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Atmospheric
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Interactive comment on "Sensitivity studies for a space-based methane lidar mission" *by* C. Kiemle et al.

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Dear AMT Editor,

Please find hereafter our answers to each of the comments by the first referee which we found very constructive.

Christoph Kiemle, 12.8.2011, on behalf of all co-authors.

(1) Introduction:

First sentence: the referee is right. Water vapour is not included in the radiative forcing calculations giving an 18% contribution by methane to the total radiative forcing by

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long-lived greenhouse gases. The sentence is indeed potentially confusing. Since the role of water vapour is not a topic of the paper we suggest to formulate the sentence as follows: "Despite its comparatively low atmospheric abundance, methane is, after carbon dioxide, the second most important greenhouse gas directly augmented by human activities, accounting for 18 % of the radiative forcing by all long-lived greenhouse gases."

Paragraph beginning at line 18: The observational requirements for methane have been established in the frame of the cited ESA study (Ehret and Kiemle, 2005) and basically comprise a methane column measurement precision of between 0.6 – 2.0 % at a spatial resolution of 50 km. As the referee suggests, we will add this key information to the introduction.

(2) Section 3 Methane absorption line selection:

According to the HITRAN database the spectral feature at 6077 cm-1 consists of two multiplets of three strong methane lines each with various intensities from about 0.5e-21 to 1.2e-21 cm-1/(molecule.cm-2), various pressure broadening coefficients from 0.041 cm-1/atm to 0.057 cm-1/atm and pressure shift coefficients from -0.0018 to -0.0218 cm-1/atm, but almost identical lower energy levels and temperature dependence of the broadening coefficients, with 220 cm-1 and 0.85 respectively. We propose to mention these two common properties in the text. Adding all of these spectroscopic details for all six strong lines of both multiplets into Table 1 would overfill the table, and would not necessarily lead to a better understanding of the spectroscopy, due to the complexity of the multiplets.

The information is found in the appendix in the paragraph following Eq. (A15): the temperature and humidity profile uncertainties were modelled using globally averaged vertical error covariance matrices calculated from ECMWF forecast difference data. These are the <dT_i.dT_j> and <dvmr_h2o_i.dvmr_h2o_j> terms in equations (A14) and (A15). In order to provide the reader with a more quantitative understanding of the

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assumed uncertainties, we propose to add two plots in the appendix that would display the error covariance matrices of temperature and humidity and their diagonals.

(3) Section 5 Results:

Table 3: Source for these reflectance values is Amediek et al. (2009), as detailed in the text at the end of section 4. We will add this reference to the figure caption for clarification.

Second paragraph: Simulations using stronger absorption lines with higher DAOD (not shown here) show a stronger increase (curvature) of the measurement uncertainty towards 0 km altitude, due to the stronger on-line signal attenuation. An atmosphere with stronger aerosol optical depth, as documented in Fig. 5b of Ehret et al. (2008), generates a similar effect on the measurement uncertainty.

Paragraph on aerosol effects: We agree that the Vaughan et al. reference with 10.6 μm lidar measurements over the Atlantic Ocean is not representative of the whole globe, and that assuming a constant Angstrom exponent down to 1.65 μm is unrealistic. We used the recommended additional literature to check and compare our median aerosol profile with the lidar measurements over the Pacific Ocean compiled in Menzies et al., JGR, 2002. We find good agreement in the backscatter coefficients between our median aerosol profile that serves as baseline in our study, extrapolated to 1 μm wavelength, and their background aerosol profiles without Asian dust and pollution layers, as displayed in their stacked histograms (Figs. 2 and 4). We therefore suggest to include this indeed important reference that complements our work, and to mention the agreement found between the wavelength-extrapolated Atlantic profiles and the unpolluted Pacific profiles that gives significant support to our approach of using the Atlantic median profile as baseline.

(4) Appendix A:

The curve corresponding to the optical depth on figure A1 was aimed at providing the reader with an illustration of the general form of the four multiplet features of table 1 (which would otherwise be absent from the paper), and of the location of the on-line wavelengths within these multiplets (i.e., in the trough). Of the four options, the selected line multiplet (option 2) was a natural choice for this purpose. The other curves aimed at showing that the selected on-line wavelength corresponds to the best possible weighting function and to a low sensitivity to temperature uncertainties. In addition to making the fonts larger in both figures of the appendix, we propose to use colour lines for a better understanding. The description of figure A1 on line 15 will also be corrected.

The representative climates are defined in the text following Eq. (A15). They were used to plot the six curves related to the relative XH4 uncertainty on figures A1 and A2, whose relatively low spread shows that the atmospheric state does not play a major role in the magnitude of the errors. This is reflected in the narrow range of variation of the errors in table 1.

The temperature-related XCH4 uncertainty is low because of the use of a more realistic approach making use of vertical error covariance matrices representative of the expected reanalysis model performance (here from ECMWF), as opposed to simpler but more pessimistic assumptions used in previous approaches (correlated 1K error over the whole atmosphere, for instance). This is to be considered as an RMS error due to temperature uncertainties over the globe, with actual errors that will be higher where the model does not perform so well and lower where the model performs better. The anti-correlation of the errors in the higher atmosphere with errors in the lower atmosphere, which is apparent in the error covariance matrices, may also contribute to a reduction of the total RMS error by partial cancellation of some terms in the sums of Eqs. (A14) and (A15). To better illustrate this we intend to add two plots in the appendix that would display the error covariance matrices of temperature and humidity and their diagonals, as proposed above.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 3545, 2011.

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