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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Time-dependent entrainment of smoke presents an observational challenge for assessing aerosol–cloud interactions over the southeast Atlantic Ocean" *by* Michael S. Diamond et al.

Anonymous Referee #3

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General comments: This manuscript examines the relationship between cloud droplet number concentration and smoke below and above the cloud layer, using data from the September 2016 deployment of the ORACLES campaign over the southeast Atlantic Ocean. The results show that the smoke from biomass burning in the boundary layer is more strongly associated with cloud microphysical changes than that near cloud top. Using theoretical boundary layer aerosol budget equations, the authors show that the timescale for CCN in the boundary layer to equilibrate with CCN in the free troposphere is on the order of days, and the strength of the aerosol-cloud interactions

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depends heavily on the time of observation, regardless of the drizzle rate. Together with back trajectory analysis from WRF-AAM and observation of marine boundary layer carbon monoxide concentrations, the authors conclude that smoke entrainment history is the key driver to the observed differences in cloud properties. The results are well presented and structured. The study is valuable for encouraging continued thought and discussion on accessing aerosol-cloud interactions over the southeast Atlantic Ocean. Recommendation: Acceptance with minor revisions

Main comment: The authors show a significant contrast between Nd vs. BC CCN and Nd vs. AC CCN relationships in Figs. 1 and 2. I am a little concerned if the better correlation between Nd and BC CCN is partly due to the different definitions of AC and BC properties. It is defined in the text(Page 4) that AC properties are 100 m averages while the BC properties are 500 m averages. I think it is worth mentioning when presenting results that the amount of data for averaging is different for BC and AC properties. Have the authors tried comparing 100 m averages for both AC and BC properties? How much difference is it in terms of R2? (The results probably would not be qualitatively different given well-mixed condition in the boundary layer.)

Specific comments: Page 2, Line 8-10: Potential edits: ....reduce cloud fraction (Hansen et al., 1997; Ackerman...) by reducing stability and relative humidity of the PBL, whereas ... (Johnson et al., 2004; Sakaeda ...)

Page 2, Line 22: add “for clouds with little precipitation” after cloud

Page 7, Line 5-12: Some of the conclusions seem to be drawn from Table 1. Add citation somewhere in this paragraph, or simply add the values of R2 to Figure 2.

Page 8, Line 1: add “(Fig. 2b)” after August

Page 8, Line 11-12: I am not sure I understand why the sequence of flight maneuvers suggests direct instantaneous smoke cloud contact

Page 12, Line 18: Zhao et al., 2017 is not in the reference.

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