Inverse analysis with in-situ/flask and GOSAT observations to disentangle regional and sectoral emission contributions to the surge of atmospheric CH_4 for 2020–2022

will soon be published from ACP
The preprint is available from EGUsphere

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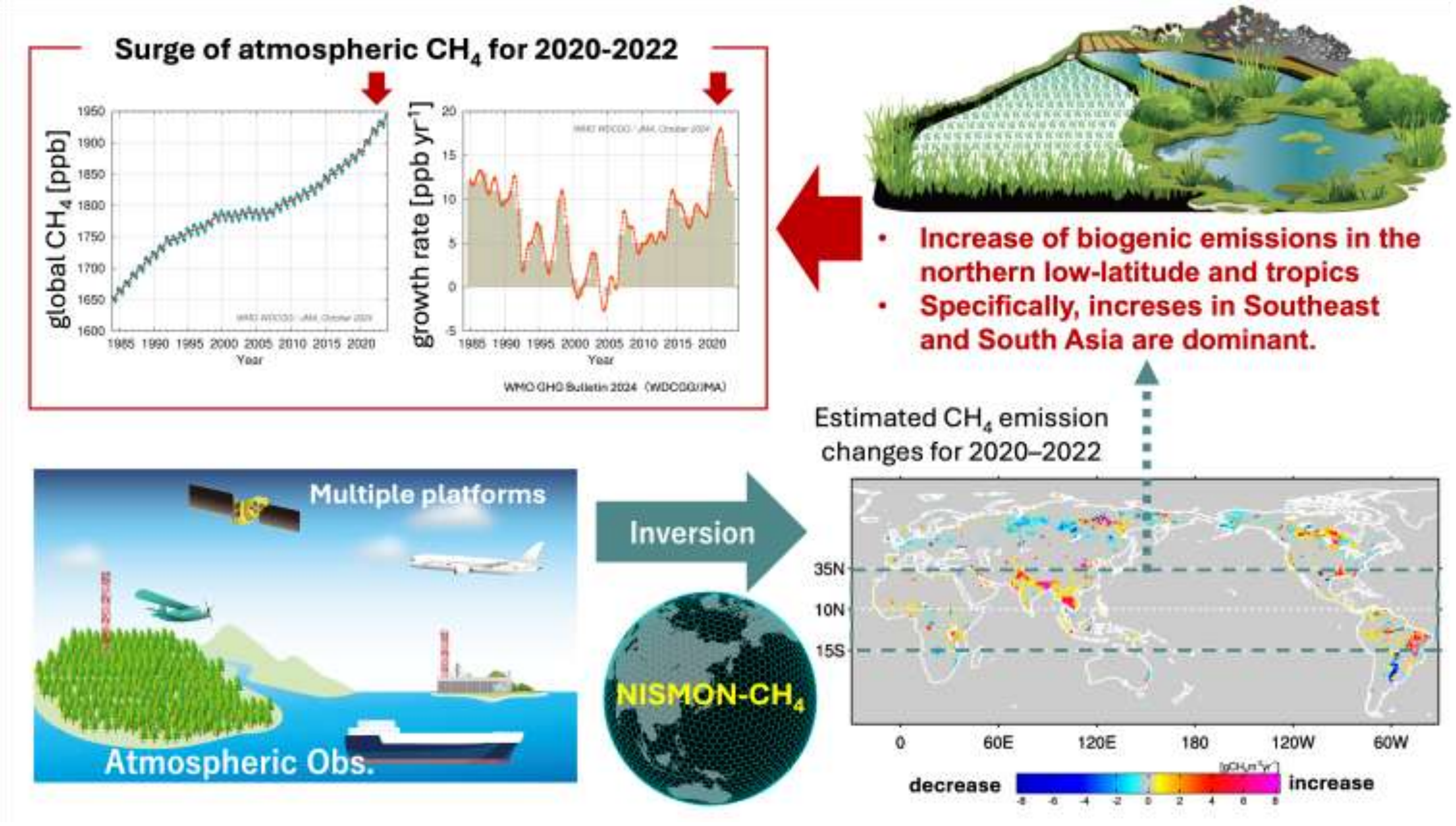
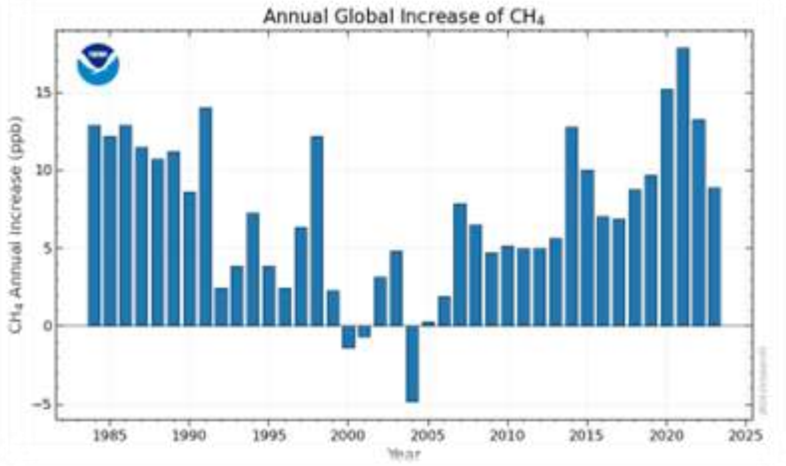
Keypoint



Surge of atmospheric CH_4 for 2020-2022
global CH_4 [ppb]
growth rate [ppb yr^{-1}]
Year
Year
WMO GHG Bulletin 2024 (WDCGG/JMA)
Increase of biogenic emissions in the northern low-latitude and tropics
Specifically, increses in Southeast and South Asia are dominant.
Estimated CH_4 emission changes for 2020–2022
Multiple platforms
Inversion
NISMON-CH_4
Atmospheric Obs.
35N
10N
15S
0
60E
120E
180
120W
60W
decrease
increase

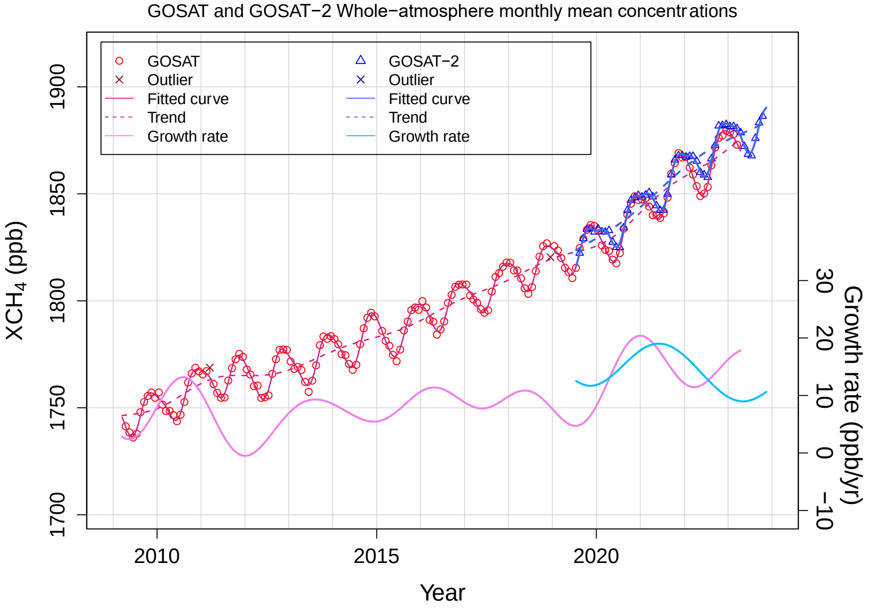
Recent rapid growth of atmospheric CH_4

NOAA/GML



Lan et al., (2024)

GOSAT/GOSAT-2

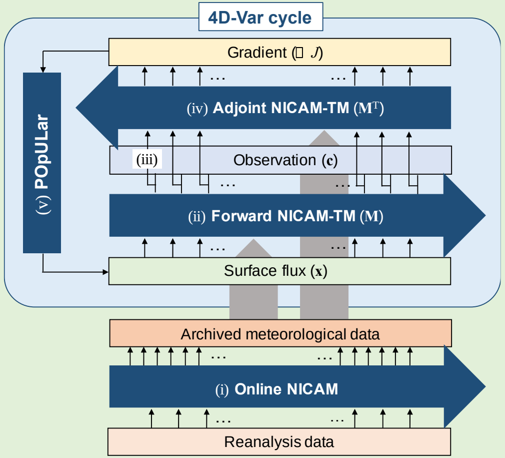


Umezawa et al., PEPS (2025)

During 2020–2022, atmospheric CH_4 rapidly increased; however, its cause is not fully understood.

Inversions with three different observation sets

4D-Var Inversion system (NISMON-CH_4)

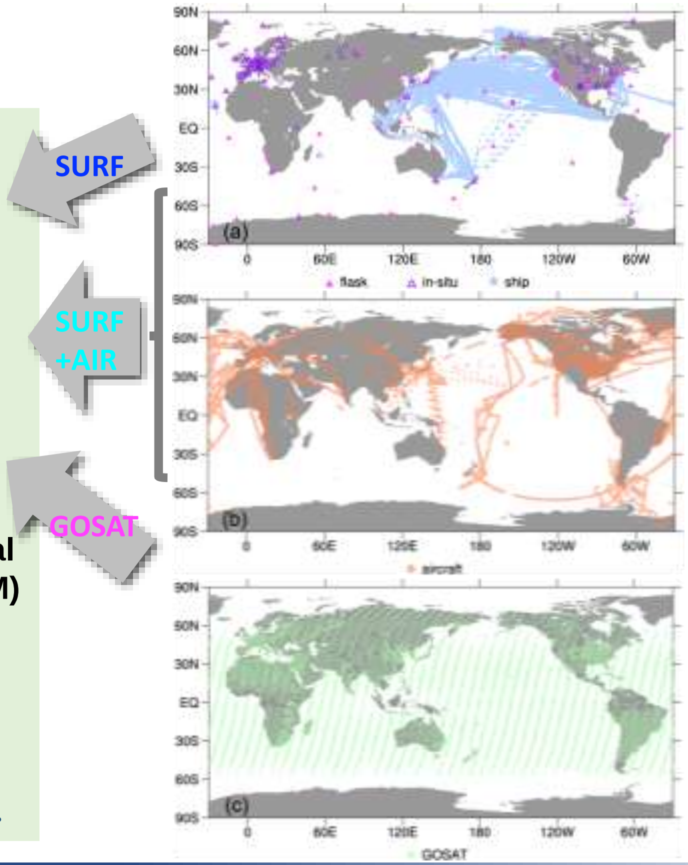


Nonhydrostatic Icosahedral Atmospheric Model (NICAM)
Satoh et al., PEPS (2014)

-based Transport Model (NICAM-TM)
Niwa et al., JMSJ (2011)

Niwa et al., GMD (2017a,b)
Niwa et al., PEPS (2022)
Saunois et al., ESSD (2020)

10 emission sectors are separately optimized at 1°×1°.



Surface

ObsPack
+ NIES obs.

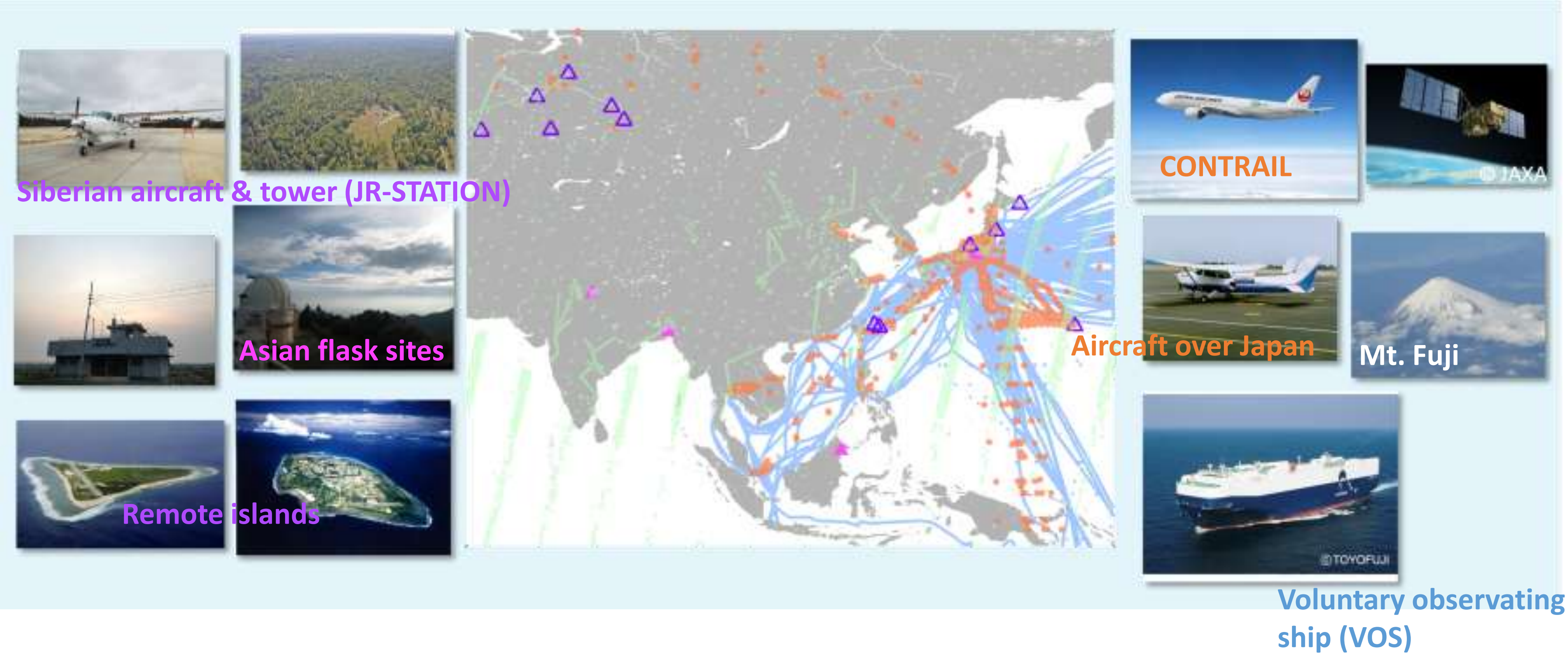
Aircraft

ObsPack
+ CONTRAIL
+ JMA
+ TU

GOSAT

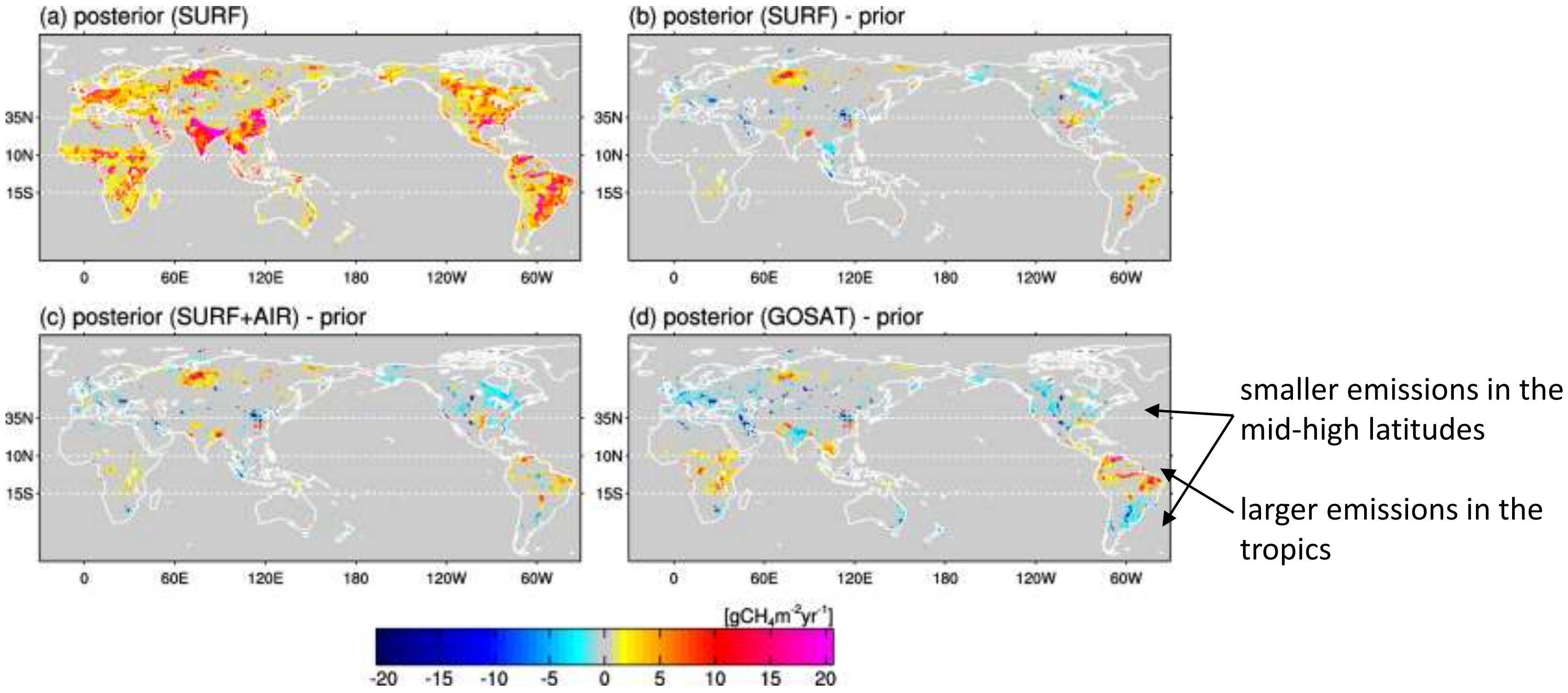
NIES Full Phys.
ver. 02.95/96

Unique network in Asia



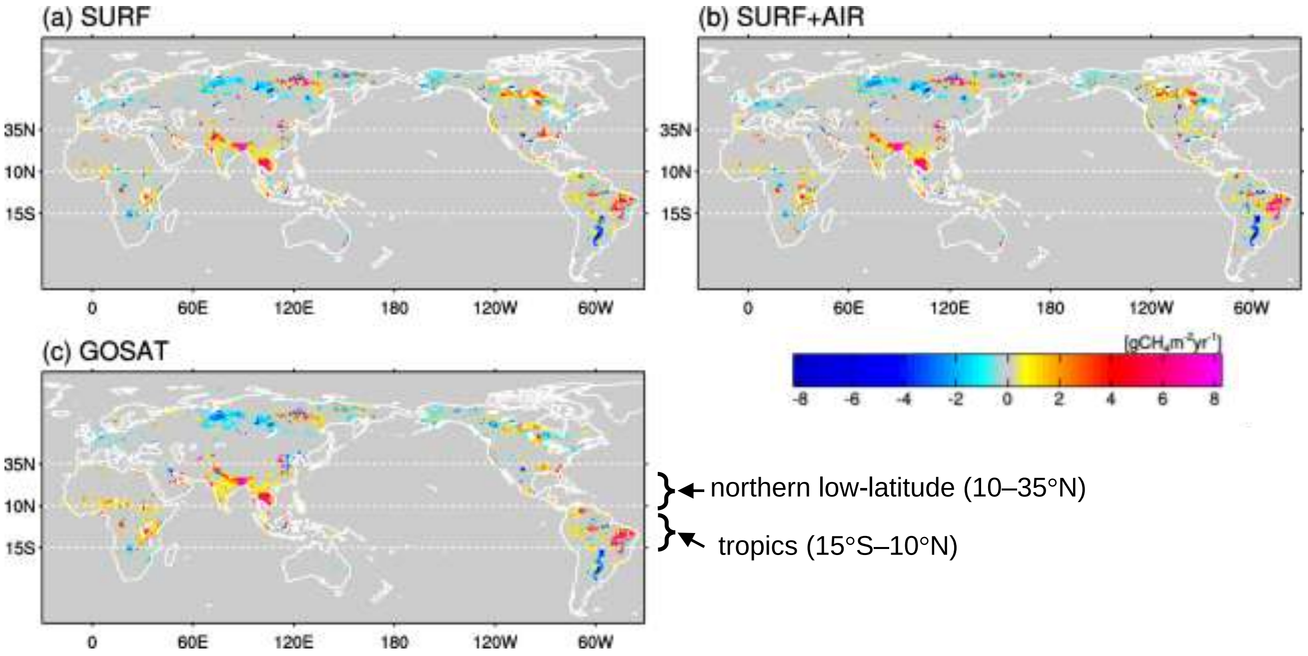
GOSAT inversion shows different flux distribution

Mean CH_4 emission for 2016–2019



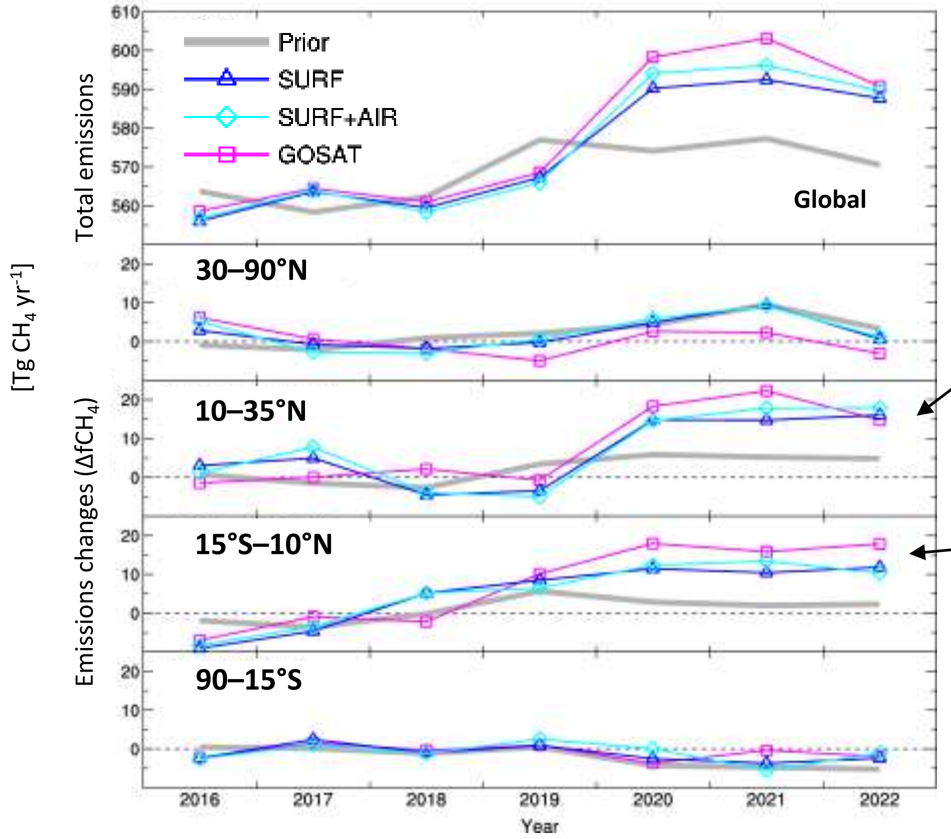
Emission increases are consistent in the three inversions

Emissions changes from 2016–2019 to 2020–2022 (**ΔfCH_4**)



Emission increases in the tropics and the northern low-latitude for 2020–2022.

Global surge in 2020 is largely contributed by the northern low-latitude



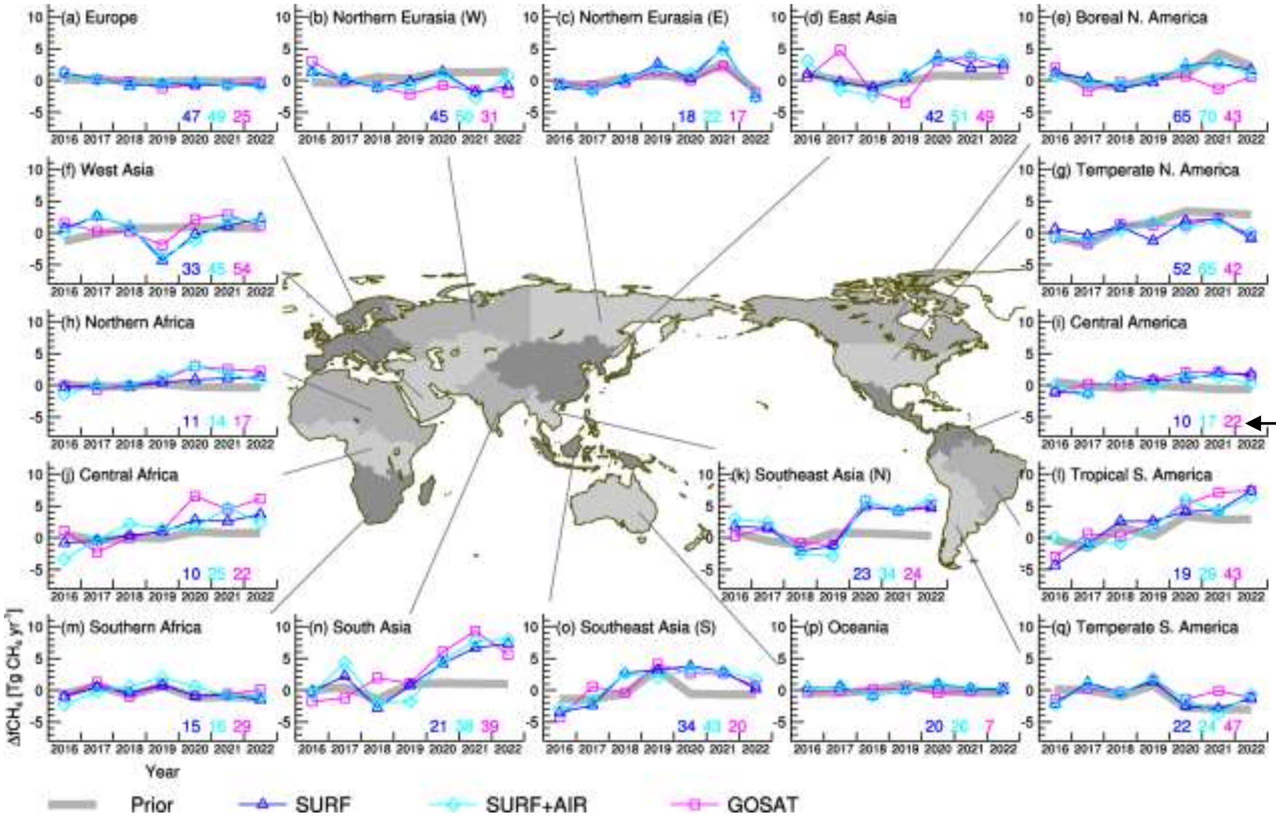
In the northern low-latitude:

A sharp rise from 2019 to 2020, and large emissions continue through 2022, whose magnitudes (ca. 20 Tg CH_4 yr^{-1}) are consistent among the inversions.

In the tropics:

Consistent increases of 10–18 Tg CH_4 yr^{-1} in 2020–2022; however, there are gradual increases from 2016.

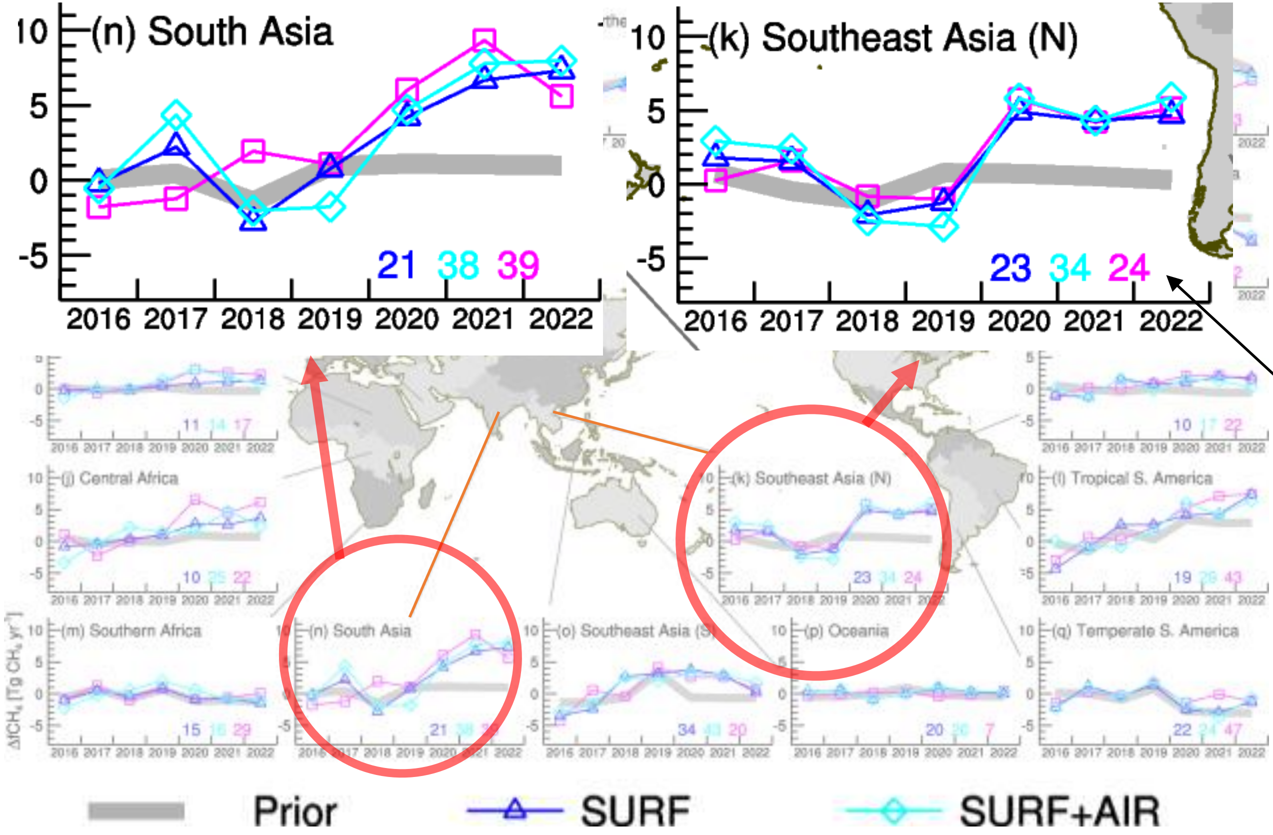
Asian regions are dominant contributors to the surge



Even for these smaller regions, general patterns are consistently estimated by the three different inversions.

Colored numbers denote uncertainty reduction ratios from prior to posterior errors.

Asian regions are dominant contributors to the surge

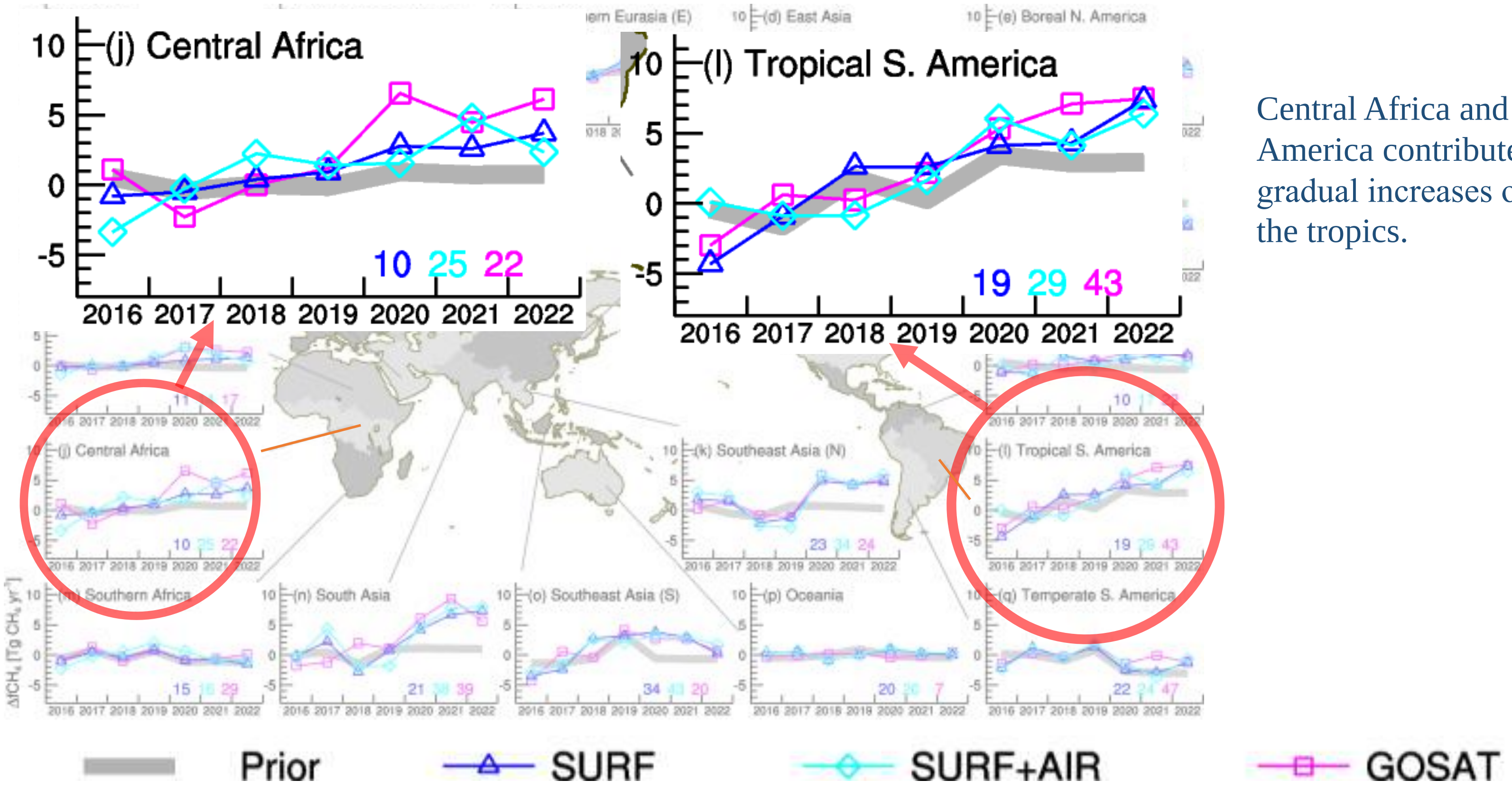


In northern Southeast Asia and South Asia, the abrupt increase of ΔfCH_4 by 5 Tg CH_4 yr^{-1} or more in 2020 and its continuation until 2022 is consistently estimated by all the inversions.

Colored numbers denote uncertainty reduction ratios from prior to posterior errors.

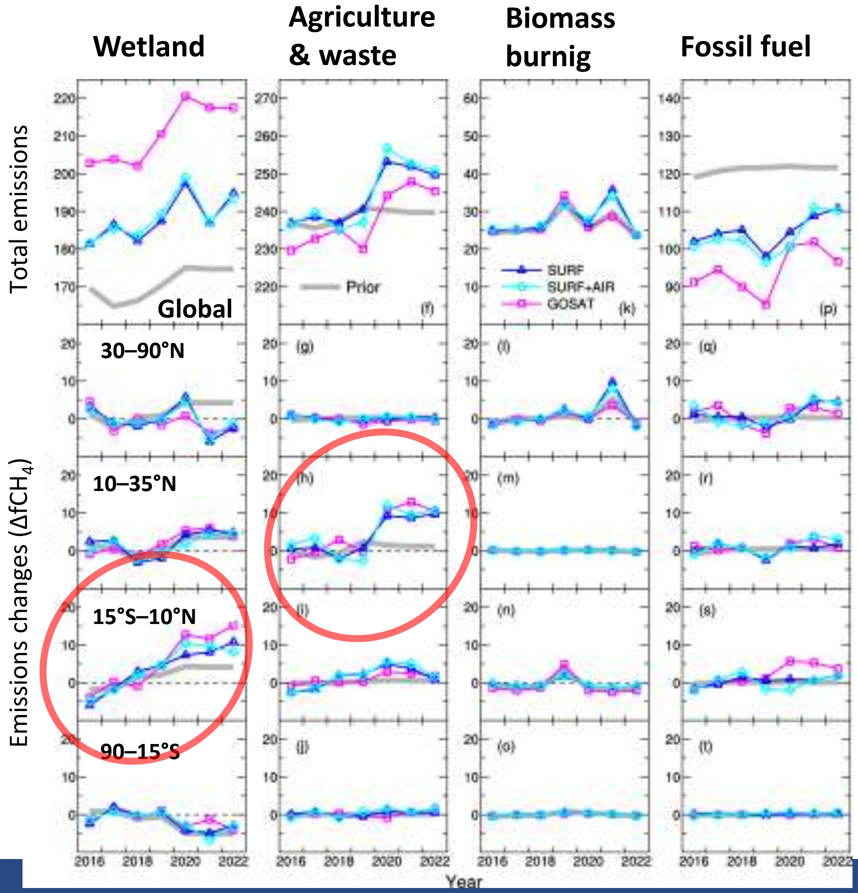
The SURF+AIR observations imposed constraints that were comparable to or 1.5 times stronger than GOSAT constraints on the flux estimates in South and Southeast Asia.

Asian regions are dominant contributors to the surge

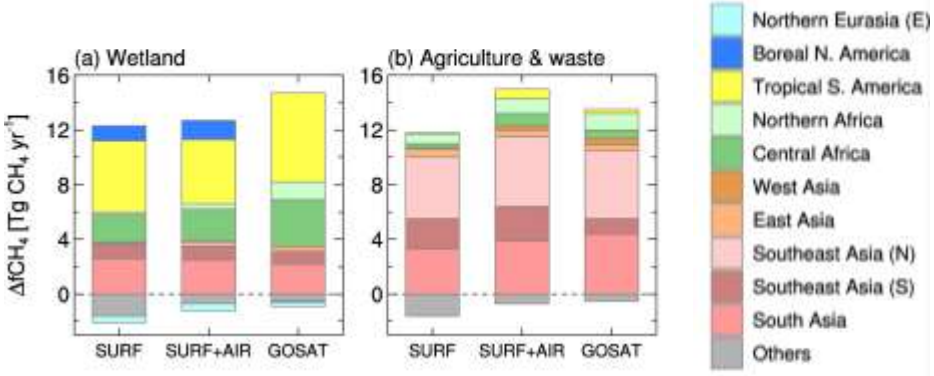


Central Africa and tropical South America contribute to the gradual increases of ΔfCH_4 in the tropics.

Large contributions from biogenic emissions

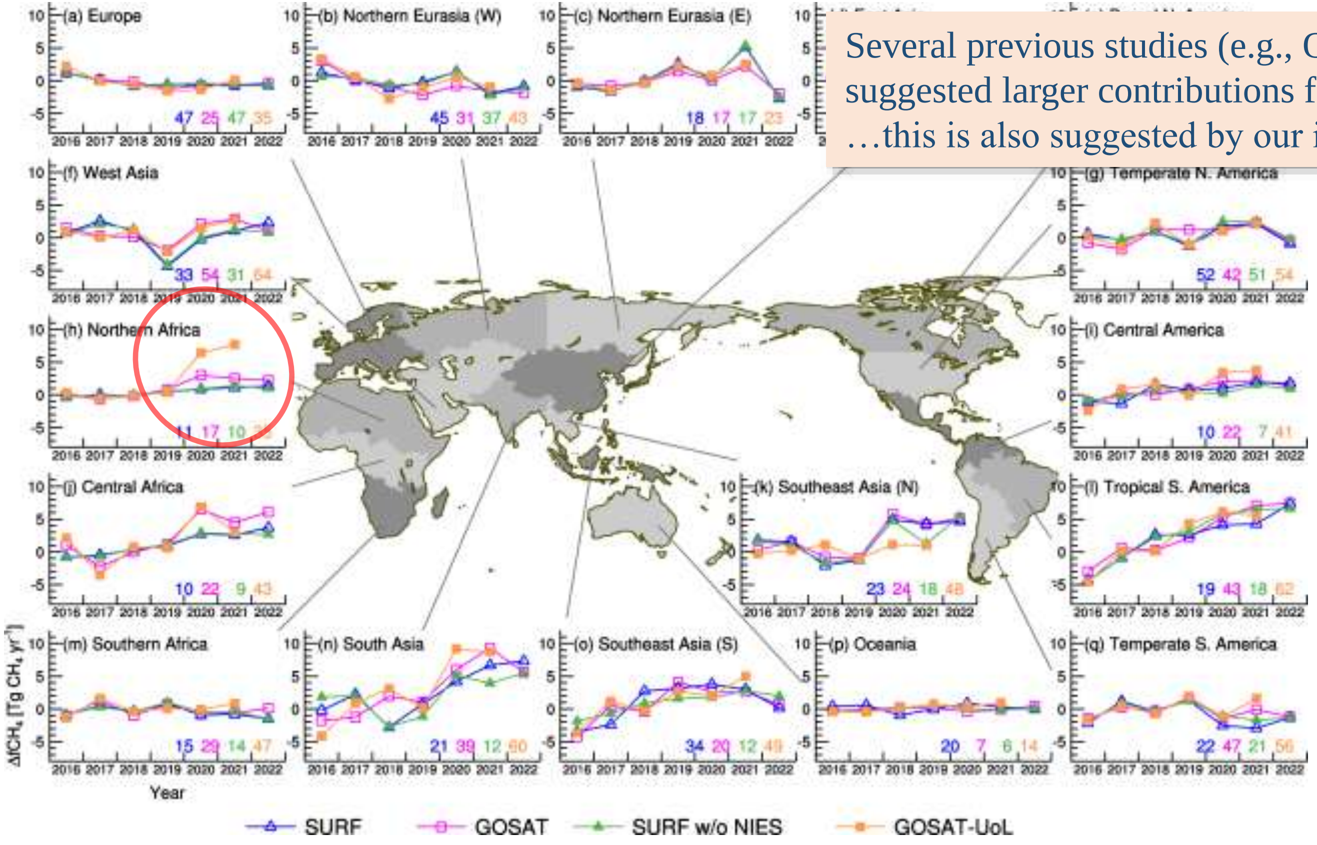


Increases are in wetland emissions in the tropics and in agriculture & waste emissions in the northern low-latitude, although their estimate have some negative correlations (from posterior error covariance) between the wetland and agriculture & waste sectors.



Regional contributions to emissions changes for 2020–2022

Africa?



Several previous studies (e.g., Qu et al., 2022; Feng et al., 2023) suggested larger contributions from Africa.
…this is also suggested by our inversion with GOSAT-UoL.

Due to the greater coverage of the UoL data in Africa?

What caused the discrepancy in Southeast Asia?

Conclusion

Different flux estimates from different satellite products:

It would be better to use different satellite products.

In-situ and flask observations would be helpful to get robust flux estimates.

However, we need more elaborate networks of in-situ and flask observations, especially in Africa.