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Multi-pollutant mobile platform measurements of air pollutants adjacent to a major roadway

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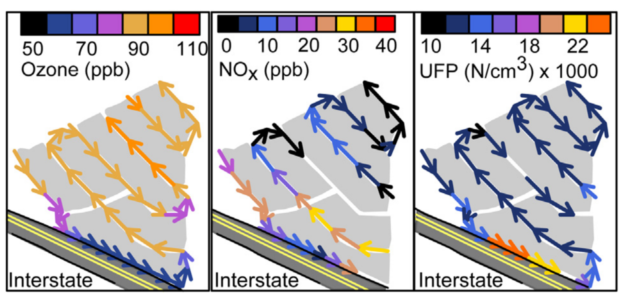
HIGHLIGHTS

- Moving platform was used to simultaneously measure multiple air pollutants.
- Near-road gradients are consistent with previously reported fixed site studies.
- Traffic-related multivariate features are identified by their near-road gradients.

GRAPHICAL ABSTRACT



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ABSTRACT

A mobile monitoring platform developed at the University of Washington Center for Clean Air Research (CCAR) measured 10 pollutant metrics (10 s measurements at an average speed of 22 km/h) in two neighborhoods bordering a major interstate in Albuquerque, NM, USA from April 18–24 2012. 5 days of data sharing a common downwind orientation with respect to the roadway were analyzed. The aggregate results show a three-fold increase in black carbon (BC) concentrations within 10 m of the edge of roadway, in addition to elevated nanoparticle concentration and particulate matter with aerodynamic diameter <1 μm (PN_1) concentrations. A 30% reduction in ozone concentration near the roadway was observed, anti-correlated with an increase in the oxides of nitrogen (NO_x). In this study, the pollutants measured have been expanded to include polycyclic aromatic hydrocarbons (PAH), particle size distribution (0.25–32 μm), and ultra-violet absorbing particulate matter (UVPM). The raster sampling scheme combined with spatial and temporal measurement alignment provide a measure of variability in the near roadway concentrations, and allow us to use a principal component analysis to identify multi-pollutant features and analyze their roadway influences.

1. Introduction

An appreciation for the complexity of pollutant dispersion and aging away from roadways in diverse urban environments has motivated innovation of new extensive monitoring designs,

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including mobile monitoring (Matte et al., 2013). Mobile monitoring platforms have been used to detect localized air pollution phenomena and to characterize their spatial and temporal extents. For example, mobile monitoring was used to detect dust carried by traffic out of industrial areas in the City of Hamilton, Ontario, Canada (DeLuca et al., 2012), to identify neighborhoods in Los Angeles impacted by heavy-duty diesel traffic servicing the port (Kozawa et al., 2009), and to identify ultrafine particle (UFP) “clouds” in neighborhoods impacted by roadway configurations (Hu et al., 2012) and the airport (Hudda et al., 2013). Mobile monitoring has also been used to help identify urban areas of high wood smoke impact (Larson et al., 2007), and urban areas with high levels of traffic related black carbon (BC) (Larson et al., 2009).

Mobile monitoring has been implemented to characterize pollutant concentrations as a function of distance-to-roadway in a variety of scenarios including roadway type (Kozawa et al., 2009), the presence of topographical features (Hagler et al., 2010), meteorology (Kozawa et al., 2012; Zhu et al., 2006), seasonal effects (Padro-Martinez et al., 2012), and time of day (Bukowiecki et al., 2002; Durant et al., 2010; Hagler et al., 2010; Hu et al., 2009; Massoli et al., 2012; Pattinson et al., 2014). As such, mobile monitoring presents the possibility to characterize spatio-temporal features of air pollutants under a variety of conditions. The results of such campaigns may improve predictive models for traffic-related air pollution, thereby advancing the science behind adverse health effects associated with distance to roadway.

Herein, we present a pilot study employing a mobile monitoring platform developed at the University of Washington Center for Clean Air Research to characterize near-roadway pollutant gradients. The sampling sites were residential neighborhood streets adjacent to a major interstate in a location with flat topography and no high-rise buildings resulting in a distinct line source with few obstructions while remaining in an urban setting. The platform recorded spatially and temporally aligned 10 s measurements of 10 different pollutant metrics, including polycyclic aromatic hydrocarbons (PAH), particle size distribution (0.25–32 μm), and ultraviolet absorbing particulate matter (UVPM). In this paper we assess the correspondence of our single pollutant near roadway gradients with those previously reported, and use principal component analysis to reveal multi-pollutant features and analyze their spatial relationship to the roadway.

2. Experimental methods

2.1. Sampling sites

Monitoring took place along the I-40 corridor in Albuquerque, NM on the Eastern side of I-25 as depicted in Fig. 1a. The city of Albuquerque sits in a basin defined by the Sandia Mountain range to the East and a volcanic mesa to the West. The Rio Grande River meanders from North to South along the bottom of this shallow basin. These features result in typical winds with a westerly component. The section of I-40 chosen for this study consisted of three westbound lanes and four eastbound lanes at the time of monitoring. Fig. 1a includes a map of the two monitoring “sites” situated on the North and South sides of I-40. A site is defined by a collection of road segments within a selected area (see Fig. 1). A highway off ramp was adjacent to the North site, but not the South site. The monitoring sites were in residential neighborhoods containing one- and two-story houses. We anticipated the flat topography and absence of high-rise buildings at these sites would simplify visualization and interpretation of near-roadway pollutant gradients relative to more complex locations.

Fig. 1 illustrates the sampling sites are behind sound barriers at the edge of roadway. These structures have the potential to alter

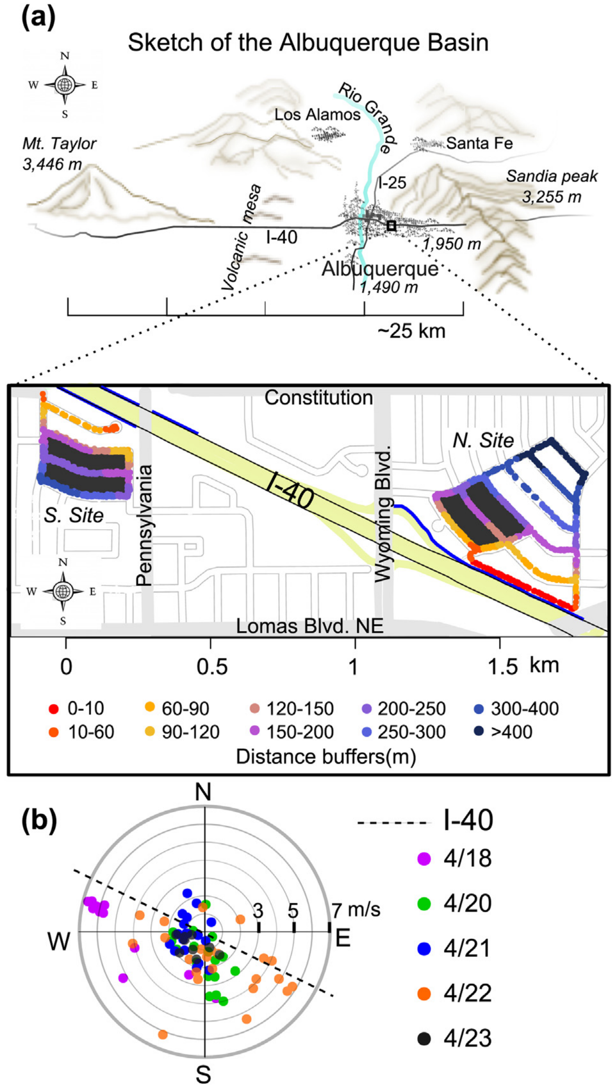

Fig. 1. **a)** Sketch of Albuquerque and surrounding area, and map of the sample sites. Sound barriers are denoted with a solid blue line. Colored dots represent GPS locations of measurements from the 5 days of data analyzed. Color gradient trends red to blue with increased distance from edge of roadway (black outline of I-40). The route consisted of the roads surrounding the shaded blocks for the dates 4/18–4/21. **b)** Wind rose of 10 min average wind direction (direction of origin) and speed (m/s) as reported by the Albuquerque International Sunport airport (7.8 km south of the monitoring sites) from sampling times of a given day. Sampling days are denoted by color; 4/18/2012 (pink), 4/20 (green), 4/21 (blue), 4/22 (orange), 4/23 (black). I-40's direction is denoted as the dashed black line.

pollutant levels adjacent to the roadway depending upon wind direction and speed, since these combine to create a variety of eddy currents, as has been established by others (Baldauf et al., 2008; Bowker et al., 2007; Finn et al., 2010; Hagler et al., 2011; Ning et al., 2010; Steffens et al., 2013). The sampling sites in this study are both completely behind the sound barriers, and are therefore insufficient for a 2-dimensional analysis of barrier influences. Instead, we reduced our data to one spatial dimension as others have done (Massoli et al., 2012).

2.2. Monitoring platform

2.2.1. Instrumentation

The mobile monitoring platform consisted of a 2012 gasoline powered Ford Escape with two sampling inlets mounted on the