Atmos. Chem. Phys. Discuss., 10, C2704–C2713, 2010
www.atmos-chem-phys-discuss.net/10/C2704/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impacts of dust on West African climate during 2005 and 2006" *by* M. Camara et al.

M. Camara et al.

moctar1sn@yahoo.fr

Received and published: 15 May 2010

Interactive comment on "Impacts of dust on West African climate during 2005 and 2006" by M. Camara et al. Anonymous Referee #1 Received and published: 22 March 2010

Question 1: The objective of this paper is to evaluate the impact of the radiative effect of mineral dust on West African climate. The feed-back between mineral dust and the regional dynamic of West Africa is a topical issue that mobilizes an increasing number of scientists. This work is based on a modelling approach by comparing simulations from a regional climatic model (Reg-CM) with and without the inclusion of dust in the model, which appear as a relevant strategy to approach this problem. Some experimental data such as aerosol optical depth from the AERONET network and vertical profiles from

radiosoundings are used for comparison with the simulations. The manuscripts suffer from several main problems. First of all, the strategy is not sufficiently described and argued. As an example, most of the results concerns the summer months but there is no argument in the text justifying the selection of this specific period. The second main problem is to estimate what specific or original contribution is given in this work compared to similar work and in particular compared to Konaré et al. (2008) and Solmon et al. (2008). Finally the simulation is performed for the years 2005 and 2006, which correspond respectively to the beginning and intensive phase of the AMMA campaign, for which large data set of observations are available. However, only few measurements are used in this study, while this work would have largely benefit from additional comparison with observations. In addition, several legends are not properly assigned to figures and the text of the figures (axes legend) is often incorrect. The figures are too small so most of the text (scales, etc.) are not readable. For these reasons, I recommend major revisions to the manuscript that are detailed below.

Response 1: In the revised version of this paper, we focus on the intra seasonal variability of Saharan dust and its impact on the West African climate which gave more originality to this work. Therefore, we considered 4 periods: Winter (December to February - DJF), Spring (March to May - MAM), Summer (June to August -JJA) and the autumn (September to November - SON). We also evaluate the capacity of the RegCM3 to capture extreme events through a case study. As a reminder, Konare et al (2008) and Salmon et al (2009) focused only on the summer period. These two years (2005 and 2006) have been chosen to take advantage of the large data set of available observation during the AMMA campaign and numerous published papers that focused on this period. To validate the model runs, we use 3 independent aerosol observed data (MISR, OMI aerosol index and AERONET data), a rainfall product (GPCP) and radiosounding data at 3 West African stations. Obviously, we can't use all AMMA available observation. We correct the texts of the figures and made them more readable in the revised version.

Question 2: General comments 1. Introduction Page 3056 The authors list several studied on the impact of dust on climatic or meteorological features of West Africa. At the end of this introduction, they should clearly state what different, original or new they propose compared to the cited work.

Response 2: In this revised version, we clearly stated what is original in our study.

Question 3: Model description Page 3057 : The authors only give a brief description of the model they use, since they refer to previously published papers. However, since they investigate the feedback between dust radiative effects and dynamic, they should clearly describe the way they estimate this forcing. In particular, it is necessary to describe and discuss the optical properties (size distribution, refractive index) uses for desert dust (in the shortwave and in the long range) and the associated uncertainties, since it will largely control the direct radiative effect and thus the intensity and sign of the feedback. Implicitly, the reader understands that only the direct radiative effect is accounted for, but this should be clearly stated.

Response 3: We clearly stated in the revised paper that we focused only on the direct radiative effect. The dust module used in this study considered four transported dust bins (effective diameters: 0.1-1; 1-2.5; 2.5 -5; 5-20). The most important term specific to dust particles in the dust version of RegCM is the surface emission, which is extensively described by Zakey et al. [2006] and summarized in Konare et al (2008). Briefly, the dust emission term accounts for both the horizontal saltating flux and the vertical dust flux. The dust emission depends on a minimum threshold friction velocity, it is a nonlinear function of the near-surface wind speed, and it depends on particle radius, soil moisture, vegetation type, and soil texture. We represent the single scattering albedo in the revised version resulting from the combination of these four dust bins and found SSA values between 0.91 and 0.94. These SSA values are consistent with recent single scattering estimations based on satellite retrieval [Hsu et al., 2004; Kaufman et al., 2001] and model estimates of Konare et al (2008) suggesting that the dust aerosol behaves as diffusive particles even above the relatively bright desert.

Question 4: 3. Results/3.1 Dust characteristics Page 3058 : The author should explain and discuss why the study focus on the summer period since they simulate the whole year and all the observations they used are available for the whole year.

Response 4: As stated above, we know focus especially on the whole season. Thanks for the contribution

Question 5: Page 3059 : The comparison with observations is extremely factual, while a critical discussion is expected. The maximum simulated AOD is not correctly located compared to TOMS AI, the seasonal cycle of AOD in not correctly reproduced in Banizoumbou and Agoufou. Convincing elements to discuss or explain these strong differences are needed. The vertical distribution in Dakar should be compared to the measurements derived from lidar system in Leon et al., ACP, 2010. In fact, it reproduce quite nicely the shift from a lows level transport in the winter and spring to a high altitude transport in the Saharan air layer in the summer.

Response 5 : The fact that the maximum simulated AOD is not correctly located compared to MISR data (in the revised version) and the differences concerning the seasonal cycle of AOD in Banizoumbou and Agoufou may be linked to several factors: Our domain does not fully take into account the bodele depression which is known to be a great source of desertic aerosol. Another reason may be linked to the parameterization of the RegCM3 in which a grid cell is considered to be either totally or not affected by dust. A possible reason is the fact that Aeronet data take into account all aerosol modes (dust and anthropogenic aerosols). While the model run focus only on dust. Thanks for your comments about the shift from a low level transport in the winter and spring to a high altitude transport in the Saharan air layer in the summer

Question 6: The sentence “Banizoumbou station is less affected by dust than the other stations throughout the year ..” is totally inconsistent with the results from figure 4, in which the station of Banizoumbou exhibit the highest AOD of the 4 stations !! The author should selected the AOD for which the angstrom coefficient gives an indiction of coarse (and thus dust) particles, to be sure that the comparison with the simulation is relevant and that the AOD is not due to other aerosols, in particular biomass burning aerosols. This section should end with a critical discussion on the performance of the model to simulate the dust distribution and thus on the possibility to use it to estimate dust feedback.

Response 6: We change the sentence concerning banizoumbou station: "Banizoumbou station is less affected by dust during the spring and summer period." We stated in the discussion of th revised paper that the discrepancies can be the results of the presence of aerosols other than dust in the AERONET AOT while the aerosol simulation of the RegCM3 focus only on dust. We ended this with a critical discussion on the performance of the model to simulate the dust distribution and thus on the possibility to use it to estimate dust feedback.

Question 7 : 3. Results/3.2 Effect of dust on environmental parameters Page 3061 This section describes the impact of dust on several meteorological characteristics of the region, such as the AEJ, the intensity of the monsoon flow, etc : : : based on the comparison of temperature, humidity and solar radiation absorbed at the surface simulated in the control run and the dust run. The authors discuss the location where differences are observed but do not ts intensity compared to the initial field. As an example, maximum differences of -2°C are simulated in the regions where the temperature is maximum, how significant is it ? Would it be possible to detect such a difference from observations or is it in the same range than the uncertainty on these parameters ? The authors indicate that dust result in a strong reduction of the incoming solar radiation. This was stated by several authors based on data from the AMMA SOP period and from the results of the ARM station. Is the intensity of the simulated reduction consistent with these previously published estimations at least in terms of order of magnitude ? The comparison is based on different field's average during July-September 2005-2006. Response 7: In the revised version, we compare our results to some papers that focused on this subject.

Question 8: What justify this average on the summer period especially over two years ? Response 8: We focus in the revised version of this paper on the intra-seasonal variability of dust and its effects on the West African climate. 2005 and 2006 have been chosen to take advantage of the AMMA campaign data and publications. This diagnostic study will be followed by another using a long temporal time series in order to get robust results and to study the behavior of other features of the West African climate under dust effects.

Question 9: Page 3063-3034 The status of the comparison between the simulated winds for the two runs with the NCEP/NCAR reanalysis is not clear. From their conclusion on this part, it seems that the authors consider the NCEP/NCAR fields as a reference. This is quite ambiguous since these fields are used as initialization and forcing of the simulations. Obviously, the control run gives a different simulation, otherwise why using a regional model ? In addition, it is expected that the regional mode provides a better simulation than the analysis. A comparison with some observations should help discussing the differences. The discussion should be revised to focus on the subject of the manuscript, i.e. the influence of mineral dust.

Response 9: We remove the NCEP/NCAR reanalysis wind and focus only on dust climatic radiative effects.

Question 10: The comparison on the precipitation fields is facilitated by the use of an external reference derived from observations. However, it is difficult, looking at figure 11 to be convinced by the conclusion that "dust implementation in the model improve the summer rainfall ..". The two simulations present the same bias in the intensity and "location" (in space and time) of the precipitation maximum. The dust run seems to be even worse. The authors argue that other simulations show the same effect of dust. This should be further discussed and explained. Why do the dust-run produce a more stable environment inhibiting convection? Is it due/sensitive to dust optical properties (too absorbing ?) or to the bias in the simulated dust distribution ?

Response 10: The reduction of precipitation in the dust run may be linked to the stability of atmospheric layers which in turn prevent deep convection and then more rainfall. Additionally, Aerosol can act as cloud condensation nuclei. An increase of cloud droplets with reduced sizes decrease the precipitation efficiency and then the rainfall (Albrecht, 1989; Rosenfeld et al., 2001; Hui et al., 2008; Klüser and Holzer-Popp, 2010). We already stated in the revised paper that the intensity improvement induced by the dust radiative effects over the Sahel region concerns only the rainfall maximum intensity on JAS which is around 8 mm/day.

Question 11: 3. Results/3.3 A case study of a strong dust outbreak The authors describe the simulation of a dust storm on the 10th September. They should comment on the selection of this case, since from figure 5, this event does not look like a very strong dust storm. As a result, this may not an optimum situation to estimate the dust impact and to detect this impact compared to observations. The simulated dust plume is compared to OMI aerosol index and tends to show a similar pattern. In addition, the author should show a comparison with the measured AOD, by adding for example the AOD measured at 12h00 in table 1. For this case study, the authors present a comparison based of the vertical profiles of dynamical and thermodynamical parameters derived from field mea surements. But they compare only the results of the dust run to the measurements and do not discuss the difference between the control and the dust runs. It is thus impossible to estimate how much dust impact these parameters and to what extend including dust improve the simulation. In addition, except a factual description of the measured and simulated profiles, the authors do not gives any conclusion of this section.

Response 11: Satellite data which offers a spatial coverage shows that Mauritania and Northern Senegal were under the dust outbreak on September 10th 2006. But this outbreak is more intense over Mauritania and Cabo verde than over Dakar and that may explain the moderate AOD value (0.6). The objective of the case study is to study the capacity of RegCM3 to simulate dust outbreaks and to compare its effects

on environmental conditions with radiosounding data. We add a comparison between dust and control cases concerning the absorbed solar radiation and the TOA radiative forcing which exhibit large changes under dust effects.

Question 12: 4. Summary and conclusion Some statements in this summary seem contradictory with previous sections. In particular, the authors write that “the dust layer extend from the surface to 500hPa with a maximum close to the surface ..”. At the first reading, it looks contradictory with the vertical profile at the four stations (figure 3), for which the dust layer are clearly shifted at high altitude in summer compared to spring. In fact this statement is based in the latitudinal averaged vertical profile from figure 2, where the maximum dust amount is located close to the surface (from which dust is emitted). However, the term “dust layer” is not relevant in this case. The sentence should be revised.

Response 12: Thanks for the contribution. We took that into account in the revised version.

Question 13: The general conclusions are too superficial both on the simulation of the dust distribution and on the feedback on dynamics. Obviously, the underestimation of the AOD means that some sources are missing or that their intensity is not correctly reproduced. The authors claim that it is due to the underestimation of the dust emissions from the Bodélé region or to their subgrid fractional emission without convincing arguments.

Response 13: We reinforced the conclusion and tried to give some arguments about the discrepancies between the model and observation.

Question 14: The authors properly describe the differences between the main meteorological characteristics of West Africa simulated by the control and the dust run and depicted with the NCEP/NCAR analysis, but no clear conclusion raised from this factual description. So finally the reader is not convinced that this study on the dust impact is relevant. The only clear conclusion is that this model, like many others, simulates a more stable atmosphere which leads to less convection (and thus less rain over the Sahel). But what the reader would like to know is whether it is realistic or not, whether the precision on the simulated dust fields is sufficient to draw any conclusion on this feedback, and/or what should be improved, in the model or in the observations, to answer to these questions.

Response 14: We strengthen our conclusion to take into account the points raised by the reviewer. Question 15: Technical comments Page 3055 : In the sentence "Dust can travel : Florida and American coast"; the pioneer work of Prospero in the 70's should be mentioned instead of recent references. Shiin et al., 2000 : not in the reference list.

Response 15 FIXED

Page 3057 : The authors should comment on the selection of the year 2005 and 2006.

Response These two years have been chosen to take advantages of data from the AMMA campaign and numerous publications focusing on that period as stated above

Page 3058 : Legends of figure 1 and 2 are inverted. FIXED

Page 3059 : The vertical axes of figure 3 are "vertical levels" while a quantitative unit is expected. FIXED

Page 3060 : In figure 5, the period with not data should have no mark. Does the percentage given in brackets corresponds to the correlation coefficient (r or r2)? Response : The percentage in bracket is r (coefficient of correlation)

Page 3061, figure 6 The figures are too small, it is impossible to read the color scale. FIXED

Page 3062 : Legends of figure 8 and 9 are inverted. FIXED

Page 3064 : Vertical axe of figure 10 is wrong. FIXED

Page 3065 : On figure 12, in the legend replace "TOMS aerosol index" by "OMI aerosol

index" and add the color axes for the simulated aerosol optical depth. FIXED

On figure 13, the text in the box is too small to read anything !! The same remark applies to the legend of the vertical axes. FIXED

Page 3070 : When AERONET data are used for a publication, the PI's of the instruments should be at least acknowledge, as described on the AERONET website. FIXED

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 3053, 2010.