Supporting Information

Phosphorus addition mitigates N_2O and CH_4 emissions in an N-saturated subtropical forest, SW China

Longfei Yu[1], Yihao Wang[2, 3], Xiaoshan Zhang[3], Peter Dörsch[1], Jan Mulder[1*]

[1]Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Postbox 5003, N-1432 Aas, Norway.

[2]Chongqing Academy of Forestry, 400036, Chongqing, China.

[3]Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, 100085, Beijing, China.

[*]Correspondence: Jan Mulder, tel. +47 67231852, E-mail jan.mulder@nmbu.no

Phosphorus adsorption by soil

The required dose of P to stimulate significant increase in soil P concentration was determined based on sorption isotherms (Singh et al., 2005). The experiment was carried out with soils (triplicates mixed within each block as one sample) in the O/A, AB and B-horizons, from each block. Briefly, 1 g dry and sieved (2 mm) soil was added to 30 ml $CaCl_2$ solution with a gradient of initial PO_4^{3-} concentrations (0, 2.5, 5.0, 10.0, 20.0, 50.0 and 100 mg P L^{-1}). Next, the suspension was shaken for 24 h at 20 ^oC. The P concentration was determined by colorimetric method (M&M) after centrifugation and filtration (0.45 μm). No P desorption was found in the zero-P treatments (only $CaCl_2$).

The results of P adsorption isotherms (Table S1 and Fig. S8) indicated medium sorption capacities in TSP soils (Singh et al., 2005). Based on P affinity constant and adsorption maxima, we chose an optimum P concentration of 1.0 mg L^{-1} for the P dose. Such dose is equivalent to 79.5 kg P ha^{-1} in TSP soil (0.3 g P kg^{-1} dw soil).

Table S1 P adsorption maximum, affinity constant and maximum buffering capacity obtained from Langmuir isotherms. The linear equation is C / (x/m) = 1 / (kb) + C / b; where C (mg P L^{-1}) is the equilibrium P concentration; x/m (mg P kg^{-1}) is the amount of P adsorbed per unit mass of adsorbent; k (L mg^{-1} P) is the P affinity constant; b (mg P kg^{-1}) is the P adsorption maximum.

		Adsorption maximum (b) (mg P kg^{-1})	P affinity constant (k) (L mg^{-1} P)	Maximum buffering capacity (mbc) (L kg^{-1})
Block 1	O/A	435	0.17	75
	AB	303	0.20	62
	B	278	1.00	277
Block 2	O/A	345	0.10	34
	AB	182	0.27	49
	B	278	0.24	65
Block 3	O/A	345	0.16	57
	AB	278	0.26	73
	B	357	0.28	99

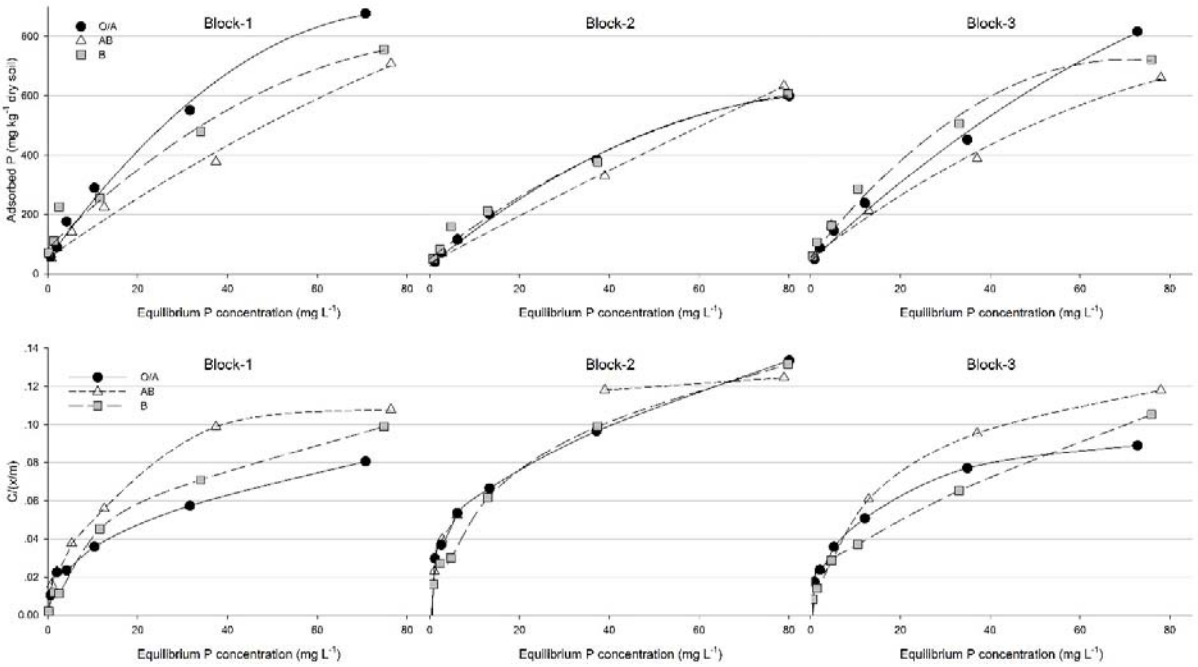

Fig. S1 Langmuir adsorption isotherms of soils from O/A, AB and B horizons in Block 1-3. The data were fitted to the Langmuir equation, after linearization.

Table S2 Na^+ concentrations in soil water at 5- and 20-cm depths in the References and P treatments. Values are means and standard deviations (in brackets) (n = 9).

Sampling date	Na^+ concentration at 5 cm (mg L^{-1})		Na^+ concentration at 20 cm (mg L^{-1})	
	Reference	P	Reference	P
14/06/18[†]	0.68 (0.58)	5.19 (3.15)	1.31 (0.98)	3.15 (2.38)
14/09/21	0.54 (0.50)	2.01 (0.86)	0.83 (0.91)	3.00 (1.33)
15/01/13	0.69 (0.31)	1.39 (0.50)	1.10 (0.68)	2.97 (1.65)
15/10/07	0.52 (0.36)	0.56 (0.65)	0.53 (0.34)	1.09 (1.25)

[†] One month after P application (14/05/04).

Table S3 Half-yearly tree biomass, 500-needle weight and needle nutrient contents in the References and P treatments[†]. Values are means and standard deviations (in brackets) (n = 9).

		500-needle g	Tree Biomass t ha^{-1}	Total C g kg^{-1}	Total N g kg^{-1}	Total P g kg^{-1}	C/N	N/P	K g kg^{-1}	Mg g kg^{-1}	Ca g kg^{-1}
Nov. 2013	Reference	13.8 (1.8)	149 (11)	510 (9)	15.2 (0.8)	0.71 (0.04)	34 (2)	22 (1)	4.6 (0.8)	1.3 (0.2)	4.5 (1.3)
	P	12.5 (1.9)	131 (25)	517 (6)	14.7 (1.0)	0.73 (0.05)	35 (2)	20 (3)	4.7 (0.7)	1.4 (0.2)	5.3 (0.6)
Nov. 2014	Reference	13.8 (2.3)	148 (12)	551 (11)	14.9 (1.5)	0.88 (0.09)	37 (7)	17 (1)	6.6 (1.2)	1.6 (0.3)	7.8 (2.4)
	P	14.3 (2.3)	133 (27)	550 (9)	14.6 (1.1)	0.85 (0.11)	38 (4)	17 (1)	5.9 (0.9)	1.6 (0.4)	5.6 (3.1)
Feb. 2016	Reference	12.9 (2.3)	143 (8)	-[*]	-	-	-	-	-	-	-
	P	10.8 (2.4)	129 (29)	-	-	-	-	-	-	-	-

[†] P addition was conducted on 14/05/04

[*] Data were not available.

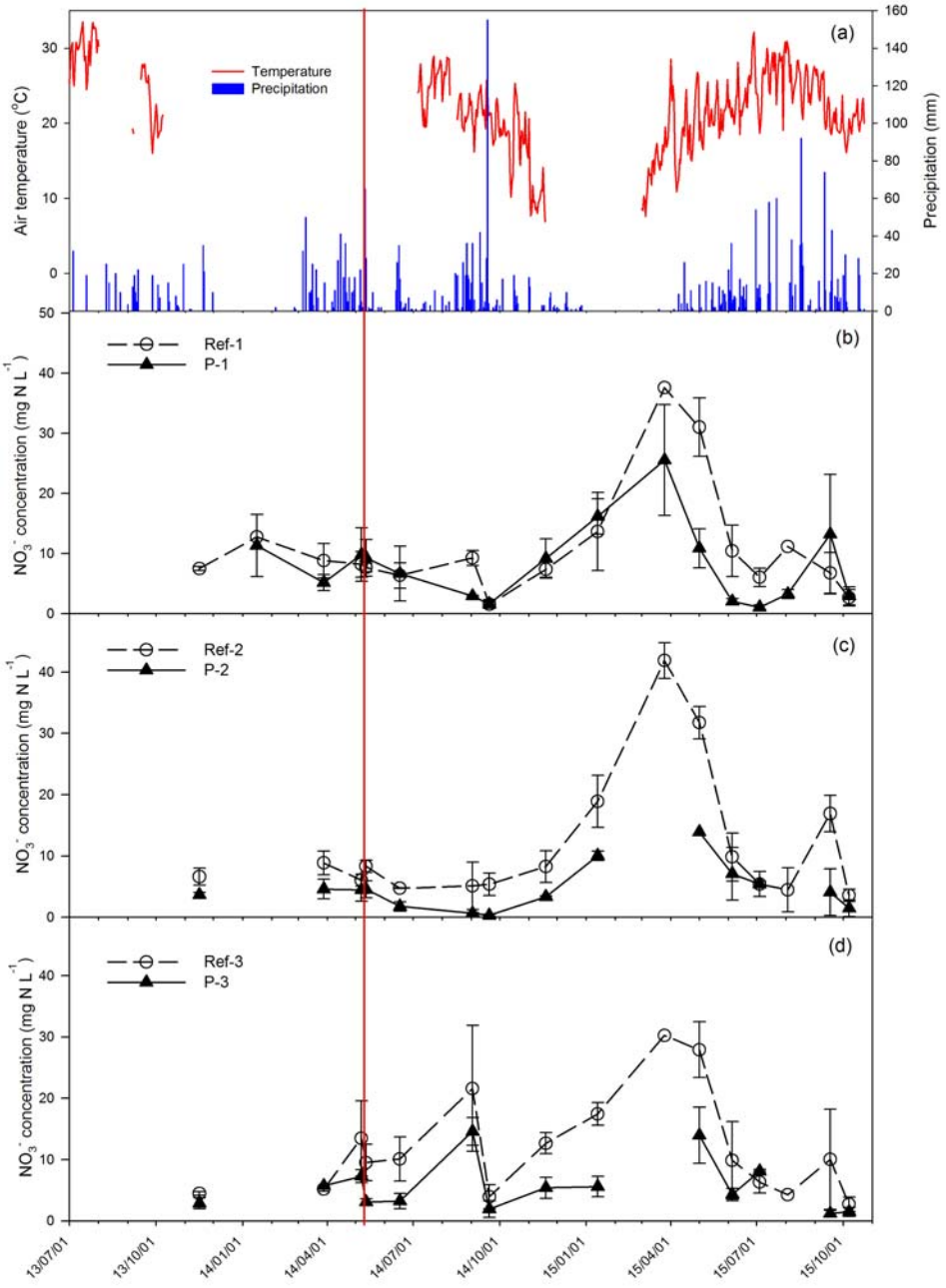

Fig. S2 Daily mean air temperature and precipitation (a), and monthly mean NO_3^- concentrations (±SE) at the 5-cm soil depth in the References and P treatments for three blocks (b-d) during two years; the red line refers to the date when P addition was conducted (for P treatments only).

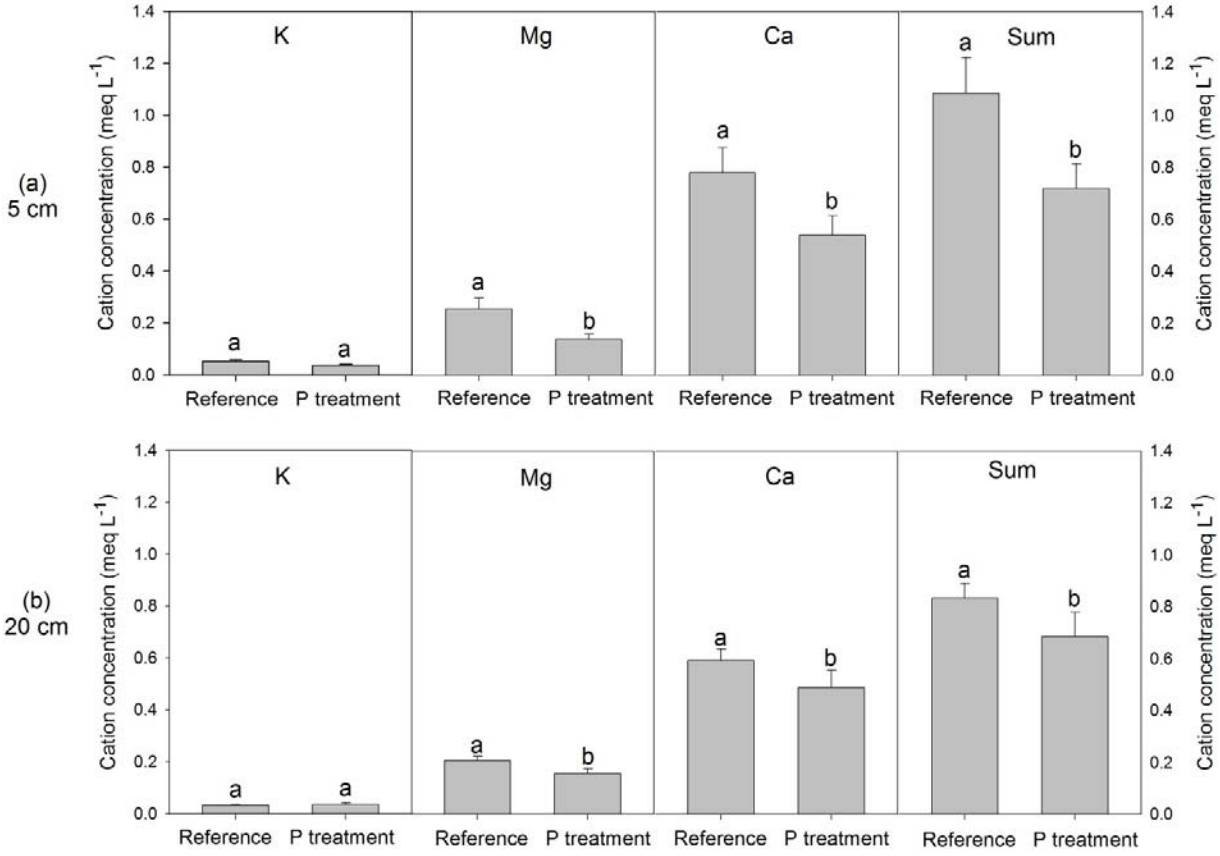

Fig. S3 Mean soil cation concentrations (K^+, Mg^{2+}, Ca^{2+} and Sum) at 5-cm (a) and 20-cm (b) soil depths in the References and P treatments during 1.5 years after P addition; small letters indicate significance levels of difference between two treatments; error bars are presented as SE.

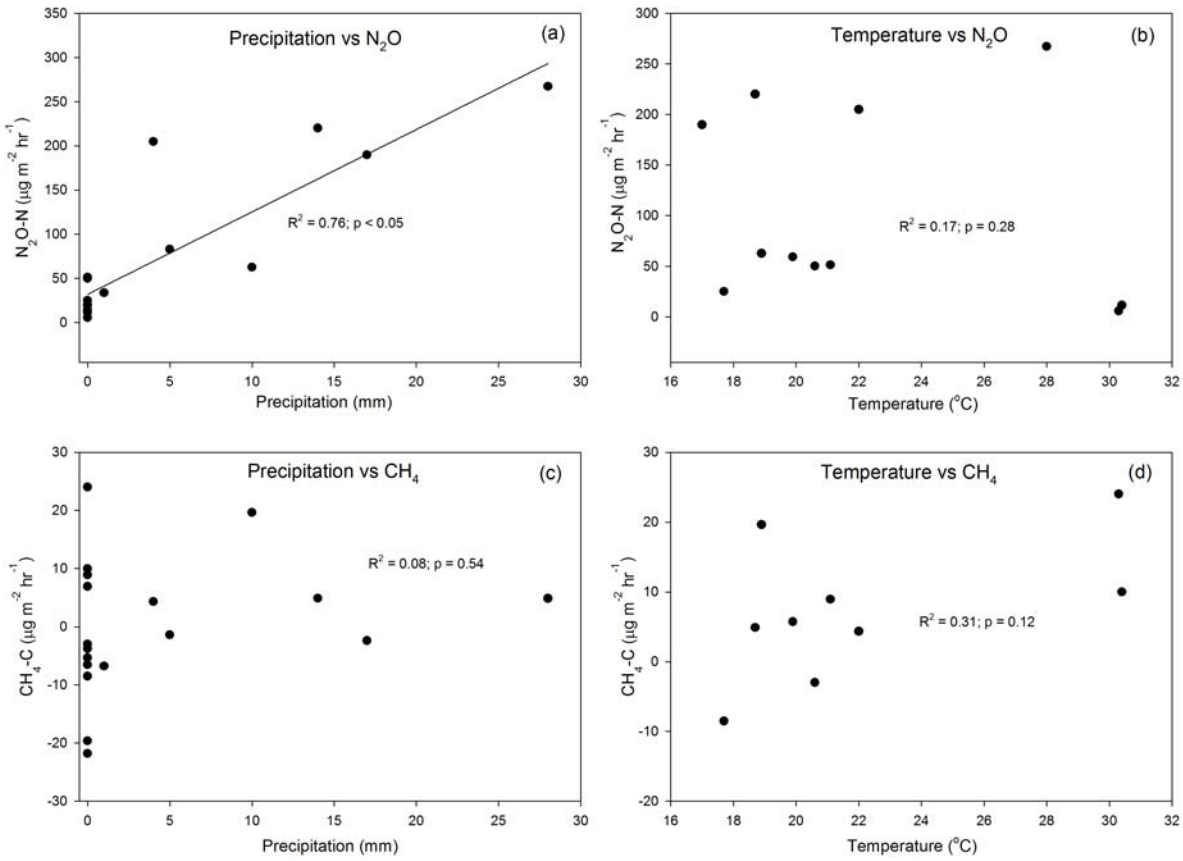

Fig. S4 Relationship between climatic factors (daily mean temperature and precipitation) and gas fluxes (mean monthly fluxes for N_2O (a&b) and CH_4 (c&d) from the References); due to temperature data missing from November 2013 to July 2014, fewer data points were presented in comparisons with temperature.

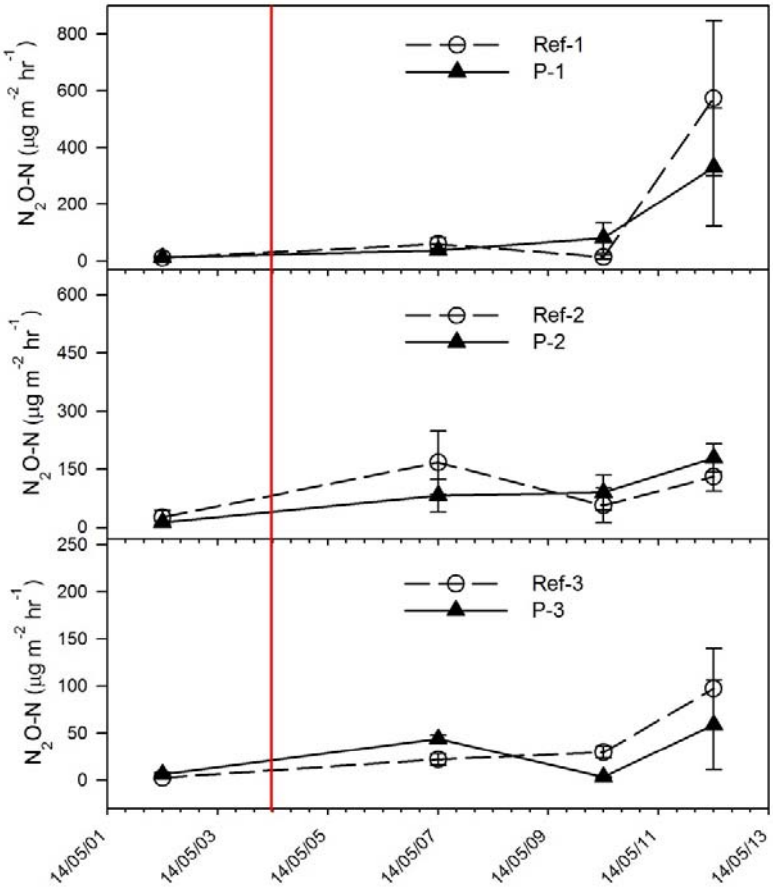

Fig. S5 Mean N_2O fluxes (±SE) in the References and P treatments for three blocks, during the 10 days before and after P application on 4 May 2014.

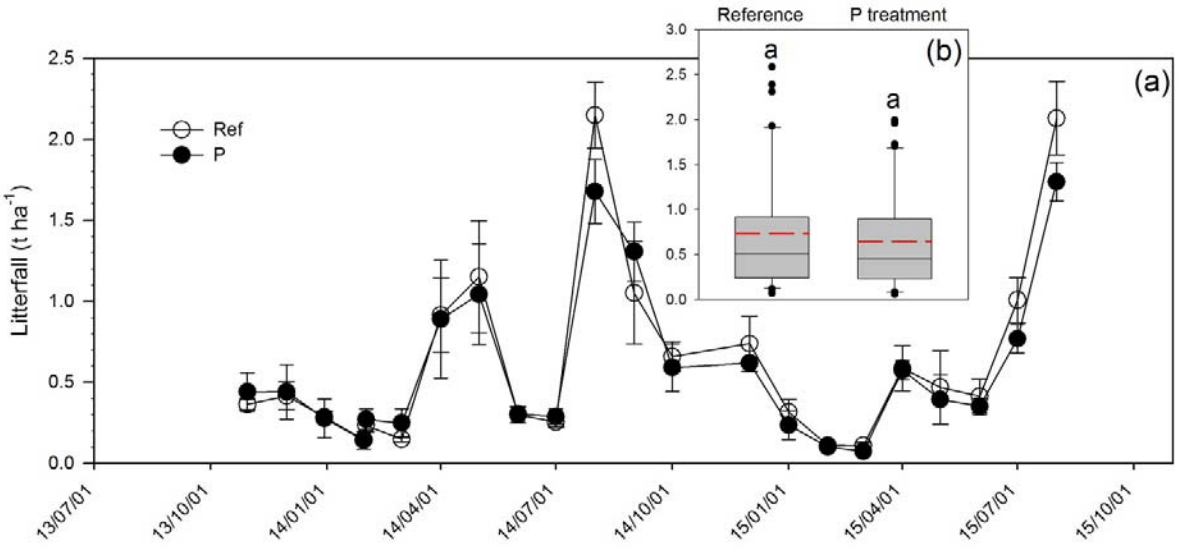

Fig. S6 (a) Mean monthly litterfall (±SE) in the Reference and P treatment during two years;

(b) Box whisker plots of monthly litterfall in the Reference and P treatment; small letters indicate significance levels of difference.

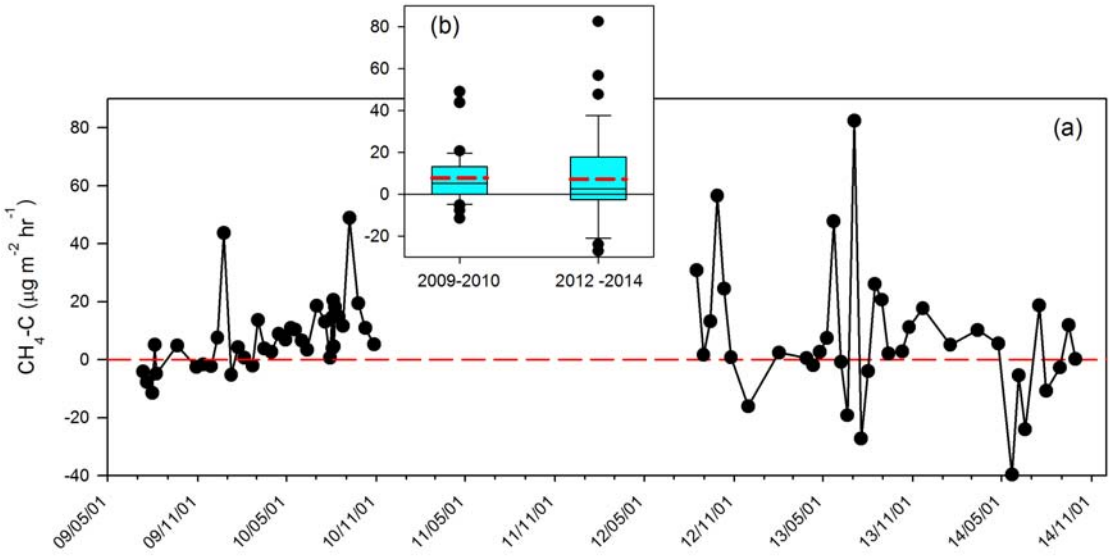

Fig. S7 (a) Temporal variations of CH_4 fluxes (±SE) from 2009 to 2014 at TSP forest; red dash line refers to the zero flux;

(b) Box whisker plots of CH_4 fluxes for 2009-2012 and 2012-2014 periods, respectively; red dash lines refer to the mean values. Data for long-term CH_4 fluxes were obtained from Zhu et al. (unpublished).