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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Transport and mixing zone of desert dust and sulphate over Tropical Africa and the Atlantic Ocean region" *by* K. V. Desboeufs and G. Cautenet

Anonymous Referee #1

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General remarks

The paper presents a modelling case study for investigating the interaction between SO_2 emissions and dust ejections from the Saharan desert leading to sulphur coated dust. The paper contains a number of quite substantial unresolved issues which need to be dealt with prior to publication.

Main points

1. Model domain: The authors chose a model domain which spans 18W;41N to

60E;5N. I assume the westernmost corner (18W) to be a typing error, as even Sal island would then be outside of the model domain (23W;16N). Still, I generally consider this model domain too small to study the dust coating process in the way the authors would like to do this. The domain excludes most of central and western Europe, where the largest SO_2 emission sources are located. Long-range transport of emissions is considerable and should not be neglected as is implied by this setup. Furthermore, the Mediterranean, an important area where potential interaction between polluted and dust-laden air masses could take place, is only covered half by the model domain. Furthermore, the authors compare some of their results with measurements in Barbados, which is also outside of the model domain. Does Fig. 1 show your actual calculation domain?

2. Emission database: The emission database EDGAR is an 5-yearly database, which version and year did you use? Looking at the EDGAR database, I see that data is given in annual total amounts, how did you convert to SO_2 emission fluxes? In 2.2 the authors note that "biomass fires, which are predominant in this season, are not assumed to be a major source of SO_2". This does not make any sense to me. The EDGAR database also contains considerable annual totals in the Sahel region, where biomass burning is considerable during boreal winter. Did you exclude the biomass buring data from your study (Fig. 1)? Also, the authors state that "the European source [] has no marked seasonal behaviour". I do not think this is true, with the majority of private heating taking place in winter. Hence, I think it is not straightforward to use the annual totals from the EDGAR database for a one-month emission study, and the authors should more carefully investigate these limitations of their study. In addition, their last paragraph of the conclusions section, the authors note that winter is generally associated with high SO2 concentrations in Europe (by the way, a conclusion that cannot be drawn from the work presented here), which is in contradiction with the earlier statement, that seasonality does not matter. How is the SO_2 emission parameterised in the model, and how is it transported?

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3. Case study limitations: The authors select January 1993 for their case study. This is perfectly fine, as long as one is aware that a case study does normally not allow to draw conclusions on the general characteristics of the issue under consideration. The authors forget about this limitation and draw general conclusions from their study in a number of cases, e.g:

- pg. 5616, l. 12-18 - pg. 5630, l. 11-21 - pg. 5621, l. 1-9 - pg. 5623, l. 20-25 - pg. 5625, l. 20-22

These generalisations need at least to be backed up, or otherwise qualified as speculation. Another possibility would be to compare two winter months, or one summer and one winter month. The motivation for choosing this particular winter month is also not clear. Some indications are given on p. 5623, l. 26-28, this should be part of the introduction/motivation of the study, and be backed up by the available literature on synoptic situations leading to dust emission.

Specific comments

1. Pg. 5617, l. 7-8: “The transport mechanisms of African dust are well-understood...”: I do not think that claim can be made so easily in general. At least, you should briefly state here what the main transport mechanisms relevant for your study area are.

2. Pg. 5617, l.9-10: “The meteorological conditions...are favourable...”: This is a far to general statement, this may be the case on some occasions, but depends crucially on the synoptic situation.

3. On pg. 5617, l. 26, it is stated that one aim is “to identify the synoptic situation where dust is likely to be coated by sulphate”. However, in the remainder of the paper, no synoptic description (e.g. SLP, PV, Z500 maps) of the dust emissions in January 1993 is given.

4. On pg. 5618, l. 14, it is stated that “January is a typical period for dust plumes over the Atlantic Ocean.” Typical in what sense? This statement should be more specific.

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Dust emissions from the Saharan take place all year, and may be different for different sections of the North African coast.

5. What exactly is your ECMWF initialisation data (analysis, reanalysis), at what interval is the data updated?

6. Pg. 5618, l. 19: What was modeled cloud cover compared with? Cloud cover is not a very well-constrained variable in atmospheric models: did you compare other output fields as well (e.g. sea level pressure or equivalent potential temperature)?

7. Pg. 5618, l. 24: "... is also very efficient." what does this mean, be specific: is all SO2 removed instantaneously?

8. Pg. 5620, l. 3-4 "...since the calcite/quartz ratio in soil and dust are in good agreement". I don't think this is generally the case, due to resuspension of dust (e.g. Schütz and Sebert, 1987).

9. Pg. 5621, l. 1-9: Please clarify what results will be presented, and distinguish clearly between the findings from your work and literature findings. What is meant by "...have early been identified"?

10. Pg. 5621, l. 16: "...lead to trajectories that originate in the North...": A number of studies have demonstrated that cyclones in the Mediterranean can be associated with dust emissions to the Mediterranean sea due to mobilisation along the cold front. Did precipitation play a role in the case you studied? What meteorological processed lead to dust mobilisation in that case, was a cyclone present at that time?

11. Pg. 5622, l. 2: "... a low-layer dust in the Saharan Air Layer (SAL)...": The SAL is most active in the summer season, and governs the mid-level dust export to the Atlantic in association with the African Easterly Jet. This is fundamentally different from the trade winds regime.

12. Pg. 5622, l. 27-28: "...located above 1000m": should this not rather be "below"?

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13. Pg. 5623, l. 1-14: Either provide an IDDI image that can for instance be compared with your model output, or reduce the paragraph to 1 sentence.

14. Pg. 5624, l. 2-3: reword sentence

15. Pg. 5624, l. 8-11: Be specific, which periods do you mean?

16. Pg. 5624, l. 12-15: Instead of looking at the percentages of the “poor” and “rich” classes, it may be more instructive to look at the total calcite content of the suspended mineral aerosol.

17. Pg. 5624, l. 28: How is Fig. 6 created, what exactly is shown here?

18. Fig. 5, 7: The authors note that the first week is a spin-up period, hence it would be useful to underlay the first seven days e.g. with a gray box.

19. Pg. 5625, l. 24-25: Being transported in the same altitude is a necessary but insufficient criterion for mixing/coating to occur

20. Pg. 5627, l. 25: Gypsum is also a component of arid soils (evaporite)

21. Pg. 5628, l. 2-4: This finding is fully dependent on the authors’ assumption, that reaction takes place immediately, and mixing within a grid cell is complete. As the authors note, these assumptions are simplifying (pg. 5620), and are not necessarily valid on the chosen modelling scale. Actual mixing may take much longer, and then take place much further away from the African coast. This implies also that Fig. 8 provides a view of the immediate “contact zones” between SO_4^{2-} and mineral aerosol, as the coating is modeled offline and takes place instantaneously.

22. Pg. 5628, l. 4-10: The comparison of your results with findings from Barbados are cumbersome, since (i) Barbados is outside your model domain, (ii) transport to the Caribbean is mainly a summer phenomenon (e.g. Goudie and Middleton, 2001), i.e. when different dust transport and SO_2 emission characteristics dominate.

References

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Schütz, L. and Sebert, M., 1987: Mineral aerosols and source identification. J. Aerosol Sci. 18(1): 1–10.

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