Response to Editor decision

We thank the editor for their positive assessment of our manuscript and for their comments regarding the chemical H_2 sink and the OH fields used in our study. The motivation for using CAMS EAC4 OH fields in our inversions is that our group and close collaborators, including Maarten Krol, Stijn Naus, Anne-Wil van den Berg, Stelios Myriokefalitakis, Pieter Rijsdijk, and Rasmus Nüß, have found these fields to perform well across a range of tracers and study contexts (see, e.g., Naus et al., 2019; Nüß et al., 2025). More broadly, the CAMS EAC4 reanalysis 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). Importantly, it is also evaluated against independent observations of these species.

We have updated Section 4 to include a more comprehensive discussion on (1) our inferred chemical H_2 sink in relation to the literature, (2) use of CAMS EAC4 OH fields, and (3) potential implications of OH biases for our inferred soil sink. We propose the following Section 4 opening:

We have high confidence in our inferred soil sink, as oxidation by OH, the only other major sink in the hydrogen budget, is relatively well constrained. 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}) 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). Our posterior range is more narrow as our inferred photochemical sink is robust across a diverse set of inversion setups, including different soil sink and photochemical source prior magnitudes and two soil sink schemes (see Appendix D). However, we emphasize that our range does not include alternative OH distributions.

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 such models can overestimate OH, which may contribute to this higher photochemical sink estimate. Supporting this, Sand et al. (2023) report CH_4 lifetimes due to OH oxidation of 8.0 [6.9–9.2] years across their ensemble of models, which is substantially shorter than the lifetime of 11.2 ± 1.3 years inferred by observations (Prather et al., 2012). We can consider a large hypothetical 20% bias in OH fields to illustrate its implications for our inferred soil sink. 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 would keep the global soil sink within its current posterior error range (47.8–56.7 Tg H_2 yr^{-1}), supporting our conclusion that the inferred soil sink is relatively robust. 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 this impact is not quantified in the work we present here.