

Seasonal and Spatial Variability in IMPROVE and CSN Composition

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INTRODUCTION

Evaluating the seasonal and spatial variability in urban and rural aerosol composition is important for understanding:

- $PM_{2.5}$ budget-
seasonal and spatial
variability
- Aerosol sources &
local/regional impacts
(urban vs rural)
- Changes in seasonality
in the context of long-
term trends

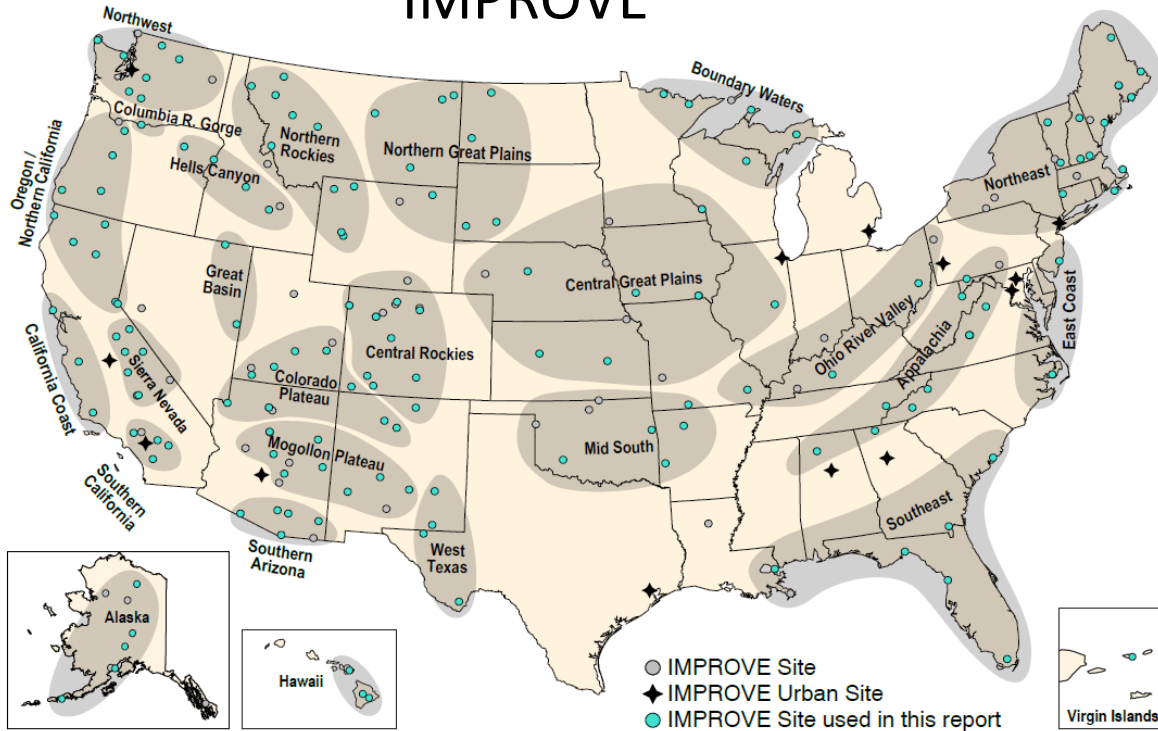


METHODS: Analysis

- 2019-2022: Monthly and annual means and mass fractions
- Completeness criteria: 50% for month, 75% for annual (2 out of 3 seasons valid)
- 128 CSN (urban) sites and 157 IMPROVE (rural) sites
- Compare to previous analyses in the series (Malm et al., 2004; Hand et al., 2012)

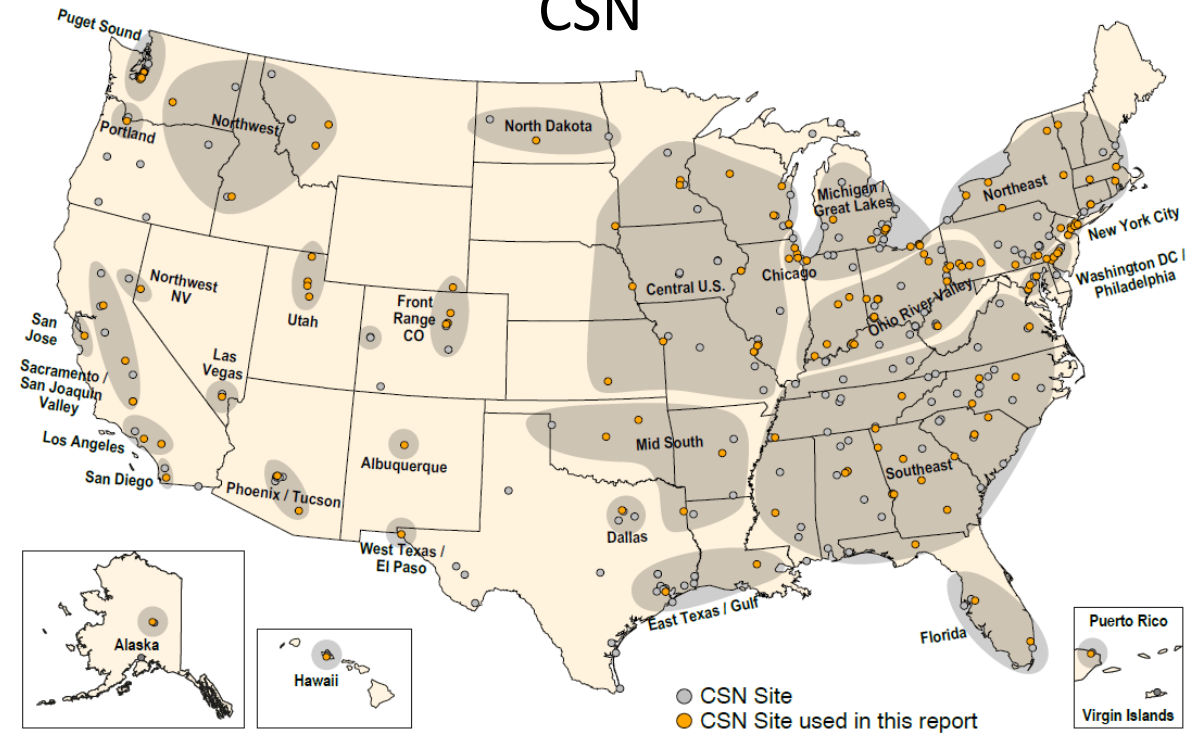
IMPROVE and CSN Regions

IMPROVE



26 regions

CSN



29 regions

Monthly mean data were semi-quantitatively aggregated into regions

METHODS: Species Assumptions

- Ammonium sulfate (**AS** = $1.375 \times \text{SO}_4^{2-}$)
- Ammonium nitrate (**AN** = $1.29 \times \text{NO}_3^-$)
- Particulate Organic Mass (**POM** = $\text{OC} \times (\text{OM}/\text{OC})$)
 - Monthly (IMPROVE) & Seasonal (CSN) OM/OC
- Elemental Carbon (**EC**)
- **Dust** (assuming common oxides of Al, Si, Ca, Fe, and Ti)
 - IMPROVE dust increased by 15%
- Sea Salt (**SS** = $1.8 \times \text{Cl}^-$)
- $\text{PM}_{2.5}$ Gravimetric Fine Mass (**FM**)
- Reconstructed Fine Mass (**RCFM** = sum of $\text{PM}_{2.5}$ speciated mass)

Methods: Network Updates

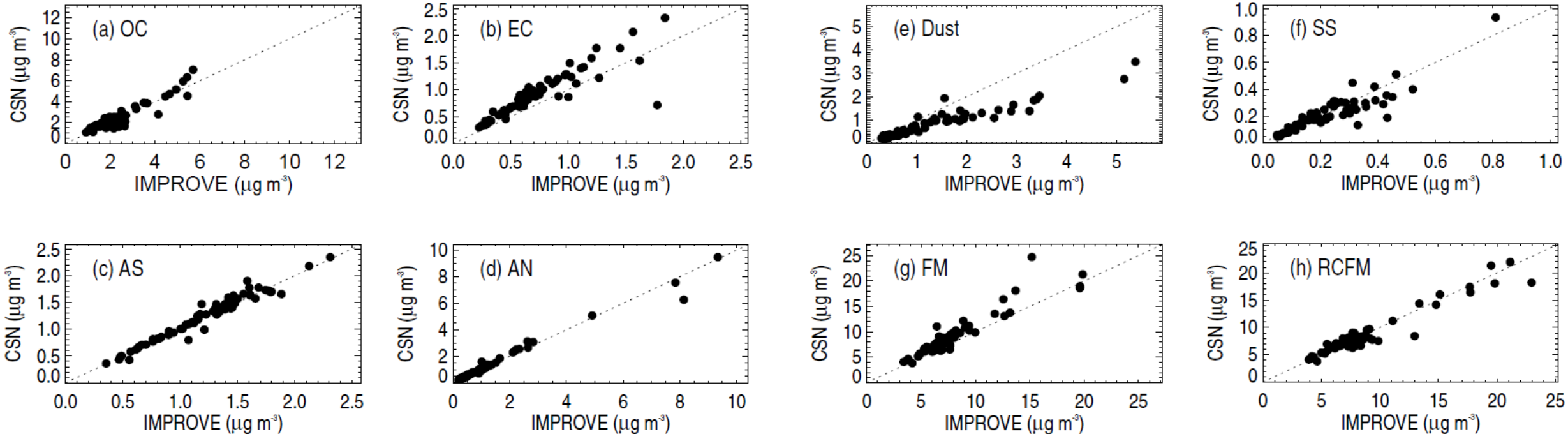
CSN

- 2014- PM_{2.5} gravimetric weighing discontinued
 - Collocated EPA FRM PM_{2.5} data incorporated
- 11/2015- Blank corrections applied to carbon and ions
- 10/2018- Carbon analysis changed from DRI TOR to Sunset TOR
- 11/2015 - Ion analysis changed from RTI to DRI
- 10/2018- Ion analysis changed from DRI to RTI

<https://www.epa.gov/amtic/chemical-speciation-2016-naamc>

<https://aqrc.ucdavis.edu/csn-documentation>

Comparisons of Collocated Data (2019-2022)

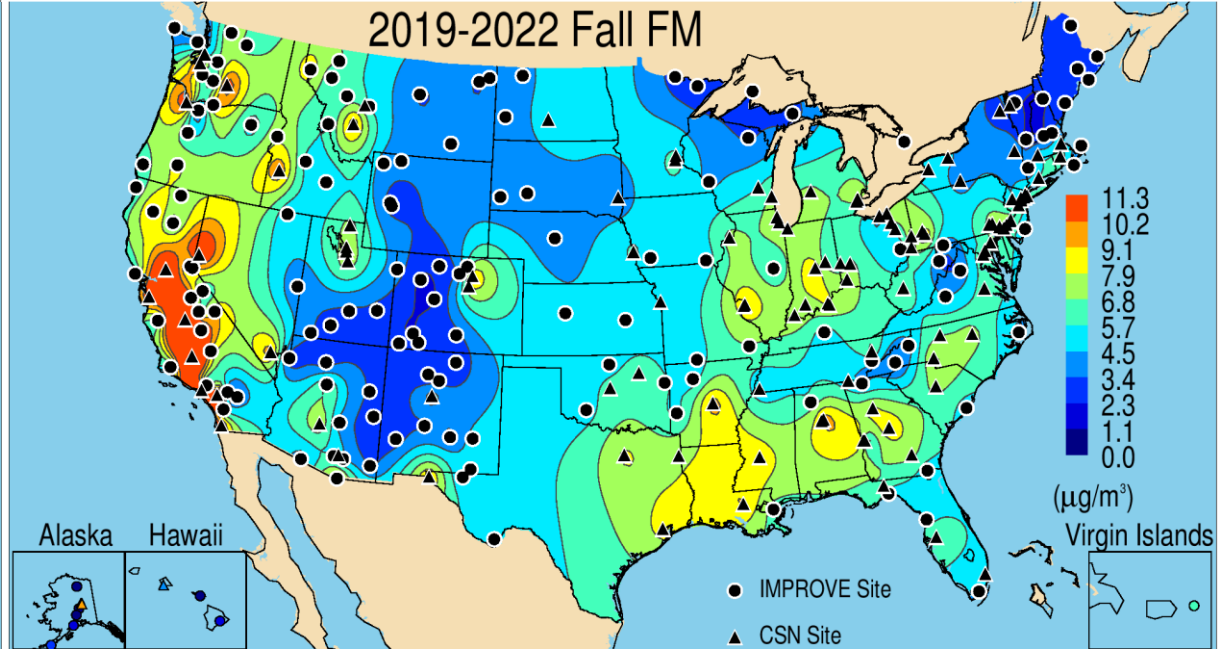
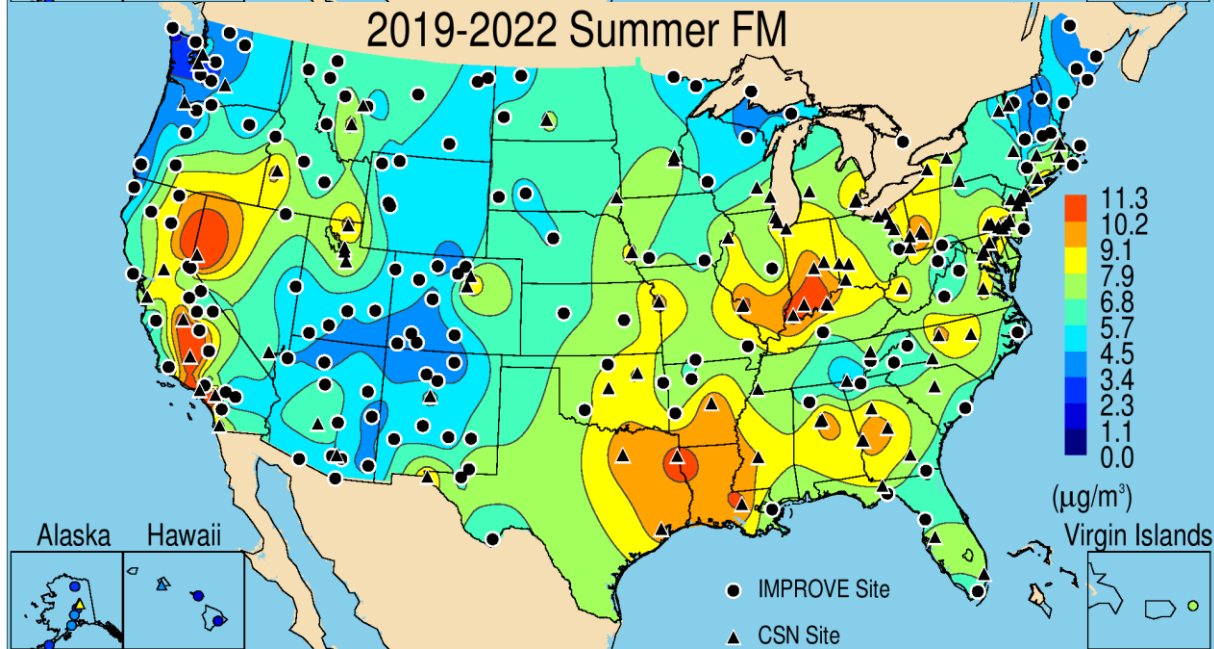
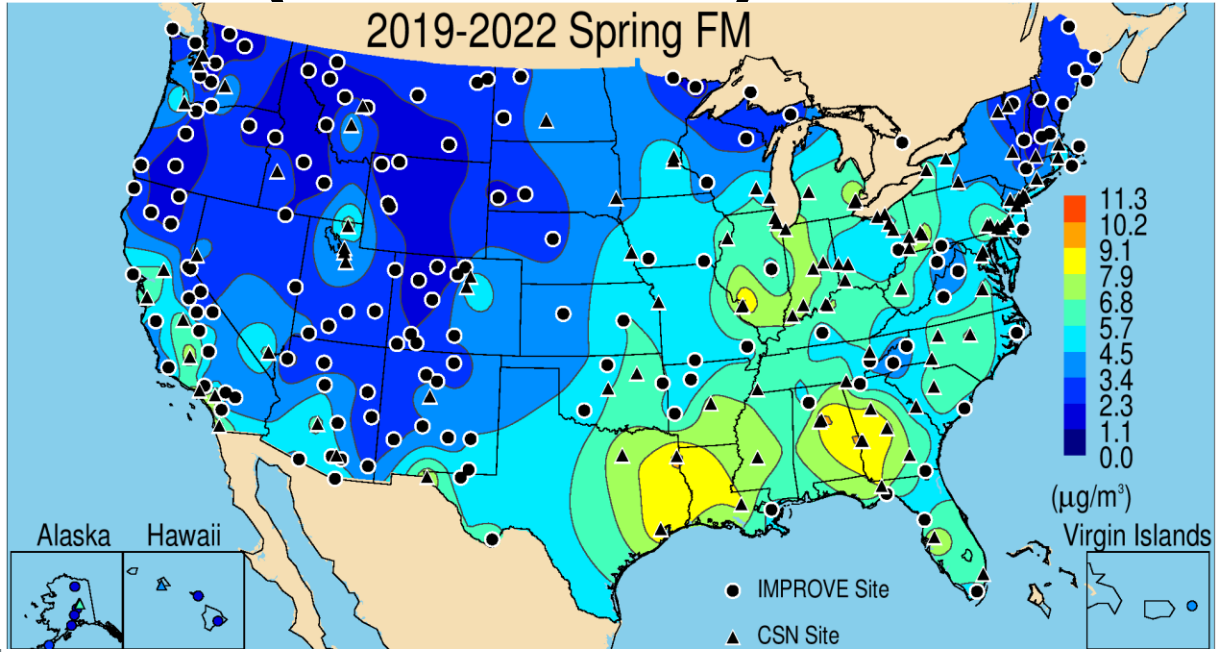
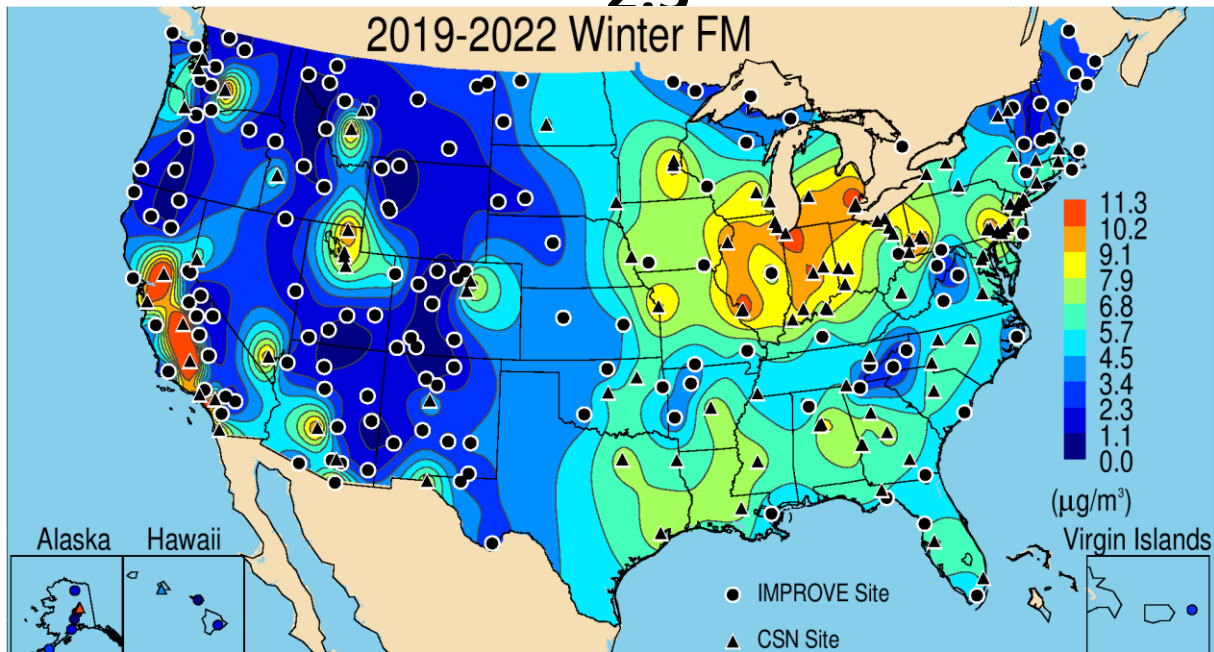


Statistic	OC	EC	AS	AN	FD	SS	FM	RCFM
Annual average IMPROVE (µg m ⁻³)	2.3	0.7	1.2	1.2	1.3	0.2	7.8	8.6
Annual Average CSN (µg m ⁻³)	2.4	0.9	1.2	1.3	0.8	0.2	9.0	8.5
Bias ¹ (%)	9	28	2	8	-34	-2	16	-0.2
Error ² (%)	17	31	3	8	36	15	17	7
r	0.93	0.88	0.98	0.99	0.95	0.90	0.93	0.96
IMP/CSN	0.94	0.81	0.98	0.97	1.60	1.06	0.87	1.02

Most errors and biases are less than 20% except for EC and fine dust

BIRM1, FRES1, PHOE1, PUSO1, ATLA1, PITT1

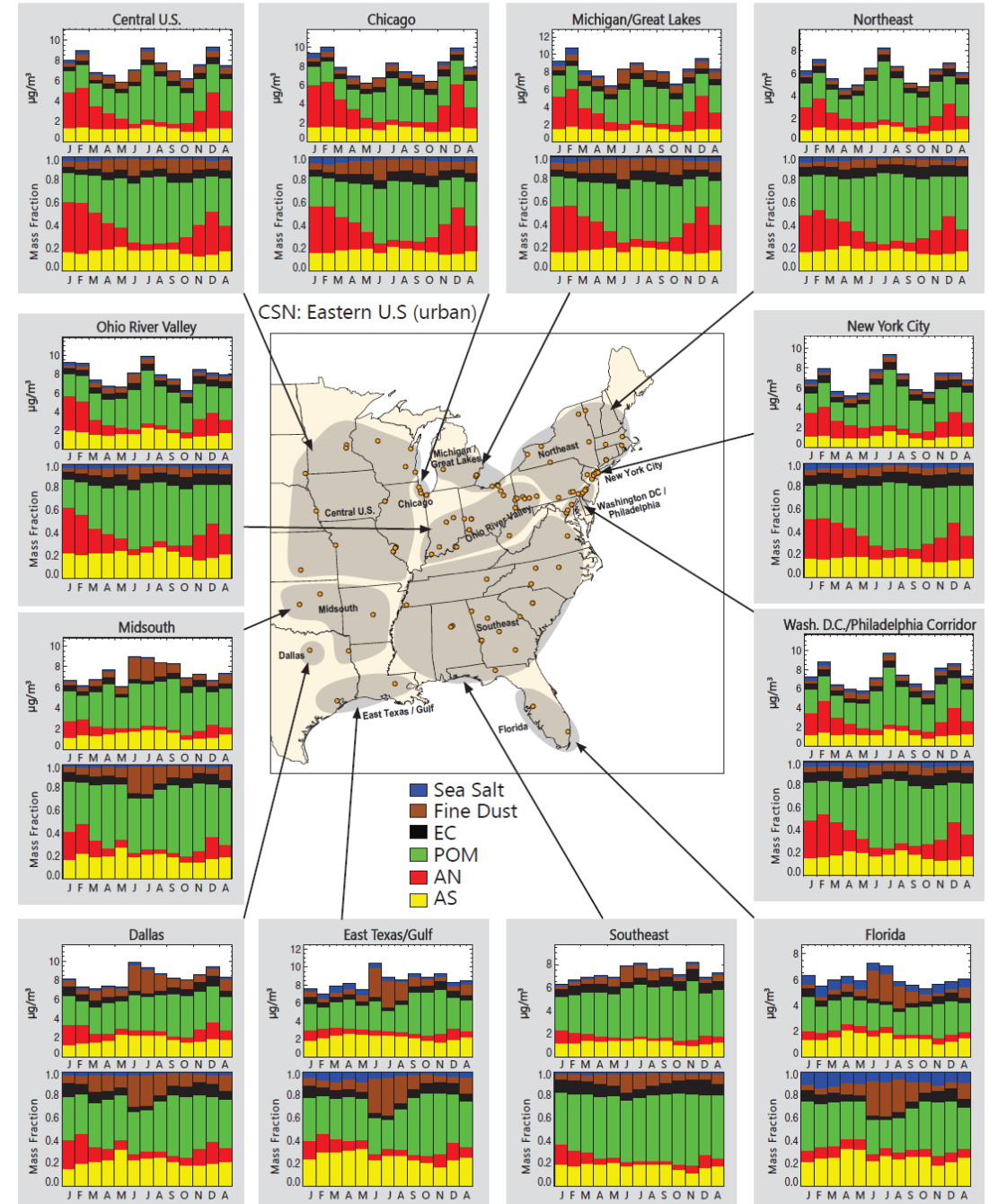
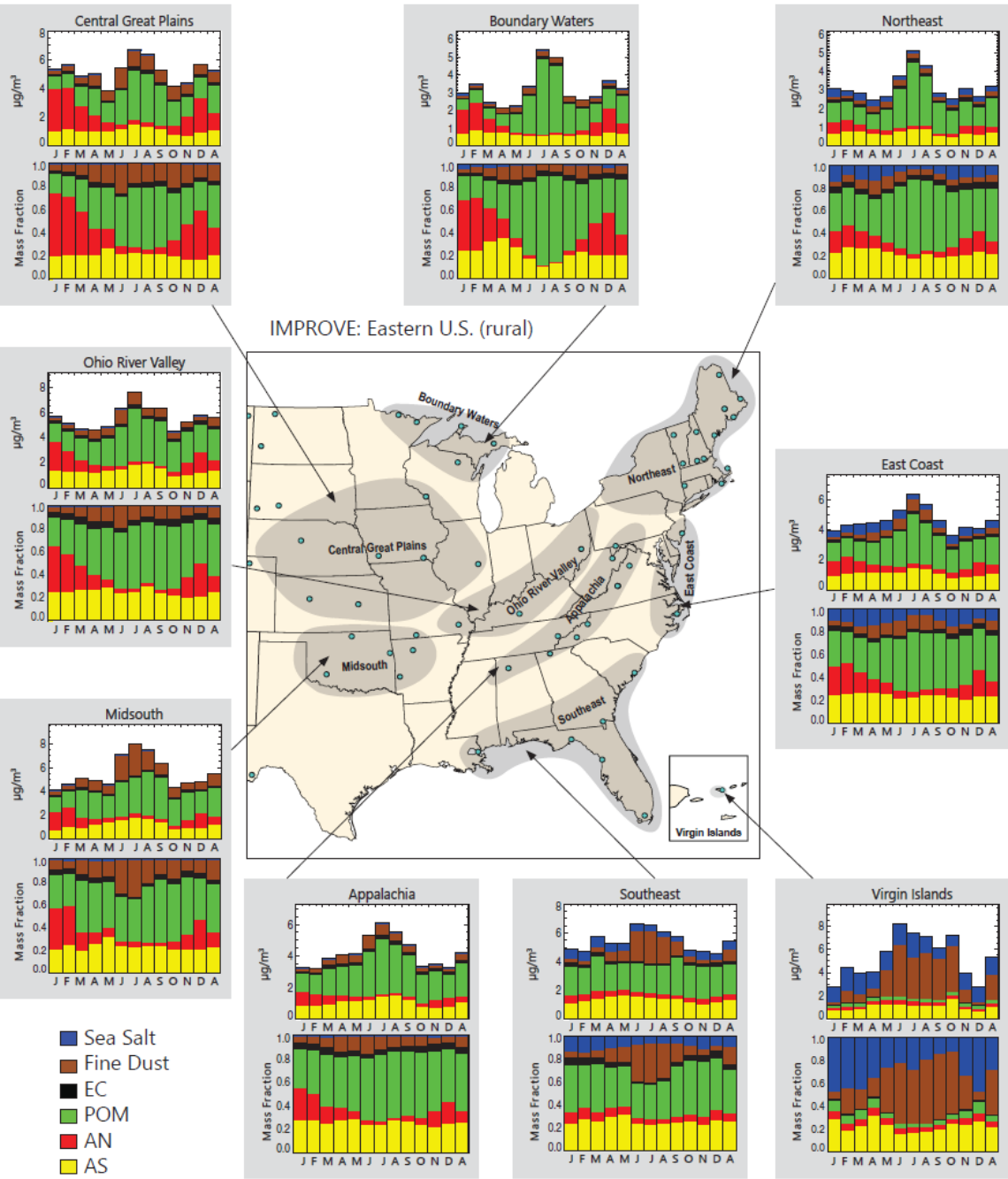
PM_{2.5} Gravimetric Mass (2019-2022)



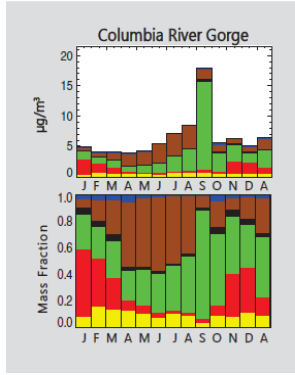
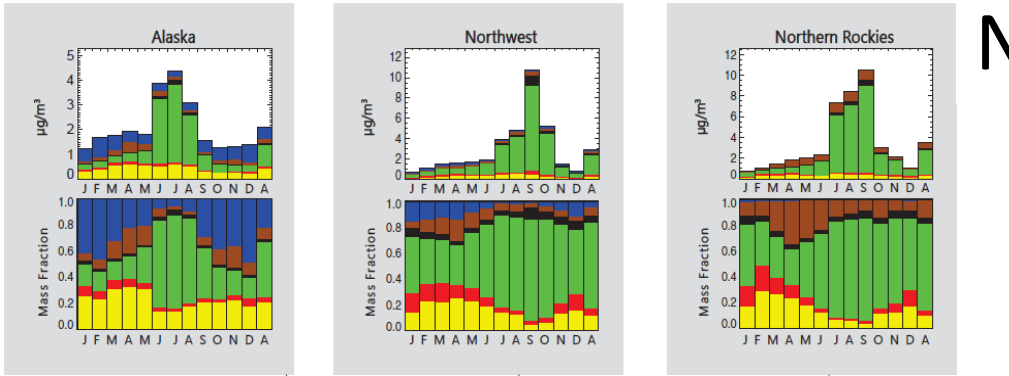
IMPROVE

East

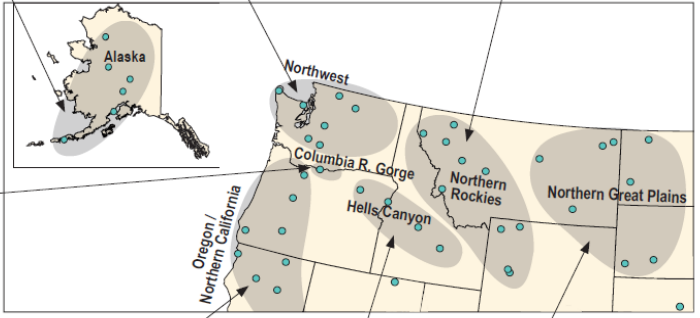
CSN



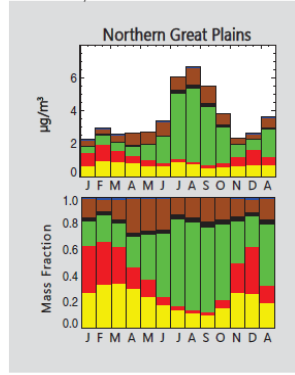
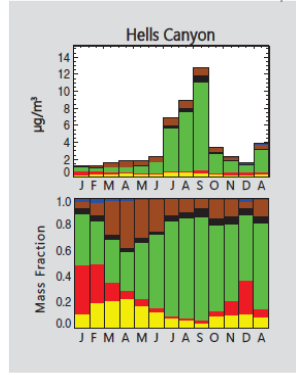
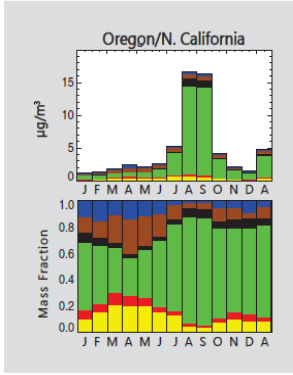
IMPROVE



IMPROVE: Northwestern U.S. (rural)

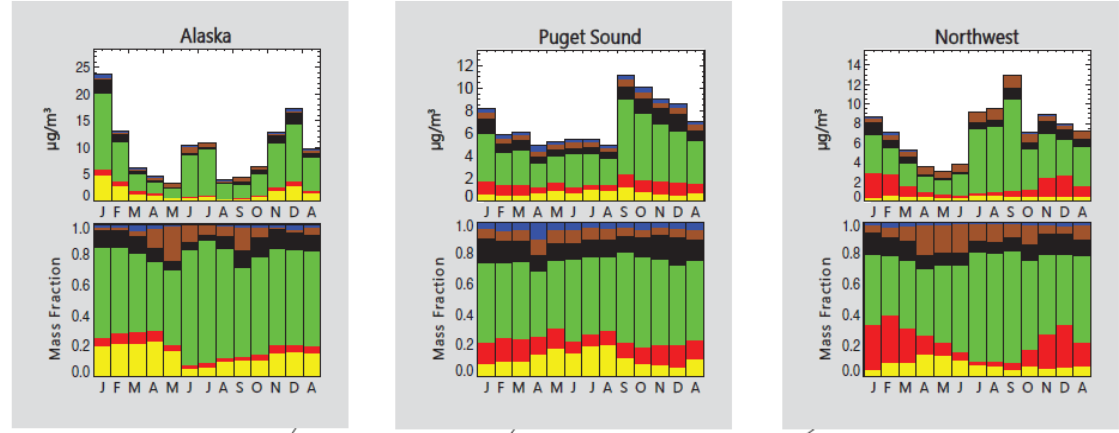


- Sea Salt
- Fine Dust
- EC
- POM
- AN
- AS

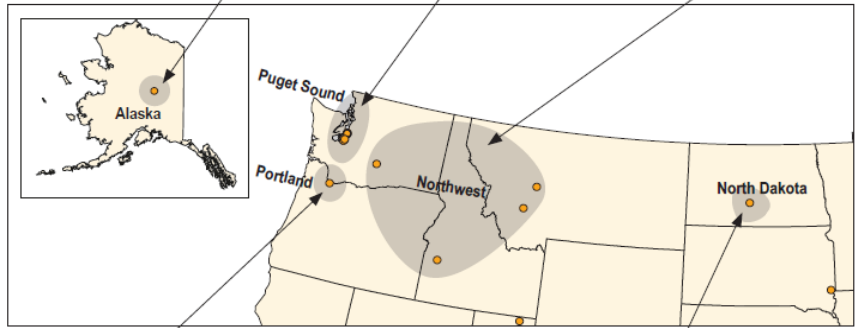


Northwest

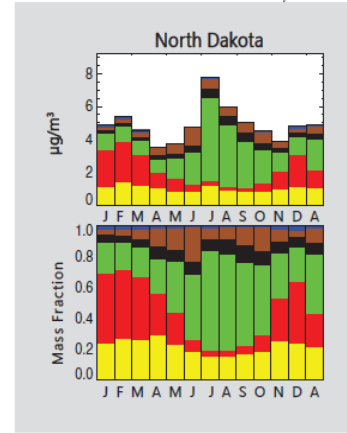
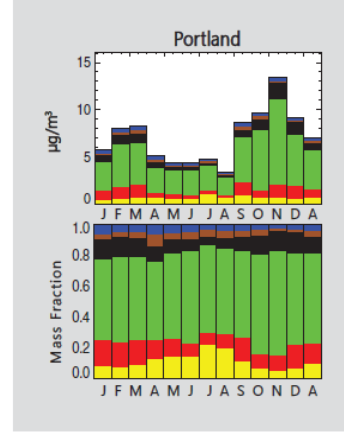
CSN



CSN: Northwestern U.S. (urban)



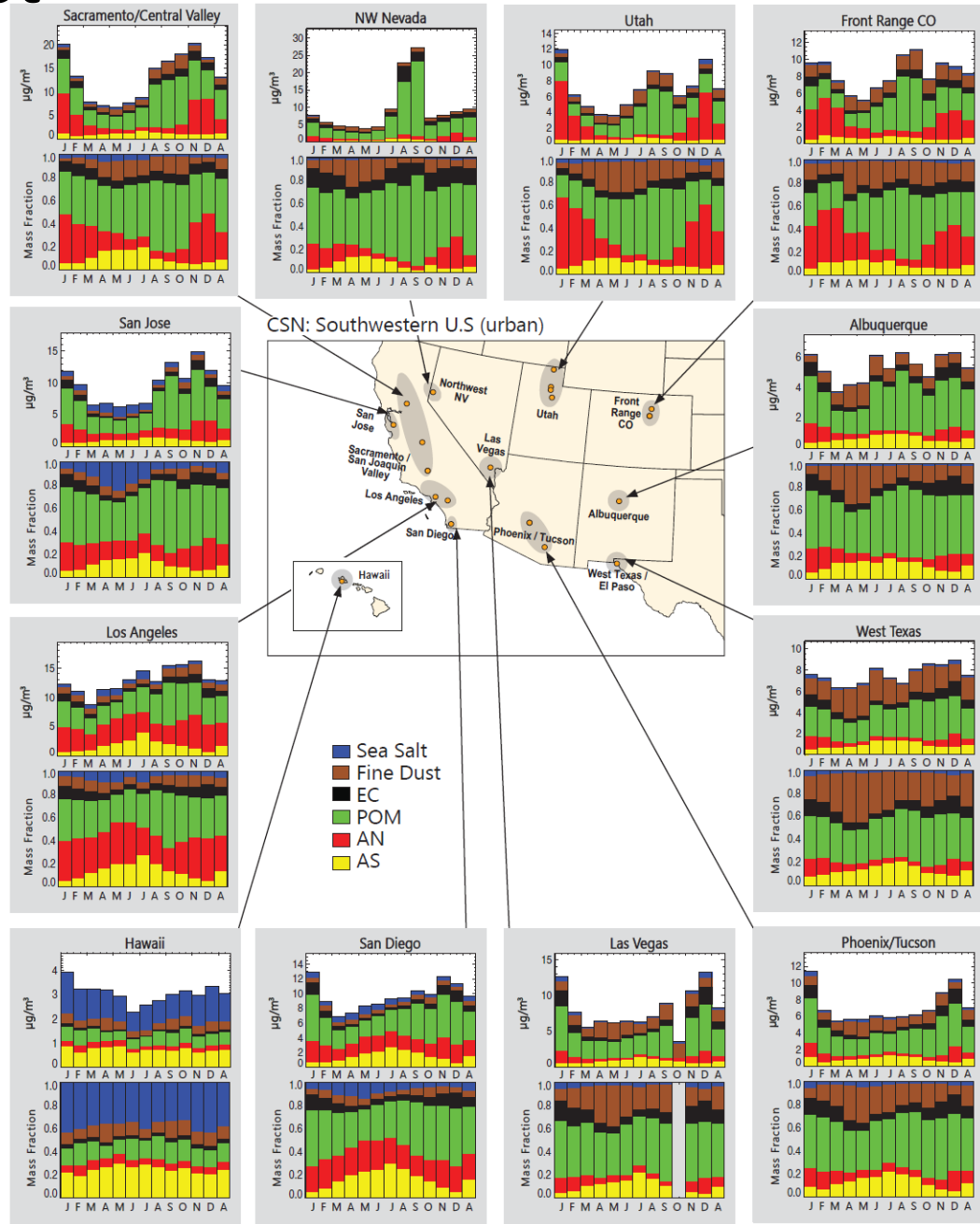
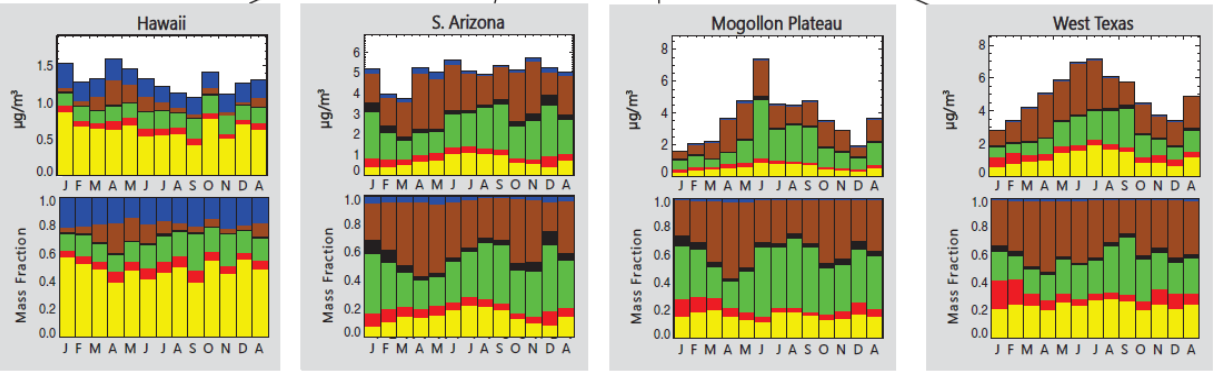
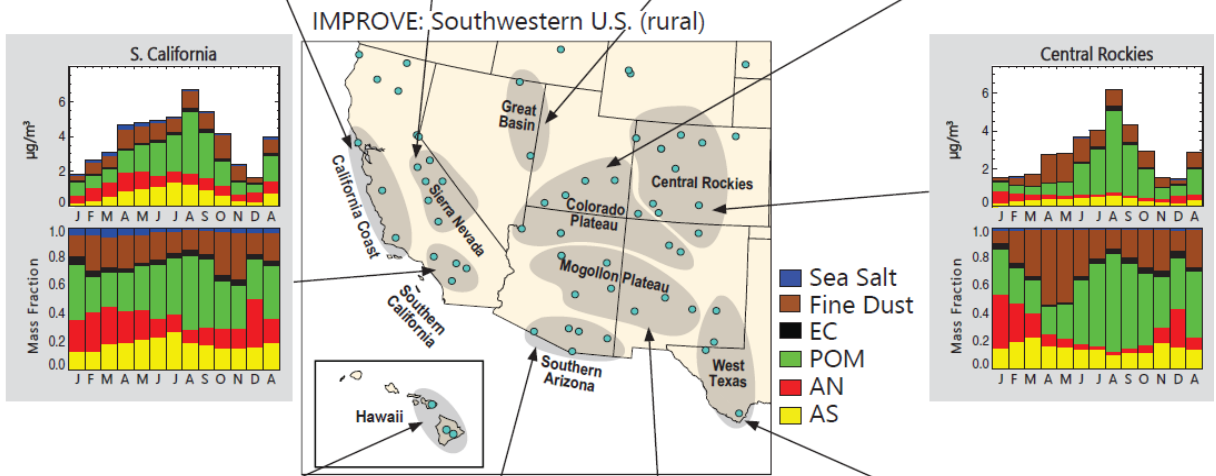
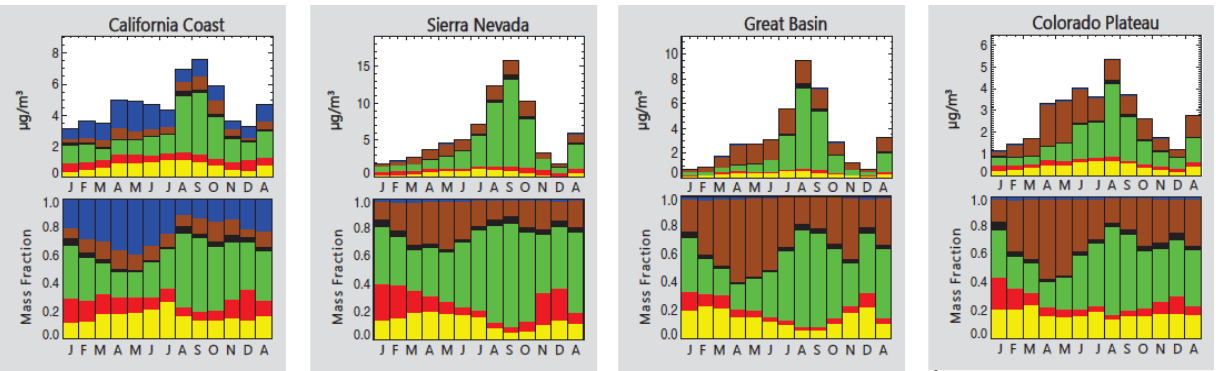
- Sea Salt
- Fine Dust
- EC
- POM
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- AS



IMPROVE

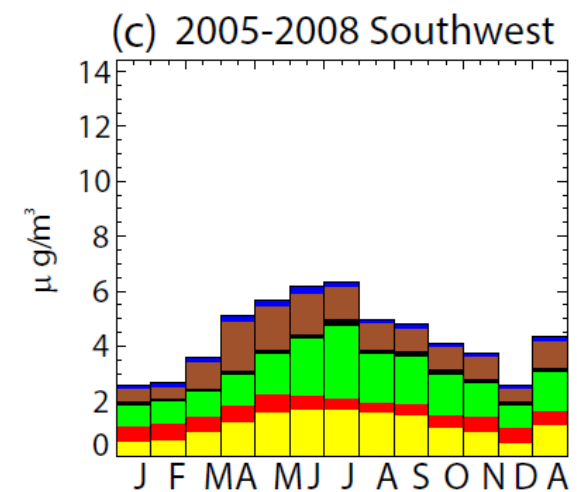
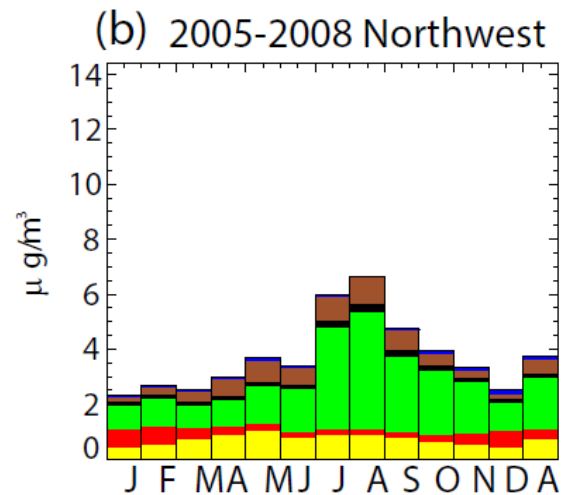
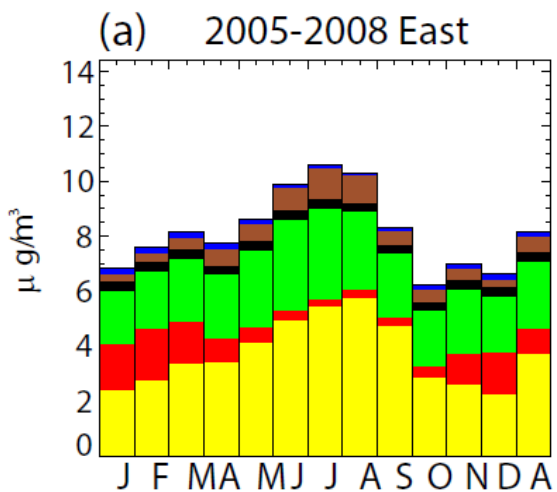
Southwest

CSN

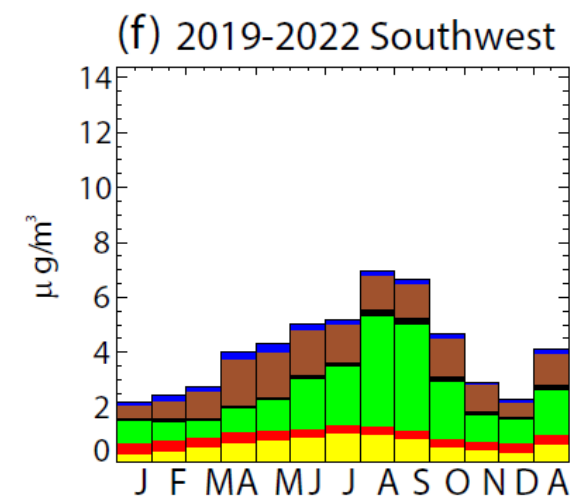
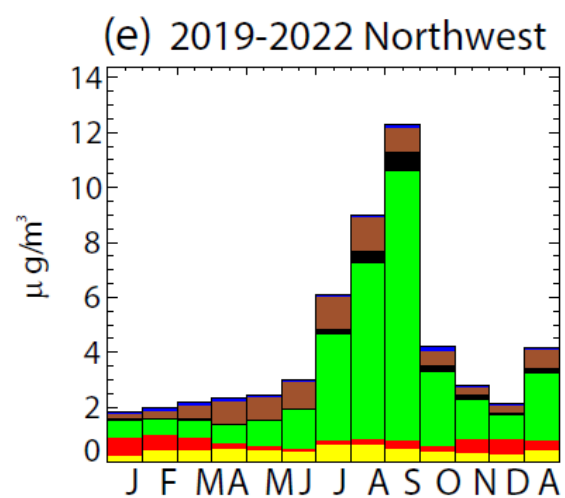
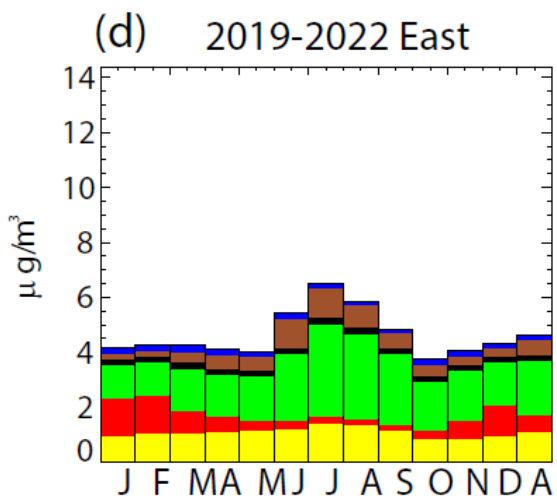


Past & Current Seasonality: IMPROVE mass

2005-
2008



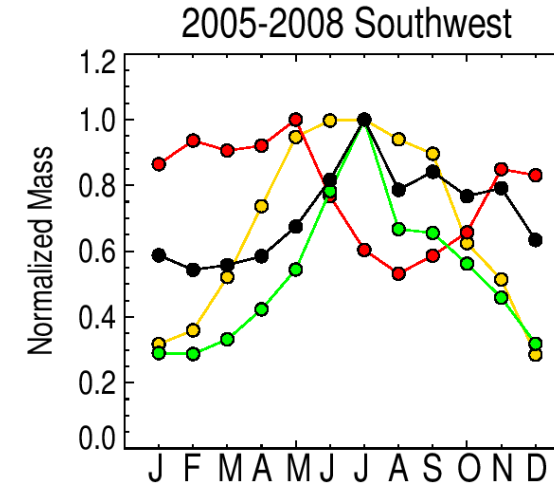
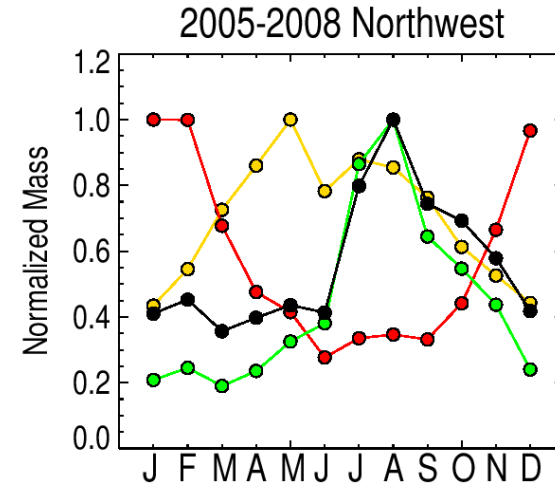
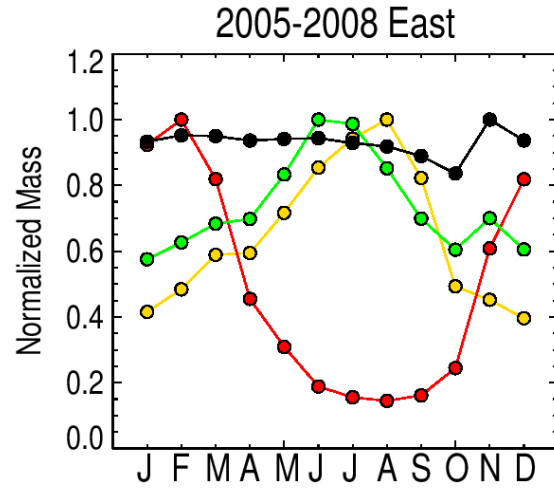
2019-
2022



Past & Current Seasonality: IMPROVE Normalized Mass

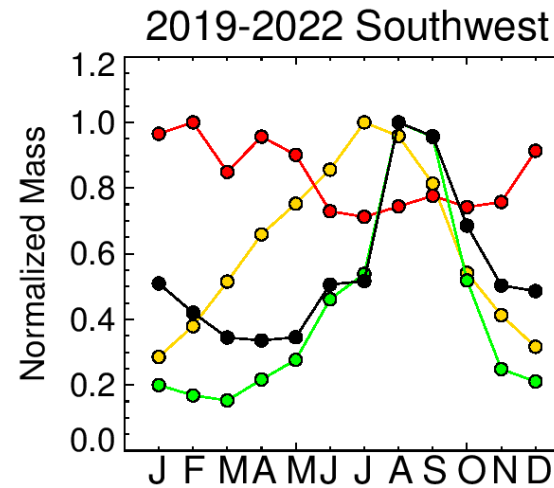
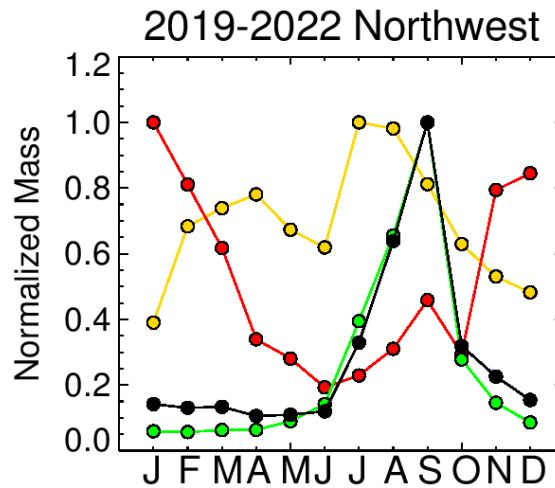
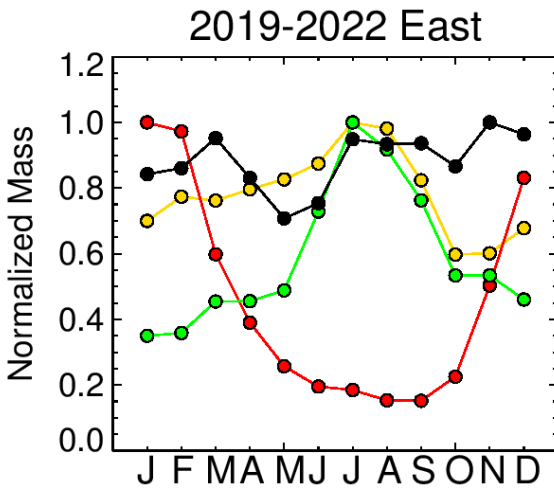
Normalized mass = monthly mean/maximum mean

2005-
2008



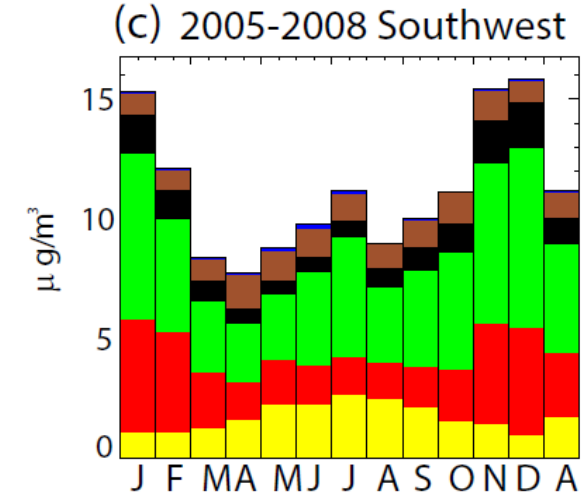
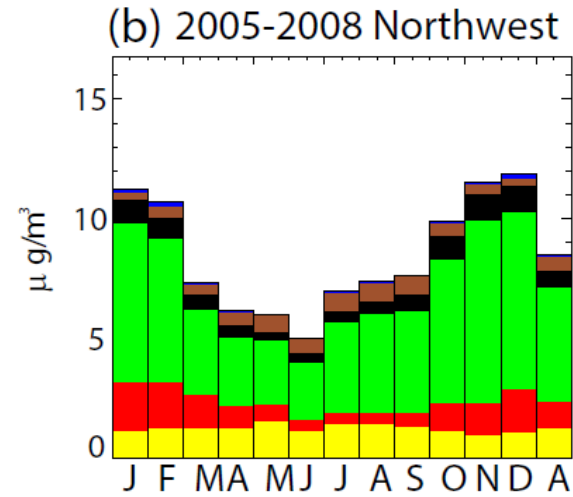
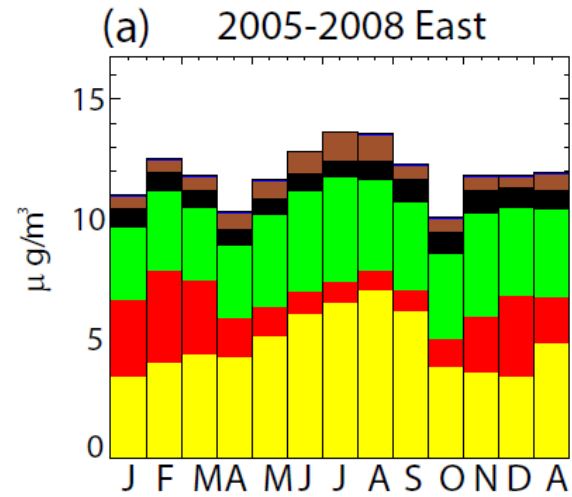
- EC
- POM
- AN
- AS

2019-
2022

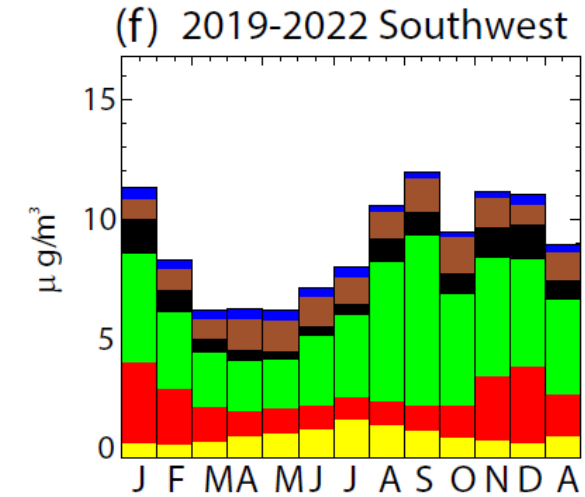
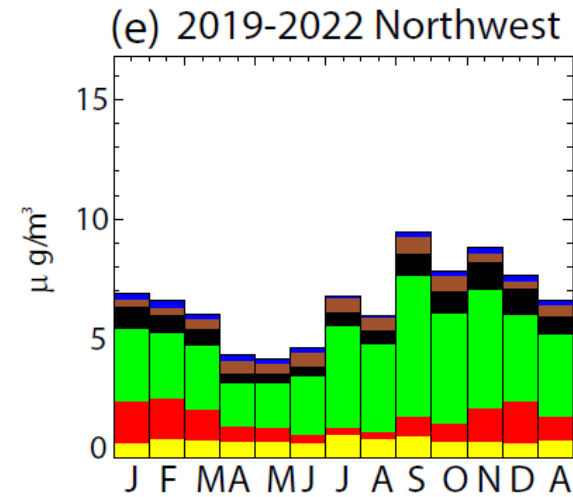
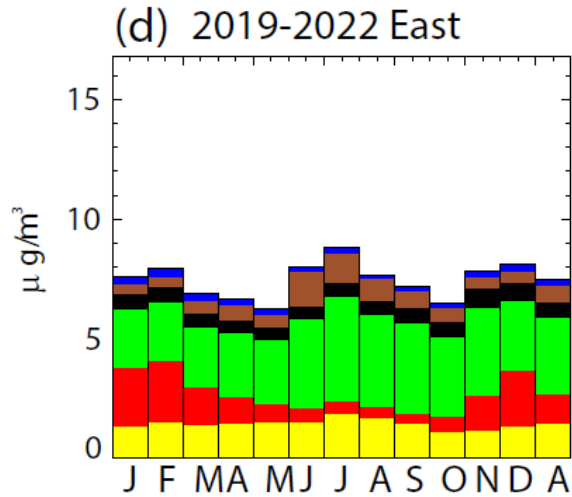


Past & Current Seasonality: CSN mass

2005-
2008



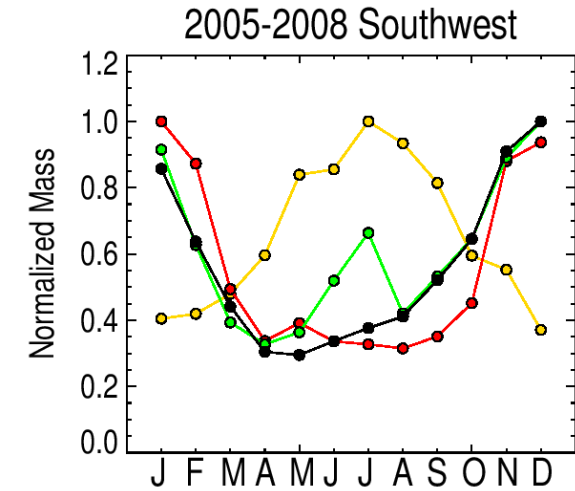
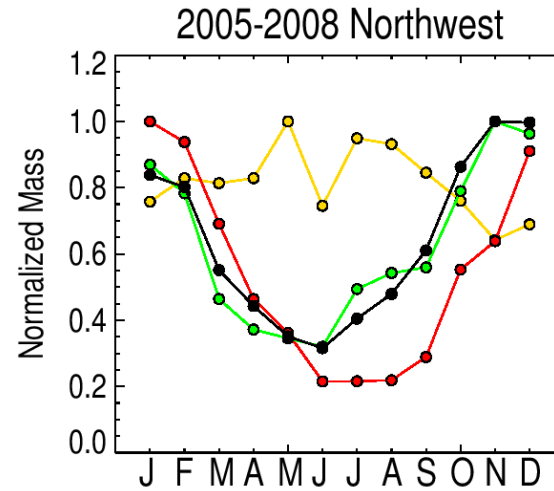
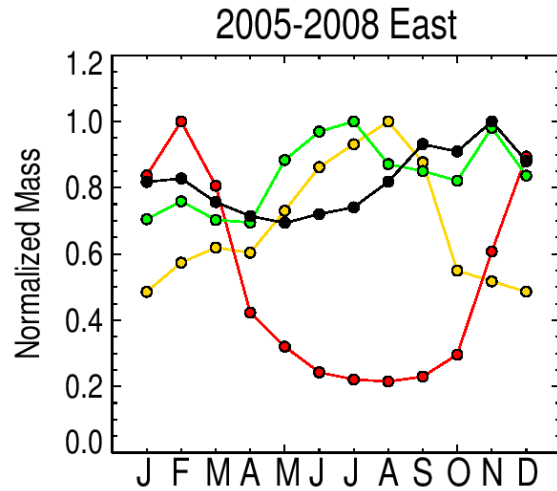
2019-
2022



Past & Current Seasonality: CSN Normalized Mass

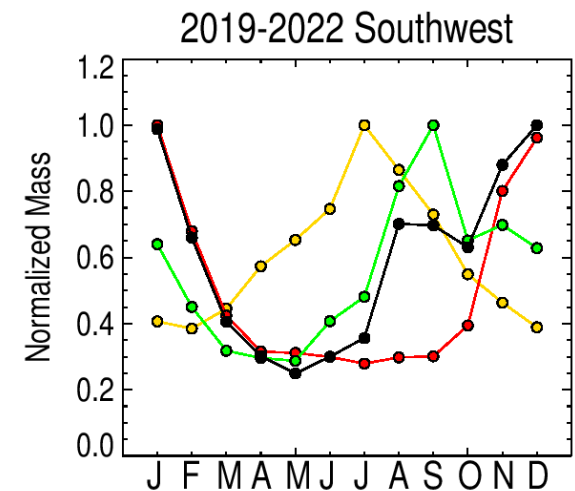
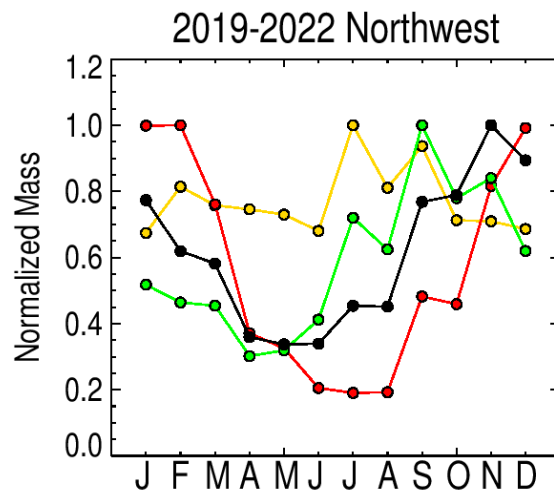
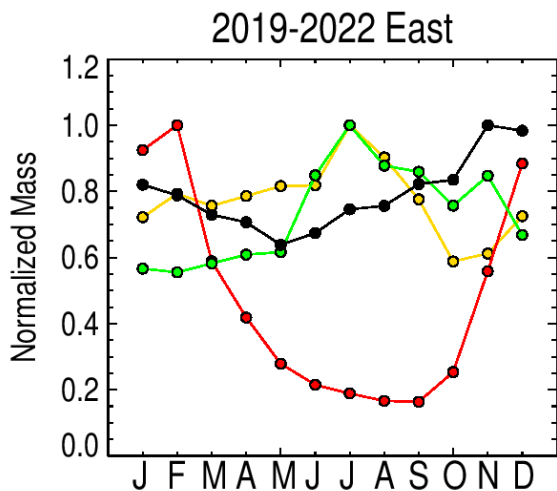
Normalized mass = monthly mean/maximum mean

2005-
2008



- EC
- POM
- AN
- AS

2019-
2022



Summary

AS: ~20% contributions, seasonally flat, Urban ~ Rural.

AN: Annual contributions are 10%-20% and highly seasonal. Urban > Rural.

POM: Annual contributions around 40%, highly seasonal, Urban > Rural.

EC: Annual contributions: 5% (rural), 10% (urban), seasonality followed POM, except in winter, Urban > Rural.

FD: Influenced by both long-range and regional transport in both rural and urban areas.

Acknowledgements



Funding:
National Park Service
Air Resources Division

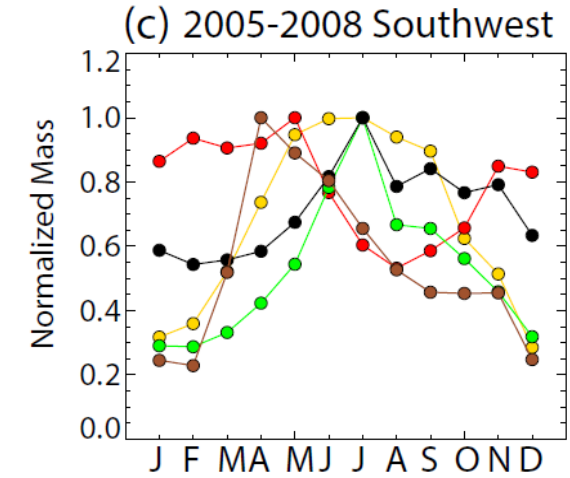
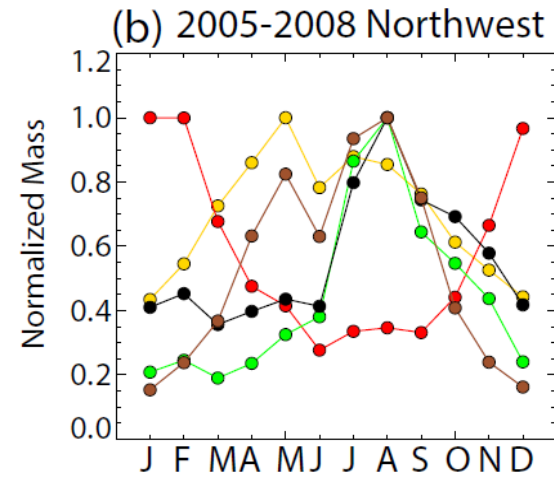
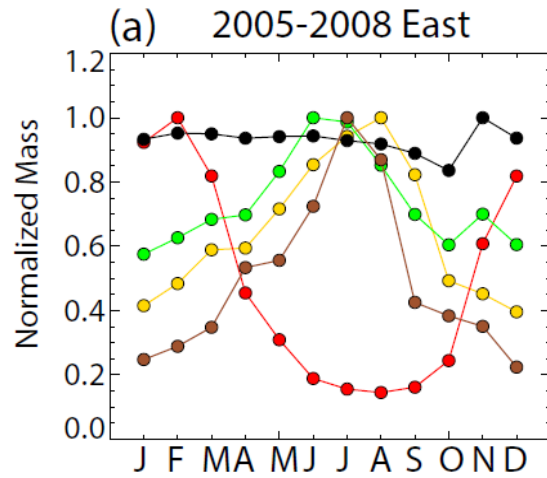
Data Sources:
IMPROVE
EPA

Contact: jlhand@colostate.edu

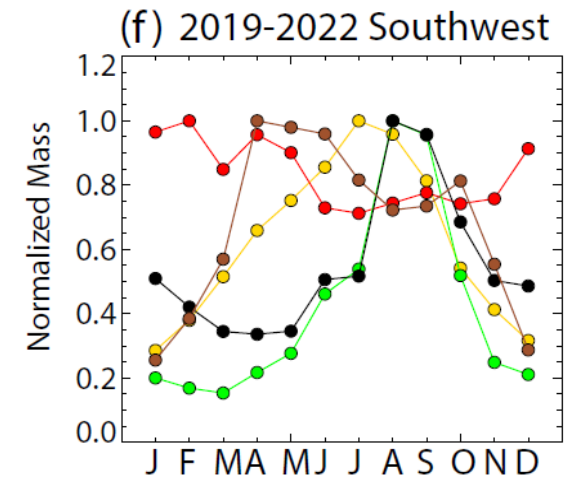
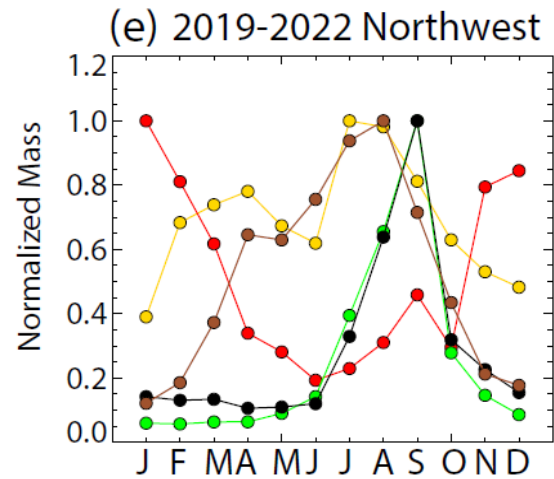
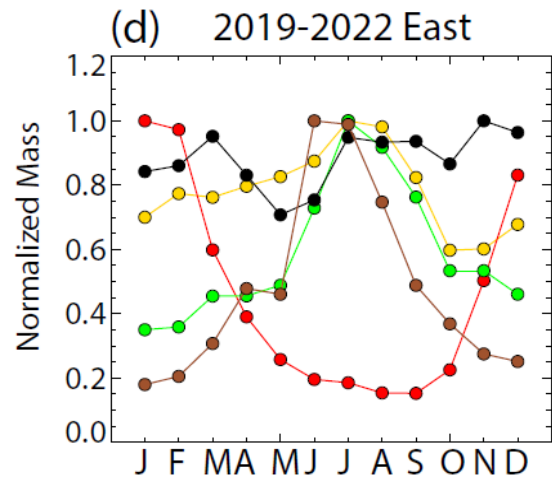
EXTRA

Past & Current Seasonality: IMPROVE Normalized Mass

2005-
2008

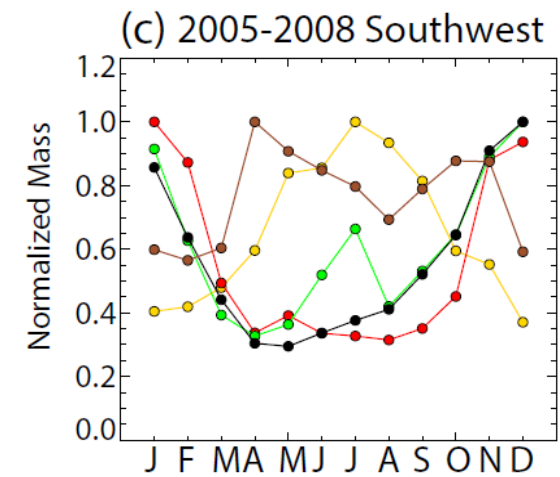
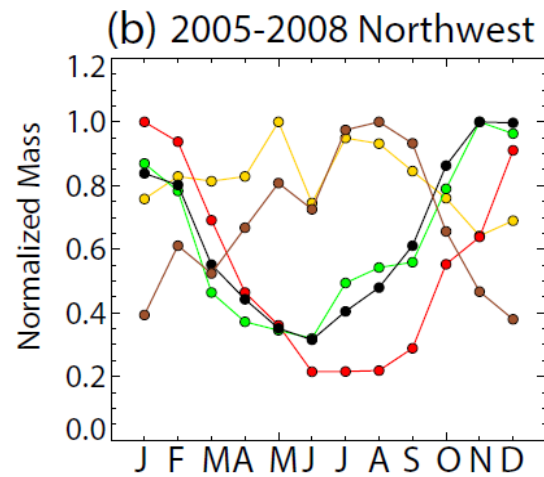
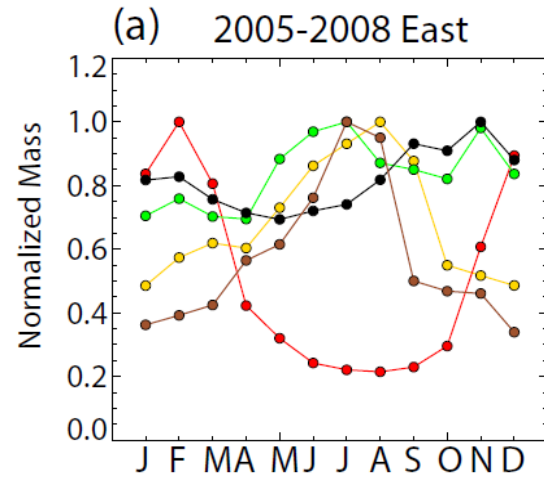


2019-
2022

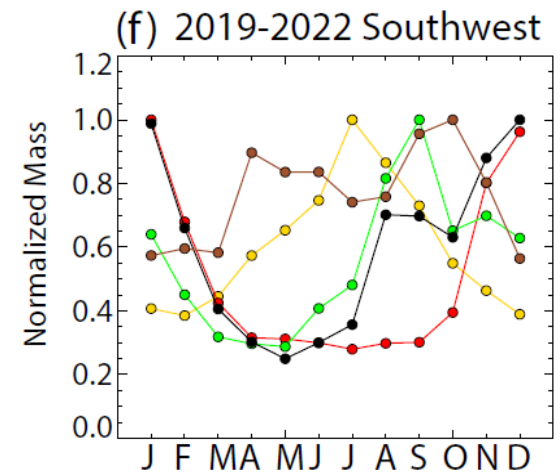
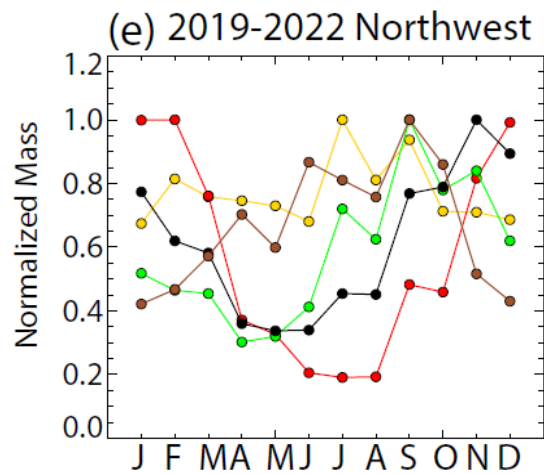
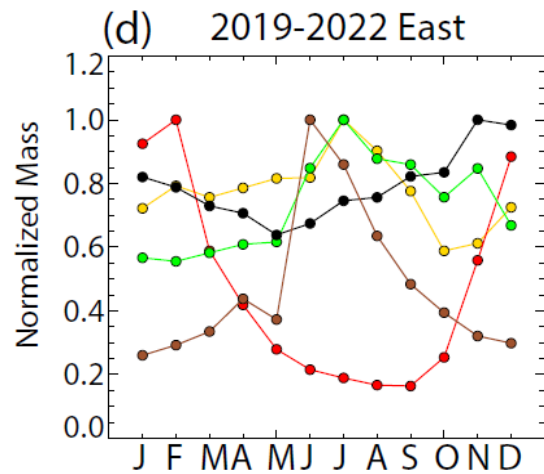


Past & Current Seasonality: CSN Normalized Mass

2005-
2008

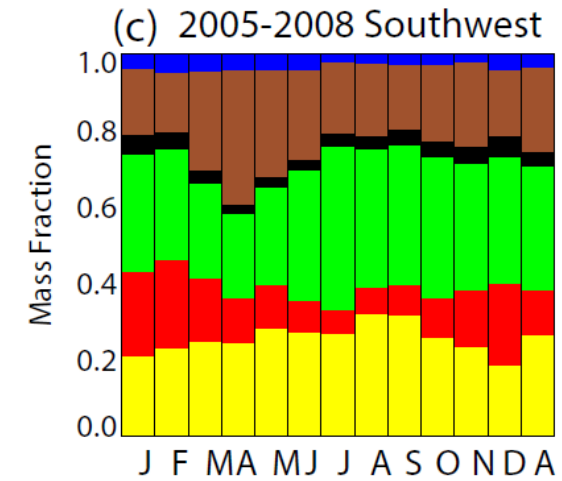
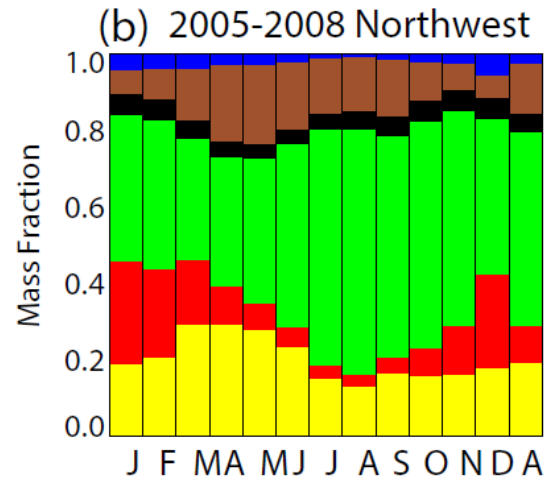
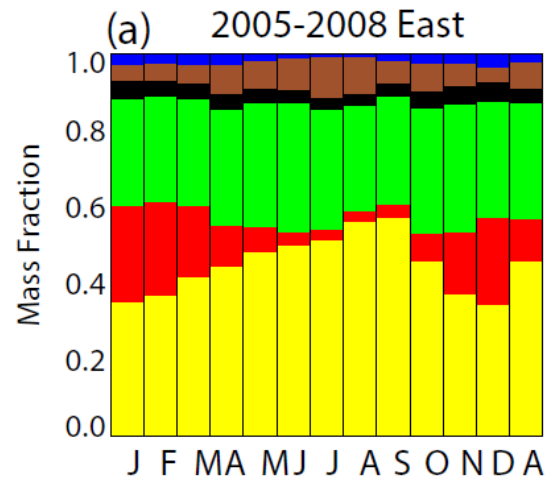


2019-
2022

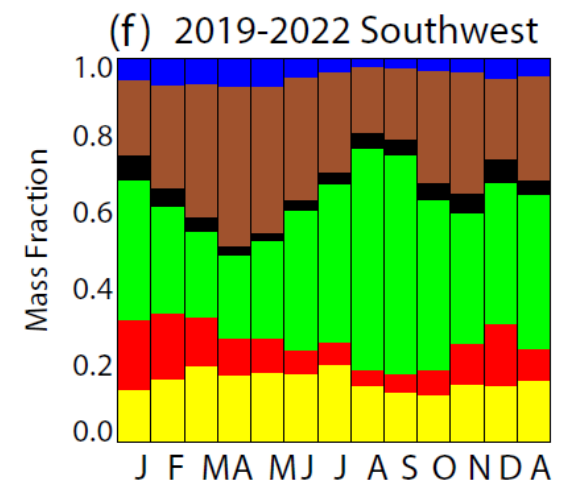
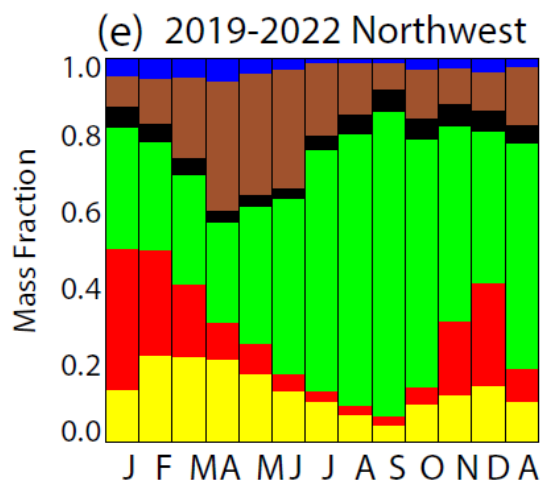
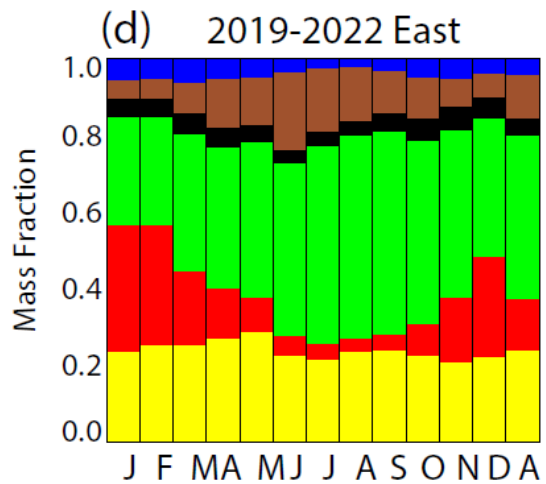


Past & Current Seasonality: IMPROVE mass fraction

2005-
2008

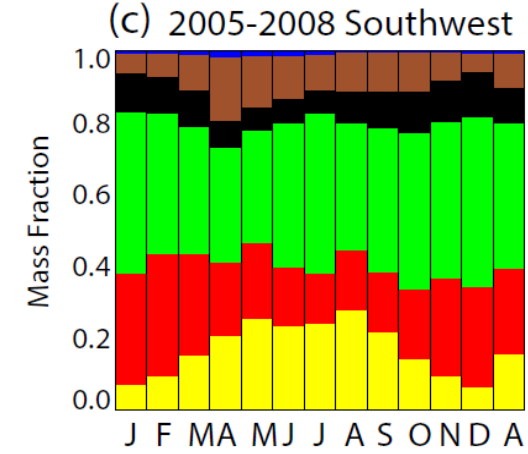
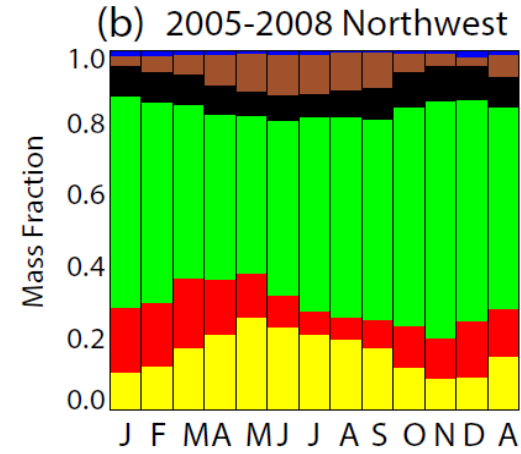
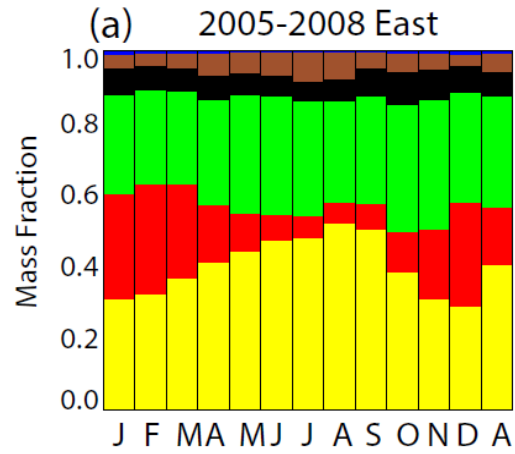


2019-
2022

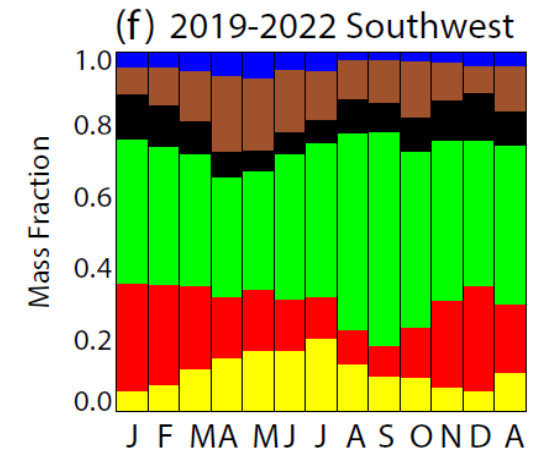
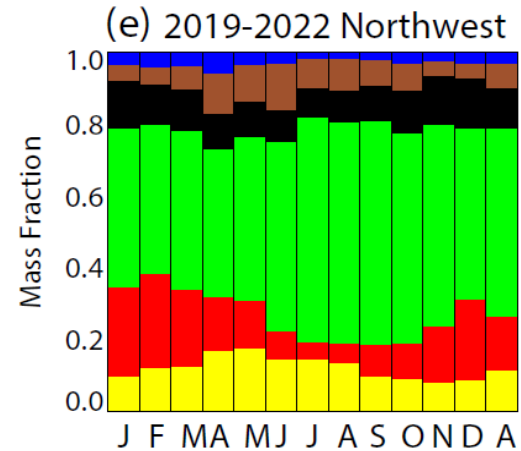
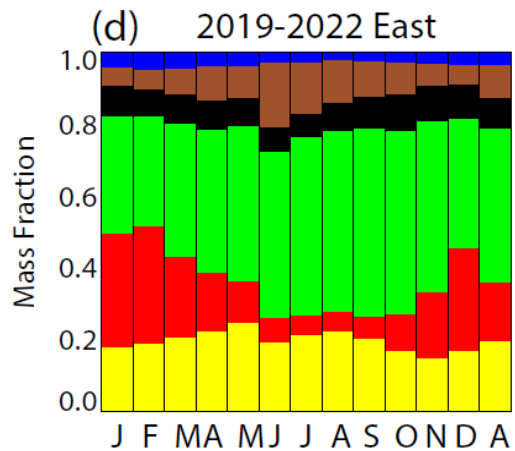


Past & Current Seasonality: CSN mass fraction

2005-
2008

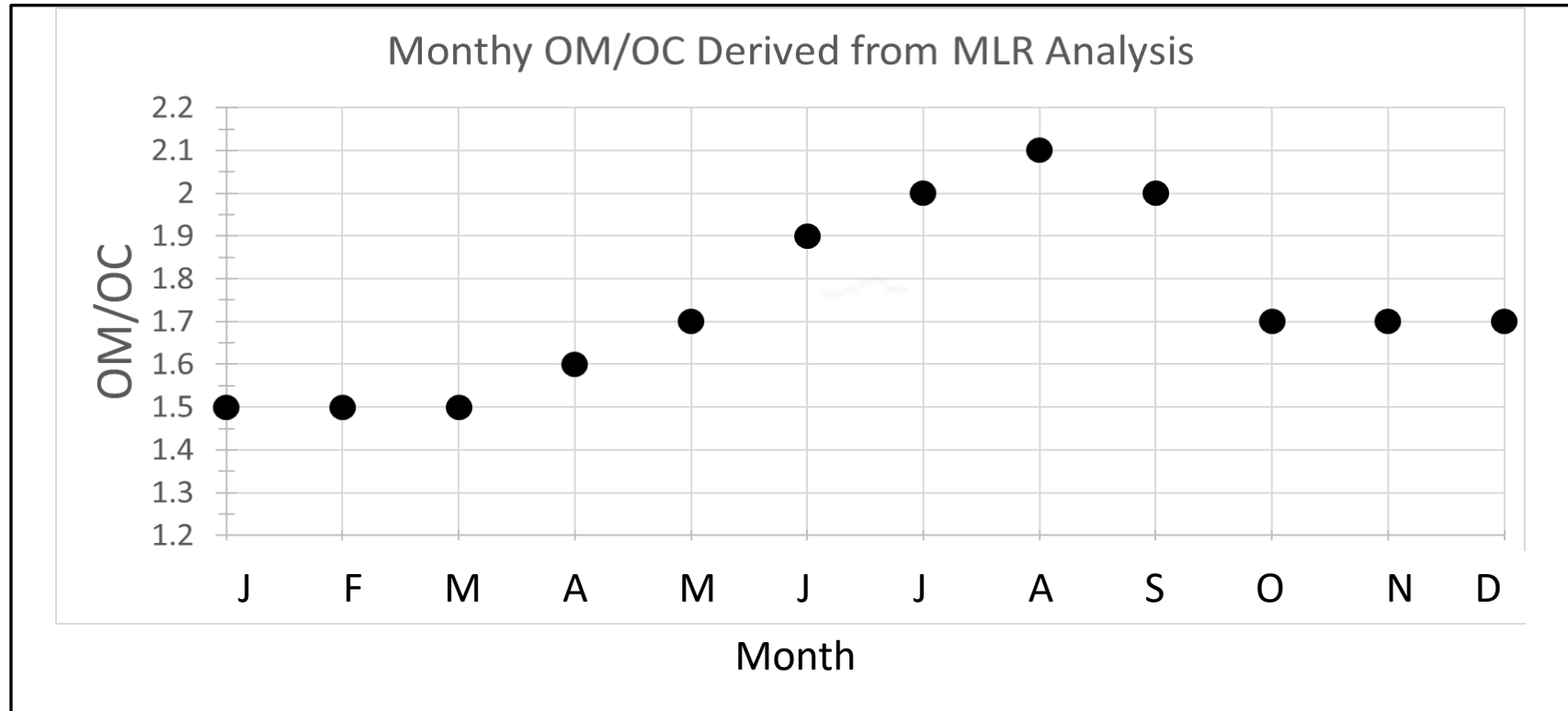


2019-
2022



Multiple linear regression: monthly mean

IMPROVE:
monthly
varying,
regionally
constant



Annual
mean: 1.7

CSN: seasonally varying, regionally constant – based on Philip et al. (2014) :
OM/OC of 1.6 (winter/spring)
OM/OC of 1.8 (summer/fall)

Continuity of CSN Data

Sean Raffuse, Warren White, Nicole Hyslop

2018 National Ambient Air Monitoring Conference

Overview

On November 22, 2015, CSN operations were shifted to new contractors

	Prior to November 22, 2015	After November 22, 2015
Sample Prep	RTI	Wood PLC
XRF Analysis	RTI	UCD
Ion Analysis	RTI	DRI
Carbon Analysis	DRI	DRI
Data Validation	RTI	UCD

Differences are expected as a result of the change in analytical labs

<https://projects.erg.com/conferences/ambientair/conferencehome18.html>