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Numerical simulation of aerosol concentration effects on cloud droplet size spectrum evolutions of warm stratiform clouds in Jiangxi, China

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Supplement

S1 Cloud-Rain Auto-conversion Threshold Function

The Cloud-Rain Auto-conversion Threshold Function (T) is an important parameter that measures the automatic conversion of cloud to rain. Its numerical value indirectly indicates the strength of the collision-coalescence process in the cloud (Liu et al., 2005, 2006).

$$T = \frac{P}{P_0} = \left[\frac{\int_{r_c}^{\infty} r^6 n(r)dr}{\int_0^{\infty} r^6 n(r)dr}\right]\left[\frac{\int_{r_c}^{\infty} r^3 n(r)dr}{\int_0^{\infty} r^3 n(r)dr}\right] \quad (S1)$$

$$r_c \approx 4.09 \times 10^{-4} \beta_{con}^{1/6} \frac{N_c^{1/6}}{C_{LW}^{1/3}} \quad (S2)$$

In this context, n(r) represents the cloud droplet spectrum, where r is the cloud droplet radius, rc is the critical radius of the auto-conversion function, and βcon = 1.15 × 10^{23}. The value of T ranges from 0 to 1, where T = 0 indicates no collision-coalescence process, and T = 1 indicates complete occurrence of the collision-coalescence process. A higher value of T indicates a higher probability of collision-coalescence occurring.

S2 Calculation of cloud droplet spectrum parameters

The average cloud droplet diameter (Rm), cloud droplet volume-weighted radius (Rv), standard deviation (σ_c) and cloud droplet spectral relative dispersion (ε) were calculated as follow:

$$R_m = \frac{1}{N}\sum_{i=1}^{k} r_i n_i \quad (S3)$$

$$R_v = \left(\frac{1}{N}\sum_{i=1}^{k} r_i^3 n_i\right)^{\frac{1}{3}} \quad (S4)$$

$$\sigma_c = \left(\frac{1}{N}\sum_{i=1}^{k} (r_i - R_m)^2 n_i\right)^{\frac{1}{2}} \quad (S5)$$

$$\varepsilon = \frac{\sigma_c}{R_m} \quad (S6)$$

ni represents the number concentration of cloud droplets in each size bin (unit: cm^{-3}), N is the total number concentration of cloud droplets (unit: cm^{-3}), ri denotes the particle radius of cloud droplets in each size bin (unit: μm), rv is the volume-weighted mean radius of cloud droplets (unit: μm), σc is the standard deviation of the cloud droplet spectrum (unit: μm), and ε represents the cloud droplet spectral relative dispersion (dimensionless).

S3 Cloud Droplet Activation Intensity

Lu et al. (2020) introduced the variable FBS (First Bin Strength), which represents the Cloud Droplet Activation Intensity.

$$Fbs = \frac{n_1}{n_c} \quad (S7)$$

n_1 represents the number concentration of the first bin in the cloud droplet spectrum, measured in cm^{-3}. When the value of FBS is larger, it indicates a higher probability of the peak of the cloud droplet spectrum occurring in the first bin, which means there are more small droplets in the cloud. This suggests a stronger influence of aerosol activation or small droplet deactivation.

S4 ε-Rv Correlation Coefficient Table

The formula for calculating the liquid water path (LWP) is as follows:

$$LWP = \int_{Zmin}^{Z_{max}} Clw(z)dz \quad (S8)$$

Clw(z) represents the liquid water content at height z, with units in g/m^3.

S5 ε-Rv Correlation Coefficient Table

Table S1 ε-Rv Correlation Coefficient

	ORG	NM	AM	CM	DTM	ITM
Rv < 4.2μm	0.291	0.326	0.434	0.504	0.600	0.439
4.2μm < Rv < 8μm	-0.021	-0.014	0.201	-0.007	-0.109	0.190
Rv > 8μm	-0.137	-0.121	-0.317	-0.124	-0.309	-0.280