

## ***Interactive comment on “Seasonal mass variations show timing and magnitude of meltwater storage in the Greenland ice sheet” by Jiangjun Ran et al.***

### **Anonymous Referee #2**

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#### GENERAL COMMENTS

Although GRACE has been used extensively to monitor Greenland ice mass loss in the literature, the authors have carved out a nice little niche with this manuscript. They try to quantify summer meltwater retention in the ice sheet in terms of magnitude and timing. Overall this is a welcome addition to the ever widening list of cryospheric/oceanographic/hydrological processes and phenomena that can be revealed by combining GRACE results with appropriate models. It is understood that these are initial results that should be corroborated by further research. The authors allude to that more or less, when saying in section 3.2.1 that "these features should

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be explained either by melt water retention or by errors in SMB- and GRACE-based estimates." Indeed, the "features" would easily fit inside the error bars. However, the following robustness/sensitivity analyses make it clear that the patterns are persisting. So, I would welcome to see this work published after certain revision, nevertheless.

#### SPECIFIC ISSUES

The abstract mentions three achievements: (1) obtaining mass loss estimates using their own methodology that are consistent with published mass estimates; (2) examining mass loss accelerations; and (3) quantifying meltwater storage. I find the first two points hardly relevant in view of the third point. Obtaining estimates that are consistent with what is known in the literature may be a good validation exercise to the authors, but hardly relevant for the reader. I am particularly suspicious of acceleration estimates given the relatively short time span of GRACE. Numerically one will always get some value and LS estimation and testing theory will tell you that this value is "significant". If, after successful GRACE-FO launch and operation, we look at this part of the time series, say 20 years from now, we'd probably see a long-term signal that is decidedly different from parabolic behavior. Moreover, there is hardly any serious discussion of the acceleration in section 3.1.

I thus strongly recommend to remove or at least tone down the estimation aspects and the acceleration estimation. This recommendation includes the removal (from text and graphics) of anything to do with the non-weighted solutions. The difference between weighted and non-weighted solutions is a technical geodetic detail that might be reported elsewhere, but constitutes distraction here. I do believe that leaving all these aspects out will strengthen the main line of the manuscript.

I also recommend the authors to reconsider the use of the phrase "(surface) mass balance". To me it is a misnomer. Equations (1) or (2) are mass balances: a bookkeeping of inputs and outputs, sinks and sources, left sides and right sides. Individual terms should not be called "mass balance". I know that this terminology is by now ingrained

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in cryospheric and GRACE communities, but I consider it wrong nevertheless. At a recent international conference I heard a presentation on "extreme mass balance". The author simply meant rapid ice mass loss.

At the same time, I have the feeling that the authors aren't clear about the mass balance equations themselves. Eqn (2) is a balance of fluxes, so SMB is a flux quantity too, say in units of Gt/yr. How about eqn (1)? If SMB and ID are flux quantities, then MB and  $\Delta m$  should be, too. But  $\Delta m$  is explained as a mass variation, i.e. time-variable mass (units of Gt), which is not a flux but a state quantity. And how about MB? And "melt water production" (fig. 9) sounds like a flux to me, although it is indicated in Gt units.

#### TECHNICAL DETAILS

- In the abstract mass losses are reported in terms of negative numbers. A negative mass loss is a mass increase.
- A hyphen is not a minus sign. Please write a minus sign, wherever it should be a minus sign, including in the legends and captions of graphs and in headers, etc.
- The acronym DS is not very helpful. Write out in full everywhere.
- Red pentagrams are not very visible in figure 1. Figure 1 can certainly be improved. Explain the blue patches outside Greenland briefly in the caption.
- Page 6, line 25: Least-squareS adjustment. (If it were singular, there is nothing to adjust).
- Be consistent in your mathematical typesetting. Take, e.g., the symbol "f" for flux gate in eqn (3) and in the line above. In the equation there are two different letters "f" and in the line above, the "f" should be set in math italic. Similarly, in line 24 (page 6), the  $v$  should be bold-math-italic. And check the N and i in the last line of page 6.
- Several graphs show mass variation with the unit (EWH: m). That is inappropriate.

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The quantity is (expressed in) EWH and its unit is m.

- Page 26, Line 5: The sentence "No regularization is applied..." is preceded by an explanation of truncated eigenvalue decomposition. Now that is definitely regularization.

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-41>, 2018.

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