Review of C. Kiemle et al., "Sensitivity studies for a space-based methane lidar mission"

General Comments:

This is a very comprehensive study, addressing the important elements that influence global-scale methane measurement sensitivity using a laser-based Integrated Path Differential Absorption (IPDA) method in an Earth-orbiting mission concept. The authors briefly introduce the scientific justification for the global-scale measurement, accompanied by citations to the literature that provides scientific/societal justification for this investment. Then the IPDA method is introduced, followed by the presentation of a high-level point design that purportedly meets the observational requirements. I recommend publication. There are a few recommendations, mostly for the sake of clarity and balance.

Specific Comments:

(1) Introduction:

In general the Introduction reads well. The cited references are all appropriate.

- The first sentence as written is potentially confusing. Indeed water vapor is the most influential greenhouse gas. Water vapor is not included, however, in the radiative forcing calculations that result in methane accounting for 18% of the total. The authors should provide a brief explanation of the radiative forcing calculation to clarify.
- Paragraph beginning at line 18: "For methane the observational requirements are considerably relaxed….." What are the observational requirements? The study should begin with a statement of the requirements and the basis. I can only infer what they might be based on the point design performance estimates that come much later.

(2) Section 3 Methane absorption line selection:

- For a better understanding of the spectroscopy, I recommend adding to Table 1 the values of the lower energy levels for these doublets, the values of the pressure broadening coefficients, the temperature dependence of the broadening coefficient, and the values of the pressure shift coefficients. The measurement precision susceptibility to temperature profile uncertainty depends on all these parameters.
- What are the underlying temperature and humidity profile uncertainties that result in the methane column-weighted mixing ratio uncertainties cited in Table 1? This information is not in this section. I don't see it in the Appendix either.

(3) Section 5 Results:

- Table 3: What are your sources for these values of reflectance? Cite them.
- Second paragraph: "A higher DAOD would lead to a stronger curvature…" It is not clear what causes this effect. What is the underlying physics?

- Paragraph on aerosol effects: The Vaughan et al. reference is informative. However the Atlantic Ocean region is a relatively small piece of the globe. Assuming an Angstrom exponent to go all the way from 10.6 micron wavelength to 1.65 micron wavelength is unrealistic, since the aerosol size distributions are typically multi-modal. You should use additional information found in the literature. Take advantage of the multi-wavelength lidar aerosol backscatter studies over the Pacific Ocean basin, including observations of backscatter from Asian dust layers, in e.g., (1) J.D. Spinhirne et al., Appl. Opt. 36, pp. 3475-3490 (1997); (2) R.T. Menzies et al., J. Geophys. Res. 107, doi 10.1029/2001JD001196 (2002). You can interpolate to 1.65 micron wavelength using these datasets.

(4) Appendix A:

- The authors are commended for providing the formalism here.
- Figure A1 is confusing. In part this is due to the attempt to provide both optical depth and relative uncertainty. Please make the fonts larger! The paragraph beginning on line 15 ("In Fig. A1, temperature uncertainties are plotted...") is not correct. The figure caption ("Relative XCH4 uncertainty due to atmospheric temperature uncertainties…") is what is really being plotted, I assume. Again, it would be good for the reader to know what the underlying temperature profile uncertainties are. What are the six different "representative climates"? It is difficult to understand why the temperature-related XCH4 uncertainty is as low as this.