Posting type	Advisory
Subject	Shift in CSN carbon data due to carbon analyzer change
Module/Filter	URG 3000N / Quartz 25mm
AQS Parameter Codes	88320, 88321, 88324, 88325, 88326, 88327, 88328, 88329, 88330, 88331, 88355, 88357, 88370, 88374, 88375, 88376, 88377, 88378, 88379, 88380, 88381, 88382, 88383, 88384, 88385, 88388
Sites	Entire CSN network
Period	October 1, 2018 - present
Recommendation	Information only
Submitter	Xiaolu Zhang, xluzhang@ucdavis.edu

Thermal-optical carbon analysis for CSN has gone through a number of changes in the sampling, analytical protocol, and instrumentation during the last 15 years. This advisory addresses the most recent analytical laboratory transition, which included a change in the model of carbon analyzers. Starting with October 2018 samples, CSN carbon analysis is performed using Sunset Laboratory model 5L analyzers at the University of California Davis, instead of DRI model 2015 analyzers at Desert Research Institute (DRI). Both labs use the IMPROVE_A TOR protocol. The two carbon analyzer models are designed and manufactured by different companies and differ in a number of aspects including laser source, carbon detection, temperature calibration method, and other instrument configurations. An inter-laboratory study was conducted to compare the measurements reported from these two analyzer models using 4000+ CSN quartz filter samples (Zhang et al., 2021). Briefly, the mean biases between the measurements from DRI-2015 and Sunset are -0.9%, 4.1%, and 11.2% for total carbon (TC), organic carbon (OC), and elemental carbon (EC) as shown in Table 1. Relatively larger and more diverse inter-model discrepancies were found for thermal subfractions of OC and EC (i.e., OC1-OC4 and EC1-EC3) as well as the pyrolized fraction (OP); subfractions with higher mass loadings showed better agreement. For most of the carbon components including TC, OC and EC, the inter-model uncertainties are larger than the within-model uncertainties (Table 1); nonetheless, the inter-model uncertainties are within expectations given the within-model uncertainties and study design. Sources of inter-model uncertainty include the lack of calibration standards for these measurements other than TC and many differences in the instrument models' hardware and software.

The trends observed in the long-term CSN carbon data are in general agreement with findings from the abovementioned inter-comparison study; TC, OC, and EC concentrations appear consistent over the transition while several subfractions (e.g., OC2, OC3, and OP) exhibit significant shifts over the transition. Figure 1 shows 10-year (2011-2020) time series of CSN TC, OC and EC concentrations as well as the EC/TC ratio, covering two instrument model transitions in 2016 and 2018. Data shown here are not artifact corrected because artifact correction was not implemented until November 2015. There is no observable discontinuity in the TC, OC or EC trend before and after the 2018 transition, while a small shift is evident in the EC/TC ratio time series, suggesting that the operationally-defined OC-EC split is sensitive to the carbon analyzer model. The empirical sensitivity of the operational split is seen more clearly in the time series of carbon subfractions (Figure 2), which Table 1 also showed to have generally larger within-model uncertainties. We accordingly recommend that studies using CSN carbon subfractions (i.e., OC1-OC4, OP, EC1-EC3), for source apportionment and to make particulate matter composition inferences, limit comparisons to measurements made with a common instrument model to avoid shifts in the data unrelated to the atmosphere.

Reference:

Zhang, X., Trzepla, K., White, W., Raffuse, S., and Hyslop, N. P.: Intercomparison of thermal–optical carbon measurements by Sunset and Desert Research Institute (DRI) analyzers using the IMPROVE_A protocol, Atmos. Meas. Tech., 14, 3217–3231, https://doi.org/10.5194/amt-14-3217-2021, 2021.

Table 1. Within-model uncertainty estimated from the scaled relative difference (SRD) of the replicate analyses by Sunset and DRI model 2015 analyzers (left columns) and inter-model bias and uncertainty between Sunset and DRI model 2015 analyzers estimated from SRD of the paired analyses of 4073 CSN samples by both analyzers (right columns). For calculation details refer to Zhang et al. (2021). In the inter-model differences, a positive bias indicates Sunset measurement is higher relative to that of DRI model 2015.

Carbon Component	Within-model Uncertainty, % (1σ of SRD)		Inter-model Difference, % (n = 4073)	
	Sunset (n = 519)	DRI-2015 (n = 518)	Bias (mean SRD, %)	Uncertainty (1σ of SRD)
Total Carbon (TC)	2.9	3.0	-0.9	6.0
Organic Carbon (OC)	3.6	3.5	-4.1	7.1
Elemental Carbon (EC)	6.8	9.7	11.2	14.9
Pyrolyzed OC (OP)	12.8	55.6	66.1	41.3
OC1	26.5	49.8	-16.0	62.5
OC2	7.9	10.3	11.3	12.3
OC3	7.7	7.2	-18.1	12.2
OC4	16.3	11	-57.5	23.7
EC1	6.6	10.6	21.9	17.6
EC2	16.4	22.5	60.6	25.0
EC3	*NA		136.5	23.2

*Too few (less than 20%) data points have mass loadings that are greater than 3 times the MDL
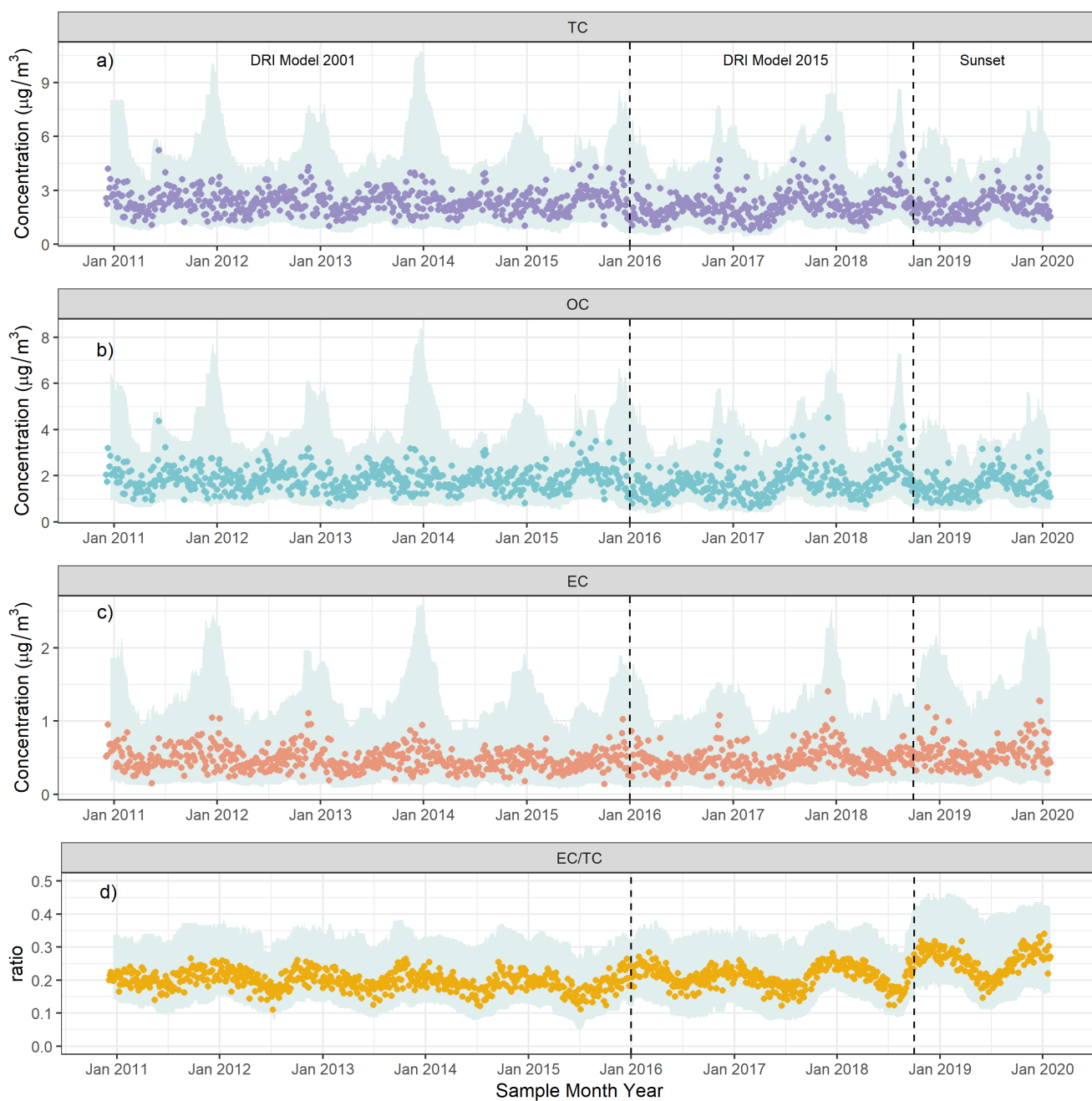
Figure 1. Time series of CSN total carbon (TC), organic carbon (OC), elemental carbon (EC) concentrations (a-c) and EC/TC ratio (d) from 2011-2020. Each point is the network median of the values at individual sites. The upper and lower bounds of the gray shade in each plot are the 95th and 5th percentiles of the daily individual-site values. Vertical dashed lines indicate the two carbon analyzer transitions, first from DRI model 2001 to DRI model 2015 on sample date 2016/1/1, and second from DRI model 2015 to Sunset on sample date 2018/10/1. Data are not blank corrected.
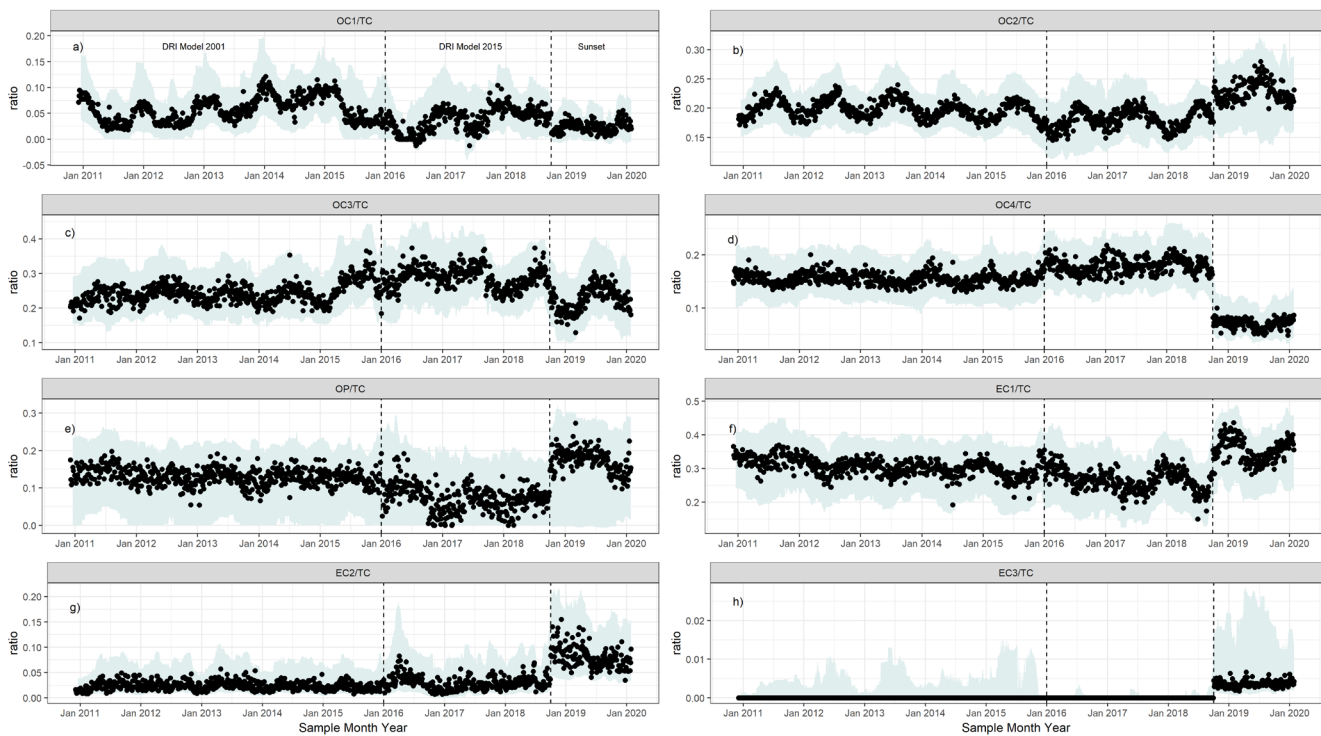
Figure 2. Time series of CSN carbon subfraction concentrations, normalized by TC concentration, from 2011-2020. Each point is the network median of the values at individual sites. The upper and lower bounds of the gray shade in each plot are the 95th and 5th percentiles of the daily individual-site values. Vertical dashed lines indicate the two carbon analyzer transitions, first from DRI model 2001 to DRI model 2015 on sample date 2016/1/1, and second from DRI model 2015 to Sunset on sample date 2018/10/1. Data are not blank corrected.