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Atmospheric Chemistry and Physics Discussions

Interactive comment on "In-situ constraints on the vertical distribution of global aerosol" *by* Duncan Watson-Parris et al.

Anonymous Referee #1

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The vertical distribution of aerosol is a critical feature to know for enhancing our understanding of aerosol life cycle, estimating climate forcing of aerosols with confidence, and constraining numerical models to better reproduce past and project future climate. Nevertheless, it is still poorly known primarily due to the lack of observations. The authors have compiled a database, the Global Aerosol Synthesis and Science Project (GASSP) from past airborne observations. They have also overcome certain statistical issues in making the data useful for constraining models in an adequate procedure. This paper presents a case of applying GASSP to evaluate the performance of the global climate model ECHAM-HAM that includes a modal aerosol model (M7) as well as a sectional aerosol model (SALSA).

The model simulations were designed straightforwardly, including a set of single-

parameter-perturbation simulations in addition to a standard case run for exploring the sensitivity of the modeled results to certain physical or chemical parameters in a rather simplistic way. The comparison between modeled and observed data covers vertical profiles of aerosol and CCN size distributions over several selected regions, serving a good purpose for identifying the model biases while as a demonstration of using GASSP to constrain models. The paper is well organized, and the result is largely presented clearly. The content of the paper is definitely suitable for the readers of ACP. The work is also informative to the similar efforts in near future. Nevertheless, there still are some issues need to be adequately addressed before the acceptance of the paper for publication.

The authors analyzed certain reasons that could cause the biases of the model, including wet removal of aerosols by precipitating particles and removal through nucleation scavenging. Since the comparison is against observations, this discussion hence should not just be limited to the processes included in the model, but also potentially important ones presently excluded in the model. Regarding the model bias in underestimating free tropospheric aerosol number concentration, there is another factor, i.e., resuspension of aerosols resulting from evaporation of cloud drops. This could be, as indicated by previous works (e.g., Hoppel et.al, 1994 JGR, D7 14443 and beyond for measurement; Grandey et al., 2018, ACP, 15783 and Kim et al., 2008, JGR D16309 for global modeling), an important source for accumulation mode aerosols in the free troposphere. Therefore, such an effect should be discussed. If this process is not included in ECHAM-HAM (perhaps the majority of global models do not include it anyway), the authors need at least mentioning the limitation of their analyses due to this reason.

The statement in Page 8 line 12 that "the inter-annual variability in aerosol burden ,... is small" appears to be made without considering the common feature of inter-annual variation of precipitation.

In comparing modeled with observational data, the authors need to provide several

additional details: (a) the number of observational samples for each of the selected regions (e.g., Fig. 3); (b) objective scores of fractional bias, e.g., vertically accumulated absolute bias in order to make a better judgement on the overall model performance in comparison with other cases.

A few specific comments.

In page 14, line 9, “20nm” should be “10 nm”?

In page 17, line 12-13, the sentence of “but by requiring . . . ageing profiles” is difficult to understand.

In page 19, line 8-9, “reducing the wet-deposition . . .”, could the authors provide an estimate of a corresponding change in aerosol lifetime?

In page 28, line 4-7, while the authors suggest that “ECHAM-HAM does not show . . . convective entrainment or dry deposition. . .”, the following sentence only provides a discussion related to dry deposition.

Figure quality: in many figures, the legend often overlaps with plotting area with data.

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