Authors' comment to RC2

We thank the anonymous reviewer for the very positive evaluation of our manuscript and the very helpful comments which improve the manuscript. Please find below how we revised the manuscript in detail in response to the reviewer's comments. Italic font indicate the referee comments. Green text indicates the authors' responses; in blue we have added text fragments indicating changes in the manuscript. Along with the revised manuscript, we have submitted a complete marked-up version, which highlights all changes made in the revised manuscript.

1. Throughout: where the text mentions "GIA result" or "estimated present-day GIA" e.g. p18,L15, it would be better to clarify which part of GIA you're talking about. GIA uplift, or GIA-related mass changes etc. There are several places where this clarification would be beneficial.

We agree and changed throughout at most places. We think that bedrock motion, i.e. uplift, will be most interesting for GIA modelling. In places where the statement applies to both the geometric effect and the gravity effect, we have left GIA result as an umbrella term.

2. Pg1L12: "GIA result" – do you mean bedrock uplift?

We reformulate this to:

GIA-related bedrock motion

3. Pg2L5: is Groh et al. (2012) the right reference here?

To our knowledge, this is the first peer-reviewed reference reporting the high uplift rates measured with GNSS in the ASE. For example, Thomas et al. (2011) did an Antarctic wide comparison of GNSS data with GIA models but had still not included any data in the ASE.

4. Pg2L16: "Global GIA models" change to "Global 1D GIA models"

Done.

5. Figure 1c: It would be useful to be able to see on this map which GNSS are continuous, and which are campaign. I suggest using a different symbol for each.

We updated the figure. Sites which are campaign sites only are indicated now with an asterisk beside the name. Unfortunately the symbols overlap. We added the following to the caption of Fig. 1

The asterisk '*' indicates sites that have been observed episodically only.

6. Pg7L8: "GIA effects" what specific effects – GIA related mass change? Uplift?

We aim to quantify both and reformulate this as follows:

In order to quantify ~~GIA effects~~ GIA-related bedrock motion and GIA-related gravity changes in the ASE,

7. Pg9L9: "based on findings from GIA modelling" What GIA modelling? This could do with some further explanation as Figure S2 also does not clarify. Also, previous line – "GIA at each location" do you mean the 20x20km grid, or what locations?

We agree that this was not a sufficient explanation. Please also refer to our comment to the other referee. We now clarified this as follows:

We use a spatial mask given the GIA density at each location in Antarctica ~~according to~~ similar as the one utilized by Riva et al. (2009)~~, which is based on findings from GIA modelling~~. They assessed this ratio between GIA-induced gravity changes and GIA-induced geometry changes from GIA forward model outputs following findings from Wahr et al. (2000) and refined it to account for self-gravitation of sea level. Following Riva et al. (2009), we generate the mask by assuming $\rho^{\mathrm{GIA}}_{\mathrm{CONTINENT}} = 4000\frac{\mathrm{kg}}{m^3}$ over the continent and $\rho^{\mathrm{GIA}}_{\mathrm{OCEAN}} = 3400\frac{\mathrm{kg}}{m^3}$ over the ocean. We assume a smooth transition between continent and ocean by using a 100 km Gaussian smoother (Fig. S2). Note that we do not run GIA forward models to tune these densities nor the length of transition between continent and ocean. Riva et al. (2009) found that a 300 kg m^{-3} increase of the GIA density leads to an 2.5 % increase of the GIA solution.

8. Pg15L28: how low is the upper mantle viscosity used in that study?

We added 4·10^{18} Pa s.

9. Pg15L29 – correct reference format

Done.

10. Pg16L2: "GIA rates" > "GIA uplift rates"

Done.

11. Pg16L6: remove "but" or "however"

We removed "however".

12. Pg18L7-10: not sure I understand– "no dominant magnitudes" – also I would expect to see viscous effects on a 10-year time scale in the ASE due to low viscosity.

We agree that this was misleading and was also criticized by the other referee. Powell et al. (2020) investigated viscous effects in solid-Earth deformation towards present-day ice mass changes and how they would be reflected in GNSS results in the ASE. Among other things, they compared vertical bedrock motion due to visco-elastic deformation under the assumption of a 3D rheology model with the simplification that bedrock motion due to recent ice mass changes induces elastic deformation only. Figure 6 in Powell et al. (2020) shows that from about 15 to 20 years of observation time with GNSS, the error is already several millimetres if the deformation due to recent ice mass changes is assumed to be only elastic. We have now clarified this, also in response to RC1, as follows:

Based on findings from Powell et al. (2020), ~~no dominant magnitudes of viscous effects in the solid earth response are expected with~~ we do not expect that significant rate changes related to viscous deformation caused by recent IMC are detectable over an investigation period of only 10 years~~and the assumption of a Maxwell rheology of the mantle. Significant~~. When assuming a low upper-mantle viscosity, significant viscous effects should be measurable from ≈20 years onwards.

References

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