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Interactive Comment

Interactive comment on "Observations of mesoscale and boundary-layer circulations affecting dust uplift and transport in the Saharan boundary layer" *by* J. H. Marsham et al.

J. H. Marsham et al.

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1 Response to reviewer 2: R. MacKenzie (Editor).

The processing of this ACPD manuscript has been significantly delayed by problems in finding a second referee. I am now acting as editor and stand-in referee but, having read the manuscript thoroughly again, and reviewed the open discussion, I find that it is necessary only for me to concur with the one review received, particularly with respect to the need for clarification of the main thrust of the arguments. That is, the authors should make sure that they are not over-interpreting the data and model results, and should be sure that they make clear

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Interactive Discussion

Discussion Paper

the similarities and differences between the case studies. In doing this, I think the authors will also make clearer the implications of the case studies for understanding (and parametrising) dust uplift.

We would like to thank the editor for taking the time to review this manuscript himself. The paper has been revised accordingly (and also to reference relevant papers published after this paper was submitted).

In the revised paper, only cospectral analysis from B302 is presented in detail (where lower along-track winds gave clearer relationships between land surface temperatures and boundary-layer properties, Section 3.1.1). Observed effects of such processes are also discussed for B301, but these are less clear due to the stronger along-track winds (Section 3.2). The old Figure 9, which showed coherence between boundary-layer variables from flight B301 on scales between 4 and 10 km has been removed, since, as described below, the analysis of these observations is beyond the scope of the paper and not required for the LEM simulations based on data from this flight. The COSMO simulations of the Saharan boundary layer are also now evaluated using aircraft data from flights B301 and B302 (thus including a new Figure 5).

A region of the low-level flight-track from B301, where it appears that dust was being uplifted is then identified. Large eddy modelling is then used to investigate the expected contribution to dust uplift made by the boundary-layer circulations resolved by the LEM, that would not be resolved by a regional or global model (Section 3.2.1). The LEM simulations shows boundary-layer rolls, with boundary-layer convection contributing to dust uplift. The analysis of the any possible linear organisation of the boundary-layer convection in reality is beyond the scope of this paper, and perhaps expected to be complex, since the flight-track was oriented almost along the axes of the modelled rolls. The LEM results are, however, consistent with the larger scale peak in the power spectrum of vertical winds from B301 compared with B302 and the observation of dusty updraughts on the scale of this peak during flight B301. The results from and limitations of this approach are clearly described in Section 3.2.1 as well as in the conclusions.

ACPD

8, S6697–S6702, 2008

Interactive Comment

Finally, the nomenclature used in this paper has been revised to aid clarity and make it consistent with the rapidly developing meteorological literature on this region. CBL is used to refer to the convective boundary-layer that is directly coupled to the land surface, SRL is used to refer residual boundary-layer that this is often observed above this in the Sahara (Saharan Residual Layer). Where the Saharan boundary-layer is advected over colder boundary-layers (e.g. the monsoon) the elevated dry almost well mixed layer is referred to as the SAL (Sahara Air Layer). Before, in the submitted paper, SAL was used instead of SRL. These terms are now introduced in the introduction,
"Over the Sahara, large surface sensible heat fluxes and deep dry convection can result in a summertime boundary layer that is up to 6 km deep (Gamo, 1996). However, profiles from the Sahara in summer typically show a shallower active convective boundary layer (CBL), with a near neutrally stratified residual layer above (the Saharan Residual Layer, SRL). This is typically capped by a strong inversion at approximately 5.5 km. Where a colder boundary-layer (e.g. from the monsoon or the ocean) has undercut the Saharan boundary layer, the resultant elevated dry layer is referred to as the Saharan Air Layer (SAL). The deep dry SAL layer allows much of the Saharan dust plume to avoid rain-out over the Atlantic, allowing the dust to be transported globally. Furthermore, it has also often been observed that the SAL and SRL can contain distinct sub-layers, each with different water vapour and dust contents."
and the remaining text has been revised accordingly to use these terms.

Details of the changes made are now given in reply to the specific comments made.

1.1 Specific Comments

Page 2, last paragraph. Add"(see section 2.2, below)"; at first mention of COSMO.

ACPD

8, S6697–S6702, 2008

Interactive Comment

This reference to COSMO has been removed.

Page 3, end of section 2.1, perhaps clarify thus: "(aircraft profiles on this day were affected by either the monsoon or the cold pool outflows elsewhere, and so cannot be used to deduce boundary layer depths)."

This has been rewritten,
"The accuracy of the CBL depth shown by COSMO in Figure 5(a) lends some support to its accuracy elsewhere along the low-level transect of B302. Figure 4(d) shows this modelled CBL depth (shown by the dashed black line and determined as the lowest model level where the potential temperature was not more than 0.5 K than the modelled mixed-layer depth)."

For B301,
"As a result both profiles to and from the low-level leg were not of use in evaluating the representation of the Saharan CBL in COSMO."
" CBL depths from COSMO suggest that the low-level leg from B301 was at an altitude approximately in the middle of the CBL, which is expected to make identification of convergence or divergence over land-surface anomalies difficult."

Section 2.2. Provide some details of the land-use categorisation from DWD used in COSMO, particularly those aspects which are important for forcing convection.

We used COSMO with the 2-layer soil model TERRA which provided temperature and specific humidity at the ground. TERRA takes into account the exchanges between plants ground and air. The roughness length and root depth, fractional plant cover and leaf area index are estimated from the land usage data of a classification scheme from the USGS land use/land cover system. This is based on the vegetation data from NDVI

ACPD

8, S6697–S6702, 2008

observations from AVHRR. TERRA distinguishes nine soil types (defined from the “Soil Map of the World” from the FAO (Food and Agriculture Organisation of the UNO).

Albedo variations in COSMO appear to be smaller than observed and this is now noted, “The land surface in COSMO includes an albedo feature at 8°W. This has an albedo of approximately 0.18 compared with 0.2 elsewhere on the aircraft flight-track (Saharan albedos in COSMO are lower than observed from the aircraft or from MODIS).”

Page 4, column 1, last paragraph. Please re-write “The maximum low-level winds upstream of the flight track lie to the east of the maximum at the latitude of the flight track (Figure 3(b)).”

This has been rewritten,
“The two main peaks in low-level dust loadings (at 6.8 and 7.5°W) are east of the position of the local maximum in windspeed (7.6 to 8°W). This is consistent with advection of dust into the flight-track from a location upstream, where the windspeed maximum was further to the east than the windspeed maximum on the flight-track. Such an eastwards displacement of the upstream windspeed maximum is shown by the COSMO model (Figure 3(b)), although as noted there are significant errors in the COSMO wind field. Overall, this does however suggest that much of the dust observed was probably uplifted by the high windspeeds upstream, rather than locally .”

Figure 5. Is "coherency" the same as "coherence"? Caption should use LST if that is the term use in the text discussing the figure.

“Coherence” is now used throughout.

Page 5, top of column 2. Are we to understand from the discussion here that

ACPD

8, S6697–S6702, 2008

mesoscale variations in windspeed are transported in the mean wind, like the dust, and are not forced locally by LST changes? How does this relate to the discussion of coherence between LST and other parameters in the previous paragraphs?

Either as you say, mesoscale variations in windspeed are transported in the mean wind, like the dust, or they are forced locally and lead to increased dust uplift and so observed dustiness. It is stated that,
"It was not possible to unambiguously relate dust and LSTs, however; this is unsurprising given that the maximum dust uplift occurred upstream of the flight track, and the effects of land-surface itself on the potential for dust uplift."

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 8817, 2008.