

# Terra Trends: A Global Slowdown in Decreasing Atmospheric CO and the Regional Interpretation Using AOD

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## Abstract

Atmospheric carbon monoxide (CO) has been decreasing globally for the last two decades. Recently, positive fire trends in Northern Hemisphere boreal regions may have impacted the decreasing CO. Additionally, time-varying air quality policies will have different impacts on atmospheric composition and related trends. Aerosols are co-emitted with CO from both fires and anthropogenic sources. Consequently, a combined trend analysis of CO and aerosol optical depth (AOD) measurements from space can help elucidate the drivers of regional differences in the CO trend. We use valuable long-term records from two instruments aboard the Terra satellite. Measurements of Pollution in the Troposphere (MOPITT) CO and AOD from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument are examined hemispherically and in sub-regions to determine trends between 2002 and 2018. The records are further split into two sub-periods in order to examine temporal stability in the trend values. We also assess the CO trends in monthly percentile values to use seasonal information when interpreting trend contributions. Our focus is on four major population centers: Southeast USA, Europe, Northeast China and North India, as well as biomass burning regions in both hemispheres. Our results show that globally, CO declines faster in the first half of the record compared to the second half. Both atmospheric species are important when interpreting trends in the smaller regions. Northern Hemisphere boreal fire regions show a regime-shift in their seasonality for both CO and AOD, which may counteract the downward trend in CO. Anthropogenic regions with minimal air quality management such as North India become more globally relevant as the global CO trend weakens. We also find clear evidence of the atmospheric impact of policy choices. Overall, we observe that local changes in biomass burning and air quality can counteract the global downward trend in CO.

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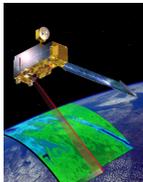
## Introduction

Atmospheric carbon monoxide (CO) has been decreasing globally for the last two decades. Building on previous studies, we update global and regional estimates of the CO trend. Recently, positive trends in wildfires in Northern Hemisphere boreal regions may have contributed to slowing down the decreasing CO. Additionally, time-varying air quality policies will have different impacts on atmospheric composition and related trends. Aerosols are co-emitted with CO from both fires and anthropogenic sources. Consequently, a combined trend analysis of CO and aerosol optical depth (AOD) measurements from space can help elucidate the drivers of regional differences in the CO trend.

## Long-term CO and AOD measurements from the Terra satellite

### MOPITT (Measurements of Pollution In The Troposphere) CO

- CO molecules absorb infrared (IR) radiation.
- Gas filter correlation radiometer; first light in 2000 [2].
- Optimal estimation inverts the IR signal into CO amount.
- Version 8, TIR-only, daytime retrievals [1].
- Converted to column average VMR using retrieved dry air column.



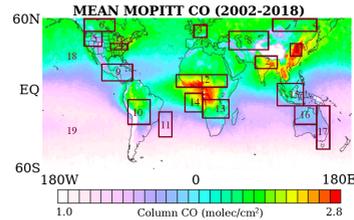
[Image: NASA]

### MODIS (Moderate Resolution Imaging Spectroradiometer) AOD

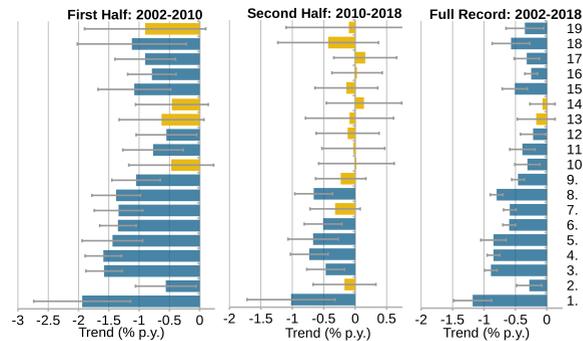
- Passive imaging radiometer: reflected solar and thermal radiation [3].
- DTDB algorithm retrieves over vegetation, oceans and deserts [3].
- Collection 6.1, Level-3, MOD08.M3 [4, 5].

## Trend analysis methodology

- Timeseries of month average values determined within regions (right).
- Remove seasonal cycle.
- Use Weighted Least Squares (WLS) weighted by  $\sigma$  to calculate trends for 2002-2018 and for two sub-periods: 2002-2010, 2010-2018.
- Also calculate Theil-Sen trends in CO percentile values separated by month for 2002-2018.



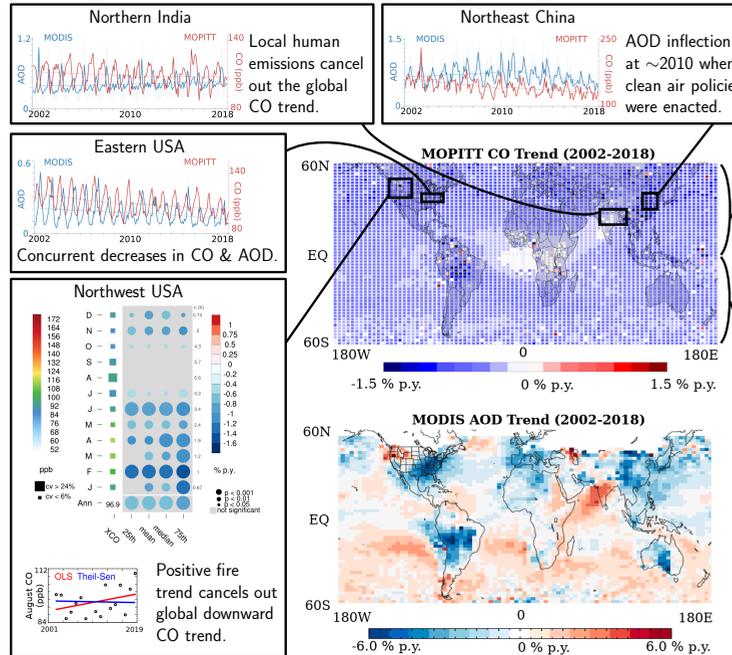
## Regional Weighted-Least-Squares Trends



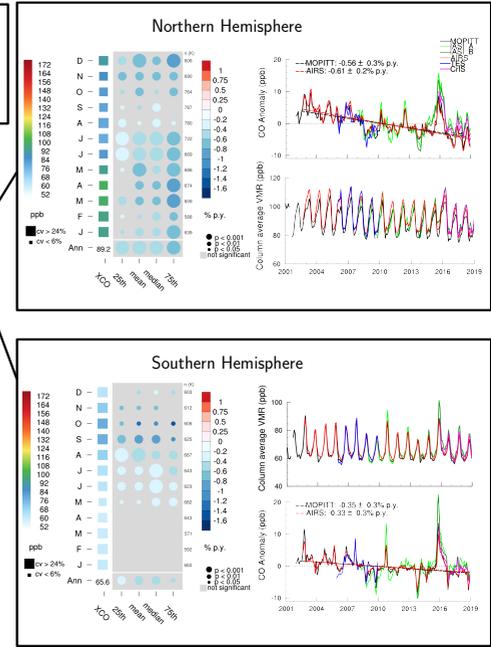
Negative trend significant outside  $1\sigma$   
 Trend not significant

- CO declines faster in the first half of the record compared to the second half or the full records.
- Northeast China (region 1) has the strongest trend in any period.
- Stronger trends in NH (regions 1-9, 12 and 18) compared to SH (regions 10-11, 13-17 and 19) shows a combination of the global reduction in fire with anthropogenic emission reductions.

## Timeseries analysis



Buchholz, R. R. et al, Air pollution trends measured from Terra: CO and AOD over industrial, fire-prone and background regions, to be submitted 2019 to the Terra Mission - 20 Years of Science collection in Remote Sensing of Environment.



## Summary

- We calculate global and regional trends in MOPITT CO and use MODIS AOD to interpret CO variability.
- CO decreases globally at  $-0.50 (\pm 0.3)$  % per year from 2002 to 2018. This is a deceleration compared to CO trends from earlier studies over shorter periods.
- Regional analysis: Areas with common fire sources and where air quality measures have been implemented, such as Eastern USA and more recently, Northeast China show similar behavior in CO and AOD.
- Climate-driven positive fire trend in the NH boreal fire-prone regions, such as Northwest USA, locally counteracts the global downward CO trend in summer.
- Analyses of trends by percentile and month indicate that strongest (most negative) trends occur in the 75th percentile for the NH and that late summertime CO trends (when CO lifetime is lowest) are the least substantial, in both hemispheres.
- Overall, local changes in biomass burning and air quality can counteract the global downward trend in CO.

## References

- Deeter, M. N. et al., (2019), *Atmos. Meas. Tech.*, 12(8), 4561-4580
- Drummond, J. R. et al., (1996), *J. Atmos. Oceanic Technol.*, 2, 314-320
- Levy, R. C. et al., (2013), *Atmos. Meas. Tech.*, 6(11), 2989-3034
- Platnick, S. et al., (2017), *NASA MODIS Adaptive Processing System*, Goddard Space Flight Center, [https://doi.org/10.5912/MODIS/MOD08\\_M3\\_006](https://doi.org/10.5912/MODIS/MOD08_M3_006)
- Sayer, A. M., et al., (2014), *J. Geophys. Res.-Atmos.*,

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