A Global Surface CO_2 Flux Dataset (2015–2022) Inferred From OCO-2 Retrievals Using the GONGGA Inversion System

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I. Introduction

Atmospheric inversion infers CO_2 fluxes by combining information from atmospheric CO_2 concentrations, prior flux estimates, and atmospheric transport.

Here we developed a global atmospheric inversion system named GONGGA (Global ObservatioN-based system for monitoring Greenhouse GAses), which was selected for the Global Carbon Project from 2022 to 2023. Using GONGGA, we generated a terrestrial and ocean carbon flux dataset (2015–2022) by assimilating OCO-2 XCO_2 retrievals (v11r) (dataset link: https://zenodo.org/records/8285446).

II. Framework of GONGGA

GONGGA uses the NLS-4DVar optimization method instead of the traditional EnKF or 4DVar. Furthermore, it adopts a novel dual-pass inversion strategy, which optimizes the initial CO_2 concentrations and surface fluxes successively within an inversion cycle to distinguish errors from initial CO_2 concentrations and fluxes.

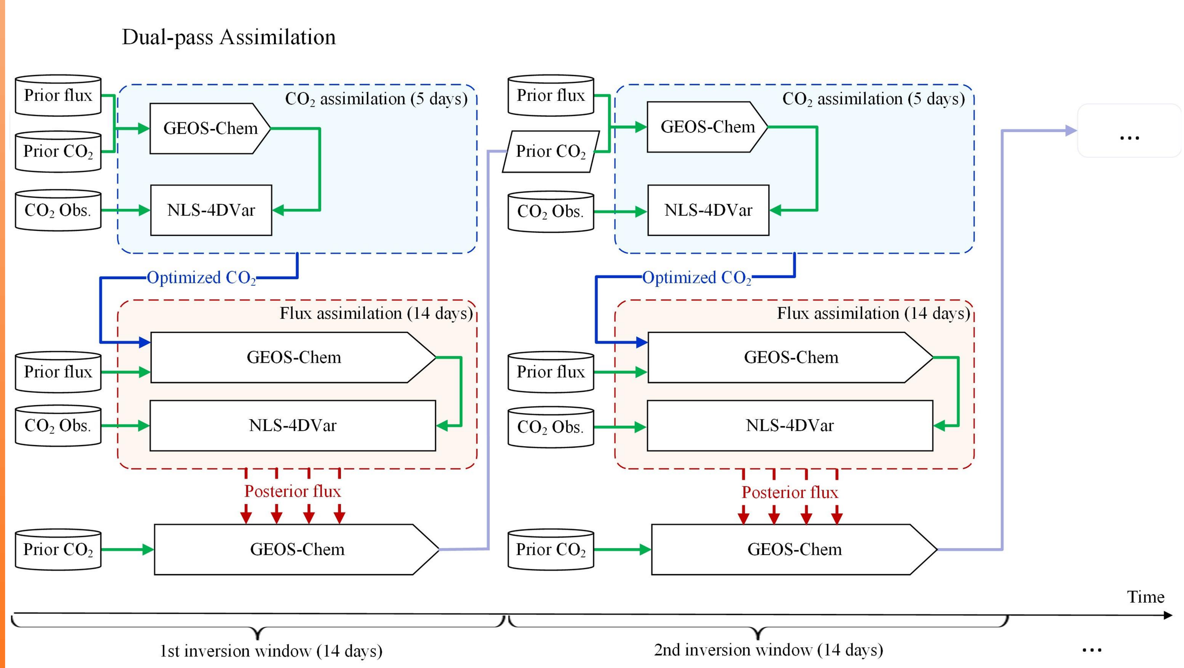

Fig1. GONGGA flowchart

III. Global Carbon Budget

We quantified the five major components of the global carbon budget, including fossil fuel CO_2 emissions (E_{FOS}), biomass burning emissions (E_{FIRE}), atmospheric CO_2 growth rate (G_{ATM}), ocean CO_2 sink (S_{OCEAN}), and terrestrial CO_2 sink (S_{LAND}). The GONGGA estimates are consistent with NOAA observations and previous studies.

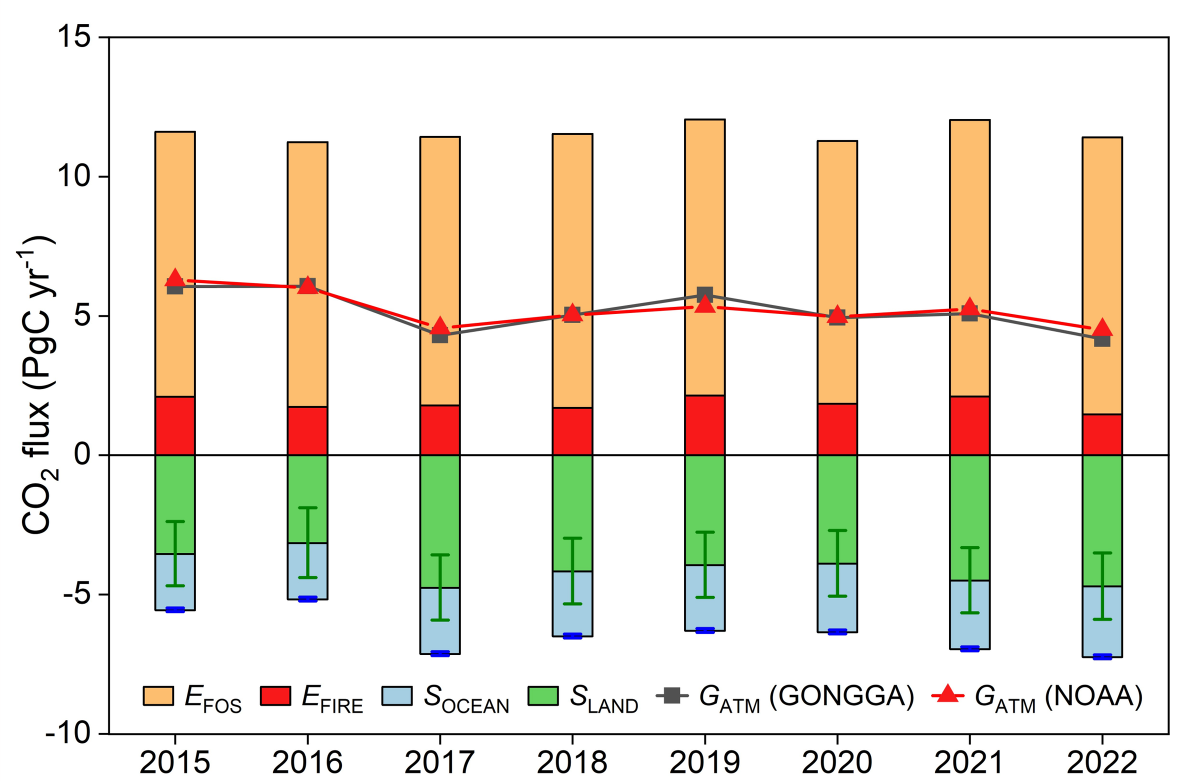

Fig 2. Global carbon budget from GONGGA.

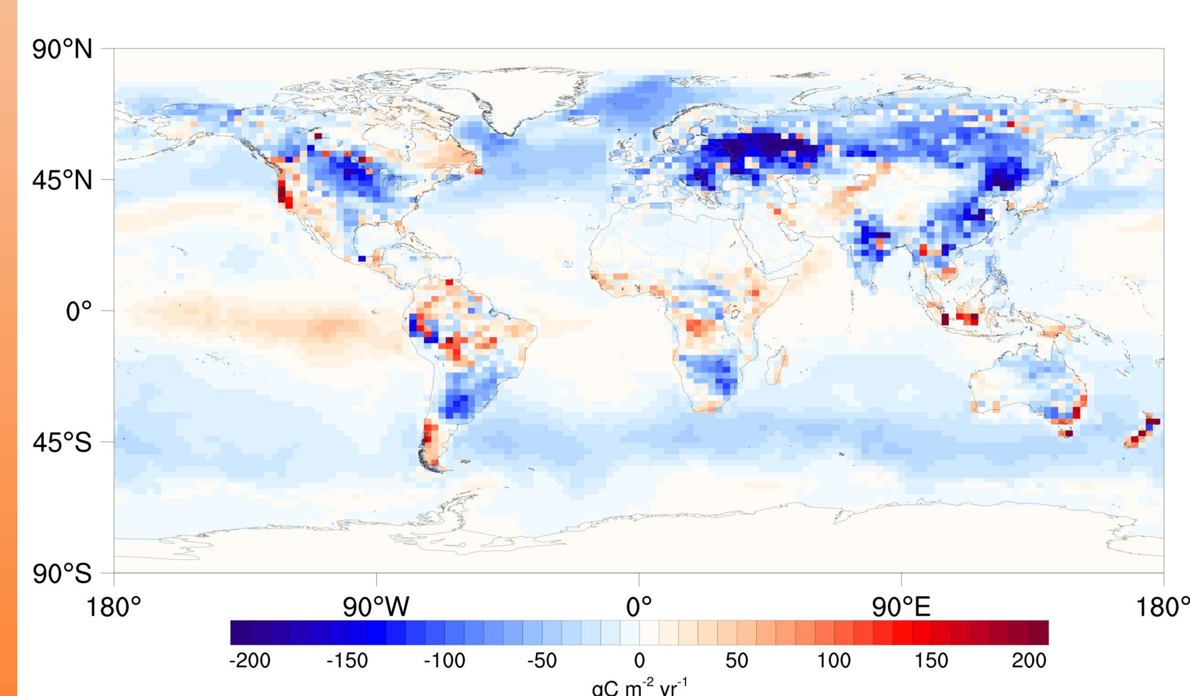

Fig 3. GONGGA-estimated global distributions of annual mean (2015–2022) NBE and ocean carbon fluxes.

IV. Regional Distribution

Here we present the GONGGA estimated annual mean NBE for 11 TransCom land regions and its comparison with OCO-2 MIP LNLG and IS inversions.

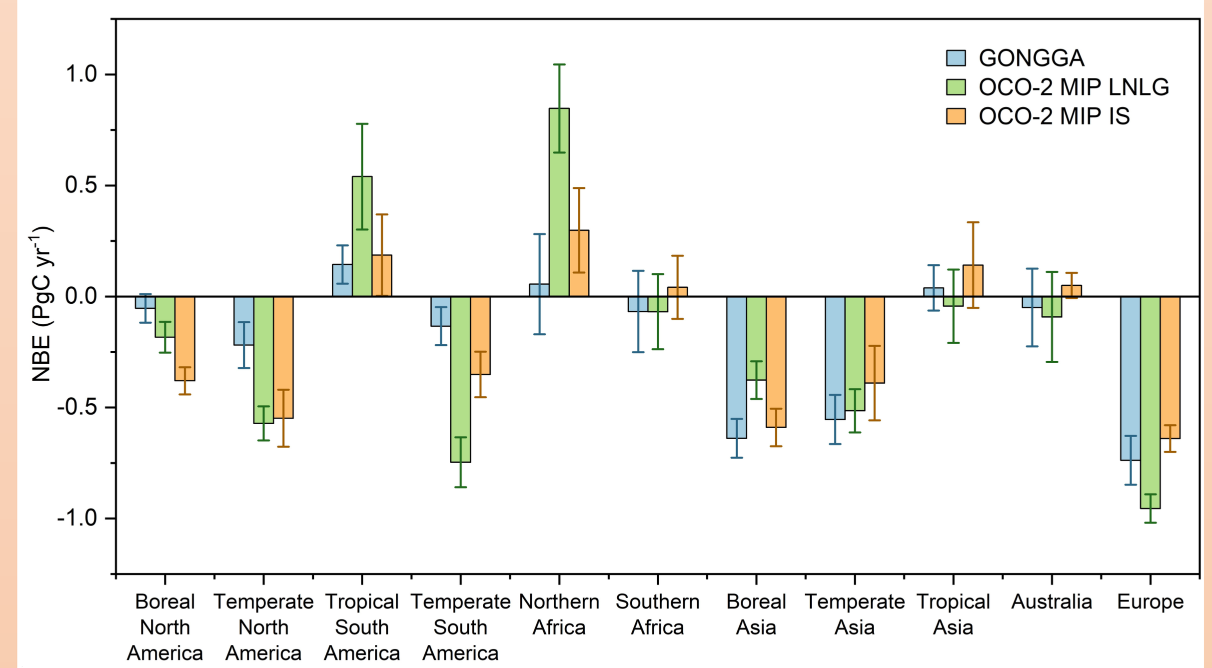

Fig 4. GONGGA regional estimates.

V. Flux Evaluation

We evaluated the posterior fluxes by comparing posterior CO_2 simulations against TCCON and ObsPack CO_2 observations.

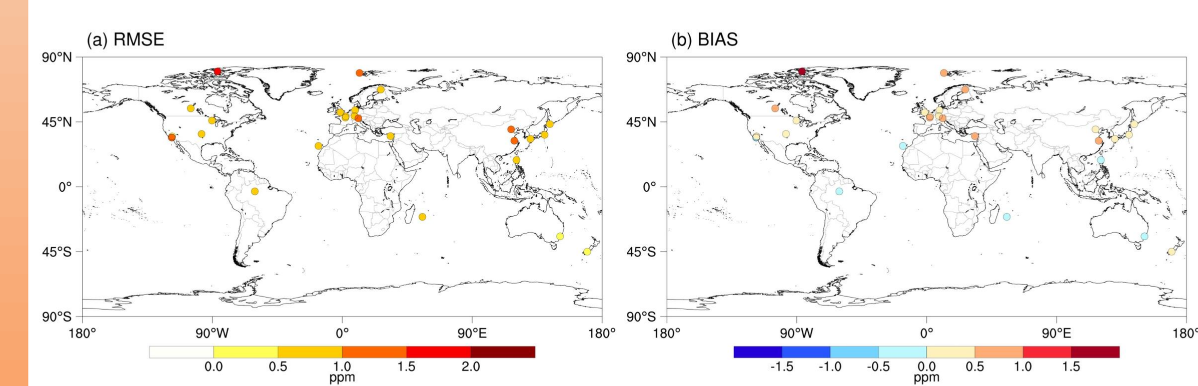

Fig 5. Comparisons between GONGGA estimated and TCCON observed XCO_2.

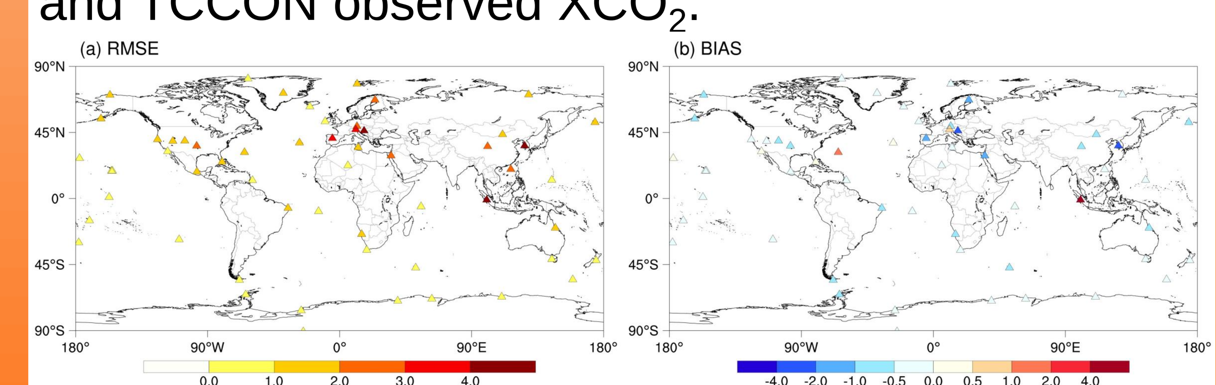

Fig 6. Comparisons between GONGGA estimated and ObsPack observed CO_2.

VI. Summary and Prospect

As a novel and efficient inversion system, GONGGA can well capture the sources and sinks of terrestrial and ocean CO_2 fluxes at the global and regional scales. We plan to update the dataset annually in the future, aiming to support scientific research and policy making.

During the process of research, we also note that the observation distribution, prior estimate, and transport modeling can have significant effects on inversion results; thus, they require continuous improvement by the research community.

VII. Reference

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