DRIZZLE and CLOUD STRUCTURE in SE PACIFIC STRATOCUMULUS

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MOTIVATION:
- Cold SST (right) and warm, subsiding air aloft make the SE Paciﬁc the most
effective region of marine stratocumulus cloud in the world.
- Little is known about the structure and dynamic role of drizzle in
  marine stratocumulus.

THE EPIC 2001 STRATOCUMULUS CRUISE:
- NOAA/NSF sponsored a cruise with the NOAA ship Ronald H Brown to the
  SE Paciﬁc stratocumulus region (Bretherton et al. 2004, see maps to right)
- Instrumentation included scanning (C-band, 5–10 cm) and vertically pointing
  millimeter (Mm): 3.8–8.9 mm) radars, ceilometer, microwave radiometer,
  8 x daily sondes, surface meteorology, turbulent and radiative ﬂuxes

KEY QUESTIONS:
1. What are the cloud-base and surface drizzle
   rates during the EPIC cruise? What factors control
   these rates?
2. What are the structural properties of drizzle?
3. Does drizzle inﬂuence cloud macropysical dynamics?

1. EPIC 2001 DRIZZLE RATES and CONTROLLING FACTORS
- Time series of cloud base and surface drizzle rates (right) show that:
  (a) drizzle rates are signiﬁcant (1 mm day −1, 30-50 m s −1)
  (b) Mean cloud base drizzle rate during EPIC is 0.7 mm day −1
  (c) Most drizzle evaporates before reaching the surface
  (d) There is a strong diurnal cycle of both cloud liquid water path (LWP)
  and cloud base precipitation rate
  (e) Periods of heavy drizzle tend to be associated with high LWP and/or low
  cloud droplet concentration N 0

Diurnal cycle (left):
- Composite diurnal cycle of cloud and drizzle properties from EPIC shows
  a strong diurnal cycle in divergence and cloud top height, a much weaker cycle
  in cloud base height, a strong diurnal cycle in LWP, and a strong diurnal cycle
  of cloud base drizzle rate.

What controls the drizzle rate?
- Drizzle rate is modulated by both cloud LWP (or equivalently cloud thickness)
  and by N 0 (right). Over the EPIC period, these two parameters explain
  about equal amounts of variance in the drizzle rate.

Rain rate at the cloud base R 0, can be parameterized as a function of LWP N 0,

Note: N 0<sub>0</sub> is inferred from combinations of LWP measured using microwave radiometer and cloud optical thickness from surface
sounding/remote detection radiometry (SARG and MUR). For an adiabatic cloud, N<sub>0</sub> is proportional to C(T<sub>0</sub>);

2. DRIZZLE STRUCTURE
- C-band radar allows an unprecedented examination of structural properties of drizzle in stratocumulus.
- Below (left) is the cloud liquid precipitation rate and the total accumulation (shading), during EPIC (below right). The total accumulation corresponds to the stratiﬁcation of the layer, for example, 1/10 the total accumulation from the stratiﬁcation of the layer, 1/10 the total accumulation from the stratiﬁcation of the layer, 1/10 the total accumulation from the stratiﬁcation of the layer.

3. INFLUENCE OF DRIZZLE on CLOUD DYNAMICS
- EPIC dataset allowed estimation of all terms contributing to the mixed layer
  budgets of energy and moisture. This allows estimation of the buoyancy
  ﬂux of 0.1 µm, recent large eddy simulations (Steinbuck 2009) suggest that
  the MBL begins to decouple when the subcloud
  buoyancy ﬂux (0.1 µm) becomes strong.

Drizzle is highly intermittent (over 50% of drizzle falls from only 5% of the drizzling area). DRIZZLE images provide evidence for
    DRIZZLE:
- Mixed layer framework shows that latent
      heating in cloud and subcloud evaporation cooling from drizzle is important during EPIC 2001, and may
      initiate MBL decoupling.

CONCLUSIONS
- The tendency for decoupling during EPIC is
  crucially dependent upon drizzle production. This suggests that the cloud macropysical structure be tied to the microphysics of drizzle.

REFERENCES
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