Development of a wireless air pollution sensor package for aerial-sampling of emissions

Xiaochi Zhou[1,2], Brian Gullett[3], William Mitchell[3], Johanna Aurell[4,5]

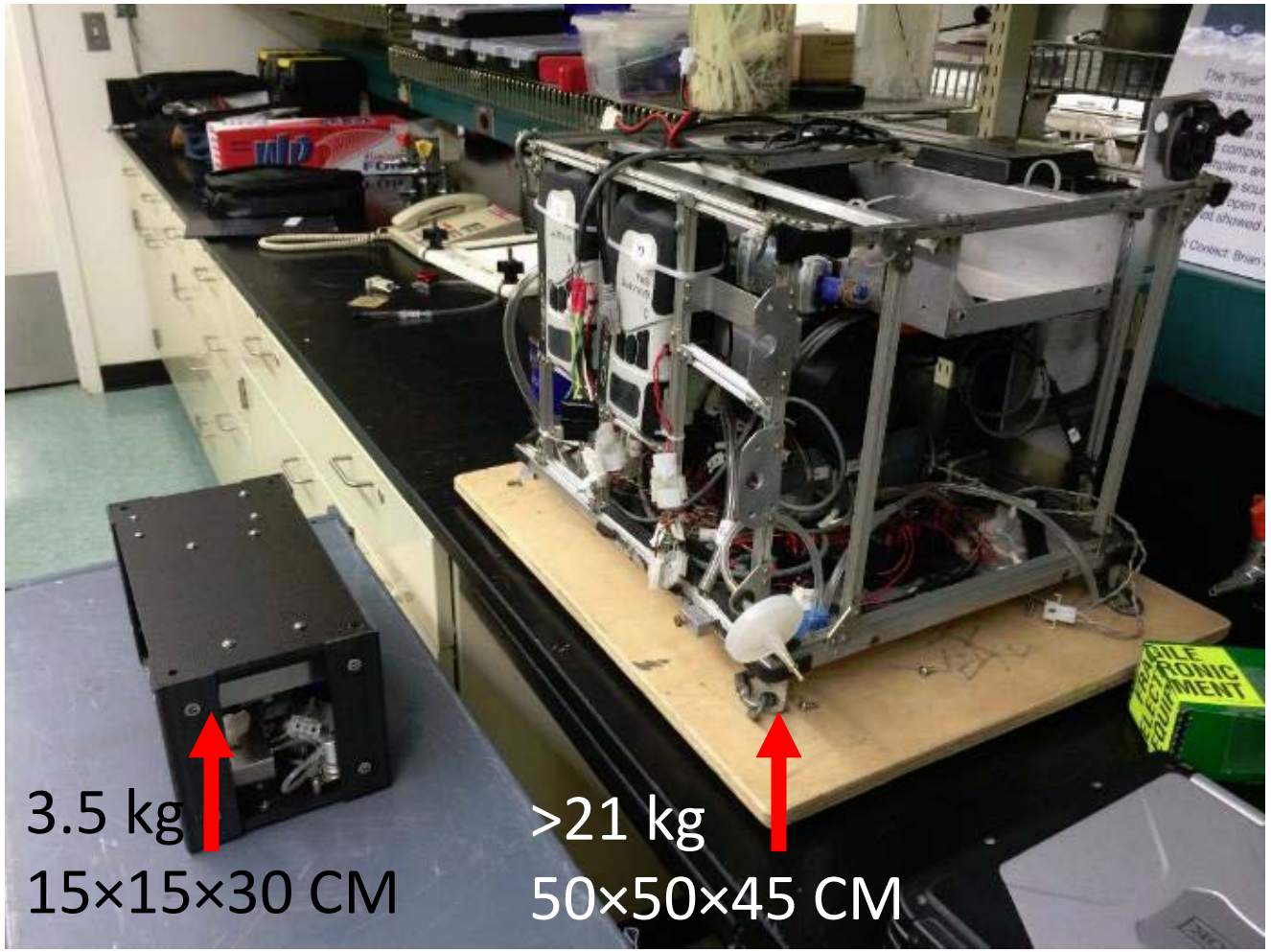
[1]Student Service Contractor, U.S. EPA, Office of Research and Development
[2]Duke University, Department of Civil and Environmental Engineering
[3]U.S. EPA, Office of Research and Development
[4]Visiting scientist, U.S. EPA, Office of Research and Development
[5]University of Dayton Research Institute

Introduction

- Emissions from forest fires contribute 12%-17% of $PM_{2.5}$ and 25.6% of volatile organic compounds in the U.S. (NEI, 2008).
- Emission factors (amount of pollutant produced per burned material) have been estimated from ground, airplane, and aerostat systems.

Purpose of this research

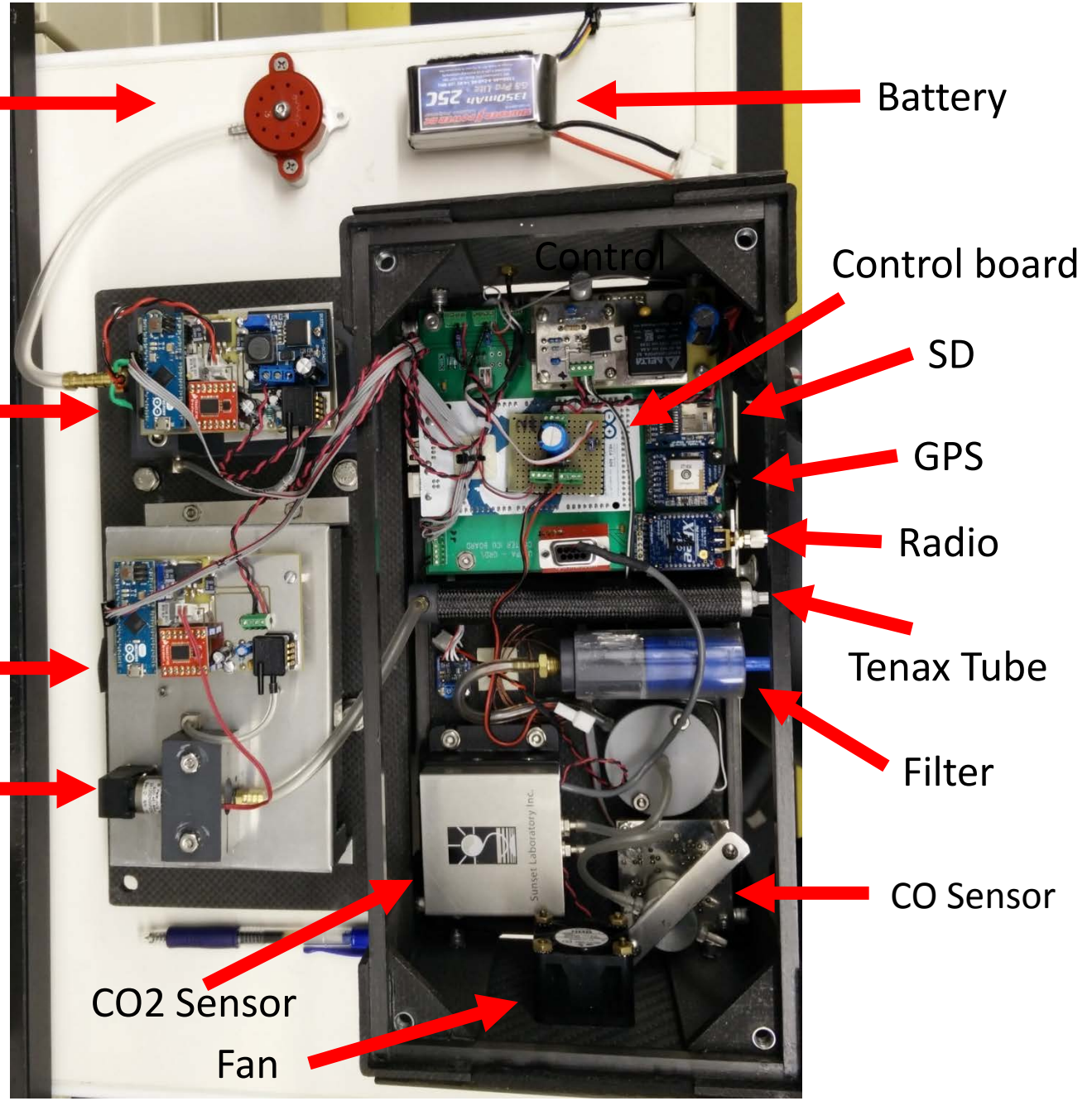
- Enhance maneuverability
  - Lightweight
  - Small
- Reduce overall cost
  - Low-cost sensor
  - Fewer personnel
- Quicker response
  - Easier deployment
- Improve safety
  - Further personnel distance



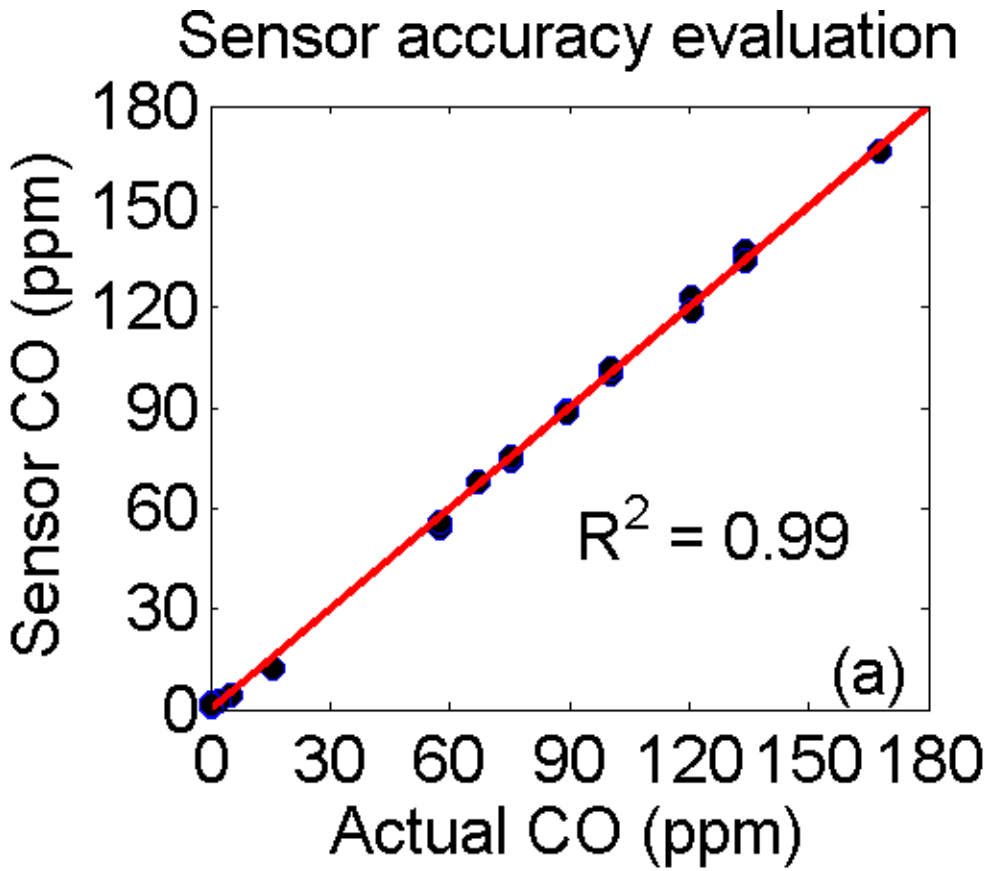
Kolibri system

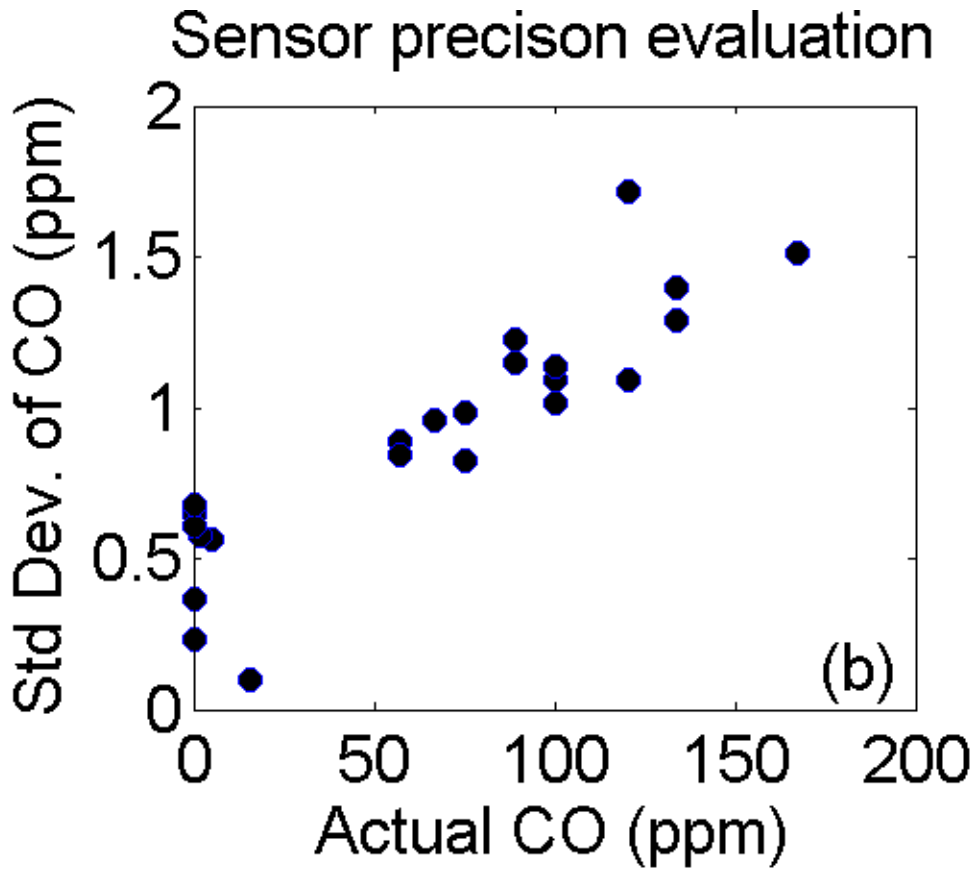
- Current measurements:
  - CO
  - CO_2
  - $PM_{2.5}$
  - Volatile organics
  - Black Carbon
- Future
  - semi-volatile organic compounds
  - Optical PM sensor
  - S, N, HC sensors

To ensure data quality, sensor performance needs meticulous evaluation



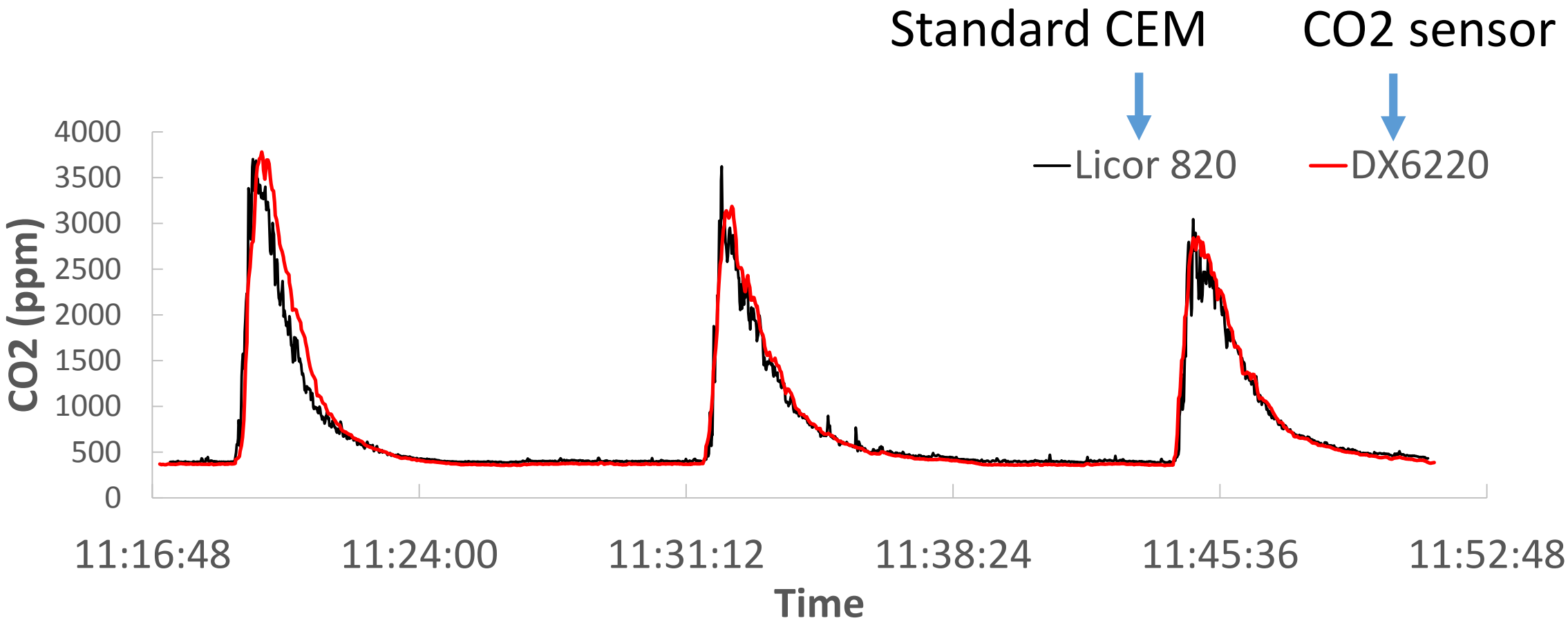
Kolibri sensor evaluation: CO





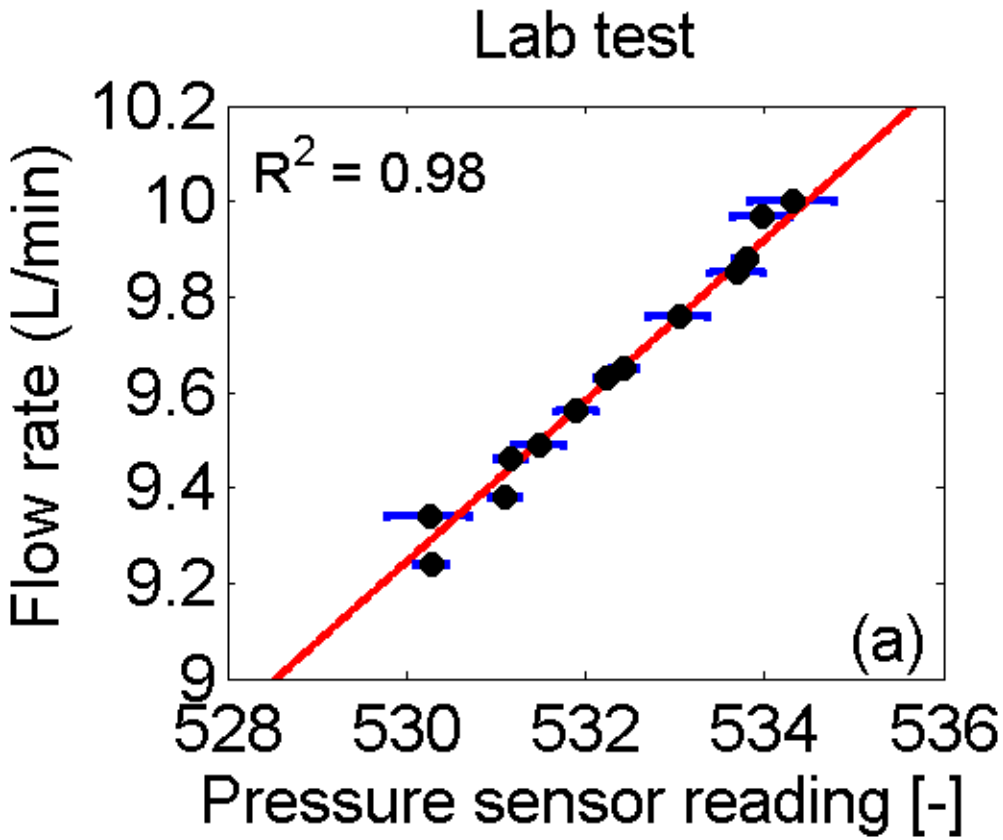
Sensor is accurate and precise at high concentrations relevant for this application

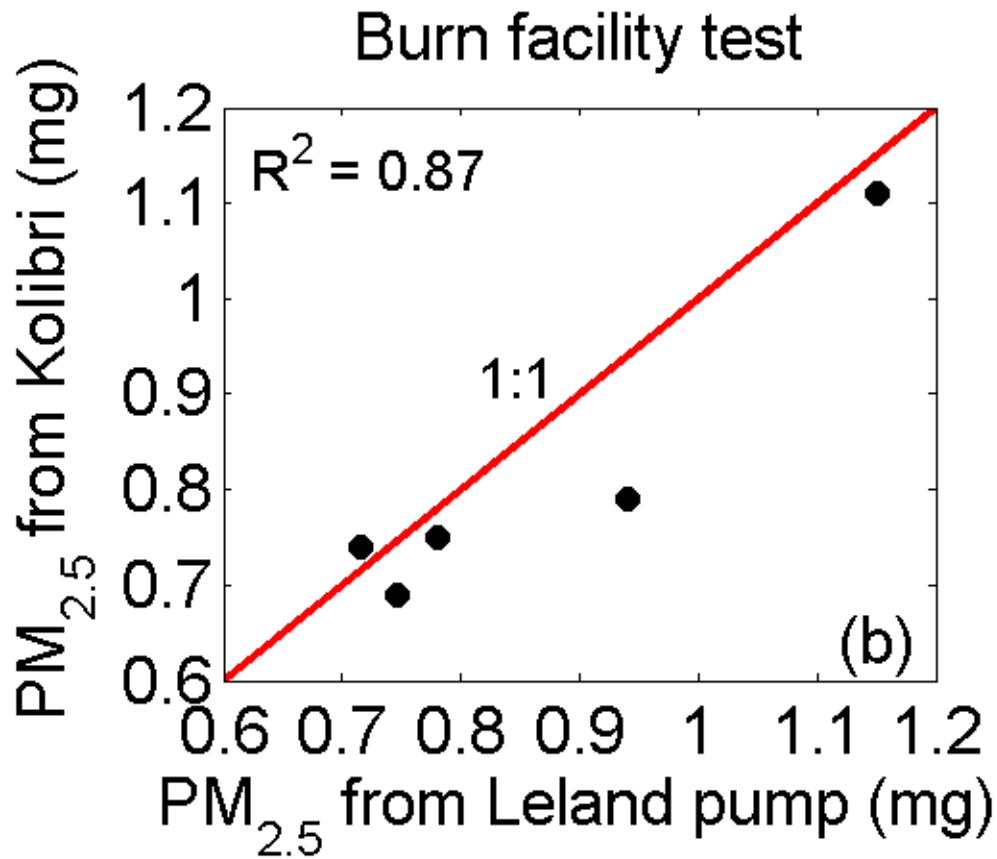
Kolibri sensor evaluation : CO_2



CO2 sensor tracks reasonably well with the Licor 820 instrument at high concentrations relevant for this application

Kolibri sensor evaluation : $PM_{2.5}$





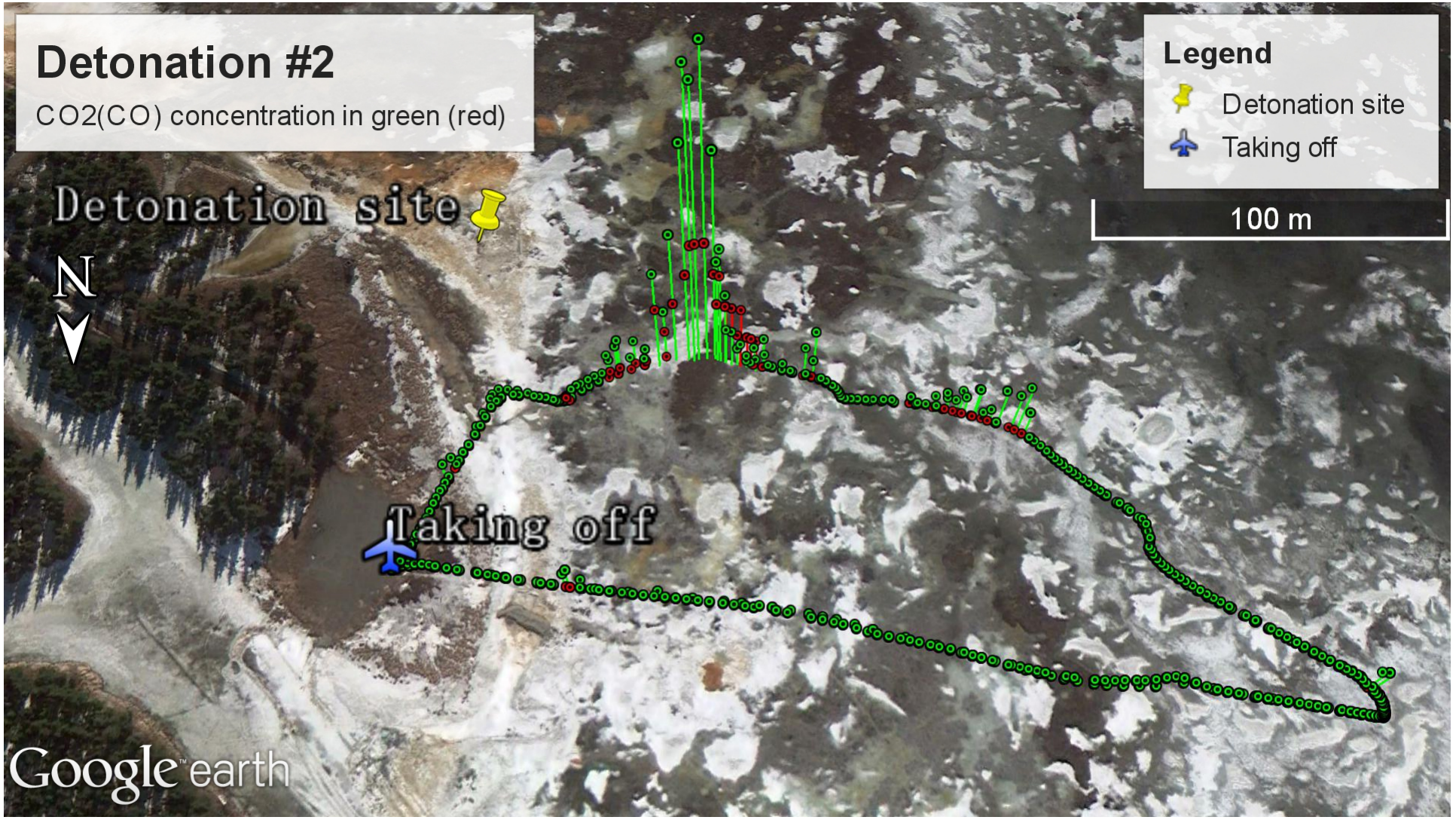
PM2.5 unit maintains 10 L/min based on a pressure sensor and performed well when comparing against a standard pump

Kolibri sensor evaluation: VOC

- Simultaneously measurement at open burn test facility
  - Tenax #1 sampled 570 ml
  - Tenax #2 sampled 3,380 ml
- Potential breakthrough
- Future test
  - Breakthrough test
  - Comparison against summa canister

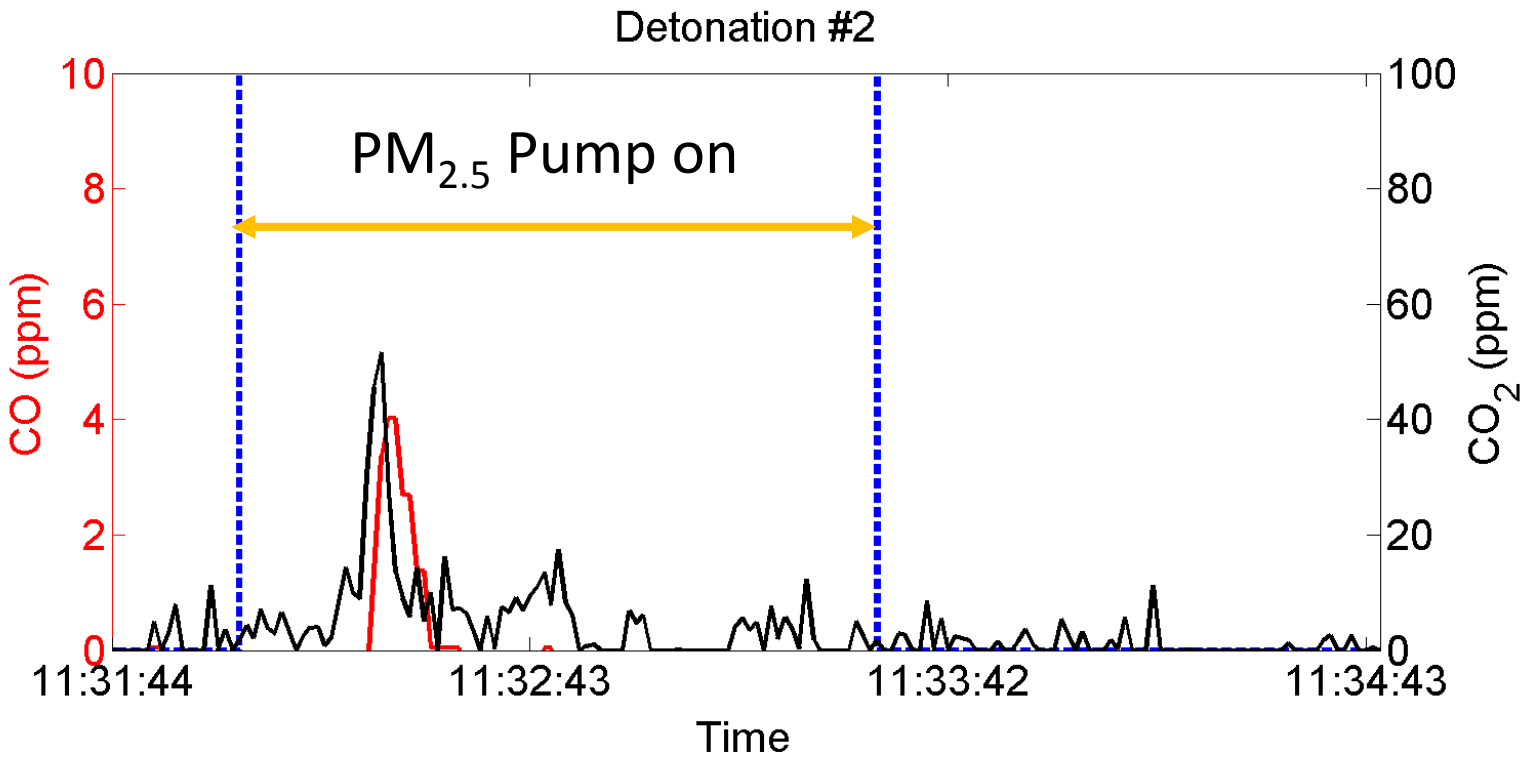
Compound/EF (µg/g biomass)	Tenax #1	Tenax #2
Benzene	95.1	27.7
Toluene	232.5	124.7
Ethyl Benzene	9.7	12.2
Xylene	11.8	17.7
Styrene	55.2	30.2
Isopropylbenzene	1.3	1
n Propylbenzene	1	1.5
1,3,5-Trimethylebenzene	0.9	0.9
1,2,4-Trimethylbenzene	2.9	3.8
Isopropyltoluene p-Cymene	1.5	3.4
Butylbenzene	0	0.6
1,3-Dichlorobenzene	0.3	0.1
1.4-Dichlorobenzene	1.8	0.7
1,2-Dichlorobenzene	14.2	3
1,2,4-Trichlorobenzene	0.2	0
Naphthalene	21.2	14.5

Application: detonation sampling in Anchorage, AK

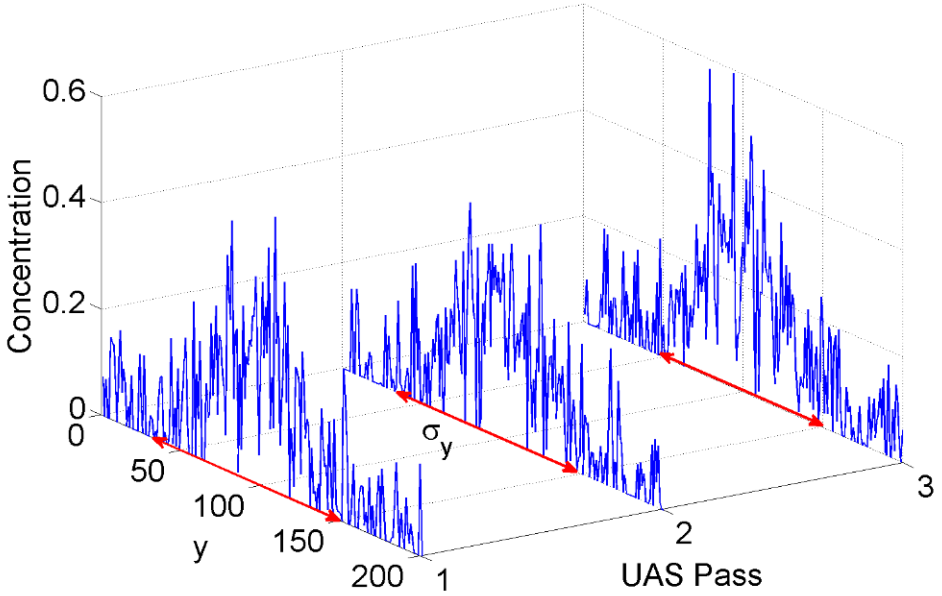


Time series of CO and CO_2 from one test

University of Alaska – Fairbanks Multicopter



Potential application: plume reconstruction



Mobile measurement of plume transects can help estimate plume dispersion and source strength

Conclusion

- Significant improvement in aerial sampling mobility.
- Enhanced sensing ability for complex/dangerous environment.
- Reduced field sampling cost and deployment time compared with aerostat system.
- Allows future modelling work with plume transect information.