

Supporting Information

The impact of new accelerometer transplant data (ACH) on GRACE Follow-On along-orbit inter-satellite laser ranging observations and monthly time-variable gravity and mascon solutions

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Text S1

We performed a statistical significance test to examine the similarity between linear trend of GRACE-FO RL06.1 and SLR $\bar{C}_{30}$ estimates from June 2018 to July 2022. We used both the currently used SLR $\bar{C}_{30}$ from version 2 of the TN-14 as well as a new test release for version 3 of the TN-14. The latter makes use of an updated background time variable gravity model based on GRACE and GRACE-FO RL06 solutions to degree/order 60 in the SLR data processing. We test the null hypothesis that the difference between GRACE-FO and SLR $\dot{\bar{C}}_{30}$ estimates is not statistically significant:

$$H_0: \dot{\bar{C}}_{30}^{\text{GFO RL06.1}} = \dot{\bar{C}}_{30}^{\text{SLR}}.$$

For that, we performed a Two-Sample Z-test and calculated the Z value using

$$Z = \frac{\dot{\bar{C}}_{30}^{\text{GFO RL06.1}} - \dot{\bar{C}}_{30}^{\text{SLR}}}{\sqrt{\frac{\sigma_{\dot{\bar{C}}_{30}^{\text{GFO RL06.1}}}^2}{n} + \frac{\sigma_{\dot{\bar{C}}_{30}^{\text{SLR}}}^2}{n}}} \quad (\text{S1})$$

where n is the number of $\bar{C}_{30}$ estimates (i.e., 48). $\dot{\bar{C}}_{30}$ and $\sigma_{\dot{\bar{C}}_{30}}^2$ represent the trend and its variance computed by least-squares through fitting a linear trend plus annual terms to the timeseries of $\bar{C}_{30}$ estimates. If the absolute value of Z is smaller than 2.757, then the null hypothesis is accepted and GRACE-FO RL06.1 and SLR $\dot{\bar{C}}_{30}$ estimates are statistically similar at a 99% confidence interval.

Table S1 reports the results. We see that the $|Z|$ value is significantly closer to 2.757 when the updated SLR $\bar{C}_{30}$ estimates are used, which validates the improvement in GRACE-FO $\dot{\bar{C}}_{30}$ by ACH. However, since all $|Z|$ values are larger than the significance threshold, this also means that trends for both RL06 and RL06.1 are statistically different from the SLR reference values. This might be an indication that when compared to SLR, the updated

accelerometer transplant dataset ACH improves $\dot{\bar{C}}_{30}$ estimates, but it does not fully correct it. Furthermore, this statistical analysis shows that GRACE-FO $\dot{\bar{C}}_{30}$ from JPL RL06.1 and ITSG-Grace2018 agree the most with the updated SLR estimates.

Table S1. Absolute value of Z based on Eq. (S1) computed from linear trend of GRACE-FO and SLR $\bar{C}_{30}$ timeseries. GRACE-FO SDS RL06.1 solutions from JPL, CSR and GFZ as well as ITSG-Grace2018 are used.

	JPL RL06.1	CSR RL06.1	GFZ RL06.1	ITSG-Graces2018
SLR #1*	22.63	24.74	26.94	12.67
SLR #2*	4.79	6.90	9.09	4.88

SLR #1 refers to the currently used version 2 of TN-14 and SLR #2 refers to a new test release of version 3 of TN-14 based on updated background time-variable gravity model used in the SLR data processing. The currently used version 2 of TN-14 makes use of a regression model containing trend and annual terms up to degree/order 10 (only retaining terms with statistical significance) from GRACE and GRACE-FO RL06 data through October 2019 as the background time-variable gravity model. The test release for version 3 of TN-14 makes use of the GRACE and GRACE-FO RL06 solutions to degree/order 60 until July 2022 as the background time-variable gravity model used in the SLR data processing.

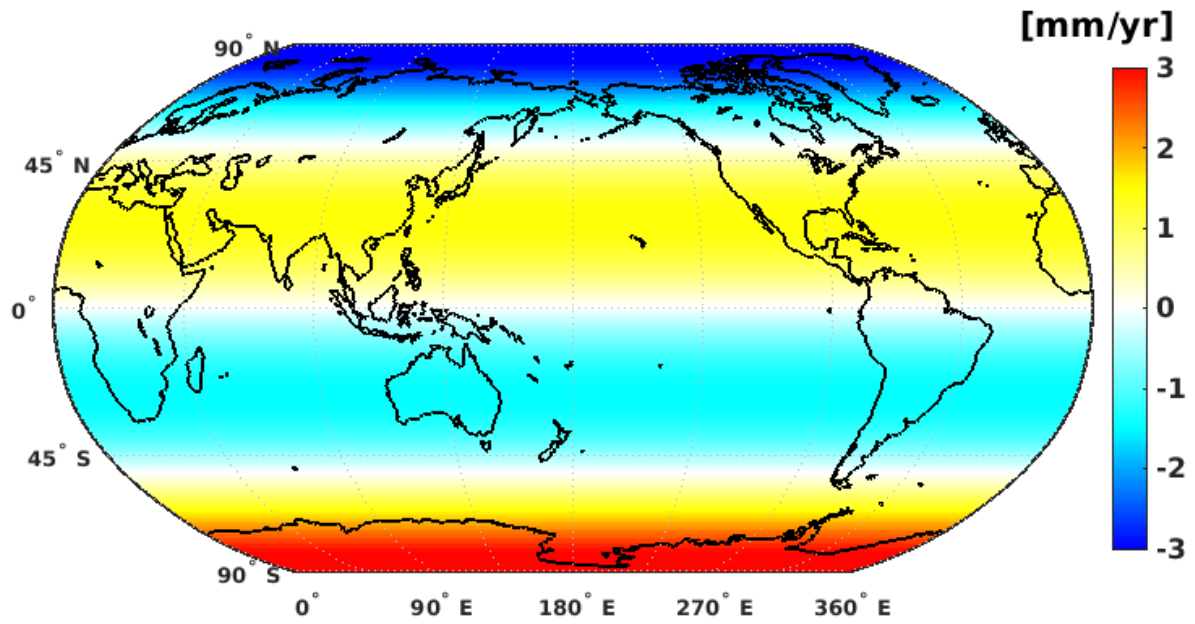


Figure S1. Surface mass change rate in terms of equivalent water height computed exclusively from GRACE-FO RL06.1 $\Delta\dot{\bar{C}}_{30}$. This is to demonstrate that a notable change in $\Delta\dot{\bar{C}}_{30}$ would significantly affect the polar ice-sheet mass change estimates for Antarctica and Greenland.

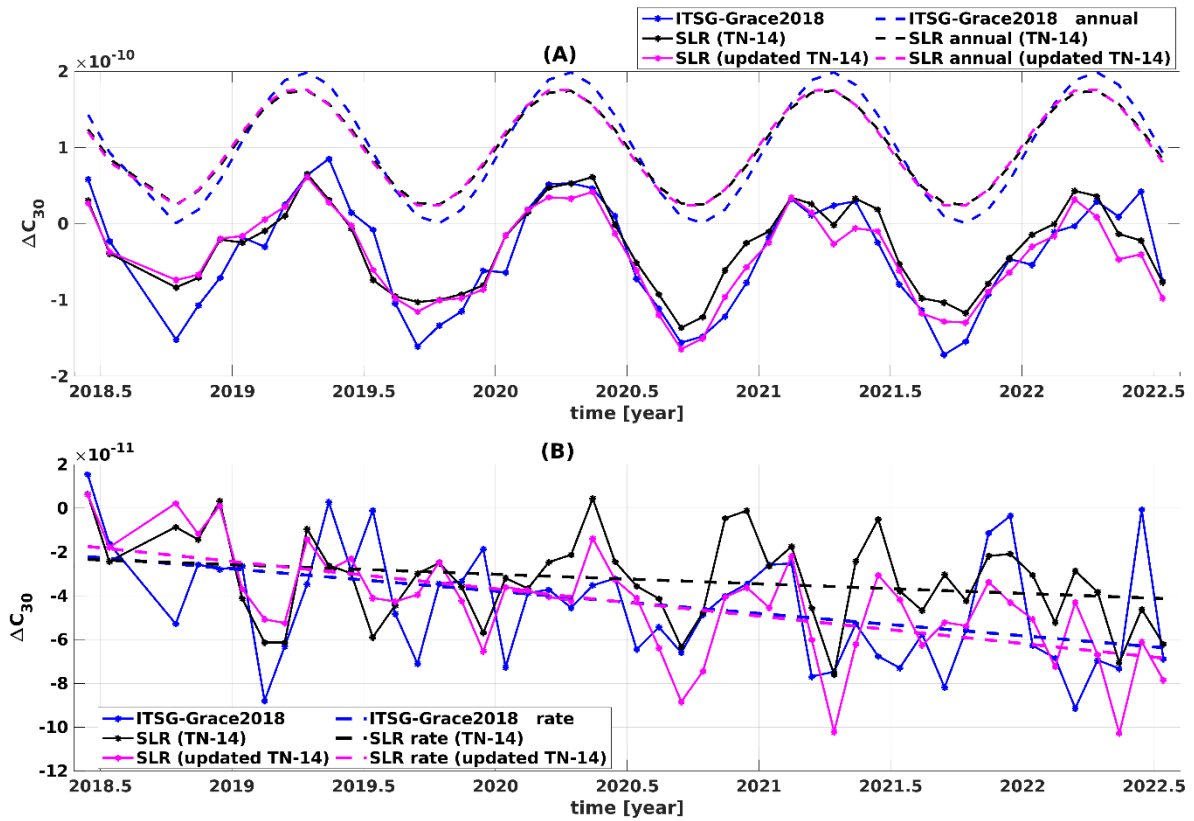


Figure S2. (A) Comparison between $\bar{C}_{30}$ timeseries from GRACE-FO ITSG-Grace2018 solutions (solid blue line) and SLR as provided in version 2 of the TN-14 (solid black line). SLR $\bar{C}_{30}$ timeseries based on a new test release of version 3 of the TN-14 (solid black line) is also provided. Dashed lines represent the annual cycle of $\bar{C}_{30}$ timeseries. (B) Deseasonalized timeseries of $\bar{C}_{30}$ values from GRACE-FO ITSG-Grace-2018 solutions (solid blue line) and SLR as provided in the currently used version 2 of the TN-14 (solid black line) as well as an updated SLR solution (solid magenta line). Dashed lines represent the linear trend of $\bar{C}_{30}$ timeseries. The $\bar{C}_{30}$ timeseries from updated SLR processing better fits the ITSG-Grace2018 $\bar{C}_{30}$ in terms of linear trend.

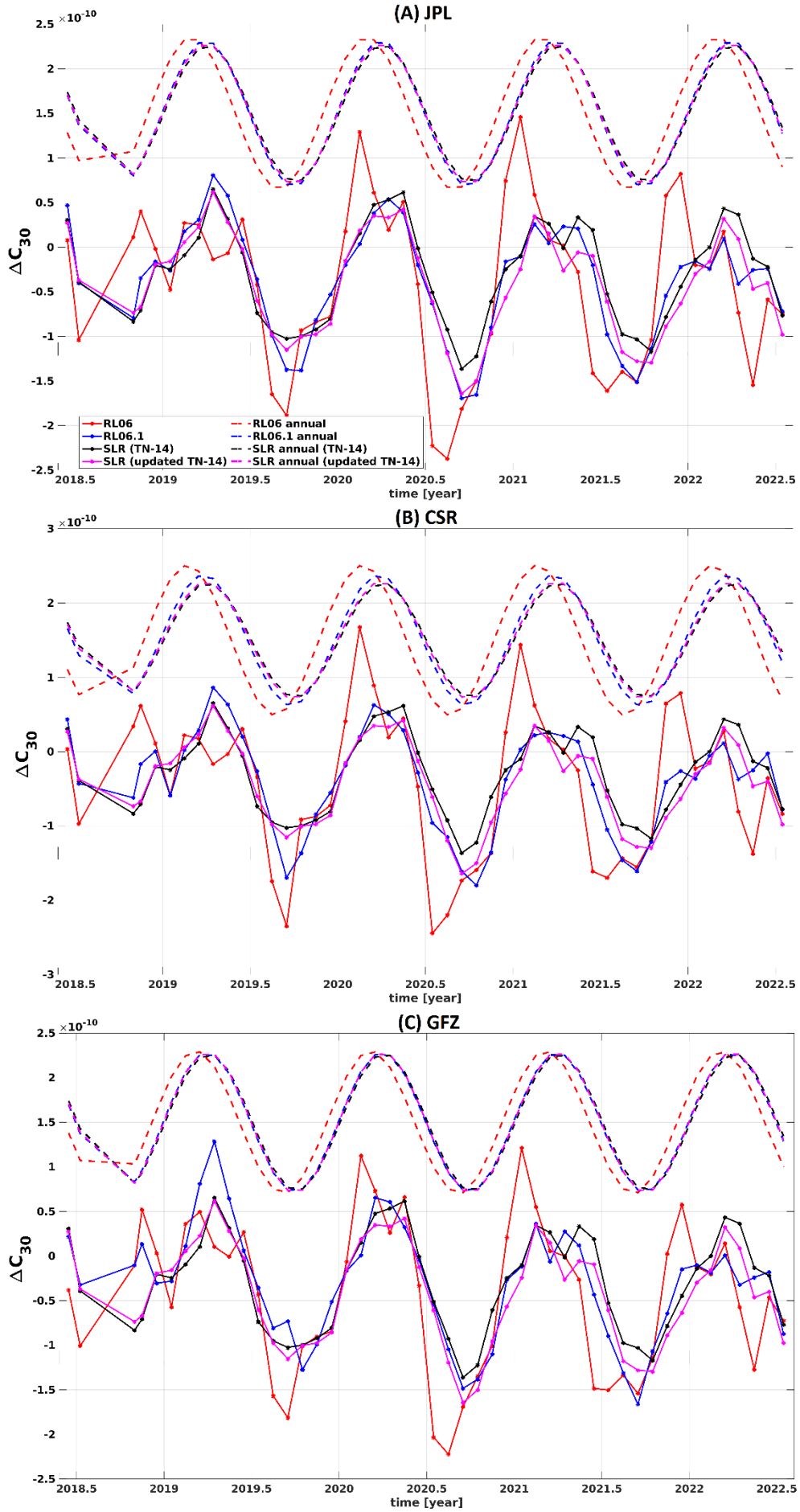


Figure S3. Impact of ACH on $\bar{C}_{30}$. Comparison of geopotential spherical harmonic coefficient $\bar{C}_{30}$ from GRACE-FO (A) JPL, (B) CSR and (C) GFZ RL06 (solid red line) and RL06.1 (solid blue line) and SLR (solid black line) as provided in version 2 of the TN-14. GRACE-FO β' angle (yellow) is also shown. SLR $\bar{C}_{30}$ timeseries from a new test release of version 3 of the TN-14 (solid magenta line) is also shown. Annual cycle of $\bar{C}_{30}$ timeseries is also shown (dashed lines).

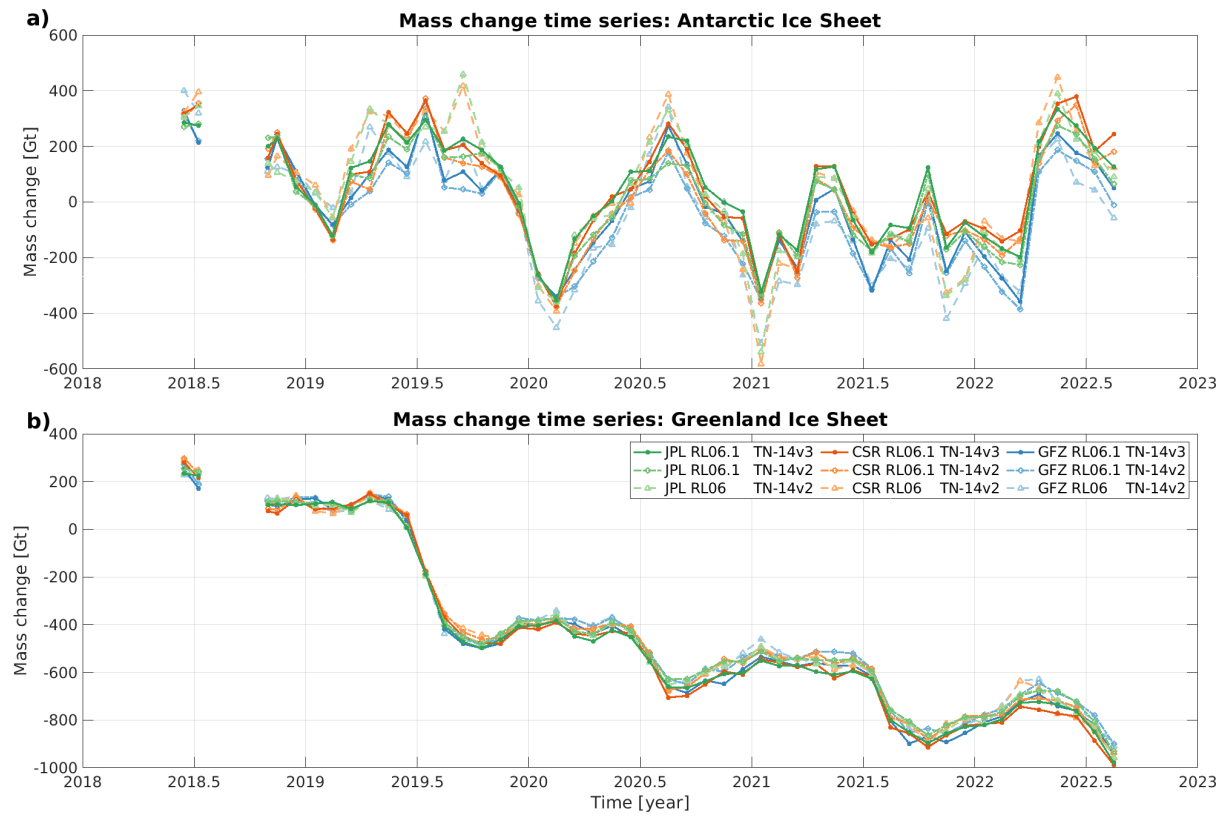


Figure S4. Time series of mass changes of (a) the Antarctic Ice-Sheet and (b) the Greenland Ice-Sheet derived from different versions of SDS L2 products.

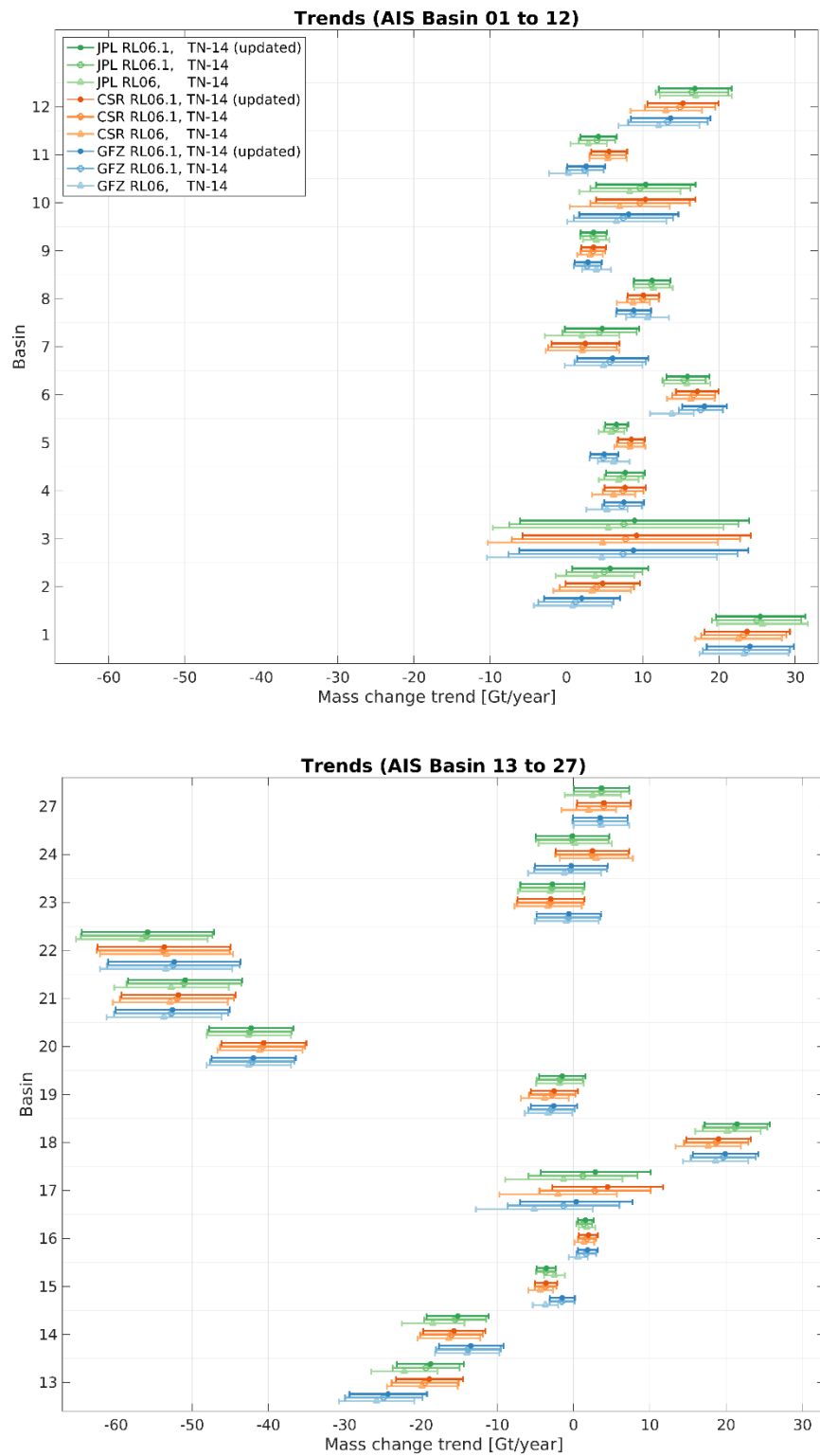


Figure S5. Mass change trend estimates for individual ice drainage basins of the Antarctic Ice-Sheet (based on Zwally et al. (2012)) derived from different versions of SDS L2 products.

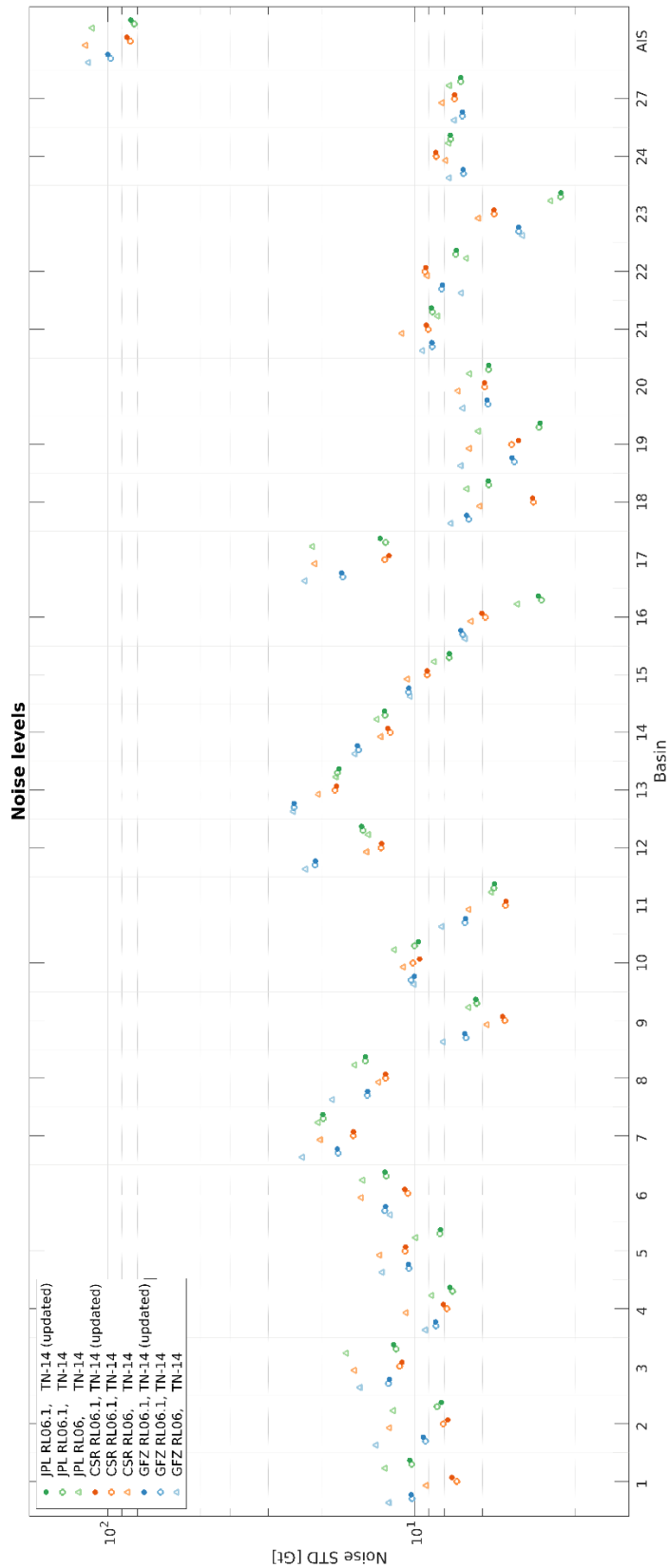
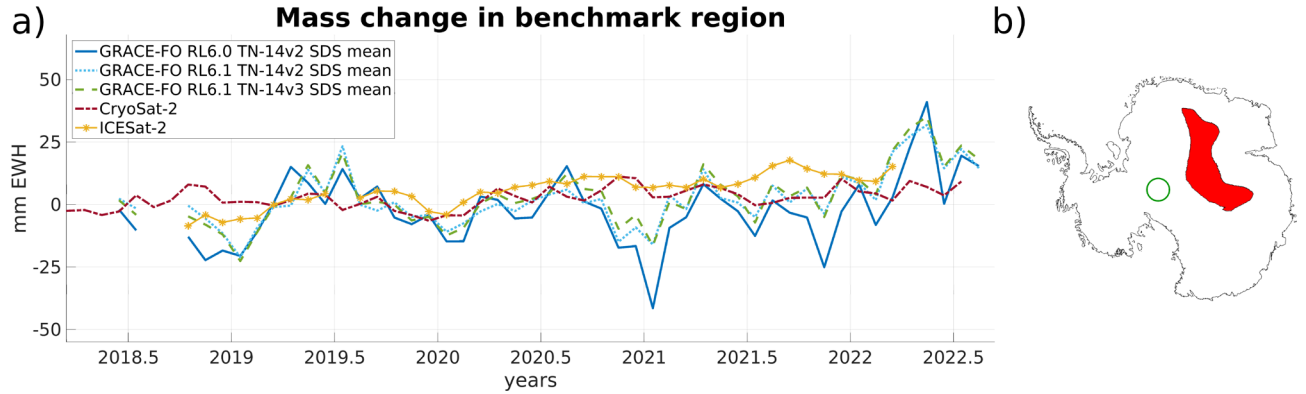


Figure S6. Noise level estimates of mass change timeseries for individual ice drainage basins of the Antarctic Ice-Sheet (based on Zwally et al. (2012)) derived from different versions of SDS L2 products.

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191 **Figure S7. (a)** Timeseries of investigated GRACE and altimetry products in the benchmark
192 region. The mean values from the SDS solutions (JPL, CSR and GFZ) are plotted to improve
193 the visibility. **(b)** Indicated is the grounding line of the Antarctic Ice-Sheet. The benchmark
194 region within the East Antarctic Ice-Sheet is highlighted with red color. The green circle
195 marks the polar gap of the CryoSat-2 and ICESat-2 missions due to their orbits with an
196 inclination of 92° .

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