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The Cryosphere Discussions

Interactive comment on "Ground penetrating radar detection of subsnow liquid overflow on ice-covered lakes in interior Alaska" *by* A. Gusmeroli and G. Grosse

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The manuscript by Gusmeroli and Grosse: "Ground penetrating radar detection of subsnow liquid overflow on ice-covered lakes in interior Alaska", is an interesting feasibility study for the application of ground-based GPR in detecting these overflows. They could show that as soon as water is present at the snow-ice interface, signal amplitudes at this interface increase significantly and thereby allow for overflow detection. I recommended reconsidering this manuscript after major revisions mainly just because I have concerns about the processing applied on the radar data and because the determination of the effective dielectric permittivity values of the so called "slush" is wrong. This

error has an influence on the modeling results and thereby will change the conclusion after correction as these values go directly into the model.

Comments in detail:

(1) I recommend applying a proper processing on all the radar data. At least you must compensate for divergence losses (gain), if you compare reflection amplitudes originating from different distances to the radar transmitter. This comparison is pretty much the basis of the presented work. As snow depths do not vary that much, you might not see a huge difference on SLO/ noSLO values but on page 3087 line 1-10 you discuss various ice thicknesses and the magnitude of reflection. Spherical divergence losses are a contributing factor and after compensation you might receive different results.

(2) The determination of the effective dielectric permittivity is wrong (page 3086, L10-13). "Slush" is not a 2 phase dielectric medium, you have to apply a 3-phase mixing formula! Snow already consists of 2 phases (air, ice) and after water percolated through the snowpack (or in your case flows into the snowpack) you have to deal with 3 phases. Mitterer et al (2011) for example discuss these circumstances in detail. You definitely want to apply a formula in way like this: eps_eff=(theta_w*eps_wˆbeta+(1-n)eps_iˆbeta+(n-theta_w)*eps_aˆbeta)ˆ(1/beta) (e.g. Perla, 1991; Roth et al., 1990). The parameters have to be set in accordance to the prevailing conditions. Furthermore, volumetric liquid water content of theta_w=0.3 is really high, you are already in the funicular regime.

[Perla, R., 1991. Real permittivity of snow at 1 MHz and 0 °C. Cold Reg. Sci. Technol. 19 (2), 215–219.]

[Roth, K., Schulin, R., Flühler, H., Attinger, W., 1990. Calibration of time domain reflectometry for water-content measurement using a composite dielectric approach. Water Resour. Res. 26 (10), 2267–2273.]

[Mitterer, C.; Heilig, A.; Schweizer, J.; Eisen, O., 2011. Upward-looking ground-penetrating radar for measuring wet-snow properties. Cold Reg. Sci. Technol. 69: 129-138.]

(3) The methodology needs to be revised. You do not explain how the spectral amplitude was calculated in the manuscript. There is a short hint in a figure caption, however, this needs to be explained in the methodology

further minor points are:

(4)I would like to see the occurrences of SLO in the overview maps you plotted. A spatial distribution along the radar transects might help the reader to identify spots of SLO on those lakes.

(5)Your figure arrangement is very confusing. Please try to be consistent (clockwise, counterclockwise...).

(6) You got confused by this arrangement by yourself for Fig 2 (p.3084 l.1-10). The figure references are random within this section.

(7)A radar wave speed of v=0.21m/ns in dry snow corresponds to a density of roh_s=507 kg/mˆ3, which is unusual for seasonal snow, especially for those shallow snow depths. Have you measured density? If so please present data. Otherwise on a frequently used snow-machine track it might be possible. Please discuss.

(8) Use international classifications for your grain definition (p.3084, l.16 + figure caption) [Fierz, C., Armstrong, R.L., Durand, Y., Etchevers, P., Greene, E., McClung, D.M., Nishimura, K., Satyawali, P.K., Sokratov, S.A., 2009. The International Classification for Seasonal Snow on the Ground. 83 HP-VII Technical Documents in Hydrology. UNESCO-IHP, Paris, France. 90 pp.]

(9) Please order your bibliography.

(10) "radar returns" (e.g. Abstract) is not unambiguous. You'll get more than just one

kind of information from radar returns (signal magnitude, phase information, frequency content), please be precise.

Comments: Abstract L1-5 3 times "access these lakes"

p.3082, l. 1-5 I doubt on this space-borne radar most likely won't have the resolution to detect SLO in the near future

p.3083 l.8 lake ranged FROM ...

l.15 ...THREE different...

p.3084 l.18-20, l.21-23 are almost exactly a repetition

instead of w use lwc or theta_w for liquid water content -see Fierz et al

p.3086, l.8 with A dry...

discussion on p.3087 l.5-15 is a matter of frequency as well

be consistent with snowpack vs. snow pack

Figure 5b: rather smooth this line the result will be easier to interpret.

Interactive comment on The Cryosphere Discuss., 6, 3079, 2012.