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Effects of thermodynamics, dynamics and aerosols on cirrus clouds based on in situ observations and NCAR CAM6

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Note: Figures S4, S7 to S12 are sensitivity tests that use in-cloud quantities from model output in the analysis, which differ from the analysis in the main text that uses grid-mean quantities from model output.

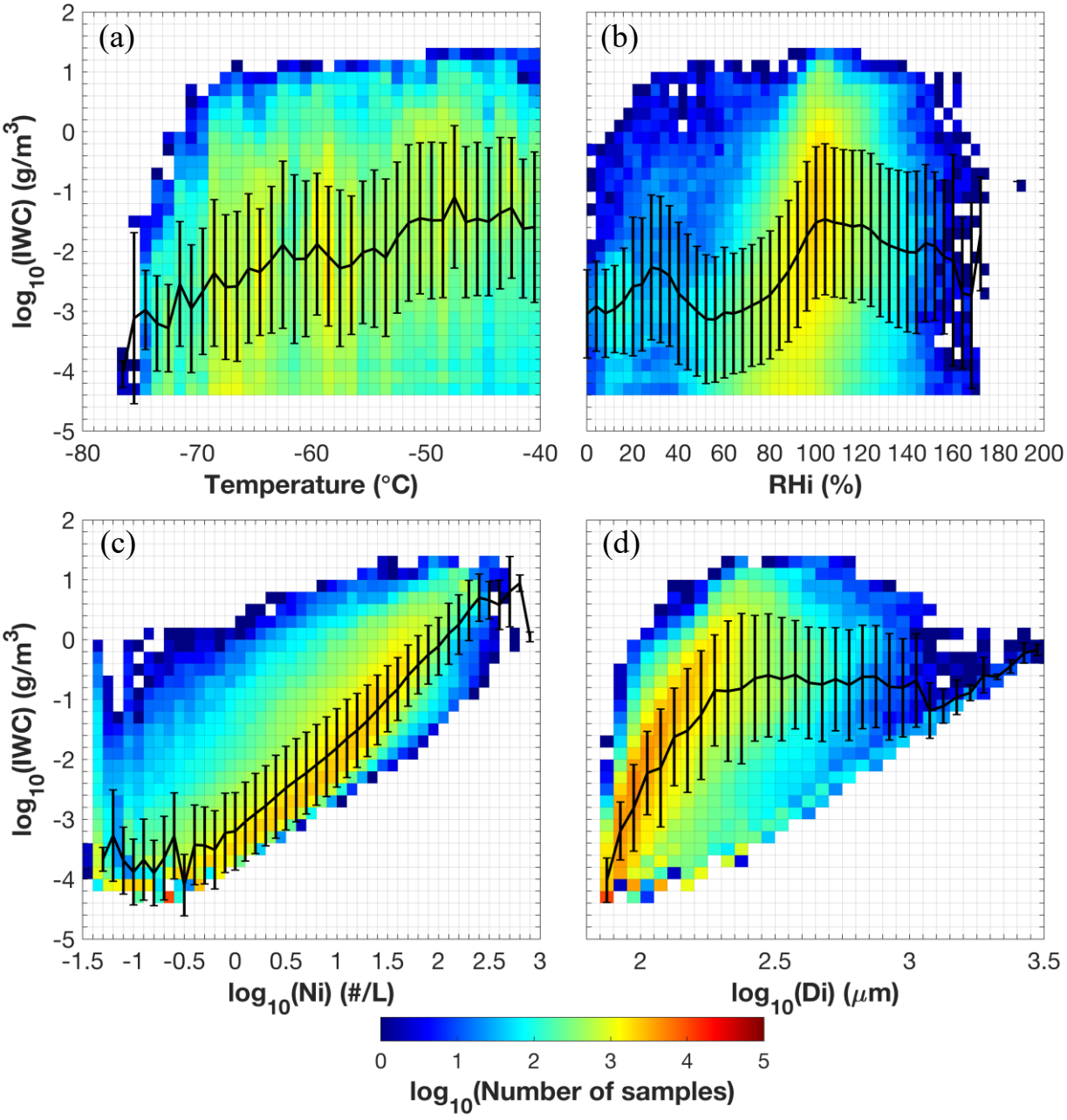

Figure S1. Number of samples of log-scale IWC values in the observations related to various meteorological conditions (i.e., (a) temperature and (b) RHi) and microphysical properties (i.e., (c) log-scale Ni and (d) Di). Average IWC values and standard deviations are represented by black lines and whiskers, respectively. Note that all samples are for temperature ≤ -40ºC.

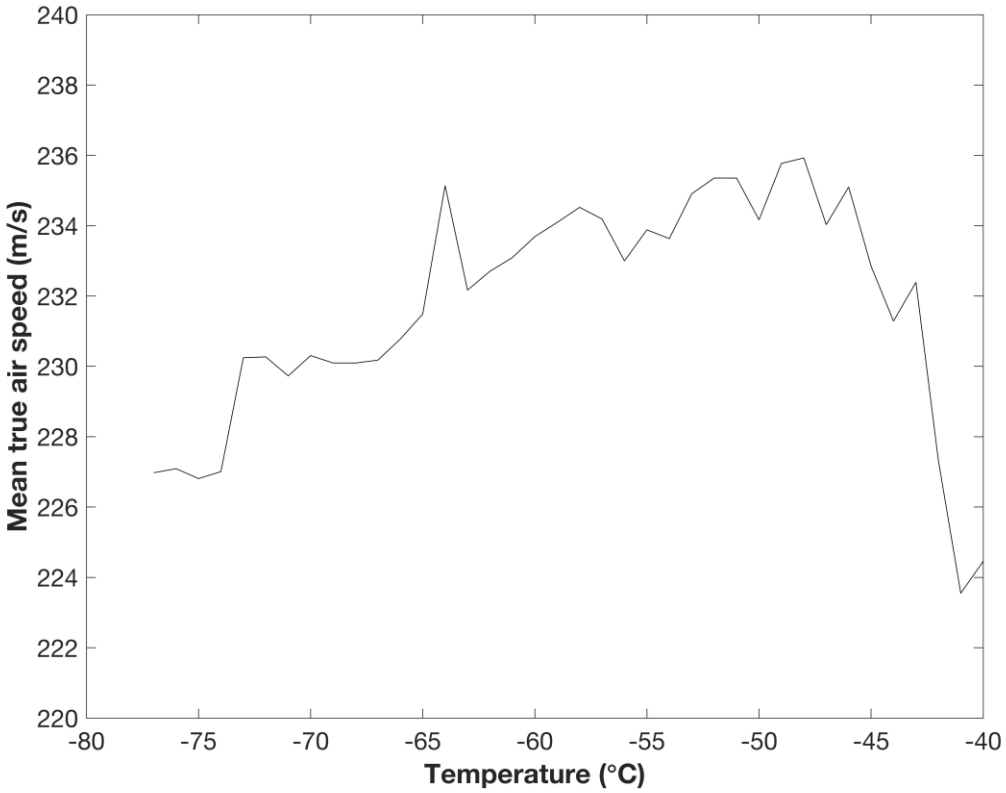

Figure S2. Average mean true air speed for temperatures ≤ -40ºC based on observations from all aircraft campaigns used in this study.

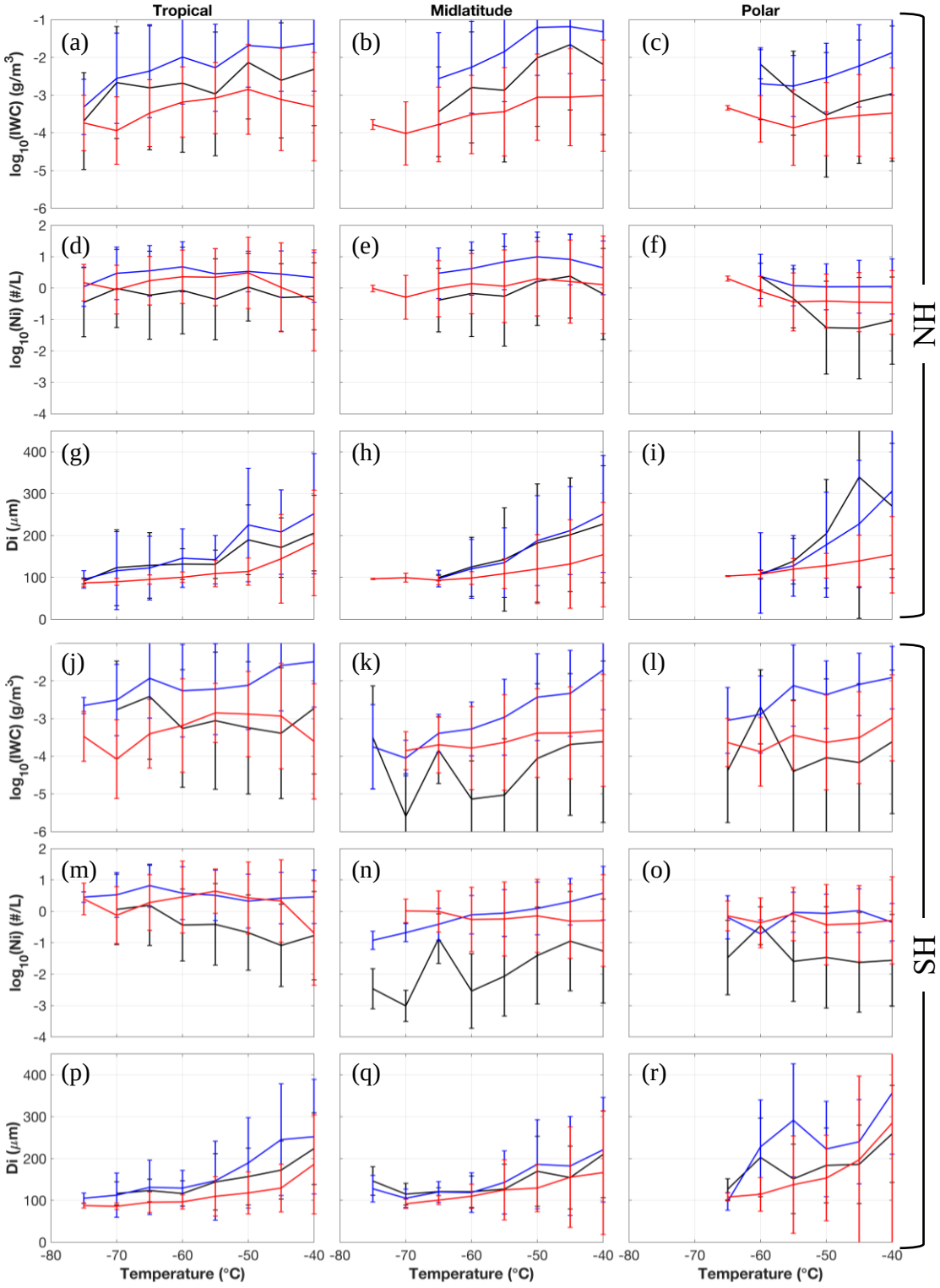
Tropical
Midlatitude
Polar
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)
(l)
(m)
(n)
(o)
(p)
(q)
(r)
log10(IWC) (g/m3)
log10(Ni) (#/L)
Di (μm)
NH
SH
Temperature (°C)
-80
-70
-60
-50
-40

Figure S3. Similar to Figure 5, except for adding whiskers representing ± one standard deviation for observations and simulations. Northern and Southern Hemispheres (NH and SH) are shown in top three rows and bottom three rows, respectively. Number of samples in this figure is the same as those shown in Figure 5 caption.

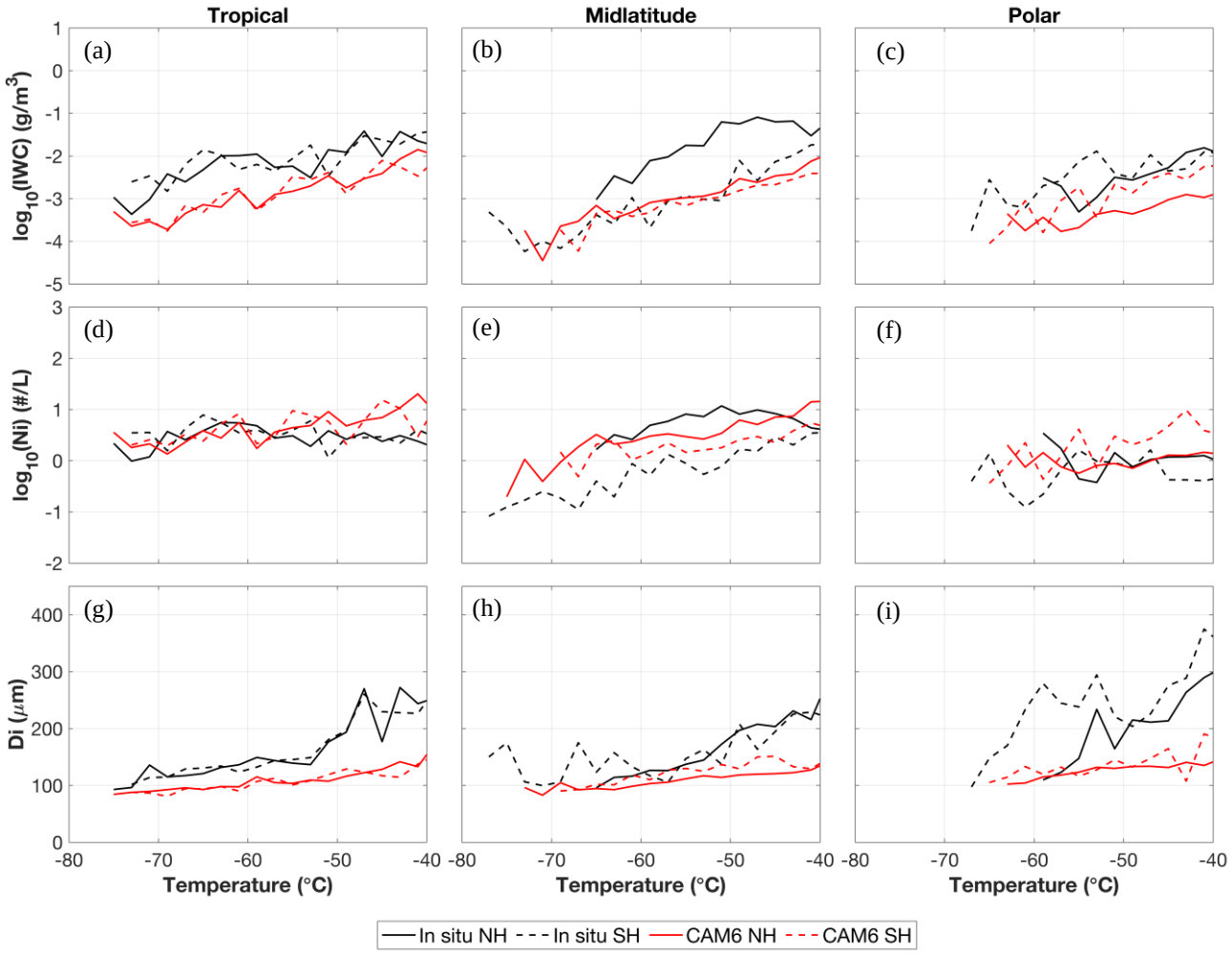

Figure S4. Similar to Figure 5, except for comparing in-cloud quantities from model output with 1-Hz observations. Geometric means of (a – c) IWC and (d – f) Ni, as well as (g – i) linear averages of Di at 2ºC temperature intervals between -80ºC and -40ºC, compared between 1-Hz in situ observations (black lines) and CAM6-nudg (red lines). Observed and simulated microphysical properties are separated into six latitudinal regions, where NH is denoted by solid lines, and SH is denoted by dashed lines.

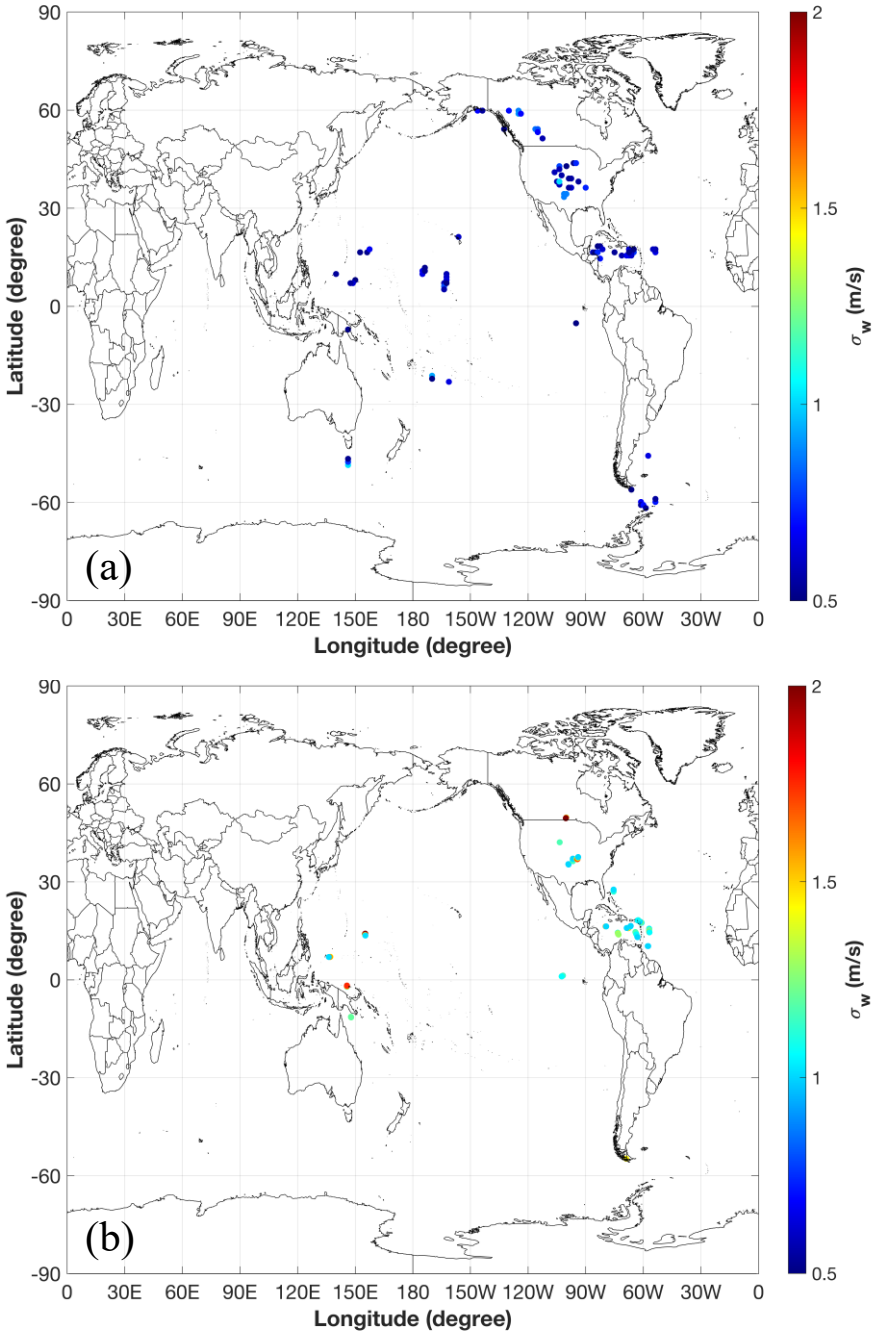

Figure S5. (a) Locations of simulated in-cloud samples with wsub > 0.5 m/s, color coded by σ_w. (b) Locations of observed in-cloud samples with σ_w > 1 m/s, color coded by σ_w calculated for every 430 seconds.

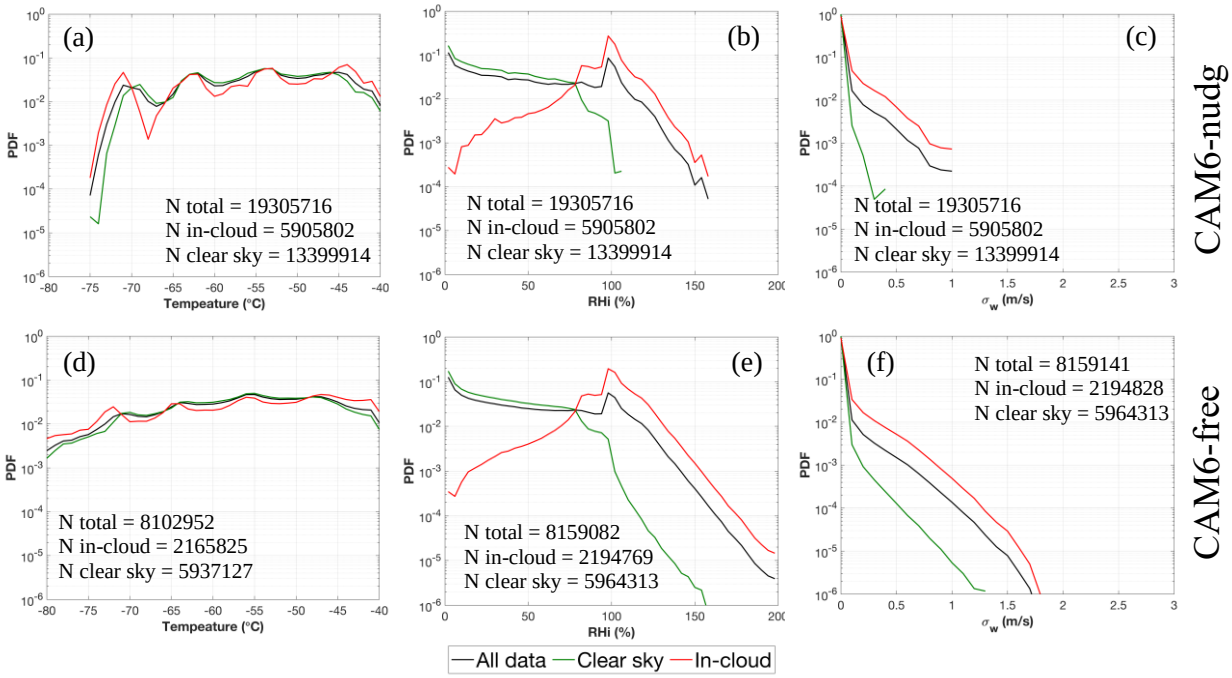

Figure S6. Similar to Figure 12, except for using ice crystals > 1 μm in the analysis of simulated in-cloud data. Probability density functions (PDFs) of temperature (first column), RHi (second column) and σ_w (third column) for (a – c) CAM6-nudg, and (d – f) CAM6-free. Figure S6 shows a 4% increase of number of samples for simulated in-cloud conditions compared with Figure 12 (restricted to ≥ 62.5 μm).

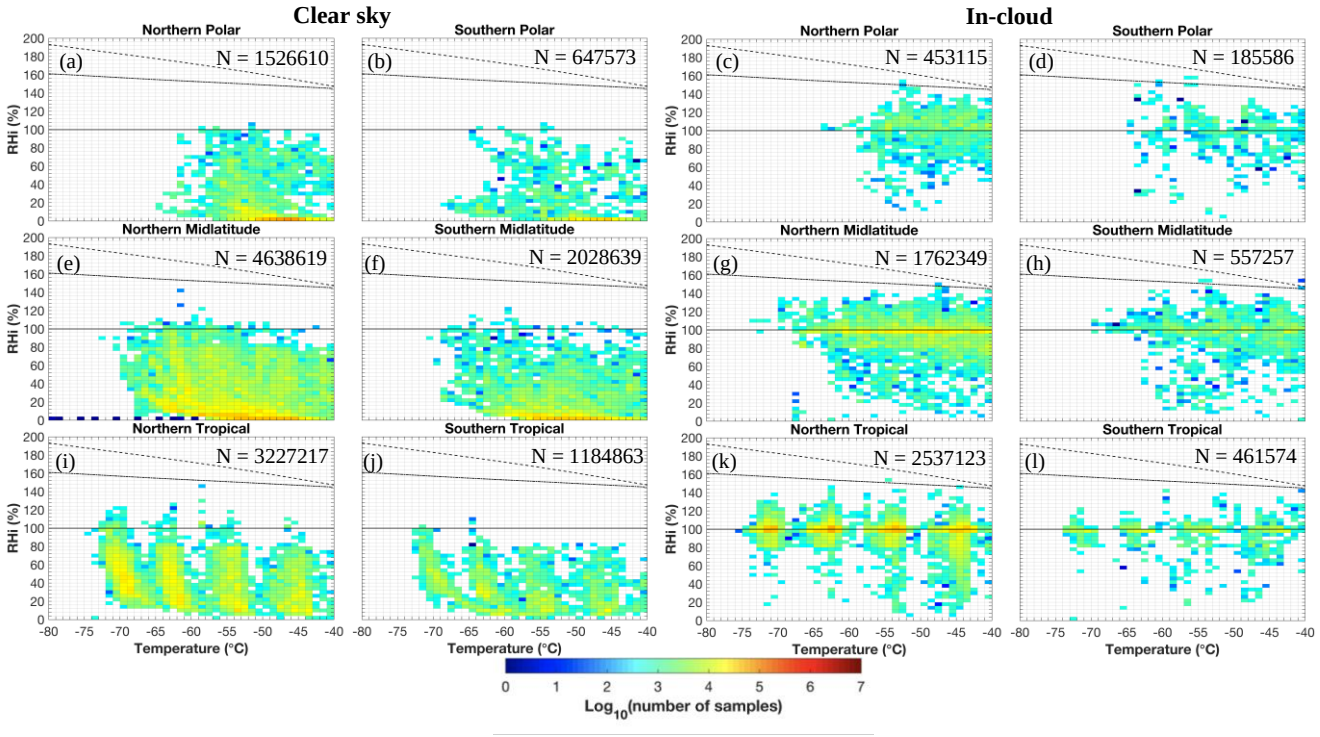

Figure S7. Similar to Figure 8, except for using in-cloud quantities from CAM6-nudg output to define in-cloud conditions. RHi values for simulations are calculated using simulated specific humidity and temperature, based on the equation of saturation vapor pressure with respect to ice from Murphy and Koop (2005).

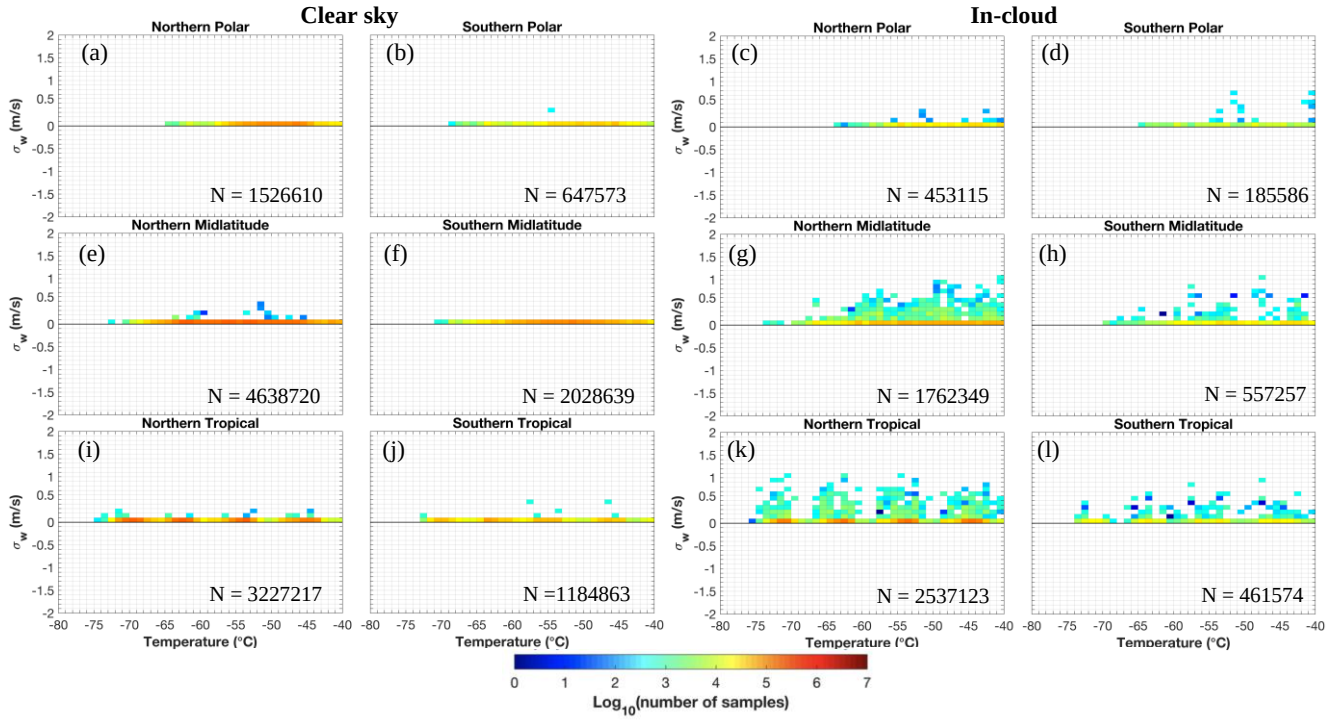

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Figure S8. Similar to Figure 11, except for using the in-cloud quantities from CAM6-nudg output to define in-cloud conditions.

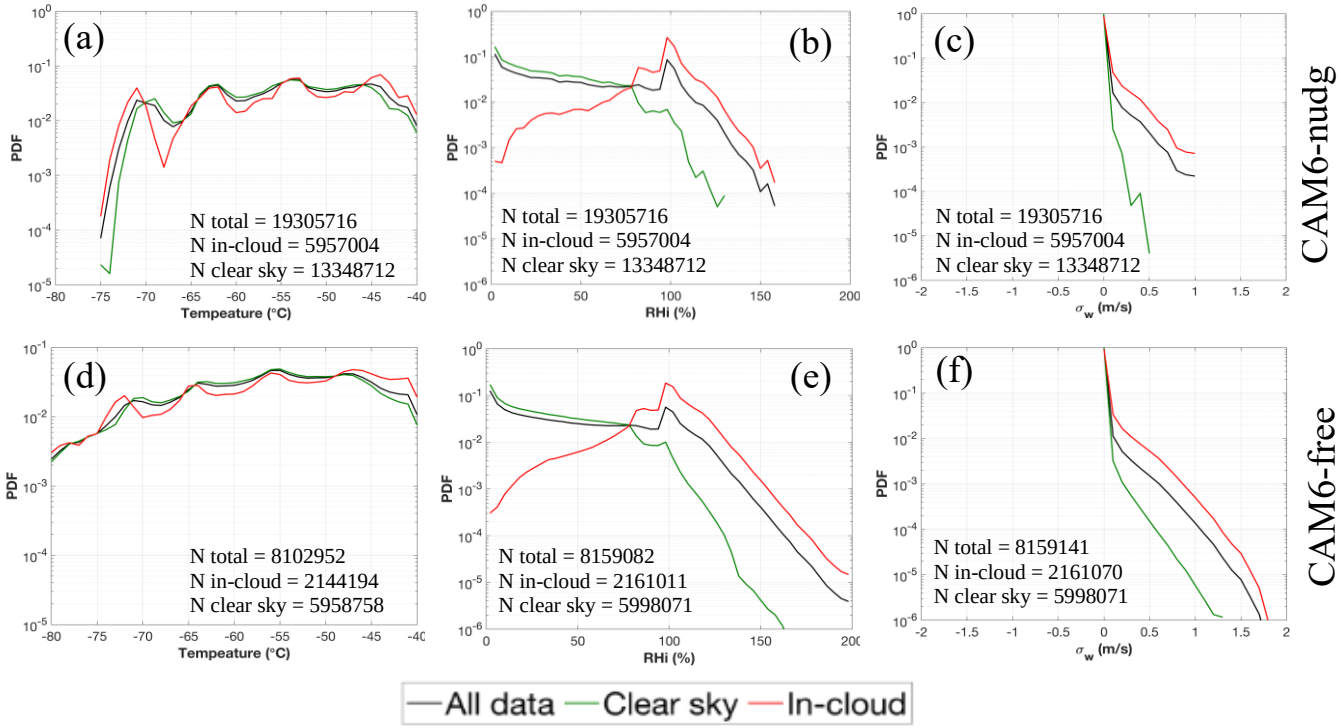


Figure S9. Similar to Figure 12, except for using in-cloud quantities of (a – c) CAM6-nudg and (d – f) CAM6-free output to define in-cloud conditions.

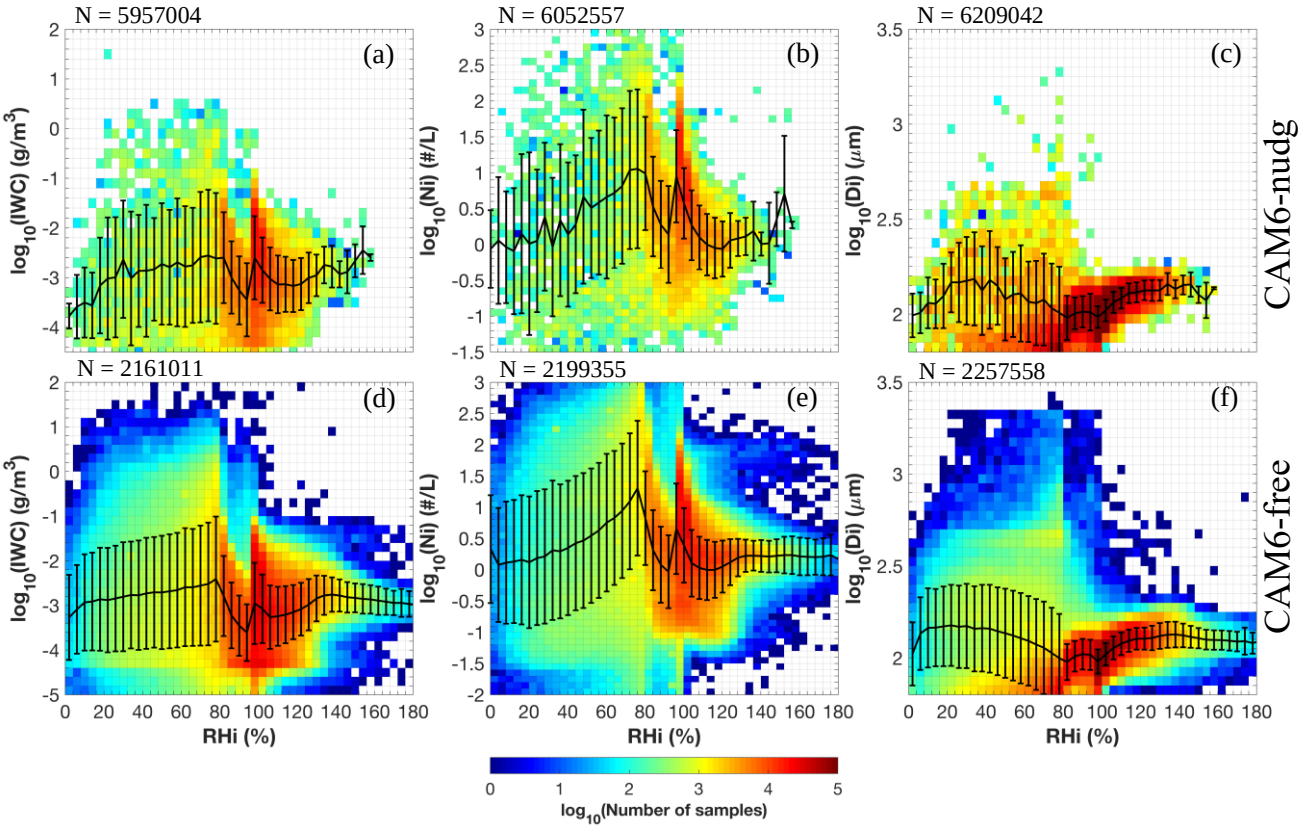
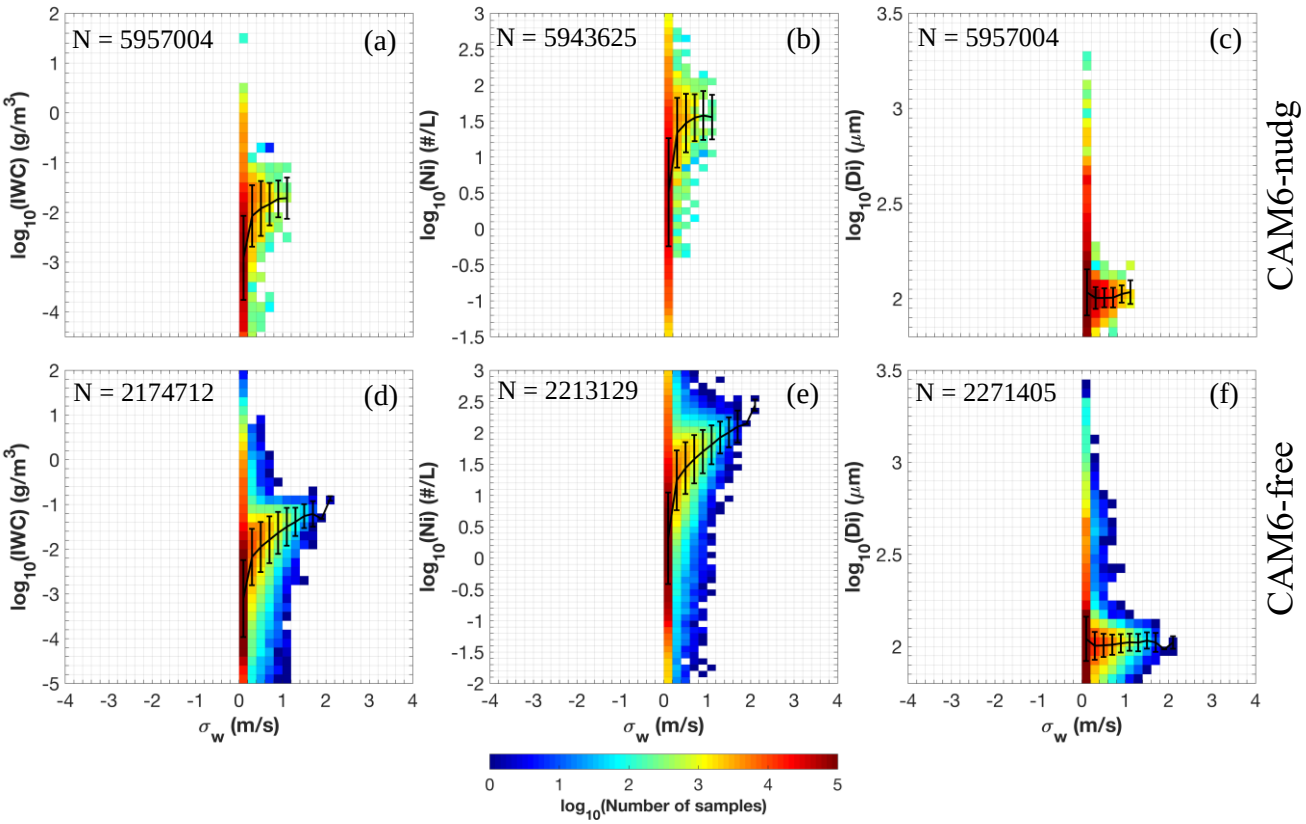


Figure S10. Similar to Figure 13 g – l, except for using in-cloud quantities of (a – c) CAM6-nudg and (d – f) CAM6-free output for the analysis of IWC, Ni and Di in relation to RHi. Black lines and whiskers denote geometric means and standard deviations, respectively.



50 **Figure S11.** Similar to Figure 14 g – l, except for using in-cloud quantities of (a – c) CAM6-nudg and (d – f) CAM6-free output for the analysis of IWC, Ni and Di in relation to σ_w.

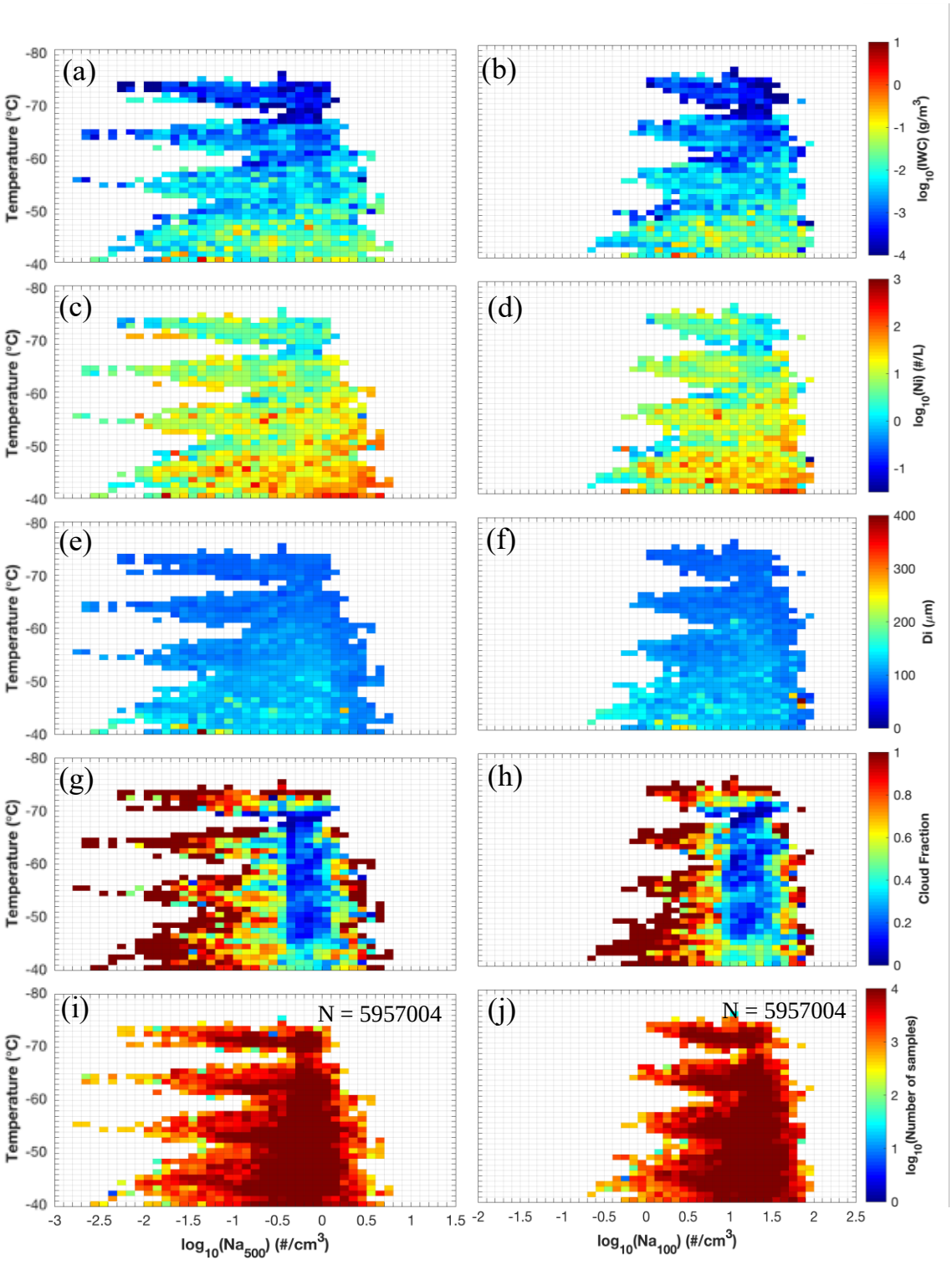

(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
N = 5957004
N = 5957004
Temperature (°C)
-80
-70
-60
-50
-40
log10(IWC) (g/m3)
log10(Ni) (#/L)
Di (μm)
Cloud Fraction
log10(Number of samples)
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
log10(Na500) (#/cm3)
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
log10(Na100) (#/cm3)

Figure S12. Similar to the last column in Figures 15 and 16, except for using in-cloud quantities of CAM6-nudg output. Aerosol indirect effects on (a, b) IWC, (c, d) Ni, (e, f) Di, and (g, h) cloud fraction, examined for (left column) $\log_{10}(Na_{500})$ and (right column) $\log_{10}(Na_{100})$. Number of samples is shown in the bottom row. Cloud fraction is calculated by the number of samples defined as in-cloud conditions over the total number of samples for a given temperature and Na bin.