in the result section (p790-792) "only" find a list of what we have found influencing the response as well as a confirmation of the hypothesis that I had during the work. Nevertheless, I do think that people working with retracking will find the manuscript of interest, despite not giving an optimal retracker algorithm working under all situations and conditions.

When it comes to retracking in different glacier zones (bullet #2 in the comment) my experience from Austfonna is that the snow surface and the near surface composition (upper \sim 30 cm) show no correlation with glacier facies there. On Austfonna the surface and near surface, is more dictated by the weather pattern during and after deposition and is changing significantly from year to year, over the season and spatially. See for example Taurisano et al., 2007 or Schuler et al., 2007. I therefore don't want to make a comparison since the surface connected return is not (or very poorly) correlating with the glacier facies there. Therefore to make a retracking recipe for Austfonna, and blindly apply that at other places without very good control of the local snow properties will likely occasionally directly fail or give poor results. Following up on bullet #3, I do have a manuscript which should have been submitted a long time ago... showing how to determine glacier facies using altimeter data. That work is based on the work of Dunse et al., 2008. Since this is not submitted yet I have chosen not to include that.

In conclusion, I do agree with you Olaf, retracking is a key issue in air- or spaceborne radar altimetry and is often overlooked. Anyway, the focus of this study has not been retracking or finding "time-zero" - it has been an experimental setup to confirm that ground based radars, utilizing larger bandwidths than currently possible on the air- or spaceborne platforms, are a valuable tool for direct validation of received waveforms from air- or spaceborne radars. I am therefore not keen to include the laser data at this stage since it won't significantly alter the conclusions. What I do consider is to more clearly state the hypothesis of the work - not to disappoint a reader wanting a ready to

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use retracking algorithm.

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