Supplementary information

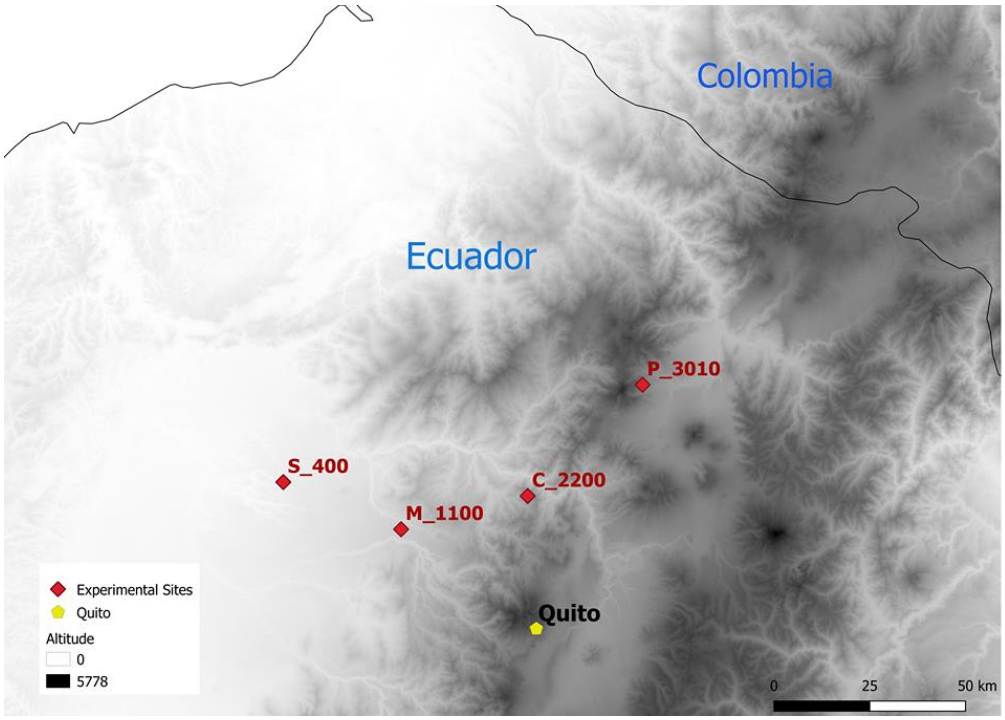

Fig. S1. Overview map with the location of the study areas: Río Silanche (400 m a.s.l.; S_400), Milpe (1100 m a.s.l.; M_1100), El Cedral (2200 m a.s.l.; C_2200) and Peribuela (3010 m a.s.l.; P_3010). Study areas projected on a DEM based on SRTM data (Jarvis et al., 2008).

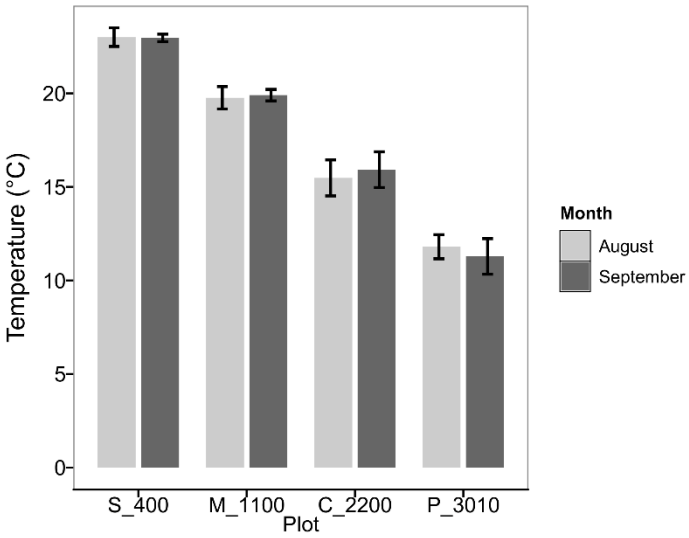

Fig. S2. Monthly average soil temperature (°C)±standard deviations (SD) at Río Silanche (400 m a.s.l.; S_400), Milpe (1100 m a.s.l.; M_1100), El Cedral (2200 m a.s.l.; C_2200) and Peribuela (3010 m a.s.l.; P_3010). Light grey: average soil temperature in August; dark grey: average soil temperature in September.

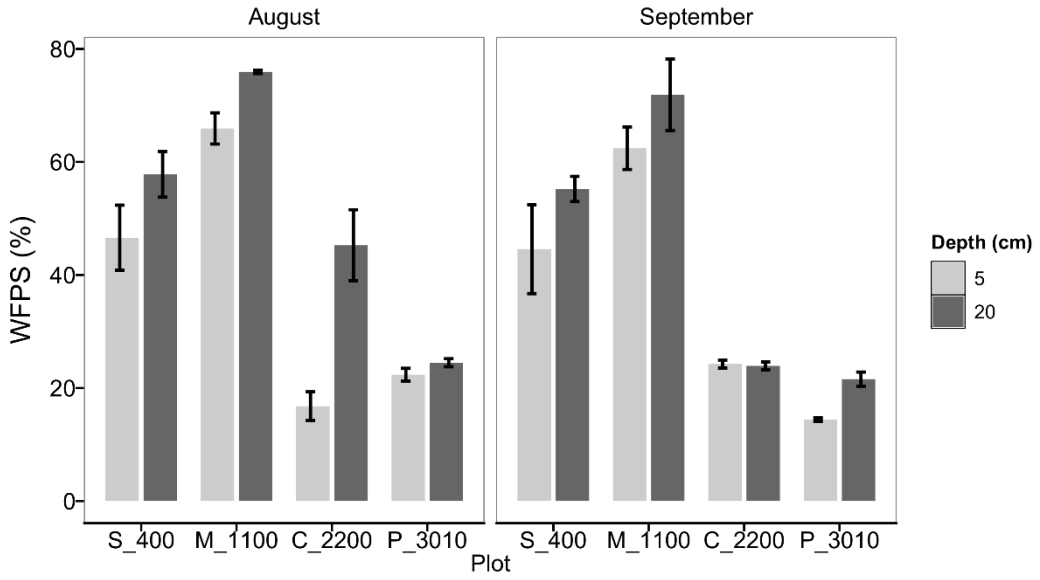

Fig. S3. Monthly average water-filled pore space (WFPS)±standard deviations (SD) at Río Silanche (400 m a.s.l.; S_400), Milpe (1100 m a.s.l.; M_1100), El Cedral (2200 m a.s.l.; C_2200) and Peribuela (3010 m a.s.l.; P_3010) at 5 and 20 cm depth. Light grey: average WFPS at 5 cm, dark grey: average WFPS at 20 cm.

Table S1. $\delta^{15}N_S^{Bulk}$ values for the point samples taken at Río Silanche (400 m a.s.l.; S_400), Milpe (1100 m a.s.l.; M_1100), El Cedral (2200 m a.s.l.; C_2200) and Peribuela (3010 m a.s.l.; P_3010) during August and September 2018. The last column indicates the N_2O flux measured for the respective chamber ID. Note: $\delta^{15}N_S^{Bulk}$ values were calculated based on a two-source mixing model, considering a threshold of 20 ppb to exclude low fluxes and thus, avoid larger uncertainties in the source calculation.

Chamber ID	**Month**	**Site**	$\boldsymbol{\delta^{15}N_S^{Bulk} - N_2O}$ **(‰)**	**N_2O flux (µg N m^{-2} h^{-1})**
M180815_3	August	M_1100	8.65	-10.48
C180821_3	August	C_2200	11.43	-0.55
C180821_5	August	C_2200	8.08	-2.43
P180828_1	August	P_3010	8.45	-6.47
S180904_2	September	S_400	-3.29	4.84
S180908_2	September	S_400	-13.08	7.43
S180908_4	September	S_400	11.54	-5.32
M180911_1	September	M_1100	11.53	-9.60
P180926_3	September	P_3010	6.10	-5.56

Table S2. Measured and estimated CO_2, CH_4 and N_2O fluxes from tropical forest soils of South America including forest type, elevation, mean annual precipitation (MAP), mean annual temperature (MAT) and method used for the measurements (manual chamber technique – MCT or dynamic chamber technique – DCT).

Country	Forest type Elevation	MAP (mm) MAT (°C)	Measured CO_2 flux; estimated CO_2 flux (Mg CO_2-C $ha^{-1}y^{-1}$) and method of measurement	Measured CH_4 flux; estimated CH_4 flux (kg CH_4 $ha^{-1}y^{-1}$) and method of measurement	Measured N_2O flux; estimated N_2O flux (kg N_2O $ha^{-1}y^{-1}$) and method of measurement	Reference
Brazil	Lowland moist forest 200 m a.s.l.	2000 25	-	-0.36 to -1.1 mg CH_4 $m^{-2}d^{-1}$, MCT *Estimated flux: -2.66*	0.54 (clay soil), 0.06 (sandy soil), 0.39 (weighted mean) ng N_2O-N $cm^{-2}h^{-1}$, MCT *Estimated flux: 12.77*	(Dalal and Allen, 2008; Silver et al., 2005)
Brazil	Lowland moist forest 200 m a.s.l.	2000 21 - 23	10.0±0.9 Mg CO_2-C $ha^{-1}y^{-1}$, DCT	-1.1±1.0 kg CH_4 $ha^{-1}y^{-1}$, MCT	4.1±1.6 kg N_2O $ha^{-2}y^{-}1$, MCT	(Davidson et al., 2004)
Brazil	Tropical moist forest (lowland) 100 m a.s.l.	3050 19.1 - 25.1	DCT *Estimated flux: 13.3*	-1.0±0.2 mg CH_4 $m^{-2}d^{-1}$, MCT	3.9±0.4 ng N_2O-N $cm^{-2}h^{-1}$, MCT	(Sousa Neto et al., 2011)
	Tropical moist forest (sub-montane) 400 m a.s.l.	3050 19.1 - 25.1	DCT *Estimated flux: 13.6*	-1.8±0.3 mg CH_4 $m^{-2}d^{-1}$, MCT	1.0±0.1 ng N_2O-N $cm^{-2}h^{-1}$, MCT	
	Tropical montane forest (montane) 1000 m a.s.l.	2300 19.1 - 25.1	DCT *Estimated flux: 12.9*	-1.6±0.1 mg CH_4 $m^{-2}d^{-1}$, MCT	0.9±0.2 ng N_2O-N $cm^{-2}h^{-1}$, MCT	
Brazil	Primary forest 130 m a.s.l.	1850 -	0.299±0.014 (wet season), 0.181±0.009 (dry season) g CO_2-C $m^{-2}h^{-1}$, DCT *Estimated flux: 20.0*	0.03±0.21 (wet season), -0.98±0.21 (dry season) mg CH_4 $m^{-2}d^{-1}$, MCT *Estimated flux: -2.1*	-	(Verchot et al., 2000)
	Secondary forest since 1976 130 m a.s.l.	1850 -	0.245±0.010 (wet season), 0.174±0.010 (dry season) g CO_2-C $m^{-2}h^{-1}$, DCT *Estimated flux: 17.9*	-0.20±0.08 (wet season), -0.34±0.18 (dry season) mg CH_4 $m^{-2}d^{-1}$, MCT *Estimated flux: -1.0*	-	
Brazil	Lowland moist forest 50 m a.s.l.	2000 24 - 26	-	-1.9e10 molecules CH_4 $cm^{-2}s^{-1}$, MCT	26e9 molecules N_2O $cm^{-2}s^{-1}$, MCT	(Keller et al., 1986)
Ecuador	Pre-montane 1000 m a.s.l.	2230 19.4	10.3±0.8 (lower slope), 10.3±0.1 (mid-slope),	-7.4±0.9 (lower slope), -7.2±1.2 (mid-slope), -	-	(Wolf et al., 2012)

			9.8±0.9 (ridge) Mg CO_2-C $ha^{-1}y^{-1}$, MCT	7.9±1.3 (ridge) kg CH_4 $ha^{-1}y^{-1}$, MCT		
	Lower montane 2000 m a.s.l.	1950 15.7	8.8±0.4 (lower slope), 7.6±0.6 (mid-slope), 6.7±0.7 (ridge) Mg CO_2-C $ha^{-1}y^{-1}$, MCT	-3.1±0.4 (lower slope), -5.7±1.2 (mid-slope), -3.6±0.4 (ridge) kg CH_4 $ha^{-1}y^{-1}$, MCT	-	
	Upper montane 3000 m a.s.l.	4500 9.4	6.4±0.4 (lower slope), 5.7±0.7 (mid-slope), 3.7±0.5 (ridge) Mg CO_2-C $ha^{-1}y^{-1}$, MCT	-0.8±1.6 (lower slope), -2.1±0.5 (mid-slope), -1.3±0.1 (ridge) kg CH_4 $ha^{-1}y^{-1}$, MCT	-	
Ecuador	Lowland moist forest -Primary forest 400 m a.s.l.	4500 22 - 25	23.9e13 molecules CO_2 $cm^{-2}s^{-1}$, MCT	2.7e10 molecules CH_4 $cm^{-2}s^{-1}$, MCT	4.5e9 molecules N_2O $cm^{-2}s^{-1}$, MCT	(Keller et al., 1986)
	Lowland moist forest - Secondary forest of 5-10 years old 400 m a.s.l.	4500 22 - 25	16.3e13 molecules CO_2 $cm^{-2}s^{-1}$, MCT	-3.5e10 molecules CH_4 $cm^{-2}s^{-1}$, MCT	4.4e9 molecules N_2O $cm^{-2}s^{-1}$, MCT	
Ecuador	Pre-montane 1000 m a.s.l.	2230 18.43±0.10	-	-	6.40±3.17 µg N_2O-N $m^{-2}h^{-1}$; 0.90±0.41 kg N_2O $ha^{-2}y$-1, MCT	(Müller et al., 2015)
	Lower montane 2000 m a.s.l.	1950 14.67±0.28	-	-	2.05±0.64 µg N_2O-N $m^{-2}h^{-1}$; 0.27±0.09 kg N_2O $ha^{-2}y$-1, MCT	
	Upper montane 3000 m a.s.l.	4500 9.80±0.26	-	-	0.47±0.62 µg N_2O-N $m^{-2}h^{-1}$; 0.08±0.06 kg N_2O $ha^{-2}y$-1, MCT	
Peru	Semi-deciduous moist forest 180 m a.s.l.	2200 26	-	-30 µg CH_4-C $m^{-2}h^{-1}$, MCT *Estimated flux: -3.50*	9.1 µg N_2O-N $m^{-2}h^{-1}$, MCT *Estimated flux: 1.26*	(Palm et al., 2002)
Peru	Pre-montane 1070 - 1088 m a.s.l.	5300 23.4	0.22±0.01 (dry season), 0.21±0.01 (wet season) g CO_2-C $m^{-2}h^{-1}$, MCT	-0.27±0.13 (dry season), -0.13±0.13 (wet season) mg CH_4 $m^{-2}d^{-1}$, MCT	-	(Jones et al., 2016)
	Lower montane	2600	0.18±0.01 (dry season),	-1.47±0.13 (dry season), -	-	

	1532 - 1769 m a.s.l.	18.8	0.17±0.01 (wet season) g CO_2-C $m^{-2}h^{-1}$, MCT	1.34±0.13 (wet season) mg CH_4 $m^{-2}d^{-1}$, MCT		
	Upper montane 2811 - 2962 m a.s.l.	1700 12.5	0.12±0.01 (dry season), 0.17±0.01 (wet season) g CO_2-C $m^{-2}h^{-1}$, MCT	-2.14±0.13 (dry season), -1.47±0.13 (wet season) mg CH_4 $m^{-2}d^{-1}$, MCT	-	
Peru	Pre-montane 600 - 1200		-	-0.32±0.11 (dry season), 0.51±0.41 (wet season) mg CH_4-C $m^{-2}d^{-1}$, MCT *Estimated flux: -0.19±0.16*	0.96±0.47 (dry season), -0.15±0.43 (wet season) mg N_2O-N $m^{-2}d^{-1}$, MCT *Estimated flux: 0.85±0.50*	(Teh et al., 2014)
	Lower montane 1200 - 2200		-	-0.84±0.07 (dry season), -0.49±0.13 (wet season) mg CH_4-C $m^{-2}d^{-1}$, MCT *Estimated flux: -0.92±0.12*	0.98±0.23 (dry season), 0.16±0.13 (wet season) mg N_2O-N $m^{-2}d^{-1}$, MCT *Estimated flux: 0.79±0.20*	
	Upper montane 2200 - 3200		-	-1.22±0.04 (dry season), -0.54±0.11 (wet season) mg CH_4-C $m^{-2}d^{-1}$, MCT *Estimated flux: -1.07±0.11*	0.19±0.17 (dry season), 0.02±0.22 (wet season) mg N_2O-N $m^{-2}d^{-1}$, MCT *Estimated flux: 0.19±0.20*	

Note: Annual estimated fluxes were taken from literature in each case (when available) but converted to the respective units (Mg CO_2-C $ha^{-1}y^{-1}$, kg CH_4 $ha^{-1}y^{-1}$, kg N_2O $ha^{-1}y^{-1}$); whereas measured fluxes are shown in the original units.

30

Dalal, R. C. and Allen, D. E.: TURNER REVIEW No. 18 Greenhouse gas fluxes from natural ecosystems, Aust. J. Bot., 56, 369–407, 2008.

Davidson, E. A., Yoko Ishida, F. and Nepstad, D. C.: Effects of an experimental drought on soil emissions of carbon dioxide, methane, nitrous oxide, and nitric oxide in a moist tropical forest, Glob. Chang. Biol., 10, 718–730, doi:10.1111/j.1529-8817.2003.00762.x, 2004.

Jarvis, A., Reuter, H. I., Nelson, A. and Guevara, E.: Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT), [online] Available from: http://srtm.csi.cgiar.org, 2008.

Jones, S. P., Diem, T., Huaraca Quispe, L. P., Cahuana, A. J., Reay, D. S., Meir, P. and Teh, Y. A.: Drivers of atmospheric methane uptake by montane forest soils in the southern Peruvian Andes, Biogeosciences, 13, 4151–4165, doi:10.5194/bg-13-4151-2016, 2016.

Keller, M., Kaplan, W. A. and Wofsy, S. C.: Emissions of N2O, CH4 and CO2 from tropical forest soils, J. Geophys. Res., 91, 11791–11802, doi:10.1029/jd091id11p11791, 1986.

Müller, A. K., Matson, A. L., Corre, M. D. and Veldkamp, E.: Soil N2O fluxes along an elevation gradient of tropical montane forests under experimental nitrogen and phosphorus addition, Front. Earth Sci., 3, 1–12, doi:10.3389/feart.2015.00066, 2015.

Palm, C. A., Alegre, J. C., Arevalo, L., Mutuo, P. K., Mosier, A. R. and Coe, R.: Nitrous oxide and methane fluxes in six different land use systems in the Peruvian Amazon, Global Biogeochem. Cycles, 16, 21-1-21–13, doi:10.1029/2001gb001855, 2002.

Silver, W. L., Thompson, A. W., McGroddy, M. E., Varner, R. K., Dias, J. D., Silva, H., Crill, P. M. and Keller, M.: Fine root dynamics and trace gas fluxes in two lowland tropical forest soils, Glob. Chang. Biol., 11, 290–306, doi:10.1111/j.1365-2486.2005.00903.x, 2005.

Sousa Neto, E., Carmo, J. B., Keller, M., Martins, S. C., Alves, L. F., Vieira, S. A., Piccolo, M. C., Camargo, P., Couto, H. T. Z., Joly, C. A. and Martinelli, L. A.: Soil-atmosphere exchange of nitrous oxide, methane and carbon dioxide in a gradient of elevation in the coastal Brazilian Atlantic forest, Biogeosciences, 8, 733–742, doi:10.5194/bg-8-733-2011, 2011.

Teh, Y. A., Diem, T., Jones, S., Huaraca Quispe, L. P., Baggs, E., Morley, N., Richards, M., Smith, P. and Meir, P.: Methane and nitrous oxide fluxes across an elevation gradient in the tropical Peruvian Andes, Biogeosciences, 11, 2325–2339, doi:10.5194/bg-11-2325-2014, 2014.

Verchot, L. V., Davidson, E. A., Cattânio, J. H. and Ackerman, I. L.: Land-use change and biogeochemical controls of methane fluxes in soils of eastern Amazonia, Ecosystems, 3, 41–56, doi:10.1007/s100210000009, 2000.

Wolf, K., Flessa, H. and Veldkamp, E.: Atmospheric methane uptake by tropical montane forest soils and the contribution of organic layers, Biogeochemistry, 111, 469–483, doi:10.1007/s10533-011-9681-0, 2012.