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Greenhouse Gas Fluxes Dataset Effected by Land-use Conversion from Double Rice Cropping to Vegetables in Southern China

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Abstract: The experimental fields are located at the Qianyanzhou Ecological Research Station (26º44′48″N, 115º04′13″E), operated by Institute of Geographic Sciences and Natural Resources Research of Chinese Academy of Sciences. We converted a portion of the area under rice which had been continuously cultivated with rice for approximately 10 years to vegetable production. The treatments included rice with (R-F) and without fertilization (R-NF) and vegetable with (V-F) and without fertilization (V-NF). There were four spatial replicates for each treatment. We also set up a sub-treatment for removing vegetation in each plot (-no plant). The static opaque chambers and gas chromatographs (GCs) were used to determine the fluxes of methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) in situ for two years. We studied the greenhouse gas fluxes changes at the beginning period of the land-use conversion from double rice cropping to upland vegetables. Besides, the effect of fertilization and the crops on the fluxes of CH_4, N_2O and CO_2 were investigated. This dataset includes: 1) Management information of the paddy and vegetable fields; 2) CH_4 fluxes of each treatment from July 2012 to July 2014; 3) N_2O fluxes of each treatment from July 2012 to July 2014; 4) CO_2 fluxes of each treatment from July 2012 to July 2014; 5) Soil ammonium and nitrate nitrogen content of 0–20 cm of paddy and vegetable fields; 6) Soil pH of 0–10, 10–20 cm of paddy and vegetable fields; 7) Daily air temperature and precipitation of the experimental area; 8) The water depth of paddy fields. The data set is archived at .xls format with the compressed data size of 286 KB. The analysis papers based on this dataset were published at *PLoS ONE* (2016) and *Chinese Journal of Applied Ecology* (2015).

Keywords: Land-use conversion; CH_4; N_2O; CO_2; China

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[2] Yuan, Y., Dai, X. Q., Wang, H. M. Greenhouse gas fluxes dataset effected by land-use conversion from double rice cropping to vegetables in Southern China [DB/OL]. Global Change Research Data Publishing & Repository, 2018. DOI: 10.3974/ geodb.2018.03.03.V1.

1 Introduction

Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are the most important greenhouse gases[1]. Agricultural lands accounts for 52% and 84% of global anthropogenic CH_4 and N_2O emissions and may also act as a sink or source for CO_2[2]. Rice and vegetables are major crops grown in southern China. Because of the different growing conditions (standing water in rice vs. aerobic condition in vegetables), greenhouse gas (GHG) emissions can be different between the two cropping systems[3–5]. In standing water or anaerobic condition, CH_4 is emitted under rice primarily through aerenchyma, diffusion, and ebullition[6]. Nitrous oxide is emitted through denitrification in water-logged condition under rice[7] and the emissions can be pronounced when flooded fields are drained or N fertilized[8]. Studies indicate that CH_4 emissions can be higher and N_2O emissions lower under rice than other crops[4,9]. Nishimura *et al*.[3,4] found that the cumulative CH_4 fluxes were 2 to 14 g C m^{-2} yr^{-1} under lowland rice and ranged from −0.02 to −0.07 g C m^{-2} yr^{-1} under upland rice and the double cropping of soybean and wheat. They found that cumulative N_2O emissions increased 4.0 to 5.3 times by changing the land-use from lowland rice to upland crops[3].

The static opaque chambers and gas chromatographs (GCs) were used to determine the fluxes of CH_4, N_2O and CO_2 in situ for two years. We studied the greenhouse gas fluxes changes at the beginning period of the land-use conversion from double rice cropping to upland vegetables. Besides, the effect of fertilization and the crops on the fluxes of CH_4, N_2O and CO_2 were investigated.

2 Metadata of Dataset

The metadata of land-use conversion from double rice cropping to vegetables affects greenhouse gas fluxes in southern China dataset is summarized in Table 1. It includes the dataset full name, short name, authors, year of the dataset, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc[10].

Table 1 Metadata summary of the Land-use conversion from double rice cropping to vegetables affects greenhouse gas fluxes in southern China

Items	Description
Dataset full name	Greenhouse gas fluxes dataset effected by land-use conversion from double rice cropping to vegetables in Southern China[10]
Dataset short name	GreenhouseGasFluxLUCSChina
Authors	Yuan, Y. G-1444-2018, Anhui Normal University, yuanye_1985@126.com Dai, X. Q. I-2852-2018, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, daixq@igsnrr.ac.cn Wang ,H. M. I-3012-2018, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, wanghm@igsnrr.ac.cn
Geographical region	Qianyanzhou Ecological Research Station (26º44′48″N, 115º04′13″E), operated by Institute of Geographic Sciences and Natural Resources Research of Chinese Academy of Sciences
Year	July 2012 to July 2014
Observation interval	Data were collected every 3 days, and when fertilizer was applied, we collected data every day for a week, and we collected data every week in winter
Experimental plot	Each plot had an area of 10 m × 12 m, and the distance between adjacent plots is 1.5−3 meters
Data format	.xlsx
Data size	286 KB (after compression)

(*To be continued on the next page*)

(***Continued***)

Items	Description
Data files	1) Management information of the paddy and vegetable fields; 2) CH_4 fluxes of each treatment from July 2012 to July 2014; 3) N_2O fluxes of each treatment from July 2012 to July 2014; 4) CO_2 fluxes of each treatment from July 2012 to July 2014; 5) Soil ammonium and nitrate nitrogen content of 0–20 cm of paddy and vegetable fields; 6) Soil pH of 0-10, 10-20 cm of paddy and vegetable fields; 7) Daily air temperature and precipitation of the experimental area; 8) The water depth of paddy fields
Foundation(s)	Ministry of Science and Technology of P. R. China (2012CB417103) and National Natural Science Foundation of China (31700415)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (data products), and publications (in this case, in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten percent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[11]

3 Methods

3.1 Study Area

In July 2012, we converted a portion of the area under rice to vegetable production by draining water from the field while leaving the remaining land under rice. The double-rice system, which is comprised of early rice (transplanted in April and harvested in late July) and late rice (transplanted in late July and harvested in November), was adopted as usual with a fallow in the winter. The converted vegetable areas were planted with three kinds of vegetables a year in turn. Each cropping system had two fertilization levels, e.g., conventional fertilization and no fertilization. Thus, the experiment included four treatments in a split plot arrangement in randomized complete block design with four replications. Land use (or crop type) was the main plot and fertilization was the split-plot treatment. The treatments included vegetable with (V-F) and without fertilization (V-NF) and rice with (R-F) and without fertilization (R-NF). Each plot had an area of 120 m^2 (10 m × 12 m). A sub treatment without vegetation (2 m × 2 m) was set up in each plot and had the same agricultural operations as normal treatments. Compound fertilizer ($N : P_2O_5 : K_2O$ = 15% : 15% : 15%) and urea were applied at a rate of 358 kg N ha^{-1} per year to the fertilized plots according to the local typical agricultural management. Conventional tillage was carried out at the beginning of each growing season. Management information of the rice and vegetable fields were shown in Table 2.

3.2 Measurement of the greenhouse gas fluxes

A static chamber was used to simultaneously measure CH_4, CO_2 and N_2O fluxes[12]. The chamber was comprised of two parts: a cylindrical steel anchor and a cover (Figure 1). The internal diameter of the anchor was 50 cm. The anchor was inserted into the soil to a depth of 15 cm for rice and 10 cm for vegetables. The bottom part of the anchor inserted into the soil contained holes for water and nutrient exchange between inside and outside of the anchor. The groove on the upper

Table 2 Management information of the rice and vegetable fields.

Land use types		Crop types	Growing seasons	Transplanting date	Time of fertilization	Fertilizer amount (kg N ha^{-1})
Paddy	Season 1	Late rice	2012-7-4 – 2012-11-14	2012-7-30	2012-7-30	71.7 (CF[a])
					2012-8-10	107.5 (Urea)
	Season 2	Fallow	—	—	—	—
	Season 3	Early rice	2013-3-28 – 2013-7-23	2013-4-24	2013-4-24	71.7 (CF[a])
					2013-5-3	107.5 (Urea)
	Season 4	Late rice	2013-7-1 – 2013-11-2	2013-7-27	2013-7-26	71.7 (CF[a])
					2013-8-12	107.5 (Urea)
	Season 5	Fallow	—	—	—	—
	Season 6	Late rice	2014-3-30 – 2014-7-25	2014-4-25	2014-4-19	71.7 (CF[a])
					2014-4-29	107.5 (Urea)
Vegetable fields	Season 1	Cowpea	2012-7-31 – 2012-10-26	—	2012-7-30	71.7 (CF[a])
					2012-8-25	53.3 (Urea)
	Season 2	White radish	2012-10-31 – 2013-3-9	—	2012-10-30	71.7 (CF[a])
					2013-4-7	71.7 (CF[a])
	Season3	Pepper	2013-4-7 – 2013-7-23	—	2013-5-24	45 (CF[a])
					2013-6-21	45 (CF[a])
	Season 4	Chinese Cabbage	2013-8-12 – 2013-10-20	—	2013-8-12	71.7 (CF[a])
					2013-8-25	53.3 (Urea)
	Season 5	White radish	2013-10-21 – 2014-4-18	—	2013-10-21	71.7 (CF[a])
					2014-3-27	71.7 (CF[a])
	Season 6	Pepper	2014-4-19 – 2014-7-17	—	2014-4-19	45 (CF[a])
					2014-6-14	45 (CF[a])

[a] Compound fertilizer (Urea-based N: P_2O_5: K_2O = 15%: 15%: 15%)

part of the anchor was equipped with a sealing strip to ensure that gas does not leak from the joint of the anchor and the cover box when gas samples were collected. The anchor was kept in place throughout the entire study period, except during tillage and planting. The cover had heights of 40 cm (used for vegetables) and 70 cm (used for rice) and internal diameter was 50 cm. Before starting the experiment measurements of greenhouse gas fluxes in the bare soil from the chambers with two different heights showed that the height had no significant effect on gas fluxes. A tin foil reflective coating was used to cover the chamber to minimize solar heating and fluctuations in the headspace temperature. Five seedlings of rice or three seedlings of vegetables were planted inside the anchor. The planting density inside the chamber was similar to that of the crop planted outside.

Five gas samples were collected from each chamber using 100 mL plastic syringes at 10-min interval twice each week between 8:00 AM and 12:00 PM throughout the growing season. Immediately after tillage, fertilization, irrigation or drainage, however, samples were collected daily for one week. The gas samples were analyzed using a gas chromatograph (GC System, 7890A, Agilent Technologies) equipped with an electron capture detector (ECD) and a flame ionization detector (FID). CH_4, N_2O and CO_2 fluxes were calculated from linear or nonlinear changes in the gas concentrations over time[13–14]. The lowest accepted correlation coefficient (r) value for the regression of CH_4, N_2O and CO_2 evolutions was 0.87. When the absolute value of r from the nonlinear model minus that from the linear model was equal to or less than 0.000,2, the fluxes from the linear model were adopted and vice versa.

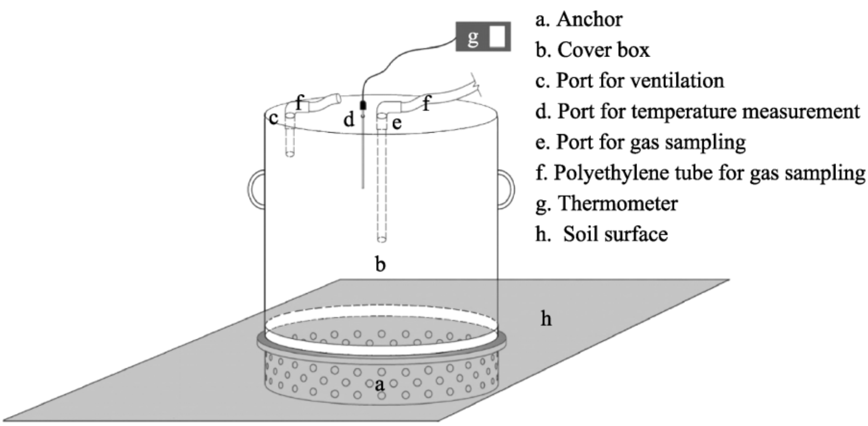

Figure 1 Design of the static chamber used for measuring greenhouse gas fluxes[15]

4 Results and Validation

4.1 Data Composition

We obtained the following data from July 2012 to July 2014.

1) Management information of the paddy and vegetable fields.
2) CH_4 fluxes of each treatment from July 2012 to July 2014.
3) N_2O fluxes of each treatment from July 2012 to July 2014.
4) CO_2 fluxes of each treatment from July 2012 to July 2014.
5) Soil ammonium and nitrate nitrogen content of 0−20 cm of paddy and vegetable fields.
6) Soil pH of 0−10, 10−20 cm of paddy and vegetable fields.
7) Daily air temperature and precipitation of the experimental area.
8) The water depth of paddy fields.

4.2 Data Products

The results indicate that land-use conversion from rice to vegetables significantly reduced CH_4 fluxes and significantly increased N_2O fluxes. The conversion had inconsistent effects on CO_2 fluxes across seasons (Figure 2, Table 3, 4, 5). The total global warming impact of the three greenhouse gases was significantly increased after the land-use conversion from paddy to vegetables. Fertilization had no significant effect on CH_4 fluxes, while significantly increased N_2O and CO_2 fluxes and had an interaction with land-use types. The changes of CH_4, N_2O and CO_2 fluxes with the land-use conversion from paddy to vegetable fields were caused by the changes of soil properties and the changes of crop types together. The authors partially elaborated on the results in "Effects of Land-Use Conversion from Double Rice Cropping to Vegetables on Methane

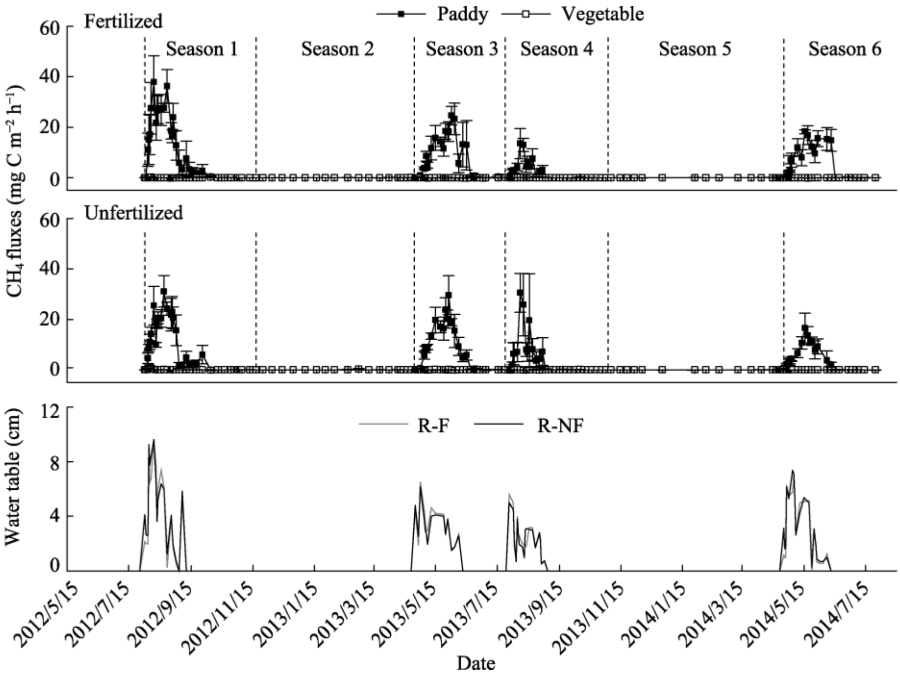

Figure 2 Seasonal variations of CH_4 fluxes and the water depth of paddy fields. The data shown are means of the four replicates for individual treatments

Table 3 Cumulative emissions of CH_4 in the observing period and each growing season (kg C ha^{-1})

	Season 1	Season 2	Season 3	Season 4	Season 5	Season 6	Year 1	Year 2	Two years
R-F	206.15±58.01a	0.34±0.17a	151.90±34.73a	42.66±9.32ab	0.11±0.49a	136.91±23.90a	358.39±91.76a	179.68±30.96a	538.07±120.12a
R-NF	167.16±31.61a	0.85±0.38a	153.68±23.02a	88.04±31.04a	−0.20±0.27a	86.34±16.16b	321.69±50.60a	174.18±29.68a	495.88±75.82a
V-F	0.29±0.29b	−0.02±0.19a	−0.76±0.28b	0.15±0.09b	−0.47±0.36a	−0.35±0.19c	−0.48±0.32b	−0.67±0.53b	−1.15±0.68b
V-NF	0.70±0.74b	0.82±0.76a	−0.13±0.14b	−0.44±0.06b	−0.37±0.18a	−0.16±0.14c	1.39±1.37b	−0.97±0.10b	0.42±1.27b
Land use (L)	$P<0.01$	$P=0.67$	$P<0.01$	$P<0.01$	$P=0.30$	$P<0.01$	$P<0.01$	$P<0.01$	$P<0.01$
Fertilization (F)	$P=0.57$	$P=0.15$	$P=0.96$	$P=0.19$	$P=0.78$	$P=0.11$	$P=0.75$	$P=0.90$	$P=0.78$
L×F	$P=0.56$	$P=0.71$	$P=0.98$	$P=0.18$	$P=0.56$	$P=0.10$	$P=0.72$	$P=0.91$	$P=0.76$

Note: Different letters within the same column represent significant differences among treatments.

and Nitrous Oxide Fluxes in Southern China"[15] and "Effects of land-use conversion from double rice cropping to vegetables on methane and carbon dioxide fluxes in southern China"[16].

Table 4 Cumulative emissions of N_2O in the observing period and each growing season (kg C ha^{-1})

	Season 1	Season 2	Season 3	Season 4	Season 5	Season 6	Year 1	Year 2	Two years
R-F	0.32± 0.10c	0.51± 0.14c	0.41± 0.03b	2.65± 0.87a	0.38± 0.16a	0.19± 0.05b	1.24± 0.18c	3.22± 1.01bc	4.46± 0.89c
R-NF	0.21± 0.09c	0.14± 0.04c	0.19± 0.02b	0.35± 0.01b	0.35± 0.18a	0.18± 0.10b	0.54± 10.15c	0.88± 0.20c	1.41± 0.22c
V-F	3.99± 0.16a	7.56± 0.63a	7.67± 1.67a	1.36± 0.35ab	0.64± 0.17a	5.19± 1.79a	19.21± 2.10a	7.19± 1.98a	26.40± 3.37a
V-NF	1.84± 0.42b	2.03± 0.53b	4.55± 1.15a	1.98± 0.52ab	0.87± 0.36a	2.41± 0.28ab	8.42± 1.80b	5.25± 0.96ab	13.67± 1.18b
Land use (L)	P<0.01	P<0.01	P<0.01	P=0.76	P=0.12	P<0.01	P<0.01	P<0.01	P<0.01
Fertilization (F)	P<0.01	P<0.01	P=0.13	P=0.14	P=0.66	P=0.15	P<0.01	P=0.10	P<0.01
L×F	P<0.01	P<0.01	P=0.18	P<0.05	P=0.59	P=0.15	P<0.01	P=0.87	P<0.05

Note: Different letters within the same column represent significant differences among treatments.

Table 5 Cumulative emissions of CO_2 by ecosystem respiration in the observing period and each growing season (kg C ha^{-1})

	Season 1	Season 2	Season 3	Season 4	Season 5	Season 6	Year 1	Year 2	Two years
R-F	5,346.01± 145.21bc	2,492.47± 178.95a	4,307.28± 257.77a	3,196.60± 245.60a	2,486.75± 369.84a	3,523.25± 164.38a	12,145.76± 358.36a	9,206.60± 694.64a	21,352.36± 1,013.00a
R-NF	3,654.73± 313.10c	2,231.48± 298.86a	3,146.98± 390.71b	2,613.04± 236.72a	2,221.52± 199.88ab	2,476.20± 311.75b	9,033.19± 584.24b	7,310.76± 505.46b	16,343.95± 1,069.88b
V-F	7,223.02± 576.56a	2,718.48± 365.69a	2,018.84± 280.26c	963.21± 156.77b	1,626.36± 100.30b	1,868.03± 356.04bc	11,960.34± 1,025.26a	4,457.59± 329.33c	16,417.94± 1,308.90b
V-NF	5,854.97± 931.50ab	2,274.26± 283.39a	2,859.25± 272.39bc	1,094.23± 258.74b	1,989.74± 182.40ab	1,330.31± 204.78c	10,988.48± 1,324.47ab	4,414.27± 260.35c	15,402.75± 1,415.45b
Land use (L)	P<0.01	P=0.65	P<0.01	P<0.01	P<0.05	P<0.01	P=0.35	P <0.01	P<0.05
Fertilization (F)	P<0.05	P=0.25	P=0.61	P=0.34	P=0.84	P<0.05	P<0.05	P=0.07	P<0.05
L×F	P=0.78	P=0.76	P<0.01	P=0.14	P=0.21	P=0.37	P=0.26	P=0.08	P=0.13

Note: Different letters within the same column represent significant differences among treatments.

5 Discussion and Conclusion

Previous studies about greenhouse gas emissions from paddy and vegetable fields were only comparison between rice paddy fields and vegetable fields that have been planted for several years, ignoring the differences in the initial conditions of the plots[17]. And most of the studies did not consider the effect of transition time[18]. In this research, we converted part of the paddy which had been continuously cultivated with rice to vegetable production to ensure that the initial conditions were the same between the two land-use types. Both the changes of soil properties and the changes of crop types have effect on greenhouse gas emissions. However, most of the previous studies did not differentiate their influence. In the present study, sub treatments without vegetation were set up to differentiate the effect of soil properties and crop types on greenhouse gas fluxes.

Author Contributions

Dai, X. Q. and Wang, H. M. designed the algorithms of dataset; Dai, X. Q. and Yuan, Y. contributed to the data processing and analysis; Yuan, Y. wrote the data paper.

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