

Interactive comment on “Cloud, precipitation and radiation responses to large perturbations in global dimethyl sulfide” by Sonya L. Fiddes et al.

Anonymous Referee #2

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The manuscript reports on the influence of natural aerosol emissions on climate systems. Specifically, it presents research on the relationship between biologically-derived dimethyl sulfoxide (DMS) and climatic parameters (e.g., cloud cover, radiation and precipitation). In addition, the manuscript provides an evaluation of the ACCESS UKCA model for examining the role of DMS in the Earth's climate, and conducted large-scale sensitivity test using ACCESS UKCA modeling system in investigation of response of climate on prescribed changes in surface DMS concentrations. The relationship between DMS and climate processes is strongly non-linear and this relationship is poorly understood due to lack of global DMS distribution data. Therefore, the research reported in the manuscript is timely and relevant.

The research presented in the manuscript had the following objectives: (1) to evalu-

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ate the application of the ACCESS UKCA model for examining the role of DMS in the Earth's climate and (2) to conduct large-scale sensitivity test using the ACCESS UKCA modeling system in investigation of climate response to prescribed changes in surface water DMS. The manuscript is well written and provides new and interesting analyses that are useful for the scientific community. It is also well structured and the methodology is consistent with the objectives of the study. I recommend it for publication following suggested revisions as described below.

A number of published studies have investigated the response of the climate system to changes in DMS flux, using modeling approaches with similar aims of understanding the effect of DMS on the global system. Therefore, the manuscript will be greatly improved by clearly stating specifically what the study contributes in addition what is already found in the literature.

In accordance to above, the Introduction and Discussion should provide a balanced and useful discussion of the results in the context of previously published work. In its present form the manuscript fails to cite a number of relevant papers which are noted below in the point-by-point comments.

Also, the problem statement is not well defined and should be improved by answering what this study makes it novel from previous studies. Only using a different GCM model (i.e. here ACCESS UKCA) does not necessarily bring originality to the study. So there should be more mentioned about what advantages the considered model bring compared to other models in terms of physics and chemistry schemes. In sensitivity tests only two extreme cases are considered (i.e., zero and zonal maximum). As already mentioned, the response of the climate to DMS is highly non-linear, such that it would be reasonable to have a better understanding of how climate responds to smaller change in DMS.

Point by point comments on the manuscript follow:

Introduction: The introduction provides relevant background regarding the role of

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aerosols in the global radiation budget. It would benefit from more background information regarding the uncertainty in DMS concentrations in the ocean. See for example: Belviso et al. (2004), Tesdal et al. (2016a).

(page 2 line 9): Additional support for the use of DMS fields in climate model are given in Belviso et al. (2004) and Tesdal et al. (2016a), and it is recommended to include these references. Hopkins et al. (2016) is not an appropriate reference for the uncertainty around observed DMS concentrations. Royer et al. (2015) is suggested.

(page 2 line 10) Charlson et al (1987) is not an appropriate reference for the role of DMS in climate systems being subject to debate, as this is the paper that introduced the hypothesis. The debate came later. A more appropriate article that also serves as a review of the CLAW hypothesis is Ayers and Cainey (2007).

(page 2 line 16) Add “s” to “contribute”

(page 2 line 23) Add “in certain regions” following “...local DMS concentrations”

(page 2 line 29) Add “in order” between “... a one year simulation” and “to quantify its importance. . .”

(page 2 line 32) Replace “for example” with “e.g.”

(page 2 line 34) Is ocean acidification meant to be an example of “anthropogenic climate change”? Please clarify.

(page 3 line 3 and throughout manuscript) Both Celsius and Kelvin temperature units are used throughout. Please use one or the other (preferably Celsius) for consistency.

(page 3 line 10) Replace “low-mid level” with “low- and mid-level”

(page 3 line 26) Add “analyzes” after “Section 4”

(page 4 line 23) Replace “of” with “detailed in”

(page 4 line 28) “ A full description of the scheme can be found in Mann et al. . .” Here

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it would be appropriate to mention the study by Bellouin et al. (2013), who compared GLOMAP-mode and CLASSIC and determine that GLOMAP-mode is more sophisticated and accurate.

(page 5 line 1) “Significant sampling biases...Northern Hemisphere (Lana et al 2011)” This sentence is not entirely clear. Is the point that the data is biased towards spring-summer and towards Northern Hemisphere?

(page 5 line 2) Replace “spring-summer” with “spring through summer”

(page 5 line 5) “The Liss and Merlivat (1986) parameterization. . .” There should be justification for why this parameterization is used. Several different parameterizations of the piston velocity in terms of wind speed have been used in modelling studies (e.g., Liss and Merlivat, 1986; Wanninkhof, 1992; Nightingale et al., 2000), leading to substantially different flux fields for a given concentration field (Tesdal et al., 2016a).

(page 5 line 16-17) Following Eq. 4, Replace “Where” with “Here,” . Insert “is” before “determined following the method of Saltzman..”

(page 5 line 20) “seawater” should not be hyphenated (Section 2.2 Model Evaluation) The evaluation should include comparison to observation of atmospheric concentration of DMS and other sulfur species, for example as described in Tesdal et al. (2016b).

(page 6 line 1) add “between” between “medium” and “440-680 hPa” and between “low” and “680-1000 hPa”

(page 6 line 17) Add period at end of sentence that begins “The Australian region....”

(page 6 line 24) Replace “that” with “the one”

(page 6 line 30) “By providing this radiative effect. . .” The text appears to imply that FAIR is a tool that provides estimates of climate response, given a simple value of radiative effect. Thus, by feeding estimates of radiative effects to FAIR one can analyze the effect on temperature and other climate variables. The text would benefit from more

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elaboration regarding the relationship between the radiative effect and the FAIR climate component.

(page 7 line 12) Add comma after “e.g.”

(page 8 line 12) “...instead reflecting more sunlight thus enhancing the albedo...” This clause is confusing. What is it that is reflecting more sunlight?

(page 8 line 20) Replace “...low clouds allowing..” with “...low clouds, which allows..”

(page 8 line 24) “This estimation is slightly greater. . .” Greater than what?

(page 9 line 20) Replace “representing” with “which is due to” or “which represents” to avoid awkward verb-gerund construction (“...representing lofting...”).

(page 9 line 23) Use appropriate subscript formatting for H₂SO₄.

(page 9 line 25) Replace “...in new particle formation, forming secondary sulfate aerosol. . .” with “...in formation of secondary sulfate aerosols,...”

(page 9 line 26) Correct formatting of H₂SO₄.

(page 10 line 5 and throughout manuscript) Replace “Whildest” with “While”

(page 10 line 26) Replace “cloud condensation nuclei” with “CCN”

(page 10 line 26-33) “Fig. 8d-e show the number. . .” The paragraph does not clearly describe the figures; sentence structure is awkward. Consider revision as follows: Fig. 8d-e show the number concentration of CCN with dry diameters greater than 70 nm (CCN₇₀) for the Ctl and the differences resulting from Exp.1. The largest absolute differences are in the tropics, which, similarly to the N3, have the highest concentration. Relatively, there is a global decrease of 5%, whilst decreases of 7% were found over the Australian region, decreases of 8% over the SO and decreases of 20% over the SEP. Differences in cloud droplet number (CDN) are shown in Fig. 8g-h. The relative differences in CDN (Exp.1-Ctl) show a similar spatial pattern to that of the CCN. Global

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mean CDN decreases by 5%. A decrease of 5% is also found for the Australian region, whereas the SO shows an 8% decrease, and the SEP shows an 18% decrease. In both the CCN₇₀ and CDN, the marine Southern Hemisphere mid-latitudes have the largest decreases of 14% (averaged between 5-35°S) despite the SO having some of the larger decreases in SO₂ and H₂SO₄.

(page 10 line 30) “Exp 1- Ctl” Is this explaining the ratio for relative difference? It is not given elsewhere when talking about relative difference.

(page 11 line 1) Replace “tropics mid-latitudes” with “mid-latitude tropics”.

(page 11 line 13) “Similar CCN sensitivities are reported in the Woodhouse et al. (2010) study.” State actual values reported in the reference.

(page 11 line 24) “...radiation scheme via aerosols and some (see Section 2.1.1).” Missing word/phrase following “some”.

(page 11 line 28) “...slightly removed from the coastline.” Not clear. From the Southern Hemisphere’s coastline? Recommend revising the whole first sentence, ending with a period after “(Fig. 9a)” and then beginning a new sentence. This would help to clarify what difference is seen in the SH generally and would parallel the structure used for the rest of the paragraph.

(page 11 line 32) “...see Section 3 in comparison to other areas. . .” Confusing. The author is comparing all of Section 3 to the areas of low cloud formation?

(page 11 line 35) “...biases exacerbate this. . .” Clarify what “this” refers to.

(page 12 line 4) Complete parentheses for “shown in Fig. 10a-b”

(page 12 line 8) Capitalize “Southern Hemisphere”

(page 12 line 13) Add “the” before “Ctl”

(page 12 line 25) Delete the comma after “magnitude”

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(page 12 line 28) Revise text to "...the SEP: increases of 42%, 172%, and 89% respectively."

(page 12 line 29) Insert "occurs" after "...a decrease of 37%"

(page 12 line 33) Insert "respectively" after "...increases by 6%, 4% and 5%"

(page 12 line 34) Insert "the" before "...SEP of 14%"

(page 13 line 2) Replace "showing" with "which show"

(page 13 line 2) Suggest "Incoming surface SW radiation" rather than "Surface incoming SW radiation. . ."

(page 13 line 6) Replace "analyzed under" with "which analyzed"

(page 13 line 8) Replace "south east" with "southeast"; Replace "these results presented" with "the results presented here"

(page 13 line 10) Insert "however" between "...the surface," and "the precipitation. . ."

(page 13 line 18) Delete "Although"; insert "and" between "...warming" and "we. . ."

(page 13 line 21) Delete comma after "...study"

(page 13 line 26) Replace "on" with "in"

(page 13 line 30) Delete duplicate "the"; insert "that" between "...this study is" and "the model. . ."; replace "underestimation of" with "underestimates"

(page 14 line 1) Replace "rather a multitude of theories" with "multiple theories have been proposed"

(page 14 line 7) "representation" should be plural

(page 14 line 13) Change "Figure 1" to "Fig. 1" for consistency with rest of manuscript

(page 14 line 14) Delete comma after SO₂

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(page 14 line 32) Break run-on sentence: Period after "importance". Next sentence: "Instead, the studies highlighted SO (Thomas et al., 2010; Mahajan et al., 2015)." Highlighted the SO in terms of what parameter(s)?

(page 14 line 35) Revise sentence as: "...slightly lower than the estimation of 2.03 Wm⁻² by Thomas. . ."

(page 15 line 1) Replace "are" with "were"

(page 15 line 5) Revise reference format: (Albrecht, 1989)

(page 15 line 16) Revise placement of subordinate clause in the sentence beginning "The cause of the discrepancy. . ." as: "Without further information, it is difficult to speculate on the cause of the discrepancy. . ."

(page 15 line 18) "Suggest" should be plural; delete comma after constraints

(page 15 line 22) Replace "Whilst" with "Though"

(page 15 line 23) Replace the colon after "For example" with a comma; replace "an as of yet" with currently; replace "for" with "as a"

(page 15 line 31) Replace the semicolon after "Six et al (2013) with "and"

(page 16 line 3) "coral-reef-derived" (2 hyphens), or "DMS derived from coral reefs"

(page 16 line 5) Replace semicolon after "Hopkins et al. (2011)" with a comma

(page 16 line 8) Insert "those" between "than" and "found"

(page 16 line 12) Make example given in this sentence parenthetical: "...increases (e.g., via solar radiation management) may have a short term cooling effects, however, without. . ."

(page 16 line 13) Delete the "a" between "...may have" and "short term..."; insert comma after "...however"

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(page 16 line 14) Delete “on” between “...impact” and “marine life . . .”

References

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