Underestimated N_2O emissions from China′s croplands

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1. Background

LETTER

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Reduced carbon emission estimates from fossil fuel combustion and cement production in China

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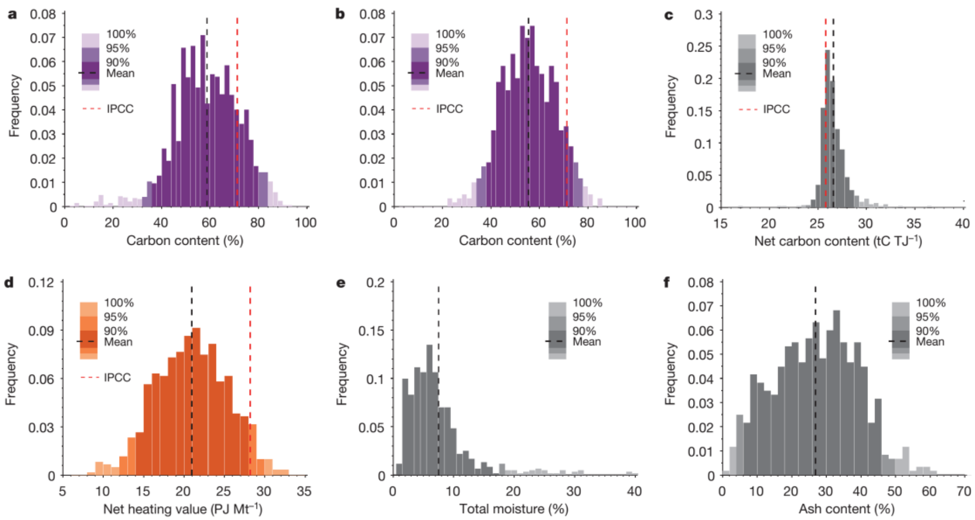
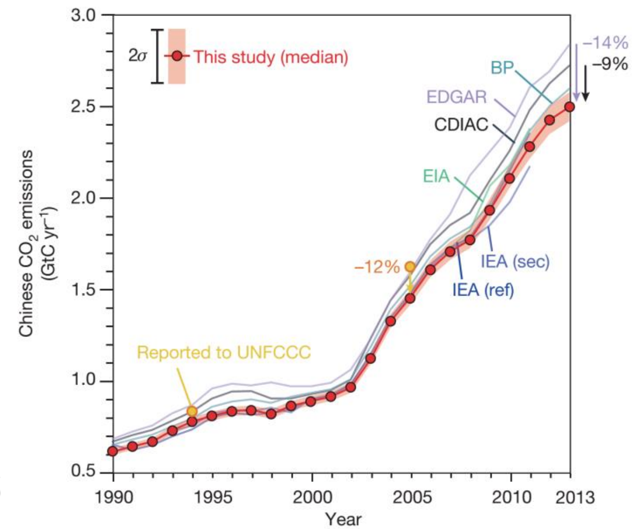




Energy consumption was **10% higher** and EF for coal was **40% lower** than IPCC default values, resulting in **14%** lower than EDGAR V4.2 in 2013

Liu et al., 2015, Nature 524, 335–338

1. Background

- $E_{N2O}=EF_{N2O} \times N_{rate}$ **+ Background** E^0
- EF_{N2O}: IPCC (1% for upland, 0.3% for paddy)

  Mean (1.1% for upland, 0.6% for paddy from Chinese dataset)

  But, it varies widely because of very few obs representative the EF across China
- N_{rate}: =**Activity data** (i.e. chemical fertilizers, livestock, rural population, crop production) × **Coefficients** (i.e. N contents in manure and excreta, ratios of manure and residues returned to croplands) **with ~50% differences between several datasets**

→ **large uncertainty (up to 46%: 4.7Tg [EDGAR] vs. 5.7 Tg [inversion] vs. 7.0 Tg [DLEM])**

- E^0: IPCC (**~0 kgN/ha**), **but little is known in background emissions in China's croplands**

Tian et al., 2014; Saikawa et al., 2014; Zhou et al., 2015

1. Background

Therefore, we developed or produced a **high-resolution & time-varying** data (1990-2012) of:

- **EF_{N2O}** (upland & rice) constrained by N_2O observations;
- **N_{rate}** (Chemical fertilizers, manure, human excreta, and crop residues) harmonized by local statistics and enhanced surveys across China;
- **E^0** constrained by N_2O observations at N_{rate}=0 (by using closed or dynamic chambers);

N_2O emissions from croplands for the period 1990-2012

2. Data and methods

- **Flux upscaling technique:** Bayesian recursive regression tree algorithm

$$E_{N_2O} = EF(x_k) \cdot N_{rate} + E^0(x_k)$$

Obs (E_{N_2O}); Environmental factor (x_k); N fertilizer application rate (N_{rate})

where

$$EF(x_k) = \Delta EF(x_k) \cdot N_{rate} + EF^0(x_k)$$

- **Process-based modeling:** DLEM, DNDC, DAYCENT, which have been calibrated by flux towers but without using new Chinese N_{rate} maps

- **Bayesian inverse modeling:** Saikawa et al. (2014) but was updated by

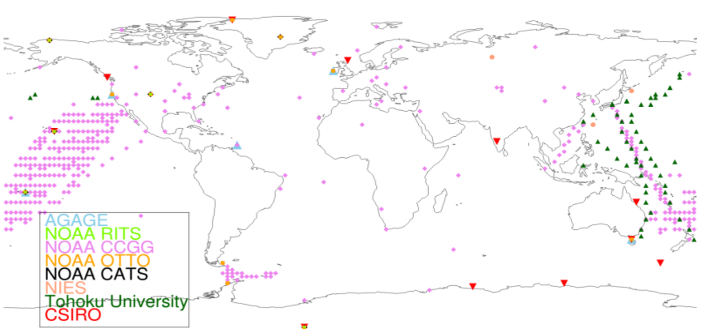
  Prior in China: this study & Zhou et al (2014)

  Prior in others: EDGAR v4.2, GEFD

  Prior for natural: CLMCN-N_2O

  Prior for ocean: Manizza et al. (2012)

  Transport model: MOZART

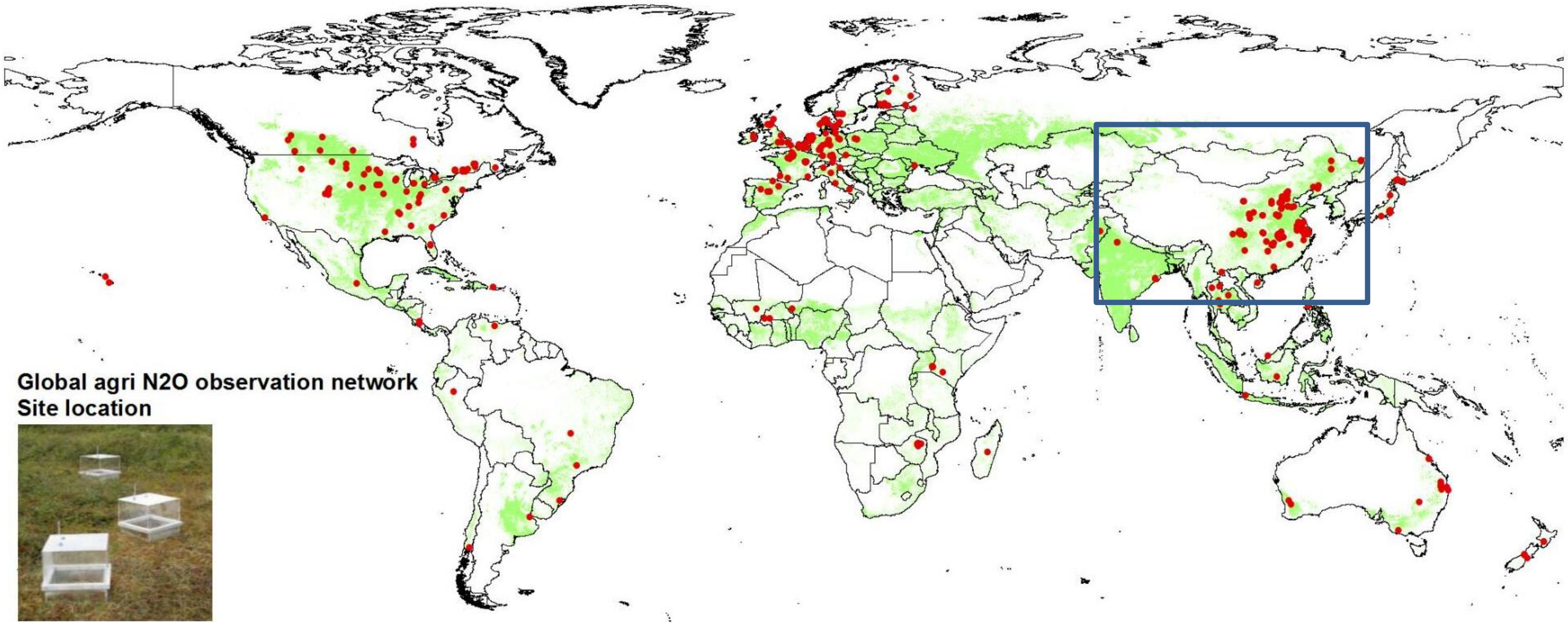


Del Grosso et al. (2009); Li et al. (2010); Saikawa et al. (2014); Tian et al. (2014); Zhou et al., 2014; 2015

2. Data and methods

2.1 Global agricultural soil N_2O observation networks

Upscaling involves inter- and extrapolation. It is important to note that it is not **geographical** space which determines if inter- or extra- takes place but **environmental** space



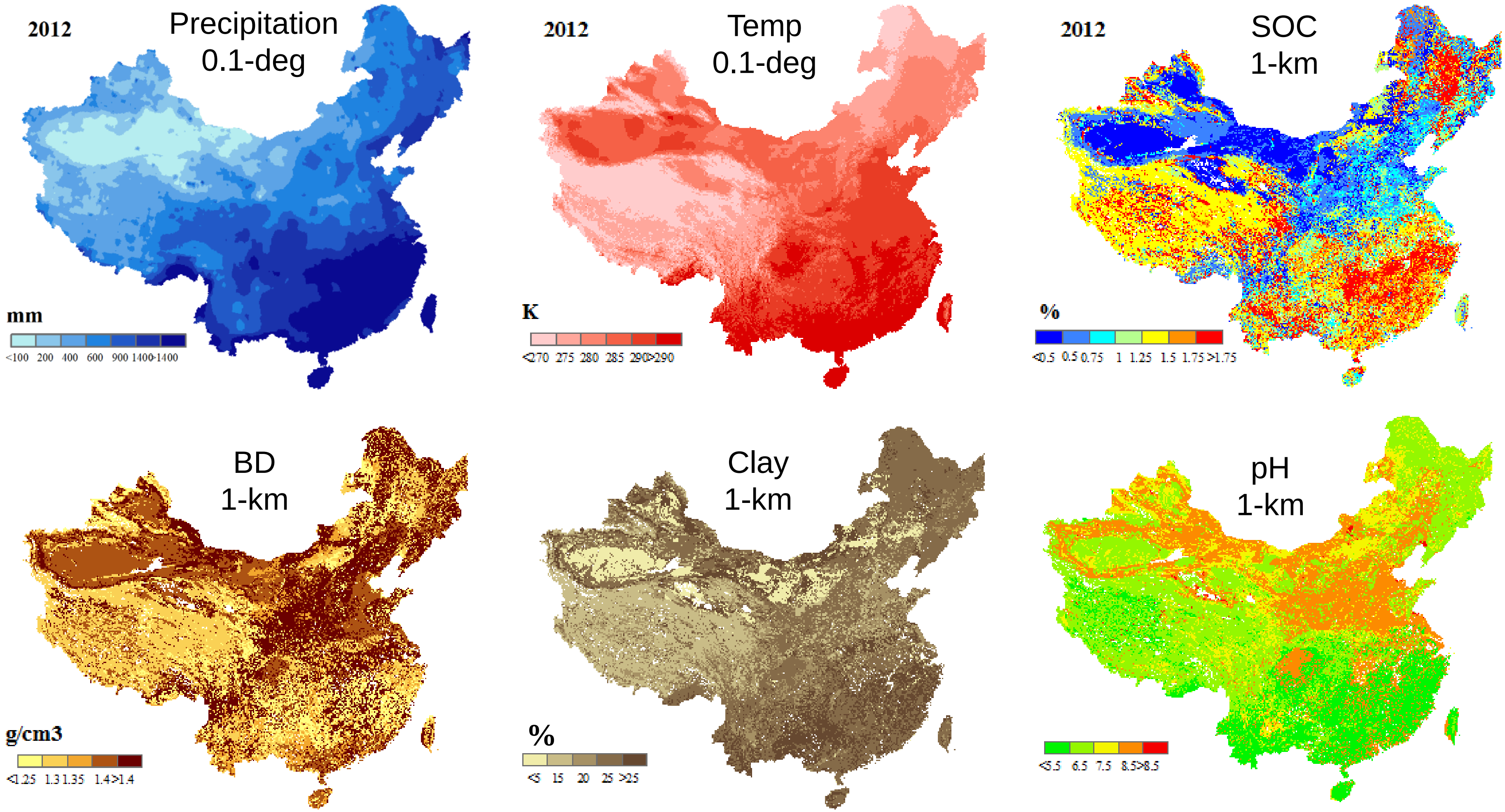
2,831 records (~800 in China) from 348 sites in 42 countries

Data source: >1500 journal articles and unpublished data from co-authors

From 34 Research groups

2. Data and methods

2.2 Environmental factors (x_k, 1990-2012)

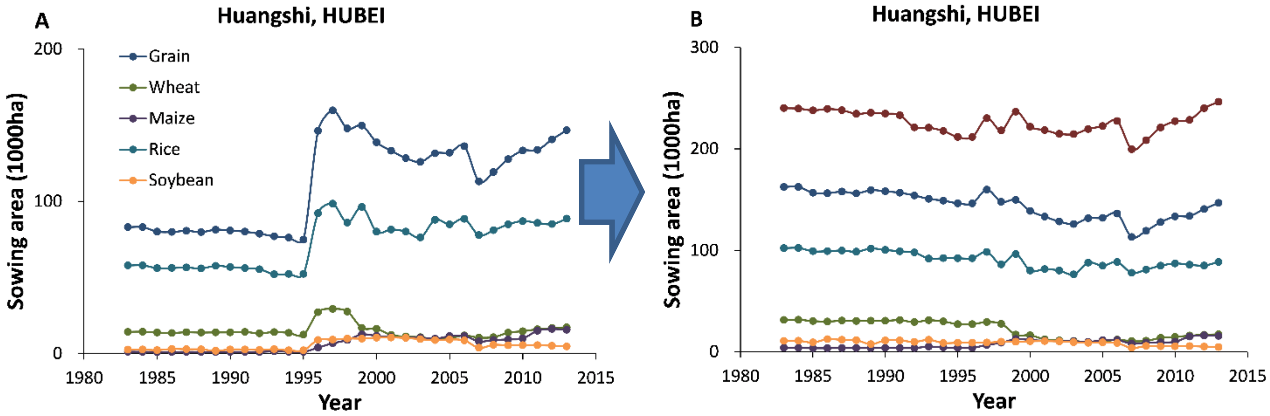


CMFD, 2012; HWSD, 2011, Yu et al., 2012

2. Data and methods

2.3 County-based activity data (1990-2012)

- N_{rate}= (Chemical fertilizers [CN] + manure +excreta + crop residues) / sowing area →**CN, livestock, crop, rural population, sowing area**
- **Changing** in number (**2,833~2,862**), administrative division, and names

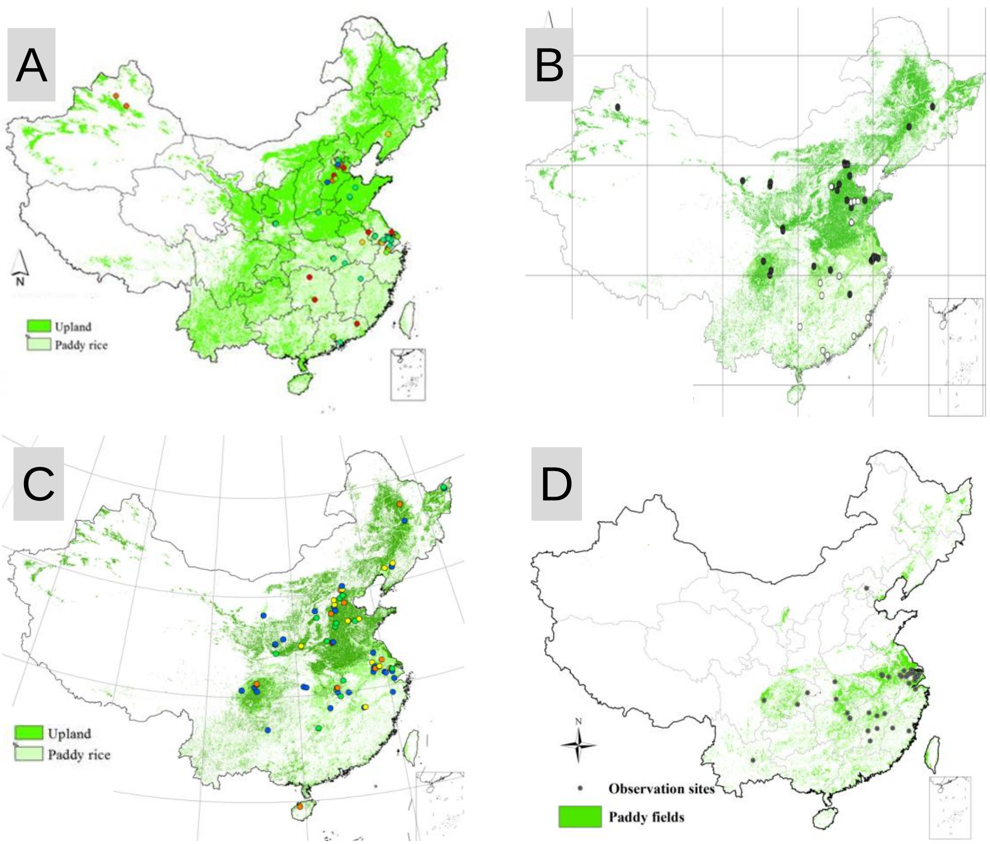


- **Missing data**: interpolated based on data for near year
- **Upland vs. paddy**: SN and crop residues for two types, but manure, human and excreta only for upland soils

2. Data and methods

2.4 County-based coefficients (1990-2012)

- **<u>N contents in manure and excreta, ratios of manure and residues returned to croplands</u>** based on observations **> 400 counties** in high-fertilized cropping areas



A: N content in manure

B: N content in residues

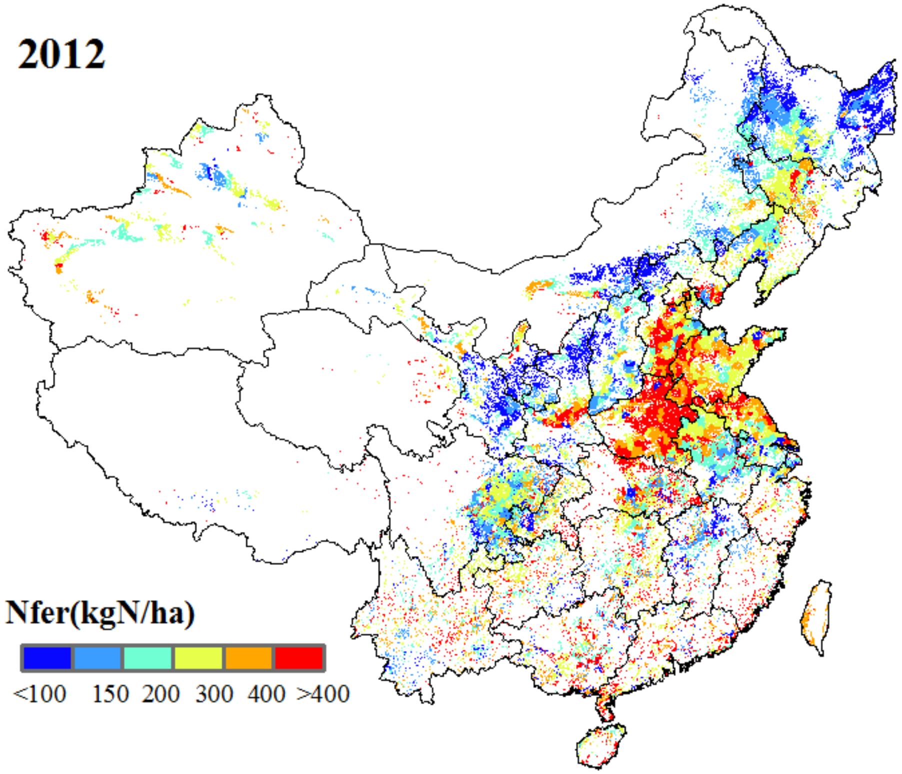
C: ratio of manure to soils

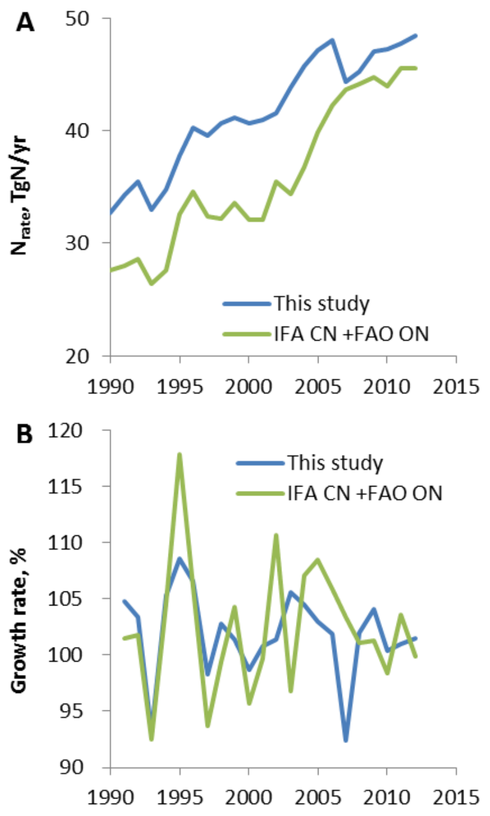
D: ratio of residue to soils

3. Results and discussion

3.1 N_{rate} (1990-2012) at 1-km scale

We estimate that cumulative N_{rate} was 16% greater than IFA mass-balance results *, but our results indicate a lower annual growth rate of N_{rate} (9%/yr vs. 12%/yr). ***We will compare with the growth rate of NH_3 columns (molec/cm^2) derived from IASI satellite observation for 2007-2012 (Van Damme et al. 2014).***

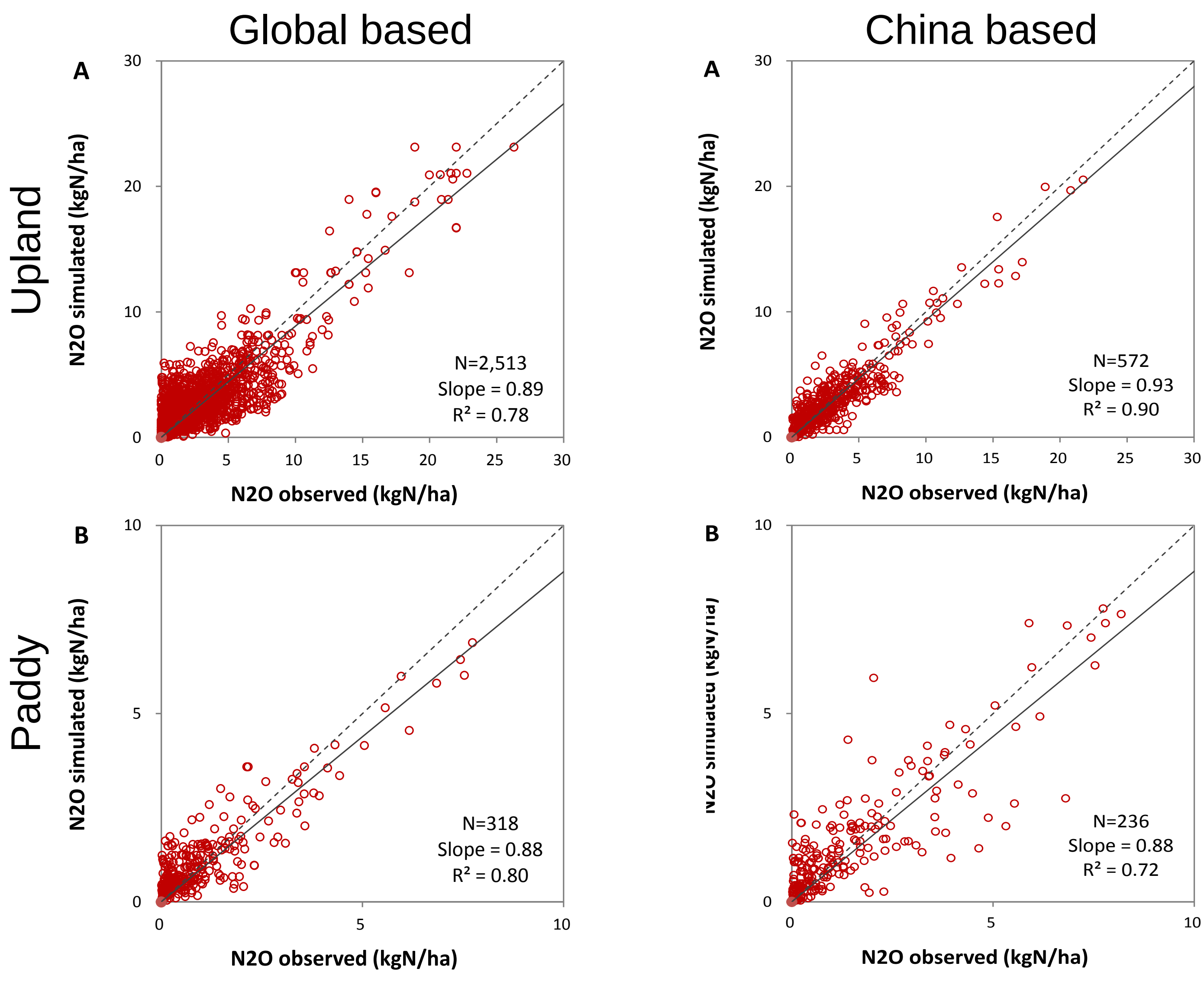




* IFA mass-balance results=IFA CN+ FAO manure + crop residues

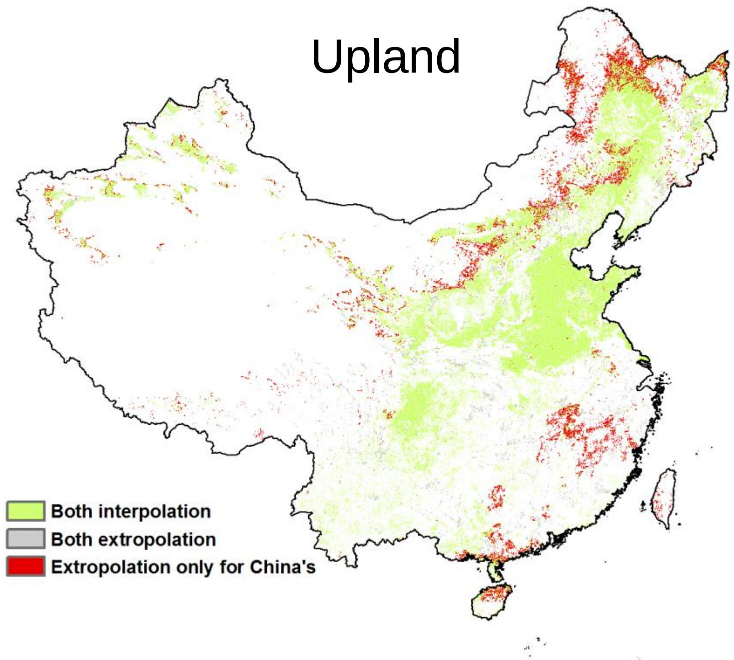
3. Results and discussion

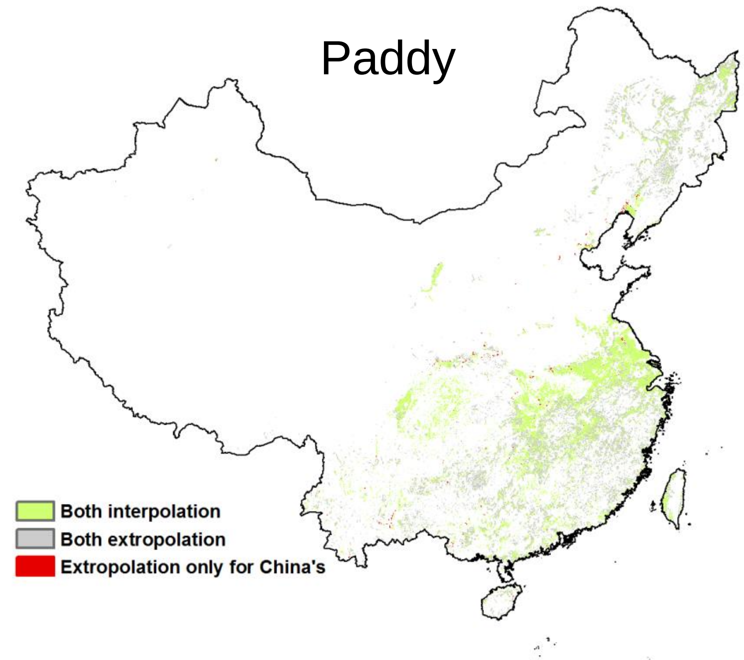
3.2 EF_{N2O} and E^0 (1990-2012)--calibration



3. Results and discussion

3.2 EF_{N2O} and E^0 (1990-2012)--Interpolation and extrapolation



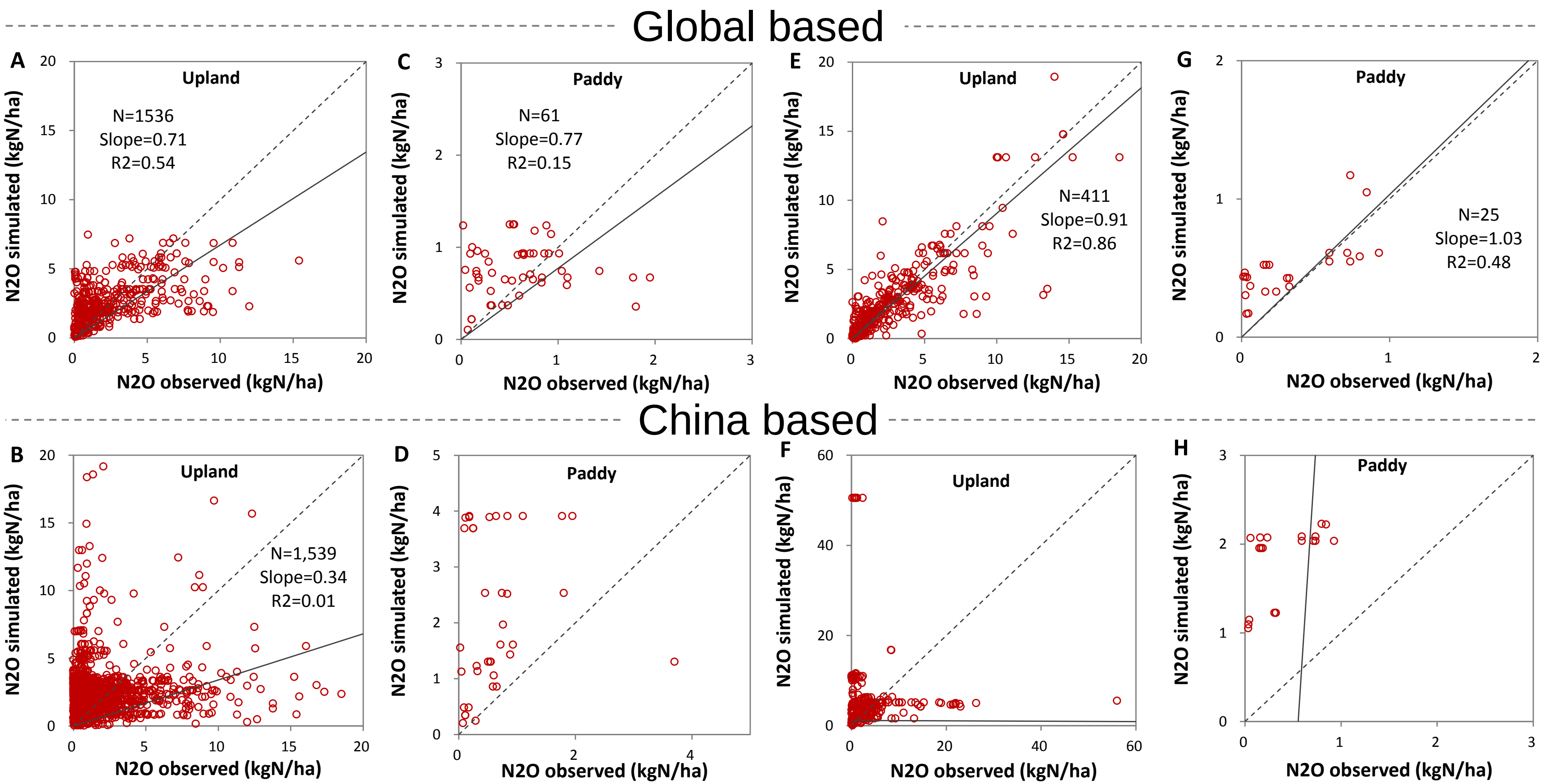


	Upland soils			Paddy soils		
Models	Global based	China based	Δ	Global based	China based	Δ
Interpolation	96%	87%	**-9%**	74%	73%	**-1%**
Extrapolation	4%	13%	**9%**	26%	27%	**1%**

3. Results and discussion

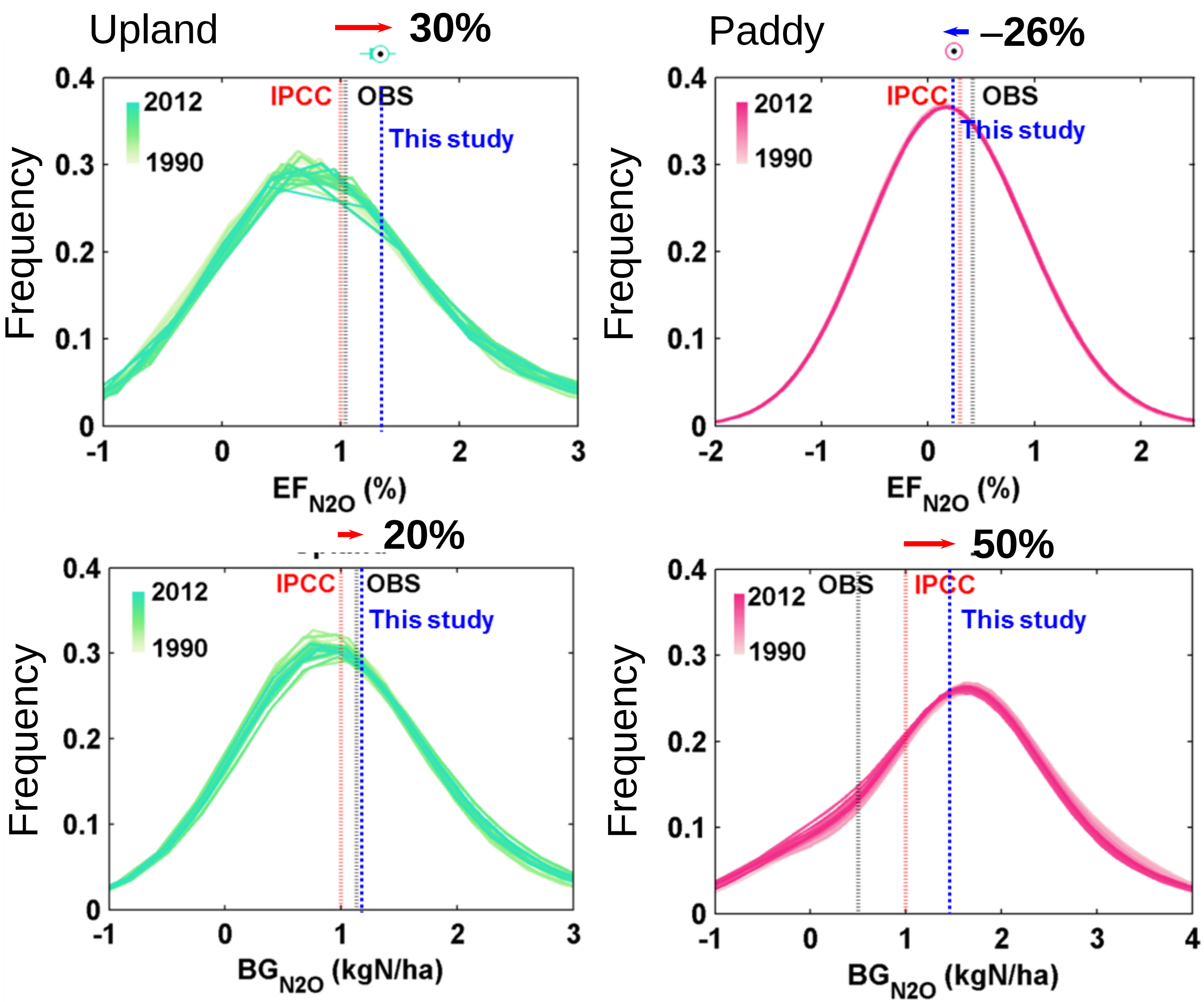
3.2 EF_{N2O} and E^0 (1990-2012)--Interpolation and extrapolation

The interpolation and extrapolation capabilities of the China-data-derived model were very lower compared to the global-data-derived one.



3. Results and discussion

3.2 EF_{N2O} and E^0 (1990-2012)—Inter-comparison



Based on global-derived model, we derive new EFs for upland and paddy soils.

The revised EFs differ from IPCC defaults by 30% and –26%.

The background emissions were 20% and 50% greater than IPCC defaults (1 kgN/ha).

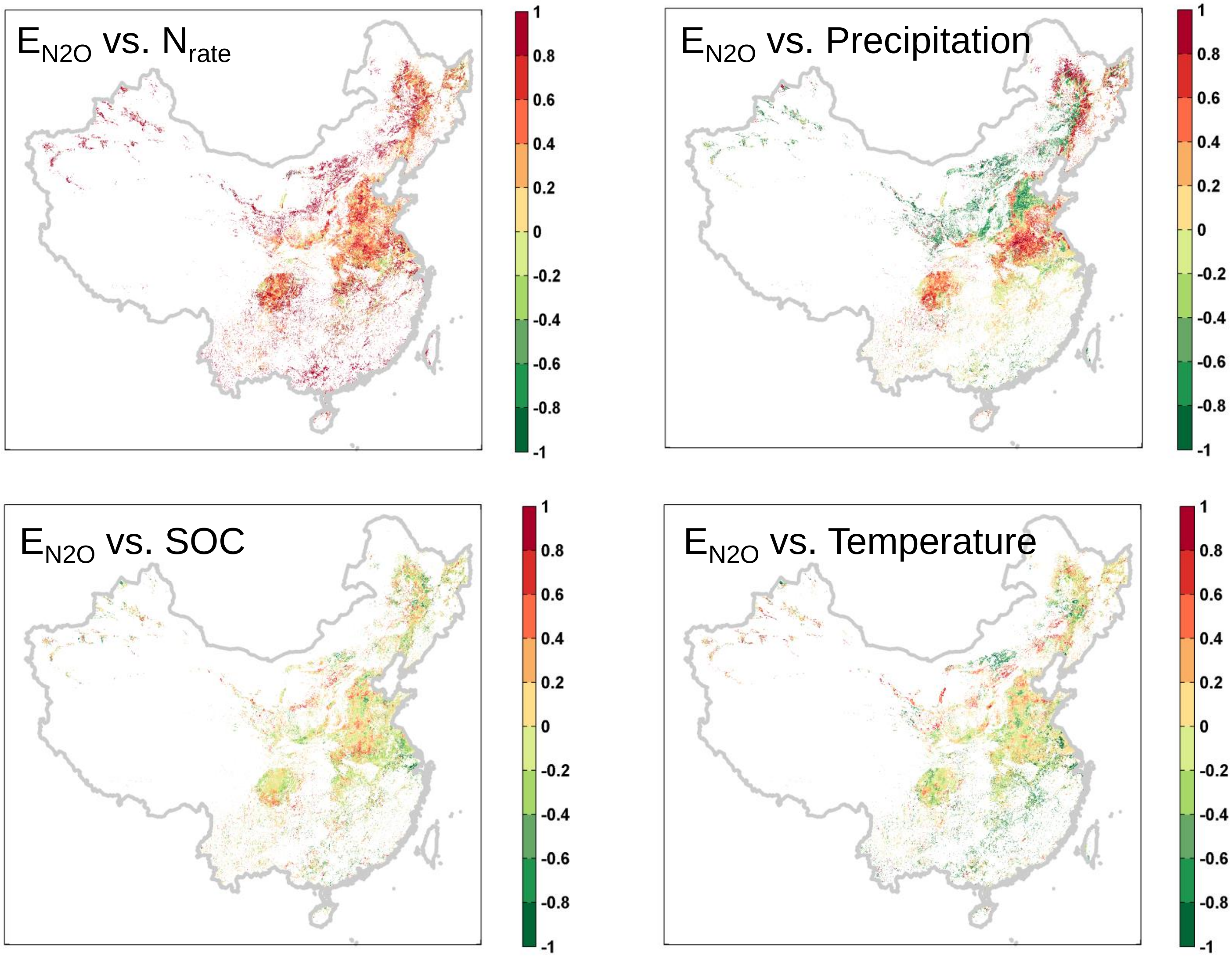
3. Results and discussion

3.3 E_{N2O} (1990-2012)—multi-model validation

Confidential

3. Results and discussion

3.4 E_{N2O} (1990-2012)—Drivers of its trends



3. Results and discussion

3.5 E_{N2O} (1990-2012)—Inter-comparison

Confidential

4. Implications

- Our new estimate represents a substantial revision of annual global CO_2 emissions, increasing the global emissions in 2012 by **0.1 $PgCO_2e$**, **20%** of the reported increase in global carbon emissions from 2011 to 2012, and a **half** of the estimated carbon sink in China's forests (**0.18 GtC/yr**) →it implies a considerable revision of the global GHGs budget.
- Over the full period 1990-2012, the upward revision of cumulative N_2O emissions in China by **2.1 $PgCO_2e$** is comparable with China's land C sink in 2000-2009 (**2.6 GtC**) and downward estimate of cumulative CO2 emissions (**2.9 PgC,** 2000-2013) by Liu et al. (2015)
- Thus, China needs to **continuously reduce** GHGs, especially through the application of the advanced agricultural management in future and adaption of climate changes

Piao et al., 2010; Pan et al., 2011; Global Carbon Project, 2013; Liu et al., 2015