The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-265-RC1, 2020
© Author(s) 2020. This work is distributed under
the Creative Commons Attribution 4.0 License.

The Cryosphere Discussions

Interactive comment on "On the attribution of industrial-era glacier mass loss to anthropogenic climate change" *by* Gerard H. Roe et al.

Lauren Vargo (Referee)

lauren.vargo@vuw.ac.nz

Received and published: 2 December 2020

This manuscript investigates the influence of anthropogenic forcing on glacier mass loss over the industrial era. The authors use a 3-stage model to simulate glacier length and mass balance changes for glaciers with different response times. I'm less familiar with this model compared with other glacier models, but it was well-described and the original paper was cited to better understand the model. The authors use different climate inputs: synthetic temperature, proxy temperature, and model temperature and precipitation. These climate inputs cover the last millennium to ensure that glaciers, even those with response times of 400 years, have reached climatic equilibrium over the industrial period for which anthropogenic forcing is calculated. Running these longer simulations is where this paper builds on previous attribution studies, par-

ticularly Marzeion et al., 2014.

This paper is well-written, the structure makes it easy to read, the figures are clear and add to the manuscript, and the paper provides insight into an important topic: investigating the influence of anthropogenic forcing on glacier mass loss, in a way that includes inherited conditions.

The main question/concern I have is if the anthropogenic contributions are calculated in an appropriate way. I understand, mathematically, why presented anthropogenic forcing values can exceed 100% (if a glacier losing mass in full forcing scenario would have gained mass in natural forcing). But, if you're looking to calculate the anthropogenic contribution to glacier mass loss, should you do so in a way that calculates that contribution to be between 0 and 100%? As negative values and values over 100% don't realistically make sense. I think calculating the influence of anthropogenic forcing in another way so that values are between 0 and 100% would make the paper and results clearer and less confusing, giving it a higher impact. I wonder if there is a better way to do this using cumulative mass change from $\sim$1880 through the end of the simulation. It also seems important that a small change in temperature between that shown in Figures 2 & 3 to Figures 4 & 5 do impact the contribution of anthropogenic forcing percentages by 1/3 to almost 1/2 for different response times.

Specific comments (intermediate):

L49-50: This line makes it feel like this is an important part of this paper- assessing all glaciers for the contribution to sea level rise. Should this go in the title, or at least abstract? But then I was waiting for the results to be tied in with sea level rise later on, but it wasn't discussed.

Overall, I wonder if it's important to emphasize that these are idealized scenarios: all glaciers globally are represented by just five different response times, and using a model that doesn't include

L308-316: Are the solar irradiance and orbital changes ensembles not analyzed at all? If you only use one and volcanic-forcing has the biggest impact, using that one makes sense. But why not include all (besides too much data/run time)?

L419: This goes along with my main comment, but results show anthropogenic contribution of over 100%.

Specific comments (minor/technical):

L35-36: Do we know this for sure/are there studies that have shown this? Is there a citation to use?

L41: "An alternative approach", referring to an alternative to Roe et al., 2017?

L46: Vargo et al 2020 shows a method that applies the method discussed here but to glaciers with limited observations (but still needs some observations, so still a subset of the total).

L58: Anthropogenic forcing would account for some observed retreat? 25% of mass loss due to anthropogenic forcing isn't nothing.

L61-70: Good setup/description for part of the problem you're addressing

L159-174: I think these assumptions are reasonable (some need to be made). But for Arctic glaciers, if 10% have a response time of over 400 years, those are probably some with the most ice mass? With larger contributions to sea level rise than smaller glaciers with quicker response times? Maybe just something to note.

L197: I wonder if/how much changing the 0.5C of white noise influences results? Maybe discussed in Roe et al., 2017.

L245: This paragraph is a nice overview.

L249: 'zThe' typo

Section 4.2: I know papers have shown that for many glaciers around the world, sum-

mer temperatures are especially important in overall mass balance. But was a summer temperature reconstruction used because that's what is available, or because it's the best value to use?

L319: Why is precipitation considered now but not with idealized scenarios? And how is it incorporated here versus in equations for the idealized scenario?

L360-364: I haven't seen this done before, but I think it makes sense.

L378 - 379: Seems odd to say it could have been done a completely different way (different input data) but results would obviously be the same. Is it obvious?

Fig 9: Is it useful to compare where measured mass loss falls/plots?

Figure 10: This took me reading a couple of times to understand, but it helps show that a problem with M14 is that glaciers with long response times (100, 200, 400 years) haven't actually reached climatic equilibrium.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-265, 2020.