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THE RICO STUDENT MISSION - FLIGHTS, GROUND OPERATIONS AND SUBSEQUENT RESEARCH

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1. INTRODUCTION

The Rain in Cumulus over the Ocean (RICO) field campaign took place during the winter of 2004/05 off the Caribbean Islands of Antigua and Barbuda. "The objective of RICO in the broadest sense was to characterize and understand the properties of trade wind cumulus at all scales, with particular emphasis on determining the importance of precipitation" (Rauber et al., 2003). To accomplish this objective, a wide variety of instrumentation was employed. Aircraft included the NCAR C-130, the Wyoming King Air, and the British BAE-146. Several instrument platforms were located on the island of Barbuda, including NCAR's SPOLKa dual polarization radar, a rawinsonde launch site and a surface meteorological station. Other observation systems included several satellite platforms, short wavelength radars and a lidar on board the Seward Johnson research ship, as well as a ground sampling station on the island of Antigua.

RICO had an unprecedented educational component. On 18 January 2005, control of all major operations of the RICO field campaign was relinquished to the graduate students. On this day, the students successfully executed flight plans they had developed to address three scientific objectives: 1) to study cloud processing of aerosols; 2) to investigate the nature of the island tail; and 3) to conduct an inter-comparison of the ground sampling station aerosol measurements with those made on the C-130. All three objectives were carried out during the same flight.

2. BACKGROUND

The morning of 18 January 2005 was characterized by low winds (~2 m/s at 100 m ASL as compared to normal values closer to 10 m/s) and low aerosol content (forward scattering spectrometer probe (FSSP) concentrations were ~1/10 of normal levels) according to flight scientists (Davison and Bereznicki, 2005). According to Caesar (2005), a weak trough with a SW-NE tilt was located west of the islands. It was caused by and ahead of an approaching cold front coming off the continental US. Caesar also noted confluence bands moving in from the east. Further characteristics affecting this day included several precipitating stratus cloud decks in the early morning, some of which burned off as the day progressed. In light of these conditions, the marine boundary layer (MBL) was relatively clean with respect to aerosols.

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3. FINDINGS

3.1 Objective 1: Cloud processing of aerosols (1310-1540 UTC)

In order to generate long sampling intervals, flight patterns were flown either parallel to or through the central axis of a single long lived cloud line (See Fig. 1). Flight legs were flown near, below and just upshear of cloud base; passes were made through the cloud at various elevations; and both cloud top and the region just downshear of it were sampled. Due to the preconditioning of the environment by the precipitating stratus clouds as well as light winds and calm seas, the air was relatively clean. As can be seen from Figure 2., except for the time just before the shift from 500 m to 100 m near 1330 (UTC), the hydrogen peroxide (H_2O_2) concentrations (shown in blue) are significantly lower than the methylhydroperoxide (CH_3OOH) concentrations (shown in red). Normally in clear air, H_2O_2 concentrations are higher than those of CH_3OOH. In cloud, this ratio shifts as H_2O_2 dissolves much more readily in water than does CH_3OOH. The older the cloudy air is and the less it is modified by entrainment,

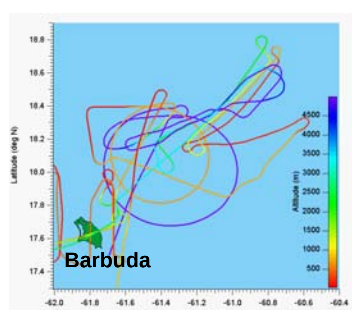


Fig. 1. Flight path of the C-130 during Objective 1

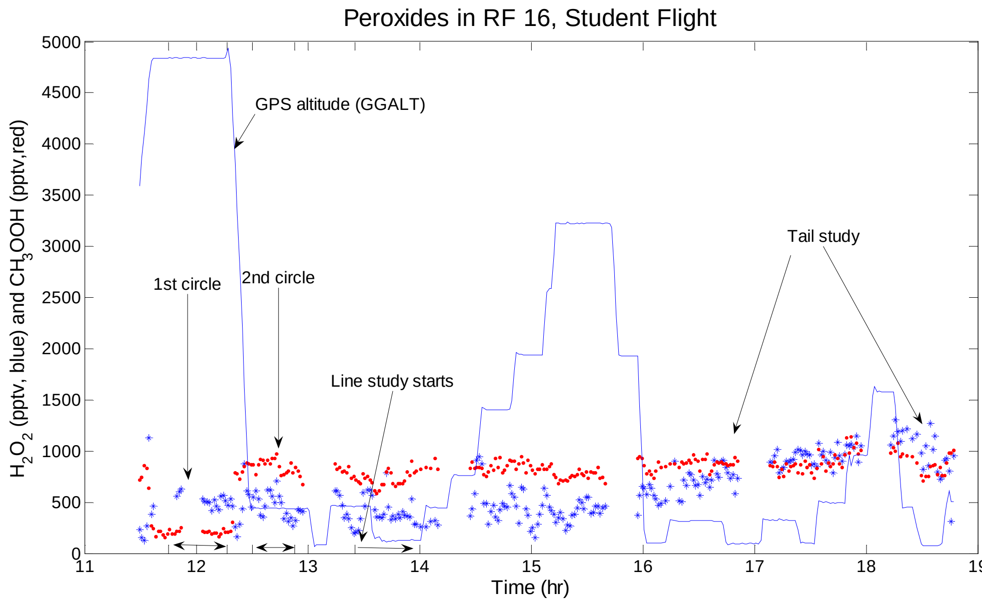


Fig. 2. Concentrations of hydrogen peroxide (H_2O_2) and methylhydroperoxide (CH_3OOH) in ppt overlaid on the C-130 flight altitude (m)

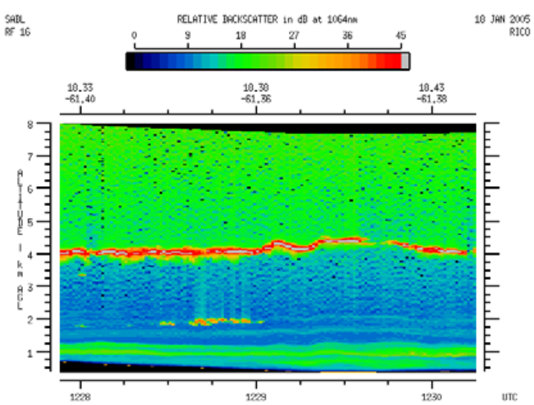


Fig. 3. SABL image taken from the C-130 during the first half of the student flight. It is representative of the environment seen during Objective 1. Note the stratus layer near 4km delineating the location of the tropical inversion.

the greater the shift in the H_2O_2/ CH_3OOH ratio. Given the time interval for Objective 1 (1310-1540 UTC), it is clear that the air sampled during this time was well modified by the cloudy environment. As is easily seen with both the SABL lidar (e.g., Fig. 3) as well as in the soundings, the tropical inversion height during this time seemed to be near 4 km.

3.2 Objective 2: Island Tails (1609-1830 UTC)

An island tail is a long, wind-parallel cloud line appearing to originate from and extending miles downwind of an island (See Fig. 4). During the RICO campaign, they were often noted to form between 10:00 and 11:00 local time, and were observed to form in the presence of even the smallest of islands. Although not present every day, the tails were present more often then not. Currently, little is known about the formation of island tails. In order to study them, flight passes cut perpendicularly across Barbuda's island tail, moving further downwind and alternating between altitudes of 300 and 1000 ft ASL (See Fig. 5). As can be seen from Figure 2, the cloudy air parcels sampled during this objective were much "younger" than those sampled under the first objective. As was seen clearly in the SABL data (Fig. 6) and supported by the soundings, the tropical inversion seems to be ~ 1km lower during the second objective than in the first. This was in spite of the fact the first objective was carried out earlier in the day. Given the synoptic conditions, this presents the possibility that the two objectives were not carried out in the same air mass. In addition to this difference in inversion height, the air properties on either side of the tail appeared to differ as well (See Figs. 6 & 7).

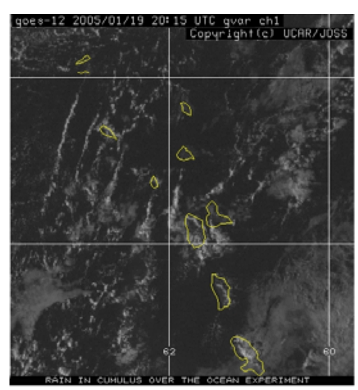


Fig. 4. GOES-12 image of island tails taken during the RICO field campaign on the day after the student flight

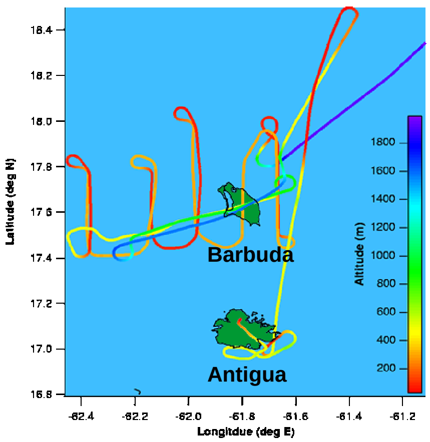
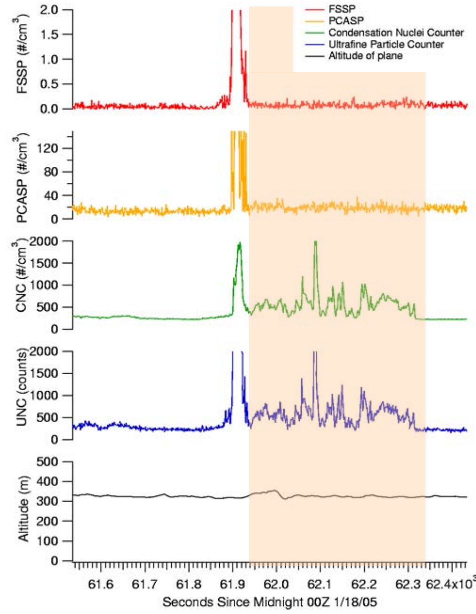


Fig. 5. Flight path of the C-130 during Objective 2.



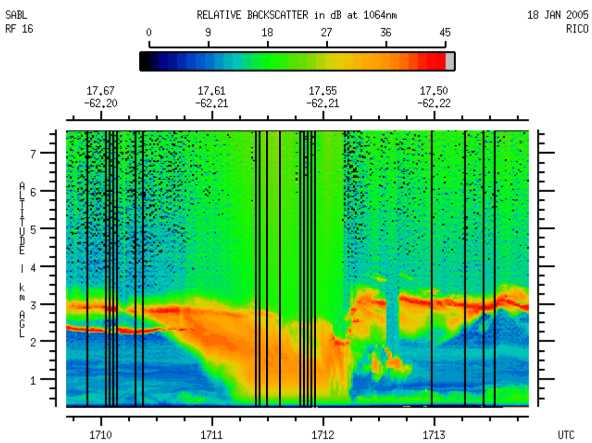


Fig. 6. SABL image taken from the C-130 during Objective 2. Image shows a cross section of the island tail. Note the stratus layer near 3km delineating the location of the tropical inversion as well as the differences between the stratus deck(s) on either side.

Fig. 7. Measurements of particles with four different instruments shown with altitude. Small aerosol particle concentrations are different on the south side of the tail (highlighted in orange) than on the north side of the tail (no highlighting). Larger particles are only present in a small burst when crossing the tail (the pronounced spike).

4.0 REFERENCES

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