

Interactive comment on “Future evolution of aerosols and implications for climate change in the Euro-Mediterranean region” by Thomas Drugé et al.

Anonymous Referee #2

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The paper analyses the differences in aerosol load and DRF between the end of the 20th century (1971-2000) and the mid-21st century (2020-2050) in the Euro-Mediterranean region using a regional climate model (CNRM-ALADIN63) coupled to the TACTIC (Tropospheric Aerosols for Climate In CNRM) interactive aerosol scheme and driven by the global CNRM-ESM2-1 Earth System Model (used in CMIP6).

The study reports the already well known decrease in sulfate and increase in nitrate between the two periods, estimating a DRF decrease of 2.6 W/m² and increase of 1.4 W/m² respectively. The study also concludes that the extra-warming attributable to the anthropogenic aerosols evolution over Central Europe and the Iberian Peninsula (0.2°

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C) during the summer period is due to "aerosol-radiation" as well as "aerosol-cloud" interactions processes.

The study is interesting and deserves publication but I have some general comments that should be convincingly addressed before a final decision on the manuscript is made:

- The title: I believe the title is slightly misleading. The study addresses the implications of the aerosol evolution upon climate change in the Euro-Mediterranean region using one regional model driven by one ESM. I also note that, despite the higher resolution of the model compared to most ESM/s, it includes several simplifications (omission of processes and simplified schemes) that do not necessarily represent the state-of-the-art when it comes to the interaction of aerosols with radiation and clouds. I believe the title should clearly reflect that the study focuses in one model (therefore implicitly conveying the more correct message that the results may be to some extent model- and assumption-dependent). As it stands the reader may expect a multi-model study including uncertainties, which is not the case. For example: "Future evolution of aerosols and implications for climate change in the Euro-Mediterranean region using the CNRM-ALADIN63 regional climate model" or something similar would be more appropriate.

- I think it is important that the authors nuance a bit more their statements in the introduction about the study of aerosol effects with a regional climate model. While resolution is important, the resolution used is not far from what some ESM models are already using. More importantly, there are other aspects that are key to understand aerosol impacts and at present many ESMs already include aerosol and cloud processes that are far more advanced than the ones represented in this study. The regional model used here includes a simplified aerosol scheme (without aerosol microphysics and number, for example), and many other simplifications (like introducing only the first indirect effect or using a constant nitric acid climatology). Besides that, regional climate modeling cannot account for slow climate responses to aerosols in the domain, and in fact heavily depends upon the ESM driver through the boundaries.

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I think these aspects and the associated limitations should be clearly explained and discussed both in the introduction and the discussion.

- Nitric acid is implemented in the model as a constant monthly climatology based on the CAMS reanalysis. One key result reflected in the abstract is the increase in nitrate and its impact upon the DRF. At least, the abstract should clearly acknowledge the constant nitric acid assumption.

- In page 6 you state: "The future period has been selected in the near future because, unlike greenhouse gases, the most important aerosol change is up to the middle of the century. Moreover, the near future horizon period is most suitable to help public decision-makers." I agree with this statement. However, I find that the selection of the reference period (1971-200) is not well justified and may even be a bit inconsistent with the argument that "is most suitable to help public decision makers". Why the reference period is 1971-2000. Is it because of sulfate and the associated large signal in the DRF? Wouldn't policy makers prefer to see the differences between mid-century and the present day?

- Given that you are using a regional climate model driven by an ESM with a similar (although not identical) aerosol scheme, they should be compared. In fact, average results of the DRF are compared to other studies throughout the paper but I really miss a clear and consistent comparison with the parent ESM. This could also respond to the question: how useful is resolution and downscaling for the diagnostics that are discussed in the paper? It would be even better if other available CMIP6 ESM results could be consistently compared within exactly the same domain. That would provide a solid comparison reference.

- Please clearly state that you are calculating the instantaneous RF. Current practice is to calculate effective radiative forcing which includes the forcing and the fast response. Also, why only the direct radiative forcing is discussed in section 3.2 and not the indirect effect? What is the relative role of both upon the total forcing? This is particularly

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strange as in section 4 you discuss on the interaction with clouds and you suggest influences of the indirect effect upon the certain results.

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