Review of "Dynamical regimes of CCN activation in adiabatic air parcels" by Gutierrez et al.

Overview

This paper explores the activation of an ensemble of monodisperse CCN in an ascending cloud parcel. The consideration is based on the solution of a system of Squires and droplet growth equations, written in the following form:

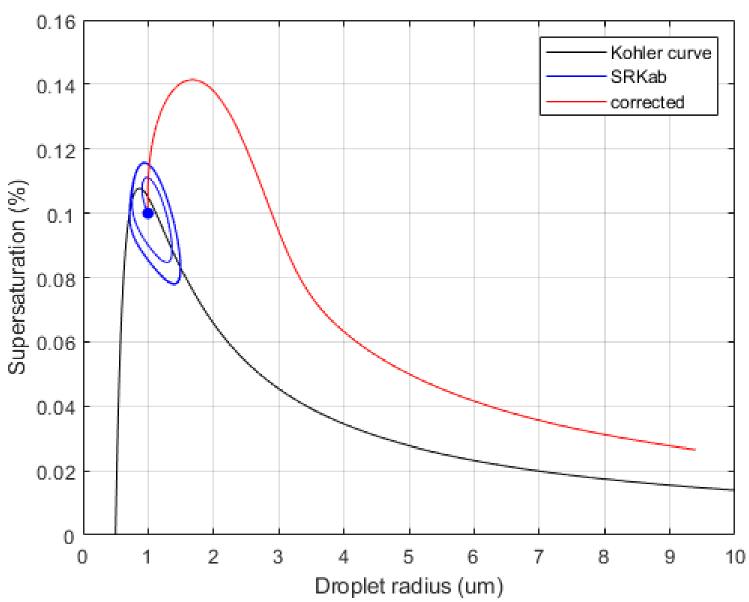
$$\frac{dS}{dt} = \tau^{-1} - \alpha(N)rS \qquad (1)$$

$$\frac{dr}{dt} = \frac{D}{r}(S - f(r)) \qquad (2)$$

The notation of variables is the same as in the manuscript.

The authors concluded that a retrograde growth rate of droplets in ascending parcels may result in droplet size fluctuations within a certain range of vertical velocities. Unfortunately, this is a fundamentally wrong conclusion, and it results from negating Kelvin's and Raoult's corrections on supersaturation in the second term in Eq.1. This term describes the growth rate of droplets mass $\frac{dq}{dt} \propto r^2 \frac{dr}{dt}$, and therefore, should be consistent with Eq.2. The supersaturation equation in form Eq.1 works well for large droplets when $S >> f(r)$. However, for the case of small droplets S becomes comparable with $f(r)$, and the neglect of this term may result in confusing solutions. Below is comparison of solutions of the original Eqs.1-2 and Eq.1 with corrected supersaturation, i.e. $\frac{dS}{dt} = \tau^{-1} - \alpha(N)r(S - f(r))$. The integration of Eqs.1-2 was performed for τ^{-1} =1.2x10^{-5} s^{-1} and N =50 cm^{-3}, and the values of the coefficients A, B, D, β were taken from Table 1.

As the figure below shows, the solution of Eqs.1-2 results in a limit cycle, which is consistent with the results described in the paper. However, the corrected equation results in continuous droplet growth.



It is also worth noting that the system of Eqs1-2 is non-adiabatic, and it does not account for changes of temperature (T), air pressure (P) and ambient humidity (E), which affect the coefficients A, B, D, α, β. The solution of a complete system of equations describing the activation and growth of a population of droplets in an adiabatic vertically ascending parcel (e.g. https://doi.org/10.1175/1520-0469(1995)052%3C3620:TIOSFO%3E2.0.CO;2) results in solutions similar to that shown by the red curve in the above figure, when A, B, D, α, β were assumed constant and their dependence on T, P, and E were neglected.

Recommendation: The paper presents an elegant mathematical consideration that results in the paradoxical behavior of an ensemble of monodisperse droplets in an ascending parcel. This is the central point of this paper. However, the corrected equation terminates this contradiction. Unfortunately, I do not see how this paper can be improved and regretfully recommend rejection.

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