

**Interactive comment on “A simple parameterization of the short-wave aerosol optical properties for surface direct and diffuse irradiances assessment in a numerical weather model” by J. A. Ruiz-Arias and J. Dudhia**

**Anonymous Referee #1**

**Received and published: 10 March 2014**

**General Comments:**

This paper is a well-organized and mostly well-written description of a thorough and focused study to test the impact of an aerosol optical property parameterization for shortwave radiative transfer within WRF for assessing modeled surface direct, diffuse and total fluxes with measurements. However, a few statements in the manuscript that are detailed in the specific comments are confusing and interrupt the flow of the text, and these will require clarification. In particular, it is misleading to state that errors in the direct and diffuse fluxes caused by misrepresentation of the aerosols cancel out in the total surface flux, since this isn't necessarily the case. Also, the conclusion that the results at the sites studied are presumed to extend to their surroundings is too general and depends on the uniformity of the surrounding environment. In addition, there are a large number of generally minor grammatical problems with the manuscript as specified in the technical comments that will have to be revised to improve readability before publication. The figures are generally well drafted, though some of the text in the figures may have to be enlarged. In summary, this paper can be recommended for publication in GMD after minor revisions as listed in the detailed comments.

First of all, we would like to express our deepest gratitude for considering the revision of our manuscript. We greatly appreciate all your suggestions and comments on the major concerns you found. They will help us to leverage the quality and relevance of our work.

**Specific Comments:**

1 Introduction

Page 596, Line 16: It's not obvious that DNI fluxes are more sensitive than DIF fluxes to “changes in the optically active components of the atmosphere”, such as aerosols for example. The intent of this sentence should be clarified.

You are right. It is not a general rule that DNI is more sensitive than DIF to changes in the optically active components of the atmosphere. In the new version of the manuscript we will remove “*particularly DNI*”.

In writing this sentence we were thinking too much about what happens under average turbidity conditions (specifically, AOD at 1micron smaller than about 0.3). But, thinking carefully, we see now that, even in these conditions the sentence might not be appropriate. First, because we are referring to the “*optically active components of the atmosphere*”, but not specifically to AOD. But also because, under the referred average turbidity conditions, absolute changes (in  $W/m^2$ ) in DNI are larger than changes in DIF, but this is not generally true thinking in relative terms (irradiance changes in percentage).

2 The need for a AOP parameterization

Page 597, Line 23: It's an oversimplification to state that "...errors in DNI and DIF fluxes caused by a misrepresentation of the aerosol load cancel out in GHI". Such errors may partly offset each other, but they do not necessarily cancel each other.

We agree with your concern. The sentence is not correct since it indicates that deviations in DNI and DIF caused by a misrepresentation of aerosol totally cancel out in GHI. This is not true in the general case so, as you suggest, we will change the sentence in the next version of the manuscript by: *"Thus, errors in DNI and DIF fluxes caused by a misrepresentation of the aerosol load partly cancel out in GHI, in the general case."*

Page 598, Line 5: The statement that AOD is the integral over the extinction coefficient over a vertical path is too specific, since the definition could be applied equally to a slant path or horizontal path. I recommend rephrasing as "Aerosol optical depth is the integral of the extinction coefficient over an atmospheric path. In an NWP model layer, this represents the attenuation by absorption and scattering events through a vertical path".

Agree. We will update the manuscript following your suggestion: *"Aerosol optical depth is the integral of the extinction coefficient over an atmospheric path. It represents the attenuation by absorption and scattering events through that atmospheric path."*

#### 4.1 Control experiment

Page 606, Line 4: The sentence that begins "The few traces of clouds generated by WRF during the simulations were cleared up..." should be clarified to specify how clear-sky conditions were ensured in these instances. Were the cloud properties merely set to zero, or were any adjustments made to the moisture profiles?

The days simulated in the control experiment are cloudless and the NWP model creates only marginal clouds. Nonetheless, at the radiative transfer calculations level, the cloud mixing ratio is set to zero in any case to assure totally cloudless conditions. We will update the statement in the new manuscript version: *"The few traces of clouds generated by WRF during the simulations were cleared up by setting the cloud mixing ratio to zero in order to ensure completely clear-sky conditions"*

#### 5.1 Dynamical range performance

Page 608, Line 27: The sentence that begins "Whereas 95% of the rural SSA..." is somewhat confusing. While the large peak in rural SSA relative frequency in Figure 4b at an apparent value of 0.93 is clear, it's not obvious from the figure that 95% of the rural SSA values are between 0.4 and 0.92 as stated in the text. Please clarify.

There are two typos in that sentence: The minimum ssa value for the rural type is 0.922, instead of 0.4, and 95% of the values are smaller than 0.940. The mean ssa value is 0.934. We have reviewed the values offered for the AERONET SSA and the urban SSA and they are correct as indicated in the manuscript. Therefore, we will correct the sentence as follows: *"For the rural type, 95% of the SSA values are between 0.92 and 0.94, with its mean value being 0.93. For the urban type, 95% of the SSA values are..."*

#### 5.2 Seasonality

Page 610, Line 22: Figure 5 shows the daily mean relative error as a percentage, though the text states that the error is "simulated values minus observations". Specify whether the percentage plotted is this difference relative to the simulated values or to the observations.

We will update the text from *"simulated values minus observations"* to *"simulated values minus observations, relative to the observations"*. We will also update the Fig. 5 caption.

## 6 Discussion and conclusions

Page 613, Line 1: The statement that “it can be presumed that it will be so in their surroundings” is too general. The degree to which the conclusion is applicable to the surrounding sites will depend on the uniformity of those sites, such as the proximity to water, elevation changes, aerosol sources, etc. This statement should be revised.

We agree. The validity of this statement depends indeed on the local characteristics of the site. However, it seems also reasonable to expect that the assumed aerosol representation error in prescribing an aerosol type can be approximately of the same order of magnitude as the expected regional variability of the hypothetical aerosol type for regions more or less homogeneous, in most cases.

Also, in the context of this work, where a gridded regional database of AOD is expected to be used (from satellite, such as MODIS, or a chemistry model, such as MACC) the local variations of the aerosol optical depth will fall in great part within the assumed representativeness error of the gridded database. The current grid size of satellite sensors is of few km in the best case (e.g. 10-km for Level-2 MODIS) but in this case an up-scaling may be pertinent to reduce the amount of data gaps produced at the cloud-screening stage of the retrieval algorithm (Ruiz-Arias et al., 2013). The spatial resolution of chemistry models is usually even worse (1.25° in the case of MACC).

In any case, we have decided to remove the following sentence: “*However, even this simple approach has proven very effective in the evaluated sites and it can be presumed that it will be so in their surroundings*”. By removing this sentence, we are still highlighting the limitation of assuming a fixed aerosol type, which is the main message, but a clearer fashion.

Ruiz-Arias et al., 2013, A geostatistical approach for producing daily Level-3 MODIS aerosol optical depth analyses, Atmos. Environ., Vol. 79, pp. 395-405, doi: 10.1016/j.atmosenv.2013.07.002

Page 613, Line 9: Is the phrase “since they hold much of the worldwide solar energy potential” meant to refer to the contribution of dust aerosol to global aerosol radiative forcing? If so, then clarify this sentence.

Desert areas have a large potential for solar energy production. However, the very particular conditions at these areas, with frequent dust storms and high turbidities, are challenging for radiative transfer models. In particular, an appropriate treatment of desert dust aerosol is required. It is characterized by small Angstrom exponent values (large particles), large and stable SSA values, and high AOD. For instance, a check of the Level-2 AERONET records at Solar Village (Saudi Arabia) reveals a mean value of AOD at 550 nm of 0.39, with 80% of the AOD records greater than 0.2. Mean SSA is always around 0.9 independently of the value of AOD at 440 nm. Mean Angstrom exponent is fairly constant at about 0.3 for AOD at 1 micron greater than 0.4, and typically smaller than 1.0 for AOD at 1 micron smaller than 0.4. An aerosol type for these very specific conditions must be considered.

### **Technical Corrections:**

Thank you for this thorough review of technical issues. We will consider your suggestions in the new version of the manuscript.

## Abstract

The abstract is a clear summary of the paper with the following exceptions:

Page 594, Line 4: Suggest replacing the phrase "...they are being more and more demanded in solar energy..." with "they are being requested more frequently by solar energy..."

Page 594, Line 7: Clarify that 'its' refers to aerosols and not models.

Page 594, Line 10: Suggest replacing 'The rest of: : : ' with 'Other: : : '

Page 594, Line 15: Suggest replacing 'along' with 'using'

Page 594, Line 20: Replace 'constraint' with 'to constrain'

## 1 Introduction

Page 595, Line 21: Suggest replacing 'is being also demanded' with 'also is being demanded'

Page 595, Line 24: Suggest replacing 'widely-spread' with 'widely-utilized'

Page 596, Line 2: Replace 'assemble' with 'assembly'

Page 596, Line 3: Suggest replacing 'long-term series' with 'long time series' for clarity

Page 596, Line 6: Replace 'in risk the power supply' with 'the power supply at risk'

Page 596, Line 7: The sentence that begins 'This is best done...' is not clear and should be reworded.

Page 596, Line 9: Suggest replacing the beginning of the sentence that begins 'As it has been...' with 'Among the radiative parameters already discussed that can be predicted at the surface...'

Page 596, Line 10: Suggest rewording the sentence that begins 'This has been very likely: : : ' with 'It is very likely that this has been motivated by the fact that DNI and DIF are challenging to calculate.'

Page 596, Line 13: Reword the phrase "as long as spatial resolution stays above few km" with "as long as the spatial resolution is more than a few km"

Page 596, Line 21: Suggest replacing "at predicting" with "and their ability to predict" to clarify the sentence.

## 2 The need for a AOP parameterization

Page 597, Line 8: Simplify "Nowadays many of the NWP models: : : " to "Many NWP models: : : "

Page 597, Line 14: Replace "is an accuracy diminishing for" with "is a reduction in accuracy at" Page 598, Line 14: Replace "datasets as" with "datasets such as"

Page 598, Line 16: Suggest replacing "surround" with "monitor", or something similar. Also, move the phrase "the best well-known" from the end of this sentence to before "being"

Page 598, Line 22: Replace "on the opposite" with "on the other hand"

Page 598, Line 24: The sentence starting "Also in recent years: : : " is poorly structured. Suggest replacing with a structure such as ": : : ACNWP models have leveraged the growing number of: : : datasets and have experienced a big advance: : : "

Page 599, Line 5: Replace "suffer of similar" with "suffer similar"

Page 599, Line 12: Replace "as the only" with "since the only"

Page 599, Line 13: Add “the” before “required”

Page 599, Line 14: Replace “need to be” with “have to be”

Page 599, Line 23: Remove “Afterwards”

Page 599, Line 24: Replace “of 1 yr” with “of a one-year”

Page 600, Line 1: Replace “Sect.” with “Section” here and all subsequent occurrences

### 3 The AOP parameterization

Page 600, Line 11: Suggest replacing “of the simulating domain” with “of the domain being simulated”

Page 600, Line 26: Suggest replacing “It will be thus the” with “Thus, it will be the”

#### 3.1 Aerosol optical depth and Angstrom exponent

Page 601, Line 8: Recommend replacing “model spectral band” with “model spectral interval” to avoid confusion with the 2-band form of the Angstrom law described in the subsequent sentences.

Page 602, Line 3: Replace “as weighting factor” with “as a weighting factor”

Page 602, Line 18: Suggest replacing “exemplifies” with “illustrates”

#### 3.3 Vertical distribution

Page 604, Line 22: Add “the” before “surface level”

Page 604, Line 23: Add “the” before “surface”

Page 605, Line 1: Add “the” before “surface”

### 4 Parameterization benchmarking

Page 605, Line 12: Suggest replacing “in a number of sites of the AERONET network” with “at a number of the AERONET network sites”

#### 4.2 Test case

Page 606, Line 11: Add “the” before “aerosol parameters”

Page 606, Line 22: Remove “it was” before “expected”

Page 606, Line 25: Replace “aerosols concern” with “aerosols are concerned”

Page 607, Line 6: Suggest replacing “Now” with “Here”, or omit the word

### 5 Validation against ground observations

Page 608, Line 3: Replace “as” with “since”

#### 5.1 Dynamical range performance

Page 608, Line 23: Replace “in the sites” with “at the sites”

Page 608, Line 25: Replace “Fig.” with “Figure” here and all other occurrences

Page 608, Line 27: Replace “with its mean value in 0.93” with “with a mean value of 0.93”

Page 609, Line 2: The “A” before “95%” is extraneous

Page 609, Line 4: Replace “the mean in 0.66” with “a mean of 0.66”

Page 609, Line 6: Remove “in” before “0.66”

Page 609, Line 15: Suggest replacing “In any case” with “In each case”

Page 609, Line 18: Replace “A experiment” with “An experiment”

Page 609, Line 20: Correct spelling of “modelled” to “modeled”

Page 609, Line 22: Replace “As it is shown” with “As shown”

Page 609, Line 23: Replace “As it is expected” with “As expected”

Page 609, Line 26: Suggest replacing “assuming the rural aerosol” with “for the rural aerosol”

Page 610, Line 1: Replace “as it is shown” with “as shown”

Page 610, Line 12: Suggest changing “from about” to read “from an underestimation of about”

## 5.2 Seasonality

Page 610, Line 21: Add “the” before “surface”

Page 611, Line 12: Replace “any” with “either”

Page 611, Line 13: Replace “up to a 5%” with “by up to 5%”

Page 611, Line 14: Replace “as” with “since”

Page 611, Line 24: Replace “consisted on” with “consisted of”

## 6 Discussion and conclusions

Page 612, Line 5: Replace “that can be either provided as” with “which can be provided either as”

Page 612, Line 6: Add “the” before “aerosol optical parameters”

Page 612, Line 7: Replace “among” with “between”

Page 612, Line 8: Replace “as it has been described” with “as described”

Page 612, Line 9: Replace “they can also be either provided as” with “this can also be provided either as”

Page 612, Line 15: Suggest replacing “The very small mismatches result” with “The very small mismatches shown result” if this is the intended meaning.

Page 612, Line 23: The meaning of the phrase “fluctuating aerosols” is not clear. This should be reworded.

Page 612, Line 23: Replace “remove” with “removing”

Page 612, Line 24: Replace “scheme that” with “scheme, which”

Page 612, Line 28: Suggest replacing “type of aerosols” with “aerosol types”

Page 613, Line 2: The phrase “the approached method” is ambiguous. Please clarify.

Page 613, Line 6: Remove “all”

## Tables and Figures

Figure 2: Revise the beginning of the last sentence of the caption to read “The grey regions encompass: : :”

Figure 3: Revise the end of the last sentence of the caption to read “: : :the white circle mark being the mean relative error”, if this is the intended meaning, otherwise clarify.

Figure 5: Specify whether the percentage plotted is the difference relative to the simulated values or to the observations.