Preliminary and on-going results with prepration of manuscript

A comparative analysis of CO fire emissions infer from TROPOMI with GFAS and GFED41s

Helene Peiro, Ivar van der Velde, Guido van der Werf, Pieter Risjdijk, and Ilse Aben

We also acknowledge Sander Houweling, Anne-Wil van den Berg, Rasmus Nüß and Stijn Nauss for their help.

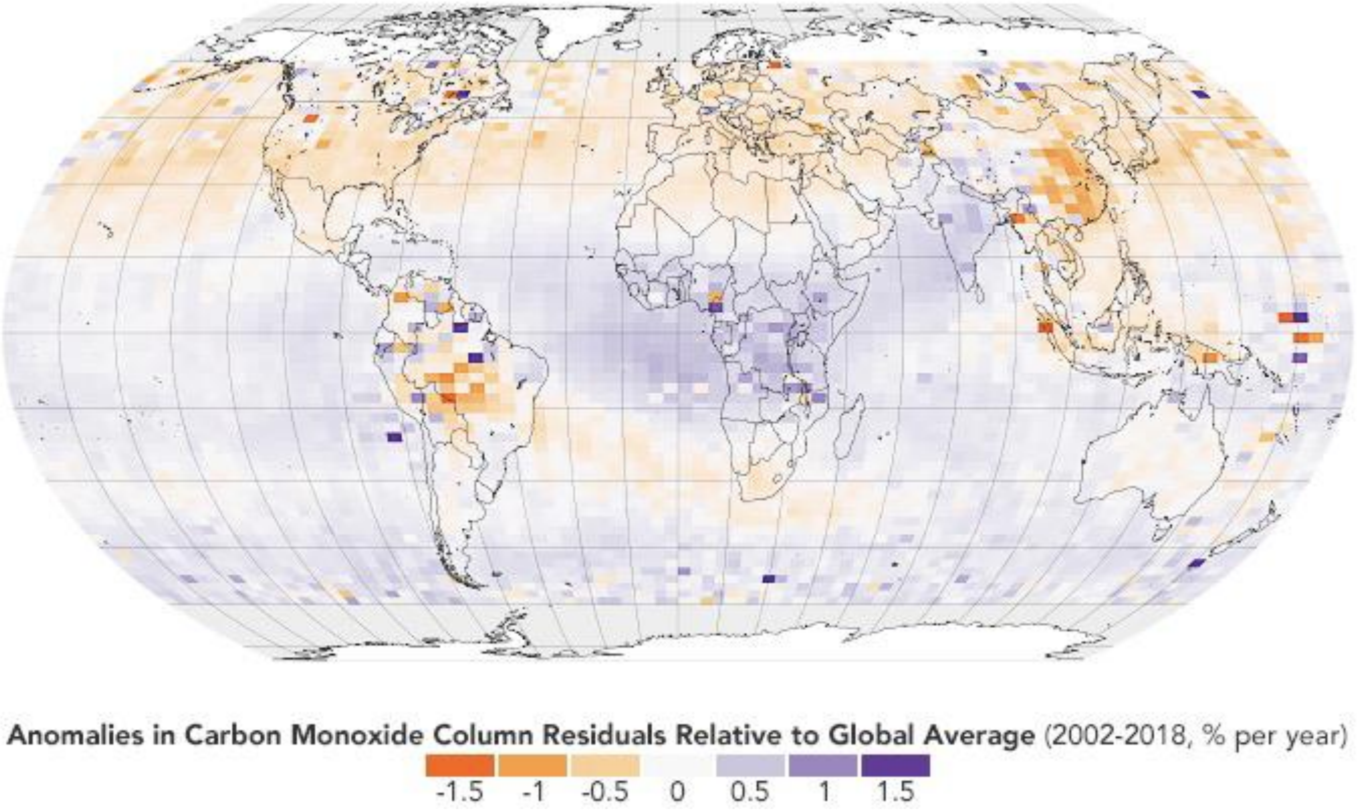
SRON SPACE RESEARCH ORGANISATION NETHERLANDS

NWO

Introduction

- Since 2000, decreasing trend of CO concentration was observed globally, due to:
    - Efficiency in anthropogenic combustion,
    - Decline from tropical fires
- **This decreasing trend is globally slowing down** mainly during the fire seasons of the Northern Hemisphere (Buchholz et al., 2022).

Using MOPITT data



(*https://earthobservatory.nasa.gov/images/*)

Introduction

- Lack of multi-years inverse modeling experiments assessing the potential of TROPOMI observations at large scale.

    - As wildfires are increasing in frequency and intensity, monitoring CO fire emissions with inverse approach and comparing it with bottom-up is critical for better estimation of fire emissions globally.

Goal:

- Assess global and regional CO fire emissions from top-down approach using TROPOMI observations and investigate the difference with bottom-up emissions during the period 2019-2024.

Methodology

TM5-4DVar globally at 3°x2° resolution offline model with ERA-5 meteo fields

3 sources of emissions and prior emissions:

- Secondary production: TM5 full chemistry 2006 (monthly)
- Fire: GFED41s or GFASv1.2 (3days correlation time-scale)
- Anthropogenic: CAMS-Glob-Ant v5.3 (monthly)

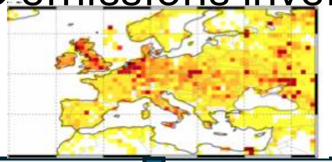
Assimilation window: 14 months with 1-month spin-up and spin-down

Methodology

- **FORWARD-RUN:** TM5 run at 3x2 degree resolution and compared to TROPOMI superobservations (0.5 degree resolution).

INPUT:

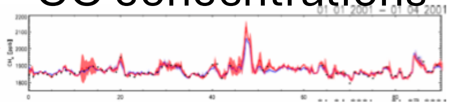
CO emissions inventories



TM5-4DVAR
forward mode

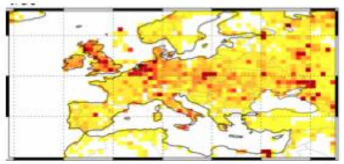
OUTPUT:

CO concentrations



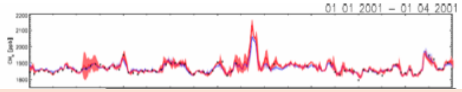
- **INVERSE RUN:** observations are assimilated in model run:

INPUT:



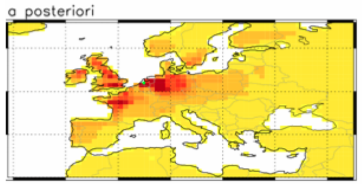
CO apriori emissions

CO concentrations



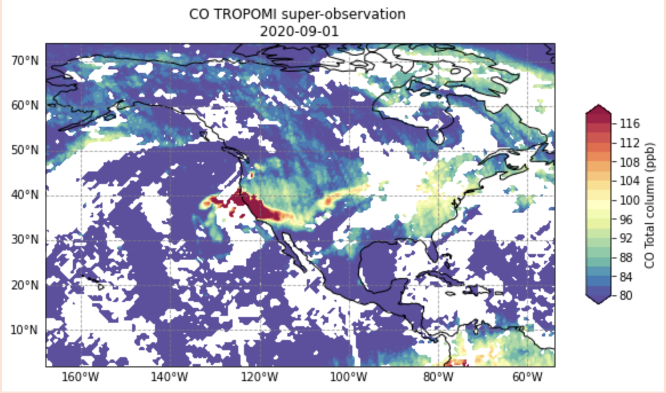
TM5-4DVAR
Inverse mode

OUTPUT:



Optimized CO emissions

TROPOMI super-observations are averaging to a 0.5° grid using weights from the grid area overlap (Miyazaki et al., 2012, Risdijk et al., 2025).

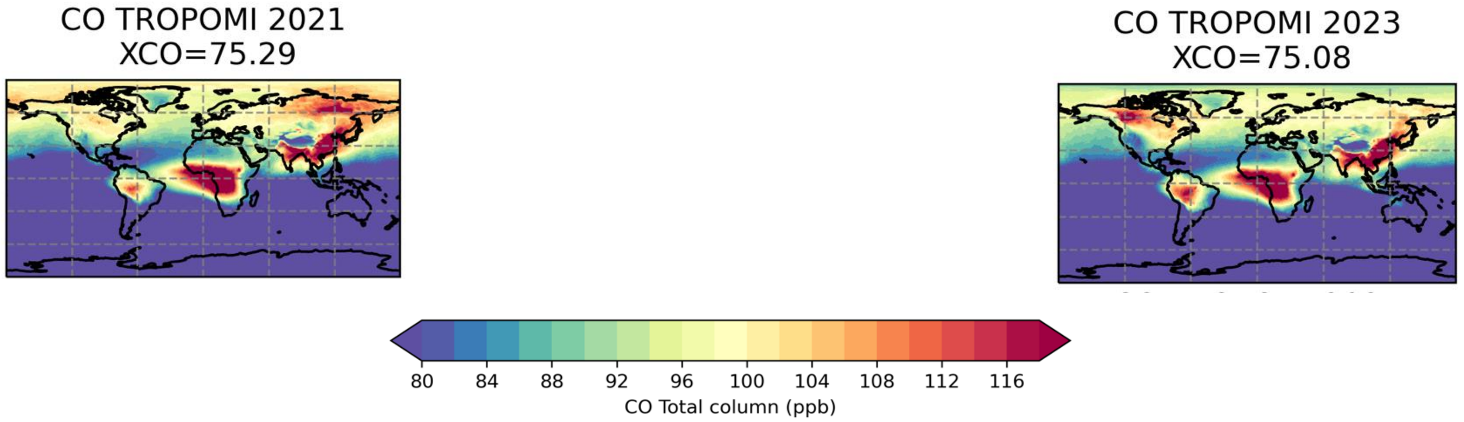


Methodology

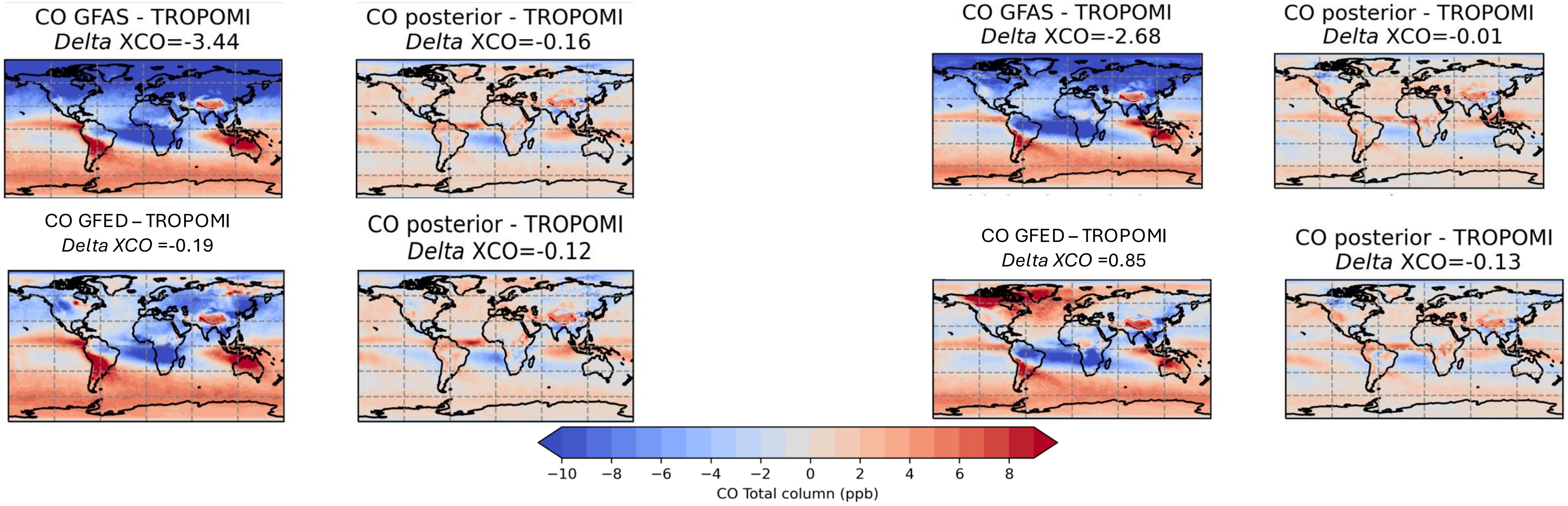
All sources optimized

		Set 1	Set 3	Set 4	Set 5	Set 6
Prior uncertainty	Nat	50	50	10	50	80
	Ant	10	50	10	10	10
	Fire	80	250	250	250	250

Results: Mixing ratio

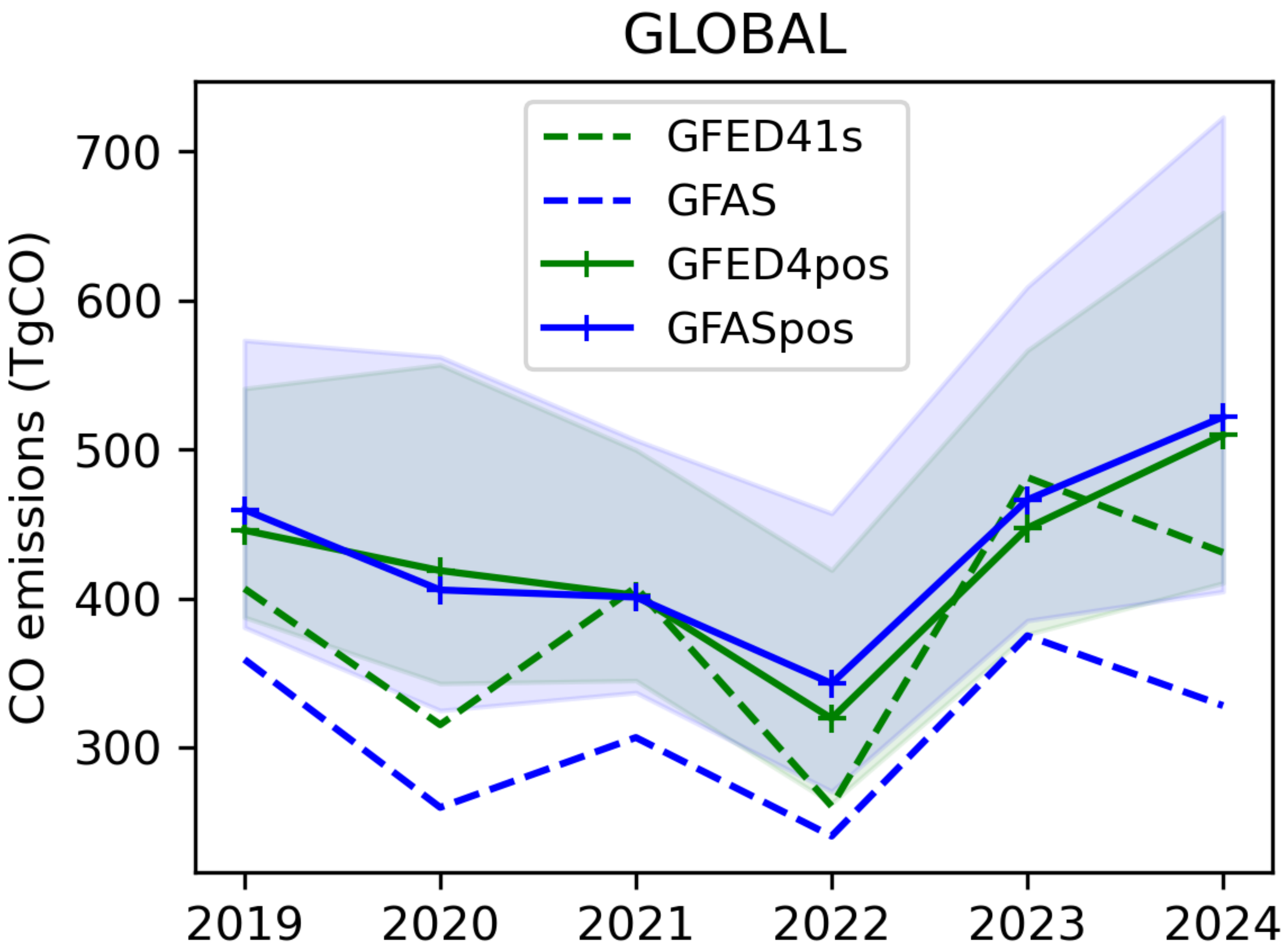


Posterior XCO reduced biases with TROPOMI in comparison to prior XCO. So, Inversion better fits the observation than TM5 prior.

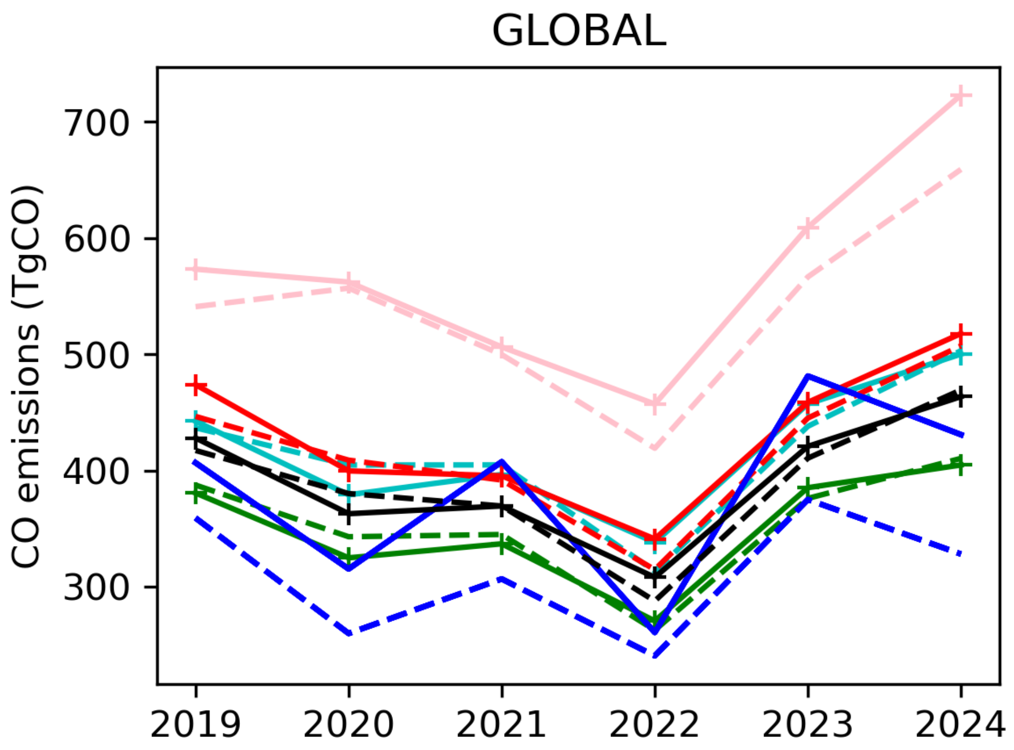


Results: Fire Emissions Comparison

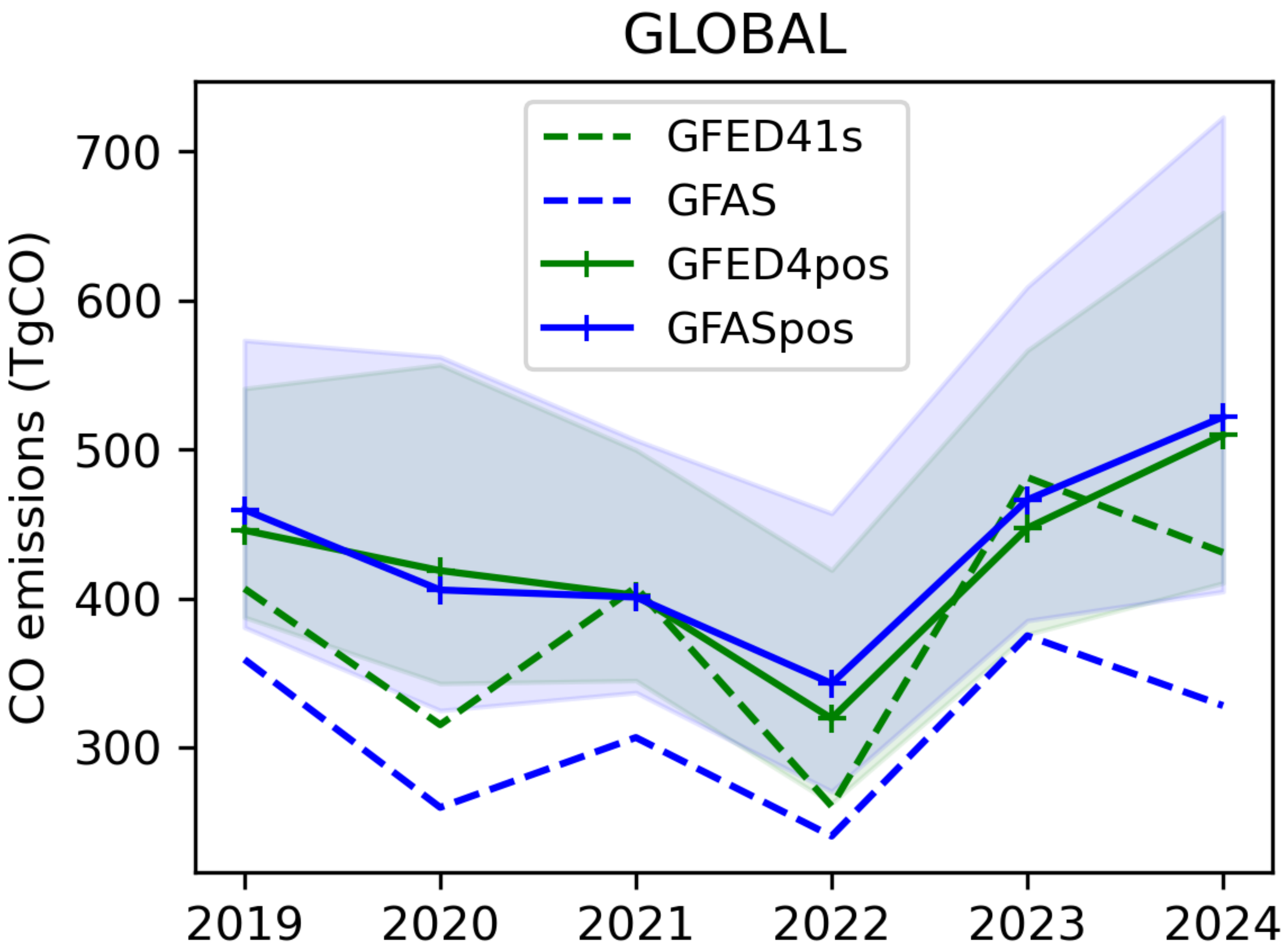
- Underestimation of prior emission compared to posterior emissions (at the excemption of 2023 for GFED4).
- GFAS lower emissions than GFED4.
- but posterior emissions very closed to each other (good constraint of the TROPOMI observations).
- Inter-annual variability of posterior different compared to prior

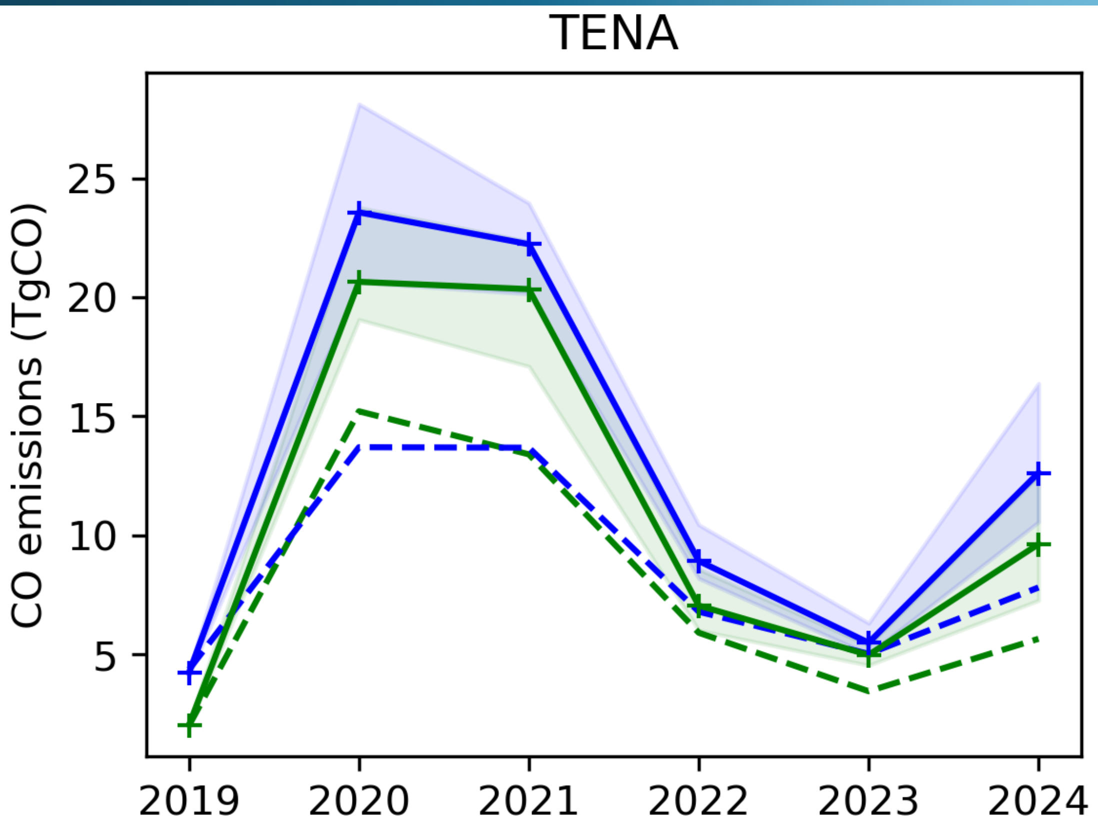


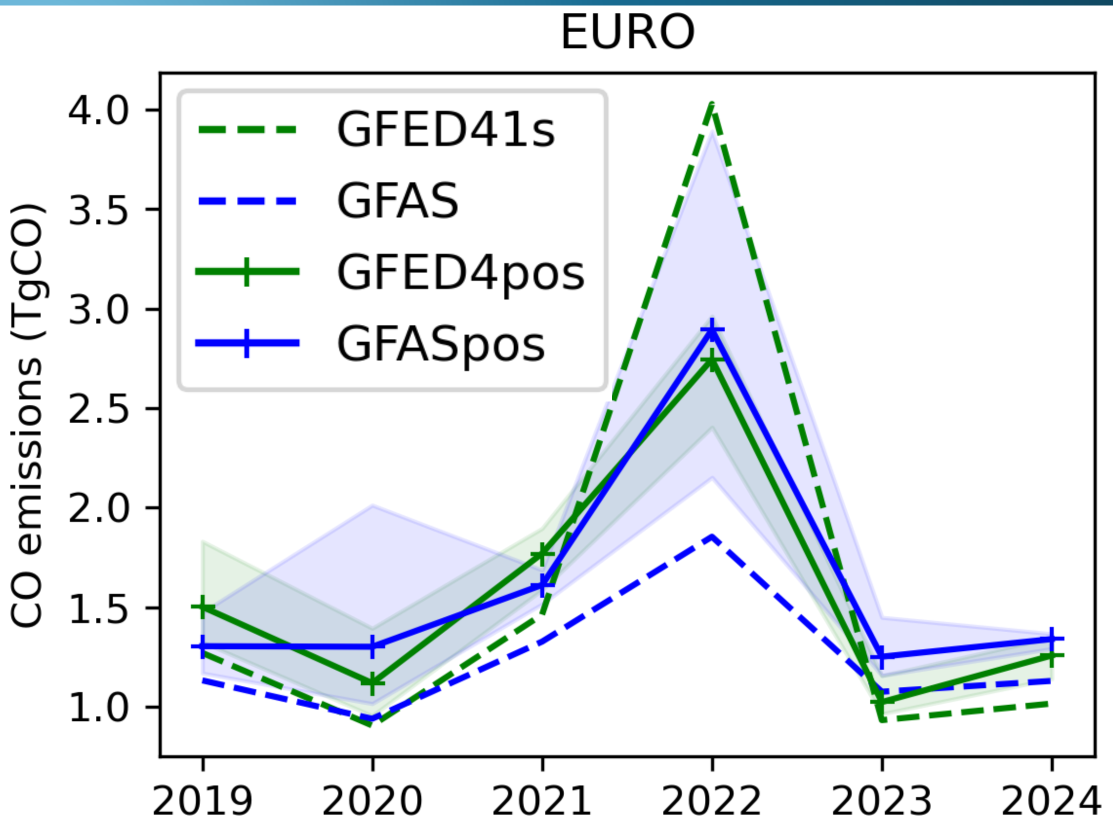
Results: Fire Emissions Comparison



		Set 1	Set 3	Set 4	Set 5	Set 6
Prior uncertainty	Nat	50	50	10	50	80
	Ant	10	50	10	10	10
	Fire	80	250	250	250	250





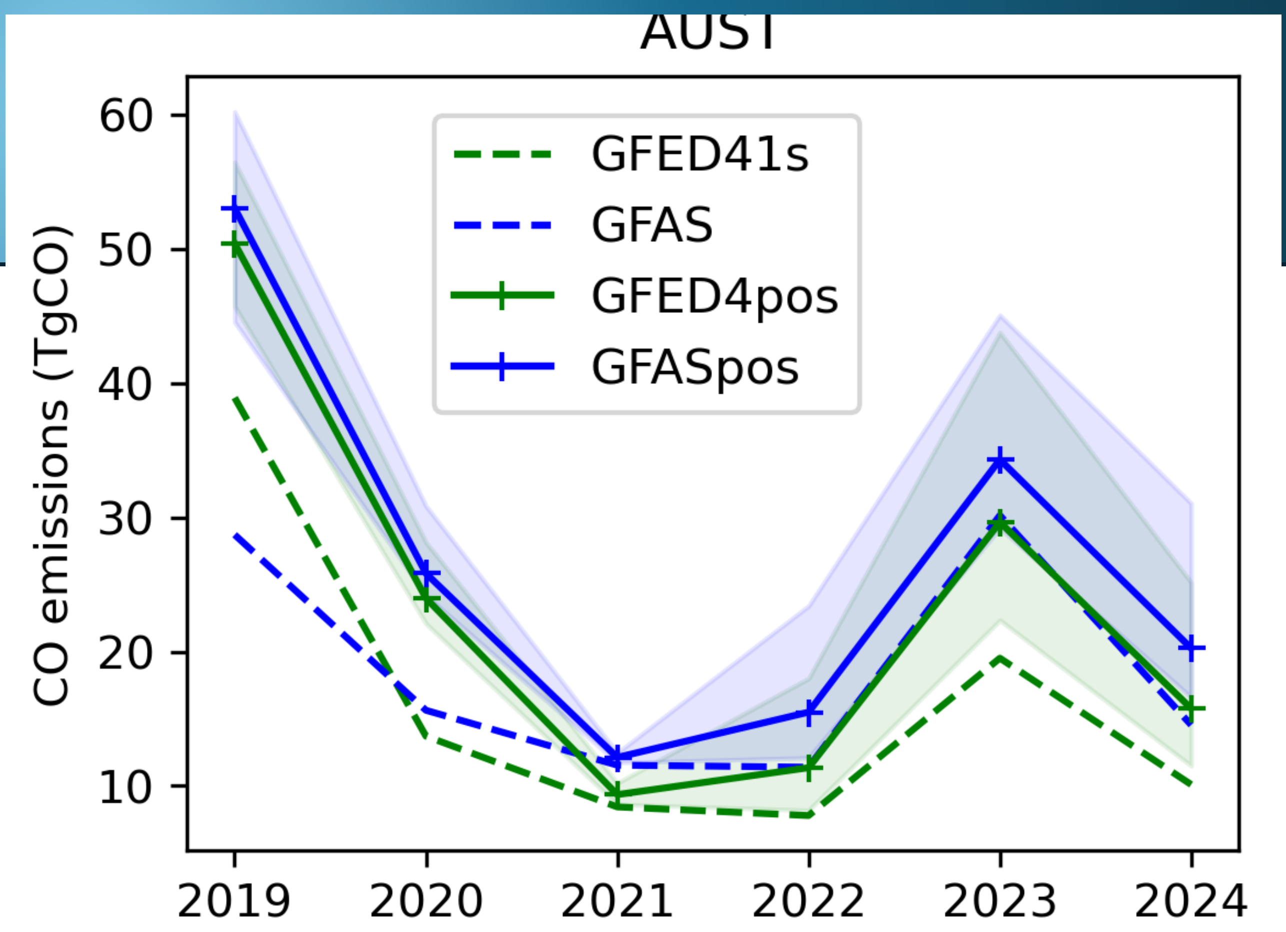


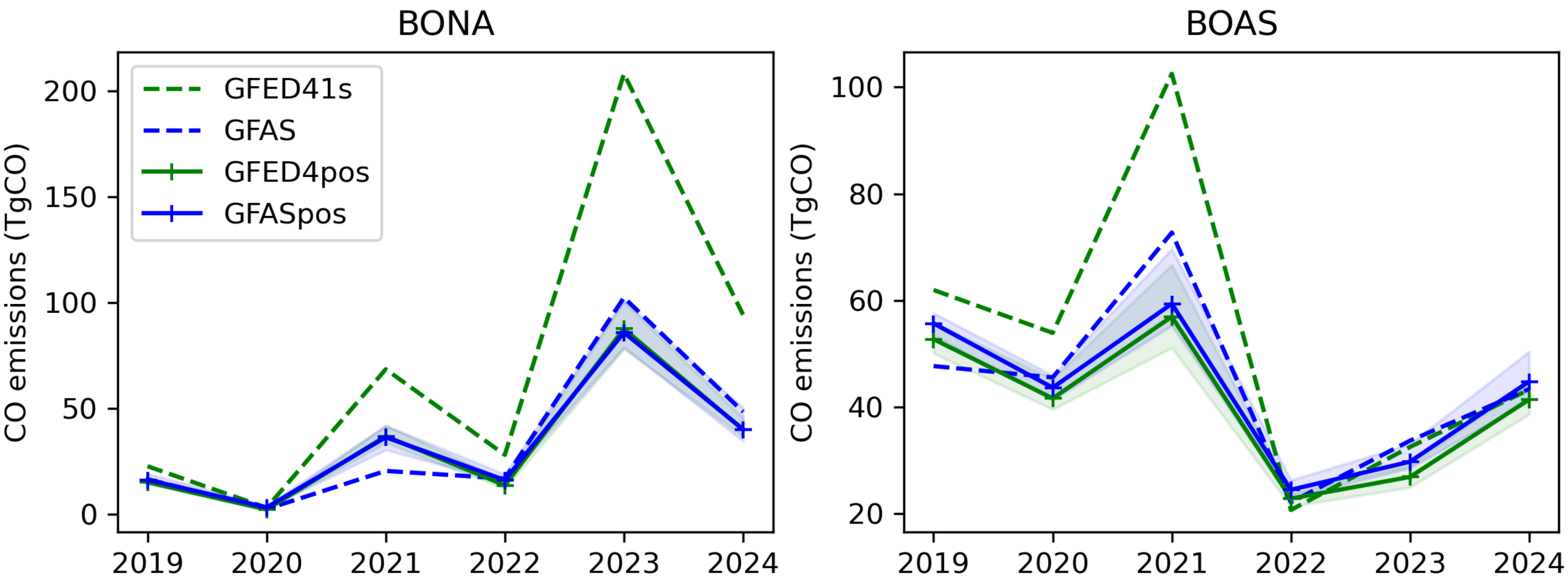
- Better agreement of prior for TENA than for EURO -> under investigation.

=> But difference in 2022 does not impact posterior emissions (again here, close to each other when considering the ensemble mean).

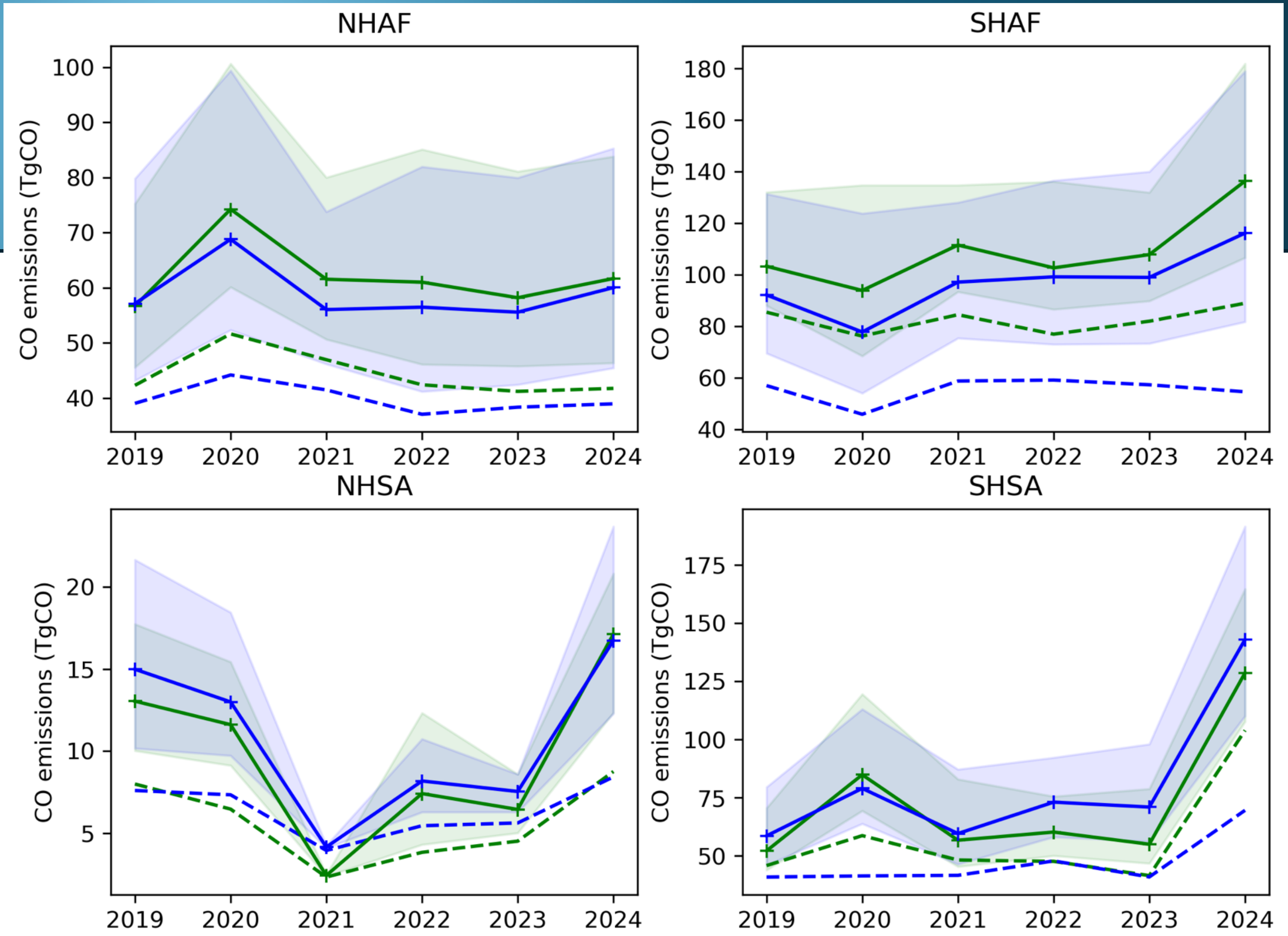
- Closer emissions (magnitude and variability) observed between priors and posteriors.

- 2019/2020 AUST: Black Fire:
  - Posterior> prior during large fire events (in agreement with previous studies).

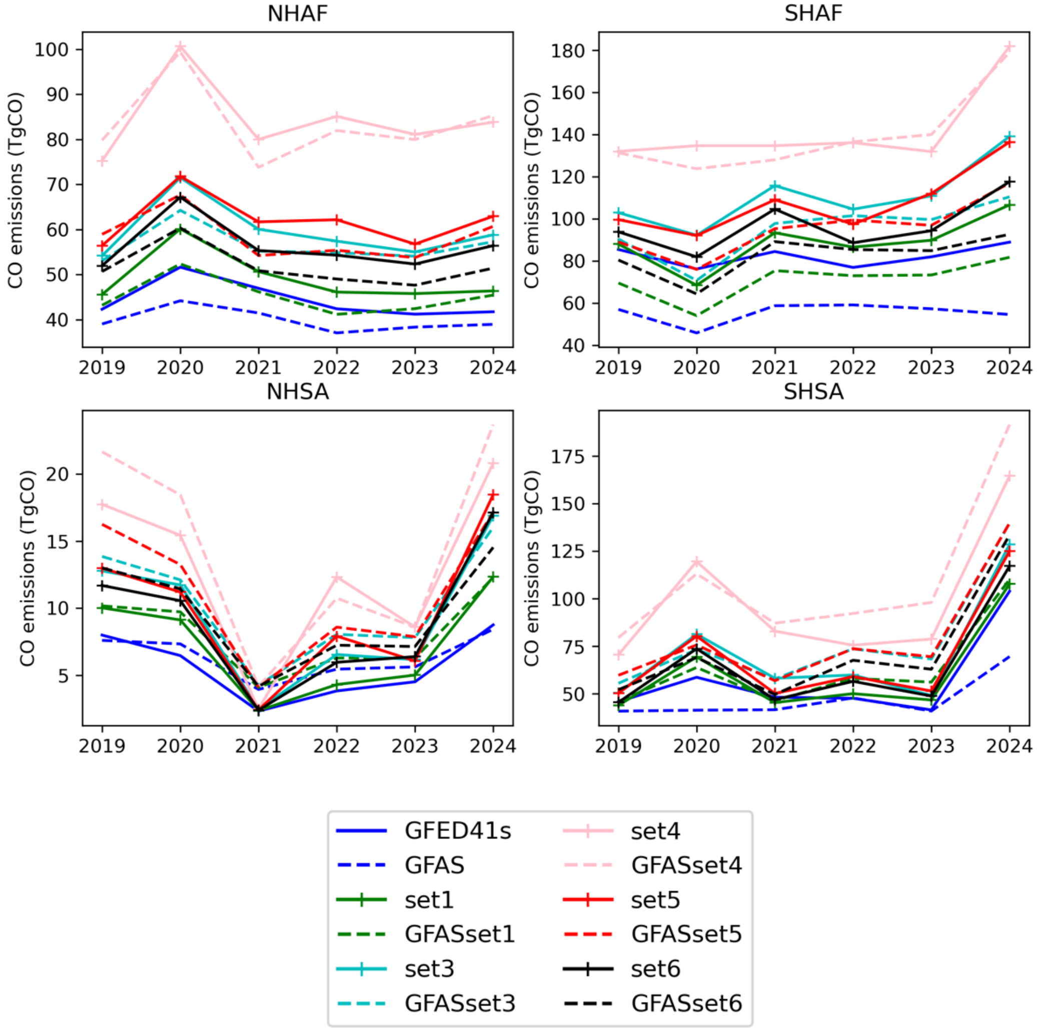


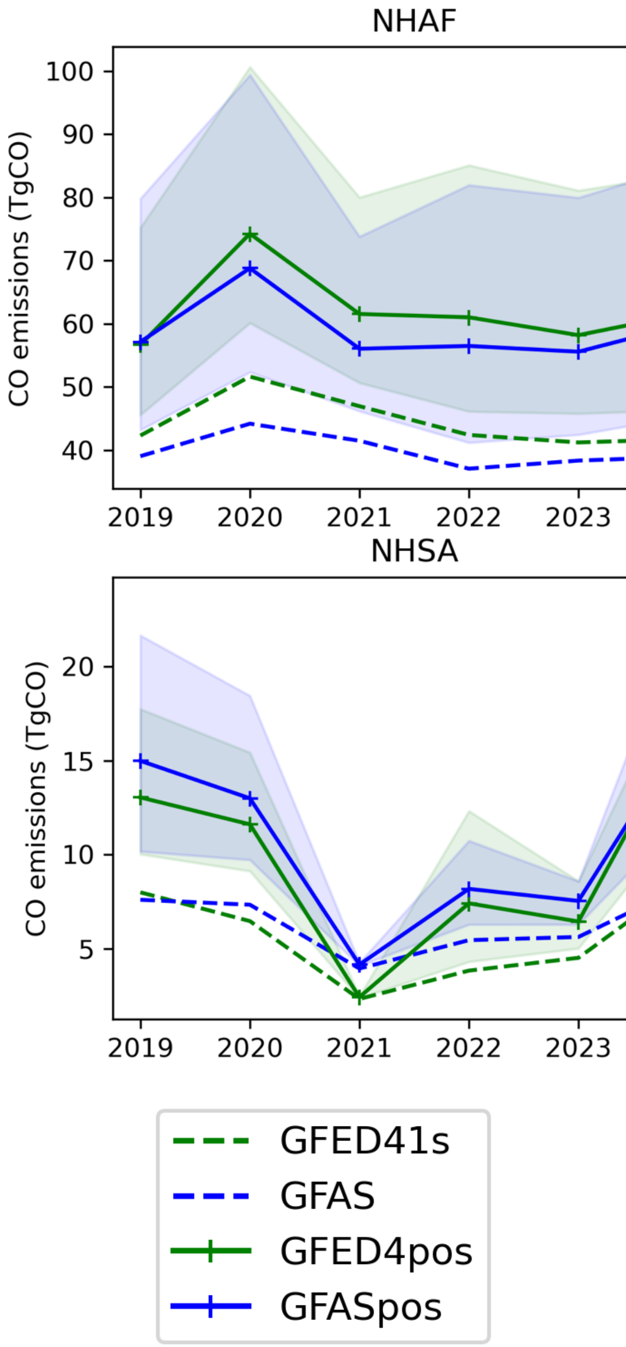


- Large overestimation of GFED41s during 2 large fire events (2023 in Canada and 2021 in Siberia) compared to GFAS and posterior emissions (see mixing ratio results).



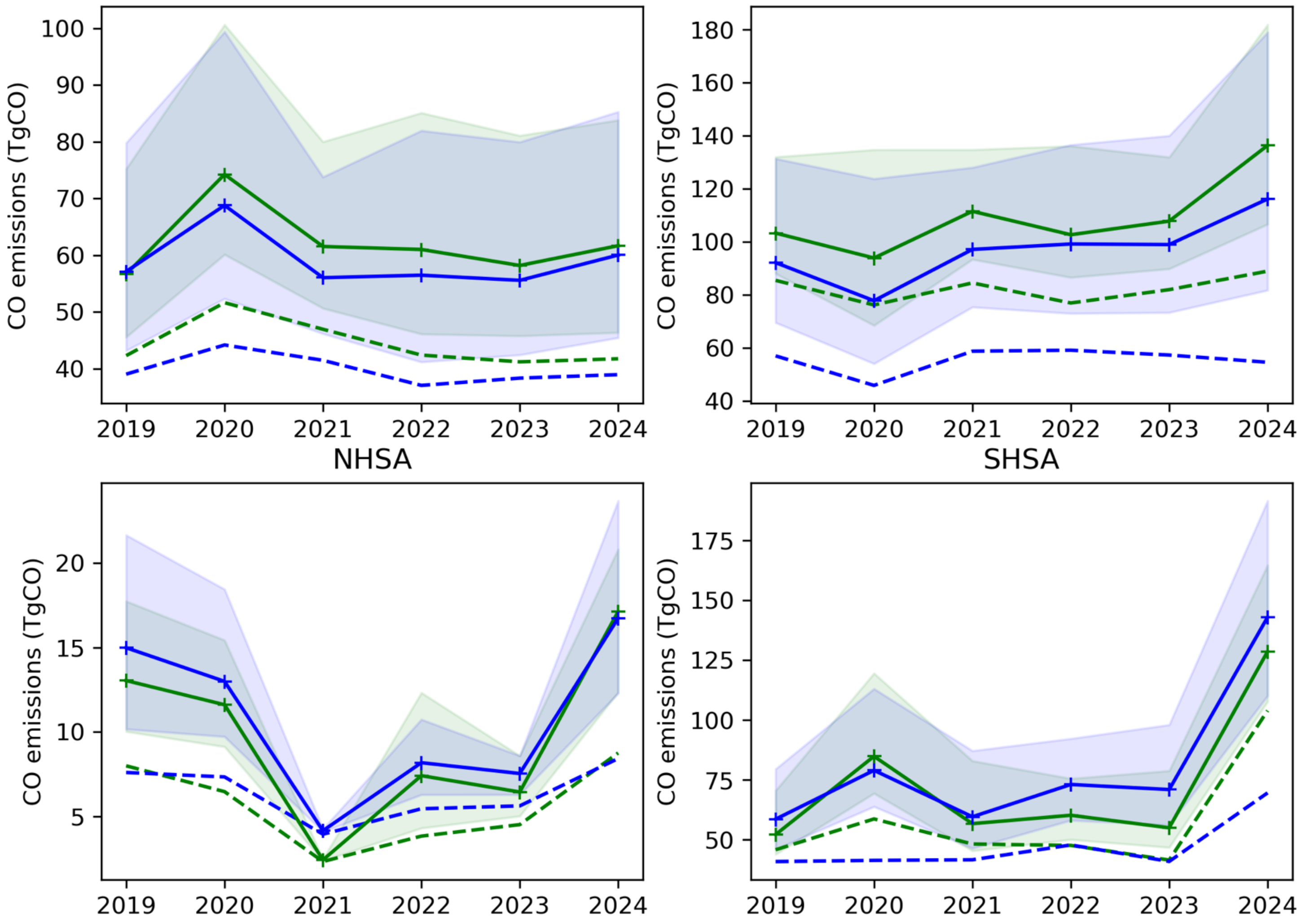
- Larger spread among the ensemble for Africa and Southern America.
- Difference of variability between posterior ensemble and priors.
- Overall, overestimation of posterior ensemble compared to priors.


NHAF
SHAF
NHSA
SHSA
CO emissions (TgCO)
2019
2020
2021
2022
2023
2024
GFED41s
GFAS
set1
GFASset1
set3
GFASset3
set4
GFASset4
set5
GFASset5
set6
GFASset6

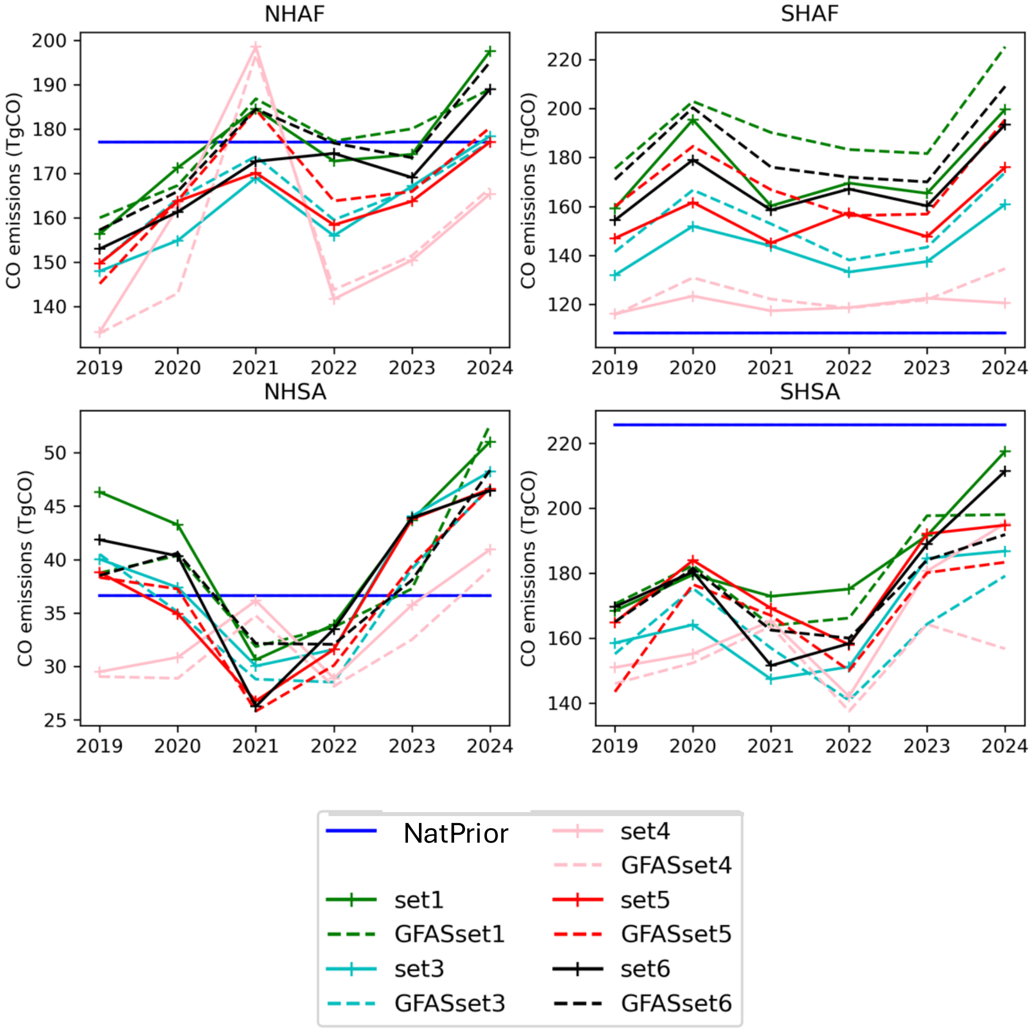

NHAF
SHAF
NHSA
SHSA
CO emissions (TgCO)
2019
2020
2021
2022
2023
2024
GFED41s
GFAS
GFED4pos
GFASpos


BONA
TENA
CEAM
NHSA
SHSA
EURO
MIDE
NHAF
SHAF
BOAS
CEAS
SEAS
EQAS
AUST

Fire Emissions



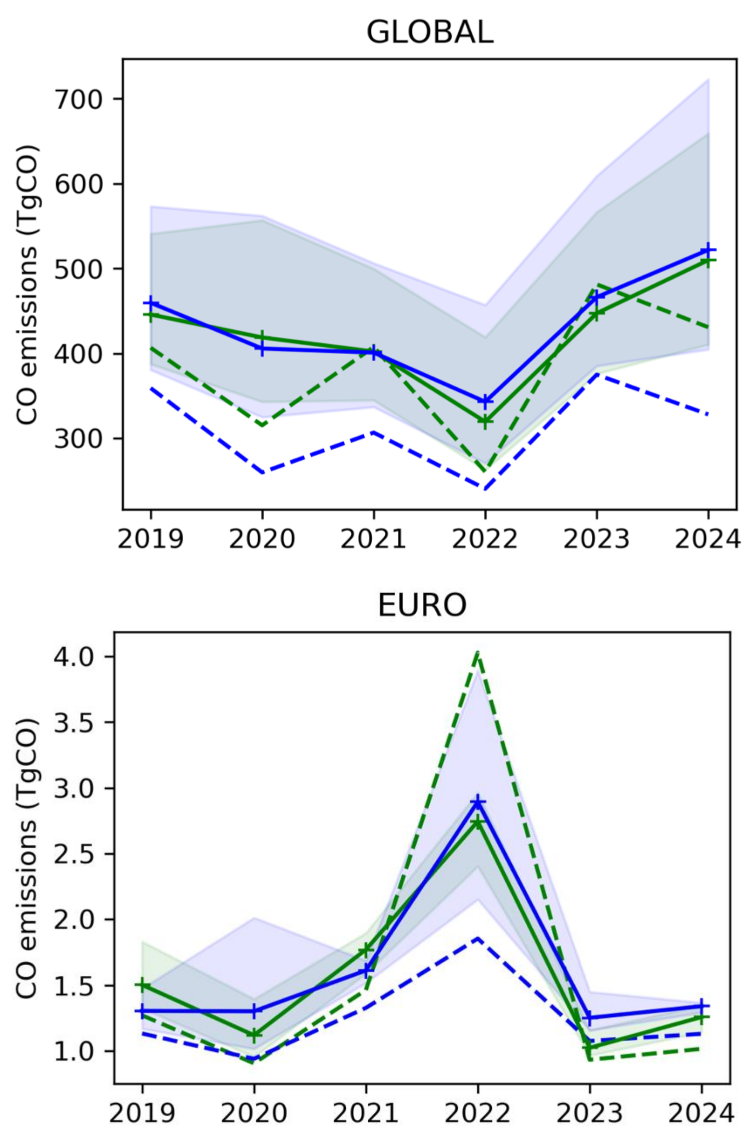
Natural Emissions



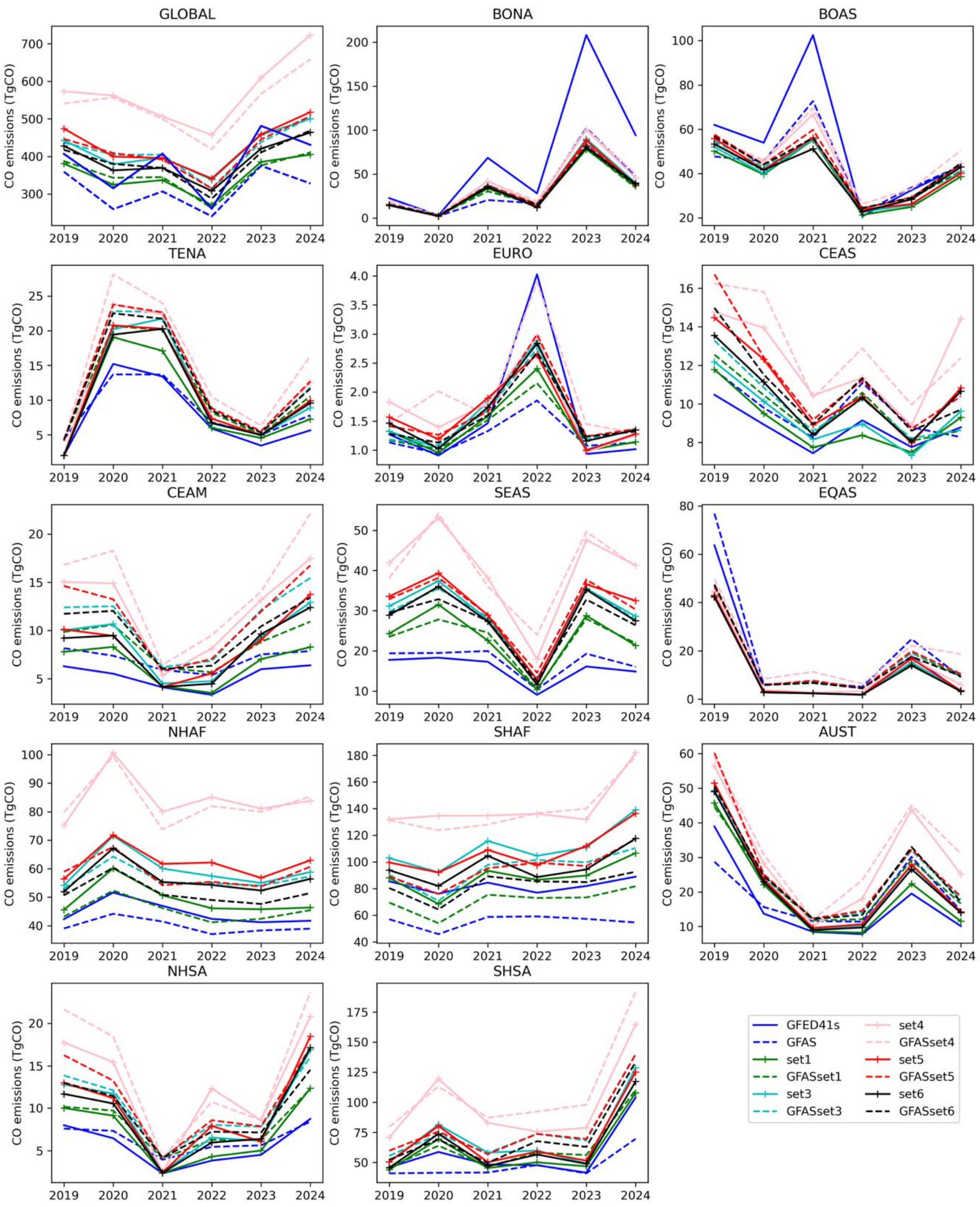
Conclusions

- **Conclusions:**
  - GFAS underestimate fire emissions compared to GFED41s for all regions.
  - Posterior ensemble emissions from GFED or GFAS are closer to each other (good constraint of data assimilation)
  - In boreal regions, posterior ensemble are closer to GFAS than to GFED41s.
  - Investigation of european fire emission in 2022 observed by GFED41s
  - Inter-annual variability globally and for some regions not matching between posterior and priors.

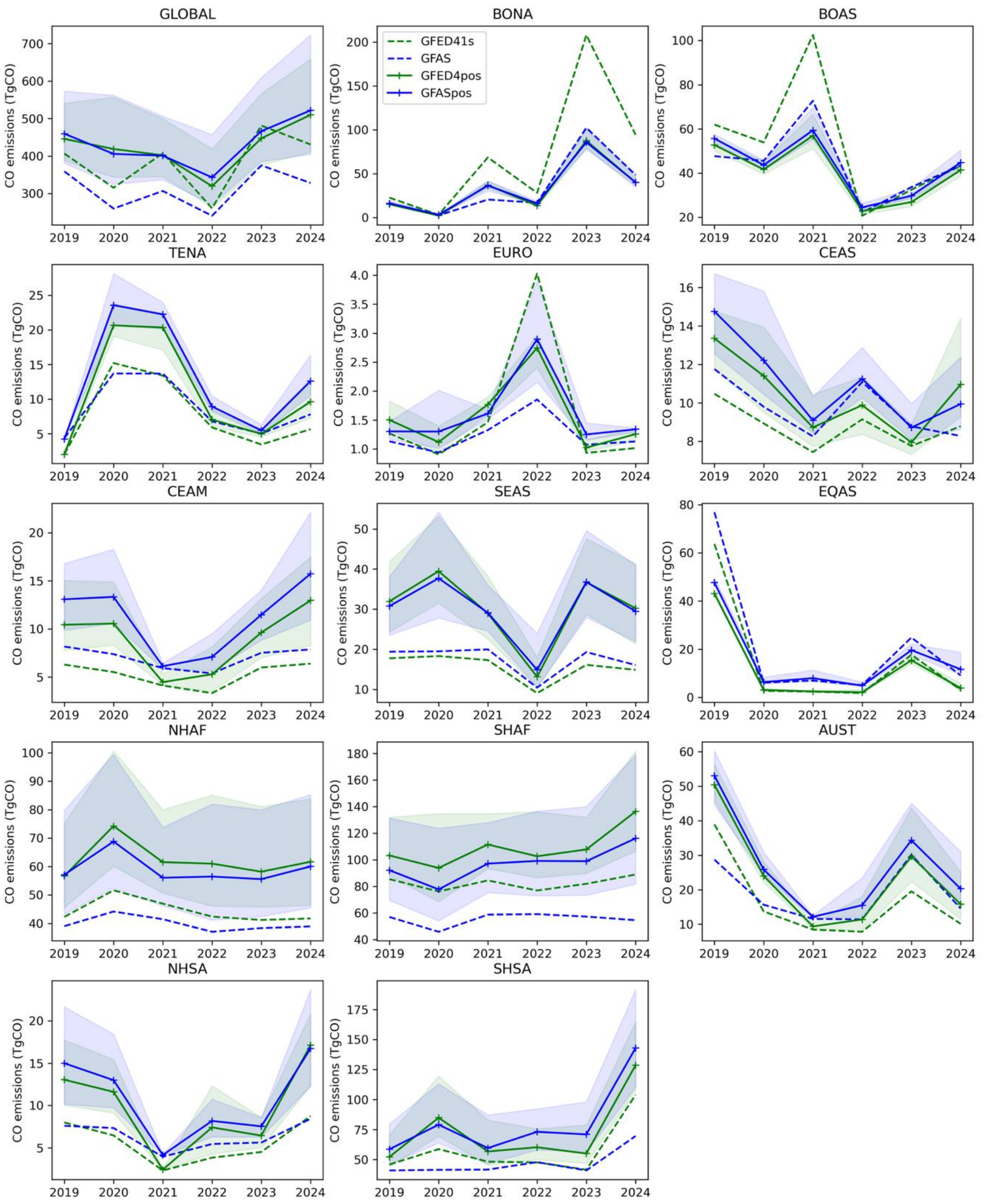
- **Not shown here but will appear in final version:**
  - MOPITT posterior ensemble using GFED41s comparison included
  - GFED5 new version included

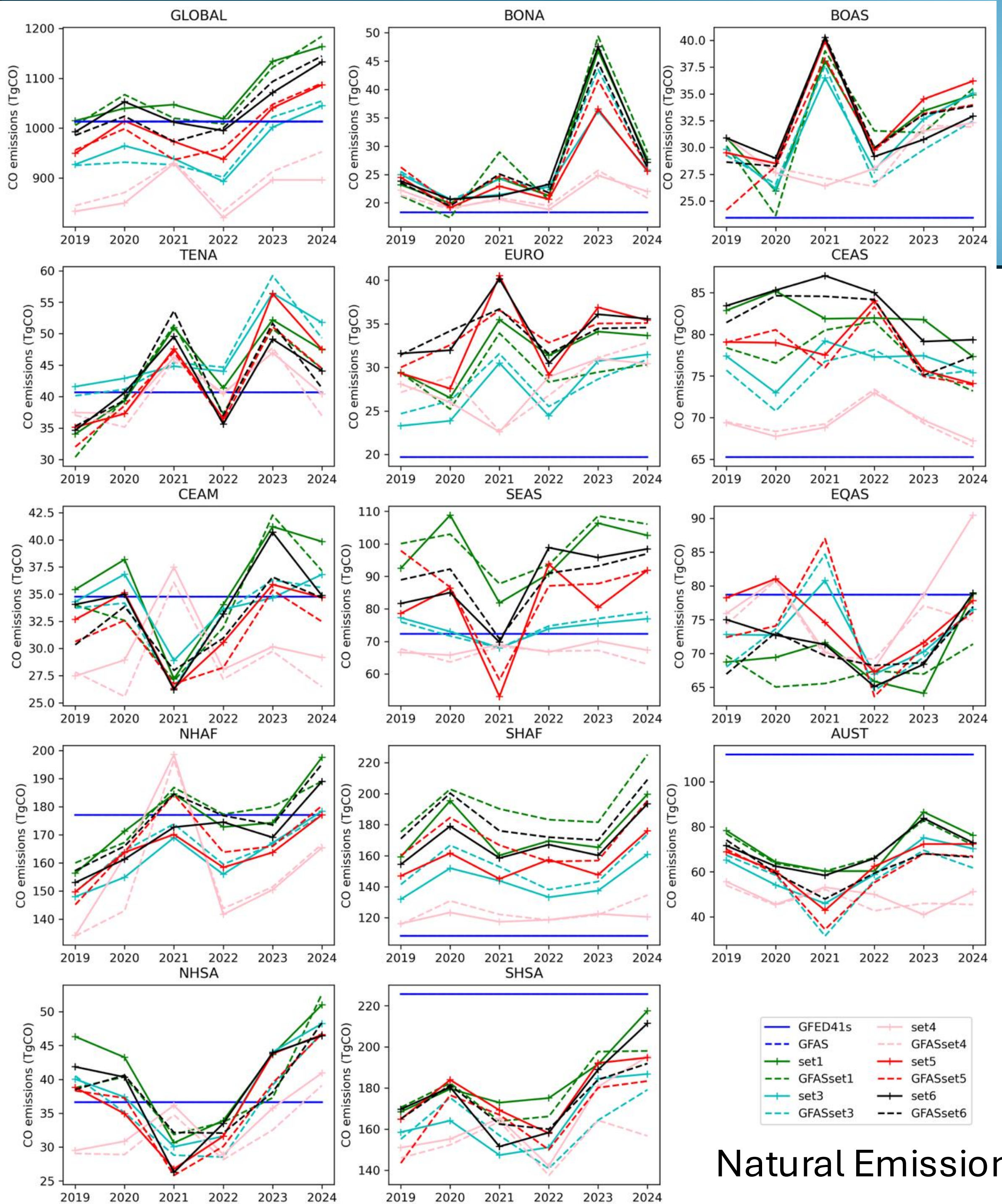


Fire Emissions

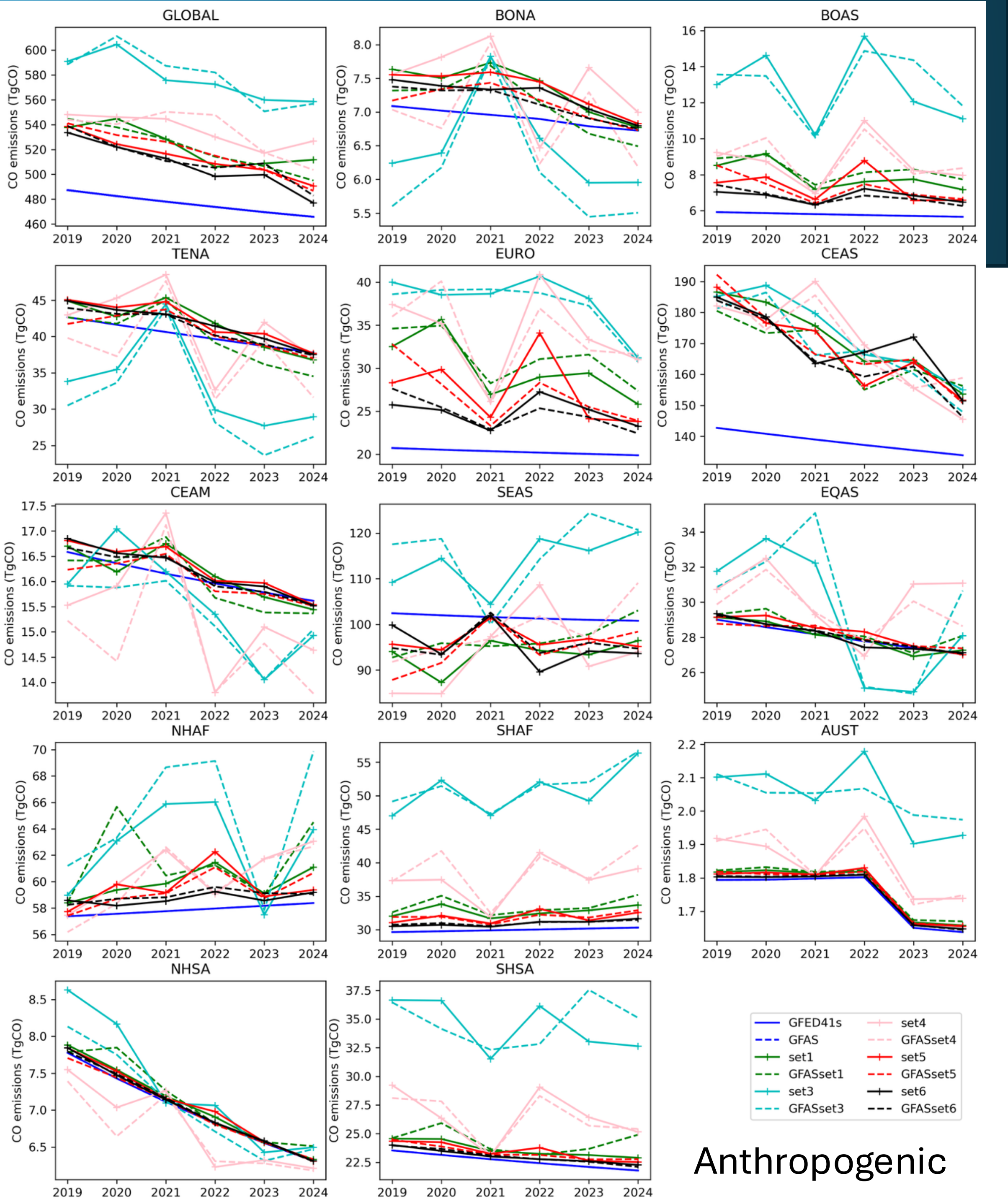


Fire Emissions





Natural Emissions



Anthropogenic