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The Cryosphere Discussions

Interactive comment on "Brief Communication "Importance of slope-induced error correction in elevation change estimates from radar altimetry"" *by* R. T. W. L. Hurkmans et al.

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This paper deals with the effect of the so-called "slope-induced error" in altimetry when looking for ice sheet mass balance. Several old studies have approached the problem for mapping topography but it is the first time that the effect of this error is investigated for temporal series interpretation. The paper makes an important point, used several data set with a well-explained methodology and an interesting conclusion. It should be published with some more or less minor corrections. I agree with previous comments about the presentation of the final conclusion. The most important is not to know the difference in the retrieval of volume change with and without this correction. The most

important is to know the reduction of error in volume change deduced from radar altimetry with respect to ATM or ICESat (e.g. clearly write volume changes difference between ATM/ICESat and Envisat without correction is xx, and volume change difference between ATM/ICESat and Envisat with correction is reduced to yy...). Also, the use of RA-2 cross-over and not the whole along-track data yields to a poor sampling that strongly penalizes RA-2 compared to ICESat. Such a study should have used along-track data. About methodology, I do not understand why they estimate the displacement via the surface slope in order to find the closest point, instead of directly look for this point on the topography map. This would allow to take into account surface curvatures and kilometric scale topography features, the closest point would be determined more precisely than with average slope alone. However, for me, the greater problem that should be addressed is the problem due to the antenna aperture versus the surface slope of the chosen area. The half antenna aperture of the Envisat RA-2 is 1.35°, (the gain is (3.3°)-2), meaning that in case of surface slope of 1°, the energy backscattered from the impact point is 4% of the energy coming back from nadir. This induces two problems. First, the waveform is strongly distorted with a long leading edge and is thus very sensitive to any change in snow-pack properties or short-scale topography features and retracking (probably both ice-1 and ice-2) gives elevation with a poor precision. Second and more important, with a surface slope of the order of magnitude of the half antenna aperture, the height retrieved from the distorted waveform does not correspond to the theoretical impact point (closest point). In general the up-slope shift is reduced and the mean elevation corresponds to a spot delimited by a convolution between antenna pattern gain and topography. This can be demonstrated with a dual frequency altimeter. Over steep areas, the lower frequency (C-band for Topex or S for Envisat) gives elevation higher than Ku-band because the antenna aperture is greater (and the energy backscattered from impact point is greater). See for instance Remy, F, Legresy B, Bleuzen S., Vincent P. and J.F. Minster, 1996, Dual-frequency Topex altimeter observation above Greenland, J. of Electromagnetic Waves and Applications, 10, 1505-1523. To be optimal, a waveform simulation must be performed with the help

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of the small-scale topography and antenna gain pattern in order to measure the height retrieved with a given retracking (maybe for a future paper...).. For now, the authors should acknowledge the problem. For me, this explains the poor contribution of the correction for the steep part of the chosen profile (see between km 10 and 40 on Fig 3.b). The correction only slightly reduces the difference with ATM/ICESat. I suggest to superimpose the surface slope in Fig 3.b (added or instead of velocity). In conclusion, if antenna pattern point is discussed and the scientific result is presented with respect to the volume change of ATM/ICESat, the paper should be published. minor comment: The profile shown on Fig 3.b could be shown on Fig. 1

Interactive comment on The Cryosphere Discuss., 6, 159, 2012.