Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-202-RC1, 2019

Atmospheric Measurement Techniques Discussions

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Interactive comment on "Potential of next-generation imaging spectrometers to detect and quantify methane point sources from space" *by* Daniel H. Cusworth et al.

Anonymous Referee #1

Received and published: 25 June 2019

Review of " Potential of next-generation imaging spectrometers to detect and quantify methane point sources from space" submitted for possible publication to AMT by D. Cusworth et al.

This paper analyzes the potential to observe atmospheric methane plume from space with the objective of estimating the emission rate. It is based on both radiative transfer simulation and retrievals as well as an analysis of airborne observations. The focus is on spatial observations that would have a spectral resolution lower than that of instrument designed for atmospheric sensing, compensated by a high spatial resolution. The paper concludes that this class of instruments would permit to detect and quantify

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methane emission for sources down to the the range 100 kg/h range.

The paper deals with a technical subject that may interest a wide community in preparation for the launch of several space instrument in the forthcoming year. It is therefore a welcome addition to the literature on the subject. The paper is mostly clear and the figure are of high quality. There are nevertheless a few methods that are unclear as well as statements that appear overly optimistic : âĂć In section 4.1, one discusses the results presented in Figure 3. Although one can “see” the plume in the retrieved images (center and right) for the homogeneous scene when one knows it is there, I am not convinced that an uneducated guest would detect the plume without a significant number of false detection. It seems rather clear that, if the source was 100 kg/h (and not 500 and 900 kg/h) as in the simulated images, the signal would be hardly distinguishable for the noise. Thus, the claim that one would be able to detect and quantify plumes from 100 kg/h source is definitely not founded. âĂćlines 229-230, it is said that the “8% precision [. . .] should enable EnMAP to successfully quantify 500 kg/h point sources in a single pass.” There is no attempt at estimating sources in this section, so that there is no ground for this claim âĂćline 235, it is said that, for a 900 kg/h source, the plume is “well defined against the background” which is an overstatement. âĂć Line 284 “but a source rate can still be estimated successfully with EnMAP”. There is no ground in the paper for that statement âĂć Line 323 : “Nevertheless, the results do confirm that EnMAP should be able to detect plumes and quantify source rates down to $\sim$100 kg /h”. The analysis of the airborne data show overestimates by a factor up to 3 (mean 2). How can one see that as a confirmation that the source can be quantified ? âĂć In the conclusion it is said that the space measurements can be used to “detect and quantify plumes of magnitude $\approx$100 kg/h over relatively bright surfaces”. Yet, the simulations have been performed with larger sources (factor 5 to 9). In addition, it is rather ambiguous whether the objective is to quantify the plume (and what that really means) or to quantify the source that generate it. This should be clarified

In addition, one major source of uncertainty for instrument with a “low” spectral res-

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olution is the knowledge of the instrument response function. I understand that the authors have assumed that this response function is perfectly known. It would be nice to add a sensitivity test to analyze the impact of some uncertainty on this important parameter. To the very least, they should mention and discuss the potential impact.

Also, the paper uses a method for plume mask through “median and Gaussian filters” which is not described. Some sentences do describe the principle of the method would be useful

In conclusion, this paper has the potential to be published in AMT, but there is a strong need to justify better, or to remove, several strong statements. See also a few comments directly on the pdf.

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2019-202/amt-2019-202-RC1-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-202, 2019.

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https://doi.org/10.5194/amt-2019-202
Preprint. Discussion started: 29 May 2019

Atmospheric Measurement Techniques Discussions

Potential of next-generation imaging spectrometers to detect and quantify methane point sources from space

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Abstract

We examine the potential for global detection of methane plumes from individual point sources with the new generation of spaceborne imaging spectrometers (EnMAP, PRISMA, EMIT, SBG) scheduled for launch in 2019-2025. These instruments are designed to map the Earth's surface with a sampling distance as fine as 30 × 30 m^2 but they have spectral resolution of 7-10 nm in the 2200-2400 nm band that should also allow useful detection of atmospheric methane. We simulate scenes viewed by EnMAP (10 nm spectral resolution, 180 signal-to-noise ratio) using the EnMAP End-to-End Simulation Tool with superimposed methane plumes generated by large-eddy simulations. We retrieve atmospheric methane and surface reflectivity for these scenes using the IMAP-DOAS optimal estimation algorithm. We find an EnMAP precision of 4-13% for atmospheric methane depending on surface type, allowing effective single-pass detection of 100+ kg h^{-1} methane point sources depending on surface brightness, surface homogeneity, and wind speed. Successful retrievals over very heterogeneous surfaces such as an urban mosaic require finer spectral resolution. We simulated the EnMAP capability with actual plume observations over oil/gas fields in California from the airborne AVIRIS-NG sensor (3 × 3 m^2 pixel resolution, 5 nm spectral resolution, SNR 200-400). We spectrally and spatially downsampled AVIRIS-NG images to match EnMAP instrument specifications and found that we could successfully detect point sources of ~100 kg h^{-1} over bright surfaces. Estimated emission rates inferred with a generic Integrated Mass Enhancement (IME) method agreed within a factor of 2 between EnMAP and AVIRIS-NG. Better agreement may be achieved with a more customized IME method. Our results suggest that imaging

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Fig. 1.

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