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Testing bottom-up (BU) methane emission inventories and their changes, using satellite methane concentration data (Top-Down or TD) for evaluating the efficacy of global emission reduction agreements, such as the Paris Agreement, requires characterizing uncertainties related to atmospheric concentration data, the chemistry and transport model used to relate emissions to concentrations, and the convolved effects of spatial resolution and prior uncertainty (or smoothing error). In this study, we demonstrate an optimal estimation framework that explicitly quantifies yearly emissions by sector using GOSAT XCH4 data from 2010 through 2022. This approach enables us to account for the choice of a priori and inversion sensitivity, thereby mitigating smoothing error when comparing these TD emissions estimates to other inventories. In particular, we evaluate USA emissions from three state-of-the-art inventories (EDGAR v8, GRAPES, and GHGI) with the GOSAT-based emissions and demonstrate: 1) that not accounting for smoothing error results in poorly informed comparisons, and 2) where the inventories may need additional scrutiny due to robust differences (differences larger than calculated uncertainty) between inventory and satellite-based estimates.
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