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Interactive comment on "Brief communication: On area- and slope-related thickness estimates and volume calculations for unmeasured glaciers" *by* W. Haeberli

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Area- and slope-related ice thickness estimates for unmeasured glaciers: plea and discussion

The following continues the discussion on area- and slope-related thickness estimates and volume calculations for unmeasured glaciers. It provides general comments on the submitted TCD Brief Communication and the feedback by the two anonymous referees. A complete version with a point-by point reply to the referee reports is provided in the attached PDF. The main goal is to make the various opinions and scientific arguments publicly accessible.

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The intention of the submitted Brief Communication was to enable a publicly accessible discussion concerning widely used approaches for estimating ice thicknesses and calculating ice volumes on the basis of glacier inventory data. As such, this Brief Communication cannot be an extensive review but aims at being a plea for

- making a clear distinction between scaling theory and empirical regression/correlation statistics used for quantitative estimates;

- carefully considering the origin and nature of the field data (thicknesses, areas) used in such statistics;

- being careful about the use of area-area self regression/correlation in volume-area statistics for existing glaciers;

- comparing available approaches concerning scatter/uncertainties, error propagation, calibration/validation and applicability of products;

- using available 3D-input information to go beyond “average thicknesses” or “total volumes”;

- recognizing the fascinating and important potential of such 3D input information for modeling detailed glacier-bed topographies in view of emerging research fields related to climate change impacts in cold regions, resulting environment/landscape dynamics, hazard conditions, land-use options and corresponding adaptation strategies, etc.

The two anonymous referees are thanked for their substantial feedback and contribution to the discussion. The constructive suggestions of Referee #2 show in what direction a detailed and systematic assessment with a more extended format than that of a short communication could go. The submitted Brief Communication can remain in its original form as a discussion or opinion paper (perhaps even a “wake-up call”). It had been elaborated over years in close communication with a number of colleagues. Together with the feedback from the two referees and the reply to these feedbacks it hopefully encourages further critical reflection. This is in support of the timely IACS

initiative mentioned by Referee #1. The fact that TCD offers a forum for such publicly accessible contributions to ongoing discussions is highly appreciated.

Concerning two aspects the view expressed in the Brief Communication clearly differs from the opinions and recommendations of the two referees: (1) the way scientific arguments have been dealt with in the literature (Referee #1) and (2) the safety and importance of numerically modeled glacier bed topographies (both referees).

(1) Without exact references, it is difficult to understand how Referee #1 cannot " . . . see any arguments that have not been extensively discussed in the literature . . .". The primary reason for publishing the Brief Communication was the fact that the essential aspects (bullet points) mentioned above still need to be adequately reflected in the scientific literature. The Brief Communication for the first time deals with these technical aspects as related to basic principles of both approaches in direct comparison. It may be seen as a complement to the quantitative inter-comparison and analysis of calculated results provided by Frey et al. (2014).

(2) The scientific arguments used by Referee #1 concerning numerically modeled glacier bed topographies (especially overdeepenings) must be more carefully considered. The robustness of spatial patterns in calculated bed topographies such as sequences of overdeepenings and riegels is not a direct function of the uncertainty related to ice thickness estimates. Spatial patterns and topologies of calculated glacier beds much more directly depend on surface slope than absolute ice thickness values calculated from highly uncertain assumptions about mass fluxes. The scientific evidence from dense radio-echo sounding networks (Gabbi et al., 2012) and exposed glacier beds (Haeberli and Linsbauer, 2013) is beyond doubt: even with strong mismatches of average ice thicknesses or total glacier volumes, spatial patterns of calculated bed topographies remain robust. Successful prediction is possible – within limits, of course – of sites with potential lake formation in overdeepenings, which become exposed by glacier retreat. In fact, spatial patterns of glacier bed topographies are safer and the corresponding knowledge more advanced (cf. Haeberli et al., 2016a, b; Linsbauer et

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al., 2016) than assumed in the report of Referee #1. This also means that such bed topographies represent far more than “noise” in comparison with total global glacier volumes as suggested by Referee #2. The importance of such local to regional and even global applications of glacier inventory data and DEMs should be emphasized even more strongly.

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Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/tc-2015-222/tc-2015-222-AC1-supplement.pdf

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