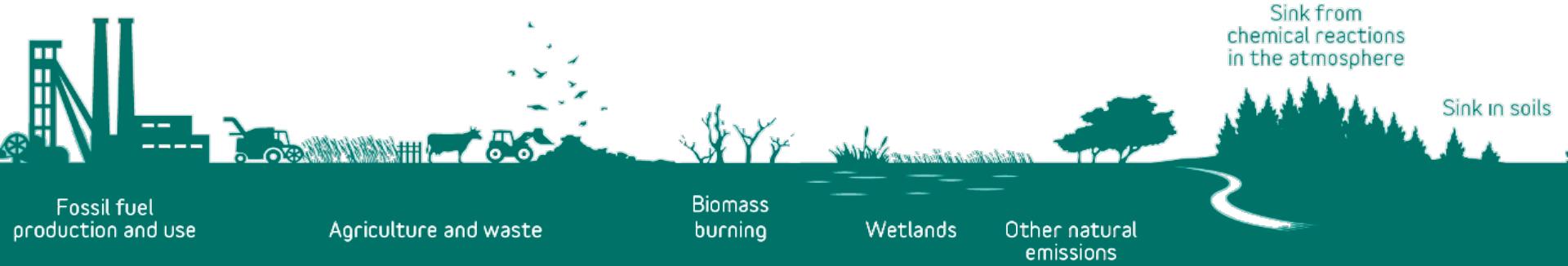
西湖大學
WESTLAKE UNIVERSITY

# Agriculture and Global Methane Emissions

# 农业与全球甲烷排放

Yuzhong Zhang **张羽中**



# Acknowledgement



Harvard
Daniel Jacob, Jianxiong Sheng, Xiao Lu, Tia Scarpelli, Lu Shen, Zhen Qu

JPL
Jet Propulsion Laboratory

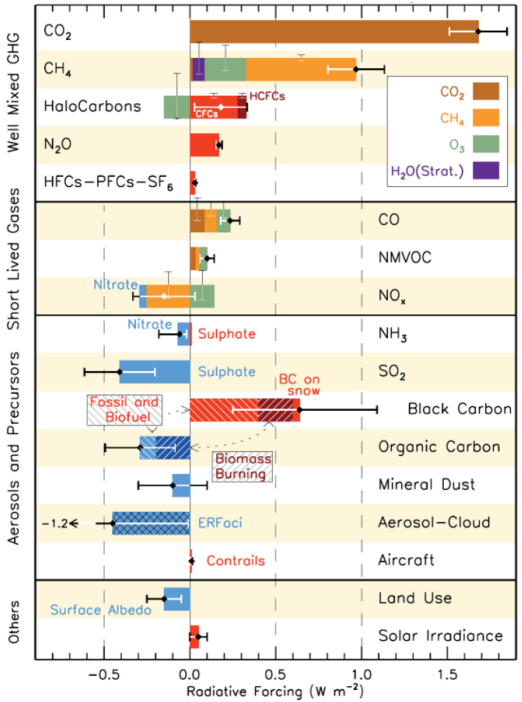
JPL John Worden, Anthony Bloom, Shuang Ma

SRON
Netherlands Institute for Space Research

SRON Bram Maasakkers

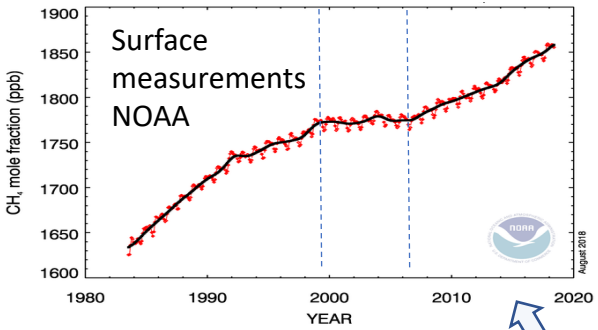
# Methane: a potent greenhouse gas

Radiative forcing

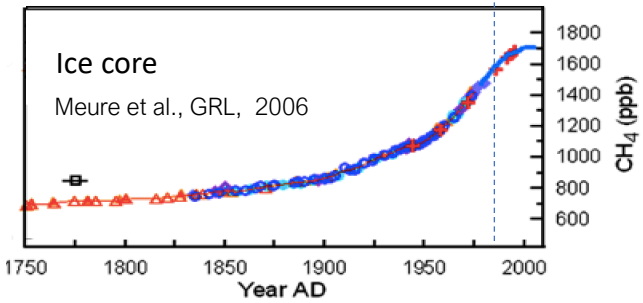



IPCC AR5

Methane concentration in last 35 years




Methane concentration in last 300 years

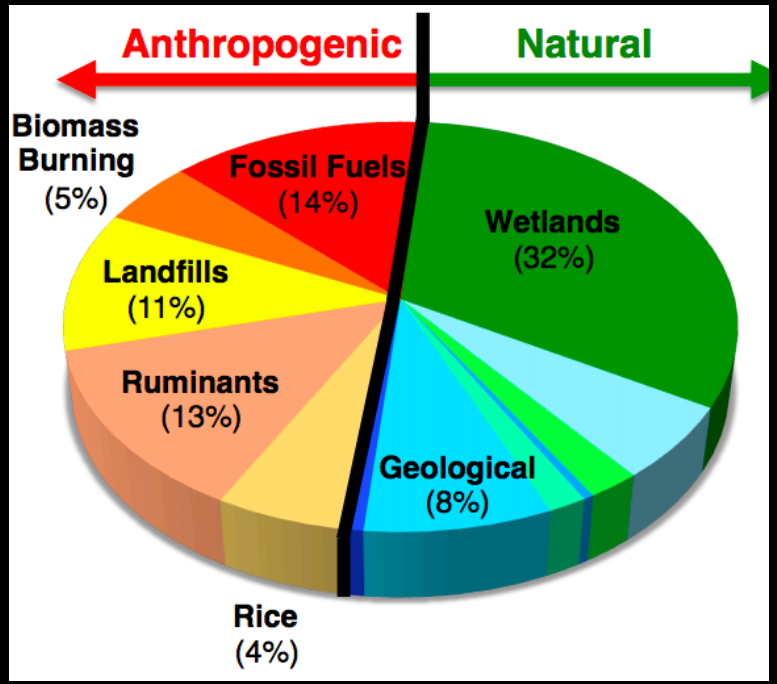


# Sources of atmospheric methane







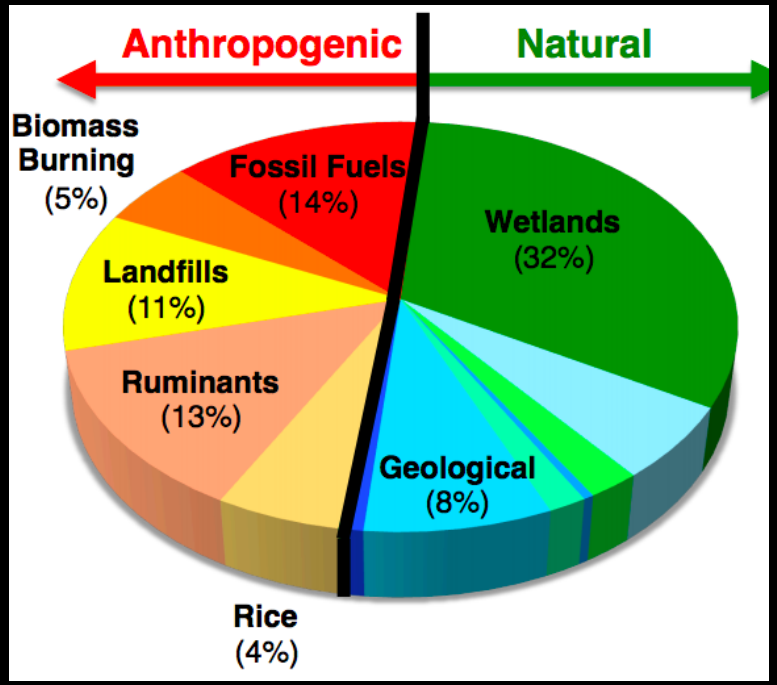


# Sources of atmospheric methane



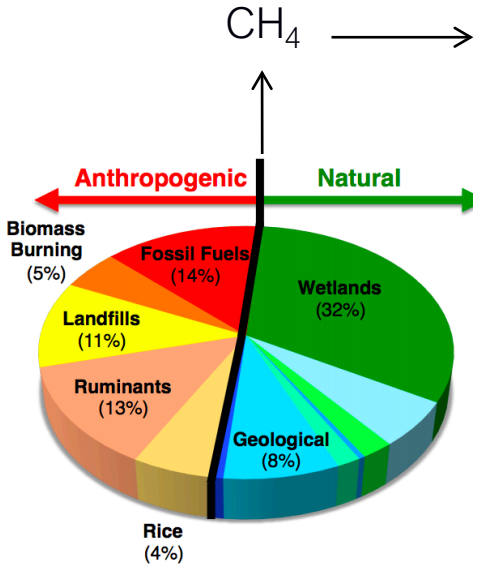







Agricultural activity

# Sink of atmospheric methane




## Source

$550 \pm 60$ Tg $a^{-1}$

## Sink

**Lifetime ~10 years**

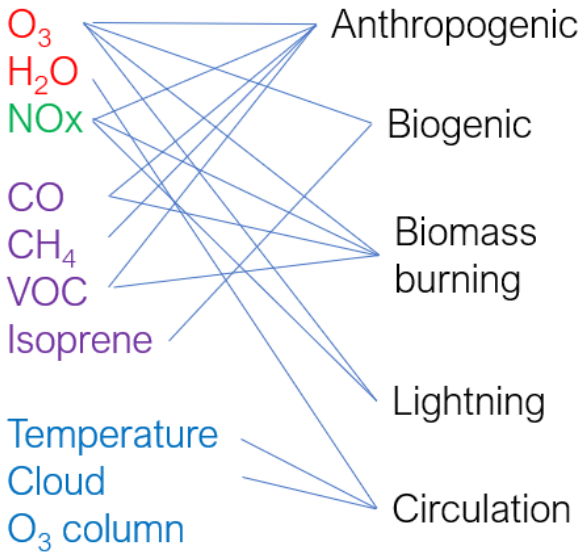
Tropospheric OH 89%

Soil Absorption

Stratospheric Loss

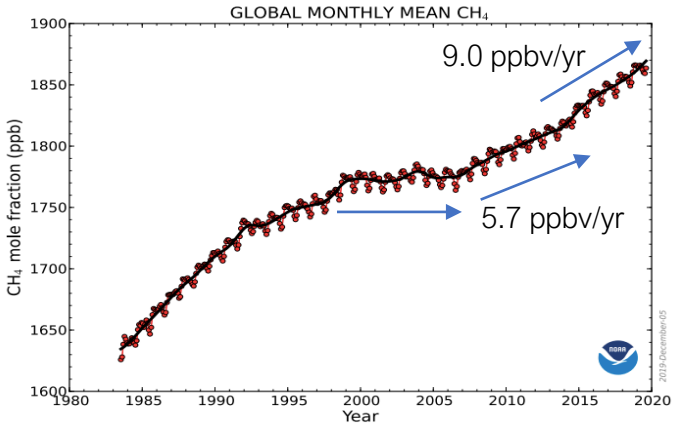
Tropospheric Cl

## Factors affecting OH



# What drives the increase of methane concentration?

## CH4 concentration in last 35 years

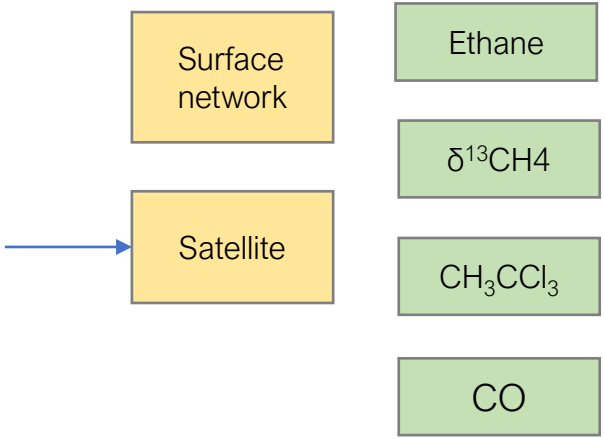


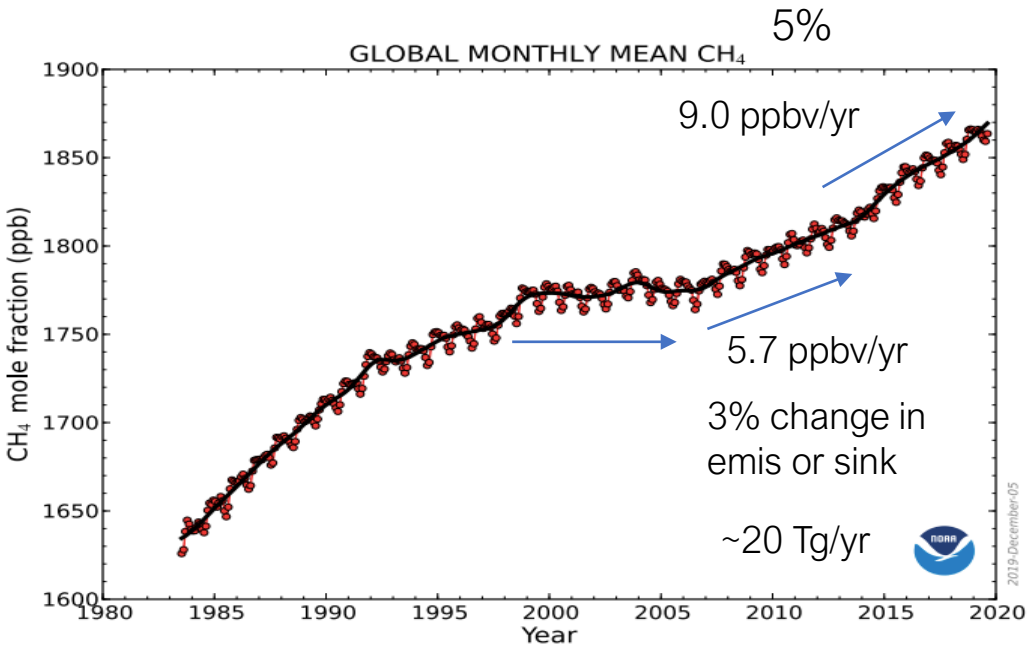

## Theories proposed to explain 2007 regrowth

| | | |
|---|---|---|
| Ethane | Increasing fossil fuel (oil/gas) emissions | Rice et al., PNAS; Hausmann et al., ACP |
| $\delta^{13}CH4$ | Increasing wetland/agriculture emissions | Nisbet et al., GBC; Schaefer et al., Science |
| $CH_3CCl_3$ | Decreasing OH concentrations | Rigby et al., PNAS; Turner et al., PNAS |
| CO | Increasing fossil fuel emissions with decreased biomass burning emissions | Worden et al., Nature Communications |

# What drives the increase of methane concentration?

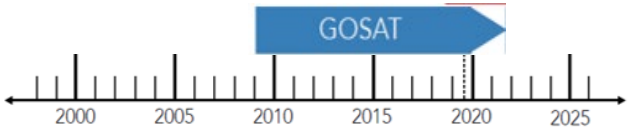
## Atmospheric constraints

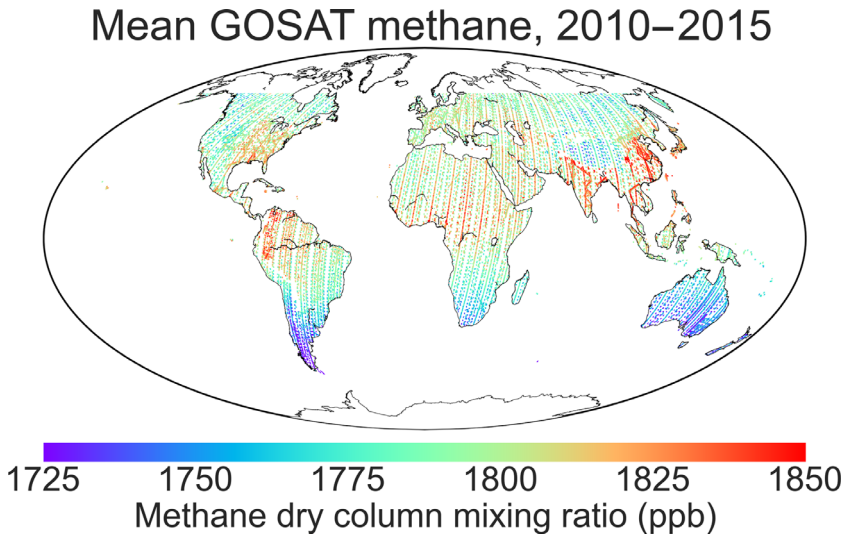


# Long-term Satellite Methane Observations

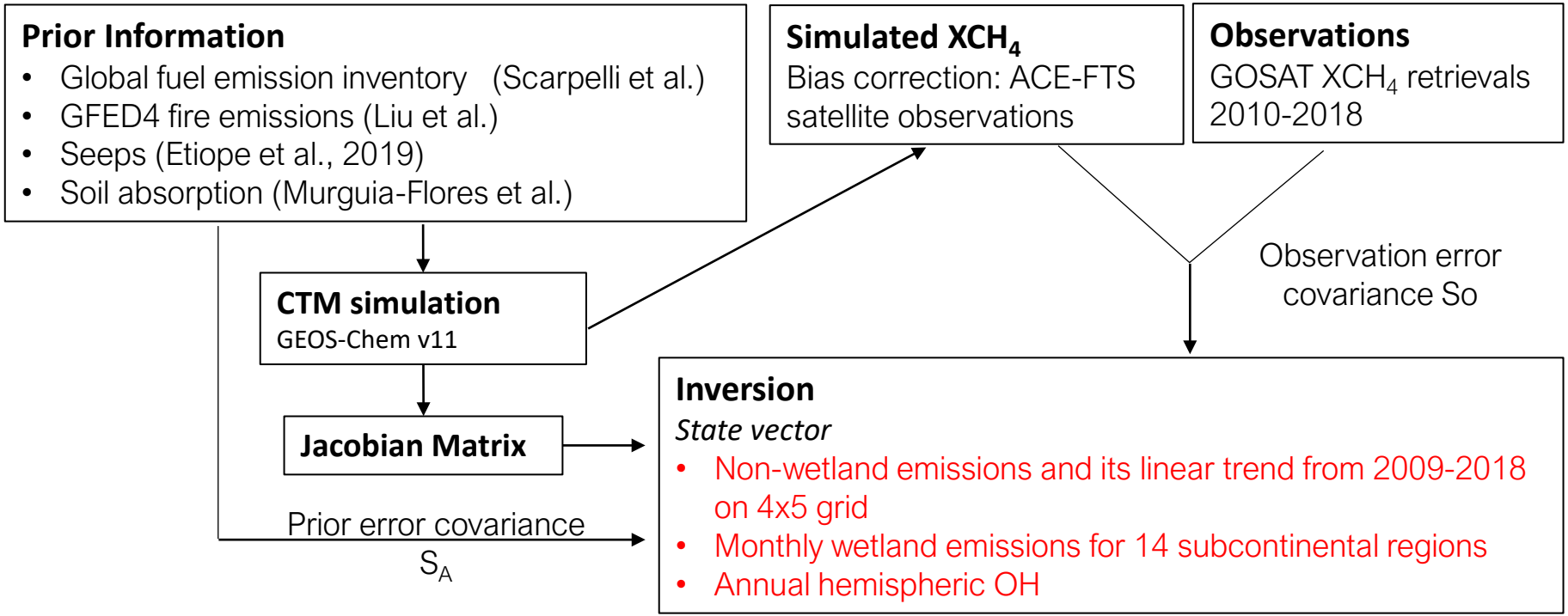
GOSAT Satellite



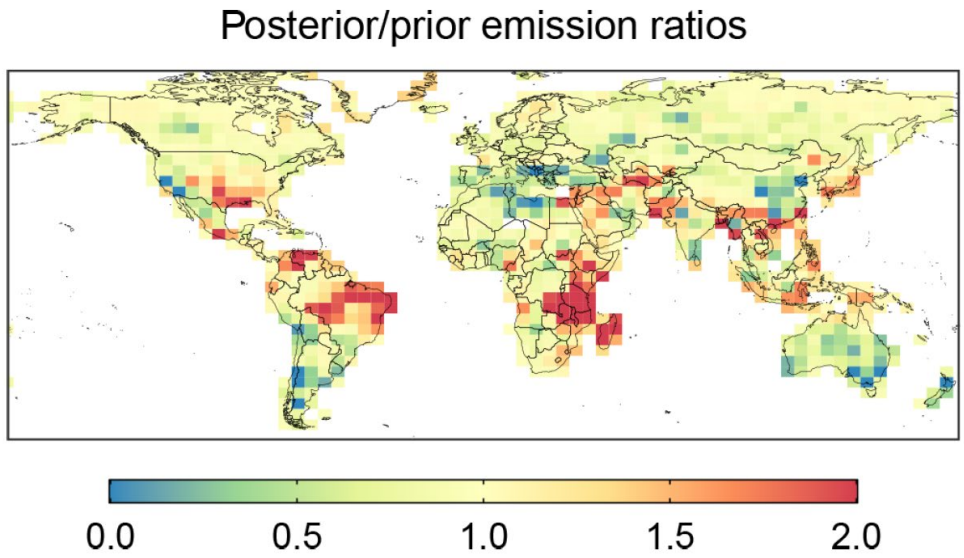

Maasakkers et al., ACP, 2019

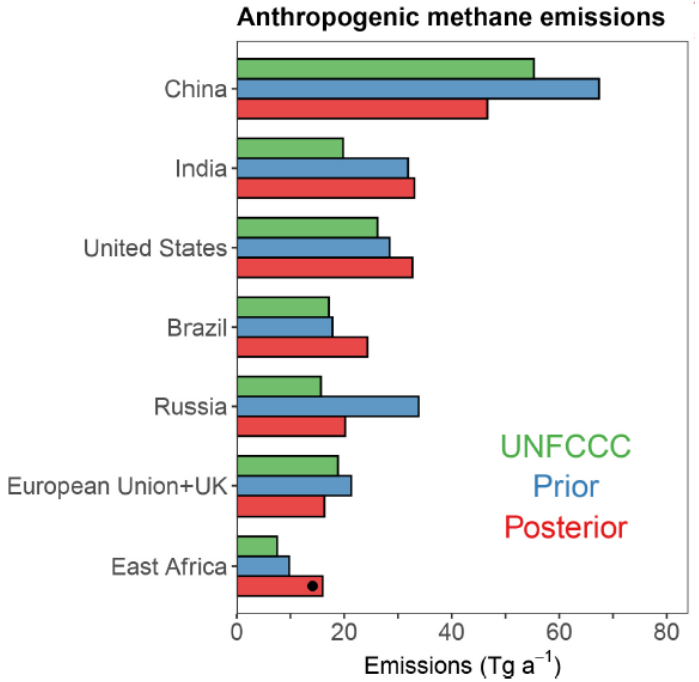
# Inversion Analysis Framework




Zhang et al., ACP, 2021

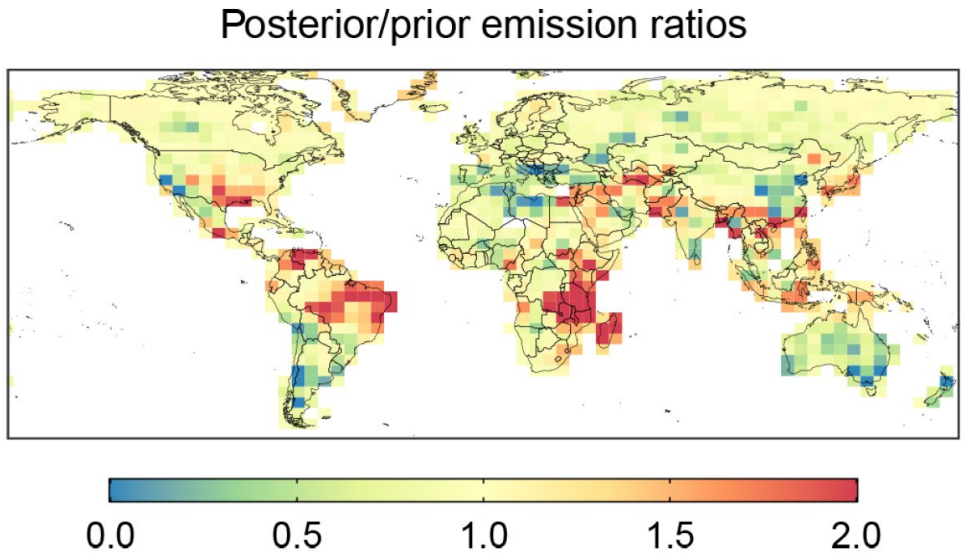
# Anthropogenic Methane Emissions

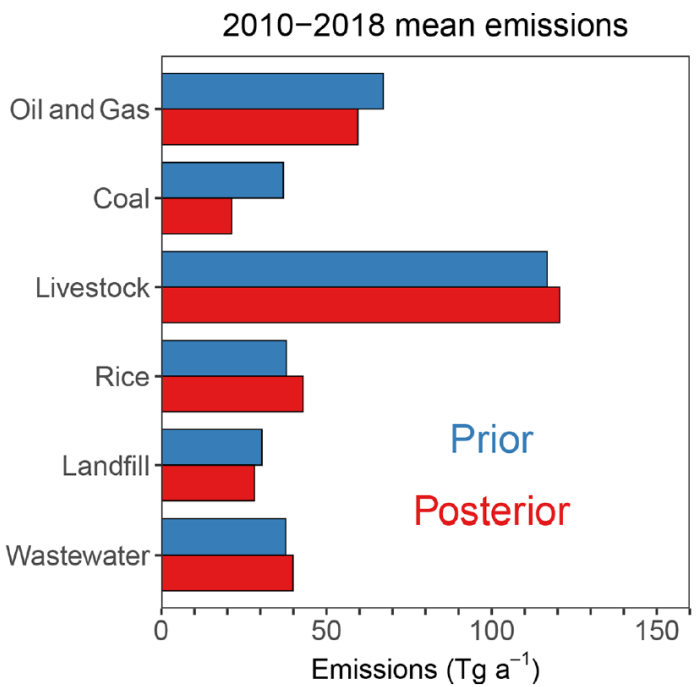


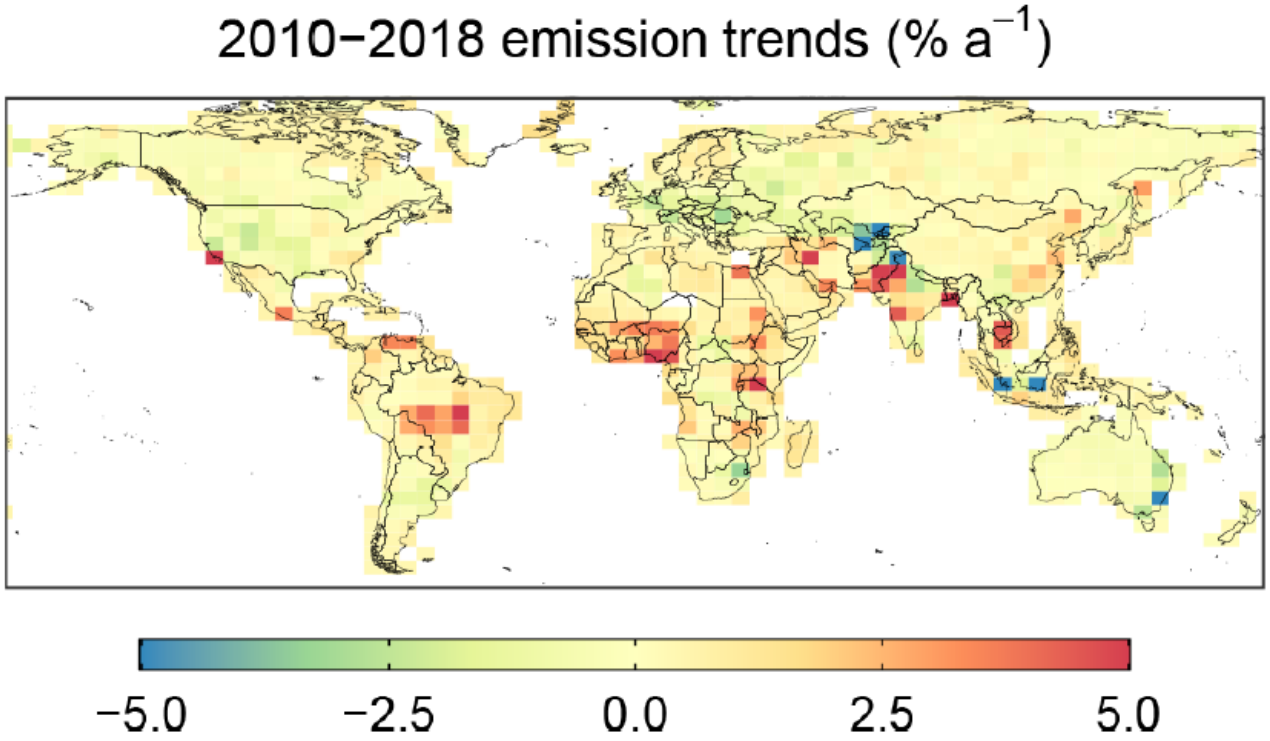

Zhang et al., ACP, 2021

# Anthropogenic Emissions: Sector Attribution

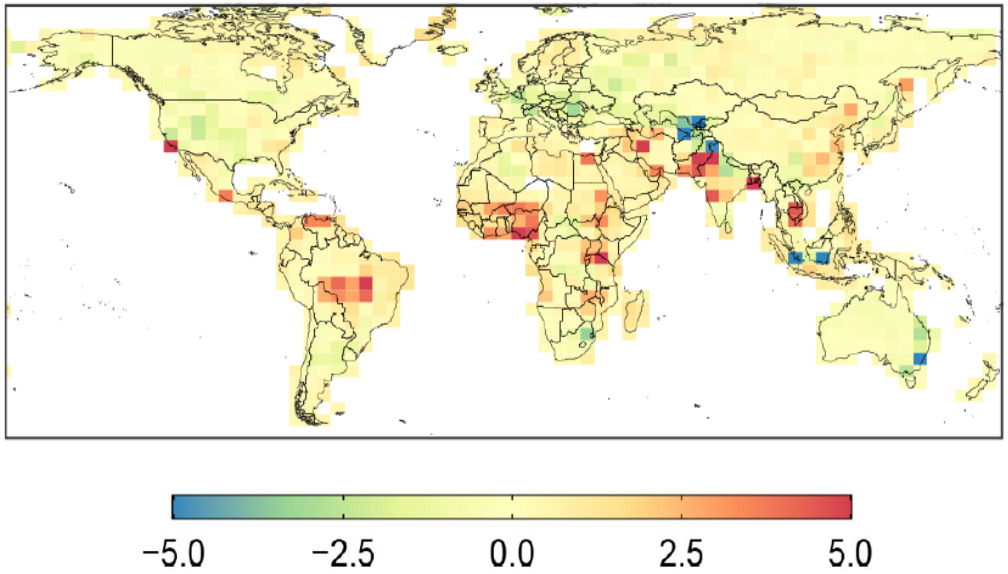


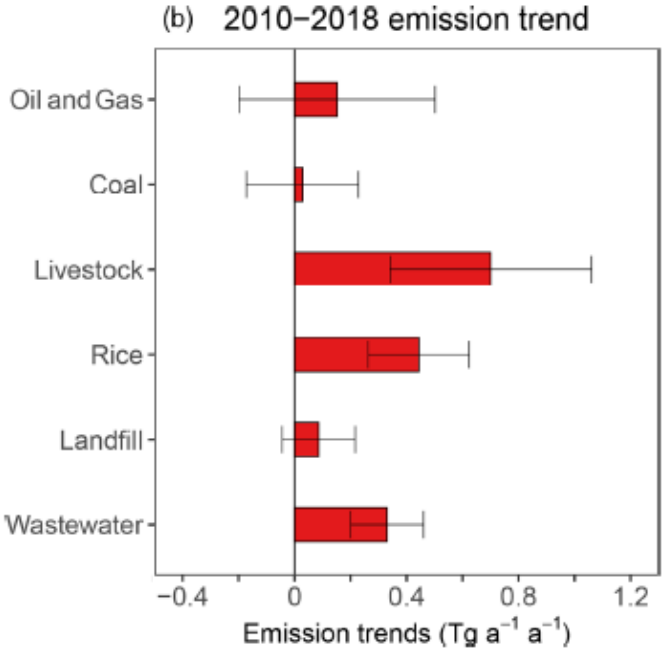



# Anthropogenic Emission Trend, 2010-2018

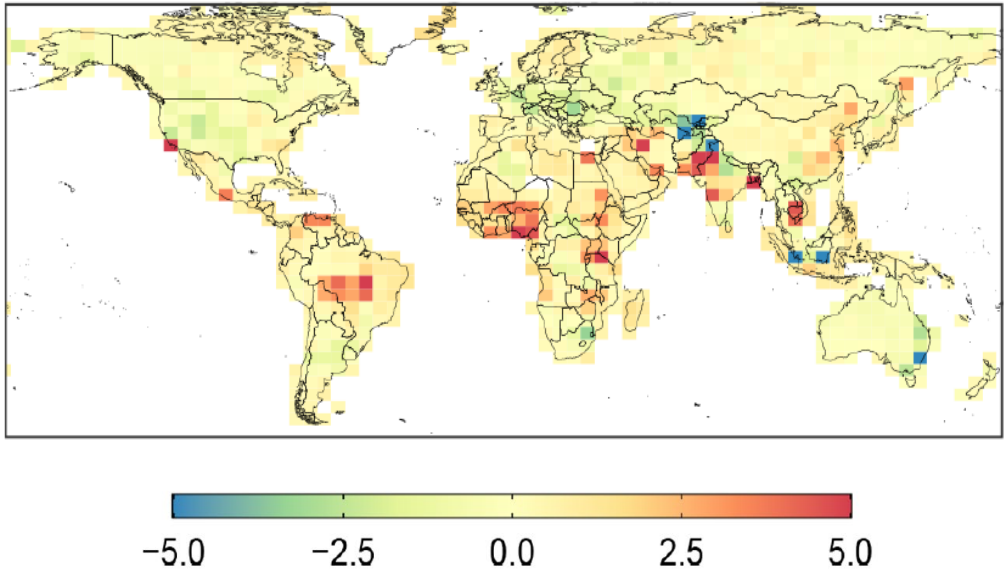


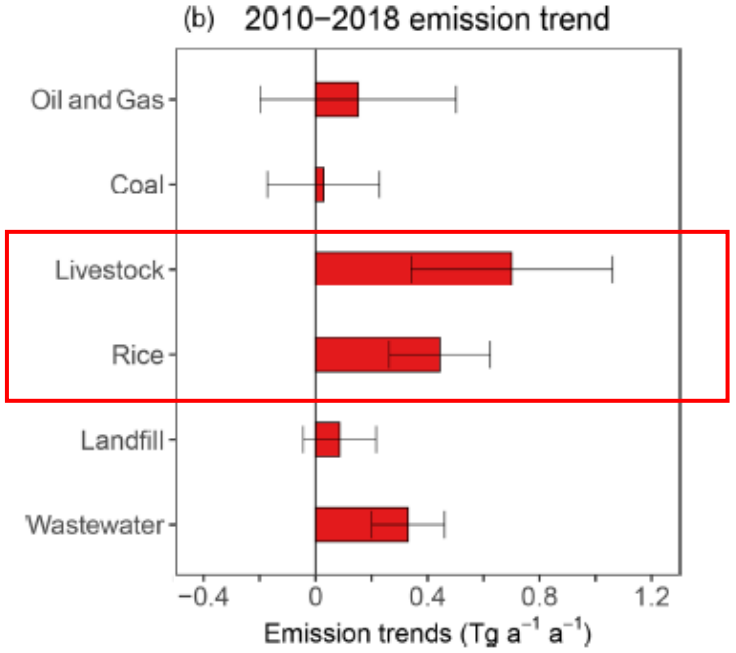
# Anthropogenic Emission Trend: Sector Attribution

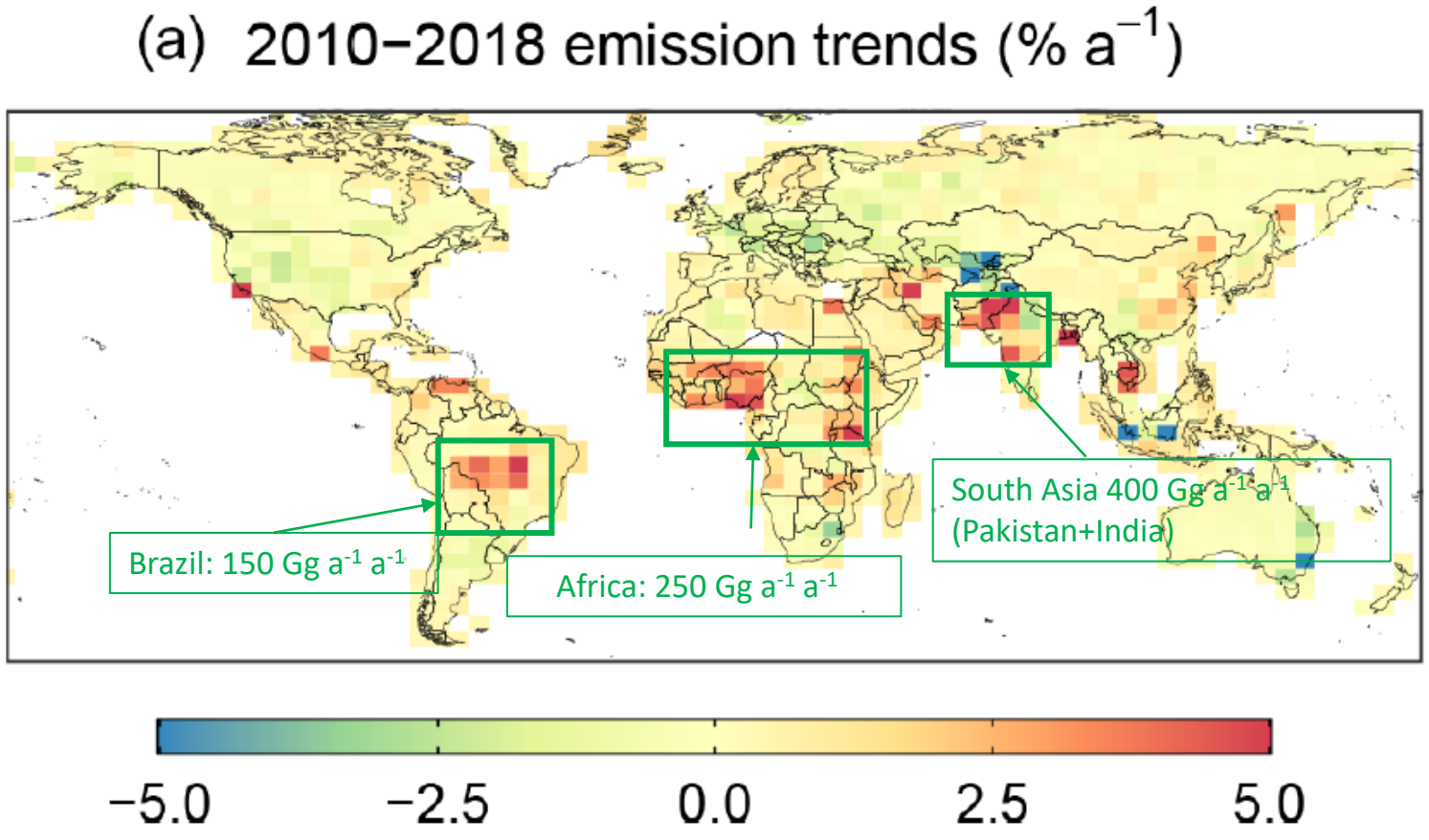


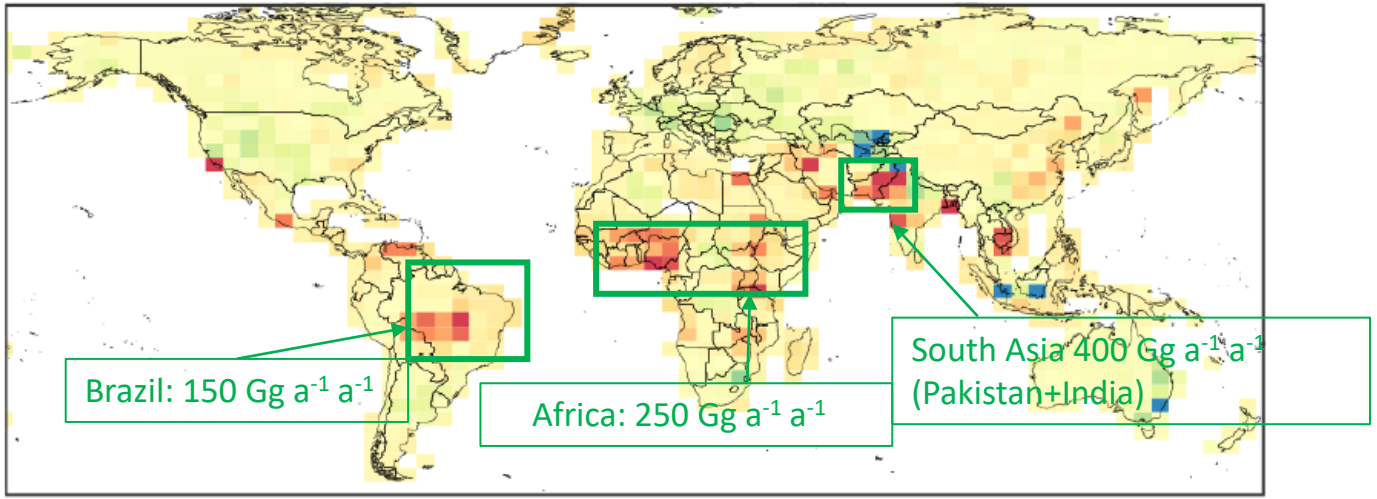



# Anthropogenic Emission Trend: Sector Attribution




(a) 2010−2018 emission trends (% a−1)
Brazil: 150 Gg a-1 a-1
Africa: 250 Gg a-1 a-1
South Asia 400 Gg a-1 a-1
(Pakistan+India)
−5.0
−2.5
0.0
2.5
5.0

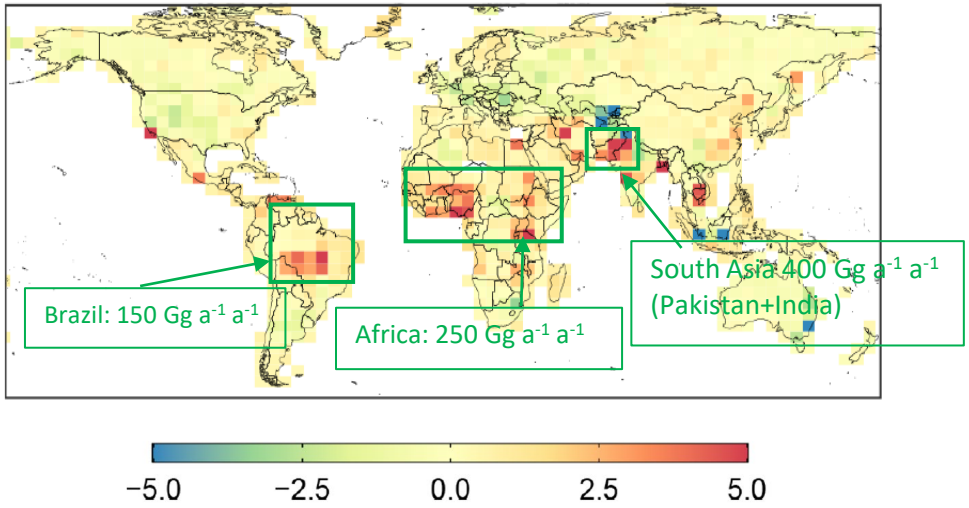



Top 5 counties with fastest growing cattle population

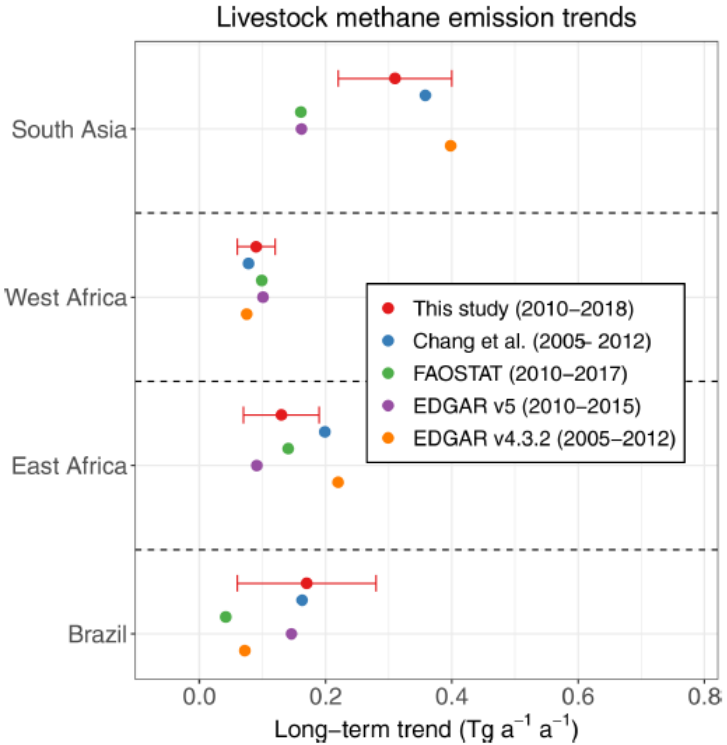
UNFAO

| Country | Trend (million head per year) |
|---|---|
| Pakistan | 1.4 |
| Ethiopia | 1.2 |
| Tanzania | 1.1 |
| Brazil | 0.9 |
| Argentina | 0.7 |

# Increasing livestock emissions

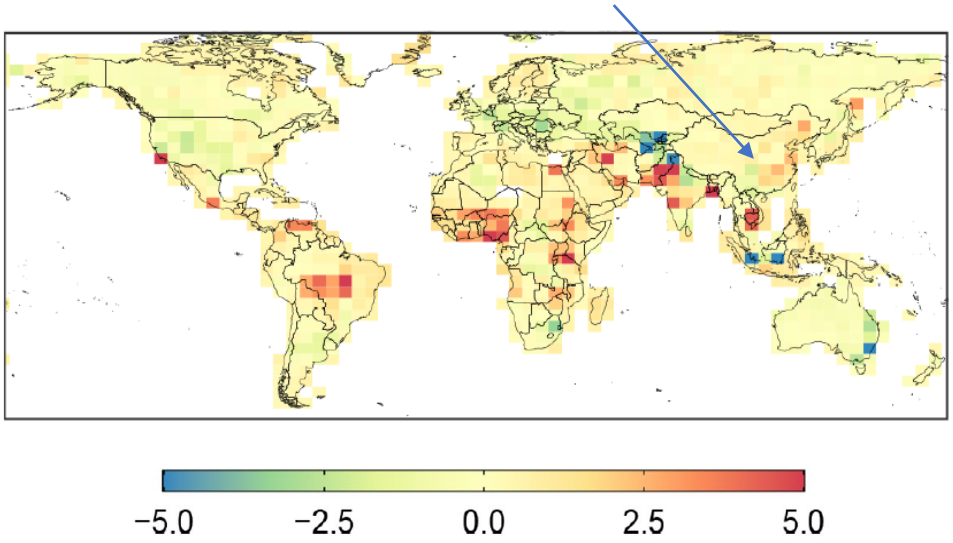



Compare with livestock inventories

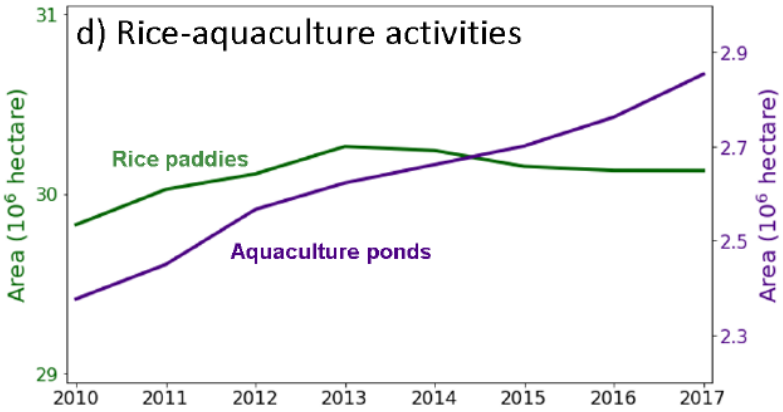


# Increasing Rice Emissions

Increase in southern & northeast China



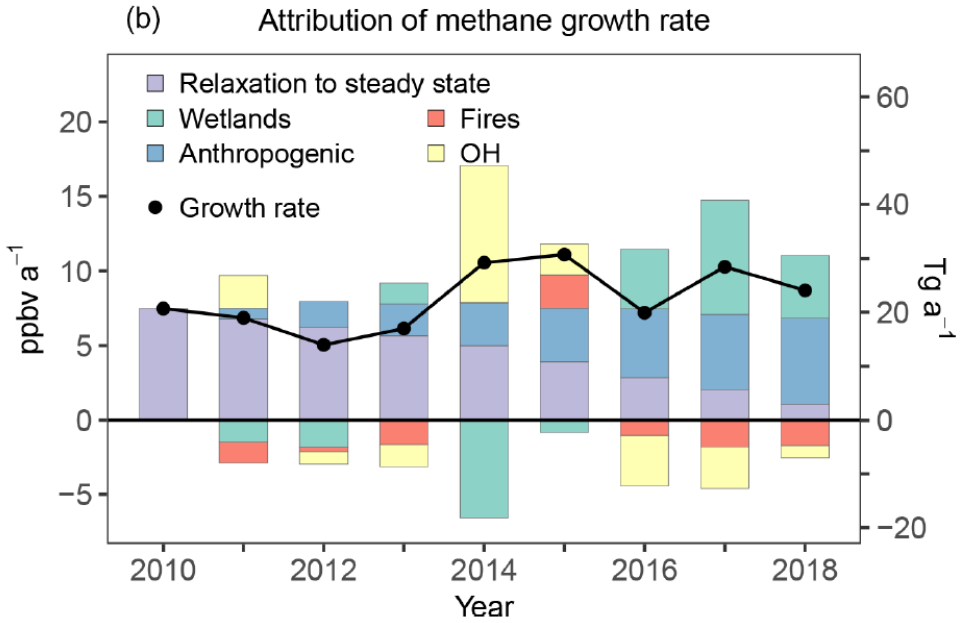

China: rice paddies & aquaculture



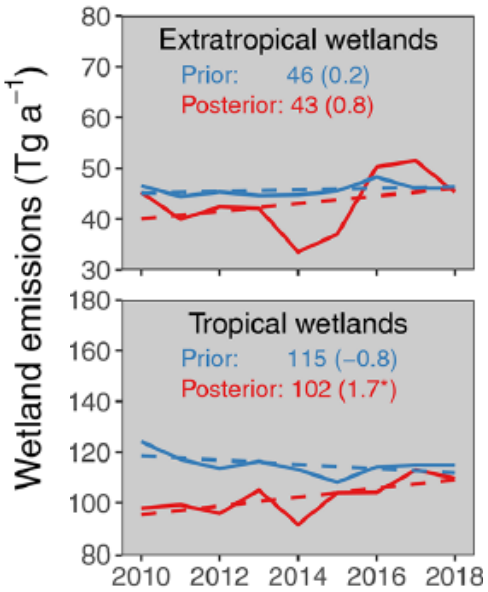

Sheng et al., Nat Geoscience, in review

# Global Methane Budget

Growth rate




Wetland Emissions



# Summary

Methane emissions from agriculture systems (livestock and rice cultivation) are

- underestimated in current emission inventory;
- largest anthropogenic contributor to increasing methane emissions

Knowledge gap in methane emissions from agriculture systems over developing regions is huge, compared to fossil fuel emissions in the North America.