Change point analysis of seasonal ozone trends and distribution across the United States

Kai-Lan Chang
CIRES, University of Colorado Boulder & NOAA Chemical Sciences Laboratory

Owen R. Cooper
NOAA Chemical Sciences Laboratory

EGU general assembly, Vienna, Austria
EGU24-4182: PICO presentation
April 2024
AS3.15 - Trends, impacts and future of tropospheric ozone
This research was supported in part by NOAA cooperative agreement NA22OAR4320151

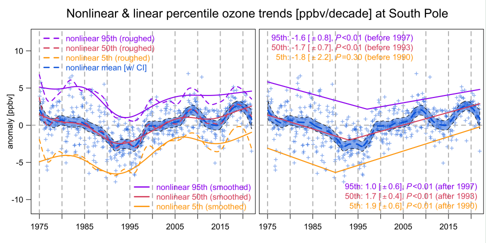
Kai-Lan Chang & Owen R. Cooper

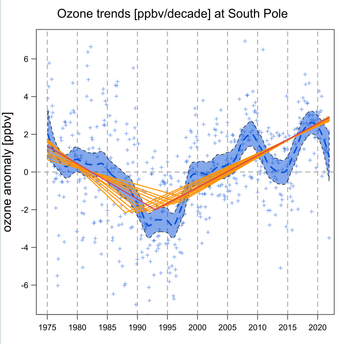
Background:
- Exposure to surface ozone has been associated with short- and long-term respiratory and cardiovascular diseases.
- Surface ozone is generally decreasing across the USA since 2000.

This study aims to carry out a change-point analysis of ozone seasonal percentiles & extremes across the USA.

A demonstration of trends at different percentiles:
Ozone trends and variability are often inconsistent across different percentiles, quantile regression is a well-developed approach for detecting heterogeneous trends.
While nonlinear trends are useful to visualize detailed interannual variability, it is challenging to quantitatively summarize the results for thousands of monitoring stations, so piecewise trends are adopted (change-points are varying at different percentiles).

Change-point analysis:
We evaluate all candidate locations (oranges), the optimized change-point (red) is selected such that signal-to-noise ratios are maximized.





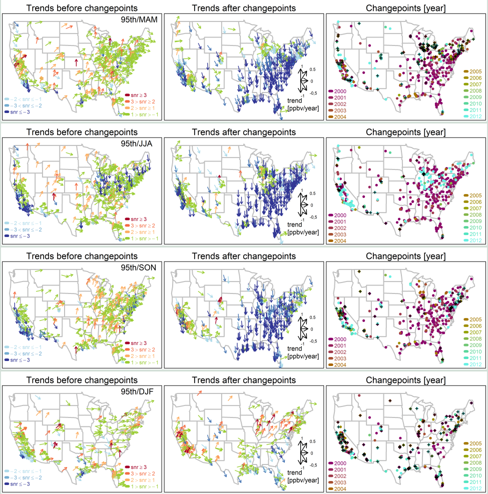
Kai-Lan Chang & Owen R. Cooper

Data selection:
To reliably detect the change-point of the trends over 1990-2022, we only select the sites with the longest time series of MDA8 (maximum daily 8-hour averages) observations from the monitoring network, i.e., beginning no later than 1992 and extending at least to 2018.

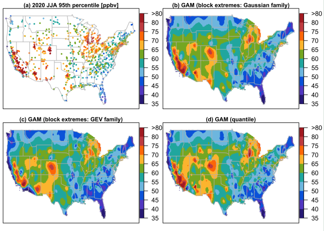
Seasonal trends at individual sites:
For each site/season, the evaluations of (1) the trend before the change-point, (2) the trend after the change-point, (3) the optimized change-point location (by year), are provided.

Based on the seasonal 95th percentile as a example, highly confident negative trends can be observed in MAM, JJA and SON in the recent period over the Eastern US, and the change-points are generally coincident in the early 2000; increasing DJF trends can be observed in the Midwest and the Southwest in a recent decade.

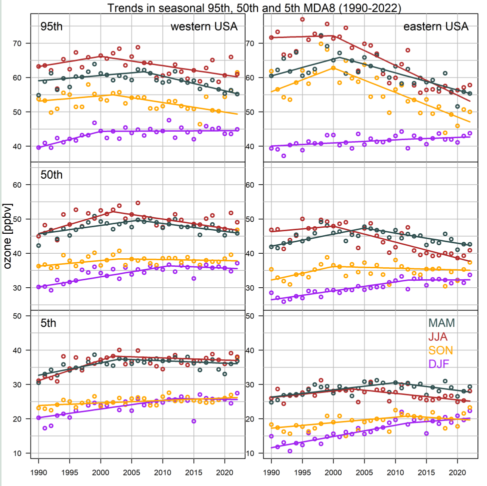
The 95th percentile



Regional trends of ozone seasonal percentiles:
Synthesizing evidences from individual stations for studying regional trends require to account for irregularly distributed measurement locations. The mapping is carried out for each season/percentile, and the results are provided in the right panels (divided by the Eastern and Western USA)

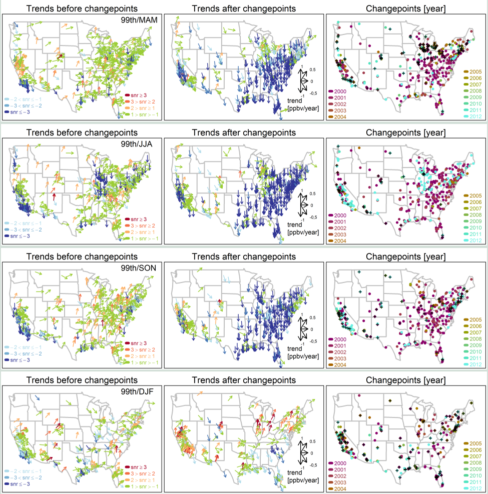


Take-home message:
Increasing ozone was observed in MAM, JJA and SON since 1990, but with varying turnaround points since the 2000s, these trends are found to be decreasing; while flat or increasing DJF trends are still observed in recent years.



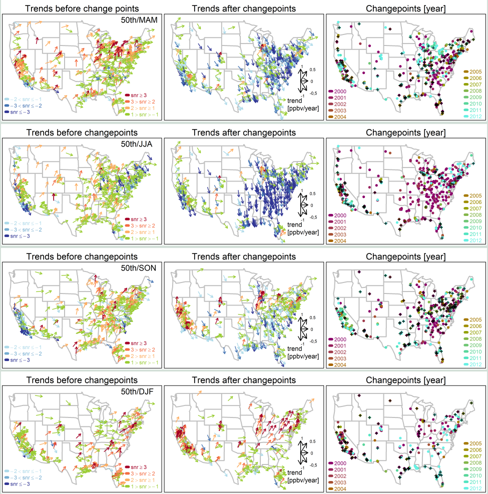
Reference:
Chang, Cooper and McDonald (2024). Trends in heterogeneous seasonal ozone over the United States: potential climate penalty for decreasing extreme events (in preparation)

The 99th percentile



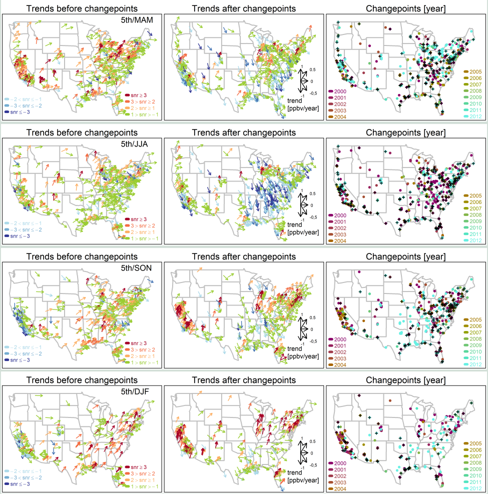
Kai-Lan Chang & Owen R. Cooper

The 50th percentile

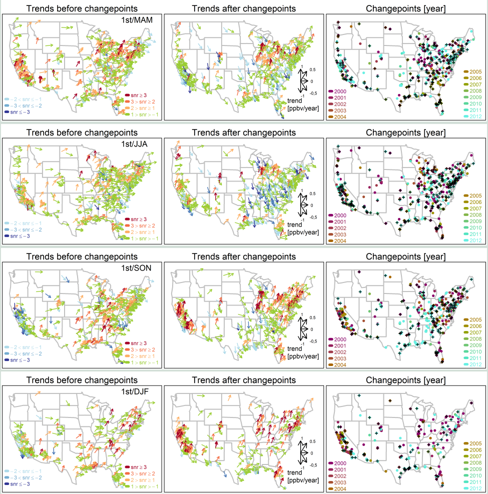


 Kai-Lan Chang & Owen R. Cooper

The 5th percentile



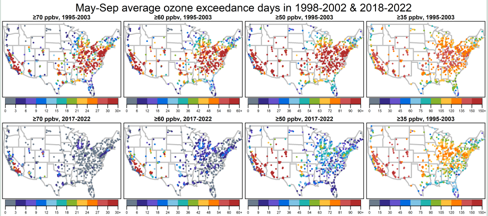
The 1st percentile

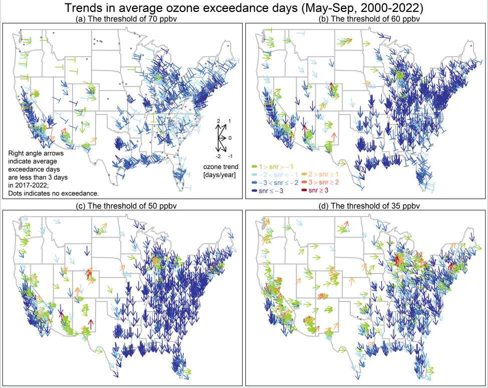


Kai-Lan Chang & Owen R. Cooper

(upper) Average exceedance days of daily MDA8 ozone in May-September above 70, 60, 50 and 35 ppbv in the early period (1998-2002) and present day (2018-2022).

(lower) Trends [days/year] in average exceedance days of daily MDA8 ozone above 70, 60, 50 and 35 ppbv (2000-2022). Gray dots indicate no exceedances (trends cannot be estimated).





(upper) Average exceedance days of daily MDA8 ozone in April-October above 70, 60, 50 and 35 ppbv in the early period (1998-2002) and present day (2018-2022).

(lower) Trends [days/year] in average exceedance days of daily MDA8 ozone above 70, 60, 50 and 35 ppbv (2000-2022). Gray dots indicate no exceedances (trends cannot be estimated).