Reply to the Interactive comment on « Dust emission size distribution impact on aerosol budget and radiative forcing over the Mediterranean region : a regional climate model approach » by P. Nabat et al.

Anonymous Referee #3

Reply : We would like first to thank the reviewer for the evaluation of our work and his positive comments. We have adressed all the comments in detail, and clarified the mentioned points. Please find below our point-by-point replies highlighted in bold. Corrections in the text are indicated in italics.

Overall comments:
The manuscript “Dust emission size distribution impact on aerosol budget and radiative forcing over the Mediterranean region: a regional climate model approach” by P. Nabat et al., explores the extent to which RegCM-4, a regional climate model, is sensitive to the different approaches used in representing dust emission distribution and the impact these different approaches have on the dust budget, aerosol optical depth and aerosol direct radiative forcing both in SW and LW radiation focusing in the Mediterranean region. To find the most realistic distributions, authors perform two simulations for the year 2008. In a next step they carry out ten-year simulations to characterize the aerosol optical depth, emission and deposition in the Mediterranean, in order to estimate their potential impact on climate through direct SW and LW radiative forcing.
Although the effect of dust on the Earth’s rediative budget has been quite extensively examined, still, there is a lot of uncertainty associated with it. Much of this uncertainty arises from the approaches used in models to represent the size distribution of the dust particles. Towards this, the present study employs a new scheme for representing the dust size distribution that is independent of wind speed, a hypothesis that has been shown to produce result that agree well with observations.
The manuscript is very well written and is a step towards the improvement of the estimation of the effect of dust on the Earth’s radiative budget. The work presented is comprehensive, including evaluation of modeled AOD with satellite records, data from AERONET and LIDAR, and simulations for different time scales that address both seasonal and inter-annual variability. Overall, the manuscript is publishable in ACP after some minor issues will be addressed.

Detailed comments :

1. Page 17848, line10: Please state where these AERONET stations are located.
Reply : Corrected.
Section 4.3 ***(page 17851, line 16): These stations are Blida (Algeria, 36.5°N, 2.9°E), representing a location in the vicinity of dust sources, Barcelona (Spain, 41.4°N, 2.1°E), located in the Western Mediterranean, and Crete (Greece, 35.3°N, 25.3°E) in the Eastern basin.***

2. Figures 9 and 10: Please add the scale bars.
Reply : Colour bars have been added.

3. Figure 11: Please add “Latitude” and “Longitude” titles.
Reply : Corrected in the new version.

4. Conclusions: Although the manuscript is quite extended and the results have been clearly presented, a quantitative presentation of the basic findings (e.g., improvement of modeling results using the new framework) would be also useful.
Reply : Numerical results have been added to the conclusion.
Conclusion :
(page 17859, line 19) The average bias in spring over the Mediterranean Sea compared to MODIS AOD has been reduced from 0.043 in REF to 0.017 in NEW.
(page 17860, line 2) The new dust emitted size distribution has increased dry deposition by 57% on average over the year 2008 because of the emission of more coarse dust aerosols.
(page 17859, line 26) The average SW RF over the Mediterranean Sea reaches -13.6 W/m² at the surface, and -5.5 W/m² at TOA. The LW RF is positive over the basin : 1.7 W/m² on average over the Mediterranean Sea at the surface, and 0.6 W/m² at TOA. It is stronger at the surface than at TOA, notably over Northern Africa (5.8 against 1.0 W/m²), because of (…)

5. As also the authors point out, the effect of not using a model that has a two-way interaction between atmosphere and oceans, involves some limitations. Please discuss in a quantitative manner how different would the results be if such a model was used.
Reply : We are aware of this limitation of our model. In an ocean-atmosphere coupled mode, we may believe that dust effects on the Mediterranean climate would be reinforced, notably because of a possible decrease of SST. This SST response is much more important for examining the climatic feedback rather than the radiative forcing. Yue et al. (2011) have shown an extra cooling simulated with the SST responses to dust forcing at the global scale. When SSTs are allowed to respond to dust radiative forcing, a decrease by 0.09 K in the global and annual mean surface air temperature is observed instead of an increase by 0.02 K with prescribed SSTs. Over the Mediterranean region, figure 7 in this paper shows a similar response (slightly positive for prescribed SSTs and negative with the response of SST), passing the 95% significance level. However we do not have the precise averages over the Mediterranean to be mentioned in our paper. Besides, ocean-atmosphere coupled models with interactive aerosols are currently being developped, notably in CNRM (ALADIN-Climat and NEMO-MED8, Somot et al., 2008, Herrmann et al., 2011) and in ENEA (RegCM-3/MIT, collaboration with ICTP, Artale et al., 2010). We aim at realizing a study with interactive aerosols and ocean-atmosphere coupling in future.
Conclusion (page 17860, line 12): on simulated dust-induced climate change (Yue et al., 2011). This study has shown an extra cooling simulated with the SST responses to dust forcing at the global scale (-0.09 K in surface air temperature on average with interactive SSTs instead of +0.02 K with prescribed SSTs).

References :

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Herrmann, M., Somot, S., Calmanti, S., Dubois, C., and Sevault, F.: Representation of spatial and temporal variability of daily wind speed and of intense wind events over the Mediterranean Sea using dynamical downscaling: impact of the regional climate model configuration, Natural Hazards and Earth System Sciences, 11, 1983–2001, doi:10.5194/nhess-11-1983-2011, 201.

Somot, S., Sevault, F., Déqué, M., and Crépon, M.: 21st century climate change scenario for the Mediterranean using a coupled atmosphere–ocean regional climate model, Global and Planetary Change, 63, 112–126, doi:10.1016/j.gloplacha.2007.10.003, 2008.

Yue, X., Liao, H.,Wang, H. J., Li, S. L., and Tang, J. P.: Role of sea surface temperature responses in simulation of the climatic effect of mineral dust aerosol, Atmospheric, Chemistry and Physics, 11, 6049–6062, doi:10.5194/acp-11-6049-2011, 2011.