Anonymous Referee #2

> **We wish to thank the referee's for their time and effort reviewing the paper. Please see our response to their comments below.**

General comments

This paper reports new and interesting data of rBC concentrations obtained from 6ice cores extracted from various remote locations on the Eastern Antarctic plateau. The temporal and the spatial significance of this study is high, illustrating very well the complexity of the mechanisms of emission, transport and deposition of rBC to East Antarctica. I have no hesitation to state that the records obtained deserve publication in ACP. In addition to the very remarkable experimental effort, the authors use interesting statistical methods for extracting the significant variability embedded in this large data set. This is a very difficult task as variations in rBC concentrations are low as well as the level of apparent coherence between the different records.

-In general, I believe that the text illustrating the statistical methods and their applications should be made much clearer for a readership that is not necessarily familiar with these procedures. In addition, the authors should try to better display the conclusion obtained, highlighting (for instance also in Fig 2 where rBC concentrations are reported) also the periods where they have inferred monotonic, linear and non-linear trends, significant intervals of low/high concentrations etc. This may provide a better sense/appreciation of the conclusions suggested.

2-1. Response:

> We agree and have rewritten the text to clarify the various transformations of the data into and out of log-space and the use of the Man-Kendall trend test and single spectral analysis in section 2 (see also response to specific comments 1-2 to 1-11 in response to referee 1). We have also highlighted the time periods with significant trends etc.

-The authors should also discuss their assumption of Na as a "proxy of local transport". While it is largely accepted that this element is a proxy of marine aerosol (or frost flowers developing on sea ice), it is not obvious that Na is a specific tracer of relatively local transport. The origin of Na might be linked to coastal sea ice, seawater surrounding Antarctica but also far distant portions of the oceans. Being most of the surface of the Southern Hemisphere constituted by oceans, I'm not sure there are in the literature really striking arguments supporting the local vs. more distant origin of Na entrapped in Antarctic ice cores. The atmospheric trajectory of marine aerosol is also uncertain and both low (as assumed by the authors) and high paths in the troposphere cannot be ruled out.

2-2. Response:

> We agree. The transport of Na to the Antarctic interior is uncertain and could occur in the upper or lower troposphere. However, assuming that both rBC and sea salt aerosols are largely dry deposited at the NUS low accumulation sites (Fischer et al., 2006), the

differences between Na and rBC argues for different input rates into the overlying atmosphere, which is not simply modulated by regional atmospheric transport. To clarify this point we have altered the text referring to Na.

Specific comments

3. 21-31092 “because of their low albedo light absorption properties”. Albedo is a general physical property of large surfaces that is eventually influenced by a large amount of rBC particles deposited on large snow fields. Thus I believe albedo cannot be refereed as a property of the individual particles in themselves. Please, consider rewording.

2-3. Response:

We replaced albedo by “high light absorption properties”.

4. 21 31095 nssS data from these six ice cores and the match performed for dating purposes with the WAIS divide ice core are important information that should be provided as supplementary electronic information. Alternatively the appropriate reference should be offered.

2-4. Response:

Dating was coherent with nssS records published by Anschutz et al. 2009 and 2011. So we added these two references to this paragraph of the manuscript. We also added the number and dates of tie points that were used to compare the WAIS ice-core to the Nor-US cores, and made some changes to the dating paragraph, to make the description clearer.

5. 4-10 31096 The method used for “further refinement of the 07-1-5 and 08-4 depth age relationship”, as described at this point of the paper, is quite obscure.

2-5. Response:

We rewrote the text to clarify the refinement process:
“The depth / age relationship of the NUS 07-1 core benefited from previously published accumulation rate data (Isaksson et al., 1999) and was used as the basis of further refinement of the 08-5 and 08-4 depth-age relationship was performed by using the Analyseries software lineage tool (Paillard, 1996) to warpusing decadal trends in the rBC records. The refinement process consisted of warping the 08-4 and 08-5 rBC non-linear trend (described in section 2.4) peaks and troughs to the 07-1 non-linear Rbc trend (Kendall test for trends at 95% significance).”within the constraints of the volcanic chronology) using the Analyseries software (Paillard, Labeyrie, and Yiou, 1996) lineage tool. The refined depth/age relationships resulted in coherent non-linear trends between the 08-4 and 08-5 records, which were drilled in the same region (separated by 17km).”

6. 3-31097 Were Z-scores calculated using the arithmetic or the geometric mean? The standard deviation or the geometric standard deviation? Or the Z-score was calculated by using the log of the measured rBC concentrations? Please, clarify.

2-6. Response:

We rewrote the concentration paragraph in section 2 to make this point clearer. Also see reviewer 1 response 1-3. Trends were calculated on the log of the concentrations. Then, the trends were back-transformed to normal space, to calculate Z-scores. Since the trends were normally distributed, we used the arithmetic mean and standard deviation.

7. 14-16_31098 Please, indicate the time periods when the monotonic trends are significant. Please show also the linear trends.

2-7. Response:

Our calculations were made on the whole record period from 1800 to 1989-2008 depending on the ice core. This was specified by the wording “from 1800-onwards”. We modified the sentence to make this point clearer (see below).
Regarding the “linear trends”, we actually meant “monotonic trend”. This was unclear and we thus removed the word “linear”, for less confusion.
The sentence is now including both comments: “Significant monotonic trends, with superimposed decadal variability (for the whole period 1800-onwards, Mann-Kendall test double-sided p values <0.0001), were found in annual rBC concentrations at sites 07-5, 08-4 and 08-5. The trends at these sites represented an increase of ~0.02 ± 0.01µg/kg/100 years.”

8. 24-25_31098 Please, describe in the text the time periods where significant non-linear trends were identified. Please, also introduce the concept of Z-scores of non-linear trends reported in Fig. 3. Or were you meaning non-linear trends of Z-scores?

2-8. Response:

The significance was calculated for the whole period, from 1800-to the end of the records, depending on the ice core. We added this precision to the text (see below).
Regarding, Z-scores, we actually meant “the Z-scores of non-linear trends”. We modified the sentence to correct this misleading wording (see below). We also hope that the sentence added to the section 2.4 “concentrations” made this point clearer (see response to comment 4).
Sentence modified to: “Significant non-linear trends **over the entire period** (**1800-onwards**, $p<0.05$, Mann-Kendall trend test) are shown in Figure 3 (**normalized as Z-scores**).”

9. 1 31099 Here non-linear trends normalized by Z scores are mentioned. It is very confusing. Please, clarify extensively the procedure adopted, adding some more background, if needed.

2-9. Response:

Please, see response to previous comment and to comment 4. We tried to make clear that the trends are only represented as Z-scores for easier comparison, but mentioning Z-scores earlier in the text. We hope that this makes the text clearer.

We also modified the caption of Fig.3 and replaced “Z-scores of non-linear trends” by “non-linear trends normalized as Z-scores”

10. 1-31099 Please, display the identified periods of low (1890-1920) and high (1920-1940) concentration also in Fig. 2 as well as the periods of low/high variance from 1940 to 1980. In the Fig. 3 caption, the NADA variance is not introduced.

2-10. Response:

This is the new Figure2 below. We also changed the period of “lows” from 1890-1920 to 1890-1910, to match the period mentioned in the conclusion.

Caption in Figure 3 now includes a description of Nada: “with NADA variance (ENSO long term variability) in dotted line, scale inverted”.

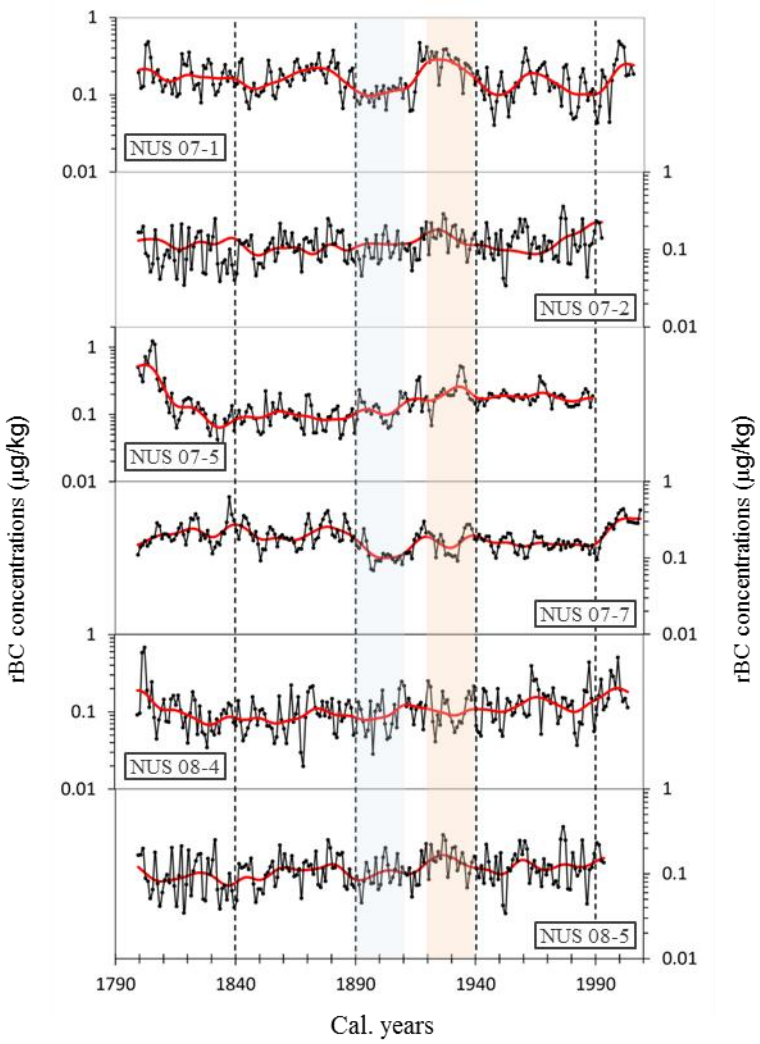

FIGURE 2: Time series of rBC concentrations. Black line is annual (piece-wise linear integration interpolation of log raw data) and red line is 21 yr k-smooth on annual (calculated in log space). The periods of relatively low values (1890-1910) and high values (1920-1940) as described in Figure 3 are indicated as shaded areas.

11. 15_31100 Please, refer to Fig. 4c in the text.

2-11. Response: Added to text.

12. 21_ 31100 The authors should explain how they extrapolate from Fig. 4 an 80% of difference of rBC due to elevation change.

2-12. Response:

The number 80% is extrapolated from the slope of BC with accumulation (0.03ug/g for 50mm) by the slope of BC with elevation (0.025ug/g for 500m): 0.03/0.025=0.083. we tried to link the explanation to the conclusion better and added a connection adverb: "The slope of the linear regression of 0.030µg in rBC for a 50mm decrease in accumulation can be compared with the increase of 0.025µg rBC estimated for every 500m in elevation, for the time period from 1800 to the present (Figure 4a, top). **Thus**, for the two time periods shown in Figure 4, the change in elevation may explain ~80% of the difference in rBC geometric mean concentrations."

13. 26_31100 The monotonic trends as well as the temporal variation in the accumulation should be displayed in the figures.

2-13. Response:

The accumulation data is limited to the time periods between major dating horizons, (volcanic eruptions etc.) and consists of three data points for the past 200 years. As such the data does not really aid in the interpretation of the figures. We would like to like to keep this in Table 1 to keep the figures simpler. Regarding the monotonic trends, we also left these off the figure 3. to simplify it. We could however, add an extra panel with the linear trends if the reviewer thinks this would improve the figure or include them as an additional figure. We have also modified the text to make the discussion clearer (and a typo in the cores names: 07-2 was replaced by 07-5):

"This relationship may explain the monotonic trend found for the record 07-5 (section 3.1), which exhibits a decrease in accumulation rate from the period 1815-onwards to the period 1963-onwards (Anschütz et al., 2011; Isaksson et al., 1999), cf. Table 1. However, it is not as clear for the two other sites, which display significant increasing monotonic trends, 08-4 and 08-5, but no strong trend in accumulations, Table 1."

14. 5_31101 Non-linear low frequency trends in the rBC records and those not found in Na record should be displayed.

2-14. Response:

We are not quite sure what is meant here? Should we also show the Na low frequency trends in Figure 3?