To: Editor, ACP

Subject: Author Comments of Manuscript, acp-2022-270

Dear Dr. Jianping Huang,

Upon the recommendation, we have carefully revised the manuscript entitled "*Future dust concentration over the Middle East and North Africa region under global warming and stratospheric aerosol intervention scenarios*" after considering all the comments and suggestions made by the Referees; all the changes made in the revised manuscript are highlighted in yellow. The following is the point-to-point response to all the comments (the reviewers' comments are rewritten in black color and the replies in blue). We appreciate the opportunity to revise our paper. We believe that the manuscript is much improved after positively addressing all the requested revisions. In the following we provide answer of Anonymous Referee #1, and Anonymous Referee #2 respectively. The main changes have been made in the new version based on the referee's comments/suggestions are as follows:

- We replaced Fig.2 with two new figures, a new figure (Fig. 9) for detailed analysis of the correlation between dust and considered variables, and a second figure (see next point).
- We provide a new figure for annual trends (Fig. 10) of all considered variables over dust hot spots to interpret the positive and negative correlation considering ascending or descending trends
- New Table for the correlation coefficient over dust hot spots, shows which variable would have more effect on the change of future dust concentration in different regions
- New figures for monthly trends using box plots (Fig. 11 and Fig. S1), to give a better view of the statistical analysis of different scenarios
- Rewrite the result section with three subsections to increase readability
- Rewrite the result, discussion, and conclusion sections based on new findings and figures
- To magnify the parameter's changes over the dust hotspot regions, these regions are specified by dashed lines, over all contour plots.

Notice: The line and page numbers refer to the pdf file of "Revised Manuscript".

Response to the Anonymous Referee #1:

Major concerns:

a) The cross-coherence analysis:

I don't find that the method is very well explained in section 2. What are the connections to the axes in Fig. 2? How do you come from the equations to the quantities (amplitude, phase?) shown in the figure? More importantly, I am also confused about the physical interpretation. There are probably annual cycles in all meteorological variables. This means that there will always be coherence between them. As the annual cycle probably is different from a pure sinusoidal, there will also be a signal at 1/2-year. So what do we actually learn from Fig. 2? In the discussion section (l365) it says that the dust is 'substantially influenced' by the changes in the other fields. But I don't think you can conclude that from the analysis. What we learn is only that there is an annual cycle in all the fields including the dust but nothing about the physical interpretation. This manuscript presents projected changes of dust storms in the Middle East and North Africa region, which is very sensitive to climate change, under future scenarios, with (SAI) and without (RCP8.5) geoengineering, focusing on the stratospheric aerosol intervention effect but discussing both of them. Therefore, the title could be modified to reflect better the content.

Reply: We thank the reviewers for the comments and suggestions. We think that by implementing the reviewers' comments and suggestions, the revised version has significantly improved.

As you mentioned correctly, Fig 2, mostly demonstrates the annual correlations between dust and considered variables. In new version of the manuscript, Fig. 2, has been replaced by two new plots (Fig. 9 and 10) to make correlations more understandable. In Fig. 9, we depicted the correlation coefficient of dust with considered parameters for all grids (i.e., cells with a horizontal resolution of 0.9° latitude by 1.25° longitude) over the MEAN region. The positive and negative correlations are shown as a contour plot for both RCP8.5 (left column) and SAI scenarios (right column). Moreover, the dust hotspots are specified using the climatology of dust concentrations in this figure (regions with no hatch-lines). The correlation coefficients for hotspots are listed in Table 3. Furthermore, annual trends of parameters over the dust hotspots are shown in Fig. 10, for both RCP8.5 and SAI scenarios. This figure depicted the intensity of annual changes for any parameter in any special region that would affect the dust change.

Regarding your suggestion about the title, as you mentioned MENA region is very sensitive to any changes in future dust. Although our focus in this study is on the stratospheric aerosol intervention geoengineering effect, in this paper we would like to give a perspective of future dust under both RCP8.5 and SAI scenarios, and we selected a title to reflect this issue (i.e., changes of future dust under both RCP8.5 and SAI scenarios). Moreover, the sections of the manuscript have been rewriting based on the new plots. The following lines and Figure were added to the new version of manuscript:

Lines 25-27 (Abstract): Detailed correlation analysis over dust hotspots indicates that lower future dust concentrations are controlled by lower wind speed and higher precipitation in these regions, under both RCP8.5 and SAI scenario.

Lines 163-169 (Data and Methods): We also calculate the correlation coefficient of dust with other considered parameters for all grids (i.e., cells with a horizontal resolution of 0.9° latitude by 1.25° longitude) over the MEAN region, for both RCP8.5 and SAI scenarios. The climatology of dust concentration is used to specify dust hotspots regions and regions with columnar dust concentration lower than 35 ($\mu g/m^3$) are depicted with hatch-line in the correlation coefficient figures. Moreover, the spatial average of annual time series over dust hotspots are used to calculate the correlation coefficients of atmospheric dust concentration with surface temperature, near-surface wind speed, total leaf area index, precipitation, and soil moisture for both RCP8.5 (2010-2097) and SAI (2020-2099) scenarios and are listed in Table 3.

Lines 256-281 (Results): Finally, to find the most efficient factors for reducing columnar dust concentration over hotspots, we calculated the correlation coefficient of dust with other considered parameters for all grids (i.e., cells with a horizontal resolution of 0.9° latitude by 1.25° longitude) over the MEAN region (Fig. 9h). The positive and negative correlations are depicted as a contour plot for both RCP8.5 (2010-2097) (Fig. 9, left column) and SAI (2020-2099) (Fig. 9, right column). Regions with columnar dust concentration lower than 35 (μg/m3) are depicted with hatch-line in the Fig 9. The correlations between dust and surface temperature are depicted in Fig. 9a and Fig. 9b. In Fig. 9c and Fig. 9d, the correlation between dust and wind speed is presented, and positive correlations are shown over the dust hotspots. Negative correlations between dust and TLAI can be seen for most hotspots in both scenarios (Fig. 9e and f). Furthermore, the correlation of dust concentration with soil water (Fig. 9g and h) and precipitation (Fig. 9i and j) show considerable negative mean values for the R4 region. Moreover, the spatially averaged correlation coefficients between dust and considered parameters for five dust hotspots over the MEAN region and under both RCP8.5 and SAI scenarios are listed in Table. 3. In this table, the most important variables for each region are highlighted in orange. According to this table, for all dust hotspots (i.e., R1 to R5), the wind speed is the main parameter that affects dust concentration change under both RCP8.5 and SAI scenarios, except for the R4 region under SAI scenario. In the R4 region the increase in precipitation and soil water under SAI scenario seems to control the reduction of dust respectively. In addition, under the SAI scenario, over dust hotspots with higher latitudes (i.e., R2 and R5), the vegetation cover is another important factor in controlling the change of dust concentration.

Moreover, to explore the annual trends of parameters over the dust hotspots, and to compare the annual mean values of different variables, we depicted the regional annual mean of considered parameters under both RCP8.5 and SAI scenarios over different hotspots regions (Fig. 10). Figure 10, indicates that the strong reduction of dust concentration for R4 and R5 and to a lesser extent for R3 under both RCP8.5 and SAI scenarios has been modeled (Fig. 10a4, a5, and a3). Although, the dust concentration over the R2 hotspot has no considerable change by the end of the century for RCP8.5, an approximately 30% reduction is projected for the SAI scenario (Fig. 10a2). Corresponding to the reduction of dust in R4 region (Fig. 10a4) under both RCP8.5 and SAI scenarios, an increase in precipitation (Fig. 10c4) and a decrease in wind speed (Fig. 10b4) are seen. Detailed analysis of annual trends for the R5 region indicates that the strong reduction of dust concentration in this region would be controlled by the decrease in wind speed and the considerable increase in leaf area index under both RCP8.5 and SAI scenarios (Fig. 10a5, b5, and e5).

Please see Fig. 1, Fig. 2, and Table 1 in the context (i.e., Fig. 9, 10 and Table 3 of the new version of the manuscript).

Table 1. The correlation coefficient of dust with considered parameters for all dust hotspots over the MEAN region. The most important variables for each region highlighted by orange color. The correlation coefficients are calculated using annual mean time series resulting from the average of all ensemble members, and spatially averaged over the corresponding dust hotspot region.

	RCP8.5 Scenario (2020-2097)					SAI Scenario (2020-2099)				
	R1	**R2**	**R3**	**R4**	**R5**	**R1**	**R2**	**R3**	**R4**	**R5**
Precipitation	-0.25	-0.11	-0.27	-0.54	-0.28	+0.02	-0.49	-0.46	-0.64	-0.21
Soil Water	-0.06	-0.22	-0.06	-0.48	+0.23	+0.18	-0.34	-0.18	-0.52	-0.09
Leaf Are Index	-0.18	-0.22	-0.09	-0.13	-0.40	-0.12	-0.52	-0.11	-0.36	-0.63
Surface Temperature	-0.04	+0.26	-0.29	-0.81	-0.76	-0.02	+0.38	-0.12	+0.44	+0.20
Wind Speed	+0.62	+0.64	+0.50	+0.59	+0.63	+0.70	+0.67	+0.84	+0.50	+0.84

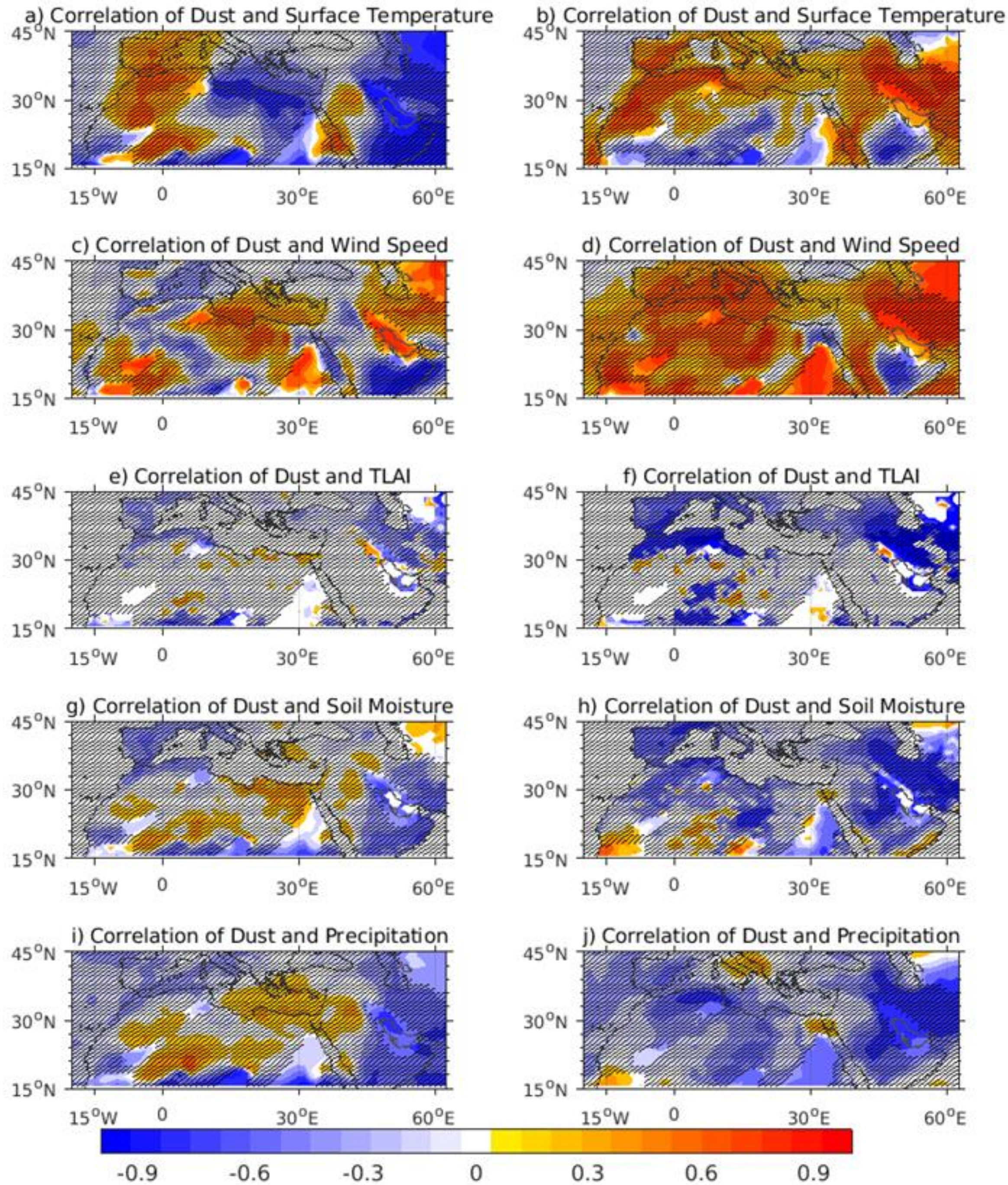

Figure 1: the correlation coefficient of dust with other considered parameters for all grids (i.e., cells with a horizontal resolution of 0.9° latitude by 1.25° longitude) over the MEAN region. The correlation is calculated using the annual mean time series of all grids. The climatology of dust concentration is used to specify dust hotspots (R1 to R5) regions. Regions with columnar dust concentration lower than 35 (μg/m3) are depicted with hatch-line in this figure.

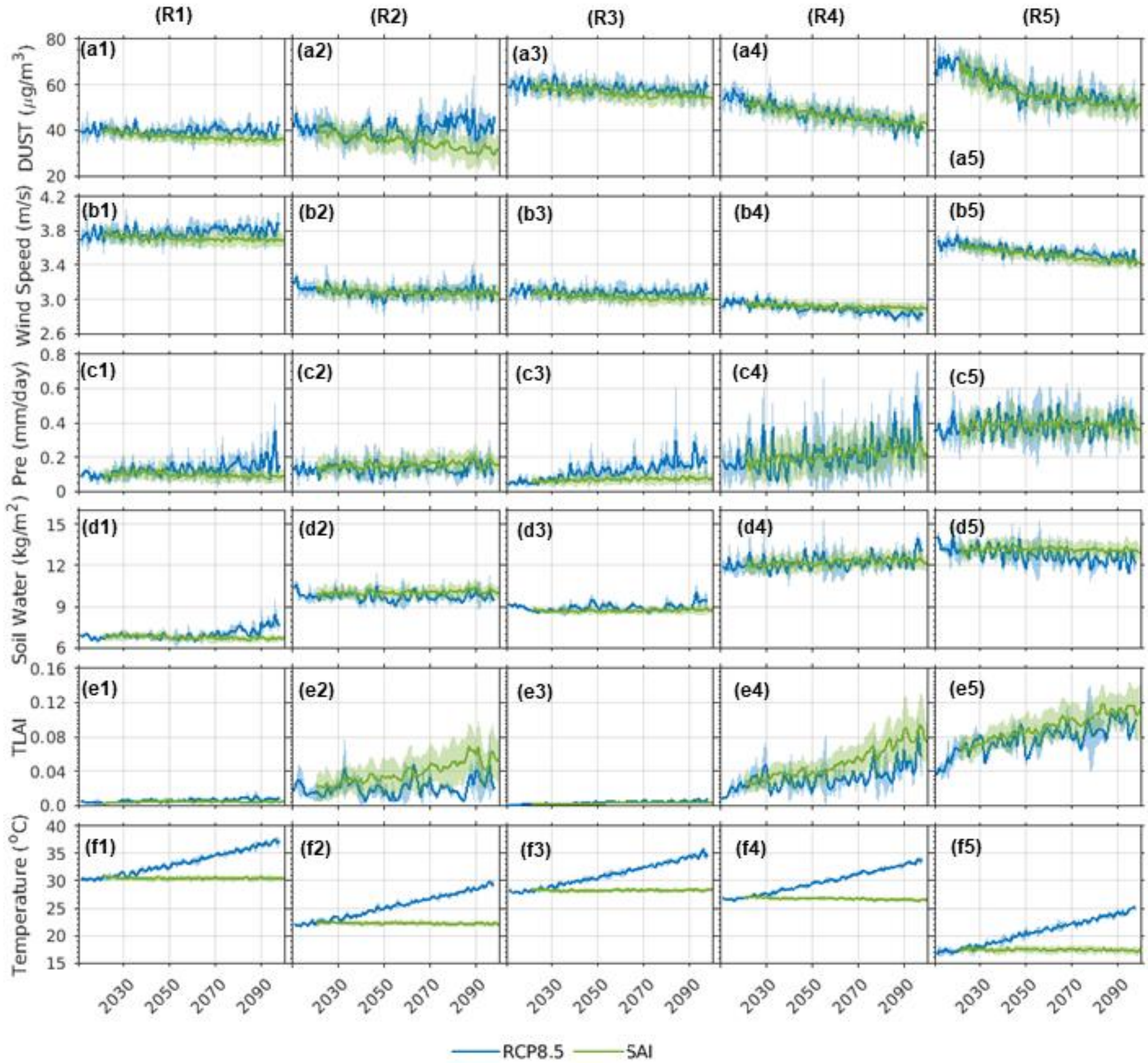

Figure 2: The annual mean values of the considered parameters for RCP8.5 and SAI scenarios. Different columns (i.e., columns 1 to 5) indicates the dust hotspots region R1 to R5, respectively, and different rows depicted the annual mean trends for different parameters with their standard deviation for all ensemble members.

b) The rest of the paper seems to me to be too much focusing on presenting the details about the changes in the different fields. I think many of the panels basically shows the same and that the number of plots and panels could be reduced. I really miss some solid analysis and results about what drives the changes in the dust. The dust generally decreases in the RCP8.5 scenario but it decreases further in the geoengineering scenario. Perhaps I am missing something but I could not find an explanation. The correlations in Table 3 could be a beginning, but the physical connection between the variables requires that the trends - which I guess determines most of the correlations here - are removed.

Reply: as you suggested, plots with the same content have been removed. Fig. 1 to 4 in the old version are combined and depicted as Fig. 1 to 3 in the new version. Fig 10, containing several same panels for with other figures for the monthly mean values, has been replaced by a new one for different hotspot regions (Fig. 11 for R4 and R5 dust hotspots and Fig. S1 for R1 to R3 dust hotspots in the new version).

As Fig. 2 and Fig. 3m (of the manuscript) depicted, the projected dust concentration has more reduction over dust hotspots for RCP8.5 scenario, compared with SAI scenario (Fig 3d, e, g and h, in new version), although, over the whole MENA region more reduction for SAI scenario has modelled (Fig. 2a-b).

As mentioned in the manuscript, because the dust emissions physically reduce with cooler temperatures, weaker winds, and wetter climate through increasing precipitation and soil moisture and, in turn, denser and broader vegetation coverage, all investigated parameters could affect dust concentration changes. Moreover, regarding the extent of the MENA region, different parts of this region have a special hydro-climate cycle, and subsequently, the different factors could be counted as a driving factor of the atmospheric dust change in different regions. By focusing on the dust hotspots, we find that, under both RCP8.5 and SAI scenarios the reduction of future dust is mainly controlled by the weaker surface wind, except for the R4 region and under the SAI scenario where an enhancement of the precipitation more than other parameters effects on the dust reduction. In the revised manuscript, Table 3 is replaced with new one with more detail about the correlation coefficient of each variable in the five dust hotspot regions. Moreover, the new figure of annual trends for parameters over the dust hotspots help the reader to understand the physical connections between the changes in dust concentrations and considered parameters (please see Fig. 10 in the new version).

Minor comments:
l54: reginal -> regional
Reply: done

l97: So this is an ensemble based on a single climate model? How are the different ensemble members generated?
Reply: the following sentences to the manuscript;
Line 97-100: For each ensemble member, the atmospheric state is initialized with 1 January conditions taken from different years between 2008 and 2012 of the reference simulation and a round-off (order of 10^{-14} K) air temperature perturbation, while the land, sea ice, and ocean start from the same initial conditions for each ensemble member.

l103: What is 'interhemispheric temperature gradient'?

Reply: the following sentences to the manuscript;

Line 104-107: The interhemispheric surface temperature gradient is defined in equation (1) of Kravitz et al (2017). It is simply the difference between the mean surface temperature in the Northern and Southern hemispheres. In the study of Tilmes et al (2018), the values for the interhemispheric differences for the different periods and scenarios are presented in Table 3 (T1).

l115-130: Is this a new method adopted for the present study? Is it described in the literature before? If it is new perhaps it should be described in more details and more background given. As it is now it is not transparent for me. For example, what is a transport bin?

Reply: this is not a new method, and the Dust Entrainment and Deposition model (DEAD) is used for the atmospheric dust mobilization scheme. Interested readers could find the detail about model in the lines 118-142 of the manuscript, and for more information could refer to the references mentioned in the manuscript.

l148: composite analysis? Is this the right word? You calculate the difference of temporal means.

Reply: the "composite analysis" phrase is replaced by "calculated the differences".

l160, Table 3: Are the correlations averages over all the ensemble members? It should be mentioned in the caption that this is annual means.

Reply: as requested, we add the following sentences in the caption: "The correlation coefficients are calculated using annual mean time series resulting from the average of all ensemble members, and spatially averaged over the corresponding dust hotspot region".

As mentioned I have problems with the presentation of the wavelet coherence. In line 171 why is [(n'-n)dt/s] the complex conjugate? Is omega_0 a constant? If it is how is it selected?

Reply: as mentioned above, to increase the understandability of correlation we replace Fig.2 with two new figures, and all sentences related to wavelet analysis have been removed.

l172: The sentence 'In this approach .. ' seems misplaced here and should be moved down near line 184.

Reply: as mentioned above the sentences related to wavelet coherence are removed.

More importantly in Fig. 2 the coherence is shown as function of time (x-axes) and period (y-axes). It is not clear from the text what these correspond to in the formulas.
Reply: as mentioned above the sentences related to wavelet coherence are removed.

Furthermore, the figure caption mention both the power and the phase which is not described in the text. The same goes for the cone of influence.
Reply: as mentioned above the sentences related to wavelet coherence are removed.

Eq. 6: Should there not be some smoothing here too?
Reply: as mentioned above the sentences related to wavelet coherence are removed.

The discussion of Fig. 2, page 7-8:
It should be pointed out more specifically in the text that Fig. 2 is for SAI. Does it look the same for the RCP8.5? Why focus on the SAI here?
Reply: as mentioned above the sentences related to wavelet coherence are removed.

The 22-years variability and variability larger than 16 years seems to be outside the cone of influence. Also, it is not significant in the GWTC. In general, the two regions in Fig. 2 look identical to me. I don't think you can say that there are significant differences.
Reply: as mentioned above the sentences related to wavelet coherence are removed.

And I don't really see any change after 2040. Perhaps just presenting the GWTC would be better.
Reply: as mentioned above the sentences related to wavelet coherence are removed.

l207: 'Out of phase'. Does this mean -180? Is it just difference in sign?
Reply: as mentioned above the sentences related to wavelet coherence are removed.

l246: How does this indicate that the model is consistent with observations? There are no observations used in the present study.
Reply: as mentioned above the sentences related to wavelet coherence are removed.

Table 3: Why the big difference between RCP8.5 and SAI for temperature correlations? Is this table only discussed in l258?

Reply: According to the time series, of surface temperature and dust concentration, these results for correlation are anticipated. Based on the model's output and as expected, the surface temperature has no considerable change under the SAI scenario. In contrast, the MENA region's surface temperature rises up to 6 degrees for the RCP8.5 scenario. In the meantime, a reduction is projected for dust concentration under both scenarios. It seems that the increasing trend of annual mean surface temperature alongside the decreasing trend of the annual mean dust concentration is the reason of the negative correlation under RCP8.5 scenarios. The results of Table. 3, are discussed in line 267-271.

Section 3 should be split in two or more subsections. Perhaps not start with the coherence?.

Reply: As you requested, the result section divided in three subsections as below (see lines: 170-290 of new version of the manuscript)

3. Results

3.1. Atmospheric Dust Concentration change under Different Scenarios

3.2. Candidate Variables change under Different Scenarios

3.3. Correlation of Atmospheric Dust Concentrations with Candidate Variables

Response to the Anonymous Referee #2:

This paper is a straight forward comparison of predictions of model ensembles using one model with two scenarios, global warming (RCP8.5) and stratospheric aerosol injection (SAI), over 80 years compared with a control run of 20 years. The variable of interest is dust and its correlation with surface temperature, leaf area index, precipitation, soil moisture and wind speed. The region of interest is north Africa and the middle east with various dust hot spots identified. The bulk of the paper rests on describing Figs 3-9 which show the spatial and temporal variation of each of these parameters under the two scenarios for monthly and annual means. The spatial differences are shown variously and absolute value or percentage depending on the variable. It is not clear why they are not all shown as percentages.

Reply: We thank the reviewers for the comments and suggestions. We think that by implementing the reviewers' comments and suggestions, the revised version has significantly improved.

In this investigation plots of absolute changes and percentages of changes have been plotted for all investigated parameters. In addition, a plot with a better description for each parameter is included in the article. We agree that showing percentage change is helping to visualize both areas changes in dust hot spots. However, for regions with very small background concentrations, for example for Europe or regions with less than 5 ($\mu g/m^3$), and even a 50 or 100% change in dust, relative changes do not make sense (Fig. 1).

The authors then make some conclusions about the differences between the RCP8.5 and SAI scenarios, a number of which are difficult to believe if the error bars are included in the discussion of the annual differences or trends in for example soil moisture, wind speed.

Reply: considering your great suggestion, and for statistical analysis we added box plots (i.e., percentile values of standard deviation) to the monthly mean values. Furthermore, we depicted the standard deviation values of all available ensemble members (indicated by shaded envelope) in the annual mean value and other trends. The new plots including errors would give a better sense to readers of the statistics of the parameter changes under different scenarios. As mentioned in the text (previous version of the manuscript), the error bars plotted on the annual time series indicate the parameter's minimum and maximum value in that year. In the new version, the standard deviation (indicated by the shaded region) is used instead of the minimum and maximum.

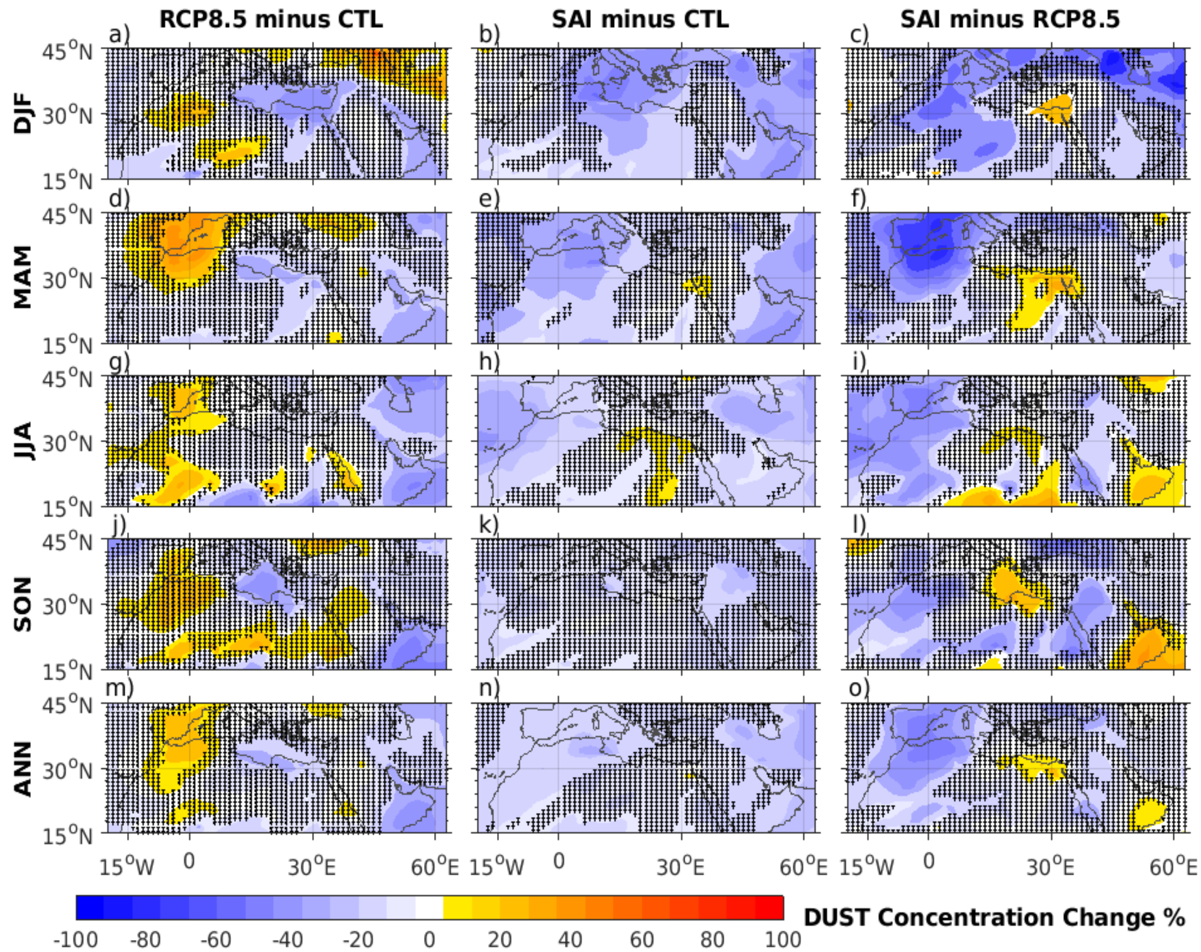

Figure 1: (a-o) Seasonal and annual changes of dust mass concentration mean value in the MENA region under different climate scenarios. All available ensemble members of the GLENS project are used to calculate mean value of dust concentration for CTL (2010-2029), RCP8.5 (2078-2097) and SAI (2078-2097). The regions without hatch line shows student's t-test analysis with 99.9% significance level.

Error bars should be included on all the figures showing mean values: monthly, annually, or spatially. Currently error bars are included only on the annual means. The same should be to Fig. 10. Then the authors discussion of notable differences can be placed in the context of how well any one variable is known.

Reply: As mentioned above, the error bars have been considered for all of the monthly, annual, or spatial analyses using shaded region or box plots. Moreover, considering referee 1 comments and suggestions, we replaced Fig 10 (in the previous version) with two new figures Fig. 2 and Fig. 3 of the text (i.e., Fig 11 and S1 in the new version) and related sentences in the context are revised.

One of the results which is rather striking, but which the authors largely ignore, is how little difference there is between the various variables, except for surface temperature and leaf area index, for the two scenarios, see e.g., Fig. 10. Similarly for most variables there is primarily little difference between the two scenarios and the control. Isn't this surprising given one scenario is global warming as usual, whereas the other is to deal with global warming. Are we to conclude that only primarily temperature will be affected?

Reply: The little difference you correctly pointed out in Fig 10 (previous version), could be the result of spatially averaged over the large area of MENA and the Middle East. The new figures of multi-monthly mean values with error bars Fig. 2 and Fig. 3 of the context (i.e., Fig. 11 and S1), alongside the contour plots over dust hotspots shows considerable differences between different scenarios more clearly and shows that the change of dust concentration over the hotspots is influenced by changes in the surface wind speed, precipitation, and vegetation cover (Please see Fig. 2, 3, 5, 7, 11, and S1 in the manuscript).
Moreover, using the atmospheric dust mobilization scheme, the surface temperature does not participate directly (see equation 1), so, we investigated five parameters that can directly or indirectly contribute to dust events to find the most effective variable for decreasing the dust concentration in this region. By the end of the century, the average temperature remained constant at the 2020 level in the geoengineering scenario, and for the RCP8.5 scenario, approximately 6 degrees increase in temperature was projected for the studied area. At first glance, the increase in temperature causes lower soil moisture and, subsequently, more probability of the formation of dust event. While for both scenarios, despite the temperature remaining constant or increasing, dust reduction has been projected over the studied region.

The paper would be improved if some discussion along these lines was added and if the authors treated the supposed differences and trends more carefully to put them in the context of the uncertainty in the knowledge of variable in question. If differences or trends are small fractions of the uncertainty, there cannot be much confidence in such predications.

Reply: As you suggested the error bars are considered for all analysis. Moreover, to decrease the uncertainty in mean monthly and annual trends, we investigate these trends over dust hotspots instead of entire MENA and Middle-East regions.

More detail on these and other points follow in paper order, including a couple of minor points.
44 From remote "regions?"
Reply: this sentence means is "MENA cannot receive humidity transferred from other regions".

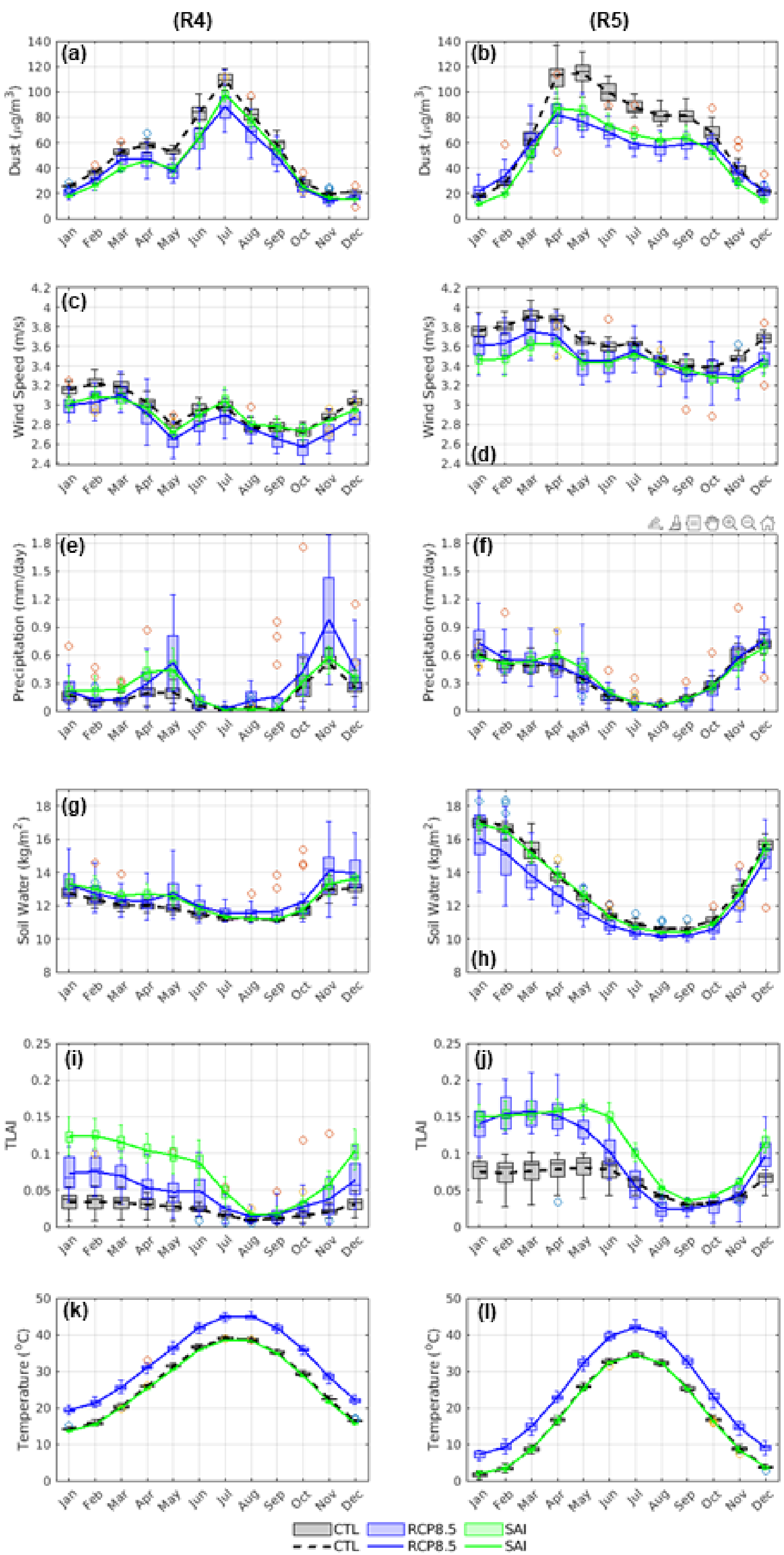

Figure 2: The multi monthly mean values of the considered parameters with percentile values as error bars for R4 dust hotspot (left column) and R5 dust hotspot (right column), for different scenarios. The box plots are depicted with the median (horizontal line), the 25–75 percentile (box), the 5–95 percentile (horizontal line), and outlier data (circle).

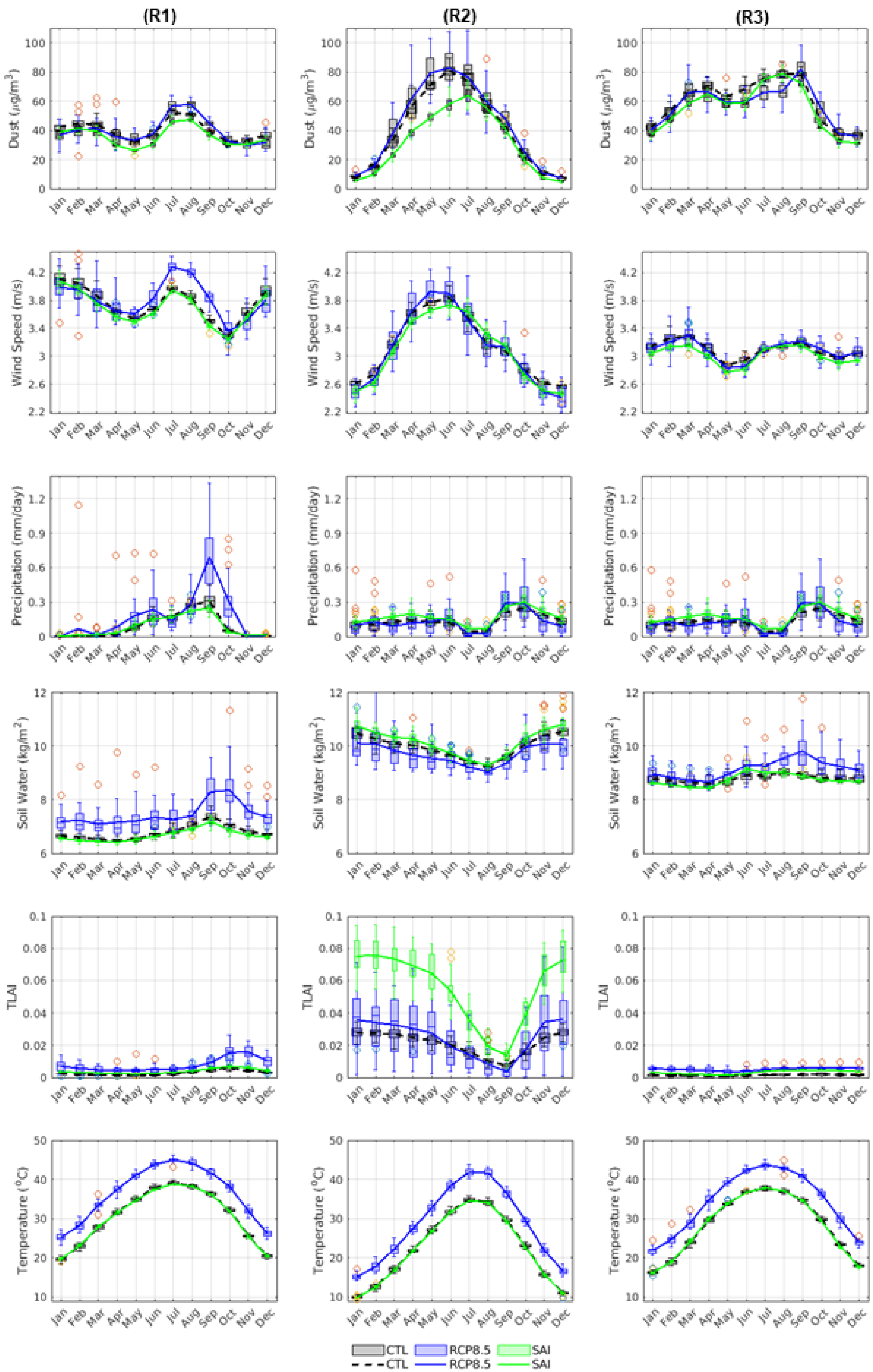

Figure 3: The multi monthly mean values of the considered parameters with percentile values as error bars for R1, R2 and R3 dust hotspots, for different scenarios. The box plots are depicted with the median (horizontal line), the 25–75 percentile (box), the 5–95 percentile (horizontal line), and outlier data (circle).

80 dioxide

Reply: is implemented.

166 Isn't it the cumulative LWTC averaged over time? Or is there a new variable WTC?

Reply: in response of Referee 1, and to show the correlation of dust concentration with considered variable we replace this figure (Fig. 2 of the previous version) with new figures.

Fig. 2 Some general comments should be made to explain the similarities of all the figures no matter the variable being correlated, particularly for readers not accustomed to such plots. For example, why is there always a strong annual cycle? Is this just the strong annual seasonal cycle? Why is there a definite semicircle traced out delineating the bright and dim colors in all plots? Is this an issue with the period versus the year, i.e., there can't be an eight year correlation for times less than 16 years beyond the start date? Presumably this is the cone of influence. But if that is the case why are there any correlations outside this cone shown on the figure?

Reply: as mentioned above the Fig. 2 and sentences related to wavelet coherence are removed.

Fig. 2 caption is unclear. 1) Isn't the cone of influence denoted by the more intense colors? If that isn't the case then it suggests the cone of influence is only from 2-20 years before 2050 and after 2070 with no influence in the center of the figure? 2) What is meant by the whole MENA region. Is that different than the MENA region? Also in the text line 199, and similarly confusing whole middle east. These regions were defined clearly earlier, now there seems to be a confusion about what they mean.

Reply: as mentioned above the Fig. 2 and sentences related to wavelet coherence are removed.

218 Again the whole MENA compared with the Middle East. Is this now not the whole Middle East?

Reply: as mentioned above the Fig. 2 and sentences related to wavelet coherence are removed.

Fig 3 c-q. Consider using percentages. The average reader may not know if 45 ug/m^3 is a lot or a little. But checking Figs 3a, b indicates that 45 ug/m^3 is 50-100% above or below the mean value, so it is a lot.

Reply: as mentioned and depicted above in the Fig. 1, if we use the percentage for the dust concentration, a decrease or increase of 50% or more are shown for some regions in Europe with no dust hot spots. For more explanation we added the following sentences to the discussion section;

lines 305-313: As our analysis reveals, the reduction of the future dust mass concentration over the MENA region (in both of the RCP8.5 and SAI scenarios) are mostly due to the weakening of the Middle East dust hotspots (Fig. 2 and 3). Moreover, the highest dust concentration of each year occurs over the Middle East during summertime (Fig. 2f and g). The reduction rate of the dust concentration is about 5-40% for the RCP8.5 scenario (compared to CTL), where it is stronger from March to September, especially for the dust emission in the Middle-East region (Fig. 2a, Fig. 3d, g, and j). Similarly, the dust concentration is also found to decline under the SAI scenario compared to CTL (Fig. 3b, e, h, and k) over the whole MENA region. Dust concentrations in the summer of the Middle East and Northeast Africa (i.e., R3, R4, and R5) under the SAI scenario are approximately 10-30% higher than in the RCP8.5 scenario (Fig. 3i).

Figs 6-9 q) which depict the annual mean value. Don't all of these figures, except fig. 6q) show that considering the error bars there is no difference between RCP8.5 and SAI. The difference in the means is a small fraction of the range of differences mapped out by the error bars. The differences shown in the monthly mean value figs p) appear at first more significant, but where are the error bars on this figure? If they were included the picture might be just as difficult in concluding a difference between RCP8.5 and SAI. Of these figures the only two that show a distinct difference outside the error bar range are surface temperature and TLAI.

Reply: As mentioned before, we considered error bars for all monthly and annual trends. As depicted in Fig. 2a, b and also Fig (5-8) p and q, the monthly and annual differences of the scenarios are seen. For example, Fig. 5p, q and r, clearly show that the TLAI increased significantly under the SAI scenario, and also the model projected an enhancement for the TLAI during winter and spring under RCP8.5. On the other hand, according to the algorithm implemented in the GLENS project, the considerable difference in temperature between the SAI and RCP8.5 scenarios is acceptable. Moreover, to reduce uncertainty we focused on the dust hotspots instead of the MENA region. The error bars on monthly mean values and annual trends in the Fig. 2-8, alongside the new figures (i.e., Fig 10, 11, and S1), depicted the difference between scenarios more clearly.

Thus the authors conclusions such as at lines 311-, "Figure 7q further shows … and under SAI, the wind speed reduction is gradually stronger than RCP8.5 starting from 2050.", or 324, "Fig 8q shows that a moderate positive trend of the annual mean value exists in the soil moisture under the SAI scenario." are deeply flawed. There is no trend that would stand under any statistical test given the size of the error bars on the data. The authors must be much more careful about what can be concluded from these monthly and annual mean values.

Reply: considering your great suggestion, and to investigate the statistics on monthly mean values, we include error bars on monthly variations plots, and tried to rewrite and update the manuscripts regarding new plots with error bars (Fig. 11 and Fig. S1). These figures are discussed in on the manuscript on line: 282-290 as a below:

"Figure 11 included error bars for monthly mean values of all considered parameters for R4 and R5 regions, and shows considerable reduction of dust concentration between the control and the two future scenarios for both regions in spring to fall with the stronger differences for R5. Differences between RCP.85 and SAI are however not significant. The monthly mean values with error bars of all considered parameters for R1, R2 and R3 regions are also shown in Fig S1. The reduction of the monthly mean value of dust concentration over the R4 region (Fig. 11a) may be a result of the increase in precipitation (Fig. 11e) and soil moisture (Fig 11g) the decrease in wind speed (Fig. 11c). Moreover, it seems that the reduction of dust concentration over the R5 region (Fig. 11b) is mainly controlled by the lower wind speed (Fig. 11d) and higher leaf area index (Fig. 11j). The results of Fig. 10 and Fig.11, are in good agreement with the results and correlation coefficients in Table 3."

Similar comment can be made about Fig. 9r), a slight difference appears in the mean values east of 50 degrees, but would this appear significant if the error bars were included on this figure? The error bar range is on the order of plus/minus 100 mm/year.

Reply: We considered the statistical analysis for your mentioned figure for all available ensemble members and depicted in new version in the Fig. 7r. In the previous manuscript, the error bar in annual trends indicated the maximum and minimum of parameters and it replaced by the standard deviation of the annual mean values for different ensemble members in new version. The model simulates an annual mean of the precipitation almost 220 (mm/year) over the entire MENA region for the CTL scenario (Fig.7q). For longitudes > 40 ^{o}E (i.e., in the vicinity of R4 and R5), the differences between the RCP8.5, SAI, and CTL scenarios is about 20-50 mm/year (Fig. 7r). This means that mentioned region receives 10-25% more precipitation in the future climate and this is a considerable amount for this semiarid region.

Fig. 10. Error bars should be included on this figure, just as they have on all the annual means shown. This is needed to put the differences noted in the context of the overall uncertainty in the predictions.

Reply: As you suggested the error bars are included in the monthly mean values. Moreover, to decrease the uncertainty in mean monthly and annual trends, we investigate these trends over dust hotspots instead of vast MEAN and Middle-East regions. Please see Fig. 2 and 3 (Fig. 11 and S1 of the new version of the manuscript).