Changes in Eastern US NOx Emissions and IMPROVE Fine Nitrate Concentrations 2002-2021

Scott Copeland

IMPROVE Steering Committee

10/17/2023

1. Strong evidence that past NOx reductions are linked to lower particle nitrate concentrations broadly across the Eastern US.
2. The resulting changes in measured fine nitrate concentrations are not necessarily reflected in Most Impaired Day (MID) *composition*, but still affect MID dv, which is the metric.
3. Simulated data suggests that past NOx reductions have improved current MID dv and that future NOx reductions will reduce measured nitrate concentrations, and consequently reduce MID dv.

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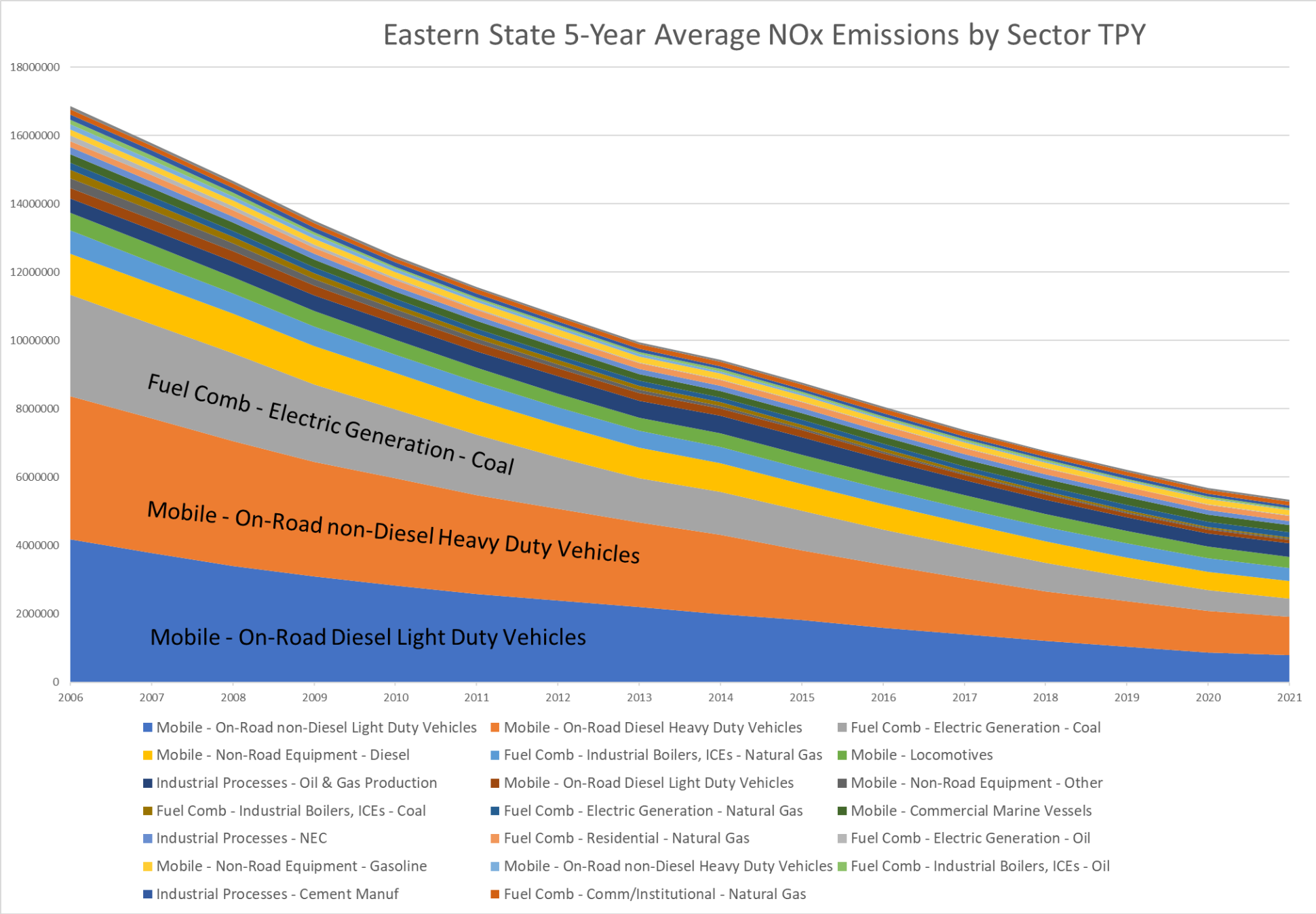
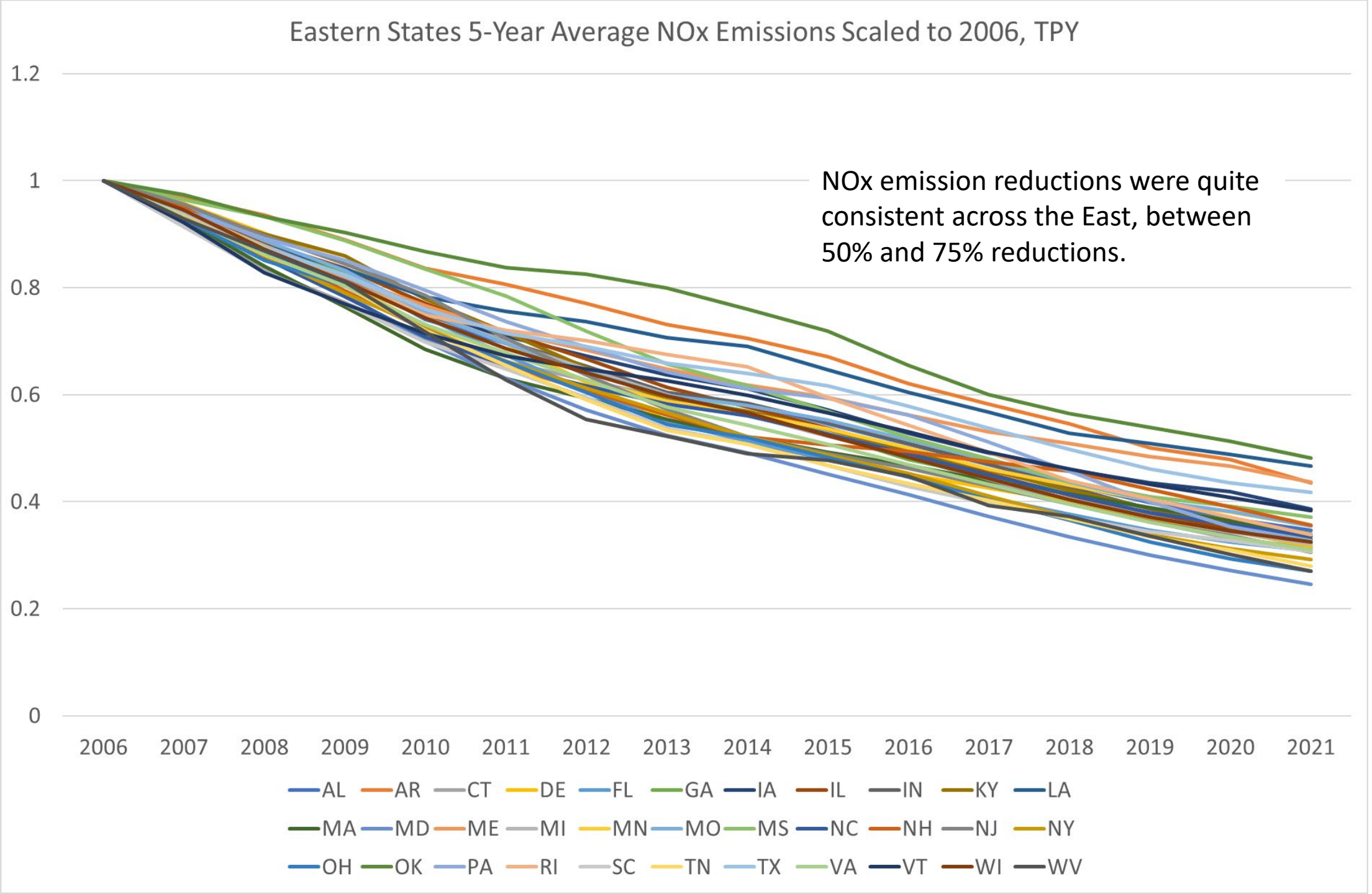
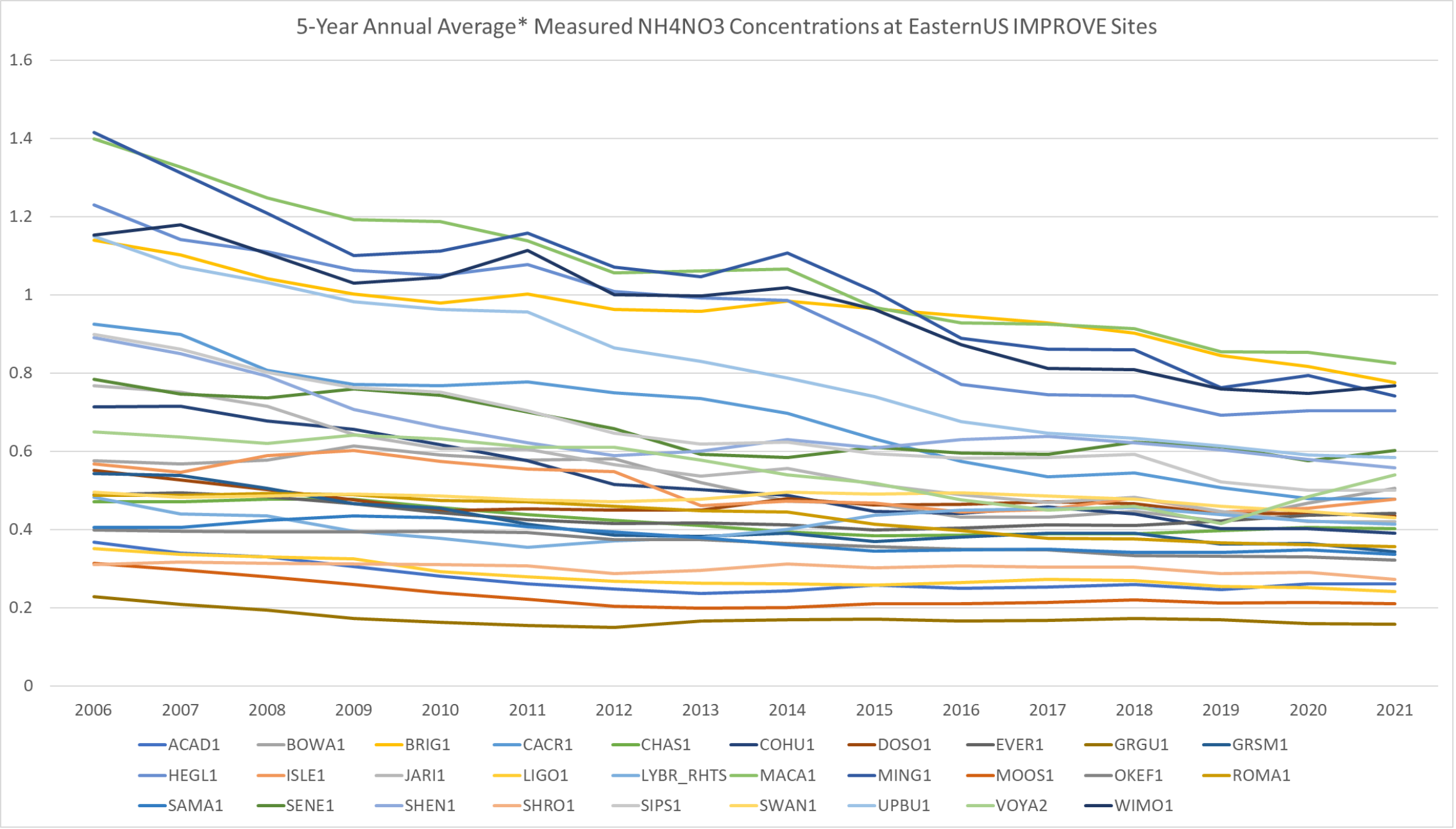
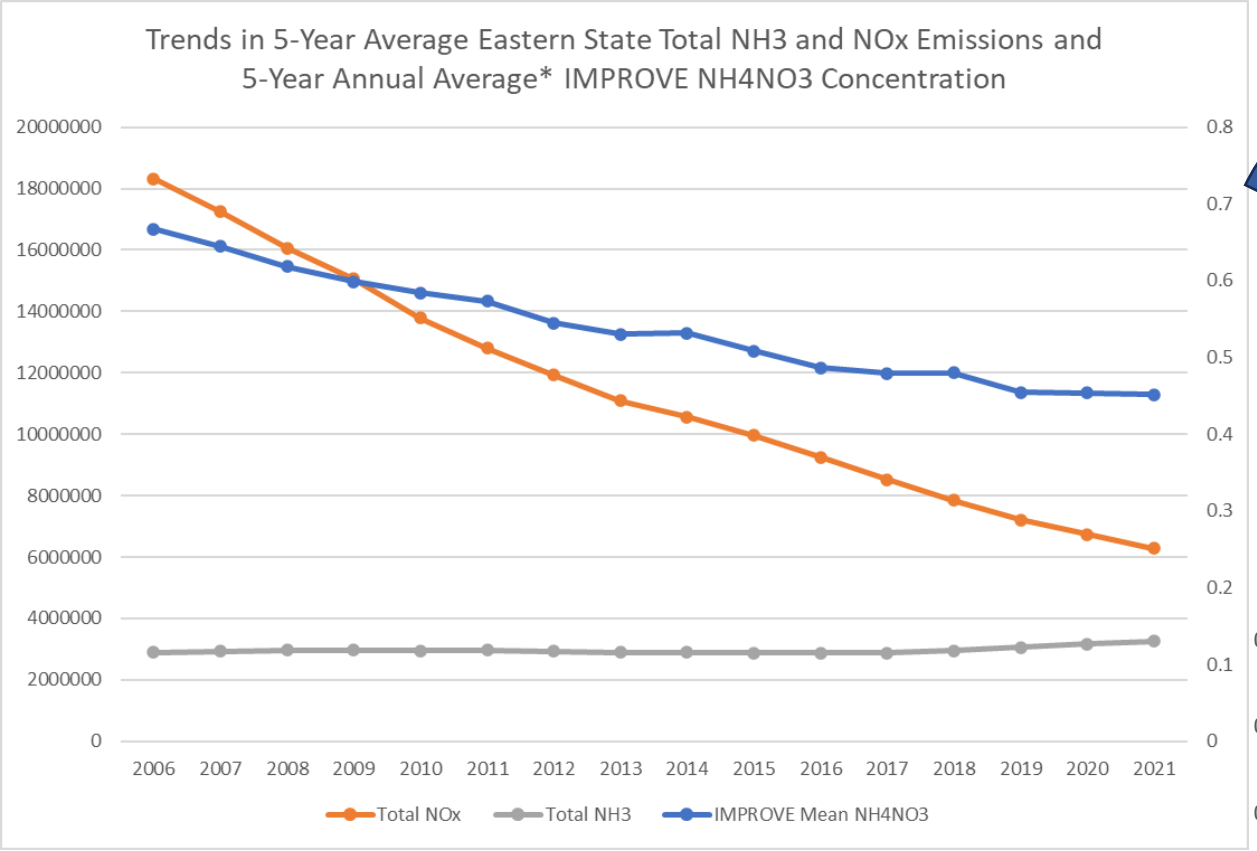


https://www.epa.gov/air-emissions-inventories/2air-pollutant-emissions-trends-data (CAPS Trends)


Eastern States 5-Year Average NOx Emissions Scaled to 2006, TPY
1.2
1
0.8
0.6
0.4
0.2
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
NOx emission reductions were quite consistent across the East, between 50% and 75% reductions.
AL AR CT DE FL GA IA IL IN KY LA
MA MD ME MI MN MO MS NC NH NJ NY
OH OK PA RI SC TN TX VA VT WI WV



*Annual average of all samples, not MID.



66% reduction in eastern US NOx results in 32% reduction in annual mean fine NH4NO3 concentrations.

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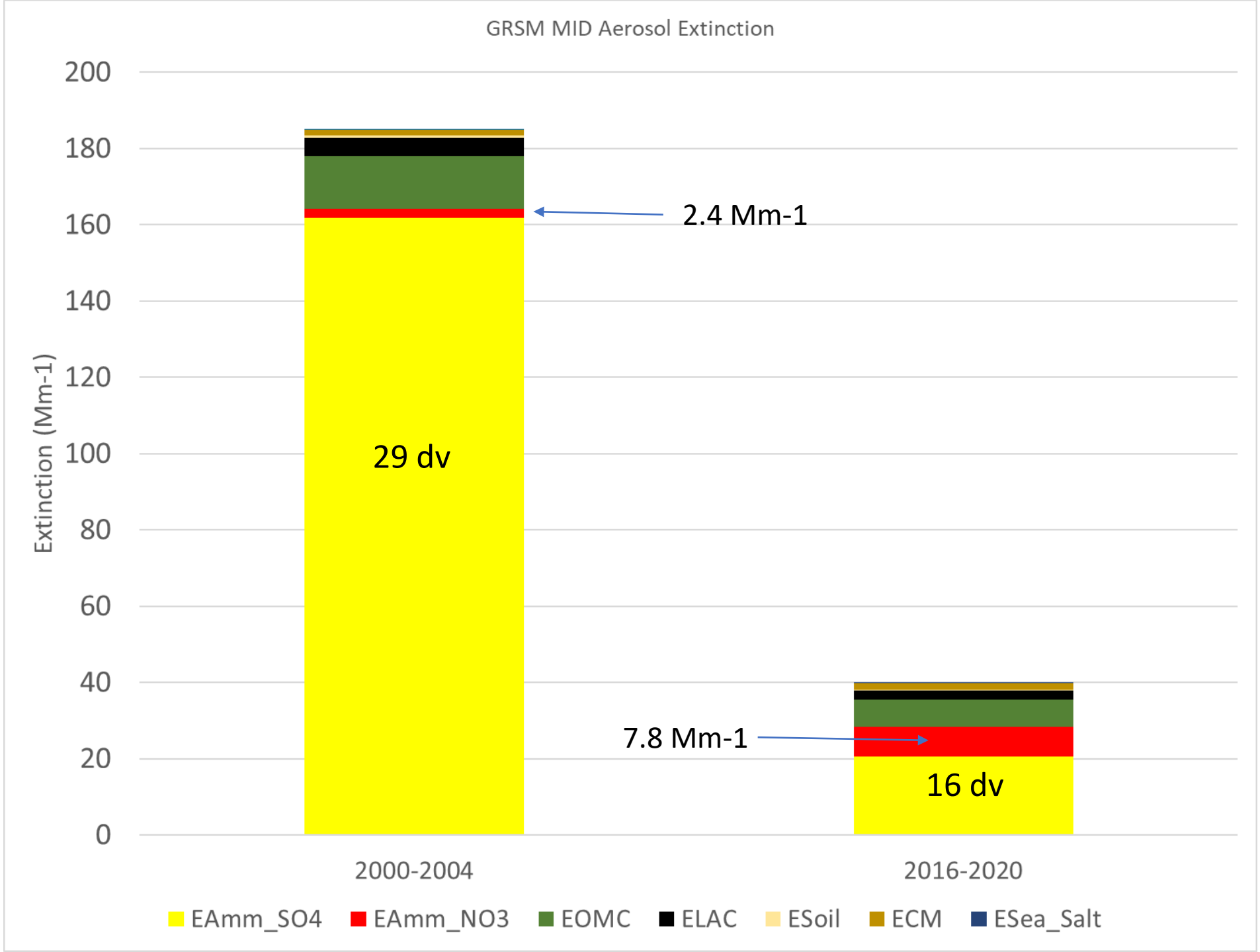
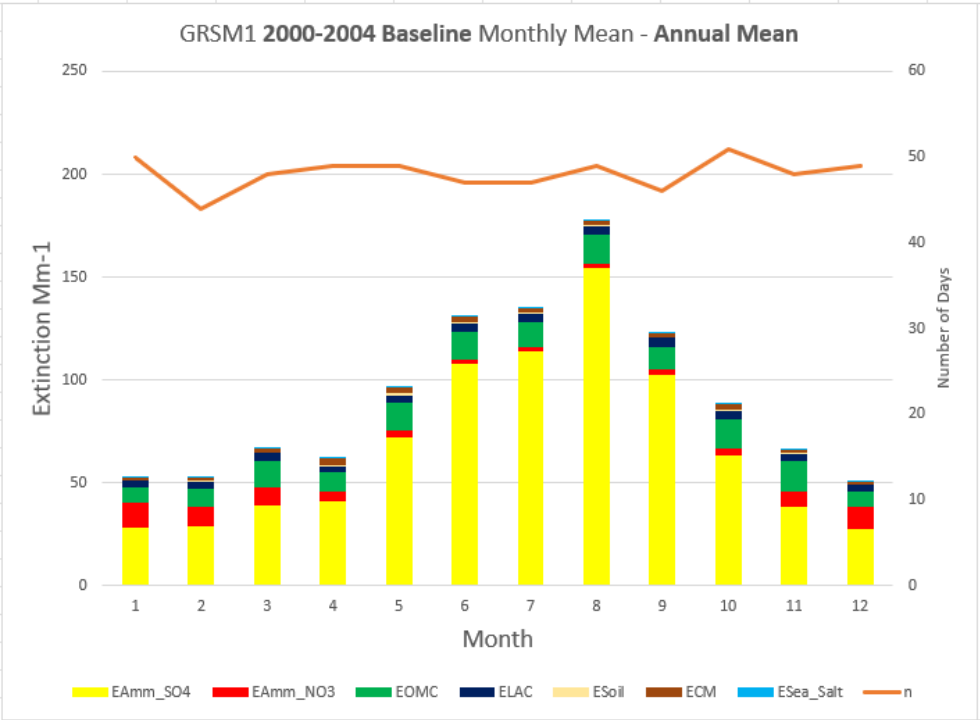
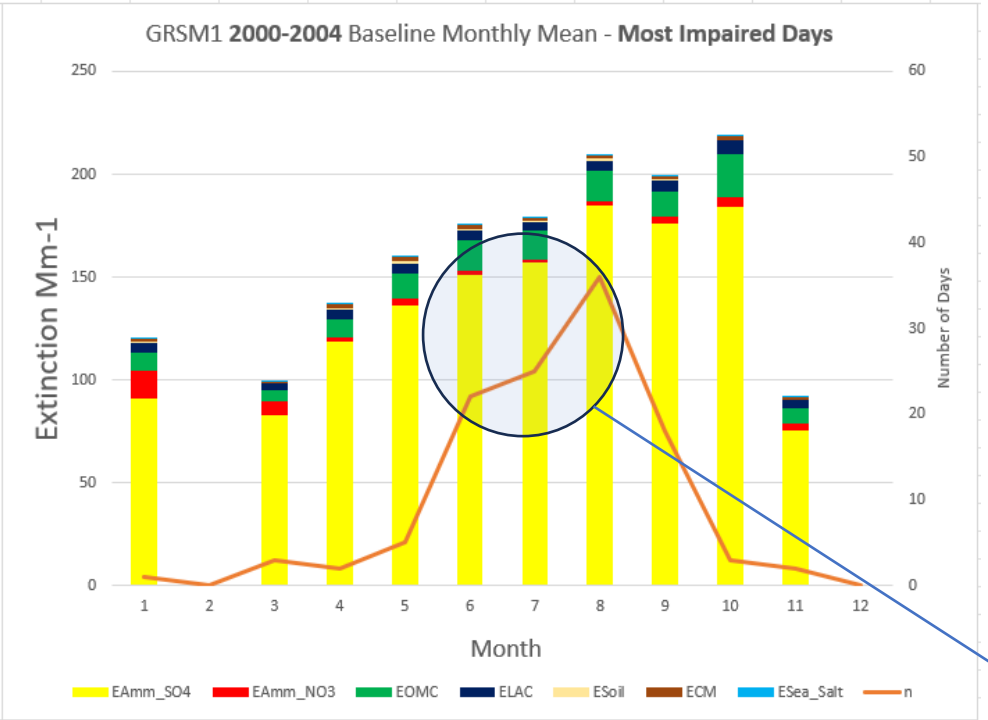
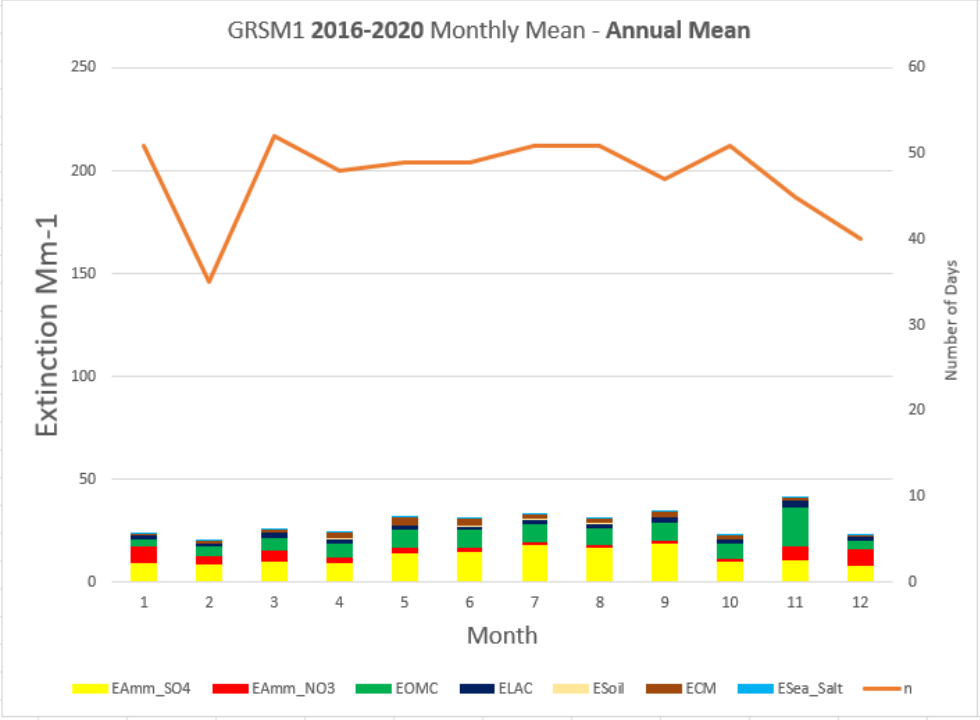

GRSM MID Aerosol Extinction
Extinction (Mm-1)
200
180
160
140
120
100
80
60
40
20
0
2.4 Mm-1
29 dv
7.8 Mm-1
16 dv
2000-2004
2016-2020
EAmm_SO4
EAmm_NO3
EOMC
ELAC
ESoil
ECM
ESea_Salt


GRSM1 2000-2004 Baseline Monthly Mean - Annual Mean
Extinction Mm-1
Number of Days
Month
EAmm_SO4
EAmm_NO3
EOMC
ELAC
ESoil
ECM
ESea_Salt
n


GRSM1 2000-2004 Baseline Monthly Mean - Most Impaired Days
Extinction Mm-1
Number of Days
Month
EAmm_SO4
EAmm_NO3
EOMC
ELAC
ESoil
ECM
ESea_Salt
n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Extinction Mm-1
Number of Days
Month
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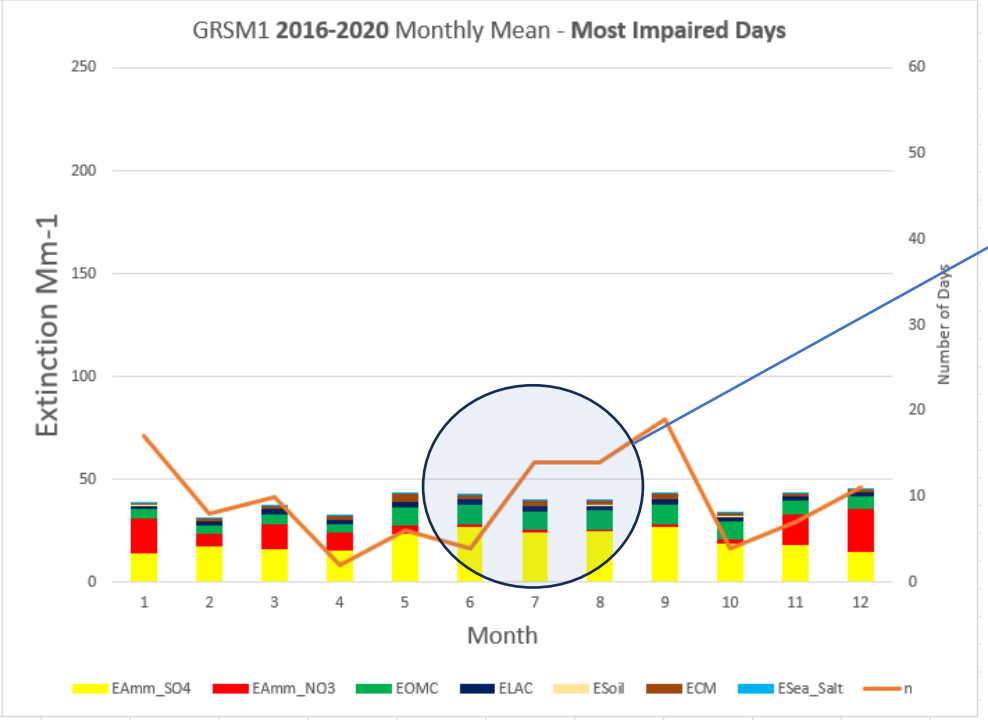
EAmm_NO3
EOMC
ELAC
ESoil
ECM
ESea_Salt
n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ESoil
ECM
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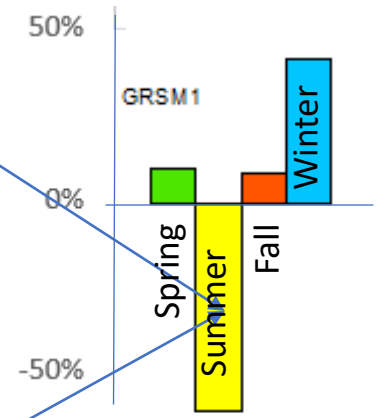
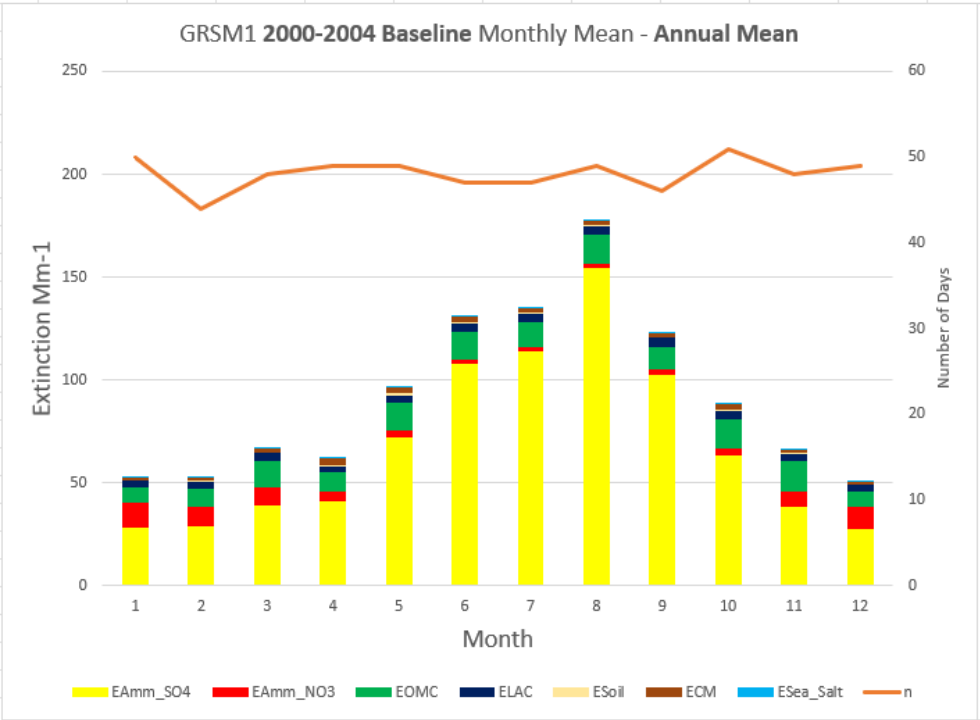
n


50%
0%
-50%
GRSM1
Spring
Summer
Fall
Winter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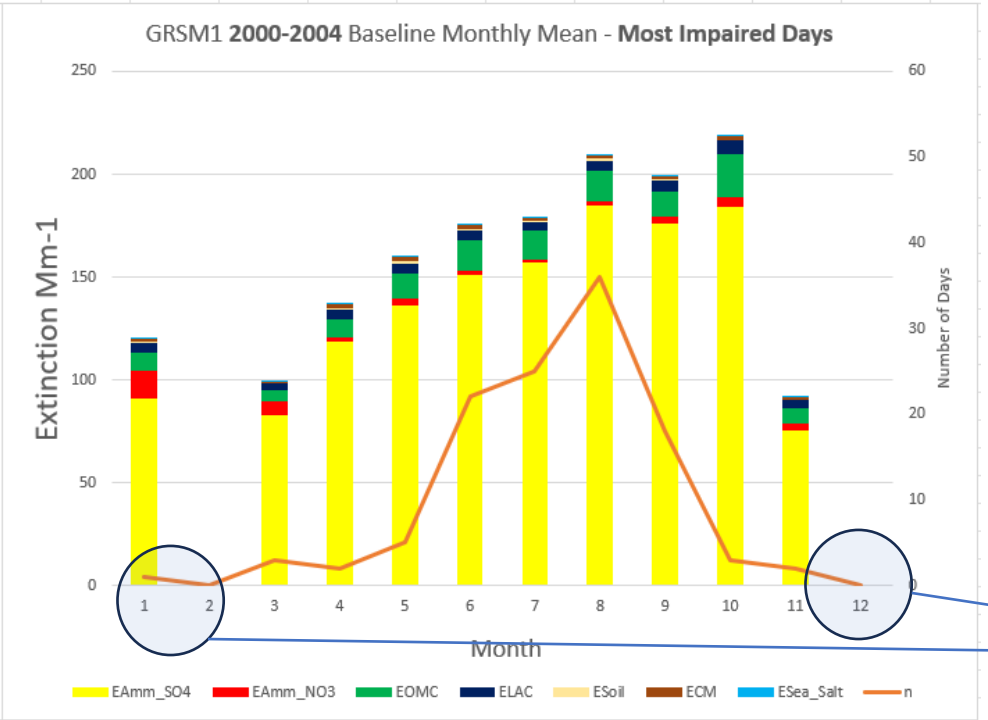
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Extinction Mm-1
Number of Days
Month
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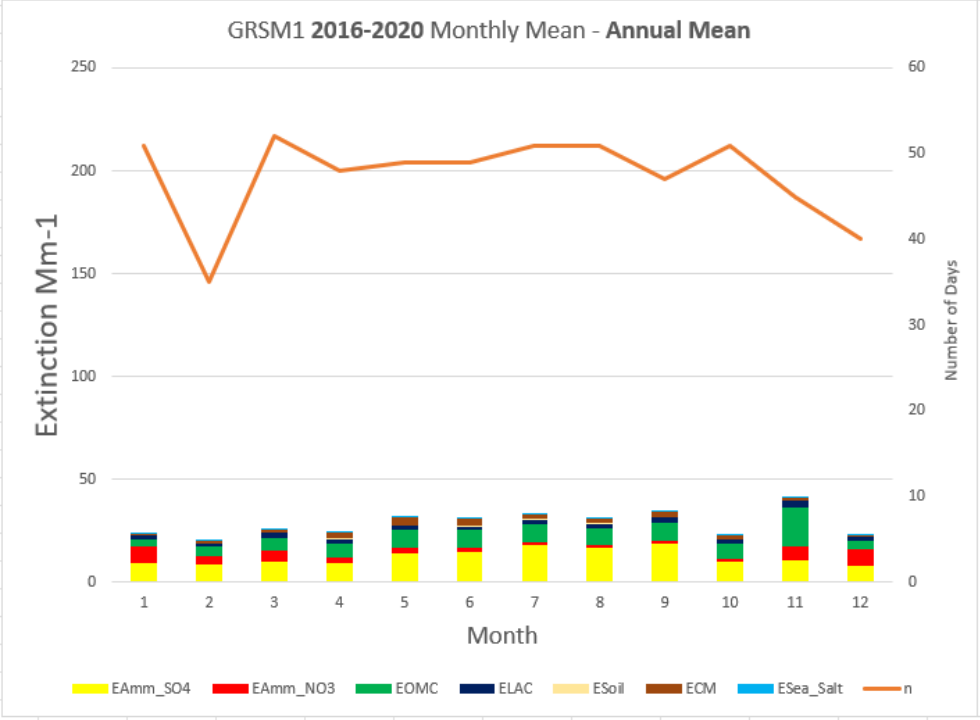
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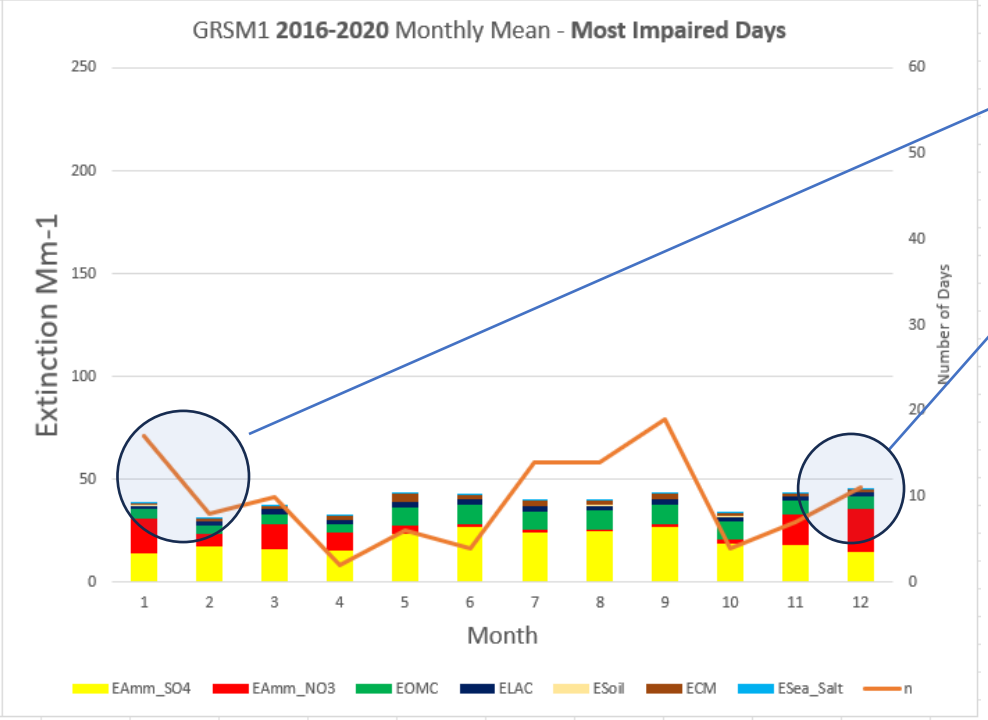
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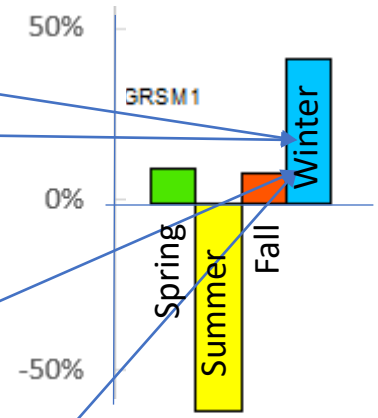
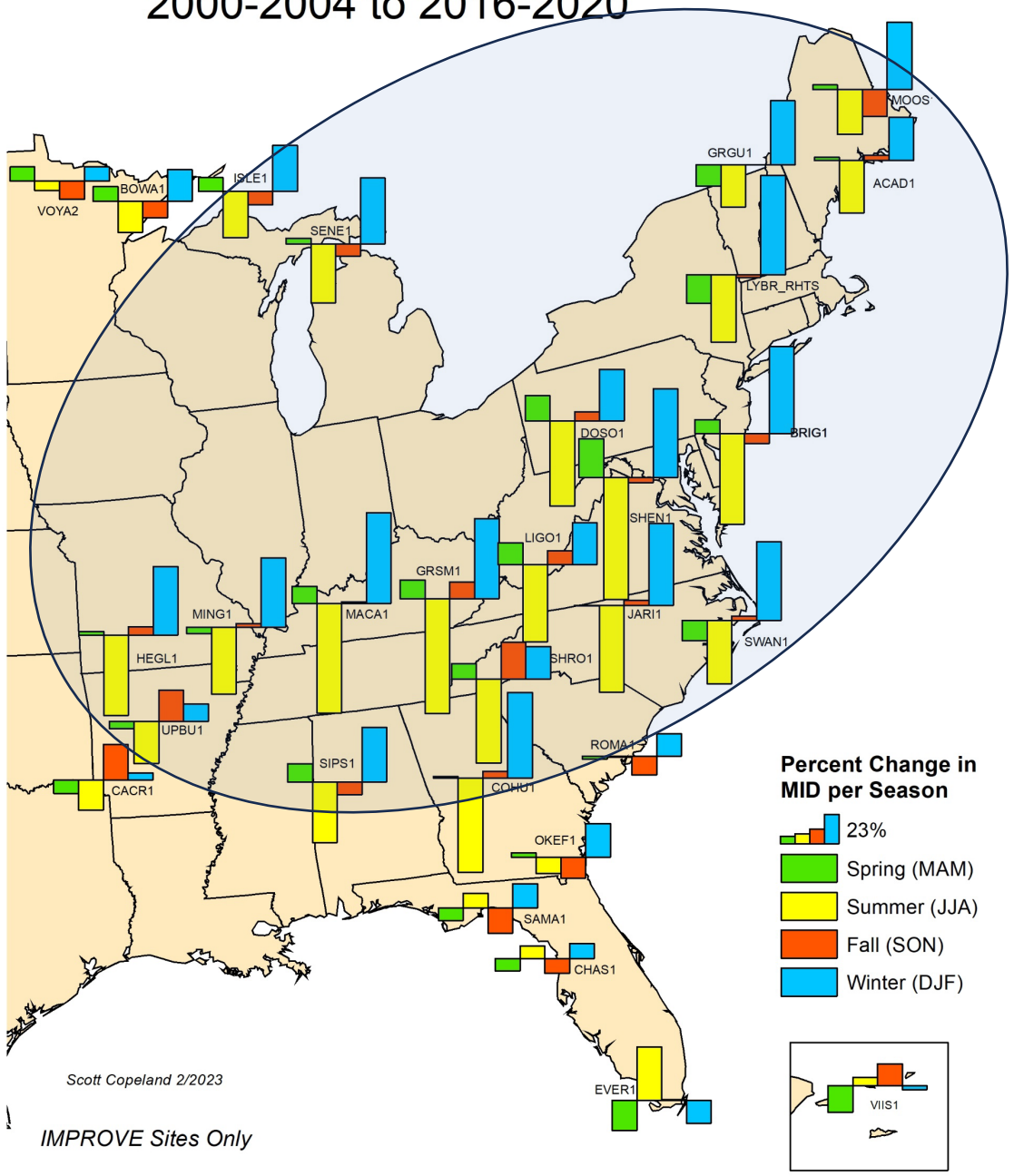

50%
GRSM1
0%
-50%
Spring
Summer
Fall
Winter

Change in Seasonality of Most Impaired Days
2000-2004 to 2016-2020



A majority of sites experienced a significant shift in the seasonality of MID, with the broader trend being more MID in the winter and fewer MID in the summer.

-> This is the cause of increased nitrate concentrations on the MID, even at sites when winter nitrate concentrations decreased.

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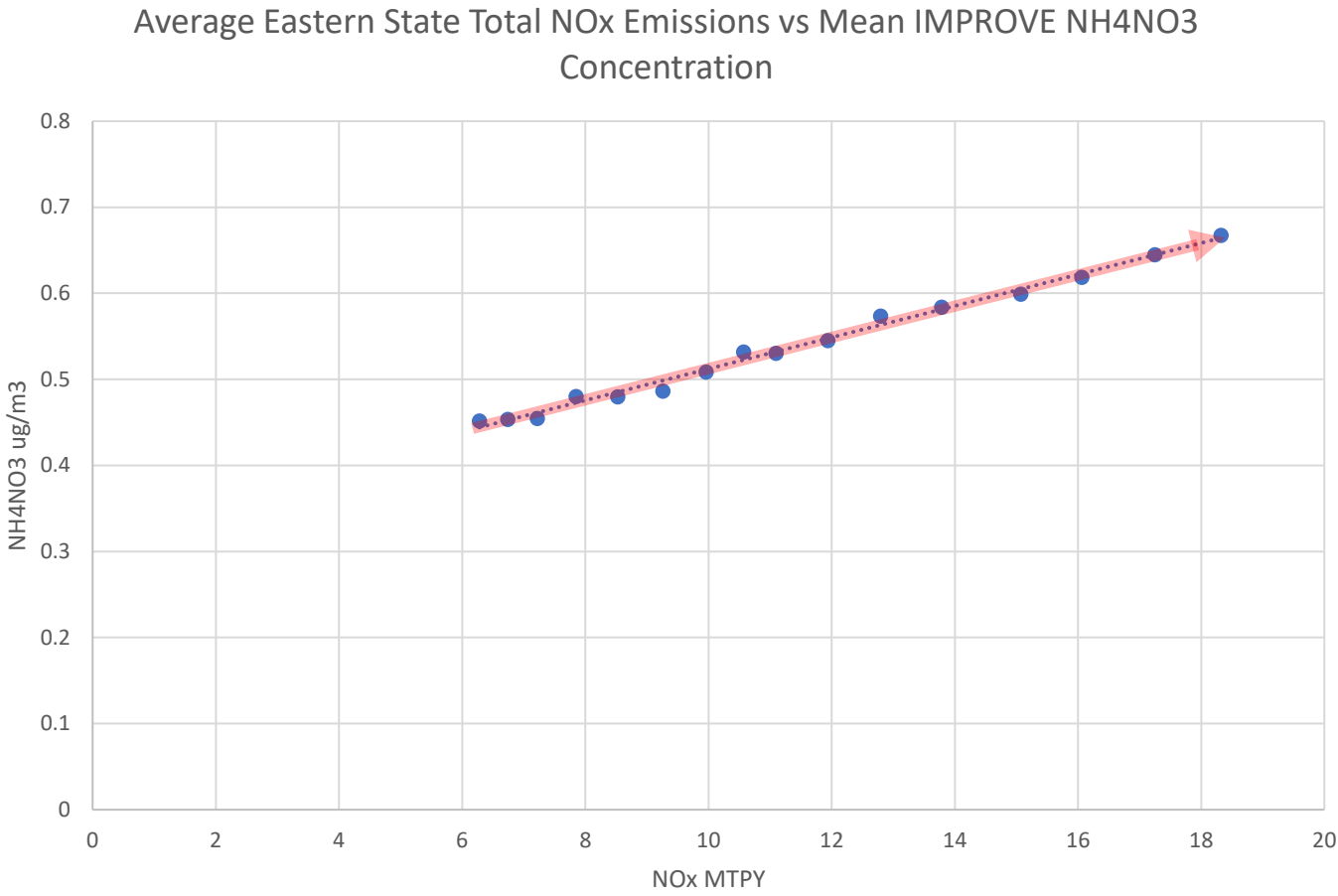
We can use the MID algorithm to simulate past and future conditions

Past: 66% reduction in eastern US NOx results in 32% reduction in annual mean fine NH4NO3 concentrations.

Results in 5.6 Mm-1 more nitrate and 0.39 dv 5-year average increase in MID compared to no reduction in NH4NO3



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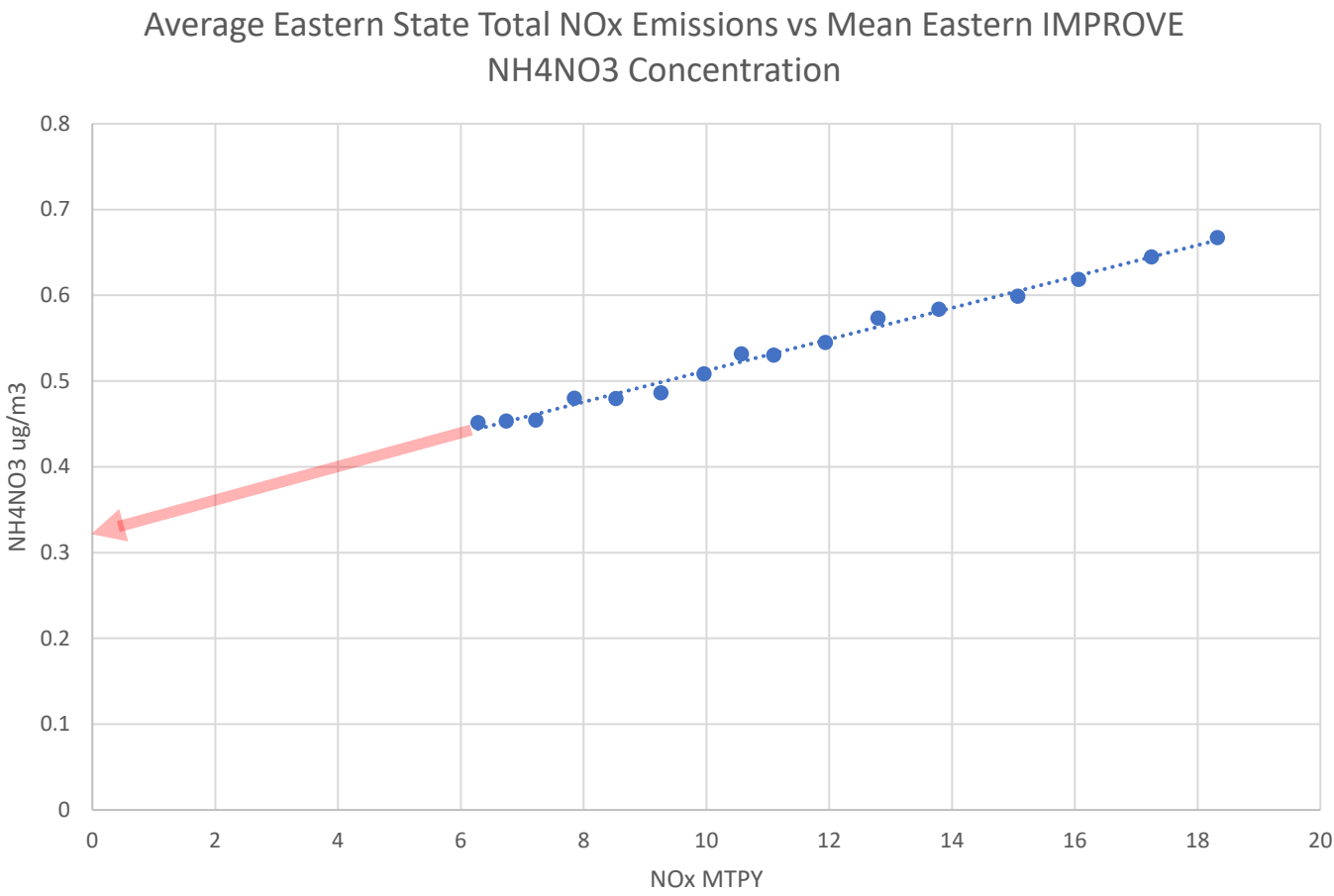
We can use the MID algorithm to simulate past and future conditions

Future: “Zeroing out” eastern US NOx, and extrapolating previous trend yields 22% additional reduction in annual mean NO3 concentrations.

Results in 2.6 Mm-1 less nitrate and 0.58 dv 5-year average improvement in MID compared to no reduction in NH4NO3



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Thank you

View of Western North Carolina from Clingmans Dome
Jim Renfro, NPS