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

<table>
<thead>
<tr>
<th>Year</th>
<th>ABCD recovery</th>
<th>Operator no-show</th>
<th>Bad installation</th>
<th>Equipment problem</th>
<th>Power outage</th>
<th>Destroyed/ No filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>93%</td>
<td>1.3%</td>
<td>1.1%</td>
<td>2.9%</td>
<td>0.9%</td>
<td>0.8%</td>
</tr>
<tr>
<td>2006</td>
<td>92%</td>
<td>1.9%</td>
<td>1.0%</td>
<td>2.8%</td>
<td>1.4%</td>
<td>0.9%</td>
</tr>
<tr>
<td>2007</td>
<td>92%</td>
<td>2.1%</td>
<td>1.0%</td>
<td>2.5%</td>
<td>1.4%</td>
<td>1.0%</td>
</tr>
<tr>
<td>2008</td>
<td>90%</td>
<td>2.1%</td>
<td>1.3%</td>
<td>4.5%</td>
<td>1.5%</td>
<td>0.6%</td>
</tr>
<tr>
<td>2009</td>
<td>91%</td>
<td>1.9%</td>
<td>1.1%</td>
<td>3.6%</td>
<td>1.8%</td>
<td>0.6%</td>
</tr>
<tr>
<td>2010</td>
<td>92%</td>
<td>2.3%</td>
<td>0.9%</td>
<td>3.1%</td>
<td>1.4%</td>
<td>0.5%</td>
</tr>
<tr>
<td>2011</td>
<td>91%</td>
<td>2.4%</td>
<td>0.9%</td>
<td>3.1%</td>
<td>1.8%</td>
<td>0.6%</td>
</tr>
<tr>
<td>2012</td>
<td>94%</td>
<td>1.9%</td>
<td>0.9%</td>
<td>1.6%</td>
<td>1.4%</td>
<td>0.6%</td>
</tr>
<tr>
<td>2013</td>
<td>94%</td>
<td>2.0%</td>
<td>1.1%</td>
<td>1.5%</td>
<td>1.2%</td>
<td>0.5%</td>
</tr>
<tr>
<td>2014</td>
<td>94%</td>
<td>2.3%</td>
<td>1.2%</td>
<td>1.0%</td>
<td>1.1%</td>
<td>0.3%</td>
</tr>
<tr>
<td>2015</td>
<td>94%</td>
<td>1.8%</td>
<td>1.3%</td>
<td>1.4%</td>
<td>1.0%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>
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
RAFA: No panel cover, mixed breaker types, single 20A supply to sampler

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

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

Combined IMPROVE and CSN Network Sites

* Insets not to scale

Alaska

Hawai'i

South Korea
Further Refinement of Sites

Relative Differences of IMPROVE and CSN Carbon Measurements After Instrument Change.
Greater Equivalency Post-Change
Proportional Uncertainty by Collocated Comparison

<table>
<thead>
<tr>
<th>Network</th>
<th>OC, %</th>
<th>EC, %</th>
<th>No. Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMPROVE-IMPROVE</td>
<td>8.5</td>
<td>12.7</td>
<td>2211</td>
</tr>
<tr>
<td>CSN-CSN Pre-Change</td>
<td>7.7</td>
<td>8.4</td>
<td>480</td>
</tr>
<tr>
<td>CSN-CSN Post-Change</td>
<td>8.1</td>
<td>13.5</td>
<td>1721</td>
</tr>
<tr>
<td>IMPROVE-CSN Pre-Change</td>
<td>16.2</td>
<td>17.2</td>
<td>1625</td>
</tr>
<tr>
<td>IMPROVE-CSN Post-Change</td>
<td>11.2</td>
<td>13.2</td>
<td>3830</td>
</tr>
</tbody>
</table>
Exciting trends in atmosphere!

• Nickel and vanadium are tracers for bunker fuel
<table>
<thead>
<tr>
<th>Bunker Fuel Regulations</th>
<th>Outside an ECA established to limit SOx and particulate matter emissions</th>
<th>Inside an ECA established to limit SOx and particulate matter emissions</th>
<th>ARB’s California OGV Fuel Requirement Percent Sulfur Content Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.50% sulfur prior to January 1, 2012</td>
<td>1.50% sulfur prior to July 1, 2010</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td>3.50% sulfur on and after January 1, 2012</td>
<td>1.00% sulfur on and after July 1, 2010</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td>0.50% sulfur on and after January 1, 2020¹,²</td>
<td>0.10% sulfur on and after January 1, 2015</td>
<td>Phase II effective January 1, 2014: Both marine gas oil (DMA) and marine diesel oil (DMB) at or below 0.1% sulfur</td>
</tr>
</tbody>
</table>

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.
Where does the effect of the limits show up?
Near the big commercial ports!
ORPI, at the top of the Gulf of California
The End

Any questions?