Authors response to anonymous reviewer #2

This study considers the question of estimating by how much global temperatures have changed since 'pre-industrial' times, assessing the uncertainty in different trend models and due to different global temperature datasets. The analysis is interesting, though the results are not too surprising. However, I have some major concerns:

1) Framing: the authors emphasize repeatedly that they are estimating changes since a particular baseline and implying that this is what the Paris agreement meant by 'preindustrial'.

This is not the case - the introduction of Hawkins et al. (which the authors cite) discusses this issue at length. In addition, Schurer et al. (2017, NCC) was very recently published, highlighting again that there was likely some additional warming due to anthropogenic factors before 1850. The authors may also like to examine Otto et al. (2015) for an alternative approach to estimating the warming since the 19th century. The text in the discussion on this topic is appropriate however.

Agreed. We propose to treat the topic of 'pre-industrial' more clearly in the discussion section, as we pointed out in our response to Reviewer #1. We will add the references to Schurer et al. (2017) and Otto et al. (2015). Consequently, we will address their findings that GHGs had a significant effect on global warming if the period 1401-1800 is compared to 1850-1900: from 0.02 to 0.20 ºC (5-95% confidence limits). If all forcings are combined (GHG, solar, volcanic) they find 0.09 [0.03 - 0.19] °C.

*2) Terminology: some of the phrasing is very confusing when referring to and/or distinguishing between natural *forced* variability (volcanic, solar) and internal *unforced* variability. These terms are sometimes mixed and it's not always clear what the authors mean. For example, in the abstract (and L86) the authors claim the models are corrected for natural variability, when they mean the forced component, but the introduction uses natural variability to mean both forced and unforced variations. On L133, the authors refer to the 'historicalNat' runs 'for natural unforced variability', which is not true - those runs include both natural forced and internal unforced variations as the next sentence correctly states. Variability is also used for the spread or range between different estimates, adding further confusion. The authors should carefully check each use of this type of phrasing and make it far more precise.*

Agreed. We propose to check the phrasing of 'natural variability' carefully, this in combination with the terms 'forced' or 'unforced' or both, 'internal variability' and 'spread'.

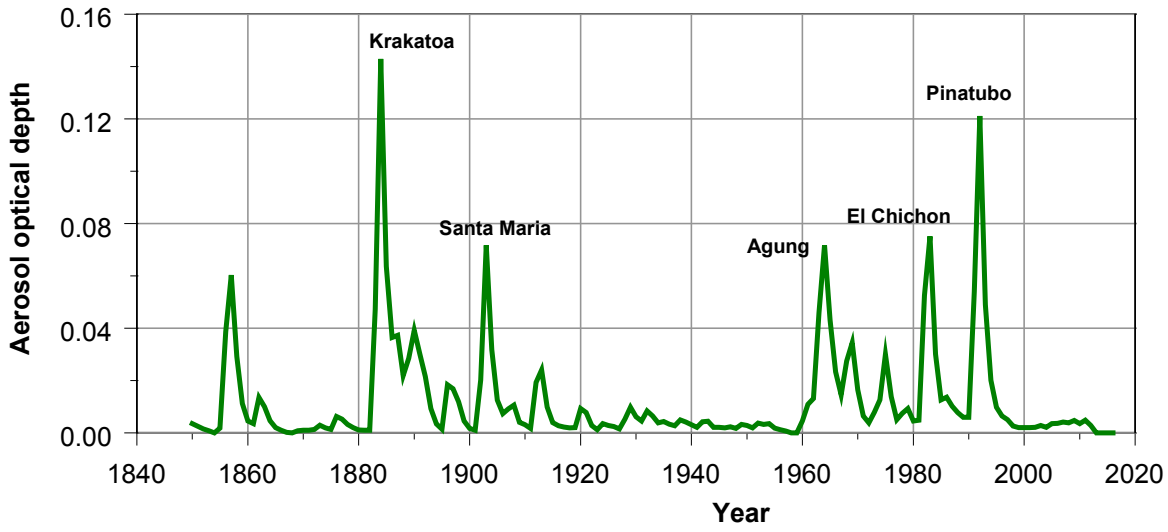
Additionally, we propose to treat the role of natural unforced variability and natural forced variability (i.e., the role of changes in irradiance of the sun and changes in volcanic activity) separately in a second item in the discussion section.

The trend analyses as given in our Table 1 are based on the IPCC definition of climate change (Glossary AR5): anthropogenic forcing combined with decadal to centennial natural variability. However, UNFCCC defines climate change as originating from GHG forcing only. In their philosophy we could argue that the Paris limits of 1.5 and 2.0 C should originate

solely from anthropogenic forcing. We propose to quantify this second view on the Paris limits.
To do so we make use of the recent study of Schurer et al. (2017, their figures S2 and S3), and the lower panel of figure 4 in our manuscript. Next to that we estimated the role of volcanos in a time-series setting by extending the Integrated Random Walk (IRW) model. For details we will refer to Visser and Molenaar (1995) and Visser et al. (2015).

It shows that the incremental values shown in Table 1 for the IRW trend are 0.04 ºC degree lower. If estimated in combination with the OLS straight line, i.e. a regression model with one explanatory variable, estimates are 0.02 °C lower than those shown in table 1. This effect, although small, will be due to the Krakatoa eruption in the period 1880-1890.

The indicator for volcanic dust is taken from NASA: aerosol optical depth (AOD). See graph below:



3) GCM analysis: the 106 members used cannot be 'one per model' as there were not that many models in CMIP5. It's not clear what the authors have used here - there must be more than one historical part of the runs for some of the models.

The reviewer addresses a good point. What we meant here is that we used one member per model, **given the use of a specific RCP scenario**. Thus, we have used 42 members for emission scenario RCP4.5, 25 members for emission scenario RCP6.0 and 39 members for emission scenario 8.5, making up a total of 106 members. We propose to clarify this in the text.

There are also 43 piControls on Climate Explorer, and very few are less than 200 years, not only the 20 that the authors have used - why have they not used the others?

Agreed. We have calculated all AR(1) coefficients for all 41 piControl runs, available in the KNMI Climate Explorer. Three of those runs showed a jump or a strong linear trend over the simulation period (varying from 200 to 1000 years). We omitted these. For the remaining 38

runs we have omitted the lowest two AR(1) coefficient estimates (lying around 0.0) and the two highest estimates (lying around 0.75). The remaining range equals the range given in our manuscript: [0.28 - 0.60]. We propose to adapt the text for this finding.

Also, in section 3.2, the authors could use the AR(1) value from each model's own control run to fit a spline to the historical run of that same model, rather than assume the same across every model. Also, how has the correction for natural forcings been applied (L250)? Has the mean across the historicalNat runs been subtracted from each historical run? If so, this is inconsistent as the response to volcanic eruptions varies significantly across models.

In our revision we propose to give values for smoothing by splines with φ=0.28 and φ=0.60, similar to shown in our figure 3. Period: 1861-2016. This gives a small change in the upper panel of our figure 4. The spread is for both smoothing options identical ± 0.50 C (2σ). The mean value of all 106 increments is 1.15 ºC for the smoothing option with φ=0.28 and 1.00 ºC for φ=0.60.