Report on "Changes in surface ozone in South Korea on diurnal to decadal time scale for the period of 2001-2021" by Kim et al.

General Comments

The manuscript entitled "Changes in surface ozone in South Korea on diurnal to decadal time scale for the period of 2001-2021" by Kim et al. gives an important quantification of surface ozone's variabilities in South Korea. Between 2001-2021, ozone increased over most of the monitoring sites by 1-2 ppbv/yr as well as the exceedances above the United States National Ambiant Air Quality Standard for ozone, 70 ppbv. The COVID-lockdown period is characterized by a decrease of ozone in spring, especially at the background sites, but not in summer.

The manuscript is well organized and written. The figures are clear and easy to read. It is very much appreciated.

I would recommend the manuscript for publication after the authors address the following minor comments.

Specific Comments

L2 P2: I believe there is a typo: Change "Increasing trends of tropospheric ozone in South Korea in the last decades have reported in several studies" to "Increasing trends of tropospheric ozone in South Korea in the last decades have been reported in several studies".

L4 P5: Could you give some details on the impact of the COVID-19 pandemic on the atmospheric composition in spring versus in summer? Has South Korea experienced several lock-downs in spring and summer 2020, or only in spring, with reduction of human activities/emissions of the precursors of ozone?

L12 P5: I believe there is a typo: Change "as following" to "as follow".

L7 P6: Could you be more specific? Could you give the starting year? Are all the 500 stations still working now? Maybe add a column "time period" in Table S1.

L9 P7: Could you be more specific on the stricter recommendations: quality assurance and cloud fraction?

L10 P7: Have you conducted or are you aware of any sensitivity test to see how much the compromise sampling statistics/quality may change the results?

L4 P9: Typo: Change "11st" to "11th" (eleventh). Could you add the year?

L11 P10: Could you add the uncertainties on the trend estimate?

L14 P10: "Insignificant" is not used anymore (Wasserstein et al., 2019). Trend reliability can be expressed with p-value (Wasserstein et al., 2019) and/or signal-to-noise (SNR) ratio (Chang et

al., 2021). Then you can apply the trend reliability scale (see table below from the *guidance note on best statistical practices for tropospheric ozone assessment report -TOAR-analyses* by Kai-Lan Chang, Martin Schultz, Gerbrand Koren and co-authors pending their approval, February 2023; the document will be posted on the TOAR website by end of April 2023 upon the TOAR steering committee approval, https://igacproject.org/activities/TOAR/TOAR-II) to report the trend and its uncertainty.

Table 3. Trend reliability scale

p-value	SNR (signal-to-noise) value	Term
$p \le 0.01$	SNR ≥ 3	very high certainty
$0.05 \ge p > 0.01$	$2 \le$ SNR < 3	high certainty
$0.10 \ge p > 0.05$	$1.65 \le$ SNR < 2	medium certainty
$0.33^1 \ge p > 0.10$	$1 \le$ SNR < 1.65	low certainty
$p > 0.33^1$	SNR < 1	very low certainty or no evidence

[1]This boundary is meant to be fuzzy around 1/3 (Mastrandrea et al., 2010).

Table taken from the *guidance note on best statistical practices for tropospheric ozone assessment report -TOAR-analyses* by Kai-Lan Chang, Martin Schultz, Gerbrand Koren and co-authors pending their approval, February 2023; the document will be posted on the TOAR website upon the TOAR steering committee approval, https://igacproject.org/activities/TOAR/TOAR-II.

L5 P11: Spell out LT = Local Time, at least the first time it is used.

L12 P11: It would be worth adding a discussion with references on summer/spring differences: meteorology condition in Seoul and Gyeonggi-do compared with other sites/regions. That would probably fit in the "Discussions" section.

L15 P11: I found 7 sites showing more exceedances in summer than in springs according to Figure 4. Why do you report only 3 of them? I also found 10 sites showing more exceedances in spring than in summer, why do you report only 3 of them?

L7 P12: "than Incheon" is not clear. I believe there is a typo in the sentence. Could you rephrase?

L13-14 P12: Is it a statement from previous studies or from this current study? Could you give a reference or cite a figure to support this statement?

L20 P14: Does "large reduction of ozone" refer to the difference between the time periods P2 and P3? It would be helpful to clarify.

L14 P15: Does "likely to be VOC-limited" mean that VOCs did not decrease between P2 and P3 in South Korea? Any reference?

L20 P15: Do we know why there are more NO2 in MAM 2019 than JJA 2019? Specific human activities, Meteorological conditions? It would be interesting to see the maps of MAM 2020 and JJA 2020.

L20 P16: Why did you choose Seoul and Gangwon-do over other sites?

L1 P17: An evaluation of WRF-Chem above Seoul and Gangwon-do would be helpful. How does the control run compare with the observations? Any sondes launched during KORUS-AQ that can be used for this evaluation? Was this model study done with annual means or did you perform it for a specific season? Showing summer and spring would be useful to echo the seasonal results on trends estimate.

L7 P17: It seems to be very small changes (almost none). Could you be more quantitative?

L3-5 P18: You probably should inform on the altitude of both Gosung and Gangwon-do sites because it is a little confusing as it is written.

L1-2 P35: Are NO2 and CO values from CAM-Chem? It is worth clarifying in the caption.

L2 P36: Can you have colors or signs to differentiate cities, provinces and background sites, as well as the definitions of these three categories. Is it according to ozone diurnal/seasonal variability? Could you add a legend?

L2 P37: Could you add the uncertainties (2-sigma values), or p-value or signal-to-noise ratio associated with the slope values S? (see my previous comment on how to report trend and its uncertainty)

L4 P41: Is the extraction over the entire country? It should be specified in the caption and section 2.4.

L4 P44: Typo in the legend of Figure 11: change "Contorl" to "Control"

References:
Chang, K.-L., Schultz, M. G., Lan, X. et al. (2021). Trend detection of atmospheric time series: Incorporating appropriate uncertainty estimates and handling extreme events. *Elementa: Science of the Anthropocene*, 9.

Wasserstein, R.L., Schirm, A. L. & Lazar, N. A. (2019). Moving to a world beyond "$p < 0.05$". *The American Statistician.*