Reply to Anonymous Referee #2

Thanks to the referee for their positive comments. Our response is below, in which the referee's comments are in red, our response is in black, and changes to the text are in blue.

Laura Revell (on behalf of all other co-authors), University of Canterbury, 4 November 2019.

This study examines model simulations of aerosol optical depth (AOD) and the relative contributions of the Aitken, accumulation, and coarse aerosol size modes to AOD throughout the seasonal cycle. Comparisons are made to MODIS and MISR satellite observations, which indicate that the model is overpredicting the amount of primary sea spray aerosol. The overprediction is attributed to the sea spray source function, and the sensitivity of the model to this source function is tested with a newly-developed empirical model derived from field observations (that is apparently explained in detail in a paper currently in preparation – Hartery et al.). Additional sensitivity simulations are performed to explore changes in the representation of gas- and aerosol-phase conversion of DMS to sulfate aerosol as described by Chen et al., 2018. Overall, the manuscript is well written, and the topic is relevant to ACP. I share the concerns of the other reviewer that the fundamental sea spray source function employed by this study is based on a paper that has not yet been even submitted, much less in a peer-reviewed form with only a cursory description (and no real validation) provided in this paper. Other than this issue, I recommend the paper for publication.

The paper describing the new sea spray source function that we test has now been submitted to the Journal of Geophysical Research: Atmospheres (Hartery *et al.,* 2019). In our response to Referee #1 we documented the types of measurements made by Hartery *et al.* (2019), how their analysis was conducted, and how they validated their function. We also included information regarding this in the methods section of the revised manuscript:

The Hartery *et al.* (2019) SSA source function is based on a series of *in situ* measurements of the total suspended sea spray concentration within the Southern Ocean boundary layer. The total concentration of sea spray was constrained from the number concentration size spectra measured with a PCASP-100X optical particle counter during a voyage from Wellington, New Zealand, to the Ross Sea in February-March 2018.

After the voyage, the Lagrangian particle trajectory model FLEXPART-WRF was used to develop source-receptor relations between the upwind environment and the *in situ* measurements. The source-receptor framework acted as a bridge through which several different formulas for the sea spray source function could be optimised. The newly optimised functions all found that the Gong (2003) parametrisation produced too much sea spray at high wind speeds, as described by Hartery *et al.* (2019) and previous studies including Madry *et al.* (2011), Jaeglé *et al.* (2011) and Spada *et al.* (2015).

One of the newly optimised parametrisations developed by Hartery *et al.* (2019) took a power-law form (i.e. Eq. 5), similar to the Gong (2003) parametrisation (Eq. 2). We selected this parametrisation to test as it was straightforward to implement in HadGEM3-GA7.1. Hartery *et al.* (2019) show that the two power-law parametrisations differ primarily at high wind speeds, which are commonly observed over the Southern Ocean. For example when u_{10} = 4 m s^{-1}, both parametrisations predict the same SSA flux. However when u_{10} = 11 m s^{-1}, the Hartery *et al.* (2019) SSA parametrisation predicts a SSA flux which is 40% smaller than that predicted by Gong (2003).

Hartery *et al.* (2019) validated their newly optimised parametrisations by comparing predicted SSA concentrations against airborne data collected on HIAPER (the NSF/NCAR High-performance Instrumented Airborne Platform for Environmental Research) as part of the SOCRATES (Southern Ocean Clouds, Radiation, Aerosol Transport Experimental Study) campaign. The goodness-of-fit between predictions and airborne measurements validated the use of the new parametrisations over the Southern Ocean.

References

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