Introduction

The fall 2016 American Geophysical Meeting was held in San Francisco, CA from December 12 to 16 2016. The conference is a gathering of 20,000+ people and is the preeminent conference for research topics from outer space to everything involving Earth and environmental sciences. That broad range therefore makes this conference an important one for all things methane. In fact, there were 70+ abstracts/papers/presentations from this conference that could have some implications for the natural gas industry. Although no one from the CMR the meeting this year, an examination of the abstracts for presentations revealed several critical areas of ongoing methane research involving field studies, instrument development, climate modeling and policy. We will summarize the abstracts from each of these key areas.

Field Studies

Abstracts that detailed results from field studies dominated the submissions. There was a mix of submissions between large-scale multi-institutional scale studies to small scale single group investigations.

Often the large-scale multi-institutional scale studies had several abstracts submitted detailing different sections of the same study or different applications of the data collected in a study. These large scale studies include one conducted over the Four Corners region where Colorado, New Mexico, Arizona, and Utah. This multi-institutional study conducted in January 2015 has already produced several publications and accounted for three of the abstracts in this category. Further areas of study included:

- Five abstracts focused on the Aliso Canyon leak.
- One each focused in the Bakken, northeastern British Columbia, over Western Wetzel County, WV and Eastern Monroe County, OH, the Colorado Front Range, the North Slope of Alaska, the Fayetteville Play, Appalachian Basin of Ohio, in San Joaquin Valley (California), around Northeastern Oklahoma, around Los Angeles (California), around Sacramento (California), and around Houston (Texas).
- One abstract on the Southeast Nexus of Climate Change and Air Quality (SENEX; June-July 2013), Shale Oil and Natural Gas Nexus (SONGNEX, March-May 2015)
- One abstract detailing mobile measurements in the UK, Kuwait, Hong Kong and E. Australia indicating that show importance of single major sources such as abandoned old wells, pipe leaks or unregulated landfills
- Two focused in Salt Lake City, Utah
- Three focused around San Francisco
- Three detailing measurements in Pennsylvania
- One on measurements being conducted at the Marcellus Shale Energy and Environment Laboratory (West Virginia)
- Two on measurements conducted in Southern California

One entire session at the conference was dedicated to “Existing and legacy oil and Gas Infrastructure” which contained several presentations detailing emissions from abandoned wells in California, West Virginia, and Pennsylvania.

Instrument Development

New instrument/method development was also a section that had several abstract submissions. Fueled particularly by the DOE ARPA-A MONITOR technologies which accounted for at least five abstracts. These included:

- Alden et al. and Coburn et al. from University of Colorado/NIST is developing a long range open path measurement system using a frequency comb spectrometer.
- Burba et al. from LICOR is developing a high speed, low power system to be used on mobile platforms.
- Travis et al. from the Planetary Science Institute, Aeris Technologies and Los Alamos National Lab is using a convolution neural net and inexpensive laser absorption methane sensor. This technique combines modeling and measurements to locate leaks.

Other developments included new adaptations of existing technologies:

- Ferrara and Howard from GHD have developed/are developing a high speed recording high flow sampler for intermittent pneumatic devices.
- Huang et al. from Los Gatos Research has developed a miniaturized off-axis integrated cavity output spectroscopy (OA-ICOS) that weighs 13.5 pounds to be used on walking surveys.
- Marshall et al. from St. Francis Xavier University (Canada) assessed the performance of the Picarro G2210-i to detect carbon 13 and C_2H_6 within plumes. They reported that the analyzer performed well.
- Belal et al. from MIRICO (UK) and the Rutherford Appleton Laboratory (UK) have used laser dispersion spectroscopy (uses tunable diode laser spectroscopy) and reflectors to detect leaks over large areas.
- Shen et al. from California Institute of Technology have developed a mid-IR (3.3 um) cavity ring down spectrometer to measure methane and ethane.
- Yerasi et al. from University of Colorado-Boulder and Ball Aerospace are developing/applying an Advanced Leak Detector Lidar – Natural Gas (ALDL-NG) originally created by Ball Aerospace that uses pulsed integrated path differential absorption (IPDA).

Unmanned aerial vehicles (UAVs) were also explored as deployment platforms for sensors:

- Fox et al. and Hugenholtz et al. from University of Calgary, Ventus Geospatial and Boreal Laser, Inc are developing a modeling and measurement platform for UAVs to detect and quantify leaks. Still in early development stage with limited success but the sensor is based on a tunable diode laser.

Others detailed advances in remote sensing:

- Jacob et al. from Harvard, the Netherlands Institute for Space Research, GHGSat, Inc. and NASA JPL detailed using satellite measurements to expand methane measurement capabilities.
- Riris et al. from NASA Goddard are pushing remote sensing of methane using LIDAR and Integrated Path Differential Absorption (IPDA).
- Thorpe et al. from NASA JPL and University of Bremen (Germany) are using a remote sensing platform for use on airplanes called the Airborne Visible/Infrared Imaging Spectrometer. Flight

campaigns were conducted over Four Corners and San Joaquin Valley. This technique has limitations and to be ideal it would need 1 nm spectral sampling.

Global Cycling and Climate Modeling

A significant body of work is being conducted on climate modeling in general. However a few abstracts in this area had applications to methane and the natural gas industry.

- Collins et al from Lawrence Berkeley National Lab and NASA Langley are trying to reduce major uncertainties with shortwave forcing by methane to understand the climate on Earth and other planets.
- Feldman et al. at Lawrence Berkeley National Lab, NASA Langley, and Atmospheric and Environmental Research are working on evaluating methane longwave radiative forcing.
- Errickson et al. from University of California Berkley and Penn State University are using climate models coupled with methane models, Bayesian calibrations and integrated assessment models to calculate the social cost of methane.
- Worden et al. from NASA JPL, University Corporation for Atmospheric Research, Netherlands Institute of Space Research, California Institute of Technology, and National Center for Atmospheric Research are doing research on recent atmospheric methane increases. They have determined that the increases are not due to fires and 1/3 of the increase is due to fossil fuels.

Others

Several other topics that do not necessarily fit into the above categories were also discussed.

- Hamburg et al. from the Environmental Defense Fund are working on the differences between top down and bottom up estimates of methane emissions and accounting for fat-tailed emission sources.
- Hamburg from the EDF presented on the completion of the 16 EDF studies on methane.
- Croes et al. from the California Air Resources Board, NASA JPL, and the California Energy Commission gave a review of the efforts in California to understand and reduce methane. From the abstract, “in order to achieve a comprehensive understanding of sources contributing to “hot spots”, CARB, the California Energy Commission, and NASA’s Jet Propulsion Laboratory are implementing a largescale statewide methane survey using a tiered monitoring and measurement program, which will include airborne and ground-level measurements of the various regions and source sectors in the State.”
- Lan et al. from NOAA and University of Colorado Boulder used existing measurements from the NOAA/ESRL Global Greenhouse Gas Reference Network to estimate trends in methane. They also conclude that propane to methane ratios are not a reliable approach to compute oil and gas methane emission trends.

Conclusions

The Fall AGU meetings appear to be a very useful platform for disseminating new information and learning the state of science. Many of the abstracts presented will not all end up as actual peer reviewed publications. Attendance at this meeting would be quite useful to stay abreast of the studies/technology development that may not always get published in the peer reviewed literature.