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2010 MIRTHE Summer Workshop

Atmospheric ammonia measurements using an external cavity-quantum cascade laser-based sensor

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[1] Rice University, CEE Department, 6100 Main St., Houston, TX 77005, USA
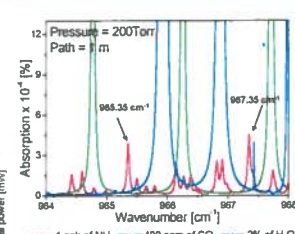[2] Rice University, ECE Department, 6100 Main St., Houston, TX 77005, USA

August 2, 2010

BRC, Rice University

Houston, TX

Slide 2

Motivation

- Ammonia (NH_3) plays a significant role in atmospheric chemistry.
  - *Particulate matter pollution (e.g. $(NH_4)_2SO_4$, NH_4NO_3)*

- In urban areas, industrial and motor vehicle activities can contribute to increases in atmospheric ammonia levels.

- For an industrial and urban area such as the Greater Houston area, data regarding atmospheric ammonia concentration are limited.
  - *typical range : 0.1-10 ppb* [1]

[1] J.H. Seinfeld, S.N. Pandis, Atmospheric Chemistry and Physics, John Wiley and Sons, Inc., Hoboken, NJ. (2006)

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Laser source and NH_3 absorption line selection

Pressure = 200Torr
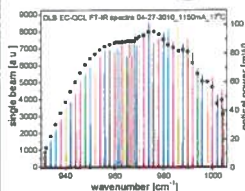Path = 1 m

985.35 cm⁻¹   987.35 cm⁻¹
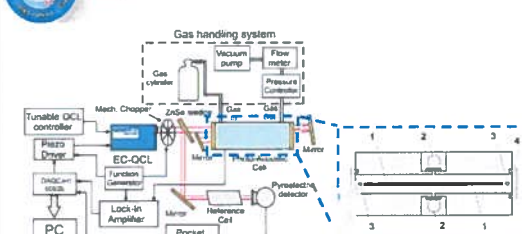
1 ppb of NH_3 — 400 ppm of CO_2 — 2% of H_2O

P_{EC-QCL} up to 95 mW (CW)
Tunability 73 cm⁻¹ (931 cm⁻¹ – 1004 cm⁻¹)

DAYLIGHT

Tuning range and optical power profile for a Daylight Solutions, Inc mid-IR CW EC-QCL system
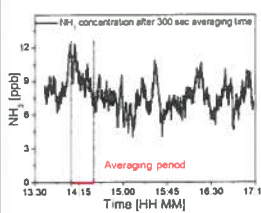
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NH_3 sensor architecture

ing differential resonance photo-acoustic cell consisting of:
1. acoustic resonator,
2. microphone,
3. gas input and output,
4. window
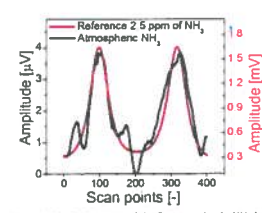
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NH_3 data output

Averaged spectrum (8min) of atmospheric NH_3 in comparison to a 2.5 ppm NH_3 reference spectrum.

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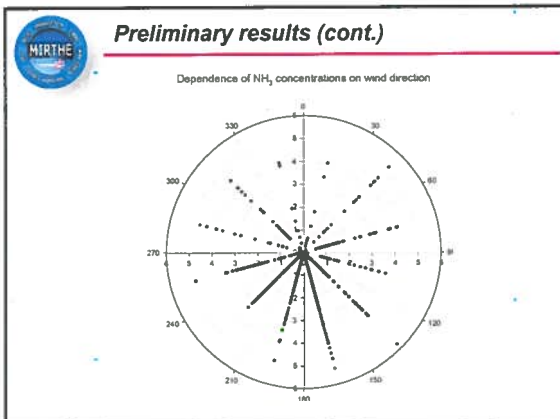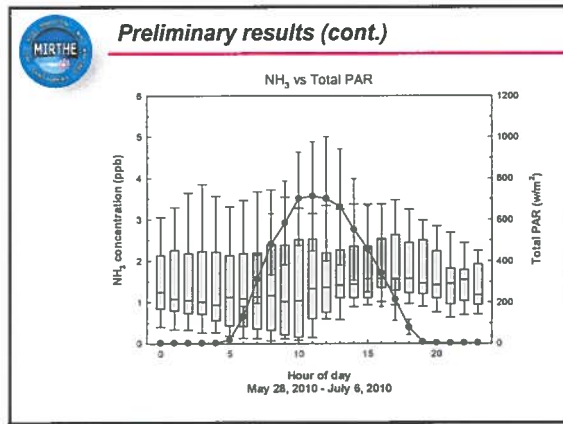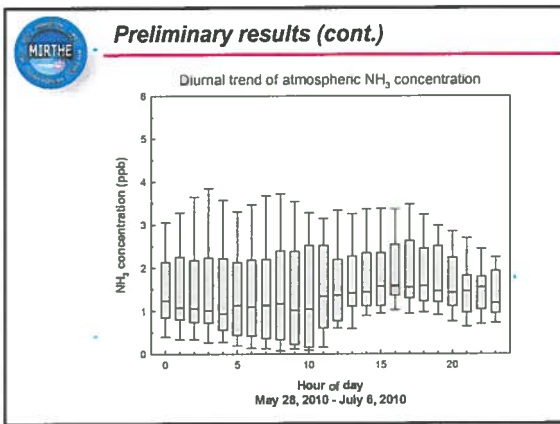### Sensor deployment at north Moody Tower

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Field scenes

Preliminary results

Diurnal trend of atmospheric NH_3 concentration

Hour of day
February 12, 2010 - March 1, 2010

Preliminary results (cont.)

Diurnal trend of atmospheric NH_3 concentration

Hour of day
May 28, 2010 - July 6, 2010

Preliminary results (cont.)

NH_3 vs Total PAR

Hour of day
May 28, 2010 - July 6, 2010

Preliminary results (cont.)

Dependence of NH_3 concentrations on wind direction
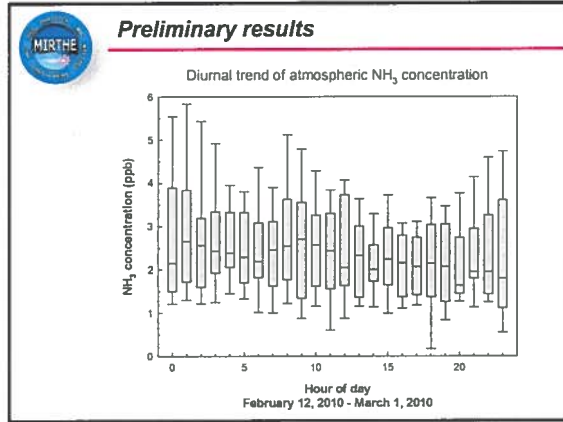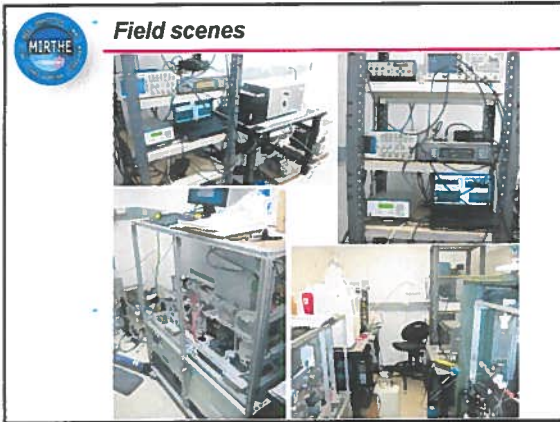
Conclusion

- A 10.4 μm EC-QCL based NH_3 sensor, employing conventional photo-acoustic spectroscopy, was demonstrated.

- Minimum detection limit, obtained for the NH_3 absorption line at 965.35 cm⁻¹, reached sub-ppb concentration levels.

- The NH_3 sensor is capable of unattended operation with continuous data acquisition for extended periods of time.

- Remote access via internet, enabling real-time monitoring of the sensor performance was established.

- Environmental data acquired by NH_3 sensor, installed on the 200-foot-high north Moody Tower roof, were used together with meteorological parameters to characterize the dynamics of atmospheric NH_3.

- Particle composition data from an Aerodyne high-resolution time-of-flight aerosol mass spectrometer (AMS) will be used to better understand the importance of NH_3 with respect to air quality.

- NH_3 measurements at ground level will be performed when the laser sensor is installed at surface facilities.