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Identification, Attribution, and Quantification of Highly Heterogeneous Methane Sources Using a Mobile Stable Isotope Analyzer

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Despite methane's importance as a potent greenhouse gas second only to carbon dioxide in the magnitude of its contribution to global warming, natural contributions to the overall methane budget are only poorly understood. A big contributor to this gap in knowledge is the highly spatially and temporally heterogeneous nature of most natural (and for that matter anthropogenic) methane sources. This high degree of heterogeneity, where the methane emission rates can vary over many orders of magnitude on a spatial scale of meters or even centimeters, and over a temporal scale of minutes or even seconds, means that traditional methods of emissions flux estimation, such as flux chambers or eddy-covariance, are difficult or impossible to apply. In this paper we present new measurement methods that are capable of detecting, attributing, and quantifying emissions from highly heterogeneous sources. These methods take full advantage of the new class of methane concentration and stable isotope analyzers that are capable of laboratory-quality analysis from a mobile field platform in real time. In this paper we present field measurements demonstrating the real-time detection of methane 'hot spots,' attribution of the methane to a source process via real-time stable isotope analysis, and quantification of the emissions flux using mobile concentration measurements of the horizontal and vertical atmospheric dispersion, combined with atmospheric transport calculations. Although these techniques are applicable to both anthropogenic and natural methane sources, in this initial work we focus primarily on landfills and fugitive emissions from natural gas distribution, as these sources are better characterized, and because they provide a more reliable and stable source of methane for quantifying the measurement uncertainty inherent in the different methods. Implications of these new technologies and techniques are explored for the quantification of natural methane sources in a variety of environments, including wetlands, peatlands, and the arctic.