Anthropogenic methane emissions in China from 1980 to 2010

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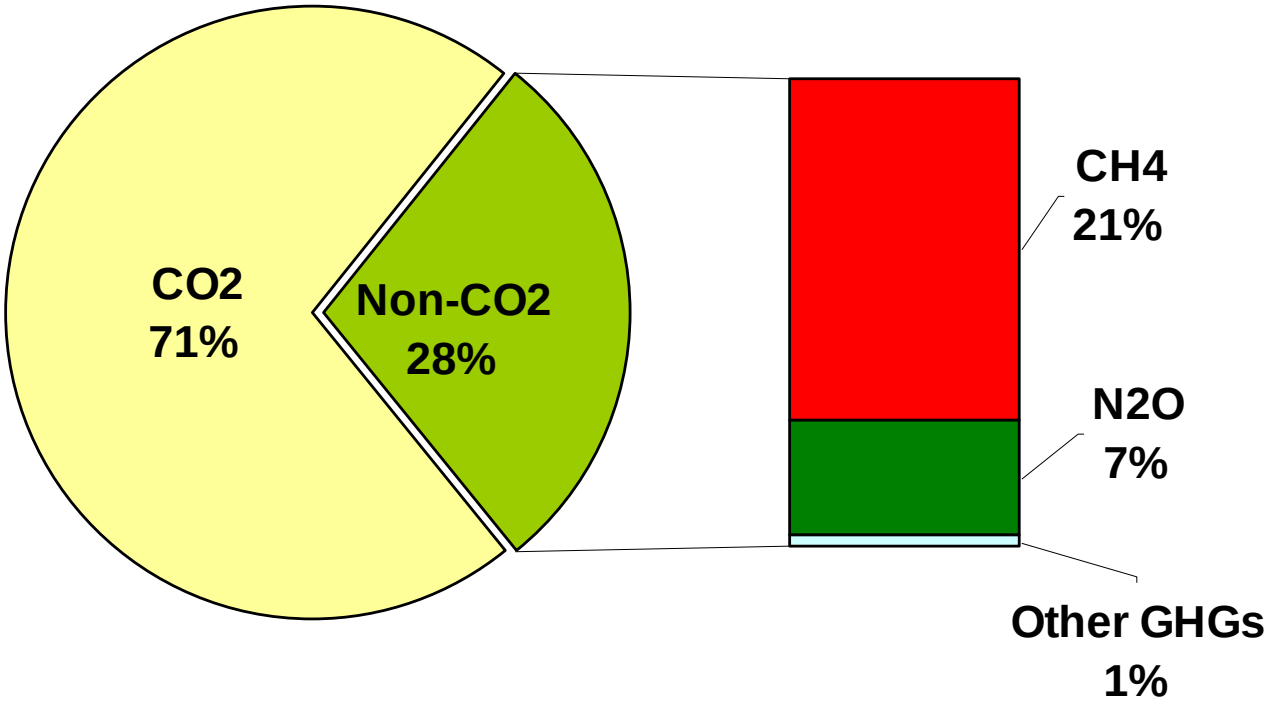
[2] LSCE

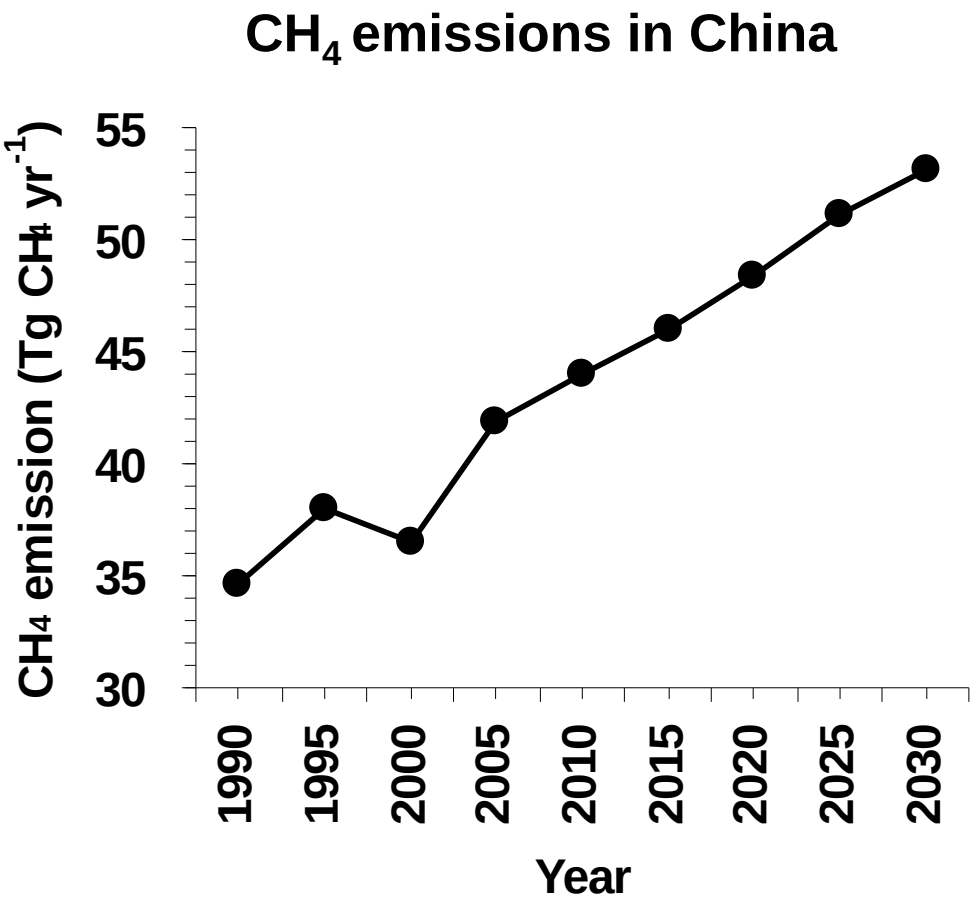
SOFIE radiative forcing workshop, 02/10/2012

Motivation



Second anthropogenic greenhouse gas in terms of radiative forcing

Motivation

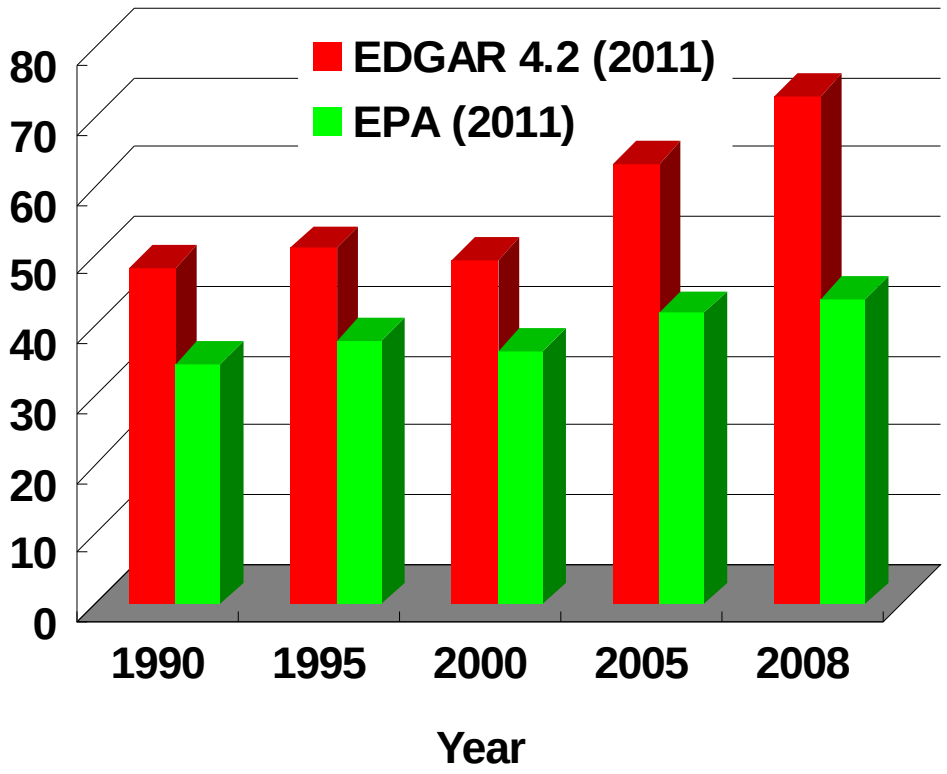


Since 2005, China is NO.1 in CH4 emission.

(www.globalmethane.org)

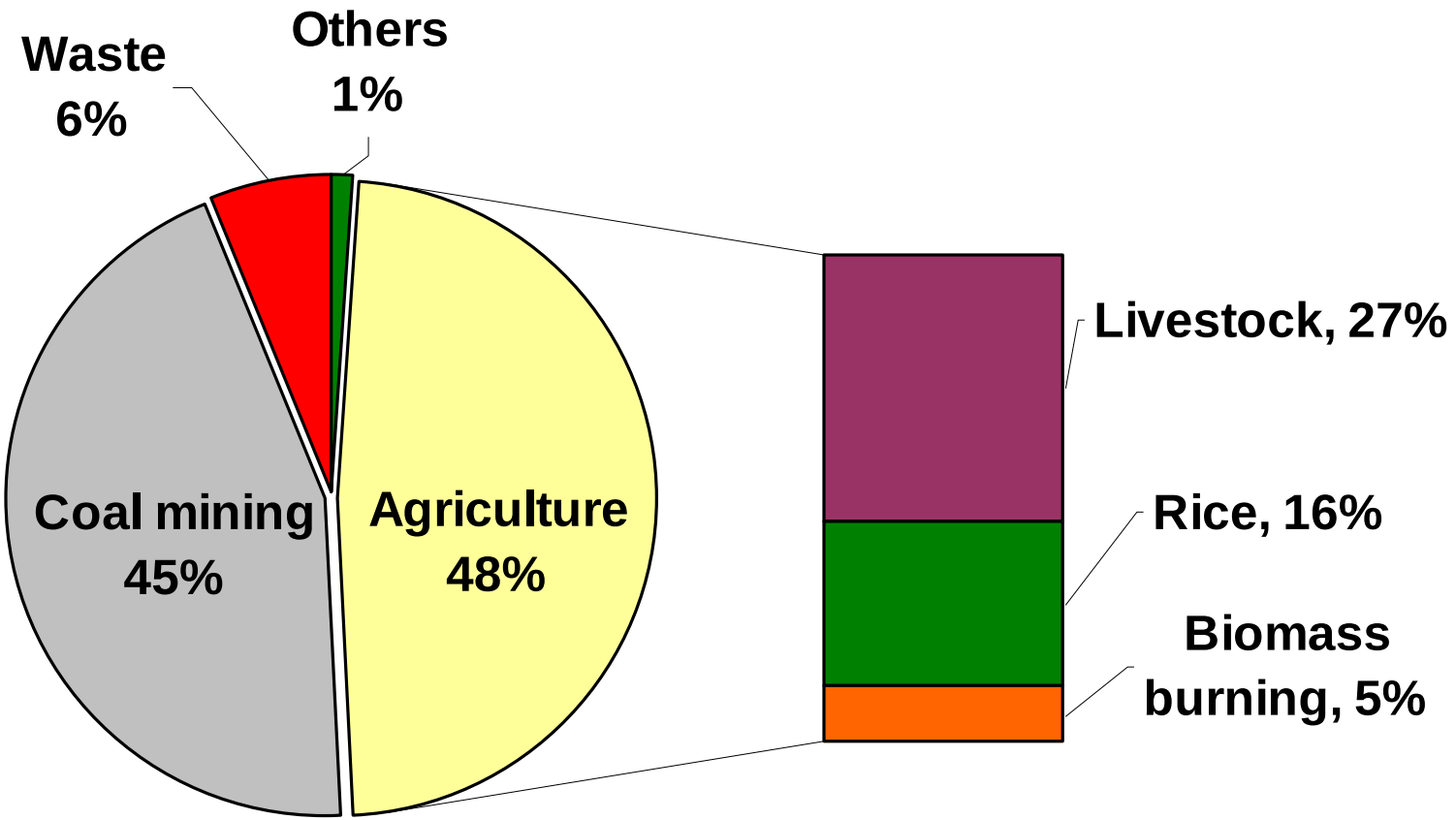
Motivation

Big uncertainty in CH_4 emissions in China



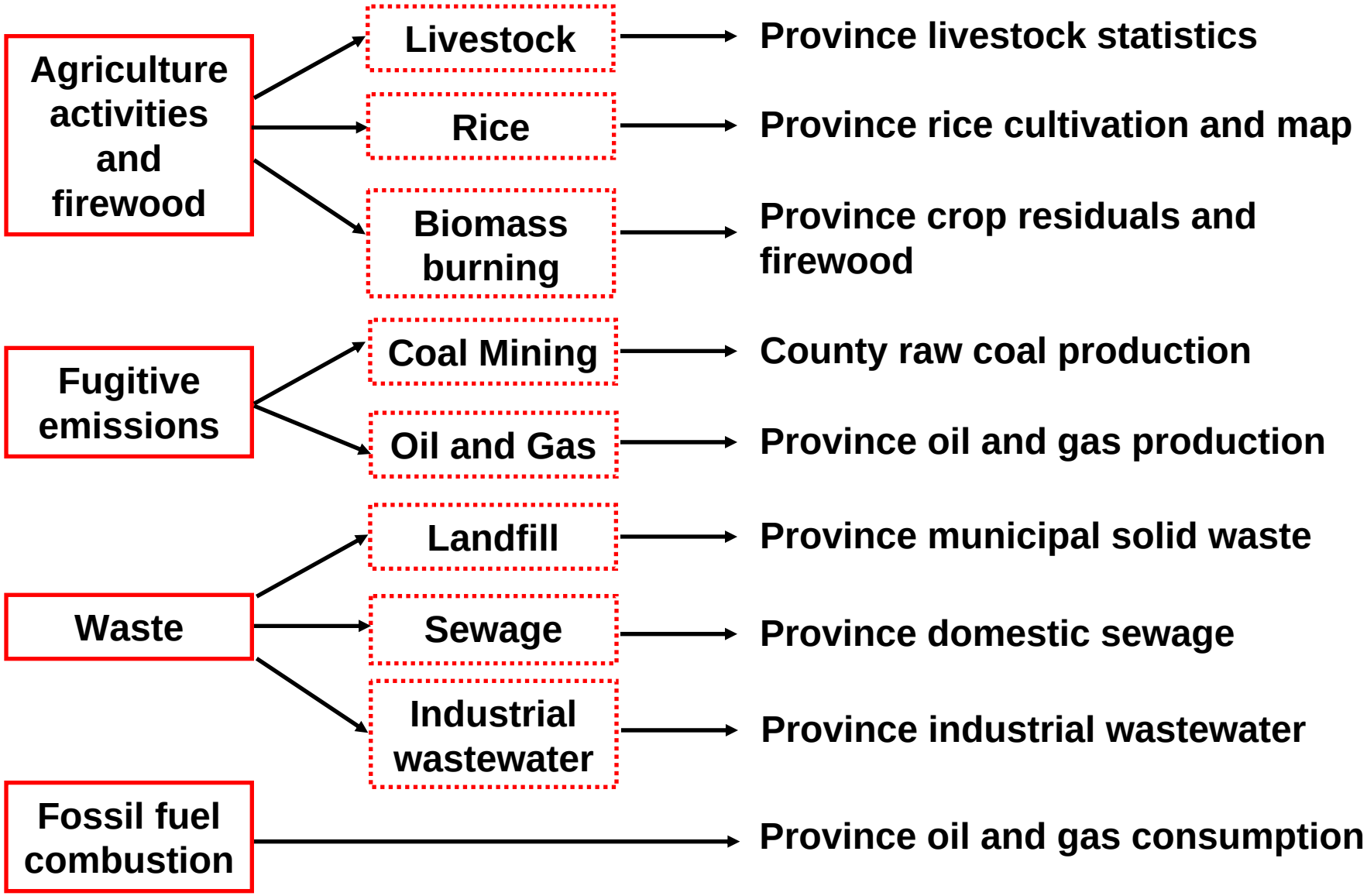
~30 Tg CH4 yr^{-1} difference between EDGAR 4.2 (2011) and EPA (2011) in 2008, and Zhang et al. (2010) reported China emit ~40 Tg CH4 in 2007.

Sources of CH_4 emissions in China



EPA, 2011; Zhang et al., 2010, Energy Policy

Methods and Datasets



Methods and Datasets

County level:

- Population
- Rural population
- GDP of agriculture
- GDP of industry,
- Total GDP

Interpolation high spatial resolution CH4 emissions maps

Data sources:

- China Agriculture Yearbook
- China Energy Statistical Yearbook
- China Environment Yearbook
- China Statistical Yearbook

Fugitive CH_4 emissions from coal mining and oil and gas systems

CH_4 emissions from coal mining

EQUATION 4.1.3
TIER 1: GLOBAL AVERAGE METHOD – UNDERGROUND MINING – BEFORE ADJUSTMENT FOR ANY METHANE UTILISATION OR FLARING

Ch_4 emissions = CH_4 Emission Factor ● Underground Coal Production ● Conversion Factor

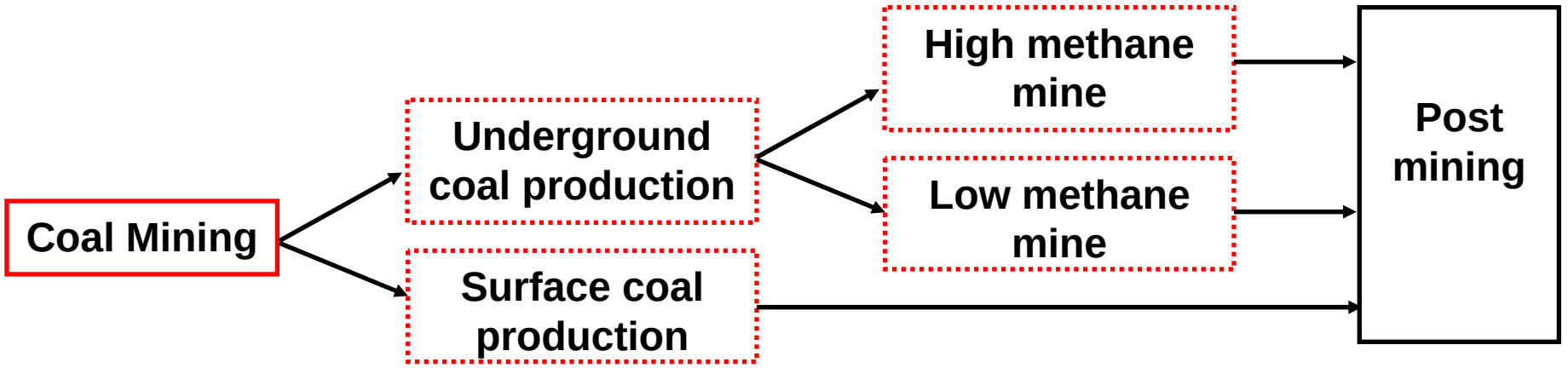
Where units are:

Methane Emissions (Gg $year^{-1}$)

CH_4 Emission Factor (m^3 $tonne^{-1}$)

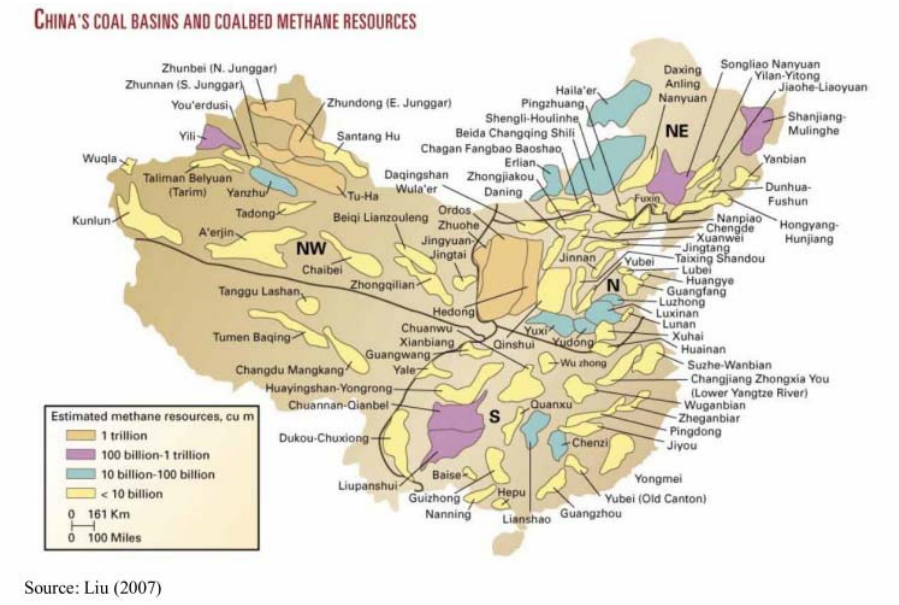
Underground Coal Production (tonne $year^{-1}$)

IPCC GHGs guideline, (2006)



CH_4 emission factors of coal mining

	Coal mining (m^3/t)		Post-mining (m^3/t)	
	Zhang and Chen, (2010)	IPCC, 2006	Zhang and Chen, (2010)	IPCC, 2006
High methane mine	**21.83**	**18**	**3.02**	**2.5**
Low methane mine	**4.53**	**18**	**1.13**	**2.5**
Surface	**2.5**	**1.2**	**0.1**	**0.1**

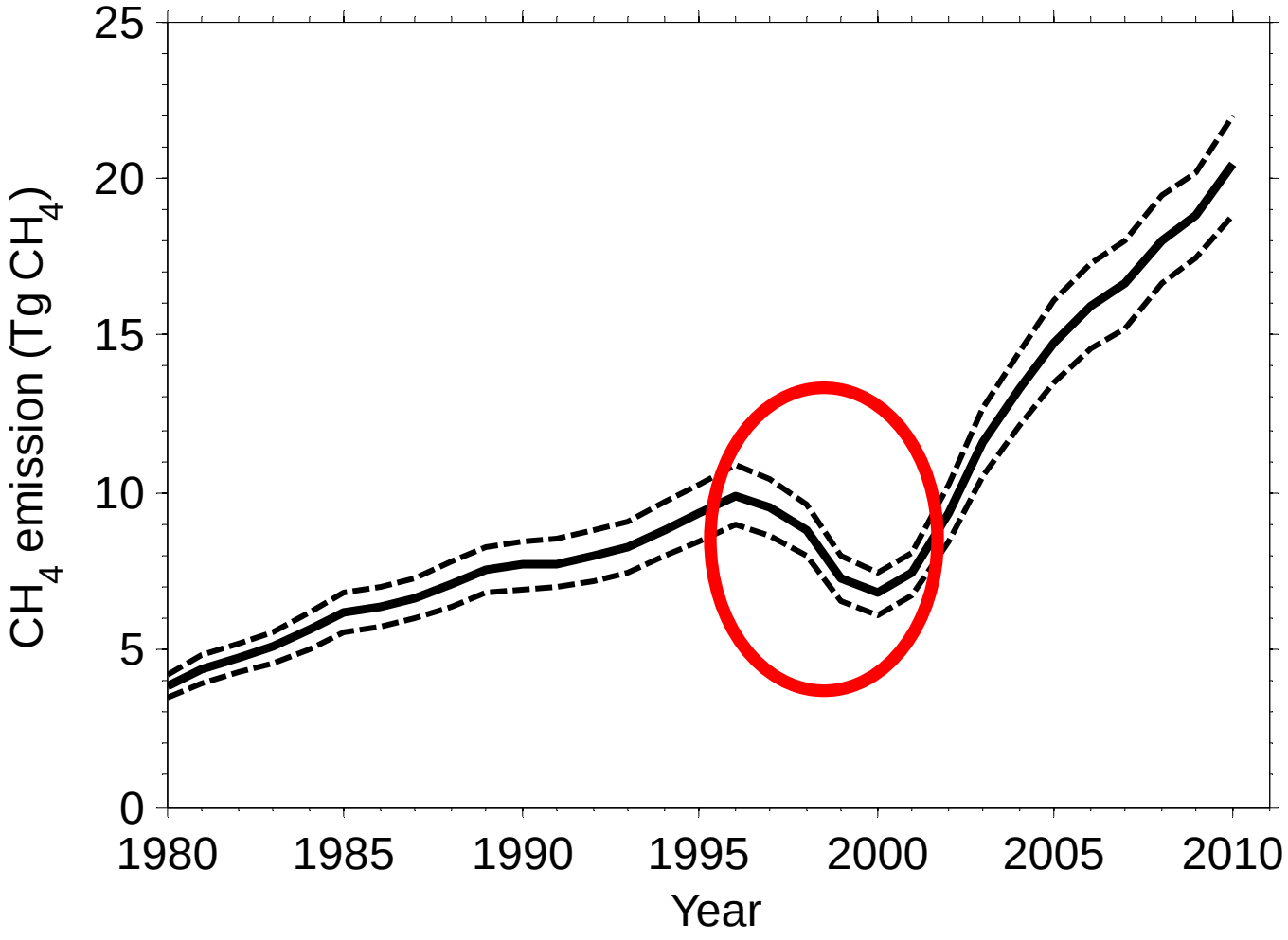


Source: Liu (2007)

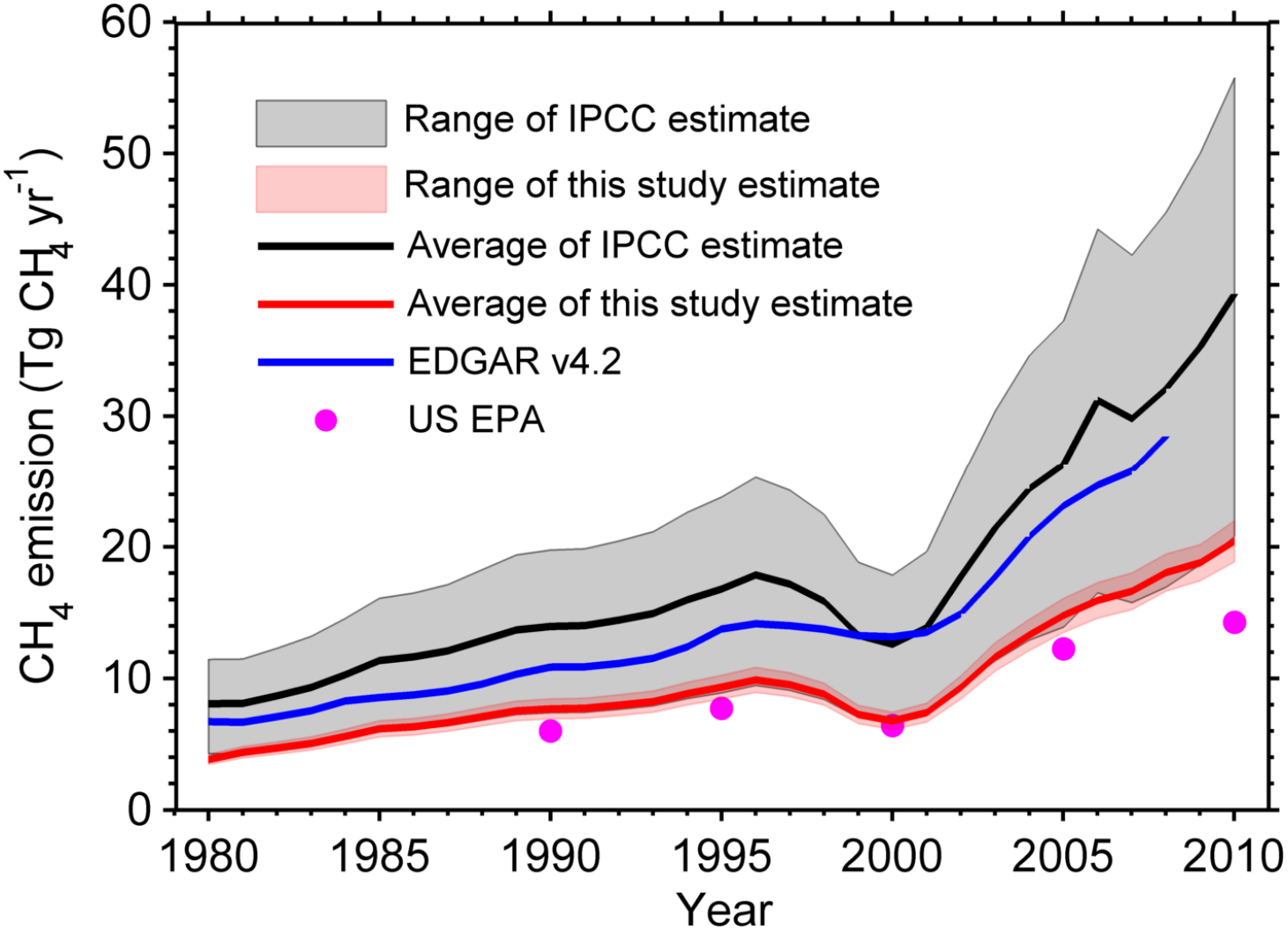
	CH_4 emission factors (m^3/t)	
	1994	2000
North	**4.18**	**6.97**
Northeast	**11.75**	**14.40**
Northwest	**6.00**	**5.97**
Southwest	**19.02**	**21.68**
Central and South	**7.19**	**7.83**
East	**5.46**	**6.22**
China	**7.92**	**9.30**

Zheng et al., (2006)

CH_4 emissions from coal mining

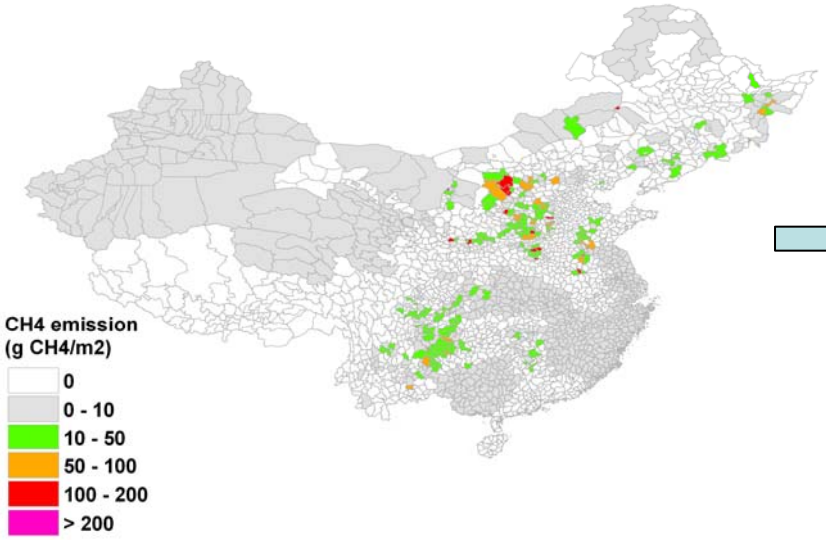


CH_4 emissions from coal mining

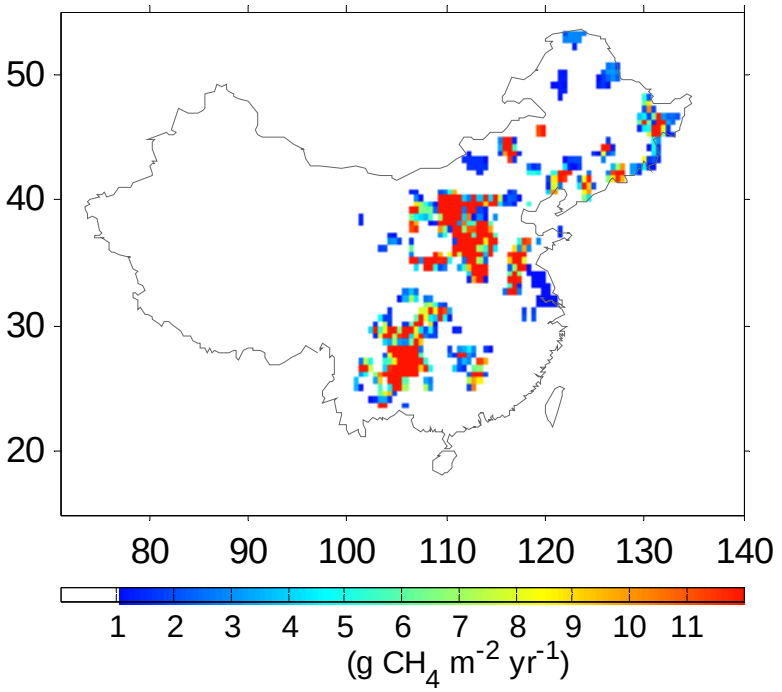


Spatial patterns of CH_4 emissions from coal mining

County level



0.5° ×0.5° grid

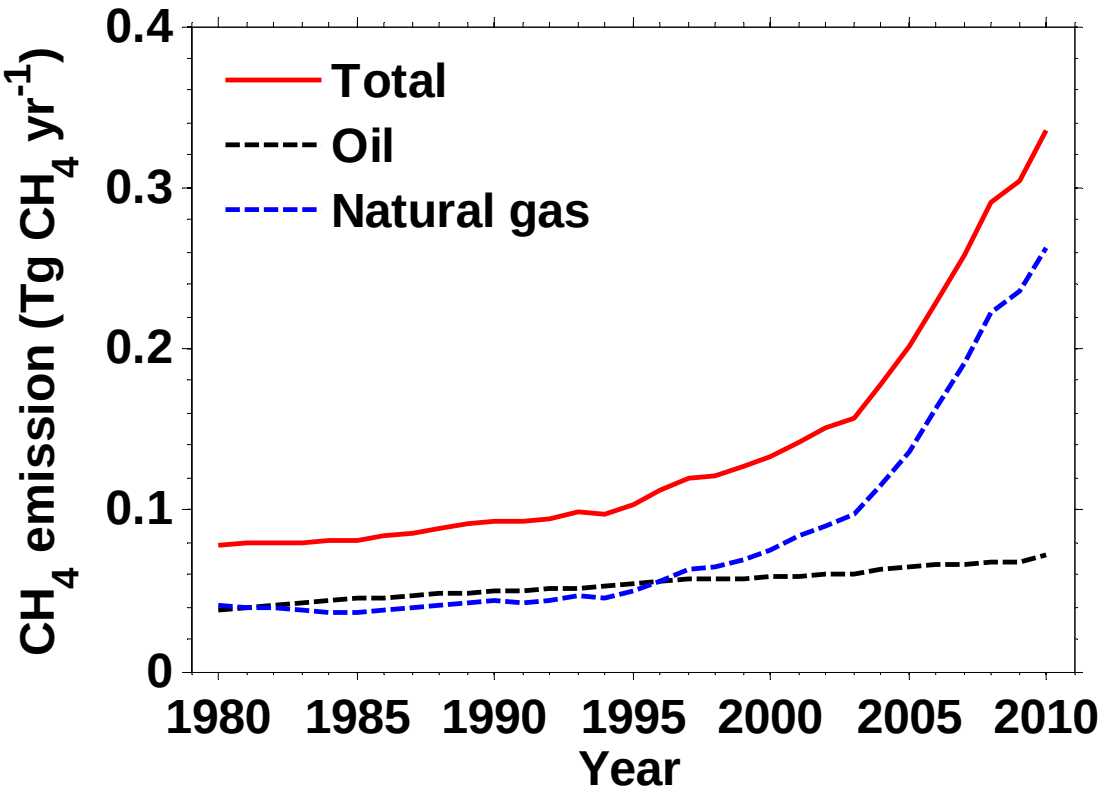


CH_4 emissions from oil and gas systems

Table 5
Fugitive emissions from oil and natural gas systems.

Fugitive emission	Petroleum	Natural gas	Total
Output	18,135.29 (10^4 t)	493.20 (10^8 m^3)	
Emission factors	3.57×10^{-7} (Gg/t)	2.77×10^{-9} (Gg/m^3)	
Emission (Gg)	66.52	191.79	258.31

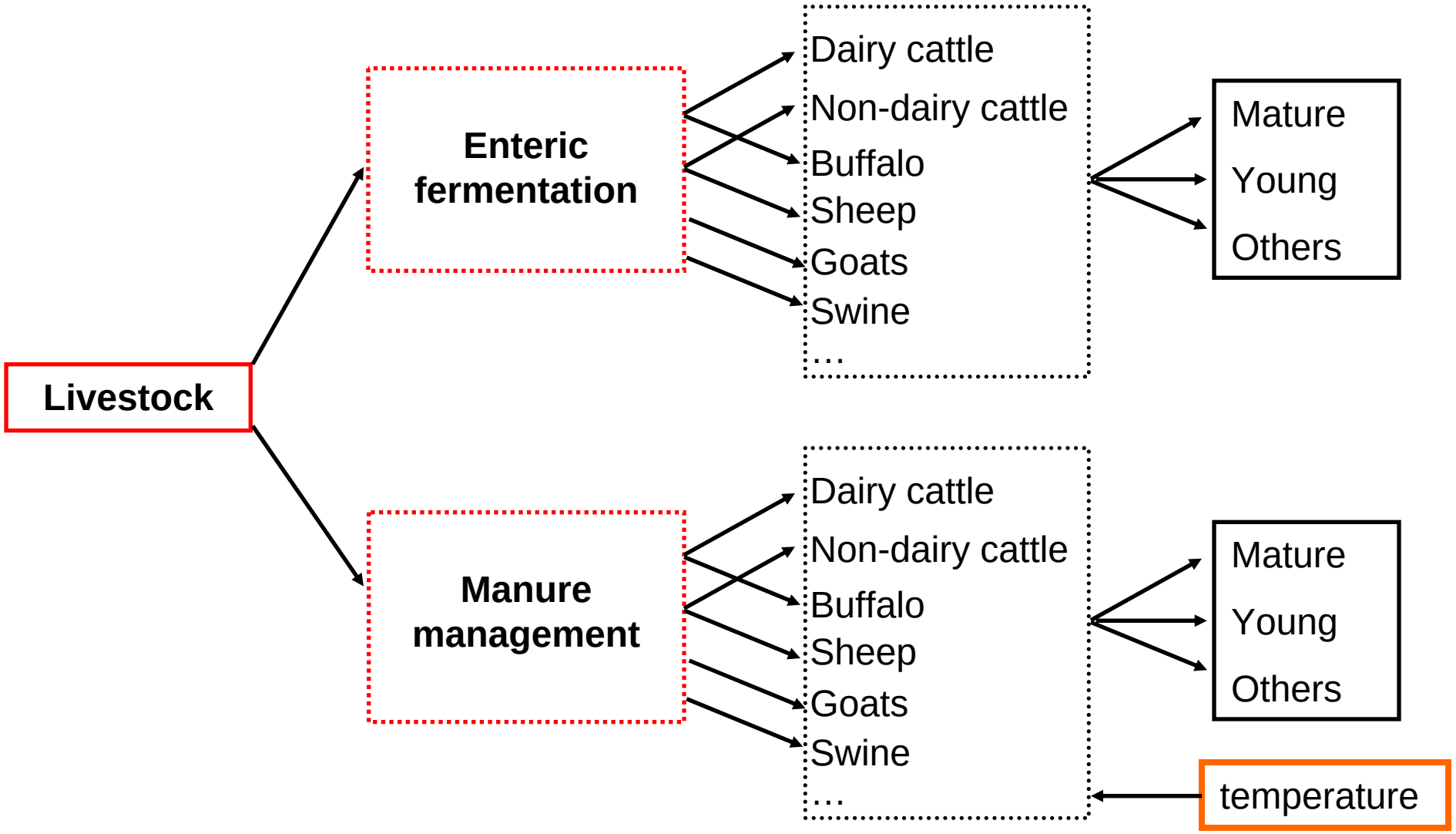
Zhang et al., (1999); Zhang & Chen, (2010);



CH_4 emissions from agricultural activities

- ✓ **Livestock**
- ✓ **Rice cultivation**
- ✓ **Biomass burning**

CH_4 emissions from livestock



CH_4 emissions factors of livestock

		Enteric fermentation (kg CH_4 $head^{-1}$ $year^{-1}$)	Manure management (kg CH_4 $head^{-1}$ $year^{-1}$)	*Total* (kg CH_4 $head^{-1}$ $year^{-1}$)
Non-dairy cattle	Mature female	59.69	44.00	64.00
	Young (<1 yr)	34.92	28.50	54.21
	Other	57.53	44.00	66.00
Dairy cattle	Mature female	78.49	44.00	78.49
	Young (<1 yr)	39.90	38.40	65.25
	Other	57.90	44.00	65.25
Buffalo	Mature female	87.55	48.00	87.55
	Young (<1 yr)	48.04	38.40	72.92
	Other	68.23	48.00	72.92
Others		57.53	44.00	66.00
Sheep	Mature female	5.34	5.00	14.00
	Young (<1 yr)	7.42	3.05	7.42
	Other	3.05	3.05	9.00
Goats	Mature female	4.62	4.62	9.00
	Young (<1 yr)	6.72	2.90	6.72
	Other	2.90	2.90	5.00
Swine	Not divided	1.00	1.00	1.00
Slaughtered	Cattle and buffalo	58.43	52.50	58.43
	Sheep and goat	3.09	3.09	5.16
	Swine	2.53	2.53	3.67

Emission factors series:

IPCC, 1996

IPCC, 2006

Yamaji et al., 2003

Verburg & Vandergon, 2001

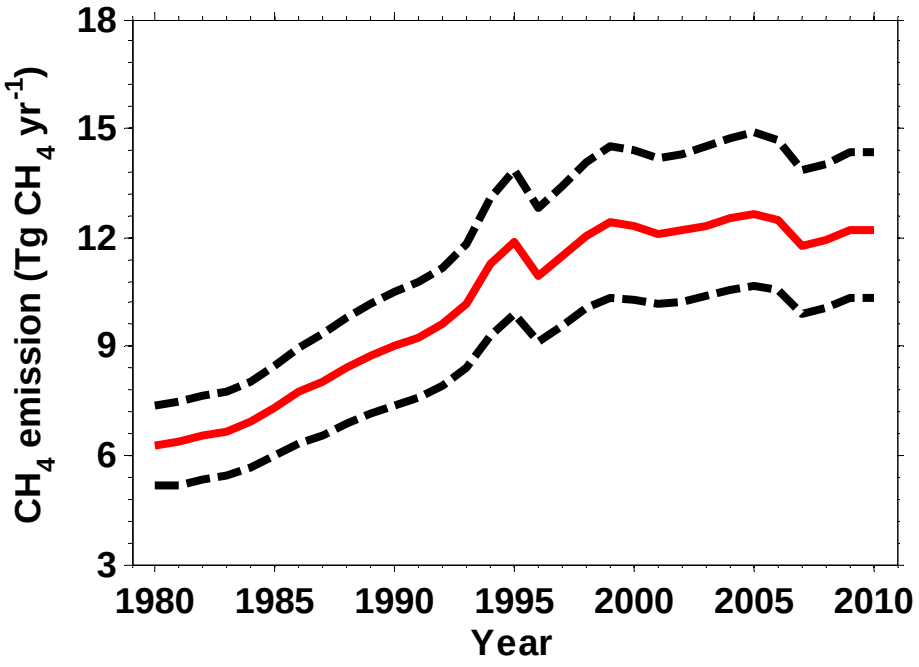
Khalil et al., 1993

Dong et al., 2004

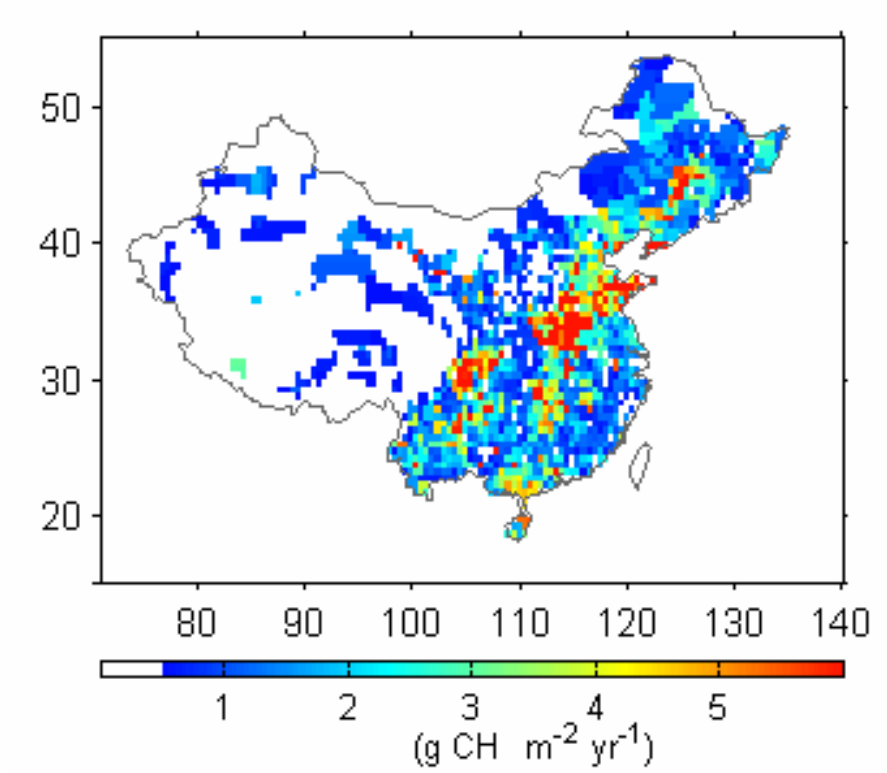
Zhang et al., 2007

CH_4 emissions from livestock

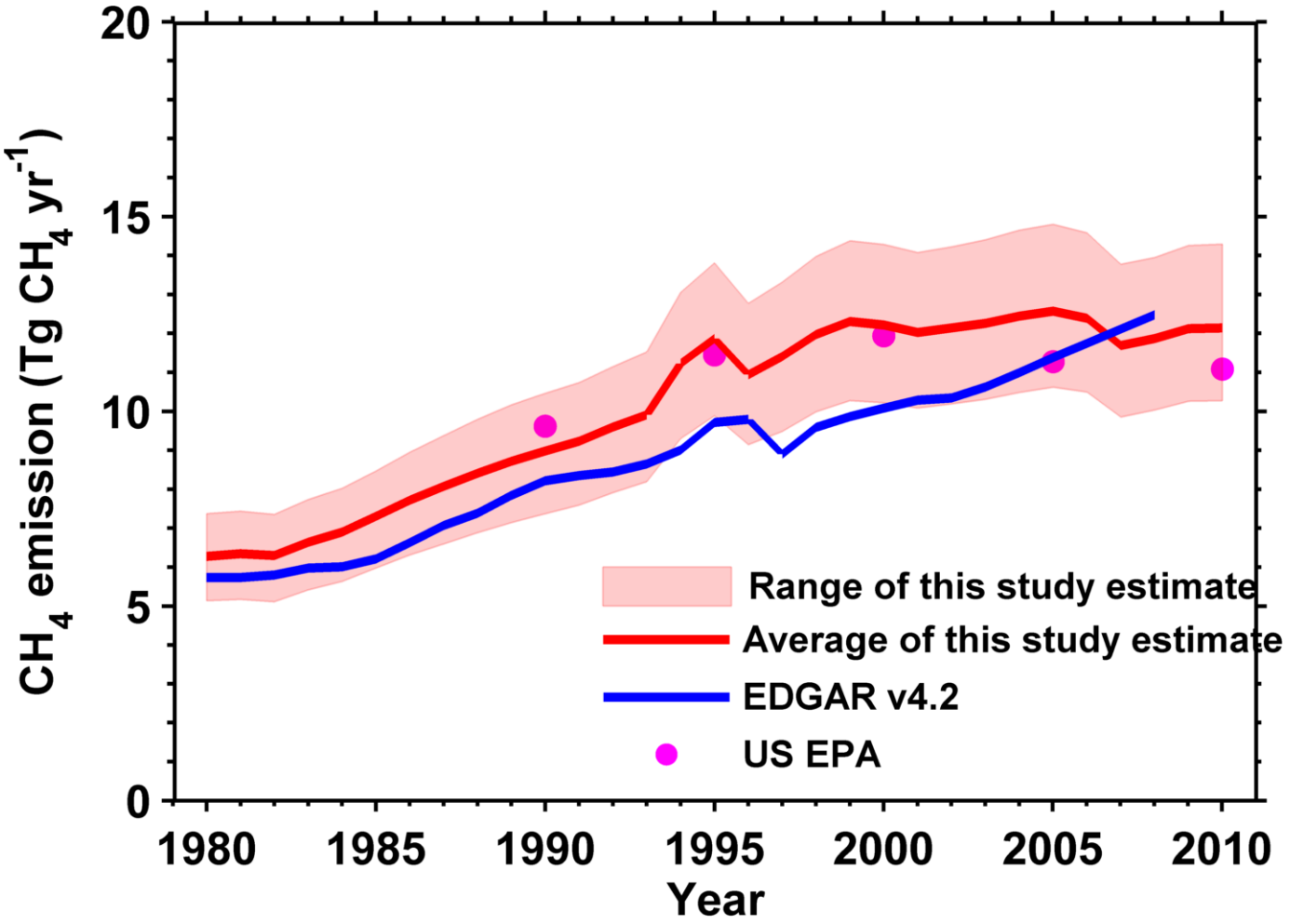
Interannual variation



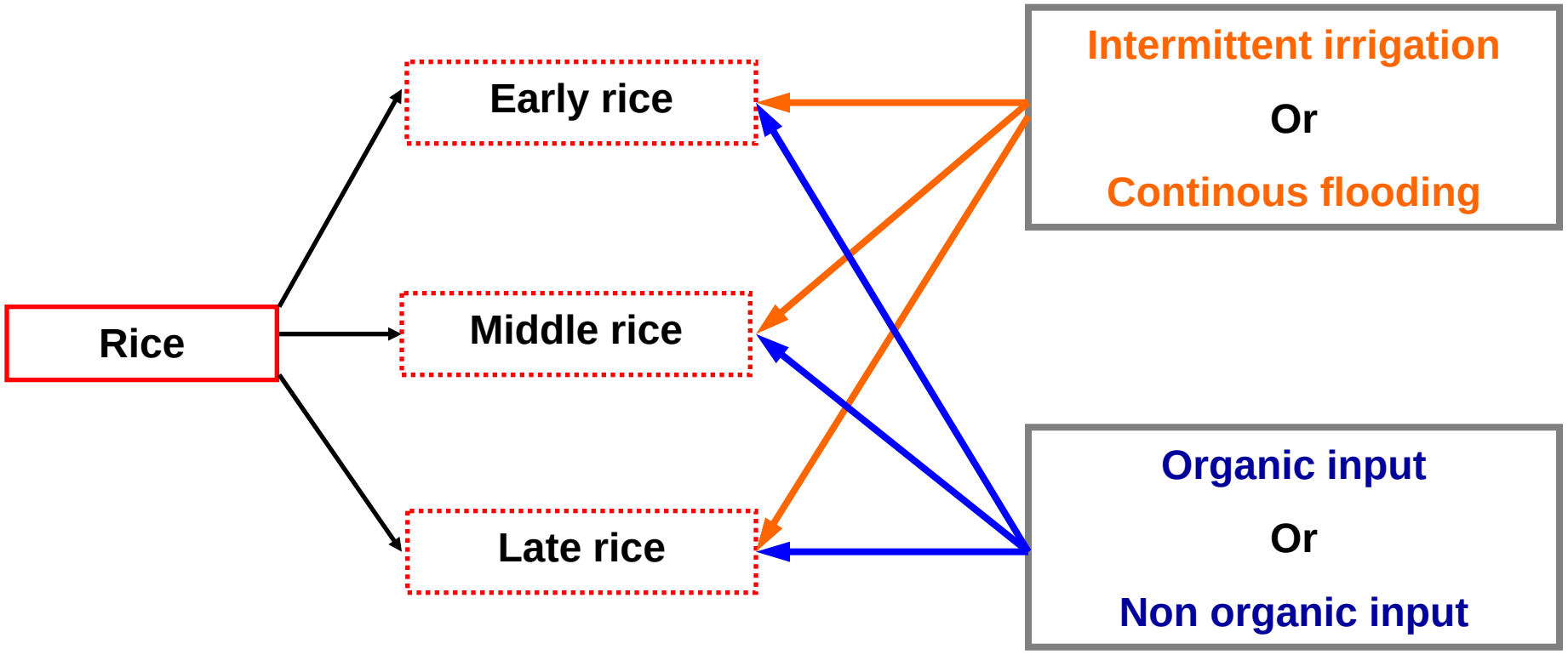
Spatial patterns



CH_4 emissions from livestock



CH_4 emissions from rice cultivation

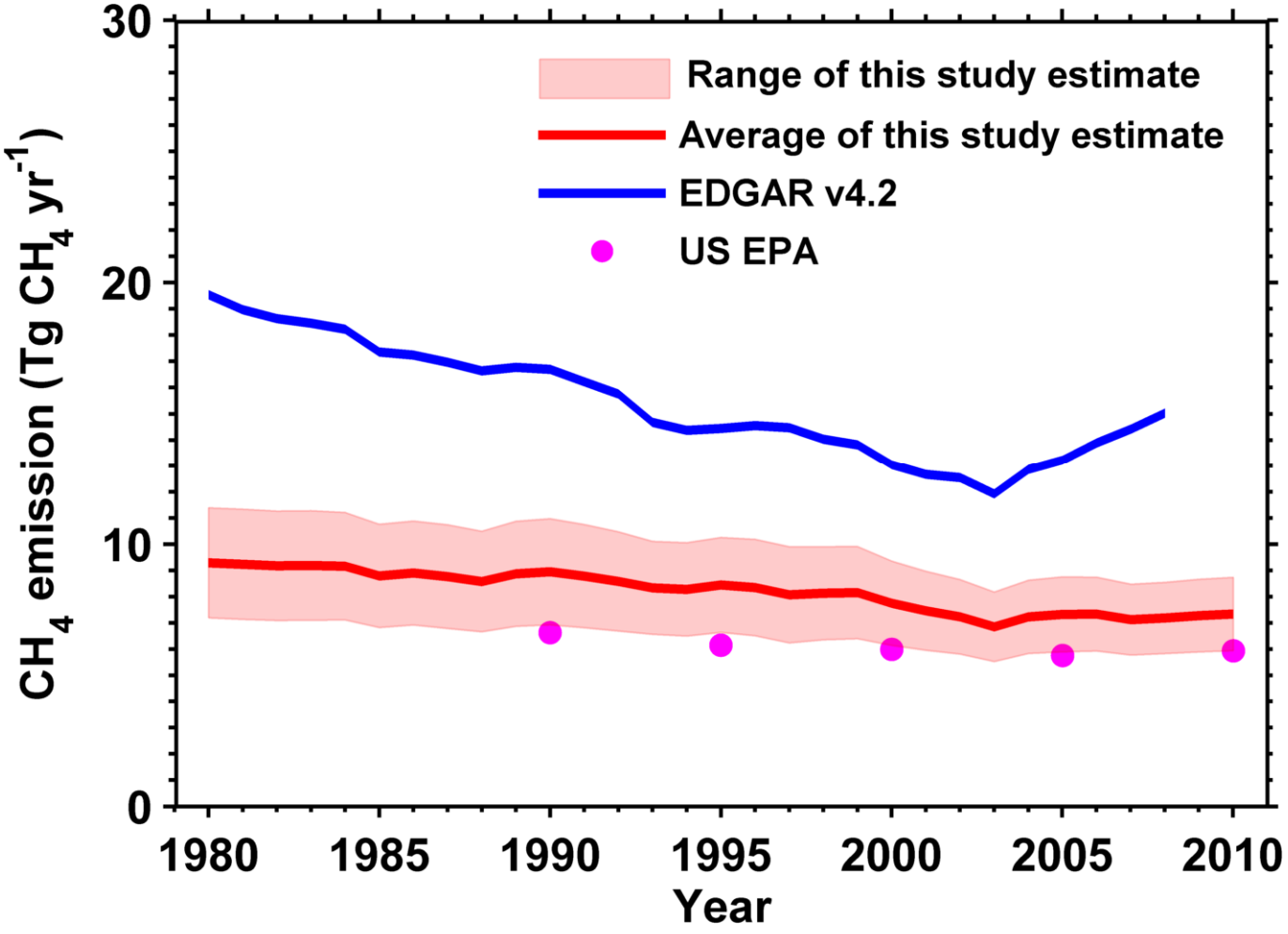


CH_4 emissions factors of rice cultivation

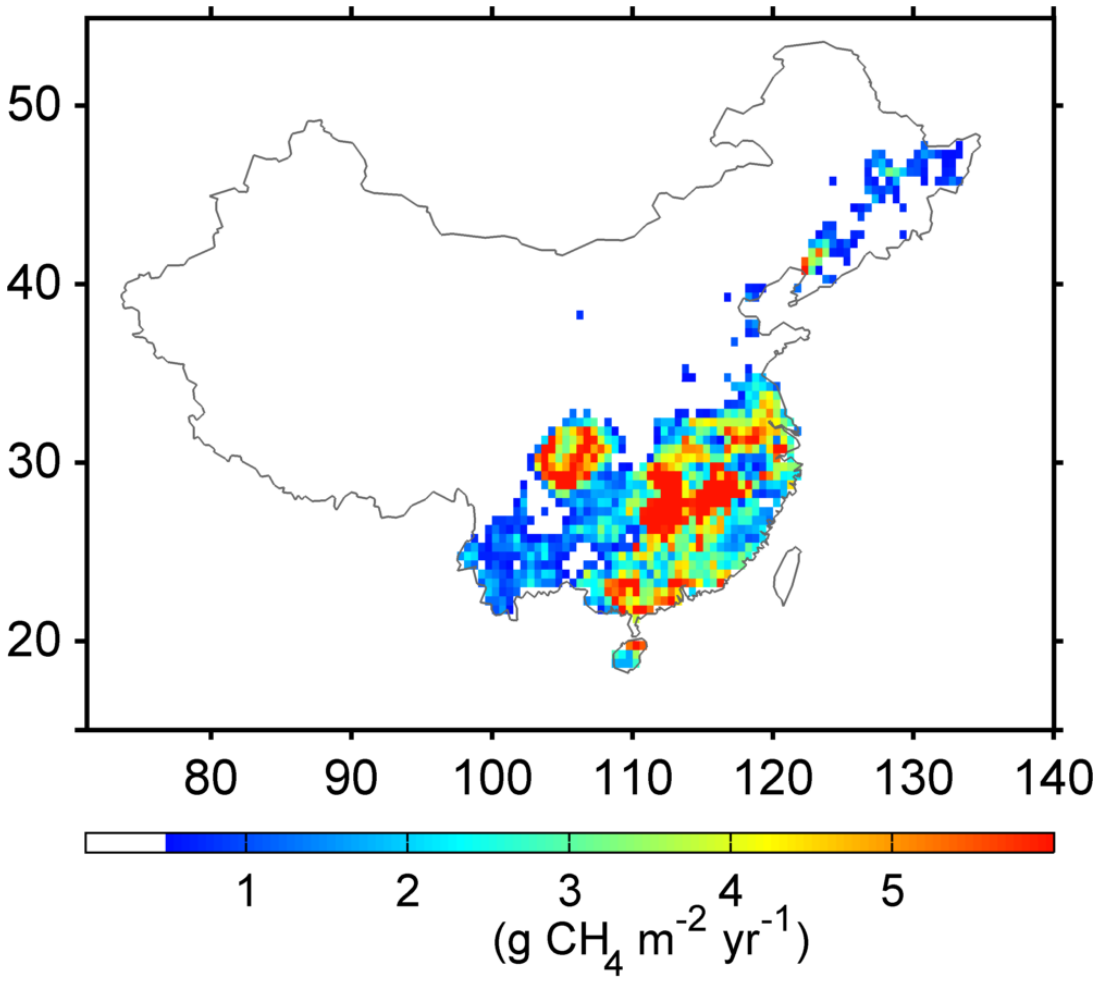
23 sites, 204 treatment measurements

Yan et al., JGR, (2003)

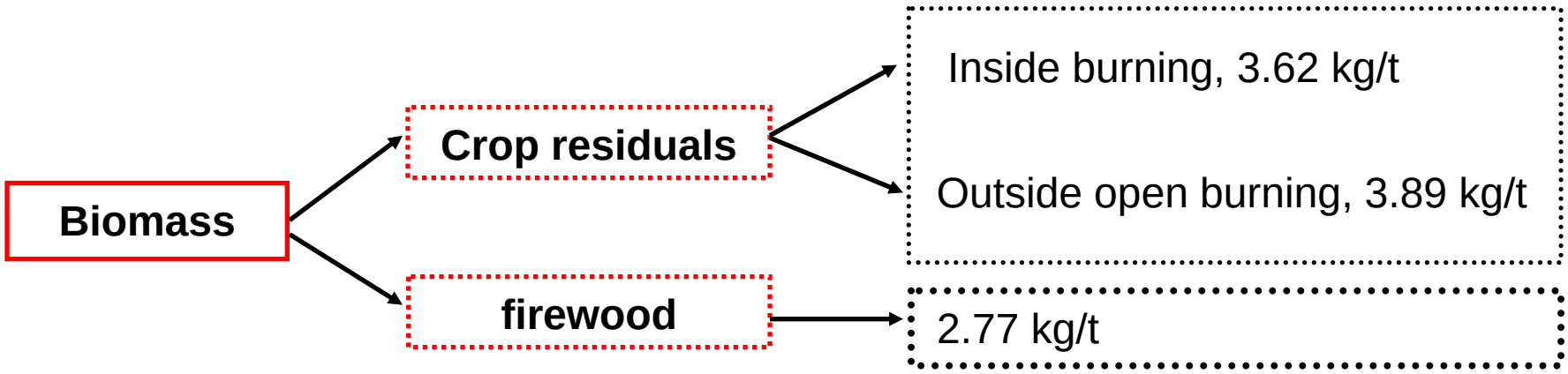
CH_4 emissions from rice cultivation



Spatial patterns of CH_4 emissions from rice cultivation

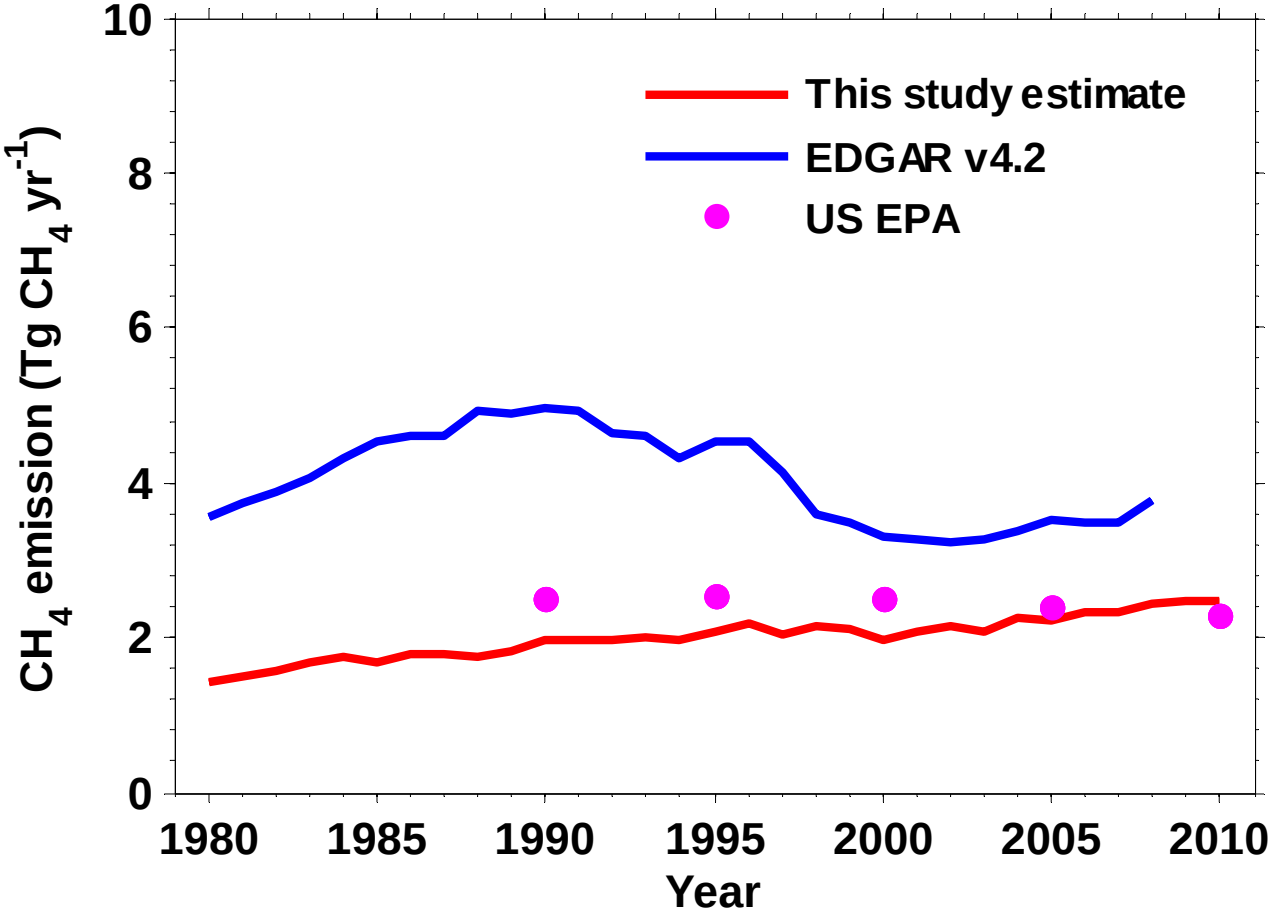


CH_4 emissions from biomass burning



Tian et al., (2011), in Chinese

CH_4 emissions from biomass burning

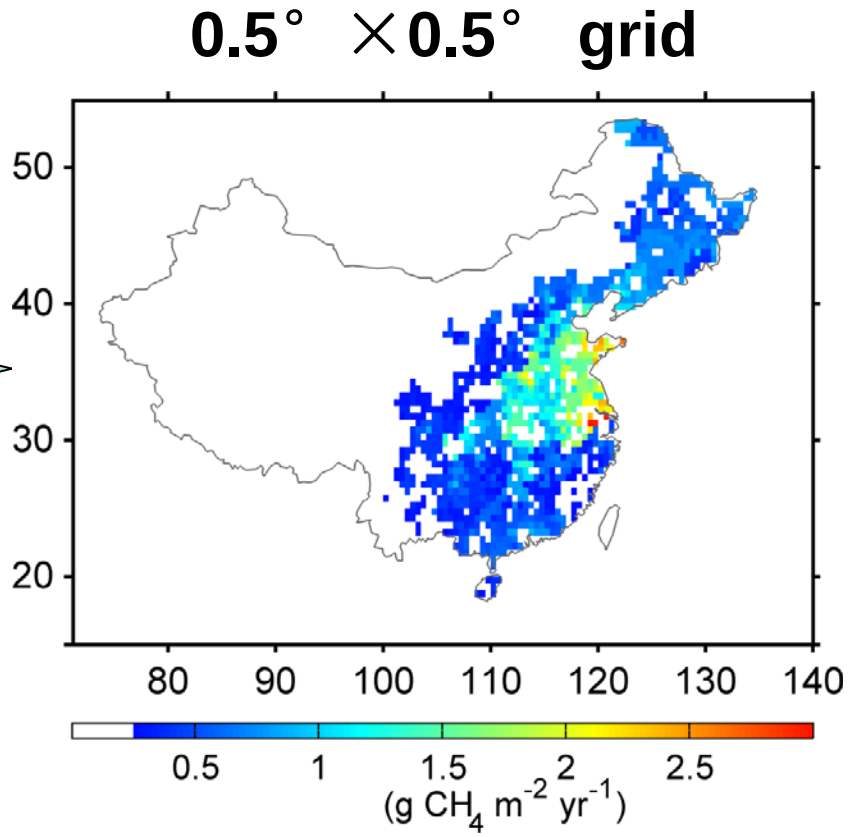


Spatial patterns of CH_4 emissions from biomass burning

Province statistics data

Rural population

Interpolation



CH_4 emissions from waste

- ✓ **Municipal solid waste**
- ✓ **Domestic sewage**
- ✓ **Industrial wastewater**

CH_4 emissions from solid waste

METHANE EMISSIONS

The CH_4 emissions from solid waste disposal for a single year can be estimated using Equations 3.1. CH_4 is generated as a result of degradation of organic material under anaerobic conditions. Part of the CH_4 generated is oxidised in the cover of the SWDS, or can be recovered for energy or flaring. The CH_4 actually emitted from the SWDS will hence be smaller than the amount generated.

EQUATION 3.1
CH_4 EMISSION FROM SWDS

$$CH_4\ Emissions = \left[\sum_x CH_4\ generated_{x,T} - R_T\right] \bullet (1 - OX_T)$$

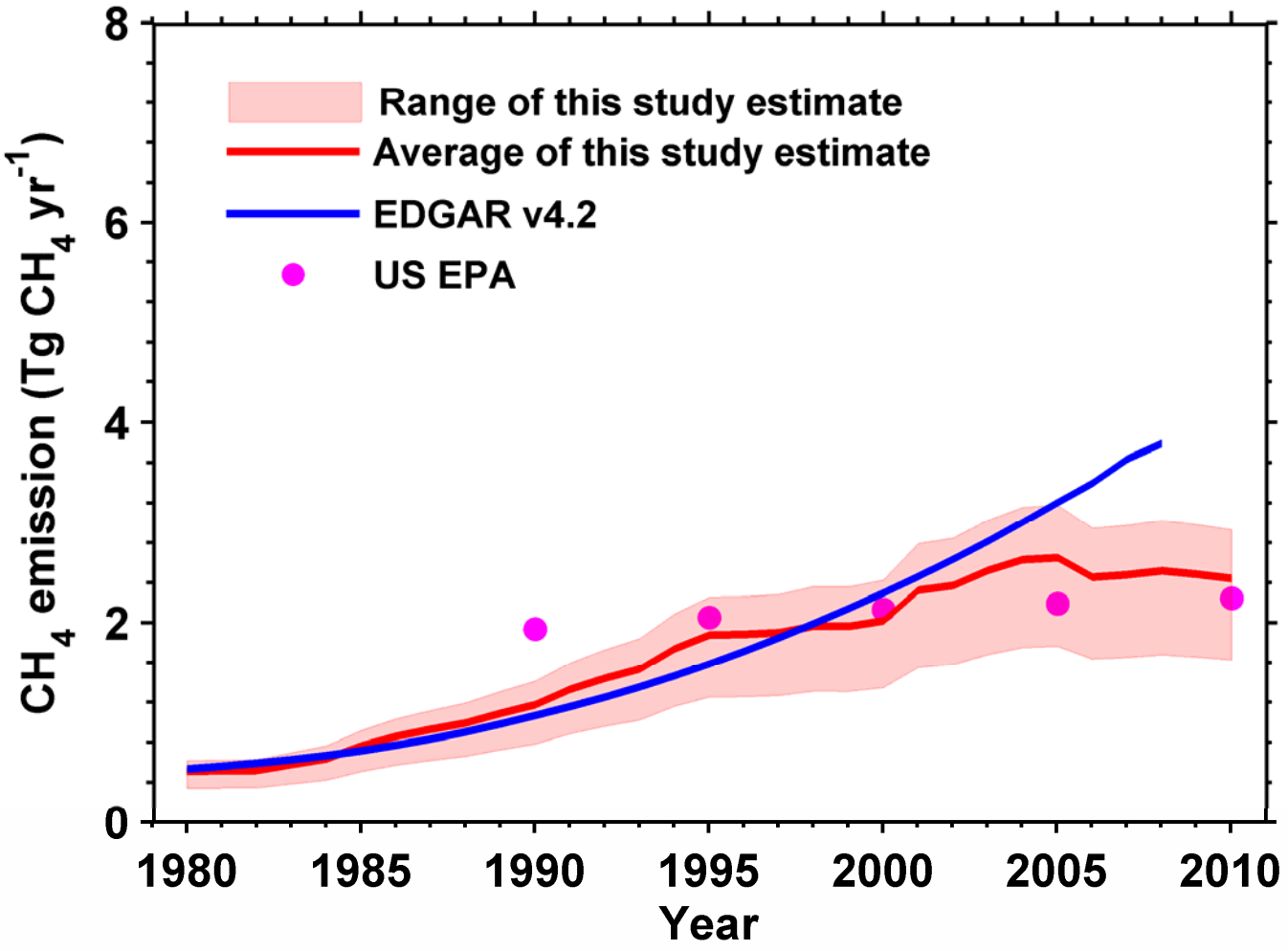
Where:

CH_4 Emissions	=	CH_4 emitted in year *T*, Gg
T	=	inventory year
x	=	waste category or type/material
R_T	=	recovered CH_4 in year *T*, Gg
OX_T	=	oxidation factor in year *T*, (fraction)

The CH_4 recovered must be subtracted from the amount CH_4 generated. Only the fraction of CH_4 that is not recovered will be subject to oxidation in the SWDS cover layer.

IPCC, (2006)

CH_4 emissions from solid waste

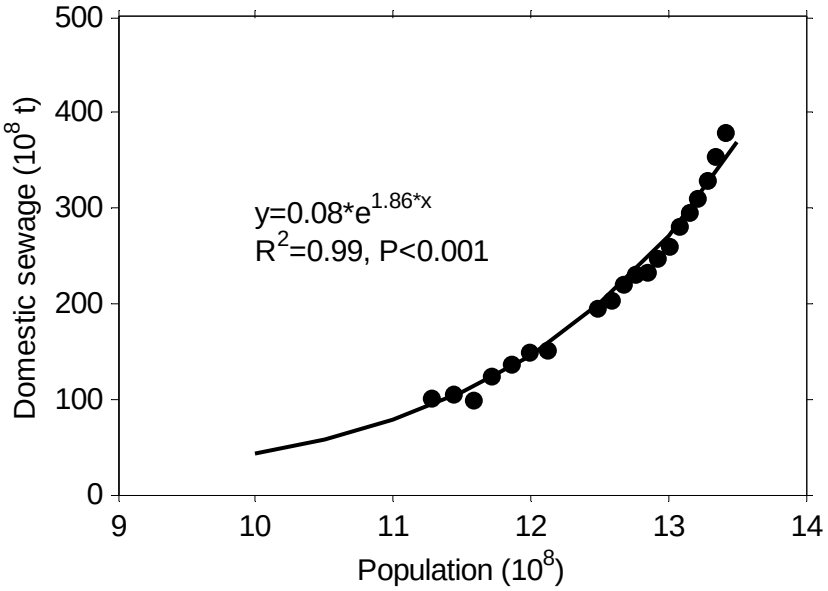


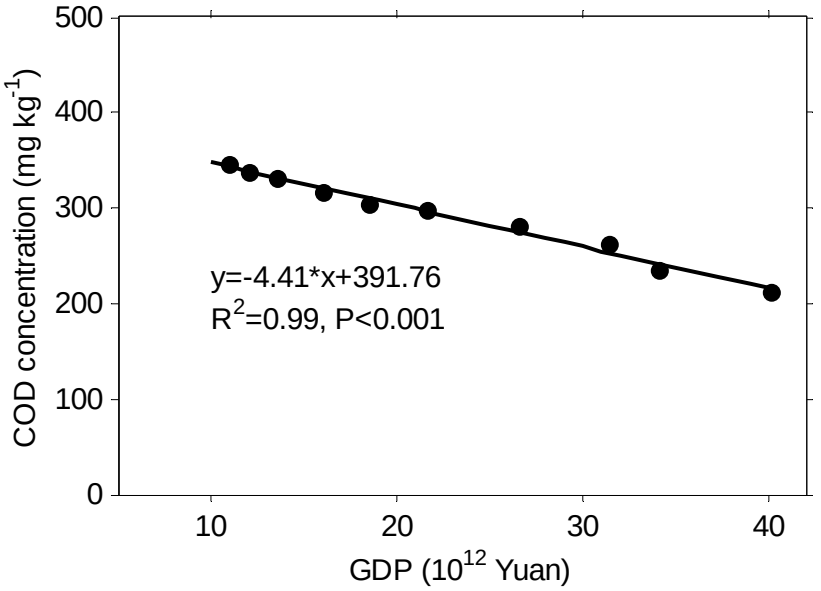
Emission factor from Gao et al., (2006) and IPCC, (2006)

CH_4 emissions from domostic sewage

Domestic sewage exponentially increase with population,

but COD decrease with economics development

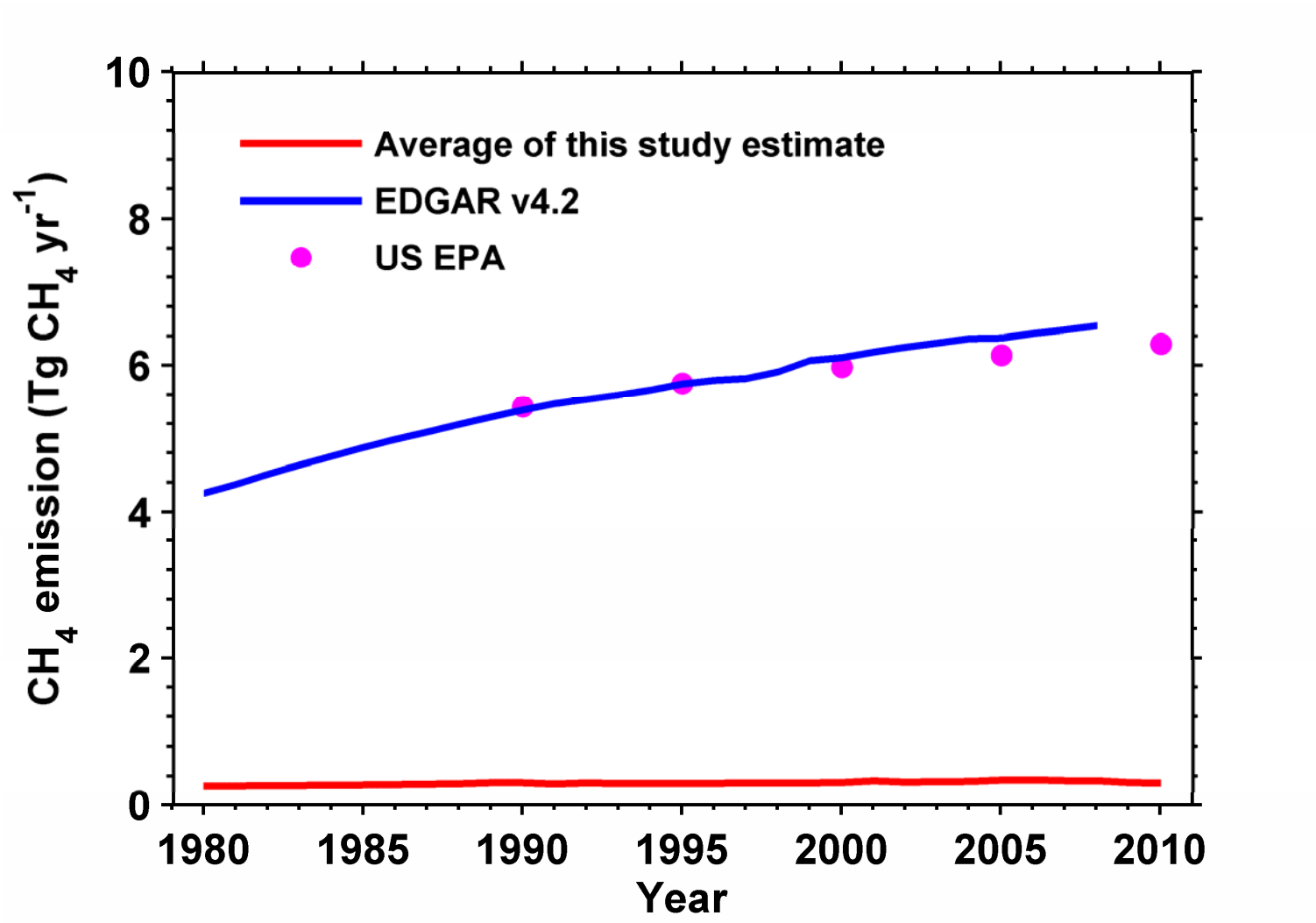




CH4 emission = Domestic sewage * COD * 0.25 kg CH4/kg COD * Methane correction factor (0.1)

Emission factor from IPCC, (2006)

CH_4 emissions from wastewater



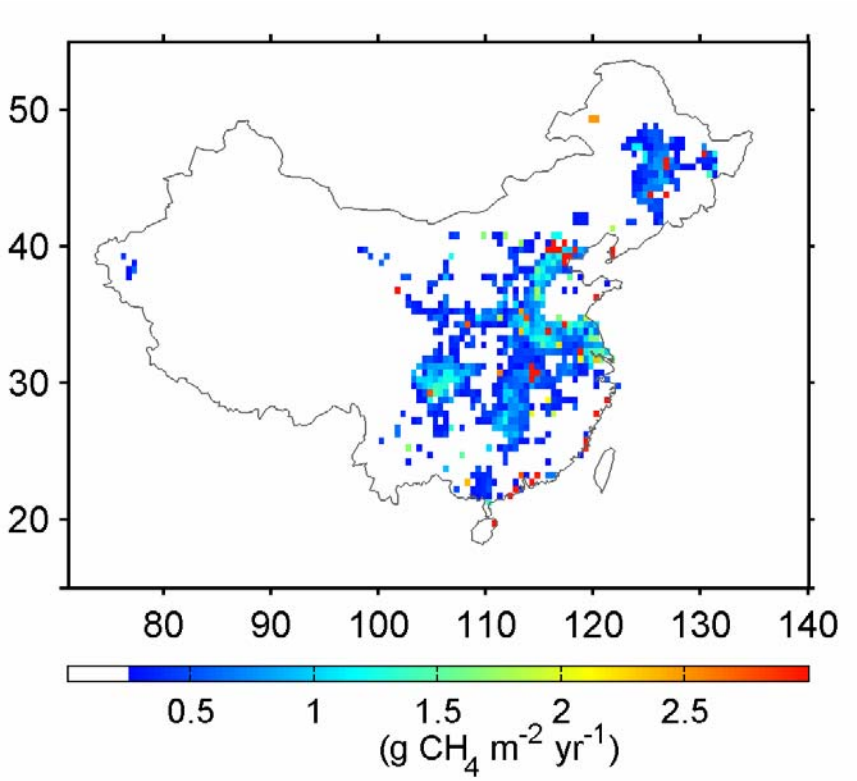
Spatial patterns of CH_4 emissions from waste

Province statistics data

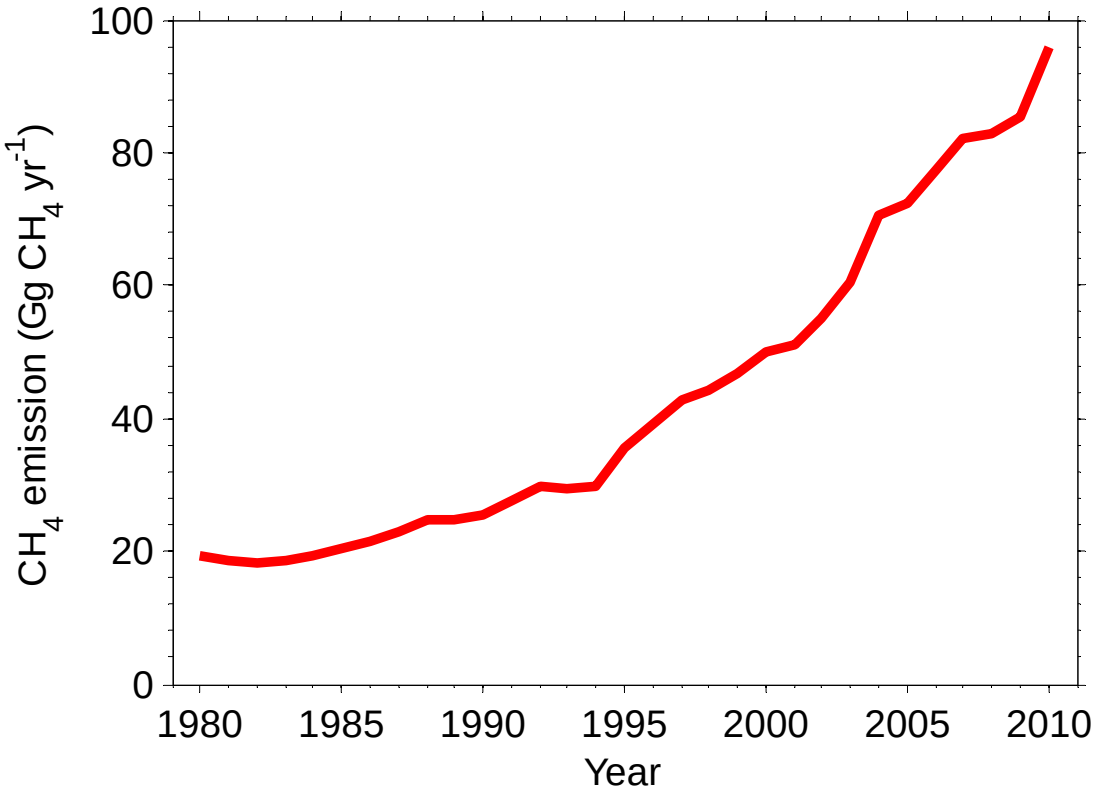
County level
Population, GDP

Interpolation

0.5° ×0.5°



CH_4 emissions from fossil fuel combustion



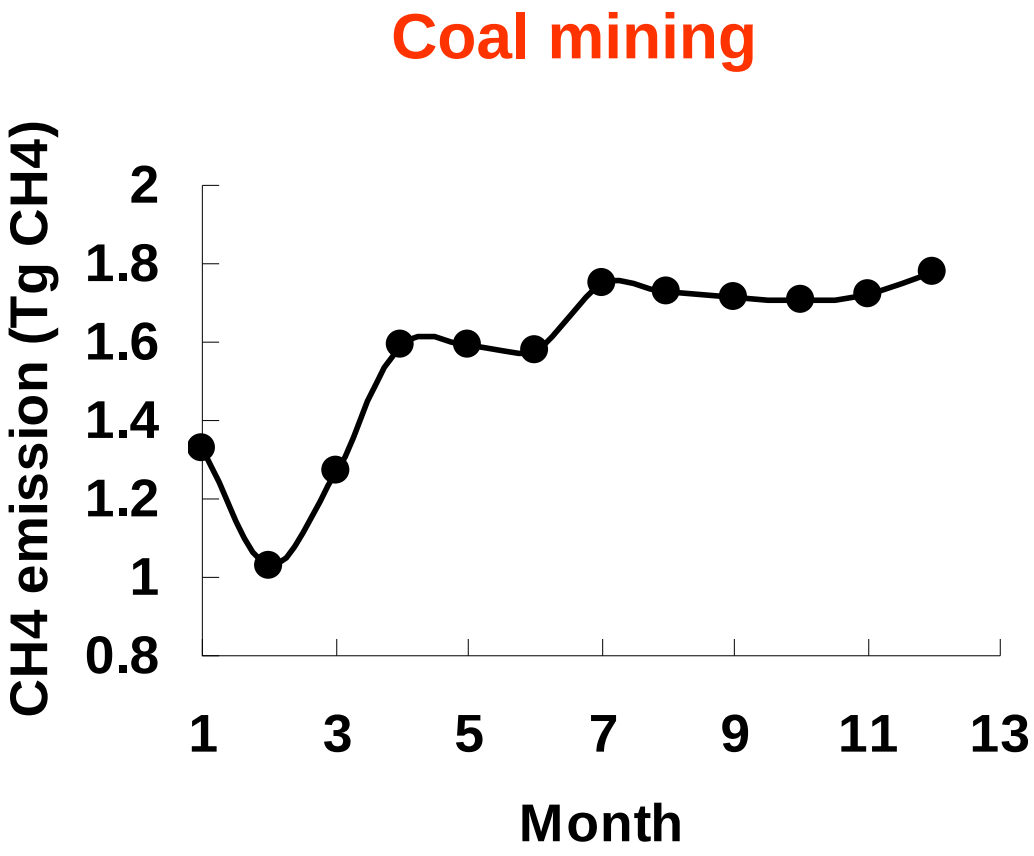
Less than 0.5% of total CH_4 emissions

Seasonal cycle of CH_4 emissions???

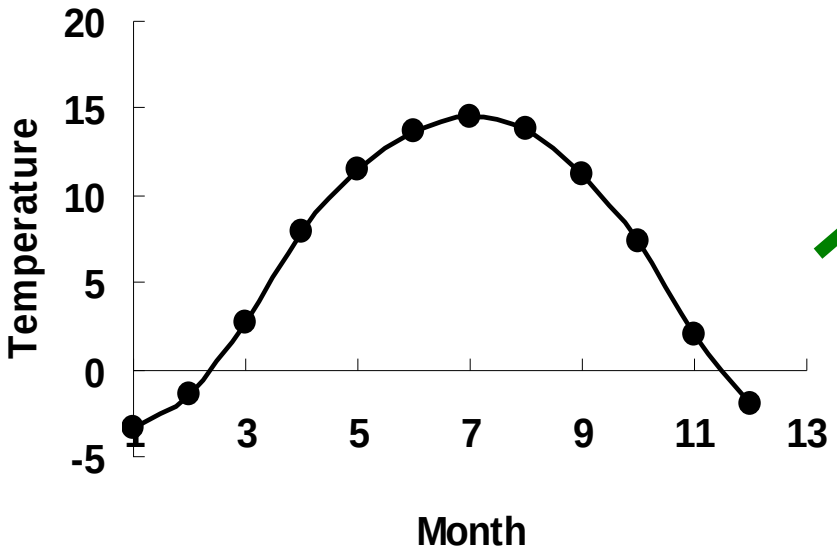
Just try it!

…

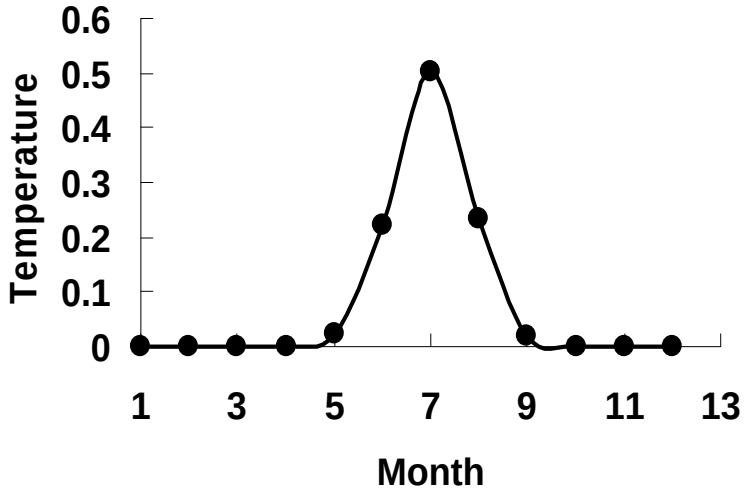
Seasonal cycle of CH_4 emissions



Seasonal cycle of CH_4 emissions



$CH_4 = a*e^{b*Temperature}$

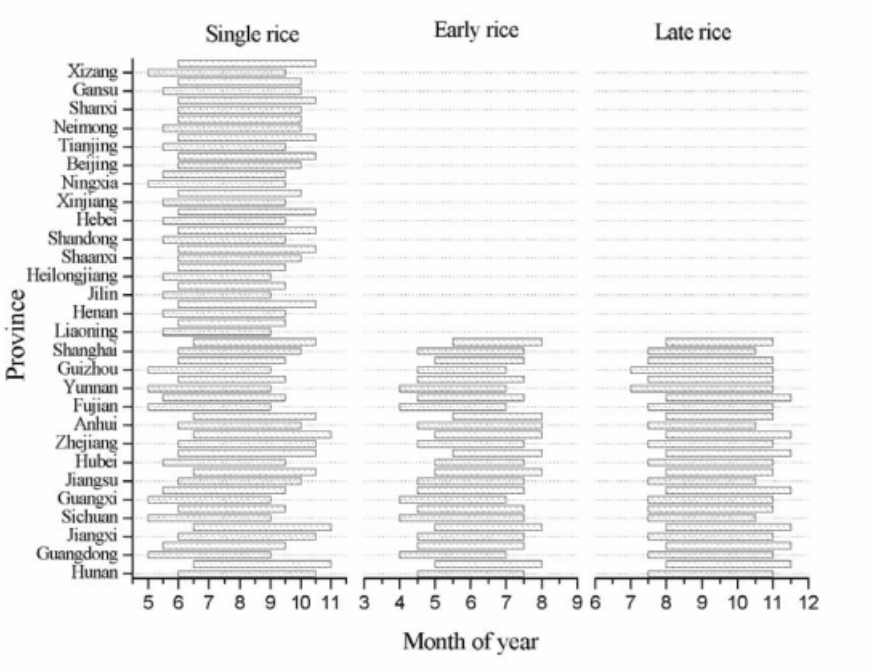


Landfills

Wastewater

Seasonal cycle of CH_4 emissions

Rice Growing seasons ⋯⋯⋯⋯▶ Rice CH4 emissions



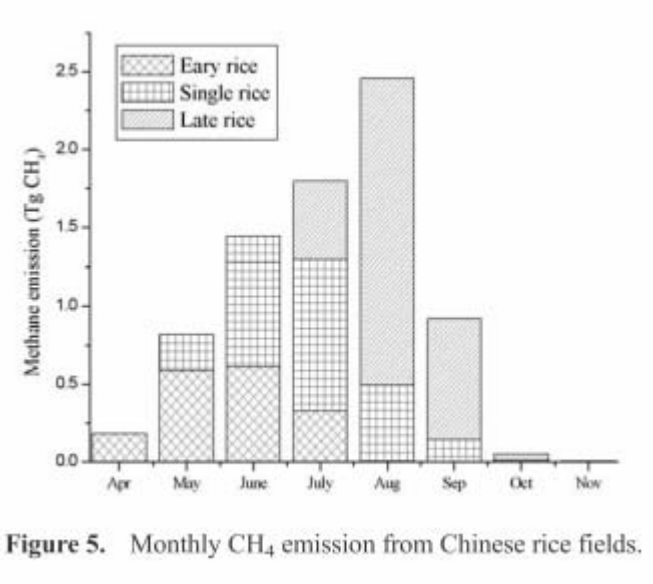
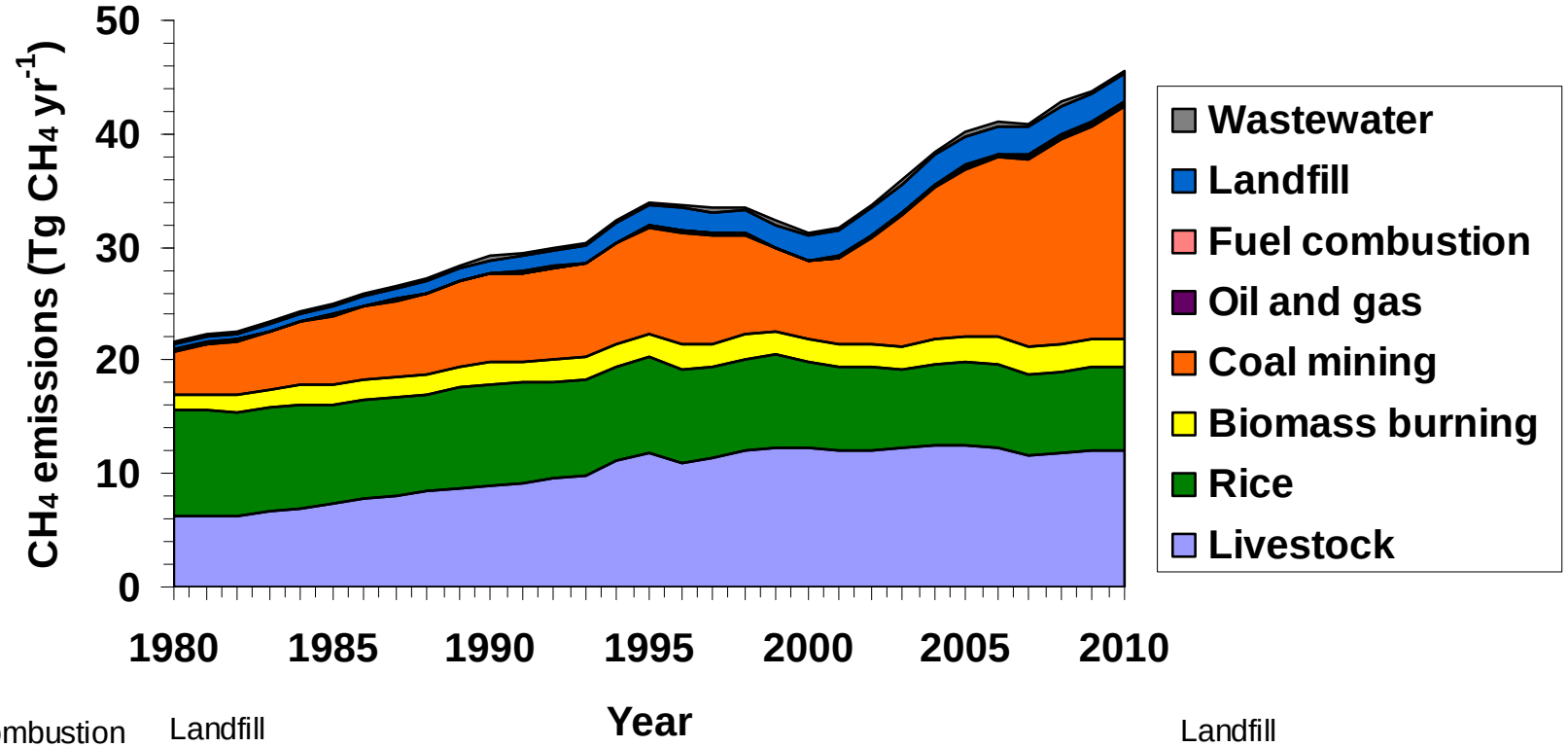
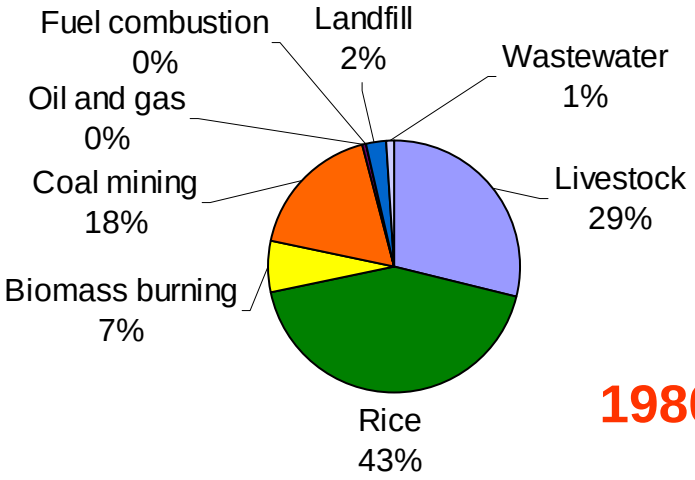


Figure 5. Monthly CH_4 emission from Chinese rice fields.

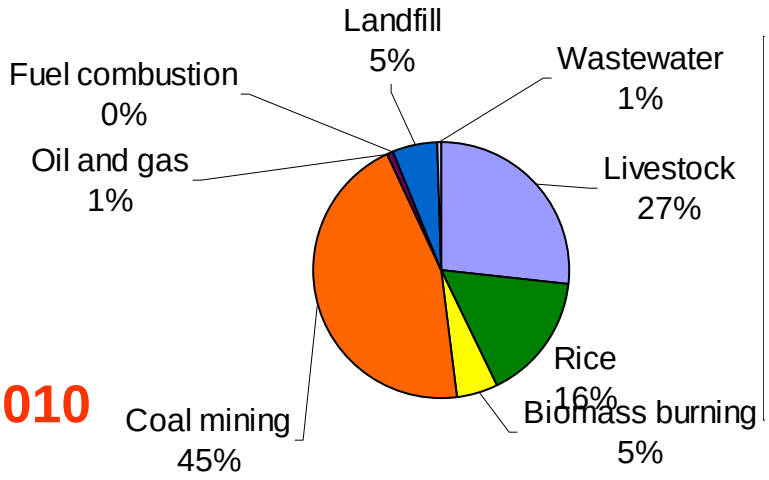
Livestock??? Maybe also temperature inverse

Summary

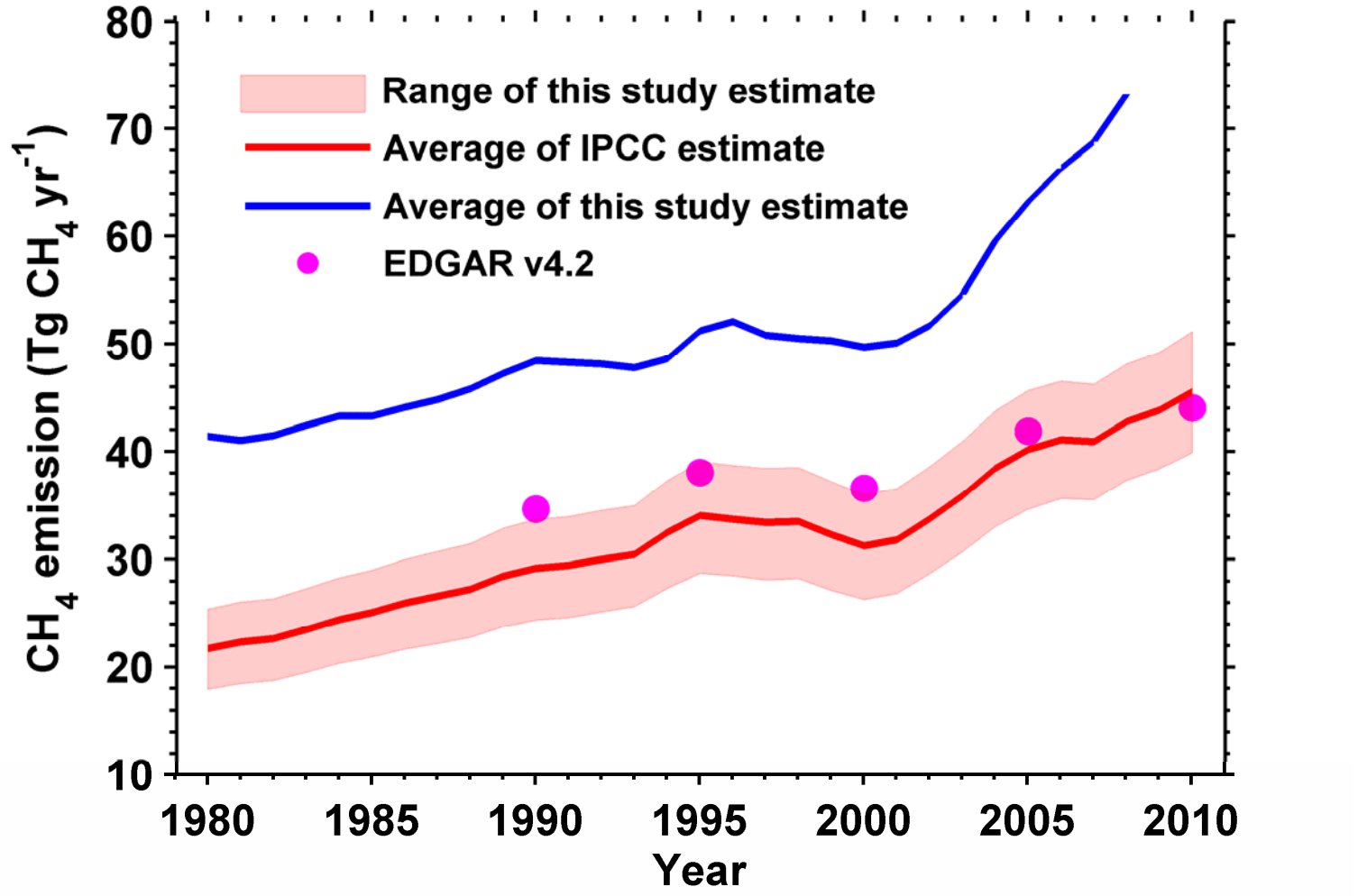




1980 → 2010



Summary


Range of this study estimate
Average of IPCC estimate
Average of this study estimate
EDGAR v4.2
CH4 emission (Tg CH4 yr-1)
Year
80
70
60
50
40
30
20
10
1980
1985
1990
1995
2000
2005
2010

County level and 0.5 degree resolution CH_4 emissions data products are available for all the sources in China during the period 1980-2010

Thank you for your attention!