

## ***Interactive comment on “Response of Antarctic Ice Sheet Mass Balance to Climate Change” by Jingang Zhan et al.***

### **Anonymous Referee #2**

Received and published: 5 December 2018

General Comments: This paper uses complex principal component analysis and wavelet amplitude-period spectrum analysis to examine the main drivers of Antarctic mass change. While the study of the effect of quasi-periodic climate patterns such as the El Niño on Antarctica are important, it is misleading to mostly attribute Antarctic mass balance to such events. Furthermore, the GRACE analysis in the paper suffers from some inadequacies. These issues are explained below. Overall, the paper in its current state is not suitable for publication as it provides misleading conclusions. Significant major revisions are required before potential further review.

The paper assumes that Antarctic changes are caused by low-frequency quasi-periodic climate phenomena and atmospheric circulation patterns, and attempts to divide the attribution of ice sheet mass balance change to such events. However, no evidence is

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provided for this assumption and yet this is a major underlying assumption of the study. This is misleading, as these events play a much smaller role in the mass balance of the AIS compared to non-cyclic long term patterns such as enhanced ice-ocean interaction and ice discharge, intrusion of warm saline water on retrograde slopes, etc. The assumption of this paper can lead to misleading conclusions as the oscillatory climate events play a much smaller role in the recent mass balance. Yet the authors attribute the components of the CPCA to climate change as far as its effects on periodic climate phenomena such as the El Nino. For example the authors claim “This result shows that changes in the low-frequency signal of the sea surface temperature anomaly in the Niño1+2 region of the equatorial Pacific Ocean may be the main reason affecting the mass change of the ice sheet in Antarctica.” Again it is misleading to attribute cyclic SST anomalies from El Nino to the main driver of AIS mass balance change. Also one has to be careful about correlations. The authors admit that the mechanisms of this proposed relationship have to be explored further in future studies, but one has to be careful with correlations between 5+ year low-frequency SST changes associated with the El Nino and Antarctic mass balance. The conclusion that air temperature is the second dominant effect on the mass of AIS is also based on the correlation between the components of quasi-periodic atmospheric circulation patterns and AIS mass balance, and the same issues and assumptions arise here. The claims of the paper should not be generalized outside of the scope of the study.

As noted in the paper, the 1x1 grid does not represent the true GRACE resolution. Given that the mass change is obtained by simply fitting the time-series for each grid on a smoothed field, it must be noted that the grids are spatially correlated and the trends of nearby basins (particularly small basins) cannot be considered separately from each other. Furthermore, there is amplitude loss in spatial smoothing so the smoothed spatial field is not the optimal way of getting regional estimates. The authors should use a synthetic field to justify their results (compare true vs. retrieved signal) or alternatively use a mascon solution, which is linked in the paper but never used. The overall loss trend of 248.6 Gt/yr seems really high with respect to other estimates.

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The only agreement was with a selected altimetry estimate. The authors claim the discrepancies with previous studies such as Velicogna and Wahr (2006) are partly due to previous releases of GRACE data and signal attenuation due to smoothing. However, more recent results are also in disagreement (such as Velicogna et al 2014), which use newer releases and a mascon approach. Furthermore, scaling factors were calculated for previous studies using synthetic fields to account for signal attenuation. And such approaches such as the spherical cap approach are in close agreement with other mascon solutions such as the JPL or CSR mascons. The authors should also consider the official mascon solutions of the processing centers as a point of comparison. While previous studies that are claimed here to be suffering from signal attenuation due to smoothing looked at scaling and gain factors, this study does not make an attempt on quantifying any attenuation with a synthetic field.

Analysis is up to September 2015. Is there a reason for this? Even with the presence of accelerometer issues near the end of the mission, at least another year can be added.

Specific Comments: Line 62: “The mass change of the ice sheet in Antarctica is the result of interactions between the atmospheric vapor and the surface water resources;” this is a misleading statement. While ultimately the mass balance is the result of surface mass balance (including precipitation) and discharge, this is the interaction of many factors such as ice-ocean interaction, bathymetry, etc. Needs to be clarified. Line 72: Mission ended after 15 years. Equation 1: If solving for surface density on the left hand side, the coefficient should not be divided by the density of water. Refer to equation (14) of Wahr et al (1998). The coefficient also needs to be in surface density units. Lines 121-125: this assumes all changes in Antarctica are caused by periodic climate events (such as El Nino etc.). This is not necessarily true and is unjustified. There could well be significant long-term non-periodic changes that are the main drivers of change.

Technical Comments: Line 64: sentence is not very clear. And careful with tense. Maybe “the mass change record contains global and local climate change information

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across time”.

Line 115: delete “the” in front of phase information.

Lines 147,150: change to “basins B19 to B27”, and the corresponding numbers in line 150.

Line 237: “in analyzing the influence of...” makes the sentence longwinded and hard to follow. I think that segment can be removed.

Line 238: “had a certain impact” is very vague. You need to be more clear as to their conclusion.

Line 272: Delete “the” before West Antarctica.

Line 345: “i.e.” is not appropriate here as the acceleration does not follow from the trend magnitude, it is a separate fact (and it would be helpful to also report the acceleration value if this is the case).

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-191>, 2018.

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