The manuscript discusses the additivity of the volcano and solar forcing (the latter using two different reconstructions of solar irradiance) in contributing to the cooling observed over the early 19th century. The paper includes interesting and detailed analysis, and the use of relatively large ensemble of MPI-ESM simulations (20 members per experiment) allows substantially narrow down the uncertainty arising from interannual variability. Some improvements in the manuscript would be needed, as detailed in the comments below, although in my opinion the manuscript should be published once these are addressed.

L11: suggested -> ', as suggested'

L12: by simulating -> that simulates

L13-14 by saying 'in general additive', do you mean global mean cooling is additive? (as opposed to regional changes, which are non additive). If so, this needs to be said explicitly, as 'in general' is too vague and confusing. This applies throughout the manuscript.

L15. I don't understand how do you obtain the units of cooling as K/month (here and in the main manuscript and summary) – feels a bit odd to express it like that in my opinion – either explain that in main text or use the maximum amplitude (as with volcanic eruptions)

L15 surface air cooling – near-surface air cooling

L17 cooling peak of -> cooling that peaks at

L17-19. Something is not fully correct with that sentence

L19-20. 'which is related to the reduction of seasonality and the increased Arctic sea-ice extent' -> 'which is related to the concurrent changes in Arctic sea-ice extent'. Not sure why do you note the reduction in seasonality here (which if I understood the manuscript correctly relates to the SST vs SAT cooling in the NH midlats)

L22 polar vortex -> stratospheric polar vortex

L23 opposite responses -> opposite-sign changes in stratospheric temperatures and zonal winds

L67. Distinct surface responses -> distinct regional and seasonal surface responses

L75-77. That's because of the dependence of the horizontal distribution of sulfate aerosols from volcanic eruption (i.e. how far north do the aerosols get), and the uncertainty in it, rather than because of some general uncertainty in AA response to volcanic forcing. You might want to clarify that.

L88. Atmospheric model top?

L105 'a larger variability' – I don't like the term as it makes it sound there is more natural variability in it. Perhaps change to something like 'larger long term changes in solar irradiance' (or similar)? That applies here and later on in the manuscript.

L102-115. One of the important things that needs to be added here is by how much does the UV radiation varies in the two reconstructions. Fig. 1 includes changes in total solar irradiance, which are most important for determining the bottom-up cooling as discussed in much of the manuscript, but since Section 4.2 discusses also the changes in the stratosphere (the 'top-down; mechanism) the

main thing that determines the response there is the UV change, and not TSI. Please add this to the manuscript.

Similarly, the paragraph talks about the prescribed ozone changes but what is unclear is whether the same ozone field is used for all 4 experiments (especially for the two solar reconstructions). The associated changes in stratospheric ozone have been found to cause ~50% of the stratospheric temperature response to the 11-year solar cycle (e.g. Gray et al., 2009), and so they will be crucial in determining the stratospheric response in Section 4.2

L118-L120. Please include the amount of SO2 injected for each eruption, as well as the altitude and latitude. Also, might be worth adding a figure, either to the main text or the supplement, that shows the latitude vs height concentrations of simulated sulfate, or at least latitudinal profile of AOD, to show the horizontal distribution of the volcanic forcing.

L140-149: might be worth explaining the rapid adjustment method further as it's still somewhat difficult to understand to a reader not familiar with the method.

L155-154. As mentioned above, unclear how do you arrive on the K/month unit. Please specify, or use a maximum amplitude to make it more comparable with the magnitude of volcanic forcing.

Fig.2 -> panel labels not included in the figure

L163: 'Maximum differences in solar irradiance and surface temperature do not coincide.' I don't fully agree - in the NH extratropics there is a good correlation between difference in TSI and temperature between the two reconstructions.

L166-167. 'This indicates that the solar forcing does not exhibit clear instantaneous response' -> add 'throughout the globe'?

L179 change to 'due to weaker westerly winds (Kwon and Joyce, 2013) and reduced freshwater flux'?

L182: 'accompanied with a smaller increase in the summer than in winter'. First, I don't think 'accompanied with' is the right word here. Second, is that right? I see as large (if not larger) increases in summer sea-ice as in winter sea-ice.

L185: 'weakening of the polar vortex due to the smaller meridional temperature gradient' -> 'weakening of the stratospheric polar vortex due to the reduction in the meridional temperature gradient'

L188. it's not a cause/effect, and rather the two things are consistent with each other.

L194-196. That would be a nice place to refer to the plot showing latitudinal distribution of sulfate aerosols or AOD, so that to illustrate where the volcanic forcing is applied.

L196: 'contribute' -> 'contribute comparatively more'

L196. 'and weaker (larger) seasonal variations are observed in the SST (SAT)' – make that a separate sentence.

L205-206. I would say it is also found in SH, it's just the initial perturbation (when aerosols are present) is so much smaller?

L214-215. 'That is, although different patterns are found in the sea-ice extent and surface pressure and the cooling magnitudes differ' – I'd say that the sea-ice extent response is similar between

volcano and solarstrong (just stronger, consistent with the stronger global mean cooling), it's just the high-lat SLP response that it different

L226-237: this paragraph needs to say upfront that the regional responses are non-additive. Also I'd argue that it's not only SST responses but also SAT responses that are non-additive, esp. in the tropics

Figure 9-> The contours are really difficult to read (both in terms of the magnitude and sign). Given the stratospheric temperature changes are critical to understand the zonal wind response, I think it would be very useful to add the changes in atmospheric temperatures (including statistical significance of these) as a separate plot (or extra 2 rows of panels in Fig. 9).

L.242: 'the reduced solar irradiance results in a weaker polar vortex' -> either use 'suggest' rather than 'result in' or note the response is not statistically significant.

L243: westerly anomalies -> easterly anomalies

L245: can cool -> can warm

L248: the warming in the tropical lower stratosphere -> add: from aerosol absorption

L253-257: please comment on how statistically significant is the difference between Volcano&Solar and (Volcano+Solar), and clarify how do you estimate this

L265-267: 'In addition, the signal is significant in the polar troposphere. This is related to a corresponding response in the same region in the Volcano experiment This indicates that the volcanic impact is more related to the surface, while the responses to the reduced solar radiation are less significant and may be more confined to the stratosphere.' -> First, what signal? Do you mean just the difference between Volcano+Solar and Volcano&Solar? Second: The way I see it, in earlier periods when volcanic forcing is strongest, the stratospheric response is overwhelmed by the warming from sulfate aerosols. But in the latter period, when aerosol forcing is smaller, there is more of an interplay of volcanic forcing (warming in the lower stratosphere driving a strengthening of the tropospheric jet) and solar forcing (cooling in the upper stratosphere driving a statistically insignificant easterly stratospheric jet response that can propagates down to the troposphere), which given non-linear nature of wave propagation in the stratosphere could (maybe) give you a somewhat different response when the two forcings are considered together.

L269. please comment also on whether the same ozone field is prescribed for both solar reconstructions, (and if so, what effect this could have).

L272 not shown – perhaps useful to include into the supplement?

L272-273: 'as they are related to the surface ocean changes, which are also additive for solar and volcanic forcing' -> Do you mean ***global mean*** surface ocean responses (as opposed to regional ones that are non-additive)? If so state that clearly.

L282: 'has weak El Niño signatures for two years after both 1809 and 1815 eruptions,' -> first, 'only a weak'. Second, please clarify what do you mean by 'for two years' here, as to me it suggests that the El Nino should last for two years, although I don't think that's what the plot shows.

L283: 'may cause a smaller El Niño tendency' -> 'may reduce the tendency towards El Nino'

L267-268: 'No significant signal is simulated for the 1810 winter and not all the 1816 winter has a significant signal' -> First , start with 'However'. Second – what metric/experiment do you refer to

here? I see positive AO in both volcano and volcano&solar. Third - For NAO, it could be that the model variability doesn't really align with the regions chosen (from observations) as NAO 'centres of action' – have you checked whether under +ve AO the model shows significant +ve and -ve sea level pressure changes in the same exact regions chosen for NAO index?

L281-190: 'After the first year, when the northern extra-tropics also encounter stronger cooling, no significant impact is found for NAO and AO' -> as above, what experiments? I see clear positive AO.

L290-291: 'which agrees with the weak response in the composite of sea level pressure (Figs 3h and 5h)' -> to me these winter high-latitude SLP responses are actually quite strong/clear (and statistically significant)

L293-294: 'which is consistent with the mix of increasing and decreasing Antarctic sea-ice related to the surface pressure and temperature changes in the same regions' -> 'consistent with the mix of decreasing and increasing temperature and sea-ice in the same region.' SLP is a signature of SAM changes and that snows a tendency towards -ve SAM. In fact, SAM index for volcano&solar and volcano(post Tambora) shows a clear tendency toward -ve SAM, and this agrees with the SLP response in 5h. Please comment on that.

Also, does 'winter' in Fig 3/5 refer to DJF, and 'summer SAM' in Fig. 10 also to DJF? (as austral summer?). that needs to be clearer I think

L296: stronger -> stronger and longer lasting

L301: 'No apparent signature is found in the AMOC (Fig. 10h).' -> In most experiments yes, but the SolarStrong shows a pretty clear weakening of AMOC.

L303 'because' -> this is not the right word here I think

L304-L305: 'by the ratio' -> 'as approximated by the ratio'

L305-308: I think one of the main message here is that there is large variability in AA for basic and solar, whilst the variability becomes (surprisingly) very small for volcanic and volcanic+solar.

L309: 'the AA in the Volcano and Volcano&SolarStrong experiments increases' -> add 'and so does the intra-ensemble spread'

L311-313: 'That is, the strength of AA cooling caused by solar and volcano are comparable (though in different cooling magnitude) after the direct volcanic forcing diminish, while weak AA is found when the volcanic forcing exists.' -> That is, the strength of AA caused by solar and volcano is comparable (despite differences in absolute global mean cooling) after the direct volcanic forcing diminishes, while only weak AA is found when the volcanic forcing exists.

L320-332: I believe this section needs more explanation of the different feedback mechanisms to help readers less familiar with the literature

L343: AA -> I would avoid using acronyms in the summary

L344-346: the way I see these plots, it is both SST and SAT that are characterised by a slow recovery, esp, in the NH extratropics..

L347: sequence -> set

L348: surface climate responses -> global mean/large scale surface climate responses

L350: ‘cause opposite responses of the polar vortex’ -> ‘cause opposite sign changes in stratospheric temperatures and thus the NH polar vortex’

L350-1: ‘shows an additional strengthening of the polar vortex’ -> ‘shows a strengthening of the polar vortex of a similar or somewhat stronger magnitude to that in a volcanic simulation alone’

L351: This indicates that the solar forcing may enhance or have no impact when imposed on the volcano-induced polar vortex change-> This suggests that the solar forcing may have little impact on, or even enhance, the volcano-induced strengthening of the polar vortex

352-353: same prescribed ozone in all experiments?

L365+: I would argue that Figure 12 should be moved to the beginning of the manuscript to give the reader some context

L356-L360: Swap the order of these sentences: sentence 1, sentence 3, sentence 2.

L371: In addition -> Finally/Lastly?

L372: the cooling contribution of AA -> AA in the context of the global cooling? cooling contribution sounds a bit odd.

L383: additive responses in general -> additive responses in global mean/large scale

385: AA cooling ->> AA associated with the global cooling

Figure 1: Meaning of the vertical magenta lines?