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Atmospheric Chemistry and Physics
Discussions

Interactive comment on “Estimation of mineral dust longwave radiative forcing: sensitivity study to particle properties and application to real cases over Barcelona” *by* M. Sicard et al.

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Answer to RC C1751

The changes in the revised manuscript (posted soon) will be indicated in bolt font.

This paper deals with SW and LW radiative calculations applied over Barcelona. The paper is very interesting and well written. The sensivity study (Fig 7 and discussion) and comparison with CERES (Fig 8 and discussion) are especially impressive.

My main suggestion for improvement is a more comprehensive review and comparison with existing literature. Some references are given but many of them are not discussed.
In addition to the references given by another reviewer, I would recommend that references (and discussion where possible) are included of the following papers (AND references therein):
REPLY: We, the authors, thank very much the referee for the long list of papers. Most of them, but not all of them, have been referenced in the revised manuscript. In particular Highwood et al. (2003), di Sarra et al. (2011) and Yu et al. (2006) have been very helpful to extend the discussion in Section 5.

Balkanski, Y.; Schulz, M.; Claquin, T. Guibert, S. Reevaluation of Mineral aerosol radiative forcings suggests a better agreement with satellite and AERONET data Atmos. Chem. Phys., 2007, 7, 81-95

Highwood, E.; Haywood, J.; Silverstone, M.; Newman, S. M. Taylor, J. Radiative properties and direct effect of Saharan dust measured by the C-130 aircraft during Saharan Dust Experiment (SHADE): 2. Terrestrial spectrum J. Geophys. Res., 2003, 108, 8578

di Sarra, A.; Biagio, C. D.; Meloni, D.; Monteleone, F.; Pace, G.; Pugnaghi, S. Sferlazzo, D. Shortwave and longwave radiative effects of the intense Saharan dust event of 25-26 March 2010 at Lampedusa (Mediterranean Sea) J. Geophys. Res., 2011, 116, D23209

Zhang, L.; Li, Q. B.; Gu, Y.; Liou, K. N. Meland, B. Dust vertical profile impact on global radiative forcing estimation using a coupled chemical-transport-radiative-transfer model Atmos. Chem. Phys., 2013, 13, 7097-7114

Zhao, C.; Liu, X.; Ruby Leung, L. Hagos, S. Radiative impact of mineral dust on monsoon precipitation variability over West Africa Atmos. Chem. Phys., 2011, 11, 1879-1893

Yu, H.; Kaufman, Y. J.; Chin, M.; Feingold, G.; Remer, L. A.; Anderson, T. L.; Balkanski, Y.; Bellouin, N.; Boucher, O.; Christopher, S.; DeCola, P.; Kahn, R.; Koch, D.; Loeb, N.; Reddy, M. S.; Schulz, M.; Takemura, T. Zhou, M. A review of measurement-based assessments of the aerosol direct radiative effect and forcing Atmos. Chem. Phys., 2006, 6, 613-666 (especially the references given in section 4.1 of this paper)

With respect to 'rather complete review of MD microphysical and optical properties', I recommend inclusion of (if the authors deem these appropriate - and see also references in these papers):

Ahmed, A.; Ali, A. Alhaider, M. Measurement of atmospheric particle size distribution during sand/duststorm in Riyadh, Saudi Arabia Atmos. Environ., 1987, 21, 2723 -2725

Gu, Y.; Rose, W. Bluth, G. Retrieval of mass and sizes of particles in sandstorms using two MODIS IR bands: A case study of April 7, 2001 sandstorm in China Geophys. Res. Lett., 2003, 30, 1805

Reid, J.; Jonsson, H.; Maring, H.; Smirnov, A.; Savoie, D. L.; Cliff, S.; Reid, E.; Livingston, J. M.; Meier, M. M.; Dubovik, O. Tsay, S.-C. Comparison of size and morphological measurements of coarse mode dust particles from Africa J. Geophys. Res., 2003, 108, 8593

Laskina, O.; Young, M. A.; Kleiber, P. D. Grassian, V. H. Infrared extinction spectra of mineral dust aerosol: Single components and complex mixtures J. Geophys. Res., 2012, 117, D18210

Chou, C.; Formenti, P.; Maille, M.; Ausset, P.; Helas, G.; Harrison, M. Osborne, S. Size distribution, shape, and composition of mineral dust aerosols collected during the African Monsoon Multidisciplinary Analysis Special Observation Period 0: Dust and Biomass-Burning Experiment field campaign in Niger, January 2006 J. Geophys. Res., 2008, 113, D00C10

Sokolik, I.; Andronova, A. Johnson, T. C. Complex refractive index of atmospheric dust aerosols Atmos. Environ., 1993, 27, 2495-2502

Sokolik, I. Toon, O. Incorporation of mineralogical composition into models of the radiative properties of mineral aerosol from UV to IR wavelenghts J. Geophys. Res., 1999, 104, 9423-9444

Balkanski, Y.; Schulz, M.; Claquin, T. Guibert, S. Reevaluation of Mineral aerosol radiative forcings suggests a better agreement with satellite and AERONET data Atmos. Chem. Phys., 2007, 7, 81-95

Claquin, T.; Schulz, M.; Balkanski, Y. Boucher, O. Uncertainties in assessing radiative forcing by mineral dust Tellus B, 1998, 50, 491-505

Minor comments: Page 8535, line 17: revise (english)
REPLY: We have changed “even though” by “although”.

Page 8535-8536: I suggest to remove the entire discussion of sea salt. I think it is not needed and out of the scope of this paper. This space would be better used to review literature on dust.
REPLY: In our initial manuscript (before the first submission) sea salt was not mentioned. We finally included it in the introduction for completeness of the topic and thinking of the referees. We still think it is worth mentioning sea salt in the introduction and will leave it in the revised manuscript. If the referee strongly disagrees with that decision, please tell us and we will remove it in the manuscript for ACP.

Page 8541, line 7: aerosol cooling effect: cooling of what? surface/atmosphere/Earth?
REPLY: ΔF can be either at the surface (BOA, (Eq. 1)) or at the top of the atmosphere (TOA, (Eq. 2)). With the convention chosen, a negative sign of ΔF (either at BOA or a TOA) will correspond to the same effect of the aerosols: a cooling effect. A positive sign will produce a heating effect. Some precisions have been added in the revised manuscript.

Page 8542, line 17: 'refined compared' this is unclear, please revise
REPLY: "compared to" has been replaced by "with respect to" in the revised manuscript.

Page 8545, line 7: 'aerosol emission'. This is correct but has not been mentioned before. Please explain.
REPLY: It is true that this sentence was not completely clear. It has been partly re-written in the revised manuscript.

Page 8545, line 13: 'the more radiation will be reflected'. I think this is not true. In my opinion, what is seen here is a temperature effect. The lower the aerosol layer, the higher its temperature, and therefore the higher its emission.
REPLY: This is totally true. The temperature effect is visible on the forcing at the surface. The revised manuscript has been revised accordingly. However the scattering effect is still mentioned as the explanation of the behavior of the forcing at the TOA (opposite to that at the surface).

Page 8550, line 14: the total atmospheric forcing. What is the physical meaning of this? Can this be measured? Please explain the importance of this quantity in some detail.
REPLY: We suppose the referee refers to ∆FATM, the atmospheris forcing, i.e. in the atmospheric layers. This quantity is an indicator of the forcing due to the absorption of aerosols. More details can be found in Roger et al. (2006): "In the case of pure scattering aerosol (SSA = 1), ∆FATM is equal to zero. The presence of aerosols contributes to a loss of energy at the surface level, this lost energy being scattered upward to space. In a case of an absorbing aerosol (SSA < 1), a part of this loss at the surface level is absorbed into the atmospheric layer. The increase in energy in the atmospheric layers leads to a heating of these layers." Theoretically ∆FATM can be measured. But as far as we know, this is not a common practice. A way to measure it

could be to measure radiation with pyranometers (shortwave) and pyrgeometers (longwave) oriented nadir and zenith in the aerosol layers, e.g. with airborne measurements.

Page 8551: It would be nice if the discussion on heating/cooling rates would be expanded. Can you explain why the peak of the SW heating rate is at such high altitude? (given that most dust occurred below 6 km?) Perhaps it is worth adding averaged dust profiles (if available).
REPLY: The profiles of the extinction coefficient showing the vertical distribution of the mineral dust for the 11 cases are added as supplementary material in the revised material and discussed at the beginning of Section 5. The discussion on heating/cooling rates has been expanded in the revised manuscript, mostly by comparing to existing literature. The vertical levels in the RTM in the shortwave are discretized at [. . . 2, 4, 6, 8, . . . km] as can be seen in Figure 10. The aerosol content in the layer [hi, hi+1] is attributed to the layer at hi+1 (e.g. in terms of AOT, the AOT at 6 km is the one cumulated between 4 and 6 km). And as can be seen in the figure of the vertical profiles of the supplement there are aerosols between 4 and 6 km in both cases 7 and 11 shown in Figure 10.

Figures: Another reviewer made a comment that the paper is also on the SW effect. I think it would be a great shame to remove all SW info from this paper. On the contrary, where possible I would expand the discussion to include SW (e.g. to show in figure 5 and figure 6 also to the SW part of the spectrum.). Perhaps the sensitivity study (Fig 7 and discussion) can be expanded to include an extra figure for the SW?
REPLY: The SW part is not removed from the paper. As we answered to S. Otto (referee), our paper is about longwave radiative forcing. During the writing of Section 5 we thought that including the SW component would allow us to estimate the ratio LW/SW and therefore quantify the importance of the LW forcing contribution in cases of dust outbreaks in Barcelona. The idea we have in mind is to draw the attention of the regional and global climate model community that the LW component is not

always negligible. We have decided to keep the sensitivity analysis (Section 4) only in the longwave and to state clearly in the introduction that SW calculations are made to quantify the importance of the LW contribution (only in Section 5). A Table containing properties of interest in the shortwave (solar zenith angle, single scattering albedo, asymmetry factor) for the 11 cases is added in the Supplement and discussed at the beginning of Section 5.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 8533, 2014.