

# Application of Personal, Spatio-Temporal Exposure Assessment for Asthmatic Children in Denver, Colorado

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## I. Abstract

A novel, temporospatially-referenced sampling method that integrated real-time particulate matter (PM) monitors, global positioning system (GPS) receivers, ambient temperature monitors and a geographical information system (GIS) was used to monitor PM exposures of elementary-age, asthmatic children. Thirty-two children carried the sampler for four consecutive 22 hr periods (Mon – Thur) during two distinct weeks throughout the school year, resulting in over 150 daily samples. The time-referenced signals (10-sec records) for fine particulate matter concentration, ambient temperature, and location were synchronized and merged within a GIS to analyze and visualize the children's exposures. Temporospatially-based algorithms were applied to apportion exposure data into four microenvironments: school, home, morning transit and afternoon transit. This method allowed examination of personal exposure patterns as a function of time, location, and activity with spatial resolution on the order of meters and temporal resolution on the order of seconds. With this technique, we generated an 'exposure budget' detailing the contribution of various microenvironments to a child's daily intake of PM. Such resolution was previously impossible with traditional, time-integrated filter measurements. Personal PM levels were greatest at home, followed by morning transit, afternoon transit and school ( $p < 0.01$ ). Correlations between personal, microenvironmental PM levels and wide-area measurements (i.e., community-based monitors) demonstrate the need for more precise exposure assessment techniques, especially to inform the design of effective interventions. Substantial 'peak exposure' events were detected during a child's morning commute to school; such peak events may contribute to asthma worsening.

## II. Materials and Methods

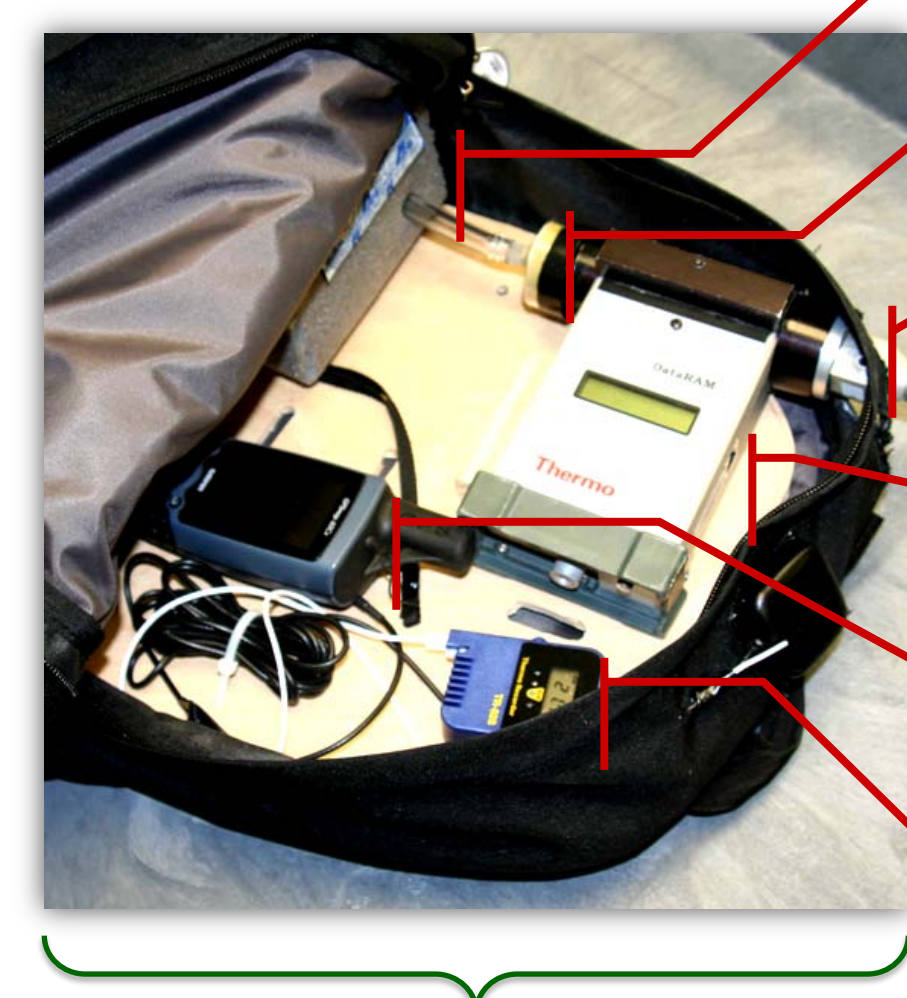
### Study Cohort

- 32 Asthmatic Children in Denver, CO:
  - Attending the Kunsberg School at National Jewish Health
  - Aged 6-12 years
  - Current diagnosis of moderate or severe asthma



### Exposure Assessment

Figure 1. Multi-Sensor Backpack Apparatus



- **Pump** (BGI Omni, 6.8 L/min)
- **Teflon Sampling Filter** (37mm, gravimetric analysis)
- **Cyclone** (KTL 2.05; PM<sub>1.5</sub>)
- **Direct-Reading PM monitor** (Thermo, pDR-1200)
- **GPS Receiver** (Garmin 60Cx, WAAS-enabled)
- **Thermometer** (Thermo Record TR-52)

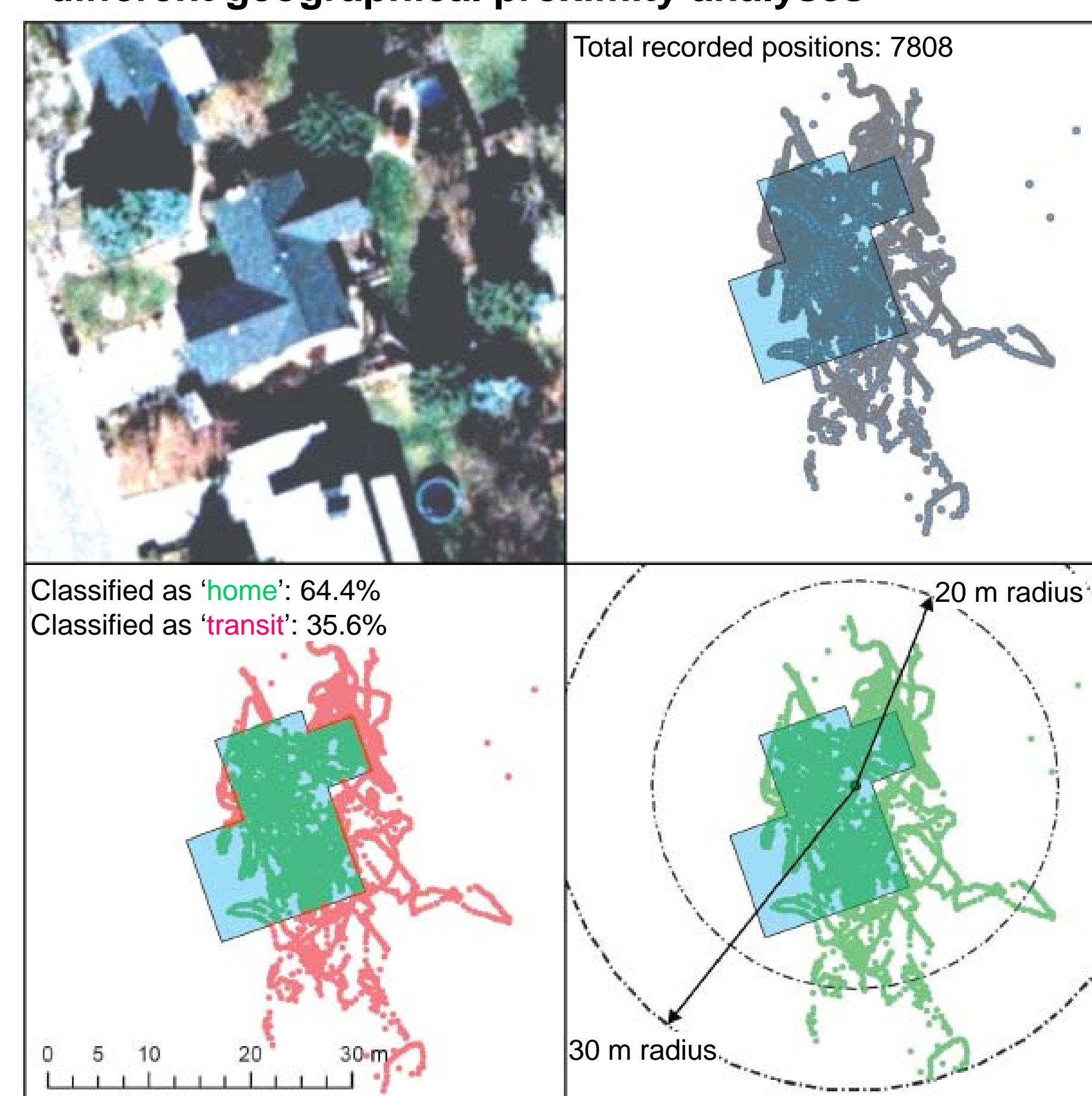
### Each Child:

- Two, 4-day Sampling Events
- Urinary LTE<sub>4</sub> (daily @ 12pm)
- Inhaler Use Records
- Activity Questionnaire
- Pulmonary flow testing
- 10-second data averages

### Exposure Apportionment

- Merge PM, GPS, Temp data streams (based on recorded time-stamp)
- Data Entered into GIS Database
- Define Spatial Buffers
  - Around each home
  - Around school
- Time-Based Rules (data quality check)
  - At home (9pm-5am)
  - At school (9am-3pm)
  - Transit (any other time)
- Four location/activity apportionments
  - **At Home**
  - **At School**
  - **Morning commute (am transit)**
  - **Afternoon commute (pm transit)**

Figure 2. Location-activity classification using different geographical proximity analyses



Reference: Adams, C., Riggs, P., Volckens, J. Development of a method for personal, spatiotemporal exposure assessment. Journal of Environmental Monitoring 2009; 11: 1331-1339.

## III. Results

### A Typical 22-hr 'Exposure Track'

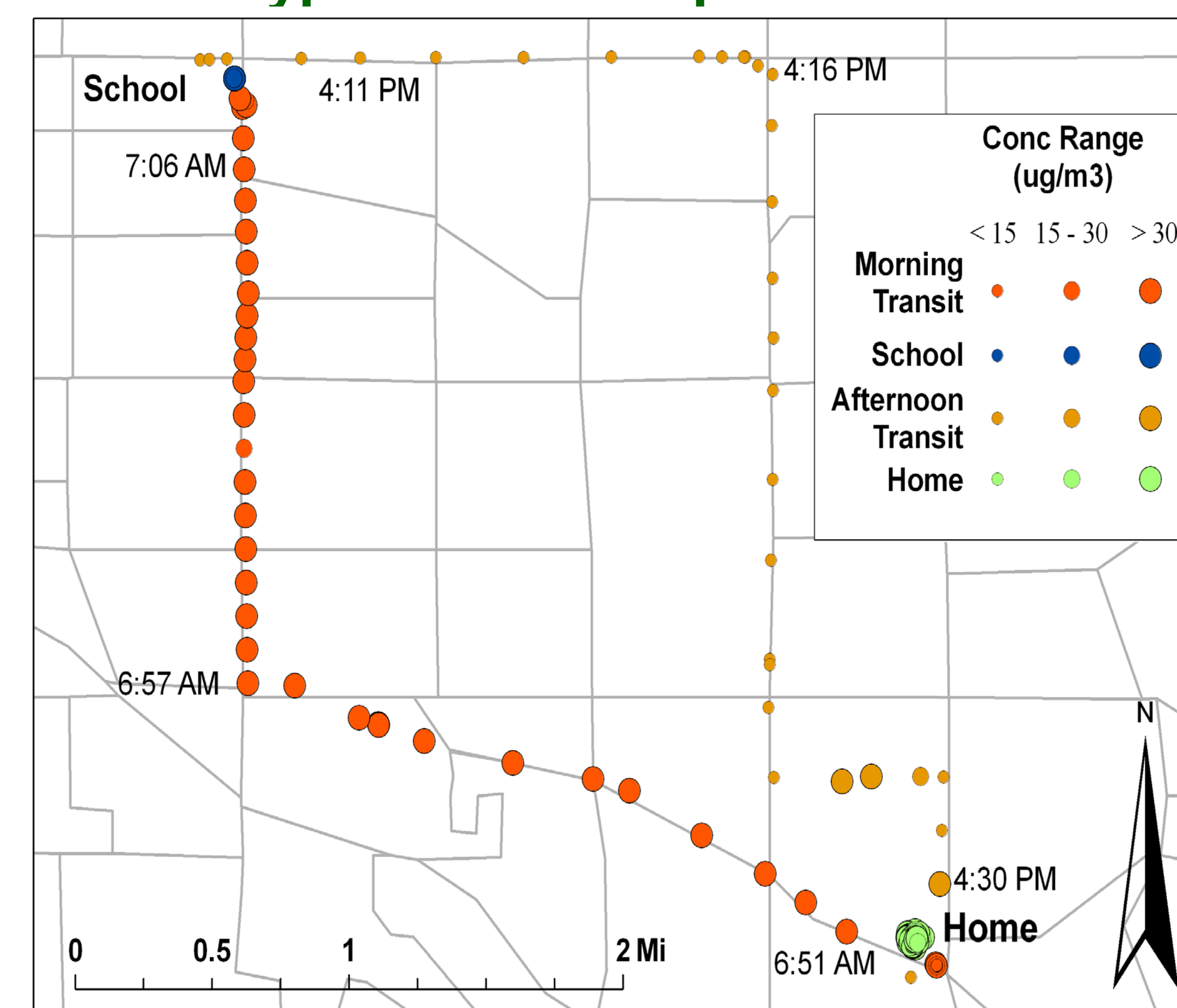


Figure 3. Street-map overlay of one child's personal PM levels. Each circle represents a 30-second average exposure of at the subject's location throughout a single day. Circle color indicates the location-activity of exposure and circle size indicates the relative magnitude of measured PM<sub>1.5</sub> levels.

### Personal PM Levels By Location

Figure 4. Histograms of average, personal PM<sub>1.5</sub> levels (entire cohort) by location/activity. Exposures appear log-normally distributed. Median levels of personal PM<sub>1.5</sub> range from 4-10 µg/m<sup>3</sup>.

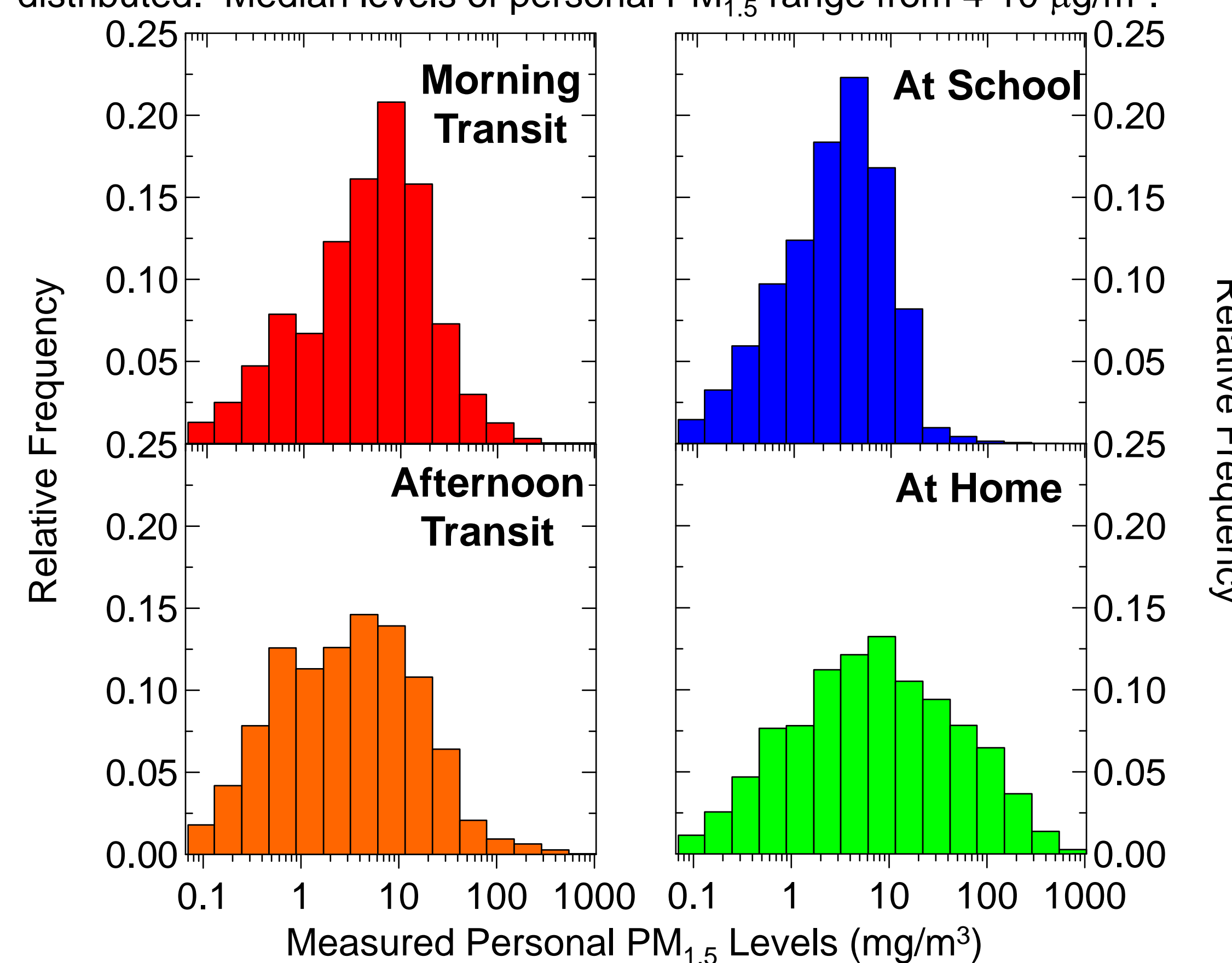
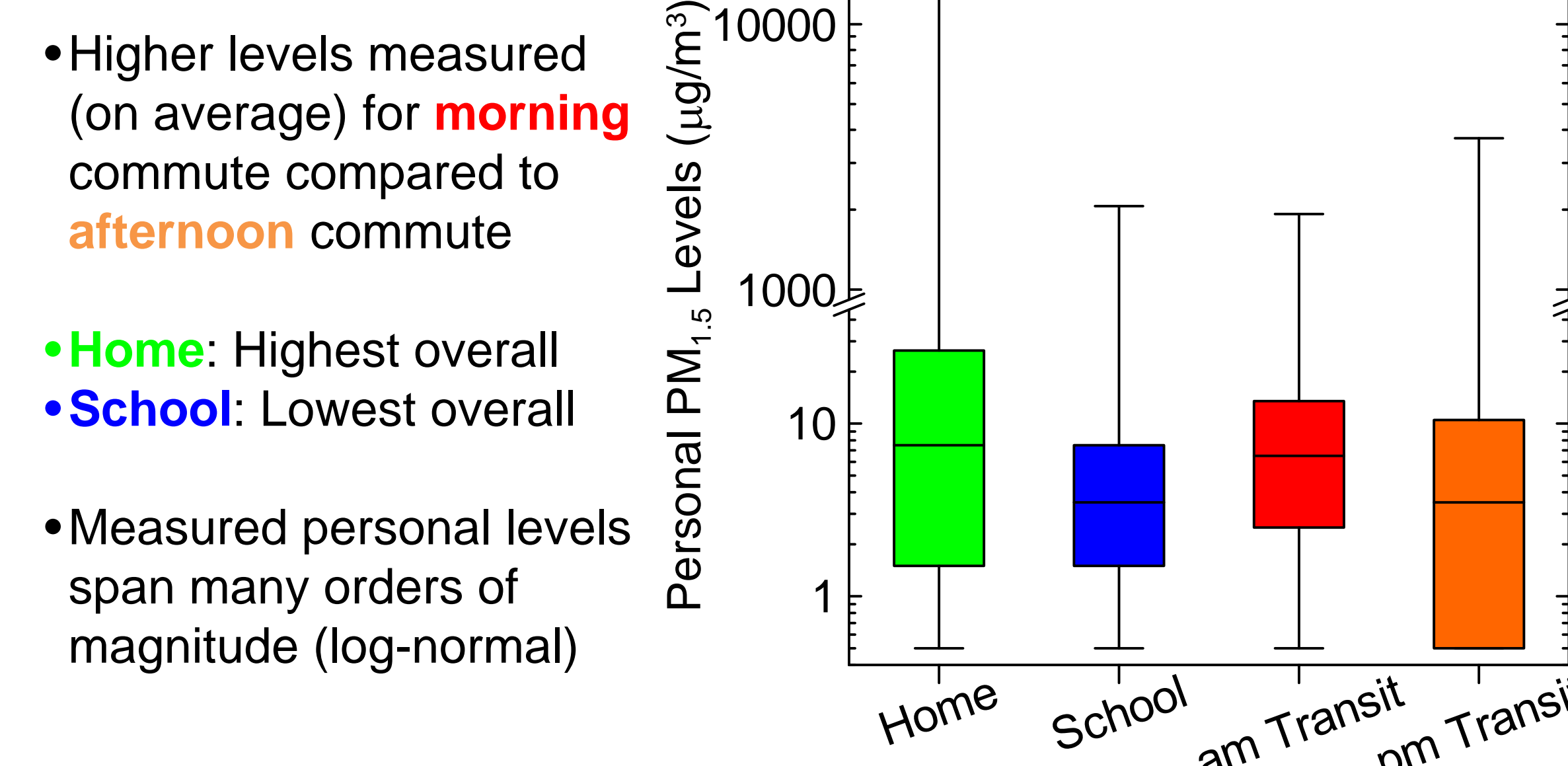


Figure 5. Box-Whisker plots of personal PM<sub>1.5</sub> levels (entire cohort) by location/activity.



### Personal PM Levels Are Not Well-Correlated with Outdoor Area Monitors

Activity/Location	School PM <sub>2.5</sub> Monitor	Metro Denver PM <sub>2.5</sub> Monitor
Transit (am)	0.16	0.18
At School	0.14	0.18
Transit (pm)	0.17	0.11
At Home	0.06	0.06

Table 1. Pearson coefficients (hourly average) between PM area monitors and personal monitors

### Home, Transit Exposures Show Major Excursions

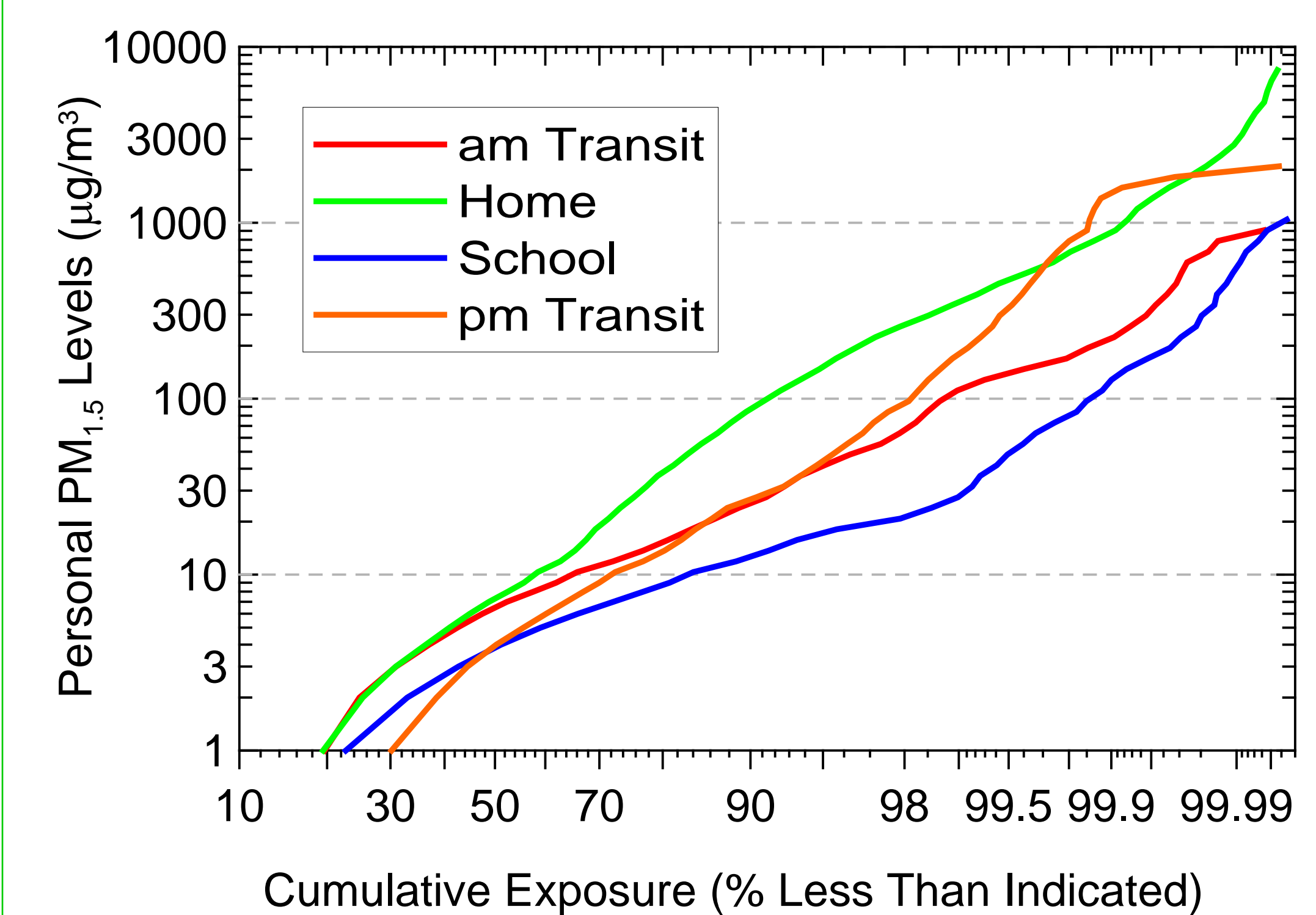
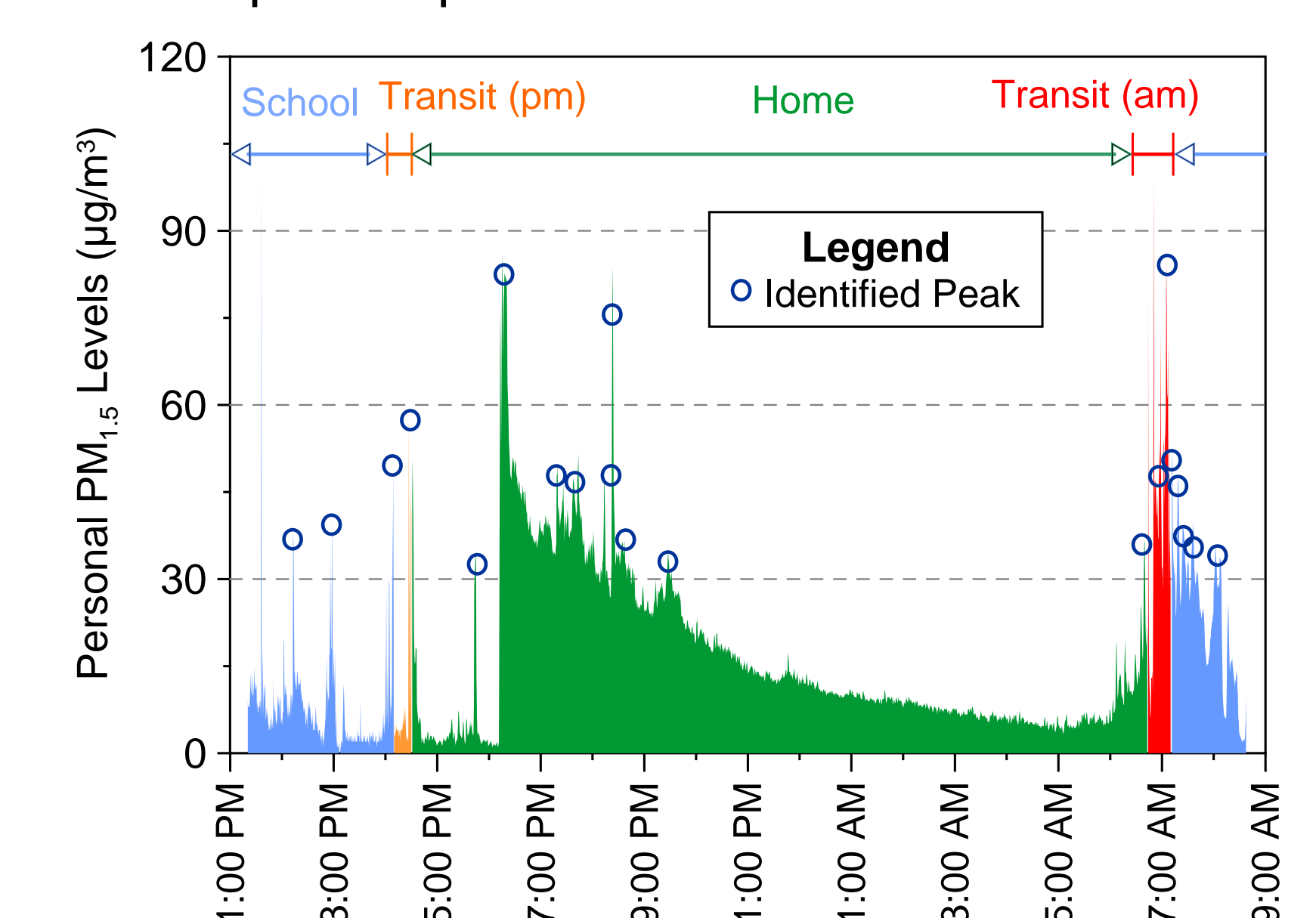


Figure 6. Cumulative distributions of personal PM<sub>1.5</sub> levels as a function of child location/activity

## IV. Future Work

- Analyze health effect associations
  - Urinary LTE<sub>4</sub>, FEV, inhaler vs. personal, area PM levels
- Examine individual exposures
  - Mixed models, smoking homes, transit routes
- Analyze 'peak' exposure events
  - Are exposure peaks associated with acute health effects?



The authors wish to thank Dr. Philip Riggs with his assistance with the exposure apportionment. This work was funded in part by a grant from the CSU/CVMB College Research Council (Volckens) and grant ES015510 from the NIEHS (Rabinovitch). Contact: [john.volckens@colostate.edu](mailto:john.volckens@colostate.edu)