Atmospheric Ammonia Measurements in Houston, TX using a 10.4 μm External-Cavity Quantum Cascade Laser-Based Sensor

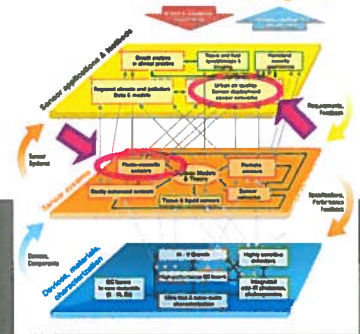L. Gong,[1] R. Lewicki,[2] R. Griffin,[1] J. Flynn,[3] B. Lefer,[3] and F. Tittel[2]

1 – Department of Civil and Environmental Engineering, Rice University
2 – Department of Electrical and Computer Engineering, Rice University
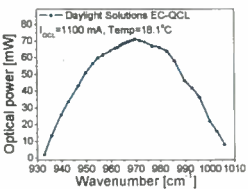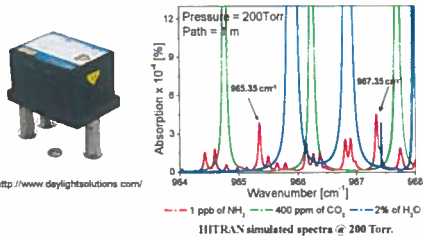3 – Department of Earth and Atmospheric Sciences, University of Houston

Introduction

Ammonia (NH_3) plays an important role in atmospheric chemistry. NH_3 has many anthropogenic (e.g., agricultural crops and mineral fertilizers) and natural (e.g., animals, oceans, and vegetation) sources in the environment. In certain areas, industrial and motor vehicle activities contribute to significant increases in local or regional NH_3 levels.
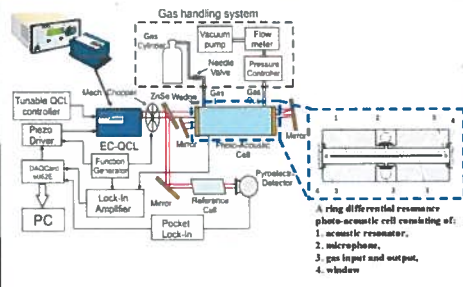
From a perspective of environmental concern, NH_3 is a precursor of particulate matter (PM) because it can lead to the production of ammonium salts (e.g., $(NH_4)_2SO_4$ and NH_4NO_3) through chemical reactions with sulfuric and nitric acid. The resultant PM has significant [delete significant, used too often] implications for regional air quality, human health, atmospheric visibility, cloud formation, radiation budget, climate patterns, and nutrient cycling. Despite this, NH_3 is not regulated.

It is critical to improve the current understanding of the dynamics of NH_3 in a major industrial and urban area such as Greater Houston where relevant data are very [delete very] limited and to characterize the importance of NH_3 with respect to PM formation in the Houston

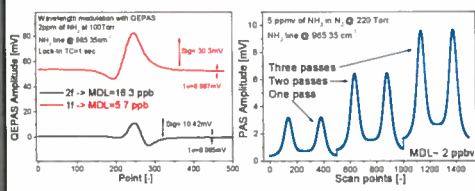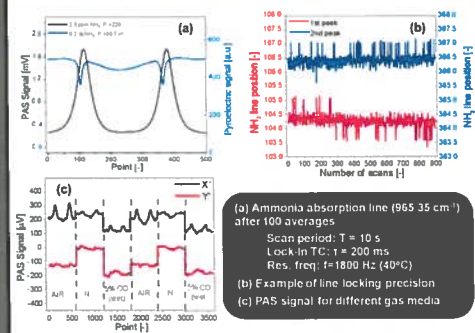## EC-QCL Spectroscopic Source and NH_3 Absorption Line Selection

Mid-IR EC-QCL based AM-PAS Sensor Platform for Atmospheric NH_3 Detection

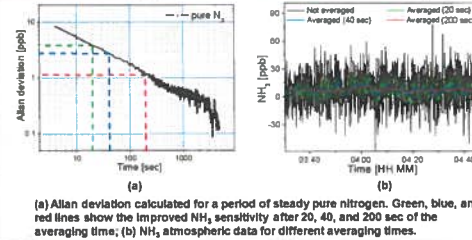A ring differential resonance photo-acoustic cell consisting of:
1. acoustic resonator,
2. microphone,
3. gas input and output,
4. window

NH_3 Measurements with QEPAS and PAS based on a Daylight Solutions CW EC-QCL Source

Data Acquisition Procedure

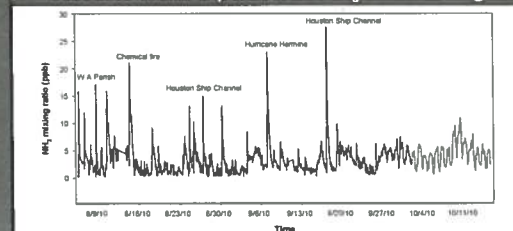(a) Ammonia absorption line (965.35 cm^{-1}) after 100 averages
Scan period: T = 10 s
Lock-In TC: τ = 200 ms
Res. freq: f=1800 Hz (40°C)
(b) Example of line locking precision
(c) PAS signal for different gas media

Stability of NH_3 Sensor Platform — Allan Deviation Plot

(a) Allan deviation calculated for a period of steady pure nitrogen. Green, blue, and red lines show the improved NH_3 sensitivity after 20, 40, and 200 sec of the averaging time; (b) NH_3 atmospheric data for different averaging times.
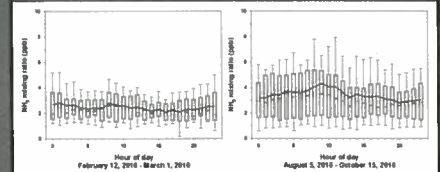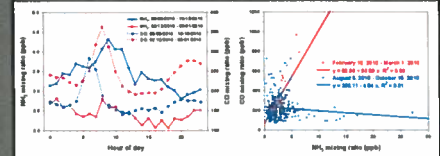
NH_3 Sensor deployment in the field
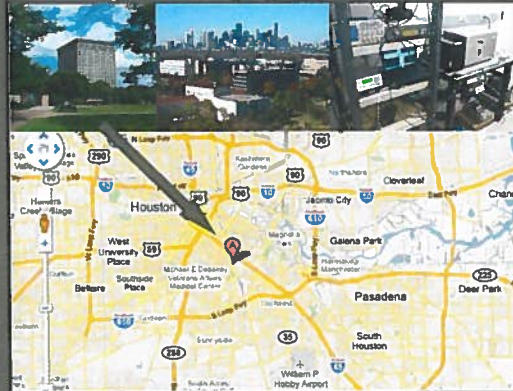
Results from a period of NH_3 monitoring
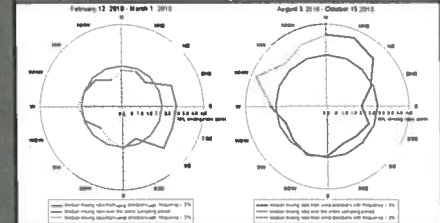

Diurnal profiles of NH_3 levels

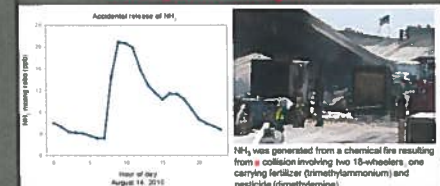## Relationships between NH_3 and traffic

Dependence of NH_3 on wind direction

Unexpected NH_3 Event

NH_3 was generated from a chemical fire resulting from a collision involving two 18-wheelers, one carrying fertilizer (trimethylammonium) and pesticide (dimethylamine).