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Long-term Monitoring of Methane Emissions from Natural Gas Production in the Marcellus shale

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According to the US Environmental Protection Agency, more than 10% of all methane (CH4) emissions in the U.S. are located along the western edge of the Appalachian mountains with the majority of these emissions coming from natural gas infrastructure and coal mines. However, short-term atmospheric top-down studies over unconventional wells in Pennsylvania have found emission rates to be much higher than reported estimates. To better understand the causes of the discrepancy, we present the first long-term (i.e.8-month) top-down estimates from a tower network deployed across the Marcellus shale, measuring continuously CH4 and isotopic mixing ratios of 13CH4 at four locations. We quantified gas-related emissions and compared our results to a high-resolution inventory and a one-month aircraft campaign with 10 mass-balance emission estimates over the region. We also use the WRF-Chem mesoscale model at 3km resolution to simulate CH4 enhancements from a customized emissions inventory and compare the modelled enhancements to observations from the 10 flights that were downwind of unconventional gas wells. Based on the same modeled wind fields coupled to a Lagrangian Particle Dispersion model, we performed an 18-month Bayesian inversion. With repeated periods of enhanced atmospheric signals, we highlight the presence of large temporal variations over four to six weeks, based on our long-term tower data set. We conclude here that both aircraft- and tower-based emissions estimates show larger CH4 emissions than reported by the US EPA. However, the overall leakage rate reported on a production basis remains small thanks to the high-producing wells across the northeastern Marcellus shale region. To solve the source attribution problem, we also present how we calibrated 13CH4 CRDS analyzers deployed at four locations which allowed us to separate natural gas from biogenic sources. Finally, recent results from the Atmospheric Carbon and Transport (ACT-America) campaign using ethane measurements to separate coal from natural gas CH4 emissions, highlighting the potential use of atmospheric tracers to attribute emissions to specific sectors of activities.