

Continuous, Regional Approach to Methane Source Detection and Sizing Using Dual Frequency Comb Laser Spectroscopy and Atmospheric Inversions

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Advances in natural gas extraction technology have led to increased production and transport activity, and, as a consequence, an increased need for reliable monitoring of methane (CH_4) leaks. A gap exists among current methods for leak detection; that is, the ability to provide continuous, time-varying estimates of emissions. For example, satellite observations have day-time and clear sky biases, and also lack the resolution to pinpoint small leaks. Current ground-based and aircraft-based approaches can only collect “snapshots” of emissions in time. These approaches can also require operators and specific atmospheric conditions and/or the use of a tracer gas. Aircraft measurements also have a mid-day bias. The new system that we present here has the potential to offer sensitive, stable, and autonomous coverage of large ($5+ \text{ km}^2$) areas that can include 10s or 100s of potential source locations. Critically, this system closes the temporal variability information gap. Our system would provide continuous (diurnal, seasonal, interannual) monitoring of emissions from oil and gas operations. We employ a dual frequency comb spectrometer, which offers high stability of trace gas measurements over time, so that concentrations can be compared across different conditions and long periods of time. We situate the spectrometer in the center of a field of well sites. A series of retroreflectors around the perimeter of the field direct light back to a detector co-located with the laser. The beam pitch and catch system sends light between 1620 and 1680 nm, with discrete line spacing of 0.002 nm, resulting in a laser system covers thousands of individual absorption features from multiple species; namely CH_4 , carbon dioxide, and water vapor. Field tests demonstrate the ability of the system to identify very small atmospheric methane concentration enhancements (10-20 ppb), leading to the detection and sizing of very small (1.3 g/m) leaks of CH_4 , with long-range ($>500 \text{ m}$) (see Fig. 1). The demonstration of sensitive CH_4 measurements over kilometer-scale open paths allows for opportunities to monitor CH_4 emissions across large areas of natural gas activity. We will present results of field trials using controlled CH_4 releases in a rural Colorado field site close to the Denver-Julesburg Basin. This work represents the first field use of dual frequency comb spectroscopy to measure long-range, open path atmospheric concentrations of CH_4 .

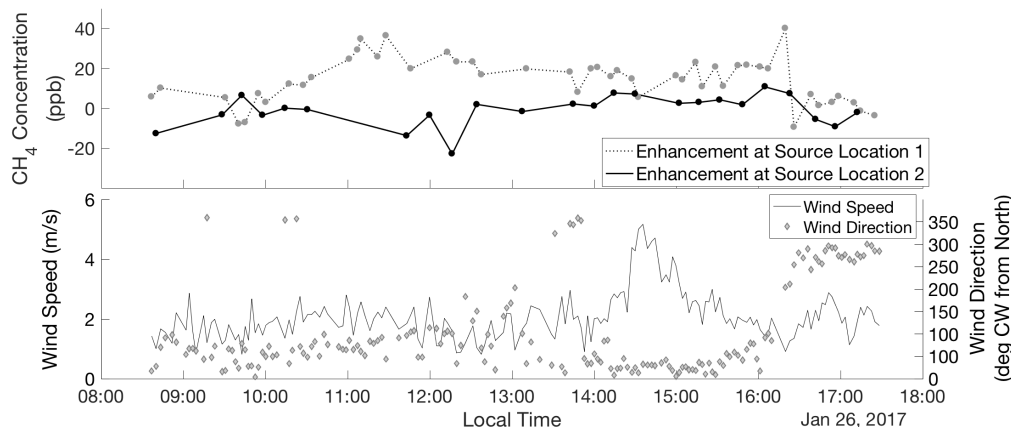


Figure 1. Atmospheric CH_4 enhancements above background along two open-path beams that bound Source Location 1, where a 1.3 g/m controlled release began at 10:00 and ended at 16:30, and non-emitting Source Location 2 (a). Wind speed and wind direction for the measurement period (b).