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Finding candidate locations for aerosol pollution monitoring at street level using a data-driven methodology

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Instrumentation for aerosol measurements

Table S1 shows the characteristics of the instruments used for the aerosol pollution measurements at the background site above the urban canopy (a balcony in a 28th floor) and transects along the streets of the neighborhood of Rochor investigated in this study.

The DustTrak sensors measure particles size segregated mass-fraction concentrations with a laser photometer, whose readings depends on the ambient himidity and particle properties, such as size distribution, morphology and refractive index. We follow the approach of Ramachandran et al. (2003) to correct the humidy effect using the relative humidity (RH) data measured by the HOBO loggers. Prior to the study, the individual response of each individual sensor to the properties of the particles in the tropical atmosphere of Singapore was evaluated through gravimetric calibrations. Similar to Apte et al. (2011), power-law regression relationships were obtained from comparisons with 24-h $PM_{2.5}$ concentrations determined by gravimetric analysis of 23 colocated filter samples with concentrations ranging from 10 to 80 $\mu g\ m^{-3}$.

Similarly, the micro-aethalometer readings of black carbon (BC) are sensitive to mechanical shock or vibrations of the instrument. The black carbon data were corrected using software based on the Optimized Noise-reduction Averaging method (ONA) available on the manufacturer website (wwww.aethlabs.com). A second correction was needed to account for the instrument's sensitivity associated with the filter load. Briefly, because BC concentration is measured by changes in the light attenuation on a disposable filter through which sample air is drawn at 100 $cm^3\ min^{-1}$, concentrations were adjusted using the empirical relationship of Kirchstetter and Novakov (2007) based on the instrument-reported attenuation coefficient.

The data collected by the Condensation Particle Counter (CPC), Compact Real-Time Diffusion Charger and Compact Real-Time Photoelectric Aerosol Sensor measuring particle number concentration, active surface area and concentration of particles-bound polycyclic aromatic hydrocarbons (pPAHs), respectively, did not require additional corrections. They only passed through a quality assurance in which suspicious data were removed using as reference notes taken during the sampling (e.g.

if the CPC does not keep a horizontal position, the internal optical sensor may deliver erroneous readings).

Prior to each day of measurement, all instruments were synchronized to a computer clock in the laboratory. This ensured that the time stamp was consistent across all instruments. Instruments with removable parts were dismantled and re-assembled for each day of sampling. Upon arrival at the background site, zero calibration procedures for the CPCs and DustTrak sensors were carried out. Instruments were then set to log data for 10 min prior to the actual sampling. All instruments were placed side-by-side with inlets close together during these parallel measurement periods. Data from this parallel measurement were later used to correct the instruments at the background site to those used in the transects at street level. The data post-processing after the measurements included a second synchronization. The lag times of each instrument were computed through cross-correlations against the DustTrak sensors to achieve better synchronization across all instruments. Lag times ranged from 2 to 15 s on average. Instruments at the background site were also adjusted to the instruments used for the transects.

Table S1. Instruments information

Parameter	Instrument	Accuracy	Lower threshold	Response time	Model	Manufac-turer
Particles size segregated mass-fraction concentration (PM_1, $PM_{2.5}$, PM_{10})	Hand-held DustTrak DRX Aerosol Monitor	1 µg m^{-3}	±0.1% of reading or 1 µg m^{-3}	1 sec	TSI 8534	TSI, MN USA
Particle number concentration (particles < 1 µm)	Hand-held Condensation Particle Counter (CPC)	± 20%	1 particle cm^{-3} (min. particle size 10 nm)	1 sec	TSI 3007	TSI, MN USA
Black carbon	Micro - aethalometer	±0.1 µg m^{-3}	1 ng m^{-3}	1 sec	AE51	AethLabs, CA USA
Active surface area	Compact Real-Time Diffusion Charger	± 15% of reading ± 2 mm^2 m^{-3}	1 mm^2 m^{-3}	10 sec	DC 2000CE	EcoChem Analytics, TX USA
Total pPAHs concentration (particles < 1	Compact Real-Time Photoelectric	± 15% of reading ± 3 ng m^{-3}	1 ng m^{-3}	10 sec.	PAS 2000CE	EcoChem Analytics, TX USA

Parameter	Instrument	Accuracy	Lower threshold	Response time	Model	Manufac-turer
μm)	Aerosol Sensor					
Temperature and relative humidity (RH)	HOBO Pro v2 logger	0.2°C, ±2.5% RH	0.02°C at 25°C, 0.03% RH	1 sec	U23-001	Onset Computer Corp., MA USA

List of Urban Parameters

There are three category of urban parameters used in our work.

For the first category, land use, the urban parameters are defined by the area occupied by 17 different types of surface covers and building uses, such as residences, parks, water bodies, open spaces, roads, commercial establishments, schools, worship places, etc. therefore, we have the following sub criteria of land use as follows:

1. Sum-Residential
2. Sum-RESIDENTIAL-WITH-COMMERCIAL-AT-1ST-STOREY
3. Sum-COMMERCIAL
4. Sum-HOTEL
5. Sum-WHITE
6. Sum-BUSINESS-1-WHITE
7. Sum-HEALTH---MEDICAL-CARE
8. Sum-EDUCATIONAL-INSTITUTION
9. Sum-PLACE-OF-WORSHIP
10. Sum-CIVIC-COMMUNITY-INSTITUTION
11. Sum-OPEN-SPACE
12. Sum-PARK
13. Sum-BEACH-AREA
14. Sum-SPORTS-RECREATION
15. Sum-WATERBODY
16. Sum-ROAD
17. Sum-TRANSPORT-FACILITIES
18. Sum-UTILITY
19. Sum-RESERVE-SITE
20. Sum-Commercial

The Space Syntax Method (Hillier et. al., 1976), which is a network analysis method, uses different analytics to measure parameters in the second category, street network indicators. *Connectivity* measures the number of immediate neighbors to a segment. Further, Space Syntax consists of three indicators, namely *Integration*, *Choice* and *Depth*. Integration calculates the numbers of turns that must be made from a street segment to reach all other street segments in the network, using shortest paths. If we consider all the segments from all the segments the radius is selected to be 'n;'

however, if one sets a limit on the possible number of turns, then the most integrated segments are those that have the highest number of connections in the limited number of. Therefore, it is common to have different integration measures based on different radii.

The second indicator is called Choice, which is a measure in the category of network flow analysis. It measures how a segment is relatively connected to other segments. Similar to integration, there are choices of radius to be analyzed around each individual node of the street network. Further, it is common to use logarithmic value of Choice indicator, which is called Log Choice in our work.

Depth measure simply calculates the distance between the centers of each segment to all the other segments. Similarly, we can limit the distance to a radius and count the number of streets nearby to each segment.

In Space Syntax methodology, there are different ways of measuring the shortest path. In this work we chose the Angular way, in which the shortest path is the one that minimizes the angle between the origin and the destination. Further, for the choice of radius there are such options as metric distance, angular or segment and segments with length as the weight. Metric distance is the usual distance. Angular radius is based on the angle between points. Segment radius is the limit on the number streets that one can pass starting from a street segment and weighted segment is when one consider the length of streets as well as the number of streets. Based on these combinations of indicators with different ways of measuring the radius and shortest paths we used the following features in the category of urban network parameters.

1. Connectivity
2. LogChoice800
3. LogChoice
4. T1024-Choice
5. T1024-Choice-R10000-metric
6. T1024-Choice-R1200-metric
7. T1024-Choice-R15000-metric
8. T1024-Choice-R2000-metric
9. T1024-Choice-R5000-metric
10. T1024-Choice-R800-metric
11. T1024-Choice-Segment-Length-Wgt
12. T1024-Choice-Segment-Length-Wgt-R10000-metric
13. T1024-Choice-Segment-Length-Wgt-R1200-metric
14. T1024-Choice-Segment-Length-Wgt-R15000-metric
15. T1024-Choice-Segment-Length-Wgt-R2000-metric
16. T1024-Choice-Segment-Length-Wgt-R5000-metric
17. T1024-Choice-Segment-Length-Wgt-R800-metric
18. T1024-IntegrationN
19. T1024-Integration-R10000-metric
20. T1024-Integration-R1200-metric
21. T1024-Integration-R15000-metric

22. T1024-Integration-R2000-metric
23. T1024-Integration-R5000-metric
24. T1024-Integration-R800-metric
25. T1024-Integration-Segment-Length-Wgt
26. T1024-Integration-Segment-Length-Wgt-R10000-metric
27. T1024-Integration-Segment-Length-Wgt-R1200-metric
28. T1024-Integration-Segment-Length-Wgt-R15000-metric
29. T1024-Integration-Segment-Length-Wgt-R2000-metric
30. T1024-Integration-Segment-Length-Wgt-R5000-metric
31. T1024-Integration-Segment-Length-Wgt-R800-metric
32. T1024-Node-Count-R10000-metric
33. T1024-Node-Count-R1200-metric
34. T1024-Node-Count-R15000-metric
35. T1024-Node-Count-R2000-metric
36. T1024-Node-Count-R5000-metric
37. T1024-Node-Count-R800-metric
38. T1024-Total-Depth
39. T1024-Total-Depth-R10000-metric
40. T1024-Total-Depth-R1200-metric
41. T1024-Total-Depth-R15000-metric
42. T1024-Total-Depth-R2000-metric
43. T1024-Total-Depth-R5000-metric
44. T1024-Total-Depth-R800-metric
45. T1024-Total-Depth-Segment-Length-Wgt
46. T1024-Total-Depth-Segment-Length-Wgt-R10000-metric
47. T1024-Total-Depth-Segment-Length-Wgt-R1200-metric
48. T1024-Total-Depth-Segment-Length-Wgt-R15000-metric
49. T1024-Total-Depth-Segment-Length-Wgt-R2000-metric
50. T1024-Total-Depth-Segment-Length-Wgt-R5000-metric
51. T1024-Total-Depth-Segment-Length-Wgt-R800-metric
52. T1024-Total-Segment-Length-R10000-metric
53. T1024-Total-Segment-Length-R1200-metric
54. T1024-Total-Segment-Length-R15000-metric
55. T1024-Total-Segment-Length-R2000-metric
56. T1024-Total-Segment-Length-R5000-metric
57. T1024-Total-Segment-Length-R800-metric

And finally, for the third category of urban parameters, building topology, the following parameters were calculated for each grid cell.

1. Total area covered by buildings
2. Average buildings' height
3. The number of corners in the buildings

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