10.5 GIANT AND ULTRAGIANT SEA-SALT AEROSOLS AND CARIBBEAN TRADE WIND CUMULI

Marilé Colón-Robles[1*], Robert M. Rauber[1], Jørgen B. Jensen[2], Sabine Göke[1], David Rogers[2], Iliana Genkova[1], and Stuart Beaton[2]

[1]*Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, , Urbana, IL, USA*

[2]*National Center for Atmospheric Research, Broomfield, CO, 80021 USA*

1. INTRODUCTION

Droplet spectral broadening and initiation of precipitation in trade wind cumuli are major unresolved scientific issues in cloud physics. One hypothesis to explain spectral broadening is that giant (1-10 μm) and ultragiant (> 10 μm) nuclei act as embryos for raindrops in the warm rain process. Although many studies of these aerosols have been made, no clear relationship has been established between their concentration and the onset of precipitation in marine cumulus. To address this issue, a comparison between wind speed and giant aerosol concentration was made during the recent RICO (Rain in Cumulus over the Ocean) experiment. Measurements used came from a unique combination of instruments on the NCAR C-130 aircraft, providing new observations on the initiation of precipitation.

2. METHODS AND RESULTS

As part of RICO, the NSF/NCAR C-130 research aircraft was flown during December 2005 and January 2006 over the tropical Atlantic Ocean in the vicinity of 61°W 18°N. Concentrations of aerosols were measured along 60-km diameter circles that were flown at the beginning and end of each flight at an altitude of 100-m above the ocean surface. The measurements were obtained using aircraft-mounted probes, FSSP-100 and PCASP (SPP-200), and the observations were limited to regions that were clear of precipitation and any cold pools (cloud-processed outflow). In addition, the CSIRO Giant Aerosol Impactor system was used to obtain concentrations of the ultragiant aerosols.

At 100 m altitude, the ambient relative humidity was typically ~70 to 80%. Particles measured by the FSSP-100 (2 – 47 μm) were assumed to be haze, i.e., deliquesced NaCl in equilibrium at the ambient relative humidity.

**Corresponding author address:* Marilé Colón-Robles, Univ. of Illinois at Urbana-Champaign, Dept. of Atmos. Sciences, 105 S. Gregory, Urbana, IL 61801; e-mail: mcolon2@atmos.uiuc.edu

Figure 1 shows the results from thirteen flights during the two-month period. Concentrations of particles were highly correlated with wind speed over the range of 4-14 m/s. No linear relationship was found for smaller sea-salt particles, as measured by the PCASP (SPP-200) (0.1 – 3.0 μm).

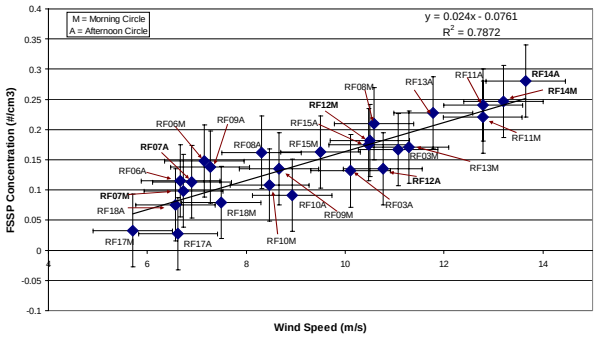

Figure 1. Clear air FSSP-100 average sea-salt concentrations versus average wind speeds for morning and afternoon 100-m above ocean along 60-km sampling circles.

Six research flights were selected to study rain formation in conditions of low, medium and high wind speeds to determine possible relationships between giant aerosol concentrations and droplet spectral broadening. A statistical approach was used to compare clouds with similar depth and penetration altitudes before any significant fall-out occurred. A threshold of 0.25 g/m^3 of liquid water content and vertical wind speeds of 0.5 m/s was selected to compare drop spectra above cloud base with the aerosol spectra from below cloud base. Data from CN counters, PCASP, FSSP-100 and a giant aerosol microscope system was used to obtain aerosol spectra.

3. DISCUSSION

A strong correlation was obtained between aircraft measurements of 100 m altitude wind speed and deliquesced giant aerosol concentrations from the FSSP-100 particle spectrometer. The concentration of dry particles of 1, 3, and 5 µm radius were calculated assuming that aerosol particles measured by the FSSP-100 were deliquesced NaCl in equilibrium with ambient relative humidity. A near-linear correlation was observed for these concentrations as a function of wind speed over the range of 4-14 m/s.

Six research flights were selected to determine any possible relationship between the concentrations of aerosols with rain formation in conditions of low, medium and high wind speeds. The CSIRO Giant Aerosol Impactor system was used to calculate the concentration of giant and ultra-giant particles.

Sea-salt particle cumulative concentration of selected slides taken at low, medium, and high wind speeds is plotted in figure 2. Higher concentrations of particles are observed for the high wind case. Particles larger than 14µm are observed for the high wind case. The low and medium wind cases have similar concentrations and the same size ranges.

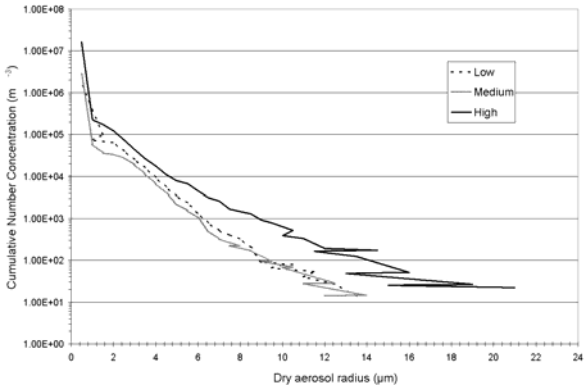

Figure 2. Sea-salt dry radius concentrations measured with the CSIRO Giant Aerosol Impactor system at 100m above the ocean surface.

Droplet spectra above cloud base do not show a linear relationship with concentration of particles found in clear air. Figure 3 shows examples of droplet spectra for clouds penetrated at similar altitudes above cloud base at different wind speeds. These preliminary results show broad spectra with low droplet concentration for low wind cases (7 m/s), while medium (10 m/s) and high (14 m/s) wind cases show narrow spectra with sharp drop off around 30µm radii. Droplet number concentrations for the high wind case are double the concentrations observed for low wind cases.

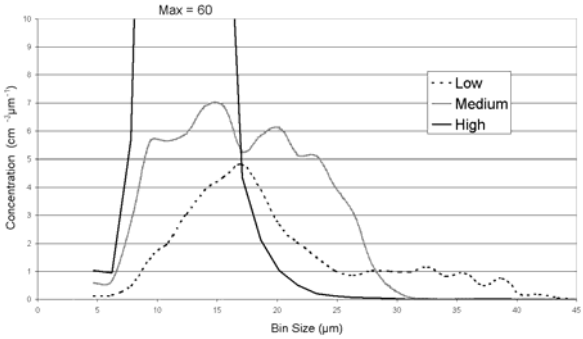

Figure 3. FSSP-100 cloud droplet concentrations of low (7 m/s), medium (10 m/s) and high (14 m/s) wind speeds for clouds penetrated above cloud base.

Results of sea-salt particle cumulative concentrations and droplet spectra above cloud base, as function of wind speed will be presented at the conference.