Investigation of CH_4 leaks from the Natural Gas Distribution System in the Houston Area

N.P. Sanchez[1], C. Zheng[2], W. Ye[2], B. Czader[1], A.K. Gluszek[2], A.J. Hudzikowski[2], D. Cohan[1], R.J. Griffin[1], F.KTittel[2]

[1]Department of Civil and Environmental Engineering, Rice University, Houston, TX

[2]Department of Electrical and Computer Engineering, Rice University, Houston, TX

1. MOTIVATION

- Oil and natural gas (NG) operations are the main known source of CH_4 emissions to the atmosphere [1]
- CH_4 is a greenhouse gas with GWP of 34 (100-yr horizon), which contributes to background ozone pollution
- CH_4 emissions can occur during pre-production, production and distribution stages in the NG system
- CH_4 leak rates as high as 2.5-6 % have been recently estimated from the NG distribution system in some urban centers in the US [2]
- Specific studies on potential leaks from the NG distribution system in the Houston area and their impact on emissions benefits of NG use are needed

2. APPROACH

1. A long path absorption spectroscopy – based sensor employing a 3.337 µm CW-DFB ICL for simultaneous detection of CH_4 and C_2H_6 at 2999.06 and 2996.88 cm^{-1}, respectively was developed [3]
2. Zones classified with expected high, medium and low probability of CH_4 leaks (based on age infrastructure and NG usage density) were selected for sampling in the Houston area [4]
3. The CH_4/C_2H_6 sensor system was deployed in a medium size vehicle and mobile-mode monitoring of trace gas concentration levels in the selected sampling zones was conducted during summer 2016

3. METHODS

+ CH_4/C_2H_6 sensor

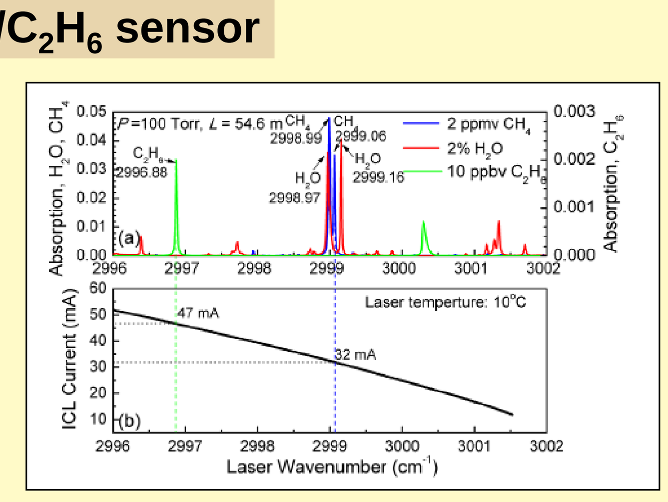

Fig. 1 CH_4 and C_2H_6 selected absorption lines

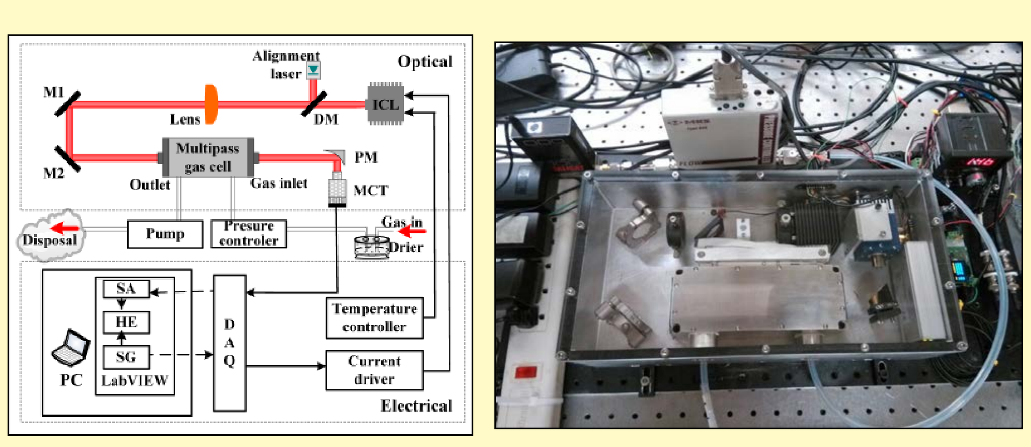

Fig. 2 CH_4/C_2H_6 sensor architecture and current sensor unit employed in the Houston field tests during summer 2016

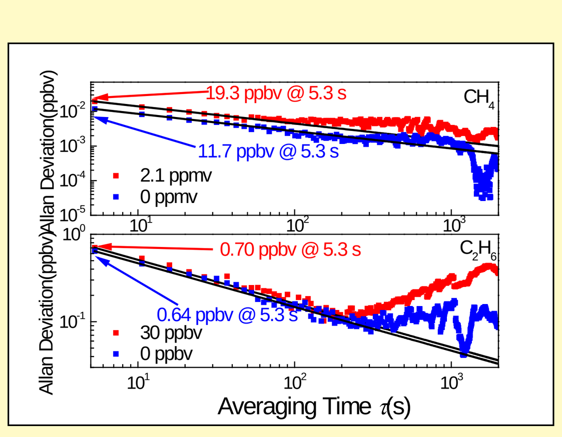

Fig 3. Allan Deviation analysis for the CH_4 /C_2H_6 sensor system

3. METHODS (Cont.)

+ Selection of sampling zones

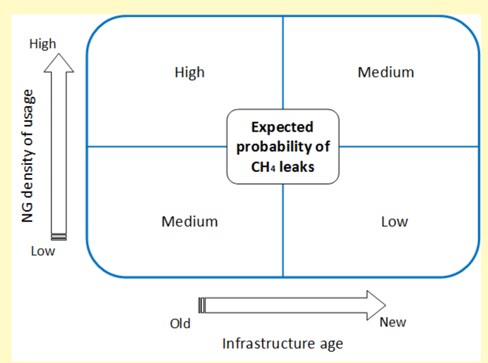

Fig. 4 Sampling criteria matrix

- A 2 x 2 sampling criteria matrix was generated
- Pre 1980:old infrastructure (pipeline materials installed were considered)
- High NG usage: >1500 housing units with NG/sq. mile
- Two sampling areas under each high/medium/low leak probability category were selected

Fig. 5 Selected sampling locations in the Houston area

+ Field tests

Fig. 6 Sensor unit with weather station, power supply, pressure and temperature control systems deployed in a vehicle at different locations in the Houston area during summer 2016

4. RESULTS

+ Spatial variation of CH_4 & C_2H_6 mixing ratios

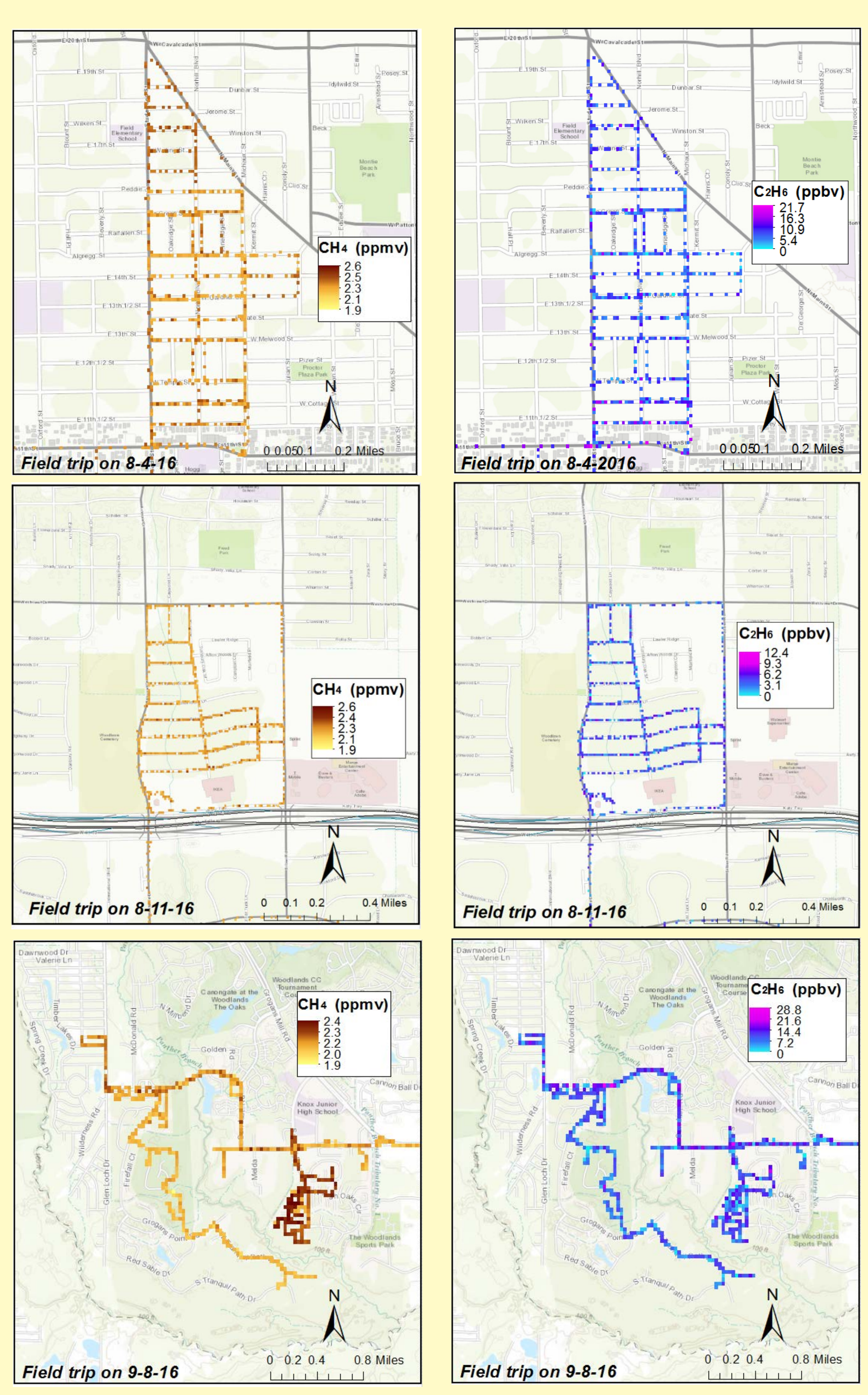

Fig. 7 Observed CH_4 & C_2H_6 mixing ratios in zones with high (H1), medium (MA2) and low (L1) expected probability of leaks (H1-north central, MA2-west central and L1-north Houston)

4. RESULTS (Cont.)

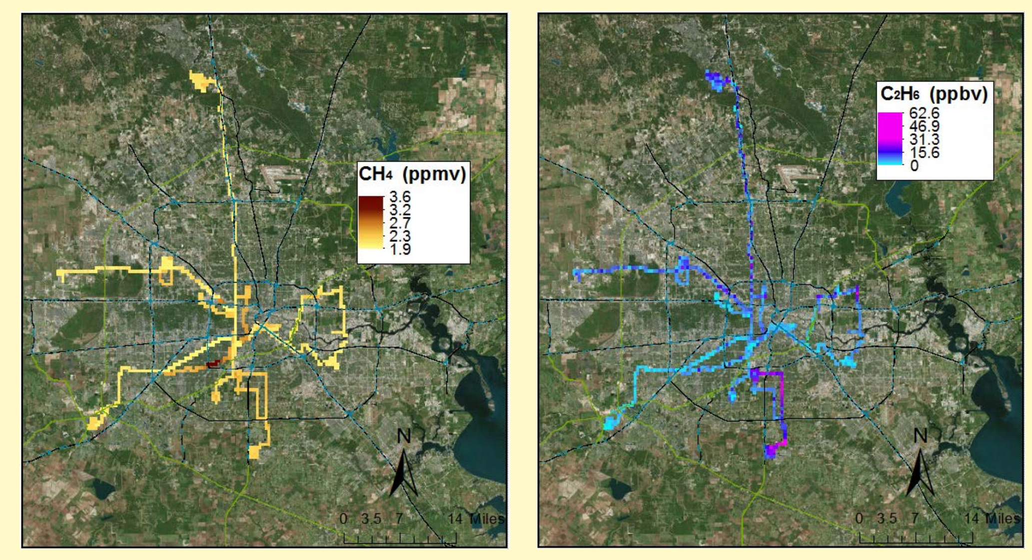

Fig. 8 Spatial distribution of CH_4 & C_2H_6 in the Houston area

+ CH_4 peaks & source discrimination

- 38 CH_4 peaks were observed during field tests
- CH_4 atmospheric background level ranged between 2.1 and 2.3 ppmv in the sampling zones
- Maximum observed enhancement in CH_4 concentration was ~1100 ppbv

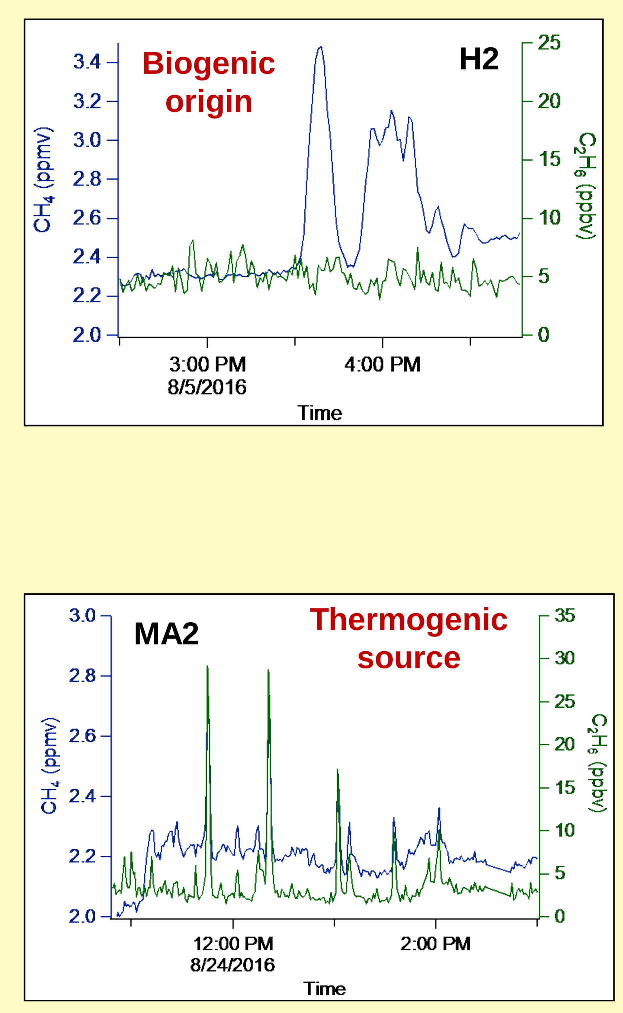

Fig. 9 CH_4 peaks observed in zones with expected high and medium probability of CH_4 leaks (H2 & MA2) in south and west central Houston, respectively

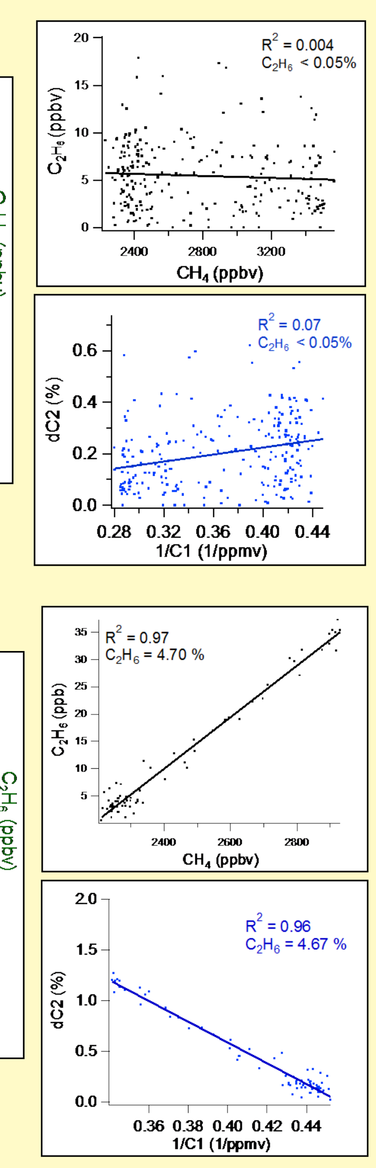

Fig. 10 C1-C2 slope and Keeling-like analysis of C_2H_6/CH_4 enhancement in CH_4 peaks in Fig. 9

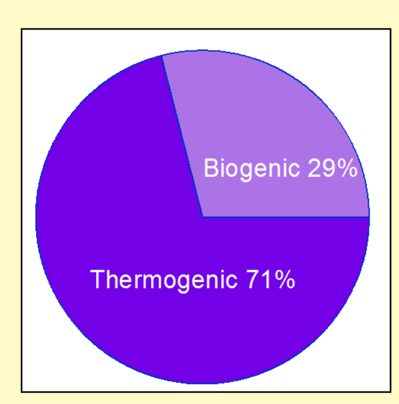

Fig. 11 Source distribution of the CH_4 peaks observed during the field tests conducted in the Houston area during summer 2016.

5. CONCLUSIONS AND NEXT STEPS

- CH_4 concentration peaks observed across Houston showed a predominant thermogenic origin as demonstrated by C_2H_6/CH_4 enhancement ratios
- CH_4 peak events related with thermogenic sources were generally below 3 ppmv, corresponding to atmospheric background enhancements of ~ 600 ppbv
- CH_4 concentration peaks related with biogenic sources exhibited maximum ambient background enhancement levels of ~ 1,100 ppbv
- Detailed analysis of meteorological data (wind speed and direction) will be conducted for more precise identification of specific CH_4 sources in the Houston area

6. REFERENCES

[1] EPA. https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane

[2] Wennberg, P.O., et al. Environmental Science and Technology, 2012, 46, 9282-9289

[3] Ye, W., et al. Mid-infrared dual-gas sensor for simultaneous detection of methane and ethane using a single continuous-wave interband cascade laser. Optics Express, 2016, 24 (15) 16973-16985

[4] Czader, B., et al. Mapping the spatial distribution of methane in Houston, Texas. 15th CMAS Conference, 2015

7. ACKNOWLEDGEMENTS

We acknowledge financial support from a National Science Foundation (NSF) ERC MIRTHE award, the Shell Center for Sustainability at Rice University and two DOE ARPA-E awards.