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The Cryosphere Discussions

Interactive comment on "Sensitivity of alpine glacial change detection and mass balance to sampling and datum inconsistencies" *by* T. Goulden et al.

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Overview

The objective of this study is to exemplify the sensitivity of the glaciological "geodetic balance", or simply elevation differences over glaciers, to differences in horizontal and vertical datums. Three study sites chosen are located in western Canada in which acquisition datums have varied through time. The study outlines 4 datum inconsistency scenarios from which the effects on elevation changes and glacier geodetic balances are assessed. The conclusions of the study are that consistent horizontal and vertical datums should be used when comparing elevation data through time over glaciers. The study is rather long to describe an elementary concept that is a "standard" pre-

processing step for any comparison between elevation data, whether on glaciers or not. Everyone knows that datums must be consistent before comparing elevation data. The findings and conclusions are not surprising but just as expected. For example, of course the relative error of a constant bias is larger over glacier sections where the elevation changes are smallest (i.e. above the ELA). Overall, it is difficult to extract the relevance of this study in relation to what is already known by the community. The study would be more useful had it focused upon the actual geodetic balance of the glaciers with a minor focus on some of the mistakes and methodological considerations ("lessons learned") that were encountered during the derivation of the geodetic balance, or if it found that previous studies did not contain consistent datums. To summarize, this manuscript in its present form does not satisfy the scientific relevance and quality for publication in the Cryosphere.

Major Remarks

- It is obvious that datums must be consistent before comparing elevation data. For vertical datums, there is a difference when considering global variations (Fig. 1) vs. local variations. Since the glaciers studied here are rather small, the global variations described between the vertical datums (Pg 61, Ln 14-end) has little relevance besides describing the potential constant bias that may persist if consistent datums are not used. It is even further described on pg 62-64 that single constant offsets are a rather good assumption for glacier sizes of this study. Therefore, maybe a single 3-D co-registration is sufficient to account for horizontal and vertical datum variations, especially if the datums are not sufficiently known. So, the reader than asks, what does this study contribute?

- The conversions between the various datums is easily performed within standard softwares, like ArcGIS or as stated from a free software provided by the Canadian geospatial service. So, the main result of this study is basically describing the magnitude (amplitude) of these transformations over the glaciers studied. These results can be easily extracted, for example, from your Fig. 1 for any glacier in the world. Why then

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spend an entire paper describing this for 3 small glaciers in western Canada?

- Section 4.2: Which direction is the horizontal datum inconsistency in Fig. 7 and 8? Is it a simple translation over the glaciers in this study or is it a higher order transformation? In both these figures a bias results from the horizontal inconsistency. Was the vertical datum corrected for first and or was the vertical bias as obtained by comparing ice-free terrain removed first? If not, it should be. If it was already removed, it means that the horizontal misalignment is somehow in a direction (aspect) parallel to the general glacier aspect. It is possible to solve this, and not sure why it is not solved for (i.e. specifically what is the x and y transformation parameters)? After the correct horizontal and vertical datums are reconciled, is there still a mis-alignment between the DEMS? Often subpixel misalignments are visible, and as stated above, these will bias your results depending upon the direction of the misalignment in relation to the direction of the glacier surface.

- [Pg 69, Ln 3-13] – why not use the entire DEMS? Moreover, why not use the terrain surrounding the glacier to describe the variations, or even better to use for deriving a statistical correction had the datums not been known... Also, co-registration between DEMs should be checked even when correct datums have been used.

- [Pg 70, Ln 1-8] – This density scenario assumes no glacier dynamics between the two epochs. Therefore, it only represents a lower bound for volume to mass conversion.

[Pg 71-72] The slope dependency on elevation errors (eq 2) due to mis-alignments or horizontal datum errors is only half of the picture. The error is also dependent upon the terrain aspect in relation to the direction of the translation, mis-registration etc. If the translation is perpendicular to the aspect direction of the steep slopes, then very little bias over those steep slopes will be incurred. Equation 2 is thus not fully valid and the full equation should be used. Having slope, aspect, and direction of the horizontal datum misalignment, one can easily model the error imposed. . . What does the reader learn here?

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