Dear Editor,

Thank you in handling our manuscript and allowing us to revise it. We are grateful to the three anonymous reviewers for their expert comments and constructive feedback of our work. We have done our best to incorporate all the comments into the manuscript in this revised version. Below are our detailed responses. Reviewers' comments are in black and our responses are in blue. Texts and quotes from the manuscript are given within quotation marks (" ").

We have also changed color combinations in Figures 2, 3 and 4 to make them colorblindness friendly, as suggested by the editorial office.

<u>Reviewer #3</u>

The complex interaction between dust aerosols and precipitation remains challenging. This study investigates the interaction between dust aerosols and precipitation along the Eastern coast of the Red Sea and the underlying mechanism by the use of WRF-Chem with an advanced double-moment cloud microphysics scheme coupled with a sectional 8-bin aerosol scheme. The simulation results show that dust aerosols increase the rainfall amount of extreme rainfall events but decrease the rainfall amount of normal rainfall events. This result theory further supports the conclusion that "dust aerosols enhance heavy rainfall events and suppress light rainfall events". The paper suggests that the direct effect of dust aerosols influences the precipitation magnitude by the sea breeze circulation, which is intriguing. It is well known that the effect of dust aerosols is normally estimated by "radiative forcing", and this study further innovatively illustrate the transform from these effects to rainfall, however, the detailed calculation methodology needs to be presented. Acceptation is recommended after revision.

Thank you for the in-depth comments.

Comment #1

extreme rainfall events: indirect (4.54%), direct (1.51%) and indirect effects were statistically significant whereas the direct effect was not.

normal rainfall events: indirect (4.76%), direct(-5.78%), all of which were statistically significant.

Here is a question, which is the constant value of water vapor or dust concentration in the premise of this conclusion? I think this is a very important question. If the dust concentration is constant value, the dust aerosols as CCN make raindrops grow enhancing the precipitation given abundant water vapor, thus, the indirect impact (4.54%) dominates the extreme rainfall events. On the contrary, the rainfall will decrease due to the competition of the raindrops for vapor, in other words, the indirect impact suppress normal rainfall events. Therefore, the reason for the indirect (+4.76%) needs to be clarified. If water vapor is constant value, the increasing dust aerosols will enhance extreme rainfall events given high vapor with the positive indirect impact. If the constant value of water vapor is very low, indirect is negative and inhibits precipitation, it still does not explain the fact that indirect effect is positive in normal rainfall events. An experiment of the ratio of dust aerosol concentration vs vapor is highly recommended to determine a threshold for the clear explanation of the indirect impact to avoid confusion as stated above.

Thank you for this important comment. We would like to clarify that the discussed conceptual mechanism is applicable to the normal rainfall events only. For extreme rainfall events, the effect mainly occurs through the indirect effect and as calculated, the indirect effect is stronger than the direct effect. We have now better explained the physical mechanism of the indirect effects, considering also the fact mentioned by the reviewer, that the water vapor plays a significant role in determining the indirect effects. We have added the following explanations in the revised manuscript:

"For normal rainfall events, the dust effect on rainfall occurs through both direct and indirect effects, which are strong and statistically significant. As Table 3 shows, the negative dust direct effect (-5.78%) is slightly stronger than the positive indirect effect (+4.76%) for the normal rainfall events. For these events, the dust direct effect is caused by the weakening of sea breeze circulation in response to SW cooling by dust as explained previously. The various pathways of dust-rainfall interactions occurring over the Red Sea coast are summarized in a schematic diagram presented in Fig. 15.

For extreme rainfall events, the direct effect was positive but was not statistically significant, which could perhaps become significant with a larger sample size. For these rainfall events, the dust effect occurs through a different physical mechanism governed by the indirect effects. As Table 3 shows, the indirect effect (+4.54%) is stronger than the direct effect (+1.51%). The reason why indirect effect is stronger than the direct effect for extreme rainfall events is that, extreme rain events are caused by larger synoptic processes, and during their occurrence, the local-scale breeze effect becomes comparatively weaker. Consequently, the indirect effect becomes dominant compared to the direct effect. Whether the indirect effect is positive or negative is mainly determined by prevailing dust concentration and water vapor availability. During the extreme rainfall events, the water vapor is abundantly available so water vapor is not a limiting factor for rain formation. Since CCN # concentrations are abundant (Figs. 7, 8), dust concentration is not a limiting factor in this desert study domain either. In such high dust concentration and abundant water vapor scenario, rain droplets keep growing (Choobari, 2018; Li et al., 2011) rendering the indirect effect to be positive. To demonstrate this mechanism further, we plotted the column-average water vapor mixing ratio for normal rainfall events and extreme rainfall events separately (Fig. 16). It is clear that the average water vapor concentration is remarkably higher in extreme rainfall events compared to normal rainfall events (note the positive difference in Fig. 16c), which supports the above explanation.

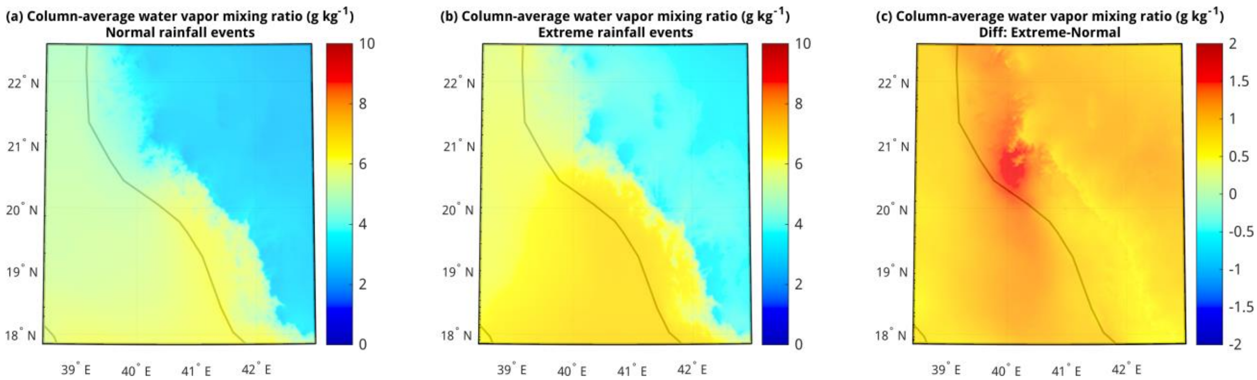

Figure 16. Column-average water vapor mixing ratio for (a) normal rainfall events (b) extreme rainfall events and (c) the difference in extreme and normal rainfall events.

The indirect effect is positive even for normal rainfall events because although average water vapor concentration in normal rainfall events is lower in comparison to the extreme rainfall events, the water vapor concentration is still high enough for droplets to grow from the moisture supplied by sea breezes on a diurnal basis. So given the abundant moisture supply, there is relatively minimal competition of raindrops, rendering the indirect effect to be positive even during the normal rainfall events.

The relative sign and magnitude of the observed effects are meaningful. The indirect effects are similar in both extreme and normal rainfall events (4.54% vs. 4.76%), which is reasonable because the indirect effect does not depend upon the breeze system. The direct effect is considerably stronger for normal rainfall events (-5.78%) than that for extreme rainfall events (1.51%), which is also sensible because the rainfall in normal rainfall is governed by breeze circulation whereas for extreme rainfall events it is not."

We have now clarified the questions raised by the reviewer about the relative magnitude and sign of direct and indirect effects. With above explanation, we believe that conducting experiment of the ratio of dust aerosol concentration vs. water vapor as suggested is deemed unnecessary. We also believe that the suggested experiments would be more meaningful in a standalone microphysical model than in a regional model setting as adopted in this study using WRF-Chem, given multiple dust feedbacks and dust-cloud-rainfall interactions.

Comment #2:

In the conceptual model (fig.15), the direct effect of the dust aerosols plays a dominating role. When the dust concentration increases, the surface cooling induced by scattering weakens the sea breeze circulation, which decreases the associated landward moisture transport, ultimately suppressing rainfall. Is that mean that the indirect effect is less important? If so, the conclusion is consistent with Koren et al.(2014) in line 530-532.

The indirect effect is weaker (+4.76%) compared the direct effect (-5.78%) for normal rainfall events as you said which is explained in the previous response but it does not mean that the direct effect is less important. We agree that the conclusion is consistent with that of Koren et al., 2014 in the sense that their results also showed that the aerosol indirect effects on warm clouds over polluted atmosphere were less sensitive than over clean atmosphere. We have now highlighted this as below in the revised manuscript.

"Since the calculated indirect effects are small, our results are also consistent with that of Koren et al., 2014 which also showed the indirect effects on warm clouds over polluted atmosphere is less sensitive to aerosol loading than over clean atmosphere."

Because dust aerosol concentration is closely related to CCN, it implies that the indirect effect of precipitation is not well related to dust concentration. If so, according to the newly developed conceptual model of the paper, it cannot explain the conclusion of increased rainfall in extreme rainfall events, because as the dust concentration increases, surface cooling induced by scattering weakens the sea breeze circulation, thus reducing land moisture transport and ultimately suppressing rainfall. These contradictions in logic need to be explained.

We believe that we have clarified this confusion in our previous responses. As explained, the physical mechanism of the extreme rainfalls is different from that for normal rainfall events.

Comment #3

Whether the relationship between dust aerosols and precipitation as shown in fig.1 and fig.2 can be explained by the conclusion derived from the conceptual model?

As per our understanding, you meant Figure 1a and 1b, not Fig. 1 and Fig. 2. We agree that some degree of direct positive relationship exists between dust aerosols and rainfall through the indirect effects as well as through the direct effect due to dust absorption of shortwave radiation, which we have explained in the paper.

line 649-650 "Although the domain-average rainfall change caused by dust averaged over multiple years (2006–2015) appeared small, the effect can be large at different grid points and times. This is a very interesting fact, which implies that the large circulation (mainly direct effect effects) has very little variation on the domain average rainfall, i.e. the conceptual model of dust and precipitation (fig.15) has very little effect on precipitation?

We believe that this is clarified in our previous responses. We refer to the sea breeze circulation as the local-scale diurnal circulation, not as the large-scale circulation. By large-scale circulation, we mean the synoptic structures that are responsible for extreme rainfall events.

Comment5:

It is an very interestingly conclusion in Lines 766-768. "However, our results suggest that cloud seeding efficiency may be affected by the presence of background dust aerosols, and that it may not be as effective in dusty regions as in clean environments." If AgI is used for cloud seeding experiments, high background dust aerosols in desert areas must be considered because both Agl and dust aerosols increase CCN, making it difficult for droplets to grow and thus inhibiting precipitation. Therefore, using Agl for cloud seeding in these areas may be a futile attempt to increase precipitation.

Thank you! We slightly revised the text to reflect your comment as below:

"However, our results suggest that cloud seeding efficiency may be affected by the presence of background dust aerosols, and that cloud seeding using commonly used materials such as AgI may not be as effective in dusty regions as in clean environments. It should also be noted that the effectiveness of cloud seeding depends upon the height of application. Therefore, before investing on expensive field experiments on cloud seeding, it would be beneficial to evaluate the effectiveness of cloud seeding through regional modeling in the areas of interest as done in this study."

Reviewer #2

This paper investigated the effects of dust on precipitation over the Red Sea coast and explored the physical key mechanism underneath. The findings and scientific significance of this paper were clearly stated. In particular, the interactions between the dust, sea-breeze circulation, and the feedback on the rain enhancement/suppression in a region with high dust load were examined. This study will certainty contribute new aspects to the field of cloud-aerosol-precipitation interactions. However, the paper needs major revision before publication. Below are my comments in detail.

The model-observation comparison requires some further justification/explanation. In the obs-model comparison plots, we could see an evident and consistent overestimation of model results. For example, Fig. 4 the wind speed is consistently stronger during the daytime in WRF-Chem. This time (around 15:00 local time) was also when the rainfall peaked and CCN-sea-breeze circulation interactions were strong. In Fig 7-8, the model overestimates the CCN concentration in all cases. The statements of "were reasonably consistent" and "produced reasonably well" throughout the manuscript were not supported by the comparison in the plots. A more quantified description/analysis is needed to support the model is comparable to observation (e.g., the relative difference of the wind speed). One suggestion is to conduct sensitivity studies to quantify how this would affect the conclusion of this study (e.g., use other driving datasets to test the impact of wind field, change the CCN concentrations, etc.).

Thank you very much for your comments. Below we respond to each of your points.

Regarding Figure 4, we have now presented a more quantitative evaluation as suggested. We have calculated the root mean squared error of the simulated wind speeds. We have added the following discussion in the manuscript:

"The root mean squared error (RMSE) of the simulated wind speed is 1.18 $m\ s^{-1}$, which is 29.6% of the observed mean. This level of discrepancy is reasonable since anemometers also typically have uncertainty up to ±0.5 $m\ s^{-1}$."

We have now checked the overuse of phrases like 'reasonably consistent' and used fairer and alternative descriptions throughout the manuscript. Regarding CCN overestimation, we have already noted and explained the implications of CCN overestimation in the end of section 3.1 and in explanations corresponding to Figure 11. Considering the suggestion, we have now also noted the mismatch of aerosol size distribution corresponding to Figure 6 as below.

"Although the size distribution patterns appear similar in model and observation, the differences in number concentrations are high particularly at 0.06-0.2 µm (note the logarithmic scale)."

Regarding the use of other driving datasets to see the effect of winds, we intended to use one of the most accurate data so that the simulations are realistic. The decision to use this data comes from our long modeling experience in the region. Considering reviewer's suggestion, we have added the following lines for clarification:

"We use 6-hourly ECMWF operational data (F640) as initial and boundary conditions, which is one of the most accurate reanalysis data assimilating several observations. The sea surface temperature (SST) was also updated every 6 hours using the skin temperature field from the same ECMWF dataset. We continue to use this data because it has worked well in our region (e.g., Parajuli et al., 2020; Mostamandi et al., 2022).

Parajuli, S. P., Stenchikov, G. L., Ukhov, A., Shevchenko, I., Dubovik, O., and Lopatin, A.: Aerosol vertical distribution and interactions with land/sea breezes over the eastern coast of the Red Sea from lidar data and high-resolution WRF-Chem simulations, Atmos. Chem. Phys., 20, 16089–16116, https://doi.org/10.5194/acp-20-16089-2020, 2020.

Mostamandi, S., Predybaylo, E., Osipov, S., Zolina, O., Gulev, S., Parajuli, S., & Stenchikov, G. (2022). Sea Breeze Geoengineering to Increase Rainfall over the Arabian Red Sea Coastal Plains, Journal of Hydrometeorology, 23(1), 3-24, https://doi.org/10.1175/JHM-D-20-0266.1.

Line 382: "The baseline experiments is calibrated against MODIS/AERONET AOD data": this sentence is a little misleading, as the study mainly compared the model output (wind speed, CCN, precipitation) against the observation, and only the conditions related to dust (dust emission fractions and dust size fractions) were adjusted. Those details should be mentioned in this statement to avoid ambiguity.

Thank you for pointing out this ambiguity. We have revised the two consecutive sentences to clarify this:

"This baseline experiment (all_aer) is calibrated against MODIS/AERONET AOD data by changing the dust emission fractions and dust size fractions as mentioned previously in section 2.3.1. The results of this baseline simulation were compared against observations, which exhibited a realistic aerosol distribution in terms of optical depth, PSD, and vertical profiles, as well as the rainfall pattern (see section 3.2.1)."

Line 474: "identical" is a very strict description. The profiles of the model and observations were not identical.

We agree, have now revised the texts to provide a fairer description.

“The profiles of the model, MERRA-2, and LIDAR data show some similarity but the model and MERRA-2 generally overestimate concentration by about 50% compared to LIDAR data. The mismatch is greater near the surface.”

Line 499: “The southern areas of the domain received more rainfall due to the presence of higher mountains”. This was evident in the model results (Fig.5a) but not so in the IMERG observations (Fig. 5b). More evidence is needed to support this statement. We could see the precipitation was stronger in the North in the observation and weaker in the South. But the opposite was found in the model.

Thank you for this comment. We have now noted the causes of these discrepancies as below:

“The rainfall pattern follows the length of the Sarawat Mountains stretching north to south. As the model shows, larger amounts of rainfall occurs in the areas with higher mountains. In the inland areas away from coast, rainfall distribution is also determined by synoptic rain events. For example, during the period of comparison, there were two events (August 7 and August 26) categorized as extreme rainfall events. This could be the reason why the IMERG data shows stronger rainfall in the north than in the south. The model has larger rainfall bias during such extreme rain events (Fig 2b) so the spatial distribution appear somewhat inconsistent with the IMERG data. However, note that IMERG data also show high RMSE (up to 30 mm) in this region compared to rain gauge measurements (Mahmoud et al., 2018).”

Mahmoud, M. T., Al-Zahrani, M. A. and Sharif, H. O.: Assessment of global precipitation measurement satellite products over Saudi Arabia. Journal of Hydrology, 559, 1-12, https://doi.org/10.1016/j.jhydrol.2018.02.015, 2018.

Line 527: “This order of difference, although large, is reasonable for microphysical parameters given the high uncertainty in their parameter”. It is not “reasonable” to make this assumption and is not a justification from a scientific perspective either. Instead, this should be seen as a limitation, as it only adds the uncertainty on top of the inherent uncertainty from current microphysical schemes. I suggest stating that as a limitation instead of making justification for this difference.

We agree with the reviewer’s assertion. We have now removed this statement and discussed this as a limitation in section 4 as suggested.

“In this study, we evaluated the relative contribution of direct and indirect effects of dust on rainfall and explored associated physical mechanisms using well-developed microphysical and aerosol schemes in WRF-Chem. Modeling rainfall processes entails some uncertainty, which is mainly related to the effect of aerosols on clouds. We indeed observed a large order of difference in simulated microphysical parameters (CCN # concentrations and aerosol size distributions) compared to observations, although they did not have much impact on the rainfall in the study region. There are several microphysical processes governing dust-cloud-rainfall interactions that are not fully understood or implemented yet in WRF-Chem (e.g., the prognostic treatment of ice nucleation by dust) (Chapman et al., 2009). Therefore, our model simulations may have not captured some dust-cloud-rainfall interactions occurring in reality, particularly those related to cold-cloud processes.”

Line 650: "at different grid points", "at different locations" will convey a more physical meaning.

Corrected as suggested.

Line 770: "It would be beneficial to evaluate the effectiveness of cloud seeding through regional modeling in the areas of interest as done in this study." I believe there were a few campaigns over the UAE area that have done such investigations. (e.g., Fonseca et al., 2022).

Thank you for pointing out this recent paper, which we were not aware of. Upon reading the paper, we found that the study was conducted using WRF (not WRF-Chem) to identify potentially suitable areas for cloud seeding with higher updrafts and deeper clouds without considering aerosols. Therefore, our suggestion still holds ground that background dust concentration may affect the cloud seeding efficiency. Note that we have added this reference along with one more paper from therein to provide more details of the cloud seeding activities in the region.

Fonseca, R., Francis, D., Nelli, N., Farrah, S., Wehbe, Y., Al Hosari, T., & Al Mazroui, A.: Assessment of the WRF model as a guidance tool into cloud seeding operations in the United Arab Emirates. Earth and Space Science, 9, e2022EA002269. https://doi.org/10.1029/2022EA002269, 2022.

Mazroui, A.A. and Farrah, S.: The UAE seeks leading position in global rain enhancement research, Journal of weather Modification, 49(1), 2017.

Fig. 1 shows the domain setup of the simulation. I suggest adding one zoomed-in map of d03 with the topography map (terrain height). Orographic effect plays a role in the sea-breeze circulation and affects the precipitation as can be seen in the analysis. It is also helpful to add KAUST and Abha in the d03 terrain map as an overview of the two key locations and their topography, as they will be frequently mentioned later. The author only showed KAUST in some of the figures, not Abha.

We have added a topographic map in Fig. 1 as suggested which is presented below.

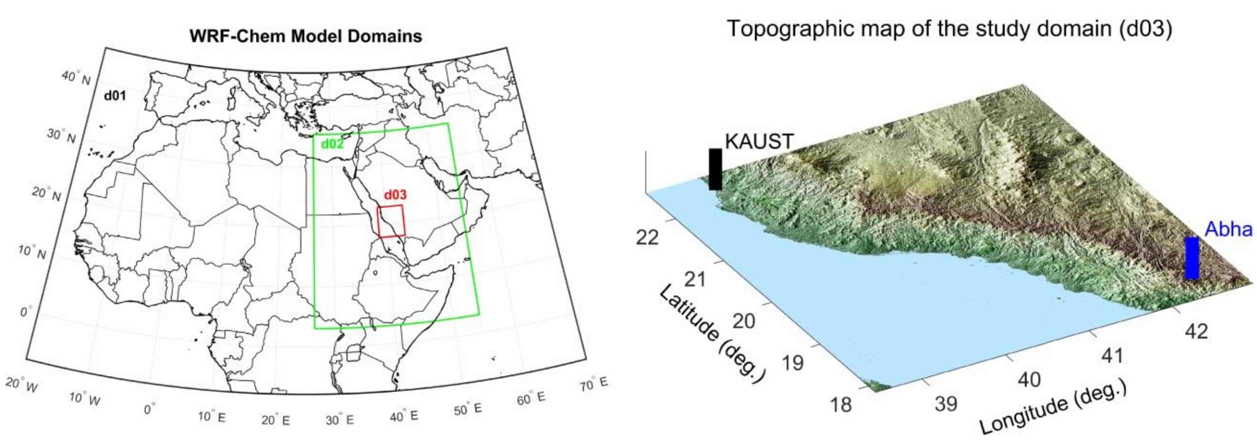

Fig. 6: a histogram/step may be better to show the modeled ASD.

We considered showing the data as histograms but use of logarithm scale created problem so we retained the line plots.

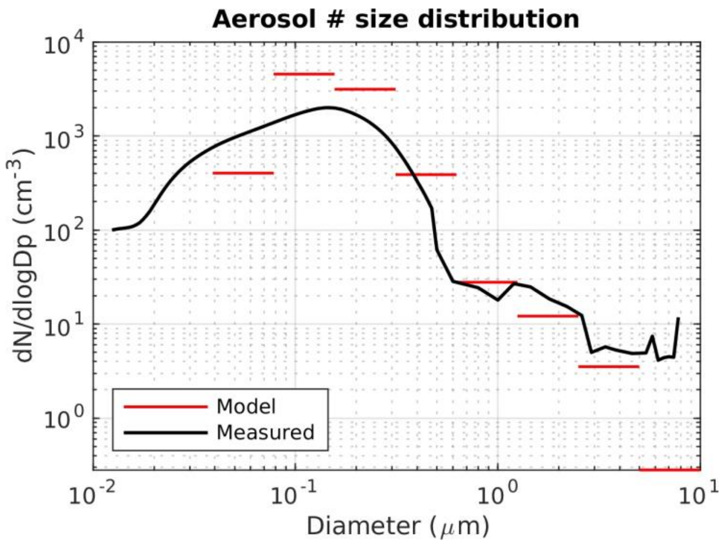

Figure 6. Comparison of model-simulated aerosol number concentrations (cm^{-3}) corresponding to MOSAIC size bins compared to flight measured values during the field campaign of August 2009. The widths of the red lines represent the widths of the eight MOSAIC bins. The model data (8-bins) were extracted at the exact latitude, longitude, and altitude corresponding to the flight data by 3d linear interpolation and averaged over the days available (Aug 11–30, 2009) during the time of measurements (~06:00 to 09:00 UTC).

Fig. 9-10 should be describing the same time point, but one said "at the time of rainfall maxima", one said "15:00". Either mention both info or use consistent description for a better reference.

Corrected as suggested.

Fig 11: I suggest using the same color scale for all plots for a better comparison among the three simulations.

The map does not show the CCN distribution well if we use the same color scale (see below), that is the reason why we used a different color scale.

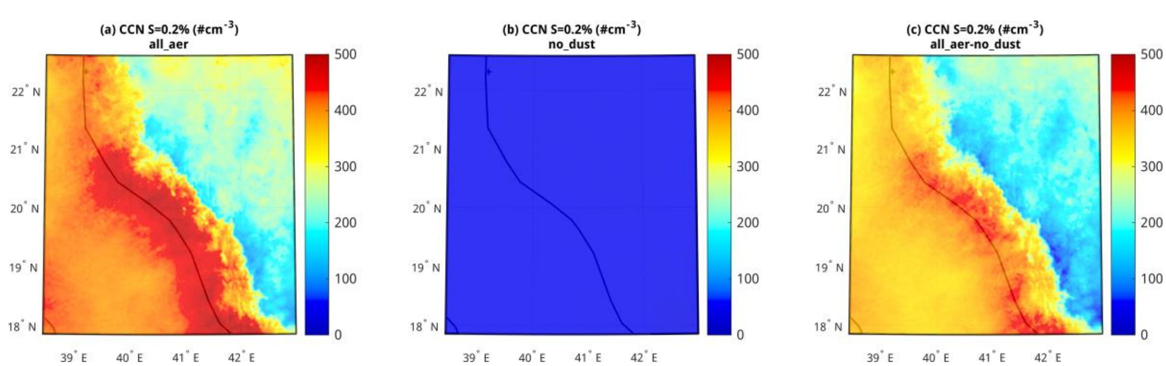

Fig. 13 (d,e,f) &Fig 14(c,d): the colorbar should not be there. The definition of the dots in the figure should be mentioned in the caption. (Author mentioned it in Line 613 but it's difficult for readers to find).

Color bars removed and the definition of dots added in the figure caption, as presented below.

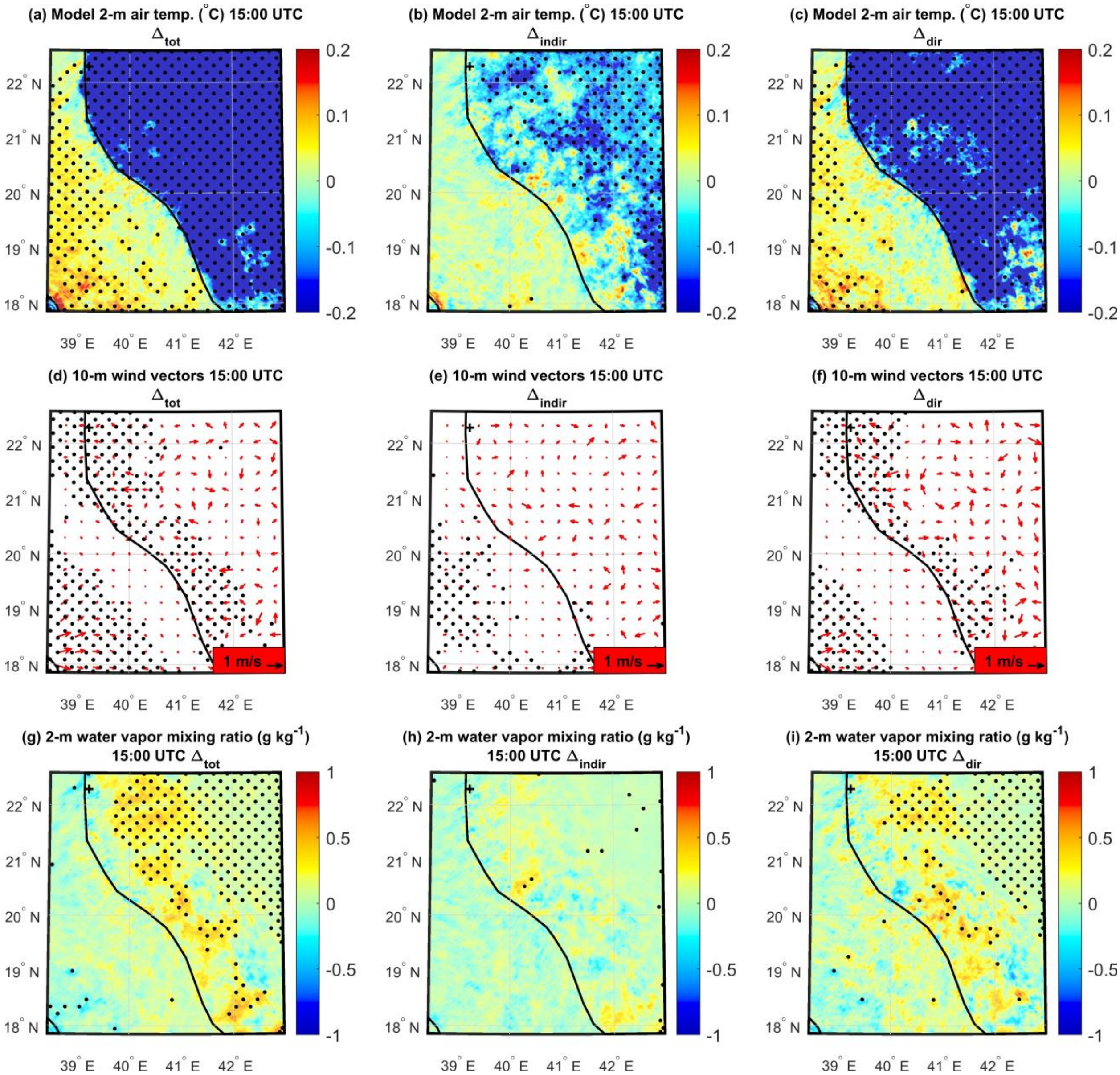

Figure 13. Spatial patterns of the Δ_{tot} (F1-F2), Δ_{indir} (F3-F4), and Δ_{dir} {(F1-F2)-(F3-F4)} for 2-m air temperature (a, b, c), 10-m winds (d, e, f) and 2-m water vapor mixing ratio (g, h, i) averaged at the time of rainfall maxima (15:00 UTC) over the entire study period (August 2006–2015). Black dots represent areas where the effect is statistically significant at 95% confidence interval.

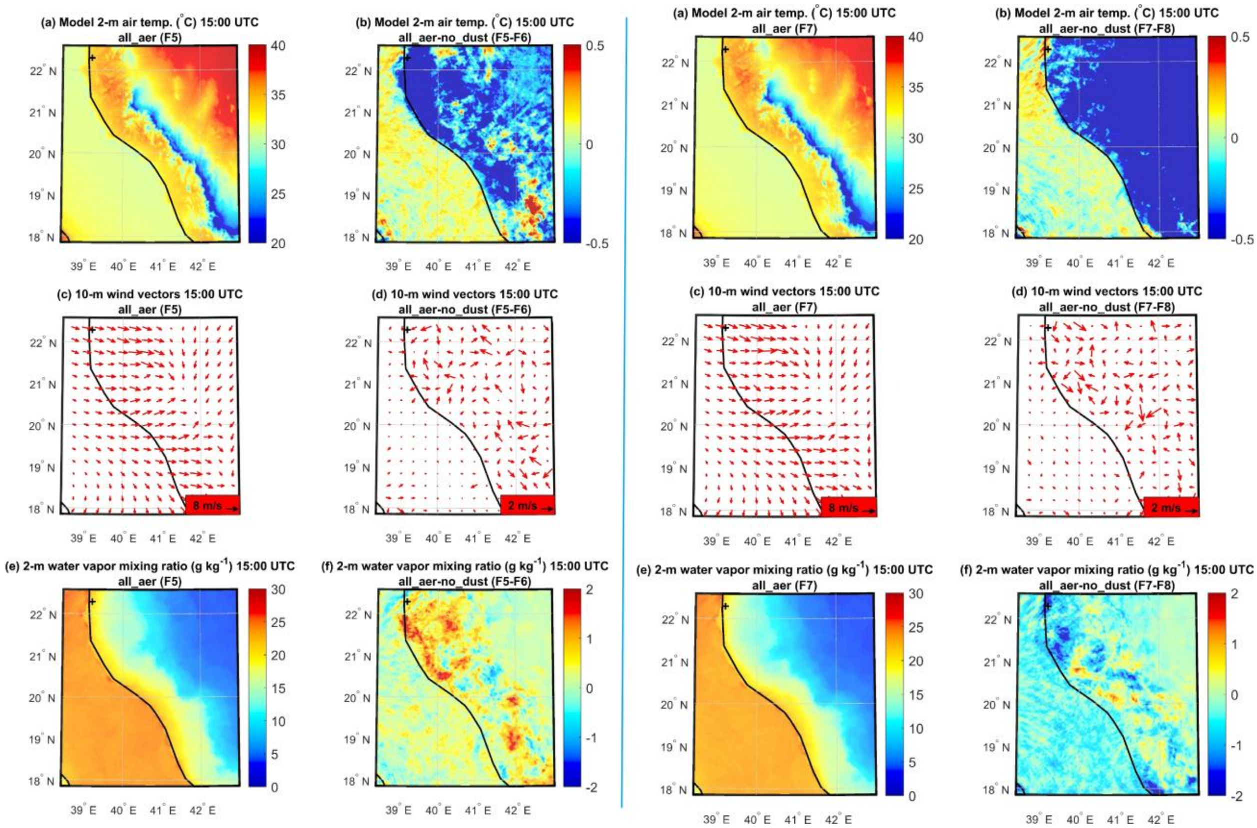

Figure 14. Left two columns: spatial patterns of 2-m air temperature (a, b), 10-m wind vectors (c, d), and 2-m water vapor mixing ratio (e, f) averaged at the time of sea breeze maxima (15:00 UTC) throughout the period of August 4–31, 2015 from the direct-effects-only experiment for all_aer case: F5 (first column) and the difference all_aer-no_dust: F5-F6 (second column). Right two columns: same as the left panel but without shortwave absorption, showing all_aer case (F7) and the difference all_aer-no_dust (F7-F8).

Reviewer #1

The paper reports an analysis of the effects of dust on rainfall over the Red Sea area. The study was performed using WRF-Chem simulations and a focus was given on direct and indirect effects of dust. The paper is interesting and suitable for the Journal. However, there are some limitations not properly discussed and some aspects not very clear (see my specific comments) that need a revision.

Thank you for your suggestions. We did our best to address your comments.

Line 21. I would say “important” rather than “the main element”.

Corrected as suggested.

Lines 37-40. This sentence does not explain at the end of the day what is the effect on average. It is an increase, a decrease or almost zero? This is an important aspect that should be discussed also in the interpretation of results.

Thank you for this comment; we agree that the average effect was not clearly mentioned. Considering your suggestion, we have revised the explanation as below for clarity:

"For extreme rainfall events (domain-average daily-accumulated rainfall of ≥ 1.33 mm), the net effect of dust on rainfall was positive or enhancement (6.05%), the indirect effect (4.54%) and direct effect (1.51%) both causing rainfall increase. At a 5% significance level, the total and indirect effects were statistically significant whereas the direct effect was not. For normal rainfall events (domain-average daily-accumulated rainfall < 1.33 mm), the indirect effect enhanced rainfall (4.76%) whereas the direct effect suppressed rainfall (-5.78%), resulting in a negative net suppressing effect (-1.02%), all of which were statistically significant."

Line 44. Why exactly 1.33 mm. It appears to be a strange choice is not explained.

We have already explained this in the end of section 2.3.2. We have copied the text below for your reference.

"Extreme rainfall events were separated from normal rainfall events using the 90th percentile value of the rainfall data from F1 experiment, which was 1.33 mm. Specifically, days with domain-average daily-accumulated rainfall values greater than or equal to 1.33 mm were considered extreme rainfall events, whereas those with values below 1.33 mm were considered as normal rainfall events. With this criterion, the effective numbers of samples (days) available for statistical analysis were 31 and 243 for extreme and normal rainfall events, respectively."

Abstract. The percentages given with two decimal digits as a consequence of a modelling that will certainly have uncertainties seems to be too much. Is 1.02% really different from 1%. Please provide an estimate of the uncertainties on this numbers.

This is mainly because of the fact that we observed small effect of dust on rainfall on average. Given the small effect, we took three digits after the decimal for a better estimate. The statistical significance of the results indicate their uncertainty, which is presented in Table 3. A low p-value ($p<0.05$) indicate that the effect is significant however small it may appear to be. Likewise, a higher p-value ($p>0.05$) indicate that the effect is not significant.

Section 2.3.1. The choice of simulating only the month of August for different years should be better explained. In the other months there is not rain? What is the percentage of cumulative annual rain associated to the month of August? It could have been better to simulate a whole year.

You are right. We chose the month of August because sea breezes are stronger during this month. We considered simulating the entire year but decided to choose one month considering the high computational cost, and rather decided to conduct simulations for multiple years for better statistical assessment of the results. We have clearly explained the reason for this choice in section 2.3.1 which is presented below for your reference:

"High-resolution simulations are usually conducted for several days or weeks due to their high computational demand. Simulating full-scale aerosol-climate interactions including indirect effects adds further computational burdens. Therefore, considering our purpose, we conducted our model simulations using WRF-Chem at a cloud resolving spatial resolution of 1.5×1.5 km for an entire month (August), of which the first three days were excluded from data analysis as spin-up period. Most model evaluations and diagnostic calculations were performed for a reference year (August 2015) unless otherwise mentioned. Additional validations are carried out for August 2009 because aerosol size distributions and microphysical data from a field campaign were available during this period.

To obtain statistically meaningful calculations of the dust effect on rainfall, 10 years of simulations (2006–2015) were conducted specifically for August of each year. The simulations were conducted over the Red Sea coast outlined by the nested domain d03 (Fig. 1), in which the parent domains d02 (4.5×4.5 km) and d01 (13.5×13.5 km) cover the Arabian Peninsula/northeast Africa and the MENA region, respectively. August was chosen because during this month the Red Sea coast receives abundant rainfall and sea breezes are relatively strong, which plays an important role in moisture transport over the coastal plains (Mostamandi et al., 2021)."

Line 262. What does it mean discarded for spin-up?

Sorry for the confusion. We meant to say that the first three days were discarded from the data analysis following the usual practice in modeling. We have now clarified the sentence as below:

"Therefore, considering our purpose, we conducted our model simulations using WRF-Chem at a cloud resolving spatial resolution of 1.5×1.5 km for an entire month (August), of which the first three days were excluded from data analysis as the spin-up period."

Line 290. Driving force for what? For the rain? Because the effects appears quite limited.

We agree that the use of phrase 'driving force' is not appropriate here. We meant to say that dust is a 'specific characteristic' of this region. We have corrected this.

Section 3.2. It is not really clear how the accuracy of model predictions is evaluated considering that no comparison with measured data is reported. It would be better to provide some kind of comparison for this goal. This will also give more information about the uncertainties of model outputs.

We have extensively compared our model results with observations in section 3.1. Simulation of indirect effect comes with a lot of uncertainty and at times may show unexpected results. Therefore, we presented further results in section 3.2 to ensure that the internal physical processes (e.g., radiative fluxes) are not out of order. Please refer to section 3.1 for the detailed comparison of model results with observations.

Table 3. Again, I see a lot of decimal digits in the prediction of the effects on rainfall arriving at 0.001 mm of H_2O. Is this really a figure obtainable by this simulations with a reasonable accuracy?

We believe that we have clarified this concern in our earlier response corresponding to your comment on abstract.