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Interactive comment on "Estimate of Greenland and Antarctic ice-sheet total discharge from multiple GRACE solutions" *by* Ida Russo et al.

Anonymous Referee #2

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The manuscript of Russo et al aims to estimate the total discharge of the ice sheets into the ocean. Although I appreciate the effort that has gone into their study, I'm afraid that the manuscript is not mature enough to be considered for publication in The Cryosphere.

First of all, the main goal of the paper doesn't appear to be very novel. Earlier studies (van den Broeke, 2009; Sasgen, 2011; IMBIE 2018) have shown that that the input-output method (that is, the combination of discharge estimates with SMB from models) agrees well with the GRACE observations of mass change of the ice sheets. What the authors present here, is very similar, except that they add (modelled) runoff to the (ice flux) discharge. Their rationale is that this represents the total freshwater influx to the ocean to the ice sheets. Such an approach has been used before in Bamber

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et al., GRL, 2012 and Bamber et al., JGR, 2018, for example, using InSAR-derived ice flux estimates with modelled runoff data. For Antarctica, the largest contributor to freshwater fluxes is basal melt and calving of ice shelves (Rignot, 2013; Depoorter, 2013), which is completely neglected by the authors.

Except for the lack of novelty, I have other major concerns:

- Outdated data is used: * GRACE data from CSR, JPL and GFZ is based on the RL05 releases. The new, improved RL06 data has now been available for almost a year, so why not use these? * It's unclear which RACMO data is used, but based on the time span and resolution, it is unlikely that the latest model run is used (van Wessem, 2018). * Why use ERA-Interim now that ERA5 is available? The latter appears to do a much better job in modelling the fluxes, especially in Antarctica.

- Only the period up to 2010 is considered. Unclear why, GRACE data is available up to mid-2016

- Lack of methodological details which makes the results irreproducible: no details are provided on how the GRACE data was processed, the only thing mentioned is that 'several pre-processsing methods have been used to low-pass filter the high-frequency noise contained in the GRACE solutions' and that 'an independent component analysis' was used (p9-10). The same goes for the ice flux estimates ('obtained by combining maps of surface velocities along the ice-sheet coasts from InSAR amd ice thickness from a DEM). Did you derive these yourself, or is the data taken directly from Rignot, 2011? And how did you derive the total mass change from the GRACE data? Simply by summing over the region outlines? This doesn't take into account the low spatial resolution of GRACE, which causes signal leakage into the ocean, and between neighboring regions. More advanced approaches are needed for this, see e.g. Wouters, 2008 ; Sasgen, 2011; etc.

- The largest source of uncertainty is neglected. Glacial isostatic adjustment is poorly know for Antarctica, but even for Greenland there are uncertainties about the regional

magnitude/distribution of the signal (Khan et al., 2016). The authors only consider only one model, which is rather outdated.

- Following up on the previous comment, there is no discussion about the uncertainties at all, which makes the comparison of the different GRACE solutions and derived discharge meaningless. The results for Antarctica (fig. 8) show a 4-fold increase in total discharge (January vs June). Since runoff is negligible in Antarctica, this means that the signal is due to ice flux, i.e. a 4-fold increase in the flow velocities in (Antarctic) winter, which has never been observed so far. This would be a truly novel finding, but it is more likely that this is an artifact due to errors in the GRACE/model data.

- Overall there is rather poor agreement between GRACE-based estimates and InSAR estimates in figure 7. Apart from being more or less in the same ball park, there doesn't seem to be any correlation in the interannual signal (on a side note, you use the term 'interannual' a few times when referring to the monthly climatology, this should be changed to 'seasonal')

- Language should be improved, the same goes for the structure of the document (for example, at the end of the conclusions, there's a discussion about the importance of freshwater fluxes for ocean modelling, this should go into the introduction.

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