Supplement of Biogeosciences, 11, 4251–4269, 2014
http://www.biogeosciences.net/11/4251/2014/
doi:10.5194/bg-11-4251-2014-supplement

Supplement of

Physical controls on CH_4 emissions from a newly flooded subtropical freshwater hydroelectric reservoir: Nam Theun 2

C. Deshmukh et al.

Correspondence to: D. Serça (dominique.serca@aero.obs-mip.fr)

Supplementary material

S1: Artificial Neural Network

The MLP will approximate highly non linear functions between input vectors X and output vectors Y (where Y=f(X)) and requires no prior knowledge of the nature of this relationship. In that study, Y is represented by the ebullition flux ($CH_{4ebullition}$) and X is represented by a set of 3 inputs (change in total static pressure, total static pressure, and bottom temperature). The non-linear function f represented by the hyperbolic tangent (tanh). All inputs and output are normalized and centered in order to avoid artifact in the training process (procedure that estimates for each normalized parameter a set of weights able to give the smallest error between actual and desired output.)

$$CH_{4fluxnorm} = w_{12} + w_{13} \cdot \tanh(S_1) + w_{14} \cdot \tanh(S_2) + w_{15} \cdot \tanh(S_3) \qquad (S1)$$

where $CH_{4fluxnorm}$ is the normalized CH_4 flux, and

$$S_1 = w_0 + \sum_{i=1}^{3} w_i v_{j,norm} \qquad (S2)$$

$$S_2 = w_4 + \sum_{i=5}^{7} w_i v_{j,norm} \qquad (S3)$$

$$S_3 = w_8 + \sum_{i=9}^{11} w_i v_{j,norm} \qquad (S4)$$

with $j=1 \rightarrow 3$

where v_1 to v_3 correspond to change in total static pressure (sum of change in water level and change in atmospheric pressure), total static pressure (water depth + atmospheric pressure) and bottom temperature, respectively; with

$$v_1{,}norm = x_1 + x_2 * v_1 \qquad (S5)$$

$$v_2{,}norm = x_3 + x_4 * v_2 \qquad (S6)$$

$$v_3{,}norm = x_5 + x_6 * v_3 \qquad (S7)$$

All weights w_i are given in Table S2 the weights w_0, w_4, and w_8 being linked to the bias neuron (constant term equal to 1).

The resulting CH_4 ebullition is finally calculated (in $mmol.m^{-2}.d^{-1}$) using:

$$CH_{4ebullition} = x_6 + x_8 * CH_{4fluxnorm} \quad (S8)$$

where x_j are the normalization coefficient, given in Table S3.

Table S1. Details of the meteorological and physical conditions at the eddy covariance site during the four different deployments. Average, standard deviation, and range are given for all variables.

	March 2009	March 2010	March 2011	June 2011
Water depth (m)	~10	~10.5	~6.7	~1.5
Wind speed ($m.s^{-1}$)	2.4 ± 1.1 (0.3−6.7)	2.9 ± 2.3 (0.2−10)	3.0 ± 1.9 (0.2−7.3)	1.4 ± 0.9 (0.2−4.3)
Friction velocity, u_* ($m.s^{-1}$)	0.25 ± 0.11 (0.07−0.7)	0.21 ± 0.11 (0.03−0.59)	0.19 ± 0.12 (0.02−0.47)	0.15± 0.08 (0.02−0.39)
Relative humidity (%)	77 ± 9 (47−91)	66 ± 14 (35−86)	72 ± 11 (45−87)	73 ± 15 (20−93)
Air temperature, T_{air} (°C)	25 ± 2 (23−30)	23 ± 4 (16−33)	22 ± 3 (17−30)	26 ± 2 (24−30)
Water temperature, T_{water} (°C)	29 ± 1 (28−31)	24 ± 2 (21−30)	23 ± 1 (21−27)	29 ± 2 (25−32)
T_{water}-T_{air} (°C)	3.6 ± 1.2 (0.2−6.2)	1.0 ± 2.6 (-5.7−5.2)	1.5 ± 1.9 (-3.1−3.9)	2.9 ±1.5 (0.2−5.3)
Net shortwave radiation ($W.m^{-2}$)	141 ± 200 (-3−634)	114 ± 169 (-4−551)	219 ± 314 (-6−880)	149 ± 253 (-5−1018)
Net longwave radiation ($W.m^{-2}$)	-28 ± 11 (-49− (-6))	-43 ± 9 (-63− (-10))	-75 ± 8 (-88−(-48))	-38 ± 15 (-61− (-6))
Net radiation ($W.m^{-2}$)	90 ± 188 (-51−596)	67 ± 171 (-60−497)	117 ± 307 (-94−777)	110 ± 251 (-66−1011)

Table S2. Weights for CH_4 ebullition modeling with neural network parameterization

Weights	
$w_{(0)}$	-0.735741
$w_{(1)}$	-1.93496339
$w_{(2)}$	-1.54455293
$w_{(3)}$	-0.38119742
$w_{(4)}$	0.67514498
$w_{(5)}$	1.81679708
$w_{(6)}$	0.30915645
$w_{(7)}$	-0.31561338
$w_{(8)}$	0.76193471
$w_{(9)}$	0.98635468
$w_{(10)}$	0.7621441
$w_{(11)}$	0.20152095
$w_{(12)}$	0.92422681
$w_{(13)}$	-1.2168297
$w_{(14)}$	-1.0238241
$w_{(15)}$	-1.92242616

Table S3. Normalization coefficients for CH_4 ebullition modeling with neural network parameterization

	Normalization Coefficients
x_1	0.3872344
x_2	12.520561
x_3	-4.370062
x_4	0.302245
x_5	-11.117316
x_6	0.557007
x_7	9.066059
x_8	9.029213

a b

c d

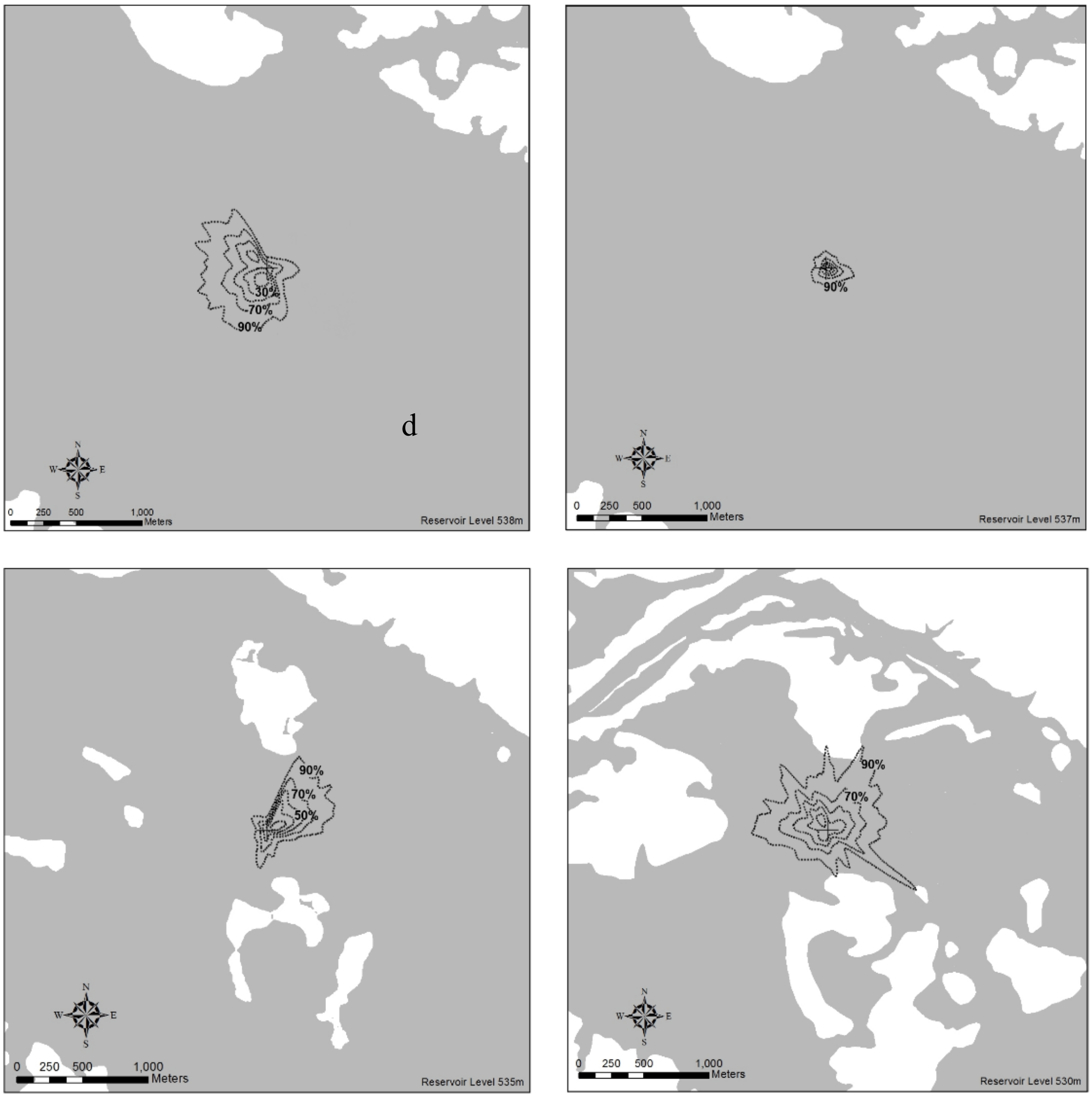

Figure S1: Footprint of the eddy covariance system at Nam Theun 2 Reservoir in (a) May 2009, (b) March 2010, (c) March 2011 and (d) June 2011. Grey area represents the water surface, white area islands and shoreline. Main shoreline is visible in the Southwest and Northeast corners

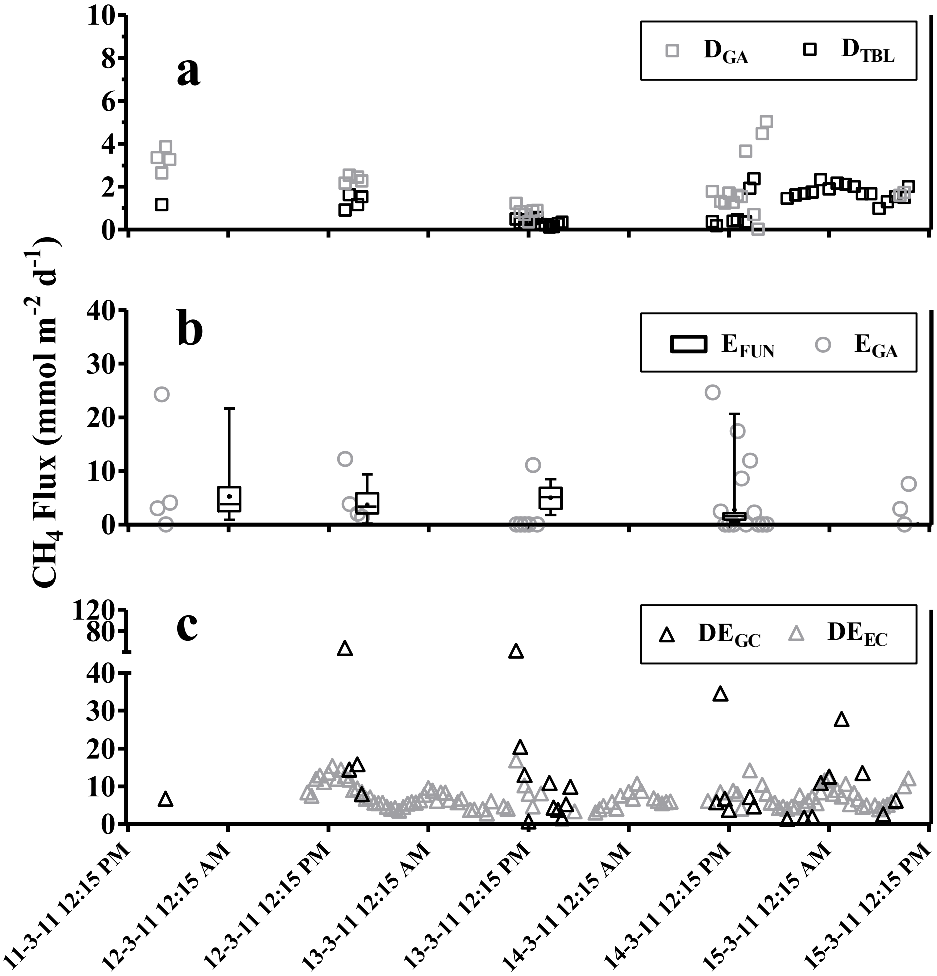

Figure S2. Time series of (a) diffusion, (b) ebullition, and (c) total (diffusion + ebullition) obtained during March 2011. In panel b, boxes show the median ebullition and the interquartile range, and whiskers denote the full range of all values. Plus sign (+) in the box is showing the mean value. D_{TBL}: Diffusion calculated by thin boundary layer (TBL) method from surface CH_4 concentrations, D_{GA}: Diffusion from FC and in situ gas analyser, E_{FUN}: Ebullition from submerged funnel, E_{GA}: Ebullition from FC and in situ gas analyser, DE_{EC}: Total emissions measured by eddy covariance, DE_{GC}: Total emissions by FC (diffusion + ebullition) affected by ebullition.

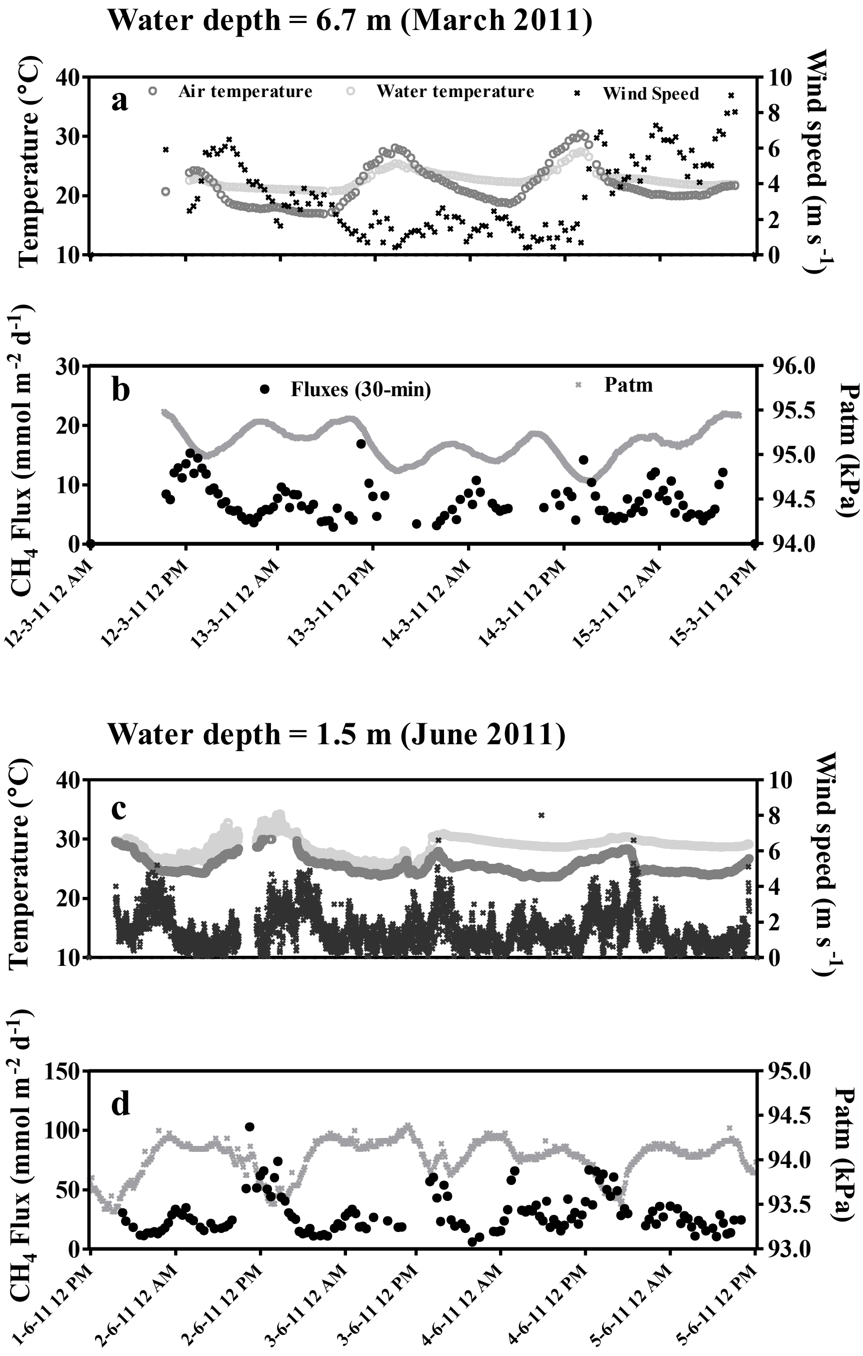

Figure S3. Time series of CH_4 emissions measured by eddy covariance (DE_{EC}) (b, d), wind speed (a, c), air temperature (a, c), surface water temperature (a, c) and atmospheric pressure (b, d), obtained during the March and June 2011 field campaigns. Note the difference in the y-axis scale between the two field campaigns.

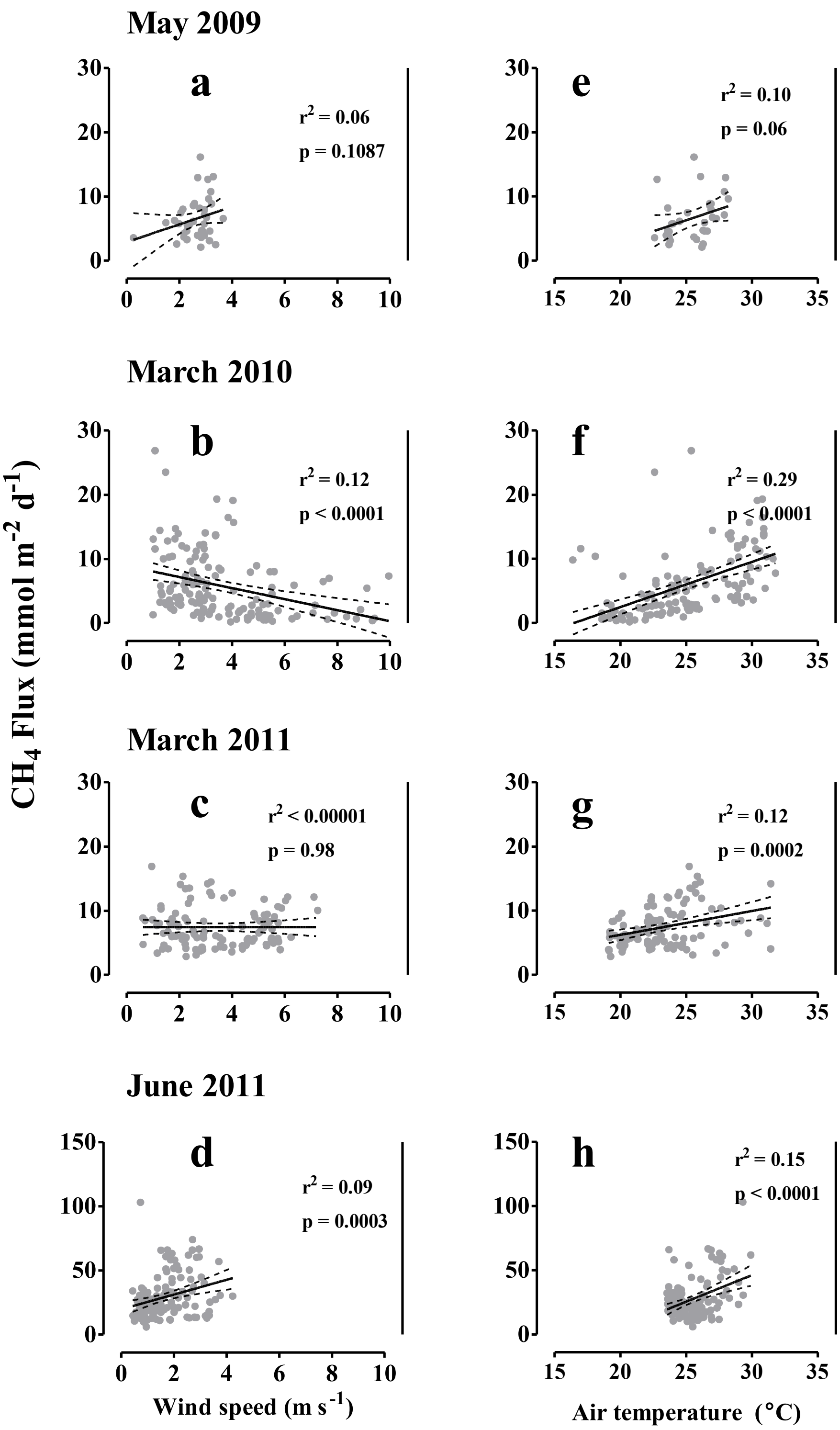

Figure S4. CH_4 emissions measured by eddy covariance (DE_{EC}) versus wind speed (a, b, c, d) and air temperature (e, f, g, h) for the four field campaigns. Note that y-axis scale differs for June 2011.

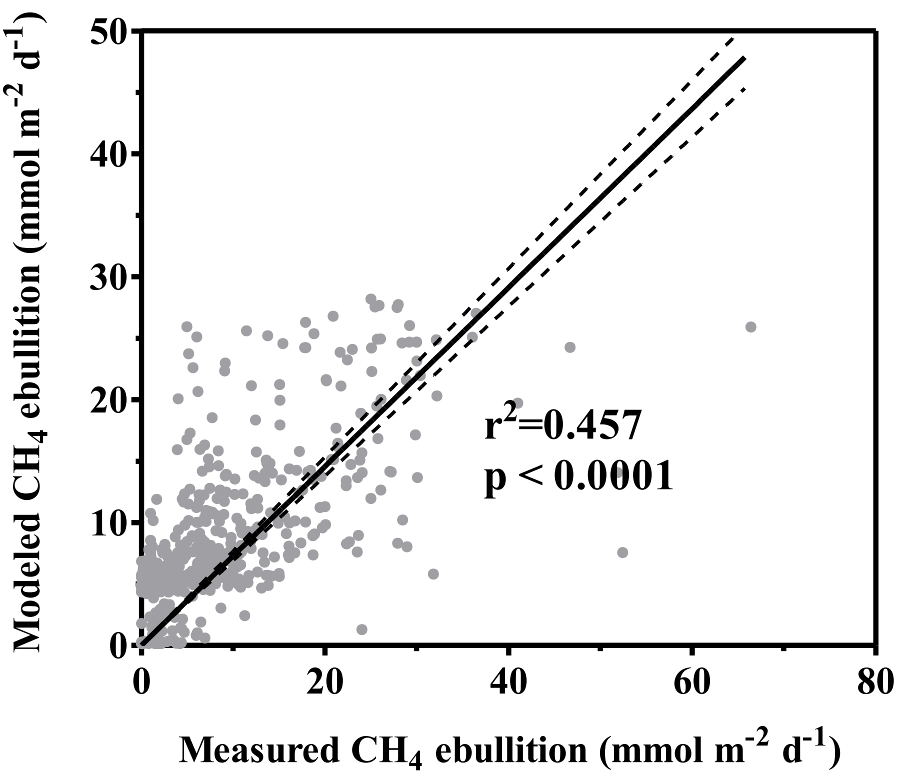

Figure S5. Funnels versus ANN modeled ebullition fluxes.