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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Optical particle counter measurement of marine aerosol hygroscopic growth" *by* J. R. Snider and M. D. Petters

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Editor's Question 1a)

The humidity-dependence of Fitzgerald's β (the Editor's γ) is shown in Figure 3 of Fitzgerald (1975). For a range of below-cloud RH values encompassing nearly all of our data points (80%$\leq$RH$\leq$96%, see right panel of our Figure 3) Fitzgerald's β varies from 1.00 to about 1.02. This variation is not negligible, but given the magnitude of the error we discuss in our submission, the effect of this variation on our analysis is not expected to be leading order.

The RH-dependence underscored by the editor can be seen when making the mathematical substitution he proposes. We will not go into that here, but we point out that RH enters into the exponential slope of the fitted size distribution, as the product of

Fitzgerald's β (the Editor's γ, RH dependent) multiplied by our β (we assumed this was a constant). We also see RH entering into the term involving the editor's "a" (Fitzgerald's α). Sticking with the editor's and our notation, here is our F300 fitting function (i.e., our Equation 6, corrected as discussed below) showing the explicit RH-dependence.

$$\left(\frac{dN}{d\log_{10} D_w}\right)_F = \alpha_F \cdot a(RH)^{-\beta} \cdot D_d^{-\gamma(RH)\cdot\beta} \quad (1)$$

This demonstrates that our Equation 5 (corrected as discussed below) can be obtained from the above Equation 1 provided $a(RH)$ is only weakly sensitive to RH (see Fitzgerald's Figure 4), that $\gamma(RH)$ is close to unity (see Fitzgerald's Figure 3), and $N(D_d) = N(D_w)$ (see Fitzgerald (1975) page 1048). With these assumptions it follows that our Equation 5 (corrected as discussed below) can be obtained from our Equation 6 (corrected as discussed below).

One strategy that could exploit the RH dependence (Equation 1, above) would be to sample portions of a flight segment having distinctly different ambient RHs, but the same dry aerosol distribution. Other types of RH and aerosol "bining" can also be envisioned. A disadvantage of this approach is that the sampling time is decreased so the number of aerosol particles sampled is decreased. This results in greater uncertainty coming from the statistics of the aerosol sampling.

In summary, we see merit in the editor's suggestion, but feel it is beyond the scope of this submission. Put another way, we anticipate that the RH dependence of the fit coefficients is a second order effect. Our basis for this assertion is three-fold: 1) Fitzgerald's β varies by only two parts in one hundred over a RH range that extends from 80 to 96% (see his Figure 3), 2) Fitzgerald's α is similarly a weak function of RH (provided RH is less than 96%, see his Figure 4), and 3) the variability associated with our below-cloud RH averages is not large. Typical RH standard deviations are 1 to 2% for the flight segments we analyzed (see the right panel of our Figure 3).

We have not yet considered the above-cloud flight segments. For these the ambient

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RH variability is larger (see left panel of our Figure 3), but for our above-cloud measurements (RH<36%) Fitzgerald's β is expected to be less sensitive to RH, or invariant with RH (e.g. if the particles are effloresced), and Fitzgerald's α is also expected to be insensitive to RH (see his Figure 4).

Editor's Question 1b)

Thank you for finding this error in our equations.

The equations should be corrected as follows (equation numbering refers to our submission dated 19 December 2007):

Equation 5: $\left(\frac{dN}{d\log_{10} D_d}\right)_P = \alpha_P \cdot D_d^{\beta}$ changed to: $\left(\frac{dN}{d\log_{10} D_d}\right)_P = \alpha_P \cdot D_d^{-\beta}$

Equation 6: $\left(\frac{dN}{d\log_{10} D_w}\right)_F = \alpha_F \cdot D_w^{\beta}$ changed to: $\left(\frac{dN}{d\log_{10} D_w}\right)_F = \alpha_F \cdot D_w^{-\beta}$

Equation 7: $\alpha_P \cdot D_d^{\beta} = \alpha_F \cdot D_w^{\beta}$ changed to: $\alpha_P \cdot D_d^{-\beta} = \alpha_F \cdot D_w^{-\beta}$

These corrections are needed to make our submission consistent with our calculations.

Editor's Question 2)

Ambient RH did vary somewhat during the below-cloud flight segments, as we discuss above and show in our Figure 3 (right panel), and it may have varied rapidly enough to violate the equilibrium assumption, e.g. in updrafts or in downdrafts sampled along the constant altitude C-130 flight segments.

Relevant to this issue is our conditional sampling of the below-cloud PCASP and F300 measurements (Section 2.2 of our submission). Our criterion is that the current datum, and the seconds both preceding and following the current datum, is associated with drizzle concentrations less than 1 per liter. In addition to minimizing potential aerosol sampling bias due to the shattering of drizzle on the inlets of the PCASP and F300, this condition also minimizes influence from time intervals associated with evaporative downdrafts or with ambient RH values within a few percent of 100%.

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Interactive Comment

The Feingold and Morley (2003) calculation does present reason to question the equilibrium assumption (see their Figure 10), yet, their result also shows the effect to be insignificant at altitudes less than 50 m below the thermodynamic cloud base. Our basis for this assertion is the convergence of updraft and downdraft backscatter profiles at an altitude of 50 m below the thermodynamic cloud base. This convergence is apparent in Figure 10 of Feingold and Morley. With the exception of a few tens of seconds of data from RF08, all of our measurements were made at a lower altitude relative to cloud base. This result can be seen in the attached plots. These figures show the time series of "Distance to Cloud Base" and ambient RH for all 24 below-cloud constant-altitude flight segments.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 12381, 2007.

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