Japan Pavilion; COP26, 2nd Oct 2021 (online; 3pm UT)

Satellite data helping estimation and evaluation of regional CO_2 and CH_4 fluxes

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with supports from MIRO4-ACTM team and Measurement colleagues

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partly funded by … #JPMEERF20172001, #JPMEERF20182002, #JPMEERF21S20800 of the Ministry of Environment, Japan

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Patra *et al. Progress in Earth and Planetary Science* (2021) 8:25
https://doi.org/10.1186/s40645-021-00420-z

Progress in Earth and Planetary Science

SBSTA51, at COP25 : Recommendation #9.
The SBSTA highlighted the importance of enhanced systematic observation and integrating data in both Earth system models and other climate models for further developing global and regional climate models (and reducing the associated uncertainty) and for improving historical reanalysis, emission estimates and future projections, including in support of the implementation of the Convention and the Paris Agreement.
(https://unfccc.int/documents/202496#eq-1)

RESEARCH ARTICLE Open Access

Evaluation of earth system model and atmospheric inversion using total column CO_2 observations from GOSAT and OCO-2

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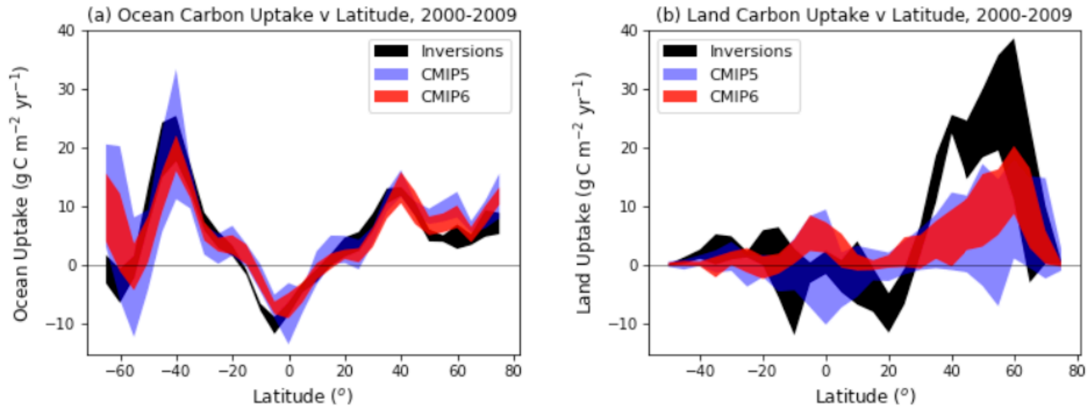


Figure 5.24: Comparison of modelled zonal distribution of contemporary carbon sinks against atmospheric inversion estimates for 2000–2009, (a) ocean carbon uptake; (b) net land uptake. Latitude runs from

Observations Inverse / Earth System Models

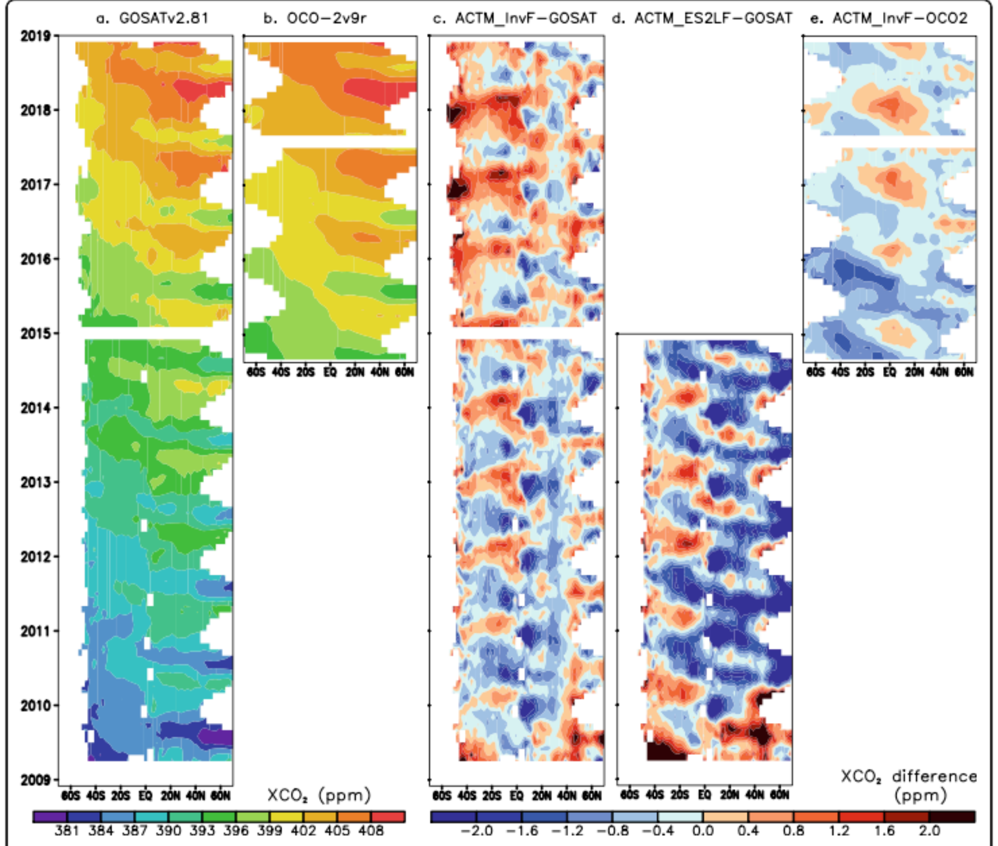


Fig. 5 Time evolution of zonal mean meridional gradients of XCO_2 as measured by GOSAT, OCO-2 in comparison with two ACTM_InvF and ACTM_ES2LF simulations. The plots by using data over land only and water only are shown in Fig. S1 and Fig. S2, respectively

Work in progress at JAMSTEC

toward delivering regional and country scale emissions and removals of CO_2, CH_4 and N_2O, along with estimated uncertainties

Inverse modelling system at JAMSTEC

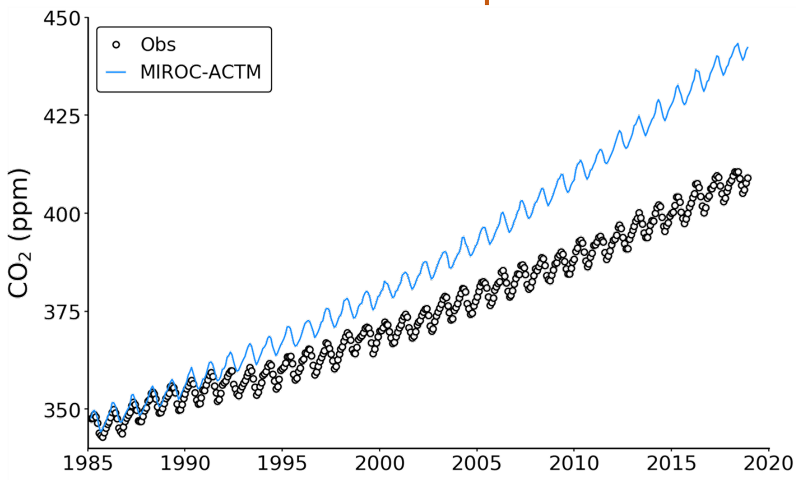
a tool to estimate causes (emissions) based on consequences (concentration in the atmosphere)

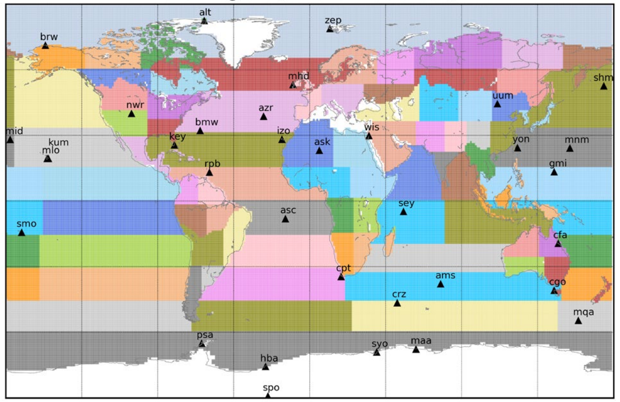
Transport Model (MIROC4-ACTM) → Simulations

Observations

Optimization → A posteriori fluxes

Consequences





Causes

Time-dependent Bayesian inverse model

$$S = S_0 + \left(G^T C_D^{-1} G + C_{S_0}^{-1}\right)^{-1} G^T C_D^{-1} (D - D_{ACTM})$$

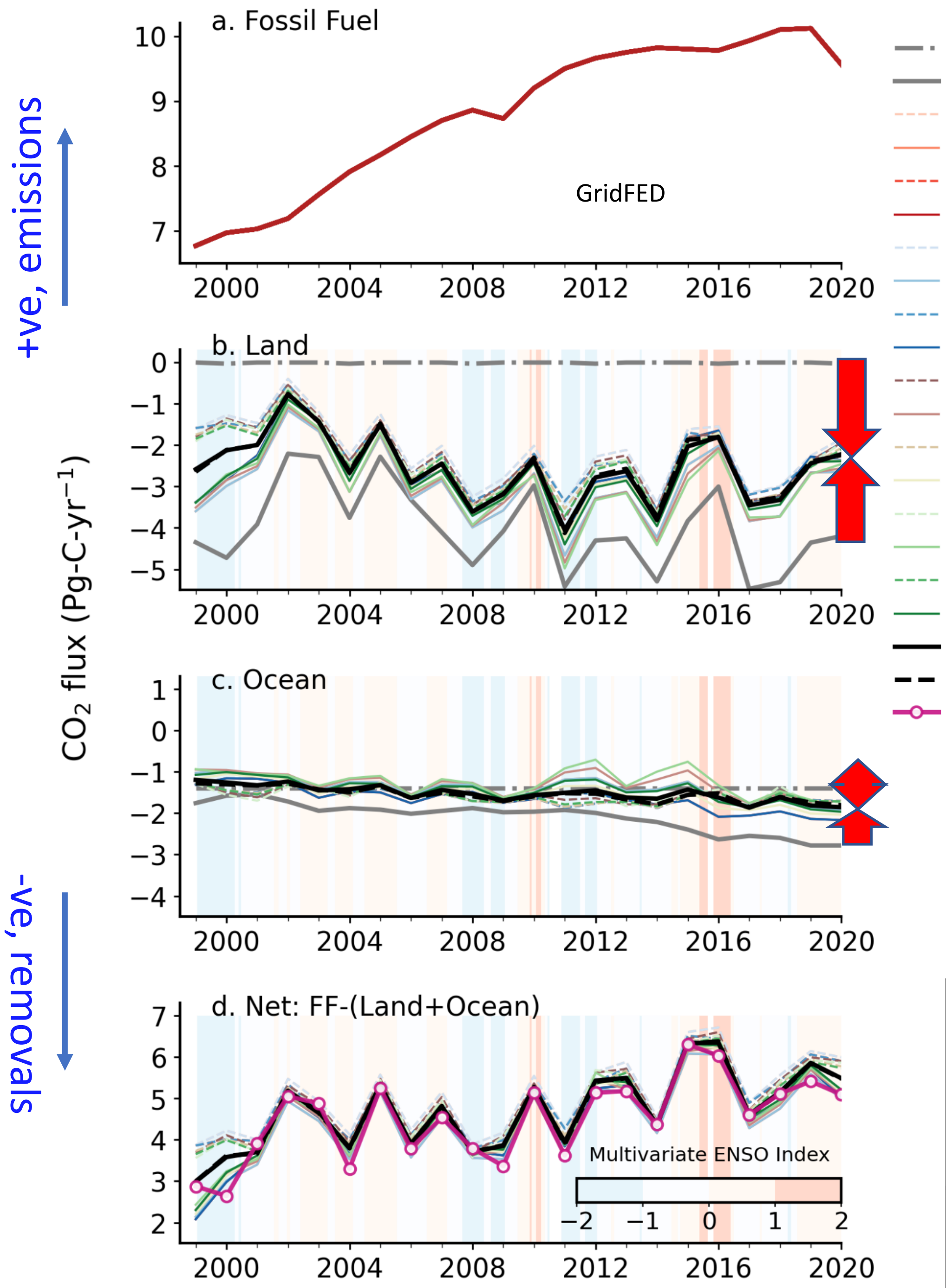
$$C_S = \left(G^T C_D^{-1} G + C_{S_0}^{-1}\right)^{-1}$$

National Institute for Environmental Studies

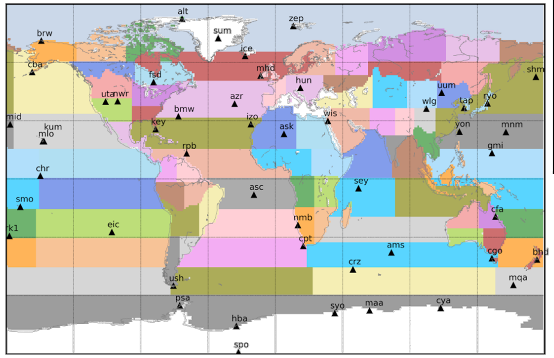
Slide by Naveen Chandra; Saeki and Patra, GOSL, 2017

Summary of inversion ensemble

(in order to provide Mean/median emissions and removals ± Uncertainty)



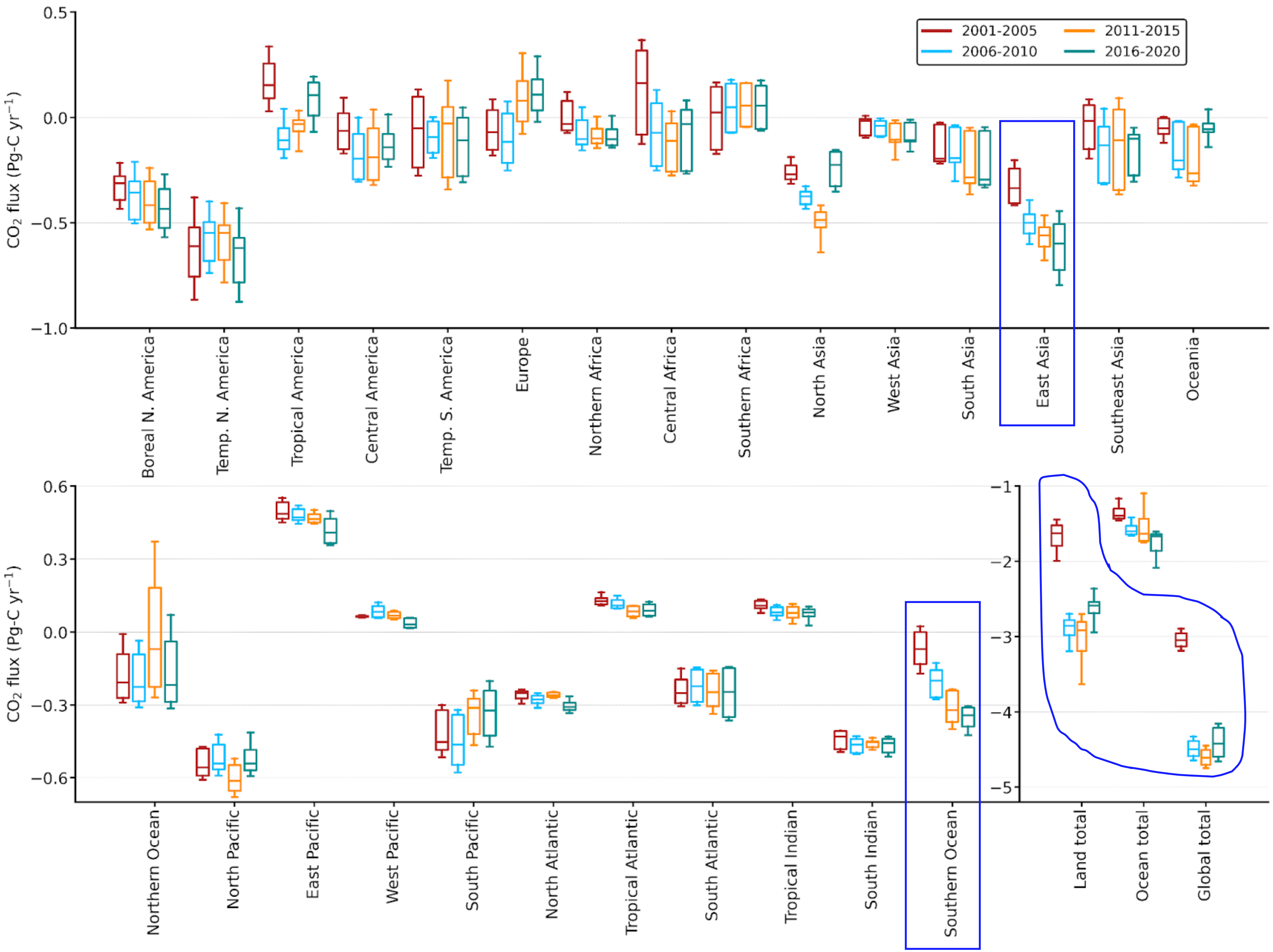
Observations taken from NOAA/GML and JMA



Prior Flux Unc (PgC/yr)	Obs. Data Unc (ppm)	Inversion case (16 in total)
ctl land = 2 ocean = 1	ux2 = 0.1 + 2 × √RSD ux4 = 0.1 + 4 × √RSD RSD: Residual standard deviation	1. ctl_ux2_gc3t 2. ctl_ux4_gc3t
		3. ctl_ux2_gvjf 4. ctl_ux4_gvjf
gpp_v2 land=0.2-2.0 ocean=0.50		5. gpp_v2_ux2_gc3t 6. gpp_v2_ux4_gc3t
		7. gpp_v2_ux2_gvjf 8. gpp_v2_ux4_gvjf
gpp_v3 land=0.4-3.0 ocean=0.75		9. gpp_v3_ux2_gc3t 10. gpp_v3_ux4_gc3t
		11. gpp_v3_ux2_gvjf 12. gpp_v3_ux4_gvjf
gpp_v4 land=0.6-4.0 ocean=1.0		13. gpp_v4_ux2_gc3t 14. gpp_v4_ux4_gc3t
		15. gpp_v4_ux2_gvjf 16. gpp_v4_ux4_gvj

Chandra et al., in prep

Chandra et al., in prep



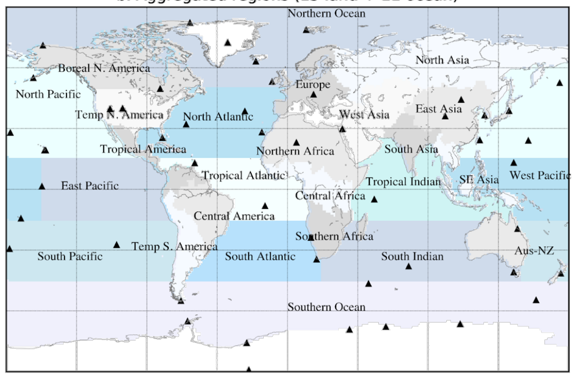
Regional fluxes at 5 yr interval - Global Stocktake?

East Asian sink increase aliasing with biased fossil-fuel emissions.

Also spill overs to other regions, e.g., North Asia is possible.

(Saeki and Patra, 2017)

b. Aggregated regions (15 land + 11 ocean)



Changes in Methane (CH_4) emissions and concentrations

A joint work with inventory emission group and satellite observations

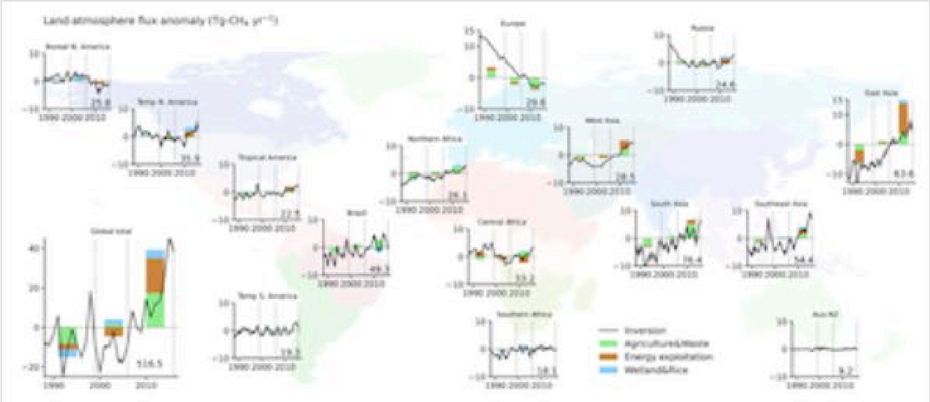


Figure 1. Timeseries (1988-2016) of global and regional CH_4 emission anomalies for 2 inversion ensembles, and the emission changes from 3 aggregated sectors during the three growth rate phases (bar plots). A long-term (2000-2016) mean for each region, given at the bottom-right of each panel (in Tg yr^{-1}), is subtracted to calculate the emission anomalies. The average emissions and range (shaded) for the two inversion cases are shown.

Volume 99 (2021) Issue 2 Pages 309-337

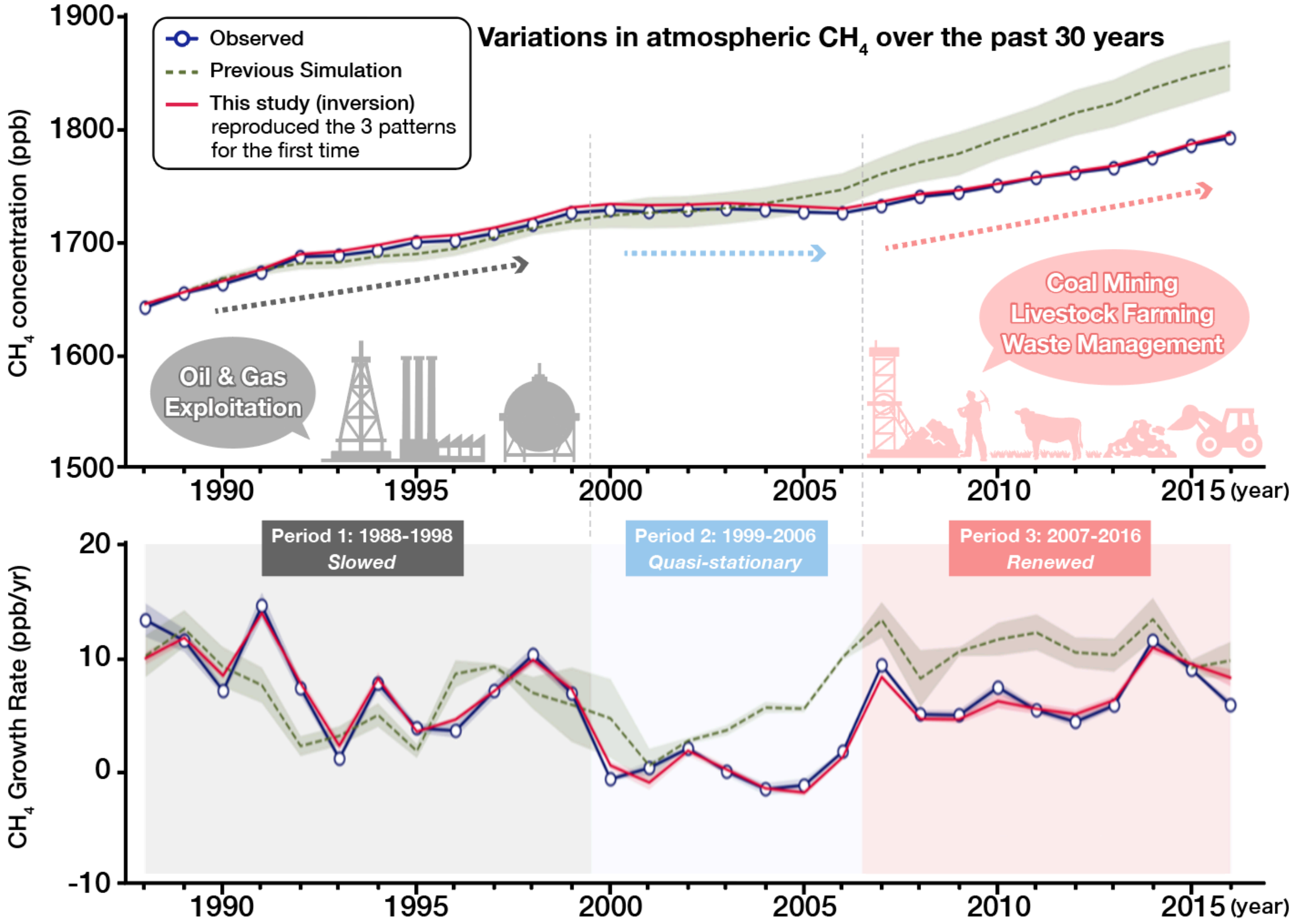
Emissions from the Oil and Gas Sectors, Coal Mining and Ruminant Farming Drive Methane Growth over the Past Three Decades

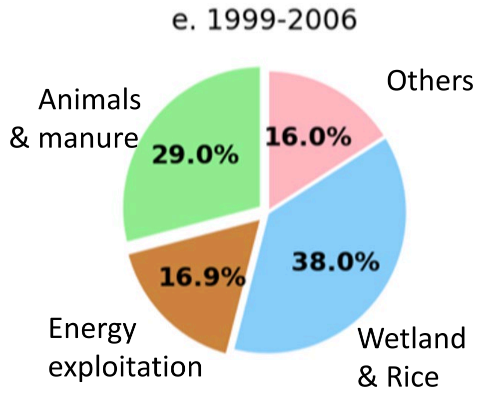
Naveen CHANDRA, Prabir K. PATRA, Jagat S. H. BISHT, Akihiko ITO, Taku UMEZAWA, Nobuko SAIGUSA, Shinji MORIMOTO, Shuji AOKI, Greet JANSSENS-MAENHOUT, Ryo FUJITA, Masayuki TAKIGAWA, Shingo WATANABE, Naoko SAITOH, Josep G. CANADELL

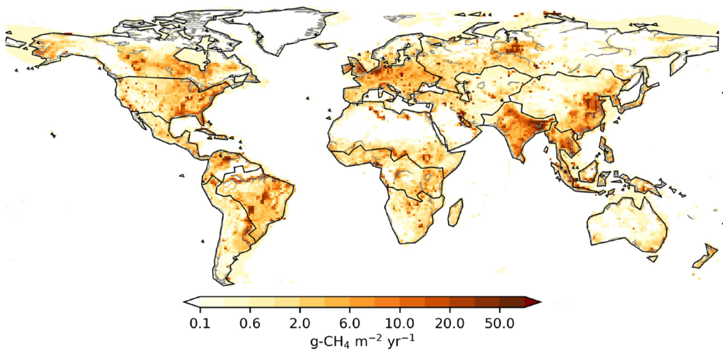
Methane (CH_4) is an important greenhouse gas and plays a significant role in tropospheric and stratospheric chemistry. Despite the relevance of methane (CH_4) in human-induced climate change and air pollution chemistry, there is no scientific consensus on the causes of changes in its growth rates and variability over the past three decades. We use a well-validated chemistry–transport

https://doi.org/10.2151/jmsj.2021-015

Methane concentrations and emissions over the past three decades:
Human activity in oil, gas and coal exploitation, livestock farming and waste management



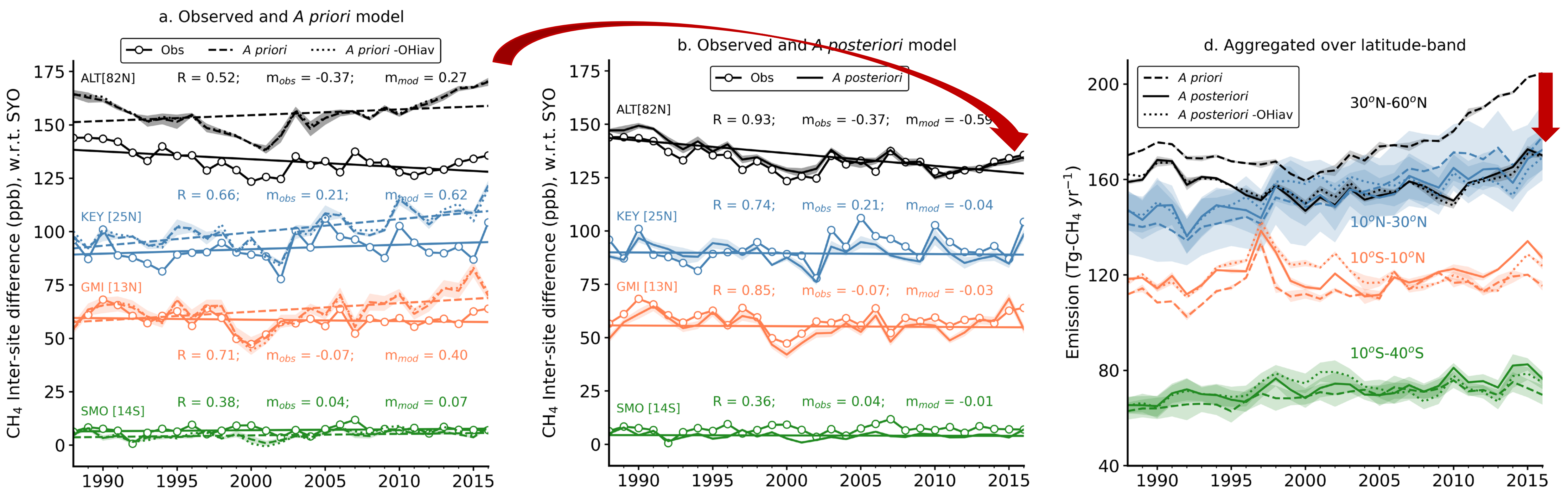




Chandra et al., JMSJ, 2021

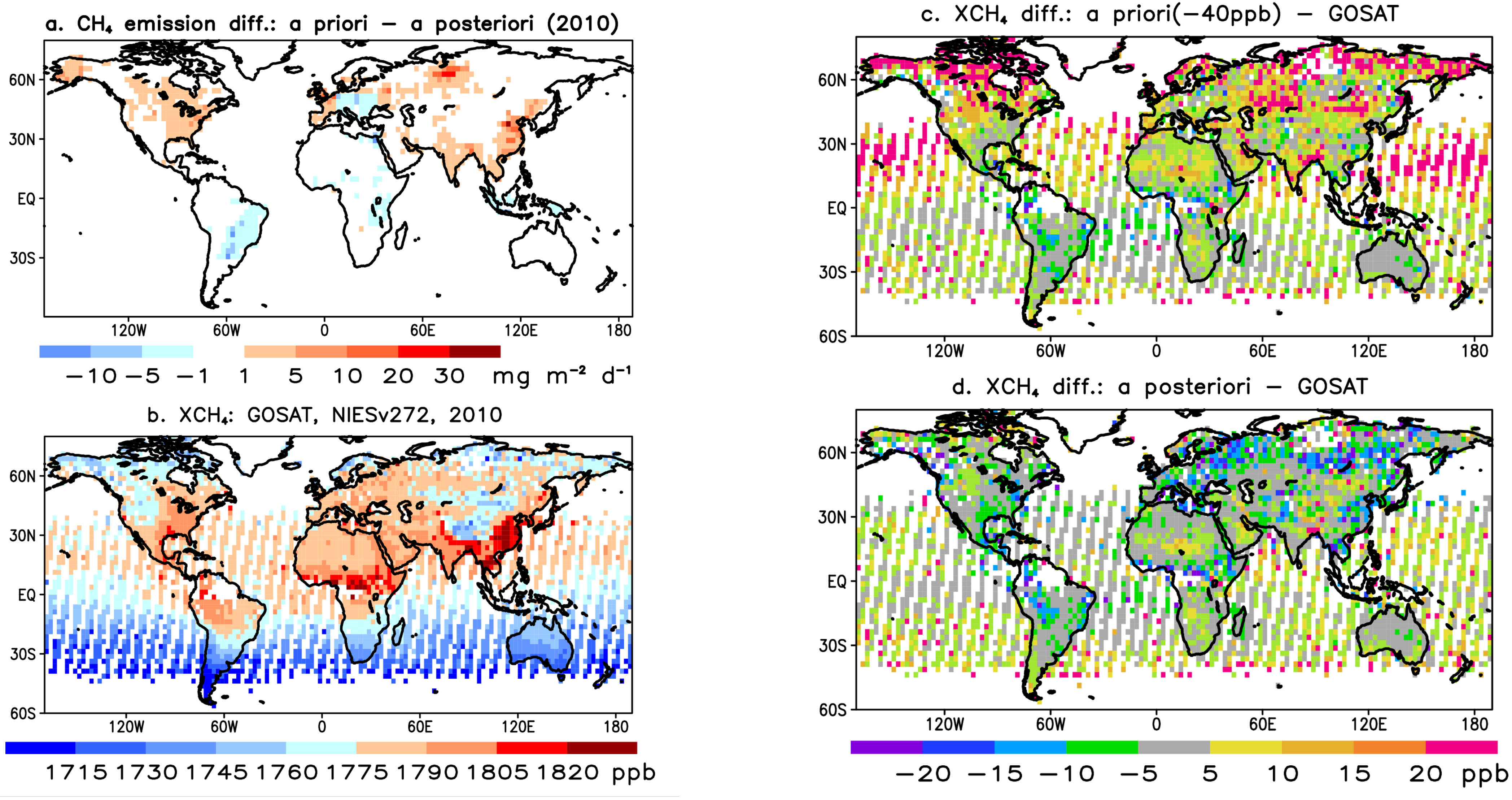
CH_4 emissions estimated to be lower lower in the high latitudes, relative to prior model

Inversion model suggested a decrease in CH_4 emissions in 30-60ºN



Chandra et al., JMSJ, 2021

Confirmation of the emission decrease by inversion using GOSAT total column (XCH_4)



Chandra et al., JMSJ, 2021

Conclusions

- Our GHG inverse modelling results (CO_2, CH_4, N_2O) have been made available to various domestic and International projects

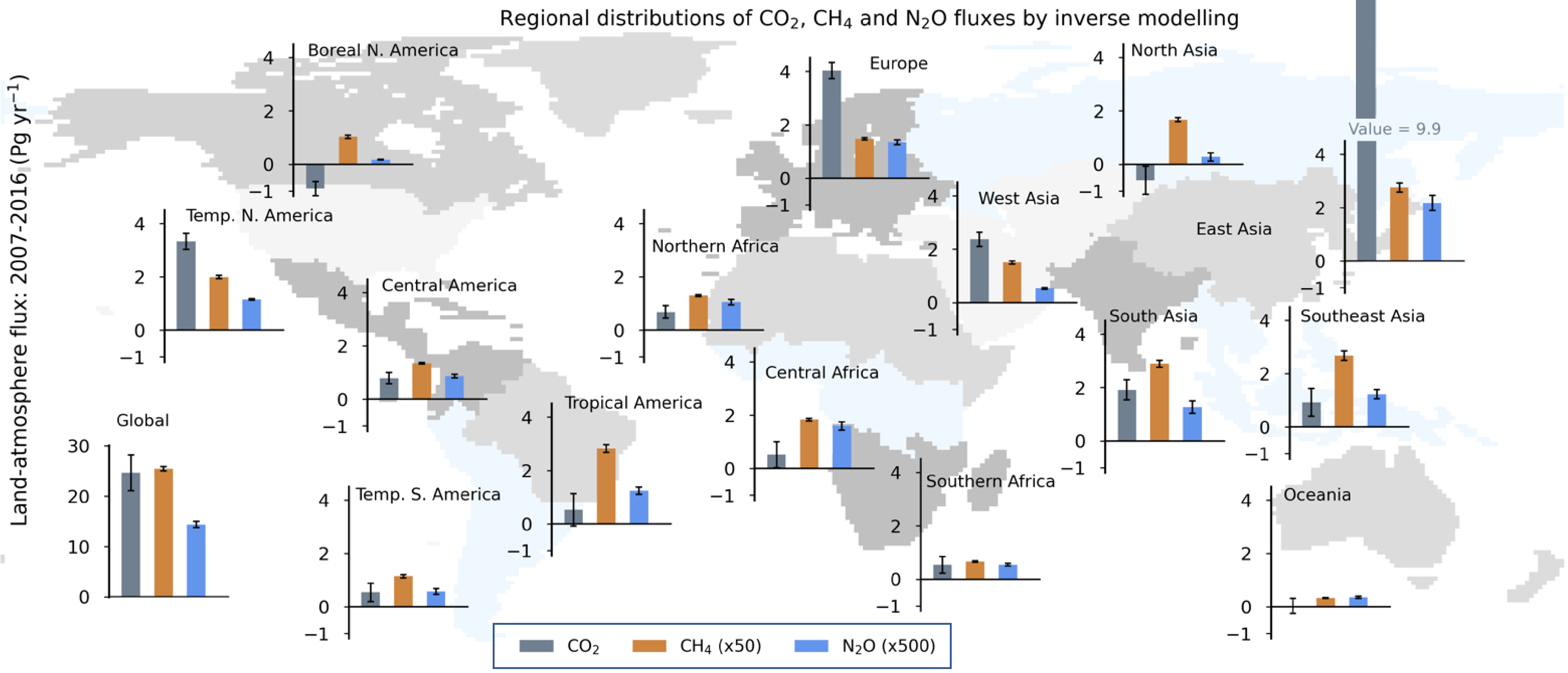
- Our study of changes in emission and removals highlights:
  - use of “high resolution” and “sectoral emission” information from inventories
  - refinement of regional scale changes by using atmospheric observations and models
  - validation against large amount of independent observations, in situ and satellites

- Regional and large country-scale changes and their uncertainty in emissions and removals are traceable on decadal timescales in support of the GS2023

Thank you

Global warming by emissions of CH_4 are as significant as that of CO_2 over 20-yr time horizon, but overwhelming dominance of CO_2 over 100-yr horizon

IPCC WG1 contribution towards Stocktake (Canadell et al., 2021), WG3 to support more directly



AR6 metric (Table 7.15): GWP-20: CH_4 = 82, N_2O = 273; GWP-100: CH_4 = 29, N_2O = 273 | GTP-50: CH_4 = 12, N_2O = 290; GTP-100: CH_4 = 6, N_2O = 233