

**Abstract:**

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Multi-gas Detectability of Fugitive Emissions at an Enhanced Oil Recovery Site

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Enhanced oil recovery (EOR) is a fundamentally important technology for securing future oil production. However, this technology requires the use and transportation of fluids at high pressures above and below ground, which can lead to unintended releases of gases, especially as infrastructure ages. Interest to monitor small variations in atmospheric concentrations has grown because these small releases represent significant liability for companies in terms of cost, safety, and environmental contamination. The EOR project located in Weyburn, Saskatchewan consists of more than 1000 active wells, several processing plants, and hundreds of kilometres of pipeline infrastructure over a 100 km² area. This highly distributed operation presents challenges for gas leakage monitoring in terms of size and complexity of gas signals, and stretches conventional techniques beyond their limits. This study confronts these challenges by comparing the ratios of observed atmospheric trace gases against the ratio fingerprints of known industrial sources (multi-gas technique), the location of several potential emission sources was constrained. This presentation discusses the development of new large footprint techniques for identifying sources and magnitudes of fugitive emissions, and to understand targeted gas evolution across multiple land uses and through time.

To observe changes in the atmospheric composition of select gases, and to ascertain how those might be related to industrial activities, we used two Cavity Ringdown Spectroscopy (CRDS) instruments and a novel trace gas detection strategy to identify atmospheric emissions in this large domain (10x10 km). These instruments measured atmospheric concentrations of CO₂, CH₄, $\delta^{13}\text{C-CH}_4$, and hydrogen sulfide (H₂S). Both instruments alternated as stationary and mobile (vehicle-based and geolocated) receptors during field campaigns in 2013-2014.

Anomalies in gas ratios of CO₂:CH₄ and CH₄:H₂S detected along route by the mobile receptor were compared to known ratios of likely industrial sources (e.g., pipeline, injection fluid, formation gases, etc.). This geochemical fingerprint was used to distinguish these sources from one another, and from other potential confounding sources including biological emissions, combustion engines, and atmospheric pooling. Our results identified several anomalies that were found to correspond with oilfield activities at the time of the survey, which were known to

have gas emission potential. This multi-gas component approach allows us to extend the utility of analyzers beyond single-mode deployments, to constrain the location and better estimate the source of potential emissions in the Weyburn field. It is a promising package for EOR, Carbon Capture and Storage (CCS), unconventional gas and hydrofracturing, and other fugitive gas monitoring programs where sensitivity and specificity are required.