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Elevation change of the Antarctic Ice Sheet: 1985 to 2020

Johan Nilsson et al.

Correspondence to: Johan Nilsson (johan.nilsson@jpl.nasa.gov)

Cross-Calibration Procedure – Single Grid Cell

Example of approach used for cross-calibration each time series for each grid-cell (Figure S1). The cross-calibration is separated into two different steps. Initially, the least-squares adjustment method is used to align all the different missions or modes to a common epoch. Secondly, the missions and modes are grouped into four different datasets residuals to the model is used to estimate the final offsets using the overlapping periods.
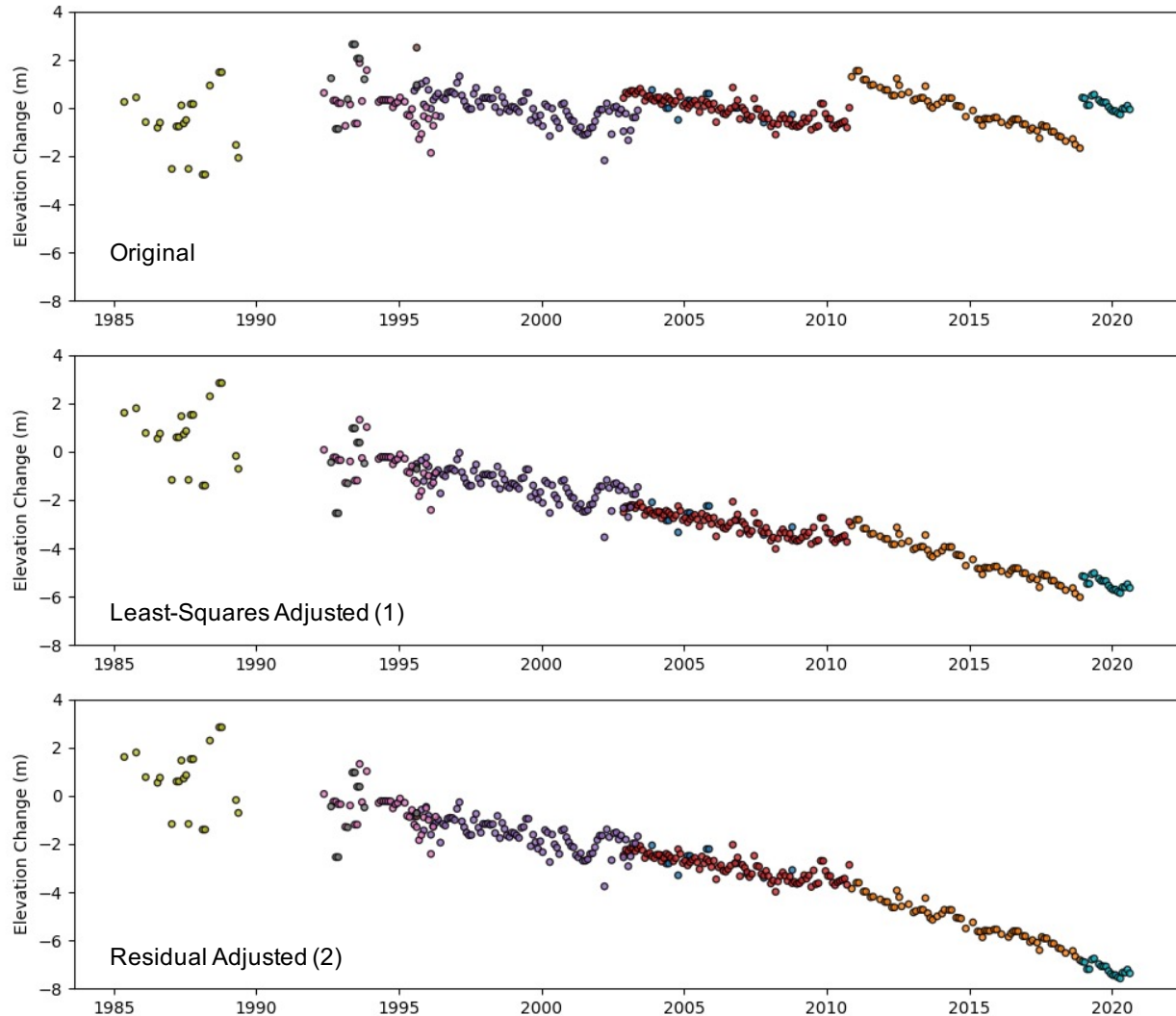

Figure S1. Cross-calibration example of a single grid-cell over Totten glacier in East Antarctica, including the two adjustment techniques. The top figure (Original) shows the initial non-calibrated time series after removal of static topography and after application of the scattering correction. The middle figure (Least-Squares Adjusted) shows the initial calibration step where an offset for each mission/mode is estimated via a least-squares and subtracted from the time series. In the final step (Residual Adjustment) the different missions/modes are grouped (ERS-1 – ERS-2, ERS-2 – Envisat/ICESat, Envisat/ICESat – CryoSat-2 and CryoSat-2 – ICESat-2) and offsets are estimated over the overlapping areas using the model residuals, with special handling of the Envisat-CryoSat-2 transition (using several methods).

Seasonal Amplitude – FDM versus JPL

Comparison of seasonal amplitude and phase between the JPL and RACMO FDM elevation change product over different regions. The regions are defined as the CryoSat-2 LRM and SARIn regions where data inside the 81.5 degrees pole-hole are not used (Figure S2). We estimate amplitude and phase over the time periods of the different missions to provide a better understating of how well the product and model agree over time (Table S1,S2).
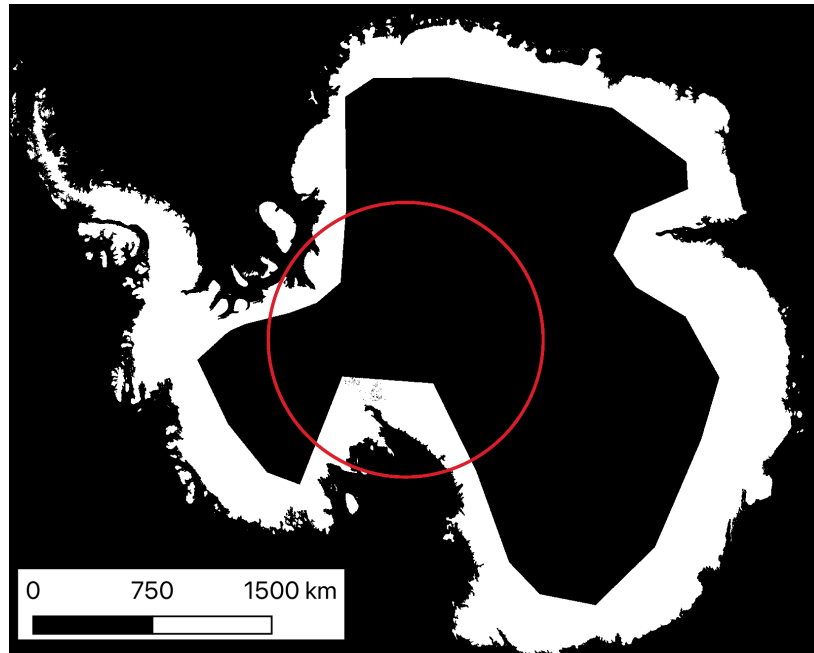

Figure S2. Mask used to define the areas for generating statistics for the FDM and JPL seasonal magnitude and phase.

To estimate the seasonal amplitude and phase for each time interval we fit a second-order polynomial (trend and acceleration) combined with a seasonal model (two-parameter: cosine and sine). The amplitude and phase are then estimated from the coefficients of this model.

Table S1. Seasonal amplitude and phase from the RACMO FDM product compared to values estimated from the JPL elevation change product. Statistics are estimated inside the CryoSat-2 LRM region and South of 81.5 degrees in latitude (see Figure S1).

Time Period	Amplitude FDM / JPL (cm)	Phase FDM / JPL (days)
1992 – 1995	1.2 / 1.9	156 / 166
1995 – 2003	1.1 / 1.9	112 / 148
2002 – 2011	1.2 / 1.4	119 / 159
2010 – 2016	1.1 / 1.6	138 / 165
1992 – 2016	1.1 / 1.2	144 / 151

Table S2. Seasonal amplitude and phase from the RACMO FDM product compared values estimated from the JPL product. Statistics are estimated inside the CryoSat-2 SARIn region and South of 81.5 degrees in latitude (see Figure S1).

Time Period	Amplitude FDM / JPL (cm)	Phase FDM / JPL (days)
1992 – 1995	5.2 / 16.4	159 / 176
1995 – 2003	4.9 / 8.7	130 / 152
2002 – 2011	5.2 / 5.9	159 / 145
2010 – 2016	5.2 / 4.8	137 / 161
1992 – 2016	4.9 / 4.2	135 / 137

Estimates from the JPL solution are slightly lower in amplitude in the later time intervals due to the smoothing effect from the interpolation and filtering procedure.

Estimating uncertainties from product and tabulated values

To estimate errors for a given region of interest or time period one can follow the approach outlies here: Select the basin or region (ROI) and the time interval from the cube (slice the data in time and mask out areas you are not interested in). Then take the monthly spatial error fields (in meters) and compute the integrated error for each month. Once, that's has been accomplished compute either the mean or RSS of these errors over the time interval. This will provide the random error (σ_m) for your ROI over the selected time interval. This can be mapped into an error rate (m a^{-1}) either by dividing by the time interval or by using Equation 7 in the manuscript. To obtain the standard rate-error the random error-rate needs to be divided by the number of un-correlated grid-cells using the correlation length provided in Table 2, or a correlation length of the users choosing. Finally, the absolute rate-error can be derived by following Equation 7 using the bias (σ_s), error (σ_r), area and correlation lengths from Table 2 (or the users own values of area and correlation length). This follows the approach outlined in this study to provide the tabulated errors in Table

3. Further, if needed σ_s and σ_r can be replaced by values from the error model in Figure 7(g,f), which are to be integrated over the ROI and substituted into Equation 7 using user defined values of correlation.

To reproduce these error rates the ICESat-ICESat-2 data can be downloaded from the following link: https://digital.lib.washington.edu/researchworks/handle/1773/45388 (latest checked 2022-03-24).