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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Regional and seasonal radiative forcing by perturbations to aerosol and ozone precursor emissions" *by* Nicolas Bellouin et al.

Anonymous Referee #1

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The manuscript documents results of specific radiative forcing (SRF) for near-term climate forcers (NTCFs) from multi-model simulations conducted under the auspices of the European project - Evaluating the Climate and Air Quality Impacts of Short-lived Pollutants (ECLIPSE). SRFs for NTCF emissions from two source regions, the shipping sector and global contributions from four global models (three chemistry-climate models and one chemical transport model) are discussed in detail providing some explanation of diversity in the results. The analysis generates estimates of region- and sector-specific SRFs and shows that diversity in these estimates comes from differences in the configuration of the control simulations in addition to the structural differences (e.g. not all models explicitly representation of aerosol indirect effects). The

paper falls within the scope and aims of ACP and is appropriate for publication. However, I found it difficult to discern new scientific knowledge generated in this work that will help advance our understanding of the influence of NTCF on climate. As such, SRF is just another way or metric for evaluating a species' radiative forcing (RF). I understand the need for considering RFs in the context of emissions of NTCFs (or their precursors), but the emissions; even the present-day estimates, themselves are highly uncertain (e.g., Granier et al., 2011). Further, from past research (as highlighted on page 5), we know that BC aerosols, methane and carbon monoxides exert positive RF, and OC, SO2, and NH3 exert negative RF. How important are monthly/seasonal RFs for understanding surface temperature response to NTCFs? If the intention of the paper is to motivate discussions on including NTCFs in a climate mitigation policy, I am not sure what to make of such diverse SRF estimates. Analyzing multi-model results is no mean feat especially in the face of model structural diversity, inconsistent simulations, and incomplete output. I commend the authors for their efforts, however, I question the value of such diverse numbers produced in this manuscript. I am, therefore, unable to recommend the publication of this paper in its current form. Below, I provide some specific comments to address issues with the paper.

Specifica Comments:

The introduction is too long. It starts out by providing a text-book summary of the radiative influence of NTCFs, describes tropospheric ozone chemistry and interactions that have radiative feedbacks, and so on until the last paragraph of page 7 where the aims of the study is described. I think much of the information up until page 7 can be condensed. For example, the tropospheric ozone chemistry and its interactions with aerosols has been covered extensively in several review papers - some recent ones are Schneidemesser et al., (2015) and Fiore et al., (2015). Paragraph 1 on page 3 and para 2 on page 4 can be combined to define RF/ERF calculations and describe the influence of aerosols. Finally, the focus should be on why regional and seasonal SRFs are important, what do we know about NTCF SRFs from previous studies (2nd paragraph on page 5) and how does this study advance the knowledge base by systematically analyzing SRFs from different models.

Page 4, line 9: Typo 'Goddart'

Page 9, lines 3-5: Please give references here.

Models and Experiment protocols: It is not clear if the 1 year simulations of CCMs (ECHAM6-HAM2, HADGEM3-GLOMAP and NorESM1) are performed in free-running mode or with fixed SST and sea-ice, or in the nudged mode with meteorological fields from reanalysis.

Page 10 lines 20-21: It would be helpful to see the spatial distribution of NTCF (or their precursor) emissions.

Page 10, Lines 21-22: It is not entirely clear what "heating" the authors are talking about. One can guess that this is the winter time heating of homes, but then the audience should not have to guess, right? Is there any analysis of how realistic the seasonal cycle in domestic emissions is?

Page 10, line 29-30: It is mentioned that results of "that last region" (Rest of the World-RotW) are obtained by adding Europe, East Asia and RotW. Why are all of these added to produce Rest of the World SRFs?

Page 11, line 1: Reference needed after "climate policy objectives".

Page 11, line 7: Referenced needed after "policy agenda".

Page 11, lines 15-17: Is it too late to correct these mistakes? These obviously add to the diversity in the SRFs for shipping.

Page 11, lines 17-21: Differences in the VOC species considered by the models (because of differences in chemical mechanisms implemented in the model) are a significant source of diversity in the simulated tropospheric ozone (Young et al., 2013). This should be highlighted here.

Page 11, lines 23-25: Do the models prescribe global mean surface CH4 concentrations or apply a latitudinal variation?

Page 13, 1st paragraph: How do methane lifetimes compare across models? ACCMIP studies have revealed diversity in simulated OH and CH4 lifetimes (Naik et al., 2013; Voulgarakis et al., 2013). Do the models considered here also suffer from this diversity?

Page 13, line 3: "BC lifetime is longer" than what? The statement is not clear.

Page 13, lines 7-10: This is a very broad-brush way of dealing with diversity. Can we not learn anything about what drives diversity in lifetimes from further analysis of model output?

Page 13, lines 18-22: Please qualify these statements with references or point the reader to a particular table that lists the papers that evaluated ECLIPSE models.

Biases and scaling of specific radiative forcing: Please consider condensing this section. There is no new evaluation presented in the two paragraphs on page 14. The discussion is referring to results from other papers, which can be succinctly summarized in section 3 to explain the results.

Section 3 - How do the SRFs for O3 and its precursors calculated here compare with estimates from previous studies including - Naik et al. (2005), Fry et al., (2012), Fry et al. (2013). Fry et al. (2014)

Page 16, lines 21-23, 28-30: I am not sure if I follow the discussion here. On lines 21-22, it is mentioned that the ari is stronger in winter than in summer but then on line it is mentioned that the SO2 is SRF is stronger for summer than winter. This appears contradictory.

Page 18, lines 15-17: Please insert a reference here to support this statement that O3 and CH4 RF are affected by BC perturbations via heterogeneous reactions.

Page 22, section 3.3: Are secondary organic aerosols (SOA) included in the quantification of OC SRFs?

Page 38, lines 19-21: There are several studies in the literature that have studied regional O3 SRFs some of which have been highlighted in my comments above. These need to acknowledged here.

References: Granier et al., (2011), Evolution of anthropogenic and biomass burning emission of air pollutants at global and regional scales during the 1980–2010 period, Clim. Change,109, 163–190.

Fiore et al., (2015), Air quality and climate connections, J. of Air & Waste Management, 65:6, 645-685, doi: 10.1080/10962247.2015.1040526.

Fry et al. (2012), The influence of ozone precursor emissions from four world regions on tropospheric composition and radiative climate forcing, J. Geophy. Res., 117, D07306, DOI:10.1029/2011JD017134

Fry et al. (2013), Net radiative forcing and air quality responses to regional CO emission reductions, Atmos. Chem. Phys., 13, 5381-5399, doi:10.5194/acp-13-5381-2013.

Fry et al (2014), Air quality and radiative forcing impacts of anthropogenic volatile organic compound emissions from ten world regions, Atmos. Chem. Phys., 14, 523–535, 2014

Naik et al. (2005), Net radiative forcing due to changes in regional emissions of tropospheric ozone precursors, J. Geophys. Res., 110, doi:10.1029/2005JD005908

Naik et al. (2013), Preindustrial to present day changes in tropospheric hydroxyl radical and methane lifetime from the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP), Atmos. Chem. Phys., 13, 5277-5298, doi:10.5194/acp-13-5277-2013

von Schneidemesser et al., (2015), Chemistry and the Linkages between Air Quality and Climate Change, Chem. Rev. 2015, 115, 3856−3897, DOI:

10.1021/acs.chemrev.5b00089.

Voulgarakis et al. (2013), Analysis of present day and future OH and methane lifetime in the ACCMIP simulations, Atmos. Chem. Phys., 13, 2563-2587, doi:10.5194/acp-13-2563-2013

Young et al. (2013), Pre-industrial to end 21st century projections of tropospheric ozone from the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP), Atmos. Chem. Phys., 13, 2063-2090.

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