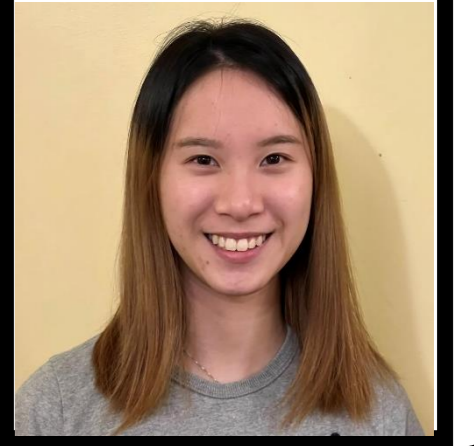# Validation of Environmental Sensors Based on the Raspberry Pi Platform

B.Sc. (Honours) in Environmental Science and Sustainable Technology
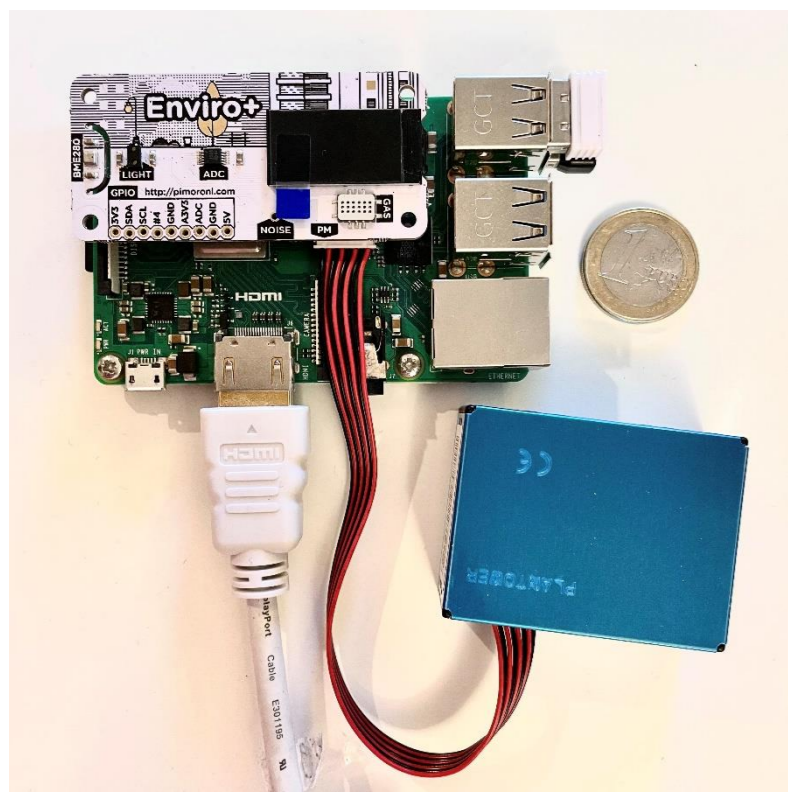
Department of Physical Sciences

Student Name: Eunice Wong

Supervisors Name: Eamonn Butler

Project Background

A suite of inexpensive Raspberry Pi compatible environmental sensors has been devised by the Irish and Scottish EPA in conjunction with an external agency to facilitate a citizen science project for educating secondary students with STEM type activities. The aim of this project was to evaluate the performance of these sensors. The suite of sensors includes air monitoring parameters such as NOx, VOCs, Light, Temperature, Pressure and Humidity. The Enviro+ air quality board and the Plantower PM sensor are considered. A total of four kits were used for intercomparison.

Methodology

Sensors Tested against Reference Instruments

Performance of the sensors were evaluated by comparison with reference instruments as listed in the table below:

| Pollutant/Parameter	Raspberry Pi kit Sensor	Reference Method / Instrument
Carbon Monoxide	MiCS6814	-
PM10 PM2.5	Plantower PMS5003	FIDAS 200
Temperature Humidity	BME280	KBF 115 Climate Chamber HC2A-S Humidity Probe
Noise	I2S MEMS Microphone	NTI Audio XL2 Sound Level Meter

The Raspberry Pi Interface
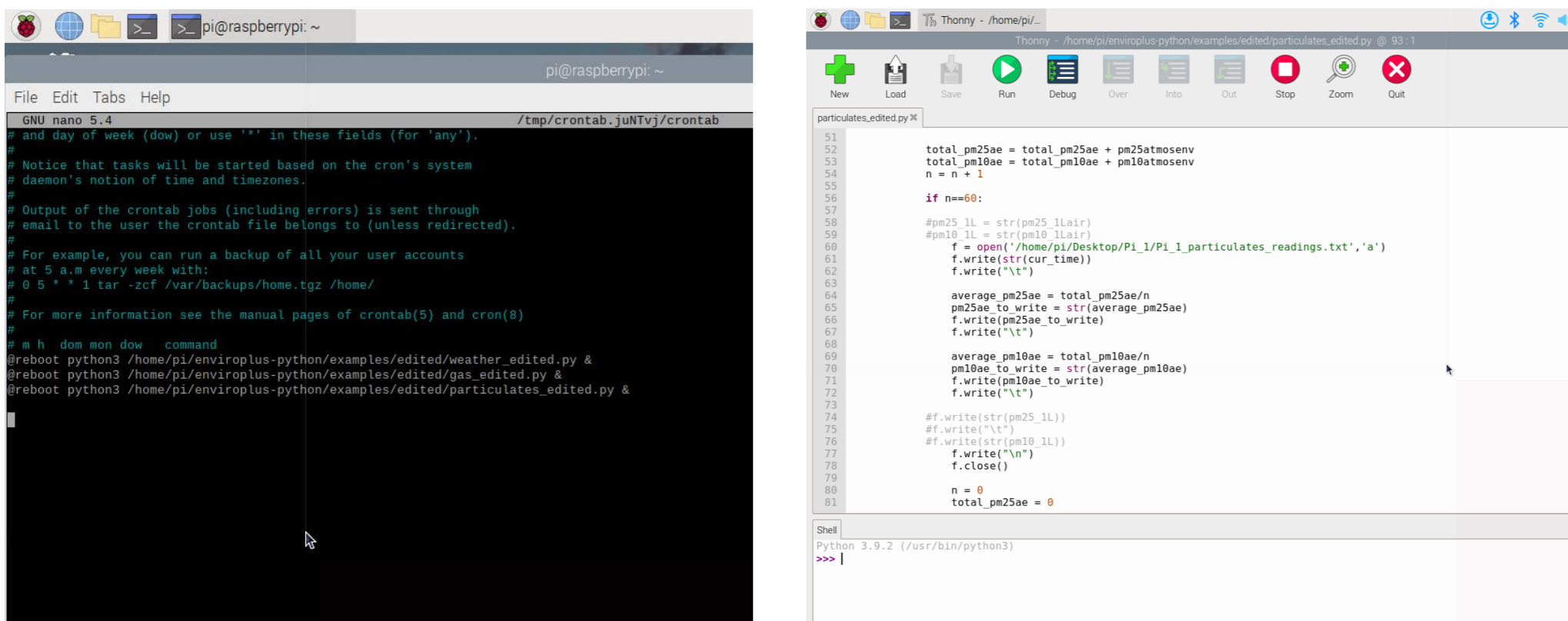
The Raspberry Pi runs Linux and the Pi OS is the main supported operating system. Python scripts for the Enviro+ sensor, PMS50003 sensor and microphone were installed and edited to run automatically on boot and record the readings to a text file for later analysis.

Main Issues Encountered

- **Time discrepancies:** Raspberry Pi does not operate a real-time clock. This caused difficulty when correlating PM, temperature and humidity measurements with reference instruments.

- **Supply chain issues:** This caused significant delays in lab work.
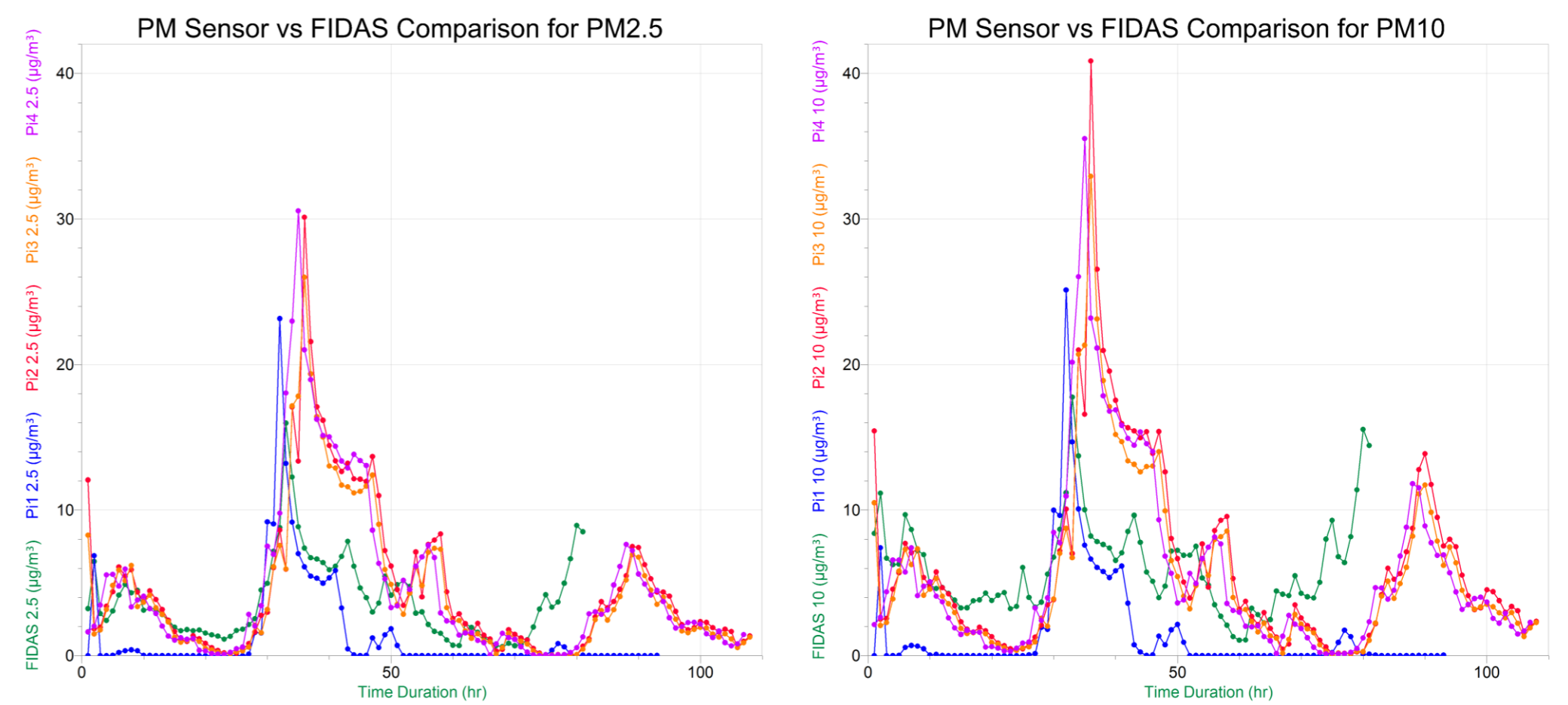
Results

Temperature and Humidity
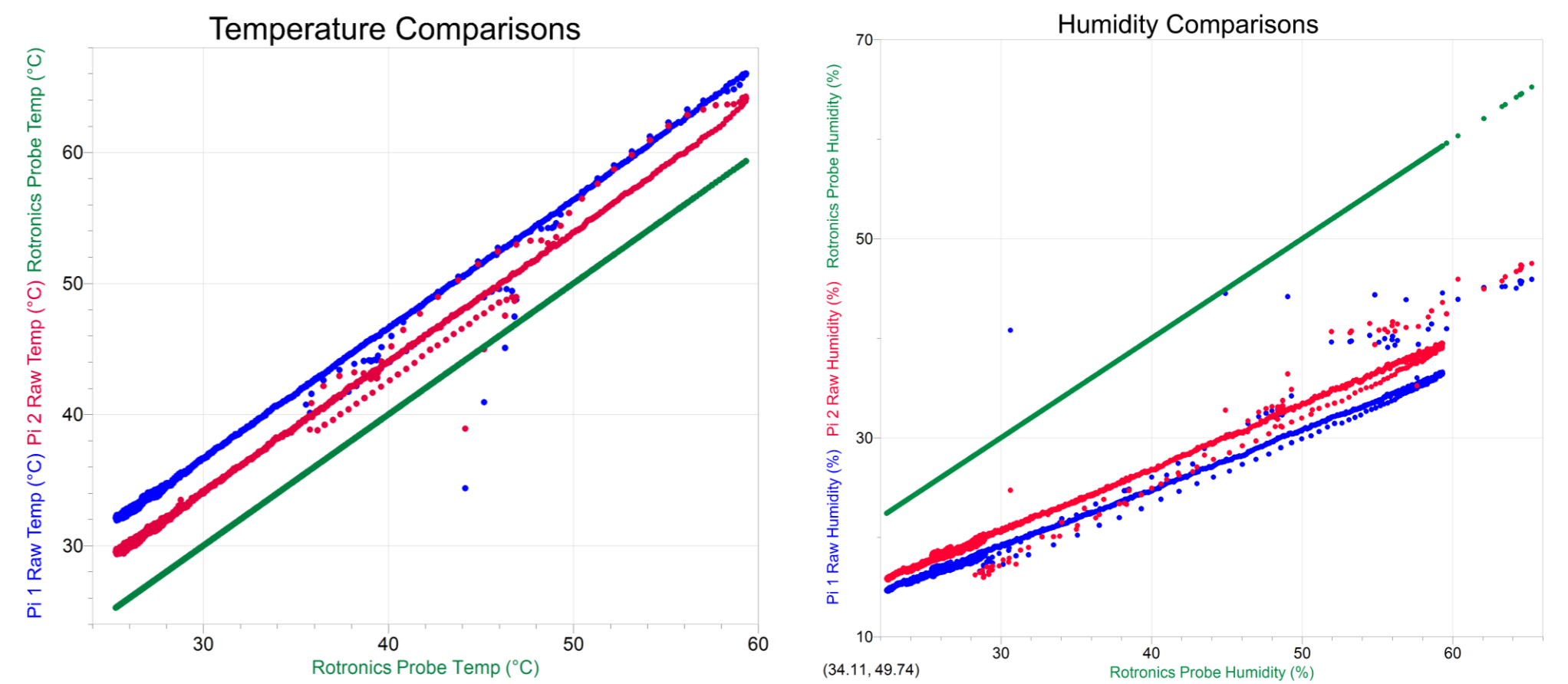
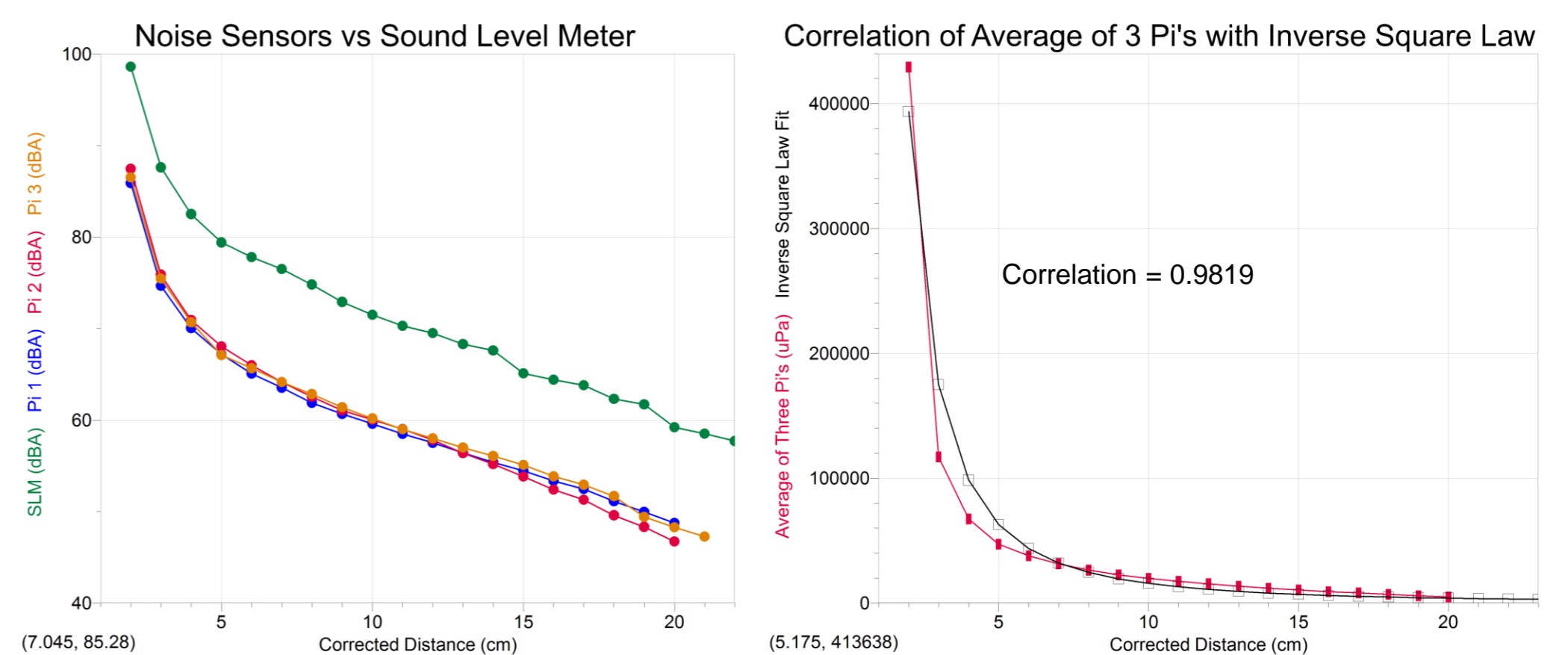| Intercomparing slopes (Ideal slope = 1)	
Temperature	Humidity
Pi 1 = 0.9789	Pi 1 = 0.6047
Pi 2 = 0.9984	Pi 2 = 0.6413

As humidity is a difficult measurement, it is not surprising that the temperature slopes were closer to 1.

PM2.5 & PM10

Four PM sensors trended in agreement with the FIDAS, however, there were some timing issues.

Noise

Three microphone sensors trended in agreement with the sound level meter (SLM), but were consistently reading low. All show very high correlation with the inverse square law.

References

- *Bosch BME280 Combined humidity and pressure sensor - Data sheet*. Bosch Sensortec, 2021.
- *MiCS-6814 1143 rev 8 Datasheet*. SGX Sensortech, 2022
- Y. Zhou, *Digital universal particle concentration sensor PMS5003 series data manual*, 2nd ed. 2016.
- "Raspberry Pi Documentation - Raspberry Pi Hardware", *Raspberrypi.com*, 2022. [Online]. Available: https://www.raspberrypi.com/documentation/computers/raspberry-pi.html.
- Macdonald, S., 2019. *Getting Started with Enviro+*. [Online] Learn.pimoroni.com. Available: https://learn.pimoroni.com/article/getting-started-with-enviro-plus.