Continuous CH4 and $\delta^{13}$CH4 Measurements in London Demonstrate Under-Reported Natural Gas Leakage

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Abstract

Assessment of bottom-up greenhouse gas emissions estimates through independent methods is needed to demonstrate whether reported values are accurate or if bottom-up methodologies need to be refined. Previous studies of measurements of atmospheric methane (CH4) in London revealed that inventories substantially underestimated the amount of natural gas CH4. We report atmospheric CH4 concentrations and $\delta^{13}$CH4 measurements from Imperial College London since early 2018 using a Picarro G2201-i analyser. Measurements from May 2019-Feb. 2020 were compared to the values simulated using the dispersion model NAME coupled with the UK national atmospheric emissions inventory, NAEI, and the global inventory, EDGAR, for emissions outside the UK. Simulations of CH4 concentration and $\delta^{13}$CH4 values were generated using nested NAME back-trajectories with horizontal spatial resolutions of 2 km, 10 km and 30 km. Observed concentrations were underestimated in the simulations by 12 %, and there was no correlation between the measured and simulated $\delta^{13}$CH4 values. CH4 from waste sources and natural gas comprised of 32.1 % and 27.5 % of the CH4 added by regional emissions. To estimate the isotopic source signatures for individual pollution events, an algorithm was created for automatically analysing measurement data by using the Keeling plot approach. Over 70 % of source signatures had values higher than -50 based on model-data comparison of $\delta^{13}$CH4 and on Keeling plot source signature emission both indicate that emissions due to natural gas leaks in London are being under-reported in the NAEI. These results suggest that estimates of CH4 emissions in urban areas need to be revised in the CH4 emissions inventories. 1 Helfter, C. et al. (2016), Atmospheric Chemistry and Physics, 16(16), pp. 10543-10557 2 Zazzeri, G. et al. (2017), Scientific Reports, 7(1), pp. 1-13
We have demonstrated that likely leaks from natural gas pipes were not entirely accounted. This suggests discrepancies in the source apportionment of the inventories, where waste emissions are likely being overestimated and natural gas emissions are underestimated. Simulations of natural gas CH$_4$ mole fractions deviate from those seen in measurements. Measurements at Imperial College London found a predominance of natural-gas CH$_4$ emissions are greater than the NAEI simulations have slopes closer to one, but typically did not capture higher CH$_4$ mole fractions. We did not find consistent patterns between the wind direction and isotopic source values. This reflects the collocation and regional and local sources.

Ambient air is sampled from an inlet mounted on a 2 m mast on the southeast corner of the Huxley building roof (26 magl, 40º 3′ 40″ N, 0º 13′ 7″ W). There is an on-campus natural-gas fired power station located ~200 m east of the air inlet. There is a large sewage works and one waste facility within 4 km south of ICL. We did not find consistent patterns between the wind direction and isotopic source values. This reflects the collocation and regional and local sources.

Footprints were combined with anthropogenic emissions from the NAEI and EDGAR inventories to form four different sets of simulations of CH$_4$ mole fractions with different horizontal spatial resolution: 30 km, 10 km, 2 km. Observed concentrations were underestimated in the simulations. Simulated CH$_4$ mole fractions were divided by the total simulated CH$_4$ mole fractions. Simulated CH$_4$ mole fractions then divided by the total simulated CH$_4$ mole fractions for the different sectors, and the background values were multiplied by their UK isotopic signature, summed and divided by the total CH$_4$ mole fraction. The analyses based on model-data comparison of ambient CH$_4$ concentrations and CH$_4$ mole fractions with NAME results were used to identify sources.