ASSESSMENT OF CARBON SAMPLING ARTIFACTS IN THE IMPROVE, STN/CSN, AND SEARCH NETWORKS

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CARBON NOMENCLATURE

VOC: .... Volatile Organic Compounds
SVOC: .... Semi-Volatile Organic Compounds
gSVOC: .... Gaseous-Phase Semi-Volatile Organic Compounds
pSVOC: ....Particle-Phase Semi-Volatile Organic Compounds
TC: ....Total Carbon (TC = OC + EC)
OC: ....Organic Carbon
pOC: .... Non-Volatile Particle-Phase Organic Carbon
EC: ....Elemental Carbon
QBT: ....Quartz-Fiber Backup Filter behind Teflon-Membrane Front Filter
QBQ: .... Quartz-Fiber Backup Filter behind Quartz-Fiber Front Filter
bQBQ: ....Blank Quartz-Fiber Backup Filter behind Quartz-Fiber Front Filter
dQBQ: ....Denuded Quartz-Fiber Backup Filter behind Quartz-Fiber Front Filter
QBQ_{top}: ....Top Half of a Sliced Quartz-Fiber Backup Filter behind Quartz-Fiber Front Filter
QBQ_{bott}: ......Bottom Half of a Sliced Quartz-Fiber Backup Filter behind Quartz-Fiber Front Filter
QF: ....Quartz-Fiber Front Filter
bQF ....Field Blank (Quartz-Fiber Filter)
dQF .... Denuded Quartz-Fiber Front Filter
QF_{top} .... Top Half of a Quartz-Fiber Front Filter
QF_{bottom} .... Bottom Half of a Quartz-Fiber Front Filter

1. INTRODUCTION

1.1. Background

The adsorption of organic vapors onto quartz-fiber filters during $PM_{2.5}$ and PM_{10} sampling for thermal/optical carbon analyses causes organic carbon (OC) concentrations to be overestimated. There organic vapors may char during thermal/optical analysis, thereby causing differences in elemental carbon (EC) corrections determined by reflectance and transmittance (Chen et al., 2004; Chow et al., 2004). The composition of the adsorbed material, its exchange between the adsorbed and gaseous phases, the degree to which filters become saturated, and how the amount of OC adsorbed differs among filter media and sampling environments has been recognized, but it is poorly understood (Kukreja and Bove, 1976; Lee et al., 1980a; 1980b; Cadle et al., 1983; Eldred et al., 1983; Galasyn et al., 1984; McDow, 1986; 1999; Coutant et al., 1988; Fung, 1988; Eatough et al., 1989; 1990; 1993; 2001; 2003a; 2003b; de Raat et al., 1990; Fitz, 1990; Helmig et al., 1990; McDow and Huntzicker, 1990; 1993; Chow et al., 1991a; 1991b; 1992; 1993; 1996; 1998; 2002; 2004; 2005a; 2006b; Lewis et al., 1991; Cotham and Bidleman, 1992; Gu et al., 1994; Hart and Pankow, 1994; Chow, 1995; Gundel et al., 1995; Chow and Watson, 1997a; 1997b; Allen et al., 1999; Kavouras et al., 1999; Kim et al., 2001; 2005; Mader and Pankow, 2000; 2001a; 2001b; 2002; Kirchstetter et al., 2001; Kirchstetter et al., 2003; Lewtas et al., 2001; Chen et al., 2002; 2004; Flanagan et al., 2002; Green et al., 2002; Baumann et al., 2003; Lim et al., 2003; Long et al., 2003; Matsumoto et al., 2003; Fan et al., 2004a; 2004b; Fung et al., 2004; Jeong et al., 2004; Khalek, 2004; Arhami et al., 2006; Galarneau and Bidleman, 2006; Galarneau et al., 2006; Grover et al., 2006; Lipsky and Robinson, 2006; Dhammapala et al., 2007; Kim and Hopke, 2007; NAREL, 2001; Obeidi and Eatough, 2002; Offenberg et al., 2007; Olson and Norris, 2005; Pang et al., 2002; Pankow et al., 1984; Pankow and Bidleman, 1991; Pimenta and Wood, 1980; Pitts, Jr. et al., 1986; Ray and McDow, 2005; Rice, 2004; Salma et al., 2004; Salma et al., 2007; Sanderson and Farant, 2005; Schwartz et al., 1981; Sihabut et al., 2005; Subramanian et al., 2004; ten Brink, 2004; ten Brink et al., 2004; Thrane and Mikalsen, 1981; Tolocka et al., 2001; Turpin et al., 1993; Turpin et al., 1994; Turpin et al., 1997; Turpin et al., 1999; Turpin et al., 2000; van Vaeck et al., 1984; Viana et al., 2006a; Viana et al., 2006b; Watson et al., 1988; Watson et al., 1991a; Watson et al., 1991b; Watson et al., 1996; Watson and Chow, 2002; Watson et al., 2005; Wittmaack and Keck, 2004; Wolff et al., 1991; Zhao et al., 2006).

This positive OC artifact is distributed throughout the filter, as evidenced by visible darkening of the back side of the filter when it chars during heating in a non-oxidizing atmosphere (Chow et al., 2004). Attempts are made to quantify and correct for the positive OC artifact in U.S. long-term monitoring networks. The Interagency Monitoring of Protected Visual Environments [IMPROVE] and the Southeastern Aerosol Research and Characterization [SEARCH] networks use quartz-fiber front filters (QF) to collect atmospheric OC and elemental carbon (EC) and use backup filters to estimate the adsorbed OC so it can be subtracted from the total. These networks also ship field blanks with the sampled filters to estimate passive adsorption. The Speciation Trends Network (STN) (or Chemical Speciation Network [CSN]) measures field blanks but does not adjust the reported data for them or propagate the variability of the blank to the OC uncertainty. There are differences in how the blanks are handled among the networks with regard to exposure times and temperatures for shipping and storage. The use of field blank and backup filter concentrations to compensate for OC artifacts is also different in each network.

Artifact corrections assume that vapors are adsorbed uniformly throughout the front and backup filters. This implies that a saturation level is attained, as organic vapors would be preferentially scavenged in the upper sections of a filter before the gas is transmitted to lower sections. When blanks are used to estimate the artifact, it is assumed that passive adsorption is the same as active adsorption. When a subset of filters is used to represent all samples, it is also assumed that the saturated OC artifact values are invariant with respect to the filter batch, sampled environment, and sampling period.

There is mounting evidence that substantial deviations from these assumptions exist in long-term U.S. networks. Kirchstetter et al. (2001) suggest that each filter may have a different capacity for organic vapor adsorption. IMPROVE observes a seasonal variability in backup filter OC and uses monthly averages for blank corrections (Chow et al., 2007c). In addition, field blanks do not always have the same exposure time as the front and backup filters.

It is possible that urban environments have more gases that can be adsorbed than non-urban environments, especially non-urban locations in the arid western U.S. where biogenic volatile organic compound (VOC) levels are low. The oxidation of low-volatility hydrocarbons is a main channel for secondary aerosol formation. Fresh plumes may contain substantial amounts of semi-volatile organic compounds (SVOCs) in both gaseous- (gSVOC) and particle-phases (pSVOC) that come into equilibrium as the plumes age. In rural and remote atmospheres (which are represented by most IMPROVE sites), many SVOCs will have evaporated or converted to more stable compounds. In this case, backup filter OC may be similar to the OC field blank, especially when both are subjected to long passive periods in the sampler. Urban locations, represented by the STN/CSN and urban/suburban SEARCH samples, experience more fresh emissions, and the adsorbable vapors may be more plentiful. These materials are more likely to be adsorbed when air is drawn through the filter than on the passive field blank. Owing to higher ambient temperatures, more of the SVOC is expected in the vapor phase during summer than during winter.

1.2. Objectives

The goal of this study is to better understand the magnitude and nature of measured OC artifacts on field blanks (bQF) and quartz-fiber filters behind quartz-fiber front filters (QBQ) and to evaluate strategies to compensate for these artifacts. Specific objectives are:

- Compile existing databases of mass, elements, and ions, non-processed data for OC, EC, and thermal fractions, as well as laboratory, field, and trip blanks for collocated IMPROVE, STN/CSN, and/or SEARCH sites.
- Describe how blanks have been handled and used in each network.
- Compare the magnitudes of adsorbed organic vapors estimated by different methods and evaluate how well the applied methods compensate for these artifacts in the reported OC concentrations.
- Examine the influence of water-soluble organics as powders and in solution on the blank/backup filters and the quantification of OC and EC with the IMPROVE and STN/CSN thermal/optical protocols.
- Acquire information that can better relate carbon measurements from the IMPROVE and STN/CSN network.

1.3. Hypotheses

The following hypotheses are tested, to the extent possible, using existing IMPROVE, STN/CSN, and/or SEARCH samples and data.

A. The sampling artifact on blank/backup filters depends on sampling protocol and differs among ambient networks.

B. Adsorbed organic carbon on the field blank is less than that on the backup filter, which is less than that on the bottom half of the front filter.

C. Aerosol aging reduces SVOC content and the organic sampling artifact.

D. OC estimated by the Sulfate, Adjusted Nitrate, Derived Water, Inferred Carbonaceous Material (SANDWICH) method better represents the particulate organic matter in $PM_{2.5}$.

E. The organic sampling artifact influences the OC/EC split for both IMPROVE and STN/CSN carbon analyses.

1.4. Report Structure

Section 1 states the background, objectives, and hypotheses being tested. Section 2 describes the experimental methods and database assembled to attain the objectives. Challenges in data retrieval and reconciling blank and sampled filters from different networks are compared. Sampling protocols for the IMPROVE, STN/CSN, and SEARCH networks are summarized. Procedures for handling laboratory, trip, and field blanks are documented. Databases are assembled to pair the collocated IMPROVE and STN/CSN samples for special studies at the three urban (Seattle, WA; Phoenix, AZ; and Washington, DC) and three rural (Mt. Rainier, WA; Tonto National Monument, AZ; and Dolly Sods Wilderness, WV) sites, and for the long-term measurements at Fresno, CA, and Big Bend National Park, TX. Filter doping with solid and liquid levoglucosan to evaluate effects of complex mixtures on filter carbon content is attempted. Section 3 uses these data sets to evaluate the five hypotheses. It compares the magnitudes of adsorbed organic artifact among laboratory, trip, and field blanks, and between blanks and backup filters. Measured OC is compared to estimated OC or organic carbon mass (OCM) using the SANDWICH method developed by Frank (2006). It also examines the influence of levoglucosan concentration on the OC/EC split using dry (resuspension) and wet (liquid injection) methods. Section 4 relates these observations to the hypotheses being tested and summarizes conclusions on the findings. Section 5 provides relevant references resulting from the literature survey performed as part of this project.

2. EXPERIMENTAL METHODS AND DATABASES

2.1. Sampling Protocols for IMPROVE, STN/CSN, and SEARCH Networks

Table 2-1 compares the sampling protocols for the IMPROVE, STN/CSN, and SEARCH networks. Site locations for these networks are shown in Figures 2-1 to 2-3, respectively. Five types of samplers, varying from single to five parallel channels, are used in STN/CSN. With respect to carbon, only the particle composition monitor (PCM3) in the SEARCH network is configured with a preceding organic denuder.

The IMPROVE, STN/CSN, and SEARCH networks also use different quartz-fiber filters that have diameters of 25 mm (Pallflex® Tissuquartz), 47 mm (Whatman QMA, with 5% borosilicate binder), and 37 mm (Pallflex® Tissuquartz), respectively. The deposit area is 3.53 cm^2 for IMPROVE, 11.76 cm^2 for STN/CSN, and 7.12 cm^2 for SEARCH samples. The deposit is denser on the smaller filters, and the amount of organic artifact relative to the deposit is less for smaller deposit areas. Sample volumes also differ among the 24-hour samples acquired in these networks, with 32.7 m^3 for IMPROVE, from 9.6 to 24 m^3 for the STN/CSN sampling systems and 24 m^3 for SEARCH. The organic artifact is larger relative to the deposit area for lower flow rates.

The filter holder (e.g., single or tandem filter packs) and magazine (i.e., R&P 2025 sequential Federal Reference Method [FRM] sampler) materials might also affect carbon blank levels owing to out gassing of organic vapors.

2.2. Procedures for Handling Laboratory, Trip, and Field Blanks

Types of blanks and backup filters used in the IMPROVE, STN/CSN, and SEARCH networks include:

- Laboratory Blanks: These are retained in the laboratory and are used for acceptance testing after pre-firing and to assess filter contamination levels and proper operation of analytical instruments. After the receipt of each batch of samples, ~2% of the samples are pre-fired and submitted for acceptance testing with the limits for each network noted in Table 2-2. Laboratory blanks are maintained for each network, but the acceptance testing data are not reported. They are used to estimate background level of the unexposed filter, but they are not used to adjust the organic artifact.

- Trip Blanks: These pre-fired filters are loaded into sample holders and accompany the sampled filter to and from the laboratory. They are not exposed to ambient air and are intended to assess contamination during shipping. They follow the same filter handling procedures as those for ambient filter samples, but they are retained in their original protective enclosures. Trip blanks are used only in STN/CSN, and constitute ~3% of all samples. These trip blank (and field blank) levels are available from July, 2003 to date (U.S.EPA, 2007). Trip blank values are reported separately and are not used to adjust for STN/CSN sampling artifacts.
- Field Blanks: Sometimes called dynamic blanks, field blanks accompany sample shipments and are placed in the sampler along with the sampled filters (Chow and Richards, 1990) The only difference is that air is not drawn through them. Field blanks allow passive deposition and adsorption to be assessed. Since the number of field blanks is relatively small compared to the number of samples, average concentrations of the measured observables are used to correct the sampled values and the standard deviation of the average is used to estimate the blank precision. Blank outliers are usually identified (values > 3 or four times the standard deviation) and excluded to minimize biases.

As shown in Tables 2-1 and 2-2, the quantity of field blanks and the time they are exposed for passive sampling differs among networks. Field blanks constitute ~2% of sample filters for IMPROVE, ~10% of sample filters for STN/CSN, ~10-25% of sample filters for Texas' non-trends CSN, and ~10% of sampled filters for SEARCH.

The passive period for the field blanks is determined by the site visit schedule. This period is on the order of 1-15 minutes for most sites in STN/CSN and SEARCH networks, which is probably insufficient to adsorb organic vapors retained by the sampled filters. For Texas' non-trends sites, which use the R&P 2025 sequential FRM sampler, the field blank stays in the magazine for 5-7 days, but it resides in the sampling position (without air being drawn through) for only a few seconds.

2.3. Quartz-fiber Backup Filter (QBQ) behind Quartz-fiber Front Filter (QF).

The IMPROVE and SEARCH networks use quartz-fiber backup filters (QBQ) behind quartz-fiber front filters (QF) to estimate the positive and negative OC artifacts. These QBQ are placed at six sites (Figure 2-1) in the IMPROVE network (i.e., Mt. Rainier National Park

[MORA]; Yosemite National Park [YOSE]; Hance Camp at Grand Canyon National Park [HANC], Chiracahua National Monument [CHIR], Shenandoah National Park [SHEN]; and Okefenokee National Wildlife Reserve [OKEF]) and at eight sites (Figure 2-3) in the SEARCH network (Mississippi pair: urban Gulfport [GLF] in Gulfport and rural Oak Grove [OAK] near Hattiesburg; Alabama pair: urban Birmingham [BHM] in North Birmingham and rural Centreville [CTR] south of Tuscaloosa; Georgia pair: urban Jefferson Street [JST] in Atlanta and rural Yorkville [YRK] northwest of Atlanta; and Florida pair: urban Pensacola [PNS] in Pensacola and suburban outlying field [OLF] northwest of Pensacola). Both networks collect QBQ on an every-third-day sampling schedule with the exception of daily sampling at the BHM and JST sites for the SEARCH network. However, only 10% of the SEARCH backup filters (selected randomly) are analyzed by DRI. Since a preceding organic denuder is used in the SEARCH PCM3 sampler, QBQ from the SEARCH network likely represent a negative OC artifact that occurs when some of the SVOC in the $PM_{2.5}$ deposit evaporates and is recaptured on the backup filter. Since IMPROVE does not remove atmospheric VOCs before the front filter, the IMPROVE QBQ represents a combination of positive and negative OC artifacts. The IMPROVE network uses the monthly median value of the carbon fractions from the six sites for blank subtraction at all sites in the network. SEARCH corrects the organic sampling artifact by calculating the quarterly mean concentrations for the QBQ and front filter field blank (bQF) and attributing them to negative and positive artifacts, respectively. Since OC front bQBQ and bQF are similar, 2 times bQF OC is subtracted as blank correction. Thus, OC (blank corrected) = $OC_{QF} + OC_{QBQ} - 2OC_{bQF}$. (Note: QBQ and bQF are quarterly mean values while QF is calculated using individual sampling days.)

2.4. Databases Acquired for the Study

Collocated IMPROVE and STN/CSN data were acquired from: 1) three urban sites (Seattle, WA; Phoenix, AZ; and Washington DC) for 10/16/2001 through 12/29/2003; 2) three non-urban sites in the vicinity of the urban sites (Mt. Rainier, WA; Tonto National Monument, AZ; and Dolly Sods Wilderness, WV) for 10/16/2001 through 12/29/2003 (Mount Rainier for 10/16/2001 through 11/1/2002); 3) the urban Fresno, CA Supersite for /1/2005 through 7/31/2005; and 4) the Big Bend, TX, IMPROVE site for 1/4/2005 through 12/30/2005. As indicated in Table 2-3, four types of STN/CSN samplers were collocated with the IMPROVE samplers.

2.5. Data Sources

Both non-processed and blank corrected mass and chemical data along with field and trip blanks were obtained from several data bases. Data validation and analysis were done using: 1) valid concurrent IMPROVE/STN/CSN data pairs, and 2) data pairs with complete mass, elements, ions (i.e., a minimum of $SO_4^{=}$ and NO_3^{-}) and carbon measurements. Non-processed IMPROVE carbon data was retrieved from the DRI SQL database server, while the STN/CSN blank data was requested from RTI (Flanigan, 2007, personal communication). Blank corrected mass and chemical composition data (including elements, ions, and carbons) from the IMPROVE-STN comparison study were requested from U.C. Davis (McDade, 2007, personal communication). The assembled database contains 1,021 data pairs for IMPROVE and STN/CSN at the six sites, including 38 IMPROVE and 142 STN/CSN field blanks.

Non-processed IMPROVE carbon data for the Fresno and Big Bend sites was retrieved from the DRI SQL server and related to blank-corrected mass and chemical composition data from VIEWS (2007). STN/CSN chemical composition data for these two sites was retrieved from the AIRS database (U.S.EPA, 2007). Due to missing nitrate (NO_3^{-}) data at the Big Bend site and incomplete 2006 data, 172 data pairs, as well as 7 IMPROVE and 32 STN/CSN field blanks were included. For carbon analysis, the completed 2005 and 2006 data provided 308 sample pairs and 49 field blanks.

2.5.1. Complications in Data Retrieval from Various Networks

IMPROVE, STN/CSN and SEARCH data bases are inconsistent with respect to: 1) parameter names, 2) treatment of blank data, and 3) data formatting. Efforts should be made to reconcile these differences. Examples of data base issues are given in Table 2-4. The following section documents some findings during data retrieval for this study.

- Observable names: Observable codes vary between sampling networks, and are not always completely defined. In order to compare data between networks, consistent parameter names for analysis methods, analytes, units, etc., are required for data queries. Concentrations are often reported in different units, which also need to be reconciled.

- Blank Data: Blank data are independent of flow rates. They should be reported as μg/cm^2 with documentation. Typically, blank data are available in measurements of absolute mass on the filter, or values normalized to the nominal sampling volume for the instrument. For this study, values were converted from µg/m^3 to µg/cm^2 for the STN/CSN sites. This correction is site-specific because of the different samplers and flow rates used at each site. Additionally, units of FRM blank data changed in AQS during early 2005 from µg/filter to µg/m^3.

- Data Formatting.: Data for the IMPROVE/STN/CSN comparison study was not in a common format, and was not uploaded to AQS or VIEWS. Special requests were made for this study, but the data received did not include blanks. The STN/CSN blank data was requested and obtained from RTI (Flanigan, 2007, personal communication), and the IMPROVE blank data was obtained from DRI's Environmental Analysis Facility (EAF) SQL server (Reno, NV).

2.6. Resuspension and Liquid Injection of Levoglucosan onto Diesel Soot and Blank Filters

Source samples from diesel exhaust were collected using a dilution sampling system (Hildemann et al., 1989) at DRI's Source Characterization Laboratory. An Onan-Cummins 12.5 kW diesel generator was operated at a load of 4 kW (Chow et al., 2006a). A portion of the exhaust (20 L/min) was diluted (nominal dilution ratio of 70:1) and allowed to reach equilibrium for ~100 seconds before being sampled onto four 47 mm filter packs with quartz-fiber front filters (QF) and quartz-fiber backup behind quartz-fiber front filters (QBQ).

A dry mixture of 46% levoglucosan (99% purity, Sigma Aldrich, St. Louis, MO) and 54% silicon dioxide (99.5% purity, Alfa Aesar, Ward Hill, MA) was resuspended onto six of the diesel soot filters and six unexposed blank filters using a laboratory resuspension chamber (Chow et al., 1994). Loadings were in the range of 5 – 76 µg/cm^2, equivalent to 2 – 34 µg carbon (C)/cm^2.

Three punches (0.53 cm^2 each) from two diesel soot filters were spiked with 10 µl of a 2.3 g/L levoglucosan solution, equivalent to 22.9 µg C/cm^2. Twenty-five single blank quartz filter punches were spiked with liquid levoglucosan (5, 10, 12, 20 µl corresponding to low 9.6 µg C/cm^2, medium 19.2 and 22.9 µg C/cm^2, and high 38.3 µg C/cm^2 loads). Figure 2-4 and Table 2-5 summarize these test matrices. The spiking of the levoglucosan on blank filters gives the possibility of determining the positive bias in the EC measurement. As there is no native EC on the blank filter, any EC measured on the filter will be due to the charred OC in the filter mistaken as EC and should be corrected by pyrolysis correction.

Chow et al. (2004) show the TOT pyrolysis corrections for the two thermal/optical protocols yield different OC and EC concentrations, but the TOR pyrolysis corrections yield the same values. Table 2-6 documents the IMPROVE, IMPROVE_A, and STN/CSN protocols. The carbon fractions in the STN_TOT protocol vary by sample loadings and are constrained by the fixed analysis time (45-90 sec) per temperature plateau, and therefore are not useful for comparison.

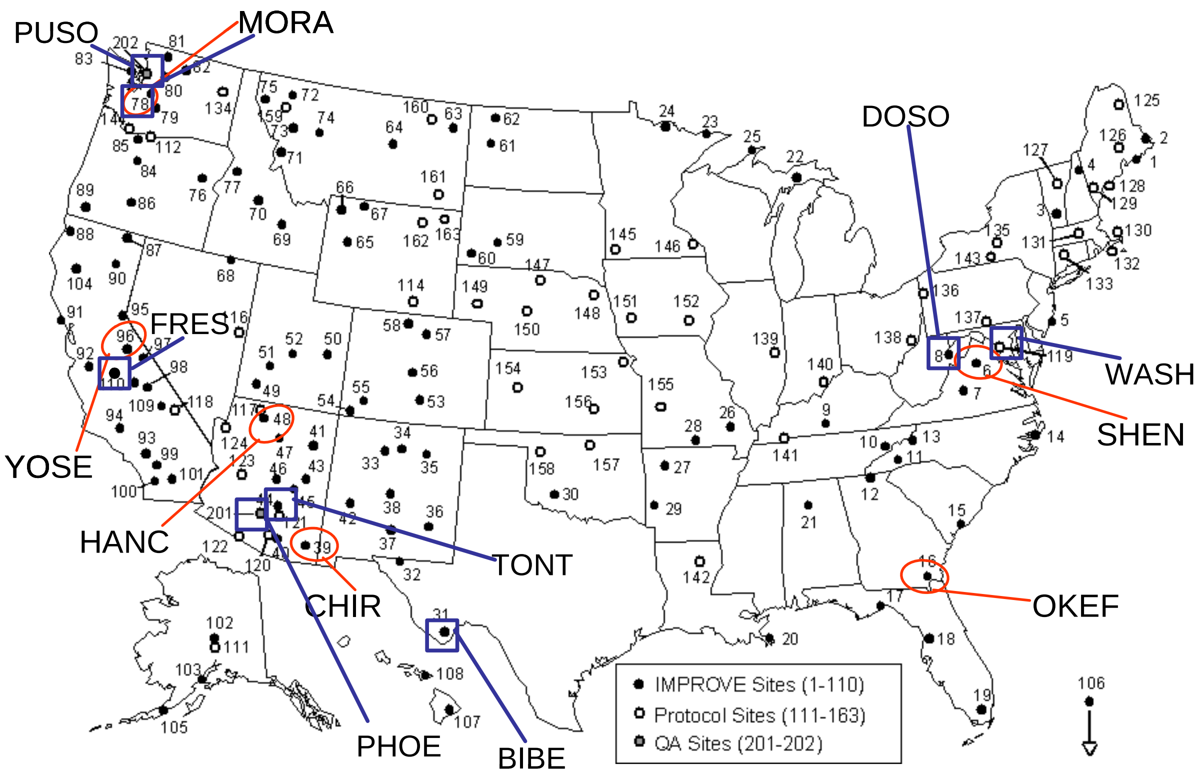


Figure 2-1. Sampling sites in the IMPROVE network from VIEWS (2007). The six circled sites are locations where secondary filters (i.e., quartz-fiber backup [QBQ] filters) are acquired~6% of the time: #78 (MORA) Mount Rainier National Park; #96 (YOSE) Yosemite National Park; #48 (HANC) Hance Camp at Grand Canyon National Park; #39 (CHIR) Chiricahua National Monument; #6 (SHEN) Shenandoah National Park; and #16 (OKEF) Okefenokee National Wildlife Refuge; the eight sites indicated by squares (#202 [PUSO] Seattle, WA; #78 [MORA] Mount Rainier National Park; #187 [FRES] Fresno, CA; #201 [PHOE] Phoenix, AZ; #44 [TONT] Tonto National Monument, AZ; #31 [BIBE] Big Bend National Park, TX; #8 [DOSO] Dolly Sods, WV; and #119 [WASH] Washington, DC) have collocated IMPROVE and STN/CSN samples.

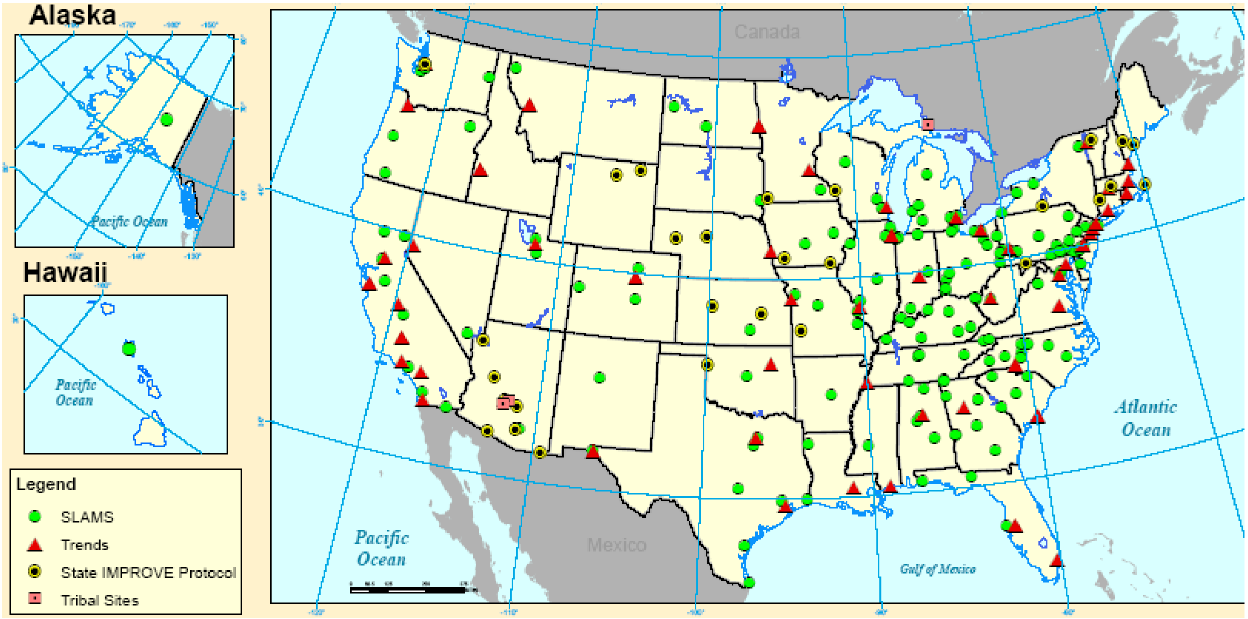


Figure 2-2. Sites in the Speciation Trends Network/Chemical Speciation Network (STN/CSN;U.S.EPA, 2006).

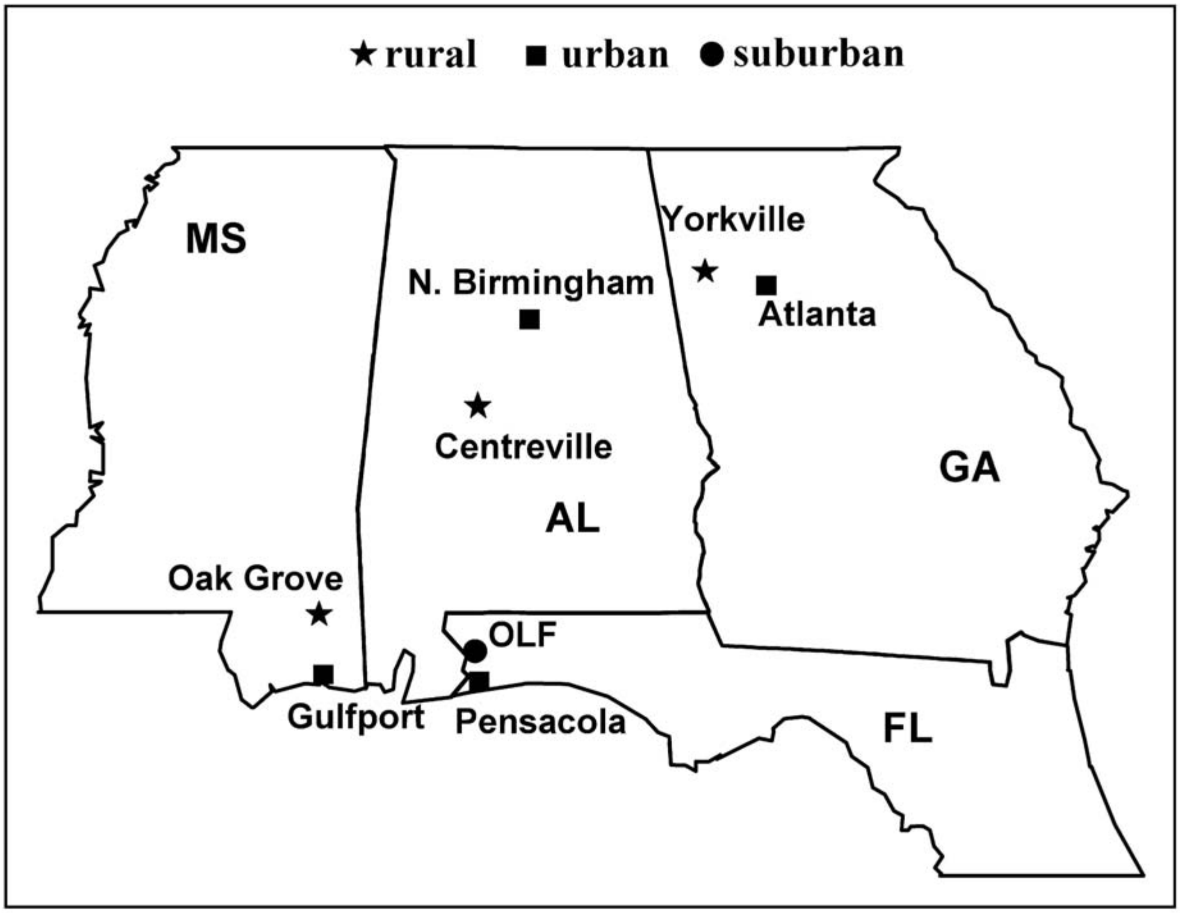


Figure 2-3. The SEARCH network, consisting of: Mississippi pair: urban Gulfport (GLF) in Gulfport and rural Oak Grove (OAK) near Hattiesburg; Alabama pair: urban Birmingham (BHM) in North Birmingham and rural Centreville (CTR) south of Tuscaloosa; Georgia pair: urban Jefferson Street (JST) in Atlanta and rural Yorkville (YRK) northwest of Atlanta; and Florida pair: urban Pensacola (PNS) in Pensacola and suburban outlying field (OLF) northwest of Pensacola.

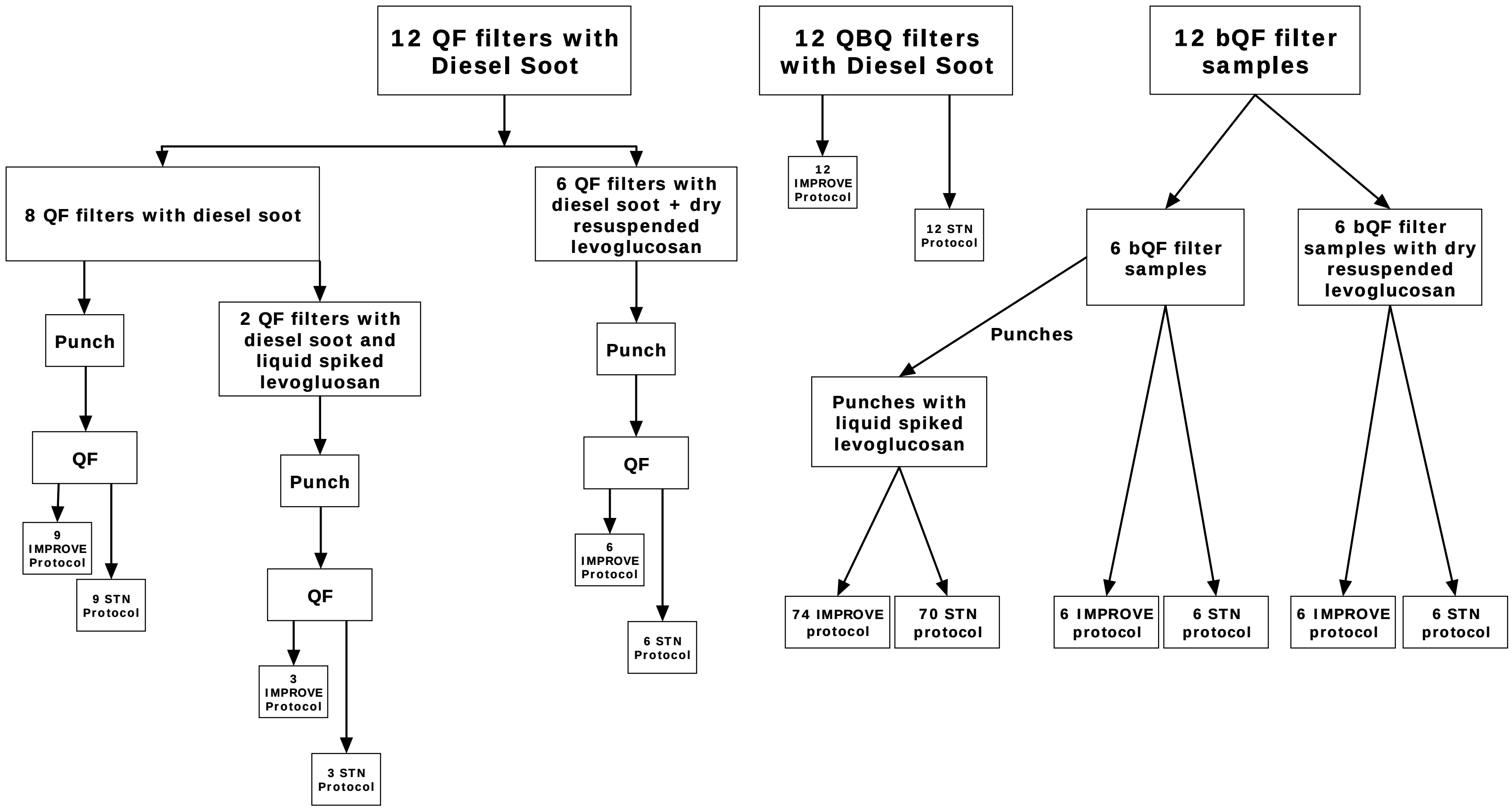


Figure 2-4. Flow diagram for diesel and levoglucosan experiments.

Table 2-1. Sampling protocols for the IMPROVE, STN/CSN, and SEARCH networks.

Variable	**Speciation Sampler**						
Network	IMPROVE	STN/CSN	STN/CSN	STN/CSN	CSN	CSN	SEARCH
Sampler Type[a]	IMPROVE	Andersen RAAS	Met One SASS	URG MASS	R&P 2300	R&P 2025 Sequential FRM	PCM3
Total Number of Sites	181	18	179	6	14	22	8
Number of Channels	3	4	5	2	4	2	3
Inlet Type[b]	AIHL cyclone	AIHL cyclone	cyclone	PM_{10} inlet/WINS	impactor	PM_{10} inlet/WINS or VSCC	cyclone/WINS impactor
Inlet Material[c]	anodized Al	anodized Al	anodized Al	anodized Al	anodized Al	anodized Al	anodized Al
Flow Rate	22.7 L/min	7.3 L/min	6.7 L/min	16.7 L/min	10.0 L/min	16.7 L/min	16.7 L/min
Face Velocity	107.2 cm/sec	10.3 cm/sec	9.5 cm/sec	23.7 cm/sec	14.2 cm/sec	23.6 cm/sec	39.1 cm/sec
Sample Volume	32.7 m^3	10.5 m^3	9.6 m^3	24 m^3	14.4 m^3	24 m^3	24 m^3
Sampling Frequency	3rd day	3rd day	3rd day	3rd day	3rd day / 6th day	3rd day / 6th day	3rd day[d]
Passive deposition time (Time Field Blank is in Sampler)	7 days[e]	1-15 min	variable[f]	1-15 min	variable[f]	5 – 7 days[g]	1-15 min
Filter Pack Configuration	QF[h] or QBQ[i]	QF[h]	QF[h]	QF[h]	QF[h]	QF[h]	carbon denuder/ QBQ[i]
Sites with Backup filters (QBQ[i])	6	0	0	0	0	0	8
Quartz Filter Deposit Area	3.53 cm^2	11.76 cm^2[j]	11.76 cm^2[j]	11.76 cm^2[j]	11.76 cm^2[j]	11.78 cm^2[k]	7.12 cm^2
Backup Filter Analysis Frequency	100%	N/A	N/A	N/A	N/A	N/A	10%
Quartz Filter Type (QF[h])	25 mm Pall[l]	47mm Whatman[m]	47mm Whatman	47mm Whatman	47mm Whatman	47mm Whatman	37 mm Pall
Lab Blank Frequency	2%	2 - 3%[n]	2 - 3%[n]	2 - 3%[n]	2 - 3%[n]		2%
Trip Blank Frequency	0%	3%	3%	3%	3%	0%	0%
Field Blank Frequency	2%	10%	10%	10%	10%	10-25%	10%
Field Blank Analysis Frequency	100%	100%	100%	100%	100%	100%	10% on QF[h]
Total Number of Field Blanks (2005-2006)	886	249	2,572	150	236	421	144

[a] IMPROVE: 4 single-channel modules (Eldred et al., 1990)

- Module A has a 2.5µm AIHL cyclone followed by a filter cartridge for up to four 25mm Teflon filter cassettes
- Module B has a sodium carbonate denuder (Ashbaugh et al., 2004) followed by a 2.5µm AIHL cyclone with a filter cartridge downstream for up to four 25mm or 37mm Nylon filter cassettes
- Module C has a 2.5µm AIHL cyclone followed by a filter cartridge for up to four 25mm quartz-fiber filter cassettes for carbon sampling. As of May 2007, the modified IMPROVE Module C, URG 3000N (URG Corp; Chapel Hill, NC) is placed in STN/CSN using Pallflex ® Tissuquartz.
- Module D has a PM_{10} inlet followed by a filter cartridge for up to four 25 mm quartz-fiber filter cassettes
- Flow rate through each channel is 22.7 L/min

Andersen Reference Ambient Air Sampler (RAAS; Andersen [now Thermo Scientific] Model 25-400; Franklin, MA) (Watson and Chow, 2002): 4 channels; each channel has a 2.5µm AIHL cyclone; all filters are 47mm in diameter

- Ch1 has a single quartz-fiber filter and samples at 7.3 L/min
- Ch2 has a single Teflon-membrane filter and samples at 16.7 L/min
- Ch3 is currently empty, but could be used for replicates at a flow of 16.7 L/min

Table 2-1. Continued

- Ch4 has a magnesium oxide denuder followed by a single Nylon filter and samples at a flow rate of 7.3 L/min

Met One Spiral Aerosol Speciation Sampler (SASS; Met One Model ; Grants Pass, OR) (NAREL, 2001): 5 channels (Super SASS can have up to 8 channels); each channel has a 2.5µm sharp cut cyclone; all filters are 47 mm in diameter

- Ch1 and Ch 2 each can have a single Teflon-membrane filter
- Ch3 has a magnesium oxide coated aluminum (Al) honeycomb denuder followed by a single Nylon-membrane filter
- Ch4 has a single quartz-fiber filter
- Ch5 is empty, can be used to acquire field blanks, but could also have a honeycomb denuder and up to two tandem filters
- The flow rate through each channel is 6.7 L/min

URG MASS (Chapel Hill, NC): 2 single-channel modules; all filters are 47 mm in diameter

- Module A (Model 400 WINS) has a 10µm size-selective inlet followed by a magnesium oxide denuder and then a two-stage filter pack (Teflon-/Nylon-membrane)
- Module B (Model 450 WINS) has a 10µm size selective inlet followed by a 2.5µm WINS impactor and then a quartz-fiber filter
- The flow rate through each channel is 16.7 L/min

R&P 2300 (Rupprecht & Patashnick [now Thermo Scientific] Model 2300; East Greenbush, NY) (Solomon et al., 2003): 4 channels (R&P also has a model that has up to 12 channels configured as a sequential sampler); each channel has a 2.5µm size selective impactor; all filters are 47 mm in diameter

- Ch1 has a single Teflon-membrane filter and samples at 16.7 L/min
- Ch2 has a single Teflon-membrane filter and samples at 16.7 L/min
- Ch3 has a single quartz-fiber filter (with an optional back-up quartz-fiber filter) and samples at 10 L/min
- Ch4 has a sodium carbonate honeycomb denuder followed by a Nylon filter and samples at 10 L/min
- Currently used at ~12 supplemental speciation sites

R&P 2025 (Rupprecht & Patashnick [now Thermo Scientific] Model 2025; Franklin, MA) (Tanner et al., 2005): 2 channels; each channel is a separate R&P 2025 sequential $PM_{2.5}$ Federal reference method (FRM) sampler; all filters are 47 mm in diameter

- Ch1 is for Teflon-membrane filters
- Ch2 is for quartz-fiber filters
- Each channel can take up to 16 filters loaded into a spun fiberglass magazine
- The flow rate through each channel is 16.7 L/min
- Currently used at ~9 supplemental speciation sites in Texas
- QBQ is an option

Particle Composition Monitor (PCM3) (Edgerton et al., 2005): 3 channels; the flow rate through each channel is 16.7 L/min

- Ch1 has a sodium carbonate denuder followed by a citric acid denuder and then has four three-stage 47mm filter packs (Teflon-membrane/Nylon-membrane/Citric Acid coated glass-fiber)
- Ch2 has a sodium carbonate denuder followed by a citric acid denuder and then has four single-stage 47mm filter packs (Nylon-membrane)
- Ch3 has a 10µm inlet cyclone followed by a 2.5µm WINS impactor and then a single two-stage 37mm filter pack (QBQ)

[b] AIHL: Air and Industrial Hygiene Laboratory cyclone (John and Reischl, 1980)
WINS: Well Impactor Ninety-Six (Peters et al., 2001a; Peters et al., 2001b; Vanderpool et al., 2001a; Vanderpool et al., 2001b; Vanderpool et al., 2007)
SCC: Sharp-Cut Cyclone (Kenny and Gussman, 2000; Kenny et al., 2000)
VSCC: Very Sharp-Cut Cyclone (Kenny et al., 2004)

[c] Al: aluminum

[d] Daily at the urban North Birmingham, AL (BHM) and Jefferson Street, Atlanta, GA (JST) sites

Table 2-1. Continued

[e] Based on the assumption of once per week site visits

[f] Field blanks usually in samplers for 1-15 minutes, but in some cases for as long as 5-7 days

[g] Field blank is in inlet and outlet magazines for as long as 5-7 days depending on the sampling frequency, but is in sampling position (without air being drawn through it) for only a few seconds.

[h] Quartz-fiber front filter

[i] Quartz-fiber backup filter behind quartz-fiber front filter

[j] RTI was 11.76 cm^2 for quartz and 11.70 cm^2 exposed area for STN/CSN

[k] DRI uses 11.78 cm^2 for quartz-fiber and Teflon-membrane exposed area for Texas' non-trends STN/CSN.

[l] Pallflex® Tissuquartz, Ann Arbor, MI

[m] Whatman QMA, Clifton, NJ

[n] 2% acceptance blanks and ~3% as daily instrument blanks

Table 2-2. Summary of filter handling procedures for different long-term networks.

	IMPROVE	**STN/CSN**	**SEARCH**
Filter Size and Type	25mm, Pall 37mm, Pall	47mm,Whatman QMA	
Filter Procurement	1,000 per box 1,000 per box	Varies by project	
Filter Pre-firing	100% of filters prefired at 900°C for minimum of 4 hours 100% of filters prefired at 900°C for minimum of 4 hours	100% of filters prefired at 900°C for minimum of 3 hours	
Filter Acceptance Testing	2%	2%	2%
Filter Acceptance Limits OC ≤1.5 µg/cm^2 EC ≤0.5 µg/cm^2	TC ≤2.0 µg/cm^2		
OC ≤1.5 µg/cm^2 EC ≤0.5 µg/cm^2	TC ≤1.0 µg/cm^2	TC ≤2.0 µg/cm^2	
Pre-shipping Storage	≤ 4°C	≤ -15°C	≤ 4°C
Shipping Schedule to the field	Approx. 1,500 per month	Project specific	Approx. 50-100 per month or as needed
Shipping Method/Temp to Field	Vacuum Sealed in FedEx Box, FedEx Standard Overnight/Ambient (20°C) Resealable plastic bag, FedEx Overnight, Cold	Vacuum Sealed in FedEx Box, FedEx 2-3 day/Ambient (20°C)	
Shipping Schedule from the field	2,000 per month	Unknown	275-300 per month
Shipping Method/Temp from field	Cold (≤ 4°C)	Cold (≤ 4°C)	Cold (≤ 4°C)
Passive Deposition Period	~every 7 days (once per week)	Varies (~1-15 minutes) with exceptions (~5-7 days)[a]	Varies (~1-15 minutes)
Special Handling	N/A	N/A	Samples returned wrapped in aluminum foil in Petri Dishes
Long-Term Storage Temperature	≤ 4°C	≤ -15°C	≤ 4°C
Long-Term Storage Period	DRI - Indefinitely	RTI - Up to 5.5 years	DRI – Indefinitely

[a] For the CSN R&P 2025 sequential Federal reference method (FRM) sampler with magazine filter holders used for the Texas non-trend sites and with R&P 2300 speciation sampler in New York

Table 2-3. Collocated $PM_{2.5}$ speciation data for the IMPROVE network and STN/CSN.

Type	Site Name	Inclusive Period	Number of Samples	IMPROVE Module	IMPROVE Data Source	IMPROVE # of Field Blanks	STN/CSN SAMPLER Anderson RAAS	STN/CSN SAMPLER MetOne SASS	STN/CSN SAMPLER URG MASS	STN/CSN SAMPLER R&P 2025 sequential FRM	STN/CSN Data Source	STN # of Field Blanks
Special Study	Puget Sound (PUSO), Seattle (Beacon Hill), WA	10/16/2001-12/29/2003	224	X	Non-processed carbon data from DRI database (µg/filter) Blank subtracted data from U.C. Davis	8			X		Field blank data from RTI Non-blank substrates Mass and chemical composition from U.C. Davis (µg/m³)	25
	Mount Rainier NP (MORA), WA	10/16/2001-11/1/2002	69	X		6			X			12
	Phoenix (PHOE), AZ	10/16/2001-12/29/2003	201	X		6		X				26
	Tonto National Monument (TONT), AZ	10/16/2001-12/29/2003	181	X		8		X				28
	Washington D.C. (WASH)	10/16/2001-12/29/2003	206	X		5	X					25
	Dolly Sods Wilderness (DOSO), WA	10/16/2001-12/29/2003	140	X		5	X					26
	Total		1021			38						142
Long-term Sites	Fresno (FRES), CA	1/1/2005-7/31/2006[a]	Complete IMPROVE + STN 146	X	Non-processed carbon data from DRI database (µg/filter) Blank subtracted data from VIEWS[b] databases (µg/m³)	4	X				Non-blank subtracted AIRS[c] database (µg/m³)	18
	Big Bend NP (BIBE), TX	1/4/2005-12/30/2005[a]	26	X		3				X		14
	Total		172									

[a] For carbon comparison, two complete years of data were used for the Fresno, CA and Big Bend National Park, TX, sites, which resulted in 227 and 81 samples, and 23 and 26 field blanks, respectively

[b] AIRS and AQS: http://www.epa.gov/ttn/airs/airsaqs/

[c] VIEWS: http://vista.cira.colostate.edu/views/

Table 2-4. Examples of organic carbon (OC) database differences among air quality networks.

Data Source	Description	Organic Carbon Code	Observable Description	Clarification
DRI	DRI uses a four letter code to represent an observable. The first two letters consist of a code for the species measured, the third letter represents the analysis method, and the fourth indicates concentrations or uncertainties of the value.	OCTC	Organic Carbon by TOR (µg/filter or µg/m^3, depending on it being in the processed or unprocessed data file.	The observable name does not indicate the thermal method used, although this is implied by the network. The size fraction is indicated in another field after the data have been processed.
VIEWS	VIEWS uses codes that indicate the species measured and the sampled size fraction. More details about the parameter are given in the code descriptions.	OCf	Total organic carbon. (Units µg/m^3 LC) where LC refers to sample volumes at local conditions (temperature and pressure).	Observable names do not indicate the thermal method used, although this is implied by the network.
AIRS	STN/CSN uses numerical codes to indicate the analysis method, the observable, and the unit. Typically, the code is specific to a fraction and an analyte, while the method specifies the sampler used and the instrument used for analysis.	88305 (STN) or 88324 (IMPROVE)	Organic carbon by STN_TOT or IMPROVE_A_TOR methods.	Parameter codes change when a sampler or measurement method is changed, requiring much manual editing to reconcile measurements for comparisons.

Table 2-5. Tests for diesel and levoglucosan-doping experiments.

Test Matrix ID	Sample Description	Generator Load	Dilution Ratio	Levoglucosan Resuspended (µg/cm²)	Levoglucosan Liquid (µgC/cm²)	No. of samples QF[a]	No. of samples QBQ[b]
I	Diesel exhaust QF	4 kW	70:1	N/A	N/A	8	6
II	Diesel exhaust QF plus resuspended solid levoglucosan	4 kW	70:1	76	N/A	6	0
III	Blank filter plus resuspended solid levoglucosan	N/A	N/A	5 and 11[c]	N/A	6	0
IV	Diesel exhaust QF plus liquid spiked levoglucosan	4 kW	70:1	N/A	22.9	6	N/A
V	Blank filter plus liquid spiked levoglucosan	N/A	N/A	N/A	9.6, 19.2, 22.9, 38.3[d]	24	N/A

[a] QF: Quartz-fiber front filter
[b] QBQ: Quartz-fiber filter behind quartz-fiber front filter
[c] Low and high concentrations
[d] Low, medium and high concentrations

Table 2-6. Comparison of the IMPROVE, IMPROVE_A, and STN/CSN thermal/optical carbon analysis protocols.

Methods' Carrier Gas	Carbon Fraction	IMP_TOR/TOT[a] Temperature, Time	IMPROVE_A_TOR/TOT[a] Temperature, Time	STN_TOT/TOR[a] Temperature, Time
He-Purge		30 °C, 90 s	30 °C, 90 s	30 °C, 90 s
He-1	OC1	120 °C, 150-580 s[c]	140 °C, 150-580 s[c]	310 °C, 60 s
He-2	OC2	250 °C, 150-580 s	280 °C, 150-580 s	480 °C, 60 s
He-3	OC3	450 °C, 150-580 s	480 °C, 150-580 s	615 °C, 60 s
He-4	OC4	550 °C, 150-580 s	580 °C, 150-580 s	900 °C, 90 s
He-5		-	-	Cool Oven
O_2/He-1[b]	EC1	550 °C, 150-580 s	580 °C, 150-580 s	600 °C, 45 s
O_2/He-2	EC2	700 °C, 150-580 s	740 °C, 150-580 s	675 °C, 45 s
O_2/He-3	EC3	800 °C, 150-580 s	840 °C, 150-580 s	750 °C, 45 s
O_2/He-4	EC4	-		825 °C, 45 s
O_2/He-5	EC5	-		920 °C, 120 s

[a] IMPROVE_TOR or IMPROVE_A_TOR Thermal/optical reflectance analysis following the IMPROVE (Interagency Monitoring of Protected Visual Environments) protocol using DRI/OGC analyzers (Desert Research Institute, Reno, NV). IMPROVE_TOR does not advance from one temperature to the next until a well-defined carbon peak has evolved (Chow et al., 1993, 2001, 2004a). Filter reflectance is monitored throughout the analysis; pyrolyzed OC (OP) is defined as the carbon evolving between the introduction of oxygen (O_2) in the helium (He) atmosphere and the return of reflectance to its initial value (the OC/EC split). OP is reported as a positive value if the OC/EC split occurs after the introduction of O_2, and as a negative value if the OC/EC split occurs before O_2 is introduced. In either case, OC equals OC1+OC2+OC3+OC4+OP and EC equals EC1+EC2+EC3-OP. Eight well-defined fractions of carbon, including four OC fractions (OC1, OC2, OC3, and OC4), three EC fractions (EC1, EC2, and EC3), and OP are reported as part of the IMPROVE_TOR protocol.

IMPROVE_TOR/TOT or IMPROVE_A_TOR/TOT Same as the IMPROVE_TOR protocol but using a DRI Model 2001 thermal/optical carbon analyzer (Atmoslytic, Calabasas, CA). The DRI Model 2001 performs charring correction through both reflectance and transmittance and reports as OPR and OPT, respectively. Subsequently, OC and EC calculated from OPR (OPT) are referred to as OCR and ECR (OCT and ECT), respectively (Chow et al., 2005b; Chow et al., 2007a).

STN_TOR/TOT .... Thermal/optical transmission/reflectance analysis following the Speciation Trends Network (STN) protocol. Filter transmittance is monitored to split OC and EC (STN_TOT). With the DRI Model 2001 thermal/optical carbon analyzer (Atmoslytic, Calabasas, CA), reflectance can also be recorded during the STN/CSN analyses. The protocol that uses STN/CSN temperature plateaus but reflectance split is referred to as STN_TOR. The STN/CSN protocol has a short and fixed residence time per temperature plateau and cannot report distinguishable carbon fractions. The STN/CSN protocol is currently applied to the United States $PM_{2.5}$ Speciation Trends Network.

[b] 2% O_2 in He.

[c] The residence time at each temperature in the IMPROVE protocol depends on when the flame ionization detector (FID) signal returns to the baseline to achieve well-defined carbon fractions.

3. RESULTS

3.1. Comparison of Field Blank Levels among the IMPROVE, STN/CSN, and SEARCH Networks

Average field blanks levels for OC, EC, and thermal carbon fractions from the IMPROVE, STN/CSN, and SEARCH networks for 1/1/2005 through 12/31/2006 are compared in Table 3-1. The first columns express the concentration density in μg/cm^2, thereby allowing the levels to be compared among the different filter sizes. The second set of columns (μg/filter) extends this to the area or the particle deposit on the front filter; this is the value that would be subtracted for blank correction. The third set of columns (μg/m^3) normalizes this to the nominal sample volumes acquired over 24-hours in each network and approximates the bias that would be encountered in the absence of a blank subtraction. EC values are at or near precision levels, indicating that passive PM deposition is negligible. As a result, OC and TC are nearly the same and can be used interchangeably. Tables 3-2 to 3-4 break down these network-wide data by sampling location. These tables should be useful to examine the extent to which there are large deviations from the mean, but the small number of samples at each site does not represent the true distribution of blank levels over the two-year sampling period.

Ambient-equivalent field blank TC concentrations are comparable for the IMPROVE (0.26 ± 0.05 μg/m^3) and SEARCH (0.24 ± 0.18 μg/m^3) networks, but four times higher for the STN/CSN network (1.03 ± 0.21 μg/m^3). Part of the reason for the large STN/CSN field blank concentrations (in μg/m^3) is the relatively low flow rate for the most commonly used Met-One SASS monitors (6.7 L/min) and the larger exposed area of the filter deposit (11.76 cm^2 vs. 3.53 cm^2 for IMPROVE and 7.12 cm^2 for SEARCH).

The areal concentration densities tell a different story; IMPROVE TC densities are 2.5 to 3 times those of the other networks (2.41 ± 0.48 μg/cm^2 for IMPROVE vs. 0.97 ± 0.27 μg/cm^2 for STN/CSN and 0.81 ± 0.61 μg/cm^2 for SEARCH). This probably reflects the longer time that the IMPROVE filters spend uncapped in the sampling system as opposed to a short period for the other field blanks (See Table 2-2). This suggests that the STN/CSN and SEARCH field blanks underestimate OC artifacts. Earlier studies in urban Los Angeles, CA, and Pittsburgh, PA, suggested a minimum exposure time for VOC absorption of several hours (Turpin et al., 1994; Subramanian et al., 2004), so these field blanks may reach the saturation for VOC absorption in the IMPROVE network, but not in the STN/CSN or SEARCH networks.

As noted above, OC concentration densities are equivalent to those for TC, at 2.36 ± 0.45 μg/cm^2 for IMPROVE, 0.95 ± 0.25 μg/cm^2 for STN/CSN, and 0.76 ± 0.57 μg/cm^2 for SEARCH. This is consistent with the OC concentration distribution among the sites shown in Figure 3-1, where the majority of the OC is in the range of 2 – 2.5 μg/cm^2 for IMPROVE, 0.5 – 1 μg/cm^2 for STN/CSN, and < 0.5 μg/cm^2 for SEARCH. For the Pallflex® Tissuquartz filters and carbon analysis protocol (IMPROVE_A), OC on the field blanks in the IMPROVE and SEARCH networks is evenly distributed among OC1, OC2, and OC3. The difference in field blank OC levels is consistent with the passive deposition period.

Table 3-5 shows that average field blank OC concentration densities vary among sampler types by a factor of two or more, from 0.74 ± 0.66 μg/cm^2 (URG MASS) to 1.49 ± 0.8 μg/cm^2 (R&P 2025 FRM). Since over 70% of the sampling sites in STN/CSN are equipped with a Met One SASS, the weighted average OC (0.95 ± 0.25 μg/cm^2) in Table 3-1 best represents the network as a whole, but the bias for non-SASS samplers is better estimated by the values in Table 3-5, with the sampler at a specific site determined from Table 3-3. The all-site average in Table 3-3 differs from the non-weighted average in Table 3-5 for this reason. The difference between the two averages is ~10%, owing to the dominance of the SASS samplers in STN/CSN.

Table 3-5 shows that the two R&P samplers (R&P 2300 and R&P 2025 sequential FRM) reported the highest field blank OC (1.3 – 1.5 μg/cm^2). The passive deposition period for the R&P 2300 is variable, in the range of minutes to seven days. More detailed records of field blank exposure periods would facilitate an evaluation of the effects of this period on the field blank levels.

3.2. Comparison between STN/CSN Field and Trip Blanks

Table 3-6 compares field and trip blanks among the five STN/CSN speciation samplers. There were 3,628 field blanks and 2,335 trip blanks acquired in STN/CSN during 2005 and 2006. These samples were submitted for carbon analysis of OC and EC following the STN/CSN thermal/optical transmittance (TOT) protocol (Peterson and Richards, 2002; Flanagan et al., 2002). The average concentration densities of field and trip blanks by sampler type are similar, agreeing within ±0.05 μg/cm^2. OC averages across the five $PM_{2.5}$ speciation sampler types are 1.05 ± 0.32 and 0.95 ± 0.23 μg/cm^2 for field and trip blanks, respectively. Trip blank OC densities range from 0.80 ± 0.69 μg/cm^2 for the URG MASS to 1.30 ± 0.48 μg/cm^2 for the R&P

2300, similar to concentration densities found in field blanks (0.74 ± 0.66 to 1.30 ± 0.51 µg/cm^2 for the URG MASS and R&P 2300, respectively).

Operators for the majority of the STN/CSN sites leave the field blank cartridges in place for a period of 1 to 15 minutes (information obtained from telephone surveys of field operators), which is similar to the field blank passive deposition times in the SEARCH network. Some operators in NY leave the field blank cartridge in channel five of the Met One SASS for a period of 5 to 7 days, but this is not done consistently throughout the state. Trip blanks are not exposed to ambient air and are expected to have much lower concentrations, similar to those found in laboratory blanks (typically 0.15 ± 0.15 µg/cm^2). The similarity of the STN/CSN field and trip blanks indicates that the passive exposure period for the field blanks is probably too short to represent the organic vapors absorbed by the sample. This would probably be the case for the SEARCH network if it also used trip blanks.

3.3. Quartz-Fiber Backup Filters from the IMPROVE and SEARCH Networks

Comparing the organic artifact among different sampling configurations with and without preceding organic denuders, Huebert and Charlson (2000) concluded that the positive organic artifact is in the range of 30 – 50%, and that negative organic artifacts could be on the order of 50% of the actual ambient OC levels. If the SEARCH denuder is 100% efficient in removing VOCs and gSVOCs from the sampled air, the increment on the backup filter over the field blank level should consist of recaptured SVOC that evaporated from particles on the front filter. This increment would represent a negative OC artifact.

Table 3-7 compares the IMPROVE and SEARCH OC backup filter levels, based on the quartz-fiber filter behind quartz-fiber front filter (QBQ), for the period from 2005 – 2006. Average OC concentration density is 3.1 ± 0.8 µg/cm^2 for IMPROVE and 1.2 ± 0.52 µg/cm^2 for SEARCH, 30 and 60% higher than the corresponding field blank levels reported in Table 3-1. With the denuded SEARCH PCM3 sampler, the average backup quartz OC level is 0.43 ± 0.97 µg/cm^2 higher than the field blank. While this might be interpreted as a negative artifact that should be added to the OC, it could also be interpreted as a better representation as the true field blank, since it spent more passive time in the sampler than the intended field blank. The variability is also large. The distributions of carbon fractions (OC1 to OC4) on these QBQ are quite similar: 18, 31, 37, and 10% for IMPROVE and 22, 29, 39, and 6% for SEARCH. The denuder does result in a lower concentration density on the backup filter, and probably minimizes the positive OC bias on the front filter deposit, but it cannot be entirely attributed to negative sampling artifact owing to passive deposition.

Since IMPROVE uses 25 mm quartz-fiber filters at a high flow rate (22.7 L/min) and SEARCH uses 37 mm filters at a lower flow rate (16.7 L/min), Table 3-7 shows that the ambient artifact OC concentrations are similar: 0.33 ± 0.10 $\mu g/m^3$ for IMPROVE and 0.35 ± 0.15 $\mu g/m^3$ for SEARCH. These levels are 30 – 50% higher than the field blank concentrations of 0.26 ± 0.05 and 0.23 ± 0.17 $\mu g/m^3$ for IMPROVE and SEARCH, respectively, but ~65% lower than the 1.01 ± 0.21 $\mu g/m^3$ found in the STN/CSN sites.

3.4. Seasonal Variations of Blanks and Backup Filter OC Concentration Density

Tables 3-8 through 3-10 summarize the number of field blanks acquired for each season among the IMPROVE, STN/CSN, and SEARCH networks. The number of field blanks for each season at a site range from zero to six for IMPROVE, zero to 16 for STN/CSN, and one to seven for SEARCH. Average OC levels by season are examined in Figure 3-2. Seasonal variations are most apparent for the IMPROVE network, with average field blank OC concentrations varying by over 40% between winter (1.97 $\mu g/cm^2$) and summer (2.92 $\mu g/cm^2$). There are no apparent changes in the abundances of the carbon fractions among the four seasons.

Seasonal variability is small for STN/CSN and SEARCH field and trip blanks, again probably due to their short passive exposure periods. Seasonal OC spans are 0.8 – 1.1 $\mu g/cm^2$ for STN/CSN and 0.52 – 1.0 $\mu g/cm^2$ for SEARCH. It is not clear why SEARCH sites shows such high levels during fall.

Seasonal variations of QBQ OC fractions for the six IMPROVE and eight SEARCH sites are presented in Figure 3-3. They follow the same pattern as those of the IMPROVE field blanks (Figure 3-2) with a summer high and winter low.

Field blank OC and TC levels do not differ between urban and non-urban locations within any of the networks, as shown in Figure 3-4. For the SEARCH sites, average field blank OC concentrations are similar between the five urban (0.64 ± 0.74 $\mu g/cm^2$) and three non-urban (0.88 ± 0.91 $\mu g/cm^2$) sites. Similar urban vs. rural field blank OC levels were found at the IMPROVE sites (2.4 ± 0.67 vs. 2.3 ± 0.75 $\mu g/cm^2$).

Backup filters are compared in Figure 3-5 for urban and non-urban locations. In this case, only the SEARCH samples had urban backup filters, and these were preceded by the carbon denuder. Average OC on the QBQ was ~20% higher at the urban (1.46 ± 1.47 $\mu g/cm^2$) than non-urban (1.20 ± 0.9 μg/cm^2) SEARCH sites, consistent with the sampled urban particles having a larger SVOC component than the non-urban particles. Table 3-11 shows that the urban increment is only found on the low temperature carbon fractions (OC1 at 140 °C and OC2 at 280 °C). The urban increment is ~75% OC1 (0.46 ± 0.80 vs. 0.26 ±0.38 μg/cm^2) and ~20% for OC2 (0.42 ± 0.46 vs. 0.35 ± 0.27 μg/cm^2). Average backup filter OC levels from the six non-urban IMPROVE sites (3.1 ± 0.8 μg/cm^2) are 2.5 times higher than the backup filter OC from the three non-urban SEARCH sites (1.2 ± 0.9 μg/cm^2), again showing the effectiveness of the denuder in removing adsorbable VOCs and gSVOCs.

3.5. Comparison of Blanks between Collocated IMPROVE and STN/CSN

The IMPROVE/STN comparison study at three urban (Seattle, WA; Phoenix, AZ; and Washington, DC) and three rural (Mt. Rainier, WA; Tonto National Monument, AZ; and Dolly Sods Wilderness, WV) sites, shown in Figure 2-1, allows for direct comparison of field blanks from the two networks. Collocated IMPROVE/STN data are also available at the urban Fresno Supersite and non-urban Big Bend National Park site.

Table 3-12 compares average TC concentrations (uncorrected) and blank levels at these sites using five different types of $PM_{2.5}$ speciation samplers. Time series of blank TC concentrations in the two networks are illustrated in Figure 3-6.

STN/CSN trip blanks are similar between urban-rural paired sites, but they differ among samplers, consistent with two-year average blanks in Table 3-6. Trip blank TC densities at the Seattle and Mount Rainier sites, using the URG MASS sampler, are 0.53 ± 0.19 and 0.67 ± 0.12 μg/cm^2, respectively, lower than the 0.84 – 1.12 μg/cm^2 found at sites using the Andersen RASS or Met One SASS samplers. Field blank TC is consistent with trip blank TC most of the time (Figure 3-6), although they were not acquired simultaneously. Occasionally, much higher TC is found on field blanks relative to trip blanks at both urban and rural sites, but the limited blank dataset does not allow for accurate evaluation of the frequency of occurrence. As discussed in Section 3.1, the short passive exposure time (1 – 15 minutes) at most STN/CSN sites for field blanks probably minimizes additional vapor adsorption over that experienced by the trip blanks.

The IMPROVE field blank TC concentration density is two to three times higher than STN/CSN field or trip blanks. As discussed in Section 3.1, the IMPROVE field blanks are exposed to ambient air for a much longer period (~7 days) and thus have a higher chance of saturation. In addition, IMPROVE uses the Pallflex® Tissuquartz while STN/CSN uses QMA filters, and these filters may differ in: 1) capacity and affinity for VOC and gSVOC adsorption and desorption, and 2) the rate to reach saturation or equilibrium between gSVOC and particulate OC (pOC).

For IMPROVE Module C field blanks (bQF), TC is most consistent among the four urban sites (Seattle, Phoenix, Washington, DC, and Fresno), ranging from 2.40 – 2.66 $\mu g/cm^2$, with lower densities measured at two rural sites: Mount Rainier (1.4 ± 0.4 $\mu g/cm^2$) and Tonto Monument (2.0 ± 1.1 $\mu g/cm^2$). The variability of STN/CSN field blanks is larger, ranging from 0.66 ± 0.42 (Mount Rainier using URG MASS) to 1.44 ± 0.48 $\mu g/cm^2$ (Big Bend using R&P 2025 sequential FRM). This supports the hypothesis that longer passive deposition periods result in higher field blank levels. There are insufficient blanks to evaluate seasonal variation for individual sites. As shown by Chow et al. (2007b), field blank TC is high in summer and low in winter throughout the IMPROVE network.

While the site-averaged non-blank corrected ambient TC concentrations in $\mu g/m^3$ among the eight collocated IMPROVE/STN sites are similar within ± 30 – 50% (Table 3-11), the site-averaged ambient TC concentration density is much lower for STN/CSN samples compared to IMPROVE samples by a factor of 5 – 11 in terms of $\mu g/cm^2$. This is due to a relatively small sample volume (e.g., 9.6 m^2 for the Met One SASS and 10.5 m^2 for the Andersen RAAS) and large filter deposit area (11.76 cm^2) of the STN/CSN samplers. This suggests that sampling artifact is more pronounced for STN/CSN and that blank corrections are needed. In rural areas where ambient OC levels are lower than in urban areas, the uncorrected STN/CSN data is positively biased. At the Dolly Sod site, the average STN/CSN field blank TC (in $\mu g/cm^2$) reaches ~49% of front filter TC, but it is only 12% for the collocated IMPROVE samples. The actual bias is probably larger, since it appears that the STN/CSN field blanks underestimate OC adsorption by the sample filter owing to the short passive exposure period.

A regression method similar to that of White and Macias (1989) is used to evaluate the relative sampling artifact between the collocated IMPROVE and STN/CSN samples. If these samples have an equivalent sampling artifact, the regression intercept of uncorrected STN/CSN TC (y-axis) against uncorrected IMPROVE TC (x-axis) should be zero. Otherwise, if appropriate assumptions are met (Chow et al., 2007c), the intercept indicates the difference between the IMPROVE and STN/CSN sampling artifact (net positive and negative sampling artifact). Using Phoenix data as an example, Figure 3-7 shows an intercept of 1.75 $\mu g/m^3$, meaning a positive

STN/CSN carbon sampling artifact of 1.75 μg/m^3 or 1.43 μg/cm^2 (note: conversion using SASS sampling volume and deposit area) relative to IMPROVE sampling artifact. Flipping the x and y axis in Figure 3-7 does not change the conclusion. Figure 3-7 also shows that the regression intercept and slope may be biased by a few outliers. To mitigate the biases, a robust regression method (Dutter and Huber, 1981), which iteratively downweights the outliers, is used. The regression was calculated for all data and seasonally segregated data from each site.

Figure 3-8 shows that the regression intercepts are positive for each season at the eight sites. This corroborates a larger STN/CSN TC or OC artifact (relative to the ambient concentrations), which has been explained by the lower TC deposit on STN/CSN filters (per cm^2). For five of the eight sites, the intercept is largest in summer. It is highest in spring at the Mount Rainier and Tonto Monument sites, and highest in fall at the Fresno site. The intercept of all data regression appears to represent the average of four seasons. Table 3-13 summarizes the intercept, slope, and correlation for the uncorrected IMPROVE/STN pairs at each site. The largest two intercepts (μg/cm^2), appear at the Phoenix and Big Bend sites using the Met One SASS and R&P 2025 sequential FRM sampler, respectively, while the lowest two appear at the Seattle and Mount Rainier sites using the URG MASS samplers. The sampler influences the magnitude of the TC/OC artifact. At the Dolly Sod (Andersen RAAS) and Big Bend (R&P 2025 sequential FRM) sites, the correlation between IMPROVE and STN/CSN TC is low (0.67 – 0.79) and therefore the regression intercept contains a larger uncertainty.

If field blank levels adequately compensate for IMPROVE and STN/CSN artifacts, the TC would be the same for the collocated blank-corrected ambient concentrations. Based on Table 3-13 and the sampling volume/deposit area of each type of sampler (see Table 2-1), the relationship between the IMPROVE and STN/CSN sampling artifacts (i.e., IMP_{art} vs. STN_{art}) is formulated as follows:

Seattle, WA: $STN_{art} = IMP_{art} \times 0.22 + 0.24$ (1)

Mount Rainier, WA: $STN_{art} = IMP_{art} \times 0.22 + 0.50$ (2)

Phoenix, AZ: $STN_{art} = IMP_{art} \times 0.088 + 1.34$ (3)

Tonto Monument, AZ: $STN_{art} = IMP_{art} \times 0.088 + 0.69$ (4)

Washington, DC: $STN_{art} = IMP_{art} \times 0.096 + 0.85$ (5)

Dolly sod, WV: $STN_{art} = IMP_{art} \times 0.096 + 0.74$ (6)

Fresno, CA: $STN_{art} = IMP_{art} \times 0.088 + 0.90$ (8)

Big Bend NP, TX: $STN_{art} = IMP_{art} \times 0.22 + 1.29$ (7)

where the sampling artifact and intercept are in µg/cm^2.

Neither IMP_{art} nor STN_{art} are known. Assuming that the average IMP_{art} is adequately estimated by the blank filters, the average STN_{art} can be calculated for each site. Table 3-14 compares the calculated STN_{art} with their corresponding field blank TC concentrations. At six of the eight sites, the STN/CSN field blank TC underestimates the sampling artifact by ~20%, except for the Fresno site (34%). At the rural Tonto Monument and Dolly Sod sites, however, the STN/CSN field blank TC (µg/cm^2) appears to better represent the STN_{art}. Despite a larger relative artifact for STN/CSN samples, the blank corrected STN/CSN TC at the two sites agrees with the blank corrected IMPROVE TC. Dolly Sod shows a poor correlation between IMPROVE and STN/CSN TC. How these blanks are handled at both IMPROVE and STN/CSN sites also warrants further investigation (for example, Figure 3-6 shows two field blanks at the IMPROVE Tonto Monument site that have very low TC concentrations: 0.4 and 0.3 µg/cm^2, well below the average).

3.6. Sulfate, Adjusted Nitrate, Derived Water, Inferred Carbonaceous Material (SANDWICH) Method

Teflon-membrane filters are believed to adsorb few organic vapors, and therefore would have a minimal positive OC artifact. The SANDWICH method (Frank, 2006) assumes that all of the unaccounted $PM_{2.5}$ mass measured on a Teflon-membrane filter when elements and ions are summed can be associated with the carbonaceous component. The SANDWICH method might minimize the influence of organic artifacts. The OC or organic carbon mass (OCM) estimated from the SANDWICH method can be compared to those measured from quartz-fiber filters using different corrections to evaluate other artifact correction methods.

The SANDWICH method was applied to 716 valid collocated filter pairs taken at four urban (i.e., Seattle, WA [PUSO]; Phoenix, AZ [PHOE]; Washington, DC [WASH] and Fresno, CA [FRES]) sites from 04/28/2001 to 12/29/2004 (Solomon et al., 2004). The number of sample pairs varied from 27 at the Fresno Supersite to 354 at the Seattle site. The total carbonaceous mass (TCM) is calculated by subtracting sulfate ($SO_4^{=}$), nitrate (NO_3^-), ammonium (NH_4^+), water (H_2O), and crustal components from the measured $PM_{2.5}$ mass. The calculated OCM is derived by subtracting measured EC from TCM. The resulting OCM is then compared to measured OC with the following equations:

$$TCM = PM_{2.5} - [(SO_4^{=}) + (\text{Retained } NO_3^{-}) + (NH_4^{+}) + (H_2O) + (\text{Crustal Material}) + (\text{Blank})] \quad (9)$$

$$OCM = TCM - EC \quad (10)$$

where:

$$\text{Crustal Material} = 3.73 \times Si + 1.63 \times Ca + 2.42 \times Fe + 1.94 \times Ti \quad (11)$$

Blank = 0.5 μg/m^3 for STN/CSN; 0 for IMPROVE

IMPROVE data were blank-subtracted using the monthly median OC from the backup quartz-fiber filters at six sites, and no additional field blank values were subtracted. Field blanks were subtracted from the STN/CSN as part of this analysis. Tables 3-15a and 3-15b summarize the average $PM_{2.5}$ sample and field blank concentrations. Site-to-site variations of average field blanks for $PM_{2.5}$ mass ranged from 0.25 ± 0.32 μg/m^3 at the Washington, DC site to 0.89 ± 1.12 μg/m^3 at the Phoenix site using the three types of STN/CSN samplers. A nominal blank value of 0.5 μg/m^3 for blank subtraction, suggested by Frank (2006), is used for this study, which is similar to the 0.66 ± 0.94 μg/m^3 three-site (field blank data for the Fresno site for this period was not available) STN/CSN field blank averages for the study period. Retained nitrate was calculated as described in Frank (2006) using the daily average temperature and relative humidity during the sampling period. Particle bound water was calculated using the Aerosol Inorganics Model (AIM) as described by Frank (2006).

OCM concentrations from the SANDWICH method are compared to measured OC using a multiplier that accounts for unmeasured hydrogen, oxygen, and other elements in the organic compounds (i.e., White and Roberts, 1977; Turpin and Lim, 2001; El Zanan et al., 2005):

$$OCM = X \times OC \quad (12)$$

where:

X = unmeasured element multiplier (assumed to be 1.4 for fresh and 1.8 for aged aerosol)

OC = measured particulate organic carbon

For urban IMPROVE samples, average OCM concentrations calculated by the SANDWICH method are 3.99 ± 2.96 μg/m^3, 4.40 ± 3.45 μg/m^3, 3.00 ± 3.16 μg/m^3, and 6.73 ± 3.56 μg/m^3 at the Seattle, Phoenix, Washington, DC, and Fresno sites, respectively. Better agreement was found for a multiplier of 1.4 rather than 1.8 for all but the Fresno site, which showed better agreement using the multiplier of 1.8. Table 3-16 shows that good agreement for the Seattle (95%), Phoenix (100%), and Washington, DC (123%) sites, between measured (OC × 1.4) and estimated [using Eq. (10)] OCM. Reasonable agreement is found at the Fresno (71%) site.

The STN/CSN samples among different samplers also agree. Using OC × 1.4, the URG MASS yields good agreement at the Seattle (90%) site. The Andersen RASS reports reasonable agreement at the Washington, DC site (79%). Good agreement is found for the Met One SASS at the Phoenix (123%) and Fresno (88%) sites.

To assess whether low, mid-range, or high concentration samples exhibit differences, Table 3-16 compares the 10th, 50th, and 90th percentiles. The percent differences between the average and median (50% of total) are similar (within ± 25%) for the sites using IMPROVE samples for multipliers of 1.4 or 1.8. At low concentrations (the 10th percentile), overestimates were observed at the Washington, DC site (217%) as compared to the median concentration. Using STN/CSN samples, the SANDWICH method overestimates OCM by a factor of two at low concentrations at the Phoenix, AZ site; but the agreement is reasonable (117%) for high concentration samples (90th percentile).

3.7. Influence of Levoglucosan on OC/EC Split for Carbon by IMPROVE and STN/CSN Protocols

The OC sampling artifact not only biases OC but also the EC measurement through the thermal/optical reflectance or transmittance charring correction. A laboratory experiment was attempted to evaluate this effect by adding solid and liquid levoglucosan ($C_6H_{10}O_5$) to unexposed blank filters and diesel soot samples. Levoglucosan, a water-soluble sugar that results from oxidation of cellulose (Lakshmanan and Hoelscher, 1970), has a melting point of 170 – 180 °C (MSDS), a decomposition temperature of 250 – 400 °C, and is often used as a marker for vegetative burning emissions (e.g., Poore, 2002; Mazzoleni et al., 2007).

Liquid levoglucosan can be added to an exposed filter using a syringe, in which case it would be expected to penetrate the depth of the filter. A solution can also be nebulized and dried to a solid prior to sampling, thereby residing on the filter surface. Levoglucosan granules can also be ground to small sizes, then resuspended and sampled onto the filter surface. The liquid penetrating the filter would appear similar to adsorbed organic vapors, whereas the solid surface deposit would simulate a sampled aerosol deposit..

3.7.1. Recovery Rate for the Solid and Liquid Levoglucosan Doping Experiment

Levoglucosan (46%) granules were mixed with silicon dioxide (SiO_2; 54%) granules for dry resuspension and sampling. SiO_2 was added to levoglucosan to de-agglomerate the powder. Resuspended dust was sampled on to parallel Teflon membrane filters for weighing and quartz filters for carbon analysis. To investigate the homogeneity of the sample deposit, the Teflon-membrane filters were submitted for X-ray Fluorescence (XRF) analysis (Watson et al., 1999) of silicon (Si). The Si concentration was converted to SiO_2 and used to calculate the expected levoglucosan concentration on each filter based on the known levoglucosan/SiO_2 ratio in the suspension mixture.

Table 3-17a shows that instead of the target of 46%, the levoglucosan consisted of 44% for the diesel plus solid levoglucosan mixture, and only 22 and 29% for the low and high concentrations levels on the blank filter samples, respectively. Using the calculated levoglucosan as a base, the recovery rate was 17 – 39% for the solid levoglucosan. The sampling process appears to be imperfect.

Table 3-18 shows that for the solid levoglucosan resuspension on the blank samples, the OC3 at 480 °C (68 – 76%) was most abundant, followed by OC2 at 280 °C (24 – 25%) using the IMPROVE_A protocol. OC3 and OC2 contain the levoglucosan decomposition and melting temperatures, respectively. The levoglucosan distribution by the STN/CSN protocol does not have a clear pattern, ranging from 21 – 27% in OC1 (310 °C) to 44 – 50% in OC2 (480 °C), and to 9 – 16% in OC3 (615 °C) for the low and high loadings. The melting point for SiO_2 (1610 °C) is higher than the maximum carbon analysis temperate (900 °C).

Table 3-17b shows the recovery rate for the liquid levoglucosan spiked on blank quartz-fiber filters and diesel soot samples. The recovery rate ranged from 93 to 97% for the IMPROVE_A protocol and from 87 to 93% for the STN/CSN protocol. While the recovery rate for medium level levoglucosan (19.2 - 22.9 $\mu C/cm^2$) was ~93 - 94% , it varied for higher levels (38.3 $\mu gC/cm^2$), with 96% recovery for the IMPROVE_A protocol and 87% for STN/CSN protocol. The distribution among carbon fractions on the blank filters for solid and liquid levoglucosan is shown in Table 3-18. For the IMPROVE_A protocol, similar distributions were found between the solid and liquid levoglucosan on blank filters: the OC3 (480 °C) fraction (68 – 76% for solid and 33 – 36% for liquid levoglucosan) is the most abundant, followed by the OC2 (280°C) fraction (19 – 21%). There is charring for liquid levoglucosan on blank filters, with 26.5 ± 0.5% by transmittance and 22.3 ± 4% by reflectance. After both TOR and TOT correction, all levoglucosan on the blank plus liquid levoglucosan was attributed to OC. Using the STN/CSN protocol, OC2 (480 °C) accounted for most of the carbon evolved (44 – 50% for solid and 28 – 34% for liquid levoglucosan), closely followed by OC4 (900 °C) fraction (6 – 7% for solid and 22-31% for liquid levoglucosan). The STN/CSN protocol detected ~16% (by transmittance) of pyrolyzed OC in one third of the samples for liquid levoglucosan spiked on blank filters, and the remaining samples with negative pyrolysis of -4 to -11%. The corresponding negative pyrolysis by reflectance ranged from -7 to -11%. Though on average less pyrolysis (< 10%) is found by the STN/CSN protocol, it reported levoglucosan as EC1 (14 ± 12% by transmission and 3 ± 23% by reflectance).

This experiment points out that water-soluble organics in liquid form do char and are detected by the IMPROVE_A protocol, and the extent of pyrolysis is higher by transmission than by reflectance. Charring is not apparent in the STN/CSN protocol, but it can be misinterpreted as EC.

3.7.2. Distribution of Carbon Fractions for Diesel Samples Mixed with Solid and Liquid Levoglucosan

Table 3-19a and 3-19b report average and standard deviation of carbon fractions for the solid resuspended and liquid levoglucosan samples, respectively. Average TC carbon from the pure diesel soot samples (Table 3-19a) ranged from 192 ± 14.8 to 213.3 ± 22.3 µg/filter with 43 – 54% of EC in TC.

Resuspended solid levoglucosan, either mixed with blank filters or diesel samples, reported negligible pyrolysis by the IMPROVE_A protocol and negative pyrolysis by the STN/CSN protocol. Under high combustion temperature (~900 °C in He atmosphere) by the STN/CSN protocol, the decomposition of organic substances may supply the oxygen (O_2) in the He atmosphere that combusted the char OC or native EC, so the optical signal returned to its original value before the O_2 was supplied in the atmosphere, resulting in negative pyrolysis (Chow et al., 2001). Solid levoglucosan plus diesel is measured as OC by the IMPROVE_A protocol, but the STN/CSN protocol appears to redistribute a portion of levoglucosan to high-temperature EC4 (825 °C in 98% He/2% O_2 atmosphere). For liquid levoglucosan doping (Table 3-19b) on blank quartz-fiber filter, pyrolysis was apparent as shown in Figure 3-9. Pyrolyzed OC accounts for 5.7 ± 0.3 µg/cm^2 by transmittance and 4.8 ± 1.0 µg/cm^2 by reflectance using the IMPROVE_A protocol. As liquid levoglucosan is doped on the diesel exhaust sample, pyrolysis became insignificant. Figure 3-10 is consistent with the saturation of optical signals with heavy aerosol loading (e.g., Arnott et al., 2005). Liquid doping also appears to mobilize soot particles on the filter, thus changing the optical baseline before thermal analysis. The effect of liquid-induced particle migration on charring correction is difficult to evaluate since it could vary from time to time and the optical corrections assume homogeneous distribution of materials on the sample punch. As shown in Table 3-19b, over 50% of the liquid levoglucosan is evolved in OC1 (at 140 °C) instead of OC3 on blank plus liquid levoglucosan filters, followed with ~10% by OC2 (at 280 °C). OPT and OPR are reported in Table 3-19b with the understanding of substantial uncertainty caused by liquid doping.

While there is no observed pyrolysis in pure diesel samples, Table 3-20 shows that lower temperature OC (i.e., OC1 at 140 °C) is most abundant (35.7 ± 8%) in OC, followed by 29.5 ± 2% in OC2 (at 280 °C) and 25.5 ± 7% in OC3 (at 480 °C), whereas high temperature EC (EC2 at 740 °C) constitutes most of the EC (80.9 ± 6%) for the IMPROVE_A protocol. The abundant OC1 and EC2 in diesel source profiles is consistent with those reported in other studies (e.g., Watson et al., 1994) and probably contains unburned liquid fuel. The OC/TC ratio by IMPROVE_A_TOR also changed from 0.57 ± 0.12 for diesel to 0.74 ± 0.09 for diesel plus solid levoglucosan. The corresponding OC/TC ratios by STN_TOT are 0.56 ± 0.11 for diesel and 0.79 ± 0.09 for diesel plus solid levoglucosan. For diesel plus solid levoglucosan, the majority of the OC was found in OC1 (45.3 ± 8%, compared to 35.7 ± 8% in pure diesel), followed by 22 ± 4% in OC2 and 24 ± 4% in OC3. Not many changes (± 1-2%) of either EC or fractional abundances of EC were observed for the diesel plus solid levoglucosan mixture

While the IMPROVE_A protocol found abundant OC1 (140 °C) and EC2 (740 °C) in diesel samples, the STN/CSN protocol reported similar abundances for low temperature OC (OC1; 310 °C) and high temperature EC (EC3; 750 °C). Despite the experimental artifact of liquid doping, Table 3-20 shows that the addition of liquid levoglucosan redistributes both OC and EC fractions with negative pyrolysis.

However the methodology is questionable owing to the lack of complete recover, and the results should not be considered quantitative until the procedural aspects of the experiment are perfected.

3.8. Radiative Transfer Modeling for the Diesel/Levoglucosan Experiment

Chow et al. (2004) indicate that charring within a quartz-fiber front (QF) filter might interfere the optical OC/EC split because filter reflectance and transmittance respond differently to pyrolyzed carbon (OP) and EC. The OC artifact, which is distributed throughout the filter while solid particles are collected on the surface, can change not only OC but also EC quantification through the charring correction. Only certain types of OC appear to char during thermal analysis. Pure diesel soot shows little charring despite the sampling artifact, and the EC fraction in diesel soot is consistently reported by various thermal/optical methods (Watson et al., 2005; Chow et al., 2006b). It is assumed that solid levoglucosan only deposits on the filter surface while liquid levoglucosan solution penetrates into the whole filter. The two approaches are expected to produce different charring characteristics, as demonstrated in the previous section.

Diesel soot with liquid levoglucosan is not studied here due to the experimental artifact mentioned in the last section. In this experiment, charring is much more pronounced for liquid levoglucosan on blank filters, than on diesel samples, where the decrease in filter transmittance, but not filter reflectance, is more pronounced. Light absorption by charred material, especially when it is imbedded in the filter, is enhanced due to a multiple scattering effects (Subramanian et al., 2006; Chow et al., 2004).

The distribution of light-absorbing material, including OP and EC, can be studied with radiative transfer equations (RTE). Chen et al. (2004) and Petzold and Schönlinner (2004) demonstrate a two-stream model. Chen et al. (2004) used a single parameter, penetration depth (d_e), to describe the particle distribution; d_e could range from zero (monolayer deposit atop the filter) to infinity (uniform deposit throughout the filter). For ambient samples d_e is consistent with a specific sampling configuration but varies between 0.014 and 0.38 for different configurations. For OP that forms during thermal analysis, d_e is much larger, at 6 – 8. Petzold and Schönlinner (2004) used a two-layer scheme: the uppermost "aerosol-filter" layer (noted by "*L*") that occupies 10–50% of the filter thickness and the remaining particle-free (but could have OP) filter matrix (noted by "*M*"). The whole filter is referred to as "*F*". The light transmitted through the aerosol-filter layer, T_L, is divided into two parts, the penetration (P_L) and forward scattered (F_L) light. Light back scattered by the two layers is noted as R_L and R_M, respectively.

As the incident radiation strikes the aerosol-filter layer, it is treated as collimated illumination. Diffuse illumination can be assumed for light propagating inside the filter. Petzold and Schönlinner (2004) use the radiative transfer scheme developed by Hänel (1987):

$$\frac{R_F}{R_F^{(0)}} = T_L^* \frac{P_L + F_L}{1 - R_L^* R_M} + \frac{R_L}{R_M} \tag{15}$$

$$\frac{T_F}{T_F^{(0)}} = \frac{P_L + F_L}{1 - R_L^* R_M} \tag{16}$$

where:

R_F: Reflected light through the whole filter (F)
R_L: Backscattered light from the aerosol filter or top half of the filter layer (L)
R_M: Backscattered light from the bottom half (or particle-free) of the filter layer (M)
T_F: Transmitted light through the whole filter (F)
T_L: Transmitted light through the aerosol filter layer
P_L: Penetration light
F_L: Forward scattered light through the whole filter
*: values derived from diffuse illumination

Eqs. (15) and (16) are used to relate P_L to measurable quantities, i.e., the reflected ($R_F / R_F^{(0)}$) and transmitted ($T_F / T_F^{(0)}$) light intensities where $R_F^{(0)}$ and $T_F^{(0)}$ are the reflectance and transmittance of a reference (blank) filter. The superscript * in Eqs. (15) and (16) indicates values derived from diffuse illumination. Details on the calculations of F_L, R_L, R_L^*, R_M, and T_L^* from particle absorption and distribution within the filter can be found in Petzold and Schönlinner (2004). With measured $R_F / R_F^{(0)}$ and $T_F / T_F^{(0)}$ ratios plus predefined fractions of L and M layer (i.e, the thickness of L layer relative to the whole filter, a measure of particle penetration thickness) and scattering asymmetric g-factor (i.e., the ratio of forward to total particle light scattering), Eqs. (15) and (16) can be solved numerically to quantify particle light absorption and single scattering albedo.

Figure 3-11 illustrates the scatter of measured $R_F / R_F^{(0)}$ versus $T_F / T_F^{(0)}$ for the pure diesel and blank with liquid levoglucosan samples during the IMPROVE_A analysis as well as their best fit with the Petzold and Schönlinner (2004) two-stream model. For this study a g-factor of 0.75 is used, leaving the fraction of L layer as the fitting parameter. In the first trial, the layer M is assumed to be pristine so the layer L represents the averaged effect of OP and EC (if any).

The pure diesel filter is best fitted with a L fraction of 0.125 (~13%), i.e., particles reside on the top 13% of the filter. The good fit indicates that light-absorbing material remains on the L

layer throughout the charring and oxidation process. For the diesel soot/solid levoglucosan mixture this pattern persists. Some char is formed according to the decrease of filter transmittance but mostly on the aerosol layer. For liquid levoglucosan on a blank filter, however, the slope of T/R is much larger, implying light-absorbing material within the filter. This is supported by the substantial decrease of filter transmittance (Figure 3-9b). In fact, the charring and oxidation is best fit with a *L* fraction of ~50%. Liquid doping apparently penetrates deep into the filter. The optical modeling for diesel and liquid levoglucosan mixture is not discussed until the problem of particle migration due to spiking is overcome in future experimental designs.

The radiative transfer model qualitatively explains the observations and is consistent with the conceptual model. Since the diesel/liquid levoglucosan mixture likely produces within-filter char, EC measurements from this type of samples are expected to be more affected. This is evidence that within-filter char could be mistaken as EC when native EC concentrations are low.

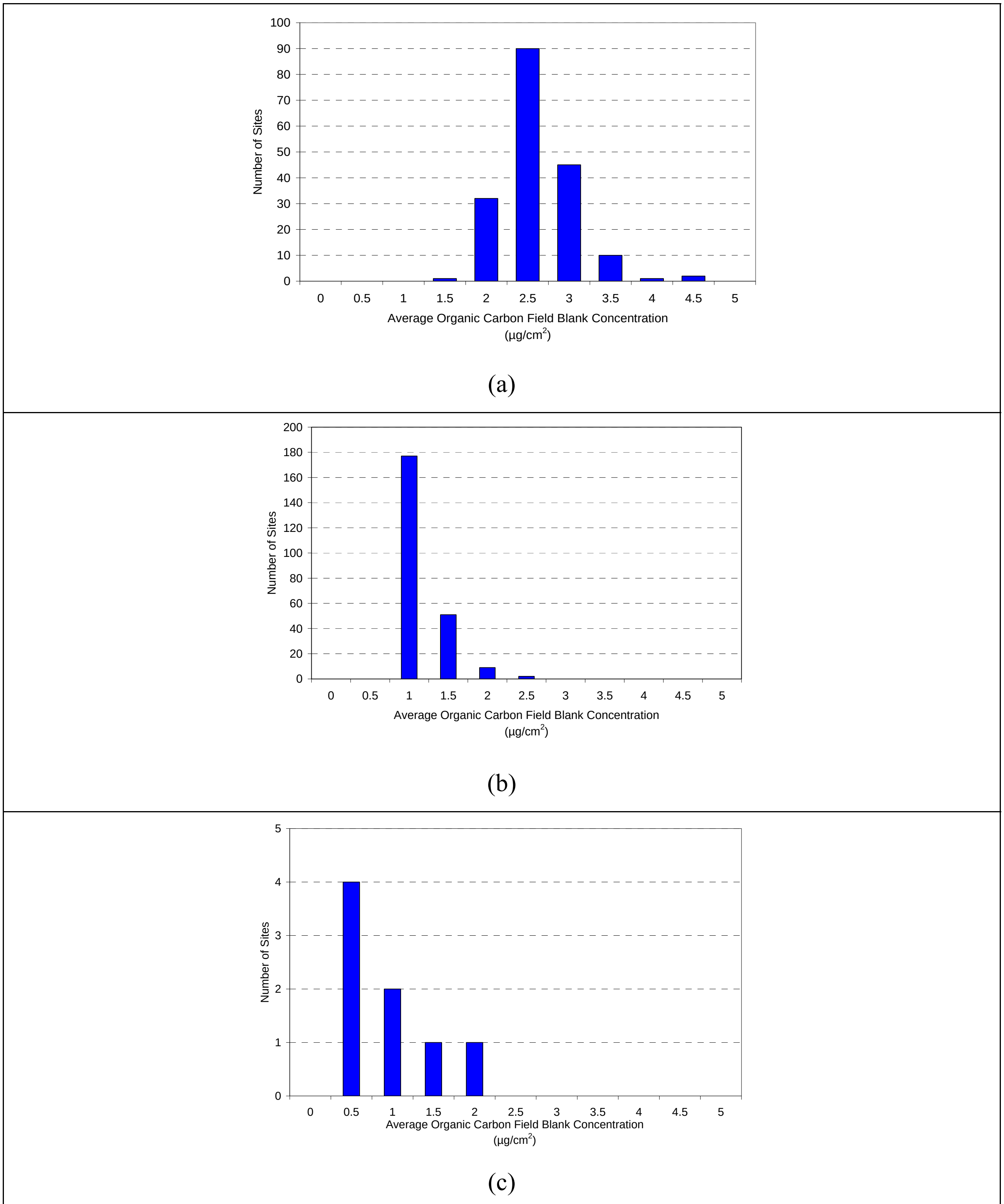


Figure 3-1. Field blank organic carbon (OC) concentration density (µg/cm^2) for: a) 181 IMPROVE sites, b) 239 STN/CSN sites, and c) eight SEARCH sites for the period from 1/1/2005 through 12/31/2006 (each bar represents the concentration sector less than or equal to the assigned value).

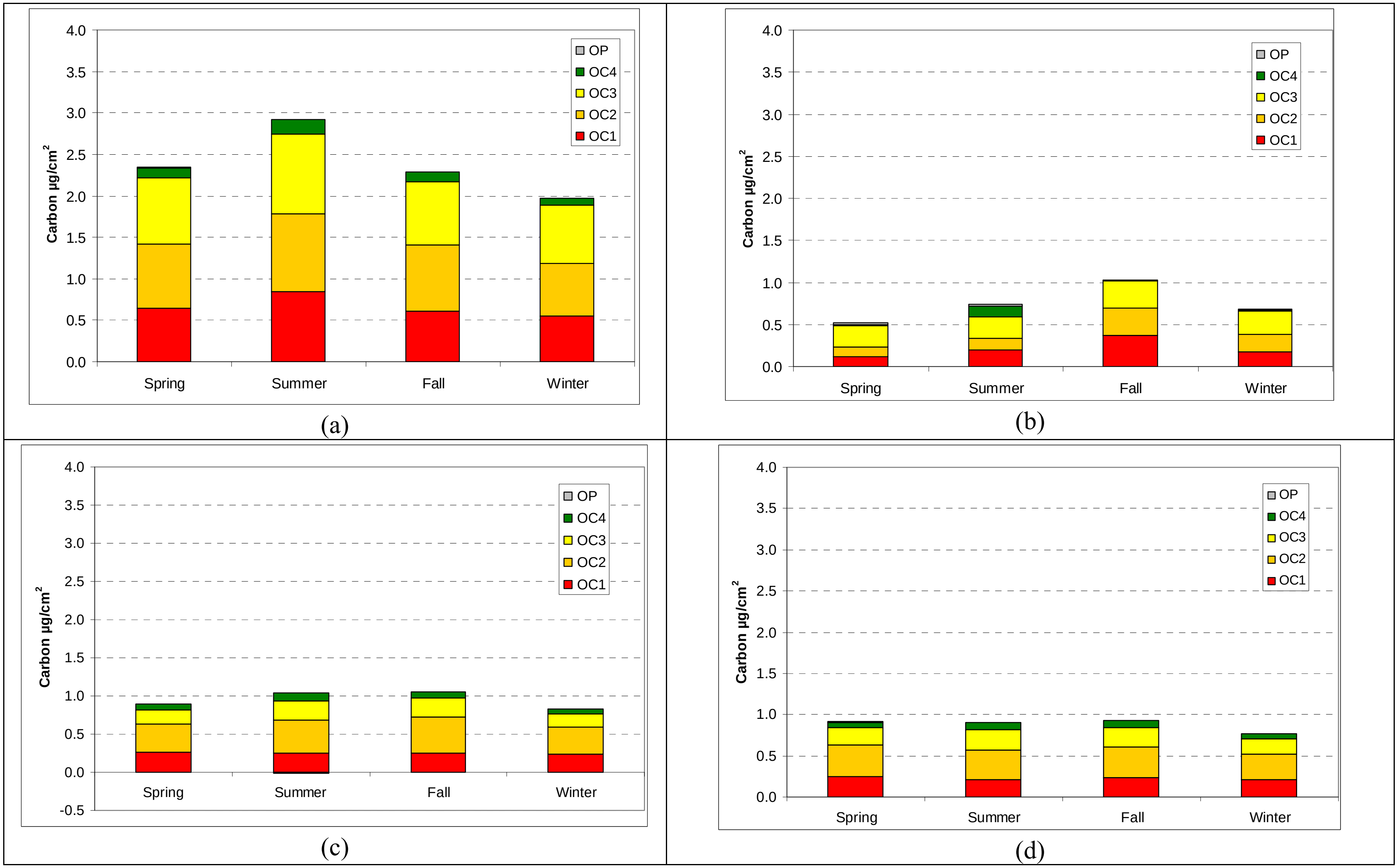


Figure 3-2. Seasonal variations of blanks among: a) IMPROVE, b) SEARCH, c) STN/CSN field blanks, and d) STN/CSN trip blanks.

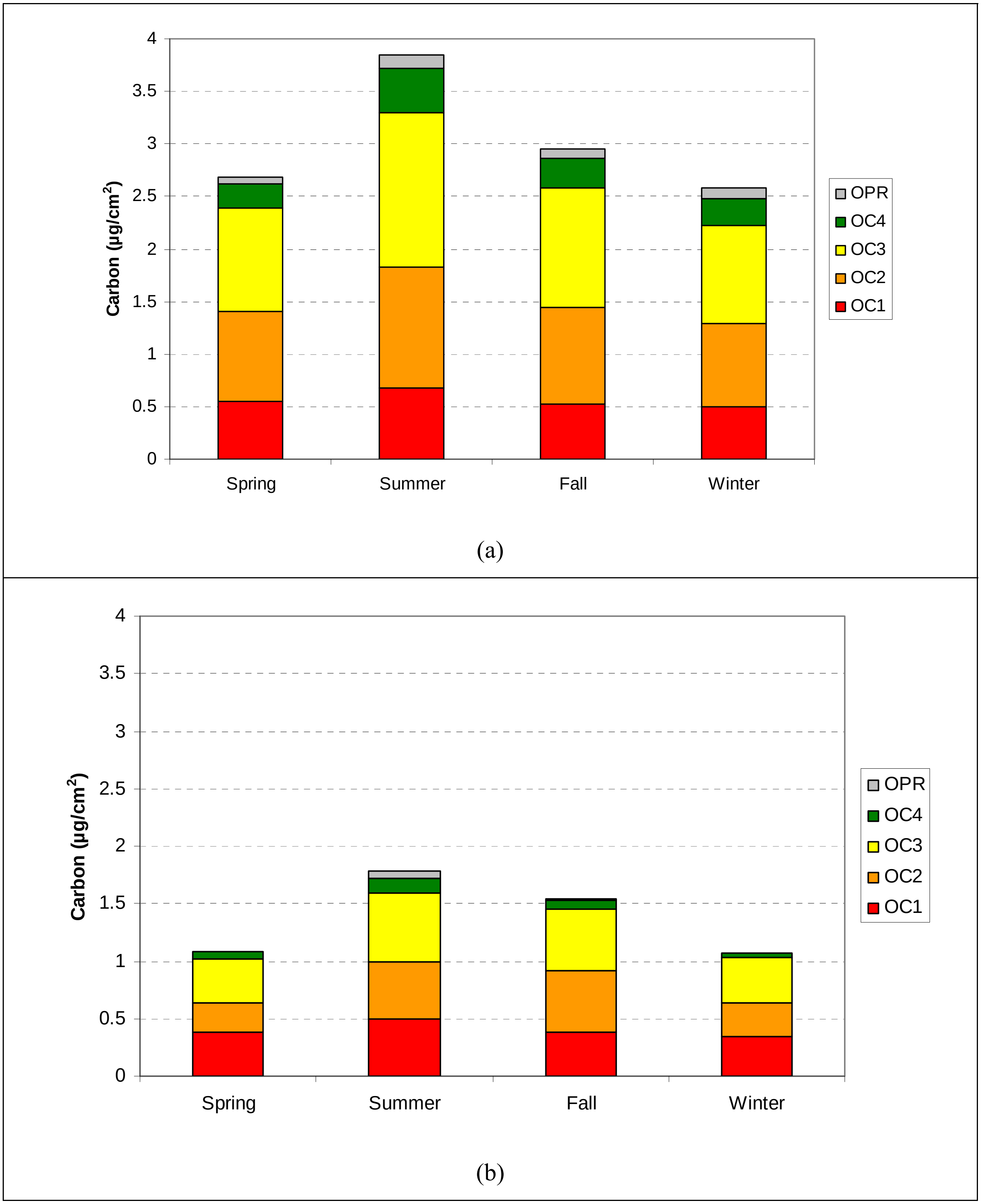


Figure 3-3. Seasonal variations of average blank quartz-fiber backup (QBQ) filter organic carbon (OC) concentrations for the: a) six IMPROVE sites, and b) eight SEARCH sites.

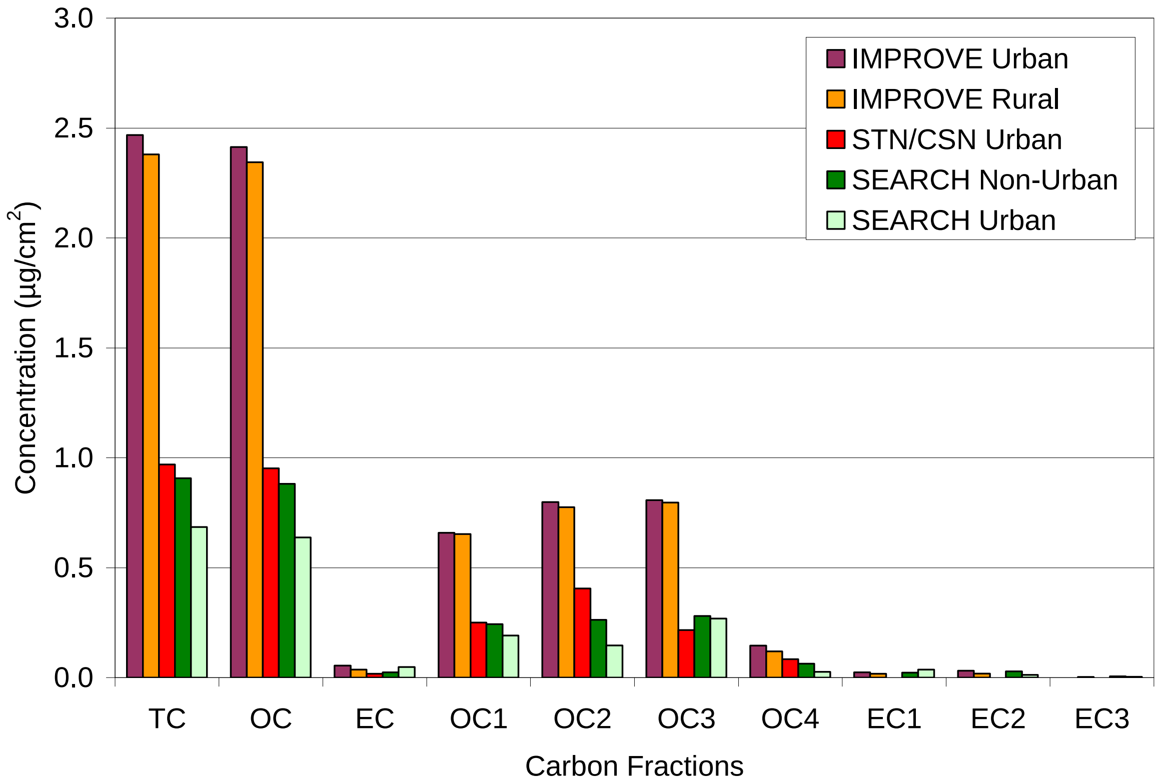


Figure 3-4. Comparison of field blank carbon concentrations between the urban, non-urban, and rural sites among the IMPROVE, STN/CSN, and SEARCH networks. There are 13 urban and 168 rural IMPROVE sites, 239 STN/CSN urban sites, and five urban and three non-urban SEARCH sites; see Table 3-8 for the urban IMPROVE site names); the IMPROVE_A_TOR protocol is used for the IMPROVE and SEARCH networks, the STN_TOT protocol is used for STN/CSN. See Table 2-6 for carbon fraction temperatures.

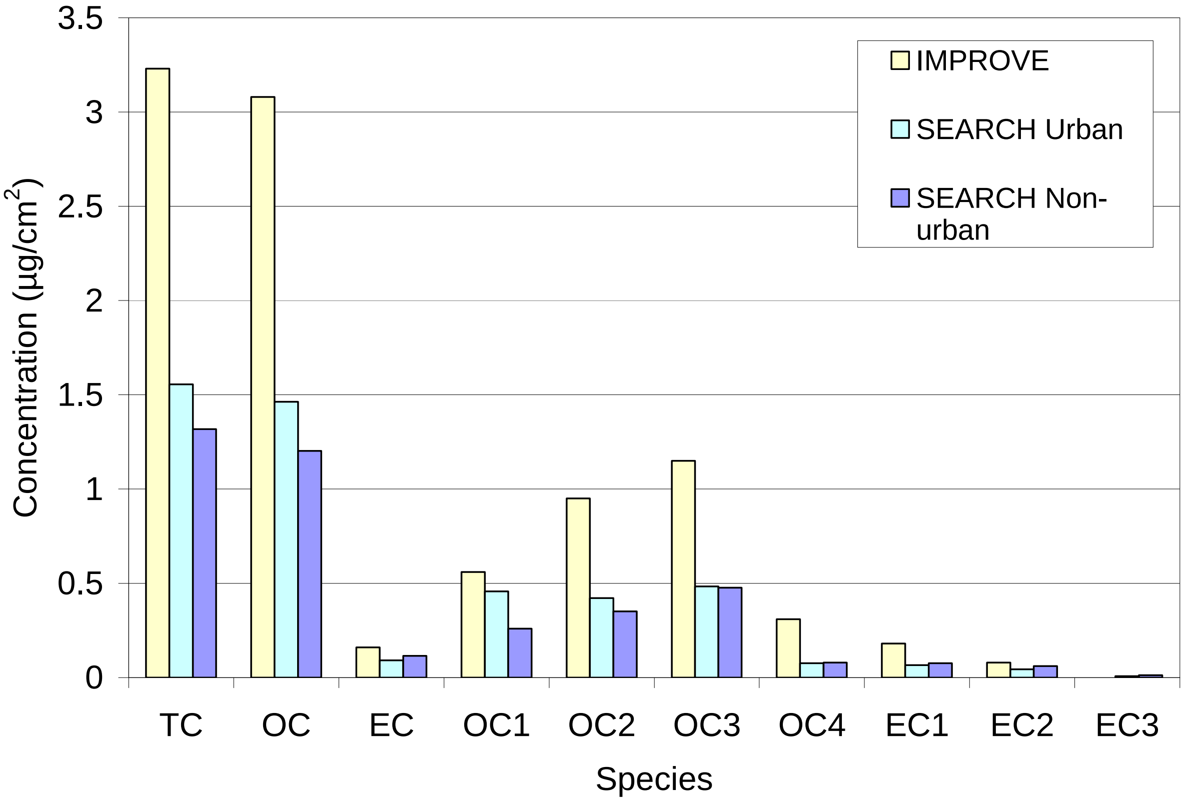


Figure 3-5. Comparison of quartz-fiber backup filter carbon fractions between the urban, non-urban, and rural sites in the IMPROVE and SEARCH networks. (See Figures 2-1 and 2-3 for the 181 IMPROVE and eight SEARCH sites. Carbon fractions follow the IMPROVE_A_TOR protocol.

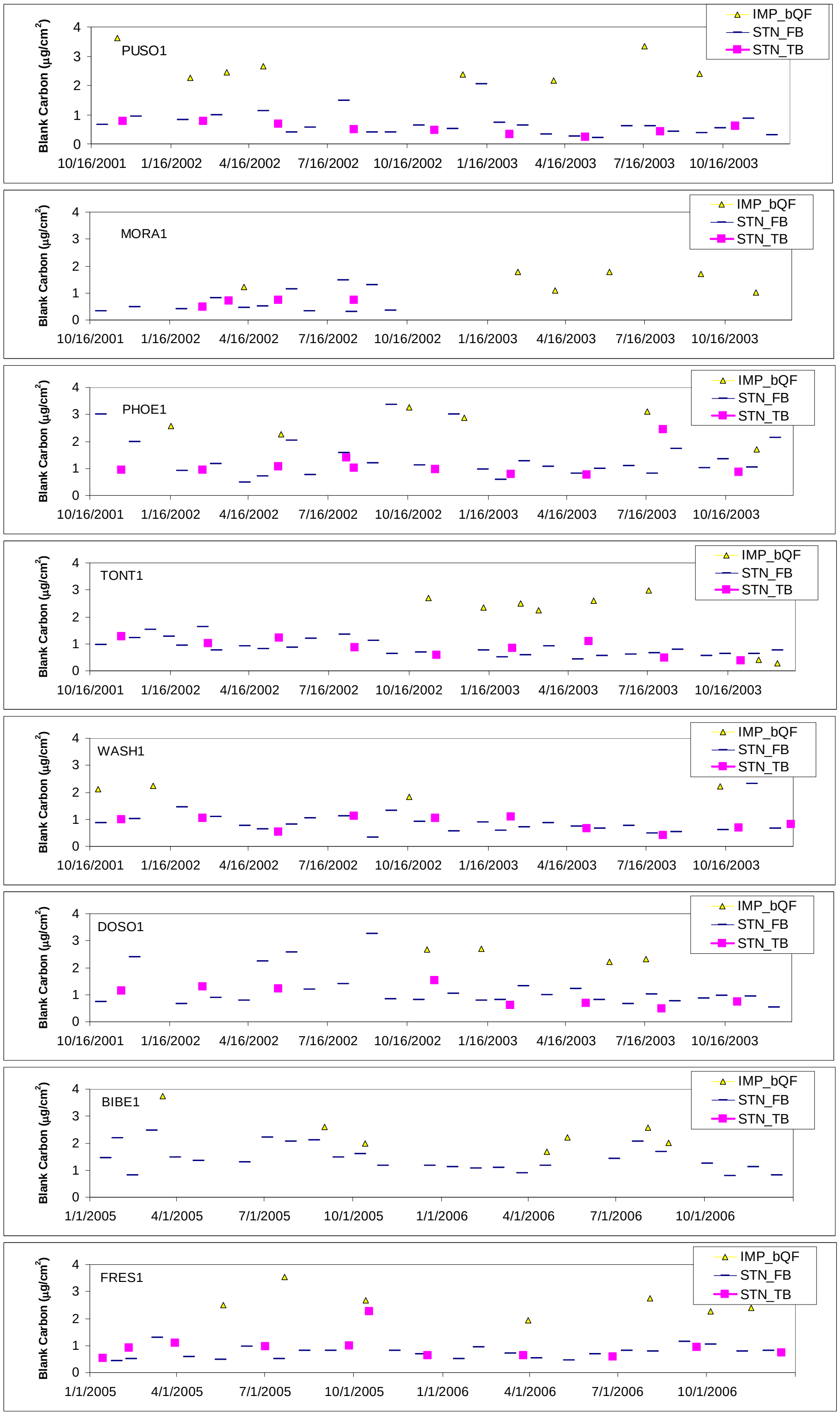


Figure 3-6. Time series of IMPROVE and STN/CSN blank TC concentrations at eight collocated sites (IMP_bQF: IMPROVE field blank filter; STN_FB: STN/CSN field blanks; STN_TB: STN/CSN trip blanks).

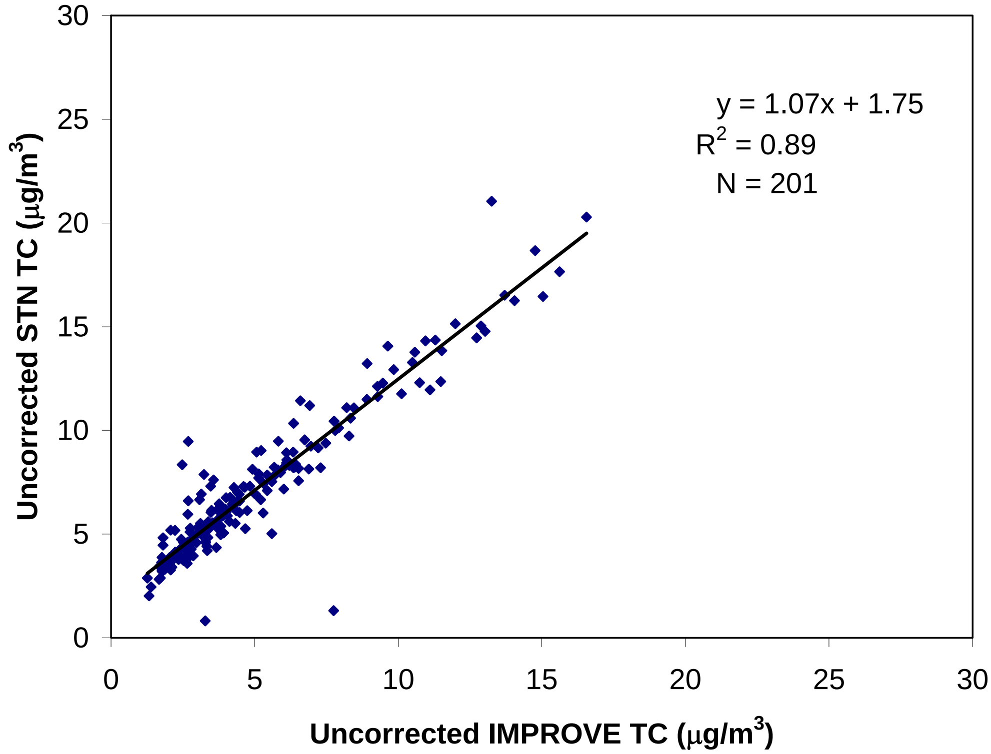


Figure 3-7. Ordinary linear regression of uncorrected STN/CSN TC against IMPROVE TC acquired from the Phoenix site (PHOE1). The non-zero intercept indicates the different sampling artifacts between STN/CSN and the IMPROVE network.

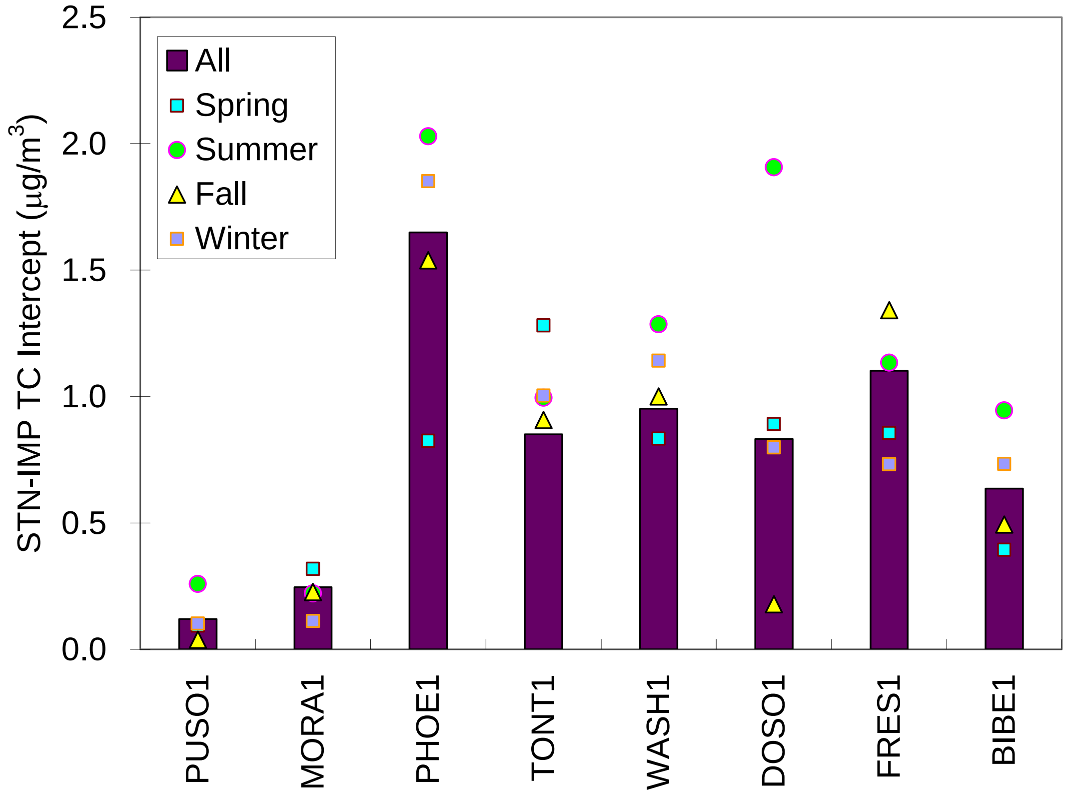
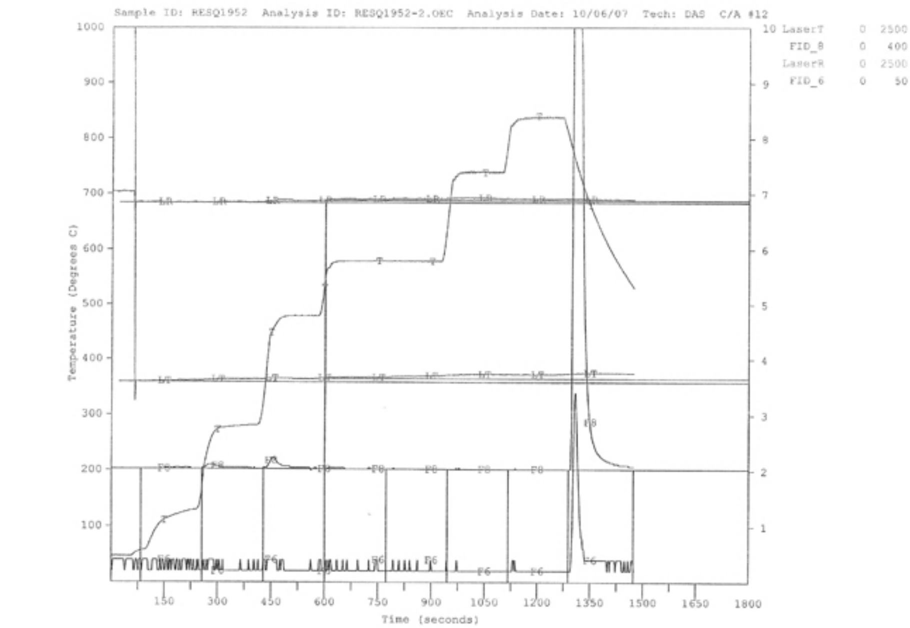
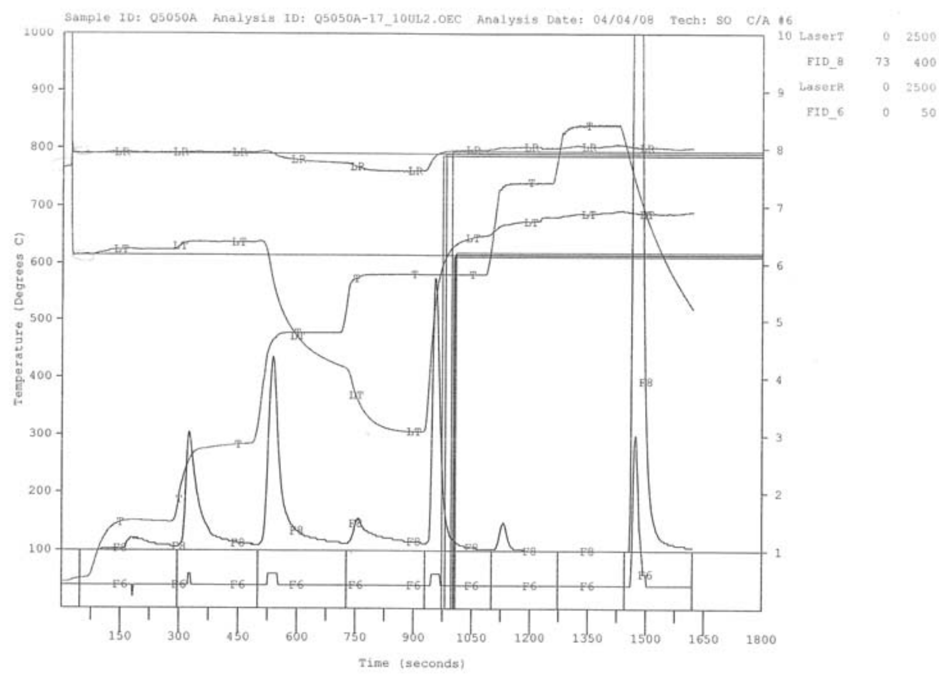


Figure 3-8. The uncorrected STN-IMPROVE TC regression Intercept for all data and seasonally-segregated data from the eight collocated sites: PUSO1 (Seattle, WA); MORA1 (Mount Rainier, WA); PHOE1 (Phoenix, AZ); TONT1 (Tonto National Monument, AZ) WASH1 (Washington, DC); DOSO (Dolly Sods Wilderness, WV); FRES1 (Fresno, CA); and BIBE1 (Big Bend National Park, TX).

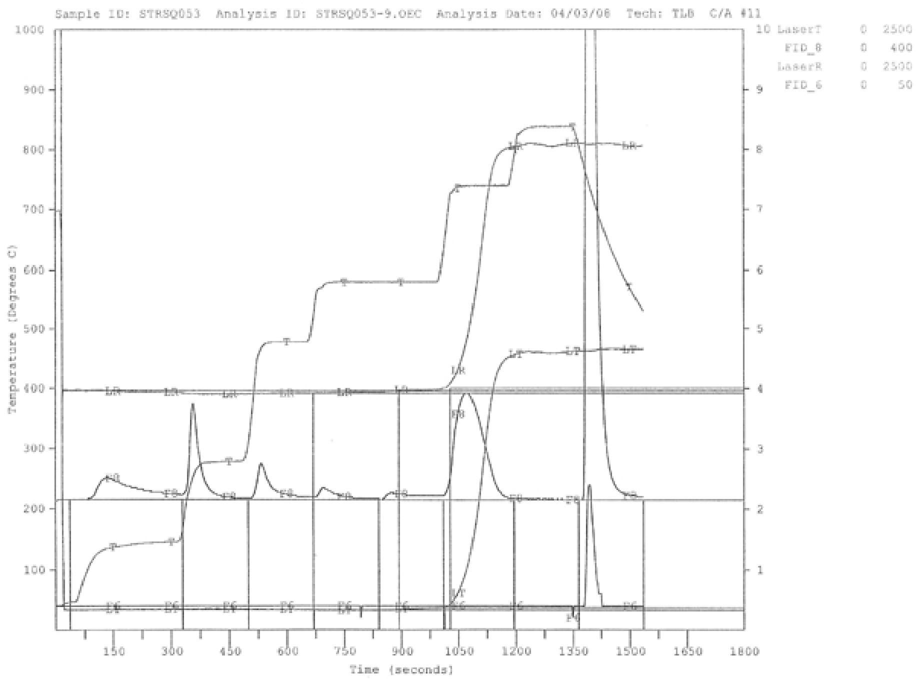


(a)

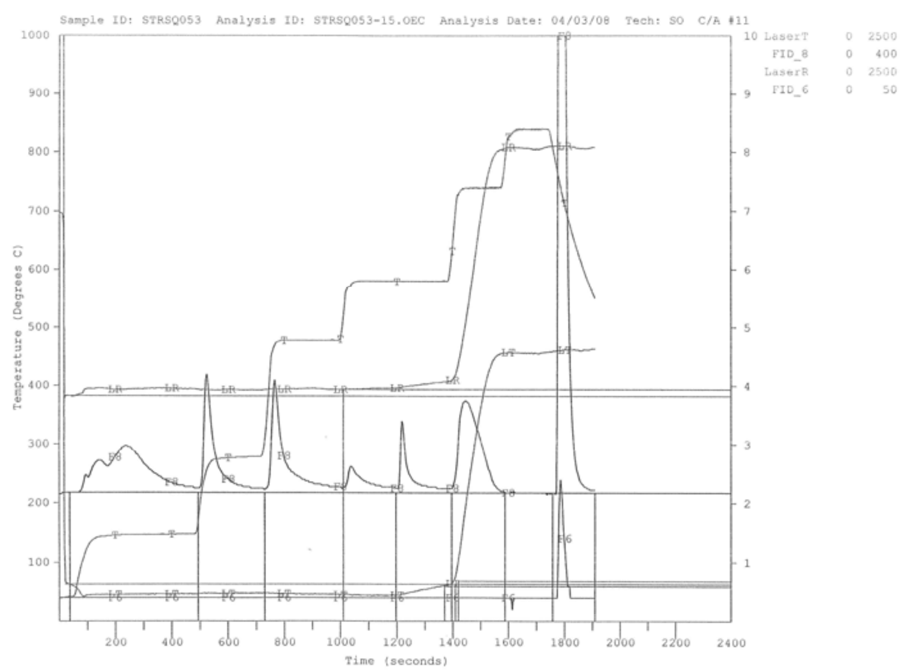


(b)

Figure 3-9. Thermograms of IMPROVE_A_TOR/TOT analyses on: a) blank filter with solid levoglucosan (0.97 μg/cm^2), and b) blank filter with liquid levoglucosan (22.9 μg/cm^2).



(a)



(b)

Figure 3-10. Thermograms of IMPROVE_A_TOR/TOT analyses on: a) pure diesel soot, and b) diesel soot/liquid levoglucosan mixture (22.9 µg/cm^2).

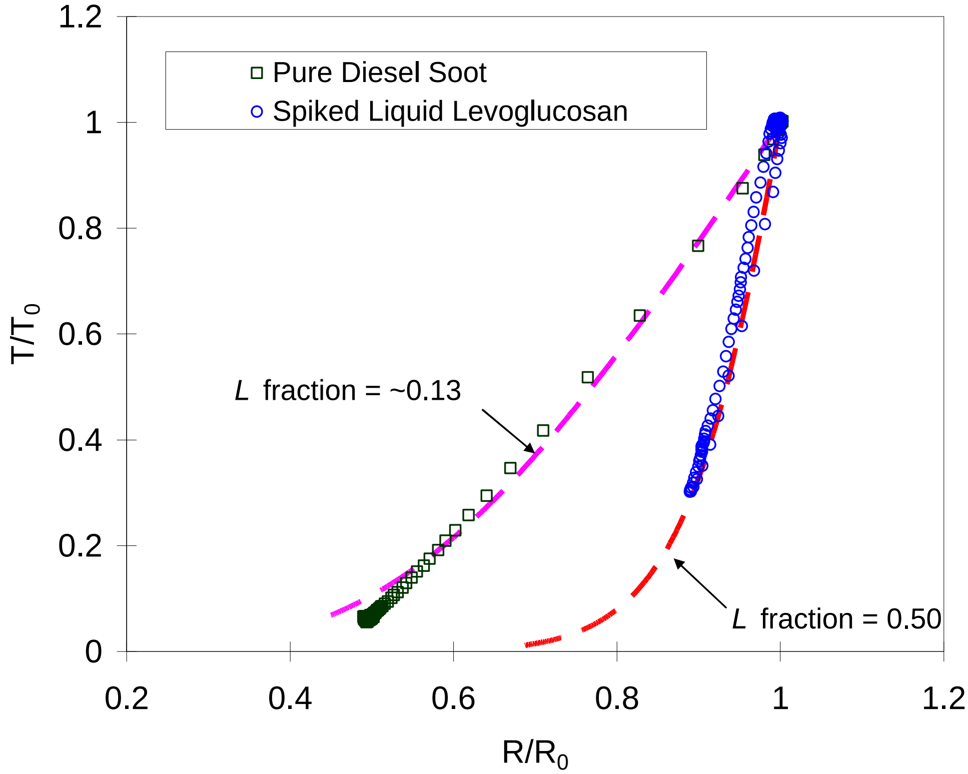


Figure 3-11. Filter reflectance (R) and transmittance (T) of pure diesel soot and liquid levoglucosan on blank filter through the IMPROVE_A thermal/optical analysis protocol. Samples are the same as those listed in Figure 3-9. R_0 and T_0 are reflectance and transmittance of blank filters, respectively. The dashed lines indicate the "best fits" with a radiative transfer equation (RTE) model (see text).

Table 3-1. Comparison of average field blank levels (± standard deviation) among the IMPROVE, STN/CSN, and SEARCH networks for the period from 1/1/2005 through 12/31/2006.

	µg/cm²			µg/filter			µg/m³		
Carbon Species	**IMPROVE**	**STN[a]**	**SEARCH[b]**	**IMPROVE**	**STN[a]**	**SEARCH[b]**	**IMPROVE**	**STN[a]**	**SEARCH[b]**
TC	2.41 ± 0.48	0.97 ± 0.27	0.81 ± 0.61	8.5 ± 1.69	11.42 ± 3.21	5.74 ± 4.32	0.26 ± 0.05	1.03 ± 0.21	0.24 ± 0.18
OC	2.37 ± 0.45	0.95 ± 0.25	0.76 ± 0.57	8.37 ± 1.6	11.22 ± 2.93	5.43 ± 4.05	0.26 ± 0.05	1.01 ± 0.21	0.23 ± 0.17
EC	0.04 ± 0.05	0.02 ± 0.03	0.04 ± 0.06	0.14 ± 0.17	0.2 ± 0.36	0.31 ± 0.43	0 ± 0.01	0.01 ± 0.02	0.01 ± 0.02
OC1	0.66 ± 0.18	0.26 ± 0.06	0.23 ± 0.3	2.33 ± 0.64	3.02 ± 0.68	1.66 ± 2.16	0.07 ± 0.02	0.28 ± 0.07	0.07 ± 0.09
OC2	0.78 ± 0.15	0.4 ± 0.14	0.2 ± 0.17	2.75 ± 0.53	4.72 ± 1.66	1.41 ± 1.21	0.08 ± 0.02	0.42 ± 0.09	0.06 ± 0.05
OC3	0.81 ± 0.16	0.22 ± 0.06	0.27 ± 0.07	2.84 ± 0.57	2.55 ± 0.71	1.95 ± 0.5	0.09 ± 0.02	0.23 ± 0.06	0.08 ± 0.02
OC4	0.12 ± 0.06	0.08 ± 0.07	0.04 ± 0.05	0.43 ± 0.21	0.96 ± 0.86	0.3 ± 0.37	0.01 ± 0.01	0.08 ± 0.05	0.01 ± 0.02
EC1	0.02 ± 0.03		0.03 ± 0.05	0.07 ± 0.1		0.25 ± 0.35	0 ± 0		0.01 ± 0.01
EC2	0.02 ± 0.02		0.02 ± 0.01	0.07 ± 0.08		0.14 ± 0.09	0 ± 0		0.01 ± 0
EC3	0 ± 0.01		0 ± 0.01	0.01 ± 0.04		0.04 ± 0.04	0 ± 0		0 ± 0
No. of Sites in Average	181	239	8	181	239	8	181	239	8
No. of Samples in Average	886	3628	144	886	3628	144	886	3628	144

[a] Weighted average depends on number of sites per type of instrument specified in Table 2-1. There are a variety of samplers using in STN. Most of them are MetOne samplers.

[b] The SEARCH network uses denuded PCM3 with preceding organic denuders

Table 3-2. Average field blank concentration by carbon fraction at the 181 sites in the IMPROVE network from 1/1/2005 to 12/31/2006.

			Sampling Period			Carbon Concentrations ($\mu g/cm^2$)									
Site ID	Site Name	State	From	To	No. of Field Blanks	TC	OC	EC	OC1	OC2	OC3	OC4	EC1	EC2	EC3
ACAD1	Acadia NP	ME	1/13/2005	1/5/2006	3	2.49 ± 0.64	2.44 ± 0.57	0.06 ± 0.1	0.56 ± 0.1	0.81 ± 0.21	0.92 ± 0.27	0.15 ± 0.07	0.06 ± 0.1	0 ± 0	0 ± 0
ADPI1	Addison Pinnacle	NY	1/13/2005	5/11/2006	6	2.09 ± 0.29	2.09 ± 0.29	0 ± 0	0.52 ± 0.11	0.76 ± 0.16	0.72 ± 0.13	0.07 ± 0.06	0.01 ± 0.03	0 ± 0	0 ± 0
AGTI1	Agua Tibia	CA	5/19/2005	11/16/2006	7	3.13 ± 0.77	3.1 ± 0.77	0.03 ± 0.03	0.91 ± 0.32	1.04 ± 0.21	1 ± 0.34	0.14 ± 0.06	0.02 ± 0.04	0.01 ± 0.02	0 ± 0
AREN1	Arendtsville	PA	1/13/2005	3/30/2006	5	2.03 ± 0.89	1.99 ± 0.85	0.04 ± 0.06	0.58 ± 0.28	0.66 ± 0.37	0.62 ± 0.25	0.13 ± 0.11	0 ± 0	0.04 ± 0.06	0 ± 0
ATLA1	Atlanta	GA	1/13/2005	11/19/2006	8	2.31 ± 0.54	2.28 ± 0.55	0.02 ± 0.04	0.59 ± 0.21	0.84 ± 0.21	0.73 ± 0.16	0.13 ± 0.07	0.01 ± 0.02	0.01 ± 0.02	0 ± 0
BADL1	Badlands NP	SD	1/13/2005	12/7/2006	7	3.17 ± 1.04	3.11 ± 0.97	0.05 ± 0.09	1.07 ± 0.75	0.9 ± 0.24	0.97 ± 0.32	0.17 ± 0.11	0.01 ± 0.02	0.04 ± 0.06	0.01 ± 0.02
BALD1	Mount Baldy	AZ	3/17/2005	6/1/2006	5	2.19 ± 0.83	2.18 ± 0.82	0.01 ± 0.02	0.75 ± 0.33	0.62 ± 0.24	0.72 ± 0.23	0.09 ± 0.08	0.01 ± 0.02	0.01 ± 0.01	0 ± 0
BALT1	Baltimore	MD	1/13/2005	12/15/2005	4	2.21 ± 0.43	2.19 ± 0.4	0.02 ± 0.03	0.63 ± 0.19	0.76 ± 0.14	0.71 ± 0.13	0.09 ± 0.06	0 ± 0	0.02 ± 0.03	0 ± 0
BAND1	Bandelier NM	NM	3/17/2005	12/28/2006	9	2.82 ± 0.83	2.79 ± 0.8	0.02 ± 0.05	0.91 ± 0.23	0.88 ± 0.33	0.87 ± 0.28	0.13 ± 0.08	0.01 ± 0.02	0.02 ± 0.03	0 ± 0
BIBE1	Big Bend NP	TX	3/17/2005	8/24/2006	7	2.4 ± 0.68	2.3 ± 0.46	0.11 ± 0.28	0.62 ± 0.13	0.77 ± 0.2	0.79 ± 0.13	0.11 ± 0.06	0.01 ± 0.03	0.02 ± 0.06	0.07 ± 0.19
BIRM1	Birmingham	AL	1/13/2005	8/24/2006	5	2.25 ± 0.41	2.25 ± 0.41	0 ± 0	0.67 ± 0.16	0.8 ± 0.18	0.7 ± 0.19	0.08 ± 0.06	0 ± 0	0 ± 0	0 ± 0
BLIS1	Bliss SP (TRPA)	CA	3/17/2005	10/26/2006	10	2.68 ± 0.64	2.62 ± 0.59	0.06 ± 0.08	0.64 ± 0.31	0.78 ± 0.15	1.02 ± 0.43	0.19 ± 0.1	0.04 ± 0.06	0.03 ± 0.04	0 ± 0
BLMO1	Blue Mounds	MN	1/13/2005	1/5/2006	4	1.53 ± 0.23	1.53 ± 0.23	0 ± 0	0.42 ± 0.13	0.47 ± 0.11	0.61 ± 0.21	0.05 ± 0.02	0 ± 0.01	0 ± 0.01	0 ± 0.01
BOAP1	Bosque del Apache	NM	1/13/2005	12/7/2006	8	3.12 ± 1.36	3 ± 1.2	0.13 ± 0.18	0.65 ± 0.24	0.98 ± 0.39	1.09 ± 0.51	0.28 ± 0.24	0.04 ± 0.06	0.08 ± 0.13	0 ± 0
BOND1	Bondville	IL	3/17/2005	11/16/2006	5	1.89 ± 0.93	1.85 ± 0.9	0.04 ± 0.03	0.41 ± 0.23	0.61 ± 0.28	0.7 ± 0.35	0.13 ± 0.08	0.02 ± 0.03	0.02 ± 0.03	0 ± 0
BOWA1	Boundary Waters Canoe Area	MN	3/30/2006	9/14/2006	3	2.01 ± 0.72	1.94 ± 0.62	0.07 ± 0.11	0.42 ± 0.09	0.71 ± 0.21	0.68 ± 0.21	0.14 ± 0.14	0.03 ± 0.06	0.03 ± 0.06	0 ± 0
BRCA1	Bryce Canyon NP	UT	7/21/2005	11/16/2006	5	3.1 ± 1.05	3 ± 0.91	0.1 ± 0.17	0.94 ± 0.43	0.96 ± 0.25	0.9 ± 0.16	0.19 ± 0.1	0.02 ± 0.03	0.06 ± 0.09	0.03 ± 0.06
BRET1	Breton	LA	2/3/2005	2/3/2005	1	2.32 ± 0	2.32 ± 0	0 ± 0	0.6 ± 0	0.78 ± 0	0.88 ± 0	0.07 ± 0	0 ± 0	0 ± 0	0 ± 0
BRID1	Bridger Wilderness	WY	5/19/2005	12/7/2006	2	2.45 ± 0.51	2.39 ± 0.39	0.07 ± 0.1	0.56 ± 0.22	0.88 ± 0.09	0.83 ± 0.18	0.13 ± 0.06	0.06 ± 0.05	0.03 ± 0.02	0.01 ± 0.01
BRID9	Bridger Wilderness	WY	1/13/2005	1/13/2005	1	2.62 ± 0	2.47 ± 0	0.15 ± 0	0.62 ± 0	0.87 ± 0	0.77 ± 0	0.21 ± 0	0.06 ± 0	0.06 ± 0	0.03 ± 0
BRIG1	Brigantine NWR	NJ	2/3/2005	5/11/2006	6	2.1 ± 0.81	2.09 ± 0.8	0.01 ± 0.02	0.57 ± 0.29	0.76 ± 0.37	0.7 ± 0.22	0.06 ± 0.06	0 ± 0	0.01 ± 0.02	0 ± 0
BRMA1	Bridgton	ME	1/13/2005	10/26/2006	6	2.19 ± 0.87	2.16 ± 0.8	0.03 ± 0.08	0.47 ± 0.23	0.71 ± 0.15	0.82 ± 0.37	0.15 ± 0.16	0.03 ± 0.08	0.01 ± 0.02	0 ± 0
CABA1	Casco Bay	ME	5/19/2005	12/28/2006	6	2.53 ± 0.68	2.52 ± 0.67	0.01 ± 0.02	0.74 ± 0.22	0.9 ± 0.2	0.76 ± 0.24	0.11 ± 0.07	0 ± 0.01	0.01 ± 0.02	0 ± 0
CABI1	Cabinet Mountains	MT	5/19/2005	2/16/2006	3	2.08 ± 0.66	2.05 ± 0.63	0.03 ± 0.04	0.67 ± 0.17	0.57 ± 0.28	0.7 ± 0.13	0.11 ± 0.07	0 ± 0	0.02 ± 0.04	0 ± 0
CACO1	Cape Cod	MA	10/13/2005	12/28/2006	2	1.93 ± 0.49	1.9 ± 0.46	0.03 ± 0.02	0.61 ± 0.04	0.68 ± 0.3	0.55 ± 0.16	0.06 ± 0.05	0 ± 0	0.03 ± 0.03	0 ± 0.01
CACR1	Caney Creek	AR	1/13/2005	9/14/2006	7	2.58 ± 0.72	2.42 ± 0.57	0.16 ± 0.25	0.48 ± 0.17	0.78 ± 0.29	0.99 ± 0.29	0.17 ± 0.07	0.11 ± 0.26	0.05 ± 0.07	0.01 ± 0.02
CADI1	Cadiz	KY	5/19/2005	11/16/2006	7	2.17 ± 0.53	2.14 ± 0.5	0.03 ± 0.04	0.56 ± 0.17	0.76 ± 0.23	0.72 ± 0.2	0.1 ± 0.09	0.01 ± 0.01	0.02 ± 0.03	0 ± 0
CANY1	Canyonlands NP	UT	7/21/2005	10/5/2006	9	2.63 ± 1.14	2.53 ± 1.02	0.1 ± 0.21	0.76 ± 0.39	0.79 ± 0.31	0.83 ± 0.27	0.15 ± 0.13	0.04 ± 0.07	0.05 ± 0.11	0.01 ± 0.03
CAPI1	Capitol Reef NP	UT	3/17/2005	12/7/2006	6	2.75 ± 0.84	2.72 ± 0.84	0.03 ± 0.05	0.82 ± 0.42	0.87 ± 0.25	0.87 ± 0.26	0.16 ± 0.1	0.01 ± 0.03	0.02 ± 0.02	0 ± 0.01
CEBL1	Cedar Bluff	KS	1/13/2005	10/26/2006	10	2.02 ± 0.69	2.01 ± 0.68	0.01 ± 0.01	0.57 ± 0.19	0.64 ± 0.27	0.72 ± 0.21	0.09 ± 0.08	0 ± 0.01	0 ± 0	0 ± 0
CHAS1	Chassahowitzka NWR	FL	6/9/2005	10/5/2006	8	2 ± 0.54	1.96 ± 0.5	0.04 ± 0.06	0.44 ± 0.16	0.67 ± 0.17	0.77 ± 0.22	0.09 ± 0.06	0.01 ± 0.04	0.03 ± 0.05	0 ± 0
CHER1	Cherokee Nation	OK	10/13/2005	9/14/2006	3	2.1 ± 0.35	2.1 ± 0.35	0 ± 0	0.53 ± 0.16	0.76 ± 0.21	0.72 ± 0.1	0.08 ± 0.05	0 ± 0	0 ± 0	0 ± 0

Table 3-2. Continued.

Site ID	Site Name	State	Sampling Period From	Sampling Period To	No. of Field Blanks	Carbon Concentrations (µg/cm2) TC	OC	EC	OC1	OC2	OC3	OC4	EC1	EC2	EC3
CHIC1	Chicago	IL	1/13/2005	3/17/2005	2	2.28 ± 0.41	2.28 ± 0.41	0 ± 0	0.71 ± 0.03	0.74 ± 0.01	0.74 ± 0.38	0.09 ± 0.05	0 ± 0	0 ± 0	0 ± 0
CHIR1	Chiricahua NM	AZ	1/13/2005	8/24/2006	5	2.23 ± 0.94	2.23 ± 0.94	0.01 ± 0.01	0.71 ± 0.47	0.74 ± 0.24	0.69 ± 0.21	0.09 ± 0.06	0 ± 0	0 ± 0.01	0 ± 0.01
CLPE1	Cloud Peak	WY	3/17/2005	4/20/2006	3	1.87 ± 0.57	1.86 ± 0.56	0.01 ± 0.01	0.56 ± 0.28	0.63 ± 0.14	0.62 ± 0.16	0.05 ± 0.04	0 ± 0	0 ± 0	0 ± 0.01
COGO1	Columbia Gorge #1	WA	3/17/2005	10/5/2006	6	2.41 ± 0.48	2.38 ± 0.46	0.03 ± 0.06	0.68 ± 0.22	0.84 ± 0.18	0.73 ± 0.11	0.13 ± 0.06	0.02 ± 0.03	0.02 ± 0.03	0 ± 0
COHI1	Connecticut Hill	NY	7/21/2005	12/15/2005	3	2.98 ± 0.87	2.94 ± 0.81	0.04 ± 0.07	0.99 ± 0.2	0.95 ± 0.3	0.87 ± 0.3	0.14 ± 0.06	0 ± 0	0.04 ± 0.07	0 ± 0
COHU1	Cohutta	GA	3/17/2005	3/17/2005	1	4.45 ± 0	4.24 ± 0	0.21 ± 0	1.77 ± 0	1.13 ± 0	1.15 ± 0	0.19 ± 0	0.14 ± 0	0.07 ± 0	0 ± 0
CORI1	Columbia River Gorge	WA	3/17/2005	12/7/2006	5	2.25 ± 0.91	2.21 ± 0.85	0.05 ± 0.06	0.58 ± 0.32	0.8 ± 0.33	0.72 ± 0.25	0.11 ± 0.08	0.02 ± 0.02	0.03 ± 0.04	0 ± 0
CRES1	Crescent Lake	NE	3/17/2005	6/1/2006	6	2.14 ± 0.35	2.14 ± 0.34	0 ± 0.01	0.69 ± 0.17	0.73 ± 0.1	0.66 ± 0.11	0.06 ± 0.04	0 ± 0	0 ± 0.01	0 ± 0
CRLA1	Crater Lake NP	OR	5/19/2005	12/7/2006	7	2.23 ± 1.14	2.22 ± 1.13	0.01 ± 0.02	0.77 ± 0.45	0.7 ± 0.35	0.68 ± 0.3	0.08 ± 0.09	0 ± 0	0.01 ± 0.02	0 ± 0
CRMO1	Craters of the Moon NM	ID	3/17/2005	5/11/2006	4	2.13 ± 0.75	2.12 ± 0.75	0 ± 0	0.64 ± 0.19	0.71 ± 0.24	0.71 ± 0.29	0.06 ± 0.06	0 ± 0	0 ± 0	0 ± 0
DENA1	Denali NP	AK	5/19/2005	12/28/2006	7	2.9 ± 0.46	2.89 ± 0.46	0.01 ± 0.01	0.89 ± 0.27	0.96 ± 0.13	0.9 ± 0.14	0.14 ± 0.04	0 ± 0	0.01 ± 0.01	0 ± 0
DETR1	Detroit	MI	4/7/2005	12/31/2006	8	2.16 ± 1.04	2.09 ± 0.87	0.08 ± 0.18	0.44 ± 0.1	0.66 ± 0.3	0.8 ± 0.36	0.18 ± 0.2	0.05 ± 0.12	0.03 ± 0.06	0 ± 0
DEVA1	Death Valley NP	CA	3/17/2005	10/5/2006	4	2.43 ± 1.23	2.17 ± 0.75	0.26 ± 0.49	0.45 ± 0.09	0.7 ± 0.23	0.84 ± 0.25	0.19 ± 0.22	0.09 ± 0.17	0.08 ± 0.16	0.08 ± 0.16
DOME1	Dome Lands Wilderness	CA	12/15/2005	12/28/2006	4	2.93 ± 1.73	2.89 ± 1.64	0.05 ± 0.09	0.74 ± 0.33	0.91 ± 0.32	1.07 ± 0.76	0.18 ± 0.24	0.02 ± 0.03	0.03 ± 0.06	0 ± 0
DOSO1	Dolly Sods Wilderness	WV	3/17/2005	9/14/2006	9	2.78 ± 0.96	2.67 ± 0.78	0.11 ± 0.24	0.77 ± 0.26	0.8 ± 0.31	0.91 ± 0.28	0.19 ± 0.11	0.03 ± 0.07	0.04 ± 0.07	0.04 ± 0.12
DOUG1	Douglas	AZ	1/13/2005	12/28/2006	6	2.91 ± 1.2	2.88 ± 1.12	0.04 ± 0.08	0.92 ± 0.53	0.9 ± 0.25	0.89 ± 0.31	0.17 ± 0.12	0.02 ± 0.04	0.02 ± 0.04	0 ± 0.01
EGBE1	N/A		9/1/2005	10/5/2006	5	2.4 ± 0.6	2.37 ± 0.55	0.04 ± 0.05	0.55 ± 0.22	0.87 ± 0.19	0.82 ± 0.16	0.13 ± 0.05	0.01 ± 0.01	0.03 ± 0.04	0 ± 0
ELDO1	El Dorado Springs	MO	7/21/2005	7/13/2006	6	2.19 ± 0.75	2.16 ± 0.72	0.03 ± 0.04	0.58 ± 0.29	0.7 ± 0.26	0.76 ± 0.21	0.12 ± 0.07	0 ± 0	0.03 ± 0.04	0 ± 0
ELLI1	Ellis	OK	3/17/2005	5/11/2006	7	2.79 ± 0.36	2.76 ± 0.36	0.03 ± 0.03	0.74 ± 0.22	0.85 ± 0.16	0.92 ± 0.14	0.21 ± 0.19	0.05 ± 0.07	0.02 ± 0.02	0 ± 0
EVER1	Everglades NP	FL	1/13/2005	9/14/2006	6	2.7 ± 0.5	2.68 ± 0.49	0.02 ± 0.04	0.68 ± 0.28	1.2 ± 0.36	0.69 ± 0.18	0.1 ± 0.07	0 ± 0.01	0.02 ± 0.03	0 ± 0
FLAT1	Flathead	MT	1/13/2005	10/5/2006	8	2.5 ± 0.81	2.49 ± 0.81	0.01 ± 0.02	0.73 ± 0.28	0.84 ± 0.26	0.79 ± 0.26	0.12 ± 0.11	0 ± 0.01	0.01 ± 0.02	0 ± 0
FOPE1	Fort Peck	MT	3/17/2005	11/16/2006	6	2.86 ± 0.66	2.83 ± 0.66	0.03 ± 0.04	0.84 ± 0.41	0.99 ± 0.29	0.87 ± 0.1	0.13 ± 0.03	0.02 ± 0.04	0.01 ± 0.03	0 ± 0
FRES1	Fresno	CA	5/19/2005	11/16/2006	7	2.58 ± 0.5	2.55 ± 0.44	0.03 ± 0.07	0.68 ± 0.14	0.86 ± 0.2	0.85 ± 0.17	0.16 ± 0.09	0.02 ± 0.04	0.02 ± 0.03	0 ± 0
FRRE1	Frostburg	MD	5/19/2005	8/3/2006	4	2.81 ± 1.01	2.78 ± 0.98	0.04 ± 0.05	0.84 ± 0.3	0.85 ± 0.33	0.92 ± 0.28	0.17 ± 0.13	0 ± 0	0.04 ± 0.05	0 ± 0
GAMO1	Gates of the Mountains	MT	5/19/2005	10/13/2005	2	2.48 ± 0.36	2.48 ± 0.36	0 ± 0	0.77 ± 0.16	0.82 ± 0.05	0.8 ± 0.12	0.09 ± 0.03	0 ± 0	0 ± 0	0 ± 0
GICL1	Gila Wilderness	NM	4/7/2005	7/13/2006	4	2.26 ± 0.95	2.26 ± 0.95	0 ± 0	0.72 ± 0.32	0.7 ± 0.3	0.76 ± 0.29	0.07 ± 0.09	0 ± 0	0 ± 0	0 ± 0
GLAC1	Glacier NP	MT	1/13/2005	11/16/2006	5	2.46 ± 0.55	2.45 ± 0.54	0.01 ± 0.02	0.72 ± 0.18	0.89 ± 0.17	0.75 ± 0.18	0.1 ± 0.09	0 ± 0.01	0.01 ± 0.01	0 ± 0
GRBA1	Great Basin NP	NV	1/13/2005	12/28/2006	10	2.48 ± 0.43	2.46 ± 0.41	0.01 ± 0.03	0.74 ± 0.23	0.9 ± 0.19	0.73 ± 0.13	0.1 ± 0.05	0 ± 0.01	0.01 ± 0.02	0 ± 0
GRGU1	Great Gulf Wilderness	NH	1/13/2005	3/9/2006	5	2.84 ± 0.47	2.76 ± 0.51	0.08 ± 0.06	0.82 ± 0.17	0.94 ± 0.27	0.83 ± 0.28	0.16 ± 0.05	0.03 ± 0.02	0.05 ± 0.05	0.01 ± 0.02
GRRI1	Great River Bluffs	MN	5/19/2005	12/15/2005	3	2.4 ± 0.99	2.35 ± 0.9	0.05 ± 0.08	0.65 ± 0.35	0.78 ± 0.31	0.78 ± 0.25	0.15 ± 0.06	0.01 ± 0.02	0.04 ± 0.07	0 ± 0
GRSA1	Great Sand Dunes NM	CO	10/13/2005	10/5/2006	3	3.31 ± 0.59	3.25 ± 0.54	0.06 ± 0.07	1.05 ± 0.24	0.95 ± 0.14	1.08 ± 0.15	0.17 ± 0.03	0.04 ± 0.07	0.02 ± 0.02	0 ± 0
GRSM1	Great Smoky Mountains NP	TN	1/13/2005	10/26/2006	6	2.18 ± 0.97	2.16 ± 0.96	0.02 ± 0.03	0.5 ± 0.26	0.68 ± 0.28	0.83 ± 0.36	0.15 ± 0.1	0.02 ± 0.03	0 ± 0	0 ± 0

Table 3-2. Continued.

Site ID	Site Name	State	Sampling Period From	To	No. of Field Blanks	Carbon Concentrations (µg/cm2) TC	OC	EC	OC1	OC2	OC3	OC4	EC1	EC2	EC3
GRSM9	Great Smoky Mountains NP	TN	1/13/2005	1/13/2005	1	4.56 ± 0	4.37 ± 0	0.19 ± 0	0.74 ± 0	1.28 ± 0	1.88 ± 0	0.46 ± 0	0.11 ± 0	0.09 ± 0	0 ± 0
GUMO1	Guadalupe Mountains NP	TX	7/21/2005	12/28/2006	5	3.55 ± 0.79	3.44 ± 0.74	0.11 ± 0.09	1.16 ± 0.23	1 ± 0.32	1.06 ± 0.19	0.22 ± 0.11	0.03 ± 0.05	0.07 ± 0.03	0 ± 0
HALE1	Haleakala NP	HI	3/17/2005	12/28/2006	8	2.09 ± 0.45	2.07 ± 0.44	0.02 ± 0.02	0.4 ± 0.19	0.78 ± 0.15	0.79 ± 0.16	0.1 ± 0.06	0.01 ± 0.02	0.01 ± 0.02	0 ± 0
HANC1	Hance Camp at Grand Canyon NP	AZ	1/13/2005	4/20/2006	3	2.15 ± 0.68	2.13 ± 0.66	0.02 ± 0.04	0.61 ± 0.41	0.61 ± 0.24	0.82 ± 0.22	0.09 ± 0.08	0 ± 0.01	0.02 ± 0.04	0 ± 0
HAVO1	Hawaii Volcanoes NP	HI	1/13/2005	12/28/2006	8	1.88 ± 0.61	1.87 ± 0.61	0 ± 0.01	0.48 ± 0.21	0.67 ± 0.24	0.65 ± 0.18	0.07 ± 0.05	0 ± 0.01	0 ± 0.01	0 ± 0
HECA1	Hells Canyon	OR	1/13/2005	11/16/2006	7	2.03 ± 0.86	1.98 ± 0.83	0.05 ± 0.09	0.39 ± 0.12	0.62 ± 0.13	0.87 ± 0.56	0.1 ± 0.1	0.04 ± 0.09	0 ± 0	0 ± 0
HEGL1	Hercules-Glades	MO	1/13/2005	11/16/2006	7	2.13 ± 0.79	2.09 ± 0.75	0.04 ± 0.05	0.65 ± 0.18	0.62 ± 0.29	0.71 ± 0.25	0.1 ± 0.09	0 ± 0.01	0.04 ± 0.05	0 ± 0
HOOV1	Hoover	CA	1/13/2005	9/14/2006	8	2.38 ± 0.6	2.35 ± 0.57	0.02 ± 0.06	0.72 ± 0.26	0.73 ± 0.17	0.8 ± 0.17	0.1 ± 0.06	0.02 ± 0.06	0 ± 0	0 ± 0
HOUS1	Houston	TX	5/19/2005	7/21/2005	2	3.44 ± 0.87	3.26 ± 0.62	0.18 ± 0.26	0.69 ± 0.11	1.1 ± 0.25	1.15 ± 0.25	0.32 ± 0.22	0.07 ± 0.1	0.11 ± 0.16	0 ± 0
IKBA1	Ike's Backbone	AZ	12/15/2005	12/15/2005	1	1.75 ± 0	1.73 ± 0	0.01 ± 0	0.72 ± 0	0.36 ± 0	0.58 ± 0	0.07 ± 0	0 ± 0	0.01 ± 0	0 ± 0
INGA1	Indian Gardens	AZ	2/3/2005	9/14/2006	6	3.77 ± 1.09	3.68 ± 1.03	0.09 ± 0.09	1.19 ± 0.39	1.21 ± 0.41	1.07 ± 0.29	0.21 ± 0.15	0.05 ± 0.05	0.04 ± 0.05	0 ± 0
ISLE1	Isle Royale NP	MI	1/13/2005	11/16/2006	6	1.54 ± 0.65	1.53 ± 0.64	0 ± 0.01	0.36 ± 0.14	0.54 ± 0.27	0.58 ± 0.22	0.06 ± 0.06	0 ± 0.01	0 ± 0	0 ± 0
JARI1	James River Face Wilderness	VA	1/13/2005	6/1/2006	5	2.42 ± 0.94	2.4 ± 0.92	0.02 ± 0.02	0.71 ± 0.4	0.86 ± 0.31	0.73 ± 0.21	0.11 ± 0.07	0.01 ± 0.02	0.01 ± 0.01	0 ± 0
JOSH1	Joshua Tree NP	CA	1/13/2005	7/13/2006	6	2.6 ± 0.28	2.59 ± 0.27	0.02 ± 0.03	0.75 ± 0.2	0.81 ± 0.28	0.92 ± 0.1	0.11 ± 0.07	0 ± 0.01	0.01 ± 0.02	0 ± 0
KAIS1	Kaiser	CA	1/13/2005	1/5/2006	5	2.92 ± 0.7	2.89 ± 0.67	0.03 ± 0.04	0.82 ± 0.25	0.99 ± 0.25	0.93 ± 0.22	0.15 ± 0.07	0.02 ± 0.04	0.01 ± 0.02	0 ± 0
KALM1	Kalmiopsis	OR	1/13/2005	11/16/2006	4	2.26 ± 0.22	2.24 ± 0.19	0.03 ± 0.04	0.54 ± 0.13	0.73 ± 0.08	0.84 ± 0.21	0.12 ± 0.09	0.02 ± 0.04	0.01 ± 0.02	0 ± 0
LABE1	Lava Beds NM	CA	1/13/2005	5/11/2006	7	1.91 ± 0.48	1.88 ± 0.44	0.03 ± 0.04	0.56 ± 0.17	0.61 ± 0.12	0.64 ± 0.15	0.08 ± 0.07	0 ± 0.01	0.02 ± 0.03	0 ± 0.01
LASU2	Lake Sugema	IA	1/13/2005	12/15/2005	3	2.22 ± 0.85	2.21 ± 0.84	0 ± 0	0.62 ± 0.13	0.78 ± 0.39	0.75 ± 0.33	0.07 ± 0.06	0 ± 0	0 ± 0	0 ± 0
LAVO1	Lassen Volcanic NP	CA	1/13/2005	1/5/2006	3	1.74 ± 0.59	1.71 ± 0.53	0.03 ± 0.05	0.39 ± 0.18	0.51 ± 0.16	0.76 ± 0.58	0.06 ± 0.1	0.03 ± 0.05	0 ± 0	0 ± 0
LIGO1	Linville Gorge	NC	3/17/2005	4/20/2006	5	2.24 ± 0.45	2.22 ± 0.41	0.03 ± 0.04	0.67 ± 0.16	0.63 ± 0.15	0.76 ± 0.15	0.15 ± 0.09	0 ± 0	0.03 ± 0.04	0 ± 0
LIVO1	Livonia	IN	1/13/2005	5/19/2005	2	3.42 ± 1.73	3.15 ± 1.34	0.28 ± 0.39	0.43 ± 0.16	0.79 ± 0.04	1.54 ± 1.01	0.38 ± 0.45	0.24 ± 0.34	0.02 ± 0.03	0.01 ± 0.02
LOST1	Lostwood	ND	5/19/2005	11/16/2006	5	2.24 ± 1.15	2.22 ± 1.12	0.02 ± 0.04	0.72 ± 0.47	0.71 ± 0.35	0.68 ± 0.24	0.1 ± 0.08	0.01 ± 0.01	0.01 ± 0.03	0 ± 0
LYBR1	Lye Brook Wilderness	VT	1/13/2005	12/7/2006	6	1.98 ± 0.61	1.97 ± 0.6	0.01 ± 0.02	0.54 ± 0.19	0.72 ± 0.19	0.64 ± 0.2	0.07 ± 0.09	0 ± 0	0.01 ± 0.02	0 ± 0
MACA1	Mammoth Cave NP	KY	5/19/2005	12/7/2006	5	2.25 ± 0.5	2.25 ± 0.5	0 ± 0	0.72 ± 0.22	0.67 ± 0.1	0.74 ± 0.15	0.11 ± 0.06	0 ± 0	0 ± 0	0 ± 0
MAVI1	Martha's Vineyard	MA	5/19/2005	7/13/2006	5	1.94 ± 0.7	1.9 ± 0.62	0.04 ± 0.08	0.49 ± 0.13	0.56 ± 0.16	0.76 ± 0.37	0.1 ± 0.11	0.03 ± 0.07	0.01 ± 0.02	0 ± 0
MEAD1	Meadview	AZ	5/19/2005	5/19/2005	1	2.51 ± 0	2.51 ± 0	0 ± 0	0.78 ± 0	0.87 ± 0	0.78 ± 0	0.09 ± 0	0 ± 0	0 ± 0	0 ± 0
MELA1	Medicine Lake	MT	3/17/2005	8/24/2006	3	2.16 ± 0.47	2.12 ± 0.41	0.04 ± 0.06	0.51 ± 0.09	0.68 ± 0.03	0.83 ± 0.37	0.1 ± 0.11	0.04 ± 0.06	0 ± 0	0 ± 0
MEVE1	Mesa Verde NP	CO	1/13/2005	12/28/2006	9	2.72 ± 0.89	2.7 ± 0.88	0.02 ± 0.04	0.86 ± 0.3	0.91 ± 0.29	0.81 ± 0.27	0.12 ± 0.1	0 ± 0.01	0.01 ± 0.03	0 ± 0
MING1	Mingo	MO	5/19/2005	9/14/2006	4	1.98 ± 0.3	1.97 ± 0.3	0.01 ± 0.01	0.54 ± 0.16	0.62 ± 0.14	0.71 ± 0.17	0.11 ± 0.03	0 ± 0	0.01 ± 0.01	0 ± 0
MKGO1	M.K. Goddard	PA	3/17/2005	8/24/2006	7	2.3 ± 0.66	2.21 ± 0.52	0.09 ± 0.16	0.61 ± 0.2	0.82 ± 0.18	0.68 ± 0.12	0.09 ± 0.07	0.02 ± 0.04	0.07 ± 0.14	0 ± 0
MOHO1	Mount Hood	OR	1/13/2005	8/24/2006	7	2.02 ± 0.64	2.01 ± 0.63	0.01 ± 0.03	0.5 ± 0.18	0.73 ± 0.19	0.7 ± 0.24	0.08 ± 0.09	0.01 ± 0.02	0 ± 0.01	0 ± 0
MOMO1	Mohawk Mt.	CT	3/17/2005	12/7/2006	4	1.63 ± 0.35	1.61 ± 0.33	0.02 ± 0.02	0.51 ± 0.2	0.53 ± 0.12	0.53 ± 0.07	0.04 ± 0.04	0 ± 0	0.02 ± 0.02	0 ± 0
MONT1	Monture	MT	1/13/2005	11/16/2006	7	2.48 ± 0.91	2.43 ± 0.85	0.06 ± 0.1	0.66 ± 0.3	0.78 ± 0.27	0.8 ± 0.29	0.15 ± 0.14	0.05 ± 0.11	0.06 ± 0.11	0 ± 0

Table 3-2. Continued.

Site ID	Site Name	State	Sampling Period From	To	No. of Field Blanks	Carbon Concentrations (µg/cm2) TC	OC	EC	OC1	OC2	OC3	OC4	EC1	EC2	EC3
MOOS1	Moosehorn NWR	ME	1/13/2005	12/7/2006	7	2.41 ± 0.41	2.39 ± 0.41	0.02 ± 0.04	0.75 ± 0.25	0.71 ± 0.22	0.8 ± 0.15	0.12 ± 0.06	0.02 ± 0.03	0 ± 0.01	0 ± 0
MORA1	Mount Rainier NP	WA	1/13/2005	11/16/2006	5	1.79 ± 0.62	1.77 ± 0.62	0.02 ± 0.05	0.57 ± 0.34	0.52 ± 0.21	0.63 ± 0.28	0.05 ± 0.05	0.02 ± 0.05	0 ± 0	0 ± 0
MORA9	Mount Rainier NP	WA	1/13/2005	1/13/2005	1	1.42 ± 0	1.42 ± 0	0 ± 0	0.37 ± 0	0.41 ± 0	0.64 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
MOZI1	Mount Zirkel Wilderness	CO	3/17/2005	11/16/2006	8	2.8 ± 0.38	2.79 ± 0.38	0.01 ± 0.02	0.82 ± 0.19	0.96 ± 0.16	0.86 ± 0.13	0.15 ± 0.04	0.01 ± 0.02	0 ± 0	0 ± 0
NEBR1	Nebraska NF	NE	1/13/2005	6/22/2006	5	3.15 ± 1.1	3.07 ± 1.05	0.08 ± 0.08	0.95 ± 0.53	0.96 ± 0.2	0.94 ± 0.27	0.22 ± 0.15	0.03 ± 0.03	0.05 ± 0.06	0 ± 0
NEYO1	New York City	NY	5/19/2005	12/15/2005	3	2.44 ± 0.48	2.41 ± 0.42	0.03 ± 0.06	0.76 ± 0.25	0.85 ± 0.2	0.69 ± 0.07	0.1 ± 0.07	0 ± 0	0.03 ± 0.06	0 ± 0
NOAB1	North Absaroka	WY	3/30/2006	10/5/2006	3	2.5 ± 1.08	2.42 ± 0.95	0.07 ± 0.12	0.6 ± 0.15	0.73 ± 0.11	0.97 ± 0.56	0.13 ± 0.13	0.07 ± 0.12	0 ± 0	0 ± 0
NOCA1	North Cascades	WA	3/17/2005	12/28/2006	7	2.62 ± 0.71	2.53 ± 0.68	0.09 ± 0.08	0.7 ± 0.29	0.81 ± 0.2	0.89 ± 0.23	0.13 ± 0.09	0.06 ± 0.08	0.03 ± 0.04	0 ± 0
NOCH1	Northern Cheyenne	MT	9/1/2005	10/5/2006	3	2.21 ± 0.34	2.21 ± 0.34	0 ± 0	0.63 ± 0.16	0.71 ± 0.16	0.75 ± 0.07	0.12 ± 0.05	0 ± 0	0 ± 0	0 ± 0
OKEF1	Okefenokee NWR	GA	6/1/2006	6/1/2006	1	2.99 ± 0	2.99 ± 0	0 ± 0	1.03 ± 0	0.86 ± 0	0.9 ± 0	0.2 ± 0	0 ± 0	0 ± 0	0 ± 0
OLTO1	Old Town	ME	5/19/2005	4/20/2006	4	1.93 ± 0.32	1.92 ± 0.31	0 ± 0.01	0.59 ± 0.02	0.62 ± 0.27	0.65 ± 0.04	0.06 ± 0.06	0 ± 0	0 ± 0.01	0 ± 0
OLYM1	Olympic	WA	2/3/2005	2/16/2006	2	1.7 ± 0.88	1.63 ± 0.81	0.06 ± 0.07	0.4 ± 0.26	0.46 ± 0.06	0.65 ± 0.33	0.12 ± 0.17	0.01 ± 0.01	0.06 ± 0.08	0 ± 0
OMAH1	Omaha	NE	3/17/2005	10/5/2006	4	2.3 ± 0.32	2.3 ± 0.32	0 ± 0	0.6 ± 0.25	0.88 ± 0.09	0.75 ± 0.1	0.08 ± 0.06	0 ± 0	0 ± 0	0 ± 0
ORPI1	Organ Pipe	AZ	3/17/2005	11/16/2006	5	2.02 ± 0.39	2 ± 0.36	0.02 ± 0.04	0.51 ± 0.08	0.71 ± 0.15	0.72 ± 0.16	0.06 ± 0.05	0.02 ± 0.04	0 ± 0	0 ± 0
PASA1	Pasayten	WA	5/19/2005	10/5/2006	6	2.29 ± 0.47	2.24 ± 0.49	0.04 ± 0.06	0.59 ± 0.16	0.7 ± 0.17	0.83 ± 0.25	0.12 ± 0.08	0.01 ± 0.02	0.03 ± 0.05	0.01 ± 0.01
PEFO1	Petrified Forest NP	AZ	3/17/2005	12/7/2006	6	2.15 ± 0.65	2.12 ± 0.61	0.03 ± 0.06	0.56 ± 0.23	0.59 ± 0.19	0.82 ± 0.28	0.14 ± 0.15	0.02 ± 0.06	0 ± 0.01	0 ± 0
PENO1	N/A		3/30/2006	8/24/2006	2	2.68 ± 0.2	2.68 ± 0.2	0 ± 0	0.72 ± 0.19	0.83 ± 0.07	0.98 ± 0.03	0.15 ± 0.03	0 ± 0	0 ± 0	0 ± 0
PETE1	Petersburg	AK	4/7/2005	9/14/2006	8	1.86 ± 0.61	1.84 ± 0.59	0.02 ± 0.03	0.56 ± 0.18	0.61 ± 0.23	0.61 ± 0.17	0.07 ± 0.07	0 ± 0	0.02 ± 0.03	0 ± 0
PHOE1	Phoenix	AZ	1/13/2005	5/11/2006	6	2.82 ± 1.02	2.73 ± 0.93	0.09 ± 0.13	0.75 ± 0.31	0.92 ± 0.26	0.88 ± 0.26	0.16 ± 0.16	0.04 ± 0.06	0.07 ± 0.1	0 ± 0
PHOE5	Phoenix	AZ	1/13/2005	5/11/2006	5	2.43 ± 0.27	2.42 ± 0.27	0.01 ± 0.01	0.74 ± 0.23	0.77 ± 0.11	0.78 ± 0.15	0.12 ± 0.03	0 ± 0	0 ± 0.01	0 ± 0
PINN1	Pinnacles NM	CA	3/9/2006	5/11/2006	2	1.93 ± 0.05	1.93 ± 0.05	0 ± 0	0.5 ± 0.1	0.67 ± 0.01	0.71 ± 0.12	0.05 ± 0.06	0 ± 0	0 ± 0	0 ± 0
PITT1	Pittsburgh	PA	1/13/2005	12/10/2006	8	2.46 ± 0.86	2.38 ± 0.73	0.08 ± 0.15	0.69 ± 0.29	0.7 ± 0.13	0.82 ± 0.25	0.17 ± 0.19	0.05 ± 0.09	0.03 ± 0.06	0 ± 0
PMRF1	Proctor Maple R. F.	VT	3/17/2005	7/13/2006	4	2.56 ± 0.41	2.56 ± 0.41	0 ± 0	0.76 ± 0.22	0.9 ± 0.19	0.79 ± 0.08	0.1 ± 0.03	0 ± 0	0 ± 0	0 ± 0
PORE1	Point Reyes National Seashore	CA	7/21/2005	11/16/2006	4	2.2 ± 0.91	2.18 ± 0.87	0.02 ± 0.04	0.64 ± 0.38	0.71 ± 0.29	0.72 ± 0.18	0.1 ± 0.08	0.02 ± 0.03	0.02 ± 0.04	0 ± 0
PRIS1	Presque Isle	ME	2/3/2005	4/20/2006	3	2.43 ± 0.28	2.43 ± 0.28	0.01 ± 0.01	0.79 ± 0.14	0.85 ± 0.16	0.7 ± 0.1	0.09 ± 0.08	0 ± 0	0.01 ± 0.01	0 ± 0
PUSO1	Puget Sound	WA	3/17/2005	1/5/2006	2	2.47 ± 0.78	2.42 ± 0.71	0.05 ± 0.08	0.58 ± 0.08	0.88 ± 0.3	0.78 ± 0.19	0.18 ± 0.14	0.02 ± 0.03	0.03 ± 0.05	0 ± 0
QUCI1	Quaker City	OH	10/5/2006	10/5/2006	1	2.98 ± 0	2.91 ± 0	0.07 ± 0	0.66 ± 0	0.99 ± 0	1.1 ± 0	0.16 ± 0	0.01 ± 0	0.06 ± 0	0 ± 0
QURE1	Quabbin Summit	MA	1/13/2005	2/16/2006	4	2.34 ± 0.87	2.34 ± 0.87	0 ± 0	0.44 ± 0.34	0.77 ± 0.29	1.08 ± 0.67	0.05 ± 0.03	0 ± 0	0 ± 0	0 ± 0
QUVA1	Queen Valley	AZ	3/17/2005	11/16/2006	3	2.63 ± 0.91	2.62 ± 0.9	0.01 ± 0.01	0.73 ± 0.42	0.92 ± 0.33	0.88 ± 0.2	0.09 ± 0.04	0 ± 0	0.01 ± 0.01	0 ± 0
RAFA1	San Rafael	CA	1/13/2005	12/7/2006	7	2.81 ± 0.68	2.78 ± 0.67	0.02 ± 0.02	0.91 ± 0.19	0.93 ± 0.23	0.81 ± 0.21	0.13 ± 0.09	0.01 ± 0.02	0.01 ± 0.02	0 ± 0
REDW1	Redwood NP	CA	1/13/2005	12/7/2006	6	2.27 ± 0.39	2.25 ± 0.37	0.02 ± 0.04	0.61 ± 0.17	0.82 ± 0.11	0.73 ± 0.15	0.1 ± 0.07	0 ± 0	0.02 ± 0.04	0 ± 0
ROMA1	Cape Romain NWR	SC	1/13/2005	7/13/2006	5	2.31 ± 1.15	2.15 ± 0.89	0.17 ± 0.33	0.5 ± 0.34	0.72 ± 0.35	0.76 ± 0.16	0.17 ± 0.15	0.06 ± 0.13	0.07 ± 0.12	0.03 ± 0.08
ROMO2	Rocky Mountain NP	CO	1/13/2005	1/13/2005	1	3.03 ± 0	3 ± 0	0.03 ± 0	0.66 ± 0	1.05 ± 0	1.11 ± 0	0.19 ± 0	0.03 ± 0	0 ± 0	0 ± 0

Table 3-2. Continued.

			Sampling Period			Carbon Concentrations (µg/cm2)									
Site ID	Site Name	State	From	To	No. of Field Blanks	TC	OC	EC	OC1	OC2	OC3	OC4	EC1	EC2	EC3
RUBI1	Rubidoux	CA	3/17/2005	7/21/2005	3	2.93 ± 0.61	2.88 ± 0.55	0.04 ± 0.07	0.73 ± 0.23	1 ± 0.12	1 ± 0.13	0.15 ± 0.1	0.01 ± 0.01	0.03 ± 0.06	0 ± 0
SACR1	Salt Creek	NM	1/13/2005	8/3/2006	5	2.26 ± 0.79	2.25 ± 0.77	0.01 ± 0.02	0.59 ± 0.24	0.85 ± 0.24	0.73 ± 0.24	0.08 ± 0.08	0 ± 0	0.01 ± 0.02	0 ± 0
SAFO1	Sac and Fox	KS	1/13/2005	2/16/2006	4	2.37 ± 0.75	2.31 ± 0.69	0.05 ± 0.07	0.53 ± 0.13	0.73 ± 0.34	0.93 ± 0.3	0.12 ± 0.07	0.04 ± 0.07	0.01 ± 0.03	0 ± 0
SAGA1	San Gabriel	CA	1/13/2005	10/5/2006	4	2.79 ± 0.38	2.77 ± 0.37	0.02 ± 0.03	0.88 ± 0.23	0.94 ± 0.11	0.8 ± 0.11	0.14 ± 0.06	0.02 ± 0.02	0.01 ± 0.02	0 ± 0
SAGO1	San Gorgonio Wilderness	CA	3/17/2005	9/14/2006	4	2.49 ± 0.07	2.47 ± 0.05	0.02 ± 0.03	0.6 ± 0.11	0.97 ± 0.09	0.78 ± 0.1	0.12 ± 0.02	0 ± 0	0.02 ± 0.03	0 ± 0
SAGU1	Saguaro NM	AZ	1/13/2005	11/16/2006	2	2.76 ± 0.66	2.76 ± 0.66	0 ± 0	0.58 ± 0.33	0.8 ± 0.07	1.13 ± 0.65	0.18 ± 0.16	0.07 ± 0.1	0 ± 0	0 ± 0
SAMA1	St. Marks	FL	5/19/2005	11/16/2006	7	2.71 ± 1.24	2.67 ± 1.19	0.04 ± 0.08	0.72 ± 0.44	0.88 ± 0.37	0.91 ± 0.34	0.16 ± 0.13	0.01 ± 0.03	0.03 ± 0.06	0 ± 0
SAPE1	San Pedro Parks	NM	3/17/2005	2/16/2006	3	2.09 ± 0.56	2.05 ± 0.52	0.04 ± 0.03	0.49 ± 0.15	0.61 ± 0.16	0.88 ± 0.34	0.07 ± 0.06	0.04 ± 0.03	0 ± 0	0 ± 0
SAWE1	Saguaro West	AZ	1/13/2005	6/1/2006	7	2.6 ± 0.66	2.59 ± 0.64	0.01 ± 0.02	0.74 ± 0.37	0.87 ± 0.18	0.85 ± 0.19	0.13 ± 0.08	0.01 ± 0.01	0.01 ± 0.01	0 ± 0.01
SAWT1	Sawtooth NF	ID	1/13/2005	11/16/2006	4	2.21 ± 0.61	2.21 ± 0.61	0 ± 0.01	0.66 ± 0.18	0.75 ± 0.2	0.7 ± 0.19	0.09 ± 0.07	0 ± 0	0 ± 0	0 ± 0
SENE1	Seney	MI	3/17/2005	11/16/2006	3	2.19 ± 0.72	2.13 ± 0.67	0.06 ± 0.05	0.45 ± 0.09	0.73 ± 0.23	0.81 ± 0.3	0.14 ± 0.12	0.04 ± 0.05	0.02 ± 0.04	0 ± 0
SEQU1	Sequoia NP	CA	12/15/2005	11/16/2006	4	2.13 ± 0.31	2.12 ± 0.32	0.01 ± 0.01	0.52 ± 0.08	0.75 ± 0.1	0.74 ± 0.08	0.11 ± 0.07	0 ± 0	0 ± 0.01	0 ± 0.01
SEQU9	Sequoia NP	CA	1/13/2005	1/13/2005	1	2.23 ± 0	2.19 ± 0	0.04 ± 0	0.76 ± 0	0.68 ± 0	0.65 ± 0	0.1 ± 0	0 ± 0	0.04 ± 0	0 ± 0
SHEN1	Shenandoah NP	VA	1/13/2005	1/5/2006	9	2.36 ± 0.88	2.33 ± 0.83	0.04 ± 0.08	0.52 ± 0.23	0.82 ± 0.28	0.84 ± 0.37	0.16 ± 0.13	0.02 ± 0.02	0.03 ± 0.05	0 ± 0.01
SHMI1	Shamrock Mine	CO	5/19/2005	5/11/2006	2	2.56 ± 0.11	2.55 ± 0.07	0.02 ± 0.03	0.81 ± 0.21	0.83 ± 0.13	0.82 ± 0.1	0.12 ± 0.06	0.01 ± 0.01	0.03 ± 0.02	0.01 ± 0.01
SHRO1	Shining Rock Wilderness	NC	3/17/2005	5/11/2006	6	2.91 ± 0.33	2.83 ± 0.27	0.08 ± 0.07	0.87 ± 0.17	0.93 ± 0.1	0.87 ± 0.13	0.16 ± 0.05	0.05 ± 0.05	0.03 ± 0.04	0 ± 0
SIAN1	Sierra Ancha	AZ	7/21/2005	10/5/2006	4	2.87 ± 0.6	2.81 ± 0.56	0.06 ± 0.04	0.74 ± 0.23	0.85 ± 0.18	1.05 ± 0.35	0.16 ± 0.07	0.02 ± 0.02	0.04 ± 0.04	0 ± 0.01
SIKE1	Sikes	LA	1/13/2005	8/3/2006	6	2.56 ± 0.65	2.49 ± 0.61	0.07 ± 0.1	0.62 ± 0.08	0.82 ± 0.26	0.9 ± 0.29	0.16 ± 0.06	0.02 ± 0.05	0.04 ± 0.05	0 ± 0.01
SIME1	Simeonof	AK	1/13/2005	10/5/2006	7	1.81 ± 0.6	1.81 ± 0.6	0 ± 0.01	0.45 ± 0.26	0.65 ± 0.17	0.65 ± 0.18	0.06 ± 0.05	0 ± 0.01	0 ± 0.01	0.01 ± 0.02
SIPS1	Sipsy Wilderness	AL	5/19/2005	12/7/2006	3	2.25 ± 0.79	2.21 ± 0.74	0.04 ± 0.05	0.8 ± 0.28	0.67 ± 0.32	0.62 ± 0.23	0.11 ± 0.05	0.01 ± 0.02	0.03 ± 0.06	0 ± 0
SNPA1	Snoqualmie Pass	WA	7/21/2005	12/28/2006	7	2.32 ± 0.9	2.31 ± 0.89	0.01 ± 0.02	0.71 ± 0.38	0.77 ± 0.27	0.72 ± 0.23	0.12 ± 0.07	0.01 ± 0.01	0 ± 0.01	0 ± 0
SPOK1	Spokane Res.	WA	5/19/2005	6/9/2005	2	1.74 ± 1.45	1.71 ± 1.39	0.04 ± 0.05	0.48 ± 0.35	0.57 ± 0.5	0.56 ± 0.37	0.12 ± 0.14	0.01 ± 0.01	0.04 ± 0.03	0.01 ± 0.01
STAR1	Starkey	OR	2/3/2005	12/7/2006	4	2.37 ± 1.3	2.28 ± 1.13	0.09 ± 0.18	0.7 ± 0.34	0.66 ± 0.28	0.79 ± 0.43	0.13 ± 0.11	0.04 ± 0.07	0.02 ± 0.03	0.04 ± 0.07
SULA1	Sula Peak	MT	5/19/2005	11/16/2006	3	2.06 ± 0.46	2.06 ± 0.46	0 ± 0	0.56 ± 0.21	0.76 ± 0.15	0.65 ± 0.1	0.09 ± 0.01	0 ± 0	0 ± 0	0 ± 0
SWAN1	Swanquarter	NC	3/17/2005	3/9/2006	5	2.18 ± 0.43	2.16 ± 0.4	0.02 ± 0.03	0.56 ± 0.14	0.8 ± 0.18	0.71 ± 0.13	0.1 ± 0.09	0.01 ± 0.01	0.02 ± 0.02	0 ± 0.01
SYCA1	Sycamore Canyon	AZ	1/13/2005	9/14/2006	6	1.91 ± 0.54	1.88 ± 0.49	0.03 ± 0.05	0.44 ± 0.17	0.55 ± 0.16	0.78 ± 0.22	0.1 ± 0.09	0.01 ± 0.03	0.02 ± 0.02	0 ± 0
TALL1	Tallgrass	KS	1/13/2005	11/16/2006	5	2.22 ± 0.7	2.21 ± 0.71	0.01 ± 0.02	0.57 ± 0.17	0.75 ± 0.3	0.78 ± 0.29	0.1 ± 0.08	0.01 ± 0.02	0.01 ± 0.02	0 ± 0
THBA1	Thunder Basin	WY	5/19/2005	11/16/2006	8	2.28 ± 0.6	2.26 ± 0.59	0.02 ± 0.02	0.67 ± 0.21	0.77 ± 0.21	0.71 ± 0.19	0.11 ± 0.05	0.01 ± 0.01	0.01 ± 0.02	0 ± 0
THRO1	Theodore Roosevelt	ND	5/19/2005	5/19/2005	1	2.13 ± 0	2.15 ± 0	0 ± 0	0.6 ± 0	0.81 ± 0	0.7 ± 0	0.08 ± 0	0.02 ± 0	0.02 ± 0	0.02 ± 0
THSI1	Three Sisters Wilderness	OR	1/13/2005	12/28/2006	5	1.94 ± 0.67	1.91 ± 0.6	0.03 ± 0.07	0.52 ± 0.11	0.66 ± 0.21	0.66 ± 0.22	0.07 ± 0.14	0.02 ± 0.03	0.02 ± 0.03	0 ± 0
TONT1	Tonto NM	AZ	12/15/2005	12/28/2006	5	1.97 ± 0.24	1.96 ± 0.24	0.02 ± 0.02	0.48 ± 0.15	0.58 ± 0.08	0.78 ± 0.17	0.12 ± 0.07	0 ± 0	0.01 ± 0.02	0 ± 0
TRCR1	Trapper Creek	AK	3/17/2005	9/14/2006	4	1.62 ± 0.37	1.62 ± 0.38	0 ± 0	0.41 ± 0.12	0.59 ± 0.17	0.6 ± 0.11	0.03 ± 0.03	0.01 ± 0.01	0 ± 0.01	0.01 ± 0.01
TRIN1	Trinity	CA	1/13/2005	7/21/2005	4	1.89 ± 0.55	1.87 ± 0.57	0.02 ± 0.03	0.52 ± 0.3	0.63 ± 0.23	0.66 ± 0.1	0.06 ± 0.05	0.02 ± 0.03	0 ± 0	0 ± 0

Table 3-2. Continued.

Site ID	Site Name	State	Sampling Period From	Sampling Period To	No. of Field Blanks	Carbon Concentrations (µg/cm2) TC	OC	EC	OC1	OC2	OC3	OC4	EC1	EC2	EC3
TUXE1	Tuxedni	AK	6/9/2005	11/16/2006	7	2.05 ± 0.76	2.04 ± 0.74	0.01 ± 0.02	0.52 ± 0.36	0.71 ± 0.21	0.74 ± 0.16	0.08 ± 0.06	0 ± 0.01	0.01 ± 0.02	0 ± 0
ULBE1	UL Bend	MT	1/13/2005	12/7/2006	7	2.23 ± 0.49	2.18 ± 0.49	0.05 ± 0.05	0.62 ± 0.21	0.7 ± 0.2	0.72 ± 0.15	0.14 ± 0.08	0.02 ± 0.02	0.01 ± 0.02	0.01 ± 0.03
UPBU1	Upper Buffalo Wilderness	AR	3/17/2005	9/14/2006	5	3.42 ± 0.55	3.31 ± 0.49	0.1 ± 0.11	0.93 ± 0.33	1.01 ± 0.18	1.15 ± 0.21	0.22 ± 0.08	0.07 ± 0.07	0.04 ± 0.06	0 ± 0
VIIS1	Virgin Islands NP	VI	3/17/2005	11/16/2006	8	1.74 ± 0.76	1.69 ± 0.69	0.06 ± 0.09	0.24 ± 0.18	0.7 ± 0.21	0.66 ± 0.29	0.08 ± 0.12	0.01 ± 0.02	0.03 ± 0.05	0.01 ± 0.03
VILA1	Viking Lake	IA	1/13/2005	7/13/2006	4	2.33 ± 0.47	2.29 ± 0.47	0.04 ± 0.03	0.79 ± 0.09	0.66 ± 0.21	0.73 ± 0.14	0.12 ± 0.04	0.01 ± 0.02	0.02 ± 0.03	0 ± 0
VOYA1	Voyageurs NP #1	MN	1/13/2005	7/13/2006	5	2.32 ± 0.7	2.3 ± 0.68	0.02 ± 0.03	0.65 ± 0.19	0.77 ± 0.22	0.77 ± 0.31	0.1 ± 0.08	0.02 ± 0.03	0.01 ± 0.01	0 ± 0
WARI1	Walker River Paiute Tribe	NV	5/19/2005	10/13/2005	4	2.64 ± 0.28	2.61 ± 0.26	0.03 ± 0.05	0.77 ± 0.07	0.94 ± 0.13	0.79 ± 0.08	0.11 ± 0.03	0 ± 0.01	0.02 ± 0.05	0 ± 0
WASH1	Washington D.C.	DC	12/7/2006	12/7/2006	1	3.53 ± 0	3.33 ± 0	0.2 ± 0	1.13 ± 0	1.06 ± 0	0.83 ± 0	0.3 ± 0	0.08 ± 0	0.12 ± 0	0 ± 0
WEMI1	Weminuche Wilderness	CO	1/13/2005	2/16/2006	4	2.43 ± 0.54	2.43 ± 0.53	0 ± 0	0.74 ± 0.11	0.84 ± 0.3	0.78 ± 0.19	0.07 ± 0.03	0 ± 0	0 ± 0	0 ± 0
WHIT1	White Mountain	NM	5/19/2005	11/16/2006	4	2.82 ± 0.97	2.77 ± 0.92	0.05 ± 0.06	0.75 ± 0.29	0.9 ± 0.21	0.99 ± 0.4	0.13 ± 0.09	0 ± 0.01	0.01 ± 0.03	0.03 ± 0.06
WHPA1	White Pass	WA	3/17/2005	7/13/2006	7	2.59 ± 0.79	2.58 ± 0.8	0.01 ± 0.02	0.8 ± 0.35	0.85 ± 0.25	0.82 ± 0.21	0.1 ± 0.08	0.01 ± 0.01	0.01 ± 0.02	0 ± 0
WHPE1	Wheeler Peak	NM	4/16/2005	4/8/2006	3	2.2 ± 0.5	2.2 ± 0.49	0 ± 0	0.67 ± 0.25	0.75 ± 0.25	0.75 ± 0.09	0.05 ± 0.04	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
WHRI1	White River NF	CO	3/17/2005	12/7/2006	4	2.76 ± 0.31	2.68 ± 0.27	0.08 ± 0.08	0.58 ± 0.23	0.84 ± 0.13	0.95 ± 0.07	0.21 ± 0.1	0.12 ± 0.2	0.06 ± 0.07	0 ± 0
WICA1	Wind Cave	SD	1/13/2005	12/7/2006	4	1.71 ± 0.74	1.69 ± 0.72	0.02 ± 0.03	0.56 ± 0.29	0.46 ± 0.14	0.62 ± 0.31	0.05 ± 0.05	0.02 ± 0.03	0.01 ± 0.01	0 ± 0
WIMO1	Wichita Mountains	OK	7/21/2005	11/16/2006	6	2.63 ± 0.45	2.63 ± 0.45	0 ± 0.01	0.73 ± 0.21	0.94 ± 0.15	0.84 ± 0.12	0.11 ± 0.05	0 ± 0.01	0 ± 0	0 ± 0
YELL1	Yellowstone NP 1	WY	1/13/2005	9/14/2006	6	2.62 ± 0.51	2.56 ± 0.44	0.06 ± 0.07	0.76 ± 0.18	0.86 ± 0.12	0.83 ± 0.17	0.12 ± 0.06	0.04 ± 0.06	0.02 ± 0.02	0 ± 0
YOSE1	Yosemite NP	CA	3/17/2005	8/24/2006	4	1.81 ± 0.68	1.8 ± 0.68	0.01 ± 0.02	0.53 ± 0.41	0.62 ± 0.13	0.61 ± 0.15	0.05 ± 0.04	0 ± 0	0.01 ± 0.02	0 ± 0
ZICA1	Zion Canyon	UT	2/3/2005	12/7/2006	5	2.13 ± 0.6	2.13 ± 0.59	0.01 ± 0.01	0.63 ± 0.26	0.75 ± 0.16	0.69 ± 0.2	0.06 ± 0.06	0 ± 0	0.01 ± 0.01	0 ± 0
All 181 Sites					**886**	**2.41 ± 0.48**	**2.37 ± 0.45**	**0.04 ± 0.05**	**0.66 ± 0.18**	**0.78 ± 0.15**	**0.81 ± 0.16**	**0.12 ± 0.06**	**0.02 ± 0.03**	**0.02 ± 0.02**	**0 ± 0.01**

Table 3-3. Average field blank concentrations by thermal carbon fractions at the 239 sites in STN/CSN for the period from 1/1/2005 through 12/31/2006.

		Sampling Period		No. of Field	Carbon Concentrations ($\mu g/cm^2$)							
Site ID	**State**	**From**	**To**	**Blanks**	**TC**	**OC**	**EC**	**OC1**	**OC2**	**OC3**	**OC4**	**$PM_{2.5}$ Speciation Sampler Type**
020900010	AK	4/13/2005	12/4/2006	18	0.83 ± 0.18	0.83 ± 0.18	0 ± 0	0.26 ± 0.09	0.3 ± 0.08	0.2 ± 0.07	0.07 ± 0.05	Met One SASS
011130001	AL	5/16/2005	11/7/2006	12	1.04 ± 0.27	1.04 ± 0.27	0.01 ± 0.02	0.26 ± 0.09	0.4 ± 0.14	0.29 ± 0.14	0.08 ± 0.07	Met One SASS
010050002	AL	1/28/2005	3/12/2006	7	0.77 ± 0.26	0.77 ± 0.26	0 ± 0	0.25 ± 0.13	0.3 ± 0.13	0.17 ± 0.08	0.04 ± 0.03	Met One SASS
010730023	AL	1/28/2005	12/4/2006	24	0.86 ± 0.33	0.85 ± 0.33	0.01 ± 0.03	0.24 ± 0.14	0.37 ± 0.16	0.19 ± 0.11	0.05 ± 0.03	Met One SASS
010970003	AL	1/28/2005	3/12/2006	7	0.91 ± 0.27	0.9 ± 0.27	0 ± 0	0.28 ± 0.15	0.38 ± 0.15	0.19 ± 0.07	0.05 ± 0.02	Met One SASS
011030011	AL	1/28/2005	9/7/2005	5	0.66 ± 0.24	0.65 ± 0.23	0 ± 0	0.2 ± 0.11	0.28 ± 0.11	0.14 ± 0.11	0.03 ± 0.01	Met One SASS
010890014	AL	1/28/2005	11/7/2006	12	0.83 ± 0.25	0.82 ± 0.24	0.02 ± 0.05	0.27 ± 0.13	0.32 ± 0.13	0.17 ± 0.09	0.06 ± 0.04	Met One SASS
011011002	AL	1/28/2005	11/7/2006	10	0.8 ± 0.19	0.78 ± 0.19	0.01 ± 0.02	0.25 ± 0.08	0.31 ± 0.12	0.17 ± 0.08	0.05 ± 0.03	Met One SASS
010731009	AL	1/28/2005	5/11/2006	9	0.88 ± 0.24	0.87 ± 0.24	0.01 ± 0.02	0.27 ± 0.13	0.34 ± 0.09	0.21 ± 0.07	0.05 ± 0.01	Met One SASS
010732003	AL	1/28/2005	11/7/2006	12	0.89 ± 0.23	0.89 ± 0.23	0 ± 0	0.26 ± 0.1	0.35 ± 0.13	0.22 ± 0.09	0.05 ± 0.03	Met One SASS
051190007	AR	1/28/2005	11/7/2006	12	0.81 ± 0.23	0.8 ± 0.23	0.01 ± 0.03	0.24 ± 0.07	0.31 ± 0.09	0.18 ± 0.1	0.05 ± 0.03	Met One SASS
050030005	AR	1/28/2005	5/16/2005	3	0.77 ± 0.13	0.77 ± 0.13	0 ± 0	0.24 ± 0.13	0.28 ± 0.08	0.19 ± 0.05	0.07 ± 0.03	Met One SASS
051450001	AR	1/28/2005	5/16/2005	3	0.73 ± 0.26	0.73 ± 0.26	0 ± 0	0.24 ± 0.1	0.31 ± 0.14	0.14 ± 0.05	0.04 ± 0.01	Met One SASS
040137003	AZ	3/11/2005	11/7/2006	11	1.09 ± 0.39	1.08 ± 0.39	0.01 ± 0.02	0.3 ± 0.1	0.48 ± 0.21	0.25 ± 0.11	0.06 ± 0.03	Met One SASS
040191028	AZ	1/28/2005	11/7/2006	11	0.78 ± 0.19	0.78 ± 0.19	0 ± 0	0.26 ± 0.08	0.3 ± 0.1	0.17 ± 0.07	0.04 ± 0.03	Met One SASS
040137020	AZ	3/11/2005	11/7/2006	11	1.01 ± 0.18	0.99 ± 0.17	0.01 ± 0.04	0.28 ± 0.09	0.43 ± 0.12	0.22 ± 0.08	0.06 ± 0.04	Met One SASS
040130019	AZ	1/28/2005	11/12/2005	6	0.91 ± 0.34	0.91 ± 0.34	0 ± 0	0.3 ± 0.17	0.31 ± 0.11	0.2 ± 0.13	0.1 ± 0.06	Met One SASS
040139997	AZ	1/28/2005	12/4/2006	24	0.83 ± 0.17	0.82 ± 0.17	0 ± 0.01	0.24 ± 0.08	0.34 ± 0.11	0.19 ± 0.07	0.06 ± 0.04	Met One SASS
040139998	AZ	1/28/2005	11/12/2005	6	0.83 ± 0.2	0.81 ± 0.2	0.02 ± 0.04	0.24 ± 0.05	0.34 ± 0.12	0.17 ± 0.09	0.06 ± 0.06	Met One SASS
060290014	CA	1/28/2005	12/4/2006	41	0.86 ± 0.61	0.85 ± 0.61	0.01 ± 0.04	0.23 ± 0.07	0.35 ± 0.3	0.21 ± 0.23	0.06 ± 0.06	Met One SASS
060670006	CA	1/28/2005	12/4/2006	24	0.78 ± 0.21	0.78 ± 0.21	0 ± 0.01	0.2 ± 0.08	0.34 ± 0.11	0.18 ± 0.08	0.05 ± 0.04	Met One SASS
060190008	CA	1/28/2005	12/4/2006	24	0.75 ± 0.23	0.75 ± 0.23	0 ± 0.01	0.2 ± 0.08	0.32 ± 0.13	0.16 ± 0.06	0.06 ± 0.03	Met One SASS
060371103	CA	1/28/2005	11/7/2006	12	0.9 ± 0.32	0.9 ± 0.32	0.01 ± 0.02	0.22 ± 0.08	0.38 ± 0.16	0.22 ± 0.13	0.07 ± 0.05	Met One SASS
061112002	CA	1/28/2005	11/7/2006	12	0.95 ± 0.25	0.95 ± 0.25	0.01 ± 0.01	0.26 ± 0.13	0.41 ± 0.13	0.22 ± 0.12	0.04 ± 0.03	Met One SASS
060658001	CA	1/28/2005	12/4/2006	34	0.77 ± 0.21	0.77 ± 0.21	0 ± 0.02	0.24 ± 0.06	0.32 ± 0.12	0.16 ± 0.07	0.05 ± 0.03	Met One SASS
060730003	CA	1/28/2005	12/4/2006	24	0.92 ± 0.72	0.92 ± 0.72	0 ± 0.01	0.21 ± 0.1	0.41 ± 0.38	0.22 ± 0.18	0.07 ± 0.12	Met One SASS
060850005	CA	1/28/2005	12/4/2006	24	0.76 ± 0.35	0.75 ± 0.34	0.02 ± 0.04	0.2 ± 0.06	0.31 ± 0.17	0.18 ± 0.14	0.06 ± 0.03	Met One SASS
080410011	CO	1/28/2005	11/7/2006	12	0.77 ± 0.19	0.76 ± 0.19	0.01 ± 0.03	0.23 ± 0.09	0.31 ± 0.12	0.16 ± 0.05	0.06 ± 0.06	Met One SASS
080770017	CO	1/28/2005	11/7/2006	12	0.91 ± 0.18	0.91 ± 0.18	0 ± 0.01	0.27 ± 0.07	0.38 ± 0.11	0.2 ± 0.08	0.05 ± 0.02	Met One SASS

Table 3-3. Continued.

Site ID	State	Sampling Period From	Sampling Period To	No. of Field Blanks	TC	OC	EC	OC1	OC2	OC3	OC4	$PM_{2.5}$ Speciation Sampler Type
					Carbon Concentrations ($\mu g/cm^2$)							
080010006	CO	1/28/2005	12/4/2006	24	0.76 ± 0.23	0.76 ± 0.23	0 ± 0.01	0.22 ± 0.08	0.31 ± 0.12	0.18 ± 0.1	0.05 ± 0.03	Met One SASS
081230008	CO	1/28/2005	11/7/2006	12	0.85 ± 0.12	0.84 ± 0.12	0 ± 0	0.26 ± 0.07	0.33 ± 0.07	0.19 ± 0.06	0.06 ± 0.04	Met One SASS
090090027	CT	1/28/2005	12/4/2006	22	0.77 ± 0.44	0.76 ± 0.44	0.01 ± 0.02	0.2 ± 0.08	0.32 ± 0.22	0.18 ± 0.18	0.06 ± 0.06	Met One SASS
100032004	DE	1/28/2005	11/7/2006	12	1.01 ± 0.18	1 ± 0.18	0.01 ± 0.03	0.28 ± 0.08	0.42 ± 0.11	0.23 ± 0.11	0.07 ± 0.05	Met One SASS
100010003	DE	1/28/2005	11/7/2006	12	1.02 ± 0.21	1.02 ± 0.21	0 ± 0	0.3 ± 0.12	0.43 ± 0.11	0.22 ± 0.11	0.07 ± 0.04	Met One SASS
120861016	FL	1/28/2005	12/9/2005	12	0.8 ± 0.44	0.8 ± 0.44	0 ± 0	0.18 ± 0.1	0.32 ± 0.15	0.24 ± 0.25	0.06 ± 0.08	Met One SASS
120730012	FL	1/28/2005	11/7/2006	12	0.97 ± 0.45	0.93 ± 0.43	0.04 ± 0.13	0.23 ± 0.06	0.4 ± 0.15	0.21 ± 0.17	0.08 ± 0.16	Met One SASS
121030026	FL	1/28/2005	12/4/2006	24	0.9 ± 0.63	0.89 ± 0.63	0.01 ± 0.02	0.21 ± 0.1	0.36 ± 0.28	0.24 ± 0.27	0.07 ± 0.08	Met One SASS
120330004	FL	1/28/2005	3/12/2006	8	1.08 ± 0.6	1.06 ± 0.6	0.02 ± 0.05	0.27 ± 0.07	0.47 ± 0.33	0.26 ± 0.23	0.06 ± 0.06	Met One SASS
120111002	FL	1/17/2006	12/4/2006	12	1.08 ± 1.34	1.07 ± 1.34	0.01 ± 0.01	0.17 ± 0.06	0.38 ± 0.33	0.42 ± 0.79	0.11 ± 0.2	Met One SASS
120573002	FL	1/28/2005	12/4/2006	24	0.97 ± 0.93	0.96 ± 0.93	0.01 ± 0.03	0.21 ± 0.15	0.41 ± 0.38	0.24 ± 0.28	0.09 ± 0.13	Met One SASS
130690002[a]	GA	1/17/2006	11/7/2006	6	1.06 ± 0.35	1.06 ± 0.35	0 ± 0	0.27 ± 0.08	0.43 ± 0.21	0.27 ± 0.14	0.09 ± 0.06	Met One SASS
132150011[a]	GA	1/28/2005	11/12/2005	6	1.05 ± 0.31	1.05 ± 0.31	0 ± 0	0.34 ± 0.21	0.39 ± 0.15	0.23 ± 0.12	0.07 ± 0.04	Andersen RAAS
131150005[a]	GA	1/17/2006	11/7/2006	6	0.94 ± 0.12	0.94 ± 0.12	0 ± 0	0.28 ± 0.07	0.4 ± 0.07	0.23 ± 0.06	0.03 ± 0.02	Met One SASS
130690002[a]	GA	1/28/2005	11/12/2005	5	0.73 ± 0.28	0.73 ± 0.28	0 ± 0.01	0.25 ± 0.12	0.27 ± 0.16	0.16 ± 0.12	0.05 ± 0.04	Andersen RAAS
131150005[a]	GA	1/28/2005	11/12/2005	6	0.72 ± 0.15	0.7 ± 0.15	0.02 ± 0.04	0.23 ± 0.1	0.26 ± 0.04	0.17 ± 0.06	0.05 ± 0.04	Andersen RAAS
130890002[a]	GA	1/28/2005	12/9/2005	12	0.89 ± 0.37	0.87 ± 0.37	0.02 ± 0.04	0.26 ± 0.09	0.38 ± 0.24	0.19 ± 0.11	0.05 ± 0.04	Andersen RAAS
130590001[a]	GA	1/28/2005	11/12/2005	7	0.91 ± 0.24	0.9 ± 0.23	0.01 ± 0.01	0.3 ± 0.15	0.32 ± 0.12	0.2 ± 0.06	0.07 ± 0.02	Andersen RAAS
130210007[a]	GA	1/28/2005	11/12/2005	6	0.91 ± 0.25	0.88 ± 0.24	0.02 ± 0.06	0.3 ± 0.15	0.32 ± 0.09	0.2 ± 0.09	0.05 ± 0.04	Andersen RAAS
130890002[a]	GA	1/17/2006	12/4/2006	13	0.95 ± 0.19	0.95 ± 0.19	0 ± 0.01	0.24 ± 0.11	0.41 ± 0.09	0.24 ± 0.07	0.05 ± 0.04	Met One SASS
132450091[a]	GA	1/28/2005	11/12/2005	6	1.03 ± 0.37	1.01 ± 0.36	0.02 ± 0.04	0.32 ± 0.13	0.44 ± 0.17	0.19 ± 0.06	0.04 ± 0.05	Andersen RAAS
130210007[a]	GA	1/17/2006	11/7/2006	6	1.17 ± 0.24	1.15 ± 0.23	0.02 ± 0.03	0.29 ± 0.06	0.53 ± 0.1	0.28 ± 0.13	0.05 ± 0.04	Met One SASS
130590001[a]	GA	1/17/2006	11/7/2006	6	1.06 ± 0.2	1.06 ± 0.2	0 ± 0	0.35 ± 0.06	0.46 ± 0.11	0.21 ± 0.09	0.04 ± 0.03	Met One SASS
132450091[a]	GA	5/11/2006	11/7/2006	4	1.18 ± 0.18	1.18 ± 0.18	0 ± 0	0.31 ± 0.11	0.5 ± 0.15	0.3 ± 0.19	0.06 ± 0.07	Met One SASS
132150011[a]	GA	1/17/2006	11/7/2006	6	1.14 ± 0.32	1.14 ± 0.32	0 ± 0.01	0.29 ± 0.02	0.51 ± 0.18	0.28 ± 0.12	0.05 ± 0.03	Met One SASS
150032004	HI	1/28/2005	11/7/2006	12	1.01 ± 0.37	0.99 ± 0.36	0.02 ± 0.04	0.26 ± 0.05	0.37 ± 0.13	0.26 ± 0.18	0.1 ± 0.12	Met One SASS
191130037	IA	1/28/2005	11/7/2006	12	1.29 ± 0.38	1.25 ± 0.35	0.05 ± 0.15	0.19 ± 0.08	0.42 ± 0.18	0.35 ± 0.16	0.29 ± 0.16	R&P 2300 Sequential Speciation
191630015	IA	1/28/2005	12/4/2006	23	1.18 ± 0.5	1.18 ± 0.5	0 ± 0	0.2 ± 0.09	0.35 ± 0.16	0.32 ± 0.2	0.3 ± 0.19	R&P 2300 Sequential Speciation
191530030	IA	1/28/2005	11/7/2006	12	1.42 ± 0.5	1.37 ± 0.49	0.05 ± 0.11	0.2 ± 0.06	0.45 ± 0.13	0.39 ± 0.2	0.32 ± 0.2	R&P 2300 Sequential Speciation
160270004	ID	1/28/2005	6/7/2006	18	0.65 ± 0.17	0.64 ± 0.17	0 ± 0	0.19 ± 0.09	0.28 ± 0.09	0.13 ± 0.04	0.05 ± 0.04	Met One SASS

Table 3-3. Continued.

		Sampling Period		No. of	Carbon Concentrations ($\mu g/cm^2$)							$PM_{2.5}$ Speciation
Site ID	State	From	To	Field Blanks	TC	OC	EC	OC1	OC2	OC3	OC4	Sampler Type
160010010	ID	7/10/2006	12/4/2006	6	0.61 ± 0.12	0.61 ± 0.12	0 ± 0	0.2 ± 0.05	0.24 ± 0.04	0.13 ± 0.08	0.04 ± 0.04	Met One SASS
170310057*	IL	1/17/2006	11/7/2006	6	1.04 ± 0.19	1.03 ± 0.19	0 ± 0.01	0.32 ± 0.13	0.4 ± 0.08	0.26 ± 0.1	0.06 ± 0.07	Met One SASS
170310076*	IL	1/28/2005	12/27/2005	13	0.63 ± 0.45	0.63 ± 0.45	0 ± 0	0.15 ± 0.09	0.27 ± 0.24	0.15 ± 0.12	0.05 ± 0.05	URG MASS450 WINS
170434002	IL	1/28/2005	11/7/2006	12	0.91 ± 0.31	0.9 ± 0.31	0.01 ± 0.02	0.25 ± 0.07	0.36 ± 0.13	0.2 ± 0.12	0.07 ± 0.05	Met One SASS
170310076*	IL	1/17/2006	12/4/2006	12	0.91 ± 0.25	0.9 ± 0.25	0 ± 0.01	0.24 ± 0.07	0.35 ± 0.14	0.25 ± 0.13	0.06 ± 0.04	Met One SASS
171150013	IL	1/28/2005	11/7/2006	12	0.99 ± 0.23	0.98 ± 0.23	0 ± 0	0.28 ± 0.06	0.43 ± 0.16	0.21 ± 0.08	0.06 ± 0.03	Met One SASS
171192009	IL	1/28/2005	11/7/2006	12	0.91 ± 0.25	0.91 ± 0.25	0 ± 0	0.25 ± 0.11	0.37 ± 0.12	0.22 ± 0.11	0.06 ± 0.05	Met One SASS
170310057*	IL	1/28/2005	11/12/2005	6	0.67 ± 0.18	0.67 ± 0.18	0 ± 0	0.24 ± 0.09	0.26 ± 0.11	0.13 ± 0.04	0.04 ± 0.02	Andersen RAAS
170314201	IL	1/28/2005	11/7/2006	12	0.81 ± 0.25	0.8 ± 0.25	0.01 ± 0.01	0.23 ± 0.08	0.34 ± 0.12	0.18 ± 0.06	0.05 ± 0.03	Met One SASS
180390003	IN	1/28/2005	11/7/2006	12	0.82 ± 0.21	0.81 ± 0.21	0.01 ± 0.01	0.26 ± 0.08	0.34 ± 0.11	0.18 ± 0.08	0.04 ± 0.02	Met One SASS
181630012	IN	1/28/2005	11/7/2006	12	0.75 ± 0.17	0.75 ± 0.17	0 ± 0.01	0.22 ± 0.06	0.31 ± 0.09	0.17 ± 0.08	0.05 ± 0.03	Met One SASS
180970078	IN	1/28/2005	12/4/2006	25	0.73 ± 0.23	0.72 ± 0.23	0 ± 0.01	0.22 ± 0.08	0.29 ± 0.13	0.16 ± 0.07	0.06 ± 0.03	Met One SASS
180372001	IN	1/28/2005	11/7/2006	12	0.72 ± 0.14	0.72 ± 0.14	0 ± 0.01	0.25 ± 0.07	0.28 ± 0.1	0.14 ± 0.04	0.05 ± 0.04	Met One SASS
180892004	IN	1/28/2005	11/7/2006	12	0.95 ± 0.42	0.94 ± 0.41	0.01 ± 0.03	0.27 ± 0.08	0.39 ± 0.32	0.21 ± 0.13	0.06 ± 0.05	Met One SASS
180650003	IN	1/28/2005	11/7/2006	12	0.69 ± 0.17	0.69 ± 0.17	0 ± 0	0.22 ± 0.08	0.26 ± 0.1	0.15 ± 0.07	0.05 ± 0.03	Met One SASS
180890022	IN	1/28/2005	11/7/2006	12	0.9 ± 0.14	0.9 ± 0.14	0 ± 0	0.28 ± 0.07	0.35 ± 0.08	0.2 ± 0.09	0.05 ± 0.03	Met One SASS
202090021	KS	1/28/2005	12/4/2006	23	0.77 ± 0.21	0.77 ± 0.21	0 ± 0.01	0.21 ± 0.06	0.32 ± 0.1	0.18 ± 0.08	0.05 ± 0.04	Met One SASS
201730010	KS	1/28/2005	11/7/2006	12	1.43 ± 0.51	1.32 ± 0.43	0.11 ± 0.27	0.22 ± 0.09	0.43 ± 0.12	0.36 ± 0.2	0.3 ± 0.2	R&P 2300 Sequential Speciation
211451004	KY	1/28/2005	1/17/2006	7	0.84 ± 0.36	0.83 ± 0.36	0 ± 0	0.25 ± 0.15	0.34 ± 0.17	0.19 ± 0.09	0.05 ± 0.02	Met One SASS
211110048	KY	1/28/2005	1/17/2006	7	0.92 ± 0.59	0.92 ± 0.59	0 ± 0	0.26 ± 0.1	0.34 ± 0.23	0.25 ± 0.29	0.07 ± 0.07	Met One SASS
210670012	KY	1/28/2005	11/7/2006	11	0.99 ± 0.24	0.98 ± 0.24	0 ± 0.01	0.29 ± 0.07	0.39 ± 0.13	0.24 ± 0.11	0.06 ± 0.05	Met One SASS
210190017	KY	1/28/2005	11/7/2006	12	0.93 ± 0.21	0.93 ± 0.21	0 ± 0	0.29 ± 0.09	0.36 ± 0.09	0.22 ± 0.08	0.06 ± 0.03	Met One SASS
211930003	KY	1/28/2005	11/7/2006	12	0.98 ± 0.19	0.98 ± 0.19	0 ± 0.01	0.31 ± 0.08	0.4 ± 0.12	0.21 ± 0.09	0.05 ± 0.04	Met One SASS
210590005	KY	1/28/2005	1/17/2006	7	0.72 ± 0.24	0.72 ± 0.24	0 ± 0	0.26 ± 0.11	0.28 ± 0.11	0.14 ± 0.07	0.03 ± 0.02	Met One SASS
211250004	KY	1/28/2005	3/12/2006	8	0.95 ± 0.24	0.94 ± 0.24	0.01 ± 0.03	0.28 ± 0.09	0.35 ± 0.1	0.23 ± 0.14	0.07 ± 0.07	Met One SASS
211170007	KY	1/28/2005	11/7/2006	12	0.87 ± 0.17	0.87 ± 0.17	0 ± 0	0.31 ± 0.11	0.32 ± 0.09	0.19 ± 0.05	0.05 ± 0.02	Met One SASS
212270007	KY	1/28/2005	1/17/2006	7	0.8 ± 0.22	0.79 ± 0.21	0.02 ± 0.04	0.23 ± 0.1	0.38 ± 0.14	0.14 ± 0.06	0.02 ± 0.02	Met One SASS
211110043	KY	1/28/2005	11/7/2006	12	0.89 ± 0.23	0.89 ± 0.23	0 ± 0	0.26 ± 0.09	0.36 ± 0.15	0.19 ± 0.08	0.07 ± 0.04	Met One SASS
220330009	LA	2/12/2005	12/4/2006	24	0.8 ± 0.64	0.8 ± 0.64	0.01 ± 0.01	0.18 ± 0.1	0.33 ± 0.33	0.22 ± 0.23	0.06 ± 0.07	URG MASS450 WINS

Table 3-3. Continued.

Site ID	State	Sampling Period From	Sampling Period To	No. of Field Blanks	Carbon Concentrations (µg/cm²) TC	OC	EC	OC1	OC2	OC3	OC4	$PM_{2.5}$ Speciation Sampler Type
220150008	LA	1/28/2005	12/1/2006	13	0.71 ± 0.58	0.7 ± 0.57	0.01 ± 0.02	0.18 ± 0.09	0.3 ± 0.32	0.18 ± 0.19	0.04 ± 0.02	URG MASS450 WINS
250130008	MA	1/28/2005	12/4/2006	20	0.91 ± 0.34	0.9 ± 0.34	0.01 ± 0.03	0.22 ± 0.08	0.39 ± 0.16	0.22 ± 0.14	0.06 ± 0.04	Met One SASS
250250042	MA	1/28/2005	12/4/2006	36	0.84 ± 0.34	0.84 ± 0.34	0.01 ± 0.03	0.21 ± 0.07	0.35 ± 0.19	0.22 ± 0.16	0.05 ± 0.04	Met One SASS
240053001	MD	1/28/2005	12/4/2006	24	0.73 ± 0.37	0.72 ± 0.36	0.01 ± 0.02	0.19 ± 0.06	0.29 ± 0.21	0.18 ± 0.13	0.05 ± 0.03	Met One SASS
240330030	MD	1/28/2005	11/7/2006	12	0.92 ± 0.23	0.92 ± 0.23	0 ± 0.01	0.31 ± 0.12	0.36 ± 0.1	0.19 ± 0.09	0.05 ± 0.04	Andersen RAAS
261130001	MI	1/28/2005	11/7/2006	12	0.81 ± 0.22	0.81 ± 0.22	0 ± 0	0.24 ± 0.06	0.31 ± 0.12	0.18 ± 0.08	0.07 ± 0.05	Met One SASS
260770008	MI	1/28/2005	11/7/2006	12	0.94 ± 0.17	0.94 ± 0.17	0 ± 0.01	0.28 ± 0.07	0.41 ± 0.13	0.19 ± 0.06	0.04 ± 0.03	Met One SASS
261630033	MI	1/28/2005	11/7/2006	12	1.63 ± 1.22	1.49 ± 1.12	0.15 ± 0.48	0.39 ± 0.26	0.62 ± 0.35	0.29 ± 0.24	0.19 ± 0.43	Met One SASS
260330901	MI	1/28/2005	3/12/2006	11	0.8 ± 0.2	0.8 ± 0.2	0 ± 0.01	0.25 ± 0.07	0.34 ± 0.13	0.16 ± 0.07	0.03 ± 0.01	Met One SASS
261630001	MI	1/28/2005	12/4/2006	23	0.79 ± 0.38	0.79 ± 0.38	0 ± 0.01	0.21 ± 0.08	0.33 ± 0.2	0.18 ± 0.11	0.06 ± 0.08	Met One SASS
261610008	MI	1/28/2005	11/7/2006	12	0.88 ± 0.11	0.88 ± 0.11	0 ± 0	0.29 ± 0.08	0.35 ± 0.08	0.19 ± 0.07	0.05 ± 0.03	Met One SASS
261150005	MI	1/28/2005	11/7/2006	11	0.95 ± 0.24	0.95 ± 0.24	0 ± 0	0.23 ± 0.05	0.48 ± 0.14	0.19 ± 0.1	0.04 ± 0.03	Met One SASS
260050003	MI	1/28/2005	3/12/2006	8	0.7 ± 0.18	0.7 ± 0.18	0 ± 0	0.22 ± 0.1	0.29 ± 0.1	0.15 ± 0.07	0.04 ± 0.02	Met One SASS
260810020	MI	1/28/2005	11/7/2006	12	0.81 ± 0.18	0.81 ± 0.18	0 ± 0	0.25 ± 0.08	0.32 ± 0.13	0.18 ± 0.07	0.05 ± 0.03	Met One SASS
270953051	MN	1/28/2005	7/15/2005	7	0.68 ± 0.32	0.67 ± 0.32	0 ± 0	0.19 ± 0.1	0.25 ± 0.13	0.16 ± 0.1	0.06 ± 0.03	Met One SASS
271230871	MN	1/28/2005	3/11/2005	2	0.7 ± 0.25	0.69 ± 0.25	0 ± 0	0.26 ± 0.12	0.32 ± 0.11	0.09 ± 0.03	0.03 ± 0	Met One SASS
271095008	MN	1/28/2005	11/7/2006	11	0.8 ± 0.22	0.79 ± 0.22	0.01 ± 0.02	0.26 ± 0.11	0.32 ± 0.11	0.17 ± 0.08	0.04 ± 0.03	Met One SASS
270530963	MN	1/28/2005	12/4/2006	24	0.92 ± 0.38	0.91 ± 0.37	0.01 ± 0.03	0.23 ± 0.08	0.41 ± 0.21	0.21 ± 0.13	0.05 ± 0.05	Met One SASS
290530001	MO	3/11/2005	5/11/2006	6	1.51 ± 0.33	1.51 ± 0.33	0 ± 0	0.18 ± 0.09	0.42 ± 0.09	0.44 ± 0.15	0.45 ± 0.24	R&P 2300 Sequential Speciation
291860005	MO	1/28/2005	12/4/2006	24	1.51 ± 0.88	1.47 ± 0.88	0.03 ± 0.11	0.22 ± 0.09	0.49 ± 0.3	0.42 ± 0.36	0.32 ± 0.3	R&P 2300 Sequential Speciation
290990012*	MO	1/28/2005	10/5/2006	21	0.78 ± 0.31	0.77 ± 0.31	0.01 ± 0.01	0.2 ± 0.1	0.34 ± 0.17	0.18 ± 0.12	0.05 ± 0.03	Met One SASS
290470005	MO	1/28/2005	12/4/2006	23	1.33 ± 0.59	1.3 ± 0.58	0.03 ± 0.1	0.2 ± 0.13	0.39 ± 0.19	0.35 ± 0.14	0.36 ± 0.26	R&P 2300 Sequential Speciation
295100085	MO	1/28/2005	12/4/2006	23	0.64 ± 0.19	0.64 ± 0.19	0.01 ± 0.02	0.21 ± 0.07	0.25 ± 0.1	0.14 ± 0.06	0.04 ± 0.03	Met One SASS
290990012*	MO	11/7/2006	12/4/2006	2	1.16 ± 0.09	1.16 ± 0.09	0 ± 0	0.2 ± 0.05	0.53 ± 0.05	0.31 ± 0.03	0.12 ± 0.06	R&P 2300 Sequential Speciation
280350004	MS	1/28/2005	11/12/2005	6	0.91 ± 0.25	0.91 ± 0.25	0 ± 0	0.26 ± 0.11	0.33 ± 0.11	0.22 ± 0.13	0.08 ± 0.03	Met One SASS
280430001	MS	1/28/2005	1/17/2006	8	1.07 ± 0.52	1.02 ± 0.51	0.05 ± 0.09	0.27 ± 0.09	0.39 ± 0.17	0.24 ± 0.16	0.11 ± 0.16	Met One SASS
280490018	MS	1/28/2005	5/11/2006	9	1.05 ± 0.31	1.05 ± 0.31	0 ± 0	0.26 ± 0.07	0.47 ± 0.21	0.24 ± 0.12	0.07 ± 0.03	Met One SASS
280470008	MS	1/28/2005	12/4/2006	19	0.92 ± 0.48	0.91 ± 0.48	0 ± 0.02	0.2 ± 0.08	0.34 ± 0.21	0.23 ± 0.16	0.14 ± 0.11	Met One SASS

Table 3-3. Continued.

Site ID	State	Sampling Period From	Sampling Period To	No. of Field Blanks	TC	OC	EC	OC1	OC2	OC3	OC4	$PM_{2.5}$ Speciation Sampler Type
280670002	MS	1/28/2005	11/12/2005	6	0.95 ± 0.31	0.93 ± 0.31	0.02 ± 0.03	0.27 ± 0.09	0.35 ± 0.16	0.2 ± 0.09	0.11 ± 0.04	Met One SASS
300530018	MT	1/28/2005	11/7/2006	12	1.02 ± 0.19	1.02 ± 0.19	0.01 ± 0.01	0.27 ± 0.08	0.42 ± 0.11	0.25 ± 0.08	0.08 ± 0.04	Met One SASS
300630031	MT	1/28/2005	12/4/2006	24	0.95 ± 0.89	0.94 ± 0.89	0.01 ± 0.02	0.23 ± 0.08	0.42 ± 0.51	0.23 ± 0.31	0.06 ± 0.05	Met One SASS
371190041	NC	1/28/2005	12/4/2006	24	0.67 ± 0.23	0.66 ± 0.22	0.01 ± 0.02	0.18 ± 0.08	0.28 ± 0.11	0.15 ± 0.07	0.05 ± 0.03	Met One SASS
370670022	NC	1/28/2005	11/7/2006	11	0.92 ± 0.17	0.91 ± 0.16	0.01 ± 0.02	0.25 ± 0.07	0.4 ± 0.12	0.21 ± 0.12	0.05 ± 0.04	Met One SASS
371830014	NC	1/28/2005	12/4/2006	17	0.68 ± 0.22	0.67 ± 0.22	0.01 ± 0.05	0.19 ± 0.07	0.28 ± 0.13	0.16 ± 0.07	0.04 ± 0.03	Met One SASS
371070004	NC	1/28/2005	11/7/2006	12	0.92 ± 0.26	0.91 ± 0.26	0.01 ± 0.02	0.28 ± 0.07	0.38 ± 0.12	0.2 ± 0.13	0.05 ± 0.04	Met One SASS
370810013	NC	1/28/2005	11/7/2006	11	0.89 ± 0.22	0.87 ± 0.22	0.02 ± 0.05	0.27 ± 0.1	0.35 ± 0.12	0.2 ± 0.07	0.05 ± 0.04	Met One SASS
370350004	NC	1/28/2005	11/7/2006	12	0.8 ± 0.16	0.8 ± 0.16	0 ± 0	0.25 ± 0.08	0.31 ± 0.08	0.18 ± 0.07	0.05 ± 0.03	Met One SASS
370570002	NC	1/28/2005	11/7/2006	12	0.99 ± 0.17	0.98 ± 0.17	0.01 ± 0.01	0.25 ± 0.11	0.36 ± 0.13	0.25 ± 0.12	0.1 ± 0.09	Met One SASS
371590021	NC	1/28/2005	11/7/2006	12	0.8 ± 0.26	0.78 ± 0.26	0.02 ± 0.05	0.22 ± 0.08	0.31 ± 0.14	0.19 ± 0.1	0.06 ± 0.05	Met One SASS
370210034	NC	1/28/2005	11/7/2006	12	0.97 ± 0.25	0.97 ± 0.25	0 ± 0.01	0.25 ± 0.07	0.46 ± 0.17	0.21 ± 0.09	0.04 ± 0.02	Met One SASS
380171004	ND	1/28/2005	12/4/2006	23	0.87 ± 0.83	0.87 ± 0.83	0.01 ± 0.02	0.2 ± 0.09	0.4 ± 0.53	0.2 ± 0.22	0.06 ± 0.04	Met One SASS
380150003	ND	1/28/2005	11/7/2006	12	1 ± 0.35	1 ± 0.35	0.01 ± 0.02	0.25 ± 0.07	0.42 ± 0.14	0.23 ± 0.15	0.08 ± 0.04	Met One SASS
380530002	ND	1/28/2005	11/7/2006	13	1.09 ± 0.5	1.08 ± 0.5	0.01 ± 0.03	0.3 ± 0.09	0.48 ± 0.33	0.24 ± 0.15	0.06 ± 0.04	Met One SASS
310550019	NE	1/28/2005	12/4/2006	24	0.83 ± 0.42	0.82 ± 0.42	0.01 ± 0.04	0.22 ± 0.07	0.36 ± 0.26	0.19 ± 0.15	0.04 ± 0.02	Met One SASS
330150014	NH	2/3/2005	12/7/2006	23	0.78 ± 0.28	0.76 ± 0.27	0.02 ± 0.07	0.23 ± 0.07	0.33 ± 0.16	0.16 ± 0.08	0.05 ± 0.04	Andersen RAAS
330110020	NH	1/28/2005	11/12/2005	5	0.95 ± 0.21	0.94 ± 0.21	0.01 ± 0.02	0.37 ± 0.19	0.32 ± 0.09	0.19 ± 0.07	0.06 ± 0.03	Andersen RAAS
340390004	NJ	1/28/2005	12/4/2006	23	0.96 ± 0.68	0.95 ± 0.68	0 ± 0.01	0.21 ± 0.09	0.43 ± 0.37	0.23 ± 0.23	0.07 ± 0.04	Met One SASS
340273001	NJ	1/28/2005	12/4/2006	23	0.79 ± 0.3	0.78 ± 0.3	0.01 ± 0.02	0.23 ± 0.1	0.32 ± 0.14	0.17 ± 0.1	0.05 ± 0.03	Met One SASS
340230006	NJ	1/28/2005	12/4/2006	34	0.8 ± 0.29	0.79 ± 0.29	0 ± 0.01	0.23 ± 0.07	0.32 ± 0.14	0.18 ± 0.11	0.06 ± 0.04	Met One SASS
340070003	NJ	1/28/2005	12/4/2006	23	0.64 ± 0.21	0.64 ± 0.21	0.01 ± 0.01	0.2 ± 0.08	0.27 ± 0.11	0.13 ± 0.08	0.04 ± 0.03	Met One SASS
350010023	NM	1/28/2005	11/7/2006	12	1.42 ± 0.3	1.41 ± 0.3	0.01 ± 0.01	0.25 ± 0.11	0.4 ± 0.12	0.36 ± 0.16	0.39 ± 0.15	R&P 2300 Sequential Speciation
320310016	NV	1/28/2005	12/4/2006	24	0.82 ± 0.27	0.81 ± 0.27	0 ± 0.01	0.21 ± 0.07	0.35 ± 0.12	0.18 ± 0.11	0.05 ± 0.05	Met One SASS
320030561	NV	1/28/2005	11/7/2006	12	0.88 ± 0.21	0.88 ± 0.21	0 ± 0	0.27 ± 0.08	0.33 ± 0.12	0.2 ± 0.08	0.07 ± 0.03	Met One SASS
360810124	NY	1/28/2005	12/4/2006	25	1.28 ± 0.46	1.26 ± 0.46	0.02 ± 0.07	0.2 ± 0.12	0.37 ± 0.14	0.37 ± 0.23	0.32 ± 0.19	R&P 2300 Sequential Speciation
361010003	NY	1/28/2005	12/4/2006	23	1.24 ± 0.32	1.22 ± 0.31	0.02 ± 0.07	0.19 ± 0.08	0.38 ± 0.13	0.36 ± 0.13	0.28 ± 0.16	R&P 2300 Sequential Speciation
360310003	NY	1/28/2005	11/7/2006	18	1.33 ± 0.44	1.28 ± 0.42	0.05 ± 0.15	0.21 ± 0.06	0.43 ± 0.22	0.37 ± 0.17	0.27 ± 0.16	R&P 2300 Sequential Speciation
360610062	NY	1/28/2005	12/4/2006	23	0.94 ± 0.71	0.87 ± 0.65	0.07 ± 0.3	0.21 ± 0.08	0.38 ± 0.43	0.21 ± 0.15	0.07 ± 0.09	Met One SASS

Carbon Concentrations ($\mu g/cm^2$) apply to columns TC through OC4.

Table 3-3. Continued.

Site ID	State	Sampling Period		No. of Field Blanks	Carbon Concentrations (µg/cm^2)							$PM_{2.5}$ Speciation Sampler Type
		From	To		TC	OC	EC	OC1	OC2	OC3	OC4	
360050110*	NY	1/28/2005	12/9/2005	8	1.18 ± 0.26	1.17 ± 0.26	0.01 ± 0.01	0.23 ± 0.09	0.36 ± 0.14	0.28 ± 0.12	0.29 ± 0.14	R&P 2300 Sequential Speciation
360551007	NY	1/28/2005	12/4/2006	24	1.23 ± 0.42	1.22 ± 0.42	0.01 ± 0.05	0.19 ± 0.1	0.38 ± 0.21	0.34 ± 0.19	0.3 ± 0.19	R&P 2300 Sequential Speciation
360050110*	NY	1/17/2006	12/4/2006	13	0.83 ± 0.53	0.83 ± 0.53	0.01 ± 0.02	0.2 ± 0.06	0.38 ± 0.34	0.2 ± 0.13	0.05 ± 0.03	Met One SASS
360290005	NY	1/28/2005	11/7/2006	12	1.54 ± 0.68	1.49 ± 0.67	0.06 ± 0.12	0.2 ± 0.07	0.48 ± 0.28	0.44 ± 0.31	0.37 ± 0.19	R&P 2300 Sequential Speciation
360050083	NY	1/28/2005	12/9/2005	12	0.79 ± 0.16	0.79 ± 0.16	0 ± 0.01	0.19 ± 0.06	0.36 ± 0.11	0.17 ± 0.08	0.06 ± 0.03	Met One SASS
390171004	OH	1/28/2005	11/7/2006	12	1.16 ± 0.88	1.15 ± 0.88	0.01 ± 0.03	0.28 ± 0.12	0.53 ± 0.45	0.27 ± 0.33	0.06 ± 0.04	Met One SASS
390933002	OH	1/17/2006	11/7/2006	6	0.78 ± 0.08	0.78 ± 0.08	0 ± 0	0.27 ± 0.05	0.35 ± 0.07	0.13 ± 0.06	0.02 ± 0.01	Met One SASS
390950026	OH	1/28/2005	11/7/2006	12	0.74 ± 0.21	0.73 ± 0.21	0.01 ± 0.03	0.23 ± 0.07	0.31 ± 0.1	0.15 ± 0.08	0.03 ± 0.02	Met One SASS
390810017	OH	1/28/2005	11/7/2006	11	0.96 ± 0.49	0.94 ± 0.49	0.02 ± 0.06	0.23 ± 0.08	0.43 ± 0.35	0.23 ± 0.17	0.05 ± 0.02	Met One SASS
390350060	OH	1/10/2005	12/4/2006	49	0.77 ± 0.29	0.77 ± 0.29	0.01 ± 0.02	0.22 ± 0.13	0.32 ± 0.19	0.17 ± 0.08	0.05 ± 0.03	Met One SASS
390870010	OH	1/28/2005	11/7/2006	11	0.81 ± 0.2	0.81 ± 0.2	0 ± 0	0.26 ± 0.08	0.33 ± 0.09	0.16 ± 0.06	0.05 ± 0.03	Met One SASS
390350038	OH	1/28/2005	11/7/2006	12	0.89 ± 0.2	0.89 ± 0.2	0 ± 0	0.28 ± 0.06	0.37 ± 0.14	0.18 ± 0.07	0.06 ± 0.04	Met One SASS
391130031	OH	3/11/2005	11/7/2006	11	0.86 ± 0.2	0.85 ± 0.2	0.01 ± 0.02	0.27 ± 0.08	0.35 ± 0.1	0.18 ± 0.06	0.05 ± 0.02	Met One SASS
390990014	OH	1/28/2005	11/7/2006	12	1.06 ± 0.21	1.05 ± 0.21	0.01 ± 0.02	0.28 ± 0.08	0.49 ± 0.17	0.23 ± 0.12	0.06 ± 0.02	Met One SASS
390930016	OH	1/28/2005	11/12/2005	6	0.73 ± 0.15	0.73 ± 0.15	0 ± 0	0.22 ± 0.08	0.28 ± 0.1	0.16 ± 0.06	0.06 ± 0.02	Met One SASS
391530023	OH	1/28/2005	11/7/2006	11	0.9 ± 0.2	0.89 ± 0.2	0 ± 0.01	0.29 ± 0.08	0.36 ± 0.09	0.2 ± 0.09	0.05 ± 0.03	Met One SASS
390610040	OH	1/28/2005	11/7/2006	12	0.93 ± 0.24	0.92 ± 0.24	0.01 ± 0.03	0.26 ± 0.06	0.43 ± 0.23	0.18 ± 0.08	0.06 ± 0.04	Met One SASS
391510017	OH	3/11/2005	9/8/2006	10	0.81 ± 0.16	0.8 ± 0.16	0 ± 0.01	0.28 ± 0.1	0.31 ± 0.1	0.17 ± 0.07	0.04 ± 0.02	Met One SASS
390490081	OH	1/28/2005	11/7/2006	12	1 ± 0.18	0.97 ± 0.18	0.03 ± 0.04	0.31 ± 0.12	0.43 ± 0.14	0.19 ± 0.09	0.04 ± 0.03	Met One SASS
401431127	OK	1/28/2005	12/4/2006	23	0.72 ± 0.25	0.71 ± 0.25	0 ± 0.01	0.18 ± 0.06	0.3 ± 0.11	0.18 ± 0.1	0.05 ± 0.04	Met One SASS
401091037	OK	1/28/2005	11/7/2006	12	0.85 ± 0.32	0.83 ± 0.32	0.02 ± 0.03	0.24 ± 0.11	0.35 ± 0.13	0.21 ± 0.14	0.03 ± 0.02	Met One SASS
400450890	OK	1/28/2005	3/12/2006	7	0.78 ± 0.37	0.77 ± 0.37	0.01 ± 0.03	0.22 ± 0.08	0.31 ± 0.17	0.19 ± 0.18	0.04 ± 0.03	Met One SASS
410510246	OR	1/28/2005	12/4/2006	24	0.73 ± 0.23	0.72 ± 0.23	0.01 ± 0.04	0.21 ± 0.1	0.3 ± 0.11	0.16 ± 0.09	0.05 ± 0.04	Met One SASS
420710007	PA	1/28/2005	11/7/2006	12	0.99 ± 0.24	0.99 ± 0.24	0 ± 0.01	0.3 ± 0.1	0.4 ± 0.14	0.2 ± 0.11	0.07 ± 0.04	Met One SASS
420290100	PA	1/28/2005	11/7/2006	11	1.14 ± 0.24	1.14 ± 0.24	0 ± 0	0.3 ± 0.09	0.43 ± 0.12	0.28 ± 0.13	0.14 ± 0.07	Met One SASS
420950025	PA	1/28/2005	11/7/2006	11	1.05 ± 0.16	1.04 ± 0.15	0.01 ± 0.03	0.28 ± 0.07	0.46 ± 0.08	0.23 ± 0.1	0.07 ± 0.07	Met One SASS
421330008	PA	1/28/2005	11/7/2006	12	0.78 ± 0.15	0.78 ± 0.15	0 ± 0	0.22 ± 0.07	0.34 ± 0.1	0.16 ± 0.06	0.04 ± 0.03	Met One SASS
421290008	PA	1/28/2005	11/7/2006	12	0.98 ± 0.22	0.97 ± 0.22	0 ± 0	0.31 ± 0.1	0.4 ± 0.1	0.22 ± 0.11	0.04 ± 0.02	Met One SASS
420270100	PA	1/28/2005	11/7/2006	12	0.91 ± 0.22	0.89 ± 0.21	0.02 ± 0.07	0.24 ± 0.07	0.4 ± 0.15	0.19 ± 0.09	0.05 ± 0.03	Met One SASS
420030064	PA	1/28/2005	11/7/2006	12	0.79 ± 0.28	0.78 ± 0.28	0.01 ± 0.02	0.22 ± 0.07	0.33 ± 0.11	0.19 ± 0.18	0.05 ± 0.03	Met One SASS

Table 3-3. Continued.

Site ID	State	Sampling Period From	Sampling Period To	No. of Field Blanks	Carbon Concentrations (µg/cm²) TC	OC	EC	OC1	OC2	OC3	OC4	$PM_{2.5}$ Speciation Sampler Type
421010136	PA	1/28/2005	11/7/2006	12	0.89 ± 0.28	0.88 ± 0.27	0.01 ± 0.05	0.26 ± 0.1	0.4 ± 0.14	0.18 ± 0.1	0.04 ± 0.03	Met One SASS
420692006	PA	1/28/2005	11/7/2006	12	1.14 ± 0.59	1.14 ± 0.59	0 ± 0	0.28 ± 0.05	0.47 ± 0.16	0.31 ± 0.34	0.07 ± 0.09	Met One SASS
420490003	PA	1/28/2005	11/7/2006	12	1.09 ± 0.37	1.07 ± 0.37	0.02 ± 0.04	0.29 ± 0.06	0.49 ± 0.21	0.23 ± 0.14	0.06 ± 0.05	Met One SASS
420030008	PA	2/12/2005	12/4/2006	21	0.72 ± 0.26	0.71 ± 0.26	0.01 ± 0.03	0.21 ± 0.1	0.3 ± 0.15	0.15 ± 0.06	0.05 ± 0.04	Met One SASS
420450002	PA	1/28/2005	11/7/2006	12	1.25 ± 0.5	1.25 ± 0.5	0 ± 0	0.24 ± 0.08	0.53 ± 0.32	0.31 ± 0.15	0.17 ± 0.09	Met One SASS
421255001	PA	1/28/2005	11/7/2006	12	0.87 ± 0.19	0.86 ± 0.19	0 ± 0.01	0.25 ± 0.08	0.38 ± 0.11	0.18 ± 0.08	0.05 ± 0.03	Met One SASS
420110010	PA	7/10/2006	11/7/2006	3	1.38 ± 0.33	1.38 ± 0.33	0 ± 0	0.32 ± 0.03	0.73 ± 0.2	0.24 ± 0.09	0.09 ± 0.05	Met One SASS
420990301	PA	1/28/2005	11/12/2005	6	0.74 ± 0.3	0.74 ± 0.3	0 ± 0	0.17 ± 0.05	0.32 ± 0.13	0.17 ± 0.11	0.06 ± 0.02	Met One SASS
421010004	PA	1/28/2005	12/4/2006	23	0.92 ± 0.77	0.91 ± 0.77	0.01 ± 0.02	0.2 ± 0.14	0.4 ± 0.47	0.25 ± 0.27	0.06 ± 0.04	Met One SASS
420430401	PA	1/28/2005	11/7/2006	12	0.89 ± 0.4	0.88 ± 0.4	0.01 ± 0.03	0.24 ± 0.08	0.38 ± 0.17	0.2 ± 0.16	0.06 ± 0.05	Met One SASS
420110009	PA	3/12/2006	5/11/2006	1	1.26 ± 0	1.26 ± 0	0 ± 0	0.34 ± 0	0.49 ± 0	0.31 ± 0	0.12 ± 0	Met One SASS
420010001	PA	1/28/2005	11/7/2006	12	0.78 ± 0.17	0.78 ± 0.17	0.01 ± 0.02	0.23 ± 0.06	0.35 ± 0.09	0.15 ± 0.08	0.04 ± 0.03	Met One SASS
720610001	PR	1/28/2005	3/12/2006	14	0.81 ± 0.29	0.79 ± 0.29	0.02 ± 0.05	0.2 ± 0.07	0.36 ± 0.17	0.18 ± 0.09	0.05 ± 0.03	Met One SASS
440070022	RI	1/28/2005	12/4/2006	24	0.82 ± 0.33	0.81 ± 0.32	0.01 ± 0.04	0.22 ± 0.06	0.31 ± 0.16	0.19 ± 0.11	0.07 ± 0.08	Andersen RAAS
450450009	SC	1/28/2005	11/7/2006	16	0.81 ± 0.4	0.81 ± 0.4	0.01 ± 0.01	0.2 ± 0.08	0.33 ± 0.16	0.21 ± 0.16	0.06 ± 0.07	Met One SASS
450790019	SC	1/28/2005	11/7/2006	12	0.9 ± 0.23	0.88 ± 0.22	0.02 ± 0.04	0.26 ± 0.1	0.38 ± 0.14	0.19 ± 0.11	0.05 ± 0.03	Met One SASS
450190049	SC	1/28/2005	12/25/2006	25	0.81 ± 0.36	0.8 ± 0.36	0 ± 0.01	0.2 ± 0.08	0.34 ± 0.21	0.21 ± 0.13	0.05 ± 0.04	Met One SASS
450250001	SC	1/28/2005	11/7/2006	12	0.97 ± 0.22	0.96 ± 0.21	0.01 ± 0.03	0.25 ± 0.07	0.42 ± 0.14	0.21 ± 0.13	0.06 ± 0.05	Met One SASS
460990006	SD	1/28/2005	11/7/2006	12	0.94 ± 0.75	0.94 ± 0.75	0 ± 0	0.22 ± 0.08	0.37 ± 0.31	0.22 ± 0.22	0.12 ± 0.19	Met One SASS
471650007	TN	1/28/2005	3/12/2006	8	0.67 ± 0.17	0.67 ± 0.17	0 ± 0	0.24 ± 0.08	0.24 ± 0.1	0.14 ± 0.07	0.05 ± 0.03	Met One SASS
470370023	TN	1/28/2005	11/7/2006	12	1.09 ± 0.51	1.09 ± 0.51	0 ± 0	0.32 ± 0.17	0.4 ± 0.16	0.28 ± 0.24	0.08 ± 0.07	Andersen RAAS
471631007	TN	1/28/2005	11/7/2006	12	0.84 ± 0.18	0.83 ± 0.18	0.01 ± 0.02	0.28 ± 0.09	0.31 ± 0.08	0.19 ± 0.08	0.05 ± 0.02	Met One SASS
470990002	TN	1/28/2005	11/7/2006	12	0.75 ± 0.17	0.74 ± 0.17	0 ± 0.01	0.23 ± 0.07	0.3 ± 0.1	0.16 ± 0.06	0.04 ± 0.02	Met One SASS
471570047	TN	1/28/2005	4/8/2006	17	0.79 ± 0.44	0.79 ± 0.44	0 ± 0.01	0.24 ± 0.07	0.26 ± 0.13	0.18 ± 0.14	0.1 ± 0.15	Andersen RAAS
471570024	TN	6/7/2006	12/4/2006	7	0.82 ± 0.23	0.82 ± 0.23	0 ± 0	0.24 ± 0.08	0.32 ± 0.13	0.2 ± 0.08	0.06 ± 0.05	Met One SASS
470931020	TN	1/28/2005	11/7/2006	12	0.94 ± 0.23	0.93 ± 0.23	0.01 ± 0.02	0.34 ± 0.09	0.39 ± 0.14	0.17 ± 0.06	0.03 ± 0.03	Andersen RAAS
470654002	TN	1/28/2005	11/7/2006	11	0.96 ± 0.54	0.95 ± 0.54	0.01 ± 0.02	0.26 ± 0.08	0.4 ± 0.31	0.23 ± 0.2	0.04 ± 0.02	Met One SASS
481670014	TX	1/5/2005	8/21/2005	12	1.62 ± 0.44	1.52 ± 0.44	0.1 ± 0.07	0.42 ± 0.14	0.8 ± 0.23	0.28 ± 0.12	0.12 ± 0.07	R&P 2025 Sequential SCC
482450021	TX	10/24/2005	12/26/2006	36	1.68 ± 1.2	1.61 ± 1.2	0.07 ± 0.11	0.33 ± 0.18	0.89 ± 0.53	0.31 ± 0.29	0.15 ± 0.34	R&P 2025 Sequential SCC
482730314	TX	1/29/2005	8/21/2005	9	1.49 ± 0.51	1.37 ± 0.51	0.11 ± 0.08	0.37 ± 0.18	0.69 ± 0.17	0.27 ± 0.16	0.15 ± 0.13	R&P 2025 Sequential WINS

Table 3-3. Continued.

Site ID	State	Sampling Period From	Sampling Period To	No. of Field Blanks	Carbon Concentrations (µg/cm²) TC	OC	EC	OC1	OC2	OC3	OC4	$PM_{2.5}$ Speciation Sampler Type
480612004	TX	10/8/2005	12/14/2006	15	1.52 ± 0.45	1.48 ± 0.44	0.04 ± 0.08	0.31 ± 0.17	0.82 ± 0.21	0.28 ± 0.12	0.1 ± 0.11	R&P 2025 Sequential SCC
482430004	TX	1/29/2005	8/1/2005	8	1.43 ± 0.41	1.33 ± 0.38	0.11 ± 0.14	0.32 ± 0.12	0.66 ± 0.21	0.29 ± 0.16	0.15 ± 0.16	R&P 2025 Sequential WINS
482030002	TX	1/17/2005	8/21/2005	19	1.46 ± 1.14	1.39 ± 1.13	0.07 ± 0.13	0.36 ± 0.34	0.7 ± 0.35	0.25 ± 0.23	0.14 ± 0.38	R&P 2025 Sequential WINS
483390078	TX	1/5/2005	8/21/2005	20	2.18 ± 1.09	2.05 ± 1.07	0.13 ± 0.15	0.46 ± 0.24	1.12 ± 0.64	0.37 ± 0.19	0.22 ± 0.21	R&P 2025 Sequential SCC
481130069	TX	1/28/2005	12/4/2006	24	0.8 ± 0.7	0.8 ± 0.7	0 ± 0	0.21 ± 0.12	0.33 ± 0.36	0.19 ± 0.21	0.07 ± 0.09	URG MASS450 WINS
481410044	TX	1/28/2005	12/4/2006	21	0.71 ± 0.44	0.71 ± 0.44	0 ± 0.01	0.19 ± 0.1	0.28 ± 0.19	0.17 ± 0.14	0.06 ± 0.06	URG MASS450 WINS
481410053	TX	1/17/2005	12/14/2006	29	1.7 ± 0.63	1.6 ± 0.62	0.1 ± 0.1	0.44 ± 0.19	0.84 ± 0.32	0.28 ± 0.14	0.13 ± 0.11	R&P 2025 Sequential SCC
482450022	TX	1/5/2005	8/21/2005	19	1.25 ± 0.41	1.19 ± 0.4	0.06 ± 0.07	0.27 ± 0.08	0.65 ± 0.24	0.24 ± 0.11	0.09 ± 0.09	R&P 2025 Sequential SCC
482010024	TX	1/5/2005	12/20/2006	30	1.42 ± 0.48	1.38 ± 0.48	0.04 ± 0.06	0.36 ± 0.22	0.75 ± 0.22	0.25 ± 0.11	0.06 ± 0.07	R&P 2025 Sequential SCC
482010055	TX	1/5/2005	8/21/2005	16	1.65 ± 0.47	1.56 ± 0.47	0.09 ± 0.08	0.41 ± 0.18	0.83 ± 0.27	0.29 ± 0.12	0.12 ± 0.09	R&P 2025 Sequential WINS
483550034*	TX	1/17/2005	4/18/2006	20	1.46 ± 0.44	1.4 ± 0.43	0.06 ± 0.07	0.34 ± 0.14	0.75 ± 0.23	0.27 ± 0.13	0.1 ± 0.09	R&P 2025 Sequential WINS
484530020	TX	10/8/2005	12/14/2006	16	2.17 ± 1.94	2 ± 1.93	0.16 ± 0.23	0.42 ± 0.35	0.93 ± 0.53	0.36 ± 0.32	0.43 ± 0.89	R&P 2025 Sequential SCC
481390015	TX	1/17/2005	8/21/2005	10	1.49 ± 0.62	1.39 ± 0.61	0.1 ± 0.13	0.38 ± 0.14	0.74 ± 0.32	0.22 ± 0.16	0.14 ± 0.17	R&P 2025 Sequential SCC
480430002	TX	1/3/2005	7/5/2005	6	1.68 ± 0.8	1.54 ± 0.78	0.13 ± 0.18	0.43 ± 0.18	0.8 ± 0.44	0.32 ± 0.24	0.13 ± 0.19	R&P 2025 Sequential WINS
482011039	TX	1/28/2005	12/4/2006	41	0.62 ± 0.25	0.62 ± 0.25	0 ± 0.01	0.18 ± 0.1	0.24 ± 0.12	0.14 ± 0.07	0.04 ± 0.04	URG MASS450 WINS
482570005	TX	1/17/2005	8/21/2005	10	1.48 ± 0.65	1.41 ± 0.64	0.07 ± 0.1	0.32 ± 0.12	0.76 ± 0.35	0.28 ± 0.16	0.12 ± 0.18	R&P 2025 Sequential SCC

Table 3-3. Continued.

Site ID	State	Sampling Period From	Sampling Period To	No. of Field Blanks	Carbon Concentrations ($\mu g/cm^2$) TC	OC	EC	OC1	OC2	OC3	OC4	$PM_{2.5}$ Speciation Sampler Type
482011034	TX	1/17/2005	8/21/2005	10	1.85 ± 1.08	1.66 ± 1.07	0.19 ± 0.19	0.47 ± 0.37	0.72 ± 0.26	0.33 ± 0.26	0.3 ± 0.34	R&P 2025 Sequential SCC
481130050	TX	1/5/2005	12/26/2006	60	1.35 ± 0.43	1.31 ± 0.42	0.04 ± 0.08	0.33 ± 0.16	0.73 ± 0.23	0.21 ± 0.12	0.07 ± 0.1	R&P 2025 Sequential SCC
483550034*	TX	5/12/2006	11/20/2006	8	1.96 ± 0.72	1.87 ± 0.71	0.09 ± 0.13	0.31 ± 0.09	0.95 ± 0.3	0.43 ± 0.2	0.26 ± 0.17	R&P 2025 Sequential SCC
483030001	TX	1/17/2005	6/10/2005	7	1.43 ± 0.53	1.33 ± 0.52	0.1 ± 0.11	0.35 ± 0.1	0.7 ± 0.26	0.26 ± 0.17	0.11 ± 0.14	R&P 2025 Sequential SCC
482010026	TX	1/5/2005	8/21/2005	20	1.71 ± 0.49	1.61 ± 0.48	0.1 ± 0.1	0.49 ± 0.25	0.82 ± 0.22	0.28 ± 0.11	0.12 ± 0.09	R&P 2025 Sequential SCC
480430101*	TX	3/25/2006	12/14/2006	9	1.25 ± 0.36	1.19 ± 0.35	0.06 ± 0.09	0.3 ± 0.13	0.68 ± 0.21	0.19 ± 0.07	0.06 ± 0.1	R&P 2025 Sequential SCC
480430101*	TX	1/17/2005	3/1/2006	17	1.54 ± 0.45	1.44 ± 0.43	0.1 ± 0.12	0.36 ± 0.19	0.77 ± 0.19	0.27 ± 0.15	0.14 ± 0.18	R&P 2025 Sequential WINS
483611100	TX	2/10/2005	8/21/2005	15	1.4 ± 0.24	1.36 ± 0.23	0.05 ± 0.07	0.35 ± 0.11	0.72 ± 0.13	0.25 ± 0.09	0.08 ± 0.08	R&P 2025 Sequential SCC
490353006	UT	1/28/2005	12/4/2006	24	0.8 ± 0.37	0.78 ± 0.37	0.02 ± 0.07	0.23 ± 0.08	0.33 ± 0.16	0.17 ± 0.11	0.05 ± 0.05	Met One SASS
490110004	UT	1/28/2005	11/7/2006	12	0.93 ± 0.24	0.92 ± 0.24	0.01 ± 0.03	0.29 ± 0.08	0.34 ± 0.13	0.21 ± 0.11	0.07 ± 0.06	Met One SASS
490494001	UT	1/28/2005	11/7/2006	12	0.93 ± 0.2	0.93 ± 0.2	0 ± 0	0.29 ± 0.08	0.4 ± 0.1	0.2 ± 0.1	0.04 ± 0.02	Met One SASS
515200006	VA	1/28/2005	9/8/2006	11	0.88 ± 0.25	0.87 ± 0.25	0 ± 0.01	0.24 ± 0.07	0.36 ± 0.14	0.21 ± 0.11	0.05 ± 0.04	Met One SASS
511390004	VA	1/28/2005	9/8/2006	12	0.69 ± 0.2	0.68 ± 0.2	0.01 ± 0.02	0.24 ± 0.1	0.28 ± 0.1	0.13 ± 0.05	0.03 ± 0.02	Met One SASS
510870014	VA	2/12/2005	12/4/2006	25	0.78 ± 0.18	0.77 ± 0.18	0.01 ± 0.02	0.21 ± 0.06	0.35 ± 0.14	0.17 ± 0.06	0.04 ± 0.03	Met One SASS
500070012	VT	1/28/2005	12/4/2006	24	0.79 ± 0.44	0.78 ± 0.44	0.01 ± 0.03	0.19 ± 0.08	0.31 ± 0.14	0.21 ± 0.25	0.06 ± 0.05	Met One SASS
530330080*	WA	1/28/2005	2/7/2006	14	1.13 ± 1.49	1.11 ± 1.49	0.01 ± 0.05	0.2 ± 0.12	0.45 ± 0.63	0.36 ± 0.64	0.11 ± 0.15	URG MASS450 WINS
530330048	WA	1/28/2005	11/7/2006	12	0.95 ± 0.31	0.95 ± 0.31	0 ± 0	0.29 ± 0.06	0.38 ± 0.19	0.21 ± 0.1	0.07 ± 0.08	Andersen RAAS
530330024	WA	1/28/2005	11/12/2005	6	0.97 ± 0.37	0.97 ± 0.37	0 ± 0	0.32 ± 0.15	0.34 ± 0.19	0.24 ± 0.21	0.06 ± 0.04	Andersen RAAS
530330057	WA	1/28/2005	11/7/2006	12	0.98 ± 0.25	0.97 ± 0.25	0 ± 0.01	0.34 ± 0.09	0.38 ± 0.15	0.2 ± 0.07	0.06 ± 0.05	Andersen RAAS
530530029	WA	1/17/2006	11/7/2006	6	1.23 ± 0.81	1.23 ± 0.81	0 ± 0	0.37 ± 0.06	0.46 ± 0.27	0.26 ± 0.23	0.09 ± 0.17	Andersen RAAS
530630016	WA	1/28/2005	11/7/2006	12	1.16 ± 0.19	1.16 ± 0.19	0 ± 0.01	0.36 ± 0.13	0.44 ± 0.1	0.29 ± 0.11	0.06 ± 0.03	Andersen RAAS
530330080*	WA	9/8/2006	12/4/2006	4	1.39 ± 0.13	1.39 ± 0.13	0 ± 0.01	0.31 ± 0.11	0.75 ± 0.24	0.28 ± 0.22	0.05 ± 0.04	Met One SASS
110010042	D.C.	2/12/2005	7/10/2006	18	0.81 ± 0.2	0.8 ± 0.2	0.01 ± 0.02	0.24 ± 0.06	0.3 ± 0.1	0.2 ± 0.11	0.05 ± 0.04	Andersen RAAS
110010043	D.C.	1/28/2005	12/4/2006	24	0.69 ± 0.18	0.69 ± 0.18	0.01 ± 0.01	0.23 ± 0.08	0.25 ± 0.07	0.16 ± 0.09	0.05 ± 0.04	Andersen RAAS

Table 3-3. Continued.

Site ID	State	Sampling Period		No. of Field Blanks	Carbon Concentrations (µg/cm^2)							$PM_{2.5}$ Speciation Sampler Type
		From	To		TC	OC	EC	OC1	OC2	OC3	OC4	
550270007	WI	1/28/2005	12/4/2006	24	0.67 ± 0.23	0.66 ± 0.23	0 ± 0	0.17 ± 0.05	0.27 ± 0.09	0.16 ± 0.1	0.05 ± 0.06	Met One SASS
551330027	WI	1/28/2005	11/7/2006	12	0.76 ± 0.19	0.75 ± 0.19	0.01 ± 0.01	0.23 ± 0.07	0.31 ± 0.12	0.17 ± 0.09	0.05 ± 0.03	Met One SASS
551198001	WI	1/28/2005	11/7/2006	12	0.76 ± 0.19	0.75 ± 0.19	0 ± 0	0.23 ± 0.08	0.31 ± 0.11	0.16 ± 0.05	0.05 ± 0.02	Met One SASS
550590019	WI	1/28/2005	11/12/2005	6	0.78 ± 0.24	0.78 ± 0.24	0 ± 0	0.2 ± 0.06	0.3 ± 0.09	0.24 ± 0.26	0.03 ± 0.02	Met One SASS
550790026	WI	1/28/2005	12/4/2006	24	0.76 ± 0.26	0.76 ± 0.26	0 ± 0.01	0.19 ± 0.06	0.32 ± 0.11	0.19 ± 0.1	0.06 ± 0.05	Met One SASS
540390011	WV	1/28/2005	12/4/2006	25	0.71 ± 0.18	0.69 ± 0.18	0.01 ± 0.03	0.2 ± 0.06	0.28 ± 0.1	0.15 ± 0.07	0.06 ± 0.04	Met One SASS
540511002	WV	1/28/2005	11/7/2006	12	0.88 ± 0.18	0.88 ± 0.18	0 ± 0.01	0.29 ± 0.11	0.33 ± 0.09	0.2 ± 0.1	0.06 ± 0.05	Met One SASS
540391005	WV	1/28/2005	11/7/2006	12	0.87 ± 0.16	0.87 ± 0.16	0 ± 0.01	0.25 ± 0.08	0.37 ± 0.12	0.21 ± 0.08	0.05 ± 0.03	Met One SASS
All 253 Sites				3628	0.98 ± 0.28	0.96 ± 0.25	0.02 ± 0.03	0.26 ± 0.06	0.4 ± 0.15	0.22 ± 0.06	0.08 ± 0.07	

[a] Site count includes 14 sites where the sampler type changed between 1/1/2005 and 12/31/2006, therefore there are 239 STN/CSN sites.

Table 3-4. Average field blank concentrations by carbon fractions at the eight sites in the SEARCH network for the period from 1/1/2005 through 12/31/2006.

			Sampling Period			Carbon Concentrations (μg/cm^2)									
Site ID	Site Name	State	From	To	No. of Field Blanks	TC	OC	EC	OC1	OC2	OC3	OC4	EC1	EC2	EC3
GLF	Gulf Port	MS	1/1/2005	10/2/2006	14	0.45 ± 0.53	0.42 ± 0.44	0.03 ± 0.1	0.03 ± 0.05	0.12 ± 0.14	0.23 ± 0.17	0.01 ± 0.05	0.04 ± 0.14	0.02 ± 0.06	0 ± 0
OAK	Oak Grove	MS	1/31/2005	12/1/2006	19	0.54 ± 0.61	0.46 ± 0.45	0.07 ± 0.21	0.05 ± 0.08	0.09 ± 0.13	0.28 ± 0.26	0.04 ± 0.12	0.02 ± 0.07	0.03 ± 0.1	0.02 ± 0.06
BHM	Birmingham	AL	1/31/2005	10/31/2006	9	0.35 ± 0.23	0.34 ± 0.22	0.01 ± 0.02	0.1 ± 0.18	0.05 ± 0.11	0.19 ± 0.07	0 ± 0	0 ± 0	0.01 ± 0.02	0 ± 0.01
CTR	Centerville	AL	1/31/2005	12/1/2006	23	0.71 ± 0.46	0.7 ± 0.46	0 ± 0.01	0.15 ± 0.23	0.24 ± 0.14	0.25 ± 0.16	0.01 ± 0.02	0 ± 0.02	0.04 ± 0.18	0 ± 0.01
JST	Jefferson St	GA	2/1/2005	11/14/2006	13	2 ± 1.24	1.82 ± 1.01	0.18 ± 0.51	0.87 ± 0.61	0.47 ± 0.28	0.39 ± 0.37	0.09 ± 0.2	0.15 ± 0.43	0.02 ± 0.08	0.01 ± 0.02
YRK	Yorkville	GA	1/31/2005	11/30/2006	20	1.49 ± 1.28	1.48 ± 1.28	0 ± 0.01	0.53 ± 0.66	0.45 ± 0.34	0.32 ± 0.19	0.15 ± 0.62	0.04 ± 0.16	0.01 ± 0.05	0 ± 0
PNS	Pensacola	FL	2/1/2005	12/29/2006	24	0.34 ± 0.2	0.33 ± 0.19	0.01 ± 0.03	0.06 ± 0.09	0.07 ± 0.08	0.19 ± 0.09	0 ± 0	0 ± 0.01	0.01 ± 0.03	0 ± 0
OLF	Outlying Field	FL	2/27/2005	12/31/2006	22	0.57 ± 0.64	0.53 ± 0.56	0.04 ± 0.11	0.07 ± 0.13	0.09 ± 0.13	0.34 ± 0.34	0.03 ± 0.11	0.02 ± 0.06	0.01 ± 0.05	0.01 ± 0.04
All 8 sites					144	0.81 ± 0.61	0.76 ± 0.57	0.04 ± 0.06	0.23 ± 0.3	0.2 ± 0.17	0.27 ± 0.07	0.04 ± 0.05	0.03 ± 0.05	0.02 ± 0.01	0 ± 0.01

Table 3-5. Average blank concentration by $PM_{2.5}$ speciation sampler type for the 239 sites in STN/CSN for the period from 1/1/2005 through 12/31/2006.

				µg/cm^2			µg/filter			µg/m^3		
Type of $PM_{2.5}$ Speciation Sampler	**Site Count**	**No. of Field Blanks**	**Sample Volume (m^3)**	**TC**	**OC**	**EC**	**TC**	**OC**	**EC**	**TC**	**OC**	**EC**
Andersen RAAS	22	249	10.5	0.88 ± 0.33	0.88 ± 0.33	0.01 ± 0.03	10.4 ± 3.95	10.3 ± 3.93	0.1 ± 0.37	0.99 ± 0.38	0.98 ± 0.37	0.01 ± 0.03
MetOne SASS	185	2572	9.6	0.86 ± 0.39	0.85 ± 0.38	0.01 ± 0.05	10.13 ± 4.55	10.03 ± 4.51	0.1 ± 0.59	1.05 ± 0.47	1.04 ± 0.47	0.01 ± 0.06
URG MASS	7	150	24	0.75 ± 0.66	0.74 ± 0.66	0 ± 0.02	8.8 ± 7.79	8.75 ± 7.79	0.05 ± 0.2	0.37 ± 0.32	0.36 ± 0.32	0 ± 0.01
R&P 2300 Sequential Speciation	15	236	14.4	1.33 ± 0.52	1.3 ± 0.51	0.03 ± 0.11	15.66 ± 6.08	15.32 ± 5.95	0.35 ± 1.27	1.09 ± 0.42	1.06 ± 0.41	0.02 ± 0.09
R&P 2025 Sequential SCC[a]	24	421	24	1.57 ± 0.77	1.49 ± 0.76	0.08 ± 0.12	18.49 ± 9.03	17.53 ± 8.93	0.95 ± 1.34	0.78 ± 0.38	0.73 ± 0.37	0.04 ± 0.06
Total	253[b]	3628		1.08 ± 0.35	1.05 ± 0.32	0.03 ± 0.03	12.7 ± 4.17	12.39 ± 3.81	0.31 ± 0.38	0.86 ± 0.30	0.83 ± 0.30	0.02 ± 0.02

[a] R&P 2025 sequential Federal Reference Method (FRM) sampler using either a WINS impactor or a sharp-cut cyclone

[b] Site count includes 14 sites where sampler type changed between 1/1/2005 and 12/31/2006. The actual number of sites is 239

Table 3-6. Summary of average (± standard deviation) field and trip blank carbon densities and equivalent ambient concentrations for each STN/CSN samplers for the period from 1/1/2005 to 12/31/2006.

			TC $\mu g/cm^2$		OC $\mu g/cm^2$		EC $\mu g/cm^2$	
$PM_{2.5}$ Speciation Sampler	**No. of Field Blanks**	**No. of Trip Blanks**	**Field Blank Average ± Std Dev**	**Trip Blank Average ± Std Dev**	**Field Blank Average ± Std Dev**	**Trip Blank Average ± Std Dev**	**Field Blank Average ± Std Dev**	**Trip Blank Average ± Std Dev**
Andersen RAAS[a]	249	241	0.88 ± 0.33	0.84 ± 0.38	0.88 ± 0.33	0.83 ± 0.34	0.01 ± 0.03	0.01 ± 0.05
Met One SASS[b]	2,572	1,832	0.86 ± 0.40	0.89 ± 0.45	0.85 ± 0.38	0.88 ± 0.45	0.01 ± 0.05	0.01 ± 0.03
URG MASS[c]	150	159	0.75 ± 0.67	0.81 ± 0.70	0.74 ± 0.66	0.80 ± 0.69	0.00 ± 0.02	0.01 ± 0.03
R&P 2300[d]	236	103	1.33 ± 0.50	1.36 ± 0.48	1.30 ± 0.51	1.30 ± 0.48	0.03 ± 0.11	0.06 ± 0.16
R&P 2025[e,f]	421	0	1.57 ± 0.83	N/A[g]	1.49 ± 0.77	N/A[g]	0.08 ± 0.11	N/A[g]
Sampler Average	3628	2335	1.08 ± 0.35	0.98 ± 0.26	1.05 ± 0.32	0.95 ± 0.23	0.03 ± 0.03	0.02 ± 0.03

			TC $\mu g/m^3$		OC $\mu g/m^3$		EC $\mu g/m^3$	
$PM_{2.5}$ Speciation Sampler	**No. of Field Blanks**	**No. of Trip Blanks**	**Field Blank Average ± Std Dev**	**Trip Blank Average ± Std Dev**	**Field Blank Average ± Std Dev**	**Trip Blank Average ± Std Dev**	**Field Blank Average ± Std Dev**	**Trip Blank Average ± Std Dev**
Andersen RAAS[a]	249	241	0.99 ± 0.37	0.94 ± 0.42	0.98 ± 0.37	0.93 ± 0.38	0.01 ± 0.03	0.01 ± 0.05
Met One SASS[b]	2,572	1,832	1.05 ± 0.49	1.09 ± 0.56	1.04 ± 0.47	1.08 ± 0.55	0.01 ± 0.06	0.01 ± 0.04
URG MASS[c]	150	159	0.37 ± 0.33	0.4 ± 0.34	0.36 ± 0.32	0.39 ± 0.34	0 ± 0.01	0.00 ± 0.01
R&P 2300[d]	236	103	1.09 ± 0.41	1.11 ± 0.39	1.06 ± 0.41	1.06 ± 0.39	0.02 ± 0.09	0.05 ± 0.13
R&P 2025[e,f]	421	0	0.77 ± 0.41	N/A[g]	0.73 ± 0.38	N/A[g]	0.04 ± 0.06	N/A[g]
Sampler Average	3628	2335	0.85 ± 0.30	0.89 ± 0.33	0.83 ± 0.30	0.87 ± 0.32	0.02 ± 0.02	0.02 ± 0.02

[a] Flow rate of 7.3 L/min, 24-hr volume 10.5 m^3
[b] Flow rate of 6.7 L/min, 24-hr volume 9.6 m^3
[c] Flow rate of 16.7 L/min, 24-hr volume 24.0 m^3
[d] Flow rate of 10 L/min, 24-hr volume 14.4 m^3
[e] Flow rate of 16.7 L/min, 24-hr volume 24.0 m^3
[f] The samples from these Texas sites are analyzed by DRI
[g] Data not available

Table 3-7. Comparison of the quartz-fiber backup (QBQ) filter behind the quartz-fiber front filter between the IMPROVE and SEARCH networks for the period from 1/1/2005 through 12/31/2006.

	μg/cm^2[a]		**μg/filter**		**μg/m^3[b]**	
Carbon Fraction	**IMPROVE (QBQ[c])**	**SEARCH (dQBQ[d])**	**IMPROVE (QBQ[c])**	**SEARCH (dQBQ[d])**	**IMPROVE (QBQ[c])**	**SEARCH (dQBQ[d])**
TC	3.23 ± 0.96	1.29 ± 0.52	11.42 ± 3.37	9.17 ± 3.69	0.35 ± 0.1	0.38 ± 0.15
OC[e]	3.08 ± 0.83	1.19 ± 0.52	10.86 ± 2.94	8.45 ± 3.67	0.33 ± 0.09	0.35 ± 0.15
EC	0.16 ± 0.13	0.1 ± 0.06	0.56 ± 0.45	0.71 ± 0.43	0.02 ± 0.01	0.03 ± 0.02
OC1	0.56 ± 0.07	0.26 ± 0.38	1.98 ± 0.25	1.82 ± 2.68	0.06 ± 0.01	0.08 ± 0.11
OC2	0.95 ± 0.23	0.35 ± 0.15	3.36 ± 0.81	2.53 ± 1.05	0.1 ± 0.02	0.11 ± 0.04
OC3	1.15 ± 0.35	0.47 ± 0.06	4.05 ± 1.22	3.37 ± 0.4	0.12 ± 0.04	0.14 ± 0.02
OC4	0.31 ± 0.18	0.07 ± 0.02	1.1 ± 0.64	0.53 ± 0.13	0.03 ± 0.02	0.02 ± 0.01
EC1	0.18 ± 0.16	0.07 ± 0.05	0.64 ± 0.58	0.47 ± 0.34	0.02 ± 0.02	0.02 ± 0.01
EC2	0.08 ± 0.06	0.05 ± 0.04	0.28 ± 0.22	0.38 ± 0.31	0.01 ± 0.01	0.02 ± 0.01
EC3	0 ± 0	0.01 ± 0.01	0.02 ± 0.01	0.07 ± 0.06	0 ± 0	0 ± 0
No. of Sites in Average	6	8	6	8	6	8
No. of Samples in Average	1401	257	1401	257	1401	257

[a] The exposed filter area is 3.53 cm^2 for the 25 mm IMPROVE Pallflex® Tissuquartz filters and 7.12 cm^2 for the 37 mm SEARCH filters

[b] The sampling volume is 32.7 m^3 for the IMPROVE Module C sampler and 24 m^3 for the PCM sampler in the SEARCH network

[c] QBQ: Quartz-fiber backup filter behind the quartz-fiber front filter

[d] dQBQ: denuded quartz-fiber backup filter (QBQ with preceding organic denuder)

[e] Following the IMPROVE_A protocol by reflectance

Table 3-8. Summary of field blanks acquired at the 181 sites in the IMPROVE network from 1/1/2005 to 12/31/2006

SiteID	Name	State	Sampling Period From	To	Total Field Blanks	# of Field Blanks by Season Spring	Summer	Fall	Winter
ACAD1	Acadia NP	ME	1/13/2005	1/5/2006	3	1	0	0	2
ADPI1	Addison Pinnacle	NY	1/13/2005	5/11/2006	6	3	1	1	1
AGTI1	Agua Tibia	CA	5/19/2005	11/16/2006	7	1	1	5	0
AREN1	Arendtsville	PA	1/13/2005	3/30/2006	5	2	0	0	3
ATLA1	Atlanta	GA	1/13/2005	11/19/2006	8	3	1	2	2
BADL1	Badlands NP	SD	1/13/2005	12/7/2006	7	1	1	1	4
BALD1	Mount Baldy	AZ	3/17/2005	6/1/2006	5	2	1	1	1
BALT1	Baltimore	MD	1/13/2005	12/15/2005	4	1	1	0	2
BAND1	Bandelier NM	NM	3/17/2005	12/28/2006	9	3	2	2	2
BIBE1	Big Bend NP	TX	3/17/2005	8/24/2006	7	3	2	2	0
BIRM1	Birmingham	AL	1/13/2005	8/24/2006	5	1	1	1	2
BLIS1	Bliss SP (TRPA)	CA	3/17/2005	10/26/2006	10	3	1	5	1
BLMO1	Blue Mounds	MN	1/13/2005	1/5/2006	4	2	0	0	2
BOAP1	Bosque del Apache	NM	1/13/2005	12/7/2006	8	0	3	2	3
BOND1	Bondville	IL	3/17/2005	11/16/2006	5	3	0	1	1
BOWA1	Boundary Waters Canoe Area	MN	3/30/2006	9/14/2006	3	2	0	1	0
BRCA1	Bryce Canyon NP	UT	7/21/2005	11/16/2006	5	0	2	3	0
BRET1	Breton	LA	2/3/2005	2/3/2005	1	0	0	0	1
BRID1	Bridger Wilderness	WY	5/19/2005	12/7/2006	2	1	0	0	1
BRID9	Bridger Wilderness	WY	1/13/2005	1/13/2005	1	0	0	0	1
BRIG1	Brigantine NWR	NJ	2/3/2005	5/11/2006	6	3	1	0	2
BRMA1	Bridgton	ME	1/13/2005	10/26/2006	6	2	0	2	2
CABA1	Casco Bay	ME	5/19/2005	12/28/2006	6	2	2	0	2
CABI1	Cabinet Mountains	MT	5/19/2005	2/16/2006	3	1	1	0	1
CACO1	Cape Cod	MA	10/13/2005	12/28/2006	2	0	0	1	1
CACR1	Caney Creek	AR	1/13/2005	9/14/2006	7	3	2	1	1
CADI1	Cadiz	KY	5/19/2005	11/16/2006	7	3	0	3	1
CANY1	Canyonlands NP	UT	7/21/2005	10/5/2006	9	1	3	3	2
CAPI1	Capitol Reef NP	UT	3/17/2005	12/7/2006	6	1	2	2	1
CEBL1	Cedar Bluff	KS	1/13/2005	10/26/2006	10	2	3	2	3
CHAS1	Chassahowitzka NWR	FL	6/9/2005	10/5/2006	8	3	2	2	1
CHER1	Cherokee Nation	OK	10/13/2005	9/14/2006	3	1	0	2	0
CHIC1	Chicago	IL	1/13/2005	3/17/2005	2	1	0	0	1
CHIR1	Chiricahua NM	AZ	1/13/2005	8/24/2006	5	2	2	0	1
CLPE1	Cloud Peak	WY	3/17/2005	4/20/2006	3	2	0	1	0
COGO1	Columbia Gorge #1	WA	3/17/2005	10/5/2006	6	3	0	2	1
COHI1	Connecticut Hill	NY	7/21/2005	12/15/2005	3	0	1	1	1
COHU1	Cohutta	GA	3/17/2005	3/17/2005	1	1	0	0	0
CORI1	Columbia River Gorge	WA	3/17/2005	12/7/2006	5	2	1	1	1
CRES1	Crescent Lake	NE	3/17/2005	6/1/2006	6	4	1	1	0
CRLA1	Crater Lake NP	OR	5/19/2005	12/7/2006	7	1	3	1	2
CRMO1	Craters of the Moon NM	ID	3/17/2005	5/11/2006	4	3	0	1	0
DENA1	Denali NP	AK	5/19/2005	12/28/2006	7	1	3	0	3
DETR1	Detroit	MI	4/7/2005	12/31/2006	8	2	2	2	2
DEVA1	Death Valley NP	CA	3/17/2005	10/5/2006	4	1	1	2	0
DOME1	Dome Lands Wilderness	CA	12/15/2005	12/28/2006	4	0	1	0	3
DOSO1	Dolly Sods Wilderness	WV	3/17/2005	9/14/2006	9	3	2	2	2
DOUG1	Douglas	AZ	1/13/2005	12/28/2006	6	1	2	1	2
EGBE1	N/A		9/1/2005	10/5/2006	5	1	2	2	0
ELDO1	El Dorado Springs	MO	7/21/2005	7/13/2006	6	2	2	1	1

Table 3-8. Continued.

SiteID	Name	State	Sampling Period From	To	Total Field Blanks	# of Field Blanks by Season Spring	Summer	Fall	Winter
ELLI1	Ellis	OK	3/17/2005	5/11/2006	7	3	1	2	1
EVER1	Everglades NP	FL	1/13/2005	9/14/2006	6	1	1	2	2
FLAT1	Flathead	MT	1/13/2005	10/5/2006	8	1	3	2	2
FOPE1	Fort Peck	MT	3/17/2005	11/16/2006	6	1	2	2	1
FRES1	Fresno	CA	5/19/2005	11/16/2006	7	2	2	3	0
FRRE1	Frostburg	MD	5/19/2005	8/3/2006	4	1	2	0	1
GAMO1	Gates of the Mountains	MT	5/19/2005	10/13/2005	2	1	0	1	0
GICL1	Gila Wilderness	NM	4/7/2005	7/13/2006	4	1	2	0	1
GLAC1	Glacier NP	MT	1/13/2005	11/16/2006	5	2	1	1	1
GRBA1	Great Basin NP	NV	1/13/2005	12/28/2006	10	2	2	2	4
GRGU1	Great Gulf Wilderness	NH	1/13/2005	3/9/2006	5	2	1	0	2
GRRI1	Great River Bluffs	MN	5/19/2005	12/15/2005	3	1	1	0	1
GRSA1	Great Sand Dunes NM	CO	10/13/2005	10/5/2006	3	1	0	2	0
GRSM1	Great Smoky Mountains NP	TN	1/13/2005	10/26/2006	6	2	1	1	2
GRSM9	Great Smoky Mountains NP	TN	1/13/2005	1/13/2005	1	0	0	0	1
GUMO1	Guadalupe Mountains NP	TX	7/21/2005	12/28/2006	5	1	3	0	1
HALE1	Haleakala NP	HI	3/17/2005	12/28/2006	8	2	1	1	4
HANC1	Hance Camp at Grand Canyon NP	CO	1/13/2005	4/20/2006	3	1	0	0	2
HAVO1	Hawaii Volcanoes NP	HI	1/13/2005	12/28/2006	8	0	3	3	2
HECA1	Hells Canyon	OR	1/13/2005	11/16/2006	7	3	1	2	1
HEGL1	Hercules-Glades	MO	1/13/2005	11/16/2006	7	2	2	1	2
HOOV1	Hoover	CA	1/13/2005	9/14/2006	8	1	4	1	2
HOUS1	Houston	TX	5/19/2005	7/21/2005	2	1	1	0	0
IKBA1	Ike's Backbone	AZ	12/15/2005	12/15/2005	1	0	0	0	1
INGA1	Indian Gardens	AZ	2/3/2005	9/14/2006	6	0	2	2	2
ISLE1	Isle Royale NP	MI	1/13/2005	11/16/2006	6	2	0	3	1
JARI1	James River Face Wilderness	VA	1/13/2005	6/1/2006	5	1	1	1	2
JOSH1	Joshua Tree NP	CA	1/13/2005	7/13/2006	6	3	1	0	2
KAIS1	Kaiser	CA	1/13/2005	1/5/2006	5	1	1	1	2
KALM1	Kalmiopsis	OR	1/13/2005	11/16/2006	4	0	1	1	2
LABE1	Lava Beds NM	CA	1/13/2005	5/11/2006	7	4	0	2	1
LASU2	Lake Sugema	IA	1/13/2005	12/15/2005	3	0	0	1	2
LAVO1	Lassen Volcanic NP	CA	1/13/2005	1/5/2006	3	0	0	1	2
LIGO1	Linville Gorge	NC	3/17/2005	4/20/2006	5	3	0	1	1
LIVO1	Livonia	IN	1/13/2005	5/19/2005	2	1	0	0	1
LOST1	Lostwood	ND	5/19/2005	11/16/2006	5	2	0	3	0
LYBR1	Lye Brook Wilderness	VT	1/13/2005	12/7/2006	6	1	1	1	3
MACA1	Mammoth Cave NP	KY	5/19/2005	12/7/2006	5	2	1	0	2
MAVI1	Martha's Vineyard	MA	5/19/2005	7/13/2006	5	3	1	0	1
MEAD1	Meadview	AZ	5/19/2005	5/19/2005	1	1	0	0	0
MELA1	Medicine Lake	MT	3/17/2005	8/24/2006	3	2	1	0	0
MEVE1	Mesa Verde NP	CO	1/13/2005	12/28/2006	9	1	4	2	2
MING1	Mingo	MO	5/19/2005	9/14/2006	4	1	0	2	1
MKGO1	M.K. Goddard	PA	3/17/2005	8/24/2006	7	4	1	2	0
MOHO1	Mount Hood	OR	1/13/2005	8/24/2006	7	3	1	2	1
MOMO1	Mohawk Mt.	CT	3/17/2005	12/7/2006	4	1	0	0	3
MONT1	Monture	MT	1/13/2005	11/16/2006	7	2	2	2	1
MOOS1	Moosehorn NWR	ME	1/13/2005	12/7/2006	7	2	1	1	3
MORA1	Mount Rainier NP	WA	1/13/2005	11/16/2006	5	2	1	1	1
MORA9	Mount Rainier NP	WA	1/13/2005	1/13/2005	1	0	0	0	1
MOZI1	Mount Zirkel Wilderness	CO	3/17/2005	11/16/2006	8	4	1	3	0
NEBR1	Nebraska NF	NE	1/13/2005	6/22/2006	5	1	2	0	2
NEYO1	New York City	NY	5/19/2005	12/15/2005	3	1	1	0	1

Table 3-8. Continued.

			Sampling Period		Total Field	# of Field Blanks by Season			
SiteID	Name	State	From	To	Blanks	Spring	Summer	Fall	Winter
NOAB1	North Absaroka	WY	3/30/2006	10/5/2006	3	1	1	1	0
NOCA1	North Cascades	WA	3/17/2005	12/28/2006	7	2	2	2	1
NOCH1	Northern Cheyenne	MT	9/1/2005	10/5/2006	3	1	0	2	0
OKEF1	Okefenokee NWR	GA	6/1/2006	6/1/2006	1	0	1	0	0
OLTO1	Old Town	ME	5/19/2005	4/20/2006	4	2	0	1	1
OLYM1	Olympic	WA	2/3/2005	2/16/2006	2	0	0	0	2
OMAH1	Omaha	NE	3/17/2005	10/5/2006	4	1	1	2	0
ORPI1	Organ Pipe	AZ	3/17/2005	11/16/2006	5	2	0	2	1
PASA1	Pasayten	WA	5/19/2005	10/5/2006	6	1	1	3	1
PEFO1	Petrified Forest NP	AZ	3/17/2005	12/7/2006	6	3	1	1	1
PENO1	N/A		3/30/2006	8/24/2006	2	1	1	0	0
PETE1	Petersburg	AK	4/7/2005	9/14/2006	8	3	1	2	2
PHOE1	Phoenix	AZ	1/13/2005	5/11/2006	6	2	0	2	2
PHOE5	Phoenix	AZ	1/13/2005	5/11/2006	5	1	0	1	3
PINN1	Pinnacles NM	CA	3/9/2006	5/11/2006	2	2	0	0	0
PITT1	Pittsburgh	PA	1/13/2005	12/10/2006	8	2	2	2	2
PMRF1	Proctor Maple R. F.	VT	3/17/2005	7/13/2006	4	2	1	1	0
PORE1	Point Reyes National Seashore	CA	7/21/2005	11/16/2006	4	1	1	2	0
PRIS1	Presque Isle	ME	2/3/2005	4/20/2006	3	2	0	0	1
PUSO1	Puget Sound	WA	3/17/2005	1/5/2006	2	1	0	0	1
QUCI1	Quaker City	OH	10/5/2006	10/5/2006	1	0	0	1	0
QURE1	Quabbin Summit	MA	1/13/2005	2/16/2006	4	0	0	2	2
QUVA1	Queen Valley	AZ	3/17/2005	11/16/2006	3	1	0	2	0
RAFA1	San Rafael	CA	1/13/2005	12/7/2006	7	1	1	2	3
REDW1	Redwood NP	CA	1/13/2005	12/7/2006	6	1	1	1	3
ROMA1	Cape Romain NWR	SC	1/13/2005	7/13/2006	5	3	1	0	1
ROMO2	Cape Romain NWR	SC	1/13/2005	1/13/2005	1	0	0	0	1
RUBI1	Rubidoux	CA	3/17/2005	7/21/2005	3	2	1	0	0
SACR1	Salt Creek	NM	1/13/2005	8/3/2006	5	1	1	2	1
SAFO1	Sac and Fox	KS	1/13/2005	2/16/2006	4	0	1	1	2
SAGA1	San Gabriel	CA	1/13/2005	10/5/2006	4	2	0	1	1
SAGO1	San Gorgonio Wilderness	CA	3/17/2005	9/14/2006	4	3	0	1	0
SAGU1	Saguaro NM	AZ	1/13/2005	11/16/2006	2	0	0	1	1
SAMA1	St. Marks	FL	5/19/2005	11/16/2006	7	2	2	2	1
SAPE1	San Pedro Parks	NM	3/17/2005	2/16/2006	3	2	0	0	1
SAWE1	Saguaro West	AZ	1/13/2005	6/1/2006	7	4	1	1	1
SAWT1	Sawtooth NF	ID	1/13/2005	11/16/2006	4	0	1	2	1
SENE1	Seney	MI	3/17/2005	11/16/2006	3	1	0	2	0
SEQU1	Sequoia NP	CA	12/15/2005	11/16/2006	4	0	0	2	2
SEQU9	Sequoia NP	CA	1/13/2005	1/13/2005	1	0	0	0	1
SHEN1	Shenandoah NP	VA	1/13/2005	1/5/2006	9	6	0	0	3
SHMI1	Shamrock Mine	CO	5/19/2005	5/11/2006	2	2	0	0	0
SHRO1	Shining Rock Wilderness	NC	3/17/2005	5/11/2006	6	4	0	1	1
SIAN1	Sierra Ancha	AZ	7/21/2005	10/5/2006	4	1	1	1	1
SIKE1	Sikes	LA	1/13/2005	8/3/2006	6	0	2	1	3
SIME1	Simeonof	AK	1/13/2005	10/5/2006	7	2	2	2	1
SIPS1	Sipsy Wilderness	AL	5/19/2005	12/7/2006	3	1	0	0	2
SNPA1	Snoqualmie Pass	WA	7/21/2005	12/28/2006	7	0	1	4	2
SPOK1	Spokane Res.	WA	5/19/2005	6/9/2005	2	1	1	0	0
STAR1	Starkey	OR	2/3/2005	12/7/2006	4	1	1	0	2
SULA1	Sula Peak	MT	5/19/2005	11/16/2006	3	1	0	1	1
SWAN1	Swanquarter	NC	3/17/2005	3/9/2006	5	2	2	1	0
SYCA1	Sycamore Canyon	AZ	1/13/2005	9/14/2006	6	1	1	1	3

Table 3-8. Continued.

SiteID	Name	State	Sampling Period		Total Field	# of Field Blanks by Season			
			From	To	Blanks	Spring	Summer	Fall	Winter
TALL1	Tallgrass	KS	1/13/2005	11/16/2006	5	0	1	2	2
THBA1	Thunder Basin	WY	5/19/2005	11/16/2006	8	2	2	2	2
THRO1	Theodore Roosevelt	ND	5/19/2005	5/19/2005	1	1	0	0	0
THSI1	Three Sisters Wilderness	OR	1/13/2005	12/28/2006	5	1	1	0	3
TONT1	Tonto NM	AZ	12/15/2005	12/28/2006	5	1	1	1	2
TRCR1	Trapper Creek	AK	3/17/2005	9/14/2006	4	1	0	2	1
TRIN1	Trinity	CA	1/13/2005	7/21/2005	4	2	1	0	1
TUXE1	Tuxedni	AK	6/9/2005	11/16/2006	7	1	3	2	1
ULBE1	UL Bend	MT	1/13/2005	12/7/2006	7	1	1	1	4
UPBU1	Upper Buffalo Wilderness	AR	3/17/2005	9/14/2006	5	1	3	1	0
VIIS1	Virgin Islands NP	VI	3/17/2005	11/16/2006	8	1	2	3	2
VILA1	Viking Lake	IA	1/13/2005	7/13/2006	4	0	1	0	3
VOYA1	Voyageurs NP #1	MN	1/13/2005	7/13/2006	5	2	1	0	2
WARI1	Walker River Paiute Tribe	NV	5/19/2005	10/13/2005	4	1	1	2	0
WASH1	Washington D.C.	DC	12/7/2006	12/7/2006	1	0	0	0	1
WEMI1	Weminuche Wilderness	CO	1/13/2005	2/16/2006	4	1	0	1	2
WHIT1	White Mountain	NM	5/19/2005	11/16/2006	4	1	1	2	0
WHPA1	White Pass	WA	3/17/2005	7/13/2006	7	3	1	1	2
WHPE1	Wheeler Peak	NM	4/16/2005	4/8/2006	3	2	1	0	0
WHRI1	White River NF	CO	3/17/2005	12/7/2006	4	1	1	1	1
WICA1	Wind Cave	SD	1/13/2005	12/7/2006	4	2	0	0	2
WIMO1	Wichita Mountains	OK	7/21/2005	11/16/2006	6	1	1	4	0
YELL1	Yellowstone NP 1	WY	1/13/2005	9/14/2006	6	2	0	2	2
YOSE1	Yosemite NP	CA	3/17/2005	8/24/2006	4	1	2	0	1
ZICA1	Zion Canyon	UT	2/3/2005	12/7/2006	5	0	2	1	2
Total					886	268	175	208	235

There are 13 Urban sites in the IMPROVE network: Atlanta, GA (ATLA); Baltimore, MD (BALT); Birmingham, AL (BIRM); Chicago, IL (CHIC); Detroit, MI (DETR); Fresno, CA (FRES); Houston, TX (HOUS); New York, NY (NEYO); Old Town, ME (OLTO); Phoenix, AZ (PHOE); Pittsburgh (PITT); Rubidoux, CA (RUBI); Washington, DC (WASH).

Table 3-9. Summary of field blanks acquired at the 239 sites in the STN/CSN network from 1/1/2005 to 12/31/2006

		Sampling Period			No. of Field Blanks by Season			
Site Code	State	From	To	Total Field Blanks	Spring	Summer	Fall	Winter
010050002	AL	1/28/2005	1/17/2006	7	2	1	2	2
010730023	AL	1/28/2005	12/4/2006	24	6	6	6	6
010731009	AL	1/28/2005	5/11/2006	9	4	1	2	2
010732003	AL	1/28/2005	11/7/2006	12	4	2	4	2
010890014	AL	1/28/2005	11/7/2006	12	4	2	4	2
010970003	AL	1/28/2005	1/17/2006	7	2	1	2	2
011011002	AL	1/28/2005	11/7/2006	10	4	1	3	2
011030011	AL	1/28/2005	9/7/2005	5	2	1	1	1
011130001	AL	5/16/2005	11/7/2006	12	3	2	5	2
020900010	AK	4/13/2005	12/4/2006	18	5	4	5	4
040130019	AZ	1/28/2005	11/12/2005	6	2	1	2	1
040137003	AZ	3/11/2005	11/7/2006	11	4	2	4	1
040137020	AZ	3/11/2005	11/7/2006	11	4	2	4	1
040139997	AZ	1/28/2005	12/4/2006	24	6	6	6	6
040139998	AZ	1/28/2005	11/12/2005	6	2	1	2	1
040191028	AZ	1/28/2005	9/8/2006	11	4	2	3	2
050030005	AR	1/28/2005	5/16/2005	3	2	0	0	1
051190007	AR	1/28/2005	11/7/2006	12	4	2	4	2
051450001	AR	1/28/2005	5/16/2005	3	2	0	0	1
060190008	CA	1/28/2005	12/4/2006	24	6	6	6	6
060290014	CA	1/28/2005	12/4/2006	41	8	9	12	12
060371103	CA	1/28/2005	11/7/2006	12	4	2	4	2
060658001	CA	1/28/2005	12/4/2006	34	9	7	9	9
060670006	CA	1/28/2005	12/4/2006	24	6	6	6	6
060730003	CA	1/28/2005	12/4/2006	24	6	6	6	6
060850005	CA	1/28/2005	12/4/2006	24	6	6	6	6
061112002	CA	1/28/2005	11/7/2006	12	4	2	4	2
080010006	CO	1/28/2005	12/4/2006	24	6	6	6	6
080410011	CO	1/28/2005	11/7/2006	12	4	2	4	2
080770017	CO	1/28/2005	11/7/2006	12	4	2	4	2
081230008	CO	1/28/2005	11/7/2006	12	4	2	4	2
090090027	CT	1/28/2005	12/4/2006	22	5	6	6	5
100010003	DE	1/28/2005	11/7/2006	12	4	2	4	2
100032004	DE	1/28/2005	11/7/2006	12	4	2	4	2
110010042	D.C.	2/12/2005	7/10/2006	18	6	5	3	4
110010043	D.C.	1/28/2005	12/4/2006	24	6	6	6	6
120111002	FL	1/17/2006	12/4/2006	12	3	3	3	3
120330004	FL	1/28/2005	3/12/2006	8	3	1	2	2
120573002	FL	1/28/2005	12/4/2006	24	6	6	5	7
120730012	FL	1/28/2005	11/7/2006	12	4	2	4	2
120861016	FL	1/28/2005	12/9/2005	12	3	3	3	3
121030026	FL	1/28/2005	12/4/2006	24	6	6	6	6
130210007	GA	1/28/2005	11/12/2005	6	2	1	2	1
130210007	GA	1/17/2006	11/7/2006	6	2	1	2	1

Table 3-9. Continued.

Site Code	State	Sampling Period From	Sampling Period To	Total Field Blanks	No. of Field Blanks by Season: Spring	Summer	Fall	Winter
130590001	GA	1/28/2005	11/12/2005	7	2	1	3	1
130590001	GA	1/17/2006	11/7/2006	6	2	1	2	1
130690002	GA	1/17/2006	11/7/2006	6	2	1	2	1
130690002	GA	1/28/2005	11/12/2005	5	1	1	2	1
130890002	GA	1/28/2005	12/9/2005	12	3	3	3	3
130890002	GA	1/17/2006	12/4/2006	13	3	3	4	3
131150005	GA	1/28/2005	11/12/2005	6	2	1	2	1
131150005	GA	1/17/2006	11/7/2006	6	2	1	2	1
132150011	GA	1/28/2005	11/12/2005	6	2	1	2	1
132150011	GA	1/17/2006	11/7/2006	6	2	1	2	1
132450091	GA	1/28/2005	11/12/2005	6	2	1	2	1
132450091	GA	5/11/2006	11/7/2006	4	1	1	2	0
150032004	HI	1/28/2005	11/7/2006	12	4	2	4	2
160010010	ID	7/10/2006	12/4/2006	6	0	2	3	1
160270004	ID	1/28/2005	6/7/2006	18	6	4	3	5
170310057	IL	1/17/2006	11/7/2006	6	2	1	2	1
170310057	IL	1/28/2005	11/12/2005	6	2	1	2	1
170310076	IL	1/28/2005	12/27/2005	13	3	3	3	4
170310076	IL	1/17/2006	12/4/2006	12	3	3	3	3
170314201	IL	1/28/2005	11/7/2006	12	4	2	4	2
170434002	IL	1/28/2005	11/7/2006	12	4	2	4	2
171150013	IL	1/28/2005	11/7/2006	12	4	2	4	2
171192009	IL	1/28/2005	11/7/2006	12	4	2	4	2
180372001	IN	1/28/2005	11/7/2006	12	4	2	4	2
180390003	IN	1/28/2005	11/7/2006	12	4	2	4	2
180650003	IN	1/28/2005	11/7/2006	12	4	2	4	2
180890022	IN	1/28/2005	11/7/2006	12	4	2	4	2
180892004	IN	1/28/2005	11/7/2006	12	4	2	4	2
180970078	IN	1/28/2005	12/4/2006	25	6	6	7	6
181630012	IN	1/28/2005	11/7/2006	12	4	2	4	2
191130037	IA	1/28/2005	11/7/2006	12	4	2	4	2
191530030	IA	1/28/2005	11/7/2006	12	4	2	4	2
191630015	IA	1/28/2005	12/4/2006	23	5	6	6	6
201730010	KS	1/28/2005	11/7/2006	12	4	2	4	2
202090021	KS	1/28/2005	12/4/2006	23	6	6	5	6
210190017	KY	1/28/2005	11/7/2006	12	4	2	4	2
210590005	KY	1/28/2005	1/17/2006	7	2	1	2	2
210670012	KY	1/28/2005	9/8/2006	11	4	2	3	2
211110043	KY	1/28/2005	11/7/2006	12	4	2	4	2
211110048	KY	1/28/2005	1/17/2006	7	2	1	2	2
211170007	KY	1/28/2005	11/7/2006	12	4	2	4	2
211250004	KY	1/28/2005	3/12/2006	8	3	1	2	2
211451004	KY	1/28/2005	1/17/2006	7	2	1	2	2
211930003	KY	1/28/2005	11/7/2006	12	4	2	4	2
212270007	KY	1/28/2005	1/17/2006	7	2	1	2	2
220150008	LA	1/28/2005	12/1/2006	13	4	2	3	4

Table 3-9. Continued.

Site Code	State	Sampling Period		Total Field Blanks	No. of Field Blanks by Season			
		From	To		Spring	Summer	Fall	Winter
220330009	LA	2/12/2005	12/4/2006	24	6	6	7	5
240053001	MD	1/28/2005	12/4/2006	24	6	6	6	6
240330030	MD	1/28/2005	11/7/2006	12	4	2	4	2
250130008	MA	1/28/2005	12/4/2006	20	6	6	4	4
250250042	MA	1/28/2005	12/4/2006	36	10	8	10	8
260050003	MI	1/28/2005	3/12/2006	8	3	1	2	2
260330901	MI	1/28/2005	3/12/2006	11	4	2	2	3
260770008	MI	1/28/2005	11/7/2006	12	4	2	4	2
260810020	MI	1/28/2005	11/7/2006	12	4	2	4	2
261130001	MI	1/28/2005	11/7/2006	12	4	2	4	2
261150005	MI	1/28/2005	11/7/2006	11	3	2	4	2
261610008	MI	1/28/2005	11/7/2006	12	4	2	4	2
261630001	MI	1/28/2005	12/4/2006	23	6	6	6	5
261630033	MI	1/28/2005	11/7/2006	12	4	2	4	2
270530963	MN	1/28/2005	12/4/2006	24	6	6	6	6
270953051	MN	1/28/2005	7/15/2005	7	3	2	0	2
271095008	MN	1/28/2005	11/7/2006	11	4	1	4	2
271230871	MN	1/28/2005	3/11/2005	2	1	0	0	1
280350004	MS	1/28/2005	11/12/2005	6	2	1	2	1
280430001	MS	1/28/2005	1/17/2006	8	2	1	3	2
280470008	MS	1/28/2005	12/4/2006	19	6	6	3	4
280490018	MS	1/28/2005	5/11/2006	9	4	1	2	2
280670002	MS	1/28/2005	11/12/2005	6	2	1	2	1
290470005	MO	1/28/2005	12/4/2006	23	6	6	6	5
290530001	MO	3/11/2005	5/11/2006	6	3	0	2	1
290990012	MO	1/28/2005	10/5/2006	21	6	6	4	5
290990012	MO	11/7/2006	12/4/2006	2	0	0	1	1
291860005	MO	1/28/2005	12/4/2006	24	6	6	6	6
295100085	MO	1/28/2005	12/4/2006	23	6	5	6	6
300530018	MT	1/28/2005	11/7/2006	12	4	2	4	2
300630031	MT	1/28/2005	12/4/2006	24	6	6	6	6
310550019	NE	1/28/2005	12/4/2006	24	7	5	6	6
320030561	NV	1/28/2005	11/7/2006	12	4	2	4	2
320310016	NV	1/28/2005	12/4/2006	24	6	6	6	6
330110020	NH	1/28/2005	11/12/2005	5	1	1	2	1
330150014	NH	2/3/2005	12/7/2006	23	6	5	6	6
340070003	NJ	1/28/2005	12/4/2006	23	6	5	6	6
340230006	NJ	1/28/2005	12/4/2006	34	10	6	10	8
340273001	NJ	1/28/2005	12/4/2006	23	6	5	6	6
340390004	NJ	1/28/2005	12/4/2006	23	6	5	6	6
350010023	NM	1/28/2005	11/7/2006	12	4	2	4	2
360050083	NY	1/28/2005	12/9/2005	12	3	3	3	3
360050110	NY	1/17/2006	12/4/2006	13	4	3	3	3
360050110	NY	2/12/2005	12/9/2005	8	3	0	3	2
360290005	NY	1/28/2005	11/7/2006	12	4	2	4	2
360310003	NY	1/28/2005	11/7/2006	18	5	4	5	4

Table 3-9. Continued.

Site Code	State	Sampling Period From	Sampling Period To	Total Field Blanks	No. of Field Blanks by Season Spring	Summer	Fall	Winter
360551007	NY	1/28/2005	12/4/2006	24	6	6	6	6
360610062	NY	1/28/2005	12/4/2006	23	6	6	6	5
360810124	NY	2/12/2005	12/4/2006	25	6	7	6	6
361010003	NY	1/28/2005	12/4/2006	23	6	5	6	6
370210034	NC	1/28/2005	11/7/2006	12	4	2	4	2
370350004	NC	1/28/2005	11/7/2006	12	4	2	4	2
370570002	NC	1/28/2005	11/7/2006	12	4	2	4	2
370670022	NC	1/28/2005	11/7/2006	11	4	1	4	2
370810013	NC	1/28/2005	9/8/2006	11	4	2	3	2
371070004	NC	1/28/2005	11/7/2006	12	4	2	4	2
371190041	NC	1/28/2005	12/4/2006	24	6	6	6	6
371590021	NC	1/28/2005	11/7/2006	12	4	2	4	2
371830014	NC	1/28/2005	11/7/2006	17	6	1	5	5
380150003	ND	1/28/2005	11/7/2006	12	4	2	4	2
380171004	ND	1/28/2005	12/4/2006	23	6	6	6	5
380530002	ND	1/28/2005	11/7/2006	13	4	2	4	3
390171004	OH	1/28/2005	11/7/2006	12	4	2	4	2
390350038	OH	1/28/2005	11/7/2006	12	4	2	4	2
390350060	OH	1/10/2005	12/4/2006	49	13	11	11	14
390490081	OH	1/28/2005	11/7/2006	12	4	2	4	2
390610040	OH	1/28/2005	11/7/2006	12	4	2	4	2
390810017	OH	1/28/2005	11/7/2006	11	3	2	4	2
390870010	OH	1/28/2005	11/7/2006	11	3	2	4	2
390930016	OH	1/28/2005	11/12/2005	6	2	1	2	1
390933002	OH	1/17/2006	11/7/2006	6	2	1	2	1
390950026	OH	1/28/2005	11/7/2006	12	4	2	4	2
390990014	OH	1/28/2005	11/7/2006	12	4	2	4	2
391130031	OH	3/11/2005	11/7/2006	11	4	2	4	1
391510017	OH	3/11/2005	9/8/2006	10	4	2	3	1
391530023	OH	1/28/2005	11/7/2006	11	4	2	3	2
400450890	OK	1/28/2005	3/12/2006	7	3	1	2	1
401091037	OK	1/28/2005	11/7/2006	12	4	2	4	2
401431127	OK	1/28/2005	12/4/2006	23	5	6	6	6
410510246	OR	1/28/2005	12/4/2006	24	6	6	6	6
420010001	PA	1/28/2005	11/7/2006	12	4	2	4	2
420030008	PA	2/12/2005	12/4/2006	21	5	6	6	4
420030064	PA	1/28/2005	11/7/2006	12	4	2	4	2
420110009	PA	3/12/2006	3/12/2006	1	1	0	0	0
420110010	PA	7/10/2006	11/7/2006	3	0	1	2	0
420270100	PA	1/28/2005	11/7/2006	12	4	2	4	2
420290100	PA	3/11/2005	11/7/2006	11	4	2	4	1
420430401	PA	1/28/2005	11/7/2006	12	4	2	4	2
420450002	PA	1/28/2005	11/7/2006	12	4	2	4	2
420490003	PA	1/28/2005	11/7/2006	12	4	2	4	2
420692006	PA	1/28/2005	11/7/2006	12	4	2	4	2
420710007	PA	1/28/2005	11/7/2006	12	4	2	4	2

Table 3-9. Continued.

Site Code	State	Sampling Period From	Sampling Period To	Total Field Blanks	No. of Field Blanks by Season: Spring	Summer	Fall	Winter
420950025	PA	1/28/2005	11/7/2006	11	3	2	4	2
420990301	PA	1/28/2005	11/12/2005	6	2	1	2	1
421010004	PA	1/28/2005	12/4/2006	23	5	6	6	6
421010136	PA	1/28/2005	11/7/2006	12	4	2	4	2
421255001	PA	1/28/2005	11/7/2006	12	4	2	4	2
421290008	PA	1/28/2005	11/7/2006	12	4	2	4	2
421330008	PA	1/28/2005	11/7/2006	12	4	2	4	2
440070022	RI	1/28/2005	12/4/2006	24	6	6	6	6
450190049	SC	1/28/2005	12/25/2006	25	6	6	6	7
450250001	SC	1/28/2005	11/7/2006	12	4	2	4	2
450450009	SC	1/28/2005	11/7/2006	16	5	2	5	4
450790019	SC	1/28/2005	11/7/2006	12	4	2	4	2
460990006	SD	1/28/2005	11/7/2006	12	4	2	4	2
470370023	TN	1/28/2005	11/7/2006	12	4	2	4	2
470654002	TN	1/28/2005	11/7/2006	11	4	2	3	2
470931020	TN	1/28/2005	11/7/2006	12	4	2	4	2
470990002	TN	1/28/2005	11/7/2006	12	4	2	4	2
471570024	TN	6/7/2006	12/4/2006	7	0	3	3	1
471570047	TN	1/28/2005	4/8/2006	17	5	3	3	6
471631007	TN	1/28/2005	11/7/2006	12	4	2	4	2
471650007	TN	1/28/2005	3/12/2006	8	3	1	2	2
480430002	TX	1/3/2005	7/5/2005	6	1	2	0	3
480430101	TX	3/25/2006	12/14/2006	9	2	3	3	1
480430101	TX	1/17/2005	3/1/2006	17	4	4	3	6
480612004	TX	10/8/2005	12/14/2006	15	2	3	7	3
481130050	TX	1/5/2005	12/26/2006	60	16	15	14	15
481130069	TX	1/28/2005	12/4/2006	24	6	6	6	6
481390015	TX	1/17/2005	8/21/2005	10	3	4	0	3
481410044	TX	1/28/2005	11/7/2006	21	5	5	6	5
481410053	TX	1/17/2005	12/14/2006	29	7	8	8	6
481670014	TX	1/5/2005	8/21/2005	12	2	6	0	4
482010024	TX	1/5/2005	12/20/2006	30	11	8	3	8
482010026	TX	1/5/2005	8/21/2005	20	8	7	0	5
482010055	TX	1/5/2005	8/21/2005	16	5	7	0	4
482011034	TX	1/17/2005	8/21/2005	10	3	4	0	3
482011039	TX	1/28/2005	12/4/2006	41	10	7	13	11
482030002	TX	1/17/2005	8/21/2005	19	8	7	0	4
482430004	TX	1/29/2005	8/1/2005	8	3	3	0	2
482450021	TX	10/24/2005	12/26/2006	36	8	8	10	10
482450022	TX	1/5/2005	8/21/2005	19	8	7	0	4
482570005	TX	1/17/2005	8/21/2005	10	3	4	0	3
482730314	TX	1/29/2005	8/21/2005	9	3	4	0	2
483030001	TX	1/17/2005	6/10/2005	7	3	1	0	3
483390078	TX	1/5/2005	8/21/2005	20	8	7	0	5
483550034	TX	5/12/2006	11/20/2006	8	1	4	3	0
483550034	TX	1/17/2005	4/18/2006	20	6	4	4	6

Table 3-9. Continued.

Site Code	State	Sampling Period		Total Field Blanks	No. of Field Blanks by Season			
		From	To		Spring	Summer	Fall	Winter
483611100	TX	2/10/2005	8/21/2005	15	7	7	0	1
484530020	TX	10/8/2005	12/14/2006	16	2	4	6	4
490110004	UT	1/28/2005	11/7/2006	12	4	2	4	2
490353006	UT	1/28/2005	12/4/2006	24	6	6	6	6
490494001	UT	1/28/2005	11/7/2006	12	4	2	4	2
500070012	VT	1/28/2005	12/4/2006	24	6	6	6	6
510870014	VA	2/12/2005	12/4/2006	25	7	6	6	6
511390004	VA	1/28/2005	9/8/2006	12	4	2	3	3
515200006	VA	1/28/2005	9/8/2006	11	4	2	3	2
530330024	WA	1/28/2005	11/12/2005	6	2	1	2	1
530330048	WA	1/28/2005	11/7/2006	12	4	2	4	2
530330057	WA	1/28/2005	11/7/2006	12	4	2	4	2
530330080	WA	1/28/2005	2/7/2006	14	3	3	3	5
530330080	WA	9/8/2006	12/4/2006	4	0	0	3	1
530530029	WA	1/17/2006	11/7/2006	6	2	1	2	1
530630016	WA	1/28/2005	11/7/2006	12	4	2	4	2
540390011	WV	1/28/2005	12/4/2006	25	7	6	6	6
540391005	WV	1/28/2005	11/7/2006	12	4	2	4	2
540511002	WV	1/28/2005	11/7/2006	12	4	2	4	2
550270007	WI	1/28/2005	12/4/2006	24	6	6	6	6
550590019	WI	1/28/2005	11/12/2005	6	2	1	2	1
550790026	WI	1/28/2005	12/4/2006	24	6	6	6	6
551198001	WI	1/28/2005	11/7/2006	12	4	2	4	2
551330027	WI	1/28/2005	11/7/2006	12	4	2	4	2
720610001	PR	1/28/2005	3/12/2006	14	4	2	3	5
Total			253[a]	3628	1065	781	984	798

[a] Site count includes 14 sites where sampler type changed between 1/1/2005 and 12/31/2006

Table 3-10. Summary of field blanks acquired at the eight sites in the SEARCH network from 1/1/2005 to 12/31/2006

Site Code	Site Name	Sampling Period From	Sampling Period To	Number of Blanks	Spring	Summer	Fall	Winter
GLF	Gulfport, MS	1/1/2005	10/2/2006	14	2	4	4	4
OAK	Oak Grove, MS	1/31/2005	12/1/2006	19	4	5	5	5
BHM	Birmingham, AL	1/31/2005	10/31/2006	9	5	2	1	1
CTR	Centreville, AL	1/31/2005	12/1/2006	23	6	6	5	6
JST	Jefferson Street, GA	2/1/2005	11/14/2006	13	3	2	6	2
YRK	Yorkville, GA	1/31/2005	11/30/2006	20	6	4	5	5
PNS	Pensacola, FL	2/1/2005	12/29/2006	24	5	7	6	6
OLF	Outlying Field, FL	2/27/2005	12/31/2006	22	7	6	4	5
Total		8		144	38	36	36	34

Table 3-11. Comparison of quartz-fiber backup filter carbon fractions among the urban, non-urban, and rural sites between the IMPROVE and SEARCH networks for the period from 1/1/2005 through 12/31/2006.

	Average ± Standard Deviation in μg/cm²		
	IMPROVE Rural	**SEARCH Urban/Suburban**	**SEARCH Non-Urban**
Number of Samples	1401	182	75
Number of Sites	13[c]	5[b]	3[a]
TC	3.23 ± 0.96	1.55 ± 1.67	1.32 ± 1.23
OC	3.08 ± 0.83	1.46 ± 1.47	1.20 ± 0.92
EC	0.16 ± 0.13	0.09 ± 0.34	0.12 ± 0.41
OC1	0.56 ± 0.07	0.46 ± 0.80	0.26 ± 0.38
OC2	0.95 ± 0.23	0.42 ± 0.46	0.35 ± 0.27
OC3	1.15 ± 0.35	0.48 ± 0.42	0.48 ± 0.26
OC4	0.31 ± 0.18	0.08 ± 0.16	0.08 ± 0.14
EC1	0.18 ± 0.16	0.07 ± 0.31	0.08 ± 0.36
EC2	0.08 ± 0.06	0.04 ± 0.20	0.06 ± 0.24
EC3	0.00 ± 0.00	0.01 ± 0.04	0.01 ± 0.07

[a] Non-Urban sites: Oak Grove (OAK) near Hattiesburg, MS; Centreville (CTR) south of Tuscaloosa, AL; Yorkville (YRK) northwest of Atlanta, GA

[b] Urban or suburban sites: Gulfport (GLF) in Gulfport, MS; Birmingham (BHM) in North Birmingham, AL; Jefferson Street (JST) in Atlanta, GA; Pensacola (PNS) in Pensacola, FL; suburban outlying field (OLF) northwest of Pensacola, FL

[c] Urban sites: #78 (MORA) Mount Rainier National Park; #96 (YOSE) Yosemite National Park; #48 (HANC) Hance Camp at Grand Canyon National Park; #39 (CHIR) Chiricahua National Monument; #6 (SHEN) Shenandoah National Park; and #16 (OKEF) Okefenokee National Wildlife Refuge

Table 3-12. Average TC blank and sample concentrations for the eight collocated IMPROVE –STN/CSN sites.

			Blank Concentration density ($\mu g/cm^2$)					
Site Code	**Site Name**	**Instrument Used**	**IMP_bQF ($\mu g/cm^2$)**	**IMP_bQF (number)**	**STN_FB ($\mu g/cm^2$)**	**STN_FB (number)**	**STN_TB ($\mu g/cm^2$)**	**STN_TB (number)**
PUSO	Seattle, WA	URG MASS	2.66 ± 0.54	8	0.68 ± 0.41	25	0.53 ± 0.19	9
MORA	Mount Rainier, WA	URG MASS	1.44 ± 0.36	6	0.66 ± 0.42	12	0.67 ± 0.12	4
PHOE	Phoenix, AZ	Met One SASS	2.63 ± 0.58	6	1.40 ± 0.77	26	1.12 ± 0.50	10
TONT	Tonto Monument, AZ	Met One SASS	2.00 ± 1.05	8	0.87 ± 0.31	28	0.86 ± 0.32	9
WASH	Washington, DC	Andersen RAAS	2.49 ± 0.87	5	0.87 ± 0.40	25	0.84 ± 0.26	10
DOSO	Dolly Sods, WV	Andersen RAAS	2.57 ± 0.31	5	1.18 ± 0.68	26	0.97 ± 0.38	8
FRES	Fresno, CA	Met One SASS	2.58 ± 0.50	7	0.74 ± 0.23	18	0.94 ± 0.48	11
BIBE	Big Bend National Park, TX	R&P 2025 FRM	2.40 ± 0.68	7	1.44 ± 0.48	15	N/A ± N/A	N/A

			Ambient Concentration density ($\mu g/cm^2$)		Number of Pairs	Ambient Concentrations ($\mu g/m^3$)	
Site Code	**Site Name**	**Instrument Used**	**IMP_QF ($\mu g/cm^2$)**	**STN_QF ($\mu g/cm^2$)**	**QF (number)**	**IMP_QF ($\mu g/m^3$)**	**STN_QF ($\mu g/m^3$)**
PUSO	Seattle, WA	URG MASS	35.99 ± 24.54	7.37 ± 4.92	224	3.88 ± 2.65	3.62 ± 2.42
MORA	Mount Rainier, WA	URG MASS	11.73 ± 9.51	2.77 ± 1.92	69	1.27 ± 1.03	1.36 ± 0.94
PHOE	Phoenix, AZ	Met One SASS	46.40 ± 29.75	5.80 ± 2.97	201	5.01 ± 3.21	7.12 ± 3.65
TONT	Tonto Monument, AZ	Met One SASS	14.54 ± 12.59	2.15 ± 1.44	181	1.57 ± 1.36	2.64 ± 1.77
WASH	Washington, DC	Andersen RAAS	35.32 ± 19.68	4.44 ± 2.24	206	3.81 ± 2.12	4.98 ± 2.52
DOSO	Dolly Sods, WV	Andersen RAAS	20.20 ± 9.16	2.41 ± 1.04	140	2.18 ± 0.99	2.70 ± 1.16
FRES	Fresno, CA	Met One SASS	49.03 ± 33.62	5.98 ± 3.67	227	5.29 ± 3.63	7.34 ± 4.51
BIBE	Big Bend National Park, TX	R&P 2025 FRM	10.67 ± 5.68	4.15 ± 1.81	81	1.15 ± 0.61	2.04 ± 0.89

Sampling Periods
10/16/2001 – 10/29/2003 at PUSO, PHOE, WASH, TONT, and DOSO
10/16/2001 – 10/20/2002 at MORA
1/4/2005 – 12/302005 at BIBE
1/1/2005 – 7/31/2006 at FRES

Table 3-12. Continued

<u>Abbreviations</u>

IMP:	IMPROVE
STN:	STN/CSN
bQF:	IMPROVE field blanks
FB:	STN/CSN field blanks
TB:	STN/CSN trip blanks. Not taken at the Big Bend National Park, TX (BIBE1), site
IMP_QF:	uncorrected IMPROVE TC concentration measured from front quartz-fiber filters
STN_QF:	Uncorrected STN/CSN TC concentration measured from front quartz-fiber filters

Table 3-13. Regression statistics of uncorrected STN/CSN TC against IMPROVE TC for data from the eight collocated sites.

Site Code	Site Name	Sampling Period	Intercept (μg/m^3)	Intercept (μg/cm^2)	Slope	Correlation (r)	N
PUSO	Seattle, WA	10/16/2001 - 12/29/2003	0.12	0.24	0.91	0.98	224
MORA	Mount Rainier, WA	10/22/2001- 10/20/2002	0.25	0.5	0.87	0.97	69
PHOE	Phoenix, AZ	10/16/2001 - 12/29/2003	1.65	1.34	1.08	0.94	201
TONT	Tonto Monument, AZ	10/16/2001 - 12/29/2003	0.85	0.69	1.06	0.92	181
WASH	Washington, DC	10/16/2001 - 12/26/2003	0.95	0.85	1.08	0.92	206
DOSO	Dolly Sods, WV	10/16/2001 - 12/29/2003	0.83	0.74	0.87	0.67	140
FRES	Fresno, CA	1/1/2005 -12/31/2006	1.1	0.9	1.16	0.95	227
BIBE	Big Bend National Park, TX	1/1/2005 -12/31/2006	0.64	1.29	1.22	0.79	81

Table 3-14. Comparison between estimated and measured field blanks for the eight collocated IMPROVE/STN sites.

Site Code	Site Name	Sampling Period	IMP bQF ($\mu g/cm^2$)[a]	Calculated STN_{art} ($\mu g/cm^2$)[b]	STN/CSN bQF ($\mu g/cm^2$)[c]	Difference (%)[d]
PUSO	Seattle, WA	10/16/2001 - 12/29/2003	2.66 ± 0.54	0.83	0.68	-18%
MORA	Mount Rainier, WA	10/22/2001- 10/20/2002	1.44 ± 0.36	0.82	0.66	-19%
PHOE	Phoenix, AZ	10/16/2001 - 12/29/2003	2.63 ± 0.58	1.57	1.40	-11%
TONT	Tonto Monument, AZ	10/16/2001 - 12/29/2003	2 ± 1.05	0.87	0.87	1%
WASH	Washington, DC	10/16/2001 - 12/26/2003	2.49 ± 0.87	1.09	0.87	-20%
DOSO	Dolly Sods, WV	10/16/2001 - 12/29/2003	2.57 ± 0.31	0.99	1.18	19%
FRES	Fresno, CA	1/1/2005 -12/31/2006	2.58 ± 0.5	1.82	1.44	-21%
BIBE	Big Bend National Park, TX	1/1/2005 -12/31/2006	2.4 ± 0.68	1.13	0.74	-34%

[a] IMPROVE field blanks

[b] Estimated STN/CSN artifact

[c] STN/CSN field blanks

[d] $$\frac{\text{measured} - \text{calculated}}{\text{calculated}} \times 100$$

Table 3-15a. Summary of average $PM_{2.5}$ concentration and field blanks at four collocated IMPROVE sites.

Site	Seattle	Phoenix	Washington D.C.	Fresno
Site Type	Urban	Urban	Urban	Urban
Site Code	PUSO	PHOE	WASH	FRES
Sampler Type	IMPROVE	IMPROVE	IMPROVE	IMPROVE
Sampling Period	7/12/2001-12/29/2004	4/28/2001-9/30/2004	7/08/2004-12/29/2004	9/03/2004-12/23/2004
Average Ambient Concentration (µg/m^3)	Average ± Std Dev	Average ± Std Dev	Average ± Std Dev	Average ± Std Dev
$PM_{2.5}$ Mass	7.94 ± 4.88	10.9 ± 4.93	15.15 ± 9.34	18.62 ± 11.37
Ammonium	0.58 ± 0.47	0.47 ± 0.28	2.22 ± 1.87	1.79 ± 2.02
Nitrate	0.97 ± 0.86	1.01 ± 1.39	1.47 ± 2.21	6.31 ± 6.07
Reduced Nitrate	0.26 ± 0.74	0.08 ± 0.64	0.57 ± 1.98	4.42 ± 6.21
Water	0.47 ± 0.3	0.43 ± 0.22	1.94 ± 1.67	1.07 ± 1.09
Sulfate	1.35 ± 0.89	1.18 ± 0.57	5.47 ± 4.66	1.34 ± 0.84
Silicon	0.08 ± 0.07	0.63 ± 0.55	0.18 ± 0.15	0.41 ± 0.41
Calcium	0.04 ± 0.03	0.22 ± 0.14	0.03 ± 0.01	0.08 ± 0.06
Iron	0.07 ± 0.06	0.28 ± 0.17	0.11 ± 0.07	0.19 ± 0.14
Titanium	0 ± 0.01	0.02 ± 0.01	0.01 ± 0	0.01 ± 0.01

[a] IMPROVE mass from VIEWS was already field blank subtracted. STN/CSN from AIRS was not field blank subtracted.

[b] Calculated ammonium based on 0.38 * (4.125 × S) + 0.29 × (1.29 × NO_3^-). The calculated ammonium was used instead of an actual measured value because the IMPROVE network does not report measured ammonium.

Table 3-15b. Summary of average $PM_{2.5}$ concentration and field blanks at four collocated STN/CSN sites.

Site	Seattle	Phoenix	Washington D.C.	Fresno
Site Type[a]	Urban	Urban	Urban	Urban
Site Code	PUSO	PHOE	WASH	FRES
Sampler Type	URG	Met One	Andersen	Met One
Sampling Period	7/12/2001-12/29/2004	4/28/2001-9/30/2004	7/08/2004-12/29/2004	9/03/2004-12/23/2004
Average Ambient Concentration (µg/m^3)	Average ± Std Dev	Average ± Std Dev	Average ± Std Dev	Average ± Std Dev
$PM_{2.5}$ Mass	8.31 ± 4.9	10.04 ± 4.58	15.15 ± 9.34	19.11 ± 12.33
Ammonium	0.45 ± 0.38	0.43 ± 0.29	2.22 ± 1.87	1.86 ± 1.99
Nitrate	0.73 ± 0.59	1.06 ± 1.42	1.47 ± 2.21	6.85 ± 5.91
Reduced Nitrate	0.13 ± 0.46	0.09 ± 0.68	0.45 ± 1.79	4.66 ± 6.15
Water	0.42 ± 0.28	0.43 ± 0.24	1.45 ± 1.04	1.15 ± 1.09
Sulfate	1.24 ± 0.8	1.25 ± 0.6	5.47 ± 4.66	1.46 ± 0.91
Silicon	0.04 ± 0.04	0.35 ± 0.32	0.18 ± 0.15	0.16 ± 0.19
Calcium	0.03 ± 0.02	0.14 ± 0.1	0.03 ± 0.01	0.04 ± 0.03
Iron	0.05 ± 0.04	0.17 ± 0.11	0.11 ± 0.07	0.12 ± 0.08
Titanium	0 ± 0	0.01 ± 0.01	0.01 ± 0	0.01 ± 0.01
Average Field Blank Mass Concentration (µg/m^3)	0.48 ± 0.74	0.89 ± 1.12	0.25 ± 0.32	NA
Number in Average	42	40	5	0

Table 3-16. Estimates of organic carbon mass (OCM) based on the SANDWICH method (Frank, 2006) for the four collocated IMPROVE/STN sites.

Site	Seattle, WA	Phoenix AZ	Washington, DC	Fresno, CA
Site Type	Urban	Urban	Urban	Urban
Site Code	PUSO	PHOE	WASH	FRES
Number of Collocated Pairs	354	290	45	27
Sampler Type	IMPROVE	IMPROVE	IMPROVE	IMPROVE
Sampling Period	7/12/2001-12/29/2004	4/28/2001-9/30/2004	7/08/2004-12/29/2004	9/03/2004-12/23/2004
SANDWICH OCM μg/m^3				
Average	3.99 ± 2.96	4.40 ± 3.45	3.00 ± 3.16	6.73 ± 3.56
10%tile	1.22	1.48	0.58	2.86
50%tile	3.16	3.27	2.47	6.16
90%tile	8	8.66	6.23	11.29
Measured OC μg/m^3				
Average	2.70 ± 2.06	3.13 ± 2.27	2.63 ± 1.51	3.42 ± 1.66
10%tile	0.87	1.32	0.90	1.47
50%tile	1.91	2.25	2.51	3.18
90%tile	5.28	6.10	4.21	5.52
Measured OC×1.4/OCM				
Average	95%	100%	123%	71%
10%tile	100%	125%	217%	72%
50%tile	85%	96%	142%	72%
90%tile	92%	99%	95%	68%
Measured OC×1.8/OCM				
Average	122%	128%	158%	91%
10%tile	128%	161%	279%	93%
50%tile	109%	124%	183%	93%
90%tile	119%	127%	122%	88%
Sampler Type	**URG MASS**	**Met One SASS**	**Andersen RAAS**	**Met One SASS**
Sampling Period	7/12/2001-12/29/2004	4/28/2001-9/30/2004	7/08/2004-12/29/2004	9/03/2004-12/23/2004
SANDWICH OCM μg/m^3				
Average	4.63 ± 3.27	4.48 ± 3.62	4.85 ± 5.14	7.66 ± 4.37
10%tile	1.57	1.03	0.65	3.08
50%tile	3.72	3.64	4.03	6.72
90%tile	9.59	9.12	9.05	14.22
Measured OC μg/m^3				
Average	2.98 ± 2	3.94 ± 2.43	2.75 ± 1.86	4.8 ± 2.71
10%tile	1.16	1.58	0.56	1.81
50%tile	2.38	3.34	2.78	4.12
90%tile	6.06	7.59	5.62	8.91
Measured OC×1.4/OCM				
Average	90%	123%	79%	88%
10%tile	103%	215%	121%	82%
50%tile	90%	128%	97%	86%
90%tile	88%	117%	87%	88%
Measured OC×1.8/OCM				
Average	116%	158%	102%	113%
10%tile	133%	276%	155%	106%
50%tile	115%	165%	124%	110%
90%tile	114%	150%	112%	113%

Table 3-17. Summary of percent recovery for: a) solid and b) liquid levoglucosan.

a) solid levoglucosan.

		Levoglucosan		**Carbon**		**Measured**		**Levoglucosan**	
	Test loading[a] (µg)	**µg/filter**	**µg / cm²**	**µg/filter**	**µg/cm²**	**IMPROVE TC (µg/filter)**	**STN/CSN TC (µg/filter)**	**IMPROVE TC Recovery (%)**	**STN/CSN TC Recovery (%)**
Diesel + Solid Resuspended Levoglucosan	2281	1049	76.0	466	33.8	318	360	26.2	36.0
Blank + Low Load Solid Resuspended Levoglucosan	331	73	5.3	32	2.3	5.4	14.0	16.7	43.1
Blank + High Load Solid Resuspended Levoglucosan	520	151	10.9	67	4.9	15.7	26.0	23.4	38.8

[a] Total amount of loading based on volume correction for all samples. Teflon-membrane filter samples from the parallel Teflon-membrane or quartz-fiber channel were first weighted and analyzed by X-ray Fluorescence (XRF) for silicon (Si). The Si concentration is then converted to SiO_2 concentration and the total amount of the levoglucosan plus SiO_2 mass that is SiO_2 is calculated. These numbers are used to calculate the percentage of mass of levoglucosan, which is then used to calculate µg levoglucosan/filter.

b) liquid levoglucosan.

	Levoglucosan	**Carbon**	**Measured**		**Levoglucosan**	
	µg / cm²	**µgC/cm²**	**IMPROVE TC (µg/cm²)**	**STN/CSN TC (µg/cm²)**	**IMPROVE TC Recovery (%)**	**STN/CSN TC Recovery (%)**
Blank + Low Load Liquid Levoglucosan	11.4	9.6	9.3	9.5	97%	93%
Blank + Medium Load Liquid Levoglucosan	22.8	19.2	17.9	17.8	93%	93%
Blank + Medium Load Liquid Levoglucosan	27.3	22.9	21.4	21.3	94%	93%
Blank + High Load Liquid Levoglucosan	45.7	38.3	36.9	33.4	96%	87%

Table 3-18. Distribution of carbon fractions on the blank samples doped with solid and liquid levoglucosan.

	IMPROVE protocol		
	Blank + Resusp. Levoglucosan		Blank + Liquid Levoglucosan
	Low loading	High loading	Medium Loading
OC1 / TC	0	0.014	0.054 ± 0.022
OC2 / TC	0.24	0.248	0.2 ± 0.01
OC3 / TC	0.76	0.683	0.344 ± 0.012
OC4 / TC	0	0.054	0.112 ± 0.004
EC1 / TC	0	0	0.265 ± 0.019
(EC1-OPR) / TC	0	0	0.04 ± 0.02
(EC1-OPT) / TC	0	-0.001	0 ± 0.02
EC2 / TC	0	0	0.025 ± 0.004
EC3 / TC	0	0.001	0 ± 0
OPT / TC	0	0.001	0.265 ± 0.005
OPR / TC	0	0	0.223 ± 0.04

	STN/CSN protocol		
	Blank + Resusp. Levoglucosan		Blank + Liquid Levoglucosan
	Low loading	High loading	Medium Loading
OC1 / TC	0.266	0.212	0.133 ± 0.072
OC2 / TC	0.438	0.495	0.312 ± 0.022
OC3 / TC	0.087	0.157	0.116 ± 0.022
OC4 / TC	0.063	0.065	0.263 ± 0.036
OC5 / TC	0.001	0	0.004 ± 0.003
EC1 / TC	0	0	0.145 ± 0.041
(EC1-OPR) / TC	0.063	0.026	0.23 ± 0.03
(EC1-OPT) / TC	0.007	0.007	0.14 ± 0.12
EC2 / TC	0	0.001	0.019 ± 0.008
EC3 / TC	0	0.001	0.003 ± 0.003
EC4 / TC	0	0	0 ± 0
EC5 / TC	0.146	0.071	0.005 ± 0.006
OPT / TC	-0.007	-0.007	-0.087 ± 0.059
OPR / TC	-0.063	-0.026	-0.09 ± 0.019

Table 3-19. Carbon fractions for the diesel/levoglucosan experiment following the IMPROVE and STN/CSN protocols.
a) Solid levoglucosan

IMPROVE protocol (µg / filter)

	Diesel Exhaust									Diesel + resuspended levoglucosan						Blank+ resusp. Levoglucosan			Blank+ resusp. Levoglucosan		
	QF			QF_{bott}			QBQ			QF			QF_{bott}			QF (low load)			QF (high load)		
	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev
TC	195.6	±	18.1	62.9	±	21.6	15	±	4.3	317.8	±	58.2	68	±	16.9	5.42	±	0.95	15.67	±	2.94
OCT	112.3	±	19.4	57.2	±	16.6	14.9	±	4.1	232.3	±	57.9	64	±	16.4	5.42	±	0.95	15.67	±	2.94
OCR	112.3	±	19.4	56.3	±	16	14.9	±	4.1	233.8	±	61.3	63.8	±	16.4	5.42	±	0.95	15.66	±	2.95
ECT	83.4	±	27	6.6	±	6.5	0.1	±	0.4	85.5	±	25	4.2	±	3.1	0	±	0	0	±	0
ECR	83.4	±	27	6.6	±	6.5	0.1	±	0.4	84	±	28.1	4.2	±	3.1	0	±	0	0.01	±	0.03
OC1	40.1	±	4	22.1	±	3.5	8.1	±	2.4	105.9	±	40.1	18.4	±	5.2	0	±	0	0.22	±	0.51
OC2	33.2	±	3.1	16	±	4.2	2.4	±	0.5	51.9	±	11.3	16.7	±	2.7	1.3	±	0.33	3.89	±	0.72
OC3	28.7	±	13	15.1	±	8.2	4.3	±	1.6	56.4	±	9.5	24.8	±	16.1	4.12	±	0.79	10.7	±	2.86
OC4	10.4	±	6.7	3.1	±	2.4	0.2	±	0.3	17.1	±	3.6	3.9	±	1.6	0	±	0	0.85	±	0.3
EC1	15.9	±	3.7	1.6	±	1.8	0.1	±	0.3	18.1	±	4.5	1.4	±	1.4	0	±	0	0	±	0
EC2	67.4	±	25.6	5	±	5.1	0	±	0.1	68.5	±	27	2.8	±	2.5	0	±	0	0	±	0
EC3	0	±	0	0	±	0	0	±	0	0	±	0	0	±	0	0	±	0	0.01	±	0.03
OPT	0	±	0	0.9	±	1.1	0	±	0	1.1	±	2.6	0.2	±	0.5	0	±	0	0.01	±	0.03
OPR	0	±	0	0	±	0	0	±	0	2.6	±	4.2	0	±	0	0	±	0	0	±	0

STN protocol (µg / filter)

	Diesel Exhaust									Diesel + resuspended levoglucosan						Blank+ resusp. Levoglucosan			Blank+ resusp. Levoglucosan		
	QF			QF_{bott}			QBQ			QF			QFbott			QF (low load)			QF (high load)		
	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev
TC	192	±	14.8	55.3	±	16.3	17.3	±	3.8	359.8	±	119.3	64.9	±	12.7	13.98	±	4.93	26	±	9.31
OCT	107.7	±	14.8	53.6	±	15.7	16.7	±	3.5	283.3	±	112.9	57.7	±	13.6	11.85	±	2.37	23.95	±	9
OCR	107.7	±	14.8	52.9	±	15.9	16.7	±	3.5	268.5	±	103.5	56.4	±	10.9	11.07	±	2.32	23.47	±	8.85
ECT	84.3	±	26.2	1.6	±	3.1	0.6	±	0.9	76.5	±	26.6	7.3	±	4.1	2.13	±	3.35	2.05	±	2.44
ECR	84.3	±	26.2	2.4	±	3.2	0.6	±	0.9	91.2	±	29.1	8.6	±	3.1	2.91	±	3.56	2.53	±	2.87
OC1	77	±	4.4	30.9	±	5	10.6	±	2.5	184	±	89.6	35.5	±	4.3	3.72	±	0.29	5.5	±	1.96
OC2	18.9	±	6.8	16.5	±	12.7	4.6	±	1.2	55.9	±	10	13.8	±	7.8	6.12	±	1.84	12.88	±	4.15
OC3	11.3	±	4.7	5.4	±	1.7	1.5	±	0.6	28.7	±	4.3	7.1	±	3.5	1.22	±	0.97	4.08	±	2.02
OC4	13.9	±	2.6	1.6	±	2.1	0.6	±	0.9	23.5	±	4.2	4.7	±	1.7	0.88	±	1.35	1.69	±	1.4
OC5	0.4	±	0.1	0	±	0	0	±	0	0.3	±	0.1	0	±	0	0.01	±	0.03	0	±	0
EC1	2.4	±	0.5	0.1	±	0.2	0	±	0	2.6	±	0.7	0	±	0.1	0	±	0	0	±	0
EC2	11.5	±	2.9	0.2	±	0.4	0	±	0	7.5	±	2.3	0.6	±	0.8	0	±	0	0	±	0
EC3	40.8	±	16.5	0.5	±	0.6	0	±	0	32.2	±	13.1	2.5	±	1.5	0	±	0	0	±	0
EC4	14.9	±	8	0	±	0	0	±	0	24.4	±	11.3	0.7	±	0.9	0	±	0	0	±	0
EC5	0.7	±	1.1	0	±	0	0	±	0	0.7	±	0.4	0	±	0	2.04	±	2.53	1.86	±	1.84
OPT	-13.9	±	2.7	-0.8	±	2	-0.6	±	0.9	-9	±	6.8	-3.4	±	1.9	-0.09	±	1.69	-0.19	±	1.61
OPR	-13.9	±	2.6	-1.6	±	2.1	-0.6	±	0.9	-23.8	±	4.3	-4.7	±	1.7	-0.88	±	1.35	-0.67	±	1.74

Table 3-19. Continued.

b) Liquid levoglucosan

IMPROVE protocol (µg / filter)

	Diesel Exhaust			Diesel + liquid levoglucosan						Blank + liquid levoglucosan			Blank + liquid levoglucosan		
	QF			QF			QF_{bott}			QF (low load)			QF (high load)		
	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev
TC	193.6	±	19.8	298.1	±	17.6	156.4	±	89.3	60.29	±	4.5	115.2	±	4.36
OCT	91.1	±	9.6	193.9	±	12.6	134.7	±	56.3	60.29	±	4.5	115.03	±	4.35
OCR	90.2	±	10.7	189.5	±	11.9	135.8	±	60.2	59.24	±	4.12	111.03	±	3.62
ECT	102.5	±	10.6	104.2	±	12	21.7	±	33.7	0	±	0	0.17	±	0.3
ECR	103.4	±	9.4	108.6	±	8	20.6	±	29.4	1.06	±	1.26	4.16	±	2.12
OC1	33.3	±	4.5	77.3	±	19.2	31.3	±	14.9	0.15	±	0.26	28.23	±	17.91
OC2	32.2	±	4.1	49.9	±	6.1	31.6	±	3.3	18.57	±	3.34	28.71	±	4.7
OC3	17.8	±	2.7	45.6	±	3.9	48.3	±	22.4	33.5	±	3.78	42.62	±	9.83
OC4	6.9	±	2.4	16.8	±	1.9	19.9	±	21.1	7.01	±	1.55	11.48	±	1.23
EC1	5.6	±	2.8	17.8	±	3.2	7.6	±	9.1	1	±	1.29	3.37	±	2.23
EC2	97.4	±	8.2	90.4	±	7.9	12.2	±	18.6	0.05	±	0.09	0.8	±	0.36
EC3	0.5	±	0.4	0.3	±	0.4	5.5	±	12.2	0	±	0	0	±	0
OPT	0.9	±	1.3	4.3	±	6.8	3.6	±	6.4	1.06	±	1.26	3.99	±	1.87
OPR	0	±	0	0	±	0	4.7	±	10.5	0	±	0	0	±	0

STN protocol (µg / filter)

	Diesel Exhaust			Diesel + liquid levoglucosan						Blank + liquid levoglucosan			Blank + liquid levoglucosan		
	QF			QF			QF_{bott}			QF (low load)			QF (high load)		
	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev
TC	213.3	±	22.3	298	±	15.7	142	±	17.4	70.13	±	0.24	127.69	±	9.31
OCT	109.6	±	14.3	193.2	±	15.3	126.7	±	18.6	64.87	±	4.68	127.48	±	8.94
OCR	97	±	10.3	181.2	±	9.8	124.3	±	15.1	62.22	±	0.17	116.36	±	6.25
ECT	103.6	±	14.1	104.9	±	14	15.2	±	7.1	5.26	±	4.46	0.21	±	0.37
ECR	116.2	±	12.1	116.9	±	10.1	17.7	±	3.3	7.91	±	0.15	11.33	±	3.2
OC1	65.1	±	4.1	113.1	±	17.8	76.8	±	9.8	26.24	±	0.23	69.12	±	2.4
OC2	21.3	±	7.5	45.9	±	9.7	30.1	±	4.5	22.34	±	0.33	28.75	±	3.15
OC3	10.6	±	3.2	22.2	±	1.6	17.4	±	1.9	13.63	±	0.31	18.49	±	1.21
OC4	15	±	8.4	26.1	±	7.8	12.7	±	1.7	7.74	±	0.26	10.93	±	2.57
OC5	0	±	0	0	±	0.1	0	±	0	0	±	0	0	±	0
EC1	1	±	0.9	1.7	±	1.8	0.4	±	0.5	0.11	±	0.19	0.18	±	0.32
EC2	5.8	±	3.2	12.7	±	10.6	1.3	±	1	0.07	±	0.06	0.02	±	0.04
EC3	27.2	±	11.6	35.1	±	7.5	2.4	±	0.8	0	±	0	0.19	±	0.33
EC4	58.4	±	13	35.9	±	23.1	1	±	0.7	0	±	0	0	±	0
EC5	8.9	±	5.9	5.2	±	3.5	0	±	0	0	±	0	0	±	0
OPT	-2.4	±	3.7	-14.2	±	7.6	-10.2	±	6	-5.08	±	4.4	0.18	±	0.32
OPR	-15	±	8.4	-26.2	±	7.9	-12.7	±	1.7	-7.74	±	0.26	-10.93	±	2.57

Table 3-20. Distribution of carbon fractions for the diesel/levoglucosan experiment following the IMPROVE_A and STN/CSN protocols.

IMPROVE protocol

	Diesel Exhaust									Diesel + resuspended levoglucosan						Diesel + liquid levoglucosan					
	QF			QF_{bott}			QBQ			QF			QF_{bott}			QF			QFbott		
	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev
OCT / TC	0.574	±	0.116	0.91	±	0.062	0.992	±	0.016	0.731	±	0.08	0.941	±	0.036	0.65	±	0.03	0.861	±	0.093
OCR / TC	0.574	±	0.116	0.895	±	0.067	0.992	±	0.016	0.736	±	0.094	0.939	±	0.042	0.636	±	0.015	0.868	±	0.077
ECR / TC	0.426	±	0.116	0.105	±	0.067	0.008	±	0.016	0.269	±	0.08	0.061	±	0.042	0.35	±	0.03	0.139	±	0.093
ECT / TC	0.426	±	0.116	0.105	±	0.067	0.008	±	0.016	0.264	±	0.094	0.061	±	0.042	0.364	±	0.015	0.132	±	0.077
OCT / ECT	1.347	±	0.775	8.701	±	11.82	121.8	±	280.2	2.718	±	1.242	15.36	±	10.34	1.86	±	0.276	6.207	±	13.87
OCR / ECR	1.347	±	0.775	8.56	±	11.85	121.8	±	277	2.785	±	1.693	15.31	±	10.37	1.746	±	0.186	6.592	±	6.798
OPT / TC	0	±	0	0.015	±	0.014	0	±	0	0.003	±	0.011	0.003	±	0.006	0.015	±	0.023	0.023	±	0.021
OPR / TC	0	±	0	0	±	0	0	±	0	0.008	±	0.014	0	±	0	0	±	0	0.03	±	0.033
OC1 / OCR	0.357	±	0.081	0.393	±	0.1	0.542	±	0.064	0.453	±	0.078	0.289	±	0.099	0.408	±	0.083	0.231	±	0.101
OC2 / OCR	0.295	±	0.022	0.283	±	0.014	0.159	±	0.041	0.222	±	0.035	0.262	±	0.084	0.263	±	0.045	0.233	±	0.091
OC3 / OCR	0.255	±	0.073	0.268	±	0.079	0.288	±	0.054	0.241	±	0.045	0.388	±	0.127	0.241	±	0.03	0.356	±	0.055
OC4 / OCR	0.092	±	0.031	0.055	±	0.03	0.01	±	0.015	0.073	±	0.018	0.061	±	0.021	0.089	±	0.014	0.147	±	0.064
EC1 / ECR	0.191	±	0.06	0.245	±	0.19	0.79	±	0.128	0.215	±	0.148	0.327	±	0.323	0.164	±	0.028	0.37	±	0.126
EC2 / ECR	0.809	±	0.06	0.755	±	0.19	0.21	±	0.128	0.816	±	0.065	0.673	±	0.323	0.833	±	0.03	0.591	±	0.115
EC3 / ECR	0	±	0	0	±	0	0	±	0	0	±	0	0	±	0	0.003	±	0.003	0.266	±	0.167

STN/CSN protocol

	Diesel Exhaust									Diesel + resuspended levoglucosan						Diesel + liquid levoglucosan					
	QF			QF_{bott}			QBQ			QF			QF_{bott}			QF			QFbott		
	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev	avg	±	stdev
OCT / TC	0.561	±	0.106	0.97	±	0.05	0.967	±	0.048	0.787	±	0.093	0.888	±	0.059	0.648	±	0.042	0.893	±	0.048
OCR / TC	0.561	±	0.107	0.957	±	0.053	0.967	±	0.048	0.746	±	0.078	0.868	±	0.037	0.608	±	0.021	0.875	±	0.015
ECR / TC	0.439	±	0.106	0.03	±	0.05	0.033	±	0.048	0.213	±	0.093	0.112	±	0.059	0.352	±	0.042	0.107	±	0.048
ECT / TC	0.439	±	0.107	0.043	±	0.053	0.033	±	0.048	0.254	±	0.078	0.132	±	0.037	0.392	±	0.021	0.125	±	0.015
OCT / ECT	1.279	±	0.655	32.57	±	107.3	28.97	±	7.76	3.704	±	2.329	7.926	±	17.01	1.842	±	0.32	8.32	±	14.36
OCR / ECR	1.277	±	0.656	22.14	±	99.86	28.97	±	7.76	2.944	±	1.34	6.569	±	1.96	1.55	±	0.141	7.02	±	1
OPT / TC	-0.072	±	0.038	-0.015	±	0.121	-0.033	±	0.059	-0.025	±	0.089	-0.053	±	0.098	-0.048	±	0.053	-0.072	±	0.02
OPR / TC	-0.073	±	0.041	-0.028	±	0.118	-0.033	±	0.059	-0.066	±	0.021	-0.073	±	0.078	-0.088	±	0.033	-0.089	±	0.018
OC1 / OCR	0.715	±	0.069	0.585	±	0.124	0.635	±	0.059	0.685	±	0.062	0.63	±	0.122	0.624	±	0.068	0.618	±	0.021
OC2 / OCR	0.176	±	0.04	0.312	±	0.116	0.277	±	0.052	0.208	±	0.04	0.245	±	0.085	0.253	±	0.061	0.242	±	0.02
OC3 / OCR	0.105	±	0.029	0.102	±	0.03	0.089	±	0.035	0.107	±	0.023	0.125	±	0.038	0.122	±	0.014	0.14	±	0.006
OC4 / OCR	0.13	±	0.013	0.03	±	0.041	0.035	±	0.054	0.087	±	0.018	0.084	±	0.015	0.144	±	0.046	0.102	±	0.009
OC5 / OCR	0.003	±	0.001	0	±	0	0	±	0	0.001	±	0	0	±	0	0	±	0.001	0	±	0
EC1 / ECR	0.029	±	0.006	0.028	±	0.021	0	±	0	0.029	±	0.005	0.004	±	0.006	0.015	±	0.015	0.021	±	0.024
EC2 / ECR	0.136	±	0.019	0.081	±	0.054	0	±	0	0.082	±	0.004	0.071	±	0.069	0.109	±	0.084	0.076	±	0.044
EC3 / ECR	0.484	±	0.064	0.222	±	0.441	0	±	0	0.353	±	0.041	0.29	±	0.071	0.301	±	0.056	0.133	±	0.036
EC4 / ECR	0.176	±	0.053	0.01	±	0.007	0	±	0	0.267	±	0.062	0.082	±	0.059	0.308	±	0.186	0.054	±	0.042
EC5 / ECR	0.009	±	0.009	0	±	0	0	±	0	0.008	±	0.005	0	±	0	0.044	±	0.027	0	±	0

Table 3-21. Ratio of the bottom half of quartz-fiber front filter (QF_{bott}) or quartz-fiber backup filter (QBQ) to quartz-fiber front filter (QF) in different carbon fractions.

IMPROVE

	Diesel			Diesel + Resus	Diesel + Liquid
	QF_{bott}/ QF	QBQ/QF	QBQ/QF_{bott}	QF_{bott}/QF	QF_{bott}/QF
TC	0.321	0.077	0.239	0.214	0.525
OCT	0.51	0.133	0.26	0.275	0.695
OCR	0.502	0.133	0.265	0.273	0.716
ECT	0.079	0.001	0.019	0.049	0.208
ECR	0.079	0.001	0.019	0.05	0.19
OC1	0.552	0.202	0.365	0.174	0.405
OC2	0.481	0.071	0.148	0.322	0.634
OC3	0.527	0.15	0.284	0.439	1.059
OC4	0.3	0.015	0.05	0.226	1.183
EC1	0.101	0.006	0.06	0.075	0.428
EC2	0.074	0	0.005	0.041	0.135
EC3	N/A	N/A	N/A	N/A	16.308
OPT	N/A	N/A	0	0.177	0.826
OPR	N/A	N/A	N/A	0	N/A

STN

	Diesel			Diesel + Resus	Diesel + Liquid
	QF_{bott}/ QF	QBQ/QF	QBQ/QF_{bott}	QF_{bott}/QF	QF_{bott}/QF
TC	0.288	0.09	0.313	0.181	0.476
OCT	0.498	0.155	0.312	0.204	0.656
OCR	0.491	0.155	0.316	0.21	0.686
ECT	0.02	0.007	0.35	0.095	0.145
ECR	0.028	0.007	0.242	0.094	0.151
OC1	0.402	0.138	0.343	0.193	0.679
OC2	0.872	0.244	0.28	0.247	0.656
OC3	0.478	0.131	0.273	0.246	0.784
OC4	0.113	0.041	0.367	0.202	0.485
OC5	0	0	N/A	0	0
EC1	0.028	0	0	0.013	0.214
EC2	0.017	0	0	0.082	0.105
EC3	0.013	0	0	0.077	0.067
EC4	0.002	0	0	0.029	0.026
EC5	0	0	N/A	0	0
OPT	0.06	0.042	0.696	0.381	0.72
OPR	0.113	0.041	0.367	0.2	0.484

4. SUMMARY AND CONCLUSIONS

Table 4-1 summarizes the results reported in Section 3 related to the hypotheses posed in Section 1. The IMPROVE, STN/CSN, and SEARCH networks have been using different sampling configurations, including specific samplers, flow rates, filter material, and filter sizes. For field blanks, which accompany sample filters to the field and are intended to emulated their passive deposition and adsorption, only the IMPROVE network provides a long enough passive exposure period to fulfill the purpose. Based on both the network averages and collocated-site studies, IMPROVE field blank TC (or OC) range from 2.0 to 2.5 μg/cm^2, while STN/CSN and SEARCH field blanks are below or close to 1 μg/cm^2. The limited exposure times in the STN/CSN and SEARCH networks are 1 – 15 minutes, compared to 7 days in the IMPROVE network. STN/CSN field and trip blank TC and OC concentrations are within ± 5% for site averages.

Regression analysis using uncorrected TC from collocated IMPROVE and STN/CSN samplers indicates a larger net sampling artifact (μg/m^3) in the STN/CSN carbon measurements. Without any correction, biases in the STN/CSN data could be 5 – 11 times higher than those in the IMPROVE data (μg/m^3), depending on the sampler type. When corrected with respective field blanks, STN/CSN TC concentrations are still higher at most sites. STN/CSN field blanks could under-represent the organic artifact by up to 34% (e.g., at Fresno, CA), if IMPROVE field blanks fully represent the artifact. Blank corrections should be made and uncertainties propagated for STN/CSN data, even though the reported OC will be under-corrected for adsorbed organic vapors.

The mass regression method and SANDWICH approach are both based on PM mass closure (i.e., the mass measured on a Teflon-membrane filter should be explained by measured organic and/or inorganic components with the difference attributed to the sampling artifact). Many species are not usually measured on Teflon-membrane filters, including carbon, nitrate, sulfate, and ammonium. For URG speciation samplers that measure ions after XRF analysis, volatile components, such as ammonium nitrate and some SVOCs, are likely to evaporate in the vacuum due to the heating during XRF analysis. Different collection/retention efficiencies of Teflon-membrane, quartz-fiber, and nylon-membrane filters with respect to these species have been reported. The mass of water and unidentified species cannot be definitely determined. All these contribute to mass closure uncertainties. Even if organic carbon mass (OCM) can be calculated from the SANDWICH method, this study shows that variation in OCM concentration due to the choice of OC multiplier (e.g., 1.4 or 1.8) is comparable to the magnitude of the organic sampling artifact (5 – 30% of OCM). It is not possible to determine whether the excess OCM mass, if any, is due to sampling artifact or the correction coefficient used to convert OC to OCM.

This study also demonstrates that sampling artifacts could influence the OC/EC split and therefore EC quantification. Charring from liquid levoglucosan on clean filters is apparent. A two-stream radiative transfer model was used to estimate the depth of layer containing light-absorbing material during thermal analysis. For a pure diesel soot sample, this layer is ~13% of the whole filter throughout the IMPROVE_A thermal/optical analysis, whereas for liquid levoglucosan doping this layer extends to ~50% of the whole filter (i.e., light absorbing material penetrates into the filter). Observational and model investigations suggest that within-filter char occurs, altering the reflectance/transmittance relationship. However, in this experiment, the effect of liquid levoglucosan additions to diesel soot samples is inconclusive due to: 1) heavy soot loading that saturates the optical signal and 2) particle migration caused by liquid spiking. Experiments using lower diesel soot loadings and better levoglucosan application techniques need to be perfected to obtain quantitative results.

5. RECOMMENDATIONS

This study shows that there is no simple way to correct for sampling artifacts using current measurements. However, sampling artifacts are reduced with increasing aerosol sample deposit. This is achieved via a higher flow rate (e.g., 22 L/min instead of 7.1 L/min) and a smaller deposit area (3.8 cm^2 instead of 11.8 cm^2). Subtractions made using blank, backup, back-half of the front filter, and/or mass closure approaches need to be evaluated against true artifact levels, which can only be achieved through well-designed field and laboratory experiments. Experiments are needed to evaluate: 1) sample duration for filter saturation; 2) dependence of saturation on particle composition, temperature, relative humidity, and sampling face velocity; 3) evaporation rates of semi-volatile compounds during sampling; and 4) source-specific variables. Near-term, middle-term, and long-term goal recommendations are:

- Near term
  - Maximize sample volume and minimize filter size
  - Standardize procedures for field blank collection frequency and duration (e.g., once a month on an every-sixth-day sampling schedule; expose field blanks for several days in the SEARCH and CSN networks)
  - Include backup filters in CSN
  - Add locations and times for field blanks and backup filters (different source environments)
- Middle term
  - Continue laboratory and field experiments to determine adsorption capacities and retention for filter media and semivolatile organic compounds
  - Evaluate modeling of simultaneous TOR/TOT to estimate adsorbed organic vapors and their influence on OC/EC split
- Long term
  - Develop, evaluate, and deploy new carbon analysis methods that achieve more information (e.g., finer thermal fractions, specific organic compounds, reflectance and transmittance at different wavelengths, inorganic as well as organic compounds) for same or lesser cost

The long-term goal may involve state-of-the-art mass and optical spectrometric detectors (e.g., Streibel et al., 2006). This development also needs to maintain the continuity of long-term trends established by the currently applied methods.

Table 5-1. Summary of findings for the five hypotheses.

Hypothesis	Findings
A: The OC artifact on blank/backup filters depends on sampling protocol and differs among ambient networks.	This is confirmed, and is demonstrated by network descriptions and comparison of the trip blanks, field blanks, and backup filters. IMPROVE field blanks TC (or OC) are generally in the range of 2.0 – 2.5 μg/cm^2 while the STN/CSN and SEARCH field blanks are below or close to 1 μg/cm^2. Since both IMPROVE and SEARCH use Pallflex® Tissuquartz filters, filter material does not appear to be the cause of the difference. The lower SEARCH and STN/CSN field blank levels are probably caused by short passive exposure periods (on the order of minutes) which do not allow sufficient time for organic vapors to diffuse to and through the filters. IMPROVE field blanks reside for seven days in the sampler with the sampled filters. Among the five STN/CSN samplers, URG MASS reports the lowest field blank levels. The IMPROVE backup filter OC (from six sites only) is ~20% higher than its network average field blank OC, while the SEARCH backup filter OC is 57% higher than network average field blank OC. For the SEARCH network, the backup filters contain both positive and negative artifacts, and the negative artifact could be enhanced by the preceding organic denuder equipped in the Particle Composition Monitor (PCM3; Chow et al., 2007c)
B: Adsorbed organic carbon on the field blank is less than that on the backup filter, which is less than that on the bottom half of the front filter.	This is confirmed, although the IMPROVE field blanks are similar to backup filters within the variability of the averages. Chow et al. (2007c) showed a decreasing gradient of OC with depth in the front and backup filters. It cannot be assumed that the front and backup filters are saturated with adsorbed organic vapors. In this study, diesel soot sample filters were sliced and it was found that the bottom half of quartz-fiber front filters contained four times higher OC than quartz-fiber backup filters. Liquid particles can also penetrate into the front and backup filters, and this will give a different result than if the same substance were collected on the surface as a dry particle. This was demonstrated by adding levoglucosan to diesel soot samples.
C: Aging of aerosol reduces SVOC content and the organic sampling artifact.	Comparisons between urban and non-urban sites in the SEARCH network are consistent with this hypothesis, but they are not sufficient to prove it. Average OC on quartz-fiber backup filters was ~22% higher at the urban sites, with 1.46 ± 1.47 μg/cm^2 at urban sites and 1.20 ± 0.9 μg/cm^2 at the non-urban sites in the SEARCH network. The urban increments between the urban and non-urban sites were ~77% for OC1 and 20% for OC2. The majority of this low temperature OC is gaseous VOCs. During the IMPROVE/STN comparison study, field blank carbon levels were not necessarily lower at rural sites than at urban sites, though this could be due to the extent of VOC saturation. The contrast between urban and rural sites can only provide indirect indication of aging effect since the degree of aging is not known.

Table 5-1. Continued

Hypothesis	**Findings**
D: OC estimated by the SANDWICH method better represents the particulate organic matter in $PM_{2.5}$.	The SANDWICH method does not provide a better representation of OC, but under certain conditions it can provide an estimate when carbon measurements are not available. Water and volatile nitrate content could strongly interfere the mass closure between the gravimetric mass measured from the Teflon-membrane filters and species measured from the quartz-fiber filters. These are also problems for the intercept approach demonstrated by Chow et al. (2007c). The SANDWICH method is inaccurate for low concentrations, for which the calculated and measured OC ratio exceeded 200% (e.g., Washington, DC). For sites where better agreement between OC and OCM was found, such as Seattle, WA and Phoenix, AZ, the difference due to the OCM/OC ratio (1.4 or 1.8) was 5 – 30% of OCM mass, comparable to the magnitude of OC artifact.
E: The organic sampling artifact influences the OC/EC split for both IMPROVE and STN/CSN analysis	This was demonstrated for a relatively simple case that mixed diesel exhaust (for which the IMPROVE_A_TOR and STN_TOT protocols usually agree) with liquid and solid levoglucosan. When a diesel soot sample is mixed with levoglucosan, the reflectance and transmittance relationship (as determined by thermal/optical methods) only changes when the liquid levoglucosan is spiked into the filter rather than when solid levoglucosan is collected onto the filter surface. When sampling artifact does char and the char occurs within the filter, it is expected to influence the OC/EC split for either TOR or TOT analysis. This is due to the different distribution and absorption efficiency between char (pyrolyzed OC) and EC. The magnitude of this influence should depend on the amount of char with respect to the amount of EC. However, in the current experiment, the effect of liquid levoglucosan doping on diesel soot samples cannot be further quantified due to: 1) heavy soot loading that saturates the optical signal and 2) particle migration caused by liquid spiking. Experiments to lower diesel soot loading and minimize particle migration are recommended for the future.

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