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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Satellite observations of atmospheric methane and their value for quantifying methane emissions" *by* Daniel J. Jacob et al.

Anonymous Referee #1

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General comments: This is very good paper reviewing Satellite observations of atmospheric methane and their value for quantifying methane emissions. It discusses current and future observational platforms and their capabilities and ability to observe and quantify regional and point sources. It also has a very good discussion on error sources and overview of inverse methods.

Specific Comments:

Figure 3 is somewhat misleading for MERLIN or LIDAR instruments in general. While it may be adequate for "SWIR" instruments LIDAR vertical sensitivity depends on the choice of wavelengths and the number of wavelengths. Grouping LIDAR (MERLIN) with "SWIR instruments" gives the impression they have similar capabilities and limitations.

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Same applies to Figure 4 which shows the atmospheric optical depths of different gases in the SWIR at 01. nm resolution. MERLIN or a LIDAR in general can have 0.1 ppm resolution.

The quoted MERLIN precision of 1% is the "Breakthrough" precision. MERLIN has Target, Breakthrough and Threshold random and relative systematic error requirements. I suggest the authors make that clear.

I enjoyed the discussion on error characterization and Overview of inverse methods. The authors very correctly point out that Random error (precision) and systematic error (accuracy) have very different impacts and that Systematic error is irreducible. They discuss spatial variability in the bias resulting from different surface reflectivities, aerosol interference etc. I wished they had gone one step further and discussed instrument biases that are often a major systematic error source. These error sources are non-stationary (have temporal variability) that are very difficult to characterize. See for example: Werle, Peter. "Accuracy and precision of laser spectrometers for trace gas sensing in the presence of optical fringes and atmospheric turbulence." Applied Physics B 102.2 (2011): 313-329 and Bomse, D. S., and D. J. Kane. "An adaptive singular value decomposition (SVD) algorithm for analysis of wavelength modulation spectra." Applied Physics B 85.2-3 (2006): 461-466. In their discussion of Rodgers the authors correctly point out that error PDFs are often assumed to be Gaussian. Instrument biases are never Gaussian and in fact they are very difficult or impossible to characterize in a real instrument prior to launch. I do not think the Adjoint or other methods (that do not assume a Gaussian PDF) offer a solution to this problem. This remains a significant metrology and calibration problem which is often overlooked. I comment the authors for their extensive list of references. For completeness I also suggest they also reference: Ohring, G., B. Wielicki, R. Spencer, B. Emery, and R. Datla, eds., Satellite Instrument Calibration for Measuring Global Climate Change, NIST Rep. NISTIR 7047, 2004.

It would be nice to add the MERLIN capabilities to Table 2

I could not find where Figure 6 is referenced in the paper.

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