IMPROVE Carbon Analysis Update

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Presented at:

IMPROVE Steering Committee Meeting

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Objectives

- Report status of IMPROVE carbon analyses
- Present comparability between Series I and II DRI Model 2015 Multiwavelength Thermal/Optical Carbon Analyzer (Aerosol Magee Scientific, www.aerosolmageesci.com)

DRI's Environmental Analysis Facility (EAF) continuously operates 10-13 Model 2015 Multiwavelength Carbon Analyzers

(January 2016- September 2023, analyzed ~290,750 samples with ~136,015 for IMPROVE)

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

Carbon Laboratory Operations

- Received an average of 1,505 IMPROVE samples per month between October 2022 and September 2023 (varied from 0 to 3,200).
- Analyzed 15,979 IMPROVE samples from October 2022 to September 2023.
- Average 10-13 hours/day, 5 days a week except for June-August period (4-6 hours/day, 5 days/week) during old/new contract transition.
- Matt Claassen and Patrick Myers are the core of the EAF Carbon team (2021-present).

Matt


Pat

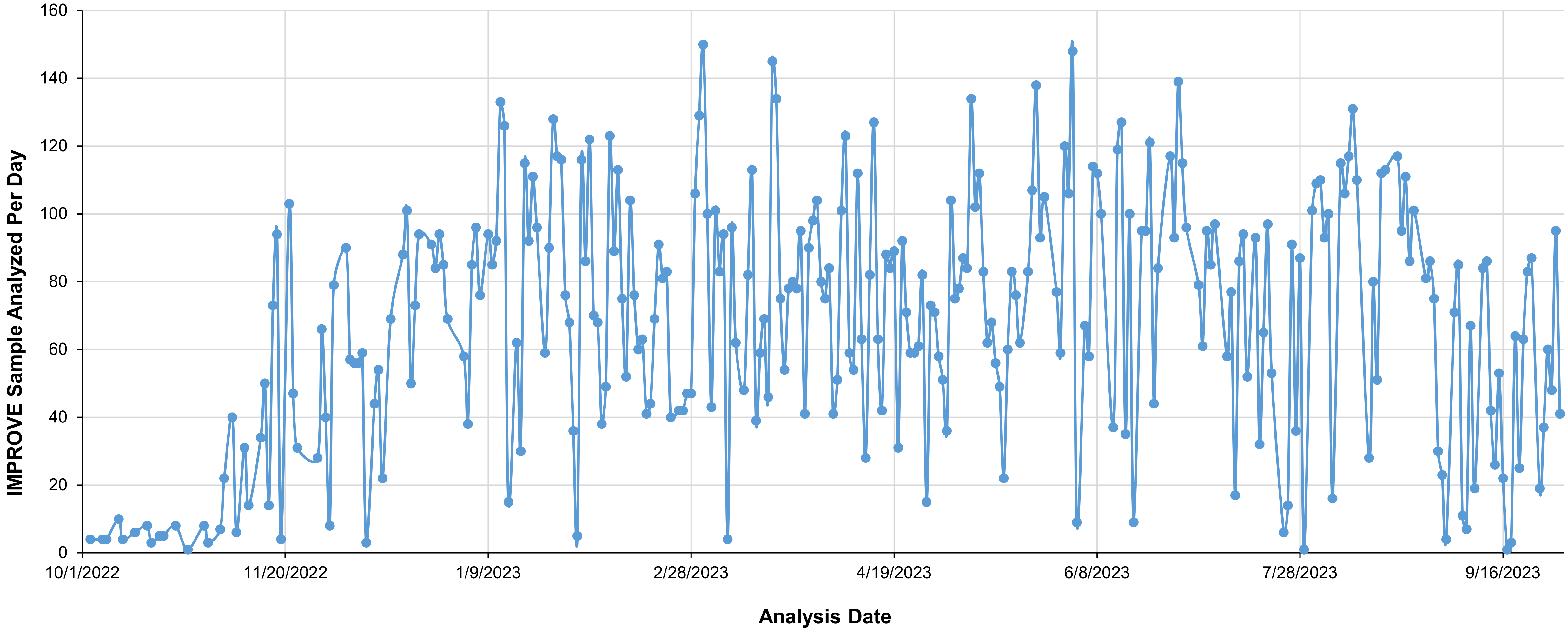

2022 sample analysis was completed in July 2023

Sampling Period	Samples Received Dates	Number of Samples Received	Analysis Completion Date
10/1/22 – 12/31/22	10/12/22 – 6/27/23	4,455	7/12/2023
1/3/23 – 9/18/23	6/1/23 – 9/28/2023	12,350	Late Dec. 2023 – Mid Jan. 2024 (est*)

*As of 10/6/2023

Carbon throughput averaged ~ 69 samples per workday (~ 8 samples per day per analyzer)*

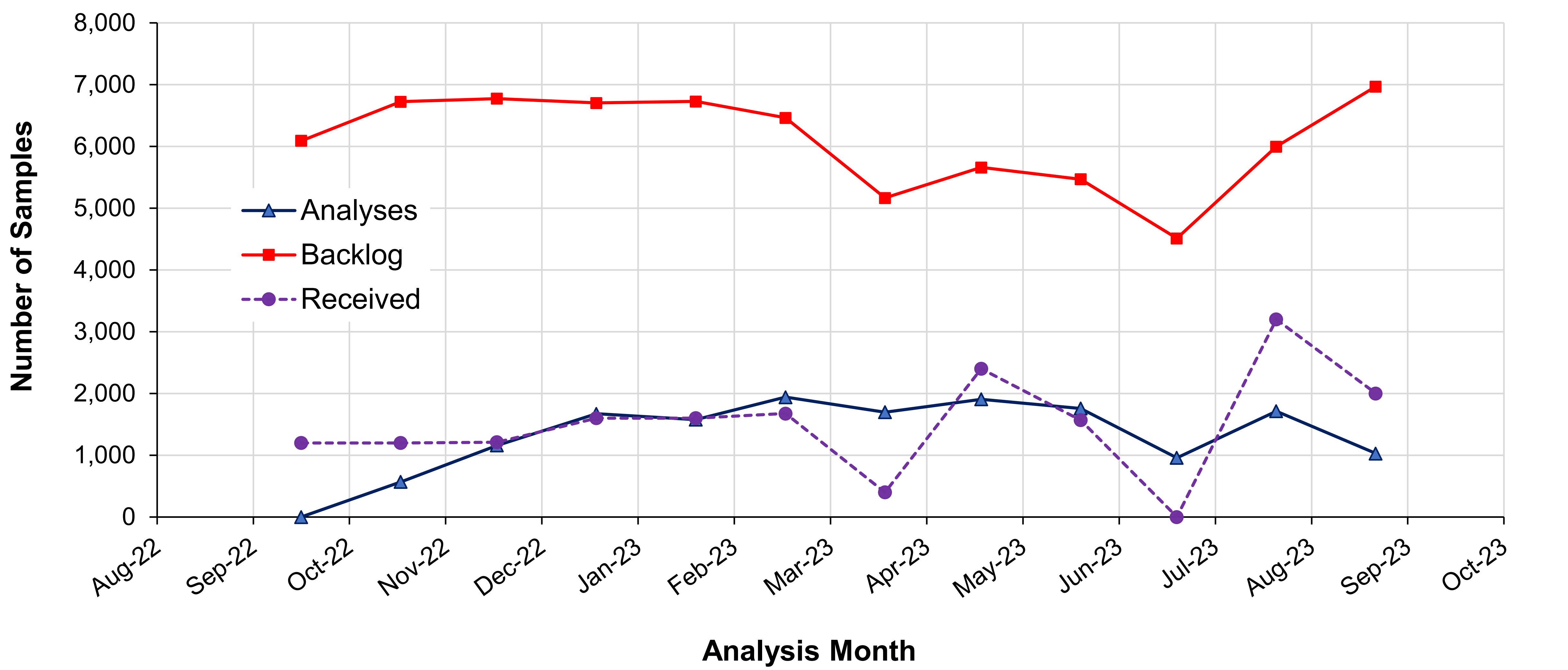
(October 2022- September 2023)



*Excludes calibration runs and other projects

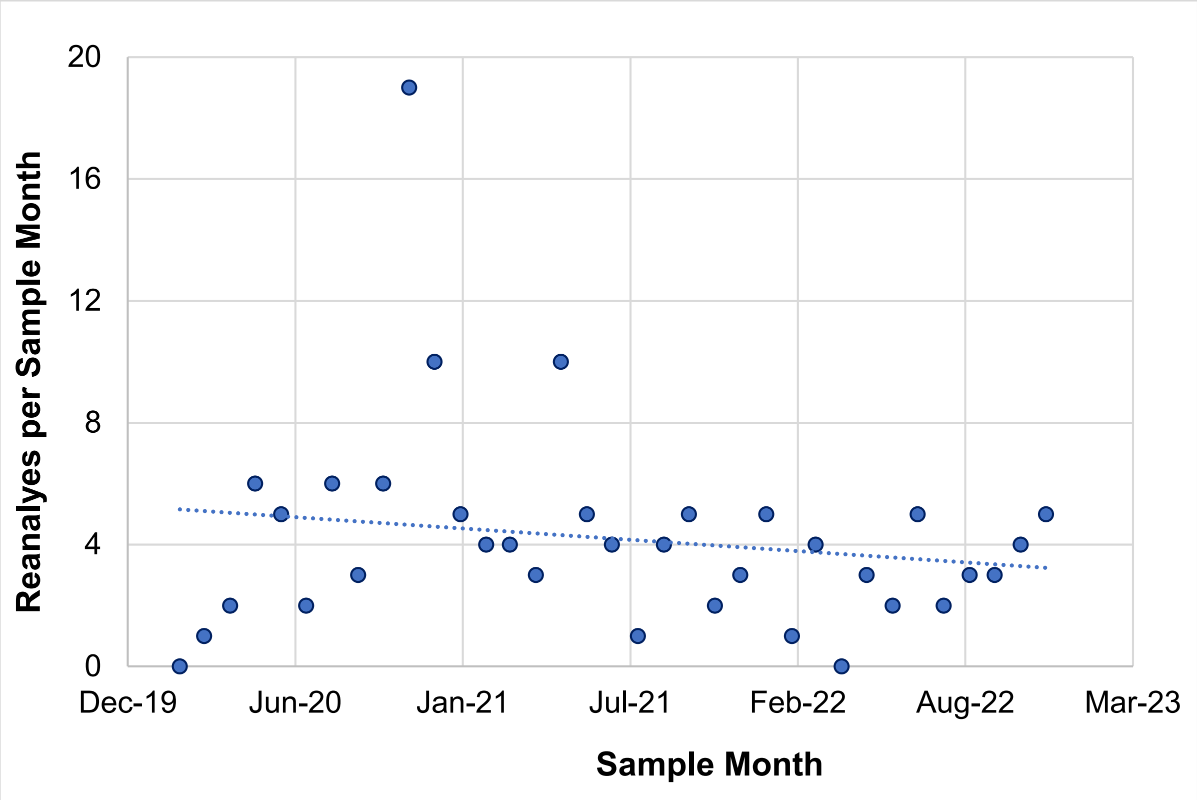
Carbon backlog and throughput remained stable

(October 2022– September 2023)

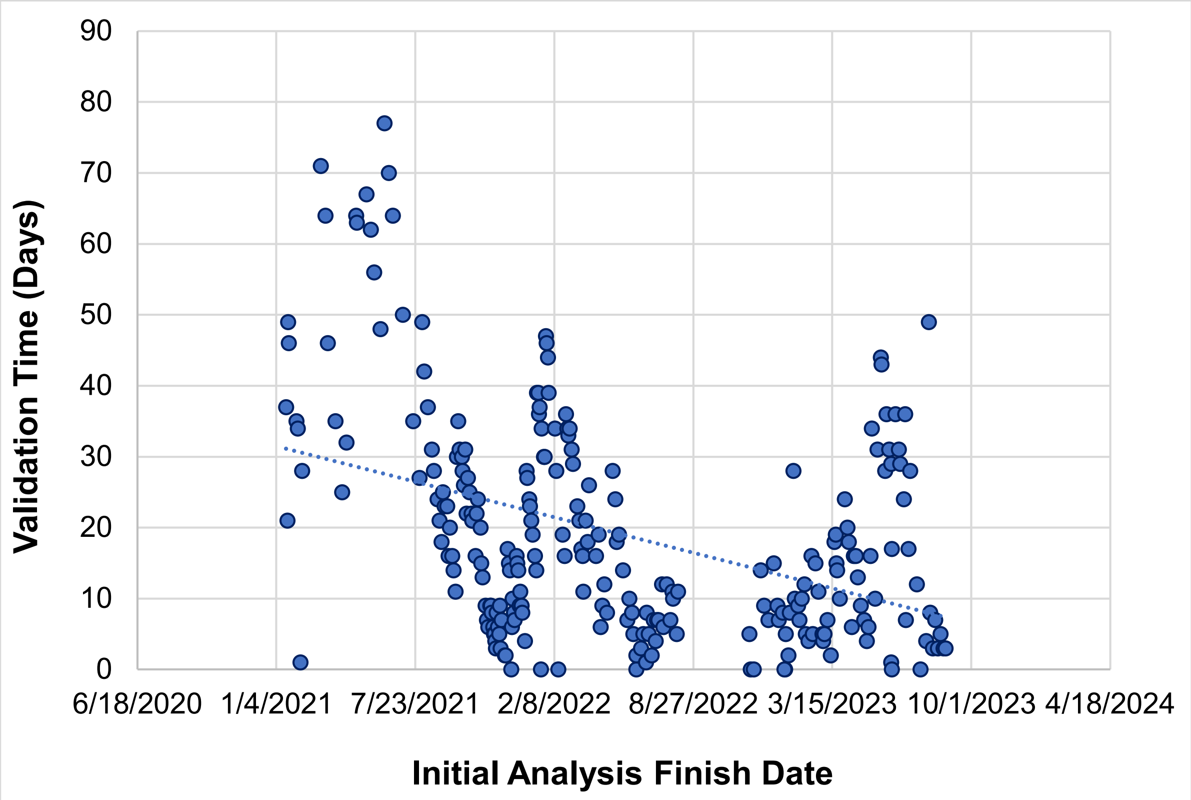


Streamlined data processing and validation have reduced reanalysis rates and shortened the reporting time

Sample reanalysis rate reduced by ~40%

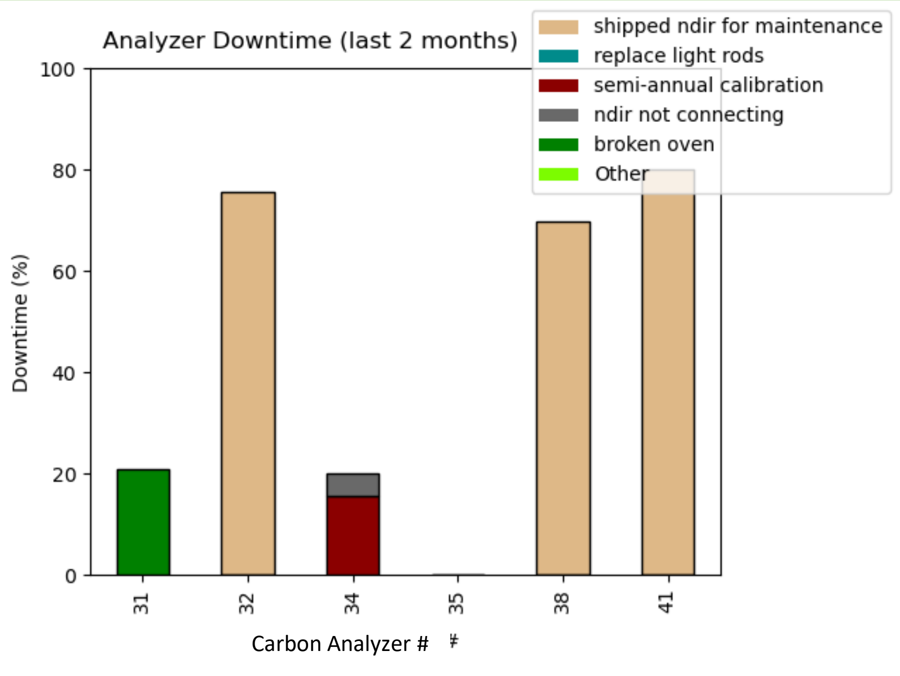


Sample validation to report duration reduced by ~70%



Updated software monitors analyzer status and tracks maintenance and calibration status

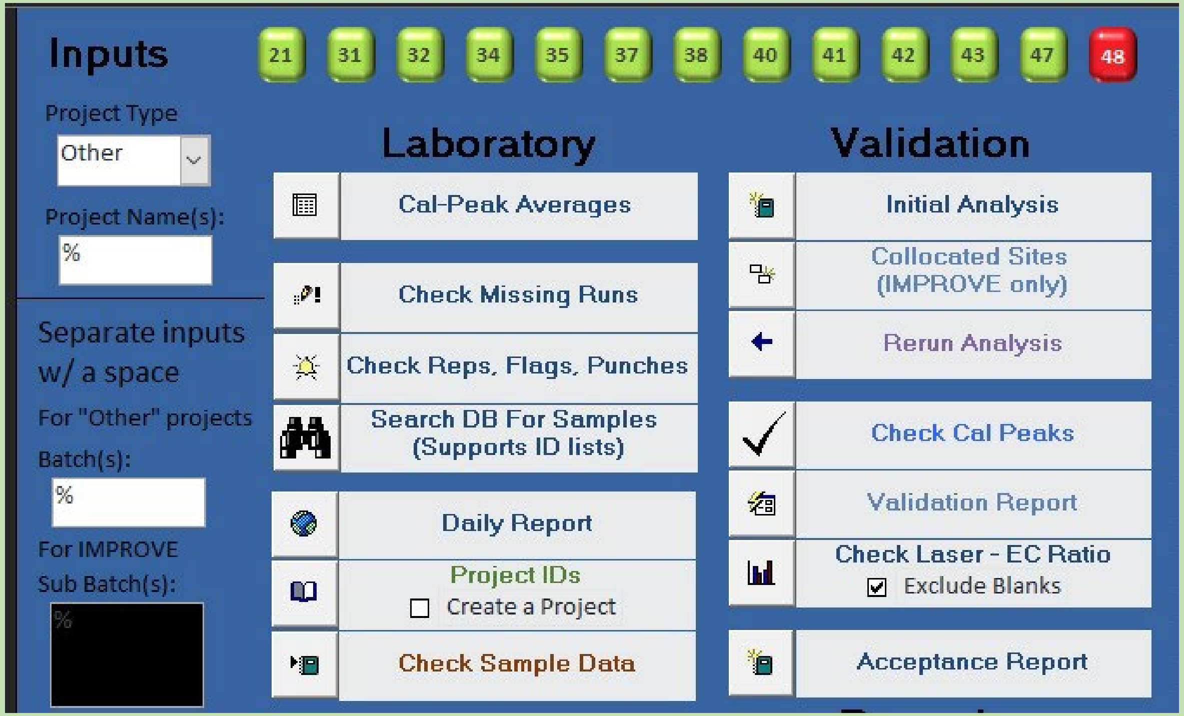
Percent of Downtime by Analyzer



Digital Display

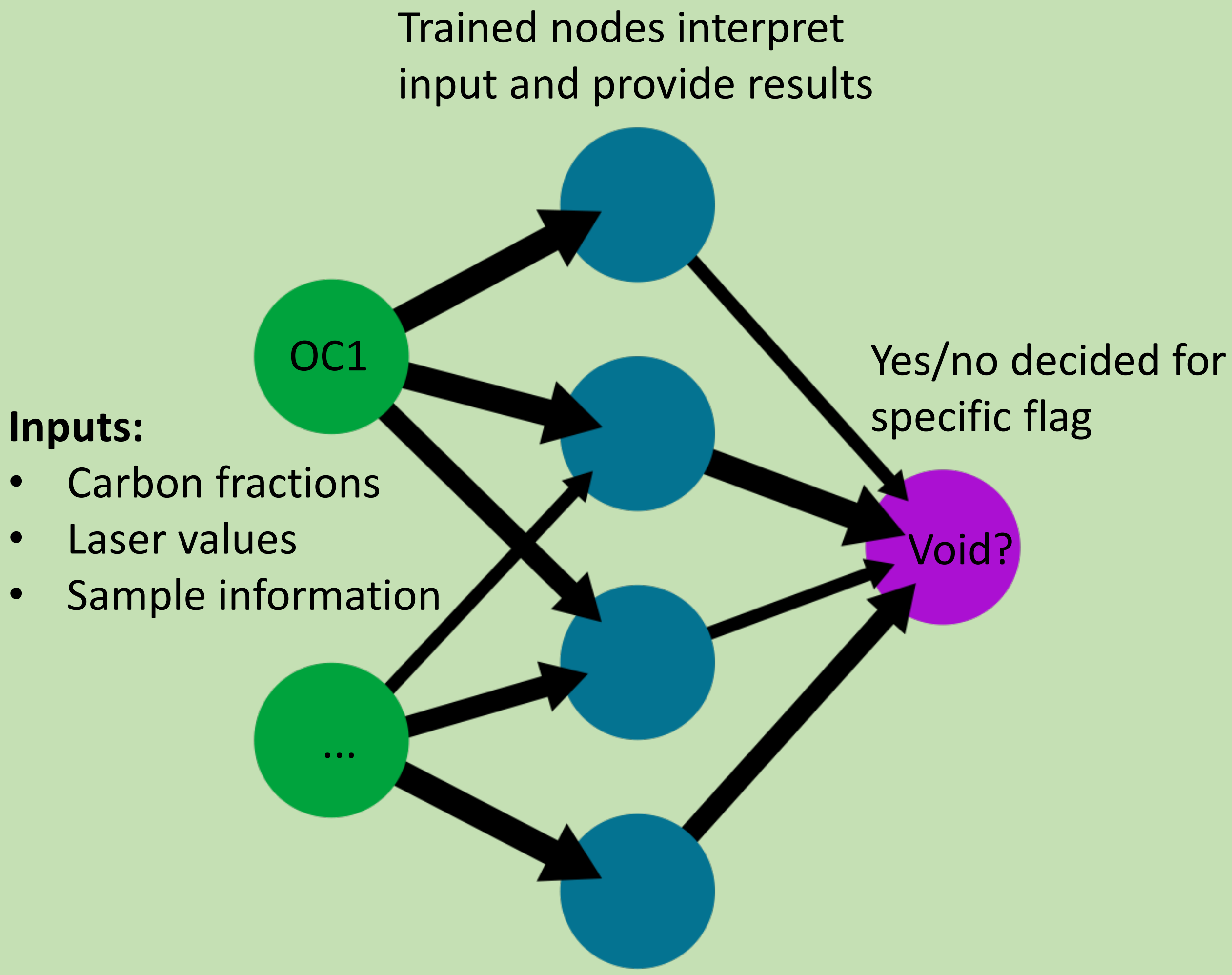
Green = Online

Red = Offline



Application of a neural network can further streamline data validation process

- Able to detect complex input combinations or single points of error
- Assign conservative warning (awaiting staff confirmation)
- Flag data by a complementary method
- Reveal insights about analyzer behavior or deposit trends



Test of Comparability Between Series I and II DRI Model 2015 Carbon Analyzers

Series I

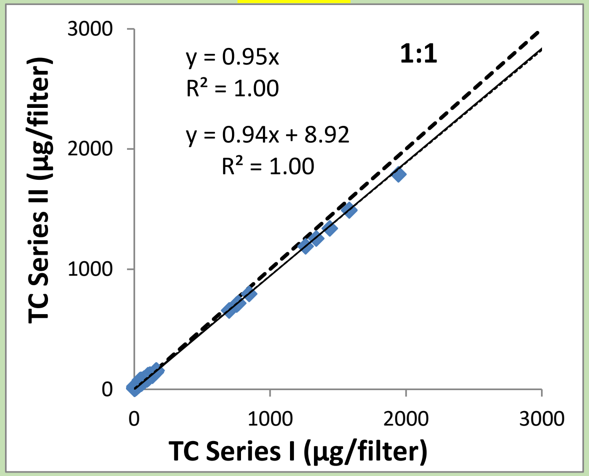
Series II

Auto-loader

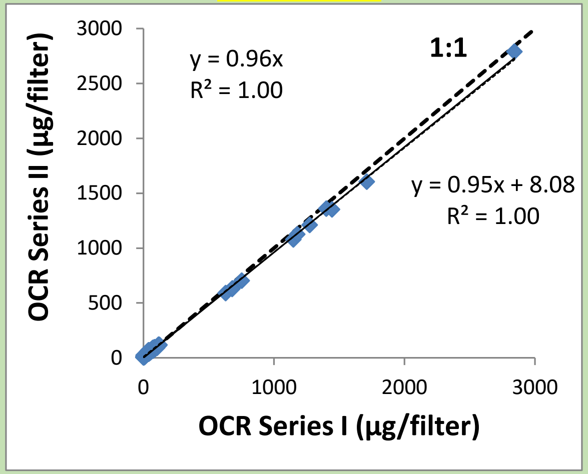
Good correlations between Series I and II for TC, OC, and EC

(n = 135)

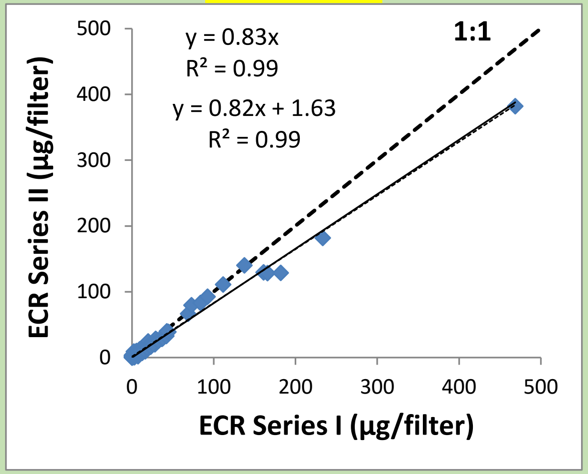
TC



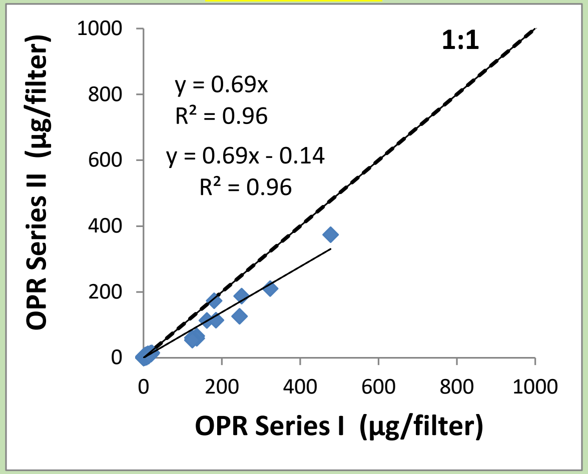
OCR



ECR

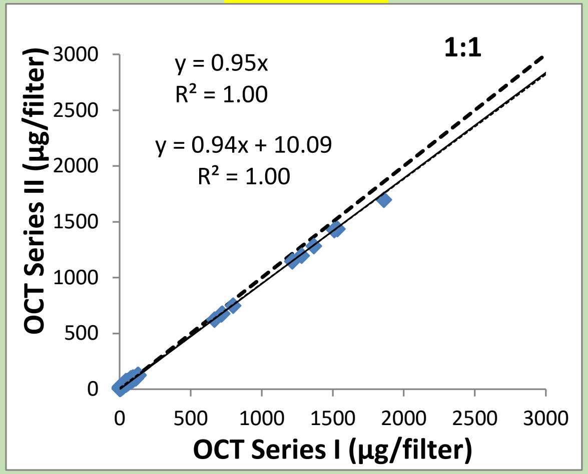


OPR

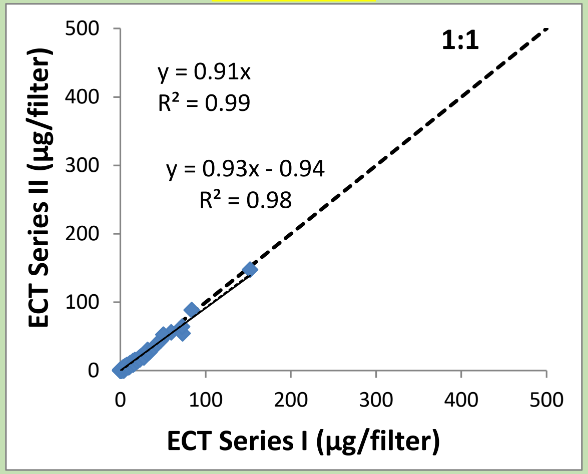


PM$_{2.5}$ Sampler (DRI Reno campus, NV)

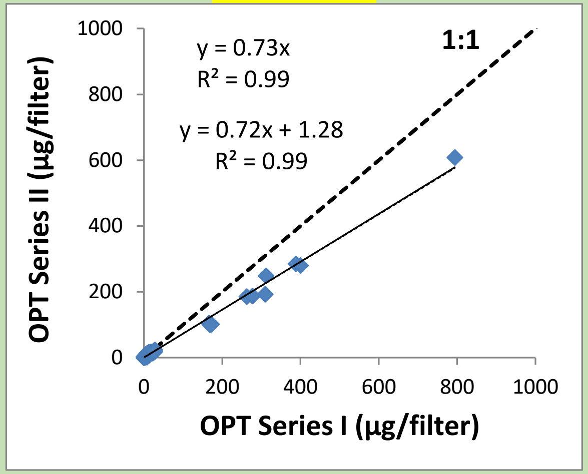
OCT



ECT



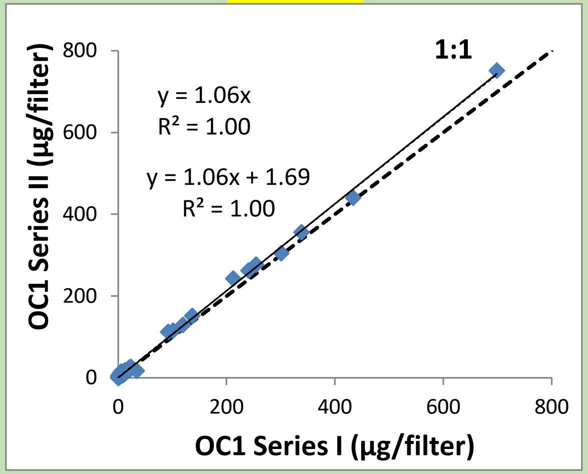
OPT



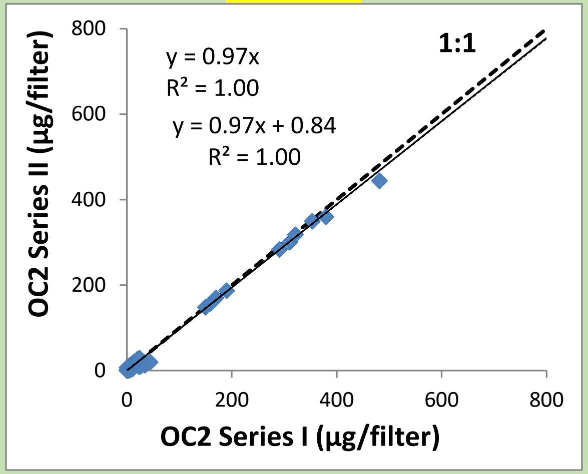
Series I and II carbon analyzers show reasonable comparability among carbon fractions

(n = 135)

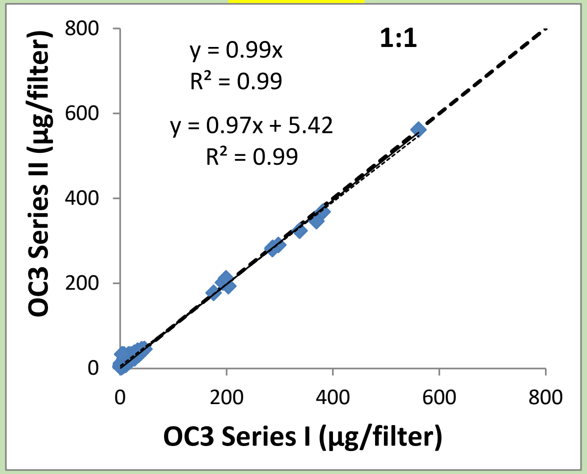
OC1



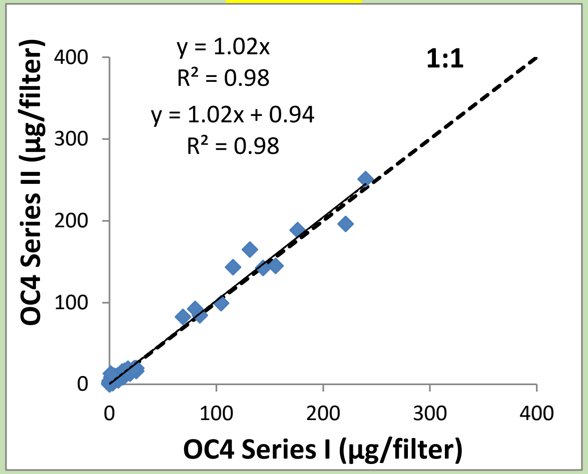
OC2



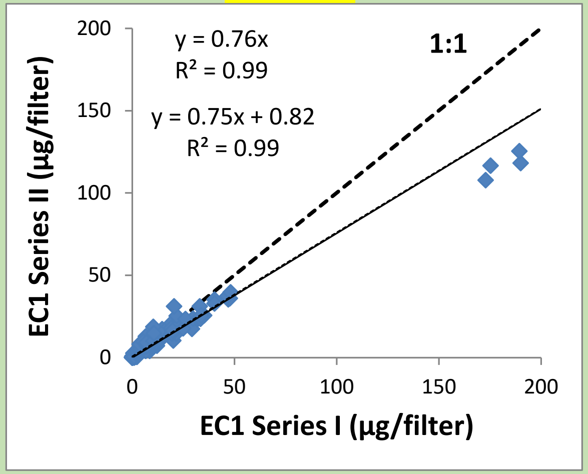
OC3



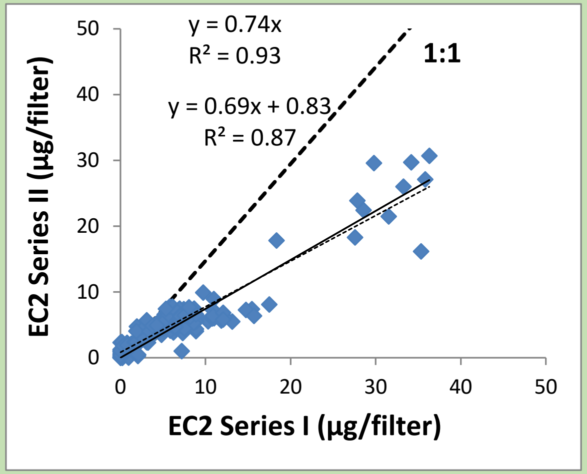
OC4



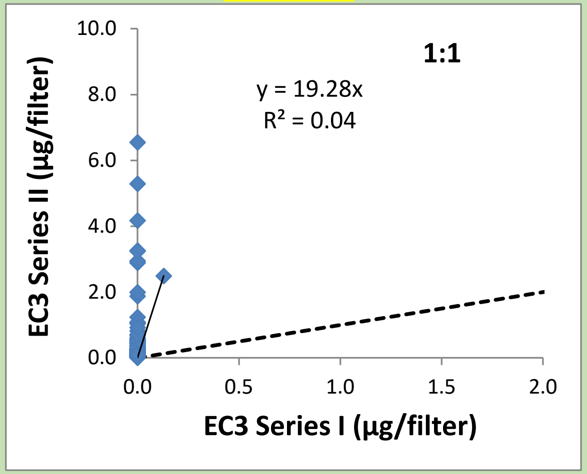
EC1



EC2

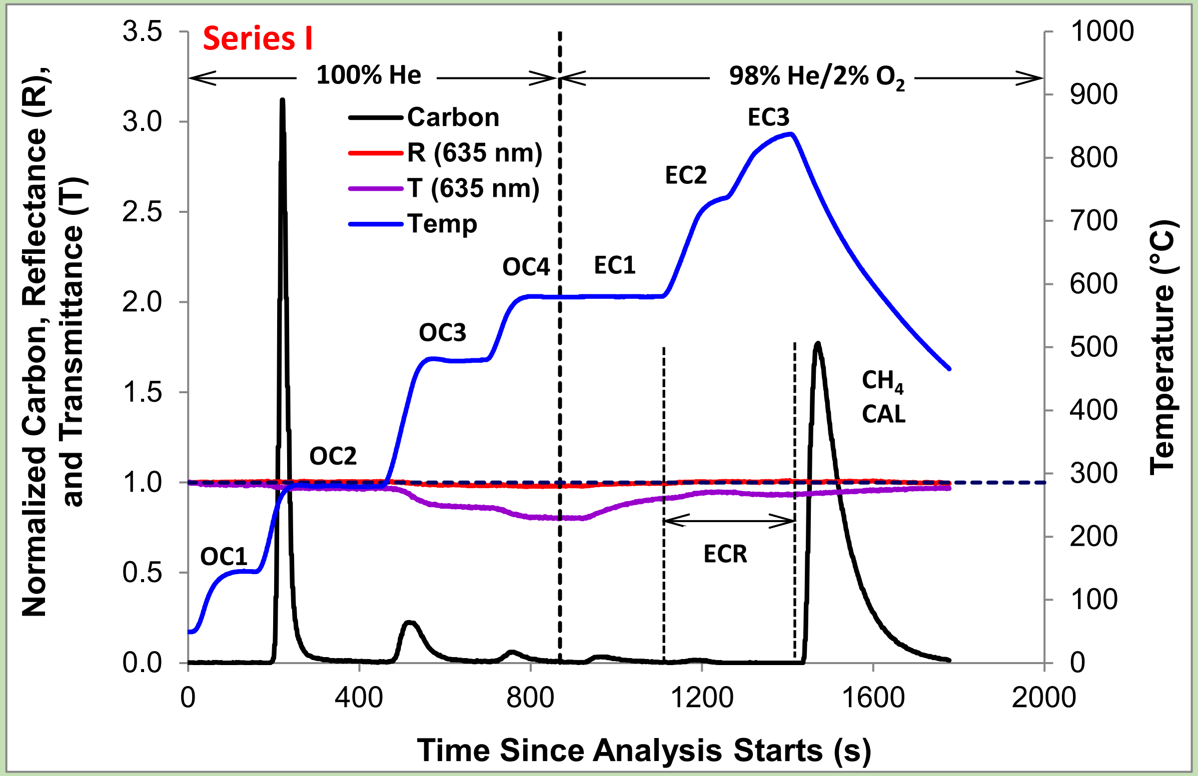


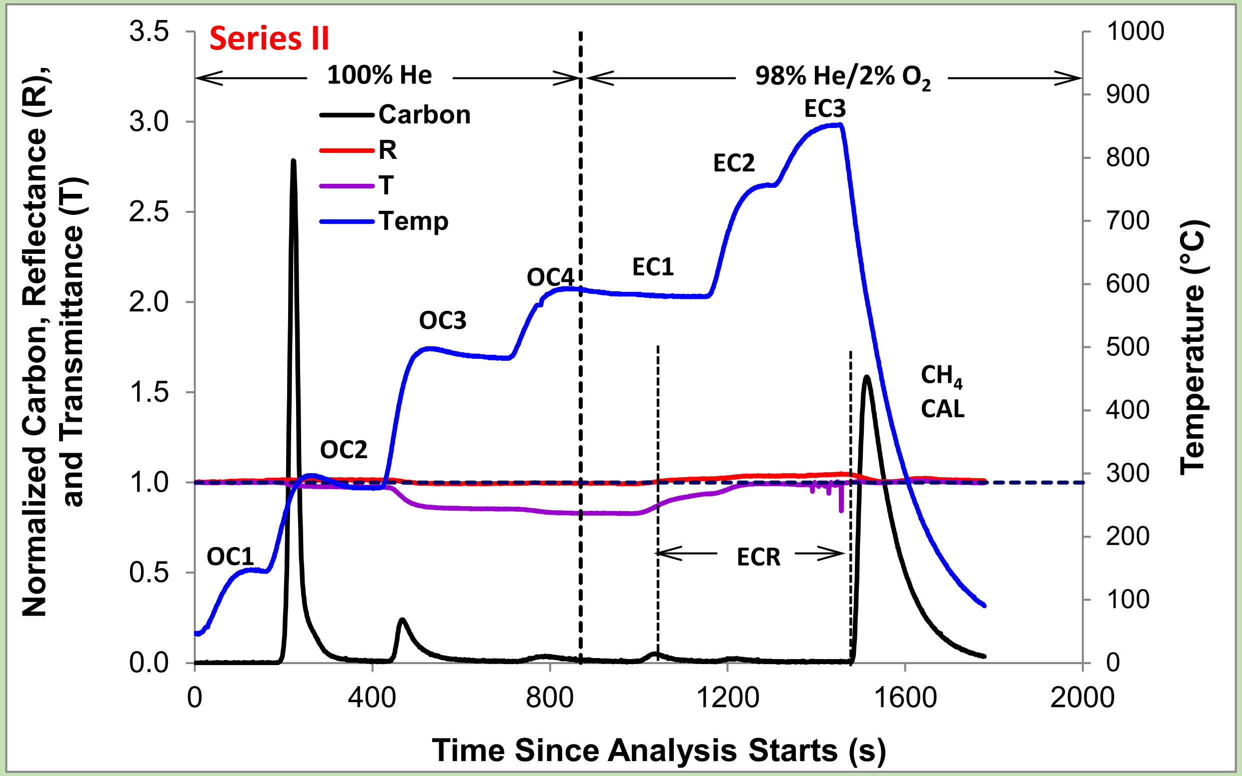
EC3



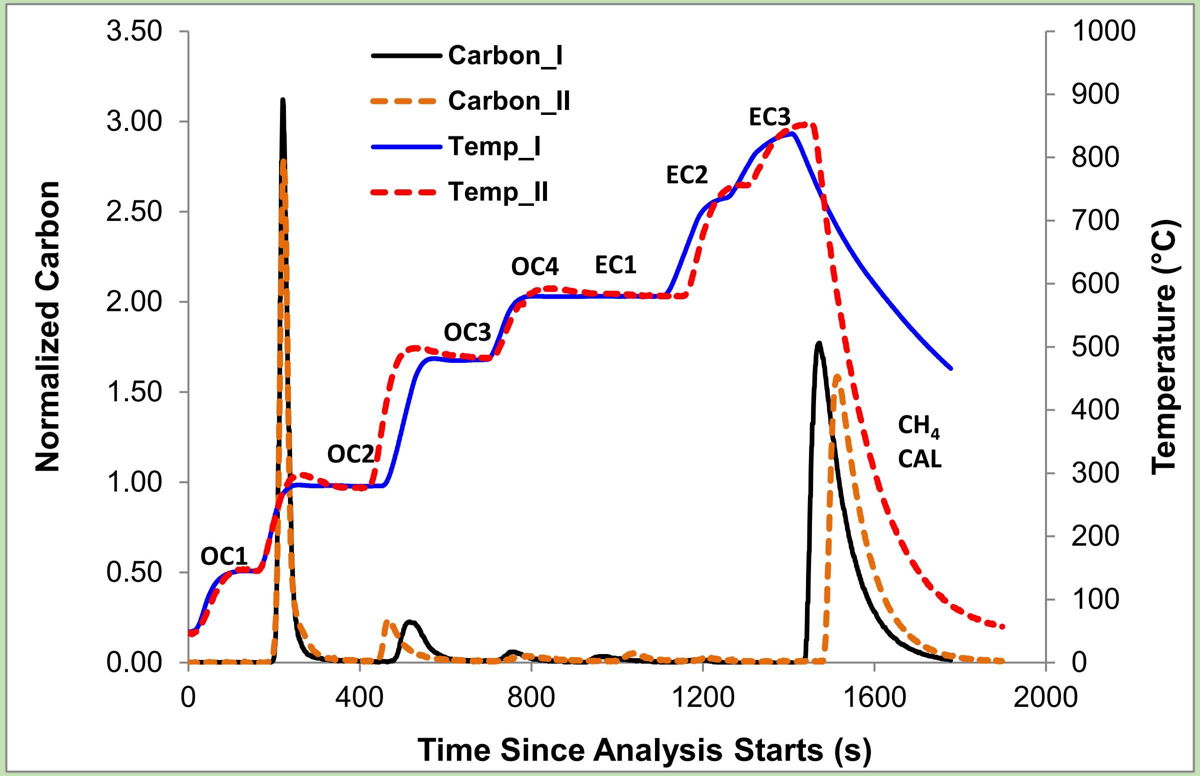
$PM_{2.5}$ Sampler (DRI Reno campus, NV)

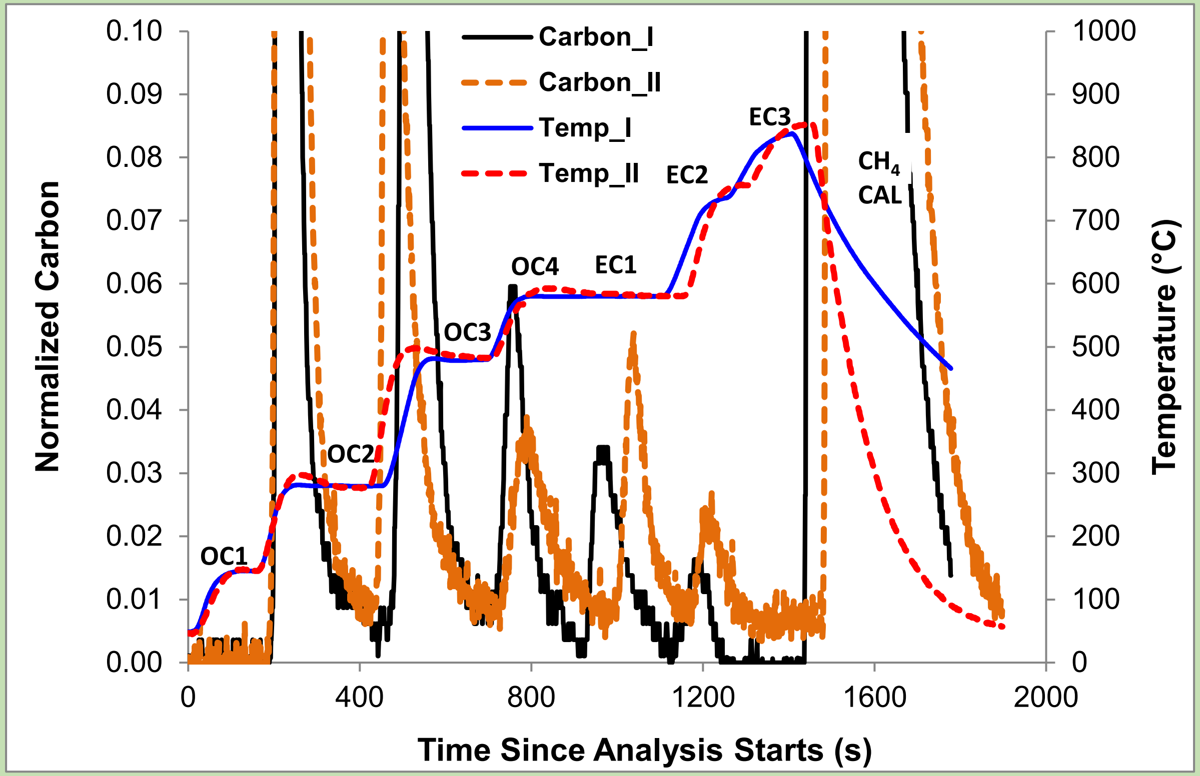
Sucrose runs show similar patterns between Series I and II





Temperature plateau and baseline adjustments are needed for Series II Model 2015



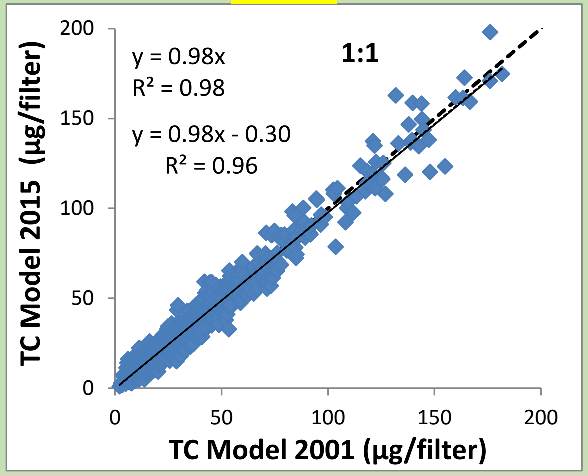


- Series II overshoots temperatures somewhat
- Series II cools much faster

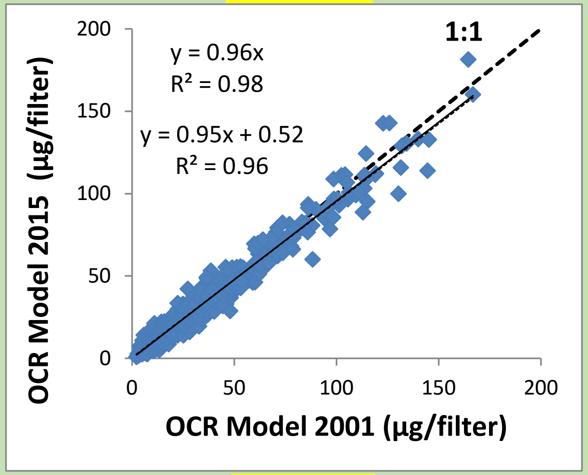
- Series II carbon signals should return to baseline

Similar comparability for TC, OC, and EC between DRI Model 2001 and Series I Model 2015 (n = 1021)*

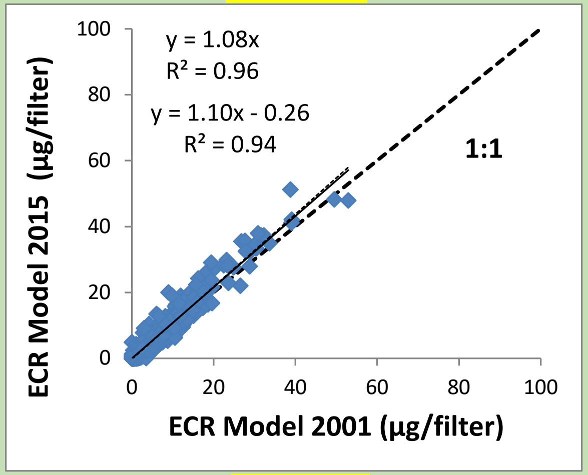
TC



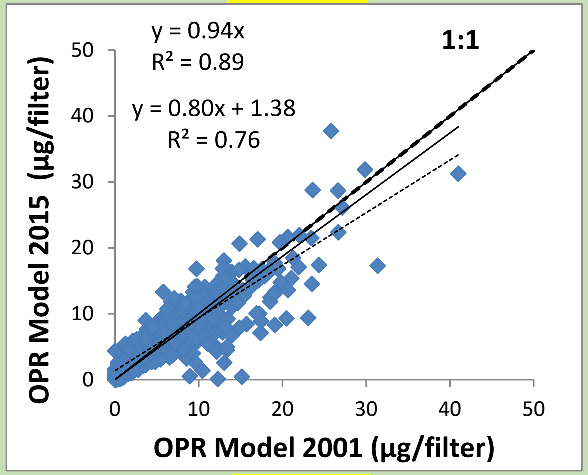
OCR

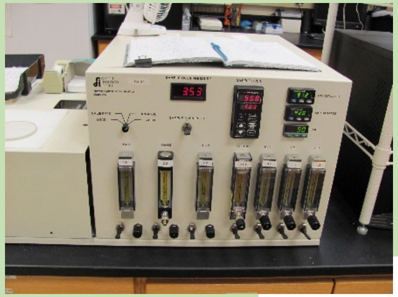


ECR

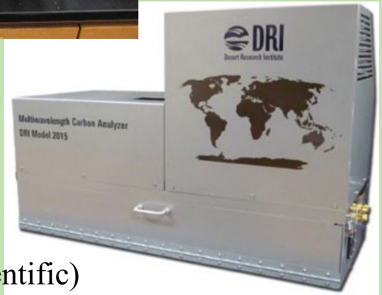


OPR



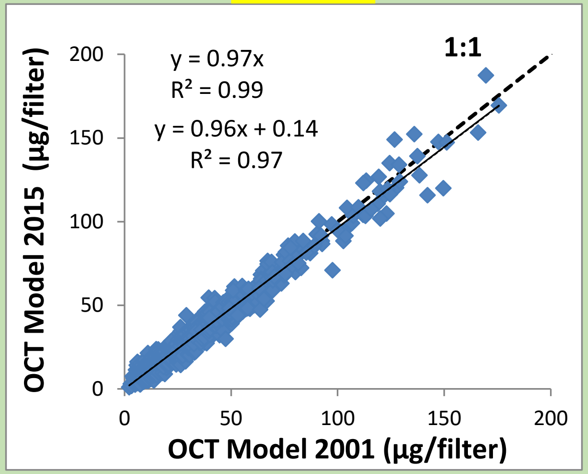


DRI Model 2001
(Atmoslytic, Inc.)

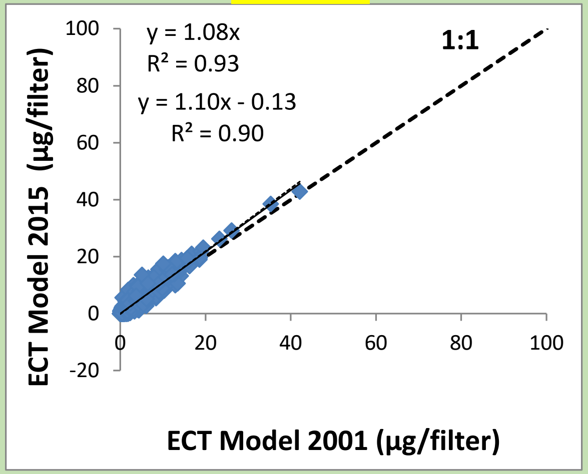


DRI Model 2015
(Aerosol Magee Scientific)

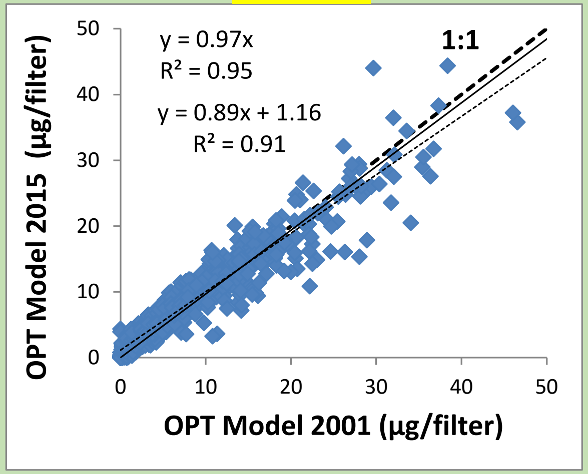
OCT



ECT



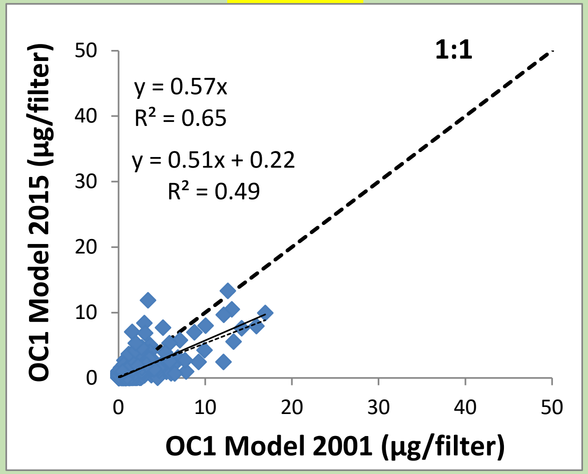
OPT



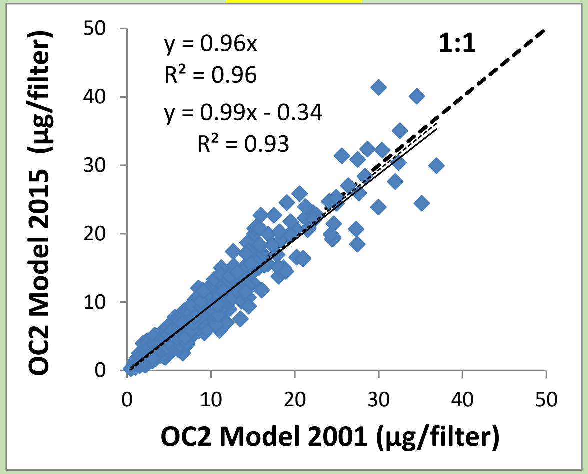
*Chow et al 2015 AAQR

Similar comparability in carbon fractions between DRI Model 2001 and Series I Model 2015 (n = 1021)*

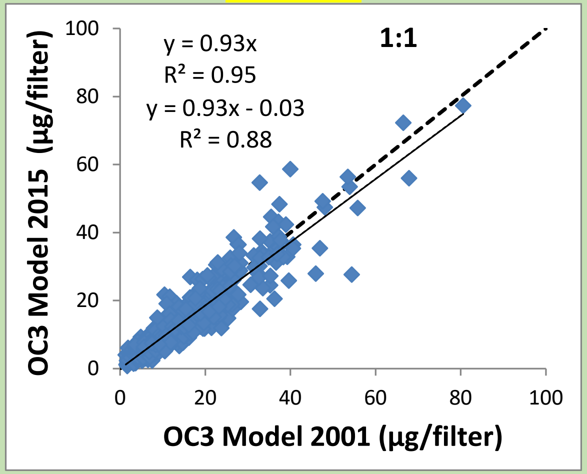
OC1



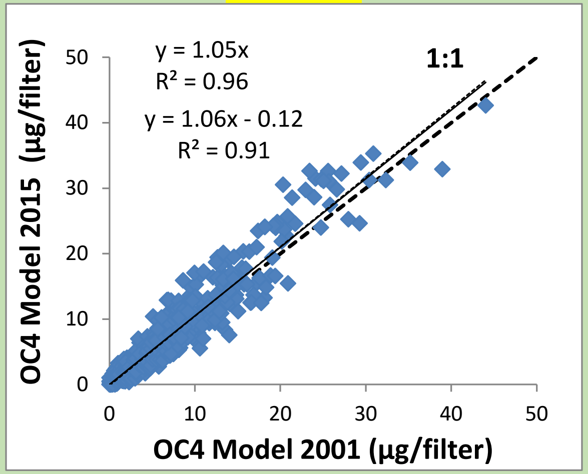
OC2



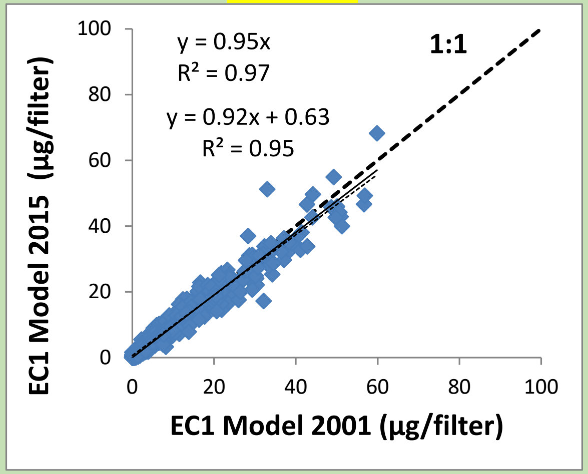
OC3



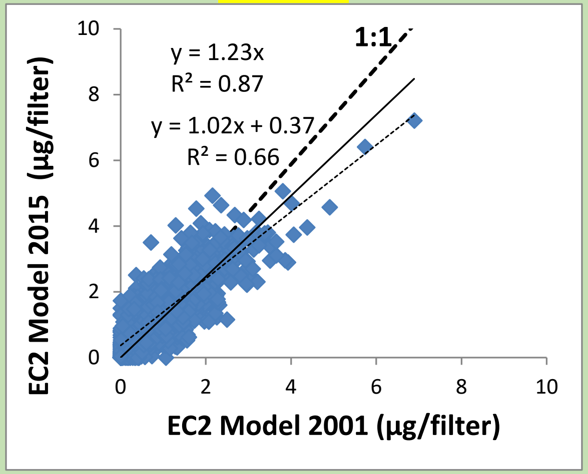
OC4



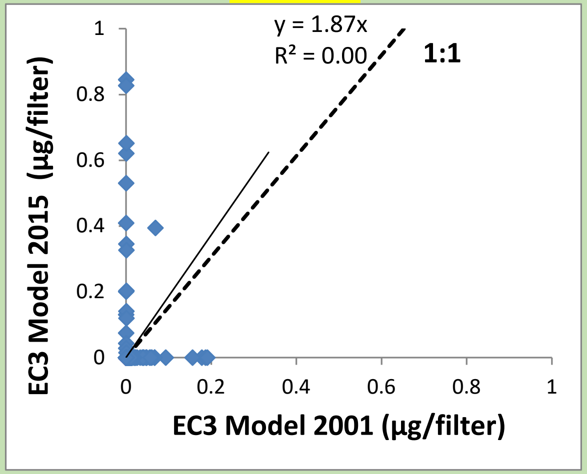
EC1

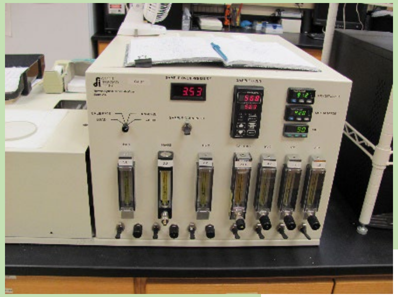


EC2

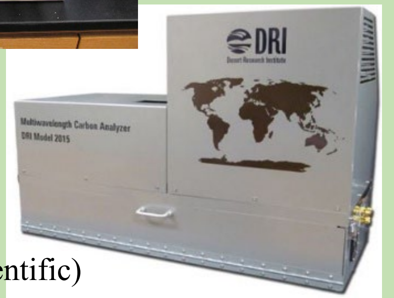


EC3





DRI Model 2001
(Atmoslytic, Inc.)

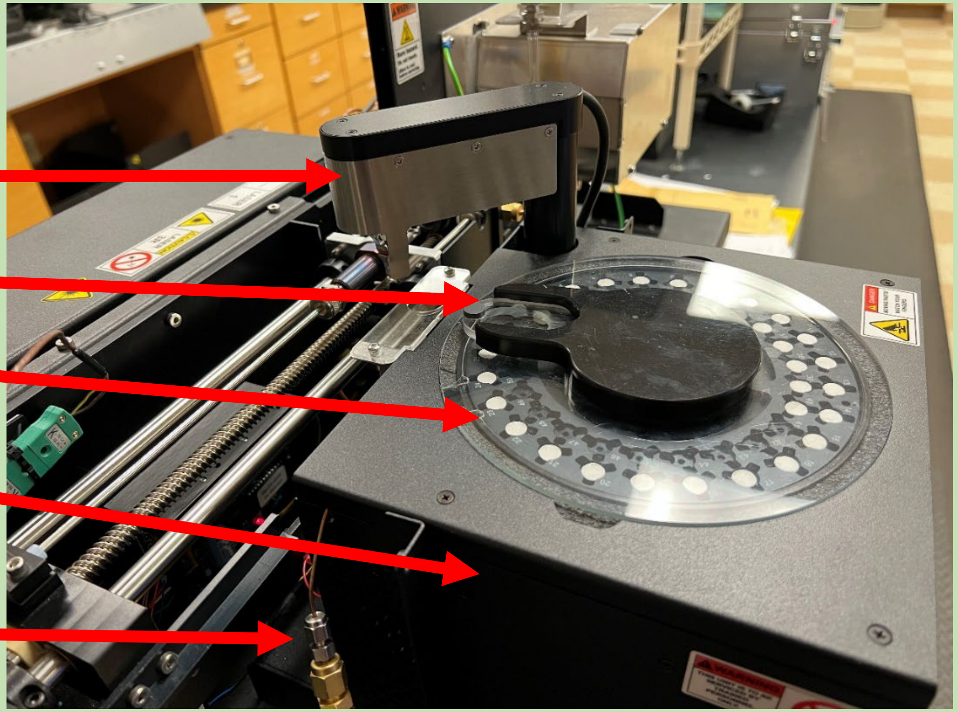


DRI Model 2015
(Aerosol Magee Scientific)

*Chow et al 2015 AAQR

Future Tasks

- Refine integration threshold and investigate the positive intercepts in Series II Model 2015 multiwavelength thermal/optical carbon analyzer
- Conduct test of auto-loader



Ongoing Research: Testing New DRI Model 2015 Carbon Analyzer with an Autoloader

Recent IMPROVE_A Publications

- Arregocés, H.A., Rojano, R., Restrepo, G., (2022). Meteorological factors contributing to organic and elemental carbon concentrations in PM10 near an open-pit coal mine. Environmental Science and Pollution Research, 29, 28854-28865. 10.1007/s11356-022-18505-7.
- Chen, L.-W.A., Wang, X.L., Lopez, B., Wu, G.Y., Ho, S.S.H., Chow, J.C., Watson, J.G., Yao, Q., Yoon, S.J., Jung, H.J., (2023). Contributions of non-tailpipe emissions to near-road $PM_{2.5}$ and PM_{10}: A chemical mass balance study. Environmental Pollution, 122283. 10.1016/j.envpol.2023.122283.
- da Costa, J.G., de Albuquerque, A.S., Ardisson, J.D., Fernandez-Outon, L.E., de Queiroz, R.S., Morimoto, T., (2023). Determination of settled dust sources by analytical techniques and chemical mass balance receptor model. Environmental Science and Pollution Research, 30, 17926-17941. 10.1007/s11356-022-23366-1.
- Debus, B., Weakley, A.T., Takahama, S., George, K.M., Amiri-Farahani, A., Schichtel, B., Copeland, S., Wexler, A.S., Dillner, A.M., (2022). Quantification of major particulate matter species from a single filter type using infrared spectroscopy - application to a large-scale monitoring network. Atmospheric Measurement Techniques, 15, 2685-2702. 10.5194/amt-15-2685-2022.
- Hasegawa, S., (2022). Experimental characterization of PM2.5 organic carbon by using carbon-fraction profiles of organic materials. Asian Journal of Atmospheric Environment, 16, 10.5572/ajae.2021.128.
- Hassan, H., Schwab, J., Zhang, J., (2023). Harmonization of the long-term PM2.5 carbon data from the CSN sites in New York State. Aerosol and Air Quality Research, 23, 10.4209/aaqr.230077.
- Hopke, P.K., Chen, Y., Rich, D.Q., Watson, J.G., Chow, J.C., (2023). Issues with the organic and elemental carbon fractions in recent U.S. Chemical Speciation Network data. Aerosol and Air Quality Research, 23, 1-7. 10.4209/aaqr.230041 https://aaqr.org/articles/aaqr-23-02-sc-0041
- Li, Z., Zhi, G., Zhang, Y., Jin, W., Sun, J., Kong, Y., Shen, Y., Zhang, H., (2023). The integrating sphere system plus in-situ absorption monitoring: A new scheme to study absorption enhancement of black carbon in ambient aerosols. Science of the Total Environment, 892, 10.1016/j.scitotenv.2023.164355.
- Michael, R., Mirabelli, M.C., Vaidyanathan, A., (2023). Public health applications of historical smoke forecasts: An evaluation of archived BlueSky data for the coterminous United States, 2015–2018. Computers and Geosciences, 171, 10.1016/j.cageo.2022.105267. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85142500569&doi=10.1016%2fj.cageo.2022.105267&partnerID=40&md5=cb3f8354a25a8c90bb2511fbc1695884
- Morris, R., Tonnesen, G., Brewer, P., Moore, T., Rodriguez, M., (2022). Assessment of progress toward regional haze rule visibility goals using United States anthropogenic emissions rate of progress. Journal of the Air and Waste Management Association, 72, 1259-1278. 10.1080/10962247.2022.2131653.
- Rüger, C.P., Neumann, A., Kösling, P., Vesga Martínez, S.J., Chacón-Patiño, M.L., Rodgers, R.P., Zimmermann, R., (2022). Addressing thermal behavior and molecular architecture of asphaltenes by a thermal-optical carbon analyzer coupled to high-resolution mass spectrometry. Energy and Fuels, 36, 10177-10190. 10.1021/acs.energyfuels.2c02122.
- Shi, H., Chen, Z., Yang, Z., Wang, J., Yang, J., Huang, Y., (2023). Secondary formation and source analysis of carbonaceous components in PM1 in a typical city, Southwest of China. Atmospheric Environment, 299, 10.1016/j.atmosenv.2023.119671.

Recent IMPROVE_A Publications

- Verma, S.R., Pervez, S., Mandal, P., Chow, J.C., Watson, J.G., Andrabi, S.M., Verma, M., Dugga, P., Khan, N.A., Pervez, Y.F., Mishra, A., Deb, M.K., Karbhal, I., Tiwari, S., Ghosh, K.K., Shrivas, K., Satnami, M.L., (2022). Atmospheric abundance of $PM_{2.5}$ carbonaceous matter and their potential sources at three high-altitude glacier sites over the Indian Himalayan range. Acs Earth and Space Chemistry, 6, 2919-2928. 10.1021/acsearthspacechem.2c00216. https://www.researchgate.net/publication/365400571_Atmospheric_Abundance_of_PM_25_Carbonaceous_Matter_and_Their_Potential_Sources_at_Three_High-Altitude_Glacier_Sites_over_the_Indian_Himalayan_Range
- Wang, X.L., Chen, L.-W.A., Lu, M.G., Ho, K.F., Lee, S.C., Ho, S.H.H., Chow, J.C., Watson, J.G., (2022). Apportionment of vehicle fleet emissions by linear regression, positive matrix factorization, and emission modeling. Atmosphere, 13, 1066. 10.3390/atmos13071066. https://www.mdpi.com/2073-4433/13/7/1066
- Wang, Y., Mahowald, N., Hess, P., Sun, W., Chen, G., (2022). The relationship between PM2.5 and anticyclonic wave activity during summer over the United States. Atmospheric Chemistry and Physics, 22, 7575-7592. 10.5194/acp-22-7575-2022.
- Wang, X.L., Firouzkouhi, H., Chow, J.C., Watson, J.G., Carter, W., De Vos, A.S.M., (2023). Characterization of gas and particle emissions from open burning of household solid waste from South Africa. Atmos. Chem. Phys., 23, 8921-8937. 10.5194/acp-23-8921-2023. https://acp.copernicus.org/articles/23/8921/2023/
- Wang, X.L., Gillies, J.A., Kohl, S.D., Furtak-Cole, E., Tupper, K.A., Cardiel, D.A., (2023). Quantifying the source attribution of PM_{10} measured downwind of the Oceano Dunes State Vehicular Recreation Area. Atmosphere, 14, 10.3390/atmos14040718.
- Wang, X.L., Gronstal, S., Lopez, B., Jung, H.J., Chen, L.-W.A., Wu, G.Y., Ho, S.S.H., Chow, J.C., Watson, J.G., Yao, Q., Yoon, S.J., (2023). Evidence of non-tailpipe emission contributions to $PM_{2.5}$ and PM_{10} near southern California highways. Environmental Pollution, 120691. 10.1016/j.envpol.2022.120691.
- Yuan, M., Wang, Q., Zhao, Z., Zhang, Y., Lin, Y., Wang, X., Chow, J.C., Watson, J.G., Tian, R., Liu, H., Tian, J., Cao, J.J., (2022). Seasonal variation of optical properties and source apportionment of black and brown carbon in Xi'an, China. Atmospheric Pollution Research, 13, 10.1016/j.apr.2022.101448.
- Zhou, Y., Chen, J., Fan, F., Feng, Y., Wang, S., Fu, Q., Feng, J., (2022). Deconvolving light absorption properties and influencing factors of carbonaceous aerosol in Shanghai. Science of the Total Environment, 839, 10.1016/j.scitotenv.2022.156280. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85131432380&doi=10.1016%2fj.scitotenv.2022.156280&partnerID=40&md5=a05c9d3ae1009fe578daf081e4433bba
- Zou, C., Wang, J., Gao, Y., Huang, H., (2023). Distribution characteristics and optical properties of carbonaceous aerosol: brown carbon and black carbon in Nanchang, inland China. Atmospheric Pollution Research, 14, 10.1016/j.apr.2023.101700.