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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Trends in air pollutants and health impacts in three Swedish cities over the past three decades" *by* Henrik Olstrup et al.

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First of all, we would like to thank the Reviewer for constructive comments and technical corrections! The changes in the manuscript have been made with track changes. The whole discussion section has been substantially revised, and large parts have been exchanged. Below follow the comments and our answers marked with yellow. Reviewers Comment: The discussion and conclusions should focus more on policy implications for emission as should be expected by a manuscript on pollution trends. Answer: We have expanded the Discussion with a new section 4.7, "Policy implications", and also added a sentence at the end of the section "Conclusions". Reviewers Comment: Page 2, lines 20-22: While the decline of NOx emissions in the EU is larger as compared to PM, it is probably not as efficient as it has been initially projected (see the rates of at-

tainment of national emission ceilings specified by the original NEC directive) and there is also a lot of between-country variation. Answer: We added a comment: It should also be noted that there are large between-country variations in NOx emission trends partly reflecting that some countries have had problems meeting the original National Emission Ceilings and the Air Quality directives (EEA, 2017). Reviewers Comment: Page 2, lines 23-30: The trend for O3 levels with regard to the target value for the protection of human health, during the period 1990-2014 in the EU, has been rather a decreasing one. This has to be taken into account and make a distinction between mean ozone levels and higher percentiles more relevant for short-term exposure. The importance of the O3 metric is already mentioned in line 28, but the authors should avoid indicating that O3 levels are increasing all over the board in Europe. Answer: We have added a comment: "Trends in ozone are also different for summer and winter, with mainly decreasing trends in summer and increasing in winter, and there are also some variations between cities in the EU (see EEA, 2016)." Reviewers Comment: Page 3: lines 14-21: It would be better to provide the fractional changes of premature mortality instead of the net numbers, especially since the populations to which the studies refer can't be adequately described in an introductory section. Answer: We agree that it would be beneficial to include the fractional changes. Unfortunately, since there are no information available regarding the fractional changes in the studies which have been referred to, we have kept the premature mortalities as net numbers instead of fractional changes. Reviewers Comment: Page 4, lines 20-30: Indicate if these stations are regulatory monitoring stations which provide measurements according to the reference methods. Answer: We added this info: They are all regulatory monitoring urban background stations using reference methods. Reviewers Comment: . Page 4, line 21: Indicate the sampling height in Malmo. Answer: We have added the sampling height of 20 m. Reviewers Comment: Page 6, line 9: The value selected for NO2 differs from the one reported by Beelen et al. (2014) in the study which also provided the PM10 RR used here. This should be discussed in section 4.4. Answer: The choice of RR in Faustini et al. (2014) instead of using Beelen et al. (2014) have been motivated in section

4.4. Reviewers Comment: Figures 3-4: There are some extremely low mean monthly values for PM10 in Gothenburg and NOx -NO2 in Malmo. Provide an explanation, is it meteorology or else? Answer: For NOx and NO2, we found some erroneous data that explained the low values. Therefore, Figure 4 has been replaced. The median trend is unaltered, while the upper and lower confidence interval only decrease by one hundredth μg m-3. For PM10, the low values are due to the way that the deseasonalisation is modelled. When we disregard the deseasonalisation, these extreme low values are not present. But we have decided to keep the deseasonalisation of the trend, in order to be consistent with all the other calculations. Reviewers Comment: Table 1: The Table repeats the information of Figures 2-4. It should be removed altogether. Answer: OK, Table removed.

Reviewers Comment: Section 4.1.: The section needs an overhaul. The discussion should be performed by pollutant at the first level and then city specific mentions should be made where important differences occur. More clarity is needed in the argumentation. The potential impact of regional emission reductions from non-transport sources should be incorporated in the discussion. Answer: Section 4.1 has been revised substantially. The discussion is based primarily on the pollutants and secondarily on the cities. The potential impact of regional emission reductions from non-transport sources has been incorporated Reviewers Comment: Page 16, line 12: Correct the phrasing here. Also, it is not clear how the dieselization has led to the reduction of NOx emissions. Krecl et al. (2017) report that NOx have remained constant during the process. Please elaborate. An indication of the change in the vehicle parc composition should be given in number. Answer: We have changed this and refer to statistics on diesel shares from BilSweden (2018). Reviewers Comment: Page 16, lines 14-15: How does the location affect the trend? Indicating the distances from major roads could be informative, although the reported sampling heights are probably too large to represent direct road traffic emissions. Answer: We agree, and we have removed this. Reviewers Comment: Page 16, lines 20-23: Given the site types and the sampling heights, it is somewhat doubtful that the primary NO2 variability could be captured. Answer:

Yes, we agree, and this is also clearly stated in the text in Section 4.1.1. Reviewers Comment: Page 17, line 21: The whole discussion regarding the increasing ozone trend is obviously founded on the assumption that photochemical processes for ozone production in Sweden should be of minor importance. Otherwise the reduction of precursor emissions would generally lead to the long-term reduction of ozone as well, as it has been observed in various studies. Please, better clarify the dominant mechanism explaining the O3 presence in the urban setting. Answer: The concentrations of ozone are lower at central urban background sites in the cities compared to outside the cities at rural background sites. This means that the net effect of the photochemistry involving ozone in the cities is that ozone is consumed, mainly due to the titration involving NOx.

Reviewers Comment Page 17, lines 29-31: Given that PM10 has been associated with vehicular emissions, shouldn't a similar to NOx weekday-weekend pattern be observed? Justify this difference. Answer: The main local source of PM10 is road wear and road dust suspension (clearly seen in Stockfelt et al., 2017 and Segersson et al., 2017). Since the emissions of road dust strongly depend on the wetness of the roads, as shown by Johansson et al. (2007) and Denby et al. (2013), the diurnal cycles will not follow the same pattern as vehicle exhaust from traffic. Reviewers Comment Page 18, lines 7-10: The hypothesis for the whole period cannot be supported by just one year of data and moreover these regional background data should be better described. Also, it is not clear why there aren't long term regional background NOx data available, when at Page 17, line 32 the availability of such data for NO2 is stated. Answer: This part is rewritten with a new Section 4.1.1. Local and non-local contributions are explained more detailed, underpinned with several new references. The regional background stations are described in Section 4.1.2. Reviewers Comment Page 20, line 24-34: The study which provided the RR for PM10 includes similar results on mortality associations for PMcoarse. This could be discussed. Answer: Since PM10 to a large extent consists of mechanically generated coarse particles in the Swedish cities, the similar results on mortality associated with PMcoarse in Beelen et al. (2014) provide increased support

for the RR that has been used. We have added a few sentences about this in Section 4.4, where RR associated with PM10 exposure is discussed. Technical corrections: Page2, line 7: Check phrasing ("ending"). The phrasing has been changed. Page 2, line 11: Check phrasing, you could replace with ". . .of the apparent major health impact of exposure to air pollutants...". It is changed to "associated with"

Page 2, line 14: Delete "amount of". Deleted Page, 2, line 16: Equals sign not in subscript. Changed Page 4, line 13: . . .represents the urban background. "the" urban is inserted. Page 4, line 13-18: Remove the coordinate information. Removed. Page 5, line 21: Delete "decreasing". Deleted. Page 6, line 22: Replace "increase" with "change" We don't want to change increase to "change", because it becomes illogical in relation to the following sentence, where the word decrease has been used. Page 7, lines 25-30: This information is already provided in the Figure caption. Remove accordingly from the text. Figure 5: Ensure that Malmo is spelled consistently throughout the manuscript. Lines 25-30 are removed, and the spelling Malmo is used consistently, including Figure 5. Page 14, lines 8-9: Check phrasing. It should be "If the change in O3 was only associated with local NO titration. . .". Increase is changed to "change". Page 16, line 10: Decrease and diminish, pick one. The whole section 4.1 has been changed. Page 19, line 14: Can be compared or can't compare? Please rephrase the sentence. Can is changed to "cannot". Page 19, line 16: Delete "extra". Deleted Page 20, line 12: "exposure occurs simultaneously"? What is meant here? Probably it refers to peak exposures. The same in section 4.5. It means that environmental exposures to NO2 and NO usually occur simultaneously, since the urban air contains both of these pollutants in varying proportions. Determining the effect of each pollutant can therefore be difficult. In Section 4.5 we clarify that double calculations regarding change in life expectancy occur if the effect of NOx and NO2 is summarized, but this is not the case for the others pollutants, where the effects are assumed to be independent of each other. Page 20, line 15: "Especially difficult is it. . .". Correct wording. This part has been removed Page 20, line 23: "Observed materials"? It is changed from "less observed materials" to "less amount of data" Page 21, line 28: You mean the population

distribution within the cities? Yes, "data" is changed to "distribution". Page 22, line 29: NO2 is formed by the reaction of nitric oxide with O3. Reformulated. Figure A1-A4: Correct decimal separators. The commas have been changed to point characters. References Beelen, R., Raaschou-Nielsen, O., Stafoggia, M., Andersen, Z. J., Weinmayr, G., Hoffmann, B., Wolf, K., Samoli, E., Fischer, P., Nieuwenhuijsen, M., Vineis, P., Xun, W. W., Katsouyanni, K., Dimakopoulou, K., Oudin, A., Forsberg, B., Modig, L., Havulinna, A. S., Lanki, T., Turunen, A., Oftedal, B., Nystad, W., Nafstad, P., De Faire, U., Pedersen, N. L., Östenson, C. G., Fratiglioni, L., Penell, J., Korek, M., Pershagen, G., Eriksen, K. T., Overvad, K., Ellermann, T., Eeftens, M., Peeters, P. H., Meliefste, K., Wang, M., Bueno-de-Mesquita, B., Sugiri, D., Krämer, U., Heinrich, J., de Hoogh, K., Key, T., Peters, A., Hampel, R., Concin, H., Nagel, G., Ineichen, A., Schaffner, E., Probst-Hensch, N., Künzli, N., Schindler, C., Schikowski, T., Adam, M., Phuleria, H., Vilier, A., Clavel-Chapelon, F., Declercq, C., Grioni, S., Krogh, V., Tsai, M. Y., Ricceri, F., Sacerdote, C., Galassi, C., Migliore, E., Ranzi, A., Cesaroni, G., Badaloni, C., Forastiere, F., Tamayo, I., Amiano, P., Dorronsoro, M., Katsoulis, M., Trichopoulou, A., Brunekreef, B., and Hoek, G.: Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project, Lancet, 383, 785-95, doi: 10.1016/S0140-6736(13)62158-3, 2014 BilSweden, 2018. http://www.bilsweden.se/statistik/arkiv-nyregistreringar_1 (2018-08-29) Denby, B.R., Sundvor I., Johansson C., Pirjola L., Ketzel M., Norman M., Kupiainen K. Gustafsson M., Blomqvist G., Omstedt G. 2013a. A coupled road dust surface moisture model to predict non-exhaust road traffic induced particle emissions (NORTRIP). Part 1: Road dust loading and suspension modelling. Elsivier, Atmospheric Environment 77, Volym 77, pp. 283-300. EEA, 2016. Air quality in Europe âĂŤ 2016 report, No 28/2016. European Environment Agency. ISSN 1977-8449. EEA, 2017. Air quality in Europe âĂŤ 2017 report, No 13/2017. European Environment Agency. ISSN 1725-9177 Faustini, A., Rapp, R., and Forastiere, F.: Nitrogen dioxide and mortality: review and meta-analysis of long-term studies, Eur. Respir. J., 44, 744-753. doi: 10.1183/09031936.00114713, 2014 Johansson, C., Norman, M., and Gidhagen,

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