Stainless Steel Contamination on CSN Filters?

Sean Raffuse, Warren White, Nicole Hyslop, Alex Murrain

UC Davis – Air Quality Research Center
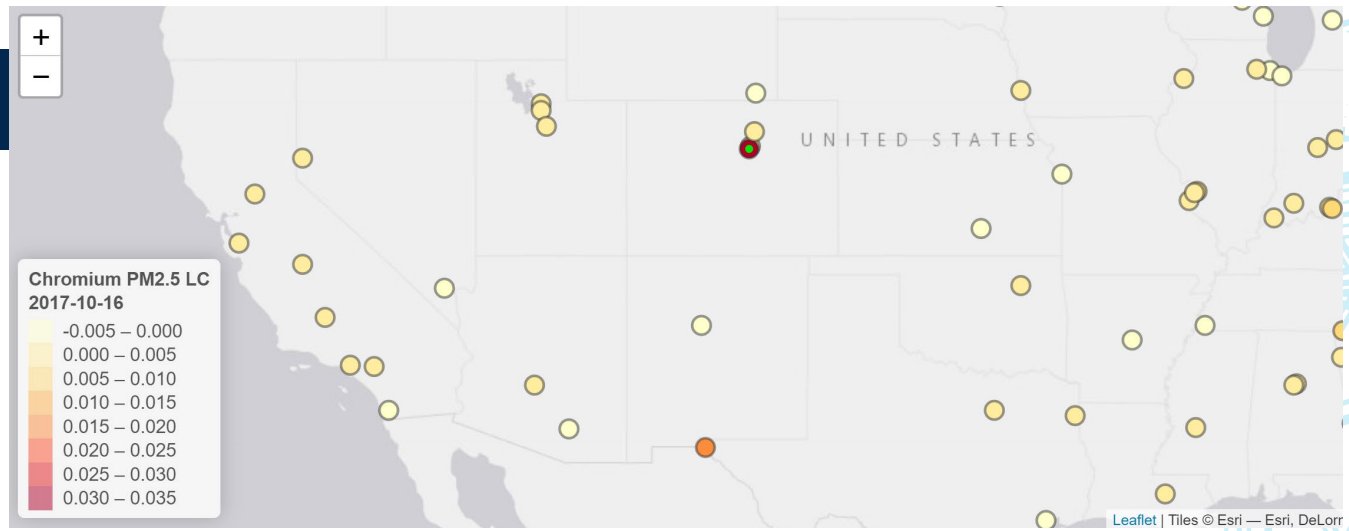
UCDAVIS
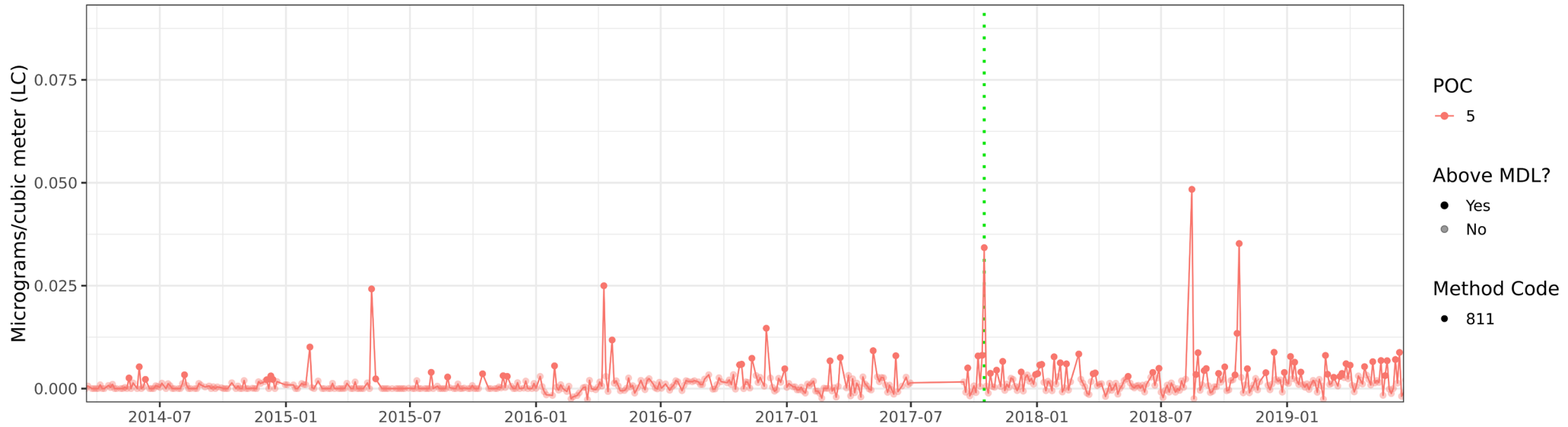
Punchline

CSN chromium (Cr) and nickel (Ni) data are intermittently contaminated. Use with caution.

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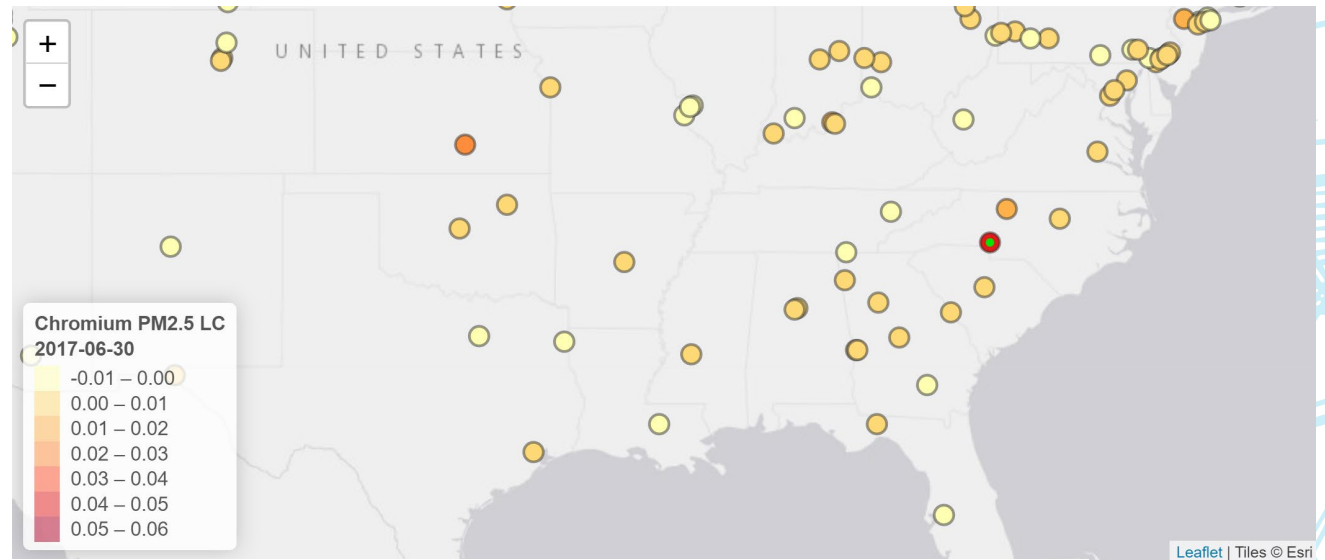
Occasional High Cr - 1

Is it real?

Chromium PM2.5 LC
2017-10-16

-0.005 – 0.000
0.000 – 0.005
0.005 – 0.010
0.010 – 0.015
0.015 – 0.020
0.020 – 0.025
0.025 – 0.030
0.030 – 0.035

08-031-0026 - La Casa -- Chromium PM2.5 LC (88112)

POC
— 5

Above MDL?
● Yes
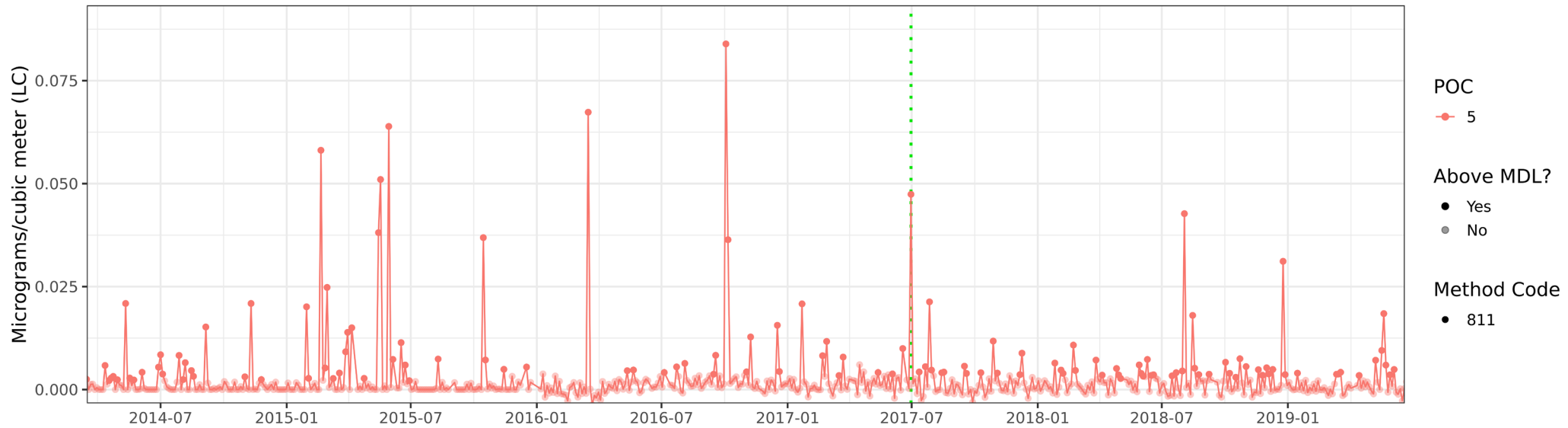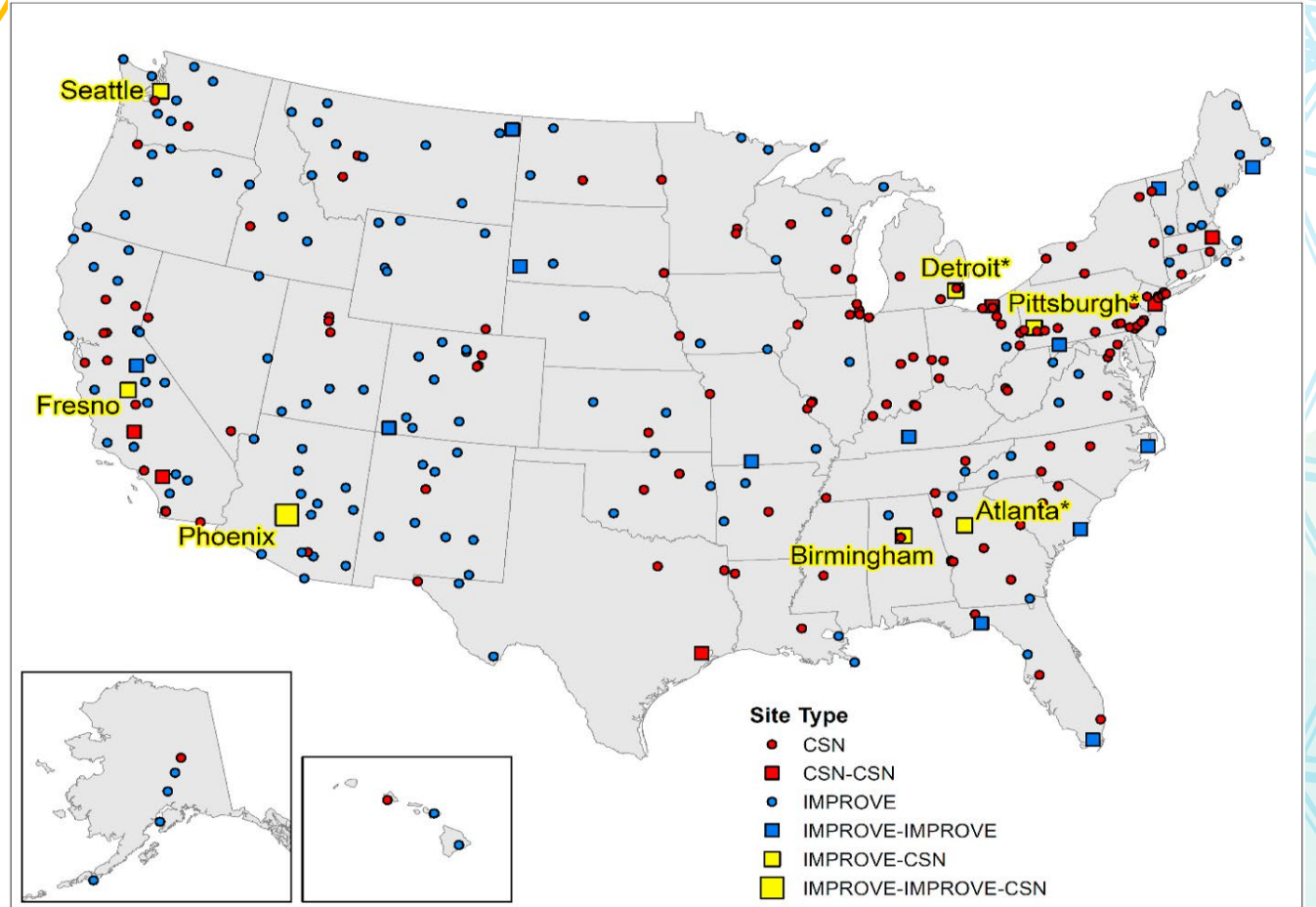● No

Method Code
● 811

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Occasional High Cr - 2

Is it real?

37-119-0041 - Garinger High School -- Chromium PM2.5 LC (88112)

Collocated CSN and IMPROVE

Gorham et al., 2021
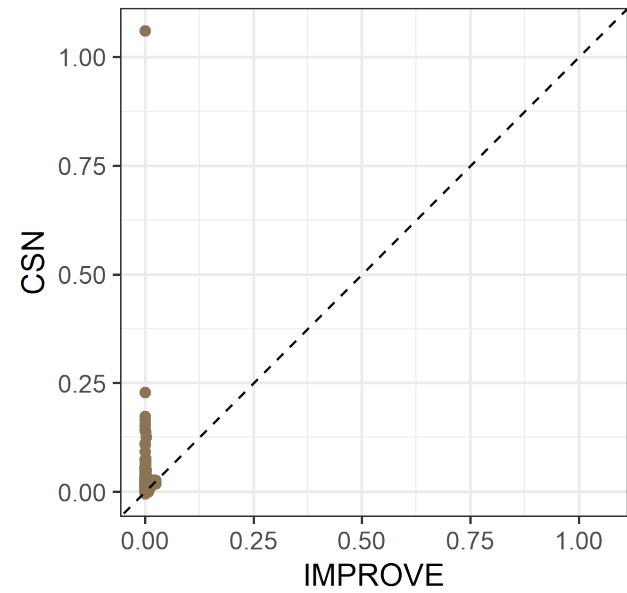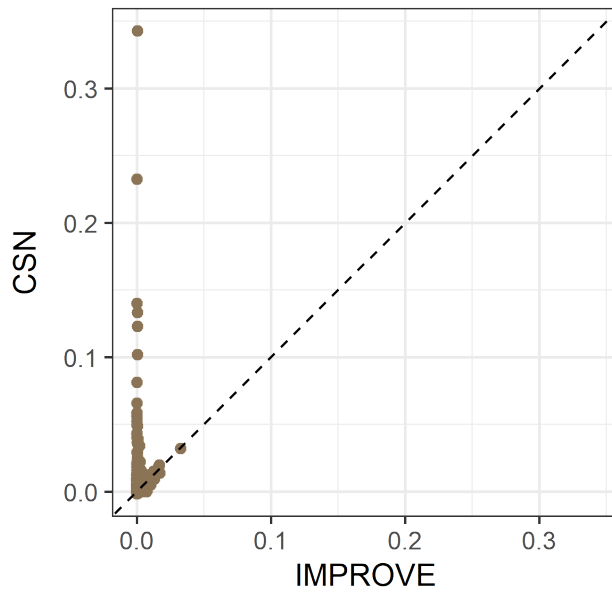
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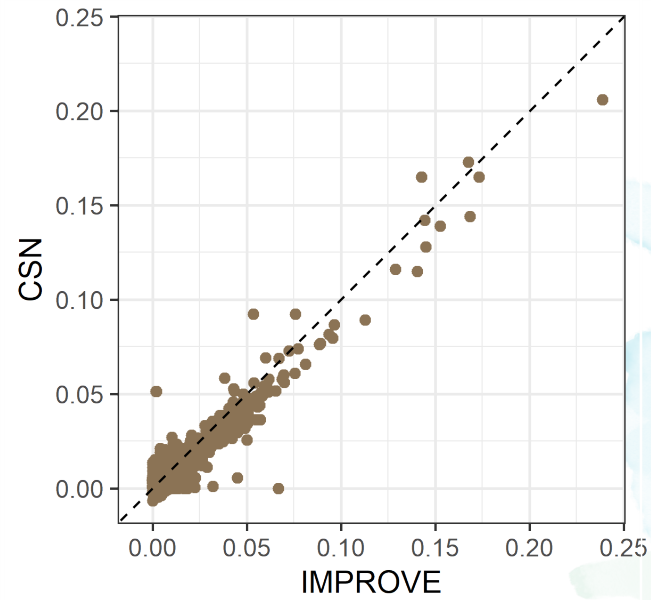# Cr and Ni in CSN often much higher than IMPROVE
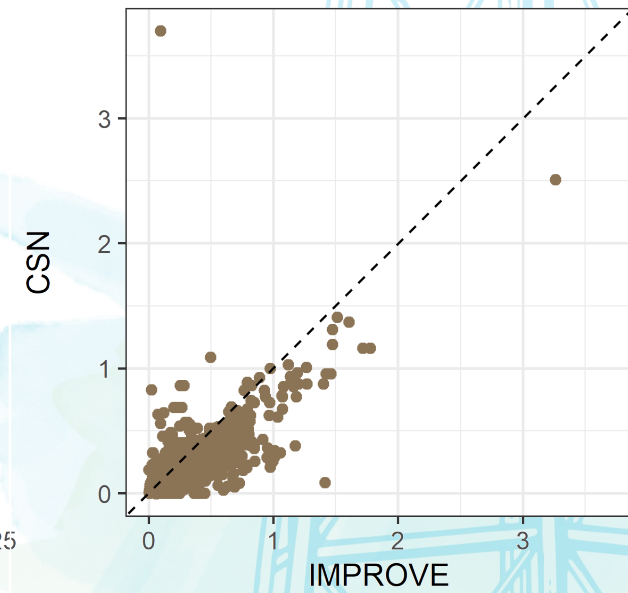
Expected Behavior in Vanadium
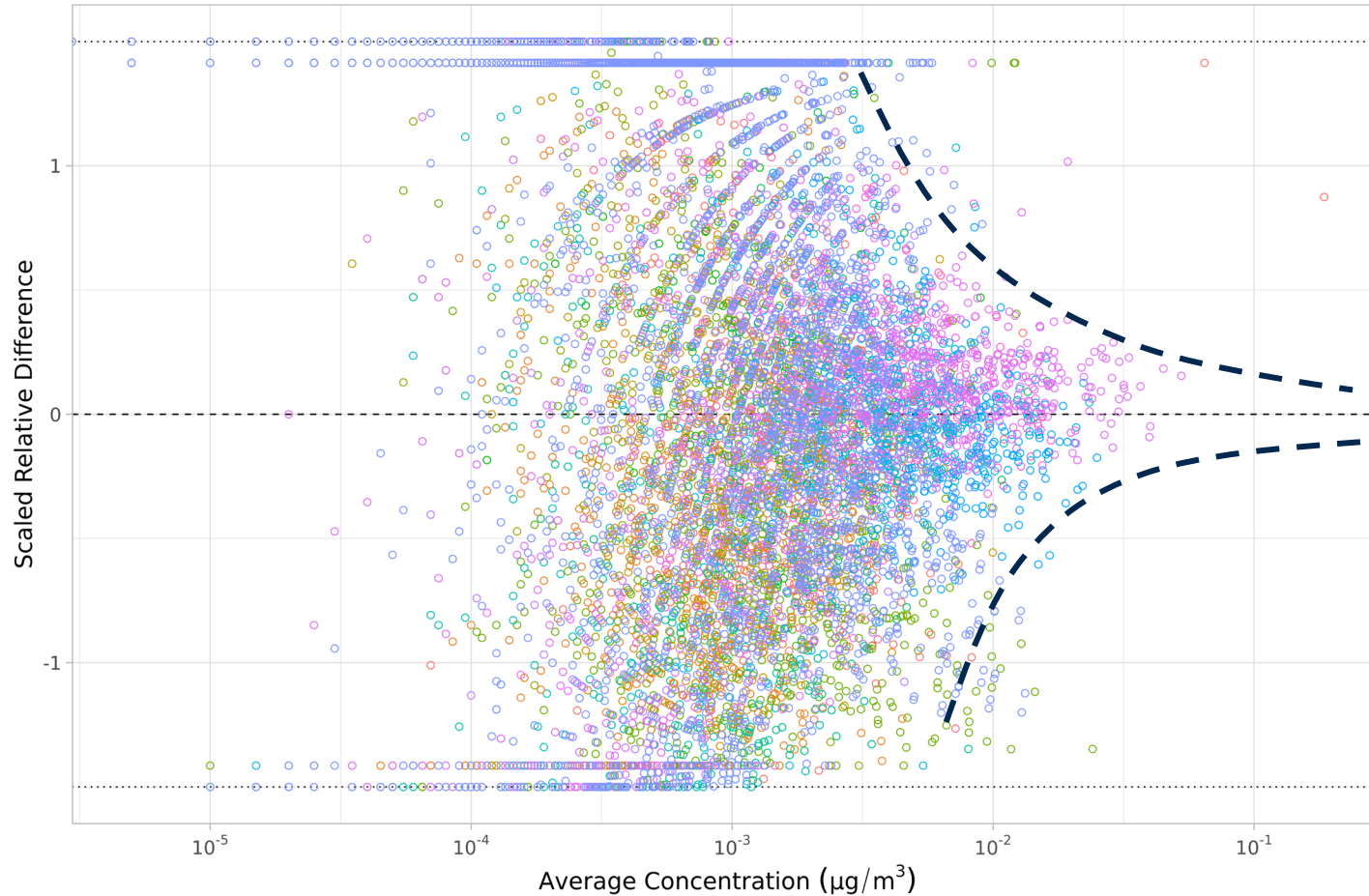
IMPROVE Higher

IMPROVE = CSN

CSN Higher

What about Chromium?

Cr - collocated pairs (2000 - 2020)

IMPROVE Higher

IMPROVE = CSN

CSN Higher

Scaled Relative Difference

Average Concentration (μg/m³)

Site
- 06-019-0008
- Addison Pinnacle
- Arendtsville
- Atlanta
- Big Bend National Park
- Birmingham Alabama
- Chicago
- Detroit
- Ellis
- Fresno
- Houston
- Mingo
- New York
- Phoenix Arizona
- Pittsburgh
- Puget Sound
- Rubidoux
- Seney
- Washington DC

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And Nickel?

Ni - collocated pairs (2000 - 2020)
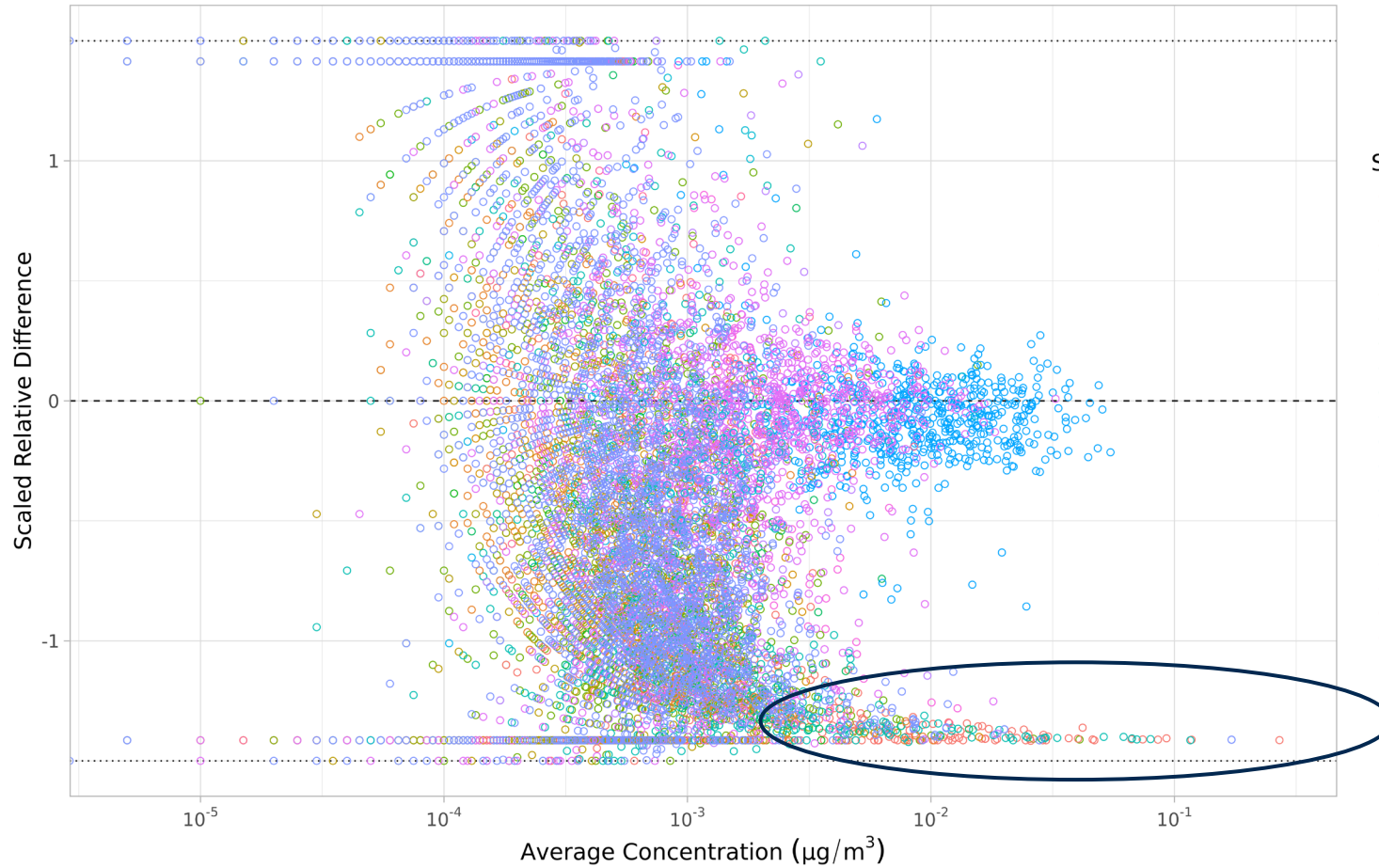
IMPROVE Higher

IMPROVE = CSN

CSN Higher

Scaled Relative Difference

Average Concentration ($\mu g/m^3$)

Site
- 06-019-0008
- Addison Pinnacle
- Arendtsville
- Atlanta
- Big Bend National Park
- Birmingham Alabama
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- Ellis
- Fresno
- Houston
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- New York
- Phoenix Arizona
- Pittsburgh
- Puget Sound
- Rubidoux
- Seney
- Washington DC
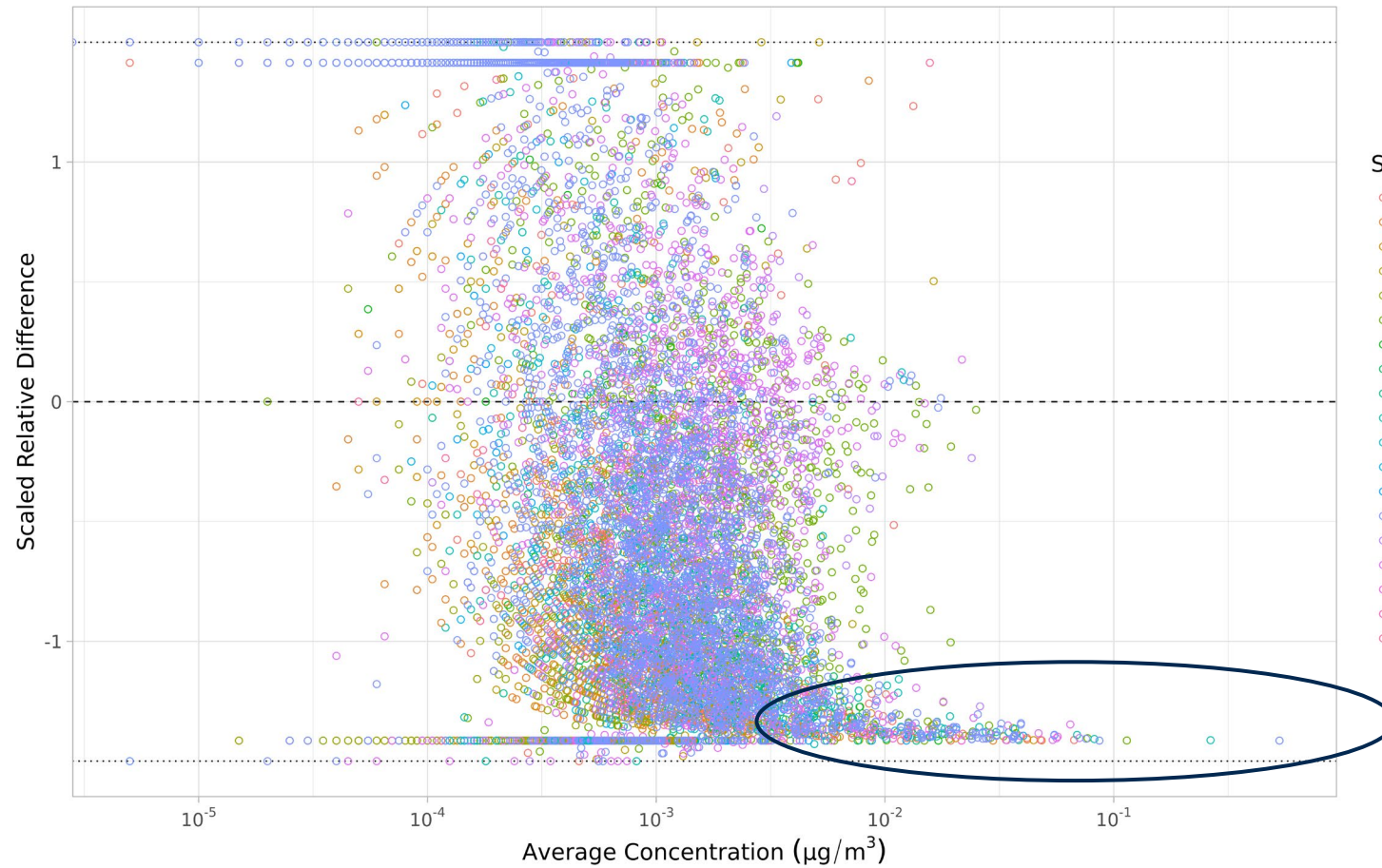
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From the lab?

IMPROVE and CSN labs for elemental analysis became the same as of late 2015

IMPROVE Higher

IMPROVE = CSN

CSN Higher

Cr - collocated pairs (2012 - 2019)
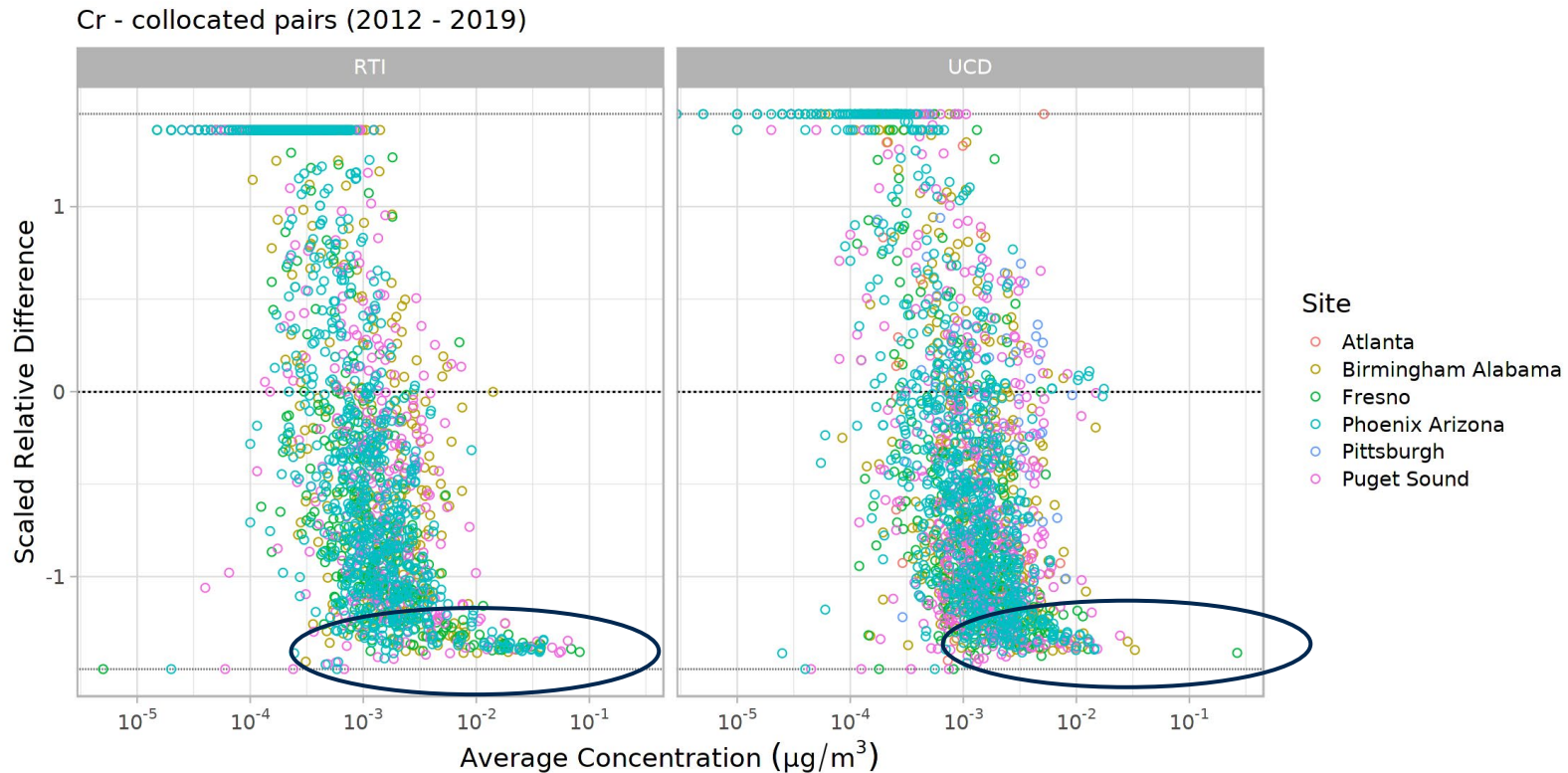
Poor agreement in both periods suggests issue is not in the lab

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Characteristic Ratios

Similar ratios of Cr/Ni and Fe/Cr for many
high values suggest a common source

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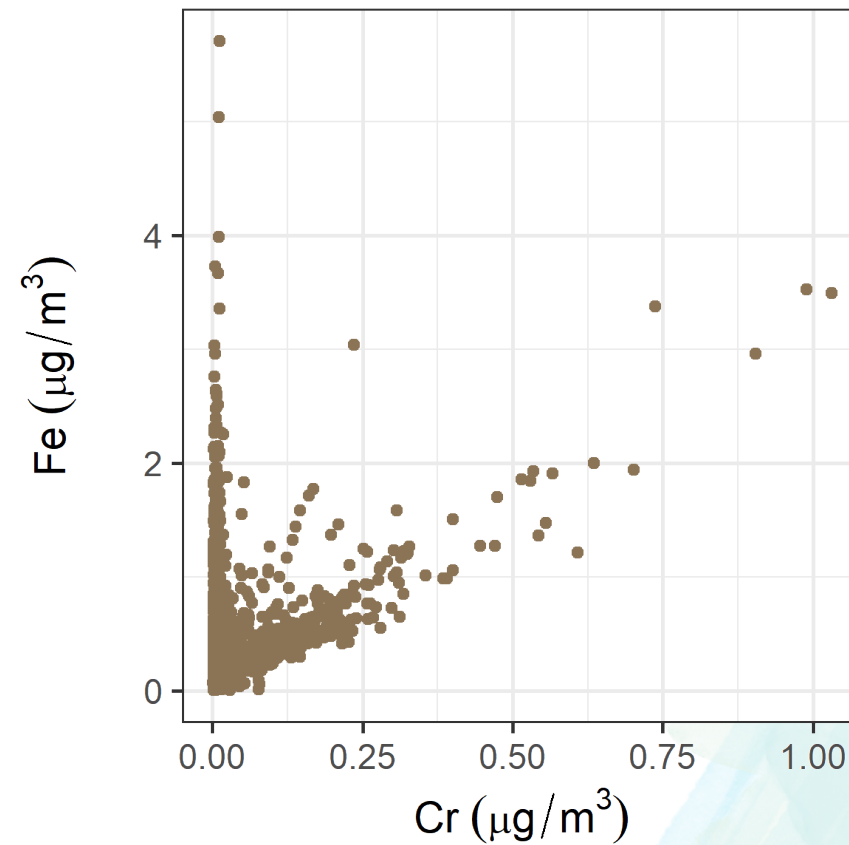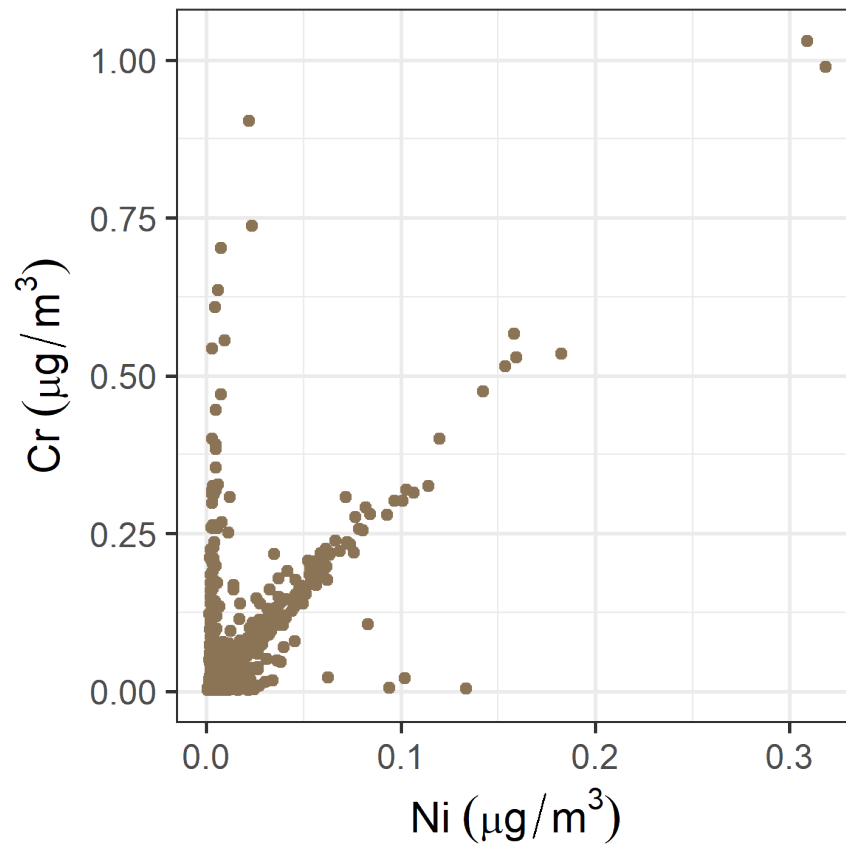
Is it the filter media?

High Cr and Ni at characteristic ratio on field blanks but not lab blanks
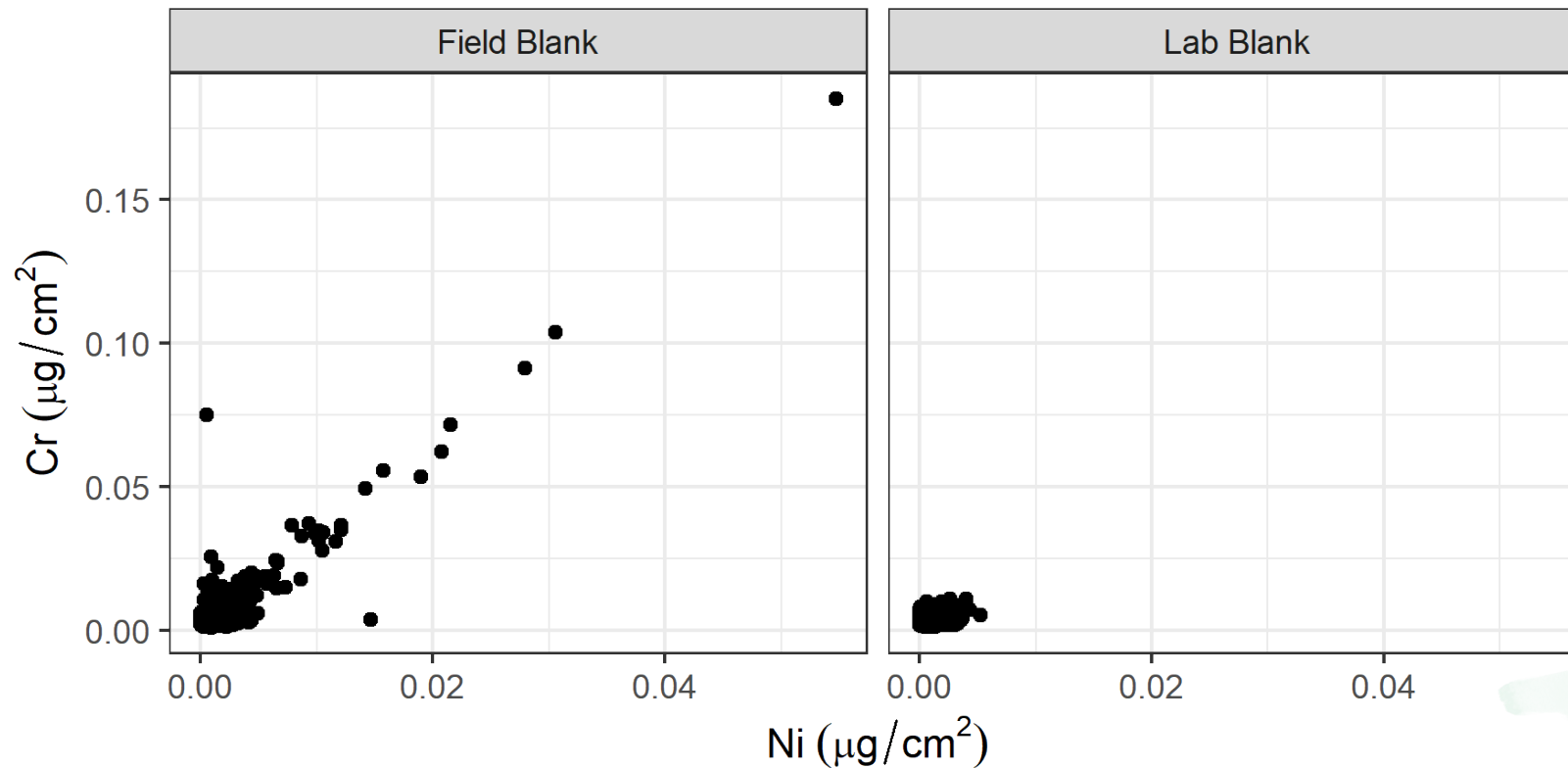

Areal density from ~10,000 field blanks and ~10,000 lab blanks analyzed from 2016-2022

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Ratios are suggestive of stainless steel

Approximate ratio of mass loadings for highlighted samples:
Ni = 1
Cr = 3
Fe = 8

Assuming Cr = 18% by weight would give:
Ni = 6%
Fe = 50%

https://www.quora.com/What-percentage-of-iron-is-in-stainless-steel

Michael Mcguire, PhD Materials Science and Engineering (1972)
Answered Oct 5, 2018

The highest amount of iron in stainless steel is found in the cheapest stainless steel, grade 409, commonly used for automotive exhaust components. Except for its 10.5% chromium, it is almost all iron.

Very expensive and exotic stainless alloys can have less than 50% iron with the rest being mostly chromium, nickel, and molybdenum.

Table 1: Austenitic Stainless Steel Chemical Compositions (Weight Percent)

Common Name	UNS No.	C	Cr	Ni	Mo	N	Mn	Cu	Other
201	S20100	0.15	16.0-18.0	3.5-5.5	-	0.25	5.50-7.50	-	-
301	S30100	0.15	16.0-18.0	6.0-8.0	-	0.10	2.00	-	-
304L	S30403	0.030	17.5-19.5	8.0-12.0	-	0.10	2.00	-	-
305	S30500	0.12	17.0-19.0	10.5-13.0	-	-	2.00	-	-
321	S32100	0.08	17.0-19.0	9.0-12.0	-	0.10	2.00	-	Ti 5x(C+N)
347	S34700	0.08	17.0-19.0	9.0-13.0	-	-	2.00	-	Cb 10xC to 1.00
309S	S30908	0.08	22.0-24.0	12.0-15.0	-	-	2.00	-	-
310S	S31008	0.08	24.0-26.0	19.0-22.0	-	-	2.00	-	-
316L	S31603	0.030	16.0-18.0	10.0-14.0	2.00-3.00	0.10	2.00	-	-
317L	S31703	0.030	18.0-20.0	11.0-15.0	3.0-4.0	0.10	2.00	-	-
317LMN	S31726	0.030	17.0-20.0	13.5-17.5	4.0-5.0	0.10-0.20	2.00	-	-
904L	N08904	0.020	19.0-23.0	23.0-28.0	4.00-5.00	0.10	2.00	1.00-2.00	-

Source: Specialty Steel Industry of North America
http://www.ssina.com/composition/chemical.html

Is it the sampler?
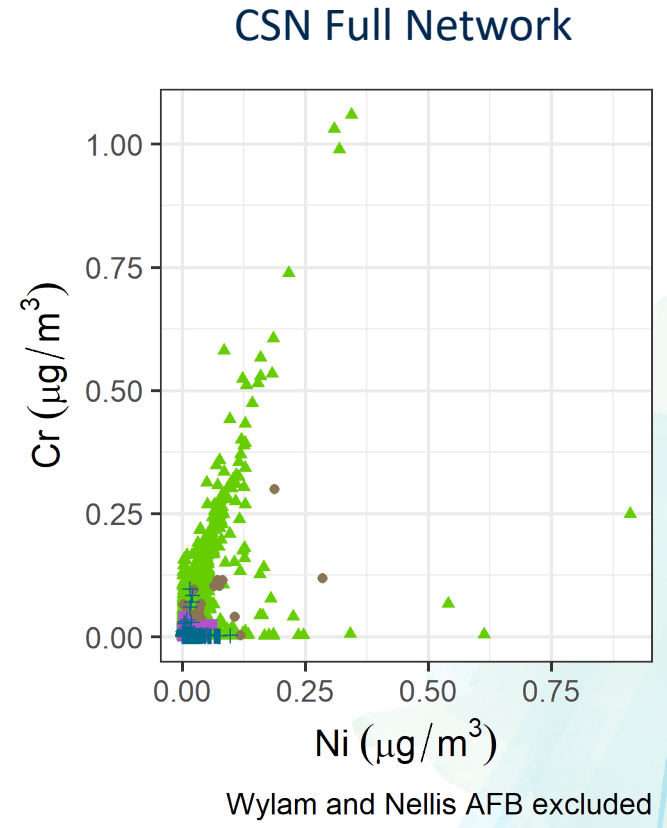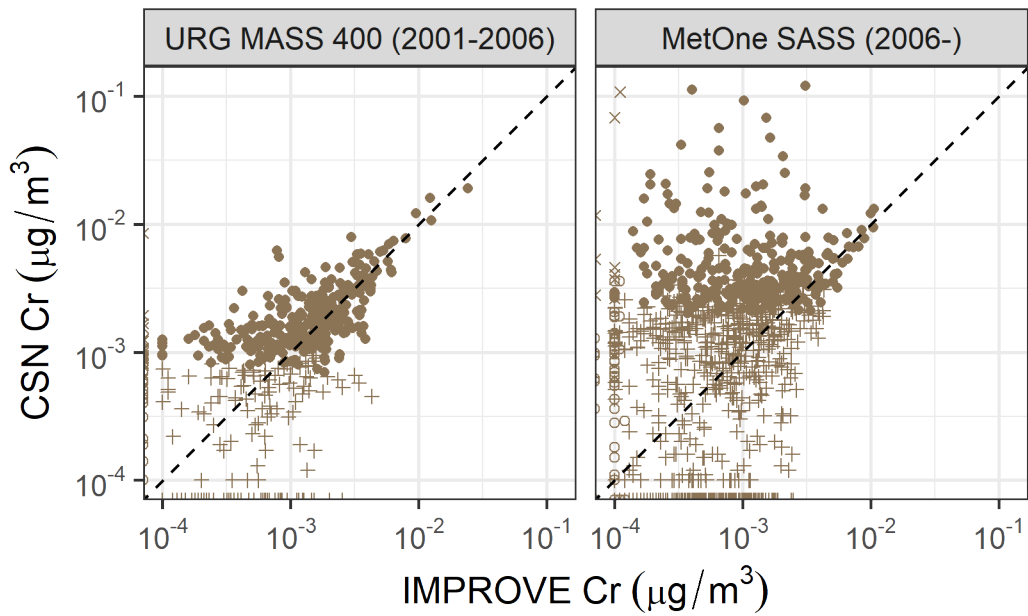
Disassembled SASS canister (from Met One SASS Field Operation Manual)

Screens?
Screws?
Canister body?

Seems to be SASS only

Seattle – Beacon Hill

CSN Full Network
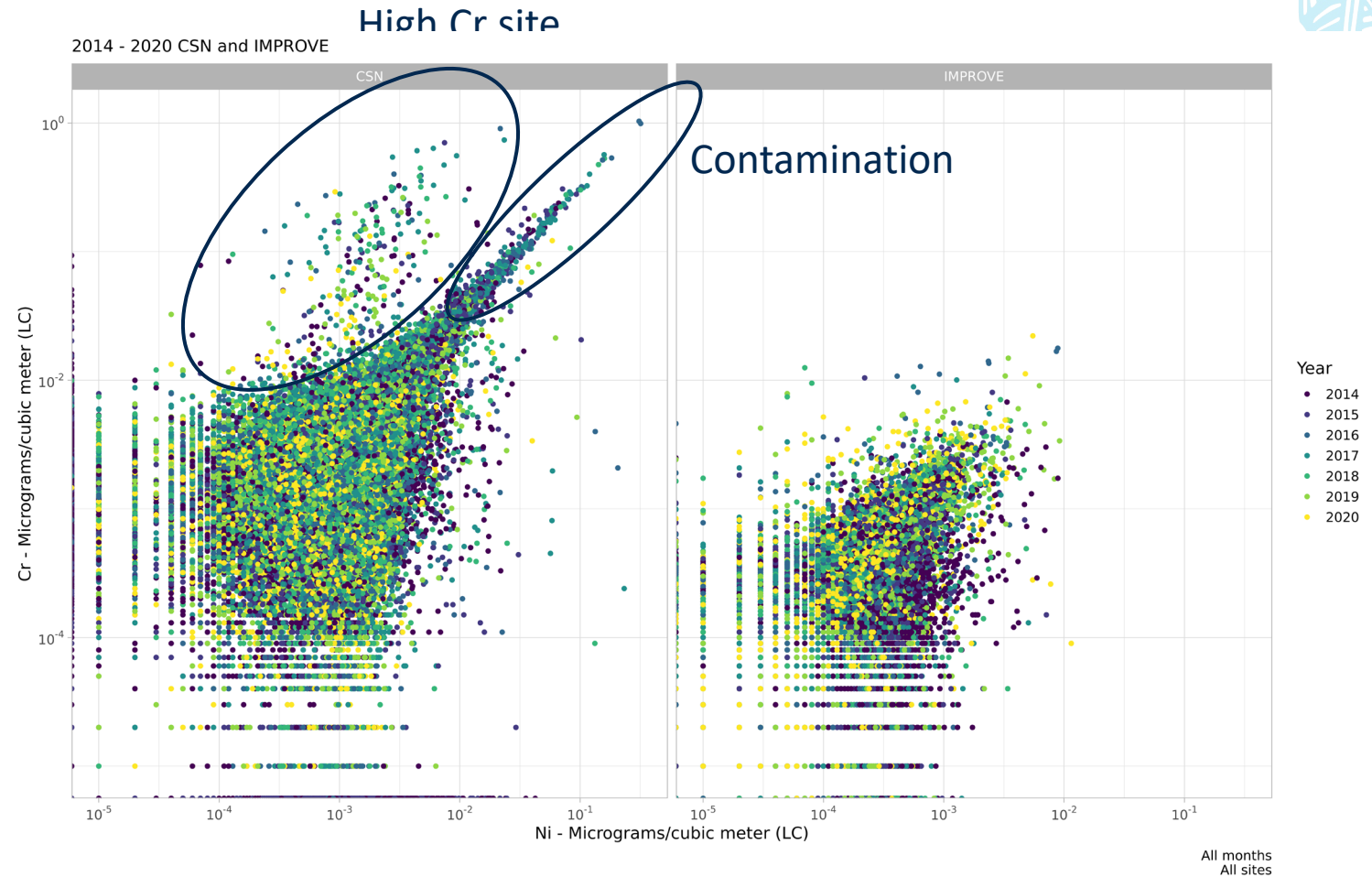
Wylam and Nellis AFB excluded

Identifying the contamination

Want to identify and flag contamination without discarding real signals

Threshold/Ratio tests:
$Cr > 0.01\ \mu g/m^3$
$1.5 < Cr/Ni < 6$
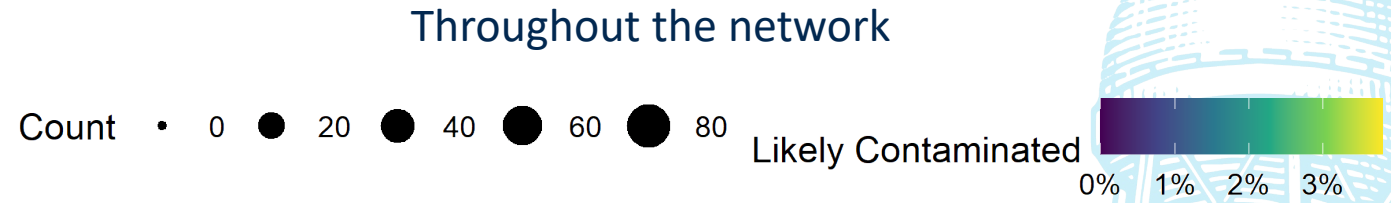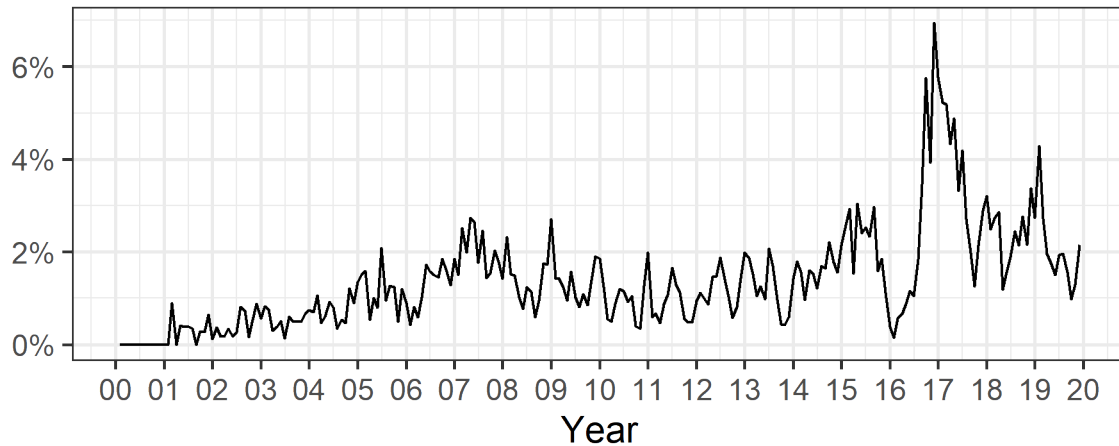$1.75 < Fe/Cr < 7$

High Cr site

Contamination

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How common is this?

Count • 0 ● 20 ● 40 ● 60 ● 80   Likely Contaminated
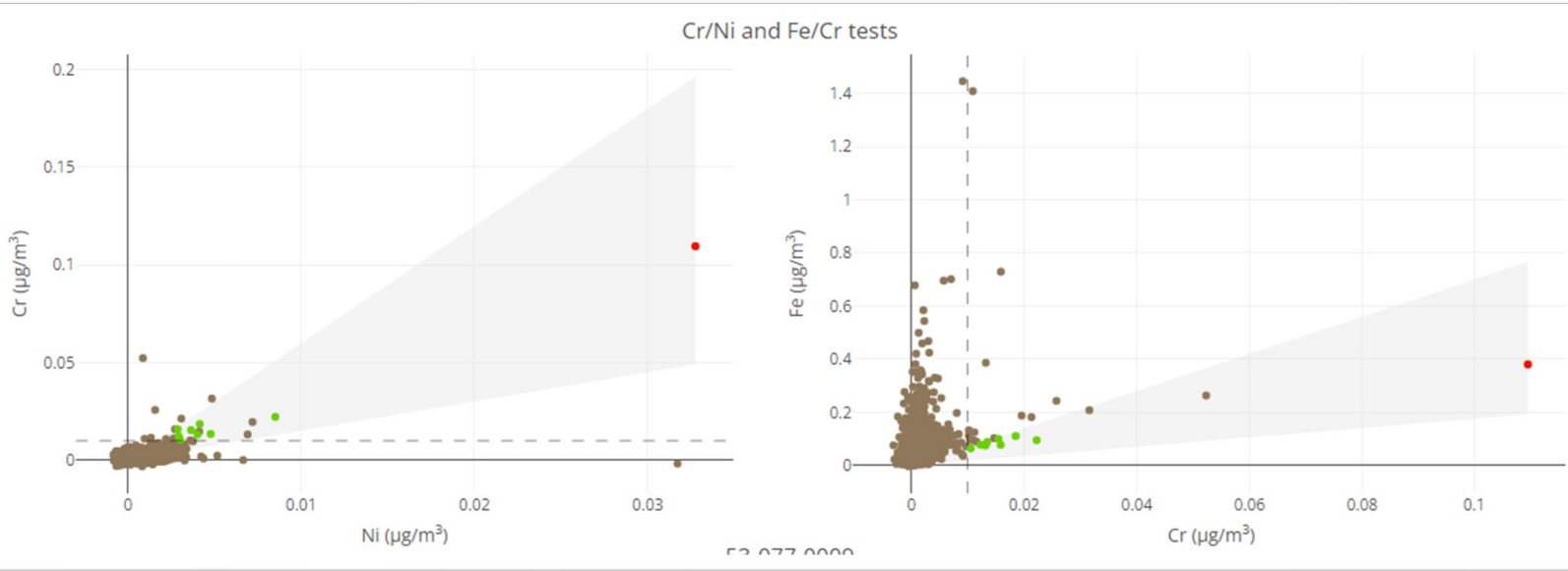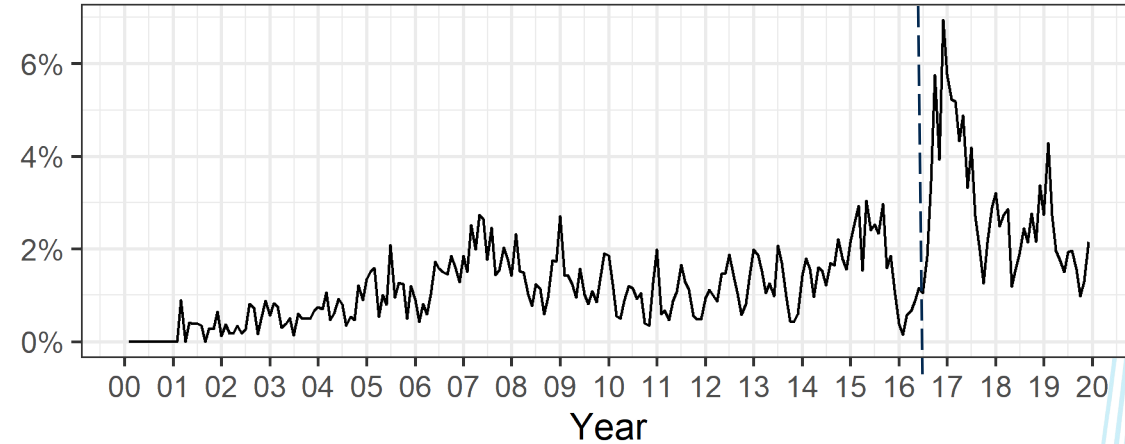0% 1% 2% 3%

Between 1-3% of all samples with a spike in 2016-2017

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Source?

Analysis of sampler components has been inconclusive, but circumstantial evidence implicates the screws

2016 NAAMC

Cr/Ni and Fe/Cr tests

Id 253661
ContractorFilterAnalysisId F252033
ContractorBatchNumber A0000079
Sampler 53-077-0009 : Yakima - 4th Ave, WA (id: 263)
IntendedUseDate 5/22/2021 12:00:00 AM
SampleStartDate 5/22/2021 12:00:00 AM
SampleEndDate 5/23/2021 12:00:00 AM
FilterPurpose SA - Sample (id: 1)
AqsNullCodeId Edit AQS Null Code

Comments Wood: Screw fell on teflon filter while unloading and left small holes and screw dust on ch 1 teflon flag 4.
— Wood 7/14/2021 8:08:29 AM

Recommendations

- 2020 data and beyond are assigned the SC null code if they are identified with the threshold/ratio tests ("sampler contamination").

- The tests are conservative, so residual contamination is present in valid data.

- Use Cr and Ni data from CSN with caution. Data prior to 2020 are not invalidated – consider applying the threshold tests.

- Fe, Co, and Cu are co-contaminants and also receive null codes, but the relative impact is smaller.

Wood PLC (Justin Knoll, Hayley Curilla)

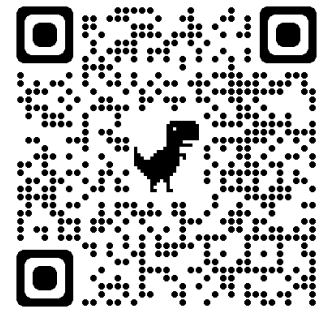RTI (Tracy Dombek, Frank Weber)

EPA (Joann Rice and Melinda Beaver)

Data advisory posted on
EPA website is here

Questions?

sraffuse@ucdavis.edu

https://www.epa.gov/sites/default/files/2021-01/documents/contamination_advisory.pdf