Efficacy of Aerosol – Cloud Interactions under Varying Meteorological Conditions

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Motivation

Entrainment Mixing

Cloud dynamical processes such as entrainment mixing may be the primary modulator of cloud optical properties in certain situations.

Entrainment of dry air alters the cloud drop size distribution by enhancing drop evaporation. The effect of entrainment mixing and other forms or turbulence is still quite uncertain.

Efficacy of Aerosol Indirect Effect

These factors and aerosol-cloud interactions should be considered together when evaluating the efficacy of aerosol indirect effects (AIE).

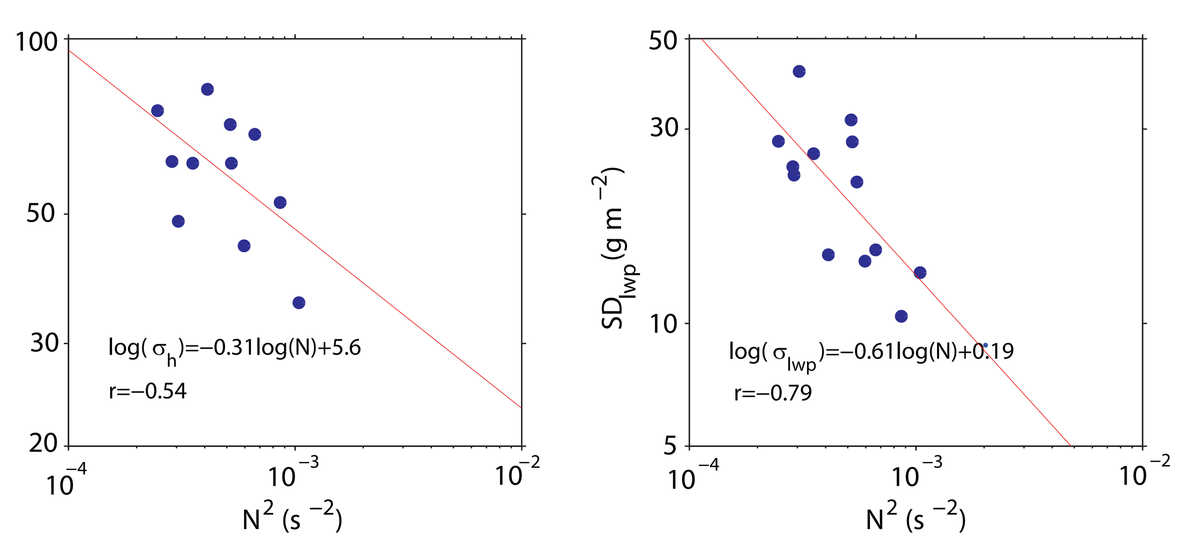
The underlying mechanisms appear to be dependent upon each other, and accounting for them is challenging with the current understanding of AIE.

This Study

Careful objective screening and analysis of observations are needed to determine the extent to which mixing related properties affect cloud optical properties, apart from the aerosol first indirect effect.

This study addresses the role of aerosol-cloud interactions in the context of varying meteorological conditions based on ARM data obtained at SGP and at Pt. Reyes, CA.

Suppression of LWP Variability



The variability in LWP exhibits significant negative correlation with N^2 (Brunt Vaisalar Frequency); suggesting that suppression of turbulence by the static stability reduces the cloud variability, which facilitates aerosol-cloud interactions (*Kim et al., JGR 2003*).

References

Kim, B.-G, M. Miller, S. Schwartz, Y. Liu, Q. Min, (2008), JGR, doi:10.1029/2007JD008961.

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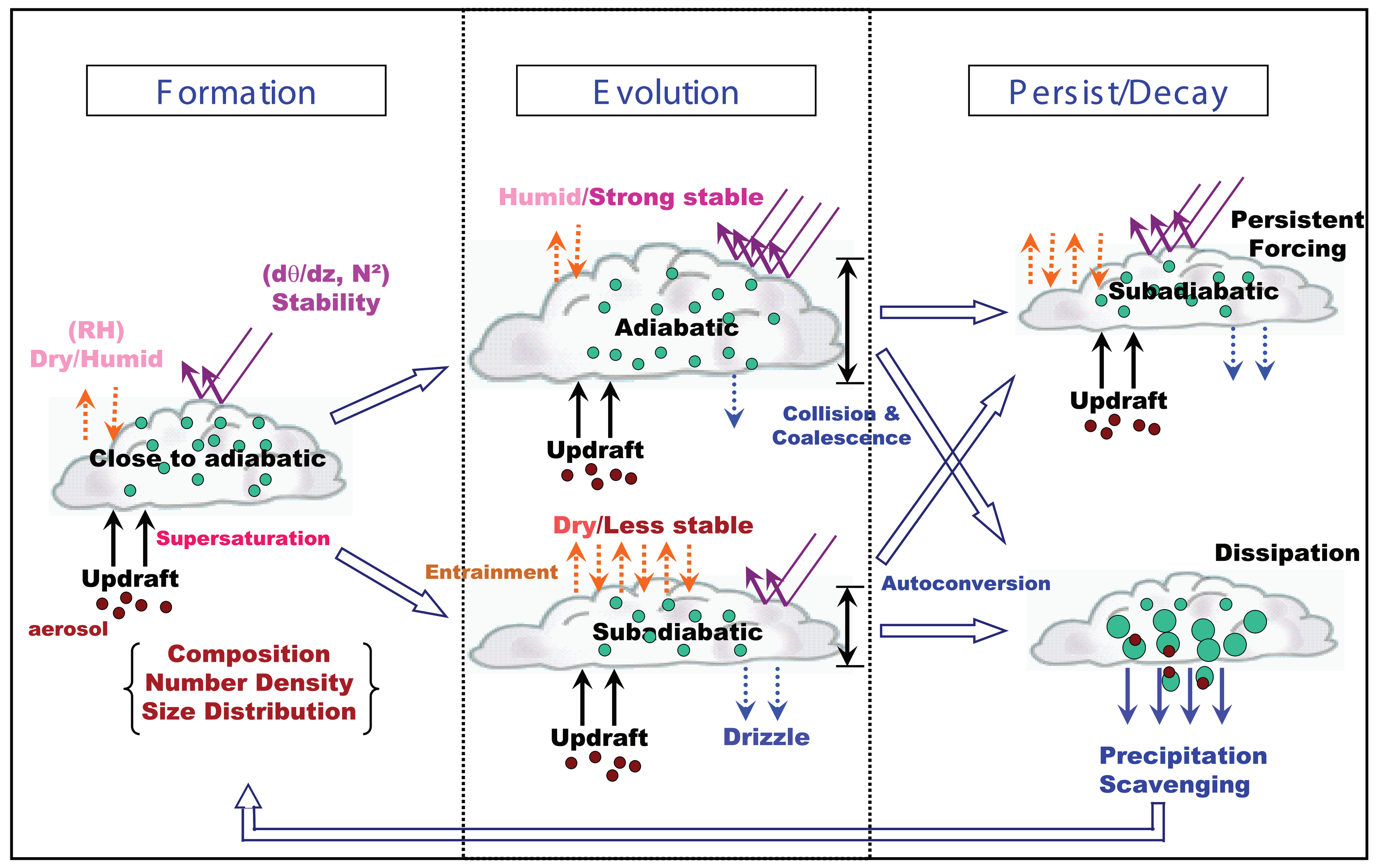
Lu, M.-L, W.C. Conant, H. Jonsson, V. Varutbangkul, R. Flagan, J. Seinfeld (2007), JGR, 112, doi:10.1029/2006JD007985.

Daum, P., Y. Liu, R. McGraw, Y.-N. Lee, J. Wang, G. Senum, M. Miller (2008), JGR in Press.

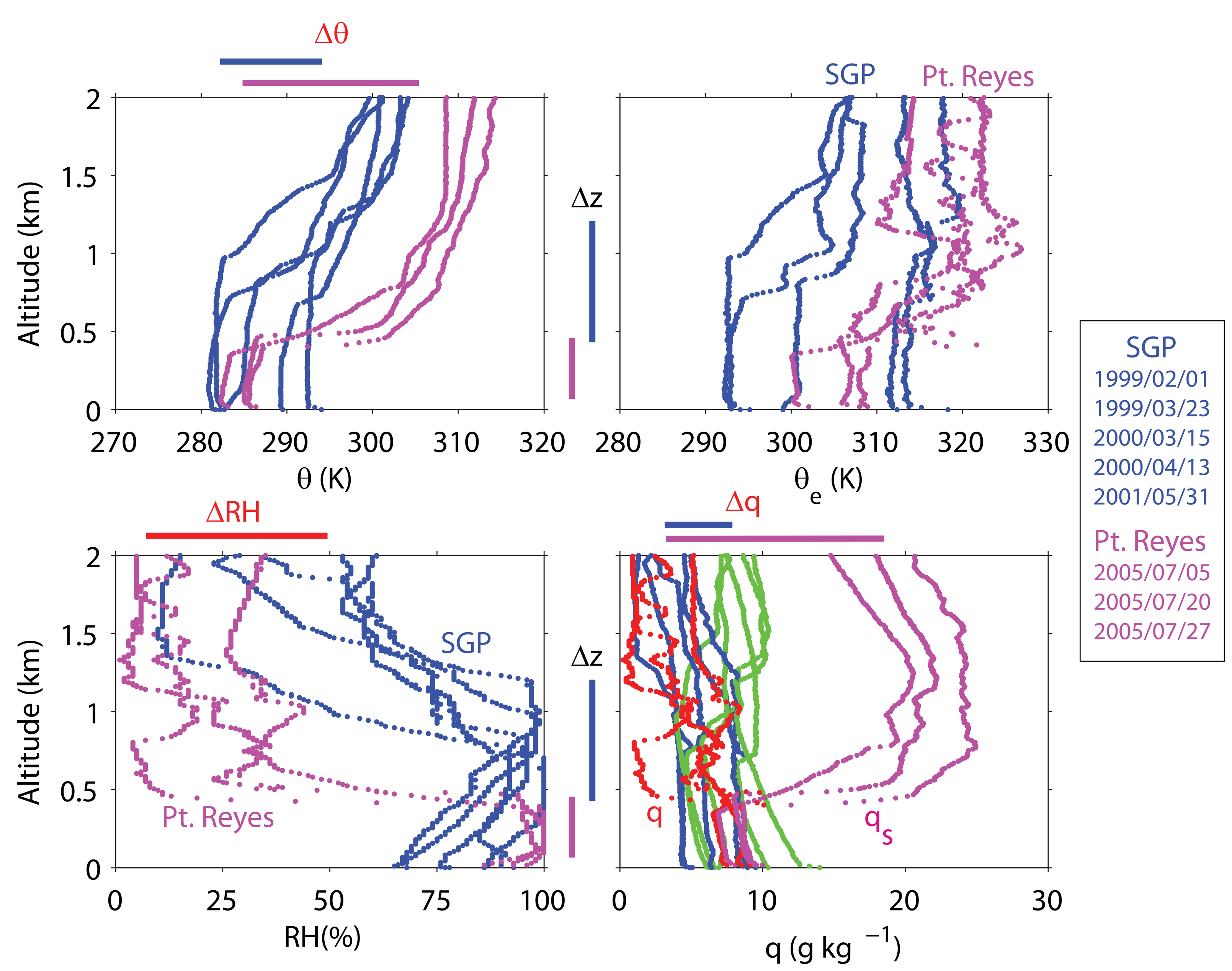
Liquid Stratiform Clouds-Aerosol Interaction



Current Issues

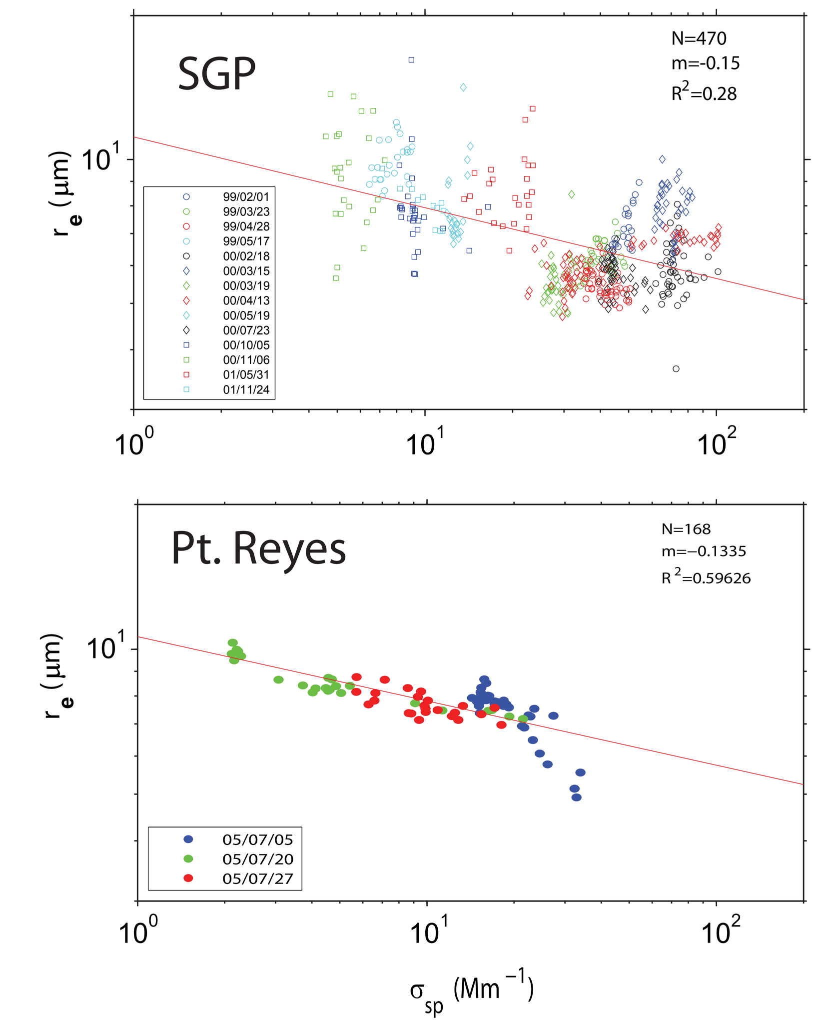
- Different mechanism is dominant with each cloud processing.
- cloud-aerosol interaction driven by varying meteorological environment (mainly humidity and stability).
- Observation limitation: just end results, not process-following.

Comparisons of Soundings



- The static stability in SGP with drier conditionis above the cloud top is about 2 times greater in Pt. Reyes than in SGP.
- Clouds with the shallow thickness in Pt. Reyes exist close to the ground (ref to Table).

Efficacy of AIE



Aerosol loading and its variations at Pt Reyes are smaller than SGP, and also strong stable condition above the cloud top. It could increase the efficacy of aerosol-cloud interaction over Pt. Reyes and even during the course of day.

Summary of SGP and MASE

	Cloud Depth(m)	LWP (gm^{-2})	r_e (μm)	σ_{sp} (Mm^{-1})	N (s^{-1})	α	RH (%)	IE
SGP[$] (1999-2001)	200-800	180-1000	5.6-10.2	4.0-120	1.0-2.7	0.3-0.5	30-70	0.15-0.17 (R^2<0.5)
MASE Pt. Reyes[@] (2005.7.15-27)	200-300	40-150	6.0-10.5	2.0-30	2.5-3.1	0.6-0.8	20-30	0.10-0.13 (R^2=0.6)
Monterey[#] (2005.7.2-17)	200-500	20-90	5.8-10.6					

[$] *Kim et al.(JGR, 2008)* SGP mostly remote sensing for 1999-2001.
[@] *Daum et al.(JGR, 2008)* MASE DOE-G1 for 2005.7.15-27.
[#] *Lu et al. (JGR, 2007)* MASE(CIRPAS) for 2005.7.2-17.

Conclusions

The consistently steady and thin maritime stratus clouds observed at Pt. Reyes are much closer to adiabatic, mostly influenced by the stronger static stability and drier condition above the cloud.

These clouds shows the better efficacy of aerosol-cloud interactions since they form in a much more homogeneous meteorological (low variability in LWP) and less entrainment-driven environment than those at the continental site.

There are still some limitations on observation artifacts and uncertainty in estimating adiabaticity based on the remote sensing.