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 2:
- Validity of the approach:
The study has a major problem regarding the approach used to evaluate the dust emission associated with depressions. The authors gave conclusions based on the coincidence in time and space between the presence of depressions and dust emission. But this doesn't mean that one is caused by the other. Add to this that most of the time depressions are present together with other mechanisms involved in dust emission in North Africa. I'm not sure the amount of dust emission you attribute to depressions in the paper is actually exclusively due to depressions. The majority of the results and conclusions related to the depressions part of the paper are based on this method and I have a great doubt on their representativeness and validity. The method, results and conclusions regarding this part should be revisited or you can shorten the paper to the cyclone part which is more convincing.
We agree that the dust emission associated to depressions must not entirely be related to the depression itself but may involve other mechanisms like the NLLJ, which we discuss in Section 3.5 and the conclusions. We also changed formulations throughout the manuscript to make the distinction between both clearer. See also our reply to reviewer #1.

- Validation of some results against observations:
What one would expect from this study is to see some use of the available observations on dust emission over North Africa to validate some of the results that are driven exclusively from models and reanalyses. There is for example a great opportunity to consider the SEVIRI observations that are now available for many years and in high temporal and spatial resolution to validate the results on the climatology of the cyclones for example, but also to validate the model regarding dust emissions and many other possibilities that will give highest impact to the results described here.
We now include a presentation and discussion of the validation of the dust source activation frequency of our dust model calculation against SEVIRI in a new Section 3.4.

- The link between wind and dust emission:
There is big assumption made here; the authors calculate the dust flux based on wind reanalyses and soil humidity, but there is a lot more that is crucial for dust emission. One of these factors for example is the availability of materials at the surface to be emitted by strong winds. How this factor is taken into account? Is the model used for dust emission was tested and validated against observations.
We use the same approach for calculating dust emission as in Fiedler et al. (2013). Potential dust sources are defined as grid boxes where at least two dust emission events have been observed based on the dust source activation frequency from Schepanski et al. (2007, 2009, 2012). The dust emission model used here is tested and validated against observations (Tegen et al., 2002) and widely used, e.g. the dust emission scheme is implemented in different research models including the global aerosol-climate model ECHAM-HAM (e.g. Zhang et al., 2012) and the regional climate model COSMO-MUSCAT (e.g. Heinold et al., 2011). In addition, we have now included a validation of the dust emission calculation against satellite observations. We added the following to Section 2:

"This dust emission scheme is validated by Tegen et al. (2002) and used in both global and regional climate models (Heinold et al. 2011, Zhang et al. 2012). Here, the dust model is driven by..."

- Missing important mechanisms for dust lofting

Many of the well-known mechanisms for dust emissions over North Africa are missing is this study (for example dust emission by the monsoon front in the intertropical discontinuity region e.g. Bou Karam et al 2008, dust emission by dry cyclones in the same region e.g. Bou Karam et al., 2009, dust emission by density currents from cold pools that migrate over the Sahara e.g. Flamant et al., 2007; Bou Karam et al., 2014, etc..). Consider mentioning them when you make the overview on the mechanisms for dust lofting in the introduction. Also, these mechanisms are present generally during summer i.e at the same time as the Heat low and associated depressions. Moreover they are often present in the same area. How the authors can be sure that the dust flux they calculated is related to one mechanism (here depressions) and not to the others?? Again the approach used here is light and not convincing (see my first comment).

We agree that other mechanisms can be embedded in the identified atmospheric depressions, particularly the summertime heat low, as we discuss in Section 3.5 and now more clearly in the conclusions. Studies by Diana Bou Karam are reviewed in Knippertz and Todd (2012) and also cited here. We have changed the following to make the distinction between case studies mentioned above and studies addressing the relative importance for dust emission on longer time scales in Section 1: "Knippertz and Todd (2012) review the literature on relevant meteorological processes for dust emission. Recently a number of studies have addressed the relative importance of meteorological processes for dust emission focusing on the meso-scale." and added "Bou Karam et al. (2008) suggest that the ITD plays a role for emitting dust aerosol and uplifting of aged dust plumes.".

- Estimation of the error associated with the numbers you give:

The results are based on model calculations, what is the error associated with the numbers you give? How confident one should be in reading them? Is the model used was able to produce realistically dust emission associated with cyclone (validation via a case study)? Does it over or under estimate dust emission (both its localization and amount)?

Consider adding a paragraph on the estimate of the error associated with your results, it is very important for the reader to know how close to the reality are the numbers you give both on the climatology and on the dust emission mass especially that these results are based on models and it is well known how it is difficult for the current models to simulate dust emission over North Africa (e.g. the introduction of this paper).

We now more clearly evaluate our results in Sections 3.5, 3.6.2 and the conclusions (please refer to responses to reviewer #1). We also include a validation and discussion of the dust emission activation frequency with satellite data in a new Section 3.4.

- Appropriateness of abstract, introduction and conclusions

Since the results after revisions based on the above comments may be quite different from the current ones these parts of the manuscript need to be revisited after revisions especially the conclusions on dust emission related to depressions.

We changed these sections accordingly.

Specific Comments:

- The title doesn't say anything about depressions although great part of the paper is on this, why?

The focus was set on cyclones initially. Identifying depressions was an intermediate step towards addressing the question asked. We now changed the title to "How important are atmospheric depressions and mobile cyclones for emitting mineral dust aerosol in North Africa?"

- P32484 'In summer, depressions, particularly Saharan heat lows, coincide with up to 90% of the seasonal total dust emission over wide areas of North Africa'. Coincide doesn't mean they are caused by. It is well known that dust emission is highest during summer because of many other factors than the heat low. See my main comment number 1.
This word choice was intended as we agree that coinciding does not imply a causal relationship. We discuss NLLJs as an embedded mechanism (please see also responses above).

- P32486 Harmattan Surge: I'm not convinced what you call Harmattan surge is a separate feature than cyclone. Although they occur a bit far from the visible cold front and cloud band of the cyclone these winds are linked to the cyclone and stop when the cyclone stops. The cyclone is mostly visible due to the cloud band which is over a much localized area, but it affects a larger area then the visible one (e.g. Bou karam et al., 2010). The paper you cited to justify this use (Knippertz and Fink, 2006) doesn't deal actually with cyclone but with an extratropical front dust emission during which Harmattan surge occurred. Consider rectification.
We extended the introduction by an explanation of the distinction between the Harmattan surge and the cyclone: "Both the cyclone and the Harmattan surge are usually caused by a wave at upper-tropospheric levels. While the trough is typically associated with the cyclone, the ridge to the west of it can cause the strengthening of anticyclonic conditions over wide areas of North Africa, which increases the northeasterly Harmattan winds. Harmattan surges may reach almost continental scale and cause dust emission – typically involving the NLLJ mechanism – as far south as the Bodélé Depression and the West African Sahel (Knippertz and Todd, 2010)."

- P32491 You describe the method by from Schepanski and Knippertz (2011) and then you say 'The criteria from Schepanski and Knippertz (2011) used to filter tracks of Sudano-Saharan depressions are not applied here', it is confusing, describe directly what is used in the present study.
Changed to: "The investigation of depressions and migrating cyclones over North Africa presented here is broader than that by Schepanski and Knippertz (2011). Here, depressions are all..."

- P32493 The way you define the cyclone-affected area in my opinion is not enough to cover all the area affected by the cyclone (see also my comment regarding Harmattan surges) although the horizontal extend of the Saharan cyclones is about 10° it doesn't mean that the wind fields beyond this area are not affected. This will lead to an underestimation of the dust emission associated with the cyclone.
We tested the sensitivity of the cyclone-affected area. Increasing the radius from 10 to 20 degrees had an overall small effect on the spatial pattern of dust emission associated with the dust emission amount (Section 2.2). This shows that the 10-degree radius usually captures the centre of action.

- Pages 32496 and 32497 consider citing Bou Karam et al., 2009 that deals with cyclones connected to AEWs.
Thanks, it is now cited.

- P32499 Paragraph 3.5.1 is too descriptive, can be more concise.
We have shortened this passage.

- P32502 Paragraph 3.5.2 Consider my comment on the definition of cyclone-affected area above.
Please refer to our response above.

- P32505 Line 7 to 26 too long and repetitive, consider simplifying.

Changed to: "These diurnal differences for late winter and spring in the north can be explained by the development of the boundary layer in the context of the synoptic-scale conditions. Dust emission occurs when the momentum transport to the surface is sufficiently large to exceed the threshold for emission onset. Reduced stability during the day enables downward turbulent momentum transport, which increases the near-surface wind speed. This effect is expected to be largest, when the daytime boundary layer is sufficiently deep for reaching layers of high wind speed in the free troposphere. Strong winds prevail relatively close to the surface during cyclone passage in winter and spring. These cyclones form in a baroclinic zone between the warm (deep) North African air mass compared to the cold (shallow) air polewards. The contrast between the air masses causes a particularly strong thermal wind, i.e. an increase of the geostrophic wind with height in the lower troposphere. Along with typically deep daytime boundary layers over North Africa momentum from the free troposphere is efficiently transported towards the surface. In the Sahara, the boundary layer reaches a sufficiently large depth at or closely after mid-day (Culf, 1992), which coincides well with the mid-day peak of dust emission found here. The time of maximum dust emission is in agreement with the observation of suspended dust in cyclones shown in Fig.1."

- P32506 Line 21. Or the difference can be due to the fact that with depressions you have the dust emission of all the other mechanisms. See my major comments number 1 and 4.
We discuss the dust emission associated with cyclones in this section. The relevance of embedded NLLJs in depressions is discussed in Sections 3.5 and for cyclones in Section 3.6.3

- P32507 line 7 to 9, sentence not clear.
Changed.

Figures
- Figure 6: Consider improving the font size, it is very small and hard to read.
Done.

- Figure 14a: The colors used are hard to distinguish.

Done.