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Satellite Retrievals of Industrial Methane Emissions at High Resolution with GHGSat-D

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GHGSat-D is the first and only satellite on orbit designed for single-site measurements of greenhouse gas emissions. Launched in June 2016, its primary differentiating characteristic is spatial resolution of less than 50 metres. When the local column density near an observed emitter exceeds the background by more than our detection threshold, the resulting high-resolution retrieval fields consist of a spatially resolved (2-D) "image" of the emissions plume in the horizontal plane. Furthermore our instrument concept essentially guarantees accurate geolocation of emissions signals within tens of metres.

We present single-pass measurements showing evidence for point-source emission plumes from industrial sites such as coal mine vents and oil and gas facilities. Furthermore, we show that emission estimates derived from these satellite observations are corroborated by third-party estimates.

Our instrument is based on an imaging Fabry-Perot spectrometer which does not produce a conventional spectrum like a grating-based system. As a result we use a novel retrievals technique where the emitter site of interest is captured in a sequence of overlapping two-dimensional images. The combined effect of the Fabry-Perot resonator and the scrolling scene gives a different spectral sampling of each surface location in every image. Crucially, the spectral properties of the instrument can be accurately characterized and modelled. As a result, although none of our data processing levels resemble a conventional hyperspectral dataset, our retrievals software is based on a forward model that predicts the per-pixel signal as a function of spatially resolved surface reflectance, atmospheric column densities and the instrument parameters. More specifically, this model includes atmospheric radiative transfer and the instrument's spectral responsivity.

We describe the optimal estimation procedure used to retrieve the spatially resolved methane column from each of the approximately 250,000 ground locations in a single-pass observation of an emitter site. In the presence of instrument errors which we are working to eliminate, the methane retrieval can contain spurious features that can generate false positives and/or limit our ability to detect plumes. We quantify the performance limits of GHGSat-D and discuss hardware improvements that are being implemented in next generation satellites.