California Methane Super-Emitter Annual Quantification Uncertainty

A recently published study by NASA JPL[1] reports on the existence of large methane point sources, termed "super-emitters," across three industry segments – landfills, dairies, and oil/natural gas. The study uses advanced remote measurement techniques to identify and quantify (in kg/hr) the point sources using instrumentation mounted on airplanes. The identification of point sources is relatively straight-forward but involves human interpretation while the quantification is completed with algorithms and is quite complex. In the study, the quantified emissions were extrapolated to estimate statewide emissions annually. This white paper describes key uncertainties that were introduced into the results from the measurements being "scaled up" both temporally and spatially.

Temporal uncertainty in the estimates (initiated from the way that point sources were scaled), were used to produce an annual emission estimate. Although the point sources were correctly assumed to not be leaking for the entire year, the estimates were scaled using a "persistence" factor. This factor was based on the best information the authors had available, the number of times a source was identified on a flight divided by the total number of times the source was flown over. Two scenarios could have impacted the calculated persistence. First, a point source could have been emitting only periodically such as a blowdown stack, or secondly, an asset could have been emitting continuously, then was fixed/remediated such as a distribution pipeline leak or a malfunctioning valve. Values for persistence ranged between 0.02 and 1, with a 1 meaning the point source emitted continuously at the measured mean rate for the entire year. A persistence of 0.25 meant the point source was emitting at 25% of the mean measured rate for an entire year. In other words, a persistence of 0.25 also meant the leak was emitting at the rate measured by the study for 3 months of the year.

Several examples exist in the database of leaks that demonstrate how the persistence impacted the emission rates that were ultimately used to calculate statewide annual emission rates. For example, a single underground distribution pipeline leak in Bakersfield, CA (S00775) was identified on 1 flight in October 2017 and was assumed to be leaking all year at 39.8 kg/hr because no other flights were conducted (measured on 1 of 1 flights). This single leak contributed 0.3% of the measured point source emissions from oil and natural gas identified in the study. Another underground distribution pipeline leak in Pacoima, CA (S00925) was quantified at 92 kg/hr on one of two flights, therefore was assumed to be leaking at 45.8 kg/hr for the entire year, for a similar contribution of 0.3% to total measured emissions from point sources.

Temporal uncertainty was introduced because some oil and natural gas assets were flown over as many as 66 times while others were flown over only once or twice. Also, although some assets were flown over 66 times, many replicate flights were performed on the same day only minutes or hours apart or all in the same month, offering limited information on the true temporal persistence of many leaks in the database.

In total, five large point sources identified on distribution gas pipelines, which had persistence estimates ranging from four months per year (persistence = 0.33) to 12 months per year (persistence = 1). The average estimated persistence for the emissions from a large distribution pipeline leak in the study was 0.55 or 6.6 months. This estimation assumed that large point sources from transmission/distribution pipelines emit methane for 6.6 months before they are fully remediated.

The use of the persistence factor, therefore, introduces a temporal uncertainty in another way, which can have an impact on the annual statewide estimation. In particular, the estimated persistence for large point source emissions from gas distribution/transmission pipelines was 6.6 months. This persistence was 2 times higher than the mean persistence of 0.26 (3.1 months) for all oil and natural gas sector point source emissions. Although, the mean sector persistence includes both engineered intermittent sources (blowdown stacks) that may be short in duration and fugitive emissions that may last months, the existence of large distribution leaks for 6 months, particularly those identified in neighborhoods is unlikely since large point sources would likely be reported by residents quickly. Unfortunately, to thoroughly address this uncertainty, more information is needed on the frequency and duration of large point source emissions in transmission/distribution gas pipelines.

Measured large point source emission rates for transmission/distribution pipelines in the JPL study ranged between 39.8 ± 17.4 kg/hr and 690 ± 158 kg/hr, which when scaled for persistence, resulted in estimated emission rates between 39.8 ± 17.4 and 148.4 ± 31.9 kg/hr. The persistence adjusted hourly emission rates were combined (summed) to obtain an hourly emission rate of 420 kg/hr for distribution/transmission pipelines. This was scaled up to an annual estimate of 0.0037 Tg/yr by multiplying by 24 hours in a day and 365 days in a year. This method of scaling meant that these five leaks accounted for 0.8% of the total measured emissions from large point sources.

The authors performed additional scaling to account for the number of miles of pipelines that were not surveyed and potential leaks that may have been missed in those non-surveyed miles. Since 31.6% of all pipelines were surveyed, the authors multiplied the 0.0037 Tg/yr by 3.16 (1/.32) that they deemed a "sectoral scalar." Once this additional scaling was performed to scale up to the entire pipeline network, it accounted for 0.0116 Tg/yr or 1.9% of the total large point source emissions annually statewide. An emission rate of 0.0113 Tg/year equates to 1327.2 kg/hr from point sources in the distribution/transmission pipeline network.

Spatial uncertainty in the annual statewide emission estimates from point sources was introduced through the "sectoral scalars" mentioned above that the authors used to extrapolate the measured emission data to the assets/pipelines that were not flown over during the study. The spatial extrapolation assumed that the assets not surveyed emitted at the same rate and frequency as those surveyed, therefore also amplifies the uncertainty introduced during the temporal scaling. The extrapolation had the greatest potential to impact the estimated statewide annual emissions for assets that had the lowest percentage of the statewide population surveyed. For example, as mentioned earlier, only 31.6% of transmission/distribution pipelines were surveyed resulting in a sectoral scalar of 3.16. This scalar equaled an assumption that 7.3 large point source emissions occurred for every 100,000 miles of pipe in the state or approximately 16 large point sources statewide from distribution/transmission pipelines. Each of these 16 large point sources was estimated to be emitting at 83.0 kg/hr for the year (1327.2kg/hr / 16 point sources). Importantly, if the number of actual large point sources were 12 (instead of 16), then the overall statewide emission estimate from transmission/distribution pipelines was 25% higher than actual emissions or if the actual number was 20 (instead of 16) then the estimate was 20% too low.

In conclusion, the NASA JPL study was thorough and scientifically sound. This type of system can be helpful in aiding the identification of large methane emission sources. However, with every study there are comprises made when an entire population cannot be studied continuously. These compromises introduce uncertainty when results are extrapolated from limited data that has been aggregated. Therefore, it is crucial to understand the impact of those uncertainties on conclusions that are drawn and/or large-scale estimates are made.

References

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