

Review on the “Assessing the Sensitivity of Aerosol Mass Budget and Effective Radiative Forcing to Horizontal Grid Spacing in E3SMv1 Using A Regional Refinement Approach” by Li et al.

Atmospheric aerosols are important implications for the Earth’s climate system. The present study explores the impact of horizontal resolution of aerosols of the E3SMv1 model in the climate system. The impact of the resolution of the regional refinement model (RRM) in 0.25 degree is estimated by comparing with the traditional and coarser low-resolution model (LR) in 1 degree. The analysis has been comprehensively conducted by comparing aerosol emission, horizontal and vertical distributions of aerosols and precursors, meteorological conditions, and direct radiative effect for the pre-industrial and present-day period, between two simulations. The method is scientifically sounding, and the manuscript is overall well organized and written. However, I have two major issues. First, there is no evaluation of the simulated aerosols throughout the paper. I see quite significant differences between the two simulations as shown in dust and sea-salt emissions. It is extremely difficult to judge if RRM is better than LR or the other way. I would strongly encourage to add evaluations with available observation data such as remote sensing AOD, IMPROVE, or field experiment. Secondly, there is a major issue in experiment design, since there are more factors involved between two models other than horizontal grid spacing as indicated in the title. This is also written in the method section of the manuscript. Considering a hierarchical nature of numeral models, it is extremely difficult to separate the impact of the horizontal gridding, from the other. I think this issue should be solved in the revision. For those reasons I would recommend “accept with major revision”.

Comments

L46: Please state how is ERF_{aer} is defined.

L134-135: Please be more specific what are the known model biases. Also please be specific if the two simulations are identical other than gridding related configurations. If not, please clarify them.

L138: Please be specific about the land component. Does it mean land model option?

L141: I think 3 month spin-up is too short for the aerosol-climate interaction in the upper atmosphere. Please state more justifying the short spin-up. At least cite previous studies. "FC5AV1C-04P2" looks too model specific. Please clarify the name.

L160: Please describe more about "nudging" such as which fields and how. It states that the model includes meteorological fields for nudging in below sentences. How about aerosols?

L178 and the paragraph: It shows now there are more differences between LR and RRL than resolution. How can authors resolve the difference between two simulations is due to resolution or differences are from other than resolution? It sounds me that the experiment

is not precisely designed. I suggest elaborating the common and differences between LR and RRM. I think a table would be an efficient way.

L210-213: It states that stronger wind is found in higher resolution. How about the changes of the area of strong wind? Please specify the difference of the area of strong wind in LR and RRM. Why does it happen? Is due to resolution, gridding, physical parameterization, or aerosol-radiation-cloud interaction?

L223: The differences in soil water content of -7.1% is quite large, since the two models trying to run same atmospheric conditions such as nudging technique. Please more elaborate the differences in the soil moisture and also wind.

Table 1 and Figure 1: The factor of 2-3 difference in dust emission between RRM and LR is concerning, since it implies very large differences in wind fields which may not be enough with the resolution effect. It needs more thorough investigation on this other than the wind strength. Please discuss friction wind and soil moisture, and the percent difference between the two simulations. How about other meteorological fields such as wind at 500 mb and PBL height? Are they also very sensitive to resolution e.g., compared to 0.25 degree linear-grid?

Figure 2 right column is the difference between LR and RRM. Dust, Seasalt, MOM are highly variable. Since these aerosols are from natural sources, the differences are the result of the change of meteorology especially surface wind both over land and ocean. It needs further analysis to explain them.

Figure 2b: Why dust emission in Region 2 is so strong? Is it supported by observations? If true, please show here.

Figure 2c-d: Why sea-salt emitted over land?

Figure 3a and 2b: Please be specific if the difference is RRL - LR or LR - RRM. Also please check the difference in wind field is consistent with the difference in emission over Utah. It seems me that the pattern is opposite between the two.

L251-254: Please be specific it is same for LR too.

L304-305: Please add numbers for cloud scavenging and below cloud scavenging.

L505: Again, it seems that LR and RRM are different in gridding schemes and associated other various factors.