We thank all the reviewers for helpful comments that will improve our manuscript. Our responses are given in red.

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The manuscript by Aamaas et al. (2017) evaluates the impact of emissions changes resolved across four latitudinal bands on temperature change. Overall, this is a very valuable work, and we appreciate several aspects of this paper, especially the multimodel efforts and exploration of the role of altitude for BC. However, discussion of the works cited in this comment and associated caveats on the use of regional temperature potentials should be included.

The use of latitudinal bands stems from the work of Shindell and Faluvegi (2009) and Shindell (2012), which evaluated climate response to radiative forcing in these bands. However, we take issue with the application of these bands for defining relationships between emissions and radiative forcing, which ignores previously published work quantifying variability of radiative forcing efficiencies within these bands of more than an order of magnitude.

We have chosen to use the RTP-concept for our temperature calculations and since the Shindell sensitivities are the only ones currently available to us, we have to use those bands. As noted in our response to other reviewers, it would be highly desirable to have more refined calculations in the future. Our approach and focus could of course have been different. In the interest of space we have limited what we have referred to and discussed. However, we see that other aspects are relevant and we include some text and some of the references given, see answers below.

As noted by another reviewer, these regions are presented in Aamaas et al. (2017) arbitrarily in the context of relating emissions to radiative forcing, without consideration of more highly resolved regions, or – even more importantly – resolving emissions at scales other than latitudinal bands.

We might be misunderstanding this comment, as we did not look at emissions from latitudinal bands, but from regions such as Europe. The RFs were estimated by Bellouin et al. (2016), and most of the review comments would have been more suitable for that paper. See response to reviewer 4 on why we do not have higher resolution for the response than four latitudinal bands. While it would be interesting to look at emissions from smaller scales (such as what was done in Henze et al. (2012) and Bowman & Henze (2012)), we decided to investigate emissions for large regions. An improvement in our study is that we separate between summer and winter emissions.

Further, we have in our own work explicitly shown that radiative forcing efficiencies of aerosol (Henze et al., 2012; Lacey et al., 2015) and ozone (Bowman and Henze, 2012) precursor emissions vary tremendously – more than 1000% – across latitudes. For aerosols, the key features modulating radiative forcing efficiency are related to aerosol lifetime over surfaces of varying albedo and the chemical environment for forming secondary PM from gas-phase precursors (such as the ratio of ammonia to sulfate and nitric acid). Latitude has little bearing on aerosol radiative forcing efficiency, although (the Himalayan region aside) it does impact the indirect effects of BC deposition on snow and ice (Lacey et al., 2015). For short term ozone direct radiative forcing (DRF) efficiency, latitude is a key variable, but also factors such as atmospheric chemistry, altitude, and the efficiency of vertical mixing play important roles. For example, Bowman and Henze (2012) find that "NOx emissions in Chicago would lead to 0.01 mW/m2 change in DRF but the equivalent absolute reduction to emissions east of Atlanta would lead to a 0.035 mW/m2 DRF reduction."

We add a sentence in the introduction (the second paragraph) on the finer scales:

"While we focus on RF from large emission regions, Bowman and Henze (2012);Henze et al. (2012) showed that radiative forcing efficiencies can vary by 1000 % for much smaller emission regions."

We have also added a paragraph in the uncertainty section:

"The ARTP values are given for large emission regions, while large variations are likely within the regions. The impact of emissions from an European city may be very different to the average we have estimated for European emissions (see Bowman and Henze, 2012;Henze et al., 2012). They found that the key determinants for aerosols are the aerosol lifetime, surface albedo, and the chemical environment. Latitude is a key variable for ozone, but atmospheric chemistry, altitude, and vertical mixing play also a role."

We hope that a revised manuscript from Aamass et al. will consider these important factors in their presentation and evaluation of regional temperature potentials, explicitly stating the uncertainties in application of their coefficients to evaluate temperature impacts of emissions changes at scales other than latitudinal bins. For example, while the latitudinal dependency of climate sensitivities imparts a strong-latitudinal dependence on the overall regional temperature potentials for emissions, the sub-latitudinal impact of emissions on radiative forcing can lead to important differences in the temperature impacts of equivalent changes to emissions in country-scale cookstove mitigation sce-narios (Lacey and Henze, 2015; Lacey et al., 2017).

We have added some more text on uncertainty based on our response to other reviewers. But we have not calculated temperature impacts based on emissions in latitude bins. We have calculated temperature due to emissions from regions, which is very similar to Lacey and Henze (2015) & Lacey et al. (2017), just at a cruder scale.

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Bowman, K. W., and D. K. Henze (2012), Attribution of direct ozone radiative forcing to spatially-resolved emissions, Geophys. Res. Lett., 39, L22704, doi:10.1029/2012GL053274.

Henze, D. K., D. T. Shindell, F. Akhtar, R. J. D. Spurr, R. W. Pinder, D. Loughlin, M. Kopacz, K. Singh, and C. Shim (2012), Spatially refined aerosol direct radiative forcing efficiencies, Environ. Sci. Technol., 46, 9511 - 9518, dx.doi.org/10.1021/es301993s.

Lacey, F., and D. K. Henze (2015), Global climate impacts of country-level primary carbonaceous aerosol from solid-fuel cookstove emissions, Environ. Res. Lett., 10, 114003, doi:10.1088/1748-9326/10/11/114003.

Lacey, F., D. K. Henze, C. Lee, A. van Donkelaar, R. V. Martin (2017), Transient climate and ambient health impacts due to national solid fuel cookstove emissions, Proc. Nat. Acad. Soc., doi:10.1073/pnas.1612430114.