Supplemental Material for ***Spatial and Temporal Variation in $PM_{2.5}$ Chemical Composition in the United States for Health Effects Studies*** (Bell et al.)

Tables

Supplemental Figures

References

Table S1. List of counties

Jefferson, AL	Madison, AL	Mobile, AL
Morgan, AL	Russell, AL	Maricopa, AZ
Pima, AZ	Ashley, AR	Pulaski, AR
White, AR	Fresno, CA	Kern, CA
Los Angeles, CA	Riverside, CA	Sacramento, CA
San Diego, CA	Santa Clara, CA	Ventura, CA
Adams, CO	El Paso, CO	La Plata, CO
Mesa, CO	Weld, CO	Fairfield, CT
New Haven, CT	Kent, DE	New Castle, DE
District of Columbia	Escambia, FL	Hillsborough, FL
Leon, FL	Miami-Dade, FL	Bibb, GA
Chatham, GA	Clarke, GA	DeKalb, GA
Floyd, GA	Muscogee, GA	Richmond, GA
Canyon, ID	Cook, IL	DuPage, IL
Macon, IL	Madison, IL	Allen, IN
Dubois, IN	Elkhart, IN	Henry, IN
Lake, IN	Marion, IN	St. Joseph, IN
Vanderburgh, IN	Linn, IA	Polk, IA
Scott, IA	Sedgwick, KS	Wyandotte, KS
Boyd, KY	Daviess, KY	Fayette, KY
Jefferson, KY	Kenton, KY	Laurel, KY
McCracken, KY	Perry, KY	Warren, KY
East Baton Rouge, LA	Anne Arundel, MD	Baltimore, MD
Prince George's, MD	Hampden, MA	Suffolk, MA
Allegan, MI	Kalamazoo, MI	Kent, MI
Missaukee, MI	Monroe, MI	Washtenaw, MI
Wayne, MI	Hennepin, MN	Mille Lacs, MN
Olmsted, MN	Ramsey, MN	Forrest, MS
Harrison, MS	Hinds, MS	Jones, MS
Clay, MO	Jefferson, MO	St. Louis City, MO
Lincoln, MT	Missoula, MT	Douglas, NE
Clark, NV	Washoe, NV	Hillsborough, NH

Rockingham, NH	Camden, NJ	Middlesex, NJ
Morris, NJ	Union, NJ	Bernalillo, NM
Bronx, NY	Erie, NY	Essex, NY
Monroe, NY	New York, NY	Queens, NY
Steuben, NY	Buncombe, NC	Catawba, NC
Cumberland, NC	Davidson, NC	Forsyth, NC
Guilford, NC	Lenoir, NC	Mecklenburg, NC
Rowan, NC	Wake, NC	Burleigh, ND
Cass, ND	McKenzie, ND	Butler, OH
Cuyahoga, OH	Franklin, OH	Hamilton, OH
Jefferson, OH	Lawrence, OH	Lorain, OH
Lucas, OH	Mahoning, OH	Montgomery, OH
Stark, OH	Summit, OH	Oklahoma, OK
Tulsa, OK	Multnomah, OR	Adams, PA
Allegheny, PA	Centre, PA	Chester, PA
Dauphin, PA	Delaware, PA	Erie, PA
Lackawanna, PA	Lancaster, PA	Northampton, PA
Perry, PA	Philadelphia, PA	Washington, PA
Westmoreland, PA	York, PS	Providence, RI
Charleston, SC	Chesterfield, SC	Greenville, SC
Richland, SC	Minnehaha, SD	Davidson, TN
Hamilton, TN	Knox, TN	Lawrence, TN
Shelby, TN	Sullivan, TN	Sumner, TN
Dallas, TX	El Paso, TX	Harris, TX
Davis, UT	Salt Lake, UT	Utah, UT
Chittenden, VT	Bristol City, VI	Henrico, VI
Page, VI	Richmond City, VI	Roanoke City, VI
King, WA	Spokane, WA	Kanawha, WV
Marshall, WV	Dodge, WI	Kenosha, WI
Manitowoc, WI	Milwaukee, WI	Taylor, WI
Waukesha, WI		

Table S2. List of $PM_{2.5}$ components

Aluminum (Al)
Ammonium Ion
Antimony (Sb)
Arsenic (As)
Barium (Ba)
Bromine (Br)
Cadmium (Cd)
Calcium (Ca)
Cerium (Ce)
Cesium (Cs)
Chlorine (Cl)
Chromium (Cr)
Cobalt (Co)
Copper (Cu)
Europium (Eu)
Gallium (Ga)
Gold (Au)
Hafnium (Hf)
Indium (In)
Iridium (Ir)
Iron (Fe)
Lanthanum (La)
Lead (Pb)
Magnesium (Mg)
Manganese (Mn)
Mercury (Hg)
Molybdenum (Mo)
Nickel (Ni)
Niobium (Nb)
Phosphorus (P)
Potassium (K)
Rubidium (Rb)
Samarium (Sm)
Scandium (Sc)
Selenium (Se)
Silicon (Si)
Silver (Ag)
Sodium ion (Na^+)
Strontium (Sr)
Tantalum (Ta)
Terbium (Tb)
Tin (Sn)
Titanium (Ti)
Tungsten (W)
Vanadium (V)
Yttrium (Y)
Zinc (Zn)
Zirconium (Zr)
Nitrate (NO_3^-)
Sulfate ($SO_4^{=}$)
Organic Carbon (OC)
Elemental Carbon (EC)
$PM_{2.5}$ total mass

Table S3. Contribution of selected components to $PM_{2.5}$ total mass, for yearly and seasonal averages

Note: These components did not contribute >1% to $PM_{2.5}$ total mass in the national yearly or seasonal averages, however do contribute >1% for at least one county for a yearly or seasonal average. The mean is across all communities. The minimum and maximum shown in parentheses are for any single community.

	Yearly	*Winter*	*Spring*	*Summer*	*Autumn*
K	0.53 (0.27 to 1.8)	0.53 (0.25 to 1.7)	0.53 (0.26 to 2.7)	0.58 (0.18 to 2.3)	0.52 (0.28 to 3.2)
Ca	0.44 (0.13 to 3.7)	0.34 (0.08 to 3.2)	0.51 (0.14 to 3.9)	0.47 (0.11 to 4.5)	0.47 (0.10 to 4.1)
Fe	0.62 (0.21 to 4.1)	0.55 (0.15 to 3.4)	0.69 (0.26 to 5.1)	0.63 (0.16 to 5.4)	0.67 (0.19 to 3.7)
Cl	0.18 (0.04 to 2.7)	0.30 (0.04 to 2.4)	0.18 (0.02 to 3.4)	0.11 (0.01 to 2.9)	0.17 (0.03 to 2.5)
Al	0.23 (0.08 to 1.4)	0.13 (0.01 to 0.87)	0.29 (0.09 to 2.2)	0.32 (0.06 to 2.9)	0.18 (0.07 to 0.83)

Table S4. Correlations among selected $PM_{2.5}$ chemical components, on average across 187 U.S. counties
Note: This table provides full information for Table 2 in the main text.

Yearly Averages

	EC	OCM	Si	Na^+	$SO_4^=$	NO_3^-	Br	Ca	Cl	Cu	Fe	Mg	K	Se	Ti
NH_4^+	0.18	0.08	-0.35	-0.01	0.72	0.64	0.48	-0.16	0.02	0.16	0.13	-0.05	0.14	0.45	-0.12
EC		0.59	0.33	0.27	0.01	0.27	0.31	0.36	0.52	0.44	0.65	0.40	0.34	0.15	0.57
OCM			0.26	0.24	0.00	0.18	0.24	0.20	0.17	0.33	0.36	0.25	0.46	-0.02	0.45
Si				0.14	-0.43	-0.02	0.02	0.68	0.21	0.22	0.46	0.40	0.32	-0.18	0.78
Na^+					-0.07	0.17	0.12	0.04	0.63	0.12	0.09	0.17	0.26	-0.19	0.31
$SO_4^=$						-0.05	0.43	-0.29	-0.15	-0.03	-0.07	-0.26	0.05	0.47	-0.25
NO_3^-							0.25	0.10	0.23	0.27	0.26	0.23	0.19	0.11	0.17

Winter Averages

	EC	OCM	Si	Na^+	$SO_4^=$	NO_3^-	Br	Ca	Cl	Cu	Fe	Mg	K	Se	Ti
NH_4^+	-0.02	-0.03	-0.19	0.00	0.39	0.86	0.31	-0.10	0.38	0.10	0.08	0.00	0.05	0.37	-0.12
EC		0.73	0.57	0.18	-0.22	0.08	0.20	0.48	0.44	0.50	0.62	0.27	0.43	-0.05	0.66
OCM			0.35	0.12	-0.23	0.10	0.14	0.25	0.23	0.40	0.40	0.17	0.64	-0.10	0.41
Si				-0.04	-0.39	0.00	0.07	0.73	0.21	0.38	0.56	0.22	0.25	-0.19	0.71
Na^+					0.08	0.01	0.07	0.02	0.37	0.06	0.02	0.08	0.30	-0.17	0.08
$SO_4^=$						-0.12	0.43	-0.24	0.02	-0.13	-0.17	-0.19	0.08	0.46	-0.29
NO_3^-							0.09	0.03	0.36	0.17	0.17	0.11	0.04	0.13	0.04

Spring Averages

	EC	OCM	Si	Na^+	$SO_4^=$	NO_3^-	Br	Ca	Cl	Cu	Fe	Mg	K	Se	Ti
NH_4^+	0.26	0.16	-0.41	-0.06	0.70	0.74	0.46	-0.19	-0.05	0.15	0.08	-0.13	0.07	0.37	-0.23
EC		0.51	0.18	0.22	0.20	0.20	0.26	0.28	0.39	0.42	0.60	0.28	0.21	0.18	0.41
OCM			0.13	0.18	0.31	-0.01	0.30	0.20	0.10	0.24	0.33	0.15	0.33	0.00	0.33
Si				0.04	-0.42	-0.18	-0.06	0.76	0.07	0.20	0.39	0.48	0.26	-0.17	0.81
Na^+					0.04	0.00	0.08	0.02	0.73	0.02	0.01	0.24	0.21	-0.18	0.16
$SO_4^=$						0.05	0.54	-0.25	-0.08	0.01	-0.06	-0.22	0.21	0.30	-0.22
NO_3^-							0.14	-0.03	0.10	0.20	0.17	0.06	-0.05	0.19	-0.07

Summer Averages

	EC	OCM	Si	Na^+	$SO_4^=$	NO_3^-	Br	Ca	Cl	Cu	Fe	Mg	K	Se	Ti
NH_4^+	0.31	0.40	-0.39	0.01	0.87	0.53	0.47	-0.28	-0.19	0.11	0.03	-0.11	0.08	0.46	-0.19
EC		0.45	0.11	0.09	0.19	0.31	0.33	0.20	0.26	0.35	0.57	0.24	0.30	0.26	0.29
OCM			-0.09	-0.03	0.38	0.28	0.32	-0.04	-0.19	0.23	0.20	0.00	0.25	0.14	0.11
Si				0.12	-0.38	-0.12	-0.08	0.57	0.26	0.11	0.54	0.27	0.23	-0.17	0.84
Na^+					-0.13	0.43	0.19	0.02	0.63	0.07	0.05	0.29	0.14	-0.17	0.28
$SO_4^=$						0.12	0.31	-0.37	-0.24	0.01	-0.05	-0.26	-0.06	0.50	-0.26
NO_3^-							0.49	0.02	0.12	0.22	0.13	0.25	0.30	0.06	0.11

Autumn Averages

	EC	OCM	Si	Na^+	$SO_4^=$	NO_3^-	Br	Ca	Cl	Cu	Fe	Mg	K	Se	Ti
NH_4^+	0.25	0.20	-0.14	0.09	0.66	0.62	0.59	-0.05	0.04	0.19	0.26	0.01	0.17	0.37	0.10
EC		0.57	0.41	0.24	0.01	0.36	0.42	0.36	0.47	0.47	0.69	0.39	0.27	0.24	0.62
OCM			0.38	0.29	0.02	0.33	0.32	0.23	0.16	0.30	0.34	0.24	0.39	-0.02	0.51
Si				0.10	-0.43	0.30	0.10	0.65	0.14	0.27	0.46	0.51	0.30	-0.10	0.75
Na^+					-0.04	0.28	0.21	0.04	0.58	0.17	0.10	0.10	0.26	-0.14	0.24
$SO_4^=$						-0.15	0.43	-0.20	-0.11	-0.01	0.00	-0.21	0.10	0.37	-0.23
NO_3^-							0.37	0.16	0.20	0.28	0.35	0.23	0.16	0.05	0.43

Table S5. Correlations among selected $PM_{2.5}$ chemical components and $PM_{2.5}$ total mass, by region

Note: This table provides full information for Table 3 in the main text.

U.S.

	Yearly	Winter	Spring	Summer	Autumn
NH_4^+	0.83	0.66	0.82	0.90	0.82
EC	0.42	0.53	0.47	0.33	0.47
OCM	0.52	0.70	0.61	0.56	0.63
Si	-0.15	0.14	-0.20	-0.28	0.07
Na^+	0.11	0.13	0.12	-0.06	0.20
$SO_4^=$	0.72	0.11	0.79	0.94	0.63
NO_3^-	0.45	0.66	0.44	0.32	0.49

Eastern U.S.

	Yearly	Winter	Spring	Summer	Autumn
NH_4^+	0.75	0.76	0.66	0.84	0.73
EC	0.54	0.50	0.53	0.37	0.48
OCM	0.69	0.59	0.70	0.63	0.73
Si	0.11	0.31	0.37	-0.14	0.26
Na^+	-0.09	0.11	0.05	-0.19	-0.07
$SO_4^=$	0.84	0.57	0.76	0.94	0.87
NO_3^-	0.22	0.52	0.20	0.31	-0.03

Western U.S.

	Yearly	Winter	Spring	Summer	Autumn
NH_4^+	0.88	0.72	0.89	0.96	0.89
EC	0.65	0.52	0.72	0.62	0.69
OCM	0.71	0.76	0.68	0.62	0.78
Si	-0.04	-0.12	-0.03	-0.11	0.23
Na^+	0.50	0.20	0.45	0.54	0.54
$SO_4^=$	0.68	0.34	0.83	0.86	0.67
NO_3^-	0.91	0.75	0.90	0.96	0.91

Table S6. OCM yearly and seasonal concentrations using two methods of estimation, on average across 187 counties (μg/m^3)

		Avg	*Stdev*	*IQR*	*Min to Max*
Yearly	OCM	3.82	0.10	1.37	(0.97 to 12.12)
	OCM2	4.19	0.10	1.37	(1.26 to 12.55)
Summer	OCM	4.41	0.08	1.43	(1.91 to 7.60)
	OCM2	4.78	0.08	1.34	(1.94 to 7.93)
Spring	OCM	3.00	0.09	1.30	(0.56 to 8.12)
	OCM2	3.39	0.09	1.43	(0.71 to 8.54)
Winter	OCM	4.00	0.19	2.15	(0.15 to 24.33)
	OCM2	4.38	0.19	2.08	(0.38 to 24.86)
Autumn	OCM	3.86	0.12	1.78	(0.85 to 13.46)
	OCM2	4.20	0.13	1.76	(1.19 to 13.87)

Table S7. Percent contributions to $PM_{2.5}$ total mass by OCM, using two methods of OCM estimation

	Yearly	*Winter*	*Summer*
Original method (OCM)	27.5%	27.7%	29.0%
Alternative method (OCM2)	30.2%	30.6%	31.5%

Table S8. Correlations between OCM and selected components using two methods of OCM estimation, on average across 187 counties

		NH_4^+	EC	Si	Na^+	$SO_4^=$	NO_3^-	$PM_{2.5}$
Yearly	*OCM*	0.08	0.59	0.26	0.24	0.00	0.18	0.52
	OCM2	0.11	0.58	0.23	0.19	0.03	0.19	0.55
Winter	*OCM*	-0.03	0.73	0.35	0.12	-0.23	0.10	0.70
	OCM2	-0.01	0.72	0.34	0.09	-0.22	0.11	0.71
Spring	*OCM*	0.16	0.51	0.13	0.18	0.31	-0.01	0.61
	OCM2	0.20	0.50	0.10	0.12	0.33	0.00	0.62
Summer	*OCM*	0.40	0.45	-0.09	-0.03	0.38	0.28	0.56
	OCM2	0.42	0.44	-0.13	-0.08	0.40	0.28	0.58
Autumn	*OCM*	0.20	0.57	0.38	0.29	0.02	0.33	0.63
	OCM2	0.23	0.57	0.37	0.25	0.04	0.33	0.66

Table S9. Potential sources for identified key $PM_{2.5}$ chemical components

Note: Although many potential sources are listed for each component, this does not reflect the relative contribution of each source. In other words, some sources may be minor contributors, and the degree of contribution may vary by region or season.

Component	*Potential sources*
$SO_4^{=}$	Motor vehicles; oil and coal combustion; wood and other vegetative burning; industry including electronics manufacturing, smelters, incinerators, coke plants, and steel mills; aged sea salt
NO_3^-	Dust; motor vehicles including diesel; vegetation burning; aged sea salt; intercontinental dust
Na^+	Sea breeze and aged sea salt; vegetation burning; oil combustion; industry such as incinerators, smelters, and coke plants; airborne soil
NH_4^+	Motor vehicles including diesel; oil and coal combustion; vegetative burning; airborne soil
Elemental Carbon	Combustion of biomass and fossil fuels, including transportation sources including diesel and combustion of coal, oil, wood, and other vegetation; aged sea salt; airborne soil; industry including coke plants, incinerators, and casting processes
Organic Carbon	Motor vehicles including diesel; coal and oil combustion; wood smoke and other vegetative burning; airborne soil; industrial sources such as cement kilns, casting processes, and incinerators
Si	Resuspended soil and intercontinental dust; unpaved roads and construction; steel processing; oil combustion; vehicles; coal combustion; cement kilns; prescribed burning

Data from: Begum et al. 2005; Canadian Federal-Provincial Advisory Committee 1999; Cao et al. 2005; Chan et al. 2005; Chang et al. 2005; Fang et al. 2005; Kang et al. 2004; Kanias et al. 2004; Kim and Hopke 2005; Kim et al. 2005; Lara et al. 2005; Lee et al. 2005; Liu et al. 2005; Lonati et al. 2005; Niemi et al. 2005; Owega et al. 2004; Sioutas et al. 2005; U.S. EPA 2002; Wang et al. 2005; Weitkamp et al. 2005; Yang et al. 2005; Zheng et al. 2005.

Figure S1. Number of $PM_{2.5}$ observations by county (2000 to 2005)

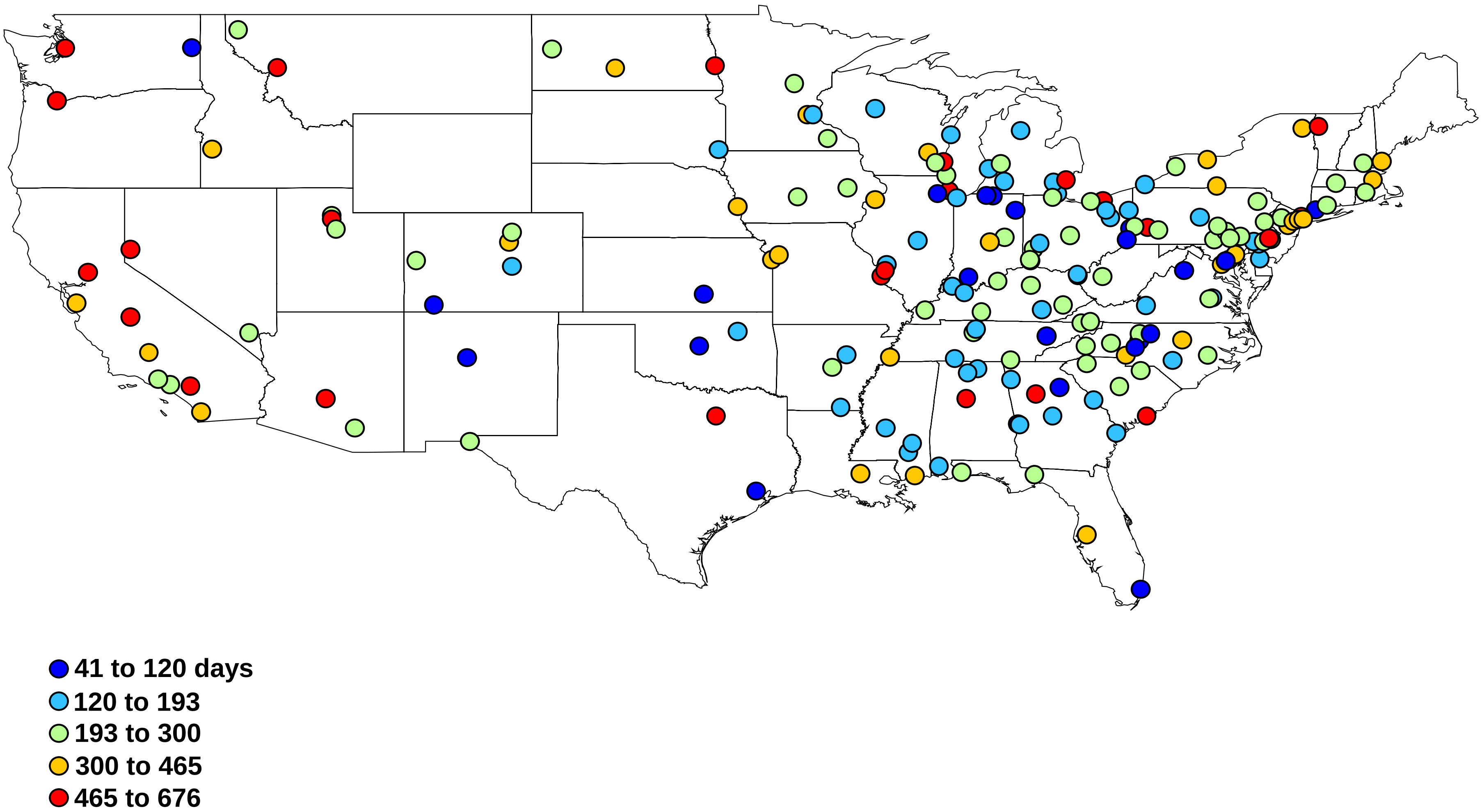
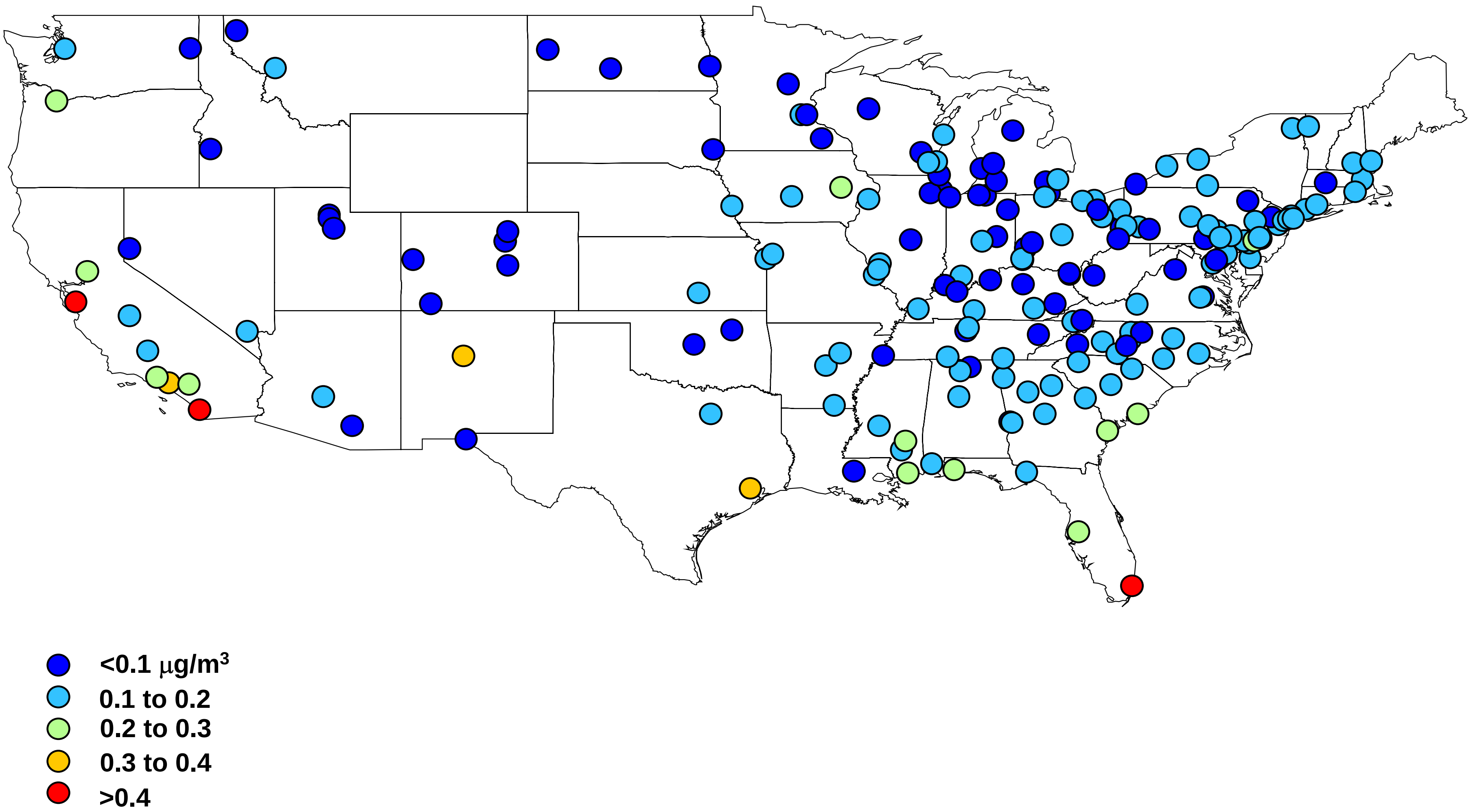


Figure S2. Sodium ion $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005



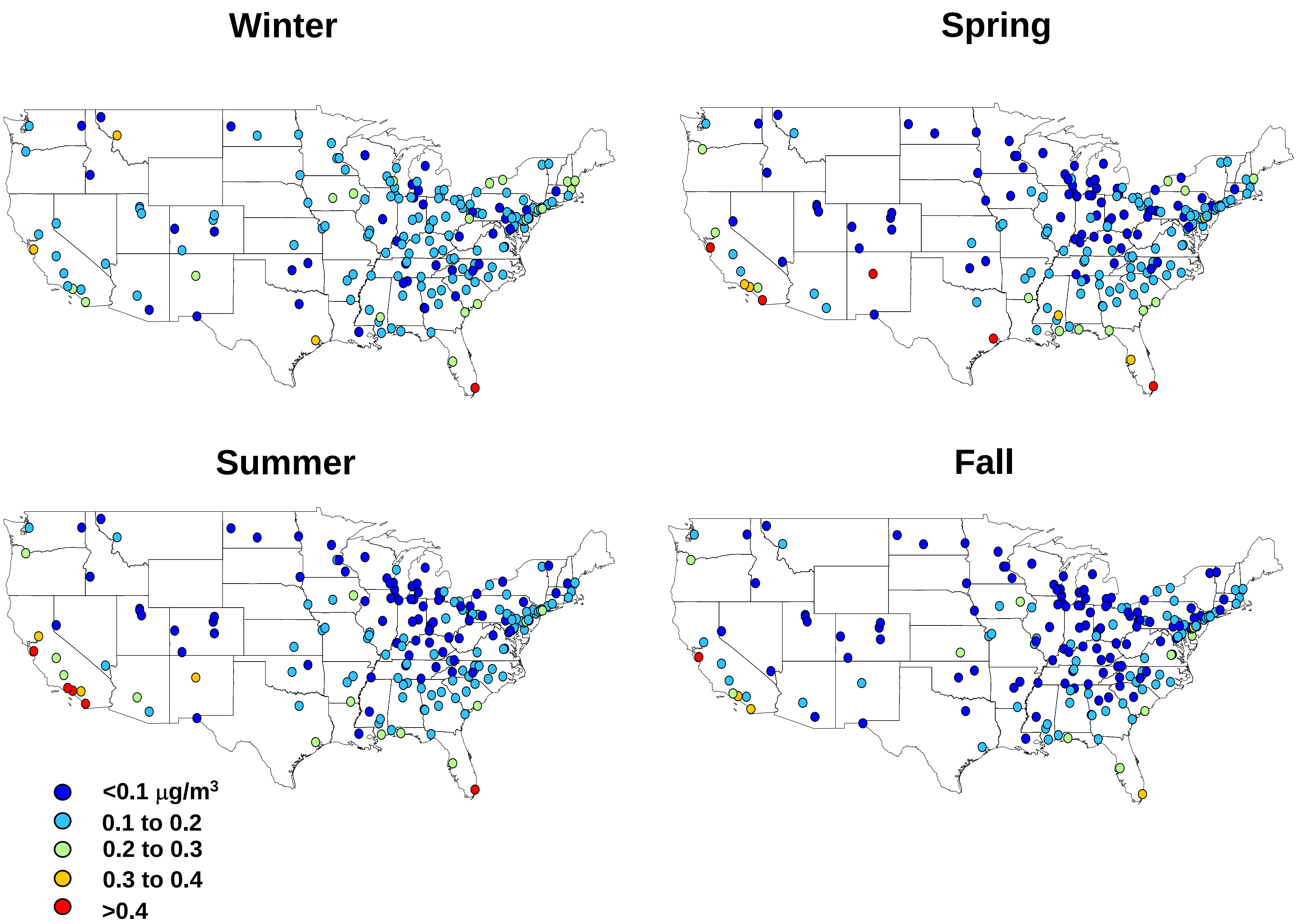
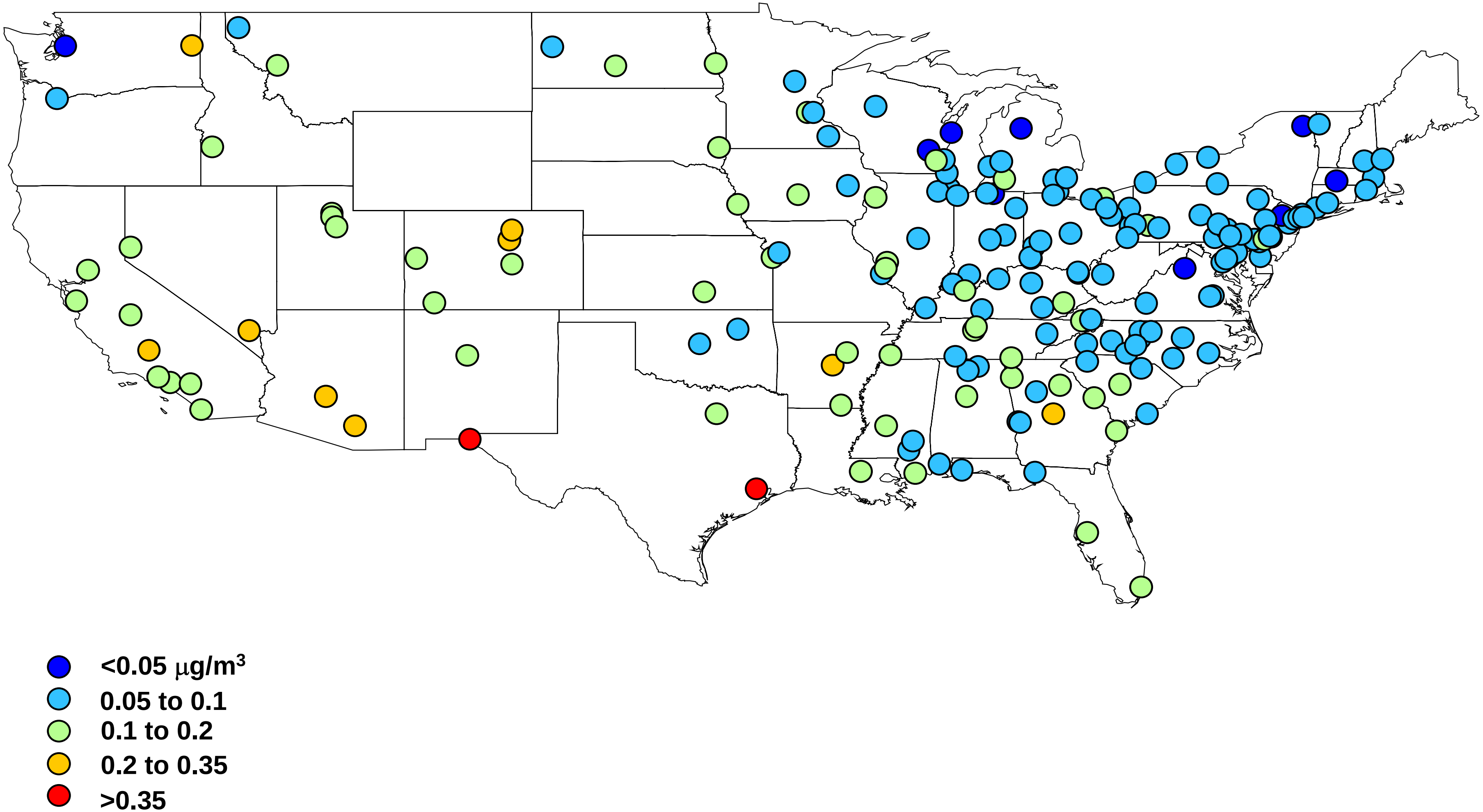


Figure S3. Seasonal sodium ion $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005

Figure S4. Silicon $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005



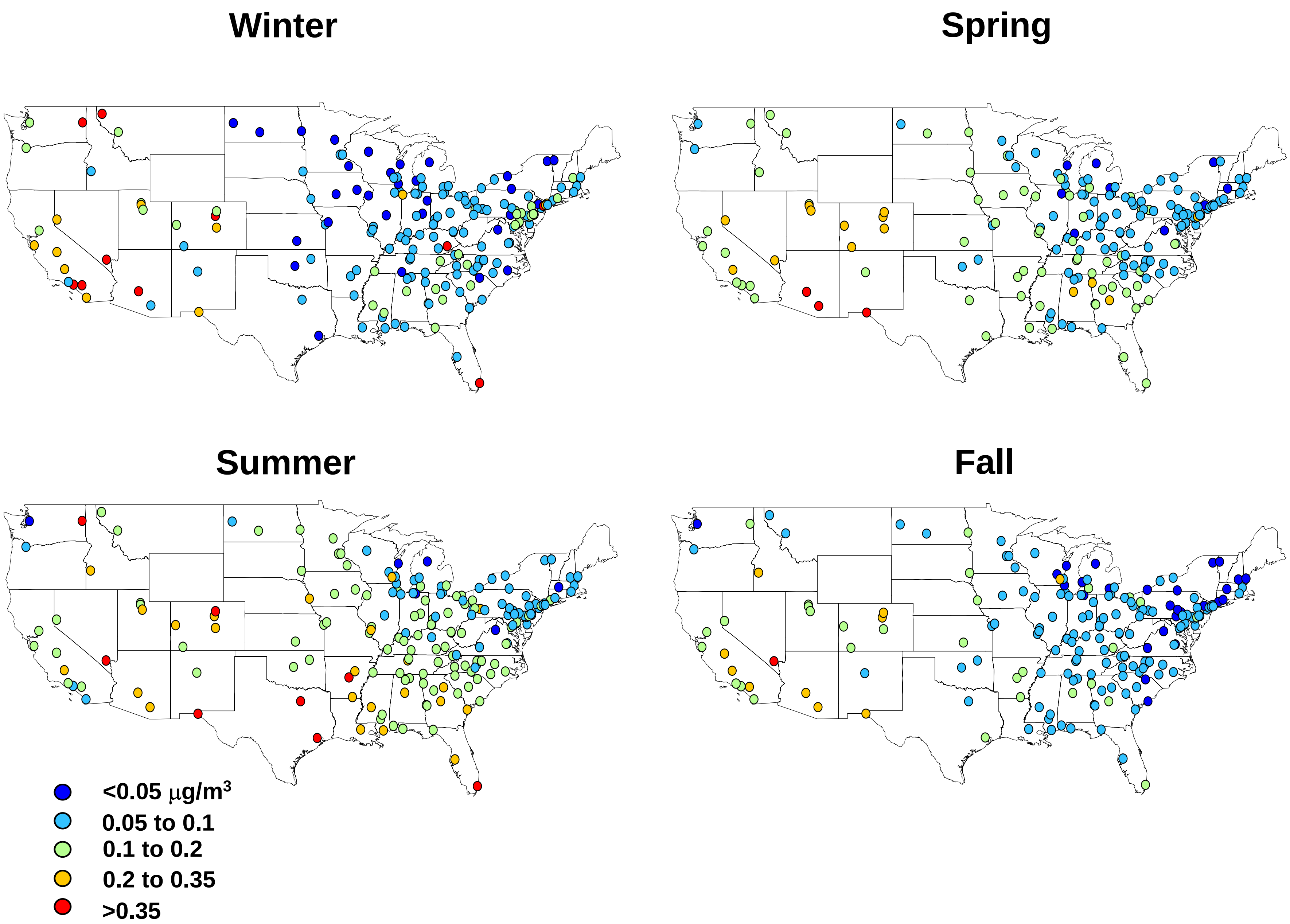
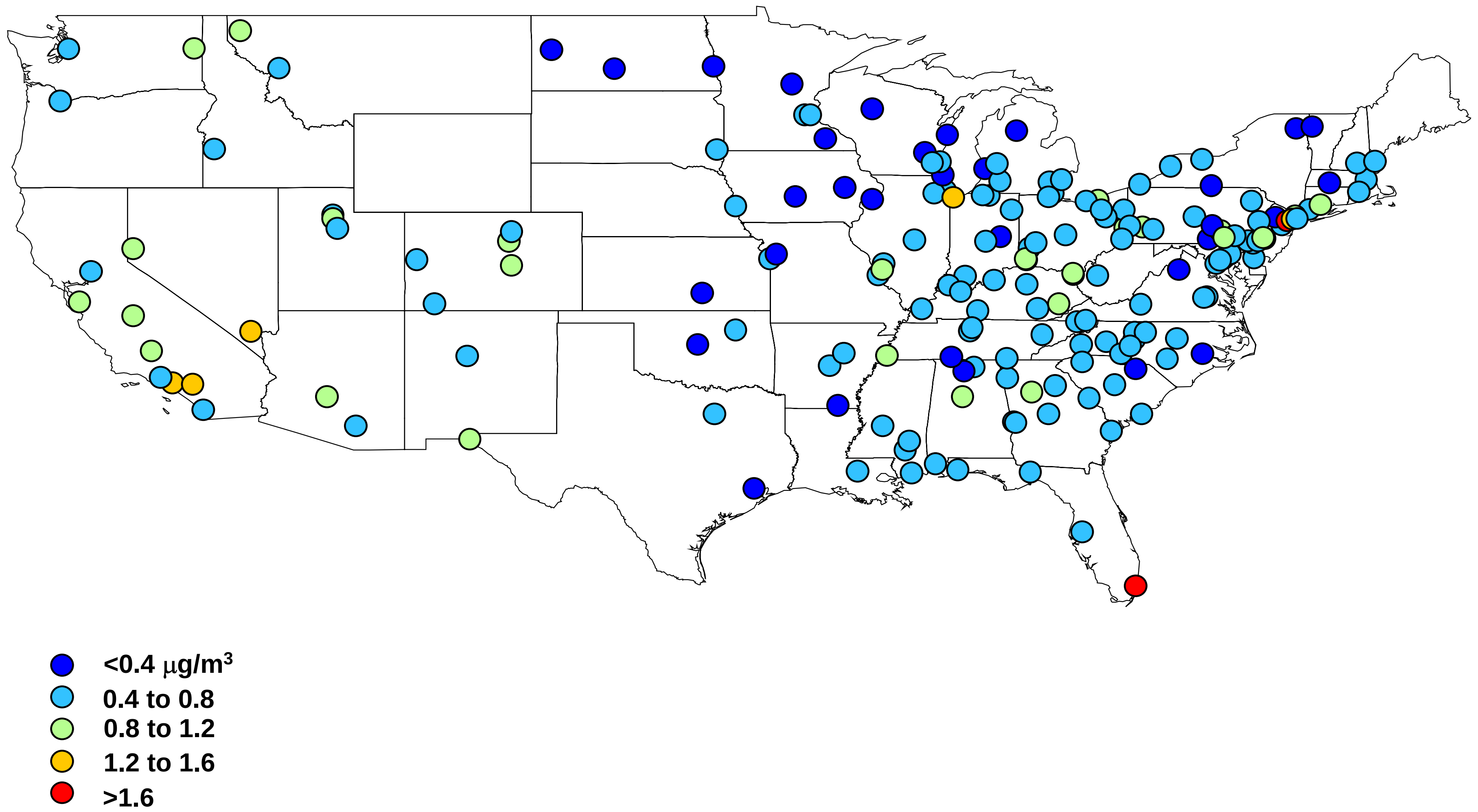


Figure S5. Seasonal silicon $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005

Figure S6. Elemental carbon $PM_{2.5}$ averages for 203 U.S. counties, 2000-2005



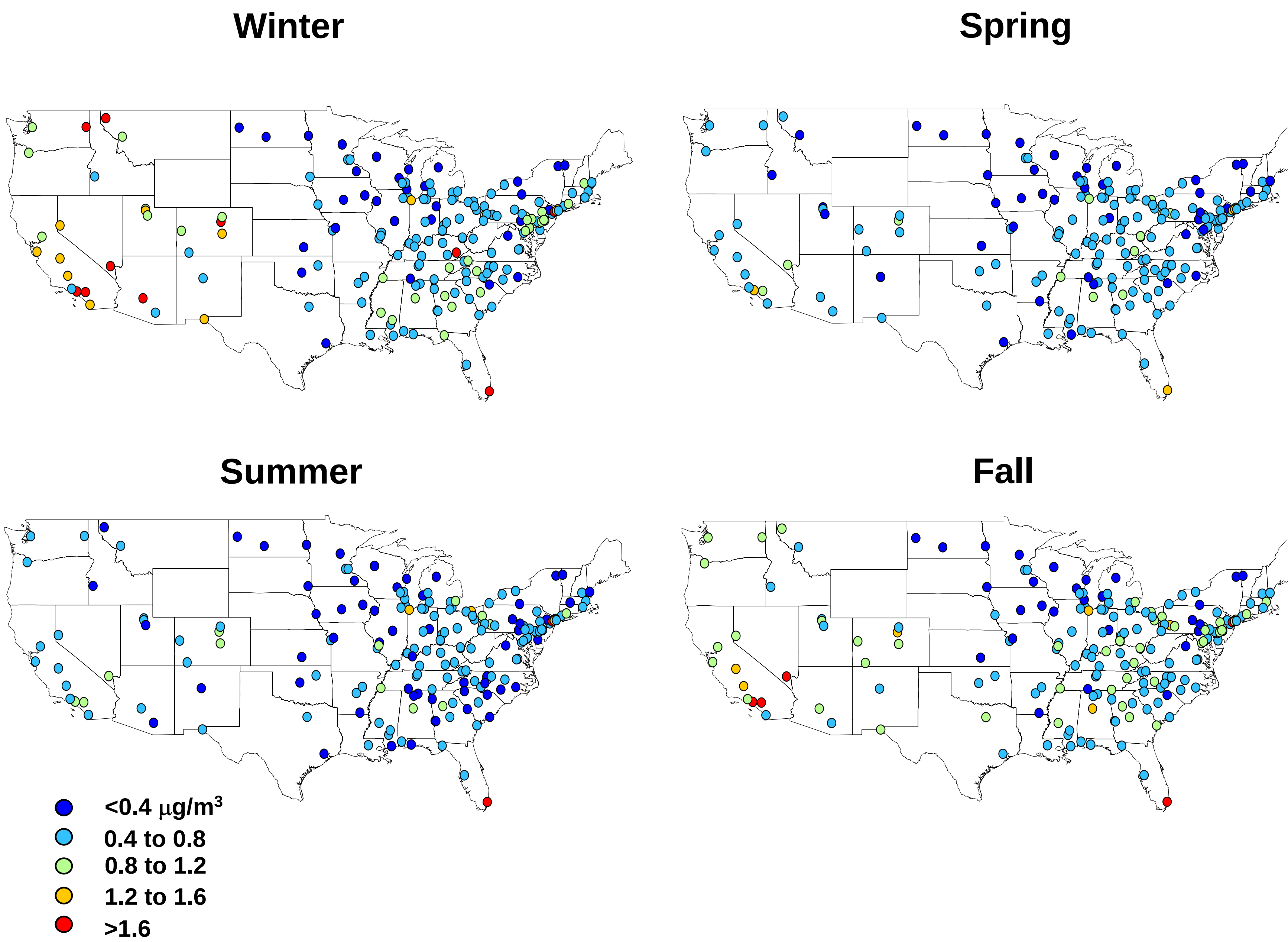
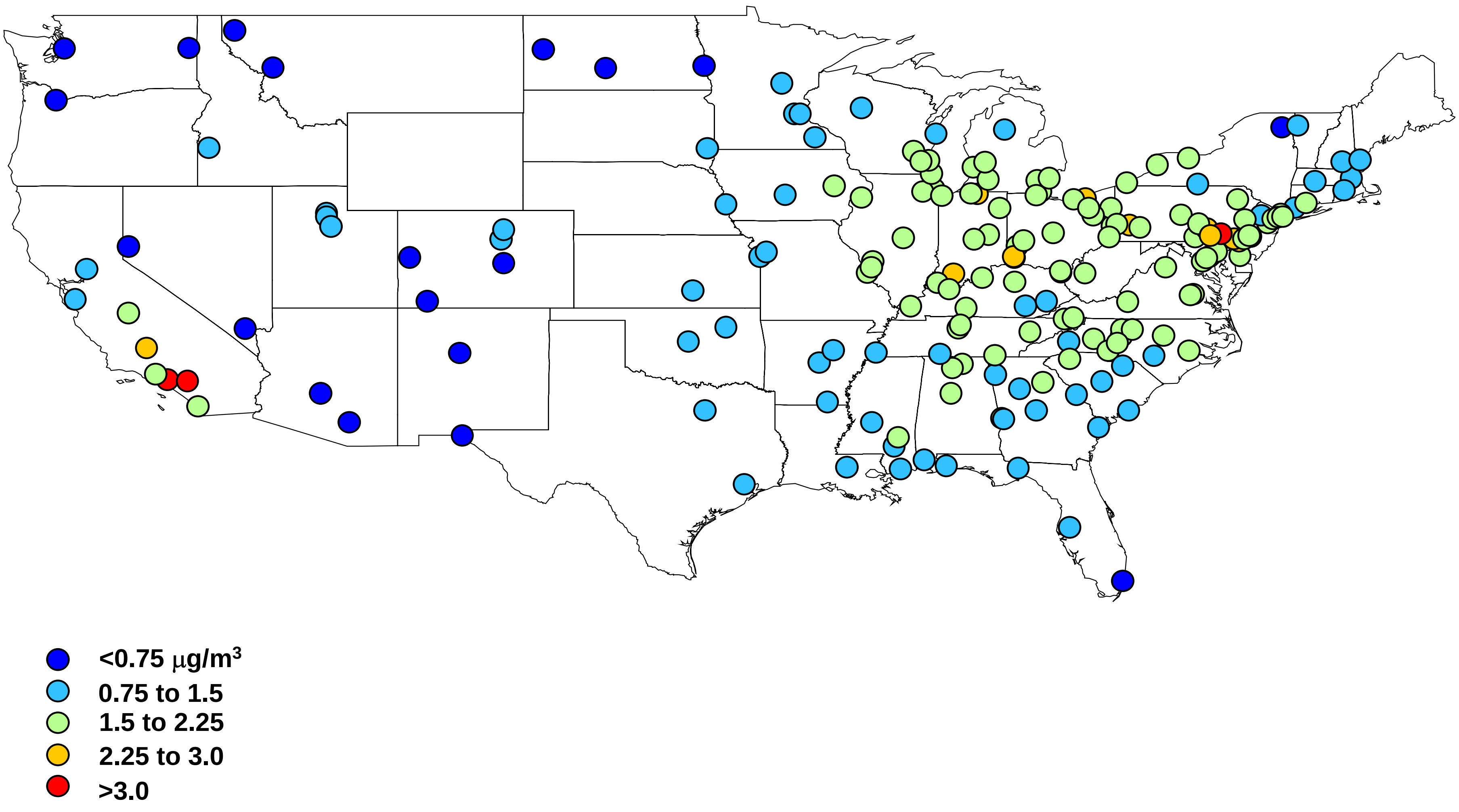


Figure S7. Seasonal elemental carbon $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005

Figure S8. Ammonium $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005



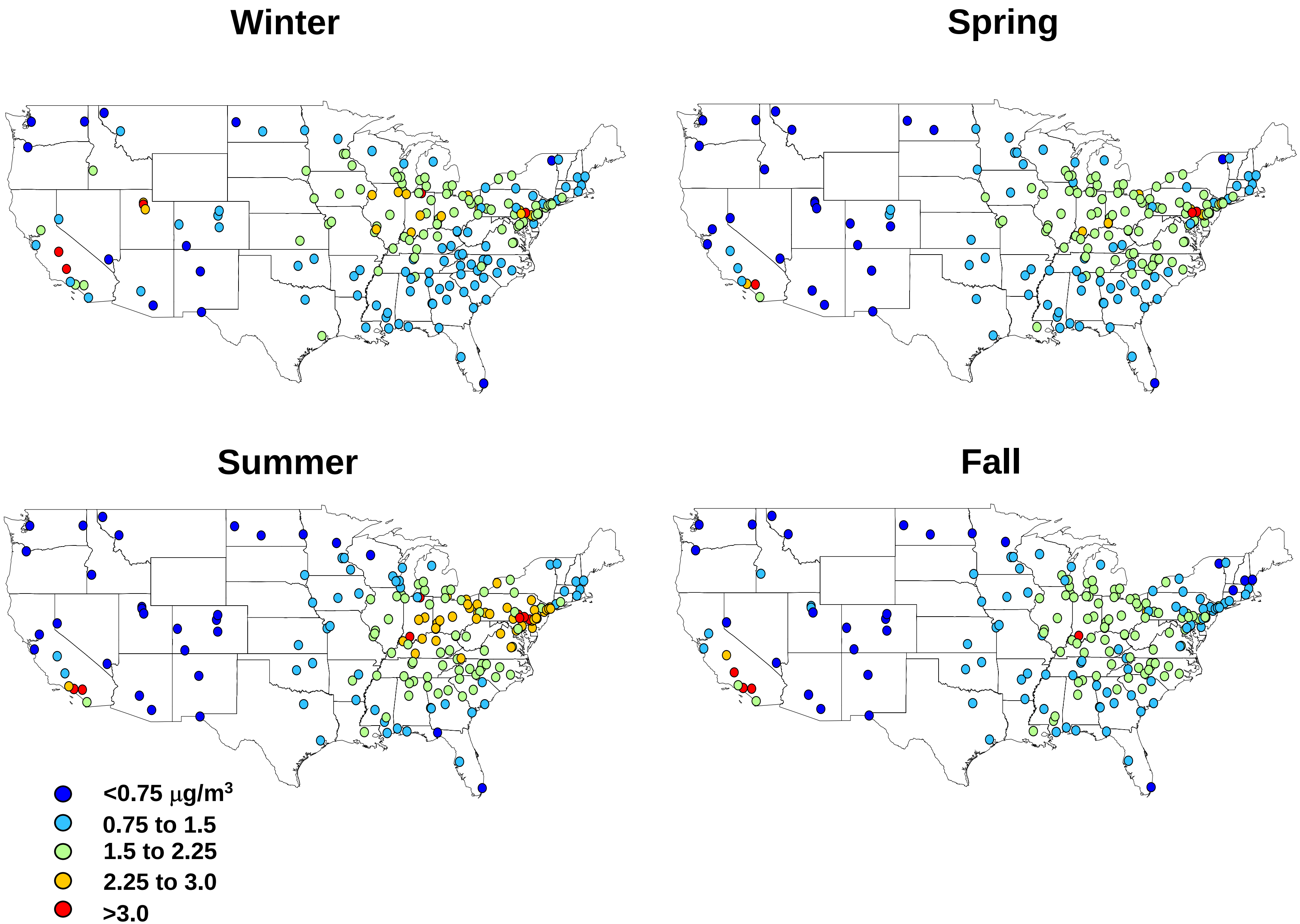
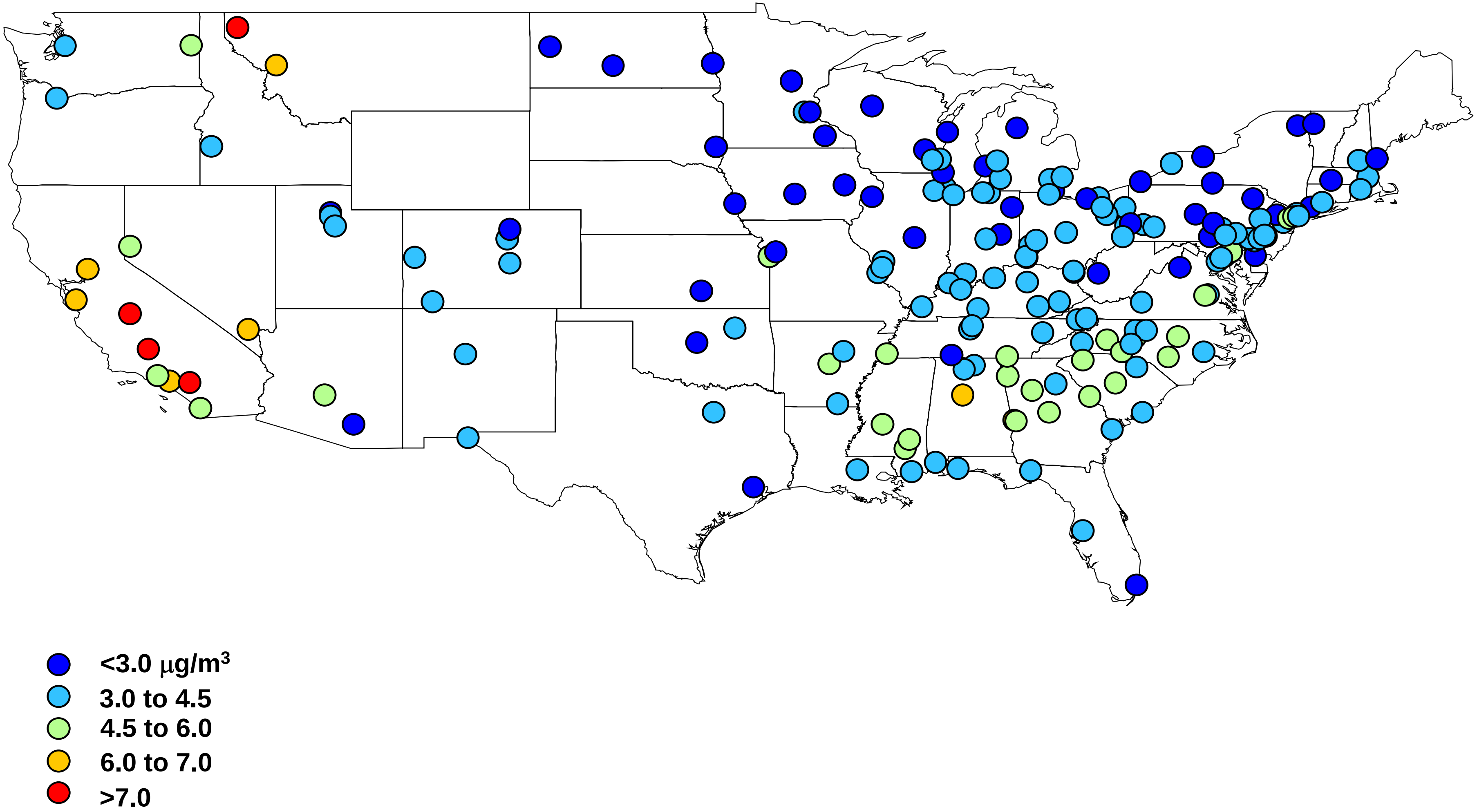


Figure S9. Seasonal ammonium $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005

Figure S10. OCM $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005



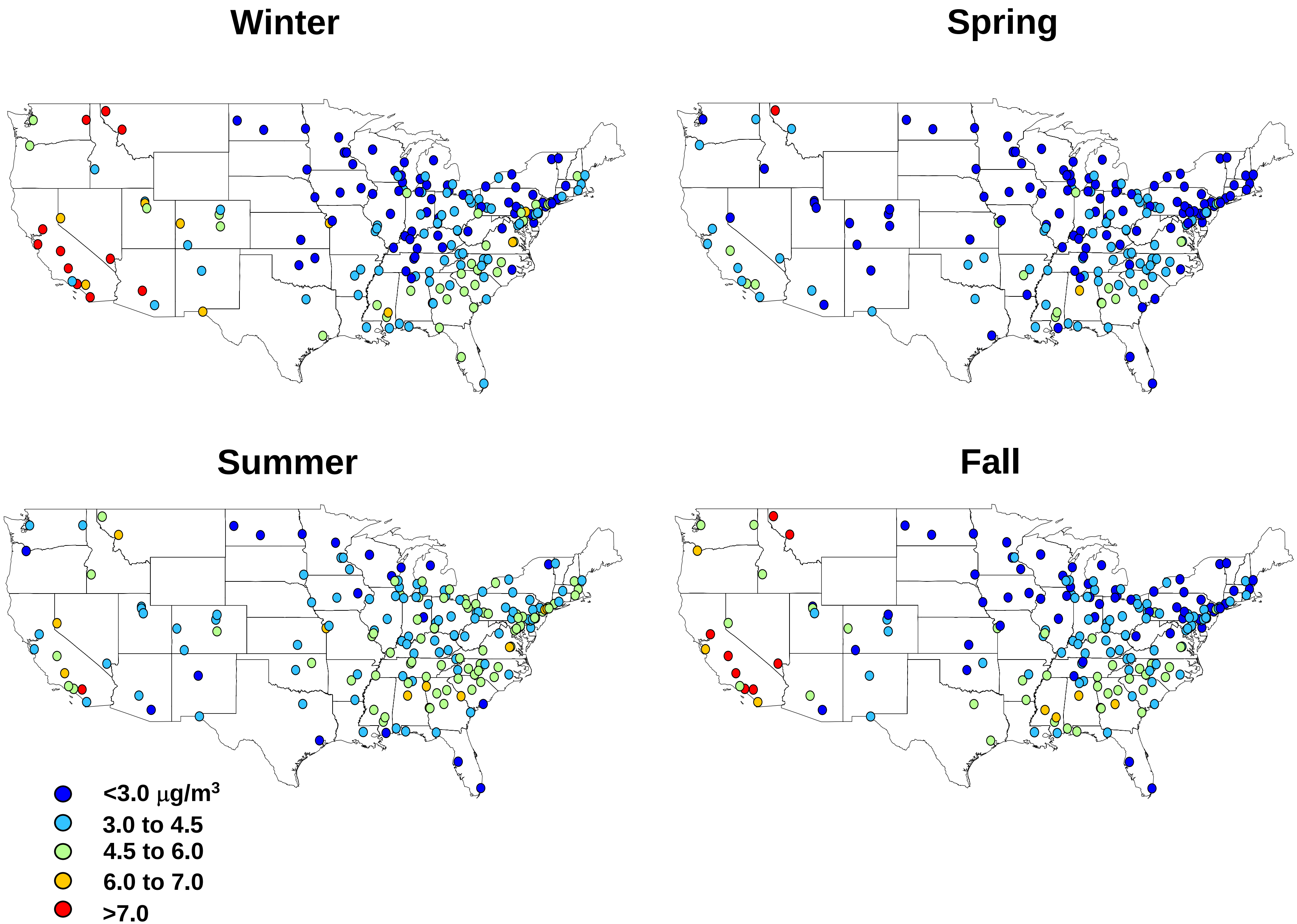


Figure S11. Seasonal OCM $PM_{2.5}$ averages for 187 U.S. counties, 2000-2005

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