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Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the Relationship Between Cloud Water Composition and Cloud Droplet Number Concentration" *by* Alexander B. MacDonald et al.

Anonymous Referee #1

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In this very nice paper the authors attack constraints on aerosol-cloud interactions using aircraft data off the California coast over many years of campaigns. Many studies use satellite observations to do this and this study provides an important ground truth evaluation of this that is needed by the field and gives additional information (for instance turbulence) that is not available from space. This study shows the utility of sulfate in predicting variability in Nd, which agrees with other studies. The data set in the study allows the authors to drill down into looking at other species (sea salt, dust, organics) that have more elusive effects on Nd. My corrections are mostly technical in nature.

L53 Adjustments may also include enhanced entrainment at cloud top (Ackerman et al., 2004).

L56 This is still the case in more recent reviews (Bellouin et al., 2020).

L181 In McCoy et al. 2018 the SS and DU was restricted to the submicron size bins from MERRA2 and only hydrophilic BC/OC were used. All mass concentrations were taken at 910hPa. Not critical to your study, but good to keep in mind to comparing to the better resolved data from aircraft.

L351 While not essential to the analysis being performed here, one interesting possibility is for the authors to train on the NiCE or FASE campaign and test the regression on the other wildfire-affected campaign (reducing the risk of overfitting). One intriguing possibility is that not all fires produce similar aerosol in terms of CCN activitiy and influence on CCN. Were the fires during these campaigns in very different environments?

L431 The R2 should always increase with more predictors, but R2_adj won't necessarily?

L413 The authors might find it helpful to make a predictor correlation matrix figure for this section: https://seaborn.pydata.org/examples/many_pairwise_correlations.html

L472 See note above regarding use of submicron SS from MERRA2 in the McCoy 2017/18 studies. One potential reason for this discrepancy is that the SS in MERRA2 is partially indicative of dynamical mixing and turbulence, which the present study has information about. Is it possible that the analysis approach in this study has disentangled this? L501 notes the strong dependence of ocean-derived species on turbulence. Would it be possible to make a bivariate plot of Nd as a function of SS and turbulence? This is done in Fig. 5, but going beyond binning into high and low turbulence might be interesting to see.

Ackerman, A. S., Kirkpatrick, M. P., Stevens, D. E., and Toon, O. B.: The impact of humidity above stratiform clouds on indirect aerosol climate forcing, Nature, 432, 1014-

1017, 10.1038/nature03174, 2004. Bellouin, N., Quaas, J., Gryspeerdt, E., Kinne, S., Stier, P., WatsonâĂŘParris, D., Boucher, O., Carslaw, K. S., Christensen, M., Daniau, A. L., Dufresne, J. L., Feingold, G., Fiedler, S., Forster, P., Gettelman, A., Haywood, J. M., Lohmann, U., Malavelle, F., Mauritsen, T., McCoy, D. T., Myhre, G., Mülmenstädt, J., Neubauer, D., Possner, A., Rugenstein, M., Sato, Y., Schulz, M., Schwartz, S. E., Sourdeval, O., Storelvmo, T., Toll, V., Winker, D., and Stevens, B.: Bounding Global Aerosol Radiative Forcing of Climate Change, Rev Geophys, 58, 10.1029/2019rg000660, 2020.

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