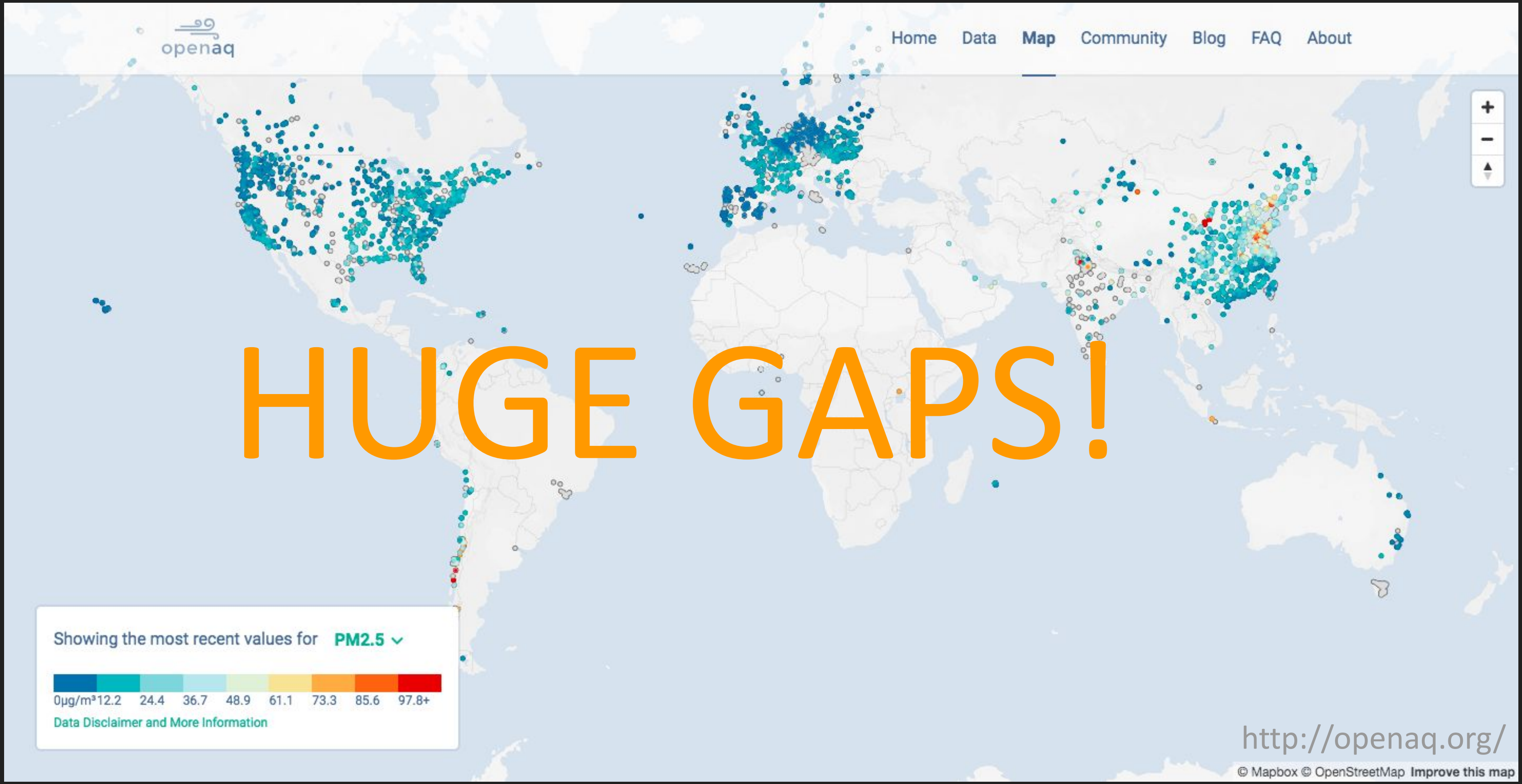
Spatial Variation of fine particulate matter levels in Nairobi before and during the COVID-19 curfew: Implications for Environmental Justice

Priyanka deSouza
Assistant Professor
University of Colorado Denver

Denver

Air Quality Data reported by countries



Air Quality Monitors: high cost to low cost

https://archive.epa.gov/pesticides/region4/sesd/pm25/web/html/p2.html

http://senseable.mit.edu/cleanair-nairobi/

deSouza, P., Nthusi, V., Klopp, J.M., Shaw, B.E., Ho, W.O., Saffell, J., Jones, R. and Ratti, C., 2017. A Nairobi experiment in using low cost air quality monitors. Clean Air Journal, 27(2), pp.12-42.

Reference Air Quality Monitoring Station

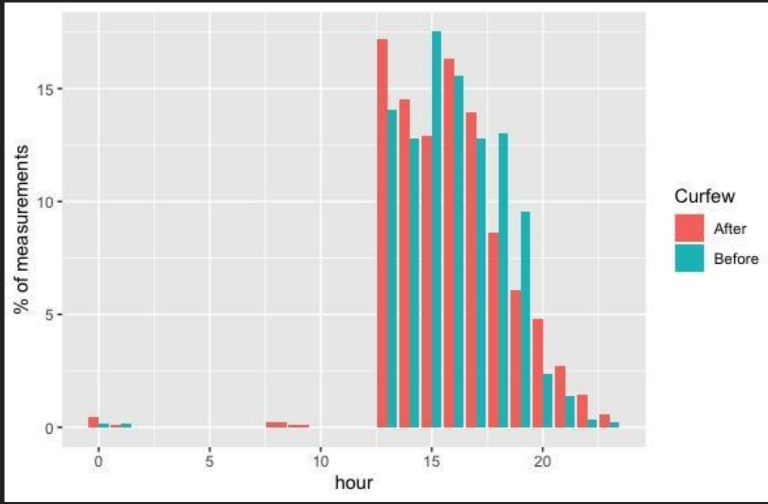
-High accuracy
-High cost ($150,000-$200,000)

Low Cost Air Quality Monitor

-Low accuracy
-Low(er) cost (~< $2,500 as defined by USEPA Air Toolbox)

What are the spatial variations in air pollution in Nairobi? How have COVID-19 policies affected these patterns

(with University of Nairobi Fablab + open-seneca)



8 Sensirion SPS-30 devices were used between March 17 - May 5/ 1,316,558 measurements over 39 unique days (Curfew started March 25)

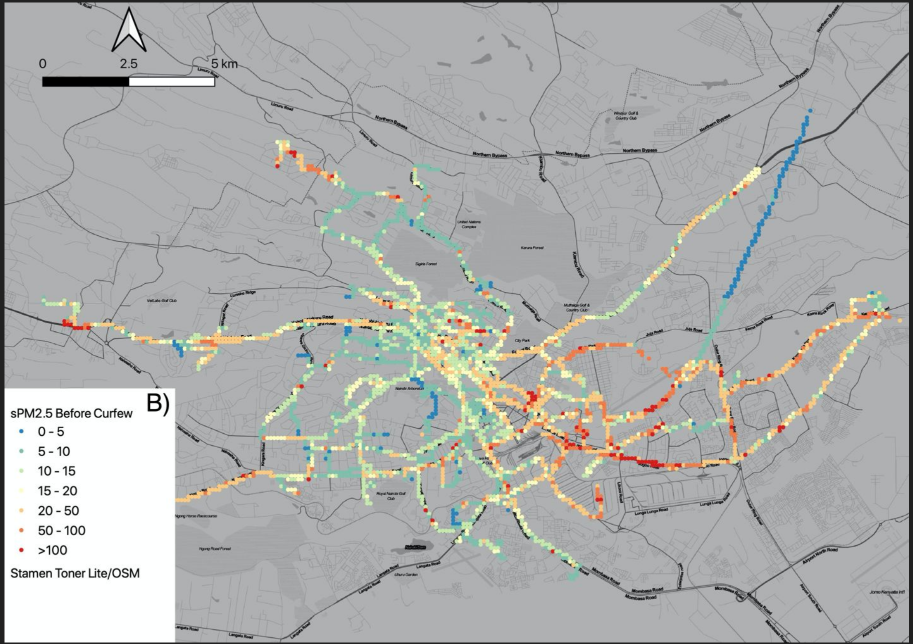
Data Pre-Processing

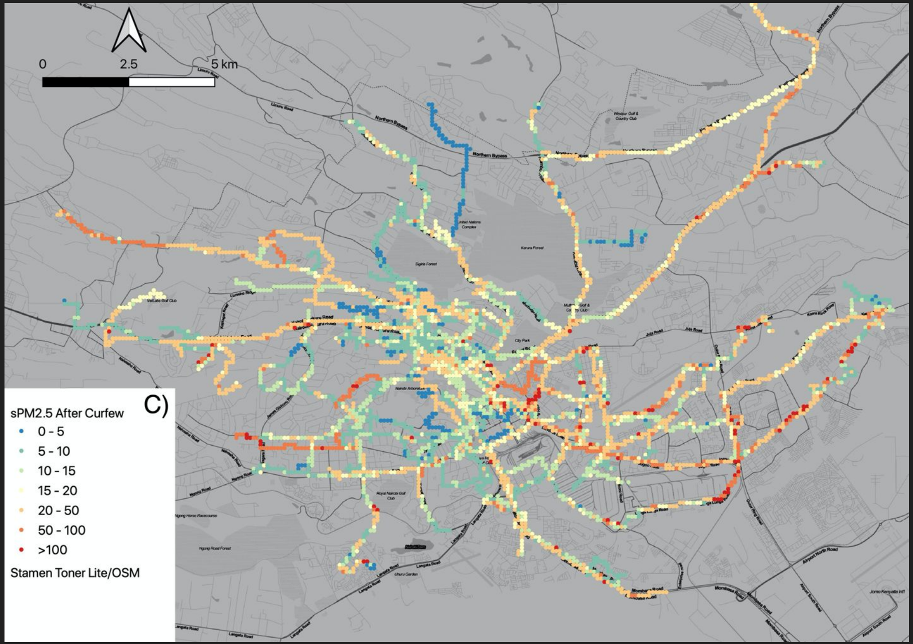
1) We divided our measurements into two time periods: before and during COVID-19
2) For each time period we estimated background pollution using a minimum-of-splines approach
3) We then performed a background correction or standardization

$$PM_{2.5c,i} = PM_{2.5,OPC\ i} - PM_{2.5,\ bkg,i} + PM_{2.5,\ bkg,median} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

4) We then dividing Nairobi into grid cells of 100 m x 100 m (3,151 before and 4,209 during the curfew)
5) We selected the median background-corrected $PM_{2.5}$ levels for each grid cell as the 'generalizable' $PM_{2.5}$ concentration

Generalizable $PM_{2.5}$ levels before and during COVID-19





Predicting $PM_{2.5}$ surface for all of Nairobi

Land use covariates:

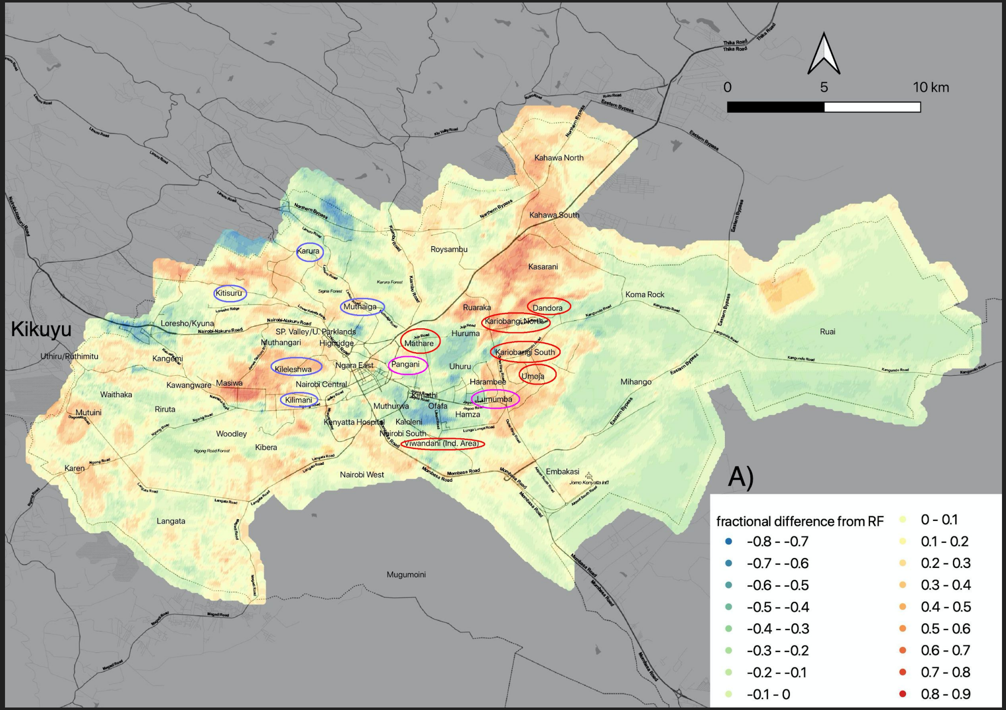
1) Population density
2) Multidimensional poverty index
3) Length of different road types
4) Average travel friction/accessibility of an area
5) Number of matatu stops
6) Number of matatu trips
7) Land use
8) Different neighborhoods

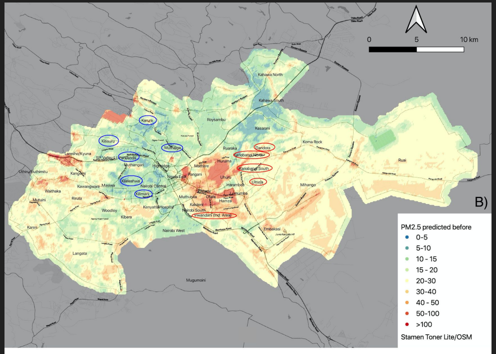
In buffers of 100 m, 200 m, 300 m

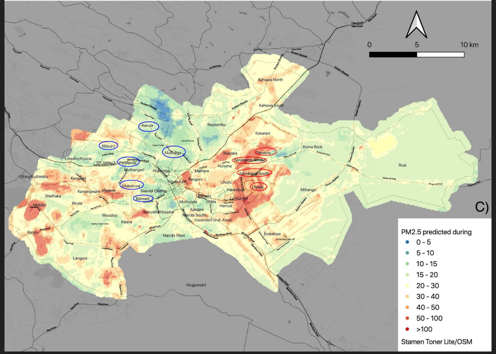
Model used: Random Forest Model (10 - fold CV)

Robustness check: Used Universal Kriging, Only used grid cells with stable generalizable $PM_{2.5}$ concentrations

We used a Random-Forest (RF) model to predict $PM_{2.5}$ before and during the COVID-19 curfew over the entire city of Nairobi

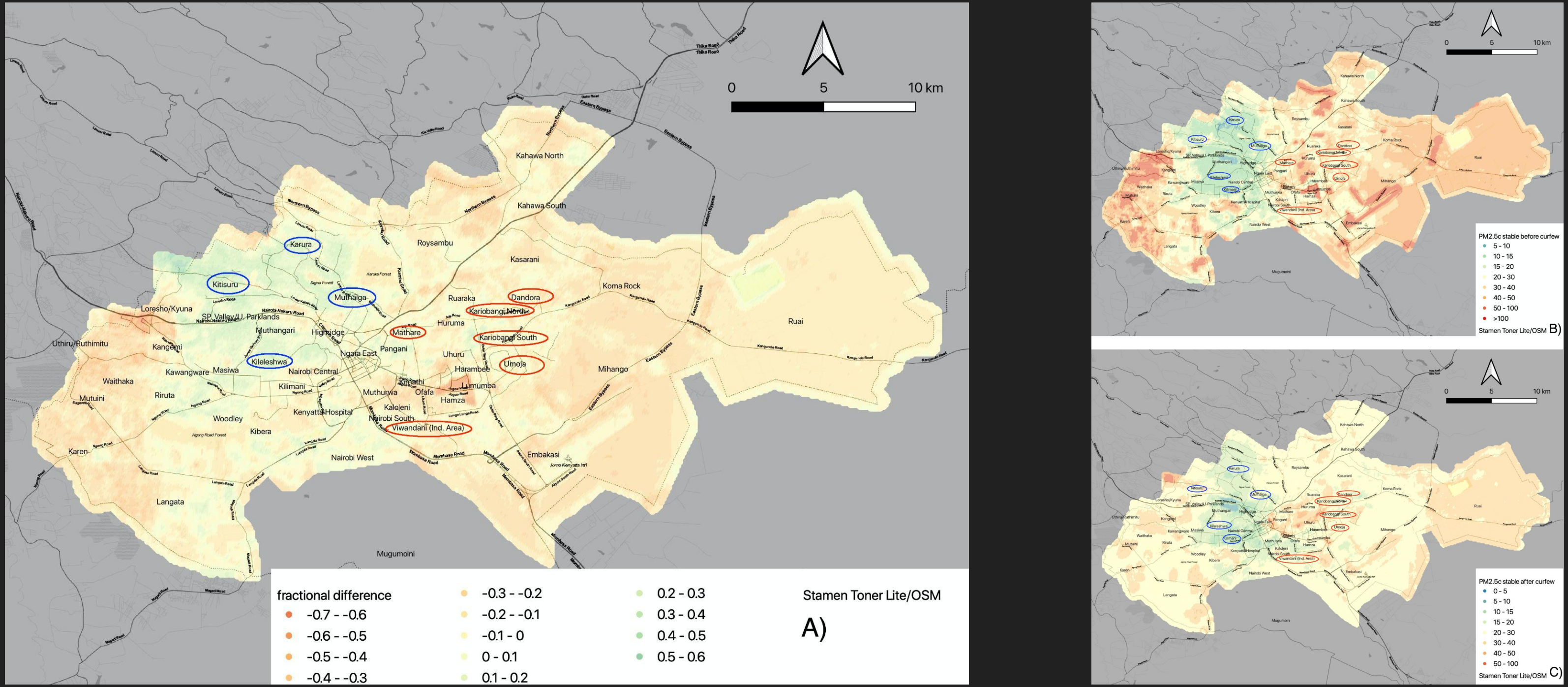




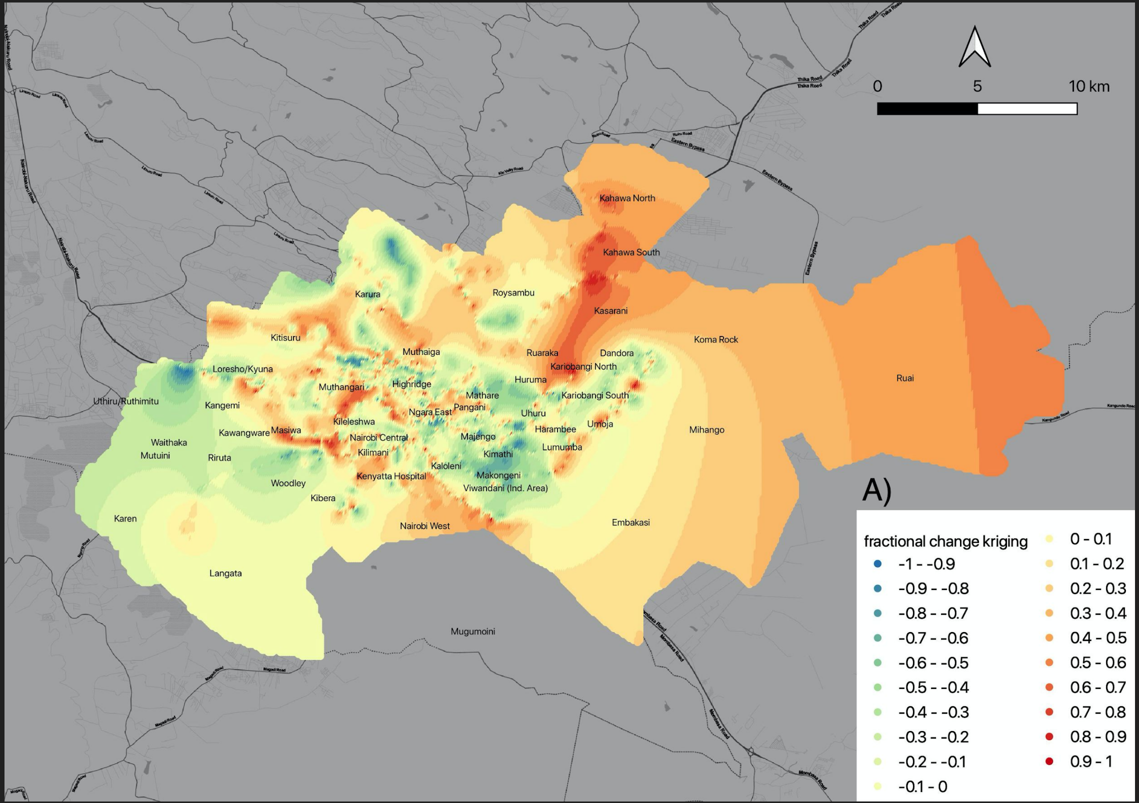


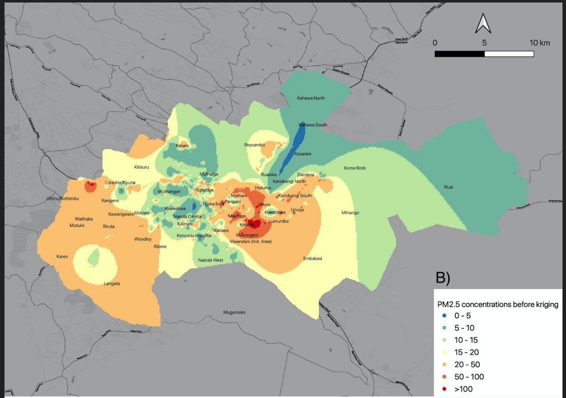
R^2 before: 0.95, after: 0.93

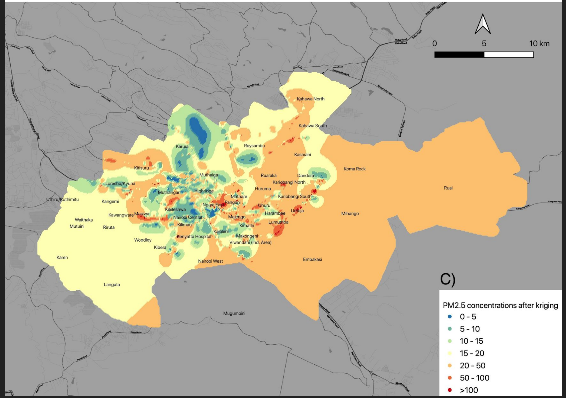
Sensitivity Analysis: We ran the RF model on all segments with a stable median $PM_{2.5}$ value (std error in median < 20%)



Sensitivity Analysis: Universal Kriging







Acknowledgements

Thanks to my co-authors: Phoebe Atsieno Oriama Peter P Pedersen, Sebastian Horstmann Lorena Gordillo-Dagallier, Charles N. Christensen Christoph O. Franck, Richard Ayah, Ralph Kahn, Jacqueline M. Klopp, Kyle P. Messier, Patrick L. Kinney

Paper can be found here:

deSouza. P., Oriama, P.A., Pedersen, P.P., Horstmann, S., Gordillo-Dagallier, L., Christensen, C.N., Franck, C.O., Ayah, R., Kahn, R.A., Klopp, J.M. and Messier, K.P., 2021. Spatial variation of fine particulate matter levels in Nairobi before and during the COVID-19 curfew: implications for environmental justice. *Environmental Research Communications*, *3*(7), p.071003.