Evidence of the First Indirect Effect in Clouds
Downwind of a Mid-size North American City

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The Problem
► Can a mid-size North American City affect microphysics and optics of small to mid-size cumulus clouds?
  - FWC occur over much of planet
  - Most sources of anthropogenic particle (e.g., cities with populations ~10 x10^3) are small relative to a few large anthropogenic sources (e.g., megacities with populations ~10 x10^6)

The CHAPS Campaign
Time: June 1-30, 2007
Location: Downwind of Oklahoma City, OK

Synoptic Pattern: Record rainfall as a result of a blocking pattern over much of North America.

Key Measurements included:
► Cloud microphysics
  - DMT Cloud, Aerosol, and Precipitation Spectrometer (CAPS)
  - Cloud Imaging Probe (CIP): precipitation
  - Cloud Aerosol Spectrometer (CAS): 20 bins, 0.63-60 μm
► CO
  - Vacuum UV Fluorimeter used as proxy to identify plumes associated with an urban source (inside and outside clouds)
► Vertical velocity (w)
  - Gust probe mounted on nose of G-1

Observations and Data Processing
CO and w: removed mean and trend—analysis focused on CO' and w'
► Cloud microphysics
  - Drops greater than 3 μm
  - Cloud droplet number concentration (CDNC), Liquid water content (LWC), and Effective radius (reff)
► Data binned according to CO' and w'
  - Mean CDNC, LWC, reff found for each bin
  - At least 10 observations/bin

Conclusions and Future Work
► Yes, a mid-size North American City can affect microphysics and optics of FWC
  - Based on observations that:
    - Aerosol effects were consistent with postulated 1st Indirect Effects
    - Changes in scattering were observed

Next steps
► Computation of cloud optical depth
► Relation of particle composition to these effects?
► Repeat measurements in simpler synoptic situation
► Add state-of-the-science measurements of black carbon, absorption
► Similar instrumentation for a 2012 ARM-supported campaign (proposed)