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

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Carnegie Mellon University

WASHINGTON UNIVERSITY IN ST. LOUIS
Per Veritatem Vis
1853

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").

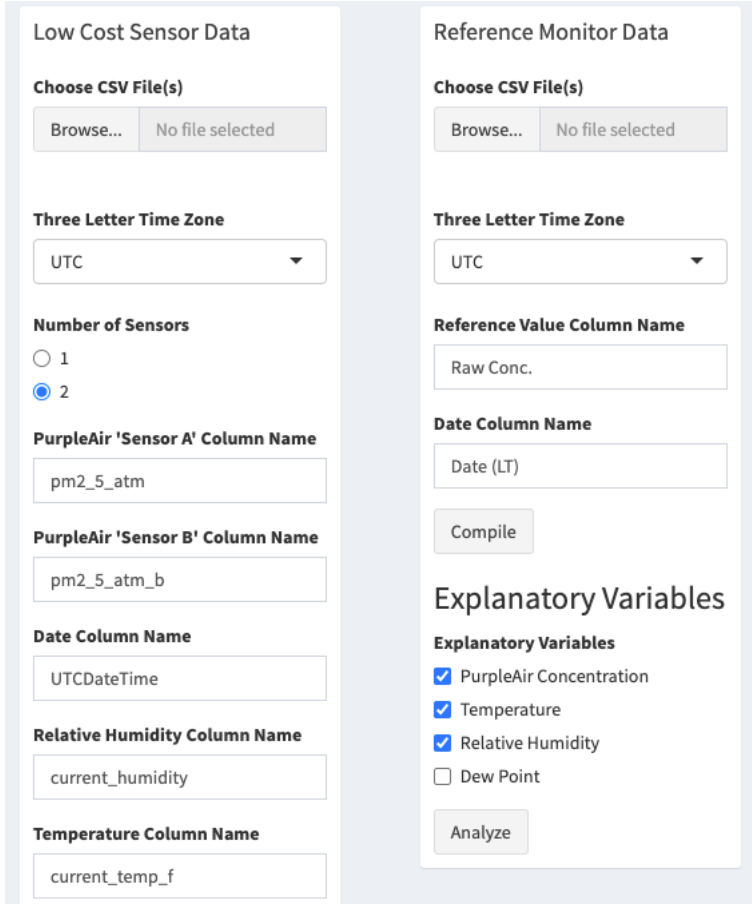
Loading required libraries

```
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)

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 Bililign

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

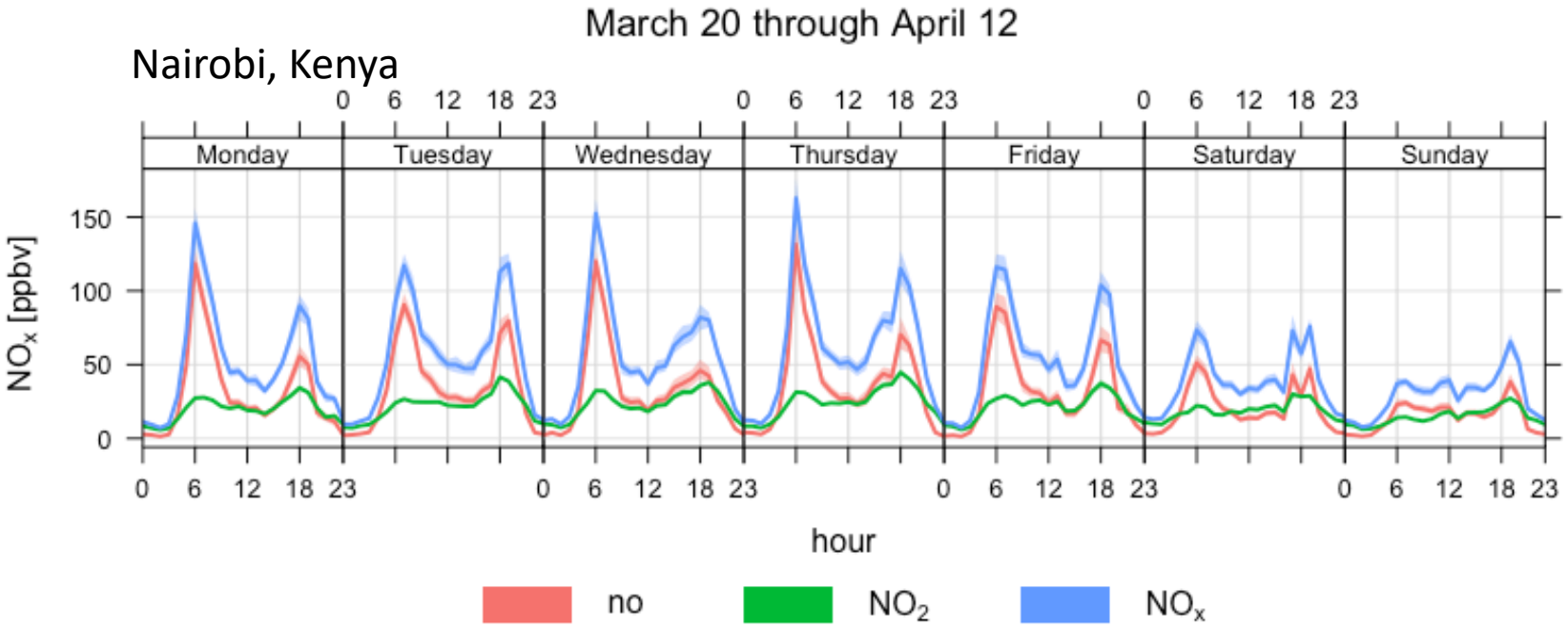
Current CAMS-Net activities: supporting meetings

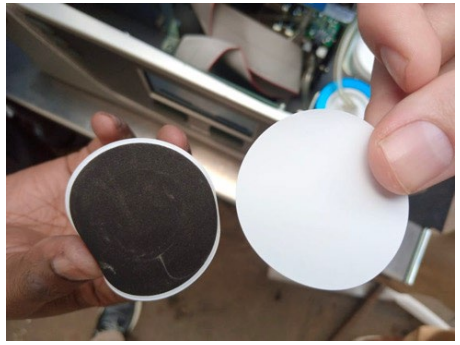
- International Conference on Air Quality in Africa (ICAQ'Africa 2022) to be held online in October 11-14, 2022.
  - CAMS-Net is a key partner/sponsor
  - All presented papers will be published in the Conference Book and authors of selected papers will be invited to submit an extended version to partnering 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, Morroco.
  - CAMS-Net will sponsor the travel of several students/postdocs from Africa
  - https://asas2022.sciencesconf.org/
  - Lead: Wahid Mellouki

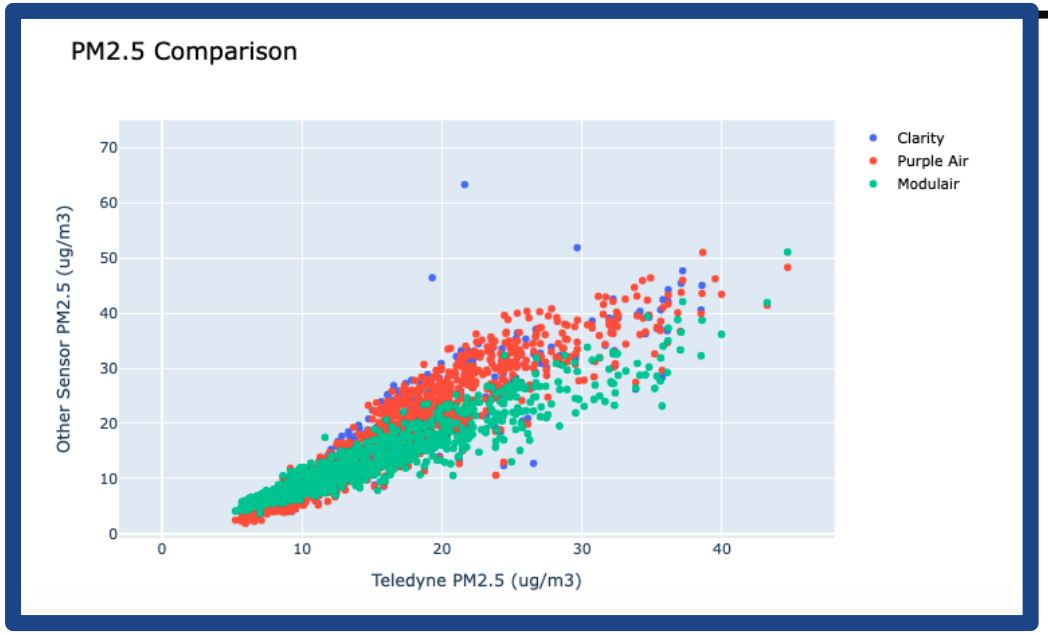
Current CAMS-Net activities: data collection

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



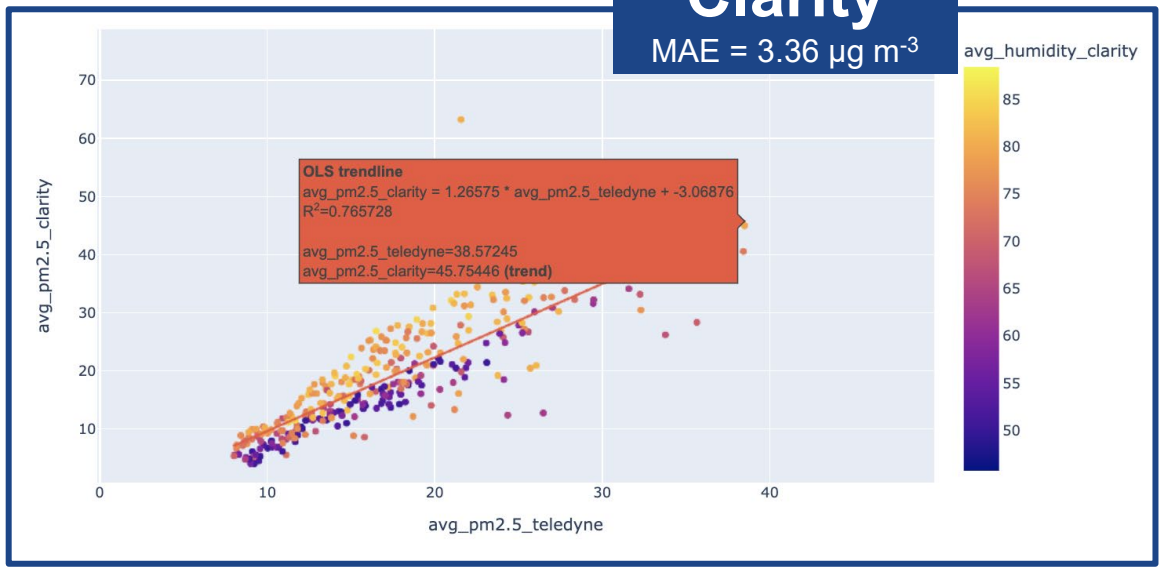


Current CAMS-Net activities: sensor calibration in West Africa



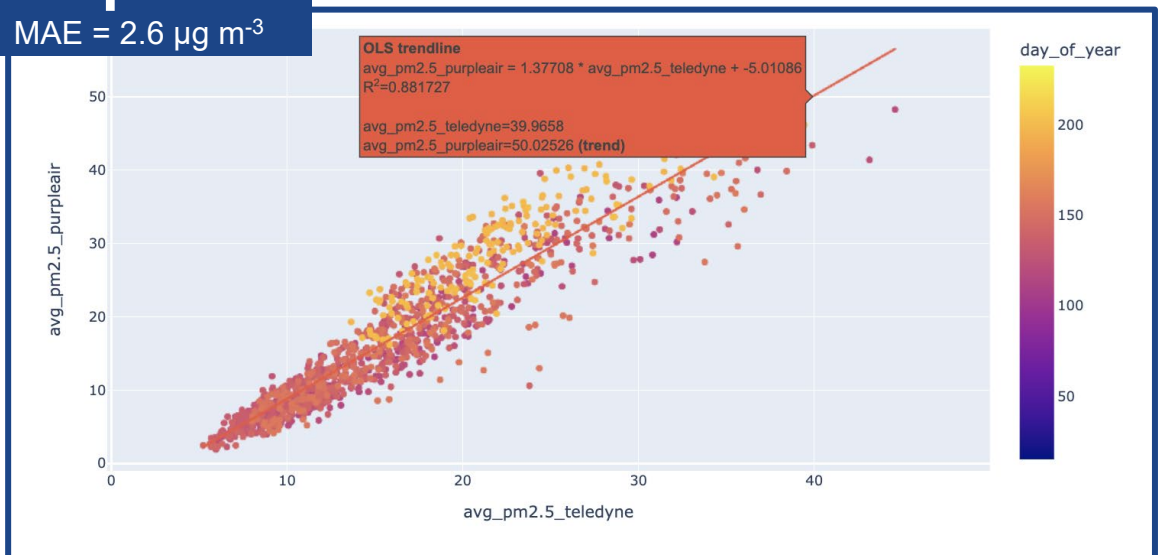
Clarity

MAE = 3.36 µg m^{-3}



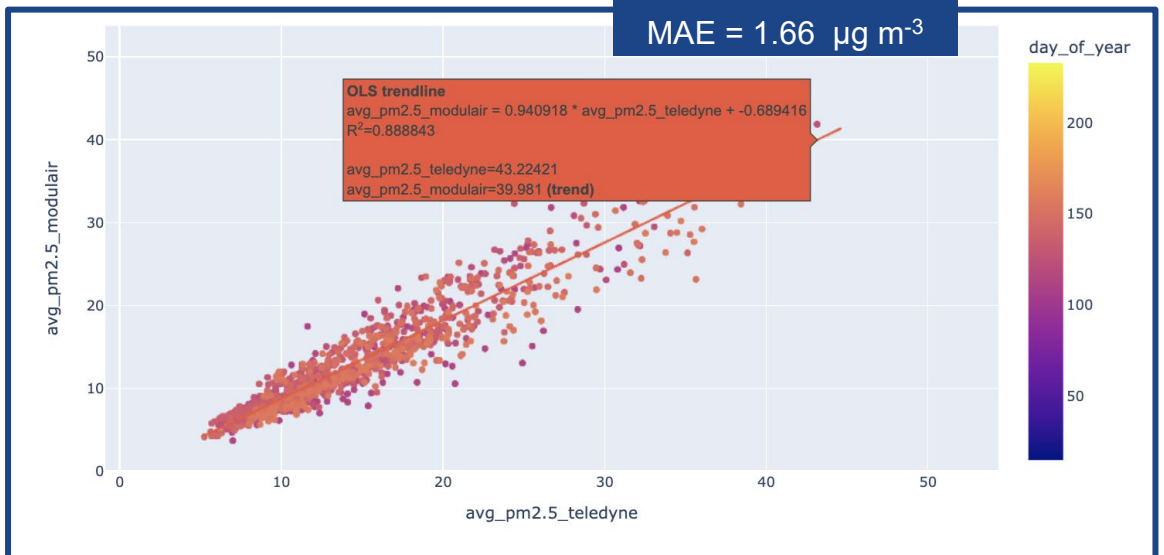
PurpleAir

MAE = 2.6 µg m^{-3}



Modulair

MAE = 1.66 µg m^{-3}



Garima Raheja

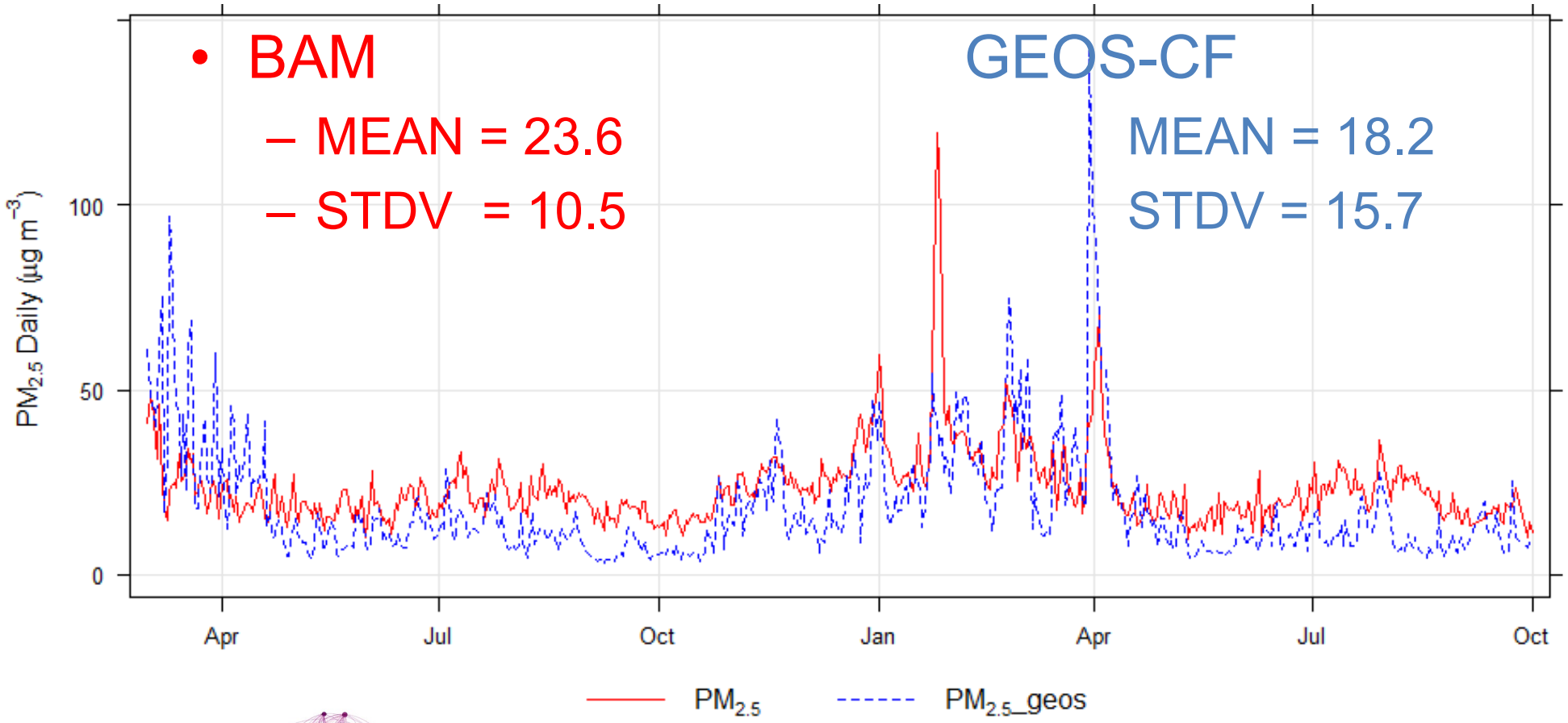
Current CAMS-Net activities: globally/regionally relevant LCS correction factors?

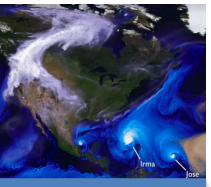
- While correction factors built on local co-locations between LCS and reference monitors are reliable, there are practical limitations to this approach
- Can we build and train a model that spans the parameter space of enough source profiles and environmental conditions to be globally or regionally 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

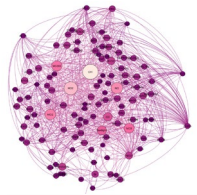
Celeste McFarlane, Garima Raheja, Carl Malings, Emmanuel K. E. Appoh, Allison Felix Hughes, and Daniel M. Westervelt*

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





GEOS Weather



GEOS-Chem

GEOS-CF

Forecast model

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!