

***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.**

Received and published: 6 April 2009

On behalf of the co-authors, I would like to thank the reviewers for the very useful comments and ideas which I certainly believe will improve our work. However, I do find the reviewers opinions about the topic/manuscript sometimes seem to be quite diverse. For example, reviewer #2 states "General comments: The paper is well written, contains significant results, and is a useful contribution to understanding of nadir-looking radar signatures from various ice regimes." while reviewer #1 writes "I think the manuscript could benefit from shortening considering that the scientific outcome is limited." and again reviewer #3 "I think the main message of this manuscript, that you can compare in-situ and air-borne data, is important".

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



I am of the opinion that lots of researchers would agree that it should be a good agreement between ground and air-borne radar measurements, such that detailed ground based measurements are a good tool to validate air-borne measurements. Often it seems to be taken for granted, but I find that there is quite a limited number of experiments (that I am aware of!) actually verifying the assumption, and thus I believe that by showing an example of good agreement, other studies and researchers would benefit and stand on a more solid ground.

We don't claim to show what physical mechanisms are causing the scattering, this seems to be a disappointment among the reviewers. The reason we can not do that is that there are no good enough methods to resolve the small scale 3D (cm and sub cm scale) heterogeneity in permittivity and conductivity of the snow, firn and ice, which is necessary for the frequency range used in this study. For example a Di-Electric Profiler (Wilhelms et al., 1998; Hawley et al., 2008) gives a smoothed record where each measurement point is a bulk measurement and influenced by the material properties over a few cm. To make a proper investigation of what causes the scattering I therefore do not agree that it is today feasible (and thus actually very useful) to make more in-situ field measurements of permittivity and conductivity since the measurements will not give an adequate resolution at these frequencies. The measurements are too coarse and not able to resolve the 3D small scale structure and variability. Instead I believe the way to go is to use 3D electromagnetic wave modelling and construct "what-if scenarios" to test what give the response and how the response depends on roughness, heterogeneity, angle relative major layering and features frequently observed in snow, firn and ice etc. This can then later be compared with field observations (i.e. field measurements are valuable! But not for direct comparison of measured and model traces at these frequencies). We have used this approach to further learn more about the electromagnetic wave interaction to glacial features (see for example Brandt et al., 2009a; Brandt et al., 2009b). This we think is the natural next step but needs background data which is here presented. To include the modelling would make the manuscript far too extensive at this stage and we are not yet there. Anyway, to present the data without

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



giving any information of the snow and firnpack composition (suggestion by reviewer #1) I believe would make the manuscript falling flat, and make the work of little or limited use for other researchers (see for example the work by reviewer #2) since it will be difficult to put the different works into a context.

Some specific comments to the different reviews:

#### Reviewer #1

We find it worth making a note that we here confirm the earlier results of Scott et al. since the environmental conditions on Austfonna is quite different from Greenland and the fact that Scott's conclusion is solely based on ground based measurements.

The reviewer writes: "I do not find that the manuscript present much novel thoughts or discussion. Many of the conclusions are already established and are just shown in a different angle". We do find it somewhat strange that the reviewer means that many of the conclusions are already established without giving specific examples of papers that confirms a good agreement between air and ground based measurements at this frequency range and subsurface. We agree that lots of researchers would agree on the main conclusion in the manuscript, but there is very limited number of experiments actually been able to verify the frequent assumption. Please, let us know if we have missed something!

#### Reviewer #2

We totally agree with the specific comment and are aware of it. The difference between the systems is a problem - but difficult to overcome. We have not found a good way so far. The difference and problem should maybe be better described in the manuscript. I think this is one of the often forgotten issues, frequently forgotten, when making the assumption that ground based radar measurements is a valuable tool for validating airborne measurements.

#### Reviewer #3

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Regarding the results of Scott et al. see comment to reviewer #1.

The focus of the manuscript has not been to validate, examine or coming up with a retracking algorithm. The comment very much boils down to the interactive comment by Olaf Eisen and is commented by me. See discussion history.

#### References:

Brandt, O., Taurisano, A., Giannopoulos, A., and Kohler, J.: What can GPR tell us about cryoconite holes? 3D FDTD modeling, excavation and field GPR data, Cold Regions Science and Technology, 55, 111-119, 2009a.

Brandt, O., Langley, K., Giannopoulos, A., Hamran, S.-E., and Kohler, J.: Radar response to firn comprising a high fraction of ice layers, validation using cores and FDTD modelling, IEEE Transactions on Geoscience and Remote Sensing, vol. 47, no. 9, September 2009b (In press).

Hawley, R. L., Brandt, O., Morris, E. M., Kohler, J., Shepherd, A. P., and Wingham, D. J.: Techniques For Measuring High-resolution Firn Density Profiles: a case study from Kongsvegen, Svalbard. Instruments and Methods, Journal of Glaciology, vol. 54, no. 186, 463-468, 2008.

Wilhelms, F., Kipfstuhl, J., Miller, H., Heinloth, K., and Firestone, J.: Precise di-electric profiling of ice cores: A new device with improved guarding and its theory, J. Glaciol., vol. 44, no. 146, 171-174, 1998.

---

Interactive comment on The Cryosphere Discuss., 2, 777, 2008.

## TCD

2, S581–S584, 2009

---

Interactive  
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

