Global atmospheric carbon monoxide budget 2000–2017 inferred from multi-species atmospheric inversions

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Atmospheric carbon monoxide (CO) has been decreasing since 2000 as observed by both satellite- and ground-based instruments, but global bottom-up emission inventories surprisingly estimate increasing anthropogenic CO emissions concurrently. In this study, we use a multi-species atmospheric Bayesian inversion approach to attribute satellite-observed atmospheric CO variations to its sources and sinks in order to achieve full closure of the global CO budget during 2000–2017. Our observation constraints include satellite retrievals of the total column mole fraction of CO from MOPITT, formaldehyde (HCHO) from OMI, and methane (CH₄) from GOSAT, which are all major components of the atmospheric CO cycle. Three inversions are performed to use the observation data to the maximum extent possible as they become available and assess the consistency of inversion results to the assimilation of more trace gas species. We identify a declining trend in the global CO budget since 2000 (three inversions are broadly consistent), driven by reduced anthropogenic emissions in the U.S. and Europe (both likely from the transport sector), and in China (likely from industry and residential sectors), as well as by reduced biomass burning emissions globally, especially in Equatorial Africa (associated with reduced burned areas). We show that the trends and drivers of the inversion-based CO budget are not affected by the inter-annual variation assumed for prior CO fluxes. All three inversions estimate that surface CO emissions contradict the global bottom-up inventories in the world’s top two emitters for the sign of anthropogenic emission trends in China (e.g., here −0.8 ± 0.5% yr⁻¹ since 2000 while the prior gives 1.3 ± 0.4% yr⁻¹) and for the rate of anthropogenic emission increase in South Asia (e.g., here 1.0 ± 0.6% yr⁻¹ since 2000 smaller than 3.5 ± 0.4% yr⁻¹ in the prior inventory). The comparison of the three inversions with different observation constraints further suggests that the most complete constrained inversion that assimilates MOPITT CO, OMI HCHO, and GOSAT CH₄ has a good representation of the global CO budget, therefore matches best with independent observations, while the inversion only assimilating MOPITT CO tends to underestimate both the decrease in anthropogenic CO emissions and the increase in the CO chemical production.