Can Saharan Dust Serve as Cloud Nuclei for Boundary-Layer Clouds in South Florida?

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1.) Introduction:
Aerosols have a large influence on global weather and climate patterns, making accurate measurement and model representation of their concentrations very important. Dust in particular is a unique aerosol, in that it is capable of nucleating warm liquid-only clouds and can serve as the nuclei for ice clouds. The Saharan is arguably the world’s largest dust source region. In South Florida, Saharan dust events are of particular importance; dust plumes from the Saharan regularly travel across the Atlantic, reaching Florida primarily during the three month period from June to August. By the time the Saharan dust reaches Florida, the dust has descended to overlie the marine boundary layer. Satellite-derived aerosol optical depths are often used within aerosol-cloud interaction studies, but it is less clear if this is appropriate for dust layers because the dust layers can be elevated and may not be vertically collocated with the cloud layers. South Florida’s CAROb (Cloud-Aerosol-Rain-Observatory), which is located at the edge of Biscayne Bay about 3 miles off of mainland Florida, has been recording cloud condensation nuclei (CCN) counts on the surface, along with depolarization lidar measurements since 2011. These measurements have been used in part to observe and analyze dust events during the summers of 2012 and 2013. The purpose of this project is to assess if, when dust is present overhead, the presence of dust can also be detected within the boundary layer, as elevated CCN measurements at the surface. If so, this indicates that the dust can affect the boundary layer clouds. The project focuses on measurements from 2013 in June, July and August when dust was observed above South Florida, and compares them to the more pristine time periods before and after the dust episodes. Ground based lidar helps assess the descent of the dust layers as they reach South Florida. The 5 day lidar plot shows depolarization ratio which is a measure of the x to y axis of the aerosol (and therefore its sphericity) which means it is a reliable indicator of where dust is present.

2.) Methods:
•Instrument used: Droplet Measurement Technology CCN Counter (see fig. 1)
•Measures CCN Concentrations at 0.2, 0.4, 0.6, 0.8, & 1.0% supersaturation levels
•Data from the CCN counter are plotted first as daily time series with points for each SS level and then plotted as daily histograms
•To begin analysis of the collected data, lidar depolarization ratio time plots (fig. 2) were analyzed for days when values are greater than 0.1
•These days are then compared to the time series and histogram plots made with the CCN counter data

3.) Data & Analysis:

Figure 1—Location of CAROb with the instruments used in this study. (A) The 39.3 m tall CCN counter and associated laboratory was located in the brown building at the center of the image. (B) The 30 m tall lidar tower was located on the rooftop of the brown building on the left. The white and yellow building at the center is the University of Miami campus. (C) The aerosol spectrometer for size identification was on the ground level near the CRN and CAROb instruments. (D) The 5 m tall lidar is on the rooftop of the white building on the right (ESR) and the 5 m tall lidar on the rooftop on the brown building is located on the left.

Figure 2—Lidar depolarization ratio time plots for June 19-24 event. (E1) A zoomed in plot of the time period with significant dust event. (E2) The orange line is from data collected in the summer of 2013. The background line is from observations at South Florida with red line from CAROb and the green line from a pristine maritime air mass. The red line in the middle and the green line on the bottom show profiles from a polluted air mass and a pristine maritime air mass respectively. Since the Miami profile has much higher concentrations at each supersaturation level than the other two plots, this indicates the Miami profile contains more polluted air. The steeper slope indicates that anthropogenic pollution is present in the Miami profile (Wallace and Hobbs). The lidar in fig. 2 shows that dust was present at the surface on the days circle in yellow. The average CCN concentrations in fig. 3 indicate that dust was able to serve as a nucleus for cloud droplets within the boundary layer during these time periods. In the period with no dust, the higher counts seen in fig. 5 can be explained by local pollution. Table 1 shows that total overall CCN concentrations were slightly higher during the June dust event

4.) Conclusion:
The data from the 2013 dust events suggests that dust is detectable at the surface and is capable of nucleating cloud particles within the boundary layer. The CCN concentrations on the average time plots are higher during the dust events, and the histogram of 0.2% supersaturation CCN concentrations for these days suggests a homogeneous dust density within the layer. The total concentrations on these days are also slightly increased during the events compared to the days without dust.