Summary and comments on the manuscript entitled

A high-resolution synthetic bed elevation of the Antarctic continent

presented on 04.07.2016
by

F. S. Graham et al.

Summary & Review

The authors present a statistical approach to create a synthetic map of the basal topography beneath the Antarctic ice sheet. The map is a superposition of a low-pass filtered Bedmap2 topography and a high-pass filtered synthetic roughness terrain (RT). The unfiltered RT is a random sample created such that the terrain roughness value and the covariance structure are preserved from the input thickness measurements. The used radar measurements are a compilation from Bedmap1 input data and the ICECAP campaigns. The approach is most valuable in areas where we have no information on bedrock topography, because statistical characteristics are preserved in the synthetic bed topography. In their abstract and the introduction, the authors state that the 'bed elevation is one of the most important controls in modelling ice-sheet dynamics'. Therefore, a 'detailed knowledge of the topography, [...], is required'. I could not agree more. This implies that a valuable bed topography map should reflect the measurements because there thicknesses are know. Yet, the big disadvantage of this map is that it fails to reproduce (within certain bounds) ice thicknesses where measurements were in fact available and used to infer the roughness and the covariance. This is important as the basal topography is a dominant source for modelling uncertainties, certainly on Antarctica. For me, this issue raises the question of what purpose the presented synthetic map can have to the modelling community because observed features are not present in this map. The authors argue that the map is useful for model sensitivity studies especially with respect to model resolution. In light of this limitation, the abstract seems to insinuate much more: '[...], the simulated bed elevation terrain has applicability in high-resolution ice-sheet modelling studies, including investigations of the interaction between topography, ice-sheet dynamics, and hydrology, where processes are highly sensitive to bed elevations.' My conclusion is therefore that I have to suggest that the manuscript should at least undergo a major revision.

The manuscript is well written and to the point.

Main comments

Unconditioned simulation

I appreciate that you mention that the map 'does not necessarily honour the exact values of the original data' and is 'not intended as a substitute for Bedmap2'. The fact that observations are not reproduced is deliberate, as you chose a non-conditional approach that will produce random thickness differences to the observations (dependent on the stochastic realisation). I wonder now if it is feasible for you to follow a conditional approach where you can constrain the bedrock elevation values to the observational input (optionally accounting for the uncertainties in the thickness measurements). Could this be solved by not using a uniform random matrix with zero mean to create the CDRT but an appropriate choice of this matrix? I fear that this might be a highly under-determined problem. An alternative could be that you drag back your synthetic terrain to the observations during the roughness scaling. I could think of some Gaussian function around the observations which force back the values to the observations. The downside is that neither the covariance structure nor the roughness will exactly be preserved from the original data. From a modelling perspective however, a conditioned map would be more valuable and could even be perceived as a regional alternative to Bedmap2. If this should not be feasible, you have to adjust the manuscript so that it becomes much clearer that the map does not necessarily reproduces the observations and that its advantages are in areas where no observations are available. In these areas, I wonder how this synthetic map would compare to other thickness reconstruction approaches (for instance the thickness reconstruction for the Peninsula from Huss et al. , 2014, doi:10.5194/tc-8-1261-2014).

Base-map and coverage

Another disadvantage is that the authors decided for Bedmap2 as the low-frequency base-map. This choice is certainly good in areas where no observations were available. In areas with observations, this implies that the synthetic map often shows a large mismatch to the observation used for inferring statistical measures. The reason why the authors relied on the Bedmap2 base-map is in my view twofold. First, they decided to present a high-resolution map for the whole of Antarctica. Second, the coverage of the available/used observations is sparse or even zero over large areas of the continent. As I said above, you have high discrepancies between the observations and Bedmap2, which are not accounted for in your approach. I wonder if it was not more consistent to adjust the base-map relying on your observations (your base-map shows anyhow a 10 times smaller grid spacing). This could be a simple interpolation between measurements and neighbouring Bedmap2 points. This guarantees that your final product shows a better match to the measurements. Your data coverage seems sufficient to do this in certain regions. If you decided for a more regions product, you have to clearly state differences of your approach to Goff et al., (2014). If you want to apply your approach to the entire continent, you might need more measurements. No matter which way you go, it

seems essential to me that your approach better reproduces the observations where they are available.

Specific comments

Figure 1 The abbreviation CDRT is not defined when you first refer to Figure 1 (P2L31). What are the numbers? In my printed version the drainage basin lines vanished. A shading could help.

Figure 2 Could you add Bedmap2 in all panels as a reference. That would help to assess the improvements or differences.

Figure 4 It is very difficult to assess this figure as the reference statistics of Bedmap2 are not given. It might be worth adding an accompanying figure with the same statistics for Bedmap2. The distributions might simply be dominated by Bedmap2 and difference would not be prominent. Then you might want to compare the distributions when you subtract the low-pass filtered Bedmap2 topography from both the original Bedmap2 and the synthetic HRES map.