IPCC Expert Meeting on Reconciling anthropogenic land use emissions

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National greenhouse gas budget reconciliation

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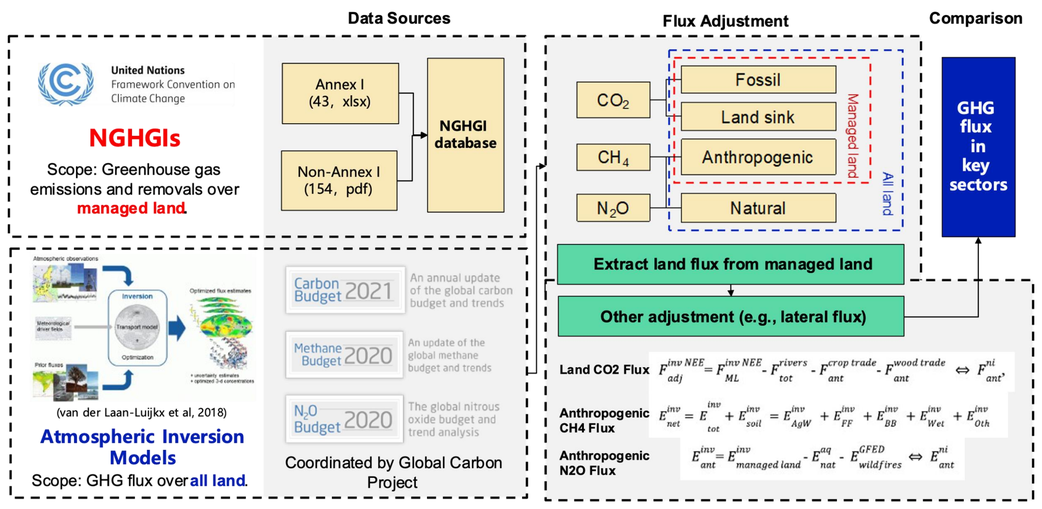
Introduction

This study aims to address:

Q1: How do inversions compare with NGHGIs for CO_2, CH_4 &N_2O?;
Q2: What are the plausible reasons for mismatches between inversions and NGHGIs?; and did the managed land masks in this study reduce the mismatch between the inversions and NGHGIs for CO_2 and N_2O?;
Q3: What independent information can be extracted from the inversions to evaluate the median values or the trends of GHG emissions and removals?; and does this information exhibit a good agreement with NGHGIs?;
Q4: How do satellite-retrieval driven inversion models differ from the surface in-situ and flask sampling driven inversion model results?

Method & Data source

Research framework



Atmospheric CO_2 inversions used in this study

Table 1 | Atmospheric CO_2 inversions used in this study (Friedlingstein et al., 2022)

Inversion System	Version	Period	Observation
CarbonTracker Europe (CTE): CTE2022_SiB4 (van der Laan-Luijkx et al., 2017)	v2022	2001-2021	Ground-based Obspack GLOBALVIEW plus v7.0 and NRT_v7.2
Jena Carboscope sEXTocNEET (Rödenbeck et al., 2003)	v2022	1960-2021	
Copernicus Atmosphere Monitoring Service (CAMS) (Chevallier et al., 2005)	v21r1	1979-2021	
The University of Edinburgh (UoE) (Feng et al., 2016)	v6.1b	2001-2021	
the NICAM-based Inverse Simulation for Monitoring CO_2 (NISMON-CO2) (Niwa et al., 2022)	v2022.1	1990-2021	
CMS-Flux (Liu et al., 2021),	v2022	2010-2021	Ground-based & ACOS-GOSAT v9r; OCO-2 v10 scaled to WMO2019
CAMS-Satellite (Chevallier et al., 2005)	FT21r2	2010-2021	bias-corrected ACOS GOSAT v9 over land until August 2014 + bias- corrected ACO S OCO-2 v10 over land, both rescaled to WMO2019
THU (Kong et al., 2022)	v2022	2015-2021	OCO-2 v10r data scaled to WMO2019
GONGGA (Jin et al., 2023)	v2022	2015-2021	OCO-2 v10r data scaled to WMO2019

Processing CO_2 inversion data for comparison with NGHGIs

$$F_{adj}^{inv\ NEE} = F_{ML}^{inv\ NEE} - F_{ML}^{rivers} - F_{ant}^{crop\ trade} - F_{ant}^{wood\ trade} \Leftrightarrow F_{ant}^{ni},$$

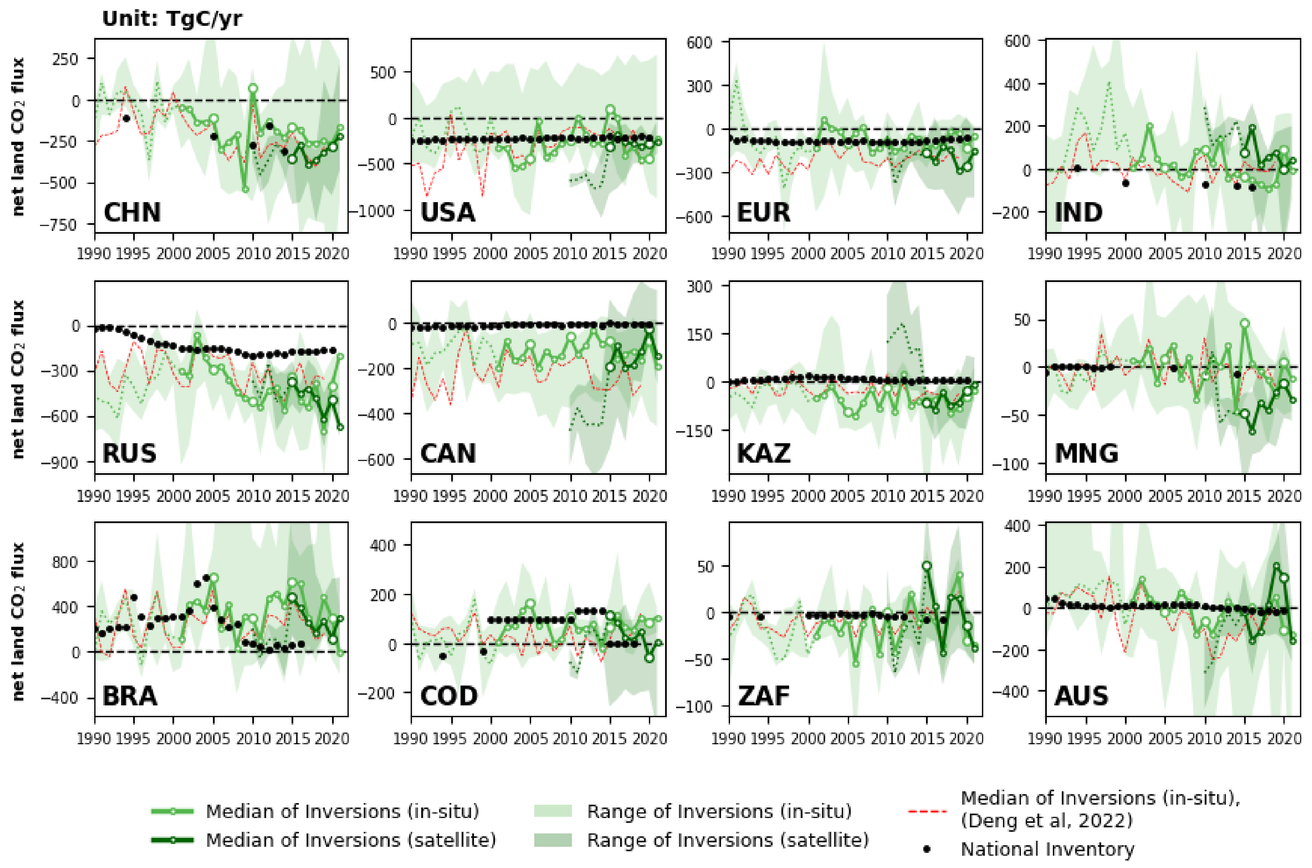
$F_{adj}^{inv\ NEE}$ represents adjusted net ecosystem exchange (NEE) of CO_2 inversion flux over managed lands, processed as follows:
1) Subtracting same fossil flux from total CO_2 flux of each inversion;
2) Extracting flux over managed lands by using maps of non-intact forests compiled by Grassi et al. (2023);
3) Adjusting CO_2 fluxes due to lateral carbon transport by crop and wood products trade and by rivers.

F_{ant}^{ni} represents net land CO_2 flux reported by NGHGIs, by grouping IPCC/CRF sectors: Total – (Energy + IPPU)

Take home messages

✓Our proposed processing framework aligns national inventories with inversion results, yet some discrepancies need further analysis;
✓Satellite-based inversions offer consistent estimates and suggest the potential of improved reliability through dense sampling;
✓Countries should report their managed land in a spatially explicit manner to facilitate a better evaluation for reconciliation.

Reconciling net land CO_2 flux from managed land



Four large $ffCO_2$ emitters:

•**China (CHN):** an increase in carbon sink over the study period, while the median of satellite inversions shows a higher carbon sink than in-situ from 2015-2021.

•**United States (USA):** a slight decline trend (0.7 TgC/yr²) in carbon sinks, with in-situ inversions showing good agreement with NGHGIs but more interannual variability.

•**European Union (EUR):** in-situ inversion aligns well with NGHGIs data, while satellite inversions indicate a higher carbon sink.

•**India (IND):** inversion fluctuated between being a carbon source and sink, while inventory show an increasing carbon sink.

Two large boreal forested countries:

•**Russia (RUS):** showing a rapid trend of increasing sink, while both in-situ and satellite inversion (-450 TgC/yr) results show larger sinks than NGHGIs (-180 TgC/yr) during 2011-2020.

•**Canada (CAN):** inversions (-125 TgC/yr) show larger carbon sinks than NGHGIs (~5 TgC/yr), while both in-situ and satellite inversions present a sudden decline of carbon sinks in 2020.

Two large countries with ground-based stations:

•**Kazakhstan (KAZ):** Consistent in-situ and satellite data from 2015 to 2021 reveal a shrinking carbon sink after 2018, contrasting with a minor carbon source suggested by the NGHGIs.

•**Mongolia (MNG):** NGHGI shows a modest increase in carbon sinks, while in-situ inversions fluctuated between sources and sinks, and satellite inversions indicate a larger but shrinking sink.

Two tropical countries with large forests:

•**Brazil (BRA):** NGHGIs and in-situ inversions both indicate a net carbon source from 1990, peaking in 2005 and declining thereafter. In-situ inversions rebounded around 2010, peaking again in 2015, with both in-situ and satellite inversions showing a declining trend in carbon emissions.

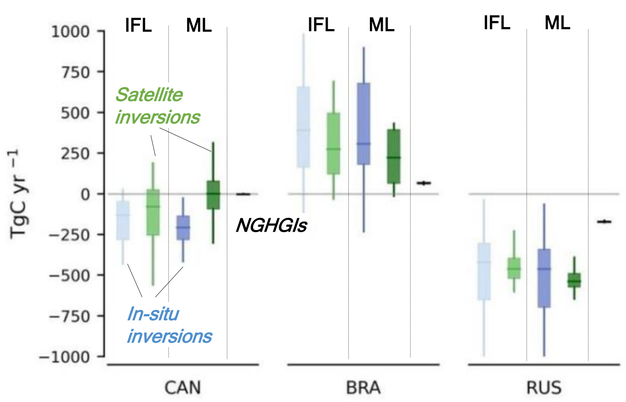
•**Democratic Republic of the Congo (COD):** NGHGIs trace a shift from a carbon sink to a source (2000-2014) and back to a small sink (2015-2018), with recent satellite inversions showing a similar decline aligning with NGHGIs.

Two large Southern Hemisphere countries:

•**South Africa (ZAF):** NGHGIs show a stable but small sink (doubling from 4 TgC/yr in 2010 to 8 TgC/yr in 2017), with fluctuations between sink and source in inversions.

•**Australia (AUS):** NGHGIs indicate a change from a small source (48 TgC/yr in 1990) to a sink (-15 TgC/yr in 2020), with large fluctuations in inversions and a carbon source anomaly in 2019 due to extreme fires.

Comparison of using different managed land masks



IFL: all lands excluding intact forest landscape (Potapov et al., 2017)

ML: following Grassi et al (2023), for CAN and BRA by using maps of managed land derived from NGHGI, and for RUS by adjusting tree-cover threshold in the tree cover map from Hansen et al. (2013) to match the average area of managed land per Oblast (province) that is used for the NGHGIs

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