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Earth System Science Data Discussions

Interactive comment on "A new 100-m Digital Elevation Model of the Antarctic Peninsula derived from ASTER Global DEM: methods and accuracy assessment" *by* A. J. Cook et al.

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Thank you to both Referees and to Hans Pfeiffenberger for the Short comment. We're grateful for your very clear and thorough reviews with constructive comments, and for the time you've taken to help improve this paper.

Firstly, to put our response in context, we would like to stress that the DEM dataset is already being widely used and this paper is written as a reference document for those who are (and will be) using it.

This part of our reply will be to the two referees as it regards the issue that you both raise, about performing a more comprehensive validation of the vertical and horizontal

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accuracy of the DEM. We have submitted individual replies to address each of the reviewers' specific comments.

1. Vertical accuracy: both reviewers point out that not all ground-truth data that is available has been used and that we limited our accuracy assessment to one region of the DEM. These comments were very helpful and we have taken this on-board. We will re-run the vertical accuracy assessment across the entire extent of the DEM, not simply the sample region. As suggested by both reviewers, we will be able to use ICESat tracks that are available for the whole Antarctic Peninsula and we will re-assess vertical accuracy based on these. The second reviewer has also helpfully suggested categorising vertical error according to slope angle. This will be important to include in the assessment as vertical offsets are highly slope-dependent. For example, a small horizontal offset between ICESat and the DEM can have a large effect on the vertical difference (i.e. on steep slopes there is much greater elevation change per horizontal distance) which could be misinterpreted as vertical error. In regions with slope angle <20° for example this will have less of an effect and so we can have far greater confidence that the error values are correct. Bias is directly related to the direction of horizontal offset and surface slope so we would expect this can be determined in a re-run of the accuracy assessment. The first referee suggests showing a histogram of the deviation from ICESat tracks for the complete DEM, which we are happy to do if it is useful for the reader to visualise the deviations. Regarding adding colour-codes to show the spatial distribution of error, at the scale of the map in Figure 5 it would be too small to determine the difference between points. The distance between the ICESat footprints is only 170 m therefore the colours would not be distinct, so we do not think we can go forward with this suggestion.

2. Horizontal accuracy: The first referee comments on the use of GPS points on peaks only. Although elevation data are available (e.g. LVIS and Operation IceBridge), this can only enable vertical differencing in the same way as ICESat. We have the same issue as stated above, that horizontal offsets affect vertical error. If the DEM

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was shifted, rotated or re-scaled horizontally to fit ground-truth elevation data, it would clearly give very different vertical accuracy results. The problem with rectifying the DEM is that considerable distortion would occur in regions lacking ground-truth data and between gaps in the data. In addition it is not possible to make a shift without first determining the scale and direction of horizontal offset across the complete DEM. The second referee suggests using a method outlined in Nuth and Kääb (2011), for co-registering the new DEM to existing elevation data. This method centres on the fact that there is a characteristic relationship between elevation differences and the direction of the terrain (aspect), which is related to the x-y-shift between the two DEMs. The co-registration process involves computing slope, aspect and vertical differences and fitting a curve between the two DEMs to allow a shift of one DEM to match the other (with further corrections for elevation-dependent bias and/or cross/along-track geometry as required). Non-stable terrain must be excluded from these calculations. Nuth and Kääb (2011) also suggest that this method can be applied using elevation data points, such as ICESat. Although this is a valuable way of co-registering datasets, we have two reasons to suggest that this cannot be applied to the new DEM:

a. The area of 'stable terrain' across the Antarctic Peninsula DEM region is only 3.15% (as calculated using rock outcrop data available in the ADD).

b. The sample size will be reduced further by the scarcity of ICESat footprints that fall within these regions. The co-registration of the new DEM to these few points would not be valid.

A further point here is that the purpose of the horizontal accuracy test is to calculate the magnitude of geo-location offsets. Mountain peaks are a good feature to choose as they are easily identifiable on each DEM, and, although GPS points are limited, we also used peaks detected on SPIRIT DEMs to obtain a sufficient coverage across the whole AP. The conclusion from all points is that horizontal accuracy is within two pixels (200m). For a DEM of 100 m pixel size we argue that there would not be sufficient gain in performing more detailed horizontal accuracy tests. We will make this clearer in the

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text.

3. Slope accuracy: In addition to calculating elevation accuracy according to surface slope categories, the second reviewer suggests calculating a slope accuracy test, using slope angle between ICESat points. These tests would be useful to perform if the dataset was horizontally corrected, but in this case we suggest that the offsets could skew the results. In addition, due to the effect of clouds there are irregular gaps in the ICESat elevation profiles, which would cause problems with measuring slope between ICESat footprints. We would argue that results would not be reliable enough and the vertical accuracy tests by slope category will give a sufficient indicator of slope accuracy.

We hope this answers the general points made by the reviewers about the accuracy assessment. We have answered each of the reviewers' specific comments in our reply comments.

Interactive comment on Earth Syst. Sci. Data Discuss., 5, 365, 2012.