

Supporting information for the manuscript: Satellite-based constraints on temperature-dependent aerosol–cloud feedback over a clean boreal forest and a polluted continental site

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A summary of the regression methods used in this study is given in Table S1. In these equations, x_i and y_i are the observed paired values, corresponding here to $x_i = \ln(N_{100})$ and $y_i = \ln(\text{CDNC})$. The quantities X_i and Y_i represent the corresponding fitted or adjusted values on the regression line. OLS regression minimizes only the vertical residuals, $y_i - Y_i$, and therefore assumes that uncertainty in x_i is negligible. In contrast, Deming and York regressions account for uncertainties in both x_i and y_i . The weights $\omega(X_i)$ and $\omega(Y_i)$ represent the inverse error variances associated with x_i and y_i , respectively. In the York regression, r_i denotes the correlation coefficient between the errors in the two variables and accounts for possible covariance between their uncertainties.

Table S1. Summary of Linear regression methods

Regression Method	Equation
OLS Regression	$\sum_{i=1}^N (y_i - Y_i)^2$
Deming Regression	$\sum_{i=1}^N (\omega(X_i)(x_i - X_i)^2 + \omega(Y_i)(y_i - Y_i)^2)$
York Regression	$\sum_{i=1}^N \left(\frac{\omega(X_i)(x_i - X_i)^2 - 2r_i \cdot \sqrt{\omega(X_i) \cdot \omega(Y_i)} \cdot (x_i - X_i) \cdot (y_i - Y_i) + \omega(Y_i)(y_i - Y_i)^2}{1 - r_i^2} \right)$

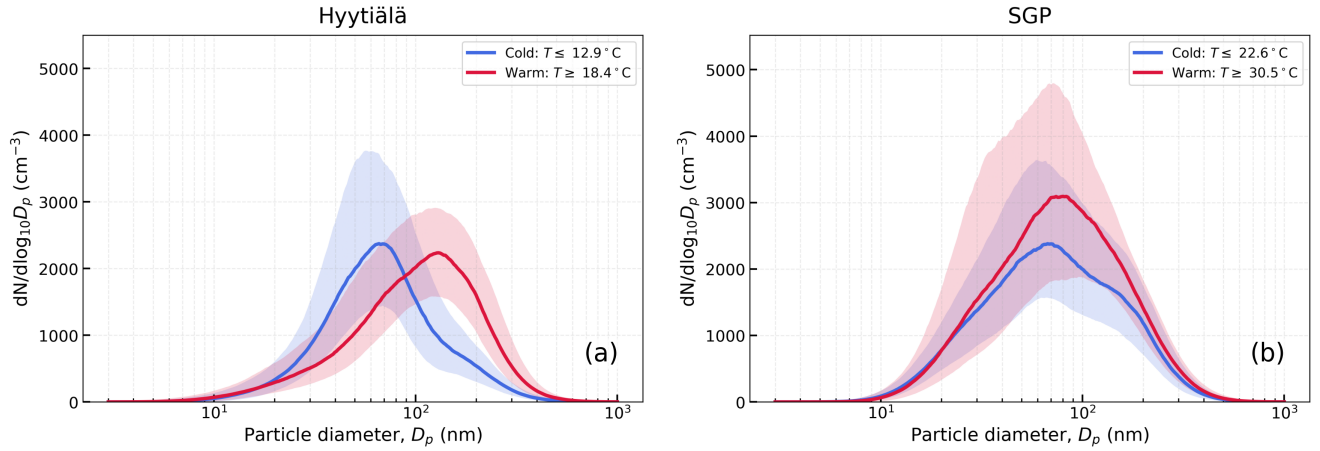


Figure S1. Aerosol size distributions under cold and warm temperature conditions at (a) Hyytiälä and (b) SGP. Cold and warm regimes are defined using the lower and upper quartiles of the collocated temperature distribution, respectively. Solid lines show the median of three-mode lognormal aerosol size distribution, and shading indicates the 25th–75th percentile range across the hourly distributions.

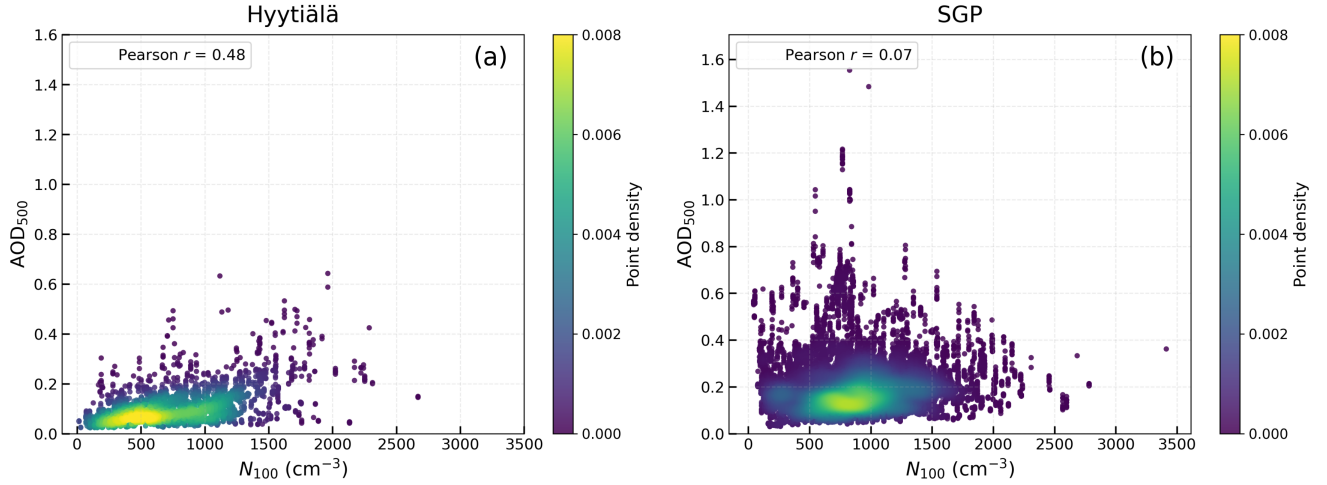


Figure S2. Density-coloured scatter plots of AERONET AOD₅₀₀ versus in situ N_{100} at (a) Hyytiälä and (b) SGP. AERONET observations were filtered for positive AOD and Ångström exponent > 0.75 , and N_{100} was collocated within ± 30 min of each AERONET measurement. Colours indicate the local point density, while the Pearson correlation coefficient quantifies the linear association between AOD₅₀₀ and N_{100} .

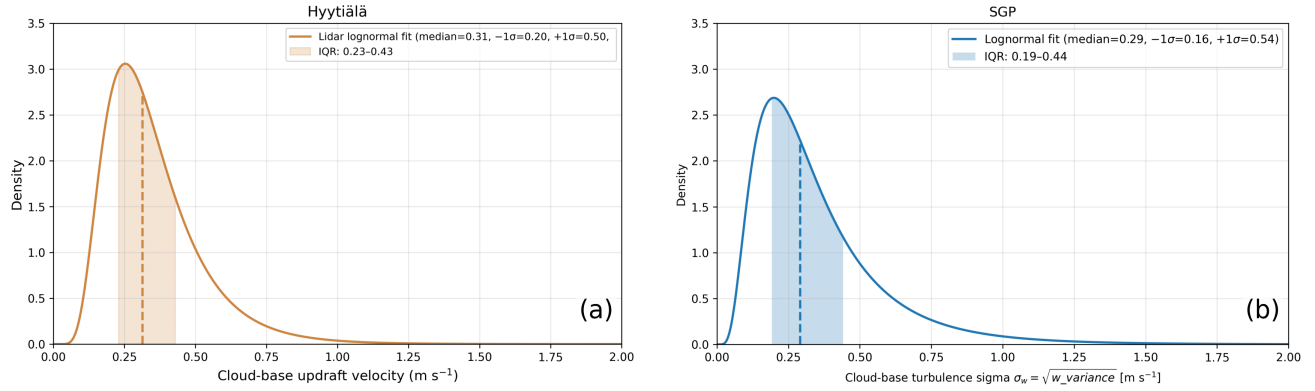


Figure S3. Lognormal fits to cloud-base vertical-velocity statistics derived from Doppler lidar observations at (a) Hyytiälä and (b) SGP. For Hyytiälä, positive Doppler-lidar vertical velocities at cloud base are used as updraft velocities and averaged hourly for July–August 2022. For SGP, cloud-base turbulence intensity is represented by $\sigma_w = \sqrt{w_{\text{variance}}}$, for low-cloud conditions. Solid curves show the fitted lognormal probability density functions, dashed vertical lines indicate the fitted median values, and shaded regions denote the interquartile range of the fitted distributions. These distributions are used to constrain the cloud-base updraft conditions for the cloud parcel model simulations.

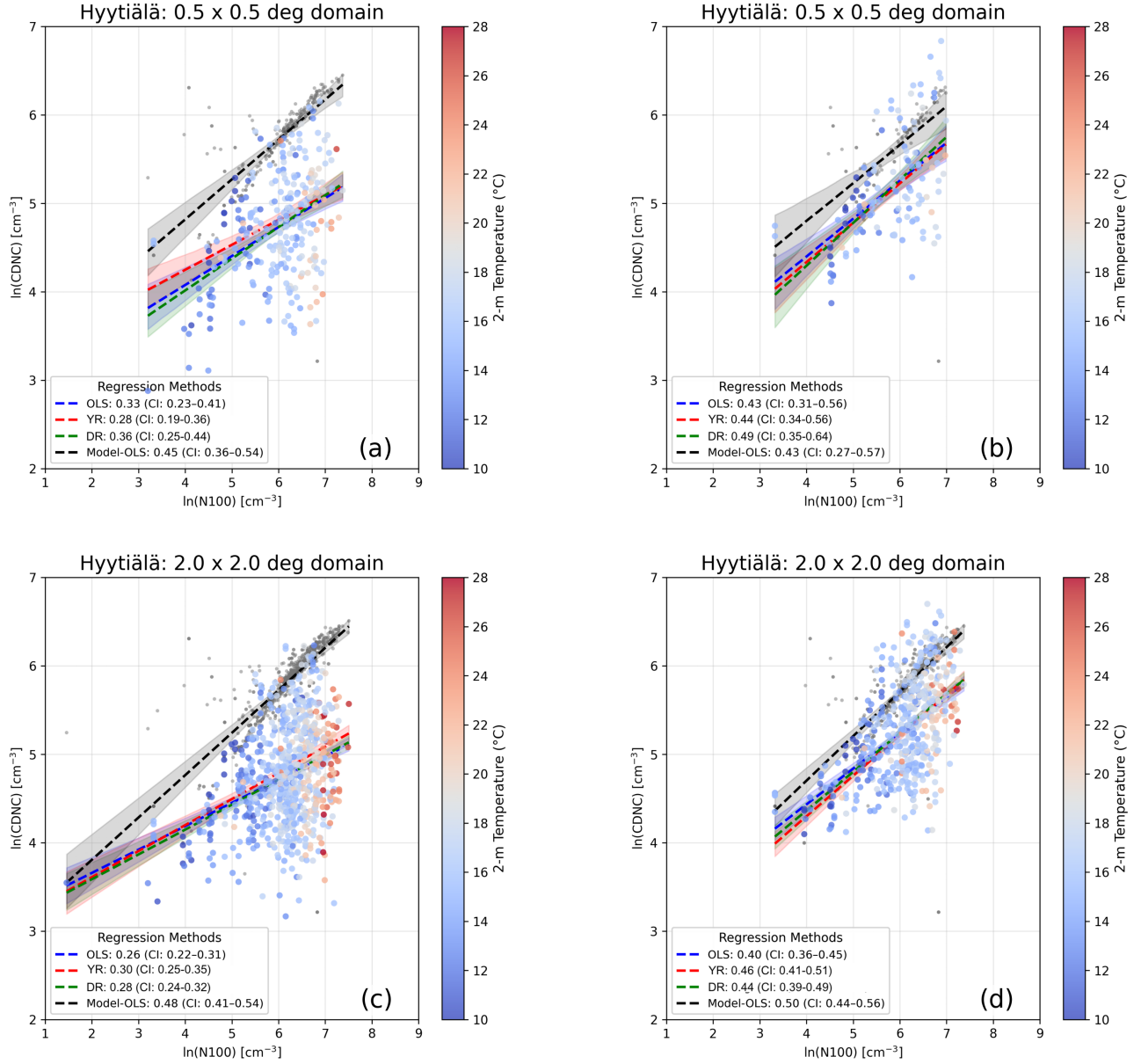


Figure S4. Aerosol–cloud susceptibility over the 0.5° (a, b) and 2° (c, d) domains around Hyytiälä. Panels show collocated $\ln(\text{CDNC})$ from MODIS Level-2 retrievals versus in situ $\ln(N_{100})$ for non-adiabatic and adiabatic sampling conditions. CDNC and N_{100} are shown in logarithmic space, and observational slopes are estimated using OLS, bivariate, and Deming regressions, with the cloud parcel model OLS slope overlaid for comparison. The slopes represent $\partial \ln(\text{CDNC}) / \partial \ln(N_{100})$, and shaded bands show 95% confidence intervals.

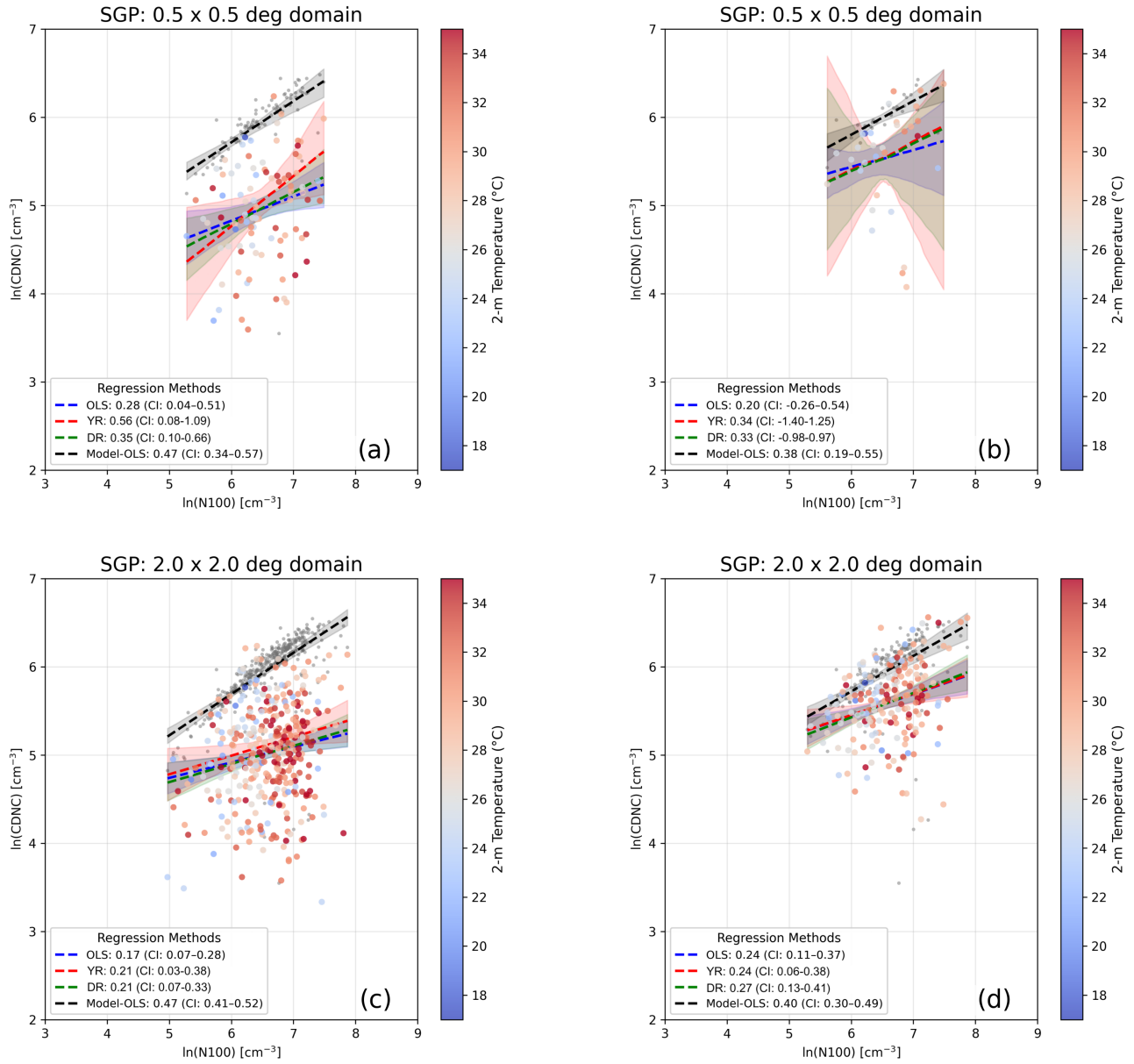


Figure S5. Aerosol–cloud susceptibility over the 0.5° (a,b) and 2° (c,d) domains around SGP. Panels show collocated $\ln(\text{CDNC})$ from MODIS Level-2 retrievals versus in-situ $\ln(\text{N}_{100})$ for non-adiabatic and adiabatic sampling conditions. CDNC and N_{100} are shown in logarithmic space, and observational slopes are estimated using OLS, bivariate, and Deming regressions, with the cloud parcel model OLS slope overlaid for comparison. The slopes represent $\partial \ln(\text{CDNC}) / \partial \ln(\text{N}_{100})$, and shaded bands show 95% confidence intervals.