Comments on “Theoretical Framework for Measuring Cloud Effective Supersaturation Fluctuations with an Advanced Optical System”

The authors proposed a theoretical framework to estimate effective supersaturation by measuring the scattering properties of interstitial and activated aerosols. Critical activation diameter (Dd) can be obtained from the measurement/knowledge of scattering coefficient of interstitial aerosols and activated aerosols at three wavelengths, with the knowledge/assumption of aerosol size distribution, size-resolved activation ratio curves, and aerosol composition. The hygroscopicity parameter (κ) can be estimated from the light scattering enhancement factor of activated aerosols based on Kuang et al. (2017). Effective supersaturation can then be calculated from Dd and κ based on κ-Kohler theory. Although I am concerned about the accuracy of the s retrieval, I do think it might be useful to have an instrument to continuously measure the scattering properties of interstitial and activated aerosols and I encourage the authors to develop new instruments to estimate s. I list my major and minor comments below. Hope they are useful to improve the quality of the paper.

Majoy comments:

1. Section 2.1. I think the definition of effective supersaturation is not correct. Line 109~120: “Fluctuations in supersaturation mean that the effective supersaturation, which directly affects aerosol activation, differs from the mean supersaturation.” It seems that the authors define effective supersaturation as supersaturation fluctuation. My understanding is that the effective supersaturation mentioned in this study refers to the critical supersaturation corresponding to a certain Da, not supersaturation fluctuation (e.g., due to turbulence). Please clarify the definition of effective supersaturation.
2. Section 3.1 is not well written. For example, Line 177: “As a result, the scattering properties…”. Please describe how the scattering properties shown in Fig.1a are calculated. I figure out the answers by reading the caption of Fig.1, later paragraphs, and supplementary materials. Since ACP does not have a page limit, I would recommend the authors add them in the main text to make it easy to read.
3. The AR curve in Fig. 1a is for the average PNSD observed in the North China Plain from six campaigns. Can you measure AR curve at a high temporal resolution? Line 202~203. “For each aerosol size distribution…” What is the temporal resolution of the measured aerosol size distribution? 10 min? Is the temporal resolution of the estimated effective supersaturation limited by the temporal resolution of the measured aerosol size distribution?

Minor comments:

1. Line 86: “but do not provide precise direct supersaturation measurements.” As far as I know, to calculate s based on direct measurements of water vapor pressure and temperature (if possible) is the best way to obtain s. Maybe you want to say “… fluctuations, but they do not provide precise supersaturation measurements at a high liquid water content.”
2. Line 114: change to “S is the saturation ratio over an aqueous solution droplet with a diameter of D,… ~~D is the droplet diameter~~, …”
3. Line 83: change “e” to “water vapor pressure”