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## ***Interactive comment on “Spatiotemporal variations of air pollutants (O<sub>3</sub>, NO<sub>2</sub>, SO<sub>2</sub>, CO, PM<sub>10</sub>, and VOCs) with land-use types” by J.-M. Yoo et al.***

### **Anonymous Referee #3**

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This manuscript provided an interesting study about the long-term air pollutant levels in South Korea. The authors innovatively investigated the spatiotemporal distribution of pollutants base on land-use types. The topic is applicable for Atmospheric Chemistry and Physics; however several concerns have been identified. Major revisions as indicated in the comments and remarks below are needed before consideration of publication in ACP.

Generally, the current manuscript is not well organized and not concisely written, which makes it hard to read. For instance, in section 2 ‘Data and Method’, the authors referred to Figures 7 and 8 (Page 16994) and discussed the land-use types (Page 16996). These explanation and discussion related to results should not be included in section 2. Lots of sentences in the current manuscript are not concise, for example, in Page

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16999 Line 17-18), I don't think the authors need to list all the air pollutants investigated in Flemming et al. and Meng et al. Examples of not concise writing include: in Page 17009 Line 14, listing the unit of NO<sub>2</sub> is not necessary; explanation about the instruments in section 2 is good but it contains too many details. There are so many places are redundant or repeat presenting same information. Especially in the conclusion part (section 8), the authors just list all the results discussed in previous chapters. It lacks emphasizing the major significance of this paper and does not discuss the possible uncertainty/error introduced in this analysis. In summary, careful revision of the manuscript is suggested to make it more concise and focused on the scientific contribution of this study.

The authors used two spatial resolutions of grids, 0.1 D and 0.25 D. However, after reading section 2, I still do not understand how these 283 site data are averaged into the 0.25 and 0.1 degree grids. Do the grids cover the whole South Korea and data are grouped into each grid? I also find one grid could be attributed to multiple land-use type, e.g. in Figure 5 areas near Seoul have been attributed to R, C, and I. How the data are processed? Also for readers who are not familiar with South Korea, it is hard to tell if the grids are urban, suburban, or rural, as well as the locations of major cities such as Seoul, Daegu, and Busan. Therefore, one map showing the raw AVHRR or MODIS land-use data and locations of the major cities is suggested. Another question is, after using 0.25 and 0.1 gridded data, what conclusion the author achieved? What are the pros/cons for each method? I found the current manuscript used both of them simultaneously and discuss the difference, but have any conclusions have been drawn? Overall, since the land-use types gridded are so important, I suggest the author add a separate section discussing this important part.

Data presented in this study are very comprehensive, and show the regional nature and trends of air pollution in South Korea. However, the current manuscript doesn't discuss the possible influence from the changing world in the past decade. For instance, can the change of Asian summer monsoon influence the summertime ozone

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pollution? How are the effects of land-use change on air pollution? Has any member from monitoring sites, 0.1 or 0.25 grids been influenced by the recent expanded urbanization? For instance, how the Seoul or SMA expanded in the past decade, did the land-use types of sites in or near SMA change from G to R/C? The revised manuscript should take them into account and discuss their potential impacts.

#### Detailed Remarks/Suggestions for Revision

Page 16988 Line 14: As discussed above, details such as ‘for NO<sub>x</sub>’ are not necessary. Using ‘Kim et al. 2011’ is suggested. Also ‘Wang et al. 2013’ does not discuss the transport of air pollutants from China, please consider using the following two papers as references:

Li C., N. A. Krotkov, R. R. Dickerson, Z.Q. Li, K. Yang, and M. Chin: Transport and Evolution of a Pollution Plume from Northern China: A Satellite-Based Case Study, *J. Geophys. Res.*, 115, D00K03, doi:10.1029/2009JD012245, 2010.

He H., C. Li, C. Loughner, Z. Li, N. A. Krotkov, R. R. Dickerson: SO<sub>2</sub> over Central China: Measurements, numerical simulations, and the tropospheric sulfur budget, *J. Geophys. Res.*, 117, D00K37, doi:10.1029/2011JD016473, 2012.

Page 16994 Line 19: Why Figure 7 & 8 were introduced before Figure 2-6? This section should only describe the dataset and method used in this study, so I don’t think Figures that are discussed later should be mentioned here.

Page 16992 Line 10-12: As discussed in the general comments, please provide detailed information about how to create these grids.

Page 17000 Line 3: As discussed above, please provide a map of South Korea showing the major cities. Line 23-30: It is hard for me to comprehend the Table 6 and 7. For instance, in line 24, it states ‘Table 6 shows the magnitude order ...’. What is the definition of ‘magnitude order’? Also I didn’t see any information about the order. Does Table 6 accidentally have the content of Table 7? Please re-write these sentences. Line

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18: The production of O<sub>3</sub> is through 'photochemical reactions'

Page 17003: Line 9-10: The high concentrations of NO<sub>2</sub> could also be caused by shallow PBL and slow photolysis rate. Line 20-22: Due to faster photochemical reactions in summer, the atmospheric lifetimes of SO<sub>2</sub> and NO<sub>2</sub> are substantially shorter. So if the transport from China dominates, it could be as important as summer Asian monsoon. Further discussion is suggested here. Line 26-27: As discussed in the general comments, this sentence described the different characteristics of 0.1 and 0.25 degree grids. It should be emphasized in the conclusion part.

Page 17008 Line 23-26: It is hard to comprehend, especially 'Seoul was defined as part of the SMA' while you have 3 regions with/without the capital city. I found Figure 9b has this information, so it should be mentioned here.

Page 17010: Line 2-3: The 'residence' areas should also be close to main and secondary roads. Why all the regions next to roads are attributed to 'commerce' in this study? Line 20: Same questions as above, 'residence' areas should have lots of traffic emissions, so how can all the areas close to roads are grouped to 'commerce'. I am confused, and further explanation/discussion is expected.

Page 17012 Line 25-25: What could be the cause? Any possible explanation? Is Seokmo downwind of major sources? A map showing these monitoring sites as well as major cities is suggested.

Page 17016 Line 4-7: The authors cited the studies in South California to discuss the 'VOCs-limiting' photochemistry intensively in this manuscript. Based on VOCs concentrations presented in Figure 10 (VOCs in G is much lower than VOCs in R/I/C), VOC measurements only focus on the traces of anthropogenic VOC emissions such as benzene, and toluene. However, at least in the G areas biogenic VOCs emissions such as isoprene could dominate. Are there any measurements or previous studies confirming that the anthropogenic VOCs suppress the influences from biogenic sources in South Korea as the study in Southern California of late 1990's? i.e., do South Korea and

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South California have the similar ozone photochemistry.

Page 17017 Line 15: The current conclusion part only re-listed all the results, and some of the materials are redundant. Rewriting (focusing on the scientific contribution of this study) is suggested. Also adding discussion of the possible uncertainty of this analysis is necessary.

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