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Atmospheric
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Discussions

Interactive comment on "Modeling of Saharan dust outbreaks over the Mediterranean by RegCM3: case studies" *by* M. Santese et al.

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Dear Referee#1,

many thanks for your comments. We have done our best to fulfill your suggestions in order to improve the paper. Answers to your comments are reported below and can also be found in the marked copy of the manuscript attached to this letter.

1. Abstract, line 18: LW forcing unit percent of what?

The abstract sentence has been changed as follows:

" This is partially offset by the LW direct radiative forcing, which is 7.6 W/m2 and 1.9

W/m2 on 17 July and 8.4W/m2 and 1.9 W/m2 on 24 July at the surface and top of the atmosphere, respectively. Hence, the daily-mean SW forcing is offset by the LW forcing of ïĄ¿ 30% at the surface and of ïĄ¿ 50% at the ToA. “

2. Introduction: What is the main step forward in view of the literature dealing with atmospheric modeling in this field of research including feedback mechanisms?

The following sentences have been added in the introduction:

“. . ..In this paper, RegCM3 is coupled with a radiatively active aerosol model with online feedback on the radiation scheme (Zakey et al., 2006, Konare et al., 2008; Todd et al., 2008; Zhang et al., 2009), and for the first time, it is used to investigate the aerosol radiative forcing (at solar and thermal wavelengths) and related climate effects during African dust intrusions over the central Mediterranean. Note that the inclusion of the aerosol feedback both at solar and thermal wavelengths can lead to a decrease of the bias between modeled and observation-based atmospheric parameters.”

“. . .. . .Note that compared to the work of Zhang et al. (2009) that is related to the simulation of dust aerosol over East Asia, our simulations also include anthropogenic aerosols. . .”

“. . . A better understanding of the model behavior can allow improving the parameterization of aerosol processes in order to contribute to the understanding of the aerosol role in the climate system. At present, there exists considerable uncertainty in model estimates of both anthropogenic-aerosol and dust emission. Therefore, the improved parameterization of aerosol processes is an important step in the further development of climate and Earth system models. “

3. The reasoning why to use regional models to look at the radiative effect of dust and other aerosol processes rather than use GCMs is not really convincing for this setup. The authors use the model with a grid spacing of 50 km, which is not that much higher than the ability of some GCMs that contain an aerosol module but those global models

could in turn provide the response at large spatial scales and response of sea surface temperatures in addition. At 50km grid resolution parameterizations of e.g. boundary layer and convection processes are required that may lead to similar shortcomings compared to global-scale models.

The following sentences have been added in section 2.3:

“ It is worth noting that the grid spacing of 50 km used in this test study is not much higher than the ones used by some GCMs with an aerosol module. Nevertheless, we believe that the selected grid spacing does not represent a limiting factor of the paper’s main scope. However, our modeling system can operate at smaller grid spacing.”

4. Section 2.2 Dust Model: Even though the optical properties of dust used in this model are described by Zhang et al., 2009, some information should be given here as well (at least on particle size, single scattering albedo), and compare those to other publications. In several instances the authors mention the importance of dust optical properties for its radiative effect, so it needs at least some description.

Additions in section 2.2 are reported below:

“. . ..The dust module has a size spectrum from 0.01 to 20.0μm, which is divided into 4 size-bins, each covering part of the whole spectrum of particle diameter: i.e. the fine (0.01-1.0 μm), accumulation (1.0-2.5 μm), coarse (2.5-5.0 μm), and giant (5.0-20.0 μm) particle mode. The evolution of each bin is described by a prognostic equation for the dry size of the dust particle (Zakey et al., 2006; Solmon et al., 2006). The radiative code in the RegCM3 employs the ïĄď-Eddington approximation for radiative flux calculations, and the wavelength spectrum is divided into 18 discrete intervals from 0.2 to 4.5 ïĄ■m. Seven of these span the ultraviolet (0.2-0.35 μm), one covers the visible (0.35-0.64 μm) and the remaining bands cover the infrared or special absorption windows. Zhang et al. (2009) provide a detailed description of the aerosol parameters used to perform radiative forcing calculations. The dust SW radiative effect is calculated using asymmetry factor, single scattering albedo, and mass extinction coefficient obtained from Mie calculations. The refractive indices of mineral dust aerosols for the relevant SW spectral windows are taken from the OPAC database (Hess et al., 1998). In the LW domain, dust effects are accounted for by introducing the dust emissivity (and hence absorptivity) according to the parameterization of Kiehle et al. (1996). The dust LW emissivity is calculated according to: (1) where D=1.66 is a diffusivity factor, b(z) is the dust burden (gm) of a given layer and is the mass absorption coefficient calculated using Mie theory for the relevant LW spectral windows, for each size bin and using LW refractive indices consistent with Wang et al. (2006). The OPAC dataset allows the calculation of dust optical properties at 61 wavelengths between 0.25 and 40μm, providing the real and imaginary parts of the refractive indices for each wavelength range. In our study we use the wavelength range from 0.2 to 4.5 μm. Figure 1 shows (a) single scattering albedo and (b) asymmetry factor versus wavelength retrieved from Mie calculations for the four size bins. The plots of Figs. 1a-b are in satisfactory accordance with the corresponding ones by OPAC dataset and with AERONET data (e.g. Bergamo et al., 2008).

5. Figure 1: What is the significance of showing the sand source for the dust model description?

The following sentence has been added in section 2.3:

“ Figure 1c shows the model domain in addition to sand source percentages (color coded plot) to indicate the location of main dust sources over the model domain. “

6. Section 3.1: Using the Navy Web address as reference for the (NASA) SeaWifs product is strange. In fact, why the comparison with true-color imagery (Figure 2), when actual aerosol optical thickness products are available (e.g. from MODIS, which is used later in Figure 4 anyway)?

MODIS AOD plots over the model domain were less clear than SeaWifs images as a consequence of missing data points. This mainly occurs in presence of clouds and SeaWifs images show the presence of clouds over the Mediterranean regions affected

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by dust intrusion.

7. Figure 4 would be more instructive if (1) the model results would be shown subdivided for the different aerosol components (dust, other aerosols), to show the importance of the dust components, and (2) show additionally the Angstrom parameter from the Aeronet data to give an indication of the presence of dust at individual times/locations.

The AOD due the anthropogenic aerosol components is very small with respect to that due to dust particles at the monitoring sites of Fig.4 and as a consequence it has not been shown. In fact, Table 3 shows that on July 17 the daily mean AOD at 550 nm is equal to 0.007 over the model domain above 35ïĆř N.

The Angstrom parameter has been added in Fig. 4 and the following sentences have been added in section 3.2

"... Daily-mean-values of the Angstrom coefficient (Å) that are plotted in Fig. 4a-e by grey dotted lines also indicate that AOD peak values are due to dust intrusion events. Å mainly depends on the aerosol size distribution and several studies have revealed that Å appears as a good marker to trace the temporal evolution of dust outbreaks (e.g. Tafuro et al., 2006). Typical values range from Å > 2 for fresh smoke particles, which are dominated by accumulation mode aerosol, to nearly zero for large dust particles (Dubovik et al., 2000)."

8. Figure 5: Why limit the comparison with MODIS AOD to Aeronet locations? Both MODIS and model AODs are available at other places!

We have added in Fig. 4 MODIS AODs referring to a site 80 km away from the Africa coast. The following comments have also been added in the paper.

"Figure 4f shows AOD daily mean values from the model (black dashed line) and from MODIS (grey solid line) retrieved ïĄ¿ 87 km away from the Africa coast (site A). The site A location (37.60° N, 5.00° E) is shown in Fig. 1c. MODIS AODs at 550 nm have been calculated by averaging all data points of a 50x50 km^2 box centered at site A. Figure 4f also shows the good model performance in catching the AOD evolution with time but, peak values of model-AODs are significantly larger than peak values of MODIS-AODs. This last result showing that the model overestimates AODs at sites closest to dust sources, are consistent with previous findings."

9. Figure 7, Comparison to Lidar at Lecce, particularly at 17. July: The authors attribute the model underestimate at low altitudes to insufficient dust transport however the dust should be expected at higher altitudes, it appears that the model in this case underestimates (local?) anthropogenic aerosol .

Comments on Fig. 7 have been improved as follows:

"…Thus, the larger extinction coefficients retrieved at Lecce by lidar measurements may also be an indication of weak long range transport of dust. Note that dust particles affect all the aerosol column few hours after the onset of the dust event, in accordance with lidar measurements, (e.g. Pavese et al., 2008). The underestimate of the anthropogenic aerosol amount also may represent a contributing factor: morphological.……"

10. The description of the forcing results (section 4) reads rather tedious. Maps of forcing efficiencies would be interesting rather than just showing the total forcing results, as this might highlight differences due to different aerosol composition.

Some sentences of section 4 have been deleted to make the section less tedious as it turns out from the revised paper. Please note that some results on FE are given in Table 1 and 2 for different domain regions. Table's data allow highlighting the differences due to different aerosol composition.

11. Section 5, Aerosol feedback: The whole feedback part is rather confusing. If the effect of forcing on aerosol transport is discussed, this should be shown by differences in AOD or mass loads rather than by differences in TOA forcing, which can depend on many things.

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In fact, the feedback effect on the aerosol column burden is at first discussed in section 5, in accordance with your suggestion.

12. In Figures 13 and 14 the aerosol extinction profiles should be included.

Aerosol extinction profiles have been added in Figs. 13-14 in addition to the following sentences.

“. . ..Figure 13d-f shows the aerosol extinction coefficient, T, MR, and WS vertical profiles provided by the model on July 17 at a different north-west Sahara location: site 2 (27.76 °N; 2.75 °E, Fig. 10b) that is rather close to a main dust source. We observe that the interactive aerosol simulation (REF) produces in the lower troposphere lower temperatures and larger MR and WS values than the Exp1-simulation, in accordance with Fig. 13a-c. It is also worth noting that extinction coefficient vertical profiles of Fig. 13d show that the interactive aerosol significantly lowers the aerosol load located from about 0.5 to 4 km. In fact, the REF-extinction coefficient takes values ïĄĂ 0.3 km-1 from 0.5 to 4 km while, the Exp1-extinction coefficient varies up ïĄĂ 0.5 km-1 from 0.5 to 4 km. Figure 13a referring to a site that is far away from dust sources shows instead that the aerosol vertical distribution is poorly affected by the simulation assumptions, in accordance with Fig. 11c. “

13. What is actually the effect of including the dust forcing on dust emissions? Earlier regional model results consistently show decrease in dust emissions due to decreasing wind speeds. If this is the case here it should be clearly stated (and shown). Interpretation of the changes in atmospheric dynamics due to the aerosol forcing is only very superficial.

Figure 11e-f has been added to show the daily-averaged differences between REF and Exp1 ground wind speeds for 17 and 24 July. More comments have been added to better explain interactive aerosol effects. In particular, the following sentences have been added:

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“ Aerosol effects on the atmospheric dynamics and hence on dust production and advection toward Europe are responsible for the marked dependence of aerosol CB values on simulation assumptions over the whole simulation domain. Figure 11e-f shows the daily-averaged differences between REF and Exp1 ground wind speeds (WS) for 17 and 24 July, respectively and it is worth noting that color-coded plots are very patchy: daily-averaged WS differences take positive and negative values that vary from -6 m/s up to 6 m/s either over Sahara or Europe. Hence, surface wind speeds markedly changed between the interactive- and non-interactive case. In particular, the comparison of Fig. 11a and Fig. 11e, and of Fig. 11b and Fig. 11f, shows that WS differences are markedly large over the domain areas significantly affected by dust transport. Daily values of ground WSs averaged both over the whole simulation domain and for the regions below and above 35ïĆř N are given in Table 1 and 2 for the REF-and the Exp 1-simulation, respectively. The domain-averaged WS difference is 0.015 and -0.014 m/s on 17 and 24 July, respectively, despite the large values of local WS differences. In addition, the mean WS difference is -0.002 and -0.052 m/s on 17 and 24 July over the western Africa domain located from 10ïĆř W to 15ïĆř E, where main dust sources are located. Therefore, the decreased CB of the REF simulation is probably associated with less efficient dust production induced either by the lower ground wind speeds and by the increased stability due to dust-forced surface cooling (Zhang et al., 2009), as outlined below. . . “

14. Comparisons of the meteorology with actual measurements are missing.

A new figure has been added to show the comparison of the temperature vertical profile by the model and by radio sounding measurements for different sites. To this end, old Figs. 6 and 7 have been coupled in one figure (new Fig. 6) and temperature vertical profiles by the model and radio sounding measurements have been plotted in Fig. 7.

Please also note the Supplement to this comment.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 19387, 2009.

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