

## ***Interactive comment on “Elevation and elevation change of Greenland and Antarctica derived from CryoSat-2” by V. Helm et al.***

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R: Volumes loss factor 7 in WAI should be more stressed A: The increased volumes loss compared to our ICESat estimates is of factor 3 for WAI. This is stated in the abstract and conclusion as one important finding.

R: Two years very short period, why not use more data? A: We extended dh/dt from 01/2011 to 01/2014

R: p.1674 l.16 A: changed

R: 1675 A: added citation Wingham, 2006

R: 1675 l. 27 A: Added: ‘However, the across-track footprint is not decreased.’

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R: 1675 l.28 – 1676 l1 A: changed to passiv

R: 1676 l. 5-9 A: added: Retracker is now described in more detail in A1

R: 1676 l. 24 A: added citation Griggs, 2009

R: 1677 l.7 A: Grid pixel size is 1 km – more clearly now.

R: 1677 l. 18 A: removed SIRAL explanation

R: 1678 l 4-9 Ridge sampling, Special method? A: We added some more details in the method section. No, we don't use any special method to fill gaps at the valleys or at the flanks of ice domes. We tried to use thin plate spline interpolation method but got better results with kriging. Special care was taken at grounding lines close to ice rises, since here the SIN data shows sometimes erroneous values, which were filtered out before the interpolation. The usage of grids with different pixel size and different search radii used for interpolation was applied to interpolate data gaps and at the same time avoid strong averaging in the final DEMs.

R: 1678 l 18 A: Slope map is the gradient of the smoothed DEM using a 20 km kernel. Reference to slope map added

R: 1679 – 1680: Residuals on slope error A: Yes we think it is a residual of the slope error and of higher surface roughness. As stated in the method section, the Retracker is designed to re-track the surface as best as possible. Therefore we use the beginning of the leading edge, to avoid influences from changing penetration due to changing extinction in the firn volume. We added some text in Appendix A1. However, this paper is not about penetration of KU-band and we are not intent to discuss this in more detail.

R: Explanation why median of DEM is larger then CryoSat/ICESat in Fig. 6 (new Fig. 9) A: It is an interpolation effect. At lower latitudes the track spacing is larger and also the slope gets larger. Therefore we see a higher median with larger slopes in the DEM. The ridge sampling leads to the same phenomena, since more data points are concentrated in the flatter ridges than at the steeper slopes. Additional the error

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inserted by the cross over analysis gets larger with higher slopes. Usually the point to point distance is around 300m. We linear interpolate between the two neighbouring points of a cross point. When we have a  $1^\circ$  slope than the elevation difference between two 300 m separated points is 5.24m, for  $1.5^\circ$  it is 7.85m. Considering this we can easily get interpolation errors. For the comparison with the DEM we bilinear interpolate the 1km grids. For slope of  $1^\circ$  the elevation difference in 1 km distance is 17.45 m for  $1.5^\circ$  26.18. Therefore the error of the interpolated DEM is larger than for the CryoSat data itself.

R: Laps of time between ICESat and DEM A: We account for the elevation change occurred between the ICESat measurements and the DEM by adding the  $dh/dt$  obtained from the ICESat data back to the ICESat elevation. We explained this already in the text: 'To avoid uncertainties inserted by elevation changes occurred between 2007 and 2012, the reference ICESat data set was corrected using the ICESat elevation change map derived in this study, assuming a constant elevation change."

R: 1680 I.25 A. changed to : However, the most recent high-resolution DEM of Greenland, produced within the Greenland Ice Mapping Project (GIMP),(Howat et.al. 2014) , give more precise results at the margins then the CryoSat DEM.

R: 1681, make clear what you see in Table 1: DEM or raw CryoSat data? A: In table 1 (new Table 2) we added DEM

R:1682 I.15 A: We extended the  $dh/dt$  by one year

R:1682 I.29 A: changed to 'volume change'

R: 1683 I.11 Add reference A: added Thomas, 2009

R:1684 I. 13 A: Figure changed. ICESat tracks are now included

R: 1684 I.14 A: Table corrected.

R: 1685 I.8 We compared to the non-interpolated values, which show roughly the same

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values, however the closest points are up to 2.5 km apart the GPS measurements. In the text we gave more than 4m/yr as comparison to the 17 m/yr derived from Hurkmans. The non-interpolated  $dh/dt$  show large variation and data gaps and max values of -5.23 m/yr at the Jacobshavn isbrae. We have large data gaps at the glacier terminus, where Hurkmans observed the very high values, as well as at the elevated parts. This is due to high slopes, where the LRM waveforms are flagged as bad. We included a line to show the mode mask in Figure 14.

R: 1685 I21 A: changed to" For Greenland we observe a~factor of 2.5 higher volume loss for the period 2011 to 2014 than for the period 2003 to 2009 revealed from ICE-Sat using the same methodology. However, our ICESat estimates are slightly lower than \citep{Soerensen\_tc\_2011, shepherd\_science\_2012}. However, the observed increase of volume loss mirrors .."

R: R. 1685 I.2 Factor 7 more loss in WA A: Text highlights this fact now. The Factor is 3 using our method for ICESat and CryoSat.

R: 1686 I.23-24 A: We used now more data from 01/2011 to 01/2014

R: 1689 I.2 VARIANCE (SD), Roughness definition A: changed to standard deviation. Added: "The slope is derived as gradient from a smoothed DEM using a kernel of 20 km. The roughness is derived as the difference of the DEM from the smoothed DEM. 20 km was chosen to represent the beam limited footprint size and therefore to give an indication of the footprint roughness.'

R: 1689 I. 7-8 A: yes, we made this clearer in Appendix A3.

R: 1690 I.1 Too difficult to follow, Give Formula for Weights? A: text changed, and equation A6 added

R: 1690 I.14 relocation method A: Explained in more detail in section 2.3, resolution is 20 m not 1km

R: 1691 I3 A: changed

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R: 1691 I: 4-5 A: processing has changed and is described in more detail

R: 1691 I. 6-7 A: We compared 5km and 1km grids. The 1 km grid resolves better smaller features, even with a 25 km radius. However, the basin wide volume change estimation presented in Table 3 (new Table 4) are the same.

R: 1691 I.16 and I.21 A: see above. We aim to have the same resolution for the DEM and the DHDT rasters.

R: 1692 eq 5 A: changed (see reviewer 1)

R: Fig6, label on x Axis A: changed

R: Fig.7 and Fig.8 A: We added Figure 15 and 16. This shows the comparison to the ICESat dh/dt and give a good indication where significant changes of dh/dt occurred.

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Interactive comment on The Cryosphere Discuss., 8, 1673, 2014.

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