Dear Dr. Patrick Jöckel,
Thank you very much for handling our manuscript. Please find below our itemized responses to the reviewer's comments.

Thank you for your consideration.

Sincerely,
Xiao Lu et al.

Reviewer #1 Dr. Julia Marshall

Comment [1-1]: The paper is much improved after revision! I have only a couple very minor comments about the new material that was added, which might clarify the interpretation. The following paragraph remains a sticking point for me:

In L575-L579 of the revised manuscript the author's state: "...in situ observations, in particular surface and tower measurements, are more effective than the satellite observations in independently constraining methane emissions independently from the sink by OH", but also that "the in-situ-only inversion yields a larger interannual variability of posterior OH concentrations and thus methane lifetime than the GOSAT only inversion (Fig.7b), due to the heterogeneous spatial and temporal distribution of the in situ observations."

Both of these things cannot be true. It cannot be that the in-situ measurements better constrain the emissions independently of the OH fields while simultaneously leading to more OH interannual variability. I think the latter finding (more interannual variability in OH in the surface-only inversion) is instead related to having only trends to optimize in anthropogenic emissions. If the model cannot allow emissions to e.g. first decrease and then increase, it can only match the data by adjusting the sink! But this does not necessarily make it a physically reasonable solution. I think this needs to be discussed in some more detail.

Response [1-1]: Thanks for pointing it out. The larger interannual variability of posterior OH in the in-situ-only inversion is mostly because the number and location of in situ observations varies in different years, in particularly for aircraft and shipboard observations. Our sensitivity inversion using only long-term surface sites indeed shows less interannual variability of posterior OH factors, with lower error correlation between the optimization of methane emissions and OH (r=-0.37). We have rephrased the text to avoid misleading information "<u>We also find that the in-situ-only inversion yields a larger interannual variability of posterior OH concentrations and thus methane lifetime than the GOSAT-only inversion (Fig.7b and Fig.S4). This is because the number and location of the observations varies from year to year, particularly for aircraft campaigns and ship cruises.</u>"

Comment [1-2]: Then a comment to the added figures: Please replace figure 7b with the interhemispheric scaling factors (like Maassakkers et. al. 2019 Figure 7d, but with two values instead of one), so the size of the scaling is clear. It is not straightforward to deduce these (especially the interhemispheric ratio) based on the lifetime alone, which is why I requested this figure in the first review.

Response [1-2]: We agree that we should show the scaling factor for OH. However, we think it

makes more sense to show the posterior methane lifetime in Fig.7b as it is more relevant to methane budget estimates. We therefore add a new Figure.S4 to show the hemispheric OH scaling factors from the inversions. Our OH scaling factors are larger than those in Maasakkers et al. (2019) mainly because we assume a large error on prior OH fields (10% vs 3%).

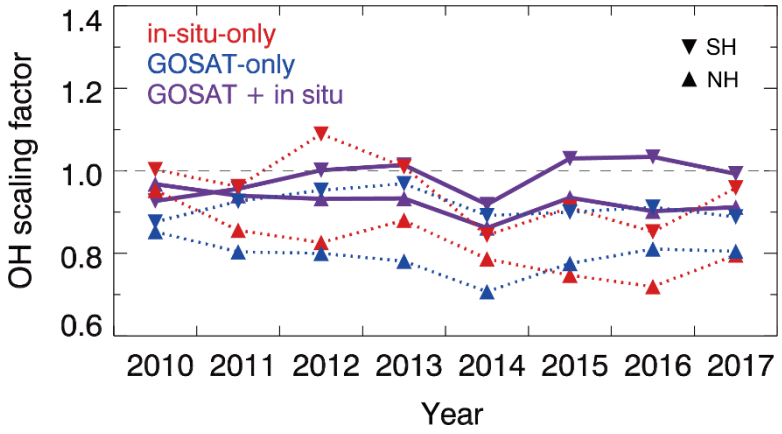

Figure S4. OH scaling factors for the Southern Hemisphere (SH) and the Northern Hemisphere (NH) from the three inversions.

Comment [1-3]: About Figure S2: Thank you for including this information! However the figure is quite difficult to see. The points are so tiny, I can hardly see the colours. Would it be possible to bin the data somewhat so that it's easier to interpret? A suggestion would be e.g. a few degrees of latitude, 1-km altitude bins, and then perhaps have slightly larger points. Perhaps the colour could show the mean value in the bin, and the size of the point the standard deviation within the bin? This way the noise in the NH mid-latitudes would be easier to interpret. This is just an example: I am sure there are different ways that the information could be plotted to make it clearer.

Response [1-3]: Thank you for pointing it out. We have revised accordingly.

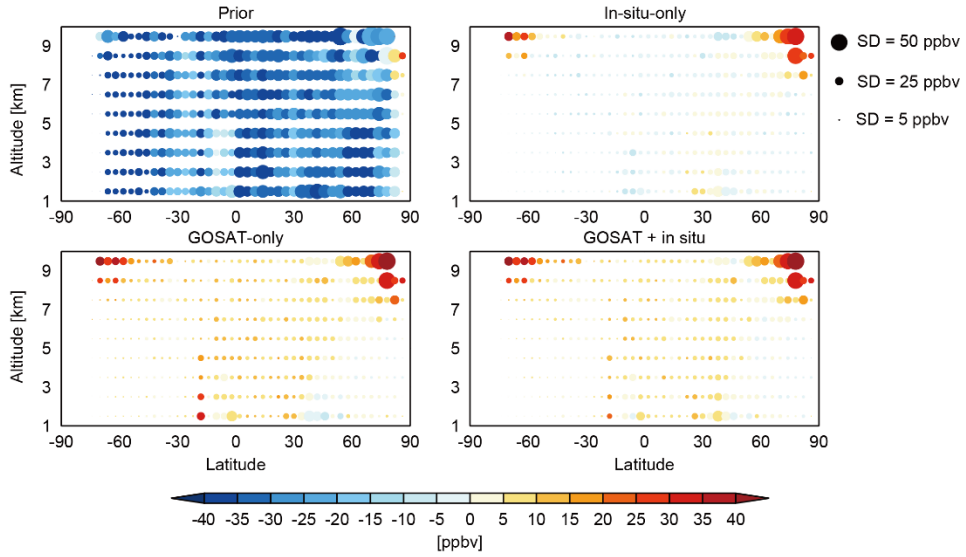

Figure S2. Differences between simulated and observed aircraft methane concentrations from the GLOBALVIEWplus ObsPack data product using GEOS-Chem

with prior estimates and with posterior estimates from the in-situ-only, GOSAT-only, and GOSAT + in situ inversions. The size of the dots represents the standard deviation (SD).