# Comparison of Ozone Concentrations

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# Introduction

- Ozone is a air pollutant when found in the lower Troposphere.
- The Pacific Ocean transports Ozone into the western United States that are "a large fraction of the US health standard."
- Quantify to develop a more complete picture of US air quality.
- Ozone lifetime of ~100 Days is longer tha the circum-global transport time (~30 days)
- Ozone concentrations at the mid latitutdes are established over weeks and months.
- Ozone concentrations are also uniform along longitudes as well as from the PBL to around the Tropopause.

# Introduction (Continued)

- Ozone concentrations are variable on both shorter and longer time scales.
  - Wildfires (Lin et al., 2017)
  - Heatwaves
  - Droughts (Lin et al., 2020)
  - Climate Variability (Lin et al., 2014)
- Short term variability was ignored working instead on a baseline.
- 1978 – 2017 data for 28 locations split into 2 year means.
- Captured 89% of variance with a RMS deviation between the fit and the means of 1.3 ppb.
- Captured 67% of variance for the 28 trend analyses.
- Agrees well with quadratic fit from trend analysis results.

# Introduction (Continued More)

| Location | *a* (intercept)[1] (ppb) | *b* (slope) (ppb/decade) | *c* (curvature) ($ppb/decade^2$) | $year_{max}$ | Years of data |
|---|---|---|---|---|---|
| Northern mid-latitudes | --- | 2.0 ± 0.6 | -1.8 ± 0.6 | 2005.7 ± 2.5 | 1978–2017 |
| Lassen Volcanic NP | 41.0 ± 0.7 | 2.6 ± 0.7 | -2.4 ± 0.8 | 2005.4 ± 2.2 | 1987–2017 |
| Pacific MBL | 32.9 ± 1.1 | 1.4 ± 1.0 | -2.5 ± 1.1 | 2002.8 ± 2.2 | 1987–2017 |
| derived from trends | --- | 3.4 ± 0.9 | -2.9 ± 0.8 | 2005.8 ± 2.2 | 1984–2017 |

Table 1. Parameter values for theQuadratic fit. northern hemisphere mid-latitudes, two data sets for the western US (Parrish et al., 2020).

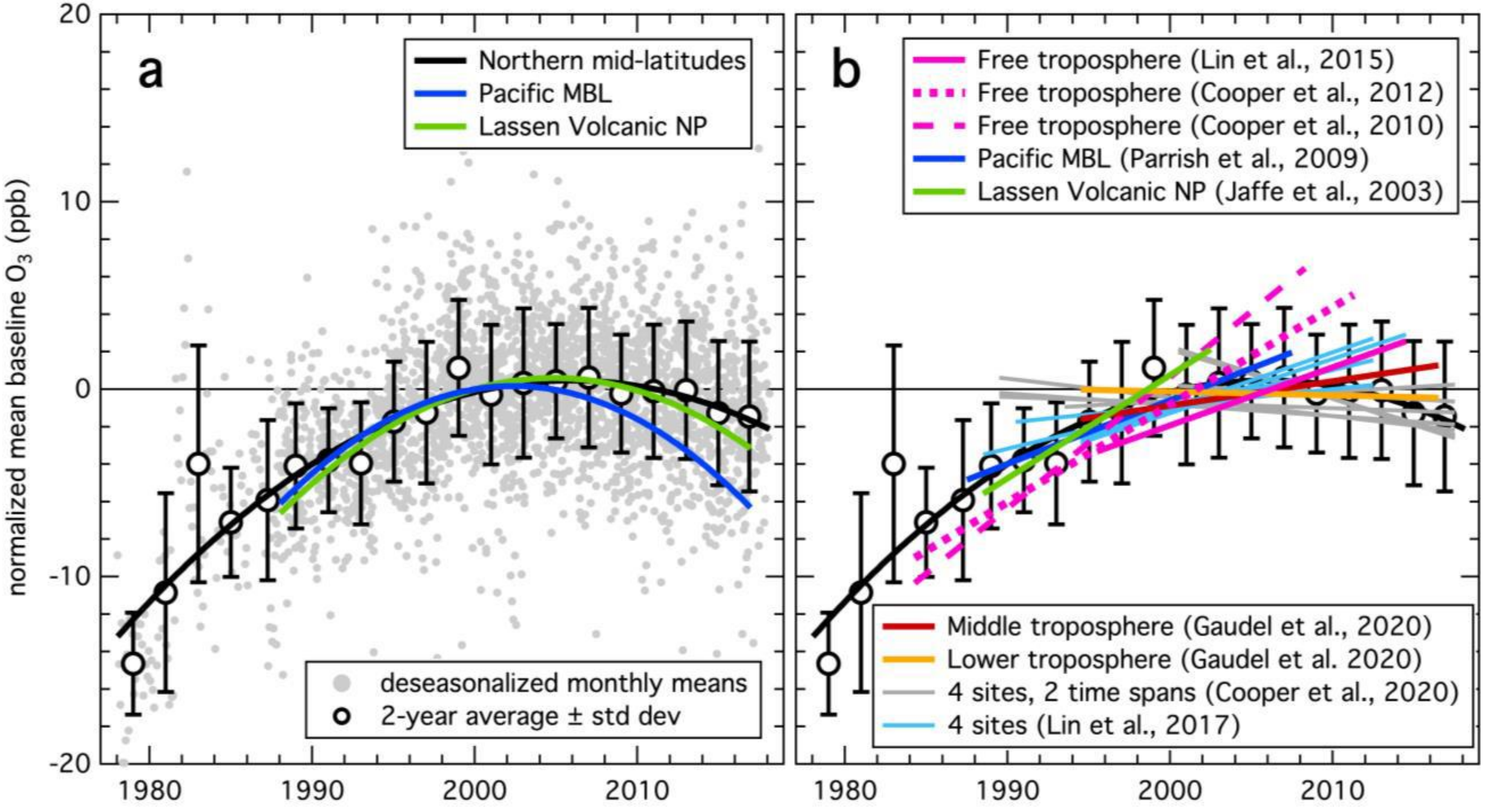
(from Parrish et al., 2021)

# Introduction (Continued Even More)

Long-term changes in Baseline ozone.

Note, Trendline was not given. Must be estimated.

(from Parrish et al., 2021)



# Methodology

- Ozone data set of 1990 through 2020.
- Power Series fit $O_3 = a + bt + ct^2$
- Maximum Ozone concentration $year_{max} = 2000 - \frac{b}{2c}$
- $slope = b + c * (t_1 + t_2)$
- Comparison made for Grand Canyon National Park.
  - b (slope) ppb decade$^{-1}$ -1.5± 0.8
  - slope from quadratic fit (ppb decade$^{-1}$ ) -0.3±1.2
  - Years of data 1995 – 2007.

# Methodology (Continued)

- Yearly averages taken for:
  - Alamo Lake La Paz, Arizona
  - Hayward, Alameda, California
  - Craters of the Moon National Monument, Butte, Idaho
  - Glacier National Park, Flathead, Montana
  - Foothills, Bernalillo, New Mexico
  - Sauvie Island – SIS, Columbia, Oregon

# Results

| State | Arizona | Arizona | California | Idaho | Montana | New Mexico | Oregon |
|---|---|---|---|---|---|---|---|
| City/County | Cocomino | La Paz | Alameda | Butte County | Flathead Co. | Albuquerque | Columbia Co. |
| Year\Name | Grand Canyon NP | Alamo Lake SP | Heyward | Craters / Moon NM | Glacier NP | Foothills | Sauvie Island |
| 1990 | 46.954 | NaN | 18.838 | NaN | 27.118 | 35.394 | 23.653 |
| 1991 | 45.830 | NaN | 21.327 | NaN | 25.667 | 37.390 | 22.284 |
| 1992 | 45.864 | NaN | 20.346 | 31.605 | 22.822 | 35.637 | 28.482 |
| 1993 | 45.214 | NaN | 20.250 | 38.861 | 22.290 | 32.410 | 22.847 |
| 1994 | 48.476 | NaN | 20.455 | 43.415 | 25.246 | 38.551 | 25.436 |
| 1995 | 49.025 | NaN | 24.958 | 39.896 | 22.141 | 39.080 | 24.028 |
| 1996 | 47.986 | NaN | 24.200 | 40.879 | 25.677 | 42.867 | 28.268 |
| 1997 | 47.628 | NaN | 26.223 | 40.154 | 20.035 | 36.959 | 24.155 |
| 1998 | 48.810 | NaN | 29.608 | 42.363 | 25.230 | 41.961 | 24.736 |
| 1999 | 49.949 | NaN | 29.420 | 42.701 | 26.276 | 44.389 | 22.417 |
| 2000 | 47.649 | NaN | 26.956 | 42.072 | 23.742 | 43.857 | 23.327 |
| 2001 | 46.975 | NaN | 27.285 | 38.444 | 23.556 | 43.137 | 26.382 |
| 2002 | 51.134 | NaN | 29.744 | 44.559 | 23.962 | 44.081 | 27.432 |
| 2003 | 49.374 | NaN | 30.877 | 42.533 | 26.389 | 46.065 | 27.222 |
| 2004 | 48.072 | NaN | 29.417 | 42.595 | 24.632 | 42.634 | 24.593 |
| 2005 | 48.346 | 46.511 | 25.906 | NaN | 24.363 | 42.209 | 25.400 |
| 2006 | 50.003 | 47.602 | 30.122 | NaN | 25.793 | 29.753 | 27.243 |
| 2007 | 49.560 | 46.630 | 27.630 | 41.759 | 25.769 | 44.136 | 24.752 |
| 2008 | 47.443 | 45.896 | 31.136 | 43.162 | 26.078 | 40.916 | 24.428 |
| 2009 | 46.098 | 45.424 | 30.114 | 40.709 | 26.473 | 40.963 | 28.364 |
| 2010 | 47.178 | 45.852 | NaN | 43.057 | 23.437 | 42.912 | 24.578 |
| 2011 | 48.319 | 46.368 | 30.434 | 43.526 | 27.414 | 44.794 | 23.973 |
| 2012 | 47.543 | 46.066 | 29.073 | 41.381 | 26.548 | 44.979 | 26.544 |
| 2013 | 46.181 | 45.512 | 28.692 | 40.027 | 25.975 | 39.383 | 23.367 |
| 2014 | 44.711 | 40.298 | 30.603 | 38.556 | 25.475 | 38.407 | 25.699 |
| 2015 | 44.358 | 41.102 | 31.723 | 39.061 | 26.011 | 40.800 | 32.542 |
| 2016 | 44.360 | 39.549 | 29.623 | 38.617 | 23.007 | 41.878 | 25.151 |
| 2017 | 46.237 | 39.252 | 32.059 | 40.470 | 27.546 | 43.664 | 27.581 |
| 2018 | 46.524 | 41.369 | 31.047 | 40.255 | 26.821 | 44.162 | 26.696 |
| 2019 | 45.648 | 39.775 | 31.212 | 39.957 | 25.894 | 42.725 | 25.262 |
| 2020 | 45.442 | 42.005 | 29.244 | 42.166 | 28.742 | 43.469 | 26.455 |

Yearly averaged ozone data for seven selected locations.

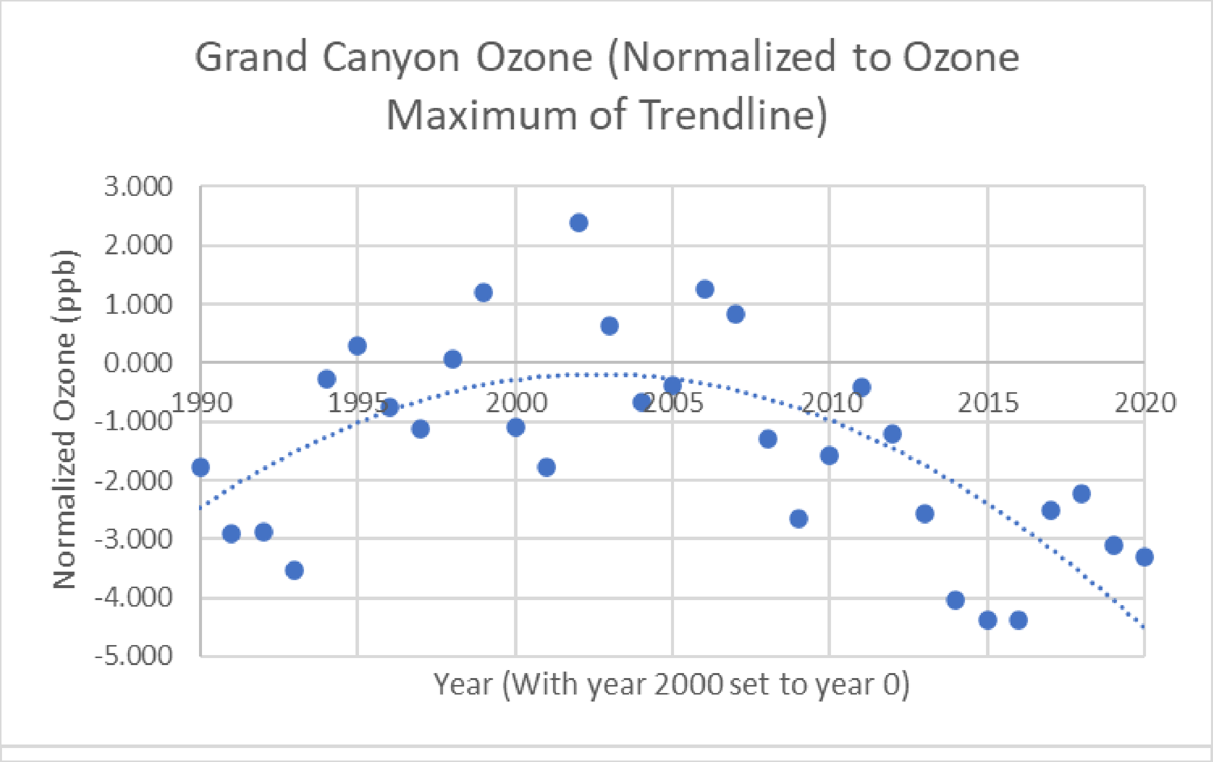
NaN – No data available for that year.

Source: https://aqs.epa.gov/aqsweb/airdata/download_files.html

# Results – Grand Canyon NP, Arizona

- Comparison to Grand Canyon:
  - b (slope) ppb decade$^{-1}$ -1.5± 0.8
  - slope from quadratic fit (ppb decade$^{-1}$ ) -0.3 ± 1.2
  - Years of data 1995 – 2007.
- My Data
  - Slope from quadratic fit (ppb decade$^{-1}$ ) -0.37 ± 0.64
  - Years of data 1990 – 2020.

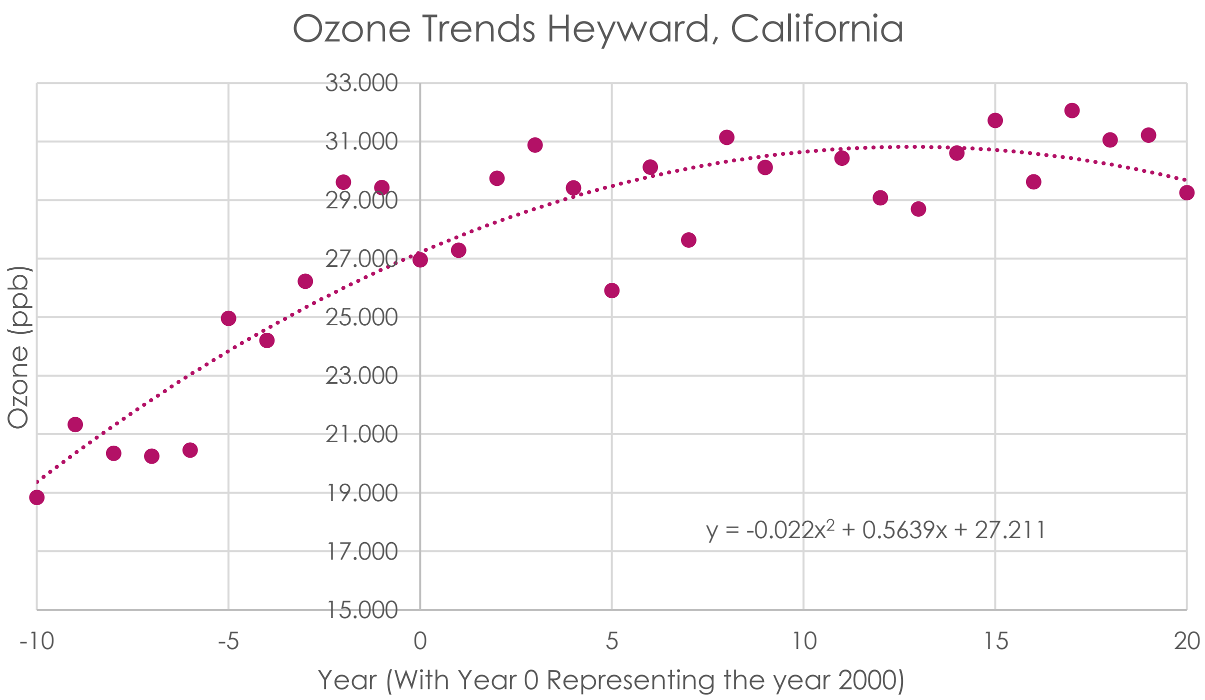
Values are within the range of their dataset.



# Results – Heyward, California

The equations are based on the year 2000 being reset to year 0 and Using: $O_3 = a + bt + ct^2$ and $slope = b + c * (t_1 + t_2)$

- My Data
  - A = 27.211
  - B = 0.5639
  - C = -0.022
  - Slope = -0.12

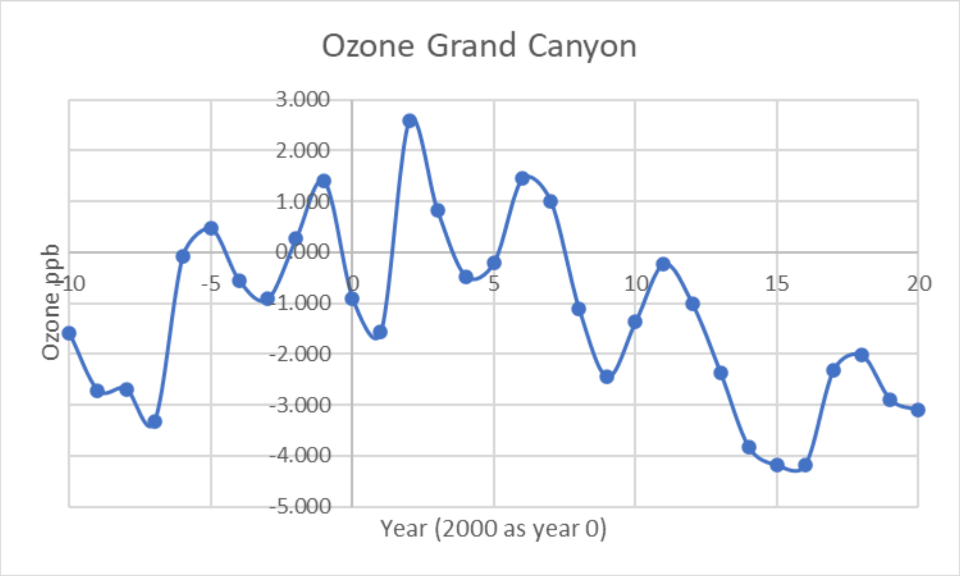


# Discussion/Conclusion

- So far, data fits Parrish et al. well.
  - Trends show maximums for the selected sites that match up well with the curves presented by Parrish et al.
  - Heyward California shows good agreement with curve.
  - Methodology for testing Parrish et al hypothesis seems sound.

# Remaining Work/Issues

- Testing more cities to verify fitting.
- Potentially explore variance of individual cities to curve.
- Norris et al issues
  - Did not provide values for their general equations, need to extrapolate or find.
  - References were inconsistent in formatting
  - Extremely wide range of ozone concentrations trends at -2.8 to +7.0 ppb/decade
  - Yearly averaging did not eliminate an apparent short term signal of ~3 - 5 years (ENSO related?)



# References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Lin, M., Horowitz, L. W., Xie, Y., Paulot, F., Malyshev, S., Shevliakova, E., et al. (2020). Vegetation feedbacks during drought exacerbate ozone air pollution extremes in Europe. *Nat. Cli. Cha.,* 10(5) 444 – 451.

# Response Notes

- Periodogram
- Change the title
- Critique their data and some of the stuff they did.
- Make sure they did a monthly averaging and not just a summer average
- Check the latitude and how well the trends fit based on the latitude.