Detecting methane super-emitters from the surface and space.

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A large oil/gas field may include thousands of individual production wells along with gathering compressor stations, processing plants, and storage compressor stations. Methane flows through these different devices on its way to distribution pipelines. Malfunction of a device may cause anomalously high methane emissions, either intermittent or continuous. Recent field campaigns find that typically a few percent of devices in oil/gas fields have anomalously high methane emissions at any given time, and that these so-called “super-emitters” may account for over half of total emissions from oil/gas production. Satellites offer a particularly attractive resource for atmospheric monitoring because of their dense spatial coverage, but are limited by cloud cover. Surface sensor networks can also be effective for detection of super-emitters, in complement or independently from satellites. The number of sensors that can practically be deployed is typically small relative to the number of candidate super-emitters, so that the problem is underconstrained. We study how different configurations of continuous atmospheric observations from satellites and ground networks can serve to detect super-emitting devices in oil/gas fields. We use L-1 methods to pinpoint certain super-emitters in the inverse problem. For optimal sensor placement, we explore both distance-based clustering methods and placement based on the influence from a chemical transport model. Optimizing the network design of methane emitters provides an avenue to optimize climate and financial benefits in the oil & gas sector.

Methane emission domain

Zavala-Ariaza et al. (2015) found that 5% of natural gas production sites account for 60% of methane emissions in the Barnett Shale, so called super-emitters.

Future satellite capability

(1) Randomly scatter super-emitters across the Barnett Shale.
(2) Given the known spatial distribution of all emitters, cluster into M divisions - M is the number of available surface monitors.
(3) Generate pseudo-observations given the surface-satellite observing network.
(4) Try to recover super-emitters using the L-1 norm. Partition coefficients into 2 clusters. The higher cluster represent super-emitters.

Preliminary Results

Recall: Ratio of true positives to true positives plus false negatives

The predictive capability for TROPOMI alone is low (for this realization), but is amplified by the number of monitors deployed.

Forward Model (STILT)

The Stochastic Time - Inverted Langrangian Transport model (STILT) simulates observations by letting “particles” flow backwards in time according to offline wind fields. The distribution of particles represents the influence of upwind emissions on the observation.

We plan to run more simulations for different satellite/surface configurations and clustering methods.

We plan to quantify how cloud cover influences the inversion.

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