COLLABORATIVE RESEARCH: Study of Aerosol Sources and Processing at the GVAX Pantnagar Supersite

Final Report

Covering the Period 4/15/2011 to 4/14/2014
Prepared 6/28/2014

Principal Investigator: Dr. Douglas Worsnop worsnop@aerodyne.com
Aerodyne Research, Inc. 978-663-9500
45 Manning Rd., Billerica, MA 01821

DOE/Office of Science Program Office: Office of Biological and Environmental Research

DOE/Office of Science Program Technical Contact: Dr. Ashley Williamson

DOE Award No. DE-SC0006002
ARI Project # 10744

3. Executive Summary

This project funded the participation of scientists from seven research groups, running more than thirty instruments, in the Winter Intensive Operating Period (January-February 2012) of the Clean Air for London (ClearfLo) campaign at a rural site in Detling, UK, 45 km southeast of central London. The primary science questions for the ClearfLo Winter IOP were, 1) what is the urban increment of particulate matter (PM) and other pollutants in the greater London area, and, 2) what is the contribution of solid fuel use for home heating to wintertime PM? An additional motivation for the Detling measurements was the question of whether coatings on black carbon particles enhance absorption.

The following four key accomplishments have been identified so far:

1) Chemical, physical and optical characterization of PM from local and regional sources (Figures 2, 4, 5 and 6).

2) Measurement of urban increment in particulate matter and gases in London (Figure 3).

3) Measurement of optical properties and chemical composition of coatings on black carbon containing particles indicates absorption enhancement.

4) First deployment of chemical ionization instrument (MOVI-CI-TOFMS) to measure both particle-phase and gas-phase organic acids. (See final report from Joel Thornton, University of Washington, for details.)

Analysis of the large dataset acquired in Detling is ongoing and will yield further key accomplishments. These measurements of urban and rural aerosol properties will contribute to improved modeling of regional aerosol emissions, and of atmospheric aging and removal. The measurement of absorption enhancement by coatings on black carbon will contribute to improved modeling of the direct radiative properties of PM.

4. Schedule Status

Year	Proposed Task	Progress
Year 1	Construct containers and integrate instruments for deployment.	Containers constructed, instruments integrated, containers deployed to Detling, UK for Jan-Feb, 2012 measurement campaign.
Year 2	Deploy containers to Pantnagar, India and make measurements. Preliminary data analysis and quality assurance.	UK deployment concluded, preliminary data analysis and quality assurance completed, final data analysis started.
Year 3	Analysis of field data and publication of results.	Final data analysis ongoing. Data posted to BADC archive and ARM archive. One article published, two in press, multiple in preparation.

5. Project Activities

This project was originally funded as a supersite in Pantnagar, India to complement the cloud and aerosol properties measured by the AMF 1 at the Nainital Observatory in India during the Ganges Valley Aerosol Experiment (GVAX). The Pantnagar site project was cancelled in late November, 2011, shortly before the scheduled shipment of instruments to India. We were approved to participate instead in the Clear Air for London (ClearfLo) campaign in January and February, 2012. ClearfLo is a large, multidisciplinary study of the London urban atmosphere aimed at understanding the relationships between surface meteorology, gas-phase composition and particulate matter at a city street site, a city background site (away from local traffic sources) and at a rural location that samples the outflow from the London megacity. In addition to year long measurements, two intensive operating periods (IOPs) were planned for January-February and July-August, 2012. The winter time studies also provide information on gas and particle emissions from home heating solid fuels. The ClearfLo project is coordinated by the UK National Centre for Atmospheric Science with support from the UK Natural Environment Research Council.

We deployed a suite of instruments to measure particulate chemical composition, including organics, inorganics and black carbon, size distributions, optical properties and hygroscopic properties, as well as gas-phase oxidants and aerosol precursors, at the rural site southeast of London at Detling, UK during the January-February, 2012 intensive. A particular focus of this study is on understanding the processing of black carbon particles. Recent results from the CalNex/CARES campaign in 2010 suggest that our understanding of the morphology of coated black carbon particles is incomplete, and this study will provide a second test case.

Several research groups joined together to provide the Detling rural site with continuous, high time resolution measurements of aerosol chemistry and microphysics, measurements of gas-phase tracers and secondary organic aerosol (SOA) precursors, and radiative and meteorological measurements. Aerodyne Research, Inc. (ARI) and Georgia Institute of Technology provided instruments to monitor aerosol chemical composition, including organics, inorganics, and black carbon, as well as extinction, and single scattering albedo. ARI also deployed instruments for state of the art measurements of trace gas species. The University of Washington, Seattle deployed a newly developed, high sensitivity mass spectrometer system (MOVI-CI_TOFMS) that is capable of near real-time measurements of molecular level composition of both gas and particle-phase organics. Los Alamos National Laboratory (LANL) provided measurements of in-situ aerosol optical properties and size distributions, and Argonne National Laboratory (ANL) provided remote sensing and meteorology measurements. A complete list of instruments that successfully collected data at the Detling site is shown in Table 1.

Table 1. Instrument List for ClearfLo Detling, UK site.

Institute / Investigator	Instrument	Species/Parameters Measured
ARI / S. Herndon	2B Tech	O3
ARI / S. Herndon	Thermo 42i	NO
ARI / S. Herndon	ARI CAPS	NO2
ARI / S. Herndon	Licor	CO2
ARI / S. Herndon	ARI QCL	CO, N2O
ARI / S. Herndon	ARI QCL	NO2
CEH / D. Famulari	ARI mini-QCL	N2O, CO2, H2O
LANL / M. Dubey	Picarro CRDS	CH4, CO2, H2O
ARI / S. Herndon	GC-FID	Gas-phase VOC
MSU / W. B. Knighton	PTR-MS	Gas-phase VOC
UW / C. Mohr	ARI MOVI-HR-ToF-CIMS	Gas and particle phase organic acids

GIT / N. L. Ng	ARI HR-ToF-AMS	Nonrefractory, submicron particulate (SO4=/NO3-/Cl-/NH4+/Organics)
ARI / L. Williams	ARI SP-AMS	Nonrefractory submicron particulate + black carbon
PSI / S. Visser	3-stage Rotating Drum Impactor	Trace elements in PM1.0, PM2.5 and PM10
PSI / P. Zotter	Hi Vol Sampler	14C in TC, EC/OC concentrations
LANL / A. Aiken	DMT SP-2	Black carbon number, mass loading and coating thicknesses
PSI / P. Zotter	Magee AE31 Aethalometer	7 wavelength aerosol optical absorption and equivalent black carbon
ARI / L. Williams	Thermo MAAP	Aerosol optical absorption and equivalent black carbon
LANL / A. Aiken	DMT PASS-3	3 wavelength aerosol optical absorption, scattering
ARI / P. Massoli	ARI CAPS PMex 630	Aerosol extinction at 630 nm
LANL / A. Aiken	ARI CAPS PMex 450	Aerosol extinction at 450 nm
LANL / A. Aiken	TSI Laser Particle Sizer 3340	Particle size and number (0.07-10 micrometer)
LANL / A. Aiken	TSI SMPS	Particle size and number (8-600 nm)
ARI / L. Williams	Portamet	T, RH, wind speed and direction
ANL / R. Coulter	Vaisala WXT520 Weather Station	T, RH, wind speed and direction, precip.
ANL / R. Coulter	Micro Pulse Lidar	Cloud base, aerosol extinction via backscatter
ANL / R. Coulter	Pyranometer SPN-1	Total, diffuse radiation
ANL / R. Coulter	SODAR	Wind field up to 400 m
ANL / R. Coulter	MFRSR	Radiance, 7 wavelengths

During Year 1, we purchased two seatainers and had them modified to our specifications. One was outfitted as a laboratory with insulation, electrical transformer and distribution panel, lighting, and unistrut on the floors, walls and ceiling for mounting instruments. Approximately half of the instruments in Table 1 were integrated into this seatainer at Aerodyne during October and November 2011. A computer system with a server and multiple redundant backup drives was also installed. These instruments were operated at Aerodyne during November to test the electrical system and the data system. The second seatainer was outfitted for shipping and storage with lighting and unistrut. The remaining instruments in Table 2 were packed in this seatainer for shipping, along with materials and supplies for the deployment.

The containers were picked up at Aerodyne at the end of December 2011 and shipped to the sampling site at the Kent Showgrounds in Detling, UK. We rented two portacabins, one for use as laboratory space and one for use as office space. We constructed a sampling tower and mounted inlet lines for both particle-phase and gas-phase instruments. A met station was also mounted on the sampling tower. A photograph of the site is shown in Figure 1.The deployment took place between January 6 and February 15, 2012. At the conclusion of the measurement period, the instruments were shipped back to Aerodyne Research, Inc, and then returned to the individual owners. Preliminary data analysis and quality assurance were completed by

Figure 1. Containers (on right), rented portacabins (on left) and sampling tower at Detling, UK site.

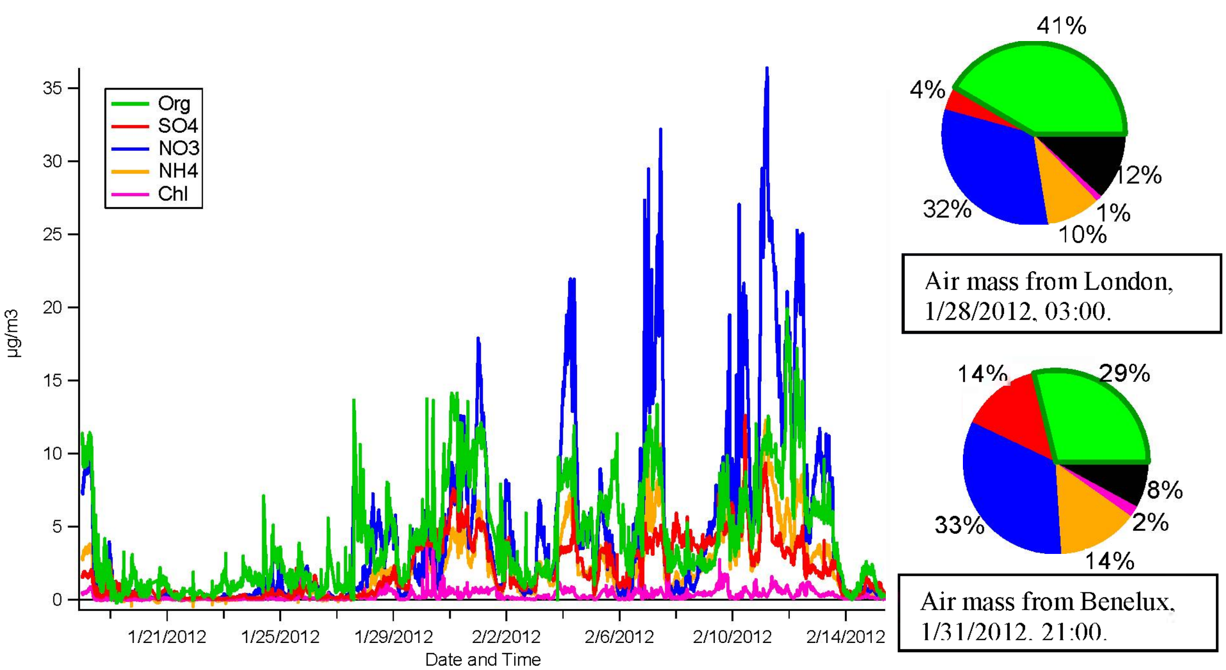

Figure 2. Left panel: HR-ToF-AMS time series for non-refractory particle mass loading of organics (green), nitrate (blue), sulfate (red), ammonia (yellow) and chloride (pink). Right panel: Fractional composition of PM1 from HR-ToF-AMS (same colors as left panel) plus MAAP for black carbon (black) for air mass from London (top) and from Benelux (bottom).

December 2012 and data were shared among the researchers using the Dropbox website: https://www.dropbox.com/sh/cqxmujz9wvo5lka/BVg-FTm6XL. Final data analysis is almost complete and data has been posted to the British Atmospheric Data Center (BADC) archive and to the ARM archive. Interpretation and publication of the data is ongoing.

The next few sections of this report highlight some of the observations at Detling. Please see the presentations and publications listed in Section 6 for more details. One highlight is the observation of high nitrate levels during time periods when back trajectories showed that the air mass arrived from polluted regions of northern Europe or from the London metropolitan area. Figure 2 shows data from the High Resolution Time of Flight Aerosol Mass Spectrometer (HR-ToF-AMS). The left panel shows the time series for the mass loading of non-refractory PM1 by chemical species where green indicates organics, red indicates sulfate, blue indicates nitrate, yellow indicates ammonia and pink indicates chloride. The variations in mass loading correlate with backtrajectories showing different origins of the air mass sampled at Detling, UK. The fractional composition is shown on the right for an air mass arriving from London on 1/28/2012 and for an air mass arriving from northern Europe (Benelux region) on 1/31/2012. The pie charts include the HR-ToF-AMS measurements of nonrefractory PM1 and the measurement of black carbon made with the multi-angle absorption photometer (MAAP). The high nitrate levels are consistent with observations from the Mexico City metropolitan area during MILAGRO/MCMA 2006.

A second highlight is the observation of an urban increment in PM mass loading between London and Detling. Detling is located about 45 km southeast of downtown London and represents the rural background. Figure 3 compares the hourly average organic mass loading (top panel), nitrate mass loading (center panel) and sulfate mass loading (bottom panel) between the urban location at North Kensington (NK) in London and the rural site at Detling. The sulfate mass loading is the same at the two

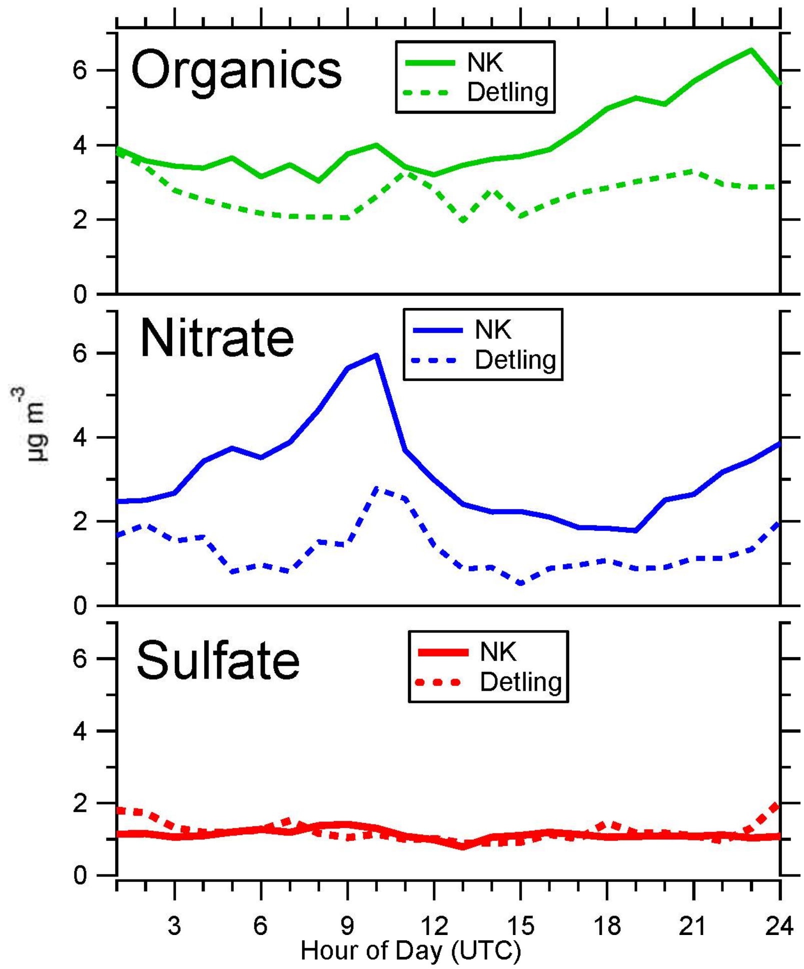

Figure 3. (Top panel) Organic mass loading at North Kensington (NK) and Detling. (Center panel) Nitrate mass loading at NK and Detling. (Bottom panel) Sulfate mass loading at NK and Detling.

locations and shows no diurnal variation as is typical of a regional pollutant. In contrast, both organics and nitrate are higher at NK than at Detling and show variation throughout the day as is typical for PM derived from local sources. The nitrate peaks in the morning due to contributions from rush hour traffic, while the organics peak at night due to contributions from home heating using solid fuels.

More detailed analysis is underway to compare the PM composition at Detling with that

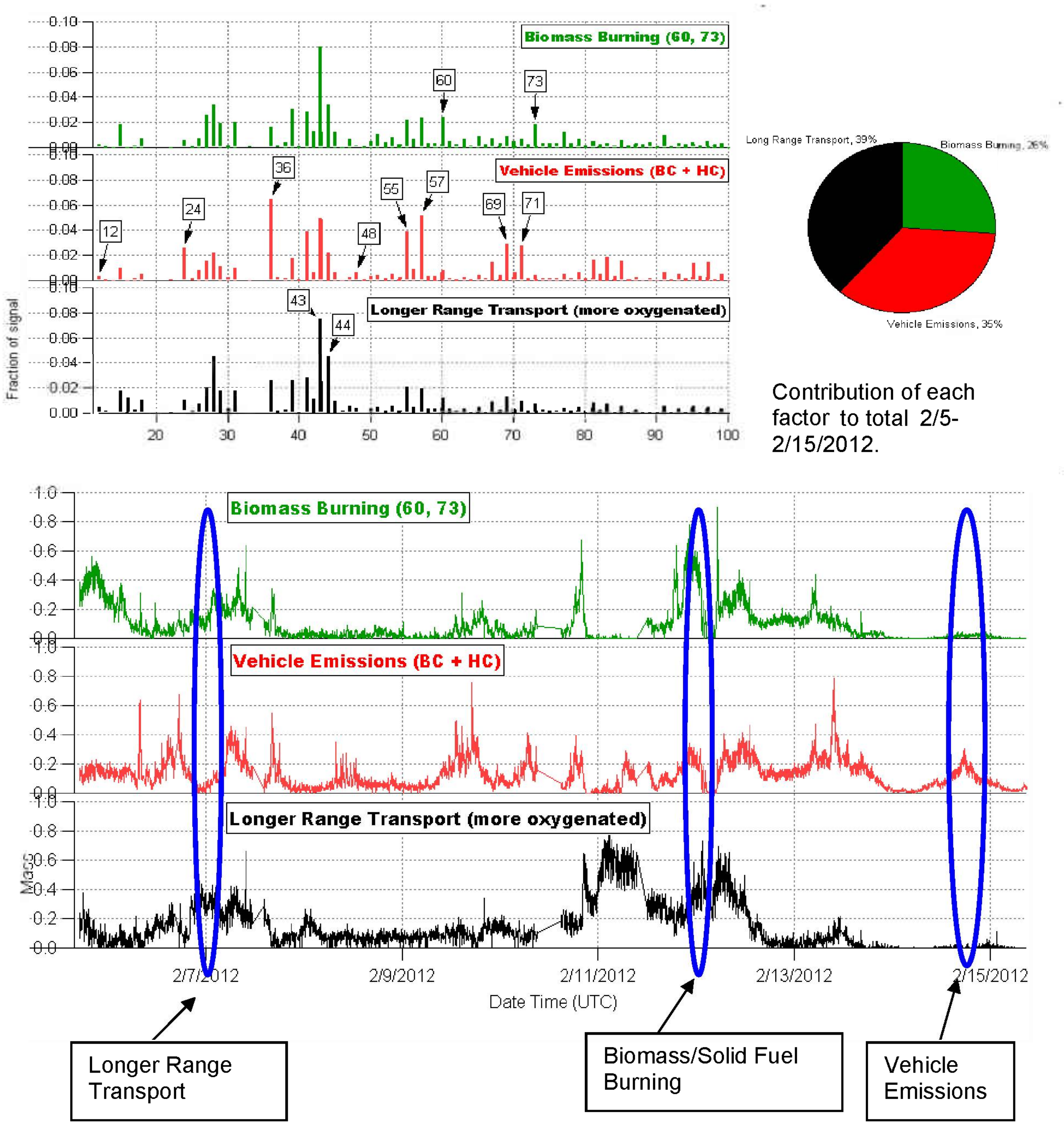

Figure 4. Top left: Mass spectra of three factors derived by positive matrix factorization of the organic coatings on black carbon containing particles measured with the SP-AMS. Top right: Contribution of each factor to total non-refractory coating on BC particles. Bottom panel: Time series of each factor. Circled regions indicate time periods dominated by one of the factors for comparison with other measurements.

measured in London. For time periods when air masses originated in Europe, passed over Detling and then over London, this comparison will address how much of the urban PM originates in London and how much is regionally influenced. For time periods when air masses passed over London and then over Detling, this comparison will address processing of urban aerosol and the contribution of urban PM to regional air quality.

A third highlight of the data analysis is the separation of the organic coatings on black carbon particles into chemical factors associated with vehicle emissions, wood burning and long range transport. The Soot Particle Aerosol Mass Spectrometer (SP-AMS) deployed in Detling had both a thermal vaporizer for detection of non-refractory PM1 (same vaporization method as the HR-ToF-AMS) and a laser vaporization module to detect black carbon. During the last ten days of the campaign (2/5 to 2/15/2012), the thermal vaporizer was removed from the SP-AMS. In this configuration, the SP-AMS detects only black carbon containing particles. The laser vaporization process followed by electron impact ionization provides quantitative measurements of both the black carbon and any non-refractory coatings on the black carbon.

Figure 4 shows the results of positive matrix factorization (PMF) applied to the non-refractory coatings plus black carbon measured by the SP-AMS. The data separate into three distinct factors whose mass spectra are shown in the top panel of Figure 4. The top mass spectrum (green) has dominant peaks at m/z 60 and 73 indicative of levoglucosan fragments and is associated with biomass or wood burning. The middle mass spectrum (red) contains most of the black carbon signal at m/z's 12, 24, 36 and 48 and also has a typical hydrocarbon pattern of paired peaks at m/z 55 and 57, and 69 and 71. This factor is associated with fresh vehicle

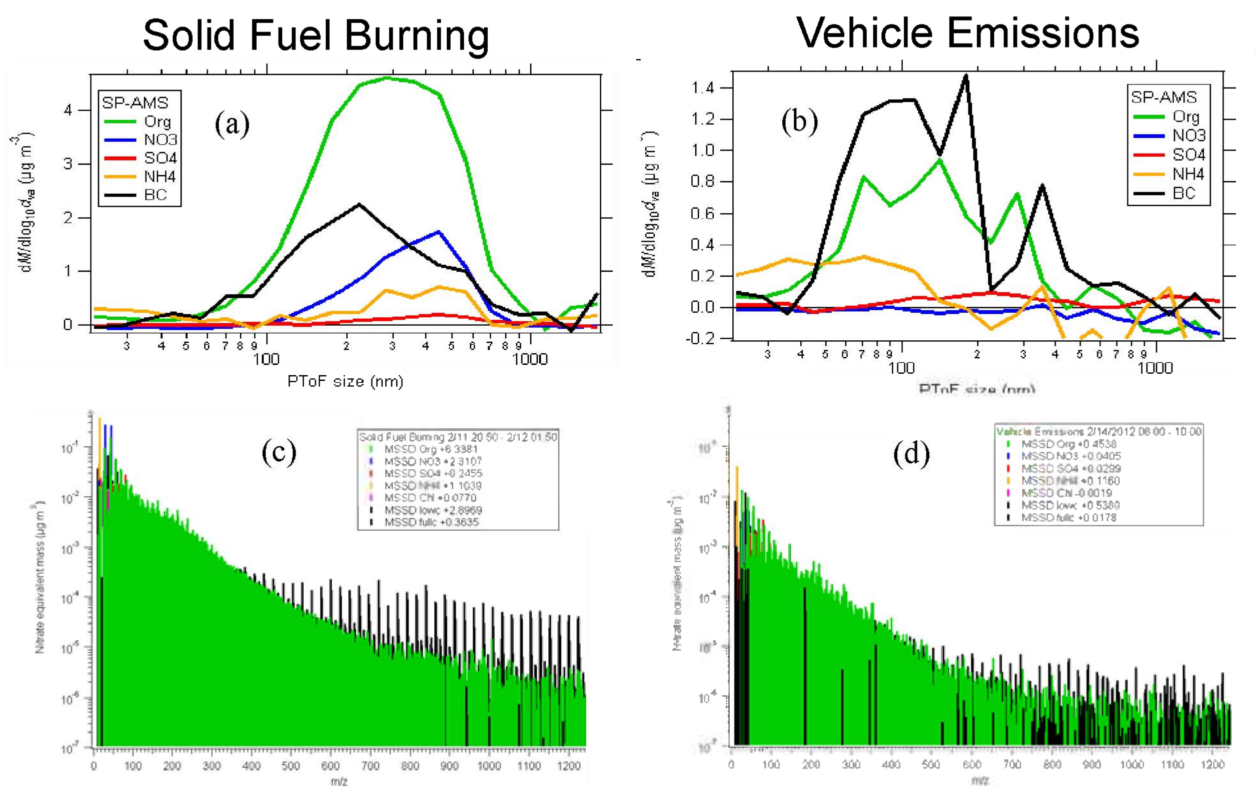

Figure 5. Chemically resolved size distributions and mass spectra for black carbon containing PM1 using the SP-AMS for a time period dominated by solid fuel burning (panels a and c) and a time period dominated by vehicle emissions (panels b and d).

emissions. The third mass spectrum (black) has relatively more signal at m/z 43 and 44 indicating more oxygenated organics and is associated with longer range transport.

The bottom panel of Figure 4 shows the time series for the three PMF factors. These time trends can be compared with air mass back-trajectories and co-located measurements of gas-phase species and aerosol optical properties in order to identify sources. However, it is clear from the time trends that most time periods have contributions from all three factors and source apportionment needs to be done carefully.

Figure 5 shows a comparison of the chemically resolved size distributions and mass spectra for the time period dominated by solid fuel burning (panels a and c) and for the time period dominated by vehicle emissions (panels b and d). The solid fuel burning time period was associated with stagnant winds, a size distribution peaking at 200 to 300 nm with high organics and high black carbon. Also note the presence of high mz black carbon peaks in the mass spectrum due to the presence of fullerenes. The vehicle emissions time period was associated with morning rush hour. Winds were from the southeast and blew across a large roadway adjacent to the sampling site. The size distribution peaked at less than 100 nm and the chemical composition was dominated by black carbon. In this mass spectrum, the high mz fullerene peaks are much smaller relative to the noise level. The presence of fullerenes in the black carbon may be a chemical fingerprint for solid fuel/biomass burning and will assist with source apportionment.

A fourth feature of the observations was the use of a thermal denuder located upstream of many of the aerosol particle measurements at Detling. The thermal denuder was stepped through several temperatures between ambient and 250 C. This enables studies of the volatility of the particles and the impact of coatings on optical properties. Figure 6 shows the mass fraction remaining for non-refractory PM1 components measured with the HR-ToF-AMS as a function of thermal denuder temperature. In the left panel, sulfate is the least volatile component, while organic, nitrate, ammonia and chloride are more easily evaporated. The right panel shows the mass fraction remaining at specific m/z's in the organic mass spectrum. The more oxygenated m/z 44 is less volatile than the less oxygenated masses at 43 and 60. This is consistent with current understanding of organic aerosol volatility.

We have used the thermal denuder data for the SP-AMS measurements of coatings on

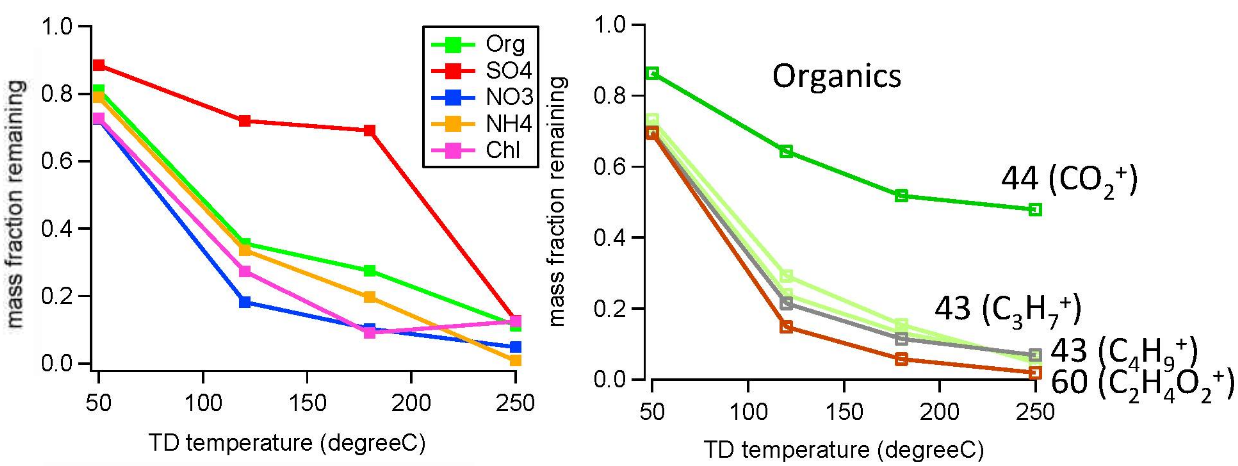

Figure 6. (Left panel) HR-ToF-AMS measurements of mass fraction remaining for chemical components of PM1 as a function of thermal denuder temperature. (Right panel) mass fraction remaining at specific m/z's as a function of thermal denuder temperature.

black carbon and for the Photo-Acoustic Soot Spectrometer (PASS) measurements of optical absorption to investigate the effect of coatings on the optical properties of black carbon containing particles. In particular, we looked for absorption enhancement in this dataset in order to compare with datasets from biomass burning plumes where absorption enhancement was observed and from CalNex/CARES where absorption enhancement was not observed. We have identified time periods with significant absorption enhancement and are working on correlating the extent of the enhancement with the source information derived from the chemistry of the coatings. A manuscript is in preparation.

6. Products

A1. Publications:

Claudia Mohr, Felipe D. Lopez-Hilfiker, Peter Zotter, André S. H. Prévôt, Lu Xu, Nga. L. Ng, Scott C. Herndon, Leah R. Williams, Jonathan P. Franklin, Mark S. Zahniser, Douglas R. Worsnop, W. Berk Knighton, Allison C. Aiken, Kyle J. Gorkowski, Manvendra K. Dubey, James D. Allan, and Joel A. Thornton, Contribution of nitrated phenols to wood burning brown carbon light absorption in Detling, UK during winter time, *Environ. Sci. Technol.*, 2013, 47 (12), pp 6316–6324, DOI: 10.1021/es400683v

S. Visser, J.G. Slowik, M. Furger, P. Zotter, N. Bukowiecki, R. Dressler, U. Flechsig, K. Appel, D.C. Green, A.H. Tremper, D.E. Young, P.I. Williams, J.D. Allan, S.C. Herndon, L.R. Williams, C. Mohr, L. Xu, N.L. Ng, A. Detournay, J.F. Barlow, C.H. Halios, Z.L. Fleming, U. Baltensperger and A.S.H. Prévôt, Kerb and urban increment of highly time-resolved trace elements in PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ winter aerosol in London during ClearfLo 2012, *Atmospheric Chemistry and Physics Discussions*, 14, 15895-15951, 2014.

Bohnenstengel SI, Belcher SE, Allan JD, Allen G, Bacak A, Bannan TJ, Barlow JF, Beddows DCS, Bloss WJ, Booth AM, Chemel C, Coceal O, Di Marco CF, Faloon KH, Fleming Z, Furger M, Geitl JK, Graves RR, Green DC, Grimmond CSB, Halios C, Hamilton JF, Harrison RM, Heal MR, Heard DE, Helfter , Herndon SC, Holmes RE, Hopkins JR, Jones AM, Kelly FJ, Kotthaus S, Langford B, Lee JD, Leigh RJ, Lewis AC, Lidster RT, Lopez-Hilfiker FD, McQuaid JB, Mohr C, Monks PS, Nemitz E, Ng NL, Percival CJ, Prévôt ASH, Ricketts HMA, Sokhi R, Stone D, Thornton JA, Tremper AH, Valach AC, Visser S, Whalley LK, Williams LR, Xu L, Young DE, and Zotter P, Meteorology, air quality, and health in London: The ClearfLo project, *Bulletin of the American Meteorology Society*, 2014, in press.

Shang Liu, Allison C. Aiken, Kyle Gorkowski, Manvendra K. Dubey, Christopher D. Cappa, Leah R. Williams, Scott C. Herndon, Douglas R. Worsnop, Swarup China, Noopur Sharma, Claudio Mazzoleni, Lu Xu, Nga Lee Ng, Dantong Liu, James D. Allan, Zoë L. Fleming, Peter Zotter, and André Prévôt, Light absorption enhanced by internally mixed black carbon from diesel and wood combustion, 2014, in preparation.

Lu Xu, Leah Williams, Puneet Chhabra, Ed Fortner, Berk Knighton, Scott Herndon, Douglas Worsnop, Domonique Young, James Allan, Nga Lee Ng, Charaterization of submicron aerosol aging in Detling, UK during winter time by HR-ToF-AMS coupled with a thermal denuder, 2014, in preparation.

L. R. Williams, S. Herndon, J. Jayne, A. Freedman, B. Brooks, J. Franklin, P. Massoli, E. Fortner, P. Chhabra, M. Zahniser, H. Stark, T. Onasch, D. R. Worsnop, F. Lopez-Hilfiker, C. Mohr, J. Thornton, N. L. Ng, L. Xu, M. Kollman, B. Knighton, M. Dubey, A. Aiken, K. Gorkowski, T. Martin, R. Coulter, S. Visser, M. Furger, P. Zotter, and A. Prévôt, Overview of ClearfLo Detling Site (January to February, 2012), 2014, in preparation.

A2. Presentations:

ASR Science Meeting, Arlington, VA, March, 2012
7 oral presentations in breakout session, 5 posters.

European Aerosol Conference, Granada, Spain, September, 2012

WG01S1P20. Optical Characterization of Aerosols at a Rural Site in Southeast England During the Winter ClearfLo IOP**,** P. Massoli, A. Aiken, K. Gorkowski, S. Herndon, E. Fortner, J. Jayne, J. Franklin, W. Brooks, P. Chhabra, T. Onasch, L. Williams, M. Dubey, D. Worsnop and A. Freedman.

WG01S4O03 Overview of ClearfLo Detling Site: Study of Aerosol Sources and Processing at a Rural Site Southeast of London**,** L. R. Williams, S. Herndon, J. Jayne, A. Freedman, B. Brooks, J. Franklin, P. Massoli, E. Fortner, P. Chhabra, M. Zahniser, H. Stark, T. Onasch, D. R. Worsnop, F. Lopez-Hilfiker, C. Mohr, J. Thornton, N. L. Ng, L. Xu, M. Kollman, W. B. Knighton, M. Dubey, A. Aiken, K. Gorkowski, T. Martin and R. Coulter.

American Association for Aerosol Research Annual Meeting, Minneapolis, MN, October, 2012

Poster 2UA.21 Overview of ClearfLo Detling Site: Study of Aerosol Sources and Processing at a Rural Site Southeast of London. LEAH WILLIAMS, Scott Herndon, John Jayne, Andrew Freedman, William Brooks, Jonathan Franklin, Paola Massoli, Edward Fortner, Puneet Chhabra, Mark Zahniser, Harald Stark, Timothy Onasch, Douglas Worsnop, Felipe Lopez-Hilfiker, Claudia Mohr, Joel A. Thornton, Nga Lee Ng, Lu Xu, Matthew Kollman, Berk Knighton, Mavendra Dubey, Allison Aiken, Kyle Gorkowski, Timothy Martin, and Richard Coulter.

Oral Presentation 4UA.1 Aerosol Composition at a Rural Site Southeast of London Measured by High Resolution Mass Spectrometry. NGA LEE NG, Lu Xu, Matthew Kollman, John Jayne, Scott Herndon, William Brooks, Leah Williams, Paola Massoli, Edward Fortner, Puneet Chhabra, Timothy Onasch, and Douglas Worsnop.

Oral Presentation 4UA.2 Optical Characterization of Aerosols at a Rural Site in Southeast England During the Winter ClearfLo Campaign. Paola Massoli, Allison Aiken, Kyle Gorkowski, Scott Herndon, Edward Fortner, John Jayne, William Brooks, LEAH WILLIAMS, Puneet Chhabra, Nga Lee Ng, Timothy Onasch, Jonathan Franklin, Mavendra Dubey, Douglas Worsnop, and Andrew Freedman.

Poster 8CA.7 Contribution of Biomass Burning and Traffic Emissions to Aerosol Optical Properties at a Rural Site in Southeast England During the Winter ClearfLo IOP. Paola Massoli, Allison Aiken, Kyle Gorkowski, Scott Herndon, Edward Fortner, John Jayne, William Brooks, Puneet Chhabra, Leah Williams, Nga Lee Ng, Timothy Onasch, Jonathan Franklin, Mavendra Dubey, Douglas Worsnop, and ANDREW FREEDMAN.

ClearfLo Science Meeting, Birmingham, UK, October, 2012

ClearfLo Detling Site: Winter IOP, L. R. Williams, S. Herndon, J. Jayne, A. Freedman, B. Brooks, J. Franklin, P. Massoli, E. Fortner, P. Chhabra, M. Zahniser, H. Stark, T. Onasch, D. R. Worsnop, F. Lopez-Hilfiker, C. Mohr, J. Thornton, N. L. Ng, L. Xu, M. Kollman, B. Knighton, M. Dubey, A. Aiken, K. Gorkowski, T. Martin, R. Coulter, S. Visser, M. Furger, P. Zotter, and A. Prévôt.

American Geophysical Union Fall Meeting, San Francisco, CA, December, 2012

Abstract A33A-0136. Aerosol Optical Properties and Black Carbon Measurements (Ambient and Thermally-Denuded) from Detling, UK During the ClearfLo IOP in Winter 2012, K. Gorkowski, A. Aiken, M. Dubey, S. Herndon, L. R. Williams, D. R. Worsnop, P. Massoli, E. Fortner, A. Freedman, N. L. Ng, J. D. Allan.

Abstract A43I-03. Characterization of Black Carbon-Containing Aerosol Particles via Soot Particle Aerosol Mass Spectrometry (SP-AMS), P. Massoli, E. Fortner, L. R. Williams, M. Canagaratna, A. Trimborn, J. T. Jayne, D. R. Worsnop, T. Onasch.

ClearfLo Science Meeting, York, UK, March, 2013

ClearfLo Detling Site: Winter IOP, L. R. Williams, S. Herndon, J. Jayne, A. Freedman, B. Brooks, J. Franklin, P. Massoli, E. Fortner, P. Chhabra, M. Zahniser, H. Stark, T. Onasch, D. R. Worsnop, F. Lopez-Hilfiker, C. Mohr, J. Thornton, N. L. Ng, L. Xu, M. Kollman, B. Knighton, M. Dubey, A. Aiken, K. Gorkowski, T. Martin, R. Coulter, S. Visser, M. Furger, P. Zotter, and A. Prévôt.

ASR Science Meeting, Potomac, MD, March, 2013

Oral presentation in breakout session and four poster presentations.

American Association for Aerosol Research Annual Meeting, Portland, OR, October, 2013

Oral Presentation 4CA.3. Enhanced Light Absorption by Internally Mixed Atmospheric Black Carbon in Europe. SHANG LIU, Allison Aiken, Kyle Gorkowski, Manvendra Dubey, Scott Herndon, Leah Williams, Paola Massoli, Edward Fortner, Andrew Freedman, Douglas Worsnop, Nga Lee Ng, Claudia Mohr, Felipe Lopez-Hilfiker, Joel Thornton, James Allan, and Christopher Cappa.

Oral Presentation 5CA.6. Black Carbon Containing Particles at a Rural Site Southeast of London, UK during ClearfLo (Winter 2012). LEAH WILLIAMS, Scott Herndon, John Jayne, Andrew Freedman, William Brooks, Jonathan Franklin, Paola Massoli, Edward Fortner, Puneet

Chhabra, Mark Zahniser, Timothy Onasch, Manjula Canagaratna, Douglas Worsnop, Felipe Lopez-Hilfiker, Claudia Mohr, Joel Thornton, Nga Lee Ng, Lu Xu, Berk Knighton, Manvendra Dubey, Allison Aiken, Kyle Gorkowski, Shang Liu, Andre Prévôt, et al.,

European Aerosol Conference, Prague, Czech Republic, September, 2013

Oral Presentation. Black Carbon Containing Particles at a Rural Site Southeast of London during ClearfLo Winter IOP, L. R. Williams, S. Herndon, J. Jayne, A. Freedman, B. Brooks, J. Franklin, P. Massoli, E. Fortner, P. Chhabra, M. Zahniser, H. Stark, T. Onasch, M. R. Canagaratna, D. R. Worsnop, F. Lopez-Hilfiker, C. Mohr, J. Thornton, N. L. Ng, L. Xu, W. B. Knighton, M. Dubey, A. Aiken, K. Gorkowski, S. Liu, T. Martin, R. Coulter, S. Visser, M. Furger, P. Zotter, and A. S. H. Prévôt

ASR Science Meeting, Potomac, MD, March, 2014

Oral presentation in plenary session and two poster presentations.

B. Websites:

The instrument and personnel lists for the Aeroflo project can be found at: tinyurl.com/Aeroflo-Detling

Preliminary data was posted at: https://www.dropbox.com/sh/cqxmujz9wvo5lka/BVg-FTm6XL

An overview of the ClearfLo project and blog entries for the Detling site can be found at: http://www.clearflo.ac.uk/news/

F. Data:

Final data for trace gas measurements have been posted at the British Atmospheric Data Center (BADC) Archive (badc.nerc.ac.uk/browse/badc/clearflo/data) and at the ARM Data Archive (http://www.archive.arm.gov/armlogin/login.jsp). The particle measurement and meteorology data is undergoing final review and will be posted by September, 2014.