Rebuttal for manuscript:
Fiedler et al (2013) How important are cyclones for mineral dust emission in North Africa?, Atmos. Chem. Phys. Discuss., 13, 32483-32528, 2013, doi:10.5194/acpd-13-32483-2013

We would like to thank both reviewers and the editor Heini Wernli for their feedback, which helped to improve our manuscript. Please find our response to each point below the reviewers' comments (bold).

Reviewer 1

My main concern is the too simple attribution of the dust emissions to a depression or cyclone without deeper analysis of the intensity of these components. In this study the authors consider the simultaneous presence of dust emissions and synoptic component as a causal relationship. AEWs and HL present a large temporal variability of intensity that could influence differently the 10m wind field and so the dust emissions.

The coincidence of depressions with dust emission suggests some level of causal relationship but this is not always clear-cut, as embedded mechanisms like NLLJs can play a role. We have expanded the discussion of this aspect in the manuscript and changed wording throughout the manuscript to make the distinction between causality and coincidences clearer.

We added a paragraph to Section 3.4: "Estimating the dust emission amount associated with the heat low likely involves a number of mechanisms. Emissions can be directly caused by the horizontal pressure gradient around the heat low, but this alone may not always be sufficient to cause substantial dust mobilization. Often mid-morning winds are enhanced through the NLLJ mechanism (Fiedler et al., 2013), which depends on the horizontal pressure gradient around the heat low, but also on the diurnal evolution of the boundary layer. Using the NLLJ identification method from Fiedler et al. (2013) to estimate the amount of dust emission associated to NLLJs within depressions results in an annual and spatial average of 12%. Between March and October 12–16% of the dust emission is associated with both phenomena, while values are below 10 % during the rest of the year (not shown). This result is in agreement with Fiedler et al. (2013) who show a frequent NLLJ formation along the margins of the Saharan heat low. Another process potentially embedded in depressions is dust emission associated with haboobs, which are presumably not well represented in ERA-Interim data due to the use of convective parameterisation. Both NLLJs and haboobs will be discussed in more detail along with mobile and long-lived depressions. These are termed cyclones in the following and will be investigated next. "

The intensity of the dust emission flux from cyclones is analyzed in Section 3.5.1. In addition we now show the anomaly factor of depressions.

Also, the contribution of the convection is not enough taken into account. The large scale components (and more specifically the cyclones) could be decomposed in two different classes following if they are associated or not with convection and with cold pools. The authors should also present the contribution and mechanisms involved with dust emissions not associated with depression or cyclone.

We agree that the contribution from cold pools over a climatological time period would be an interesting analysis. ERA-Interim does, however, not resolve or parameterize cold pools in agreement with the reviewer's point of view. The implication of the missing representation of cold pools for the results in this manuscript is discussed in Section 3.6.2 and in the conclusions. We discuss the relevance of other processes in the introduction, and analyse NLLJs as dust-emitting mechanism within atmospheric depressions in Section 3.5 and migrating, long-lived cyclones in Sections 3.6.2 and 3.6.3 (see also the previous point).

Also, before to analyze the contribution of each component on dust emissions, the authors should discussed the impacts of these components on the 10m wind speed distribution.
We discuss the near-surface wind associated with cyclones in Section 3.6.3.

Finally, reanalysis are less good to represent fine scale processes, especially cold pool, this tends to promote large scale origins of dust emissions. This also should be discussed.
Cold pools are currently not parameterized. Evidence exists that their missing ventilation of the summertime heat low in a 40-day convection permitting simulation may lead to a stronger heat low during summer (Marsham et al., 2011, 2013). The net effect on the dust emission amount is uncertain due to the nonlinear dependency of dust emission on wind speed. We comment on the missing representation of cold pools in Sections 3.5, 3.6.2 and in the conclusions.

Detailed comments:
p32488 l9: I am not sure that the reference (Todd et al) is well adapted here.
The time period investigated in this study is relatively short, but is based on unique observations from the central Sahara during the Fennec project. We have added Lavaysse et al. (2009) as reference to include a climatological analysis of the heat low too.

P32488 l29: Please add this reference about the origins of AEWs: Leroux, Stephanie, Nicholas M. J. Hall, George N. Kiladis, 2011: Intermittent African Easterly Wave Activity in a Dry Atmospheric Model: Influence of the Extratropics. J. Climate, 24, 5378–5396.
Thanks, we added the following to Section 1: "More recent work suggests deep convection (Mekonnen et al., 2006, Thorncroft et al. 2008) and extra-tropical influence (Leroux et al., 2011) as trigger of AEWs."

p32491 l23: About the point 3. I am not convince by the method to exclude heat lows. A decreasing core pressure could be also associated with heat low.
We use all three criteria (decreasing core pressure, horizontal displacement and lifetime) simultaneously to identify cyclones. We added this to Section 2: "... identified by the following filter criteria that have to be fulfilled simultaneously"

P32494 l4: In figure 2 and in the text '... with 40-100 events in the 20-yr period ...', the authors should present the results in term of occurrence probability instead of number. That takes into account the duration of the events and will be more useful when the impacts of these events on dust emissions will be discussed.
Changed as suggested.

P32495 l10: How do the authors explain the presence of depression in the Senegal coast?
We added the following to Section 3.1: " Particularly the atmospheric depressions close and offshore of the West African coast point to the presence of AEW signatures.".

P32498 l10: The authors should show the occurrence probability of the depression over the Sahara during the year and for each season. The heat low is always detected over Sahara in summer. That means that the authors consider all dust emissions are associated with the heat low during this summer period? The authors should use the intensity of the depression and analyze the influence of the hl activity on the 10 m wind field then the contribution on dust emissions.

The results suggest that the majority of summertime dust emission is associated with the Saharan heat low, but embedded mechanism may play a role. This aspect is now discussed in more detail (please refer to responses above).

p32499 The section on seasonal climatology is too descriptive. Please reduce this subsection and clarify the most important results.
We have shortened this part.

P32501 l29: 'This results gives evidence ...' Please compare these results with the occurrence probability of each component. The heat low is present all year long. It is statistically evident to find a contribution larger than an another rarer component. The comparison between the ratio of dust emission contribution vs. the occurrence probability should be done.
We have extended the comparison of the dust emission fraction with the occurrence frequency of depressions.

P32503 l5: Could the authors clarify the method to distinguish each quadrant. Maybe these quadrants should be relative to the cyclone displacement instead of East/West.
The direction of the cyclone displacement is discussed in the context of the dust emission per quadrant. We have chosen a geographical position of the cyclone quadrants. Added: " Here, dust emission is analyzed in four quadrants the position of which follow their geographical orientation depicted in Figure 13."

P32505 l7: 'The diurnal ...' it is difficult to interpret this figure since these emissions occurred at different places following the season.
The diurnal cycle is shown for different months. Most cyclones and the dust emission associated with them occur during winter and spring in the north. Changed to: "These diurnal differences for late winter and spring in the north can be explained by the development of the boundary layer."

P32506 l21: Where does the soil moisture data come from?
The soil moisture is from ERA-Interim (Section 2): "The dust model is driven by three-hourly 10m-wind speeds and soil moisture of the uppermost soil layer from ERA-Interim forecasts (Dee et al. 2011)."

P32506 l26: This paragraph is not clear. Could the authors clarified the method used to assess the soil moisture impacts?
Changed to: "The magnitude of the effect is studied with two dust emission calculations with and without accounting for soil moisture, respectively (Section 2). "

Figure 5: Please simplify the orography.
Done.

Figure 7: Please add the annual occurrence probability of depressions (and its radius of influence).
We now show the occurrence frequency in this and the following figures. The radius of influence is set to 10 degree, which is now added to the figure captions: "Dust emission within a radius of 10 degrees from the depression/cyclone centre is considered (Section 2). "

Figure 8: As previously, the occurrence probability of depressions should be added.
Done

Figure 10 and 11, same as previously. Ratio of dust emissions should be compared with the occurrence probability.
Done

Figure 14: The authors should compare these distribution with dust emissions that occurred without cyclone. Without this kind of comparison, I am not sure to understand the interest of this figure.
The fraction of dust emission associated with cyclones is shown in Figures 10 and 11. The dust emission not associated with cyclones must by definition be associated with other processes. The original Figure 14 addressed the distribution of dust emission associated with cyclones on sub-daily scales at the top and the effect of soil moisture on dust emission in the annual cycle at the bottom. We now use two separate figures to explain the quantities shown more clearly.