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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Spatiotemporal variations of air pollutants (O_3, NO_2, SO_2, CO, PM_{10}, and VOCs) with land-use types" *by* J.-M. Yoo et al.

J.-M. Yoo

yjm@ewha.ac.kr

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We appreciate the reviewers' comments for improving our manuscript. Our response to the comments is given below. All responses refer to the revised version. Response to Referee #1 Scientific comments: Q1) Since the study presents an outlook on Ozone control strategy in South Korea, it would be reasonable to also mention what are the standards of Ozone set by the Korean govt. and are the current levels already exceeding those standards?

A1) Thank you very much for your nice suggestion. The standards of the surface O3 concentration for its government control in South Korea are less than 0.1 ppm for the O3 average during one hour, and less than 0.06 ppm for the O3 average during

eight hours (NIER, 2010). Furthermore, The Korean Ministry of Environment developed standards for the public with three warning stages based on the surface ozone concentrations: 1) 'ozone alert' for concentrations of 0.12 ppm/hr or higher, 2) 'ozone warning', 0.3 ppm/hr or higher, and 2) 'ozone grave warning', 0.5 ppm/hr or higher. In South Korea, on an annual average basis, ozone alerts have been issued about 84 times for 28 areas (cities), and ozone warnings have also been issued about 83 times for 27 areas (cities) during the 12-year period. According to Table 5 of this study, surface ozone values vary seasonally from 0.018 ppm in winter to 0.035 ppm in spring, which are 15-30% of the minimum warning standard (i.e., that for ozone alert). However, given the increasing trend of surface ozone (Fig. 7a), it will be necessary to continuously monitor its concentrations and keep making efforts to reduce the level. (https://seoulsolution.kr/content/ozone-warning-system-ozone-warning-system-protect-citizens%E2%80%99-health?language=en). Please see Lines 537-549 of New Version.

Q2) Please be more clear on why were the data points converted to gridded data-mention the need to grid the data into 0.1 deg and 0.25 deg. This has to be especially justified because in this study no grid to grid comparison has been made with any other similar dataset, say a model output or satellite data of pollutant concentrations. Also, during the gridding no interpolation has been made in the interior points of the study area (which is often the purpose of gridding a dataset- to fill up missing points). Therefore this has to be justified strongly (for example- two stations might have been very close to each other and how gridding will remove bias, etc.)

A2) In this study we rearranged the non-gridded pollutant data on the two spatial grids ($0.1°\times0.1°$ and $0.25°\times0.25°$) to examine urban characteristics of the gridded land-use type data due to the non-uniform distribution of the pollution monitoring stations. The pollutants, except for VOCs, were investigated as time-averaged in the two spatial grids after categorizing the 283 station data in the four land-use types. The stations are mostly located in the urban areas with a very sparse distribution in the rural areas (Fig.

1). The higher spatial resolution of the $0.1^{\circ}\times0.1^{\circ}$ grid generally tends to represent the characteristics of large urban cities better than in suburban regions, when they were compared to those of coarser resolution (i.e., $0.25^{\circ}\times0.25^{\circ}$). For example, the more urbanized stations over the SMA contribute more to the number of the high resolution grid than that of the low resolution grid. In other words, since the number of stations are larger in the big cities (i.e., more urban features) than in the small cities (i.e., fewer urban features), the higher resolution grid displays more in the former cities than in the latter. Although this tendency is also shown in the lower resolution grids, the weighting effect of the big city characteristics is more substantial in the $0.1^{\circ}\times0.1^{\circ}$ grid than in the $0.25^{\circ}\times0.25^{\circ}$ grid. Because of the difference in the numbers of stations in each grid, the grid numbers that returned valid grid-averages of observations at the $0.1^{\circ}\times0.1^{\circ}$ and $0.25^{\circ}\times0.25^{\circ}$ resolutions with respect to the non-gridded 283 stations were reduced to 196 (R; 89, C; 42, I; 32, G; 33) for the $0.1^{\circ}\times0.1^{\circ}$ and 146 (R; 59, C; 30, I; 25, G; 32) for the $0.25^{\circ}\times0.25^{\circ}$ resolutions, respectively. Different land-use type data (e.g., two residential and three greenbelt stations) can coexist in a given grid. In this case, the pollution data in the grid have been utilized for the arithmetic average calculation for the residential and greenbelt types, respectively. The choice of either $0.1^{\circ} \times 0.1^{\circ}$ or $0.25^{\circ} \times 0.25^{\circ}$ grid boxes as an optimal spatial grid scale represents a compromise based on keeping the intrinsic spatial variability of the pollutants (O3, CO, NO2, SO2 and PM10) of interest, namely their concentrations, at comparable levels and still having large enough total sample size, i.e. the number of grid boxes with the pollutant data, for a robust computation. The variability has been examined in terms of some dimensionless measure (i.e., the ratio of standard deviation (σ) to mean (X ÌĚ); Yoo et al., 2014) in the climatological annual average distribution of the pollutants. The σ/X ÌĚ values for the five air pollutants at the two different types of grids range from 15.0 % to 45.0 %. Since the σ/X ÌĚ values at a $0.1^{\circ} \times 0.1^{\circ}$ grid are 16.3-44.0 %, they are within the range (15.0-44.9 %) at a $0.25^{\circ} \times 0.25^{\circ}$ grid (Table A1). A separate section (i.e., section 3) was added to the text in order to address the grid issue of Referee #3 (New Version; section 3, Lines 273-305).

Table A1. Values (%) of intrinsic spatial variability for pollutant concentrations at the two spatial grids of 0.1o x 0.1o and 0.25o x 0.25o, respectively, in terms of σ/X ÌĚ. Here the values of mean (X ÌĚ) and standard deviation (σ) for the pollutant variables can be obtained from the annual average distribution. σ/X ÌĚ (%) at a 0.1o x 0.1o grid σ/X ÌĚ (%) at a 0.25o x 0.25o grid O3 23.5 24.3 CO 22.4 22.2 NO2 44.0 44.9 SO2 36.6 34.9 PM10 16.3 15.0

Q3) Line no. 10 page no. 16998: “These results suggest that the meteorological conditions.... level of pollutants”- be more clear on this. What do you exactly mean by the “seasonality” and “level” of pollutants and how are they different? Elaborate.

A3) The word ‘magnitude’ has been used instead of ‘level’ to clarify the sentence (New Version; Line 343).

Q4) While gridding the datasets, which interpolation method was used? (for example bilinear interpolation, etc) and why was it chosen over other methods?

A4) Please see A2.

Q5) The idea of ranking the pollutant with respect to land-use is interesting.

A5) Thank you for your comment.

Q6) Line no. 9 page no. 17003, “The NO2 wintertime maxima could be associated with fossil fuel consumption and photochemical oxidation of NO to NO2”. Why not also due to lower PBL height during winter?

A6) We added ‘the lower PBL’ to the text (New Version; Line 468).

Q7) The method used to verify the 4 land use categories (Residence, Commerce, Industry and Greenbelt) using MODIS and AVHRR satellite products (and the results produced in Figure 3) is very interesting and has to be appreciated.

A7) Thank you for your comment.

Grammatical/Language corrections: Q8) Please remove “respectively” in line no. 14 page no. 16987 (abstract), as it is unnecessary.

A8) Corrected (New Version; Line 31).

Q9) Remove “over” in line no. 24 page no. 16989

A9) Corrected (New Version; Line 92).

Q10) In line no. 2 page no. 16996, please mention the table no. in “In the table”.

A10) Corrected (New Version; Line 250).

Q11) Line no. 27 page no. 16998, correct the units of PM10.

A11) Corrected (New Version; Line 355).

Q12) Line no. 5 page no. 17005, “..the local part related with the background..”. Double check with grammar.

A12) The ‘contribution’ word has been used instead of ‘part’ to clarify the sentence (New Version; Lines 514-515).

Q13) Line no. 20 page no. 17011 “and, therefore, thus the VOC...”. Please remove either “therefore” or “thus”.

A13) Corrected (New Version; Line 704).

Q14) Line no. 16 page no. 17014 “The weekly cycles of the ratio were almost negligible except for several stations.” Correct grammar here. Use something like “except for some stations”. It cannot be “almost negligible” if it is not negligible in “several” stations.

A14) The word, ‘several’, is changed into ‘some’ (New Version; Line 779).

Q15) Line no. 29 page no. 17014, correct “Jin at al.” to “Jin et al.”

A15) Corrected (New Version; Line 791).

Q16) Line no. 24 page no. 17016 correct “..was more pronouced in the layer of the planetary boundary layer (PBL)” to “...was more pronounced in the planetary boundary layer (PBL)”

A16) Corrected (New Version; Line 840).

Q17) Avoid using redundant statements in the conclusions section. For example in line no. 11 page 17018

A17) The redundant expression ‘suburban areas of’ has been removed in the text (New Version; Line 880).

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/15/C5658/2015/acpd-15-C5658-2015-supplement.zip

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Interactive comment on Atmos. Chem. Phys. Discuss., 15, 16985, 2015.