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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Dust emission in farmland caused by aerodynamic entrainment and surface renewal" *by* Hongchao Dun and Ning Huang

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This paper presents a theoretical modeling study of dust emission from aerodynamic entrainment and saltation including an implementation of the surface renewal mechanism. Specifically, a parameterization of the free dust layer and a soil moisture transport module are developed and incorporated. The model simulated dust emission rates are compared with the observations from a field study.

It is an interesting modeling study, as it illustrates the time evolution of dust emission rates on the process level, governed by the ambient conditions such as surface wind speeds and soil moisture. The effects of wind erosion and soil moisture changes due to evaporation are modeled in both aerodynamic entrainment and saltation processes.

While the quantitative results may depend on the model specifications, it characterizes the relative importance and temporal dependence of the surface wind and soil properties in dust emission processes.

However, the manuscript needs major revisions in model description and evaluation before it could be considered for publication. There are two major concerns. First, a main contribution of this work is the development of this process model for dust emission. But the discussions about the model formulation and uncertainties in parameters are insufficient (detailed below in specific comments), making it difficult to determine if the results/conclusions are reasonable and where the model is applicable (or not). Further, the model evaluation includes one case study only comparing the simulated dust emission fluxes with a dust experiment. And the analysis of the model-data comparison is ad hoc and insubstantial.

Specific comments are given below: (1) The parameterization of the free dust area in Equation (1) is introduced the first time by this study. It is not justified how it is formulated: is it physically based or empirically fitting based on the experimental data? The equation implies a sharp decrease in available free dust fraction close to the surface. Since the predicted changes of dust emissions due to the aerodynamic entrainment is sensitive to the function, verification of the predicted free dust area with the experimental data or theoretical justification is necessary. (2) Also, in Equation (1), it is unclear what the R value is used for the radius of free dust grains and how it is determined; and is this parameter variable, depending on the surface type? How does this equation relate to the results in Section 3.1 and Section 3.2, Figures 2 and 3, i.e., is the dry soil thickness (H_d) sensitive to R in Equation (1)? (3) Equation (10) and (11): what is the definition of m and what is its typical value? (4) Equation (12): is the calculation of theta and evaporation rate applicable only over the wet soil? If the fraction of dry soil is > 0, i.e.,f_dust in Equation (1), will the theta and evaporation rate be calculated for that layer and how? (5) Section 2.4: a flow diagram would help illustrate the procedure. Lots of the detail about the model experiment are omitted. As mentioned in the main comment above, without those detail it is difficult to determine whether the results are reasonable. For instance, what is the initial soil moisture profile used? Is it representative for farmland, which seems to be the land surface type of interest? The model domain is unclear: is it a 1-D or 3-D model? What is the model horizonal and vertical resolution? Are there any horizonal variability in the initial conditions of soil moisture content and surface winds? (6) Figure 3: there is no black lines plotted in any of the panels (a)-(c). During the first hour when H_d>0, why the soil moisture remains constant but there is a slow increase in evaporation rate? is the stepwise increase in evaporation rate and soil moisture related to the initial soil moisture profile assumed? (7) Figure 4: in order to attribute the dust emission flux to a primary mechanism, it would make sense to plot the contribution of aerodynamic entrainment separately from that due to saltation transport. Sensitivity studies of other important parameters in the model such as soil moisture profile and surface air temperature/humidity would help in strengthening the findings from the model simulations. (8) Section 3.4: this model evaluation section needs to be expanded. As mentioned in the main comment, it is unclear if the model configuration is comparable to the experimental conditions such as soil type, moisture content and profile. More quantitative analysis of the model-data differences is needed, for instance, in terms of RMSE, correlation, or other statistical measures. The impact due to Surface Renewal and Evaporation (SRE) is visible only after 6 hours; however, this seems to be inconsistent with the model simulations in Section 3.1-3.3, which show that the SRE effects occur within $\sim$ 1hr. Why is that? Even after including the SRE effect, the differences between the model and observations are still quite large. It is not very convincing that the developed model captures the time evolution of the dust emission fluxes effectively in this case study. Furthermore, to attribute the changes of dust emission to a specific process: aerodynamic entrainment of free dust or saltation transport due to wind erosion, it is necessary to decompose the predicted dust emission fluxes by process. (9) Page 9, lines 14-15: dust emission caused by aerodynamic entrainment has been demonstrated in a number of previous studies such as Klose and Shao (2012) and Zhang et al. (2016). For the statement

"this model simulated the dust emission process caused by aerodynamic entrainment in nature for the first time", clarification about how this study is different from previous studies on this process is needed.

Overall, the manuscript is an interesting modeling study of dust emission processes based on the theoretical understanding. However, it requires significant improvement and justification in model description and evaluation, in order to support the findings of their model simulations.

Please also note the supplement to this comment:
https://acp.copernicus.org/preprints/acp-2020-1021/acp-2020-1021-RC2-supplement.pdf

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