1 Response to A. Colette, Topical Editor

Dear Topical Editor,

Thank you for your initial decision. Your remarks and suggestions appear below in italics, together with our responses to these remarks and suggestions. Our proposed amendments to the text of our paper appear in bold.

1. *Reviewer 1, Question 6: This point seemed to be quite a concern for the referee, and a modification to the manuscript should be considered. For instance by adding the last statement in your reply on the 10% difference when switching off this process in the nudged simulation.*

   We have added the following sentence in our revised paper page 19 line 14:

   Total AOD in a nudged simulation (2004) without the re-evaporation process is lower by up to 20% maximum over most of the globe (global means of -11.3% and -13.2% in DJF and JJA respectively).

2. *Reviewer 2, Question 4: The discussion of how the differences in the design of the two dust schemes can lead to such differences in emission fluxes is interesting and you could consider including part of it to the paper.*

   We have modified paragraphs 2.3.2 and 4.1.3 of our revised paper to include some of this discussion. These paragraphs now read:

   Paragraph 2.3.2

   Dust aerosols simulated with ARPEGE-Climat and the dust scheme described in Section 2.2 confirmed the underestimation of dust aerosols already outlined by *Melas et al.* (2013) and *Huneeus et al.* (2011) when using a similar dust scheme within the IFS ECMWF model. This IFS dust scheme utilises spatially broad empirical factors developed at a time where the soil information required by other approaches was not available (*Morcrette et al.*, 2009). Therefore, as a more complex scheme could be put into place in view of the detailed soil characteristics parameters available in ARPEGE-Climat from the ECOCLIMAP database (*Masson et al.*, 2003), an additional dust emission parameterisation has been included in the aerosol scheme, allowing for comparisons between the two parameterisations. This dust emission parameterisation comes from *Marticorena and Bergametti* (1995), which is very common in aerosol global models, and takes into account soil information such as the erodible fraction and the fractions of sand and clay. The horizontal saltation flux is calculated as a function of the soil moisture, the surface roughness length and the wind velocity at the model's lowest level. The vertical flux is then inferred from this saltation flux, and the emitted dust size distribution is based on the work of *Kok* (2011) that corrects for a general drawback of GCMs to overestimate the mass fraction of the dust fine mode while underestimating the fraction of coarser aerosol. More details about this dust emission parameterisation can be found in *Nabat et al.* (2012, 2014c). Note that the normalization constant c_α proportional to the vertical to horizontal flux ratio (*Nabat et al.*, 2012) had to be adjusted to the horizontal resolution of our simulations to a value of $c_\alpha = 5.10^{-7}$ to bring our 2004 AODs in the Sahelian region, the major global source of dust, into reasonable agreement with satellite and AERONET observations. Such adjustment is common in models (*Todd et al.*, 2008), while some modeling groups even adopt scaling factors depending on the region (*Tosca et al.*, 2013).

   Second paragraph of section 4.1.3

   Total DD emissions are multiplied by a factor of 14 by this change of emission scheme (NudSim versus NudSimd2 simulation), knowing that factors are of 2.8, 2.9 and 20.9 for the DDbin01, DDbin02 and DDbin03 respectively. These factors are large but we think that the *Marticorena and Bergametti* (1995) and *Kok* (2011) scheme is more realistic to use in the end, for the reasons detailed in paragraph 2.3.2.

References

Huneeus, N., M. Schulz, Y. Balkanski, J. Griesfeller, J. Prospero, S. Kinne, S. Bauer, O. Boucher, M. Chin, F. Dentener, T. Diehl,12, R. Easter, D. Fillmore, S. Ghan, P. Ginoux, A. Grini, L. Horowitz, D. Koch, M. C. Krol, W. Landing, X. Liu, N. Mahowald, R. Miller, J.-J. Morcrette, G. Myhre, J. Penner, J. Perlwitz, P. Stier, T. Takemura, and C. S. Zender (2011), Global dust model intercomparison in AeroCom phase I, *Atmos. Chem. Phys.*, 11, 7781-7816, 2011, www.atmos-chem-phys.net/11/7781/2011/, doi:10.5194/acp-11-7781-201

Kok, J. F.: A scaling theory for the size distribution of emitted dust aerosols suggests climate models underestimate the size of the global dust cycle, *Proc. Natl. Acad. Sci.* USA, 108, 1016-1021, 2011.

Marticorena, B., and G. Bergametti (1995), Modeling the atmospheric dust cycle: 1. Design of a soil-derived dust emission scheme, *J. Geophys. Res.*, 100(D8), 16415Ž01316430, doi:10.1029/95JD00690.

Masson, V., Champeaux, J., Chauvin, F., Meriguet, C., and Lacaze, R.: A global database of land surface parameters at 1-km resolution in meteorological and climate models, *Journal of Climate*, 1190 16, 1261-1282, 2003.

Melas D. et al. (2013), Validation report of the MACC reanalysis of global atmospheric composition Period 2003-2012, *MACC-II Deliverable D_83.5*, 2013.

Morcrette, J.-J., O. Boucher, L. Jones, D. Salmond, P. Bechtold, A. Beljaars, A. Benedetti, A. Bonet, J. W. Kaiser, M. Razinger, M. Schulz, S. Serrar, A. J. Simmons, M. Sofiev, M. Suttie, A. M. Tompkins, and A. Untch (2009), Aerosol analysis and forecast in the European Centre for Medium-Range Weather Forecasts Integrated Forecast System: Forward modeling, *J. Geophys. Res.*, 114, D06206, doi:10.1029/2008JD011235.

Nabat, P., Solmon, F., Mallet, M., Kok, J. F., and Somot, S.: Dust emission size distribution impact on aerosol budget and radiative forcing over the Mediterranean region: a regional climate model approach, *Atmospheric, Chemistry and Physics*, 12, 10 545- 10 567, doi:10.5194/acp-12-10545-2012, 2012.

Nabat, P., Somot, S., Mallet, M., Michou, M., Sevault, F., Driouech, F., Meloni, D., Di Sarra, A., Di Biagio, C., Formenti, P., Sicard, M., LÃ©on, J.-F., and Bouin, M.-N.: Dust aerosol radiative effects during summer 2012 simulated with a coupled regional aerosol-atmosphere-ocean model over the Mediterranean, Atmos. Chem. Phys. Discuss., 14, 25351-25410, doi:10.5194/acpd-14-25351-2014, 2014c.

Todd, M. C., et al. (2008), Quantifying uncertainty in estimates of mineral dust flux: An intercomparison of model performance over the Bodélé Depression, northern Chad, J. *Geophys. Res.*, 113, D24107, doi:10.1029/2008JD010476.

Tosca, M. G., Randerson, J. T., and Zender, C. S.: Global impact of smoke aerosols from landscape fires on climate and the Hadley circulation, *Atmos. Chem. Phys.*, 13, 5227-5241, doi:10.5194/acp-13-5227-2013, 2013.