

Single Near-Infrared Cavity-Ringdown Spectroscopy Instrument

Gregor Lucic ¹, Shaojie Zhuang ², Philippe Van Overbeke ², Magdalena Hofmann ¹, Renato Winkler ¹, David Kim-Hak ¹

¹ - Picarro Inc., 3105 Patrick Henry Drive, Santa Clara, California, USA, ² - Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Mellebeke, Belgium

1. INTRODUCTION

Summary

- Ammonia is a toxic pollutant that has harmful effects on human health and the environment. Agricultural activities and processes, such as fertilizer use, decomposition of biological material and animal excretions, account for most of the NH₃ emitted into the atmosphere.
- The characterization and quantification of NH₃ emissions in livestock environments are pivotal in assessing the issue and in helping agencies craft environmental regulations.
- Measuring NH₃ emission in naturally ventilated livestock houses is a technical challenge due to irregular air flow patterns and low concentration levels. No general agreement on a reference technique has been established.
- In response, at a dairy farm part of the Flemish Institute for Agriculture and Fisheries Research (ILVO), a sampling line system was installed throughout the barn to measure NH₃ levels in various locations using an in-situ, real-time NH₃ analyzer – a Picarro G2508.

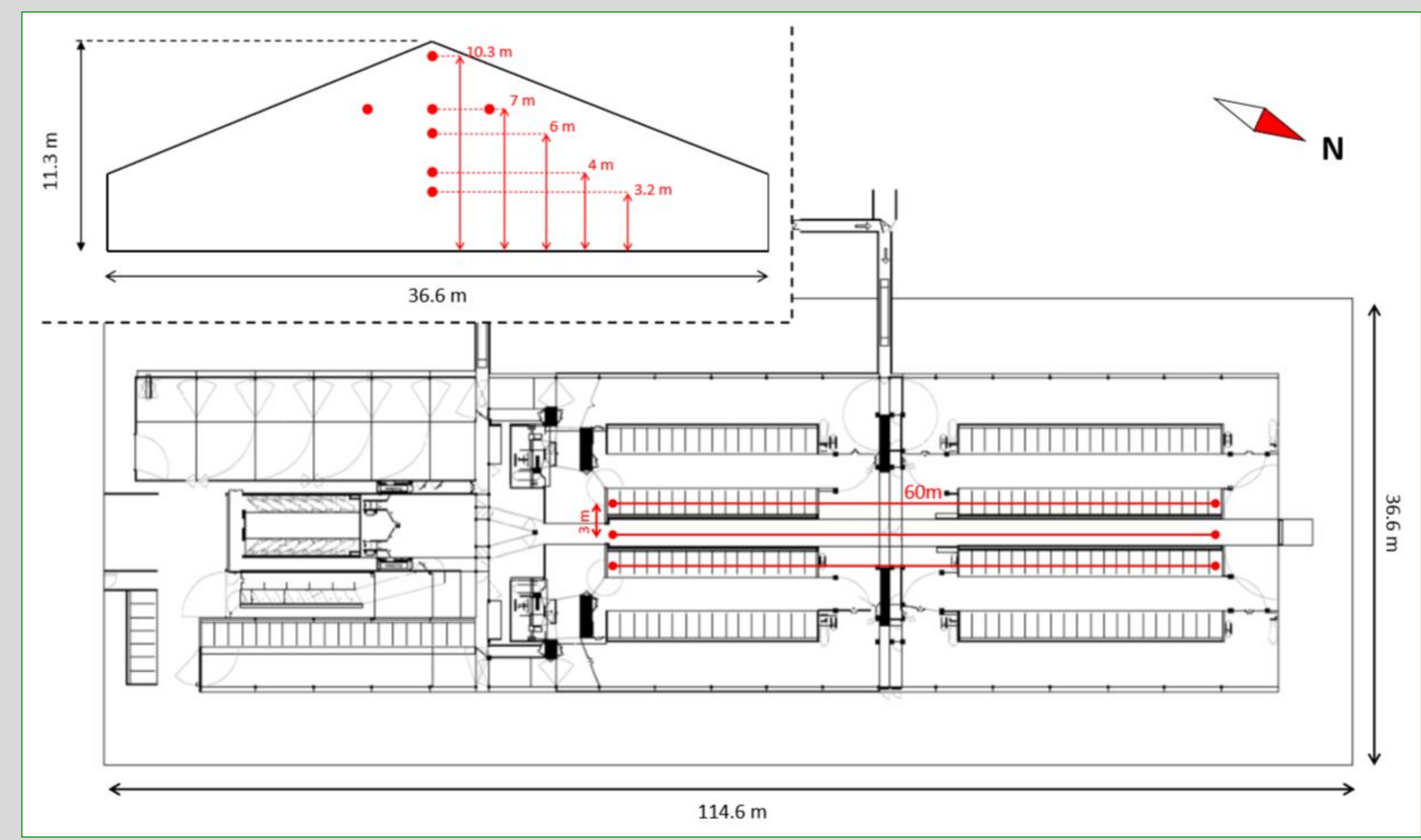


2. OBJECTIVES

1. Inter-comparison between an open-path tunable diode laser (OPL) and the Picarro cavity ring-down spectrometer (CRDS).
2. Evaluate the Picarro measurement accuracy of NH₃ and other greenhouse gases (CO₂, CH₄ and N₂O) in different conditions - a dairy barn and a pig barn.
3. Investigate the feasibility of using the Picarro instrument for exploring the spatial variation of gas concentrations in livestock houses.

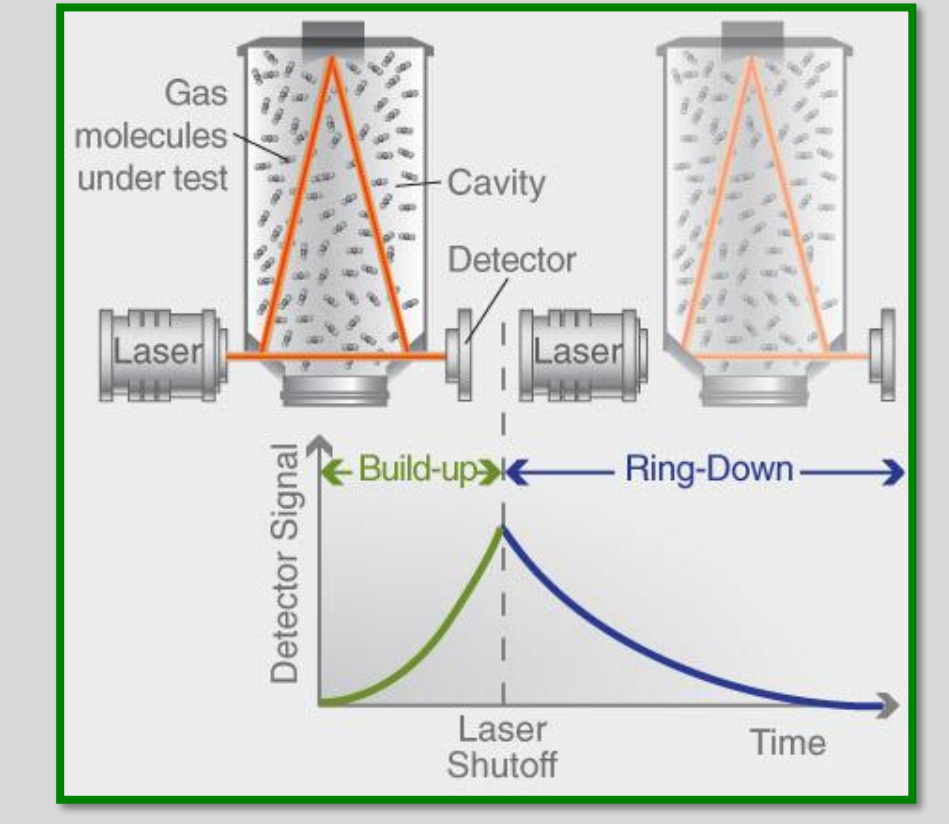
3. FIELD SITE AND METHODS

Site and Sampling Design



- Sampling inlets (s. steel) and tubing (PTFE) were positioned at various locations and heights in the dairy and pig barns.
- A custom multisampler and additional pump were used to pull gases to a central location where the analyzers were housed.
- Ventilation in the dairy barn was natural with reduced cross-ventilation, while the pig barn was ground-channel ventilated with support from a mechanical ventilation system.

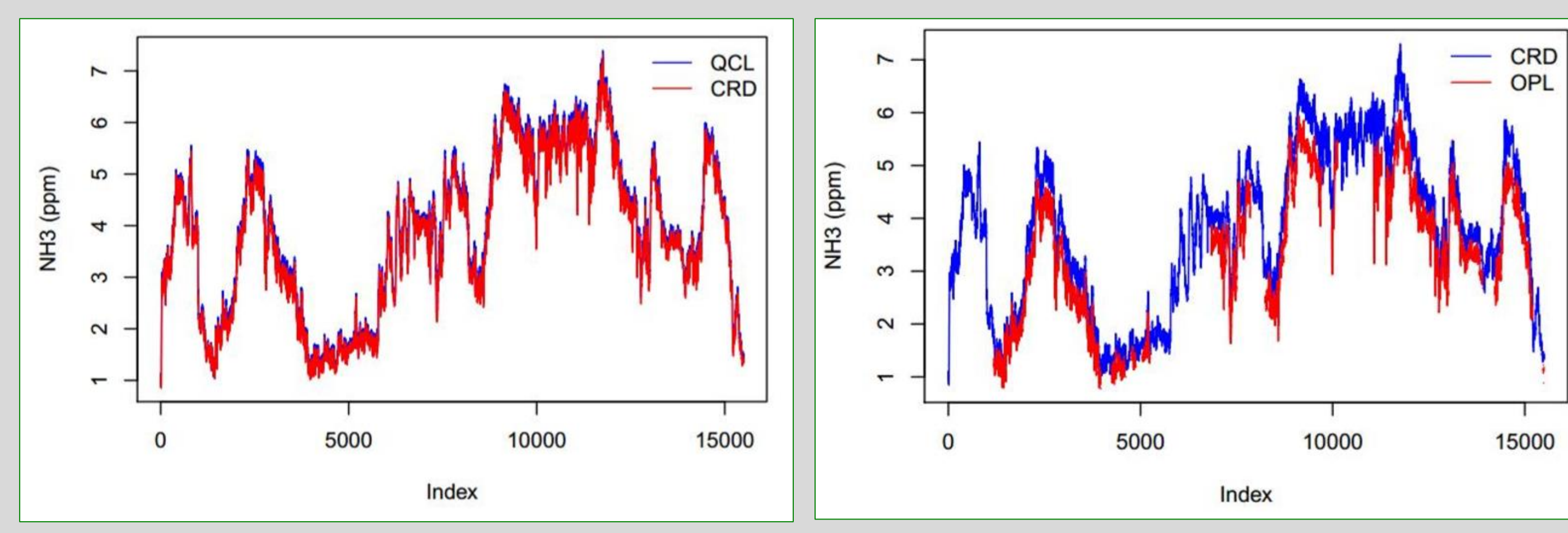
Picarro G2508 CRDS



- Cavity Ring-Down Spectroscopy (CRDS) enables high-precision, low-drift measurements of CO₂, CH₄, N₂O, NH₃ and H₂O.
- Fast response time and low adsorption of NH₃ due to a Teflon upgrade of the internal sample handling and an increased flow-rate.
- Built in water-vapor and cross-talk correction for continuous measurements in atmospheric, indoor and chamber applications.

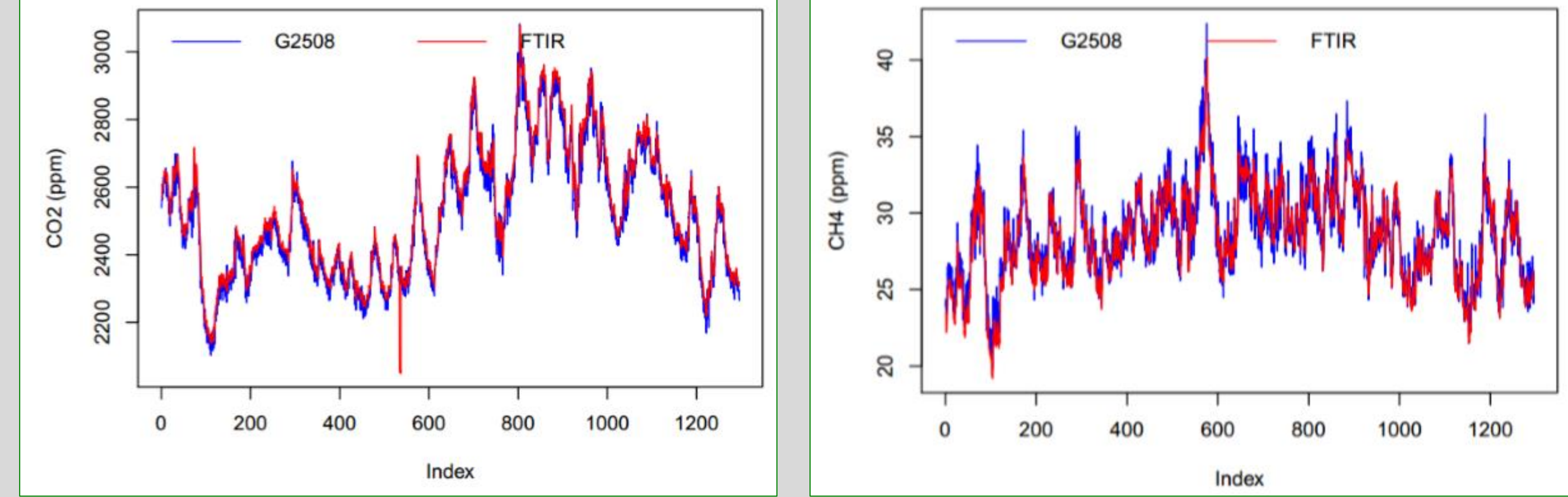
5. FINDINGS

CRDS vs OPL Comparison (NH₃)



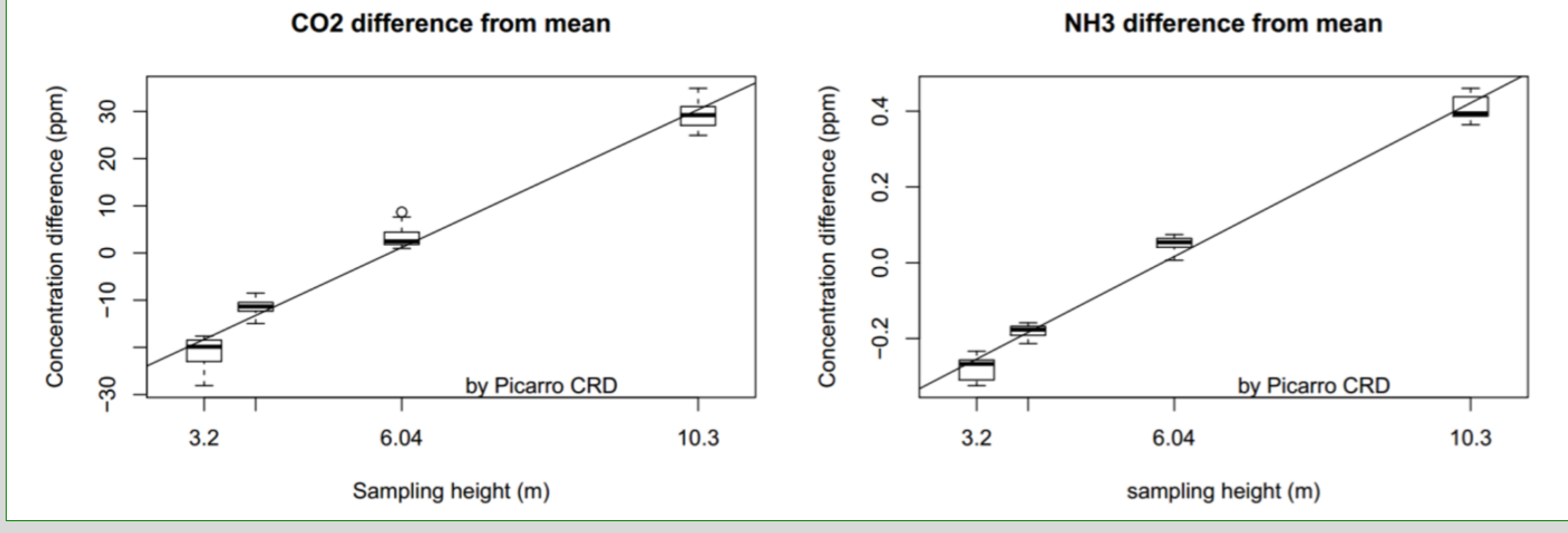
The G2508 showed **good accuracy** and **no evident drift over the two-month field tests**. Within all the tests in the dairy barn and the pig barn, the measured NH₃ concentration by G2508 was closer to the mean value of all methods. Boreal OPL and Emerson QCL were used for comparison.

GHG Comparison (CO₂ and CH₄)



There was **good correlation** between the G2508 and the FTIR measurements of CO₂ and CH₄ from both the Pig and Dairy barns. Small differences between instruments lead to minor under- or over-estimation of absolute concentrations. Further inter-comparison is needed to evaluate measurements of N₂O.

Spatial Stratification of Gases



A **significant vertical variation** of gas distribution in the dairy barn was observed. Both NH₃ and CO₂ concentration increased with height. Little or no cross-ventilation lead to buoyancy dominating the vertical distribution of gases. **Horizontal variation was irregular** and the difference between test locations was not evident.