

Supplementary information to

Cloud processing signatures in boreal forest aerosol revealed by long-term in-situ observations

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1. Supplementary figures

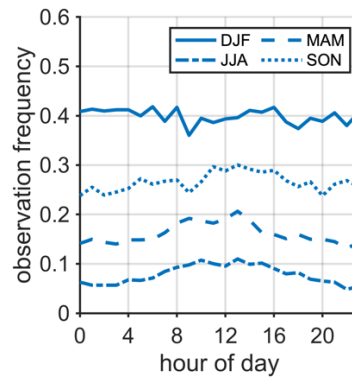


Figure S.1 Diel pattern of PNSD_{Hoppel} cluster member observation frequency during different seasons.

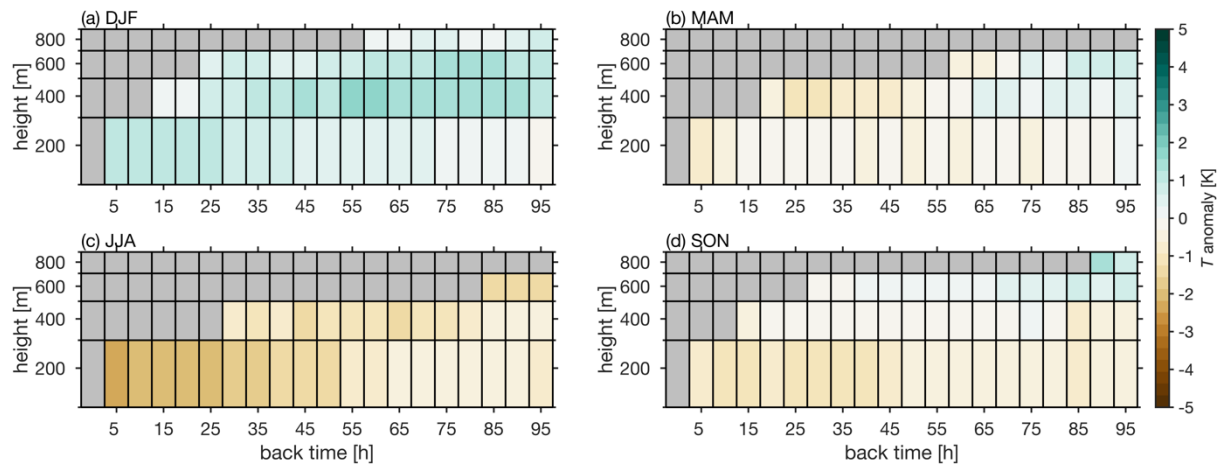


Figure S.2 Temperature (T) anomalies associated with the detection of PNSD_{Hoppel} cluster members for all seasons (a–d). A height-resolved 3-hourly T climatology is derived using all HYSPLIT back trajectories ran over the 8-year-long period.

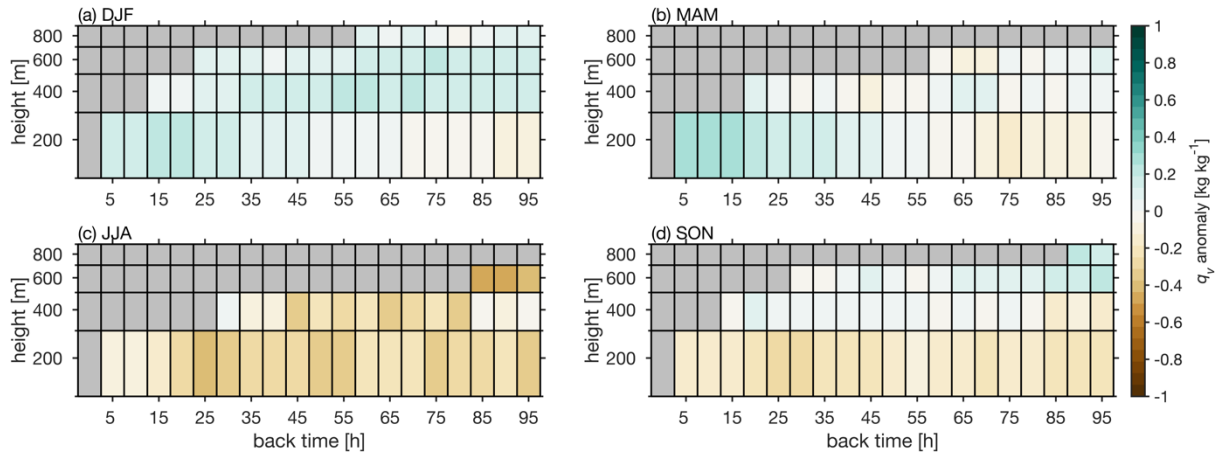


Figure S.3 Specific humidity (q_v) anomalies associated with the detection of PNSD_{Hoppel} cluster members for all seasons (a–d). A height-resolved 3-hourly q_v climatology is derived using all HYSPLIT back trajectories ran over the 8-year-long period.

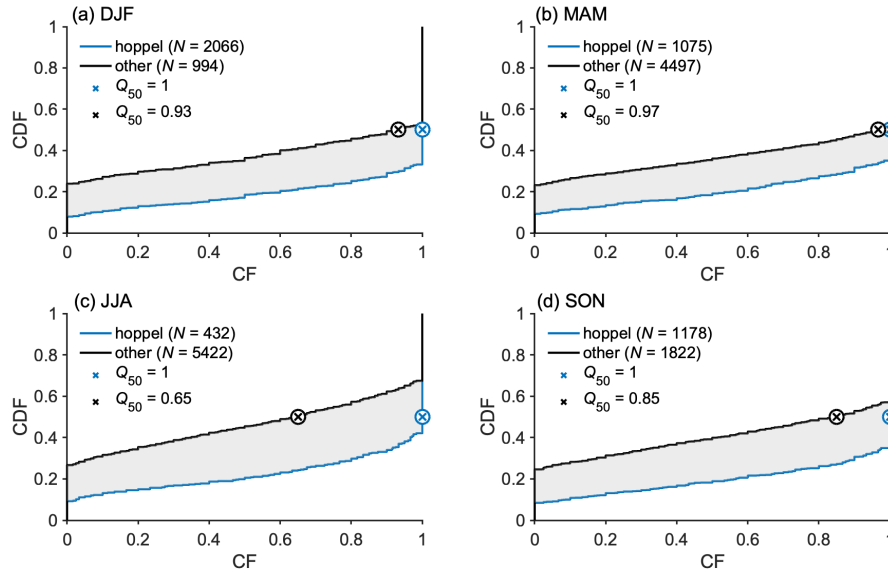


Figure S.4 Cumulative density function (CDF) plots describing the distribution of cloud fractions (CF) measured together with PNSD_{Hoppel} (in blue) or in absence of PNSD_{Hoppel} (in black). Y-axes refer to CDF and x-axes to the CF values. The median values (Q_{50}) are highlighted with markers in the graph and provided in the graph legend. The panels refer to different seasons: **(a)** winter (December–February), **(b)** spring (May–March), **(c)** summer (June–August), **(d)** fall (September–November).

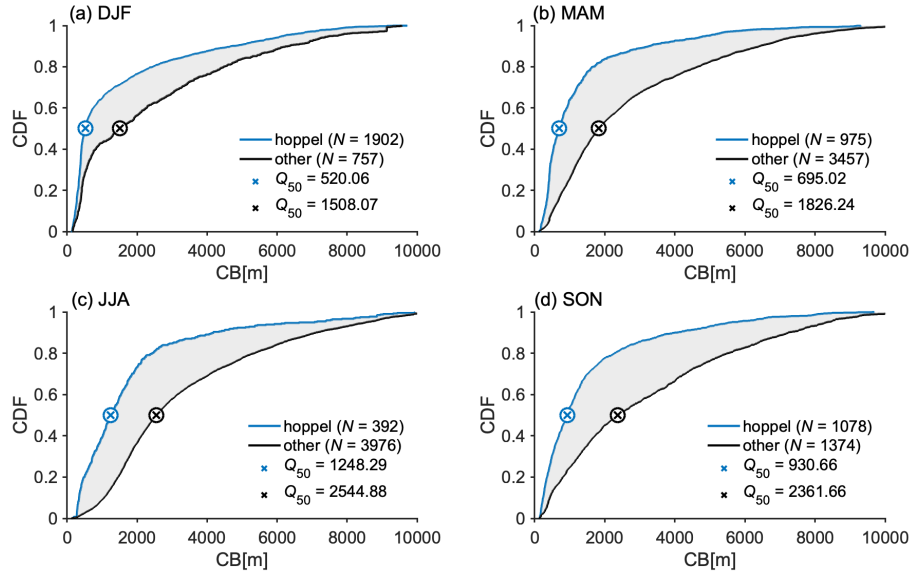


Figure S.5 Cumulative density function (CDF) plots describing the distribution of cloud base height (CB) measured together with PNSD_{Hoppel} (in blue) or in absence of PNSD_{Hoppel} (in black). Y-axes refer to CDF and x-axes to the CB values. The median values (Q_{50}) are highlighted with markers in the graph and provided (in meters) in the graph legend. The panels refer to different seasons: **(a)** winter (December–February), **(b)** spring (May–March), **(c)** summer (June–August), **(d)** fall (September–November).

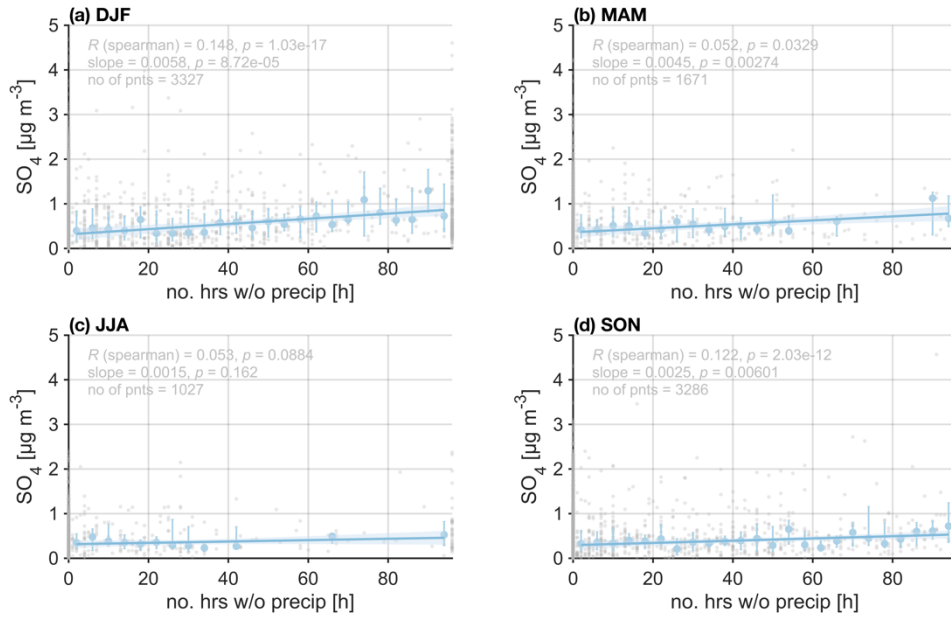


Figure S.6 The relationships between sulfate (SO_4) mass concentration and precipitation-free transport time prior to arrival at SMEAR II. Points show individual observations for PNSD_{Hoppel}, conditioned on increasingly strict precipitation filtering based on air mass history. Linear fits to the 4-hourly binned medians (solid lines) with 95% confidence intervals (shaded) are shown for each season. Spearman rank correlations (R) and linear regression slopes (in $\mu\text{g m}^{-3} \text{h}^{-1}$) are reported in each panel. Panels correspond to different seasons: **(a)** winter (December–February; DJF), **(b)** spring (March–May; MAM), **(c)** summer (June–August; JJA), **(d)** fall (September–November; SON).

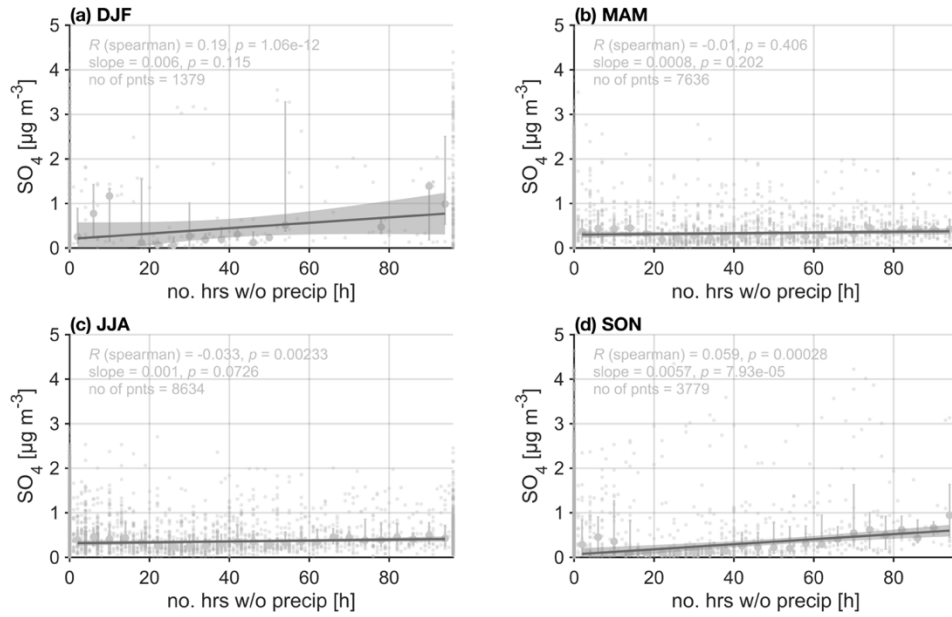


Figure S.7 The relationships between sulfate (SO_4) mass concentration and precipitation-free transport time prior to arrival at SMEAR II. Points show individual observations for PNSD_{OtherI}, conditioned on increasingly strict precipitation filtering based on air mass history. Linear fits to the 4-hourly binned medians (solid lines) with 95% confidence intervals (shaded) are shown for each season. Spearman rank correlations (R) and linear regression slopes (in $\mu\text{g m}^{-3} \text{ h}^{-1}$) are reported in each panel. Panels correspond to different seasons: (a) winter (December–February; DJF), (b) spring (March–May; MAM), (c) summer (June–August; JJA), (d) fall (September–November; SON).

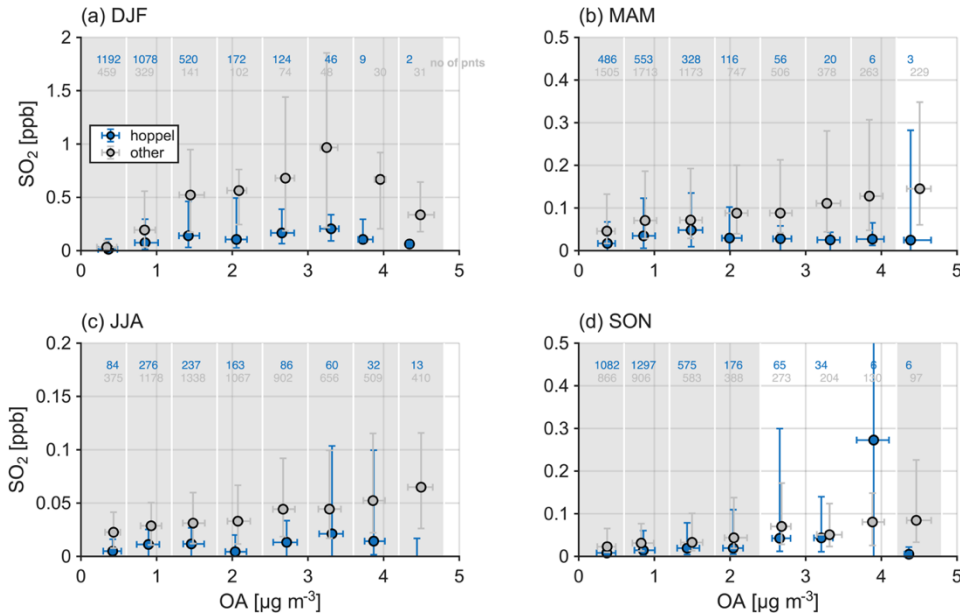


Figure S.8 Median sulfur dioxide (SO_2) concentrations as a function of organic aerosol (OA) concentration, shown for different seasons: (a) winter (December–February), (b) spring (March–May), (c) summer (June–August), (d) fall (September–November). Blue markers represent measurements associated with PNSD_{Hoppel} while gray markers denote PNSD_{Other}. Numbers at the top of each panel indicate the number of data points within each OA bin for PNSD_{Hoppel} (blue) and PNSD_{Other} (gray) respectively. Horizontal error bars show the interquartile range (IQR) of OA concentrations within each bin, and vertical error bars indicate the IQR of sulfate concentrations. Shaded regions highlight statistically significant differences between PNSD_{Hoppel} and PNSD_{Other} (medians of PNSD_{Other} > PNSD_{Hoppel} with 95% confidence interval).

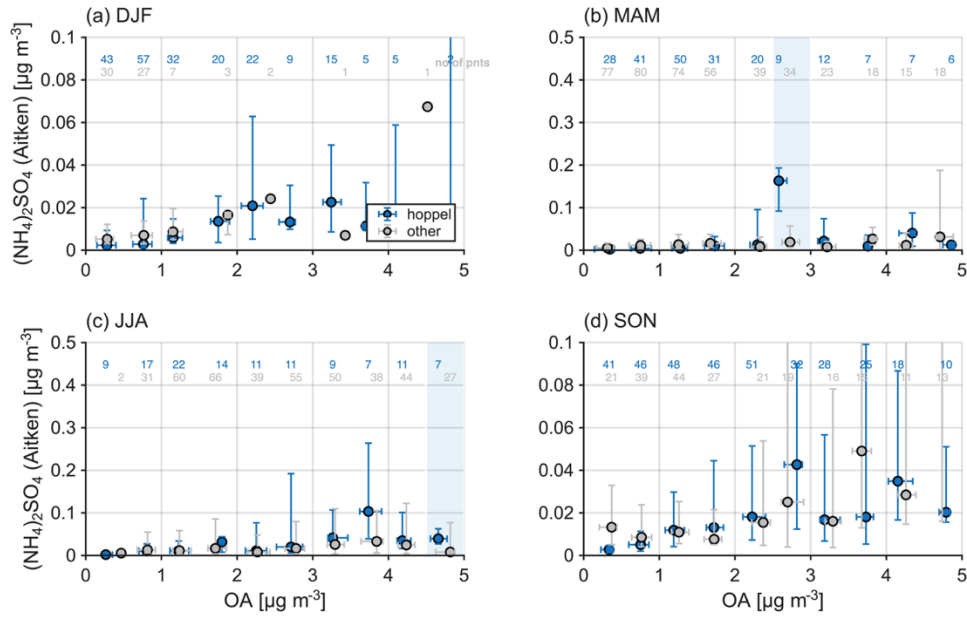


Figure S.9 Median Aitken mode ammonium sulfate ($(\text{NH}_4)_2\text{SO}_4$) concentrations as a function of organic aerosol (OA) concentration, shown for different seasons: **(a)** winter (December–February), **(b)** spring (March–May), **(c)** summer (June–August), **(d)** fall (September–November). Blue markers represent measurements associated with $\text{PNSD}_{\text{Hoppel}}$ while gray markers denote $\text{PNSD}_{\text{Other}}$. Numbers at the top of each panel indicate the number of data points within each OA bin for $\text{PNSD}_{\text{Hoppel}}$ (blue) and $\text{PNSD}_{\text{Other}}$ (gray) respectively. Horizontal error bars show the interquartile range (IQR) of OA concentrations within each bin, and vertical error bars indicate the IQR of ammonium sulfate concentrations. Shaded regions highlight statistically significant differences between $\text{PNSD}_{\text{Hoppel}}$ and $\text{PNSD}_{\text{Other}}$ (medians of $\text{PNSD}_{\text{Hoppel}} > \text{PNSD}_{\text{Other}}$ with 95% confidence interval).

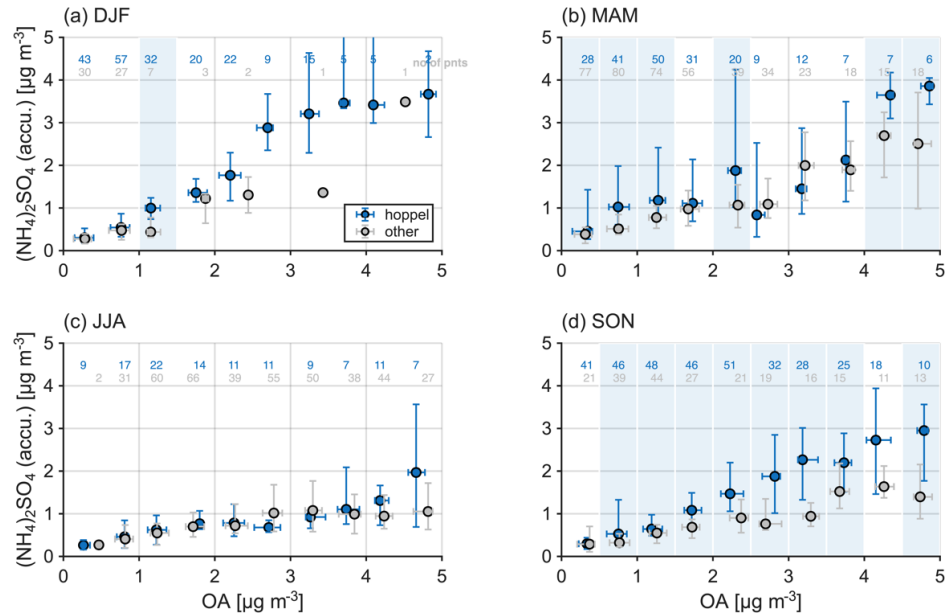


Figure S.10 Median accumulation mode ammonium sulfate ($(\text{NH}_4)_2\text{SO}_4$) concentrations as a function of organic aerosol (OA) concentration, shown for different seasons: **(a)** winter (December–February), **(b)** spring (March–May), **(c)** summer (June–August), **(d)** fall (September–November). Blue markers represent measurements associated with $\text{PNSD}_{\text{Hoppel}}$ while gray markers denote $\text{PNSD}_{\text{Other}}$. Numbers at the top of each panel indicate the number of data points within each OA bin for $\text{PNSD}_{\text{Hoppel}}$ (blue) and $\text{PNSD}_{\text{Other}}$ (gray) respectively. Horizontal error bars show the interquartile range (IQR) of OA concentrations within each bin, and vertical error bars indicate the IQR of ammonium sulfate concentrations. Shaded regions highlight statistically significant differences between $\text{PNSD}_{\text{Hoppel}}$ and $\text{PNSD}_{\text{Other}}$ (medians of $\text{PNSD}_{\text{Hoppel}} > \text{PNSD}_{\text{Other}}$ with 95% confidence interval).

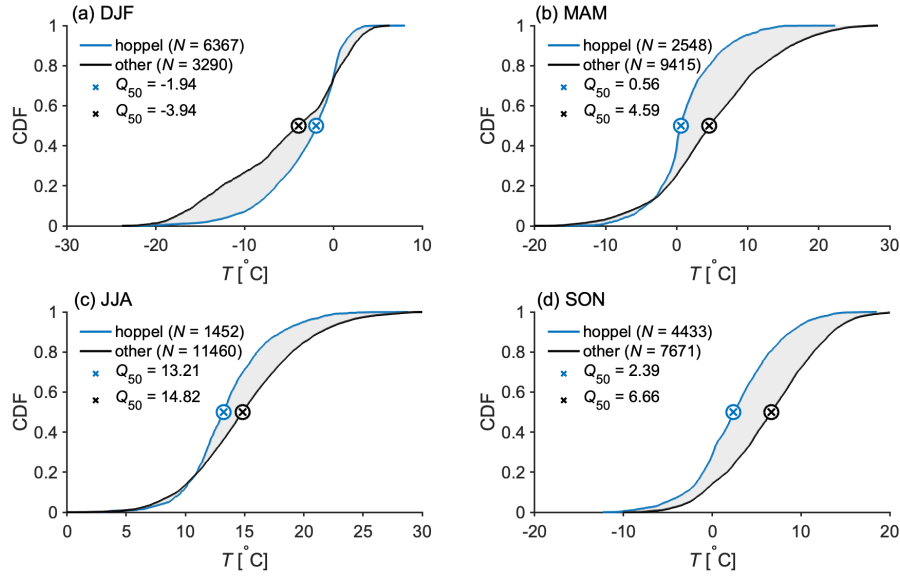


Figure S.11 Cumulative density function (CDF) plots describing the distribution of temperature (T) measured at SMEAR II together with $\text{PNSD}_{\text{Hoppel}}$ (in blue) or in absence of $\text{PNSD}_{\text{Hoppel}}$ (in black). Y-axes refer to CDF and x-axes to the measured temperatures. The median values (Q_{50}) are highlighted with markers in the graph and provided (in $^{\circ}\text{C}$) in the graph legend. The panels refer to different seasons: **(a)** winter (December–February), **(b)** spring (May–March), **(c)** summer (June–August), **(d)** fall (September–November).

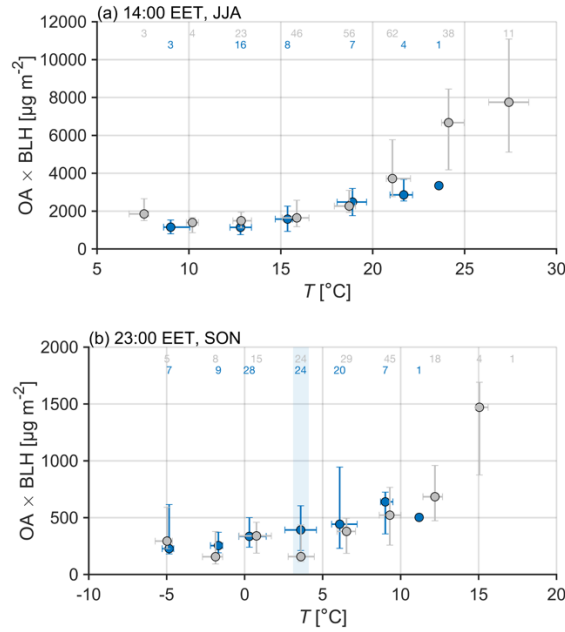


Figure S.12 Median $\text{OA} \times \text{BLH}$ (OA burden) ratios as function of temperature (T), shown separately for daytime (14:00 EET; panel **a**) and nighttime (23:00 EET; panel **b**), respectively. Blue markers represent measurements associated with $\text{PNSD}_{\text{Hoppel}}$ while gray markers denote $\text{PNSD}_{\text{Other}}$. Numbers at the top of each panel indicate the number of data points within each temperature bin for $\text{PNSD}_{\text{Hoppel}}$ (blue) and $\text{PNSD}_{\text{Other}}$ (gray), respectively. Horizontal error bars show the interquartile range (IQR) of temperature within each bin, and vertical errorbars indicate the IQR of the corresponding variable. Shaded regions highlight statistically significant differences ($p < 0.05$) between $\text{PNSD}_{\text{Hoppel}}$ and $\text{PNSD}_{\text{Other}}$: The blue shading on panel **b** indicates significantly higher values for $\text{PNSD}_{\text{Hoppel}}$ for only one temperature bin. Summer and Fall are chosen to be shown in panels **a** and **b**, respectively, due to their temperature ranges overlapping with significant differences shown in Figure 13 panels **g** and **h**, respectively.