

# Clean Air Monitoring and Solutions Network: Sustaining a global international network for obtaining useful, actionable data from air sensors

Prof. Dan Westervelt

Columbia University, Lamont-Doherty Earth Observatory, New  
York, USA

Lamont-Doherty Earth Observatory

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# A global network for getting useful, actionable data out of air 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
- Hosted sessions at ASIC 2022 and 2024



COLUMBIA UNIVERSITY  
IN THE CITY OF NEW YORK



CAMS-Net Session  
Friday 2:45pm RC-FC

# Clean Air Monitoring and Solutions Network (CAMS-Net)

- Website: [www.camsnet.org](http://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, and underserved areas of the United States



# Capacity building: advanced training for data analysis

- 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](mailto:cmm2349@columbia.edu)

This document will serve as an introduction to building multiple linear regression models between reference grade data and low-cost sensors. For the purpose of this tutorial, we will need the packages lubridate, tidyverse (which includes the packages dplyr, stringr, readr, purr, tibble, ggplot2), caTools and SimDesign. You can install packages by typing in the R-console `install.packages("package")`.

### Loading required libraries

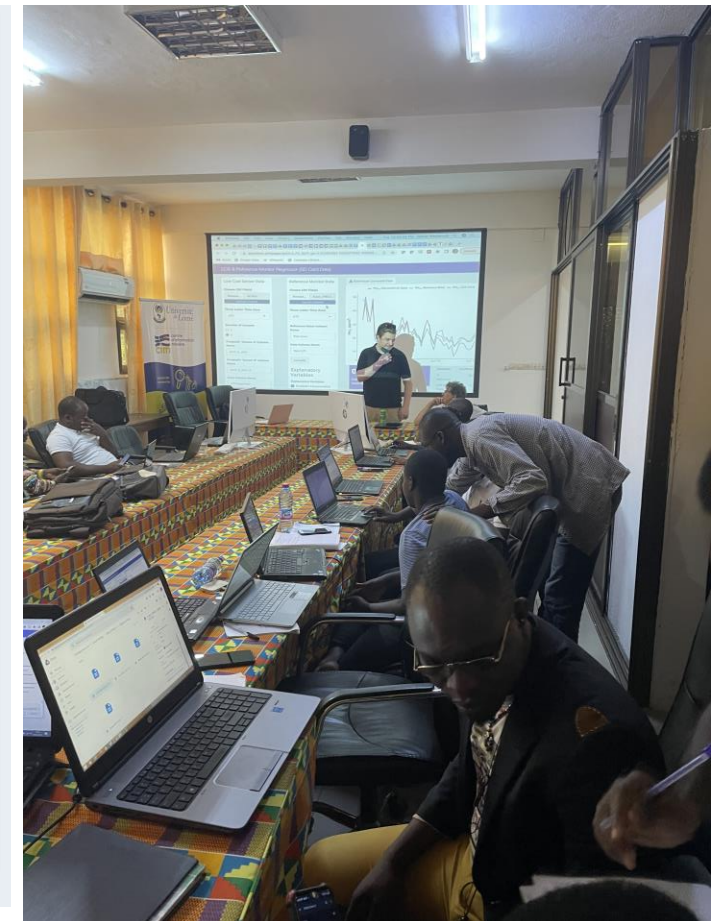
```
library(tidyverse)
library(lubridate)
library(SimDesign)
library(caTools)
```

### 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

Low Cost Sensor Data	Reference Monitor Data
<b>Choose CSV File(s)</b> <div>Browse... No file selected</div>	<b>Choose CSV File(s)</b> <div>Browse... No file selected</div>
<b>Three Letter Time Zone</b> <div>UTC</div>	<b>Three Letter Time Zone</b> <div>UTC</div>
<b>Number of Sensors</b> <div><input type="radio"/> 1 <input checked="" type="radio"/> 2</div>	<b>Reference Value Column Name</b> <div>Raw Conc.</div>
<b>PurpleAir 'Sensor A' Column Name</b> <div>pm2_5_atm</div>	<b>Date Column Name</b> <div>Date (LT)</div>
<b>PurpleAir 'Sensor B' Column Name</b> <div>pm2_5_atm_b</div>	<div>Compile</div>
<b>Date Column Name</b> <div>UTCDateTime</div>	<b>Explanatory Variables</b> <div><input checked="" type="checkbox"/> PurpleAir Concentration <input checked="" type="checkbox"/> Temperature <input checked="" type="checkbox"/> Relative Humidity <input type="checkbox"/> Dew Point</div>
<b>Relative Humidity Column Name</b> <div>current_humidity</div>	<div>Analyze</div>
<b>Temperature Column Name</b> <div>current_temp_f</div>	





# Previous meeting

- The CAMS-Net project held its first in-person meeting on May 10, 2022 in Pasadena, California as a side meeting of the Air Sensors International Conference. About 20 project members representing various networks attended.
- CAMS-Net also sponsored 3 oral sessions at ASIC throughout the rest of the week. These were very well received and well attended, with over 100 attendees at our Thursday session.

 **Air Sensors International Conference**  
Pushing ahead: application and communication in science

**NEW Parallel Symposium!**

We are excited to announce a partnership with the Clean Air Monitoring and Solutions Network that will bring more air monitoring discussions based on their international network. This parallel symposium will take place as a daily session at the Pasadena Convention Center with all current ASIC sessions. Read the description below and submit an abstract through the portal.

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**Clean Air Monitoring and Solutions Network: getting useful, actionable data out of low cost sensors for air quality action**



# First African School on Atmospheric Sciences

- African School on Atmospheric Science
  - November 2022 in person in Morocco at UM6P
  - CAMS-Net will provide training materials and lecturers
  - <https://asas2022.sciencesconf.org/>





# CAMS-Net + AfriqAir meeting



## General Meeting and Air Quality Conference

March 7-10, 2023  
CMU-Africa, Kigali, Rwanda



# Next CAMS-Net meeting: Bengaluru, India, Aug 26-30, 2024

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- Joint meeting with ICAS (India Clean Air Summit)
- Partnership with CSTEP (Center for Study of Science, Technology and Policy)
- Theme: South-South-North collaboration towards clean air for all
- **Session Titles:**
  1. Let's talk data! Air quality data analysis (training)
  2. Introduction to Land Use Regression Models (training)
  3. Air sensor hardware: hands-on (training)
  4. Which Air Pollution Monitor? Global experiences with standardized air sensor evaluations and the path forward
  5. Clean air in every neighbourhood: Sensor networks to support air quality management (Case studies from India, Africa, USA)
  6. Advanced data analysis techniques for new insights from sensor networks
  7. What are you breathing at home and at the office? Indoor Air Quality Management and Sensors
  8. Air sensors – towards a South Asia Community of Practice





# Seeding pilot projects among CAMS-Net partner networks

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Member networks	Project Title
AfriqAir, Alioune Diop University (Senegal), AirQo, University of Douala (Cameroon)	DESIGN AND TESTING OF NETWORKS OF LCS FOR AIR POLLUTANTS MONITORING IN WEST AND CENTRAL AFRICAN CITIES
See presentation Friday 2:45 by Dr. Collins Hodoli	
Clean Air One Atmosphere, Univeristy of Ghana, Clarity, AfriqAir	Exploring the robustness of LCS for understanding the impacts of location specific agricultural practices on local air quality.
AfriqAir, AirQo, ISGlobal, Manhica Center for Health Research	Expanding air quality monitoring, capacity, and health research in Mozambique
GMET, Ghana EPA, UGhana, Clean Air one Atmosphere	Schools Air Quality Outreach

# Example research project: next generation AQ monitoring in Accra, Ghana

RETURN TO ISSUE | < PREV DATA SCIENCE NEXT >

## Low-Cost Sensor Performance Intercomparison, Correction Factor Development, and 2+ Years of Ambient PM<sub>2.5</sub> Monitoring in Accra, Ghana

Garima Raheja\*, James Nimo, Emmanuel K.-E. Appoh, Benjamin Essien, Maxwell Sunu, John Nyante, Mawuli Amegah, Reginald Quansah, Raphael E. Arku, Stefani L. Penn, Michael R. Giordano, Zhonghua Zheng, Darby Jack, Steven Chillrud, Kofi Amegah, R. Subramanian, Robert Pinder, Ebenezer Appah-Sampong, Esi Nerquaye Tetteh, Mathias A. Borketey, Allison Felix Hughes, and Daniel M. Westervelt\*

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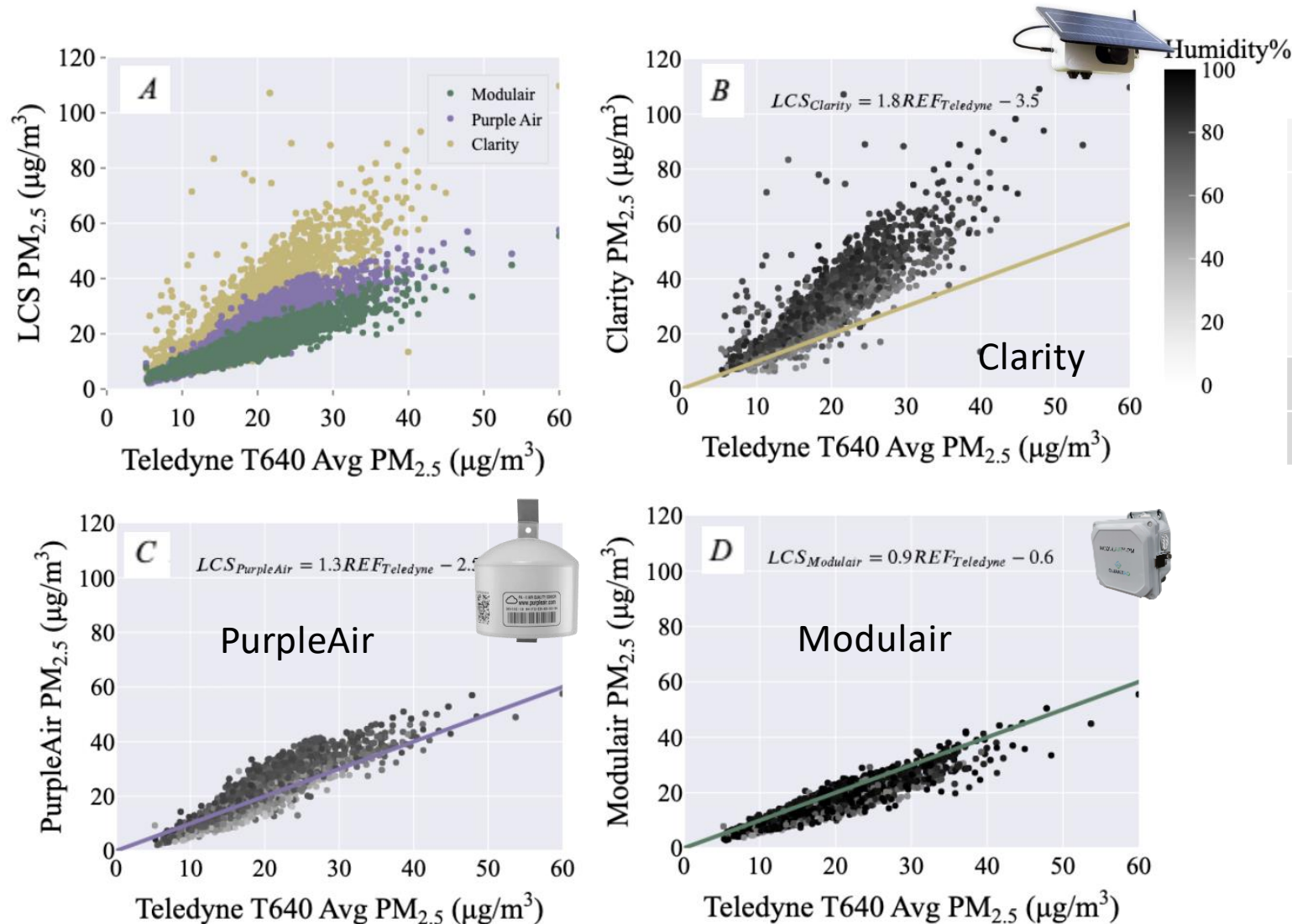


Environmental Science & Technology  
View



Project seeded the African Sensor Evaluation and Training Center (Afri-SET)

# Performance between different vendors against reference PM2.5



Model	Purple Air		Clarity		Modulair	
	$R^2$	MAE (μg/m <sup>3</sup> )	$R^2$	MAE (μg/m <sup>3</sup> )	$R^2$	MAE (μg/m <sup>3</sup> )
Manufacturer-Reported	0.82	4.54	0.69	13.68	0.84	3.04
MLR	0.87	1.96	0.74	2.49	0.86	2.15
GMR	0.89	1.76	0.79	2.27	0.87	1.89

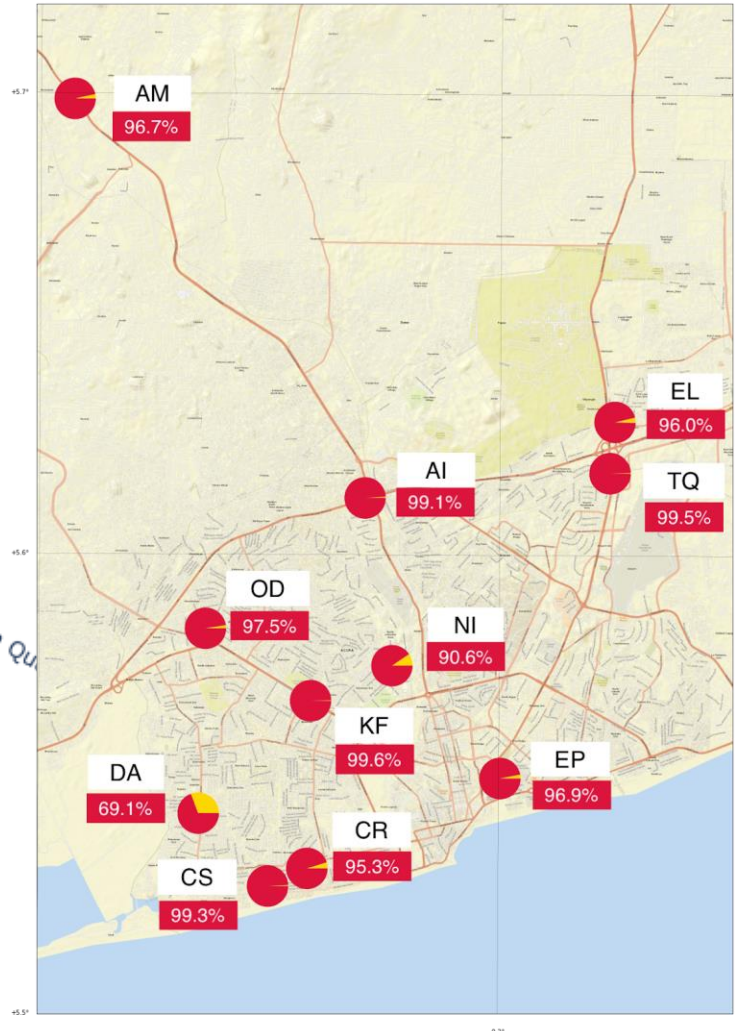
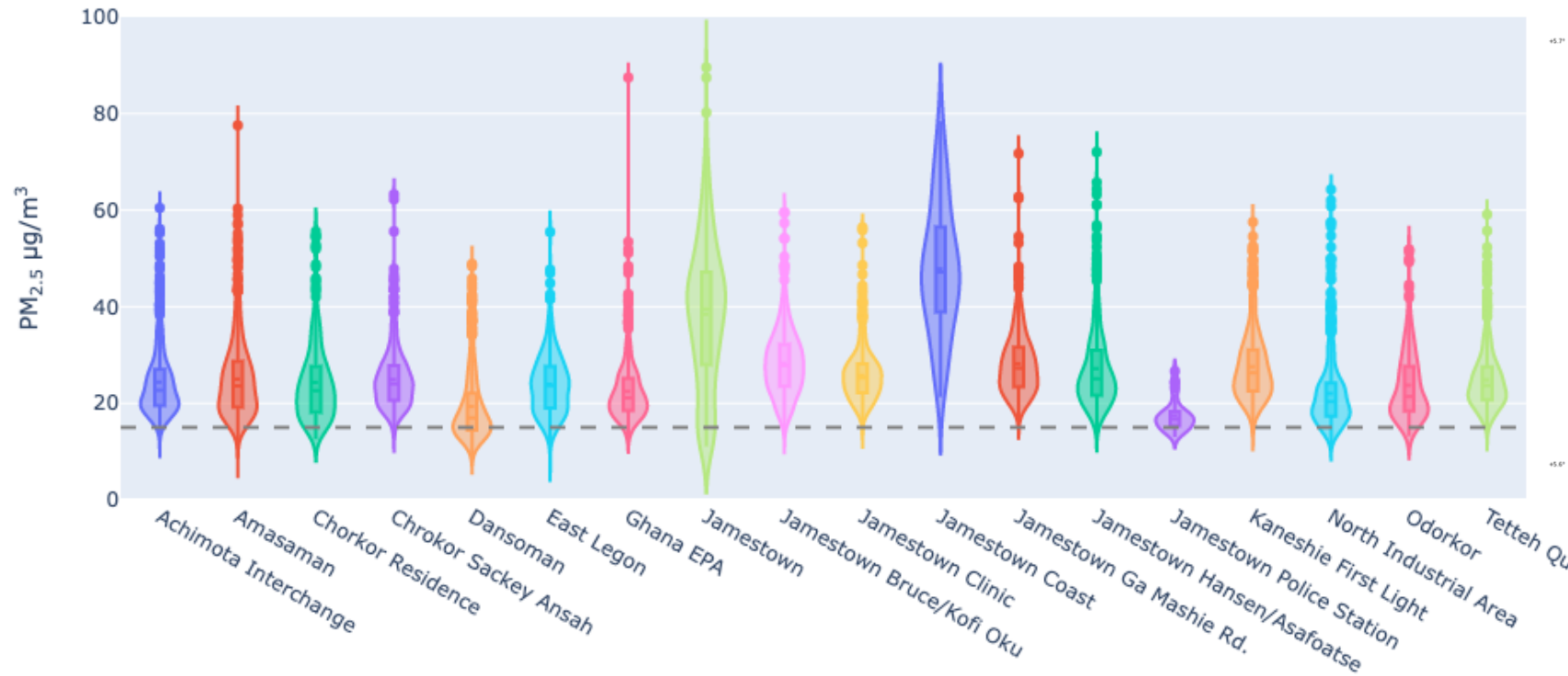
Set aside some fraction of the data to as “training data” to develop “correction factor”





# With well-calibrated air sensors in resource-limited countries, we can quickly close the air pollution data gap!

- Applying the correction factor to PM<sub>2.5</sub> sensor networks in Accra, Ghana



# Summary

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- What has worked well in CAMS-Net
  - Travel funding for meetings including ASIC
  - Training sessions online and in person
  - Meetings in the Global South to avoid visa denying issues
  - Fostering collaborations between
- Hybrid networks of reference monitors and air sensors can close the air quality data gap
  - 3+ year 18-node network reveals degraded air quality in Accra ( $23.4 \mu\text{g m}^{-3}$  for 24-hour mean)