Evaluation of soil NO emissions in the Tropics using field data and TROPOMI NO_2 columns

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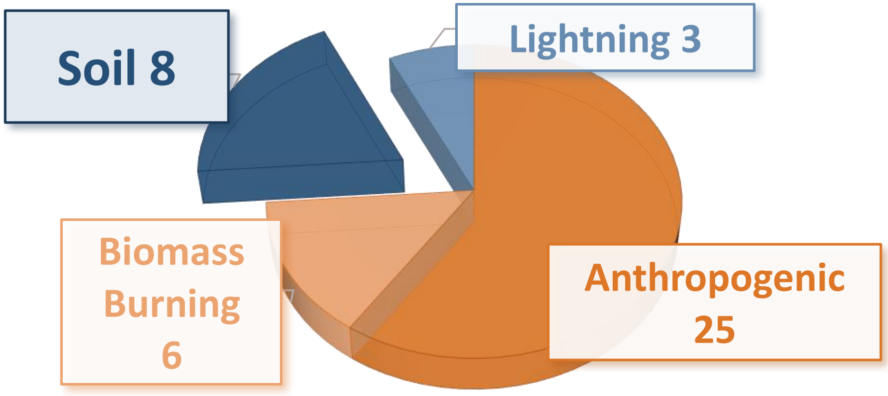
Soil NO emission fluxes

- **Important contribution** to global NO_x emissions, in particular in **remote** environments
- **Tropics** contribute for almost 70%
- **Origin:** Microbial nitrification, denitrification and chemodenitrification
- **Fluxes depend** on temperature, precipitation (pulsing), canopy uptake, vegetation, fertilization, deposition, ...
- **Large uncertainties in soil NO estimates**
  - Bottom-up inventories:

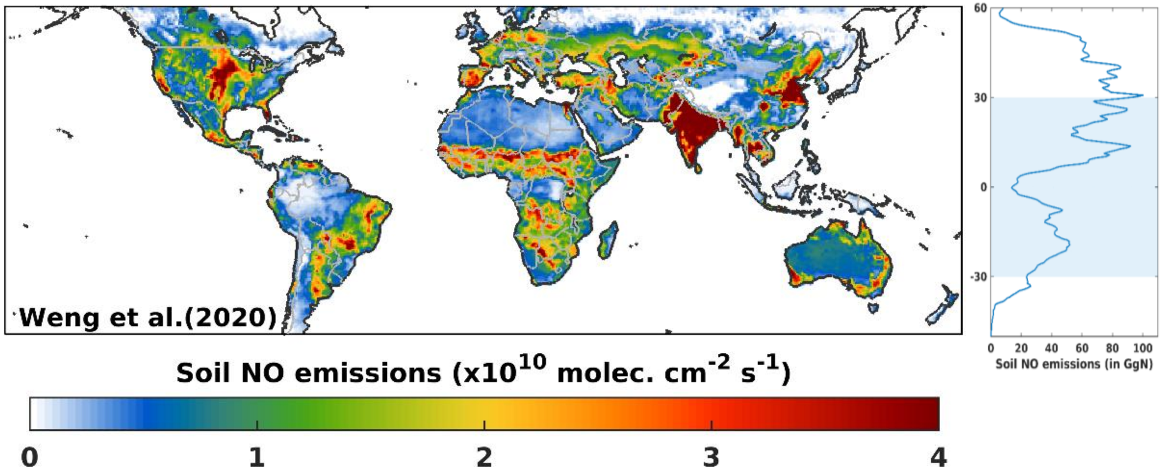
    4-34 Tg N/yr (Yan et al., 2005, Steinkamp and Lawrence, 2011)
  - Top-down (inverse modelling) estimates:

    9-20 Tg N/yr (Jaeglé et al., 2005, Stavrakou et al., 2013)



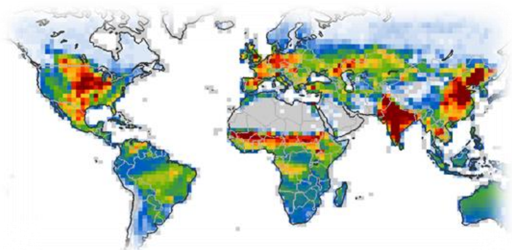
GLOBAL ANNUAL TOTAL: ~40 TgN $year^{-1}$

Annual global and latitudinal average emissions

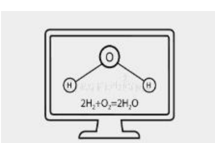


Inverse modelling methodology

BOTTOM-UP (BU)
Soil NO emissions



STEP 1

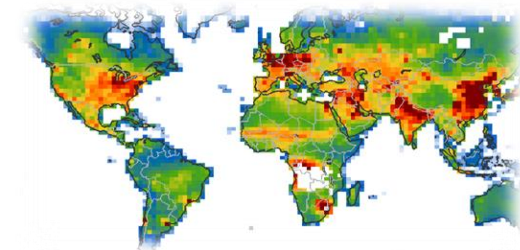


Chemistry Transport Model
(MAGRITTEv1.1 CTM)
with ADJOINT INVERSION MODULE
(Müller et al., 2019)

STEP 2a

A PRIORI NO_2 columns

TOP-DOWN (TD) CONSTRAINT
TROPOMI NO_2 columns (v2.2)
(van Geffen et al., 2022)



STEP 2b

A POSTERIORI NO_2 columns

A POSTERIORI NO_x emission fluxes

Anthropogenic

Soil

Lightning

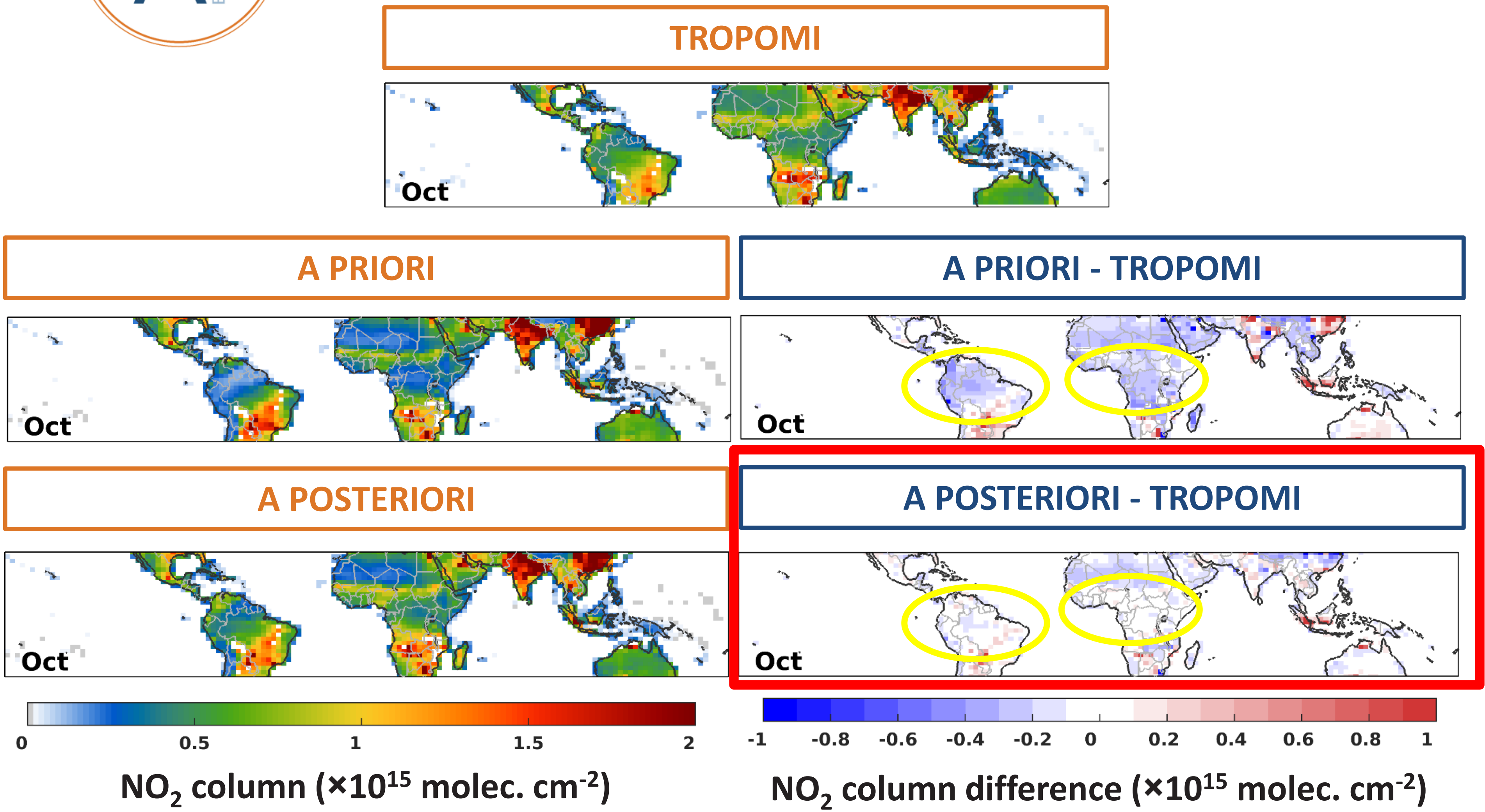
Simulations for 2019: (1) GLOBAL @ 2°×2.5° (2) REGIONAL over Africa @ 0.5°

In situ soil NO flux measurements

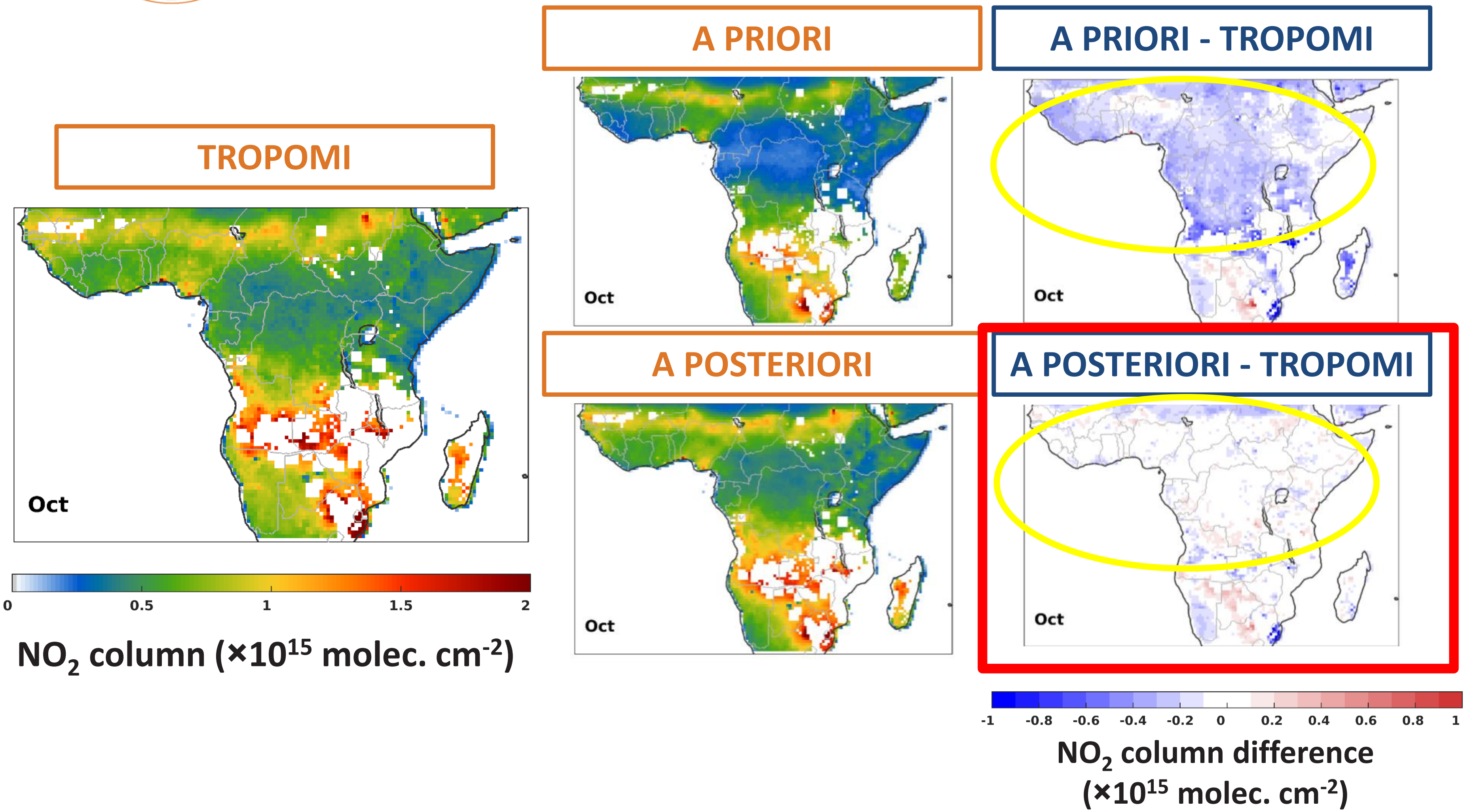
TROPICS	America	Africa	Asia
30 sites	14 sites	11 sites	5 sites
n = 63	n = 33	n = 19	n = 11

- Compiled from **32 peer-reviewed publications**
- Measurements conducted **from 1985 to 2016**
- Across **various biomes** (forest, savannah, crop, grass)

Global inversion: TROPOMI NO_2 columns suggest an increase in NOx emissions over most remote regions



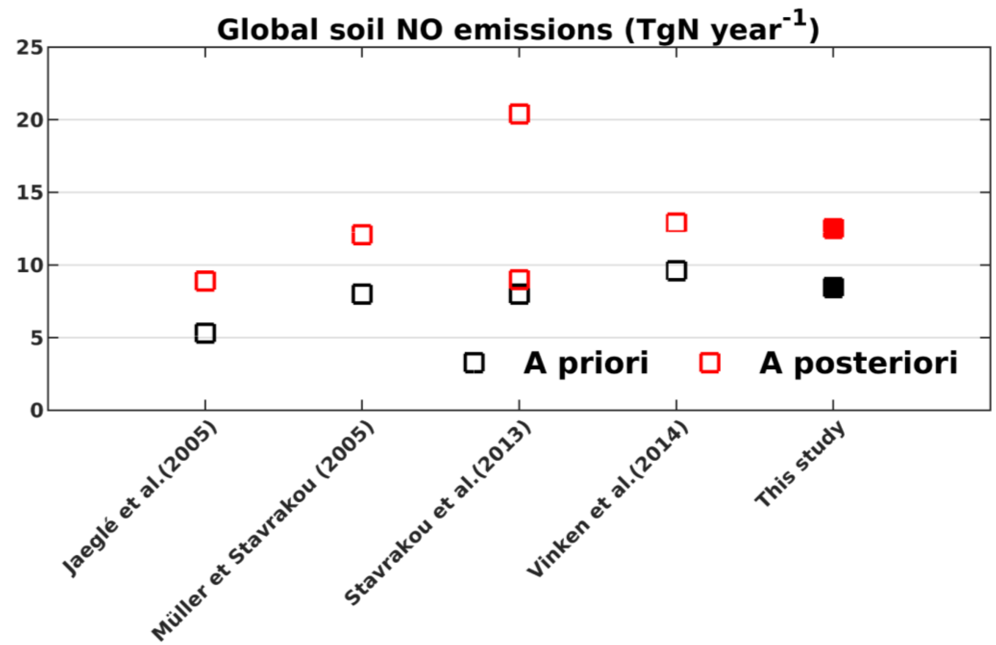
Regional inversion: TROPOMI NO_2 columns suggest an increase in NOx emissions except close to biomass burning scenes



A posteriori soil NO emissions: global annual total increases by ~50%

GLOBAL total 2019 emissions (TgN)

Source category	A priori	A posteriori
Anthropogenic	28.1	21.0 (-25%)
Soil	8.5	12.5 **(+48%)**
Lightning	3.4	4.2 (+24%)
Biomass Burning	6.1	N.A.



AFRICA 2019 soil NO emissions (TgN)

A priori	Regional A posteriori	Global A posteriori
2.41	4.26 **(+77%)**	3.11 **(+29%)**

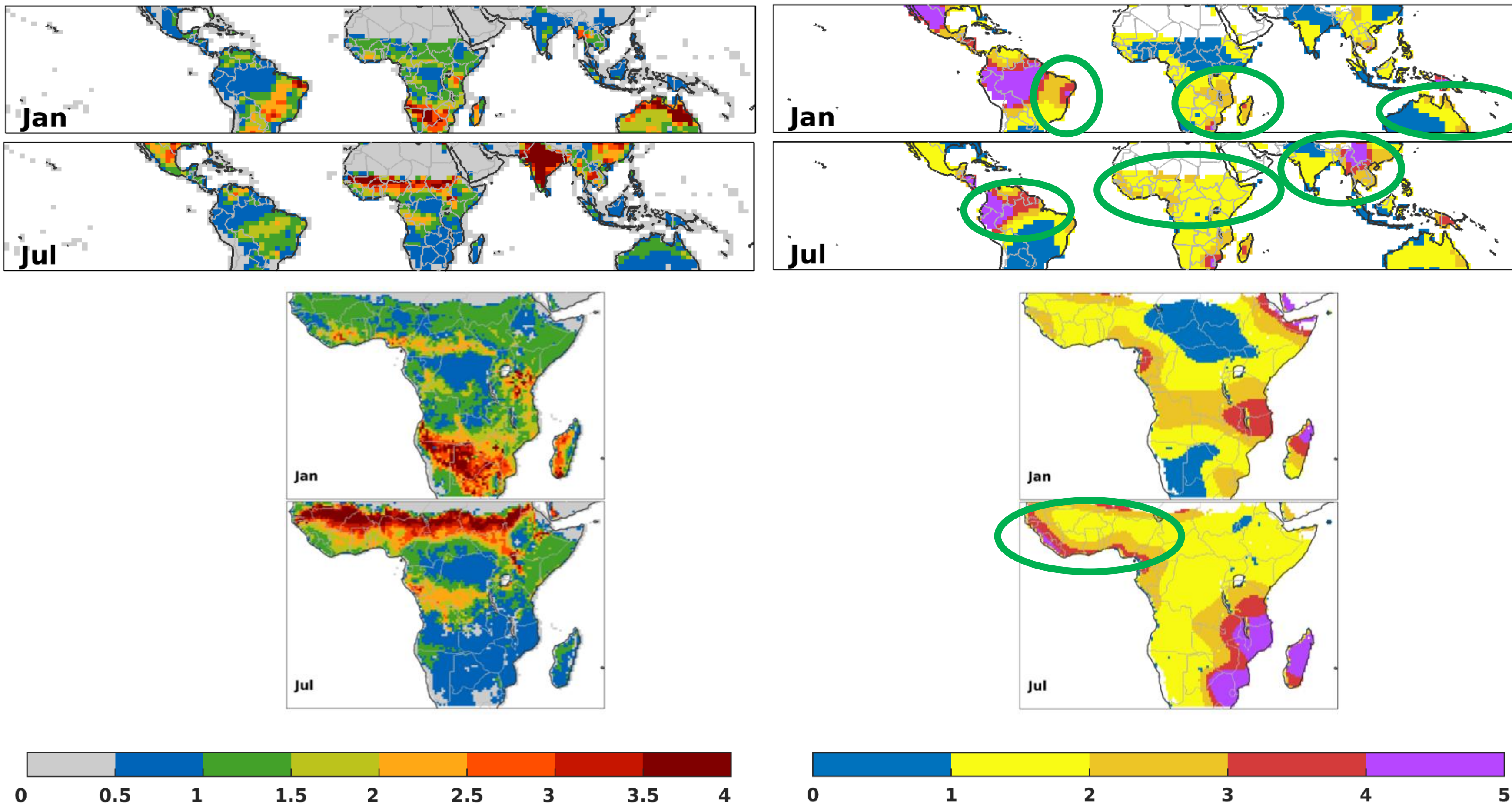
Substantial increases inferred in the Tropics

A PRIORI soil NO (10^{10} molec. cm^{-2} s^{-1})

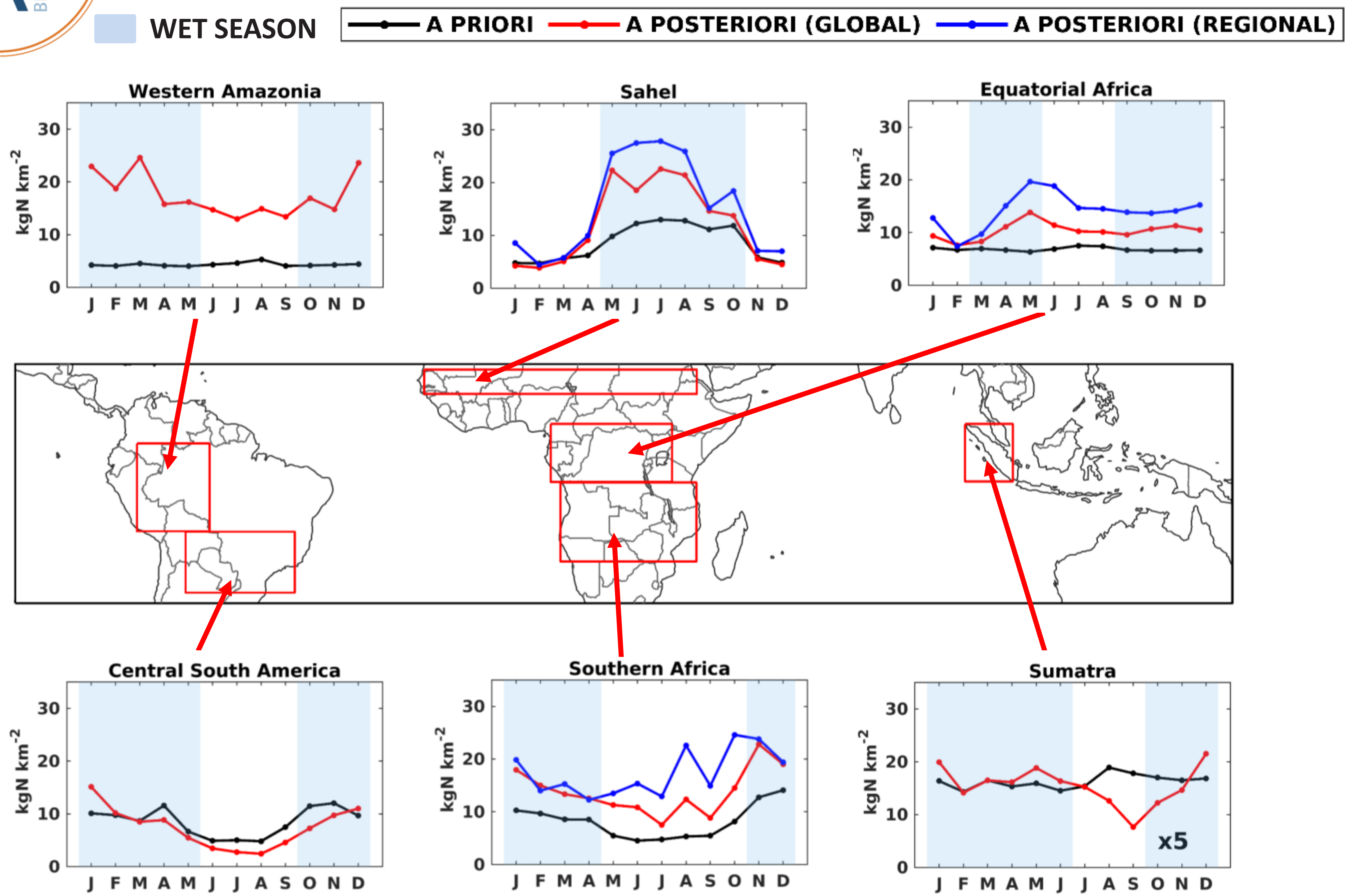
MULTIPLYING FACTOR

GLOBAL

REGIONAL

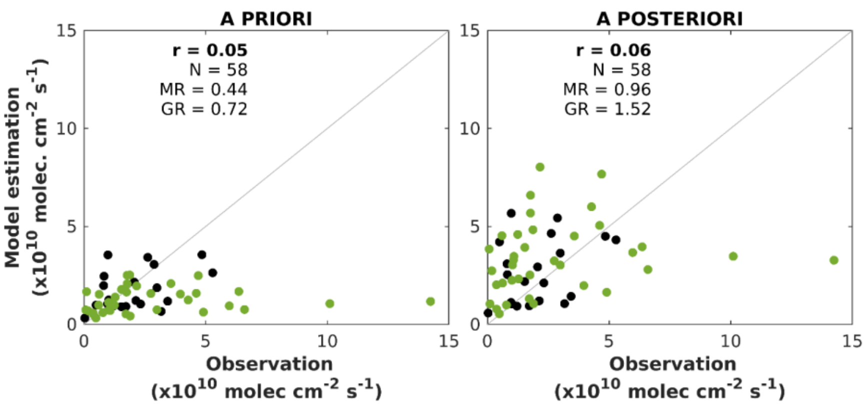


Soil NO variability is modified in A POSTERIORI simulations



Optimisation removes general model underestimation of soil fluxes against in situ data but leads to overestimations over Africa

TROPICS

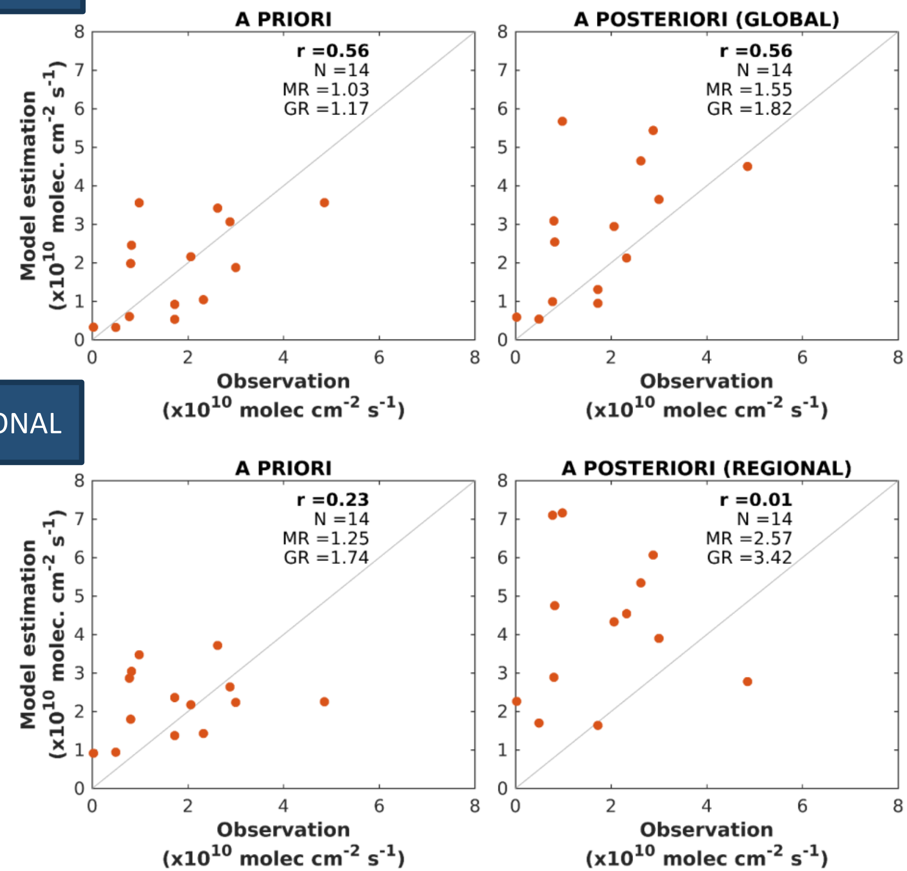


FOREST

AFRICA

GLOBAL

REGIONAL



r: Pearson's coefficient of correlation

N: number of points

$$\mathbf{MR} = \frac{\sum MOD_i}{\sum OBS_i}; \quad \boldsymbol{GR} = \frac{\prod MOD_i}{\prod OBS_i}$$

Take-aways

- The TROPOMI NO_2 data suggest :
  - An increase in soil NO emissions by 50% in the global total, in particular in the Tropics.
  - Changes in the soil NO seasonality

- Over Africa: higher soil NO emissions inferred from the regional simulation compared to global simulation

Next ?

- Use alternative a priori inventories (HEMCO or CAMS) in the model
- Identify added value of the inversions at high spatial resolution, for Africa and South America
- Extend the in situ comparison dataset using literature studies

THANK YOU!

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