Geophysical Research Abstracts
Vol. 21, EGU2019-4629, 2019
EGU General Assembly 2019

Top-down quantification of methane emissions using in-situ observations in a region of coal seam gas production

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A 3-year study of monitoring of methane (CH4) within the Surat Basin, Queensland, Australia, was undertaken as part of CSIRO's Gas Industry Social and Environmental Research Alliance (GISERA). The Surat Basin is a significant region of coal seam gas (CSG), agricultural and coal mining activities.

The main aim of the study was to quantify CH4 emissions across the region using long-term in-situ observations of atmospheric CH4 concentrations from two stations which were 80 km apart and established on either side of existing and future-projected CSG activity.

A gridded "bottom-up" methane emission inventory for the region was compiled for a domain of 350 km x 350 km. When used in a regional transport model (TAPM), it yielded a lower frequency and magnitude of concentration peaks than measured. Possible reasons include weaker/missing sources in the inventory, particularly near the monitors, and errors in the modelled transport.

A novel "top-down" (or inverse) methodology was then devised to estimate regional CH4 emissions. It combines a Bayesian inference approach, a backward-in-time setup of the regional transport model, and a posterior probability density function sampling scheme. It uses the hourly CH4 timeseries from the two stations and options for the prior with specified uncertainties. The results indicate that even without a prior, the measured concentrations are able to constrain the emissions realistically. The use of the inventory as a prior leads to the best emission estimates (as judged from their ability to describe the CH4 data). The inferred emissions in a smaller subdomain covering areas around the two stations are 30% higher than the inventory emissions, although the total emission is very similar. These areas are where there are CSG emissions and potentially other sources not accounted for in the inventory. The results presented suggest that overall the inverse methodology is robust and provides an update of inventory emissions from multiple sources based on data from only two stations.