Response to Editor decision

We thank the Editor for their helpful comments. We agree that the narrow range reported for the photochemical sink requires further clarification, particularly in the context of broader uncertainties in global OH. We have revised the manuscript to clarify that our reported range of 19.1–19.7 Tg H_2 yr^{-1} represents variability in the mean photochemical sink over 2003–2023 across our inversion experiments, rather than an uncertainty estimate that includes OH uncertainty. This variability arises from differences in the posterior photochemical source, posterior soil sink, and posterior mole fractions across the inversion experiments, as the photochemical sink itself is not optimized. We acknowledge this was not sufficiently clear in our original text and have made this more explicit in our revision below. We also agree that our reported photochemical sink range is likely narrower than expected based on broader uncertainties in global OH-distributions. The narrow range is likely caused by our use of the same CAMS EAC4 OH fields across all inversion experiments. Therefore, we deliberately chose a large hypothetical 20% bias in OH fields to assess its impact on the inferred soil sink in the sensitivity calculation that was added in the previous manuscript iteration.

In response to the Editor's comments, we propose the following revised Section 4 opening:

We have relatively high confidence in our inferred soil sink, supported by the use of observationally constrained OH fields and the agreement of our estimated photochemical sink with other bottom-up estimates. To estimate the photochemical sink, we used OH fields from the CAMS EAC4 reanalysis, which provides globally consistent atmospheric composition fields constrained by satellite observations of O_3, CO, NO_2, and aerosol optical depth, alongside meteorological observations (Inness et al., 2019). Our resulting photochemical sink of 19.2 [19.1–19.7] Tg H_2 yr^{-1} falls within the range of other bottom-up estimates (15.0–22.8 Tg H_2 yr^{-1}; see Table 2) and is very close to the mean estimate of 18.4 [16.2–20.6] Tg H_2 yr^{-1} reported by Ouyang et al. (2025). We note that Sand et al. (2023) reported a higher photochemical sink of 25 [22–30] Tg H_2 yr^{-1} from an ensemble of global three-dimensional atmospheric chemistry models. However, Yang et al. (2025) showed that these models tend to overestimate OH, which explains the higher estimates of the photochemical H_2 sink. Supporting this, Sand et al. (2023) reported CH_4 lifetimes due to OH oxidation of 8.0 [6.9–9.2] years across their ensemble of models, substantially shorter than the lifetime of 11.2 ± 1.3 years inferred from observations (Prather et al., 2012).

We note that our reported range of 19.1–19.7 Tg H_2 yr^{-1} represents variability in the mean photochemical sink over 2003–2023 across our inversion experiments, rather than an uncertainty estimate that includes OH uncertainty. This variability arises from differences in the posterior photochemical source, posterior soil sink, and spatiotemporal distribution of posterior mole fractions, as the photochemical sink is not directly optimised in our inversions. We are aware that the range in our photochemical H_2 sink is narrow relative to the broader uncertainties in global OH distributions, which partly reflects our use of the same CAMS EAC4 OH fields in all experiments. Therefore, to illustrate the potential implications of OH-field uncertainties, we consider a hypothetical 20% bias in OH fields. Under a first-order approximation, assuming full compensation in the inversion by an opposite change in the soil sink, this would result in a change in our posterior soil sink of approximately 3.9 Tg H_2 yr^{-1}. This change is relatively small compared to the posterior error range on the soil sink (47.8–56.7 Tg H_2 yr^{-1}), supporting our conclusion that the inferred soil sink is relatively robust against 20% variations in OH. Changes in the north–south gradient of OH (Naik et al., 2013; Naus et al., 2021) or in its interannual variations (Patra et al., 2021) would likely affect the photochemical sink and hence soil sink patterns within this global constraint, but these effects are not quantified in our study.

We have also updated the caption for Table 2:
Optimised global H_2 budget for 2003–2023 based on the mean of the best-estimate inversions using the Sanderson and Bertagni soil sink schemes. Bracketed values indicate posterior error ranges for the

optimised photochemical source and soil sink, and variability across inversion experiments for the non-optimised photochemical sink (see Appendix Sect. D). Literature values are shown for comparison, noting differences in analysis periods.

And have changed ‘chemical loss’ to ‘photochemical sink’ in Table 2.