

Interactive comment on “Modelling sea salt aerosol and its direct and indirect effects on climate” by X. Ma et al.

Anonymous Referee #1

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The manuscript presents a global modeling study on the sea salt aerosol and its climatic effects. The modeling framework has been previously applied by the authors in investigating sulphate aerosols, but here the model has been developed further. First, the sea salt aerosol is represented using a new numerical technique and second, the optical properties of sea salt particles are calculated with a revised Mie theory parameterization. The model predictions are evaluated by comparing predicted sea salt aerosol concentrations with observations.

The main achievement of the study lies in quantifying the direct and indirect forcings of the sea salt aerosol. As the authors conclude, the results are subject to large uncertainties, though. The uncertainties are partially caused by the simplified representations of the sea salt aerosol and their impact on the cloud optical properties (see major com-

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ments below). Nevertheless, I recommend the manuscript for publication ACP after the authors have considered the following remarks.

Major comments:

1. The sea salt aerosol distribution is prescribed using a single mode with fixed mean size and width. The number concentration of the mode is allowed to depend only on the wind speed. The authors state that this involves less uncertainties and approximations than a flux-based approach (without giving any arguments for this), but they do not mention all the drawbacks of their treatment. First, the empirical approach is based on a limited data set and as such, may not represent the global variation of the sea salt aerosol (for example, it remains unclear why model has problems in predicting sea salt concentrations in tropics). Second, the representation does not link the sea salt aerosol distributions with their production and removal mechanisms and therefore the model may fail to capture some important dynamical feedbacks. Third, the current parameterization neglects smaller sea salt particles (Figure 8) which may cause problems when diagnosing cloud droplet concentrations (CDNC) from the aerosol size distribution.

Overall, the authors should give throughout discussion on the potential errors related to the simplified representation of the sea salt aerosol.

2. The model calculates CDNC (eq. 14, p. 14950) as a function of the sulphate and sea salt concentrations. Such a highly parameterized empirical approach suffers from the same drawbacks as the treatment of the sea salt aerosol distributions. The authors should discuss on the uncertainties that are associated with the combination of a simplified cloud droplet activation scheme and a simplified sea salt representation (see also the first comment above).

Minor comments:

1. In page 14944, the authors state that 'The parameterization is limited to the particle

diameters greater than 0.1 μm as there are few observations for smaller particles and concentrations are generally expected to be small'. The latter argument should be contrasted with the results of Clarke et al. (2006).

2. Section 3.2. Given that sea salt particles having a diameter $<0.1 \mu\text{m}$ are not considered, the Kelvin effect does not affect the water activity significantly. The authors may want to mention this.

3. Second paragraph of the section 4. The authors do not cite any experimental studies on the aerosol activation.

4. Section 4. Mechanistic activation parameterizations have been implemented to GCMs recently, see e.g. Penner et al.: 'Model intercomparison of indirect aerosol effects'(ACP, 6, 3391-3405, 2006). The authors should cite these works.

5. Page 14951, line 15. The author state earlier (section 2) that both the sea salt mass and number are included as new tracers in the model (four new tracers in total). Therefore this seems to be an inconsistent statement.

6. Section 6.3. How the sea salt aerosol distributions are calculated in the model when the sea salt flux parameterization of Clarke et al. is used?

Technical comments

1. Page 14940, line 25. 'And', not 'at'.

2. Page 14941, line 27. 'Seinfeld'.

3. Page 14947, line 16. 'constants'.

4. Equation 13. Are the units for the terms in the right-hand side correct?

5. Page 14951, line 19. No reference is given for Lohmann et al., 1999.

6. Page 14952, line 2. No reference given for Khairoutdinov and Kogan, 2006.

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