Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., author comment AC2
https://doi.org/10.5194/acp-2021-594-AC2, 2021

Reply on RC2

Peter A. Taylor

Author comment on "Constant flux layers with gravitational settling: links to aerosols, fog and deposition velocities" by Peter A. Taylor, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-594-AC2, 2021

I appreciate Referee#2's comments. The main concern (re line 148) relates to the discussion of surface resistance, R_s, and deposition velocity, V_{dep}, and the comparisons with Zhang et al (2001).
Digging deeper into the deposition velocity literature I find that, for me, a very satisfactory treatment is provided by Seinfeld and Pandis (1998, Chapter 19, on Dry Deposition), hereafter S&P. The 1998 version is the 2nd edition and unfortunately I do not yet have access to a copy of the 2016, 3rd edition, but Chapter 19 contents appear to be similar. Seinfeld and Pandis split the Slinn (1982)/Zhang et al (2001) surface resistance, R_s, into two parts. These are a "Quasi-laminar layer resistance", r_b in S&Ps notation, and a "canopy resistance", r_c. For aerosol particles, as against gases, S&P, argue that r_c can be zero. In my approach, S&P's r_b could be represented by ln $(z_{om}/z_{0c})/(ku□)$ where z_{om} and z_{0c} are roughness lengths for momentum and aerosol. I had failed to appreciate that in the Slinn/Zhang approach, the "aerodynamic resistance", R_a was based on z_{0m}, while mine used z_{0c}, and that R_s should include the S&P r_b term and would not be zero, unless z_{om} = z_{0c}.
In view of this I will limit the discussion of deposition velocity, V_{dep}, in the revised version of the present paper to pointing out the dependence of V_{dep} on the reference height, z_{ref}, and the friction velocity, $u□$, which often seems to be overlooked. The constant flux layer Qc profiles in Figures 1 and 4 can be simply inverted to show $V_{dep}(z)/V_{dep}(50) = 1/[Q_c/Q_c(50)]$ to illustrate this point, and can be discussed in sections 2 and 4 (Some Profiles). Section 3 (Dry Deposition Velocities) and Figure 3 will be removed. Note that the original version had a section numbering error (two sections 4), which will be corrected.

I would agree that a revised version of the present paper could be considered as a "Short communication? Deposition velocity is however a topic of wide interest and I will continue to work on that aspect in a broader context, perhaps for a future paper.

Concerning other comments, I will expand the abstract and reorganise the final paragraph of the introduction. I can also make the suggested changes to lines 125 and 130.

The suggested extension to cover all stratifications could be done via numerical solution of the equation on line 249 but, in unstable stratification (L < 0), it is not clear what an appropriate stability function, $\Phi_{Qc}(z/L)$ should be. For stable stratification it is generally accepted that $\Phi_H = \Phi_M$ and an extension to use the same equation for Φ_{Qc} seems reasonable. For unstable stratification $\Phi_H \neq \Phi_M$ and it is not clear what should be used for Φ_{Qc}. In addition, it should be noted that in the stable case I could find an analytic solution, but that would be more difficult with the unstable case. In the advective marine fog situations which initiated this work we were only concerned with warm air over cold water and so focussed on stable stratification.

References
Seinfeld, J.H., and Pandis, S.N., Atmospheric Chemistry and Physics, 2nd Edition, Wiley New York, 1998
Slinn, W.G.N., Predictions for particle deposition to vegetative surfaces. Atmospheric Environment, 16, 1785-1794. 1982.
Zhang,.L, Gong, S., Padro, J., Barrie, L.: A size-segregated particle dry deposition scheme for an atmospheric aerosol module, .Atmos. Environ. 35:549–560, 2001