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Spatio-temporal variability in urban air quality, source impacts, and pollution controls in Pittsburgh, Kigali, and Paris with well-characterized low-cost sensors

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Low-cost sensors for major air pollutants like carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and fine particulate mass ($PM_{2.5}$) can be used to map air pollution across a city with high spatial and temporal density. One such low-cost sensor package is the Real-time Affordable Multi-Pollutant (RAMP) monitor, which incorporates Alphasense electrochemical sensors for gases and a nephelometer for PM. Machine learning algorithms applied to the gas sensors have resulted in data quality that matches US EPA guidelines for hotspot identification (precision and bias errors less than 30%) and supplemental monitoring (precision and bias errors under 20%) for NO_2, CO, and O_3. The optical nephelometers were collocated with regulatory-grade beta attenuation monitors (BAMs) and corrected to BAM-equivalent $PM_{2.5}$ measurements using either a physical model that uses information about aerosol chemical composition or empirical fits; both methods were found to perform similarly. The optical nephelometers also show promising performance for PM_{10} in ongoing testing next to a TEOM in Paris. About 50 RAMPs were deployed in Pittsburgh, Pennsylvania, USA for over a year and show that industrial facilities 5-20 km away from Pittsburgh can increase average $PM_{2.5}$ by as much as 40% in some city neighborhoods, while other parts of the city are relatively unaffected. RAMPs deployed in Kigali, Rwanda for over 16 months were used to determine the split between regional and local contributions to $PM_{2.5}$. Local sources including traffic-related air pollution (TRAP) and domestic biofuel use could contribute as much as 50% of $PM_{2.5}$ in the wet seasons but less than 30% during the dry seasons. Kigali has also implemented a “car-free Sunday” policy, which the RAMPs show reduces peak $PM_{2.5}$ concentrations by an average of 20%. We shall also present plans for high spatial density air quality monitoring in Paris starting in 2019 using stationary RAMPs and comparisons with high-resolution chemical transport models through the “Make Air Quality Great Again” project funded by the “Make Our Planet Great Again” program.