Supplement of "An airborne study of the aerosol effect on the dispersion of cloud droplets in a drizzling marine stratocumulus cloud over eastern China"

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1. Synoptic situation of this study

Figure S1 shows the synoptic field using National Centers for Environmental Prediction reanalysis data at 00:00 UTC on 4 September 2016. The 500-hPa geopotential height shows two typical pressure lows impacting the experimental region. The 850-hPa wind directions indicate that winds from the east dominated.

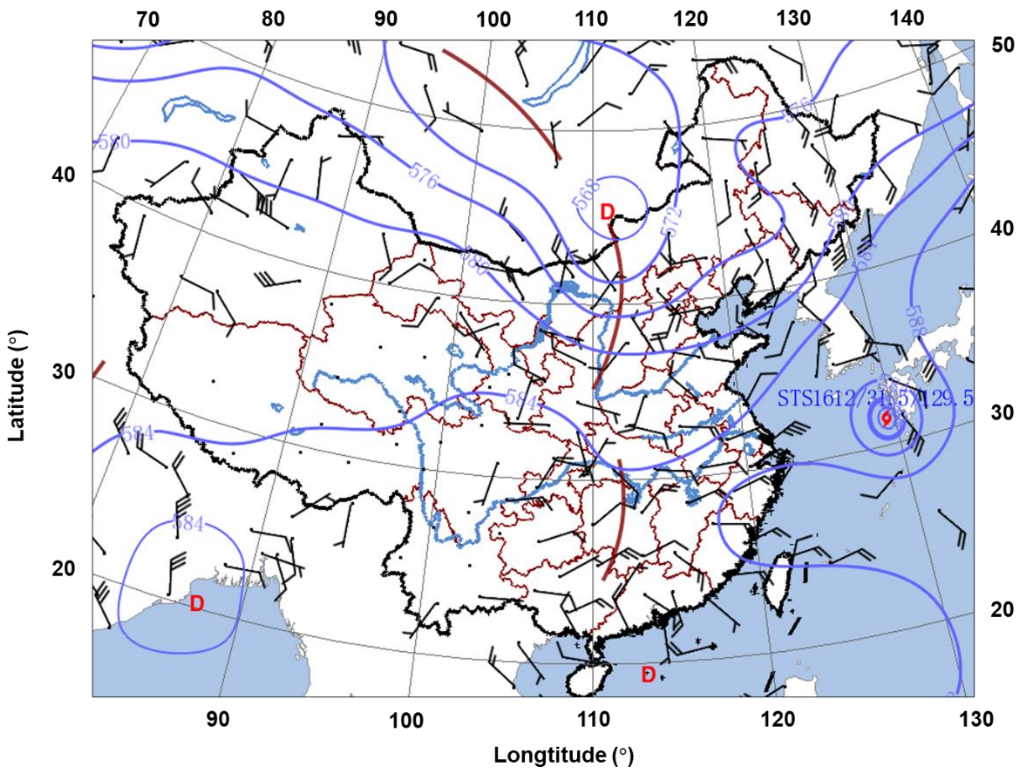

Figure S1. Geopotential heights at 500 hPa at 00:00 UTC on 4 September 2016 with 850-hPa wind directions superimposed.

2. Discussion of the number of sampled data during cloud penetration

Unlike a convective cloud, which has clear boundaries that distinguish between inside and outside of the cloud, a stratocumulus cloud's boundaries are more extensive and complicated. In this study, the research aircraft took about 10 min to fly from a cloud-free area to the interior of the cloud (Figure S2). Five hundred to six hundred data samples were collected nearing the cloud and at the cloud boundary in addition to sampled data inside the cloud and in the cloud-free area.

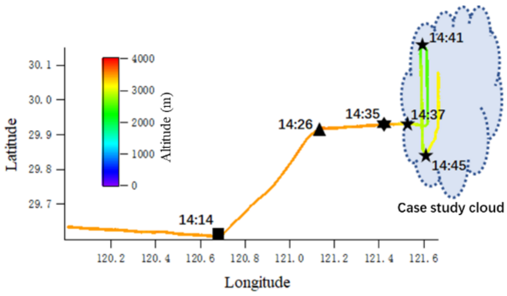

Figure S2. Schematic diagram showing the flight track of the research aircraft from the cloud-free area to the interior of the cloud. The black symbols represent UTC times at specific spatial positions corresponding to Figure 6 in the paper.

3. Parameterization of *ε* and *β*

The parameter β can be parameterized by establishing a relationship between ε and β. According to previous research on cloud microphysical schemes in GCMs, lognormal, gamma, and Weibull distribution functions are most commonly used.

From the definition of ε and β, we have the following expressions for $\beta(\varepsilon)$:

For the lognormal droplet size distribution:

$$\beta = 1 + \varepsilon^2 . \tag{S1}$$

For the gamma droplet size distribution:

$$\beta = \frac{\left(1+2\varepsilon^2\right)^{\frac{2}{3}}}{\left(1+\varepsilon^2\right)^{\frac{1}{3}}} . \tag{S2}$$

For the Weibull droplet size distribution:

$$\beta = 1.04 \frac{\Gamma^{\frac{2}{3}}\left(3\varepsilon\right)}{\Gamma\left(2\varepsilon\right)} \varepsilon^{-\frac{1}{3}} . \tag{S3}$$

Figure S3a shows the relationship between β (calculated using observational data) and ε for cloud droplets. Also shown are parameterized β based on the three functions. Here, the gamma and lognormal distributions describe better the cloud droplet size distribution (coefficient of determination, $R^2 = 0.92$). The Weibull distribution slightly overestimated most of the calculated β ($R^2 = 0.89$). For drizzle drops (Figure S3b), calculated and parameterized βs matched the best when $\varepsilon < 0.5$. As ε increased, the scatter in calculated β increased, and the three parameterizations deviated more from each other. The correlation between calculated and lognormal-parameterized β ($R^2 = 0.76$) was better than that based on the gamma- ($R^2 = 0.69$) and Weibull-based parameterizations ($R^2 = 0.70$). Overall, the correlation between cloud droplet β and ε was tighter than that for drizzle drops. Summarizing, the lognormal, gamma, and Weibull distributions are, in general, more suitable for fitting the cloud droplet spectrum but can be used to fit the drizzle drop spectrum for values of $\varepsilon < 0.5$.

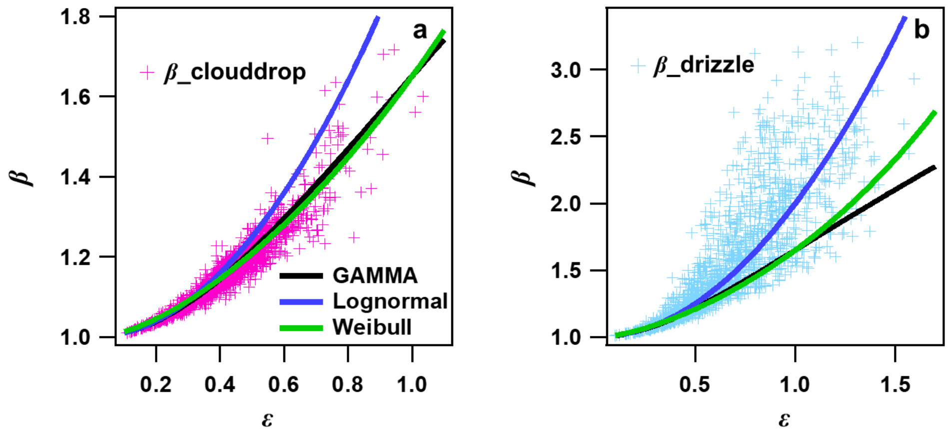

Figure S3. Effective radius ratio (β, calculated from observational data) as a function of relative dispersion (ε) for (a) cloud droplets (pink crosses) and (b) drizzle drops (blue crosses). Black, blue, and green curves correspond to parameterized β based on lognormal, gamma, and Weibull distributions.

Table S1. Coefficients of determination between calculated β (based on observational data) and parameterized β (based on lognormal, gamma, and Weibull distributions).

Function	R^2_cloud droplet	R^2_drizzle
Gamma distribution	0.92	0.69
Lognormal distribution	0.89	0.76
Weibull distribution	0.92	0.70

4. Representativeness of the case study cloud

We analyzed the differences in microphysical parameters (such as ε, ε-N_c, k, and so forth) between the cloud examined in this study and clouds reported in previous studies to discuss the representativeness of the case study. Table S1 lists the relationships between ε and N_c from other studies as an example, providing a perspective of this study with respect to previous ones.

Table S2. Relationship of ε and N_c from previous studies.

Reference	Relationship	Fitting equation	Cloud type	Method
Liu and Daum (2002)	Positive		Marine stratus	Observation
Rotstayn and Liu (2003); Rotstayn and Liu (2009)	Positive	ε = 1-0.7exp(-0.003N_c)	Marine stratus	Observation; Modeling
Pandithurai et al. (2012)	Positive		Warm continental cumuli	Observation
Anil Kumar et al. (2016)	Positive		Warm continental clouds	Observation
M.-L. Lu et al. (2007)	Negative		Marine Stratus/Stratocumulus	Observation
C. Lu et al. (2012)	Negative		Continental cumulus	Observation
Pawlowska et al. (2006)	Negative			Observation
Ma et al. (2010)	Negative	ε = 0.694-0.000426N_c	Non-precipitating continental clouds	Observation
Martins and Silva Dias	Negative		Marine stratocumulus	Observation

(2009)				
Desai et al. (2019)	Negative			Observation
Grabowski (1998)	Negative	ε = 0.146-5.964×10^{-2} ln(N_c /2000)	Maritime and continental clouds	Theoretical calculation
Daum et al. (2007)	Negative	ε = 0.82-0.00134N_c	Marine Stratus/Stratocumulus	Observation
Cecchini et al. (2017)	Negative			Observation
Zhao et al. (2006)	Convergent		Continental clouds	Observation
Deng et al. (2009)	Convergent		Continental clouds	Observation
Tas et al. (2015)	Uncorrelated			Observation
M.-L. Lu et al. (2008)	Unclear		Continental cumuli	Observation

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