These are the reports that came after the publishing in the ACPD

Anonymous Referee #1

Q: P.4, Ln 22-23: Dust aerosol is known to be non-spherical. The use of spherical aerosol model (Mie) would cause errors for the radiance simulations. I have not studied the effect of spherical assumption on fluxes which may be non-negligible and potentially affecting diurnal cycle (as a function of solar zenith angle SZA). Can you provide an assessment of uncertainty from using spherical aerosol model on computed fluxes?

R: The shortwave aerosol optical properties are now derived assuming a mixture of randomly orientated spheroids, following the approach of Dubovik et al. (2006). Non-spherical effects are expected to be small for longwave calculations (Haywood et al., 2005) and Mie theory is still used to generate the scattering properties of the particles in these regime. All relevant figures have been updated. Multiple minor text changes have been done to indicate that spheroids model is being used in SW: abstract (p. 2, ln. 4), aerosols section (p. 7, ln. 10), conclusions, all the relevant numbers (such as root-mean-square errors) through the text. We found that for a typical dust loading over the Arabian Peninsula the relative difference in daily mean SW fluxes is about 0.5-1.5% in experiments where dust aerosol is treated as a mixture of randomly oriented spheroids and as a mixture of spheres.

Q: P.6, Ln 17, 19: Please provide references for the uncertainties unless these are your own assessments.

R: references have been provided (Mlawer et al., 1997)

Q: P.23, Ln. 7 (and in several other places): replace “then” to “than”.

R: noted and replaced (p 14, ln 16, ln 19, p 16, ln 15, p 18, ln 21, p 21, ln 10, p 23, ln 8, p 24 ln 23)

Anonymous Referee #2

Q: My only major remark has to do with the fact that RRTM (Rapid Radiative Transfer Model) is used only for clear-sky conditions. The authors never justify why they made the choice not to treat clouds and although clouds over the region are not ubiquitous and influence infrequently the scenes studied, accounting for them would have made the study even more relevant.

R: In this work we tried to achieve as high accuracy as possible in calculating fluxes and dust DRFs. That is why we chose the most cloud free locations and Solar Village is a great example (judging from the cloud fraction profided on the figures). From technical point of view adding clouds to the calculations is relatively easy but unfortunately there is too little data available to derive the precise cloud optical properties. Thus a number of significant assumptions would have to be done which would introduce significant uncertanties into calculations.

Q: Page 12307 lines 8 to 10: "3. RRTM_SW error with respect to line-by-line calculations is 1Wm−2 for direct and 2Wm−2 for diffuse irradiance, respectively 4. RRTM_LW error with respect to line-by-line calculations is 1.5Wm−2 .Please explain why you give absolute errors for the SW and LW calculations. Are these errors independant of the of the value of the irradiance or are they given for the maximum daily value of the irradiance ?

R: These errors are provided by the RRTM developers as a part of the model validation. Corresponding references to the papers with details has been added (p 6, ln 18, ln 19, Mlawer et al., 1997)

Q: Page 12309 Equation 5 : Please indicate that, σ, is in this equation, is the neperian log of the width of the size distribution.

R: σ has been replaced with σ_i and is now consistent with the definitions introduced in equation 1 (p 8, ln 12). Please note that all definitions follow and are consistent with Aeronet Inversion product (http://aeronet.gsfc.nasa.gov/new_web/Documents/Inversion_products_V2.pdf)

Q: Pages 12315-12316 : At the same time, we have stronger forward scattering in calculations (partially because of the particle sphericity assumption and/or underestimating number of large particles by Aeronet, Muller et al., 2010; McConnell et al., 2008) then in observations as indicated by the positively biased diffuse flux (RMSE is 37Wm−2 and RMSE is 20 %). When the proportion of larger particles increase, the forward scattering also increase, so if you underestimate these large particles you also underestimate the forward scattering. This goes against your explanation as to why you have larger forward scattering. Please correct 'then' to 'than' in the sentence above.

R: Thank you for pointing it out. The statement in parenthesis has been removed.

Q: Page 12320, line 5: you did not indicate the units of the chlorophyll concentration: ". . .chlorophyll concentration (chl = 0.15)."

R: units have been added (p 18, ln 15, ln 16)

Q: Page 12320 and Figure 11 : for which period did you collect AERONET AOT level 2.0 data to produce Fig. 11 ?

R: all data available for a given station have been used. "Data span is 2012-2014 at KAUST and 1999-2013 at Solar Village" has been added to the Figure 11 caption.

Q: Page 12324, line 7, if you want to stay consistent with the rest of the text, replace : '' (Balkanski 1.5 %) '' with ''(B15)".

R: All usages of Balkansky refractive indices has been converted to B09, B15 or B27 after they have been introduced (Figure 12 caption, p 22, ln 10, figure 15 caption, p 26, ln 26, ln 28)

Figure captions

Q: Fig. 2 : Indicate 'top panel' and 'bottom panel' before you describe what is on the Figure. Instead of '' SW surface downwelling perturbed experiment. . . are provided in the top panel" Indicate '' The top panel presents SW SW surface downwelling perturbed experiment. . ." idem for bottom panel. Change red circles to red symbols and blue circles to blue symbols. Change green to green circles.

R: Thank you for the 'panels' suggestion. It has been incorporated and figure caption should be easier to read. Please note that circle markers refer to observations, while stars indicate calculations. We think it should make easier to read the figures and thus no changes has been done with regard to the markers.

Q: Fig 5 : Mention that you are showing outgoing fluxes.

R: it was mentioned, "TOA upwelling fluxes". Figure 5 caption has been rearranged.

Q: Fig.10 : Instead of having 2 lines on the first panel, why not present only 1 line with the ratio of coarse AOD/fine AOD ? It is not clear from the Figure caption that σ, refers to the symbol in Equation 5. Is r0 a modal diameter on these figures, it it is, please indicate it in the caption !

R: We think that keeping the same colorcoding for each lognormal mode among all 3 panels is natural. Thank you for pointing out the labels, they have been updated and are now consitent with equation 1 (Figure 10 caption, r_0 and σ have been replaced with r_i and σ_i)

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Report #1

Q: This is a large and comprehensive study for the world region of significant dust emissions which has not been extensively studied. The work should be published in ACPD. My only concern is the use of spherical dust model in calculations, but this can be addressed later (e.g., a spheroidal model could be used from Dubovik, Lapaenak, Sinyuk; or some analysis provided showing that spherical assumption has little effect on computed fluxes)

R: this question is similar to the one posted by referee 1 and has been adressed.

Report #2

Q: In order to help the reader, you need to remind him (her) the optical parameters used for the 2 modes in the d'Almeida et al. (1991) paper, please indicate the modal radius and the with of the distribution.

R: Optical properties are derived from Aeronet using Mie and Dubovik approach (p. 7, ln. 10), from d'Almeida we only use formulas for the external mixture. r_i and σ_i are now indicated (p. 7, ln. 14)

Q: Please define the 'dust belt area' page 4.

R: reference to Prospero et al., 2002, where dust belt area is defined, has been added (p. 4, ln. 27)

Q: Equation (5), you write that reff = ri . exp(5/2*sigma**2) In this equation, what you name sigma is not the width of the size distribution but rather the neperian log of the width. I recommend that you write equation (5) as: reff = ri . exp(5/2*(ln(sigma))**2)

R: this comment is similar to the referee #2 and has been addressed. Please note that all definitions follow and are consistent with Aeronet Inversion product (http://aeronet.gsfc.nasa.gov/new_web/Documents/Inversion_products_V2

Q: As you revise the manuscript during the Discussion, you could show a map that delimits the region you indicate for CALIPSO on page 8.

R: The considered region is mentioned in the text (p. 8, ln. 15) and exact latitude, longitude boundaries are specified. In addition to that text specifies that the area covers Arabian Peninsula, Red Sea and Arabian Gulf.

Q: I believe that the guy you refer to as 'Balkanski' and 'Balkansky' in your manuscript is the same guy.

R: this has been fixed prior to publishing in the ACPD right after the first submission