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Interactive comment on "Global inverse modeling of CH$_4$ sources and sinks: An overview of methods" *by* Sander Houweling et al.

Sander Houweling et al.

s.houweling@uu.nl

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Response to Anonymous Referee 2

We would to thank the referee for the time and effort spent to help improve our manuscript. The structure of this document is as follows: Referee text's are in Italic font, answers are in Roman, modifications to the text are in bold font.

Overview: The manuscript "Global inverse modeling of CH4 sources and sinks: An overview of methods" by Houweling et al. provides an analysis of the current status of the application of inverse modeling techniques to methane flux estimation, along with a discussion of both their history and their future potential. This paper is a useful documentation and provides some clear ideas for the future. I recommend publication after a few minor changes.

Section 3: Perhaps some mention (here or elsewhere) of the fact that the tropospheric chlorine sink of methane is often not included in inversions. Although relatively small, this will have had some effect on the inversion results that you show in Figure 1.

The following sentence has been added to section 2. Page 5, line 10: **Furthermore, the use of MCF to constrain tropospheric methane oxidation does not account for the contribution of other potentially important oxidants, such as chlorine radicals in the marine boundary layer (Allen et al, 2005).**

Page 13, lines 3-5: The authors write that SF6 "provides an important constraint on inter-hemispheric exchange". This should be explained a little further. Do the authors mean that the SF6 observations should be used actively within an inversion in some way, in order to contain the inter-hemispheric transport? Or as in Monteil et al., (2013) in order to improve the advection parameterisation before an inversion is undertaken?

The following sentence has been added to section 6: Page 13, line 3: **So far, transport and methane fluxes have been optimized in separate steps, although they could in theory be combined in a single inversion.**

Page 15, line 5: The authors state that: "Measurements of the vertical profile of CH4 may further improve the separation between surface sources and atmospheric sinks." This statement should be expanded upon, as it is not clear how this would be true given the long lifetime of methane.

This is a good point, which we indeed didn't give sufficient thought. To quantify the sensitivity we did two forward runs: 1) The standard TM5 CH4 setup, 2) As setup 1) with sources and sinks increased by 10%. Results of these simulations are evaluated in the 4th year. They represent 2 solutions that yield approximately the same global burden. The question is whether vertical profile measurements could detect the difference. Figure 1 shows those differences averaged seasonally. As can be seen there is an approx. 10 ppb difference between the surface and the tropopause. It is stronger in winter than in summer (when convection reduces vertical gradients). Gradients de-

velop despite the short time scale of vertical mixing, because: 1) Down-welling of CH4 depleted air from the stratosphere. 2) The north-south gradient is increased when the CH4 lifetime reduces, influencing the exchange of methane in the tropical upper troposphere. A 10 ppb gradient is detectable, although transport model errors may result in similar or even larger differences, which is why we added the subsequent sentences indicating that in practice it is not easy to make use of this information.

Technical corrections: Page 16, line 14: "To make" -> "making"

Done.

Page 16, line 16: "from" -> "for"

Done.

Figure 3: The use of a blue-red colorbar in this figure implies positive and negative contributions. You should consider changing to non-diverging colors.

Done.

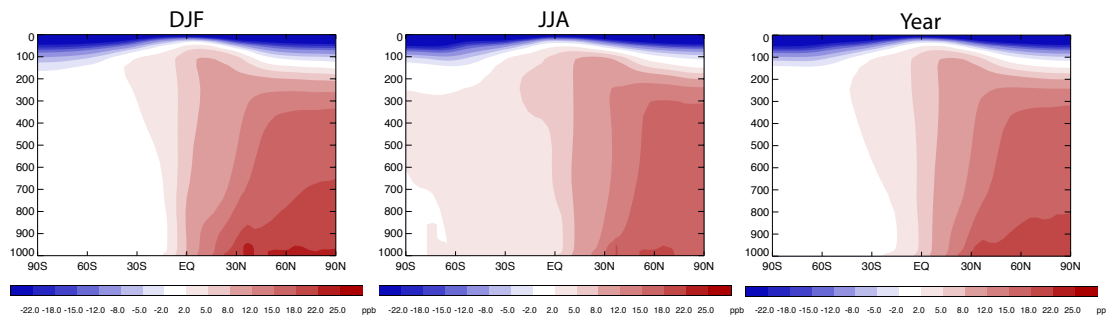Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-572, 2016.

Fig. 1. Zonal mean differences in CH4 mixing ratio between a standard CH4 simulation and a simulation in which sources and sinks are both increased by 10% (difference= 10% Increase - Standard).

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