# Toward Continuous Monitoring of Climate Pollutant Emissions at Site- to Regional- Scales

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Continuous, high-precision monitoring of anthropogenic emissions of climate pollutants faces tradeoffs between cost, coverage and precision. This is particularly true for the detection of methane leaks that can occur during natural gas production, processing, and distribution. Large-scale, continuous monitoring of atmospheric methane by satellite or as part of the NOAA/ESRL network of tall-tower sampling provides invaluable information about regional methane concentrations, but tools do not currently exist for attributing atmospheric enhancements at large scales to leaks at individual sites or facilities. On the other hand, high-intensity measurement campaigns, using point sensor or LIDAR measurements of methane at or near natural gas facilities can provide high-fidelity leak detection and sizing, but the cost and man-power requirements of such campaigns preclude them from being reasonable long-term solutions for continuous monitoring. We present a new solution for methane leak monitoring that can provide continuous, long-term, and high-precision monitoring of all natural gas facilities within a >12 $km^2$ area with one instrument, leading to relatively low per-site costs. We position a dual-frequency comb spectrometer (DCS) in the center of a field of gas wells, and orient retroreflectors (small reflective mirrors) 0.1 to 2+ km away from the DCS in the area of well sites to be monitored. We measure atmospheric methane with the DCS by sending light to the retroreflectors at many near-infrared wavelengths where methane is known to absorb. The laser light is reflected back to a detector co-located with the spectrometer, and the measured absorption is used to infer the average methane concentration along the length of the beam path (from the spectrometer to the retroreflector). Recent measurements with the DCS indicate a measurement precision of approximately 4 ppb-km (precision scales with the length of the light path) for a measurement averaged over 90 seconds. A separate sensor provides 2-D wind speed and wind direction data as DCS measurements are taken, such that atmospheric inversions can be performed with an atmospheric transport model based on the local meteorological data. Initial tests of this novel measurement configuration using synthetic data with real noise parameters have shown the ability of the system to accurately locate and size leaks of 3.17E-5 kg/s within an 18-day period. We will present our observing system design configuration, background estimation methods, inversion methodology, and results of synthetic data testing at the Boulder Atmospheric Observatory site, where we will begin taking measurements of controlled methane releases in summer 2016.

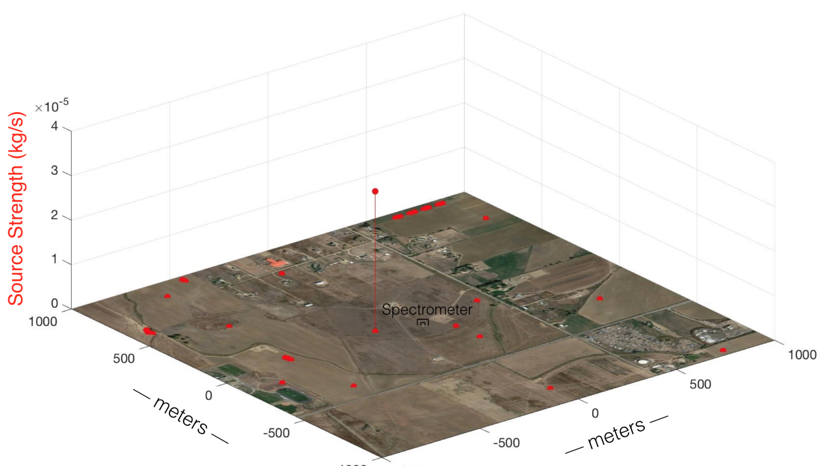


**Figure 1.** Natural gas wells (red points) in a 2km x 2km area near the BAO site in Erie, Colorado (data from the Colorado Oil & Gas Conservation Commission). The strength of a theoretical leak is shown on the vertical axis. Such a leak would be detectable using a system of retroreflectors and 1 spectrometer (shown as a box in the middle of the domain).