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Interactive comment on "Modeling the global emission, transport and deposition of trace elements associated with mineral dust" *by* Y. Zhang et al.

Anonymous Referee #1

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1 General comments

The modelling study by Zhang et al. that is presented here attempts to assess the effect of the spatial variability in the elemental composition of dust sources on the transport and deposition of trace elements by dust. Presently, the deposition of trace elements is often calculated from bulk dust deposition, assuming a fixed elemental composition of dust; given that dust sources can differ quite dramatically in their elemental composition this is a significant progress and certainly justifies publication in Biogeosciences.

The first step in the study by Zhang et al. is the compilation of a map of soil elemental

composition using a high resolution soil data set from the FAO, then estimating the fractions of different minerals in the different soils, following Claquin et al. (1999) and Nickovic et al (2012), finally combining them with data sets on the elemental composition of different minerals from the literature. As the authors acknowledge, the assumptions on the mineral composition of soil types likely underestimates the variability present. The authors also note that impurities in gypsum, calcite and quartz can lead to variability in trace elements that is disregarded here. Very likely thus the spatial variability in dust source elemental composition is underestimated by the approach taken here; nevertheless, the first-order-trends are likely correct. For iron, similar attempts have been undertaken by Nickovic et al. (2013) (side-note: Only the precursor to that paper, Nickovic et al., 2012, is cited) and Journet et al. (2014), but the extension to more elements is a significant step that also allows a better validation.

The second step is then to calculate the the emission, transport and deposition of this dust, using the Community Earth System Model that has already been widely used for dust transport modelling before. The novel aspect here is that the model now transports the different elements individually, so that at each point in space and time the elemental composition varies.

Finally, in a third step the modeled elemental composition of dust and of dust deposition are verified by comparing them to a dataset of ground-based observation at a number of sites around the world.

Although the results of the validation are somewhat mixed, the paper presents a significant step forward, and I think the paper should be published after suitable revision. However, before coming to my points of criticism, I'd like to mention that the whole paper is still written in an English that contains too many errors to list all of them at the end of this review, so I will limit myself to listing only a subset. In this form the paper cannot be published and I would urge the native English speaking coauthors to help the first author to rewrite it.

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2 Main points of criticism

For the review of the paper I have several main points that I would like the authors to answer:

Firstly, the transport of the different elements in the dust by the earth system model is applied to each element individually; in reality, the elements are bound together in different particles of variable composition. The assumption of individual elemental transport is likely to introduce some smoothing, i.e. an error. The situation is similar to that in marine ecosystem models with variable stoichiometry, where the variable stoichiometry of individual phytoplankton cells is mixed through by the ocean models advection and diffusion. For the latter case, Christian (2007) has examined the magnitude of the error introduced by that assumption (and generally found it to be handle-able); maybe the authors could have a look into that paper and come up with a similar argumentation?

Secondly, the authors validate their model to a large extent with averaged elemental fractions in dust (line 21 to 23 on page 17505), but do not describe adequately how they calculated the average. Did they calculate the elemental fractions and then average those temporally for each location, or did they first average the amount of element and dust (or element and dust flux) at a location and then form the ratio of the two? And then, averaging the elemental fractions at the different validation sites, did they weigh the fractions by the amount of dust or dust flux? Depending on what you do the results may differ quite a bit. It would be interesting to see method of averaging affect e.g. the elemental fraction of iron (lines 8-10 in page 17506).

Thirdly, the authors describe that the comparison between modeled and observed elemental fractions is not very good for two elements, namely magnesium and manganese (see e.g. the correlations in table 3). However, the authors do not discuss why that is. I suspect that it has to do with the uncertainty in the assumed average mineral composition (table 1); calcite e.g. often contains quite a bit of magnesium, but the assumed fraction in table 1 is zero. Maybe the authors could try to discuss the propagation of

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errors in table 1 onto their results a bit.

Fourthly, and most importantly, the authors use the ratio of the median elemental fraction in model and observations (documented in table 3) to 'tune' their results. This is a quite drastic step, and I wondered what the justification for that step is. I think the authors should give more reasons for this step than just the last line in table 3. Does it bring the models closer to the observations at all measurement sites uniformly? Does it reduce bias? What is the variance ratio between model and data?

And finally, at the present size many the figures resemble more a stamp collection and are almost completely useless to the reader. The authors should think about ways to present their results in a form that allows the reader to have a look without magnifying glasses.

3 An incomplete list of typographical, language and other errors

The list of smaller language errors would quite long, and I have therefore not listed minor ones, such as omitted 'the' etc.

Page 17497: many errors on this page; one example: line 27, 'calculating' should be 'calculation'
Page 17498: What does the sentence 'Here the minral dependent method is defined as M1' mean? I have no idea.
Page 17502, lines 4-5: What does the sentence want to say?
Page 17502: Many small errors, like missing empty spaces between word, missing word like 'are found (in) dust' Page 17502, lines 23-25: what is a 'relative location'? I don't understand the sentence. The importance of something adds complexity in applying something else?
Page 17503, lines 15 ff: 'The monthly variability is calculated by': No, the variability is something that is already defined. I would write 'An index describing montly vaiability..

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Page 17504, lines 22-24: Where is the verb in that sentence? Page 17508, lines 16-18: Sentence unclear. Table 2, column 1: textbfAfrica -> **Africa**
Table 3: Capitalization of words in column 1 needs to be checked
Table 4: caption: ifferent -> different
footnote b: tunning -> tuning
Table 5: I don't understand the footnote! Also, the table is much too small to be read
Figure 4: Why do the right and left panels have different sizes? Also the colourmap in d) is different from the others. Figure 5: All colorscales are identical! This is probaly wrong. Figure 13: The text in the caption is almost un-understanable

References not already present in the manuscript

Christian, J.R. (2007). Advection in plankton models with variable elemental ratios. Ocean Dynamics, 57(1), 63-71. doi:10.1007/s10236-006-0097-7

Nickovic, S., Vukovic, A., and Vujadinovic, M. (2013). Atmospheric processing of iron carried by mineral dust. Atmos. Chem. Phys., 13, 9169–9181, doi:10.5194/acp-13-9169-2013, 2013.

Interactive comment on Biogeosciences Discuss., 11, 17491, 2014.