Reviewer 1

We thank the reviewer for the constructive comments and appreciate the review.

Please find a point by point response below:

A. General Comments

Atmospheric methane is the second important greenhouse gas, but their emission estimate from different source sectors has large uncertainties. Imaging spectrometers using large number of pixels is a powerful tool to detect CH4 plumes. Their selection of spectral range and resolution and integration time impact the performance directly.

Existing works mainly study trade-off between instrument noise and spectral resolution using CH_4 absorption spectra only, which results in too optimistic results. In real measurements, surface albedo estimation is one of the major error sources. The simulation tool and analytical methods in this paper are realistic and present consistent results.

Objectives of the CH_4 measurements with a new instrument seem to be both detection of unknown emission source and estimation of emission quantitatively. The former is well written, but the latter is not clear. It will help readers' understanding to list at least the possible error sources and discuss how to reduce uncertainty briefly.

In this work, we focused on demonstrating how a better choice of instruments can significantly reduce the retrieval error of methane concentration in each pixel. This directly leads to an improvement in both the detection and quantification of methane emissions, which is not a part of the current study. For the quantification aspect, typical methods rely on the total enhancement of methane plume around the source pixels (referred to as IME in Varon et al. 2018, Jongaramrungruan et al. 2019). These studies show that if high retrieval errors occur due to surface interference near the source, it could significantly add to the uncertainties in the total enhancement, and therefore emission rate estimates (such as a falsely high flux rate for an actual small source). However, when retrieval error is minimized, we could remove this source of error from the flux inversion step, resulting in a more reliable flux estimate down the line. The most important factor is to randomize and de-correlate error sources so that aggregate emissions estimates are not biased.

I recommend publication after minor revision.

B. Specific Comments

(1) Page 2, line 32, "methane emission"

It not clear. Methane emission of what?

“For instance, just the question whether or not the leak rate in the natural gas extraction system is 1 or 2% is equivalent to a 100% uncertainty in methane emissions.”

By this, we mean that estimation of methane emission rates from the natural gas extraction system can be highly uncertain due to the fact that the overall leak rates from these systems are not precisely known. We adjusted the text in the manuscript to be “For instance, just the question whether or not the leak rate in the natural gas extraction system is 1 or 2% is equivalent to a 100% uncertainty in methane emissions from these leaks” for more clarity.

(2) Page 5, Incoming solar irradiance,

Just a comment. Recently published paper “The TSIS-1 Hybrid Solar Reference Spectrum” 10.1029/2020GL091709, discussed uncertainty in the continuum at 1.6 and 2.3 micron regions and includes Toon’s line spectra.

We appreciate the reviewer pointing to this paper. We will look into the possibility of using the new solar reference spectrum product in our future related work. For the current synthetic sensitivity study, the choice of the solar model will have a minor impact.

(3) Page 13, Figure 6 caption

Brief description of the selected surface area will help readers’ understanding. For example, “our database of different surface albedos from the ECOSTRESS spectral library”.

We have added this additional description to the caption of Figure 6 accordingly.

(4) Page 18, 3.4.1. Occurrence of false positive and false negative

Larger degrees of polynomial provide better fit. However, too many retrieval parameters also produce larger errors. Authors mention that the optimized degree depends on the spectral resolution of the instrument. This paper described in detail. Once the design is fixed or when readers already used their existing imaging spectrometers, it will be very helpful if there are index or criteria to determine the optimized degree of polynomial.

As the reviewer mentioned, in a situation where the instrument specification is fixed, an optimized degree of polynomial can be found based on the spectral observations and its fit. In this work, we highlighted the benefit of using higher-resolution FWHM in the instrument to allow for higher degree of polynomial to be used. In the future, methods such as backward elimination could potentially provide a real-time determination of the number of polynomial degrees needed, for a given instrument over a certain surface type.

C. Technical Corrections

(1) Page 3, line 84

The sentence “Hence the origination of this study” looks incomplete.

We modified the sentence to be “This motivates the origination of this study.”