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Interactive Comment

Interactive comment on "Transport of dust particles from the Bodélé region to the monsoon layer: AMMA case study of the 9–14 June 2006 period" *by* S. Crumeyrolle et al.

Anonymous Referee #2

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General comments

This manuscript examines the impact of vegetation cover in West Africa on the transport of dust emitted remotely. It focusses on an observational case study from the AMMA campaign using aircraft data in a region with marked contrasts in forest cover. Spatial variability in boundary layer dust concentrations is shown to be coherent with surface cover, with locally high concentrations in a mesoscale area of cropland bounded by shrub and woodland. The observations provide a very neat illustration of the impact of land cover on vertical transport processes. The authors complement the observations with a set of mesoscale model simulations in which they switch sedimentation on and off. They show a pair of additional runs with the radiative impact of the dust switched off in order to isolate the impact of sedimentation on transport in the absence of dynamical feedbacks. This is an attractive aspect of the model runs. The simulated sensitivity of dust to land cover is less well explored, and would benefit from additional simulations and more detailed diagnosis of the model

Specific comments

Major comments

1 Set up and diagnosis of the model

The authors make a good case for correlating observations of a dusty PBL above the croplands with increased entrainment driven by locally high H. A similar case is not well made in the model. This of course is not helped by the use of what the authors imply is an inappropriate vegetation map, which does not capture the variability around 11N. I'm left somewhat confused about the discussion of the latitude of the dust maximum in the model and its relation to local vegetation cover (p5068-5071). The model does have locally reduced forest cover between 7 and 8N, though no local increase in PBL aerosol is evident there in Figure 9. The authors have not presented clearly the evidence that the ECOCLIMAP forest cover field is controlling sensible heat flux and inversion height, and hence aerosol concentration. Other factors may also influence the sensible heat in the model, notably the surface model formulation and its sensitivity to vegetation cover, the underlying soil moisture, and incoming radiation. A much cleaner set of simulations would greatly benefit this study, one which assesses the sensitivity of dust to land cover in the region where it was observed. The authors themselves concede in their response (C4012) that this would be a better way of demonstrating the impact of the land cover on dust. Such simulations could be performed over a single diurnal cycle to minimise the impact of feedbacks and drifts that they note there.

2 Linking Dust to Land Cover Maps

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The authors make a critical distinction between the land cover north of 12.5N and the cover around 11N (p5065). They make this distinction based on calculating wood/shrub cover from the GlobCover classification, ~20% around 11N compared to less than 10% north of 12.5N. (Note that in the manuscript, the authors comment, and figures 8 and 12, there is an inconsistency in the units of forest shrub cover – e.g. I think the axis on Fig 8 should go up to 70 rather than 0.7%). The authors are of course well aware from their comparison of ECOCLIMAP with GlobCover (which gives both regions 40+% woody cover) that global land cover maps may not be particularly accurate in terms of defining this property. There could also be a seasonally varying component in the emission of aerosol from croplands, with more exposed soil in June than later in the growing season. This is particularly true in 2006 when NDVI shows a delay of 1 month in the growing season relative to the longer term mean. I therefore think they need to justify much better their assertion that there is no local emission of aerosol around 11N and discuss explicitly the shortcomings of using a single global land cover map to determine woody cover. This is an important part of their story. Also on this issue, the authors refer to observations at Djougou – is the vegetation cover there similar to the extensive cropland at 11N?

3 Boundary Layer Processes

There is a lack of clarity in the manuscript about the boundary layer processes linking spatial variability in dust to vegetation. The abstract claims “The goal of the present study was to determine the process that facilitates the sedimentation of dust particles from the Saharan Air Layer (SAL) to the boundary layer”. The study highlights the observed correlation between aerosol concentration and forest cover, and uses the model to try to confirm this. However they have not isolated the dynamical process(es) responsible for the correlation. Two likely causes which the authors highlight are (i) entrainment of aerosol-rich air into the PBL above a surface with high sensible heat fluxes and (ii) additional entrainment associated with mesoscale circulations driven by horizontal variations in sensible heat flux. The second effect is discussed (p5066), and is further emphasised by the authors in the opening section of their response to Referee 1 (C4005), yet no evidence of coherent circulations is presented, either in the model or observations. This needs to be clarified with more detailed model diagnosis.

Minor comments

4 Initialisation of the surface

It is not stated explicitly (p5057), but I assume that soil moisture was initialised from the ECMWF analysis. It is not good practice to translate soil moisture values directly from one land model to another, as discussed by e.g. Koster et al, J Clim 2009. This could impact the results as the sensitivity of H to vegetation cover depends, amongst other things, on soil moisture. A far-preferable alternative would be to use the offline ALMIP-generated soil moisture from the ISBA model to initialise the model and minimise soil moisture spin-up issues.

5 Discussion of profiles (p5064)

"These key dynamical and thermodynamic parameters are well represented in the simulation, although at 10_ N (Fig. 6b) the top of the monsoon layer is overestimated by 400 m. The observed and simulated wind speed profiles are similar; nevertheless the simulated values are most often underestimated in the monsoon layer (2–4ms$-$1) as well as in the Harmattan layer (2ms$-$1). The simulated and observed 10 potential temperature profiles are almost the same for the four dropsondes." The height of the inversion is critical for studying entrainment. Whilst it is true that the comparison of potential temperature is pretty good over the lowest 7km of the atmosphere, an inversion height error of 400m (compared to the observed value $\sim$1500m) should not be swept under the carpet as it might influence the results.

6 It would greatly help the reader if a measure of aerosol from Figure 7 was included on Figure 8.

7 "Recent studies investigated the impact of vegetation heterogeneities on the dynam-

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ics 5 within the planetary boundary layer (Taylor et al., 2003, 2007; Garcia-Carreras et al., 2010). These studies highlighted a strong relationship between the boundary layer temperatures, the boundary layer top, the meridional wind velocity and the fraction of forest or shrub cover" (p5066). Only the latter study investigated woody cover, the other two focused on soil moisture forcing.

8 The use of Bowen ratio (p5066) is misleading given the contrasts in roughness and albedo between forest and cropland which will affect the total turbulent flux and surface temperature. "The boundary layer temperature anomalies caused by variations in sensible heat flux or Bowen ratio at boundaries between forest/shrub and cropland lead to an increase in the boundary layer top" and "Over the area running from 9.9_ N to 12.3_ N, the forest/shrub cover diminishes (15%) from 9.9_ N to 11.1_ N, and as a consequence of an increase in Bowen ratio, the surface temperature increases."

9 "Thus, the BL height has been estimated using the method described in Hopkins et al. (2009)" (p5066). An additional sentence here would be helpful to describe the method.

10 "Garcia-Carreras et al. (2010) show that the vegetation anomalies are related to the vertical transport of isoprene from the surface to the upper layers" (p5067). Cause and effect are not clear in this phrase.

11 The discussion of Figure 10 is confused for me by referring to an "evolution as a function of latitude". Is this an evolution as the air mass travels south, or as the south-bound aircraft launched sondes?

12 What is the time of day in Figure 11?

13 "The top of the monsoon flux, marked with the black line (Fig. 11), has been delineated using the method given by Lamb (1983)" (p5068). "Monsoon flux"? The height of the inversion would be a useful property to show here.

14 "Furthermore, this sedimentation process leads to the presence of dust in the

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boundary layer down to 800 m, corresponding to the higher altitude of the ATR-42 flight plan, between 7.3_ N and 8.8_ N" (p5068). I would have expected the dust concentration to extend throughout the PBL here, as it does between 10 and 12N in Fig 11.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 5051, 2010.

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