

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2022-228

Anonymous Referee #2

Referee comment on "The simulation of mineral dust in the United Kingdom Earth System Model UKESM1" by Stephanie Woodward et al., Atmos. Chem. Phys. Discuss.,
<https://doi.org/10.5194/acp-2022-228-RC2>, 2022

This is a well-written manuscript that provides a fairly detailed model description and some useful results on the effects of changes in the dust cycle when interactive vegetation is considered when including dust in an Earth system model. It is to be expected that the results described are model-dependent, but it is still useful to see possible magnitudes and direction of the effects of this model configuration.

Major comments:

- The results in the paper may to some extent depend on the tuning strategy, which is not described in the manuscript. Please provide some details on this aspect.

- the fact that the results for the changes dust radiative effects are small is largely due to

the cancellation of positive and negative effects, so it would be useful to also give minimum/maximum values or ranges of changes that occur with the changed design.

- Please adapt the number significant digits given in the results to reflect their uncertainty range. E.g. three significant digits for the radiative effects clearly overstates its accuracy. Overall, some discussion on model uncertainties and variabilities should be provided to put the results of this work in context.

Specific comments:

- Equation 1 (page 3) – please provide units for the variables -is the factor D dimensionless?
- Page 4+5 – various dimensionless tunable constants are mentioned (D, k1, k2) – please provide the actual values, maybe in a table.
- Which datasets are used for the input data used to describe soil properties?
- Line 118 - please provide the limits for the size bins
- Line 136 – in which regions are seasonally varying dust sources occurring?
- Overall, Section 3.1 would benefit from a discussion of uncertainties
- Line 195 – Dust load results are compared to AEROCOM means from Textor et al (2006) – more recent AEROCOM results that should be used as benchmark are found e.g. in: Gliss et al. 2021 (<https://acp.copernicus.org/articles/21/87/2021/acp-21-87-2021.pdf>)
- Figure 1 compares results from the different model versions, they also differ in their treatment of seasonal sources. It would be interesting to see the regional effect of turning on/off seasonal sources, even if the overall impacts of seasonality are small.
- Section 5.3 – In addition to the comparison of AERONET AODs I suggest to also compare Angstrom parameters from the AERONET data as well – these should provide additional information for the particle sizes.
- Table 2 on page 15 summarizes key results but is difficult to read - possibly separating into two tables for absolute values and percentages, respectively, would help? Also, for TOA the forcing values over land and ocean would differ and partly cancel each other, so it would be useful to list them separately.
- Line 363 – please provide information on the quantitative change of the bare-soil source area.
- Line 363-365 – the effects from vegetation changes on meteorology and soil moisture are a central new result of this work, the description of these effects should be more

detailed.

- Line 372 – is the change in modelled size distribution due to different emission schemes or datasets or due to a different meteorology?
- Line 401 “all the processes in UKESM1” – please elaborate
- Figure 10+11 can hardly be read due to the small panels – it could be split up in several parts. Also consider to move them to an Appendix.
- Discussion: Page 25 – here issues are mixed. The discussion on differences in the dust size distribution should be clearly separate from discussion of the effects of computing dust in an Earth system model with interactive vegetation.

Typos

- Line 231 Remove double period at end of sentence
- Line 233 dimeter -> diameter