Reply to Anonymous Referee #2: Marsham et al., The contrasting roles of water and dust in controlling daily variations in radiative heating of the summertime Saharan Heat Low

Marsham et al. detail a very interesting study on the roles of water vapor, aerosols and clouds on the radiative forcing at the top of the atmosphere and at the surface over the Sahara. For their purpose they have used the unique and comprehensive dataset acquired during the 2011 IOP of Fennec in the Saharan Heat Low (SHL) region (so-called BBM supersite) and ERA-I reanalyses from ECMWF. The importance of water vapor in the Saharan region is a hot topic and this study is an important contribution to the subject. Water vapor variability over the Sahara has an influence on the West African Monsoon system across la wide spectrum of scales, from synoptic to decadal. Overall, the paper is well written and well structured. The paper refers to all the relevant literature on the topic, to date. I only have small changes and clarification to suggest at this stage. The paper is acceptable almost as it is.

We would like to thank the reviewer for their valuable review. We address the reviewer's points in turn.

Minor comments

Introduction p 19450, end 1st paragraph: you only are mentioning global operational models. How about mesoscale operational numerical weather prediction models?

This is now clarified,

"Operational models use either prognostic dust or dust climatologies, but struggle to capture variations in summertime dust, partly as cold-pool outflows from convection (haboobs) provide a key uplift mechanism that is missing in operational models that use parametrised moist convection [Marsham et al, 2011; Heinold et al., 2013; Marsham et al., 2013a]."

Method p 19451: line 8: define GERB

Added, "GERB (Geostationary Earth Radiation Budget experiment) measurements"

p 19452: lines 4-5: the count of days is not good, should be 11 days. p 19452: line 5: the count of days is not good, should be 4 days.

Corrected

p 19452, sunphotometer: Is there a reason why you do not consider integrated water vapor retrievals from the sunphotometer in BBM?

The radiosondes give a more consistent measurement frequency and only level 1.5 AERONET data were available for 2012, with level 2 for 2011, so we believe the radiosondes are a more reliable measure of chnages in diurnal-mean water vapour, which is the key requirement for our study.

p 19452: line 18: How do you come up with this number, 3 W m-2?

As stated, “This means that the surface-based Kipp and Zonen can miss up to 3.5 W m^{-2} net shortwave atmospheric heating as would be seen by GERB and up to 3.8 W m^{-2} of the net longwave as would be seen by GERB (Banks et al., 2014).”, but these are maximum errors and the diurnal-mean error in atmospheric radiative heating would be lower. To be more explicit we have changed to “up to 4 W m^{-2}”

Results p 19453: line 11: How do you define your appreciation of “good surface data”?

Now clarified,

“Relationships are shown using days where surface data are available (referred to as “Good surface data”),”

p 19453: lines 25:-27: I fully agree. Does this mean that the LLJ associated with the harmattan is the mechanism controlling the relationship between AOD and TCWV? Is this how you explain the low correlation of 0.29?

No. The dry Harmattan LLJ does give dry dusty air, but the main mecahnisms is haboobs and monsoon surges, which both give moist dusty air. There is therefore a positive correlation between TCWV and AOD. This is now clarified,

“The mechanisms underlying this correlation are understood: Marsham et al. (2013a) shows how moist monsoon surges from the south are associated with dust at BBM. This is because the moist surges are associated with both dusty haboobs and moist nocturnal low-level jets (LLJs) that together dominate the dust uplift at BBM in June 2011 [Marsham et al., 2013a; Allen et al., 2013]. The association between dust and water vapour is consistent with Figure 16 in Marsham et al. (2013a), which shows a statistical link between AOD and cloud cover at BBM. Intense dust uplift does sometimes occur in dry air, however, mainly in the dry Harmattan LLJs [Marsham et al., 2013a; Allen et al., 2013].”

Discussion p 19462: line 5: Up to?

Corrected

Conclusion p 19464: line 17: How important is it to have an accurate dust aerosol representation in such models? Would a prognostic dust model improve the correlations in ERA-I?

The paper shows that although dust is important for surface net radiation, TCWV is more important for TOA net radiation. As stated in the conclusions, “The results show that it is important that models used for predictions can accurately capture the processes controlling the water vapour distribution over the Sahara, as well as the dust.” A prognostic dust model might improve ERA, but given the dominance of haboobs at BBM and the problems that models have with these we would prefer not speculate.