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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A global process-based study of marine CCN trends and variability" *by* E. M. Dunne et al.

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We thank the referees for their helpful comments, and present the following response for their consideration.

Section 3.3: When addressing the influence of continental aerosols, I had three additional questions:

1) Is the marine CCN continental aerosol influence a linear spectrum or are marine areas either pristine or not pristine with some tipping point in between?

The influence of continental aerosol on marine CCN is a spectrum, and will depend on the length and course of transport routes, and on meteorology along the transport pathway. For the purposes of this paper, we use low mass concentration of black carbon aerosol as a metric of how pristine a region is. As such, we do not have an exact numeric value to separate pristine areas from areas with strong continental influence.

2) Does each region have a similar value of low carbonaceous aerosol concentrations when other aerosol components correlate with marine CCN?

It would be very challenging to come up with a threshold value of carbonaceous aerosol below which the other components correlate with CCN, because the local CCN concentration also depends on transport of natural CCN from other regions, as well as dry and wet deposition of particles. Furthermore, sulphate has both continental and marine sources, and therefore it is not possible to distinguish completely between continental and marine aerosol sources.

3) Is there a trend in the 1990-2004 dataset in which marine regions have become more or less pristine?

Because the emphasis in these simulations was to examine long-term trends in wind-driven, marine aerosol, the same continental emissions were used for each of the fifteen years in the simulations. Only trends in aerosol removal processes due to changes in meteorology will affect the simulated concentrations of continental aerosol in marine regions. We found that no marine region in the model became more or less pristine over the 15-year period, although the same may or may not be true in reality.

Figure 1: I think that a global map of the linear trend in CCN concentration should be added as a part (b) to give spatial context to the Figure 3 CCN plots.

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The figure is shown as Figure 1 of the supplement to this document; however, given that one of the main findings of the paper is that linear trends are insufficient to determine the response of the aerosol system to wind speed, it will not be included in the revised manuscript.

Figure 3: I would suggest combining the left and right columns into one plot with a primary and secondary y-axis to improve comparison of the trends.

The revised Figure 3 is Figure 2 in the supplement to this document.

Figure 5: Please describe how the accumulation-mode concentrations were normalised.

The concentrations were scaled to be between the minimum and maximum values of CCN, as described in Eqn. 1. "Scaled" is a better term than "normalised", and will be substituted in the paper. Essentially, the limits of the mass line is confined to the range of the CCN line, purely for ease of visual comparison.

$$m_{scale} = min(ccn) + [max(ccn) - min(ccn)] * \frac{max(mass) - m)}{max(mass) - min(mass)} \quad (1)$$

An error in the plotting subroutine meant that the lines were mis-scaled in the original draft. The new versions, which are properly scaled, have been included as Figure 3 of the supplement of this document.

Figure 6-8: Please put the accumulation mode mass units in concentrations (eg. g m^{-3} or ng m^{-3}) more typical of other models and observations.

The units have been adjusted and the figures re-plotted - they are included as

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Figures 4-6 of the supplement to this document.

Additional (supplemental?) figures: After reading about continental aerosol-influenced vs pristine environments, I think that there two additional figures would help inform the reader about the representativeness of the three regions:

1) A series of 4 global maps showing the Pearson coefficients between monthly mean CCN and monthly mean aerosol component mass for each grid cell;

2) I'm not sure of the metric, but I was wondering if it is possible to produce a global map showing the spatial extent of pristine regions predicted by the model?

The Pearson coefficient maps in Figure 7 of the supplement to this document show correlations at 915 hPa between concentrations of CCN and mass concentrations of each of the four aerosol components traced in the model. Where a particular component makes a strong contribution to CCN - sea spray in the Southern Ocean, for example - that component will show a strong correlation with CCN concentration. However, if CCN concentrations increase or decrease, mass concentrations of all aerosol components would also increase or decrease to a certain extent. As a result, there can be strong correlations between CCN concentrations and mass concentrations of multiple components, even when changes in a given component do not affect CCN concentrations. The maps therefore do not provide sufficient information to infer a causal link, and will be omitted from the revised manuscript.

Figure 8 of the supplement shows the concentration of black carbon in ng m^{-3} at 915 hPa. The concentration of BC is a good proxy for continental influence in these simulations, since marine carbonaceous aerosol is not included in these simulations. By comparing Fig. 8 with Fig. 7(d), we identify a region in the Southern Ocean (approximately 30-60S, 30-90E) where black carbon has a concentration of a few ng

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m^{-3} , and CCN concentrations correlate with marine aerosol - sea spray and sulphate - and does not correlate with carbonaceous aerosol. However, while this map provides a guideline as to which regions have stronger or weaker continental influence, it cannot definitively map out pristine marine regions. For this reason, we will also omit this map from the revised manuscript.

Figures are included in the attached supplement.

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