Atmos. Chem. Phys. Discuss., 15, C6857–C6861, 2015
www.atmos-chem-phys-discuss.net/15/C6857/2015/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The contrasting roles of water and dust in controlling daily variations in radiative heating of the summertime Saharan Heat Low" *by* J. H. Marsham et al.

Anonymous Referee #1

Received and published: 15 September 2015

The authors provide a comprehensive empirical observational study of relationships between water vapor, dust aerosol and radiation over the important Sahara Heat Low region. Recent research suggests that this area is of importance in determining feedbacks on climate and the regional water cycle (e.g. Evan et al. 2015 doi:10.1175/JCLI-D-14-00039.1; Dong and Sutton, 2015, doi: 10.1038/nclimate2664). The analysis, though quite simple, is very well composed and useful in assessing the key drivers of radiative energy balance in the region and use of new observations make the evaluation quite novel. I have a number of mostly minor points outlined below that I consider the authors should address before the paper is ready for publication.

GENERAL POINTS

1) Since this is an empirical study it cannot demonstrate cause and effect. Figures 2-4 show relationships between variables (not "trends" or cause/effect). Further detailed radiative transfer calculations and additional modeling is required to do so. Presuming this is beyond the scope of the study, there are a number of places where this should be stressed and the text modified accordingly (see specific points).

2) How representative is 2011 and 2012 of the regional climatology. Some further analysis or links to previous work would help in answering this.

3) It would be beneficial to consider or at least mention the CERES radiation data. The SYN product can provide daily averaged fluxes based upon satellite overpasses and geostationary diurnal cycle "shape". There are also estimates of surface and atmospheric fluxes that require the combination of reanalysis and additional satellite data with CERES measurements.

4) There is some good evaluation of ERA Interim (e.g. p.19459-60). It would be useful to also consider work that has included model simulations in which the effects of dust are included (e.g. Allan et al. 2011, doi: 10.1002/qj.717).

5) Given the strong influence of cloud on radiative fluxes and the co-variation between cloud, AOD and TCWV implied in the present work a more detailed analysis of these co-variations and influences of cloud would be beneficial.

6) In places the meaning of net fluxes or heating/cooling are potentially ambiguous (e.g. p.19458). It should be stated clearly if net fluxes are defined as downward and whether increased net downward fluxes correspond to an increased heating (SW) or reduced cooling (LW).

SPECIFIC CHANGES

p.19448, L6 - please provide information on the site location (abstract and also in the Introduction)

p.194448, L11 (abstract) - it is not necessarily TCWV which is driving these changes as it may be clouds associated with the TCWV variability.

p.19460, line 3-6 (Section 3.3) - it is not correct to say that increased LW heating is expected with increased water vapor and clouds as this depends very much upon the altitude (low clouds or moisture will increase longwave radiative cooling to the surface)

Table 1 - please check units. Does AOD:TOA Net mean dAOD/dNet (Wm-2)-1?

p.19450 - do inadequacies in model simulation of dust mean that responses of the hydrological cycle are questionable (e.g. Dong and Sutton, 2015, doi: 10.1038/nclimate2664)?

p.19451 - MPEF is a simple IR-based cloud product which may miss low cloud so some further justification or explanation is required to justify its use.

SECT 3.1 - "Figure 2a shows that water vapour warms the atmosphere, with a trend in TOA net radiation with TCWV of +2.2Wkg-1." This is not strictly incorrect. Figure 2a shows that net downward radiation at the top of the atmosphere increases with TCWV. It is not a "trend" but a relationship and cause and effect is not demonstrated for which radiative transfer calculations or other modeling would be required.

p.19453, L24 - remove 1st ","

p.19455, L4 - remove "presumably"

p.19455, L12: relationship not a trend (also p.19457, L8; p.19459, L21; p.19460, L16)

p.19455, L17 - "shortwave cooling" is misleading as it is reduced shortwave heating

p.19457, L13 (Sect 3.2) - again a relationship (not a trend) is shown and so a "control" on net radiation by AOD changes has not been demonstrated

p.19458, line 14-19 - I was slightly unsure about where the PCA analysis fits in and was confused about this discussion which seems to suggest AOD and TCWV both increase

together in mode 1 but are anti-correlated in mode 2. What physically do these modes represent?

p.19458, L25 - does "greater net surface longwave" mean that net downward surface longwave becomes less negative?

p.19459 - the influence of dust aerosol on atmospheric net radiative cooling is also discussed by Slingo et al. (2006) doi:10.1029/2006GL027869 and Slingo et al. (2009), doi:10.1029/2008JD010497.

p.19460, L3 - "The increase in net longwave heating with TCWV is expected due to the warming from both water vapour and clouds." This is not precise since the longwave changes depend very much on the altitude of water vapor (e.g. Previdi 2010 doi:10.1088/1748-9326/5/2/025211) and cloud. Increased low level cloud or water vapor will increase atmospheric radiative cooling to the surface but influence the TOA only marginally.

p.19460, L5-6 - please check this sentence and also reference Fig. 1i on L9

p.19461, L3: "errors"; L5-7 the altitude of water vapor is important (changes in mid and upper tropospheric humidity are rather important for TOA clear-sky longwave)

p.19462, L6-10 - this is an interesting discussion but it should be caveatted by the need for radiative transfer calculations or additional modeling to confirm cause and effect.

p.19462, L21 - please define ITD

p.19463, L6-7 - I suggest "due to longwave radiative cooling that is partially offset by shortwave radiative heating"

p.19463, L14 - TCWV may be associated with daily fluctuations in TOA radiation but could this be through co-variability in temperature and cloud

p.19463, L27 - is there a reference for the ERA-I underestimation in cloud (also next page L23)?

p.19464, L4 - although the effect of TCWV is weak overall there is a strong physically robust influence on surface net longwave which could be stressed here

p.19465, L3 "it is important that"

p.19463-5 - can the energy advection be implied from these results?

Figure 1 is a bit small

Figure 5 is a nice idea - I think it could have more impact to simply show a moist dusty and dry clear profile in a 2-panel figure

Figure 4 - "convergence" in the y-axis title is potentially misleading and should be changed to radiative convergence/divergence or heating/cooling

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Interactive comment on Atmos. Chem. Phys. Discuss., 15, 19447, 2015.