P2.6 THE EFFECT OF ANTHROPOGENIC POLLUTION ON CLOUD FORMATION WITHIN THE ITCZ

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1. INTRODUCTION

Aerosols play a major role in cloud formation and precipitation development. The fact that anthropogenic pollution can influence the reflectivity of clouds has been recognized for some time (e.g., *Twomey*, 1974). Increasing the number of cloud condensation nuclei (CCN) increases the concentration of cloud droplets; hence the increase in cloud reflectivity. Aerosols can also inhibit precipitation. When many CCN compete for the available water vapor, droplets may not grow by condensation or coalescence to precipitation. Analysis of satellite images suggest that precipitation is suppressed in those clouds within plumes of anthropogenic aerosols (*Rosenfeld*, 2000). Additional evidence of how pollution can alter cloud processes has been found from measurements of aerosol and cloud properties in the ITCZ over the eastern pacific. These observations are discussed below.

2. MEASUREMENT PROGRAM

Measurements were made from the NCAR C-130 as part of the EPIC program (September 1 – October 15, 2001). Nine of the flights were dedicated to aerosol and cloud studies within a region from 8° - 12° N and 93° - 97°W, approximately 800-1000 km from Central America (Fig. 1). Cloud penetrations were made at 30 m, 300 m, 1000 m, 2500 m, 4000 m and 6000 m. The lowest flight level was made to define aerosol properties near the sea surface. The 300 m level was just above cloud base. The aerosol properties were characterized by concentrations of CN and CCN, size distributions from 0.1 to 20 μm, and the scattering and absorption coefficients. The cloud properties measured were liquid water content (LWC) and droplet and drizzle size distributions and concentrations.

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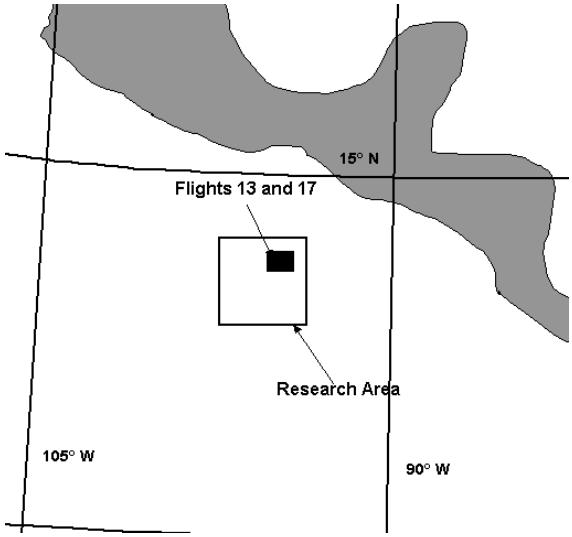

Figure 1
EPIC research area showing general region of cloud investigations and particular area of clouds studied in flights 13 and 17.

3. RESULTS

Two of the flights (13 and 17) were of particular interest because of a sharp contrast in aerosol and cloud properties. The altitude profiles of the average aerosol properties outside of cloud (Fig. 2) illustrate these differences. Panel A shows that the CN concentrations on one day were 4-10 times larger than the other day. As CN concentrations in a clean, maritime environment are typically < 300 cm^{-3}, the day with higher concentrations was probably under the influence of anthropogenic particles. Panels B and C show a similar contrast in the scattering and absorption coefficients. The large absorption coefficients imply high concentrations of black carbon. Panel D shows that the "clean" day had winds from the SSW, while the "polluted" day had much stronger winds from the east (U and V are the zonal and meridional components, respectively).

The cloud properties mirror the differences in aerosol properties as seen in Fig. 3. The droplet concentrations in panel A are much higher for the polluted day, as is the LWC (panel B). The median volume diameters of droplets, however, are ≈ 5

μm smaller for the same day. The drizzle concentration (panel D) is about the same for both days at the highest two flight levels (6000 and 4000 m, respectively) but more than a factor of 10 smaller at 2500 m on the polluted day. There was no drizzle or precipitation measured below 1000 m on the polluted day.

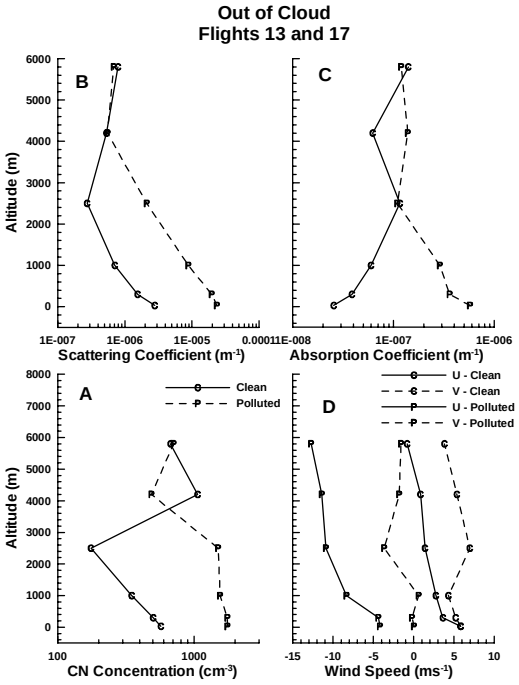

Figure 2

Vertical profiles of average aerosol properties A) CN concentration, B) scattering coefficient, and C) absorption coefficient. Panel D shows the average winds with height.

4. DISCUSSION

Measurements show marked differences in the aerosol and cloud particle properties on two different days. The two days are also differentiated by the wind strength and direction. On the clean day the winds are mostly from the southwest. As there are no major land masses within 4000 km to the west of the research area, the aerosols should be primarily of maritime origin. On the polluted day the winds are strong from the east. Central America lies approximately 800 Km to the east, so it is likely that anthropogenic aerosol from biomass burning or urban areas are the source of higher CN and optical coefficients.

The higher droplet concentrations and lower median volume diameters suggest that a large fraction of the anthropogenic aerosols are CCN. Subsequently, even though the LWCs are somewhat higher on the polluted days, the larger number of droplets that compete for the available water vapor leads to slower growth of all the droplets. This is reflected in the smaller median volume diameters and lack of drizzle on the polluted day.

The impact of anthropogenic aerosols on clouds in the ITCZ has climatic ramifications although the mechanisms are complicated and further studies are clearly needed to better understand these mechanisms and the magnitude of their effects.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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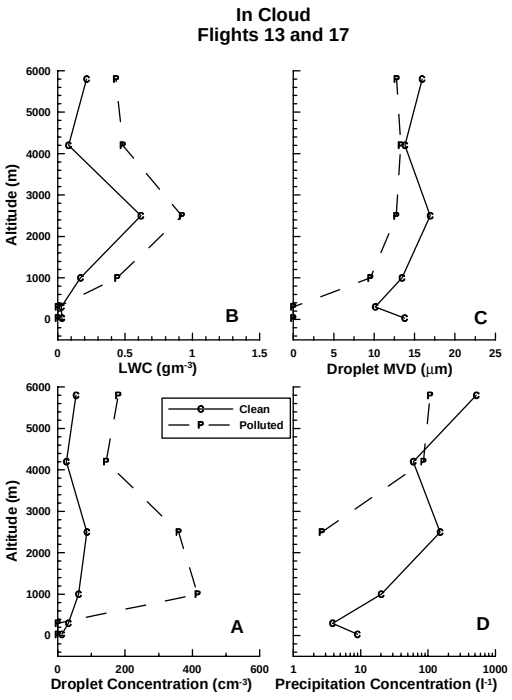

Figure 3

As in Fig. 2 but for cloud properties A) droplet concentration, B) LWC, C) median volume diameter and D) drizzle and precipitation concentration.