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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Characterising energy budget variability at a Sahelian site: a test of NWP model behaviour" *by* Anna Mackie et al.

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Thank you for your helpful comments. We have made some changes in light of these.

- Limitation of significance as only one site

Please see response to reviewer #1, which addresses this issue.

- Abstract: It would be useful to add a sentence mentioning the biases for the surface fluxes as you did for the TOA

We have added sentence: "At the surface the daily average bias is 12(13)Wm-2 for the longwave downwelling (upwelling) longwave radiation flux, and -21(-13) Wm-2 for the shortwave downwelling (upwelling) radiation flux."

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Discussion paper

- Lines 9-13: The observed discrepancies in the radiation fluxes, particularly during the dry period, are also attributed to the misrepresentation of aerosol fields in the model since it is utilized a climatology instead of a dynamic approach.

We have added a slightly modified sentence: “We also attribute observed discrepancies in the radiation fluxes, particularly during the dry season, to the misrepresentation of aerosol fields in the model from use of a climatology instead of a dynamic approach.”

- Line 16: Replace “A proportion of incoming...” with “A proportion of the incoming...”.

Done

- Introduction: A short paragraph must be added describing how meteorological variables (e.g. humidity), clouds, aerosols and surface albedo can affect the SW and LW radiation in the Earth-Atmosphere system. This will provide a link with the discussion in the Results section.

We have added a sentence mentioning that we have these data from the AMF, as the effects of these variables on radiation is discussed in further detail in section 2.1: “Data collected during this campaign consists of not only high frequency surface radiation measurements, but also coincident measurements of atmospheric variables relevant to the study of radiation transfer, including aerosol optical depth, atmospheric humidity, 2 m air temperature and data from sonde ascents. “

- Line 45: I don’t think that this sentence is useful there. It is better to move it in the relevant part (Section 4.1) of the manuscript.

“Appendix A shows a comparison of radiation fluxes in 43r1 and ERA-Interim.” has been removed.

- Lines 53-58: This part of the text can be extended by adding 2-3 sentences providing some information regarding the progression of the West African monsoon (this can be mentioned also in lines 88-91) as well as the seasonal variation of aerosols’ regime aerosols’ type and intensity).

The West African monsoon in particular is discussed in further detail further down in the same paragraph, where we believe it is better suited. However, this section has been slightly expanded from: “Regional dust storms and biomass burning plumes significantly impact the energy budget (Slingo et al., 2006; McFarlane et al., 2007), and the annual progression of the West African monsoon (WAM) imposes a strong seasonal cycle on radiation fluxes due to the onset of the wet season (Slingo et al., 2008).” To: “Regional dust storms and biomass burning plumes significantly impact the energy budget (Slingo et al., 2006; McFarlane et al., 2007), with dry season aerosol loading composed of varying proportions of mineral dust and biomass burning aerosol from agricultural fires (Johnson et al., 2008). Additionally, the annual progression of the Intertropical Front (ITF) drives the West African monsoon (WAM) and imposes a strong seasonal cycle on radiation fluxes due to the onset of the wet season from approximately April-October (Slingo et al., 2008).”

- Line 65: Why is specified only for the Sahel and not for the Earth-Atmosphere system?

Sentence has been amended from: We have amended this from “Figure 1 is used to present the key features of radiative transfer over the Sahel.” To: “Figure 1 is used to present the key features of radiative transfer of the Earth-Atmosphere system, with the following section outlining key aspects of this in Niamey.”

- Lines 68-71: This sentence causes some misunderstandings and is better to remove it. Under clear-sky conditions the impact of aerosols and gases on the SW radiation is more important compared to water vapour which plays a key role at longer wavelengths as you are correctly stating in Line 82.

This has been removed: “Under clear-sky conditions, water vapour plays the dominant role in modulating the tropospheric absorption of solar radiation (1a) and hence the seasonal variability in the amount of direct solar radiation reaching the surface (2a).” And the next sentence has been edited to: “When water vapour (1a), cloud (1b) or aerosol (1c) is present, a significant fraction of the incident solar beam will be absorbed

or scattered. Some of the scattered radiation will be scattered down to the surface as 'diffuse' solar radiation (2a,2b,2c)."

- Line 80: Figure 1 describes the key features of radiative transfer within the Earth-Atmosphere system and not only for Niamey. Your description is generic and should not be restricted for a specific location (Niamey).

We have changed this from: "Longwave radiation fluxes also depend on the meteorological conditions at Niamey." to: "Longwave radiation fluxes also depend on the meteorological conditions."

- Lines 99-101: Due to clouds the RSR also increases attributed to the reflection of the incoming solar radiation.

We have changed this from: "This results in decreases in DSR and increases in DLR due to atmospheric warming." To: "This results in decreases in DSR, increases in RSR and increases in DLR due to atmospheric warming."

- Lines 139-140: In Table 1 are listed only the non-radiative data. You should add also the radiative variables.

These have been added.

- Lines 161-162: The uncertainties of AMF variables are not provided in Table 1. Which are the uncertainties for the IWP and LWP?

The uncertainties for the AMF variables have been added to Table 1, and the mean uncertainty of IWP and LWP from CMSAF have been added to the text: "while those in IWP and LWP are provided by CMSAF and have an annual mean of 0.021 and 0.015 kgm-2 respectively"

- Line 170: This sentence can be removed.

We have removed: The extent of the interpolation required is indicated in Figs. 2,3 and 4. And added a line into Fig. 2 caption: "Lines become dashed when values are from

interpolation (see Sec. 3)"

Line 213: Remove "the" after "than".

Done

Line 221: Replace "However, the the majority" with "However, the majority".

Done

- Lines 229-230: During wet season, the simulated DLR and ULR reveal higher temporal variability compared to observations. More specifically, during the first half of the wet season (days 100-200), the model underestimates DLR and ULR while the opposite is found between days 200 and 300. Therefore, the zero and negligible biases for DLR and ULR, respectively, result from the counterbalance of the negative and positive model discrepancies and do not indicate a good performance of the model since the temporal variability is not captured.

We have extended the sentence "Wet season average bias in DLR and ULR is small at 0 and 1 Wm-2, respectively" by adding ", though this is due to cancellation of the model underestimation of DLR and ULR in the first part of the wet season (days 126–200) with the overestimation in the second part of the wet season (days 200–300)."

- Lines 232-235: Please rephrase this part of the text.

This was originally: "Figure 4 indicates that radiative fluxes can be affected by non-radiative processes. Figure 4 shows observed and modelled 2 m air temperature, TCWV, LHF, SHF, aerosol optical depth (AOD) and IWP and LWP. Tables 2 and Table 3 present mean statistics corresponding to radiative and non-radiative variables, respectively." Which we have changed to: "Figure 4 presents observed and modelled 2 m air temperature, TCWV, LHF, SHF, aerosol optical depth (AOD) and IWP and LWP, with mean statistics shown in Table 3."

- Lines 259-261: I would say that negative biases are found between 500 - 700 hPa

and positive between 200 - 400 hPa.

We have amended to these ranges

- Line 270: Remove the blank.

Done

- Line 293: The discrepancies are not defined as observations - model throughout the analysis? Why in Sections 4.2.1 (Surface downwelling shortwave radiation) and 4.2.2 (Surface upwelling shortwave radiation) are defined as model-observations?

This is a mistake, these have all been corrected to observation – model discrepancy and are now consistent with the Figures.

- Lines 311-312: Replace “0.29-0.14” with “0.14-0.29”.

Done

- Lines 373: When you are referring to the total downwelling radiation do you mean the net radiation at TOA? If so, then the term total downwelling radiation is not correct.

This has been changed, also the caption to Fig. 6

- You should re-organize the order of the tables and figures in the manuscript. More specifically, tables must be presented first (after references) and then the figures.

Done

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