

Exploration of IMPROVE and CSN Fine Particulate Carbon Spatial and Temporal Patterns

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Objectives

- Integration of three sampling/analysis system
 - CSN Met One – NIOSH TOT carbon
 - CSN URG – IMPROVE TOR carbon
 - IMPROVE – IMPROVE TOR carbon
- Homogenization of carbon data
 - Assume IMPROVE and CSN URG carbon concentrations are comparable
 - Adjust CSN Met One NIOSH TOT data to be similar to IMPROVE
- Seasonal and Spatial patterns in TC, OC, and EC concentrations
- 2000 – 2009 trends in seasonal and annual TC concentrations

Relating CSN-MetOne-TOT Carbon to IMPROVE Carbon

EXPECTATION:

$$[TC]^{CSN} = [EC]^{IMP} + (1+B^{IMP*})[OC]^{IMP} + A^{CSN}/V_{MetOne}$$

OLS REGRESSION:

$$[TC]^{CSN} = (1+b_{EC})[EC]^{IMP} + (1+b_{OC})[OC]^{IMP} + a_1 + \dots + a_{12} + e$$

2005-6 observations at 7 MetOne sites (excluding Phoenix):

$$b_{EC} = 0.008 (+/-0.05)$$

no sampling artifact for IMPROVE EC

$$b_{OC} = 0.22 (+/-0.03)$$

~ 20% sampling loss for IMPROVE OC

$$\text{rms}(e) = 0.9 \text{ ug}/\text{m}^3$$

$$(r^2 = 0.986, n = 779)$$

a_{mm} → next slide

From Warren's work using 2005-06 collocated data (excluded Phoenix)

Converting CSN Carbon to IMPROVE

Equations:

To convert CSN EC to IMPROVE EC: $EC-IMP = EC-CSN * 1.3$

To convert CSN OC to IMPROVE OC:

$$OC-IMP = ((OC-CSN - 0.3 * EC-CSN) - A) / M$$

A - additive positive artifact

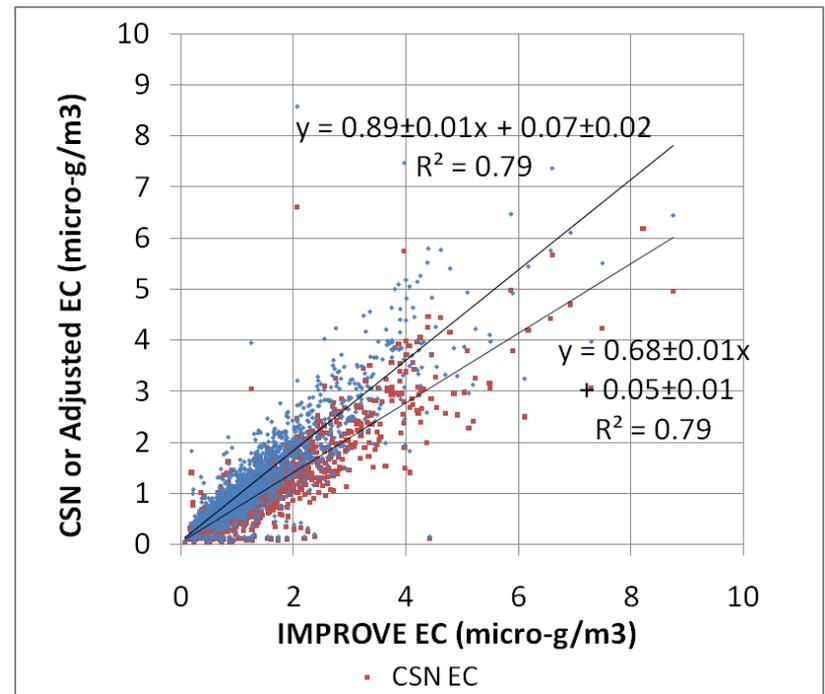
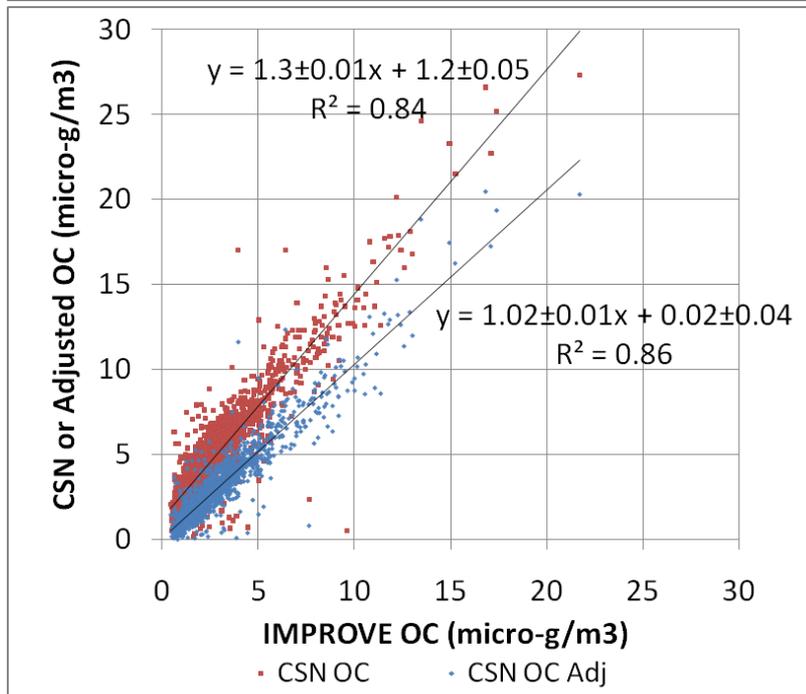
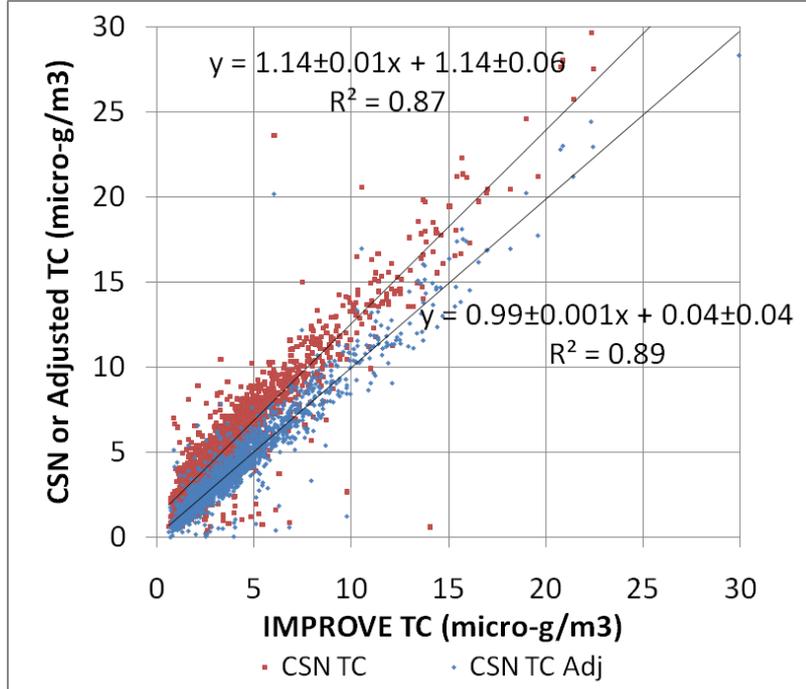
	813	823	833	853, 843, 847
month	Met One	Anderson	URG	R&P
1	1.11	1.00	0.11	0.55
2	1.26	1.15	0.13	0.63
3	1.21	1.10	0.12	0.61
4	1.38	1.25	0.14	0.69
5	1.56	1.42	0.16	0.78
6	1.66	1.50	0.17	0.83
7	1.78	1.62	0.18	0.89
8	1.91	1.74	0.19	0.96
9	1.45	1.31	0.14	0.72
10	1.08	0.98	0.11	0.54
11	1.02	0.93	0.10	0.51
12	1.07	0.97	0.11	0.53

**M - multiplicative negative artifact
(sampler artifact, (SA))**

Sampler	SA	Face Vel (cm/s)
Met one (813)	1.2	9.5
Anderson (823)	1.1	10.3
URG (833)	1	23.7
R&P-2025 (843)	1.2	23.6
R&P-2025 (847)	1.2	23.6
R&P-2300 (853)	1.2	14.4
IMPROVE	1	107.2

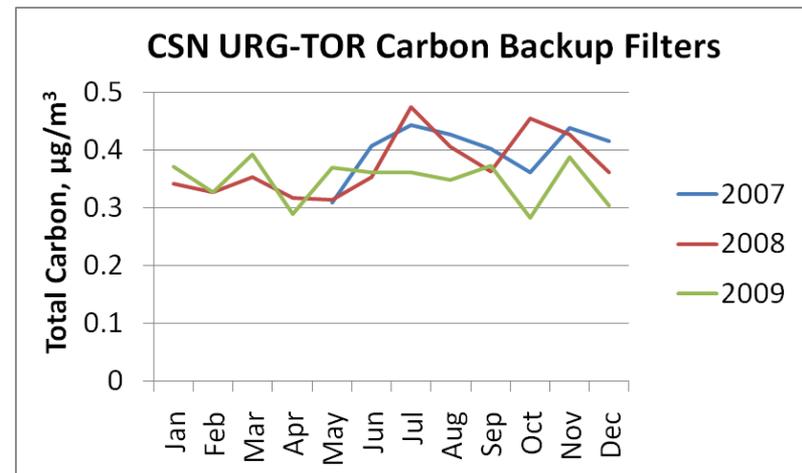
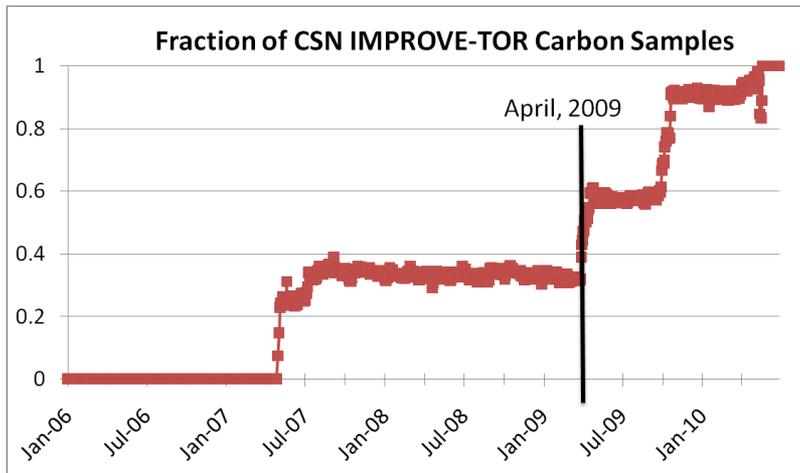
Note: All three R&Ps were lumped together. Probably a mistake due to differing face velocities

Comparison of 2005-06 Collocated Data



CSN URG IMPROVE-TOR C vs IMPROVE C

- In 2007 CSN began to phase in IMPROVE like, URG samplers to collect PM_{2.5} samples to be analyzed by DRI using IMPROVE-TOR analysis
 - The raw CSN data are not blank corrected, but backup filter blanks are analyzed and reported
 - We assume that the OC/EC split is identical to IMPROVE data

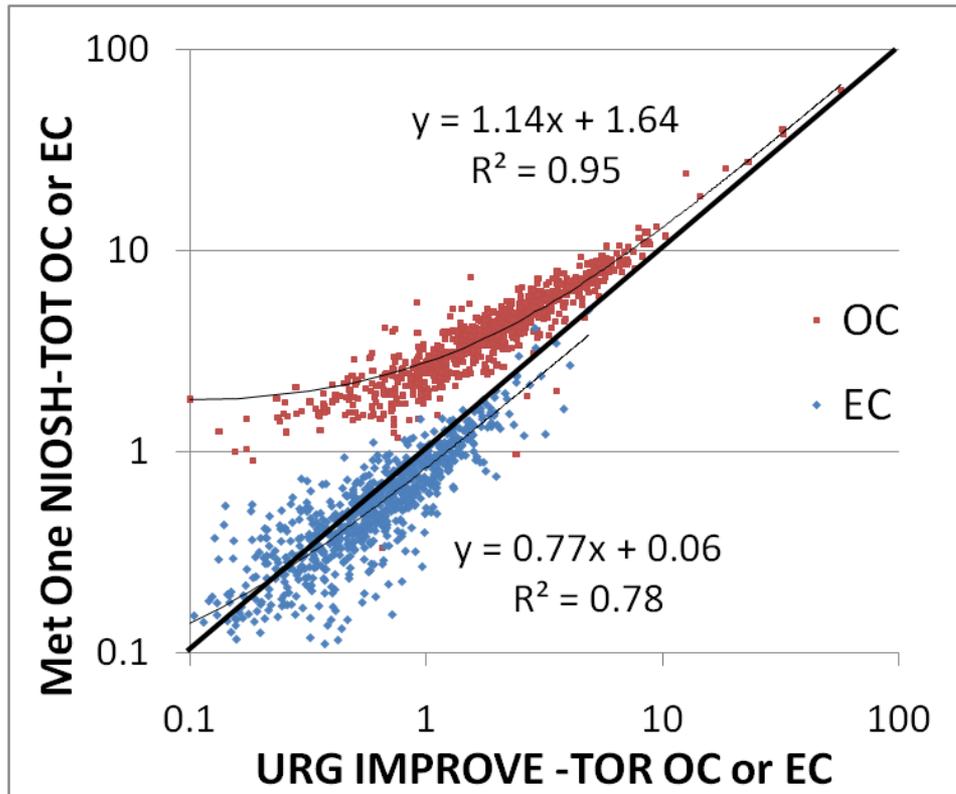


- URG samplers were phased over three periods: May 2007; April 2009 and October 2009

- Backup filter TC is low: $0.3 - 0.45 \mu\text{g}/\text{m}^3$
- The TC is similar from year to year with no consistent seasonal cycle
- EC was $\sim 0.01 \mu\text{g}/\text{m}^3$ and was ignored
- A constant $0.35 \mu\text{g}/\text{m}^3$ was used to correct all CSN-URG-TOR OC concentrations for the positive carbon artifact

Relating CSN-Met One-TOT and CSN-URG-IMPROVE-TOR Carbon

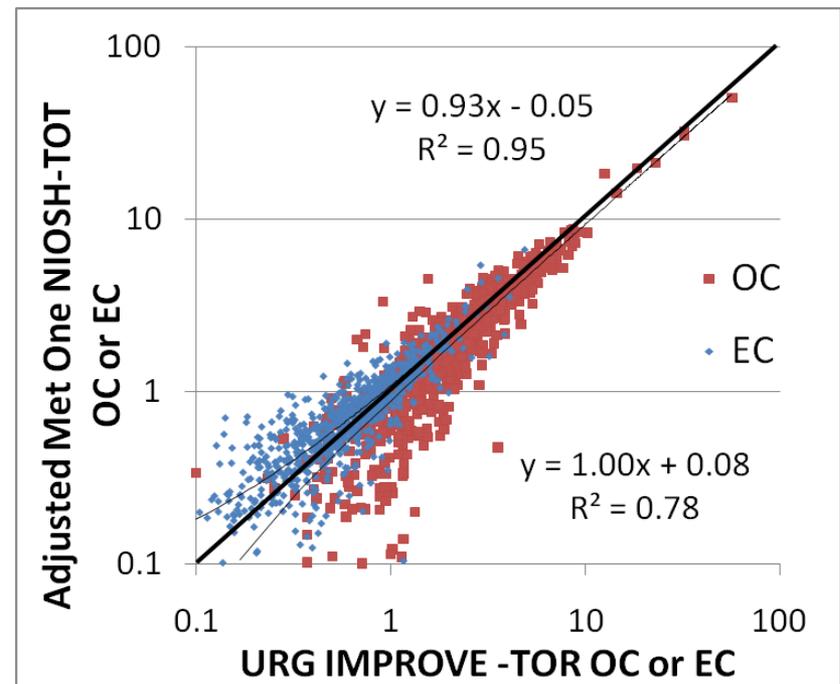
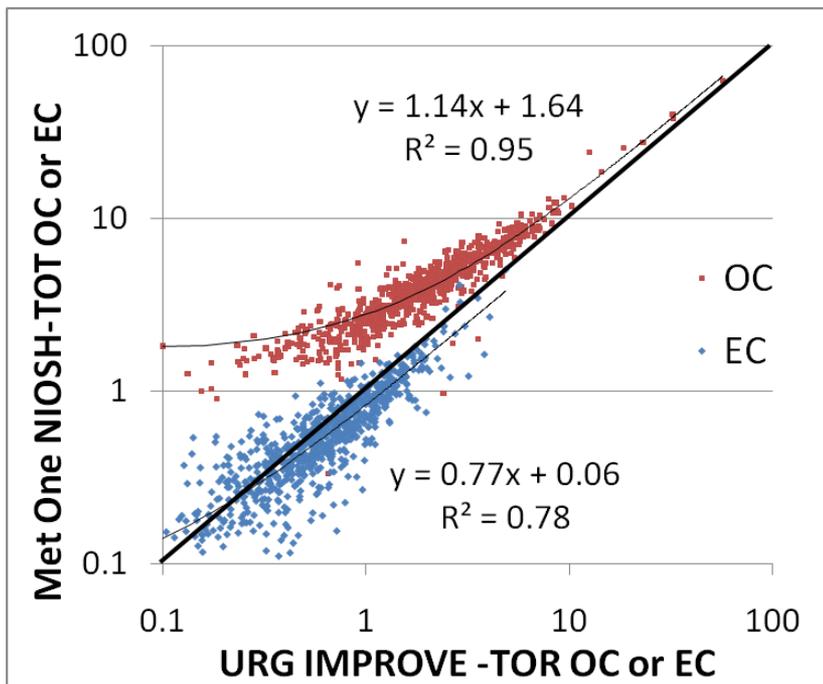
- Prior to exchanging the CSN samplers with the new URG samplers, CSN operated the two samplers side by side for a month
- These collocated data from May 2007 – April 2009 were used to assess the suitability of the CSN carbon adjustments derived using IMPROVE data



- Met One NIOSCH OC Concentrations
 - A large positive artifact, $> 1 \mu\text{g}/\text{m}^3$)
 - A positive multiplicative bias consistent with a negative artifact associated with the high URG face velocity
- Met One NIOSCH EC concentrations
 - Little evidence of a + artifact
 - A multiplicative bias consistent with lower EC-TOT than EC-TOR
- These results are consistent with past comparisons of NIOSH-TOT to IMPROVE-TOR carbon

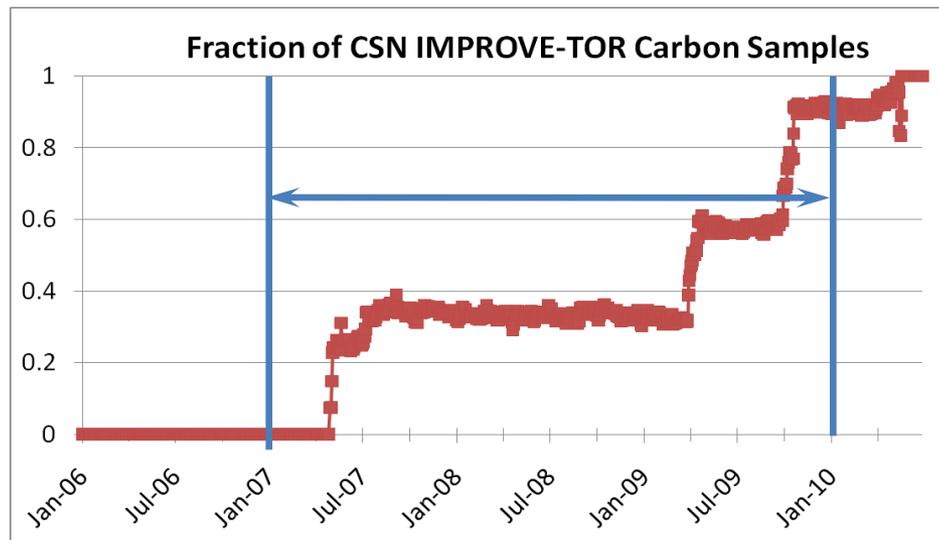
Adjusted Met One NIOSH-TOT Carbon vs URG IMPROVE-TOR

- The NIOSH-TOT carbon data were adjusted using the NIOSH-TOT to IMPROVE-TOR method
- The biases have been significantly reduce, though the adjusted OC and TC underestimated the IMPROVE TOR values by ~5% and the EC is overestimated by ~10%

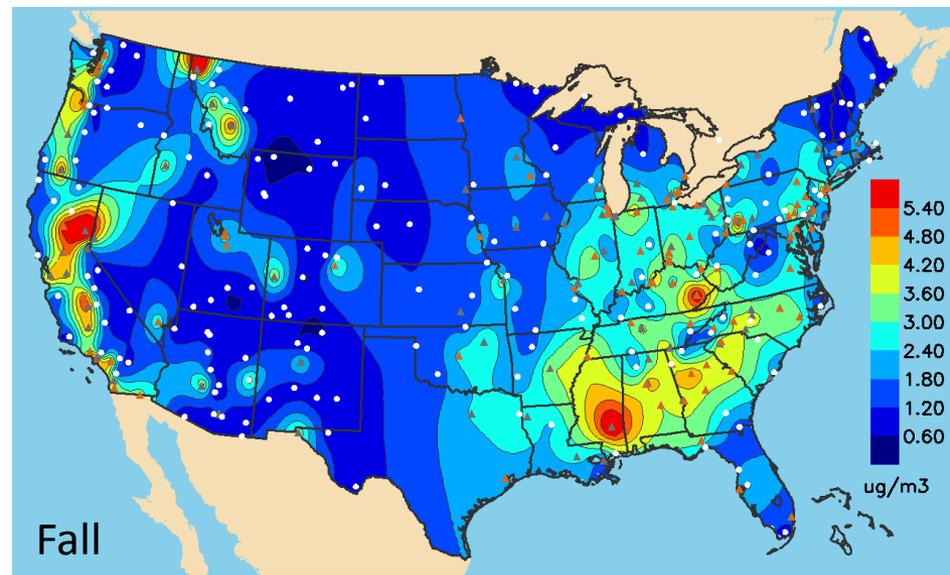
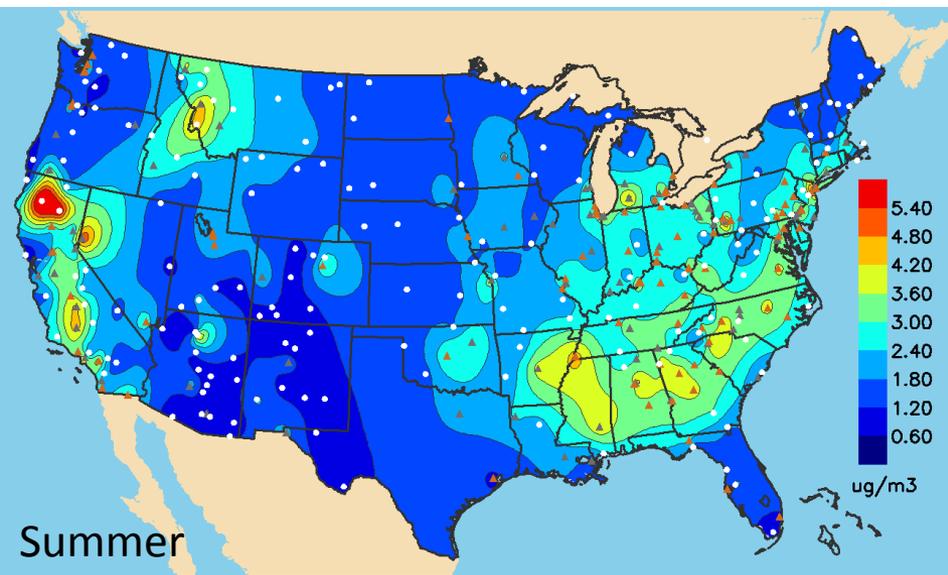
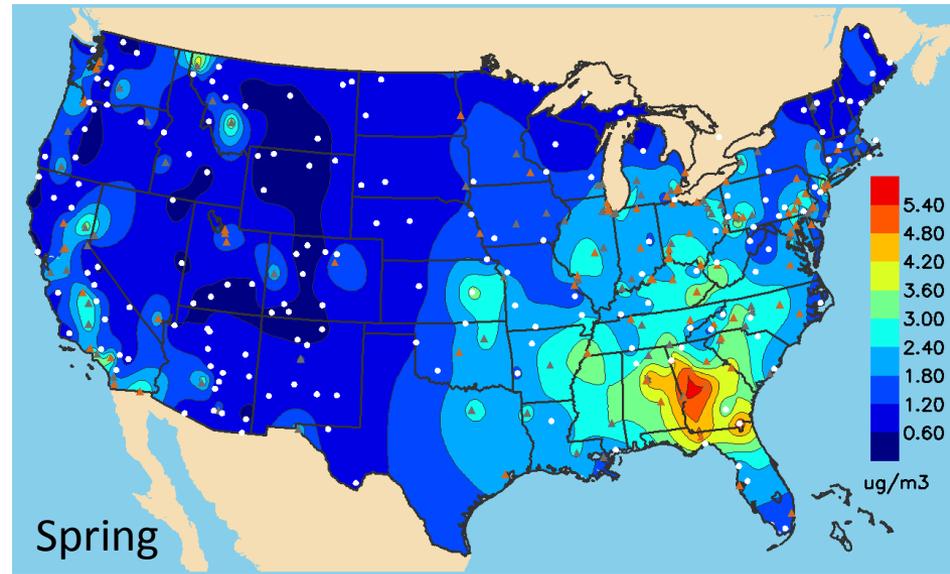
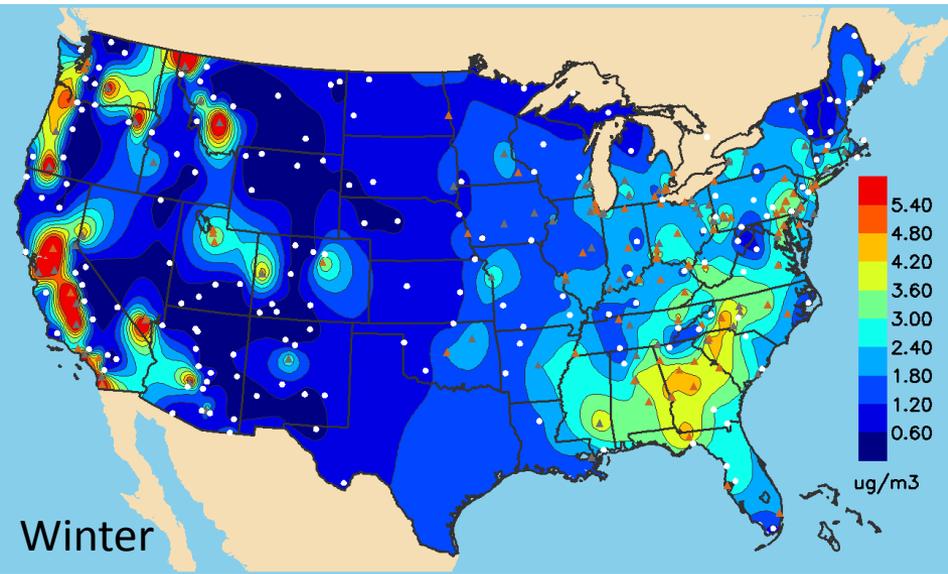


OC/EC Spatial Patterns

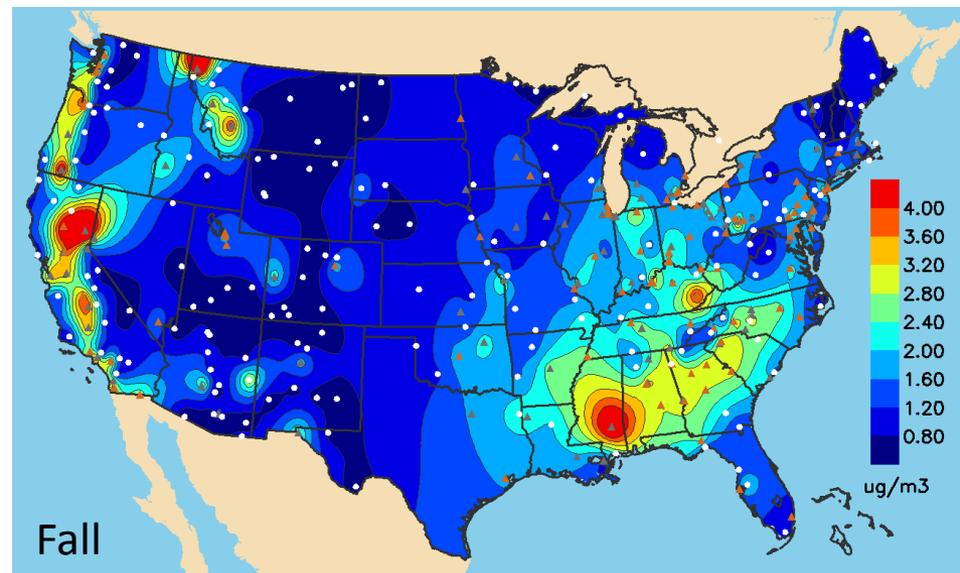
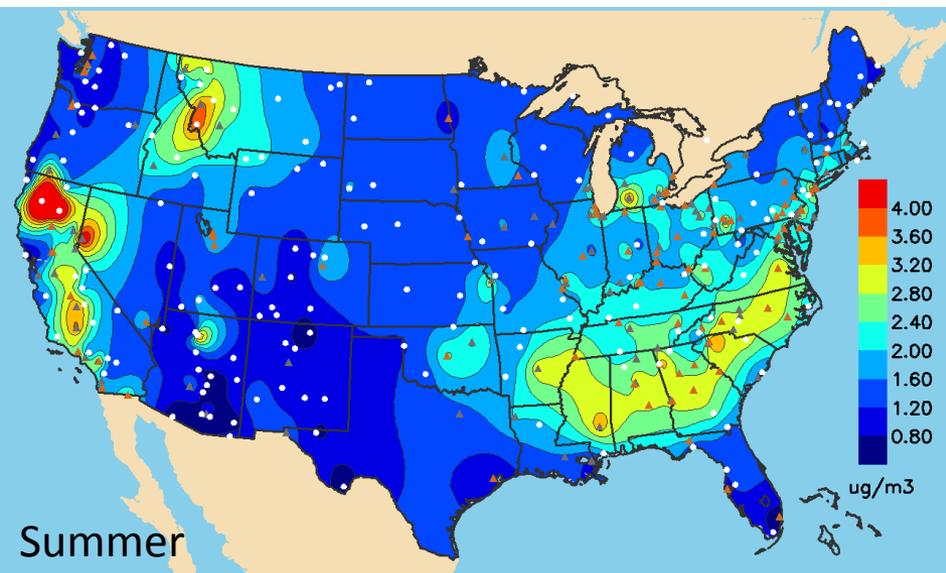
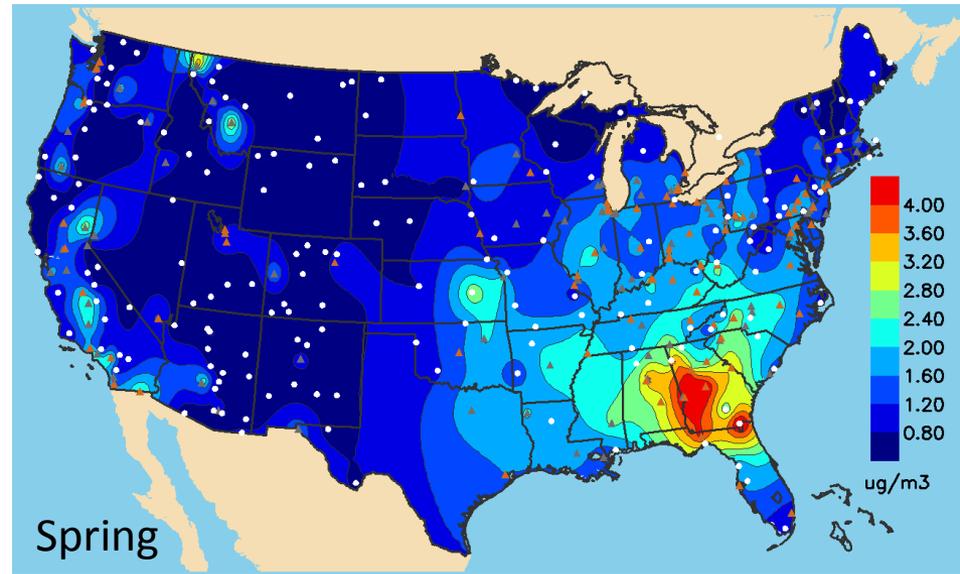
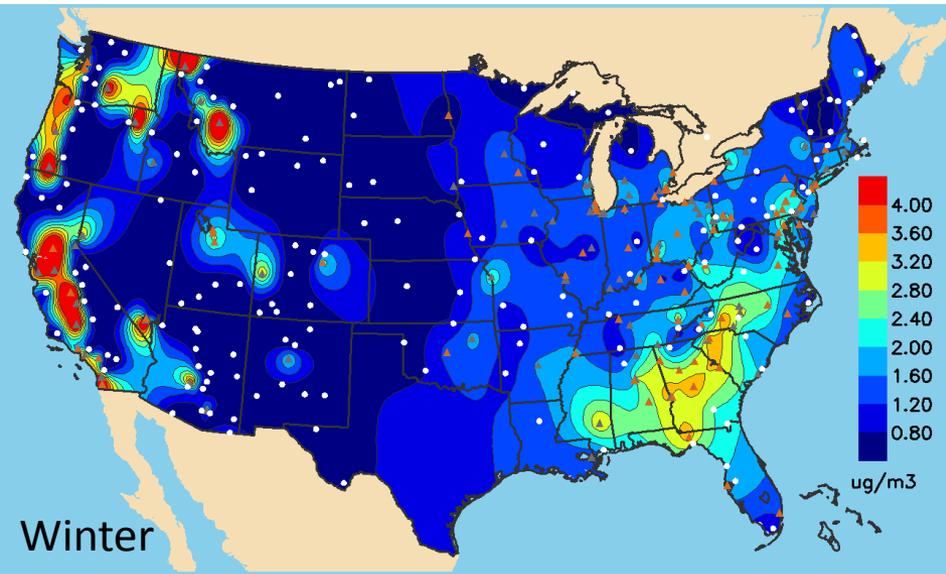
- IMPROVE and CSN seasonal and annual TC, OC and EC concentrations
- Three years of data 2007 – 2009
- All CSM Metone-NIOSH and URG IMPROVE-TOR carbon data were used
- 2/3 completeness criteria



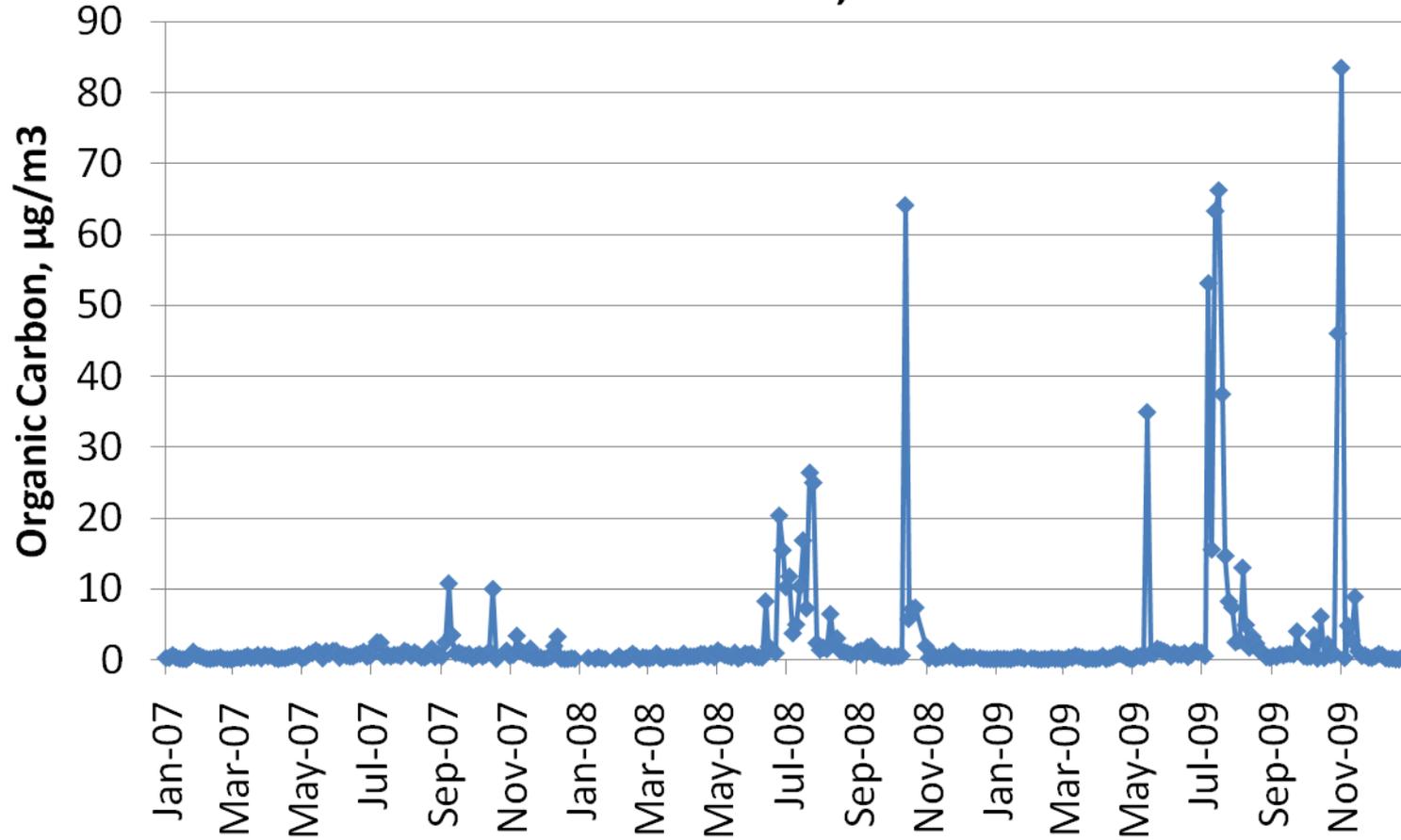
Seasonal TC Concentrations



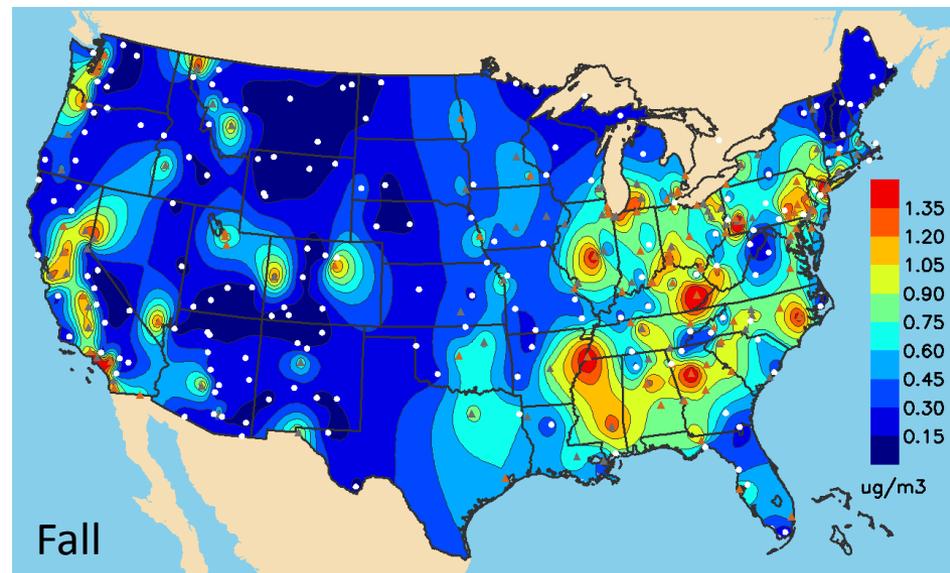
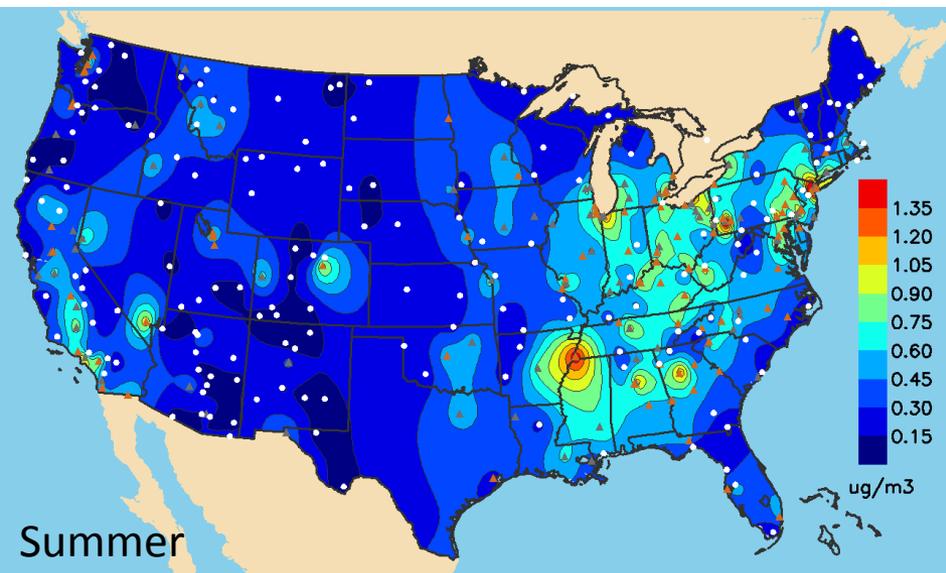
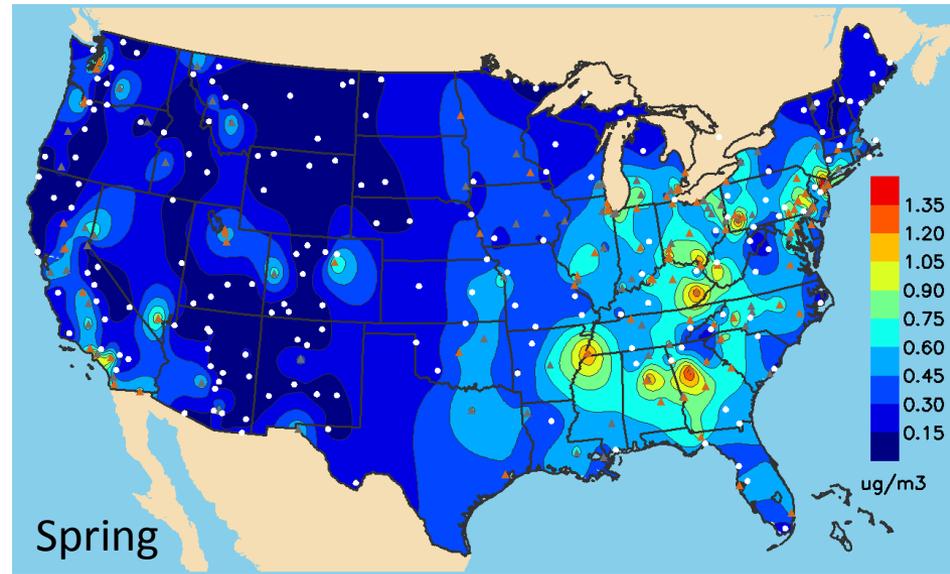
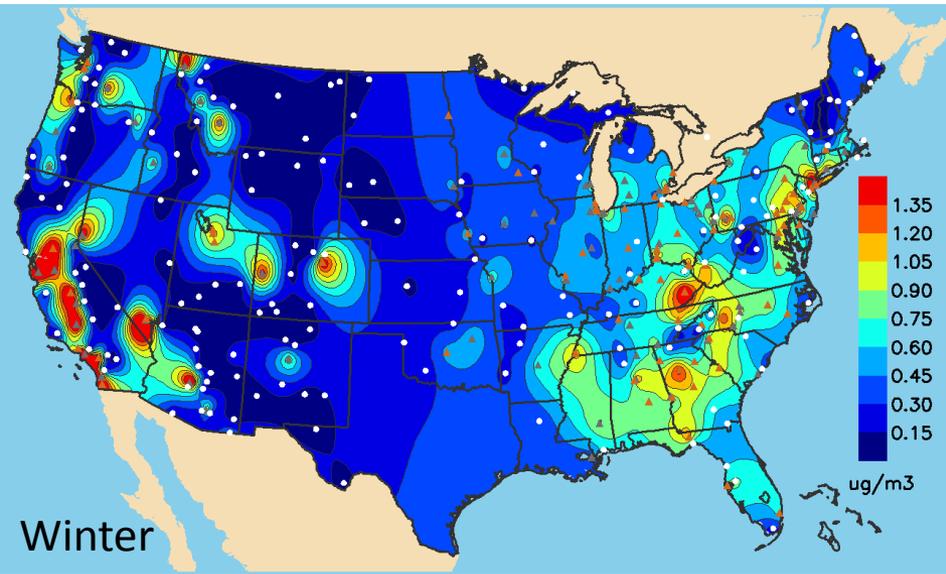
Seasonal OC Concentrations



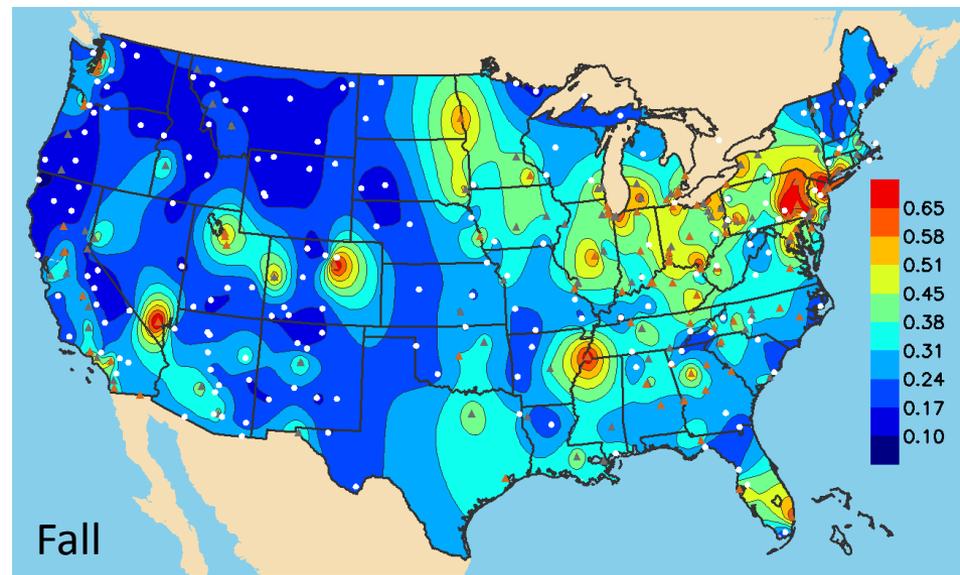
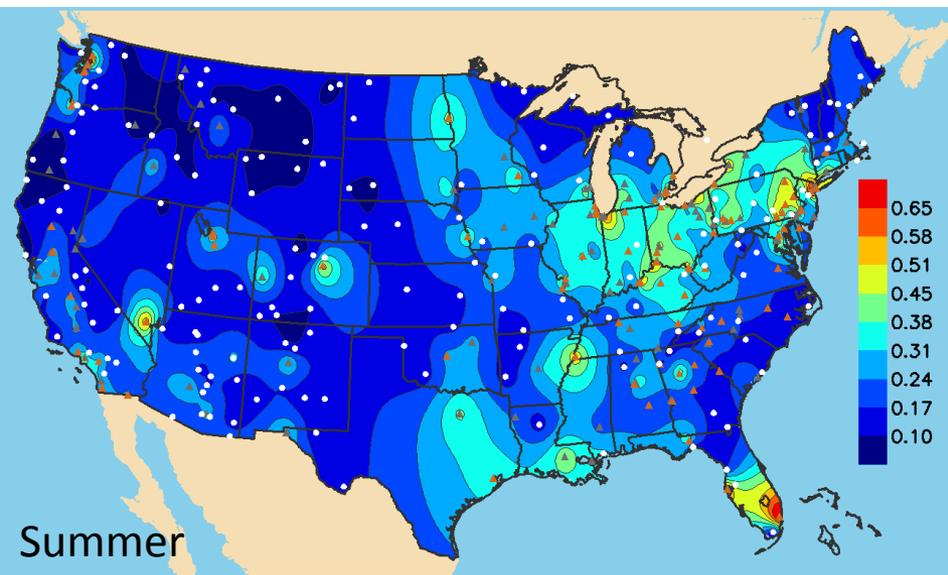
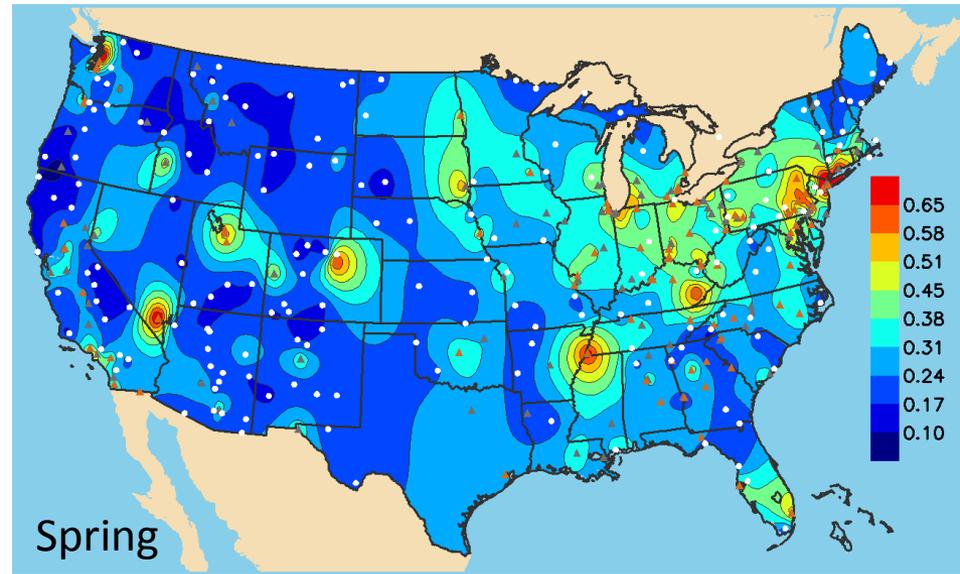
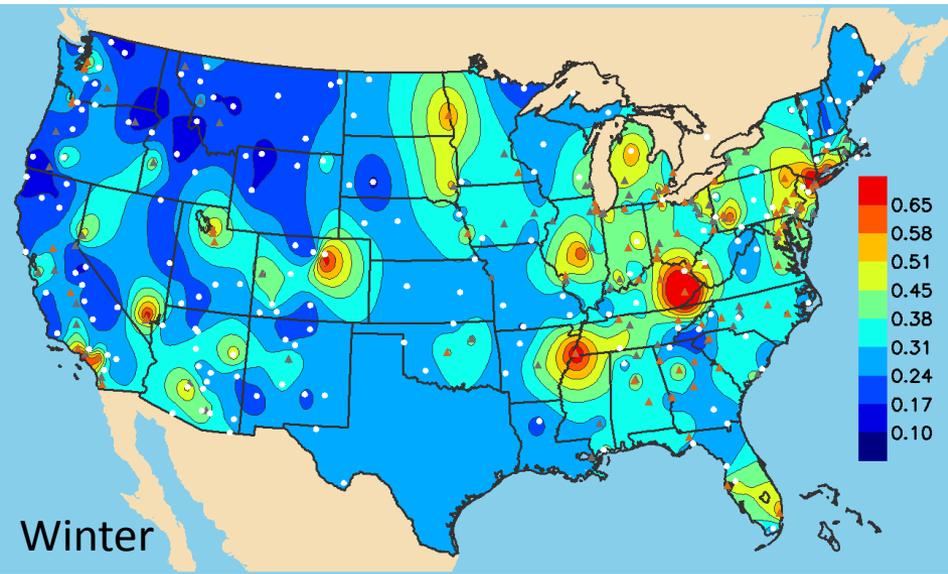
Lassen Volcanic , NP



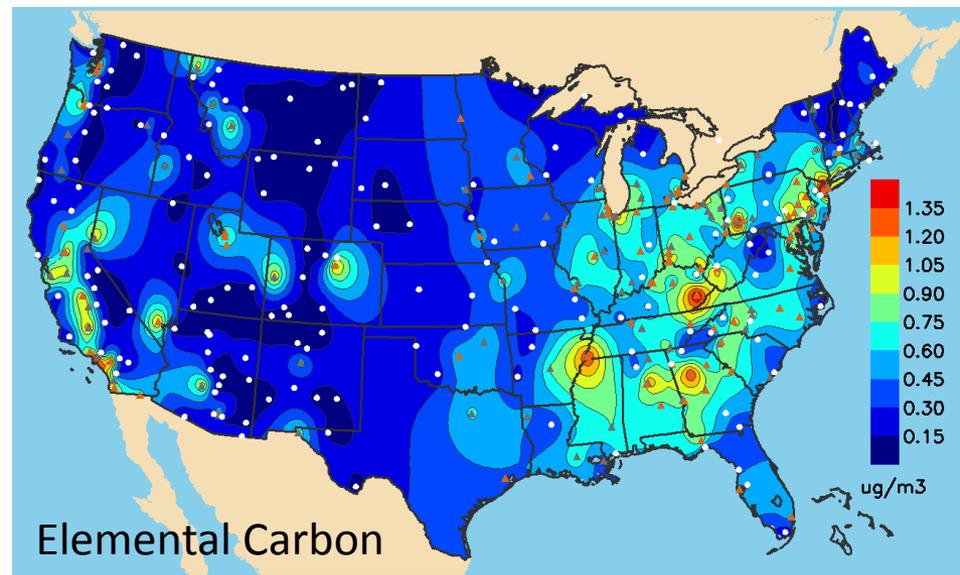
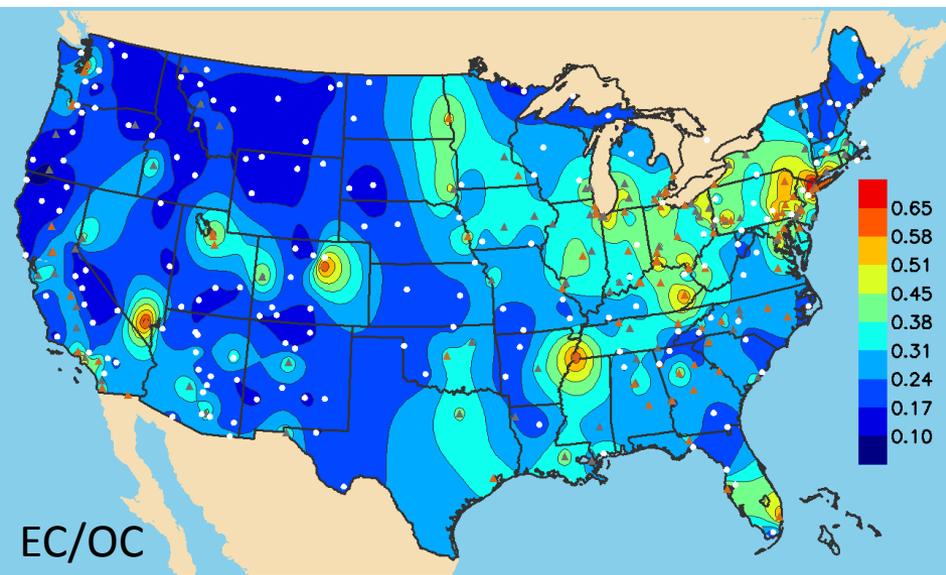
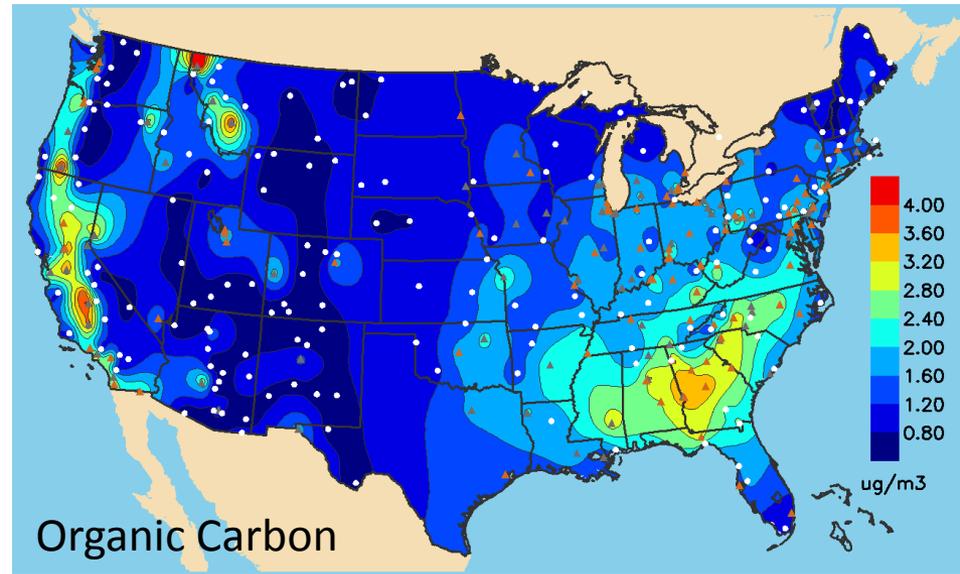
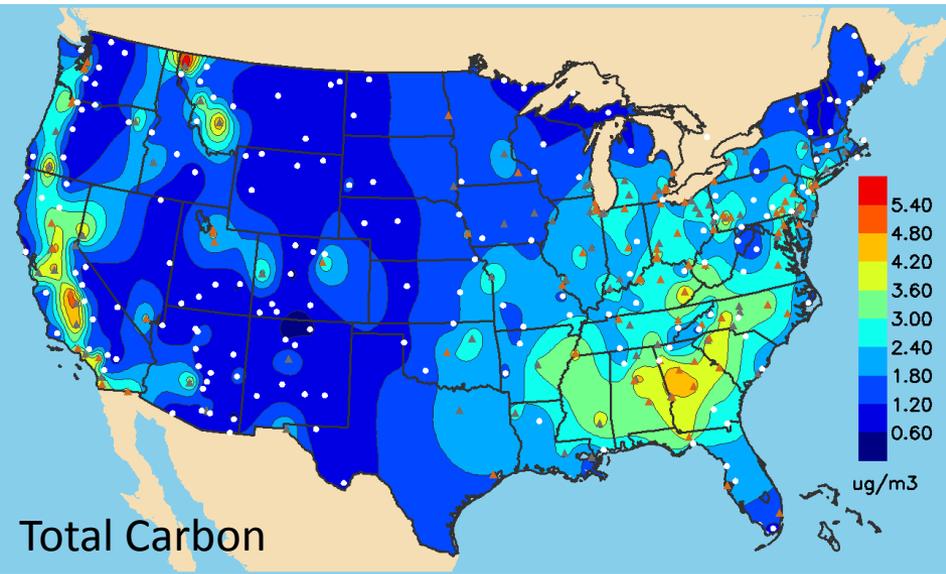
Seasonal EC Concentrations



Seasonal Median EC/OC Ratios



Annual Carbon Concentrations



IMPROVE Average Seasonal TC Source Attribution (ratio of averages)

Winter

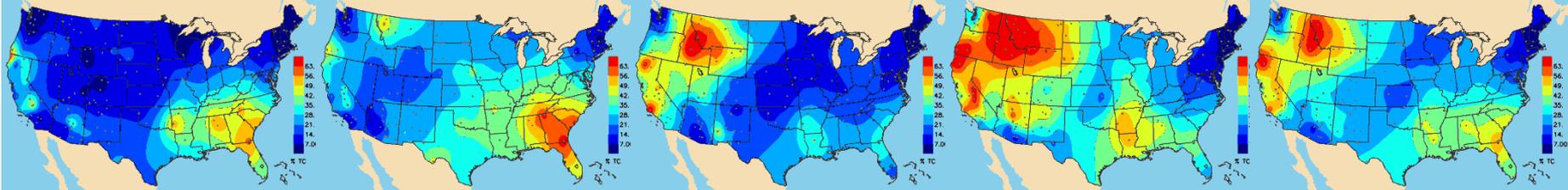
Spring

Summer

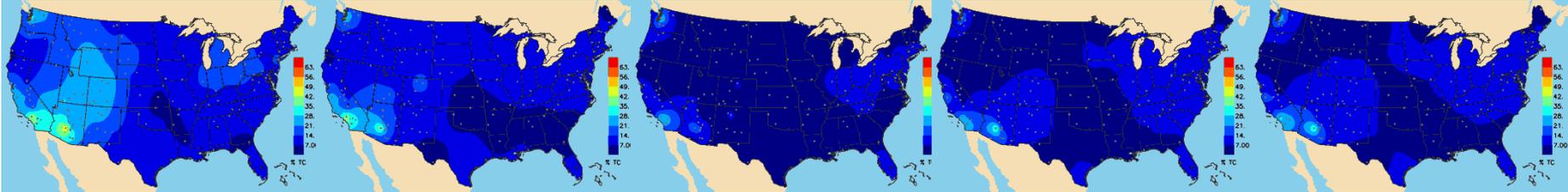
Fall

Annual

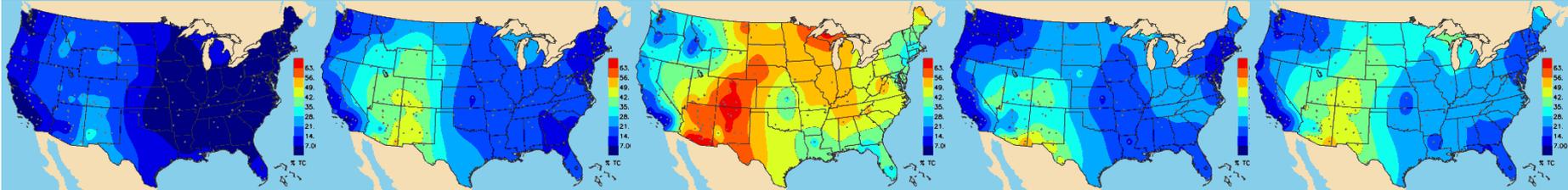
Fire



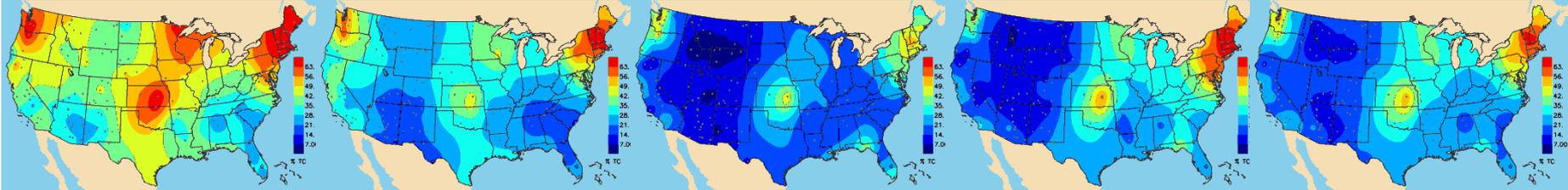
Mobile



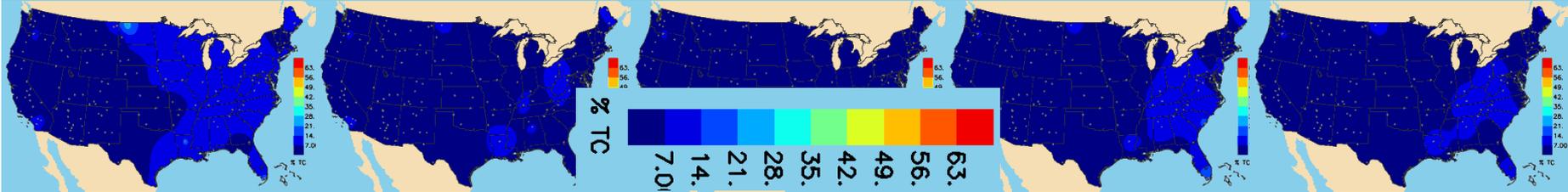
Vegetation



Area



Point



IMPROVE Seasonal 10th %-ile TC Source Attribution (Avg of Ratios)

Winter

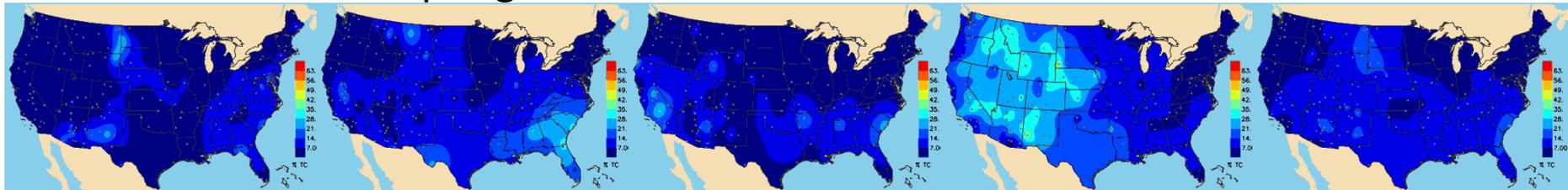
Spring

Summer

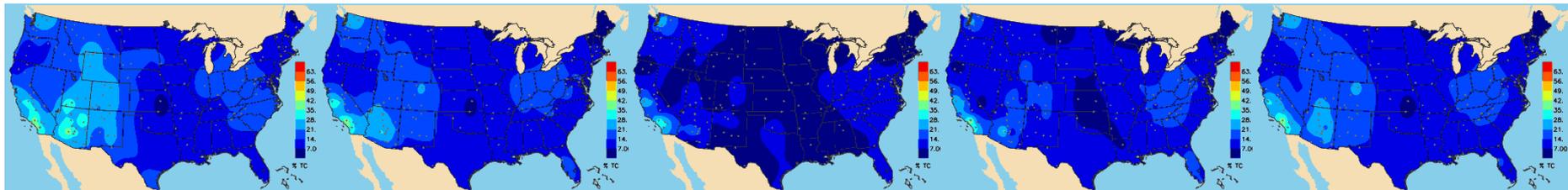
Fall

Annual

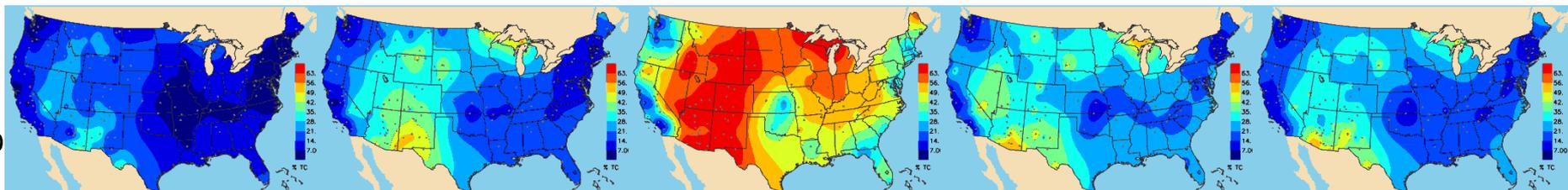
Fire



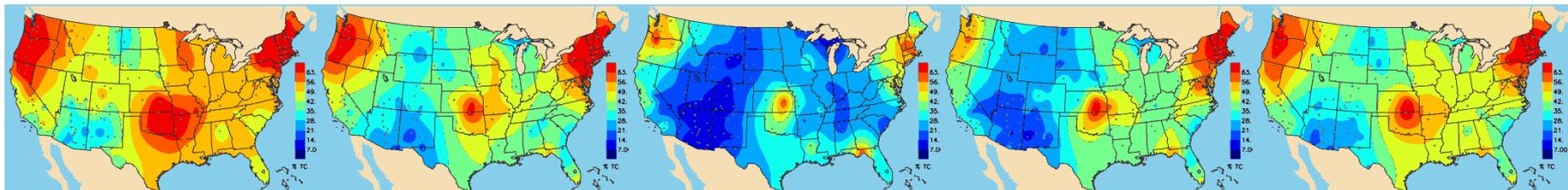
Mobile



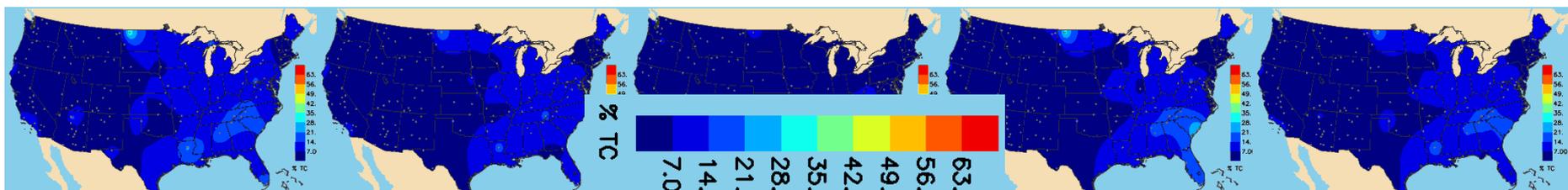
Vegetation



Area



Point



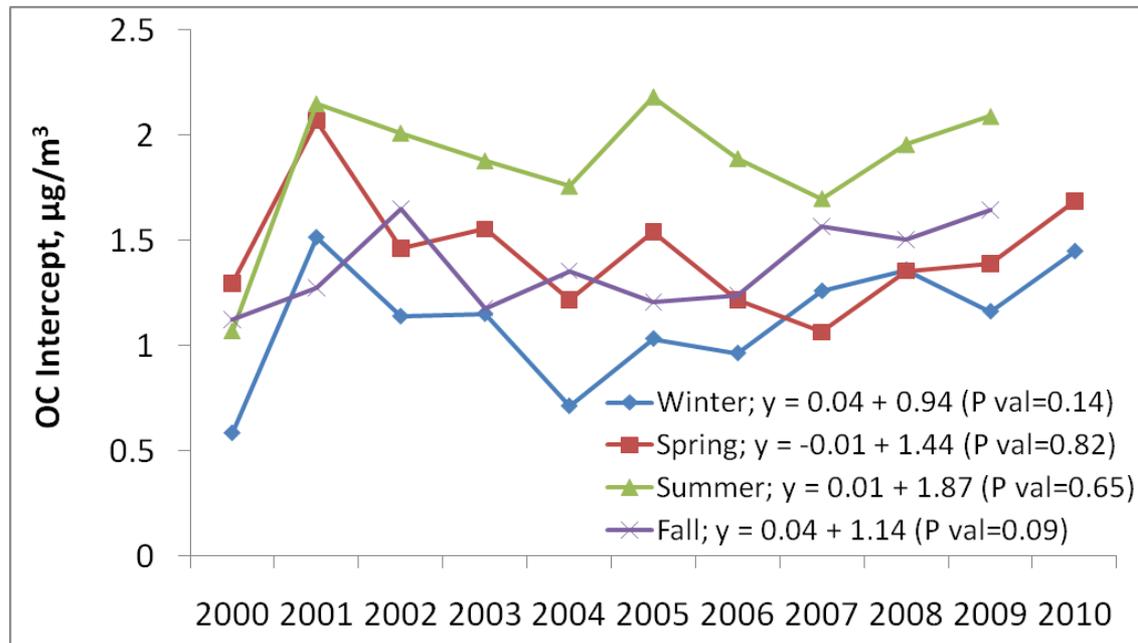
% TC



Trends

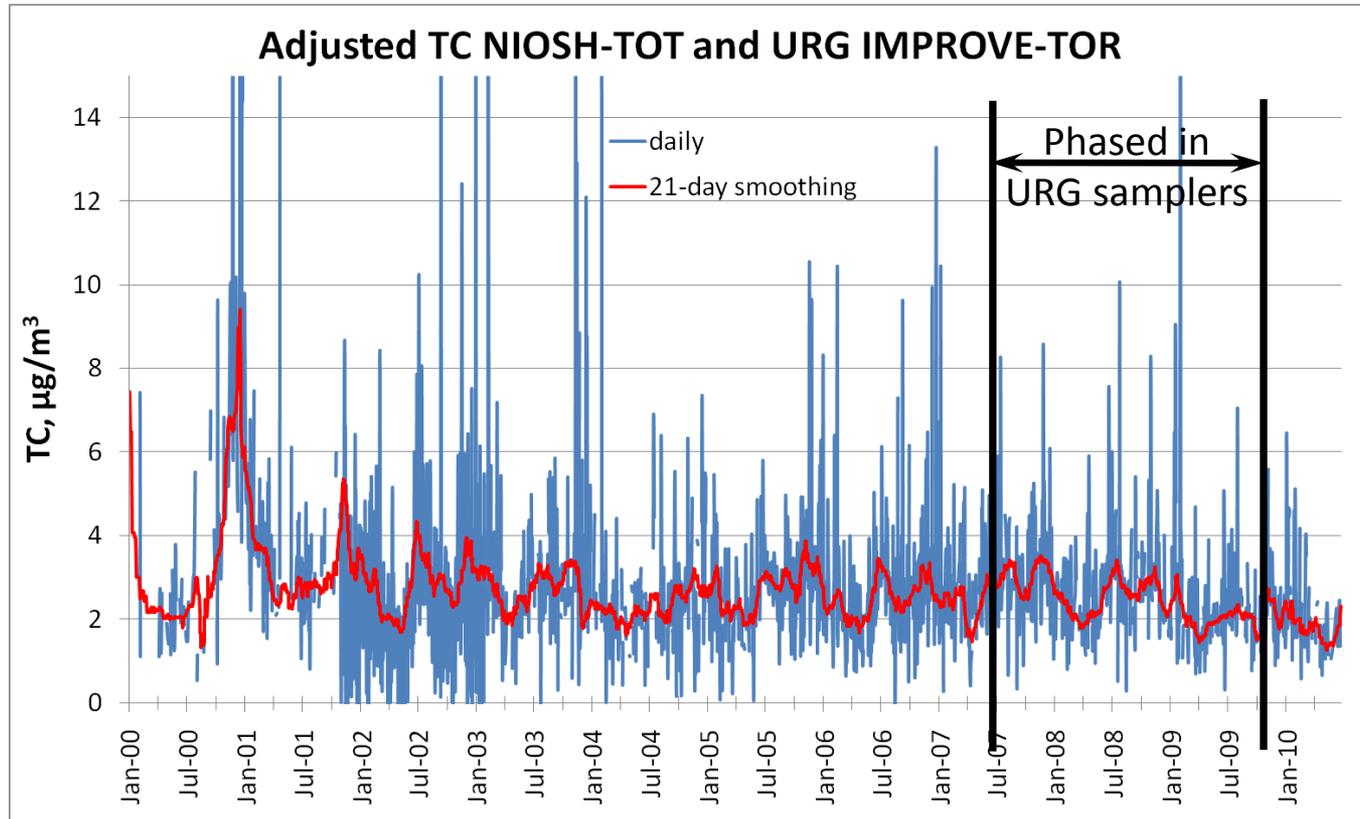
- Long Term Trends in IMPROVE and CSN seasonal and annual TC concentrations
- 10 years of data 2000 – 2009
- All CSN-Met One-TOT, CSN-URG-TOR, and IMPROVE-TOR carbon data were used
- Thiel regression analysis with 7 or more years of data
- 2/3 completeness criteria
- Slopes with p-values > 0.2 were set to 0

Trends in CSN Met One NIOSH Carbon Positive Artifacts



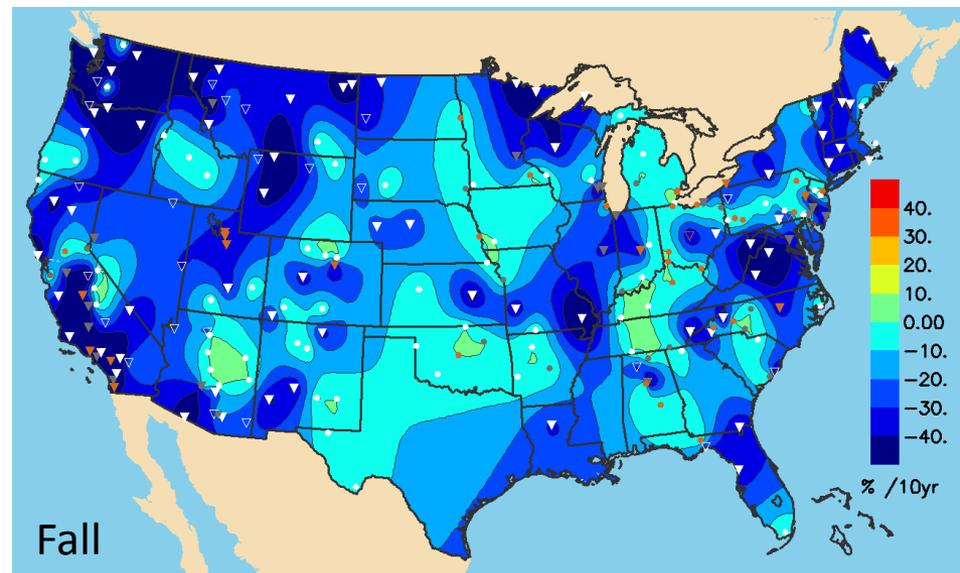
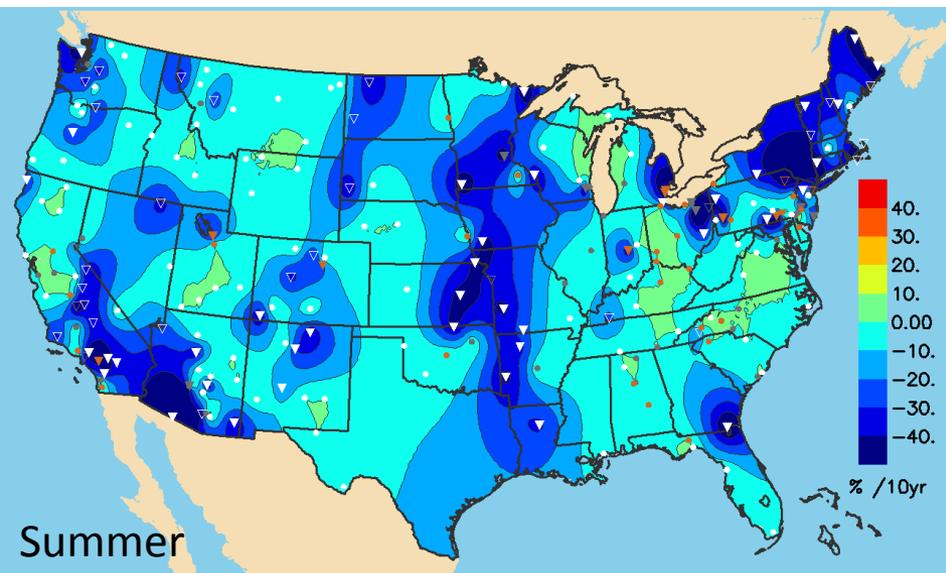
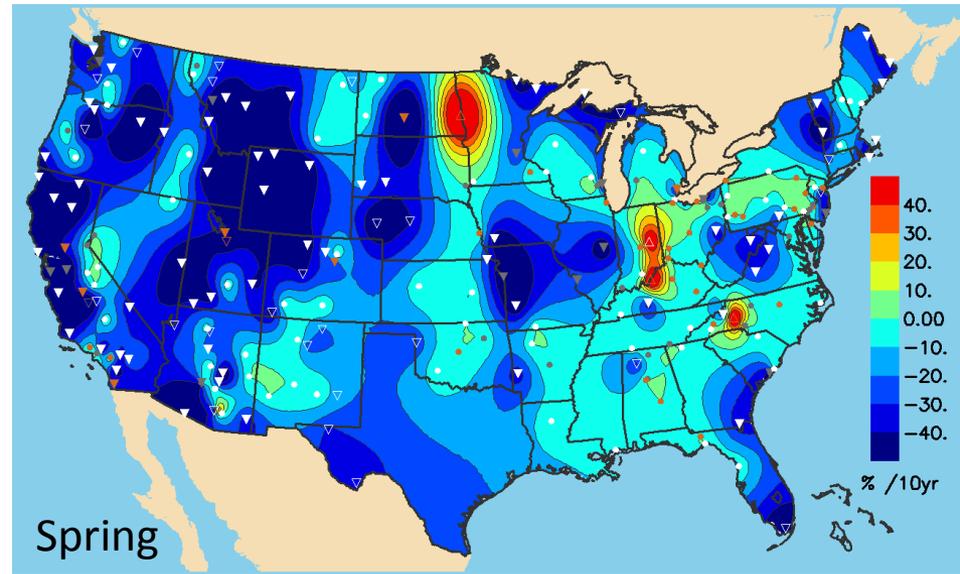
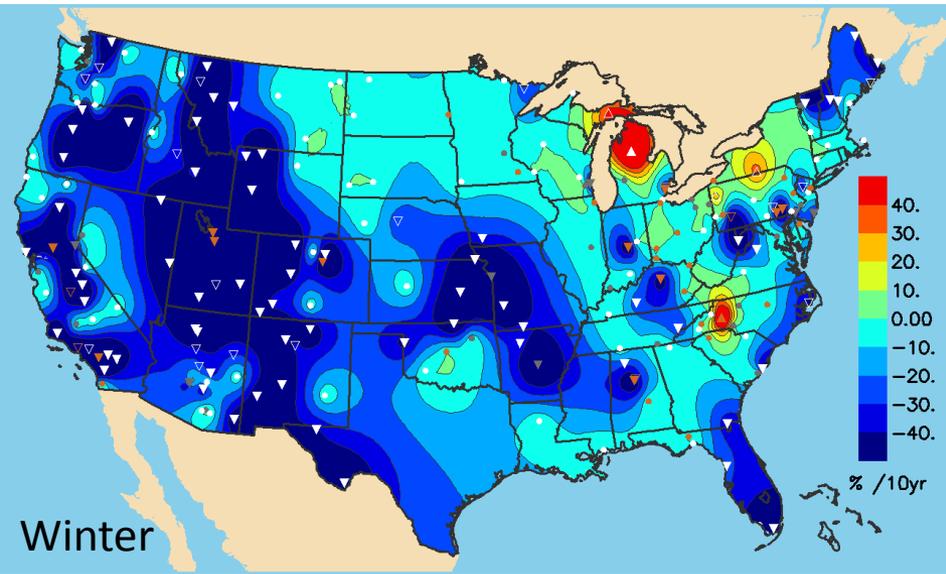
- The CSN Met One NIOSH OC was regressed against PM2.5-ASO4-Soil using Tiel Regression
- The intercept is assumed to be related to the positive organic carbon artifact
- There are no significant trends in the OC intercept values over time

Median CSN TC for each Sample Day

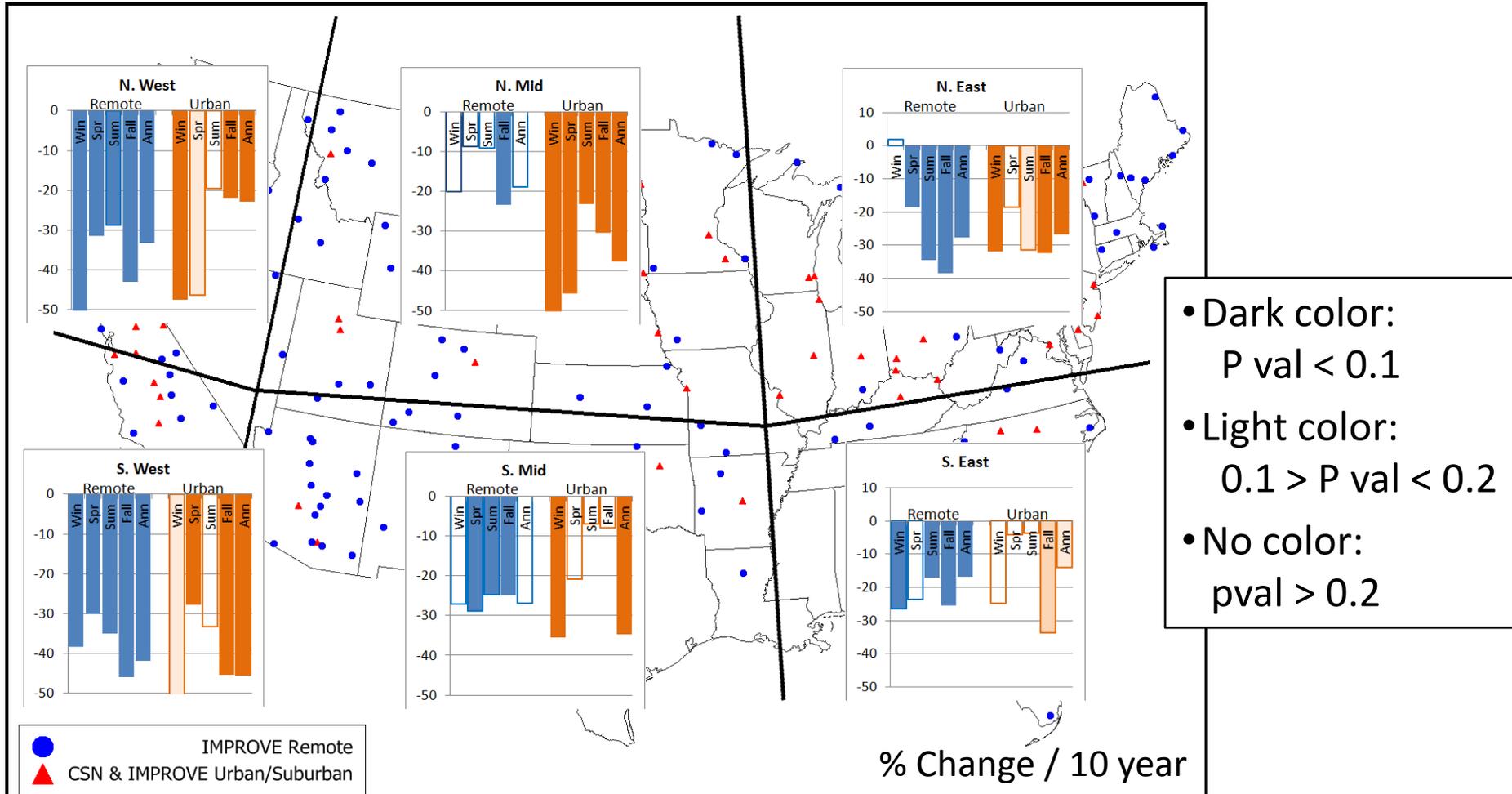


- Data from October 2002 – March 2003 have higher variability with large fraction of values below 0
- No sharp discontinuities in concentration trend, though the decrease in April 2009 TC coincides with continued phase in of URG samples

Trends in Seasonal TC, 2000-09 (medians)

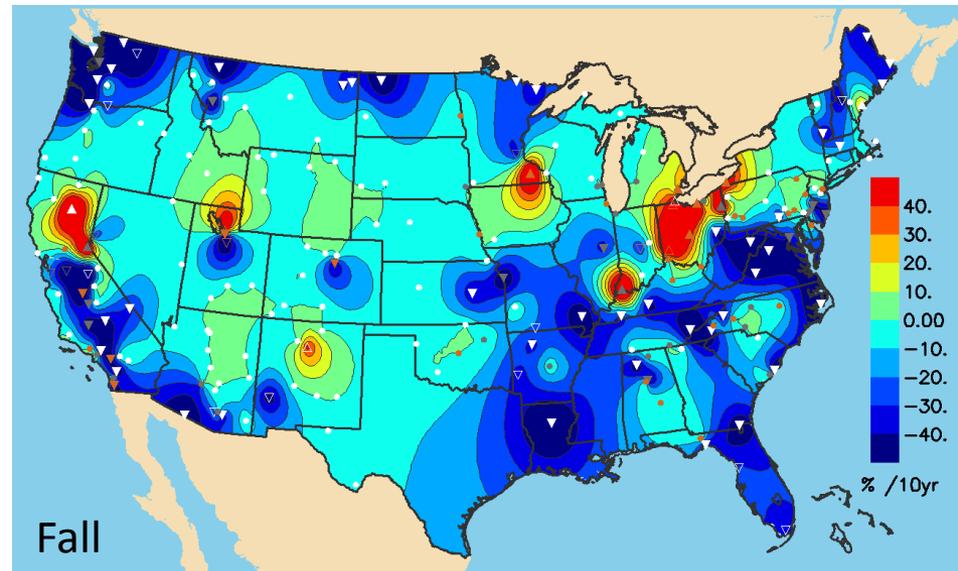
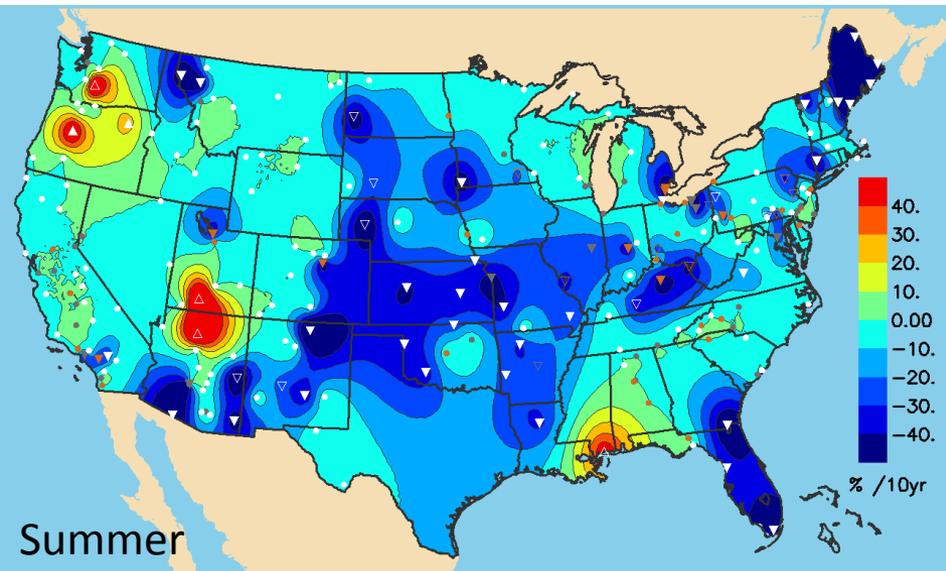
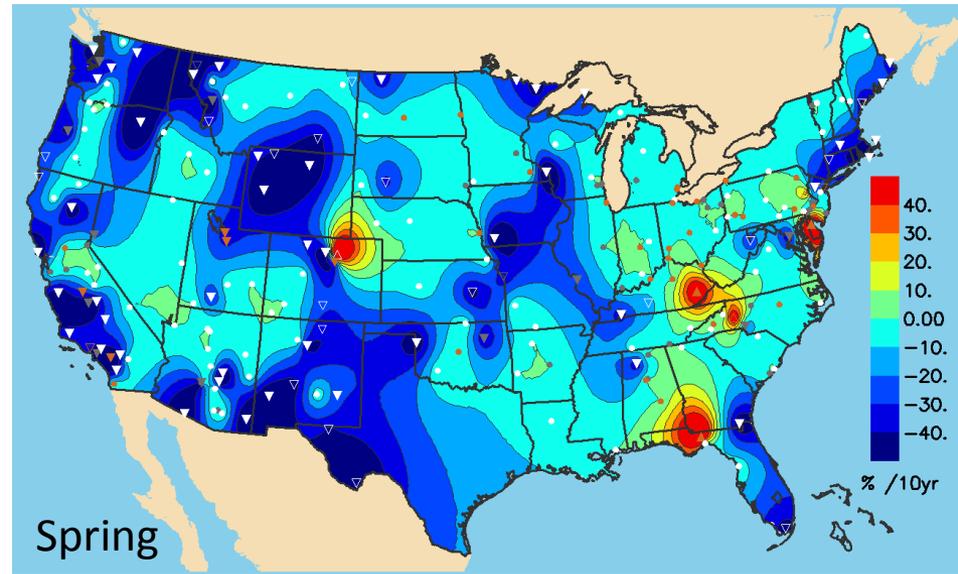
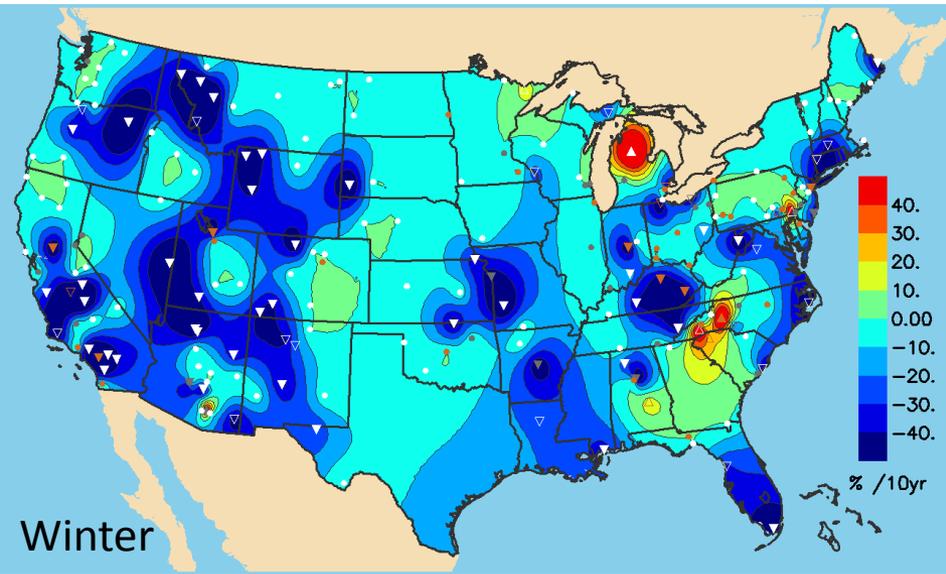


Urban and Rural Regional TC Trends

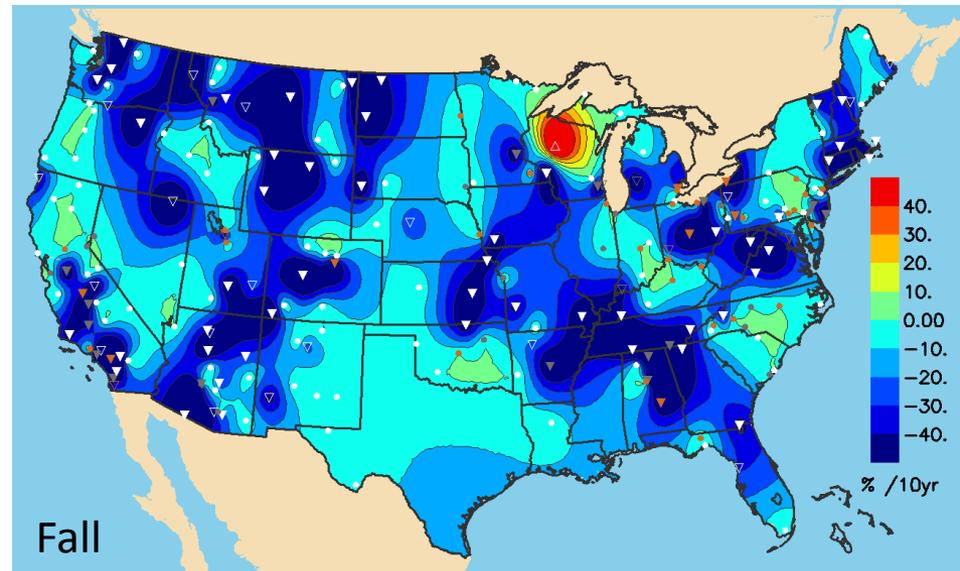
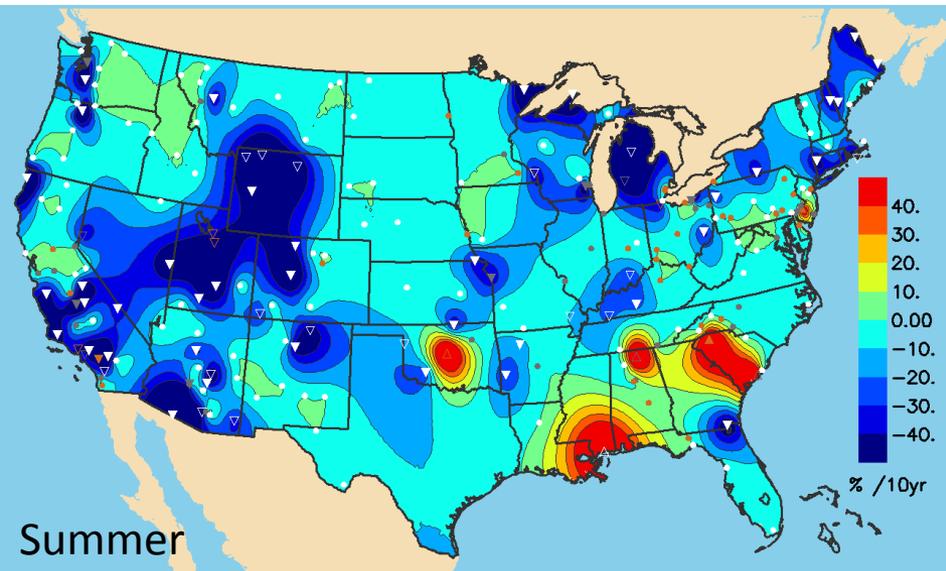
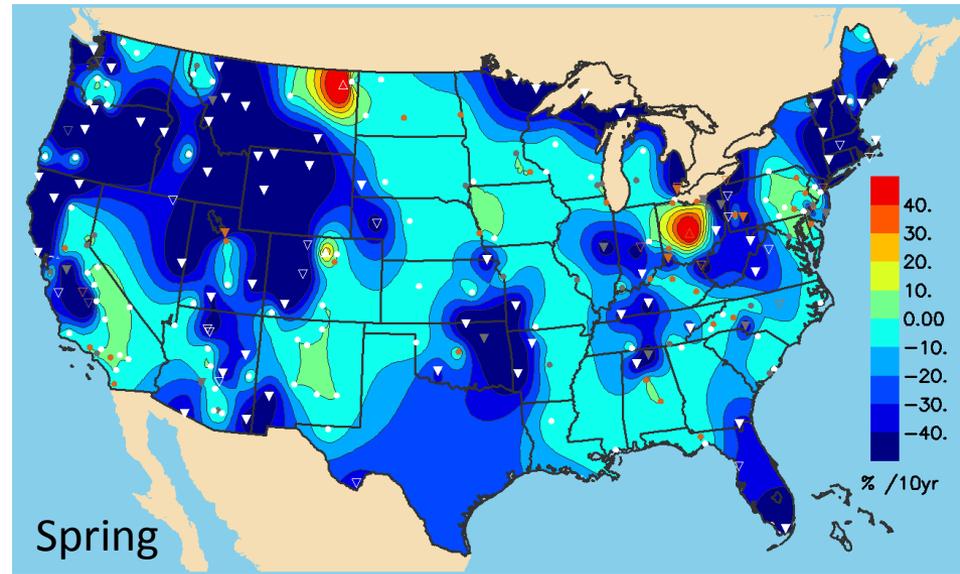
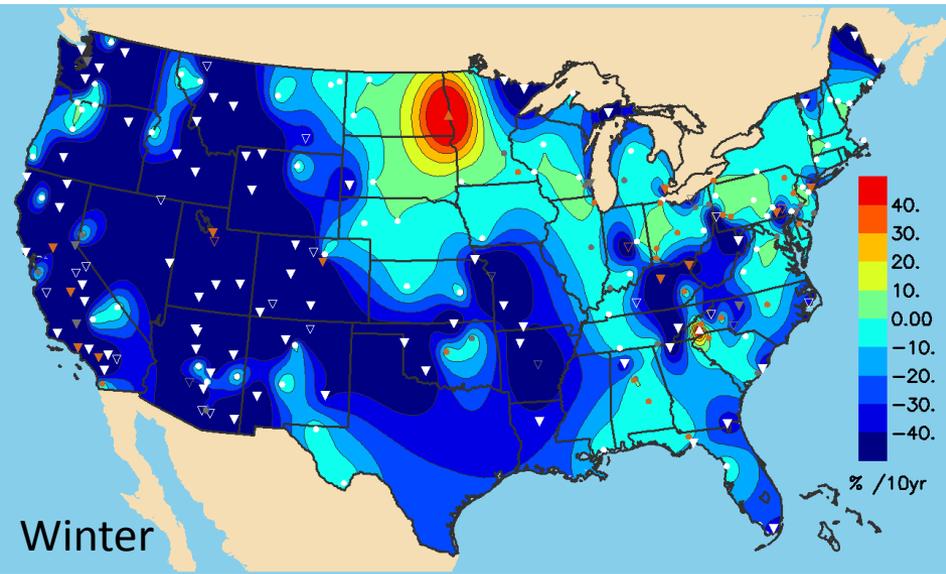


Aggregated median values from all sites in a given region from 2001-09

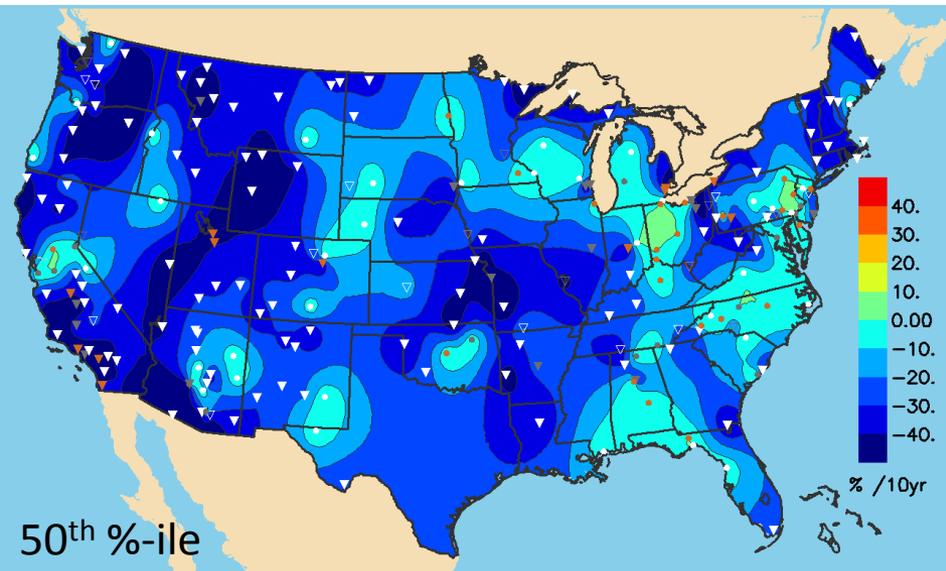
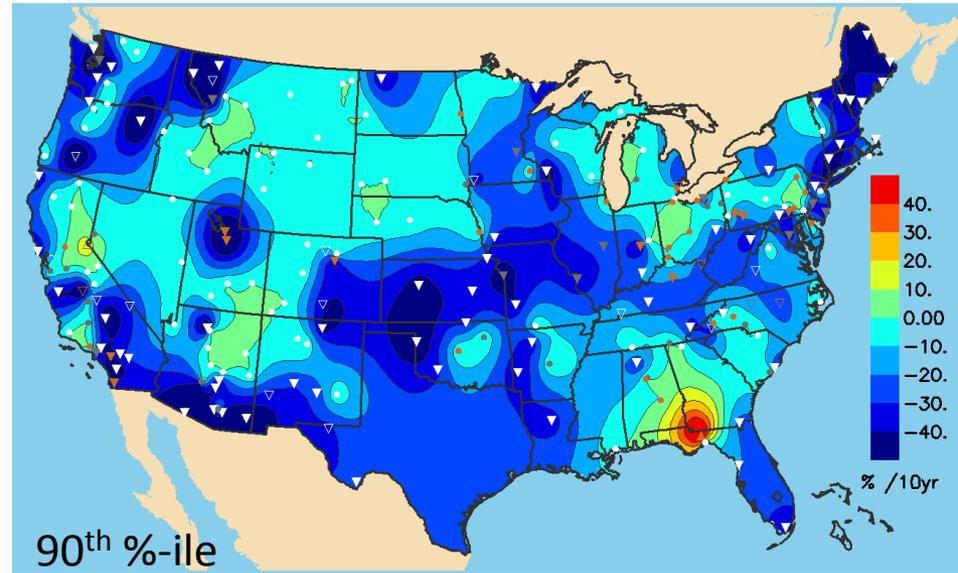
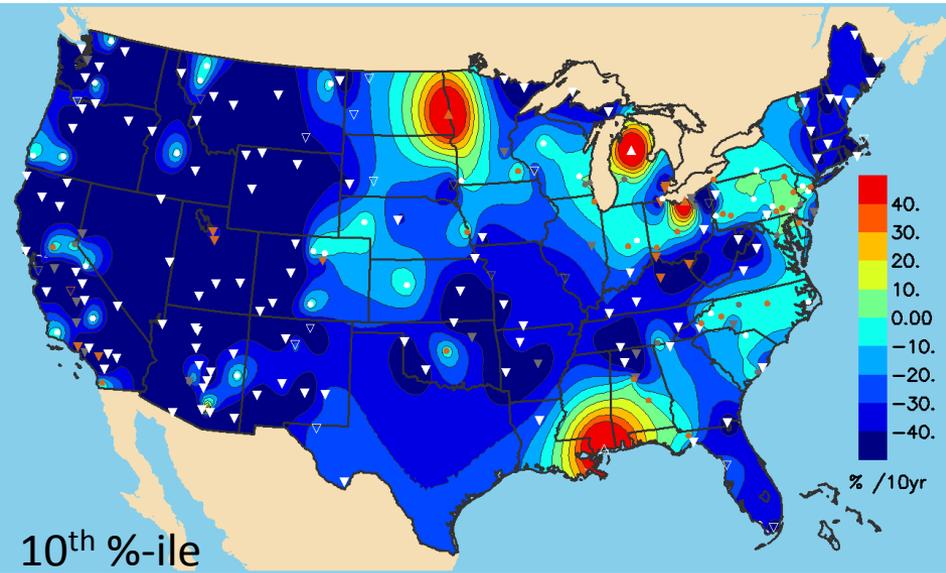
Trends in Seasonal 90th %-ile TC, 2000-09



Trends in Seasonal 10th %-ile TC, 2000-09

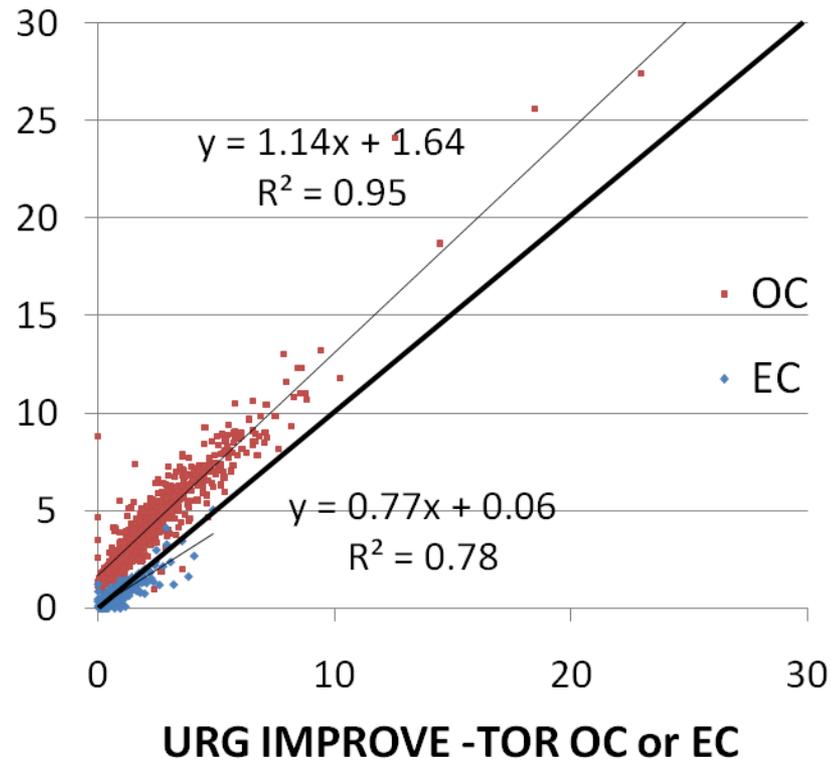


Trends in Annual TC, 2000-09

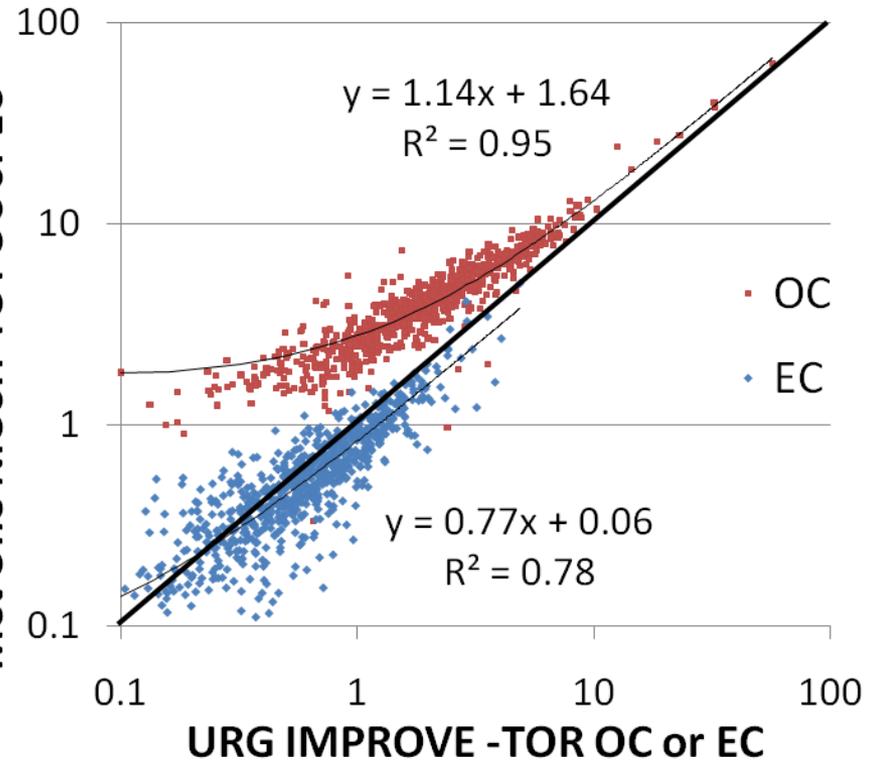


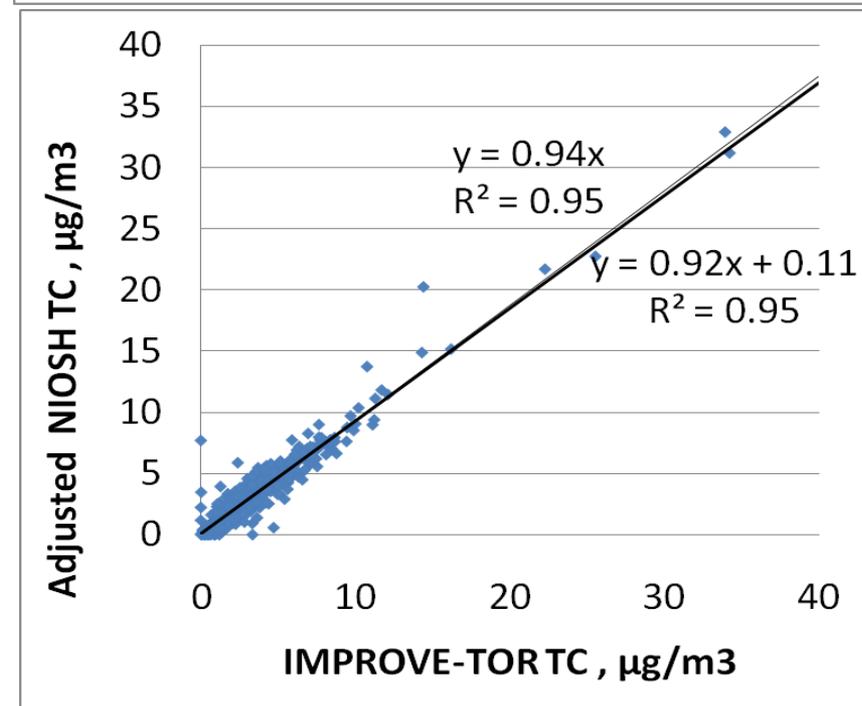
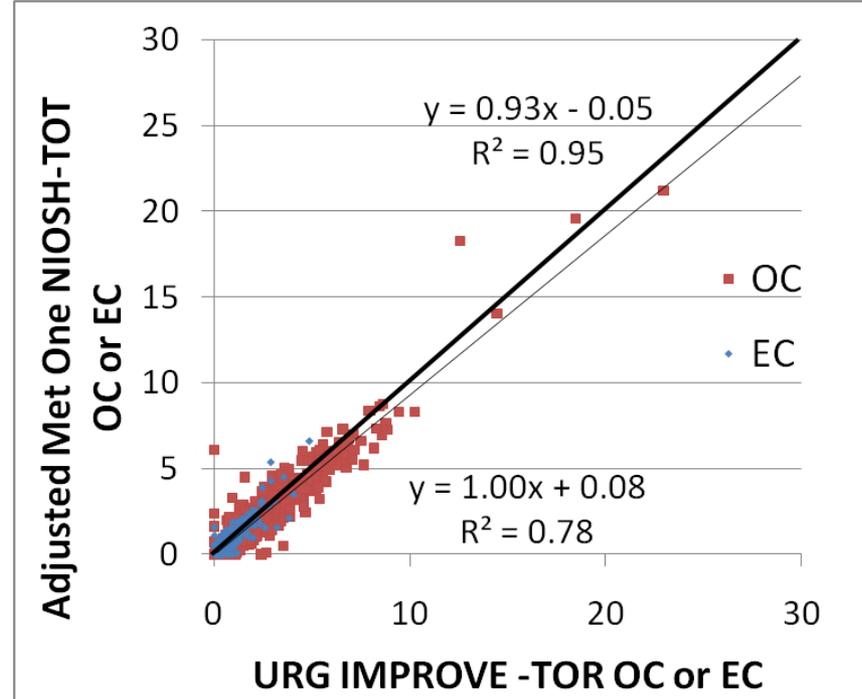
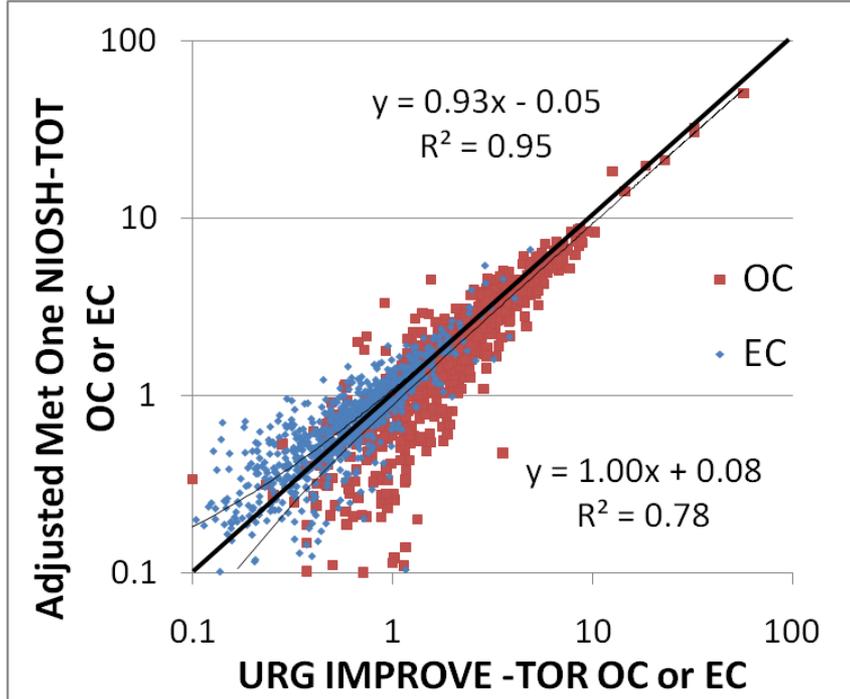
- Backups

Met One NIOSH-TOT OC or EC

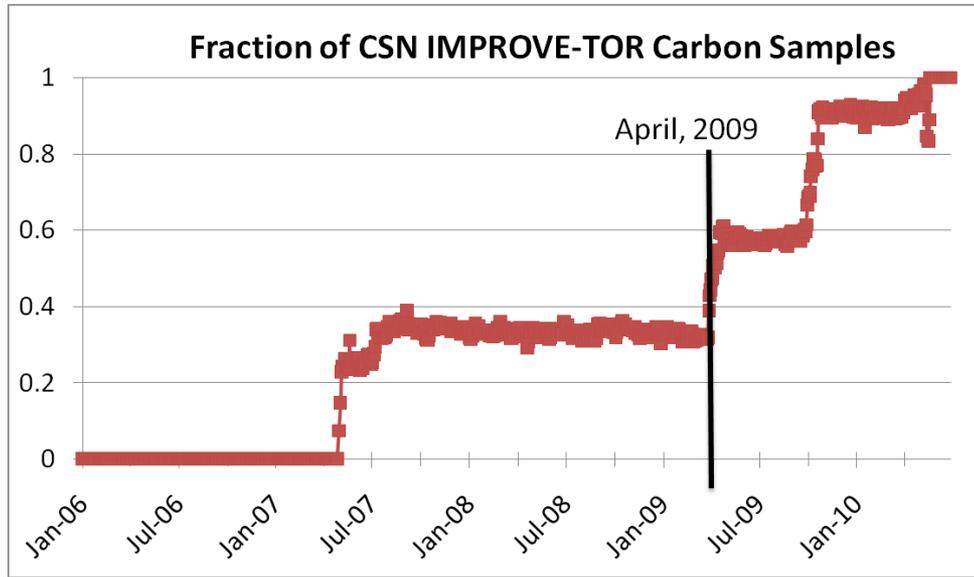


Met One NIOSH-TOT OC or EC

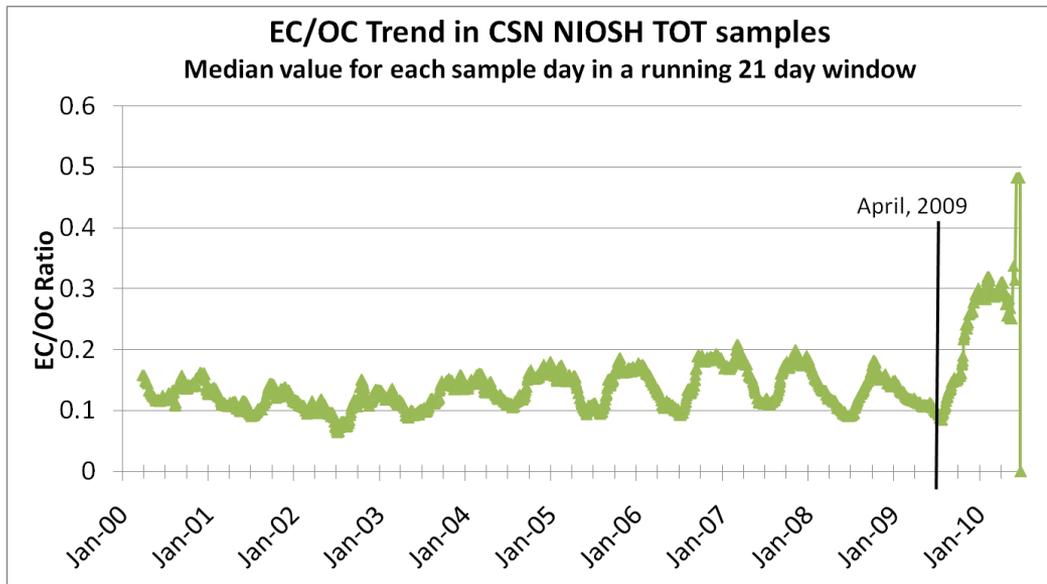




Matching MetOne NIOSH TOT and URG IMPROVE TOR Carbon

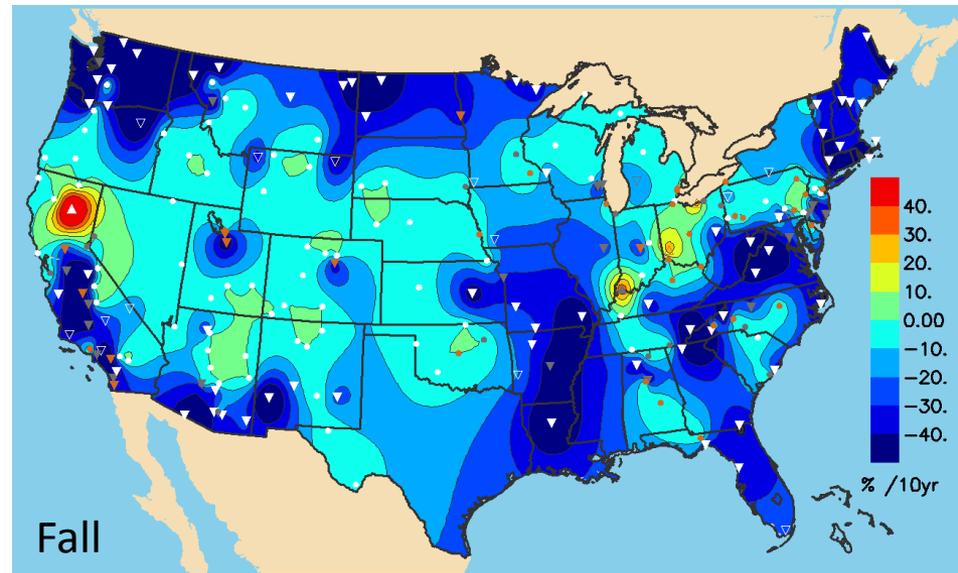
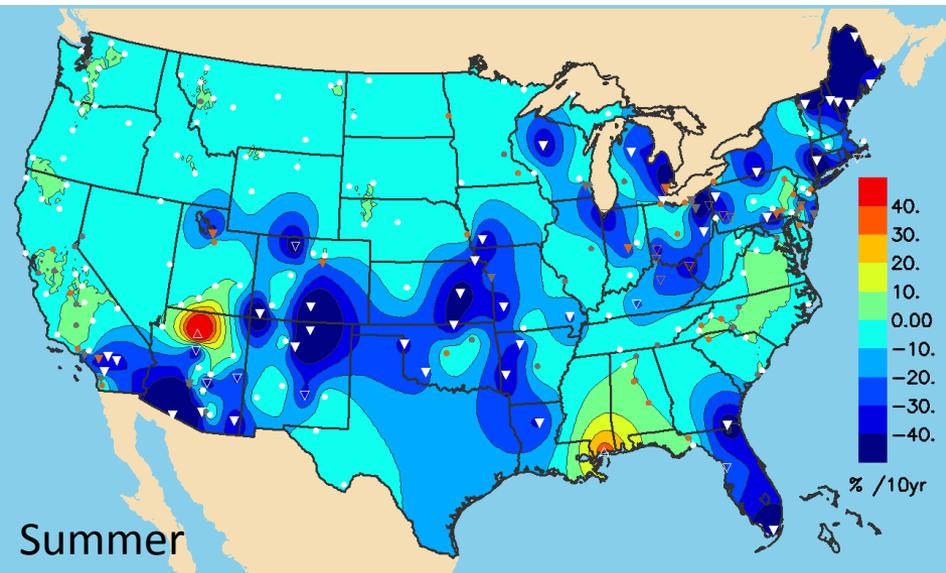
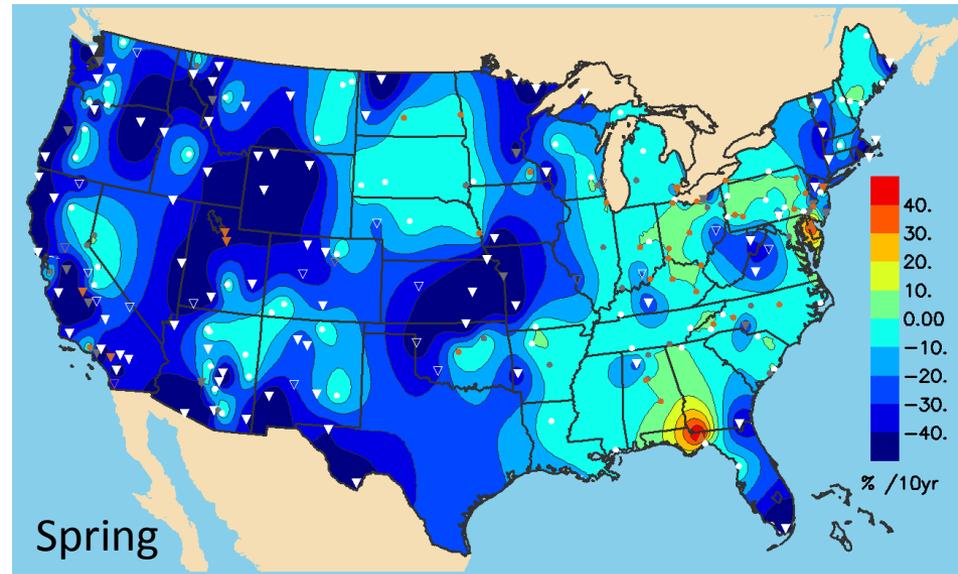
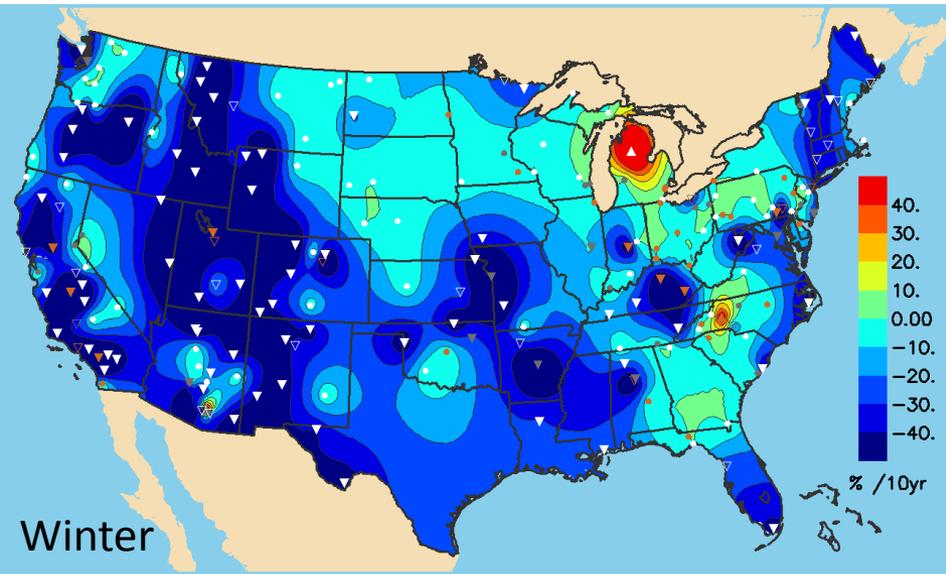


- In 2007 CSN began to phase in IMPROVE like URG samplers and IMPROVE TOR analysis for carbon

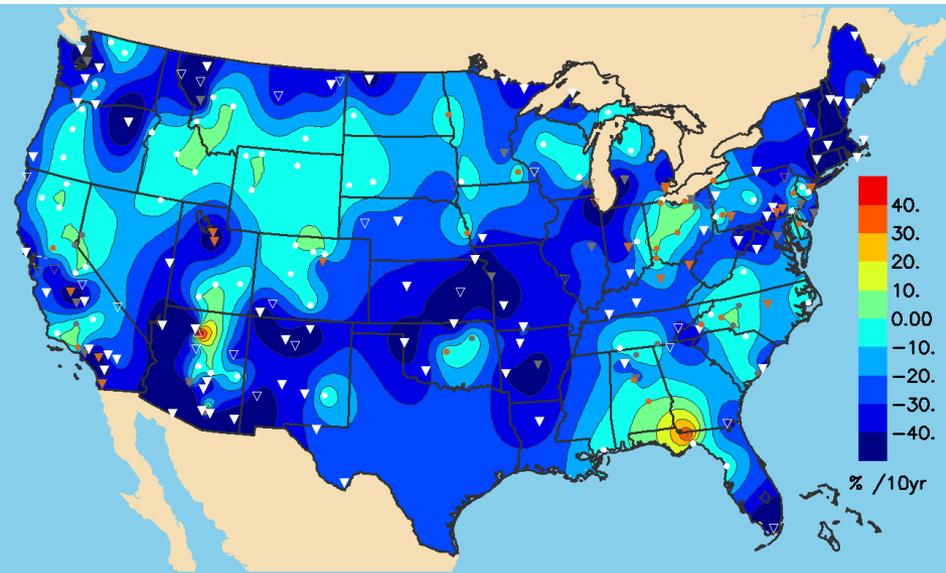


- The EC/OC ratio is relatively stable until after April, 2009. This coincides with an increase in the URG samplers

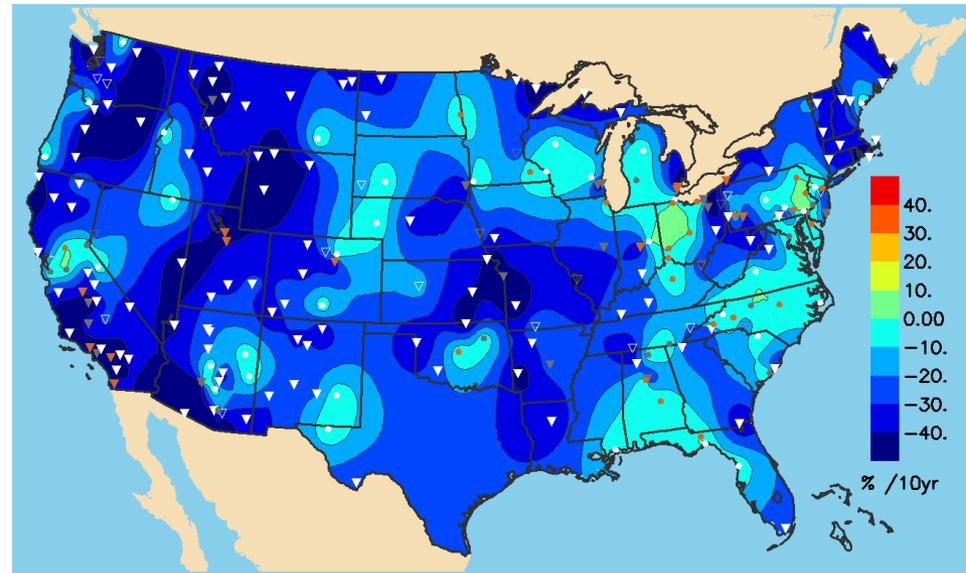
Trends in Seasonal TC, 2000-09 (means)



Trends in Annual TC, 2000-09 (means)



Annual TC Trends 2000-09 (means)



Annual TC Trends 2000-09 (median)

IMPROVE Seasonal 90th %-ile TC Source Attribution (Avg of Ratios)

Winter

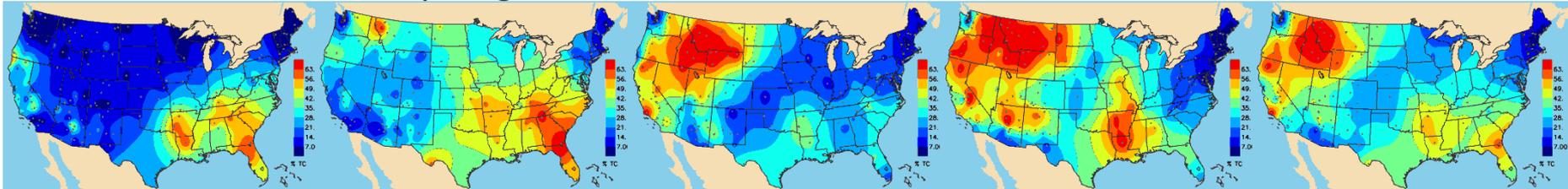
Spring

Summer

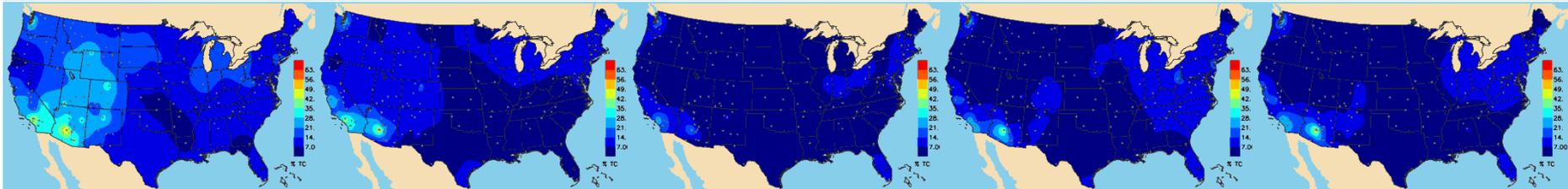
Fall

Annual

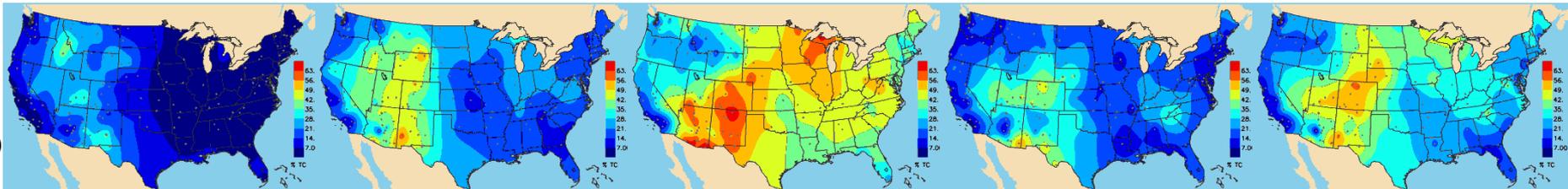
Fire



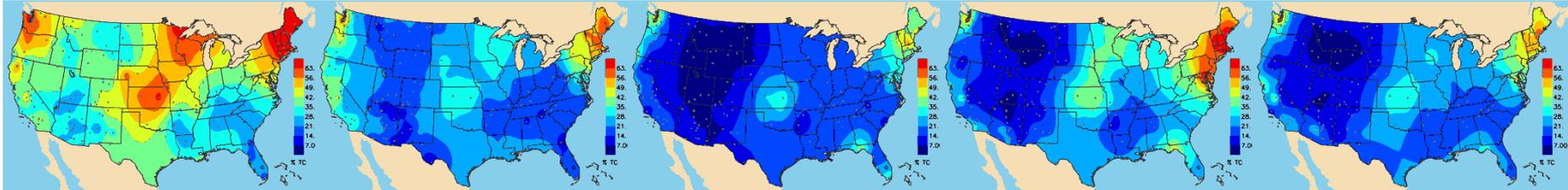
Mobile



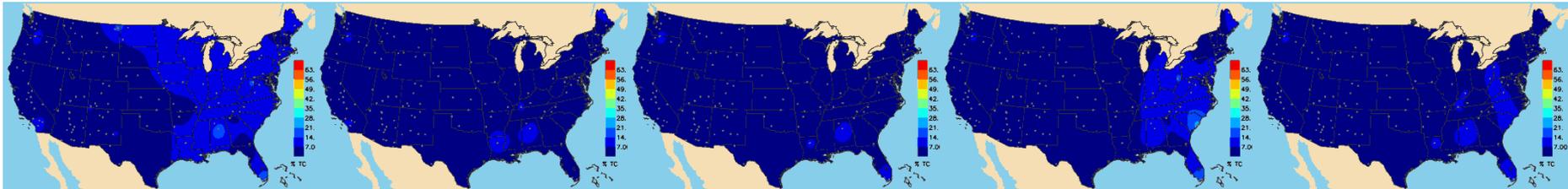
Vegetation



Area



Point



IMPROVE Average Seasonal TC Source Attribution (Avg of Ratios)

Winter

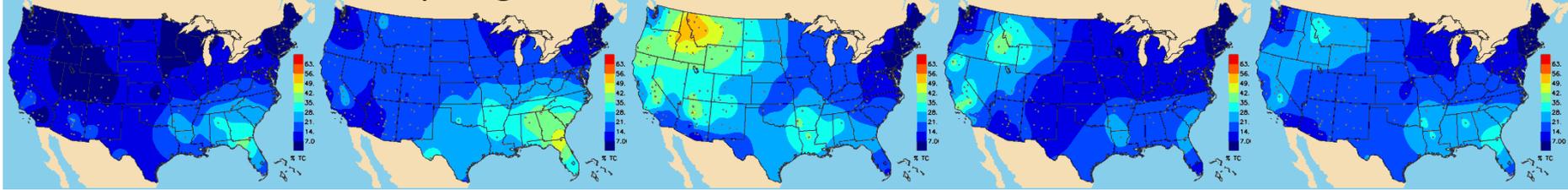
Spring

Summer

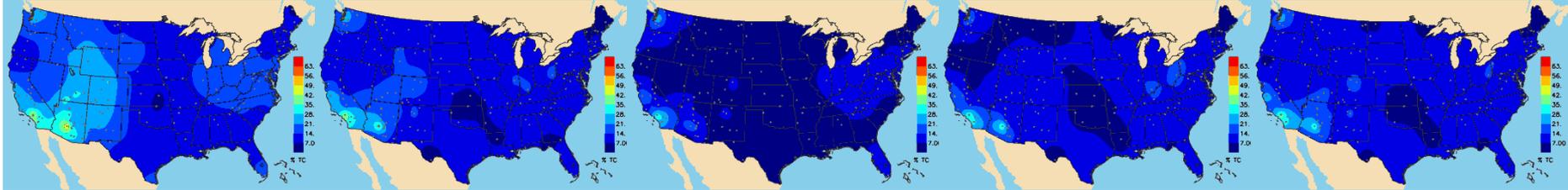
Fall

Annual

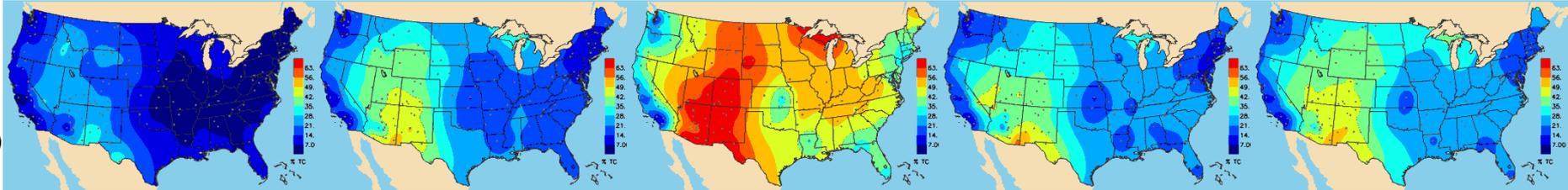
Fire



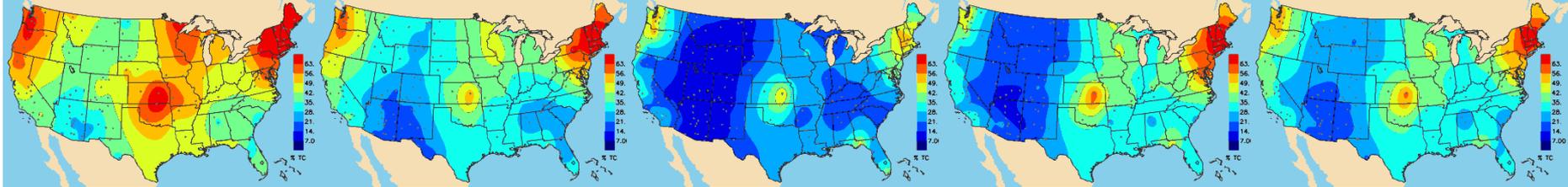
Mobile



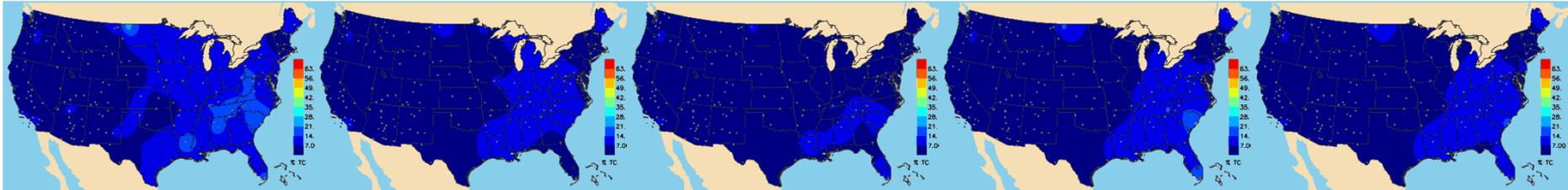
Vegetation



Area



Point



IMPROVE Average Seasonal TC Source Attribution ($\mu\text{g}/\text{m}^3$)

Winter

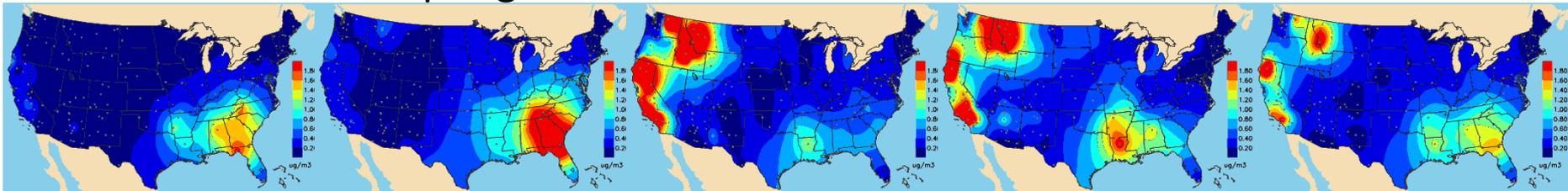
Spring

Summer

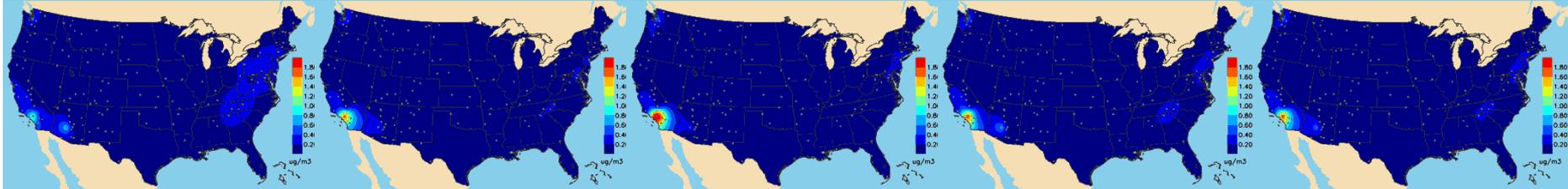
Fall

Annual

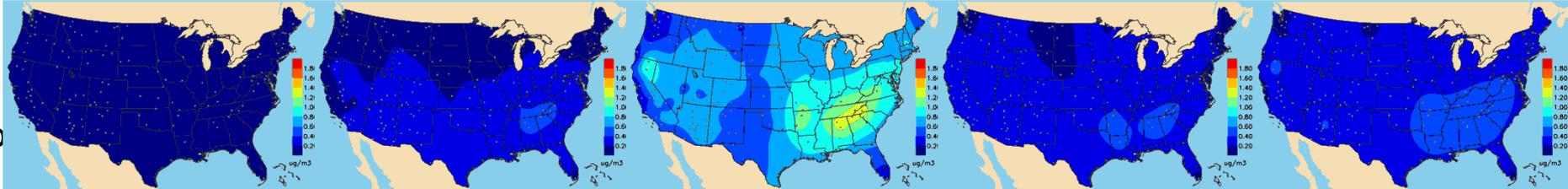
Fire



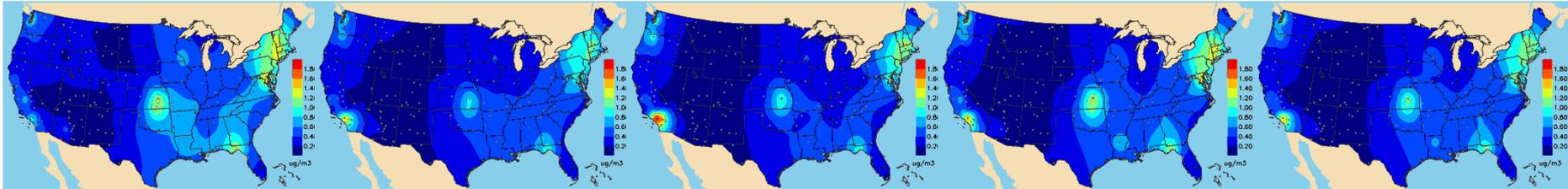
Mobile



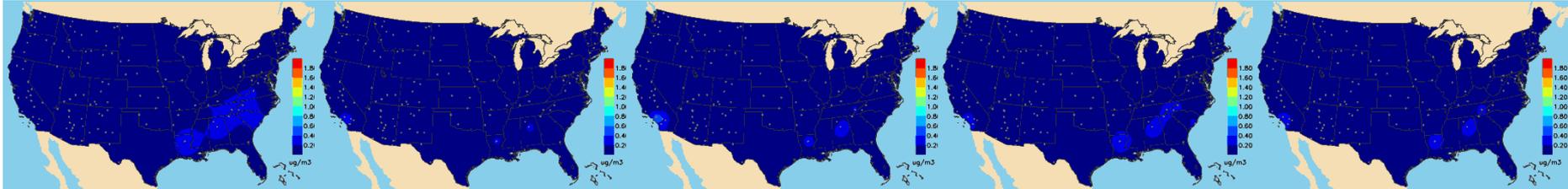
Vegetation



Area



Point



Variable					Speciation Sampler	
Network	IMPROVE	CSN Andersen RAAS	CSN	CSN	CSN	CSN R&P2025 sequential FRM
Sampler type	IMPROVE		Met One SASS	URG MASS	R&P2300	
Number of Sites (2006)	181	18	179	6	14	22
Number of Channels	4	4	5	2	4	2
Flow Rate	22.7l/min	7.3l/min	6.7l/min	16.7l/min	10.0l/min	16.7l/min
Filter Face Velocity	107.2cm/sec	10.3cm/sec	9.5cm/sec	23.7cm/sec	14.2cm/sec	23.6cm/sec
Sampling Frequency	3rdday	3rdday	3rdday	3rdday	3rdday/6thday	3rdday/6thday
Quartz Filter Pack Configuration	Q For QBQ	QF 47mmWhatma n	QF 47mmWhatma n	QF 47mmWhatma n	QF 47mmWhatma n	QF 47mmWhatma n
Quartz Filter Type	25mmPall					