# Impacts of Aerosols on Deep Convective Storms


Joseph W.G. Moody[1], Prof. Chris Kummerow[2], and Paula Brown[2]

[1]University of Northern Colorado, Greeley, Colorado

[2]Colorado State University, Fort Collins, Colorado


## Introduction

Cloud condensation nuclei (CCNs) encourage the formation of cloud droplets that form rain through collision and coalescence. CCN concentrations vary throughout the atmosphere. Their effects on warm and cold rain processes are a matter of ongoing study. Research shows that large concentrations of CCNs in convective storms reduce precipitation. Examine now, a year of reanalysis data of CAPE, vertical velocity, aerosols, and remote precipitation measurements.

## Data & Methods

**Convective available potential energy (CAPE) and vertical velocity.**

- European Centre for Medium Range Weather Forecast (ECMWF) reanalysis.
- Grid spacing (CONUS) is 0.75° latitude and longitude.

**Aerosol data**

- chemical transport model (CTM)
- Goddard Earth Observing system (GEOS).
- TOMAS: An aerosol module extension.
- CCNs of diameter greater than 40 nm (N40).
- 2.0° grid spacing.

**Radar reflectivity and precipitation**

- Global Precipitation Measurement (GPM) satellite.
- Horizontal GPM data is a resolution of 125 m$^2$ pixels.
- Vertical layers averaged to a 500 m resolution.

Nearest ECMWF and GEOS-Chem TOMAS forecast grid points are paired with every GPM pixel that has recorded precipitation in the area of 20° to 56° latitude, -132.5° to -62.5° longitude and a time period from 0Z 01-09-2014 to 0Z 29-08-2015.

## Aerosols

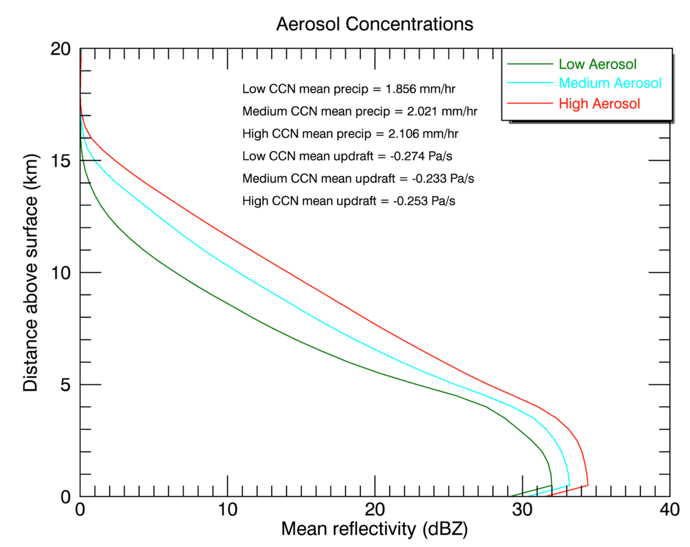


**Figure 1**: GPM radar reflectivity profiles divided into three aerosol concentration terciles.

High aerosol concentrations show significantly different reflectivity profiles.

## Goals

- Determine what effect different aerosol concentrations have on deep convection using observations.
- What ways do aerosols affect cold and warm rain processes?
- Are there any anthropogenic aerosol influences that can affect the weather on the weekends Vs. the weekdays?

## Impact of CAPE

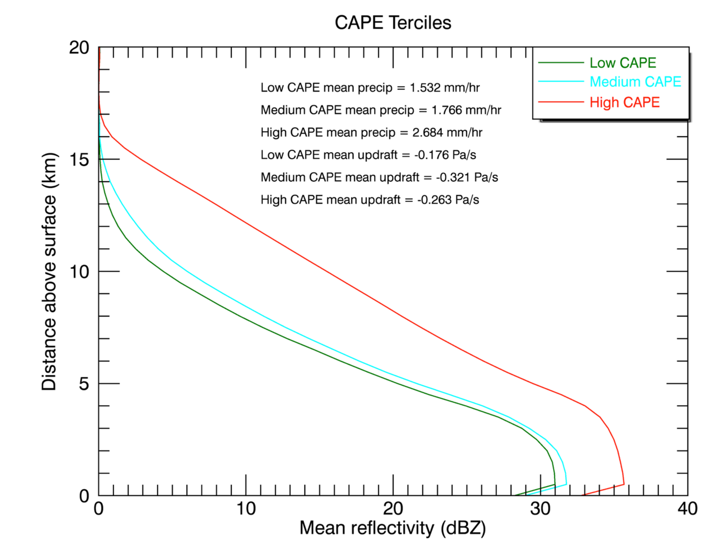


**Figure 2**: GPM radar reflectivity profiles with CAPE divided into three sample terciles.

CAPE also has a large influence on storm size and precipitation.

## The Impact of Aerosols on different CAPE Environments

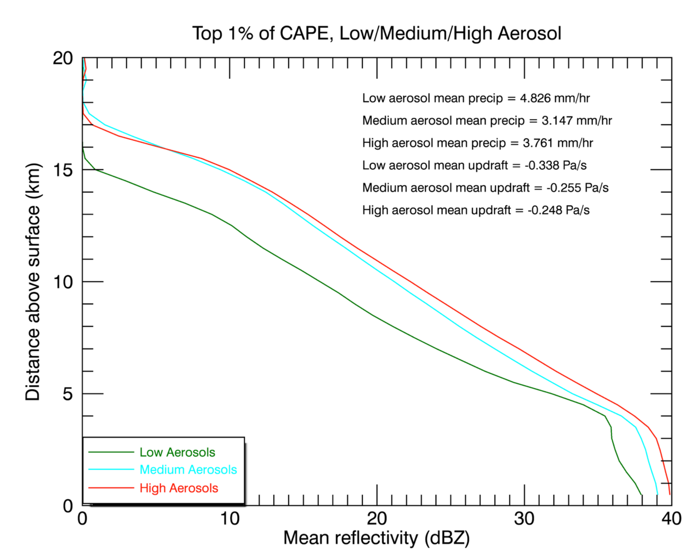


**Figure 3**: GPM radar reflectivity profiles with CAPE above 2,571 j/kg divided into three aerosol concentration terciles.

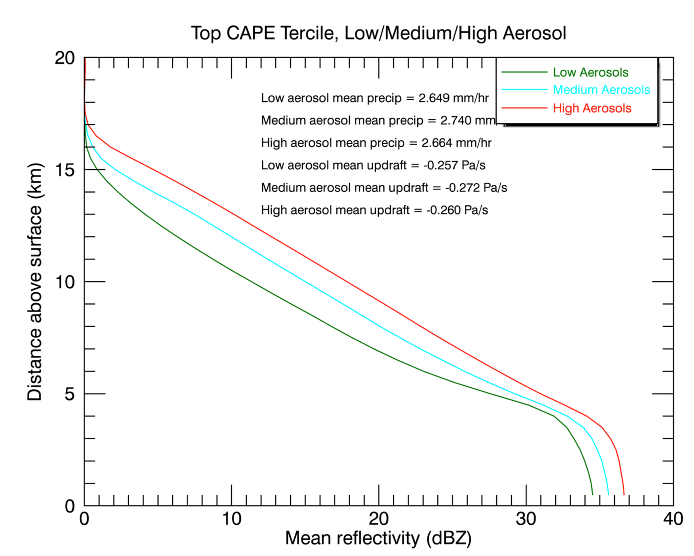


**Figure 4**: GPM radar reflectivity profiles with CAPE above 233 j/kg divided into three aerosol concentration terciles.

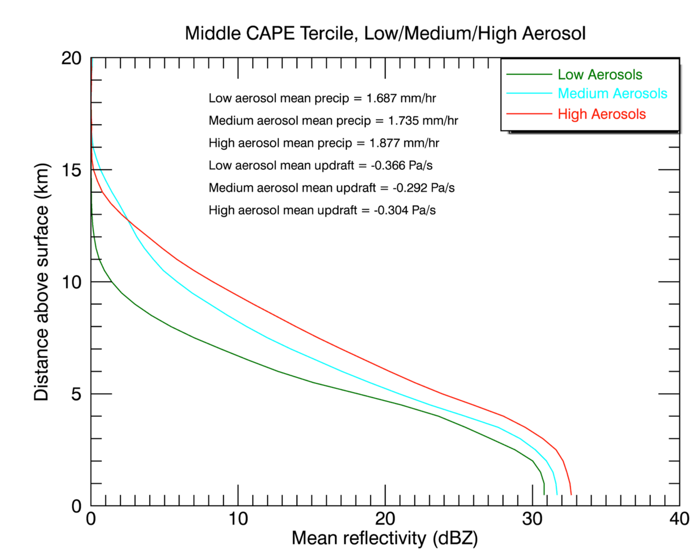


**Figure 5**: GPM radar reflectivity profiles with CAPE of 44-233 j/kg divided into three aerosol concentration terciles.

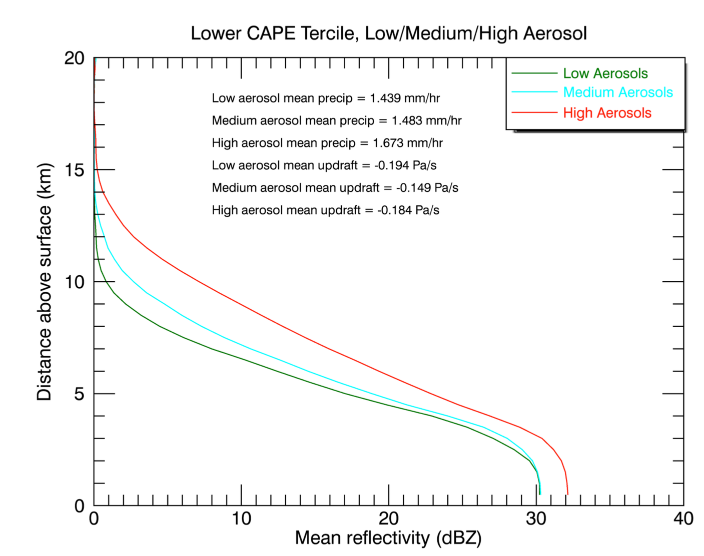


**Figure 6**: GPM radar reflectivity profiles with CAPE of 0-44 j/kg divided into three aerosol concentration terciles.

Radar reflectivity of the top 1% CAPE and different aerosol concentrations show significant differences

Each of the three CAPE terciles (high, medium, low) are also grouped into N40 aerosol concentration terciles. In middle and lower CAPE terciles higher aerosol concentrations correlated to higher rain rates. Deeper convection is less suppressed by aerosols. Reflectivity magnitude and depth increases with aerosols.

## Aerosols & Weekends?

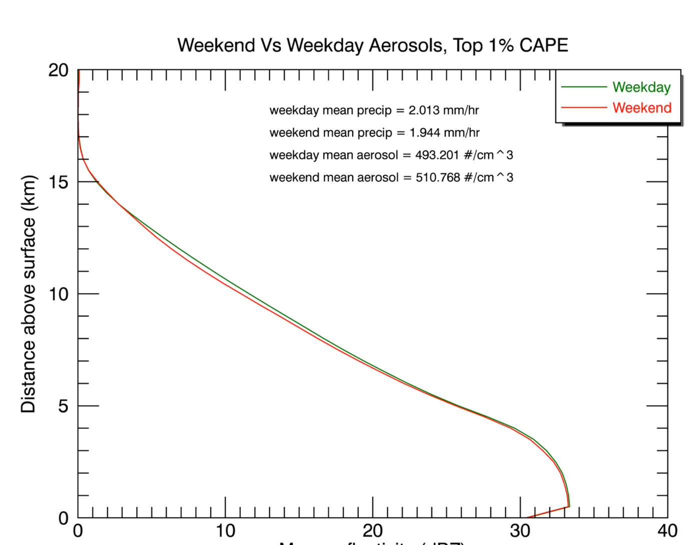


**Figure 7**: GPM radar reflectivity profiles with CAPE above 2,571 j/kg divided by weekday and weekend.

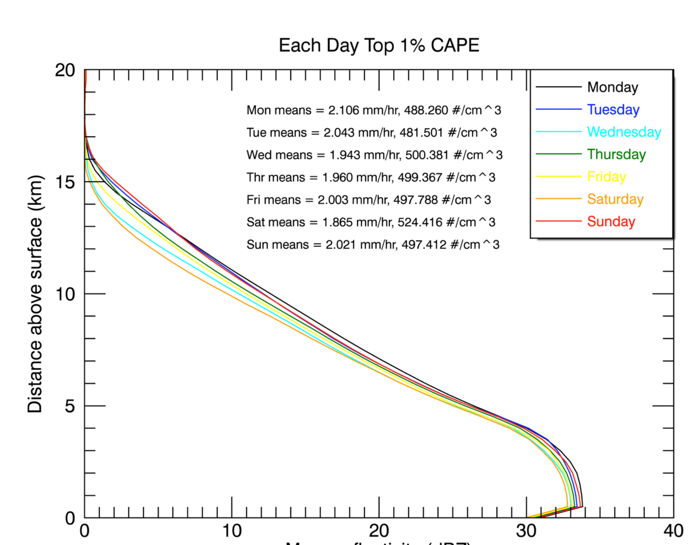


**Figure 8**: GPM radar reflectivity profiles with CAPE above 2,571 j/kg divided by day of the week.

Do anthropogenic factors arise from activity associated with the work week and weekends? Mondays and Saturdays are the biggest outliers in aerosol concentrations and precipitation rates.

## Examining the east coast

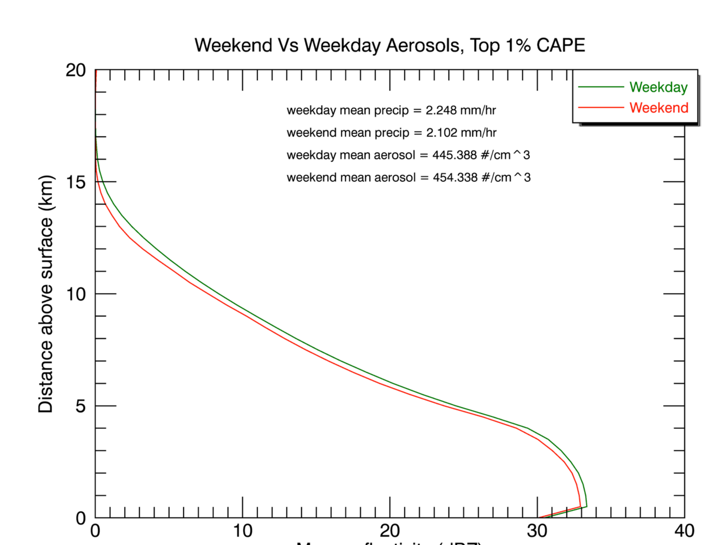


**Figure 9**: East coast GPM radar reflectivity profiles with CAPE above 2,161 j/kg divided by weekday and weekend.

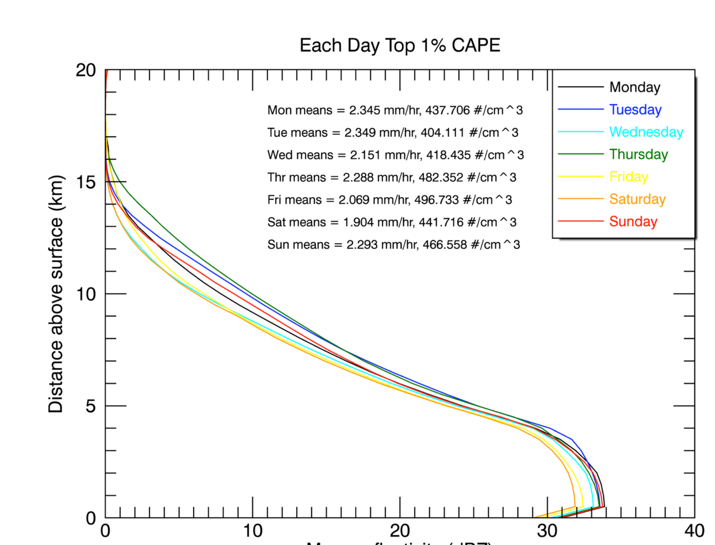


**Figure 10**: East coast GPM radar reflectivity profiles with CAPE above 2,571 j/kg divided by day of the week

In the western United States there are likely more natural aerosols compared to the more populated east coast. By adjusting longitude from -80° to -62.5° (the east coast of CONUS) there is greater variation in day to day averages.

## Conclusions

- High aerosol concentrations increase storm heights.
- Warm rain is suppressed while cold rain is enhanced by aerosols.
- In larger convective storms high aerosol concentrations can reduce surface precipitation rates.
- There is a small difference between weekend and weekdays in deep convection. Anthropogenic causes cannot be identified in this data set.

It is important to note that surface clutter is present in radar reflectivity for many of the lowest level layers. Desired future work on this would include investigating the role of vertical wind shear and available moisture. Isolate smaller regions to better capture human aerosol activity.

## References


Stolz, D. C., S. A. Rutledge, and J. R. Pierce (2015), Simultaneous influences of thermodynamics and aerosols on deep convection and lightning in the tropics, J. Geophys. Res. Atmos., 120, 6207–6231, doi:10.1002/2014JD023033.

Tao, W. K., J. P. Chen, Z. Li, C. Wang, and C. Zhang(2012), Impact of aerosols on convective clouds and precipitation, Rev. Geophys., 50, RG2001, doi:10.1029/2011RG000369


## Acknowledgements


This work has been supported by the National Science Foundation Research Experiences for Undergraduates Site in Climate Science at Colorado State University under the cooperative agreement No. AGS-1461270.

I would like to thank Chris Kummerow, Paula Brown, Mark Branson, Kelly Wittmeyer, Melissa Burt, and Torrie Moss for their time, knowledge and support on this project.