NEW PERSPECTIVES ON THE ROLE OF 'LUCKY DROPS' IN DRIZZLE FORMATION

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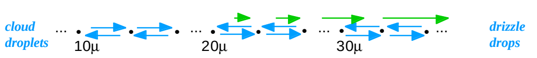
1. Introduction

The fact that ordinary cloud droplets outnumber drizzle droplets by several million to one leads naturally to the notion of drizzle drops as somehow 'lucky'. One approach, taking into account the distribution of waiting time interval between collection events, shows a few lucky drops experiencing a succession of unusually small time intervals between successive collection events early on in their growth history [Kostinski and Shaw, BAMS 86, 235 (2005)]

In this paper we show that the new kinetic potential (KP) theory, which treats drizzle formation as an activated barrier crossing phenomenon, offers a new perspective: Lucky drops are the ones that cross the barrier first.

2. Fluxes for Drizzle Formation



cloud droplet growth kinetics

condensation $\beta_g^{cond} = D_g$

evaporation γ_g^{eff}

Bracketed fluxes are often neglected in theories of precipitation, but they play a key role in getting the process started and in shaping the droplet size distribution.

collection $\beta_g^{coll} = \frac{dg}{dt} = \frac{1}{v_1}\frac{dv(drop)}{dt} \approx 3.13\times10^{-13} g^2 L$

(Long's polynomial collection kernel)

Basic idea: Evaporation exceeds condensation in the pre-collection size regime (on account of the vapor depletion effect). Thus drizzle is a kinetically up-hill process and only a few 'lucky drops' make it into the collection regime

[McGraw and Liu, 2006]

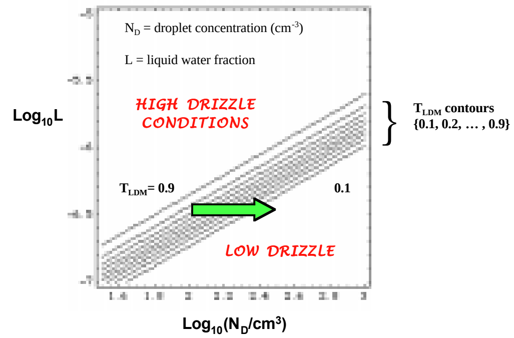
3. Threshold Function (T_{LDM})

[Liu et al., 2005]

Autoconversion parameterizations can be generically written as:

$$P = P_0 T$$

where P_0 is the rate after onset of the autoconversion process and T describes the threshold behavior.

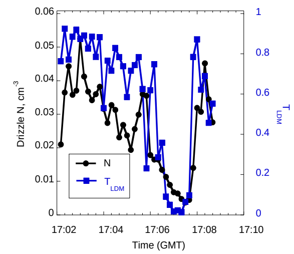


Arrow shows the effect of increasing droplet concentration on reducing drizzle rate

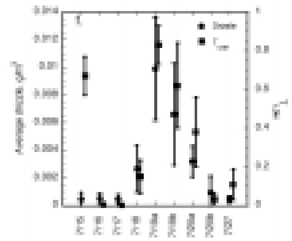
Contour plot of the LDM threshold function showing threshold behavior and a positive Albrecht effect. Contours locate the activated regime where there is a barrier to the drizzle process due to droplet competition for limited vapor – this is the depletion effect previously described.

4. Comparison of MASE 2005 Drizzle Observations With the Threshold Function (T_{LDM})

[Daum et al., 2007]



Aerosol plume leads to an increase in N_D and a decrease in mean drop size. This results in a decrease in T_{LDM}, and a nearly complete suppression of drizzle.



Comparison of average drizzle with the T_{LDM}.

Preliminary results look promising - stay tuned!

5. References

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Kostinski A. B. and R. A. Shaw (2005). Fluctuations and luck in droplet growth by coalescence. Bull. Amer. Meteor. Soc. 86, 235-244.

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