

## ***Interactive comment on “Parametrization of convective transport in the boundary layer and its impact on the representation of diurnal cycle of wind and dust emissions” by F. Hourdin et al.***

**F. Hourdin et al.**

Frederic.Hourdin@lmd.jussieu.fr

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### **Answer to reviewer 2**

We would like to thank the anonymous referee # 2 for his/her positive and constructive remarks to the manuscript (in particular for all the corrections of colloquialism).

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You will find enclosed a point to point answer to those remarks. The pdf showing the modifications of the paper itself is also available for control.

We have to add in introduction to this answer that we found a small error in the computation of the Weibull distribution. A normalizing factor was missing, which was systematically lowering the emissions. We thus updated all the figures with the new simulations. No conclusion is affected especially because we are focusing on the sensitivity to parameterizations more than on the realism of the simulated dust distribution. Comparison with observation is now better for the dust (surface concentration and AOT) but we insist (as in the first draft) on the fact that this good agreement may be more a question of chance, since a number of parameters which were not explored here may affect emission. In particular, taking into account an a priori subgrid scale variability through Weibull distribution strongly enhances dust emission, and may be seen as a trick to compensate our inability to account for sub-grid scale turbulent or mesoscale processes. To simplify a little bit the discussion on this subgrid scale distribution, the  $W^*$  term in the emission was omitted in the new set of simulations. All the figures were redone with those new simulations that rely on a somewhat upgraded version of the LMDZ model, which also marginally affects the wind but without changing any of the conclusion or comment.

The Reviewer comments are reproduce in "script" font together with the answers.

Hoping you will find our answer appropriate,

with best regards,

Frédéric Hourdin

Overall this is a very interesting article that makes a nice contribution to our understanding of both surface wind simulations, as well as dust generation. I have a few minor comments on the paper, as well as many edits on the English in the paper, which needs some more work: because of the scientific quality of the work, and my interest in

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this area, I was willing to do the extra work to edit the text.

Thanks a lot for the help. And sorry. We tried to do our best.

``The most uncertain dust-related process is emission which depends non linearly upon the friction velocity  $U_*$ .'' I disagree. There are so many uncertain dust related processes, including dry and wet deposition! I would rephrase: ``One of the important and uncertain dust related processes. . .''

Done

Equation (1): I found this equation odd in the introduction. You could make the same point without including such a complicated equation: just cite the articles you cite already to make the point the extremes in the wind are really important.

The equation was moved to the section that describes Chimere emissions.

`` $U_{th}$ '' I find the nomenclature of the  $Th$  in superscript disconcerting, and I kept mis-reading it as an exponent: I recommend a more standard placement of the  $Th$  in the subscript.

Done

We use here the version of the scheme described by Rio et al. (2010) and used in LMDZ5B (Hourdin et al., 2013b).'' You can't say it's really important and then just send us off to another paper! We are full of suspense: give us a 1 sentence description of how to make this closure.

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*Added after the citation: "In this version, air is entrained into (resp. detrained from) the plume as a function of the buoyancy of plume air parcels divided by the square of the vertical velocity when this buoyancy is positive (respectively negative). Entrainment is strong near the surface, where it feeds the plume. Then detrainment is strong at the top of the mixed layer, when the plume decelerates. Entrainment can be active again above cloud base, for cloud-topped boundary layers when cumulus clouds are buoyant. The plume air is then detrained close to the top of the cloud. Entrainment and detrainment rates also depends on  $\alpha_{th}$ . The vertical velocity is computed with the plume equation (Eq. 1) with additional buoyancy and drag terms on the right and side. The plume fraction is diagnosed as a the ratio of the  $f$  and  $w_{th}$ ."*

``Note that even the NP3 simulation underestimates the actual AOT as illustrated later on.'' Please specify where instead of 'later on'.

The sentence was removed since this point is discussed afterward.

Section 4: comparison with observations: I think the description of the data should be in a methods section instead of in with the results. Please change the Section 2 ``Model description and simulation setup'' to be titled ``Methods'' and add a final section that describes the data you are using. At least the first paragraph of the section 4 should be instead in that section, plus probably some discussing how much we should trust this data, etc. I would argue that a really important point of this paper is value of the data, to compare to the model versions.

Done

``Although the stations are not located in the emission area discussed above, model results show very similar diurnal variations of wind at these sites.'' I'm not sure I understand this sentence, could you clarify?

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Removed. The introduction of this section (section 4) was rewritten after moving the description of observations to the section "Methods" (section 2.5).

The authors switch between using NP to NP3 or NP48. For consistency, I think you should use the full case name in all cases (or tell us in the into what it means if you leave off the number)

We went through all the occurrences and used SP3, NP3 and NP48 when referring to the simulations, and NP and SP, when referring to the model version.

Figure 5: missing the ``obs \_\_\_\_'' legend.\affaire{Binta}

Done

Top of P. 27439: you say that the results are the same whatever time period you look at, but presumably you only looked at a particular time period, so please indicate which years you analyzed this behavior for, even if this is in the methods.

Changed to: *"Note that this diurnal cycle is very similar whatever the period selected within the winter season for the years 2006 and 2007 considered here."* We also give this information which was missing at the end of section 2.4 *"Model configuration and simulations"*.

``In particular, tuning of emission algorithms with overestimated winds from reanalyzes may lead to artificially underestimate the emissions when better winds are given to the emission module, as is the case here.'' I think you are talking about certain groups which have done this in the past, and that this might not work? Maybe you want to point to these papers (e.g. Tegen et al., papers with the GISS model did this, but perhaps you are thinking of others?

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Yes. In fact this comment was too general. And it assumes that the ERAI winds may be overestimated everywhere over the region while we have observations over the Sahel only. So we removed the sentence in the revised manuscript.

``Significant conclusions may be drawn that do not depend on the particular model used for representation of dust'' I agree that your conclusions are likely to be model independent, but you have not shown this. I would rewrite as ``Significant conclusions may be drawn that are likely to be model independent''

Done

``It clearly attributes the observed morning peak of near surface wind to the downward transport of momentum by the compensating subsidence of thermal plumes, at their first stage, when they reach the height of the low-level jet which develops during the night at a few hundred meters above the surface, when the wind is decoupled from the surface'' This is the result of analysis and model results, so I would write this less strongly and remove clearly.

Rephrased: *" The morning peak of near surface wind observed quite systematically over Sahel is well captured by the NP version of the physical parameterizations. In the model, this peak is due to the rapid downward transport of momentum by the compensating subsidences when the thermal plumes reach the height of the low-level jet which develops during the night at a few hundred meters above the surface."*

``Of course many points could be investigated to try to understand the origin of this underestimation. Whatever those points, it does not alter the main result of the paper which is that an 15 accurate representation of the diurnal evolution of the boundary layer and transport of momentum by boundary layer convective cells must be taken into account for a good

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representation of winds, and that such a good representation is accessible now to the modeling community.'' I found these sentences a bit vague and redundant. I would just say ``Although there may be other errors in the model, our results suggest that the thermal plume model allows a more accurate representation of the diurnal evolution of the boundary layer and transport of momentum by boundary layer convective cells and it improves the representation of wind and dust in models..''

Rephrased a little bit differently: " *This underestimation does not question however the main result of the paper which is that an accurate representation of the diurnal evolution of the boundary layer and transport of momentum by boundary layer convective cells must be taken into account for a good representation of winds, and that such a good representation can be obtained through a combination of turbulent diffusion and mass flux representation of the boundary layer convection.*"

I would also like to know what happens in your free running GCM: does it get similar diurnal cycle with and without the new scheme? Just a brief comment about this would help provide context for other modeling groups.

To answer this question, we performed simulations in free climate mode inside the zoom area. The diurnal cycle is very close to that obtain with nudging. We added in the conclusions: " *Note that the mean diurnal cycle is almost identical when simulations are conducted in free climate mode, without nudging (results not shown).*"

Edits for English (please do reread carefully, as I probably missed a few)

Line 1:

``boundary layer transport'' should be `boundary layer'?

Not sure to understand why but done.

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``It also reinforces dust emissions in better agreement with observations, but the aerosol optical thickness is still significantly underestimated.'' Replace ``reinforces'' with `gen- erates'.

Done

``Desert dust is a secondary but significant contributor to the atmospheric radiative transfer, with regional signature organized around desert area like Sahara, which is estimated to contribute to 25 to 50% of the global dust emissions'' suggest replace with ``Desert dust is secondary but significant contributor to atmospheric radiative transfer, with regional signatures dominated by desert areas like North Africa, which is esti- mated to contribute 25-50% of the global dust emissions.''

Done

``that base the anticipation of future climate changes'' replace with ``on which future climate change estimates are based.''

Done

``the importance of a good representation of the boundary layer transport, contrast between nocturnal turbulence in a stable atmosphere and convective transport during the..'' replace with: ``the importance of a good representation of the boundary layer transport, especially the contrast between nocturnal turbulence in a stable atmosphere and convective transport during the..'' but this sentence is a bit long and probably could be cut into two.

The statement was simplified " *Todd et al. (2008) and Knippertz and Todd (2012) underline the importance of a good representation of the contrast between nocturnal turbulence in a stable*

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*atmosphere and convective transport during the day for the representation of this nocturnal jet and its impact on surface wind."*

``The counter-gradient term he proposed to reconcile the diffusive formulations with convection conditions was later on given a more explicit formulation based on the non local aspect of convective transport by Troen and Mahrt (1986) and by Holtslag and Boville (1993).''  
Replace ``later on'' with ``later'' (colloquialism)

Done

``The present study aims at exploring the impact of those new parameterizations on the representation of dust emission and transport and anticipate''. Replace 'those' with 'the above described', replace 'anticipate' with 'anticipates'.

Done

``Here air is assumed to enter the plume with the concentration of the large scale , which is equivalent to neglect the plume fraction'' replace 'large scale' with 'large scale grid box', replace ``neglect' with 'neglecting'.

Changed to: *"Here air is assumed to enter the plume with the mean grid cell concentration q, which is equivalent to neglecting ..."*

``Coupling of LMDZ with the CHIMERE emission module follows the way CHIMERE is currently forced by regional climate models'' replace with ``The coupling of LMDZ with the CHIMERE emissions module is done similarly to the standard method used to couple CHIMERE by regional climate models.''

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Done

``both computation giving very similar results.'' Replace computation with computations

The sentence was modified.

``a Weibull parameterization is used to account for the effect of spatial inhomogeneities of wind speed within a grid mes'' A weibull distribution, not parameterization, right?

Yes. Modified.

``with a distribution following a logarithmic increase'' replace with ``with a lognormal dis- tribution

Rephrased: *"In order to accurately describe this size distribution both in number of particles and in mass, it is common to use a discretization in size that follows a logarithmic law (Seinfeld and Pandis, 1998)."*

``by a mean mass median diameter,  $D_p$ '' do you really want both mean and median in the same noun-phrase?

Rephrased: *"The boundaries for the 12 dust bins used here are 0.09, 0.19, 0.67,1.49,2.27, 3.46,4.81,5.58,6.79,12.99,26.64 ,41.60 and 63.0  $\mu$  m."*The notation  $D_p$  is not used anymore.

``the model is run with its zooming capability''  $\rightarrow$  ``the model are conducted with the zooming capability.'' (run is a colloquialism)

Done

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``was described in details by Coindreau`` replace `details` with `detail`

Done

``The zoom consists in a refinement of the longitude and latitude discretization. Here, the zoom covers West Africa and the tropical Atlantic ocean.`` Should be `consists of`, but these sentences are a little redundant, please combine to one sentence.

Changed to: *"The zoom consists of a refinement of the global grid discretization in both longitude and latitude over West Africa and the tropical Atlantic ocean."*

``the zoom was chosen so as to get a`` replace to get with to obtain (colloquialism)

Done

``A nearest neighbor method was retained instead that provides much better results.`` Replace `retained` with `implemented`.

Done

``The LMDZ model is most commonly used in climate mode: integrated from an initial 5 state just imposing some boundary conditions such as insolation, sea surface temperature`` replace ``just imposing`` with ``with imposition of ``.

Done

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``The longer the time constant the weakest the constraint by the analyzed wind fields.`` Replace ``weakest`` with ``weaker`` and `by` with `of`

Done

``interactif`` should be `interactive`

Done

``In order to interpret at process level the``: should be `at a process le

Done

``while the wind distribution for the NP version explores much larger values.`` `explores` should be `includes` ``At the opposite, when the emissions are related to the daily-mean wind speed (right panel of Fig. 2) it appears that the wind explored are on average weaker in the NP than in the SP version.``. many issues: recommend: ``On the other hand, the relationship between daily mean wind speed and emissions (Figure 2b), suggest that the winds in the NP are smaller than SP, but emissions are larger for these lower wind speeds.``

Changed to: *"On the other hand, the relationship between daily mean wind speed and emissions (right panel of Fig. 2), suggests that the winds in the NP3 simulation are smaller than in SP3, but emissions are larger for these lower wind speeds."*

p. 27436 line 14 ``reinforces`` should be ``increases``

Done

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``Consistently with Fig. 3,``: should be ``consistent with Fig. 3``.

Done

``it is for both stations the NP versions that give the best results`` should be ``it is the NP versions that give the better results for both stations.``

Done

``As for dust evaluation,`` should be ``In order to evaluate the dust``

Done

``This station is considered at first`` should be ``This station is considered first``

Done

``A more systematic and synthetic comparison`` should be ``A more systematic and complete comparison`` (synthetic means fake)

Changed to: *"A more systematic comparison is shown"*

``We finally analyze`` should be ``Finally, we analyze``

Done

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``bias in the reanalyzes winds used for nudging. . .`` should be ``or bias in the reanalyses winds used for nudging.``

Done

p.27439 ``At the opposite,`` should be ``On the other hand``

Done

p.27440 first line: there should be their

Done

``driven by the unbalance between the Coriolis`` unbalance should be imbal

Done

``The thermals still accelerates the surface layer`` accelerate

Reformulated

``This conclusion goes beyond this particular model since many chemistry transport models rely on reanalyzes for the computation of near surface wind.`` Should be ``This conclusion is important for many chemical transport models which rely on reanalyses for the computation of near surface winds.``

Done

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``as large as 48 h the synoptic situation is still rather well  
constraint,`` constraint should be constrained

Done

``the model seriously underestimates the observed dust loading of the  
atmosphere,`` remove seriously (seriously is a colloquialism, and in  
boring english science writing we rarely include adverbs)

Done

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