Supplemental Online Material for:

The 2005 Study of Organic Aerosols in Riverside (SOAR): Overview, Instrumental Intercomparisons, and Fine Particle Composition

Kenneth S. Docherty[1,2,@,*] , Allison C. Aiken[1,2,#], J. Alex. Huffman[1,2,%], Ingrid M. Ulbrich[1,2], Peter F. DeCarlo[1,3,^], Donna Sueper[1,2,4], Douglas R. Worsnop[4], David C. Snyder[5,»], Brett D. Grover[6], Delbert J. Eatough[6], Allen H. Goldstein[7], Paul J. Ziemann[8], and Jose L. Jimenez[1,2,*]

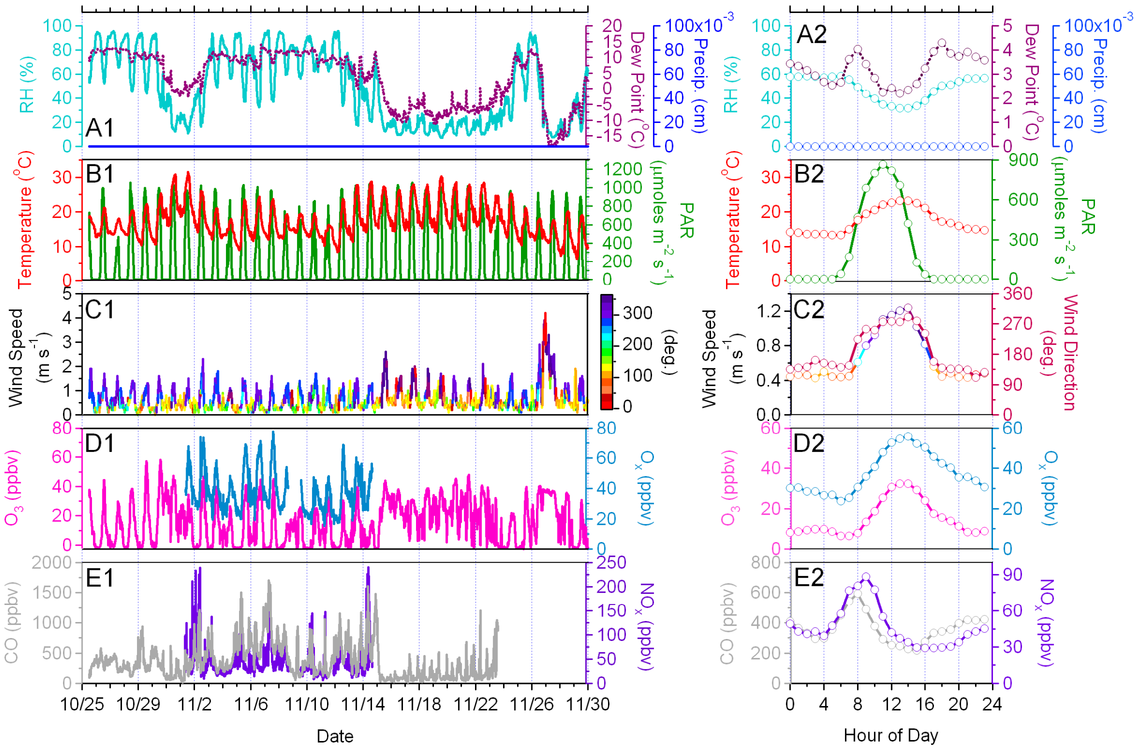

Figure S1. Time series (left) and diurnal averages (right) of meteorological conditions (RH, temperature, wind speed and direction), gas-phase species (O_3, O_x, CO, and NO_x), and elemental carbon during SOAR-2. Note that CO concentrations (in panels E1 and E2) have been offset vertically to account for a CO background of approx. 100 ppb.

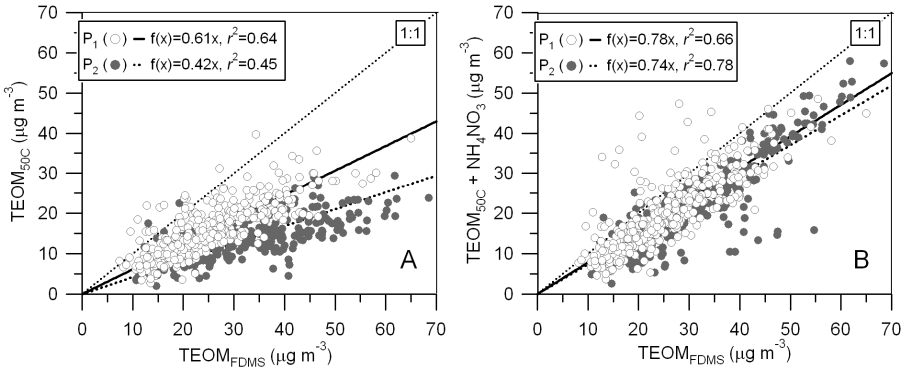

Figure S2. Comparison of TEOM measurements as reported, and after adding estimated NH_4NO_3 concentrations. $TEOM_{50C}$ measurements are plotted against $TEOM_{FDMS}$ in Fig. S2A while $TEOM_{50C}$ supplemented by calculated NH_4NO_3 mass are plotted against $TEOM_{FDMS}$ measurements in Fig. S2B along with the results of linear regression and correlation coefficients in both cases. Open symbols represent period P1 (7/18-8/1/2005) while filled symbols represent P2 (8/2-8/13/2005) measurements.

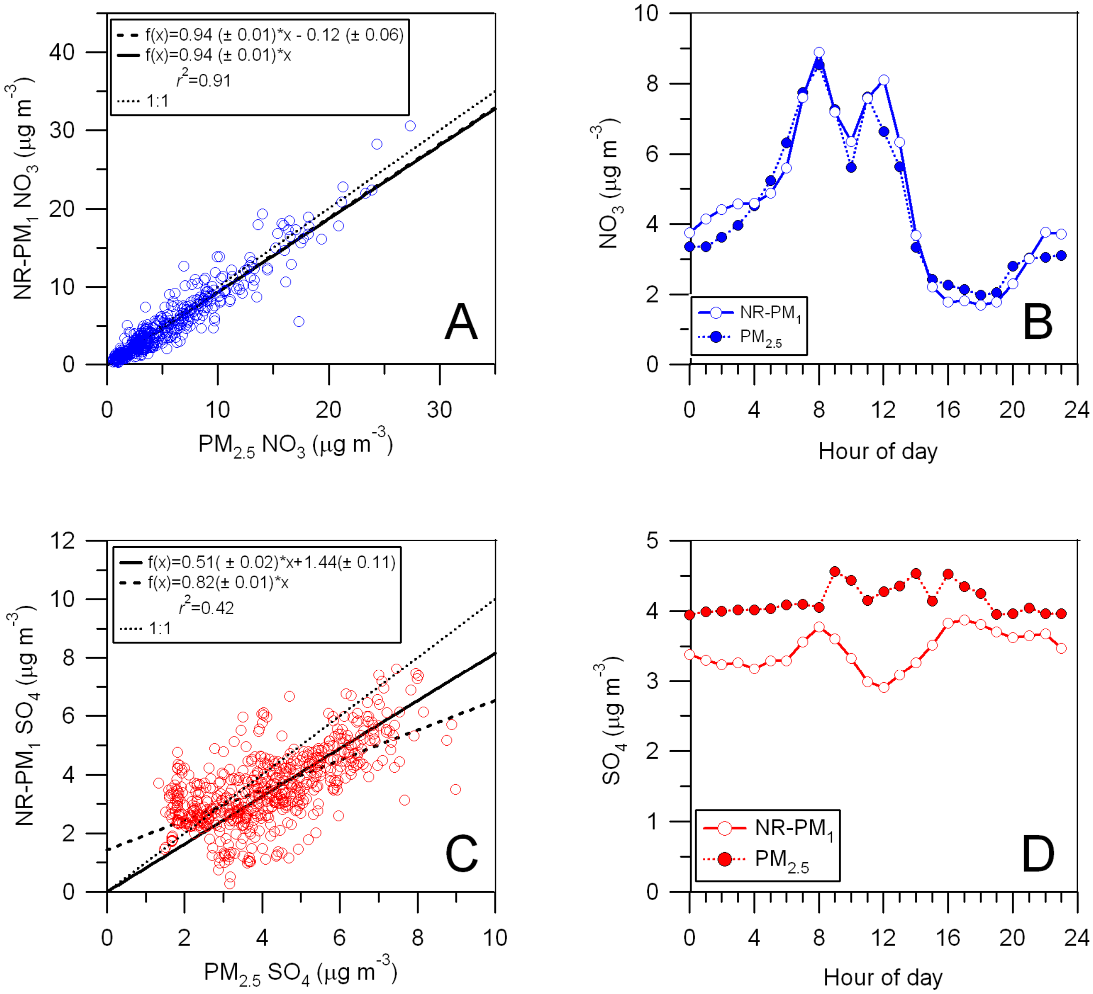

Figure S3. Comparison of NR-PM_1 and $PM_{2.5}$ NO_3 and SO_4 concentrations throughout the duration of SOAR-1. NR-PM_1 NO_3 and SO_4 concentrations obtained from the AMS are plotted against corresponding $PM_{2.5}$ concentrations in panels A and C, respectively, along with results of linear regression and correlation coefficients (r^2). Average diurnal profiles for both NR-PM_1 and $PM_{2.5}$ NO_3 and SO_4 measurements are also shown in panels B and D, respectively.

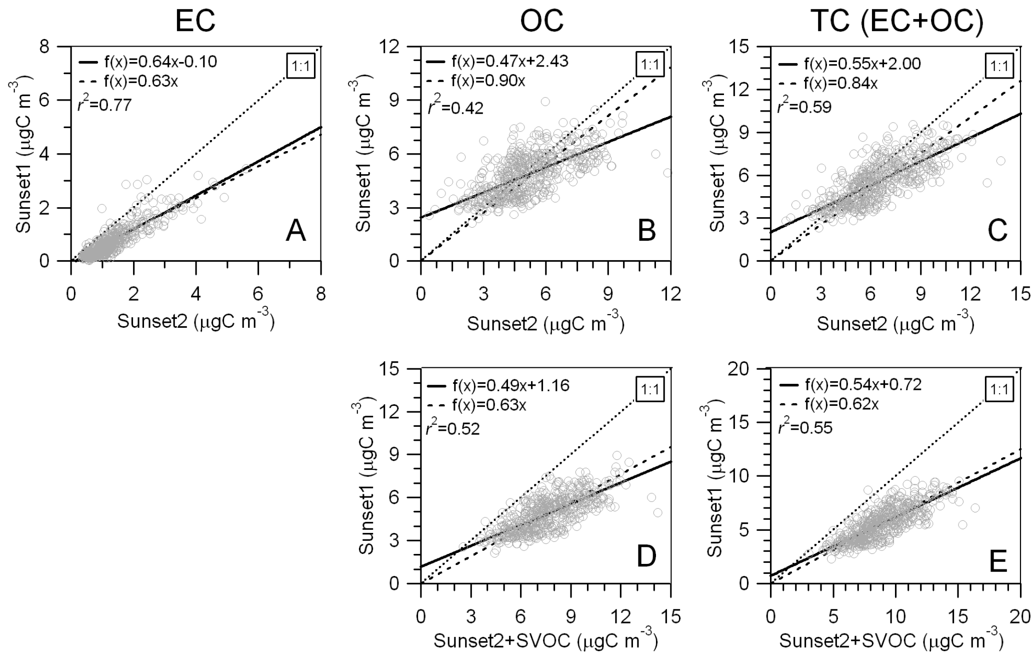

Figure S4. Comparison of EC, OC, and total carbon (i.e., EC+OC, TC) measured by Sunset1 and Sunset2 and Sunset2+SVOC.

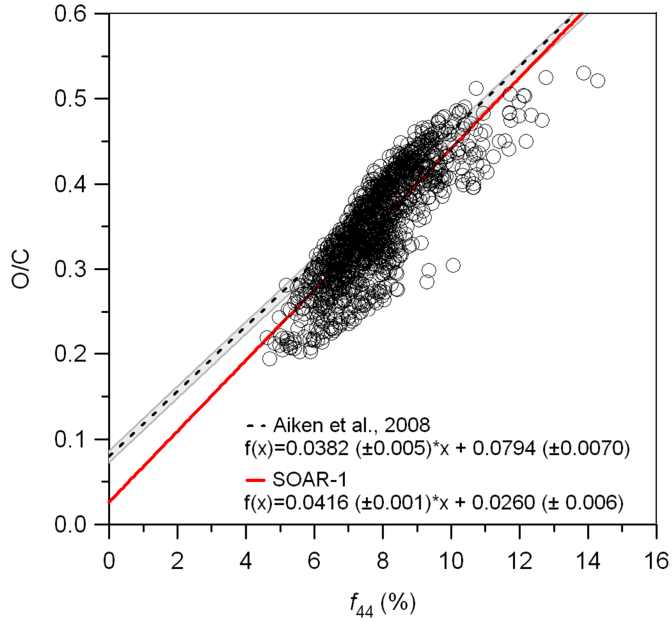

Figure S5. Scatter plot of f_{44} vs. O/C derived from HR-AMS high-resolution data during SOAR-1. Results in linear regression of SOAR-1 data are shown along with similar results from Aiken et al. (2008) for comparison.

Table S1. Research groups participating in SOAR along with their institution, measurements, and publications.

Group	Institution	Measurement	SOAR-1	SOAR-2	Publications including results from SOAR	Funding Sources
Arey	University of California-Riverside	$PM_{2.5}$ filter sampling	■			
Eatough	Brigham Young University	monitor, $TEOM_{FDMS}$, $TEOM_{50C}$, PC-BOSS, IC-NO_3, IC-SO_4	■		Eatough et al. 2008; Grover et al. 2008; Eatough et al. 2009; Grover et al. 2009; Docherty et al., this paper	NSF ATM-0407695
Fitz	University of California-Riverside	$PM_{2.5}$ filter sampling	■			US EPA R831087
Goldstein	University of California-Berkeley	Thermal desorption aerosol GC/MS (TAG), GC/MS for VOC analysis CO, Ozone, meteorological measurements	■	■	Gentner et al. 2009; Kreisberg et al. 2009; Williams et al. 2010a; Gentner et al. 2010; Willaims et al 2010b; Docherty et al. 2008; Docherty et al., this paper	US EPA RD-83096401-0 CARB 03-324
Hannigan	University of Colorado-Boulder	$PM_{2.5}$ filter sampling	■			
Hering	Aerosol Dynamics, Inc.	Thermal desorption aerosol GC/MS (TAG), CPC bank including nano-water CPC	■		Iida et al. 2008; Kreisberg et al. 2009; Williams et al. 2010a; Williams et al. 2010b	US DOE DE-GF-02-05ER63997 NSF ATM-0506674 CARB 04-03
Hopke	Clarkson University	$PM_{2.5}$ filter sampling	■		Reemtsma et al. 2006	US EPA STAR R827354, RD832415
Jimenez	University of Colorado-Boulder	HR-ToF-AMS, C-ToF-AMS, Thermal denuder, SMPS, Cloud condensation nuclei counter, Grimm OPC Aerosol particle mass analyzer (APM)	■	■	DeCarlo et al. 2006; Zhang et al. 2007; Docherty et al. 2008; Cubison et al. 2008; Jimenez et al. 2009; Huffman et al. 2009a; Huffman et al. 2009b; Heald et al. 2010; Ng et al. 2010; Ervens et al. 2010; Farmer et al. 2010; Docherty et al., this paper	US EPA STAR RD-83216101-0, R831080 NSF ATM-0449815 NSF/UCAR S05-39607 NOAA NA08OAR4310565
Paulson	University of California - Los Angeles	Filter sampling, HPLC-flourosence peroxide analysis	■		Wang et al. 2010	CARB 04-319
Prather	University of California-San Diego	Aerosol Time-of-Flight Mass Spectrometer (ATOFMS), Ultrafine ATOFMS, Aircraft ATOFMS, SMPS Aerosol particle sizer (APS)	■	■	Spencer et al. 2007; Denkenberger et al. 2007; Shields et al. 2008; Moffet et al. 2008; Pratt et al. 2009a; Pratt et al. 2009b	NSF ATM-0321362, ATM-05011803, ATM-0528227 CARB 04-336 US EPA PM Center R827354
Schauer	University of Wisconsin-Madison	Standard Sunset semi-continuous EC/OC analyzer, 7-channel aethelometer, Hg speciation sampler, $PM_{2.5}$ filter sampling	■		Snyder et al. 2007; Snyder et al. 2008; Stone et al. 2009a; Stone et al. 2009b; Docherty et al. 2008; Sheelsey et al. 2010 Docherty et al., this paper	US EPA STAR R831080, RD-83216101-0, R-82979 NSF ATM-0449815
Seinfeld	California Institute of Technology	C-ToF-AMS, PILS-IC at Caltech (Pasadena)	■		Docherty et al. 2008	
Sioutas	University of Southern California	Ultrafine aerosol concentrator Aerosol particle mass analyzer (APM)	■		Geller et al. 2006; DeCarlo et al. 2006	US EPA STAR 53-4507-0482, 53-4507-7721
Thiemens	University of California-San Diego	Sulfate and nitrate isotope analysis	■			
Weber	Georgia Institute of Technology	PILS-WSOC, PILS-OC	■		Peltier et al. 2007; Docherty et al. 2008	CARB 98-316, EPA STAR RD-83216101-0
Worsnop	Aerodyne Research Inc.	HR-ToF-AMS, C-ToF-AMS with soft ionization	■			US DOE DE-FG02-04ER83890
Ziemann	University of California-Riverside	spectrometer NO_x analyzer	■	■	Docherty et al., this paper	

Table S2. Average $TEOM_{FDMS}$, AMS+EC, and $TEOM_{50C}$ final particle mass concentrations during SOAR-1 periods 1 (P1) and 2 (P2)

	P1 (7/18-8/1)		P2 (8/2-8/14)		P1 (7/18-8/1)		P2 (8/2-8/14)	
Measurement	Avg. ($\mu g\ m^{-3}$)	+/- S.D. ($\mu g\ m^{-3}$)	Avg. ($\mu g\ m^{-3}$)	+/- S.D. ($\mu g\ m^{-3}$)	ratio[a] ($\mu g\ m^{-3}$)	+/- S.D. ($\mu g\ m^{-3}$)	ratio[a] ($\mu g\ m^{-3}$)	+/- S.D. ($\mu g\ m^{-3}$)
$TEOM_{FDMS}$	26.36	10.89	31.79	11.4	na	na	na	na
AMS+EC	18.29	7.98	24.36	10.46	0.69	0.6	0.77	0.56
$TEOM_{50C}$	15.87	6.55	13.96	4.88	0.6	0.58	0.44	0.5

[a] Ratio of measurement to $TEOM_{FDMS}$ mass (e.g., $x/TEOM_{FDMS}$)

Table S3. Statistical comparison of OC measurements by HR-AMS and Sunset instruments

	HR-AMS	Sunset 1	Sunset 2	Sunset 2 (+ SVOC)
Average (μgC m^{-3})	5.61	5.13	5.16	7.60
n	531	652	556	556
Absolute Difference[a]				
HR-AMS				
Sunset 1	1.09			
Sunset 2	1.28	1.04		
Sunset 2 (+ SVOC)	2.36	2.71	2.44	
Relative Difference[b]				
HR-AMS		0.21	0.25	0.31
Sunset 1	0.19		0.20	0.35
Sunset 2	0.23	0.20		0.32
Sunset 2 (+ SVOC)	0.42	0.53	0.47	
Relative Difference[c]				
HR-AMS		0.21	0.30	0.31
Sunset 1	0.20		0.23	0.34
Sunset 2	0.25	0.22		0.33
Sunset 2 (+ SVOC)	0.53	0.58	0.55	
r^2				
HR-AMS				
Sunset 1	0.53			
Sunset 2	0.36	0.42		
Sunset 2 (+ SVOC)	0.45	0.52	0.84	
Uncentered r^2				
HR-AMS				
Sunset 1	0.73			
Sunset 2	0.53	0.64		
Sunset 2 (+ SVOC)	0.54	0.66	0.98	

[a] Global average of absolute difference between measurements (e.g., avg[abs(row$_i$-column$_i$)])

[b] Absolute difference normalized by column global average (e.g., avg[abs(row$_i$-column$_i$)]/avg(column$_i$

[c] Average value of individual relative absolute difference (e.g., avg[abs(row$_i$-column$_i$)/column$_i$])

Table S4. Average concentration of NR-PM_1 components and composition of AMS+EC

	Concentration		Mass fraction of AMS+EC
Species	Avg. ($\mu g\ m^{-3}$)	S.D. ($\mu g\ m^{-3}$)	(%)
7/18-8/13-2005			
OA	9.12	3.59	44.40
EC	0.89	0.74	4.33
NH_4	2.48	1.38	12.07
NO_3	4.42	4.55	21.52
SO_4	3.55	1.09	17.28
Cl	0.09	0.08	0.44
AMS+EC	20.54	9.42	
7/18-8/1/2005 (P1)			
OA	8.90	3.53	48.66
EC	0.99	0.81	5.41
NH_4	2.03	1.01	11.10
NO_3	2.93	3.03	16.02
SO_4	3.37	1.02	18.43
Cl	0.07	0.07	0.38
AMS+EC	18.29	7.98	
8/2-8/13/2005 (P2)			
OA	9.50	3.67	44.48
EC	0.70	0.56	3.28
NH_4	3.25	1.56	15.22
NO_3	6.94	5.47	32.49
SO_4	3.85	1.15	18.02
Cl	0.11	0.09	0.51
AMS+EC	21.36	10.46	

References

Eatough, D. J., and Farber, R.: Apportioning Visibility Degradation to Sources of PM2.5 Using Positive Matrix Factorization, J. Air Waste Manage. Assoc., 59, 1092-1110, 10.3155/1047-3289.59.9.1092, 2009.

Ervens, B., Cubison, M. J., Andrews, E., Feingold, G., Ogren, J. A., Jimenez, J. L., Quinn, P. K., Bates, T. S., Wang, J., Zhang, Q., Coe, H., Flynn, M., and Allan, J. D.: CCN predictions using simplified assumptions of organic aerosol composition and mixing state: a synthesis from six different locations, Atmos. Chem. Phys., 10, 4795-4807, 10.5194/acp-10-4795-2010, 2010.

Farmer, D. K., Matsunaga, A., Docherty, K. S., Surratt, J. D., Seinfeld, J. H., Ziemann, P. J., and Jimenez, J. L.: Response of an aerosol mass spectrometer to organonitrates and organosulfates and implications for atmospheric chemistry, Proc. Natl. Acad. Sci. U. S. A., 107, 6670-6675, 10.1073/pnas.0912340107, 2010.

Geller, M., Biswas, S., and Sioutas, C.: Determination of particle effective density in urban environments with a differential mobility analyzer and aerosol particle mass analyzer, Aerosol Sci. Technol., 40, 709-723, 10.1080/02786820600803925, 2006.

Gentner, D. R., Harley, R. A., Miller, A. M., and Goldstein, A. H.: Diurnal and Seasonal Variability of Gasoline-Related Volatile Organic Compound Emissions in Riverside, California, Environ. Sci. Technol., 43, 4247-4252, 10.1021/es9006228, 2009.

Gentner, D. R., Miller, A. M., and Goldstein, A. H.: Seasonal Variability in Anthropogenic Halocarbon Emissions, Environ. Sci. Technol., 44, 5377-5382, 10.1021/es1005362, 2010.

Huffman, J. A., Docherty, K. S., Mohr, C., Cubison, M. J., Ulbrich, I. M., Ziemann, P. J., Onasch, T. B., and Jimenez, J. L.: Chemically-Resolved Volatility Measurements of Organic Aerosol from Different Sources, Environ. Sci. Technol., 43, 5351-5357, 10.1021/es803539d, 2009b.

Pratt, K. A., Hatch, L. E., and Prather, K. A.: Seasonal Volatility Dependence of Ambient Particle Phase Amines, Environ. Sci. Technol., 43, 5276-5281, 10.1021/es803189n, 2009a.

Pratt, K. A., Mayer, J. E., Holecek, J. C., Moffet, R. C., Sanchez, R. O., Rebotier, T. P., Furutani, H., Gonin, M., Fuhrer, K., Su, Y. X., Guazzotti, S., and Prather, K. A.: Development and Characterization of an Aircraft Aerosol Time-of-Flight Mass Spectrometer, Anal. Chem., 81, 1792-1800, 10.1021/ac801942r, 2009b.

Sheesley, R. J., Deminter, J. T., Meiritz, M., Snyder, D. C., and Schauer, J. J.: Temporal trends in motor vehicle and secondary organic tracers using in situ methylation thermal desorption GCMS, Environ. Sci. Technol., 44, 9398-9404, 10.1012/es102301t, 2010

Shields, L. G., Qin, X. Y., Toner, S. M., and Prather, K. A.: Detection of ambient ultrafine aerosols by single particle techniques during the SOAR 2005 campaign, Aerosol Sci. Technol., 42, 674-684, 10.1080/02786820802227378, 2008.

Snyder, D. C., Dallmann, T. R., Schauer, J. J., Holloway, T., Kleeman, M. J., Geller, M. D., and Sioutas, C.: Direct observation of the break-up of a nocturnal inversion layer using elemental mercury as a tracer, Geophys. Res. Lett., 35, 5, L17812, 10.1029/2008gl034840, 2008.

Williams, B. J., Goldstein, A. H., Kreisberg, N. M., Hering, S. V.: In situ measurements of gas/particle-phase transitions for atmospheric semivolatile organic compounds, Proc. Natl. Acad. Sci. U. S. A., 107, 15, 6676-6681, 2010.