Vertical structure and controlling factors of cloud condensation nuclei activation over eastern China: Insights from aircraft measurements and interpretable machine learning

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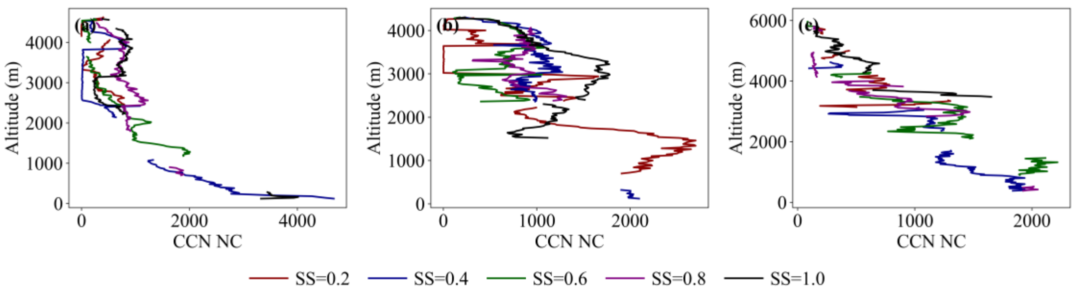

Fig.S1. shows the vertical variation of NCCN under different supersaturations for the three flights: (a) F2, (b) F3, and (c) F4.

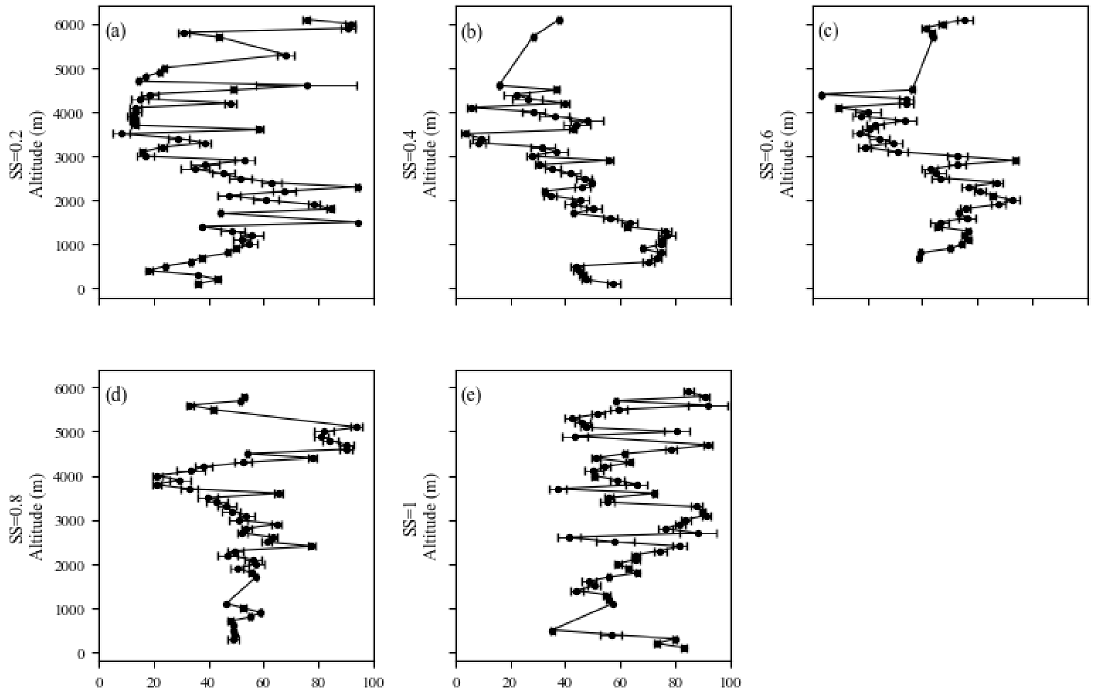

Fig.S2. Vertical variation of CCN activation ratio under different supersaturations. The dots represent the mean values, and the vertical bars indicate the standard deviations.

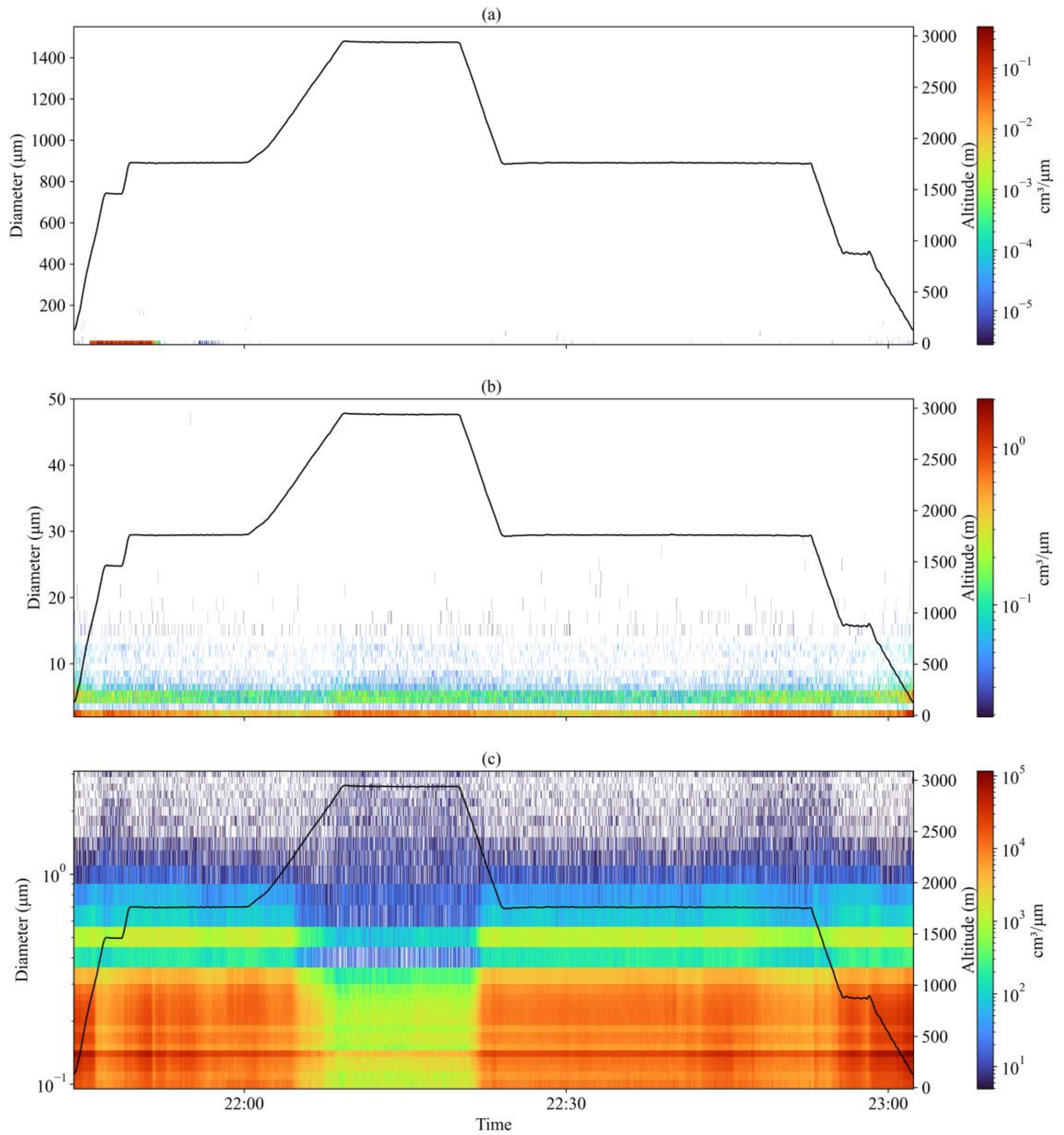

Fig.S3. Temporal variation of the spectral concentration distribution of (a) ice crystals, (b) cloud droplets, and (c) aerosols in F1. The black line represents the flight trajectory.

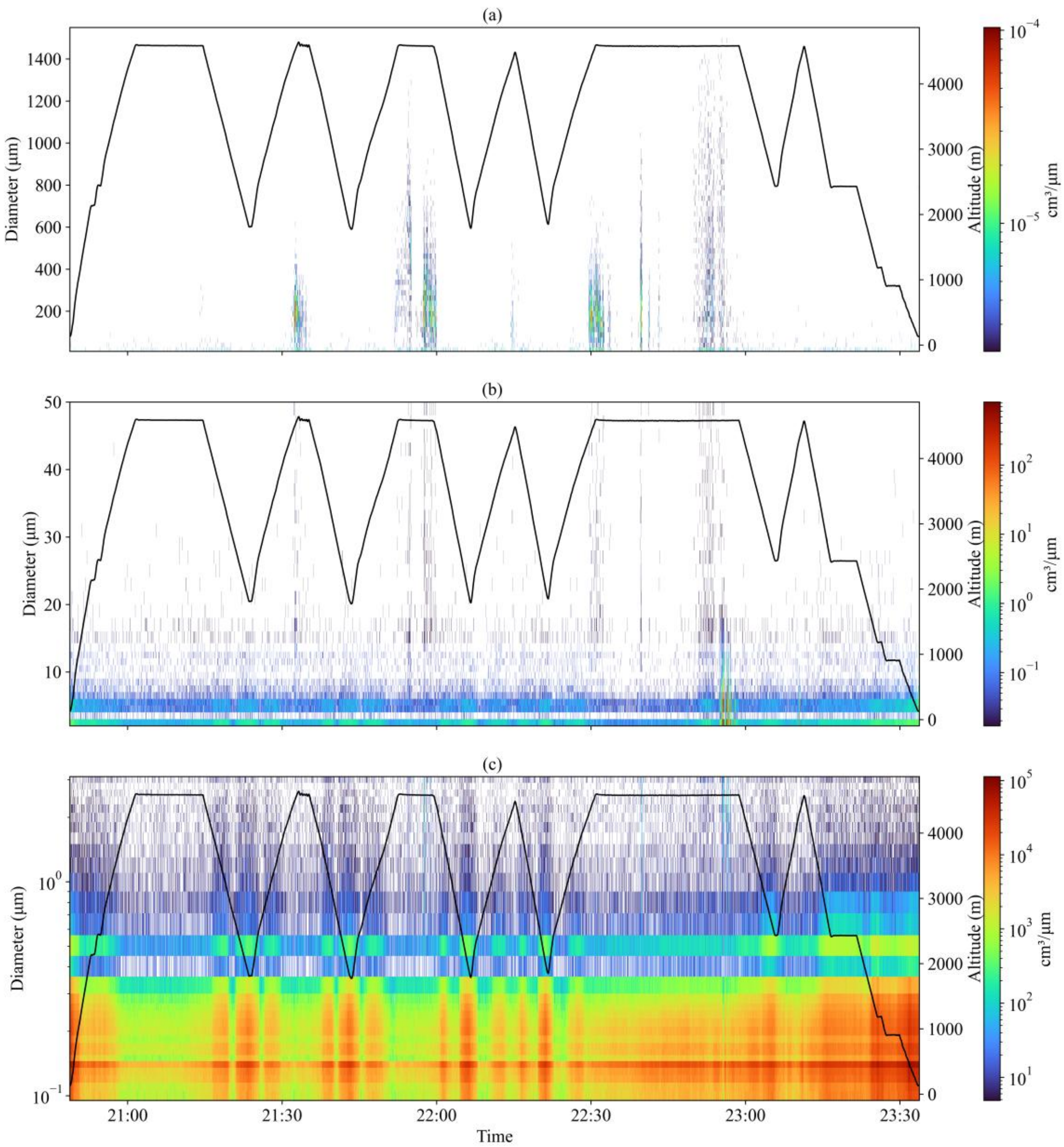

Fig.S4. Temporal variation of the spectral concentration distribution of (a) ice crystals, (b) cloud droplets, and (c) aerosols in F2. The black line represents the flight trajectory.

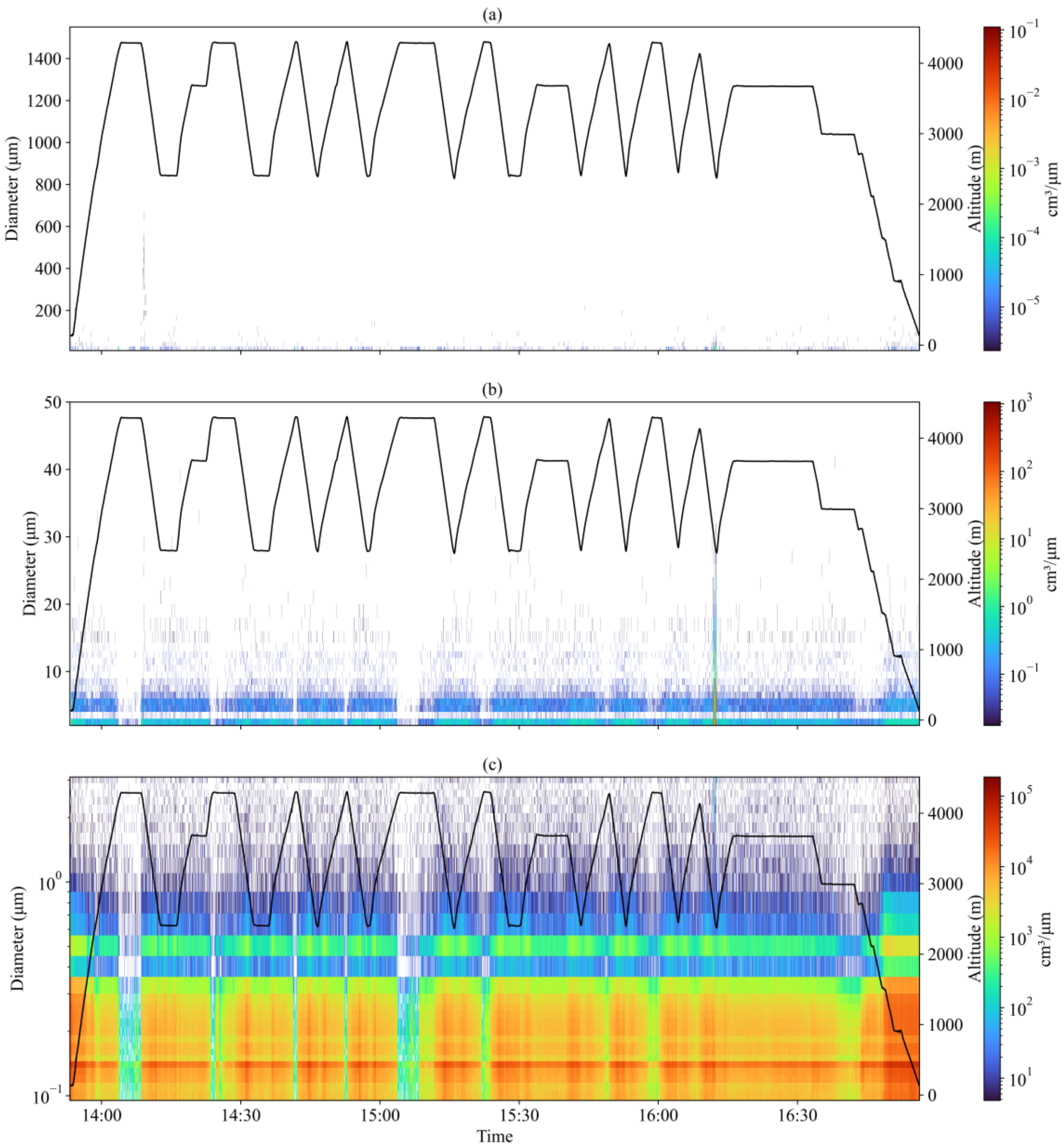

Fig.S5. Temporal variation of the spectral concentration distribution of (a) ice crystals, (b) cloud droplets, and (c) aerosols in F3. The black line represents the flight trajectory.

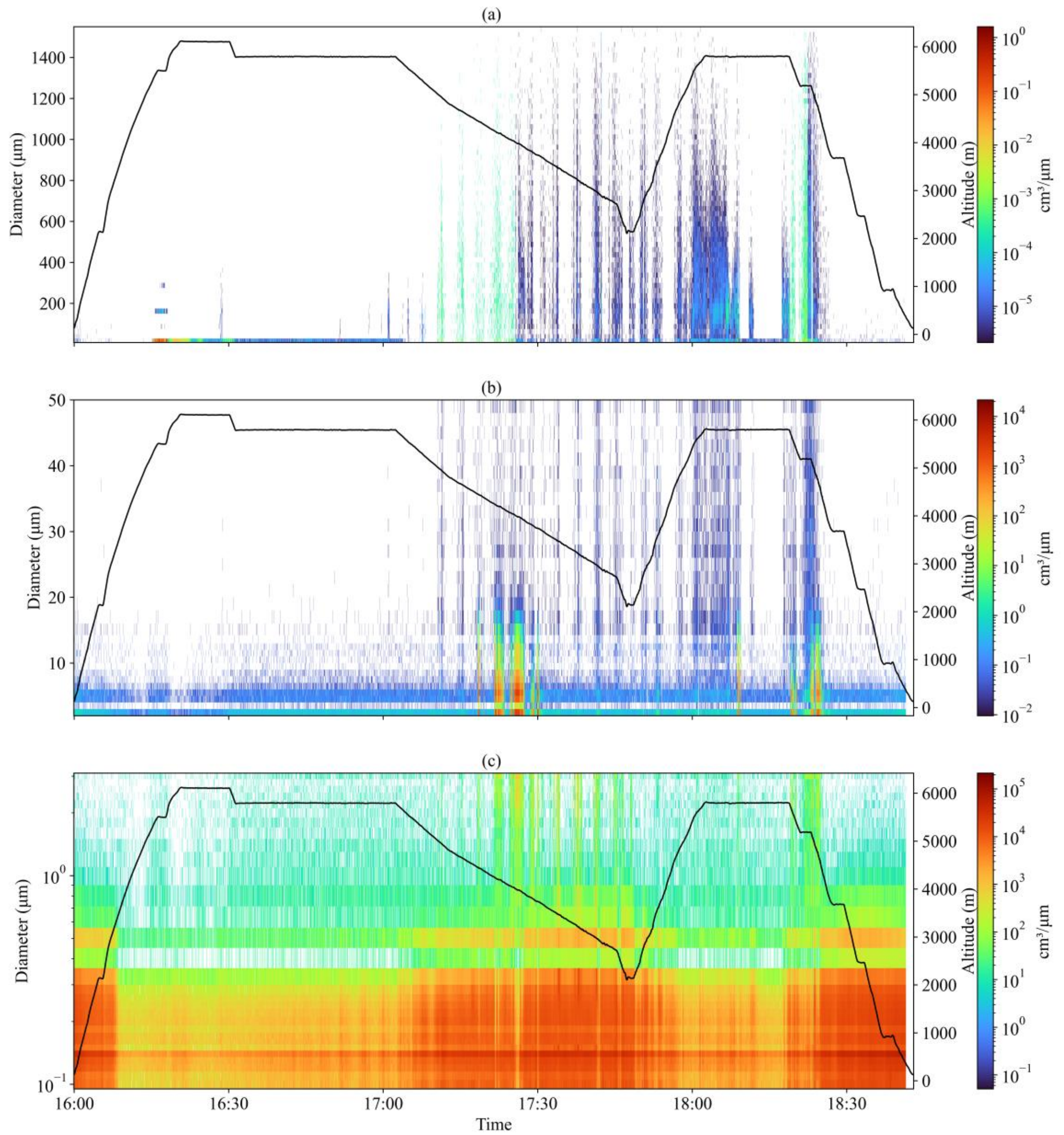

Fig.S6. Temporal variation of the spectral concentration distribution of (a) ice crystals, (b) cloud droplets, and (c) aerosols in F4. The black line represents the flight trajectory.

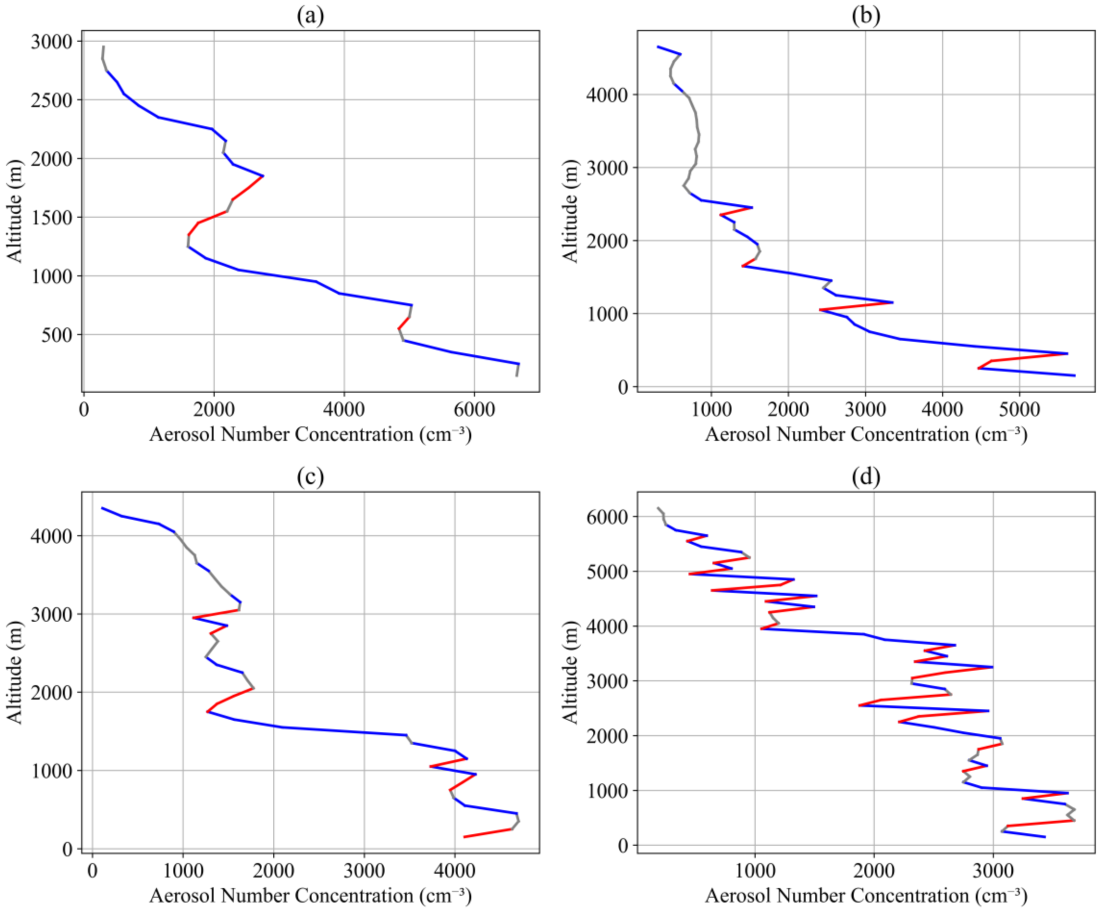

Fig.S7. Vertical variation of aerosol number concentration in clear-sky and cloud-free conditions for F1–F4. Panels (a), (b), (c), and (d) correspond to F1–F4, respectively. Red indicates aerosol concentration increasing with height (increase profile), gray indicates relatively constant aerosol concentration with height (stable profile), and blue indicates aerosol concentration decreasing with height (decrease profile).

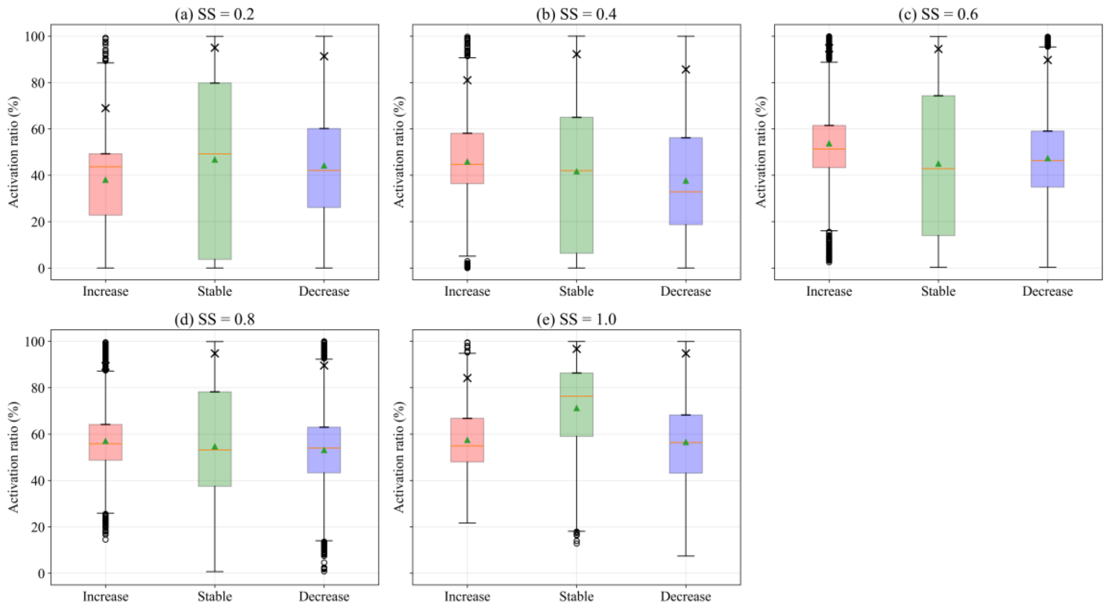

Fig.S8. Distribution of aerosol activation ratio under different supersaturation (SS) conditions and

aerosol vertical structural regimes. Boxplots show the activation ratio (AR, %) of aerosol particles activating into cloud condensation nuclei (CCN) under three aerosol vertical structures (increasing, stable, and decreasing types) across five supersaturation levels (SS = 0.2, 0.4, 0.6, 0.8, and 1.0). The activation ratio is defined as AR = (CCN NC / Aerosol NC) × 100%. In each boxplot, the central line represents the median, the box indicates the interquartile range (25th–75th percentiles), and whiskers extend to 1.5 times the interquartile range. Black circles denote outliers. Triangle markers represent the arithmetic mean value of each group. Additionally, the 75th percentile (horizontal line) and 95th percentile (cross marker) are shown to highlight upper-tail variability and the distribution of high activation efficiency under different conditions.**

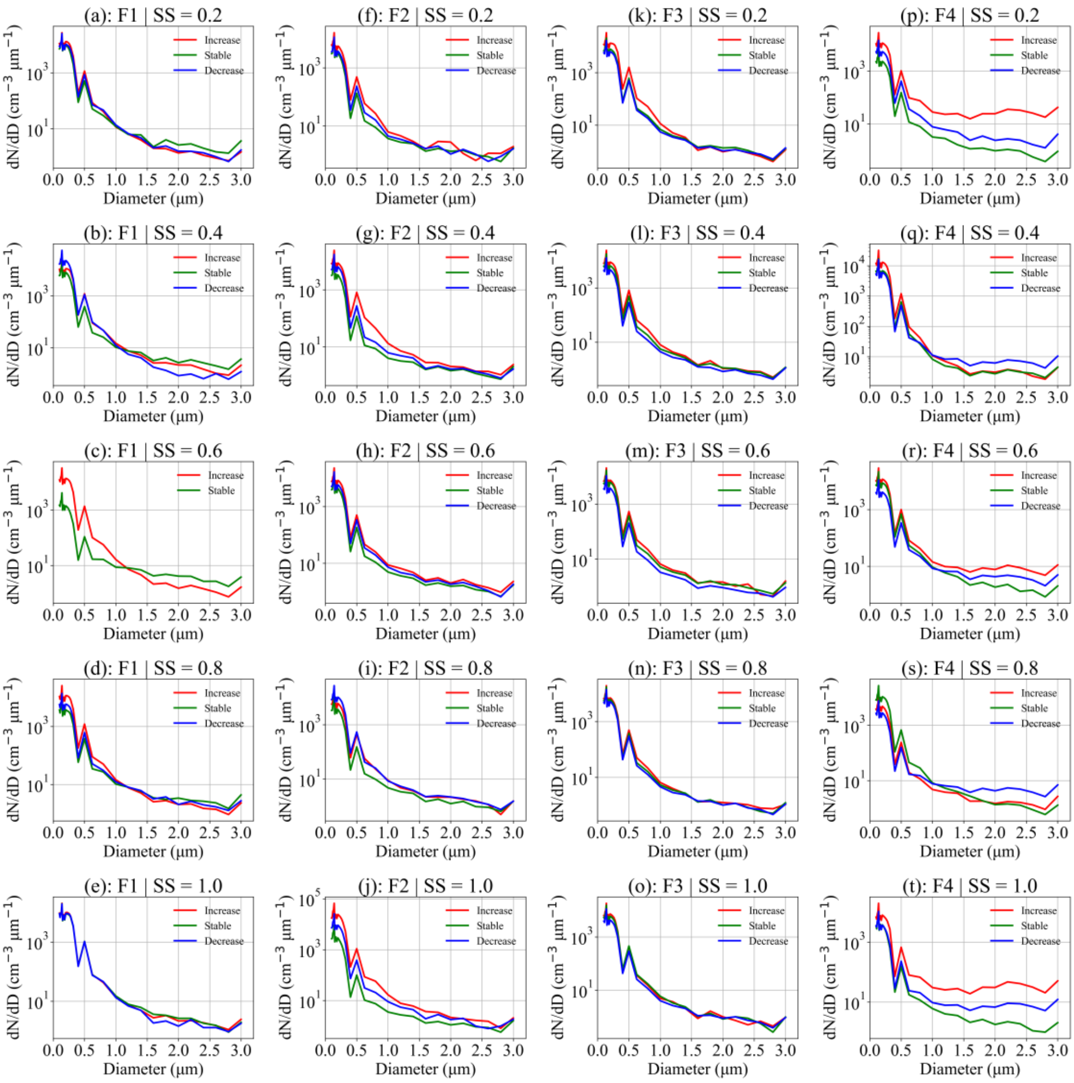

Fig.9. Aerosol size distributions under different supersaturations and aerosol vertical profiles for flights F1–F4. Each column corresponds to the same flight, and each row corresponds to the same supersaturation. Red curves represent the increase profile, green curves represent the stable profile, and blue curves represent the decrease profile.

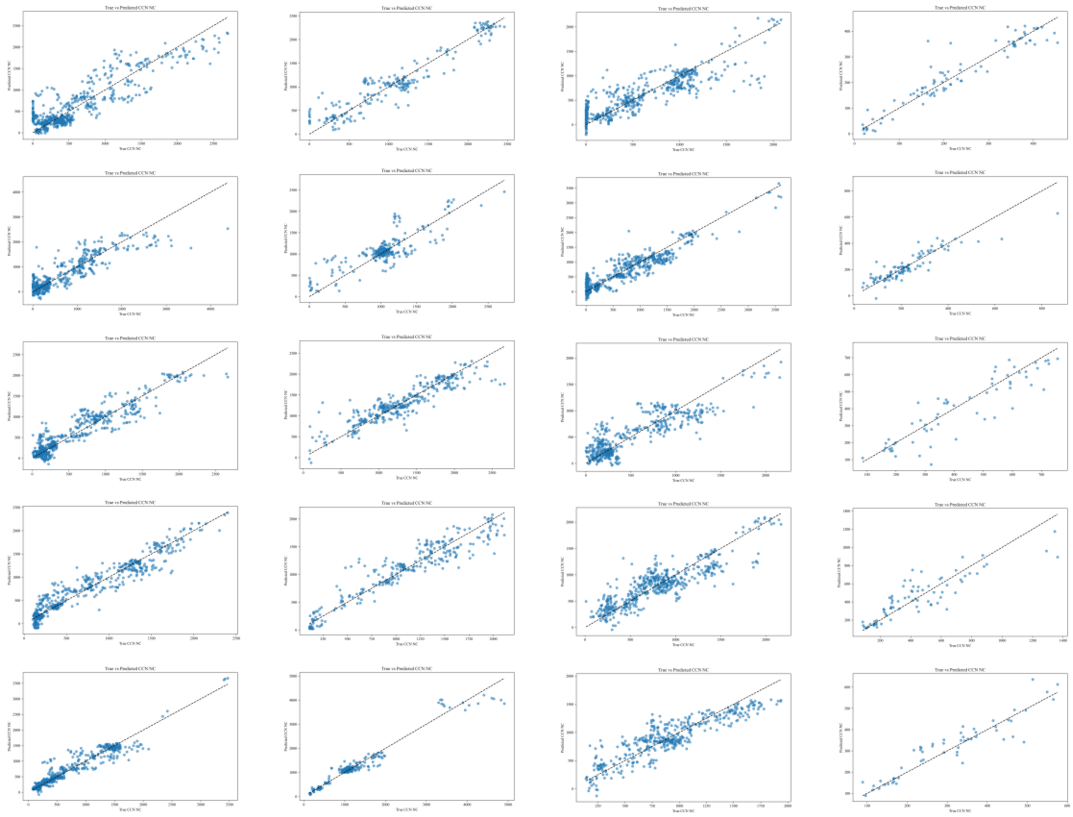

Fig.S10. Scatter plots of predicted versus observed NCCN under different scenarios. The first column represents the decrease profile, the second column the increase profile, the third column the stable profile, and the fourth column deep clouds. Rows from top to bottom correspond to supersaturations from SS0.2 to SS1.0. The black line indicates the 1:1 reference line.

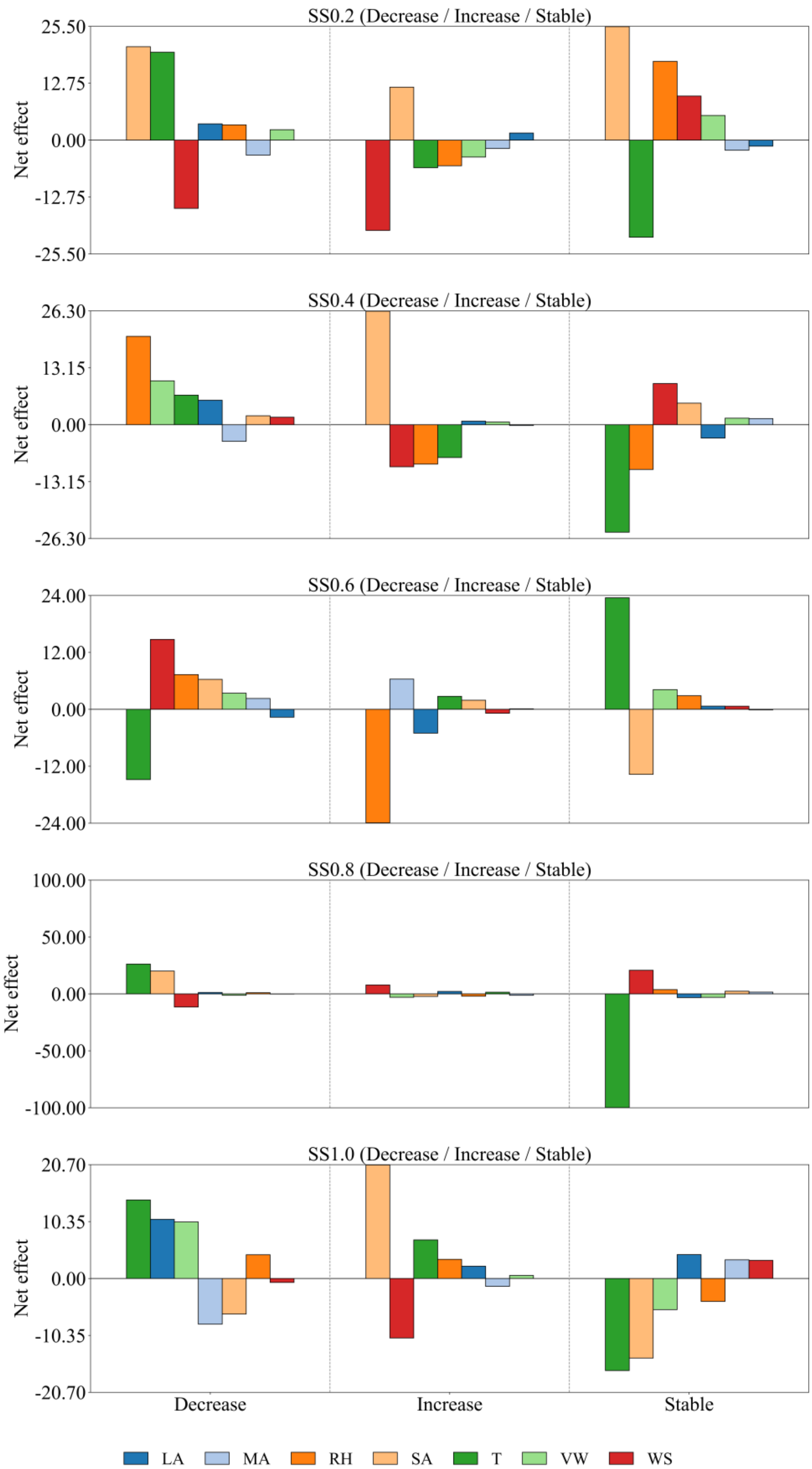

Fig.S11. Net SHAP contributions of different factors under various aerosol vertical profiles.

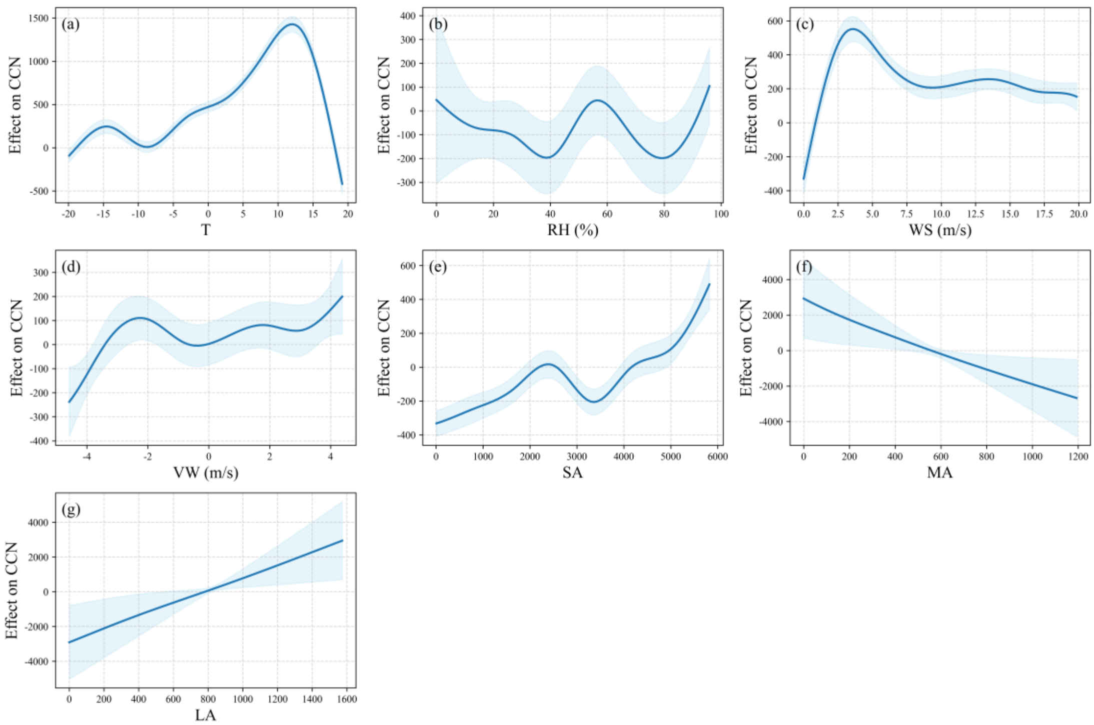

Fig.S12. SHAP values of different factors as a function of factor values under SS = 0.2 in the Decrease aerosol stratification.

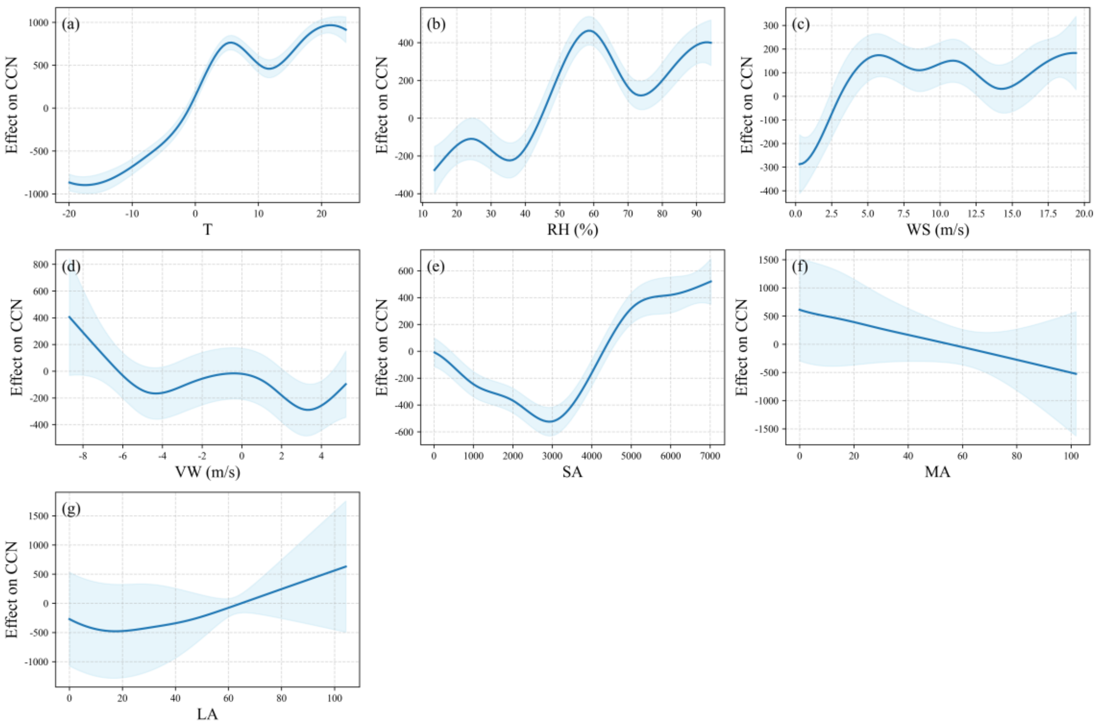

Fig.S13. SHAP values of different factors as a function of factor values under SS = 0.4 in the Decrease aerosol stratification.

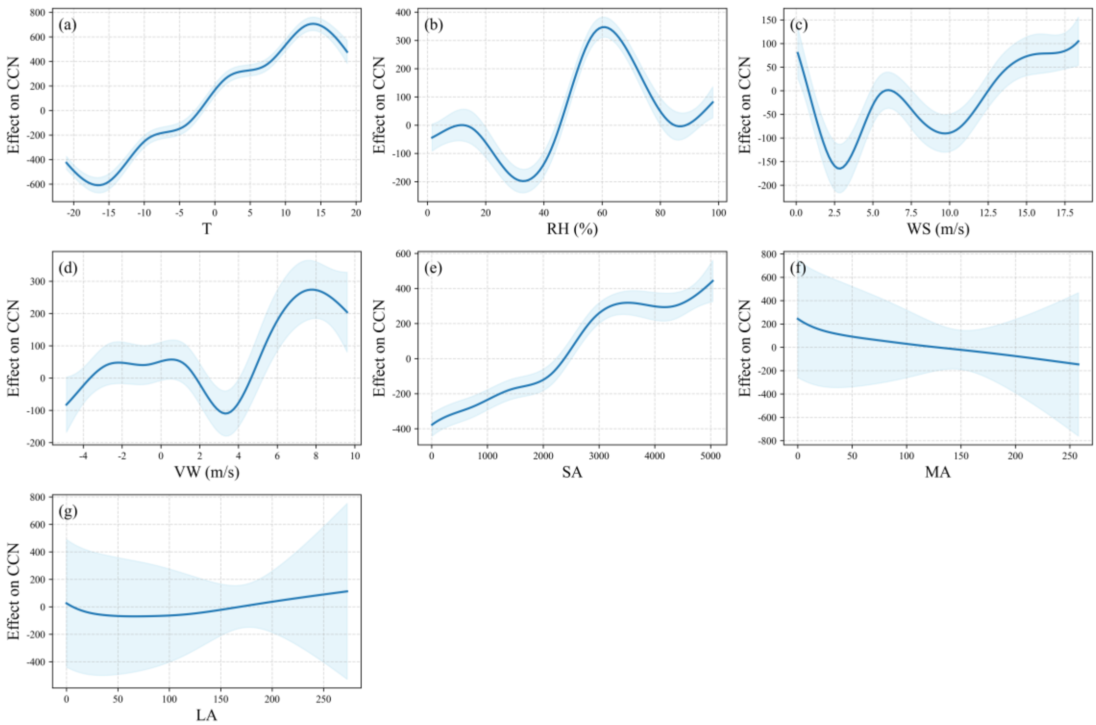

Fig.S14. SHAP values of different factors as a function of factor values under SS = 0.6 in the Decrease aerosol stratification.

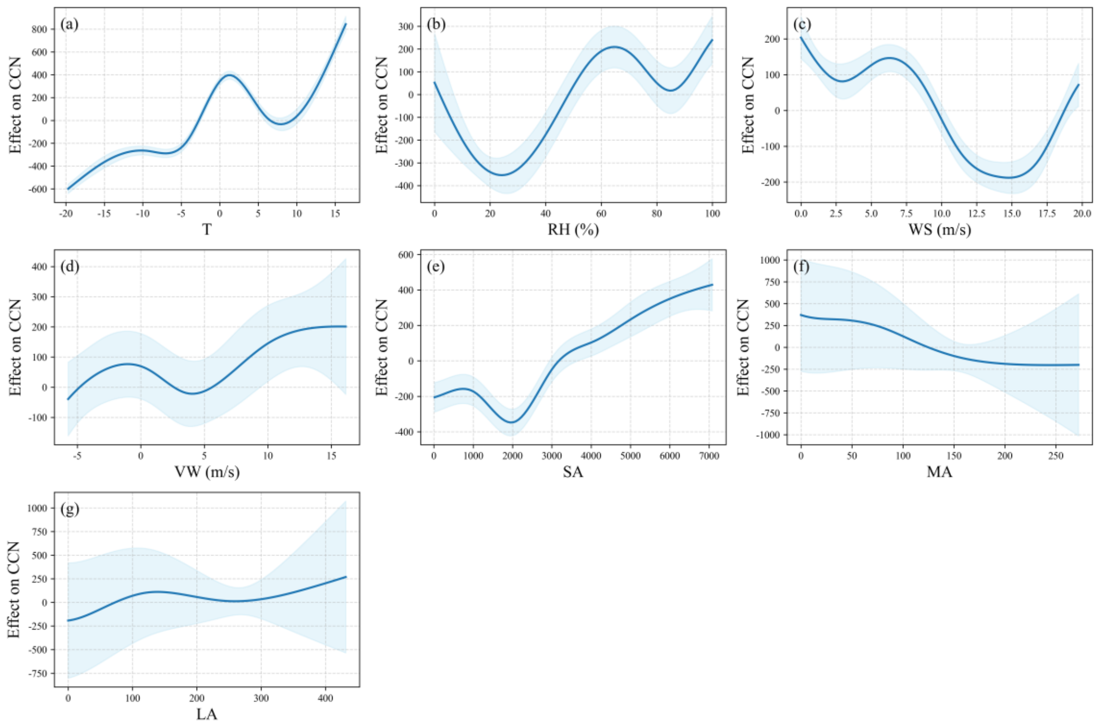

Fig.S15. SHAP values of different factors as a function of factor values under SS = 0.8 in the Decrease aerosol stratification.

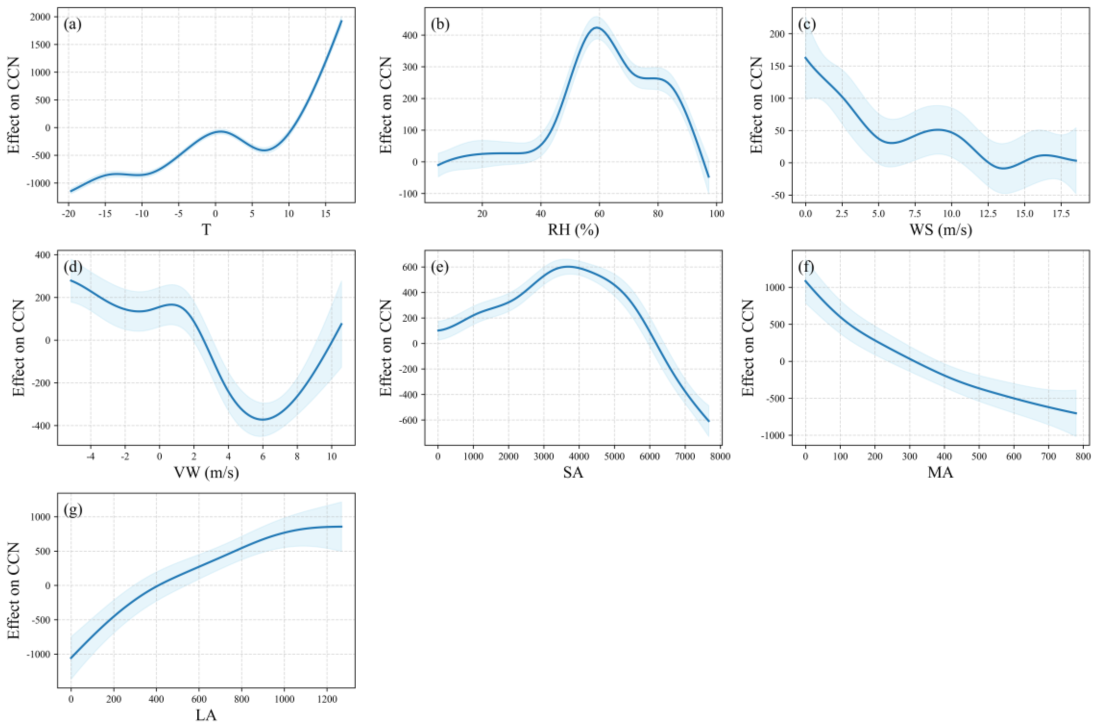

Fig.S16. SHAP values of different factors as a function of factor values under SS = 1.0 in the Decrease aerosol stratification.

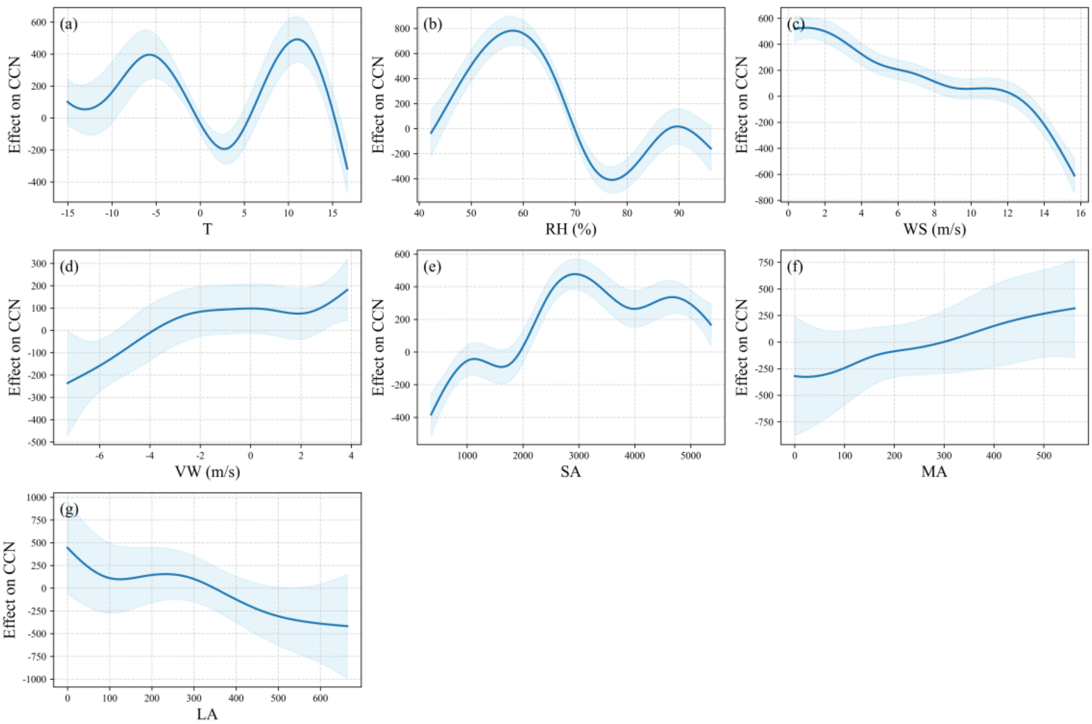

Fig.S17. SHAP values of different factors as a function of factor values under SS = 0.2 in the Increase aerosol stratification.

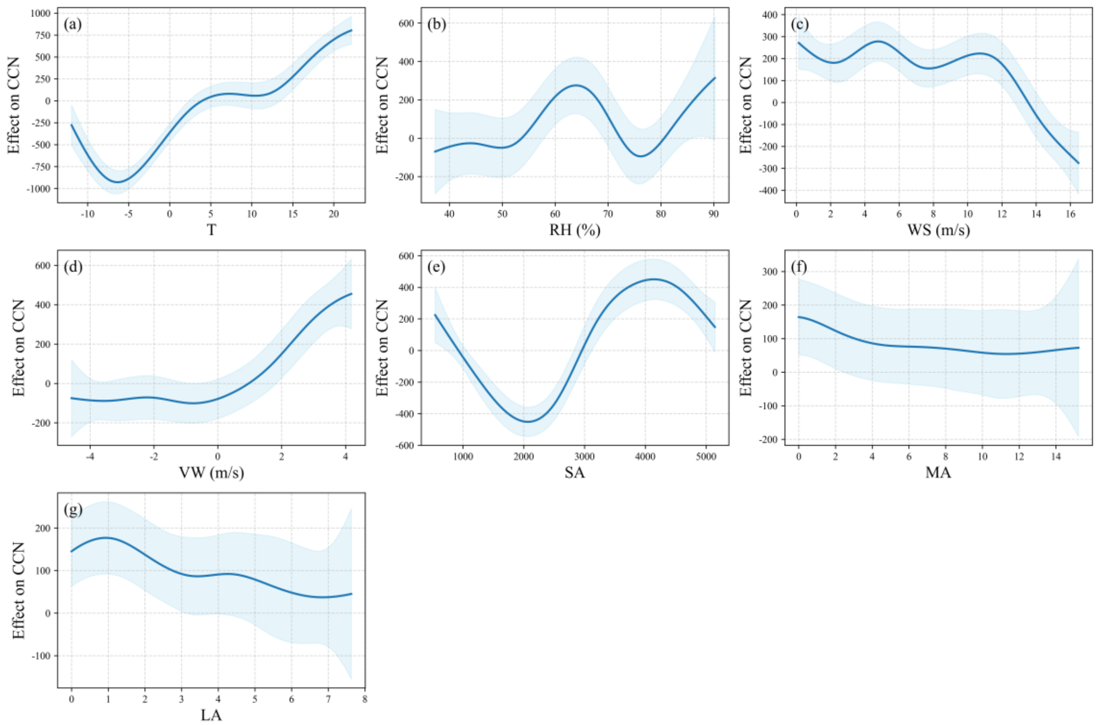

Fig.S18. SHAP values of different factors as a function of factor values under SS = 0.4 in the Increase aerosol stratification.

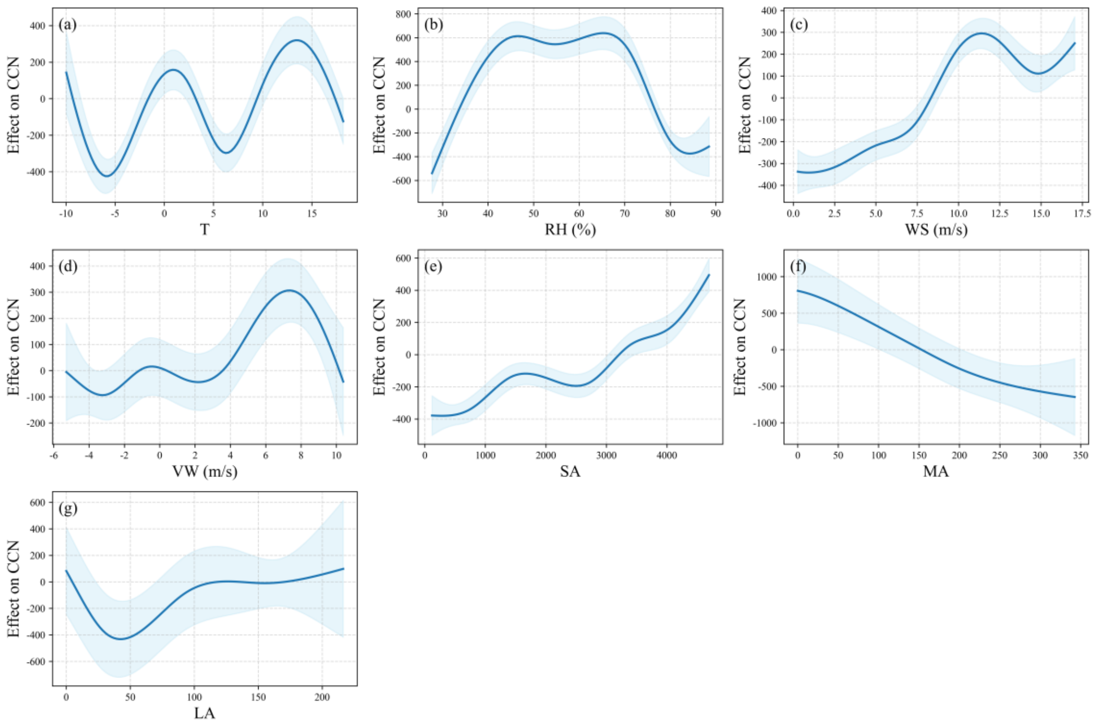

Fig.S19. SHAP values of different factors as a function of factor values under SS = 0.6 in the Increase aerosol stratification.

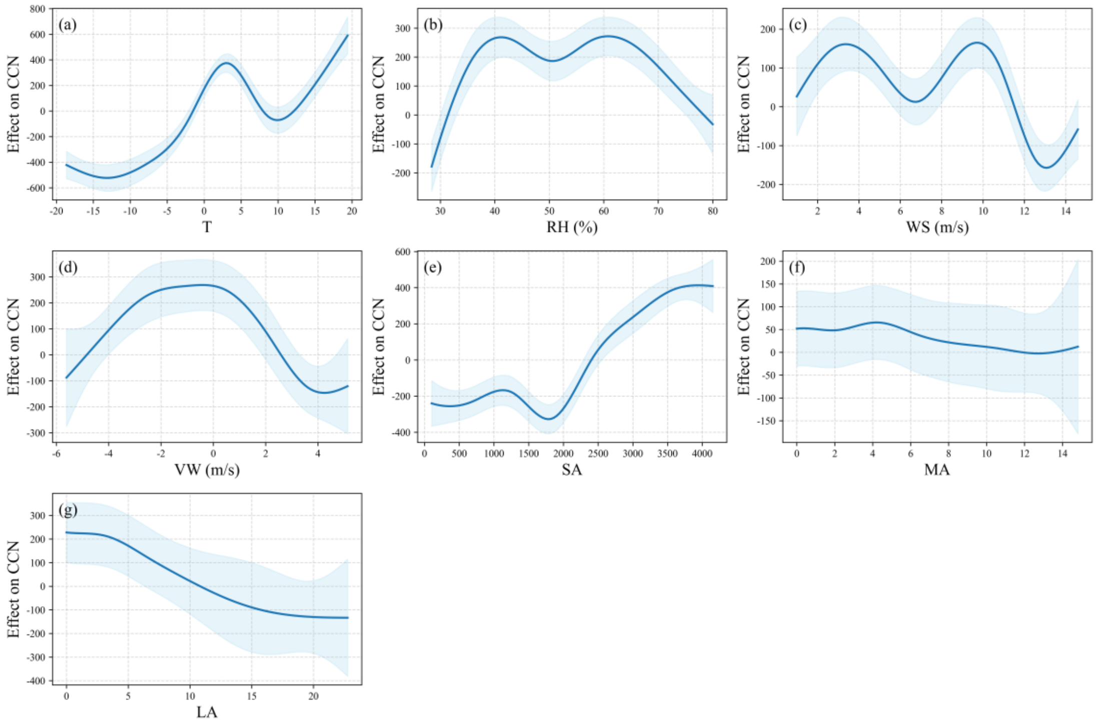

Fig.S20. SHAP values of different factors as a function of factor values under SS = 0.8 in the Increase aerosol stratification.

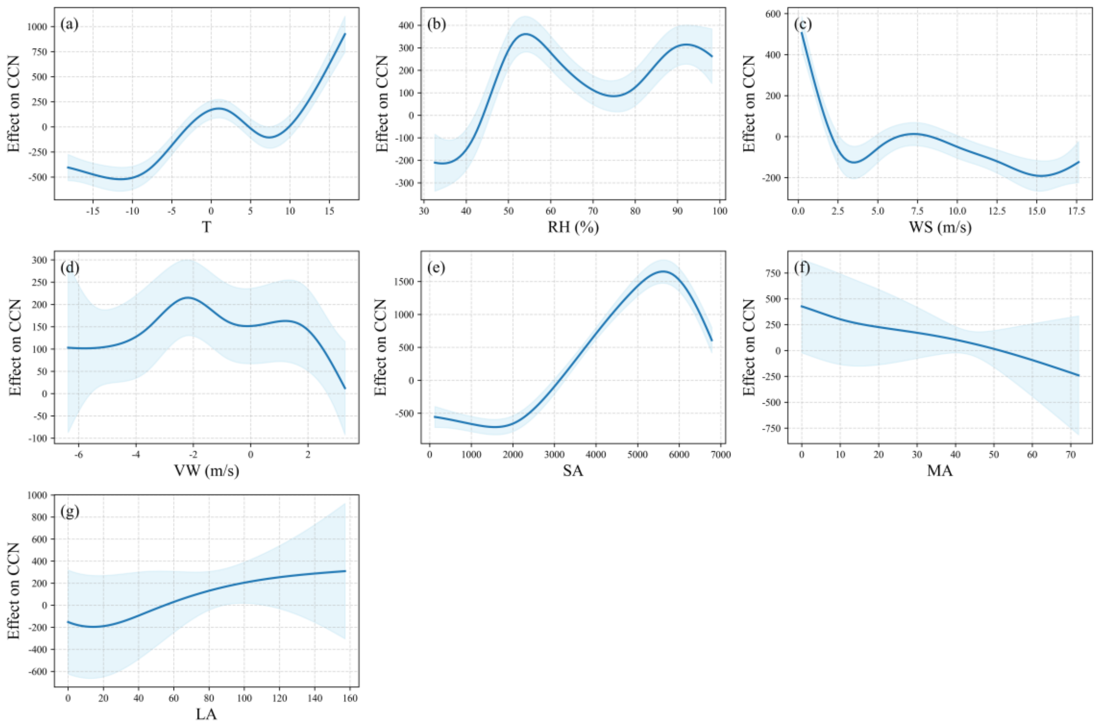

Fig.S21. SHAP values of different factors as a function of factor values under SS = 1.0 in the Increase aerosol stratification.

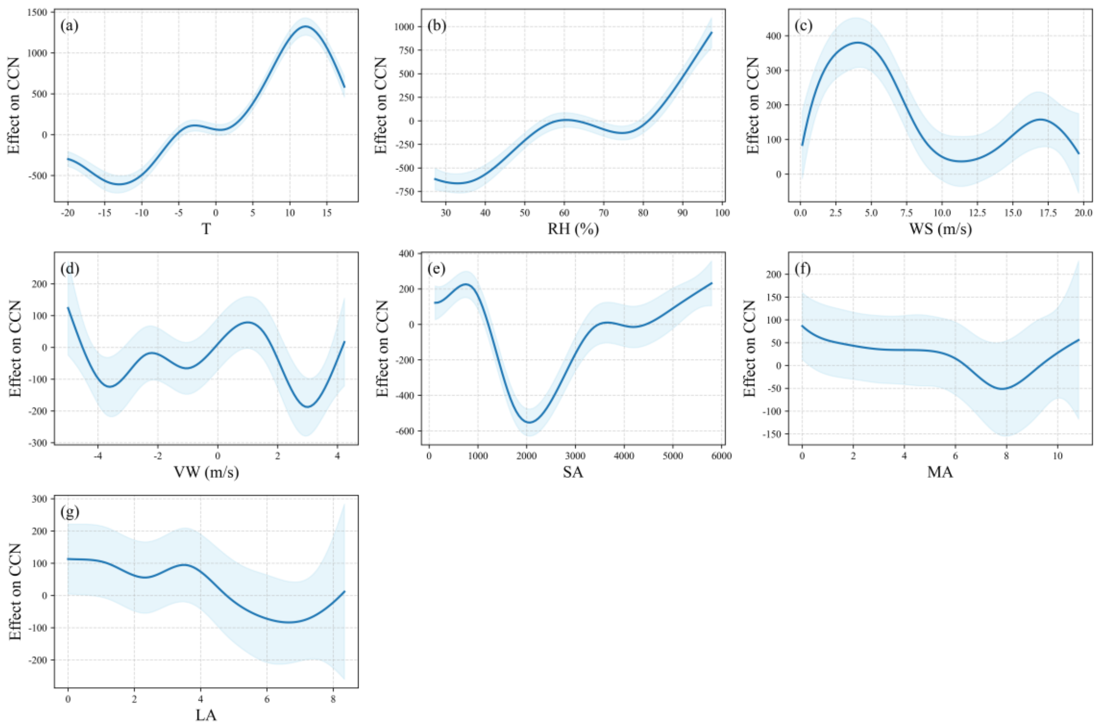

Fig.S22. SHAP values of different factors as a function of factor values under SS = 0.2 in the Stable aerosol stratification.

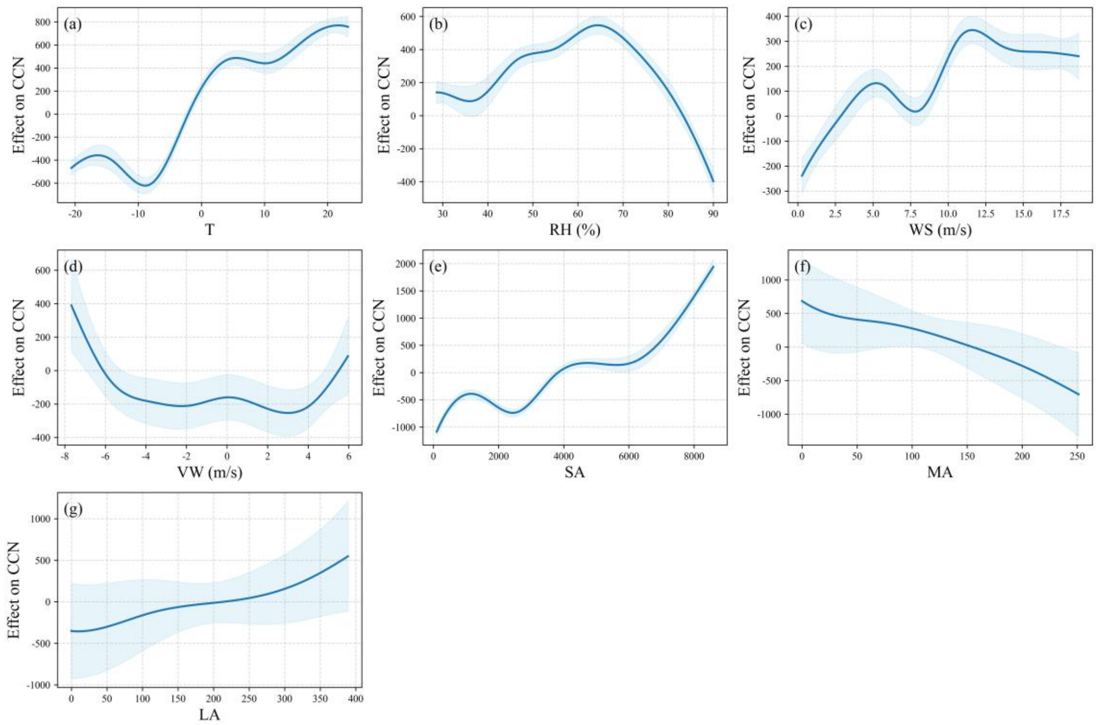

Fig.S23. SHAP values of different factors as a function of factor values under SS = 0.4 in the Stable aerosol stratification.

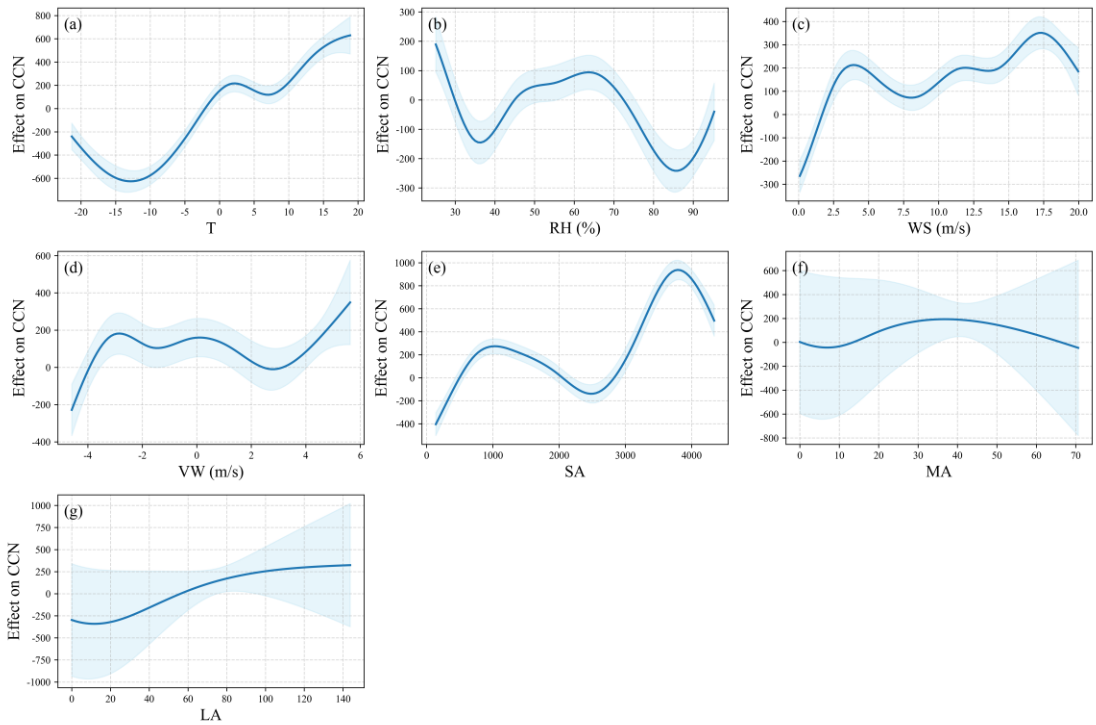

Fig.S24. SHAP values of different factors as a function of factor values under SS = 0.6 in the Stable aerosol stratification.

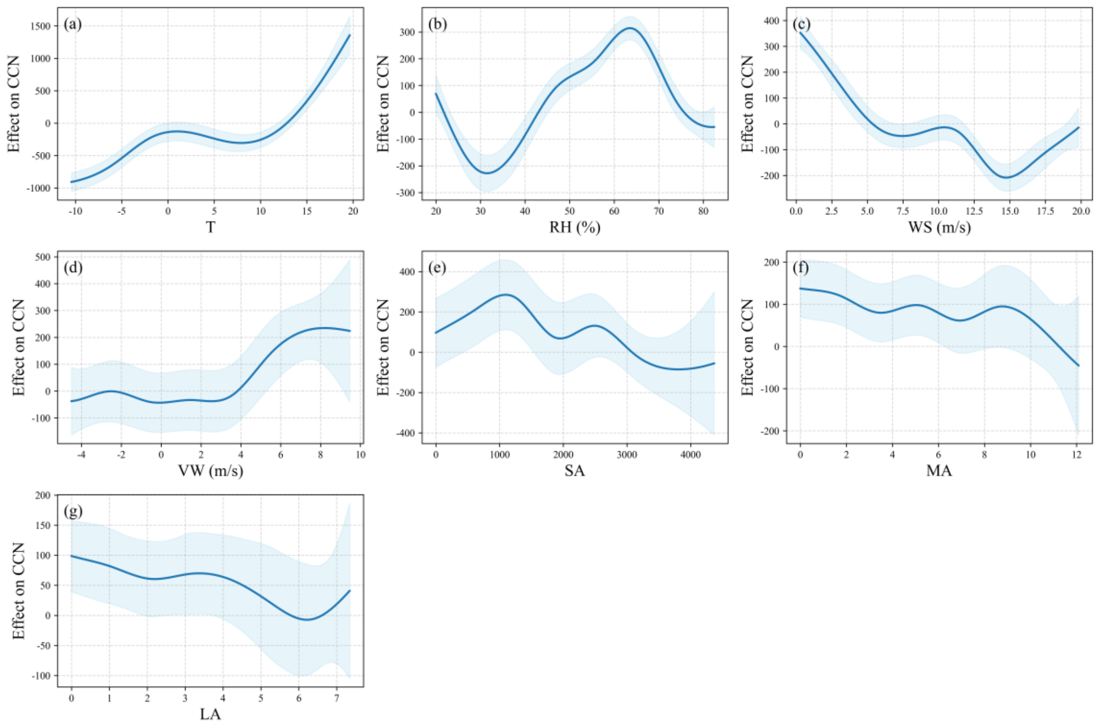

Fig.S25. SHAP values of different factors as a function of factor values under SS = 0.8 in the Stable aerosol stratification.

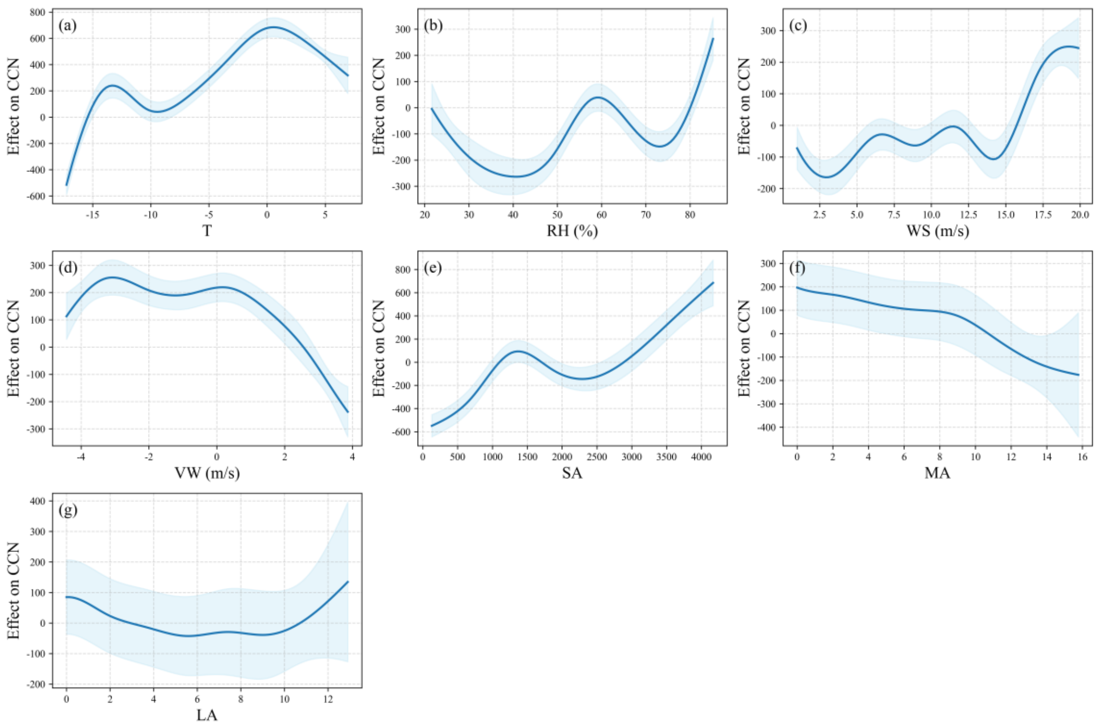

Fig.S26. SHAP values of different factors as a function of factor values under SS = 1.0 in the Stable aerosol stratification.

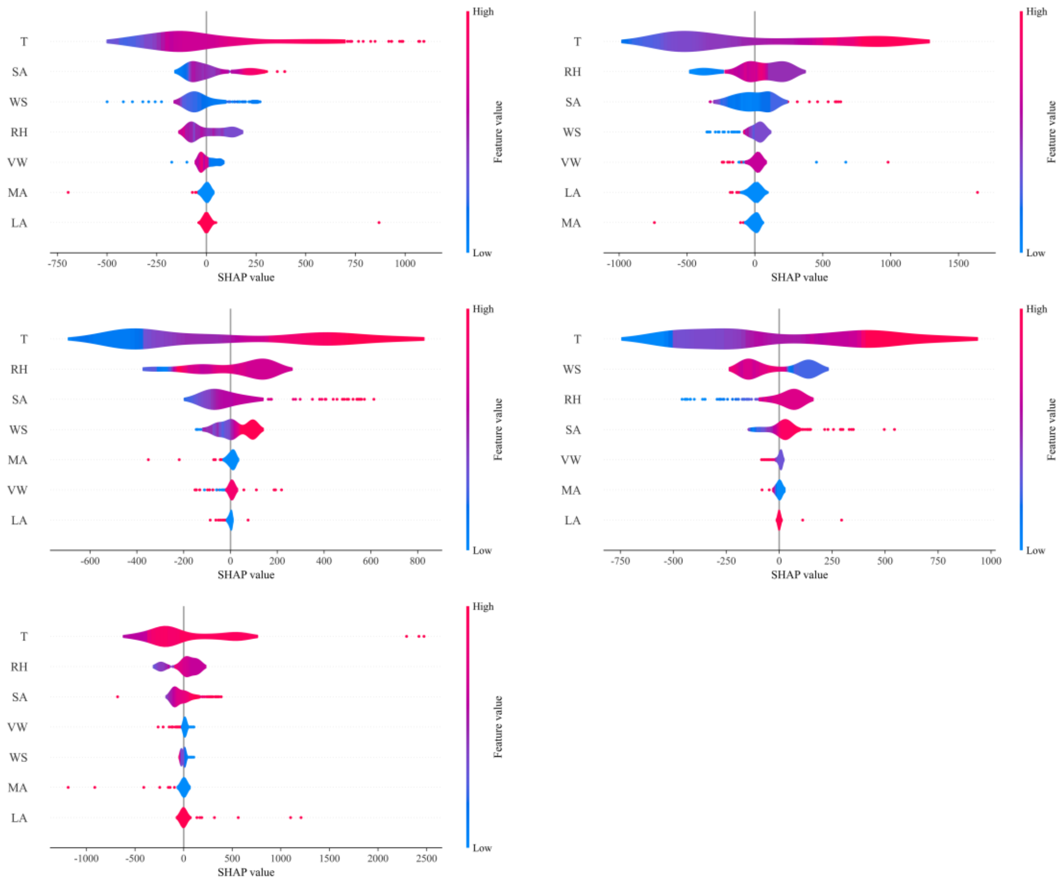

Fig.S27. Stacked SHAP values of different factors under the decrease aerosol vertical profile

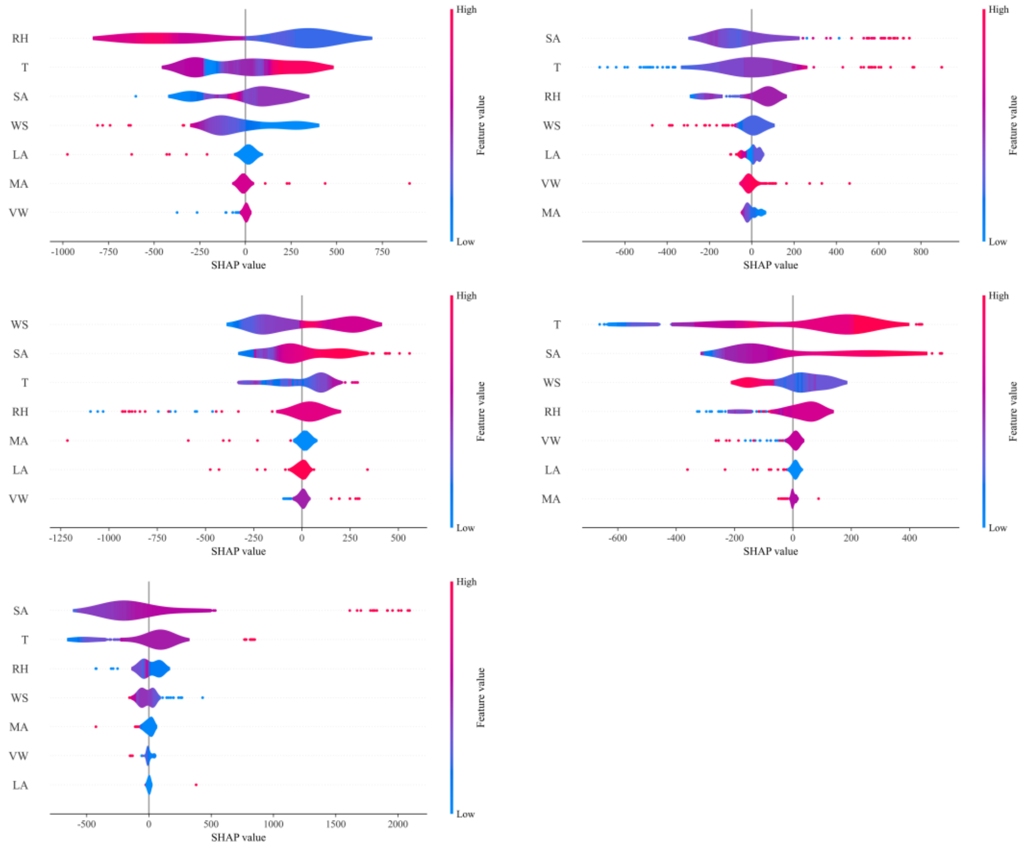

Fig.S28. Stacked SHAP values of different factors under the increase aerosol vertical profile

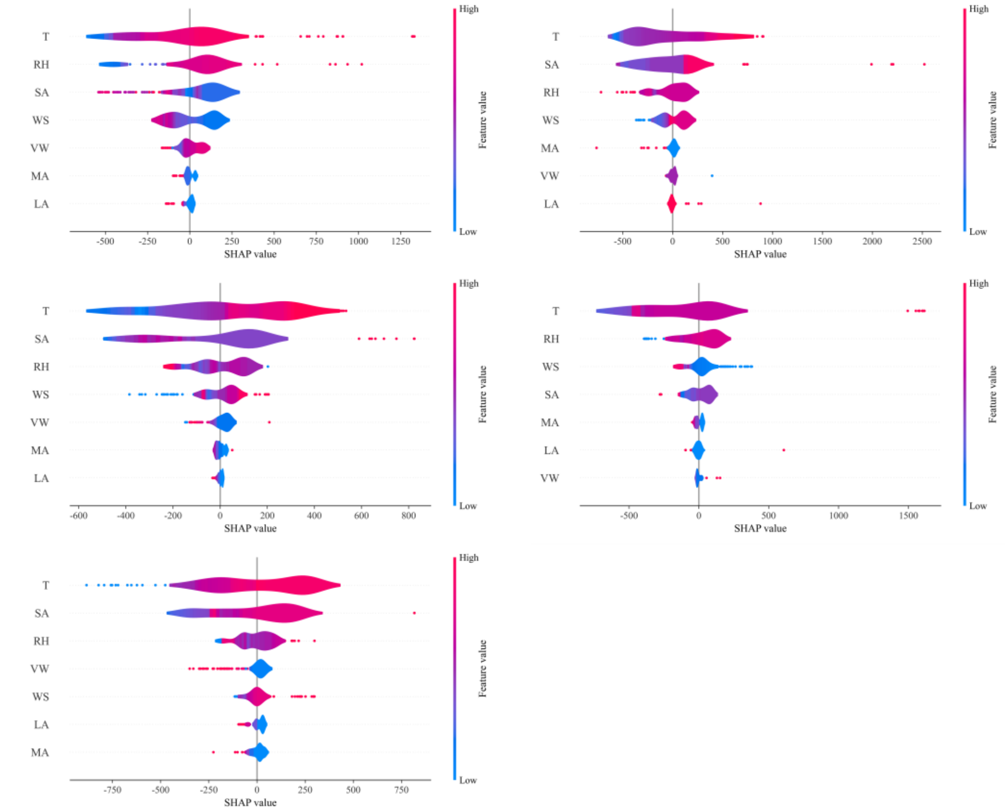

Fig.S29. Stacked SHAP values of different factors under the stable aerosol vertical profile