Comment on egusphere-2022-1039
Anonymous Referee #2

Referee comment on "The effect of uncertainties in natural forcing records on simulated temperature during the last Millennium" by Lucie J. Lücke et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-1039-RC2, 2022

Summary: The study explores the consequences of uncertain in the external forcing for the simulated temperature over the past millennium. The authors force a simple climate model with a large ensemble of reconstructions of the external forcing (solar and volcanic) that span the range of uncertainty, and compare the simulated temperature with proxy-based reconstructions.

The main conclusion is that the temperature simulated using small variations of solar forcing better agree with temperature reconstructions.

Recommendation: The manuscript is well written and the conclusion is important for the design of paleo simulations with GCMs. I have a few suggestions that the authors may want to consider, most of them related to clarify some technical aspects of the study, and on the structure of the Conclusion section.

1) When constructing the volcanic forcing ensemble, it is not totally clear if the 1-sigma volcanic uncertainty is unique to each eruption or is it an average value across all eruptions. Related to this, are the gaussian-distributed uncertainties (or z-scores thereof) added to the central estimate individually for each eruption or as a single time series. From other description in the text it seems to me that the realizations of the errors for each eruptions are uncorrelated, but it would be helpful if this could be explicitly stated.

line 110 'For all eruptions, we perturbed the VSSI amount by a normally distributed random variable of mean zero and standard deviation of the reported VSSI uncertainty'

For all eruptions or for each eruption separately?
2) line 46 Despite these latest advances, substantial uncertainties remain in the reconstruction of volcanic forcing from ice core records regarding e.g. timing, magnitude, injection height and latitude of eruptions et al., 2006; Gao et al., 2008; Schmidt et al., 2012a; Crowley and Unterman, 2013; Stoffel et al., 2015; Schneider et al., 2017; Stevenson et al., 2017; Marshall et al., 2021)

The sentence looks a bit strange, since most of the reference are a decade old

3) line 48 ‘Solar forcing is primarily driven by photospheric magnetism, leading to varying numbers of sunspots and faculae concentrations on the solar surface, which modulate the total solar irradiance (TSI)

However, prior to the telescopic era, the reconstruction of solar variation is based mainly on cosmogenic isotopes deposited in polar ice cores and tree-rings, of which sunspot numbers can be estimated by applying a chain of physics-based models.’

In my understanding, the paragraph seems to me a bit unclear or misleading. Sun spots are regions of reduced luminosity. The fact that periods with higher numbers of sun spots display higher TSI is because the occurrence of sun spots is correlated with faculae, which display a higher luminosity and have a stronger impact. The link between both is however non-linear. Thus it is not the sun spot number that is actually reconstructed by physics-based models but directly the TSI.

3) Figure 1 displays the volcanic forcing but the figures also shows slightly positive values. I guess these are anomalies, as for solar forcing

4) line 110 normal distribution of volcanic uncertainty.

Perhaps this is not terribly important, but a gaussian assumption would lead in some small eruptions to positive values of the volcanic forcing, which is unrealistic.
5) line 115 ..’ This procedure was iterated to produce 1000 different timeseries of VSSI, each an equally probable version of past volcanic activity given the estimated values and uncertainties listed in eVolv2k. For each eruption, the eVolv2k-ENS members produce a distribution of potential VSSI amount and timing, with the original default eVolv2k values at the peak of the distribution, representing the estimated most probable value.’

I am a bit confused by this paragraph. I would say that the ensemble is a sampling of the underlying probability distribution, but I do not think that each member is equally probable. The probability of a number in the case of continuous distribution is not really defined, only the probability density. Also, the part of the sentence stating that the original eVolv2k represents the most probable value is in contradiction with the statement that each member is equally probable.

6) line 121 ‘The volcanic forcing ensemble therefore represents a best estimate of the range of possible volcanic#

In which sense ‘best estimate’? I would say it is just a sample from the distribution. A second sampled can be drawn and this will be different from the first. Both cannot be the best estimate.

7) line 255 For N = 20 years all models are consistent within the lower and upper quartile of the population, showing that most of the models roughly agree on the extent of decadal variability

Which population? It cannot be the population of models, as only 50% would be within the lower and upper quartile.

8) line 435 ‘In this study, we have, for the first time, estimated the effects of both volcanic and solar forcing uncertainty on simulated temperature, with volcanic forcing uncertainty including magnitude, timing and ahmwhatelse uncertainty’

Indeed life is full with uncertainty but we should not despair

9) The discussion and conclusion section is rather comprehensive. I would suggest to include some structure into it, for instance by highlighting one conclusion as a bullet point followed by the discussion related to it.

10) Why was the impulse response model fitted to a volcanic-only simulation instead of a full forcing simulation? This choice seems not totally logical, and may raise the suspicion that the better agreement of the low-amplitude solar forcing with the proxies may be rooted in this choice? If the solar forcing has a minor importance, the tuning would not be
very different. Perhaps the difference of the model parameters could be included in the ms.