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Interactive comment on "Gains and losses in surface solar radiation with dynamic aerosols in regional climate simulations for Europe" *by* Sonia Jerez et al.

Anonymous Referee #2

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This manuscript, submitted to Geoscientific Model Development, presents a sensitivity study on the role of dynamic aerosols in regional climate simulations over Europe, carried out with the WRF model. The authors consider both present and future simulations, and discuss the role of aerosol-radiation and aerosol-cloud interactions respectively. They conclude that the response of downwelling surface shortwave radiation (rsds) to aerosols is mainly driven by the impact of aerosols on cloudiness. Overall this question is very interesting and needs to be studied, I found the present manuscript presents major problems of methodology, that is the reason why I would suggest not to publish it in GMD.

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Discussion paper

Main comments:

- The authors are ambiguous about the objective of their study, to begin with the title. I do not understand if they want (1) to show the added values of representing interactive dynamic aerosols in regional climate simulations, compared to regional climate simulations with climatological aerosols, or (2) if they want to show the mean impact of aerosols in regional climate simulations compared to simulations which would not have any aerosols. Given the title, I was expected the first option, which is a very interesting question, not very much documented in literature, but this requires a rigorous protocol in which we compare regional climate simulations with the same aerosol content on average. This is not the case here. So I suppose the authors were in the second option, which is much less interesting, as it has already been studied in different publications. In that case, I suggest to remove the word dynamic from the title, and avoid overly affirmative expressions such as “a reduction about 5% in RSDS was found when aerosols are dynamically solved by the RCM”.

- Another major concern about this study is the fact that the authors draw conclusions on the impact of aerosols on rsds future evolution, while they keep constant anthropogenic emissions in their future simulation. The authors are aware of discrepancies in the rsds future evolution between global and regional climate simulations, which could be due to the use of constant aerosols in RCMs contrary to GCMs (Boé et al. 2020). That is the reason why I do not understand the authors keep anthropogenic aerosol emissions constant in future simulations, while they should evolve as in the GCM simulation.

- The last major concern is about the RCM used in this study. The version of WRF used here, namely 3.6.1 is quite old (reference paper from 2008), and above all a precise description of how aerosols and their effects on climate are represented is missing. For example, I wonder what aerosol climatology is used in the BASE simulation (if it is not zero). I am also very worried about the very low values of summer AOD shown in Figure 1g-h, which shows that WRF clearly underestimates AOD over Europe. WRF

values range from 0.05 to 0.09 over Europe, while observations typically range from 0.1 to 0.2 (Papadimas et al. 2008, Nabat et al. 2013, Schultze and Rockel 2018). That could lead to an underestimation of aerosol effects. In such a study, an evaluation of AOD (even brief) is needed in order to ensure the consistency of the results.

Other comments :

- page 2 line 31: land use change is not specific to regional climate simulations, I think it is even more used in global climate simulations.

- page 3 lines 57-63: please avoid such long lists of references, and clarify the conclusions of each of them

- page 3 lines 70-71: “which still remain largely a mystery”. Other studies such as Giorgi et al. (2016), Sørland et al. (2018) and Boé et al. (2020) have also underlined differences between RCMs and GCMs in future projections. The role of aerosols is even discussed in Boé et al. (2020), which should be mentioned here.

- page 5 lines 140-141: it is not clear for me how aerosol-cloud interactions are represented in the simulations.

-page 6 lines 144-146: This way of calculating clear-sky variables in simulations is not common in modeling studies. It would be appropriate for a comparison to observations (it is exactly how satellites do for example), but in models, you generally compute clear-sky variables at each time step, removing clouds in radiative transfer. This would avoid the numerous missing values.

- page 6 section 3: This section should be divided in several sub-sections, with more precise titles than only “Results”.

- page 6 line 165: “The inclusion of interactive aerosols reduce the JJA mean values of RSDS”. This is typically an example of my first main comment. This decrease in rsds is likely due to the mean effect of aerosols, and not their interactive pattern.

- page 7 line 172: “ARI and ACI lead to more cloudiness in central and northern regions”. This is not really the case when looking at the figure.

- page 7 lines 184-187: This conclusion is not justified.

- Figures 1-4: From my point of view it would be easier to understand to have differences in absolute values rather than in percentages. Indeed, I suspect here we look at very low values which could be unsignificant.

- Figures 1-4: Why consider only land points ? It would be interesting to show also ocean points on figures.

- Figure 3: When comparing the evolution of rsds, cct and aod in the simulations, I suspect a possible bug in the figure or in the simulation. Indeed, the strong decrease in rsds in northern latitudes (for example in Iceland), is neither explained by cct nor by aod.

- Page 8 lines 218-219: If “the anthropogenic component is disregarded”, there should be no possible conclusion on the future evolution of rsds.

- The manuscript suffers from many typographical and English spelling errors that need to be corrected.

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