Response to comments on "A broad supersaturation scanning (BS2) approach for rapid measurement of aerosol particle hygroscopicity and cloud condensation nuclei activity"

General comments

The manuscript "A broad supersaturation scanning (BS2) approach for rapid measurement of aerosol particle hygroscopicity and cloud condensation nuclei activity" described a novel approach based on a CCN counter to rapidly measure the cloud condensation nucleation (CCN) activity. In this approach, the supersaturation setting(temperature) can be kept constant and the continuous SS profile in the activation unit was used. Therefore, it does not need scan over different SS, which can improve the time resolution and potentially enhance the measurement stability. The application of this approach was shown using a nano-CCN measurement. Such an approach could be applied the commonly used CCN counter and may be useful especially for CCN measurement requiring fast time resolution such as airborne measurement. Thismanuscript is well written and clear and the idea is novel and very interesting. I recommend it to be published on AMT after addressing some specific comments.

Response:

We thank Referee #2 for the positive evaluation and please find below our detailed responses.

Specific comments

1. Pg 9715, line 22, "BS2-CCNC may be built with simple modifications of existing DMTCCNC…",it would be useful if the authors can briefly elaborate what kind of modifications should be done in order to achieve the approach.

Response:

We need to modify the system so that it can be run at a higher aerosol-to-sheath flow ratio. For a high aerosol-to-sheath ratio, the most critical effects may be the generation of turbulence in the mixing of aerosol and sheath flows. Since the generation of supersaturation in a DMT-CCNC requires a laminar flow, it won't work under turbulent conditions. But according to our FLUENT calculations, the stable laminar flow can be achieved with some new designs of the flow system in the DMT-CCN instrument. We are also working on a manuscript describing the technical development of a prototype BS2-CCN instrument.

Comments:

2. Pg 9717, line 4, Eq. (1) , S_{tube} is a function of r. It is more informative to express in "$S_{tube}(r)$".

Response:

This is a good point. We have used S_{tube}(r) in the revised manuscript.

Comments:

3. Pg 9718, line 3, for "Application" section, a brief description of main details of the setup used in Sect. 3.3 is desirable.

Response:

Following the referee's suggestion, we have included the following description in the "Application" section:

"To demonstrate the concept of BS2 approach, a nano-CCN counter (Wang et al., 2015) was employed to perform size-resolved measurements of laboratory-generated aerosol particles. The nano-CCN counter was developed to measure aerosol activation activity at the size range of 2 to 10 nm. In this size range, aerosol particles are of high diffusivity and go beyond the initial flow constraint. Thus aerosol particles are widely distributed in the activation unit of a nano-CCNC and BS2 analysis can be directly applied without modification of the system. "

Comments:

4. Pg 9718, line 15, I suggest that the authors explicitly remind the reader that the results are from model results. Also here, *if I understand correctly, in order to derive kappa, the size resolved/selected measurement is needed. It would be helpful to mention this explicitly.*

Response:

We have revised the text by explicitly mentioning the modeling background.

" Figure 3 shows the modelled size-resolved F_{act}–κ relation for a $S_{\mathrm{tube}}(r)$ profile as given in Fig. 2b."

We have specified that the BS2 analysis relies on size-resolved measurements in the end of the introduction section:

" This study presents a new approach, termed broad supersaturation scanning (BS2) methods, which measures the activation of size-resolved CCN simultaneously over a continuous range of *S*."

Comments:

5. Pg 9719, line 26 (and Fig. 5a), specifying the exact probability density function used here is appreciated.

Response:

We have described the probability density function $h(\kappa)$ in the revised manuscript "

$$h(\kappa) = \frac{a_1}{\sqrt{2\pi}\log\sigma_1}\exp\left(-\frac{\left(\log\kappa-\log\kappa_{g1}\right)^2}{2(\log\sigma_1)^2}\right)+\frac{1-a_1}{\sqrt{2\pi}\log\sigma_2}\exp\left(-\frac{\left(\log\kappa-\log\kappa_{g2}\right)^2}{2(\log\sigma_2)^2}\right)$$

"

Technical comments

1. Pg. 9715, line 19, "infinitely small", may be not the right wording. For the time resolution of DMT-CCNC, it is 1s.

Response:

Accepted. Now it reads:

"...for *S* scan to infinitely small (in practice the time resolution of the instrument, e.g., 1 second for DMT-CCNC)."

2. Fig. 6, panel (b), the number of x-axis should be 0.3-0.9.

Response:

The number of x-axis is correct. I think the referee's comments come from the κ values of large particles. Due to its definition, κ is not a constant for the same compound but depends on the droplet concentration and particle size. That's why κ of 2.5 nm particles are quite smaller than that of larger particles.