Update of IMPROVE Carbon Analysis

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2021 IMPROVE Technical Steering Committee Meeting
Virtual Meeting
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Objectives

• Report status of IMPROVE carbon analyses

• **Review internal quality control (QC) checks**

• Discuss operational challenges and improvements
DRI’s Environmental Analysis Facility (EAF) continuously operates 10-13 Model 2015 Multiwavelength Carbon Analyzers (2016-Present, analyzed over ~225,000 samples with ~100,000 for IMPROVE)

EAF Carbon Laboratory (Magee Scientific, Berkeley, CA and Aerosol, d.o.o., Ljubljana, Slovenia)
Carbon Laboratory Operations

(July 2020 – June 2021 samples, n= ~12,000)

- Received ~1,660 IMPROVE samples per month (varies from 0 to 4,800 samples per month)

- Operated ~13 hours per day, 5 days per week, increased to ~18 hours per day, 7 days per week since August.

- Vinay Amin moved to the Financial Services Office and is pursuing his MBA degree. Matt Claassen has assumed responsibility since June 2021.
**Completed analyses of 2020 samples in August 2021 and currently analyzing May 2021 samples**

(July 2020 to June 2021 samples)

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Sample Receive Dates</th>
<th>Number of Samples Received</th>
<th>Analysis Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/1/20 – 12/31/20</td>
<td>8/25/20 – 4/14/21</td>
<td>10,016</td>
<td>August 2021</td>
</tr>
<tr>
<td>1/1/21 – 6/30/21</td>
<td>4/30/21 – 9/30/21*</td>
<td>9,961*</td>
<td>December 2021 (est.)</td>
</tr>
</tbody>
</table>

*as of 11/08/21
Carbon throughput averaged ~90 samples per day*

(Analysis Period: January 2020 – October 2021)

*Excludes calibration runs and includes other projects
Sample throughput has increased in recent months

(Operation from January 2020 - October 2021)
Average 34 runs per day are dedicated to multiple quality control (QC) checks

(October 2020 - September 2021)

n=12,370 QC runs per year
A more efficient oxygen test was implemented to verify $\text{O}_2<100$ ppm in the He carrier gas (measured $\text{O}_2<60$ ppm).

All DRI Model 2015 Carbon Analyzers are tested for trace oxygen on a semi-annual basis.
Established new protocols for data validation

• Automated procedures to increase accuracy and efficiency
  - Generate comparisons for replicates, reruns, and collocated samples
  - **Identify extreme values** (e.g., high, low, zero, and negative)
  - Monitor deviations from calibration peaks and sending alert to signal instrument malfunction
  - **Streamline data validation and reporting**

• Created visualization tools
  - Examine relationship between light attenuation and elemental carbon
  - **Evaluate temporal variation** (e.g., comparison with historical medians)

Sample rerun rates have been reduced from 8% to 3%
Additional protocols were added to facilitate efficient data validation

• Implemented additional automated processes
  - Find missing or mislabeled runs
  - **Inspect manual inputs for correctness**
  - Automate final report generation and replicate acceptance for uncertainty calculations

• Use Machine Learning for future automation in data validation
  - Apply large historical dataset for model training
  - **Rerun prediction is approaching 60% accuracy during testing**
Recent publications highlight the applications for multiwavelength data and brown carbon
Empirical adjustment factors of 2-4 may be needed to apportion light absorption to BC and BrC

Chow et al. 2021, Particuology
Filter loading adjusted ATN$_{BrC,405}$ tripled for CSN (3.6 to 10.7%) and 1.25 times for IMPROVE (23.7 to 29.5%).

Chow et al. 2021, Particuology
Using paired wavelength derived $\text{AAE}_{\text{BC}}$ increased BrC light attenuation for CSN by twofold (10.7 to 21.6%) and for IMPROVE by 11% (29.5 to 32.7%)
Large seasonal variations found in brownness of organic aerosol
(Higher brownness index during winter than summer months)

Chen et al., 2021, EST
Higher brownness index during winter in the Northeastern and Midwest regions

(IMPROVE winter [June, Feb, & Dec] and summer [June, July, & Aug])

\[ \gamma_{\text{BrC}}, \text{brownness index} = \frac{[\text{BrC}]}{[\text{OC}^*]} \]

with \( \gamma_{\text{BrC}} \) between 0 to 1

Chen et al., 2021, EST
GEOS-Chem/GCM models reproduce the spatiotemporal pattern of $\text{BrC}_{\text{AAOD}}^*$

(Circles are IMPROVE BrC)

PBL AAOD: Planetary Boundary Layer Absorption Aerosol Optical Depth at 365 nm
$= \text{MAC}_{\text{BrC}_\lambda} \times \text{Mass}_{\text{BrC}} \times \text{PBL}_{\text{height}}$

June et al., 2020, GRL
BrC absorption radiative effect (DRE) shows higher impacts over the Northern high latitude

BrC can account for over 50% of BC+BrC warming in Northern high latitude during spring and summer

June et al., 2020, GRL
Example 2020-2021 publications and reports using the IMPROVE_A protocol (n=45)


Example 2020-2021 publications and reports using the IMPROVE_A protocol (n= 45)


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