

Interactive comment on “Detecting the influence of fossil fuel and bio-fuel black carbon aerosols on near surface temperature changes” by G. S. Jones et al.

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Response to Anonymous Referee #2 Comments:

Major comments

Whilst the results do not show a robust detectable contribution of fBC to near surface temperatures over the last 50 years, it is detected robustly in the last 50 years of the 20th century. We state in the conclusions of the paper :- " fBC is detected with a warming contribution in the 1950-1999 period of about 0.4 K/century, but not in the 1957-2006 period." We also state that "this is not a robust conclusive detection of fossil fuel and bio-fuel sources of black carbon" as it is dependent on the period being

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examined. However we still think this is an interesting result as "it is the first time that it [fBC] has been detected separately from other aerosols." in any period and shows the difficulties in attempting to detect its influence. Previous studies have also detected climate signals in one period but not others (e.g. Tett 2002), and in our study we discuss some of the possible reasons behind the sensitivity in the analysis. We hope this study may prompt further research to try to detect black carbon's influence unambiguously as it has potential significance in climate change mitigation policymaking. We have made minor additions to the abstract, section 4.2 and conclusions to clarify that there the detection of fBC is sensitive to the choice of period and that this may be related to the different strength of the fBC temperature response in the periods. We respond further to the reviewer's concerns about the clarity of the results below.

Specific comments

P20922 L20: We have changed the text to "The attributed warming of fBC was found to be consistent with the warming from fBC unscaled by the detection analysis" which is fully explained within the main body of the paper.

L20927 L8-L11: Whilst there have been no direct comparisons of simulated aerosols within HadGEM1 and the limited available direct observations of individual aerosol species, the overall response of the model to aerosols appears to be credible when compared with indirect measures of the impact of aerosols, such as TOA fluxes (P20927 L6-21).

Figure 2: We feel it is useful to keep Figure 2 in the main body of the paper as it gives extra information about how the fBC aerosol concentrations is distributed that is not obvious from Figure 1; such as the concentrations of fBC over the North Atlantic and Arctic changing between the two periods.

Figure 3: The small decrease in estimated SW radiative forcing in the GHG is significant. Such change in the SW forcing is consistent with well known slight absorption of SW in the stratosphere by CO₂ which causes a relatively small (compared to LW

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forcing) negative troposphere SW forcing (Cess 1993, Myhre 1998). We do not feel this is of particular relevance to our study to mention.

P20930 L13: We do not have the simulations to differentiate between the sulfate and biomass burning aerosols, so we have reworded the sentence to reflect that.

Figure 4: Volcanic aerosols in the stratosphere scatter incoming SW, thus decreasing SW forcing. The aerosols also absorb near infra red from the Sun and outgoing LW. This increases temperature in the stratosphere and thus produces downward LW radiation. We have rephrased this sentence to note the LW forcing increase and point to a reference for anyone interested in why to follow up. This also helps to answer the query from the reviewer regarding stratospheric warming below.

P20933 L12-L14: In this section we are just highlighting similarities and differences between the observed and simulated global near surface changes and not attributing observed changes. We do not have any specific understanding for the differences between the datasets in the first decades of the 20th century, although they are possibly emphasised due to the 1961-1990 reference period being used (compare with fig 9.5 in the Working group 1 IPCC 2007 report). We have added some text to describe in general that some of the differences and similarities between the series may be due to uncertainties in the forcings, internal climate variability and observational error.

P20933 L24-25: We agree that the current text is unclear. The intention is to point out that whilst observed surface temperatures did not show an obvious cooling following the El-Chichon eruption in 1982, this was due to the large El-Nino that occurred at the same time offsetting the cooling. This is consistent with the warming in the stratosphere following the El-Chichon eruption being observed and being consistent with the modelled stratospheric temperature change. We have made this clearer in the text.

P20934 L29-P20935 L2: In the text we associate the overall cooling in the Northern Hemisphere with the emissions of aerosols from Europe, North America and then later Asia. The model allows transport of the aerosols away from the original emission

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sources (Figure 2 demonstrates that for fBC aerosol for instance) and climate teleconnections can mean there is climate change in regions distant from where the forcing agent is directly acting. We have added to the text references that discuss and note the regional high latitude response to aerosols.

P20935 L2-L3: We were attempting to point out that the patterns of fBC near surface temperature changes were in similar regions but not following the same time variation as for OA (but of an opposite sign), and that was due to the different evolution of the regional emissions. We have amended the text to clarify that.

Figures 9 and 10: We state at the start of section 4 that "detection" is deduced by testing the null hypothesis that the scaling factor is zero, i.e. if the 5-95% range of the scaling factor does not cross zero then it can be said to be detected. We then describe the consistency test to check if there is under/over fitting within the regression. So it is possible for a signal to be "detected" but for the regression to fail the consistency test. For the 1907-2006 A+N result we noted (P20938 L16-18) that it is detected robustly across the range of truncations (i.e. scaling factors greater than 0), which is what is also shown in figure 9. However we also noted (P20938 L21-27) that the regression passes the consistency test at the maximum truncation, but not most of the lower eof truncations, which we hoped the reader would infer means that the confidence that result is reasonable is low. We have added text to explain that whilst the A+N is robustly detected across the range of truncations the failure of the consistency test for many of the truncations reduces our confidence that this particular result is meaningful. We have also added text to clarify what "detection" means.

P20939 L29: In this part of the paper we explain plausible reasons for a scaling factor greater than 1 for the solar and volcanic climate response, i.e. the model response is too weak and/or the forcings (from solar and volcanic) used in the model are too small than occurred in the actual climate and/or the detection analysis method is flawed. There would be an inconsistency with the statement about recent total solar irradiance reconstructions giving smaller increase over the last 100 years than used in this study

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if we claimed the results strongly implied a larger solar forcing change than simulated. We do not make this claim so we do not see an inconsistency in our statement.

P20940 L8: The concept of signal to noise ratio (SNR) is well known in data analysis. The calculation is straight forward and is clearly explained in Tett 2002 (section 4.6). We could not improve on the description in Tett 2002 and it would break up the flow of the narrative if we were to try to do so.

P20943 L20-L22: We have added to the text that the cooling within the decade is only obvious for the reconstruction of N in the 1957-2006 period as N is not detected in the earlier period.

P20943 L23-L26 and P20941 L25-L27: In the paper (P20943, L23-26) we do mention several possible reasons for the sensitivity of the detection of fBC to the period chosen, not just aliasing errors. We also state that the forcings used have uncertainties that may change with time (e.g. particular uncertainties post 2000 due to using a SRES scenario and not observational estimate) and that the SNR of the fBC changes which can make a detection more difficult. But we agree that the way it is written does put a lot of focus on the "aliasing" explanation, whereas the change in strength in the fBC signal may be the most obvious reason for the difference in the results.

We have re ordered the sentence, with the possible explanations, to refer to the change in SNR of fBC first. We have also added text later in the same paragraph to point out that the trend of the fBC signal before it is scaled in the regression analysis (as shown in fig 14) is larger in the earlier period than in the later period. We now explain that this is inline with the SNR values and that it suggests the possibility that the detection of fBC in the earlier, but not the later period is due to fBC having a stronger signal in the first period. We have also added a line in the conclusions to repeat this.

We have separately examined different 50 year periods starting between 1949 and 1958. Those results show fBC is detected in the earlier periods but not the later ones, so the results presented in the paper are representative of the sensitivity to the choice

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of period. We do not feel it would help clarify the issue by including the results of every possible period that could be examined as we would need to discuss the sensitivity of the scaling factors to truncation and the consistency tests. We hope we have struck the right balance by showing the results of two nearby periods that demonstrate sensitivity in some of the detection results to choice of period. Previous studies have also detected climate signals in one period but not other periods (e.g. Tett 2002), so we have also added text to show that similar issues have been seen before for different forcing factors.

Technical comments

'Numbers at the beginning of every section but Abstract and Conclusions should be removed.': The numbers appeared at the type-setting stage of submission, we will endeavour to make sure they do not appear in final version.

P20923 L6: The typo appeared at the type-setting stage of submission, we will endeavour to make sure it is corrected in the final version.

P20930 L5: The typo appeared at the type-setting stage of submission, we will endeavour to make sure it is corrected in final version.

P20931 L18-L19: We have changed the sentence to state that the climate feedback factor for the forcings is assumed to be the same as for CO2.

P20934 L12: Figure 6 is the correct figure being referred to.

Figure 8: We have clarified that the first four panels (from the left) are latitude/time plots of 10 year running means and the far right panel is the annual version for the natural simulation plot.

P20939 L28: We have replaced the phrase with "natural forcings".

Figure 10: We have changed the figures to darken and thicken the green lines and changed them to dashed lines to help in separating the lines.

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P20945 L20: The comma has been changed to a fullstop.

P20946 L6: Brackets have been placed around the citation.

P20946 L7: We have corrected the spelling mistake to "disproportionate"

P20946 L19: This value did not appear elsewhere in the paper. We have added to section 3.2 on Near surface temperature response to the simulations, where fBC is being discussed, that the trend over the last 50 years of the 20th century is 0.47+/-0.31K/century.

P20952 L28: We have corrected the spelling mistake to "Nozawa"

P20954 L28: We have corrected the spelling mistake to "Prediction"

P20955 L12: The typo appeared at the type-setting stage of submission, we will endeavour to make sure it is corrected in the final version.

References

Cess RD et al., Uncertainties in carbon dioxide radiative forcing in atmospheric general circulation models, *Science*, 1993

Myhre, G et al., New estimates of radiative forcing due to well mixed greenhouse gases, *GRL*, 1998

Tett, SFB et al Estimation of natural and anthropogenic contributions to 20th Century temperature, *JGR*, 2002

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 10, 20921, 2010.