

Interactive comment on “Novel index to comprehensively evaluate air cleanness: the “Clean Air Index”” by Tomohiro O. Sato et al.

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[Overall summary] It is highly appreciated that the author defined “Clean Air Index = CII” as a new concept and aimed to apply it worldwide. The author has developed “CII: Air Cleanliness” for the first time in the world and proposed to set it as an international standard of air quality, which has been diverged in various countries until now. It contributes to environmental science in that air quality observation and future prediction can be done quantitatively. It also contributes to social aspects such as utilization in urban planning. “Delicious air” is of great interest in areas with severe environmental problems (especially China, Vietnam, Thailand, Indonesia, etc.). CII is an important factor for people moving abroad or staying longer. In addition, it is wonderful to open up the possibility of using CII to set a standard for incorporating “delicious air” as a tourism

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resource. CII can also be highly evaluated for its potential to become a standard for tourism and migration.

[Comments and questions for the whole] ĩĈij The reliability of CII is not a problem because it uses the index set by WHO. ĩĈij Is there a correlation between the global distribution of CII and healthy life expectancy in each country? ĩĈij I think that it is too few to carry out model verification at 6 points. Why did it not be done at all points? ĩĈij Can you visualize the global distribution of CII in near real time? What tools do you need to do that? ĩĈij When creating CII for countries other than Japan, especially for emerging countries such as Africa and Southeast Asia, is there any data equivalent to that of the Japanese Ministry of the Environment? ĩĈij The goal of making CII as a global standard should be clearly stated as an issue for the future and written in the abstract. ĩĈij Please tell us why you normalized human activity in the population. Since this paper uses NO₂ and SO₂ for CII, I thought that the number of cars and the number of factories were more appropriate than the population density. ĩĈij Are there any plans to visualize the CII information on Web system in the future? Developing the system which can overlay CII with other information (disaster prevention and disaster prevention information app) and enable easy access to thematic map, e.g. land risk assessment, would be one of social implementations. ĩĈij Can you create CII for other countries with significant air pollution? For example, China, Southeast Asia, India, Nepal, Mongolia and Ulaanbaatar. ĩĈij Although there is a solid observation network in Japan, why do you use the model? Please write reason for needs of the model at the beginning of the appropriate chapter.

[Minor comments and questions] 25. Change a word, “Furthermore”. In the sentence after “Furthermore”, the reason for the change in air quality is written, so that it is not adequate. 26. Add references; why reduced labor productivity leads to increased demand for projected energy. 27. Why does GDP increase due to harvest loss derived from air pollution? How about excerpting one sentence from OECD2016? 28. How about excerpts from “McCarty and Kaza, 2015” about important issues in city plan-

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ning? The reason for the change in air quality is written as "Increase in pollutants", but the reason for the importance of urban planning for air quality is not written. Therefore, the sentence balance in the paragraph is bad. 29-30. With regard to "clean water is", we insist on the necessity of creating an index based on "same as water", but is there a water world index? Provide references if any. If not, cut this sentence. 30. The meaning of "allow people to make more informed choices" is unknown. Please write specifically. 31. Easy access for citizens, easy to read, easy to understand, this is an important perspective for journals. This expression is written at the beginning of the sentence, and "Upgrading with experts and scientific data" will be described later. 35. Correct spelling. indexes or indices? 39. What are the selection criteria for that chemical? It is written a little in Chapter 2, what is the reason for making only 4? For example, is there a reference, whether it is a high rank, is it attracting attention in Japan, or is the standard that the country is most interested in? 40. I understood the meaning of "optimizing the numerical criteria" after reading Chapter 2. This means that the user can set any value. Since "optimizing" is likely to be misunderstood as an advanced optimization algorithm, it is expressed to avoid misunderstanding. 57. "O3, PM, NO2 and SO2 following the WHO AQG (WHO, 2005)" overlaps with Chapter 1. There is no need to erase. But write something already mentioned above, such as "mentioned above". 67. The health risks written in the introduction are also motivating research. Is it consistent with chemical substances SPM that are not health risks? 69. According to the cited document (1993), volcanic eruptions are said to have the highest SO2 emissions, but I hear that there is also a document that "the amount of sulfur supply to the atmosphere is more due to industrial activity than volcanic activity." Are there any recent papers, not 1993 references? 70. Regarding volcanoes, it is stated that SO2 emissions are high, and in line 110, it is stated that SO2 volcanic emissions were ignored in Japan, and there is a conflict. Furthermore, it is not consistent to include Kagoshima to evaluate the effects of volcanoes. Devise how to write. 89. Nudging is performed according to the 6-hour data. What is the time interval of the WRF-CMAQ calculation results? 100. Are the NOX, SO2, and SPM boundary conditions other than

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O3 set in MOZART? 105. How did you find "the statistical secular changes in the annual total anthropogenic emissions"? Give a reference. 116. What is the reason for setting "R = 16km"? Is the domain grid interval related to 20km? 117. Outside of the domain such as Okinawa, it may not be necessary to consider CII. Evaluation is difficult because the scale is different. 130. As stated in "Volcanic emissions of SO2 were ignored (L110)", is it consistent with selecting Kagoshima because of the volcanoes? 134. It is written that the site of Sakurajima was excluded because it did not consider volcanoes in CMAQ, but are other sites in Kagoshima city susceptible to volcanoes? From Table 2, Kagoshima has a particularly poor correlation between NO2 and SO2. Is this the reason for the volcano? Or for reasons other than volcanoes? Did you enter Kagoshima to insist that the impact of the volcano is not so great? Clarify the intention to include Kagoshima. Or Kagoshima is not needed. Or let CMAQ consider Sakurajima's volcano. Do you have emission data for Sakurajima? 139. Correct the spelling. abovementioned-> above-mentioned 140. A good agreement with a correlation coefficient of 0.61 is a bit overstated. Is this a problem with the resolution and representativeness of the 10km model? 141. In Table 2, why is "CII" better in Akita and Nagano than in Kagoshima, where NO2 and SO2 are bad? 141. As with the time series, are the values in Table 2 a comparison of daily averages? 146. Put a dot after the formula number R. 146. Since it is a reaction by "hv", do the values in Table 2 and CII change depending on the presence of sunlight, that is, day and night? I think that the result of each day and night also has utility value (social needs). I think there is demand for people who need delicious air at noon and those who need it at night. 150. The reaction R3 causes the model to underestimate O3 and overestimate NO2, resulting in a poor correlation between O3 and NO2. Since CII is added together, it is offset and the correlation of CII does not deteriorate. Isn't it possible to properly devise an underestimation of O3 and an overestimation of NO2 in the model? And why does the correlation worsen in areas with few human origins such as Akita and Nagano? 153. Since the elimination of the NO2-O3 offset problem depends on the type of model, I think it will not be an advantage for all models. 157. There are things that look asym-

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metric and those that don't. Devise how to write. 158. I think $1-\sigma$ is a convention in this field. However, readers in other fields can easily misunderstand "-" as minus, and mistakenly read it as 1 minus σ . Isn't it just σ ? 165. Which agency's data follows the denominator "s" for Seoul and Beijing's numerical criteria? 174. Write that the time being stated is around May. The writing style is unified. 185. Does "amount of O3 was relatively higher than the value of s" mean that x/s is larger than other spices? 187. The famous city name, Mega City, is written on the vertical axis in Figure 5. 193. In response to the above paragraph, it will not be "Consequently". It does not lead to cross-border pollution. How do you interpret Figure 5 to get evidence of cross-border pollution? I think there is cross-border pollution, but I can't interpret it from Figure 5 alone. 194. Since it overlaps with the 187th line of the upper paragraph, delete the sentence, "The variation in O3 had the most significant effect on seasonal variation in the CII. The spatial distribution of CII corresponded to those of NO2 and SO2." 195. The impact of domestic local sources can be seen in the vertical stripes in Figure 5, but there is insufficient evidence for "outside of Japan". 200. From Figure 6, it is difficult to tell the difference between good and bad places such as northern Japan. Devise the color scale to a palette of about 8 colors. 222. Add a reference to show that "Generally, the transboundary pollution effect" is significant in Japan in the spring. Write the reasons, such as the monsoon, or the high demand for coal-fired power generation in China in winter. 222. In the case of cross-border pollution, it is difficult to understand unless it is compared with a model such as PM2.5 that is expressed in time series. In addition, photochemical smog is a phenomenon under some very special circumstances in some areas, so it is better to expand the data representation a little more. That will be a future issue. 225. Is "The 30 highest daily mean CII values" shown in Fig. 6 (c)? 225. Based on the data in 6 prefectures in Japan, the municipalities in the prefecture are selected. However, from the nationwide data, there are naturally other regions with high value, so it is better to use these 6 cases. It may also be a good idea to list the seasons roughly. 232. Why is it "not fair" when it is fair to quantify CII on an objective basis? 245. Does normalization in human activity (population density)

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mean to exclude the influence of human activity? Why is that? Is it for seeking potential cleanliness of the air? Want to see the impact of cross-border pollution? Write the reason and purpose at the beginning of the chapter. 250. Is it not just "neighboring municipality" but also transboundary pollution? For example, if the distribution of yellow sand and the distribution in Figure 7b overlap in previous studies, this is evidence of cross-border contamination. 282. Due to the circumstances of each individual, it is not necessary to strongly recommend moving to Hokkaido. Write about the causal relationship with healthy life expectancy, or write other reasons, such as clean air is better in nature and is more sustainable. However, just as people and factories set out to seek clean water, if people seek for clean air, they can put a load on clean nature and have the opposite effect. Sometimes it is better not to be a tourism business. 284. "enabled" is too much to say. Rather than saying that Korea and China alone can be applied to other countries, it is better to write that this method is simple and can be applied to countries and municipalities around the world.

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