



Universidade de São Paulo
Instituto de Astronomia, Geofísica e Ciências Atmosféricas



Development of a low-cost Portable Emission Measurement System

Andre L. S. Forcetto

Advisor: Dr. Maria de Fatima Andrade - IAG USP

Co-advisor: Dr. Flavio Guilherme de Vaz Almeida Filho - Poli USP

Doctorate in Atmospheric Pollution

Atmospheric Pollution in São Paulo

▪ Main pollutants: Ozone / PM_{2,5}

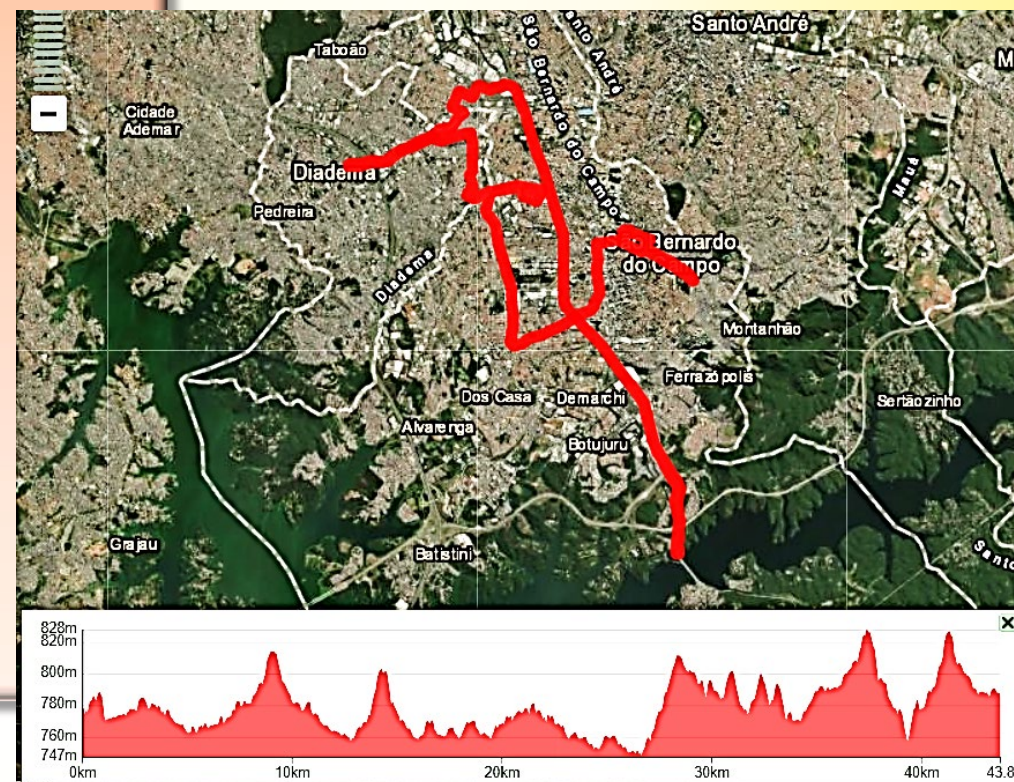
○ São Paulo Atmosphere:

- VOC limitant
- NO_x from Heavy Duty Vehicles
- HC from flexfuel Light Vehicles (gasoline + ethanol)
- High aldehyde presence due to ethanol as fuel



RDE in Brazil

- Based on European RDE
- Regulation: after 2022 (monitor) / 2025 (CF: 2.0)
- Main differences:
 - CO₂ / CO / NO_x / THC (NMOG)
 - Trip share: 65% *Urban* x 35% *Rural* x *No motorway*
 - ~50 km long
 - Altitude gain: between 600 to 1,200 m/100km
 - Moderate conditions:
 - Altitude < 1,000 m
 - Temperature: 15-35°C



The (regulatory) PEMS in Brazil



■ Advantages:

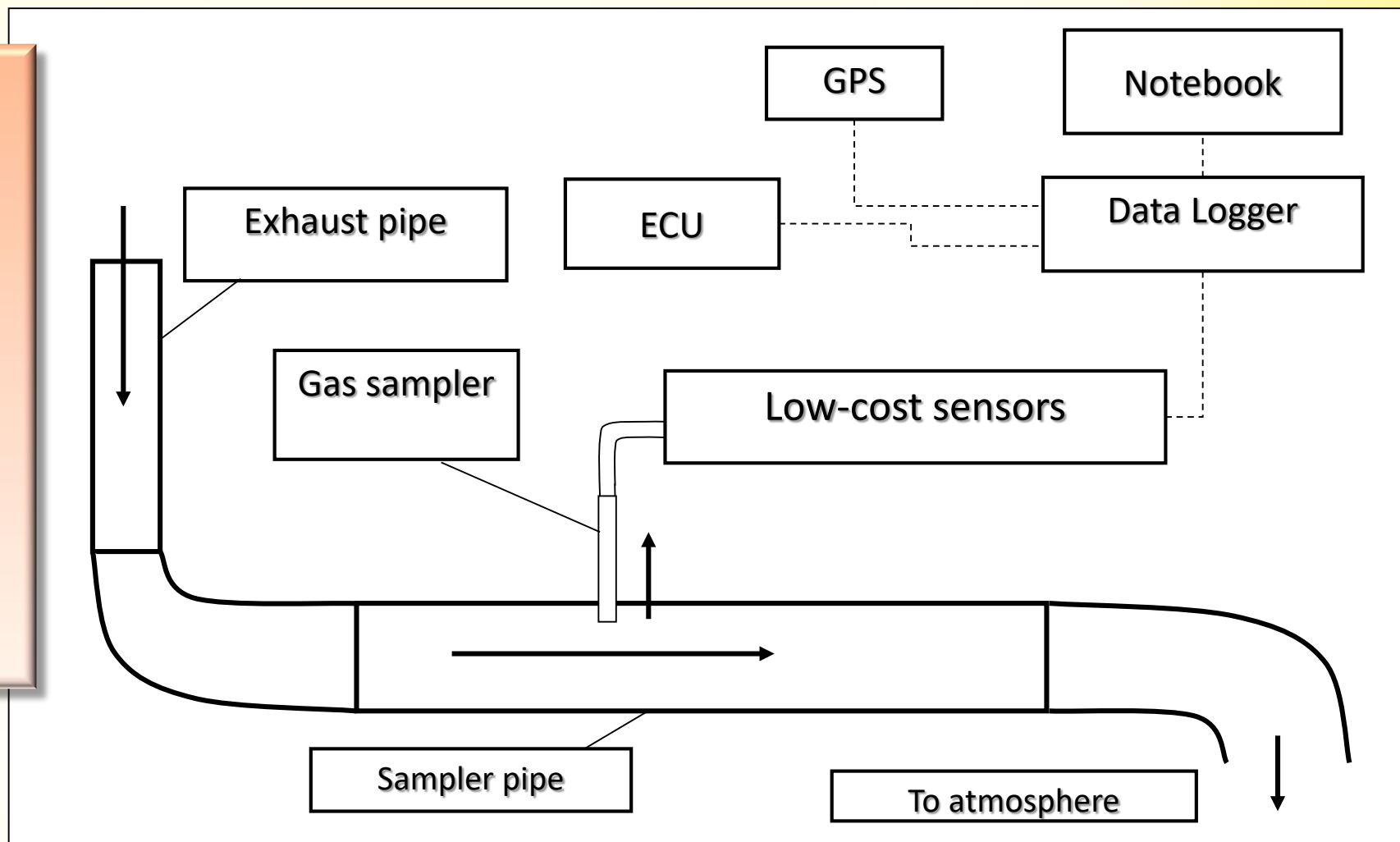
- Laboratory grade precision
- Real-world measurement

■ Disadvantages:

- Big & heavy: ~200 kg
(PEMS + batteries + gas bottles + flowmeter + computer + etc.)
- Costly: ~ US\$250k or ~R\$1.5mi
- “Turn-key” system

Project: Low-cost PEMS

- Low weight
- Compact
- Taylor-made
- Interesting pollutants: CO₂, CO, HC, NO_x
- For flexfuel cars



The low-cost PEMS project



Low-cost PEMS

▪ Achievements:

- ~15 kg
- Free SW: Raspbian / Python / C+
- < US\$ 1,000
- R^2 : $\text{CO}_2 / \text{CO} > 0.9$, $\text{THC} > 0.7$
- Robust

▪ Challenges:

- Sensor measurement ranges
- Influence of humidity (CO / HC sensor)
- Zero / spam check
- Linearity equations: specific for E22/E100

▪ Future:

- Free access to Research Institutes
- Adaptable for motorcycles





Universidade de São Paulo
Instituto de Astronomia, Geofísica e Ciências Atmosféricas



Q/A TIME

Contact: aforcetto@gmail.com

Phone / Whatsapp: (+55 11) 97017-9755