Author Response to Anonymous Referee #2

The authors would like to thank Referee #2 for the careful review of our manuscript. The subject-specific as well as the linguistic comments and suggestions will help to improve the quality of the paper. In the following we list the referee comments together with our response.

General Comment 1:

The authors need to clearly describe what distinction is being made between clear and all-sky model AOD for the comparisons with remote sensing retrievals in Section 4. This distinction is made for in section 5 for radiative forcing.

ECHAM-HAM computes AOT at 550 nm for clear-sky conditions. The model calculates a separate Relative Humidity (RH) for the clear (RH < 100 %) and cloudy (RH = 100 %) parts of a grid-box based on the grid-box mean specific humidity and the cloud fraction (see Stier et al. 2005, Sect. 2.6). The modelled AOT provides global coverage and can be evaluated by comparison to observational AOT values which always refer to clear sky conditions. We will add this description in section 4 in the revised manuscript.

General Comment 2:

Please make the numerical scales the same across panels within Figures 5-8. It's important to easily compare the variability and magnitude etc between regions, but this is hard when the scales change. Please also consider making the scales the same in panels within each figure.

We agree that an adjustment of all scales to the same range in Figure 7 and Figure 8 will improve the readability of these plots. For Figure 5 and Figure 6, scales will be adjusted region-wise in the revised paper. However, we prefer to keep different scales for different regions in Figure 5 and Figure 6 as the maximum yearly AOT shows large differences of up a factor of 7 between regions.

Specific comments

Title: I do not think that 'Black Carbon' should be capitalized

We will apply this change in our revised manuscript.

P6696 L2: change "former studies" to "previous studies"

The change will be applied.

P6696 L5: as discussed in 4.3, the importance of emissions heights has been quantified previously. Perhaps you mean to say, the sensitivity to emission height is still uncertain and has been examined with only a few models.

We admit that the term 'climate impact of emission heights' is indeed a somewhat imprecise term. We will replace the sentence 'Although former studies indicated that the height of the aerosol-radiation interaction crucially affects the overall climate impact, the importance of fire emission heights in particular remains to be quantified.' by

'Previous case studies indicated that the height of the aerosol-radiation interaction may crucially affect atmospheric radiation, but the sensitivity to emission heights has been examined with only a few models and is still uncertain.'

P6699 L22: Omit "We identified a fraction of" at the start of this sentence.

We will omit this phrase in the revised manuscript.

P6706 L10: In addition to the spatial and temporal collocation, what distinction is being made between clear and all-sky model AOD? My understanding is that the AOD retrievals considered in this study will be clear-sky only. If no distinction is being made for the model, to what degree is this contributing to the discrepancies between model and each different retrieval?

See general comment 1.

P6707 L19: Omit 'considerable', change 'entail' to 'cause', omit 'subsequent'

P6707 L23: Omit 'therefore'

We will apply these changes in the revised manuscript.

P6710 L4: Suggest providing possible reasons for the non-linear increase in BC burden w/ emissions, even if only speculative.

The dampening of the increase in atmospheric BC concentrations for increased emissions can be attributed to the interaction of multiple aerosol microphysical and atmospheric effects. These include but are not limited to non-linear particle formation, coagulation and deposition, micro-physical cloud processes and atmospheric feedback via changes in vertical temperature profiles due to changes in aerosol concentrations and radiation. However, in the framework of this study, it is impossible to disentangle the contribution of particular processes to the overall non-linear source-receptor

relationship. We will add this information in the revised manuscript and refer to the study by Zhang et al., 2014 which investigates this relationship in more detail.

P6713 L17: Following the general comment, for Figures 5 & 6, please use the same y-axis scale in all the time series.

We will consistently apply the same scales for each individual region, see general comment #2.

P6717 L3: 'is in the following analyzed:" sounds awkward

We will drop 'in the following' in the revised manuscript.

P6720 L4: suggest replacing 'Besides two..' with 'In addition to..'

We will apply this change in the revised manuscript.

P6722 L5: When mentioning the importance of emissions fluxes, I think it's important here to re-iterate that the GFAS aerosol emissions still require a substantial (3.4) correction factor.

We will replace the first sentence of page 6722 as follows:

'Applying a correction factor of 3.4 to the GFAS wildfire emission inventory, fire emission heights turned out to be of limited importance compared to emission fluxes and removal processes.'