

An International Network of Networks for Obtaining Useful, Actionable Air Quality Data from Low-Cost Sensors

Prof. Dan Westervelt
and the CAMS-Net team

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

A global network for getting useful, actionable data out of low cost sensors

- Clean Air Monitoring and Solutions network (CAMS-Net)
- Create an international network of networks that provides a forum for exchange of knowledge, ideas, and data among scientists, decision-makers, citizen groups, the private sector, and other stakeholders towards the goal of improved usage and application of low-cost sensor (LCS) data for air quality
- Getting useful, actionable data out of LCS and exploring uses of this data for air quality modeling, satellite observations, policy recommendations, and health studies



Clean Air Monitoring and Solutions Network (CAMS-Net)

- Website: www.camsnet.org
- Over 50 partner networks including universities, government agencies, non-profits, media, citizen science groups, private companies
- Global scope with emphasis on Global South, including South Asia and Africa



Current CAMS-Net activities: capacity building

- Capacity building for academics and decision-makers
- Example: Calibration tool and tutorial for low cost sensors

Multiple Linear Regression Tutorial

Celeste McFarlane – cmm2349@columbia.edu

This document will serve as an introduction to building multiple linear regression models between reference grade data and low-cost sensor data.

For the purpose of this tutorial, we will need the packages lubridate, tidyverse (which includes the packages dplyr, stringr, readr, purr, tibble and ggplot2), caTools and SimDesign. You can install packages by typing in the r-console `install.packages("package")`.

Loading required libraries

```
library(tidyverse)
library(lubridate)
library(SimDesign)
library(caTools)
```

Loading and Cleaning Data

We will begin with a folder of multiple .csv files containing the purple air data. We will first set our working directory to this folder in order to load the files.

Load in Data

Both freely available as
ShinyApps (written in R)

The screenshot shows a Shiny calibration tool interface with two main panels: 'Low Cost Sensor Data' and 'Reference Monitor Data'. Both panels have a 'Choose CSV File(s)' section with a 'Browse...' button and a 'No file selected' indicator. Below this is a 'Three Letter Time Zone' dropdown menu set to 'UTC'. The 'Low Cost Sensor Data' panel has a 'Number of Sensors' section with radio buttons for 1 and 2 (2 is selected), and three input fields for 'PurpleAir Sensor A' Column Name (pm2_5_atm), 'PurpleAir Sensor B' Column Name (pm2_5_atm_b), and 'Date Column Name' (UTCDateTime). The 'Reference Monitor Data' panel has a 'Reference Value Column Name' input field (Raw Conc.), a 'Date Column Name' input field (Date (LT)), and a 'Compile' button. At the bottom right, there is an 'Explanatory Variables' section with checkboxes for 'PurpleAir Concentration', 'Temperature', 'Relative Humidity', and 'Dew Point', and an 'Analyze' button.

Current CAMS-Net activities: capacity building

- Air Quality Science and Management in East Africa Certificate Program
 - Funded also by the US State Department
 - July 26-30, 2021, online
 - 100 attendees daily from Kenya, Uganda, and Rwanda



COLUMBIA CLIMATE SCHOOL
Clean Air Toolbox for Cities



Certification of Participation

Awarded to

Jane Q. Student

For participation in a 5 day executive/non-credit
education course in

Air Quality Management and Science in East Africa

Offered by the Columbia University Clean Air Toolbox from 26 July
2021 to 30 July 2021.

Prof. Daniel M. Westervelt

Prof. Solomon Biligun



Current CAMS-Net activities: networking

- "Meet the Networks" series: monthly (or biweekly) events introducing networks to one another
- Looking for more presenters this summer and fall
 - Good way to meet researchers and potential collaborators, get feedback, exposure, etc

The screenshot shows a Zoom meeting interface. At the top, there are video thumbnails for participants: Subramanian Ramachandran, Mike Giordano, Dan Westervelt, Carl Malings, Abhishek Anand, and Emmanuel Appoh. The main content is a presentation slide titled "AfriqAir Collaboration to increase data & research". The slide features the AfriqAir logo, a map of Africa with several location markers, and text describing the consortium and its goals. At the bottom of the slide, the website <http://afriqair.org/> and the Twitter handle @AfriqAirQuality are displayed. On the right side of the Zoom window, a "Participants (21)" list is visible, showing names and status icons. Below the list is a "Chat" window with messages from Deo Okure and Mike Giordano.

AfriqAir Collaboration to increase data & research

- Consortium of 15 institutes
 - Multi-disciplinary – atmospheric scientists, epidemiologists, economists, and more
- Overarching goals:
 - Infrastructure development → more permanent/long-term monitors
 - Capacity building → sensors run, analyzed by local scientists and technicians
 - Open access data → access for governments, scientists, and local populations
- Open data & local capacity building → **long-term sustainability**

<http://afriqair.org/> @AfriqAirQuality

Participants (21)

Find a participant

- Subramanian Ramachandran (Me)
- Dan Westervelt (Host)
- Mike Giordano
- Abhishek Anand
- Albert Presto
- Brenna Walsh
- Bryan Duncan
- Carl Malings
- Deo Okure

Chat

From Deo Okure to Everyone:
Hi everyone

From Me to Everyone:
mike@afriqair.org if you are interested :)

Current CAMS-Net activities: supporting meetings

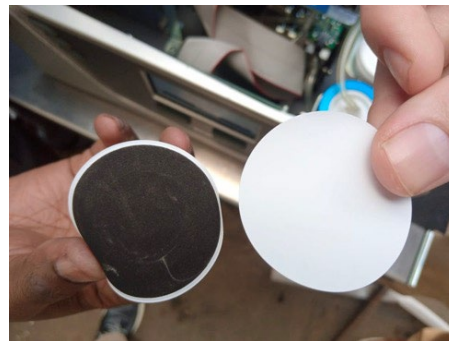
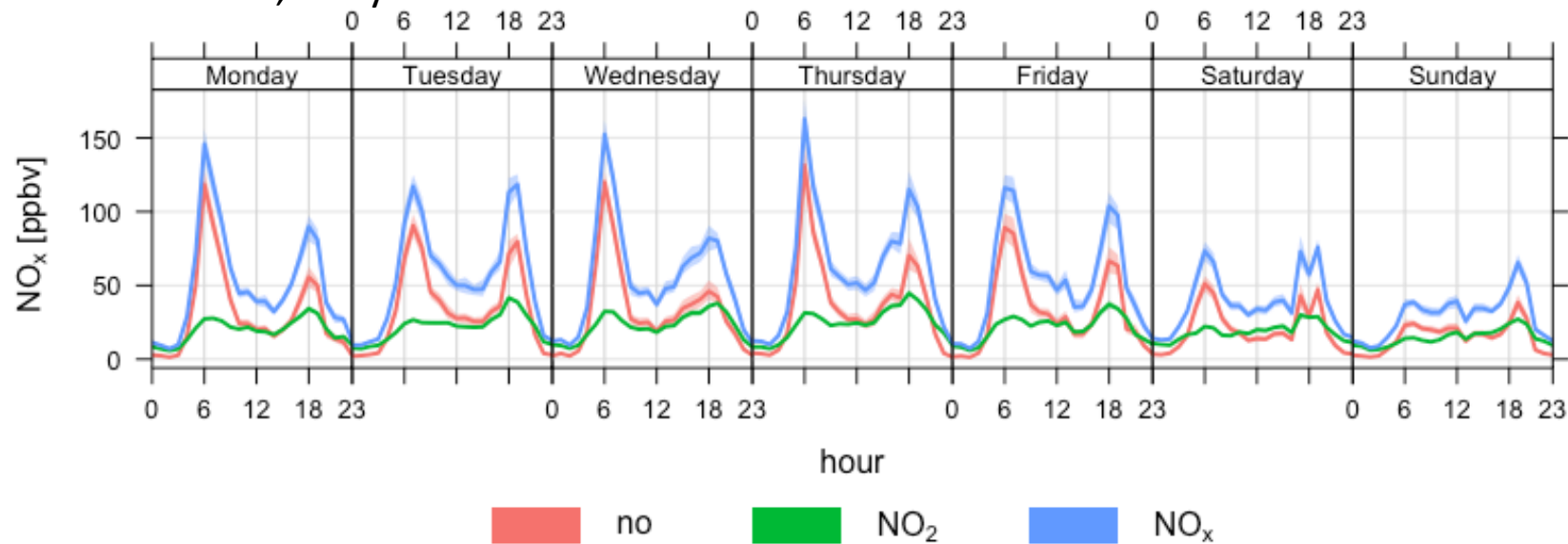
- International Conference on Air Quality in Africa (ICAQ'Africa 2022) to be held online in October 11-14, 2022.
 - CAMS-Net is a key partner/sponsor
 - All presented papers will be published in the Conference Book and authors of selected papers will be invited to submit an extended version to partnering journals
 - Lead: Bertrand Tchanche Fankam afs4aq@gmail.com
 - <http://www.as4aq.org/events/icaq-2022>
- African School on Atmospheric Science
 - October/November 2022 in person in Marrakech, Morocco.
 - CAMS-Net will sponsor the travel of several students/postdocs from Africa
 - <https://asas2022.sciencesconf/>
 - Lead: Wahid Mellouki

Current CAMS-Net activities: data collection

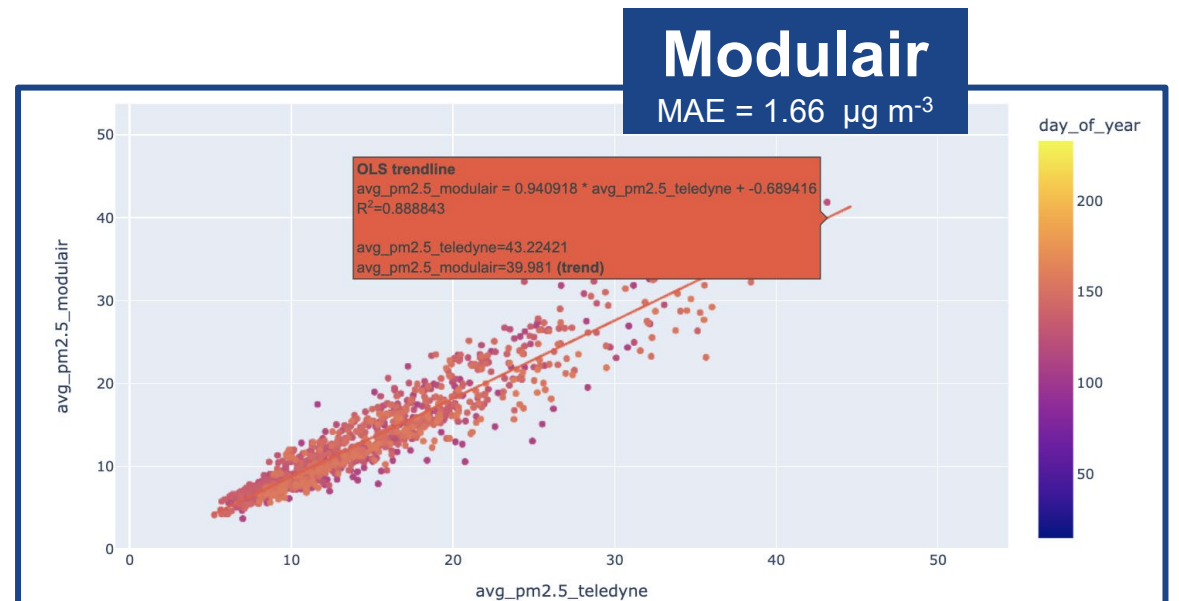
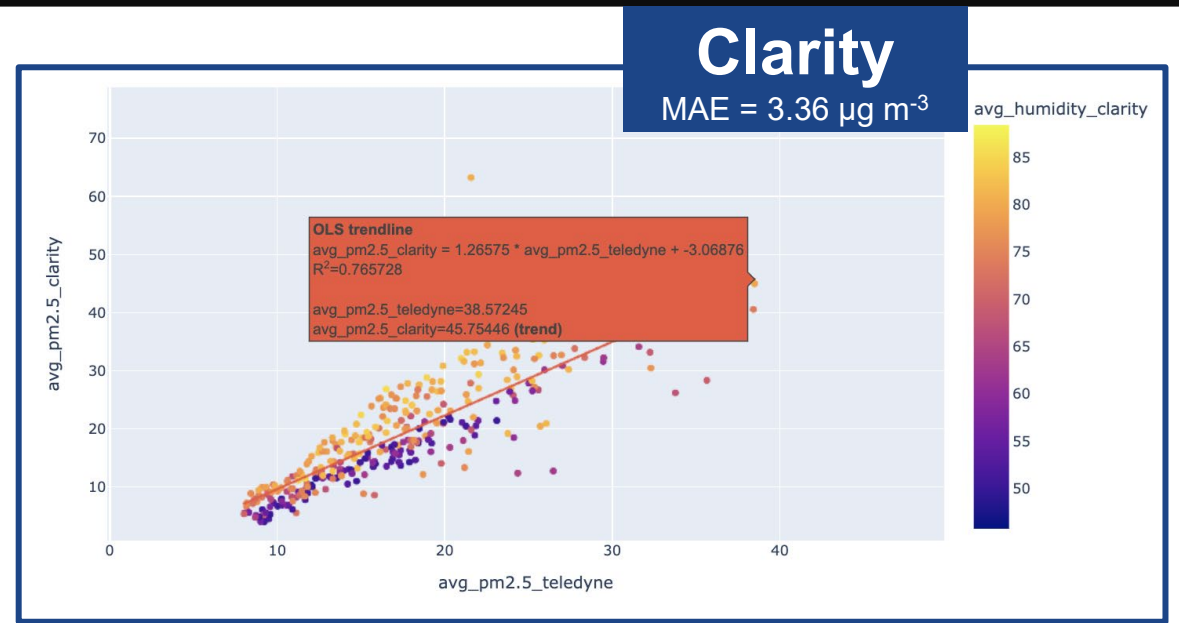
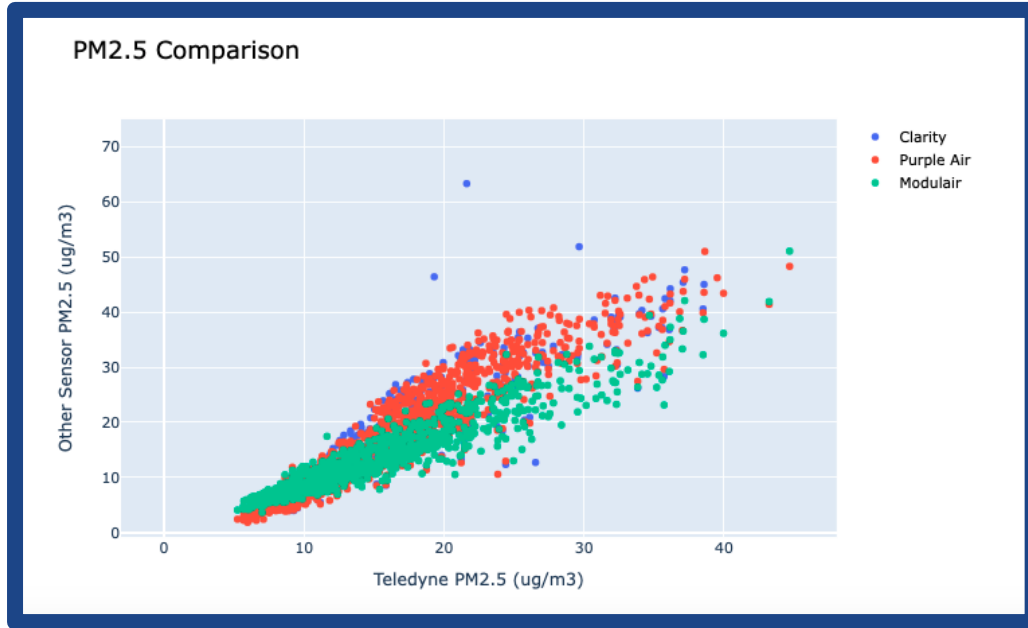
- Reference monitors and low cost sensors, PM and gas-phase

March 20 through April 12

Nairobi, Kenya



Current CAMS-Net activities: sensor calibration in West Africa



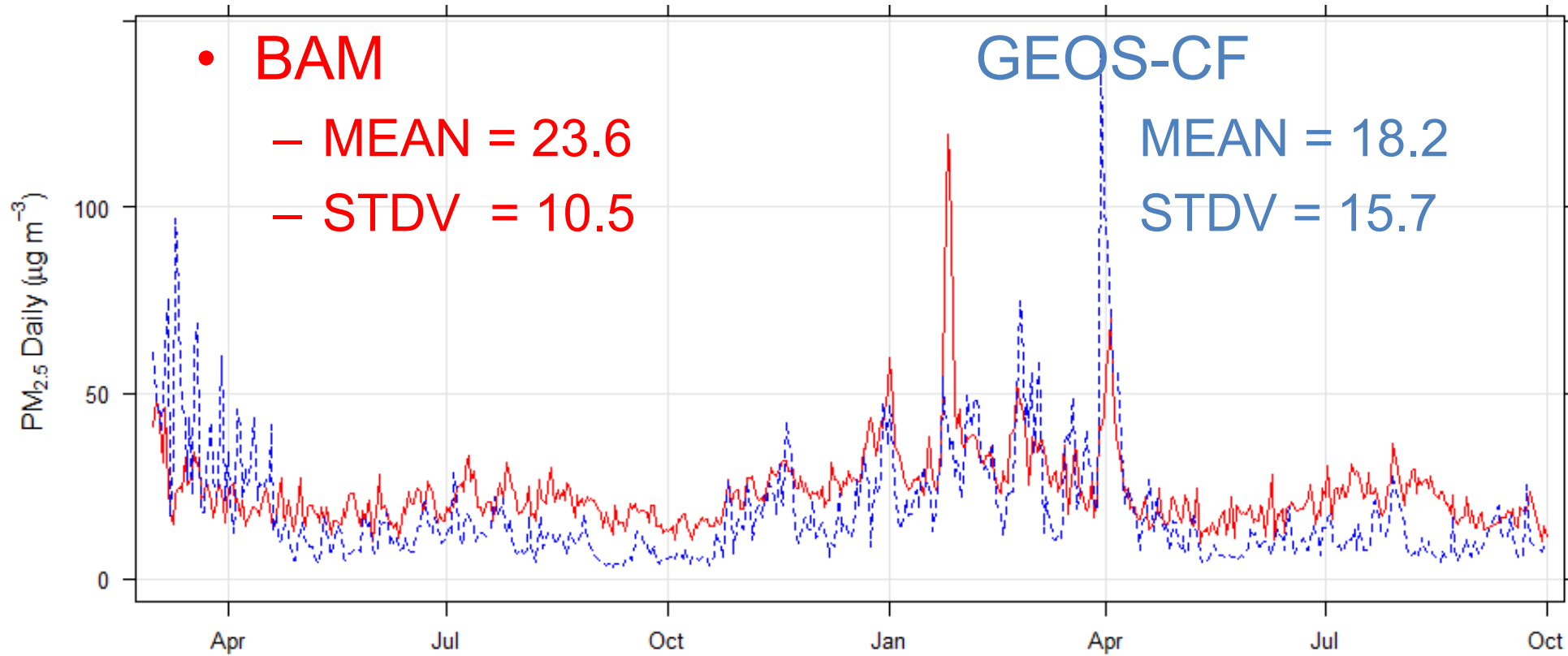
Current CAMS-Net activities: globally/regionally relevant LCS correction factors?

- While correction factors built on local co-locations between LCS and reference monitors are reliable, there are practical limitations to this approach
- Can we build and train a model that spans the parameter space of enough source profiles and environmental conditions to be globally or regionally applicable?
- Use nonlinear approaches to fit a model that uses raw PM readings, temperature, humidity, but also additional data sources such as population, location, etc
- Allows for “mixture” of correction models that best fit the particular dataset
 - E.g., use a mixture of regressions of several similar “training cities” that best fit the “test city”
- Multiple linear regression is not ideal for building a globally applicable, location-dependent correction model for LCS
 - Why? It is not possible to assign unique weights of a certain regression to a given data point with MLR

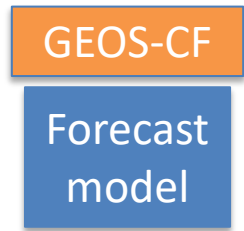
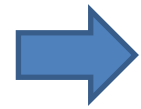
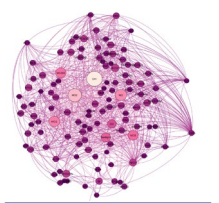
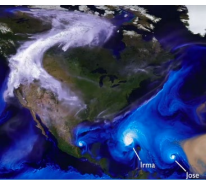
Application of Gaussian Mixture Regression for the Correction of Low Cost PM_{2.5} Monitoring Data in Accra, Ghana

Celeste McFarlane, Garima Raheja, Carl Malings, Emmanuel K. E. Appoh, Allison Felix Hughes, and Daniel M. Westervelt*

Current CAMS-Net activities: air quality forecasting for West Africa



— PM_{2.5} - - - PM_{2.5}_geos



25x25 km² horizontal resolution
5 day forecast
250 Chemical species

Victoria
Owusu
Tawiah

Summary

- Air pollution data is sparse in globally.
- Low cost sensors can help, but it is vital to calibrate them against reference or equivalent method monitors
- CAMS-Net is an international network of networks that seeks to accelerate novel research into use and application of low cost sensors
- Come talk to us, or find us online (www.camsnet.org) if you want to learn more or join!