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Atmospheric Measurement Techniques Discussions

Interactive comment on "The GHGSat-D imaging spectrometer" *by* Dylan Jervis et al.

Anonymous Referee #1

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General comments: Jervis et al. describe a space-borne imaging spectrometer using a fixed-cavity Fabry Perot interferometer (FP) for wavelength selection at around 1650nm. The FP, together with an order sorting filter is placed inside a camera optics, causing rings of equal FP transmission on the detector array through the FP's incidence angle dependence. Thereby, in a series of recorded images, points within the FOV are observed with several different FP spectral transmissions through the satellite movement. The resulting interferograms are evaluated for methane absorption by inversion of a combined instrument and atmospheric model. The high spatial resolution allows for detecting very strong methane gradients, for instance emissions (e.g. leaks) from industrial facilities. The paper has a clear structure and fits into the scope of AMT. I have two major points:

1) Scattering at aerosol is neglected in the atmospheric model motivated by e.g. the work of Houweling et al., 2005, which treats total column CO2 measurements. I think

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Discussion paper

that the finding of a decreased aerosol induced error for narrow layers close to Earth's surface cannot directly be transferred to the presented study of localised and strong emission plumes with much higher spatial resolution. The presented methane emission measurements show a different geometry with very high concentrations at low altitude. For low altitude aerosol and particularly for co-emitted aerosol (as mentioned in the manuscript, l.4,p.8), induced light path changes are likely to have a stronger impact on the vertical column density quantification. And thus, the influence of aerosol on the flux determination can become relevant.

2) The authors mention the absorption of CO2 and water vapour in the chosen wavelength window (p4, l13-14). If CO2 and water vapour amount are fixed parameters in the model inversion, their cross interferences need to be quantified in order to exclude any significant influence on the methane measurement. The influence of local gradients (e.g. emission plumes or co-emission) of these gases, as well as aerosol induced light path variations (see above) should be quantified (e.g. by using the introduced model).

Specific Comments

3) Figure. 3 (a) indicates that within the pass band of the order sorting filter there are three FP transmission fringes. This should be mentioned/motivated in the instrument description. Selecting 3 transmission peaks triples the light throughput compared to a measurement with a single peak and therefore enhances the SNR by sqrt(3). On the other hand, a dilution of the absorption signal of strong absorption lines is expected, reducing the SNR by up to a factor of 3. For the FP's free spectral range correlating with the spectral separation of strong periodic absorption structures (e.g. as in Vargas-Rodriguez and Rutt, 2009 or Kuhn et al., 2019) the sensitivity, selectivity and the SNR would be increased by using several FP transmission peaks. The instrument description does not mention if such a correlation is used.

4) How does the measurement error/sensitivity vary across the imaging FOV? In Fig.

4 (a)-(d) the rings of equal FP transmission are faintly visible. A pixel located in the centre of the detector will see a different FP interferogram compared to a pixel close to the detector edge. I.e. the progression of the signal as shown in Fig. 4 (e) is dependent on the location of a pixel on the detector. A slight tilt of the FP in along track direction would increase the radii of the FP rings within the FOV. This could have the advantage of a better coverage of the whole FOV with similar FP interferograms and also it would increase the range of FP tuning ($\sim$cos(alpha)) per pixel. Thereby the spectral information of the measurement could be further enhanced and areas on the detector with low dynamics in spectral FP changes (e.g. the centre area of the detector) were avoided.

5) Fig. 3 (c) shows the 'instrument signal' as a function of the radius. Here it would be illustrative to show the differential instrument signal between a typical methane plume and a plume free region. Thereby the sensitivity of the method in terms of measured optical depth per methane amount would become more clear. Also the influence of typical CO2 and water vapour absorption gradients could be illustrated that way.

References

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