Review on "Modelling the mineralogical composition and solubility of mineral dust in the Mediterranean area with CHIMERE 2017r4" by Menut et al., 2020

The manuscript introduces a version of the CHIMERE regional chemistry-transport model, in which the mineralogical composition of dust aerosols is taken into consideration. It also presents results from an evaluation of the simulated dust mineral species and other aerosols versus observational data for the region of Europe, the Mediterranean, and North Africa, compared to a baseline simulation that takes into account only bulk dust without mineral speciation.

The explicit modeling of the mineralogical composition does not lead to an improvement of the simulated soil dust cycle or aerosol optical depth (AOD), according to the presented results. The model version with the minerals allows to explicitly simulate regional variations of nssCa^{2+} and its ratio to total dust, though, which is important for biochemical cycles.

There have not been many models, regional or global ones, that consider the mineralogical composition of soil dust so far, and the presented one is a valuable addition to the few. I have a concern with respect to methodology and a few other points that should be addressed before publication, though.

1. **Section 4.4.1:** My main concern is with respect to the approach that is chosen to account for the wet-sieving bias in the database of the mineral fractions in soil by *Journet et al.* (2014), which is used as input. The authors present functions in Equation 1 to compensate for the wet-sieving bias, with the parameters chosen in a way that the values of the functions approximate the contributions of the soil clay and silt fractions to dust aerosols in Table 2a in *Scanza et al.* (2015). This may be a valid approach, principally. However, the reasoning by the authors for doing this is that they have not been able to reproduce the numbers in Table 2a by *Scanza et al.* (2015), using the equations in that paper. The authors assume anyhow that the numbers in the Table, which are approximated were correct. On what basis do they have confidence that their own formula adequately represents the contributions of the soil clay and silt fractions to the dust aerosol distribution then? That needs to be clarified.

2. **Page 4, Section 3.2, lines 107–108:** The simulations with the GOCART model that are used for the boundary limits of the CHIMERE model domain only provide total dust fluxes. How are the mineral fractions of dust treated at the boundary limits?

   Furthermore, for better reproducibility of the results from the current study, the information on what model simulations were used for the boundary limits of the model domain should be more specific than just naming on what papers they are based. Where can the simulations be accessed?

3. The authors should add a more comprehensive description of the wet deposition scheme that is used in CHIMERE to **Section 4.4.2**, since it seems to be a crucial

part for understanding the results on wet deposition, which are presented in the manuscript.

4. It will be informative, if results (figures and/or tables) for the resulting simulated volume/mass size distribution of the total dust concentration as well as the distribution of the mineral mass fractions over the dust size bins are also shown in the manuscript, even though measurements for evaluating them are not available. It still will be valuable for comparing with other models that simulate the mineralogical composition of dust aerosols. The lack of differentiation between different dust minerals with different particles densities by gravitational settling during transport may be due to the simulated size distribution.

5. **Page 16, lines 285–286, and legend of Figure 7:** The experiment for which the absolute AOD is shown in the top panel should be explicitly named there.

6. **Page 17, line 292:** The manuscript states, "Statistical scores are calculated over 32 AERONET stations. Results are presented for selected sites in Table 6".

   The phrasing is confusing. The statistical parameters are calculated and valid for the sample of all 32 stations, are they not? In what way are results shown for "selected sites" in the table?

7. **Page 18, lines 312–313:** A conclusion is stated there: "Since the precipitations are well represented in the model, it indicates that the strength of the mineral dust plumes is overestimated in the simulation."

   This conclusion is not clear to me. The model simulated wet deposition flux of $nssCa^{2+}$ has a low bias, compared to measurements. Even if the error in the simulated precipitation is not large, the error in the deposition flux can have different causes. The entire simulated dust cycle, including the wet deposition flux may be too weak, or the simulated fraction of $nssCa^{2+}$ in dust may be too small, or the wet deposition scheme that is used to calculate the deposition fluxes may not be sufficiently efficient with respect to dust tracer removal.

8. **Page 18, lines 317–320:** I do not understand what this paragraph says. Please rephrase and explain this more clearly.

9. Units of shown variables should be added to the legend of those figures and tables where they are missing.

Typos and language issues:

1. **Page 3, line 71:** Remove "latter".

2. **Page 4, line 107:** Replace "where" with "for which".

3. **Page 7, line 159:** Fix typo in "individual".

4. **Page 12, lines 217–218:** Replace *"M"* with *"i"* in the description of the denotations of the equations, since *"i"* stands for the individual mineral and *"M"* for the total number of the minerals.

References

Journet, E., Y. Balkanski, and S. P. Harrison (2014), A new data set of soil mineralogy for dust-cycle modeling, *Atmos. Chem. Phys.*, *14*(8), 3801–3816, doi:10.5194/acp-14-3801-2014.

Scanza, R. A., N. Mahowald, S. Ghan, C. S. Zender, J. F. Kok, X. Liu, Y. Zhang, and S. Albani (2015), Modeling dust as component minerals in the Community Atmosphere Model: development of framework and impact on radiative forcing, *Atmos. Chem. Phys*, *15*, 537–561, doi:10.5194/acp-15-537-2015.