1. Introduction
Recent observational studies of stratocumulus have identified robust scalings relating cloud properties and microphysical processes. Examples of such scalings for drizzle rate are...

- $R = H N^{-1}$ (Pawloska and Brenquier 2003)
- $R = (LWP/N)^{1.75}$ (Comstock et al. 2004)
- $R = H N^{1.5}$ (VanZanten et al. 2005)

Recent theoretical and numerical studies have suggested that coalescence processing, the reduction of cloud droplet concentration (and ultimately, CCN), scales as...

- $D = R N^{-1}$ (Wood 2006)
- $D = (RN)^{1.07}$ (Mechem et al. 2006)

Such scalings are potentially useful in representing under-resolved microphysical processes in large-scale models. Because of fundamental differences in dynamics, however, we should not expect these scalings to apply to all cloud types.

With this in mind, can we tease similar scalings out of trade cumulus?

2. Approach
We employ the SAMEX model (System for Atmospheric Modeling — Explicit microphysics) with size-resolving microphysics to a series of cases based on the RICO trade cumulus intercomparison. CCN are specified as a bimodal distribution, with contributions of median radius 0.03 and 0.14 μm. The total number of each mode is varied, resulting in differences in droplet concentration, precipitation, and coalescence processing.

3. Evolution of clouds and cloud systems
- Strongly precipitating case tends to exhibit greater LWP variability.
- Precipitation tends to slightly decrease cloud fraction.
- Precipitating case has at times higher and lower magnitudes of turbulence, which is related to (though does not necessarily cause) changes in inversion height.

(above) Evolution of a trade cumulus cell over 30 min. Top panels show the young updraft and predominantly cloud-sized droplets; bottom panel represents the decaying stage of the same cell, characterized by larger (r>80 μm) droplets.

(above) Simple scaling relationships for coalescence processing. Dashed line represents the scaling from Mechem et al. (2006).

The coalescence processing takes place in the clouds, yet obtaining an area-mean rate is surprisingly problematic. The sensitivity to cloud fraction is particularly acute, since the latter does not necessarily represent where precipitation growth is occurring.

Although in-cloud precipitation and coalescence processing rates are much higher than in stratocumulus, because of the low cloud fraction in the trade cumulus regime and deepness of the inversion (relative to the cloud heights), domain-mean processing rates are in fact smaller than for stratocumulus.

4. Minimum LWP threshold for given precipitation rate?

Results suggest a minimum cloud thickness (LWP) required for a given precipitation rate. Or, conversely, each LWP value is associated with a maximum precipitation rate.

5. Scalings for $R$

Long time averages (last 8 h, left panel) support a simple scaling. Scalings from a greater number of (hourly, right) individual realizations indicate a more complex scaling.

Simple scalings based on $N$ is not surprising, given the small variation between LWP. Differences in final $z$ between the simulations is one measure of mean entrainment rate.

6. Scalings for $D$

(above) Simple scaling relationships for coalescence processing. (D) based on precipitation rate (R, left panel) and the product of precipitation rate and droplet concentration (N, right panel) from the last 8 hours of the five RICO simulations. Dashed line represents the scaling from Mechem et al. (2006).

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7. Summary
- Preliminary analyses of LES results from RICO-based simulations with varying CCN concentrations hint at simple power-law scaling behaviors, as was found for marine stratocumulus.
- Mean LWP is similar in all runs, so differences in $R$ are mainly explained by variations in $N$. However, we suspect this scaling may not be general from case to case.
- Simulations show simple scalings for coalescence processing that are a function of precipitation rate and droplet concentration.
- Future work... formulating the scalings for domain-mean regions, as opposed to only cloudy areas.

Obtained From Simulations of Trade Cumulus

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A41C-0118

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