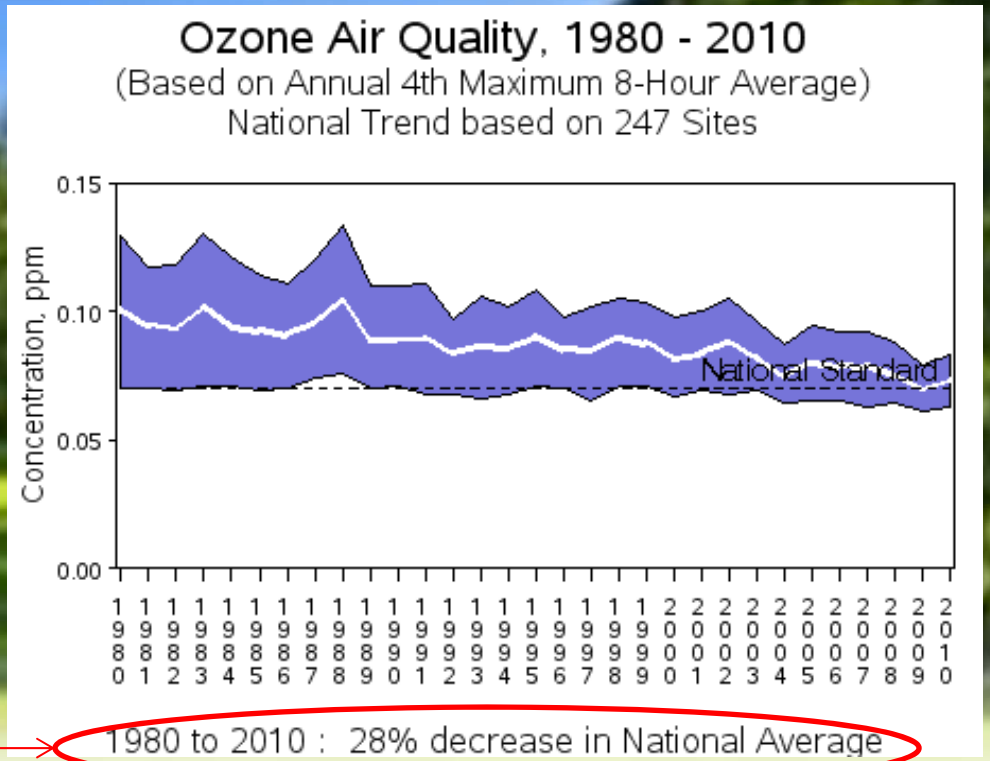
An Analysis of Ozone Data in St. Louis: Dirty Air is Getting Cleaner and Clean Air is Getting Dirtier

Jason Welsh
Graduate Research Assistant
Meteorology, Air Quality Concentration, M.S. 2014
Saint Louis University
B.S., Chemistry, WSU, 2010

- Ozone as an Environmental Problem
- Trends of ozone in the background troposphere
- Analysis and Results of the St. Louis Metropolitan area
- Questions

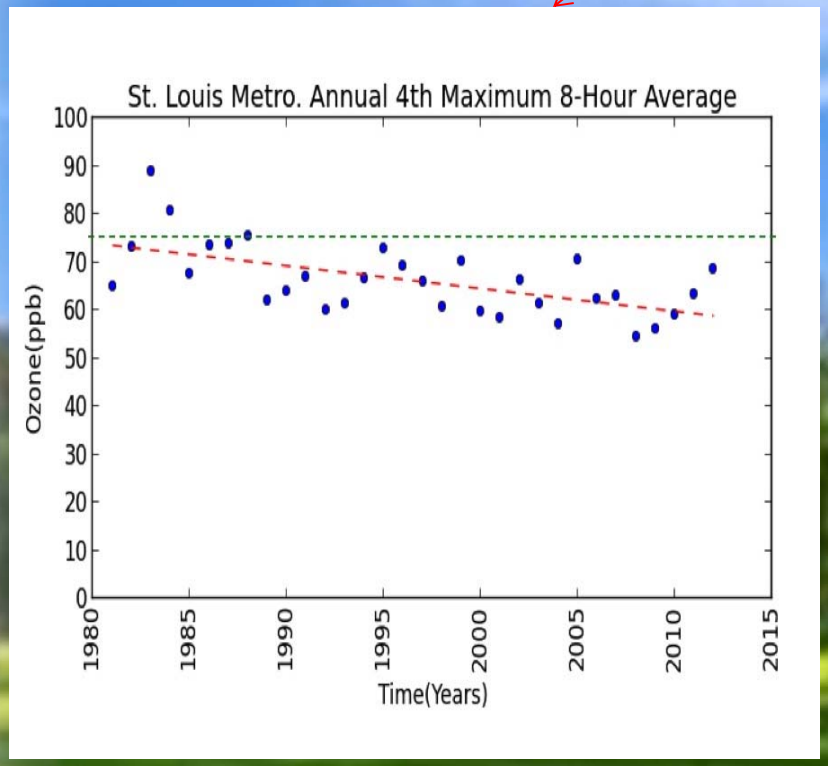
In many urban areas the air quality situation is getting better

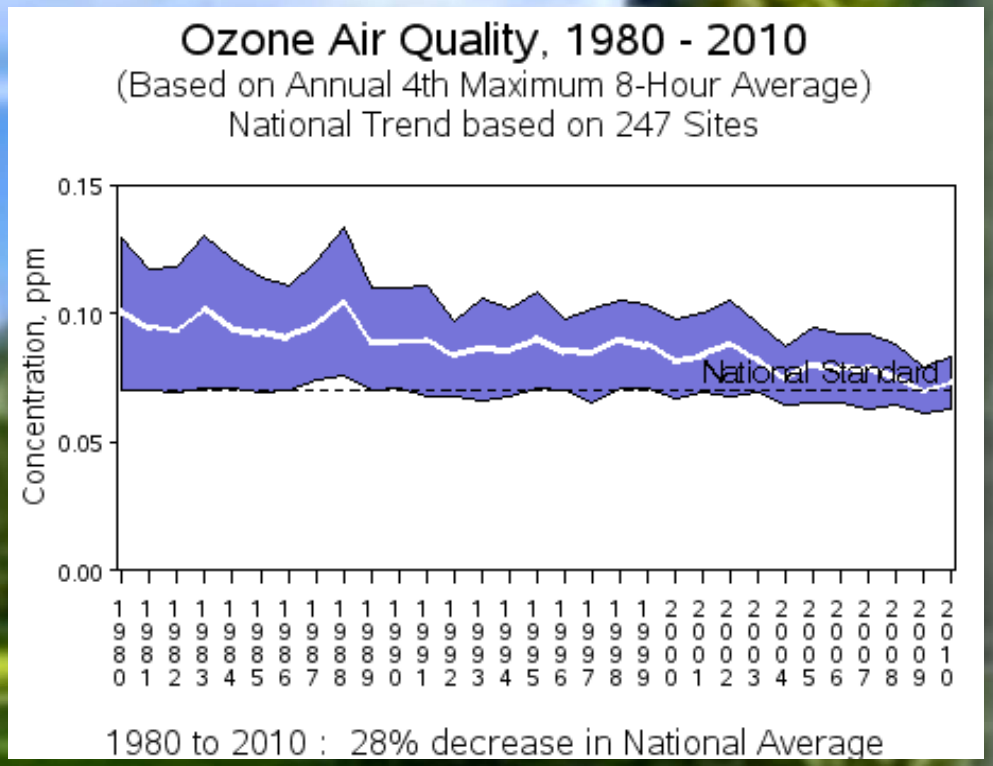
U.S. Air Quality for ozone has been on the decline from 1980-2010

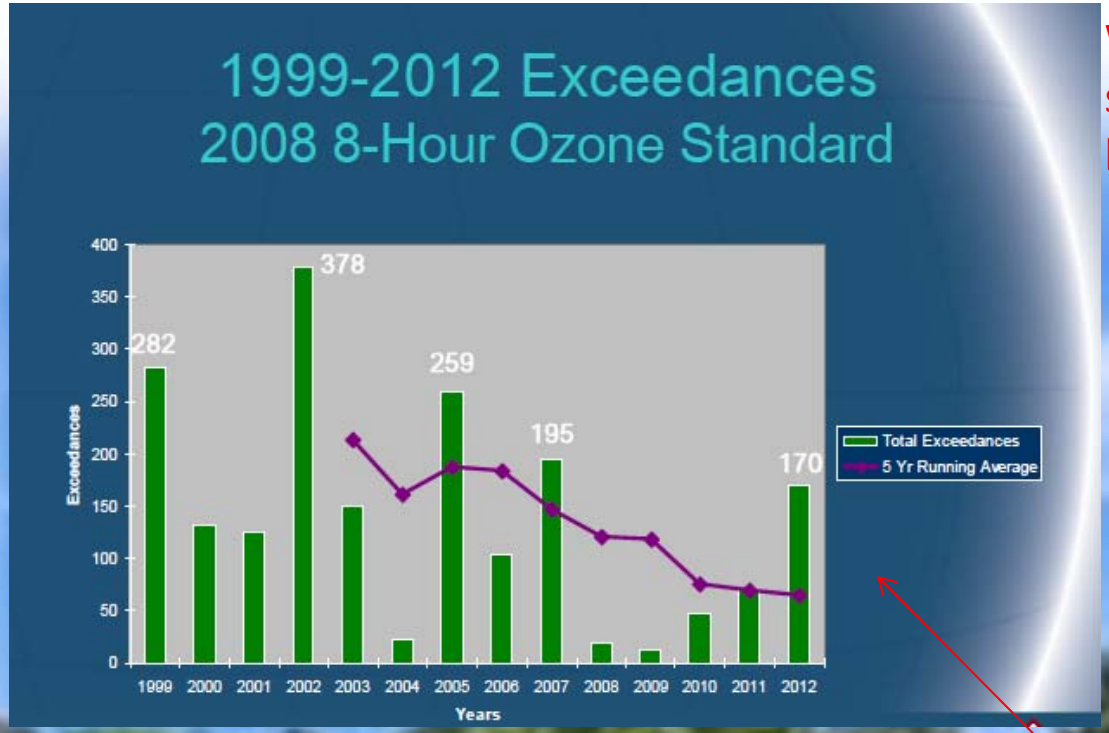


These declines show a 28% decline in the national average from 1980-2010

Both our analysis and the national trend are very similar





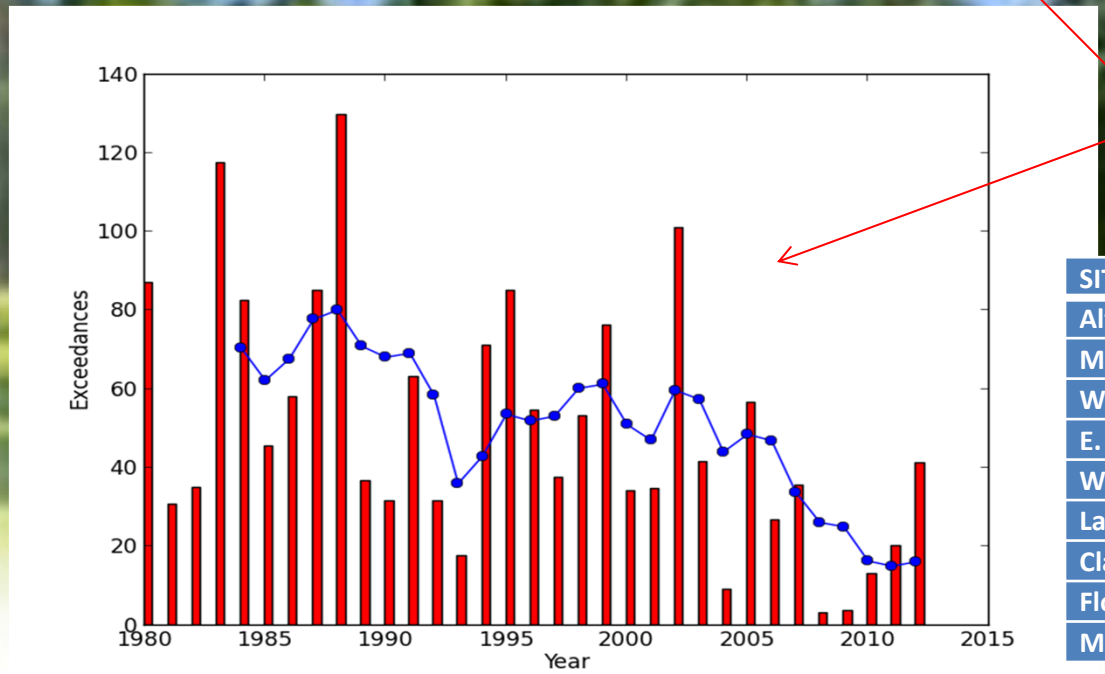


When comparing these figures you can see that high ozone events in Missouri have decreased over time….

A primary reason for the difference in our analysis versus Mike Coulson's analysis…

1. not all the stations were included during those years
2. we only selected those stations that have long term records

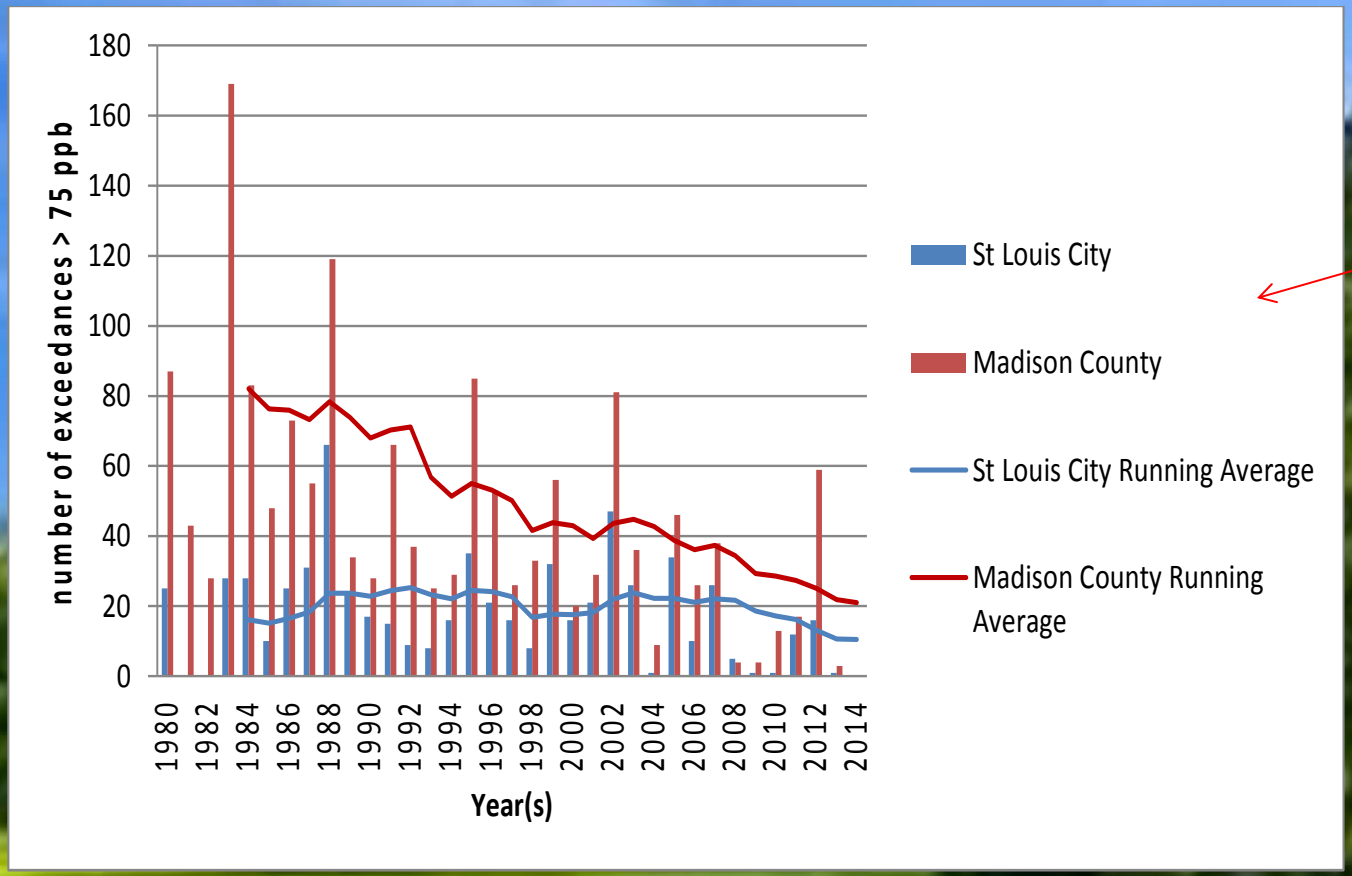
Mike Coulson's analysis is very similar to our analysis but ours goes back to 1980



SITE NAME	STATION(-)	Data Availability
Alton, IL	171190008	1980-2012
Maryville, IL	171191009	1980-2012
Wood River, IL	171193007	1980-2012
E. Saint Louis, IL	171630010	1980-2012
West Alton, MO	291831002	1980-2012
Lafayette Farms, MO	291890006	1980-2005
Clayton, MO	291893001	1980-2004
Florissant, MO	291895001	1980-2004
Maryland Heights, MO	291890014	2005-2012

Here we show an extended analysis of the type provided by AQAC…

Thus, despite equal number of observations, we find considerably more exceedances downwind of the city than in the city…

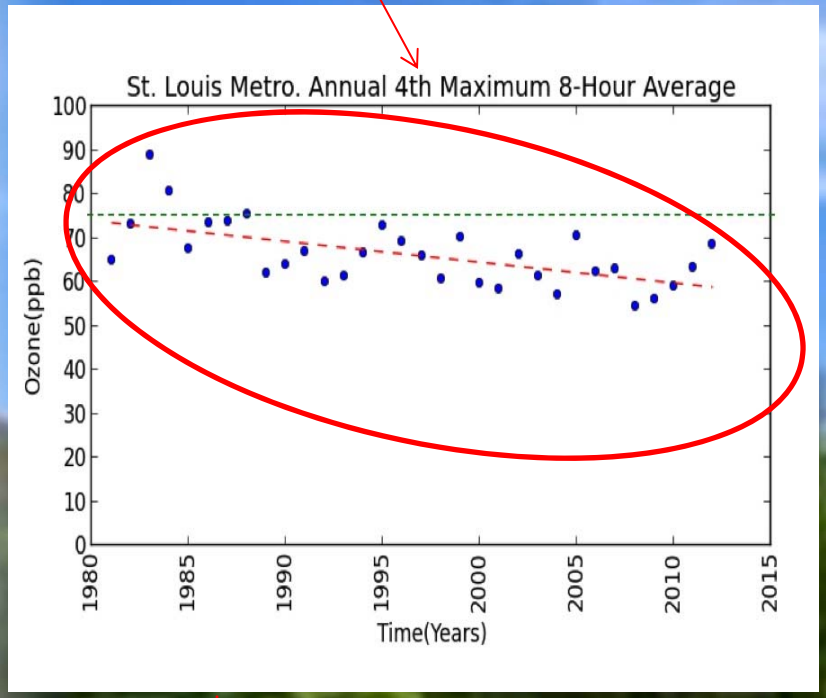


Shows the number of exceedances of the 2008 8-Hour Ozone Standard.

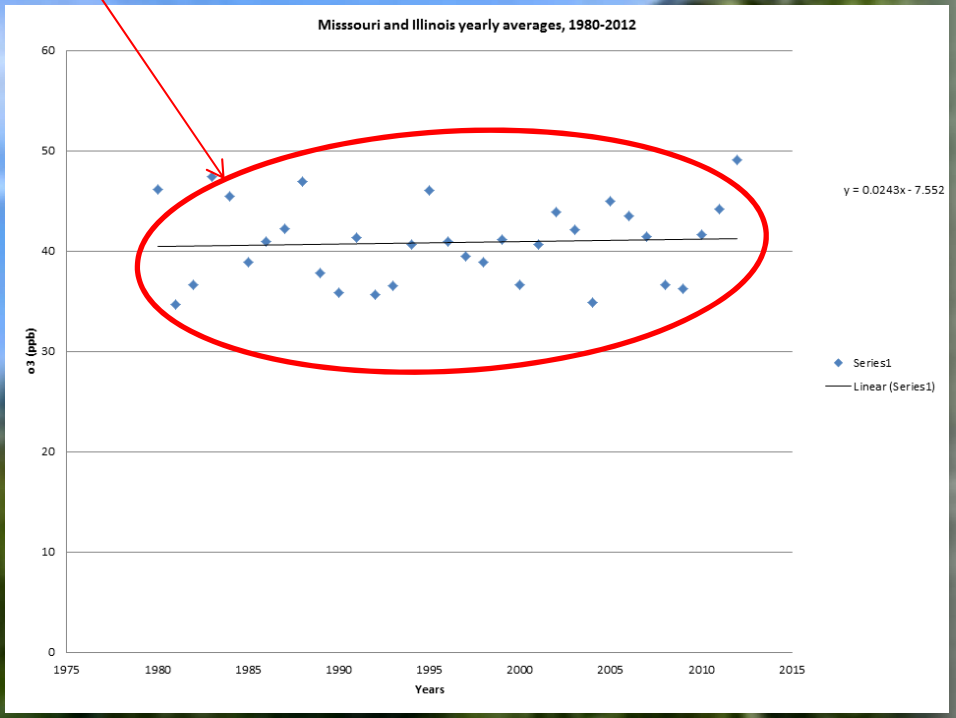
This finding is consistent with what would be expected since highest ozone concentrations are typically found downwind of the source region for ozone precursors.

In fact, an analysis of the 4th highest maximum shows a 15 % decline

Whereas an analysis of all the data from these sights **shows a slight increase in concentration, a trend that seems inconsistent with the findings indicated in the trend for the 4th highest daily maximum value**, which is used by EPA to determine effectiveness of reducing harmful O_3 concentrations



Trend of 4th highest seasonal average over St. Louis metropolitan area between 1980 and 2012



Trend of AQS data in St. Louis metro area between 1980 and 2012.

Result: it shows a downward trend similar to the national trend

Paradoxically, there is considerable evidence that ozone concentrations in the non-urban atmosphere are increasing…

Global Analysis of Increasing Ozone values completed by Morenco et al. 1994

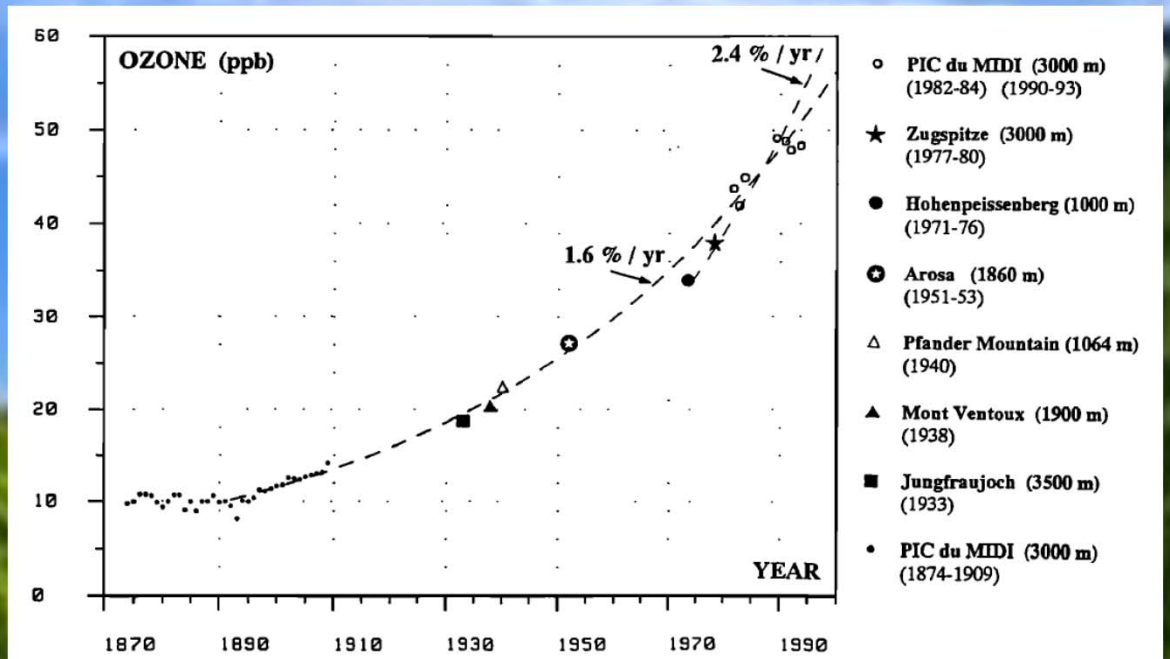
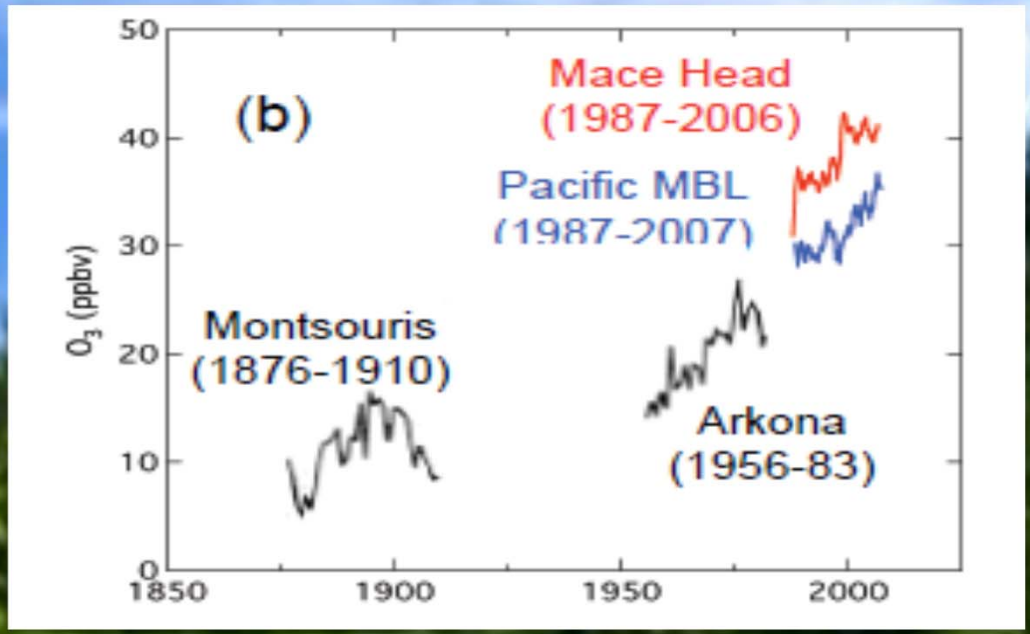


Figure 5. Ozone evolution in the free atmosphere over western Europe, from measurements at the Pic du Midi and in various European stations at high altitudes (see text).

Their analysis showed that there was an increase in ozone by a factor of five ever since the start of the twentieth century through 1992

He reconstructed a dataset derived from measurements taken over Western Europe from 1876-1993

Subsequently another study by Parrish et al. 2009 looked at the west coast of North America and found that background levels of ozone are still increasing past the study completed by Marenco et al. 1994

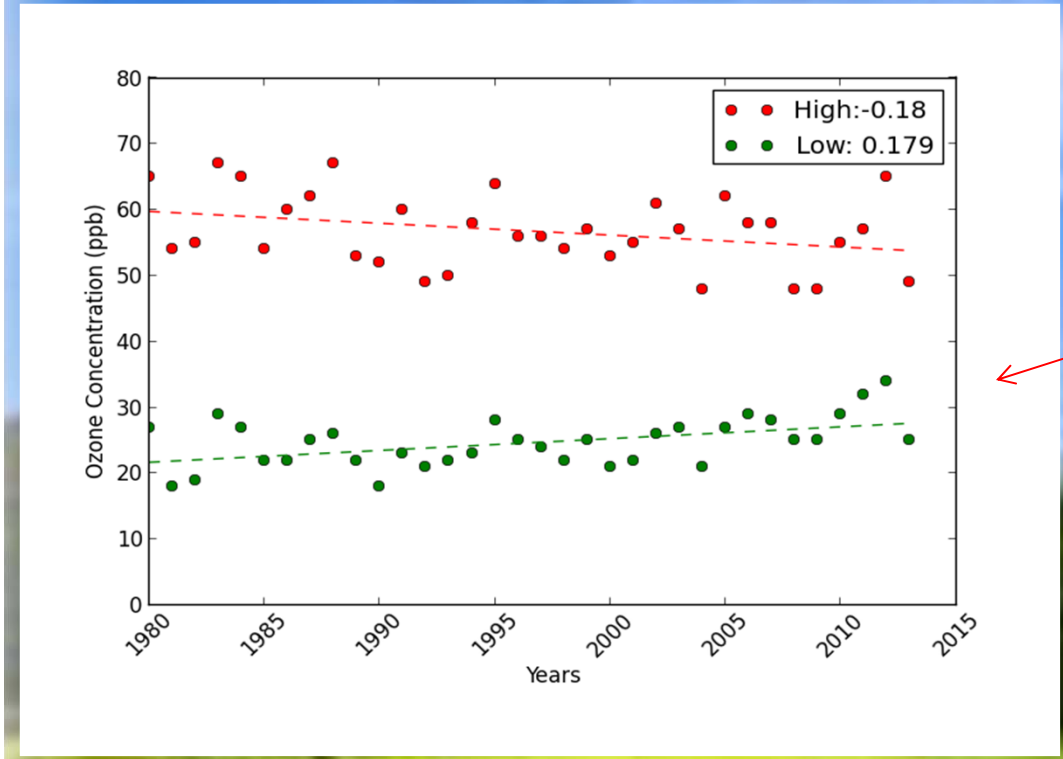


The annual averages from two European sites (Montsouris and Arkona) by Volz and Kley (1988) and Mace Head, Ireland in red and Pacific MBL in blue from study completed by Parrish et al. 2009.

We then computed the data…

1. Python was used to process the data
2. Using these values for each month, the daily eight hour averages were computed for an entire month (*Note the eight hour averages start at 00 UTC and go through 1600 UTC)
3. The eight hour averages for each month are then used to retrieve the highest and lowest 6 values for each month
4. The highest eight hour averages were averaged and plotted as a function of years
5. Then the eight hour exceedances (> 75 ppb) for any given year using the computed eight hour averages for each year were graphed

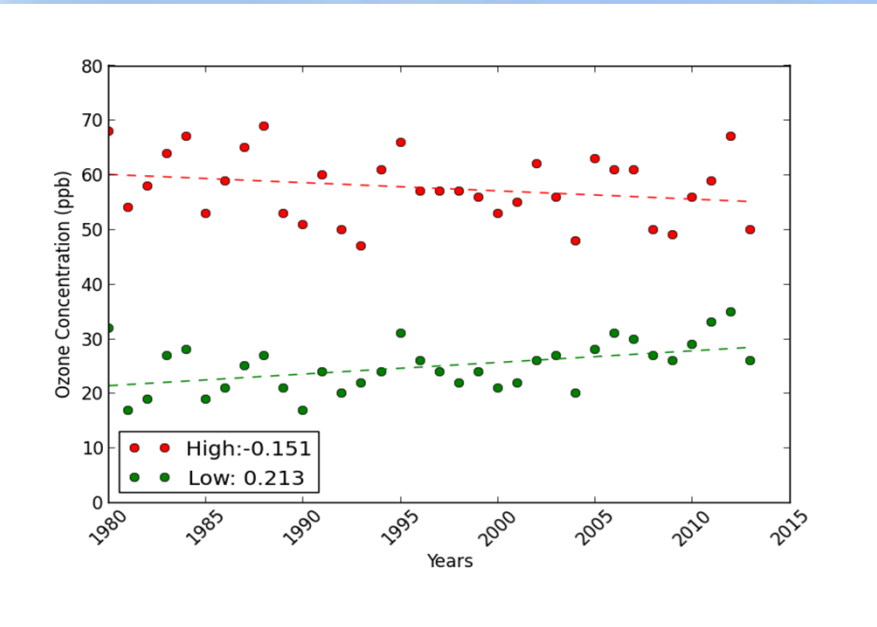
Comparing this analysis with St. Louis metropolitan area for May-October, shows that the values for June, July and August are **enhanced** for downward and upward trend when a smaller dataset is used



Shows the St. Louis Metropolitan area analysis highest (red dots) and lowest (green dots) 20% for June, July and August over a 30 year time period

Using these three months only reflects the ozone trend during the time that vegetation most actively grows

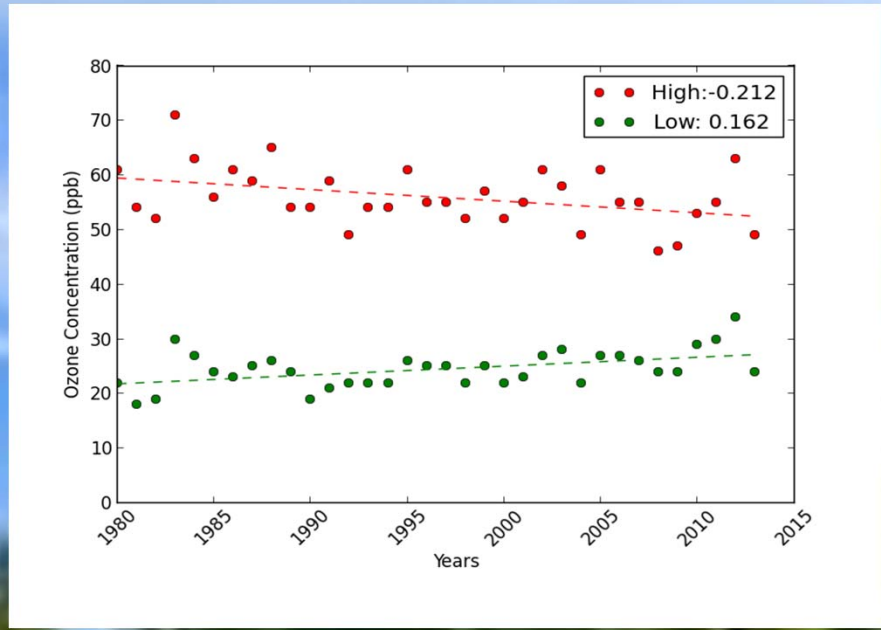
Missouri



Trend analysis for the Missouri stations for June, July and August from 1980-2013. Red circles indicate highest 20% ozone values and green indicates lowest 20% ozone values.

High ozone values are declining at a rate of **-0.15 ppb/year** whereas background is increasing **+0.21 ppb/year which is greater than the clean air trend of all the data in the metropolitan St. Louis area. Therefore if MO air is not being affected by pollution and represents background air, then background air has increased by nearly 8 % since 1980**

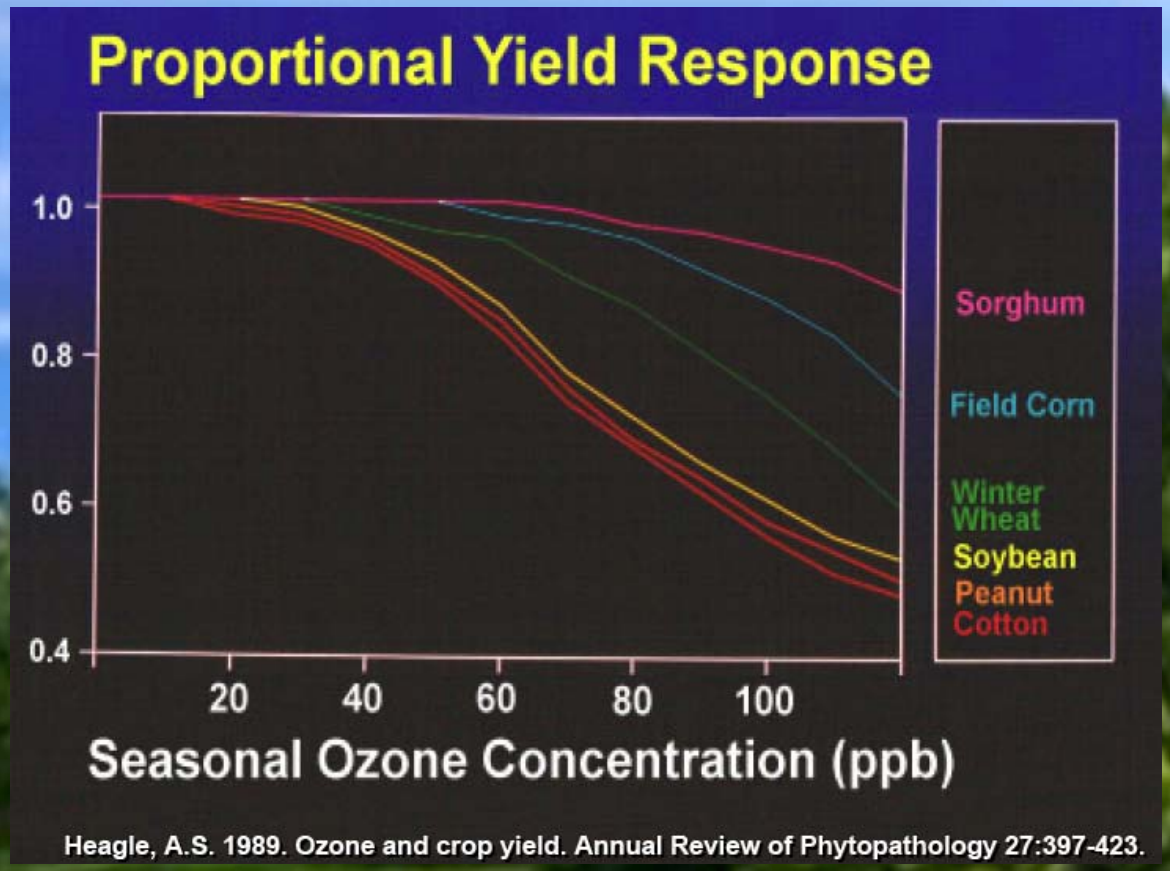
Illinois



Trend analysis for the Illinois stations for June, July and August from 1980-2013. Red circles indicate highest 20% ozone values and green indicates lowest 20% ozone values.

The highest values are decreasing by a slope of -0.21 which is higher than the downward trend for all the data (-0.165 ppb yr^{-1}) (i.e., St. Louis Metropolitan area)

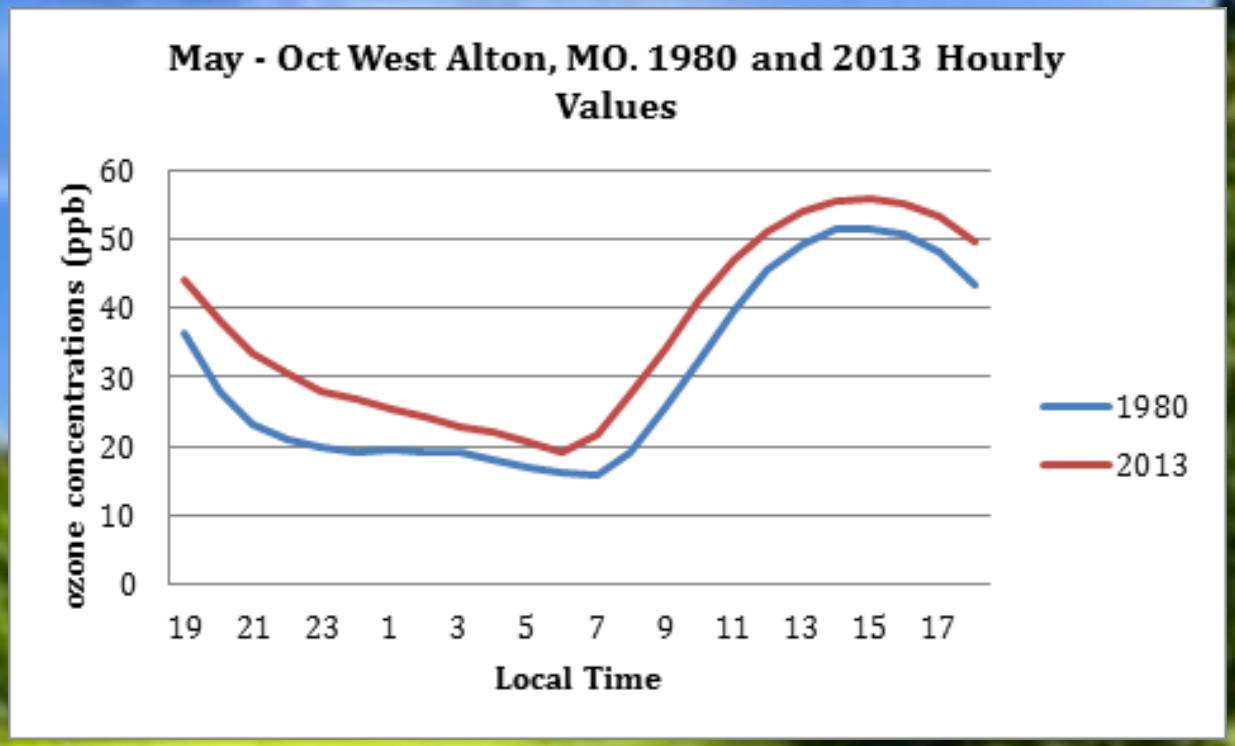
Also, another study by Heagle 1989 shows crop yield decreases substantially when ozone concentrations exceed 40 ppb



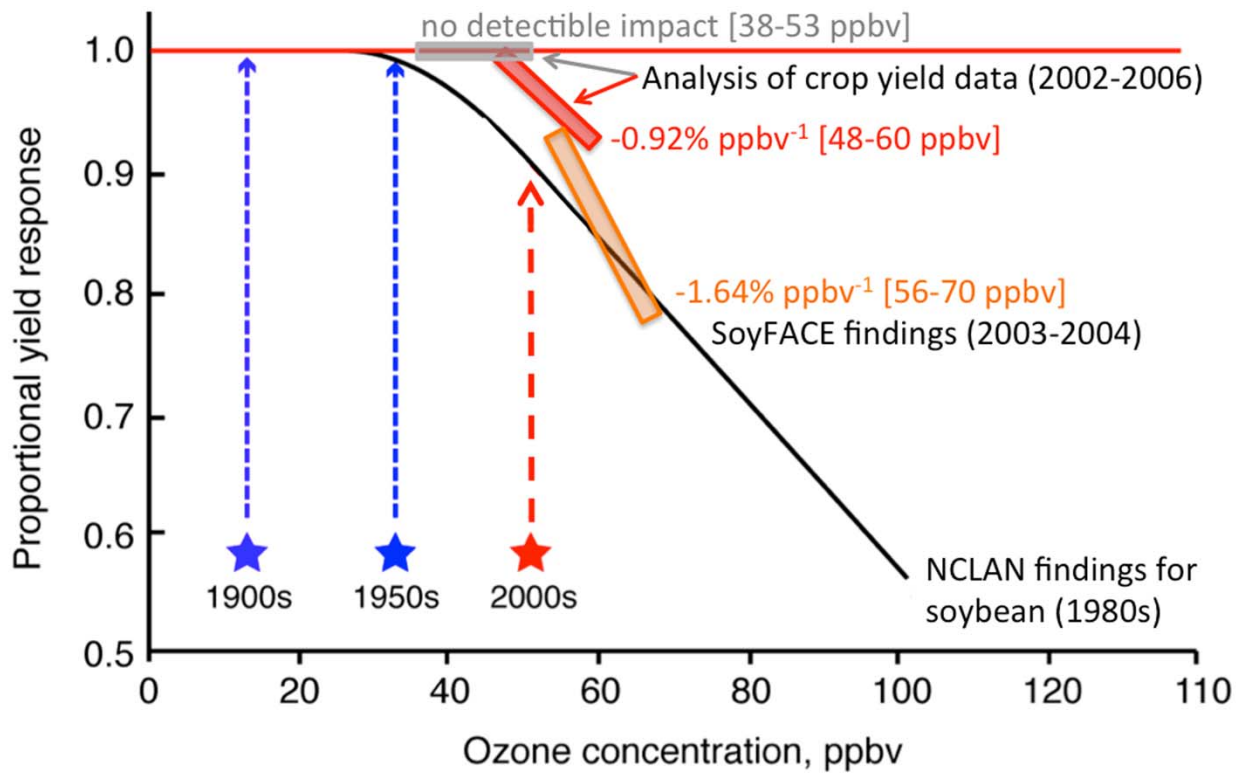
Heagle 1989 NCLAN study shows how plant yield decreases when concentrations exceed 40 ppb

Overall, this foliar damage not only has devastating aesthetic consequences for parks and recreational facilities nationwide but on the health of the economy

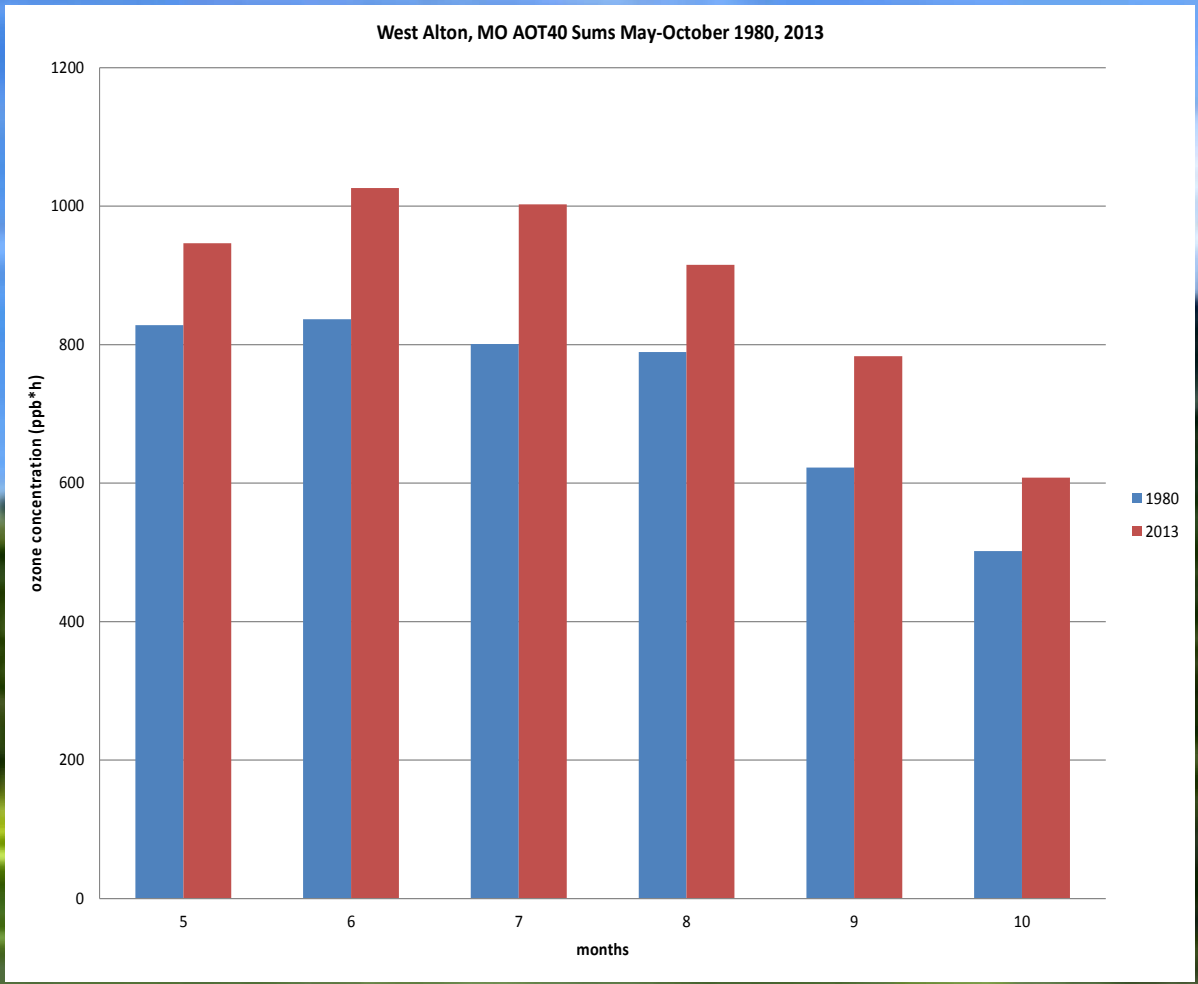
Shows the average diurnal cycle of ozone at West Alton, MO. for the entire ozone season for each hour of observation…



Overtime, the effects of yield of soybeans has been dramatically reduced due to ozone exposure



Shows that ozone exposure to crops over the ozone season has increased from 1980 to 2013…



Summary

- U.S. Air Quality Exceedances for ozone have been on the decline since 1980-2012
- We find more exceedances downwind of the City
- When graphing all the data, it shows a slight increase which is inconsistent with the 4th highest daily maximum value
- We see decreasing high ozone concentrations but increases in background ozone concentrations consistent with what has been found
- As a result, this has a huge impact upon agriculture as plants can be susceptible to ozone damage; especially in light of the secondary standard being considered

We would like to extend a special thank-you to NASA AQAST for helping fund this research

AQAST

NASA Air Quality Applied Sciences Team

Thank-you, any questions?