UC Davis Status Report to IMPROVE Steering Committee

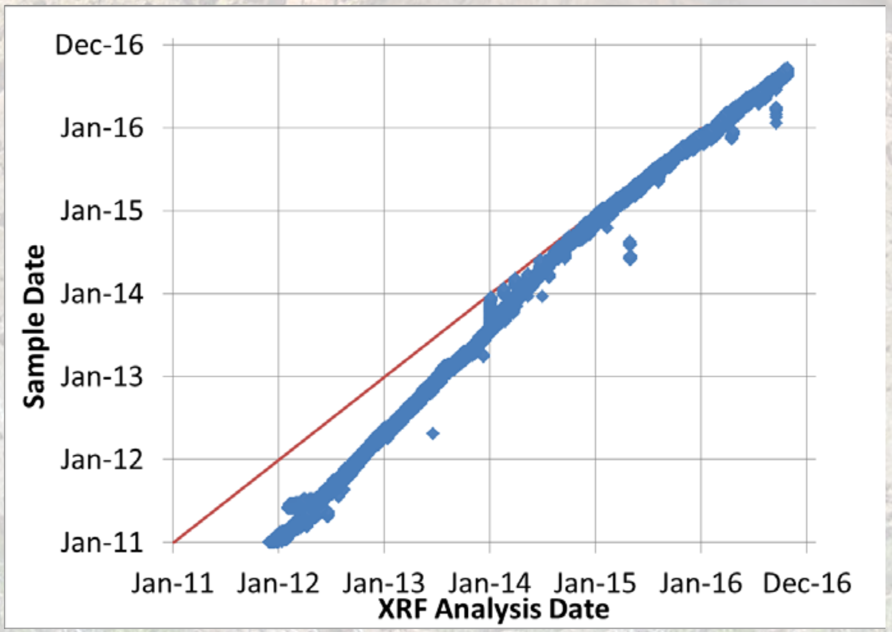
Nicole Hyslop, Sean Raffuse, Krystyna Trzepla, Nick Spada, and Yongjing Zhao
University of California, Davis

Presented in Santa Fe, NM
November 1, 2016

- **No sites shutdown in 2016**
- **2 new sites are in the works**

Data Submittal Status

- Preliminary data reported through March 2016
  - Data delivery is now 9 months after sample collection
  - Data deliveries have been 7-10 months after collection for past few years
  - Data are delivered 2-3 weeks after receipt of analysis data for quarter
- XRF analysis occurs within a month of sample receipt
  - Even with FTIR analysis performed prior to XRF



Reasons for Sample Losses

Year	ABCD recovery	Operator no-show	Bad installation	Equipment problem	Power outage	Destroyed/ No filter
2005	93%	1.3%	1.1%	2.9%	0.9%	0.8%
2006	92%	1.9%	1.0%	2.8%	1.4%	0.9%
2007	92%	2.1%	1.0%	2.5%	1.4%	1.0%
2008	90%	2.1%	1.3%	4.5%	1.5%	0.6%
2009	91%	1.9%	1.1%	3.6%	1.8%	0.6%
2010	92%	2.3%	0.9%	3.1%	1.4%	0.5%
2011	91%	2.4%	0.9%	3.1%	1.8%	0.6%
2012	94%	1.9%	0.9%	1.6%	1.4%	0.6%
2013	94%	2.0%	1.1%	1.5%	1.2%	0.5%
2014	94%	2.3%	1.2%	1.0%	1.1%	0.3%
2015	94%	1.8%	1.3%	1.4%	1.0%	0.7%

Regional Haze Rule (RHR) Completeness Criteria

- RHR requires for all modules:
  - >75% annual recovery
  - >50% recovery in each quarter
  - <11 consecutive missed samples
- Number of Sites failing RHR completeness criteria
  - 2009 11 sites
  - 2010 9 sites
  - 2011 7 sites
  - 2012 6 sites
  - 2013 5 sites
  - 2014 4 sites
  - 2015 5 sites
  - 2016 2-4 sites so far (depending on how you count)

Sites Not Meeting RHR Criteria

2015

- 5B, FL (FWS, IMPROVE)
  - Spider web in D module resulted in almost 2 months of lost samples
- Sierra Ancha, AZ (FS, IMPROVE)
  - Failed to meet annual completeness criteria by losing 34 samples
  - Also failed in 2014 and 2016
  - No backup operator at the site, and primary operator has many other responsibilities
- Sula Peak, MT (FS, IMPROVE)
  - UCD maintenance discovered cyclone throat had fallen out
  - Samples invalidated from 12/31/14 to 8/28/15
- Monture, MT (FS, IMPROVE)
  - Obstruction in the inlet that was left over by our maintenance crew. Affects data from 7/31/14 till 5/4/2015.
  - Implemented immediate review of sulfur/sulfate ratios
- Trinity, CA (FS, IMPROVE)
  - No site operator since July 2015

Sites Not Meeting RHR Criteria

2016

- Sierra Ancha, AZ (FS, IMPROVE)
  - 13 consecutive terminal samples
  - Also failed RHR completeness criteria in 2014 & 2015
- Lake Sugema, IA (State, Protocol)
  - 33 consecutive terminal samples
  - D Module Sierra inlet obstructed by spider webs
- Trinity Alps, CA (FS, IMPROVE)
  - Operator contract expired in July 2015. No operator since then.
- Swanquarter, NC (FWS, IMPROVE)
  - 26 consecutive terminal samples
  - D Module Sierra inlet obstructed by mud wasps.
  - Fortunately, SWAN has a collocated D module

Sampler Maintenance Interval Doubled

- No experimental data to determine if change impacted filter weights or compositions
- Difficult to observe effect on site cleanliness
  - varies widely based on factors such as site location, operator upkeep, etc.
- UCD compensated by spending more time during each visit, expanded task list during maintenance
  - Pump hoses armored, all o-rings replaced, components disassembled for inspection, attention to weatherproofing, leak check criteria tightened
  - Inspection of site electrical supply during maintenance
  - Result is longer hours in the field

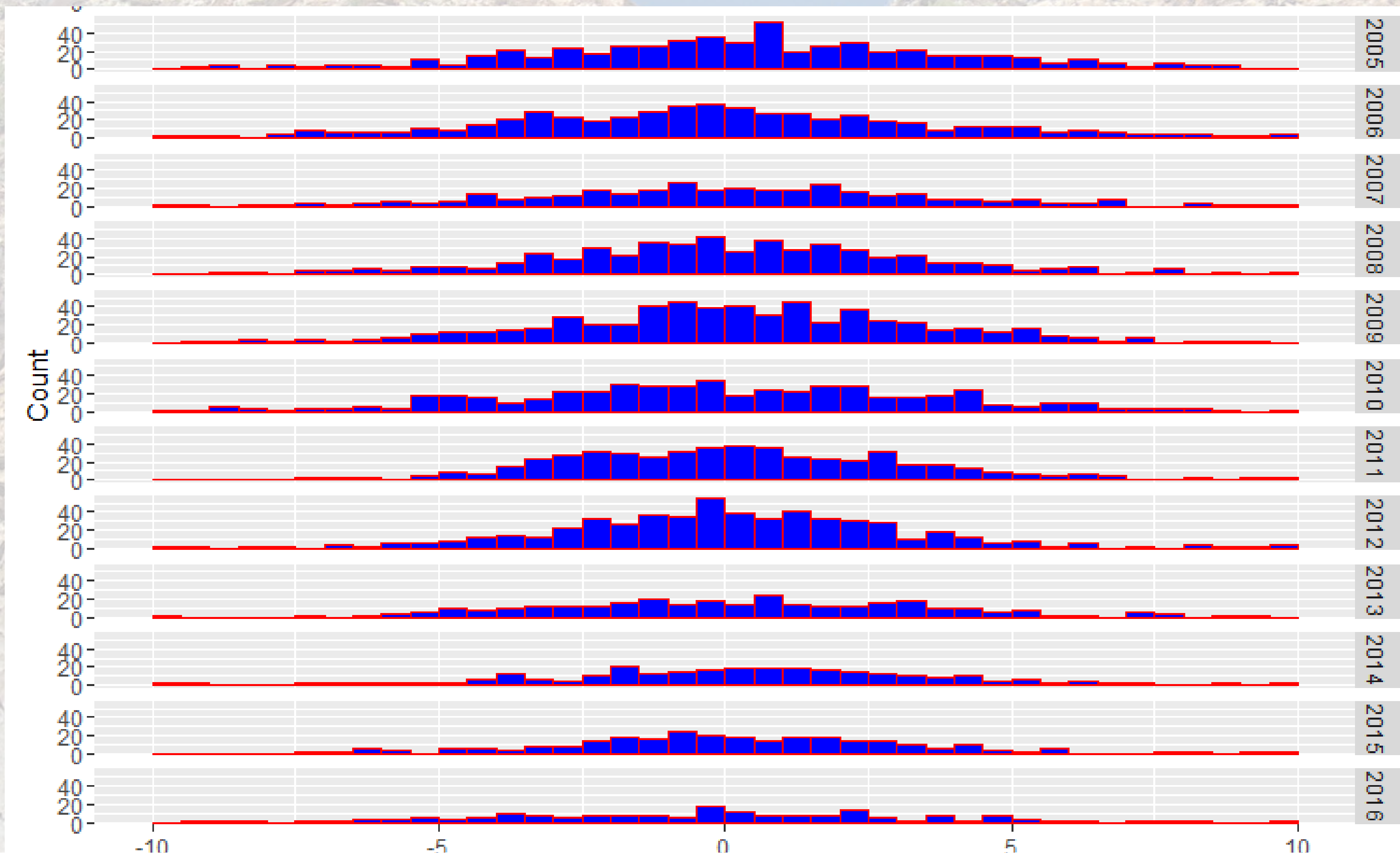
Maintenance Interval - Potential Risks

- Slower deployment of modifications to equipment and methods
- Fewer opportunities to catch and remedy wear in the sampler, such as leaks created by repeated manifold motion, worn o-rings, hoses, etc.
- Fewer training opportunities with local site operators
  - Training videos created and available online

Flow Rate Calibration Method

- Adjustment to the calibration method relating a primary standard flowmeter to the flow check device used in the field
- Method reexamined in response to flow bias found during EPA audits
- Markedly improved EPA flow audit results in 2016

Results of Maintenance Visit Flow Calibration Checks



Percent Difference between the Transfer Standard Flow Rate and Sampler Flow Rate

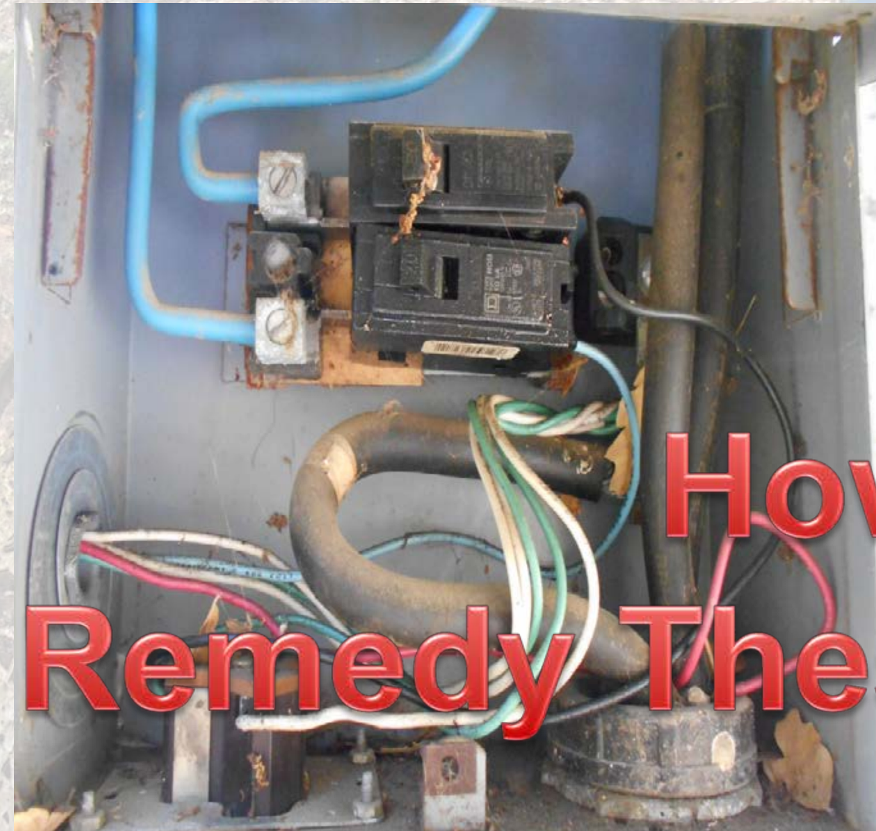
Fall Safety

- Serious fall hazards at some sites
- Asking site owners to provide safe access to sites

WHPA

This unguarded edge exposes site operators to a potential 20’ fall

Electrical Safety at Site



How to Remedy These Problems?

RAFA: No panel cover, mixed breaker types, single 20A supply to sampler

Bypassed meter sockets, exposed 240V, visible weathering and corrosion of bypass bars

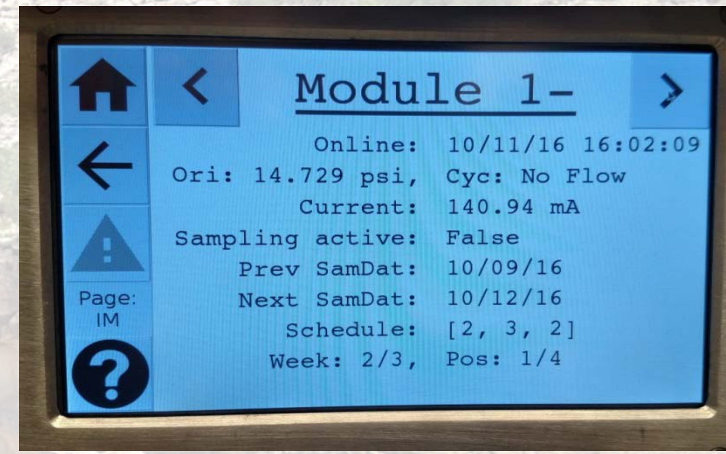
Redesigned Controller

Old TERN-based Controller
2000

New ARM/Linux Controller
2016

Controller Hardware

- Modular card-based system allows easy field replacement of critical components
- 7 inch color touch-screen, compatible with gloves
- USB, Serial, I2C, CAN, and Ethernet ports available
- Expansion slots for networked communication, additional hardware, other future uses



New Sampler Electronics Deployment

- Have been running on UCD roof for ~4 months
  - Hardware is finalized
  - Now working through software bugs
- Test deployments planned for
  - Phoenix collocated sampler: low risk and relatively easy access
  - Fresno: close to UCD
  - Lassen Volcano or Bliss State Park: close to UCD
- If all goes well, we will start installing new electronics on 2017 maintenance trips

Instructional Videos

- Weekly sample change
- Flow check
- Flow calibration
- Disengaging manifold motor
- Equipment replacement:
  - Controller
  - Inlet
  - Electronics box
  - Module cable
  - Module
  - Pump
  - Relay box
  - Temperature probe

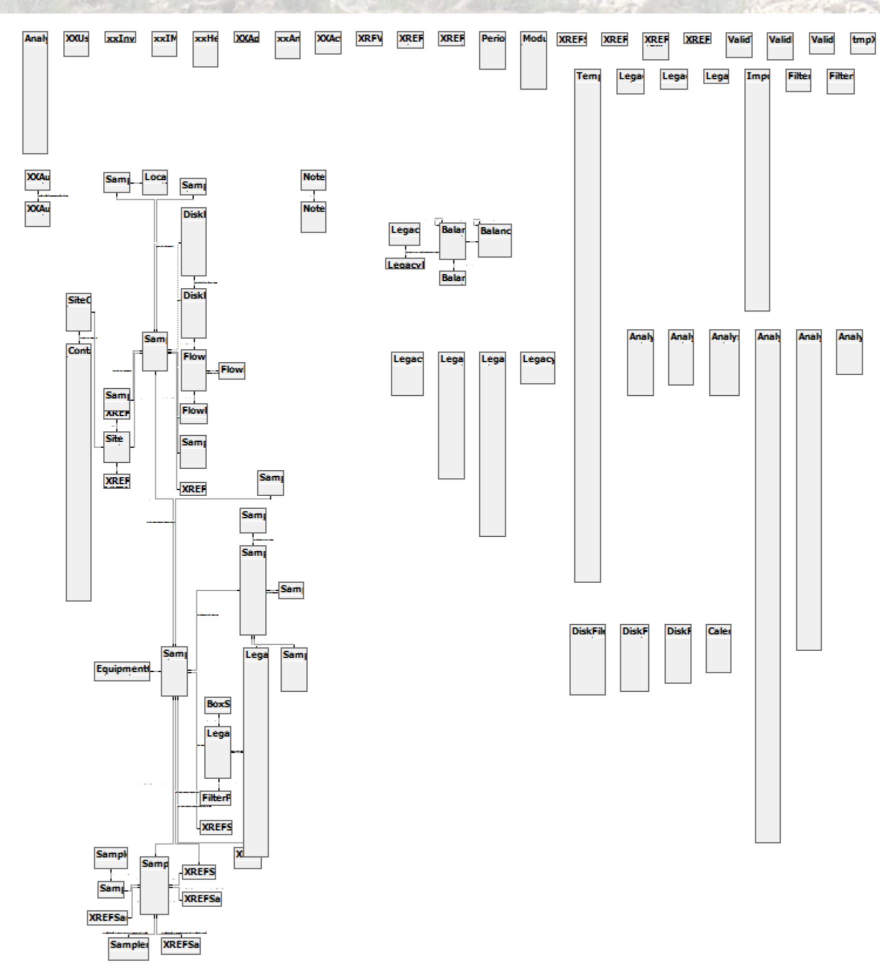
Data Management Transition - Goals

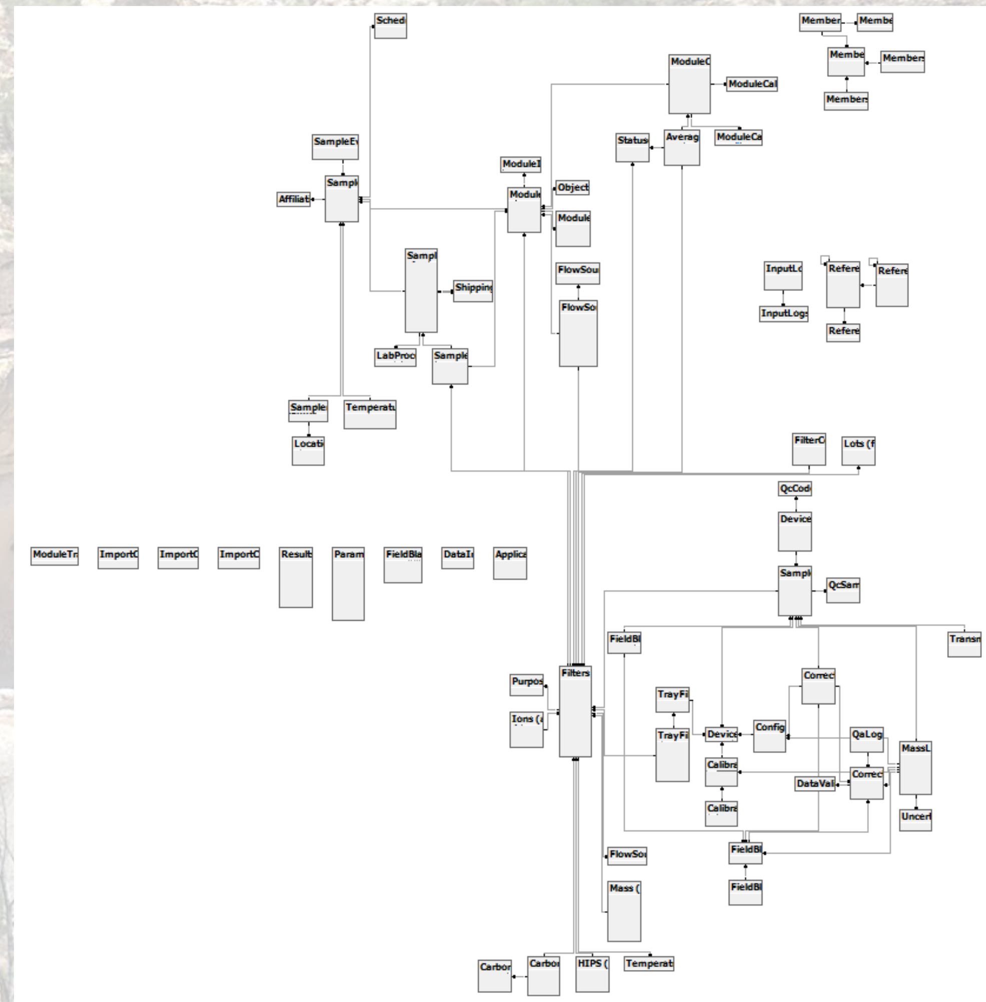
- Produce a more maintainable, secure, flexible, and supported system
  - Eliminate any dependencies on FoxPro
  - Redesign the database
  - Build professionally engineered software using modern technologies
- Make it easier to
  - Improve data processing and update equations
  - Deliver new parameters (blanks, multiwavelength, etc.)
- Provide tools to the internal team for lab, network, and data management; outreach; and analysis

Data Management Transition – New System

- New, normalized SQL database
- .NET applications for laboratory management
- R Shiny applications for data visualization
- R packages for data processing, validation, and analysis
- New tools and support as needed

Database Transition – it's complicated



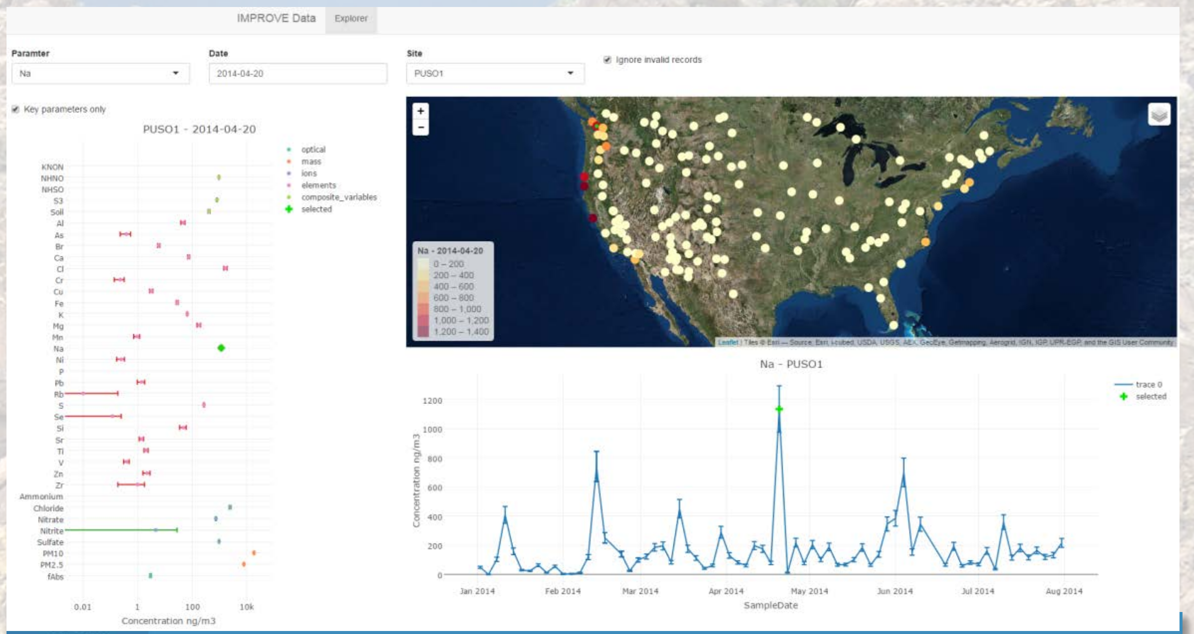


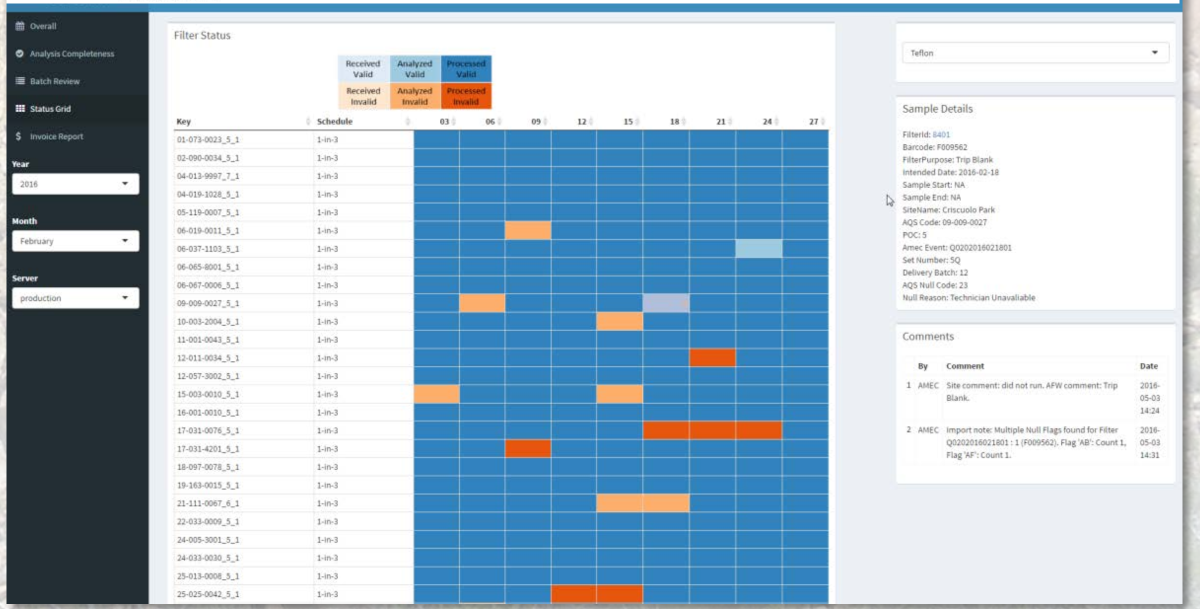
Data Management Transition – Timeline

- 2014
  - Lab application and XRF processing application into production
- 2015 - mid 2016
  - Data management web application into production
  - Data visualization web applications into production
  - Database redesign developed and tested by data management team
- July - December 2016
  - Deploy new database and connect Lab App and Web App for testing in lab
  - Feedback, bug fixing, and iteration
  - Complete transition to new database and components
- 2017 and beyond
  - Critical features for lab and shop management
  - Better tracking of filters throughout process
  - Better tracking and tools for sampler component inventory
  - Integration of field and maintenance notes with data QA tools
  - Etc…

2017 and Beyond

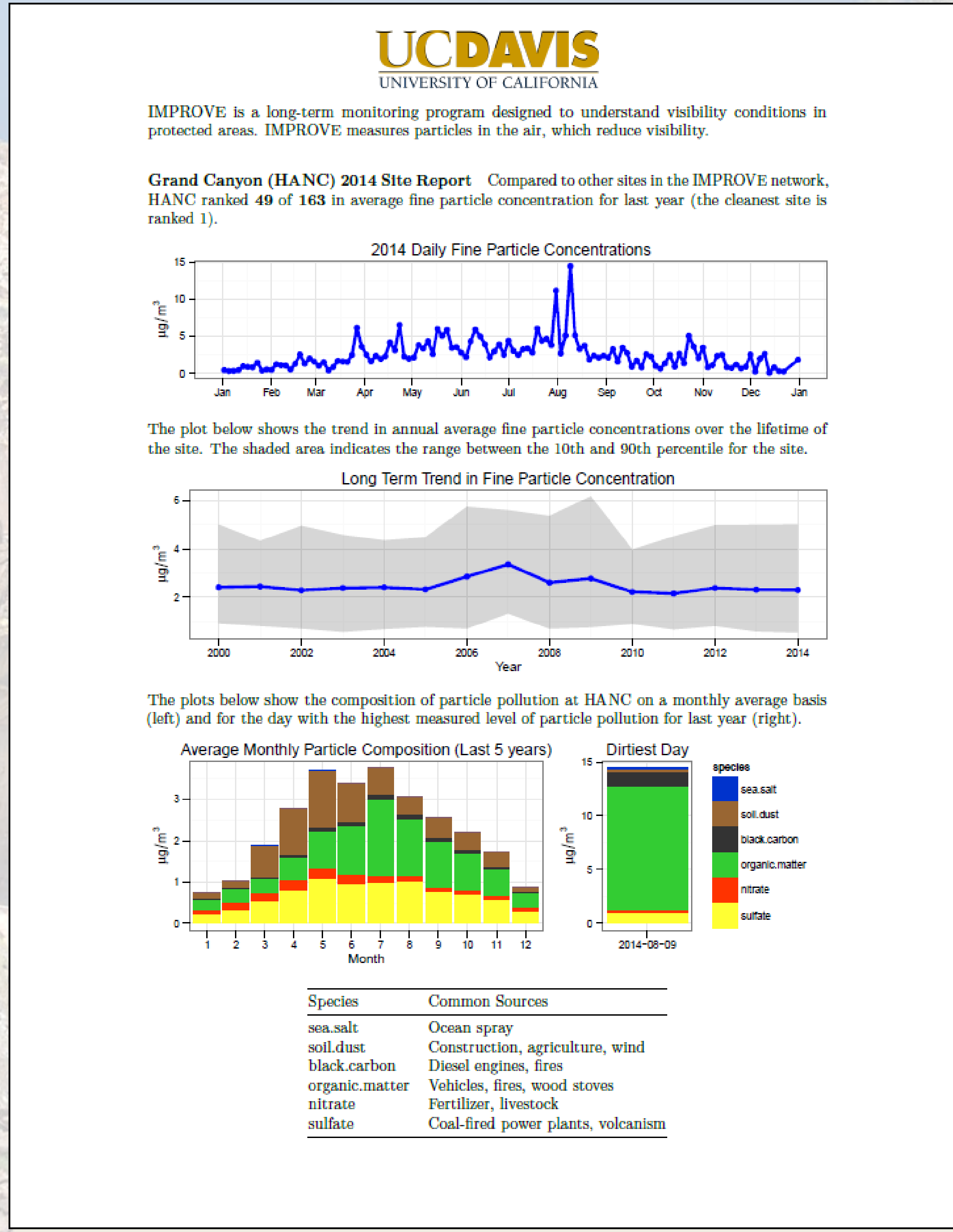
- New database design allows for rapid development of tools
- Port tools developed for CSN to IMPROVE
  - Operational status/ completeness
  - Data validation views
  - Analysis and exploration tools





Annual Site Summary

- Developed last year to create more invested and reliable operators through outreach
- Automatically generated through R Markdown
- Delivered to operators during maintenance visits
- Excellent feedback and interest with suggestions for improvement



UCDAVIS
UNIVERSITY OF CALIFORNIA

IMPROVE is a long-term monitoring program designed to understand visibility conditions in protected areas. IMPROVE measures particles in the air, which reduce visibility.

Grand Canyon (HANC) 2014 Site Report Compared to other sites in the IMPROVE network, HANC ranked **49** of **163** in average fine particle concentration for last year (the cleanest site is ranked 1).

The plot below shows the trend in annual average fine particle concentrations over the lifetime of the site. The shaded area indicates the range between the 10th and 90th percentile for the site.

The plots below show the composition of particle pollution at HANC on a monthly average basis (left) and for the day with the highest measured level of particle pollution for last year (right).

Species	Common Sources
sea.salt	Ocean spray
soil.dust	Construction, agriculture, wind
black.carbon	Diesel engines, fires
organic.matter	Vehicles, fires, wood stoves
nitrate	Fertilizer, livestock
sulfate	Coal-fired power plants, volcanism

Annual Site Summary

New version incorporates feedback from the field and the last steering committee meeting

UCDAVIS
UNIVERSITY OF CALIFORNIA

IMPROVE
Interagency Monitoring of Protected Visual Environments

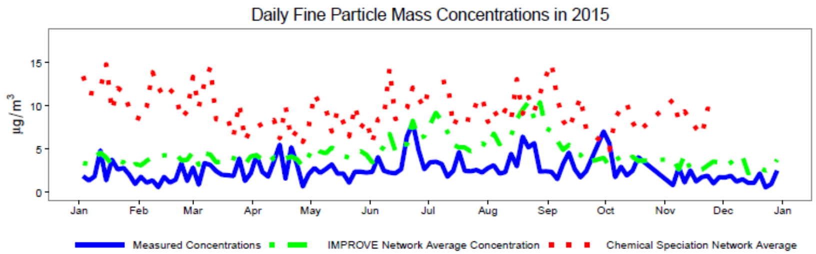
Bandelier (BAND) 2015 Site Report

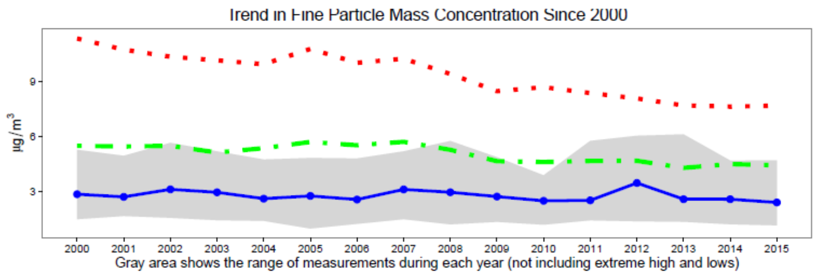
The Interagency Monitoring of Protected Visual Environments (IMPROVE) is a long-term air pollution measurement program designed to document and track visibility in protected areas. IMPROVE samples and analyzes the haze particles that impair visibility so their sources can be identified and addressed.

Percent of Samples from BAND Successfully Collected and Analyzed Per Year

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
86	98	96	81	96	86	86	95	85	89	91	91	94	96	98	93

In the plots below, mass concentrations measured at Bandelier give a sense of the seasonal trends of air quality in the area as well as show significant air quality events such as wildfires and dust storms. These are plotted alongside the average measurements across the IMPROVE network as well as its related Chemical Speciation Network (CSN). The CSN sites are located in urban areas where the populations are highest. In general, lower concentrations would suggest better visibility.





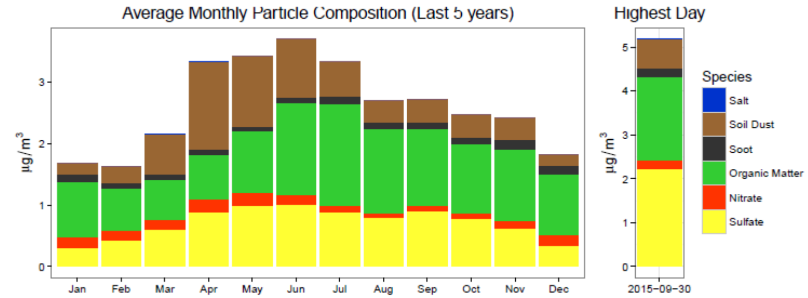
More Information

To view and download IMPROVE data, you can visit: www3.epa.gov/airquality/airdata/
The Univ. of California, Davis website with information about current research and publications: airquality.crocker.ucdavis.edu
The Colorado State Univ. website with data resources, literature, and visibility overviews: vista.cira.colostate.edu/improve/
The EPA website with guidance documents and background information: www3.epa.gov/ttnamti1/visdata.html
Real-time air monitoring data for the United States: www.airnow.gov

UCDAVIS
UNIVERSITY OF CALIFORNIA

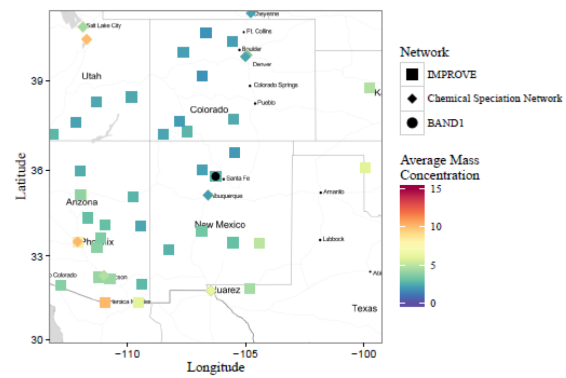
IMPROVE
Interagency Monitoring of Protected Visual Environments

The following plots summarize the chemical composition of particles collected at this site on a monthly average (left) and for the day with the highest measured mass during 2015 (right).



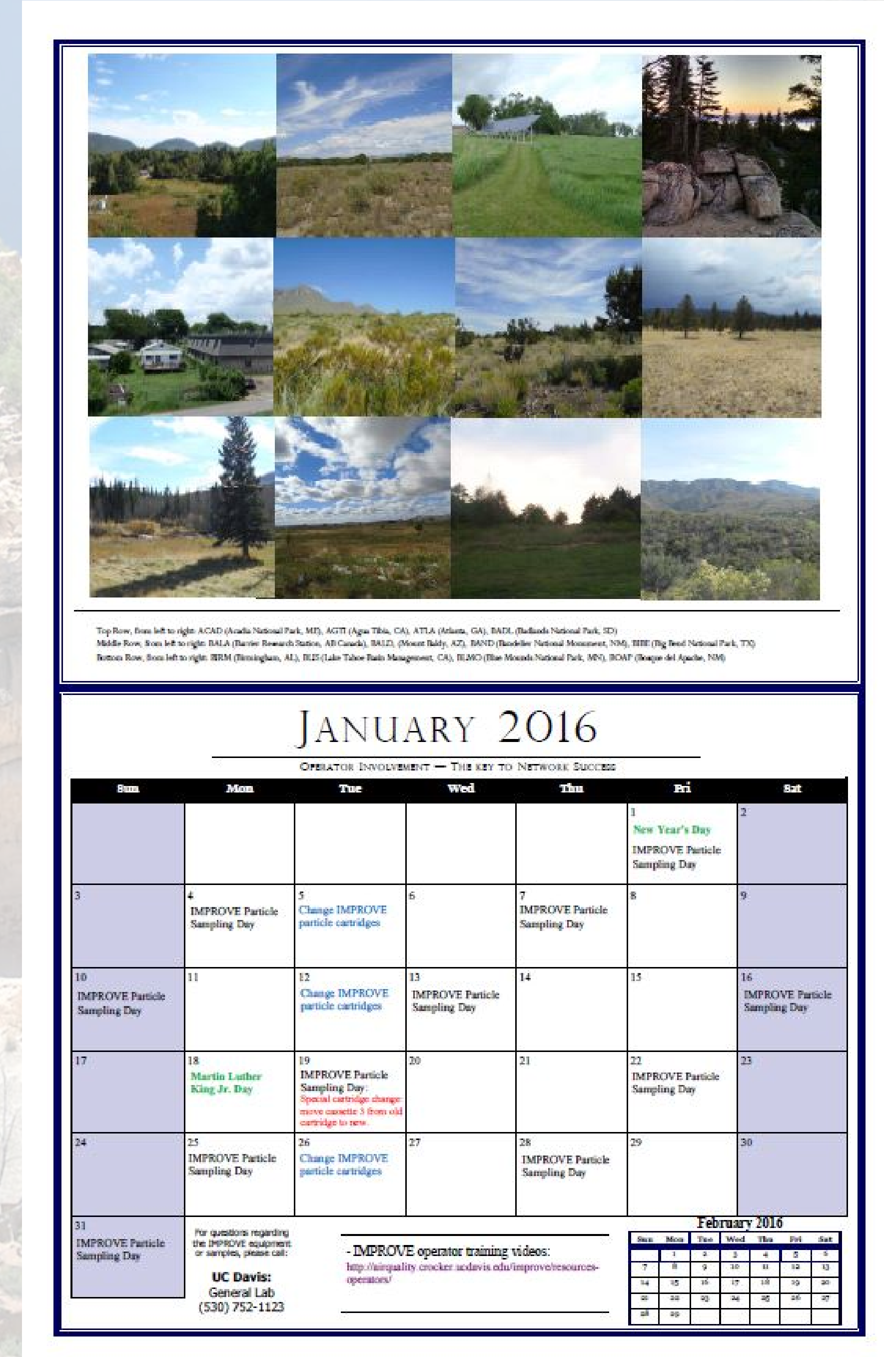
Species	Natural Sources	Human-Made Sources
Salt	Ocean spray, dry lakebeds	Chemical manufacturing, lake consumption
Soil Dust	Soil resuspension, dust storms	Construction, agriculture, deforestation, unpaved roads
Soot	Wildfires	Motor vehicles, wood burning, smoking
Organic Matter	Plants, animals, wildfires	Motor vehicles, cooking oils, household cleaners
Nitrate	Plants, animals	Fertilizer, stock yards, chemical manufacturing
Sulfate	Volcanism	Coal-fired power plants, chemical manufacturing

The following map shows the average mass concentrations for both IMPROVE and the urban Chemical Speciation Network (CSN) sites in the region. The symbols indicate which network the sites are associated with. The color bar indicates the average annual mass concentration (micrograms per cubic meter) measured at each site in 2015.



IMPROVE Calendar

- UCD created 2015 and 2016 calendars and is currently working on 2017 calendar



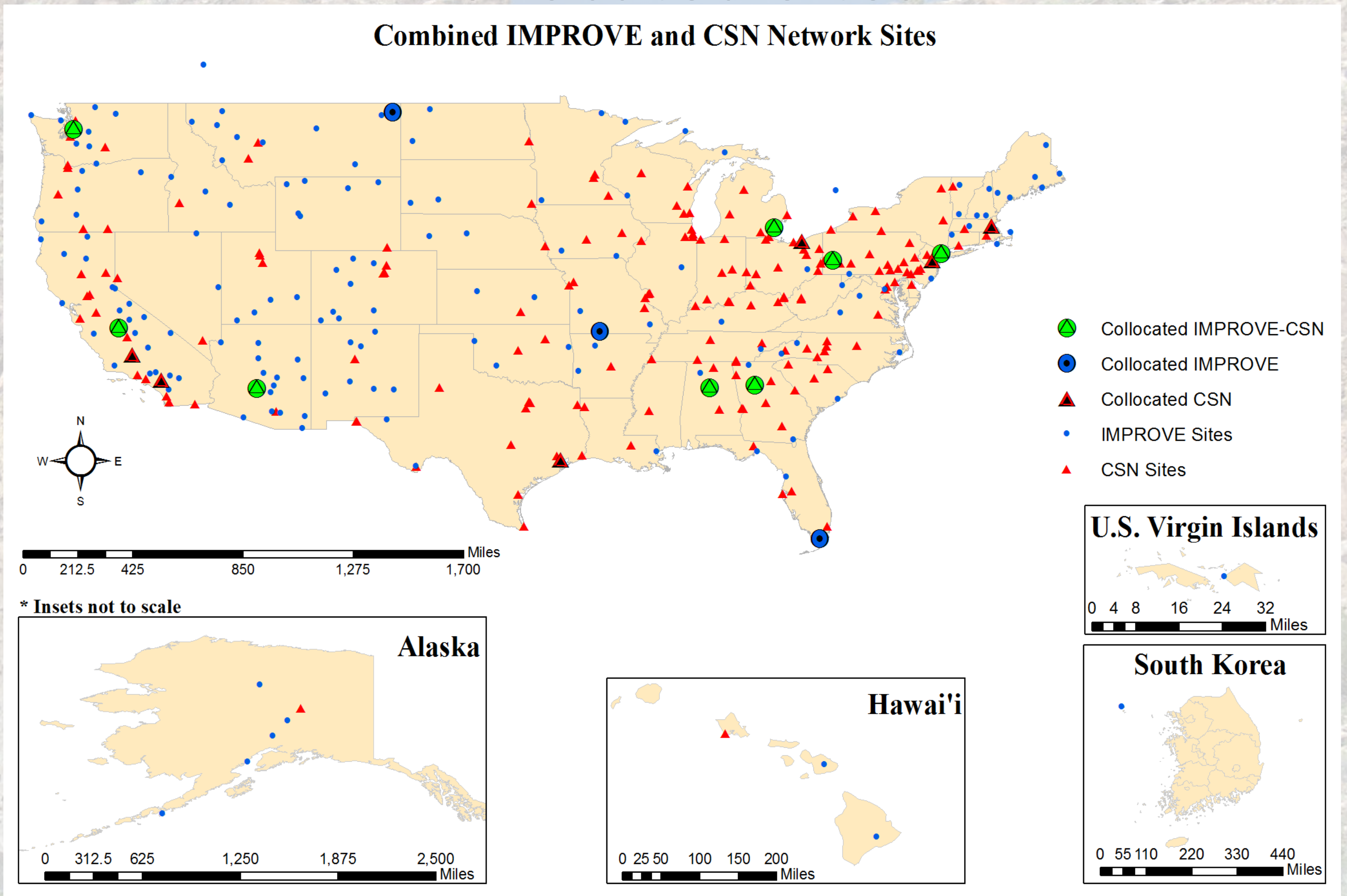
The Impact of CSN Instrumentation Change on OC and EC Concentration Measurements

A Comparison of Pre and Post Measurements Using Data from IMPROVE, CSN, and CSN-IMPROVE Collocated Sites: 2005 Through 2015

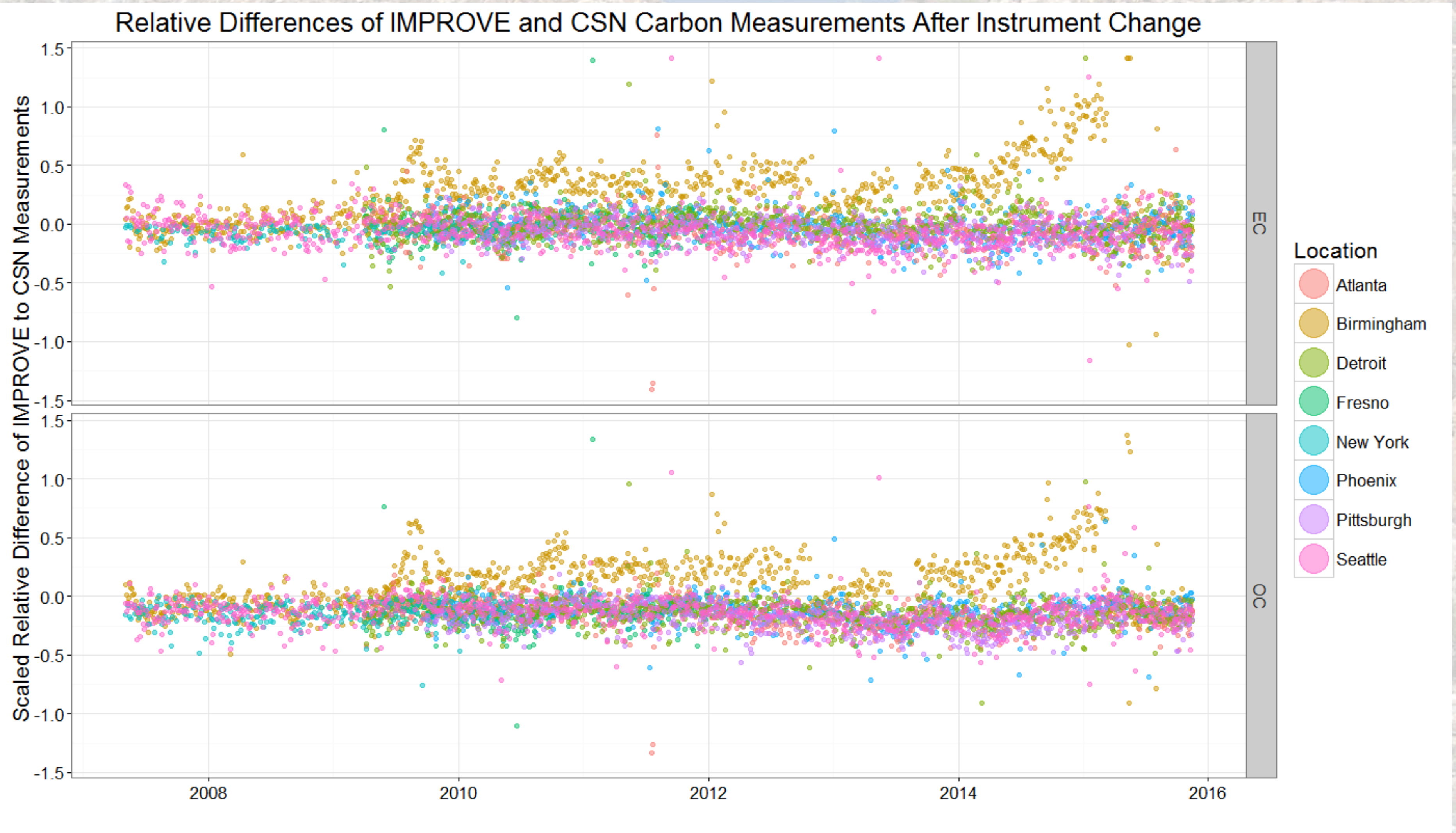
CSN Carbon Measurements

- Beginning in 2007, CSN adopted the IMPROVE-style carbon sampler (URG-3000N) and analysis method to provide consistency for $PM_{2.5}$ carbon data across urban and rural areas.
- The IMPROVE_A analysis method adopted in 2005.
- The replacement of instrumentation occurred over two years, 2007 – 2009
- The data used for this analysis is restricted to IMPROVE_A TOR for OC and EC from 2005 through 2015

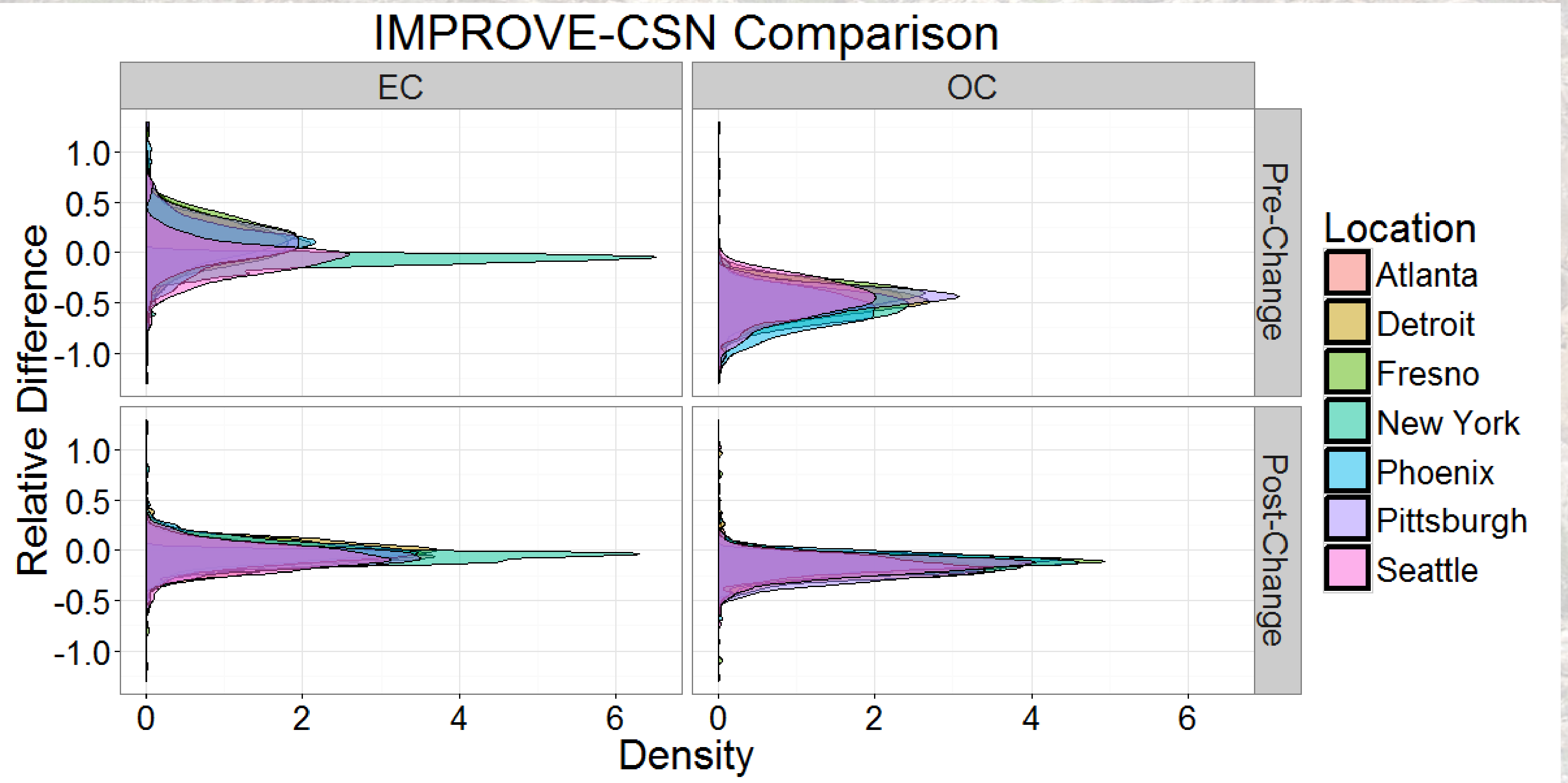
Collocated Sites



Further Refinement of Sites



Greater Equivalency Post-Change



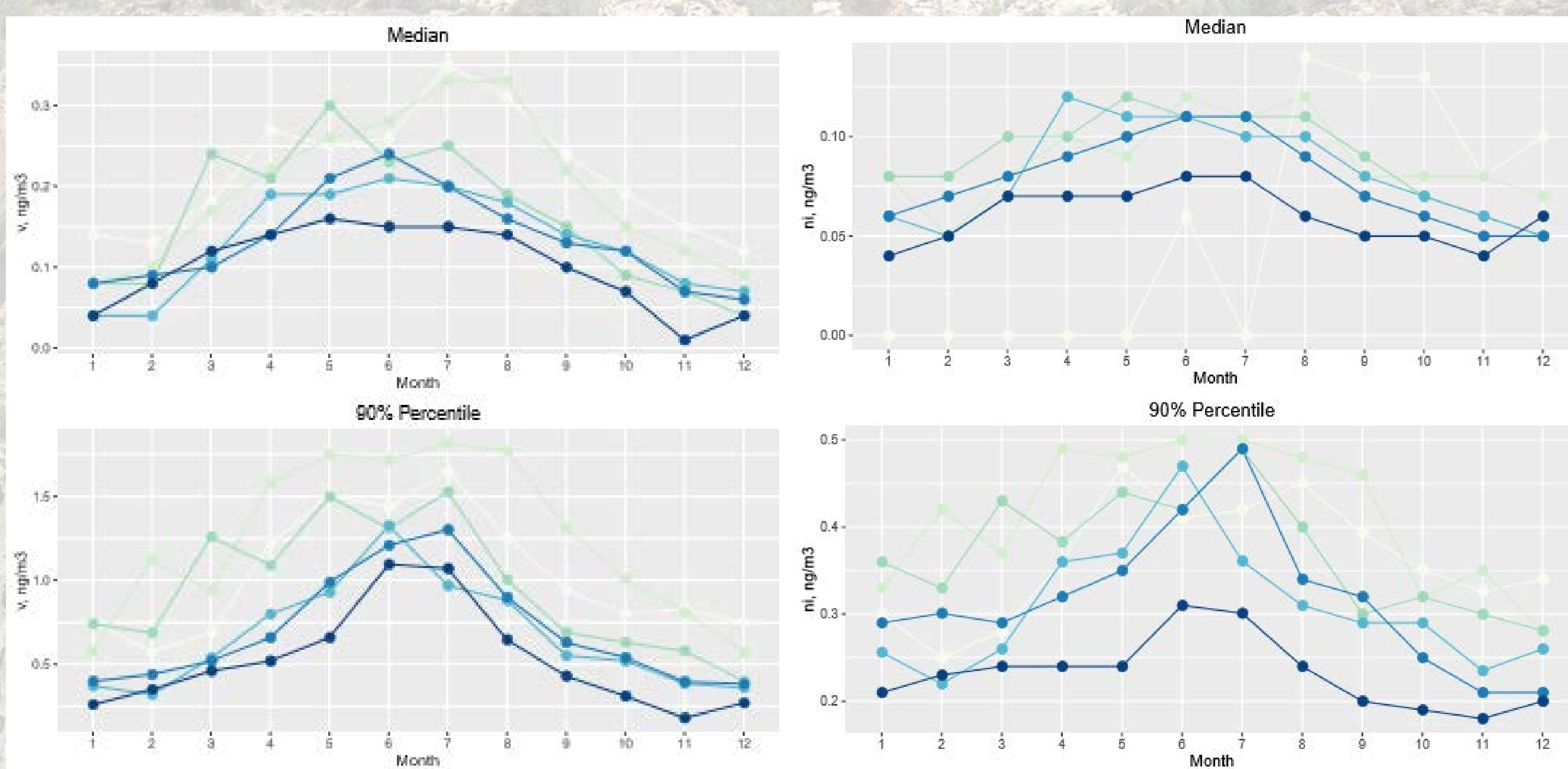
Proportional Uncertainty by Collocated Comparison

Network	OC, %	EC, %	No. Pairs
IMPROVE-IMPROVE	8.5	12.7	2211
CSN-CSN Pre-Change	7.7	8.4	480
CSN-CSN Post-Change	8.1	13.5	1721
IMPROVE-CSN Pre-Change	16.2	17.2	1625
IMPROVE-CSN Post-Change	11.2	13.2	3830

Exciting trends in atmosphere!

Vanadium

Nickel



- Nickel and vanadium are tracers for bunker fuel

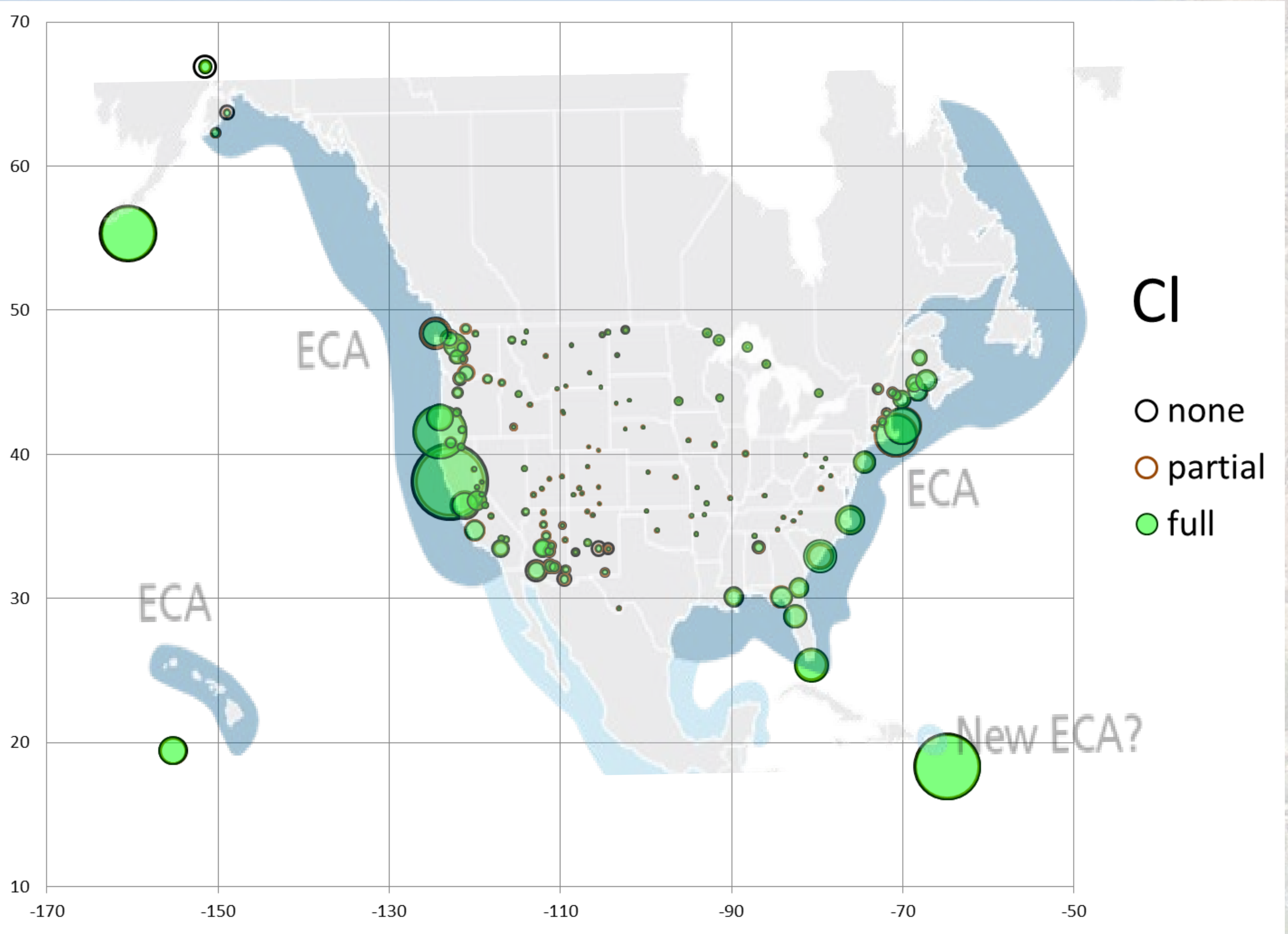
From http://www.turnermason.com/index.php/all-in-the-family-what-is-happening-with-the-bunkers/

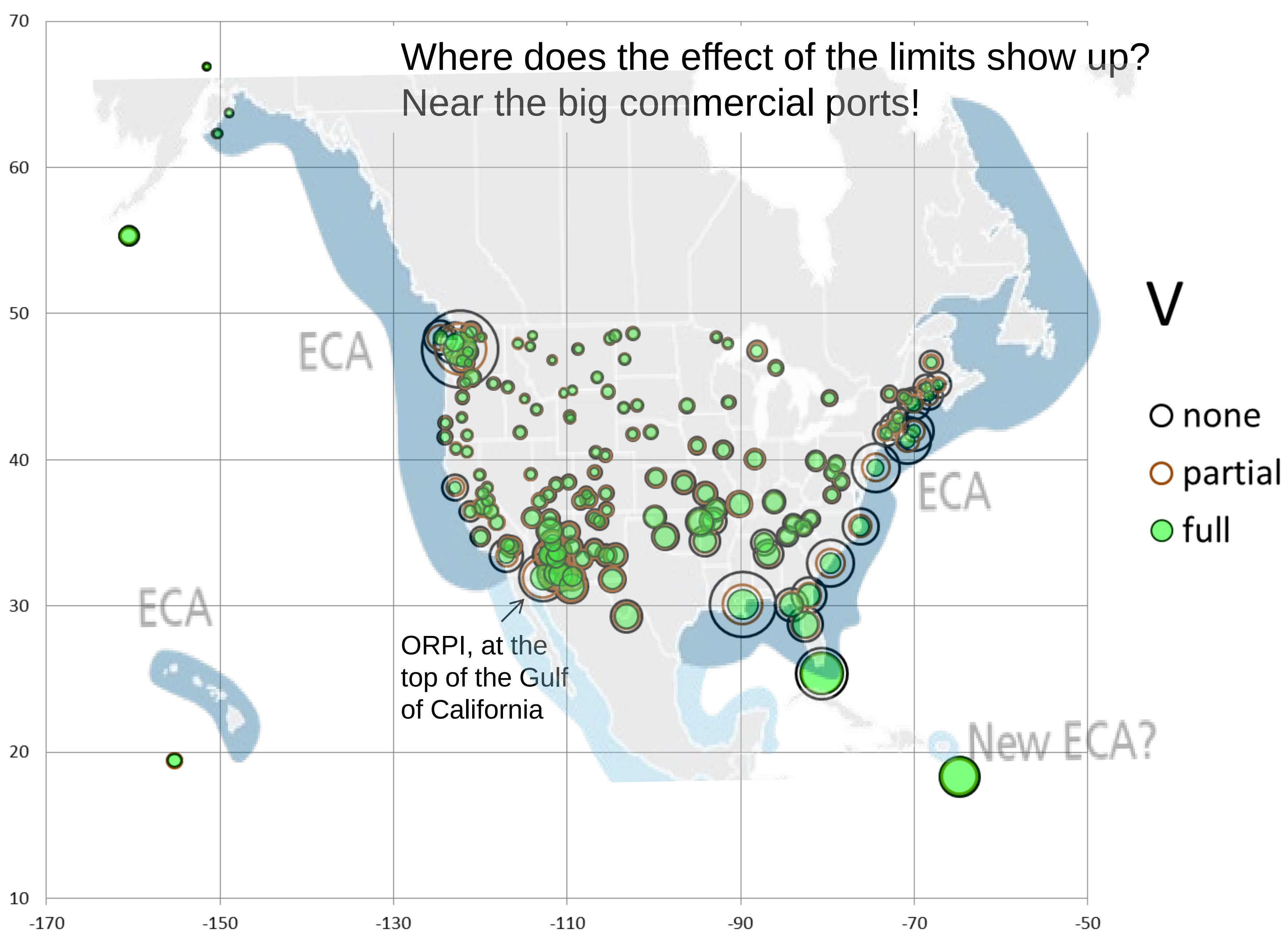
Table 1

Bunker Fuel Regulations		
Outside an ECA established to limit SOx and particulate matter emissions	**Inside an ECA established to limit SOx and particulate matter emissions**	**ARB's California OGV Fuel Requirement Percent Sulfur Content Limit**
4.50% sulfur prior to January 1, 2012	1.50% sulfur prior to July 1, 2010	Phase I effective July 1, 2009: Marine gas oil (DMA) at or below 1.5% sulfur; or Marine diesel oil (DMB) at or below 0.5% sulfur
3.50% sulfur on and after January 1, 2012	1.00% sulfur on and after July 1, 2010	Phase I effective August 1, 2012: Marine gas oil (DMA) at or below 1.0% sulfur; or Marine diesel oil (DMB) at or below 0.5% sulfur
0.50% sulfur on and after January 1, 2020[1,2]	0.10% sulfur on and after January1, 2015	Phase II effective January 1, 2014: Both marine gas oil (DMA) and marine diesel oil (DMB) at or below 0.1% sulfur

1 depending on the outcome of a review, to be concluded by 2018, as to the availability of the required fuel oil, this date could be deferred to January 1, 2025.

2 European Union Directive 2012/33/EU mandates a maximum fuel sulfur content of 0.5% to be burned in ships in the European Economic Zone in areas outside of ECAs, beginning in 2020.


ECA
ECA
ECA
New ECA?
Cl
none
partial
full
70
60
50
40
30
20
10
-170
-150
-130
-110
-90
-70
-50



Where does the effect of the limits show up?
Near the big commercial ports!
ECA
ECA
ECA
New ECA?
ORPI, at the top of the Gulf of California
V
none
partial
full
70
60
50
40
30
20
10
-170
-150
-130
-110
-90
-70
-50

The End

Any questions?