

mmaqshiny v1.0: R-Shiny package to explore Air-Quality Mobile-Monitoring data

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Software

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Summary

Stationary air-quality monitors do not capture spatial variations in air-pollution. Mobile-monitoring or “sensors on a mobile platform”, is an increasingly popular approach to measure high-resolution pollution data at the street level. Coupled with location data, spatial visualisation of air-quality parameters helps detect localized areas of high air-pollution, also called hotspots. In this approach, portable sensors are mounted on a vehicle and driven on predetermined routes to collect high frequency data (1 Hz). Analysing this data involves cleaning and combining location data with pollutant data from different instruments. Some instruments are sensitive to factors like signal attenuation, humidity and vibrations; and require additional correction algorithms that are unique to each instrument. A typical mobile-monitoring campaign involves collecting millions of data points and a high burden of quality assurance and quality control. Our package attempts to automate and simplify the process using a Shiny app.

The package `mmaqshiny` analyses, visualises and produces a spatial map of the high-resolution air-quality data collected by specific devices installed on a moving platform. With the click of a button, the app generates: summary statistics, time-series plots and spatial maps of pollutant concentrations. The app thus reduces the time consumed in analysing each pollutant individually. It also helps check the quality of the data at near real-time (same day) and instantly visualise pollution hotspots. The time-series plots of each pollutant help in understanding the temporal patterns of concentrations and performance of the instruments. The app can effectively assist air-pollution researchers and citizen scientists interested in conducting mobile measurements.

Specific details of instruments and parameters measured can be found in the “Instrument Details” section. `mmaqshiny` package can handle high frequency (1 Hz) measurements collected by popular portable instruments. Specifically, the following parameters are measured: PM_{2.5} (mass concentrations of particulate matter with size less than 2.5 microns), black carbon mass concentrations (BC), ultra-fine particle number concentrations; carbon dioxide (CO₂), GPS coordinates and relative humidity (RH).

Under the hood, this app performs two basic functions: data correction and joining (location data + pollutant concentration data). As mentioned earlier, air-pollution measurements on a mobile platform, especially BC from microAeth are susceptible to vibration-related noise due to the road conditions and vehicle suspension efficiency. The package incorporates an algorithm to remove this noise employing the method recommended by Apte et al. (2011), followed by a loading correction as suggested by Ban-Weiss, Lunden, Kirchstetter, & Harley (2009). Since PM_{2.5} measurements from optical instruments are also sensitive to Relative Humidity (RH), an algorithm is applied to DustTrak PM_{2.5} to correct for RH, following the method suggested by Chakrabarti, Fine, Delfino, & Sioutas (2004). Furthermore, for calibration of DustTrak PM_{2.5} values, we have derived a calibration equation using a reference grade device. This equation

can vary with study location and season. Hence, several linear calibration equations from individual studies can be available in literature. Researchers can derive their own equation as well. Accommodating for these options, the app allows users to input linear regression coefficients of their choice for calibrating the $PM_{2.5}$ data. Often, on-road concentrations can be much higher than ambient concentrations and sometimes even exceed the measurement range of sensors. CPC3007 has a fixed dynamic measurement range, and number concentration measurements beyond this range can be biased. Traditionally, this is addressed by adding a diluter (characterised by a dilution factor) to the instrument inlet. Therefore, for the ultra-fine particle number concentration data from CPC3007, provision is made for a dilution correction factor (default value is 1, implying no diluter used). After data correction, the app joins the data to generate a downloadable csv file.

The app is designed to accept multiple files for each parameter from a single day of measurements. The input file names should have a date prefix of the format `yyyy_mm_dd`. The app uses this prefix to check that all input files are from the same date and generates an error message if the prefixes don't match. The package requires GPS file (`.gpx`) as a mandatory input along with timezone which can be selected using a dropdown menu (a link to all accepted timezone in R is included). All other pollutant files are optional.

Mobile-monitoring is a relatively new technique and the instruments used are also highly customised. To the authors' knowledge, currently there is no application that can integrate the above mentioned devices, though there are a few apps that deal with cleaning, and visualisation from a single instrument (Salmon, Vakacherla, Milà, Marshall, & Tonne, 2017). In pleasant contrast, `mmaqshiny` integrates data from several devices along with location data, and offers unique correction algorithms for different instruments and parameters as described above.

App Display

The output is displayed in five different tabs.

- 1) Joined File displays raw, cleaned and corrected data.
- 2) Summary displays summary statistics for each parameter.
- 3) Plots displays interactive time series line plots for raw parameters.
- 4) Map provides a spatial map for the user selected pollutant on OpenStreetMap basemap.
- 5) Alarm and Settings displays settings and alarms (if any).

Limitations

- 1) It can handle only single day data at a time.
- 2) There is provision for only linear correction coefficients of $PM_{2.5}$.
- 3) It is instrument specific.
- 4) It is mandatory to rename files (with date prefix).

Installation

`mmaqshiny` can be installed from [GitHub](#).

Load and run `mmaqshiny` as follows:

```
devtools::install_github("meenakshi-kushwaha/mmaqshiny")
library(mmaqshiny)
mmaqshiny::mmaqshiny_run()
```

A preloaded dataset appears which is a joined file of sample data collected during a mobile-monitoring campaign in Bangalore, India.

Instrument Details

Instrument (model/ make)	Parameters	Units	Operating Principle
GPSMAP 64s (Garmin)	Location (latitude, longitude, altitude)	°, °, m	Trilateration
USB RH probe (Omega)	Relative Humidity (RH)	%	Electrical detection
microAeth (AE51, Aethlabs)	Black Carbon mass concentration (BC)	ng/m ³	Light absorption technique
DustTrak II (DT8530, TSI)	PM _{2.5}	mg/m ³	Light scattering technique
Li-850 (LICOR)	CO ₂	ppm	Non-Dispersive Infrared
CPC (3007, TSI)	Particle concentration	count/cm ³	Light scattering technique

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