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Poster
Satellite measurements of carbon dioxide (CO2) provide an important tool to improve our understanding of the global carbon cycle in a changing climate. Inverse methods that use these observations to estimate the surface-atmosphere exchange of CO2 are increasingly used in policy applications such as the Global Stocktake under the Paris Agreement. Quantifying the uncertainty of these fluxes is critical to the effective use of these estimates, including determining where and at what spatiotemporal resolution satellites can constrain fluxes. We estimate monthly CO2 fluxes for 2015 to 2022 at 4 degrees by 5 degrees resolution globally constrained by atmospheric CO2 column observations from the Orbiting Carbon Observatory-2 instrument.

The optimized fluxes, associated uncertainties, and information content are generated by analytical minimization of a Bayesian cost function regularized by an initial (prior) flux estimate. We reduce computational cost while maximizing information content through an optimal reduced-rank approximation of the observing system developed by Nesser et al. (2021) and implemented for a methane inversion by Nesser et al. (2024). We demonstrate a new method for characterizing the full prior error covariance matrix for the biosphere and oceans, for which initial estimates are provided by the CARbon DAta-MOdel fraMework (CARDAMOM) and the ECCO-Darwin ocean biogeochemistry state estimate. The resulting prior error covariance matrix is consistent in aggregate, by latitude, and by land cover with the ranges given by multiple process-based models and atmospheric inversions. We also include fossil fuel uncertainty in our inversion framework. The analysis is developed to be reproducible within the new GEOS-Chem carbon simulation and supports future development including increased spatiotemporal resolution, the incorporation of additional datasets, and the addition of joint inversions with other trace gases.
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