Review of Roe, Christian and Marzeion 2020

General comments

This is an important topic of very high relevance to the journal and science community. The paper is clear and well written. The central message is clear but the way it is presented is, in my view, misleading and unhelpful as explained below and this is my only major issue with the paper.

The issue relates to the definition of the proportion (fraction) of mass **change** (not loss) that is due to anthropogenic climate change (ACC) versus natural which will I've called internal variability (IV). It is unhelpful to define the fractional change in the way the authors have done. As they point out this leads to infinite fractional values for ACC. If the authors plotted the IV fraction this could also have an infinite value when FULL passes through zero, clearly nonsensical and unhelpful in providing clarity in the central message of the paper. When FULL = 0, it means that IV=ACC but with opposite signs. It would seem reasonable to define that as IV and ACC having an equal, fractional contribution to the instantaneous mass balance (mb), but the definition used does not do this and leads, therefore, in the subsequent plots of cumulative mb attribution to misleading values. I do not dispute the fundamental message that almost all of the industrial era mass loss from glaciers is due to ACC (see final comment in this section) but the way this has been defined and presented, does not help.

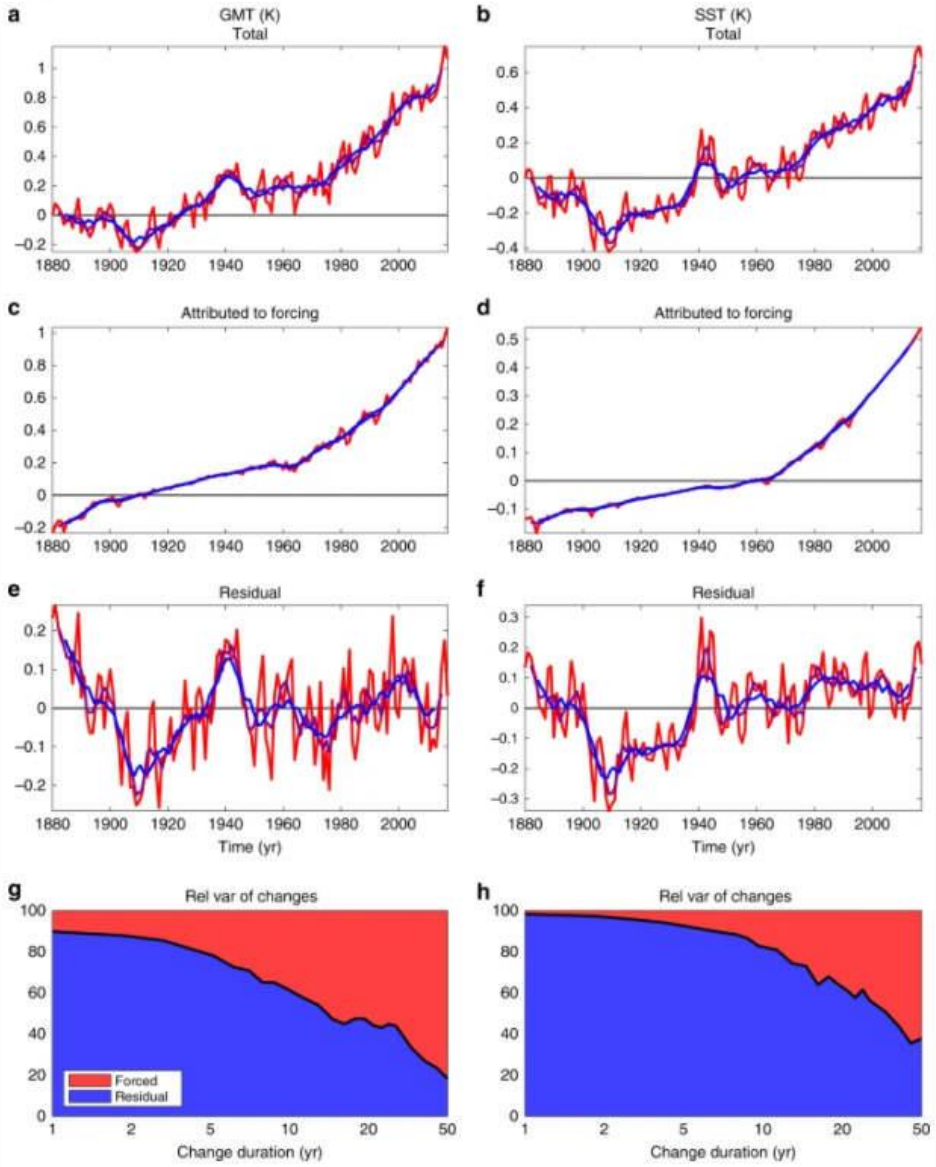
Attribution of temperature change is relatively challenging and there have been several different approaches used, which result in somewhat different contributions from ACC and IV to temperature anomalies since 1880. This matters, because the proportional contribution from ACC and IV will directly impact the proportion assigned to glacier mass balance. Below is one example of attribution from (Sévellec and Drijfhout 2018). The linear ACC trend from 1880-1920 is about half the IV trend for the same period. Using a different definition for fractional contribution to mb would result in ~66% of the cumulative instantaneous anomaly being due to IV and ~33% to ACC (approximately). Let's assume that from 1920-2005, the contribution from ACC is 100% and IV 0% (i.e. the sum is 1), which is roughly supported by the figure below. Over the full time period this gives a 22% contribution from IV and 78% from ACC. This is assuming an unrealistic instantaneous response and is given simply to illustrate that the way the authors have chosen to define the fractional attribution is, in my view, unhelpful.

Fig 8c suggests that the cumulative mb anomaly from 1850-1920 is ~ zero, for the case where τ=10 yrs, while the ACC % is 125% for the full period from 1850-2005, which is, again, counter intuitive. It also doesn't seem to square with the integral of Fig 8e if the extreme values are ignored. In this case, the ACC % only exceeds (in a meaningful way) 100% from ~1960 onward. I do not understand, therefore, how a value of 125% is achieved, or in what way It is a meaningful way of representing the ACC contribution to mass change for this example. Likewise for the integral of 8h. For these shorter time constant glaciers, the ACC % only approaches 100% in the second half of the 20th C. This is not so far from the inference made in M14, at least for the short τ glaciers.

For the longer time constant glaciers, presumably there is a +ve mb memory locked in that compensates for the >100% ACC percentage but this somehow contradicts the authors' own claims in the abstract: "the anthropogenic component of the mass loss is essentially 100%." In the case of large τ, the authors are stating it is 200%. If the authors stand by the values in Fig 8 then the ACC contribution for all glaciers is significantly >100% but nowhere is that stated or claimed for reasons that I believe the authors know themselves.

In many respects, I found Fig 9 a more informative and clear demonstration of the role of ACC in post industrial glacier mb trends alongside the sentence starting at line 385.

Fig. 1



Attribution of observed global-mean surface air temperature (GMT) and sea surface temperature (SST). **a**, **b** The total (red) annual, (purple) 5-year and (blue) 10-year variations in GMT and SST measured from 1880 are decomposed (through an attribution method based on multivariate linear regression onto volcanic eruptions, aerosol concentration, and greenhouse gas concentration[2]) into **c**, **d** a forced contribution and **e**, **f** a residual. **g**, **h** Relative variance of forced and residual GMT and SST changes as a function of the duration of these changes. Variations are mainly controlled by the residual, rather than forcing on interannual to decadal timescales. The observed GMT are from NASA GISS temperature data, and SST is from the NOAA ERSSTv5 record

Technical comments

In the synthetic temperature figures (e.g. Fig 1) it wold be helpful to include a vertical dashed line in the length and mb columns indicating the start of the perturbation in temperature.

Eqn 1. Replace = with ≈.

L299-300. This statement is misleading. The synthetic temperature experiments are useful to illustrate a point but they are **not** representative of the true temperature anomalies over the last 150 years and, in particular, the gradient of the ACC temperature trend over that time period. See Figs 1a and c above. There is a change in gradient from ~1960 onward. Something that is sort of apparent in Fig 9a and sort of implicitly captured in Figs 8e and h but not discussed at all.

L333 “The models” => The model.

L373 Fig 7e to I => Fig 9 e to i

L418 See previous comment. The definition used means it is > 100%, and for long τ glaciers closer to 200%.

There is a further inconsistency in the way this study has undertaken the difficult attribution part of the problem. As far as I can tell, the decline in length and mb in Fig 6 begins in ~1820, which is consistent with some temperature reconstructions for the last 2 millennia, which have an increase starting ~1800 of ~0.2 degs. That pre-dates any ACC contribution unlike the expt shown in Fig 5 and is not apparent in any other plots because they all start in 1850.

References

Sévellec, F. and S. S. Drijfhout (2018). "A novel probabilistic forecast system predicting anomalously warm 2018-2022 reinforcing the long-term global warming trend." Nature Communications **9**(1): 3024.