Tornadoes do not have a Weekly Anthropogenic Cycle and Supercells have Minimal Susceptibility to Aerosol Influence

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Introduction

We analyzed tornado data to critically examine the findings in Rosenfeld and Bell's paper, *Why do tornadoes and hailstorms rest on the weekends* (2011, JGR, RB2011). They claim that high concentrations of aerosol modulate the frequency of tornadoes yielding an anthropogenic weekly cycle in tornado occurrence. Contrary to their findings, we found that:

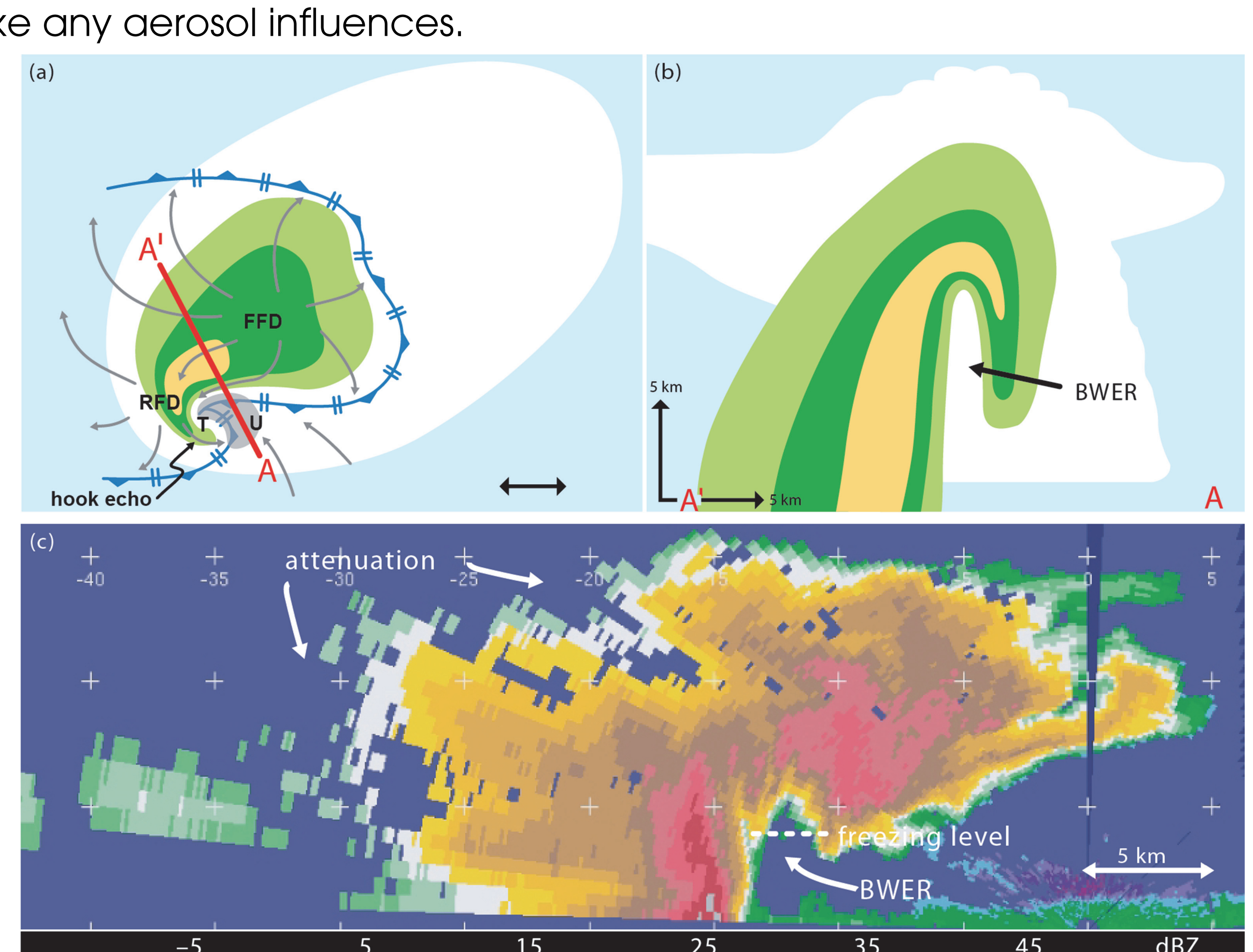
1) There is not a robust weekly cycle or mid-week maximum in tornado occurrence or tornado days
2) RB2011's physical explanation for how increased aerosol concentrations would cause increased frequency and severity of tornadoes and hail in supercells is inconsistent with actual supercell storm structures and their environments
3) RB2011's method of averaging aerosol and tornado data from 100°W eastward conflates an aerosol weekly cycle in one geographic location with tornado occurrence in another

Bounded Weak Echo Regions and the Role of Aerosols in Updrafts

RB2011 states that the effect of aerosols on supercells is to suppress coalescence; rain is delayed and a larger fraction of the cloud water ascends above the 0°C level. We question whether RB2011's chain of aerosol influences is applicable to supercells on the basis that there is little time for droplet growth below the 0°C level within supercell updrafts

A recurring radar signature of supercells which is most prominent at midlevels is a relative minimum in reflectivity, co-located with the updraft, surrounded by an annulus of higher reflectivity. This so-called *bounded weak echo region* (BWER) is where updraft velocities are sufficiently strong to inhibit both precipitation formation and precipitation fallout.

BWERs illustrate that droplets do not have much time to grow via collision-coalescence below the 0 °C level in most supercell updrafts. The conditions needed to obtain large supercooled liquid water content and enhanced riming aloft are actually routinely present in supercells, without the need to invoke any aerosol influences.



Schematic representation of a supercell thunderstorm

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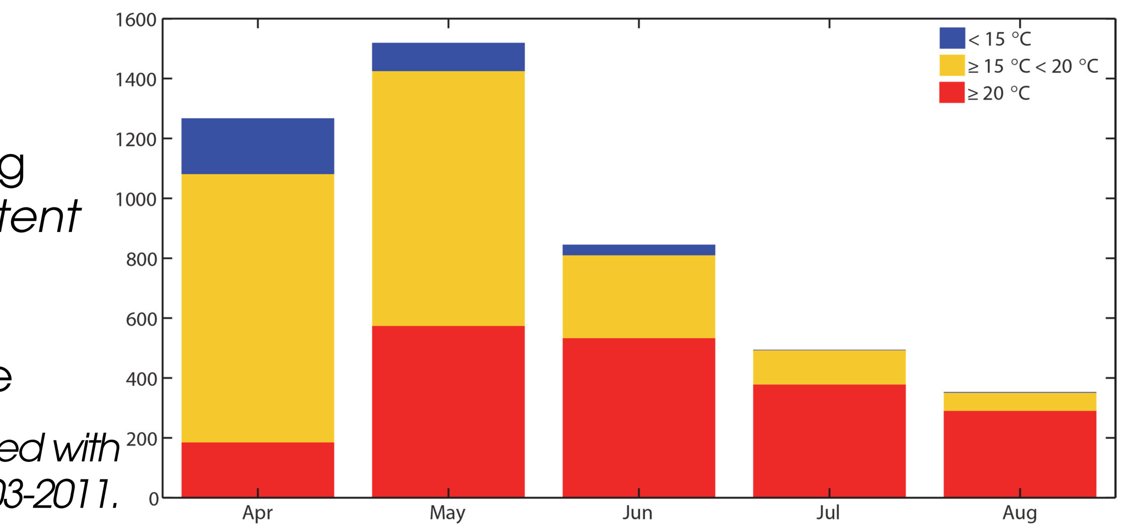
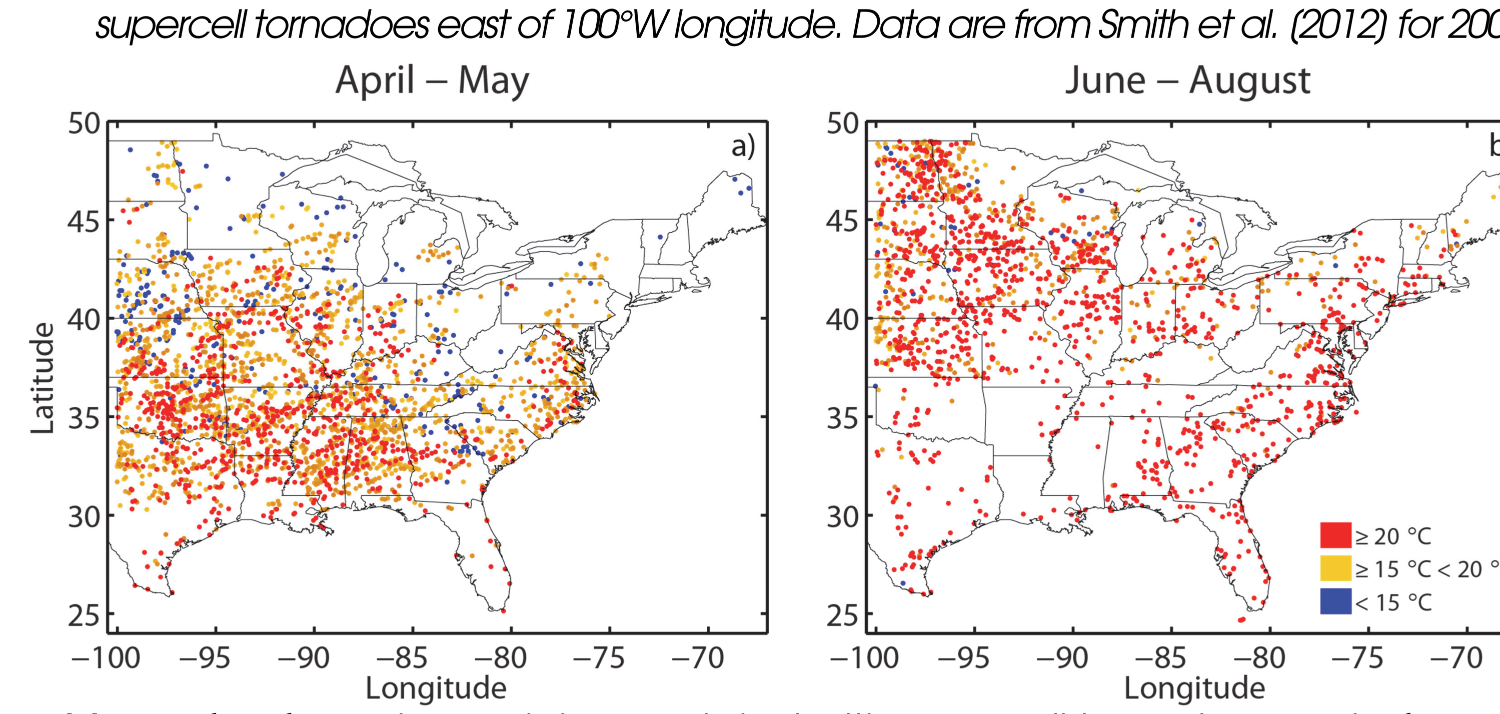
Patterns in Dew Point and Aerosol Weekly Cycles

According to RB2011, dew points ≥15°C are necessary in order to have sufficiently warm cloud bases for aerosol effects to occur.

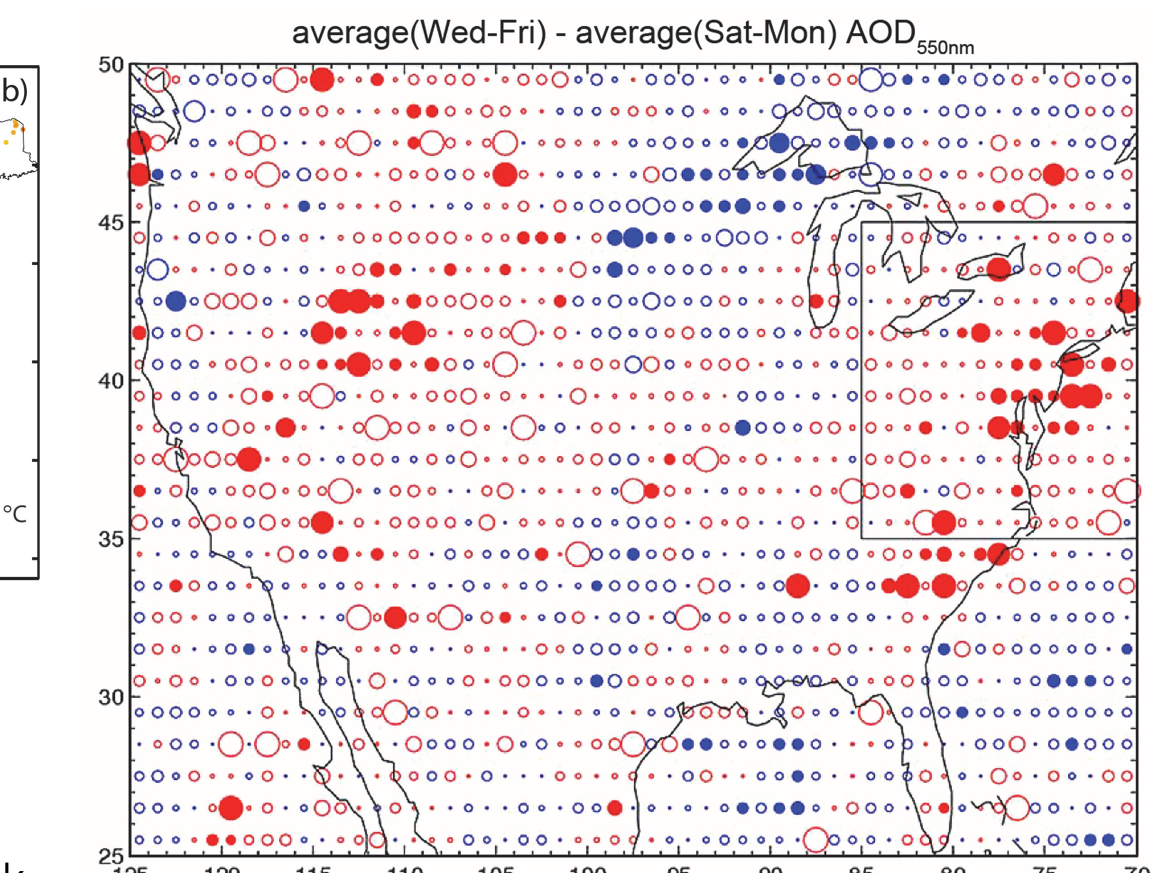
RB2011 found no weekly cycle in tornadoes during April and May saying that monthly mean dew point values were routinely <15°C and "*consistent with the diminution of the convective invigoration effect in cool base clouds*". The use of monthly average values to characterize storm environments is illogical. In fact, 90% of supercells in April and May have surface dew points ≥15°C.



Bar plot of surface dew points associated with supercell tornadoes east of 100°W longitude. Data are from Smith et al. (2012) for 2003-2011.



Maps of surface dew points associated with supercell tornadoes east of 100° W for a) April and May and b) June, July, and August. Data are from Smith et al. (2012) for 2003-2011.



Difference in MODIS AOD percent departure from the weekly average during the weekday (Wednesday to Friday) and during the weekend (Saturday to Monday). The red and blue circles represent AOD during the weekday that is larger/lower than that during the weekend. Filled circles are significant at the 90% confidence level. The diameter of the circles is proportional to the magnitude of the AOD weekly cycle. From Xia et al., 2008.

MODIS AOD observations from Xia et al. (2008) show a mid-week peak in aerosol concentrations (red circles) over the Eastern US, but lower amplitude cycles (smaller circles) with a weekend peak (blue circles) over the Central US where most tornadoes occur.

RB2011 have conflated phenomena in different geographic regions: an aerosol cycle that is stronger in the eastern US and tornadoes that occur more frequently in the central US.

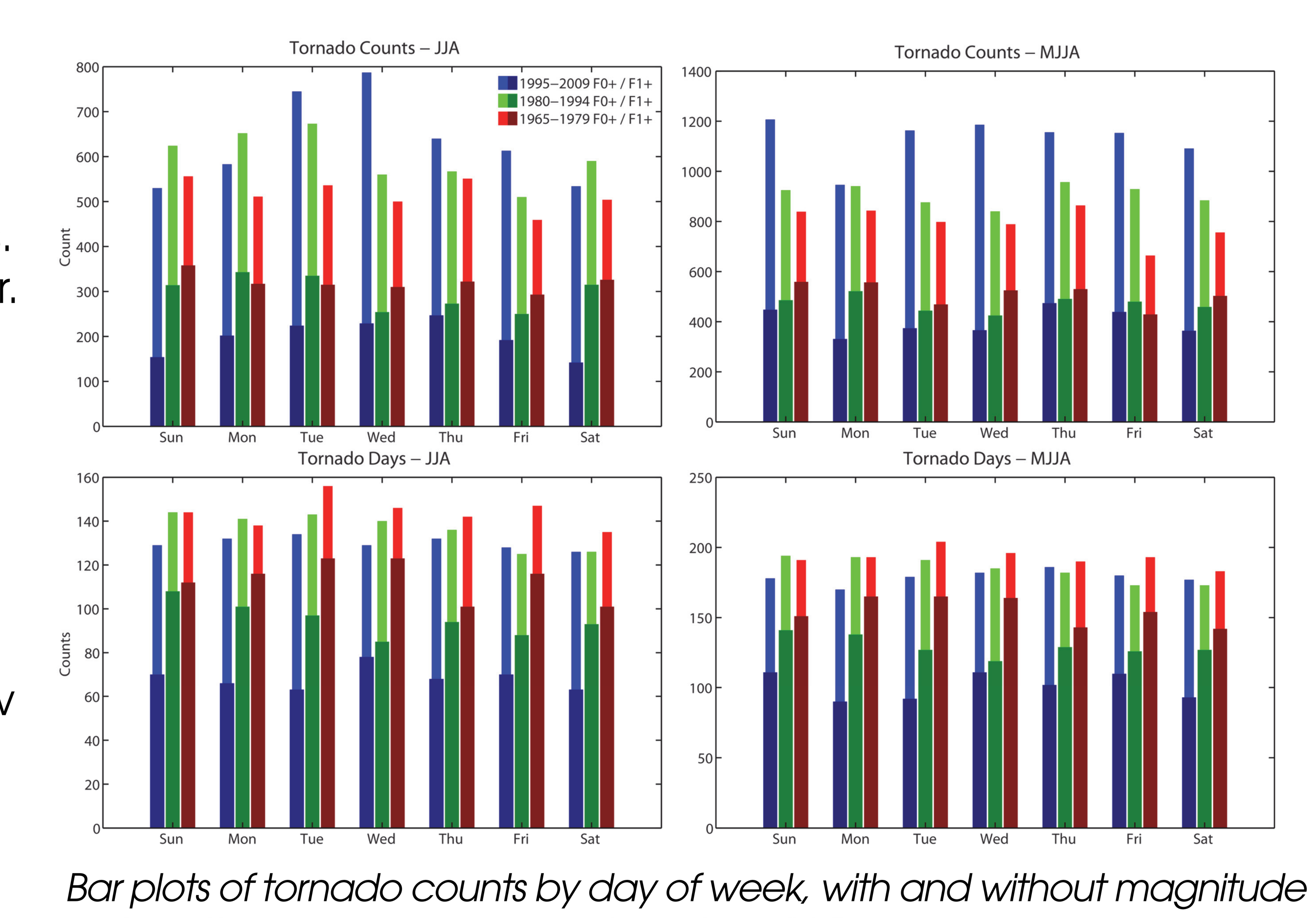
Anthropogenic Weekly Cycles of Tornado Occurrence are a Statistical Illusion

Intermittent phenomena, such as tornadoes, are unlikely to have uniform mean occurrence values day-to-day. The synoptic-scale atmospheric environment can favor the formation of groups of storms each producing many tornados. These groups of tornadoes are not independent of each other.

Counts of tornadoes by day of week over a multi-year period are prone to becoming non-uniform due to a few individual, highly prolific tornado events.

The days of the week for which the maximum and minimum in tornado counts occur are sensitive to tornado intensity (≥F0 or ≥F1) and the period of data examined.

The use of tornado counts can be problematic because a few days have large outbreaks of tornadoes whereas many days have no tornadoes. Examination of the number of days on which any tornado occurred shows a lower amplitude cycle regardless of the time period examined.



Bar plots of tornado counts by day of week, with and without magnitude F0 tornadoes, for different 14 year periods. Data from SPC tornado report data base.