Supplementary information

Cloud response to co-condensation of water and organic vapors over the boreal forest

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Supplementary figures

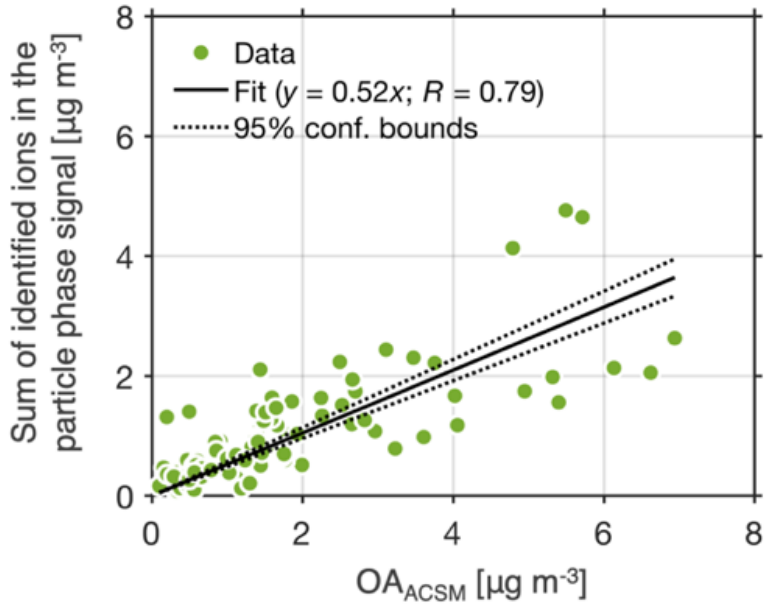

Figure S.1 A comparison between the FIGAERO-I-CIMS particle phase (sum of signals of identified ions in the particle phase) and the OA concentration measured with the ACSM. The data shown here are daytime values only (hour of day >9 and <19) during the BAECC campaign.

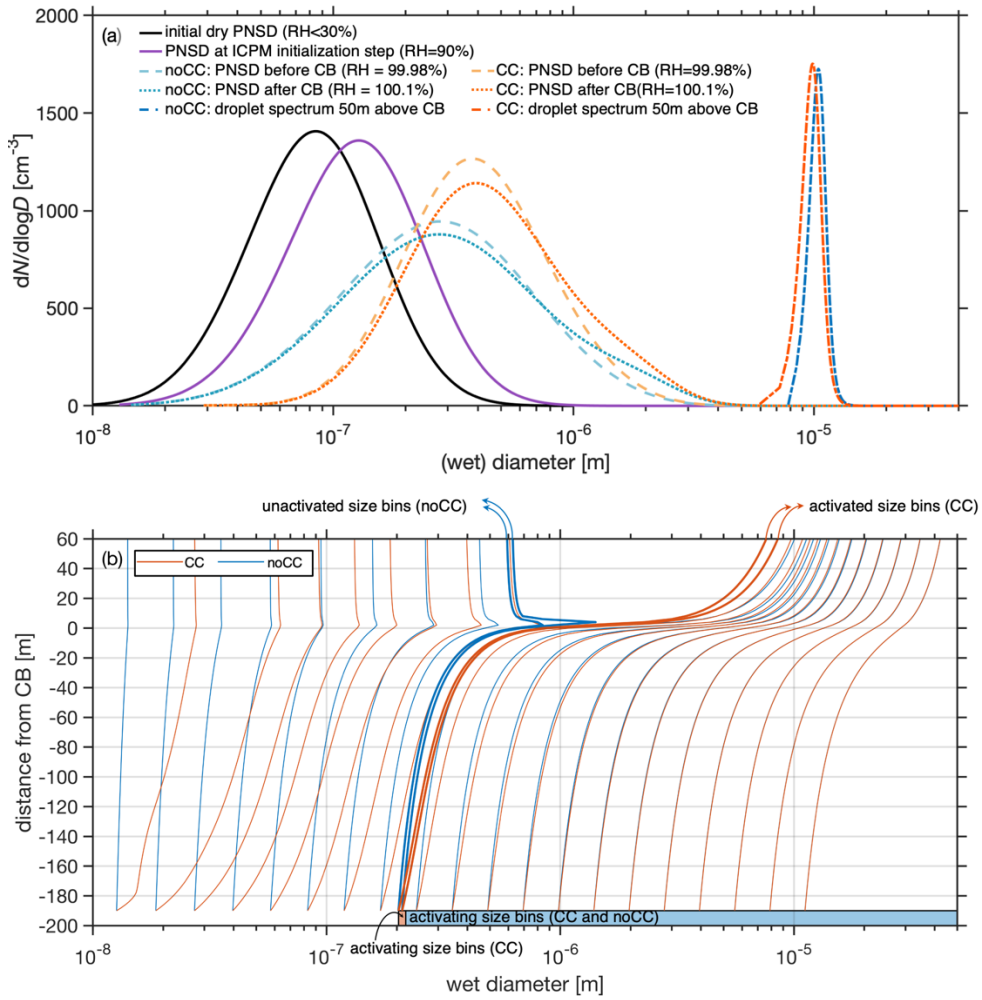

Figure S.2 (a) The evolution of the particle number size distribution (PNSD) during the May 11th case is shown in Fig. 3. The size distributions are obtained from the simulations using a 0.1 m s^{-1} updraft velocity. Red lines correspond to simulations with co-condensation (CC; F volatility distribution) and blue lines simulations without co-condensation (noCC). **(b)** The evolution of the parcel model bin sizes (wet diameter; x-axis) as a function of altitude with respect to cloud base (CB; y-axis). The data shown correspond to the simulation shown in panel (**a**). The bin sizes grow below the cloud base more in the co-condensation simulations which makes the red and blue lines drift as a function of altitude. The bolded curves show the evolution of size bins corresponding to the range from the smallest activated dry radii with CC (r^*_{CC}=66.0 nm) to that modeled when CC is turned off (r^*_{noCC}=71.9 nm). In this range size bins activate only when CC is turned on (red shaded area). This results in activation of 4 more size bins as opposed to simulations where CC is turned off. Within the blue shaded area, all size bins activate. The figure composes every 20th size bin out of the 400 bins included in the simulations. Within the red shaded size range, every 2nd bin is displayed with bolded lines.

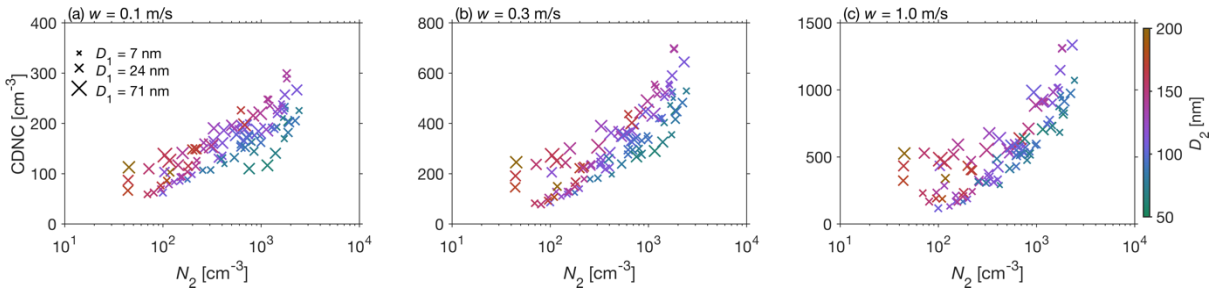

Figure S.3 The relationship between cloud droplet number concentration (CDNC; y-axis) and accumulation mode number concentration (N_2; x-axis), accumulation mode geometric mean diameter (D_2; color-coding), and Aitken mode geometric mean diameter (D_1; marker size) for the 0.1, 0.3 and 1.0 m s^{-1} updraft scenarios, respectively (panels **a–c**) during BAECC. The CDNC is obtained from simulations without co-condensation (noCC). N_2, D_2, and D_1 are used as model input data and represent the bimodal fits performed on the measured PNSD using the fitting algorithm by Hussein et al. (2005).

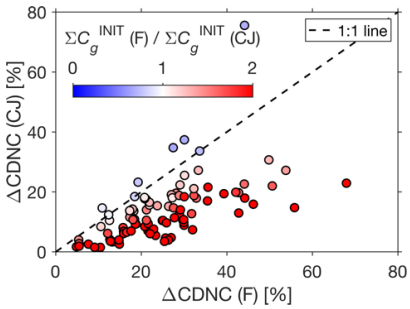

Figure S.4 The relationship between CDNC enhancements due to co-condensation (ΔCDNC) when F volatility distribution is utilized (x-axis) vs when CJ distribution is utilized (y-axis). The markers from every 97 simulations are color-coded with the initial concentration of organic vapor ($\sum c_g^{INIT}$) in both simulation sets. The majority of the markers are red indicating that there is more vapor present at the initial step of the ascent in simulations using the F volatility distribution. These red lines drift from the 1:1 agreement predicting higher ΔCDNC for the F simulations as opposed to CJ. When the difference in $\sum c_g^{INIT}$ between F and CJ simulations is negligible (white markers) also ΔCDNC agree.

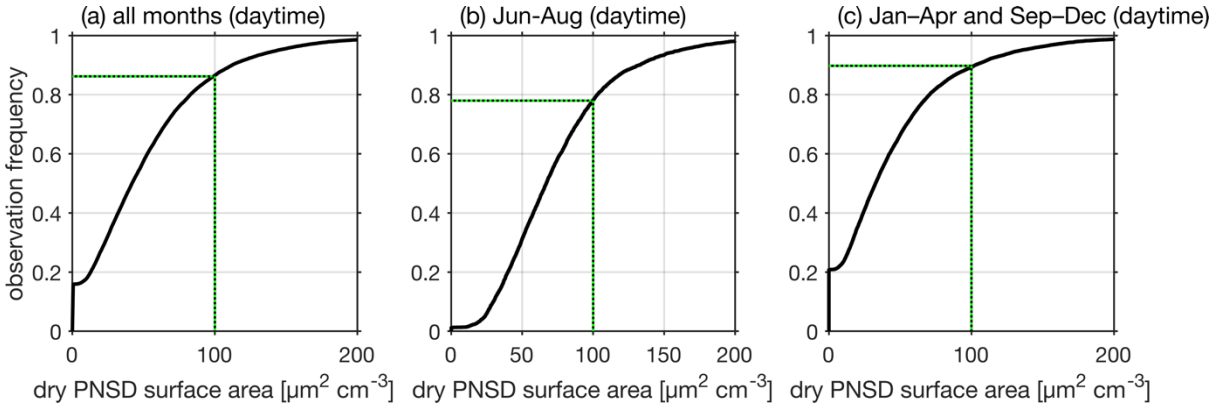

Figure S.5 Cumulative density functions of the dry PNSD surface area calculated from the 2012–2017 SMEAR II DMPS data. Panel **a** contains all the data, panel **b** the summer months and panel **c** the months outside summer. The green lines depict the 100 μm^2 cm^{-3} threshold and the frequencies to which the calculated surface areas remain higher (86% of the time in panel **a**, 78% of the time in panel **b** and 90% of the time for panel **c**).

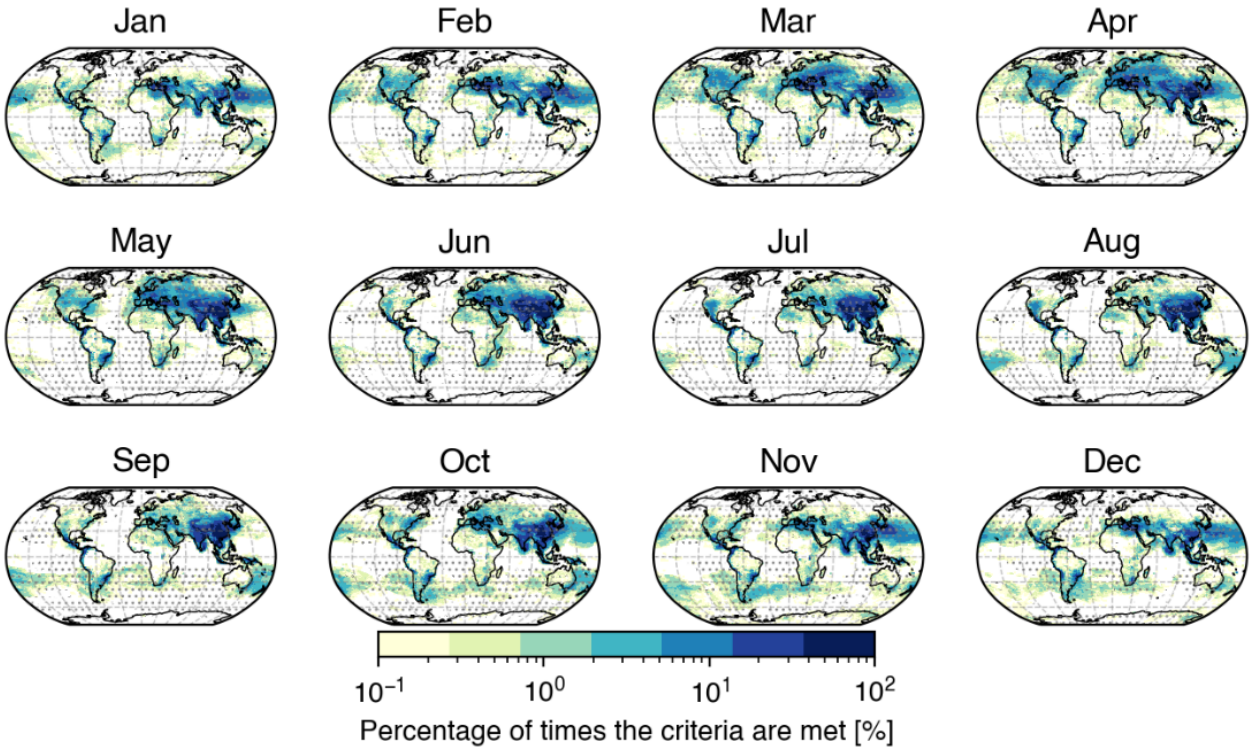

Figure S.6 A global picture of the percentage of times the criteria are met in a 2009–2013 UKESM1 simulation. D_2, D_1 and N_1 are the modal parameters representing the accumulation mode and Aitken mode parameters. The gray markers refer to boreal grid cells, where the median updraft velocity at cloud base is between 0.2 and 0.5 m s^{-1}. Note the logarithmic axis of the color scale.

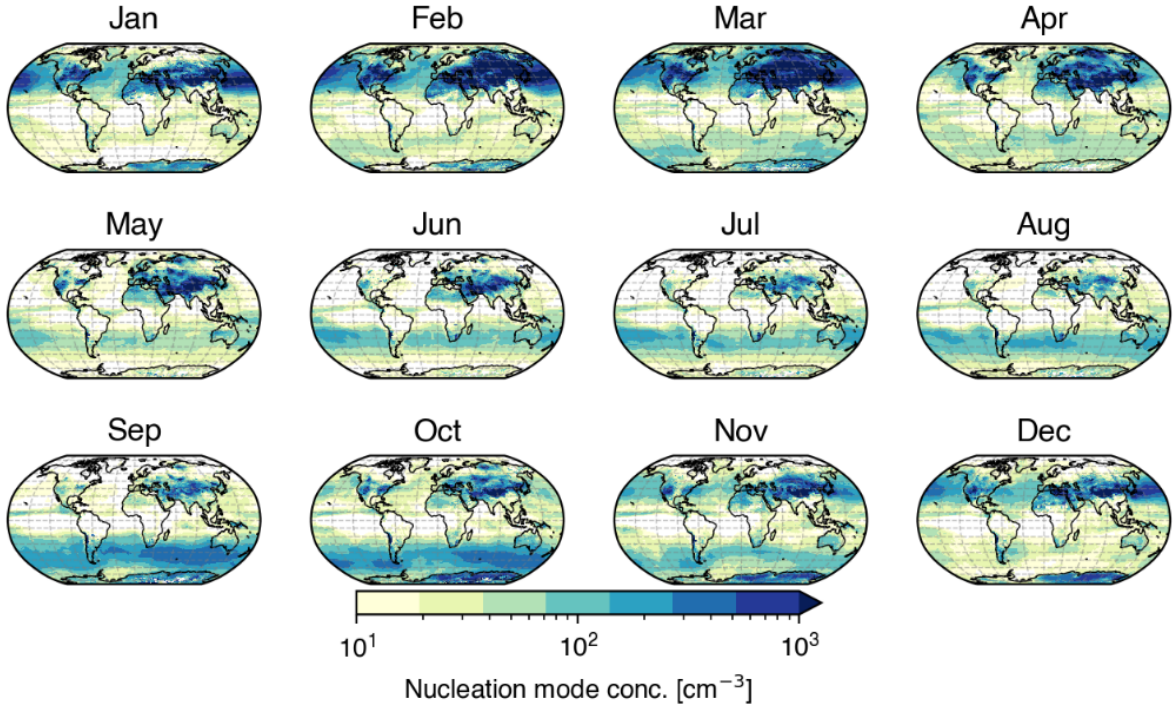

Figure S.7 A global picture of the average daytime concentrations of the nucleation mode in the 2009–2013 UKESM1 simulation. Note the logarithmic axis of the color scale.

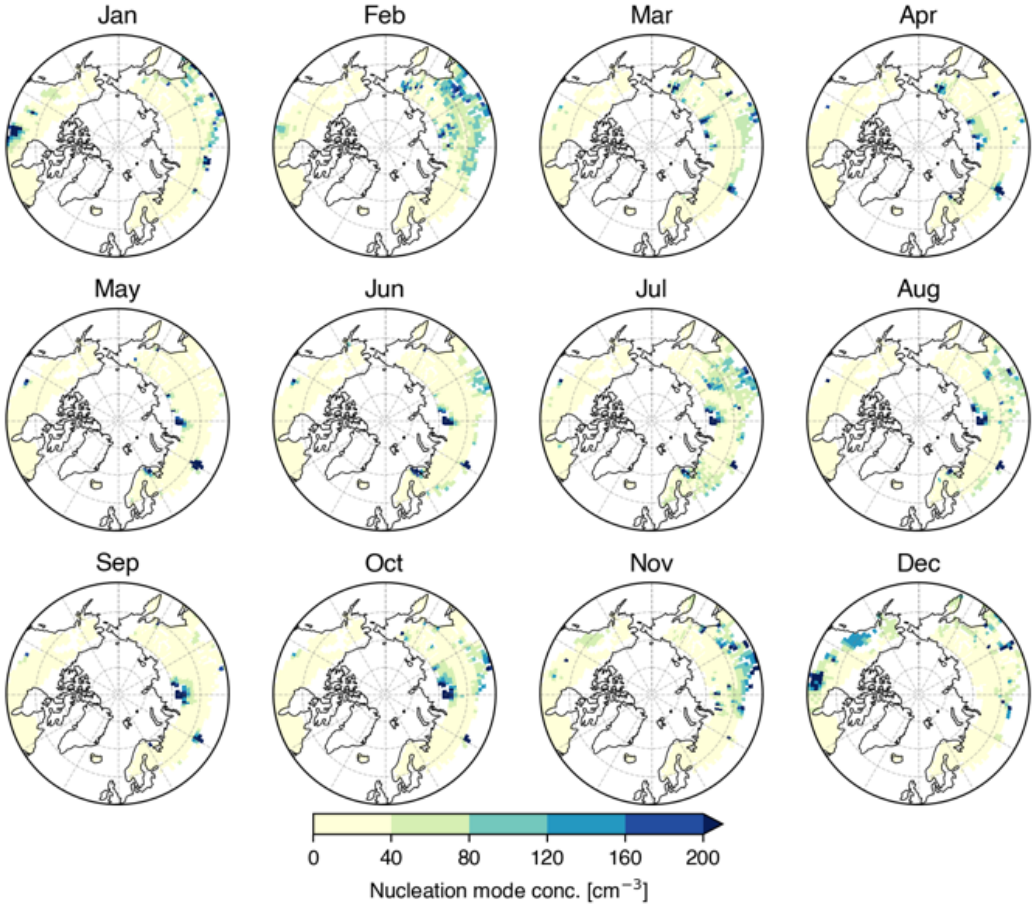

Figure S.8 The average daytime concentrations of the nucleation mode in the 2009–2013 UKESM1 simulation. Only boreal grid cells are shown.