N_2O emissions in China from 1978 to 2008 by F ZHOU

Abstract: Nitrous oxide (N_2O) emissions from China have received increasing attention because of its importance on global climate forcing. A new and high-resolution N_2O emission inventory (PKU-N2O-CHINA) has been developed with the following improvements: (i) All of anthropogenic and natural emission sources were considered excluding LULUCF in IPCC category; (ii) the emission factors (EFs) and the associate parameters were updated to reflect country-specific conditions and spatial heterogeneity; (iii) a 1×1 km gridded map was produced for 2008 based on county-level activity data; (iv) temporal trends were derived for total and each emission source from 1978 to 2008; (v) uncertainties associated with the inventory were quantified. It was estimated that 1762 Gg of N_2O were emitted in China in 2008, which is lower or slightly lower than that previously reported. Manure management systems (29%) was the largest contributor, following by synthetic fertilizers (20.5%), indirect emission from atmospheric N deposition (10.4%), public electricity and heat production (7.9%), and organic fertilizers (6.9%). By using county-level data directly and regional EFs and parameters, spatial bias in previously national or province-level disaggregation was reduced by 120.7%, resulting mainly from uneven intensities of fertilizer and energy uses within nation or provinces. Total and per-capita emissions increased monotonically and steadily since 1978, while agricultural N_2O emissions per cereal productivity rapidly fell down after 2003 because of nutrient management implemented and high-yield crop varieties promoted. N_2O emissions in China would be effectively reduced if improving nutrient or energy use efficiencies as well as shifting human dietary choice with lower per capita calorific intake.

China's N_2O emissions (PKU-N2O-CHINA) from 1978 to 2008

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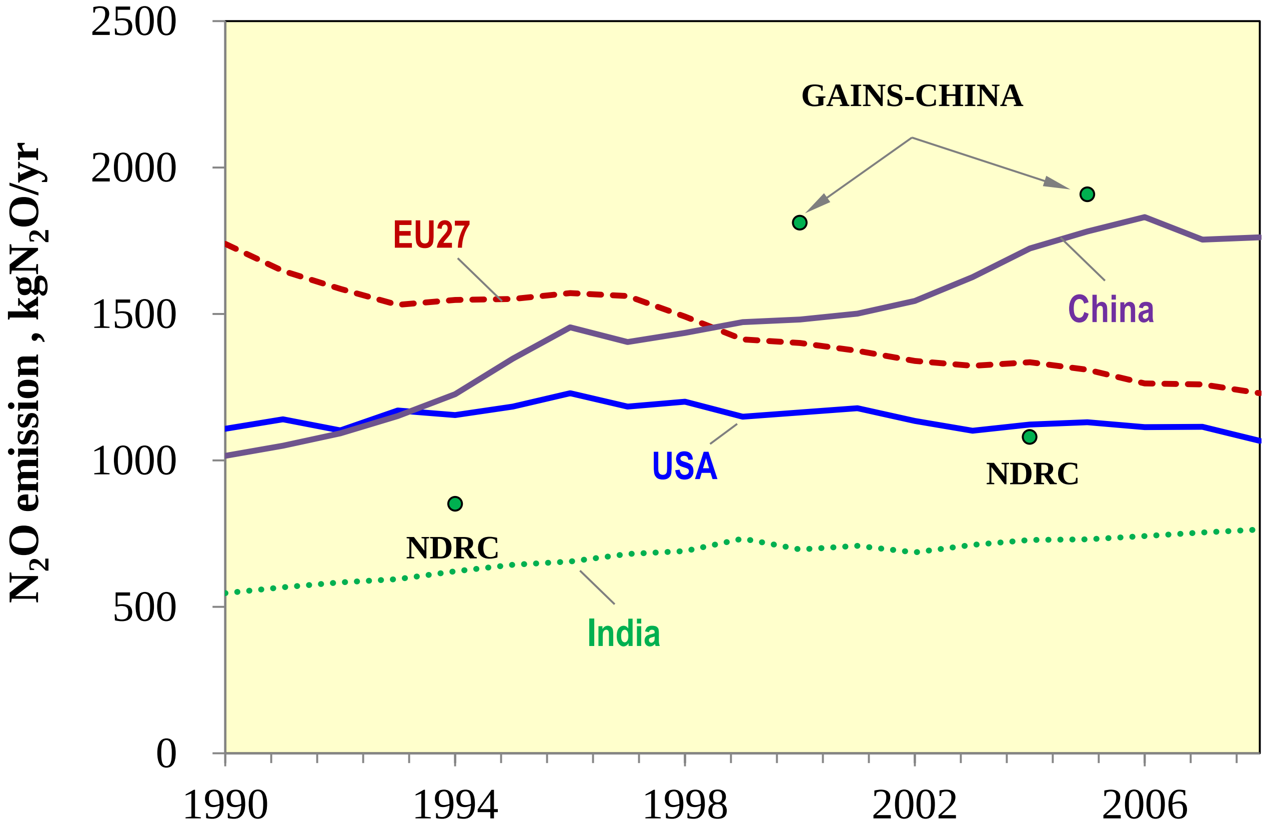
1. Motivation

- China contributed ~18% of global anthropogenic N2O emissions and becoming largest emitter.
- However, we didn't have our emission inventory…



From EDAGR v4.2, IIASA-GAINS

1. Motivation

If we choose bottom-up approach, then

Emission factors ?   Activity data ?

$$E = \sum_{i,j,k} \left(EF_{ijk} \times \beta_{ijk} \times AD_{ijk} \right)$$

Sources ?   Parameters ?

1. Motivation

Source$_{ijk}$ need to be considered comprehensively

Agriculture (62.5%)

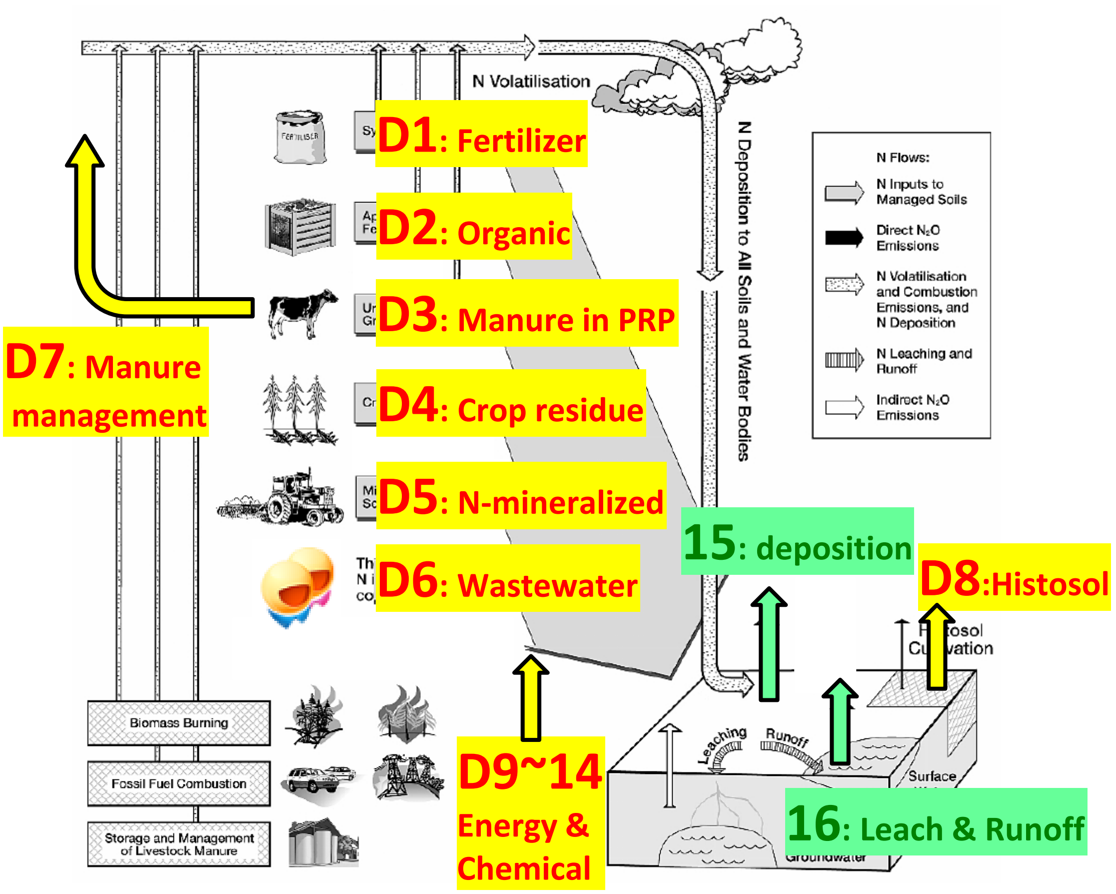
Energy (17.1%)

Industrial (3%)

Waste (5.5%)

Wildfires (0.3%)

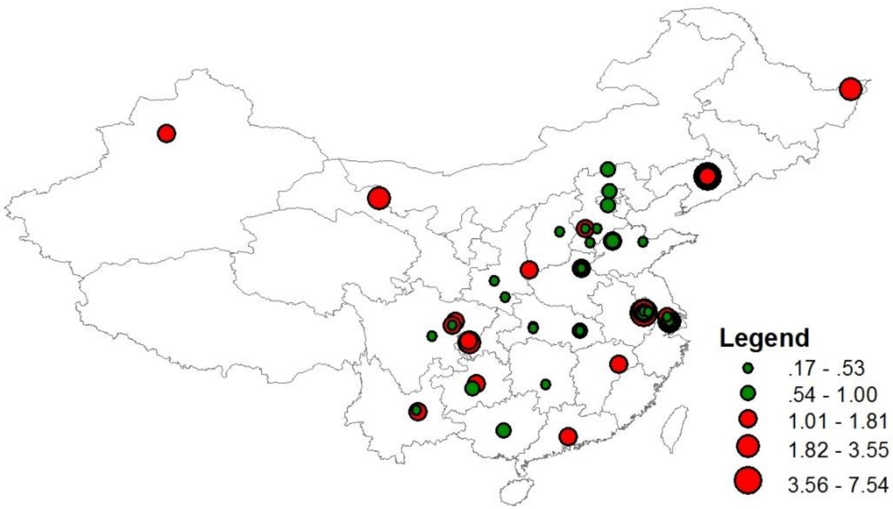
Indirect (11.3%)



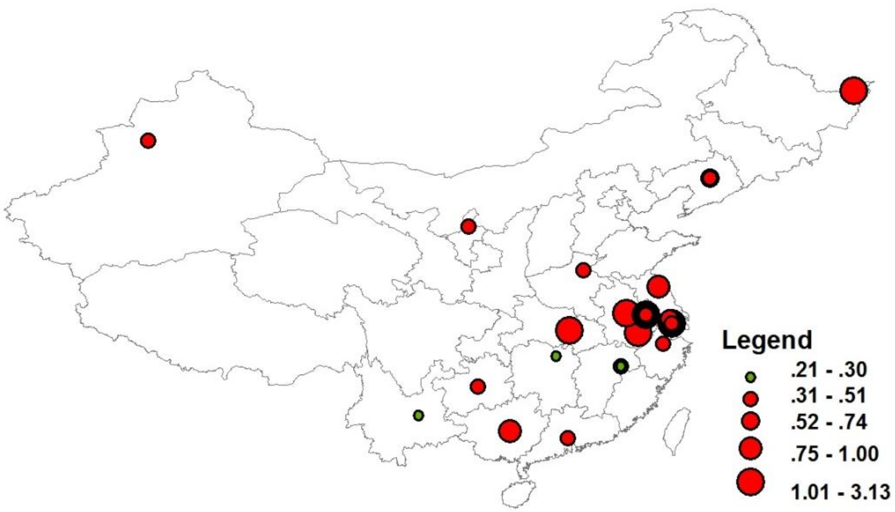
1. Motivation

EF_{ijk} need to be country-specific and spatial explicit

EF_{N2O} for upland



EF_{N2O} for paddy



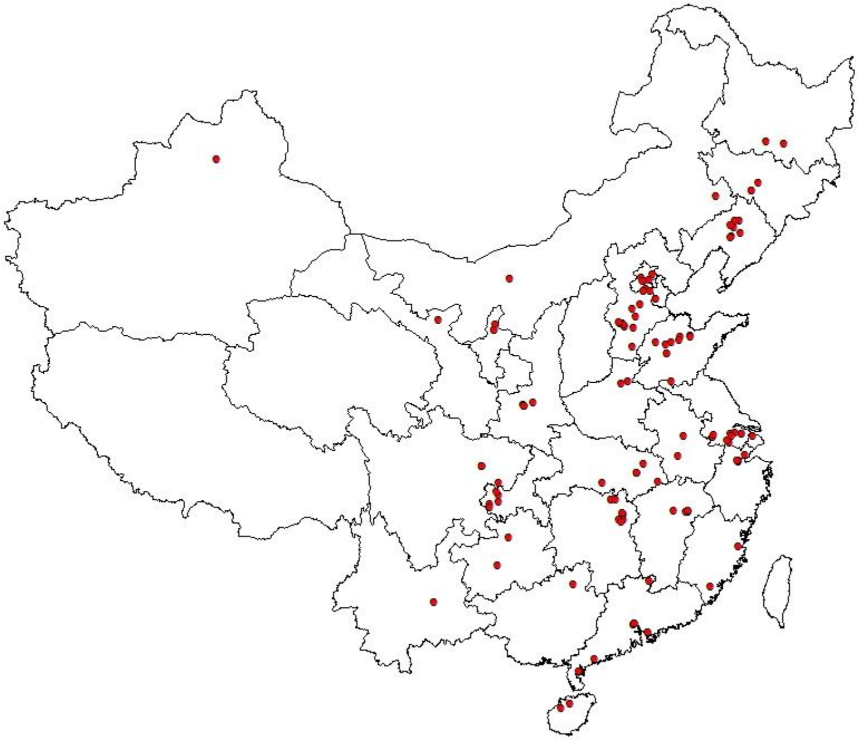
Smaller, 87% of IPCC default

Larger, 170% of IPCC

1. Motivation

β_{ijk} need to be also country-specific and spatial explicit

N leaching+runoff ratio



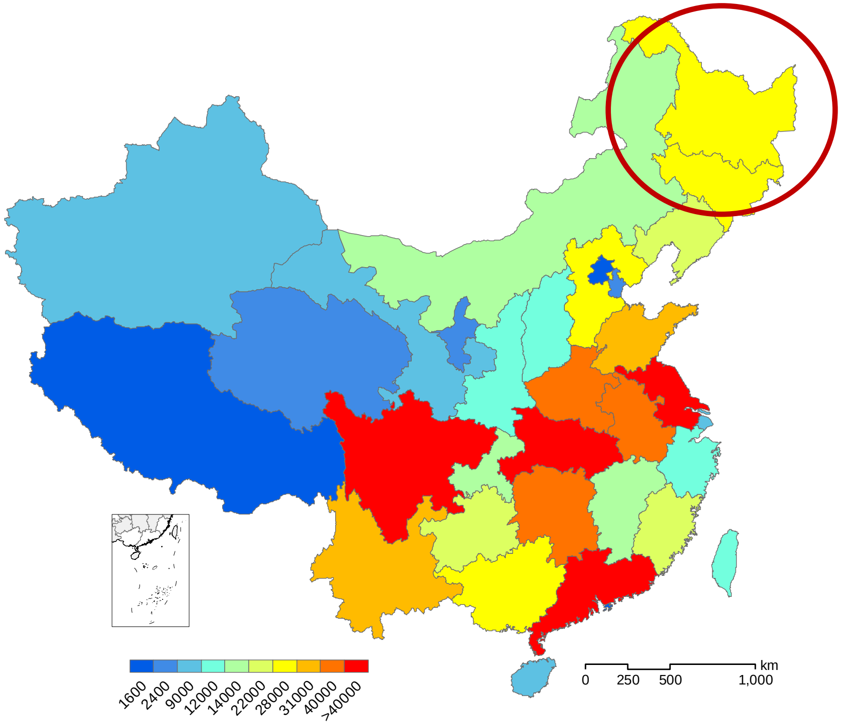
12% of IPCC defaults

Crop	Region	IPCC,%	China	SD
1-Paddy	1-Region I	30	8.00	1.37
	2- Region II	30	3.45	0.32
	3- Region III	30	4.13	0.40
	4- Region IV	30	1.68	3.43
	5- Region V	30	1.22	0.90
	6- Region VI	30	1.21	0.47
2-non-paddy	1-Region I	30	4.94	4.62
	2- Region II	30	0.45	0.43
	3- Region III	30	2.49	4.12
	4- Region IV	30	6.26	8.56
	5- Region V	30	7.92	3.53
	6- Region VI	30	0.76	1.59

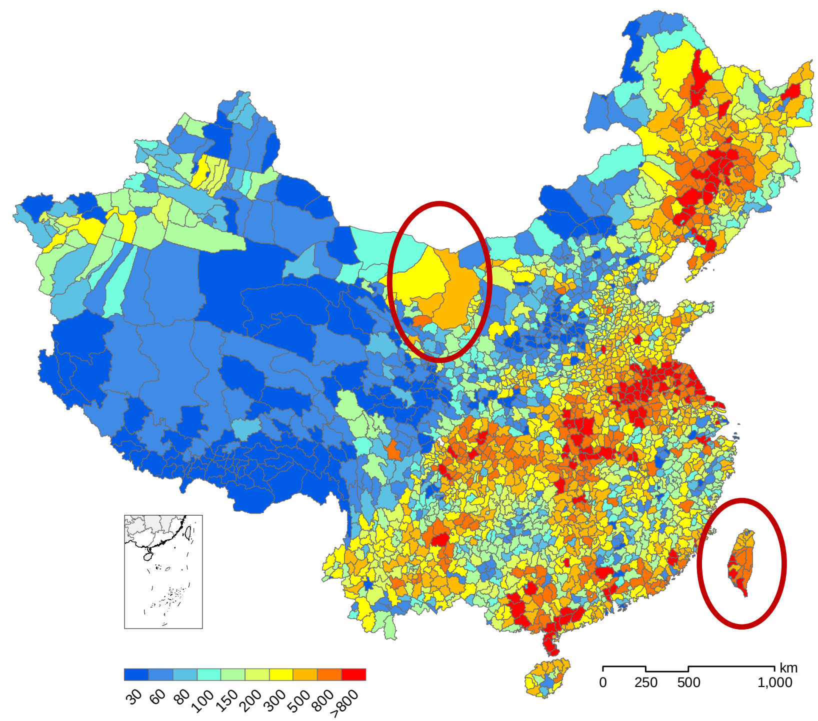
1. Motivation

Resolution of AD_{ijk} need to be as higher as possible for the following spatial allocation

Fertilizers (Provincial)



Fertilizers (County)



2. Methodology

- So, PKU-N2O-CHINA was produced based on following **local, regional and high-resolution** datasets for **all** emission sources

New Emission factors **High-resolution** Activity data

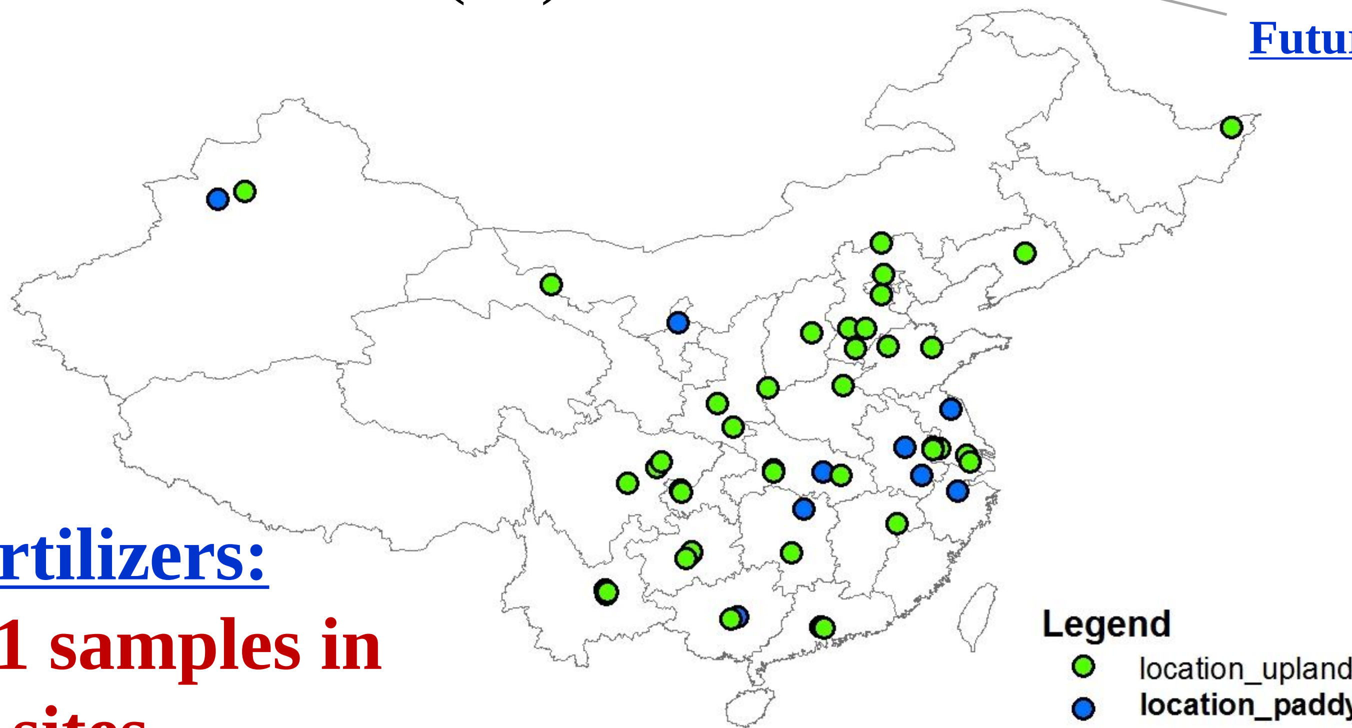
$$E = \sum_{i,j,k} \left(EF_{ijk} \times \beta_{ijk} \times AD_{ijk} \right)$$

All Sources **New and regional** Parameters

2. Methodology

- **New EF_{N2O}** for fertilizers (381), organic soils (12), manure management systems (**6**), energy (66), indirect emissions (45)

Future work



Fertilizers:

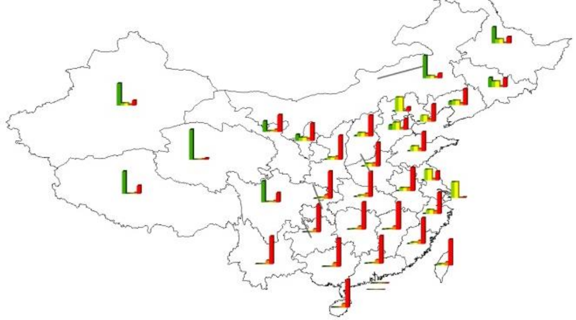
381 samples in 89 sites

More details can be found in Zhou *et al.* to be submitted

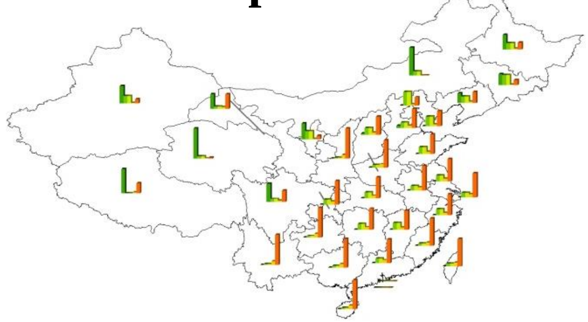
2. Methodology

- **New and regional parameters** for **fertilizers, manure management systems, crops**, and indirect emissions

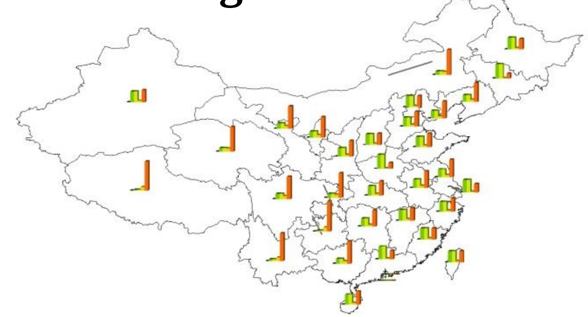
Cattle: MMS



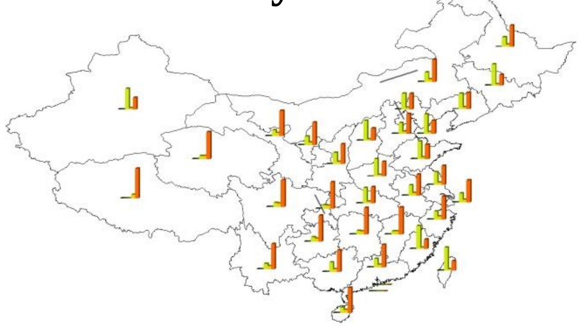
Sheep: MMS



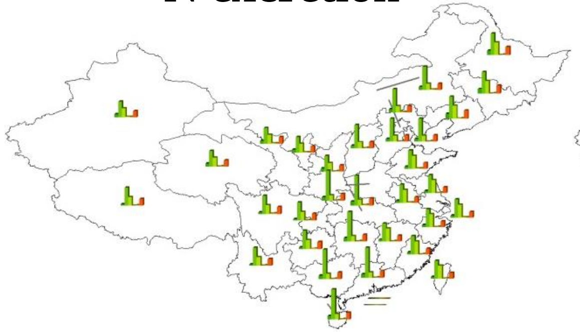
Pig: MMS



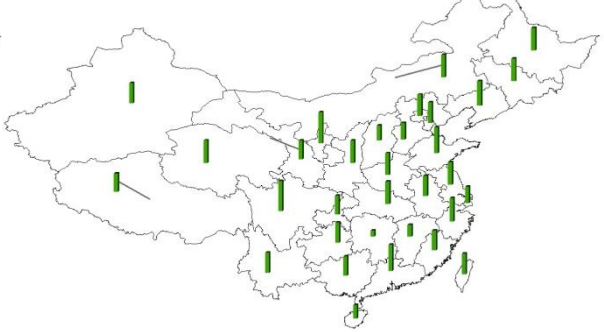
Poultry: MMS



N excretion



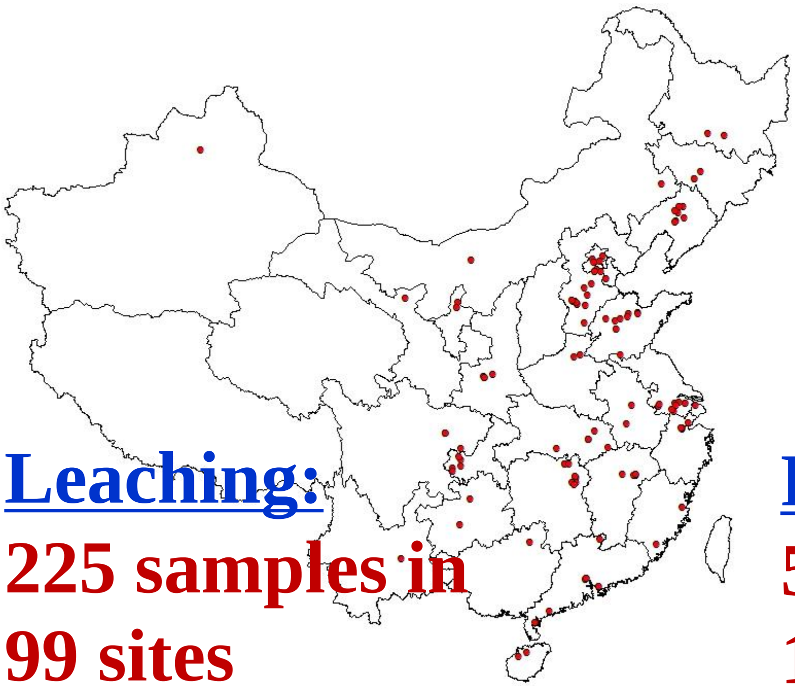
Residue removed



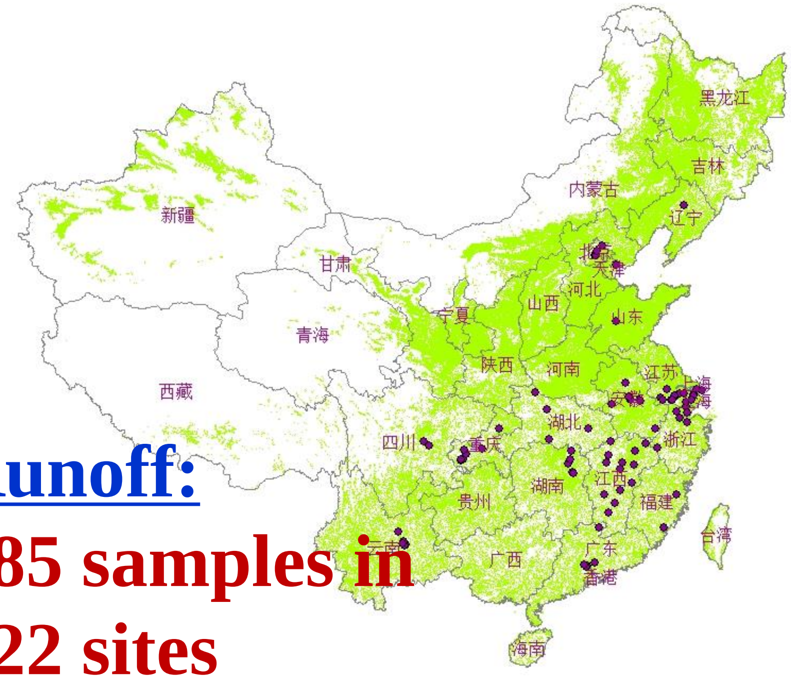
M1: Manure in pasture, M2-S: slurry in intensive system, M2-D: drylot in intensive system, M3-S: slurry in free-range system, M3-D: drylot in free-range system

2. Methodology

- **New and regional parameters** for fertilizers, manure management systems, crops, and **<u>indirect emissions</u>**



Leaching:
225 samples in 99 sites

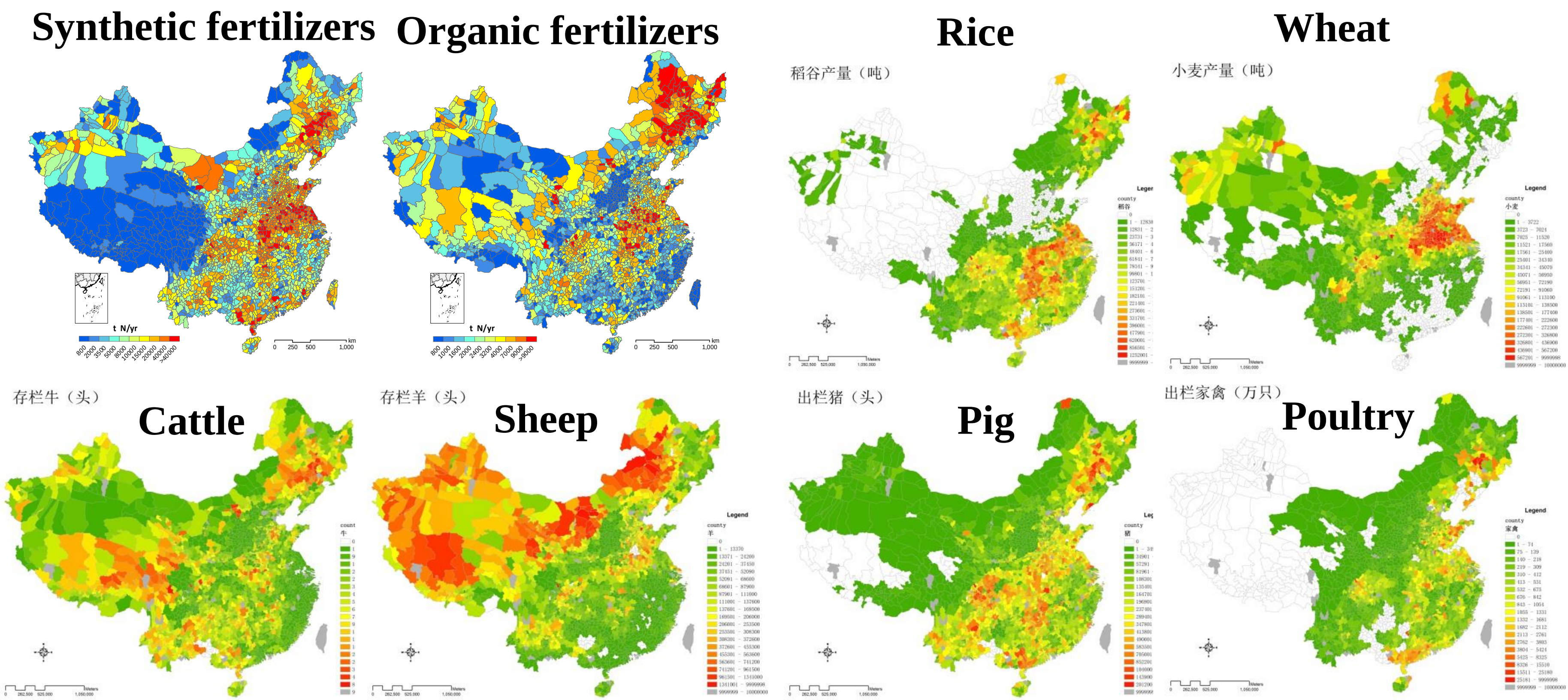


Runoff:
585 samples in 122 sites

More details can be found in Zhou *et al.* to be submitted

2. Methodology

- **High-resolution activity data** for agriculture, energy, wastes, and indirect emissions



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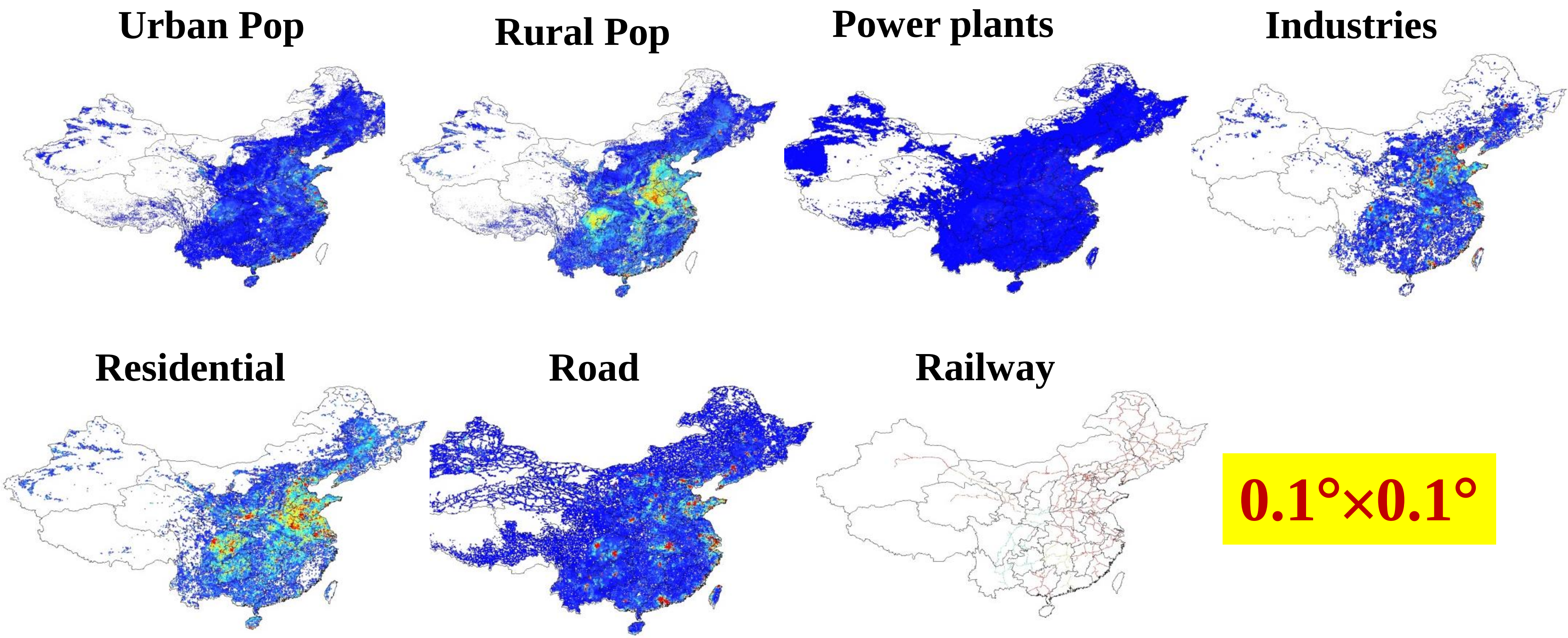
2. Methodology

- **High-resolution activity data** for agriculture, energy, wastes, and indirect emissions



0.1°×0.1°

More details can be found in Zhou *et al.* to be submitted

2. Methodology

- **Spatial allocation** into 1×1 km gridded maps

Source	Allocation proxy
Agriculture	1*1 km cropland
Manure in PRP	1*1 km grassland
Manure management systems	1*1 km rural population
Energy, indirect from N depositions	1*1 km total population
Industries	1*1 km Urban and built-up
Waste	1*1 km urban population

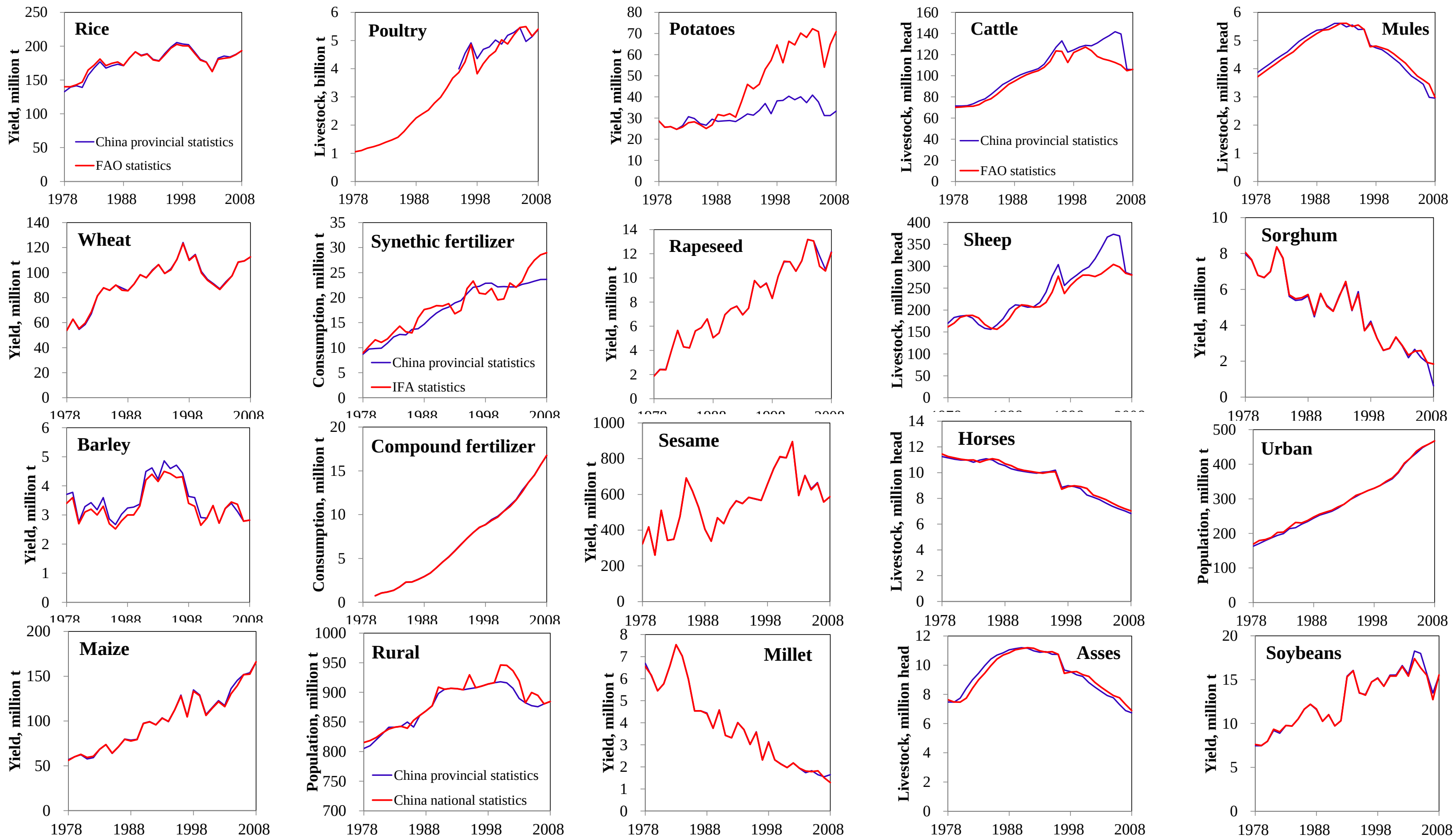
Base on EDGAR V4.2; Huang et al., 2011; Wang et al., 2012

2. Methodology

- **Uncertainty estimation** through Monte Carlo simulation (1 million runs)

Activity data

Differences with FAO, IEA, IFA

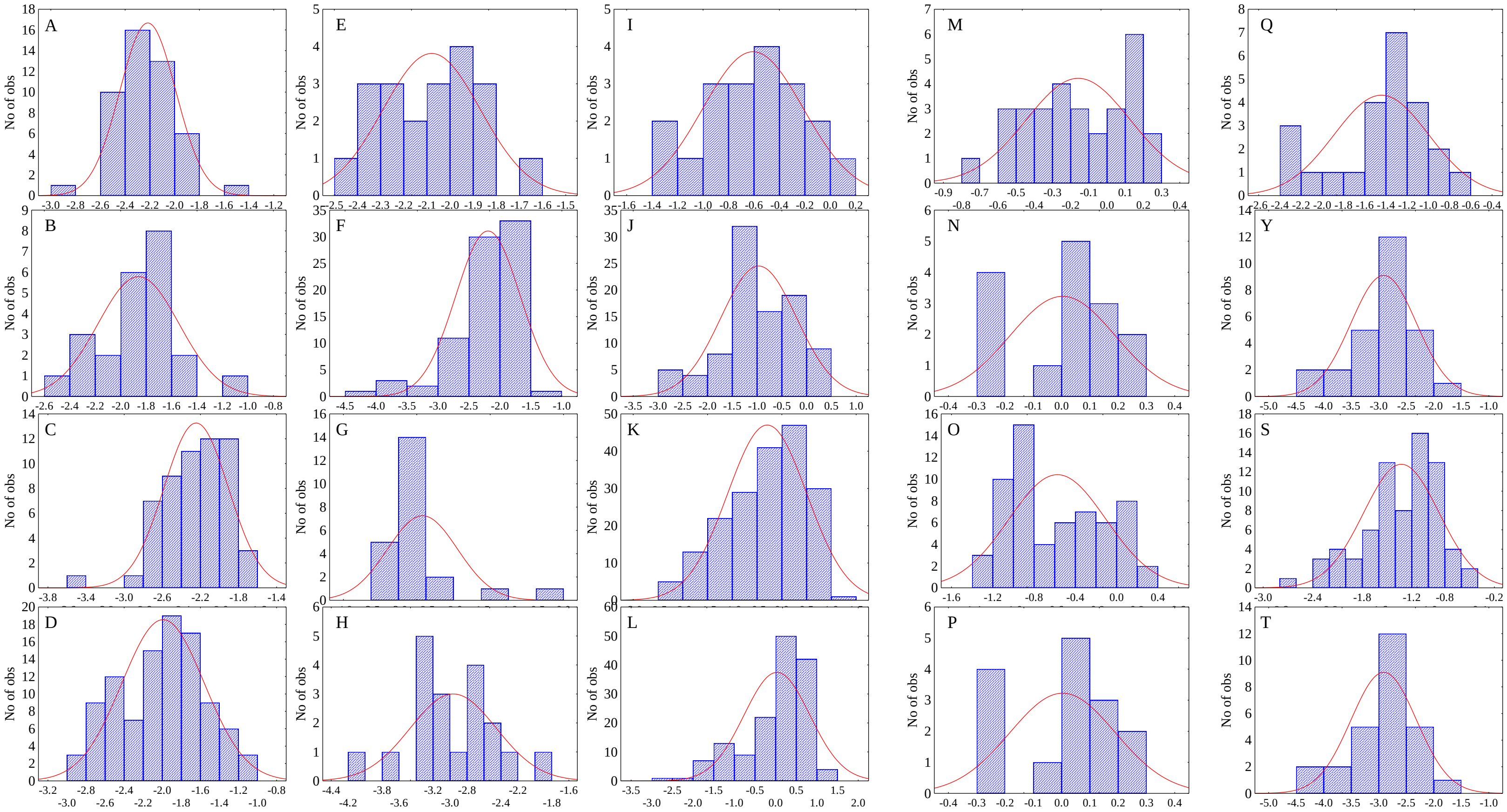


2. Methodology

- **Uncertainty estimation** through Monte Carlo simulation (1 million runs)

EF_{N2O} and Parameters

Median and SD after log-normal transfer



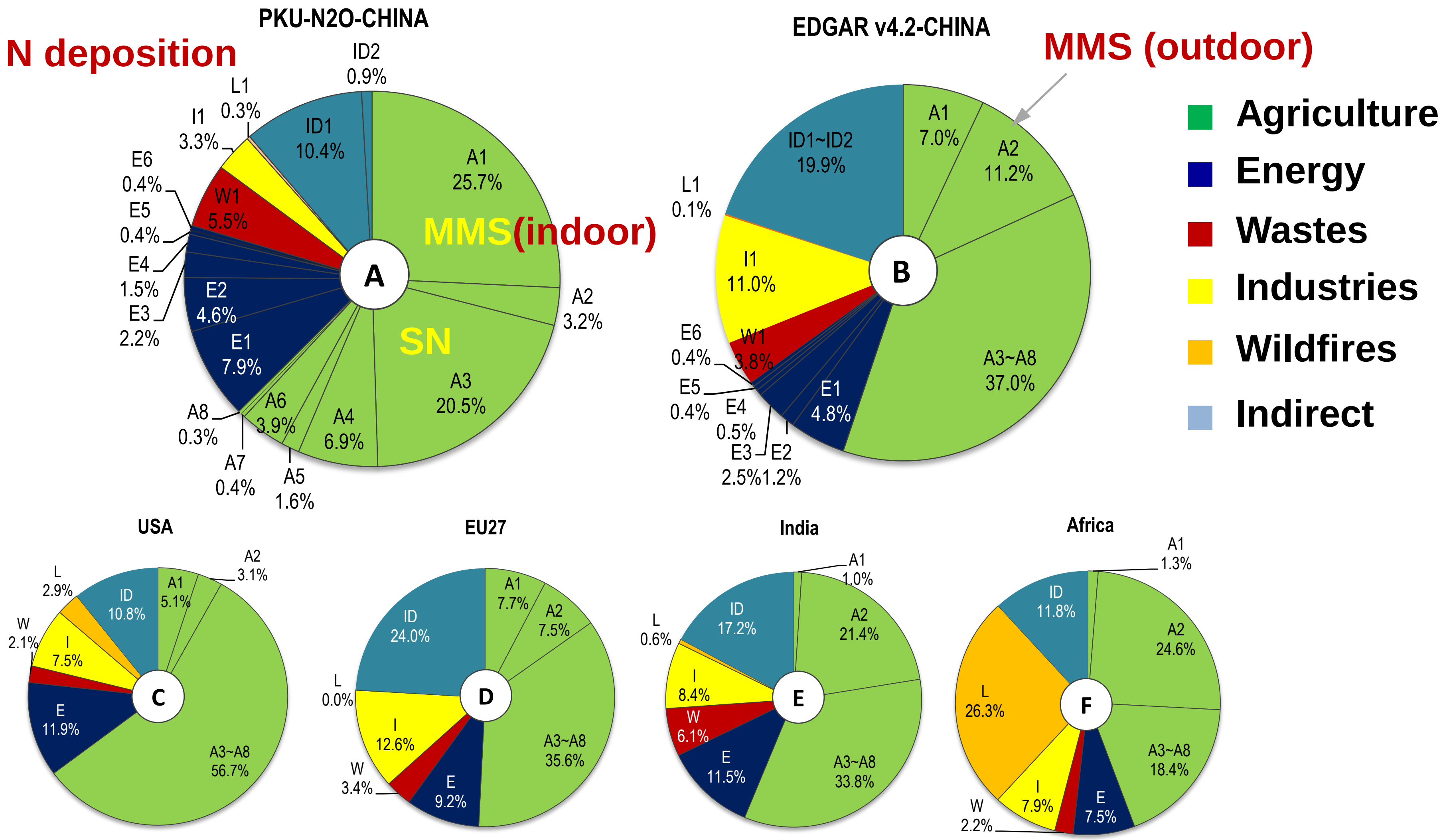
3. Total emission and source profile in 2008

- Total emissions (GgN_2O/yr)

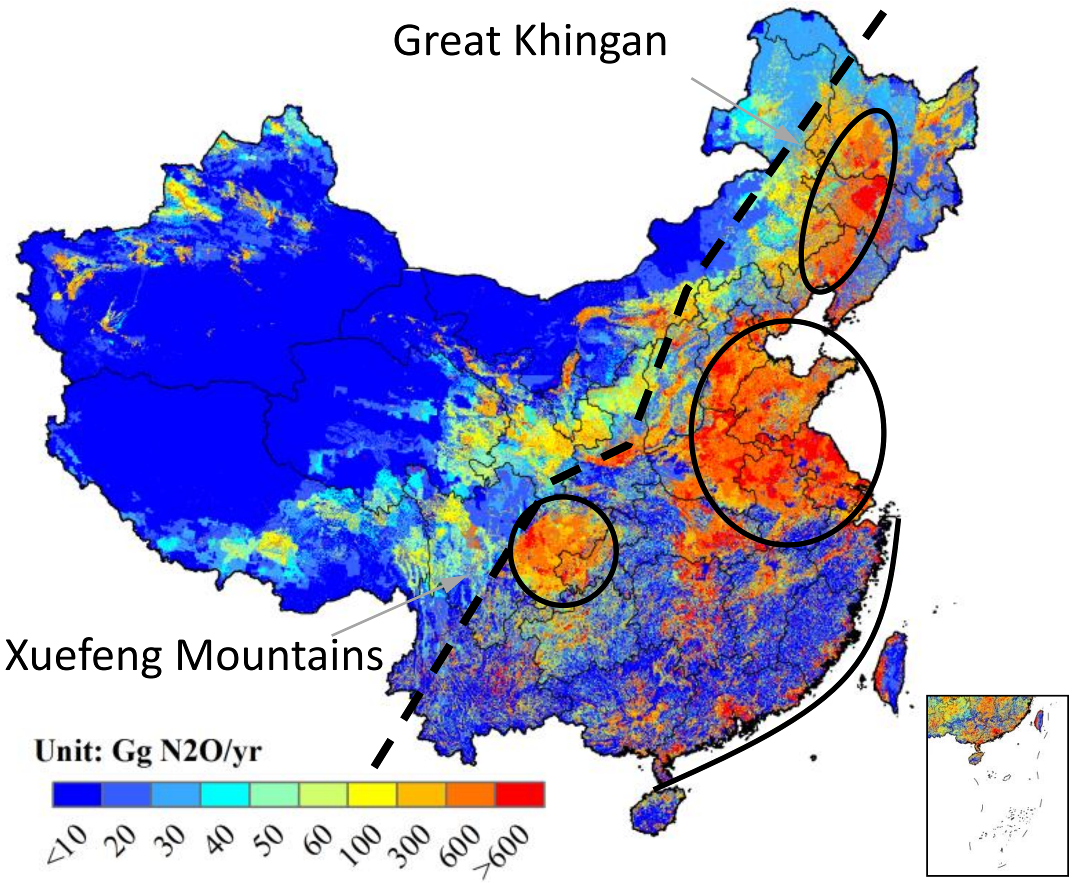
Type	PKU-N2O-CHINA	EDGAR v4.2	GAINS-CHINA
Direct: Agriculture	1102 (62.5%)	981	1697.8
Direct: Energy	300 (17.1%)	176	132.3
Direct: Wastewater	97.6 (5.5%)	68	135.8
Direct: Industry	58.1 (3%)	196	42.5
Wildfires	4.8 (0.3%)	2.4	--
Indirect emissions	199 (11.3%)	354	--
TOTAL	**1762 (706~2667)**	**1778**	**2008.4**

3. Total emission and source profile in 2008

- Source profile



4. N_2O spatial pattern in 2008



East China:

70%, 0.43 Mg·km^{-2}·yr^{-1}

West China:

30%, 0.078 Mg·km^{-2}·yr^{-1}

But, contributions of **industries** and **indirect** are near identical with each other

4. N_2O spatial pattern in 2008

(1) agriculture

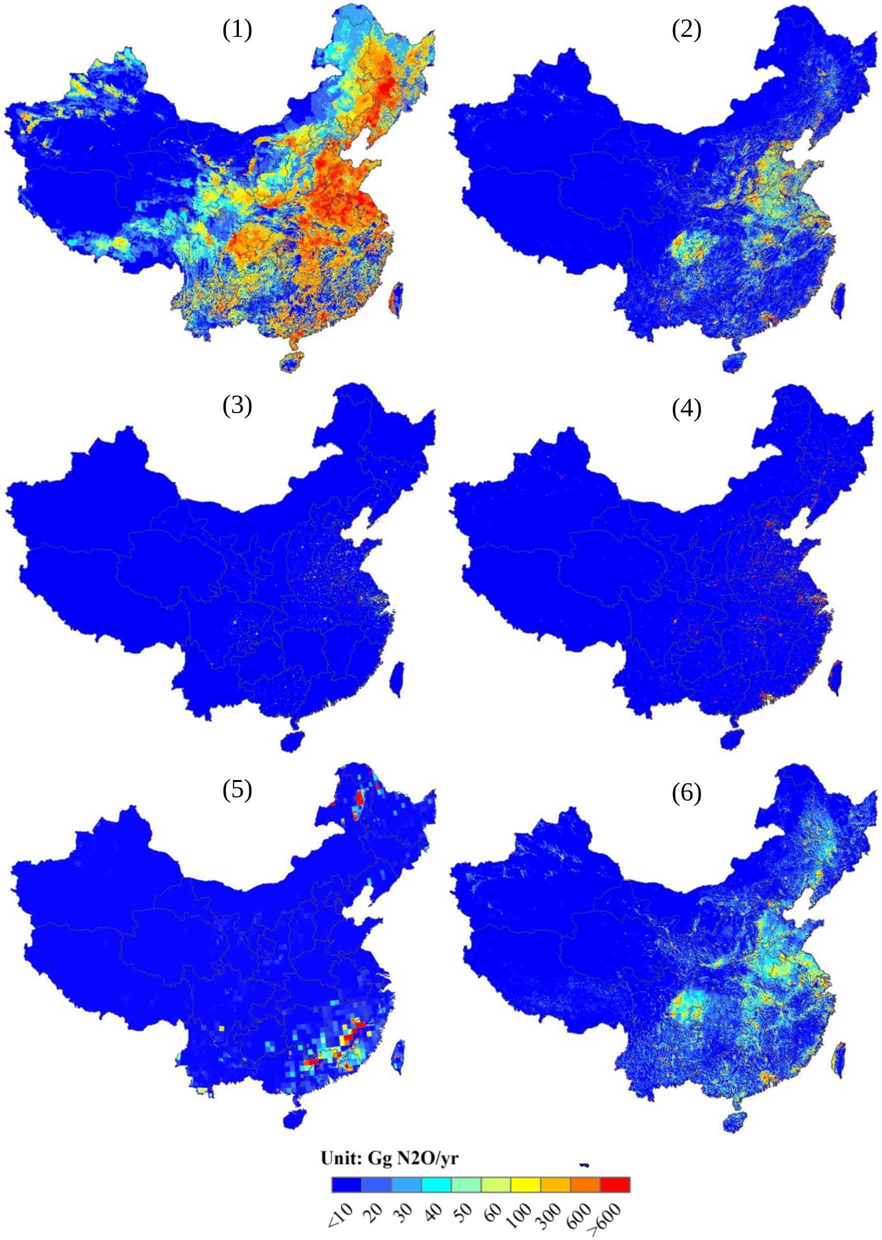
(2) Energy

(3) industrial processes/product use

(4) Waste

(5) Wildfires

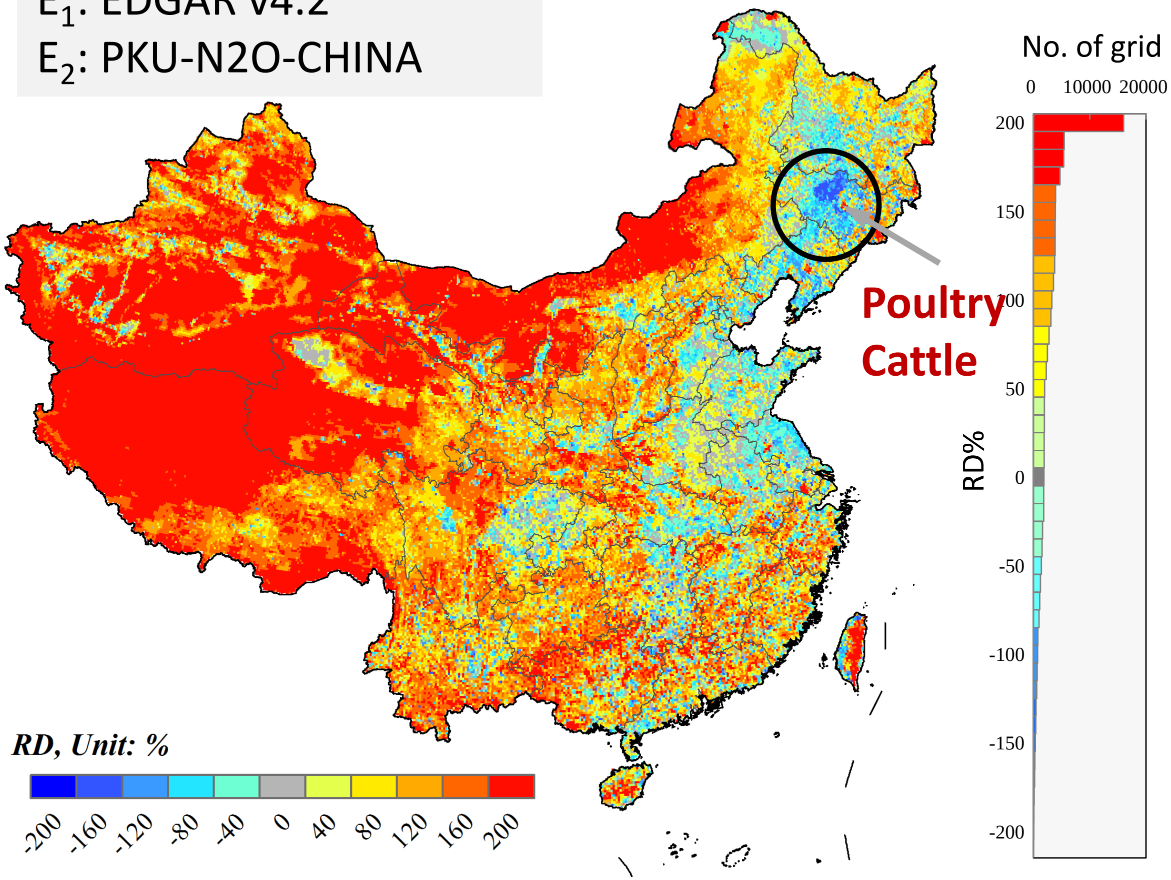
(6) indirect emissions



4. N_2O spatial pattern in 2008

- Comparison with EDGARS at 0.1°×0.1° resolution

RD=0.5(E$_1$ – E$_2$)/(E$_1$ + E$_2$)
E$_1$: EDGAR v4.2
E$_2$: PKU-N2O-CHINA



average absolute RD:
121%
absolute RD>100%:
64% of total grids

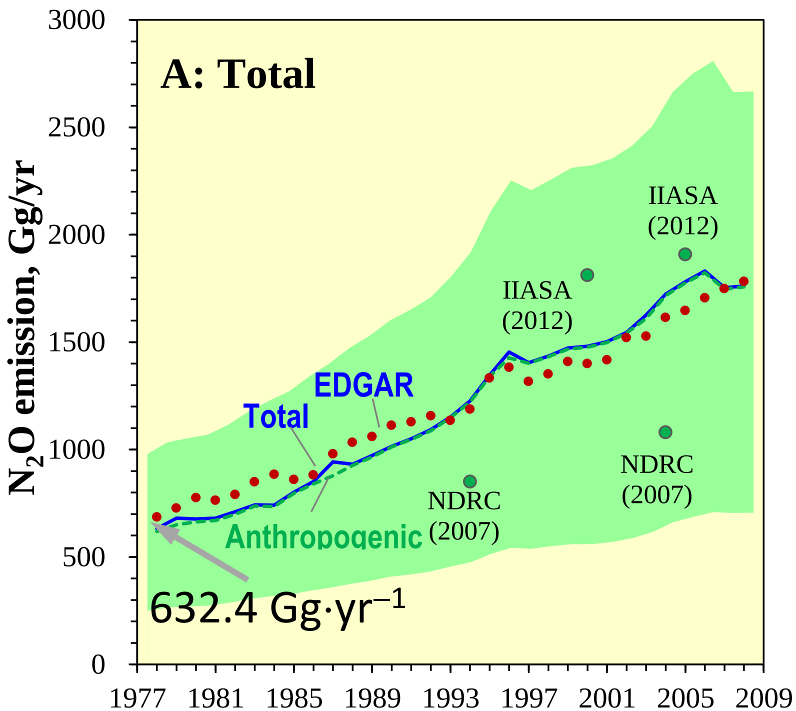
larger positive RDs were found in the lower-emission regions

larger negative RDs in higher-emission

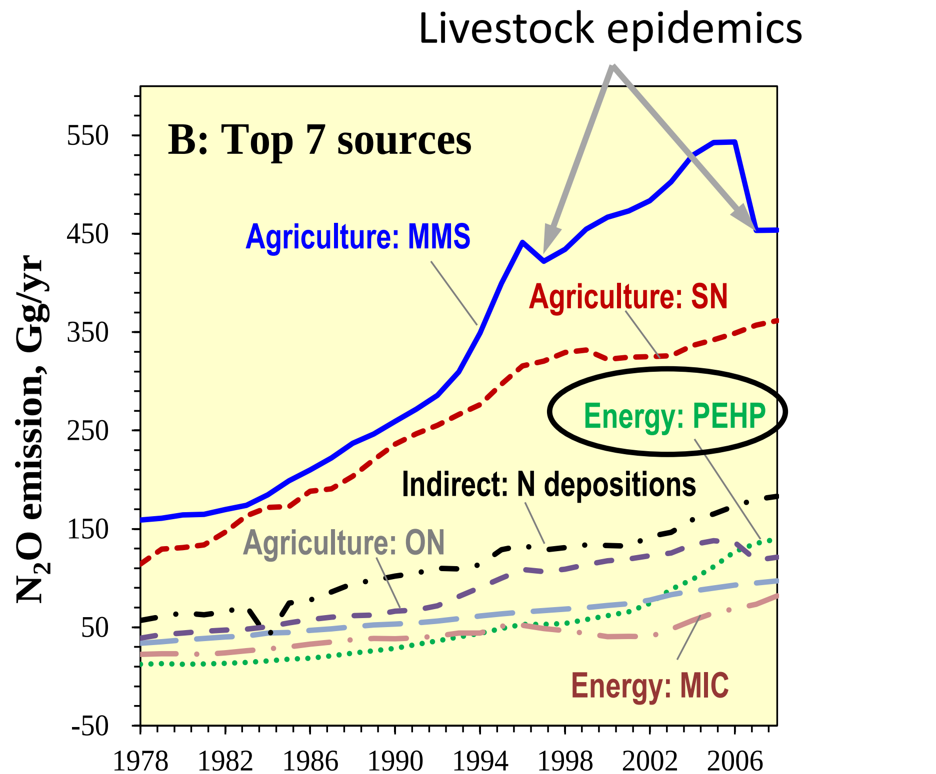
Implication: mitigation strategies focus on fewer regions but achieve reduction targets

5. N_2O temporal trends

- (2.7% yr^{-1}, 1978-1984)→(5.8% yr^{-1}, 1985-1996) →(1% yr^{-1}, 1997 to 2002)



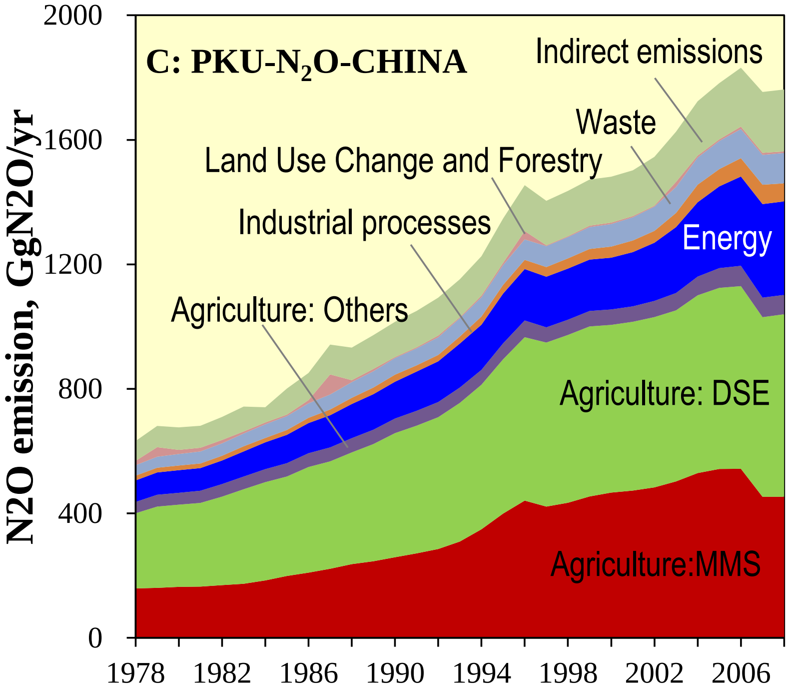
5~20% smaller before 1992 but 0.3%~7% higher than EDGAR v4.2

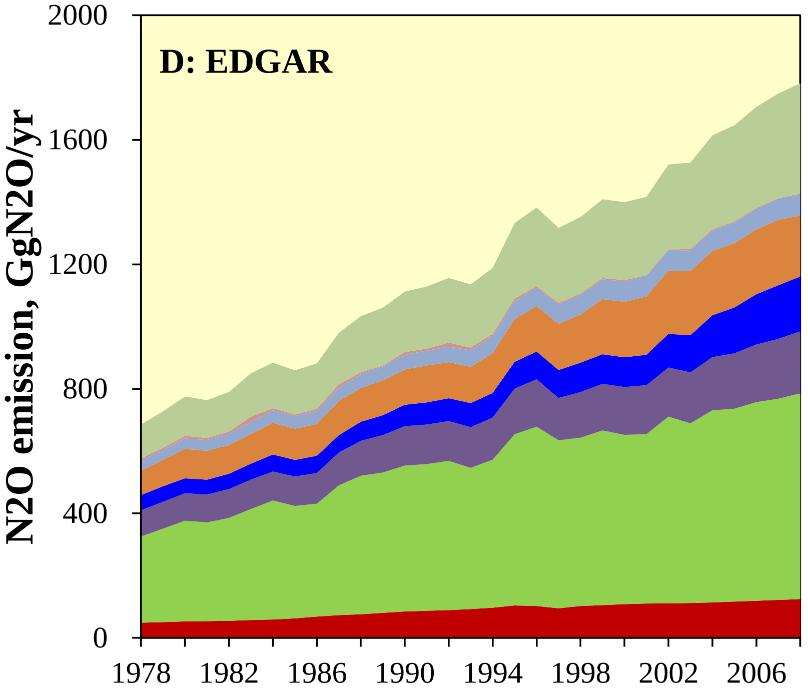


per hectare cereal yield ↑, N use (117-470) ↑, partial factor productivity (31-12kg/kg) ↓

5. N_2O temporal trends

- Comparisons on source profile

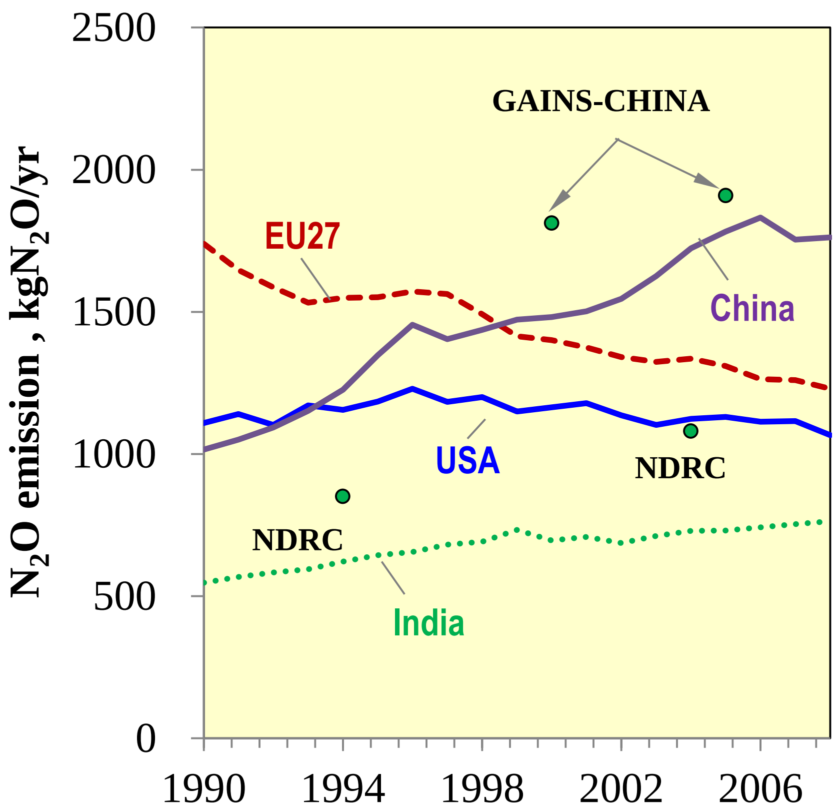




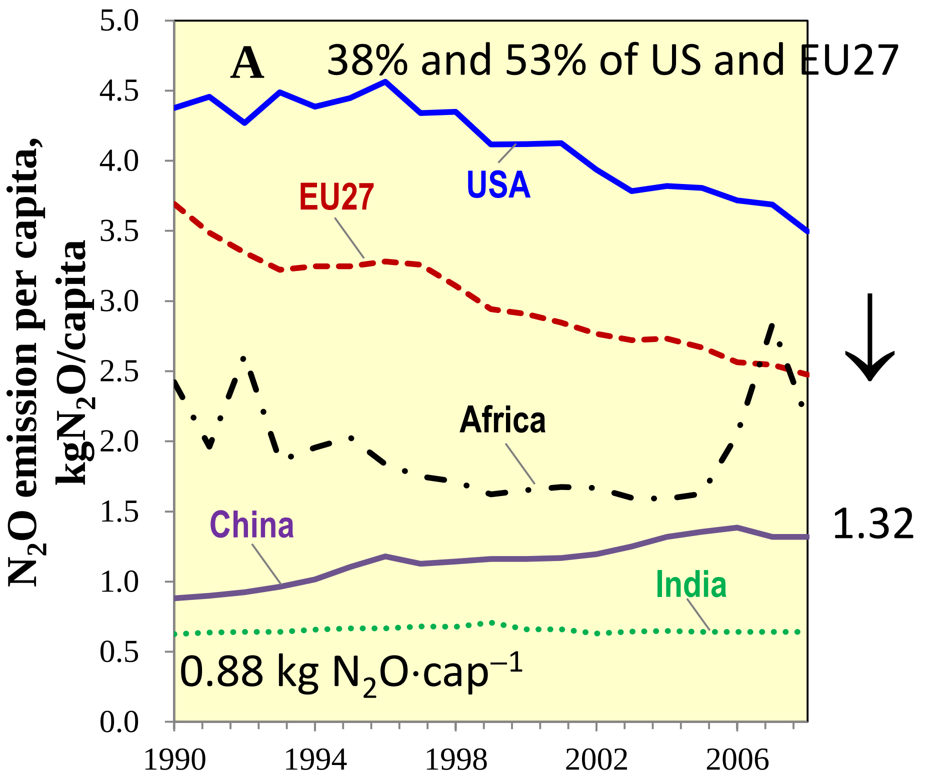
- MMS and energy are higher consistently than EDGAR
- Industrial, indrect are significantly lower

6. Implications

Total emissions



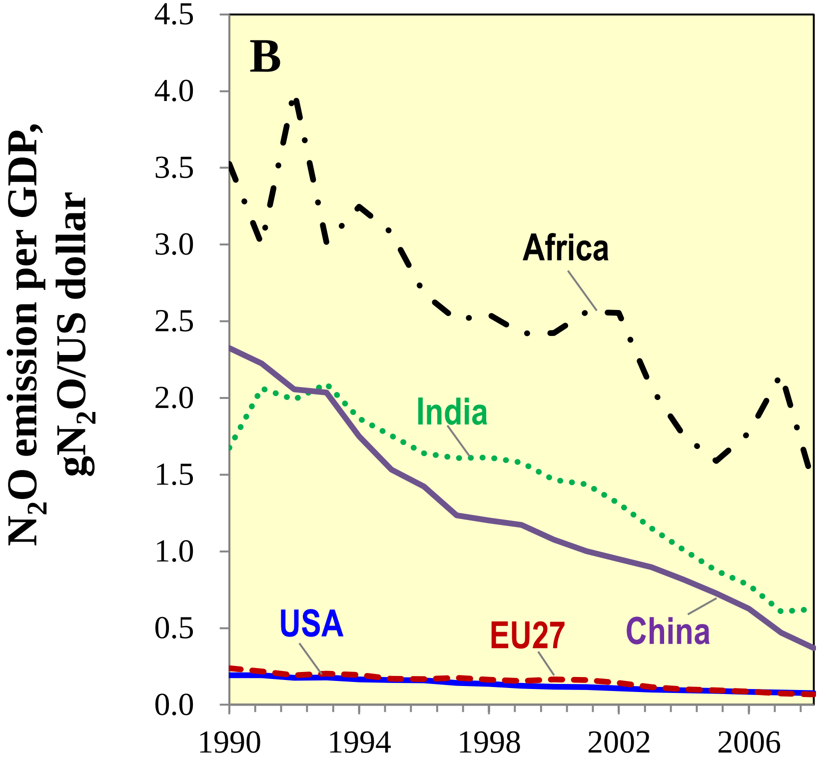
per capita emissions



- largest source of N2O emissions and maintaining a positive increasing trend
- economic structure and lifestyle of new urban residents stimulated the increase of food and energy consumptions

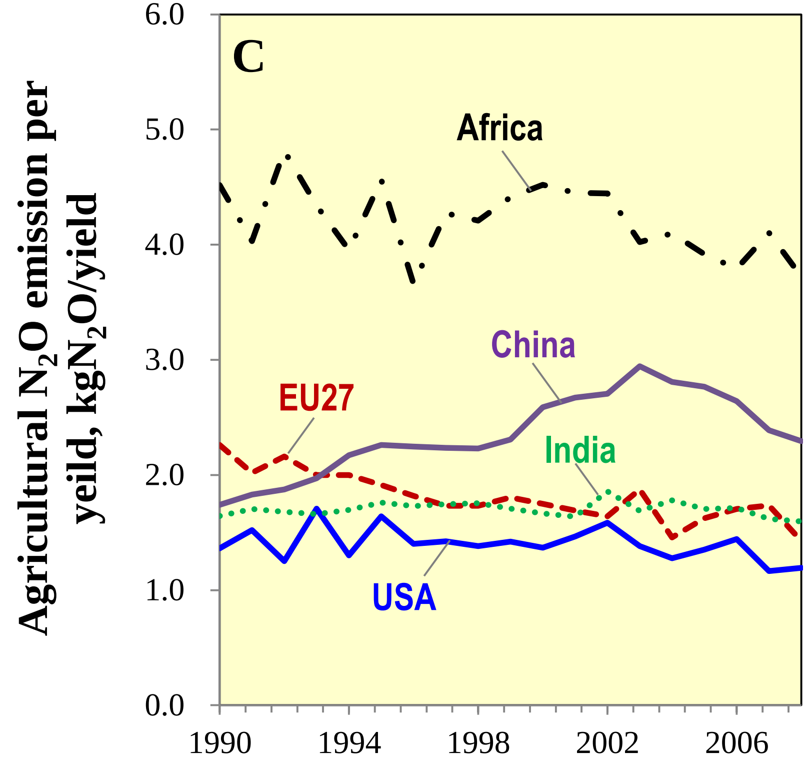
6. Implications

per GDP emissions



$2.32\ g\ N_2O \cdot dollar^{-1}$ to $0.37\ g\ N_2O \cdot dollar^{-1}$
half or a quarter of Indian or African

Agricultural emissions per yield



$1.7\ kg \cdot t^{-1}$ in 1978, ↑ 2.9, ↓ 2.3 in 2008

- Requirement of nutrient management, anaerobic digester for MMS, human dietary shift

7. Remarks for next step

- Comparison with inverse modeling?
- Estimating effects of N_2O emissions on climate forcing?
- Understanding the drivers of N_2O emissions regionally using Kaya identity?
- Modeling N2O emissions by OCHIDEE?
- With NH3+NOx emissions, estimating effects of N-related emissions on ozone destructions and N deposition?