

Reply to Reviewer 2

Dear Reviewer,

We greatly appreciate your thoughtful comments that helped improve the manuscript. We trust that all of your comments have been addressed accordingly in a revised manuscript. Thank you very much for your effort.

In the following, we give a point-by-point reply to your comments:

Based on the type of sensor, I think these observations pertain principally to rather small particles – on the order of 0.02-0.05 micrometer dia. I think the size relevance should be made clearly in the abstract and the body of the paper. Don't just give us the sensor specs – give some interpretation.

We fully agree that our number flux measurements are dominated by sub-50 nm particles. Our condensation particle counter detects particles in a nominal range from 11 nm to about 3 μm . However, taking into account typical particle size distributions measured during ASCOS onboard the ice-breaker, and earlier observations of a distinct Aitken mode as a general feature of aerosol size distributions in the central Arctic Ocean (Covert et al., 1996; Leck and Bigg, 2005a), we expect the number concentration (and thus the number fluxes) to be dominated by sub-50 nm particles for most of the time. This has been implicitly stated in the original manuscript on p. 24969, 1.4. We have now added this piece of information in the abstract and also in section 2 when describing the CPC.

The presentation of the relationship between covariance flux vs source and deposition is confusing. I suggest a brief section starting with the basic conservation equation and then simplifying the cases. The net flux is $F = \langle w'n' \rangle - Vg \langle n \rangle = S_n z - Vt \langle n \rangle$ Where $S_n z$ is the effective surface source strength realized at measurement height z . The turbulent flux is the net flux when Vg is negligible. Steady state implies F is constant with height whilst equilibrium implies $F=0$. The mixed layer equation [line 8, P24976] comes from integrating the conservation equation. In steady state and when there is no surface source and the particles are very small, then $\langle w'n' \rangle = -Vt \langle n \rangle$.

We modified the section introducing the covariance flux and the transfer velocity to clarify the presentation as suggested by the reviewer. For aerosol fluxes dominated by sub-50 nm particles we consider it a valid assumption to neglect the gravitational settling velocity.

Very small particles behave a lot like more conventional scalars (temperature, . . .) and the equilibrium case rarely occurs. Perhaps refer to paper Xia and Taylor, BLM 105, 471-482, 2007.

Xiao and Taylor (2007) discuss the equilibrium between vertical turbulent diffusion and gravitational settling of particles. Because we neglect gravitational settling, we think it would be confusing for the reader to introduce and discuss this concept just to make the point that the equilibrium case does probably not apply to our conditions dominated by sub-50 nm particles.

The discussion of different formulae for deposition velocity is about the right mix of references and equations. Personally, I think the paper would benefit from a few lines describing how they are related (i.e., turbulent, gravitational, vs inertial terms).

We added brief descriptions of the individual terms (diffusion, impaction, interception) of the presented equations in the revised manuscript.

I found the discussions associated with figs. 5-7 rather hard to follow.

We slightly modified the discussions of Figs. 5 and 6. We now give a better explanation of the mixing height associated with the thought experiment presented in Fig. 7. We also revised Fig. 7 to include scenarios corresponding with the best estimates of the effective mixing height in both examples for better comparability.

P24966, L26. Not sure what 'theory' you are referring to. Do you mean the empirical result that σ_w/u^ is on the order of 1.25 under neutral conditions in the surface layer?*

Indeed, Thomas and Foken (2002) did not give a theory, but a parameterization. We changed the text accordingly.

P24967. You have neglected stability in Eq 1. Usually a decent approximation with an instrument at 2 m height. Did you check?

We evaluated stability using z/L and found that z/L is within ± 0.1 in more than 90 % of the cases. Therefore, we think it is justified to neglect stability in Eq. 1. For clarification, we added the statement that the stability parameter z/L is close to zero in most cases to the discussion of Fig. 5.

P24967. Eq5 doesn't look quite right to me. Is this an approximation?

We have modified this passage. Because we neglect gravitational settling, we removed v_g from Eq. 5.

P24967. Eq6 appears to have a sign error in the first nu exponent.

We corrected Equation (6), adding a negative sign to the exponent of ν . Thank you!

P24972, first paragraph. Perhaps worth noting that $\langle w'n' \rangle = 0$ is not the dividing point between surface production and deposition. It is ambiguous without knowing the other terms of the budget.

We followed the reviewer's suggestion and added a brief note in the revised manuscript.

P24976. I am not sure about the statement "It should be noted that the net particle flux will be zero as soon as a uniform distribution with height is reached."

In order to clarify our statement, we modified this sentence to read: "It should be noted that a uniform particle distribution with height implies lack of a particle gradient, and thus, no net turbulent particle flux would occur."

P24976. The use of mixed layer heights comparable to the measurement height would violate the conventional assumption $z \ll h$ that is invoked to claim the flux measurement represents the surface flux. I am not sure this section gains a lot by considering mixed layer heights much lower than observed. Nothing wrong with just saying the mixed layer height was 25 m and the flux accounts for 10% of the observed concentration change.

We agree that measurement heights comparable to the mixing layer heights are not applicable to surface flux measurements. However, we do not actually measure fluxes at heights comparable to the mixing layer height. We use fluxes measured close to the surface to derive concentration changes that would occur under variable conditions (including variable mixing layer heights) in a thought experiment. In this thought experiment, the measured aerosol flux can be considered a given true surface flux. The actual measurement height is not important. Then, we evaluate the particle number concentration changes for various mixing layer heights which correspond to the given particle number flux, and compare them with the observed particle number change. This does not invalidate the original flux measurement. We think information about the mixing heights that would be required to explain the observed concentration change are valuable for the reader. We therefore suggest keeping the original presentation of the thought experiment. Note, however, that we clarified the term "mixing layer height" in the revised manuscript.

Fig. 1 The ogive is presented in conventional form with the integral of the cospectrum initialized as 0 at high frequency and integrated to low frequency. However, in the case of significant loss of high frequency signal from various lowpass filter effects, it is better to start at low frequency and integrate to high frequency. You can also play around with the normalization to clearly show the lowpass effects.

We would like to point out that the direction of integration does not change the generic shape of the ogives. The ogives should flatten out both at high and low frequencies, converging towards zero and one. Nevertheless, we acknowledge that certain features may be better visualized if the direction of integration is reversed. However, we modified the presented median ogives in the revised manuscript and not only discuss high frequency losses, but also low frequency contributions and variability in all frequencies following a comment by reviewer 1. Therefore, we kept the conventional direction of integration, but we clearly point out in the revised discussion of Fig. 1 that high frequency losses are visible in the presented ogives.

Additional references:

Covert, D.S., Wiedensohler, A., Aalto, P., Heintzenberg, J., McMurry, P.H., and Leck, C.: Aerosol number size distributions from 3 to 500 nm diameter in the arctic marine boundary layer during summer and autumn, *Tellus B* 48, 197-212, 1996.